



## FOUNDATION INVESTIGATION REPORT

# Highway 65, Station 17+077, Township of James Culvert Replacement Ministry of Transportation, Ontario GWP 5204-14-00

Submitted to:

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1896349-R01

June 17, 2019

GEOCRES NO: 41P-77

LAT: 47.717213

LONG: -80.306919



## Distribution List

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**PART A**

**FOUNDATION INVESTIGATION REPORT  
HIGHWAY 65, STA 17+077, TOWNSHIP OF JAMES  
CULVERT REPLACEMENT  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5204-14-00**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services related to the replacement of the culvert on Highway 65 at Station 17+077, approximately 2.4 km southeast of the intersection with Highway 560, in the Township of James, Ontario. The Key Plan of the general location of this section of Highway 65 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface conditions at the culvert replacement site by borehole drilling with laboratory testing carried out on selected soil samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated February 2018, and the subsequent clarifications/addenda, which forms part of the Consultant's Assignment Number 5017-E-0039 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 November 2018.

## 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 typically referenced to project north and therefore may differ from magnetic north shown on Drawing 1. For the purpose of this report, Highway 65 is oriented in a west-east direction with the culvert positioned perpendicular to the highway generally in a north-south orientation. At the culvert location the creek flows in a north-south direction.

The existing culvert consists of a 1.4 m diameter 29 m long Corrugated Steel Pipe (CSP). The culvert inlet (north end) and outlet (south end) inverts are approximately Elevations 283.7 m and 283.1 m, respectively. In general, the topography in the vicinity of the culvert consists of relatively flat terrain, with the Montreal River flowing easterly about 80 m south/southwest of Highway 65. At the culvert location, the highway grade is at approximately Elevation 288.0 m and the embankment is approximately 4.6 m high relative to the culvert invert. The ground surface conditions at select locations in the culvert area are shown on Photographs 1 to 4.

## 3.0 INVESTIGATION PROCEDURES

Field work for this subsurface investigation was carried out between October 11 and October 17, 2018, during which time five boreholes (Boreholes C8-1 to C8-5) were advanced at approximate locations shown on Drawing 1. Three boreholes were advanced through the roadway embankment and two boreholes were advanced near the toes of the highway embankment slopes adjacent to the culvert inlet/outlet ends using a track mounted CME-55LC drill rig supplied and operated by George Downing Estate Drilling of Grenville-Sur-La-Rouge, Quebec. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

The boreholes were advanced using 108 mm I.D. Hollow Stem Augers and NW casing with wash boring techniques. 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) procedure (ASTM D1586). The groundwater level inside the augers/casing was observed during the drilling operations. The boreholes were backfilled using the native sand soil cuttings upon completion of drilling, consistent with Ontario Regulation 903 (as amended) considering the consistent subsurface soil conditions at the

site. The roadway surface at the boreholes drilled through Highway 65 were capped at ground surface using cold patch asphalt.

Field work was supervised on a full-time basis by a member 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, grain size distributions, and Atterberg limits was carried out on selected soil samples. The geotechnical laboratory testing was completed according to ASTM and MTO LS standards, as applicable.

The as-drilled borehole locations were measured relative to highway chainages/stations marked on the pavement by a member of our technical staff to an accuracy of 0.1 m and converted into northing/easting coordinates on the plan drawing. The ground surface elevation at the borehole locations as surveyed by Golder relative to the highway and culvert centreline to an accuracy of 0.1 m, with the elevation of the roadway centreline provided by AECOM. The MTM NAD83-CSRS CBN v6-2010.0 (Zone 12) northing and easting coordinates, geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD 83 Northing (m) [Latitude]	MTM NAD 83 Easting (m) [Longitude]	Ground Surface Elevation (m)	Borehole Depth (m)
C8-1	5286683.5 (47.717171)	356811.5 (-80.306745)	288.0	15.9
C8-2	5286692.4 (47.717252)	356791.6 (-80.307011)	287.8	15.9
C8-3	5286683.8 (47.717174)	356800.4 (-80.306893)	287.9	20.4
C8-4	5286701.3 (47.717331)	356805.1 (-80.306829)	284.9	9.8
C8-5	5286668.6 (47.717037)	356794.0 (-80.306981)	284.8	9.8

## 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 subsoils in the vicinity of the culvert site are located within a glaciolacustrine plain, consisting of clay and sand.

Based on geological mapping (MNDM)<sup>2</sup>, the site is underlain by mafic and related intrusive rocks generally consisting of diabase sills and diabase dikes.

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

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

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the summary 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 discussed in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile shown 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, however, the factual data presented on the record of borehole governs any interpretation of the site conditions. A summary description of the soil deposits and groundwater conditions encountered in the boreholes is provided below. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

### 4.2.1 Asphalt/Fill

An approximately 50 mm to 100 mm thick layer of asphalt (pavement) was encountered in the roadway Boreholes C8-1 to C8-3 between Elevations 288.0 and 287.8 m. A 3.1 m to 3.6 m thick layer of embankment fill consisting of sand and gravel, sand, or sandy silt was encountered below the asphalt in Boreholes C8-1 to C8-3. In Borehole C8-4, a 0.8 m thick layer of sandy silt was encountered from ground surface at Elevation 284.9 m.

The SPT "N"-values measured within the fill range between 4 blows and 100 blows per 0.3 m of penetration, indicating a very loose to very dense compactness condition.

Grain size distribution analysis was carried out on two samples of the fill and the results are presented on Figure B-1 in Appendix B. The natural moisture content measured on two samples of the fill were 4 and 5 per cent.

### 4.2.2 Topsoil / Peat

In Borehole C8-4, a 0.6 m thick layer of amorphous peat was encountered below the fill at Elevation 284.1 m and in Borehole C8-5, a 0.1 m thick layer of topsoil was encountered from ground surface at Elevation 284.8 m.

