



FOUNDATION INVESTIGATION REPORT

Highway 65, Station 20+638, Township of James Culvert Replacement Ministry of Transportation, Ontario GWP 5204-14-00

Submitted to:

AECOM Canada Ltd

189 Wyld Street, Suite 103
North Bay, ON P1B 1Z2

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
HIGHWAY 65, STA 20+638, 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 20+638, in the Township of James, Ontario, approximately 3.3 km northwest of the intersection with Payne Road. 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 services 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 services have been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering 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 perpendicular to the highway generally in a north-south orientation. At the culvert location, the creek flows in a north to south direction.

The existing culvert consists of a 1.8 m diameter, 33 m long Corrugated Steel Pipe (CSP). The culvert inlet (north end) and outlet (south end) inverts are approximately Elevations 281.3 m and 280.6 m, respectively. In general, the topography within the vicinity of the culvert consists of relatively flat terrain, with the Montreal River flowing easterly about 300 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 6.6 m high relative to the culvert invert. The ground surface conditions at select locations for the culvert area are shown on Photographs 1 to 4.

3.0 INVESTIGATION PROCEDURES

Field work for this subsurface investigation was carried out between November 7 and 14, 2018, during which time five boreholes (Boreholes C14-1 to C14-5) 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 and outlet. Boreholes C14-1, C14-2 and C14-4 were advanced using a track mounted CME-55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. Boreholes C14-3 and C14-5 were advanced 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.

Boreholes C14-1, C14-2, C14-4 and C14-5 were advanced using 108 mm I.D. Hollow Stem Augers while Borehole C14-3 was advanced with 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

drilling operations. The boreholes were backfilled in accordance with Ontario Regulation 903. 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 distribution, 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. A soil sample was submitted to an accredited analytical laboratory (Maxxam) for testing of a suite of corrosivity indicator parameters.

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 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 drilled depths of each borehole 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)
C14-1	5284082.6 (47.693581)	359201.9 (-80.275211)	287.6	15.9
C14-2	5284102.5 (47.693761)	359184.4 (-80.275441)	287.4	15.9
C14-3	5284088.8 (47.693637)	359192.6 (-80.275334)	287.4	20.4
C14-4	5284107.4 (47.693803)	359207.4 (-80.275134)	282.8	9.8
C14 -5	5284087.9 (47.693631)	359173.3 (-80.275591)	282.0	11.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS)¹ 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)², the site is underlain by mafic and related intrusive rocks and mafic dikes.

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

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 profiles 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 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 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 90 mm to 100 mm thick layer of asphalt pavement was encountered from ground surface in the roadway Boreholes C14-1 to C14-3 between Elevations 287.6 m and 287.4 m. Below the asphalt, a 0.2 m to 0.3 m layer of sand and gravel fill was encountered underlain by a 100 mm to 200 mm thick layer of asphalt pavement. Underlying the second layer of asphalt, a 4.5 m to 6.1 m thick layer of embankment fill consisting of interlayers of silt, sandy silt to silt and sand to sand and gravel and was encountered. Boreholes C14-1 and C14-3 encountered auger grinding at depths between about 2.3 m and 4.6 m below ground surface. A 100 mm layer of asphalt pavement was encountered in Borehole C14-3 at Elevation 282.8 m. The fill in Borehole C14-1 contains trace organics between Elevations 285.6 m and 285.5 m. Borehole C14-3 encountered trace organics and trace wood between Elevations 286.0 m and 285.3 m and wood pieces between Elevations 282.7 and 280.8.

An approximately 0.3 m thick layer of sandy topsoil fill was encountered from ground surface in Borehole C14-4 at Elevation 282.8 m, underlain by an approximately 0.5 m thick layer of silt fill.

An approximately 0.8 m thick layer of silty sand fill was encountered from ground surface in Borehole C14-5 at Elevation 282.0 m, underlain by a 100 mm thick layer of asphalt pavement, underlain by a 0.5 m thick layer of silty sand fill.

The SPT “N”-values measured within the silt to silty sand to sand to sand and gravel fill range between two blows and 36 blows per 0.3 m of penetration and one SPT “N”-value of 71 blows per 0.3 m of penetration within a zone noted as auger grinding, generally indicating a very loose to dense compactness condition.

Grain size distribution analysis was carried out on three samples of the fill and the results are presented on Figure B-1 in Appendix B. The water content measured on the samples of the fill generally range from 3 per cent to 10 per cent and one water content of 24 per cent water content.

4.2.2 Peat

An approximately 0.3 m thick layer of amorphous peat was encountered in Borehole C14-1 at Elevation 282.6 m. An approximately 0.1 m thick deposit of silty peat was encountered within Borehole C14-3 at Elevation 280.8.

