



FOUNDATION INVESTIGATION REPORT

Highway 65, Station 17+580, Township of James Culvert Replacement Ministry of Transportation, Ontario GWP 5204-14-00

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1896349-R04

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GEOCRES NO: 41P-79

LAT: 47.713721

LONG: -80.302905



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PART A

FOUNDATION INVESTIGATION REPORT
HIGHWAY 65, STA 17+580, 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 located on Highway 65 at Station 17+580, approximately 3.1 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 the Drawing 1. For the purpose of this report, Highway 65 is oriented in a west-east direction with the culvert positioned at a skew 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 1.1 m diameter, 31 m long Corrugated Steel Pipe (CSP). The culvert inlet (north end) and outlet (south end) inverts are approximately Elevations 282.7 m and 282.2 m, respectively. In general, the topography within the vicinity of the culvert consists of relatively flat terrain to the north with the Montreal River flowing easterly about 80 m to the south of Highway 65. At the culvert location, the highway grade is at approximately Elevation 287.5 m and the embankment is approximately 5.0 m high relative to the culvert invert. The ground surface conditions at select locations for the culvert area are shown on Photographs 1 to 3.

3.0 INVESTIGATION PROCEDURES

Field work for this subsurface investigation was carried out on October 12, October 16 and November 16, 2018 during which time five boreholes (Boreholes C9-1 to C9-5) were advanced at the approximate locations shown on Drawing 1. Three boreholes were advanced through the roadway embankment and one borehole was advanced near the north toe of the highway embankment slope adjacent to the culvert inlet using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling (Downing) of Grenville-Sur-La-Rouge, Quebec. One borehole was advanced near the south toe of the highway embankment slope adjacent to the culvert outlet using a portable tripod rig supplied and operated by Downing. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

Boreholes C9-1 to C9-4 were advanced by the drilling rig using 108 mm I.D. Hollow Stem Augers and NW casing with wash boring techniques. Borehole C9-5 was advanced by portable tripod using 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 or cathead hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). The split-spoon sampler utilized by the portable drilling equipment to obtain soil samples in Borehole C9-5 was driven by a ½ weight hammer and the SPT “N”-values were adjusted to the inferred values that would have been obtained using a standard weight (63.6 kg) hammer. The groundwater level inside the augers/casing was observed during the drilling operations. The boreholes were backfilled using the silt to sand native soil cuttings upon completion which is consistent with Ontario Regulation 903 as amended and the roadway surface at the boreholes drilled from Highway 65 was restored 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 and organic 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/station 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 provided by AECOM. The ground surface elevation at the borehole locations was surveyed by Golder relative to the highway and culvert centreline to an accuracy of 0.1 m, with the elevation of the centreline provided by AECOM. The MTM NAD 83 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)
C9-1	5286291.7 (47.713621)	357118.9 (-80.302695)	287.3	15.9
C9-2	5286303.5 (47.713729)	357103.6 (-80.302898)	287.7	15.9
C9-3	5286296.9 (47.713669)	357107.6 (-80.302845)	287.5	20.4
C9-4	5286312.3 (47.713807)	357116.9 (-80.302721)	284.0	9.8
C9-5	5286287.7 (47.713587)	357096.5 (-80.302994)	283.8	9.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)¹ mapping, the culvert site is located within a glaciolacustrine plain, consisting of clay and sand.

Based on geological mapping (MNDM)², the site is underlain by mafic and related intrusive rocks and mafic dikes.

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 in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profiles on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The results of the analytical laboratory testing (by Maxxam) are summarized in Section 4.4 and the detailed laboratory testing report is included in Appendix B.

The subsurface conditions will vary between and beyond the borehole locations, however, the factual data presented on the Record of Borehole sheets govern 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

Boreholes C9-1 to C9-3 drilled from the borehole surface between Elevation 287.7 m and 287.3 m penetrated an approximately 50 mm to 100 mm thick layer of asphalt (pavement). A 2.9 m to 3.1 m thick layer of embankment fill consisting of an upper 1.3 m thick layer of sand to sand and gravel was encountered below the asphalt in Boreholes C9-1 to C9-3, underlain by a lower 1.0 m to 1.8 m thick layer of silt to silty sand in Boreholes C9-1 to C9-3. A 0.7 m thick layer of gravelly sand was encountered in Borehole C9-3 under the silt to silty sand layer, at Elevation 285.1 m.

From ground surface in Borehole C9-5, a 1.5 m thick layer of sandy silt fill was encountered at Elevation 283.8 m.

The SPT “N”-values measured within the sand to sand and gravel and silt to silty sand fill range between 11 blows and 85 blows per 0.3 m of penetration indicating a compact to very dense compactness condition. The SPT “N”-values measured within the sandy silt fill in Borehole C9-5 are 3 blows and 5 blows per 0.3 m of penetration, indicating a very loose to loose compactness condition.

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

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

A grain size distribution analysis was carried out on one sample of the sandy silt fill and the result is presented on Figure B-1 in Appendix B. The organic content on the sample of the sandy silt fill is 2.5 per cent. The natural moisture content measured on the sample of sandy silt fill is 23 per cent.

4.2.2 Topsoil/Peat

From the ground surface at Borehole C9-4, an approximate 50 mm layer of topsoil was encountered at Elevation 284.0. A 50 mm thick layer of peat was encountered below the embankment fill at Elevation 284.5 m in Borehole C9-2.

4.2.3 Silt to Silt and Sand

In Boreholes C9-1 to C9-5, a 0.5 m to 2.2 m layer of silt to silt and sand was encountered between Elevations 284.5 m and 282.3 m, underlying the fill and topsoil/peat layers.

The SPT “N”-values measured within the deposit range from 2 blows to 14 blows per 0.3 m of penetration, indicating a very loose to compact compactness condition.

Grain size distributions analysis was carried out on four samples of the silt to silt and sand deposit and the results are presented on Figure B-2 in Appendix B. Three Atterberg limit tests were conducted on samples recovered from the deposit; two tests yielded non-plastic results; while one test measured a liquid limit of 26 per cent, a plastic limit of 20 per cent, and a plastic index of 6 per cent and the results are presented on Figure B-3 in Appendix B. The natural moisture content measured on samples of the deposit ranges from 23 per cent to 31 per cent.

