



June 27, 2018

## FOUNDATION INVESTIGATION REPORT

**REPLACEMENT OF NAGAGAMISIS NARROWS BRIDGE - SITE NO. 38N-001  
HIGHWAY 631, TOWNSHIP OF FROST, ONTARIO  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5569-09-00, WP 5312-14-01**

**Submitted to:**

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REPORT





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# PART A

FOUNDATION INVESTIGATION REPORT  
REPLACEMENT OF NAGAGAMISIS NARROWS BRIDGE – SITE NO. 38N-001  
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MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5569-09-00, WP 5312-14-01



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Nagagamisis Narrows Bridge (Site No. 38N-001). The bridge is located on Highway 631 about 50 km southwest of Hearst and about 30 km north of Hornepayne, in the Township of Frost, Ontario.

The purpose of this investigation is to establish the subsurface soil and bedrock conditions at the proposed bridge location, including the associated approach embankments and detour alignment, by borehole drilling, rock coring and laboratory testing on selected soil and rock core samples.

The Terms of Reference and Scope of Work for the Foundation Investigation are outlined in MTO's Request for Proposal dated April 2016. Golder's proposal for foundation engineering services associated with replacement of this structure is contained in Section 17.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundations engineering services for this project, dated November 1, 2016.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and therefore may differ from magnetic north shown on the drawing. Highway 631 is generally oriented in a north-south direction.

## **2.0 SITE DESCRIPTION**

The surrounding land at the site is generally flat, with dense tree-covered terrain. The bridge is located within the Nagagamisis Provincial Park. The Nagagamisis Narrows Bridge is situated at a narrows which separates the Nagagamisis Lake into two sections. The Narrows is about 16 m wide at the existing bridge and the water flows in a westerly direction.

The existing bridge is a three-span bridge about 27 m long by 10 m wide, consisting of wood deck on steel girders that was originally constructed in 1959. The existing approach embankments are about 2 m to 3 m high relative to the lake. The existing highway grade is between approximately Elevations 289.6 m and 289.8 m. The water level in Nagagamisis Narrows was measured at the bridge site at Elevation 286.9 m in November 2016, Elevation 287.4 m in May 2017, Elevation 287.2 m in June 2017 and Elevation 286.8 m in August 2017.

Photographs at the bridge are shown on Photographs 1 to 4, following the text of this report.

## **3.0 INVESTIGATION PROCEDURES**

The field work was carried out on May 29, 2017, between June 10 and June 12, 2017, and on August 17 and 18, 2017, during which time a total of eight boreholes (Boreholes NG-1 to NG-8) were advanced at the locations shown on Drawing 1. The borehole and drillhole records are presented in Appendix A. The field investigation was carried out using the following drilling equipment:

- Boreholes NG-1, NG-2, NG-4, and NG-7 were advanced using a CME-55 truck-mounted drill rig supplied and operated by Landcore Drilling Inc. (Landcore) of Sudbury, Ontario.
- Boreholes NG-3 and NG-8 were advanced using a CME-55 track-mounted drill rig supplied and operated by Downing Drilling Inc. (Downing) of Grenville-sur-la-Rouge, Quebec.



- Boreholes NG-5 and NG-6 were advanced using a Boart Longyear LF-70 DD skid-mounted drill supplied and operated by Downing.

The boreholes were advanced using solid stem augers, 108 mm inner diameter hollow stem augers and/or NW casing and wash boring. Where coring through cobbles, boulders or bedrock was required, an NQ-size core barrel was used. Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586).

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and a standpipe piezometer was installed in Borehole NG-1 to permit monitoring of the groundwater level. The piezometer consisted of a 50 mm diameter polyvinyl chloride (PVC) pipe, with a slotted screen, sealed within a sand filter pack at a selected depth interval within the borehole. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled with bentonite pellets to create a seal and cuttings were placed to the pavement structure. The piezometer installation details and water level readings are indicated on the borehole records contained in Appendix A. The piezometer was abandoned in accordance with Ontario Regulation 903 (as amended) on September 19, 2017.

The field work was supervised on a full-time basis by a member of Golder's staff, who located the boreholes in the field, arranged for the clearance of underground services, directed the drilling and sampling operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers and transported to Golder's Sudbury Laboratory for further examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Index and classification tests consisting of water content, Atterberg limits and grain size distribution were carried out on selected soil samples and uniaxial compressive strength (UCS) tests were carried out on selected bedrock core samples. The results of the laboratory testing on samples from the boreholes are presented on the borehole and drillhole records in Appendix A, and on figures in Appendix B.

Soil samples were obtained on May 29, 2017, from Boreholes NG-7 and NG-8, using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

Classification of the rock mass quality of the bedrock with respect to the Rock Quality Designation (RQD) and UCS are described based on Table 3.10 and Table 3.5, respectively, of the *Canadian Foundation Engineering Manual* (CFEM, 2006<sup>1</sup>). The degree of weathering of the bedrock samples (i.e., fresh to slightly weathered) and the strength classification of the intact rock mass based on field identification (i.e., strong to very strong) are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM<sup>2</sup>) standard classification system.

The borehole locations and elevations were measured in the field by Golder personnel, relative to existing site features and surveyed to point HCP-101. The borehole locations (referenced to the MTM NAD83 co-ordinate

<sup>1</sup> Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4<sup>th</sup> Edition.

<sup>2</sup> International Society for Rock Mechanics Commission on Test Methods, 1985. *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.* Vol 22, No. 2, pp. 51-60.



system), ground surface elevations (referenced to Geodetic datum) and borehole depths are presented on the borehole records in Appendix A, and are summarized below.

Borehole	Location (MTM NAD 83, Zone12)		Location (World Geodetic System 84)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing	Easting	Latitude	Longitude		
NG-1	5482064.5	252206.8	49.474146	-84.725752	289.8	9.6
NG-2	5482075.2	252218.0	49.474243	-84.725599	289.7	14.8
NG-3	5482101.1	252243.1	49.474478	-84.725256	289.6	14.5
NG-4	5482112.6	252253.5	49.474583	-84.725114	289.6	9.8
NG-5	5482064.7	252222.7	49.474149	-84.725532	287.8	13.8
NG-6	5482094.4	252252.8	49.474419	-84.725121	286.9	11.5
NG-7	5482078.4	252214.2	49.474272	-84.725651	289.8	14.6
NG-8	5482104.2	252239.8	49.474506	-84.725302	289.6	14.5

## 4.0 SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>3</sup> mapping, the Nagagamisis Narrows Bridge site is located within a kame field/terrace/moraine deposit consisting primarily of sand and gravels.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)<sup>4</sup>, the site is underlain by bedrock from the metasedimentary suite of rocks comprised of wacke, arkose, argillite, slate, marble, chert, iron formation and minor metavolcanic rock and bordered by muscovite-bearing granitic rocks comprising muscovite-biotite and cordierite-biotite granites and granodiorite-tonalite.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced in the vicinity of the Nagagamisis Narrows bridge replacement, with the results of the laboratory tests carried out on selected soil and bedrock samples, are presented on the borehole records in Appendix A, and the laboratory test sheets in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the borehole records and in Section 4 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile and cross-sections on Drawings 1 and 2 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil and bedrock conditions will vary between and beyond the borehole locations. Descriptions of the subsurface conditions encountered in the boreholes are provided in the following sub-sections of this report.

Groundwater levels/conditions encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized.

<sup>3</sup> Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 42FNE

<sup>4</sup> Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543



Groundwater levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt.

## 4.2.1 Subsoil Conditions

A description of the soil deposits encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Surface Elevation (m)	Deposit Thickness (m)	N Values (blows)	Laboratory Testing
				Relative Density	
Asphalt	NG-1 to NG-4, NG-7 & NG-8	289.6 – 289.8	0.025 – 0.1	n/a	n/a
Reclaimed Asphalt Pavement (RAP)	NG-1 to NG-4	289.56 – 289.76	0.05 – 0.11	n/a	n/a
Gravelly Sand to Sand (Fill)	NG-1 to NG-4, NG-7 & NG-8 (containing additional asphalt/RAP layers in NG-3)	289.2 – 289.6	2.0 – 4.5	N = 2 – 68	w = 5% – 26% 5 – M (Fig. B1)
				Very Loose to Very Dense	
Sandy Peat or Organic Silty Sand	NG-1, NG-3, NG-8	285.1 – 287.6	0.2 – 1.1	N = 2	w = 72% and 112% Oc = 3.7% and 13.5% 1 – MH (Fig. B2)
				Very Loose	
Sand <sup>1</sup> (Silt and Sand in Borehole NG-8)	NG-1, NG-2, NG-4 to NG-8	284.0 – 287.8	0.9 – 5.0	N = 1 – 49	w = 8% – 50% 11 – M (Fig. B3) 1 – MH (Fig. B4) 1 – NP
				Very Loose to Dense	
Sandy Clayey Silt	NG-7	282.6	0.6	n/a	w = 41% 1 – AL (Fig. B5) 1 – MH (Fig. B6) w <sub>l</sub> = 27% w <sub>p</sub> = 19% I <sub>p</sub> = 8%
(TILL) <sup>2</sup> Silty Sand or Sand and Gravel	NG-1 to NG-8	281.7 – 284.7	> 1.5 – 6.2	N = 18 – 118	w = 6% – 18% 9 – MH (Fig. B7)
				Compact to Very Dense	

**Where:**

N = SPT 'N'-value; number of blows for 0.3 m of penetration  
w = natural moisture content (%)  
M = sieve analysis for particle size  
MH = combined sieve and hydrometer analysis  
AL = Atterberg Limit Tests

NP = non-plastic test result in Atterberg limits  
w<sub>p</sub> = plastic limit (%)  
w<sub>l</sub> = liquid limit (%)  
I<sub>p</sub> = plasticity index (%)  
Oc = organic content test

**Notes:**

- 1) A 0.6 m sand and gravel layer was encountered at 3.8 m depth in NG-4.
- 2) Cobbles and boulders ranging from 75 mm to 230 mm were encountered in the till deposit in all of the boreholes.





## 4.2.2 Bedrock/Refusal

Bedrock was cored in Boreholes NG-2, NG-3, and NG-5 to NG-8 and the depth/elevation of the bedrock surface is presented below.

Borehole No.	Location	Depth to Bedrock (m)	Bedrock Surface Refusal Elevation (m)	Bedrock Coring (m)
NG-2	South Abutment	11.6	278.1	3.2 m
NG-3	North Abutment	11.1	278.5	3.4 m
NG-5	South Abutment (Detour)	10.4	277.4	3.4 m
NG-6	North Abutment (Detour)	8.4	278.5	3.1 m
NG-7	South Abutment	11.6	278.2	3.0 m
NG-8	North Abutment	11.0	278.6	3.5 m

The retrieved bedrock cores from the boreholes are described as fresh, fine to coarse-grained, grey to black/pink granite. More detailed descriptions of the bedrock cores are presented on the drillhole records in Appendix A, including data regarding the discontinuity frequency and type. Photographs of the bedrock core samples are shown on Figure B8 in Appendix B. The bedrock properties, as encountered in the cored boreholes and/or tested on selected samples, are summarized below. The UCS laboratory test sheet is presented in Table B2 in Appendix B.