4.2.3 Silt to Silt and Sand

A deposit of non-cohesive, interlayered strata comprised of silt to sandy silt to silt and sand to sand was encountered underlying the fill or peat in Boreholes C14-1 to C14-5 between Elevations 282.3 m and 280.6 m. Pockets of organic soil ranging from 0.6 m to 0.8 m thick were encountered in Boreholes C14-2, C14-4 and C14-5 within the samples near the surface of the deposit as noted on the Record of Boreholes. Silty clay layer/seams ranging in thickness between 25 mm and 400 mm were encountered in Boreholes C14-3 to C14-5 within lower portions of the non-cohesive deposit as noted on the Record of Boreholes. Boreholes C14-1 to C14-5 were terminated within the silt to silt and sand deposit after exploring the deposit for thicknesses between 9.0 m and 13.7 m.

The SPT “N”-values measured within the silt to sand and silt deposit range from 0 blows (weight of hammer) to 18 blows per 0.3 m of penetration indicating that the deposit is in a very loose to compact compactness condition.

Grain size distribution analysis was carried out on twelve samples of the deposit and the results are presented on Figure B-2 in Appendix B. Atterberg limits tests were carried out on two samples of the non-cohesive portion of the deposit and one sample of the cohesive interlayers/seams. The non-cohesive samples yielded non-plastic results while the sample from the cohesive interlayer measured a liquid limit of 48 per cent, a plastic limit of 17 per cent and a plastic index of 31 per cent. The result of the Atterberg limits test on the cohesive sample is presented on Figure B-3 in Appendix B and indicates that the cohesive layers are comprised of silty clay of intermediate plasticity. The water content measured on thirteen samples of the deposit range from 21 per cent to 25 per cent, with a water content of 36 per cent measured and sample of silty clay seam.

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 top of frozen creek surface near the culvert outlet, as surveyed by Golder on November 14, 2018, was about Elevation 280.0 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)
C14-1	5.6	282.0
C14-2	5.0	282.4
C14-3	4.3	283.1
C14-4	1.6	281.2
C14-5	2.0	280.0

4.4 Analytical Laboratory Testing Results

Analytical testing of a suite of corrosivity indicator parameters was carried out on a silty sand soil sample recovered from Borehole C14-3 by Maxxam Analytics of Sudbury, Ontario. 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)	Sulphide (µg/g)	Chloride (Cl) Content (µg/g)	pH
C14-3	8	6.1 – 6.7	1,200	868	<20 ¹	7.35	430	7.23

Note:

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

5.0 CLOSURE

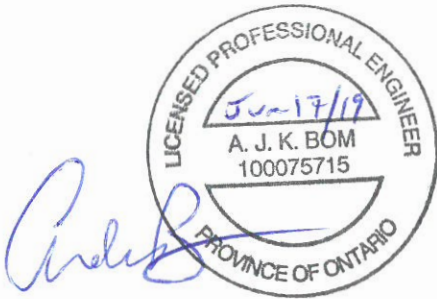
The field drilling program was carried out under the supervision of Mr. Tibor Berecz, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Gavin Mundry, and Mr. André Bom, P.Eng., provided a technical review of the report. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant for Golder, conducted an independent quality control review of the report.

Signature Page

Golder Associates Ltd.



Gavin Mundry, EIT
Geotechnical Engineer-in-Training



André Bom, P.Eng.
Senior Geotechnical Engineer, Associate



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

GM/AB/JMAC/sb

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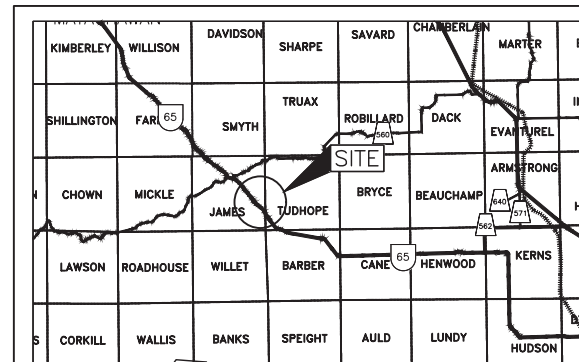
https://golderassociates.sharepoint.com/sites/1809001/deliverables/foundations/2_reporting/r05-jam114/3_final/1896349-r-rev0-aecom culvert 14 hwy 65 fir 17jun_19.docx

