Final

Packwood Lake Intake
Fish Entrainment Monitoring Plan

for

Energy Northwest's
Packwood Lake Hydroelectric Project
FERC No. 2244
Lewis County, Washington

Submitted by:

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1.0 INTRODUCTION

Energy Northwest's (EN) Packwood Lake Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. P-2244, received its initial license in 1960. The majority of the Project is located in the Gifford Pinchot National Forest. The Project consists of an intake canal, a concrete drop structure (dam) and intake building on Lake Creek located about 424 ft. downstream from the outlet of Packwood Lake, a 21,691-foot system of concrete pipe and tunnels, a 5,621-foot penstock, a surge tank, and powerhouse with a 26,125 kW turbine generator.

The source of water for the Project, Packwood Lake, is situated at an elevation of approximately 2,857 ft. above mean sea level (MSL), about 1,800 ft. above the powerhouse. Water discharged from the Project is released to the Cowlitz River via a tailrace channel. Power from the Project is delivered over an 8,009-foot 69 kV transmission line to the Packwood substation.

EN filed its Final Application for New License of the Project on February 24, 2008. FERC issued a new license for the Project on October 11, 2018.

1.1 Plan Justification

EN, in consultation with the United States Department of Agriculture - Forest Service (USFS), FERC, United States Department of Commerce – National Oceanic and Atmospheric Administration/National Marine Fisheries Service (NMFS), United States Department of the Interior - Fish and Wildlife (FWS), Washington State Department of Ecology (WDOE), Washington State Department of Fish and Wildlife (WDFW), consulting biologists, and EN subject matter experts, has developed this Packwood Lake Intake Fish Entrainment Monitoring Plan (Plan) in response to the requirements specified in the FERC License Order as USDA Forest Service Federal Power Action Final Section 4(e) Term and Condition No. 9 (FERC 2018).

1.2 Purpose and Scope of the Plan

The primary purpose of the Plan is to provide a process for protecting the rainbow trout population in Packwood Lake from potential mortality associated with approach velocity exceedances on sections of the traveling screens at the Project intake (Forest Service 2009). Relicensing studies have shown that the traveling screens are not fully compliant with WDFW approach velocity criteria (at higher inflow velocities; EES Consulting 2008). Studies have shown that a small percentage of the total trout population have been found on the intake traveling screens (EES Consulting 2007a and 2008). Accordingly, the overarching goal of the Plan is to determine whether intake traveling screen approach velocities in excess of the State of Washington criteria cause detrimental impacts to the rainbow trout population in Packwood Lake.

Through numerous discussions and data analysis, the relicensing participants have concluded that the November 2006 rain on snow event, misaligned outer debris screens and weakened post

spawning fish may account for much of the impingement observed during the 2007 entrainment study. However, there is still some question about what magnitude of mortalities that are occurring during normal operating conditions and what effect this may be having on the trout population in the lake. Due to these uncertainties, the USFS provided a modified FPA Section 4(e) condition, Condition No. 9 Entrainment in Project Intake (March 2009) that allowed the Project to continue as currently operated but also established a set of biological criteria that must be met in order to allow the Project to continue to operate its existing intake structure in the future.

The Plan is also designed to provide monitoring direction and methodology for operation and maintenance of the intake screens, and evaluation of trout behavior associated with the intake wells to EN for the first five years post-license Issuance and to provide the framework for establishing future monitoring frequency and actions after that time. These future decisions about monitoring frequency and actions will be dependent upon the results of the initial monitoring period and will be collaboratively agreed upon between EN, the USFS, and other resource agencies. The Resource Agencies Committee (RAC) includes but is not limited to the United States Forest Service (USFS), Cowlitz Indian Tribe (CIT), Federal Energy Regulatory Commission (FERC), National Marine Fisheries Service (NMFS), National Park Service (NPS), United States Fish and Wildlife (FWS), Washington State Department of Archaeology and Historic Preservation (DAHP), Washington State Department of Ecology (WDOE), Washington State Department of Fish and Wildlife (WDFW), Yakama Nation (YN), consulting biologists, and EN subject matter experts.

1.3 Elements of the Monitoring Plan

Elements of the Plan are described in USFS Term and Condition No. 9. USFS Term and Condition No. 9 specifies the following 15 required Plan elements and have been organized by functional area. The functional descriptions are expanded into goals and measurable objectives and implementation measures and tasks as described in Sections 2.1 and 2.2 below.

Monitoring Plan Purpose, Communication, Coordination and Management

- Identify the Plan goals and identification of measurable objectives;
- Specify roles and responsibilities of all involved parties;
- Schedule for implementation; agency coordination requirements and preparation of draft and final reports.

Screen Operation and Maintenance

- Implement screen maintenance and modification; operation (traveling screen rotation: auto vs. manual) and placement and configuration of the removable outer debris screen;
- Recommended inspection and cleaning frequency for the forebay area;

- Evaluate proposed stop log placement at the entrance to the removable debris screen.

Packwood Lake Rainbow Trout Population

- Monitor the Packwood Lake rainbow trout population including identification of methods and frequency of monitoring. Methods could include: hydroacoustic sampling, mark re-capture, tributary spawning surveys (including identification of frequency of surveys, tributary and reach selection, counts of redds and adult fish), and out-migrant tributary trapping to estimate fry densities in the lake. The intent is to obtain a high detection rate (80% - 95% of total population) for juvenile and adult trout in the lake;
- Monitoring method data analysis used to estimate lake population density.

Traveling Screen Impingement and Mortality

- Identify methods and frequency of monitoring necessary for accurately quantifying traveling screen impingement and mortality/injury.

Mortality Decay Rates

- Account for the potential loss of impinged fish due to predation and decay between sample periods. Test the persistence of dead fish found on the traveling screens by identifying the natural decay rates and the effects of scavengers feeding at the intake system (including but not limited to crayfish and fish scavenging).

Fish Behavior

- Identify observation monitoring methods for fish movement in the intake wells and forebay (including but not limited to underwater cameras) and recommended timing and frequency of observation.

Data Analysis and Adaptive Management

- Develop impingement criteria including but not limited to: estimates of total population of rainbow trout in the lake; total fry in each monitored cohort, and identification of a threshold level of allowable mortality associated with the intake screen. For the initial five-year sampling period, no more than 1.5% per year of the total Packwood Lake rainbow trout population in the lake shall be injured or killed as a result of impingement on the intake screen;
- Determine whether mortality was caused by impingement or if mortality occurred prior to impingement. Fish that can be shown to have suffered from post spawning mortality shall

be identified as such and included in the total fish mortality count but not included in the 1.5% impingement mortality criteria;

- Identify methods to adapt mortality criteria during the life of the license if the rainbow trout population in Packwood Lake decreases significantly as determined by monitoring;
- Specify required mitigation actions if impingement threshold is exceeded in any monitoring period. EN shall be required to implement these actions as necessary to protect the Packwood Lake rainbow trout population.

1.4 Entrainment Overview

1.4.1 Entrainment Initial Study

An initial entrainment study at the Packwood Lake intake structure began in October 2004. The results from this early study were considered preliminary and it was determined that additional sampling would be necessary before conclusions regarding the efficacy of the screens and the magnitude of impingement could be determined. A study plan was developed in August 2005 and field work began in 2006.

A total of 63 fish were found on the intake screens from May 23 through September 28, 2006 (EES Consulting 2007a, Table 3-3; Figure 3-18). All fish found on the screens were rainbow trout. There were a total of 36 fish collected on Screen 1 and 27 fish collected on Screen 2.

The size of fish entrained on the intake screens averaged 194 mm, ranging from a minimum of 64 mm to 324 mm. Seven percent (5 fish) were less than 100mm in length; over 76% of the rainbow trout (48) ranged from 161 mm – 240 mm (approximately 6.4 – 9.5 inches) (EES Consulting 2007a, Figure 3-19). Nearly 60% (37) of the fish were found on the screens during the two inspections in May. All of these fish exceeded 146 mm in length, averaging 206 mm.

A total of 357 rainbow trout were entrained on the intake screen during the period January through August 2007. On Screen 2 there were 198 fish observed; 159 fish on Screen 1. The distribution of fish on the screens was bimodal; an early peak occurred in late winter/early spring, with the other occurring during the summer (EES Consulting 2007a, Figure 3-20; Table 3-3).

The highest number of fish found at one time was on March 15, 2007 when 69 were observed. The period of time from January to early May was dominated by fish being found mainly on Screen 2 (137 of 176 total fish). From mid-May to early July, more fish were found on Screen 1 (120) than Screen 2 (61). No fish were found after July 6, although the screens were checked weekly into September 2007. The majority (72%) of the fish entrained on the screens with measured lengths had fork lengths in the range of 201-250 mm (EES Consulting 2007a, Figure 3-21) and no fish were smaller than 50 mm. The size ranges of 151-200 mm and 251-300 mm were almost equal with 20 and 21 fish, respectively. The size distribution of the fish on both screens was centered on the 201-250 mm size range.