Borehole No.	Total Core Recovery (TCR)	Rock Quality Designation (RQD)	Quality Classification (Table 3.10 of CFEM 2006 <sup>5</sup> )	UCS (MPa)	Strength Classification (Table 3.5 of CFEM 2006)
NG-2	100%	100%	Excellent	146	(R5) Very Strong
NG-3	100%	100%	Excellent	128	(R5) Very Strong
NG-5	100%	90% - 100%	Excellent	94	(R4) Strong
NG-6	100%	95% - 100%	Excellent	87	(R4) Strong
NG-7	100%	100%	Excellent	180	(R5) Very Strong
NG-8	100%	100%	Excellent	118	(R5) Very Strong

## 4.3 Groundwater Conditions

The following table summarizes the unstabilized groundwater levels measured in the open boreholes upon completion of drilling, and groundwater levels measured in the piezometer on June 12, 2017. Water levels should be expected to vary depending on the time of year and precipitation events.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater Level (m)	Approximate Groundwater Elevation (m)
NG-1 (In piezometer)	289.9	2.5	287.3
NG-2	289.7	2.7	287.0

<sup>5</sup> Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition.





<b>Borehole No.</b>	<b>Ground Surface Elevation (m)</b>	<b>Depth to Groundwater Level (m)</b>	<b>Approximate Groundwater Elevation (m)</b>
NG-3	289.6	2.4	287.2
NG-4	289.6	3.0	286.6
NG-5	287.8	0.6	287.2
NG-6	286.9	0.0	286.9
NG-7	289.8	2.7	287.1
NG-8	289.6	2.1	287.5

The lake water level was surveyed by others at Elevation 286.9 m in November 2016 and by Golder at Elevation 287.4 m in May 2017, at Elevation 287.2 m in June 2017 and at Elevation 286.8 m in August 2017.

## **5.0 CLOSURE**

The field drilling program was supervised by Mr. Shane Albert and Mr. Mathew Riopelle. This Foundation Investigation Report was prepared by Ms. Aronne-Kay De Souza, EIT, and the technical aspects were reviewed by Mr. André Bom, P.Eng., a geotechnical engineer and Associate of Golder. Ms. Lisa Coyne, P.Eng., a senior geotechnical engineer, Principal of Golder and Designated MTO Foundations Contact for Golder, conducted an independent quality control review of this report.

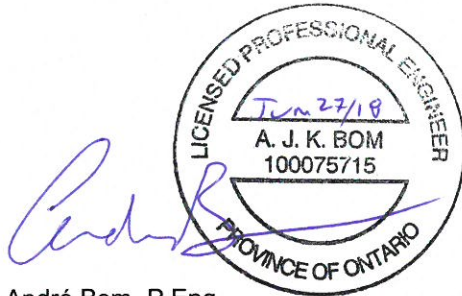


## Report Signature Page

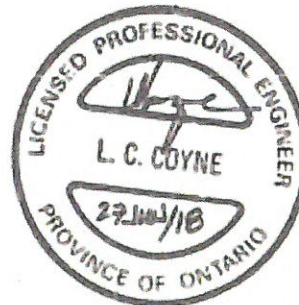
GOLDER ASSOCIATES LTD.

*Aronne-Kay De Souza*

Aronne-Kay De Souza, EIT  
Geotechnical Engineering Intern



André Bom, P.Eng.  
Geotechnical Engineer



Lisa C. Coyne, P.Eng.  
Designated MTO Foundations Contact, Principal

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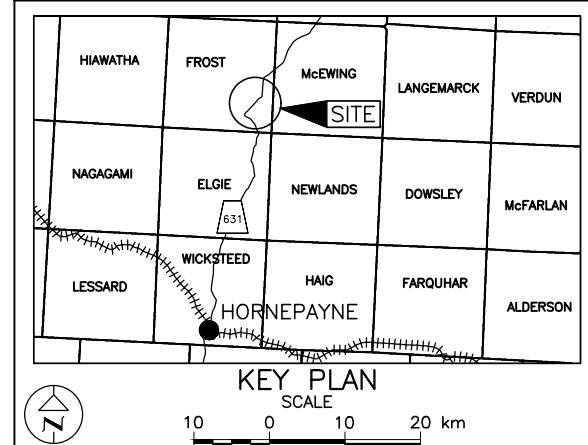
WL Elev. 286.8 m  
Aug. 20, 2017  
WL Elev. 287.2 m  
June 12, 2017

€ N. ABUT. BRGS.






**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN  
STATIONS IN KILOMETRES + METRES

CONT No.  
WP No. 5312-14-01

# HWY 631 NAGAMISIS NARROWS BRIDGE BOREHOLE LOCATIONS AND SOIL STRATA



## LEGEND

- |   |  |
|---|--|
|    | Borehole – Current Investigation                                   |
|    | Seal   |
|    | Piezometer   |
| N   | Standard Penetration Test Value                                    |
| 16  | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |
| 100%  | Rock Quality Designation (RQD)                                     |
|  | WL in piezometer, measured on JUN 12, 2017                         |
|  | WL upon completion of drilling                                     |

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 13)			
No.	ELEVATION	NORTHING	EASTING
NG-1	289.8	5482064.5	252206.8
NG-2	289.7	5482075.2	252218.0
NG-3	289.6	5482101.1	252243.1
NG-4	289.6	5482112.6	252253.5
NG-5	287.8	5482064.7	252222.7
NG-6	286.9	5482094.4	252252.8
NG-7	289.8	5482078.4	252214.2
NG-8	289.6	5482104.2	252239.8

## NOTES

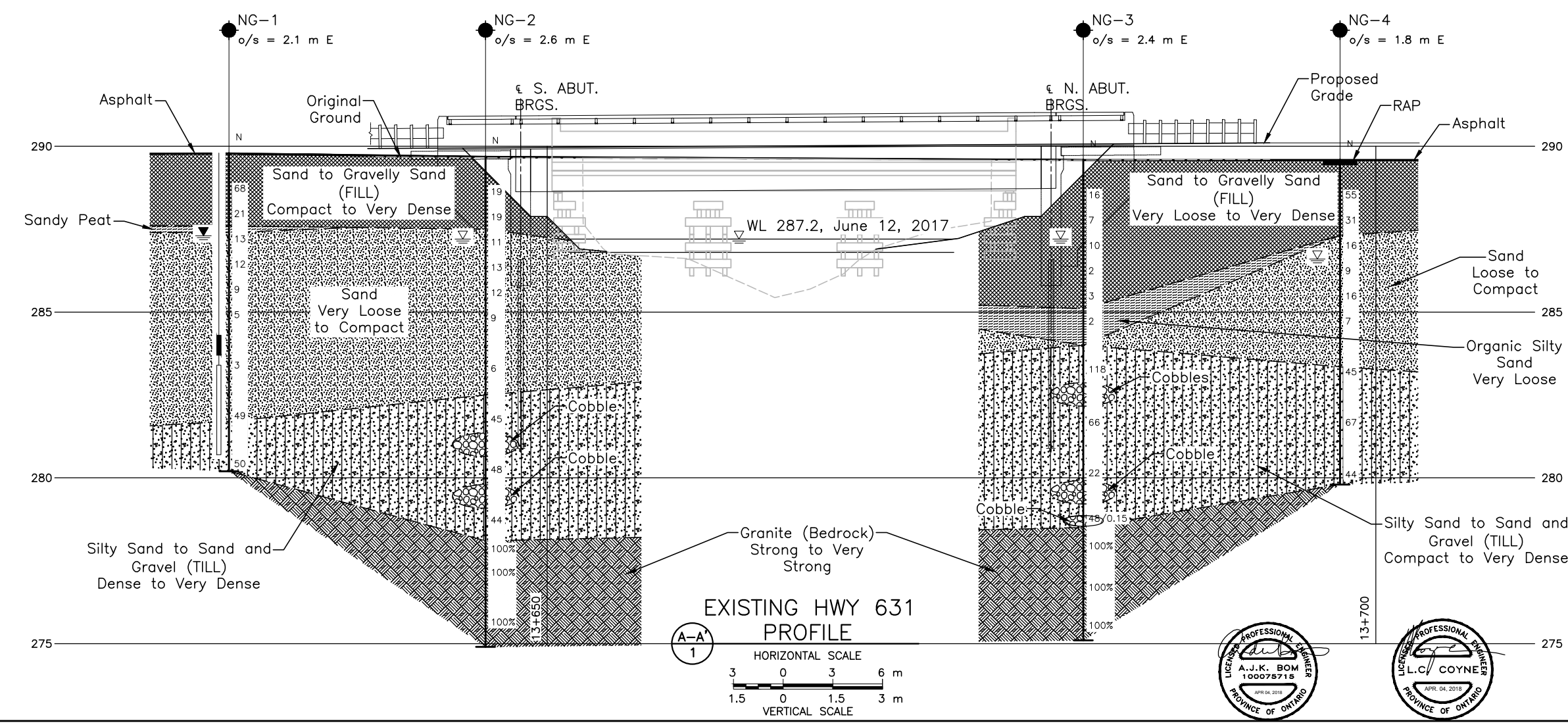
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Cobbles shown on this drawing are based on the conditions encountered in the boreholes. Cobbles and/or boulders are to be expected randomly throughout the till deposit.

## REFERENCE

Base plans provided in digital format by LEA Consulting LTD., drawing file nos. 17197-Nagagamis-General Arrangement.dwg and 17197-Detour General Arrangement-D1.dwg, received AUG 15, 2017.



