MEETING IN ST JOHN'S AND VISIT TO MUSKRAT FALLS - SEPTEMBER 21-23, 2015

Prepared for: Nalcor Energy

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Quality Assurance Statement

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Revision Schedule

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1. GENERAL

The Independent Engineer team represented by Nik Argirov and John Young attended a project briefing and participated in site visits and meetings for the Muskrat Falls Project during September 21 to 24, 2015, as follows:

- A project briefing was carried out by representatives of the Lower Churchill Management Corporation (LCMC), the Nalcor Energy subsidiary responsible for project development and management activities associated with the Lower Churchill Project (LCP) in the Project Delivery Office in St John's on September 21, 2015. The briefing presentations covered various aspects of the work and project progress.
- A site visit was made to the Dowden's Point electrode site, and the Soldier's Pond AC/DC conversion facility and AC substation on September 22, 2015.
- A one day site visit to the Muskrat Falls Generation site, was made on September 23, 2015. The North Spur was visited during the morning; all ongoing site works, including the cut-off wall, excavations and various fill placement activities were reviewed. Emphasis was placed on reviewing the geotechnical aspects of this work. The spillway and powerhouse sites were toured during the afternoon.
- Topic specific discussions were held with technical resources back in the St. John's Project Delivery Office on September 24, 2015 including a wrap-up/debriefing with LCMC management.

Principal observations and comments are presented in the following paragraphs. Labeled photographs are presented in sections 1, 2, 3, and 4 of Appendix A.

2. DOWDEN'S POINT

Construction of the Dowden's point facility was very advanced at the time of the September 22, 2015 site visit. Photographs taken during the visit are presented in Appendix A – Section 1. The following items were observed:

- The shoreline dyke is at an advanced stage of construction (Photo 1.1). The eastern end (Photo 1.2) and central areas are completed. Work was progressing on the western end (Photo 1.3) of the dyke at the time of the site visit.
- The electrode wells have been installed adjacent to the inner toe of the dyke (Photo 1.4 and 1.5) and work on the conductor bedding trench was progressing (Photos 1.4 and 1.6).
- The upper inner slope, crest and full height outer slope of the dyke are covered by armour stone erosion protection (Photos 1.6 and 1.7). The armour stone consists of equidimensional blocks of very strong granitic rock and Precambrian siltstone. This material was obtained from various off-site sources and is stockpiled at Dowden's Point. Approximately 80% of the armour stone has been placed and 100% has been delivered to the site. In general the rock is of very good quality although a few of the metamorphosed siltstone blocks had numerous tight incipient cracks that could cause some spalling and breakdown over time.
- All of the work on excavations, well installations and fill placement is high quality and in keeping with accepted standards. In particular the armour stone placement works (Photo 1.6 and 1.7) are of exceptionally high quality, generally better than the norm for breakwater installations.

3. SOLDIER'S POND

The following observations were made during the September 22, 2015 site visit to Soldier's Pond. Photographs taken during the visit are presented in Appendix A – Section 2

- Virtually all site preparation, including site grading excavations and fill placements has been completed.
- The cut slopes at various locations around the perimeter of the complex have been excavated and are generally of good quality. Photo 2.2 shows the slope at the western side. At this location upper slope is covered by porous coconut/wire mesh slope protection. No seeding has been done and this mat has deteriorated in many places. Rip rap layer is placed on the lower slope.
- In general, most of the ongoing work is focused on foundation construction for many major facilities. Foundation footings and/or base slabs are being constructed for the converter building (Photo 2.1), gantries for the AC substation (Photo 2.8), and the converter transformer (Photos 2.9 and 2.10). The footings of the converter facility are at an advanced stage of completion at the south side of this facility (Photo 2.9) and in the very initial stages of construction at the north side (Photo 2.10).
- The footings of the AC substation control building (Photo 2.4) and the base slab of the oil/water separator for the converter facility (Photo 2.6) at the western end of the site have been completed.
- Formwork has been erected for the sides of the water tank at the converter transformers location (Photo 2.3).
- Erection of the steel framework of the synchronous condenser building is at an advanced stage (Photo 2.5).
- It is understood that site work is on schedule. It was observed that construction works quality is being done to a high standard.

