FOUNDATION INVESTIGATION REPORT

Highway 65, Station 10+780, Township of Kerns
Culvert Replacement
Ministry of Transportation, Ontario
GWP 5204-14-00

Submitted to:

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FOUNDATION INVESTIGATION REPORT
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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 crossing Highway 65 at Station 10+780, in the Township of Kerns, Ontario, approximately 2.3 km west of the intersection with McCool 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 exploration 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 on a skew to the highway generally in a north-south orientation. At the culvert location, the creek flows in a south-north direction.

The existing culvert consists of a 1.7 m diameter, 127 m long Corrugated Steel Pipe (CSP). The culvert inlet (south end) and outlet (north end) inverts are approximately Elevations 237.4 m and 235.5 m, respectively. In general, the topography within the vicinity of the culvert consists of relatively flat farmland and forest areas. At the culvert location, the highway grade is at approximately Elevation 246.6 m and the embankment is approximately between 9.2 m and 11.1 m high relative to the culvert invert at the inlet (south end) and outlet (north end), respectively. 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 exploration was carried out on November 18, 2018, and February 20 and 21, 2019, during which time three boreholes (Boreholes C77-1 to C77-3) were advanced at approximately the locations shown on Drawing 1. Borehole C77-1 was advanced through the roadway embankment using a track mounted CME-55LC drilling rig supplied and operated by George Downing Estate Drilling (Downing) of Grenville-Sur-La-Rouge, Quebec. Boreholes C77-2 and C77-3 were advanced near the toes of the highway embankment slopes adjacent to the culvert inlet/outlet using a potable tripod rig supplied and operated by Landcore Drilling (Landcore) of Chelmsford, Ontario. Traffic control, where required, was performed in accordance with MTO's Ontario Traffic Control Manual Book 7 – Temporary Conditions.

Borehole C77-1 was advanced through the roadway using 108 mm I.D. Hollow Stem Augers. Boreholes C77-2 and C77-3 were advanced at the toes of the embankment slopes 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 or cathead hammer in accordance with the Standard Penetration

Test (SPT) procedure (ASTM D1586). The portable tripod rig, supplied by Landcore, used a standard weight (63.6 kg) hammer. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strength (ASTM D2573) using an MTO Standard "N" size vane. The groundwater level inside the augers/casing was observed during and upon completion of drilling operations. The boreholes were backfilled in accordance with Ontario Regulation 903. The roadway surface at the borehole drilled through Highway 65 was 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 determination, 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.

The as-drilled borehole locations were measured relative to highway chainages/station marked on the pavement by a member of our technical staff and converted into northing/easting coordinates on the plan drawing. The ground surface elevations at the borehole locations were surveyed relative to the highway and culvert centreline, 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)
C77-1	5278348.0 (47.638802)	389087.5 (-79.878217)	246.6	20.4
C77-2	5278381.1 (47.639091)	389160.0 (-79.877246)	235.2	9.8
C77-3	5278313.8 (47.638498)	389055.7 (-79.878647)	238.2	9.6

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, and the subsoils in the area primarily consist 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 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 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 100 mm thick layer of asphalt pavement was encountered in Borehole C77-1 at Elevation 246.6 m. A 140 mm thick layer of reclaimed asphalt pavement (RAP) was encountered directly below the asphalt layer in the roadway borehole and a 360 mm thick layer of sand and gravel fill was encountered directly below the RAP. An approximately 2.4 m thick upper layer of sand fill was encountered below the sand and gravel fill at Elevation 246.0 m, underlain by an approximately 4.2 m thick layer of clayey silt fill at Elevation 243.6 m, in turn underlain by a 1.5 m thick lower layer of sand and gravel fill at Elevation 239.4 m.

Boreholes C77-2 and C77-3 encountered a 0.7 m and 1.5, thick layer of clayey silt with sand to clayey silt from ground surface at Elevations 235.2 m and 238.2 m, respectively.

The SPT "N"-values measured within the upper layer of sand fill and the lower layer of sand and gravel fill encountered in Borehole C77-1 at Elevations 246.0 m and 239.4 m, respectively), range between 7 blows and 23 blows per 0.3 m of penetration, indicating a loose to compact compactness condition. The SPT "N"-values measured within the clayey silt fill layer encountered in Borehole C77-1 range from 4 blows to 12 blows per 0.3 m of penetration, indicating a firm to stiff consistency. The STP "N"-value measured within the clayey silt with sand and clayey silt fill layers in Boreholes C77-2 and C77-3 range between 2 blows and 13 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency, with the upper sample likely influenced by frozen ground condition.

A grain size distribution analysis was carried out on one sample of the sand fill and one sample of the lower sand and gravel fill and the results are presented on Figure B-1 in Appendix B. The natural moisture content measured on the sand fill sample is 4 per cent and measured on the sand and gravel sample is 2 per cent.

An Atterberg limits test was carried out on one sample of the cohesive clayey silt fill from Borehole C77-1 and measured a liquid limit of 28 per cent, a plastic limit of 14 per cent, and a plastic index of 14 per cent. The result, which is presented on Figure B-2 in Appendix B, indicates that the cohesive fill is a clayey silt of low plasticity. A grain size distribution analysis was carried out on one sample of the clayey silt fill and the result is presented on

Figure B-3 in Appendix B. The natural moisture content measured on the one sample of the clayey silt fill is 16 per cent.

4.2.2 Clayey Silt to Silty Clay with Silt Laminations

A deposit of clayey silt to silty clay with silt laminations throughout was encountered underlying the fill in each of the boreholes, between Elevations 237.9 m and 234.5 m. All boreholes were terminated within the clayey silt to silty clay deposit after exploring the deposit for a thickness between 8.1 m and 11.7 m.

