Interconnection System Impact Study

[redacted]
Septimus Creek Wind Project

Report No: T&S Planning 2014-068

November 2014

[redacted]

British Columbia Hydro and Power Authority

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This report was prepared and reviewed by T&D, Interconnection Planning and approved by both Interconnection Planning and Transmission Generator Interconnections.

Revision Table

Revision Number	Date of Revision	Revised By

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EXECUTIVE SUMMARY

[redacted] the Interconnection Customer (IC), is proposing Septimus Creek wind farm (SCW) in the Peace River region of British Columbia. The wind project consists of 7 wind turbines each rated at 2.05 MW. The Point-of-Interconnection (POI) is on the 138 kV circuit 1L377 between Taylor (TAY) and Dawson (DAW) substations, 9.5 km from TAY. The Commercial Operation Date (COD) proposed by the IC is June 2 2015.

This report documents the evaluation of the system impact of interconnecting the proposed generation facilities and identifies the required system modifications to obtain acceptable system performance with the interconnection of the subject project. To interconnect the IC's project and its facilities to the BCH Transmission System, this System Impact Study (SIS) has identified the following conclusions and requirements:

- There are no unacceptable pre-contingency or single contingency (N-1) steady-state overloads or voltage conditions observed for the proposed maximum power injection from SCW. Hence, no transmission element would need to be upgraded.
- In order to connect SCW to the Transmission System using a tap on 1L377, the line protection for 1L377 needs to be replaced with a telecommunication assisted scheme. A new microwave backbone system in the area is being implemented in a separate project (Pease Region Load Shedding RAS, or PRLS) and the scheduled in service date of the new microwave system is early 2016.
- Septimus Wind will need to establish a frequency-diversity microwave link to the new microwave system. Because of this dependency, the IC's proposed in-service date of June 2015 is not achievable.
- A transfer trip from TAY to the SCW 138 kV circuit breaker will be needed to isolate the wind farm when 1L377 is disconnected from the system due to protective and non-protective tripping. Equipment addition and replacement will be required at TAY and DAW substations.
- The existing 1L377 line terminal Surge Arrester at DAW will need to be replaced with a 132 kV rated SA IEC class 3.

The good faith non-binding cost estimate to complete the BC Hydro's Network Upgrades required for Septimus connection is $3.09 million. The Interconnection Facilities Study report will provide greater details of the necessary requirements and estimated timeline for the interconnection project. Because this project depends on the completion of a new microwave system from the PRLS project, the Septimus Wind proposed COD will need to be re-scheduled to the 2nd half of 2016.

The work required within the IC facilities is not part of this estimate and schedule.

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1.0 INTRODUCTION

[redacted] is proposing to develop a wind farm at Septimus Creek in the Peace River region. Septimus Creek wind farm consists of seven Senvion wind turbines. The total output from these wind turbines is 14.35 MW. The generated power will flow along an IC built, 26.3 km 34.5 kV feeder to an IC built station named Septimus Creek Wind (SCW). Two mechanically switched capacitor banks each rated at 2.6 Mvar provide additional reactive support on the 34.5 kV side of SCW. Voltage at SCW will be stepped up from 34.5 kV to 138 kV. An IC built 138 kV overhead transmission line, 0.5 km long, connects SCW to the Point-of-Interconnection (POI) on the 138 kV circuit 1L377 between Taylor (TAY) and Dawson (DAW) substations.

The POI is a tap point on 1L377, 9.5 km from TAY and 46 km from DAW.

Table 1 below provides a summary of the project:

Table 1: Septimus Wind -- Project Information Summary

Project Name	Septimus Creek Wind Project	
Interconnection Customer (IC)	[redacted]	
Point of Interconnection (POI)	A tap on 1L377, 9.5 km from TAY	
IC Proposed COD	June 2 2015	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)*	13.5 (Summer)	13.5 (Winter)
Number of Generator Units	7	
Plant Fuel	wind	

* *Note: The total capacity of the wind turbines is 14.35 MW. After accounting for losses inside the wind farm, only 13.5 MW is available for injection into the grid.*

The following diagram illustrates the configuration of the Septimus Wind farm.

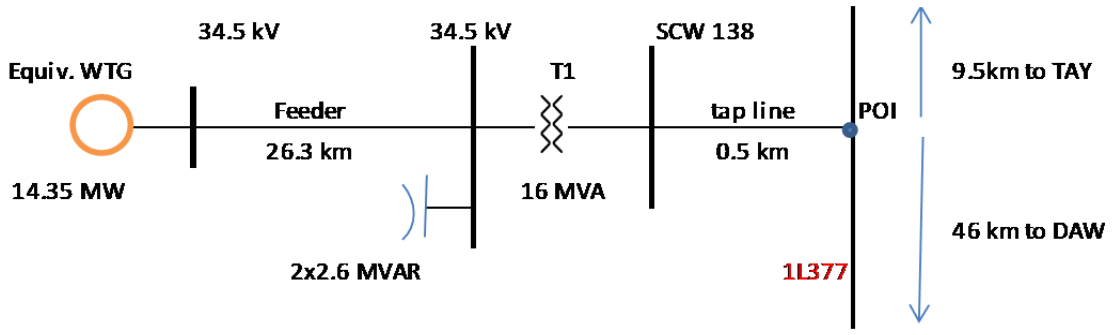


Figure 1: Sketch of Septimus Creek Wind Farm

Septimus Wind Farm is located in the Peace River region in northern British Columbia, a dynamic area with many new load interconnections plus a number of wind generation additions. The Dawson Creek and Groundbirch areas are experiencing rapid load growth. Most of these new loads are industrial loads and require transmission system reinforcements in order to be served.

