[redacted]

Wart and Pothole Wind Farm Project
(Point of Interconnection on circuit 1L251)

Interconnection Feasibility Study

Report No: T&S Planning 2016-056

July 2016

British Columbia Hydro and Power Authority

DISCLAIMER OF WARRANTY, LIMITATION OF LIABILITY

This report was prepared by the British Columbia Hydro And Power Authority ("BCH") or, as the case may be, on behalf of BCH by persons or entities including, without limitation, persons or entities who are or were employees, agents, consultants, contractors, subcontractors, professional advisers or representatives of, or to, BCH (individually and collectively, "BCH Personnel").

This report is to be read in the context of the methodology, procedures and techniques used, BCH's or BCH's Personnel's assumptions, and the circumstances and constraints under which BCH's mandate to prepare this report was performed. This report is written solely for the purpose expressly stated in this report, and for the sole and exclusive benefit of the person or entity who directly engaged BCH to prepare this report. Accordingly, this report is suitable only for such purpose, and is subject to any changes arising after the date of this report. This report is meant to be read as a whole, and accordingly no section or part of it should be read or relied upon out of context.

Unless otherwise expressly agreed by BCH:

1. any assumption, data or information (whether embodied in tangible or electronic form) supplied by, or gathered from, any source (including, without limitation, any consultant, contractor or subcontractor, testing laboratory and equipment suppliers, etc.) upon which BCH's opinion or conclusion as set out in this report is based (individually and collectively, "Information") has not been verified by BCH or BCH's Personnel; BCH makes no representation as to its accuracy or completeness and disclaims all liability with respect to the information;

2. except as expressly set out in this report, all terms, conditions, warranties, representations and statements (whether express, implied, written, oral, collateral, statutory or otherwise) are excluded to the maximum extent permitted by law and, to the extent they cannot be excluded, BCH disclaims all liability in relation to them to the maximum extent permitted by law;

3. BCH does not represent or warrant the accuracy, completeness, merchantability, fitness for purpose or usefulness of this report, or any information contained in this report, for use or consideration by any person or entity. In addition BCH does not accept any liability arising out of reliance by a person or entity on this report, or any information contained in this report, or for any errors or omissions in this report. Any use, reliance or publication by any person or entity of this report or any part of it is at their own risk; and

4. In no event will BCH or BCH's Personnel be liable to any recipient of this report for any damage, loss, cost, expense, injury or other liability that arises out of or in connection with this report including, without limitation, any indirect, special, incidental, punitive or consequential loss, liability or damage of any kind.

COPYRIGHT NOTICE

EXECUTIVE SUMMARY

[redacted]., the Interconnection Customer (IC), is proposing to develop the Wart and Pothole Wind Farm facility (WPWX) to inject energy into the BC Hydro (BCH) system. The wind project, which consists of twenty 3.0 MW Vestas – Type 4 turbines, will be located in the Nicola – Thompson area of British Columbia.

The IC proposed two separate interconnection options for this wind farm, one connected on the 138 kV line, 1L244, between Nicola substation (NIC) and West Bank substation (WBK), and the other on 1L251 between NIC and Copper Mountain Mine substations (SCO/CUM). These two interconnection options are mutually exclusive and treated as two separate interconnection projects.

This report identifies the required system modifications at a preliminary level for interconnecting the wind farm to the BCH system on 1L251 only. The Point of Interconnection (POI) is a distance of approximately 30.9 km from NIC and will be at a new (to-be-built) BCH owned three circuit-breaker station called Wart and Pothole Terminal Station (WPTY). The maximum power injection from WPWX into the BCH system at the POI is 58.0 MW and the proposed Commercial Operation Date (COD) is January 1, 2019.

The study of this WPWX project interconnection to the BCH Transmission System at the proposed POI has resulted in the following conclusions and requirements:

- A 138 kV three circuit breaker station with associated equipment is required at the POI to accommodate the WPWX project;
- No unacceptable transmission equipment overloads or unacceptable voltage conditions in the transmission system were observed in the power flow simulations due to the WPWX wind farm facility under pre-contingency (N-0) and post-contingency (N-1) steady-state scenarios;
- New line protection at WPTY terminal station and modification of existing line protection at NIC is required;
- Primary (PY) and Standby (SY) WECC Class-2 telecommunication is required between stations:
  - NIC and WPTY (1L251)
  - WPTY and WPWX (1L259);
- Islanded operation with existing BCH or FBC customers is not arranged for the Wart and Pothole Wind project. WPWX facility is required to stay offline whenever 1L251 is out-of-service. Power Quality protection (i.e. under and over voltage/frequency protection) is required at the WPWX facility.

