Black Canyon Hydroelectric Project
FERC Project No. P-14110
Environmental Flows Study Plan
January 2013

Prepared for
Black Canyon Hydro, LLC
3633 Alderwood Avenue
Bellingham, WA 98225

Table of Contents

List of Tables

1 INTRODUCTION

Black Canyon Hydro, LLC, (BCH) plans to file an application with the Federal Energy Regulatory Commission (FERC) 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, 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.

Intake Alternative A

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.

Intake Alternative B

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.

Powerhouse

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 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 instream flows within the Project Reach. The Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Ecology (Ecology) also require an instream flow study so that they have sufficient information on which to base instream flow requirements in the Clean Water Act Section 401 water quality certification for the Project (WDFW and Ecology 2008).

1.1 Scope of Revised Study Plan

As required by the Integrated Licensing Process (ILP) and schedule imposed by FERC, BCH filed Proposed Study Plans (PSPs) on September 7, 2012. A total of 16 PSPs were filed covering a wide range of technical subject areas. The various agencies, tribes, and stakeholders participating in the Black Canyon Hydro ILP were allowed 30 days to

formally comment the PSPs. After the formal comment period ended, BCH held two days of meetings with project participants to discuss the study plans.

This document updates and replaces the "Proposed Instream Flow Study Plan" that was included in the first round of submittals. It addresses additional studies requested by FERC, WDFW, Ecology, and other project participants that pertain to instream flows and ramping rates, with the exception of whitewater boating and power generation studies, which are described in the Recreational Boating and Access Study Plan and the Hydropower Potential and Project Economics Study Plan.

At the request of Dr. Hal Beecher of WDFW, we have added a data collection and analysis component to this study to validate, refine, or replace, as appropriate, existing habitat suitability curves for resident juvenile and adult trout[1]. The curves will be applied to hydraulic model outputs to simulate habitat availability in the Project Reach as a function of flow under pre-project (i.e., existing) and post-project conditions.

Other reviewers requested more detail on the approach that will be used to develop minimum flow and ramping rate recommendations for the Project Reach. Accordingly, instream flow modeling and habitat studies and a collaborative process involving project participants are proposed that would facilitate the derivation of new minimum flow and ramping rate standards for the Project Reach. If the recommended minimum flows and ramping rates differ from existing minimum flow requirements but would yield significantly greater benefits, Ecology, at its discretion, would be able to prescribe them as conditions in the CWA Section 401 water quality certification of the project (Chris Maynard, Ecology, personal communication).

This study plan describes instream flow and ramping rate investigations that will be conducted in 2013 and published in 2014. Other studies that address biological resources and related physical components and processes will be conducted concurrently. The studies have been designed to ensure efficiency and maximize the amount and quality of information generated during the pre-application period of the Black Canyon Hydro ILP.

[1] Non-anadromous rainbow trout and cutthroat trout populations are both present in the North Fork Snoqualmie River. The two species, especially smaller individuals, look alike and are difficult to differentiate from a distance. In food limited systems like the North Fork, rainbow trout and cutthroat trout exhibit similar life histories, have similar ecological requirements, and are found in similar habitats. Although rainbow trout appear to be more numerous in the Black Canyon reach of the North Fork (Sweeney et al. 1980; Thompson et al. 2011), for the purposes of this study, we refer to both species as a single entity – trout. Moreover, we assume that data collected on either species is representative of both species, and that impacts and mitigative measures would affect both species similarly.

Their primary purpose is to establish an environmental baseline, evaluate potential project effects, and identify Protection, Mitigation and Enhancement (PM&E) measures that can be implemented to minimize or mitigate any project impacts.

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.

To protect physical and biological components and processes that are influenced by the flow regime in rivers, seasonally varying minimum flow and ramping rate requirements are typically imposed by state and federal regulators as a condition for the licensing of new hydroelectric projects. As defined by the State of Washington (Washington Administrative Code 173-507), instream flows are flows needed to protect and preserve instream resources and values, such as fish, wildlife and recreation. Ramping rate is the rate of change in river stage or flow that results from the diversion or release of water due to project operations. In the context of hydroelectric project licensing/relicensing, instream flows and ramping rates have traditionally focused on the protection of sensitive or economically important fish species.

