Black Canyon Hydroelectric Project
FERC Project No. P-14110
Proposed Groundwater Study Plan
September 2012

Prepared for
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Table of Contents

List of Tables

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.

The Project would consist of the following new facilities: 1) a 8-foot-high, 162.4-foot-long inflatable rubber diversion with associated fish passage and intake structures; (2) 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; (3) a power conduit tunnel consisting of an approximately 450-foot-deep vertical tunnel into an approximately 8,300-foot-long, 12-foot-diameter horizontal tunnel and penstock connecting to; (4) a 60-foot-long, 100-foot-wide metal powerhouse with two Francis turbine units, one rated at 16 MW and the other rated at 9 MW; (5) a 200-foot-long, 24-foot-wide tailrace; (6) a 4.2-mile-long, 115-kilovolt overhead transmission line that transmits project power to the regional grid (transmission line would be an overbuild of an existing transmission line with only approximately 0.65 miles of new transmission); (7) a 0.75-mile-long and a 0.5-mile-long extension of two existing logging roads that lead to the project facilities; and (8) appurtenant facilities (switchyard, maintenance building, etc.).

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 groundwater near 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. The goal of this study is to evaluate existing groundwater supplies, particularly the City of Snoqualmie's water supply source (termed "Canyon Springs") that may be affected by construction and operation of the proposed project, and to assess the potential effects of the project on groundwater supply in the study area. If potential adverse impacts to water supply sources are identified, with a focus on the City of Snoqualmie's water supply source, the study will outline steps to monitor the groundwater system to identify impacts as early as possible and propose mitigation options to reduce any significant adverse impacts when identified.

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

- Evaluate the impacts of partial river diversion on the recharge to groundwater at different times of the year. Develop a specific methodology to evaluate the potential impacts of partial river diversion on the City of Snoqualmie water source, and any domestic wells in the immediate vicinity of the river upstream of the tailrace.
- Evaluate the potential of partial river diversion to affect natural springs or shallow water table areas, particularly in very shallow groundwater zones that create wetlands.

More specific objectives for the study are:

- Objective 1: Identify water rights holders, in addition to the City of Snoqualmie, that have groundwater or spring use rights in the study area that could be affected by the proposed project.
- Objective 2: Obtain records from the City of Snoqualmie regarding their use of the water source, including daily, monthly, and annual volumes of water removed; percent of the City's requirements, additional water sources for the City, water quality information, and projected use of the water source for the duration of the proposed project life.
- Objective 3: Estimate the storage capacity of the gravel aquifer at Crystal Springs by estimating the areal extent and depth of the aquifer, the porosity, the recharge from rainfall, and the seasonal fluctuation. Estimate the hydraulic conductivity and transmissivity of the aquifer.
- Objective 4: Conduct a geophysical survey in the area of the proposed intake and powerhouse to estimate the depths to bedrock.

- Objective 5: Use the information from the geophysical survey to evaluate the need for wells or piezometers in the vicinity of Canyon Springs. If wells or piezometers are needed, the installation will be coordinated with geotechnical studies for the facility.
- Objective 6: Evaluate the potential for seasonal shortages to the groundwater supply in the area of Canyon Springs. Conduct groundwater modeling of capacity and extraction. If hydraulic conductivity values cannot be predicted reliably from available descriptions of soil gradation, evaluate the need for aquifer pumping tests or slug testing.

3 STUDY AREA

The groundwater study area will include:

- The areas within a defined portion of the watershed of the North Fork that are potentially within the zones of influence of the potentially affected water rights holders; and
- Wetland areas (none currently identified, but if present) along the portion of the North Fork between the intake and the tailrace.

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.

A primary focus is on the "Canyon Springs" water resource, and potential impacts to the City of Snoqualmie water supply collection system. The main resource management goal is to understand whether the municipal water supply that is derived from the perched groundwater zone would be adversely affected by the construction and operation of the proposed project. Compiling existing information on current uses, projected uses for the life of the proposed project, and hydrogeologic information about the nature of the aquifer will allow prediction of adverse impacts on municipal water supply.

Another resource management goal is to evaluate the potential for the diversion to have adverse impacts on wetlands. Wetlands in the study area will be identified as part of another study plan, and information from that work will be evaluated in terms of potential groundwater supply impacts.

