



## FOUNDATION INVESTIGATION AND DESIGN REPORT

Holdridge Creek Bridge Rehabilitation (Site No. 43-004)  
LAT. 46.682091, LONG. -79.907647  
Highway 64, Nipissing District, Thistle Township  
Ministry of Transportation, Ontario  
GWP. 5182-14-00 WP. 5182-14-02  
GEOCRES NO: 31L-216

Submitted to:

**Mr. Michael Lang, P.Eng.**

D.M. Wills Association Ltd.  
150 Jameson Drive  
Peterborough  
K9J 0B9

Submitted by:

**Golder Associates Ltd.**

33 Mackenzie Street, Suite 100, Sudbury, Ontario  
P3C 4Y1, Canada  
+1 705 524 6861

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**PART A**

FOUNDATION INVESTIGATION REPORT  
HOLDRIDGE CREEK BRIDGE – SITE NO. 43-004  
HIGHWAY 64, NIPISSING DISTRICT,  
THISTLE TOWNSHIP  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP. 5182-14-00 WP. 5182-14-02

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. (DM Wills) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the rehabilitation of the Holdridge Creek Bridge (Site No. 43-004). The Holdridge Creek Bridge is located in the Nipissing District on Highway 64 at about Station 20+743, Thistle Township (approximately 11.8 km south of the Highway 11 junction). The general location of this section of Highway 64 is shown on the Key Plan on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at temporary protection systems locations at the approach embankments adjacent to the existing bridge by borehole drilling and rock coring with laboratory testing carried out on selected soil and rock core samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated March 14, 2017, and the subsequent clarifications/addenda, which forms part of the Consultant's Assignment Number (5016-E-0035) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for Foundation Engineering services for this project, dated September 5, 2017.

## 2.0 SITE DESCRIPTION

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. For the purpose of this report, Highway 64 is oriented in a north-south direction with Holdridge Creek flowing in a west-east direction at the bridge structure.

In general, the topography of the site and surrounding area is relatively flat with gently rolling/undulating terrain and dense tree cover beyond the highway right-of-way. The existing Holdridge Creek Bridge consists of an approximately 21.3 m long by 10.4 m wide (overall) single span, precast girder structure, which was constructed in 1968. Based on the information provided in the Request for Proposal (RFP) and the General Layout drawing (Contract 68-148), we understand that the existing bridge is supported by shallow spread footings founded on rockfill pads within the approach embankment.

Based on General Arrangement (GA) drawing provided by DM Wills (drawing 4631-Holdridge Creek Bridge-General Arrangement.dwg, received April 3, 2018), the bridge deck is at Elevation 284.2 m and 283.4 m at the north and south abutments, respectively. The existing approach embankments are between 3 m and 4 m high and the embankment side slopes are inclined at about 2 Horizontal to 1 Vertical (2H:1V). Ground surface conditions at the bridge location are shown on Photographs 1 to 4.

## 3.0 INVESTIGATION PROCEDURES

Field work for this subsurface investigation was carried out on October 22, 2017, and November 28, 2017, during which time two boreholes (Boreholes HC-1 and HC-2) were advanced at the bridge approaches at the approximate locations shown on Drawing 1.

The boreholes were advanced from the existing roadway platform using a track mounted drill rig supplied and operated by George Downing Estate Drilling of Grenville-Sur-La-Rouge, Quebec. The boreholes were advanced using 108 mm inside diameter hollow stem augers, NW casing with wash boring, and NQ coring techniques.

Water utilized for NW casing advance with wash boring and NQ coring was obtained from Holdridge Creek. Traffic control was performed by Bartlett's Towing of North Bay, Ontario in accordance with Ontario Traffic Control Manual Book 7 – Temporary Conditions. 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 level in the open boreholes was observed during the drilling operations. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended). The coreholes advanced through the existing concrete approach slab were backfilled with a mixture of bentonite and granular fill and the upper 200 mm to 250 mm was sealed with tamped cold patch asphalt.

Field work was monitored on a full-time basis by members of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined the soil samples. The soil samples were identified in the field, placed in labelled containers, and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations and grain size distributions were carried out on selected soil samples. In addition, an unconfined compressive strength (UCS) test was carried out on one selected specimen of the bedrock core recovered from the boreholes. The geotechnical laboratory testing on soil and rock core samples was completed according to MTO LS standards.

The as-drilled borehole locations and ground surface elevations were measured by a member of our technical staff, referenced to the highway centerline and existing bridge structure, and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centerline was obtained from the survey drawing (GWP 5182-14-00.dwg) provided by DM Wills. The MTM NAD83 Zone 10 northing and easting coordinates and geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (Latitude)	MTM NAD83 Easting (Longitude)	Ground Surface Elevation	Borehole Depth
HC-1	N 5171453.8 (46.681951)	E 273617.0 (-79.907629)	283.3	15.7
HC-2	N 5171485.8 (46.682238)	E 273614.0 (-79.907670)	284.4	14.1

Note: Borehole depths include 2.9 m and 3.1 m of bedrock coring, respectively.