In this study, we emphasize the importance of evaluating potential project effects and mitigation options based on a consideration of the full range of ecological components, functions, and processes of the North Fork. We also recognize other flow-related beneficial uses, such as municipal water supply, whitewater boating, and power generation. For this reason, we use the term “environmental flows” when referring to the various streamflow-mediated components that will be investigated and considered in decisions related to project operation and resource protection and mitigation.

Environmental flows do not have a formal legal or regulatory meaning, but nevertheless are meant to provide a conceptual basis for recommending flows that are prescribed in the Clean Water Act Section 401 water quality certification issued by the Washington Department of Ecology, and subsequently included in the FERC license for the project. In this study, we use the term to refer to flows in the Project Reach that satisfy Section 401 requirements, as well as additional allocations of flow that achieve other desirable ecological and social objectives, such as increased opportunity for recreation.

The basic premise of this study is that environmental flows can be identified and implemented that preserve the ecological integrity and enhance the benefits provided by

the North Fork. As currently conceived, the Project will divert between 90 cfs and 900 cfs of flow from the North Fork at RM 5.0. The water will be conveyed from the intake in a buried pipeline to a powerhouse, where turbines and a generator will generate electricity, and then discharged back into the North Fork at RM 2.4 via a 200-foot long tailrace. Although streamflows in areas downstream of the tailrace discharge point may be affected to some degree by project operations, because this is a run-of-river project, the primary hydrologic impact of the project will be an attenuation of flows in the Project Reach. As described in the Hydrology Study Plan, water diversion will increase the frequency and duration of low-to-moderate flows, and decrease the magnitude and variability of moderate flows in the Project Reach. No change is expected in the frequency or duration of very low flows in the Project Reach since the project will not likely be operated during the summer baseflow period. Similarly, only minor changes are expected in the magnitude and timing of high flows, since flows in this range are commonly on the order of several thousand cfs. For example, annual peak flows measured over the past 80 years at USGS Gage 12142000, located 4.3 miles upstream of the intake, average 8,100 cfs (median, 7660 cfs) – far greater than the 900 cfs maximum hydropower generation capacity of the project.

Two additional points warrant mentioning with respect to project operations: (1) the project will not store and release water, and therefore will not result in artificially high (i.e., peaking) or low flows downstream of the powerhouse; and (2) flows will be diverted from the North Fork into the intake only if minimum flow requirements for the Project Reach are met. This means that streamflows must exceed the minimum flow in effect at that particular time by at least 90 cfs before water can be diverted from the river. In late summer, when streamflows in the North Fork are at their lowest levels, the amount of surplus water available is unlikely to exceed the prevailing minimum flow by 90 cfs. Therefore, water will not likely be diverted and power will not be generated at this time.

At other times of the year, when flows exceed the prevailing minimum flow by at least 90 cfs, water will be diverted from the North Fork and the Project Reach will receive less water than it otherwise would have. If flows drop below this minimum flow-plus-90 cfs level, the project will be shut down and the entire river discharge will flow down the Project Reach.

When the Project is operating, that is, diverting anywhere from 90 to 900 cfs from the river, flows in the Project Reach will remain relatively constant (i.e., at minimum flow

levels) until maximum capacity is reached, at which point, the rate of change in stage in the Project reach will be proportional to the natural rate of change.

The potential for Project-induced changes in flow in the Project Reach will be greatest during the periods that follow Project startup and shutdown. The Project will begin operating as soon as natural flows exceed the corresponding minimum flow levels by 90 cfs. The Project will cease operating when river flows drop below that level.

Existing minimum flow requirements range from a low of 130 cfs in August and September to a high of 300 cfs in the spring and early summer months. Based on a lengthy record of historical flows, we conclude that river discharge is likely to exceed the minimum flow requirements by at least 90 cfs during most months, with the exception of the July through September period. During these months, the project is likely to operate sporadically or be shut down altogether due to the lack of adequate flow.

The potential effects of Project operations on streamflows and aquatic resources in the Project Reach will be investigated in this study, and in the Hydrology, Hydropower Potential and Project Economics, and Aquatic Resource studies. The results of these studies will be synthesized and presented to the ARWG, which will assist BCH in the development of minimum flow and ramping rate recommendations for the Project Reach.

This information will be evaluated further with respect to the abundance and vulnerability of trout fry inhabiting nearshore areas in the Project Reach at different times of the year. The results of the analysis will be presented to the ARWG, which will be asked to recommend ramping rates for the Project that minimize the risk of stranding trout fry and other aquatic organisms.