The results of the 2006 and 2007 studies were included in a final report submitted for the relicensing effort (EES Consulting 2007a). The report notes that the 2007 sampling period was affected by a large storm event in November 2006 that degraded water quality in the lake and caused an extended period of high turbidity. This storm event inundated the lake with a high volume of sediment resulting in excessive turbidity. During the event, the lake experienced inflows that exceeded 1100 cfs over several days and the turbid conditions persisted into mid-July. These conditions as well as other factors contributed to the higher than expected mortality rate of rainbow trout that was observed in 2007 at the Packwood Lake intake. The report concluded that high Project flows and extended period of poor water quality, combined with the debris screens being out of alignment contributed to the higher entrainment numbers observed during this period (EES Consulting 2007a).

In late 2007 and early 2008, discussions between EN and the natural resource agencies resulted in EN electing to measure the traveling screen approach velocities at a range of operating flows and lake elevations. This study was conducted in September 2008, with the debris screens removed and while the lake was being lowered prior to the annual maintenance shutdown (EES Consulting 2008). Testing during the 2008 study determined that at certain flows and lake elevations, observed screen velocities were in excess of the screen velocity criteria provided by the WDFW (Washington Administrative Code/Revised Code of Washington Title 77) (EES Consulting 2008). As a result of this determination, the agencies directed EN to develop a monitoring plan (i.e., this plan) to determine whether the intake screen approach velocities in excess of the State of Washington criteria cause detrimental impacts to the Packwood Lake trout population.

EN continued the traveling screen inspections and fish mortality observations following the conclusion of the relicensing studies in 2007. The traveling screens have been operated in manual and fish counts conducted during the period of time when access to the intake structure was possible. These counts take place during weekly inspections, when possible. Certain circumstances have and may warrant the deferral of performing weekly monitoring. Such circumstances include but are not limited to personnel on planned or unplanned absence, project-related emergent activities, adverse weather, and/or road/trail conditions."

In 2008, 67 fish were found on the traveling screens, with 32 in 2009 and 121 in 2010 (see Figure 1). In most years, the majority of the fish are found on the screens in the months of May, June and July. This trend in the monthly data is more clearly seen if the unusual data from 2007 is removed (Figures 2 and 3). This timing is consistent with the spawning and post-spawn mortality period for Packwood Lake rainbow trout. A minor entrainment peak also occurs in November.

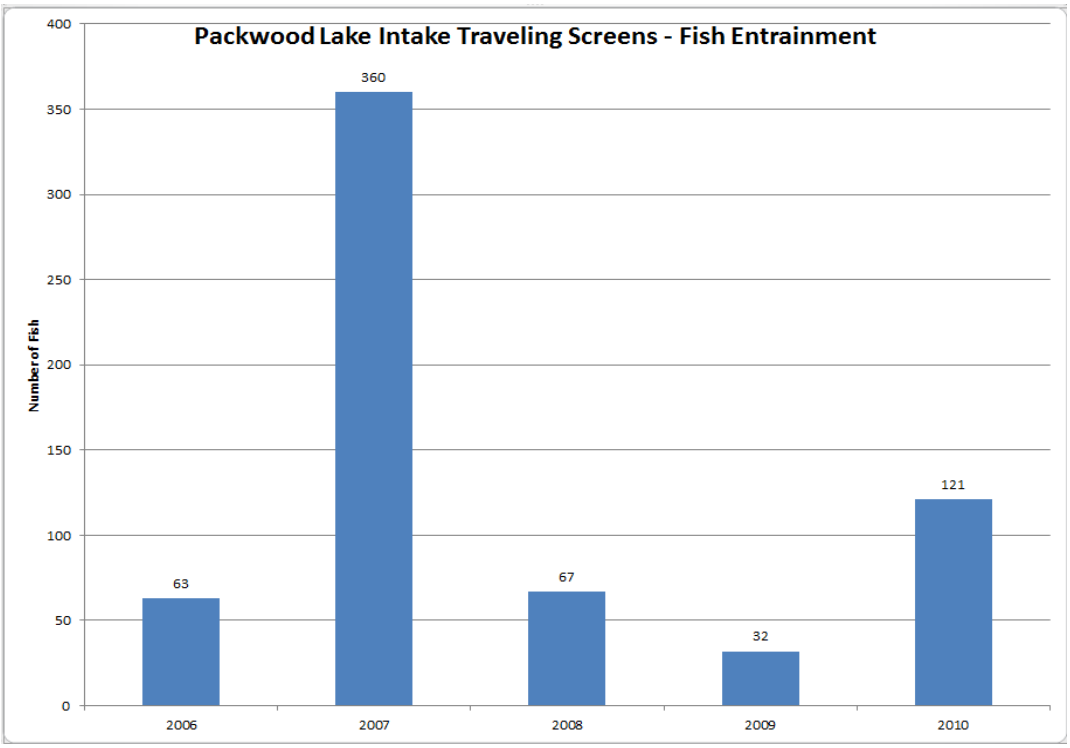

Figure 1. Intake Traveling Screens Fish Entrainment Data for 2006 - 2010.

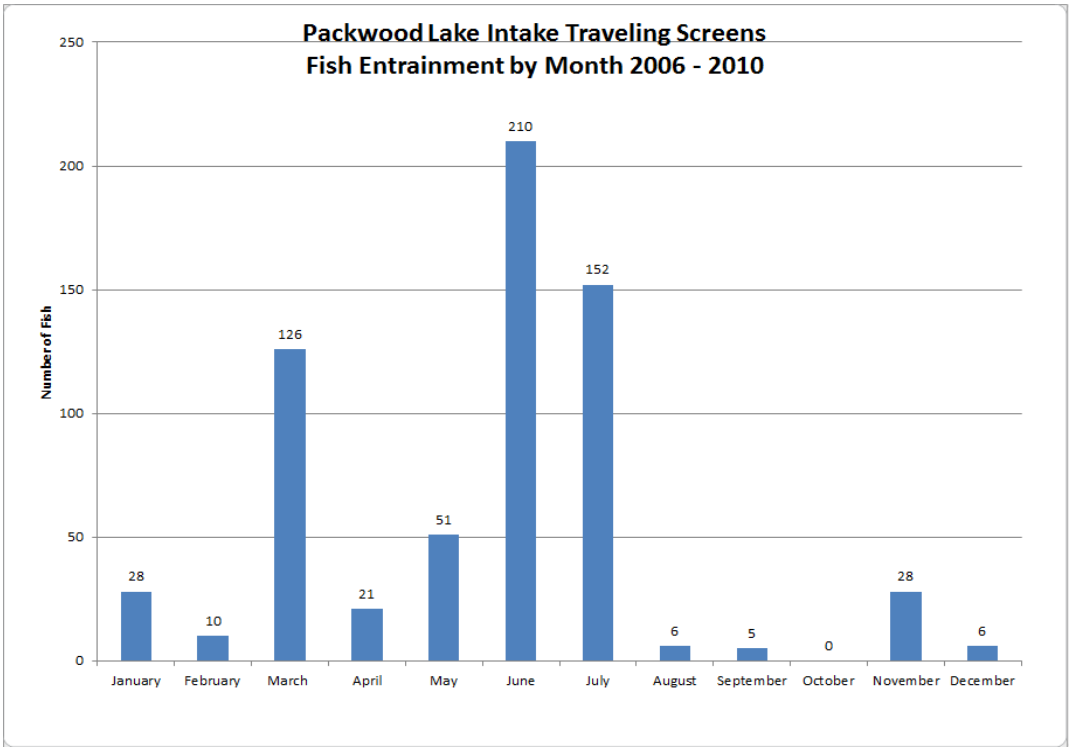

Figure 2. Intake Traveling Screens Fish Entrainment Data by Month for 2006-2010.

