March 2013

PRELIMINARY FOUNDATION INVESTIGATION REPORT

Highway 401/Holt Road Underpass Structure
Clarington, Ontario
G.W.P. 2101-08-00

Submitted to:
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GEOCRES No. 30M15-119

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REPORT

Golder Associates

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (URS) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the Highway 401/Holt Road Interchange reconfiguration in the Town of Clarington, Regional Municipality of Durham, Ontario.

This report addresses the results of the subsurface investigation carried out for the reconstruction/replacement of the Interchange underpass structure.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2008-E-0059 dated March 2009 and associated clarifications, and in Section 5.8 of the *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

The existing Highway 401/Holt Road Underpass bridge is located near the entrance to the Darlington Nuclear Power Plant approximately 10 km east of Oshawa, Ontario. According to the original design drawings prepared by Department of Highways – Ontario, dated 1961, the existing four-span underpass structure is about 60 m long with inner span lengths of about 18 m and outer span lengths of about 12 m, and the bridge deck is about 10 m wide. Based on the original design drawings, the existing abutments are supported on piles driven into the very dense native till deposits and the piers are supported on spread footings founded on the native glacial till deposits between about Elevation 108.2 m and 109.4 m.

Based on the preliminary drawings of the new Highway 401/Holt Road Interchange provided by URS (Holt Road – Conceptual Preferred Plan, on September 13, 2012), we understand that the existing bridge will be removed and a new Underpass bridge constructed about 30 m to the east of the existing bridge.

In general, the terrain in the area of the proposed new bridge is relatively flat, with the natural ground surface in the vicinity of the structure site ranging between about Elevation 111 m and 113 m.

The Highway 401 grade in the vicinity of the existing and the new Holt Road Interchange is at about Elevation 112 m. The existing Holt Road Underpass approach embankments consist of earth fill, up to about 6.5 m high, with the Holt Road surface at about Elevation 118.5 m. The existing approach embankment side slopes are oriented at approximately 2 horizontal to 1 vertical (2H:1V).

2.1 Previous Investigation

The results of a previous geotechnical investigation carried out at the existing Highway 401/Holt Road bridge site were obtained from the MTO GEOCRES library, as summarized in a letter prepared by the Department of Highways – Ontario titled "Darlington Twp. Bridge No. 8, Holt Road Underpass at Highway 401 Intersection, District No. 7", dated March 7, 1961, GEOCRES No. BA851-E.

During the previous investigation, a total of seven (7) boreholes (Borehole Nos. 1 to 7, inclusive) were advanced in the general vicinity of the existing bridge as shown on Drawing 1. A copy of the original borehole logs is included in Appendix C.

In general, the subsoils encountered in the above noted boreholes consist of a surficial deposit of granular fill, 0.3 m to 1.5 m thick, underlain by a 0.3 m to 1.4 m thick layer of topsoil. The topsoil is underlain by a deposit of silty sand till. The silty sand till is described in the borehole logs as gravelly / pebbly. The surface of the silty sand till was encountered between depths of about 0.6 m and 2.1 m below ground surface (between Elevation 111 m and 110 m according to the reference datum used on the borehole logs). The boreholes were terminated within the silty sand till at depths ranging from about 3 m to 9 m below ground surface (Elevation 108 m to 103 m). There were no groundwater levels nor any indication of groundwater being encountered during drilling shown on the borehole logs.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on November 22, 2012, during which time two boreholes (Boreholes HR-1 and HR-2) were advanced using a track-mounted CME-55 drill rig, supplied and operated by Strong Soil Search Inc. of Claremont, Ontario. Borehole HR-1 was advanced on the east side of the proposed north abutment and Borehole HR-2 was advanced on the west side of the proposed south abutment, approximately at the locations shown on Drawing 1.

The boreholes were drilled using 108 mm diameter solid stem augers to depths of 7.8 m and 6.3 m below ground surface. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth in the boreholes, using a 50 mm outside diameter split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1].

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and are noted on the borehole records contained in Appendix A. The boreholes were backfilled in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's engineering staff who located the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits and grain size distribution were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO procedures and/or ASTM standards as applicable.

The as-drilled borehole locations and ground surface elevations were measured/surveyed in the field relative to temporary benchmarks provided by URS. The borehole locations (referenced to the MTM NAD83 coordinate system) and ground surface elevations (referenced to geodetic datum) are summarized below and are shown on Drawing 1.

[1] ASTM International, ASTM D1586 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
HR-1	4,860,786.9	367,290.0	111.7	7.8
HR-2	4,860,707.2	367,300.7	111.7	6.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 401 is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2] and *Urban Geology of Canadian Cities* (Karrow and White, 1998)[3]. The Iroquois Plain extends around the western shores of Lake Ontario. The Plain is comprised of the flat to undulating lakebed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession.