CONT No.
GWP No. 5204-14-00



HIGHWAY 65
STATION 20+638
TOWNSHIP OF JAMES CULVERT

BOREHOLE LOCATIONS AND SOIL STRATA





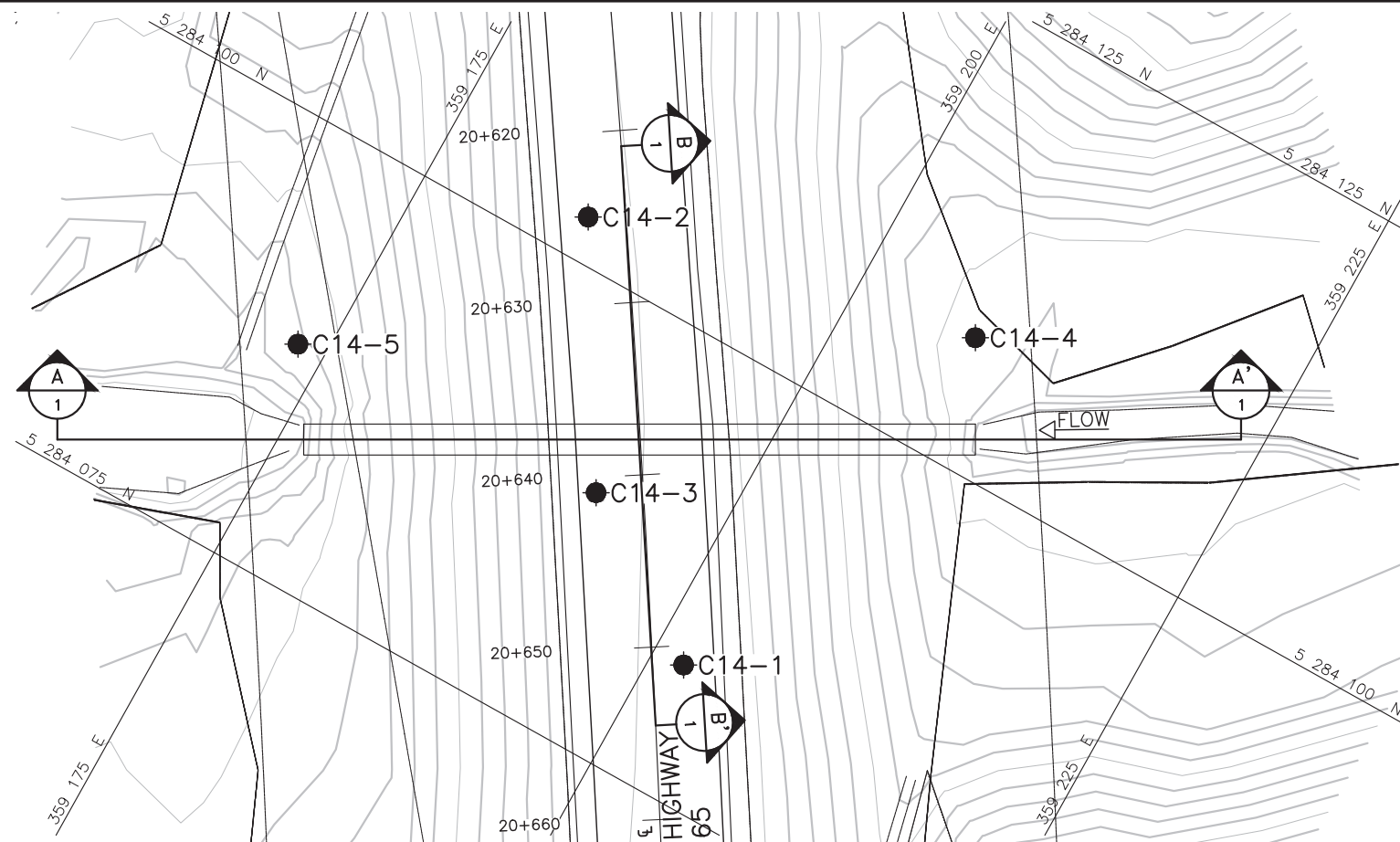
KEY PLAN

SCALE



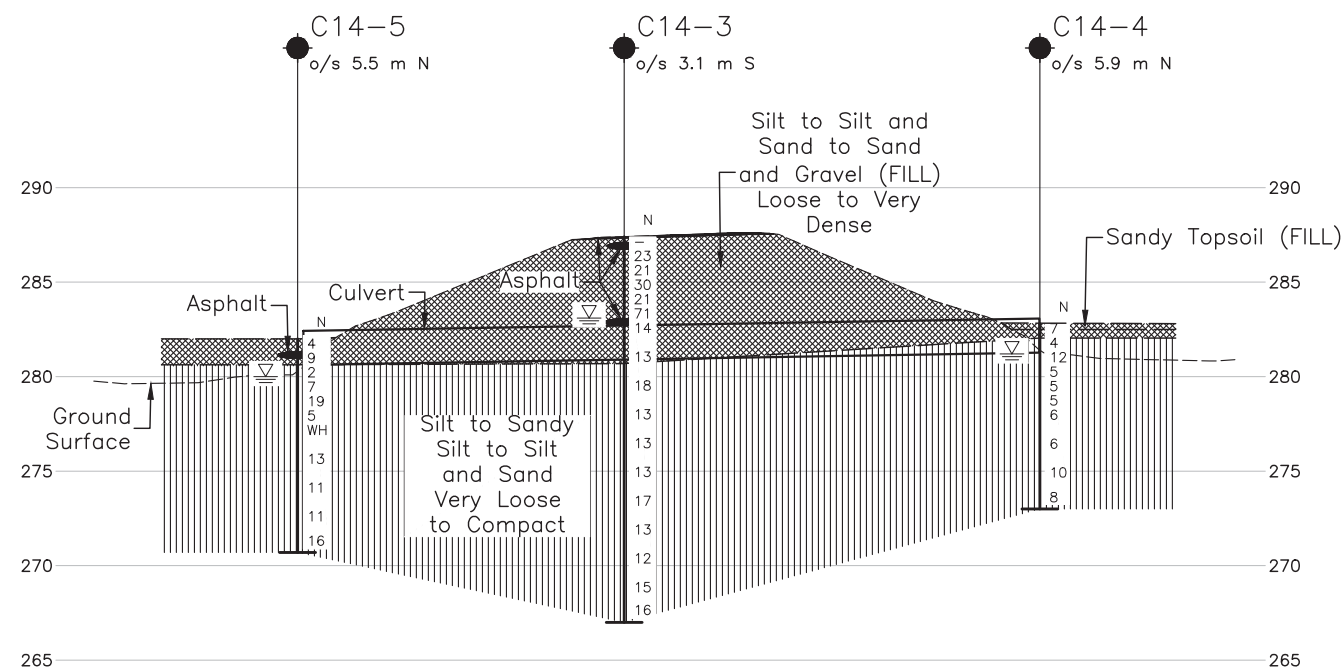
LEGEND

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



PLAN

SCALE



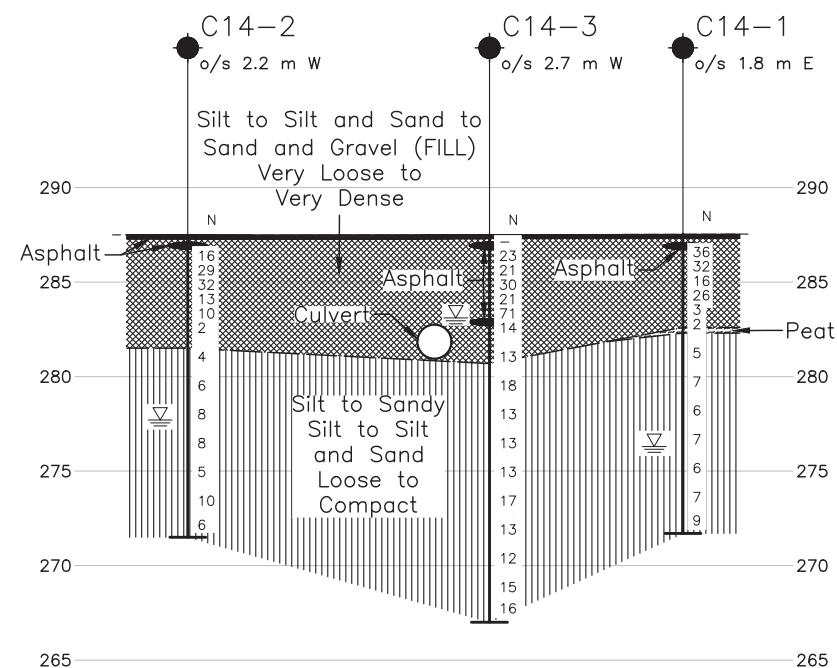
 CULVERT CENTERLINE PROFILE

$$\frac{A-A'}{1}$$

HORIZONTAL SCALE



VERTICAL SCALE


HIGHWAY CENTERLINE PROFILE

HORIZONTAL SCALE



0 4
VERTICAL SCALE

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
C14-1	287.6	5284082.6	359201.9
C14-2	287.4	5284102.5	359184.4
C14-3	287.4	5284088.8	359192.6
C14-4	282.8	5284107.4	359207.4
C14-5	282.0	5284087.9	359173.3

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-80					
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 North from Road Surface (November 2018)



Photograph 2: Culvert Outlet (South End) Facing South from Road Surface (November 2018)



Photograph 3: Culvert Inlet (North End), Borehole C14-4 location, Facing Southeast (November 2018)



Photograph 4: Culvert Outlet (South End), Facing Southeast from Road Surface (November 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

PROJECT 1896349		RECORD OF BOREHOLE No C14-1		1 OF 2 METRIC																