One SPT "N"-value measured within the peat is 6 blows per 0.3 m of penetration, indicating a firm consistency.

### 4.2.3 Silt to Silt and Sand

A non-cohesive deposit of silt with clay pockets/layers to silt and sand was encountered in Boreholes C8-1 and C8-3 to C8-5 between Elevations 284.8 m and 283.5 m. The thickness of the deposit ranges between 1.1 m and 3.7 m.

The SPT "N"-values measured within the deposit range from 1 blow to 15 blows per 0.3 m of penetration, indicating that the deposit has a very loose to compact compactness condition.

Grain size distribution analysis was carried out on eight samples of the deposit and the results are presented on Figure B-2 in Appendix B. Atterberg limits tests was carried out on five samples of the deposit: two samples were determined to be non-plastic and three samples yielded liquid limits ranging from 21 per cent to 26 per cent, plastic limits ranging between 17 per cent and 20 per cent and plasticity indices ranging between 4 per cent and 7 per cent. The results of the three Atterberg limit tests are presented on Figure B-3 in Appendix B and together with the two non-plastic results indicate the overall deposit is comprised of clayey silt - silt of slight plasticity to silt. The natural moisture content measured on samples of the deposit ranged from 19 per cent to 27 per cent.

#### 4.2.4 Sand

A sand deposit was encountered in Boreholes C8-1 to C8-5, between Elevations 284.6 m and 281.0 m. Boreholes C8-1 to C8-5 were terminated within the sand deposit, penetration into the deposit for thicknesses between 6.0 m and 14.8 m.

The SPT “N”-values measured within the sand deposit range from 1 blow to 36 blows per 0.3 m of penetration indicating that the deposit has a very loose to dense compactness condition.

Grain size distribution analysis was carried out on ten samples of the deposit, the results are presented on Figure B-4 in Appendix B. The natural moisture content measured on samples of the deposit range from 8 per cent to 28 per cent.

### 4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface measured inside the casing or auger upon completion of drilling are summarized below. The creek water level near the culvert outlet, as surveyed by Golder on October 11, 2018, was about at Elevation 283.1 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
C8-1	7.0	281.0
C8-2	6.6	281.2
C8-3	7.3	280.6
C8-4	4.6	280.3
C8-5	4.1	280.7

## 4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a soil sample recovered from Borehole C8-3. The soil sample was submitted to Maxxam Analytics of Sudbury, Ontario for corrosivity testing. The analytical laboratory test results are summarized below, and the detailed analytical laboratory test report is included in Appendix B.

Borehole No.	Sample No.	Depth (m)	Parameters				
			Resistivity (ohm/cm)	Electrical Conductivity (µmho/cm)	Soluble Sulphate (SO <sub>4</sub> ) Content (µg/g)	Chloride (Cl) Content (µg/g)	pH
C8-3	3	1.5 – 2.1	3,300	302	<20 <sup>1</sup>	71	7.81

Note:

1. The sulphate concentration is below the reportable detection limit of 20 µg/g.

## 5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Tibor Berecz, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Tibor Berecz, and Mr. André Bom, 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.

## Signature Page

**Golder Associates Ltd.**

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

TB/AB/JMAC/sb

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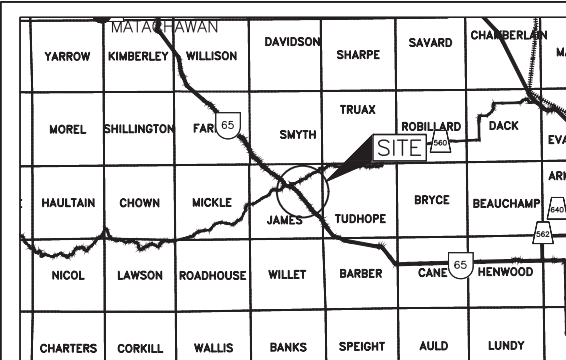
[https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2\\_reporting/r01-jam-108/3\\_final/1896349-r-reva-aecom-jam-108-hwy-65-fir-17jun\\_2019.docx](https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2_reporting/r01-jam-108/3_final/1896349-r-reva-aecom-jam-108-hwy-65-fir-17jun_2019.docx)

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

CONT No.  
GWP No. 5204-14-00



**HIGHWAY 65**  
STATION 17+077  
TOWNSHIP OF JAMES CULVERT  
**BOREHOLE LOCATIONS AND SOIL STRATA**



**KEY PLAN**  
SCALE  
10 0 10 20 km

**LEGEND**

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling



BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
C8-1	288.0	5286683.5	356811.5
C8-2	287.8	5286692.4	356791.6
C8-3	287.9	5286683.8	356800.4
C8-4	284.9	5286701.3	356805.1
C8-5	284.8	5286668.6	356794.0

