From: Carter, Paul
To: Coffey, Bernard (Clerk of the Executive Council)
Subject: FW: July"16 IE Ste Visit Report
Date: Tuesday, November 22, 2016 3:11:23 PM
Attachments: 2016-09-09 Nalcor -July 11 to 15 2016 IE Site Visit Report.pdf

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Bern, Can you call me on this. See attached. Paul 691-6503

From: StevePellerin@lowerchurchillproject.ca [mailto:StevePellerin@lowerchurchillproject.ca]
Sent: Tuesday, November 22, 2016 11:24 AM
To: Carter, Paul
Subject: Fw: July'16 IE Ste Visit Report

I got this yesterday evening.........this file will be posted to the Project website.

Stephen Pellerin
Special Projects & 3rd Party Coordination Manager
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----- Forwarded by Steve Pellerin/NLHydro on 11/22/2016 11:23 AM -----

From: "Nik Argirov" <nik@argirovglobal.com>
To: "'Krupski, Joseph \(NRCan/RNCan\)'" <joseph.krupski@canada.ca>, "'John Medland'" <jmedland@blairfranklin.com>, <amanzer@casselsbrock.com>, "'Sullivan, Peter J.'" <psullivan@casselsbrock.com>, <emilia.casado@tdsecurities.com>, <JamesMeaney@lowerchurchillproject.ca>, "'Martis_Xeno'" <xmartis@fasken.com>, "'Soomro, Humayun \(NRCAN/RNCAN\)'" <humayun.soomro@canada.ca>, "'McHattie, Joseph \(NRCan/RNCan\)'" <joseph.mchattie@canada.ca>, "'Dickson, Samantha M \(NRCan/RNCan\)'" <samantham.dickson@canada.ca>, <tanyapower@lowerchurchillproject.ca>, <StevePellerin@lowerchurchillproject.ca>, "Martina Mishkova" <Martina.Mishkova@mwhglobal.com>
Date: 11/21/2016 06:34 PM
Subject: RE: July'16 IE Ste Visit Report

Please find attached the final issue of the July 11-15'16 IE Site Visit Report – Nalcor.
Due to a minor typo on p.3 correction please replace the earlier issue with this one (the final).

Regards,
Nik

From: Nik Argirov [mailto:nik@argirovglobal.com]
Sent: Wednesday, November 2, 2016 11:44 AM
To: 'Krupski, Joseph (NRCan/RNCan)' <joseph.krupski@canada.ca>; 'John Medland' <jmedland@blairfranklin.com>; 'amanzer@casselsbrock.com' <amanzer@casselsbrock.com>; 'Sullivan, Peter J.' <psullivan@casselsbrock.com>; 'emilia.casado@tdsecurities.com' <emilia.casado@tdsecurities.com>; 'JamesMeaney@lowerchurchillproject.ca' <JamesMeaney@lowerchurchillproject.ca>; 'Martis_Xeno' <xmartis@fasken.com>; 'Soomro, Humayun (NRCAN/RNCAN)' <humayun.soomro@canada.ca>; 'McHattie, Joseph (NRCan/RNCan)' <joseph.mchattie@canada.ca>; 'Dickson, Samantha M (NRCan/RNCan)' <samantham.dickson@canada.ca>;

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Subject: July'16 IE Ste Visit Report

Please find attached the July 11-15’16 IE Site Visit Report - Nalcor.

Regards,
Nik

MWH

MEETINGS IN ST. JOHN'S AND VISITS TO LOWER CHURCHILL PROJECT SITES, JULY 11 TO 15, 2016

Prepared for: Natural Resources Canada and Nalcor Energy

IE Point of Contact: Nik Argirov

Date: November 2, 2016

Quality Assurance Statement

Office Address	740-1185 W Georgia Street, Vancouver BC, V6E 4E6
Prepared by	John Young, Paul Hewitt and Nik Argirov
Reviewed by	Nik Argirov and Howard Lee
Approved for Issue by	Howard Lee

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TABLE OF CONTENTS

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1. GENERAL

The Independent Engineer (IE) team, together with a representative of Natural Resources Canada (NRCan) attended project briefings at the Lower Churchill Project delivery Office in St. John's and participated in site visits to various construction sites during July 11 to 15, 2016. Site visits were made to project works sites in Muskrat Falls, Churchill Falls, and Forteau in Labrador, and to Shoal Cove and Soldiers Pond on the Island. Joe Krupski represented NRCan on the site visits, the Independent Engineer was represented by Nik Argirov (IE Team Lead), John Young (IE Geotechnical Subject Matter Expert (SME)), Paul Hewitt (IE Cost & Schedule SME) and Hamdy Khalil (IE Transmission Lines SME). Representatives from the Government of Newfoundland & Labrador included Cluney Mercer and Cory Grandy. The itinerary and activities were as follows:

- Monday, July 11: A project briefing was carried out by NALCOR supervisory staff in the SNC/Nalcor Project offices in St. John's. The briefing presentations covered various aspects of the work and project progress.
- Tuesday, July 12:
  - AM: Charter flight from St. John's to St. Anthony for site tour of the Shoal Cove cable landfall and transition compound work sites. Witnessed the final landing pull in of Cable No. 2 from the inclined borehole.
  - PM: Travel to the Forteau site by chartered aircraft and bus to tour the cable landfall facilities and progress on the transition compound facilities. Returned to St. John's by chartered aircraft in the evening.
- Wednesday, July 13:
  - AM: Travel to Goose Bay from St. John's by Air Canada.
  - AM and PM: Tour of the dam works, spillway, Powerhouse and switchyard at the Muskrat Falls site.
  - Overnight in Goose Bay.
- Thursday, July 14
  - AM: Inspection tour of the North Spur.
  - PM: Team traveled to Churchill Falls via NALCOR's King Air to inspect the switchyard facilities works. Returned to Goose Bay in the late afternoon. John Young separated from the team at noon and spent the afternoon touring the Muskrat Falls South Dam foundation and various grouting works with a Nalcor geotechnical specialist.
  - All the team flew to St. Johns by Air Canada flight in the evening.
- Friday, July 15:
  - AM visit to the Soldiers Pond site.
  - Wrap-up meetings at Nalcor's offices in St. John's.

Principal observations and comments are presented in the following paragraphs. Labeled photographs are presented in Appendix 1.

2. SHOAL COVE

Construction of the Shoal Cove facilities was at an advanced stage at the time of the July 12 site visit. Photographs taken during the visit are presented in Appendix 1, Section A. The following items were observed:

- Submarine Cable # 1 had been pulled ashore during the recent past and is awaiting splicing with the land cable (Photos A. 1 and A.2)

- The cable laying vessel Skagerrak was about 2 km offshore and work was underway towards completing the installation of the Shoal Cove end of this cable during the IE site visit. Pulling of the cable was completed during the early afternoon while the IE team was still at the site. (Photos A.3, A.4, A.5 and A.6).

- Work on the landward buried cables has been completed and the cable route has been graded and covered with concrete paving stones (Photos A.7 and A.8). A small creek crosses the mid-point of the buried cables (Photo A.7). Additional works are planned to increase erosion resistance in the area above the cables.

- A number of HVdc towers near the Shoal Cove site were viewed (Photo A.9). It is understood that there are significant delays in executing work for the HVdc transmission line.

- Work on grading, foundation construction and preliminary concrete works for the transition compound facility is well advanced (Photos A10 to A.12). In general, most of the ongoing work is focused on foundation construction for the facilities.

It is understood that site work is generally on schedule. It was observed that construction work is being done to a high standard of quality.

3. FORTEAU

The following observations were made during the July 12, 2016 site visit to the Forteau work site. Photographs taken during the visit are presented in Appendix 1, Section B.

- Submarine cable # 1 has been already pulled ashore at Forteau (Photo B.1) and work on splicing it to the land cable was underway at the time of the IE site visit (Photo B.2). The inclined boreholes for submarine cable # 2 and # 3 are completed and have the messenger lines installed (Photo B.3) waiting for submarine cables pull in.

- Work on the landward buried cables has been completed and the cable route has been graded and covered with concrete paving stones (Photo B.4).

- Virtually all site preparations, including site grading excavations and fill placements, have been completed in the transition compound area. In general, most of the ongoing work is focused on foundation construction for the facilities (Photos B.5 and B.6).