EXISTING HWY 631  
PROFILE

HORIZONTAL SCALE

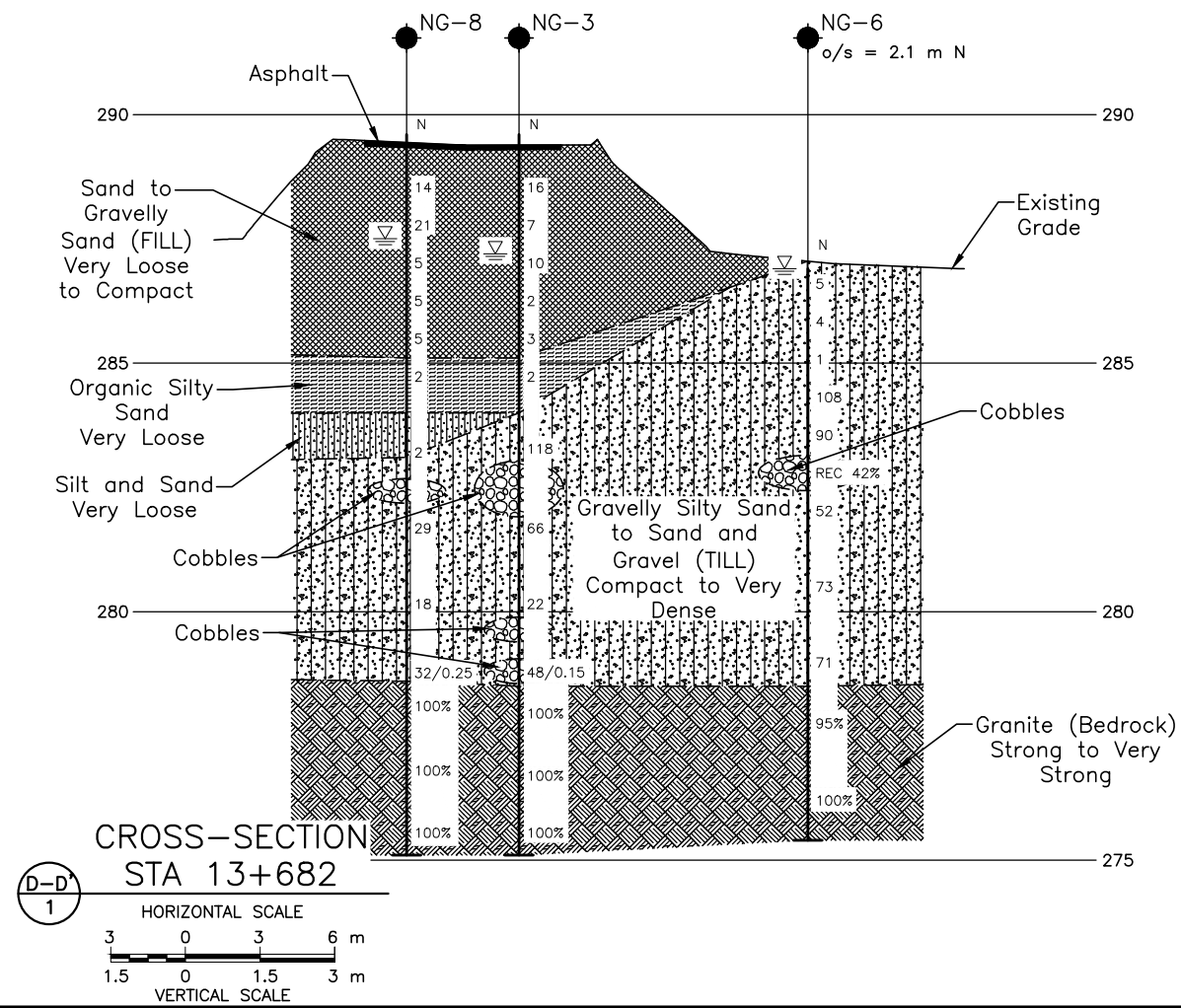
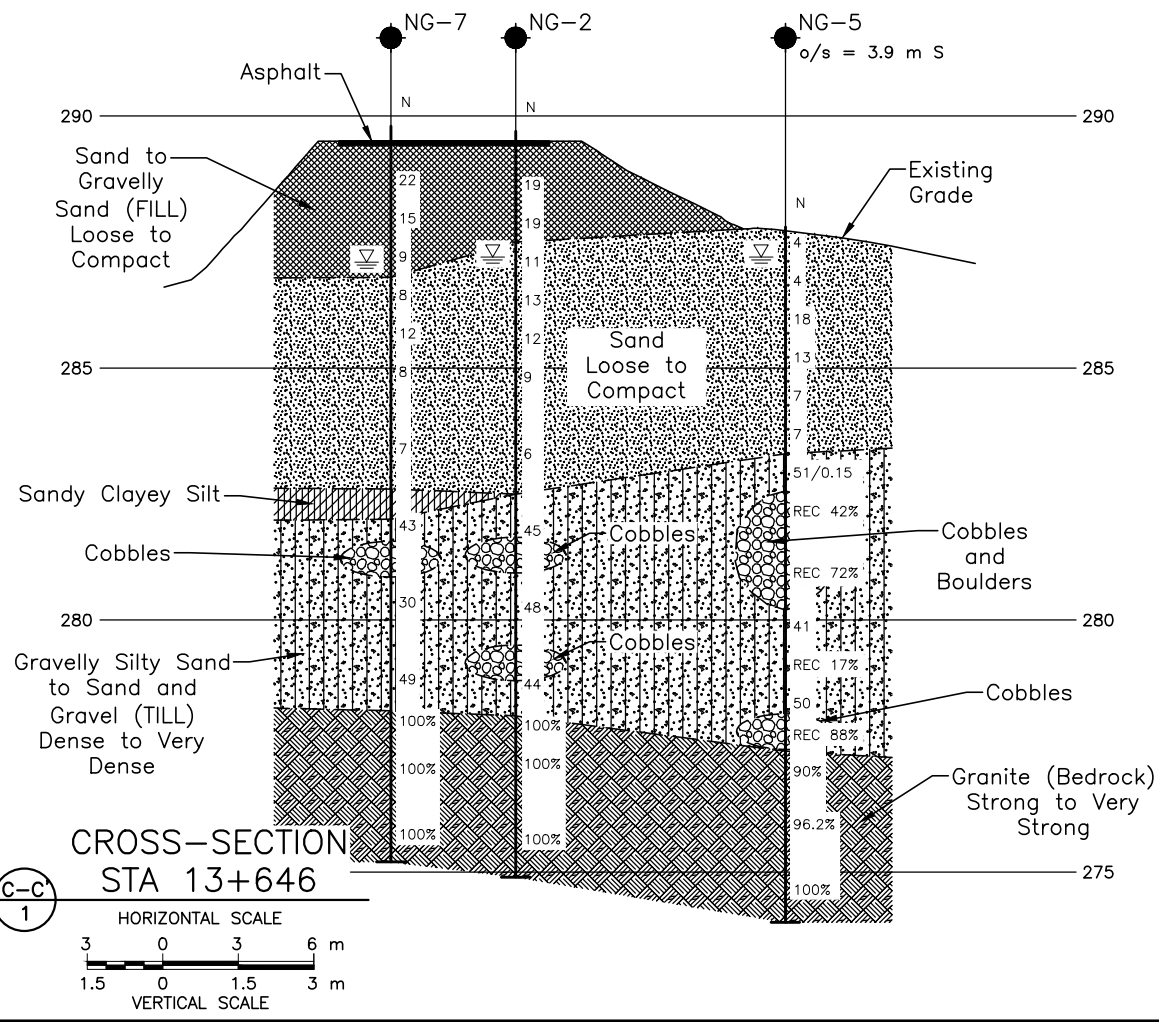
3 0 3 6 m


1.5 0 1.5 3 m





VERTICAL SCALE



-	-	-	-	-
NO.	DATE	BY	REVISION	
<b>Geocres No. 42F-054</b>				
HWY. 631		PROJECT NO. 1661607		DIST. .
SUBM'D.	CHKD. AC	DATE: 4/3/2018		SITE: 38N-001E
DRAWN: JJL/TB	CHKD. AB	APPD. LCC		DWG. 1



CONT No. WP No. 5312-14-01	
HWY 631 NAGAGAMISIS NARROWS BRIDGE SOIL STRATA	SHEET
	

LEGEND	
	Borehole – Current Investigation
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
REC	Recovery (%)
100%	Rock Quality Designation (RQD)
	WL upon completion of drilling

BOREHOLE CO-ORDINATES (NAD83 MTM ZONE 13)			
No.	ELEVATION	NORTHING	EASTING
NG-2	289.7	5482075.2	252218.0
NG-3	289.6	5482101.1	252243.1
NG-5	287.8	5482064.7	252222.7
NG-6	286.9	5482094.4	252252.8
NG-7	289.8	5482078.4	252214.2
NG-8	289.6	5482104.2	252239.8

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Base plans provided in digital format by LEA Consulting LTD., drawing file nos. 17197–Nagagamis–General Arrangement.dwg and 17197–Detour General Arrangement–D1.dwg, received AUG 15, 2017.



-	-	-	-	-
NO.	DATE	BY	REVISION	
<b>Geocres No. 42F-054</b>				
HWY. 631		PROJECT NO. 1661607		DIST. .
SUBM'D..	CHKD. AC	DATE: 4/3/2018	SITE: 38N-001	
DRAWN: TB	CHKD. AB	APPD. LCC	DWG. 2	





## PHOTOGRAPHS

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**Photograph 1: Nagagamisis Lake Bridge  
East elevation Looking North-West (May 2017)**



**Photograph 2: Nagagamisis Lake Bridge  
Looking North at South-East embankment (May 2017)**







## PHOTOGRAPHS

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**Photograph 3: Nagagamisis Lake Bridge  
North-East embankment bank looking South (May 2017)**



**Photograph 4: Nagagamisis Lake Bridge  
East elevation looking South-West (May 2017)**





# APPENDIX A

## Record of Boreholes





## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_C$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	secondary compression index
$m_v$	coefficient of volume change
$C_v$	coefficient of consolidation (vertical direction)
$C_h$	coefficient of consolidation (horizontal direction)
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

#### Dynamic Cone Penetration Resistance (DCPT); $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

#### (b) Cohesive Soils Consistency

	$c_u, s_u$	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

### V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

**Faintly weathered:** weathering limited to the surface of major discontinuities.

**Slightly weathered:** penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

**Moderately weathered:** weathering extends throughout the rock mass but the rock material is not friable.

**Highly weathered:** weathering extends throughout rock mass and the rock material is partly friable.

**Completely weathered:** rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

### BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

### JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

### GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: \* Grains greater than 60 microns diameter are visible to the naked eye.