4.2.4 Sand

A deposit of sand was encountered in Boreholes C9-1 to C9-5, with the surface of the deposit between Elevations 283.8 m and 280.8 m. In Boreholes C9-1 to C9-3, the deposit was 7.8 m to 9.6 m thick and encountered between Elevations 283.8 m and 282.2 m. Boreholes C9-4 and C9-5 were terminated within the sand deposit after exploring the deposit for thicknesses of 9.2 m and 6.8 m, respectively.

The SPT “N”-values measured within the deposit range from 2 blows and 19 blows per 0.3 m of penetration, indicating a very loose to compact compactness condition.

Grain size distribution analysis was carried out on ten samples of the sand deposit, and the results are presented on Figure B-4 in Appendix B. The natural moisture content measured on samples of the deposit ranges from 17 per cent and 30 per cent.

4.2.5 Silt and Sand

A deposit of sand silt and sand was encountered in Boreholes C9-1 to C9-3, with the surface of the deposit between 275.6 m and 274.2 m. All three boreholes were terminated in the silt and sand deposit after exploring the deposit for thicknesses between 2.6 and 7.1 m.

The SPT “N”-values measured within the deposit range from 16 blows to 35 blows per 0.3 m of penetration, indicating a compact to dense compactness condition.

Grain size distribution analysis was carried out on one sample of silt and sand deposit, and the results are presented on Figure B-5 in Appendix B. The natural moisture content measured on this sample is 22 per cent.

4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface measured inside the casing or hollow stem augers upon completion of drilling are summarized below. The creek water level near the culvert inlet, as surveyed by Golder on October 12, 2018, is about Elevation 284.8 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)
C9-1	6.1	281.2
C9-2	7.5	280.2
C9-3	3.9	283.6
C9-4	3.5	280.5
C9-5	2.0	281.8

4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a soil sample recovered from Borehole C9-3. The soil sample was submitted to Maxxam Analytics of Sudbury, Ontario for testing of a suite of corrosivity parameters. 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 ₄) Content (µg/g)	Chloride (Cl) Content (µg/g)	pH
C9-3	Sa 3	1.5 – 2.1	2,500	396	<20 ¹	170	7.76

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 and Mr. Mat Riopelle, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Gavin Mundry, EIT, and Mr. André Bom, P.Eng. carried out 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 the report.

Signature Page

Golder Associates Ltd.



Gavin Mundry, EIT
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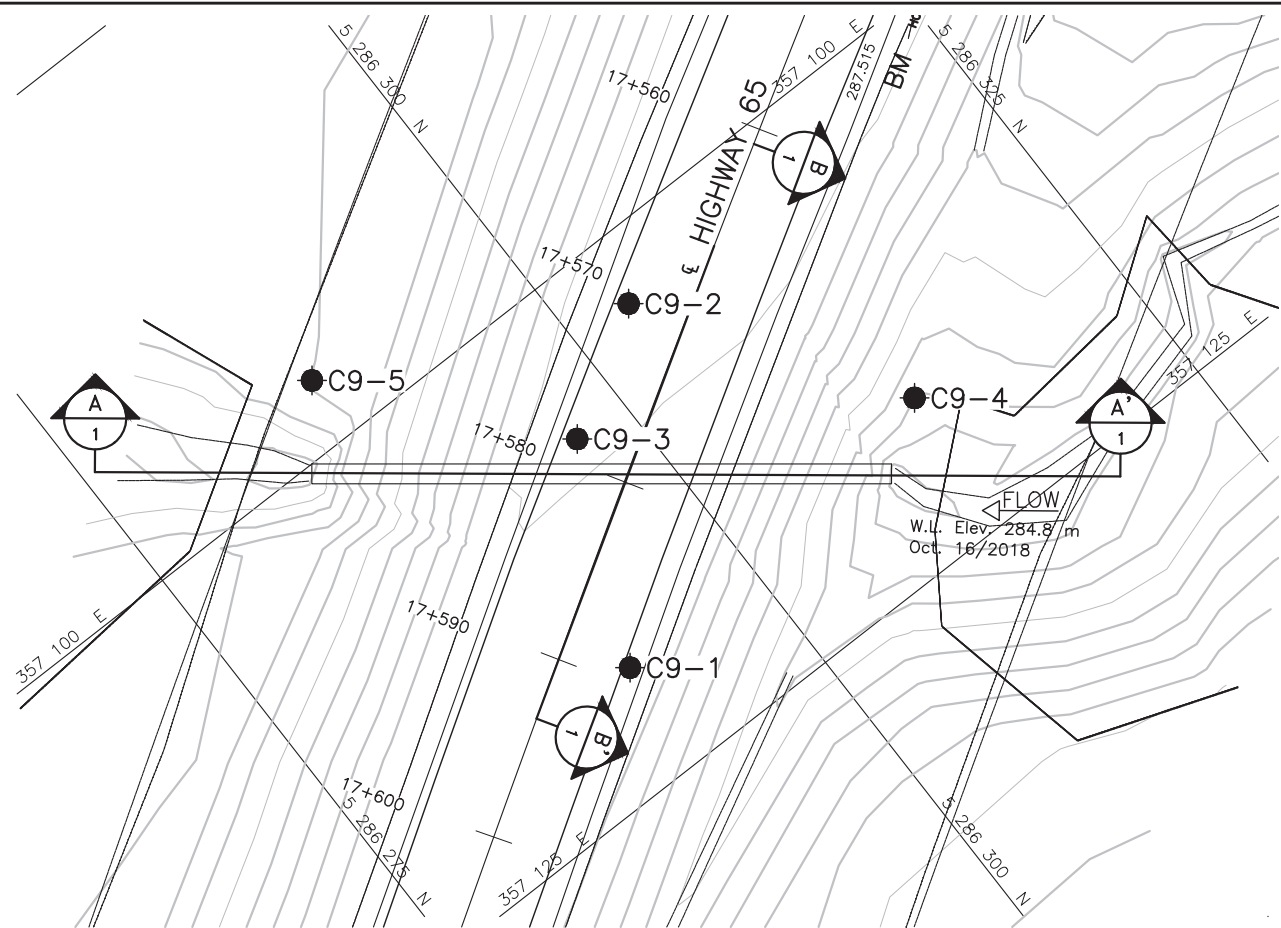


