Black Canyon Hydroelectric Project
FERC Project No. P-14110
Aquatic Resources Study Plan
January 2013

Prepared for
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Table of Contents

List of Tables

1 INTRODUCTION

Black Canyon Hydro, LLC, (BCH) plans to file an application for an original license for the Black Canyon Hydroelectric Project (Project), FERC Project Number P-14110, and associated facilities on the North Fork Snoqualmie River (North Fork), approximately 4 miles northeast of North Bend in King County, Washington. The Project has a proposed generation capacity of 25 megawatts (MW) and would be located entirely on private lands.

<u>Intake Alternative A</u>

Alternative A would consist of the following new facilities: (1) an 8-foot-high, 162.4-foot-long inflatable rubber diversion with an associated water intake structure; (2) a natural or roughened fish passage channel; (3) a variable pooling area behind the diversion with a normal water surface elevation of 971 feet above mean sea level and a maximum pooling of 2.83 acres; (4) a power conduit tunnel consisting of an approximately 450-foot-deep vertical tunnel into an approximately 8,350-foot-long, 9-foot-diameter horizontal tunnel and penstock; and (5) for access, Alternative A would utilize an existing logging road to minimize disturbance, and require only 825-feet of additional road.

<u>Intake Alternative B</u>

Alternative B would consist of the following new facilities: (1) a control sill to maintain a consistent river bottom elevation, which would allow water, fish, sediment, large woody debris, and whitewater recreationists to pass unimpeded, with an associated water intake structure; (2) a power conduit tunnel consisting of an approximately 450-foot-deep vertical tunnel into an approximately 9,175-foot-long, 9-foot-diameter horizontal tunnel and penstock; and (3) for access, Alternative B would utilize an existing logging road to minimize disturbance, and require only 500-feet of additional road.

<u>Powerhouse</u>

The power conduit tunnel and penstock from either Alternative A or B would terminate at the powerhouse proposed upstream of Ernie’s Grove. Initially, the PAD described the powerhouse as being a metal building approximately 60-feet-wide by 100-feet-long. However, as a result of construction from the power conduit tunnel, an underground powerhouse of similar dimensions may be feasible. Tailrace dimensions have also been revised from a 60-foot-wide by 100-foot-long tailrace, to a 24-foot-wide by 200-foot-long tailrace. Whether above or below ground, the powerhouse would include two Francis turbine generator units, one rated at 16 MW and the other rated at 9 MW, as well as appurtenant facilities (switchyard, maintenance building, etc.). Additionally, a temporary, 2,600-foot-long construction access road would extend from the powerhouse to the North Fork Road (while avoiding Ernie's Grove).

Transmission

As presented in the PAD, transmission would consist of a 4.2-mile-long, 115-kilovolt overhead transmission line that transmits project power to the regional grid (transmission line would be an over-build of an existing transmission line with only approximately 0.65 miles of new transmission). However, an additional option, depending on minimum instream flow requirements, land use designations, and cost, may be to have the Project connect to the existing 34 kV transmission line running from the existing Black Creek Hydroelectric Project to Snoqualmie Falls. A transmission line could be run from the powerhouse back through the power conduit to the intake structure. From the intake structure a buried or overhead transmission line would only have to travel approximately 6,745-feet along an existing logging road through clear cuts.

The project would operate in run-of-river mode. The combined maximum hydraulic capacity of the two project turbines would be 900 cubic feet per second (cfs). The project would divert water from a 2.6-mile-section of the North Fork Snoqualmie River referred to as the Project Reach.

BCH filed a Notice of Intent (NOI) and the associated Pre-Application Document (PAD) to commence the FERC Integrated Licensing Process on March 27, 2012. In response to the subsequent study requests filed by FERC staff and other stakeholders and as detailed in 18 CFR 5.11, BCH is required to submit relevant resource study plans. This includes a study of fish and other aquatic resources within the study area, consistent with the requirements of 18 CFR 5.11(b)-(e).

1.1 Revisions to Proposed Study Plans

In response to comments on Proposed Study Plans submitted by FERC, agency, tribal, and non-governmental stakeholders, BCH agreed to expand the scope of several studies to address additional information needs. The Proposed Fisheries Study Plan, which was filed with FERC on September 7, 2012, described studies that would collect data on resident fish populations and their habitat in the North Fork Snoqualmie River, but did not propose sampling of other aquatic biota, such as periphyton (primarily algae), macroinvertebrates, and mollusks.

The fisheries studies proposed earlier were expanded to include these additional aquatic resources. For this reason, the Proposed Fisheries Study Plan is replaced by this document, referred to as the Aquatic Resources Study Plan. The methods, schedules, and expected outputs of the fish, periphyton, macroinvertebrate, and mollusk studies are described below under the general heading of "Biological Conditions."

The agencies and stakeholders also recommended that the studies of fish habitat be expanded to include the collection of data that will be used to model the response of fish habitat to changes in flow in the project area. The modeling effort and the application of model results is described in a separate study plan[1], but the activities that will be implemented to collect fish habitat utilization data are described in this study plan. This information would complement assessments of habitat availability and utilization conducted over the entire study area, as described in the Proposed Fisheries Study Plan. Methods, schedules, and expected outputs of reach-wide surveys of habitat and more detailed measurements of habitat utilization by fish observed at project study sites are described in this study plan under the heading of "Physical Conditions."

This study plan describes biological and physical components and processes within the project study area that will be sampled in 2013. The studies have been designed to maximize sampling efficiency and the amount and quality of information generated during the pre-application period of the licensing process. The primary purpose of the studies is to establish an environmental baseline. This information would enable BCH and FERC to identify and evaluate potential project effects, and to propose PM&Es to minimize or offset project effects. If FERC issues a license for the project, and sampling continues into the future as part of a long-term monitoring plan, the data collected in 2013 can be combined with data from subsequent years to form a time series that can be analyzed for trends caused by project and non-project factors, such as water diversion and climate change. Armed with this knowledge, managers can modify the design and operation of the project, or take other steps as appropriate to minimize and mitigate for unwanted impacts.

2 STUDY DESCRIPTION AND OBJECTIVES

In accordance with 18 CFR §5.11(d)(1), this section describes the goals and objectives of the study and the information to be obtained.

The Aquatic Resources Study is intended to document existing (baseline) conditions so that managers can decide what level of protection is required to preserve the ecological integrity of the North Fork. This study will interact with and inform other studies to

[1] See "Environmental Flows Study Plan"

determine the nature and degree of project impacts, and appropriate design and management measures that will avoid or mitigate undesirable project impacts. While it is anticipated that the information generated by these studies will be sufficient to meet FERC's requirements for licensing a new hydropower project, it is also likely that additional studies will be conducted in the future under a long-term monitoring plan, should a license be issued.[2]

The specific study objectives and metrics that will be measured for each biological and physical component during the license application (pre-project) period are enumerated below:

Fish. Of primary interest are attributes associated with the long-term viability of resident fish populations and, more generally, the fish community as a whole, within the study area. Fish population attributes include abundance, spatial distribution, age structure, and habitat utilized by selected species and life stages of fish. Fish community attributes include species composition and diversity.