Project-induced changes in flow may affect a wide range of physical, chemical, and biological components and processes within and downstream of the Project Reach. Water temperatures, nutrients, algae and macroinvertebrates, and fish populations will be affected by the chosen design parameters of the project, Section 401 minimum flow and ramping rate requirements, and the hydrology of the North Fork. The flow regime of the North Fork is expected to continue to change in the future as a result of the local effects of global warming on precipitation and runoff. The effects of these variables on streamflows, power generation, and aquatic biota will be evaluated in the Hydrology, Hydropower Potential and Project Economics, and Aquatic Resources studies.

With this in mind, the following objectives are proposed for the Environmental Flows Study:

1. Identify/clarify management goals and priorities for flow-dependent biological, recreational, and other resources in the study area.
2. Investigate the effects of Project-related flow alterations on fish, fish habitat, and other aquatic resources in the study area.
3. Identify flow-related measures, including Project Reach environmental / minimum flows and ramping rates, that would protect or improve existing beneficial uses, including aquatic resources, recreational opportunities, and hydropower generation, or that would avoid, reduce, or compensate for impacts caused by the project.
4. Develop a long-term Black Canyon Hydroelectric Project Monitoring and Adaptive Management Plan to ensure that environmental flows and other conservation goals are being met, and unwanted impacts are being adequately addressed.

The specific tasks designed to meet these study objective are discussed in detail below (see Section 6.0 Methods).

The Environmental Flows Study will be coordinated with other BCH licensing studies that are intended to inform decisions regarding project infrastructure and operations, conserve natural resources, and provide increased opportunities for recreation. To facilitate interaction and feedback among project participants, an Aquatic Resources Work Group has been formed comprising agency, tribal, and non-governmental organization representatives. The ARWG met in December 2012 to discuss instream flow study objectives and methods, and will continue to meet in 2013 and 2014 to assist BCH with the implementation of the Environmental Flows Study Plan. ARWG members will be invited to provide input, review and comment on proposed methods and results of the study, and participate in the development of environmental flows, mitigation measures, and a Project Monitoring and Adaptive Management Plan.

2 STUDY AREA

The Environmental Flows Study area comprises the proposed Project Reach of the North Fork Snoqualmie River, and 1.0-mile sections of river immediately up- and downstream of the Project Reach, referred to as Reference Reaches. The 2.6-mile long Project Reach extends from the point of diversion at the water intake (RM 5.0) downstream to the point where water is returned to the river via the powerhouse tailrace channel (River Mile 2.4). Study sites have been established in the Project and Reference Reaches to establish an

environmental baseline and facilitate monitoring and evaluation of the project's effects on the physical, chemical, and biological characteristics of the study area after the project begins operation.

3 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.

Fish and other aquatic species that make up the biological community of the North Fork represent a valuable and unique natural resource. Although the project area is located upstream of Snoqualmie Falls, and is therefore above the anadromous fish zone, the Northwest Power and Conservation Council has designated the section of the North Fork that includes the proposed Project Reach a "Protected Area". Conventional (storage dam) hydroelectric development is discouraged in these areas due to the risk it poses to local fish and wildlife populations.

This stretch of river has 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).

The Washington State Department of Ecology (Ecology) recommends minimum instream flows for streams and rivers that are intended protect a range of instream values and to prevent the over-appropriation of water for out-of-stream uses. The Snohomish River Basin Instream Resources Protection Program (IRPP) established minimum instream flows for the North Fork, as measured at USGS Gage 12143000, for specified dates during the year. The Supplemental Environmental Impact Statement for the IRPP concluded that the minimum flows would protect fish habitat and improve recreational boating opportunities in the North Fork.

The proposed study will assist in the development of measures to conserve ecological and recreational values of the North Fork. Specifically, it will investigate the effects of the project on instream resources and recreational opportunities under a range of plausible operational scenarios. Environmental flows will be developed that, in combination with other structural and operational features of the project, conserves fisheries and other aquatic resources in affected areas of the North Fork throughout the year. The project's

primary goals are to maintain or improve ecological components and functions, and to improve opportunities for fishing and boating in the project area relative to existing levels. When presented with information gained through this and other studies, FERC will need to decide whether the proposed action is in the public's best interest, as measured by the environmental and social costs and benefits of the project.