4. NORTH SPUR

Construction work on the slope stabilization measures at the North Spur was proceeding well at the time of the September 23, 2015 site visit. Photographs taken during the visit are presented in Appendix A – Section 3. The site visit observations are summarized as follows.

Upstream Slope Excavation

- All excavation work in the upstream slope was completed by the time of the site visit. The original excavation formed a bench along the base of the trimmed and excavated slope (Photos 3.1 and 3.3 show the overall view). The cutoff wall is collared from the el 20m level.
- In the north end of the slope, where the wall is completed, the impervious blanket has been placed up to el 24m (Photo 3.2). The impervious blanket consists of compacted silty till, overlain by a granular transition zone.

Upstream Slope Cutoff Wall

- Most of the upstream cutoff wall has been completed. A total of 46 of planned 49 panels have been placed. Each panel is 0.6 to 1.0 m wide, 13.5 m long and 6 to 17 m deep (dimensions may vary locally) (Photos 3.7, 3.8 and 3.9). Panels had a minimum longitudinal overlap of 200 mm and a minimum transverse overlap of 400 mm to ensure that no windows form between them. The wall was placed in a single step, the bentonite/cement mixture was added dur-

ing 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.

- To date, the wall was excavated with a long-stick backhoe (Photo 3.16). This excavator can dig to depth of just below 17m. Bentonite/cement slurry was mixed on site (Photo 3.18) and delivered to trench by pipe. The slurry is a plastic bentonite/cement mixture with a 28 day strength of 300 to 400 KPa. Batching quantities are as follows
    - 1000 kg water
    - 280 kg cement (contains about 25% silica fume)
    - 35 kg bentonite
    - 5 kg Aquatix (fluidizer which also retards the set)
- The upstream slope wall was excavated through the stratified drift zone 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 lower clay. The lower clay has different properties from the upper sand and clay / silt and is readily identified during excavation. The top of the lower clay is nominally at approximately el 5m to el 10 m, but "as built" construction experience documented that the surface of the clay is irregular and varies by about 3 to 5 m. At 46 panels the top of the lower clay was within 15 m depth and the wall was successfully installed to a maximum depth of about 17 m. At three of the panels, nos. 32, 33 and 34, the top of the clay is a few metres below the effective reach of the long stick backhoe and excavation of these panels will be done with the clam shell excavator (Photo 3.17). The clam shell excavator will also be used in the northwest cut-off wall which will cut across the axis of the North Spur.
- A program of quality control is carried out during the cutoff wall construction. Depth and alignment are monitored by GPS receivers mounted on the arm of the backhoe. Regular field testing of the slurry consist of density, marsh cone viscosity and bleed. Other laboratory testing is carried out on slurry samples.

Upstream slope Geological Observations

- The Upper Sand and Upper Clay are exposed in the upstream slope above el 20m. Site geotechnical engineer report that the material is most interlayered sand and silt (Photos 3.13 and 3.14). Most of the laying is discontinuous and most layers pinch out horizontally.
- There are numerous water seepages from sand layers in the excavated faces (Photo 3.14). This causes minor localized washouts but has not caused any significant geotechnical issues. It was noted that temporary slopes in the sands and slits are very susceptible to erosion but once again this is not a problem since the slopes are temporary and will later be covered and protected.
- No manifestations of sensitive or "quick" behavior in clay/silt materials have been noted during excavations in the upstream slope of the North Spur. It was observed by geotechnical site staff that excavated material adheres together in clumps, even after dumped into the haul trucks. This is unlike typical "quick" materials which would normally lose cohesion and liquefy to slurry after such rough handling. Also, the cut-off wall trench panels were stable during excavation in the upper sands and silts and no liquefaction of "quick" materials was noted during excavation works.
- The lower clay rises to high levels at the south end of the North Spur. Recently excavated material was examined during the September 23 site visit (Photo 3.15). This material which was examined could be seen to be very different

from the upper sand and silt/cay. It is dark greenish grey, firm and plastic with no tendency for liquefaction behaviour when disturbed.

- Bedrock is exposed adjacent to the cutoff near the rock knoll at the south end of the North Spur (Photos 3.11 and 3.12). 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.