Snoqualmie Falls, located downstream of the confluence of the NF and Middle Fork Snoqualmie River, is a natural and total barrier to upstream migrating fish. Previous fisheries studies (R.W. Beck and Associates 1985; Thompson et al. 2011) and a fish and fish habitat survey of the North Fork funded by BCH in 2012 (Jamie Thompson, personal communication) determined that non-anadromous rainbow and cutthroat trout are the dominant fish species present in the study area[3]. The 2012 survey quantified the number of fish in different habitats (pools, glides, riffles, and cascades) within the lower 15 miles of the North Fork Snoqualmie River. The Project and Reference reaches will be resurveyed in 2013 to determine whether fish abundance, distribution, size structure, and habitat use patterns remain the same a year later. The 2012 and 2013 data will be compared to continuous longitudinal profiles of fish abundance and distribution reported by Thompson et al. (2011) for the South Fork, Middle Fork, and other segments of the North Fork Snoqualmie River.

Additional fisheries studies are proposed for 2013, including more intensive sampling of fish populations at study sites using snorkeling and electrofishing techniques within the 2.6-mile-long Project Reach and adjacent Reference Reaches. These estimates will be

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[2] The sampling framework described in this study plan was designed so that researchers could continue to sample fish and other biological and physical metrics in future years, with the goal of detecting changes and their underlying causes over time. However, the purpose and scope of long-term biological monitoring, should it be required by FERC, will depend on the results of the 2013 studies and negotiations between BCH, agencies, tribes, and other participants in the licensing process.

[3] Rainbow trout and cutthroat trout, especially smaller individuals, are similar in appearance, difficult to differentiate by eye underwater, and occasionally interbreed to produce hybrid progeny. Because accurate identification is not always possible, we refer to both species as "trout."

used to adjust reach-wide estimates of fish abundance. They will also enable testing of hypotheses concerning the spatial distribution of fish within the study area.

As mentioned above, we will also map positions of individual fish relative to key "microhabitat" attributes, including water velocity, depth, substrate, and cover. These data will be used to validate or, if appropriate, modify existing habitat suitability (electivity) criteria for target species and life stages. The criteria will serve as input to a PHABSIM[4] model of the Project Reach, which will enable predictions of fish habitat suitability as a function of flow within the Project Reach. The PHABSIM modeling approach and anticipated outputs will be used to assess the effects of incremental changes in streamflow on fish habitat within the Project Reach, and are discussed in the Environmental Flows Study Plan.

Periphyton. The term periphyton refers to algae, mosses, and small organisms that live on or near the streambed surface. In the present context, periphyton refers only to algal species, including diatoms. The different species of algae present in periphyton have specific physical and chemical requirements, and frequently respond differently to changes in local environmental conditions. Under the auspices of its Freshwater Ambient Biological Monitoring Program, the Washington State Department of Ecology (Ecology) uses periphyton to assess the health of streams relative to pristine conditions, based on known tolerances of individual taxa and data collected from numerous reference streams around the state (Ecology 2010). A less diverse periphyton community than expected, especially one lacking algal species that are known to be sensitive to disturbances, reflects degraded environmental conditions at the time of sampling.

In the context of the Black Canyon Hydroelectric Project licensing studies, the objectives of periphyton sampling are twofold: (1) to characterize the existing ecological status of the project study area, in conjunction with other biological, physical and chemical data; and (2) to serve as an environmental baseline against which future conditions can be compared. Periphyton samples will be collected from representative riffle and pool habitats at each study site during the late summer after streamflows have stabilized. Sampling will be conducted within a short time period at the same time that other biological, physical, and chemical parameters are measured. The methods used to sample and analyze periphyton will conform to Ecology's FABM procedures (Ecology 2010).

[4] The Physical Habitat Simulation Model is the principal component of the Instream Flow Incremental Methodology (IFIM) developed by Ken Bovee, Roger Milhous, and others to facilitate stream habitat analysis (Bovee 1982; Milhous et al. 1984).

Macroinvertebrates. Macroinvertebrates are animals that are large enough to see with the naked eye, and that do not have a backbone. Aquatic macroinvertebrates comprise mostly insects such as mayflies, stoneflies, and caddis flies, as well as crustaceans, mollusks, worms, and other less familiar species. This added study component will include sampling of aquatic macroinvertebrates associated with the streambed, referred to as benthic macroinvertebrates (BMI), and macroinvertebrates transported by water currents, referred to as macroinvertebrate drift (MID).

The objectives of the BMI study component are to determine the composition, diversity, and relative abundance of BMI communities at Project and Reference Reach study sites in the study area. The methods we propose to use to collect, process, and analyze BMI data are consistent with those recommended by Ecology for their Freshwater Ambient Biological Monitoring program (Ecology 2010). Thus, BMI data collected in the BCH study area can be compared to and analyzed jointly with data that have been collected from other Washington streams and rivers using similar sampling and analytical procedures.[5]

The objectives of the MID study component are to document the composition and abundance of drifting macroinvertebrates in the water column that are available to feeding trout at the time that stomach content samples are taken. The number, biomass, and taxonomy of organisms captured in drift sample nets deployed at each study site over a 24 hour period in late summer will be tabulated.

The BMI and MID data will be compared and analyzed to determine whether differences exist between study sites, or between Project and Reference Reaches. Similar to data collected on fish and fish habitat, the macroinvertebrate data will serve as a baseline for monitoring future trends in the ecological status of the North Fork Snoqualmie River.

Mollusks. Freshwater mollusks (gastropods), including snails and mussels, are common in western Washington streams and rivers. Certain native species of mollusks, such as the western pearlshell mussel, *Margaritifera falcate*, and snails of the genus *Juga*, are relatively common in unpolluted, swift-flowing streams and rivers with large substrates in Washington State. Other species, including the invasive zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*), and the New Zealand mud snail *(Potamopyrgus antipodarum*), are non-native, but are becoming increasingly common in western Washington waterways. Once established, these species are capable of rapid increases in abundance, causing severe ecological and economic damage. While there is

[5] The addition of BCH data to the Ambient Freshwater Biological Monitoring program database will increase the accuracy of current multimetric and multivariate models used to analyze the health of streams across the state.

no reason to believe that these species have spread to the North Fork Snoqualmie River, limited sampling is proposed to determine whether invasive mollusk species are present within the study area and, if so, to what extent.

Western pearlshells are large bodied (up to 12.5 cm in length), long-lived (average life span, 60-70 years), hard-shelled mussels that inhabit cold streams and rivers throughout the western US, including Washington State. They require salmon or trout to successfully complete their life cycle. Free-swimming glochidia (larvae) attach to salmonids, burying themselves in the fish's gills, where they encyst and grow for several months before metamorphosing into juvenile mussels, and then dropping off and attaching themselves to stream substrates to complete their life cycle. Western pearlshell mussels are relatively widespread in western Washington, and have been studied extensively in a few streams in King County (but not in the North Fork Snoqualmie River), where they have generally declined in number (King County 2005). Because this species is sensitive to environmental disturbances, including water withdrawals, it is considered an excellent biological indicator of water quality (Xerces Society 2012). For this reason, the status of western pearlshell mussels in the project study area is of primary interest. Concentrations of adult mussels will be counted and mapped during the continuous reach profiles described below for fish and fish habitat. We will obtain precise estimates of the number of adult mussel colonies (beds) in each of the study sites, and the age structure and number of live and dead individuals with a subsample of the colonies. The locations of mussel colonies will be mapped, and mean water velocity, depth, and substrate particle size will be measured for each colony.

