

**Information Note**  
**Department of Environment and Conservation**

**Title:** Lower Churchill Project- Muskrat Falls- North Spur.

**Issue:** It is the opinion of few groups and individuals that the North Spur portion of the Muskrat Falls hydroelectric development presents an ill-defined level of risk for the entire project. This note has been provided for information purposes.

**Background and Current Status:**

- The North Spur is a geographic feature located on the north shore of the Churchill River approximately 43 km from the outlet. It is a spur of land that forms a natural dam on the Churchill River comprised of a rocky knoll at the southern tip, connected to the shoreline by soil deposits. There is extensive scarring of both the upstream and downstream sides of the North Spur from landslide scarps.
- Investigative works on the North Spur began in 1965 with the drilling of 2 boreholes. Additional work was carried out in 1979, 1981, 1997, 1998, 2009, and 2013 including additional borehole drilling, the installation of a pumpwell system, installation of monitoring instrumentation, and soil testing.
- The stratigraphy of the North Spur is as follows:
  - a. Upper sand– el. 60 to 50 m
  - b. Stratified layer– 50 to 10 m
  - c. Lower Marine Clay– 10 to -50 m (also known as “quick clay”)
  - d. Lower Aquifer– -50 to -210 m
  - e. Bedrock– -210 m
- Eleven past landslides have been identified upstream of the North Spur on both the north and south bank of the Churchill river up to 100 km from the outlet.
- Cabot Martin and Dr. Stig Bernander have been outspoken critics of the Muskrat Falls project and in particular the stability of the North Spur. The crux of their argument is that naturally occurring “quick clay” layers in the North Spur may fail leading to catastrophic failure.
- The Lower Churchill Generation project underwent an extremely rigorous environmental assessment and public review lead by an independent five-member panel (Joint Review Panel). Very strict terms and conditions have been placed on the project to ensure that it exceeds all safety requirements.
- Approval for the Muskrat Falls dam and North Spur stabilization works by the Department of Environment and Conservation was issued on July 10, 2013 under a Permit to Alter a Body of Water (ALT6933) under the authority of Section 48 of the Water Resources Act.
- Independent third party review of the engineering design for the Lower Churchill Generation Project, including the North Spur, has been undertaken by:
  - a. Public Utilities Board- Muskrat Falls Review (<http://www.pub.nf.ca/applications/MuskratFalls2011/index.htm>).
  - b. Independent Engineer for the Government of Canada- MWH Americas Inc., Various Reports (<https://muskratfalls.nalcorenergy.com/newsroom/reports/>).

- c. Manitoba Hydro International, Various Reports (<http://www.pub.nf.ca/applications/MuskratFalls2011/MHIreport.htm> and <http://www.powerinourhands.ca/pdf/MHi.pdf>).
- d. Cold Eye Review undertaken by Hatch.

Opinion from these reviews is that the current design is adequate.

- Stabilization work began on the North Spur in March 2015. To date, activities have included the removal of trees and bushes, removal of clay material, slope stabilization work, and work on the cut-off wall. Work on the North Spur to above the 25 m mark is to be completed before initial reservoir filling. It is important to note that engineering design for the North spur was undertaken by qualified geotechnical engineers with SNC Lavalin, and has had the benefit of extensive field investigations to support the engineering design. The design includes several preventative barriers that will help to address the issue of the stability of the North Spur. These barriers include but are not limited to:
  - a. Flattening both the upstream and downstream slopes to increase the overall safety factor against sliding failures.
  - b. Placement of rockfill and riprap slope erosion protection on all areas of the upstream and downstream slopes.
  - c. Placement of stabilizing fill in selected areas of the downstream slope to improve local toe stability and reduce the potential for retrogressive failures in sensitive marine clays.
  - d. Construction of an impervious fill blanket at the upstream slope and installation of a cut-off wall at the base of the blanket to block water seepage into the spur from the reservoir.
  - e. Construction of a second cut-off wall across the north end of the spur to cut off seepage from the high ground north of the river.
  - f. Construction of toe relief drains and a major drainage trench to further lower the water table in the North Spur.
  - g. Lowering of the piezometric level through pumping.
  - h. Long term monitoring of the piezometric conditions within the spur during operation of the reservoir.
  - i. Diversion and stabilization of discharge from the Kettle Lakes.
  - j. Consultation with and planned oversight of contractors concerning best management practices and work procedures to meet design objectives during the construction phase (e.g., avoiding human activity such as pile driving that could induce landslides, having a geotechnical expert on-site during construction, instrumentation to monitor groundwater, etc.).
- The stabilization work being undertaken at the North Spur is comprised of multiple barriers that will all contribute to the increased stability of the area. This type of design allows for a certain level of redundancy. The stability of the North Spur is not dependent on one element alone. The presence of multiple barriers in the stabilization works decreases the probability of a failure event, and the overall risk.
- The presence of “quick clay” in the North Spur area was initially identified back in the 1960’s. While there is evidence of landslides both upstream and downstream of the North Spur, the main failure type of landslides in the area has been identified as progressive slides. The identified trigger for all landslides in the areas has been toe erosion.