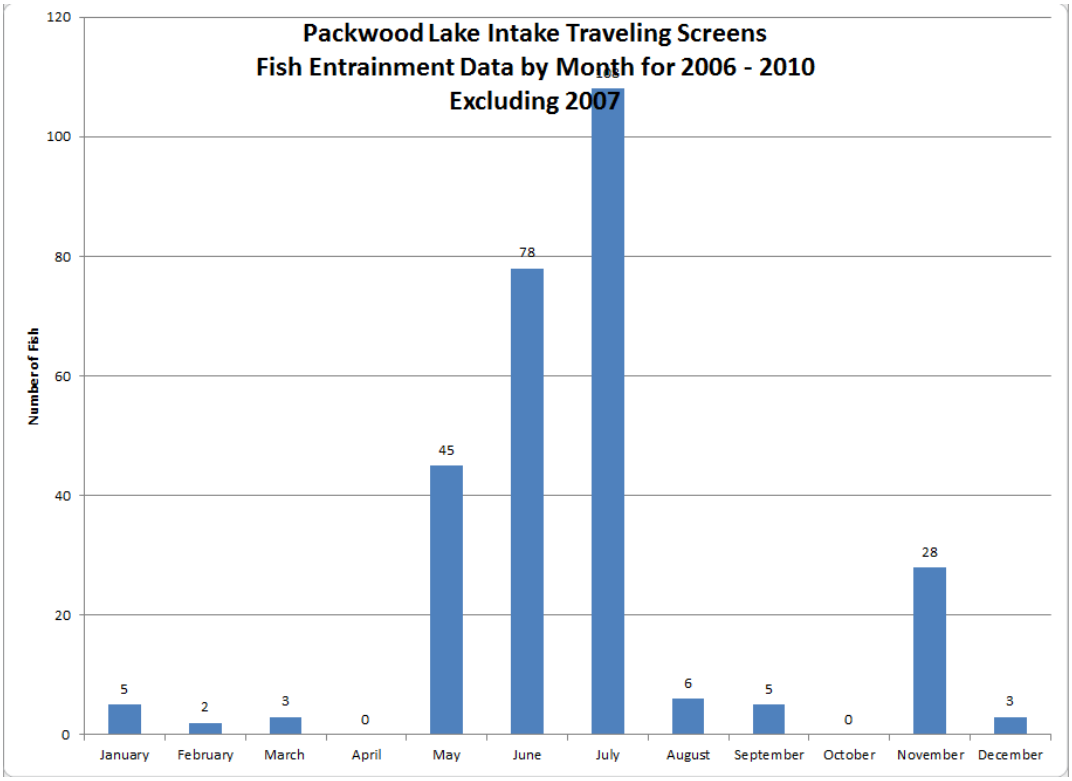

Figure 3. Intake Traveling Screens Fish Entrainment Data by Month for 2006 - 2010 excluding 2007.

The existence of post-spawn mortalities was originally noted by Lucas and Chilcote (1982) in their study of Packwood Lake trout. They reported that, "The majority of fish apparently die after spawning as numerous carcasses were evident on the lake bottom where tributaries flowed into the lake. Scales from only one fish showed any evidence of scale re-absorption, often characteristic of re-spawners." This observation and the timing correlation between spawning and peak impingement led EN to hypothesize that a majority of the fish found on the screens were weakened or dead post-spawn fish that drifted downstream from tributaries and were subsequently drawn into the intake. This entrainment monitoring plan has been designed to further distinguish between this hypothesis and mortalities due to high velocities or adverse screen configurations within the intake building.

EES Consulting conducted weekly rainbow trout spawning surveys in Packwood Lake tributaries in 2007. Figure 4 shows fish entrainment at the intake structure compared with spawner counts in the tributaries (escapement). This graph indicates a high correlation between the two, given lag time between spawning and down-lake migration to the Project intake.

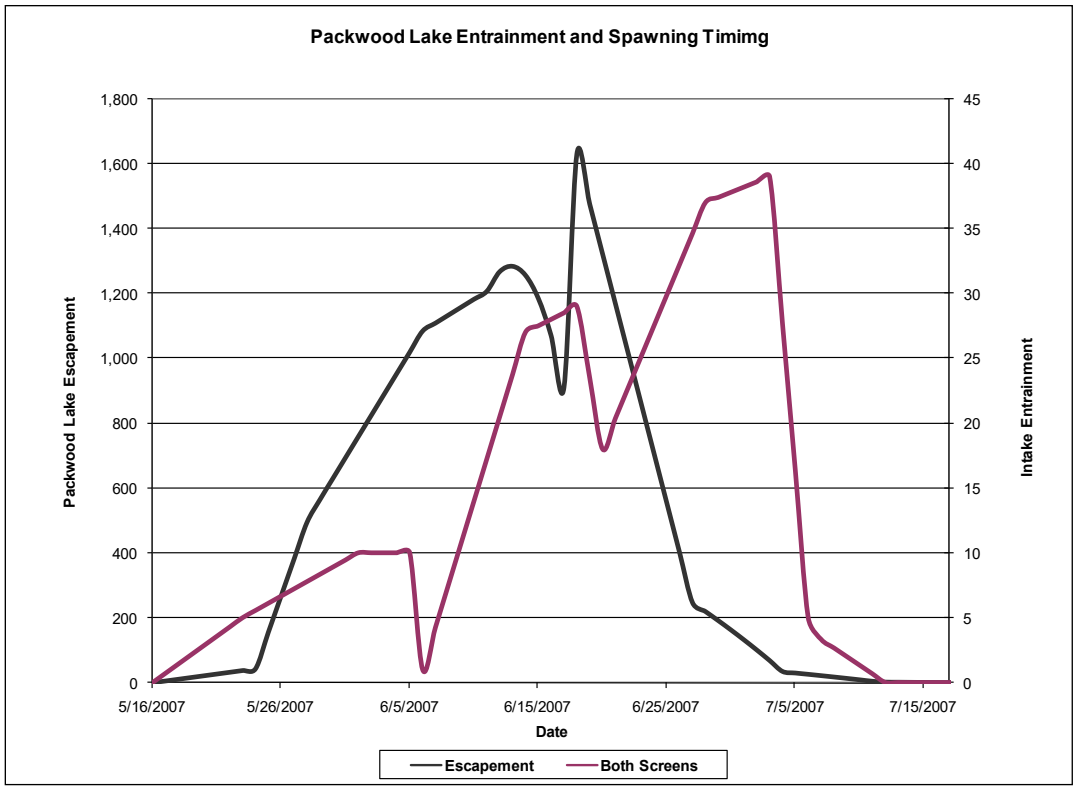

Figure 4. Packwood Lake Spawning and Impingement Timing, 2007.

1.4.2 Packwood Lake – Adfluvial Rainbow Trout

Packwood Lake and its major tributaries currently support a self-sustaining population of adfluvial rainbow trout *Oncorhynchus mykiss* spp., the only species of fish ever documented to exist in Packwood Lake. Genetic comparisons of Packwood Lake *O. mykiss* spp. with "inland" and "coastal" populations found that Packwood Lake fish are more closely related to inland populations. Although five distinct populations of non-indigenous rainbow trout were stocked in Packwood Lake from 1954 through 1965, no fish have been stocked in the lake since 1965 and there appears to have been no genetic introgression of hatchery stocks with natural resident fish in Packwood Lake.

Two hydroacoustic fish population surveys were conducted in Packwood Lake in May 2007 and August 2007 (EES Consulting 2007b). The first survey took place on May 23, 2007, prior to adult migration into the tributaries for spawning. The second survey was conducted on August 8, 2007, after the adults migrated back to the lake. There were 96 and 211 fish detected during the May 2007 and August 2007 hydroacoustic surveys, respectively. After extrapolating the transect data to encompass the entire lake volume, a total of 21,127 rainbow trout were estimated to inhabit Packwood Lake in May 2007. Once adult rainbow spawners had returned to the lake in mid-August and juvenile outmigration had begun, the estimated number of rainbow trout inhabitants increased to 31,278. The majority of these were found to occupy the "transition" and "deep" portions of Packwood Lake.

Packwood Lake is fed by seven fish bearing tributaries (Crawford, Osprey, Trap, Muller, Upper Lake Creek, Beaver Bill, and Southeast Trap creeks) that total an approximate three miles of fish accessible habitat. The two tributaries that have consistently supported the most spawning are Muller and Upper Lake creeks. Spawning activity within these tributaries varies from year to year. A typical year would see fish migrating from Packwood Lake into the tributaries in May and June. Peak spawning would occur in mid-June and the spawners typically would return to the lake by early July. The fry outmigration period would extend from July through to the latter part of August.

In 2007, 76% of the fish spawning in the tributaries to Packwood Lake were observed in Muller Creek, although a substantial number of spawners were also observed in Crawford and Osprey creeks. The abundance of fry in the tributaries to Packwood Lake correlated with the proportion of spawners observed in each creek, and as expected, the tributaries with the higher average water temperatures (Crawford and Trap creeks), had the shortest incubation periods.

1.5 Intake Configuration

Three sets of screens are present at the intake structure and described below. Schematics of the intake structure, showing the traveling screens and trash racks, are provided in Figures 5-7.