Downstream Slope and Kettle Lakes Outlet Area

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

- Brush clearing is complete in the area and various features are now more visible than was the case in earlier site visits. Photo 3.19 shows the back scarp of the 1978 landslide. Slide debris from that event can still be seen in some areas.
- A toe berm has been excavated and some slope trimming has been done in the lower slope (Photo 3.20).
- Water collection ditches and berms have been constructed at the toe of the slope (Photos 3.20 and 3.21).
- Work on the southernmost finger drain is at an advanced stage (Photo 3.22). The finger drain will be embedded within the fill that will form the lower slope in this area. These drains are part of the water control measures designed to depress the water table in the slope.
- Rip rap, underlain by a granular transition zone, has been placed on the permanent slope below the toe berm.
- The Kettle lakes outlet gully (Photo 3.25) and the outlet drain of the dewatering wells (Photo 3.26) were inspected. As can be seen on Photo 3.26, the wells were discharging a small continuous flow, estimated to be less than 10 l/min at the time of the site visit.

5. SPILLWAY

Concrete works in the spillway structures were at a very advanced stage during the site visit on September 23rd. At that time only eight major concrete pours remained. Photographs taken during the visit are presented in Appendix A – Section 4.

- Photos 4.1 and 4.2 show views of the downstream side of the spillway structure. Formworks for the final concrete pours are visible at the tops of the pier structures.
- Photo 4.3 shows the right gate guide of the downstream stop logs of Bay Number 2.
- Photos .4.4 shows the downstream side of the spillway gate structure.
- Photos 4.5and 4.6 the right and left upstream corners respectively. The transition dams are shown on each side are visible in these photos.

It is understood that spillway work conforms to current schedules. The quality of all concrete works is very good.

6. POWERHOUSE/TAILRACE

Excavation of the Power Intake/Powerhouse/Tailrace channel is 100 % complete and construction of the planned permanent works was well under way at the time of the IE site visit on September 23rd. Photographs taken during the visit are presented in Appendix A – Section 4. Comments and observations are as follows:

- Astaldi's progress on the powerhouse construction is behind schedule. This work is on the critical path and directly impacts initial power generation at Muskrat Falls. Nalcor is currently evaluating new completion dates for the works and will release new completion dates when mitigation plans have been agreed and discussions with Astaldi have been concluded.
- The partially completed ICS (Integrated Cover System) shelter, which was covering Units 1 and 2, is currently being dismantled to allow better over head access for two new cranes to be installed. (Photos 4.7 and 4.8). Winter shelter for various works will be provided by local heated shelters, similar to those used for the spillway works.
- The concrete dam between the powerhouse and spillway is at an advanced stage of construction (Photo 4.9).
- Formwork construction for the scroll cases at Units 1 and 2 (Photos 4.10, 4.11 and 4.12) is at an advanced state. At the time of the site visit no similar formwork was in place at Units 3 and 4 (Photos 4.13 and 4.14).

7. CONCLUSIONS

- Civil works at Dowden's Point are at an advanced stage and the work is on schedule. The protection dyke is about 80% complete and the line of electrode wells has been installed. Remaining work includes completion of the west end of dyke, installation of the conduit and related civil works.
- Work at the converter facility and AC substation at Soldier's Pond is proceeding on schedule. All general site grading has been completed. Current work is focusing on foundation construction for most of the facilities. Erection of the steel framework of the synchronous condenser building is at an advanced stage.
- The concrete works at the spillway gate structure are mostly completed and at the time of the site visit only eight concrete pours remained. This work is in compliance with current schedules.
- Work is progressing at the powerhouse but there has been schedule slippage for this structure, which is on the critical path for generation of electricity at Muskrat Falls. The ICS structure is currently being dismantled. Local heated shelters will be erected to permit winter works. The construction of formwork for the scroll cases of Units 1 and 2 was being carried out at the time of the site visit.
- The civil works construction viewed during the site visit is of good quality and in compliance with accepted standards.

APPENDIX NO. 1

Site Photographs

Section 1: Dowden's Point, September 22, 2015

Photo 1.1: Dowden's Point dyke. Note the line of electrode wells at the base of the dyke.

Photo 1.2: East end of the dyke

Photo 1.3: West end of the Dowden's Point dyke. Note the ongoing armour stone placement work.

Photo 1.4: Looking west along the line of electrode wells and the conductor bedding trench.

Photo 1.5: Electrode well casing installation

Photo 1.6: Placing and dressing the armour stone at the west end of the dyke. Electrode wells visible in foreground.

