Document Front Sheet

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NE-LCP Contractor/Supplier

Contract or Purchase Number and Description:	Contractor/Supplier Name:
LC-G-002 (Project No. 505573)	SNC-Lavalin Inc.

Document Title:	Total Number of Pages Incl. Front Sheet
315 kV HVac GEOTECHNICAL BASELINE Muskrat Falls to Churchill Falls	85
Contractor/ Supplier Document Number:	Revision Number:
EPC(M) Document Number: 505573-361B-4GER-0001	Issue Number: 00

NE-LCP Document Number:	NE-LCP Issue Number:
MFA-SN-CD-6140-TL-RP-0012-01	B1

Approver's Signature:	Date (dd-mmm-yyyy):	Review Class:
[signature]	14-SEP-2012	
Comments:		Equipment Tag or Model Number:

NE-LCP or EPC(M)

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- [x] 01 – REVIEWED AND ACCEPTED – NO COMMENTS
- [ ] 02 – REVIEWED – INCORPORATE COMMENTS, REVISE AND RESUBMIT
- [ ] 03 – REVIEWED - NOT ACCEPTED
- [ ] 04 – INFORMATION ONLY
- [ ] 05 – NOT REVIEWED

Lead Reviewer:	Date (dd-mmm-yyyy):	Area Manager:	Date (dd-mmm-yyyy):
[signature]	18-Sep-2012	[signature]	18-Sep-2012
NE-LCP or EPC(M) Management: [signature]	Date (dd-mmm-yyyy): 18-Sep-2012		

General Comments:

SNC·LAVALIN

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Lower Churchill Project

315 kV HVac GEOTECHNICAL BASELINE

Muskrat Falls to Churchill Falls

SLI Document No. 505573-361B-4GER-0001-Rev.00

Nalcor Reference No. MFA-SN-CD-6140-TL-RP-0012-01-Rev.B1

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REVISION LIST

Revision						Remarks
N°	By	Chec.	Appr.	Appr.	Date	
00	MDB	JPS	GS	KK	14-SEP-2012	Issued for bid.

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1 INTRODUCTION

This document should be read in conjunction with the "315 kV HVac Foundations Design Criteria" (document No. MFA-SN-CD-6140-TL-DC-0004-01) for the HVac line between Muskrat Falls and Churchill Falls.

A general description of the line features, design features and environmental conditions is given in the introduction section of the "315 kV HVac Transmission Line Design Criteria" (document No. MFA-SN-CD-6140-TL-DC-0002-01).

2 PURPOSE - GENERAL

The purpose of the Geotechnical Baseline Report is to define the soil and rock data required for the foundation design, including the definition of the selected soil parameters to be used, the selection of the appropriate foundation type for each of the tower location and to define the geotechnical investigations to be done to reduce the level of uncertainty due to the lack of appropriate data for each tower location.

3 REFERENCES

- MFA-SN-CD-6140-TL-DC-0001-01 - 315 kV HVac Tower Design Criteria, Muskrat Falls to Churchill Falls
- MFA-SN-CD-6140-TL-DC-0002-01 - 315 kV HVac Transmission Line Design Criteria, Muskrat Falls to Churchill Falls
- MFA-SN-CD-6140-TL-DC-0004-01 - 315 kV HVac Foundations Design Criteria, Muskrat Falls to Churchill Falls
- CL0021 - LCP-PT-ED-0000-EN-RP-0001-01 – Lower Churchill Project – Basis of Design
- CL0011 - LCP-PT-ED-0000-EN-PH-0021-01 – Design Philosophy for HVac Transmission Lines
- AC1030 – Field Investigations and Construction Requirements - 735 kV TL - GI to CF (Final Report, Feb-2008) (old SLI No. 722850-AC1030-40ER-0001-00)
- AC1060 – Field Investigations and Construction Requirements - 230 kV TL - MF to GI (Final Report, Feb-2008) (old SLI No. 722850-AC1060-40ER-0001-00)
- Memo from AMEC, 315 kV HVac Muskrat Falls to Churchill Falls Transmission Line 2 (North line) – Nalcor Energy – Lower Churchill Project (LCP) – Geotechnical Conditions Along Centerline, AMEC file No. TF1116574, by Calvin Miles, 21-Oct-2011.
- Memo from AMEC, 315 kV HVac Transmission Line Foundation, Muskrat Falls to Churchill Falls: Geotechnical Design Parameters, AMEC file No. TF1116574, by Andrew Peach, draft 21-Nov-2011
- Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 2 – 1998 Geotechnical Investigations prepared by SNC Lavalin/AGRA, 1999.
- GI1010 – Gull Island 2007 Site Investigations Volume 3A – Borrow Areas B2, B6 and B6B, Volume 12 – Drawings, prepared by SNC Lavalin, 2009.

- MF1300 – Muskrat Falls 2010 Site Investigations, Volume 2C – Geotechnical Report for Switchyard, Converter Station and Accommodation Complex, prepared by SNC Lavalin, 2011.
- Muskrat Falls Power Development & 345 kV Transmission Intertie to Churchill Falls. 1979 Field Investigation, prepared by SNC/Lavalin Newfoundland Limited, 1980.
- LiDAR images and air photos prepared by Terrapoint Canada Inc. and provided by Nalcor, 2011.
- Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Landforms and Surficial Geology maps and Granular Aggregate Resource maps provided on several NTS 1:50,000 scale map sheets along the route.
- SNC Lavalin – spreadsheets, prepared on September 26, 2011 and October 18, 2011, providing tower staking and type along the route.
- Canadian Foundation Engineering Manual, 2006. 4th Edition. Canadian Geotechnical Society.
- A.W. Hannah, J.P. Schell, D. Butt, 230 kV CAT ARM TRANSMISSION FACILITY USE OF EXISTING TOWER DESIGNS IN SEVERE LOADING REGIONS, Newfoundland and Labrador Hydro and Monenco Consultants Limited, March 1986, paper prepared for presentation to the Canadian Electrical Association, Transmission Section, Engineering and Operating Division, Toronto.
- Tomlinson, M.J., Pile Design and Construction Practice, fourth edition
- Graham, J., Raymond. G.P., and Suppiah, A. (1984). Géotechnique 34, No. 2. 173-182.
- Bowles, J.E., 1996. Foundation Analysis and Design, 5th Edition, McGraw-Hill.
- Peck, R.B., Walter H.E., and Thornburn, T.H., 1953. Foundation Engineering. John Wiley & Sons, Inc.
- Hough, B.K., 1969. Basic Soils Engineering, Second Edition. The Roland Press Company, New York.

- Conception des fondations des pylônes à treillis de type rigide, SN-41.6 (préliminaire), Hydro-Québec Équipement, 2007.
- Kiessling, F., Nefzger, P., Nolasco, J.F., Kaintzyk, U., 2003. Overhead Power Lines:
- Planning, Design, Construction. Springer – Verlag Berlin Heidelberg.
- Post Tensioning Institute, 2004. Recommendations for Progressed Rock and Soil Anchors, 4th Edition.
- Wyllie, D.C. 1999. Foundations on Rock. E&FN Spon.
- Richard Richardson, Helical Pier Systems Ltd., Technical Presentation, SNC Lavalin LCP Project Office, St. John’s, NL, October 27, 2011.

4 CODES AND STANDARDS

Unless specifically stated otherwise, the design of the foundations for the 315 kV HVac transmission line towers will be based on the applicable parts of the latest revision of the following codes, specifications, standards, regulations and other documents. In the event of conflicting requirements, the most stringent will apply:

- CAN/CSA – C22.3 No. 60826 – Design Criteria of Overhead Transmission Lines
- ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- CSA S37-01: Antennas, Towers, and Antenna Supporting Structure (Reaffirmed, 2006).
- IEEE-691: Guide for Transmission Structure Foundation Design and Testing, 2001.
- Newfoundland and Labrador Hydro Standards, TM Series.

5 SAFETY / LOADING FACTORS

Safety factors to be used for the foundation design are given in the Foundation Design Criteria Document No. MFA-SN-CD-6140-TL-DC-0004-01. One of the most useful documents to be used for the application safety factors is the 230 kV paper prepared by Hannah, Schell and Butt, in 1986.

The following table compares the safety factors used for projects done in Newfoundland (TL's 247 and 248) and the 315 kV lines in Labrador.

Table 5-1: Comparison of Overload / Safety Factors

Item	TL's 247 and 248 1986	315 kV HVac 2012
Towers	All towers; 1.1	Towers A, B; 1.11 (or 1/0.9) Towers C, D, E; 1.25 (or 1/0.8)
Footing bearing	1.5	2.0
Footing uplift/stability	1.25	1.375
Conductors, shield wires	Loadzones 1-4.7; 1.25 Loadzones 5,6,8; 1.33	1.33
Guy wires	1.1	Broken condition; 1.11 (or 1/0.9) Intact condition; 1.43 (or 1/0.7)
Suspension insulators	1.5	2.0
Strain insulators	2.0	2.0

In summary, for the 315 kV Transmission Lines, each of the safety factors are equal to or exceeding the safety factor defined for previous significant projects done in Newfoundland and Labrador.

6 WATER TABLE

Based on previous geotechnical investigations and test pit reports, the water table varies with the season and the location. The uplift criteria will assume the water table to be at 1.0 m depth and selected as the most appropriate depth applicable for the line.

7 SOIL/ROCK DENSITY AND BEARING PRESSURE

Two types of soil are defined within the next section for foundation Type 1 and Type 2.

Two types of soil were used by AMEC when defining the preliminary foundation type selection and estimating the proportion of each foundation type. The Appendix D shows the foundation selection along the north line (Line #2).

For the rock bearing capacity and the grout-rock adhesion, two types of rock are defined for the rock foundation Type 3 in Section 8.

Soil and rock data used for the foundation design are based on the definition of the type of soils and rock present along the transmission line as defined by AMEC report.

The “315 kV HVac Foundations Design Criteria” (document No. MFA-SN-CD-6140-TL-DC-0004-01) details how the calculations are performed using the selected soil and rock data as defined within this document.

8 FOUNDATION TYPES

The Appendices A and B define the soil and required parameters for the design of the foundation types.

Due to the large variety of soil and rock conditions, it was decided, based on past experience, to define two sets of soil data and to define two foundation types for granular soils, one type for rock, and one type for deep clayey or sandy soil:

- Type 1: Compact granular and dense granular soil, using a steel grillage foundation for the mast of the tower Types A and B and for the legs of the tower Types C, D and E. For the backfill material, the average frustum angle of 25° will be used, assuming a modified Proctor dry unit weight of 20.7 kN/m^3 and a submerged density of 12.9 kN/m^3. For the Type 1 foundation, the minimum net allowable bearing capacity is assumed to be 250 kPa. In the cases where the minimum bearing pressure cannot be met or the soil density and frustum angle cannot be reached, foundation Type 2 will be the first alternative. See Section 9.2.3 of the “Foundation Design Criteria" for the guy wire anchor in this type of soil for tower Types A and B.
- Type 2: Less compact granular and less dense granular soil, using a steel grillage foundation for the mast of the tower Types A and B and for the legs of the tower Types C, D and E. For the backfill material, the average frustum angle of 20° will be used, assuming a modified Proctor dry average unit weight of 13.6 kN/m^3. For the Type 2 foundation, the minimum net allowable bearing capacity is assumed to be 100 kPa. In the cases where the minimum bearing capacity is between 80 kPa and 100 kPa, a 500 mm granular pad will be used. If the soil density and angle frustum angle cannot be reached, then the Type 4 deep foundation will be used. See Section 9.2.3 of the “Foundation Design Criteria" document for the guy wire anchor in this type of soil for tower Types A and B.
- Type 3: This is the rock foundation and it includes an adjustable steel stub to reach the bedrock level foundation for the mast of the tower Types A and B and for the legs of the tower Types C, D and E. Two types of rock will be assumed with two bearing capacities: 3000 kPa and 1000 kPa. Four mechanical rock anchors will be used for the mast

foundation on rock (tower Types A and B) and four mechanical rock anchors will be used for the legs on rock (tower Types C, D and E). In most of the cases, the total length of the rock anchor is defined by the volume of rock with the appropriate apex angle. Two apex angles will be used to define the rock anchor length: an apex angle of 90° will be used for normal rock and an apex angle of 60° will be used for weak rock or highly fractured rock. If the apex angle is not appropriate because of bad rock condition, then an appropriate design will be undertaken on a case by case basis. See section 9.2.4 of the “Foundation Design Criteria” document for the guy wire grouted rock anchor for tower Types A and B. Appendix C describes the anchor calculation method for single anchor and for a group of anchors.

- Type 4: Where foundation Types 1, 2 and 3 are not suitable, deep foundation will be used. For the tower Types A and B mast footings and the tower Types C, D and E leg footings, foundations will be either a driven pile design or a modified grillage design, depending upon the specific soil conditions at the tower site and the relative cost of each.

  For the guy anchors for tower Types A and B, the design will be either a longer drilled over burden guy anchor or a grillage design, again; depending upon the specific soil conditions at the tower site.

Where foundation Types 1, 2, 3 and 4 are not applicable, special foundations will be designed on a case by case basis. There may be locations where the on-site conditions indicate that relocating the tower is the best choice.

For rock locations, precautions will be taken to protect concrete and grout from water while the concrete and grout is setting.

9 FROST PROTECTION

According to the geotechnical recommendations (APPENDIX L), the maximum depth of frost penetration in Labrador is defined as per the following table:

Table 9-1: Frost Depth

Transmission Line Location	Calculated Frost Depth (m)	Foundation Depth (m)
Muskrat Falls - Pope's Hill km 0 to km 56.5	3.0	3.25
Pope's Hill - Churchill Falls km 56.5 to km 24.7	3.5	3.75

A buffer of 0.25 m is added to the frost depth to obtain the total foundation depth. The foundation depth is controlled by the frost depth for all of the mast foundations for tower Types A and B. For the tower Types C, D and E, all the foundation depth will be 3.75 m for the uplift capacity calculations.

10 UPLIFT CAPACITY OF FOUNDATIONS

The uplift capacity of the steel grillages Types 1 and 2 for soil and of the rock foundation Type 3 are defined in Sections 9.1, 9.4 and 9.5, respectively, of the Foundation Design Criteria document for the 315 kV HVac line.

11 REPORTS AND RESULTS BASED ON THE EXISTING DATA

The Appendices E to K present the SLI recommendations for the geotechnical investigation to be completed, including details of the investigation types, equipments and costs.

APPENDIX A

AMEC TECHNICAL MEMO 16-MAR-2012

"315 kV HVac Transmission Line Foundations, Muskrat Falls to Churchill Falls: Geotechnical Design Parameters"

Memo

To	**SLI Foundation Design Team (SLI)**	File no	**TF1116574**
From	**Andrew Peach, P. Geo (AMEC)**	cc	**Calvin Miles (AMEC)** **Prapote Boonsinsuk (AMEC)**
Tel	**709.722.7023**		
Fax	**709.722.7353**		
Date	**March 16, 2012**		

Subject **315 kv HVAC Transmission Line Foundations, Muskrat Falls to Churchill Falls: Geotechnical Design Parameters.**

INTRODUCTION

In late September 2011, members of AMEC's Environment and Infrastructure (AMEC) St. John's office were requested to join SNC Lavalin's (SLI) Lower Churchill Project (LCP) team in order to provide geotechnical expertise with respect to the surficial and bedrock geology that would be encountered along the AC and DC line corridors, and to provide specific geotechnical parameters related to design of the transmission tower foundations along the corridors. AMEC has completed their assessment of the AC line corridor and the results are summarized in this technical memorandum.

SURFICIAL & BEDROCK GEOLOGY

Sources of Information

Information was obtained from several sources as follows:

- Technical reports prepared for Nalcor associated with the LCP:
    - AC1030 – Field Investigation & Construction Requirements, 735 kV Transmission Line, Gull Island to Churchill Falls, prepared by SNC Lavalin, 2008.
    - AC1060 - Field Investigation & Construction Requirements, 230 kV Transmission Line, Muskrat Falls to Gull Island, prepared by SNC Lavalin, 2008.
    - Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 2 – 1998 Geotechnical Investigations prepared by SNC Lavalin/AGRA, 1999.
    - MF1602 – Bank Stability and Fish Habitat 2010 Field Investigation Reports, Volume 1 – Bank Stability Assessment, Volume 2 – Fish Habitat Substrate Classification, prepared by AMEC, 2011.

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- GI1010 – Gull Island 2007 Site Investigations Volume 3A – Borrow Areas B2, B6 and B6B, Volume 12 – Drawings, prepared by SNC Lavalin, 2009.

- MF1300 – Muskrat Falls 2010 Site Investigations, Volume 2C – Geotechnical Report for Switchyard, Converter Station and Accommodation Complex, prepared by SNC Lavalin, 2011.

- Muskrat Falls Power Development & 345 kV Transmission Intertie to Churchill Falls. 1979 Field Investigation, prepared by SNC/Lavalin Newfoundland Limited, 1980.

- LiDAR images and air photos prepared by Terrapoint Canada Inc., and provided by Nalcor, 2010.

- Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Landforms and Surficial Geology maps. And Granular Aggregate Resource maps provided on several NTS 1:50,000 scale map sheets along the route.

- SNC Lavalin – spread sheets, prepared on September 26, 2011 and October 18, 2011, providing tower staking and type along the route.

Summary of Results

Bedrock – Approximately 354 (55%) towers will require foundations on bedrock. Bedrock is estimated to be at or within 2.75 m depth of the mineral soil surface, i.e., below the organic layer, for approximately 55% of the structure locations. The proportion of towers to be founded on bedrock increases westward toward Churchill Falls.

Clean Uniform Sand – Approximately 73 (11%) towers will be founded on clean uniform sand. This material underlies approximately 11% of the structure locations and is found only at the eastern end of the route between Muskrat Falls and the Pinus River area.

Fluvial Sand and Gravel – Approximately 45 (8%) towers will be founded on sand and gravel with varying amounts of cobbles and small boulders, interpreted to be derived from a fluvial source, either modern day fluvial deposits or historic deposits pertaining to eskers or esker complexes. The deposits usually contain trace fines. These soils are more common along the central portion of the route.

Sand and Gravel derived from Glacial Till – Approximately 127 (20%) towers will be founded on till that is a diamicton of sand and fines, with gravel, cobbles and boulders. This material was deposited directly by a glacier with little or no sorting and can vary in composition and thickness over short distances. These soils are most common along the central portion of the route where thicknesses of 3 m or more are expected. Till is also present as a thin layer, usually a metre or two, over much of the area identified above as bedrock.

Silty/Clayey Sand, Silt and Clay – Approximately 40 (6%) towers will be founded on apparent glaciomarine or glaciolacustrine sediments comprised generally of a mix of fine grained materials such as silt, and clay. Included in this category is sand with some organic material that is interpreted to exist on the modern and historic flood plains of the Edward's River.

TOWER FOUNDATION DESIGN PARAMETERS

Sources of Information

Information was obtained from and reference has been made to the following sources:

- Canadian Foundation Engineering Manual, 2006. 4th Edition. Canadian Geotechnical Society.
- Graham, J., Raymond. G.P., and Suppiah, A. (1984). Géotechnique 34, No. 2. 173-182.
- Bowles, J.E., 1996. Foundation Analysis and Design, 5th Edition, McGraw-Hill.
- Peck, R.B., Walter H.E., and Thornburn, T.H., 1953. Foundation Engineering. John Wiley & Sons, Inc.
- Hough, B.K., 1969. Basic Soils Engineering, Second Edition. The Roland Press Company, New York.
- Conception des foundations des pylônes à treillis de type rigide, SN-41.6 (PRÉLIMINAIRE), Hydro-Québec Équipement, 2007.
- CSA S37-01: Antennas, Towers, and Antenna Supporting Structure (Reaffirmed 2006).
- IEEE-691: Guide for Transmission Structure Foundation Design and Testing, 2001.
- Kiessling, F., Nefzger, P., Nolasco, J.F., Kaintzyk, U., 2003. Overhead Power Lines: Planning, Design, Construction. Springer – Verlag Berlin Heidelberg.
- Post Tensioning Institute, 2004. Recommendations for Prestressed Rock and Soil Anchors, 4th Edition.
- Habibagahi, K., and J.A. Langer, 1983. Laterally Loaded Deep Foundations: Analysis and Performance. ASTM Special Technical Publication 835.
- Wyllie, D.C. 1999. Foundations on Rock. E&FN Spon.
- Randy Richardson, Helical Pier Systems Ltd., Technical Presentation, SNC Lavalin LCP Project Office, St. John's, NL, October 27, 2011.

Minimum Foundation Depth for Frost Protection

The frost penetration depth along the transmission line corridor was calculated as outlined in the AMEC Technical Memorandum dated December 9, 2011. Based on these depths, SLI determined the minimum foundation depths to reduce the effects of seasonal frost as summarized in the following table.

Table 1: Estimated Frost Penetration Depths and Minimum Foundation Depths.

Transmission Line Location	Tower Types	Calculated Frost Depth (m)	Foundation Depth [1] (m)
Muskrat Falls - Pope's Hill	A & B	3.0	3.25
Pope's Hill - Churchill Falls	C,D&E	3.5	3.75[2]
Muskrat Falls - Pope's Hill	C,D&E	3.0	3.75[3]
Pope's Hill - Churchill Falls	A & B	3.5	3.75

Notes: 1) As provided by SLI.
2) Minimum depth due to required uplift resistance, as provided by SLI.
3) All C, D, & E Towers will have same foundation depth, as provided by SLI.

Allowable Bearing Capacity (Granular Soils) – General Shear Failure Criterion

SLI requested that only two (2) types of granular soils be considered with respect to the bearing surface and allowable bearing capacities along the AC line corridor, i.e., Type 1 – good soil, Type 2 – poor soil. SLI also requested that these soils be selected so that the Type 1 soil should generally have an allowable bearing capacity of 250 kPa and that the Type 2 soil should generally have an allowable bearing capacity of 100 kPa. In accordance with SLI standard practice the allowable bearing capacities cited above are based on a Factor of Safety (FOS) of two (2) due to ultimate design loads being considered.

In order to accommodate the request for two soil types AMEC has made a number of assumptions regarding the soil data with respect to each soil type. Soil description and soil data associated with each soil type can be found in the following table.

Table 2: Granular soil types and parameters for steel grillage foundations (shear failure).

Soil Type	Internal Friction Angle	Cohesion (kPa)	Dry Unit Weight (kN/m^3)	Submerged Unit Weight (kN/m^3)
Compact, well-graded, silty, sand and gravel (Type 1 soil)	32°	0	18.4	11.6
Loose, clean, uniform sand (Type 2 soil)	26°	0	13.6	8.4

Notes: 1) Groundwater table set at 1.0 mbgs (SLI design condition).
2) Soil data was estimated based on Peck et al, 1953, and B.K. Hough, 1969.
3) Dry unit weight to be used for soils above the water table instead of moist unit weight.
4) The bearing surface (see Table 1) will be located at either 3.25 or 3.75 mbgs (Tower types A & B) or 3.75 mbgs (Tower type C, D & E)

SLI has provided AMEC with ultimate design loads and other data related to each tower type. Using the ultimate bearing capacity equation (10.1) presented on page 150 of the Canadian Foundation Engineering Manual, 2006, AMEC has confirmed, on a preliminary basis (see next paragraph), that if the soil types described above have, as a minimum, the corresponding soil parameters, then the required allowable bearing capacities for each soil type, with a FOS of 2, can be achieved.

It should be noted that the bearing capacity equation was originally developed based on theoretical and experimental work using footings that are in full contact with the bearing surface and, therefore, may not accurately calculate the ultimate bearing capacity for a steel grillage made up of a number of individual sleepers (I-beams). However, it has been reported (see Graham *et al*., 1984), because of interference effects associated with the *failure* zones underneath each individual sleeper, the bearing capacity of the soil may be higher compared to individual footings of the same contact area, provided that the ratio of the centerline spacing of the sleepers to the width of an individual sleeper does not exceed four (4). Considering the evidence presented in Graham *et al*., 1984, the bearing capacity equation cited above, when applied to a steel grillage made up of individual I-beams, may lead to some minor differences in the ultimate bearing capacity of a steel grillage. Therefore, for ease of calculating the bearing capacity of a steel grillage, the gross footprint of a steel grillage (from its outer edge to the opposite outer edge, with full-contact area) can be considered.

Allowable Bearing Pressure (Granular Soils) – Settlement Criterion

Several methods can be used to provide a preliminary indication of the amount of settlement that can be expected underneath a footing, e.g., Burland and Burbidge, 1985, Peck *et al*., 1974, (details of both methods can be found on Page 173 of the Canadian Foundation Engineering Manual, 2006) and Bowles, 1996, however each method has its limitations.

SLI geotechnical personnel advocate the use of Bowles, 1996, (equation in Figure 4-7) for settlement calculations involving granular soils. This figure provides estimates of the allowable bearing pressure with settlement limited to 25 mm. However, this equation is for surface loaded footings and may not accurately calculate the allowable bearing pressure, with settlement limited to 25 mm, and where loads are being transferred by truss action to the surface of a steel grillage located at a depth greater than or equal to approximately 3.10 mbgs.

In addition, the foundation width used in this equation, as with the other equations cited above, is for footing in full contact with the bearing surface and therefore may not be entirely suitable for predicting settlement underneath a steel grillage comprised of a number of sleepers. For example, the same reference cited in the previous section, i.e., Graham *et al*., 1984, found that the same interference effect, which contributes to increased bearing capacity at failure, also causes an increase in pre-failure settlements.

For these reasons AMEC recommends that careful consideration be given to the choice of equation used to perform settlement calculations as well as its applicability to a steel grillage foundation. Additionally, the amount of bearing pressure and how it is calculated can also have a considerable impact on settlement, i.e., if the gross area of the grillage is used versus the effective contact area. Due to the potential for increased settlement because of the possible interference effects between sleepers AMEC recommends that any preliminary or rough

calculations that are used to estimate the amount of settlement be based on the actual contact area of the grillage. Furthermore, AMEC recommends that detailed analyses for settlement using the actual grillage area and a proper analytical method (e.g., finite element method) be used, if accurate settlement calculations are required. Otherwise, the use of any other semi-empirical or empirical methods/equations should be substantiated by full-scale loading tests.
The use of safety factors to limit foundation settlement should be evaluated based on the method used and the level of confidence in the applicability of the method. Additionally, more than one method should be used and the results compared.

For design purposes SLI have placed settlement limits of 50 mm for foundations supporting the mast on tower types A& B (guyed towers) and 25 mm for the foundations supporting the legs of lattice towers, tower types C, D, & E.