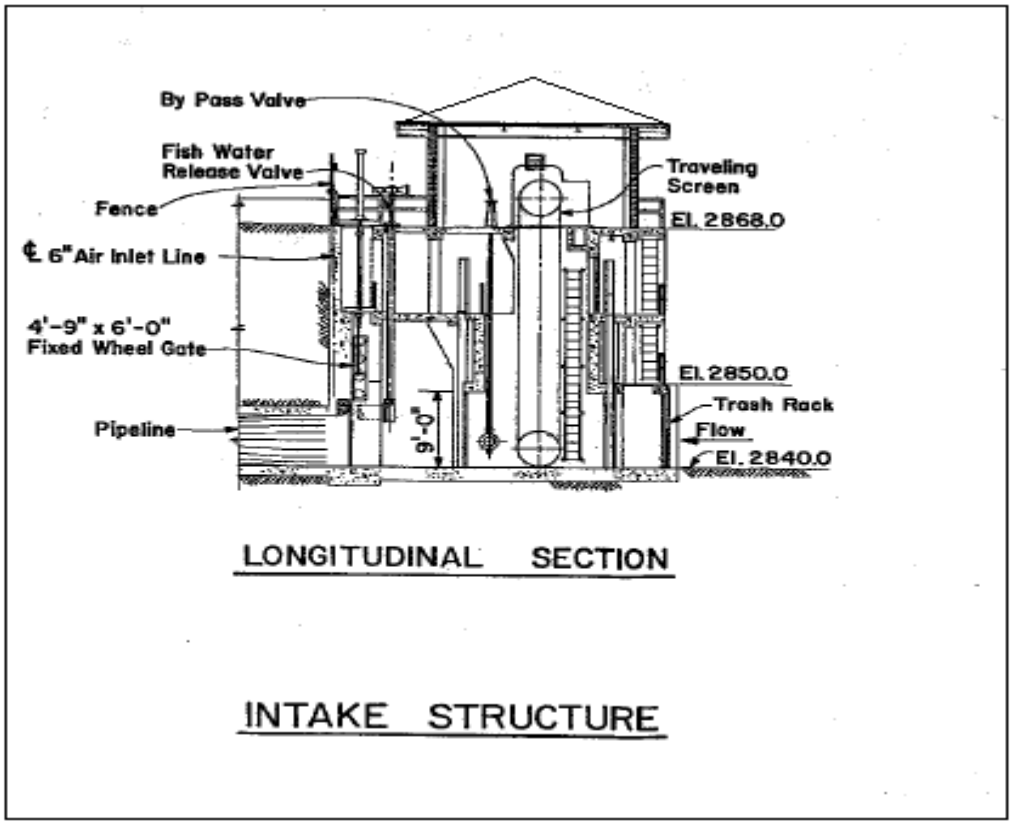

Figure 5. Schematic of Intake Structure.

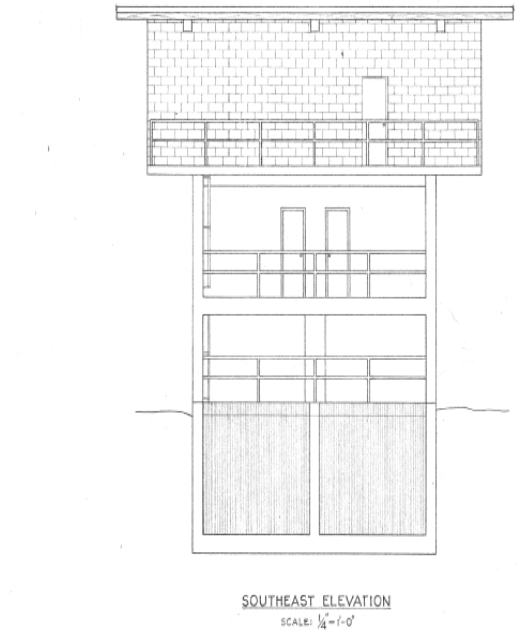

Figure 6. Front View of Packwood Lake Intake.

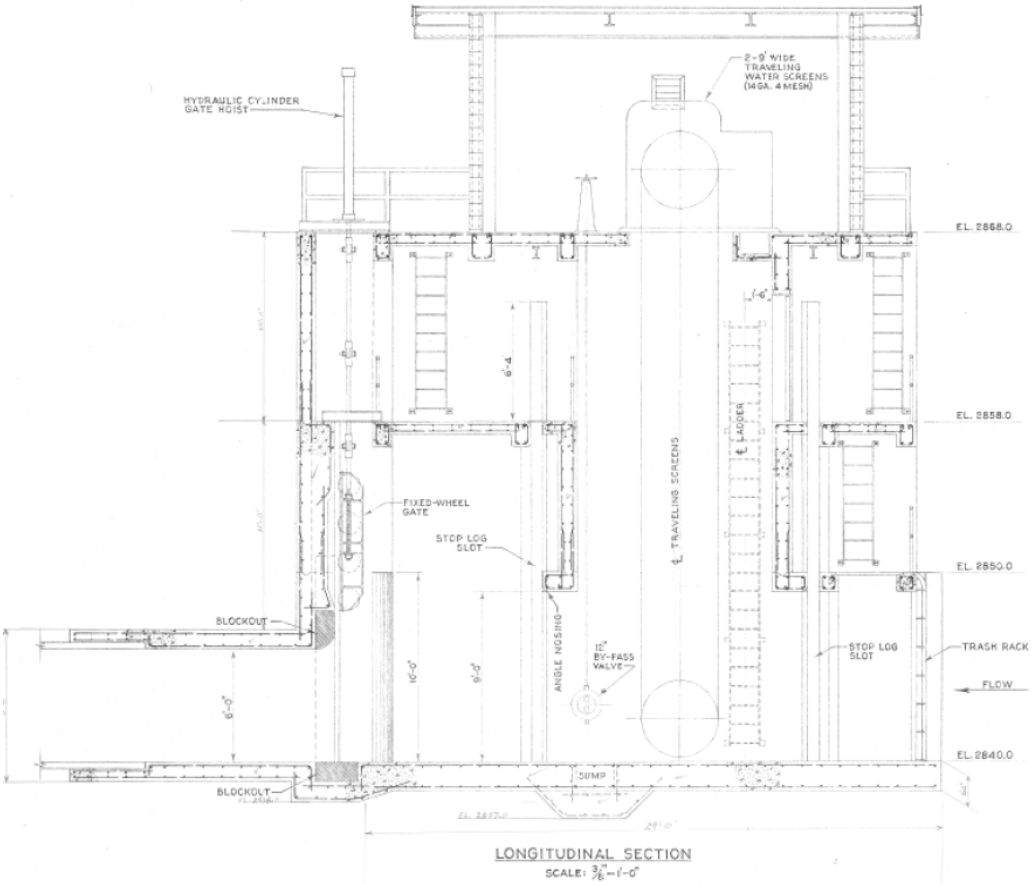

Figure 7. Longitudinal Section of Packwood Lake Intake.

1.5.1 Removable Debris Screens (Outermost)

To help manage the routine cleaning of the intake, two removable aluminum debris screens have been placed in front of the two primary water inlet openings at the intake building. These screens are designed to capture smaller debris from the lake that would otherwise foul either the permanent trash racks bars or the rotating screens.

The aluminum grating used for these screens has square shaped openings approximately 2-¼ in. x 2-¼ in. made of ¼ in. round stock, as indicated in Figure 8. These removable screens are configured in an "L" shape with an attached horizontal "platform" that extends out approximately 4 ft. from the base of the screens to catch unattached debris that falls from the screen face during the lifting process. The screens are placed directly in front of the trash rack gratings and extend down from the normal lake level to a point approximately 2 ft. above the floor of the intake building. Each screen is approximately10 ft. wide x 12 ft. high. They are each hung by a single chain and held in place against the trash racks by water flow. They are not otherwise attached to the building. The screens do not completely cover the trash racks due to the open area at the bottom. This lower open area was previously filled with an accumulation of woody debris that was removed by divers in 2009.

The screens are visually inspected to determine the degree of fouling during the routine intake building check (during the period of time when access to the intake structure is possible). Cleaning is performed as necessary using the judgment of the operator to determine if flow is being sufficiently impeded to warrant cleaning. Cleaning is normally performed as necessary throughout the operating cycle.

1.5.2 Permanent Trash Racks

The permanent trash racks cover the vertical and horizontal openings into the intake building and are designed to prevent the entry of large debris. The two main vertical grates, each 10 ft. high x 11 ft. wide, screen the two primary water inlets to the intake structure. These gratings extend from the floor of the intake building at 2,840 ft. MSL to the top of the opening at 2,850 ft. MSL. The grating was constructed using 2-½ in. wide x 5/16 in. thick steel bars on edge with 2-5/16 in. openings between the bars. Water can also enter the structure through two smaller horizontal grates that form a walkway at elevation 2850 directly above the main inlet openings (normally underwater). The water flowing through these grates immediately joins with the flow through the main openings. Each of these two gratings are 10.5 ft. x 3 ft. in dimension with 1-3/16 in. openings (constructed of 1-1/4 in. x 1/8 in. bar).

1.5.3 Traveling Screens

Two traveling screens prevent fish from entering the project water conveyance at the intake structure. All water that enters the intake building flows through these two screens before it passes to either the powerhouse pipeline or the bypass pipe to Lake Creek. Both screens are 9 ft. wide and exceed 28 ft. high. The screens utilize a 4 x 4 woven wire mesh fabric (four wires per inch in both the horizontal and the vertical) with a wire diameter of 0.080 in. (this results in screen openings of 4 mm x 4 mm). The base elevation of the intake building and the traveling screens is

2,840 ft. MSL. When the lake is at its normal elevation of 2,857 ft. MSL, the two screens have a combined screen area of about 306 sq. ft. The traveling screens are designed to be self-cleaning and operate automatically when fouling causes the water elevation across the screens to exceed the differential pressure set point. Screen rotation allows small debris to be removed from the screens by backwashing into the powerhouse flow while still excluding fish. However, as specified in this study plan, the screens are to be operated in a manual mode to facilitate fish mortality counts.