Jorge M. A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

GM/AB/JMAC/sb

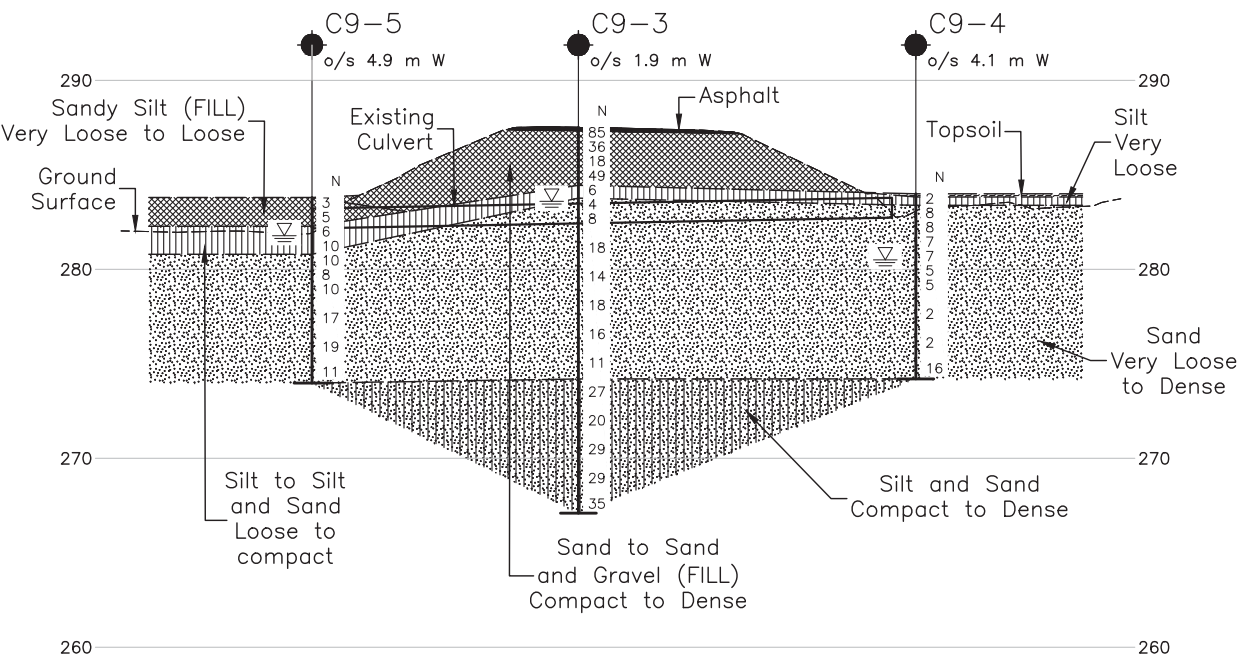
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[https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2. reporting/r04 - jam 109/3. final/1896349-rev0-aecom culvert 9 \(jam 109\) hwy 65 fir 17jun_19.docx](https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2. reporting/r04 - jam 109/3. final/1896349-rev0-aecom culvert 9 (jam 109) hwy 65 fir 17jun_19.docx)



PLAN

SCALE

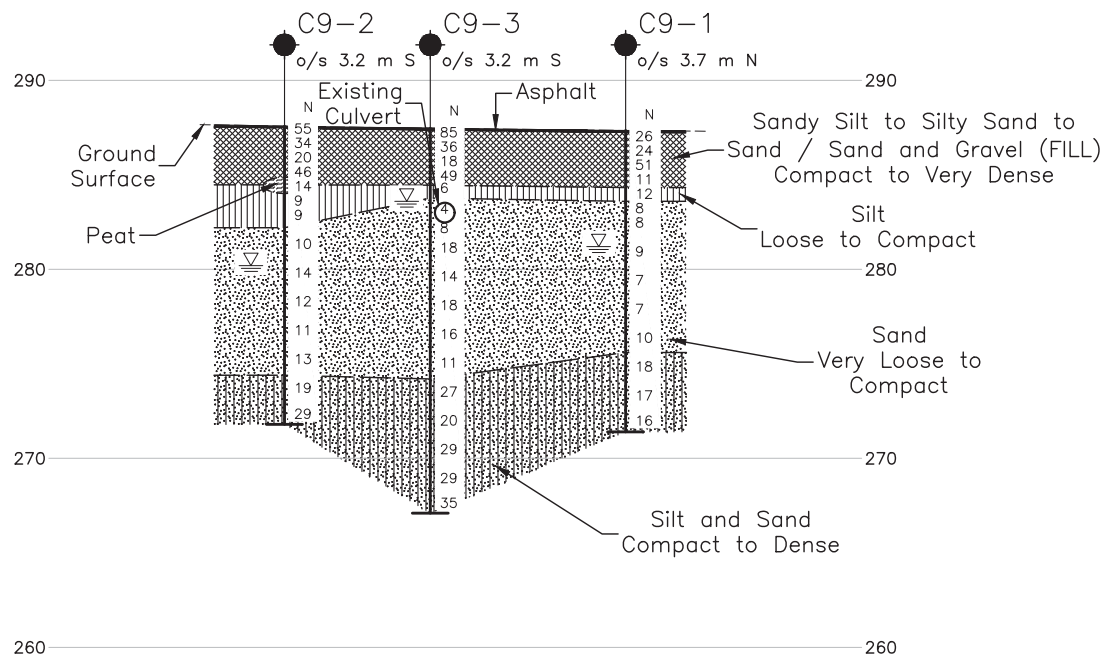


CULVERT CENTERLINE PROFILE

HORIZONTAL SCALE



VERTICAL SCALE



HIGHWAY CENTERLINE PROFILE

HORIZONTAL SCALE



VERTICAL SCALE

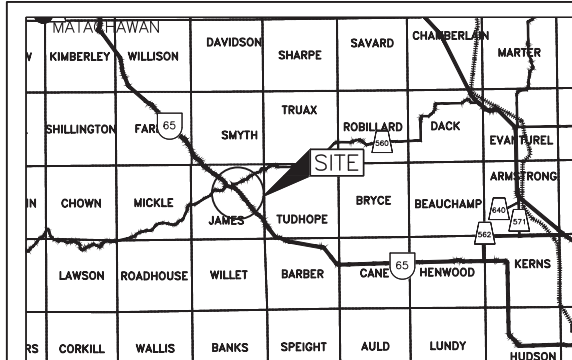
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 5204-14-00