Uplift Capacity (Granular Soils) – Grillage Foundations

For design calculations relating to uplift capacity, the earth cone method can be used to calculate stability. This method assesses the volume and thus weight contained in an inverted frustum cone, which is then compared to the required uplift resistance. A general form of the equation for the calculation can be found on Page 6, of Conception des foundations des pylônes à treillis de type rigide, SN-41.6 (PRÉLIMINAIRE), Hydro-Québec Équipement, 2007. The method outlined in that document utilizes an average unit weight for the soil contained in the inverted frustum. However, it is unclear how the average is obtained.

Another way to calculate the total volume of soil contained within the frustum is to calculate two separate volumes, i.e., volume of material below the water table and one above. Two separate unit weights would then be used to calculate the total weight of soil contained in the inverted frustum. A comparison between the two methods indicates that using a weighted average (when the groundwater level is fixed) produces more conservative results, compared to the two volume method, when the same frustum angle is used.

When calculating the volume of soil, the depth should be taken from the top of the steel grillage, for example, if the grillage is made of W150 x 22 beams and placed at a depth of 3.75 m, then the depth to be used in the calculation is approximately 3.60 m. The thickness of the organic layer, if present at ground level, should not be used in the calculation.

It has been indicated to AMEC that SLI's design team will use a FOS of 1.25 for preliminary design calculations. Such a FOS governing uplift capacity is 2 to 3 times lower than those normally used for compression. A FOS higher than 1.25 is suggested for SLI's consideration.

For preliminary design purposes, the data presented in Table 3 can be used. It should be noted that the magnitude of the earth frustum angle depends on the installation method of the foundation, its dimensions, the type of backfill and the degree of compaction. The frustum angles cited below are based on the backfill being compacted in layers not exceeding 150 mm and optimal compaction of the backfill is achieved. Where groundwater is encountered, the excavation must be kept dry through pumping and frozen backfill is not to be used.

In addition, all the voids within the steel grillage must be filled. A geotextile should be placed over the grillage prior to placement of the backfill, if approved by the site engineer. Terrafix 360R or equivalent is recommended.

It should be noted that there are other methods available for calculating uplift resistance and it is recommended that at least one additional method be used to evaluate uplift capacity. IEEE Standard 691-2001 provides additional methods.

Table 3: Granular backfill soil types and parameters for steel grillages (uplift capacity Tower Types C, D & E)

Soil Type	Dry Unit Weight (kN/m^3)	Submerged Unit Weight (kN/m^3)	Average Unit Weight (kN/m^3)	Earth Frustum Angle (β)	Type of Compaction
Compact, clean, uniform sand	15.7	9.7	11.4	16°	Controlled + 90% modified Proctor
Compact, well graded, silty sand and gavel	18.4	11.6	13.5	20°	Controlled + 90% modified Proctor
Produced Granular A	*18.8	*11.7	13.7	22°	Controlled + 90% modified Proctor
Produced Granular B	*20.7	*12.9	15.1	25°	Controlled + 90% modified Proctor

Notes:
1) Groundwater table set at 1.0 mbgs (SLI design condition).
2) Soil data was estimated based on Peck et al, 1953; B.K. Hough, 1969 and *based on unpublished results produced by AMEC for 90% modified proctor values, the moist unit weights have been converted.
3) Frustum angles were based on several sources; the most consideration was given to Kiessling *et al.*, 2003.
4) Dry unit weight to be used for soils above the water table versus moist unit weight.
5) Percentages (27.8%, 72.2%) used to calculate the weighted average were based on groundwater being at 1.0 mbgs and the maximum depth to grillage being 3.60 m.

Uplift Capacity (Granular Soils) – Gravity Grouted Soil Anchors

In general, soil anchors offer an alternative solution to ground engineering problems if they are installed in stiff clay, or dense silts, sands and gravels, and provided that the design load places the required bond length within practical limits.

For guyed towers type A & B, SLI has indicated that gravity grouted soil anchors may be used to resist uplift. The average ultimate bond stress (cohesionless soil/grout) for gravity grouted anchors with a straight shaft is 0.07 – 0.14 MPa (PTI, 2004). Normal practice is to then apply a minimum FOS of 2.0 in order to obtain the working bond stress. The above values are for preliminary design purposes only and subject to confirmation by field investigation and further analysis.

Normally the bond length for soil anchors is in the range of 6 - 12 m, bond lengths greater than 15 m are usually not efficient (PTI, 2004). In addition, as a rule of thumb the Post Tensioning Institute recommends that a free stressing length of 3 m be added to the required bond length. This puts a practical limit of 9 - 15 m for the required length of soil anchor.

Geotechnical Design of Stub Members (Granular Soils)

For grillage foundations each tower type design will utilize a stub which will transmit the tower loads to and from the subsurface grillage foundation. One aspect of tower design is the lateral resistance/support of the soil surrounding the stub to withstand lateral deflections along the length of the stub.

The Broms method, as per the Canadian Foundation Engineering Manual, 2006 (Figure 18.9) can be used to estimate the ultimate lateral resistance along the stub.

For design purposes Rankine coefficients based on the specified material's internal angle of friction can be used.

The coefficient of horizontal subgrade reaction method is a simplified method that can be used to analyze the stub response to lateral loads and moments. This method requires that strength/deformation characteristics of the adjacent soil be modeled by springs for which values of the coefficient of horizontal subgrade reaction (k_h) are required. In granular soils the coefficient of variation, n_h, is used to calculate k_h, based on the relationship:

$$k_h = n_h\,(z/D)$$

where: n_h = the coefficient of variation
z = depth below grade
D = stub width

The recommended value for n_h is 4400 kN/m^3, and is representative for a compact, submerged sand that has an internal friction angle of 34^o (Habibagahi and Langer, 1983). Such an internal friction angle can be achieved by backfilling the area surrounding the stub and the excavation for grillage with clean sand compacted in 150 mm lifts, each to a minimum of 90% modified Proctor compaction.

It should be noted that the stub will be located within the zone of frost penetration and consideration should be given to the effect that freeze/thaw cycles will have on lateral resistance/support.

Preliminary Design Bearing Pressure (Bedrock)

Bedrock throughout the AC corridor is comprised predominantly of igneous and metamorphic rocks and the quality of these rocks with respect to bearing capacity can vary considerably depending on the degree of weathering, discontinuity spacing and aperture, attitude of foliations, etc.

For igneous and non foliated metamorphic rocks in sound condition, i.e., minor cracks have a spacing not closer than 1 m, a preliminary design bearing capacity of 10,000 kPa can be used (Canadian Foundation Engineering Manual, 2006). However, for this project, a lower bearing capacity of 3,000 kPa should be sufficient for tower foundation.

For foliated metamorphic rocks in sound condition (see definition above) a preliminary bearing capacity of 3000 kPa can be used. The foliations must be parallel or nearly so with the base of the foundation and the area must have lateral support (Canadian Foundation Engineering Manual, 2006).
For foliated metamorphic rocks and igneous rocks with an RQD between 50-90%, a preliminary design bearing capacity of 1000 kPa can be used (Wyllie, 1999).

In the case of very weak rock, (e.g., highly weathered gneiss) or a rock with very closely spaced joints, allowable bearing capacities should be analyzed on a case by case basis.

Uplift Capacity (Bedrock) – Grouted Rock Anchors

AMEC understands that grouted rock anchors may be used to resist uplift for each tower design and the detailed design plans have not been provided to AMEC at this time. SLI has asked AMEC to provide working bond stress (rock/grout) values for preliminary design purposes.

In the absence of testing of bedrock, the working bond stress (rock/grout) can be taken as 700 kPa, however, for weak rock, i.e., the uniaxial compressive strength is less than 25 MPa (Canadian Foundation Engineering Manual, 2006), a working bond stress of 350 kPa should be used (PTI, 2006).

The previous values are for preliminary design purposes only and subject to confirmation by field investigation and further analysis.

For preliminary design purposes an apex angle of 90° can be used to calculate the cone of rock mobilized by the rock anchor. For weak rock or highly fractured rock, 60° should be used. Additionally, the position of the apex should be taken at the midpoint of the bond length.

AMEC has not been asked to provide confirmation of SLI calculations with respect to the total length of rock anchor required for each tower type. However, AMEC recommends that for the determination of uplift capacity the buoyant weight of the mobilized cone of rock, as well as the resisting force developed on the surface of the mobilized cone of rock, should be used to determine the ultimate uplift capacity for a particular rock anchor with respect to the weight of rock cone at the midpoint of the bond length being uplifted. A minimum factor of safety of 2.0 should be applied. For a detailed treatment of tension foundations and rock anchors, Wyllie, 1999 and PTI, 2004 should be referred to.

If more than one rock anchor is to be use for a particular foundation element then group effects need to be considered.

As with soil anchors, the Post Tension Institute recommends a free stressing length of 3 m in addition to the required bond length (PTI, 2004).

Grout must have a minimum compressive strength of 21 MPa at the time of stressing (PTI, 2006) and must have a minimum compressive strength of 25 MPa at 28 days (CSA S37-01, 2006).

Helical Piles - General Comments

It is AMEC's understanding that the design of the helical pile will be carried out by the supplier and would be done so based on information supplied by SLI, i.e., required compression load, uplift resistance, lateral resistance, soil properties, etc.
Helical piles may offer an alternative solution to foundations required in granular soils. For example, areas comprised of uniform sands may also be a good candidate for helical pile foundations. Combining the percent of uniform sand and cohesive deposits, which are expected to be encountered along the AC corridor, means that approximately 17% of the AC line could potentially utilize helical pile foundations.

A technical presentation to SLI was given by Randy Richardson (Helical Pier Systems), held on October 27, 2011 outlining helical pile capabilities. At the request of SLI, the general recommendations given at the meeting are summarized below and are not necessarily the opinions of AMEC.

> "Some of tower foundations will be founded in cohesive soils. Helical piles offer an alternative solution to foundations required in cohesive, as well as cohesionless soils, provided that there is enough soil cover to allow adequate design.
>
> In general, a minimum of 3 metres of soil cover, where there is at least one helical diameter below frost depth, is required before helical piles become effective.
>
> The deposits classified as fluvial sands and gravel and glacial till may also be amenable to helical pile foundations, however, material can be present within these deposits that can interfere with pile installation. For example boulders with a minimum diameter of 200 – 300 mm can cause problems during installation.
>
> Bedrock along the AC corridor is not anticipated to be soft enough to permit helical pile installation; therefore screwing the pile into bedrock is not an option. Also, helical piles are generally not suitable for very dense material, i.e., soils with an SPT N value greater than 50".

Closure

This summary of geotechnical conditions interpreted to exist along AC corridor and the cohesionless soils data provided herein was prepared for the exclusive use of SNC Lavalin (SLI) and their client Nalcor Energy (Nalcor) for specific application to the project site. The interpretation of the geological conditions and soils data was performed using generally accepted geological practices used in the industry and in accordance with the work plan developed with SLI. No other warranty is expressed or implied. The limitations of this technical memorandum are attached.

We trust that this information meets your current needs, if you have any questions or concerns please do not hesitate to contact us.

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Attachments

- Limitations

AMEC Environment & Infrastructure
A division of AMEC Americas Limited

LIMITATIONS

The information and design criteria given in this Technical Memorandum are based on information provided to AMEC Environment and Infrastructure (AMEC) from SNC - Lavalin (SLI), as well as acceptable geotechnical engineering practices and methods currently used in the industry. The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Intrusive field investigations were not included in the current Scope of Work and conditions may become apparent during future investigations/works, which could not be detected or anticipated at the time that this Technical Memorandum (Memorandum) was prepared. It is the recommended practice that the Geotechnical Consultant of record be retained during any future works to confirm that the subsurface conditions across the site, *i.e.*, the current (at the time of this report) layout for the proposed 315 kv HVAC corridor from Muskrat Falls to Churchill Falls, Labrador, as defined by SLI and as part of the Scope of Work, does not deviate materially from the assumptions made in this report.

The design criteria given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this Memorandum. Since all details of the design are not known, we recommend that we be retained during the final stage to verify that the transmission tower foundation designs and the geotechnical parameters/properties used in the design are consistent with our Memorandum and that the assumptions made in our report are valid.

Any comments made in this Memorandum on potential construction problems and possible methods are intended only for guidance of the designer. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.

The work performed as part of this Memorandum was carried out in accordance with the Standard Terms and Conditions made as part of our contract with SLI, as well as verbal requests from the client (SLI). The information presented herein is based solely upon the scope of services and time and budgetary limitations described in our contract. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

This report was prepared exclusively for SNC-Lavalin (SLI) and their client Nalcor Energy (Nalcor) by AMEC Environment and Infrastructure, a division of AMEC Americas Limited (AMEC). The quality of the information, summaries and estimates contained herein is consistent with the level of effort involved in AMEC's services and based on: i) information available at the time of preparation, ii) data supplied by SLI and iii) the assumptions, conditions and qualification set forth in this report. This report is for use by the SLI and their Client (Nalcor), subject to the terms and conditions of its contract with AMEC.

Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC Americas Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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APPENDIX B

QUALITAS 315 KV HVAC DESIGN PARAMETERS

SNC•LAVALIN INC.
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Canada A1A 4E1
Telephone: (709) 752-3460
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MEMORANDUM

TO:	Michel Belanger	**Date:**	10-Nov-2011
C.C.:	Regis Bouchard	**Document number:**	**505573**
FROM:	Yves Descôteaux		
Subject:	Design parameters		

Bearing Capacity

A) Grillage foundation on soil

1- Failure

Allowable bearing capacity at failure will be determined by using the equation 10.1 of the CFEM 4th Edition, considering the maximum load and a safety factor of 2. Soils properties (Ndc, N, Su) will be determined 2B below foundation level.

2- Settlement

For non cohesive soil, allowable bearing capacity against settlement will be determined using the equations presented in Figure 4.7 of Bowles, J.E., Foundation Analysis and Design, 5 Edition.

For cohesive soils, the One-Dimensional Consolidation Method will be used. Settlement will be estimated from regional consolidation tests, and than correlation with Su and Ip for other locations.
Settlement tolerance :

- 50 mm for Guy Towers
- 25 mm for Lattice Towers

3- Frost protection : 2.5 m

B) Grillage foundation on rock

For RQD value greater than 25%, the design bearing stress on rock is 3 000 kPa. A minimum value of 1 000kPa should be taken for highly fractured rock and thinly bedded sedimentary rock.

C) Pile foundation

Pile foundations (compression) will be designed with a safety factor of 2.

1- Screw piles

Scew piles will be designed by the supplier as part of a "Performance Design Built". Calculations will have to be reviewed by SLI geotechnical engineers. Proof tests will have to be performed.

2- HP type piles

HP type piles will be designed according to section 7.5 of Hydro-Quebec SN-41.6, sept. 2007.

Uplift Resistance

A) Grillage foundation

- Water table estimation for uplift resistance : 1 m
- Frustum angle : see Table 1
- Average unit weight : see Table 1

Table 1
Soil parameters for uplift resistance calculation

Soil type	Frustum angle	Average unit weight (kN/m3)	
	Degres	SNCL (note *)	H-Q (including reduction factor)
Granular A and B compacted at 90% PM or minimum 20 kN/m3	28 2/3 de phi phi = 42 à 90%PM	14,4	12,56 k=0,8
Till compacted to a minimum 18 kN/m3 (close to de 90% PM)	24 2/3 de phi phi = 37	12,3	12,69 k=0,9
Sand, sand and gravel compacted to a minimum 17 kN/m3 (close to 90% PM)	20 2/3 de phi phi = 30	11,2	14,1 k=1
Uniform sand or silt or cohesive soils compacted to a minimum 16 kN/m3	16 2/3 de phi phi = 25	10,0	14,1 k=1

Water table supposed at 1 m depth

(*) : for 3,5 m deep foundation (1 m total weight + 2,5 submerged).

For angle towers, the backfill will consist of Granular A or Granualr B compacted at 90 % PM. If water table is at surface, an average unit weight of 10 kN/m3 will be taken.

Values given in this table are ultimate values (no safety factor). For uplift resistance, the CFEM recommend a resistance factor of 0,6 if anchor are tested and 0,4 if not.

B) Rock gravity grout anchors

1- Consider 4 types of failure (see attached Qualitas rock anchor calculation method)

a. Tensile stress in steel rod (steel rod manufacturer)
b. Bond between steel rod and grout
c. Bond between rock and grout (based on unconfined compressive strength of rock (q_u) and grout (f'_c) - see Qualitas calculation method)
d. Rock pull-up :
   - β= 45 deg for RQD > 50%
   - β= 30 deg for RQD ≤ 50%
   - SF = 2 against working load
   - Submerged unit weight of rock is 16 kN/m3

2- Free stress length related to rock discontinuities and frost effect : 1 m

3- Minimum diameter of hole 100 mm

4- Minimum bond length
   - RQD < 50 : 40 x hole diameter
   - RQD > 50 : 30 x hole diameter
   - Thinly bedded slates and shales : 80 x hole diameter
   - Minimum 3 m

Without information on unconfined compressive strength of rock, Table 2 gives allowable bond stress rock-grout for estimation purpose.

Table 2
Bond stress rock-grout (kPa)

Rock type	**Allowable SF=2**
Granite and Basalt	1300
Dolomite Limestone	700
Soft Limestone	600
Slate and Hard Shale	550
Soft Shale	250
Sandstone	700

C) Rock mechanical anchors

- No good in thinly bedded sedimentary rock.
- Rock pull-up (see attached Qualitas rock anchor calculation method).
- Free stress length related to rock discontinuities resulting from frost effect : 1 m

D) Soil gravity grout anchors

- Only 2 types of soil are suitable for soil gravity grout anchor:

1. Dense till - sand and gravel : 36,5 kN/m allowable bond stress
2. Dense sand (Ndc>45) : 18,5 kN/m allowable bond stress

- Free stress length : 3 m

- Minimum hole : 100 mm

- Minimum bond length : 4,5 m

APPENDIX C

QUALITAS ANCHOR CALCULATION METHOD

1. ROCK ANCHOR DIAGRAM

- L : Total anchor length (m)
- L_s : Bonded length (m)
- L_w : Cone depth (m)
- D : Diameter of the drilled hole (m)
- β : Half angle of the cone apex (°)
- P : Total pullout load (kN)

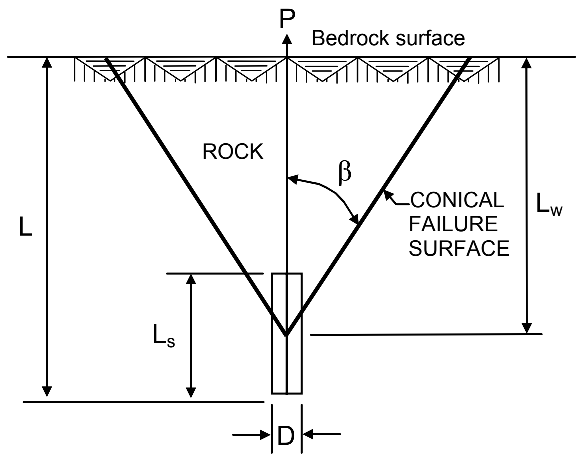

FIGURE 1

2. OBJECTIVES OF THE METHOD

The purpose of an anchorage system is to develop a resistance load higher than the pullout load.

$$R_a \geq P \qquad R_a = \frac{R}{F}$$

where
- R_a : Allowable resistance load (kN)
- R : Ultimate resistance load (kN)
- P : Total pullout load (kN)
- F : Safety factor

Section 3 calculation below, consider 4 types of failure :

- Tensile stress in the steel rod
- Bond between steel rod and grout
- Bond between rock and grout
- Rock pull-up

The resistance must be calculated for each of these types of failure. The lowest resistance value obtained from those 4 criteria shall be used in the final design.

3. CALCULATION METHOD

TENSILE STRESS IN THE STEEL ROD

The allowable resistance developed by the steel rod in function of the rod characteristics (section, tensile, yield strength …). The steel rod manufacturer will specify the characteristics. The safety factor must be sufficient.

BOND BETWEEN THE STEEL ROD AND THE GROUT

The purpose of this calculation is to obtain a bonded rod length between the steel rod and the grout, which is long enough to develop the allowable resistance. This resistance is determined according to the following formula :

$$R_a = \pi \ d \ L_{s1} \ S_b$$

where d : Rod diameter (m)

L_{s1} : Bonded length between rod and grout (m)

S_b : Bonded strength between rod and grout (kPa)

where $$S_b = \frac{0.95\sqrt{f'_c}}{F} \times 1000 \ \text{(kPa)}$$

f'_c : Unconfined compression strength of the grout, generally specified as 30 MPa at 28 days (MPa)

F : Safety factor, at least 3

Therefore $$L_{s1} = \frac{R_a}{\pi \ d \ S_b}$$

3.3 BOND BETWEEN THE ROCK AND THE GROUT

The purpose of this calculation is to obtain a bonded rod length between the rock and the grout, which is long enough to develop the allowable resistance. This resistance is determined according to the following formula :

$$R_a = \pi \; D \; L_{s2} \; S_r$$

where
- D : Drilled hole diameter (m)
- L_{s2} : Bonded length between rock and grout (m)
- S_r : Bonded strength between rock and grout (kPa)

S_r equals the lowest value obtained from the 3 following criteria :

$$S_r \leq 0.1 \frac{q_u}{F} \qquad S_r \leq 0.1 \frac{f'_c}{F} \qquad S_r = 1\,300 \text{ kPa}$$

where
- q_u : Unconfined compressive strength of the rock (kPa)
- f'_c : Unconfined compressive strength of the grout, generally specified as 30 MPa at 28 days (kPa)
- F : Safety factor equal to 3

Therefore $$L_{s2} = \frac{R_a}{\pi \; D \; S_r}$$

Furthermore, the following criteria must also be considered :

a) For fair to excellent rock quality (RQD > 50 %), the bonded length L_{s2} must equal at least 30 times the drilled hole diameter of the anchor.

b) For poor to very poor rock quality (RQD ≤ 50 %), the bonded length L_{s2} must equal at least 40 times the drilled hole diameter of the anchor.

c) For shale or rock with shaly beds, the bonded length L_{s2} must equal at least 80 times the drilled hole diameter of the anchor.

d) For all other cases, the bonded strength L_{s2} must equal at least 3 m.

3.4 ROCK PULL-UP

This calculation is used to evaluate the total anchor length required to ensure that the working load will be resisted safely without failure occurring in the rock mass. For this analysis, it is assumed that for a single rock anchor at failure, an inverted cone of rock is pulled out of the rock mass. The conical failure surface has its apex at the middle of the anchor assuming a contained angle of 2 times β.

$$R_a = \frac{L_w^3 \gamma \tan^2 \beta}{F} \qquad L_w = L - \frac{L_s}{2} \quad \text{(see Figure 1)}$$

where
- L_w : Length of the inverted cone, from the middle of the anchor to the bedrock (m)
- L : Total anchor length (m)
- L_s : Bonded length, higher value of L_{s1} and L_{s2} obtained from steps 3.2 and 3.3 (m)
- γ : Unit weight of the rock (kN/m^3)
- β : Half angle of the cone apex (°)
  - β = 30 ° for very poor to poor rock quality (RQD ≤ 50 %)
  - β = 45 ° for fair to excellent rock quality (RQD > 50 %)
- F : Safety factor equal to 2

Therefore, the total anchor length is :

$$L = L_w + \frac{L_s}{2}$$

or

$$L = \left(\frac{F \ R_a}{\gamma \ \tan^2 \ \beta} \right)^{1/3} + \frac{L_s}{2}$$

4. INTERACTION OF ANCHORS

4.1 RECOMMENDED EXACT METHOD

For a group of anchors, the interaction of the conical failure surface with that of each adjacent anchor should be taken into account by reducing the load per anchor as followed :

$P' = \psi' P$

where P' : Reduced pullout load due to the interaction of one adjacent anchor (kPa)

P : Pullout load of one single anchor (kPa)

ψ' : Reduction factor to take into account adjacent anchors function of a/r

For 1 adjacent anchor : $\psi' = 0.5 + 0.4\ a/r$ if $0 < a < 1.25\ r$

For 2 adjacent anchors : $\psi' = (0.5 + 0.4\ a/r)^2$ if $0 < a < 1.25\ r$

$\psi' = 1$ if $a \geq 1.25\ r$

where a : Distance between 2 anchors (m)

r : Distance between the center of the anchor and the conical failure surface at the bedrock (m)

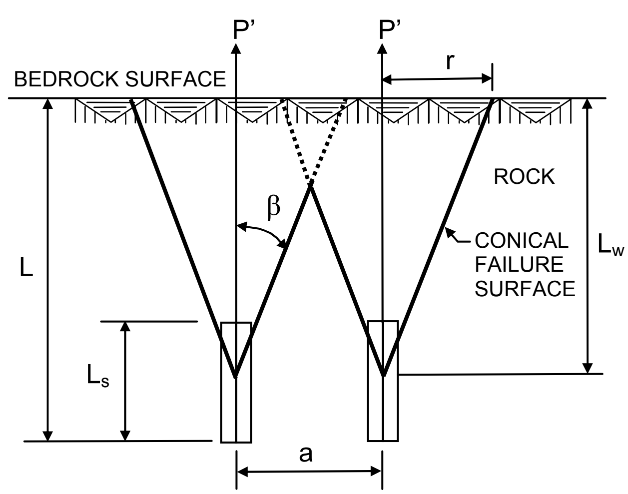

FIGURE 2

4.2 CONCENTRATED ANCHORS, GLOBAL METHOD

A group of closely spaced anchors (between 5 and 10 times the drilled hole diameter) can be considered as one unit in rock pull-up. The rock failure surface forms an inverted truncated pyramid as shown in Figure 3.