Direct Transfer Trips (DTTs) to remove the IC's generation source may be required to minimize any potential impacts to WBK customers during the islanding conditions. Mitigation methods of the IC's transformer energization inrush current may also be needed. Both of these conditions will be studied in greater detail at the next SIS stage.

The non-binding good faith cost estimate for the above Network Upgrades necessary to interconnect the proposed combined project to the BCH Transmission System for an injection of 58.0 MW is $28,303.000 M. The estimated time to implement the identified work is up to 30-36 months.

The above estimate and schedule do not include the work associated with Revenue Metering nor does it include the work required within the IC's facilities. Within the WPWX facility, the IC is required to provide protection in accordance with "60 kV to 500 kV Technical Interconnection Requirements for Power Generators."

Additional Network Upgrade requirements may be identified in the System Impact Study (SIS) or Facilities Study (FS) stages. The Interconnection SIS and FS reports will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

Table of Contents

1.0 INTRODUCTION

The project reviewed in this Interconnection Feasibility Study report is as described in Table 1 below.

Table 1: Summary Project Information

Project Name	Wart and Pothole Wind Farm	
Interconnection Customer	[redacted]	
Point of Interconnection	Three circuit-breaker station on 1L251, 30.9 km from NIC	
IC Proposed COD	January 01, 2019	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection at POI (MW)	58.0 (Summer)	58.0 (Winter)
Number of Generator Units	20	
Plant Fuel	Wind	

[redacted]., the Interconnection Customer (IC), is proposing to develop a 60 MW wind generating facility near the Nicola – Thompson area in the South Interior region. The IC has requested two different Points of Interconnection (POIs) for their facility in two separate applications, one on 1L251 and the other on 1L244. Both projects are mutually exclusive with each other and are treated separately.

The Wart and Pothole Wind Station (WPWX) consists of a total of 20 Wind Turbine Generators (WTGs), each with a capacity of 3.0 MW. All 20 WTGs are Vestas turbines proposed with Type 4 technology, i.e. Full Converter Units. Five WTGs are allocated to individual feeders with a total of four feeders that will bring in the maximum power (60 MW) generated from all 20 turbine units to a 34.5 kV bus. From the 34.5 kV bus, the power is stepped up to the 138 kV system through an 83 MVA, 138/34.5 kV (high side Y-gnd) station transformer unit. The power will then be transmitted through an IC owned 22.6 km, 138 kV transmission line (designated as 1L259) into a new (to-be-built) BC Hydro (BCH) owned station called Wart and Pothole Terminal Station (WPTY). The WPTY switching station is the official Point of Interconnection (POI) and will be located approximately 30.9 km from Nicola Station (NIC) on 1L251 (NIC – SCO/CUM). The IC's proposed maximum injection into the BCH system at the POI, after losses, is 58.0 MW. The proposed Commercial Operation Date (COD) for this project is January 01, 2019.

Circuit 1L251 is a 99 km line which is operated at the 138 kV voltage level and built to the 230 kV standard (first 85 km section from NIC). This circuit serves the Copper Mountain Mining Corporation stations (CUM and SCO) at the end of the circuit. The contracted demand for these stations is around 65 MVA and 2.1 MVA respectively. Circuit 1L251 is also used to supply Fortis BC's (FBC's) Princeton Station (PRI) load when PRI has lost its normal supply. During this condition, 1L251 can be used to supply up to 40 MW of FBC peak load which comprises predominantly of residential with some commercial and industrial loads. 1L251 is energized up to the Normally Open (N.O.) PRI-CB2 circuit breaker which, using

operator action, is closed when required. At NIC, Transformers T5 and T6 (230/138/12.6 kV, 300 MVA) are equipped with on-load tap changers that regulate the NIC 138 kV bus. The WPWX wind farm is expected to have acceptable voltage control which should not affect the voltage regulation for NIC 138 kV.