5 EXISTING INFORMATION

In accordance with 18 CFR §5.11(d)(3), this section describes existing information on groundwater resources in the area of the Project, and the need for additional information.

Canyon Springs is located just upstream of the proposed powerhouse, where the contact of an unconsolidated sand and gravel unit with the underlying bedrock is exposed in the canyon wall north of the river. The hydrogeologic unit of focus in the study area is the predominantly glacially-derived outwash and alluvial sands and gravels with a thickness of approximately 300-feet and with an apparent perched groundwater zone. This unit is underlain by relatively impermeable pre-Tertiary metasediments and metavolcanics. Upstream of the proposed powerhouse location, the geologic contact between the outwash gravels with the underlying bedrock is exposed as the river downcuts through the contact. The perched groundwater discharges as springs that form at the exposed contact.

Based on information provided by the Washington State Department of Ecology's Water Rights Explorer, there are four water rights holders in the study area, as shown below:

File Number	Name of Record	Document Type	Water Right Class	Priority Date	CFS	Source
S1-28645	Snohomish County PUD 1	New App	Surface water	01/11/10	30	Unnamed
S1-24092	Black Creek Hydro, Inc.	Certificate	Surface water	04/08/82	40	Black Creek
S1-06205CWRIS	Snoqualmie City	Certificate	Surface water	10/18/44	2	Canyon Springs
G1-26617(A)	City of North Bend	Permit	Ground water	06/16/92	2.646[1] 3.094[2]	Well NB-3

Note(s)
1. Maximum gallons per minute
2. Maximum acre-feet per year
cfs = cubic feet per second

Of the four water rights holders identified, only the City of Snoqualmie, File Number S1-06205CWRIS, appears to be in the study area and has any potential to be affected by the project. BCH observed the location of this water source during a site visit on August 2, 2012. Water is extracted by the City of Snoqualmie with a passive collector, described as

a perforated drain pipe, which is positioned to collect up to 2 cfs. Canyon Springs is interpreted to be located at an exposure of the contact between the coarse glacial outwash with the relatively impermeable bedrock below. This stratigraphic contact is exposed in the wall of Black Canyon about 300 feet upriver from the proposed power plant location. The river has down-cut through the contact of the units and water is discharged at a high rate as a surface spring. On the day observed, a significant amount of water flowed from the area, despite the City's passive collection system in place.

Water that is to be diverted at the proposed intake location (90 to 900 cfs) is only a fraction of the total base flow discharge of the North Fork. That diverted water is then placed back into the river at the tailrace. There is a 2.6-mile Project Reach that will continue to have significantly higher base flow rates, ranging from a minimum of approximately 260 cfs to a maximum of over 12,000 cfs. The minimum flow rate will be discussed in more detail in the other study plans, including the hydrology and fisheries study plans.

In addition to the information discussed above, more information is needed on the water utilization rates of Canyon Springs by the City of Snoqualmie, the capacity of the perched aquifer, and the seasonal variability of both.

6 NEXUS TO PROJECT

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

Construction and operation of the Black Canyon Hydroelectric Project could affect groundwater supplies in the study area by diverting river water that otherwise could have recharged the groundwater in the perched gravel aquifer in losing portions of the reach.

This study will help define the effects of the project on the groundwater storage capacity in the perched aquifer, and whether, and to what degree, the municipal water utilization rates could be seasonally impacted by diverting the surface water during the project operation. If significant impacts are likely, based on the study results, the study will propose mitigation options, including early warning monitoring so municipal supplies are not affected without advance warning.

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).

This section lays out specific methods to address the study objectives identified above.

The proposed methodology for each of the study objectives are discussed below:

7.1 Identify Water Right Holders

In addition to the City of Snoqualmie, BCH will identify other water rights holders that have groundwater or spring use rights in the study area that could be affected by the proposed project by obtaining records from the Washington State Department of Ecology.

7.2 Records Request to City of Snoqualmie

BCH will request records from the City of Snoqualmie of their use of the Canyon Springs water source, including daily, monthly and annual volumes of water removed; the percentage of the City's requirements that Canyon Springs represents, what the additional water sources for the City are, and projected use of the water source for the duration of the proposed project life. Water quality information will be requested for use in the water quality study, including any information on current treatment of the water prior to use as a municipal water supply. Information collected that is relevant to this and other study plans will be organized and summarized, and evaluated for use in subsequent tasks.