2.1 Coordination with Other Licensing Studies

The Aquatic Resource studies are part of a series of field investigations designed to document existing physical, chemical, and biological components and processes in the study area. Some of this information will derive from studies described in other study plans, including the Hydrology, Instream Flows, and Geomorphology, Large Wood, and Sediment Transport study plans. Sampling efforts have been carefully coordinated across plans to produce as much cross-Referenced information as possible during the time available, and, more importantly, to yield a more complete picture of existing conditions. To the extent practicable, sampling of physical, chemical, and biological metrics will be carried out simultaneously so that causal links can be explored and a more robust characterization of environmental conditions attained. The data and analyses will help managers determine the likely response of aquatic resources in the study area to changes in streamflow, sediment and wood load, water quality, and other variables that may result from the construction and operation of the proposed project. It will also help pinpoint specific measures that can be implemented to avoid, reduce, or mitigate impacts that may be caused by the project.

3 STUDY AREA

Aquatic resources that could conceivably be affected by project construction or operation are located within the lower 5 miles of the North Fork Snoqualmie River, including active channel and floodplain areas. The studies described below will be carried out within this defined area.

4 RESOURCE MANAGEMENT GOALS

In accordance with 18 CFR §5.11(d)(2), this section describes resources management goals of agencies or Indian tribes with jurisdiction over the resources to be studied.

Sections 4(e) and 10(a) of the FPA require that the Commission give equal consideration to all uses of the waterway on which a project is located. When reviewing a proposed action, the Commission must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power and developmental values. As a result, describing the effects of project construction and operation on aquatic habitat is necessary to fulfill the Commission's responsibilities under NEPA. Ensuring that potential environmental measures associated with aquatic resources are analyzed is relevant to the Commission's public interest determination.

Additionally, the Northwest Power and Conservation Council has designated sections of the North Fork that includes the proposed Project reach as a "Protected Area." Portions of the North Fork have also been recommended to Congress by the US Forest Service (USFS) for inclusion in the national Wild and Scenic River system based on its outstanding recreation value and resident trout fishery (USFS 1990). The National Park Service has reviewed documents related to the Project and has offered guidance and comments to FERC regarding relevant resource management goals (NPS 2012).

Finally, Ecology recommends minimum instream flows for streams and rivers included in the Snohomish River Basin Instream Resources Protection Program (IRPP; Ecology 1979). These minimum instream flows are intended protect a range of instream values and prevent the over-appropriation of water for out-of-stream uses. The IRPP established minimum instream flows for the North Fork, as measured at USGS Gage 12143000, downstream of the Project tailrace, for specified dates during the year.

5 EXISTING INFORMATION

The fish and fish habitat elements of this study plan derive substantively from fisheries research conducted recently in the Snoqualmie River basin by the Washington Department of Fish and Wildlife (Thompson et al. 2011). The WDFW inventoried fish populations and habitat in the South Fork, Middle Fork, and North Fork of the Snoqualmie River, with the exception of the Black Canyon segment (i.e., the Project Reach) of the North Fork. The inventory included classification, delineation, and measurement of habitat units (i.e., pools, glides, riffles, and cascades); measurement of substrate particle size; counts and mapping of large woody debris; counts of fish by species and, when possible, by life stage; and estimation of trout densities, age, growth, and harvest.

BCH contracted with Jamie Thompson, the fisheries biologist who led the WDFW study of fish populations and fish habitat in the Snoqualmie River basin (Thompson et al. 2011), to conduct a similar survey of the Project Reach in late summer, 2012. The 2012 inventory confirmed the presence of healthy populations of resident rainbow trout and cutthroat trout throughout the North Fork, including the Project Reach (Figure 1).

The only other fish species recorded by Thompson (unpublished information) were sculpins, *Cottus spp*.[6], of which several species are present. Sculpins, too, are not easily differentiated underwater, and therefore are recorded under the genus name *Cottus*. Two large-bodied species of fish, mountain whitefish, *Prosopium williamsoni*, and largescale sucker, *Catostomus macrocheilus*, were observed in the NF downstream of Fantastic Falls, a complete barrier to upstream fish movement located a few hundred meters of the point where water from the hydroelectric facility is to be returned to the NF. Thus, although whitefish and suckers will be enumerated in downstream areas, the primary focus of the fish component of the aquatic resources study will be on trout, which are found throughout the study area.

A review of the published literature did not turn up any information on other aquatic resources in the study area, and a request for unpublished data from project participants yielded no new information. However, it is possible that unpublished information exists that may prove useful in the analyses discussed below. Therefore, a more thorough search and review of unpublished literature is recommended as a precursor to the

[6] Sculpin species include shorthead *(C. confuses),* mottled *(C. bairdi),* torrent *(C. rhotheus),* Pauite *(C. Beldingii),* and reticulate *(C. perplexus)* (Thompson et al. 2011).

proposed aquatic resource studies. This information will need to be reviewed, analyzed, and compared to the results of the studies outlined in this study plan.

6 NEXUS TO PROJECT

In accordance with 18 CFR §5.11(d)(4), this section describes any nexus between Project operations and aquatic resources.

Small, run-of-the-river hydropower facilities that divert water from rivers and streams to generate power alter the volume and timing of water flowing down the Project Reach, and in doing so, disrupt the transport of sediment, wood, and other material to downstream areas (Kibler 2011). Flow alterations and modifications of the stream channel can reduce the quantity and quality of habitat for fish and other aquatic organisms in the Project Reach, with corresponding impacts on resident biota. If water diversion and tailrace facilities are improperly designed, fish can be injured, killed, or prevented from swimming up or downstream.

