MEETINGS IN ST. JOHN'S AND VISITS TO LOWER CHURCHILL PROJECT SITES, NOVEMBER 27 TO DECEMBER 01, 2017

Prepared for: Natural Resources Canada and Nalcor Energy

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Date: January 22, 2018

Quality Assurance Statement

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APPENDIX 1 - Site Photographs

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1. GENERAL

The Independent Engineer (IE) team attended project briefings and meetings at the Lower Churchill Project Delivery Office in St. John's on November 27, 29, 30 and December 01, 2017 and visited Muskrat Falls, Soldiers Pond and Dowden's Point construction sites on November 28-29, 2017. Paul Carter from the Government of Newfoundland & Labrador and Humayun Soomro from Natural Resources Canada also attended the briefings and site visits. NALCOR management and project team representatives accompanied the group on all site visits.

IE team: Nik Argirov (IE Team Lead)
Vlad Kahle (IE Electrical SME)
Tim Little (IE Geotechnical SME)

The trip itinerary was as follows:

Nov. 26:

- Arrive in St John's NL

Nov. 27:

- Orientation meeting and project updates in Nalcor's LCP Delivery office

Nov. 28:

- Commercial flight from St. John's to Goose Bay
- Site visit to Muskrat Falls Generating Plant and dams, AC and DC switchyards, Gas Insulated Switchgear (GIS) building and converter building.
- Commercial flight from Goose Bay to St. John's.

Nov. 29:

- Site visit to Dowden's Point Grounding Site
- Site visit to Soldiers Pond (SOP) Converter Building, Converter Station AC and DC yards, and Synchronous Condenser building
- P&C status and Recap Meetings in LCP office

Nov 30:

- Technical sessions and project updates in LCP office.

Dec. 01:

- Document transfer and meeting in LCP office
- Depart St John's for home bases

Transportation to and from all sites was by commercial flights and by road.

2. MUSKRAT FALLS RESERVOIR

Photographs taken during the visit are presented in Appendix 1, Section A.

- The reservoir level was at about El. 22 m at the time of the IE site visit.
- The debris/ice/safety boom is now installed. Small pans of ice were floating downstream but the ice had not yet formed a continuous cover at the boom. Some ice pans were migrating downstream between the boom sections (Photos A.1 and A.2).
- Later in the week, Nalcor reported that a helicopter inspection found that substantial ice cover has formed in the upper reservoir.

3. MUSKRAT FALLS POWERHOUSE AND INTAKES

Photographs taken during the visit are presented in Appendix 1, Section B.

- The powerhouse superstructure is fully erected and enclosed and mezzanine floors are installed. Primary concrete placement by Astaldi for the powerhouse and intakes is complete (Photos B.1 to B.4).
- Units 1 to 3 have been handed over from Astaldi to Andritz for turbine and generator installation.
- Installations of circular passage and draft tube steel liners are in progress in Units 1 to 3. Liner components are being assembled in the service bay, then moved into position using the overhead crane. Once each liner is aligned and anchor welding is completed, second stage concrete is placed between the liner and the first stage concrete (Photos B.3, B.6, B.7).
- The Unit 1 stay ring is in the service bay, being prepared for installation (Photo B.5).

3. MUSKRAT FALLS SPILLWAY

Photographs taken during the visit are presented in Appendix 1, Section C.

- The spillway is fully functional. At the time of the IE site visit, two spill gates were open to maintain the reservoir level and the Churchill River flow.
- Small ice pans were being easily passed through the open spill bays (Photos C.1 to C.4).

4. MUSKRAT FALLS NORTH RCC OVERFLOW DAM

Photographs taken during the visit are presented in Appendix 1, Section D.

- Roller compacted concrete (RCC) placement has been completed for the 2017 season and will resume in the Spring of 2018.
- The top of the RCC dam is currently at El. 15.69 m. In 2017, 39% (88,610 m^3) of the total RCC and 77% (14,392 m^3) of the total conventional concrete (CVC) were placed. Much of the CVC was placed as leveling concrete on the irregular bedrock foundation; a layer of CVC was also placed at the outer sides of the RCC.