Photo 1.7: Armour stone blanket on the outer slope.

Section 2: Soldier's Pond, September 22, 2015

Photo 2.1: AC/DC converter site

Photo 2.2: Cut slope in glacial moraine at west end of the facility. The upper slope is covered by porous coconut/wire mesh slope protection. No seeding has been done and this mat has deteriorated in many places. Rip rap layer in place on the lower slope.

Photo 2.3: Formwork and rebar installation for water tank for synchronous condenser facility

Photo 2.4: AC Substation Control Building foundation

Photo 2.5: Synchronous condenser building

Photo 2.6: Base slab for oil/water separator

Photo 2.7: Manhole for the oil water separator for the synchronous condenser facility at the west side of the site.

Photo 2.8: Foundation pads of the gantries in the AC substation

Photo 2.9: DC transformer foundation pads, southern area

Photo 2.10: DC transformer foundation southern area

Section 3: North Spur, September 23, 2015

Photo 3.1: Upstream slope - Overall view of the upstream slope of the North Spur, showing the excavated slope and the cut-off wall line along el 20m the toe berm. View is looking towards the north. The working platform at el 20m is visible along the toe of the excavated and trimmed slope. In the back ground, the el 24m and el 28m fill intermediate placement berms can be seen.

Photo 3.2: Upstream slope. View of the el 28m level at the north end of the upstream slope.

Photo 3.3: Upstream slope works, looking south from the north end.

Photo 3.4: Upstream slope. El 28m berm at the north end of the cutoff. View shows, from right to left, the zoning of the rip rap, transition zones, and sandy fill.

Photo 3.5: Upstream slope. Upstream rip rap blanket as viewed looking north from the el 24m level.

Photo 3.6: Upstream slope - Upstream rockfill as viewed looking south from the el 24m level.

Photo 3.7: Upstream slope - Upstream toe at el 20m; top of cutoff wall, covered by a compacted till is visible running from the lower left corner of the photograph. View is looking south.

Photo 3.8: Upstream slope. Top of the cement/bentonite cut-off wall at el 20m. Note ongoing placement of the till blanket covering the wall in the background of the photograph.

Photo 3.9: Upstream slope - Compacted fine grained till placed over the top of the cut-off wall.at el 20m.

Photo 3.10: Upstream slope. Placing granular transition for the impervious blanket at the south end of the upstream slope.