HIGHWAY 65
STATION 17+580
TOWNSHIP OF JAMES CULVERT
BOREHOLE LOCATION AND SOIL STRATA

SHEET



KEY PLAN
SCALE



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
C9-1	287.3	5286291.7	357118.9
C9-2	287.7	5286303.5	357103.6
C9-3	287.5	5286296.9	357107.6
C9-4	284.0	5286312.3	357116.9
C9-5	283.8	5286287.7	357096.5

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-79			
HWY. 65	PROJECT NO. 1896349		DIST. .
SUBM'D. GM	CHKD. TB	DATE: 5/21/2019	SITE: .
DRAWN: TR	CHKD. AB	APPD. JMAC	DWG. 1



Photograph 1: Culvert Inlet (North End), Facing Southeast (October 2018)



Photograph 2: Embankment North Slope at Culvert Area, Facing Northwest (October 2018)



Photograph 3: Embankment South Slope at Culvert Area, Facing Southwest (October 2018)

APPENDIX A

Record of Boreholes

LIST OF SYMBOLS

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

I. GENERAL

π	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

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	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
γ'	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_{α}	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
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	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 ρ . Unit weight symbol is γ 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 cm² 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 ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
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)
γ	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

SUD-MTO 001 S:\CLIENTS\MTO\HWY65&66\02 DATA\GINT\1896349.GPJ GAL-MISS.GDT 5-22-19 TR

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

PROJECT <u>1896349</u>		RECORD OF BOREHOLE No C9-1				2 OF 2 METRIC											
G.W.P. <u>5204-14-00</u>		LOCATION <u>N 5286291.7; E 357118.9 NAD83 MTM ZONE 12 (LAT. 47.713621; LONG. -80.302695)</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>GM</u>											
DATUM <u>GEODETIC</u>		DATE <u>October 16, 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 γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			W _L
--- CONTINUED FROM PREVIOUS PAGE ---																	
271.4 15.9	SILT and SAND Compact Brown to grey Wet		12	SS	18	275											
						274											
			13	SS	17	273											
			14	SS	16	272											
	END OF BOREHOLE																
	Note: 1. Water level at a depth of 6.1 m below ground surface (Elev. 281.2 m) upon completion of drilling.																

PROJECT 1896349		RECORD OF BOREHOLE No C9-2		1 OF 2 METRIC																						
G.W.P. 5204-14-00		LOCATION N 5286303.5; E 357103.6 NAD83 MTM ZONE 12 (LAT. 47.713729; LONG. -80.302898)		ORIGINATED BY TB/GM																						
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring		COMPILED BY GM																						
DATUM GEODETIC		DATE October 12, 2018		CHECKED BY AB																						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE																			
287.7	GROUND SURFACE																									
0.0	ASPHALT (100 mm)		1	SS	55		287																			
0.1	Sand and gravel (FILL) Dense to very dense Brown Moist		2	SS	34																					
286.3	Sandy silt to silty sand (FILL) Compact to dense Brown Moist		3	SS	20		286																			
1.4			4	SS	46		285																			
284.4	PEAT (50 mm)		A	SS	14																					
3.4	SILT, some sand, some clay Loose to compact Brown Wet		5	SS			284																			
			B	SS																						
			6	SS	9																					
			7	SS	9		283																			
282.2	SAND Loose to compact Brown to grey Wet						282																			
5.5			8	SS	10		281																			
			9	SS	14		280																			
							279																			
			10	SS	12		278																			
			11	SS	11		277																			
							276																			

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

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PROJECT 1896349		RECORD OF BOREHOLE No C9-2				2 OF 2 METRIC											
G.W.P. 5204-14-00		LOCATION N 5286303.5; E 357103.6 NAD83 MTM ZONE 12 (LAT. 47.713729; LONG. -80.302898)				ORIGINATED BY TB/GM											
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE October 12, 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					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	20 40 60	20 40 60						
274.4	SAND Loose to compact Brown to grey Wet		12	SS	13		275										
13.3	SILT and SAND Compact Brown to grey Wet		13	SS	19		274										
							273										
271.8			14	SS	29		272										
15.9	END OF BOREHOLE Note: 1. Water level at a depth of 7.5 m below ground surface (Elev. 280.2 m) upon completion of drilling.																

PROJECT		1896349		RECORD OF BOREHOLE No C9-3		1 OF 2 METRIC								
G.W.P.		5204-14-00		LOCATION		N 5286296.9; E 357107.6 NAD83 MTM ZONE 12 (LAT. 47.713669; LONG. -80.302845)								
DIST		HWY 65		BOREHOLE TYPE		108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring								
DATUM		GEODETIC		DATE		October 12, 2018								
						ORIGINATED BY TB/GM								
						COMPILED BY GM								
						CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
287.5	GROUND SURFACE													
0.0	ASPHALT (100 mm)													
0.1	Gravelly sand (FILL)		1	SS	85									
286.8	Very dense Brown Moist													
0.7	Sand, some gravel, trace silt (FILL)		2	SS	36									
286.1	Dense Brown Moist													
1.4	Silt, trace clay (FILL)		3	SS	18									
285.1	Compact Brown to grey Moist													
2.4	Gravelly sand (FILL)		4	SS	49									
284.4	Dense Brown Moist													
3.1	SILT, some clay, trace sand		5	SS	6									
283.8	Loose Brown Moist													
3.7	SAND, trace to some silt		6	SS	4									
	Loose to compact Brown Moist to wet													
			7	SS	8									
			8	SS	18									
			9	SS	14									
			10	SS	18									
			11	SS	16									

