

# INDEPENDENT ENGINEER PROJECT STATUS REPORT FOR 2020 - 2021

Prepared for: Natural Resources Canada and Nalcor Energy

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## *Quality Assurance Statement*

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## LIMITATIONS AND SCOPE

**This report has been prepared by Argirov Engineering Inc. solely in its capacity as Independent Engineer for Canada as represented by the Minister of Natural Resources. No other use of, or reliance on, this report is permitted for any purpose.**

Due to Covid 19 pandemic travel restrictions the Independent Engineer (IE) team has been unable to visit project sites since December 2019. Information for this Report is based on the Construction and other Reports, briefing documents, e-mails, and teleconferences with Nalcor representatives as well as on the observations from the virtual tours of Power Electronics Stafford (PES), Muskrat Falls generating station and LIL synchronous condensers and converter stations.

This Report recapitulates the Project deliverables as well as the technical challenges encountered during the period from January 2020 to March 2021. Due to external factors and equipment failures the schedules remained fluid throughout the reporting period.

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Source Material:

Construction Reports January 2020 to March 2021

Briefing and Meeting Notes

Virtual meetings presentations

Unit 2 Inner Head Cover Bolting report dated 28-Jan-2021

Dam Safety Weekly Monitoring Reports January 2020 to February 2021

Muskrat Falls Generation Independent Dam Safety Program Audit #5 report dated 02 February 2021

## COVID - 19

On March 13, 2020, General Partner declared a Force Majeure on Contracts CD0501-001 and CD0534-001. Both Contractors responded with their agreement and the parties took whatever measures possible to mitigate the impacts. As of March 17, 2020, a Force Majeure was issued to all Contractors involved in the construction work at the Muskrat Falls site and the site was placed into a care and maintenance mode. Contractors remained engaged and supported the project in ensuring that all engineering issues and technical documents are complete and up to date; and made progress during this period in advancing essential administrative work and closeout activities with respect to completed work scopes.

Soldiers Pond Site was placed into care and maintenance mode on March 28, 2020.

Due to the unknown duration of the shutdown, reliable forecast dates for the key milestones were not provided and the Integrated Project Schedule was not regularly updated.

Limited operations resumed at the Muskrat Falls site on May 18, 2020. While operating in care and maintenance mode and in anticipation of construction restart, updated protocols and procedures were implemented to facilitate safe operation of the Muskrat Falls site. On June 1, 2020, the Force Majeure under the construction contracts was lifted. At the time, the delay to Project completion was assessed by Nalcor to potentially range from 6 to 10 months.

Notification to end Force Majeure on Contracts CD0501-001 and CD0534-001 was issued to GE Grid and GE Power, respectively, on June 11, 2020. General Partner evaluated the consequences of the COVID-19 Pandemic on Project cost and schedule. The full impact on both the final forecast cost and the key schedule milestones remained unknown at that time. An update of the Integrated Project Schedule (IPS) was to be completed by the end of September 2020.

On November 14, 2020, a GE Grid worker at Soldiers Pond Converter Station tested positive for COVID-19. Contact tracing was carried out by Public Health officials. Workers who were deemed to be in close contact with that individual were tested and all results were negative. The Converter Building was closed from November 14-16 and was cleaned as per the Project's COVID-19 protocol.

At the Soldiers Pond Site, declaration of Force Majeure for a period of two weeks was issued on February 13, 2021. This was a precautionary measure in alignment with the NL Public Health special measures order and it ended on February 17, 2021.

## 1. CONSTRUCTION ACTIVITIES - MUSKRAT FALLS

### 1.1 Powerhouse

At the beginning of 2020, mechanical completion and commissioning activities were ongoing throughout the Powerhouse, with a continued focus on pre-completion walkdowns to eliminate punch list items. As of November 2020, powerhouse construction was complete.

IE submitted to Nalcor Project Delivery Team (PDT) their opinion on the design of Emergency Shutdown and Emergency Intake Gate Close facilities. Suggested design features aligned with good utility practice were provided to PDT for reference. Technical information exchanges are ongoing, and the issue remains unresolved at the time of the Report writing. This matter is discussed at greater length in section 4.

### 1.2 Spillway

Work necessary to enable spillway operation during Spring freshet 2020 was planned to be completed prior to April 1, 2020. This work was completed in March 2020. Remaining work and repairs were to be undertaken under more favorable conditions after Spring freshet. Post rollway and secondary concrete work at Spillway Bays 2, 3, and 4 commenced in April. Repair work to gate guides, secondary concrete and heater tubes was planned and carried out by Andritz and their sub-contractors (Note: This work is subject of an Insurance Claim under the Project Construction All Risks policy).

Preventative maintenance work and repairs on the spillway were restarted by end of June. By end of November 2020 repairs to spillway gate guides, guide heaters, and secondary concrete in all bays were completed.