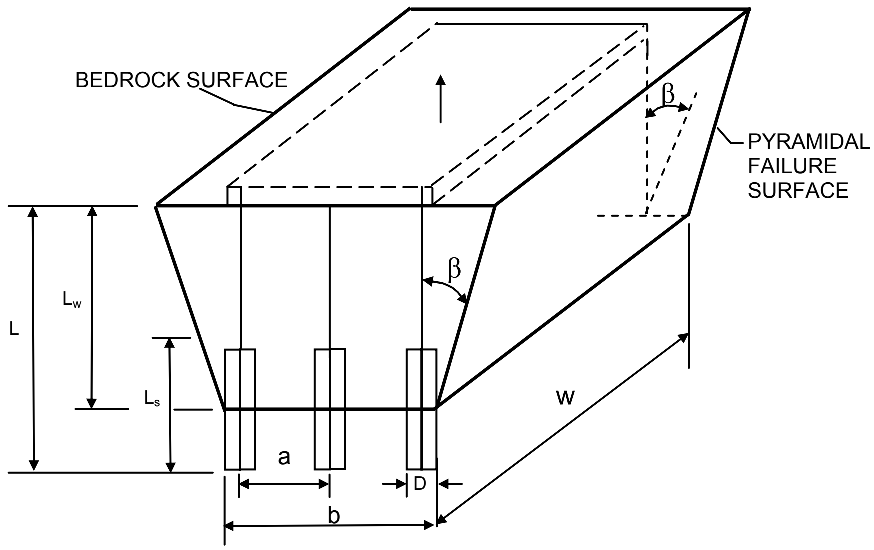

FIGURE 3

For a < 10 D, the resistance load is :

$$R_{ag} = \frac{1}{3} \frac{\gamma L_w}{F} (A_1 + A_2 + \sqrt{A_1 A_2})$$

where
- R_{ag} : Global allowable resistance load (kPa)
- F : Safety factor equal to 2
- γ : Unit weight of the rock (kN/m^3)
- L_w : Length of the inverted truncated pyramid from the middle of anchors to the bedrock surface (m)
- A_1 : Area of the group anchors (m^2) ($A_1 = b \times w$)
- A_2 : Area of the upper base of the inverted pyramid (bedrock) (m^2)
  $A_2 = 4 L_w^2 \tan^2 \beta + 2 L_w \tan \beta (b + w) + b w$
- b : Width of the group anchors (m)
- w : Length of the group anchors (m)
- β : Half angle of the cone apex (°)
  - $\beta = 30°$ for very poor to poor rock quality (RQD ≤ 50 %)
  - $\beta = 45°$ for fair to excellent rock quality (RQD > 50 %)
- a : Distance between 2 anchors (m)
- D : Diameter of the drilled hole (m)

5. FURTHER RECOMMENDATIONS

The minimal distance between 2 adjacent anchors must be greater than 5 times the diameter of the drilled hole in the rock.

The holes have to be filled up with a lean grout above the bonded length in order to protect the anchors.

Two anchors will have to be tested on the site. The maximum load must reach at least 1.33 times the calculated resistance load R_a.

6. REFERENCES

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APPENDIX D

315 KV HVAC GEOTECHNICAL CONDITIONS ALONG THE LINE

247000 TO 493900

315kV HVAC
Geotechnical Conditions
Muskrat Falls to Churchill Falls

Caution	Line rerouted. See interpretation of new route at the end of this spread sheet.
Investigation Recommended	
Bedrock Expected	

FINAL July 29, 2012

This is a summary of the original review plus discussions with SNC design engineers on June 22, 2012.

STRUCTURE NUMBERS FOR THREE ALIGNMENTS	STATION	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type by SNC for Original Numbering Sequence	Review of 32 Sites North Line	High Level General Review New North Line	High Level General Review New South Line	FINAL REVIEW COMMENTS JULY 29 2012
1	246,935	silt/clay	surface	API, MF1300 CS-TP-13-10		deep	D+0.0				None
2	246,986	silt/clay	surface	API, MF1300 CS-TP-13-10		deep	E+7.5				None
3	247,328	silt/clay	surface	API, MF1300 CS-TP-13-10		deep	A+12.0				None
4	247,730	silt/clay	surface	API, MF1300 CS-TP-13-10		deep	A+12.0				None
5	248,066	sand/silt/clay	surface	API, MF1300 CS-TP-13-10		deep	E+6.0				None
6	248,358	sand/silt/clay	surface	API, investigate		deep	A+0.0				Investigate
7	248,707	sand/silt/clay	surface	API, investigate		deep	C (strain) + 0.0				Investigate
8	248,914	sand/silt/clay	surface	API, MF1602 TP MR-001		deep	E+12.0				Investigate
TL2-str#1	2723.6	~ 2.0 m - 6.0 m of sand/silt, trace clay and gravel	~ 1 m	API, MF1300 BH-28-10 and BH-30-10. Further investigation may be required to delinate bedrock depth at structure depth.		deep	D+9.0		Altermate Removed		None
TL2-str#2	2,937.07	> 3.7 m of sand/silt, with some clay and gravel.	~ 1 m	API, MF1300 BH-06-10, BH-27-10 and BH-33-10.		deep	A+10.5		Altermate Removed		None
TL2-str#3	3,203.11	sand/silt, trace to some gravel	surface	API, investigate		deep	A+1.5		Altermate Removed		None
TL2-str#4	3,503.13	sand/silt, trace to some gravel	surface	API, investigate		deep	A+4.5		Altermate Removed		None
TL2-str#5	3,786.04	sand/silt, trace to some gravel	surface	API, investigate		deep	D+7.5		Altermate Removed		None
TL2-str#6	4,113.00	sand/silt/clay	surface	API, investigate		deep	D+6.0		Altermate Removed		None
TL2-str#7	4,305.59	sand/silt/clay	surface	API, MF1602 TP MR-001		deep	E+12.0		Altermate Removed		None
9	249,412	<1 m to bedrock		API, BHs M1and BH M2 in 1998 SNC-AGRA 1998	3,000	rock bolts	C (strain) + 12.0				None
10	249,582	1.5 m to bedrock		API, BHs M1and BH M2 in 1998 SNC-AGRA 1998	3,000	rock bolts	D+0.0				None
11	249,957	> 10 m sand	>6 m	API, BH C1 SNC Lavalin 1979	100	grillage	C (strain) + 10.5				None
12	250,169	> 10 m sand	>6 m	API, BH C1 SNC Lavalin 1979	100	grillage	C (strain) + 4.5				None
13	250,476	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+4.5				None
14	250,809	sand/dune	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+3.0				None
15	251,120	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+7.5				None
16	251,388	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	D+1.5				None
17	251,754	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998, AC1060 HA-5	100	grillage	E+6.0		Edge of Bog	Edge of bog	None
18	252,137	sand/silt/clay	1 m	API, bog nearby, investigate		deep?	A+9.0				None
19	252,551	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
20	252,956	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
21	253,365	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
22	253,654	> 10 m sand	>6 m	API, MF1602 - 1 - BH - B	100	grillage	C (strain) + 0.0				None
23	253,983	>10 m sand/dune	>6 m	API	100	grillage	A+0.0				None
24	254,369	>10 m sand/dune	>6 m	API	100	grillage	A+0.0				None
25	254,669	>10 m sand/dune	>6 m	API	100	grillage	A+0.0				
26	254,962	> 10 m sand	>6 m	API	100	grillage	D+6.0				
27	255,155	> 10 m sand	>6 m	API	100	grillage	A+4.5			In Bog	
28	255,486	>10 m sand/dune	>6 m	API	100	grillage	A+3.0		Edge of Bog		
29	255,883	> 10 m sand	>6 m	API	100	grillage	A+10.5				
30	256,306	> 10 m sand	>6 m	API	100	grillage	A+9.0	Old 31			
31	256,675	sand/silt/clay	~1 m	On a low terrace of Lower Brook, investigate		deep	A+12.0	Old 32			
32	257,161	silt/clay	~1 m	API, NC, MF1120 TP - 04, 05, investigate		deep	A+10.5	Old 33			
33	257,493	silt/clay	~1 m	API, NC, MF1120 TP - 04, 05, investigate		deep	A+9.0				
34	257,815	>4.5 m of sand, gravel and cobbles	3.5	API, NC, MF1120 TP - 06, 07	250	grillage	E+4.5	Old 35		New 34 at Edge of Bluff	
35	258,218	sand/silt/clay	~3 m	API, NC,(Lower Brook) located near a bluff adjacent to probable old slides on either side - investigate		deep	D+7.5			New 35 at Edge of Bluff	
36	258,405	> 10 m sand	>4 m	API, NC, MF1120 BH 02 07		deep	C (strain) + 6.0				
37	258,634	> 10 m sand	>4 m	API, NC, MF1120 BH 02 07		deep	C (strain) + 6.0				
38	259,211	~2 m till on bedrock	~2 m	API, NC	3,000	rock bolts	B+12.0		New 38 now sand		
39	259,554	~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	C (strain) + 6.0				
40	259,757	<1 m to bedrock		API, NC	3,000	rock bolts	A+1.5				
41	260,203	<1 m to bedrock		API, NC	3,000	rock bolts	A+0.0				None
42	260,492	<1 m to bedrock		API,NC, AC1060_PO-1 and PO--2	3,000	rock bolts	C (strain) + 12.0				None
43	260,781	<1 m to bedrock		API, NC, AC1060_PO-1 and PO--2	3,000	rock bolts	A+1.5				None
44	261,099	<1 m to bedrock		API, NC	3,000	rock bolts	A+6.0				None
45	261,416	~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	A+9.0			New 45 <1 m to rock	None
46	261,916	~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	A+7.5				None
47	262,162	<1 m to bedrock		API, NC	3,000	rock bolts	B+9.0		New 47 now sand at edge of bluff	New 47 now sand	None
48	262,613	>10 m sand/dune	>6 m	API	100	grillage	B+10.5				None
49	263,053	>10 m sand/dune	>6 m	API	100	grillage	B+9.0				None
50	263,501	>10 m sand/dune	>6 m	API	100	grillage	A+12.0				None
51	263,919	> 10 m sand	>6 m	API	100	grillage	A+10.5				None
52	264,349	> 10 m sand	>6 m	API	100	grillage	D+9.0				None
53	264,763	>10 m sand/dune	>6 m	API	100	grillage	A+10.5				None
54	265,205	> 10 m sand	>6 m	API	100	grillage	A+10.5				None
55	265,611	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
56	266,029	> 10 m sand	>6 m	API	100	grillage	A+7.5				None
57	266,455	> 10 m sand	>6 m	API	100	grillage	A+10.5				None
58	266,875	>10 m sand/dune	>6 m	API	100	grillage	A+7.5				None
59	267,306	>10 m sand/dune	>6 m	API	100	grillage	A+12.0				None
60	267,721	>10 m sand/dune	>6 m	API	100	grillage	A+10.5				None
61	268,163	>10 m sand/dune	>6 m	API	100	grillage	A+10.5				None
62	268,583	>10 m sand/dune	>6 m	API	100	grillage	A+7.5				None
63	269,003	>10 m sand/dune	>6 m	API	100	grillage	A+7.5				None
64	269,426	> 10 m sand	>6 m	API	100	grillage	A+10.5				None
65	269,860	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
66	270,272	> 10 m sand	>6 m	API	100	grillage	A+7.5				None
67	270,715	>10 m sand/dune	>6 m	API	100	grillage	D+3.0				None
68	271,120	>10 m sand/dune	>6 m	API	100	grillage	A+10.5				None
69	271,406	> 10 m sand	>6 m	API	100	grillage	A+6.0				None
70	271,800	>10 m sand/dune	>6 m	API	100	grillage	A+4.5				None
71	272,195	> 10 m sand	>6 m	API	100	grillage	A+4.5				None
72	272,548	> 10 m sand	>6 m	API, NC-deep borrow pit in sand at adjacent highway	100	grillage	A+3.0				None
73	272,915	>10 m sand/dune	>6 m	API, NC-deep borrow pit in sand at adjacent highway	100	grillage	A+4.5	Old 74			None
74	273,359	>10 m silt/clay	surface	API, deep erosion and heavy forest, investigate		deep	A+4.5				Investigate
75	273,730	>10 m silt/clay	surface	API, deep erosion and heavy forest, investigate		deep	A+9.0				Investigate
76	274,152	>10 m silt/clay	surface	API, AC1060 TP - 2 > 6 m of ML, firm to stiff, investigate		deep	A+12.0				Investigate
77	274,594	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+9.0				Investigate
78	275,020	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+10.5				Investigate
79	275,449	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+12.0				Investigate
80	275,880	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+12.0				Investigate
81	276,297	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	B+9.0			New 81, beaver dam 200m east	Investigate
82	276,649	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+6.0		New 82, beaver dam 200 m east		Investigate
83	277,021	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	B+3.0				Investigate
84	277,365	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+9.0		New 84 probable bog		Investigate
85	277,771	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+7.5				Investigate
86	278,160	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+7.5				Investigate
87	278,558	~4 m sand	1 m	API, deep erosion and heavy forest and bogs, investigate		deep	D+7.5		Old 88 Beaver dam 60 m E	Beaver dam 60 m NE	Investigate
88	278,962	sand/silt/clay	surface	API, NC and beaver pond nearby, investigate/hydrology study		deep	A+6.0				Investigate
89	279,344	~ 4 m till	1 m	API, NC	250	grillage	A+6.0				None
90	279,740	~ 4 m till	1 m	API, NC	250	grillage	A+7.5			New 90 at edge of bluff	None
91	280,147	~ 4 m till	1 m	API, NC	250	grillage	A+9.0				None
92	280,594	~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+9.0				None
93	280,908	~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+0.0			Same comment as old 96	None
94	281,211	~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+0.0				None
95	281,507	>10 m sand	~4 m	API, NC,	100	grillage	B+0.0	Same comment as old 96			None
96	281,778	sand with some organic material	surface	API, TP AC1060-4, on modern flood plain of Edwards River, hydrology study recommended, investigate		deep	C (strain) + 3.0	Same comment as old 97			None
97	282,087	sand with some organic material	3 m	API, TP AC1060-4, on older flood plain of Edwards River, hydrology study recommended, investigate		deep	C (strain) + 0.0				None
98	282,388	> 10 m sand	>4 m	API	100	grillage	A+4.5				None
99	282,882	> 10 m sand	>4 m	API, keep tower a minimum of 30 m back from edge of bluff	100	grillage	A+4.5				None
100	283,235	> 10 m sand	>4 m	API	100	grillage	A+6.0				None
101	283,589	> 10 m sand	>4 m	API	100	grillage	A+3.0				None
102	283,955	> 10 m sand	>4 m	API	100	grillage	A+7.5				None
103	284,407	~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5			New 101 is probably in sand over till >4 m overall	None
104	284,745	~ 4 m till	2 m - 3 m	API	250	grillage	A+7.5				None
105	285,121	~ 4 m till	2 m - 3 m	API, long distance without testing	250	grillage	B+10.5			New 105 near ravine	None
106	285,510	~4 to 6 m sand	>4 m	API	100	grillage	D+1.5				None
107	285,877	sand over till at about 3 m then till >3 m	~3 m	API	100	grillage	A+10.5				None
108	286,247	~ 4 m till	2 m - 3 m	API	250	grillage	A+6.0				None
109	286,585	~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5				None
110	286,974	~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5				None
111	287,331	~ 4 m till	2 m - 3 m	API	250	grillage	A+9.0				None
112	287,637	~ 4 m till	2 m - 3 m	API	250	grillage	A+4.5				None
113	288,065	~ 4 m till	2 m - 3 m	API	250	grillage	A+9.0				None
114	288,391	~ 4 m till	2 m - 3 m	API, AC-1060- 6	250	grillage	A+7.5				None
115	288,726	~ 4 m till	2 m - 3 m	API, AC-1060- 7	250	grillage	A+10.5				None
116	289,120	~ 4 m till	2 m - 3 m	API, AC-1060- 8	250	grillage	A+10.5			New 116 on steep hillside, probable till	None
117	289,425	~ 4 m till	2 m - 3 m	API, AC-1060- 8 and 9	250	grillage	C (strain) + 3.0			New 117 >10 m sand	None

SNC Lavalin/Nalcor
Lower Churchill Project

315kV HVAC
Geotechnical Conditions
Muskrat Falls to Churchill Falls

Amec Americas Limited
Earth and Infrastructure
Amec Project Number TF1116574
Date Printed 7/29/2012

Caution	Line rerouted. See interpretation of new route at the end of this spread sheet.
Investigation Recommended	
Bedrock Expected	

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STRUCTURE NUMBERS FOR THREE ALIGNMENTS	STATION	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type by SNC for Original Numbering Sequence	Review of 32 Sites North Line	High Level General Review New North Line	High Level General Review New South Line	FINAL REVIEW COMMENTS JULY 29 2012
118	289,655	~ 4 m till	2 m - 3 m	API, AC-1060- 9	250	grillage	A+4.5		New 118 is probable sand	Edge of bog	None
119	289,949	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
120	290,333	> 10 m sand	>6 m	API	100	grillage	D+4.5		Edge of bog		None
121	290,634	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
122	291,028	> 10 m sand	>6 m	API	100	grillage	A+10.5				None
123	291,463	> 10 m sand	>6 m	API	100	grillage	A+12.0				None
124	291,874	> 10 m sand	>6 m	API, AC1060-15 and 16	100	grillage	C (strain) + 9.0				None
125	292,226	> 10 m sand	>6 m	API, AC1060 16	100	grillage	A+0.0				None
126	292,635	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
127	292,942	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
128	293,256	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
129	293,629	> 10 m sand	>6 m	API	100	grillage	A+9.0				None
130	293,997	> 10 m sand	>6 m	API	100	grillage	A+1.5				None
131	294,493	>5 m sand and gravel	2	API	100	grillage	A+7.5				None
132	294,802	>5 m sand and gravel	2	API	100	grillage	A+3.0				None
133	295,137	>5 m sand and gravel	2	API, near bluff/flood plane - review hydrology and move away from bluff a minimum of 30 m	250	grillage	A+7.5	moved	New 133 may be on flood plain		None
134	295,653	>5 m gravel, cobbles and boulders	surface	Structure is located in the Pinus River on low island that floods during high water conditions and is influenced by frazzle ice, hydrology study recommended	250	grillage	A+12.0	moved			None
135	295,987	>5 m sand and gravel	>6 m	API, Hand dug test pits 1 and 2 in nearby erosion scar	250	grillage	B+12.0				None
136	296,504	> 10 m sand	>6 m	API	100	grillage	C (strain) + 3.0				None
137	296,746	> 10 m sand	>6 m	API	100	grillage	A+0.0				None
138	297,037	> 10 m sand	>6 m	API, AC1060 16	100	grillage	D+7.5				None
139	297,411	>5 m sand and gravel	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006	100	grillage	A+12.0				None
140	297,870	> 10 m sand	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006	100	grillage	A+9.0				None
141	298,282	> 10 m sand	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006 (adjacent to cabin)	100	grillage	A+7.5				None
142	298,669	sand over till or silt	surface	API, in small stream, investigate		deep	A+3.0	In or adjacent to small stream			Investigate
143	299,025	bog over sand over till or silt	surface	API, in low lying wet area, boggy, investigate		deep	A+3.0				Investigate
144	299,373	sand over till or silt	surface	API, in or adjacent to small stream, investigate		deep	A+1.5				Investigate
145	299,765	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5				None
146	300,161	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	E+3.0				None
147	300,311	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	E+3.0				None
148	300,687	~ 2 m till		API	3,000	rock bolts	B+9.0				None
149	301,088	~ 3 m till	2 m - 3 m	API	250	grillage	A+12.0				None
150	301,431	~ 2 m till		API	3,000	rock bolts	B+9.0				None
151	301,740	~ 2 m till		API	3,000	rock bolts	B+9.0				None
152	302,098	~ 3 m till	2 m - 3 m	API	250	grillage	B+12.0				None
153	302,406	~ 2 m till		API	3,000	rock bolts	B+9.0				None
154	302,935	>5 m till	>4 m	API, GI1010 TP B6B-003, 005, 001, 002, 012	250	grillage	B+6.0				None
155	303,217	>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	A+0.0				None
156	303,439	>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	D+4.5				None
157	303,874	>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	A+12.0				None
158	304,231	~ 3 m till	2 m - 3 m	API, Pope's Hill area	250	grillage	B+9.0			New 158 ~2 m till	None
159	304,654	~ 3 m till	2 m - 3 m	API	250	grillage	A+12.0				None
160	304,885	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	C (strain) + 7.5	~2 m till		New 160, ~ 2 m till	None
161	305,399	~ 3 m till	2 m - 3 m	API	250	grillage	B+10.5				None
162	305,907	~ 3 m till	2 m - 3 m	API	250	grillage	B+10.5	~2 m till			None
163	306,304	~ 3 m till	2 m - 3 m	API	250	grillage	A+7.5				None
164	306,755	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5			new 164 is in or at edge of bog	None
165	307,141	~ 3 m till	2 m - 3 m	API	250	grillage	A+9.0				None
166	307,565	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5				None
167	308,010	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+9.0				None
168	308,425	~ 3 m till	2 m - 3 m	API, long area without testing or NC	250	grillage	A+10.5				None
169	308,880	~ 3 m till	2 m - 3 m	API	250	grillage	A+9.0		Edge of stream		None
170	309,299	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	D+10.5				None
171	309,697	~ 3 m till	~1 m	API	250	grillage	A+10.5				None
172	310,084	~ 3 m till	~1 m	API	250	grillage	A+9.0				None
173	310,443	~ 3 m till	~1 m	API	250	grillage	A+7.5				None
174	310,916	~ 3 m till	surface	API	250	grillage	B+12.0		Moved away from wet area		None
175	311,386	~ 1 m of till on bedrock		API	3,000	rock bolts	A+7.5				None
176	311,712	~ 1 m of till on bedrock		API	3,000	rock bolts	A+9.0			~2 m till	None
177	312,156	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5				None
178	312,482	~ 3 m till	2 m - 3 m	API	250	grillage	A+7.5		~2 m till		None
179	312,910	~10 m till	>4 m	API, NC	250	grillage	A+6.0				None
180	313,313	~10 m till	>4 m	API	250	grillage	A+10.5				None
181	313,716	~4 m, fluvial on top of till	2 m - 3 m	API	250	grillage	A+9.0		~2 m soil		None
182	314,137	~4 m, fluvial on top of till	2 m - 3 m	API	250	grillage	A+10.5		~2 m soil		None
183	314,574	~10 m till	~1 m	API	250	grillage	A+10.5				None
184	314,986	~10 m till	~1 m	API	250	grillage	A+12.0				None
185	315,416	~10 m till	~1 m	API	250	grillage	D+6.0				None
186	315,754	~10 m till	~1 m	API	250	grillage	A+7.5				None
187	316,146	~10 m till	>4 m	API	250	grillage	A+9.0			~2 m till	None
188	316,529	~10 m till	surface	API	250	grillage	A+7.5				None
189	316,943	~10 m till	surface	API	250	grillage	A+10.5				None
190	317,332	~ 3 m till	~1 m	API, NC	250	grillage	A+7.5			in bog	None
191	317,792	~4 m, fluvial on top of till	2 m - 3 m	API, NC	250	grillage	A+7.5		~2 m till		None
192	318,217	~ 3 m till	surface	API, NC	250 or 3000	grillage or rock bolts	D+7.5				None
193	318,599	~ 3 m till	~1 m	API	250	grillage	A+12.0				None
194	319,017	~ 3 m till	~1 m	API	250	grillage	A+10.5				None
195	319,389	~ 3 m till	surface	API	250	grillage	A+10.5		Near stream		None
196	319,825	~ 3 m till	~1 m	API	250	grillage	A+12.0				None
197	320,246	~ 3 m till	~1 m	API	250	grillage	A+10.5				None
198	320,564	~1 m till on rock		API	3,000	rock bolts	A+1.5				None
199	320,994	~1 m till on rock		API	3,000	rock bolts	A+9.0				None
200	321,425	~1 m till on rock		API	3,000	rock bolts	A+4.5				None
201	321,819	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+10.5			New 201 at edge of bog	None
202	322,246	~2 m till, rock nearby	surface	API, long area without testing or NC	3,000	rock bolts	A+10.5				None
203	322,680	~2 m till, rock nearby	surface	API	3,000	rock bolts	A+10.5			New 203 in bog	None
204	323,102	~2 m till, rock nearby	surface	API	3,000	rock bolts	A+9.0				None
205	323,507	~2 m till, rock nearby	surface	API	3,000	rock bolts	A+3.0				None
206	323,852	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+4.5				None
207	324,309	~2 m till, rock nearby	surface	API	3,000	rock bolts	A+9.0				None
208	324,676	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+7.5				None
209	325,067	~1 m till on rock		API, NC	3,000	rock bolts	A+9.0				None
210	325,467	~1 m till on rock		API, NC	3,000	rock bolts	A+1.5				None
211	325,755	~1 m till on rock		API, NC	3,000	rock bolts	A+9.0				None
212	326,086	~1 m till on rock		API, NC(quarry 300 m away), AC1030 TP-17, 18	3,000	rock bolts	D+6.0				None
213	326,348	~1 m till on rock		API, NC (quarry 200 m away), AC1030 TP-17, 18	3,000	rock bolts	A+12.0				None
214	326,844	~1 m till on rock		API, NC, AC1030 TP-17, 18	3,000	rock bolts	B+9.0				None
215	327,344	<1 m to bedrock		API, NC	3,000	rock bolts	A+10.5				None
216	327,617	<1 m to bedrock		API, NC	3,000	rock bolts	A+12.0				None
217	328,042	<1 m to bedrock		API, NC	3,000	rock bolts	A+9.0				None
218	328,480	<1 m to bedrock		API, NC	3,000	rock bolts	A+12.0				None
219	328,874	~1 m till on rock		API, NC	3,000	rock bolts	D+10.5				None
220	329,089	~1 m till on rock		API, NC	3,000	rock bolts	A+0.0				None
221	329,509	<1 m till on rock		API, NC, AC1030 PO 2	3,000	rock bolts	A+6.0				None
222	329,906	<1 m till on rock		API, NC	3,000	rock bolts	A+10.5				None
223	330,277	~ 3 m till	~1 m	API	250	grillage	A+12.0				None
224	330,617	~ 3 m till	~1 m	API	250	grillage	A+9.0				None
225	331,033	~ 3 m till	~1 m	API	250	grillage	A+12.0				None
226	331,453	~ 3 m till	~2 m	API	250	grillage	A+9.0			New 226 in bog	None
227	331,896	~ 3 m till	~2 m	API	250	grillage	A+9.0				None
228	332,310	~ 3 m till	~1 m	API	3,000	rock bolts	B+4.5			New 228 at edge of bog	None
229	332,681	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+4.5				None
230	332,983	Bedrock		API	3,000	rock bolts	A+7.5				None
231	333,385	~1 m till on rock		API, NC	3,000	rock bolts	A+9.0			<1 m to rock	None
232	333,807	~1 m till on rock		API, NC	3,000	rock bolts	A+10.5			<1 m to rock	None
233	334,234	~1 m till on rock		API, NC	3,000	rock bolts	A+12.0		<1 m soil	<1 m to rock	None
234	334,678	Bedrock		API	3,000	rock bolts	A+9.0			<1 m to rock	None
235	335,093	Bedrock		API	3,000	rock bolts	A+9.0			<1 m to rock	None
236	335,435	~1 m till on rock		API	3,000	rock bolts	A+10.5				None
237	335,861	~1 m till on rock		API	3,000	rock bolts	A+9.0		2 m till on rock		None
238	336,190	~1 m till on rock		API	3,000	rock bolts	D+0.0				None
239	336,474	~1 m till on rock		API	3,000	rock bolts	A+1.5				None
240	336,769	~1 m till on rock		API	3,000	rock bolts	A+0.0				None
241	337,161	~6 m esker	~3 m	API, NC	250	grillage	A+0.0			New 241 appears wet	None
242	337,554	~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+10.5				None
243	337,918	~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+12.0				None
244	338,290	~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+9.0			New 244 ~3 m till	None
245	338,730	~ 3 m till	~1 m	API	250	grillage	A+10.5				None
246	339,161	~ 3 m till	~1 m	API	250	grillage	A+12.0				None
247	339,561	~ 2 m till	~1 m	API, NC - road cut	3,000	rock bolts	A+10.5				None
248	339,951	~ 2 m till	~1 m	API, NC - road cut	3,000	rock bolts	A+6.0				None
249	340,389	3 m esker complex	2.5 m	API, NC, AC1060 TP 20	250	grillage	A+9.0		Wet area	New 249, ~3 m till	None
250	340,789	3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	D+10.5			New 250 on top of esker	None
251	341,232	3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	A+10.5			New 251 on top of esker	None
252	341,635	3 to 4 m of esker complex	~1 m	API, NC, AC1060 TP 20	250	grillage	C (strain) + 3.0		Wet area	New 252 on top of esker	None
253	341,983	3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	C (strain) + 7.5			Wet, ~3 m till	None
254	342,418	>4 m of esker complex	3.5	API, NC, AC1060 TP 21	250	grillage	A+10.5				None
255	342,830	>4 m of esker complex	3.5	API, NC, AC1060 TP 21	250	grillage	A+4.5				None
256	343,241	~ 3 m till	~1 m	API	250	grillage	A+7.5				None

Caution

Line rerouted. See interpretation of new route at the end of this spread sheet.