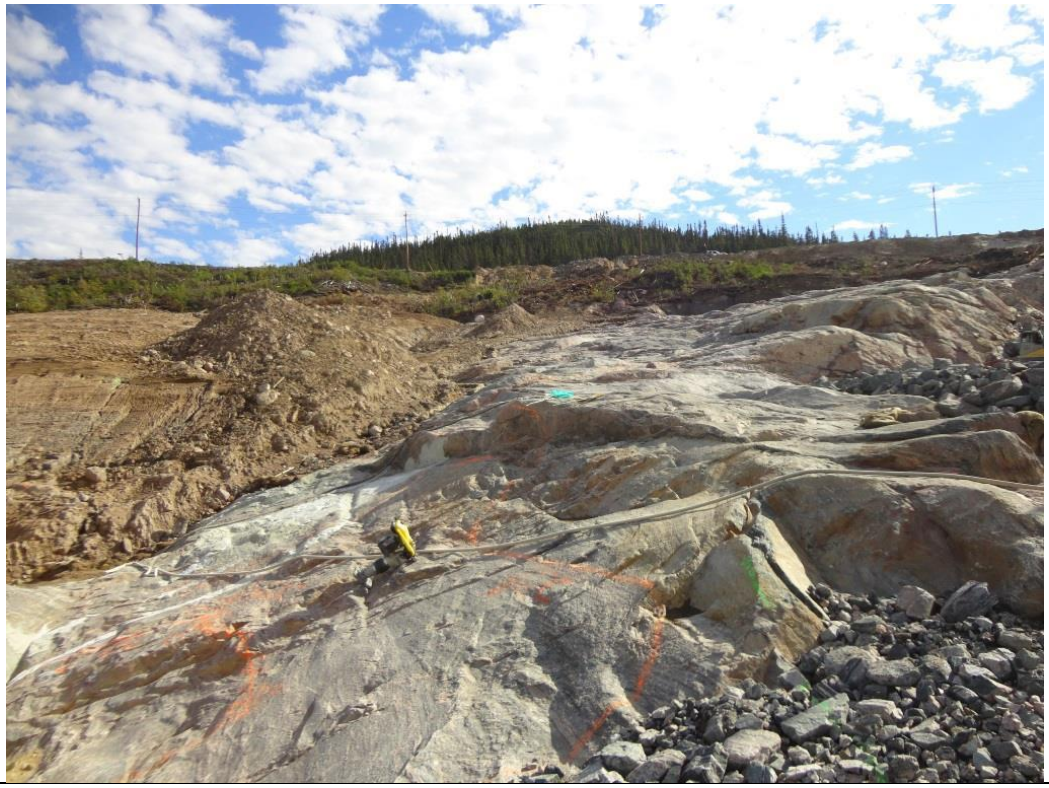

Photo 3.11: Upstream slope. Granitic bedrock exposed at the periphery of the rock knoll at the south end of the upstream slope.

Photo 3.12: Upstream slope. Placement of fine grained till and granular transition on the bedrock outcrop at the south end of the upstream slope.

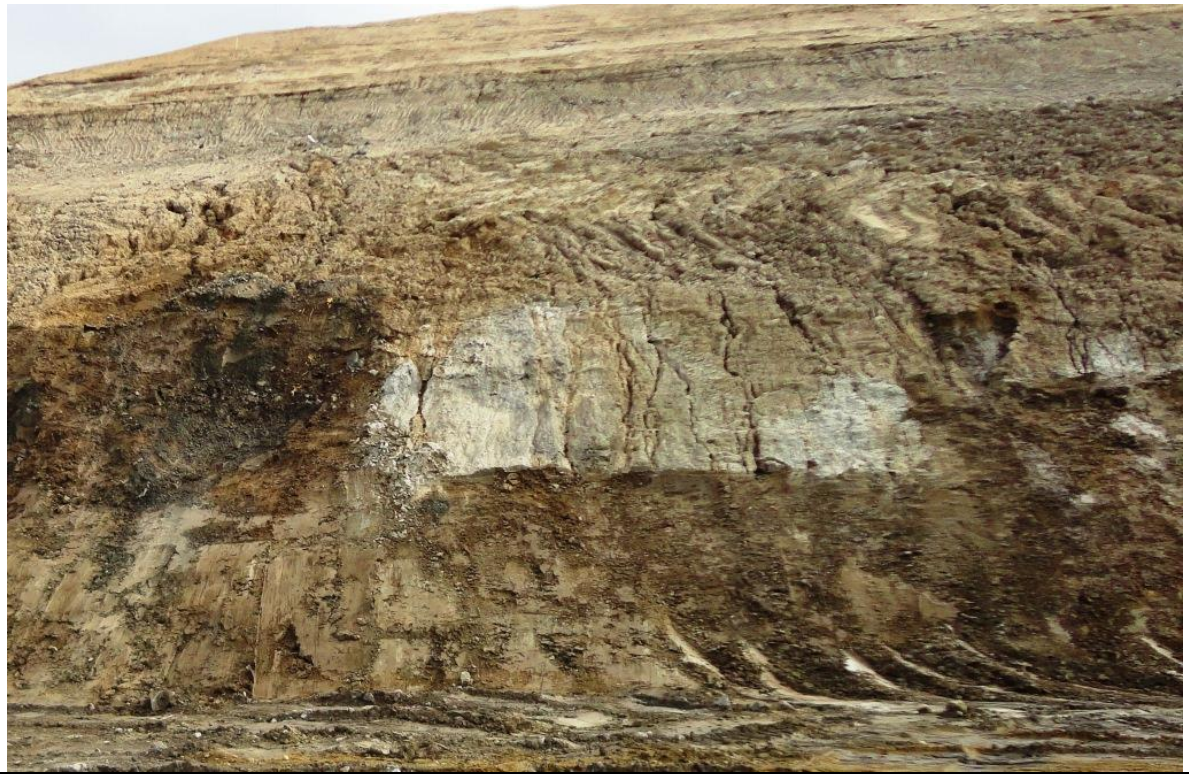

Photo 3.13: Upstream slope- Excavated slope in the upper clay and sand. Note the erosion runnels in the sand/silt at mid height.

