

**Black Canyon Hydroelectric Project
FERC Project No. P-14110
Revised Geomorphology, Large Wood, and Sediment Transport Study Plan
January 2013**

Prepared for
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1 INTRODUCTION

Black Canyon Hydro, LLC, (BCH) ultimately 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.

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 Snoqualmie River.

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 geomorphology, large wood, and sediment transport within the Project reach which follows the requirements of 18 CFR 5.11(b)-(e).

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.

Several participants in the Black Canyon Hydro Licensing process have commented on the key role that sediment and large wood play in maintaining desirable habitat for fish and wildlife in the North Fork. When inflated, the diversion will create a minor pool and hydraulic conditions that promote sediment deposition. Streamflows that would normally mobilize and transport coarse sediment (bedload) downstream in the North Fork could be

reduced in magnitude by diversion at the intake (up to a maximum of 900 cfs). Lower flows could become more common in the Project Reach, and moderate flows that would normally transport significant quantities of bedload could occur less frequently. High flows (i.e., those that significantly exceed the intake capacity), although infrequent and diminished in magnitude, will continue to occur on a regular basis, resulting in the mobilization and downstream transport of coarse sediment and large woody debris. A major question is whether the modified flow regime will affect the amount of sediment and wood delivered, stored, and transported in the Project Reach. Due to the anticipated reduction in the frequency of moderate flows in the Project Reach, there could be a change in sediment and wood delivery in the Project Reach relative to historical patterns. The objectives of this study are to use flow-duration data to assess stream power duration in the study area, the expected yield of sediment and large wood from upstream, and expected changes in timing of transport and deposition of sediment and large wood in the study area. This information would be used to address concerns raised by stakeholders about the potential effects of the project on fish habitat in the Project Reach and downstream areas.

The North Fork in the study area is moderately steep. Gravel suitable for fish spawning is transported through the reach by high flows but does not generally accumulate in large volumes before being remobilized, although deep pools often retain gravel. Even with periodic sluicing of gravel from behind the diversion, the natural pattern of gravel movement and accumulation may be disrupted to varying degrees depending on methods of construction and operational protocol of the diversion. The altered flow regime will include longer periods of low flow volumes that are interrupted by sporadic high-flow events. The alterations in the natural flow regime may lead to changes in the amount and distribution of gravel habitat throughout the Project Reach. The current channel geomorphology, distribution of large wood, and sediment transport processes associated with the natural flow regime will be carefully assessed to better understand project impacts and to establish baseline data for monitoring and mitigation.

The study will be carried out to achieve the following specific goals:

- Goal 1: Identify suitable sites for field assessment of geomorphology and distribution of sediment and large wood in the upstream and downstream control reaches and, to the extent safe access is possible, in the Project Reach.
- Goal 2: Obtain existing, available information on stream flow and topography and earlier studies of geomorphology, large wood, and sediment transport in the study area.

- Goal 3: Conduct a geomorphic assessment of the structure and bed material type of the Project Reach and the upstream and downstream control reaches.
- Goal 4: Characterize and rank the relative importance of mechanisms for sediment and large wood delivery to the Project Reach and transport of that sediment and large wood through the Project Reach.
- Goal 5: Characterize how seasonal variations in the duration of flows in the Project Reach each impact the timing and quantity of sediment and large wood flux into and through the Project Reach.
- Goal 6: Assess how project design and operational alternatives may impact flow duration, stream power, and resulting channel forming processes, including the abundance, distribution and transport of sediment and large wood and issues of how flow returns and mixing might affect potential scour and riverbank erosion near the point of return from timing of reduced sediment in the return flow.
- Goal 7: Define potential scenarios for sediment and large wood transport to affect project infrastructure, including the diversion and inlet screens.
- Goal 8: Coordinate geomorphic assessments with other technical studies affected by the results of this study.

The proposed geomorphology, large wood, and sediment transport study will include assessment of yields from upstream of sediment and large wood but will not evaluate upstream or downstream factors and sources outside the control of BCH or the proposed hydroelectric generation project.