### 1.3 Dam Safety

As of November 2020, construction of water retaining structures (the dams, spillway and North Spur) was complete.

Responsibility for dam safety monitoring was transferred to Operations in October 01, 2020.

Independent Dam Safety Program Audit #5 was carried out by Hatch in September 2020 and concluded that *“the dam safety management program at the site is in compliance with the Canadian Dam Association guiding principles and continues to meet or exceed good industry practice”*.

The audit also reviewed the response of the water retaining structures, including the North Spur, to impounding the reservoir to full pool El 39 m and concluded that *“The independent auditor considers these structures performed appropriately and in accordance with good industry practice”*.

The audit also reviewed public safety aspects of the project in comparison with the CDA guidelines and concluded that *“safety procedures and practices observed are in accordance with good industry practice”*.

In summary, no dam safety deficiencies were noted in the audit. Ten opportunities for improvement were noted, mostly pertaining to procedural details and updating specific details in the Operation Maintenance and Surveillance manual. Another three opportunities for improvement were noted with respect to public safety, related to updating specific details in the public safety plan, and ensuring public awareness of safety sirens.

### 1.4 Turbine and Generator (T&G) installation and commissioning activities - Significant Events

#### January 2020

At the beginning of the year commissioning of T&G systems to support first power from Unit 1 was in progress. Under Contracts CH0031 and CH0032, Cahill-Ganotec and Andritz Hydro completed their objectives necessary to achieve the Ready to Turn milestone. Under contract CH0030 for the Turbines and Generators, Andritz Hydro watered up Unit 1 and commenced wet commissioning on January 28<sup>th</sup>. The Contractor advised that replacement of the generator rotor rim keys would be required on the Muskrat units and they expedited fabrication of the new keys.

Unit 2 rotor was installed, and upper bracket assembly was ongoing however, progress on the unit continued to trend behind the plan. Ready for Operation forecast was adjusted from early March to mid-April. Replacement of the rotor rim keys for Units 2, 3, and 4 was to be completed in parallel with other activities without affecting their construction schedules.

#### February 2020

Andritz's overall performance was lagging significantly behind their estimates. Project Delivery Team (PDT) updated the remaining Muskrat Falls milestone dates based on its assessment of Andritz's demonstrated performance to date and their potential for schedule recovery for parallel work on Units 3 and 4.

#### March-June 2020

As noted above, limited progress occurred during this period due to pandemic and declaration of Force Majeure.

#### July 2020

Movement was noted between the radial arms of the lower bracket and the lower bracket sole plates during the July 8<sup>th</sup> Unit 1 test run. Investigation found that the radial keys did not fit snugly, allowing movement, which caused cracking in the weld between the keys. Redesign of the key arrangement was completed to ensure a proper fit and improved weld detail

between the keys. Due to this rework, the forecast for completion of Unit 1 commissioning and Ready for Operation has moved out by two weeks into September 2020.

Work also restarted on Unit 2 with completion of commissioning and Ready for Operation forecasted for November 2020.

#### August 2020

Mechanical completion including 150% overspeed test of Unit 1 was achieved. The issue with the unit lower bracket keys reported in the June 2020 was addressed prior to the completion of 150% overspeed test. Completion of the Unit 1 commissioning and Ready for Operation was forecasted for September 2020. IE reviewed and commented on completed Unit 1 Inspection and Test Plans (ITP's). Anomalies and comments were recorded and provided to Nalcor.

Unit 2 pre-commissioning and dry commissioning activities continued. Completion of the Unit 2 commissioning and Ready for Operation was forecasted for November 2020.

Assembly of Unit 3 continued. The generator shaft was installed in the unit and rotor pole installation was underway at the South Service Bay.

Assembly of Unit 4 continued. The wicket gates and outer head cover were installed; assembly of the unit runner continued.

#### September 2020

Unit 1 inspection was completed, and the unit was watered up and prepared for on-line commissioning scheduled to take place later in the month. On September 22<sup>nd</sup> Unit 1 was synchronized to the Labrador power grid for the first time marking the achievement of the First Power milestone. Commissioning activities for Unit 1 were completed including the following 72-hour trial run. Unit 1 was kept off-line until early November to complete preventative maintenance on its intake gates.

Unit 2 was turned for the first time marking the beginning of wet commissioning activities that continued into October 2020. Completion estimate for Unit 2 commissioning and Ready for Operation was moved to December 2020.

Unit 3 assembly continued, and the rotor was moved from the South service bay into the unit pit. Unit 3 commissioning and Ready for Operation was at this time forecasted to be achieved in May 2021.

Unit 4 rotor piling, and pole installation continued; unit commissioning and Ready for Operation was at this time forecasted to be achieved in September 2021.