**NOTES**

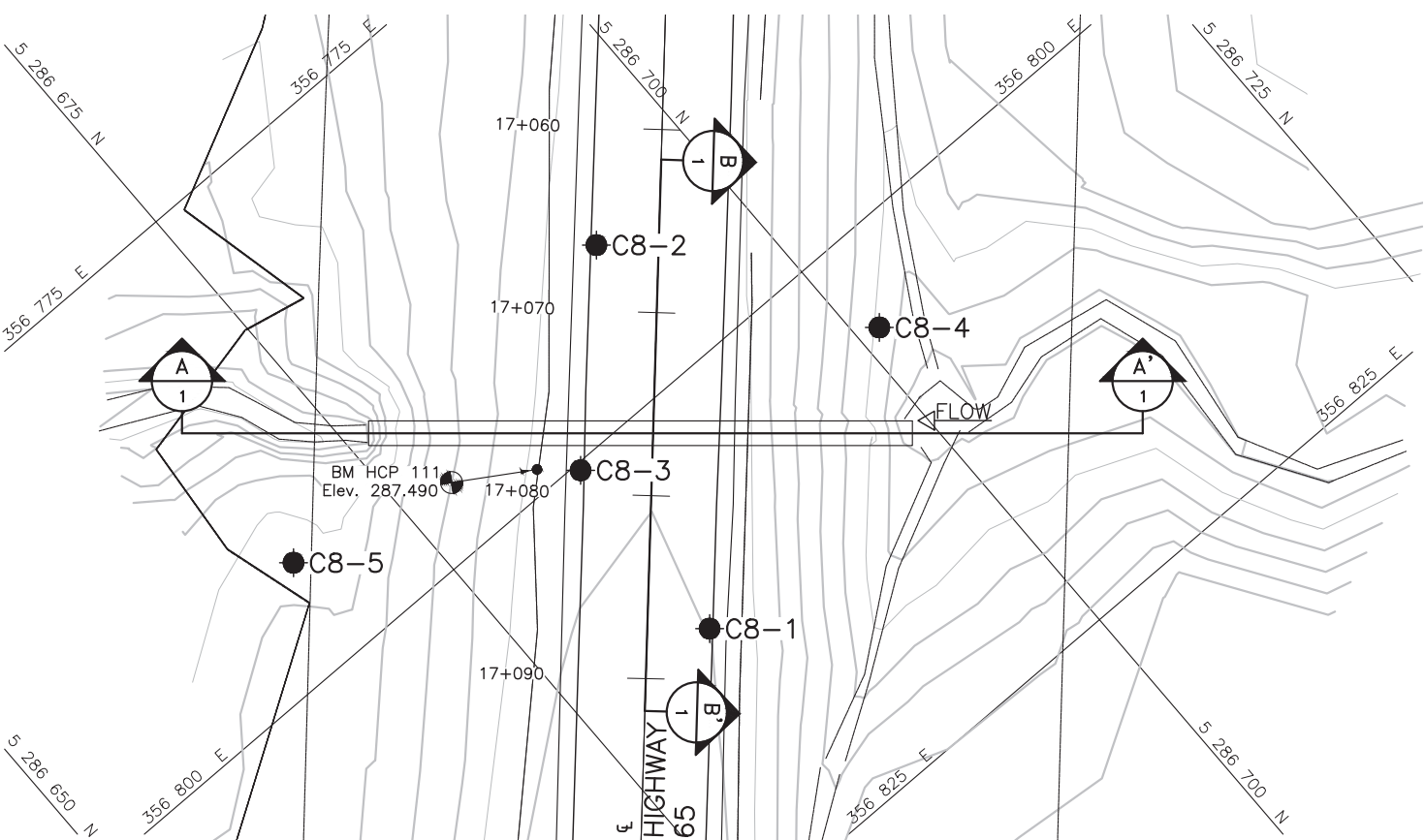
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

**REFERENCE**

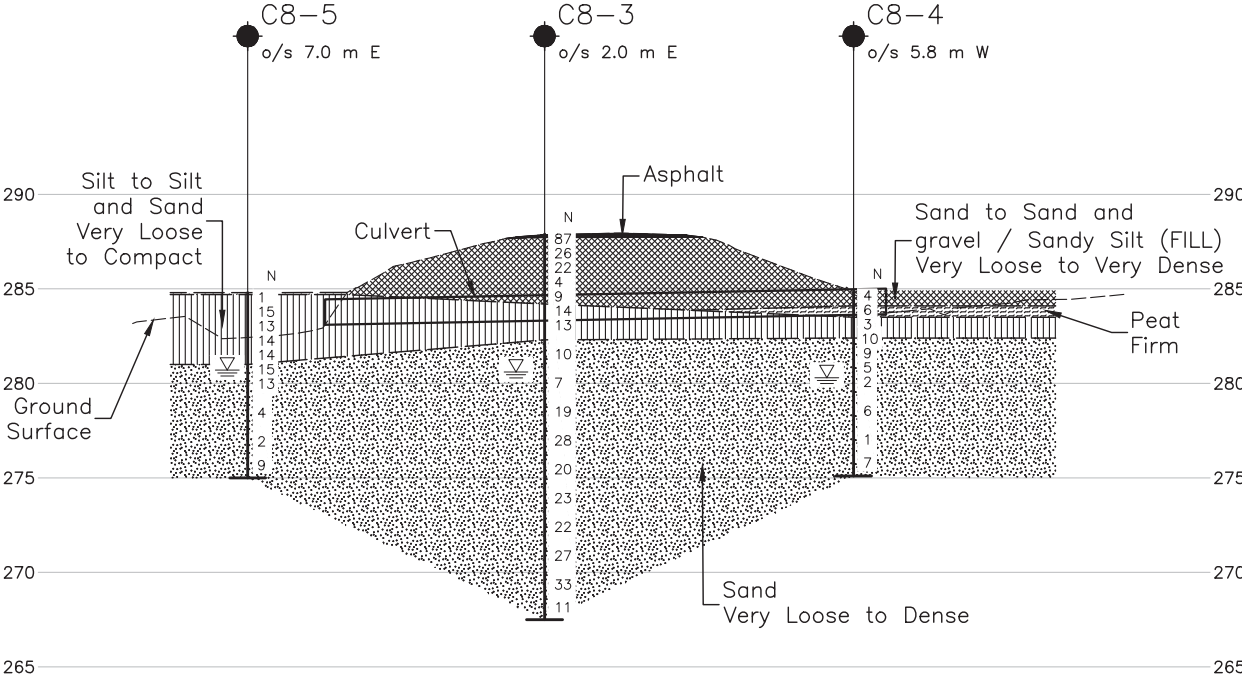
Base plans provided in digital format by AECOM, drawing file nos. B065JAM.dwg, received MAR 15, 2019.

