

Date : 5/12/2017 10:23:08 AM
From : "Carter, Paul"
To : "Bown, Charles"
Subject : FW: Attached letter from Gilbert Bennett
Attachment : Paul Carter - May 11.pdf;ATT00001.jpg;

Paul Q. Carter
Executive Director – Muskrat Falls Oversight Committee
Cabinet Secretariat, Executive Council
Government of Newfoundland and Labrador
PO Box 8700
St. John's, NL
A1B 2Z8
Phone: 709-729-3681
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From: KathyKnight@nalcenergy.com [mailto:KathyKnight@nalcenergy.com]
Sent: Friday, May 12, 2017 8:53 AM
To: Carter, Paul
Subject: Attached letter from Gilbert Bennett

Hi Paul:

Please find attached a letter from Gilbert Bennett regarding North Spur Stability. The original is in the mail to you.

Regards, Kathy



Kathy Knight
Executive Assistant
Executive Leadership
Nalcor Energy
t. 709 737-1805 c. 709 685-9828 f. 709 737-1782
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**Lower Churchill Management Corporation**

Corporate Office
500 Columbus Drive
P.O. Box 12800
St. John's, NL Canada A1B 0C9

LCP Rec. No. L010-G009-200-010642-00001

May 11, 2017

Mr. Paul Carter
Executive Director – Muskrat Falls Oversight Committee
Government of Newfoundland and Labrador
P. O. Box 8700
St. John's, NL
A1B 4J6

Dear Mr. Carter:

RE: North Spur Stability – Letter Dated 31 March 2017

This correspondence is in response to your letter dated 31-Mar-2017 related to North Spur Stability.

Hardcopies of all stamped design documents for the North Spur stabilization works will be made available to the Muskrat Falls Oversight Committee for review in the Records Room at the Lower Churchill Project office on Torbay Road. Please contact Mr. Stephen Pellerin at 570-5969 (StevePellerin@lowerchurchillproject.ca) to make arrangements.

Record Drawings will be finalized once all the North Spur stabilization work is completed later this year. Once these documents are ready, they will be made available to the Muskrat Falls Oversight Committee for review at the Records Room at the Lower Churchill Project office on Torbay Road. Mr. Pellerin will contact you and notify you when these documents are ready for review.

Please find attached the following documents:

1. Letter from SNC Lavalin dated 13-April-2017; in response to your requests for confirmation of work completed to date and compliance with Canadian Dam Safety Guidelines.

2. Memo from SNC Lavalin dated 21-April-2017; in response to your request on the 2014 "Cold Eye Review of Design and Technical Specifications, North Spur Stabilization Works".

If you have any questions please feel free to contact me.

Sincerely,



Gilbert J. Bennett, P. Eng., FCAE
Executive Vice President, Power Development

Enclosures



SNC-Lavalin Inc.
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April 13, 2017

SLI REFERENCE No.: 505573-0000-30CC-I-1495
LC Ref. No: S011-L010-200-170330-00269

Lower Churchill Management Corporation
350 Torbay Road, Suite 2
St. John's, NL, A1A 4E1 CANADA

Attention: Scott O'Brien

Subject: Lower Churchill, Phase 1 Development
Agreement LC-G-002
Engineering Procurement and Construction Management (EPCM) Services
Muskrat Falls – North Spur Design

Dear Scott:

This letter is to confirm that all stabilization work completed to date on the North Spur is in accordance with the SNC-Lavalin stamped drawings and specifications. Any modifications or changes made during construction to adapt to actual conditions were reviewed and approved by the Engineer of Record, documented through the project change process and will be included in the record drawings and documents for the project.

SNC-Lavalin further confirms that the North Spur design criteria for the stabilization work on the North Spur, and the dam safety management procedures that have been implemented are in conformance with the recommendations of the Canadian Dam Safety Guidelines (2007).

SNC-LAVALIN INC.