- The RCC dam has been insulated for the winter, based on the results of a thermal analysis. On the upstream side and upper downstream side of the dam, the vertical formwork has been left in place for the winter; the formwork was temporarily separated from the concrete and tarps were inserted to provide adequate insulation. Other exposed surfaces were covered with tarps. RCC temperatures are being monitored with thermocouples (Photos D.1 to D.3).
- Backfill was placed and the water level between the upstream cofferdam and the RCC dam was raised to El. 9 m at the end of October, which reduces the differential head through the dam. Seepage flows dropped from about 10 m^3/min to about 6.5 m^3/min, and have remained stable (Photo D.4).
- Nalcor informed the IE that the downstream face of the RCC dam will be stepped, and the steps will be constructed using formwork in 2018.

5. MUSKRAT FALLS SOUTH EMBANKMENT DAM

Photographs taken during the visit are presented in Appendix 1, Section E.

Construction of the south embankment dam was completed in Fall 2017 (Photos E.1 to E.3).

6. NORTH SPUR

The North Spur was snow-covered at the time of the IE site visit and was not inspected.The work however is completed and the Contractor has demobilized.

7. DAM SAFETY

- Nalcor's dam safety management program includes dam safety monitoring of reservoir and tailwater levels, all cofferdams, the North Spur, powerhouse, spillway, and separation wall. Monitoring includes visual inspections and measurements of piezometric levels, seepage flows and movements using instruments and surveys.
- Instrumentation data are collected automatically or manually, depending on factors such as the types of instruments and their locations. Data are regularly entered into a computer database and plots can be viewed on-line. The results of the dam safety inspections and instrumentation data are presented in Dam Safety Weekly Monitoring Reports. The IE receives copies of these reports.
- To date, no unusual conditions or dam safety concerns have been identified.

8. MUSKRAT FALLS SWITCHYARD

Photographs of the Muskrat Falls Switchyard, Converter Building and GIS Building taken during the visit are presented in Appendix 1, Section F.

The following observations were made during the Nov. 28, 2017 site visit to the Muskrat Falls Switchyard (Photo F.1):

- Power apparatus and the structures have been installed and are in final commissioning stages.
- 315kV Churchill Falls Transmission line and four powerhouse collector feeder towers have been erected and connected.

9. MUSKRAT FALLS CONVERTER BUILDING

- Converter building is in final stages of completion (Photo F.2).
- Converter transformers have been installed on their pads.
- HVDC Valves have been installed, cooling system is being tested (Photo F.3).
- Fibre optic cables will be installed following the tests and clean up (Photo F.2).

10. MUSKRAT FALLS GIS BUILDING

- GIS equipment and Local Control cabinets have been installed, low voltage cables have been pulled in and the building is in final stages of construction (Photos F.5 and F.6).

11. SOLDIERS POND CONVERTER BUILDING

Photographs of Soldiers Pond facilities taken during the visit are presented in Appendix 1, Section G .

- At the time of the IE site visit the construction work is nearing the final stages (Photos G.1 to G.3). Completion work is in phase with the Muskrat Falls site.

12. SOLDIERS POND CONVERTER STATION AC & DC YARDS

- Valve cooling heat exchangers have been completed (Photo G.4).
- Converter transformers are on their pads and have been oil filled.

13. SOLDIERS POND SYNCHRONOUS CONDENSER BUILDING

- Unit 1, 2 and 3 are on their pads, and rotors and stators are assembled (Photo G.5).
- Exciter, switchgear and Protection cubicles have been been installed (Photo G.6).
- Synchronous Condenser Power and Exciter Transformers are on their pads.

14. SOLDIERS POND AC SWITCHYARD

The Switchyard was energized and fully commissioned in November 2017.

15. DOWDEN'S POINT GROUNDING SITE

Photographs of Dowden's Point facilities taken during the visit are presented in Appendix 1, Section H .

- Construction is nearing completion, electrode wells and their instrumentation are in place (Photos H.1 to H.3).
- Site is awaiting shipment of harmonic filters for the fault locating equiment.