NO.	DATE	BY	REVISION
Geocres No. 41P-77			
HWY. 65	PROJECT NO. 1896349		DIST. .
SUBM'D. GM	CHKD. TB	DATE: 5/21/2019	SITE: .
DRAWN: TR	CHKD. AB	APPD. JMAC	DWG. 1



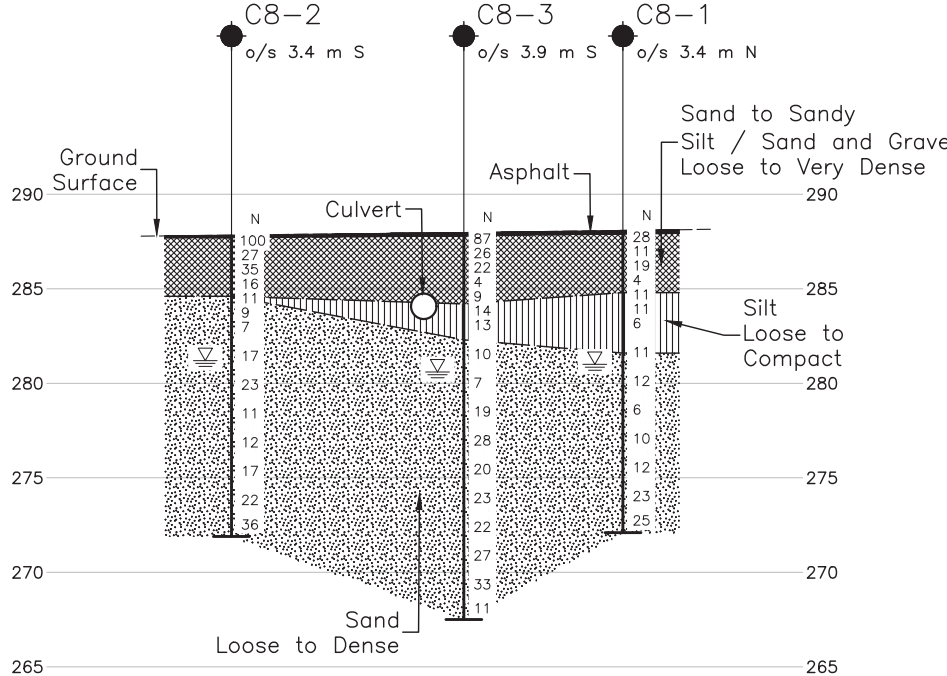
**PLAN**

SCALE  
4 0 4 8 m



**CULVERT CENTERLINE PROFILE**

HORIZONTAL SCALE  
4 0 4 8 m  
VERTICAL SCALE  
4 0 4 8 m



**HIGHWAY CENTERLINE PROFILE**

HORIZONTAL SCALE  
4 0 4 8 m  
VERTICAL SCALE  
4 0 4 8 m



**Photograph 1: Borehole C8-3, Facing South (October 2018)**



**Photograph 2: Borehole C8-2, Facing North (October 2018)**



**Photograph 3: Borehole C8-4, Facing South (October 2018)**



**Photograph 4: Borehole C8-5, Facing South (October 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 <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

PROJECT 1896349		<b>RECORD OF BOREHOLE No C8-1</b>		1 OF 2 <b>METRIC</b>										
G.W.P. 5204-14-00		LOCATION N 5286683.5; E 356811.5 NAD83 MTM ZONE 12 (LAT. 47.717171; LONG. -80.306745)		ORIGINATED BY TB/GM										
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring		COMPILED BY TB										
DATUM GEODETIC		DATE October 17, 2018		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						
288.0	PAVEMENT SURFACE													
0.0	ASPHALT (65mm)													
287.4	Sand and gravel, 100 mm thick asphalt layer at 0.3 m depth. (FILL)		1	SS	28									
0.6	Compact Brown Moist													
	Sandy silt to sand, trace to some gravel (FILL)		2	SS	11									
	Loose to compact Brown to grey Moist													
			3	SS	19									
			4	SS	4									
284.8														
3.2	SILT with clay pockets/layers, trace to some sand		5	SS	11									0 8 70 22
	Loose to compact Brown Moist													
			6	SS	11								NP	0 26 70 4
			7	SS	6									0 17 65 18
281.6														
6.4	SAND, trace silt, trace gravel		8	SS	11									
	Loose to compact Brown to grey Moist to wet													
			9	SS	12									2 95 (3)
			10	SS	6									
			11	SS	10									

Continued Next Page

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

SUD-MTO 001 S:\CLIENTS\MTOT\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

PROJECT <u>1896349</u>		<b>RECORD OF BOREHOLE No C8-1</b>				2 OF 2 <b>METRIC</b>	
G.W.P. <u>5204-14-00</u>		LOCATION <u>N 5286683.5; E 356811.5 NAD83 MTM ZONE 12 (LAT. 47.717171; LONG. -80.306745)</u>				ORIGINATED BY <u>TB/GM</u>	
DIST <u>          </u> HWY <u>65</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring</u>				COMPILED BY <u>TB</u>	
DATUM <u>GEODETIC</u>		DATE <u>October 17, 2018</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>		
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED									
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SAND, trace silt, trace gravel Loose to compact Brown to grey Moist to wet		12	SS	12												0 96 (4)
			13	SS	23												
272.1			14	SS	25												
15.9	END OF BOREHOLE  Note:  1. Water level at a depth of 7.0 m below ground surface (Elev. 281.0 m) upon completion of drilling.																