Appendix A illustrates the Nicola - Thompson electrical system with the proposed IC connection as well as higher queued projects in the area.

2.0 STUDY PURPOSE AND SCOPE

The Feasibility Study is a preliminary evaluation of the system impact and cost of interconnecting the proposed project to the BCH Transmission System. The study scope is restricted to power flow and short circuit analysis and investigates potential system constraints associated with the interconnection of the proposed project.

3.0 TERMS OF REFERENCE

This study investigates voltage and overloading issues of the transmission networks in the vicinity as a result of the proposed interconnection. BCH planning methodology and criteria in compliance with the North America Reliability Corporation (NERC) Mandatory Reliability Standards are used in the studies.

The Feasibility Study does not include stability analysis, harmonic mitigation, or electro-magnetic transient analysis. Operating restrictions and other factors for possible second contingency outages are also not studied at this stage. Subsequent system impact/facilities studies and internal network studies will determine the requirements for reinforcements or operating restrictions/instructions for the above mentioned types of events.

4.0 STUDY ASSUMPTIONS

The study is carried out based on the latest data and information submitted by the IC in April 2016 and the latest BC Hydro Interconnection Queue information. Reasonable assumptions are made to complete the study and the report, whenever such information is unavailable.
The power flow conditions studied include generation, transmission facilities, and load forecasts representing the queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. The 2019 winter and summer system configurations were selected for this study.

The following assumptions were applied to the feasibility study base cases:

- Existing generation and higher priority queued projects in the Nicola - Thompson area such as Pennask and Shinnish Wind project (PSW) and Mount Mabel Wind project (MMWX) are included in the study.
- Copper Mountain Mining Corporation loads are assumed to be offloaded (i.e. offline) whenever the NIC 1L251 terminal is opened and cannot be served from FBC's PRI station.

Appendix B contains the power flow single line drawing reflecting the electrical orientation of the project within the BCH system. Appendix C provides other study assumptions.

5.0 STUDY RESULTS AND REQUIRED UPGRADES

A new BCH owned three circuit breaker ring configuration station at the POI, named Wart and Pothole Terminal Station (WPTY), is required to be built to accommodate the WPWX wind farm facility. With the addition of the new WPTY switching station, circuit 1L251 NIC-CUM will be sectionalized into two 138 kV lines, one between NIC and WPTY which will still be designated as 1L251 and one between WPTY and CUM which will be designated as 1L260. The need for the new switching station and segmenting of circuit 1L251 is based on the long line tap (22.6 km) and size of generation injection (60 MW). The addition of the new station will be able to maintain system reliability to serve all BCH and FBC customers in the area.

The BC Hydro Stations summary of work is as follows:

- Design, supply, install and commission a new 138 kV switching station;
- Station initially to be built in a 2000 A rated, three breaker ring configuration. Provision will be made to expand the ring by one breaker;
- Incomer disconnect switches must be rated for 230 kV. Incomer transmission tower for lines 1L251 and 1L260 must be designed for 230 kV with shielding.

The following protection work is required at BCH stations:

- Primary (PY) and Standby (SY) WECC Class-2 telecom circuits are required between stations:
  - NIC and WPTY (1L251);
  - WPTY and WPWX (1L259);
- New line protection is required at WPTY terminal station. Protection modifications are required at NIC.

There are no pre-contingency or single contingency (N-1) steady-state transmission equipment over-loading problems or voltage violation conditions identified for the proposed maximum power injection from Wart and Pothole Wind project into the BCH system. Thus, there are no further upgrades of transmission elements elsewhere required at this study stage.

At the WPWX facility, the IC is required to provide entrance protection, power quality protection, and redundant protection for the IC's line, 1L259, in accordance with BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators." Also required at WPWX are 138 kV Voltage Transformers (VTs) for power quality protection (i.e. under and over voltage/frequency protection).

Islanded operation is not allowed for the WPWX project. When circuit 1L251 is out-of-service, WPWX is required to be offline in order that it does not supply existing BCH and FBC customers. Islanding conditions can occur when circuit 1L251 is lost for protective or non-protective tripping of its terminal breakers at NIC or WPTY. In addition to power quality protection, Direct Transfer Trips (DTTs) may likely also be needed and will be studied in greater detail at the next SIS stage.