16. LCP PROJECT OFFICE MEETINGS ON NOVEMBER 27 AND 30 AND DECEMBER 1, 2017

Power Development- Muskrat Falls Overview

- Powerhouse (PH) is now enclosed on all sides.
- Work on the turbines by Andritz is on schedule.
- Intake gate manufacturing is complete.
- Draft tubes 1 to 4 are in their completion stages with the last unit scheduled for installation in Jan. 2018.
- Work on the balance of plant (BOP) has been mobilized and is on track.
- Interfacing between the powerhouse and converter building is in progress.
- Spillway is functional and is in use.

PH Integration- Update on the Process

- Weekly meetings are being held to identify the interfaces between the contractors and the interface handovers.
- Daily meetings resolve any potential issues.
- Communications throughout the LCP team with respect to interface management have been emphasised.

Environmental Management System – Briefing

- Initiatives are in place to reduce the cost and impact of potential environmental incidents.
- Transformer insulation oil transfers have been accomplished without a spill.
- No non- compliance report has been issued to date.

Transmission Link - Completion Status

- Strait of Belle Isle = 100%.
- Labrador Transmission Asset (LTA)= 99%.
- Labrador Island Transmission Link (LITL) = 97%.
- Overland HVDC line = 100%.
- Churchill AC Substation = 99%.
- MF AC Substation = focus is on finishing the work in early 2018.
- MF Converter station = 79%.
- SOP AC Substation is connected to the grid power.
- SOP Converter station = 84%.
- SOP Synchronous Condensers = 81%.
- Transition Compounds = 89 and 93% (Shoal Cove and Forteau Point respectively)
- Grounding Sites = 93 and 94% (Dowden's Point and L'Anse au Diable respectively).

- Project identified risks are maintaining safety and P&C development and testing progress at Stafford, UK.

Completion and Ready for Operation (RFO) Plan

- This Plan is a framework for development of the process that will facilitate commissioning of the equipment and the systems.
- Contractor developed the test sheets for both the mechanical and electrical tests. Completion certificates will be issued and countersigned on completion and acceptance of these tests.
- Completion certificates will be issued for both the static and dynamic tests.
- Data base (d.b.) for all of the equipment, systems and subsystems is in place. GE populated the d.b. with NALCOR staff's assistance. It is a repository of all equipment documentation and the test results and it will serve as a check list.

Transition to Operation (TTO)

- This process will transfer the operation of the assets to the 'operating entity'. It is understood that this entity encompasses the operations, maintenance as well as the finance/ HR/ operating contracts.
- Numbers of studies have taken place and are being carried out by consultants (Trans Grid Solutions (TGS)) in conjunction with the utilities (EMERA, Newfoundland and Labrador System Operator(NLSO)). The studies will lead to development of start- up plans. Those plans will be reviewed (and approved) by the system operator.
- Operating instructions are being developed for two purposes::

(i) HVDC System operating instructions will be based on the TGS and Energy Control Centre (ECC) studies. Those will govern operation of the HVDC link in the NL grid.

(ii) HVDC Converter Stations operating instructions are developed by GE for use by the HVDC Station Operators and maintenance staff (Note: SOP will be staffed 24/7, MF will have a day shift only). This GE project deliverable is scheduled to be finalized in Q1 of 2018.

- Ready for Commercial Integration (RFCI) process will address commercial aspects of the Project such as financing, regulatory and relationship with EMERA.
- The Project has been designed in compliance with the NERC standards. Formal compliance is not required and it will not be pursued at this time.

HVDC Control Development Status

- 21% of the factory system tests (FST) have been successfully completed. Following FST, the software enters company witnessed Factory Acceptance Tests (FAT) and is tested on the delivery hardware.
- It is noted that interlocking and HMI (Human Machine Interface) programming is being developed remotely but managed from GE's facility in Stafford, UK.
- Degree of coordination between the site commissioning work and factory software development has not been determined by the IE.
- It is expected that following the phased approach testing of all assembled software (S/W) modules, factory acceptance testing (FAT) certificate will be issued on the entire S/W package.