SUD-MTO 001 S:\CLIENTS\MTOT\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02 DATA\GINT\1896349.GPJ GAL-MISS GDT 4-2-19 TR

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



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

SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02 DATA\GINT\1896349.GPJ GAL-MISS GDT 4-2-19 TR

PROJECT 1896349		RECORD OF BOREHOLE No C8-3		1 OF 2 METRIC																
G.W.P. 5204-14-00		LOCATION N 5286683.8; E 356800.4 NAD83 MTM ZONE 12 (LAT. 47.717174; LONG. -80.306893)		ORIGINATED BY TB																
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring		COMPILED BY TB																
DATUM GEODETIC		DATE October 11, 2018		CHECKED BY AB																
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			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		ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL			
								20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			20 40 60 80 100		
287.9	PAVEMENT SURFACE																			
0.0	ASPHALT (50 mm)																			
0.1	Sand and gravel (FILL)		1	SS	87															
287.3	Very dense Brown Moist																			
0.6	Sand, some silt, some gravel (FILL)		2	SS	26		287													
	Loose to compact Brown Moist																			
			3	SS	22		286													
			4	SS	4		285													
			5	SS	9															
284.2																				
3.7	SILT with clay pockets/layers, some sand		6	SS	14		284													
	Compact Brown Moist																			
			7	SS	13		283													
282.3																				
5.6	SAND, trace silt, trace gravel		8	SS	10		282													
	Loose to dense Brown to grey Moist to wet																			
			9	SS	7		281													
			10	SS	19		280													
			11	SS	28		277													
							276													

Continued Next Page

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

SUD-MTO 001 S:\CLIENTS\MTOT\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

PROJECT 1896349		<b>RECORD OF BOREHOLE No C8-3</b>				2 OF 2 <b>METRIC</b>												
G.W.P. 5204-14-00		LOCATION N 5286683.8; E 356800.4 NAD83 MTM ZONE 12 (LAT. 47.717174; LONG. -80.306893)				ORIGINATED BY TB												
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring				COMPILED BY TB												
DATUM GEODETIC		DATE October 11, 2018				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 $\gamma$ 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										
--- CONTINUED FROM PREVIOUS PAGE ---							<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED + FIELD VANE</span> <span>● QUICK TRIAXIAL × REMOULDED</span> </div>											
	SAND, trace silt, trace gravel Loose to dense Brown to grey Moist to wet		12	SS	20		275											
							274									0 97 (3)		
			13	SS	23		273											
							272											
			14	SS	22		271											
							270											
			15	SS	27		269											
							268											
			16	SS	33													
			17	SS	11													
267.5 20.4	END OF BOREHOLE  Note:  1. Water level at a depth of 7.3 m below ground surface (Elev. 280.6 m) upon completion of drilling.																	

SUD-MTO 001 S:\CLIENTS\MTOT\HWY65&amp;66\02\_DATA\GINT\1896349.GPJ GAL-MISS.GDT 4-2-19 TR

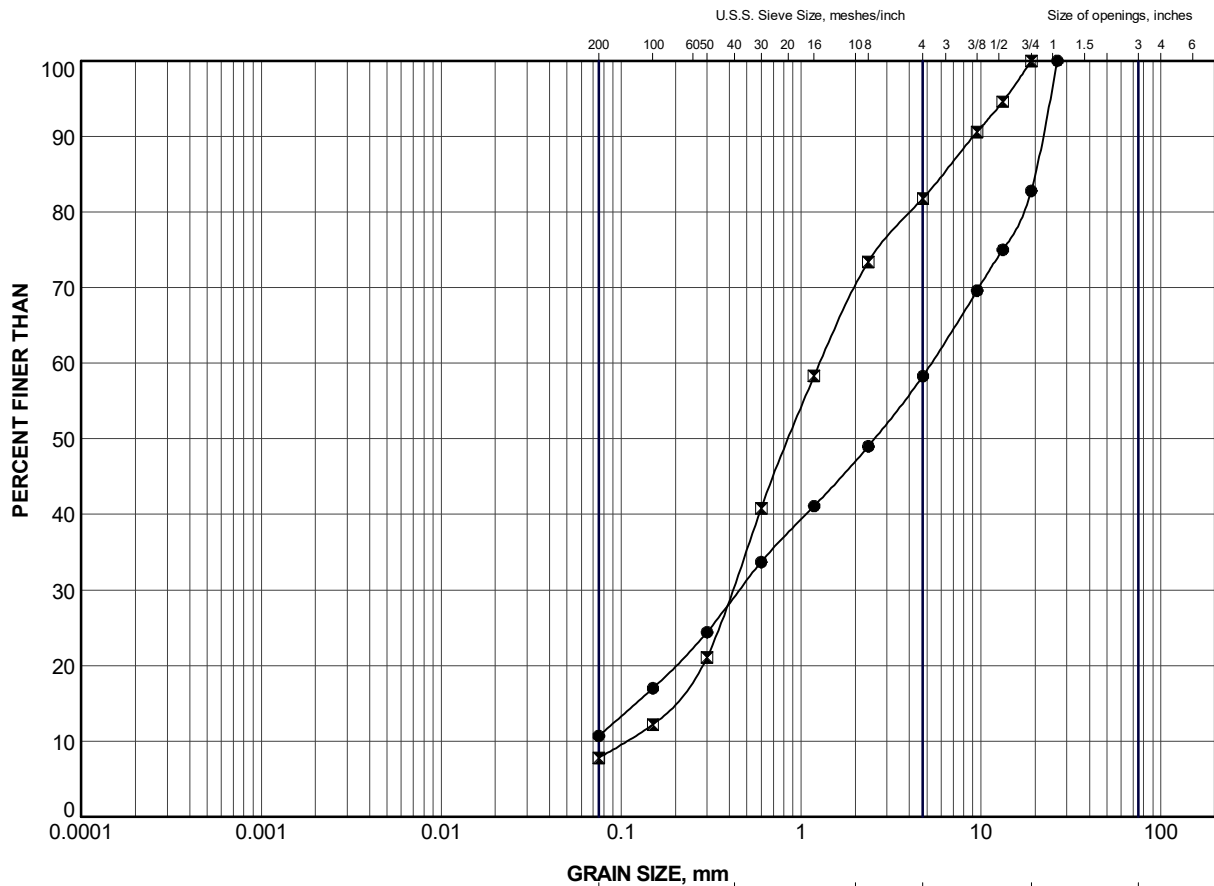
SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02 DATA\GINT\1896349.GPJ GAL-MISS GDT 4-2-19 TR