The SPT “N”-values measured within the clayey silt to silty clay deposit range between 1 blow and 6 blows per 0.3 m of penetration. The in-situ field vane undrained shear strengths measured within the cohesive deposit range between about 48 kPa and 86 kPa, indicating that the deposit has a firm to stiff consistency.

Atterberg limits tests were carried out on seven samples of the deposit and measured with liquid limits between about 29 per cent and 41 percent, plastic limits between about 19 per cent and 20 per cent, and plastic indices between about 9 per cent and 22 per cent. The results of the Atterberg limits tests are presented on Figure B-4 in Appendix B and indicate that the deposit is comprised of clayey silt of low plasticity to silty clay of intermediate plasticity. Grain size distribution analyses were carried out on four samples of the deposit and are presented on Figure B-5 in Appendix B. The natural moisture content measured on seven samples of the deposit range between 32 per cent and 38 per cent.

4.3 Groundwater Conditions

The unstabilized groundwater levels relative to ground surface measured inside the casing or augers upon completion of drilling are summarized below:

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
C77-1	Dry	-
C77-2	0.0	235.2
C77-3	0.0	238.2

The ice level of the creek water level near the culvert inlet, as surveyed by Golder on February 21, 2019, was about Elevation 238.4 m. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

4.4 Analytical Laboratory Testing Results

Analytical testing was carried out on a sample of the silt deposit recovered from Borehole C77-1. 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 (SO4) Content (µg/g)	Sulphide (S^-) (µg/g)	Chloride (Cl) Content (µg/g)	pH
C77-1	9	9.1-9.8	3,800	266	<20[1]	0.64	90	7.60

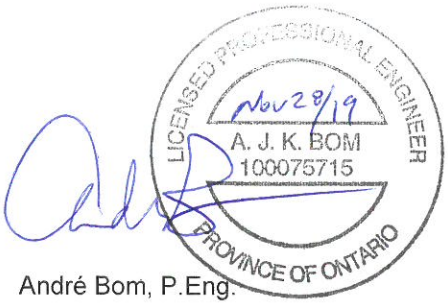
Note:
1. The sulphate concentration is below the reportable detection limit of 20 µg/g.

5.0 CLOSURE

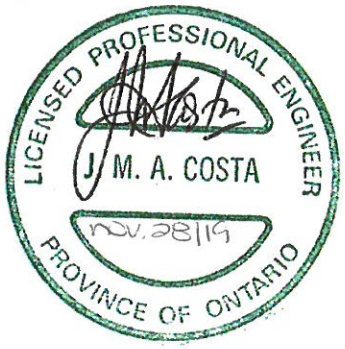
The field exploration program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. André Bom, P.Eng. This Foundation Investigation Report was prepared by Mr. Gavin Mundry, and Mr. André Bom, P.Eng. provided a technical review of the report. Mr. Jorge Costa,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

Signature Page

Golder Associates Ltd.