G.W.P. 5204-14-00		LOCATION N 5284082.6; E 359201.9 NAD83 MTM ZONE 12 (LAT. 47.693581; LONG. -80.275211)		ORIGINATED BY SA																
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers		COMPILED BY GM																
DATUM GEODETIC		DATE November 8, 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					
287.6	GROUND SURFACE																			
0.0	ASPHALT (100 mm)																			
287.2	Sand and gravel (FILL)																			
0.5	ASPHALT (100 mm)																			
	Sand to sand and gravel, some gravel, some silt (FILL)																			
	Compact to dense Brown Moist		1	SS	36		287													
	Trace laminate organics from 2.0 m to 2.1 m depth		A	SS	32		286										18 68 (14)			
			2	SS																
			B	SS																
	Auger grinded on inferred cobbles at 2.3 m and 2.9 m depth		3	SS	16		285													
			4	SS	26		284													
283.8	Silty sand (FILL)																			
3.8	Very loose Brown Moist to wet		5	SS	3		283													
			6	SS	2															
282.6	Amorphous PEAT																			
282.3	Dark brown Wet																			
5.3	Sandy SILT to SILT and SAND, trace clay Loose Grey Wet		7	SS	5		282													
							281													
			8	SS	7		280										0 52 44 4			
							279													
			9	SS	6		278													
							277													
			10	SS	7															
							276													
275.9																				
11.7																				