It is understood that site work is on schedule. It was observed that construction work is being done to a high standard of quality.

4. POWERHOUSE

Work on the Muskrat Falls Power Intake/Powerhouse/Tailrace was ongoing at the time of the IE site visit, however, Astaldi's progress on the Powerhouse construction is considerably behind the original baseline schedule. This work is on the critical path and directly impacts initial power generation at Muskrat Falls. Construction rates have been significantly improving during the past year, however, there has been a noticeable decline since the formwork collapse at Unit 2 on May 29, 2016. Safety investigations were still ongoing as result of this incident and construction activities around the collapsed formwork were still banned by a stop work order. Nalcor is currently evaluating new completion dates for the works and will release them in the near future.

Observations made during the July 13, 2016 IE site visit include the following:

- It is reported by Nalcor that about 26% of concrete placement has been completed (80,600 m^3 of the required 310,000 m^3 for the powerhouse/intake complex).

- Concrete works for the waterways and lower sections of the piers between the units is at an advanced stage (Photos C.1, C.2, C.3, C.4 and C.5).

- Work is progressing on concrete placement of the intakes and draft tubes of the four units (Photos C9 to C.13).

- A formwork failure at the draft tube of Unit 2 occurred on May 29, 2016 where 528 m3 of concrete was released into the lower draft tube. No personal injuries occurred although a number of workers were inundated in wet concrete and had to be rescued. The OHS issued a “stop work” edict for all draft tube construction at that time. This has been mostly rescinded for Units 1, 3 and 4 where new work is currently progressing. The “stop work” edict was still in place for Unit 2 at the time of the July 13 IE visit and no formwork repairs or cleanup of the spilled concrete (Photos C.10 and C.11) had been done due to the OHS restriction. Design issues, faulty materials (some of the formwork timbers suffered from dry rot) and shoddy construction have been identified as potential contributing factors in the incident. Formwork in Draft Tubes #3 and #4, as well as plans to reconstruct formwork for #2 were under review at the time of the site visit and both wood and steel forms systems were under consideration. An example of poor construction work could be seen in old formwork in Unit 3 (Photo C.12) where the steel column is misaligned with the wooden beam that it is supporting.

- Except for the situation at Unit 2, it was observed by the IE that the construction works quality is of a high standard.

5. SPILLWAY

At the time of the July 13 site visit, preparatory works for river diversion were being carried out. Concrete work in the spillway was essentially completed and installation of the five gates was being finalized during the IE site visit. At that time, only eight major concrete pours remained to complete the works on the downstream spillway apron. Photographs taken during the visit are presented in Section D of Appendix 1.

- Concrete works for the spillway structure were essentially completed at the time of the IE visit on July 13, 2016 (Photo D.1).

- All 5 gates have been installed and final detailing was being carried out (Photos D.2, D.5 and D.7).

- Work on the concrete transition dam between the powerhouse and spillway structures is essentially completed (Photo D3).

- Preparatory works were underway in the upstream channel, including removal of wire mesh slope protection from the rock slope were being carried out (Photos D.8, D.9, D.10 and D.11). The new temporary construction bridge across the intake channel has been erected (Photos D.8 and D.9).

- Demolition of the RCC cofferdam adjacent to the spillway was substantially completed at the time of the IE site visit.

- Final preparatory works have been carried out in the channel floor area downstream of the concrete apron. This consisted of tensioned rock bolts to effect erosion resistance and dental concrete placement in rock depressions (Photos D.12, D.13 and D.14).

- It was observed by the IE that the construction works quality is of a high standard and that activities were on tract for river diversion in mid-July, 2016.

6. UPSTREAM COFFERDAM

At the time of the IE site visits some preparatory work was being carried out on the rock fill starter berm on the right bank of the river (Photo D-14). Since that time the upstream berm has been extended across the river to facilitate diversion through the spillway. The IE reviewed the cofferdam design and the following comments are presented.

The Muskrat Falls Upstream cofferdam is a 450 m long embankment structure located upstream of the planned main RCC dam. It will be approximately 24 m high and consists of lower dumped starter dam topped off by a compacted fill embankment dam, as shown on Figure 6.1 below. The starter dam is a 5 m to 12 m high structure, that consists of two rock fill groins constructed from the riverbed up to el. 17m (upstream) and el. 14 m (downstream) with a dumped till impervious zone placed in between them. Dumped transition rock fill zones are placed on the groin slopes upstream and downstream of the impervious zone and a granular filter zone will be sandwiched between the downstream impervious and transition zones. A 12 m high conventional center core embankment dam will be constructed on top of the starter dam up to el 26 m. The overall design of the cofferdam is conventional and in line with accepted practice. The IE believes, however, that there is some risk of relatively high foundation leakage in a few areas, as discussed in the following paragraphs:

The rockfill groins of starter dam will be placed on the natural riverbed. The impervious fill zone will be about 12.5 m wide at the base and will be placed on the cleaned riverbed between the groins. Much of the impervious foundation will not likely be fully dewatered because of copious water flow. Due to likely water inflows hand/air pressure cleaning will not be possible for much of the foundation and these areas will be machine cleaned with backhoes. Most of the riverbed bedrock foundation will have been scoured clean by river flows and will provide a good seal at the base of the impervious fill. In submerged areas that have not been scoured by the river, machine cleaning will remove most of the debris and overburden from the bedrock surface. It is possible, however, that the machine cleaning will miss some debris materials or zones of disturbed, broken rock.

The IE submits that there is a risk of serious leakage in submerged foundation areas where debris, boulders, broke/disturbed rock have not been completely removed by machine cleaning. Significant water flows can generate extra costs in terms of schedule delays, beneath the impervious zone. It appears that the designers have considered this risk by including the contingency jet grouting in the design. Details of the contingency jet grouting program are shown on Drawing MFA-SN-CD-2340-CV-SE-0002-01 Rev C2. The grout holes would be drilled through the core into the permeable material at its base. The IE notes that jet grouting will be very effective in sandy or granular overburden, but will have limited success in open-work boulders or broken rock.

The July 3, 2016 Barnard Pennecon North & South Dams Work Plan document is in line with current practice for cofferdam construction. This document describes the planned machine cleanup and final bathymetric surveys for the foundation area between the groins. This plan is acceptable. However, no details of the contingency grouting are presented or discussed. It is not clear if the contractor has made any provisions to do this work if it proves to be needed. Jet grouting requires specialized equipment and long delays can be incurred if this has not been procured in advance.

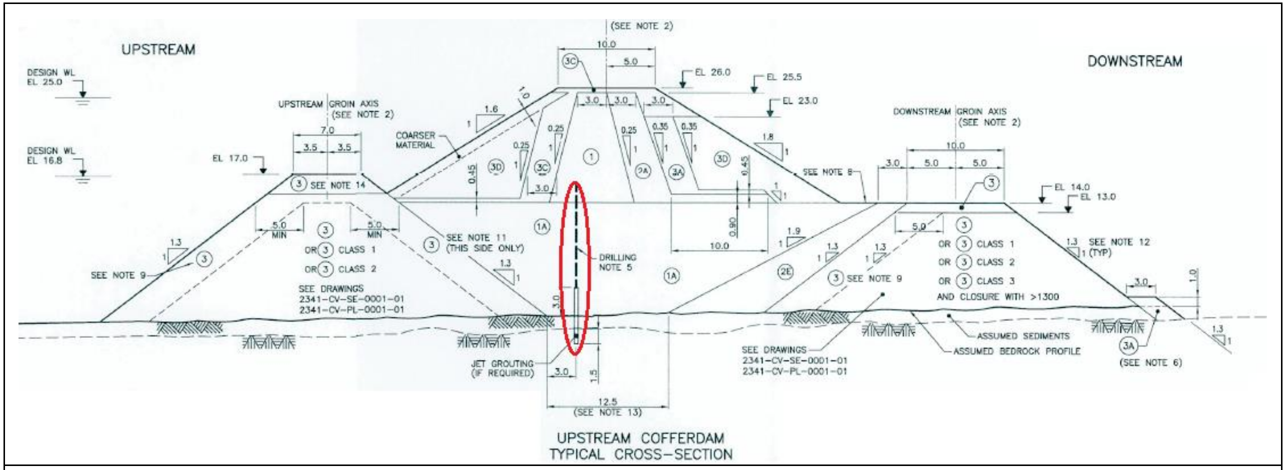

Figure 6.1: Upstream cofferdam cross section. Provisional cutoff curtain outlined in red.