### CORE CONDITION

#### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

#### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

#### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

### DISCONTINUITY DATA

#### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

#### Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

#### Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

#### Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

**RECORD OF BOREHOLE No NG-1**

1 OF 1 **METRIC**

PROJECT 1661607  
 W.P. 5312-14-01 LOCATION N 5482064.5; E 252206.8 MTM ZONE 12 (LAT. 49.474146; LONG. -81.725752) ORIGINATED BY SA  
 DIST            HWY 631 BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers COMPILED BY AC  
 DATUM GEODETIC DATE June 11, 2017 CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
289.8	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (40 mm)																
0.2	RAP (110 mm)																
289.3	Gravelly sand (FILL)																
0.5	Brown Moist																
	Sand, trace to some gravel, trace to some silt (FILL) Compact to very dense Brown Moist		1	SS	68		289										
			2	SS	21		288									18	74 (8)
287.6	Sandy PEAT, some silt Black Wet																
2.4	SAND, trace gravel, trace silt Very loose to dense Brown to grey Wet		3	SS	13		287										
			4	SS	12		286										
	200 mm to 300 mm of sand heaving in augers at Samples 5 to 7.		5	SS	9		285									6	89 (5)
			6	SS	5		284										
			7	SS	3		283										
281.7	Silty SAND, some gravel, trace clay (TILL) Dense to very dense Grey Wet		8	SS	49		282									5	90 (5)
8.1	Augers grinding from 8.1 m to 9.1 m depth.																
			9	SS	50		281										
280.2	END OF BOREHOLE															10	53 33 4
9.6	Note:  1. Water level at a depth of 2.5 m below ground surface (Elev. 287.3 m) upon completion of drilling and measured in piezometer on June 12, 2017.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA\_5015-E-0049\_NE REGION02\_DATA\GINT\1661607.GPJ GAL-MISS.GDT 11/8/17 TB\JUL


<b>PROJECT</b> 1661607		<b>RECORD OF BOREHOLE No NG-2</b>		1 OF 3 <b>METRIC</b>	
W.P. 5312-14-01		LOCATION N 5482075.2; E 252218.0 MTM ZONE 12 (LAT. 49.474243; LONG. -81.725599)		ORIGINATED BY SA	
DIST _____ HWY 631		BOREHOLE TYPE Solid Stem Augers, NW Casing and NQ Coring		COMPILED BY AC	
DATUM GEODETIC		DATE June 10 and 11, 2017		CHECKED BY AB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED	20	40	60	80	100	w <sub>p</sub>	w		w <sub>L</sub>				
289.7	GROUND SURFACE																				
0.0	ASPHALT (40 mm)																				
0.2	RAP (110 mm)																				
289.0	Gravelly sand (FILL) Brown Moist																				
0.7	Sand, some gravel, some silt (FILL) Compact Brown Moist		1	SS	19																
			2	SS	19																
287.5																					
2.2	SAND, trace gravel, trace silt Loose to compact Brown to grey Wet		3	SS	11													8	86   (6)		
			4	SS	13																
			5	SS	12																
			6	SS	9													11	85   (4)		
	150 mm to 200 mm of sand heaving in augers at Samples 6 and 7.																				
			7	SS	6																
282.5																					
7.2	SAND and GRAVEL to Gravelly Silty SAND, trace clay (TILL) Dense Gret Wet		8	SS	45													57	36   6   1		
	Four 100 mm diameter cobbles encountered from 8.2 m to 9.1 m depth.																				
			9	SS	48																
			10	SS	44																
278.1																					
11.6	Two 75 mm diameter cobbles encountered at 11.2 m and 11.3 m depth.		1	RC	REC 100%																
			2	RC																	

Continued Next Page

+ 3,  $\times$  3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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PROJECT <u>1661607</u>		<b>RECORD OF BOREHOLE No NG-2</b>				2 OF 3 <b>METRIC</b>												
W.P. <u>5312-14-01</u>		LOCATION <u>N 5482075.2; E 252218.0 MTM ZONE 12 (LAT. 49.474243; LONG. -81.725599)</u>				ORIGINATED BY <u>SA</u>												
DIST <u>          </u> HWY <u>631</u>		BOREHOLE TYPE <u>Solid Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>												
DATUM <u>GEODETIC</u>		DATE <u>June 10 and 11, 2017</u>				CHECKED BY <u>AB</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
--- CONTINUED FROM PREVIOUS PAGE ---																		
274.9 14.8	GRANITE (BEDROCK)  Bedrock cored from 11.6 m depth to 14.8 m depth.  For coring details see Record of Drillhole NG-2.		2	RC	REC 100%	277											RQD = 100%	
			3	RC	REC 100%	276												RQD = 100%
			275															
	END OF BOREHOLE  Note:  1. Water level at a depth of 2.7 m below ground surface (Elev. 287.0 m) upon completion of drilling.																	

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PROJECT: 1661607  
LOCATION: N 5482075.2; E 252218.0  
MTM ZONE 12 (LAT. 49.474243; LONG. -81.725599)  
INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: NG-2

SHEET 3 OF 3  
DATUM: GEODETIC

DRILLING DATE: June 11, 2017  
DRILL RIG: CME 55 Truck Mount  
DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY		FRACT INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION	
								FLUSH	TOTAL CORE %		SOLID CORE %	R.Q.D. %	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr				Ja
			REFER TO PREVIOUS PAGE		278.1															
12	CME 55 Truck Mount NQ Coring	GRANITE Very strong Fresh Fine to medium grained Grey to black / pink			11.6	1	GREY	100												
13					2	LIGHT GREY	100													
14					3	LIGHT GREY	100													
15		END OF DRILLHOLE			274.9															
16					14.8															
17																				
18																				
19																				
20																				
21																				
22																				
23																				

UCS = 146 MPa

DEPTH SCALE  
1 : 60



LOGGED: SA  
CHECKED: AB



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+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT: 1661607  
 LOCATION: N 5482101.1; E 252243.1  
 MTM ZONE 12 (LAT. 49.474478; LONG. -81.725256)  
 INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: NG-3

SHEET 3 OF 3  
 DATUM: GEODETIC

DRILLING DATE: June 10, 2017  
 DRILL RIG: LC CME 55 Track Mount  
 DRILLING CONTRACTOR: Gerge Downing Estate Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	JN - Joint FLT - Fault SHR - Shear VN - Vein CJ - Conjugate	BD - Bedding FO - Foliation CO - Contact OR - Orthogonal CL - Cleavage	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular	PO - Polished K - Slickensided SM - Smooth Ro - Rough MB - Mechanical Break	BR - Broken Rock	NOTES WATER LEVELS INSTRUMENTATION
		REFER TO PREVIOUS PAGE		278.5									
	NW	GRANITE Very strong Fresh Fine to medium grained Light grey to black		11.1	1	GREY	100						UCS = 128 MPa
12													
13					2	GREY	100						
14					3	GREY	100						
		END OF DRILLHOLE		275.1 14.5									
15													
16													
17													
18													
19													
20													
21													
22													
23													

DEPTH SCALE  
 1 : 60



LOGGED: MR  
 CHECKED: AC/AB

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**RECORD OF BOREHOLE No NG-4**

1 OF 1 **METRIC**

PROJECT 1661607  
W.P. 5312-14-01 LOCATION N 5482112.6; E 252253.5 MTM ZONE 12 (LAT. 49.474583; LONG. -81.725114) ORIGINATED BY SA  
DIST HWY 631 BOREHOLE TYPE NW Casing and Wash Boring COMPILED BY AC  
DATUM GEODETIC DATE June 12, 2017 CHECKED BY AB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× REMOULDED	WATER CONTENT (%)					
							20	40	60	80	100		20	40	60		
289.6	GROUND SURFACE																
0.0	ASPHALT (35 mm)																
	RAP (110 mm)																
0.3	Gravelly sand (FILL) Brown Moist																
	Sand, trace gravel, some silt (FILL) Dense to very dense Brown Moist		1	SS	55												
			2	SS	31								○				3 79 (18)
287.3																	
2.3	SAND, trace gravel Loose to compact brown Wet		3	SS	16												
			4	SS	9												
	A 0.6 m sand and gravel layer was encountered at 3.8 m depth.		5	SS	16								○				45 48 (7)
			6	SS	7												
283.4			7A														
6.3	Silty SAND, some gravel, trace clay (TILL) Dense to very dense Grey Wet		7B	SS	45								○				18 54 24 4
			8	SS	67												
			9	SS	44												
279.8																	
9.8	END OF BOREHOLE																
	Note:  1. Water level at a depth of 3.0 m below ground surface (Elev. 286.6 m) in open borehole 20 minutes after completion of drilling.																

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


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PROJECT 1661607		RECORD OF BOREHOLE No NG-5				1 OF 3 METRIC																																
W.P. 5312-14-01		LOCATION N 5482064.7; E 252222.7 MTM ZONE 12 (LAT. 49.474149; LONG. -81.725532)				ORIGINATED BY MR																																
DIST _____ HWY 631		BOREHOLE TYPE NW Casing and NQ Coring				COMPILED BY AC																																
DATUM GEODETIC		DATE August 18, 2017				CHECKED BY AB																																
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)																										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL																										
287.8 0.0	GROUND SURFACE SAND, trace to some gravel, trace silt Loose to compact Brown to grey Wet		1	SS	4		287					5 91 (4)																										
			2	SS	4		286					18 75 (7)																										
			3	SS	18		285																															
			4	SS	13		284																															
			5	SS	7																																	
			6	SS	7							3 94 (3)																										
283.3 4.5	Gravelly Silty SAND, trace clay (TILL) Dense to very dense Grey Wet  Cobbles and boulders were encountered at the following depths and sizes:  <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Depth (m)</th> <th>Size (mm)</th> </tr> </thead> <tbody> <tr><td>5.7</td><td>75</td></tr> <tr><td>5.8</td><td>75</td></tr> <tr><td>5.9</td><td>105</td></tr> <tr><td>6.0</td><td>120</td></tr> <tr><td>6.1</td><td>460</td></tr> <tr><td>6.6</td><td>120</td></tr> <tr><td>6.7</td><td>120</td></tr> <tr><td>6.8</td><td>150</td></tr> <tr><td>9.8</td><td>460</td></tr> <tr><td>10.0</td><td>200</td></tr> <tr><td>10.3</td><td>90</td></tr> <tr><td>10.4</td><td>105</td></tr> </tbody> </table> No recovery in Samples 8 and 9 after 2 attempts.	Depth (m)	Size (mm)	5.7	75	5.8	75	5.9	105	6.0	120	6.1	460	6.6	120	6.7	120	6.8	150	9.8	460	10.0	200	10.3	90	10.4	105		7	SS	51/0.15		283					
Depth (m)	Size (mm)																																					
5.7	75																																					
5.8	75																																					
5.9	105																																					
6.0	120																																					
6.1	460																																					
6.6	120																																					
6.7	120																																					
6.8	150																																					
9.8	460																																					
10.0	200																																					
10.3	90																																					
10.4	105																																					
			-	RC	REC 42%		282																															
			-	RC	REC 72%		281																															
			8	SS	41		280																															
			-	RC	REC 17%		279																															
			9	SS	50		278																															
			-	RC	REC 88%																																	
277.4 10.4	GRANITE (BEDROCK)  Bedrock cored from 10.4 m depth to 13.8 m depth.  For coring details see Record of Drillhole NG-5.		1	RC	REC 100%		277					RQD = 90%																										
			2	RC	REC 100%		276					RQD = 96%																										

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA\_5015-E-0049\_NE REGION02\_DATA\GINT\1661607.GPJ GAL-MISS.GDT 11/8/17 TBAJL

PROJECT <u>1661607</u>		<b>RECORD OF BOREHOLE No NG-5</b>				2 OF 3 <b>METRIC</b>												
W.P. <u>5312-14-01</u>		LOCATION <u>N 5482064.7; E 252222.7 MTM ZONE 12 (LAT. 49.474149; LONG. -81.725532)</u>				ORIGINATED BY <u>MR</u>												
DIST <u>          </u> HWY <u>631</u>		BOREHOLE TYPE <u>NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>												
DATUM <u>GEODETIC</u>		DATE <u>August 18, 2017</u>				CHECKED BY <u>AB</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub> W   W <sub>L</sub>					
	--- CONTINUED FROM PREVIOUS PAGE ---						20   40   60   80   100 ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED 20   40   60   80   100					WATER CONTENT (%)						
	GRANITE (BEDROCK)		2	RC	REC 100%													RQD = 96%
	Bedrock cored from 10.4 m depth to 13.8 m depth.  For coring details see Record of Drillhole NG-5.		3	RC	REC 100%													RQD = 100%
274.0 13.8	END OF BOREHOLE  Note:  1. Water level at a depth of 0.6 m below ground surface (Elev. 287.2 m) upon completion of drilling.																	