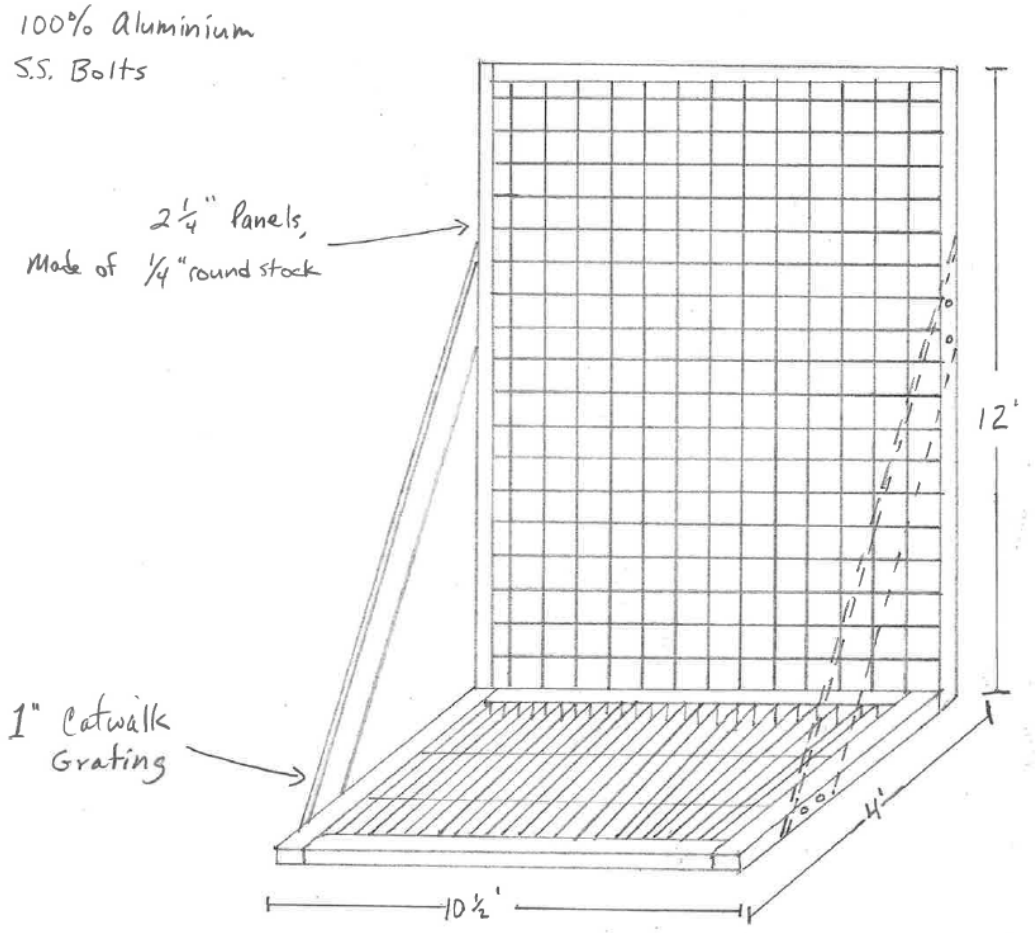

Figure 8. Aluminum Screen Configuration.

2.0 MONITORING PLAN

2.1 Goals and Measurable Objectives

The overarching goal of the Plan is to determine whether intake traveling screen approach velocities in excess of the State of Washington criteria cause detrimental impacts to the Packwood Lake rainbow trout population[1].

2.2 Implementation Measures and Tasks for Objectives

To accomplish the stated goal, implementation of measurable objectives is required. The seven objectives and associated implementation measures and tasks are presented below.

Objective 1: Specify how the Plan will be coordinated and managed between EN, the USFS, and the RAC

This section describes the roles and responsibilities, communication and coordination, and Plan management. It is intended that this Plan be conducted in accordance with the Plan elements specified below as well as those specified in the Resource Coordination Plan (RCP). The RCP provides the overarching administrative direction for the Project's conduct under the new license. The RCP addresses a process for information exchange, communications, and reporting by EN, future planning and coordination of activities necessary to implement license conditions and management plans, roles and responsibilities of the parties, and the conduct of the RAC.

Implementation Measure 1.1: Roles and Responsibilities of all involved parties

The RCP establishes a single process for use by EN to coordinate the conduct of each of its license compliance activities with timely oversight by the USFS and the RAC.

Implementation Measure 1.2: Communication and Coordination

The RCP establishes a process for EN to exchange information and coordinate its efforts to implement the conditions and ongoing operations and maintenance activities. The RCP describes how and when EN will communicate with the USFS and the RAC by specifying annual cycle of data submittals, review meetings, field work, future planning and report preparation. The RCP establishes a dispute resolution process to resolve disputes related to license conditions.

[1] The USDA Forest Service provided FPA Section 4(e) Condition No. 9 to be consistent with agency laws, regulations and policy. The Gifford Pinchot National Forest Land and Resource Management Plan (1990) as amended by the Northwest Forest Plan (1994) provides specific management direction to maintain viable populations of all native wildlife, fish and plant species in habitats distributed throughout their geographic range and avoid actions that may cause a species to become listed as threatened or endangered. As such, the USDA Forest Service will review Energy Northwest annual monitoring data and conclusions for consistency with federal laws, regulations and policy.

Implementation Measure 1.3: Plan Management

Task 1.3a: Plan Development and Updates

This Plan shall be developed in consultation with the RAC within three months of issuance of the new license. The approved Plan shall be implemented annually for the first five years of the new license. Subsequent monitoring frequency and actions will be dependent upon the results of the initial monitoring period, and collectively agreed to by the RAC members.

EN, in consultation with the USFS and the RAC, will review, update, and/or revise the Plan as needed after the initial five-year monitoring period. The revised Plan will be developed cooperatively among the RAC identifying appropriate methods, monitoring schedules and impingement thresholds. At the commencement of the next monitoring period, this revised Plan shall be implemented for one or more years (to be determined by the USFS and the RAC) to examine whether the traveling screens are continuing to meet identified impingement criteria. New impingement criteria will be determined at the beginning of each new monitoring cycle and based on the estimated Packwood Lake rainbow trout population density.

The updated or revised Plan will document the consultation process. EN will submit the updated Plan to FERC by the end of the calendar year (December 31) in which the review and updates occur, with copies sent to the RAC. The initial five-year update of the Plan will be completed during the sixth calendar year of the license and will include subsequent monitoring frequency and actions developed by the RAC.

Task 1.3b: Reports and Meetings

Each year's monitoring results will be reported to the RAC for review and comment prior to the beginning of subsequent years of monitoring and within 90 days of completion of the year of observation. The annual monitoring reports will be discussed at the annual Resource Coordination meeting (USFS Condition No. 2; Resource Coordination Plan).

The draft final report summarizing the results from the five-year initial monitoring period will be submitted to the RAC at the end of the fifth year for a 60-day review and comment, and discussed at the annual Resource Coordination meeting prior to filing with FERC.

At a minimum the annual and final reports will summarize all activities undertaken during the monitoring period including:

- Estimates of Packwood Lake rainbow trout population density by size class and location,

- Impingement numbers by size class (note any species other than rainbow trout),
- Timing (date of sampling period) of impingement,
- Decomposition rates,
- Scavenger summary (identify vertebrates, crustaceans or insects)
- Analysis of impingement, timing and decomposition rates by size class,
- Lake levels, intake and bypass flows,
- Video or visual monitoring of fish movement or behavior,
- Summaries of previous years monitoring and an analysis of any trends observed relative to the fish population,
- Information on effectiveness of any modifications made at the intake debris screens or traveling screens, and
- Analysis and development of impingement criteria after the initial 5-year monitoring period.

This Plan will be subject to the timelines and protocols established in the RCP (USFS Condition No. 2).

Objective 2: Specify screen operation and maintenance requirements.

Implementation Measure 2.1: Implement screen maintenance and modification; operation (traveling screen rotation: auto vs. manual) and placement and configuration of the removable outer debris screen

***Task 2.1a*:** The removable debris screens will be cleaned of all debris as necessary. Once clean, the screens will be re-seated so that the bottom of the debris screens sits approximately 1-1/2 ft. to 2 ft. off the bottom (e.g., bottom elevation of the screens at 2,841.5 – 2,842.0 ft. MSL), leaving a vertical opening for fish to move easily from the intake structure to the forebay.

The traveling screens at the intake have two settings: automatic and manual. When the screens are in automatic, they are set to rotate when a differential head of 6 in. is detected from the front of the screen to the back of the screen, indicating debris accumulation. When this situation occurs, the screens rotate automatically to remove the debris. When the screens are set in manual mode, Project personnel must be present at the intake building in order to rotate the screens via the local control power switch.

For the duration of the monitoring program, the screens shall remain in manual mode to ensure that Project personnel are able to identify and document all fish found on the screens. Screens will be monitored during the period of time when access to the intake structure is possible.

Implementation Measure 2.2: Recommended inspection and cleaning frequency for the forebay area

Task 2.2a: Debris is removed annually from the area in front of the permanent trash racks during the annual maintenance outage. Removal of the debris from this area has created the most conducive environment for uniform flow through the intake and provided for enhanced fish passage in and out of the intake when the removable debris screens are in place. Since waterlogged debris accumulates slowly, this task will only be performed as necessary based on the results of the annual visual inspections of the forebay performed during the annual outages.