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

PROJECT 1896349		RECORD OF BOREHOLE No C8-5				1 OF 1 METRIC								
G.W.P. 5204-14-00		LOCATION N 5286668.6; E 356794.0 NAD83 MTM ZONE 12 (LAT. 47.717037; LONG. -80.306981)				ORIGINATED BY TB/GM								
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY TB								
DATUM GEODETIC		DATE October 17, 2018				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	SHEAR STRENGTH kPa		W <sub>p</sub> W W <sub>L</sub>			γ	GR SA SI CL
284.8	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	TOPSOIL							20 40 60 80 100	20 40 60					
0.1	SILT, some sand, trace to some clay, trace organics in upper 0.9 m Very loose to Compact Brown to grey Moist to wet		1	SS	1		284							
			2	SS	15									
			3	SS	13		283							0 15 79 6
			4	SS	14		282							
			5	SS	14									0 17 74 9
281.0	SAND, trace silt Very loose to compact Brown to grey Wet		6	SS	15	▽	281							
3.8			7	SS	13		280							
			8	SS	4		279							0 98 (2)
			9	SS	2		278							
			10	SS	9		277							
275.0	END OF BOREHOLE						276							
9.8	Note: 1. Water level at a depth of 4.1 m below ground surface (Elev. 280.7 m) upon completion of drilling.						275							

**APPENDIX B**


# Laboratory Test Results

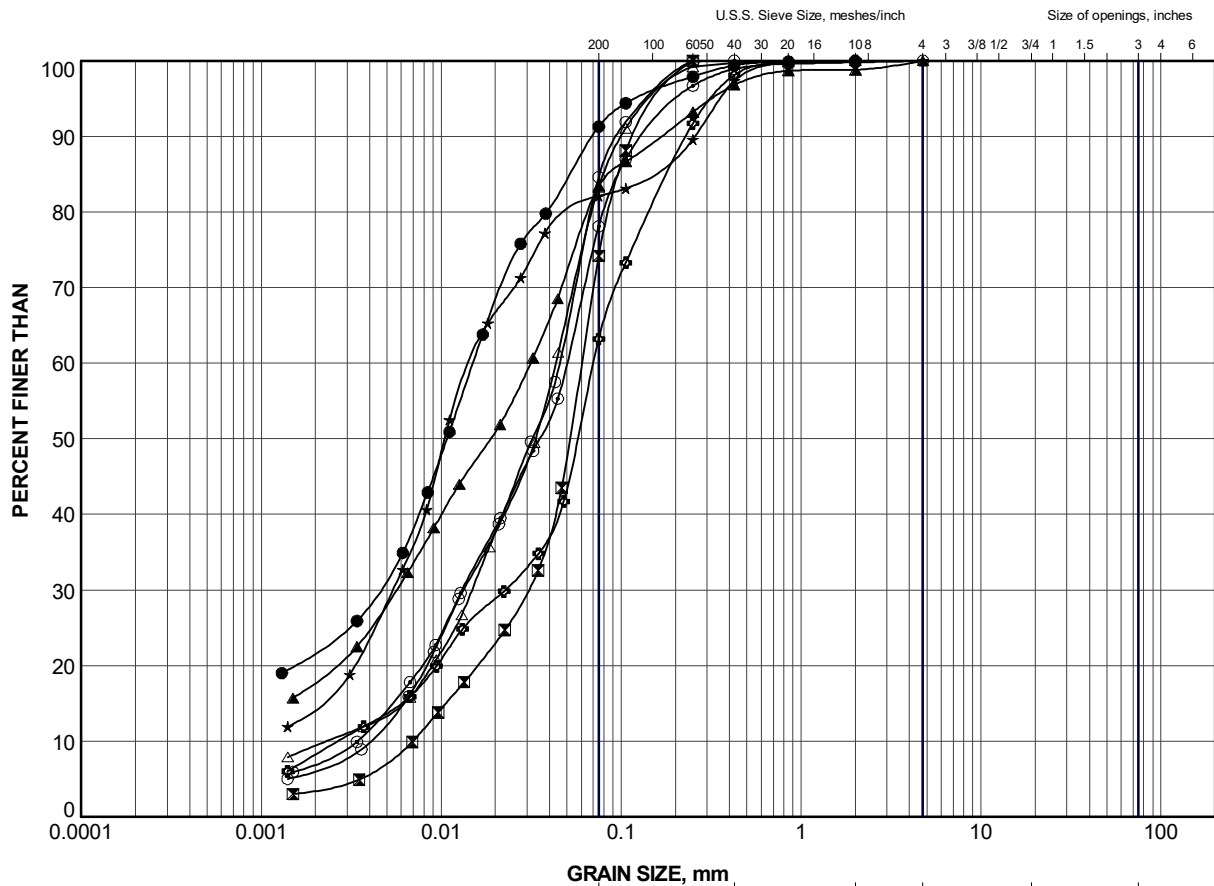


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-2	4	285.2
×	C8-3	5	284.6

PROJECT						HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT					
TITLE						<b>GRAIN SIZE DISTRIBUTION</b> SAND / SAND and GRAVEL (FILL)					
PROJECT No.				1896349		FILE No.				1896349.GPJ	
DRAWN		TR		Apr 2019		SCALE		N/A		REV.	
CHECK		AB		Apr 2019		APPR		JMAC		Apr 2019	
 <b>GOLDER</b> SUDBURY, ONTARIO				<b>FIGURE B-1</b>							