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INCLINATION: -90°      AZIMUTH: --

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DATUM: GEODETIC

1 : 60



CHECKED: AB



PROJECT 1661607			<b>RECORD OF BOREHOLE No NG-6</b>				1 OF 3 <b>METRIC</b>									
W.P. 5312-14-01		LOCATION N 5482094.4; E 252252.8 MTM ZONE 12 (LAT. 49.474419; LONG. -81.725121)				ORIGINATED BY MR										
DIST HWY 631		BOREHOLE TYPE NW Casing and NQ Coring				COMPILED BY AC										
DATUM GEODETIC		DATE August 17, 2017				CHECKED BY AB										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
286.9	GROUND SURFACE						20	40	60	80	100	20	40	60		
0.0	SAND, trace to some gravel, trace organics Very loose to loose Brown to grey Wet		1	SS	5											
			2	SS	4										11	85 (4)
			3	SS	1											
284.7																
2.2	Gravelly Silty SAND to Silty SAND and GRAVEL, trace clay (TILL) Very dense Grey Wet  90 mm and 140 mm diameter cobbles were encountered at 3.7 and 3.8 m depths, respectively		4	SS	108											
			5	SS	90										37	38 20 5
			-	RC	REC 42%											
			6	SS	52											
			7	SS	73										28	44 24 4
			8	SS	71											
278.5																
8.4	GRANITE (BEDROCK)  Bedrock cored from 8.4 m depth to 11.5 m depth.  For coring details see Record of Drillhole NG-6.		1	RC	REC 100%											RQD = 95%
			2	RC	REC 100%											RQD = 100%
275.4																
11.5																

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Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT <u>1661607</u>		<b>RECORD OF BOREHOLE No NG-6</b>				2 OF 3 <b>METRIC</b>																			
W.P. <u>5312-14-01</u>		LOCATION <u>N 5482094.4; E 252252.8 MTM ZONE 12 (LAT. 49.474419; LONG. -81.725121)</u>				ORIGINATED BY <u>MR</u>																			
DIST <u>          </u> HWY <u>631</u>		BOREHOLE TYPE <u>NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>																			
DATUM <u>GEODETIC</u>		DATE <u>August 17, 2017</u>				CHECKED BY <u>AB</u>																			
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>								
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between; font-size: small;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between; font-size: x-small;"> <span>○ UNCONFINED   + FIELD VANE</span> <span>● QUICK TRIAXIAL   × REMOULDED</span> </div>																		
	END OF BOREHOLE  Note:  1. Water level at ground surface (Elev. 286.9 m) upon completion of drilling.																								

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PROJECT: 1661607  
LOCATION: N 5482094.4; E 252252.8  
MTM ZONE 12 (LAT. 49.474419; LONG. -81.725121)  
INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: NG-6

SHEET 3 OF 3  
DRILLING DATE: August 17, 2017  
DATUM: GEODETIC

DRILL RIG: Boart Longyear LF-70 DD  
DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate										BD - Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage				PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular				PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break				BR - Broken Rock				NOTES WATER LEVELS INSTRUMENTATION
								RECOVERY		R.Q.D. %	FRACT INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q' AVG.											
								TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s																
																			FLUSH	80 80														

DEPTH SCALE  
1 : 60



LOGGED: MR  
CHECKED: AB

<b>PROJECT</b> 1661607		<b>RECORD OF BOREHOLE No NG-7</b>		1 OF 3 <b>METRIC</b>	
W.P. 5312-14-01		LOCATION N 5482078.4; E 252214.2 MTM ZONE 12 (LAT. 49.474272; LONG. -81.725651)		ORIGINATED BY SA	
DIST _____ HWY 631		BOREHOLE TYPE Solid Stem Augers, NW Casing and NQ Coring		COMPILED BY AC	
DATUM GEODETIC		DATE May 29, 2017		CHECKED BY AB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED							
289.8	GROUND SURFACE															
0.0	ASPHALT (50 mm)															
0.3	Gravelly sand (FILL)															
	ASPHALT (50 mm)															
	Sand, trace to some gravel, trace to some silt (FILL)															
	Loose to compact Brown Moist to wet															
			1	SS	22											
			2	SS	15									9 78 (13)		
			3	SS	9											
286.8																
3.0	SAND, trace to some gravel, trace silt Loose to compact Brown Wet		4	SS	8									14 79 (7)		
	Trace organics noted in Sample 4.		5	SS	12											
			6	SS	8											
			7	SS	7									5 92 (3)		
282.6																
7.2	Sandy CLAYEY SILT, trace gravel Loose to compact Grey Wet		8A											6 20 66 8		
282.0			8B	SS	43											
7.8	Gravelly Silty SAND to SAND and GRAVEL (TILL) Dense Grey Wet															
	Cobbles less than 100 mm encountered between 7.6 m and 10.7 m depth.		9	SS	30											
			10	SS	49									36 51 13 0		
278.2			1	RC	REC 100%									RQD = 100%		

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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PROJECT <u>1661607</u>		<b>RECORD OF BOREHOLE No NG-7</b>				2 OF 3 <b>METRIC</b>										
W.P. <u>5312-14-01</u>		LOCATION <u>N 5482078.4; E 252214.2 MTM ZONE 12 (LAT. 49.474272; LONG. -81.725651)</u>				ORIGINATED BY <u>SA</u>										
DIST <u>          </u> HWY <u>631</u>		BOREHOLE TYPE <u>Solid Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>										
DATUM <u>GEODETIC</u>		DATE <u>May 29, 2017</u>				CHECKED BY <u>AB</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100					
	GRANITE (BEDROCK)		2	RC	REC 100%	277										RQD = 100%
	Bedrock cored from 11.6 m depth to 14.6 m depth.  For coring details see Record of Drillhole NG-7.		3	RC	REC 100%	276										
275.2 14.6	END OF BOREHOLE  Note:  1. Water level at a depth of 2.7 m below ground surface (Elev. 287.1 m) upon completion of drilling.															

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PROJECT: 1661607  
 LOCATION: N 5482078.4; E 252214.2  
 MTM ZONE 12 (LAT. 49.474272; LONG. -81.725651)  
 INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: NG-7

SHEET 3 OF 3  
 DRILLING DATE: May 29, 2017  
 DATUM: GEODETIC

DRILL RIG: CME 55 Truck Mount  
 DRILLING CONTRACTOR: Landcore Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate										BD - Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage				PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular				PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break				BR - Broken Rock  NOTE: For additional abbreviations refer to list of abbreviations & symbols.				NOTES WATER LEVELS INSTRUMENTATION
							RECOVERY		R.Q.D. %	FRACT INDEX METRES	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q AVG.													
							TOTAL CORE %	SOLID CORE %			B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s																
							FLUSH	80 80																									

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DEPTH SCALE  
 1 : 60



LOGGED: SA  
 CHECKED: AB


PROJECT 1661607		<b>RECORD OF BOREHOLE No NG-8</b>				1 OF 3 <b>METRIC</b>										
W.P. 5312-14-01		LOCATION N 5482104.2; E 252239.8 MTM ZONE 12 (LAT. 49.474506; LONG. -81.725302)				ORIGINATED BY MR										
DIST _____ HWY 631		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring				COMPILED BY AC										
DATUM GEODETIC		DATE May 29, 2017				CHECKED BY AB										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
289.6	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT (50 mm)															
289.3	Gravelly sand (FILL)															
0.3	Sand, trace silt, trace asphalt (FILL) Loose to compact Brown to grey Wet															
			1	SS	14											
			2	SS	21											
			3	SS	5											
			4	SS	5											
	Trace organics at 3.8 m depth.		5	SS	5											
285.1																
4.5	ORGANIC Silty SAND, trace wood Very loose Black Wet		6	SS	2											
284.0																
5.6	SILT and SAND, trace clay, trace gravel, trace organics Very loose Grey Wet		7A	SS	2											
283.1			7B													
6.5	SAND and GRAVEL, trace to some silt to Gravelly Silty SAND (TILL) Compact to dense Grey Wet  A 125 mm cobble encountered at 6.6 m below ground surface.  A 250 mm cobble encountered at 7.1 m below ground surface.															
			8	SS	29											
			9	SS	18											
			10	SS	32/0.25											
278.6																
11.0	GRANITE (BEDROCK)															
	Bedrock cored from 11.0 m depth to 14.5 m depth.		1	RC	REC 100%											
	For coring details see Record of Drillhole NG-8.															

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA\_5015-E-0049\_NE REGION02\_DATAGINT\1661607.GPJ GAL-MISS.GDT 11/8/17 TB\JUL



PROJECT <u>1661607</u>		<b>RECORD OF BOREHOLE No NG-8</b>				2 OF 3 <b>METRIC</b>										
W.P. <u>5312-14-01</u>		LOCATION <u>N 5482104.2; E 252239.8 MTM ZONE 12 (LAT. 49.474506; LONG. -81.725302)</u>				ORIGINATED BY <u>MR</u>										
DIST <u>          </u> HWY <u>631</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AC</u>										
DATUM <u>GEODETIC</u>		DATE <u>May 29, 2017</u>				CHECKED BY <u>AB</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub> W   W <sub>L</sub>			
--- CONTINUED FROM PREVIOUS PAGE ---																
	GRANITE (BEDROCK)															
	Bedrock cored from 11.0 m depth to 14.5 m depth.  For coring details see Record of Drillhole NG-8.		2	RC	REC 100%											RQD = 100%
			3	RC	REC 100%											RQD = 100%
275.1 14.5	END OF BOREHOLE  Note:  1. Water level 2.1 m below ground surface (Elev. 287.5 m) inside augers prior to switching NW casing.															