Greg Snyder, FEC, P.Eng.
Engineering Manager, Muskrat Falls
PROJECT DELIVERY TEAM
Lower Churchill Project

c.c.: R. Power, L Clarke, P. Cattelan, M. Tremblay, J. Leone

Power





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MEMO

TO: File **DATE:** 21-Apr-2017

CC: Scott O'Brien
Robert Woolgar
Darren Protulipac
Clyde McLean
Michel Tremblay
Joe Leone **DOC NO.** 0000-30CC-I-1496

FROM: Greg Snyder
Regis Bouchard
Alvaro Ceballos **LC REF:** S011-L010-200-170330-00270

SUBJECT: Review and Disposition of North Spur Cold Eyes Review by Hatch Ltd.

Hatch undertook a Cold Eyes Review of the North Spur Design in September 2013, followed by the issue of a report entitled "Cold Eyes Review of Design and Technical Specifications, North Spur Stabilization Works" (MFA-HE-CD-2800-GT-RP-0001-01). The Hatch report summarized the observations and findings from the review which were valid at that time. At the time of the review, the design report was not yet complete and issued by SNC. A number of recommendations were made and included in the report. This memo is a follow-up to that report which provides a review of the recommendations and provides the disposition of each.

1 North Spur Stabilization Design

The design of the North Spur Stabilization measures has taken into account the extensive information available. The general conclusions of a Cold Eyes Review performed by Hatch were that the design approach was considered to meet the general requirements for the satisfactory and long term stability of the North Spur. It was also noted that the Technical Specifications and the Contract Document Exhibits that were reviewed (Exhibit 1 and Exhibit 12) were well written and complete.



1.1 THE UPSTREAM AND DOWNSTREAM SLOPES

The upstream and downstream slopes of the North Spur have been designed to meet normally accepted slope stability factors of safety criteria under various loading conditions.

1.1.1 The Upstream Slope

The upstream slope will be covered by an impervious glacial till blanket with a minimum thickness of 6.0m and connected to a cement bentonite cut-off wall which extends to the lower marine clay. The cut-off wall extends northwards from the rock knoll along both the upstream slope and continues in a northwest direction towards the kettle ponds. The slope is protected by granular, rock fill and riprap zones as per normal practice.

Hatch noted that this approach is considered to be an effective means of reducing inflow into the North Spur. Some specific recommendations with regards to this design that were made were as follows:

- **Hatch Comment:** The basis of the extent of the northwest cut-off wall was not provided in the design documents and it is suggested that a seepage analysis be carried out to determine its effectiveness.
 - **SNC Response:** This analysis was completed in the 3D hydrogeological model (Ref.: MFA-HE-CD-2800-GT-RP-0003-01).
- **Hatch Recommendation:** The cut-off wall should be extended at least 3.0m into the lower marine clay or that a specific assessment is made to confirm the minimum embedment needed to ensure hydraulic gradients are at acceptable levels at the interface between the lower clay layer and the overlying horizon.
 - **SNC Response:** A 3D hydrogeological model was developed and results confirmed the design that 2m embedment was sufficient (Ref.: MFA-HE-CD-2800-GT-RP-0003-01).
- **Hatch Recommendation:** At the cut-off wall contact with the rock knoll on the south side it is recommended that provision for grouting the upper bedrock is included. This can be undertaken easily through the cut-off wall. These measures have little incremental cost and could prove to be beneficial in ensuring an effective seating in the marine clay and bedrock.



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- **SNC Response:** Provision for grouting of upper bedrock was made on the IFC documents and the record drawings will show where it was used, if required.
- **Hatch Recommendation:** It is recommended that a provision of a chisel be made in the technical specification should boulders be encountered in the cut-off wall excavation and for removing any weak and open jointed rock at the bedrock contact.
 - **SNC Response:** Provision to deal with boulders and weak or open jointed rock during construction works was made on the IFC documents and the record drawings will show where it was used, if required.
- **Hatch Recommendation** The technical specification states that the minimum strength of the cut-off wall shall be 200 kPa. This appears to be low and a review of the stiffness of the cut-off wall and the surrounding soil should be undertaken to closely match the two so as to minimize deformation and or cracking of the cut-off wall.
 - **SNC Response:** An extensive effort was done to develop a slurry mix design able to mimic the properties and behaviour of the native soils.
- **Hatch Recommendation:** Some form of protection of the upper part of the cut-off wall needs to be included during compaction of the overlying till blanket.
 - **SNC Response:** Material and compaction over the cut-off walls were adjusted in the IFC documents.