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)<sup>1</sup> mapping, the Holdridge Creek Bridge site is located within a zone of undulating to rolling bedrock knobs bordered by hummocky moraine deposits consisting primarily of sand and gravel.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)<sup>2</sup>, the site is underlain by felsic igneous bedrock comprised of tonalite, granodiorite, monzonite, granite, and syenite. The igneous bedrock mass is bordered by migmatitic rock and gneisses; commonly consisting of layered biotite gneisses and migmatites with quartzofeldspathic gneisses, orthogneisses and paragneisses in localized areas.

### 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in-situ field tests (i.e., SPT 'N' values) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsurface conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt, concrete and granular fill comprising the roadway structure underlain by a deposit of compact to very dense sand and gravel till. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Surface Elevation (m)	Deposit Thickness (m)	N Values (blows)	Laboratory Testing
				Compactness Condition	
Asphalt	HC-1 & HC-2	283.3 & 284.4	0.18 & 0.15	n/a	n/a
Concrete	HC-1 & HC-2	283.1 & 284.2	0.28 & 0.25	n/a	n/a
(FILL) Sand to Sand and Gravel; trace to some silt, brown, moist	HC-1 & HC-2	282.8 & 284.0	3.2 & 4.1	N = 11 – 31  <b>Compact to Dense</b>	w = 5% – 6% 3 – M (Fig. B1)

<sup>1</sup> Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41LNW

<sup>2</sup> Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543



Deposit/Layer Description	Boreholes	Deposit Surface Elevation (m)	Deposit Thickness (m)	N Values (blows)	Laboratory Testing
				Compactness Condition	
Sand and Gravel (TILL); trace to some silt, trace clay, brown to grey, wet	HC-1 & HC-2	279.6/276.1 & 279.9	2.3/5.6 & 6.5	N = 6 – 68 (16/0.15 and 74/0.15)	w = 8% – 12% 3 – M/MH (Fig. B2)
				<b>Loose to Very Dense</b>	
Sand (Pocket); trace to some silt, trace to some gravel, brown, wet	HC-1	277.3	1.2	N = 32	w = 20% 1 – M (Fig. B3)
				<b>Dense</b>	

**Where:**

N = SPT 'N' values; number of blows for 0.3 m of penetration

w = Natural moisture content (%)

M = Sieve analysis

MH = Combined sieve and hydrometer analysis

**Sand and Gravel Till**

An SPT 'N' value of 6 blows per 300 mm was measured in the till deposit at a depth of about 9.4 m depth. This sample was collected within a cobble/boulder nest where NW casing with wash boring and NQ coring was utilized to advance the borehole. The SPT 'N' value is inferred to be a result of disturbance during wash boring and not indicative of the compactness condition of the till deposit.

In one instance, the split-spoon sampler did not penetrate the entire SPT depth (16 blows per 0.15 m of penetration), due to the presence of cobbles and boulders as typically present within glacially derived till deposits and as encountered in Borehole HC-1 between the depth of about 8.4 m and 12.6 m below ground surface (Elevations 274.9 m to 270.7 m). In another instance, the split-spoon sampler did not penetrate the entire SPT depth (i.e. 74 blows per 0.15 m of penetration) due to refusal (i.e. split spoon bouncing) at the bedrock interface.

**Bedrock**

Bedrock was cored in Boreholes HC-1 and HC-2 and the depth to / elevation of the bedrock surface is presented below.

Borehole No.	Location	Depth to Bedrock (m)	Bedrock Surface Elevation (m)	Core Length (m)
HC-1	South Approach	12.8	270.5	2.9
HC-2	North approach	11.0	273.4	3.1

The retrieved bedrock core is described as fresh to slightly weathered, pink and black, medium grained, strongly foliated, metamorphic granite gneiss. Additional details of the bedrock core are presented in the Record of Drillhole sheets in Appendix A, including data on the discontinuity frequency and type. Photographs of the retrieved bedrock core samples are shown on Figure B4 in Appendix B. The bedrock properties as encountered in the cored boreholes and/or selected samples for laboratory testing are summarized below.

Borehole No.	Total Core Recovery (TCR)	Rock Quality Designation (RQD)	Quality Classification (Table 3.10 of CFEM 2006 <sup>3</sup> )	Uniaxial Compressive Strength (MPa)	Strength Classification (Table 3.5 of CFEM 2006)
HC-1	100%	33% - 100%	Poor to Excellent	57	(R4) Strong
HC-2	100%	100%	Excellent	n/a	n/a

## Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek water level was surveyed by others at Elevation 279.3 m in December 2017. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
HC-1	4.2	279.1
HC-2	4.2	280.2

Note: Boreholes HC-1 and HC-2 were advanced using NW Casing and wash boring and NQ coring and as such, the measured groundwater level may not be representative of the in-situ groundwater conditions.