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



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

GM/AB/JMAC/sb/ca

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

CONT No.
GWP No. 5204–14–00

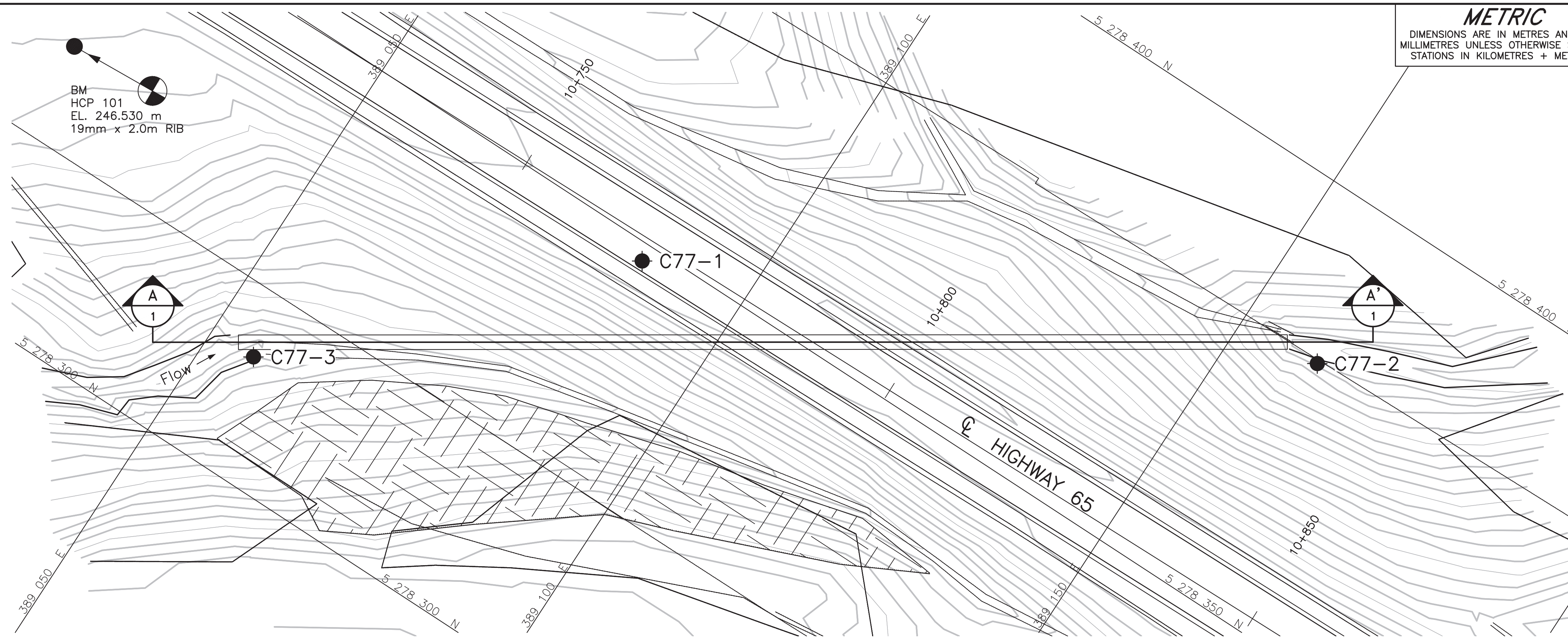
SHEET

HIGHWAY 65

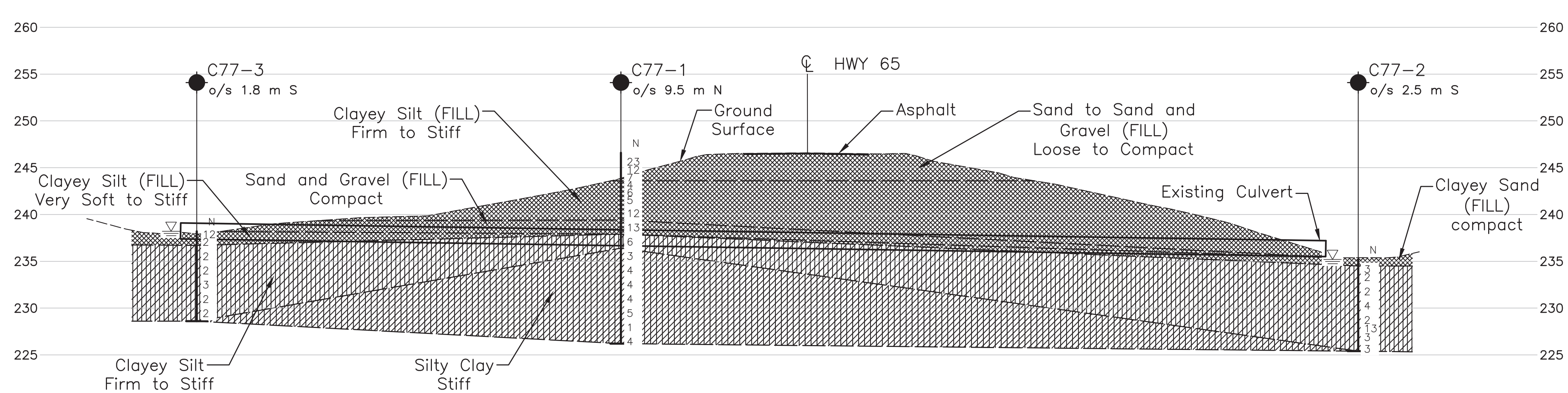
STATION 10+780 TOWNSHIP OF KERNS CULVERT

BOREHOLE LOCATIONS AND SOIL STRATA

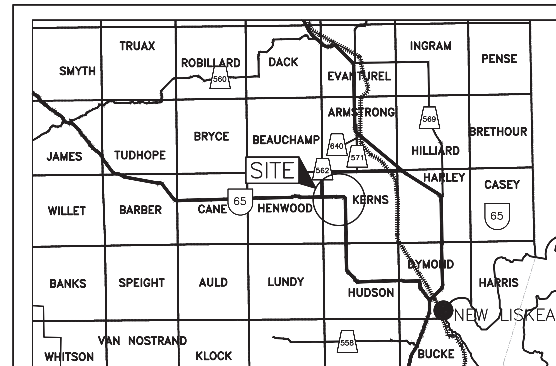
GOLDER



PLAN
SCALE
6 0 6 12 m



PROFILE
SCALE
6 0 6 12 m



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

J.M.A.COSTA — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO — NOV 26, 2019

A.J.K. BOM 100075715 — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO — NOV 26, 2019

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
C77–1	246.6	5278348.0	389087.5
C77–2	235.2	5278381.1	389160.0
C77–3	238.2	5278313.8	389055.7

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 LTD. drawing file no. B065KER SITE 177.dwg, received JUNE 13, 2019.