The surficial soils in this area of the Iroquois Plain are typically comprised of glaciolacustrine clays, silts and sands to gravelly sands, which are underlain by an extensive till deposit that is mapped in this area as the Bowmanville Till. Within the area approximately bounded by Holt Road and Morgan's Road, the surficial glaciolacustrine deposits are absent or of limited thickness and the Bowmanville Till unit is frequently present immediately below the ground surface. Between these limits, an extensive surficial deposit of clayey silt to silty clay is present over the Bowmanville Till (Karrow and White, 1998). More recent alluvial deposits of gravel, sand, silt and/or clay are present in the valleys associated with Bowmanville Creek, Soper Creek, Wilmot Creek and Graham Creek.

The overburden soils are underlain by limestone bedrock of the Lindsay Formation, Simcoe Group (Geological Survey of Canada, 1997).[4]

4.2 Subsurface Conditions

As part of the subsurface investigation, two boreholes were advanced at the proposed new Highway 401/Holt Road Underpass structure site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A. The detailed results of geotechnical laboratory testing are also presented on Figures B1 to B3 contained in Appendix B. The stratigraphic boundaries shown on the Record of Boreholes and on the interpreted stratigraphic section on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsurface conditions encountered at the site consist of a fill deposit comprised of loose to compact sandy silt between 1.8 m and 2.3 m thick, underlain by a very dense sandy silt to sand and silt till deposit interlayered

[2] Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

[3] Karrow, P. F., and White, O. L., 1998. *Urban Geology of Canadian Cities.* Geological Association of Canada Special Paper No. 42. St. John's, Nfld.

[4] Ontario Geological Society, 1991. *Geology of Ontario*. Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

with clayey silt till. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.2.1 Sandy Silt to Silty Sand (Fill)

A deposit of sandy silt to silty sand fill was encountered immediately below ground surface in both of the boreholes. The deposit was encountered at Elevation 111.7 m and the thickness of the deposit is 2.3 m and 1.8 m, in Boreholes HR-1 and HR-2, respectively.

The fill consists of sandy silt to silty sand containing trace clay, trace to some gravel and organics and rootlets.

The Standard Penetration Test (SPT) "N" values measured within the fill deposit range from 7 blows to 15 blows per 0.3 m of penetration, indicating a loose to compact relative density

The natural water content measured on three samples of the fill ranges between 11 per cent and 16 per cent.

4.2.2 Clayey Silt Till

A deposit of clayey silt till was encountered below the fill in Borehole HR-1 and within the upper portion of the sandy silt to sand and silt till deposit in Borehole HR-2. The surface of the clayey silt till was encountered at a depth of 2.3 m below ground surface, approximately Elevation 109.4 m, in both boreholes. This till deposit is about 1.5 m and 0.6 m thick in Boreholes HR-1 and HR-2, respectively.

The measured SPT "N" values within this deposit range from 28 to 33 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

This glacial till deposit consists of clayey silt with sand to some sand, containing trace to some gravel. The results of grain size distribution tests completed on two selected samples of the clayey silt till are shown on Figure B1 in Appendix B. The grain size distribution for the clayey silt till sample taken from Borehole HR-1 closely resembles the grain size distributions of the sandy silt to sand and silt till, suggesting the clayey silt till layer is likely a transition zone to the underlying more granular till deposit.

Atterberg limits testing was conducted on two selected samples of the clayey till and measured plastic limits of 10 per cent and 15 per cent, liquid limits of 15 per cent and 33 per cent and plasticity indices of approximately 5 per cent and 18 per cent. These test results, which are plotted on a plasticity chart on Figure B2 in Appendix B, confirm that the deposit consists of clayey silt of low plasticity.

The natural water content measured on two samples of the clayey silt till was 10 and 15 per cent.

4.2.3 Sandy Silt to Sand and Silt (Till)

A deposit of sandy silt to sand and silt till was encountered underlying the fill at a depth of 1.8 m below ground surface in Borehole HR-2 and underlying the clayey silt till at a depth of 3.8 m below ground surface in Borehole HR-1, at Elevation 109.9 m and 107.9 m, respectively. Both of the boreholes were terminated within this till deposit at depths of 6.3 m and 7.8 m (Elevation 105.4 m and 103.9 m), in Boreholes HR-2 and HR-1, respectively.

This glacial till deposit consists of sandy silt to sand and silt, containing trace to some clay and trace to some gravel. The results of grain size distribution tests completed on three selected samples of the sandy silt to sand and silt till are shown on Figure B3 in Appendix B.

The natural water content measured on four samples of the sand and silt till deposit ranges from about 7 to 8 per cent.

The measured SPT "N" values within this deposit range from 14 blows per 0.3 m of penetration to between 100 blows per 0.13 m of penetration and 100 blows per 0.07 m of penetration, indicating a compact to very dense (but typically very dense) relative density.

4.3 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets in Appendix A of this report. The water level in the open boreholes was measured at 4.9 m and 4.7 m below ground surface (corresponding to Elevation 106.8 m and 107.0 m) upon completion of drilling in Boreholes HR-1 and HR-2, respectively.