Implementation Measure 2.3: Evaluate proposed stop log placement at the entrance to the removable debris screen

Task 2.3a: If monitoring and observation of the removable debris screens and permanent trash racks determines it would be of benefit in stopping waterlogged debris from accumulating and to aid fish movement out of the intake wells, a horizontal stop log may be anchored at the bottom of the forebay. Placement of the stop log will be determined in consultation with the RAC. The purpose of the stop log would be to help prevent debris from clogging the fish passage opening created when the removable debris screens are suspended (1-1/2 ft. to 2 ft. off the bottom) and to create a velocity shadow that fish will be able to utilize for refuge and egress to and from the intake.

Objective 3: Accurately describe and enumerate the rainbow trout population size and spatial distribution in Packwood Lake

Implementation Measure 3.1: Monitor the Packwood Lake rainbow trout population using hydroacoustic sampling (see below for additional technical detail). If deemed necessary, supplemental methods may include: mark re-capture; tributary spawning surveys (including identification of duration and frequency of surveys, tributary and reach selection, counts of redds and adult fish), and out-migrant tributary trapping to estimate fry densities in the lake. The intent of the Plan is to obtain a high detection rate (80% to 95%) for juvenile and adult trout in the lake.

Task 3.1a: Hydroacoustic surveys will be conducted to determine fish population in the lake. Surveys will be performed annually for five years in September, after spawning outmigration is complete. The survey equipment sensitivity will be set to detect a wide range of fish sizes and the survey grid is to include the littoral zone to count juveniles and fry.

All equipment used in Packwood Lake must be cleaned prior to use to prevent the spread of disease or invasive species.

During the initial year of the new license four hydroacoustic surveys will be performed during September after spawning is complete and the fish have returned from the tributaries. During the initial year, the first two surveys shall be conducted on two consecutive days in early September. Following a two-week break, the third and fourth surveys shall also be conducted back to back on two consecutive days. This survey protocol is intended to provide some assurance of repeatability when the survey data is compared. If a survey takes longer than 1 day due to weather or equipment problems, the surveys are to be completed as soon as practicable.

Upon completion of the first-year surveys, the data will be compiled and presented to the RAC for analysis at the annual meeting. If the data obtained from the first four surveys is consistent (within 15% of total fish count by size class), then the hydroacoustic survey method will be considered dependable and the program will continue with a single hydroacoustic survey performed each year in September for years two through five. After the completion of five years of hydroacoustic fish population surveys, the RAC will meet to determine if future surveys are necessary. If the total fish counts show a variance of greater than 15%, the RAC will determine what the next course of action will be. Additional surveys may be required by the RAC in years two through five if unexpected results or unusual natural conditions occur in Packwood Lake that would prompt a change in the sampling program.

A BioSonics 200 MHz, Split-Beam transducer and Echosounder (or similar equipment and software with equal or better performance) will be employed for the surveys, which is the same equipment used in the 2007 lake population estimates. The equipment is capable of providing an accurate population estimate of the entire lake as well as determining fish size ranges and locations in the water column.

EN will place between 12 and 14 transects throughout the lake to sample three depth zones (littoral, transition and deep) (Figure 9). Each transect will be replicated immediately following its measurement to note any variance in fish target numbers. The entire water column will be sampled at each cross section and individual fish will be analyzed based on their size and location. The size of each fish will be measured by “target strength.” Target strength is the response of the echo sent into the water column after it has struck the air bladder of a fish; the larger the air bladder, the larger the fish. Fish location is a function of the amount of time it takes for the echo to reflect off the target (e.g., fish) and to return to the Echosounder. The BioSonics system has the ability to measure very small aquatic organisms and to distinguish organism depth to less than 0.1 ft.

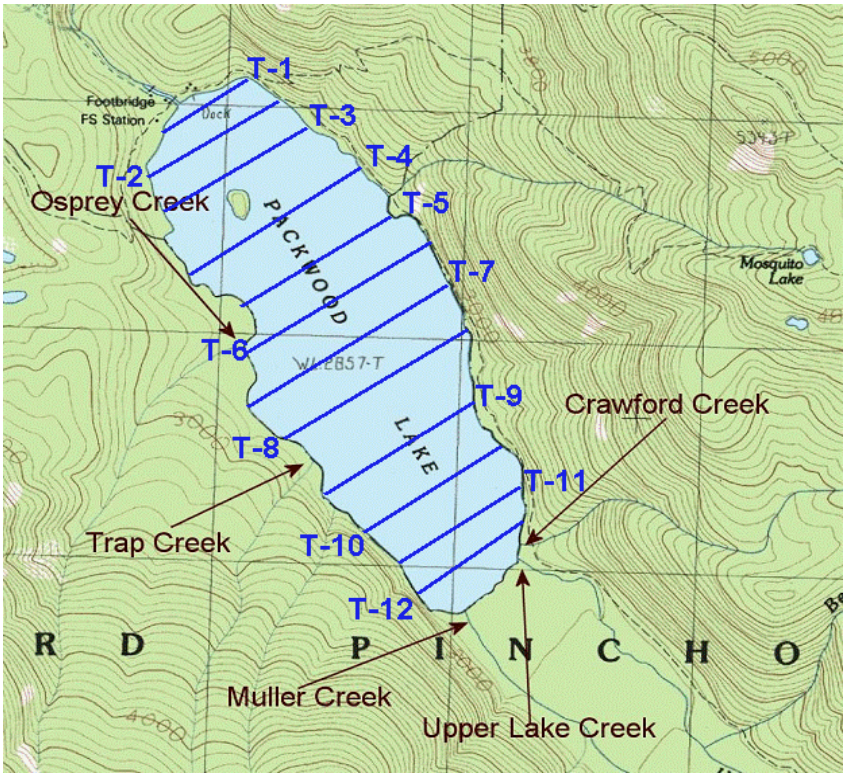

Figure 9. Transect locations on Packwood Lake for hydroacoustic analysis.

Through discussions between the USFS and the RAC, hydroacoustic sampling techniques will initially be used to estimate the Packwood Lake rainbow trout population, the only fish species known or documented to inhabit Packwood Lake and its tributaries. Dependent upon the reliability and confidence in the hydroacoustic results, the supplemental methods listed above may be employed to provide additional data relating to the rainbow trout population in Packwood Lake. Hydroacoustic data will be discussed annually with the RAC and consensus will be obtained on the reliability of the data before continuation of hydroacoustic sampling. Other population monitoring methods may be specified by the RAC if it is determined that the hydroacoustic method is not reliable.

Implementation Measure 3.2: Estimate fish population density in Packwood Lake using hydroacoustic data analysis.

> ***Task 3.2a***: Analysis of hydroacoustic data calculates the volume of water sampled on each transect and for the total survey (m^3). This is referred to as the "sample volume." In order to estimate the total number of fish in the lake, an expansion factor (EF) is calculated as:
>
> $$EF = \frac{\text{Lake Volume } (m^3)}{\text{Sample Volume } (m^3)}$$

Every "return" of a fish is an individual "fish echo." These echoes are then analyzed to determine the total number of fish (known as "fish targets"). It takes several fish echoes to constitute one fish. This analysis was conducted by BioSonics, Inc., developers of the hydroacoustic equipment used in this study.

Total number of fish in Packwood Lake is determined by:

EF x Fish Targets = Estimated fish population in Packwood Lake

Task 3.2b: Estimate fish population in Packwood Lake by size class.

Based on Task 3.2a, estimate the rainbow trout population in Packwood Lake by the following size classes:

- Fry: Less than or equal to 50 mm
- Juvenile: 51 to 249 mm
- Adult: Greater than or equal to 250 mm

Objective 4: Identify and record all fish impingement and mortality on Project traveling screens.

Implementation Measure 4.1: Identify methods for traveling screen impingement and mortality examination

Task 4.1a: The screens will be inspected and all fish found on the screens will be documented during the period of time when access to the intake structure is possible. When snow, downed trees, and other weather issues preclude EN from accessing the lake during the winter and spring months, the screens will be checked as often as possible. Inspections to collect data may not be performed during those times when the plant has not operated since the last inspection and the flow through the intake building has been limited to bypass flow only (e.g., outages or maintenance shutdowns). In those cases log entries will be made denoting the reason for the missed inspections.

The traveling screens will be inspected during the period of time when access to the intake structure is possible. Information collected at each inspection will include:

- Date, lake level and plant flow
- Number of fish present
- Tray and screen number where the fish are found

- Fish length
- Physical condition of fish (healthy to evidence of physical abnormalities)
- Water temperature
- Significant visual observations including anomalous natural weather/hydrologic events (if any)
- Photographs (as necessary) to document abnormal conditions

Task 4.1b: The method for determining the depth of impingement is detailed below.