NO.	DATE	BY	REVISION

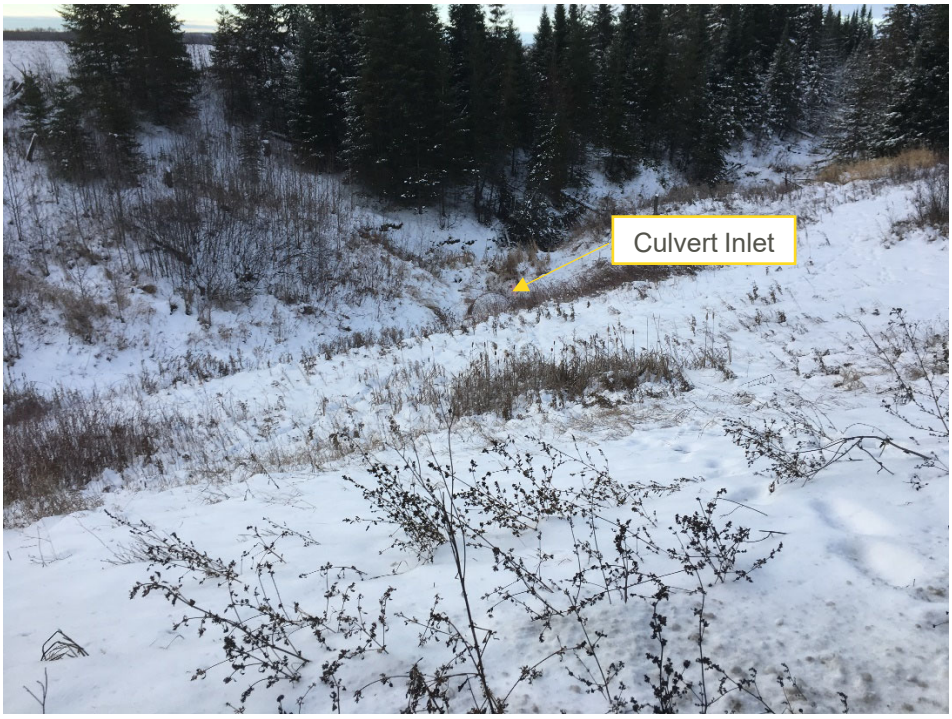
Geocres No. 31M–127

HWY. 65	PROJECT NO. 1896349	DIST.
SUBM'D.	CHKD. TB	DATE: 11/22/2019	SITE:
DRAWN: TR	CHKD. AB	APPD.	DWG. 1

PLOT DATE: November 27, 2019

Photograph 1: Road Surface at Sta. 10+780 Culvert, Facing West (November, 2018)

Photograph 2: Road Surface at Sta. 10+780 Culvert, Facing East (November, 2018)



Photograph 3: Embankment South Slope and Culvert Inlet looking south from Roadway Surface (November 2018)

Photograph 4: Embankment North Slope and Culvert Outlet looking north from Roadway Surface (November 2018)

APPENDIX A

Record of Boreholes

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS
MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS[1,2]

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (*i.e.,* SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (*i.e.,* some sand)
≤ 10	trace (*i.e.,* trace fines)

1. Only applicable to components not described by Primary Group Name.
2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , 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, Gs)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

COARSE-GRAINED SOILS

Compactness[1]

Term	SPT 'N' (blows/0.3m)[2]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	➢ 50

3. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
4. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

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
υ	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

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

(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 = $(w_l - w_p)$
NP	non-plastic
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 δ
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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

GOLDER

RECORD OF BOREHOLE No C77-1

1 OF 2 **METRIC**

PROJECT 1896349
G.W.P. 5204-14-00
DIST _____ HWY 65
DATUM GEODETIC

LOCATION N 5278348.0; E 389087.5 NAD83 MTM ZONE 12 (LAT. 47.638802; LONG. -79.878217)
BOREHOLE TYPE 108 mm I.D. Hollow Strem Augers
DATE November 18, 2018

ORIGINATED BY MR
COMPILED BY GM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.6	GROUND SURFACE										
0.0	ASPHALT (100 mm)										
0.2	Reclaimed asphalt pavement (RAP)										
246.0	Sand and gravel (360 mm) (FILL)										
0.6	Sand, trace gravel, trace silt (FILL) Loose to compact Brown Moist		1	SS	23		246				
			2	SS	12		245		○		6 86 (8)
			3	SS	7		244				
243.6											
3.0	Clayey silt, some sand, trace gravel (FILL) Firm to stiff Grey w>PL		4	SS	4		243				
			5	SS	6				⊢●⊣		16 38 22 24
			6	SS	5		242				
			7	SS	12		241				
239.4							240				
7.2	Sand and gravel, trace silt, trace clay (FILL) Compact Brown Moist		8	SS	13		239		○		31 62 5 2
237.9							238				
8.7	CLAYEY SILT, with silt laminations Loose Grey Wet		9	SS	6		237		⊢○⊣		0 0 45 55
236.4											
10.2	SILTY CLAY, with silt laminations Stiff Grey w>PL		10	SS	3		236		⊢○⊣		
							235	2+			

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No C77-1

2 OF 2 **METRIC**

PROJECT 1896349
G.W.P. 5204-14-00
DIST HWY 65
DATUM GEODETIC

LOCATION N 5278348.0; E 389087.5 NAD83 MTM ZONE 12 (LAT. 47.638802; LONG. -79.878217)
BOREHOLE TYPE 108 mm I.D. Hollow Strem Augers
DATE November 18, 2018

ORIGINATED BY MR
COMPILED BY GM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY CLAY, with silt laminations Stiff Grey w>PL		11	SS	4		234	2			
			12	SS	4		233				
			13	SS	4		232	2			0 0 54 46
			14	SS	5		231	2			
			15	SS	1		230	2			
			16	SS	4		229	2			
226.2							228				
20.4	END OF BOREHOLE Note: 1. Borehole dry upon completion of drilling.						227	2			

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

GOLDER

RECORD OF BOREHOLE No C77-2

1 OF 1 **METRIC**

PROJECT 1896349
G.W.P. 5204-14-00
DIST HWY 65
DATUM GEODETIC

LOCATION N 5278381.1; E 389160.0 NAD83 MTM ZONE 12 (LAT. 47.639091; LONG. -79.877246)
BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring
DATE February 20 and 21, 2019

ORIGINATED BY MR
COMPILED BY GM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.2	GROUND SURFACE					▽	235				
0.0	Clayey sand, trace to some organics, trace gravel (FILL) Compact Grey Frozen										
234.5											
0.7	CLAYEY SILT, with silt laminations Firm to stiff Grey w>PL		2	SS	3		234				
			3	SS	2				○		0 0 51 49
							233	2			
			4	SS	2		232				
							231	2			
			5	SS	4		230				
								2			
			6	SS	2		229		○		0 0 72 28
			1	SS	13		228	2			
			7	SS	3		227				
								2			
			8	SS	3		226				
225.4											
9.8	END OF BOREHOLE										