The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring season and periods of precipitation. Given the presence of a deposit of granular fill overlying very stiff to hard/very dense till, perched groundwater conditions can be expected to be present directly above the till deposit.

5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Mr. Matthew Kelly, P.Eng., and reviewed by Mr. Kevin Bentley, P.Eng., a geotechnical engineer and Associate with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact for Golder and Principal, conducted an independent review and quality control audit of this report.

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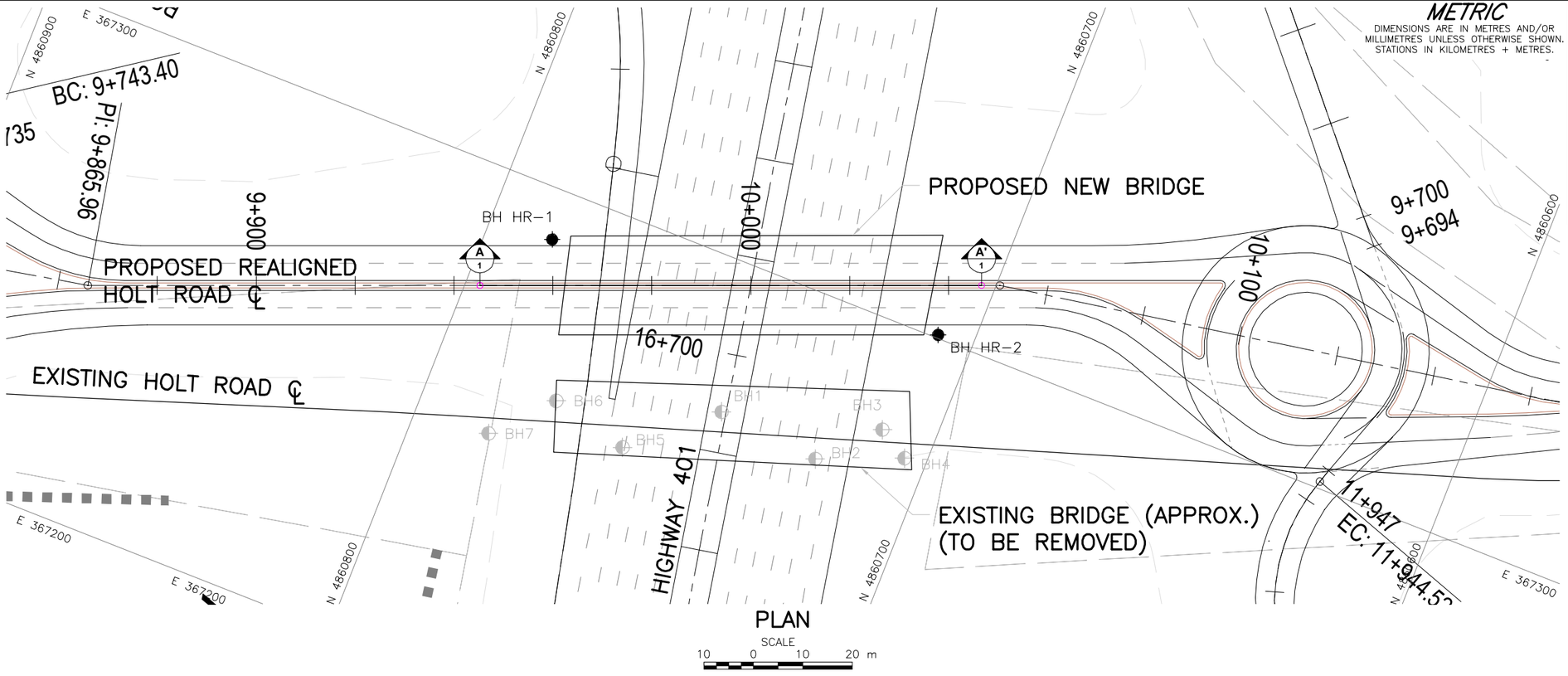
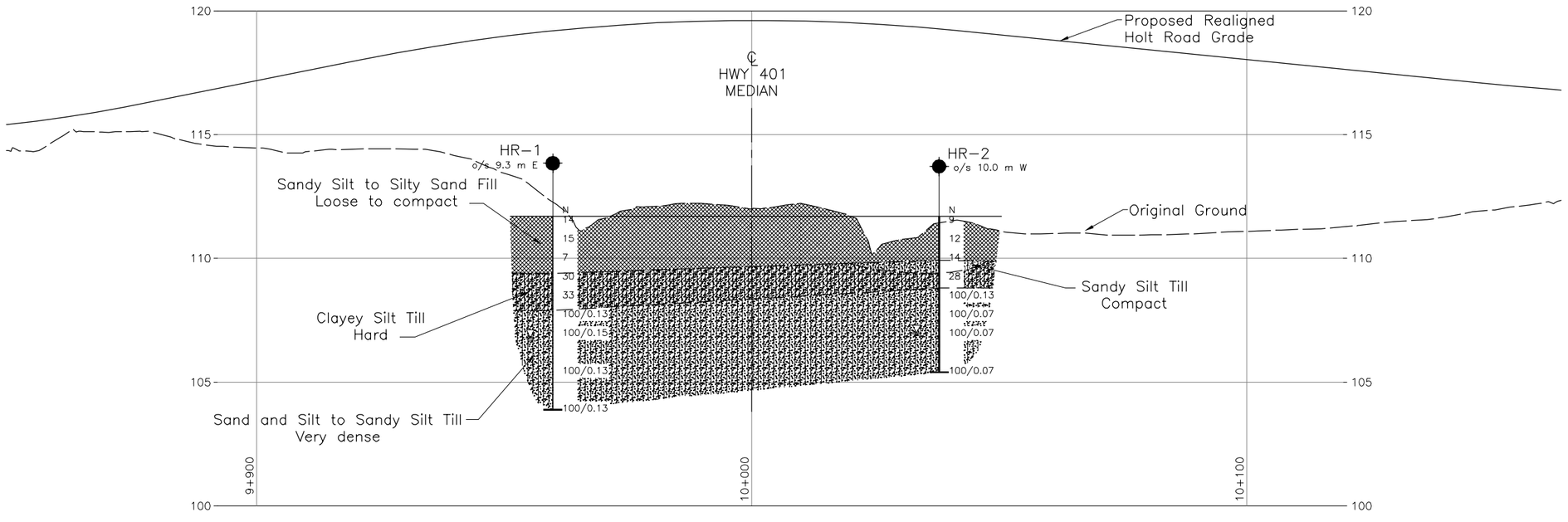