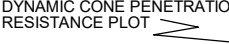
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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT 1896349		RECORD OF BOREHOLE No C9-3				2 OF 2 METRIC											
G.W.P. 5204-14-00		LOCATION N 5286296.9; E 357107.6 NAD83 MTM ZONE 12 (LAT. 47.713669; LONG. -80.302845)				ORIGINATED BY TB/GM											
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE October 12, 2018				CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
274.2	SAND, trace to some silt Loose to compact Brown Moist to wet		12	SS	11		275										
13.3	SILT and SAND Compact to dense Brown to grey Wet		13	SS	27		274										
							273										
			14	SS	20		272										0 60 35 5
							271										
			15	SS	29		270										
							269										
			16	SS	29		268										
267.1	END OF BOREHOLE		17	SS	35												
20.4	Note: 1. Water level at a depth of 3.9 m below ground surface (Elev. 283.6 m) upon completion of drilling.																

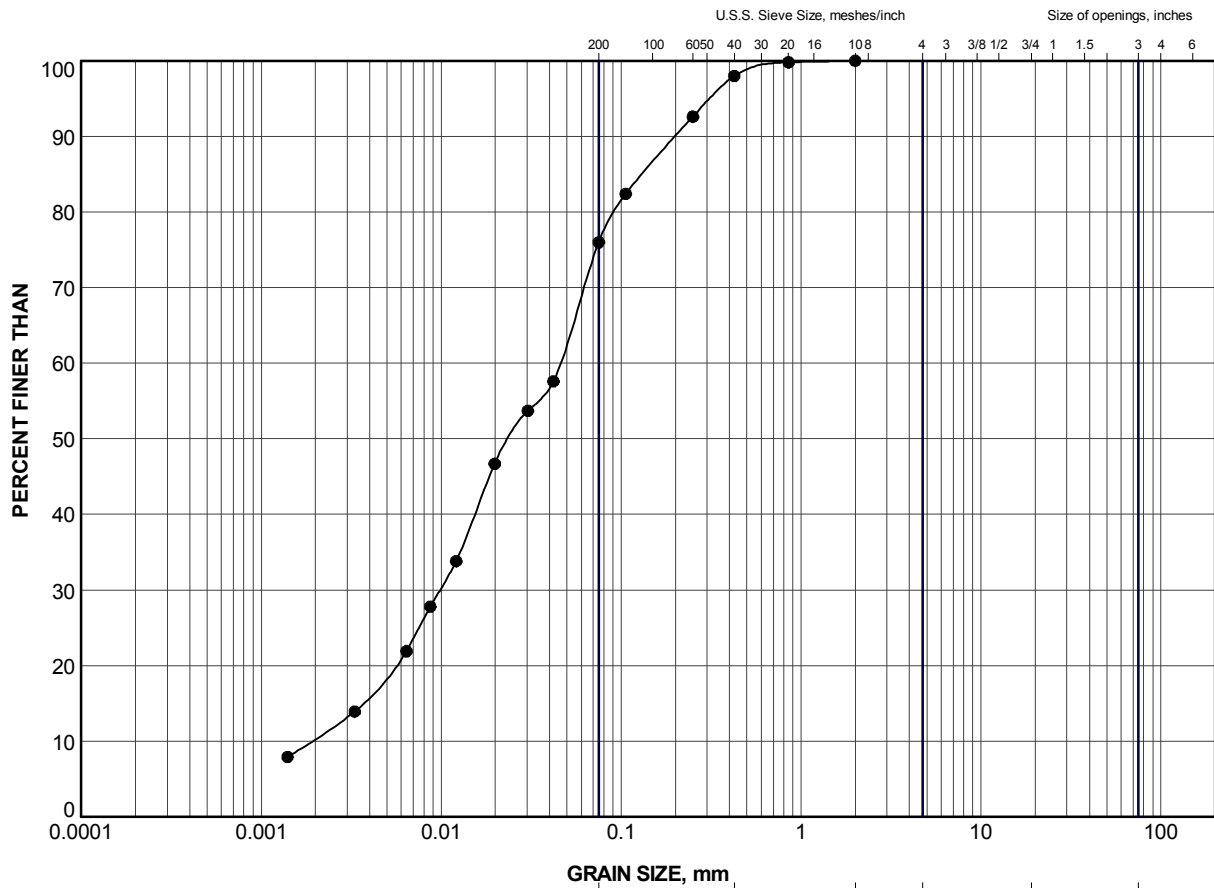
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PROJECT 1896349			RECORD OF BOREHOLE No C9-4				1 OF 1 METRIC				
G.W.P. 5204-14-00			LOCATION N 5286312.3; E 357116.9 NAD83 MTM ZONE 12 (LAT. 47.713807; LONG. -80.302721)				ORIGINATED BY TB/GM				
DIST _____ HWY 65			BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY GM				
DATUM GEODETIC			DATE October 16, 2018				CHECKED BY AB				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
284.0	GROUND SURFACE										
0.9	TOPSOIL (50 mm)		1	SS	2						
283.4	SILT, trace to some sand Brown Very loose Wet		2	SS	8						
0.6	SAND Very loose to compact Brown to grey Wet		3	SS	8						
			4	SS	7						
			5	SS	7						
			6	SS	5						
			7	SS	5						
			8	SS	2						
			9	SS	2						
			10	SS	16						
274.2	END OF BOREHOLE										
9.8	Note: 1. Water level at a depth of 3.5 m below ground surface (Elev. 280.5 m) upon completion of drilling.										