- A complete downward progressive failure of the North Spur during construction is not considered probable. The failure scenario proposed by Dr. Bernander of liquefaction of the North Spur and the river cutting a new channel and by-passing Muskrat Falls is extremely unlikely.
- There have been no significant landslides observed at or near the project site to date. There was some localized surficial sloughing along the downstream side of the North Spur in 2015. There was a landslide that occurred in spring 2014 downstream of the site, most likely influenced by heavy ice conditions and undercutting of the toe embankment. NALCOR does have protocols in place for the monitoring of potential landslides at the North Spur during construction on a 24/7 basis, including a communications protocol for unusual conditions.
- Nalcor has examined the effects of landslide induced waves on the Lower Churchill Generation Project with information being incorporated into the final design of the project, including the design of the North Spur stabilization works.
- Multiple dam failure scenarios have been investigated by Nalcor as part of this project including monolithic failure of the North Roller Compacted Concrete (RCC) Dam by overturning or sliding (identified as the worst case possible dam failure scenario), and North Spur failure. Both of these failure and inundation scenarios consider the release of the impounded volume of water. These studies met the requirements of the CDA Dam Safety Guidelines, 2007 and were deemed adequate by ENVC. The CDA Dam Safety Guidelines require evaluation of the failure scenario that would result in the worst case consequences. ENVC does not consider that the warning time available to populations at risk for failure of a stabilized North Spur would be less than that available for monolithic failure of the North RCC Dam.
- ENVC has accepted the North RCC dam failure scenario as the one that would result in the worst case consequences with respect to the magnitude of flood wave, area to be inundated, loss of life, damage to the environment, and loss of infrastructure. The dam classification that results from this scenario is Extreme (the highest risk classification possible). The Extreme classification has been used by both ENVC and NALCOR in terms of providing guidance on the standard of care expected in relation to dam safety of the entire Muskrat Falls site.
- The Lower Churchill Project Dam Break Study (2008) can be found at: [http://www.ceaa.gc.ca/050/documents\\_staticpost/26178/39444/at-01.pdf](http://www.ceaa.gc.ca/050/documents_staticpost/26178/39444/at-01.pdf). According to this study, if the main dam fails there will be 1 to 2 hours of warning time in Happy Valley-Goose Bay. Inundation mapping for areas affected down to Mud Lake are also available. Economic damage is estimated at \$59 million for the loss of residential homes plus additional infrastructure losses, and the estimated potential loss of life is 187. Failure of the North Spur during construction would not result in worse consequences than those already identified for the worst case dam failure scenario.
- Dam break flood inundation studies are necessary under the Canadian Dam Association, Dam Safety Guidelines (2007), to help determine the dam classification based on the potential consequences of failure of the dam. The dam consequence classification for Muskrat Falls is extreme, the highest classification available. This classification was incorporated into permit ALT6933 for the construction of the Muskrat Falls dam and informs the standard of care NALCOR is required to take in the design and construction of the dam.