4 EXISTING INFORMATION

In accordance with 18 CFR §5.11(d)(3), this section describes existing information on instream flows at the Project, and the need for additional information.

4.1 Habitat vs. Flow Simulations

In 1985, the consulting firm R.W. Beck and Associates conducted an instream flow study within the Project Reach of the North Fork on behalf of its client, the Weyerhaeuser Corporation (R.W. Beck and Associates 1985). Weyerhaeuser was exploring the feasibility of constructing a hydroelectric facility on the North Fork that was similar in many respects to the project being proposed by Black Canyon Hydro, LLC. The purpose of the 1985 study was to simulate changes in habitat availability as a function of flow using the Physical Habitat Simulation System (PHABSIM; Milhous et al. 1984). PHABSIM is the hydraulic and habitat suitability modeling component of the Instream Flow Incremental Methodology (IFIM) (Stalnaker et al. 1995), a broad conceptual and analytical framework for addressing stream flow management issues.

In the 1985 instream flow study conducted by R.W. Beck, water depth, water velocity, and substrate composition were measured at three flows (range 32 – 800 cfs) at 1 to 2 ft intervals along 14 transects within two study reaches in the Project Reach. The study reaches were located near the upstream and downstream ends of the proposed Project Reach, and sampled all but the steepest, most turbulent areas of the channel.

The PHABSIM hydraulic simulation model was used to predict water depth and velocity at each sampling point for a range of flows. Habitat suitability curves developed for different life stages of rainbow trout, which the researchers determined to be the numerically dominant fish species in the study area, were applied to the hydraulic output to quantify the amount and spatial distribution of weighted useable area (WUA, an index of habitat suitability) for a range of flows within the two study reaches. The resulting WUA versus stream discharge curves were used to identify flows at which habitat was maximized for each life stage of both species. A habitat optimization matrix was constructed for each month of the year that defined the amount of WUA present for each

life stage at flows 50, 60, 70, 80, and 90 percent monthly exceedance flows, which were calculated from historical streamflow records (R.W. Beck 1985).

The R.W. Beck (1985) instream flow study found that flows associated with maximum spawning and adult rainbow trout habitat (300 cfs and 225 cfs, respectively) were higher than those that maximized juvenile and fry rainbow trout habitat (l70 cfs and 50 cfs), when averaged across the two study sites. The WUA estimates and flow exceedance information were used to generate several instream flow scenarios for the North Fork, taking into consideration the timing and habitat requirements of different rainbow trout life stages.

Based in part on the results of the R.W. Beck (1985) instream flow study, Ecology promulgated instream flow rules for the North Fork in 1988 under the Snohomish River Basin Instream Resources Protection Program (Chapter 173-507 of the Washington Administrative Code). Minimum instream flows were specified at semi-monthly intervals for normal and critical water years (Table 2). The compliance point for the specified flows is at River Mile 2.2, located immediately downstream of the point of discharge of the proposed powerhouse tailrace channel.

4.2 Fisheries Data

Fish populations and habitat in the Snoqualmie River Basin have been surveyed on several occasions over the past several decades (Sweeney et al. 1981; R.W. Beck and Associates 1985; Thompson et al. 2011); summaries of these studies may be found in the BCH Pre-Application Document (BCH 2012). In 2008-2010, the upper Snoqualmie River and several of its tributaries, including the North Fork, were surveyed by WDFW biologists as part of Puget Sound Energy's efforts to relicense the Snoqualmie Falls Hydroelectric Project (FERC No. 2493). The results of the survey included information on fish species composition, abundance, distribution, age, and life history data (Thompson et al. 2011). The North Fork was sampled up- and downstream of the proposed Project Reach; however, the Project Reach was not sampled due to time constraints and safety concerns.

In 2012, 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 entire North Fork, including the Project Reach, in late August. The 2012 inventory confirmed the presence of healthy trout populations throughout the North Fork (Figure 1). As described in the Aquatic

Resources Study Plan, the 2012 fish and fish habitat data will be evaluated in conjunction with additional data that will be collected in 2013.

Additional Information Needed

As discussed elsewhere, updated information is needed on the timing and relative abundance of different fish species and other aquatic species in the North Fork. This information will be obtained through studies proposed in the Aquatic Resources Study Plan. Similarly, updated statistical analyses of streamflow data are needed to characterize the existing flow regime, which can then be related to the ecological components, functions, and processes of the North Fork in areas that are likely to be affected by the proposed project. These analyses will be performed in the Hydrology Study.