The IE recommends the following actions:

- Barnard Pennecon should supplement its work plan with a contingency plan for dealing with unexpectedly high water flows through the cofferdam foundation. This must include plans for pumping leakage water downstream of the cofferdam and construction of a cut-off through the base of the core if needed.

- The cut-off can be the jet grouting scheme proposed by the designers on Drawing MFA-SN-CD-2340-CV-SE-0002-01 Rev C2 (see Figure 6.1 above). Alternatively, a local slurry cut-off wall could be constructed using equipment already present at the site. It is noted that a slurry cut-off is better suited for dealing with open-work boulders than jet grouting.

- The contractor should demonstrate that equipment can be available on a timely basis to deal with unexpected foundation water inflows so that the potential impact on schedules is minimized.

7. NORTH SPUR

Construction work on the slope stabilization measures at the North Spur was proceeding well at the time of the July 14, 2016 IE site visit. Photographs taken during the visit are presented in Appendix 1, Section E. The site visit observations are summarized as follows.

a) Upstream Slope

- All excavation of the upstream slope is completed (Photo E.1).

- Fill placement, including slope protection rip rap was proceeding as per plan (Photos E.1, E.2 and E.3). It was projected that the top of fill placement would be at El 39.0 m in many areas. Rip rap/slope protection will be well above minimum elevation of El 27.0 m by the time river diversion takes place. This will be sufficient to contend with river diversion and reservoir impounding during construction period. The projected completion of all fill placement will be October 31, 2016.

- In the north end of the slope, where the wall is completed, the impervious blanket has been placed up to el 28m. The impervious blanket consists of compacted silty till, overlain by a granular transition zone.

- The Upstream Cutoff Wall is completed.

- Bedrock is exposed near the rock knoll at the south end of the North Spur (Photo E.6). This is a competent granitic rock. The surface of the rock has been cleaned to an acceptable standard and locally forms the base of the impervious till blanket above el 20m.

b) Downstream Slope

To date, and in accordance with the planned schedule, relatively limited work has been carried out in the downstream slope area. The following items were observed during the site visit:

- Approximately 85% of the downstream slope excavation has been carried out.

- A toe berm has been excavated and some slope trimming has been done in the lower slope (Photo E.8).

- Work on the finger drains was at an advanced stage. Excavation and fill placement was being carried out on finger drain no. 3 and on one of the connected upper drains at the time of the IE site visit (Photos E.11 and E.12).

- Rip rap, underlain by a granular transition zone, has been placed on the permanent slope below the toe berm.

c) North West Cutoff Wall

- Work on the North West Cutoff Wall was underway using a clamshell bucket mounted on a crane (Photos E.14 and E.15). Current work was along the section east of the central access road. This wall, which is approximately 39 to 40 m deep in this area, was approximately 21% complete at the time of the IE site visit.

- The wall depths are currently in the range of 39 to 40 m at the present location. Like the upstream Cutoff Wall, the North West Cutoff Wall is being placed in a single step. The final bentonite/cement mixture was added during excavation to; (a) be a stabilizer to keep the trench open, and (b) to be left in place to set and become the final cut-off wall. The slurry is a plastic bentonite / cement mixture with a minimum 14-day strength of 300 to 400 KPa. Batching quantities are as follows:
  - 1000 kg water
  - 140 kg cement (90% slag cement, 10% GU cement)
  - 35 kg bentonite
  - 1.5 l Aquatix (fluidizer which also retards the set)

- The cutoff wall is being excavated through the upper sand and stratified drift zone (formally known as upper clay) down to the top of the lower clay. The base of the wall was embedded a minimum of 2 m below the top of the plastic lower clay. The cohesive, plastic lower clay has different properties from the upper clay silt and is readily identifiable during excavation (Photos E.16 and E.17).

- A program of quality control is carried out during the cutoff wall construction. Depth and alignment are monitored by an electronic monitoring system provided by Jean Lutz s.a.. Regular field testing of the slurry consists of density, marsh cone viscosity and bleed. Other laboratory testing is carried out on slurry samples.

d) North Spur Geological Notes

- The Upper Sand and Stratified Drift units are exposed in the upstream and downstream slopes above approximately el 17m (upstream water level) and 5 m respectively. The reported highly sensitive clay zones occur in the upper clay. LCP team reports that the material is most interlayered sand and silt (Photo E.11). Most of the layering is discontinuous and most layers pinch out horizontally.

- There are numerous water seepages from sand layers in the excavated faces. This causes minor localized washouts but has not caused any significant geotechnical issues. Temporary slopes in the sands and silts are very susceptible to erosion but once again this is not a problem since the slopes will be covered by erosion resistant material.

- As reported in our previous November 2015 visit report, NALCOR and site engineering staff have indicated that very few manifestations of high sensitive or "quick clay" behavior in clay/silt materials have been reported during excavations of the North Spur. In most cases, it was observed by geotechnical site staff that excavated material adhered together in clumps, even after dumped into the haul trucks. This is unlike typical "quick clay" materials which would normally lose cohesion and liquefy to slurry after such rough handling. Also, the north-west cut-off wall trench panels were stable during excavation in the upper sands and stratified drift and no liquefaction of materials was noted during excavation works.

- A unique occurrence of "very sensitive" or "quick clay" occurred at an area of the downstream slope during excavations in late 2015. Nalcor reported in November 2015 quick clay at excavations in a localized area. This material liquefied when being placed in the dumps of the trucks and flowed back out of the trucks as they proceeded upgrade. Nalcor/SNC geotechnical staff informed the IE in January, 2016 that material is local and, so far, is limited to two pockets of material. They reported that only single layers have been identified and the strata is not continuous along the downstream area. It was stated that layers were identified at elevations varying between 27 m and 25 to 22 m in the area of station 0+350 and at elevations varying between 33 m and 30 to 28 m in the area of station 0+410. According to site staff, high sensitive clays had been expected and included in slope designs but the amount encountered to date is far less than expected.

- A project meeting was held in the offices of SNC in Montreal on 14 January 2016 to discuss geological features of the North Spur. Two features were included in the discussion:
  - An anomalous feature in the upstream slope, located above el 27.0 m near the transition between the Upstream and Downstream cutoff walls. This feature had anomalously inclined bedding and could be a result of relict slope movements or melting of an embedded glacial block (described in the November 2015 IE site visit report).
  - The November, 2015 occurrence of liquefiable material in the downstream slope described above.

  It was noted during the January 2016 Montreal meeting that very little information was being documented or mapped by site staff about geological features. It was agreed that geological mapping of surficial geology and soil mechanics related features would be done in the future. The IE geotechnical specialist reviewed the current information with site staff during the July 2016 site visit. The following items of field documentation were being completed at that time:

  - A 1/500 surficial geology map has been done of the upstream face. This shows the outlines of the main soil units as encountered in the excavation. Very little geotechnical information concerning items such as water seepage lines, local slumps/structural anomalies or sample locations was recorded

- No "as built" geological mapping plots have been done of the downstream slope. The locations of liquefiable material are generally known but they have not been surveyed or plotted on a suitable map. The IE was informed that this information is recorded and that mapping compilations will be done later, however, no factual or surveyed information was shown by the site staff. In view of the critical nature of liquefiable soils in the slope, the IE contends that a much more systematic review of surficial geology is needed. In particular, the presence of major water seepage, location of known liquefiable materials and their relationship to known stratigraphy is crucial. This information could be crucial if there is ever a slope stability incident or other occurrence which requires an external review of previously documented information.
- A number of soil samples have been taken and sent to the laboratory for soil mechanics classification testing. Several test results were shown to the IE. It is understood that more test data would be forthcoming in the near future. This data should be integrated with available geological mapping data to establish the "as built" geological model.