A-A' / 1 CENTRELINE PROFILE ALONG REALIGNED HOLT ROAD

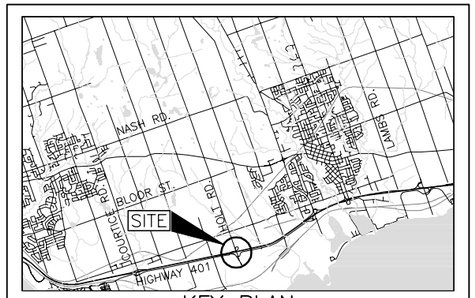
HORIZONTAL SCALE
10 0 10 20 m
VERTICAL SCALE
2 0 2 4 m

CONT No.
WP No. 2101-08-00

HIGHWAY 401
HOLT ROAD INTERCHANGE STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation (1961)
- 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			
No.	ELEVATION	NORTHING	EASTING
BH HR-1	111.7	4860786.9	367290.0
BH HR-2	111.7	4860707.2	367300.7
BH1	112.8	4860742.3	367270.1
BH2	112.5	4860721.2	367268.3
BH3	111.9	4860710.7	367278.7
BH4	111.9	4860704.4	367275.0
BH5	112.9	4860758.3	367256.1
BH6	111.6	4860774.2	367260.0
BH7	111.5	4860784.5	367248.8

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.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plan provided in digital format by URS, drawing file no. 120921-X-Design_Holt Preferred_ACAD 2007.dwg, received January 3, 2013

NO.	DATE	BY	REVISION

Geocres No. 30M15-119

HWY. 401	PROJECT NO. 09-1111-0019		DIST.
SUBM'D. MWK	CHKD. MWK	DATE: 26/03/2013	SITE:
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 1

APPENDIX A

Borehole Records

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
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
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, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

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

Piezo-Cone Penetration Test (CPT)
A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 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) Cohesionless Soils

Density Index / Relative Density	N 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	c_u, s_u 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

Percent 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 (cohesionless) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

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

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
σ_1, σ_2, σ_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 = $(w_l - w_p)$
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

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RECORD OF BOREHOLE No HR-1

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0019
W.P. 2101-08-00
DIST HWY 401
DATUM Geodetic

LOCATION N 4860786.9 ;E 367290.0
BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Power Augering
DATE November 22, 2012

ORIGINATED BY BM
COMPILED BY MS
CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
111.7	GROUND SURFACE							
0.0	Sandy silt to silty sand, trace clay, trace to some gravel, containing rootlets and organics (FILL) Loose to compact Brown to grey Moist	1	SS	14				
		2	SS	15				
		3	SS	7				
109.4								
2.3	CLAYEY SILT with sand, some gravel (TILL) Hard Grey Moist	4	SS	30	12	38	38	12
		5	SS	33				
107.9								
3.8	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist	6	SS	100/0.13	16	40	32	12
		7	SS	100/0.15				
		8	SS	100/0.13	5	40	43	12
104.7								
7.0	Sandy SILT, trace clay, trace to some gravel (TILL) Very dense Grey Moist	9	SS	100/0.13				
103.9								
7.8	END OF BOREHOLE							

NOTES:

1. Water level in open borehole measured at a depth of 4.9 m below ground surface (Elev. 106.8 m) on completion of drilling.