## 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Foundation Investigation Report was prepared by Ms. Lindsay Palmer, B.A.Sc. and Mr. David Muldowney, P.Eng. provided a technical review of the report. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

<sup>3</sup> Canadian Geological Society, 2006. Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition.

## Signature Page

### Golder Associates Ltd.



David Muldowney, P.Eng.  
*Senior Geotechnical Engineer*



Jorge M.A. Costa, P.Eng.  
*MTO Foundations Designated Contact, Senior Consultant*

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[https://golderassociates.sharepoint.com/sites/14033g/deliverables/foundations/3\\_reporting/r02 - holdridge creek bridge/3\\_final/1777318 r-rev0 r02 dmw mto holdridge creek hwy 64 fidr\\_05oct\\_18.docx](https://golderassociates.sharepoint.com/sites/14033g/deliverables/foundations/3_reporting/r02_holdridge_creek_bridge/3_final/1777318_r-rev0_r02_dmw_mto_holdridge_creek_hwy_64_fidr_05oct_18.docx)

**PART B**

FOUNDATION DESIGN REPORT  
HOLDRIDGE CREEK BRIDGE REHABILITATION – SITE NO. 43-004  
HIGHWAY 64, NIPISSING DISTRICT, THISTLE TOWNSHIP  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP. 5182-14-00 WP. 5182-14-02

## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation engineering design recommendations in support of the temporary protection system (to be designed by others) and general design considerations as related to the proposed rehabilitation of the existing Holdridge Creek Bridge (Site 43-004). The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. The discussed and recommendation presented are intended to provide the designers with sufficient information to assess the feasible alternative and carry out the design of temporary protection systems. The foundation investigation report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO), and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project and for which special provisions may be required in the Contract Documents. The requiring information of the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### 6.1 General

The Holdridge Creek Bridge is located in the Nipissing District on Highway 64 at about Station 20+743, Thistle Township (approximately 11.8 km south of the Highway 11 junction). Based on discussions with DM Wills, we understand that excavations up to about 1.8 m below the existing roadway surface will be required behind the existing bridge abutments to facilitate the proposed rehabilitation. The estimated depth of frost penetration in this area is 2.1 m, as interpreted from OPSD 3090.100 (Foundations, Frost Penetration Depths for Northern Ontario)

### 6.2 Excavations and Temporary Cut Slopes

The proposed works will require removal of the asphalt, concrete approach slab, and partial excavation of the existing granular embankment fill material. Based on discussions with DM Wills, we understand that temporary roadway protection systems will be required at each bridge approach from a traffic staging perspective.

Open cut excavation side slopes in the existing embankment fill (i.e., sand and gravel fill and sand fill) should remain stable during construction if the temporary side slopes are cut back no steeper than 1 Horizontal to 1 Vertical (1H:1V) above the groundwater level. The excavation slopes should be flattened to 3H:1V below the groundwater level (if encountered).

Based on the subsurface conditions encountered during this investigation, groundwater is not expected to be encountered within the proposed excavation depths. Perched water, if encountered, should be drained by pumping or by gravity via local ditching and sources of surface water should be diverted away from the excavation area prior to beginning the excavation. Some sloughing of excavated slopes due to perched water or surface water runoff may occur and flatter side slopes may become necessary.

During construction, stockpiles should be placed at a distance away from the edge of the excavation not less than 1.5 times the depth of excavation, and their heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope.

All excavations should be carried out in accordance with the latest edition of the Ontario *Occupational Health and Safety Act* and Regulations for Construction Projects. The existing embankment fill and native soils are classified as Type 3 soils above the groundwater level and Type 4 soils below.

As the temporary open cut excavations required to allow for bridge rehabilitation works to be carried out are expected to be of limited depth (about 1.8 m) slope stability issues are not anticipated for the reconstructed section of the embankments, provided the embankments are reinstated using engineered granular fill [i.e., OPSS.PROV 1010 (Aggregates) Granular A or Granular 'B' Type I or II] inclined at a profile grade of 2H:1V similar to the existing configuration.

### 6.3 Temporary Roadway Protection

It is anticipated that a temporary roadway protection system will be required to facilitate staged construction at this site. The temporary roadway protection system could consist of either sheet piling or soldier piles and lagging. Support to the system could be in the form of struts and wales and rakers or anchors. At this site, installation of sheet-piles for temporary shoring could potentially be impeded by the presence of cobbles and/or boulders as typically present within glacially derived till deposits and as encountered in Borehole HC-1. As such, soldier piles and lagging may need to be considered. If sheet piling is used, it may be necessary to select a heavier sheet pile section in attempt to drive through the obstruction. If a temporary roadway protection system is required, it is recommended that an NSSP be included in the contract documents to address obstructions; a sample NSSP is included in Appendix C.