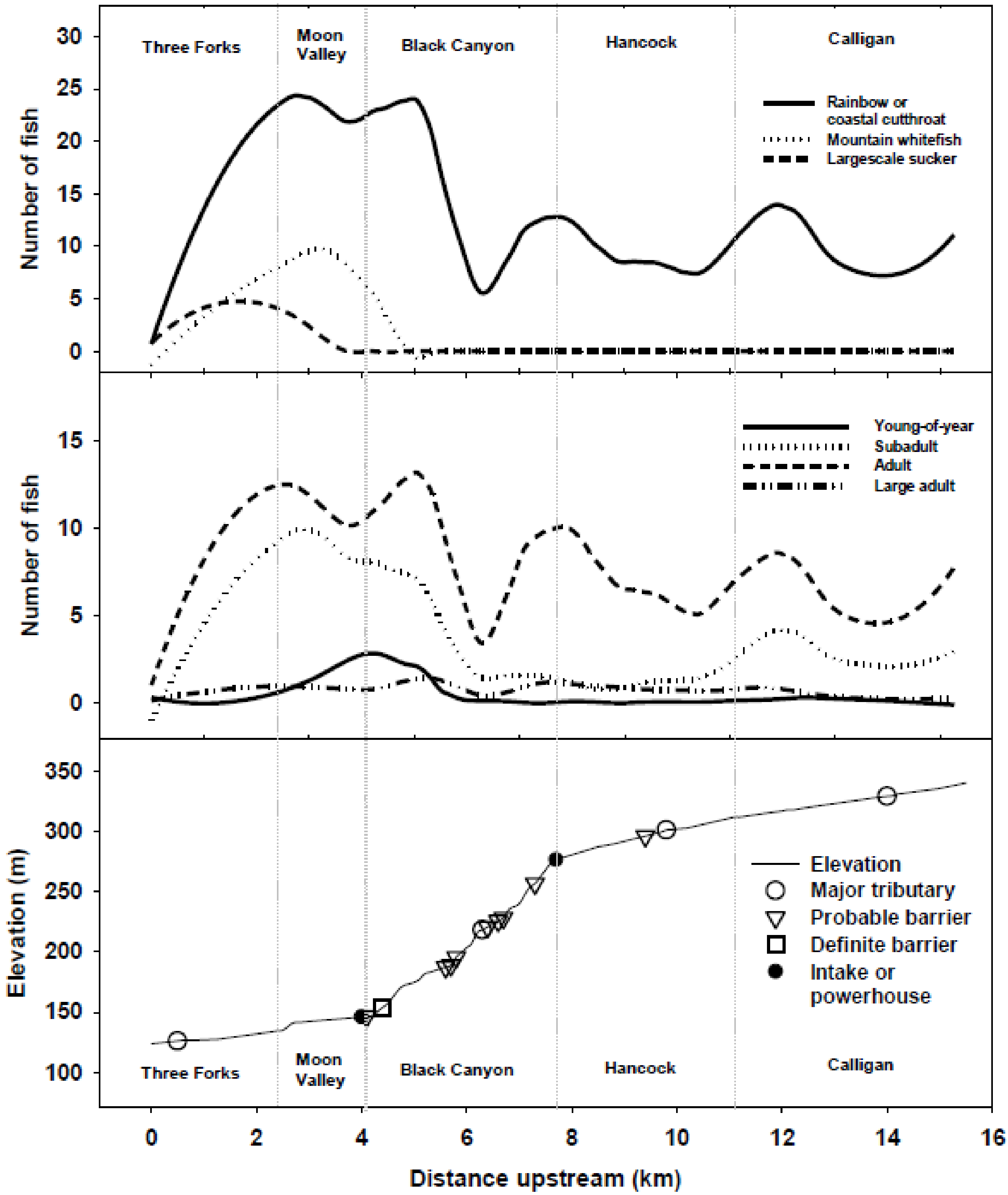

Figure 1. Estimated relative abundance of fish in the North Fork Snoqualmie River, based on a longitudinally continuous snorkeling survey of the entire system conducted in late August, 2012. Vertical dotted lines delineate river segments. (Source: J. Thompson, unpublished information).

This study will address many of the project-related concerns and critical uncertainties identified by FERC and other project participants. It will generate fish and fish habitat data needed to complete the Instream Flows and Fish Passage studies. And, most importantly, it will help us accurately assess the existing status and trend of key aquatic resources in the study area, the potential effects of the project on these resources, and ultimately a facility design and protective measures that minimize the environmental impacts of the project.

7 METHODS

In accordance with 18 CFR §5.11(d)(1) and §5.11(d)(5), this section provides a detailed description of the proposed study methodology, including data collection and analysis techniques, or objectively quantified information, sampling strategy, and a schedule including data collection and analysis techniques, or objectively quantified information, sampling strategy, and a schedule including appropriate field season(s) and the duration (see “Schedule” heading below for schedule).

7.1 Sampling Framework

This study plan describes aquatic resources that will be sampled in each of the study reaches in 2013, and the objectives, methods, schedule, and expected outputs associated with each study component. Additional sampling of the same components may occur in subsequent years if BCH commits to a long-term monitoring plan. A balanced temporal-spatial sampling framework based on a Before-After, Control-Impact (BACI) design was selected based on study objectives and the desirability of conducting long-term monitoring. The BACI design has the greatest potential for detecting project effects in the future, should those effects occur. In the context of the BCH licensing studies, sampling will occur “Before” the hydroelectric project is constructed, and again “After” the project is constructed, at paired “Control” (Reference Reach) and “Impact” (i.e., Project Reach) study sites (see below). The study sites may exhibit different physical or biological conditions (e.g., trout abundance) during the before-project period, but if the differences increase or decrease significantly following project construction, then a project effect can be inferred. Taking measurements at two pairs of “Control” and “Impact” study sites at the same time in 2013 will increase our ability to detect an effect, if sampling continues in the future. The statistical power of the proposed design can be improved further by increasing the number of years sampled during the before -project and after-project time periods[7].

[7] For example, if the project is licensed in 2014, but not constructed until later, it may be possible to collect another year or two of before-project data. Data collected in 2013 will enable us to decide whether additional sampling is recommended.

7.1.1 Study Reaches

For the purposes of this study, three reaches of the North Fork Snoqualmie River were designated:

- A 2.6-mile-long Project Reach bounded at its upstream end by the proposed intake site (RM 5.0), and at its downstream end by the proposed tailrace discharge site (RM 2.4);
- An Upper Reference Reach extending approximately 1 mile *upstream* from the proposed intake site; and
- A Lower Reference Reach extending approximately 1 mile *downstream* from the proposed tailrace discharge site[8].

Project and Reference reaches were established to account for spatial variations in physical, chemical, and biological components and processes within the study area; and to facilitate spatially explicit analyses of conditions that exist before and after the hydro facility is built.

7.1.2 Study Sites

Four study sites, each measuring approximately 150-200 meters long, will be selected for fine-scaled measurements of habitat and fish, periphyton, macroinvertebrate, and mollusk populations. One study site will be located in the Upper Reference Reach, one in the Lower Reference Reach, and two in the Project Reach. The study sites will be selected to be representative of conditions within non-sampled areas of the associated reach. Due to the difficulty of sampling the less accessible areas of Black Canyon, the two study sites in the Project Reach will be located near the Upper and Lower ends, respectively, of that reach.[9]

7.2 Physical Components

The proposed physical conditions studies are intended to identify and measure environmental attributes that influence the status and trend of aquatic resources in the

[8] Since the Project will not alter the timing, frequency, or magnitude of flows downstream of the tailrace return, the potential for adverse effects on fish populations in areas below the Project Reach is expected to attenuate rapidly in the downstream direction.

[9] The number of Project Reach study sites may be reduced from two to one depending on initial results obtained at the other study sites, site accessibility concerns, and cost-related decisions made during the final scoping of the study.

study area. In this study component, we focus on resident trout habitat since we have a good understanding of the habitat requirements of this species, and the response of trout to habitat perturbations.