NOTES:

1. Water level at ground surface (Elev. 235.2 m) inside casing upon completion of drilling.

+3, ×3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

SUD-MTO 001 S:\CLIENTS\MTO\HWY65\866102_DATA\GINT\1896349.GPJ GAL-MISS.GDT 7/2/19 TR

GOLDER

RECORD OF BOREHOLE No C77-3

1 OF 1 **METRIC**

PROJECT 1896349
G.W.P. 5204-14-00
DIST HWY 65
DATUM GEODETIC

LOCATION N 5278313.8; E 389055.7 NAD83 MTM ZONE 12 (LAT. 47.638498; LONG. -79.878647)
BOREHOLE TYPE Portable Equipment, NW Casing, Wash Boring
DATE February 20, 2019

ORIGINATED BY MR
COMPILED BY GM
CHECKED BY AB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
238.2	GROUND SURFACE					
0.0	Clayey silt, trace organics, trace gravel (FILL) Very soft to stiff Grey Frozen		1	SS	12	
			2	SS	2	
236.7						
1.5	CLAYEY SILT, with silt laminations Firm to stiff Grey w>PL		3	SS	2	
			4	SS	2	
			5	SS	3	
			6	SS	2	
			7	SS	2	
228.6						
9.6	END OF BOREHOLE					

NOTES:

1. Water level at ground surface (Elev. 238.2 m) inside casing upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED
20 40 60 80 100

ELEVATION SCALE: 238, 237, 236, 235, 234, 233, 232, 231, 230, 229

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
20 40 60

UNIT WEIGHT γ kN/m^3

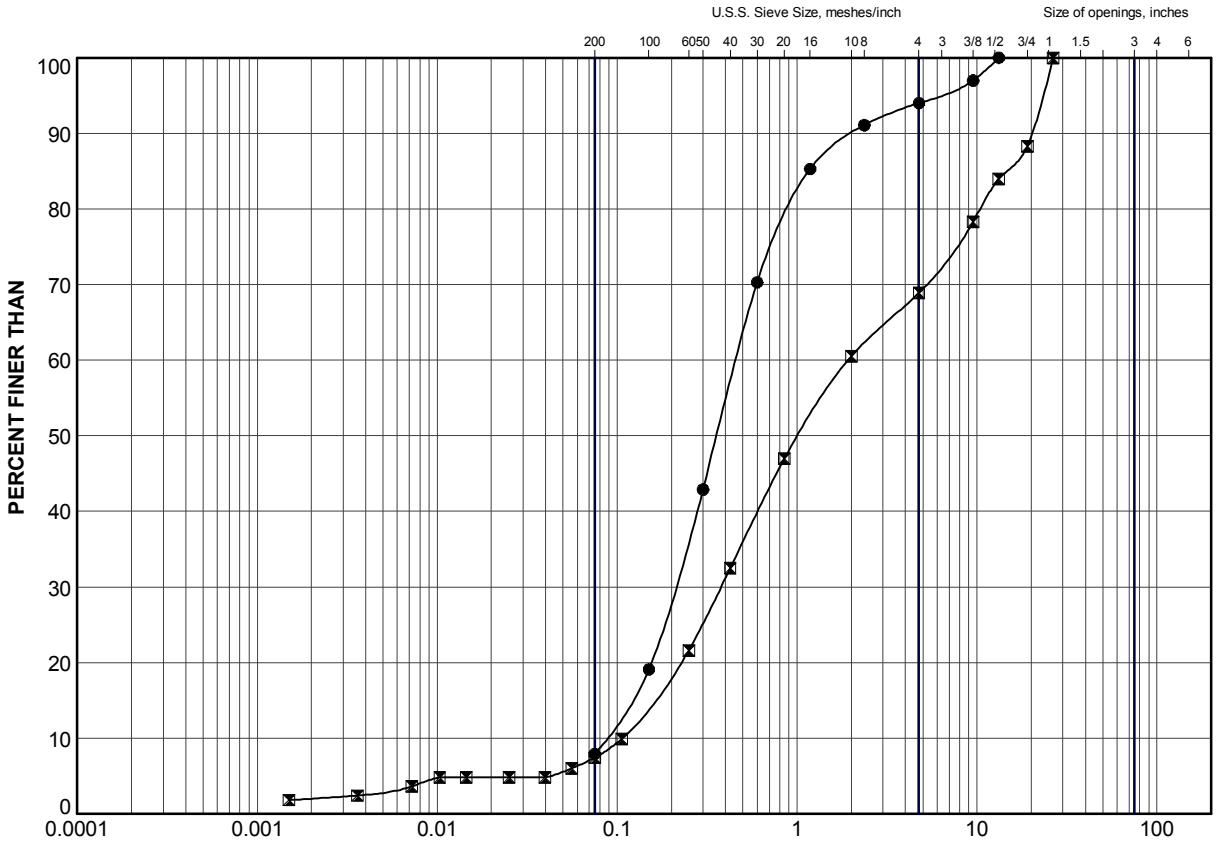
REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