A major part of the Environmental Study will entail the application of PHABSIM models to evaluate project impacts and develop environmental flows for the Project Reach. The hydraulic data collected in the 1985 instream flow study (R.W. Beck and Associates 1985) appear adequate as input to a more current version of the PHABSIM hydraulic model. Additional measurements may be taken to better define river discharge-stage relationships and roughness coefficients within the two study reaches. The relative weight assigned to the instream flow study transects will be updated based on data collected in the Aquatic Resources, and the Geomorphology, Sediment and Wood Transport studies.

Based on comments received Project licensing participants, the habitat suitability criteria (HSCs) used to develop habitat vs. discharge curves for rainbow trout in the 1985 R.W. Beck instream flow study are out-of-date and need to be updated. We propose to develop new HSCs for juvenile and adult trout based on habitat availability and utilization data collected in the Project reach, a review of trout HSCs used in other instream flow studies, and consultation with Ecology, WDFW, and other knowledgeable experts. We will also seek agency input on HSCs for other trout life stages, and for other fish species and aquatic organisms to be included in the instream flow modeling study.

The effects of natural flow fluctuations on the distribution and survival of fish in the Snoqualmie River system has not been studied. The potential for dewatering areas of the streambed, and either stranding fish or exposing them to greater risk of predation, is influenced by the rate and extent to which inundated areas of stream are exposed by receding water levels. Rapid decreases in river stage, especially in river channels having extensive side channels and broad, gently sloping bars or streambanks, can result in significant mortality of smaller fish, including salmonid fry.

In most systems, streamflows attenuate gradually following cessation of storm events, allowing fish time to relocate to safer areas. It is not uncommon, however, for fry to become trapped in pools, potholes, and other depressions that become isolated from the main flow. These habitats may reconnect to the main channel during subsequent high flow events, but more commonly dry out as water evaporates or drains through porous substrates during prolonged dry periods.

Reductions in flow, natural or otherwise, may also dewater fish eggs or alevins in streambed gravels. In these cases, the length of time eggs are exposed, and thus their probability of survival, is influenced by the rate at which water levels fluctuate in the intragravel environment.

The potential for stranding of fish and other aquatic organisms, and dewatering redds, is greater in streams and rivers in which flows fluctuate as a result of water storage or diversion (Hunter 1992). To protect sensitive biota from the negative impacts of rapid decreases in stage, the State of Washington has established ramping rates, defined as the rate of change in stage resulting from regulated discharges, to protect fish and other aquatic resources.

In its Section 401 water quality certification of hydroelectric power projects, Ecology typically specifies a maximum allowable rate of flow reduction for reaches affected by project operations (WDFW and Ecology 2008). This study and consultation with knowledgeable agency and tribal biologists will assist in identifying ramping rates and a schedule suitable for the Black Canyon Hydro Project.

5 NEXUS TO PROJECT

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

When reviewing a hydropower license application, the Commission must consider the environmental, recreational, fish and wildlife, and other non-developmental values of the project, as well as power and other socioeconomic benefits. To do this effectively, the Commission requires up-to-date, reliable information on existing resources, an accurate description of the effects the project may have on these resources, and recommendations on how effects that are not in the public interest can be avoided, minimized, or mitigated.

Potentially detrimental effects of the project include alteration of hydrologic and hydraulic processes, especially in the Project Reach, where flow attenuation will be accompanied by reductions in water volume, depth, velocity, and surface area. Project infrastructure and operations are also likely to alter sediment and large wood transport and depositional processes, which may affect in turn the morphology of the channel and availability and quality of habitat over time. These and other Project-related effects may adversely impact resident biota. Although these physical and biological impacts will be primarily limited to the Project Reach, there is potential for them to influence ecological components, functions, and processes in areas downstream of the project.

This study will inform project management decisions so that undesirable project impacts can be avoided or mitigated in the future.

6 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).

The Environmental Flows Study will comprise the following Objectives and Tasks:

Objective 1: Identify/clarify management goals and priorities for flow-dependent biological, recreational, and other resources in the study area.