7.3 Estimate Aquifer Conditions

BCH will use available information to estimate aquifer conditions. Boring logs from two deep borings in the study area provide information on the soil gradation and stratigraphy. From this information, and surficial geologic mapping from earlier studies, BCH can make preliminary estimates of the aquifer parameters, including areal extent and depth of the aquifer, the porosity, hydraulic conductivity, transmissivity, storage capacity, recharge from rainfall, and how the groundwater supply fluctuates seasonally.

7.4 Geophysical Survey to Estimate Depth to Bedrock

BCH will conduct a geophysical survey in the area to estimate the depths to bedrock. Depending on site access constraints, additional geophysical surveys may be conducted up slope from Canyon Springs, at the proposed intake and powerhouse sites, and along the water conveyance tunnel alignment, to further evaluate variations in the depth to the top of the bedrock across the site. The geophysical methods to be used will be a combination of seismic refraction, electrical resistivity tomography, and multi-channel analysis of surface waves.

7.5 Evaluate Need for Wells or Piezometers

BCH will use the information obtained from Objectives 1 through 4 to evaluate the need for wells or piezometers in the vicinity of Canyon Springs. If wells or piezometers are needed, the drilling and installation will be coordinated with geotechnical studies for the facility. Geotechnical borings can be converted to wells or piezometers as deemed necessary to evaluate the groundwater levels in the vicinity of Canyon Springs. As part of any drilling program, representative samples of the outwash sands and gravels would be obtained for grain size distribution analyses. Groundwater levels would be noted at the time of drilling, and estimates of soil and bedrock hydraulic conductivity could be made by in situ slug testing (in soil) and packer tests (in bedrock) during boring advancement. Drilling through coarse gravels and cobbles down to the underlying bedrock requires specialized air rotary or sonic drilling rigs, with rock coring capabilities. The greater the desired penetration depth, the more powerful, and generally, larger the drilling rig needed. Consequently, there may be severe constraints on the locations available for drilling with the steep topography and heavy forestation in portions of the study area.

7.6 Groundwater Modeling

BCH will use groundwater modeling to evaluate the potential for seasonal shortages to the groundwater supply in the area of Canyon Springs as a result of the proposed diversion. Groundwater modeling of capacity and extraction will be conducted using the information obtained. If aquifer design parameters cannot be reliably predicted from grain size analysis, then the need for additional aquifer pumping tests will be evaluated.

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.

Additionally, BCH believes it might be helpful to develop a system for more regular progress reporting directly with the City of Snoqualmie on issues related to "Canyon Springs."

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*
File Revised Study Plan	January 7, 2013
Revised Study Plan Comments Due	January 22, 2013
Identify water rights holders in study area. Obtain and evaluate City of Snoqualmie information on "Canyon Springs" use. Estimate aquifer conditions	May 2013
Geophysical survey	August 2012
Evaluate need for wells or piezometers. If warranted, implement drilling and well installation, groundwater monitoring	July 2013
Evaluate need for groundwater modeling, wait for preliminary well information from previous	November 2013

task, conduct modeling, if warranted	
Initial Study Report filed with FERC	February 6, 2014
Initial Study Report Meeting	February 21, 2014
Initial Study Report Meeting Summary	March 10, 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 $47,650 for the initial tasks and if drilling of wells and groundwater modeling is warranted, a potential additional $160,000 may be required. Costs for full scale pump testing are not included at this time because of the wide range of costs that could be incurred depending on the test type and duration.

One mid-level hydrogeologist would be expected to review existing information, obtain information from the City of Snoqualmie, Washington State Department of Ecology, and other identified groundwater users in the study area. Geologic information will be combined with geophysical information, and cross-sections through the study area will be developed. Hydrogeologic information will be used to estimate seasonal groundwater flow and water supply conditions by a senior hydrogeologist. A senior hydraulic engineer with expertise in groundwater modeling will evaluate the potential need for groundwater modeling, the model type(s), parameters, boundary conditions, and other conditions that could be tested in a model; cost ranges of potential modeling approaches will be presented. Depending on the degree of reliability of the results, a senior hydrogeologist will evaluate whether a drilling and well installation program is required as a follow-up study. Total costs for a groundwater study are dependent on the extent of the drilling and modeling efforts, and the extent of information that might be obtained from existing sources. A breakdown by task is shown in Table 2 below.