APPENDIX B

Laboratory Test Results



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	2	244.8
⊠	C77-1	8	238.7

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

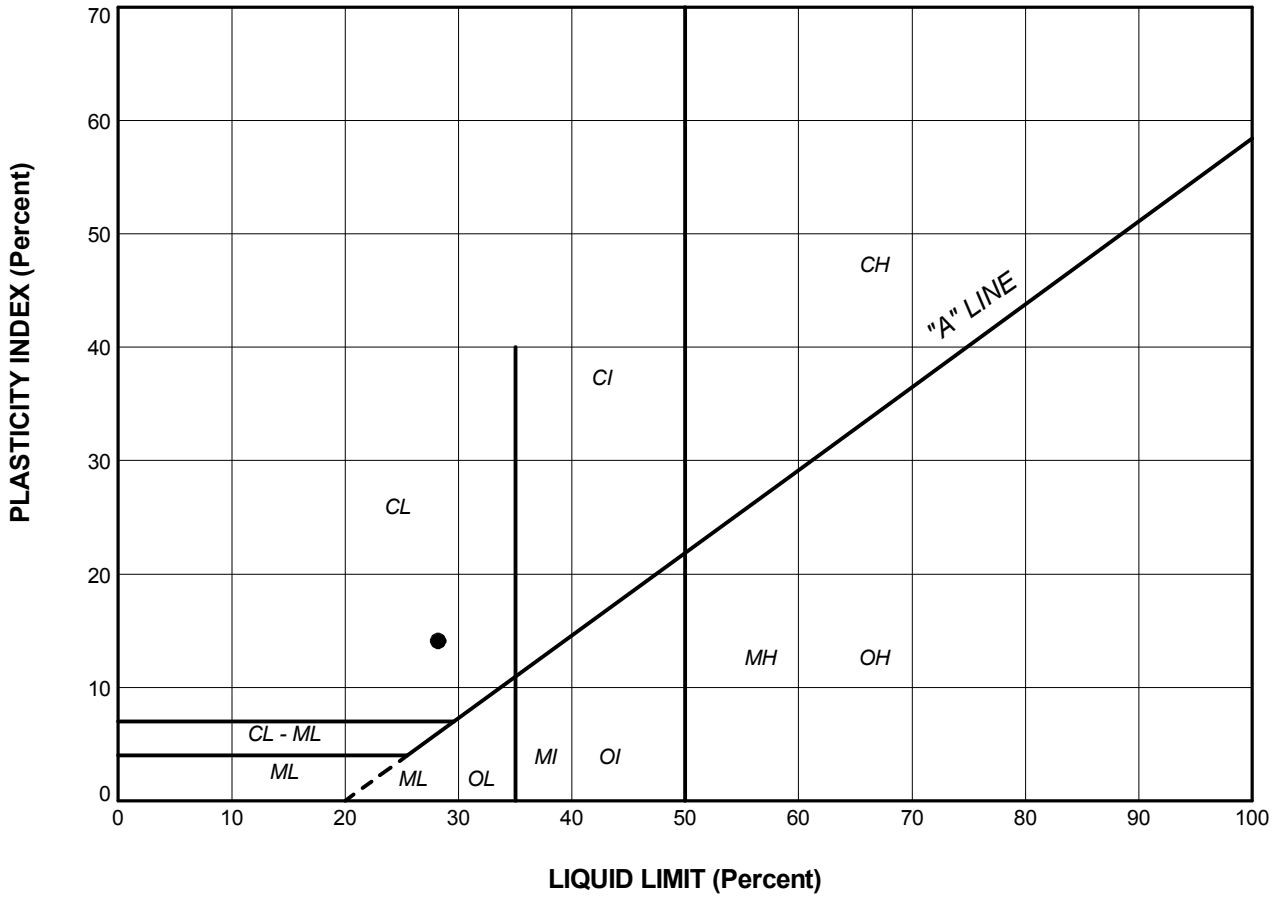
Sand to Sand and Gravel (FILL)

GOLDER

SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.		1896349.GPJ
DRAWN	TR	Jul 2019	SCALE	N/A	REV.
CHECK	AB	Jul 2019			
APPR	JMAC	Jul 2019	FIGURE		B-1

SUD-MTO GSD GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C77-1	5	28.2	14.1	14.1

PROJECT
HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

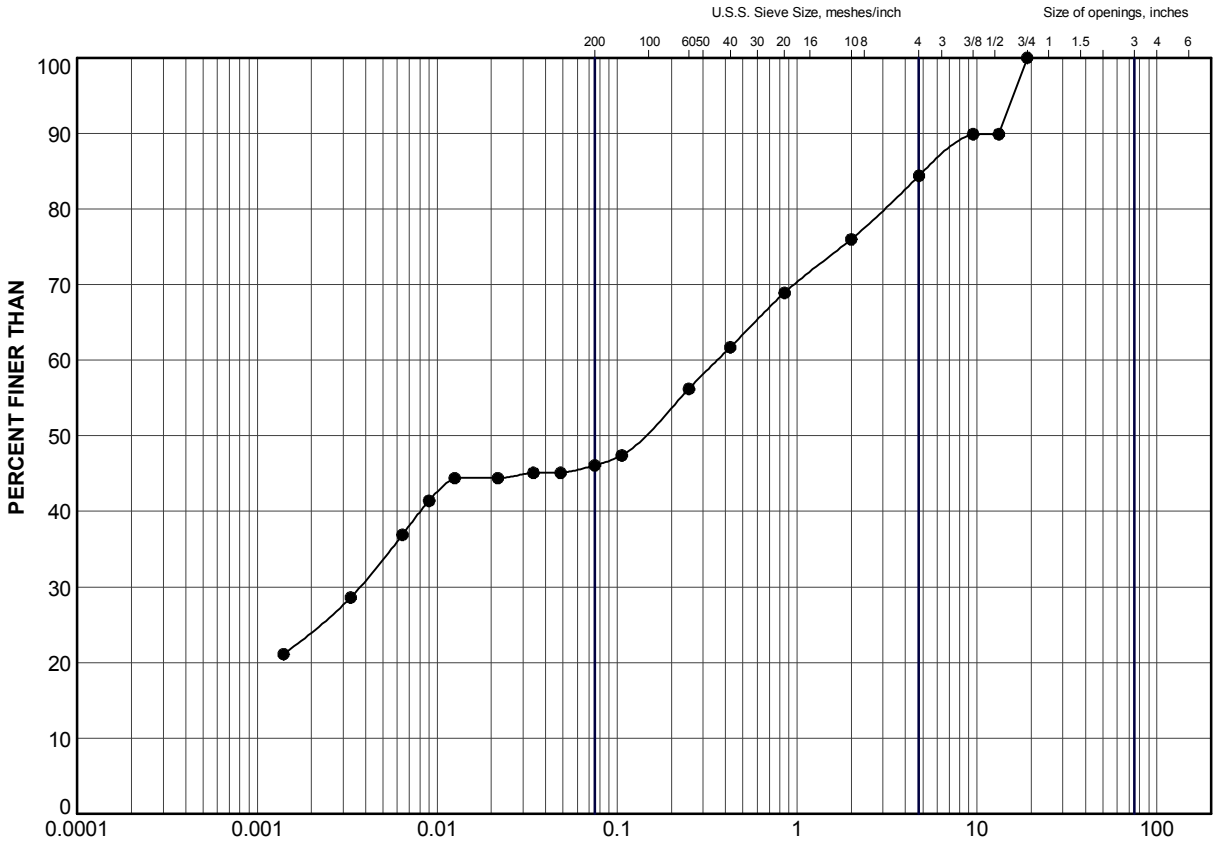
TITLE
PLASTICITY CHART
Clayey Silt (FILL)