A regional transmission reinforcement project, referred to as Dawson Creek Area Transmission project (DCAT), is planned to provide supply capacity from the 230 kV system originated from Gordon M Shrum generating station (GMS) to the 138 kV system. The project is currently in the implementation phase. The proposed DCAT project includes a new substation Sundance Lakes (SLS) which is situated at the intersection of the existing 138 kV line 1L358 (between Chetwynd or CWD substation and Bear Mountain Terminal or BMT) and 230 kV line 2L312 (between Sukunka or SNK, and Louisianna Pacific or LAP substations), two 60 km 230 kV lines from SLS to BMT, and a 12 km double circuit 230 kV line from BMT to DAW operated at the 138 kV level. The two existing 138 kV lines, 1L358 (section from SLS – BMT) and 1L362 (BMT – DAW) will be decommissioned. Refer to Figure 2 below.

In addition to the DCAT project, load shedding is also required for certain contingent scenarios. Peace Region Load Shedding RAS, or PRLS, is the project to address violations caused by outages of key regional transmission system elements. As part of the PRLS project, a new microwave system and repeater stations will be installed for the area. This microwave system will provide a foundation to facilitate the Septimus Creek Wind interconnection via a simple line tap. However, the scheduled in-service date of the microwave system is in early 2016, which will affect the proposed Septimus Creek Wind COD. Refer to Section 5.7 for more details. The figure below shows the geographic location of Septimus Creek Wind IPP in the Peace River region.

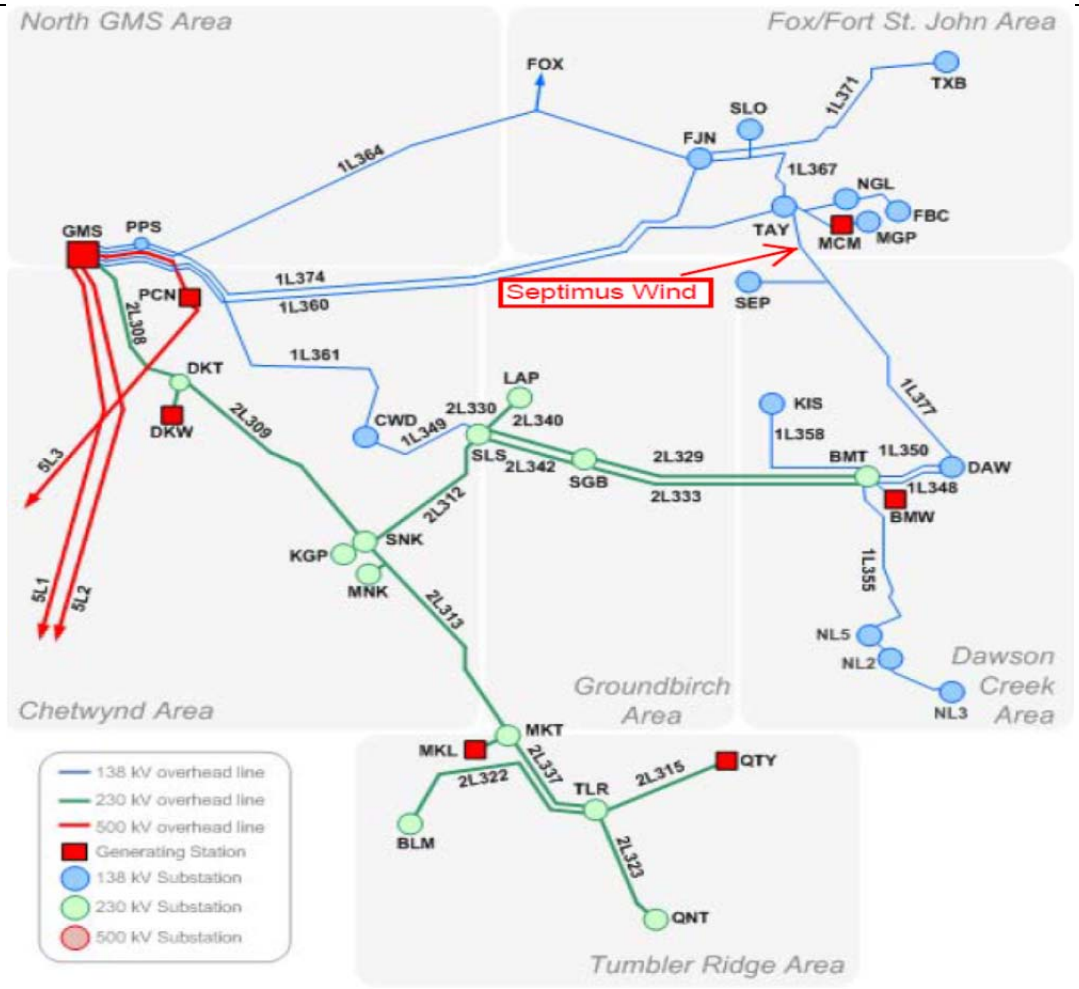


Figure 2: Peace River region Transmission System with DCAT and Septimus Creek Wind Project