8. SOUTH DAM, INTAKE COFFERDAM AND GROUTING WORKS

The IE geotechnical specialist, together with the Nalcor site geotechnical engineer, reviewed the South Dam Foundation preparation area, intake cofferdam fill placement works and grouting operations in the galleries of the Powerhouse Intake Structure and the Spillway Gate structure. The following observations were made:

- Foundation preparation works for the Muskrat Falls South dam were inspected. This structure will be a center core embankment dam between the south side of the spillway intake transition dam and the right bank of the Churchill River. Photographs are presented in Appendix F. At the time of the site visit the bedrock under the core had been exposed (Photos F.1, F.2, F.3 and F.4). Foundation cleaning and grout curtain work were being carried out. The bedrock consists of widely jointed, slightly weathered to unweathered granitic gneiss. The foundation runs along the natural bedrock surface which is irregular with local relief in the order of about 1 to 2.5 m (Photos F.3 and F.4). There are zones of loosened rock and a few steeply inclined low scarps (Photo F.3). Remedial works consist of local dental excavations to remove loosened material and localized backfill concrete/mortar to smoothen out the topography and flatten steep scarps in some areas. Detailed topographical surveys and geological mapping is being carried out as part of the foundation documentation. All the geotechnical and foundation preparation works are being carried out to a very high standard.

- Fill placement work and internal zoning for the embankment Intake Cofferdam are shown on Photo F.5. This work is proceeding on schedule and is being done to a high standard.

- Grout curtain work was being carried out in the foundation of the South Dam and in grouting galleries at the bases of the Powerhouse Intake and Spillway Gate structures during the site visit. Photo F.6 shows the grout monitoring equipment being used in the South Dam foundation and photos F.7 to F.9 show grouting work being carried out in the Powerhouse Intake Grout Gallery. Equipment being used in the Spillway gallery is shown on Photos F.10 and F.11. The following observations were made by the IE:
    - The grouting is being carried out by the Grout Intensity Number (GIN) method. This method uses a single "stable" mix and follows injection volume/pressure criteria computed with the GIN formula. Strict controls of grout viscosity and cohesion are carried out by simple field tests (Photo F.10) and follow-up laboratory testing. Injection pressures and grout volumes are controlled with computerized electronic monitoring (Photo F6). GIN grouting is ideally suited for competent, hard rock like the Muskrat Falls granitic gneiss and achieves a superior result as compared with conventional multi-mix grouting.

- o The drilling is being carried by rotary, cored drilling methods (Photo F.7).
- o In the galleries, the drill holes are being drilled through preplaced grout sleeves in the concrete floors into rock (Photo F.9). All holes are steeply inclined towards the upstream direction.
- o The nominal grout pattern in the surface grouting of the South Dam foundation calls for vertical holes. It was noted that the vertical holes are being supplemented by inclined holes in areas of prominent subvertical fractures. This enables better grouting of these fractures. This excellent practice is a good example of the integration of geological information for optimizing grouting design.
- o Grout holes drilled in the surface foundation of South dam are being collared in the natural rock surface. This acceptable practice is in most areas where the rock is massive and surface leakage potential is very low. However, the project should consider the use of a grout cap in areas of fractured rock where surface leakage might prevent thorough grouting of rock immediately beneath the rock surface. A grout cap is a block of concrete poured into a vertical sided trench approximately 1.2 m wide and about 1 m deep. The grout cap enables the use of pressure at the rock surface which enables better spreading of grout in near-surface fractures.

9. MUSKRAT FALLS SWITCHYARD

The following observations were made during the July 13, 2016 site visit to the Muskrat Falls Switchyard (photographs of this site are presented in Appendix 1-Section G):

- At the Convertor Station, all concrete interior works were completed. Valve hall pole 1 and 2 were substantially completed with minor punch list items remaining. The roofing installation was completed at the valve halls and was in very advanced stage at the control room. All transformer pads and containment pits for Pole 2 were completed and those for pole1 were in very advanced stage with completion scheduled for the end of July'16. Work on the fire walls for both, Pole 1 and 2 was underway (Photos G.1 and G.2).

- GIS building foundation repair work was near completion. The steel frame of the building was half way in place. The balance of the structural steel was to be erected upon completion of the foundations' repair work (Photos G.3, G.4 and G.5).

- The neighbouring Control Building concrete foundations were in advance stage of completion (Photo G.6).

10. CHURCHILL FALLS SWITCHYARD

A site visit was made to the Churchill Falls Switchyard on July 14, 2016. Photographs are presented in Section H of Appendix 1. The following observations were made during the visit:

- All cast in place gantry footings and precast concrete piers were completed, including those at the interconnection extension to the main switchyard (Photos H.1, H.2 and H.9).

- All transformers were installed on the finished concrete pads/containment pits and assembly dressing was well underway and close to completion (Photos H.3 and H.4).

- GIS building was fully assembled (Photos H.5 and H.6) and the Control building foundations work was nearing completion (Photo H.7).

- Civil works at the interconnection point to the existing Churchill Falls Switchyard were ongoing (Photo H.10).

11. SOLDIERS POND

At the time of the July 15th site visit the construction work was proceeding well with many activities underway. Photographs taken from this site are presented in Appendix 1, Section I. The following observations were made during the site visit:

- At the Convertor Station, all concrete interior works were completed. The roofing installation was in progress as well as interior steel erection and installation of wall panels (Photos I.1, I.2 and I.3). All transformer pads and containment pits were completed and protective coating operations were on the way (Photos I.4, I.5, I.6 and I.7). Backfilling and site grading were ongoing.

- The Convertor oil/water separator (Photo I.8) at the southern end of the site was also completed and partially backfilled.

- Cast in place footings and precast piers were ready for erection of gantries and post supports for various equipment (Photo I.9). Trenching for duct banks work was underway.

- The assembly of the pre-engineered control building was near completion (Photos I.10 and I.11).

- At the Synchronous Condenser (SC) building the main floor concrete slab as well as the machine foundations for unit 1 and 2 are completed (Photos I.12, I.13, I.14 and I.15). HVAC installation was ongoing in the electrical gallery and at the mezzanine level. Installation of steel studs, masonry and mechanical rough-ins was also taking place on the mezzanine floor. Grounding installation was ongoing throughout the building.

- Works on the roof installation were underway.

- SC Transformer contractor has completed all testing on the transformers and has demobilized from site.

- Works on the three SC Exciter Transformer concrete foundations were ongoing and nearing completion (Photo I.16).

- Testing of the oil/water separator has been completed and the tank was partially backfilled (Photo I.17).

- Pipe running from building to man hole 7 has been installed and ready to be backfilled (Photo I.18).

- It was observed that construction works quality is being done to a high standard. The site work appeared to be on schedule.

12. TRANSMISSION LINES

- The HVac line between Muskrat Falls and Churchill Falls is substantially finished (Photos E.7 and H.8).

- There is significant schedule slippage with the HVdc lines in Labrador and on the island of Newfoundland. This is a primary cost risk and according to contractor's reports is driven by issues with access works. It had been planned to provide only winter access to many areas of the HVdc line. At the insistence of Vallard this plan has been modified, it is now planned to construct all-weather access for most areas. Access is problematic in the Long Range Mountains. A detailed access plan is now being drawn up.

- Displaced strand (popped crowded wire) of the HVdc conductor cable has been observed in installed cable at a number of locations. Surveys are being carried out to determine how much of the installed cable has a displaced strand. This issue is very significant and may necessitate the replacement of cable that has already been strung and/or is being stored in the stock yards. It is likely that installation methods and winding design will need to be reevaluated for the use of cable in future installations.

- The following geotechnical issues are affecting schedule:
  - As per contractor's reports unfavorable bog foundations and areas of problematic wet and soft soil have been encountered which reportedly have reduced progress. Additional test pit investigations are currently planned to better delineate areas of poor soil conditions.
  - There will be a large number of overburden foundations which, under the current design, will use grillage footings. The contractor has proposed to substitute many grillage footings with a macro-pile design. The macro-piles will be quicker to install but would be more expensive. This issue is still under consideration.

Note: Nalcor does not necessarily agree with all contractor's reported statements and/or claims and reserves the right to challenge same and work collaboratively towards cost effective solutions.

13. CONCLUSIONS AND COMMENTS

- Civil works at Shoal Cove and Forteau were at an advanced stage and the work is generally on schedule. The submarine cable No. 1 has been pulled ashore through the inclined boreholes on each side of the Strait in Shoal Cove and Forteau.