Table 2. Level of Effort and Cost

Task	Labor and Expenses
Identify Water Rights Holders in Study Area	$1,450
Obtain and Evaluate City of Snoqualmie Information on Canyon Springs Use	$3,900
Estimate Aquifer Conditions	$9,500
Geophysical Survey	$27,200 (initial phase)
Evaluate Need for Wells or Piezometers	$2,800 (initial evaluation)

	$131,000 (potential, if needed)
Evaluate Need for Groundwater Modeling.	$2,800 (initial evaluation)
Total	$47,650 (potentially +$131,000)

11 REFERENCES

A reference list has been developed that provide sources of information that are pertinent to this study plan and that will be used in the proposed study. Relevant references include the following:

Bethel, John. 2004. An Overview of the Geology and Geomorphology of the Snoqualmie River Watershed, Prepared for King County Water and Land Resources Division Watershed Team, p. 51.

Booth, D. B. 1990. Surficial Geologic Map of the Skykomish and Snoqualmie Rivers Area, Snohomish and King Counties, Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1745, 2 sheets, scale 1:50,000, with 22 p. text.

Booth, D. B. 1986. The formation of ice-marginal embankments into ice-dammed lakes in the eastern Puget Lowland, Washington, U.S.A., during the late Pleistocene: Boreas, v. 15, no. 3, p. 209-264.

Booth, D. B. 1984. Glacier dynamics and the development of glacial landforms in the eastern Puget Lowland, Washington: University of Washington Doctor of Philosophy thesis, 217 p., 1 plate.

Booth, D. B. and Hallet, B. 1993. Channel networks carved by subglacial water: observations and reconstructions of the eastern Puget Lowland of Washington; Geological Society of America Bulletin, v. 105, p. 67-683.

Bradford, D. C.; Waters, A. C. 1934. The Tolt River earthquake and its bearing on the structure of the Cascade Range: Seismological Society of America Bulletin, v. 24, no. 2, p. 695-707.

Dragovich, J. D.; Littke, H. A.; Anderson, M. L.; Hartog, R.; Wessel, G. R.; DuFrane, A. S.; Walsh, T. J.; MacDonald Jr., J. H.; Mangano, J. F. and Cakir, R. 2009. Geologic Map of the Snoqualmie 7.5-Minute Quadrangle, King County, Washington: Washington Division of Geology and Earth Resources Geologic Map, GM-75, scale 1:24,000, 2 sheets.

Dragovich, J. D.; Logan, R. L.; Schasse, H. W.; Walsh, T. J.; Lingley Jr., W. S.; Norman, D. K.; Gertsel, W. J.; Lapen, T. J.; Schuster, J. E. and Meyers, K. D. 2002. Geologic Map of Washington – Northwest Quadrant: Washington Division of Geology and Earth Resources Geologic Map, GM-50, scale 1:250,000, 3 sheets, with 72 p. text.

Kremer, D. E. 1959. The geology of the Preston-Mt. Si area: University of Washington Master thesis, 103 p., 1 plate.

Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Whetten, J. T.; Waitt, R. B. 2000. Geologic map of the Snoqualmie Pass 30 X 60 minute quadrangle, Washington: U.S. Geological Survey Geologic Investigations Series Map I-2538, 1 sheet, scale 1:100,000, with 57 p. text. [http://geopubs.wr.usgs.gov/i-map/i2538/]

Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Whetten, J. T.; Waitt, R. B., Jr.; Zartman, R. E. 1982. Preliminary geologic map of the Skykomish River 1:100,000 Quadrangle, Washington, U.S. Geological Survey Open-File Report: 82-747, 1 sheet, scale 1:100,000, with 31 p. text.

Tabor, R. W.; Frizzell, V. A., Jr.; Booth, D. B.; Whetten, J. T.; Waitt, R. B., Jr.; Zartman, R. E. 1993. Preliminary geologic map of the Skykomish River Quadrangle, Washington, U.S. Geological Survey Miscellaneous Investigations Series Map I-1963, 1 sheet, scale 1:100,000, with 42 p. text. [http://pubs.usgs.gov/imap/i1963/skygm.pdf].

12 APPENDIX A: Groundwater Study Area