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

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

PROJECT <u>1896349</u>			RECORD OF BOREHOLE No C14-1				2 OF 2 METRIC	
G.W.P. <u>5204-14-00</u>			LOCATION <u>N 5284082.6; E 359201.9 NAD83 MTM ZONE 12 (LAT. 47.693581; LONG. -80.275211)</u>				ORIGINATED BY <u>SA</u>	
DIST <u> </u> HWY <u>65</u>			BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>GM</u>	
DATUM <u>GEODETIC</u>			DATE <u>November 8, 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					WATER CONTENT (%)				
								20	40	60	80	100	W _p	W	W _L		
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SILT, trace to some sand, trace clay Loose Grey Wet		11	SS	6		275									0 11 85 4	
							274										
			12	SS	7												
							273										
			13	SS	9		272										
271.7																	
15.9	END OF BOREHOLE Note: 1. Water level at a depth of 5.6 m below ground surface (Elev. 282.0 m) upon completion of drilling.																

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

PROJECT <u>1896349</u>		RECORD OF BOREHOLE No C14-2				2 OF 2 METRIC												
G.W.P. <u>5204-14-00</u>		LOCATION <u>N 5284102.5; E 359184.4 NAD83 MTM ZONE 12 (LAT. 47.693761; LONG. -80.275441)</u>				ORIGINATED BY <u>SA</u>												
DIST <u> </u> HWY <u>65</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers</u>				COMPILED BY <u>GM</u>												
DATUM <u>GEODETIC</u>		DATE <u>November 7, 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 (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W			W _L	
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					20 40 60 WATER CONTENT (%)						
271.5	Sandy SILT to SILT and SAND, trace clay, organic pockets in upper 0.8 m Loose Dark brown to black Wet	 	11	SS	5		275											
								274										
								273										
								272										
15.9																		
15.9	END OF BOREHOLE																	
	Note: 1. Water level at a depth of 5.0 m below ground surface (Elev. 282.4 m) upon completion of drilling.																	

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

PROJECT 1896349		RECORD OF BOREHOLE No C14-3				2 OF 2 METRIC											
G.W.P. 5204-14-00		LOCATION N 5284088.8; E 359192.6 NAD83 MTM ZONE 12 (LAT. 47.693637; LONG. -80.275334)				ORIGINATED BY MR/GM											
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers, NW Casing and Wash Boring				COMPILED BY GM											
DATUM GEODETIC		DATE November 13, 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 ---																
275.1 12.3	SILT to sandy SILT, some gravel, some clay, silty clay layers/seams Compact Grey Wet Sandy SILT / SILTY CLAY interlayers Compact / stiff to very stiff Grey Wet		12	SS	13		275										0 0 94 6
							274										
			13	SS	17		273										
							272										
	SILTY CLAY layer at 15.4 m depth		14	SS	13		271										
							270										
			15	SS	12		269										
							268										
			16	SS	15		267										
							266										
267.0 20.4	END OF BOREHOLE Note: 1. Water level at a depth of 4.3 m below ground surface (Elev. 283.1 m) upon completion of drilling.		17	SS	16		265										

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PROJECT 1896349		RECORD OF BOREHOLE No C14-4				1 OF 1 METRIC											
G.W.P. 5204-14-00		LOCATION N 5284107.4; E 359207.4 NAD83 MTM ZONE 12 (LAT. 47.693803; LONG. -80.275134)				ORIGINATED BY SA											
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY GM											
DATUM GEODETIC		DATE November 8, 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									
282.8	GROUND SURFACE																
0.0	Sandy topsoil (FILL)																
282.5			1	SS	7												
0.3	Silt, some sand, trace organics (FILL)																
282.0	Grey Moist																
0.8	SILT, trace sand, trace clay Loose to compact Grey Wet		2	SS	4												
	Organic pockets from 0.8 m to 1.4 m																
			3	SS	12												
			4	SS	5												
			5	SS	5												
			6	SS	5												
			7	SS	6												
			8	SS	6												
	25 mm to 50 mm thick SILTY CLAY seams/layers below 6.6 m																
			9	SS	10												
			10	SS	8												
273.0	END OF BOREHOLE																
9.8	Note: 1. Water level at a depth of 1.6 m below ground surface (Elev. 281.2 m) upon completion of drilling.																