Investigation Recommended

Bedrock Expected

FINAL July 29, 2012

This is a summary of the original review plus discussions with SNC design engineers on June 22, 2012.

STRUCTURE NUMBERS FOR THREE ALIGNMENTS	STATION	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type by SNC for Original Numbering Sequence	Review of 32 Sites North Line	High Level General Review New North Line	High Level General Review New South Line	FINAL REVIEW COMMENTS JULY 29 2012
257	343,658	~ 3 m till	~1 m	API	250	grillage	A+6.0				None
258	344,080	~1 m till on rock		API	3,000	rock bolts	A+0.0				None
259	344,478	~ 3 m till	~1 m	API	250	grillage	A+9.0			New 259 at edge of bog	None
260	344,857	~ 3 m till	surface	API, boggy	250	grillage	A+6.0		Wet area		None
261	345,297	~1 m	surface	API, boggy	3,000	rock bolts	A+6.0			new 261, ~2 m till	None
262	345,640	~ 2 m till	surface	API, boggy	3,000	rock bolts	A+0.0		Wet area	New 262, ~1 m till	None
263	345,970	~1 m	surface	API, near small stream	3,000	rock bolts	A+9.0				None
264	346,306	~1 m		API	3,000	rock bolts	A+3.0				None
265	346,783	~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+7.5				None
266	347,150	~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+4.5				None
267	347,538	~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+7.5				None
268	347,956	~ 2 m till	surface	API, boggy, located in low area with nearby drainage	3,000	rock bolts	A+9.0				None
269	348,376	~ 3 m till	~1 m	API	250	grillage	A+7.5				None
270	348,771	~ 3 m till	~1 m	API	250 or 3000	grillage or rock bolts	D+6.0				None
271	349,143	>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	A+10.5				None
272	349,541	>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	B+9.0				None
273	349,883	>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	A+0.0				None
274	350,204	>4 m till	surface	API, AC1030 TP 22, NC - road cuts, adjacent to bog and stream	250	grillage	A+1.5				None
275	350,479	3 m till	2 m	API, AC1030 TP 22, NC - road cuts	250	deep	C (strain) + 10.5				None
276	350,926	~2 m till		API, NC - road cuts (till and rock), many large boulders	3,000	rock bolts	A+7.5				None
277	351,290	2 m till	surface	API, NC - road cuts (till and rock), many large boulders, on flood plane of nearby stream	3,000	rock bolts	A+4.5		Bog, floodplain	New 277 Bog, floodplain	None
278	351,668	2 m till	surface	API, NC - road cuts (till and rock), many large boulders, on bog about 1 m deep, possible flood plane of nearby stream, hydrology	250 or 3000	grillage or rock bolts	A+4.5		Bog, floodplain		None
279	352,078	~ 3 m till	~2 m	API, NC	250	grillage	A+7.5				None
280	352,467	~ 3 m till	~2 m	API	250	grillage	A+7.5				None
281	352,878	~ 3 m till	~2 m	API	250	grillage	A+7.5				None
282	353,315	~ 3 m till	~2 m	API	250	grillage	A+9.0				None
283	353,725	~ 3 m till	~1 m	API, near stream	250	grillage	A+4.5				None
284	354,101	~ 3 m till	~1 m	API, adjacent to stream	250	grillage	A+7.5				None
285	354,538	~2 m till	surface	API, many large boulders	3,000	rock bolts	A+9.0				None
286	354,944	~2 m till	~1 m	API, many large boulders	3,000	rock bolts	A+7.5			New 286, wet, boggy	None
287	355,386	~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5				None
288	355,796	~1 m		API, many large boulders	3,000	rock bolts	D+4.5				None
289	356,159	~1 m		API, many large boulders	3,000	rock bolts	A+7.5				None
290	356,597	~1 m		API, many large boulders	3,000	rock bolts	A+6.0			New 290, wet, boggy	None
291	357,016	~1 m		API, many large boulders	3,000	rock bolts	A+7.5		Wet, boggy		None
292	357,356	3 m to 4 m till	3	API, many large boulders, AC1030 TP-23 >4 m till, dry	250	grillage	A+9.0				None
293	357,814	~ 3 m till	surface	API, boggy area	250	grillage	A+4.5				None
294	358,186	~ 3 m till	2	API	250	grillage	A+6.0				None
295	358,634	~1 m		API	3,000	rock bolts	B+3.0				None
296	359,183	~1 m		API	3,000	rock bolts	B+10.5				None
297	359,572	~1 m		API	3,000	rock bolts	A+4.5				None
298	359,876	~1 m		API	3,000	rock bolts	A+10.5				None
299	360,302	~1 m		API, many large boulders	3,000	rock bolts	A+12.0				None
300	360,692	~1 m		API, many large boulders	3,000	rock bolts	A+10.5				None
301	361,126	~1 m	surface	API, many large boulders	3,000	rock bolts	C (strain) + 1.5		Wet, boggy		None
302	361,477	~1 m		API, many large boulders	3,000	rock bolts	A+7.5		Wet, boggy		None
303	361,864	~1 m		API, many large boulders	3,000	rock bolts	A+3.0				None
304	362,186	~1 m		API, many large boulders	3,000	rock bolts	A+0.0				None
305	362,642	~1 m	~1	API, many large boulders	3,000	rock bolts	A+4.5				None
306	363,055	~1 m	~1	API, many large boulders	3,000	rock bolts	A+10.5				None
307	363,480	~1 m	surface	API, many large boulders	3,000	rock bolts	D+9.0				None
308	363,887	~1 m	surface	API, many large boulders, AC1030 TP-24	3,000	rock bolts	A+9.0				None
309	364,334	~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5		Wet, boggy		None
310	364,760	~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5		Wet, boggy		None
311	365,182	~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5		Wet, boggy	New 311 nay be wet	None
312	365,602	~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5		Wet, boggy		None
313	366,000	~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5				None
314	366,417	~ 3 m till	2	API	250	grillage	A+9.0				None
315	366,775	~ 3 m till	2	API	250	grillage	A+9.0				None
316	367,202	~1 m		API	3,000	rock bolts	A+10.5				None
317	367,605	~1 m		API	3,000	rock bolts	A+7.5				None
318	367,993	~1 m		API	3,000	rock bolts	A+3.0			New 318 at edge of bog	None
319	368,351	~1 m	surface	API	3,000	rock bolts	A+9.0			New 319 at edge of bog	None
320	368,769	~1 m		API	3,000	rock bolts	A+10.5				None
321	369,212	~1 m		API	3,000	rock bolts	A+10.5				None
322	369,623	~1 m	surface	API, boggy	3,000	rock bolts	A+10.5				None
323	370,026	~1 m	surface	API, adjacent to stream	3,000	rock bolts	A+7.5				None
324	370,439	~1 m		API, AC1030 TP-25	3,000	rock bolts	A+10.5				None
325	370,829	~1 m		API, AC1030 TP-25	3,000	rock bolts	A+0.0				None
326	371,163	~1 m		API, AC1030 TP-25	3,000	rock bolts	D+7.5				None
327	371,412	~1 m		API, esker nearby	3,000	rock bolts	A+0.0				None
328	371,741	~1 m	surface	API	3,000	rock bolts	A+0.0				None
329	372,087	~1 m		API, many boulder fields nearby	3,000	rock bolts	A+7.5				None
330	372,482	~1 m		API	3,000	rock bolts	A+6.0				None
331	372,893	~1 m		API	3,000	rock bolts	A+10.5				None
332	373,304	~1 m	surface	API	3,000	rock bolts	A+10.5				None
333	373,687	~1 m	surface	API	3,000	rock bolts	A+6.0				None
334	374,122	~1 m		API	3,000	rock bolts	A+9.0				None
335	374,547	~1 m		API	3,000	rock bolts	A+9.0				None
336	374,959	~1 m	surface	API	3,000	rock bolts	A+7.5				None
337	375,335	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5				None
338	375,753	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+9.0				None
339	376,184	~1 m		API, NC	3,000	rock bolts	A+12.0				None
340	376,599	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
341	377,031	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
342	377,433	~1 m		API, NC	3,000	rock bolts	A+12.0				None
343	377,800	~1 m	surface	API, AC1030 TP-26, rock at 0.5 m, boulder fields nearby	3,000	rock bolts	D+4.5				None
344	378,182	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+4.5				None
345	378,571	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+6.0				None
346	379,002	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0				None
347	379,442	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5				None
348	379,848	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+6.0			New 348, boggy	None
349	380,242	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+4.5				None
350	380,688	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5			New 350, boggy	None
351	381,089	~1 m		API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+7.5				None
352	381,552	~1 m	surface	API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+10.5				None
353	381,913	~1 m		API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+9.0				None
354	382,369	~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5				None
355	382,788	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0				None
356	383,220	~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	A+3.0				None
357	383,577	~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	D+10.5				None
358	383,984	~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	A+9.0				None
359	384,415	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5				None
360	384,835	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+9.0				None
361	385,213	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
362	385,635	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0				None
363	386,009	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0				None
364	386,468	~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0				None
365	386,863	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5				None
366	387,343	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+10.5				None
367	387,760	~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5		Wet, boggy		None
368	388,137	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0				None
369	388,383	~2 m till	surface	API, NC, AC1030 TP - 29 - rock at 2.0 m	3,000	rock bolts	D+6.0				None
370	388,845	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+3.0			New 370, ~2 m till	None
371	389,234	~3 m till	surface	API, NC	250	grillage	A+9.0		Wet, boggy		None
372	389,637	~3 m till	surface	API, NC	250	grillage	A+6.0		Wet, boggy		None
373	390,057	~2 m till	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
374	390,477	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5				None
375	390,916	~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0				None
376	391,319	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+7.5				None
377	391,850	3 till	>3 m	API, AC1030 TP - 30	3,000	rock bolts	C (strain) + 12.0				None
378	392,249	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+0.0				None
379	392,525	~2 m esker	surface	API, NC	3,000	rock bolts	A+4.5			New 379, ~2 m till	None
380	392,882	~2 m esker		API, NC	3,000	rock bolts	A+6.0				None
381	393,321	~2 m esker		API, NC	3,000	rock bolts	A+6.0				None
382	393,754	~2 m esker		API, NC	3,000	rock bolts	A+12.0				None
383	394,155	3 to 4 m esker	3 m	API, on top of esker remnant	250	grillage	A+9.0			New 383	None
384	394,568	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5				None
385	394,961	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0			New 385 on bog	None
386	395,356	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
387	395,781	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	D+0.0				None
388	396,151	~2 m till		API, NC	3,000	rock bolts	A+3.0				None
389	396,513	3 m to 5 m fluvial	1 m	API, NC, AC1030 TP-31	100	grillage	A+7.5				None
390	396,879	3 m to 5 m fluvial	1 m	API, NC, AC1030 TP-31	100	grillage	C (strain) + 4.5				None
391	397,268	3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+7.5				None
392	397,636	3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+1.5				None
393	397,994	3 m to 5 m fluvial	1 m	API, NC, edge of wet area	250	grillage	A+10.5				None
394	398,412	3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+9.0				None
395	398,825	3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+7.5				None
396	399,257	>4 m till	1 m	API, NC	250	grillage	A+6.0				None
397	399,615	>4 m till	1 m	API, NC	250	grillage	A+1.5				None
398	399,946	>4 m till	1 m	API, NC	250	grillage	A+3.0				None
399	400,355	>4 m till	1 m	API, NC	250	grillage	A+6.0				None
400	400,754	>4 m till	1 m	API, NC, road cut in apparent till	250	grillage	A+9.0				None
401	401,130	>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0				None
402	401,410	>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0		Boggy		None
403	401,735	>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0				None
404	402,059	>4 m in glaciofluvial over till	1 m	API, NC, nearby road cut, AC1030 TP - 32	250	grillage	A+0.0				None

Caution	Line rerouted. See interpretation of new route at the end of this spread sheet.
Investigation Recommended	
Bedrock Expected	

FINAL July 29, 2012

This is a summary of the original review plus discussions with SNC design engineers on June 22, 2012.

STRUCTURE NUMBERS FOR THREE ALIGNMENTS	STATION	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type by SNC for Original Numbering Sequence	Review of 32 Sites North Line	High Level General Review New North Line	High Level General Review New South Line	FINAL REVIEW COMMENTS JULY 29 2012
405	402,407	>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	205	grillage	C (strain) + 6.0				None
406	402,751	>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	250	grillage	A+0.0				None
407	403,105	>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	250	grillage	A+3.0				None
408	403,429	>4 m in glaciofluvial over till	1 m	API	250	grillage	A+7.5				None
409	403,838	~2 m till		API	3,000	rock bolts	D+6.0				None
410	404,261	~2 m till		API	3,000	rock bolts	A+7.5				None
411	404,664	3 m to 4 m till	surface	API, boggy area	250	grillage	A+9.0				None
412	405,098	3 m to 4 m till	surface	API	250	grillage	A+6.0				None
413	405,487	~2 m till		API	3,000	rock bolts	A+6.0				None
414	405,896	~2 m till		API	3,000	rock bolts	A+7.5				None
415	406,311	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5				None
416	406,727	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+9.0				None
417	407,166	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5				None
418	407,586	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0			New 418 in boggy area	None
419	408,004	~2 m till		API	3,000	rock bolts	A+9.0				None
420	408,449	~2 m till		API	3,000	rock bolts	A+9.0				None
421	408,870	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
422	409,280	rock at surface		API, NC, AC1030 TP - 33 - 0.5 to bedrock	3,000	rock bolts	A+7.5				None
423	409,664	~1 m		API, NC, AC1030 TP - 33 - 0.5 to bedrock	3,000	rock bolts	A+7.5				None
424	410,138	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+9.0				None
425	410,462	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0				None
426	410,785	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
427	411,177	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5				None
428	411,495	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	D+12.0				None
429	411,896	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+10.5				None
430	412,317	3 m to 4 m	3 m	API, NC, AC1030 TP - 34 - >4 m of esker	250	grillage	A+7.5				None
431	412,743	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5				None
432	413,086	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0				None
433	413,538	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+1.5				None
434	413,840	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5				None
435	414,402	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+9.0				None
436	414,889	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0				None
437	415,206	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	C (strain) + 6.0				None
438	415,405	~1 m	surface	API, bedrock structure visible beneath thin till	3,000	rock bolts	A+0.0				None
439	415,792	~2 m till		API, bedrock structure visible beneath thin till	3,000	rock bolts	C (strain) + 4.5				None
440	415,991	~2 m till		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+1.5				None
441	416,311	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	B+12.0				Investigate
442	416,700	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	D+9.0				Investigate
443	417,166	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+6.0				Investigate
444	417,434	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	C (strain) + 6.0				Investigate
445	417,771	> 4 m lacustrine, silt??	>3 m	API, NC, AC1030 TP - 35 nearby, investigate		deep	A+4.5				Investigate
446	418,091	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+4.5				Investigate
447	418,450	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	C (strain) + 12.0				Investigate
448	418,794	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+12.0			new 448 in wet area	Investigate
449	419,256	<1 m		API, NC	3,000	rock bolts	D+6.0				None
450	419,663	<1 m		API, NC	3,000	rock bolts	A+12.0				None
451	419,965	<1 m		API, NC	3,000	rock bolts	A+9.0				None
452	420,280	<1 m		API, NC	3,000	rock bolts	A+3.0			New 452, ~2 m till	None
453	420,659	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
454	420,995	<1 m		API, NC	3,000	rock bolts	A+4.5				None
455	421,279	<1 m		API, NC	3,000	rock bolts	A+12.0				None
456	421,724	<1 m		API, NC	3,000	rock bolts	A+1.5				None
457	422,076	<1 m		API, NC	3,000	rock bolts	B+12.0				None
458	422,602	<1 m		API, NC	3,000	rock bolts	C (strain) + 3.0			Not spotted	None
459	422,812	<1 m		API, NC	3,000	rock bolts	A+0.0			Not spotted	None
460	423,073	<1 m		API, NC	3,000	rock bolts	A+0.0				None
461	423,331	<1 m		API, NC	3,000	rock bolts	C (strain) + 9.0				None
462	423,757	<1 m		API, NC	3,000	rock bolts	B+0.0				None
463	424,178	<1 m		API, NC	3,000	rock bolts	A+4.5				None
464	424,396	<1 m		API, NC	3,000	rock bolts	A+9.0				None
465	424,737	<1 m		API	3,000	rock bolts	A+4.5				None
466	425,111	<1 m		API	3,000	rock bolts	A+12.0				None
467	425,429	<1 m		API, AC1030 TP - 36 nearby at lower elevation in granular soil > 5 m deep	3,000	rock bolts	A+3.0				None
468	425,767	<1 m		API	3,000	rock bolts	C (strain) + 1.5				None
469	425,980	<1 m		API	3,000	rock bolts	A+1.5				None
470	426,209	~2 m till		API	3,000	rock bolts	C (strain) + 9.0				None
471	426,627	<1 m		API	3,000	rock bolts	A+3.0				None
472	426,948	<1 m		API	3,000	rock bolts	A+0.0				None
473	427,284	<1 m		API	3,000	rock bolts	A+3.0				None
474	427,639	<1 m	surface	API	3,000	rock bolts	A+10.5				None
475	428,085	<1 m		API	3,000	rock bolts	A+10.5		Edge of bog		None
476	428,495	<1 m		API	3,000	rock bolts	A+9.0				None
477	428,958	<1 m		API	3,000	rock bolts	A+7.5				None
478	429,369	<1 m		API	3,000	rock bolts	A+7.5				None
479	429,787	~2 m till		API	3,000	rock bolts	A+9.0				None
480	430,215	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
481	430,546	~2 m till	surface	API	3,000	rock bolts	A+7.5				None
482	430,971	~2 m till		API	3,000	rock bolts	A+9.0			not spotted, edge of bog	None
483	431,382	~2 m till	surface	API	3,000	rock bolts	A+9.0				None
484	431,805	~3 m till		API	250	grillage	A+10.5				None
485	432,225	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
486	432,598	~2 m till		API, NC	3,000	rock bolts	A+7.5				None
487	432,963	~3 m till	2 m	API	250	grillage	A+9.0				None
488	433,358	> 4 m esker	2 m	API	250	grillage	C (strain) + 10.5		Lacustrine?		None
489	433,747	> 4 m esker	>4	API	250	grillage	D+7.5		Lacustrine?	Lacustrine?	None
490	434,152	~3 m till	2 m	API	250	grillage	B+0.0			Lacustrine?	None
491	434,386	~2 m till		API	3,000	rock bolts	A+0.0		~1 m till		None
492	434,857	~3 m till	2 m	API	250	grillage	A+6.0			~1 m Till	None
493	435,240	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
494	435,599	~3 m till	surface	API, NC	250	grillage	A+3.0				None
495	435,915	~3 m till	2 m	API, NC	250	grillage	A+0.0				None
496	436,282	~3 m till	2 m	API, NC	250	grillage	A+7.5				None
497	436,718	> 4 m esker	2 m	API, NC	250	grillage	A+9.0				None
498	437,139	>3.5 m	surface	API, NC, AC1030 TP - 37, >3.5, wet	250	deep	C (strain) + 12.0				None
499	437,475	> 4 m esker	2 m	API, NC	250	grillage	A+1.5				None
500	437,814	> 4 m esker	2 m	API, NC	250	grillage	A+4.5				None
501	438,222	> 4 m esker	2 m	API, NC	250	grillage	A+1.5		till?		None
502	438,613	> 4 m esker	2 m	API, NC	250	grillage	A+4.5				None
503	439,004	> 4 m esker	2 m	API, NC	250	grillage	A+9.0				None
504	439,419	>4 m till	2 m	API, NC, AC1030 TP - 38, >4 m till, dry to 4 m	250	grillage	C (strain) + 9.0				None
505	439,832	>4 m till	2 m	API, NC, AC1030 TP - 38, >4 m till, dry to 4 m	250	grillage	A+10.5		Many boulders in area		None
506	440,265	>4 m till	2 m	API, NC	250	grillage	A+10.5				None
507	440,680	>3 m till	2 m	API, NC	250	grillage	A+9.0				None
508	441,088	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
509	441,494	~2 m till		API, NC	3,000	rock bolts	D+7.5			New 510, >3 m till	None
510	441,877	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
511	442,284	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
512	442,683	~2 m till		API, NC, AC1030 TP - 39 dug 300 m south in probable glacio-lacustrine soil with >3 m thickness	3,000	rock bolts	A+4.5				None
513	443,071	~1 m	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	A+4.5				None
514	443,505	~1 m	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	D+9.0				None
515	443,931	~2 m till	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	A+12.0				None
516	444,368	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
517	444,790	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
518	445,234	~3 m till	1 m	API, NC, near stream	250	grillage	A+10.5				None
519	445,667	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
520	446,068	~3 m till	2 m	API, NC	250	grillage	A+10.5				None
521	446,500	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
522	446,942	~2 m till	1 m	API, N, near bog	3,000	rock bolts	A+12.0				None
523	447,334	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
524	447,712	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
525	448,152	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
526	448,581	~1 m	surface	API, NC	3,000	rock bolts	A+10.5				None
527	449,018	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
528	449,453	1.5 m till	surface	API, NC, AC1030 TP - 41	3,000	rock bolts	D+12.0				None
529	449,886	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
530	450,327	~1 m		API, NC	3,000	rock bolts	A+9.0				None
531	450,712	~1 m		API, NC	3,000	rock bolts	A+3.0				None
532	451,040	~1 m		API, NC	3,000	rock bolts	A+4.5				None
533	451,414	~1 m		API, NC	3,000	rock bolts	A+6.0				None
534	451,788	~1 m		API, NC	3,000	rock bolts	A+4.5				None
535	452,149	~1 m		API, NC	3,000	rock bolts	A+3.0				None
536	452,510	~1 m		API, NC	3,000	rock bolts	A+3.0				None
537	452,944	~1 m		API, NC	3,000	rock bolts	A+9.0				None
538	453,373	~1 m		API, NC	3,000	rock bolts	A+1.5				None
539	453,680	~1 m		API, NC	3,000	rock bolts	A+1.5				None
540	454,055	~2 m till		API, NC	3,000	rock bolts	A+7.5				None
541	454,460	~2 m till	surface	API, NC, boggy	3,000	rock bolts	A+6.0				None
542	454,808	~2 m till	surface	API, NC, stream nearby	3,000	rock bolts	A+4.5				None
543	455,186	~2 m till	surface	API, NC, AC1030 TP - 42 - 2.5 m to rock	3,000	rock bolts	D+10.5				None
544	455,611	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
545	456,030	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
546	456,433	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
547	456,864	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
548	457,306	~3 m till	2 m	API, NC	250	grillage	A+7.5		Boggy		None
549	457,738	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
550	458,136	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
551	458,549	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
552	458,966	~1 m		API, NC	3,000	rock bolts	A+9.0				None
553	459,413	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
554	459,837	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
555	460,281	~2 m till		API, NC	3,000	rock bolts	A+10.5				None

Caution

Line rerouted. See interpretation of new route at the end of this spread sheet.