GROUND WATER CONDITIONS: ▽

ELEVATION SCALE: 111, 110, 109, 108, 107, 106, 105, 104

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 (%): 10 20 30

UNIT WEIGHT γ kN/m^3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

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

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RECORD OF BOREHOLE No HR-2

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0019
W.P. 2101-08-00
LOCATION N 4860707.2 ;E 367300.7
ORIGINATED BY BM
DIST HWY 401
BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Power Augering
COMPILED BY MS
DATUM Geodetic
DATE November 22, 2012
CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
111.7	GROUND SURFACE										
0.0	Sandy silt, trace clay, trace gravel, containing rootlets and organics (FILL) Loose to compact Brown to grey Moist		1	SS	9						
			2	SS	12		111		○		
109.9											
1.8	Sandy SILT, trace clay, trace gravel (TILL) Compact		3	SS	14		110				
109.4											
2.3	Grey Moist		4	SS	28		109		⊖		1 12 52 35
108.8	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Grey Moist		5	SS	100/0.13				○		5 47 34 14
2.9	SAND and SILT, some clay, trace to some gravel (TILL) Very dense Grey Moist		6	SS	100/0.07		108				
			7	SS	100/0.07	▽	107		○		
105.4			8	SS	100/0.07		106				
6.3	END OF BOREHOLE										

NOTES:

1. Water level in open borehole measured at a depth of 4.7 m below ground surface (Elev. 107.0 m) on completion of drilling.

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

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

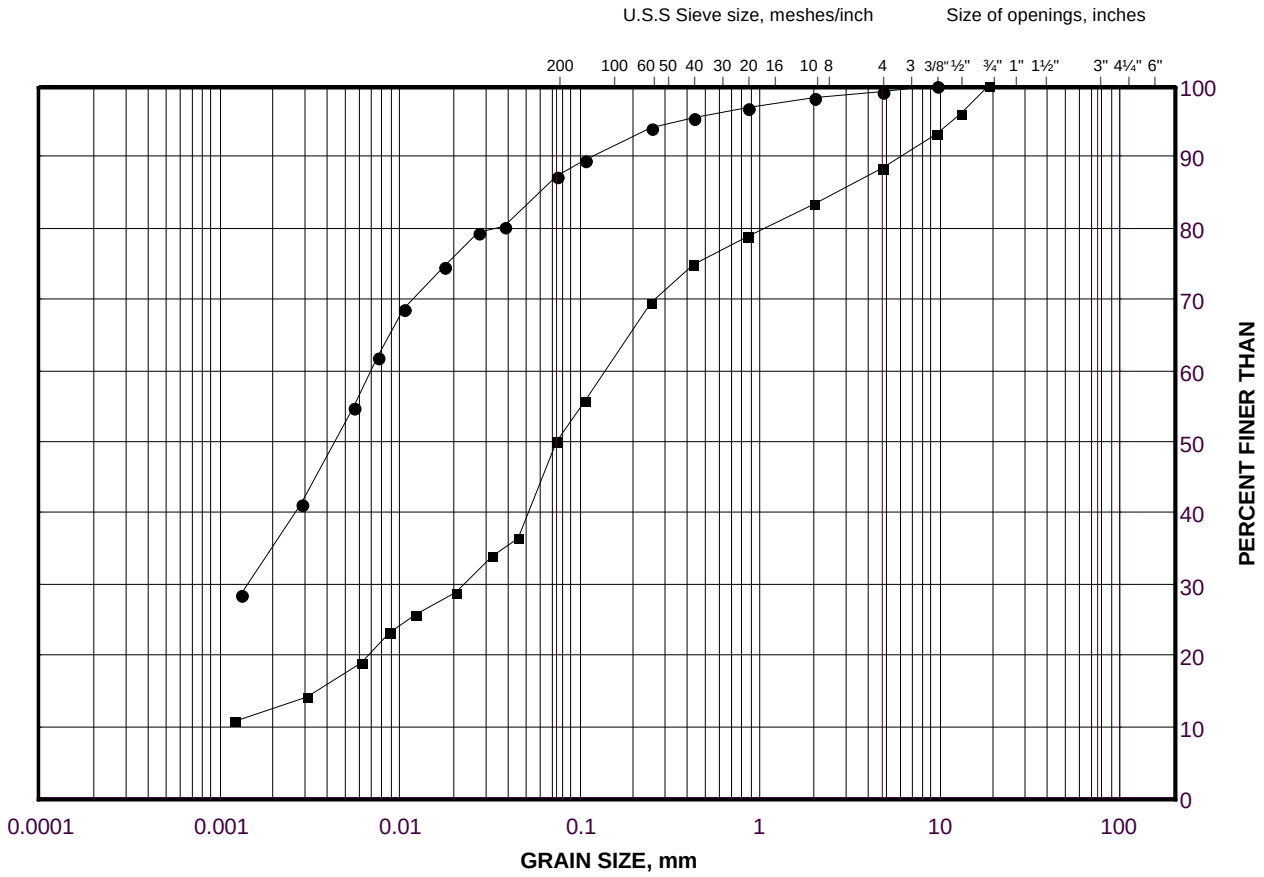
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE B1