In reality, habitat comprises myriad factors – physical, chemical, and biological – that interact over different spatial and temporal scales to influence the distribution, abundance, movements, and growth of resident trout. Although the suitability of a particular location as trout habitat within a stream or river varies in response to changing conditions, trout are known to associate with or respond consistently to different levels and combinations of environmental factors.

Trout habitat in the North Fork will be assessed in two ways: (1) by identifying and mapping discrete units of habitat (i.e., pools, glides, riffles, and cascades) throughout the Project and Reference reaches; and (2) by measuring water velocities, depths, and substrates at a large number of randomly selected locations within the Project Reach study sites. The latter information will be combined with measurements of velocity, depth, and substrate at locations where individual fish are observed to develop habitat suitability criteria. Both habitat assessment approaches have practical value in terms of being able to discern spatial patterns and causal relationships between habitat and trout population characteristics at different spatial scales.

7.2.1 Habitat Typing

Habitat typing is a form of classifying discrete areas of stream (habitat units) based on their morphological and hydraulic characteristics. Past studies have shown that different species and life stages of salmonids, including resident trout, prefer and utilize certain habitat types over others, and that the precision of fish abundance estimates can be significantly improved if stratified by habitat type (Hankin and Reeves 1984).

In previous stream-wide inventories of physical and biological conditions in the North Fork Snoqualmie River, Thompson et al. (2011) and Thompson (2012) delineated and categorized habitat units into four habitat types – pools, glides, riffles, and cascades. Although alternative habitat classification systems exist, we recommend that the same habitat types be used in this study.

During late August or early September, when streamflows have declined to summer low flow levels, a crew of two snorkelers and one data recorder will identify, delineate, and measure each habitat unit within the Project and Reference reaches, starting at the head of the Upper Reference Reach and ending at the lower end of the Lower Reference Reach.

The basic physical attributes of each habitat unit, including their average length, width, and depth; flow characteristics, and bed material composition and size, will be estimated in the field. Certain reach characteristics (e.g., gradient) and water quality (e.g., water temperature) will also be recorded during the longitudinal continuous habitat surveys.

The proposed longitudinal habitat surveys will provide a useful inventory of the diversity and type of habitat present in the study area, and its utilization by fish species, over space and time. Habitat typing measurements and corresponding trout population estimates will be considered quantitative since they will be performed by the same crew of highly experienced individuals, led by Jamie Thompson, and because the data will be collected under low flow conditions in late summer, when habitat units are readily identified and classified according to habitat type, and underwater visibility is maximal.

7.2.2 Habitat Availability

In his comments on the proposed study plans, the WDFW representative requested that data be collected to describe habitat utilization by different size classes of trout within the study area. This information would be used to validate or, as appropriate, modify existing habitat suitability criteria developed from utilization data collected in other stream systems. As described in the Instream Flow Study Plan, the revised habitat suitability criteria will be applied to hydraulic model outputs to predict how trout habitat in the Project Reach would respond to changes in flow.

Habitat suitability criteria, also referred to as electivity or preference functions, for different life stages of trout in the Project Reach will be derived from measurements of fish locations relative to habitat conditions that exist at the time of sampling. Separate criteria will be developed for velocity, depth, and substrate to indicate the preference of a species or life stage for different levels of each habitat attribute. The methods for measuring habitat availability (i.e., the range of conditions from which fish are able to choose) and habitat utilization (i.e., the habitat actually used by fish) within the Project Reach are described below. The methods for combining habitat availability and utilization data to create habitat suitability criteria, and for verifying or revising existing suitability criteria, are described in the Instream Flow Study Plan.

To describe existing habitat conditions in the Project Reach, mean water velocity (measured at 0.6 of the depth), depth, and substrate will be measured at a minimum of 200-300 randomly selected nodes of a 1.0 meter square grid overlaid on the two Project Reach study sites. It is assumed that this sample size would reflect the entire range of existing conditions present at the time when fish measurements are taken. Habitat availability data would be collected in conjunction with fish observations and other habitat measurements, as described below in Section 7.3.1.3 Habitat Utilization. As time and resources permit, additional habitat availability and utilization data will be collected at higher flows to ensure that the habitat suitability criteria are representative of the range of flows evaluated in the instream flow study. This information will be combined with fish observation data to create habitat suitability criteria for resident trout in the Project Reach.

7.3 Biological Components

The biological studies described in this plan are designed to collect data on several biological components in the North Fork Snoqualmie River, including fish, macroinvertebrates, algae (periphyton), and mollusks. Information on the abundance and distribution of aquatic biota within the project area will help us evaluate the current ecological status of the river so that the potential effects of the Black Canyon Hydro project can be reliably evaluated, and suitable PM&E measures prescribed.

The primary focus of the proposed studies, however, is on the dominant fish species present within the project area – rainbow and cutthroat trout. A sampling framework is recommended that allows us to quantify the number of trout present in the study area, map their distribution, evaluate what they eat, and describe the habitat in which they are found. To better understand the relationships between trout and habitat within the study area, and how these relationships may be affected by the propose project, we need to know how much habitat is available, what its quality is, and how it is likely change in response to flow alterations caused by the project.

7.3.1 Fish

7.3.1.1 Distribution and Abundance

Two commonly used methods – underwater visual observation (snorkeling) and electrofishing - will be used to enumerate fish in the project study area under late summer flow conditions. The two techniques are complementary in that they allow more accurate estimates of fish density, sampling of a wider range of habitats, and the ability to sample individual fish for length, weight, and stomach contents.

Snorkeling was selected as the primary sampling method for documenting fish composition, distribution, and abundance in Project and Reference reaches for several reasons:

- It was the method used by Thompson et al. (2011) to sample other areas of the upper Snoqualmie Basin.
- It enables quantitative sampling of key attributes of individual fish, fish populations, fish communities, and distribution and use of associated habitats
- When stratified sampling is used, a relatively large number of habitat units can be sampled, thereby reducing errors in expansions of counts due to variation in fish densities between the sampled units.
- It is less time-consuming than most other techniques.
- Statistical techniques for analyzing and describing snorkeling data are well-developed
- It enables rapid collection of a large amount of data at relatively low cost
- It is well suited to sampling habitats with high water clarity
- It permits ready identification and enumeration of fish; salmonids in particular, due to their territorial nature.
- It is less likely to disturb the observed fish than do other sampling methods.
- It is particularly well-suited to remote, difficult-to-access locations like Black Canyon.

Snorkeling will be used to document fish species and life stages, and to estimate the number of trout present in Project and Reference reaches and associated study sites, following protocols described in Thompson et al. (2011). The approach entails systematic counts of different species and size classes of fish by snorkelers within habitat units (categorized as pool, riffle, glide, or cascade habitat) in each reach or study site. The number of snorkelers conducting the fish counts will be adjusted so that all fish residing in each habitat unit can be identified and recorded. All habitat units will be surveyed except for very shallow riffles and glides or turbulent cascades. The number of fish in each habitat unit will be counted and tallied to estimate fish abundance by habitat type for the associated reach. Habitat unit locations will be GPS-recorded and unit boundaries delineated at the same time fish counts are made, but their dimensions and physical characteristics (e.g., substrate composition, large woody debris abundance) will be measured afterwards to avoid disturbing fish while counts are being made. Natural fish passage limitations or potential barriers and other geomorphic features will be documented and pictures will be taken throughout the surveys.