- At the time of the July 13th site visit, preparatory works for river impoundment were being carried out. Concrete works in the spillway structures is completed and installation of the 5 gates was being finalized during the IE site visit. At that time, only eight major concrete pours remained. Additional works were being done to prepare the downstream spillway apron and remove the cofferdams in preparation for river diversion. The new access bridge across the upstream spillway channel was installed and final works on the approach way and deck were being carried out. This work is of acceptable quality and in compliance with current schedules.

- Power Intake/Powerhouse/Tailrace construction was at an advanced state at the time of the IE site visit, however, Astaldi's progress on the powerhouse construction is considerably behind schedule. This work is on the critical path and directly impacts initial power generation at Muskrat Falls. Construction rates have been significantly improving during the past year but there has been a significant decline since the formwork collapse at Unit 2 on May 28, 2016. Safety investigations are still ongoing as result of this incident and construction activities around the collapsed formwork are still banned. Nalcor is currently evaluating new completion dates for the works and will release new completion dates in the near future.

- At the time of the IE site visits some preparatory work was being carried out on the rock fill starter berm on the right bank of the river. Since that time the upstream berm has been extended across the river to facilitate diversion through the spillway. The IE reviewed the cofferdam design and comments were presented.

- North Spur stabilization works were proceeding well and were generally on schedule at the time of the July 14th 2016 site visit. All excavation of the upstream slope and construction of the upstream cut-off wall were completed. Upstream fill placement (including slope protection rip rap) was proceeding as per plan and is on schedule to allow the river diversion and resulting partial impoundment of the river. Everything is on track for completion by October 31, 2016. Work on the downstream slope was generally proceeding on schedule and approximately 85% of the excavation work was completed at the time of the site visit. Work on the North Cutoff Wall was underway and was approximately 21% complete at the time of the IE site visit. It was noted by the IE that geological mapping of the downstream face was not being plotted as per discussions in January 2016.

- Foundation preparation works for the Muskrat Falls South dam were at an advanced stage and fill placement for the Intake Cofferdam was proceeding on schedule. Grouting works in dam foundation and the grouting galleries of the Powerhouse Intake structure and the Spillway Gate structure are proceeding well.

- Work at the Switchyards at Churchill Falls, Muskrat Falls (MF) and Soldiers Pond (SOP,) as well as at the AC/DC Convertor Stations at MF and SOP is proceeding on schedule. The Synchronous Condenser facility at SOP is also advancing as planned. Current activities at these sites are focusing on completion of the civil works and building assembly of the facilities.

- The HVdc Transmission line work is behind schedule. Technical issues with the DC conductor are also now under investigation and may cause further delays to the project.

- The construction civil works viewed during the site visit were of good quality and in compliance with accepted standards.

Appendix 1

Site Photographs

Photo A.1: Land end of Cable No. 1 on the Shoal Cove shoreline. (July 12, 2016)

Photo A.2: Cable No. 1 at Shoal Cove; exit from the inclined borehole on the Shoal Cove shore. (July 12, 2016)

Photo A.3: Cable No 2 emerging from the casing of the inclined borehole. Note coating of lubricant grease. (July 12, 2016)

Photo A.4: Cable No 2 emerging from the casing of the inclined borehole. (July 12, 2016)

Photo A.5: Cable No.2; final pull work to emplace the cable along the Shoal Cove shoreline work area. (July 12, 2016)

Photo A.6: Winch pulling Cable No 2. (July 12, 2016)

Photo A.7: Creek crossing over the buried cables near the midway point. Further erosion control works are planned to protect the buried cables. (July 12, 2016)

Photo A.8: View looking eastwards along the buried cables line. (July 12, 2016)

Photo A.9: DC transmission towers immediately east of the Shoal Cove facilities. (July 12, 2016)

Photo A.10: Shoal Cove Transition compound preparatory works. (July 12, 2016)

Photo A.11: Shoal Cove Transition compound preparatory works. (July 12, 2016)

Photo A.12: Shoal Cove Transition compound – buried land cables termination points. (July 12, 2016)

Photo B.1: Cable #1 (yellow cable) at the inclined borehole and anchor point. (July 12, 2016)

Photo B.2: Cable #1 at the cable jointing facility. (July 12, 2016)

Photo B.3: Anchor point for Cable #2. (July 12, 2016)

Photo B.4: View looking eastwards along the buried land cables line. (July 12, 2016)

Photo B.5: Transition compound - buried land cables termination points. (July 12, 2016)

Photo B.6: Transition compound – ongoing work on concrete foundations for gantries and equipment. (July 12, 2016)

Photo C.1: Downstream face of the powerhouse. (July 13, 2016)

Photo C.2: View of powerhouse looking northwest. (July 13, 2016)

Photo C.3: View of powerhouse from spillway area looking south. (July 13, 2016)

Photo C.4: Units 1, 2 and 3, view looking upstream. (July 13, 2016)

Photo C.5: Units 3 and 4, view looking upstream. (July 13, 2016)

Photo C.6: Concrete walls at intake of Unit 1, view looking downstream. (July 13, 2016)

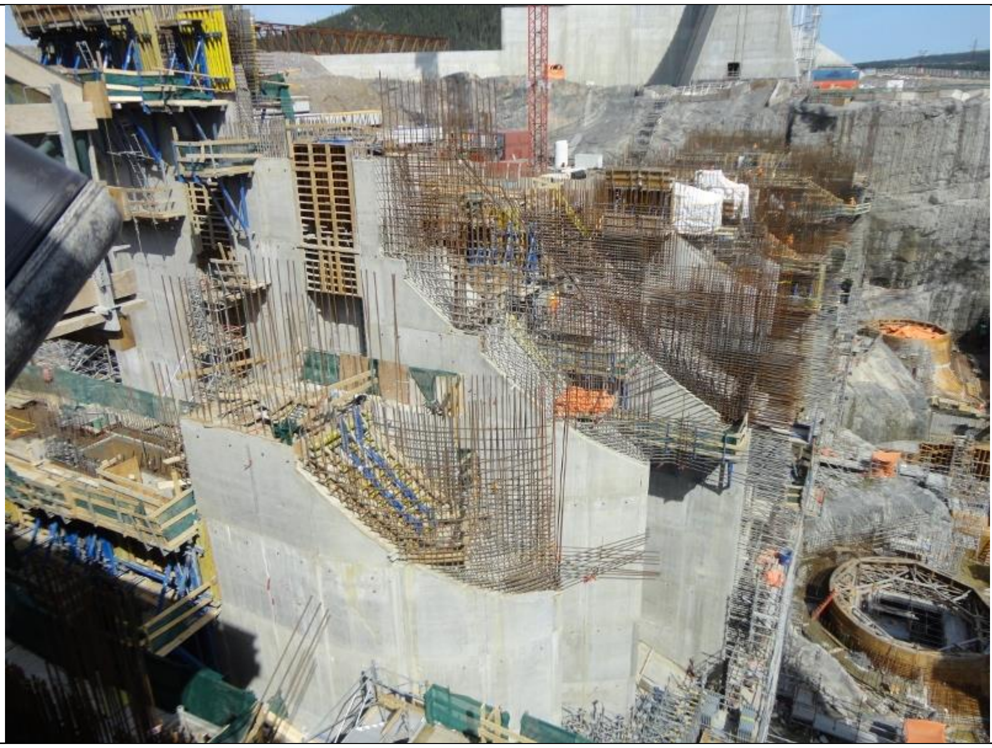

Photo C7: Downstream end of intake piers of Units 1 and 2, view looking north. (July 13, 2016)

Photo C.8: Intake face for Unit 1. (July 13, 2016)

Photo C.9: Unit 1, Draft tube formwork. (July 13, 2016)

Photo C.10: Units 2, 3 and 4. (July 13, 2016)

Photo C.11: Unit 2, note collapsed formwork in pyramidal shaped are on right side. (July 13, 2016)

(a)

(b)

Photo C.11: Unit 2 formwork failure above draft tube (Photo 'a') and spilled concrete in the bottom of the draft tube area (Photo 'b'). (July 13, 2016)