Investigation Recommended

Bedrock Expected

FINAL July 29, 2012

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STRUCTURE NUMBERS FOR THREE ALIGNMENTS	STATION	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type by SNC for Original Numbering Sequence	Review of 32 Sites North Line	High Level General Review New North Line	High Level General Review New South Line	FINAL REVIEW COMMENTS JULY 29 2012
556	460,709	~2 m till		API, NC	3,000	rock bolts	A+12.0				None
557	461,114	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
558	461,524	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
559	461,957	~2 m till		API, NC, AC1030 TP - 43 nearby on lower elevation ground, 2 m to bedrock	3,000	rock bolts	D+10.5			New 569 in bog	None
560	462,310	~2 m till		API, NC	3,000	rock bolts	A+9.0			New 570 in bog	None
561	462,720	~1 m		API, NC	3,000	rock bolts	A+7.5				None
562	463,151	~1 m		API, NC	3,000	rock bolts	A+6.0				None
563	463,452	~1 m		API, NC	3,000	rock bolts	A+6.0				None
564	463,838	~1 m		API, NC	3,000	rock bolts	A+6.0				None
565	464,230	~1 m		API, NC	3,000	rock bolts	A+9.0				None
566	464,700	~1 m		API, NC	3,000	rock bolts	A+6.0				None
567	465,093	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
568	465,467	~2 m till		API, NC	3,000	rock bolts	A+4.5				None
569	465,875	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
570	466,278	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
571	466,688	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
572	467,110	~2 m till		API, NC	3,000	rock bolts	A+9.0				None
573	467,463	~1 m		API, NC	3,000	rock bolts	A+7.5				None
574	467,760	~1 m		API, NC	3,000	rock bolts	A+1.5				None
575	468,145	~1 m		API, NC, AC1030 TP - 44, 1.4 m to rock	3,000	rock bolts	D+6.0				None
576	468,500	~1 m		API, NC	3,000	rock bolts	A+7.5				None
577	468,880	~1 m		API, NC	3,000	rock bolts	A+4.5				None
578	469,263	~1 m		API, NC	3,000	rock bolts	A+4.5				None
579	469,666	~1 m		API, NC	3,000	rock bolts	A+9.0				None
580	470,079	~1 m		API, NC	3,000	rock bolts	A+10.5				None
581	470,490	~1 m		API, NC	3,000	rock bolts	A+7.5				None
582	470,888	~2 m till		API, NC	3,000	rock bolts	A+10.5		~3 m till		None
583	471,315	~2 m till		API, NC	3,000	rock bolts	A+10.5		~3 m till		None
584	471,730	~2 m till		API, NC	3,000	rock bolts	D+7.5		~3 m till		None
585	472,159	~1 m		API, NC	3,000	rock bolts	A+10.5				None
586	472,584	~1 m		API, NC	3,000	rock bolts	A+12.0				None
587	473,022	~2 m till		API, NC	3,000	rock bolts	A+12.0		~3 m till		None
588	473,454	~2 m till		API, NC	3,000	rock bolts	A+12.0		~3 m till		None
589	473,866	~2 m till		API, NC	3,000	rock bolts	A+12.0		~3 m till		None
590	474,302	~2 m till		API, NC	3,000	rock bolts	A+7.5		~3 m till		None
591	474,735	~1 m		API, NC	3,000	rock bolts	A+10.5				None
592	475,174	~1 m		API, NC	3,000	rock bolts	A+7.5				None
593	475,509	~1 m		API, NC	3,000	rock bolts	A+10.5				None
594	475,952	~2 m till		API, NC	3,000	rock bolts	A+4.5				None
595	476,369	~3 m till	2 m	API, NC	250	grillage	A+7.5				None
596	476,747	~2 m till		API, NC	3,000	rock bolts	A+7.5				None
597	477,140	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
598	477,482	~2 m till		API, NC	3,000	rock bolts	A+3.0				None
599	477,892	~1 m		API, NC	3,000	rock bolts	D+12.0				None
600	478,313	~1 m		API, NC	3,000	rock bolts	A+9.0			New 600 in bog?	None

601	478,711	~2 m till		API, NC	3,000	rock bolts	A+10.5				None
602	479,159	~3 m till	2 m	API, NC	250	grillage	A+9.0				None
603	479,590	~1 m		API, NC	3,000	rock bolts	A+7.5				None
604	479,978	~1 m		API, NC	3,000	rock bolts	A+7.5				None
605	480,402	~2 m till		API, NC	3,000	rock bolts	A+7.5				None
606	480,776	~1 m		API, NC	3,000	rock bolts	A+7.5			New 606 in bog?	None
607	481,211	~1 m		API, NC	3,000	rock bolts	A+9.0				None
608	481,633	~1 m		API, NC	3,000	rock bolts	A+7.5			New 608 in bog?	None
609	482,048	~1 m		API, NC	3,000	rock bolts	A+7.5				None
610	482,406	~1 m		API, NC	3,000	rock bolts	A+7.5			New 610 in stream or on flood plain	None
611	482,802	~1 m		API, NC	3,000	rock bolts	D+7.5			New 611 ~ 2 m till	None
612	483,175	~2 m till		API, NC	3,000	rock bolts	A+6.0				None
613	483,592	~1 m		API, NC	3,000	rock bolts	A+7.5			New 613 in bog, ~2 m till	None
614	483,978	~1 m		API, NC	3,000	rock bolts	A+10.5			New 614 ~1 m till	None
615	484,421	~1 m		API, NC	3,000	rock bolts	A+10.5				None
616	484,834	~1 m		API, NC	3,000	rock bolts	A+9.0				None
617	485,247	~1 m		API, NC	3,000	rock bolts	A+6.0				None
618	485,671	~1 m		API, NC	3,000	rock bolts	A+10.5		~2 m till		None
619	486,107	~1 m		API, NC	3,000	rock bolts	A+7.5		~2 m till		None
620	486,495	~1 m		API, NC	3,000	rock bolts	A+9.0		~2 m till		None
621	486,980	~1 m		API, NC	3,000	rock bolts	B+10.5				None
622	487,416	~1 m	surface	API, NC, AC1030 TP - 45, 1 m to bedrock, wet	3,000	rock bolts	E+6.0				None
623	487,824	~1 m		API, NC	3,000	rock bolts	A+12.0				None
624	488,284	~3 m till		API, NC, old bulldozer test pit nearby	250	grillage	B+10.5			New 624 ~2 m till	None
625	488,670	~1 m		API, NC	3,000	rock bolts	A+12.0			New 625 ~3 m till	None
626	489,019	~1 m		API, NC	3,000	rock bolts	A+0.0			New 626 ~1 m till	None
627	489,461	~2 m till		API, NC,	3,000	rock bolts	A+6.0		<1 m to rock		None
628	489,830	~1 m		API, NC	3,000	rock bolts	A+7.5				None
629	490,247	~1 m		API, NC	3,000	rock bolts	A+9.0				None
630	490,694	~2 m till		API, NC,	3,000	rock bolts	A+9.0				None
631	491,040	~2 m till		API, NC,	3,000	rock bolts	A+6.0				None
632	491,437	~2 m till		API, NC,	3,000	rock bolts	A+7.5				None
633	491,848	~1 m		API, NC	3,000	rock bolts	A+0.0				None
634	492,308	~1 m		API, NC	3,000	rock bolts	A+6.0				None
635	492,643	~2 m till		API, NC,	3,000	rock bolts	A+7.5		~3 m till		None
636	493,026	~2 m till		API, NC,	3,000	rock bolts	A+6.0		~1 m till		None
637	493,453	~2 m till		API, NC,	3,000	rock bolts	A+7.5		~2 m till		None
638	493,820	~2 m till		API, NC,	3,000	rock bolts	C (strain) + 10.5		Missing	~3 m till	None
639	493,963	~2 m fill		API, NC,	3,000	rock bolts	D+9.0		Missing		None

L2x-24		sand	>6 m	API,	100	grillage	
L1x-24		*sand*	*>6 m*	*API,*	*100*	*grillage*	
L2x-25		sand	>6 m	API,	100	grillage	
L1x-25		*sand, silt/clay may be near surface*	*~2 m*	*API,*		*deep*	
L2x-27		sand	>6 m	API,	100	grillage	
L1x-27		*sand*	*>6 m*	*API, near ravine - move back*	*100*	*grillage*	
L2x-28		sand	>6 m	API,	100	grillage	
L1x-28		*sand*	*>6 m*	*API,*	*100*	*grillage*	
L2x-29		sand	>6 m	API,	100	grillage	
L1x-29		*sand*	*>6 m*	*API,*	*100*	*grillage*	
L2x-30		sand	>6 m	API,	100	grillage	
L1x-30		*sand*	*>6 m*	*API,*	*100*	*grillage*	
L2x-31		sand	>6 m	API,	100	grillage	
L1x31		*sand*	*>6 m*	*API,*	*100*	*grillage*	
L2x-32		sand	>6 m	API, will be located on a bluff when reservoir floods, potential high erosion area, investigate	100	grillage	Investigate
L1x-32		*sand*	*>6 m*	*API, will be located on a bluff when reservoir floods, potential high erosion area, investigate*	*100*	*grillage*	Investigate
L2x-33		~ 4 m till	1 m	API, NC, test pits AC1060-MF1120-8 and 9	250	grillage	
L1x-33		*~ 4 m till*	*1 m*	*API, NC, test pits AC1060-MF1120-8 and 9*	*250*	*grillage*	
L2x-34		~ 4 m till	1 m	API, NC, test pits AC1060-MF1120-8 and 9	250	grillage	
L1x-34		*~ 4 m till*	*1 m*	*API, NC, test pits AC1060-MF1120-8 and 9*	*250*	*grillage*	
L2x-35		<1 m to bedrock		API, NC	3,000	rock bolts	
L1x-35		*<1 m to bedrock*		*API, NC*	*3,000*	*rock bolts*	
L2x-36		<1 m to bedrock		API, NC	3,000	rock bolts	
L1x-36		*<1 m to bedrock*		*API, NC*	*3,000*	*rock bolts*	
L2x-37		<1 m to bedrock		API, NC	3,000	rock bolts	
L1x-37		*<1 m to bedrock*		*API, NC*	*3,000*	*rock bolts*	
L2x-41		<1 m to bedrock		API, NC	3,000	rock bolts	
L1x-41		*<1 m to bedrock*		*API, NC*	*3,000*	*rock bolts*	
EDWARDS RIVER AREA - NEW ROUTE							
L2x-91		~ 4 m till	1 m	API, NC, test pit AC1060-3	250	grillage	
L1-90		*~ 6 m till*	*4 m*	*API, NC,located near crest of quarry - move back*	*250*	*grillage*	
L2x-92		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	
L1x-91		*~ 4 m till*	*2 m - 3 m*	*API, TP AC1060-3, NC*	*250*	*grillage*	
L2x-94		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	
L1x-92		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	
L2x-95		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	
L1x-93		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	
L2x-96		sand with some organic material	3 m	API, TP AC1060-4, on older flood plain of Edwards River, move SE away from escarpment		deep	
L1x-94		*sand with some organic material*	*3 m*	*API, TP AC1060-4, on older flood plain of Edwards River, move SE to accommodate L2x-96 move*		*deep*	

APPENDIX E1

AMEC 315 KV HVAC GEOTECHNICAL INVESTIGATION RECOMMENDATION

(Acceptance of this report does not constitute approval of proposed geotechnical program.)

Memo

To	**Michel Belanger, P Eng**	File no	**TF1116574**
From	**Calvin Miles, P. Geo**	cc	**A. Peach** **P. Boonsinsuk**
Tel	**722 7023**		
Fax	**722 7353**		
Date	**February 15, 2012**		

Subject: 315 kV HVAC Muskrat Falls to Churchill Falls Transmission Line 2 (north line) – Nalcor Energy – Lower Churchill Project (LCP) – Geotechnical Conditions Along Centreline

Terms of Reference

The attached table has been prepared which provides, at each tower site, the anticipated subsurface conditions, indication of the groundwater level, and recommended bearing pressure. Comments and the source of information are also included. This information is compiled in a spread sheet which accompanies this memo.

Data supplied by SNC:

- Tower number, station and proposed structure type.
- Minimum grillage depth will be 2.75 m taking into consideration a frost penetration depth of 2.5 m;
- Maximum grillage depth will be 3.5 m which is required for foundations designed for uplift.
- If bedrock is encountered within 2.75 m depth then rock anchors will be used.

Sources of Information

Information was obtained from several sources as follows:

- Technical reports prepared for Nalcor associated with the LCP:
  - AC1030 – Field Investigation & Construction Requirements, 735 kV Transmission Line Gull Island to Churchill Falls, prepared by SNC Lavalin, 2008.
  - AC1060 - Field Investigation & Construction Requirements, 230 kV Transmission Line Muskrat Falls to Gull Island, prepared by SNC Lavalin, 2008.
  - Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 2 – 1998 Geotechnical Investigations prepared by SNC Lavalin/AGRA, 1999.
  - MF1602 – Bank Stability and Fish Habitat 2010 Field Investigation Reports, Volume 1 – Bank Stability Assessment, Volume 2 – Fish Habitat Substrate Classification, Prepared by AMEC 2011.
  - GI1010 – Gull Island 2007 Site Investigations Volume 3A – Borrow Areas B2, B6 and B6B, Volume 12 – Drawings, Prepared by SNC Lavalin 2009.

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- MF1300 – Muskrat Falls 2010 Site Investigations, Volume 2C – Geotechnical Report for Switchyard, Converter Station and Accommodation Complex, Prepared by SNC Lavalin 2011.
- Muskrat Falls Power Development & 345 kV Transmission Intertie to Churchill Falls. 1979 Field Investigation, prepared by SNC/Lavalin Newfoundland Limited, 1980.

- LiDAR images and air photos prepared by Terrapoint Canada Inc. And provided by Nalcor, 2010.

- Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, Landforms and Surficial Geology, and Granular Aggregate Resources provided on several NTS 1:50,000 scale map sheets along the route.

- SNC Lavalin – spread sheets, prepared on September 26, 2011 and October 18, 2011, providing tower staking and type along the route.

Summary of Results

Bedrock – Approximately 354 (55%) towers will require foundations on rock. Rock is estimated to be at or within 2.75 m of the mineral ground surface for approximately 55% of the structure locations. The proportion of towers on rock increases westward toward Churchill Falls.
Clean Uniform Sand – Approximately 73 (11%) towers will be founded on clean uniform sand. This material underlies approximately 11% of the structure locations and is found only at the eastern end of the route, between Muskrat Falls and the Pinus River area.

Sand and Gravel from a Fluvial Source – Approximately 45 (8%) towers will be founded on sand and gravel with varying amounts of cobbles and small boulders, interpreted to be derived from a fluvial source, either modern day deposits near rivers or ancient deposits pertaining to eskers or esker complexes. It usually contains a trace of fines. This material is estimated to underlay about 8% of structure locations. These soils are more common in the central portion of the route.

Sand and Gravel derived from Glacial Till – Approximately 127 (20%) towers will be founded in till that is a diamicton of sand, gravel with some cobbles, boulder and fines. This material is deposited directly from the glacier with little or no sorting and can vary in composition and thickness over short distances. These soils are most common in the central portion of the route where depths of 3 m or more are expected. Till is also present as a thin layer, usually a metre or two, over much of the area identified above as bedrock.

Silt and Clay or Sand, Silt and Clay – Approximately 40 (6%) towers will be founded on apparent marine or lacustrine sediments comprised generally of a mix of fine grained materials such as sand, silt and clay. Included in this category are sand with some organic material that is interpreted to exist beneath Structures 95 and 96 on the modern and older flood plains of Edward's River. At other locations, such as the proposed switchyard for Gull Island Hydroelectric Project the unconfined compressive strength as measured by hand penetrometer, on near surface samples, was about 0.75 kg/cm^2 which equates to about a S_u of 1.5 kg/cm^2. These values indicate a relatively strong soil. However, results of laboratory testing on samples retrieved from deep boreholes in similar material within the Churchill River Basin indicated that these soils are very sensitive and have relatively low remoulded strength.

Recommendations for Further Field Investigations

Geotechnical Investigations

There are eighteen (32) sites were additional investigations are recommended. These sites are interpreted to be underlain by fine grained soil such as silt and clay with varying amounts or layers of sand. These soils are at tower sites as follows: 6, 7, 18, 35, 74 to 88, 96, 97, 142 to 144, and 441 to 448. In addition there are three long sections along the route where intrusive testing was not performed and the line is at a kilometre or more from the Route 500. The interpretation of the subsurface materials in these areas was strictly by air Photo Interpretation. Structures located near the centre of these locations are 105, 168, and 202.

Structure 35 is located in a particularly vulnerable area on a bluff between two probable landslide areas at lower Brook. The tower is at approximate elevation of 48 m. A borehole located 600 m west of this location encountered clay with a significant amount of silt at elevation 59.4 m depth and till at elevation 42.9 m. The nearby stream channel located about 400 m south of this location and at a lower elevation has an active erosion scar where the prime mechanism appears to be sliding on fine grained material. Bedrock outcrops in the stream bed 300 m northeast of this structure location. The surficial geology of the area is somewhat complex. To determine the founding conditions and provide information for a slope stability assessment for the area, additional soil information is required. As a minimum, deep test pits should be excavated adjacent to the foundation and several more in the general vicinity. Within these test pits and in any area that is suitable the soil strength properties should be further determined by using a Nilcon field borer.

Hydrological Investigations.

Several structure locations are either located in or appear to be very close to streams. These structures are:

- Structure 35 is located on a narrow bluff within the meandering flood plain of Lower Brook.
- Structures 78 to 88 are located in a wet area with several streams and many bogs.
- Structures 96 and 97 are located on the meandering flood plain of Edward's River.
- Structure 133 is located near the edge of a bluff near Pinus River. Air photo interpretation reveals that the river has meandered close to this bluff causing erosion in the past. Structure 134 is located on a small island in the middle of the Pinus River. There is little vegetation on the island indicating that it floods on a regular basis by either ice, frazzle ice or persistent high water. The high water mark on the adjacent shoreline appears to be at a higher elevation.
- Structures 142, 143 and 144 are located in a low lying area one to two kilometres west of the borrow pits at the Pinus River. Two of the structures appear to be located in or very close to a small stream. The third structure is on a bog and may also be on the flood plain of the stream.
- Structure 278 may be located on the flood plain of a small stream.

Additional Observations

- Structure 141 is located on top of a small cabin.

Disclaimer

Acceptance of this report does not constitute approval of proposed geotechnical program

Closure

This summary of geotechnical conditions interpreted to exist along the transmission lines was prepared for the exclusive use of SNC Lavalin and their client Nalcor Energy for specific application to the project site. The interpretation was performed using generally accepted geological practises used in the industry and in accordance with the work plan developed with SNC Lavalin. No other warranty is expressed or implied.

APPENDIX E2

AMEC GEOTECHNICAL INVESTIGATION - BUDGET AND SCHEDULE

SNC - Lower Churchill Project

SNC Project 505573
Geotechnical Services Transmission Lines
Proposed Budget and Schedule

AMEC Americas Limited
Environmental and Infrastructure
Page 1 of 1
Date Printed 18/03/2012

AMEC GEOTECHNICAL SERVICES - BUDGET AND SCHEDULE

Name	Position	No of Hours	Rate	Amount
	FEES			
Dr. Prapote Boonsinsuk	Senior Engineering Review	28	$184	$5,152
Calvin Miles	Project Manager/Senior Geologist	300	$184	$55,200
Melissa McComiskey	Staff Hydraulic Engineer	106	$104	$11,024
Allan Moore	Health and Safety Coordinator	265	$78	$20,670
Janet Williams	Senior Geotechnical Engineer	145	$121	$17,545
Andrew Peach	Staff Engineering Geologist	435	$109	$47,415
Brad Walsh	Staff Engineering Geologist	230	$90	$20,700
Juanita Abbott	GIS/Drafting	55	$95	$5,225
Office Support		31	$65	$2,015
	Total manhours	1,595		$184,946
	EXPENSES			
Mobilization/Demobilization **Drill**	LS	1	$6,000	$6,000
Operating rate for all activities	Hour	210	$225	$47,250
Daily travel to sites and hotel	Hour	42	$165	$6,930
Equipment wear rate	Metre	500	$25	$12,500
Consumables such as Shelby tubes	Estimate			$2,000
Miscellaneous freight, etc	Estimate			$1,000
Mobilization/Demobilization **Excavator**	LS	1	$5,000	$5,000
Operating rate for all activities	Hour	50	$220	$11,000
Daily travel to sites and hotel or home base	Hour	10	$50	$500
Pickup Trucks	Day	120	$180	$21,600
Nilcon Vane	Week	4	$2,000	$8,000
Accommodations and Meals		150	$200	$30,000
Sample Shipment	Estimate			$2,000
AMEC Lab	Estimate			$3,000
Outside Lab for Specialized Testing	Estimate			$10,000
Airfare supplied by Nalcor				
			Total Sub Expenses	$166,780
			5% Markup on Expenses	$8,339
			Total Expenses	**$175,119**
				$360,065
			HST Extra	

Name	Nov 4	Nov 11	Nov 18	Nov 25	Dec 2	Dec 9	Dec 16	Dec 23	Dec 30	Jan 6	Jan 13	Jan 20	
Dr. Prapote Boonsinsuk		2	2	2	2	5	5	5				5	
Calvin Miles		15	75	75	75	30	10	10		5		5	
Melissa McComiskey		3	10	60	20	10						3	
Allan Moore		20	75	75	75	20							
Janet Williams		5	5	5	10	20	30	30		30		10	
Andrew Peach		40	75	75	75	40	40	40		40		10	
Brad Walsh		20	60	20			40	40		40		10	
Juanita Abbott		10				10	20	10				5	
Office Support		5	5	5	5	5		2		2		2	

Note: Dates are week ending on Friday.

APPENDIX F

QUALITAS 315 KV HVAC GEOTECHNICAL INVESTIGATION RECOMMENDATION

(Acceptance of this report does not constitute approval of proposed geotechnical program.)

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
1	246,935		silt/clay	surface	API, MF1300 CS-TP-13-10		deep	D+0.0
2	246,986		silt/clay	surface	API, MF1300 CS-TP-13-10		deep	E+7.5
3	247,328		silt/clay	surface	API, MF1300 CS-TP-13-10		deep	A+12.0
4	247,730		silt/clay	surface	API, MF1300 CS-TP-13-10		deep	A+12.0
5	248,066		sand/silt/clay	surface	API, MF1300 CS-TP-13-10		deep	E+6.0
6	248,358		sand/silt/clay	surface	API, investigate		deep	A+0.0
7	248,707		sand/silt/clay	surface	API, investigate		deep	C (strain) + 0.0
8	248,914		sand/silt/clay	surface	API, MF1602 TP MR-001		deep	E+12.0
TL2-str#1	2723.6	DC/V	~ 2.0 m - 6.0 m of sand/silt, trace clay and gravel	~ 1 m	API, MF1300 BH-28-10 and BH-30-10. Further investigation may be required to delinate bedrock depth at structure depth.		deep	D+9.0
TL2-str#2	2,937.07	Exist log	> 3.7 m of sand/silt, with some clay and gravel.	~ 1 m	API, MF1300 BH-06-10, BH-27-10 and BH-33-10.		deep	A+10.5
TL2-str#3	3,203.11	DC/V	sand/silt, trace to some gravel	surface	API, investigate		deep	A+1.5
TL2-str#4	3,503.13	DC/C	sand/silt, trace to some gravel	surface	API, investigate		deep	A+4.5
TL2-str#5	3,786.04	DC/V	sand/silt, trace to some gravel	surface	API, investigate		deep	D+7.5
TL2-str#6	4,113.00	DC/V	sand/silt/clay	surface	API, investigate		deep	D+6.0
TL2-str#7	4,305.59	DC/V	sand/silt/clay	surface	API, MF1602 TP MR-001		deep	E+12.0
9	249,412	Exist log	<1 m to bedrock		API, BHs M1and BH M2 in 1998 SNC-AGRA 1998	3,000	rock bolts	C (strain) + 12.0
10	249,582	C	1.5 m to bedrock		API, BHs M1and BH M2 in 1998 SNC-AGRA 1998	3,000	rock bolts	D+0.0
11	249,957	Exist log	> 10 m sand	>6 m	API, BH C1 SNC Lavalin 1979	100	grillage	C (strain) + 10.5
12	250,169	Exist log	> 10 m sand	>6 m	API, BH C1 SNC Lavalin 1979	100	grillage	C (strain) + 4.5
13	250,476	Exist log	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+4.5
14	250,809		sand/dune	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+3.0
15	251,120		> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	A+7.5
16	251,388	Exist log	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998	100	grillage	D+1.5
17	251,754	DC	> 10 m sand	>6 m	API, Test Pits S-3-1 to 6 and S-5-1 to 5 SNC-AGRA 1998, AC1060 HA-5	100	grillage	E+6.0
18	252,137	DC/V	sand/silt/clay	1 m	API, bog nearby, investigate		deep?	A+9.0
19	252,551		> 10 m sand	>6 m	API	100	grillage	A+9.0
20	252,956		> 10 m sand	>6 m	API	100	grillage	A+9.0
21	253,365		> 10 m sand	>6 m	API	100	grillage	A+0.0
22	253,654	DC/V	> 10 m sand	>6 m	API, MF1602 - 1 - BH - B	100	grillage	C (strain) + 0.0
23	253,983		>10 m sand/dune	>6 m	API	100	grillage	A+0.0
24	254,369		>10 m sand/dune	>6 m	API	100	grillage	A+0.0
25	254,669		>10 m sand/dune	>6 m	API	100	grillage	A+0.0
26	254,962	DC	> 10 m sand	>6 m	API	100	grillage	D+6.0
27	255,155		> 10 m sand	>6 m	API	100	grillage	A+4.5
28	255,486		>10 m sand/dune	>6 m	API	100	grillage	A+3.0
29	255,883		> 10 m sand	>6 m	API	100	grillage	A+10.5
30	256,306		> 10 m sand	>6 m	API	100	grillage	A+9.0
31	256,675	DC/V	sand/silt/clay	~1 m	On a low terrace of Lower Brook, investigate		deep	A+12.0
32	257,161		silt/clay	~1 m	API, NC, MF1120 TP - 04, 05, investigate		deep	A+10.5
33	257,493		silt/clay	~1 m	API, NC, MF1120 TP - 04, 05, investigate		deep	A+9.0
34	257,815	DC	>4.5 m of sand, gravel and cobbles	3.5	API, NC, MF1120 TP - 06, 07	250	grillage	E+4.5
35	258,218	B+P	sand/silt/clay	~3 m	API, NC,(Lower Brook) located near a bluff adjacent to probable old slides on either side - investigate		deep	D+7.5
36	258,405	B+P	> 10 m sand	>4 m	API, NC, MF1120 BH 02 07		deep	C (strain) + 6.0
37	258,634	B+P	> 10 m sand	>4 m	API, NC, MF1120 BH 02 07		deep	C (strain) + 6.0
38	259,211		~2 m till on bedrock	~2 m	API, NC	3,000	rock bolts	B+12.0
39	259,554	C	~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	C (strain) + 6.0
40	259,757		<1 m to bedrock		API, NC	3,000	rock bolts	A+1.5
41	260,203		<1 m to bedrock		API, NC	3,000	rock bolts	A+0.0
42	260,492	C	<1 m to bedrock		API,NC, AC1060_PO-1 and PO--2	3,000	rock bolts	C (strain) + 12.0
43	260,781		<1 m to bedrock		API, NC, AC1060_PO-1 and PO--2	3,000	rock bolts	A+1.5
44	261,099		<1 m to bedrock		API, NC	3,000	rock bolts	A+6.0
45	261,416	C	~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	A+9.0
46	261,916		~2 m till on bedrock	~1 m	API, NC	3,000	rock bolts	A+7.5
47	262,162		<1 m to bedrock		API, NC	3,000	rock bolts	B+9.0
48	262,613	B+P	>10 m sand/dune	>6 m	API	100	grillage	B+10.5
49	263,053		>10 m sand/dune	>6 m	API	100	grillage	B+9.0
50	263,501		>10 m sand/dune	>6 m	API	100	grillage	A+12.0
51	263,919		> 10 m sand	>6 m	API	100	grillage	A+10.5
52	264,349	DC	> 10 m sand	>6 m	API	100	grillage	D+9.0
53	264,763		>10 m sand/dune	>6 m	API	100	grillage	A+10.5
54	265,205		> 10 m sand	>6 m	API	100	grillage	A+10.5
55	265,611	DC	> 10 m sand	>6 m	API	100	grillage	A+9.0
56	266,029		> 10 m sand	>6 m	API	100	grillage	A+7.5
57	266,455		> 10 m sand	>6 m	API	100	grillage	A+10.5
58	266,875	DC	>10 m sand/dune	>6 m	API	100	grillage	A+7.5
59	267,306		>10 m sand/dune	>6 m	API	100	grillage	A+12.0
60	267,721		>10 m sand/dune	>6 m	API	100	grillage	A+10.5
61	268,163		>10 m sand/dune	>6 m	API	100	grillage	A+10.5
62	268,583		>10 m sand/dune	>6 m	API	100	grillage	A+7.5
63	269,003		>10 m sand/dune	>6 m	API	100	grillage	A+7.5
64	269,426	DC	> 10 m sand	>6 m	API	100	grillage	A+10.5
65	269,860		> 10 m sand	>6 m	API	100	grillage	A+9.0
66	270,272		> 10 m sand	>6 m	API	100	grillage	A+7.5
67	270,715	DC	>10 m sand/dune	>6 m	API	100	grillage	D+3.0
68	271,120		>10 m sand/dune	>6 m	API	100	grillage	A+10.5
69	271,406		> 10 m sand	>6 m	API	100	grillage	A+6.0
70	271,800		>10 m sand/dune	>6 m	API	100	grillage	A+4.5
71	272,195	DC	> 10 m sand	>6 m	API	100	grillage	A+4.5
72	272,548		> 10 m sand	>6 m	API, NC-deep borrow pit in sand at adjacent highway	100	grillage	A+3.0
73	272,915		>10 m sand/dune	>6 m	API, NC-deep borrow pit in sand at adjacent highway	100	grillage	A+4.5
74	273,359	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest, investigate		deep	A+4.5
75	273,730	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest, investigate		deep	A+9.0
76	274,152	DC/V	>10 m silt/clay	surface	API, AC1060 TP - 2 > 6 m of ML, firm to stiff, investigate		deep	A+12.0
77	274,594	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+9.0
78	275,020	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+10.5
79	275,449	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+12.0
80	275,880	DC/V	>10 m silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+12.0
81	276,297	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	B+9.0
82	276,649	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+6.0
83	277,021	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	B+3.0
84	277,365	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+9.0
85	277,771	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+7.5
86	278,160	DC/V	>10 m sand/silt/clay	surface	API, deep erosion and heavy forest and bogs, investigate		deep	A+7.5
87	278,558	DC/V	~4 m sand	1 m	API, deep erosion and heavy forest and bogs, investigate		deep	D+7.5
88	278,962	DC/V	sand/silt/clay	surface	API, NC and beaver pond nearby, investigate/hydrology study		deep	A+6.0
89	279,344	DC/C	~ 4 m till	1 m	API, NC	250	grillage	A+6.0
90	279,740		~ 4 m till	1 m	API, NC	250	grillage	A+7.5
91	280,147		~ 4 m till	1 m	API, NC	250	grillage	A+9.0
92	280,594		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+9.0
93	280,908		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+0.0
94	281,211		~ 4 m till	2 m - 3 m	API, TP AC1060-3, NC	250	grillage	A+0.0
95	281,507	DC	>10 m sand	~4 m	API, NC,	100	grillage	B+0.0
96	281,778	DC	sand with some organic material	surface	API, TP AC1060-4, on modern flood plain of Edwards River, hydrology study recommended, investigate		deep	C (strain) + 3.0
97	282,087	B+P	sand with some organic material	3 m	API, TP AC1060-4, on older flood plain of Edwards River, hydrology study recommended, investigate		deep	C (strain) + 0.0
98	282,388		> 10 m sand	>4 m	API	100	grillage	A+4.5
99	282,882	B+P	> 10 m sand	>4 m	API, keep tower a minimum of 30 m back from edge of bluff	100	grillage	A+4.5
100	283,235	DC	> 10 m sand	>4 m	API	100	grillage	A+6.0