#### November 2020

In early November Unit 2 wet commissioning was halted after the generator upper cooling air rubber shroud was dislodged during the 130% overspeed test. The shroud came into contact with the rotor causing the rubber seals and associated hardware to come free and enter the unit air gap. This event caused damage to multiple generator components including the stator winding and stator core. Damage to the rotor poles and field winding consists of minor impact damage to the field leads and copper pole collars and pole face. The most likely reason for this incident was that a lower hanger connection became loose which caused the nose of the shroud to drop until contact with the rotor occurred.

Estimated repair time was four weeks with an additional four week delay due to the Christmas break. The projected completion of Unit 2 commissioning and Ready for Operation was revised to mid-February 2021.

#### December 2020

Unit 1 protection system tripped the generator on December 11. Subsequent inspection found wire in contact with the top and bottom bars as they exit the top end of the core from slot #517. Some surface damage was observable on both bars.



Investigation concluded that damage to the slot 517 bottom bar was limited to the surface and can be repaired in situ. The top bar had a puncture failure and was no longer suitable for service. Andritz determined that the bar should be either replaced or bypassed. Bypassing one turn in the circuit results in circulating currents and increased heating. With the bar bypassed, the generator can be operated without any specific derating providing the total temperature rise does not exceed 120 °C. To ensure that, total winding RTD temperature (ambient temperature + temperature rise) is not to exceed 120 °C and the surface air cooler outlet air temperature should not exceed 30°C. This allows the unit to have the same capability curve and it allows using most of the present protection settings. Unit 1 was released for service and transferred to Operations on December 22, 2020. A permanent repair, involving replacement of the damaged stator bar, will be undertaken later.

During this period, the Contractor also completed the repairs to Unit 2 arising from the failure of the generator upper air shroud. The machine was deemed to be ready for the resumption of overspeed testing after the holiday break. The milestone for completion of the Unit 2 commissioning and Ready for Operation was moved to mid-March 2021.

COVID-19 pandemic related travel restrictions prevented IE visits to the sites in 2020. During that period IE reviewed approx. 100 Inspection and Test Plans (ITP's) for Unit 1 commissioning, provided comments to Nalcor and tracked the non-conformance events. In addition, IE reviewed Dry Commissioning, Wet Commissioning, Pre-commissioning and Start-up, Efficiency and Off-line tuning Manuals as well as the MF Generation Completion Plan. In 2020 PDT also organized powerhouse virtual tours and project update video conferences. All of those activities were just a partial substitute to actual IE site visit inspections. Nevertheless, they established high degree of confidence that all appropriate manuals and test/quality tracking documents were in place and the commissioning tests proceeded in well-organized manner.

#### February 2021

Unit 2 off-line commissioning was further delayed due to identified design issue with the bolts between the turbine inner and intermediate head covers. The Contractor determined that the bolts were subjected to excessive radial loading caused by relative movement between the flanges during the overspeed conditions. The movement resulted in metal fatigue that led to eventual failure of those fasteners. Andritz developed and implemented modifications to this bolt arrangement which includes installation of redesigned bolts and series of dowels (fitted studs) intended to prevent movement between the two covers. While undertaking these modifications to Unit 2, Andritz identified weld defects on the head cover stiffener plates. More information is included in section 4. Completion of Unit 2 commissioning and Ready for Operation is forecast for May 2021 as of the date of this report.

The head cover joint modification and weld inspection/rectification will also be carried out on Units 1, 3, and 4.

Unit 3 assembly is nearing completion, with installation/assembly approximately 94% complete. Unit 3 commissioning and Ready for Operation is forecast for July 2021 as of the date of this report.

Unit 4 rotor has been installed with the overall installation/assembly approximately 79% complete. Unit 4 commissioning and Ready for Operation is forecast for September 2021 as of the date of this report.

#### 1.5 Balance of Plant:

At the beginning of 2020 Cahill-Ganotec, under Contract CH0031 for Supply and Install Mechanical and Electrical Auxiliaries (Balance of Plant) continued with the powerhouse work in accordance with their baseline execution plan.

After the Force Majeure restrictions were lifted work commenced on fire dampers, fire protection and fire detection systems. Base scope was 95% complete as of November 2020.

## 1.6 Intakes:

Construction of the intakes is substantially complete. Commissioning of Intakes 1 through 4 is being completed in coordination with commissioning and start-up activities for each unit.

During inspection of the upstream water passage for Unit 1 some concrete debris was uncovered in the water passage. Based on the shape of the erosion, debris appeared to be secondary concrete from the intake embedded components. Once the results from remotely operated vehicle (ROV) survey were available, the extent of the secondary concrete issues were assessed, and a repair method was presented by Andritz in August 2020. Repair using epoxy filler was completed in September 2020.