Photo C.12: Old formwork inside Unit 3 draft tube. Note misaligned steel beam and wooden column. (July 13, 2016)

Photo C.13: Units 4 and 3, view looking east; Unit 4 is nearest the camera. (July 13, 2016)

Photo C.14: Downstream draft tubes of Unit 1. (July 13, 2016)

Photo C.15: Unit 3 intake chute, view looking upstream. (July 13, 2016)

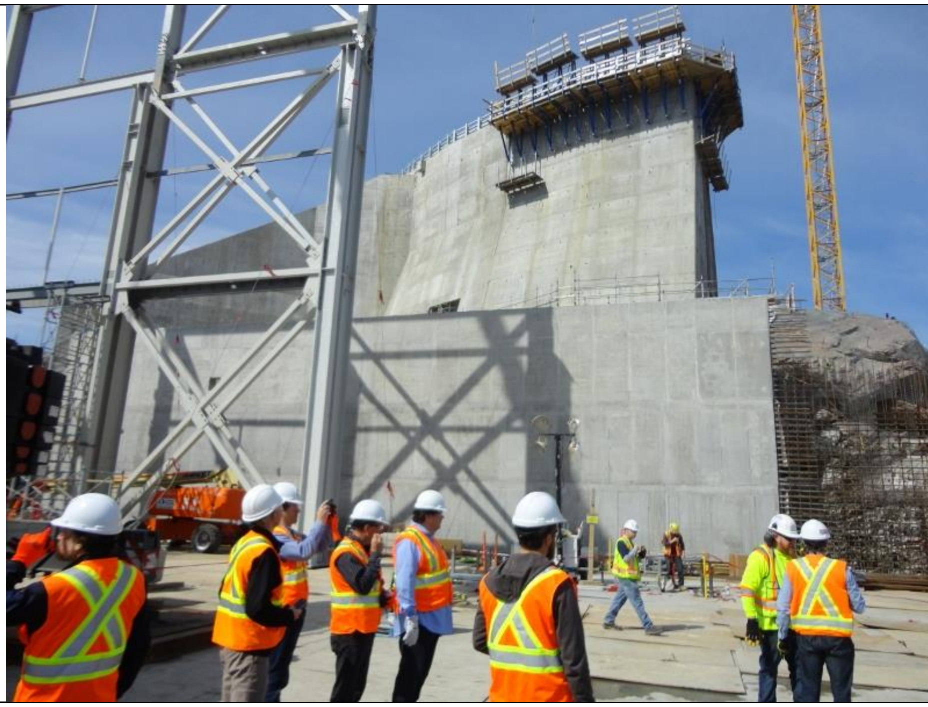

Photo C.16: Powerhouse south service bay with a view towards Central Transition Dam. (July 13, 2016)

Photo D.1: Downstream view of the spillway gate structure. (July 13, 2016)

Photo D.2: Upstream view of the spillway gates. (July 13, 2016)

Photo D.3: South side of spillway, Powerhouse/Transition dam shown on the right. (July 13, 2016)

Photo D.4: RCC cofferdam being demolished with a hydraulic hoe ram. (July 13, 2016)

Photo D.5: Deck on top of the spillway gate structure. (July 13, 2016)

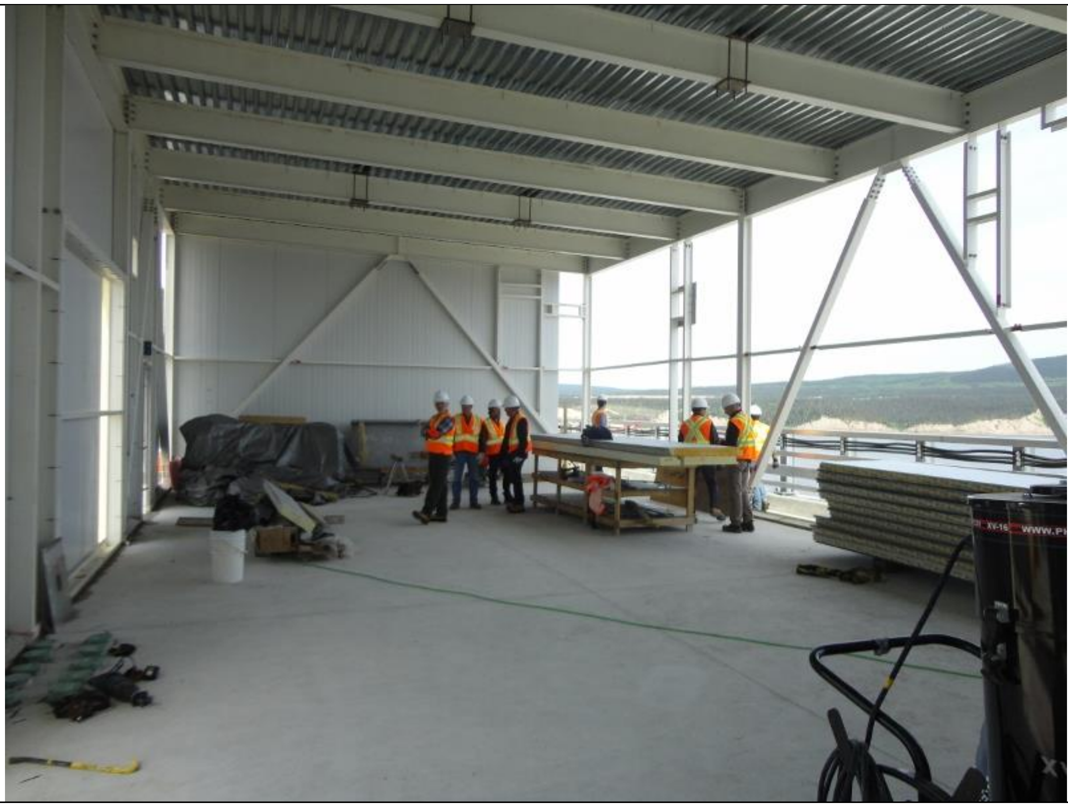

Photo D.6: Control room on top of the spillway gate structure. (July 13, 2016)

Photo D.7: Top of gate No. 1, view from the top of the spillway gate structure. (July 13, 2016)

Photo D.8: Spillway intake channel and temporary bridge. View looking towards upstream. (July 13, 2016)

Photo D.9: Spillway intake channel and temporary bridge. View looking downstream. (July 13, 2016)

Photo D.10: Left side of the spillway intake channel. Note the black stop log segments stored on the bases of the channel in the foreground. (July 13, 2016)

Photo D.11: Spillway approach channel. Removal of steel mesh from the left side rock face. (July 13, 2016)

Photo D.12: Spillway apron, removal of cofferdam and preparation of the apron surface. (July 13, 2016)

Photo D.13: Spillway apron, removal of cofferdam and preparation of the apron surface. Steel reinforcement mats are being placed in rock depressions adjacent to the concrete apron, in preparation for placement of dental concrete. (July 13, 2016)

Photo D.14: Preparation of the Spillway apron surface. Dental concrete (dark colored) has been placed in the steel reinforced depressions adjacent to the concrete apron. (July 13, 2016)

Photo D.15: Preparation of the left starter dyke of the Upstream Cofferdam. (July 13, 2016)

Photo E.1: North Spur, upstream slope. (July 14, 2016)

Photo E.2: North Spur, upstream slope. North end, view looking north. (July 14, 2016)

Photo E.3: North Spur, upstream slope. View looking south. (July 14, 2016)

Photo E.4: North Spur, upstream slope. Old gully scar near the intersection of the north and upstream cut-off walls. (July 14, 2016)

Photo E.5: North Spur, upstream slope. Old gully scar at the mid-point. (July 14, 2016)

Photo E.6: North Spur, upstream slope. Exposed bedrock at the south end of the slope. (July 14, 2016)

Photo E.7: North Spur. View looking north at the HVac transmission line along the top of the North Spur. (July 14, 2016)

Photo E.8: North Spur, downstream slope. View long south. (July 14, 2016)

Photo E.9: North Spur, upper level of the downstream slope. Area where liquefiable material was encountered in 2015 is outlined by the red ellipse. (July 14, 2016)