This study will be conducted in close cooperation with other studies that may be undertaken at the same time and that are informed by this study. This study will require considerable input on flow duration statistics and projected trends to be developed with the Hydrology Study. Other complementary studies that will use results from this study include the Instream Flow; Wildlife, Vegetation, and Sensitive Habitats; Fish Passage; Fisheries; Water Quality studies; and to a lesser degree the Aesthetics; Recreational Boating and River Access; and Recreational Resources studies.

3 STUDY AREA

The geomorphology, large wood, and sediment transport study area will include:

- The 2.6-mile Project Reach, from approximately river mile 5.0 (the diversion point) to river mile 2.4;
- The 0.5-mile control reach upstream of the Project Reach and point of diversion, approximately from river mile 5.5 to 5.0;

- The 0.5-mile control reach downstream of the Project Reach and point of return and powerhouse, approximately from river mile 2.4 to 1.9;
- The point of diversion at river mile 5.0; and
- The point of return and powerhouse at river mile 2.4, near where former US Geological Survey (USGS) Gage 12143000 was located.

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.

Section 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.

Describing the proposed project's effect on geomorphology, large woody debris, and sediment transport in the project area is necessary to fulfill the Commission's responsibilities under the National Environmental Policy Act (NEPA) and is relevant to the Commission's public interest determination.

5 EXISTING INFORMATION

In accordance with 18 CFR §5.11(d)(3), this section describes existing information on geomorphology, large wood, and sediment transport in the Project Reach, and the need for additional information.

There is limited existing information on geomorphology, large wood, and sediment transport in the study area. As part of an earlier study of hydropower at this location, studies were conducted that included characterizing the study area (Weyerhaeuser, 1985).

Detailed data on soils and geology are available from the Natural Resources Conservation Service (NRCS) and USGS. Also, light detection and ranging (LiDAR) ground elevation mapping of the project area is available. LiDAR provides detailed topographic information of the river and can supplement other topographic mapping information that is available from USGS, including historic river profile data from 1914.

Aerial photography is available through the Washington Department of Natural Resources (DNR) and USGS. Flow data, including daily mean and peak flows, are available for two locations in or near the study area. USGS Gage 12143000 is located on the North Fork at river mile 2.4 near the proposed location of the powerhouse, and USGS Gage 12142000 is located upstream of the diversion and intake structure at river mile 9.3. Detailed information regarding the data that are available for these gages is presented in the Hydrology Study Plan.

Additional Information Needed:

To complete the Geomorphology, Large Wood, and Sediment Transport Study, additional data will need to be obtained regarding site-specific conditions. This data would include characteristics of the geometry and substrate material in the Project Reach and upstream and downstream control reaches. Collecting the required information is addressed under Goal 1 in Section 7.1.

6 NEXUS TO PROJECT

In accordance with 18 CFR §5.11(d)(4), this section describes any nexus between Project operations and effects on geomorphology, large wood, and sediment transport in the Project Reach.

Construction and operation of the Black Canyon Hydroelectric Project would alter the flow duration curve for the Project Reach. As a result, there is potential for the Project to affect the geomorphology of the Project Reach and the upstream and downstream control reaches by changing the transport capacity and lateral distribution of sediment and large wood in these reaches. When the sediment transport capacity is sufficiently altered, deposition of sediment and greater entrapment of large wood may occur near the upper end of the Project Reach resulting in reduction of sediment and large wood transported through the Project Reach and to the downstream reach. This may affect the availability and distribution of gravel beds and large wood shelter for fisheries habitat for spawning and rearing.

The results of this study will be used to inform the design and operation of the hydropower facility to avoid, minimize, or mitigate for adverse effects in the area of geomorphology, large wood, and sediment transport in the study area.

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).