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PROJECT: 1661607  
LOCATION: N 5482104.2; E 252239.8  
MTM ZONE 12 (LAT. 49.474506; LONG. -81.725302)  
INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: NG-8

SHEET 3 OF 3  
DRILLING DATE: May 29, 2017  
DATUM: GEODETIC

DRILL RIG: CME 55 Truck Mount  
DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN		JN - Joint FLT - Fault SHR- Shear VN - Vein CJ - Conjugate	BD- Bedding FO- Foliation CO- Contact OR- Orthogonal CL - Cleavage	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	PO- Polished K - Slickensided SM- Smooth Ro - Rough MB- Mechanical Break	BR - Broken Rock  NOTE: For additional abbreviations refer to list of abbreviations & symbols.	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
								RECOVERY	SOLID CORE %						R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA						HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
																	TOTAL CORE %	SOLID CORE %	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
11	NW  LC CME 55 Truck Mount NQ Coring	REFER TO PREVIOUS PAGE		278.6	1	GREY 100%																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

LOGGED: MR  
CHECKED: AB



DEPTH SCALE  
1 : 60

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# APPENDIX B

## Laboratory Test Results



**Table B1 - Summary of Analytical Testing of Soil Sample**

Parameter	Units	South Abutment (Borehole NG-7)	North Abutment (Borehole NG-8)
Resistivity	ohm-cm	3,900	3,200
Conductivity	µmho/cm	257	314
pH	pH	8.12	7.05
Sulphate	µg/g	Not Detected	Not Detected
Chloride	µg/g	81	43

Notes:

1. Sample obtained May 29, 2017
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: AD  
Reviewed by: AB

**Golder Associates Ltd.**

33 Mackenzie Street, Suite 100  
 Sudbury, Ontario, Canada P3C 4Y1  
 Telephone: (705) 524-6861  
 Fax: (705) 524-1984



## TABLE B2 - SUMMARY OF ROCK CORE TEST DATA

PROJECT NO.: 1661607

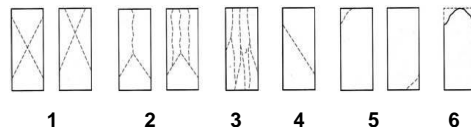
JOB NAME: Nagagamisis Narrows Bridge

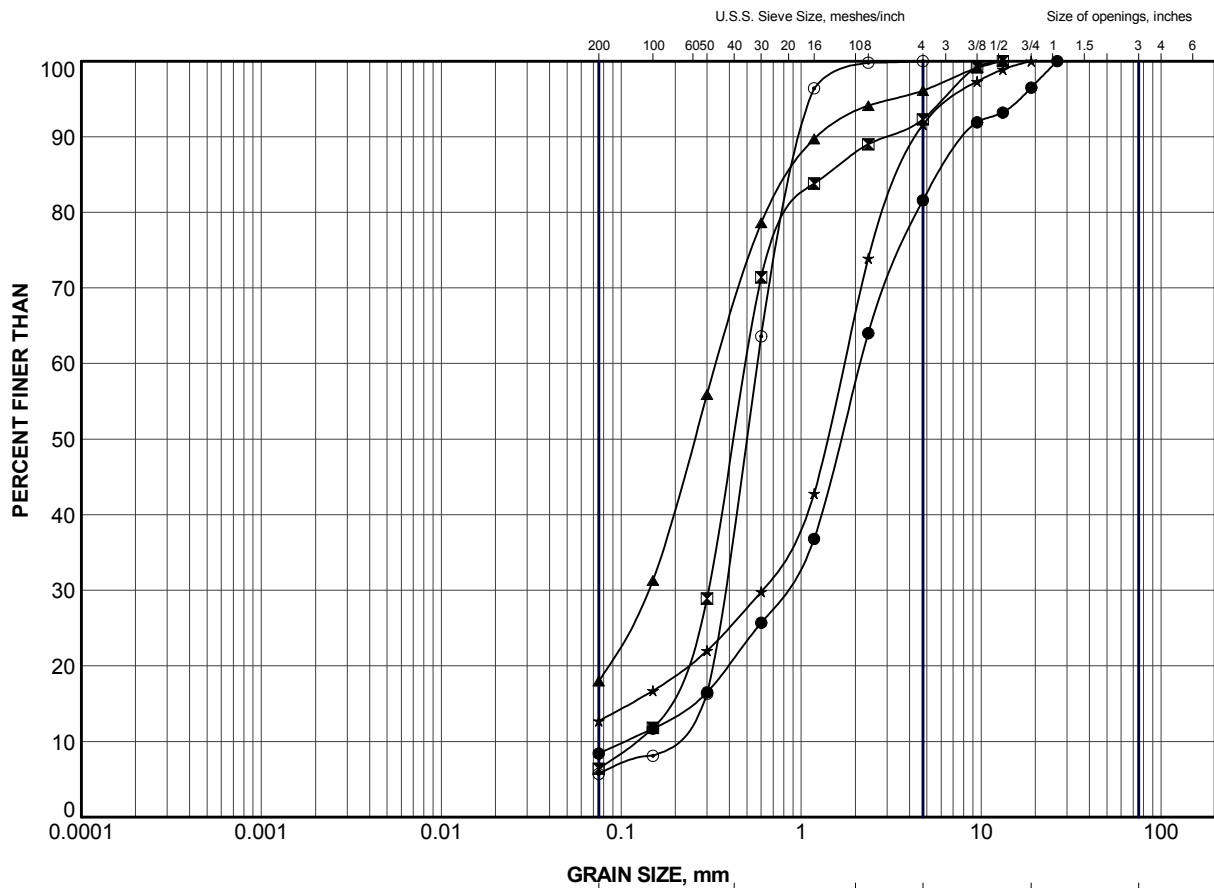
TYPE OF UNIT: Bedrock Core

BOREHOLE	NG-2	NG-3	NG-5	NG-6	NG-7	NG-8
GOLDER LAB #	C1012	C1017	C1528	C1532	C647	C641
DATE TESTED	Jul. 25, 2017	Jul. 25, 2017	Sept. 19, 2017	Sept. 19, 2017	Jun. 9, 2017	Jun. 9, 2017
TESTED BY	JM/DM	JM/DM	JP	JP	EHS	EHS
DEPTH OF TESTED CORE (m)	13.1	11.3	11.9	9.8	11.9	12.5
LENGTH (mm)	100.9	97.5	100.3	101.0	95.8	96.1
DIAMETER (mm)	47.0	47.3	47.0	47.0	47.1	47.6
DENSITY (kg/m3)	2625	2625	2585	2568	2661	2554
COMPRESSIVE STRENGTH (MPa)	145.6	128.0	94.0	86.7	180.1	117.9
TYPE OF FRACTURE	1	1	2	3	1	1

Checked by : AB

Type of Fracture





### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-1	2	288.0
⊠	NG-3	3	287.0
▲	NG-4	2	287.8
★	NG-7	2	288.0
⊙	NG-8	3	287.0

PROJECT

HIGHWAY 631  
NAGAGAMISIS NARROWS BRIDGE

TITLE

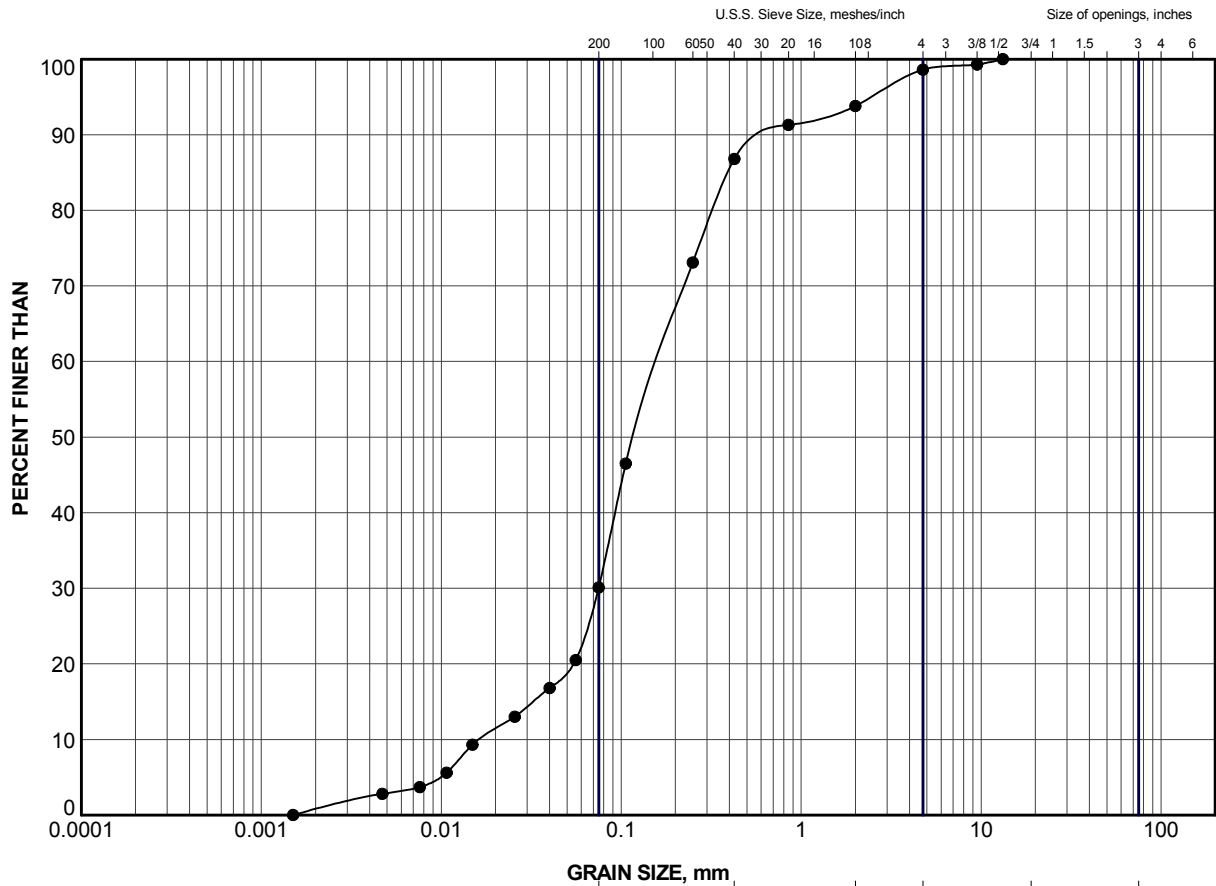
**GRAIN SIZE DISTRIBUTION**  
SAND (FILL)