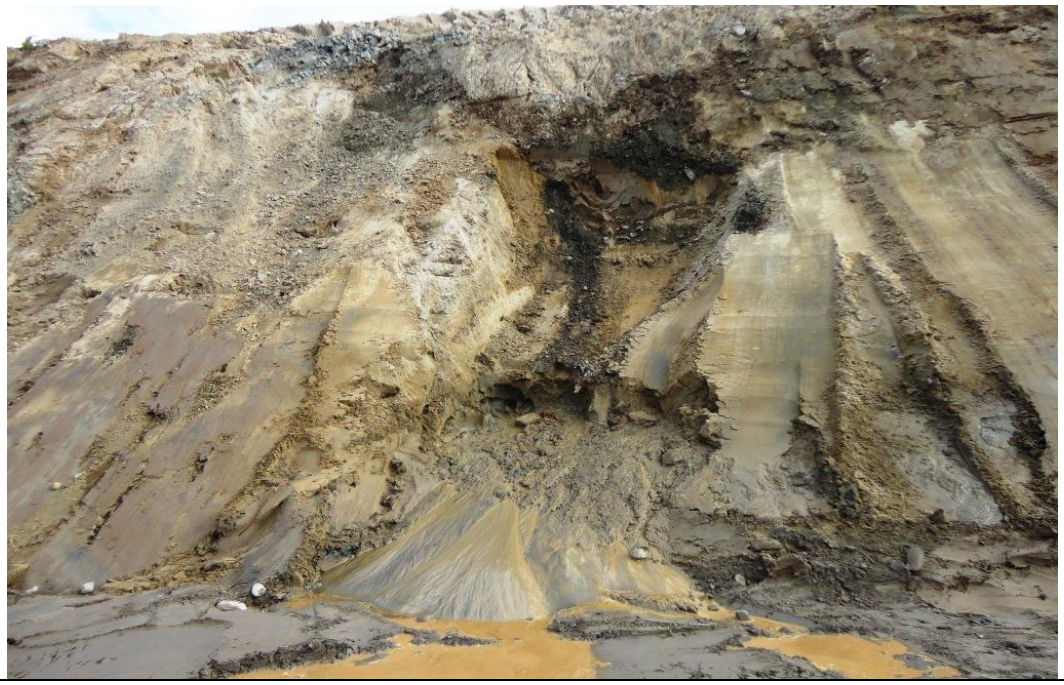

Photo 3.14: Upstream slope, layered Upper Clay/Sand zone. Note the water seepage from sand layers at lower and upper slope levels. This has caused localized washout of materials.

Photo 3.15: Upstream slope- Excavated greenish grey “lower clay” from the south end of the cut-off. The lower clay is a firm, plastic clay with low sensitivity. This material is at approximate el 20m along most of the upstream face and is the impervious material that the base of the cut-off wall is seated in.

Photo 3.16: Upstream slope- Long stick backhoe excavator used to excavate most of the upstream slope cut-off wall to depths of about 15m

Photo 3.17: New clamshell buckets, to be used for deeper sections of the cut-off wall.

Photo 3.18: Plant for mixing the cement bentonite slurry of the cut-off wall.

Photo 3.19: Downstream slope. View of the scarp of the 1978 landslide.

Photo 3.20: Downstream slope; water collection and silt fences at toe of slope. Some slope trimming has been done in the lower slope. Some debris from the 1978 slide are visible in the background (upslope from the white pick-up trucks).

Photo 3.21: Downstream slope. Water collection ditch at the toe of the slope.

Photo 3.22: Downstream slope; finger drain near the toe of the slope. The finger drain filters extend across the slope.

Photo 3.23: Downstream slope. Toe rip rap and granular transition zone.

Photo 3.24: Downstream slope, toe rip rap

Photo 3.25: Kettle lakes outlet gully

Photo 3.26: Pumped wells outlet pipe in the ravine downstream of the kettle lakes.

Photo 3.27: Lowest kettle lake.

Section 4: Spillway and Powerhouse, September 23, 2015

Photo 4.1: Spillway structure.

Photo 4.2: Spillway, downstream side as viewed looking upstream.