- NALCOR project team representatives are at Stafford witnessing, approving, and monitoring all aspects of the Protections and Controls (P&C) testing. In addition, daily/ weekly updates are received and documented.
- Senior HVDC solutions engineer R. Sellick, Ph.D is reported to be assisting / overseeing the Stafford S/W design efforts. That said, IE recommends that NALCOR develops in-house expertise for monitoing of the HVDC control commissioning tests and provision of future technical support to the operating staff.
- NALCOR Engineering Technical Specification CD0501 on Control Systems for HVDC, Contractor document no. 505573-8000-48ES-5002, Equipment Software Characteristic on pages 61 to 63 is quite specific regarding the S/W programming, outsourcing of work and mandatory documentation. IE recommends that NALCOR confirms the Contractor's compliance with respect to the Control S/W development methodology and documentation.
- At this time IE does not have concrete evidence that factory testing at Stafford will commence as claimed by the contractor on the December 22nd, 2017. Failure to meet that target would likely push the completion of the FAT past mid-January 2018.
- This activity has been flagged for continuous monitoring.

17. CONCLUSIONS AND COMMENTS

- At the time of the site visit the HVDC Labrador Island overhead line was already completed with only punch list items remaining to be further addressed.
- The HVDC Control System development remains to be the main schedule risk associated with the phased approach for completion of LIL.
- The construction works viewed during the site visit were of good quality and in compliance with accepted standards.

Appendix 1

Site Photographs

Photo A.1: Upstream view of lower reservoir, with debris/ice/safety boom installed. Reservoir level is about El. 22 m. Snow-covered area in background is upstream side of North Spur.

Photo A.2: Small ice pans just upstream of spillway approach channel.

Photo B.1: Upstream side of power intake structure with Unit 4 intake at left (3 intake bays per unit).

Photo B.2: Panorama view of powerhouse building and centre transition dam.

Photo B.3: Interior of powerhouse, with Unit 1 draft tube in foreground and Unit 1 intakes at centre left.

Photo B.4: Mezzanine floors inside powerhouse (above service bay).

Photo B.5: Unit 1 turbine stay ring.

Photo B.6: Turbine pit liner with external Nelson stud anchors that will be embedded in second stage concrete.

Photo B.7: Draft tube liner.

Photo C.1: Centre transition dam and spillway.

Photo C.2: Upstream side of spillway with two gates open.

Photo C.3: Open spillway gates showing entrance flow conditions (left) and exit flow conditions (right).

Photo C.4: Spillway discharge entering river.

Photo D.1: Southerly view between RCC dam (left) and upstream cofferdam (right). RCC formwork is being left in place through the winter for insulation purposes.

Photo D.2: Northerly view between upstream cofferdam (left) and RCC dam (right). Wooden structure at left houses the cofferdam dewatering system.

Photo D.3: Northerly view along downstream side of RCC dam. Formwork remains in place on the upper part of the dam and the lower part has been covered with blue tarps for winter insulation.

Photo D.4: Upstream cofferdam dewatering system housed inside insulated temporary structure. Inside each vertical corrugated metal pipe is a seepage collection sump with a pump. Pumped flows are measured by flow meters and returned to the reservoir.

Photo E.1: Upstream side of completed south embankment dam.

Photo E.2: View along crest of completed south embankment dam.

Photo E.3: Downstream side of south embankment dam and contact with south transition dam.

Photo F.1: Muskrat Falls DC switchyard.

Photo F.2: Muskrat Falls converter building control room (left) and P&C room (right).

Photo F.3: Muskrat Falls converter building valve hall.