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
101	283,589		> 10 m sand	>4 m	API	100	grillage	A+3.0
102	283,955	DC	> 10 m sand	>4 m	API	100	grillage	A+7.5
103	284,407		~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5
104	284,745		~ 4 m till	2 m - 3 m	API	250	grillage	A+7.5
105	285,121	C	~ 4 m till	2 m - 3 m	API, long distance without testing	250	grillage	B+10.5
106	285,510	DC	~4 to 6 m sand	>4 m	API	100	grillage	D+1.5
107	285,877	DC	and over till at about 3 m then till >3	~3 m	API	100	grillage	A+10.5
108	286,247		~ 4 m till	2 m - 3 m	API	250	grillage	A+6.0
109	286,585		~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5
110	286,974	C	~ 4 m till	2 m - 3 m	API	250	grillage	A+10.5
111	287,331		~ 4 m till	2 m - 3 m	API	250	grillage	A+9.0
112	287,637		~ 4 m till	2 m - 3 m	API	250	grillage	A+4.5
113	288,065		~ 4 m till	2 m - 3 m	API	250	grillage	A+9.0
114	288,391	C	~ 4 m till	2 m - 3 m	API, AC-1060- 6	250	grillage	A+7.5
115	288,726		~ 4 m till	2 m - 3 m	API, AC-1060- 7	250	grillage	A+10.5
116	289,120		~ 4 m till	2 m - 3 m	API, AC-1060- 8	250	grillage	A+10.5
117	289,425	DC/C	~ 4 m till	2 m - 3 m	API, AC-1060- 8 and 9	250	grillage	C (strain) + 3.0
118	289,655		~ 4 m till	2 m - 3 m	API, AC-1060- 9	250	grillage	A+4.5
119	289,949	B+P	> 10 m sand	>6 m	API	100	grillage	A+9.0
120	290,333	DC	> 10 m sand	>6 m	API	100	grillage	D+4.5
121	290,634		> 10 m sand	>6 m	API	100	grillage	A+0.0
122	291,028		> 10 m sand	>6 m	API	100	grillage	A+10.5
123	291,463		> 10 m sand	>6 m	API	100	grillage	A+12.0
124	291,874	DC	> 10 m sand	>6 m	API, AC1060-15 and 16	100	grillage	C (strain) + 9.0
125	292,226	B+P	> 10 m sand	>6 m	API, AC1060 16	100	grillage	A+0.0
126	292,635	B+P	> 10 m sand	>6 m	API	100	grillage	A+0.0
127	292,942		> 10 m sand	>6 m	API	100	grillage	A+0.0
128	293,256	DC	> 10 m sand	>6 m	API	100	grillage	A+0.0
129	293,629		> 10 m sand	>6 m	API	100	grillage	A+9.0
130	293,997		> 10 m sand	>6 m	API	100	grillage	A+1.5
131	294,493	DC	>5 m sand and gravel	2	API	100	grillage	A+7.5
132	294,802		>5 m sand and gravel	2	API	100	grillage	A+3.0
133	295,137	DC	>5 m sand and gravel	2	API, near bluff/flood plane - review hydrology and move away from bluff a minimum of 30 m	250	grillage	A+7.5
134	295,653	DC	>5 m gravel, cobbles and boulders	surface	Structure is located in the Pinus River on low island that floods during high water conditions and is influenced by frazzle ice, hydrology study recommended	250	grillage	A+12.0
135	295,987	DC	>5 m sand and gravel	>6 m	API, Hand dug test pits 1 and 2 in nearby erosion scar	250	grillage	B+12.0
136	296,504	B+P	> 10 m sand	>6 m	API	100	grillage	C (strain) + 3.0
137	296,746		> 10 m sand	>6 m	API	100	grillage	A+0.0
138	297,037	DC	> 10 m sand	>6 m	API, AC1060 16	100	grillage	D+7.5
139	297,411	V	>5 m sand and gravel	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006	100	grillage	A+12.0
140	297,870		> 10 m sand	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006	100	grillage	A+9.0
141	298,282	DC/V	> 10 m sand	>6 m	API, GI1010 TPs B6 - 003, 004, 005, 006 (adjacent to cabin)	100	grillage	A+7.5
142	298,669	DC/V	sand over till or silt	surface	API, in small stream, investigate		deep	A+3.0
143	299,025		bog over sand over till of silt	surface	API, in low lying wet area, boggy, investigate		deep	A+3.0
144	299,373	DC/V	sand over till or silt	surface	API, in or adjacent to small stream, investigate		deep	A+1.5
145	299,765		~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5
146	300,161	C	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	E+3.0
147	300,311	C	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	E+3.0
148	300,687		~ 2 m till		API	3,000	rock bolts	B+9.0
149	301,088		~ 3 m till	2 m - 3 m	API	250	grillage	A+12.0
150	301,431		~ 2 m till		API	3,000	rock bolts	B+9.0
151	301,740	C	~ 2 m till		API	3,000	rock bolts	B+9.0
152	302,098		~ 3 m till	2 m - 3 m	API	250	grillage	B+12.0
153	302,406		~ 2 m till		API	3,000	rock bolts	B+9.0
154	302,935		>5 m till	>4 m	API, GI1010 TP B6B-003, 005, 001, 002, 012	250	grillage	B+6.0
155	303,217		>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	A+0.0
156	303,439	DC/C	>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	D+4.5
157	303,874		>5 m till	>4 m	API, GI1010 TP B6B-010, 011	250	grillage	A+12.0
158	304,231		~ 3 m till	2 m - 3 m	API, Pope's Hill area	250	grillage	B+9.0
159	304,654		~ 3 m till	2 m - 3 m	API	250	grillage	A+12.0
160	304,885	C	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	C (strain) + 7.5
161	305,399		~ 3 m till	2 m - 3 m	API	250	grillage	B+10.5
162	305,907		~ 3 m till	2 m - 3 m	API	250	grillage	B+10.5
163	306,304		~ 3 m till	2 m - 3 m	API	250	grillage	A+7.5
164	306,755	C	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5
165	307,141		~ 3 m till	2 m - 3 m	API	250	grillage	A+9.0
166	307,565		~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5
167	308,010		~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+9.0
168	308,425		~ 3 m till	2 m - 3 m	API, long area without testing or NC	250	grillage	A+10.5
169	308,880		~ 3 m till	2 m - 3 m	API	250	grillage	A+9.0
170	309,299	C	~ 3 m till	2 m - 3 m	API	250 or 3000	grillage or rock bolts	D+10.5
171	309,697		~ 3 m till	~1 m	API	250	grillage	A+10.5
172	310,084		~ 3 m till	~1 m	API	250	grillage	A+9.0
173	310,443		~ 3 m till	~1 m	API	250	grillage	A+7.5
174	310,916	C	~ 3 m till	surface	API	250	grillage	B+12.0
175	311,386		~ 1 m of till on bedrock		API	3,000	rock bolts	A+7.5
176	311,712		~ 1 m of till on bedrock		API	3,000	rock bolts	A+9.0
177	312,156	C	~ 3 m till	2 m - 3 m	API	250	grillage	A+10.5
178	312,482		~ 3 m till	2 m - 3 m	API	250	grillage	A+7.5
179	312,910		~10 m till	>4 m	API, NC	250	grillage	A+6.0
180	313,313		~10 m till	>4 m	API	250	grillage	A+10.5
181	313,716	DC	~4 m, fluvial on top of till	2 m - 3 m	API	250	grillage	A+9.0
182	314,137		~4 m, fluvial on top of till	2 m - 3 m	API	250	grillage	A+10.5
183	314,574		~10 m till	~1 m	API	250	grillage	A+10.5
184	314,986		~10 m till	~1 m	API	250	grillage	A+12.0
185	315,416	DC	~10 m till	~1 m	API	250	grillage	D+6.0
186	315,754		~10 m till	~1 m	API	250	grillage	A+7.5
187	316,146		~10 m till	>4 m	API	250	grillage	A+9.0
188	316,529	DC	~10 m till	surface	API	250	grillage	A+7.5
189	316,943		~10 m till	surface	API	250	grillage	A+10.5
190	317,332	C	~ 3 m till	~1 m	API, NC	250	grillage	A+7.5
191	317,792	DC	~4 m, fluvial on top of till	2 m - 3 m	API, NC	250	grillage	A+7.5
192	318,217	DC	~ 3 m till	surface	API, NC	250 or 3000	grillage or rock bolts	D+7.5
193	318,599		~ 3 m till	~1 m	API	250	grillage	A+12.0
194	319,017		~ 3 m till	~1 m	API	250	grillage	A+10.5
195	319,389		~ 3 m till	surface	API	250	grillage	A+10.5
196	319,825	C	~ 3 m till	~1 m	API	250	grillage	A+12.0
197	320,246		~ 3 m till	~1 m	API	250	grillage	A+10.5
198	320,564		~1 m till on rock		API	3,000	rock bolts	A+1.5
199	320,994		~1 m till on rock		API	3,000	rock bolts	A+9.0
200	321,425		~1 m till on rock		API	3,000	rock bolts	A+4.5

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
201	321,819		~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+10.5
202	322,246		~2 m till, rock nearby	surface	API, long area without testing or NC	3,000	rock bolts	A+10.5
203	322,680		~2 m till, rock nearby	surface	API	3,000	rock bolts	A+10.5
204	323,102		~2 m till, rock nearby	surface	API	3,000	rock bolts	A+9.0
205	323,507	C	~2 m till, rock nearby	surface	API	3,000	rock bolts	A+3.0
206	323,852		~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+4.5
207	324,309		~2 m till, rock nearby	surface	API	3,000	rock bolts	A+9.0
208	324,676		~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+7.5
209	325,067		~1 m till on rock		API, NC	3,000	rock bolts	A+9.0
210	325,467		~1 m till on rock		API, NC	3,000	rock bolts	A+1.5
211	325,755		~1 m till on rock		API, NC	3,000	rock bolts	A+9.0
212	326,086	C	~1 m till on rock		API, NC(quarry 300 m away), AC1030 TP-17, 18	3,000	rock bolts	D+6.0
213	326,348		~1 m till on rock		API, NC (quarry 200 m away), AC1030 TP-17, 18	3,000	rock bolts	A+12.0
214	326,844		~1 m till on rock		API, NC, AC1030 TP-17, 18	3,000	rock bolts	B+9.0
215	327,344		<1 m to bedrock		API, NC	3,000	rock bolts	A+10.5
216	327,617		<1 m to bedrock		API, NC	3,000	rock bolts	A+12.0
217	328,042		<1 m to bedrock		API, NC	3,000	rock bolts	A+9.0
218	328,480		<1 m to bedrock		API, NC	3,000	rock bolts	A+12.0
219	328,874	C	~1 m till on rock		API, NC	3,000	rock bolts	D+10.5
220	329,089		~1 m till on rock		API, NC	3,000	rock bolts	A+0.0
221	329,509		<1 m till on rock		API, NC, AC1030 PO 2	3,000	rock bolts	A+6.0
222	329,906		<1 m till on rock		API, NC	3,000	rock bolts	A+10.5
223	330,277	DC	~ 3 m till	~1 m	API	250	grillage	A+12.0
224	330,617		~ 3 m till	~1 m	API	250	grillage	A+9.0
225	331,033		~ 3 m till	~1 m	API	250	grillage	A+12.0
226	331,453	DC	~ 3 m till	~2 m	API	250	grillage	A+9.0
227	331,896		~ 3 m till	~2 m	API	250	grillage	A+9.0
228	332,310		~ 3 m till	~1 m	API	3,000	rock bolts	B+4.5
229	332,681	C	~2 m till, rock nearby	~1 m	API	3,000	rock bolts	A+4.5
230	332,983		Bedrock		API	3,000	rock bolts	A+7.5
231	333,385		~1 m till on rock		API, NC	3,000	rock bolts	A+9.0
232	333,807		~1 m till on rock		API, NC	3,000	rock bolts	A+10.5
233	334,234		~1 m till on rock		API, NC	3,000	rock bolts	A+12.0
234	334,678		Bedrock		API	3,000	rock bolts	A+9.0
235	335,093	C	Bedrock		API	3,000	rock bolts	A+9.0
236	335,435		~1 m till on rock		API	3,000	rock bolts	A+10.5
237	335,861		~1 m till on rock		API	3,000	rock bolts	A+9.0
238	336,190	C	~1 m till on rock		API	3,000	rock bolts	D+0.0
239	336,474		~1 m till on rock		API	3,000	rock bolts	A+1.5
240	336,769		~1 m till on rock		API	3,000	rock bolts	A+0.0
241	337,161	C	~6 m esker	~3 m	API, NC	250	grillage	A+0.0
242	337,554	DC	~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+10.5
243	337,918		~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+12.0
244	338,290	DC	~6 m esker	~3 m	API, NC, AC1030 TP - 19	250	grillage	A+9.0
245	338,730	C	~ 3 m till	~1 m	API	250	grillage	A+10.5
246	339,161		~ 3 m till	~1 m	API	250	grillage	A+12.0
247	339,561		~ 2 m till	~1 m	API, NC - road cut	3,000	rock bolts	A+10.5
248	339,951		~ 2 m till	~1 m	API, NC - road cut	3,000	rock bolts	A+6.0
249	340,389		3 m esker complex	2.5 m	API, NC, AC1060 TP 20	250	grillage	A+9.0
250	340,789	DC	3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	D+10.5
251	341,232		3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	A+10.5
252	341,635	DC	3 to 4 m of esker complex	~1 m	API, NC, AC1060 TP 20	250	grillage	C (strain) + 3.0
253	341,983	DC	3 to 4 m of esker complex	~2 m	API, NC, AC1060 TP 20	250	grillage	C (strain) + 7.5
254	342,418		>4 m of esker complex	3.5	API, NC, AC1060 TP 21	250	grillage	A+10.5
255	342,830		>4 m of esker complex	3.5	API, NC, AC1060 TP 21	250	grillage	A+4.5
256	343,241		~ 3 m till	~1 m	API	250	grillage	A+7.5
257	343,658		~ 3 m till	~1 m	API	250	grillage	A+6.0
258	344,080		~1 m till on rock		API	3,000	rock bolts	A+0.0
259	344,478	DC	~ 3 m till	~1 m	API	250	grillage	A+9.0
260	344,857		~ 3 m till	surface	API, boggy	250	grillage	A+6.0
261	345,297		~1 m	surface	API, boggy	3,000	rock bolts	A+6.0
262	345,640	C	~ 2 m till	surface	API, boggy	3,000	rock bolts	A+0.0
263	345,970		~1 m	surface	API, near small stream	3,000	rock bolts	A+9.0
264	346,306		~1 m		API	3,000	rock bolts	A+3.0
265	346,783	DC	~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+7.5
266	347,150		~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+4.5
267	347,538		~ 4 m till	~2 m	API, NC - road cuts	250	grillage	A+7.5
268	347,956	C	~ 2 m till	surface	API, boggy, located in low area with nearby drainage	3,000	rock bolts	A+9.0
269	348,376		~ 3 m till	~1 m	API	250	grillage	A+7.5
270	348,771	DC	~ 3 m till	~1 m	API	250 or 3000	grillage or rock bolts	D+6.0
271	349,143		>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	A+10.5
272	349,541		>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	B+9.0
273	349,883		>4 m till	3 m	API, AC1030 TP 22, NC - road cuts	250	grillage	A+0.0
274	350,204		>4 m till	surface	API, AC1030 TP 22, NC - road cuts, adjacent to bog and stream	250	grillage	A+1.5
275	350,479	DC	3 m till	2 m	API, AC1030 TP 22, NC - road cuts	250	deep	C (strain) + 10.5
276	350,926		~2 m till		API, NC - road cuts (till and rock), many large boulders	3,000	rock bolts	A+7.5
277	351,290		2 m till	surface	API, NC - road cuts (till and rock), many large boulders, on flood plane of nearby stream	3,000	rock bolts	A+4.5
278	351,668	C	2 m till	surface	API, NC - road cuts (till and rock), many large boulders, on bog about 1 m deep, possible flood plane of nearby stream, hydrology	250 or 3000	grillage or rock bolts	A+4.5
279	352,078		~ 3 m till	~2 m	API, NC	250	grillage	A+7.5
280	352,467		~ 3 m till	~2 m	API	250	grillage	A+7.5
281	352,878	C	~ 3 m till	~2 m	API	250	grillage	A+7.5
282	353,315		~ 3 m till	~2 m	API	250	grillage	A+9.0
283	353,725		~ 3 m till	~1 m	API, near stream	250	grillage	A+4.5
284	354,101	C	~ 3 m till	~1 m	API, adjacent to stream	250	grillage	A+7.5
285	354,538		~2 m till	surface	API, many large boulders	3,000	rock bolts	A+9.0
286	354,944		~2 m till	~1 m	API, many large boulders	3,000	rock bolts	A+7.5
287	355,386		~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5
288	355,796	C	~1 m		API, many large boulders	3,000	rock bolts	D+4.5
289	356,159		~1 m		API, many large boulders	3,000	rock bolts	A+7.5
290	356,597		~1 m		API, many large boulders	3,000	rock bolts	A+6.0
291	357,016		~1 m		API, many large boulders	3,000	rock bolts	A+7.5
292	357,356		3 m to 4 m till	3	API, many large boulders, AC1030 TP-23 >4 m till, dry	250	grillage	A+9.0
293	357,814	C	~ 3 m till	surface	API, boggy area	250	grillage	A+4.5
294	358,186		~ 3 m till	2	API	250	grillage	A+6.0
295	358,634		~1 m		API	3,000	rock bolts	B+3.0
296	359,183		~1 m		API	3,000	rock bolts	B+10.5
297	359,572		~1 m		API	3,000	rock bolts	A+4.5
298	359,876		~1 m		API	3,000	rock bolts	A+10.5
299	360,302		~1 m		API, many large boulders	3,000	rock bolts	A+12.0
300	360,692		~1 m		API, many large boulders	3,000	rock bolts	A+10.5

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
301	361,126	C	~1 m	surface	API, many large boulders	3,000	rock bolts	C (strain) + 1.5
302	361,477		~1 m		API, many large boulders	3,000	rock bolts	A+7.5
303	361,864		~1 m		API, many large boulders	3,000	rock bolts	A+3.0
304	362,186		~1 m		API, many large boulders	3,000	rock bolts	A+0.0
305	362,642		~1 m	~1	API, many large boulders	3,000	rock bolts	A+4.5
306	363,055		~1 m	~1	API, many large boulders	3,000	rock bolts	A+10.5
307	363,480	C	~1 m	surface	API, many large boulders	3,000	rock bolts	D+9.0
308	363,887		~1 m	surface	API, many large boulders, AC1030 TP-24	3,000	rock bolts	A+9.0
309	364,334		~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5
310	364,760		~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5
311	365,182		~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5
312	365,602		~1 m	surface	API, many large boulders	3,000	rock bolts	A+7.5
313	366,000		~1 m	surface	API, many large boulders	3,000	rock bolts	A+10.5
314	366,417	C	~ 3 m till	2	API	250	grillage	A+9.0
315	366,775		~ 3 m till	2	API	250	grillage	A+9.0
316	367,202		~1 m		API	3,000	rock bolts	A+10.5
317	367,605		~1 m		API	3,000	rock bolts	A+7.5
318	367,993		~1 m		API	3,000	rock bolts	A+3.0
319	368,351		~1 m	surface	API	3,000	rock bolts	A+9.0
320	368,769		~1 m		API	3,000	rock bolts	A+10.5
321	369,212		~1 m		API	3,000	rock bolts	A+10.5
322	369,623	C	~1 m	surface	API, boggy Near road	3,000	rock bolts	A+10.5
323	370,026		~1 m	surface	API, adjacent to stream	3,000	rock bolts	A+7.5
324	370,439		~1 m		API, AC1030 TP-25	3,000	rock bolts	A+10.5
325	370,829		~1 m		API, AC1030 TP-25	3,000	rock bolts	A+0.0
326	371,163	C	~1 m		API, AC1030 TP-25	3,000	rock bolts	D+7.5
327	371,412		~1 m		API, esker nearby	3,000	rock bolts	A+0.0
328	371,741		~1 m	surface	API	3,000	rock bolts	A+0.0
329	372,087		~1 m		API, many boulder fields nearby	3,000	rock bolts	A+7.5
330	372,482	C	~1 m		API	3,000	rock bolts	A+6.0
331	372,893		~1 m		API	3,000	rock bolts	A+10.5
332	373,304		~1 m	surface	API	3,000	rock bolts	A+10.5
333	373,687		~1 m	surface	API	3,000	rock bolts	A+6.0
334	374,122		~1 m		API	3,000	rock bolts	A+9.0
335	374,547		~1 m		API	3,000	rock bolts	A+9.0
336	374,959		~1 m	surface	API	3,000	rock bolts	A+7.5
337	375,335		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5
338	375,753		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+9.0
339	376,184	C	~1 m		API, NC Near road	3,000	rock bolts	A+12.0
340	376,599		~2 m till		API, NC	3,000	rock bolts	A+10.5
341	377,031		~2 m till		API, NC	3,000	rock bolts	A+10.5
342	377,433		~1 m		API, NC	3,000	rock bolts	A+12.0
343	377,800	C	~1 m	surface	API, AC1030 TP-26, rock at 0.5 m, boulder fields nearby	3,000	rock bolts	D+4.5
344	378,182		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+4.5
345	378,571		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+6.0
346	379,002		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0
347	379,442		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5
348	379,848		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+6.0
349	380,242		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+4.5
350	380,688		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
351	381,089		~1 m		API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+7.5
352	381,552		~1 m	surface	API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+10.5
353	381,913		~1 m		API, NC, AC1030 TP - 27 - rock at 1.2 m	3,000	rock bolts	A+9.0
354	382,369		~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
355	382,788		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0
356	383,220		~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	A+3.0
357	383,577	C	~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	D+10.5
358	383,984		~1 m		API, NC, AC1030 TP - 28 - rock at 1.0 m	3,000	rock bolts	A+9.0
359	384,415		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5
360	384,835		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+9.0
361	385,213		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
362	385,635		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0
363	386,009		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0
364	386,468	C	~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0
365	386,863		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
366	387,343		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+10.5
367	387,760		~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
368	388,137		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0
369	388,383	C	~2 m till	surface	API, NC, AC1030 TP - 29 - rock at 2.0 m	3,000	rock bolts	D+6.0
370	388,845		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+3.0
371	389,234	DC	~3 m till	surface	API, NC	250	grillage	A+9.0
372	389,637		~3 m till	surface	API, NC	250	grillage	A+6.0
373	390,057		~2 m till	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
374	390,477		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
375	390,916		~1 m	surface	API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0
376	391,319		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+7.5
377	391,850	DC	3 till	>3 m	API, AC1030 TP - 30	3,000	rock bolts	C (strain) + 12.0
378	392,249		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+0.0
379	392,525		~2 m esker	surface	API, NC	3,000	rock bolts	A+4.5
380	392,882	C	~2 m esker		API, NC	3,000	rock bolts	A+6.0
381	393,321		~2 m esker		API, NC	3,000	rock bolts	A+6.0
382	393,754		~2 m esker		API, NC	3,000	rock bolts	A+12.0
383	394,155	DC	3 to 4 m esker	3 m	API, on top of esker remnant	250	grillage	A+9.0
384	394,568		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5
385	394,961	C	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0
386	395,356		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
387	395,781	C	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	D+0.0
388	396,151		~2 m till		API, NC	3,000	rock bolts	A+3.0
389	396,513		3 m to 5 m fluvial	1 m	API, NC, AC1030 TP-31	100	grillage	A+7.5
390	396,879	DC	3 m to 5 m fluvial	1 m	API, NC, AC1030 TP-31	100	grillage	C (strain) + 4.5
391	397,268		3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+7.5
392	397,636		3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+1.5
393	397,994		3 m to 5 m fluvial	1 m	API, NC, edge of wet area	250	grillage	A+10.5
394	398,412		3 m to 5 m fluvial	1 m	API, NC	250	grillage	A+9.0
395	398,825	DC	3 m to 5 m fluvial	1 m	API, NC Near road	250	grillage	A+7.5
396	399,257		>4 m till	1 m	API, NC	250	grillage	A+6.0
397	399,615	DC	>4 m till	1 m	API, NC	250	grillage	A+1.5
398	399,946		>4 m till	1 m	API, NC	250	grillage	A+3.0
399	400,355		>4 m till	1 m	API, NC	250	grillage	A+6.0
400	400,754	DC	>4 m till	1 m	API, NC, road cut in apparent till	250	grillage	A+9.0