- Each rotating screen (1 and 2) has permanent numbers embossed on the individual screen segments (trays) for positive identification.
- The screen consists of 35 segments each 23-1/2 in. high. A reference chart will be developed that will allow the operators to determine where in the water column, based on lake elevation, a particular screen was located.
- By counting screen segments the operators can determine where each segment was located in the column.
- Lake level and plant flow will be obtained from the instrumentation in the intake building or from the lake level staff gauge on the outside of the building.
- Prior to rotating the screens the operators will open the access doors on the front of the screen housing and assure there is enough light to see fish on the screen segments.
- While rotating the screens keep track of the screen segments until the first wetted segment becomes visible and record that number on the log.
- Identify any fish found by screen and segment / tray number and determine at what depth in the water they were located.
- Record the data as required on the form similar to that provided in Appendix A. It is especially important to perform an accurate survey and keep track of which screen segment and the depth of that segment.

Task 4.1c: Fish impingement and mortality data will be recorded on data sheet shown in Appendix A and made available to the RAC at a specified reporting period.

Objective 5: Determine the decay rates of fish carcasses found on the traveling screens to estimate amount of un-sampled impingement and mortality.

Implementation Measure 5.1: Test the persistence of dead fish found on the traveling screens considering the natural decay rates and the effects of scavengers feeding at the intake system (including but not limited to crayfish and fish scavenging).

Task 5.1a: Determine if fish decompose or are being scavenged at rates that would allow them to escape detection and bias the sample low. Determine the adequate number of dead rainbow trout to be acquired either from Packwood Lake (preferred), or from another location, such as the Cowlitz Hatchery Complex operated by WDFW.

The persistence of fish found on the traveling screens shall be determined by conducting tests at three different times during the first year of the new license. The dead rainbow trout will be attached to the traveling screens during the Spring, Summer, and Fall of the first year and be subjected to normal Project operating flows to determine their decay rate. The test fish will be attached to screen trays in both the high and low velocity zones of the screen that were identified in the 2008 velocity test. Fish will be marked in such a way as to be distinguishable at an advanced state of decay. Fish will be attached to the travelling screens with a zip-tie that also has a tag number attached to it. If the fish is completely decayed and removed from the tie, a tag will be left behind to document the placement. The screens will be checked during the period of time when access to the intake structure is possible.

Task 5.1b: Record any visual observations of scavenging of found fish from the visual observations made with the underwater camera, Task 6.1a.

Task 5.1c: Record the results of all observations. This information will be used to develop an adequate decomposition rate for each season (Spring, Summer and Fall). The results will be submitted in the first annual report and discussed with the RAC.

Task 5.1d: Analysis of the data will be performed to determine an adequate screen sampling frequency. The results will be submitted in the first annual report and discussed with the RAC.

Objective 6: Examine fish behavior in the intake wells and the forebay immediately in front of the intake.

Implementation Measure 6.1: Observe fish movement in the intake wells and forebay (including but not limited to underwater cameras) and determine the recommended timing and frequency of observation. Observation methods are as follows:

Task 6.1a: An underwater camera will be utilized to observe fish presence and behavior in each of the two intake wells and the adjoining forebay area (i.e., immediately in front of the two intake wells). The camera will also visually observe the attached dead fish on the traveling screens to determine any scavenging. Surveys will be conducted monthly from May through September. Each of the three areas will be systematically surveyed for approximately 15-30 minutes depending upon fish or scavenger presence.

Each survey will examine the two intake wells from inside of the intake structure to record fish presence and observe their behavior. Surveys of the intake wells will include observation of fish behavior near the traveling screens and trash racks, and the attached dead fish on the traveling screens. Surveys of the forebay area will focus on fish passage in and out of the intake building. Lake levels and plant flows will be documented and the observations will be recorded. A recording will be produced as a part of the annual report, documenting the significant video collected.

Objective 7: Evaluate the impingement criteria (no more than 1.5% of total Packwood Lake rainbow trout population) and provide an adaptive management process to improve data collection and analysis.

For each year of the initial five-year sampling period, no more than 1.5% of the total Packwood Lake rainbow trout population in the lake shall be injured or killed as a result of impingement on the intake screen. The annual 1.5% threshold for Project-related impingement mortality will be re-evaluated if the Packwood Lake rainbow trout population suffers a stochastic (random) event between monitoring periods. New impingement criteria will be determined at the beginning of each new annual monitoring cycle and based on the estimated Packwood Lake rainbow trout population density.

Implementation Measure 7.1: Develop impingement criteria included but not limited to: estimates of total population of rainbow trout in the lake, total fry in each monitored cohort, and identification of a threshold level of allowable mortality associated with the intake screen.

Task 7.1a: Determine the annual traveling screen mortality percentage by size class. The annual Packwood Lake rainbow trout population estimate will be determined by performing hydroacoustic surveys (Task 3.1a). The fall surveys are timed so as to account for all fish that have returned to the lake from the spawning tributaries.

Compare the annual rainbow trout population densities by size class (Task 3.1a) with the annual mortality data for the traveling screens (Task 4.1a), and determine the annual impingement percentage. It should be noted that for each year of the initial five-year sampling period, no more than 1.5% of the total Packwood Lake rainbow trout population shall be killed as a result of velocity impingement on the intake screen. Fish that have suffered from post spawning mortality shall be identified as such, included in the total fish mortality count, but not included in the 1.5% impingement mortality criteria.

If the impingement criteria is exceeded on an annual basis due to high screen velocities or other design defect of the intake (i.e., not due to natural conditions or a stochastic event beyond the control of EN), EN will initiate consultation with the RAC and will take the steps necessary to correct the condition (see Implementation Measure 7.3).

The Packwood Lake rainbow trout population estimate is subject to the natural variation of population size and the unpredictable influence of natural events and lake conditions. Accordingly, the annual population estimate and impingement data will need to be reviewed each year by the RAC at the annual Resource Coordination meeting (USFS Condition No. 2) to determine if the year-to-year (or survey-to-survey) changes in lake population are caused by impingement at the intake.

All monitoring data will be reviewed and discussed in deriving and applying the impingement criteria.

Implementation Measure 7.2: Determine whether mortality was caused by impingement or natural causes.

The purpose of this measure is to determine the probable cause of fish mortality by observing the screen location where fish are found. This measure will collect data to determine if the fish mortalities observed on the traveling screens are due to natural causes (post-spawning mortalities) or are due to the high velocities that have been observed on the lower sections of the intake building traveling screens.

Task 7.2a: To help confirm if spawning or other natural causes of fish mortality account for fish found on the traveling screens and physical location on the screens, EN will examine transport between the lake and the intake building.

The fish that are retrieved during the routine screen rotation in June and July of the first year will be counted and logged (Task 4.1a). Those fish recovered from the screens that are intact and not in an advanced state of decay will be tagged with a unique number and released back into the inlet canal, either above the trail bridge or in the lake outside the log boom. The purpose of this activity is to determine whether a fish mortality that occurs in the lake can be drawn into the forebay and be found on the rotating screens. If a tagged fish is recovered on the screen, it will be logged to document the release date and location as well as the recovery date and screen impingement position. The recovery of a tagged fish will not be counted as a new mortality. This transport test will be repeated as necessary to confirm or refute the mechanism.

A sample data sheet for the release activity will be developed similar to that shown in Appendix B.

Task 7.2b: If the RAC determines that the results from Task 7.2a are insufficient to help determine the cause of death of impinged fish and that such a determination is still necessary, then the RAC shall investigate if other economical and reliable analysis methods are available to resolve this issue.

Implementation Measure 7.3: Methods to adapt impingement criteria during the life of the license if the rainbow trout population in Packwood Lake decreases significantly as determined by monitoring.

Task 7.3a: If the impingement criteria identified in the Plan for all size classes are satisfied after the initial five-year monitoring period, EN will retain the existing traveling screen facility and operational mode as the primary fish exclusion device for a period to be determined collectively between EN, the USFS and the RAC based on the initial five-year monitoring program results. At this time, a revised Plan will be developed cooperatively among the USFS and the RAC identifying appropriate methods, monitoring schedules, and impingement thresholds. At the commencement of the next monitoring period, this revised Plan shall be implemented for one or more years (to be determined by the USFS and the RAC) to examine whether the traveling screens are continuing to meet identified impingement criteria. New impingement criteria will be determined at the beginning of each new monitoring cycle and based on the estimated Packwood Lake rainbow trout population density.

Task 7.3b: If the impingement criteria are met, then EN shall prepare an intake structure operation instruction for USFS approval within one year after filing the final monitoring report. The instruction will specify screen monitoring intervals, maintenance intervals, and the actions that will be taken given significant events, including load rejection, overtopping flows over the drop structure, bypass flow failures, penstock leaks, landslides, earthquakes and fires.

Task 7.3c: If the monitoring data indicates that the impingement criteria identified in the Plan are not met then the USFS and the RAC will discuss the data determining the reasons for not meeting the criteria impingement and EN shall implement Tasks 7.3d and 7.3e as necessary.

Task 7.3d: EN, in consultation with the USFS and the RAC, will determine at this time whether to experiment with a baffling system and other minor modifications (including limiting plant flow at certain lake elevations) or pursue a major screen redesign.