PROJECT 1896349		RECORD OF BOREHOLE No C14-5				1 OF 2 METRIC												
G.W.P. 5204-14-00		LOCATION N 5284087.9; E 359173.3 NAD83 MTM ZONE 12 (LAT. 47.693631; LONG. -80.275591)				ORIGINATED BY MR/GM												
DIST _____ HWY 65		BOREHOLE TYPE 108 mm I.D. Hollow Stem Augers				COMPILED BY GM												
DATUM GEODETIC		DATE November 14, 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									WATER CONTENT (%)	
								20	40	60	80						100	20
282.0	GROUND SURFACE																	
0.0	Silty sand, trace organics (FILL) Loose Brown Wet		1	SS	4													
281.2	ASPHALT (100 mm)																	
0.9	Silty sand, trace gravel, with silt seams (FILL) Loose		2	SS	9													
280.6	Loose Grey Wet																	
1.4	SILT, trace to some sand, trace clay Very loose to loose Grey Wet		3	SS	2													
	Brown / black organic pockets from 1.4 m to 2.1 m		4	SS	7											0 10 81 9		
279.0	SILT and SAND, trace gravel, trace clay Very loose to compact Grey Wet		5	SS	19													
3.0			6	SS	5													
			7	SS	WH											1 44 50 5		
276.4	SILT, trace to some sand, trace clay Compact Grey Wet		8	SS	13													
5.6																		
			9	SS	11											0 10 86 4		
	25 mm to 50 mm thick SILTY CLAY seams/layers at 9.3 and 9.5 m depth		10	SS	11													
	75 mm thick SILTY CLAY seam at 11.3 m depth		11	SS	16													
270.7	END OF BOREHOLE																	
11.3																		

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

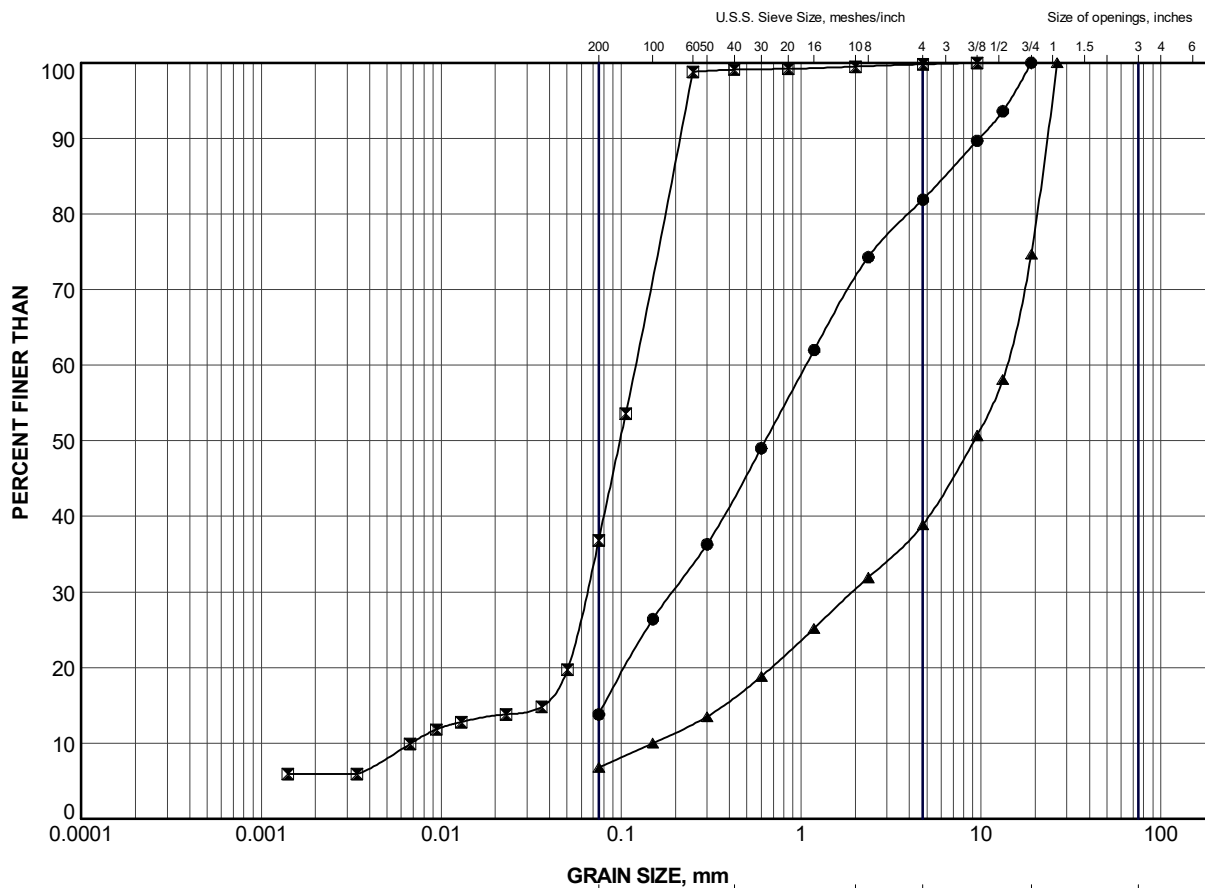


+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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APPENDIX B