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
401	401,130		>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0
402	401,410	DC	>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0
403	401,735		>4 m in glaciofluvial over till	1 m	API, NC, road cut and borrow pit	250	grillage	A+0.0
404	402,059		>4 m in glaciofluvial over till	1 m	API, NC, nearby road cut, AC1030 TP - 32	250	grillage	A+0.0
405	402,407	DC	>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	205	grillage	C (strain) + 6.0
406	402,751		>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	250	grillage	A+0.0
407	403,105		>4 m in glaciofluvial over till	1 m	API, NC, AC1030 TP - 32	250	grillage	A+3.0
408	403,429		>4 m in glaciofluvial over till	1 m	API	250	grillage	A+7.5
409	403,838	DC	~2 m till		API	3,000	rock bolts	D+6.0
410	404,261		~2 m till		API	3,000	rock bolts	A+7.5
411	404,664		3 m to 4 m till	surface	API, boggy area	250	grillage	A+9.0
412	405,098	DC	3 m to 4 m till	surface	API	250	grillage	A+6.0
413	405,487		~2 m till		API	3,000	rock bolts	A+6.0
414	405,896		~2 m till		API	3,000	rock bolts	A+7.5
415	406,311		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5
416	406,727		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+9.0
417	407,166		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+10.5
418	407,586		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0
419	408,004		~2 m till		API	3,000	rock bolts	A+9.0
420	408,449	C	~2 m till		API	3,000	rock bolts	A+9.0
421	408,870		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
422	409,280		rock at surface		API, NC, AC1030 TP - 33 - 0.5 to bedrock	3,000	rock bolts	A+7.5
423	409,664		~1 m		API, NC, AC1030 TP - 33 - 0.5 to bedrock	3,000	rock bolts	A+7.5
424	410,138		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+9.0
425	410,462	C	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+6.0
426	410,785		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
427	411,177		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+7.5
428	411,495	C	~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	D+12.0
429	411,896		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+10.5
430	412,317	C	3 m to 4 m	3 m	API, NC, AC1030 TP - 34 - >4 m of esker	250	grillage	A+7.5
431	412,743		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+10.5
432	413,086		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+12.0
433	413,538		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+1.5
434	413,840		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	A+4.5
435	414,402		~1 m		API, bedrock structure visible beneath thin till, NC	3,000	rock bolts	B+9.0
436	414,889		~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+12.0
437	415,206	C	~1 m		API, bedrock structure visible beneath thin till	3,000	rock bolts	C (strain) + 6.0
438	415,405		~1 m	surface	API, bedrock structure visible beneath thin till	3,000	rock bolts	A+0.0
439	415,792		~2 m till		API, bedrock structure visible beneath thin till	3,000	rock bolts	C (strain) + 4.5
440	415,991		~2 m till		API, bedrock structure visible beneath thin till	3,000	rock bolts	A+1.5
441	416,311	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	B+12.0
442	416,700	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	D+9.0
443	417,166	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+6.0
444	417,434	B+P	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	C (strain) + 6.0
445	417,771	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, AC1030 TP - 35 nearby, investigate		deep	A+4.5
446	418,091	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+4.5
447	418,450	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	C (strain) + 12.0
448	418,794	DC/V	> 4 m lacustrine, silt??	>3 m	API, NC, investigate		deep	A+12.0
449	419,256	C	<1 m		API, NC	3,000	rock bolts	D+6.0
450	419,663		<1 m		API, NC	3,000	rock bolts	A+12.0
451	419,965		<1 m		API, NC	3,000	rock bolts	A+9.0
452	420,280		<1 m		API, NC	3,000	rock bolts	A+3.0
453	420,659	C	~2 m till		API, NC	3,000	rock bolts	A+6.0
454	420,995		<1 m		API, NC	3,000	rock bolts	A+4.5
455	421,279		<1 m		API, NC	3,000	rock bolts	A+12.0
456	421,724		<1 m		API, NC	3,000	rock bolts	A+1.5
457	422,076		<1 m		API, NC	3,000	rock bolts	B+12.0
458	422,602	C	<1 m		API, NC	3,000	rock bolts	C (strain) + 3.0
459	422,812		<1 m		API, NC	3,000	rock bolts	A+0.0
460	423,073		<1 m		API, NC	3,000	rock bolts	A+0.0
461	423,331	C	<1 m		API, NC	3,000	rock bolts	C (strain) + 9.0
462	423,757		<1 m		API, NC	3,000	rock bolts	B+0.0
463	424,178		<1 m		API, NC	3,000	rock bolts	A+4.5
464	424,396		<1 m		API, NC	3,000	rock bolts	A+9.0
465	424,737		<1 m		API	3,000	rock bolts	A+4.5
466	425,111		<1 m		API	3,000	rock bolts	A+12.0
467	425,429		<1 m		API, AC1030 TP - 36 nearby at lower elevation in granular soil > 5 m deep	3,000	rock bolts	A+3.0
468	425,767	C	<1 m		API	3,000	rock bolts	C (strain) + 1.5
469	425,980		<1 m		API	3,000	rock bolts	A+1.5
470	426,209	C	~2 m till		API	3,000	rock bolts	C (strain) + 9.0
471	426,627		<1 m		API	3,000	rock bolts	A+3.0
472	426,948		<1 m		API	3,000	rock bolts	A+0.0
473	427,284		<1 m		API	3,000	rock bolts	A+3.0
474	427,639	C	<1 m	surface	API	3,000	rock bolts	A+10.5
475	428,085		<1 m		API	3,000	rock bolts	A+10.5
476	428,495		<1 m		API	3,000	rock bolts	A+9.0
477	428,958		<1 m		API	3,000	rock bolts	A+7.5
478	429,369		<1 m		API	3,000	rock bolts	A+7.5
479	429,787		~2 m till		API	3,000	rock bolts	A+9.0
480	430,215	C	~2 m till		API, NC	3,000	rock bolts	A+9.0
481	430,546		~2 m till	surface	API	3,000	rock bolts	A+7.5
482	430,971		~2 m till		API	3,000	rock bolts	A+9.0
483	431,382		~2 m till	surface	API	3,000	rock bolts	A+9.0
484	431,805	DC	~3 m till		API	250	grillage	A+10.5
485	432,225		~2 m till		API, NC	3,000	rock bolts	A+10.5
486	432,598		~2 m till		API, NC	3,000	rock bolts	A+7.5
487	432,963		~3 m till	2 m	API	250	grillage	A+9.0
488	433,358	DC	> 4 m esker	2 m	API	250	grillage	C (strain) + 10.5
489	433,747	B+P	> 4 m esker	>4	API	250	grillage	D+7.5
490	434,152	DC	~3 m till	2 m	API	250	grillage	B+0.0
491	434,386		~2 m till		API	3,000	rock bolts	A+0.0
492	434,857		~3 m till	2 m	API	250	grillage	A+6.0
493	435,240	C	~3 m till	2 m	API, NC	250	grillage	A+9.0
494	435,599		~3 m till	surface	API, NC	250	grillage	A+3.0
495	435,915		~3 m till	2 m	API, NC	250	grillage	A+0.0
496	436,282	C	~3 m till	2 m	API, NC	250	grillage	A+7.5
497	436,718	C	> 4 m esker	2 m	API, NC	250	grillage	A+9.0
498	437,139	DC	>3.5 m	surface	API, NC, AC1030 TP - 37, >3.5, wet	250	deep	C (strain) + 12.0
499	437,475		> 4 m esker	2 m	API, NC	250	grillage	A+1.5
500	437,814	DC	> 4 m esker	2 m	API, NC	250	grillage	A+4.5

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
501	438,222		> 4 m esker	2 m	API, NC	250	grillage	A+1.5
502	438,613	DC	> 4 m esker	2 m	API, NC	250	grillage	A+4.5
503	439,004		> 4 m esker	2 m	API, NC	250	grillage	A+9.0
504	439,419	C	>4 m till	2 m	API, NC, AC1030 TP - 38, >4 m till, dry to 4 m	250	grillage	C (strain) + 9.0
505	439,832		>4 m till	2 m	API, NC, AC1030 TP - 38, >4 m till, dry to 4 m	250	grillage	A+10.5
506	440,265		>4 m till	2 m	API, NC	250	grillage	A+10.5
507	440,680	DC	>3 m till	2 m	API, NC	250	grillage	A+9.0
508	441,088	C	~2 m till		API, NC	3,000	rock bolts	A+12.0
509	441,494	DC	~2 m till		API, NC	3,000	rock bolts	D+7.5
510	441,877		~2 m till		API, NC	3,000	rock bolts	A+6.0
511	442,284	B+P	~2 m till		API, NC	3,000	rock bolts	A+10.5
512	442,683	DC	~2 m till		API, NC, AC1030 TP - 39 dug 300 m south in probable glacio-lacustrine soil with >3 m thickness	3,000	rock bolts	A+4.5
513	443,071		~1 m	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	A+4.5
514	443,505	C	~1 m	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	D+9.0
515	443,931		~2 m till	surface	API, NC, AC1030 TP - 40	3,000	rock bolts	A+12.0
516	444,368		~2 m till		API, NC	3,000	rock bolts	A+10.5
517	444,790	C	~3 m till	2 m	API, NC	250	grillage	A+9.0
518	445,234		~3 m till	1 m	API, NC, near stream	250	grillage	A+10.5
519	445,667		~3 m till	2 m	API, NC	250	grillage	A+9.0
520	446,068	C	~3 m till	2 m	API, NC	250	grillage	A+10.5
521	446,500	C	~2 m till		API, NC	3,000	rock bolts	A+9.0
522	446,942		~2 m till	1 m	API, N, near bog	3,000	rock bolts	A+12.0
523	447,334		~2 m till		API, NC	3,000	rock bolts	A+12.0
524	447,712		~2 m till		API, NC	3,000	rock bolts	A+12.0
525	448,152	C	~2 m till		API, NC	3,000	rock bolts	A+10.5
526	448,581		~1 m	surface	API, NC	3,000	rock bolts	A+10.5
527	449,018		~2 m till		API, NC	3,000	rock bolts	A+12.0
528	449,453	C	1.5 m till	surface	API, NC, AC1030 TP - 41	3,000	rock bolts	D+12.0
529	449,886		~2 m till		API, NC	3,000	rock bolts	A+9.0
530	450,327		~1 m		API, NC	3,000	rock bolts	A+9.0
531	450,712		~1 m		API, NC	3,000	rock bolts	A+3.0
532	451,040		~1 m		API, NC	3,000	rock bolts	A+4.5
533	451,414		~1 m		API, NC	3,000	rock bolts	A+6.0
534	451,788		~1 m		API, NC	3,000	rock bolts	A+4.5
535	452,149		~1 m		API, NC	3,000	rock bolts	A+3.0
536	452,510		~1 m		API, NC	3,000	rock bolts	A+3.0
537	452,944		~1 m		API, NC	3,000	rock bolts	A+9.0
538	453,373		~1 m		API, NC	3,000	rock bolts	A+1.5
539	453,680		~1 m		API, NC	3,000	rock bolts	A+1.5
540	454,055	C	~2 m till		API, NC	3,000	rock bolts	A+7.5
541	454,460		~2 m till	surface	API, NC, boggy	3,000	rock bolts	A+6.0
542	454,808		~2 m till	surface	API, NC, stream nearby	3,000	rock bolts	A+4.5
543	455,186	C	~2 m till	surface	API, NC, AC1030 TP - 42 - 2.5 m to rock	3,000	rock bolts	D+10.5
544	455,611		~2 m till		API, NC	3,000	rock bolts	A+10.5
545	456,030		~2 m till		API, NC	3,000	rock bolts	A+12.0
546	456,433		~2 m till		API, NC	3,000	rock bolts	A+10.5
547	456,864	C	~2 m till		API, NC	3,000	rock bolts	A+6.0
548	457,306		~3 m till	2 m	API, NC	250	grillage	A+7.5
549	457,738	C	~3 m till	2 m	API, NC	250	grillage	A+9.0
550	458,136		~2 m till		API, NC	3,000	rock bolts	A+9.0
551	458,549		~2 m till		API, NC	3,000	rock bolts	A+9.0
552	458,966		~1 m		API, NC	3,000	rock bolts	A+9.0
553	459,413		~2 m till		API, NC	3,000	rock bolts	A+6.0
554	459,837	C	~3 m till	2 m	API, NC	250	grillage	A+9.0
555	460,281		~2 m till		API, NC	3,000	rock bolts	A+10.5
556	460,709		~2 m till		API, NC	3,000	rock bolts	A+12.0
557	461,114		~2 m till		API, NC	3,000	rock bolts	A+10.5
558	461,524		~2 m till		API, NC	3,000	rock bolts	A+10.5
559	461,957	C	~2 m till		API, NC, AC1030 TP - 43 nearby on lower elevation ground, 2 m to bedrock	3,000	rock bolts	D+10.5
560	462,310		~2 m till		API, NC	3,000	rock bolts	A+9.0
561	462,720		~1 m		API, NC	3,000	rock bolts	A+7.5
562	463,151		~1 m		API, NC	3,000	rock bolts	A+6.0
563	463,452		~1 m		API, NC	3,000	rock bolts	A+6.0
564	463,838		~1 m		API, NC	3,000	rock bolts	A+6.0
565	464,230		~1 m		API, NC	3,000	rock bolts	A+9.0
566	464,700		~1 m		API, NC	3,000	rock bolts	A+6.0
567	465,093	C	~2 m till		API, NC	3,000	rock bolts	A+6.0
568	465,467		~2 m till		API, NC	3,000	rock bolts	A+4.5
569	465,875		~2 m till		API, NC	3,000	rock bolts	A+9.0
570	466,278	C	~2 m till		API, NC	3,000	rock bolts	A+9.0
571	466,688		~2 m till		API, NC	3,000	rock bolts	A+9.0
572	467,110		~2 m till		API, NC	3,000	rock bolts	A+9.0
573	467,463		~1 m		API, NC	3,000	rock bolts	A+7.5
574	467,760		~1 m		API, NC	3,000	rock bolts	A+1.5
575	468,145	C	~1 m		API, NC, AC1030 TP - 44, 1.4 m to rock	3,000	rock bolts	D+6.0
576	468,500		~1 m		API, NC	3,000	rock bolts	A+7.5
577	468,880		~1 m		API, NC	3,000	rock bolts	A+4.5
578	469,263		~1 m		API, NC	3,000	rock bolts	A+4.5
579	469,666		~1 m		API, NC	3,000	rock bolts	A+9.0
580	470,079		~1 m		API, NC	3,000	rock bolts	A+10.5
581	470,490		~1 m		API, NC	3,000	rock bolts	A+7.5
582	470,888	C	~2 m till		API, NC	3,000	rock bolts	A+10.5
583	471,315		~2 m till		API, NC	3,000	rock bolts	A+10.5
584	471,730	C	~2 m till		API, NC	3,000	rock bolts	D+7.5
585	472,159		~1 m		API, NC	3,000	rock bolts	A+10.5
586	472,584		~1 m		API, NC	3,000	rock bolts	A+12.0
587	473,022	C	~2 m till		API, NC	3,000	rock bolts	A+12.0
588	473,454		~2 m till		API, NC	3,000	rock bolts	A+12.0
589	473,866		~2 m till		API, NC	3,000	rock bolts	A+12.0
590	474,302	C	~2 m till		API, NC	3,000	rock bolts	A+7.5
591	474,735		~1 m		API, NC	3,000	rock bolts	A+10.5
592	475,174		~1 m		API, NC	3,000	rock bolts	A+7.5
593	475,509		~1 m		API, NC	3,000	rock bolts	A+10.5
594	475,952	C	~2 m till		API, NC	3,000	rock bolts	A+4.5
595	476,369	C	~3 m till	2 m	API, NC	250	grillage	A+7.5
596	476,747		~2 m till		API, NC	3,000	rock bolts	A+7.5
597	477,140		~2 m till		API, NC	3,000	rock bolts	A+6.0
598	477,482		~2 m till		API, NC	3,000	rock bolts	A+3.0
599	477,892	C	~1 m		API, NC	3,000	rock bolts	D+12.0
600	478,313		~1 m		API, NC	3,000	rock bolts	A+9.0

Caution

Investigation Recommended

Bedrock Expected

DRAFT

*Depth = 2.75 m, Friction angle of 26 degrees, Submerged unit weight of 8.4 kN/m3, Backfill is compact with friction angle of 30 degrees, Dry unit weight of 15.7 kN/m3 and submerged unit weight of 9.7 kN/m3, Considering the grillage as a spread footing,

LINE 2 (NORTH LINE)

STRUCTURE NUMBER	STATION	QUALITAS INVESTIGATION as per Appendices D and G	SUBSURFACE CONDITIONS (estimated or proven)	WATER TABLE	COMMENTS / SOURCE OF INFORMATION (TP = test pit. BH = borehole, PH = hand probe hole, API = air photo interpretation including LiDAR and fly over and observations at nearby wood poles, BP = bog probe, NC = nearby construction or borrow pit)	Recommended Bearing Capacity in kPa*	Recommended Foundation Type	Proposed Structure Type -
601	478,711		~2 m till		API, NC	3,000	rock bolts	A+10.5
602	479,159	C	~3 m till	2 m	API, NC	250	grillage	A+9.0
603	479,590		~1 m		API, NC	3,000	rock bolts	A+7.5
604	479,978		~1 m		API, NC	3,000	rock bolts	A+7.5
605	480,402	C	~2 m till		API, NC	3,000	rock bolts	A+7.5
606	480,776		~1 m		API, NC	3,000	rock bolts	A+7.5
607	481,211		~1 m		API, NC	3,000	rock bolts	A+9.0
608	481,633		~1 m		API, NC	3,000	rock bolts	A+7.5
609	482,048		~1 m		API, NC	3,000	rock bolts	A+7.5
610	482,406		~1 m		API, NC	3,000	rock bolts	A+7.5
611	482,802	C	~1 m		API, NC	3,000	rock bolts	D+7.5
612	483,175	C	~2 m till		API, NC	3,000	rock bolts	A+6.0
613	483,592		~1 m		API, NC	3,000	rock bolts	A+7.5
614	483,978		~1 m		API, NC	3,000	rock bolts	A+10.5
615	484,421		~1 m		API, NC	3,000	rock bolts	A+10.5
616	484,834		~1 m		API, NC	3,000	rock bolts	A+9.0
617	485,247		~1 m		API, NC	3,000	rock bolts	A+6.0
618	485,671		~1 m		API, NC	3,000	rock bolts	A+10.5
619	486,107		~1 m		API, NC	3,000	rock bolts	A+7.5
620	486,495		~1 m		API, NC	3,000	rock bolts	A+9.0
621	486,980		~1 m		API, NC	3,000	rock bolts	B+10.5
622	487,416	C	~1 m	surface	API, NC, AC1030 TP - 45, 1 m to bedrock, wet	3,000	rock bolts	E+6.0
623	487,824	C	~1 m		API, NC	3,000	rock bolts	A+12.0
624	488,284	DC	~3 m till		API, NC, old bulldozer test pit nearby	250	grillage	B+10.5
625	488,670		~1 m		API, NC	3,000	rock bolts	A+12.0
626	489,019		~1 m		API, NC	3,000	rock bolts	A+0.0
627	489,461		~2 m till		API, NC,	3,000	rock bolts	A+6.0
628	489,830	C	~1 m		API, NC	3,000	rock bolts	A+7.5
629	490,247		~1 m		API, NC	3,000	rock bolts	A+9.0
630	490,694		~2 m till		API, NC,	3,000	rock bolts	A+9.0
631	491,040	C	~2 m till		API, NC,	3,000	rock bolts	A+6.0
632	491,437		~2 m till		API, NC,	3,000	rock bolts	A+7.5
633	491,848		~1 m		API, NC	3,000	rock bolts	A+0.0
634	492,308		~1 m		API, NC	3,000	rock bolts	A+6.0
635	492,643	C	~2 m till		API, NC,	3,000	rock bolts	A+7.5
636	493,026		~2 m till		API, NC,	3,000	rock bolts	A+6.0
637	493,453		~2 m till		API, NC,	3,000	rock bolts	A+7.5
638	493,820	C	~2 m till		API, NC,	3,000	rock bolts	C (strain) + 10.5
639	493,963	C	~2 m fill		API, NC,	3,000	rock bolts	D+9.0

APPENDIX G

QUALITAS 315 KV HVAC GEOTECHNICAL INVESTIGATION PROGRAM (Acceptance of this report does not constitute approval of proposed geotechnical program.)

Qualitas

Geotechnical investigation program and cost estimation

315 kV HVAC Transmission Line Foundations
From Muskrat Falls to Churchill Falls

Project Description

- Construction of 2 adjacent 315 kV line from Muskrat Falls to Churchill Falls, mainly near an existing HV line and the Trans Labrador highway.
- Each line consists of 638 steel lattice towers (1276 in total)
- Out of the 638 towers, 77 are type C, D, and E (self-supporting tower).
- This results in a total of 1738 individual foundations.
- The camps and marshalling sites are not included in the scope of work.

General Soil Conditions

The line route in most part follows the north bank of the Churchill River. In Muskrat Falls, the soil condition (origin, properties, geometry) varies along the line route. The main types of soil in this region are:

- large fluvial or eolian sand deposit over silt and clay (marine) sediment
- topographic feature shows large soil slide area, few areas are regressive
- the “rock section” (Churchill Falls) show a glacial till deposit (thickness variable) over a good quality rock.

Geotechnical information is available at Muskrat Falls and in different site along the line route, for instance:

- borehole and other types of investigation data mainly for the hydraulic dam and other structure at Muskrat Falls
- test pit and bog probing information along the line (this was done prior to the final tower spotting)
- some borehole for a stability study near slides area
- a geomorphological interpretation by using the LIDAR map, orthophotography, geological and soil mapping.

There is no geotechnical information at the exact tower location, for example:

- the mechanical properties of the soil (to confirm the bearing capacity of 100 or 250 kPa)
- soil stratigraphy , primarily in zone where the rock is at a critical depth (between 2.75 m – 3.5 m)
- stability verification when towers are near slopes or any other problematic location that may have a impact during construction.

The expected geotechnical soil conditions (from AMEC report) are:

Site Condition	Site	%
▪ Bedrock less than 2.75 m	354	54
▪ Sand	73	11
▪ Sand & Gravel (fluvial)	45	8
▪ Sand & Gravel (till)	127	20
▪ Silt & Clay	40	6

As a result, with the current information at hand and without further precision, the error in foundation prediction is considerably great (more than 30%, approximately). We can reduce the error percentage to nearly zero if we investigate each foundation site, but it will very costly.
This error can also be reduced by adapting a geotechnical investigation program. The main objective of the program is to characterize the soil in homogeneous portion of ground. This can be done by using light and efficient techniques such as: site visit by a geologist, dynamic cone test (for sandy soil parameters), in situ vane shear test (for clayey and silty soil parameters), percussion soil probing and test pits (to confirm bedrock depth).

Soil Investigation Techniques

The proposed investigation techniques are as follow:

- Geologist or geotechnical technician site visit

Cartography of each tower site is the most important site characterization operation. During this site visit, the geologist can confirm the nature of soil deposit, the rock position (surface or very shallow) and can propose additional investigation techniques to obtain the required geotechnical information in specific problematic region. Tower location will be done with a High precision GPS.
Generally, site visit are done by an experimental geologist or a geotechnical engineer.

- Dynamic cone penetrometer (DC)

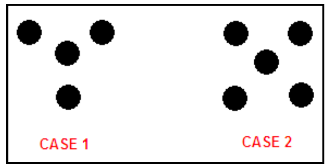
This test is performed by using a light tripod operated by a 2 men crew under the supervision of a soil technician. A stem rod with a bottom cone (lost) is used with a 140 pounds hammer. In cohesionless (sand) deposits, the N_{DC} value can be obtained and used to confirm the bearing capacity. The test can be done up to the required depth. On occasion, the water table depth can be obtained. In general a single DC test should be performed per tower or site and depending on the geologist visit.

- Nilcon vane shear test (V)

The vane shear test provides the in situ shear resistance profile (C_u). This parameter can be used to confirm the bearing capacity of cohesive soil (100 or 250 kPa). The vane is pushed into the soil with a special portable frame. The Cu parameter is measured at each 1 m layer depth. This operation can be performed by a 2 men crew under supervision of a soil technician.

- Percussion penetrometer (C)

This test consists of a percussion portable hammer (Cobra, Pionjär type) with a stem soil rods. The objective is to confirm the presence of bedrock depth (2.75 m or 3.5 m). In case of presence of cobbles or boulders, this test should be executed in 2 different patterns, see diagram below. In some cases, the water level and bearing capacity can be estimated by using the percussion penetrometer test.



This equipment can be operated by a 2 men crew with a soil technician. This test should be performed in difficult access site location. Otherwise, a test pit should be used.