## 2. CONSTRUCTION ACTIVITIES - LIL

### 2.1 Software Development-Significant Events

#### January 2020

At the beginning of the year Project forecast anticipated: Interim Software FAT completion on Feb. 2, 2020, Low Load Dynamic Commissioning completion on March 15, 2020, Final Software FAT complete and delivered to site June 9, 2020, and Full Functionality Dynamic Commissioning completed on July 15, 2020 (at available power). At that time, the risk for schedule slippage associated with the Interim Software FAT Release to Site milestone was considered high with resulting impact on the Final Software delivery schedule.

Throughout the year discussions between the Nalcor project team and IE were held about the contractual requirements to test Operation in Monopole 'Overload' Mode at 900MW. Final disposition of this item is pending. More details can be found in Section 4.

#### February 2020

General Partner updated the Integrated Project Schedule (IPS) to reflect GE Grid's slower than planned progress by revising the anticipated Dynamic Commissioning completion date to August 31, 2020. GE Grid started Open Circuit Test (OCT) / Open Line Test (OLT) at the Muskrat Falls and Soldiers Pond Sites. Duration of FAT was adversely impacted by COVID-19 restrictions.

#### April 2020

General Partner project management resources and IE participated in virtual oversight of software testing from their home offices. A number of the FST cases were unsuccessful. In order to allow Factory Acceptance Testing (FAT) to proceed, Nalcor and the Independent Third Parties (ITP) reviewed the GE Grid's proposed deliverables variance and agreed to eliminate a limited number of non-essential functions in the final version of the software. Parties agreed that further schedule adjustment would be required.

#### May 2020

Software development work continued in Stafford, UK. GE Grid worked on classifying the bugs and the preparation of revised schedule for bug fixing and software delivery. Software testing and remote witnessing continued during this period of travel restrictions.

### June 2020

Bipole software development continued at the GE Grid facility in Stafford, UK. The revised schedule for Interim software delivery anticipated commencement of Trial Operations on September 14, 2020. Commencement date for Trial Operations remained unchanged, i.e., September 14, 2020. Punch-list closeout was ongoing at Muskrat Falls, Soldiers Pond and both transition compounds.

### July 2020

GE Grid commenced Factory Acceptance Testing (FAT) for the Interim Bipole Software (Release A) on July 13, 2020. Regression Testing and Factory Acceptance Testing (FAT) for this software was completed on July 24<sup>th</sup> followed by release of software to site on July 30<sup>th</sup>. Outstanding deficiencies identified during FAT, as well as any identified during the upcoming Dynamic Commissioning of “Release A”, will be corrected in “Release B” (Note: All deficiencies are required to be resolved prior to the start of Trial Operations).

### October 2020

On October 23<sup>rd</sup> GE Grid completed Factory Acceptance Testing (FAT) for Release B of the Interim Bipole Software. Release B was ready for installation; however, resumption of commissioning activities was contingent on resolution of the valve hall support beam issues, see section 2.2 below.

With respect to the Final Bipole milestone dates, Trial Operations start was, at the time, projected for August 1, 2021 and to be complete by September 30, 2021 (Note: Trial Operations is complete after 30 consecutive days of power transfer without a system trip).

### November 2020

Bipole Final Software and Dynamic Commissioning are classified as ‘critical work’. Dynamic Commissioning (Interim Software) of Pole 1 recommenced on November 28<sup>th</sup>.

### December 2020

Dynamic Commissioning tests of Pole 1 were completed on December 15<sup>th</sup>. December 16<sup>th</sup> inspection of the valve hall found no further issues or degradation of beam resistivity. On December 18, 2020, the Labrador Island Link (LIL) was re-energized and transmitted power nearly continuously until January 8, 2021. During that period peak power flow from Muskrat Falls and Churchill Falls over the LIL was 150 MW. The LIL experienced one hardware related converter trip on the night of December 29, 2020. LIL was returned to service one day later.

### January 2021

Dynamic Commissioning tests of Pole 2 started on January 7<sup>th</sup> and were completed on Jan. 31<sup>st</sup> (Note: Pole 1 was taken offline during Pole 2 testing). Successful 225 MW monopole heat-run tests were run on both Pole 1 and Pole 2. On January 11<sup>th</sup> Operations discovered damage to five crossarms on Electrode Line 1 (EL 1) in Labrador. Following the damage assessment, Pole 2 dynamic commissioning tests resumed on January 16, 2021 while planning for the repairs was underway. Power transfer levels on Pole 2 have reached 210 MW. Dynamic Commissioning tests were paused on January 19, 2021 for EL1 repair.

### February 2021

During bipole dynamic commissioning the LIL experienced an unplanned trip of Pole 2. Correct operating sequence of the protection and controls transferred the LIL bipole load to monopole on Pole 1 with no resulting loss of load transmission.