- It is expected that the reservoir impoundment for the Muskrat Falls Facility will result in an increase in frequency of landslides in the first 10-20 years followed by long-term stabilization of shoreline banks in the area.
- NALCOR has two years from the start of reservoir filling to submit the first Dam Safety Review Report. As per the CDA Dam Safety Guidelines, Dam Safety Reviews are not required until after commissioning of the dam. A Dam Safety Review Report must be submitted to ENVC a maximum of every five years thereafter. This requirement will contribute to the long-term and continued safe operation of the Muskrat Falls dam after completion of the project.

**Analysis:**

- The design of the Muskrat Falls dam has been an iterative process that has occurred over decades. This timeframe has ensured that the design is as robust as possible, ensuring a standard of care equivalent to that of the risk posed by the dam. Initial field work and investigations have been repeated and expanded to provide a comprehensive hazard assessment.
- There is no doubt that the Lower Churchill Project is a massive undertaking with inherent risk involved; however, that risk can be managed through meeting regulatory requirements and following the best practices of the *Canadian Dam Association Dam Safety Guidelines*.
- The CDA Dam Safety Guidelines apply to the entire dam system which includes the North Spur.
- All improvement work on the North Spur will incrementally improve the safety and stability of the area.
- There have been no documented cases of a downward progressive failure trigger reported in the eastern Canadian Clay formation as proposed by Dr. Bernander. Accordingly, ENVC considers the method and safety factors used in assessing slope stability to be sufficient.
- It is also expected that the reservoir impoundment for Muskrat Falls will have a long-term stabilizing effect on bank stability in the area.
- The most likely mechanism of failure for the North Spur has been identified as seismic activity.
- Information from the NALCOR studies indicates that the most critical time for landslide events is generally associated with initial filling of the reservoir and for a period of up to two years after completion, and that most landslides occur at pre-existing landslide features.
- Earthquake loading for the North Spur has been established for a risk classification of Extreme as per the CDA Dam Safety Guidelines and as per the National Earthquake Hazard Reduction Program to ensure the dam meets minimum criteria for resistance to a design earthquake with an annual exceedance probability of 1:10,000.
- The Lower Churchill Generation Project has already gone through thorough public and technical review as part of the Environmental Assessment process, Joint Review Panel process, permitting process, and third party engineering design reviews. No additional independent review board is deemed necessary at this time.

- Over \$1 billion in total project costs for the LCP at Muskrat Falls is for North Spur stabilization work.
- Dr. Bernander has not seen the conceptual design for the North Spur and cannot comment on its effectiveness. Dr. Bernander's opinion on the stability of the North Spur is based on his research in Europe with no first-hand knowledge about the sources, causes and types of previous land-slides in North Spur area.

**Action Being Taken:**

- NALCOR has prepared a Project Wide Emergency Response Plan (PWERP) that includes a section on dam related emergencies and on the North Spur. The PWERP has 3 levels of emergencies– Level 3 involve emergencies which are not contained to the project work site (eg. downstream impacts). This would include emergencies that may affect residents of Happy Valley-Goose Bay and Mud Lake, and protocols are in place for warning those potentially affected downstream. The PWERP is relevant for all current construction activities underway at Muskrat Falls.
- NALCOR submitted to ENVC a draft Emergency Preparedness Plan (EPP) in January 2016. This document was required prior to the filling of the reservoir, which is scheduled to occur in the fall of 2016. This required EPP will help to address the risk posed to those downstream of the dam in the event of a possible dam failure event.
- ENVC will continue to review reports produced by NALCOR that deal with hydrotechnical aspects of the LCP at Muskrat Falls, and will deal with NALCOR to address any issues.
- ENVC meets quarterly with NALCOR to discuss progress on the project and any outstanding issues.
- ENVC staff visit the Muskrat Falls project site approximately 8 times per year.

**Prepared/Approved by:** P.Dawe/ H.Khan/M.Goebel, ADM/  
**Ministerial Approval:**

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