2.0 PURPOSE OF STUDY

The purpose of this study is to assess the impact on the BCH Transmission System due to the connection of the Septimus Creek Wind Farm. This study will identify constraints and Network Upgrades required for interconnecting the wind farm such that its performance is compliant with the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) reliability standards, and the BCH transmission planning criteria.

3.0 TERMS OF REFERENCE

This study investigates and addresses the overloading, voltage deviation and stability issues of the transmission network in the Peace River region as a result of integrating Septimus Creek wind farm. Topics studied include equipment thermal loading and rating requirements, system transient stability and voltage stability, transient over-voltages, protection coordination, operating flexibility, telecom

requirements and high level requirements for Remedial Action Schemes (RAS). BCH planning methodology and criteria are used in the studies.

The SIS does not investigate operating restrictions and other factors for possible second contingency outages. Subsequent BC Hydro system studies will determine the requirements for reinforcements or operating restrictions/instructions for those kinds of events. Any use of firm or non-firm transmission delivery will require further analysis specific to the transmission service that may be requested later and will be reviewed in a separate study. Determination of any upgrades on the IC's facilities is beyond the SIS scope.

The work necessary to implement the network improvements identified in this SIS report will be described in greater detail in the Interconnection Facilities Study report for this project.

4.0 ASSUMPTIONS

The study was carried out based on the model, data and information submitted by the IC in March 2014 for the System Impact Study. Reasonable assumptions are made to complete the study whenever such information is unavailable.

The BCH 2015, 2016 and 2017 transmission system with summer and winter load/generation conditions were selected in the studies.

The following assumptions are used in this System Impact Study:

- Generation in the area is set to Maximum Continuous Rating (MCR) levels in the Peace River region as listed in Table 2 below:

Table 2: Generation Level

Generation levels		
	Plant	MCR (MW)
1	Dokie Wind	144
2	McMahon Gas	105
3	Bear Mountain Wind	102
4	Quality Wind	142
5	Meikle Wind	186

- Peace Region Electricity Supply (PRES), formerly known as GMS Dawson Creek Area Transmission (GDAT) project was not included as it is still in the early planning stage.

- Site C project has a higher priority in the BCH interconnection queue but is uncertain. The Septimus Wind Farm study is carried out without Site C for conservative study purpose.

- Dawson Creek Area Transmission (DCAT) reinforcements are included in the bases cases used for Septimus Wind Project study.

- New microwave system and repeater stations will be built under the PRLS project. The scheduled in-service date for these new telecommunication facilities is early 2016. An assumption is made that Septimus COD can be postponed to the second half of 2016, after the new microwave system is in service.

5.0 SYSTEM STUDIES AND RESULTS

Power flow, short circuit, and transient stability studies were carried out to evaluate the impact of the proposed interconnection. Studies were also performed to determine the protection, control and communication requirements and to evaluate possible over-voltage issues.

5.1 Steady State Power Flow Studies

In the power flow analysis, equipment loading and voltage conditions in the Transmission System were investigated under system normal and single contingency conditions. Steady state voltage profiles in the nearby area of Septimus Creek were found to be within acceptable limits under various system load condition. Load flow results for the system light load and heavy load conditions are presented in Tables 3 below. An area single-line diagram for the Peace River region with Septimus Wind Project connected is shown in Appendix A.

Table 3: System Normal and Single Contingency Load Flow Results
With 13.5 MW Injections from Septimus Creek Wind project

System Load Condition	Contingency	Bus Voltage (in per unit)			MVA Flow			
		TAY 138 kV	SCW 138 kV	DAW 138 kV	1L377 @ TAY	1L377 @ DAW	1L367 @ TAY	1L360 @ TAY
2015 HW	System Normal	1.00	0.99	1.00	28	42	78	24
	Loss of 1L367	0.99	0.99	1.00	9	12	-	34
	Loss of 1L360	0.99	0.99	1.00	33	48	67	-
2015 HS	System Normal	1.01	1.01	1.01	8	19	52	21
	Loss of 1L367	1.00	1.00	1.01	17	12	-	25
	Loss of 1L360	1.00	1.00	1.01	9	25	45	-
2015 LS	System Normal	1.01	1.01	1.01	17	26	56	19
	Loss of 1L367	1.00	1.00	1.01	11	12	-	33
	Loss of 1L360	1.00	1.00	1.01	13	27	57	-
2017 HW	System Normal	0.99	0.99	1.00	31	47	81	25
	Loss of 1L367	0.99	0.99	1.00	31	47	81	25
	Loss of 1L360	0.98	0.98	1.00	36	54	69	-
2017 HS	System Normal	1.00	1.00	1.01	31	48	67	20
	Loss of 1L367	0.99	0.99	1.01	2	21	-	37
	Loss of 1L360	0.99	0.99	1.01	33	52	62	-
2017 LS	System Normal	1.00	1.00	1.01	-34	53	67	19
	Loss of 1L367	0.99	0.99	1.01	4	27	-	42
	Loss of 1L360	0.99	0.99	1.01	32	53	68	-