Cause of the outage was Pole 2 HVdc line conductor falling to the ground due to failed eyebolt on an insulator. Dynamic Commissioning and power transfer were paused from February 7<sup>th</sup> to 21<sup>st</sup> while repairs to the Pole 2 conductor and EL 1 took place. On February 21<sup>st</sup>, the LIL was reenergized and it transmitted power to the island in bipole mode with EL 1 in service. Bipole Dynamic Commissioning tests recommenced on February 24<sup>th</sup>.

Protection and Controls remains the current priority.

## 2.2 Soldiers Pond (SOP) and Muskrat Falls (MF) Converters - Significant Events

While operating in care and maintenance mode Soldiers Pond commissioning of the LFL (line fault locators) (CD0501) continued as well as the services and maintenance related to the COVID-19 Pandemic.

### August 2020

Energization of Pole 2 of the Labrador-Island Link (LIL) took place on August 13<sup>th</sup>. During dynamic commissioning, a flashover on surface of SOP Pole 2 valve hall fiberglass beams resulted in the LIL trip. Several days after the SOP Pole 2 trip similar incident occurred at MF. The beams serve as both the structural components and insulators for the converter valves and the valve-based electronics. The flashover was later attributed to residue present on some of the fiberglass beams. Testing at both sites determined that the residue caused dielectric breakdown leading to loss of beams' insulating properties and subsequent flashovers. Analysis indicated that dielectric breakdown of the material was the result of insufficient heat curing in the factory. GE Grid confirmed that all of the beams supplied by the primary vendor, totaling 348, will have to be replaced as part of the final remediation plan. Approximately 10% of all beams were supplied by secondary vendor; none of those beams have failed resistivity tests and will not be replaced. GE Grid has placed an order with the secondary vendor for the replacement beams.

### November 2020

GE Grid implemented interim plan, which focused on restarting Dynamic Commissioning of Pole 1 first, followed by Pole 2. That interim remediation plan included: removal of beams from the SOP Pole 1 valve hall that did not pass the resistivity test, heat curing them at a facility in St. John's, and reinstalling them back in Pole 1. At Muskrat Falls, beams that did not pass the resistivity test in Pole 1 were replaced with 'healthy' beams from Pole 2. Those interim measures allowed dynamic commissioning of Pole 1 to re-commence on November 28, 2020. Valve hall remediation is classified as 'critical work'.

### December 2020

Interim valve hall remediation work and re-installation of the heat cured beams on Pole 2 was completed.

### January 2021

Prototype replacement beam has been designed, manufactured, and sent to PES, UK for testing. Delivery date of the replacement beams is critical for determining final schedules. Pole 1 beams are to be delivered by end of March 2021, Pole 2 by end of April 2021.

It is noted that in the event the Final Bipole Software is delivered before the replacement beams (in July-August 2021), the interim valve hall solution will not limit dynamic commissioning of the final software or power transfer over the LIL.

## 2.3 SOP Synchronous Condensers

### January-May 2020

At the beginning of the year preliminary analysis of synchronous condenser vibration and machine shaft binding indicated that axial vibration was associated with the bearing housing (half-moon) support and the lateral vibration was attributed to the foundations' deficiency resulting in resonance. SC 1 and SC 2 bearings and housings were removed for modification. Commissioning of all three units was planned for May 2020. The synchronous condensers were not on critical path and their availability did not impact LIL HVDC commissioning at low power at that time.

Synchronous Condenser (SC) 2 modified bearing housing was re-installed, and the unit was first spun in early March 2020 when the binding issue was considered resolved. GE Power and their external expert, FZA, continued to assess the options for resolution of the lateral vibration. Commissioning of all three units had moved from Q2 2020 (June) to Q3 2020 (August). At that time the schedule was May-June-August for SC 3, SC 2, SC 1, respectively.

At Soldiers Pond COVID-19 work suspension took place on March 28, 2020.

Phased re-mobilization of personnel to site started on May 12, 2020 followed by re-commencement of commissioning activities on SC 2 on May 25, 2020.

### June-August 2020

As of late June, SC 2 rotor was successfully balanced, and Contractor started commissioning of the hydrogen system. During hydrogen filling a sensor indicated leak in SC 2 and the gas flow was stopped. Emergency alarm and stop system worked as designed, however, the source of the hydrogen leak remained undetermined. Commissioning of SC 2 continued without hydrogen (at full speed of 900 rpm and up to 45MVAR using air).

GE Power proposed an elliptical design modification to the bearing face that has the potential to reduce the lateral vibrations without resorting to foundation remediation. To minimize impact on the schedule the bearing redesign work was done in parallel with foundation retrofit design work. GE Power selected Vector Construction Ltd from Winnipeg, MB for the foundation remediation.

Installation of SC 1 bearings and housings was on hold pending completion of the commissioning tests of SC 3 equipped with redesigned elliptical bearing.