LEGEND

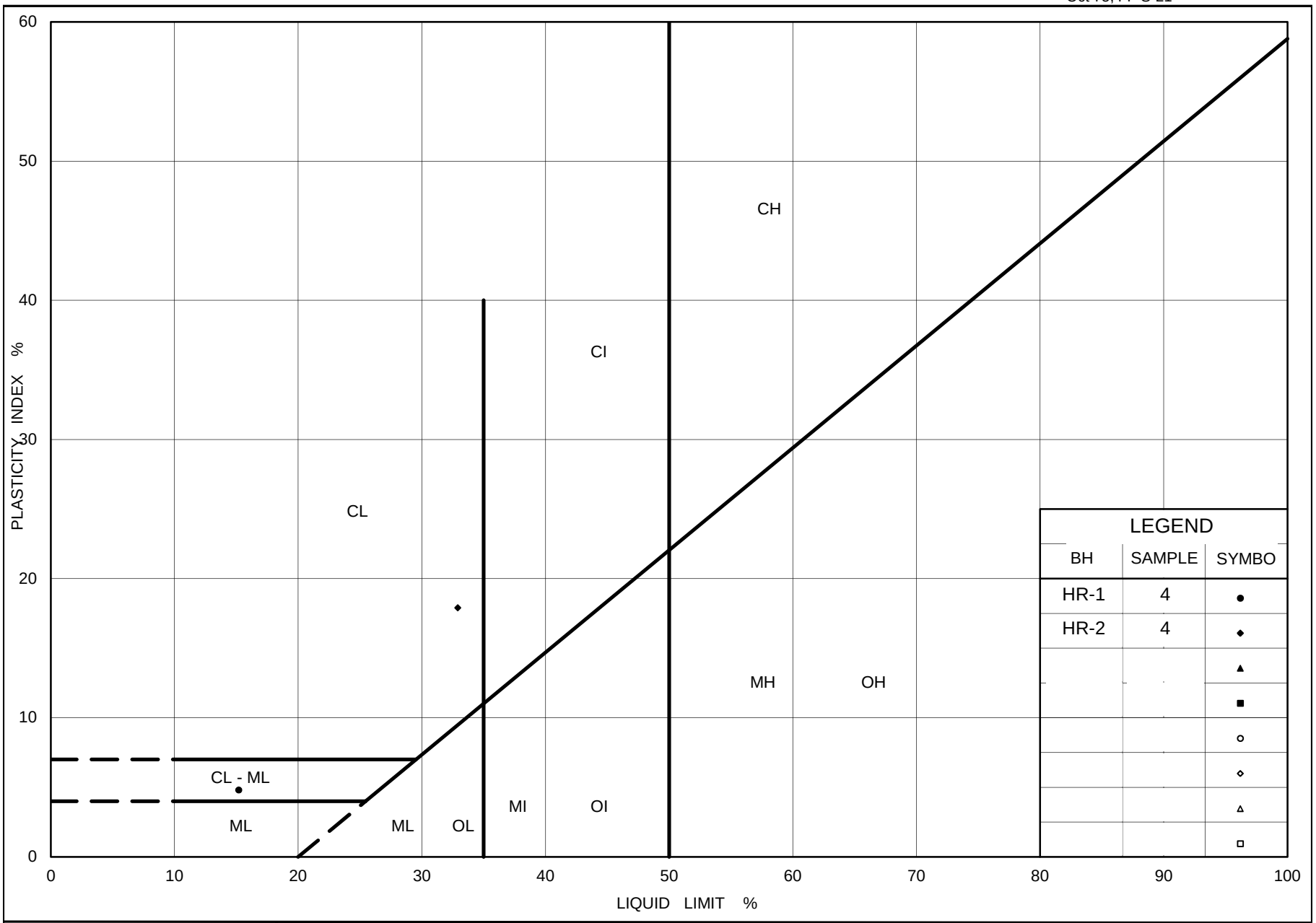
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HR-2	4	109.1
■	HR-1	4	109.1

Project Number: 09-1111-0019

Checked By: _____

Golder Associates

Date: 24-Jan-13



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt (Till)