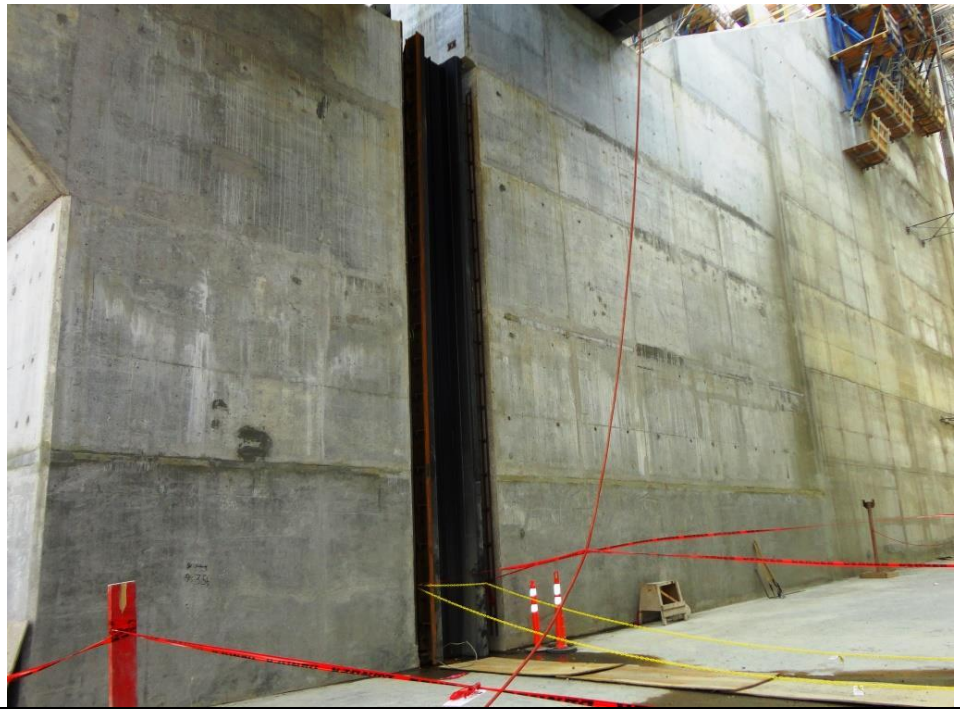

Photo 4.3: Spillway, Bay No. 2. Guide for downstream stop logs.

Photo 4.4: Spillway looking towards downstream. From right to left, Bays 1, 2, 3, and 4 are visible.

Photo 4.5: Spillway, view of upstream right corner. The left end of the concrete transition dam is visible in the upper central area of the photograph.

Photo 4.6: Spillway, right upstream corner. The RCC cofferdam and partially completed concrete transition dam are visible.

Photo 4.7: Powerhouse – ICS shelter structure over units 1 and 2 is currently being dismantled.