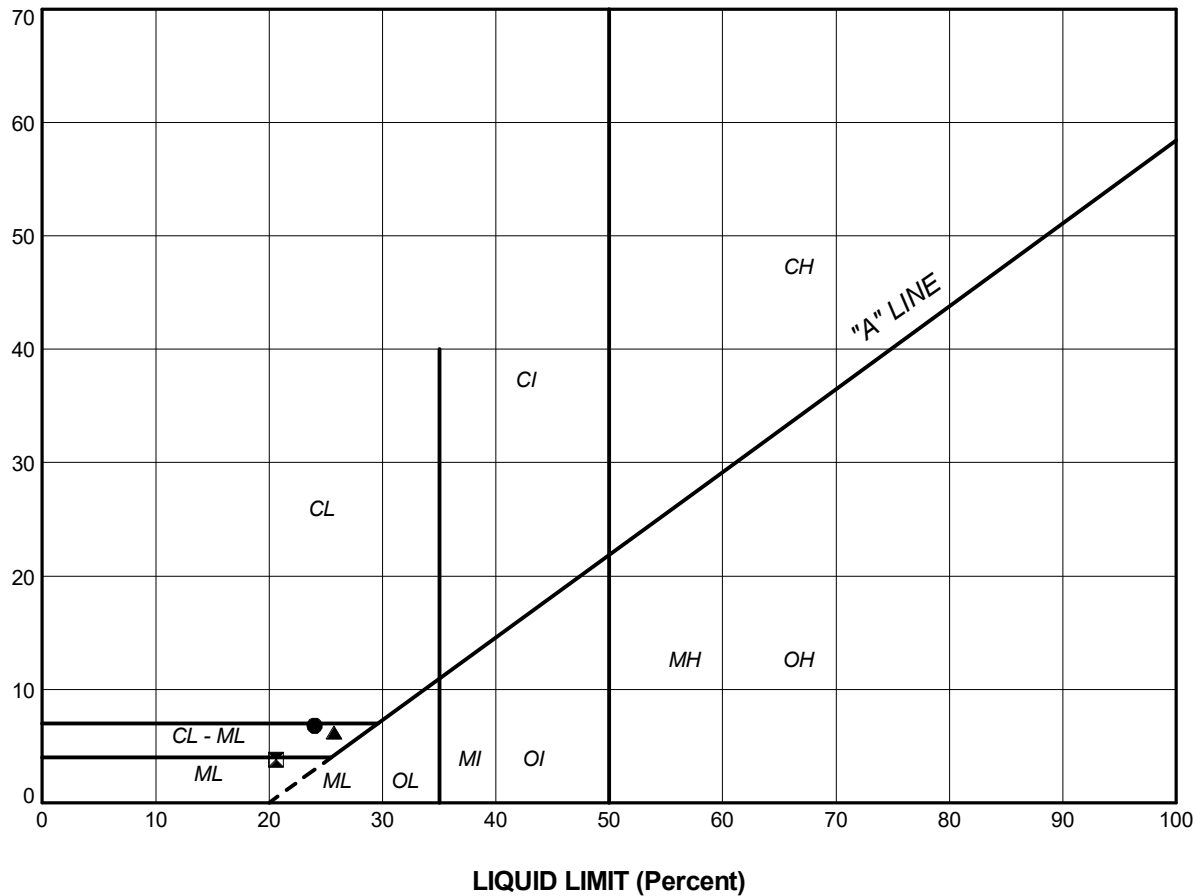


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C8-1	5	284.6
⊠	C8-1	6	283.9
▲	C8-1	7	283.1
★	C8-3	6	283.8
⊙	C8-3	7	283.0
⊗	C8-4	3	283.1
○	C8-5	3	283.0
△	C8-5	5	281.5

PROJECT		HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT			
TITLE		<b>GRAIN SIZE DISTRIBUTION</b> SILT with CLAY POCKETS / LAYERS to SILT and SAND			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	Apr 2019	SCALE	N/A	REV.
CHECK	AB	Apr 2019	<b>FIGURE B-2</b>		
APPR	JMAC	Apr 2019			
GOLDER		SUDBURY, ONTARIO			

PLASTICITY INDEX (Percent)