Mitigation of the IC's transformer energization inrush current will be required to avoid potential voltage sag and power quality impacts on other BCH and FBC customers. At the next SIS stage, BCH will review and provide comments on the IC's proposed solution/configuration to meet the PQ requirements.

At this study stage, there are no Remedial Action Schemes (RAS) or special protection and control facilities specified to address or mitigate potential problems that may be identified as a result of future stage studies.

6.0 COST ESTIMATE AND PROJECT SCHEDULE

Table 2 identifies facilities and system upgrades required in the BCH system to interconnect the proposed project to the system. It also provides a non-binding good faith cost estimate for these upgrades that would be the responsibility of the IC. The cost estimate or the project schedule does not include any of the work on Revenue Metering.

Table 2: Cost Estimate for the Required System Upgrades

Work Definition	**Facilities**	Estimated Cost
Stations, P&C, and Telecommunication	Build a new 138 kV three circuit breaker station. Addition, modification, and review of existing protection settings at various sites with associated upgrades.	
	Estimated Interconnection Network Upgrade Cost:	**$30.1M**

The estimated time to implement the Network Upgrades required to interconnect the project to the BCH system is indicated in Table 3 below. This estimate assumes subsequent study work has been completed and a Standard Generator Interconnection Agreement has been executed.

Table 3: Estimated Project Schedule

0 - 6 months	☐	36 - 42 months	☐
6 -12 months	☐	42 -48 months	☐
12- 18 months	☐	48- 54 months	☐
18 - 24 months	☐	54 - 60 months	☐
24 – 30 months	☐	60 – 66 months	☐
30 - 36 months	☒	66 – 72 months	☐

7.0 CONCLUSIONS & DISCUSSION

The interconnection of this project to the BCH Transmission System at the proposed POI, WPTY, has resulted in the following conclusions and requirements:

- A 138 kV three circuit breaker station with associated equipment is required at the POI to accommodate the WPWX project;
- No unacceptable transmission equipment overloads or unacceptable voltage conditions in the transmission system were observed in the power flow simulations due to the WPWX wind farm facility under pre-contingency (N-0) and post-contingency (N-1) steady-state scenarios;
- New line protection at WPTY terminal station and modification of existing line protection at NIC is required;
- Primary (PY) and Standby (SY) WECC Class-2 telecommunication is required between stations:
  - NIC and WPTY (1L251)
  - WPTY and WPWX (1L259);
- Islanded operation with existing BCH or FBC customers is not arranged for the Wart and Pothole Wind project. WPWX facility is required to stay offline whenever 1L251 is out-of-service and cannot be used to serve FBC customers when the source at NIC terminal is lost.

Direct Transfer Trips (DTTs) to remove the IC's generation source may be required to minimize any potential impacts to WBK customers during the islanding conditions. Mitigation methods of the IC's transformer energization inrush current may also be needed. Both of these conditions will be studied in greater detail at the next SIS stage.