- In consultation with agency, tribal, and non-governmental organization representatives, BCH will identify priority ecological, recreational, and developmental resources that will be the focus of the environmental flows study. Management priorities are constrained in part by state and federal laws and regulations that govern hydropower development and licensing. However, it is possible to modify project goals and activities based on local circumstances and values. To facilitate discussion of management priorities for water and other resources of the North Fork, an Aquatic Resources Work Group has been organized. The ARWG will be asked to establish management goals for flow-dependent resources in the study area that strive to balance local conservation and development interests. To facilitate this process, BCH will compile existing information on fish and other aquatic biota, water quality, habitat, recreation, and other flow-dependent resources within the study area.

Objective 2: Investigate the effects of Project-Related flow alterations on fish, fish habitat, and other aquatic resources in the study area.

The tasks to be performed under this objective fall into two general categories: Instream Flows and Ramping Rates.

<u>Instream flows</u>

- Collect data and develop habitat suitability criteria (HSCs) for juvenile and adult trout in the Project Reach. As described in the Aquatic Resources Study Plan, habitat availability within the Project Reach will be characterized in terms of velocity, depth, and substrate frequency distributions compiled from a large number of random measurements carried out at Project Reach study sites in 2013 under low to moderate flow conditions. Habitat utilization by individual juvenile and adult trout in the Project Reach will be measured at the same time. Habitat suitability criteria[2] for these life stages will be calculated as habitat use-to-availability ratios following protocols described by Waddle (2001). The empirically derived HSCs will be compared to "composite" HSCs that have been

[2] The HSCs will reflect the preference (i.e., utilization) by fish for different levels of velocity, depth, and substrate, taking into account the availability of these resources within the stream environment.

developed from data collected from other stream systems and trout populations in Washington State, using methods described by Thomas and Bovee (1993). BHC will consult with the ARWG on the species/life stages and associated HSCs to be used in habitat modeling, impact assessment, and environmental flow prescriptions for the Project Reach.

- Relying as much as possible on hydraulic and structural data collected in earlier instream flow studies, develop a PHABSIM hydraulic simulation model for the Project Reach. If necessary, collect additional flow, hydraulic, channel morphology, substrate, etc. data to update the Project Reach hydraulic model. Verify that the recalibrated hydraulic model accurately predicts water velocities and depths at measurement locations over a range of flows.
- Using species/life stage HSCs that have been developed in consultation with the ARWG, run the PHABSIM hydraulic and habitat simulation models to predict the amount of available habitat, expressed as Weighted Useable Area (WUA), for different flows in the Project Reach.
- Model WUA in the Project Reach under the existing (i.e., pre-project, or baseline) flow regime. Determine whether habitat has changed significantly in recent decades due to changes in stream hydrology.
- Model WUA in the Project Reach under the future (i.e., post-project) flow regime, assuming existing minimum flow requirements and anticipated project withdrawals (see Hydrology and Hydropower Potential and Project Economics Study Plans).
- Model WUA in the Project Reach under the future (i.e., post-project) flow regime, assuming new minimum flow requirements (see Objective 3 below) and anticipated project withdrawals.
- Compare the amount of habitat available in the Project Reach under pre- and post-project flow regimes. Habitat time series and statistical summaries of habitat availability will be used to make the comparisons. In particular, Indicators of Hydrological Alteration (IHA) software will be used to evaluate pre- and post-project differences in both hydrology and habitat availability. As conventionally applied, the IHA software analyzes hydrologic data to compare flow regimes from two time periods in terms of their flow magnitude, timing, frequency, duration and rate of change (Richter et al. 1996). While the IHA metrics are useful descriptors of flow characteristics that influence the biological and physical aspects of a river, they do not in themselves provide a clear indication of the types or degree of biological response expected. To gain a better appreciation of the potential impacts the Project will have on fish habitat in the Project Reach, we will convert daily streamflow data used in the IHA analysis of pre-project and post-project hydrologic differences into corresponding estimates of weighted useable area. An

IHA analysis will then be run to statistically describe and contrast the magnitude and temporal variability of WUA in the Project Reach under pre- and post-project conditions. This information will be useful in establishing new minimum flow requirements and specifying PM&Es for the Project.