SC 2 was operating at low capacity (up to 45MVAR) since August 3<sup>rd</sup> in support of the LIL commissioning. The earlier hydrogen leak was attributed to failed leak sensor. The sensor was to be relocated in September.

As noted above, in order to maintain work schedule to the greatest degree possible, work on the foundation remediation design continued in parallel with the bearing redesign. GE consultants presented pros and cons for the two most promising foundation remediation concepts. Duration of possible remediation sequences ranges between 21 and 60 weeks depending on whether the work on the three units is carried out sequentially or in parallel. Nalcor indicated that the remediation selection would be based on a decision matrix that includes: SC 3 elliptical bearing performance, SC 2 vibration analysis, LIL commissioning status, and the requirement to have synchronous condensers on-line.

### September 2020

In September, 60% design review of the foundation remediation took place, and the preliminary schedule was to follow design review. GE Power and General Partner were working on the priorities and logistics for construction mobilization. Foundation remediation work was planned to start on SC 1. Remediated SC 1 performance was to be compared to SC 3

(elliptical bearing solution) in order to determine if, (a) further foundation work is required for the remaining units or, (b) if those units will only require their bearing modifications.

Vibration analysis on SC 2 continued from September to October 2020.

#### October 2020

In October GE Power completed the hydrogen detection system modifications on SC 2. Hydrogen filling of SC 2 was complete on October 17, 2020 and on-load testing was planned to commence in the week of October 26.

#### November 2020

In November dynamic commissioning continued on SC 2, the unit has been synchronized to the grid and tested with hydrogen up to 110MVAR output. With respect to the foundation work, 100% design phase was completed, and the drawings have been issued for construction. Foundation work on SC 1 was carried out concurrently with SC 3 elliptical bearing retrofit and its dynamic commissioning of SC 3. Decision on foundation remediation was pending at that time.

The SCs dynamic commissioning and vibration reduction were classified as 'critical work'. At the same time no SC's are required for Interim Bipole Software tests at less than 225 MW transfer. One SC and one Holyrood unit are required for 225-500 MW transfer. To test Final Bipole Software at 900 MW, two SC's or two Holyrood units on-line and three Muskrat Falls generating units on-line are required (Note: Holyrood will remain in operation until 2024). The third synchronous condenser at SOP is effectively a spare.

#### December 2020

In December GE Power completed dynamic commissioning of SC 2 and SC 3. Both units were synchronized to the grid and tested with hydrogen up to 130 MVAR load. After conclusion of commissioning tests for SC2 and SC3, GE Power reported that the elliptical bearing is a suitable solution to address the vibration issues. General Partner and the external technical experts reviewed the vibration report and discussed with GE Power logistical and commercial implications of the foundation remediation versus the elliptical bearing retrofit. A final decision on both the technical and commercial aspects was made in March 2021 (see section 3 for further information).

### 2.4 HVac Transmission Lines (LTA)

Scope is completed and the asset has been turned over to Operations.

Emergency replacements: As contingency, a design for wood structures was prepared for emergency as well as a design for composite poles for hard access area. Procurement for composite poles is in progress.

### 2.5 HVdc Transmission Lines LITL):

Scope is completed and the asset has been turned over to operations. With respect to HVdc Specialties, the only remaining construction for the CD0501-001 contract is to calibrate the Electrode Line Fault Locator (ELFL) system while online in bipole operation. GE requires resources from the UK to complete the work later this year.

On January 11, 2021, following an ice storm in Labrador, Power Supply - Operations discovered damage to the electrode line. Damage was isolated to five crossarms on Electrode Line 1 (EL1). Since then, additional damage to 36 spans has occurred on EL1 and Electrode Line 2 (EL2). Corrective maintenance will consist of conductor splicing, conductor repair or restringing, and repair/ replacement of 11 crossarms. As of February 22, 2021, 11 crossarms and 23 electrode conductor sections have been repaired. All repairs were complete on February 25, 2021 and both electrode lines are now available for use.

On February 3, 2021, during bipole dynamic commissioning, the LIL experienced an unplanned trip on Pole 2. Operations crews near Forteau, Labrador, found Pole 2 conductor has fallen to the ground. Investigation found failed eyebolt that secures the insulator to the dead-end tower. Second failed eyebolt was found on the same line in the vicinity (Note: Neither of those failures have been attributed to the ice storm. Contract resource was mobilized to execute the repair which was completed on February 18, 2021. Further inspections of the similar hardware in this area are planned.

On February 7, 2021, a span of conductor on EL2 failed causing ice to fall in the vicinity of workers below. In order to minimize the risk of working on the repairs, third party with experience in removing ice from transmission lines was contracted to reduce the ice loading on the lines. Ice removal was complete on February 16, 2021.

On February 21, 2021 after completion of repairs to Pole 2 and EL1, LIL was reenergized and transmitted power to the island in bipole mode. Root Cause Analysis is underway on both of these issues and further preventative work may be required.