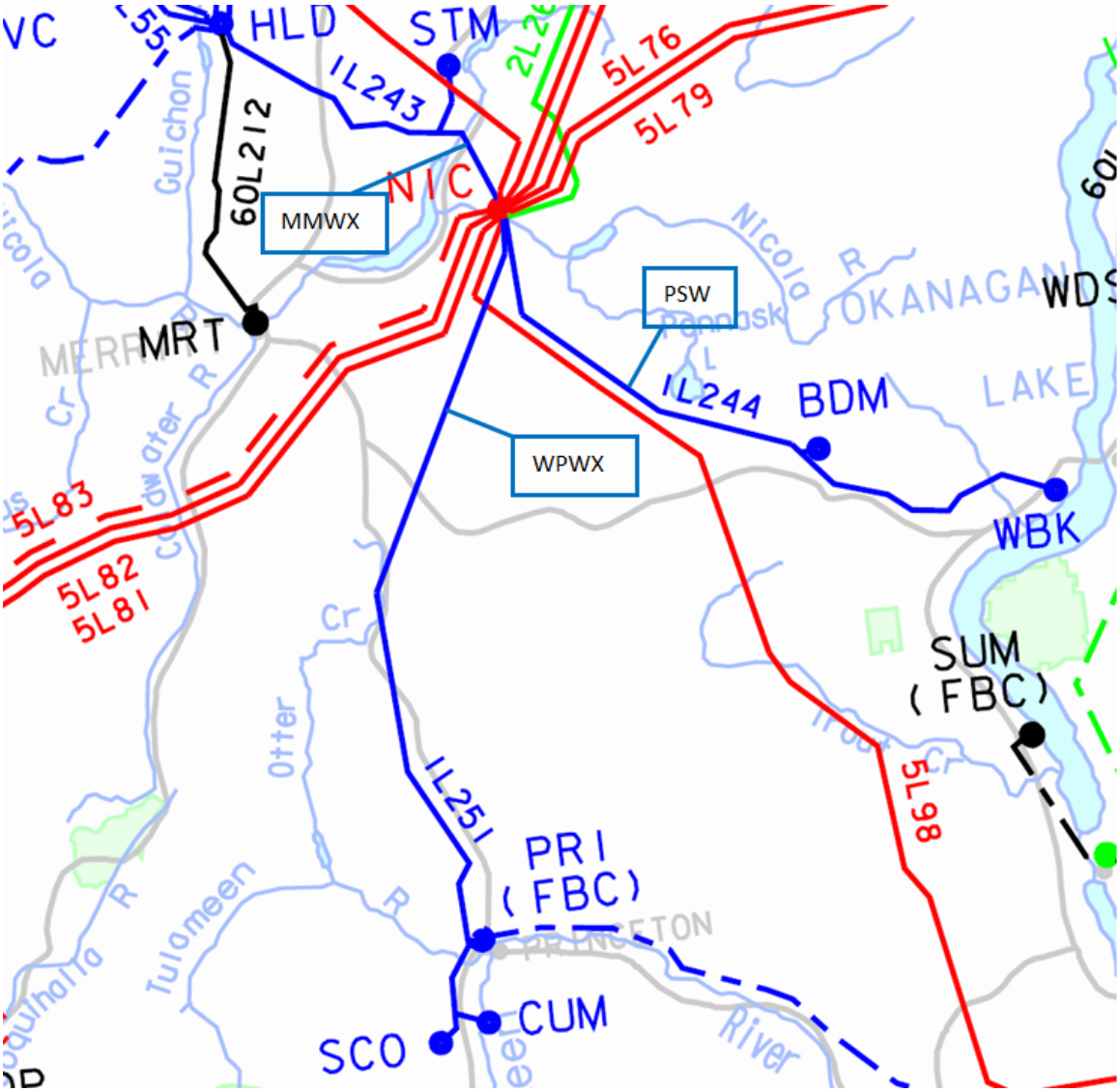
The IC is required to provide entrance protection and redundant protection for the IC's line, 1L259, in accordance with BC Hydro's "60 kV to 500 kV Technical Interconnection Requirements for Power Generators." At the WPWX facility, 138 kV Voltage Transformers (VTs) are required for power quality protection.

Please note that the above conclusions are based on the steady state power flow study results. Other system performance measures such as transient stability, transient overvoltage, etc., have yet to be