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.		1896349.GPJ
DRAWN	TR	Jul 2019	SCALE	N/A	REV.
CHECK	AB	Jul 2019			
APPR	JMAC	Jul 2019			

FIGURE B-2

SUD-MTO PL GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	5	242.5

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

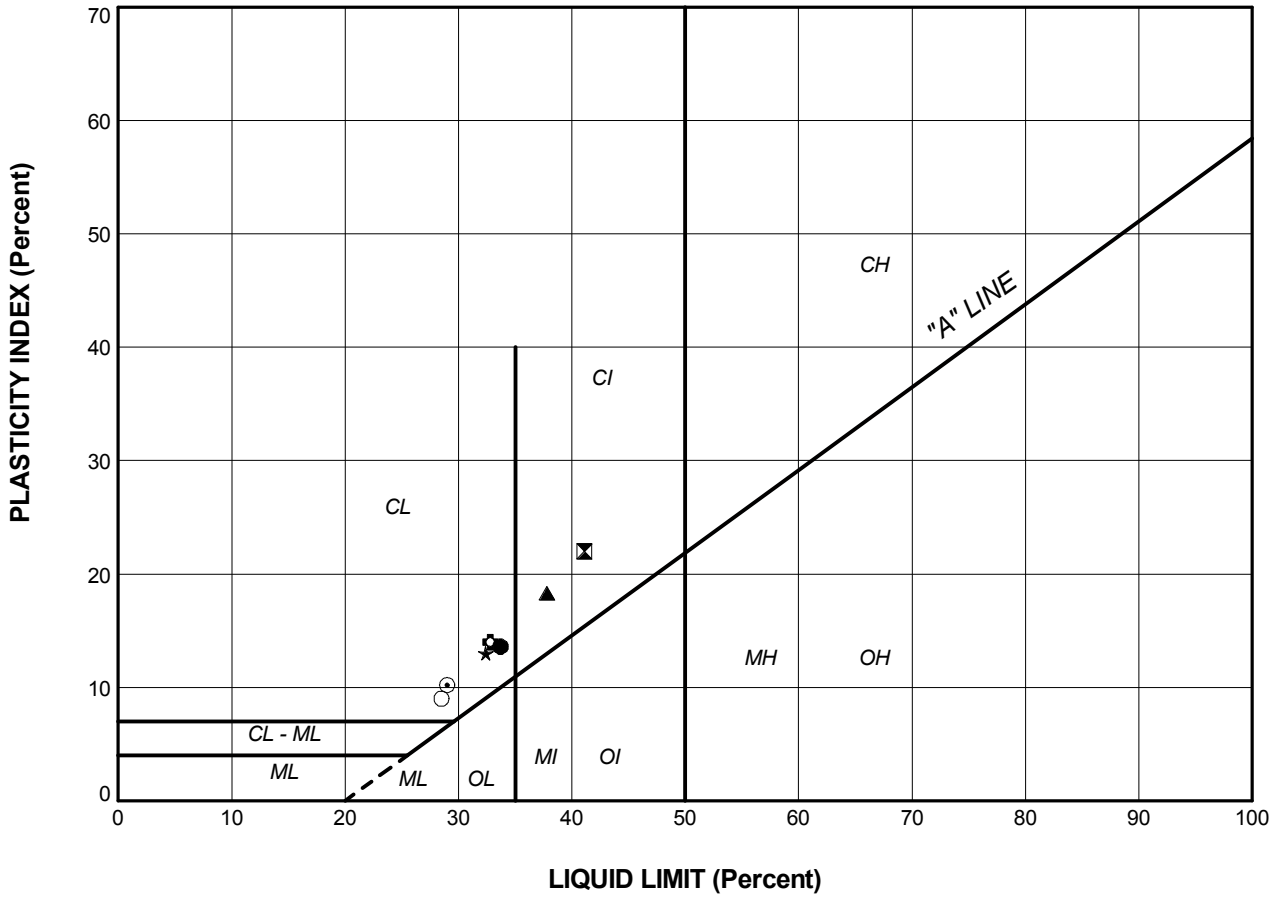
GRAIN SIZE DISTRIBUTION

Clayey Silt (FILL)