Ramping rates

- Investigate the potential effects of different ramping rates on fish and other aquatic organisms in the Project Reach. As described in the Aquatic Resources Study Plan, nearshore areas of the Project Reach study sites will be visually surveyed and electrofished to estimate the abundance of trout fry and characterize their use of shallow water habitat.
- The PHABSIM hydraulic model and the IHA analysis will be used to describe the rate and frequency of change in water surface elevation at representative cross-sections in the Project Reach.
- The magnitude and variability in flow level fluctuations observed under existing conditions, as indexed by modeled river stages and IHA rate of change metrics, will be compared with (1) similar estimates derived for post-project conditions in the Project Reach, (2) data collected from other ramping rate studies, and (3) standard ramping rates specified for hydroprojects in Washington State (Hunter 1992; WDFW and Ecology 2008).
- This information and agency consultation will assist in identifying ramping rates, schedules, and critical areas and flows.

Objective 3: Identify flow-related measures, including Project Reach environmental / minimum flows and ramping rates, that would protect or improve existing beneficial uses, including aquatic resources, recreational opportunities, and hydropower generation, or that would avoid, reduce, or compensate for impacts caused by the project.

- In consultation with the ARWG, identify opportunities for modifying project operations to create a flow regime in the Project Reach that would benefit resident fish, habitat, and increase opportunities for high quality recreational experiences, relative to existing conditions. Specifically, develop recommendations for environmental flows (i.e., new minimum flows) and ramping rates for the Project Reach.
- Identify flows that will provide for the unrestricted movements of fish and other aquatic organisms, and a range of flow-mediated sediment, wood, and nutrient processes and outcomes, in the Project Reach, subject to flow availability.

Objective 4: Develop a long-term Black Canyon Hydroelectric Project Monitoring and Adaptive Management Plan to ensure that environmental flows and other conservation goals are being met, and unwanted impacts are being adequately addressed.

- BCH has installed two streamflow gages: one just downstream at the proposed intake site and the other just downstream of the proposed tailrace discharge point. The upper gage will be used to measure compliance with Project Reach minimum flow and ramping rate requirements. The lower gage will ensure compliance with minimum flows for the North Fork Snoqualmie River, pursuant to WAC 173-507. The Project Monitoring and Adaptive Management Plan will identify resources and a schedule for monitoring and reporting on compliance with minimum flow and ramping rate requirements.

- Based on information obtained from this and other studies, long-term monitoring of key physical, chemical, biological resources will be recommended to ensure that project operations can be modified, if necessary, and other measures implemented to avoid, reduce, or mitigate for unwanted Project impacts.

7 PROGRESS REPORTING

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 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 filled 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 understands that any changes to the ILP plan and schedule will be noticed by FERC staff.

Progress on the Environmental Flows Studies will be described in memoranda and presented at regular meetings of the Aquatic Resource Work Group, but no less frequent than at 3 month intervals. The progress reports will describe the status of the studies,

discuss significant findings, and identify adjustments or changes necessary to meet study objectives. The progress reports will be discussed at ARWG meetings.

8 SCHEDULE

In accordance with 18 CFR §5.11(b)(2), the schedule for conducting the study is provided in Table 1 below.

9 LEVEL OF EFFORT AND COST

In accordance with 18 CFR §5.11(b)(2), the schedule for conducting the study is provided in Table 1 below.

Table 1. Schedule and Level of Effort and Cost

BCH Environmental Flows Study Plan

Table xx. Study Schedule

Table xx. Level of Effort and Cost.

Objectives and Tasks	Completion Date	Labor and Expenses
Objective 1: Identify/clarify management goals and priorities.		
· Convene Aquatic Resources Work Group	November 2012 – March 2014	$5,000
· Establish management goals for flow-dependent resources	January 2013	$1,500
Objective 2: Investigate the effects of flow alterations on fish and other beneficial uses		
Instream flows		
· Develop habitat suitability criteria for juvenile and adult trout, other species and life stages.	August – October 2013	$12,000
· Develop a PHABSIM hydraulic simulation model for the Project Reach.	August – November 2013	$15,000
· Calculate habitat availability (WUA) in the Project Reach for different flow levels.	October – November 2013	$5,000
· Model WUA in the Project Reach under the existing flow regime.	October – November 2013	$5,000
· Model WUA for post-project flow regime, assuming existing minimum flows and anticipated project operations.	November – December 2013	$3,000
· Model WUA for post-project flow regime, assuming new minimum flows and anticipated project operations.	December 2013 – January 2014	$3,000
· Use IHA software to analyze/compare existing and post-project hydrology and habitat availability.	December 2013 – January 2014	$8,000
Ramping rates		
· Compile existing information on fry abundance and habitat use in Project Reach.	August – October 2013	$8,000
· Use hydraulic model and IHA software to analyze the rate and frequency of change in stage in the Project Reach.	October – November 2013	$12,000
· Compare results with data and ramping rates for other river systems.	November – December 2013	$3,000
Objective 3: Identify minimum flows, ramping rates, and other flow-related measures to reduce or mitigate Project impacts.		
· Recommend environmental/minimum flows for Project Reach.	December 2013 – January 2014	$8,000
· Recommend ramping rates for Project Reach.	January – February 2014	$5,000
· Identify other flow-related measures to reduce or mitigate Project impacts.	January – March 2014	$3,000
Objective 4: Develop Monitoring and Adaptive Management Plan.		
· Ensure compliance with Project minimum flow and ramping rate requirements.	March 2013	$1,000
· Develop monitoring strategy for key physical, chemical, biological resources	March – April 2014	$15,000
· Identify process for evaluating, reducing, and mitigating Project impacts.	March – April 2014	$4,000
	Total	**$116,500**