If a baffling system or other minor modification is selected in years four or five of the initial monitoring program (or any year thereafter), then the Plan will be extended for at least two more years to test the modifications and will be completed by the end of the second year from modification completion. If the impingement criteria are satisfied by a baffling system or other modification then EN shall prepare the intake structure operation instruction

described above (Task 7.3b). If the impingement criteria are not satisfied after one modification to the screens then EN will provide for a major redesign of the traveling fish screens to meet State of Washington fish screen criteria.

Task 7.3e: Major Fish Screen Redesign: A major screen redesign may mean significant changes to the existing screens or replacement of the existing screens. EN shall consult with qualified engineers to explore options for screening that will satisfy State of Washington approach velocity criteria then in consultation with the USFS and the RAC, determine the new screen design. The timeline for the redesign process is as follows:

- Proposed conceptual designs will be made available to the USFS and the RAC within one year after it is determined the existing intake structure does not meet impingement criteria.
- Final design decision will be made one year after the conceptual designs are approved.

3.0 CONSISTENCY WITH AGREEMENTS MADE DURING RELICENSING PROCEEDINGS

What follows is an itemized and chronological list (most recent first) of key milestones associated with the entrainment study conducted during relicensing activities, data reporting, collaboration and appropriate measures for the new license and subsequent agreements and formal communications to relevant parties. All reporting, data result summaries and meeting minutes have been shared with stakeholders, catalogued on EN ‘s website and where required, filed with FERC.

- Terms and Conditions No. 9 Material for Team Meeting, June 2009
- Packwood Lake Intake Screen Velocity Test Report November 2008, EN to FERC, May 2009
- Section 10(j) Meeting Minutes, April 2009
- Comments on the Draft Environmental Assessment and Request for Section 10(j) Resolution, WDFW to FERC, March 2009
- USDA Forest Service Comments on the February 2009 Draft Environmental Assessment; Modified FPA 4(e) Term and Condition; Justification Statements for the Terms and Conditions, and the Schedule for Finalization of the 4(e) Terms and Conditions, USDA FS to FERC March 2009
- Draft Environmental Assessment Comments, EN to FERC, March 2009
- Section 10(j) Preliminary Determination of Inconsistency, FERC to WDFW, February 2009

- Decision on Biological Monitoring at the Packwood Lake Intake, WDFW to EN, January 2009
- Packwood Lake Entrainment Intake Screen Velocity Screen Results presentation, January 2009
- Intake Fish Monitoring Program draft, January 2009
- Packwood Lake Intake Screen Velocity Test Report, November 2008
- Response to Agency Preliminary Terms and Conditions, EN to FERC, October 2008
- Packwood Lake Intake Velocity Study Plan, September 2008
- Recommendations Terms and Conditions, WDFW to FERC, August 2008
- Packwood Lake Intake Velocity Study Plan, July 2008
- USDA Forest Service Preliminary FPA 4e Terms and Conditions draft, July 2008
- PME Language from FLA and BA presentation, April 2008
- Proposed PMEs presentation, April 2008
- Fish Entrainment Meeting presentation, March 2008
- Review of Summary of Proposed Project Operations and Environmental Measures Draft Dated February 2, 2008, WDFW to EN, February 2008
- Application for New License, EN to FERC, February 2008
- Response to Agency Comments on Relicensing Study Reports, EN to FERC, January 2008
- Packwood Lake Entrainment Intake Screen Proposal presentation, January 2008
- Response to Agency Comments on Relicensing Study Reports, EN to FERC, December 2007
- Packwood Lake Entrainment Study Results presentation, October 2007
- Packwood Lake Entrainment Study Report Final, October 2007
- Meeting Summaries, EN to FERC, August 2007
- Study Progress Report, EN to FERC, August 2007
- Packwood Lake Entrainment Study Status Report presentation, August 2007
- Study Reports Meeting, August 2007
- Response to Filings, EN to FERC, February 2007
- Response to Initial Study Report Findings, USFS to FERC, January 2007

- Meeting Summaries, EN to FERC, December 2006
- Packwood Lake Entrainment Study presentation, December 2006
- Study Reports Meeting, December 2006
- Study Progress Report, EN to FERC, September 2006
- Comments on Revised Study Plans and Comments on Article 37 Waiver Request, USFS to FERC, September 2005
- Submittal of Revised Study Plans, and Request for Comments on Waiver for License Article 37, WDFW to EN, September 2005
- Submittal of Revised Study Plans, EN to FERC, August 2005
- Packwood Lake Entrainment Study Plan Revised, August 2005
- Comments on Draft Study Plans, USFS to FERC, July 2005
- Comments on Preliminary Study Plan Documents, WDFW to FERC, July 2005
- Proposed Study Plans Meeting, June 2005
- Proposed Study Plans Meeting, May 2005
- Submittal of Proposed Study Plans, EN to FERC, April 2005
- Packwood Lake Entrainment Study Plan Proposed, April 2005
- US Fish and Wildlife Service Comments on the Pre-Application Document, Scoping Document 1, and Study Requests, USDI FWS to FERC, March 2005
- Comments on PAD and Scoping Document 1 and Study Requests, USDA USFS to FERC, March 2005
- Scoping Meeting, February 2005
- Packwood Lake Entrainment Investigations preliminary draft, January 2005
- Pre-Application Document, Supplement 1, December 2004
- Fish, Aquatics and Instream Flow Committee Meeting, September 2004
- Update on Study Protocols and Agreements, EN to Fish, Aquatics, and Instream Flow Committee, August 2004
- Responses to Comment Letters, EN to Fish, Aquatics, and Instream Flow Committee, June 2004

4.0 SCHEDULE

The general Plan schedule is listed below (Table 1). The schedule and Plan will be reviewed and modified as necessary according to the consultation process established in the Resource Coordination Plan.

Table 1. Packwood Entrainment Monitoring Plan Schedule.

Task	Time Frame	Frequency
Initial Development and Filing of Entrainment Plan	Within 3 Months of License Issuance	One time
Initial Fisheries Monitoring at the Project Intake and Packwood Lake	First 5 years after license issuance	Annually for the first 5 years of the new license
Keep Traveling Screens in Manual Mode	For the duration of the monitoring effort	Continuous for the duration of the monitoring effort
Monitoring of and Debris Removal From the Permanent Trash Racks	Annually during maintenance outage	For the duration of the monitoring period
Rainbow Trout Population Surveys in Packwood Lake	September	Annually for the first 5 years of the new license
Monitor Fish Impingement at the Traveling Screens	For the duration of the monitoring effort	As often as possible during any visit to lake infrastructure
Determination of Decay Rates of Fish Found on Traveling Screens	During the spring, summer and fall of the first year after license issuance	As often as possible during any visit to lake infrastructure
Examine Fish Behavior in the Intake Wells	May through September of the first year after license issuance	Monthly during the first year after license issuance
Evaluate Impingement Criteria and Determine Need for Adaptive Management Measures	At the culmination of the monitoring program, after the first 5 years of the new license	Series of potential measures. Frequency and implementation schedule dependent on monitoring results
Monitoring Report	Annually for the first 5 years of the new license in accordance with the monitoring program	Once per year as part of the RAC reporting process and RAC annual meeting

5.0 LITERATURE CITED

EES Consulting. 2007a. Final Packwood Lake Entrainment Study Report for Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, Lewis County, Washington. Prepared for Energy Northwest. October 2007.

EES Consulting. 2007b. Supplement to Fish Distribution and Species Composition (Outmigration and Hydroacoustics) for Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, Lewis County, Washington. Prepared for Energy Northwest. October 2007.

EES Consulting. 2008. Packwood Lake Intake Screen Velocity Test Report for Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, Lewis County, Washington. Prepared for Energy Northwest. November 2008

Federal Energy Regulatory Commission (FERC). 2018. Order Issuing New License, Packwood Lake Hydroelectric Project (P-2244). October 2018.

Lucas, R.E., and M.W. Chilcote. 1982. Life history and possible genetic origins of rainbow trout from Packwood Lake, Washington. Washington Department of Game Technical Report.

USDA Forest Service (USFS). 2009. Forest Service Manual 2670.12 and 2760.22.

APPENDIX A

INTAKE SCREEN FISH MONITORING LOG (SAMPLE)

Intake Screen Fish Monitoring Log

Date:	**Time:**	**Initials:**	**Lake Elevation:**
Plant Flow:	**Bypass Flow:**	**Water Temperature:**	

Traveling Screen = TS #1/2 or Debris Screen = DS #1/2

Fish #	**Fork Length (in/mm)**	**Traveling Screen #**	**1st Wet Tray #**	**Fish Tray #**	**Elevation**	Eggs?	Tail Abraided?	Fungus?	**Fish Physical Condition / Comments**

APPENDIX B

INTAKE SCREEN FISH RE-CAPTURE LOG (SAMPLE)

Intake Screen Fish Re-Capture Log

Tag #	Fork Length (in/mm)	Carcass Condition	Release Date	Release Location	Return to Screen Date	Screen Tray #	Elevation	Comments