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.		1896349.GPJ
DRAWN	TR	Jul 2019	SCALE	N/A	REV.
CHECK	AB	Jul 2019			
APPR	JMAC	Jul 2019	FIGURE		B-3

SUD-MTO GSD GLDR_LDN.GDT



SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	C77-1	9	33.7	20.1	13.6
⊠	C77-1	10	41.1	19.1	22.0
▲	C77-1	13	37.8	19.5	18.3
★	C77-2	3	32.4	19.4	13.0
⊙	C77-2	6	29.0	18.8	10.2
✿	C77-3	3	32.8	18.8	14.0
○	C77-3	6	28.5	19.5	9.0

PROJECT
HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

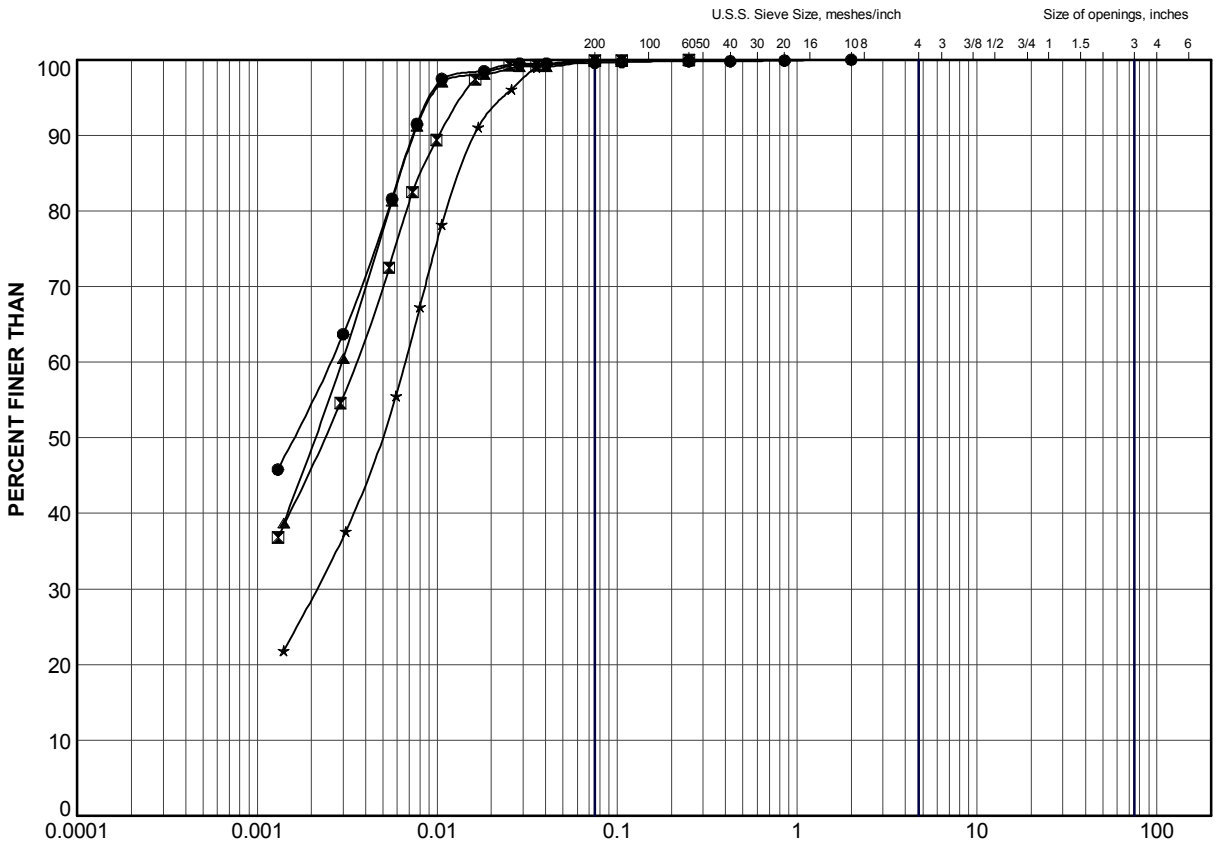
TITLE
PLASTICITY CHART
Clayey Silt to Silty Clay with Silt Laminations

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.		1896349.GPJ
DRAWN	TR	Jul 2019	SCALE	N/A	REV.
CHECK	AB	Jul 2019			
APPR	JMAC	Jul 2019			

FIGURE B-4

SUD-MTO PL GLDR_LDN.GDT



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	C77-1	9	237.2
⊠	C77-1	13	231.1
▲	C77-2	3	233.4
★	C77-2	6	228.0

PROJECT

HIGHWAY 65
STATION 10+780
TOWNSHIP OF KERNS CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay with Silt Laminations

GOLDER
SUDBURY, ONTARIO

PROJECT No.		1896349	FILE No.		1896349.GPJ
DRAWN	TR	Jul 2019	SCALE	N/A	REV.
CHECK	AB	Jul 2019			
APPR	JMAC	Jul 2019	FIGURE		B-5

SUD-MTO GSD GLDR_LDN.GDT

Maxxam Job #: B8V6548
Report Date: 2018/12/05

Golder Associates Ltd
Client Project #: 1896349 PHASE 2100
Site Location: HWY 65
Sampler Initials: MR

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

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

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