Note: 'HW', 'HS' and 'LS' stand for heavy winter, heavy summer and light summer, respectively
Summer continuous rating of 1L360 is 133.8 MVA and winter continuous rating is 161.3 MVA
Summer continuous rating of 1L367 is 124.3 MVA and winter continuous rating is 155.4 MVA
Summer continuous rating of 1L377 is 124.3 MVA and winter continuous rating is 155.4 MVA

5.2 Transient Stability Study

Transient stability studies have been performed using the 2015 and 2017 light summer base cases to assess the impact of 14.35 MW maximum power injections from Septimus Creek Wind Project on the transmission network.

No transient instability phenomenon and transient voltage violations were observed based on the studied scenarios and contingencies. The following table shows the summary of the transient stability studies performed:

Table 4: Transient Stability Study Results
(Pre-outage condition: 2017 LS with 13.5 MW Injections from Septimus Creek Wind project)

Case	Outage	3Φ Fault Location	Fault Clearing Time (Cycles)		Min. Transient Voltage			IPP Low Voltage Ride Through Performance
			Close End	Far End	TAY 138 kV	FJN 138 kV	DAW 138 kV	
1	1L350 (DAW – BMT)	Close to BMT	BMT 8	DAW 9	>1.0	>1.0	>1.0	Acceptable
2	1L348 (DAW – BMT)	Close to DAW	DAW 8	BMT 9	>1.0	>1.0	>1.0	Acceptable
3	1L360 (GMS – TAY)	Close to GMS	GMS 8	TAY 9	0.97	0.98	>1.0	Acceptable
4	1L360 (GMS – TAY)	Close to TAY	TAY 8	GMS 41	>1.0	>1.0	>1.0	Acceptable
5	1L367 (TAY – FJN)	Close to TAY	TAY 8	FJN 26	>1.0	>1.0	>1.0	Acceptable
6	1L367 (TAY – FJN)	Close to FJN	FJN 8	TAY 14	0.86	>1.0	0.95	Acceptable
7	1L375 (TAY – MGP)	Close to NGL	TAY 8	NGL/FBC 26	>1.0	>1.0	>1.0	Acceptable

5.3 Fault Analysis

The short circuit analysis for the System Impact Study is based upon the latest BCH system model, which includes project equipment and impedances provided by the IC. The model included higher queued projects and planned system reinforcements but excluded lower queued projects. Thevenin impedances, including the ultimate fault levels at POI, are not included in this report but will be made available to the IC upon request.

BCH will work with the IC to provide accurate data as required during the project design phase.

5.4 Analytical Studies

An EMTP-RV study was performed using detailed WTG model provided by the wind turbine manufacturer Senvion Canada. Base on high voltage star grounded configuration in the SCW power transformer and a line tap connection on 1L377 for SCW, the observed study results confirm the wind farms expected behavior is in line with BCH's requirements in "60 kV -500 kV Technical Interconnection Requirements (TIR) for Power Generators". The proposed tap connection is acceptable. In addition, new station equipment and protection modifications are also identified in this EMTP-RV study and specified in Sections 5.6 and 5.7.

5.5 Transmission Line Upgrades

No transmission line upgrade has been identified.

A tap structure will be constructed on 1L377 to serve as the POI for Septimus Wind. A 138 kV non-load break switch will be installed on the tap line between the POI and SCW 138 kV station.

5.6 BCH Station Upgrades or Additions

In conjunction with 1L377 line protection replacement, the following station works are identified for the Dawson Creek substation:

- Replacement of the existing 144kV surge arrestor (1SA16) with a 132kV rated surge arrestor IEC class 3;
- Addition of one isolating disconnect switch (1DS16) to 1SA16 to allow for a quick line restoration in case of SA operation in failure mode.

5.7 Protection & Control and Telecommunications

Protection Requirements

The following protection requirement has been identified for Septimus wind farm connection using a tap on 1L377:

- Replace 1L377 Primary (PY) and Secondary (SY) protection with two SEL-411L relays at TAY.
- Replace 1L377 PY and SY protection with two SEL-411L relays at DAW.
- Septimus Wind should provide two SEL-411L relays (with the same part number and firmware as the BCH ends) as PY and SY PN for 1L377. BCH will provide part number and core settings.
- Implement Transfer Trip to SCW for 1L377 protective and non-protective tripping. The DTT will be transferred to IC's SCW station from TAY via the line protection relays.

Control Requirements

The IC is required to provide telemetry, status and meteorological information via a DNP3 RTU/IED to the BC Hydro Control Centres per the BC Hydro's TIR. Broadband satellite communications is also an acceptable option.

In association with the 1L377 line protection replacement, some minor control work is required at Taylor and Dawson substations.