The Contractor is responsible for the completed detailed design of the temporary protection system. The temporary roadway protection system may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength	Coefficient of Earth Pressure		
	( $\gamma$ , kN/m <sup>3</sup> )	( $\phi$ , degrees)	( $S_u$ , kPa)	Active $K_a$	At Rest $K_o$	Passive $K_p$
New Granular 'A'	22	35	-	0.27	0.43	3.65
New Granular 'B' Type I	21	32	-	0.31	0.47	3.25
New Granular 'B' Type II	21	35	-	0.27	0.43	3.65
Existing Granular Embankment Fill (compact to dense)	20	30	-	0.33	0.50	3.00
Sand and Gravel Till including sand pocket (compact to very dense)	20	30	-	0.33	0.50	3.00

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.

The temporary protection systems shall be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems shall be designed to Performance Level 2 for any excavation adjacent to existing roadway. Design of the temporary support system should include an evaluation of base stability, soil squeezing stability, and hydraulic uplift stability as defined in the Canadian Foundation Engineering Manual (CFEM 2006). The design should also include a stability analysis to be completed by the Contractor based on their selected temporary shoring system and shoring design. An NSSP should be included in the Contract to alert the Contractor to this requirement. A sample NSSP is included in Appendix C.

Consideration could be given to either partial or full removal of the temporary protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the temporary shoring system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the bridge site. Based on the soil conditions at this site, the risks associated with pile adhesion and/or subgrade disturbance during removal are considered to be relatively low. As such, from a foundations perspective, we recommend full removal where temporary roadway protection systems are utilized.

## 6.4 Obstruction

The contractor should be alerted to the presence of cobbles and boulders within the native soils as typically present within glacially derived till deposits and as encountered by coring in Boreholes HC-1. The extent and depth of the cobble and boulder obstructions may vary beyond and between the borehole location(s). Although not encountered as part of the current investigation, the Contractor should also be alerted to the presence of rockfill pads below the existing bridge footings as noted in the General Layout drawing (Contract 68-148). A sample NSSP is included in Appendix C (as noted in section 6.3).

## 7.0 CLOSURE

The Foundation Design Report was prepared by Ms. Lindsay Palmer, B.ASc., and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of this report.

## Signature Page

### Golder Associates Ltd.



David Muldowney, P.Eng.  
*Senior Geotechnical Engineer*



Jorge M.A. Costa, P.Eng.  
*MTO Foundations Designated Contact, Senior Consultant*

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## REFERENCES

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

Occupational Health and Safety Act and Regulation for Construction Projects (as amended)

Ministry of Natural Resources. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41LNW

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543

Ministry of Transportation (2014). Ontario Traffic Manual Book 7 – Temporary Conditions. Queen's Printer for Ontario. ISBN 978-1-4606-3505-6.

ASTM International: ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

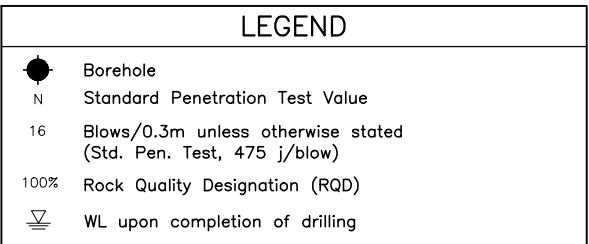
OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090.100 Foundation, Frost Penetration Depths for Northern Ontario.

Ontario Water Resource Act: Regulation 903Wells (as amended)

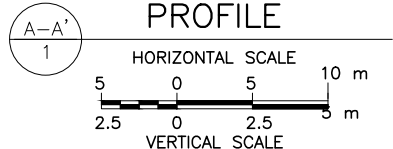


BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 10)			
No.	ELEVATION	NORTHING	EASTING
HC-1	283.3	5171453.8	273617.0
HC-2	284.4	5171485.8	273614.0

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

Base plans provided in digital format by DM Wills, drawing file no. 4631—Holdridge Creek Bridge—General Arrangement.dwg, received April 3, 2018.