Emergency replacements: As contingency a design of wood by-pass structures was prepared for the case of emergency. Procurement for major items is in progress.

### 3. STATUS AS OF MARCH 2021

#### 3.1 Muskrat Falls

- *Unit 1: Unit 1 was released for service and transferred to operations on December 22, 2020. Unit 1 February inspection showed no issues.*
- *Unit 2: As noted earlier, while undertaking the head cover joint modifications Andritz identified weld defects on the head cover stiffener plates. These welds are deemed critical, and a repair plan has been developed to rectify the stiffener plate welds. Andritz is undertaking analysis to confirm whether other welds may require inspection and rework. The head cover joint modification and weld inspection/rectification will be undertaken on Units 1, 3, and 4. Unit 1 requires monthly inspections and/or inspection after unit overspeed. Rework will be scheduled during a planned outage. Rework for Units 3 and 4 will be completed prior to commissioning.*
- *Unit 3: Assembly is near completion. Installation/assembly is approximately 96% complete. The head cover modification and weld inspection/rectification will be completed prior to commissioning.*
- *Unit 4: Rotor has been installed. Installation/assembly is approximately 79% complete. Head cover modification and weld inspection/rectification will be completed prior to commissioning.*
- *Balance of Plant: Work is continuing on the following systems:*
  - HVAC priority systems commissioning
  - HVAC Heating systems for North, Center and South dams
  - HVAC and Fire Water seismic restraints

- Temporary and Permanent Heating Solutions
  - Fire Proofing Cement Board Installation
  - Hatch cover for oil water separator
  - Fire caulking and painting doors
- *Spillway*: Contractor has substantially completed all planned 2020 repairs to the spillway gate guides, guide heaters, and secondary concrete in all spillway bays.
  - *Intakes*: Similar to Unit 1 some concrete defects were uncovered in the bay 1 water passage of Unit 2. Repair using epoxy filler is planned for the end of March 2021. Unit 3 and 4 intakes' concrete is to be assessed during the Wet Commissioning phase of the respective unit.
  - *Dam Safety*: Ongoing dam safety monitoring includes visual inspections and instruments to measure piezometric pressures, seepage flows, displacements, and seismic shaking. Some instruments are read manually, and others are connected to dataloggers or an automatic data acquisition system. Dam safety monitoring observations and recorded instrumentation data are reported in Dam Safety Weekly Monitoring Reports.

The reservoir has been maintained at a steady level since being filled to full pool in September 2019. The downstream tailwater level has varied within a total range of about 3 m, depending on seasonal conditions and the flow volume being passed through the dam. Dam safety instrumentation in the dams and their foundations showed some initial response to reservoir filling. Since then, most instruments have shown stable conditions with some small cyclic trends that appear to be related to seasonal temperature variations. Seepage flows in the dam galleries are very low. Some periodic sharp spikes in flows in the north RCC dam are reported to be caused by water entering the gallery through contraction joints due to wind-driven wave splash-up, or due to melting ice or snow on the dam crest.

Survey monuments on the dams have been surveyed annually since reservoir filling. There have not yet been enough surveys to reliably identify any trends, but the displacements interpreted to date are very small.

The upstream and downstream slopes on the North Spur are reported to be stable and in good condition. There are some local areas of surficial erosion of sand by wind and surface runoff on the upper slopes which are not of concern. Nalcor has been hydroseeding and planting alders in these areas which should eventually stop such erosion.

Dam safety instrumentation indicates that there have been no movements in the North Spur since reservoir filling. Piezometers near the northwest seepage cutoff wall show little to no response to reservoir filling, which is considered to indicate that the cutoff wall is performing well. Piezometric levels in the lower aquifer of the North Spur continue to vary with the downstream tailwater level. Piezometers in the intermediate aquifer mostly indicate stable levels; some of these instruments still show small gradually increasing levels that are interpreted to reflect that groundwater levels in that geologically complex aquifer may still be adjusting to the regional effect of the new reservoir.

An accelerometer installed on the North Spur has not been seismically triggered since the reservoir was filled.

In summary, there have been no anomalous responses or behaviour recorded, and no dam safety concerns have been identified.