Telecommunication Requirements:

To make Septimus connection economically feasible, installing fibre optic cables along 1L377 to serve as the telecommunication facility has been ruled out because of high costs and long implementation time. The new microwave system that is being constructed under PRLS project is planned to be in service in early 2016, and will be relied on to provide the telecommunication backbone. Hence, the Septimus wind project COD will need to be coordinated with the schedule for the new microwave system addition.

The telecommunication requirement for Septimus Wind is to construct a frequency-diversity microwave link between Septimus Wind and a proposed microwave tower at Fort Saint John substation (FJN) or TAY. The Septimus microwave tower should be strategically located and has adequate height to assure that there is a line-of-sight radio path to available microwave antenna positions at both FJN and TAY.

5.8 Islanding

Islanded operation is not arranged for Septimus Wind Farm. Direct transfer trips (DTT) will be utilized to disconnect Septimus Wind farm should an islanding scenario is detected. The back-up to the DTT are the wind farm's local protection which should enable the wind farm to disconnect itself from the system when an islanded condition is detected.

5.9 Black Start Capability

BCH does not require the proposed Septimus Wind farm to have black start (self-start) capability.

However, if the IC desires their facilities to be energized from the BCH system, the IC is required to apply for an Electricity Supply Agreement.

5.10 Cost Estimate and Schedule

The cost estimate for implementing the identified Network Upgrades is $3.09 million. The estimated time to implement the upgrades is up to 20 months after receiving approval of implementation funding and necessary outages. Because this project depends on the completion of a new microwave system from the PRLS project, Septimus Wind COD for will need to be re-scheduled to the 2nd half of 2016.

This estimate does not include any costs associated with Revenue Metering. Work required in any of the ICs sites is not a part of this estimate and schedule.

6.0 REVENUE METERING

Measurement Canada (MC) approved and sealed Revenue Class meters will be supplied by BCH and installed at the IC's generating site at Septimus Creek. The main point of metering (POM) is to be located in the high side of the main power transformer inside the IC's 138 kV station SCW. Additional points-of-metering is required at Septimus Creek generation site.

The IC is responsible for securing the real estate for the main point of metering. The IC is also responsible for supplying auxiliary power and telecom for revenue metering use. Metering equipment including CTs and VTs and the location of the POM are subjected to approval by BC Hydro's Revenue Metering department. The IC is responsible for the maintenance of the CTs and VTs, and BC Hydro is responsible for the meters. Please refer to Appendix E for more detailed information.

The IC is encouraged to contact BCH Hydro Metering Department for more detailed information and requirements. metering.revenue@bchydro.com

7.0 CONCLUSIONS & DISCUSSION

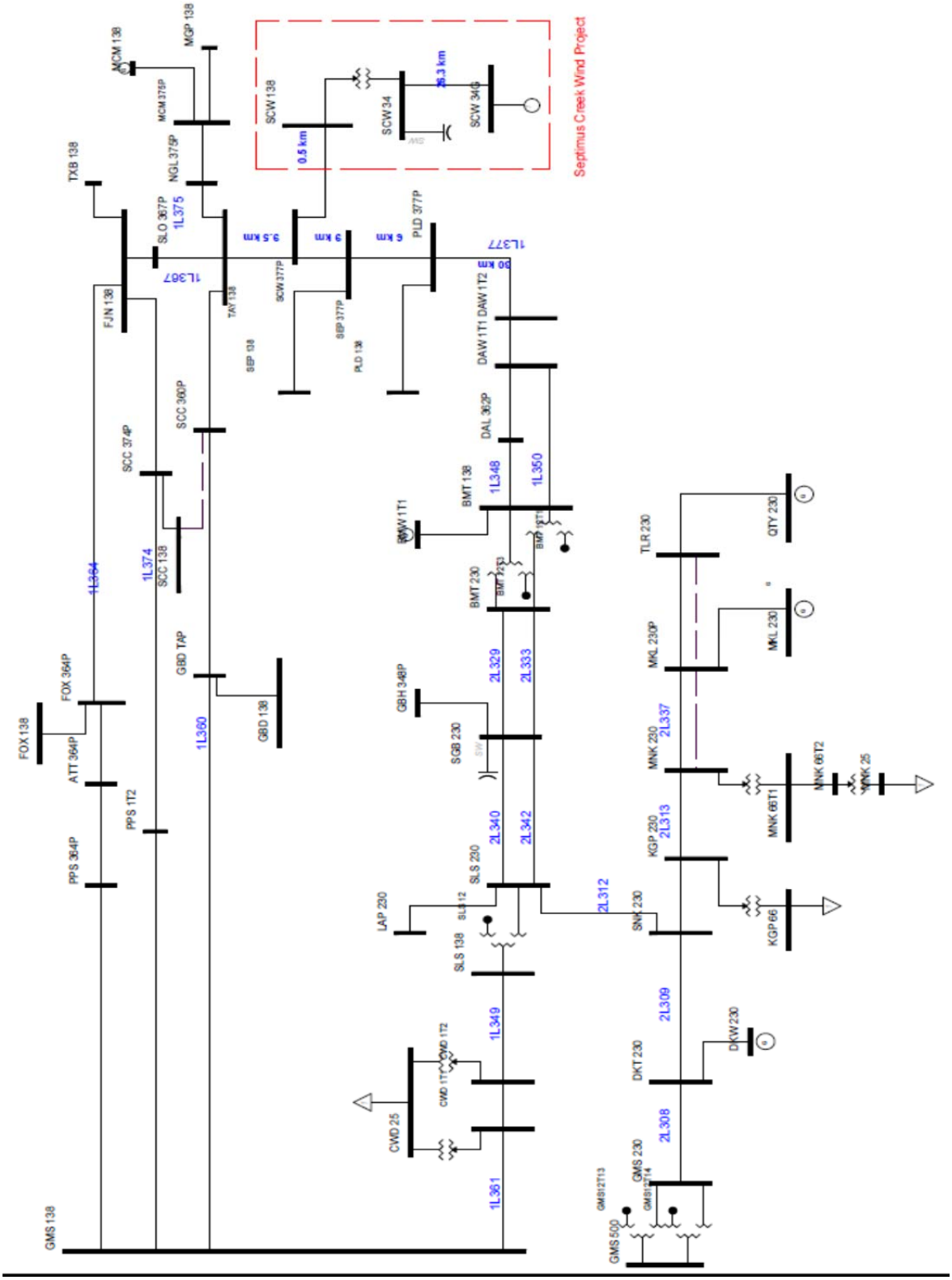
In power follow and transient stability studies, Septimus Wind Farm is not observed to cause any equipment overload, voltage violation and instability concerns. No transmission element upgrade has been identified.