To obtain visually-based fish count data, highly experienced snorkelers will record the number of fish in each habitat unit by species and size group (0–50, 50–99, 100–149, 150–229, 230–299, 300–379, ≥380 mm total length). Salmonids will be recorded as "trout" unless they can be accurately identified to species. Fish will be grouped in the following life stages: fry = 0–50 mm, subadult = 50–149 mm, adult = 150–299 mm, and large adult = 300–≥380 mm).

To obtain accurate estimates of trout densities at Project study sites, and to calibrate estimates obtained for Project and Reference reaches, we will use a sampling approach developed by Hankin and Reeves (1988) that employs both snorkeling and electrofishing techniques. At each study site, habitat units will be classified and delineated by habitat type, as described above. Habitat unit surface areas will be measured to enable accurate fish density calculations by habitat type. Snorkelers will visually estimate the number of fish by size class in each habitat unit within the study site. The number of fish in each size class will be summed across all habitat units to obtain abundance estimates, by size class, for the entire study site.

Following Hankin and Reeves (1988), electrofishing-based estimates will also be obtained for a subset of habitat units of each type, and used to calibrate visual counts obtained by snorkeling. The proportional area of the wetted stream surface area comprising different habitat types will be estimated, and visual counts will be expanded by habitat type to obtain absolute abundance estimates for the associated reach. This will result in an estimate of total fish abundance by species and size class in the study reaches.

After snorkel-based trout abundance estimates are generated for each study site, trout abundance will be re-estimated using non-lethal electrofishing techniques. Electrofishing will be conducted within a few days of snorkeling and under similar low streamflow conditions. Study sites will be blocked at both ends with nets and multiple passes will be made with the electroshocker. Fish collected in each pass will be retained in separate live cages until the last pass is made, and then counted and measured for length and weight. A subsample of fish will be sampled for stomach contents.

A multiple pass estimator (Zippen 1958) will be applied to the electrofishing data to estimate the population size at each site. Separate estimates will be generated for each habitat type and size class, if possible. These estimates will be used to calibrate visual counts obtained by snorkeling.

Although electrofishing may be impractical in deeper water, it is generally more effective and accurate than snorkeling for enumerating trout in most wadeable streams (Hankin and Reeves 1988). Assuming this is true for the Project and Reference Reach study sites, snorkel-based fish density estimates obtained for non-electrofished habitat units and study reaches will be adjusted upwards by multiplying them by the following ratio:

Study Site Trout Density (electrofishing) / Study Site Trout Density (snorkeling)

The proportion of each project reach comprising different habitat types will be estimated, and the above ratio will be applied to each habitat type to obtain absolute abundance estimates for the associated reach. Calculation of confidence intervals for adjusted density estimates will follow methods described by Hankin and Reeves (1988). This will result in an estimate of total fish abundance and confidence intervals by species and size class in the study reaches.

Electrofishing will also be used to document the use of nearshore shallow water habitat by trout fry and other fish. These areas are generally too shallow to be effectively snorkeled. This information will be used to evaluate the potential for stranding of juvenile fish due to rapid flow fluctuations in the Project Reach caused by project operations.

7.3.1.3 Habitat Utilization

Habitat utilization data are needed to develop and evaluate habitat suitability criteria that will be used to model trout habitat suitability in the Project Reach as a function of structural and hydraulic conditions that prevail at different flows. The accuracy of the model output is highly dependent on the accuracy of the habitat suitability criteria; the key question is whether existing suitability criteria, which are based on measurements of habitat utilization by trout in other stream systems, can be used to reliably simulate habitat suitability in the Project Reach of the North Fork Snoqualmie River.

Habitat selection by trout is not only influenced by the structural and hydraulic features, as indicated above, but also by the size and physiological condition of the fish, and by the availability of food, the presence and abundance of competitors and predators, season, time of day, and thermal regime. For modeling purposes, however, it is assumed that velocity, depth, and substrate are the primary environmental attributes affecting habitat quality and quantity, and therefore the distribution and abundance of trout, in the Project Reach. Note that trout preference for cover, a fourth variable that is frequently included in fish habitat models, may also be measured if we decide to include it as a model parameter.

In the present study, the positions of individual fish in the Project Reach study areas will be measured relative to key “microhabitat” variables, including water velocity, depth, and substrate. The relative proportion of fish associated with different levels of each variable, considered independent of the other variables, will serve as an index of preference or electivity by fish for those conditions.

Habitat utilization data will be collected for active juvenile and adult trout observed in the Project Reach during daylight hours in late summer, at approximately the same time and under the same low flow conditions that habitat availability and fish population data are collected at each study site (see above). Active fish are defined as those feeding or swimming in position. Juveniles are classified as individuals ranging from 50 to 149 mm in length, and adults as any fish equal or greater than 150 mm in length. A minimum of 50 fish of each size class will be measured. Fish will be sampled in all habitat units at the Project Reach study sites (and in adjacent Project Reach areas, if necessary) in order to achieve the desired sample sizes and avoid bias associated with non-uniform habitat availability.

If time and resources permit, and measurements can be made during the summer growth season, additional habitat availability and utilization data will be collected at a second, higher discharge.

Direct underwater observation by snorkelers will be used to locate the positions of active (but undisturbed) trout within each habitat unit. After an extended period of observing the fish present and recording their sizes and general movements, snorkelers will mark the position most frequently occupied by each fish by placing a colored 1-in diameter washer on the stream substrate directly below the fish. Mean water column velocity (measured at 0.6 the total depth), depth, and substrate composition will be measured at each marked location.

7.3.2 Periphyton

Periphyton will be sampled from natural substrates in representative riffle and pool habitat units in the Project and Reference reach study sites. Sampling, sample processing, and data analysis protocols will follow those described in Appendices C3 and C4 in Ecology (2010), which were derived from U.S. Environmental Protection Agency's "Regional Environmental Monitoring and Assessment Program" (Barbour et al. 1999). As such, the BCH data will be comparable to reference data collected by Ecology from other streams in the Cascade region.

Field sampling of periphyton will occur during the late summer, when flows are low and stable, at undisturbed riffle and pool habitats in each of the four study sites. Periphyton and benthic macroinvertebrates will be collected from eight riffle and eight pool habitat units spaced at roughly equal distances throughout the site. Periphyton samples will be collected from small, relatively smooth and flat rocks (10 cm average diameter) collected near the middle of each habitat unit. The samples will be taken immediately prior, and in close proximity, to benthic macroinvertebrate samples. Periphyton collected from rocks in eight riffles will be added to a sample jar to create a single composite riffle sample for the site. The same procedure will be followed for samples collected from pool habitats.