1.1.2 The Downstream Slope

The downstream slope protection work is, in general, appropriate as a deterrent against instability.

Some specific recommendations with regards to the downstream stabilization measures were as follows:

- **Hatch Recommendation:** The long term efficiency of a geotextile filter planned to be used was questioned as it may be prone to clogging from mineral deposition.
 - **SNC Response:** The geotextile was replaced by granular material as shown on the IFC documents.



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- **Hatch Recommendation:** The number of pressure relief wells at the toe which penetrate into the Lower Aquifer needs to be justified notwithstanding that additional relief wells may be added depending on piezometric data after impoundment.
 - **SNC Response:** Number of relief wells was established at ten during the final design. The hydrogeologic model indicated that these wells may not be necessary. The necessity for the relief wells and final quantity and arrangement, if required, is to be evaluated after final impoundment to el 39.0m.
- **Hatch Recommendation:** The number and spacing of the potential upper wells needs to be designed accounting for various piezometric scenarios so that alternative measures can be implemented quickly should they be deemed necessary.
 - **SNC Response:** Please see above.
- **Hatch Recommendation:** To prevent rain and surface infiltration into the Spur, the engineering report refers to a geomembrane cover on the surface of the spur to a distance of 200m from the rock knoll at the narrowest part of the spur. Hatch was informed that this will only be installed if deemed beneficial after observations post impoundment.
 - **SNC Response:** The geomembrane was deleted and not included in the IFC documents.
- **Hatch Recommendation:** Recommended that additional seismic assessment be performed accounting for topographic effects as this could affect amplification factors.
 - **SNC Response:** This assessment was done as part of the dynamic studies (Ref.: MFA-SN-CD-2800-GT-RP-0007-01).
- **Hatch Recommendation:** Resolve discrepancies in the values of the sensitivities reported for both the upper and lower marine clays.
 - **SNC Response:** Observed and measured sensitivity values were clarified in the design report (Ref.: MFA-SN-CD-2800-GT-RP-0004-01).
- **Hatch Recommendation:** Recommended a 2D Flac analysis utilizing an appropriate time history for the relevant Earthquake and soil parameters from existing data to determine the strains generated which would then be compared to the peak strain from the triaxial testing.



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In addition, stresses at the toe need to be examined carefully as local overstressing can lead to a progressive failure even in slopes with an adequate factor of safety.

- **SNC Response:** This analysis was done as part of the dynamic studies (Ref.: MFA-SN-CD-2800-GT-RP-0007-01).
- **Hatch Recommendation:** Engage at least two senior consultants with expertise in the behavior of sensitive marine clays. These consultants should be requested to provide guidance before implementation of any analyses and then to review the results when the work is completed.
 - **SNC Response:** Dr. Idriss and Dr. Leroueil, experts in sensitive clays, were engaged by the project for this task.

1.2 INSTRUMENTATION

- **Hatch Recommendation:** Recommend that seepage measurement devices be installed in the collector pipes from the pressure relief wells. In addition, the possible installation of slope indicators is considered to be of benefit and should be considered.
 - **SNC Response:** Weirs in collector pipes and inclinometers were incorporated in IFC drawings.

2 References

MFA-HE-CD- 2800-GT-RP-0001-01	Cold Eyes Review of Design and Technical Specifications, North Spur Stabilization Works
MFA-HE-CD-2800-GT-RP-0003-01	CH0008 - North Spur Stabilization Work - Three Dimensional (3D) Hydrogeological Study for the North Spur
MFA-SN-CD-2800-GT-RP-0007-01	CH0008 - North Spur Stabilization Work - North Spur Stabilization Works - Dynamic Analysis Study
MFA-SN-CD-2800-GT-RP-0004-01	North Spur Stabilization Works - Design Report

Greg Snyder, P. Eng., FEC
 Engineer Manager, Muskrat Falls
 Lower Churchill Project
 Muskrat Falls Hydroelectric Project