To allow for a line tap on 1L377 as the POI for Septimus Wind, existing 1L377 line protection will need to be replaced with telecom assisted protection. New telecommunication facility will be required to support the new line protection scheme.

To make this project economically feasible, the new microwave system being implemented in PRLS project will be used as the telecommunication foundation for Septimus Wind project. However, this will impact the proposed Septimus COD of June 2 1015 due to the fact that the new microwave system and repeater stations will not be ready until early 2016. Consequently, a realistic COD for Septimus Wind will be in the 2nd half of 2016.

Although a non-microwave option could be used to provide the needed telecommunication facility when replacing 1L377 line protection, the expected high costs and long implementation time render the option un-practical for the Septimus Wind project. Aligning Septimus Wind COD with the in service date of the new microwave system is most economically feasible and therefor recommended.

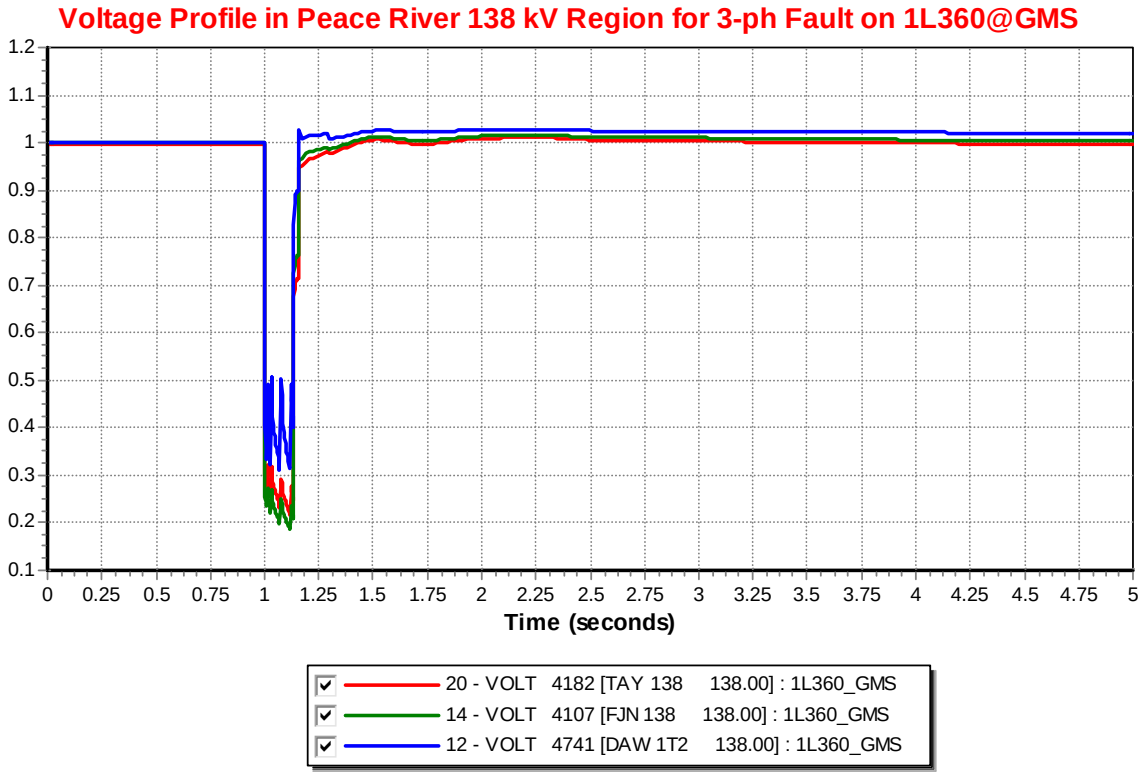
APPENDIX A – Area Single-line Diagram

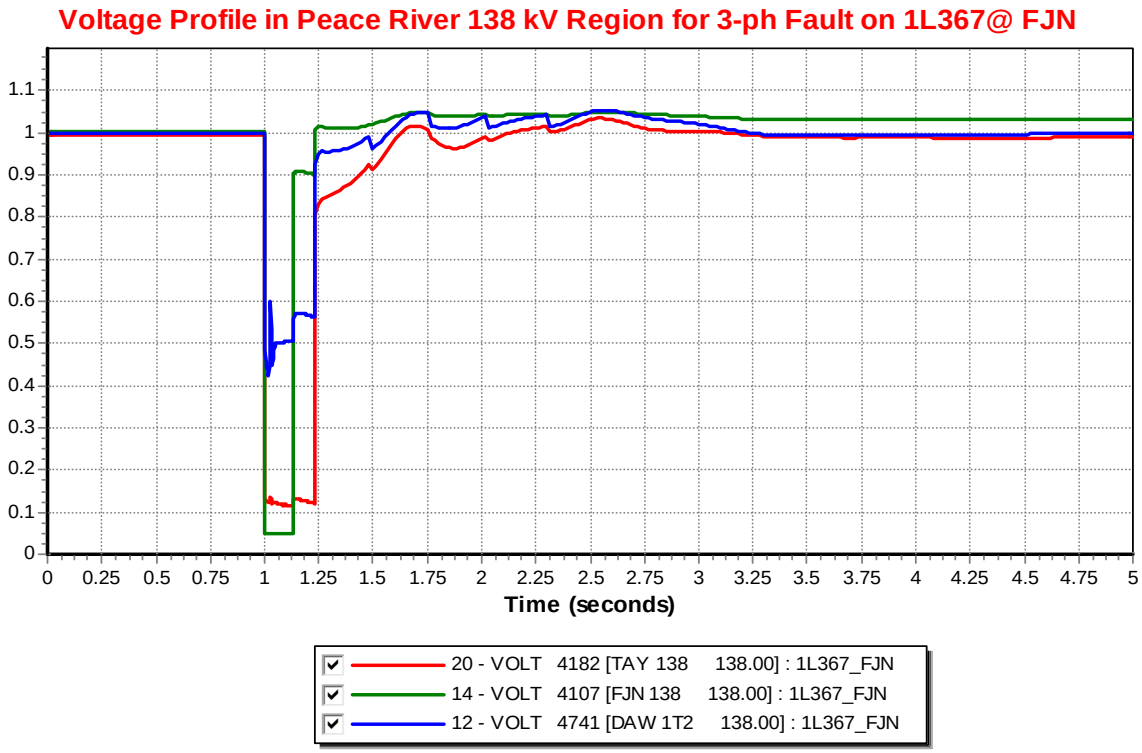


APPENDIX B – Dynamics Data

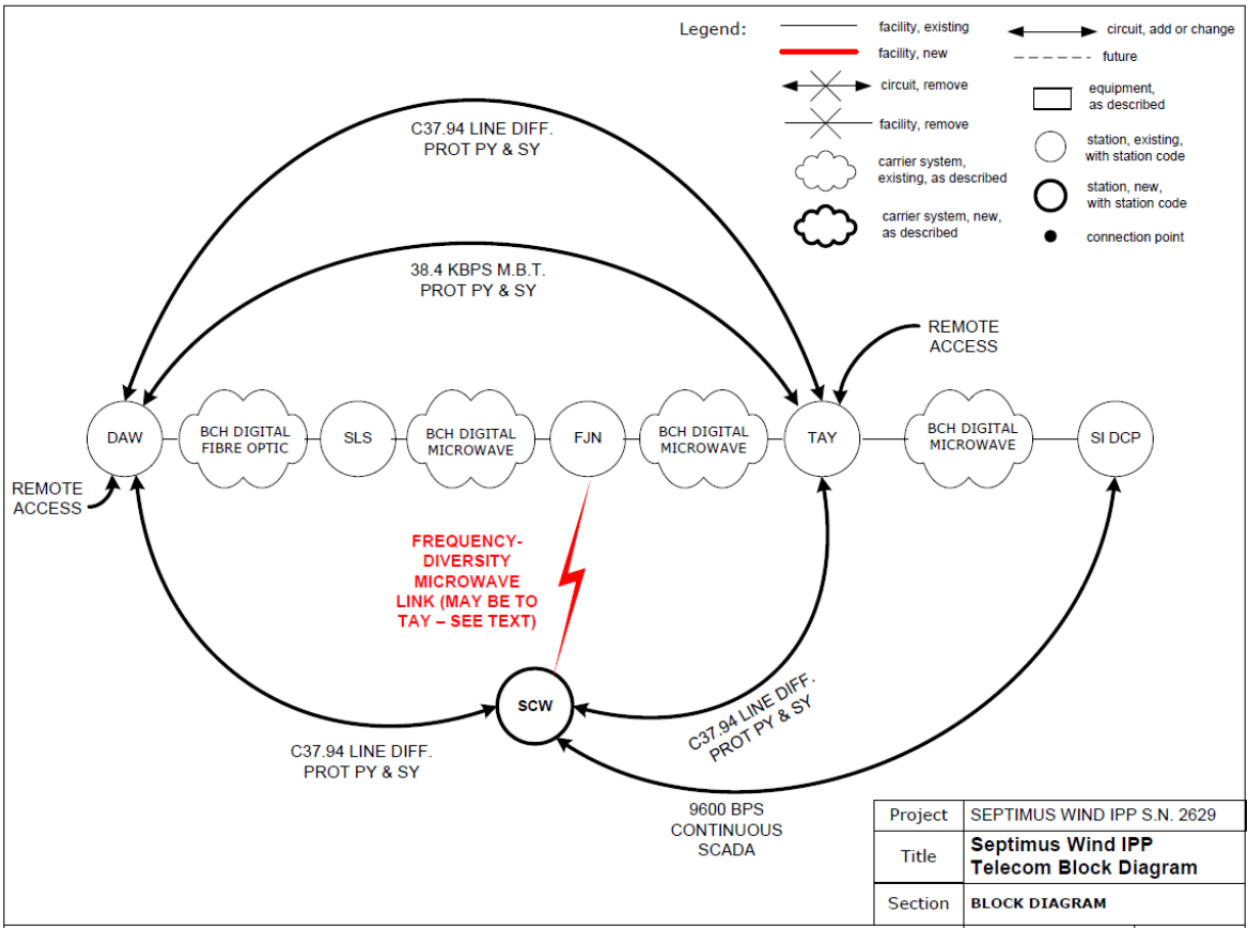
The wind turbine model used in this Septimus Wind Farm studies are proprietary and their data are not presented here.