-	-	-	-	-
NO.	DATE	BY	REVISION	
<b>Geocres No. 31L-216</b>				
<b>Hwy. 64</b>		<b>PROJECT NO. 1777318</b>		<b>DIST. .</b>
<b>SUBM'D.</b>		<b>CHKD. AD</b>	<b>DATE: 10/2/2018</b>	<b>SITE: 43-004</b>
<b>DRAWN: TR</b>		<b>CHKD. DAM</b>	<b>APPD. JMAC</b>	<b>DWG. 1</b>



**Photograph 1: North Abutment - Facing North (October 2017)**



**Photograph 2: North Abutment - Facing South (Google Earth Image, 2018)**





**Photograph 3: South Abutment – Facing North (October 2017)**



**Photograph 4: South Abutment - Facing South (Google Earth Image, 2018)**

**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

#### (a) Index Properties

$\rho(\gamma)$	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

$\tau = c' + \sigma' \tan \phi'$   
shear strength = (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; $N_d$ :

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

Compactness	N
Condition	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
$SO_4$	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



## 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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
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	





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

PROJECT 1777318		RECORD OF BOREHOLE No HC-1				2 OF 2 METRIC															
G.W.P. 5182-14-00		LOCATION N 5171453.8; E 273617.0 NAD83 MTM ZONE 10 (LAT. 46.681951; LONG. -79.907629)				ORIGINATED BY MR															
DIST _____ HWY 64		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring				COMPILED BY TB															
DATUM GEODETIC		DATE October 22, 2017				CHECKED BY DAM															
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	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60	20 40 60
270.5	SAND and GRAVEL, trace silt, trace clay (TILL) Loose to dense Brown Wet		12	SS	16/0.15		271														
12.8	METAMORPHIC GRANITE GNEISS (BEDROCK)  Notes: 1. Bedrock cored from 12.8 m to 15.7 m depth. 2. For coring details see record of drillhole HC-1		1	RC	REC 100%		270														RQD = 100%
			2	RC	REC 100%		269														RQD = 33%
			3	RC	REC 100%		268														RQD = 95%
267.6	END OF BOREHOLE.  Note: 1. Water level at a depth of 4.2 m below ground surface (Elev. 279.1 m) upon completion of drilling.																				
15.7																					

PROJECT: 1777318

LOCATION: N 5171453.8; E 273617.0

NAD83 MTM ZONE 10 (LAT. 46.681951; LONG. -79.907629)

INCLINATION: -90° AZIMUTH: ---

**RECORD OF DRILLHOLE: HC-1**

SHEET 1 OF 1

DRILLING DATE: October 22, 2017

DATUM: GEODETIC

DRILL RIG: CME 55 LC

DRILLING CONTRACTOR: George Downing Estate 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.	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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DEPTH SCALE

1 : 60

**GOLDER**

LOGGED: MR

CHECKED: DAM

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PROJECT 1777318		RECORD OF BOREHOLE No HC-2		1 OF 2 METRIC								
G.W.P. 5182-14-00		LOCATION N 5171485.8; E 273614.0 NAD83 MTM ZONE 10 (LAT. 46.682238; LONG. -79.90767)		ORIGINATED BY MR								
DIST _____ HWY 64		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring		COMPILED BY TB								
DATUM GEODETIC		DATE November 28, 2017		CHECKED BY DAM								
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					
284.4	GROUND SURFACE											
0.0	ASPHALT (150 mm)											
	CONCRETE (245 mm)											
	SAND and GRAVEL (FILL)											
0.6	SAND, trace to some gravel, trace to some silt (FILL) Compact to dense Brown Moist		1	SS	31							
			2	SS	23							
			3	SS	18							18 67 (15)
			4	SS	12							
			5	SS	15							12 73 (15)
279.9	SAND and GRAVEL, trace to some silt (TILL) Compact to dense Brown to grey Wet		6	SS	24							
4.5	Auger refusal at 5.2 m depth. Switched to NW casing and NQ coring.  Auger grinding throughout.		7	SS	19							
			8	SS	32							58 30 (12)
			9	SS	20							
			10	SS	74/0.15							
273.4	Split spoon refusal (hammer bouncing) at 11.0 m depth.		1	RC	REC 100%							RQD = 100%
11.0												

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Continued Next Page

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

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

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PROJECT: 1777318  
LOCATION: N 5171485.8; E 273614.0  
NAD83 MTM ZONE 10 (LAT. 46.682238; LONG. -79.90767)  
INCLINATION: -90° AZIMUTH: ---

## RECORD OF DRILLHOLE: HC-2

SHEET 1 OF 1  
DATUM: GEODETIC

DRILLING DATE: November 28, 2017  
DRILL RIG: CME 55 LC  
DRILLING CONTRACTOR: George Downing Estate Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY				R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY				Diametral Point Load Index (MPa)	RMC -Q' AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
								TOTAL CORE %	SOLID CORE %	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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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DEPTH SCALE