Figure No. B2

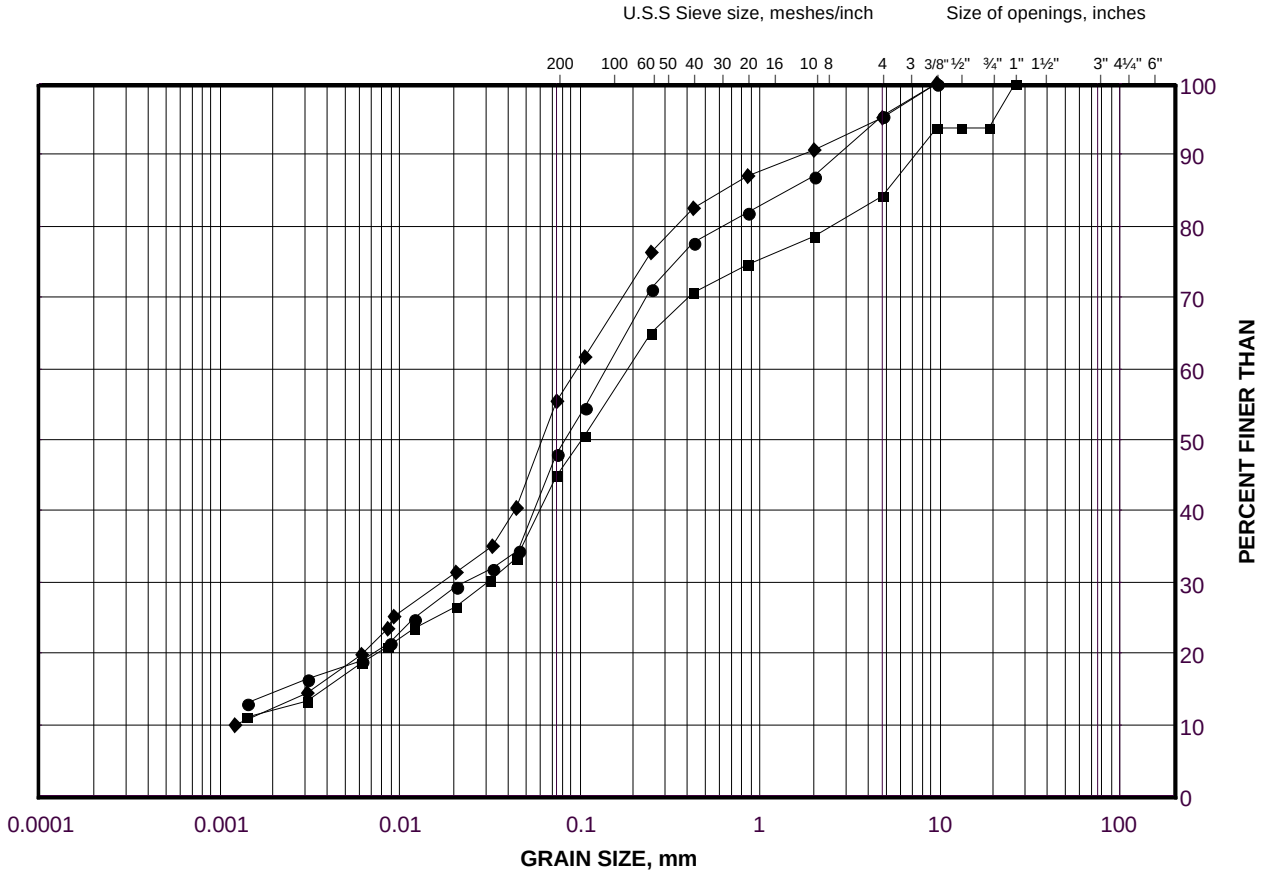
Project No. 09-1111-0019

Checked By: MWK

GRAIN SIZE DISTRIBUTION TEST RESULTS

Sandy Silt to Sand and Silt Till

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HR-2	5	108.6
■	HR-1	6	107.8
◆	HR-1	8	105.5

Project Number: 09-1111-0019

Checked By: _____

Golder Associates

Date: 24-Jan-13

APPENDIX C

Borehole Logs – Previous Investigation

OFFICE REPORT OF SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 1

JOB 61-F-15 STATION See drawing

DATUM 370.0' COMPILED BY B.K.

BORING DATE Mar. 2/61 CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
3" SHELBY
CASING

LEGEND

UNCONFINED COMPRESSION (Q_u)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

DESCRIPTION	ELEV. FEET	DEPTH FEET
↓ Groundlevel	370.0	0
Granular Fill	365.0	
Dark brown clayey silt (Topsoil)	363.0	
Light brown pebbly silty sand (till)	351.0	10
		20
Grey pebbly silty sand (till)	345.5	
End of borehole		30
		40

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200

CONSISTENCY

MOIST. CONTENT - % DRY WT.

10 20 30

SAMPLE	NATURAL UNIT WT. P.C.F.
S1	-
S2 S3	-
S4	145.8
S5	-
S6	-

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 2

JOB 61-F-15 STATION See Drawing

DATUM 369.0' COMPILED BY B.K.

BORING DATE Mar. 2/61 CHECKED BY V.K.