APPENDIX C – Selected PSSE Dynamic Results





APPENDIX D – Telecom Block Diagram



APPENDIX E – REVENUE METERING REQUIREMENTS

The revenue class meters for all Points-of-Metering (POM) will be Measurement Canada (MC) approved and supplied and maintained by BC Hydro. The main meter will be leased by BCH to the Power Generators (PGs). As per federal regulations, the meter should be periodically removed and re-verified in a MC authorized laboratory. The CTs and VTs supplied by the PG and used on the metering scheme shall also be of a model/type approved by Measurement Canada. The PG should submit the models/maker/MC Approval number for BCH RM approval before committing to purchase the units.

The PG's remote read load profile revenue metering should be in accordance with the BC Hydro Requirements for Complex Revenue Metering. The latest version of this document is published at BC Hydro webpage under Forms and Guides. The revenue metering responsibilities and charges (PG and BCH) shall be in accordance with Section 10 (10.1 and 10.2). For details about the specific responsibilities, see table on pages.23-25.

Main and backup bi-directional load profile interval meters are required to measure the power received and the power delivered (by BCH to the PG) during each 30 minute time period. The meters will be programmed for 5 minutes interval and will be remotely read each day by BCH/ABSU Enhanced Billing Group using MV-90; the POM shall have a dedicated communications line (landline or wireless BCH approved IP alternative) available for revenue metering use only. If there is digital cell phone coverage for data, BCH will supply the wireless communications. In this case, there will be an incremental cost for the PG.

The revenue class meters (main and backup) are Measurement Canada (MC) approved and will be supplied and maintained by BC Hydro. The main meter will be leased by BCH to the PG. The revenue class instrument transformers (CTs and VTs units) are supplied by the PG and should be Measurement Canada (MC) approved models.

The location of the POM(s) is (are) subjected to approval by BC Hydro's Revenue Metering department.

A *3*--element metering scheme with 3 CTs and 3 VTs connected L-N (L-Grd) shall be used at the PG Sub when the point of metering (POM) is located on the BC Hydro side of the power transformer.

For generation applications, all instrument transformer compartment doors shall be **key interlocked** with a BC Hydro side disconnect device and a Power Generator side disconnect device(s). The key interlocks shall prevent opening instrument transformer compartment door(s) unless all disconnect devices are visibly open. *Where the POM is on the Power Generator side of the power transformer, the BC Hydro side disconnect device shall be on the BC Hydro side of the power transformer to insure that no-load losses."*

The impedance and losses between the POM and the Point of Delivery/Receival (PODR) are significant; the meters will be programmed to account for the line and/or transformer losses between the POM and

PODR. The PG or its consultant shall provide the line parameters data and the power transformer testing data signed and stamped by a professional engineer.

Note that where two or more PGs or one PG with more than one generation station/generator share a power line to connect to the BCH system, a main POM on the BC Hydro side of the power transformer or in the POI will be needed, as well as an individual POM for each one of the generation stations/generators.

During the planning phase, BCH Revenue Metering department should be contacted to discuss the specifics of the project. The PG should send drawings to BCH Revenue Metering Department showing the Single Line Diagram (SLD) and informing the planned metering scheme, meter cabinet location, CTs and VTs model/maker, connections, location and MC Approval numbers, as well as any other related document.

The BC Hydro's Revenue Metering department can be contacted at: metering.revenue@bchydro.com