1 : 60



GOLDER

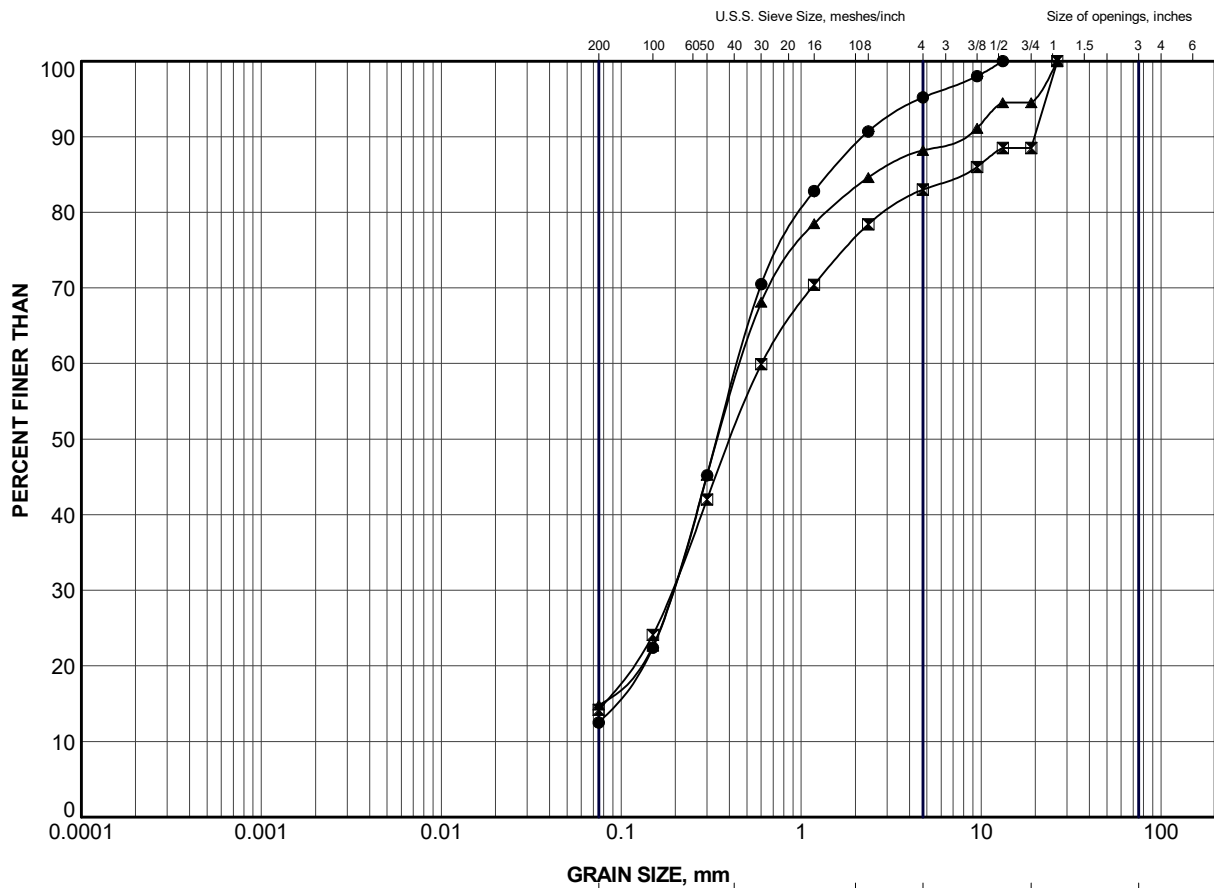
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**APPENDIX B**