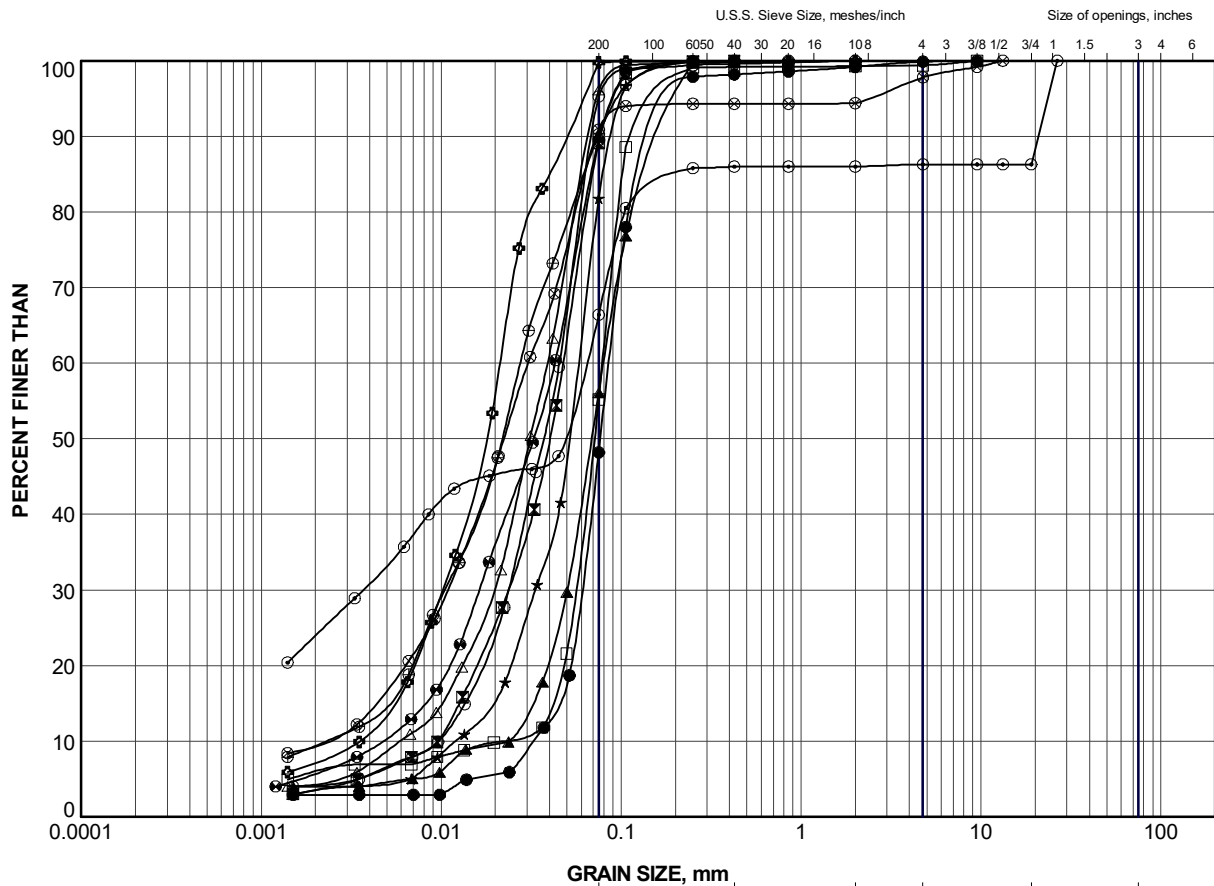
Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C14-1	2A	285.9
⊠	C14-2	4	284.1
▲	C14-3	6	283.3

PROJECT		HIGHWAY 65 STATION 20+638 TOWNSHIP OF JAMES CULVERT			
TITLE		GRAIN SIZE DISTRIBUTION Silt and Sand to 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			
 GOLDER SUDBURY, ONTARIO			FIGURE B-1		