### 3.2 Labrador Island Link

- *Software Development*: Dynamic commissioning tests for the Pole 1 were completed on December 15, 2020 followed by a period of power transfer over Pole 1 until Pole 2 was ready to start dynamic commissioning on January 7, 2021. Pole 2 dynamic commissioning tests were completed on January 31, 2021 including successful 225 MW heat run tests



on both Pole 1 and Pole 2. Bipole dynamic commissioning tests recommenced on February 24, 2021, followed by the start of Limited Function Bipole Trial Operations on March 19, 2021. Final Bipole Software development is ongoing at GE Grid's facility in Stafford, England. The February 2021 Independent Third Party (ITP) Audit Report notes that GE Grid's schedule has slipped by approximately one month, and as a result the forecasted milestone dates were reported as follows: FAT complete on July 29, 2021; Dynamic Commissioning complete on September 7, 2021; and Trial Operations start on Sept 7, 2021. Nalcor has updated its Integrated Project Schedule (IPS) to reflect GE Grid's FAT completion date of July 29, 2021, followed by forecast for Dynamic Commissioning complete on Sept 14, 2021, start of Trial Operations on September 15, 2021, and completion of Trial Operations on November 14, 2021. Discussions on overload testing at 900MW are ongoing. According to Nalcor the High-Power Testing milestone will be determined based on availability of power from Muskrat Falls and Churchill Falls.

- *SOP and MF Converters:* With respect to the final valve hall remediation plan, replacement beam prototype has been designed and manufactured and is currently at GE Grid's facility in Stafford, England undergoing testing. GE Grid's current schedule for start of beam manufacturing has slipped from early March to late March 2021. As a result, beams for Pole 1 will be complete by the end of April 2021 and beams for Pole 2 will be complete by the end of May 2021. Currently GE Grid is scheduled to start the beam replacement campaign in May 2021 and finish in June 2021. This work is within the current schedule and not on project critical path.
- *SOP Synchronous Condensers:* The CD0534-001 Contractor, GE Power, completed all planned commissioning tests for SC 2 and SC 3. In March 2021 LCP notified GE Power that they can proceed with their elliptical bearing approach. Work has commenced on SC 2 to remove the 4-lobe bearing in preparation for receipt of the 2-lobe elliptical bearing from American Babbit in early March 2021. Series of commissioning tests have to be performed before start of Trial Operations. Currently all three synchronous condensers are scheduled to be complete by August 2021. The schedule will be updated to reflect the elliptical bearing approach.

## 4. OUTSTANDING ISSUES

### 4.1 LIL- Operation in Monopole 'Overload' Mode

This automatic sequence transfers load from failed monopole to the healthy one. This is one of the most important functionalities of the Final Software and it was required by the Operations in order to maintain the grid/system stability during loss of one pole and to mitigate the risk of underfrequency load shedding and/or system blackouts. Nalcor's position is that full load test poses significant risk to the grid, 900MW is not yet available and the contractual obligation with GE is established by the maximum power transfer available at the time of commissioning. Therefore, acceptance of the LIL from GE may occur without an actual test at the ambient temperature established overload transfer limit. In order to be confident GE has delivered the 900MW capability, tests up to available power supplemented with FAT and other testing will be relied on.

IE is of the opinion that in order to verify the functionality of overload mode systems, to confirm basis of design and to comply with the GE Grid contractual requirements for Testing and Commissioning, full load tests should be conducted on each pole via their Lane 1 and Lane 2 control computers. Official resolution is pending.

### 4.2 Unit 1 Failed Bar

By-passed bar in slot #517 needs to be replaced (refer to December 2020 event above).

### 4.3 Unit 2 Headcover Joint Bolt Failure and Weld Deficiencies

Along with the headcover bolt replacement and addition of dowels, weld defects on the head cover stiffener plates were remediated. Integrity of those welds is deemed critical and Andritz is undertaking analysis to confirm whether other welds may require inspection and rework. Unit 1 requires inspections monthly and/or every time after the unit is subjected to overspeed. Retrofit of redesigned bolts and dowels between the two covers is required (refer to November 2020 incident on Unit 2 above). These issues will be addressed on Units 3 and 4 as part of the installation activities.

### 4.4 MF- Emergency Stop and Emergency Intake Gate Close

In December 2018 IE reviewed MF Emergency Stop circuit arrangement and pointed out to Nalcor that good utility practice for design of hydroelectric powerplant emergency flow shut- off sequences consists of directly wired and independently powered intake gate close circuits. Contrary to that, MF intake gates emergency close circuits are wired via 86F lock-out relays powered by shared 125 Volt DC protection panel supplies. That introduces single points of failure and unwanted additional link in the circuit.

In addition, there is an intake gate Emergency Close function, added due to apparent need to drop the intake gates without tripping the unit. This design assumes that during this Emergency Close operation the unit will be safely tripped by the reverse power protection relays when the water flow drops off. Such an arrangement introduces an indirect permissive function that is not in accordance with good utility practice for design of emergency commands.

Nalcor advised that the Emergency Stop and Emergency Close design was specified by their engineer of record, executed by Andritz who assume the responsibility for their approach, and it was accepted by the Operations. Nalcor communicated they are aware of IE concerns pertaining to the design of the MF emergency commands. It remains a matter of record that the IE does not accept either solution. Nalcor is reviewing the IE's latest memo on this subject and will arrange a technical briefing in Q2 2021 to review further.