# Laboratory Test Results

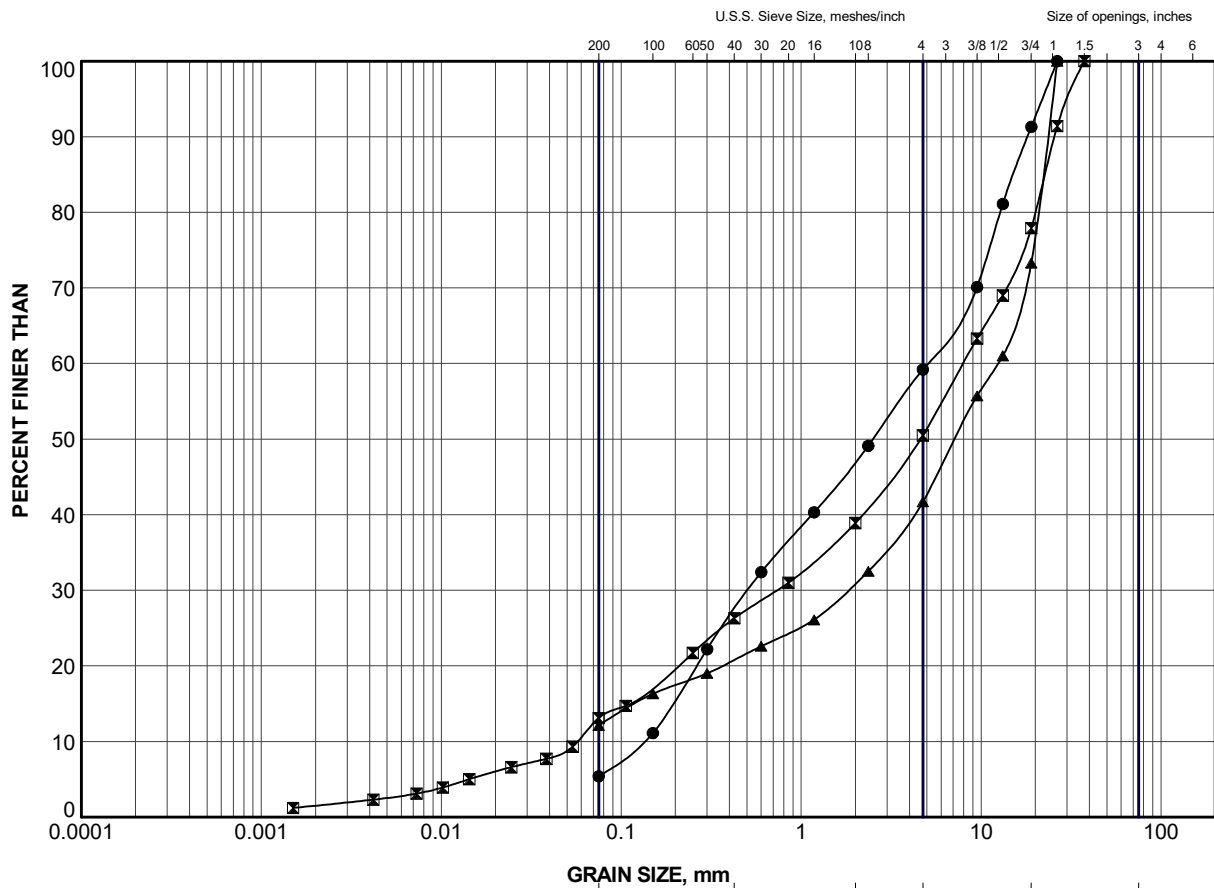


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HC-1	2	281.5
⊠	HC-2	3	281.8
▲	HC-2	5	280.2

PROJECT					
HIGHWAY 64 HOLDRIDGE CREEK BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		1777318		FILE No.	
DRAWN		TB		Jul 2018	
CHECK		DAM		Jul 2018	
APPR		JMAC		Jul 2018	
SCALE		N/A		REV.	
 <b>GOLDER</b>				<b>FIGURE B1</b>	
SUDBURY, ONTARIO					