**Golder Associates**  
SUDBURY, ONTARIO

PROJECT No. 1661607		FILE No. 1661607.GPJ	
DRAWN	TB	Sep 2017	SCALE N/A
CHECK	AB	Sep 2017	REV.
APPR		Sep 2017	

**FIGURE B1**

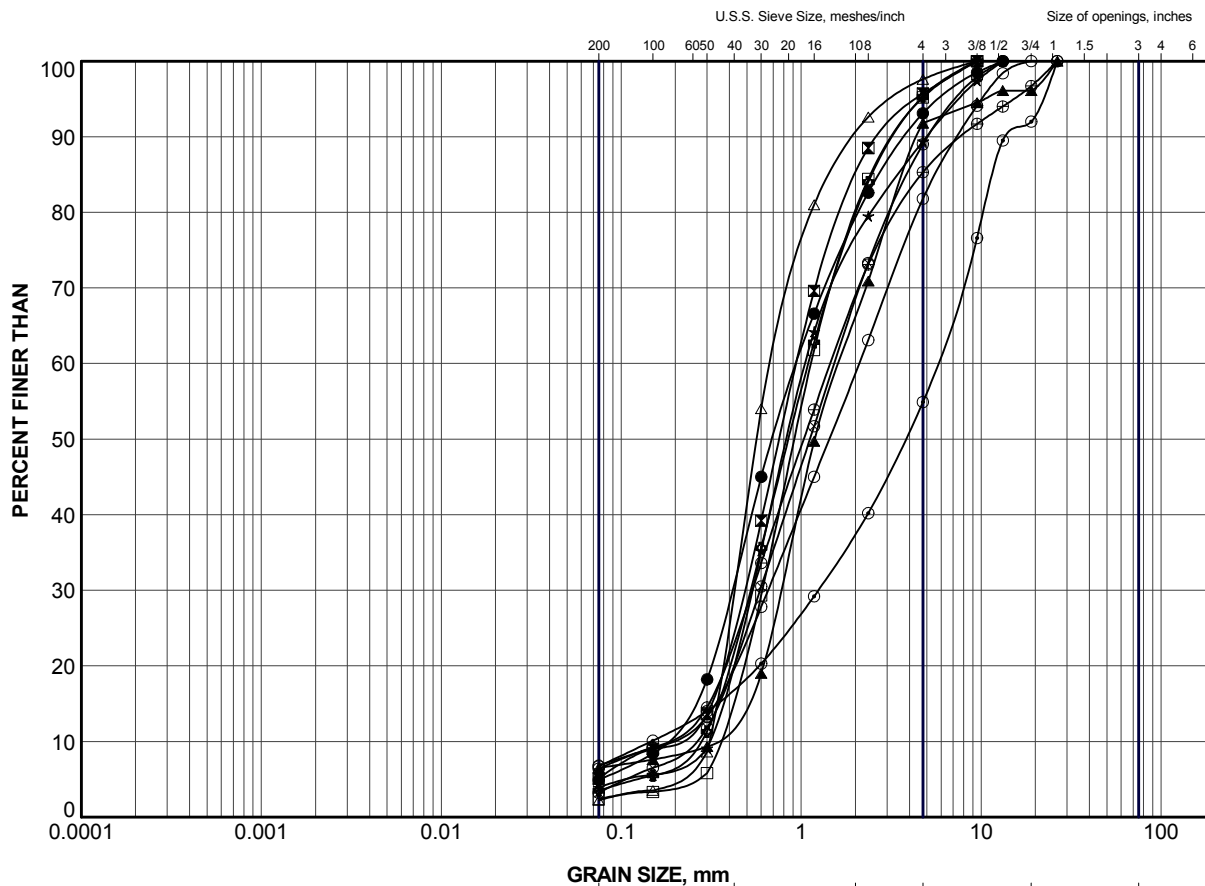


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-3	6	284.7

PROJECT					
HIGHWAY 631 NAGAGAMISIS NARROWS BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION ORGANIC SILTY SAND					
PROJECT No.		1661607		FILE No. 1661607.GPJ	
DRAWN	TB	Oct 2017	SCALE	N/A	REV.
CHECK	AB	Oct 2017			
APPR		Oct 2017			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B2</b>		



CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-1	5	285.7
⊠	NG-1	8	281.9
▲	NG-2	3	287.1
★	NG-2	6	284.8
⊙	NG-4	5	285.5
⊕	NG-5	1	287.5
○	NG-5	3	286.0
△	NG-5	6	283.7
⊗	NG-6	2	285.8
⊕	NG-7	4	286.5
□	NG-7	7	283.4

PROJECT

HIGHWAY 631  
NAGAGAMISIS NARROWS BRIDGE

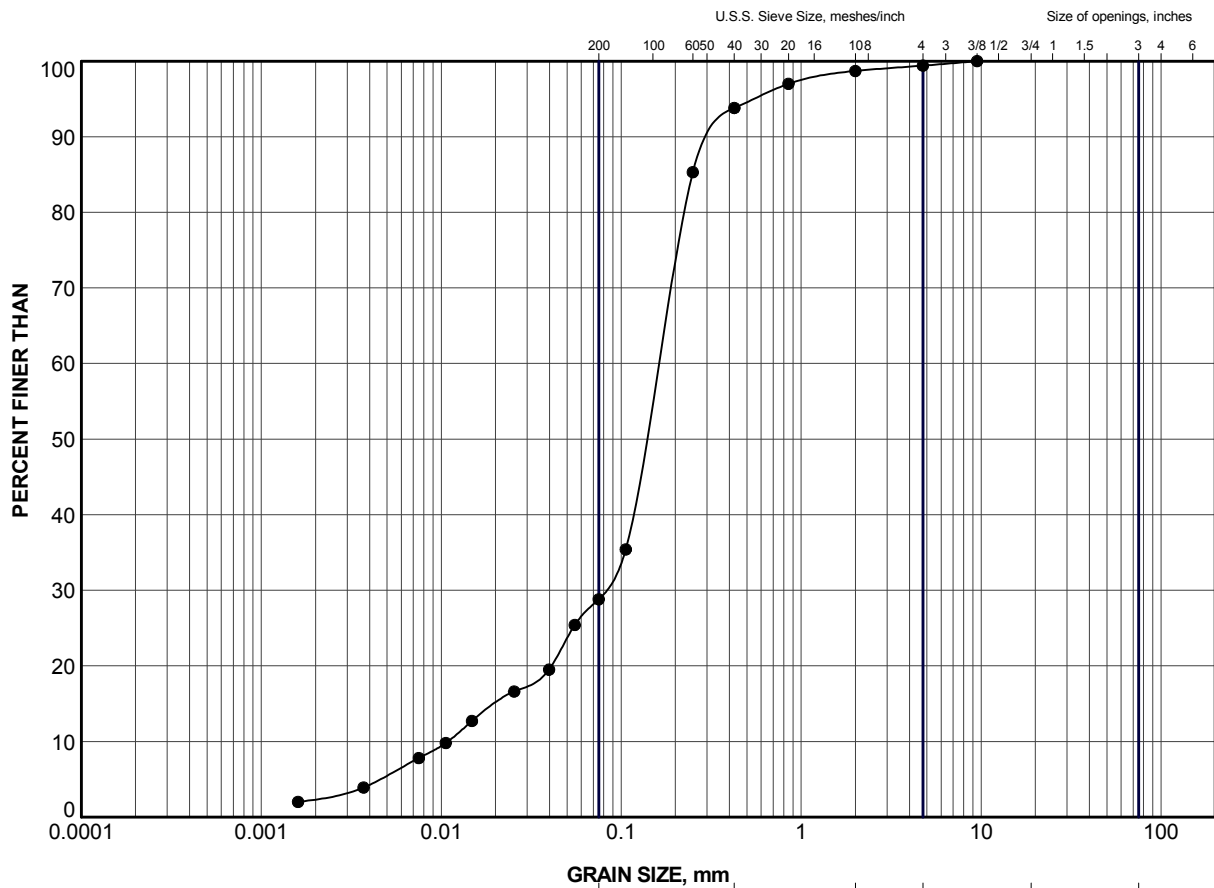
TITLE

**GRAIN SIZE DISTRIBUTION**  
SAND (and SAND and GRAVEL LAYER)



PROJECT No.		1661607	FILE No.		1661607.GPJ
DRAWN	TB	Oct 2017	SCALE	N/A	REV.
CHECK	AB	Oct 2017	<b>FIGURE B3</b>		
APPR		Oct 2017			





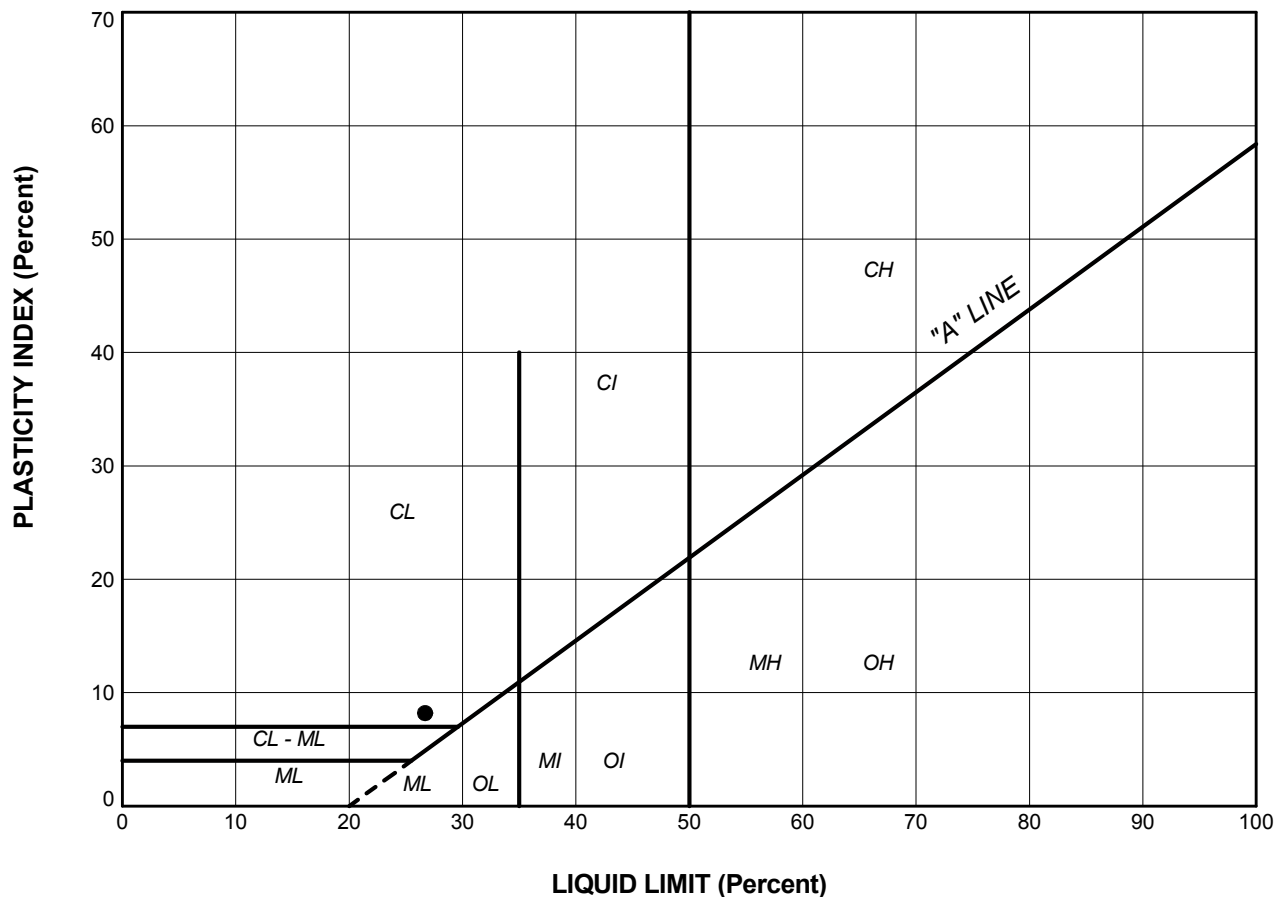
GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-8	7A	283.3