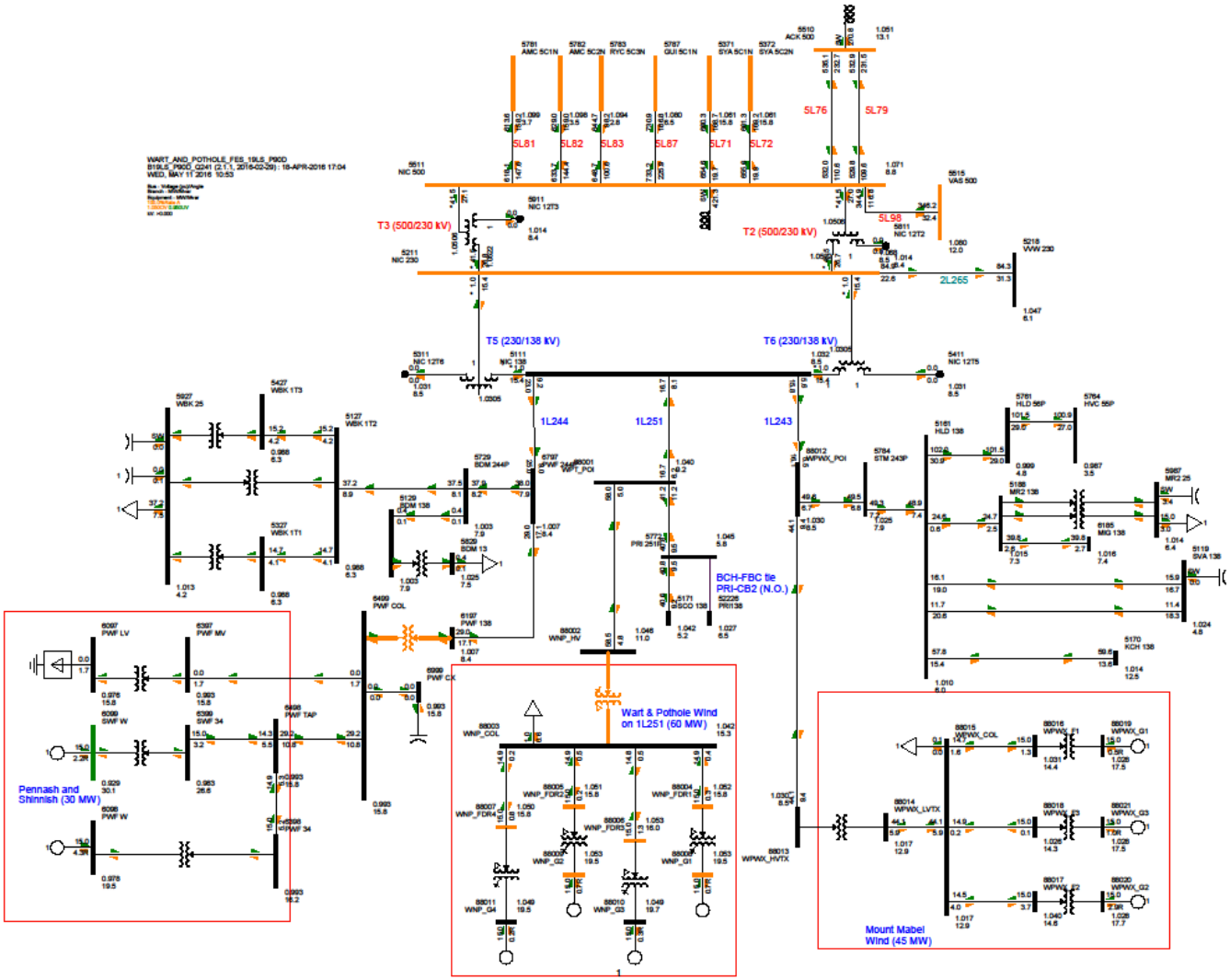
determined. Those issues will be dealt with in the System Impact Study stage and may indicate the need for additional network upgrades. This study does not include stability analysis, harmonic mitigation, electro-magnetic transient analysis, and other analytical studies or calculations or site visits. Equipment that may be determined during future stage studies is not included in the cost estimate nor considered in the estimated schedule provided herein.

Additional Network Upgrade requirements may be identified in the System Impact Study (SIS) or Facilities Study (FS) stages. The Interconnection SIS and FS reports will provide greater details of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

APPENDIX A – PROJECT LOCATION MAP



APPENDIX B – SINGLE LINE DIAGRAM



APPENDIX C – OTHER ASSUMPTIONS

Assumptions related to the BCH transmission system:

Power Flow

Power flow study is based upon the base case that includes generation, transmission facilities, and load forecast representing the queue position of the project applicable to the study of this project. Applicable seasonal conditions and the appropriate number of study years for the study horizon have also been incorporated.

Short Circuit

Short circuit study is based upon the complete short circuit model of BC Hydro System including contributions from the interconnecting utilities and private power generators. The model not only includes the existing facilities but also all those under construction.

Financial and Estimating Assumptions

Cost estimates are based on an order of magnitude assumption and are non-binding and provided in good faith. The cost estimate included in this report does not and cannot account for a variety of issues not under the control of BCH including, but not limited to:

- The impact of additional equipment required as the result of more detailed studies;
- Actual equipment specified during engineering design;
- Fluctuations in costs over time;
- First Nation considerations;
- Property-related costs and issues;
- Any Certificate of Public Convenience and Necessity (CPCN) required from the British Columbia Utilities Commission (BCUC);
- Physical space constraints in network facilities.