The Geomorphology, Large Wood, and Sediment Transport Study will be conducted in close conjunction with other concurrent studies, as noted in Section 2.0. Existing topographic data will be combined with flow-duration data to be gathered as part of the Hydrology Study to develop flow duration curves to be used in the stream power computations. The duration curves represent alternate operational scenarios for the proposed Black Canyon Hydroelectric Project which will be related to sediment transport capacity in the Project Reach and upstream and downstream control reaches. By relating these alternative operational flow duration curves to transport capacity and to the available yield of sediment and large wood from upstream flows, this study can quantify the potential effects of construction and operation of the proposed facilities on in-stream sediment and wood.

To complete the study, BCH proposes the following study elements:

- Literature review. Existing sources will be compiled and reviewed to identify relevant literature and data.
- Geomorphology summary. A geomorphology summary will be prepared distilling results of the Hydrology Study and this study. Data will be analyzed at the level of the shortest stream segments available in the USGS data set to evaluate short-duration flow characteristics, such as the North Fork’s response to precipitation events and diurnal variation in flows due to snowmelt, and how these characteristics affects geomorphology, large wood, and sediment transport in the study area.

The following sections lay out specific methods to address each study goal identified in Section 2.0. Section 8.0, Progress Reporting, indicates the relationships among these studies and proposes several opportunities for stakeholder involvement.

7.1 IDENTIFY SUITABLE SITES FOR FIELD ASSESSMENT

- Use information from prior studies including an earlier Instream Flow study (Weyerhaeuser, 1985) and the initial reconnaissance conducted to support this study plan to identify representative locations for field assessment in the control reaches upstream and downstream of the Project Reach and, if safe access is feasible, in the Project Reach.
- Obtain permission from respective private property owners to access field assessment sites.

7.2 OBTAIN EXISTING AVAILABLE INFORMATION

- Coordinate with the Hydrology Study team so that the flow analyses conducted as part of that study are suitable to support the assessments to be conducted as part of this study.
- Obtain additional information, including historical and current aerial photography and ground elevation data, such as LiDAR.
- Solicit additional information sources from project stakeholders and obtain the identified information if readily available.

7.3 CONDUCT A GEOMORPHIC ASSESSMENT OF THE STRUCTURE AND BED MATERIAL TYPE

This will involve characterization of the bathymetry, gravel size, extent of gravel deposits at low flow, and elevations of gravel deposits relative to surface water elevations at the survey locations to be determined in addressing Goal 1. In addition, the quality and quantity of gravel in the area will be identified in coordination with the Fisheries study.

- Conduct pebble counts to determine the spatial variability of gravel size and the presence or absence of an armored layer.
- Measure the extent of gravel deposits at low flow and the elevations of gravel bars relative to surface water elevations.

7.4 CHARACTERIZE AND RANK THE RELATIVE IMPORTANCE OF MECHANISMS FOR SEDIMENT AND LARGE WOOD DELIVERY AND TRANSPORT

- Conduct a literature review of sediment transport studies conducted in similar geologic and hydrologic regimes.

- Evaluate available fluvial and hillslope sediment transport equations and mass flux estimates.

7.5 CHARACTERIZE IF AND HOW SEASONAL VARIATIONS IN THE DURATION OF FLOWS IN THE PROJECT REACH IMPACT THE TIMING AND QUANTITY OF SEDIMENT AND LARGE WOOD FLUX INTO AND THROUGH THE PROJECT REACH

- Utilize measurements of bed materials made as part of the study addressing Goal 3, available sediment transport equations, and flow duration statistics to determine a sediment mass balance.
- Model time series of stream power using flow duration data from the Hydrology Study, and relate to yield of sediment and large wood into the study area.

7.6 ASSESS IF AND HOW PROJECT DESIGN AND OPERATION ALTERNATIVES MAY IMPACT FLOW DURATION, STREAM POWER, AND RESULTING CHANNEL FORMING PROCESSES

- Quantify how the proposed project operational scenarios may alter the flow regime and sediment transport processes using the models developed as part of Goal 5.
- Describe how the inflatable dam would impact the natural flow of sediments during operation.
 - Predict the amount of sediment and debris that the inflatable diversion may retain.
- Model alternative time series of stream power using flow duration data from the Hydrology Study for project design and operational alternatives, relate to yield of sediment and large wood into the study area, and compare to the baseline conditions to identify potential effects.