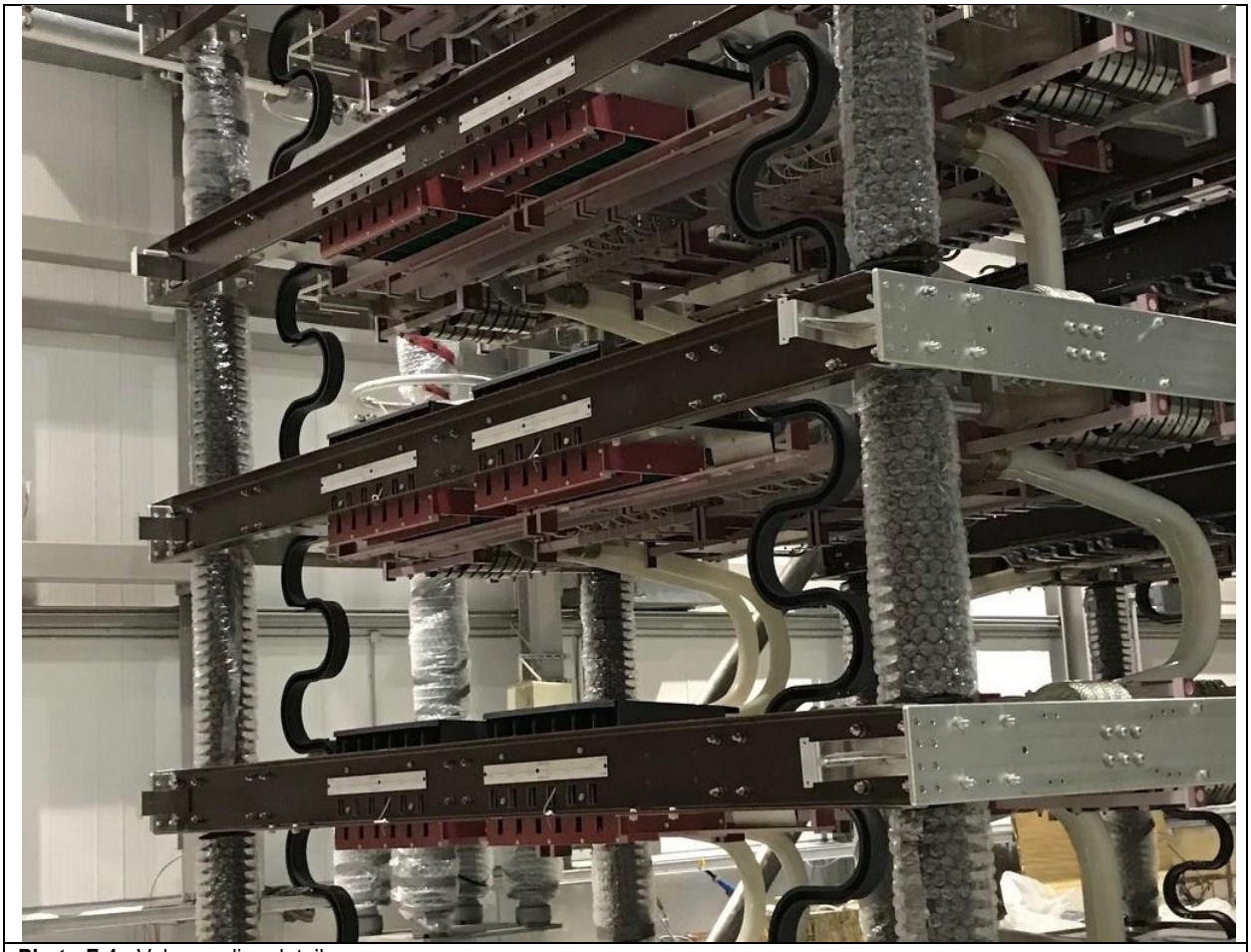

Photo F.4: Valve cooling detail.

Photo F.5: GIS equipment.

Photo F.6: GIS equipment, cable trays and control cabinets.

Photo G.1: Soldier's Pond converter building interior works nearing completion.

Photo G.2: Control cabinets wiring completion and testing in progress.

Photo G.3: Soldier's Pond converter building valve hall.

Photo G.4: Valve cooling heat exchangers.

Photo G.5: Synchronous condensers.

Photo G.6: Synchronous condenser control cabinets.

Photo H.1: Grounding line on west side of Dowden's Point site.

Photo H.2: Dowden's Point grounding lines terminations.

Photo H.3: Dowden's Point electrode wells.