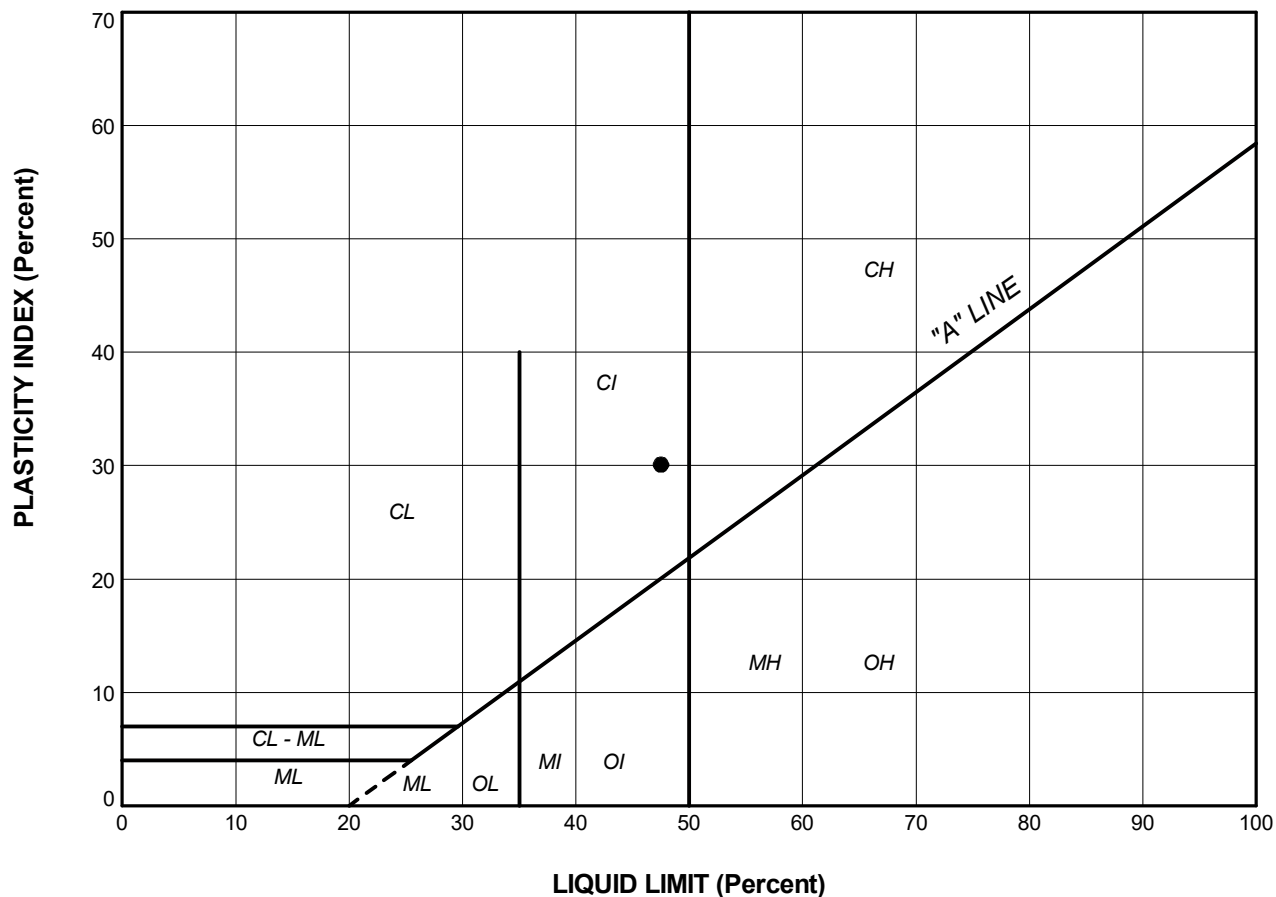


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C14-1	8	279.7
⊠	C14-1	11	275.1
▲	C14-2	9	278.0
★	C14-2	11	274.9
⊙	C14-3	9	279.5
⊕	C14-3	12	274.9
○	C14-4	4	280.2
△	C14-4	7	277.9
⊗	C14-4	9	274.9
⊕	C14-5	4	279.4
□	C14-5	7	277.1
⊗	C14-5	9	274.1

PROJECT		HIGHWAY 65 STATION 20+638 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	FIGURE B-2		
APPR	JMAC	Apr 2019			
GOLDER		SUDBURY, ONTARIO			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C14-3	14	47.5	17.4	30.1

PROJECT						HIGHWAY 65 STATION 20+638 TOWNSHIP OF JAMES CULVERT					
TITLE						PLASTICITY CHART SILTY CLAY					
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-3					

RESULTS OF ANALYSES OF SOIL

Maxxam ID		IKA226			IKA226			IKA227	IKA228		
Sampling Date		2018/11/13 10:41			2018/11/13 10:41			2018/11/17 11:30	2018/11/18 12:13		
COC Number		62170			62170			62170	62170		
	UNITS	C14-3 SA 1	RDL	QC Batch	C14-3 SA 1 Lab-Dup	RDL	QC Batch	C27-1 SA 1	C77-1 SA 1	RDL	QC Batch
CONVENTIONALS											
Sulphide	ug/g	7.35	0.50	5872398				<0.55	0.64	0.55	5872398
Calculated Parameters											
Resistivity	ohm-cm	1200		5859836				2000	3800		5859836
CONVENTIONALS											
Redox Potential	mV	140	N/A	5865933				140	130	N/A	5865933
Inorganics											
Soluble (20:1) Chloride (Cl-)	ug/g	430	20	5862969				250	90	20	5862969
Conductivity	umho/cm	868	2	5863312	909	2	5863312	508	266	2	5863312
Available (CaCl2) pH	pH	7.23		5864763				7.54	7.60		5864763
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5862489				<20	<20	20	5862489
Physical Testing											
Moisture-Subcontracted	%	24	0.30	5872397				17	25	0.30	5872397
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate N/A = Not Applicable											



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