Photo E.10: North Spur, downstream slope. Close-up view of the area where liquefiable silt/clay was reportedly excavated during 2015 (See Photo E.9 above). It was reported that material obtained from this area was liquefied when loaded into dump trucks, it flowed out of the back of the truck as it climbed the slope. To date no further information on the extent or properties of this liquefiable material has been presented to the IE. (July 14, 2016)

Photo E.11: North Spur, downstream slope. Exposure of plastic silt/clay with interlayered fine sand of the Upper Stratified Drift. This location is near in the southern area at the base of the downstream slope. No evidence of liquefaction properties could be seen at this location. (July 14, 2016)

Photo E.12: North Spur, downstream slope. Sloping finger drain. (July 14, 2016)

Photo E.13: Excavation and fill placement for finger drain at the south end of the downstream slope. (July 14, 2016)

Photo E.14: Excavation of the North Cut-off, in the area east of the road crossing. (July 14, 2016)

Photo E.15: Dumping of clay material from the North Cutoff. (July 14, 2016)

Photo E.16: Plastic "lower clay" from the base of the north Cutoff. (July 14, 2016)

Photo E.17: Sample of cohesive, plastic "lower clay" from the base of the North Cutoff. (July 14, 2016)

Photo F.1: South Dam foundations, cleaned granitic gneiss rock along the impervious core footprint. View looking south up the abutment. Note the irregular surface. (July 14, 2016)

Photo F2: South Dam foundation, cleaned rock along the impervious core footprint. View looking north down the abutment. (July 14, 2016)

Photo F.3: Irregular granitic gneiss foundation surface. Dental excavation and concrete/mortar backfilling required in many areas. (July 14, 2016)

Photo F.4: North end of the South Dam foundation. Cleaned, irregular granitic gneiss in foreground and the south end of the concrete transition dam is in the background. (July 14, 2016)

Photo F.5: Intake Diversion Dam. Compacted impervious till core and adjacent transition/filter zones are visible. (July 14, 2016)

Photo F.6: Grout monitoring station at the South Dam foundation. (July 14, 2016)

Photo F.7: Powerhouse Intake grouting gallery. Drill rig boring cored, inclined grout holes. (July 14, 2016)

Photo F.8: Powerhouse Intake grouting gallery, south end. (July 14, 2016)

Photo F.9: Powerhouse Intake grouting gallery, grout sleeves in the upstream floor. (July 14, 2016)

Photo F.10: Spillway grouting gallery, Lombardi type grout cohesion measuring plate for use with GIN grouting. (July 14, 2016)

Photo F.11: Spillway grouting gallery, grout mixing plant. (July 14, 2016)

Photo G.1: Muskrat Falls Switchyard – Convertor Transformers pads and containment pits with ongoing work on fire walls formwork and reinforcement erection. (July 13, 2016)

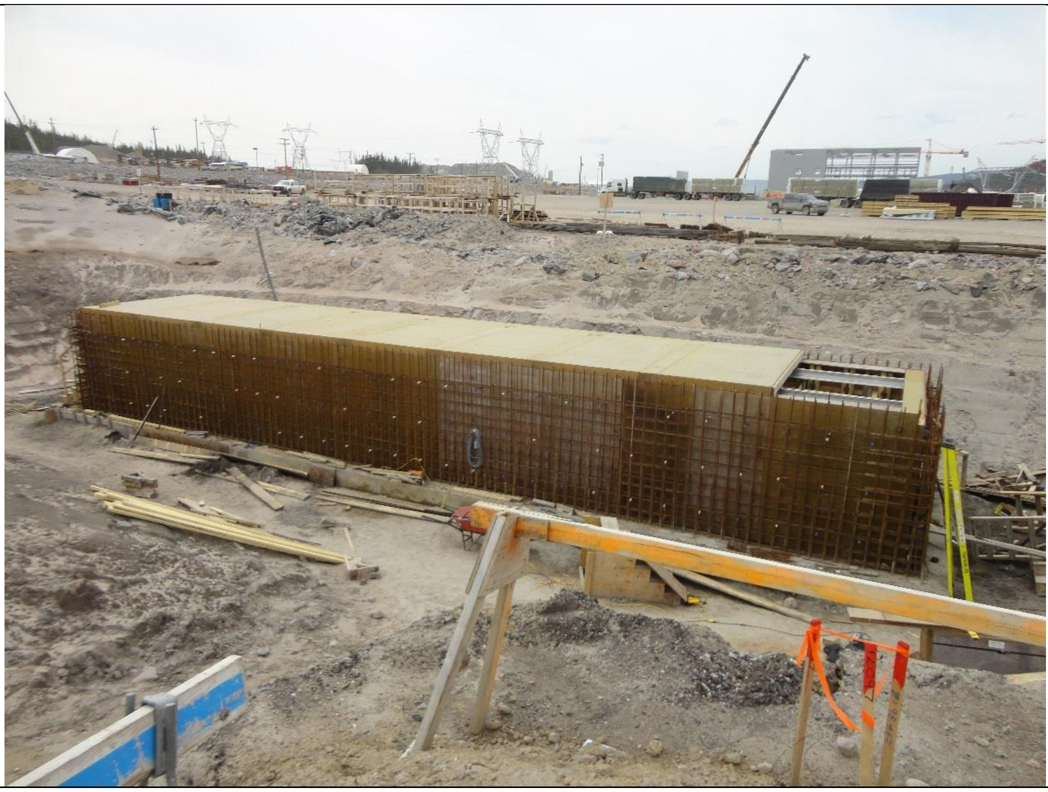

Photo G.2: Convertor station oil / water separator – work ongoing on reinforcement and formwork erection. (July 13, 2016)

Photo G.3: GIS building- Partially installed structural steel frame. Steel erection will recommence upon completion of foundations (at right) repair work. (July 13, 2016)

Photo G.4: GIS building with partially erected steel frame. Repair work on the building foundations (at right) was ongoing. (July 13, 2016)

Photo G.5: Close-up of foundation column in stage of repair. (July 13, 2016)

Photo G.6: Control building foundations ready for the pre-engineered building erection. (July 13, 2016)

Photo H.1: Overall view of Switchyard with installed transformers and GIS Building on background. (July 14, 2016)

Photo H.2: Complete cast-in-place gantry foundation and pre-cast pole insulator footings – backfilled and ready for equipment installation. (July 14, 2016)

Photo H.3: Transformers already installed on concrete pads within containment pits complete with fire walls. (July 14, 2016)

Photo H.4: Close-up of assembled transformer. (July 14, 2016)

Photo H.5: Exterior view of fully erected GIS Building. (July 14, 2016)

Photo H.6: Interior view of GIS Building. (July 14, 2016)

Photo H.7: Concrete foundations of Control Building near completion. (July 14, 2016)

Photo H.8: Dead-end towers of the HVAC 315 kV transmission line at the line's entrance into the Switchyard. (July 14, 2016)

Photo H.9: Extension of the new Switchyard for interconnection to the existing Churchill Falls Switchyard. (July 14, 2016)

Photo H.10: Newly installed precast footings for bus and equipment supports at interface location between the new and the existing Churchill Falls Switchyards. (July 14, 2016)

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Photo I.1: Soldiers Pond - Convertor Station and HVdc yard. (July 15, 2016

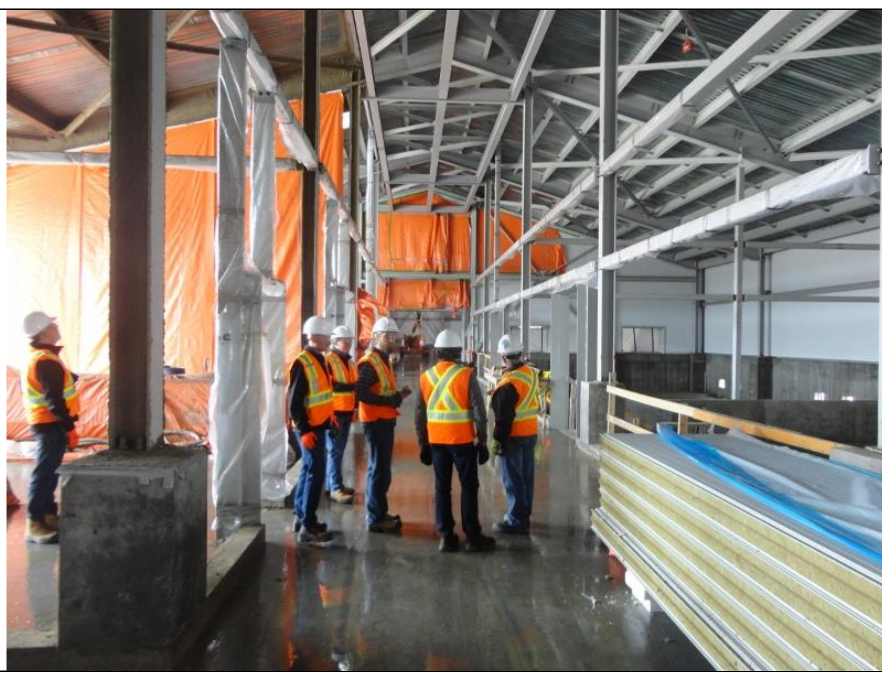

Photo I.2: Soldiers Pond – Convertor Station control room interior. (July 15, 2016)