PROJECT 1896349		RECORD OF BOREHOLE No C9-5				1 OF 1 METRIC											
G.W.P. 5204-14-00		LOCATION N 5286287.7; E 357096.5 NAD83 MTM ZONE 12 (LAT. 47.713587; LONG. -80.302994)				ORIGINATED BY MR											
DIST _____ HWY 65		BOREHOLE TYPE NW Casing, Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE November 16, 2018				CHECKED BY AB											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
283.8	GROUND SURFACE							20	40	60	80	100					
0.0	Sandy silt, trace organics (FILL) Very loose to loose Black and brown Frozen / moist		1	SS	3												
			2	SS	5												
282.3	SILT and SAND, trace gravel, trace clay Loose to compact Brown Wet		3	SS	6												
1.5			4	SS	10												
280.8	SAND, trace silt Loose to compact Brown Wet		5	SS	10												
3.0			6	SS	8												
			7	SS	10												
			8	SS	17												
			9	SS	19												
			10	SS	11												
274.0	END OF BOREHOLE																
9.8	Note: 1. Water level at a depth of 2.0 m below ground surface (Elev. 281.8 m) upon completion of drilling. 2. Split Spoon samples obtained by driving with a 1/2 weight hammer. SPT 'N' values have been adjusted to the inferred values that would be obtained using a standard weight hammer.																

APPENDIX B


Laboratory Test Results

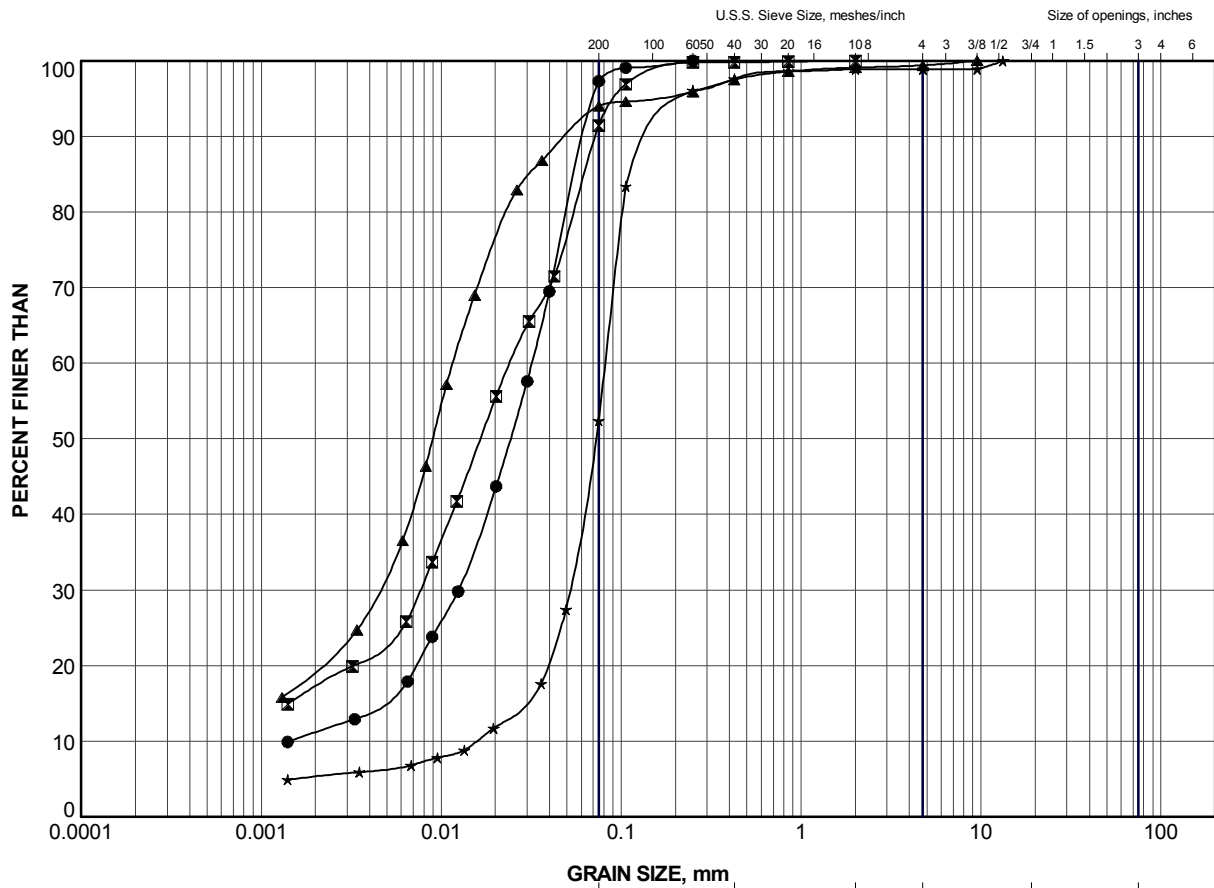


GRAVEL SIZE, mm							Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse		
	SAND SIZE			GRAVEL SIZE			