Composited periphyton samples will be sent to a certified laboratory, where they will be subsampled for chlorophyll α analysis and taxonomic identification by a taxonomist experienced with freshwater periphyton of the Pacific Northwest. Diatoms will be identified to species, and non-diatom (soft-bodied) algal species will be identified to genus. Laboratory processing and reporting procedures will adhere to Ecology (2010) protocols. For each study site riffle and pool composite sample, data will consist of

1. The original (signed) chain-of-custody form;
2. Copies of bench sheets used by the laboratory;
3. Copies of all QA/QC documentation;
4. A list of algal taxa for each sample; and
5. Metric calculations.

Taxa lists and metric calculations for each sample will be recorded in Microsoft Excel spreadsheet format. Based on guidelines provided by Ecology (2010), the primary periphyton metrics of interest include:

All species:
1. Total number of algal divisions;
2. Total number of algal general; and
3. Total number of algal species.

Diatoms only:
1. Total number of diatom genera;
2. Total number of diatom species;
3. Shannon Diversity Index; and
4. Pollution Index.

Additional periphyton metrics may be developed if deemed relevant. The metrics will be analyzed in conjunction with other biological, physical, and chemical data. Statistical tests for differences in periphyton assemblages in riffle and pool habitats and in Project Reach and Reference Reach study sites will be performed.

7.3.3 Macroinvertebrates

7.3.3.1 Benthic Macroinvertebrates

Targeted sampling of benthic macroinvertebrates (BMI) will also be conducted at Project Reach and Reference Reach study sites. BMI samples will be collected from riffle and pool habitats using sampling protocols described by Plotnikoff and Wiseman (2001) and Ecology (2010). The BMI data collection and analysis procedures are similar to those used in other BMI monitoring programs developed for Pacific Northwest streams and rivers.

Based on their unique hydraulic characteristics, riffle and pool habitats are expected to support different BMI communities. The primary reason for surveying these two habitats is that they may respond differently to project effects, such as changes in hydrologic and sediment transport regimes. Changes in benthic macroinvertebrate assemblages over time in riffle and pool habitats, and at Project and Reference Reach study sites, may also reveal the effect of prior natural disturbances.

The BMI study comprises field sampling, data analyses, and reporting. To facilitate comparisons with other biological components, BMI sampling will be conducted in late summer at each of the four intensively sampled study sites. BMI samples will be collected with kick nets at the same time that periphyton samples are collected. Eight riffle and eight pool habitats will be sampled simultaneously with periphyton samples at each study site. A single composite sample will be created by combining the eight subsamples for each habitat type. Samples will be processed by certified taxonomists. Macroinvertebrates will be identified to species level if taxonomic keys are available, and to genus level otherwise.

Several metrics can be calculated from the BMI data. One that has strong interpretive value as an index of biotic integrity is the EPT Index, calculated as the number of taxa belonging to the Ephemeroptera, Plecoptera, and Trichoptera (Wallace et al. 1996).

In western Washington, the Benthic Index of Biotic Integrity (BIBI) is used extensively to assess and compare the biological condition of streams. Depending on the taxonomic level to which collected macroinvertebrates are identified, BIBI metrics include:

1. Total Taxa Richness
2. Ephemeroptera (Mayfly) Taxa Richness
3. Plecoptera (Stonefly) Taxa Richness
4. Trichoptera (Caddisfly) Taxa Richness
5. Intolerant Taxa Richness
6. Clinger Taxa Richness and Percent
7. Long-Lived Taxa Richness

8. Percent Tolerant
9. Percent Predator
10. Percent Dominance

The individual BIBI metrics and their ecological significance are discussed at Puget Sound Stream Benthos website: http://www.pugetsoundstreambenthos.org/

BIBI scores will be calculated for riffle and pool BMI samples collected at Project Reach and Reference Reach study sites. In calculating a BIBI score, individual metrics are given a score of 1 through 5 and then added together to obtain a composite BIBI score; the higher the score, the more pristine (or less disturbed) the stream.

Table 1. BIBI Biological Condition Categories (from Karr et al. 1986), modified by Morley 2000).

Biological Condition	Description	Species-Family	Species-Genus	Family	Ecology Puget Lowland MMI
Excellent	Comparable to least disturbed reference condition; overall high taxa diversity, particularly of mayflies, stoneflies, caddis flies, long-lived, clinger, and intolerant taxa. Relative abundance of predators high.	[46, 50]	[46, 50]	[23, 25]	
Good	Slightly divergent from least disturbed condition; absence of some long-lived and intolerant taxa; slight decline in richness of mayflies, stoneflies, and caddis flies; proportion of tolerant taxa increases	[38, 44]	[38, 44]	[19, 22]	(30, 50]
Fair	Total taxa richness reduced – particularly intolerant, long-lived, stonefly, and clinger taxa; relative abundance of predators declines;	[28, 36]	[28, 36]	[14, 18]	[20, 30]

	proportion of tolerant taxa continues to increase				
Poor	Overall taxa diversity depressed; proportion of predators greatly reduced as is long-lived taxa richness; few stoneflies or intolerant taxa present; dominance by three most abundant taxa often very high	[18, 26)	[18, 26)	[9, 13)	[10, 20)
Very Poor	Overall taxa diversity very low and dominated by a few highly tolerant taxa; mayfly, stonefly, caddis fly, clinger, long-lived, and intolerant taxa largely absent; relative abundance of predators very low	[10, 16]	[10, 16]	[5, 8]	

Assuming that BMI data will continue to be collected after the project is constructed, changes in the diversity or relative abundance of BMI that are similar in magnitude and direction for all study reaches would be taken as evidence of the effects of environmental variables operating over a larger area. Changes in BMI attributes in the Project Reach following project construction that differ significantly from those measured at similar times and under similar conditions in the Reference Reaches would indicate potential project effects. This information would guide management decisions intended to conserve the biological integrity and ecological quality of the North Fork.

7.3.3.2 Macroinvertebrate drift

MID will be sampled over a 8 hour period in late summer at each study site, starting at approximately 3 PM and ending at approximately 11 PM. Drift nets (0.5 m square frame, 500 μm mesh size) will be deployed at the downstream ends of three riffles within each study site for four 1-hr sampling periods, with the first and second deployments occurring before sunset, and third deployment commencing at sunset (around 8 PM in late August), and the fourth deployment commencing at around 10:00 PM. Nets will be placed just above the streambed and, ideally, will reach the water’s surface.

MID collected in the three nets will be combined into a single sample jar at the end of each sampling period. Nets will be cleaned after each deployment. Thus, for each study site, two daytime samples and four nighttime samples will be collected. The four study sites will be sampled successively over a 4 to 6 day period. Periphyton, benthic macroinvertebrates, and trout stomach samples will be collected during the same period.

Mean velocity will be measured in front of each net at the beginning of each sampling period; the velocity and net frame cross-section area will be used to calculate the rate of flow through each net. Stream discharge will be measured simultaneously at nearby Project streamflow gages. These values will be used to determine the density of invertebrates (individuals m^{-3}) as a function of stream discharge. Since the total discharge is related to the number of animals drifting past a sampling point, comparisons of drift numbers should be expressed per unit volume rather than per unit time (Elliot 1968).