PROJECT					
HIGHWAY 631 NAGAGAMISIS NARROWS BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SILT and SAND					
PROJECT No.		1661607		FILE No. 1661607.GPJ	
DRAWN	TB	Sep 2017	SCALE	N/A	REV.
CHECK	AB	Sep 2017			
APPR		Sep 2017			
			<b>FIGURE B4</b>		



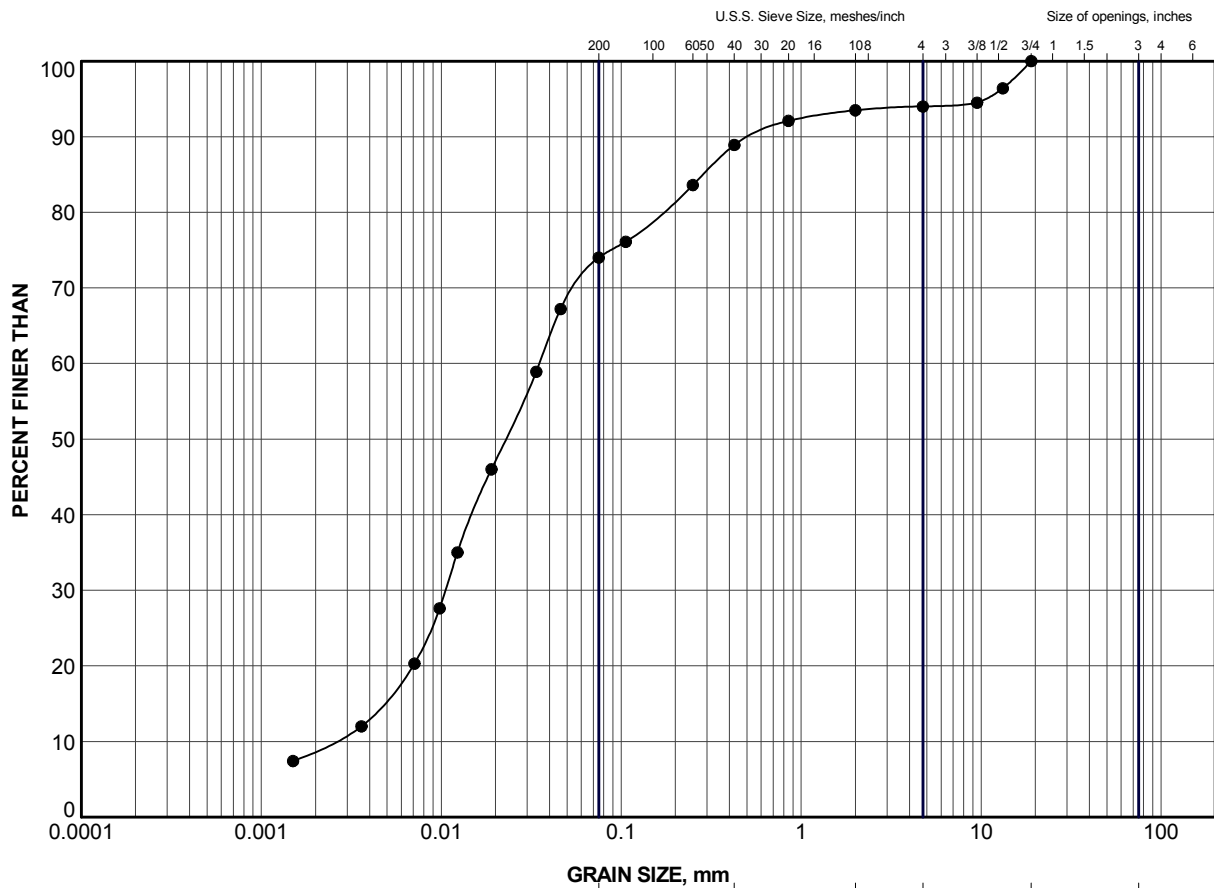


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	NG-7	8A	26.7	18.5	8.2

PROJECT					
HIGHWAY 631 NAGAGAMISIS NARROWS BRIDGE					
TITLE					
PLASTICITY CHART SANDY CLAYEY SILT					
PROJECT No.		1661607		FILE No.	
DRAWN		TB		Oct 2017	
CHECK		AB		Oct 2017	
APPR				Oct 2017	
SCALE		N/A		REV.	
FIGURE		B5			




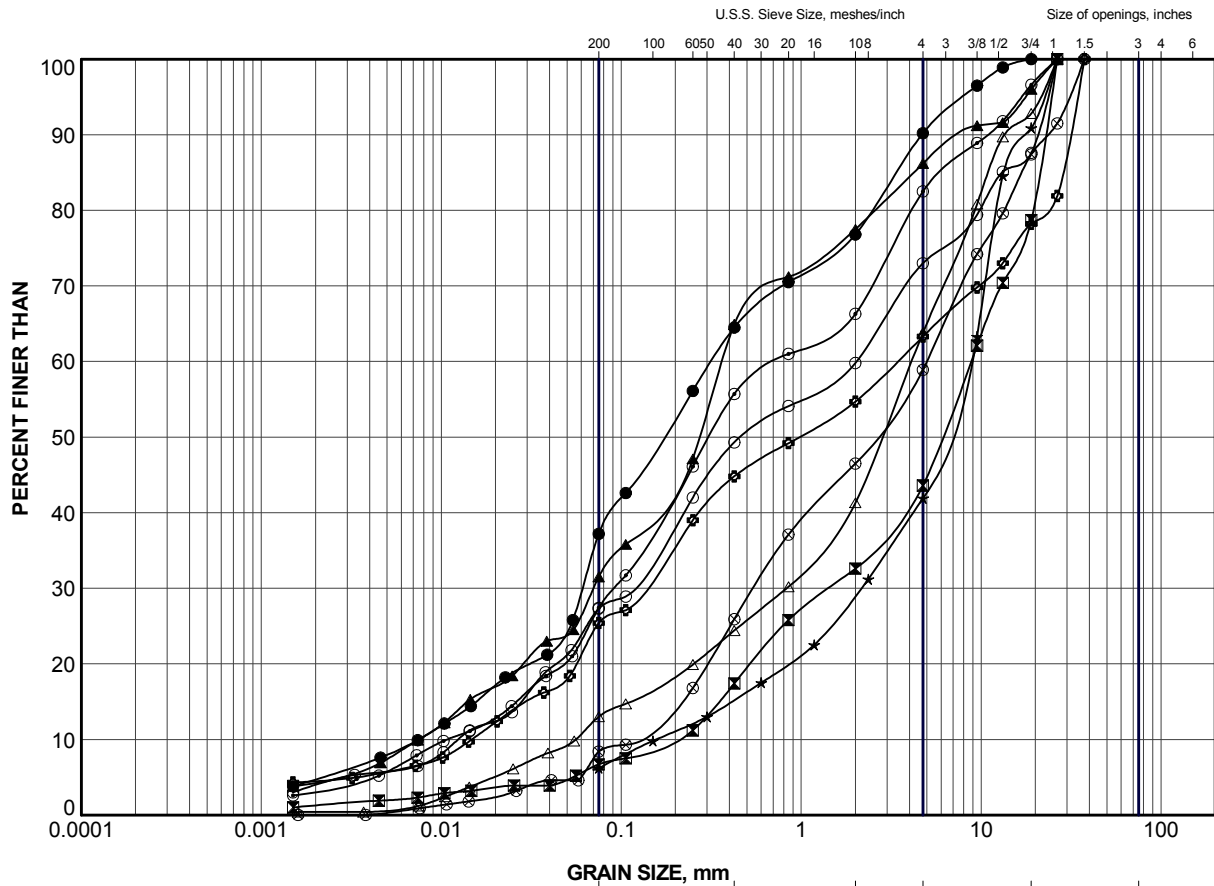


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-7	8A	282.1

PROJECT						HIGHWAY 631 NAGAGAMISIS NARROWS BRIDGE					
TITLE						GRAIN SIZE DISTRIBUTION SANDY CLAYEY SILT					
PROJECT No.			1661607			FILE No.			1661607.GPJ		
DRAWN	TB	Oct 2017	SCALE	N/A	REV.						
CHECK	AB	Oct 2017									
APPR		Oct 2017									
 <b>Golder Associates</b> SUDBURY, ONTARIO						<b>FIGURE B6</b>					



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	NG-1	9	280.4
⊠	NG-2	8	281.8
▲	NG-3	8	281.7
★	NG-3	10	278.8
⊙	NG-4	7B	283.1
⊕	NG-6	5	283.6
○	NG-6	7	280.5
△	NG-7	10	278.8
⊗	NG-8	10	278.7

PROJECT

HIGHWAY 631  
NAGAGAMISIS NARROWS BRIDGE

TITLE

**GRAIN SIZE DISTRIBUTION**  
SILTY SAND to SANDY GRAVEL (TILL)



**Golder  
Associates**  
SUDBURY, ONTARIO

PROJECT No.		1661607	FILE No.		1661607.GPJ
DRAWN	TB	Sep 2017	SCALE	N/A	REV.
CHECK	AB	Sep 2017	<b>FIGURE B7</b>		
APPR		Sep 2017			

### Borehole NG-2



Box 1: 11.6 m – 14.8 m

### Borehole NG-3



Box 1: 11.1 m – 14.5 m

### Borehole NG-5



Box 1&2: 10.4 m – 13.8 m

### Borehole NG-6



Box 1&2: 8.4 m – 11.5 m

### Borehole NG-7



Box 1: 11.6 m – 14.6 m

### Borehole NG-8



Box 1: 11.0 m – 14.5 m

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT

**Highway 631  
Nagagamisis Narrows Bridge**

TITLE

**Bedrock Core Photographs**



PROJECT No. 1661607			FILE No. ---		
DESIGN	TB	SEP 17	SCALE	NTS	REV.
CADD	--		<b>FIGURE B8</b>		
CHECK	AC	SEP 17			
REVIEW					

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