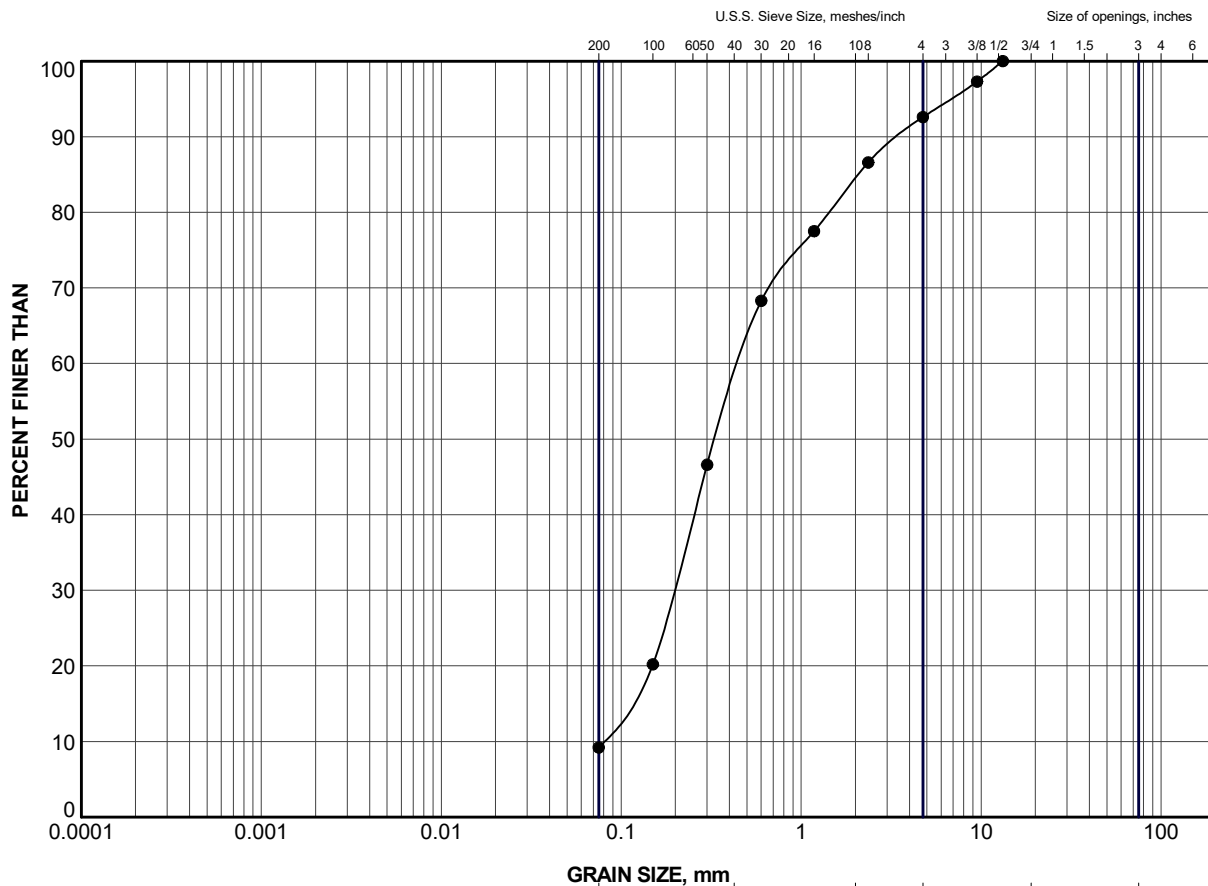




### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HC-1	5	279.1
⊠	HC-1	11	272.3
▲	HC-2	8	276.5

PROJECT					
HIGHWAY 64 HOLDRIDGE CREEK BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SAND and GRAVEL (TILL)					
PROJECT No. 1777318			FILE No. 1777318.GPJ		
DRAWN	TB	Jul 2018	SCALE	N/A	REV.
CHECK	DAM	Jul 2018			
APPR	JMAC	Jul 2018			
GOLDER			FIGURE B2		
SUDBURY, ONTARIO					



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

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	HC-1	8	276.8

PROJECT						HIGHWAY 64 HOLDRIDGE CREEK BRIDGE					
TITLE						GRAIN SIZE DISTRIBUTION SAND (POCKET)					
PROJECT No.				1777318		FILE No.				1777318.GPJ	
DRAWN	TB	Jul 2018		SCALE	N/A	REV.					
CHECK	DAM	Jul 2018									
APPR	JMAC	Jul 2018									
GOLDER						FIGURE		B3			
SUDBURY, ONTARIO											

# Bedrock Core Photographs

Holdridge Creek Bridge Rehabilitation – Site 43-004  
Highway 64

Figure B4



Borehole HC-1  
Elevation 270.5 m to 267.6 m



Borehole HC-2  
Elevation 273.4 m to 270.3 m



**APPENDIX C**

# Non-Standard Special Provisions

## **TEMPORARY PROTECTION SYSTEMS – Item No.**

---

### **Non-Standard Special Provision**

---

#### **Amendment to OPSS 539, November 2014**

##### **539.01 SCOPE**

Section 539.01 of OPSS 539 is amended by the addition of the following:

This specification also covers the requirements for excavation depths greater than 1.2 m below grade adjacent to Temporary Concrete Barriers.

##### **539.04 DESIGN AND SUBMISSION REQUIREMENTS**

###### **539.04.01.01 General**

Subsection 539.04.01.01 of OPSS 539 is amended by the addition of the following:

Stability analyses for the proposed excavation faces and Temporary Protection Systems shall be completed by the Contractor, based on their specific Temporary Protection Systems and relevant soil parameters.

The Contractor shall maintain an offset between the back edge of the Temporary Concrete Barriers and the rear edge of the Temporary Protection Systems as detailed in the Contract Documents. Excavation faces shall be shored for the entire height of excavation adjacent to Temporary Concrete Barriers.

##### **539.07 CONSTRUCTION**

###### **539.07.03.03.01 General**

Subsection 539.07.03.03.01 of OPSS 539 is amended by the addition of the following:

A Professional Engineer shall carry out weekly visual inspection and review the constructed Temporary Protection Systems to confirm adequate working conditions of the Temporary Protection Systems and safety of the workers. An inspection report shall be completed and submitted to the Contract Administrator within two (2) business days of the inspection being completed.

**EARTH EXCAVATION FOR STRUCTURE – Item No.**

---

Non-Standard Special Provision

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**Amendment to OPSS 902, November 2010**

**Excavating and Backfilling – Structures**

**902.07 CONSTRUCTION**

Section 902.07 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the potential presence of cobbles and boulders within the embankment fill as encountered in Borehole HC-1 and as typically present within glacially derived till deposits such as those encountered at the Holdridge Creek Bridge site. The extent and depth of the cobbles and boulders may vary beyond and between our borehole location(s). The Contractor is also alerted to the presence of rockfill pads below the existing bridge foundations as noted in the original General Layout drawing (Contract 68-148) included in the Contract Documents. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations and temporary protection systems.



**[golder.com](http://golder.com)**