Photo I.3: Soldiers Pond – Convertor Station control room interior steel frames and wall panels. (July 15, 2016)

Photo I.4: Soldiers Pond Convertor Transformers fire walls. (July 15, 2016)

Photo I.5: Soldiers Pond – Convertor transformer containment pit covered for curing the finished protective coating of the pit floor and walls. Separation fire walls and Convertor Station on the background. (July 15, 2016)

Photo I.6: Soldiers Pond – Convertor transformer pad, fire walls and containment pit in preparation for final protective coating application. (July 15, 2016)

Photo I.7: Soldiers Pond– Convertor Transformer concrete pad and containment pit with protective compound applied and cured. (July 15, 2016)

Photo I.8: Soldiers Pond – Convertor Station oil / water separator tank partially backfield. (July 15, 2016)

Photo I.9: Soldiers Pond – AC switchyard with completed gantry and posts foundations. Structural steel members and boxes with equipment stored on site and ready for installation. (July 15, 2016)

Photo I.10: Soldiers Pond – Control building fully assembled. (July 15, 2016)

Photo I.11: Soldiers Pond – Interior view of Control Building. (July 15, 2016)

Photo I.12: Soldiers Pond – Synchronous Condensers transformers and the building on the background. (July 15, 2016)

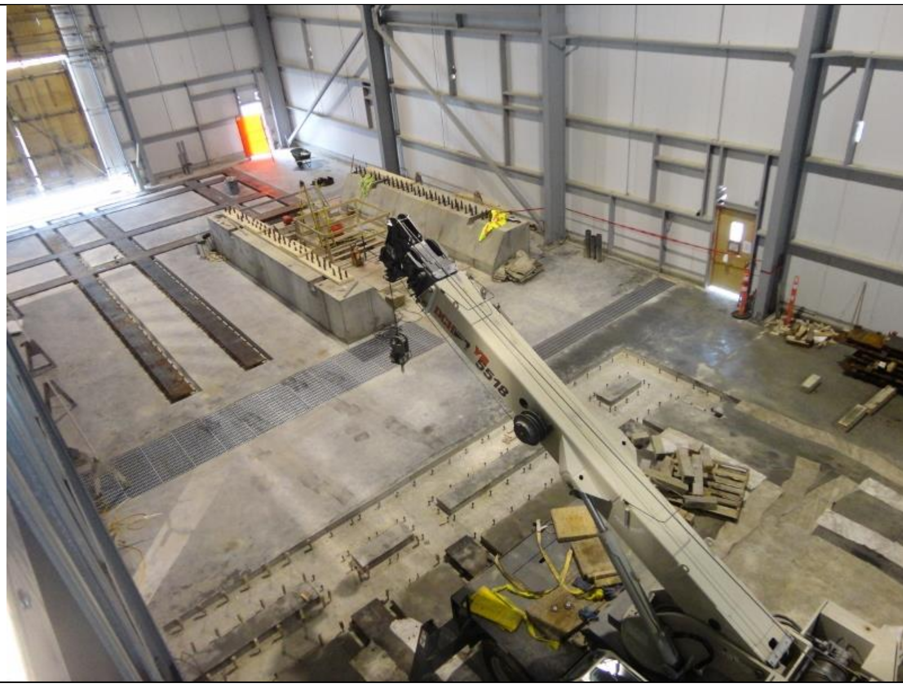

Photo I.13: Soldiers Pond – Synchronous Condensers building- interior view of machine hall with completed footings for unit 1. Floor embedment parts at unit 1 bay are ready for grouting and are yet to be installed at unit 2 bay. (July 15, 2016)

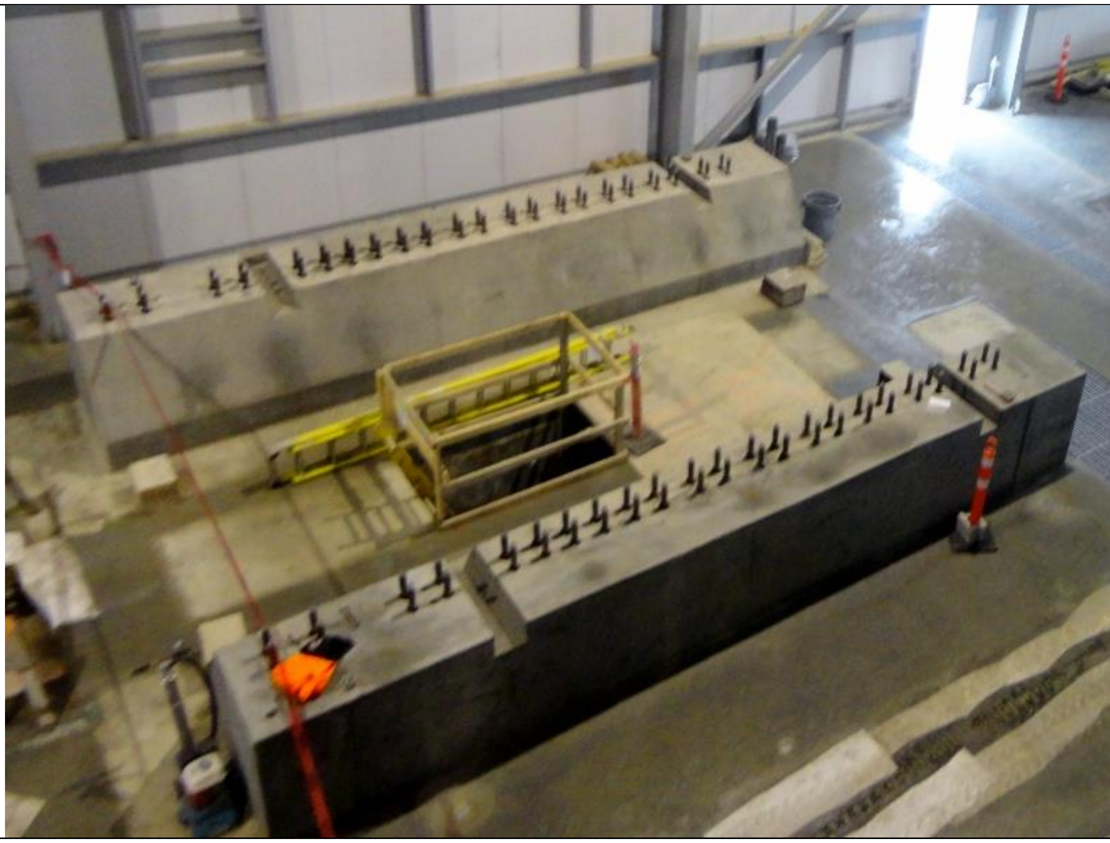

Photo I.14: Soldiers Pond – Completed footings for unit 2. (July 15, 2016)

Photo I.15: Soldiers Pond – Close-up of embedment plates at unit 1 bay, ready for grouting. (July 15, 2016)

Photo I.16: Soldiers Pond – Synchronous Condensers transformers and the building on the background. (July 15, 2016)

Photo I.17: Soldiers Pond – Synchronous Condenser oil / water separator, partially backfield. (July 15, 2016)

Photo I.18: Soldiers Pond – Synchronous Condenser building, drainage pipe connected to man hole 7 and ready for backfill. (July 15, 2016)