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-5	2	282.7

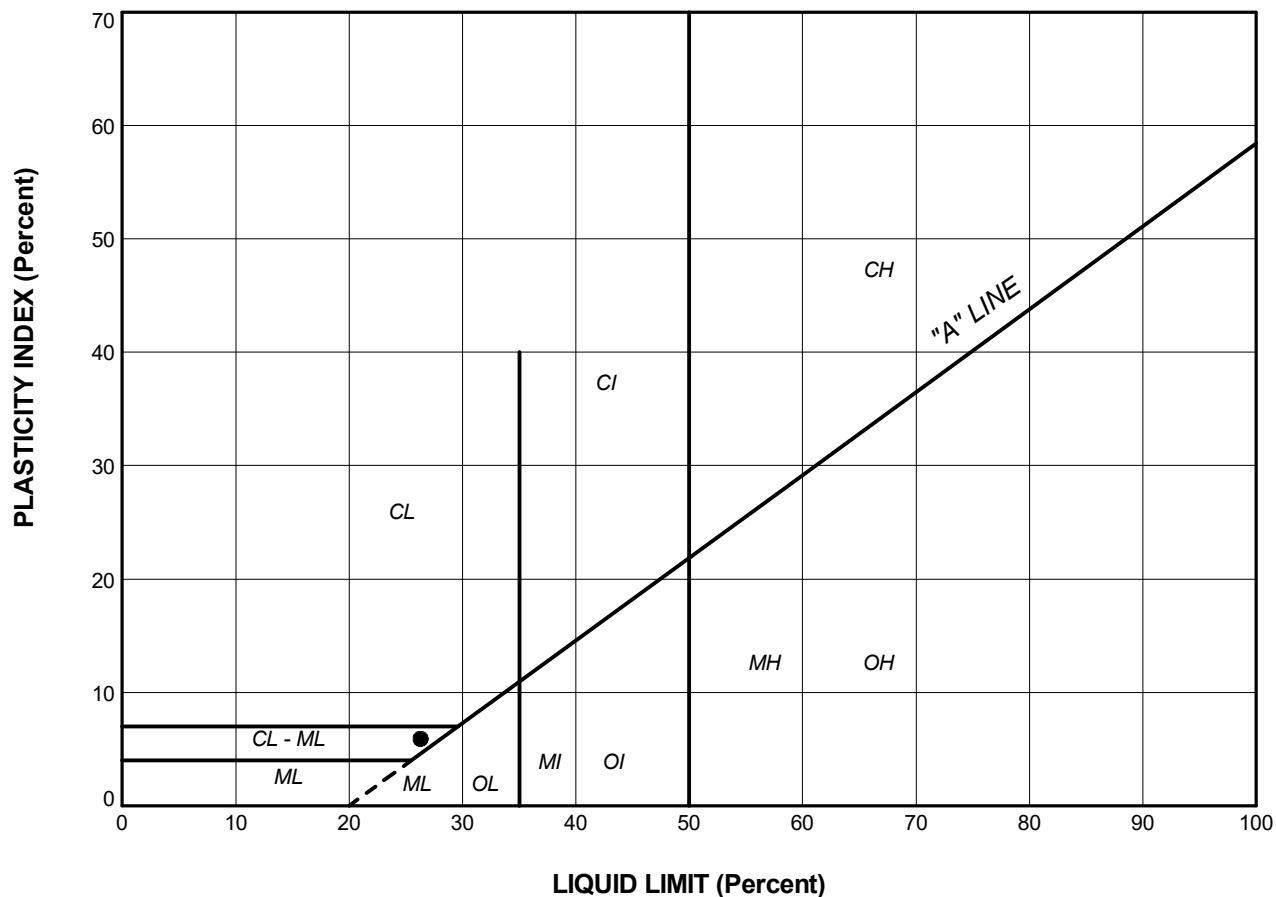
PROJECT		HIGHWAY 65 STATION 17+580 TOWNSHIP OF JAMES CULVERT			
TITLE		GRAIN SIZE DISTRIBUTION Sandy Silt (FILL)			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	Apr 2019	SCALE	N/A	REV.
CHECK	AB	Apr 2019			
APPR	JMAC	Apr 2019			
 GOLDER SUDBURY, ONTARIO		FIGURE B-1			



LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-1	5	283.9
■	C9-2	6	283.6
▲	C9-3	5	284.2
★	C9-5	4	281.2

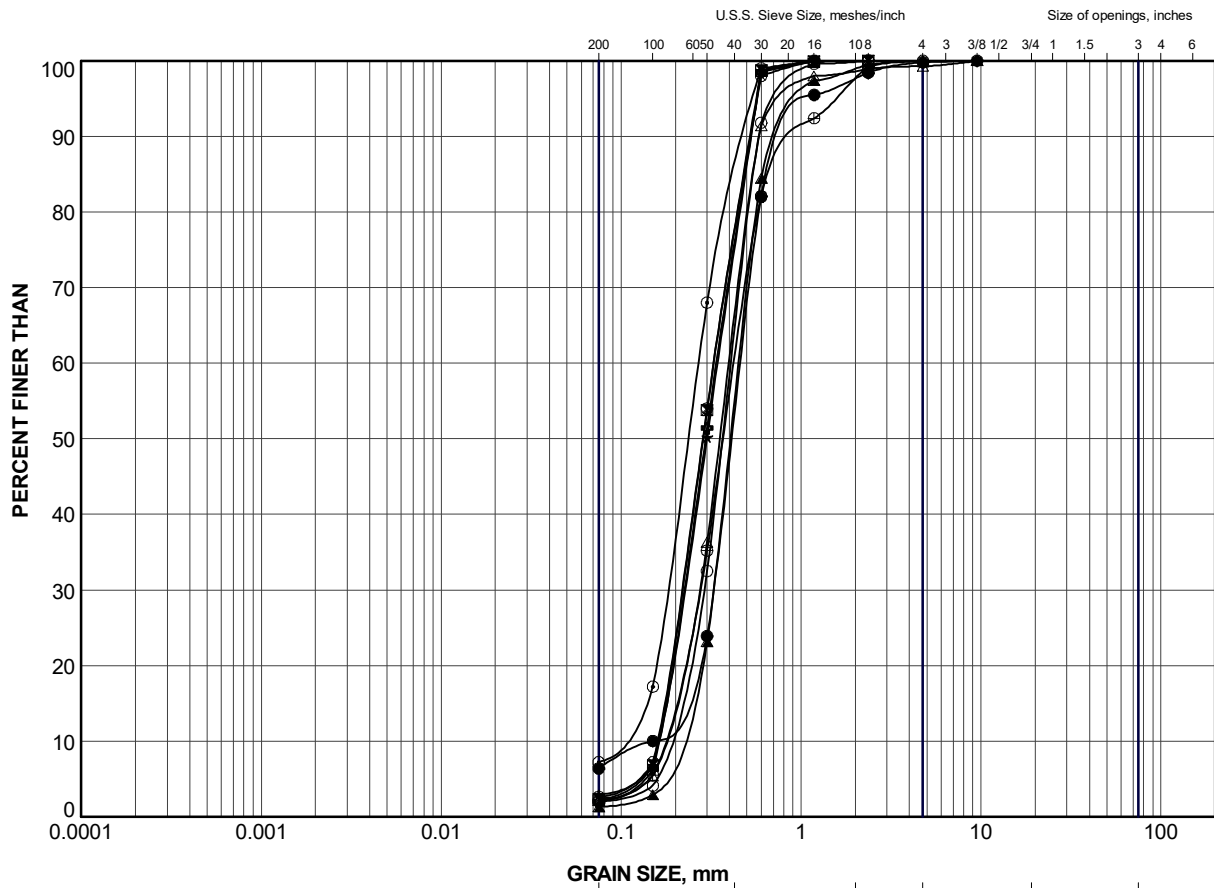
PROJECT		HIGHWAY 65 STATION 17+580 TOWNSHIP OF JAMES CULVERT			
TITLE		GRAIN SIZE DISTRIBUTION SILT to SILT and SAND			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	Apr 2019	SCALE	N/A	REV.
CHECK	AB	Apr 2019			
APPR	JMAC	Apr 2019			
 GOLDER SUDBURY, ONTARIO			FIGURE B-2		