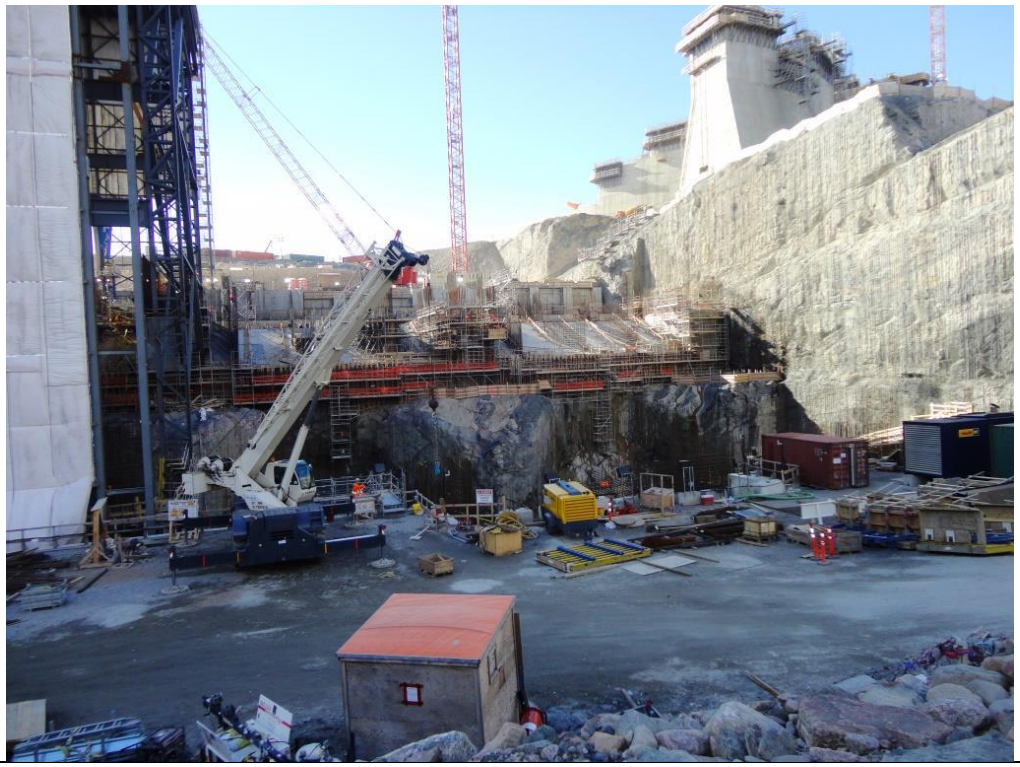

Photo 4.8: Powerhouse. Rock excavations for Units 3 and 4 are visible in the centre of the photo..The concrete transition dam is visible at the upper right side of the photograph.

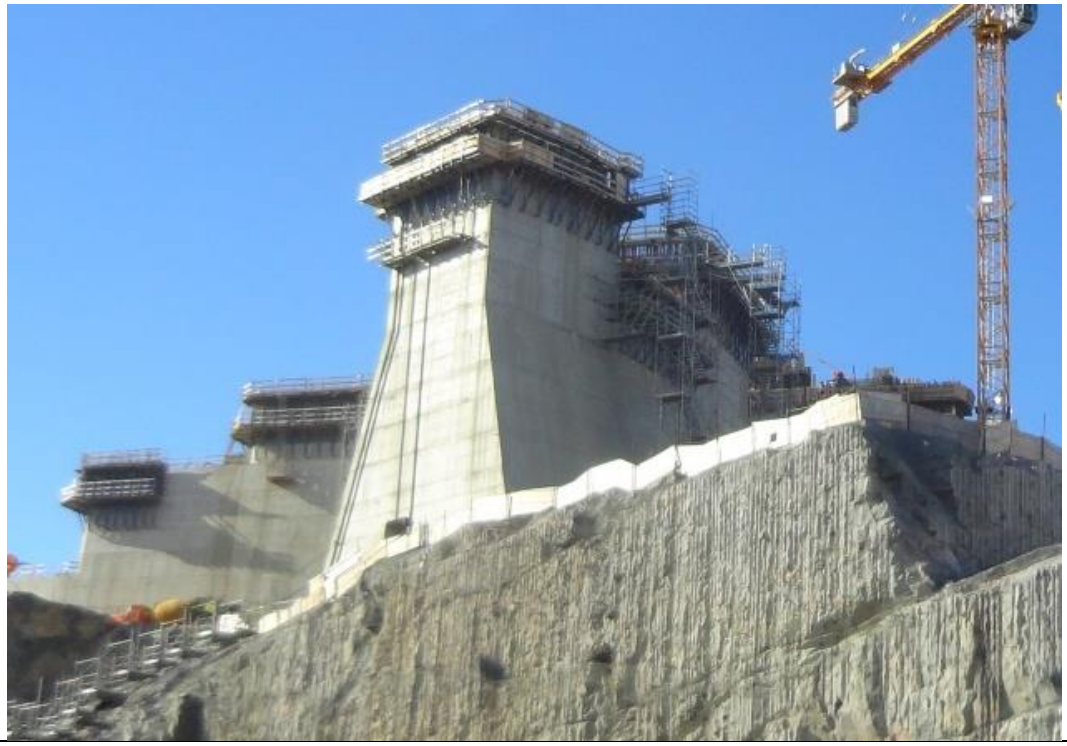

Photo 4.9: Concrete transition dam between the powerhouse and the spillway

Photo 4.10: Powerhouse, Unit 1. Formwork for the scroll case is visible

Photo 4.11: Powerhouse, Unit 2. Formworks are visible.

Photo 4.12: Powerhouse. Formwork in Unit 2.

Photo 4.13: Powerhouse, Unit 3.

Photo 4.14: Powerhouse, Unit 3.