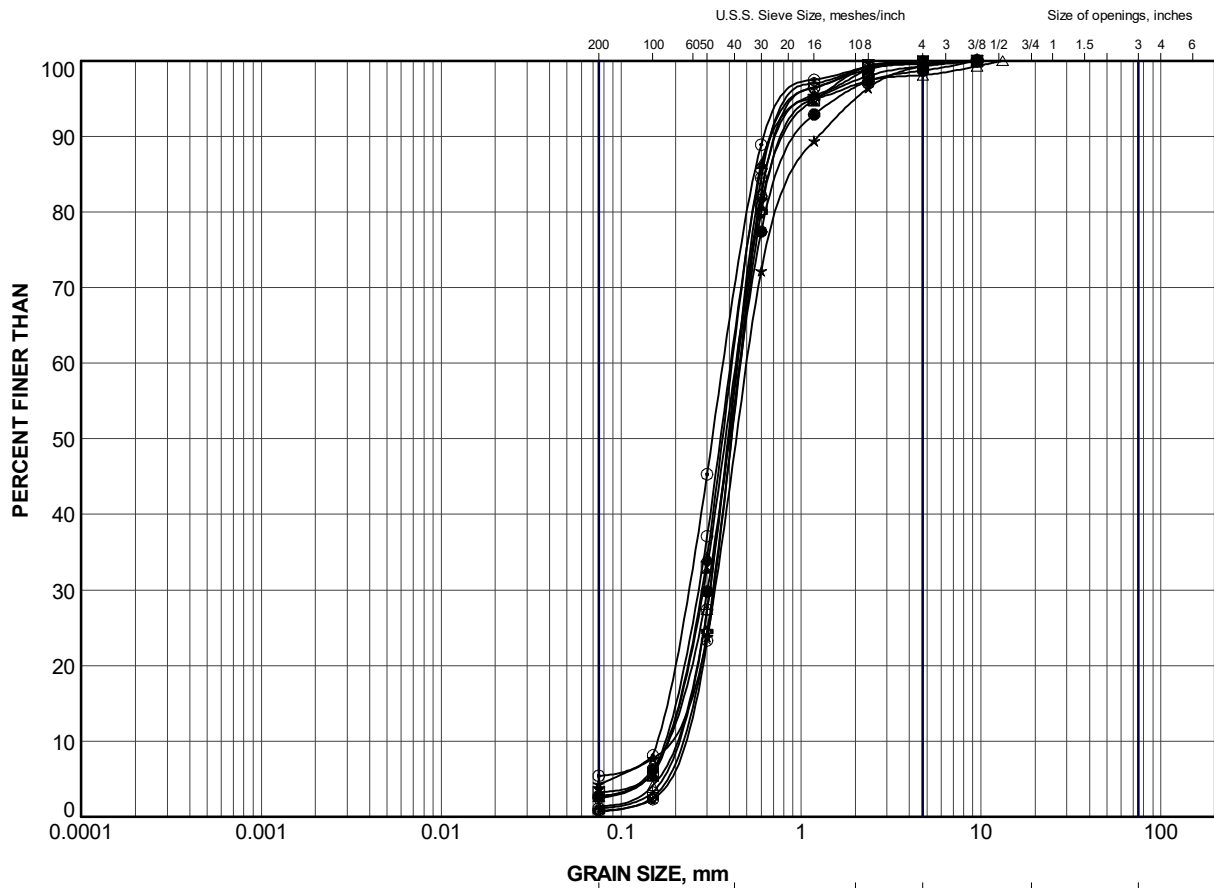
**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C8-1	5	24.0	17.2	6.8
⊠	C8-1	7	20.6	16.8	3.8
▲	C8-3	6	25.7	19.5	6.2


PROJECT		HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT			
TITLE		<b>PLASTICITY CHART</b> SILT with CLAY POCKETS / LAYERS			
PROJECT No.		1896349		FILE No.	
DRAWN		TR	Apr 2019	SCALE	N/A
CHECK		AB	Apr 2019	REV.	
APPR		JMAC	Apr 2019	<b>FIGURE B-3</b>	
 <b>GOLDER</b> SUDBURY, ONTARIO					



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)
●	C8-1	9	280.1
⊠	C8-1	12	275.5
▲	C8-2	6	283.7
★	C8-2	9	279.9
⊙	C8-2	12	275.3
⊕	C8-3	10	278.5
○	C8-3	13	273.9
△	C8-4	5	281.6
⊗	C8-4	8	278.5
⊕	C8-5	8	278.4

PROJECT						HIGHWAY 65 STATION 17+077 TOWNSHIP OF JAMES CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SAND					
PROJECT No.				1896349		FILE No.				1896349.GPJ	
DRAWN		TR		Apr 2019		SCALE		N/A		REV.	
CHECK		AB		Apr 2019		APPR		JMAC		Apr 2019	
 <b>GOLDER</b> SUDBURY, ONTARIO						<b>FIGURE B-4</b>					

### RESULTS OF ANALYSES OF SOIL

<b>Maxxam ID</b>		IBQ378	IBQ379			IBQ379			IBQ380		
<b>Sampling Date</b>		2018/10/18 08:42	2018/10/11 09:58			2018/10/11 09:58			2018/10/12 09:34		
<b>COC Number</b>		35870	35870			35870			35870		
	<b>UNITS</b>	<b>C2-3 SA# 4A</b>	<b>C8-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C8-3 SA# 3 Lab-Dup</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C9-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>

#### Calculated Parameters

Resistivity	ohm-cm	2300	3300		5794629				2500		5794629
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#### Inorganics

Soluble (20:1) Chloride (Cl-)	ug/g	150	71	20	5799805	77	20	5799805	170	20	5799805
Conductivity	umho/cm	429	302	2	5797627				396	2	5797627
Available (CaCl2) pH	pH	7.74	7.81		5796193				7.76		5796193
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	5799807	<20	20	5799807	<20	20	5799807

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Lab-Dup = Laboratory Initiated Duplicate

<b>Maxxam ID</b>		IBQ380			IBQ381		
<b>Sampling Date</b>		2018/10/12 09:34			2018/10/13 09:21		
<b>COC Number</b>		35870			35870		
	<b>UNITS</b>	<b>C9-3 SA# 3 Lab-Dup</b>	<b>RDL</b>	<b>QC Batch</b>	<b>C19-3 SA# 3</b>	<b>RDL</b>	<b>QC Batch</b>

#### Calculated Parameters

Resistivity	ohm-cm				10000		5794629
-------------	--------	--	--	--	-------	--	---------

#### Inorganics

Soluble (20:1) Chloride (Cl-)	ug/g				21	20	5799805
Conductivity	umho/cm	397	2	5797627	99	2	5797627
Available (CaCl2) pH	pH				6.22		5796193
Soluble (20:1) Sulphate (SO4)	ug/g				<20	20	5799807

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Lab-Dup = Laboratory Initiated Duplicate



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