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C9-3	5	26.3	20.4	5.9

PROJECT						HIGHWAY 65 STATION 17+580 TOWNSHIP OF JAMES CULVERT					
TITLE						PLASTICITY CHART SILT					
PROJECT No.			1896349			FILE No.			1896349.GPJ		
DRAWN	TR	May 2019	SCALE		N/A	REV.					
CHECK	AB	May 2019									
APPR	JMAC	May 2019									
 GOLDER SUDBURY, ONTARIO						FIGURE B-3					

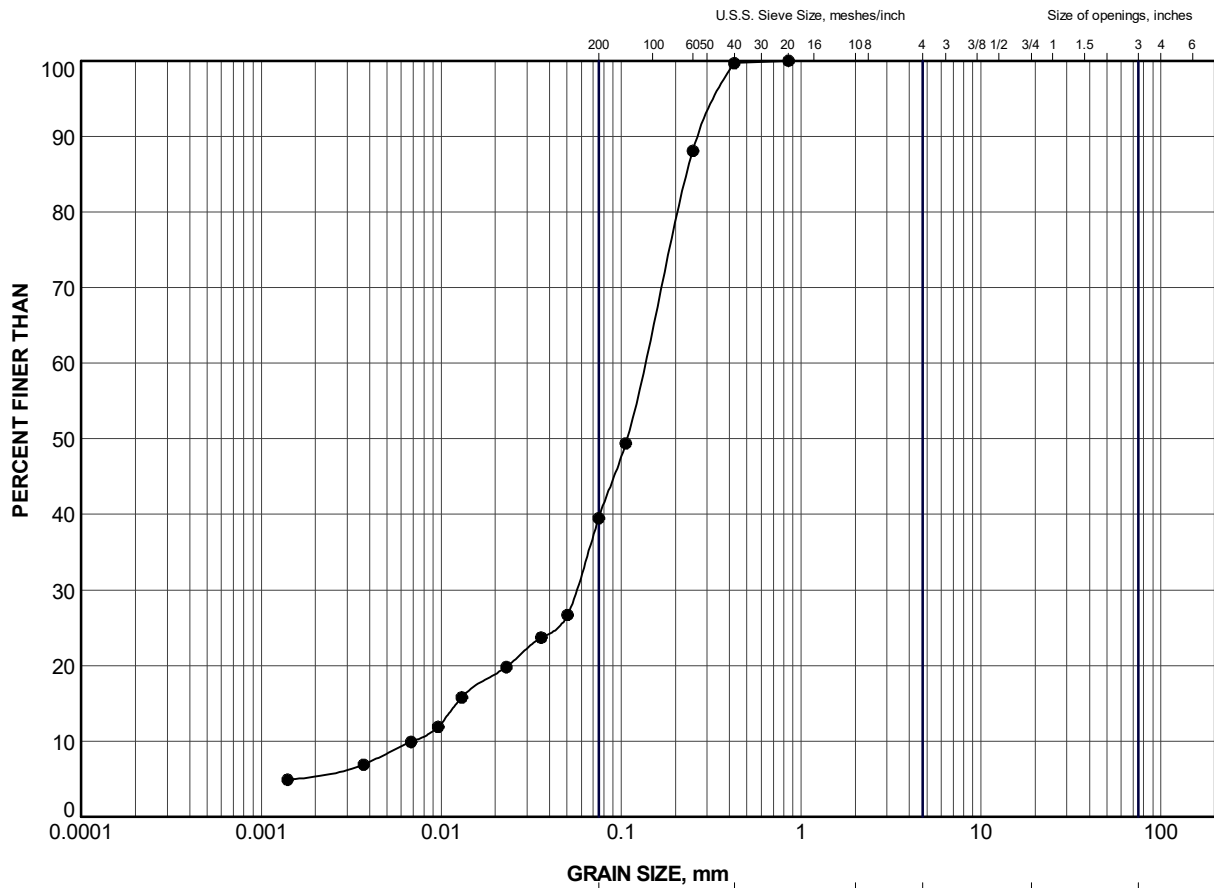


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-1	8	280.9
⊠	C9-1	11	276.3
▲	C9-2	9	279.8
★	C9-2	12	275.2
⊙	C9-3	8	281.1
⊕	C9-3	11	276.5
○	C9-4	3	282.2
△	C9-4	6	279.9
⊗	C9-4	8	277.6
⊕	C9-5	7	278.9


PROJECT		HIGHWAY 65 STATION 17+580 TOWNSHIP OF JAMES CULVERT			
TITLE		GRAIN SIZE DISTRIBUTION SAND			
PROJECT No.		1896349		FILE No. 1896349.GPJ	
DRAWN	TR	May 2019	SCALE	N/A	REV.
CHECK	AB	May 2019	FIGURE B-4		
APPR	JMAC	May 2019			
GOLDER		SUDBURY, ONTARIO			



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C9-3	14	272.0

PROJECT						HIGHWAY 65 STATION 17+580 TOWNSHIP OF JAMES CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SILT and SAND					
PROJECT No.			1896349			FILE No.			1896349.GPJ		
DRAWN	TR	May 2019	SCALE	N/A	REV.	FIGURE B-5					
CHECK	AB	May 2019									
APPR	JMAC	May 2019									
 GOLDER SUDBURY, ONTARIO											

RESULTS OF ANALYSES OF SOIL

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

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

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

Calculated Parameters

Resistivity	ohm-cm				10000		5794629
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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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