10 REFERENCES

BCH Pre-Application Document (BCH 2012)

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. United States Fish and Wildlife Service FWS/OBS- 82/26. 248pp.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. State of Washington Department of Fisheries Technical Report No. 119. Olympia. 46 pp.

Milhous, R. T. , D. L. Wegner, and T. Waddle, 1984. User's Guide to the Physical Habitat Simulation System (PHABSIM). Instream Flow Information Paper 11. U.S.D.I. Fish and Wildlife Service, Office of Biological Services. FWS/OBS—81/43 Revised.

National Park Service (NPS). 2012. Letter from Michael Linde, National Park Service, to Kimberly D. Bose, Secretary, FERC, Re: Black Canyon Hydroelectric Project (P-14119), North Fork Snoqualmie River, King County, Washington. FERC eLibrary Accession Number 20120719-5037. July 17.

NPS. 1993. "Nationwide Rivers Inventory." U.S. Department of the Interior. http://www.nps.gov/ncrc/programs/rtca/nri/. Accessed August 1, 2012.

R.W. Beck and Associates. 1985. Black Canyon North Fork Snoqualmie Instream Flow Study. Report prepared for Weyerhaeuser Corporation. 42 pp + appendices.

Stalnaker, C., B. L. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. The Instream Flow Incremental Methodology - A Primer for IFIM. Biological Report 29, March 1995, U.S. Department of the Interior, National Biological Service, Fort Collins, Colorado.

Sweeney, S.J., K.W. Kurko, and T.C. Juelson. 1981. North Fork Snoqualmie River Basin Wildlife Study. Final report of the Washington Department of Game to the U.S. Army Corps of Engineer. Contract DACW67-79-C-0050. 239 pp. + Appendices.

Thomas, J. A., and K. D. Bovee. 1993. Application and testing of a procedure to evaluate transferability of habitat suitability criteria. Regulated Rivers: Research & Management 8:285-294.

Thompson, J.N., J.L. Whitney, and R.E. Lamb. 2011. Snoqualmie River Game Fish Enhancement Plan – final report of research. Washington Department of Fish and Wildlife. Submitted to Puget Sound Energy in partial fulfillment of the Snoqualmie Falls Hydroelectric Project FERC No. 2493.

USFS 1990. Mt. Baker Snoqualmie Forest Plan.

Waddle, T.J., ed., 2001, PHABSIM for Windows: User's Manual and Exercises: Fort Collins, CO, U.S. Geological Survey, 288 p.

Washington Department of Ecology. 1979. Snohomish River Basin Instream Resources Protection Program Including Proposed Administrative Rules, and Supplemental Environmental Impact Statement (Water Resource Inventory Area 7). Olympia, Washington. August 28. https://fortress.wa.gov/ecy/publications/SummaryPages/79IRPP7.html. Accessed July 31, 2012.

Washington Department of Fish and Wildlife. 2011. Snoqualmie Falls Hydroelectric Project, FERC No. 2493: Snoqualmie River Game Fish Enhancement Plan. 289 pp.

Washington Department of Fish and Wildlife, and Washington Department of Ecology. 2008. Instream Flow Study Guidelines: Technical and Habitat Suitability Issues Including Fish Preference Curves. Updated April 05, 2004 and February 12, 2008.

11 APPENDIX A: Environmental Flows Study Area