7.7 DEFINE POTENTIAL SCENARIOS FOR SEDIMENT AND LARGE WOOD TRANSPORT TO AFFECT PROJECT INFRASTRUCTURE

- Assess how potential aggradation and degradation of the streambed may impair project infrastructure.
 - Provide information related to changes to the streambed behind the inflatable diversion and analyze whether there will be a downstream impact on turbidity (results will inform the Water Quality study report).

- Develop project operational alternatives that could be used to mobilize or retain specific sizes of bed material in order to maintain the structure and function of the Project Reach.
 - This analysis would also include an explanation of maintenance procedure and anticipated frequency, if any, for clearing accumulated sediment while avoiding dredging.
 - Describe bedload movement under various operational alternatives.
 - Evaluate possibility of gravel monitoring and an adaptive management plan.

7.8 COORDINATE GEOMORPHIC ASSESSMENTS WITH OTHER TECHNICAL STUDIES

- Maintain contact with the Hydrology Study Plan team throughout the project duration so that flow duration and other hydrologic data developed as part of the Hydrology Study will support the analyses needed as part of this study.
- Maintain contact with other study teams throughout the project duration so that information developed from this study will support the project needs of those studies.

8 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 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 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's understanding that any changes to the ILP plan and schedule will be noticed by FERC staff.

Prior to the completion of the Initial Study Report, BCH will provide an opportunity for technical review of the draft study results and analysis. When the draft version of the Initial Study Report has been completed, it will be posted to the project website (www.blackcanyonhydro.com) and BCH will send notice of its availability by e-mail to contacts included on the mailing list identified in the “Revised Communication and Information Protocol” (filed electronically with the FERC on November 27, 2012). Stakeholders will have 15-days from the issuance of this notice to provide written comments to BCH through the project website’s “Contact” tab.

9 SCHEDULE

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

Table 1. Resource Study Schedule

Component	Completion Date*
Literature Review/Background Information	February – April 2013
Field Reconnaissance/Data Collection	May – August 2013
Geomorphic Assessment	August – October 2013
Sediment Transport Analysis	Winter 2013
Prepare Wood Management Plan	Winter 2013
Draft Initial Study Report Notice & Informal Comment Period	Winter 2013
Initial Study Report Due	February 6, 2014

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

10 LEVEL OF EFFORT AND COST

In accordance with 18 CFR §5.11(d)(6), the anticipated level of effort and cost are provided in Table 2 below.

The estimated cost of this work is approximately \$48,550, depending upon the extent of the analysis, fieldwork, and coordination needed with other studies; the level of information that might be obtained from existing sources; and the additional modeling that might be conducted.

One principal geomorphologist would be expected to review existing data sources; obtain and review additional data; evaluate and assess the processes and trends relating to

geomorphology and transport of sediment and large wood in the North Fork study area; coordinate with other studies; and draft and finalize maps and reports.

The principal geomorphologist would be supported by additional staff and be aided by independent senior in-house staff for quality assurance/quality control review.

Depending on the degree of success in conducting the initial assessment, it is possible that additional modeling of transport processes will be needed to complete the evaluation of potential effects. These costs can be estimated at a later time when the scope and need for that modeling are sufficiently developed.

Table 2. Level of Effort and Cost

Task	Labor and Expenses
Literature Review/Background	\$4,000
Field Reconnaissance / Data Collection	\$8,500
Geomorphic Assessment	\$11,000
Sediment Transport Analysis	\$9,000
Prepare Wood Management Plan	\$4,050
Draft and Finalize Technical Report	\$12,000
Total	\$48,550

11 REFERENCES

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12 APPENDIX A: Geomorphology Study Area