- Test pit (TP)

This test is done by using a hydraulic excavation when access is permitted, otherwise the percussion penetrometer test should be performed. The test pit can identify the soil, water level, and the bedrock depth. In conjunction with pocket equipment such as a pocket penetrometer or a pocket vane, additional soil parameter can be obtained which in turn can estimate the bearing capacity of soil.

Boreholes and piezometers (B+P)

Sampling borehole will be done on site under certain specific condition such as slope stability problem, very weak soil deposit or other difficulties. A light weight drill is used. The drill can be transported by an Astar B-2 helicopter (or equivalent). The transportation time should be less than 2 hours. The drill can penetrated more than 30 m into soil or rock material. This is a 2 men crew operation; a soil technician should take all necessary information. Disturbed and undisturbed soil sample (cohesionless or cohesion) can be extracted in order to perform additional laboratory test.

The decision chart, shown in Appendix A, illustrates the investigation techniques described above.

Geotechnical Investigation Program

For the 315 kV HVac double circuit line, it is recommended to go through a partial investigation program based on the existing information and preliminary soil evaluation. In fact, it is advised to use existing sounding information but with more investigation work:

- each self-supporting tower site type C, D, and E should be investigated
- some homogeneous (soil or rock condition) will be partially visited
- special site (stability, weak soil, others) will be investigated

Investigation program is shown on table 2 below:

Type of Investigation	Quantity (Site)*	%

Geologist Site Visit	638	100
Dynamic Cone or Vane Test	98	15
Percussion Penetrometer or Test Pit	96	15
Borehole (Piezometer)	12	2
TOTAL	206	32

* Quantities are shown for both tower sites (2 line route).

The detailed investigation program is with appendix B.

Cost estimation

Based on the investigation program we prepare an estimation cost to realize the work.

The following information are taking into account:

- The estimation is not a formal proposal to do the works
- A formal proposal should be prepare after a site visit
- The work will be done during spring or summer, after snow melt
- The base operation is in Happy Valley-Goose Bay
- The quantity of different type of investigation should change
- The estimation is make for site, not for tower
- A health and safety coordinator as been included
- Native people will be include in field crew

- The camps and marshalling sites are not included in the scope of work.
- Every tower location will be located with a high precision GPS

Conclusion

In relation with the construction of two HVAC 315kV transmission lines, we look for use existing geotechnical information to prepare the foundation selection at each tower site (see Appendix D). On that base, we expect at least 30 % of bad foundation choice. To reduce bad choice selection, we prepare a geotechnical investigation program for sites characterization.

The program consists to do investigation, following a logical decision chart up to obtain the information required to do a correct foundation choice at each tower. The proposed method is based on well known transmission lines soil and rock investigation and our experiences. At beginning, all tower sites should be visited by a well trained geologist. This visit should direct to complementary investigation work up to recommend foundations selection.

At the end of the work, a detailed table presents all the results for each tower, with: recommendation for the selected foundation, water level in ground, rock position, possibility to reuse the excavated soil and pertinent comments (see appendix C).

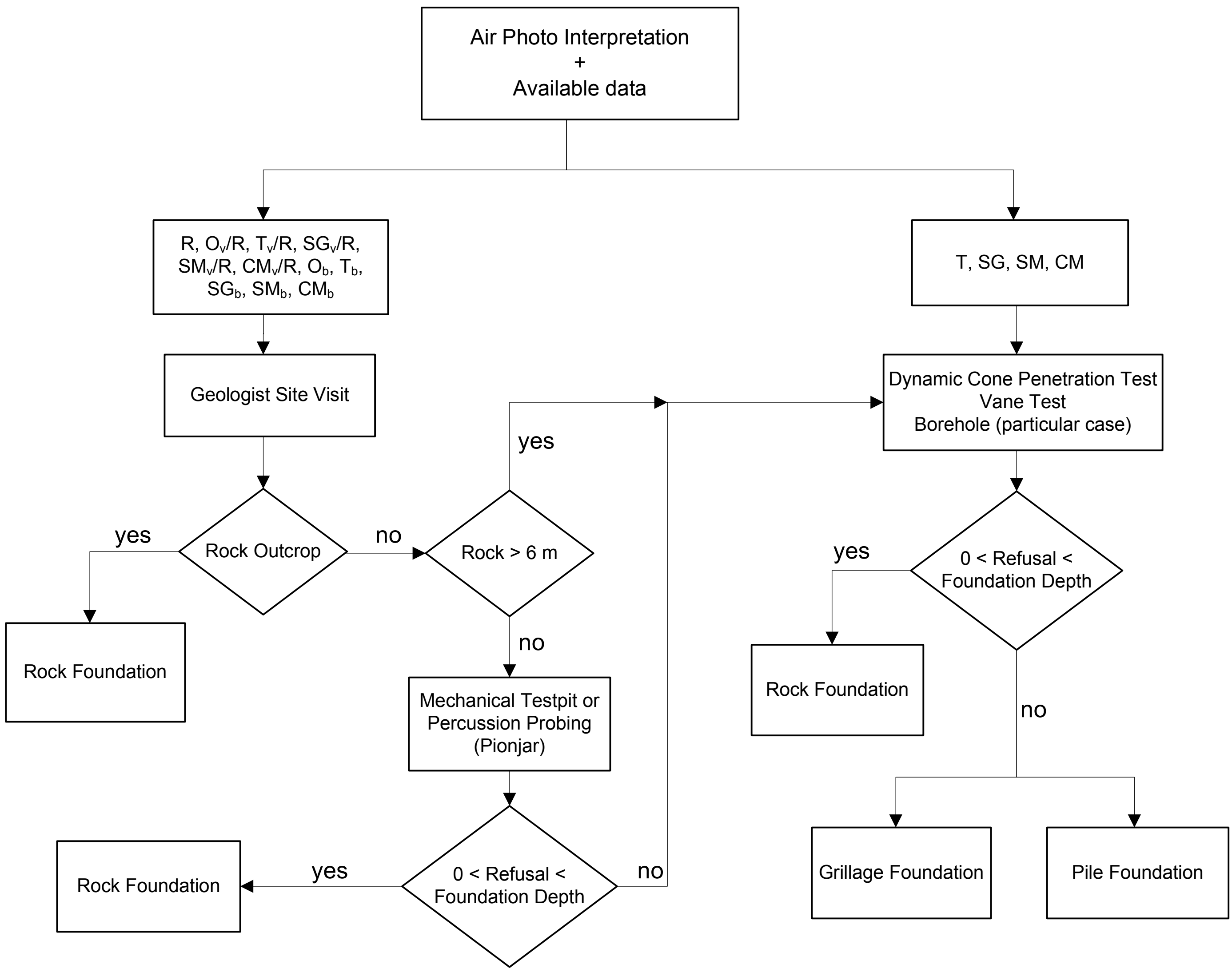
For the HVAC 315kV project, we do some hypothesis based on existing information, to build preliminary cost estimation. Estimation is based on doing intrusive soil investigation work on approximately 32 % of sites along the line route. The estimation taking into account the special cases like: slope stability, very weak soil, etc. The estimation results are shown in details in Table 1 and 2 in appendix D.

In using the proposed method, we are confident to reduce the percentage of possible change in foundation selection to less than 5%.

APPENDIX H

FOUNDATION TYPE SELECTION DECISION CHART

DECISION CHART



Note: Site visit by geologist and intrusive testing will be performed at every angle structure location and where rock is expected between 0 and foundation depth. Elsewhere, segmentation of the line will be done, and some intrusive testing will be performed at representative location.

<u>Legend</u>

R: Bedrock
O_v/R: Less than 2 m organic soil over bedrock
T_v/R: Less than 2 m till over bedrock
SG_v/R: Less than 2 m sand or sand and gravel over bedrock
SM_v/R: Less than 2 m sandy silt to silty sand over bedrock
CM_v/R: Less than 2 m clayey silt to silty clay over bedrock
O_b: 2 to 6 m organic soil
T_b: 2 to 6 m till
SG_b: 2 to 6 m sand or sand and gravel
SM_b: 2 to 6 m sandy silt to silty sand
CM_b: 2 to 6 m clayey silt to silty clay
T: More than 6 m till
SG: More than 6 m sand or sand and gravel
SM: More than 6 m sandy silt to silty clay
CM: More than 6 m clayey silt to silty clay

APPENDIX I

FOUNDATION TYPE SELECTION AND TEST RESULTS TABLE

NALCOR ENERGY

TRANSMISSION LINE GEOTECHNICAL INVESTIGATION
RESULTS AND RECOMMANDATIONS COMPILATION
FILE NUMBER

LEGEND

Soil Type:	**F** : Fill; **C** : Cobbles and Boulders; **Tv** : less than 2 m till; **Tb** : 2 to 6 m till; **T** : more than 6 m till; **SGv** : less than 2 m Sand or Sand and Gravel; **SGb** : 2 to 6 m Sand or Sand and Gravel; **SG** : more than 6 m Sand or Sand and Gravel **Ov** : Organic Soil less than 2 m; **Ob** : 2 to 6 m Organic Soil; **CMv** : less than 2 m Clayey Silt to Silty Clay; **CMb** : 2 to 6 m Clayey Silt to Silty Clay; **CM** : more than 6 m Clayey Silt to Silty Clay **SMv** : less than 2 m Sandy Silt to Silty Sand; **SMb** : 2 to 6 m Sandy Silt to Silty Sand; **SM** : More than 6 m Sandy Silt to Silty Sand; R = Bedrock
Sounding Method:	API Air Photo Interpretation; Borehole with SPT : **BH**; Dynamic Cone Penetration Test : **DCPT**; Vane Test : **V**; Mechanical Testpit : **TP_{me}**; Manual Testpit : **TP_{ma}**; Percussion Probing : **PB**; Rod Probing: **RP**; Site Visite: **SV** Bog Probes: **BP;** Nearby Construction or Borrow Pit/Quarry; **NC**
Geotechnical Parameters	**$S_{u\ average}$** : Average Undrained Shear Strength (2B below foundation); **s'_p** : Preconsolidation Pressure (estimated from Su and I_p); **$N_{average}$** : Average Standard Penetration Test Index (2B below foundation); **$Ndc_{average}$** : Average Dynamic Cone Penetrometer Blow Count (2B below foundation)

GENERAL INFORMATION					GEOTECHNICAL INFORMATION											FOUNDATION RECOMMANDATION							REMARKS
Structure Number	Kilometric Point (m)	Proposed Tower Type (angle)	Foundation ID	Ground Surface Elevation (m)	Subsurface Conditions	Sounding Method	Peat Thickness (m)	Water Table (m)	Geotechnical Parameters	Refusal Depth (m)					Rock Elevation (m)	q_{all} failure (kPa)	q_{all} settlement (kPa) (note 1)	Rock Foundation Type	Soil Foundation Type	Piles, length (m)	Reuse of excavated soils	Water Infiltration	
1	2	3	4	5	6	7	8	9	10	11A	11B	11C	11D	11E	12	13	14	15	16	17	18	19	20

TBC : To be calculated

note 1 : Allowable bearing capacity determined for 50 mm settlement for Guy anchored tower and 25 mm settlement for Lattice towers.

Caution
Investigation Recommended
Bedrock Expected

APPENDIX J

315 KV HVAC GEOTECHNICAL INVESTIGATION COST ESTIMATION MOB DEMOB

Qualitas

Geotechnical Investigation, HVAC 315 kV Lines
Table 1 - Preparation and Mob-demob (estimate cost)

O/Project: 9951114

		Activity	Unité	Unit cost	Quatity	Total cost
A		**Preparation**				
	1	Manager	hour	185.00 $	20	3,700.00 $
	2	Clerk	hour	44.00 $	10	440.00 $
	3	Tecnician (5)	hour	80.30 $	40	3,212.00 $
	4	Operator (4)	hour	64.90 $	60	3,894.00 $
					Sub-total	**11,246.00 $**
		Mobilisation				
B		***Drill and Equipment transportation***				
	1	Drill crew and equipment (Qualitas)	km	3.00 $	1450	4,350.00 $
	2	Board and room (2 persons)	d/p	120.50 $	2	241.00 $
					Sub-total	**4,591.00 $**
C		***Field Qualitas crew***				
		Manager				
	1	*Time*	hour	185.00 $	10	1,850.00 $
	2	*Travel expenses*	estimate	750.00 $	1	750.00 $
		Geologist (2)				
	3	*Time*	hour	100.10 $	20	2,002.00 $
	4	*Travel expenses*	estimate	750.00 $	2	1,500.00 $
		Technician (5)				
	5	*Time*	hour	80.30 $	50	4,015.00 $
	6	*Travel expenses*	estimate	750.00 $	5	3,750.00 $
		Operator (2)				
	7	*Time*	hour	64.90 $	20	1,298.00 $
	8	*Travel expenses*	estimate	750.00 $	2	1,500.00 $
					Sub-total	**16,665.00 $**
D		***Field local crew***				
		Healt and safety coordonator				
	1	*Time*	hour	78.10 $	10	781.00 $
	2	*Travel expenses*	estimate	750.00 $	1	750.00 $
		Line cutter (on site)				
	3	*Time*	hour	35.20 $	4	140.80 $
	4	*Travel expenses*	estimate			- $
		Test pit operator (on site)				
	5	*Time*	hour	70.00 $	2	140.00 $
	6	*Travel expenses*	estimate			- $
		Native people helper (6)				
	7	*Time*	hour	35.00 $	12	420.00 $
	8	*Travel expenses*	estimate			- $
		Clerk (on site)				
	9	*Time*	hour	44.00 $	2	88.00 $
	10	*Travel expenses*	estimate			- $
					Sub-total	**2,319.80 $**
					Total	**23,575.80 $**
		Periodic break (if required)				
E		***Qualitas***				
	1	Crews	hour	1,046.30 $	20	20,926.00 $
	2	Travel expenses (by pers.)	pers	1,500.00 $	10	15,000.00 $
		Local				
	3	Crews (2 pers.)	hour	122.10 $	20	2,442.00 $
	4	Travel expenses (by pers.)	pers	1,200.00 $	2	2,400.00 $
						40,768.00 $

Demobilisation

F		***Drill and Equipment transportation***				
	1	Drill crew and equipment (Qualitas)	km	3.00 $	1450	4,350.00 $
	2	Board and room (2 persons)	d/p	120.50 $	2	241.00 $
					Sub-total	**4,591.00 $**
G		***Field Qualitas crew***				
		Manager				
	1	*Time*	hour	185.00 $	10	1,850.00 $
	2	*Travel expenses*	estimate	750.00 $	1	750.00 $
		Geologist (2)				
	3	*Time*	hour	100.10 $	20	2,002.00 $
	4	*Travel expenses*	estimate	750.00 $	2	1,500.00 $
		Technician (5)				
	5	*Time*	hour	80.30 $	50	4,015.00 $
	6	*Travel expenses*	estimate	750.00 $	5	3,750.00 $
		Operator (2)				
	7	*Time*	hour	64.90 $	20	1,298.00 $
	8	*Travel expenses*	estimate	750.00 $	2	1,500.00 $
					Sub-total	**16,665.00 $**
H		***Field local crew***				
		Healt and safety coordonator				
	1	*Time*	hour	78.10 $	10	781.00 $
	2	*Travel expenses*	estimate	750.00 $	1	750.00 $
		Line cutter (on site)				
	3	*Time*	hour	35.20 $	4	140.80 $
	4	*Travel expenses*	estimate			- $
		Test pit operator (on site)				
	5	*Time*	hour	70.00 $	2	140.00 $
	6	*Travel expenses*	estimate			- $
		Native people helper (6)				
	7	*Time*	hour	35.00 $	12	420.00 $
	8	*Travel expenses*	estimate			- $
		Clerk (on site)				
	9	*Time*	hour	44.00 $	2	88.00 $
	10	*Travel expenses*	estimate			- $
					Sub-total	**2,319.80 $**
					Total	**23,575.80 $**

APPENDIX K

315 KV HVAC GEOTECHNICAL INVESTIGATION COST ESTIMATION SUMMARY

Geotechnical Investigation, HVAC 315 kV Lines
Table 2- Field work, Lab test and Report, (Cost Estimation)
O/Project: 9951114

		Activities	Unit	Unit Cost	Qty	Estimate Cost
A		**Preparation**	Lump sum	11,246.00 $	1	**11,246.00 $**
B		**Mobilisation**	Lump sum	23,575.80 $	1	**23,575.80 $**
		Field Work				
C		**Management and logistic**				
	1	Manager	hour	185.00 $	300	55,500.00 $
	2	Health and safety coordonator	hour	78.10 $	300	23,430.00 $
	3	Clerk (Local)	hour	44.00 $	300	13,200.00 $
	4	Board and room (2 person for 30 days)	day	120.50 $	60	7,230.00 $
	5	Line cutter (2)	hour	70.40 $	300	21,120.00 $
				Sub-Total		**120,480.00 $**
D		**Sites visit**				
	1	Geologist (No 1)	hour	100.10 $	300	30,030.00 $
	2	Helper(No 1) (Local)	hour	35.00 $	300	10,500.00 $
	3	Geologist (No 2)	hour	100.10 $	300	30,030.00 $
	4	Helper (No 2) (Local)	hour	35.00 $	300	10,500.00 $
	5	High precision GPS (2)	month	2,500.00 $	2	5,000.00 $
	6	Board and room (2 person for 30 days)	day	120.50 $	60	7,230.00 $
	7	Pick-up (2)	day	150.00 $	60	9,000.00 $
	8	Pick-up expenses (2)	day	50.00 $	60	3,000.00 $
				Sub-Total		**105,290.00 $**
E		**Sample Borehole (12 borehole, 240 m total estimate length)**				
	1	Drill Equipment	day	450.00 $	30	13,500.00 $
	2	Operator	hour	64.90 $	300	19,470.00 $
	3	Technician	hour	80.30 $	300	24,090.00 $
	4	Helper (Native) (Local)	hour	35.00 $	300	10,500.00 $
	5	Board and Room (2 men for 30 days)	day	120.50 $	60	7,230.00 $
	6	Pick-up	day	150.00 $	30	4,500.00 $
	7	Pick-up expenses	day	50.00 $	30	1,500.00 $
	8	Drilling consummable	m	25.00 $	240	6,000.00 $
	9	Piston sampler	day	25.50 $	5	127.50 $
	10	Work in cold condition (if required)	day	120.00 $		- $
	11	Water heather (if required)	day	60.00 $		- $
	12	Piezometers (estimate)	each	250.00 $	12	3,000.00 $
						89,917.50 $
F		**Dynamic penetrometer and in situ vane testing**				
	1	Equipments	day	375.00 $	36	13,500.00 $
	2	Operator	hour	64.90 $	360	23,364.00 $
	3	Technician	hour	80.30 $	400	32,120.00 $
	4	Helper (Native) (Local)	hour	35.00 $	400	14,000.00 $
	5	Board and Room (2 men for 36 days)	day	120.50 $	72	8,676.00 $
	6	Pick-up	day	150.00 $	40	6,000.00 $
	7	Pick-up expenses	day	50.00 $	40	2,000.00 $
	8	Sounding consummable	sounding	20.00 $	98	1,960.00 $
						101,620.00 $

		Activities	Unit	Unit Cost	Qty	Estimate Cost
G		**Percussion testing**				
	1	Equipment (No 1)	day	180.00 $	36	6,480.00 $
	2	Operator (No 1)	hour	64.90 $	360	23,364.00 $
	3	Technician (No 1)	hour	80.30 $	400	32,120.00 $
	4	Helper (Native) (No 1) (Local)	hour	35.00 $	400	14,000.00 $
	5	Equipment (No 2)	day	180.00 $	36	6,480.00 $
	6	Operator (No 2)	hour	64.90 $	360	23,364.00 $
	7	Technician (No 2)	hour	80.30 $	400	32,120.00 $
	8	Helper (Native) (No 2) (Local)	hour	35.00 $	400	14,000.00 $
	9	Board and Room (4 men for 30 days)	day	120.50 $	120	14,460.00 $
	10	Pick-up (2)	day	150.00 $	72	10,800.00 $
	11	Pick-up expenses (2)	day	50.00 $	72	3,600.00 $
	12	Sounding consummable (200 sounding estimate)	sounding	10.00 $	200	2,000.00 $
						182,788.00 $
H		**Test Pit**				
	1	Excavator	day	90.00 $	10	900.00 $
	2	Operator	hour	64.90 $	10	649.00 $
	3	Technician	hour	80.30 $	10	803.00 $
	4	Board and Room (1 men for 10 days)	day	120.50 $	10	1,205.00 $
	5	Pick-up	day	150.00 $	10	1,500.00 $
	6	Pick-up expenses	day	50.00 $	10	500.00 $
						5,557.00 $
I		**Investigation expenses**				
J		**Demobilisation**	Lump sum	23,575.80 $	1	**23,575.80 $**
K		**Lab testing**				
	1	Water content	test	23.50 $	36	846.00 $
	2	Sample description	test	56.00 $	24	1,344.00 $
	3	Sieves analysis (greater then 5 mm)	test	108.00 $	20	2,160.00 $
	4	Sieves analysis (smaller then 5 mm)	test	71.00 $	30	2,130.00 $
	5	Grain size distribution (Sedimentation test)	test	84.00 $	12	1,008.00 $
	6	One dimension consolidation	test	600.00 $	3	1,800.00 $
	7	Maximum volumetric mass (Proctor)	test	191.00 $	5	955.00 $
	8	Soil index (Atterberg's Limits)	test	85.00 $	6	510.00 $
	9	Triaxial test (CIU)	test	750.00 $	3	2,250.00 $
		Report				**13,003.00 $**
L		**Work following at the office, Calculations and Report**				
	1	Senior engineer	hour	185.00 $	100	18,500.00 $
	2	Intermediate engineer	hour	100.00 $	200	20,000.00 $
	3	Junior engineer	hour	75.00 $	100	7,500.00 $
	4	Office support	hour	65.00 $	30	1,950.00 $
	5	Drafting	hour	93.75 $	100	9,375.00 $
	6	Rapport expenses (on cost)	estimate	2,500.00 $	1	2,500.00 $
						59,825.00 $
				Total:		**736,878.10 $**

		Others cost (not included)				
		Helicopter estimation cost (20 days, 4 hours a day) (estimate)	hour	1,650.00 $	80	**132,000.00 $**
		Mid campaign break (if required)	each	40,768.00 $	1	**40,768.00 $**

APPENDIX L

AMEC TECHNICAL MEMO ON FROST DEPTH FOR THE LOWER CHURCHILL PROJECT

Memo

To	**SLI Foundation Design Team (SLI)**	File no	**TF1116574**
From	**Janet Williams, P. Eng (AMEC)**	cc	**Calvin Miles** **Prapote Boonsinsuk**
Tel	**709.722.7023**		
Fax	**709.722.7353**		
Date	**December 9, 2011**		

Subject **Transmission Line Foundations, Lower Churchill Project: Frost Depth Estimation**

INTRODUCTION

In late September, 2011, members of AMEC's Environment and Infrastructure (AMEC), St. John's office were requested to join SNC Lavalin's (SLI), Lower Churchill Project (LCP) team in order to provide geotechnical expertise with respect to the surficial and bedrock geology that would be encountered along the AC and DC line corridors and to provide specific geotechnical parameters related to design of the transmission tower foundations along the corridors. As part of this work, AMEC was asked to provide the estimated depth of frost along the transmission line corridor. Below is a summary of the methodology used to determine the frost penetration depths.

METHODOLOGY

The transmission line corridor was divided into six sections, in accordance with mean freezing index conditions, as follows:

HVDC
1. Soldier's Pond- Sunnyside
2. Sunnyside to Grand Falls
3. Grand Falls - Shoal Cove
4. Forteau - Muskrat Falls

HVAC
1. Muskrat Falls - Pope's Hill
2. Pope's Hill - Churchill Falls

As per the Canadian Foundation Engineering Manual, 4th Edition (CFEM), the modified Berggren equation was used to calculate the frost penetration depths. The primary input for this calculation is the surface freezing index which is estimated from the design air freezing index and a ground surface interface factor. Common practice is to use the coldest winter data for the last ten years to determine the design surface freezing index. However, an in depth evaluation

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of historical climate data was not possible since this data is not available for much of the line corridor. Therefore, a modified equation given in the CFEM, which calculates the design air freezing index based on the mean freezing index, was used. The mean freezing index was obtained from Environment Canada's National Climate Data and Information Archive website. For each line segment, data from weather stations near the line corridor were evaluated and the highest mean air freezing index for each line segment was used in the design air freezing index calculation. The ground surface interface factor was taken as 0.7 for bare soil as per Technical Manual No. 5-852-6, Air Force Regulation AFR88-19, Volume 6.

Another input into the Berggren equation is the thermal conductivity of the frozen soil. CFEM provides two charts (after Kerstren, 1949) to determine this value; one for coarse grained soil and one for fine grained soil. The majority of the foundations that will be founded on soil are located in areas of glacial till which is a diamicton of sand and fines, with gravel, cobbles and boulders and fits neither the definition of fine grained or coarse grained soil. Also the moisture content of the soil, which affects the thermal conductivity value, varies depending on the water table location. Therefore the thermal conductivity was determined by evaluating the glacial till as both a fine grained and coarse grained material and with varying moisture contents. The highest thermal conductivity (which results in the deepest frost penetration) was assumed to be a moist, coarse grained material with a moisture content of 10%. The dry unit weight of the glacial till was taken as 18.4 kN/m^3 as per AMEC's memo dated November 21, 2011.

Following the methodology outlined in CFEM, the frost penetration depth was calculated as summarized below:

Table 1. Estimated Frost Penetration Depths

Transmission Line Location	Calculated Frost Depth (m)
HVDC	
Soldier's Pond- Sunnyside	1.7
Sunnyside to Grand Falls	2.0
Grand Falls - Shoal Cove	2.3
Forteau - Muskrat Falls	3.0
HVAC	
Muskrat Falls - Pope's Hill	3.0
Pope's Hill - Churchill Falls	3.5

CLOSURE

This memo was prepared for the exclusive use of SNC Lavalin (SLI) and their client Nalcor Energy (Nalcor) for specific application to the project site. The interpretation of the geological conditions and soils data was performed using generally accepted engineering/geological practices used in the industry and in accordance with the work plan developed with SLI. No other warranty is expressed or implied.

We trust that this information meets your current needs, if you have any questions or concerns please do not hesitate to contact us.

Sincerely,

AMEC Environment & Infrastructure
a division of AMEC Americas Limited

Janet Williams, P. Eng.
Geotechnical Engineer

Calvin Miles, P Geo
Senior Associate

Reviewed By:

Prapote Boonsinsuk, Ph.D., P. Eng.
Principal Geotechnical Engineer