MID samples will be described in terms of their number of taxa and individuals, and biomass (wet and dry weights). Taxonomic identification will be conducted by the same taxonomists employed to process and analyze BMI samples. The same metrics described above for BMI samples will be calculated using MID data. Statistical methods will be used to test hypotheses concerning differences in MID between time periods at each study site, and between study sites.

7.3.4 Mollusks

Mollusks (primarily small snails and mussels) collected in BMI samples at each of the study sites will be identified to species, counted, and incorporated into BMI indices of community structure, diversity, and relative abundance. Comparisons will be made between study sites, and between riffle and pool habitats within study sites.

Each study site will be carefully surveyed throughout its entire length for colonies of pearlshell mussel by snorkelers and waders during periods of low flow, using visual and tactile surveying techniques described by Strayer and Smith (2003) and King County (2005). Surveyors will record the location of each mussel colony using Global Positioning System (GPS) technology. The type of habitat in which the mussel colony is located will be recorded, along with key habitat metrics (habitat unit width, length, and depth; mean velocity, and substrate). The number of mussels in each colony will be counted, noting live and dead mussels. A subsample of dead mussels within each colony will be measured along their longest axis to the nearest millimeter.

Mollusk densities calculated from BMI sampling data will be analyzed to determine whether differences exist between riffle and pool habitats, or between Project and Reference Reaches study sites. Pearlshell mussel distributions will be mapped and analyzed in relation to habitat variables and densities will be compared between study sites. If sampling is repeated after the hydroelectric project begins operations, it will be possible to analyze for project effects on the relative abundance of mollusks in Project Reach study sites.

8 PROGRESS REPORTING

8.1 Technical Report

A final technical report will be submitted that details the objectives, methods, results and implications of the physical and biological aquatic resource components of this study.

Specific subjects that will be addressed in the report include:

- Sampling Framework and Design: selection of study sites, statistical analysis of the data; critical uncertainties and assumptions.
- Data Quality Assurance: field and laboratory procedures, data verification, treatment, and analysis; reporting.
- Habitat Typing: delineation, classification, and measurement of habitat units; longitudinal continuous profiles of habitat units (by type), maximum depths, wetted and active channel widths, dominant and subdominant substrates sizes, and LWD counts in Project and Reference reaches. Reach contrasts. Comparison of 2013 data with similar data collected data obtained previously by WDFW (Thompson 2011) in other North Fork Snoqualmie River segments in 2009-2010 and by Thompson in 2012.
- Habitat Availability: frequency distributions of different levels (classes) of water velocity, depth, and substrate composition available to trout in Project Reach study sites. Contrast with habitat utilization data.
- Fish: Longitudinal continuous profiles of fish abundance by fish size class and habitat type in Project and Reference reaches. Reach contrasts. Comparison of 2013 data with similar data collected in 2009-2010 and 2012. Electrofishing of study sites will enable more accurate estimates of fish density that can be used to adjust snorkel-based abundance estimates, contrast study sites, and evaluate changes over time caused by project and non-project factors.
- Periphyton: Composition and abundance (density, biomass, chlorophyll). Diversity and functional metrics. Relationship to other environmental variables. Study site/reach contrasts.
- Benthic Macroinvertebrates: Composition and abundance (density, biomass) in study site riffle and pool habitats. Biotic integrity metrics. Relationship to other environmental variables. Study site/reach contrasts.

- Macroinvertebrate Drift: composition and abundance (number, biomass) of organisms available to feeding trout during late summer at project study sites. Study site/reach contrasts.
- Mollusks: estimates of snail and mussel densities based on benthic macroinvertebrate sampling in riffle and pool habitats at each study site. Presence/absence of invasive species. Locations and densities of pearlshell mussel colonies. Associated habitat characteristics. Counts of live and dead mussels within colonies. Habitat type and study site/reach contrasts.

9 SCHEDULE

In accordance with 18 CFR §5.11(b)(3), this section describes provisions for periodic progress reports, including the manner and extent to which information will be shared; and the time allotted for technical review of the analysis and results.

Study reports will be submitted as required by the FERC Integrated Licensing Process (ILP). The most recent schedule, issued by FERC in Appendix B of Scoping Document 1, includes a number of opportunities for progress reports, exchange of analysis and results between stakeholders, and information sharing. After proposed study plans are filed with FERC there will be a study plan meeting and comment period before a revised study plan is filed and a comment period passes. Once studies begin, the ILP also has deadlines for an Initial Study Report to be submitted, an Initial Study Report Meeting, and an Initial Study Report Meeting Summary. However, this schedule is subject to change by FERC staff and should not necessarily be relied upon. It is BCH's understanding that any changes to the ILP plan and schedule will be noticed by FERC staff.

The following page contains a schedule titled as follows:
Table 2. Resource Study Schedule

10 LEVEL OF EFFORT AND COST

In accordance with 18 CFR §5.11(d)(6), the anticipated level of effort and cost are provided below. The total estimated cost of this work is approximately $188,250. At least one senior fish biologist and two to five technicians would be required to perform the task laid out in this plan as well as drafting and finalizing reports.

See the table on the following page for a detailed cost breakdown:

Table 3. Level of effort and cost

Table 2. Resource Study Schedule
Table 3. Level of effort and cost.

Tasks	Completion Date*	Labor and Expenses
1. Site reconnaissance and field study mobilization	May – July 2013	$15,000
2. Habitat		
· Classification, delineation, and measurement of habitat units in study reaches and sites.	August 2012 – August 2013	$18,750
· Measurements of velocity, depth, and substrate frequency distributions at Project Reach study sites	August – September 2013	$7,500
3. Fish		
· Longitudinal profiles of fish abundance and habitat use within Project and Reference reaches.	August 2012 – August 2013	$15,000
· Fine-scaled measurements of habitat utilization at Project Reach study sites	August – September 2013	$18,000
· Quantitative estimates of trout population size/density at study sites	August – September 2013	$24,000
4. Periphyton		
· Collection and analysis of samples collected from riffle and pool habitats at each study site.	August – November 2013	$7,500
5. Macroinvertebrates		
· Collection and analysis of BMI samples from riffle and pool habitats at Project and Reference Reach study sites.	August – September 2013	$7,500
· Collection and analysis of MID samples at Project and Reference Reach study sites.	August – September 2013	$7,500
6. Mollusks		
· Analysis of mollusk data collected in BMI samples from riffle and pool habitats at Project and Reference Reach study sites.	October – November 2013	$3,000
· Longitudinal profiles of pearlshell mussel distribution and abundance in Project and Reference reaches.	September 2012 – November 2013	$7,500
· Detailed mapping and quantification of pearlshell mussel colonies at Project Reach study sites.	August – September 2013	$12,000
7. Data analysis and study report preparation	August 2012 – March 2014	$45,000
	Total	**$188,250**

* Dates based on schedule created and presented by FERC in Scoping Document 1 and subject to change.

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12 APPENDIX A: STUDY AREA