LEGEND

2" DIA. SPLIT TUBE
2" SHELB TUBE
2" SPLIT TUBE
3" DIA. CORE
2" SHELBY
CASING

1/2 UNCONFINED COMPRESSION (Qu) C
VANE TEST(C) AND SENSITIVITY(S) +*
NATURAL MOISTURE AND LIQUIDITY INDEX W
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	↓ Groundlevel	369.0	0
	Granular Fill	365.0	
	Dark brown clayey silt (topsoil)	362.0	
	Light brown pebbly silty sand (Till)		10
		351.0	20
	Grey pebbly silty sand (till)	346.0	
	End of borehole.		30
			40

STRENGTH AND PENETRATION RESISTANCE P.S.F.
50 100 150 200
BLOWS/1'

CONSISTENCY
MOIST. CONTENT % DRY WT.
10 20 30

SAMPLE NATURAL UNIT WT. P.C.F.

S1 –
S2 –
S3 –
S4 –

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 3

JOB 61-P-15 STATION See Drawing

DATUM 367.0' COMPILED BY B.K.

BORING DATE Mar. 2/61 CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
3" DIA. CONE
2" SHELBY
CASING

LEGEND

½ UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Groundlevel	367.0	0
	Granular fill	366.8	
	Dark brown silty clay (topsoil)	361.5	
	Light brown pebbly silty sand (till)	351.0	
	Grey pebbly silty sand till	342.0	
	End of borehole		40

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 BLOWS/FT. 200

CONSISTENCY

MOIST. CONTENT - % DRY WT.

SAMPLE

NATURAL UNIT WT. P.C.F.

S1 -
S2 -
S3 -
S4 -
S5 -

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 4

JOB 61-F-15 STATION See Drawing

DATUM 367.0' COMPILED BY B.K.

BORING DATE Mar. 2/61 CHECKED BY V.K.

2" DIA SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Groundlevel	367.0	0
	Granular Fill	366.0	
	Dark brown clayey silt (topsoil)	362.0	
	Brown gravelly silty sand	351.0	10
	Grey gravelly silty sand till	337.0	20
	End of borehole		30
			40

STRENGTH AND PENETRATION RESISTANCE
P.S.F. 500 1000 1500 2000
BLOWS PER FT. 50 100 150 200

CONSISTENCY
MOIST. CONTENT - % DRY WT. 10 20 30

SAMPLE	NATURAL UNIT WT. P.C.F.
T1	123.0 131.8
S2	-
S3	-
S4	-
S5	-
S6	-
S7	-

FORM DB-MC-126 (REV. 1959) - 58-5891

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 5

JOB 61-F-15 STATION See Drawing

DATUM 369.0' COMPILED BY B.K.

BORING DATE Mar. 3/61 CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

STRATA	DESCRIPTION	ELEV. FEET	DEPTH FEET
	↓ Groundlevel	369.0	0
	Granular Fill	364.5	
	Dark brown clayey silt (topsoil)	362.5	
	Light brown pebbly silty sand (till)		10
		349.5	20
	End of borehole		30
			40

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 BLOWS/FT

CONSISTENCY

MOIST. CONTENT % DRY WT.

10 20 30

SAMPLE

S1
S2
S3
S4

NATURAL UNIT WT. P.C.F.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 6

JOB 61-F-15 STATION See Drawing

DATUM 366.0' COMPILED BY B.K.

BORING DATE Mar. 3/61 CHECKED BY V.K.

LEGEND

2" DIA SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
3" DIA CONE
3" SHELBY
CASING

UNCONFINED COMPRESSION (Qu)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND LIQUIDITY INDEX
LIQUID LIMIT
PLASTIC LIMIT

SOIL	DESCRIPTION	ELEV FEET	DEPTH FEET	SAMPLE	NATURAL UNIT WT P.C.F.
	↓ Groundlevel	366.0	0		
	Granular fill	363.5			
	Dark brown clayey silt (topsoil)	361.0			
	Light brown pebbly silty sand (till)	353.0	10	S1	-
				S2	-
			20	S3	-
	Grey pebbly silty sand (till)			S4	-
		341.7		S5	-
	End of borehole		30		
			40		

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 P.S.F.

CONSISTENCY

MOIST. CONTENT % DRY WT

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 118-58 BORE HOLE NO. 7

JOB 61-F-15 STATION See Drawing

DATUM 365.5' COMPILED BY B.E.

BORING DATE Mar. 3/61 CHECKED BY V.K.

LEGEND

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
3" DIA. CONE
3" SHELBY
CASING

1/2 UNCONFINED COMPRESSION (Qu) O
VANE TEST (C) AND SENSITIVITY (S) +
NATURAL MOISTURE AND LIQUIDITY INDEX X
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	± Groundlevel	365.5	0
	Granular fill	364.5	
	Dark brown clayey silt (topsoil)	363.5	
	Light brown pebbly silty sand (till)		
		355.0	10
	End of borehole		

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 P.S.F.

0
10
20
30
40

CONSISTENCY

MOIST. CONTENT - % DRY WT.

SAMPLE	NATURAL UNIT WT. P.C.F.
S1	-
S2	-
S3	-

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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