



March 28, 2017

FOUNDATION INVESTIGATION REPORT

Highway 401 Structural Culvert, Site No. 21-489/C
Structural Culverts Rehabilitation/Replacement
Highway 35/115 and Highway 401
Ministry of Transportation, Ontario
G.W.P. 2186-15-00

Submitted to:

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GEOCRES No. 30M15-305
Report Number: 1540419-3

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REPORT





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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. (D.M. Wills) on behalf of Ministry of Transportation, Ontario (MTO) to provide Foundation Engineering services for the replacement of the structural culvert at Station (STA) 17+730 on Highway 401 in the Regional Municipality of Durham, Ontario (MTO Structural Site No. 21-489/C), approximately 1 km east of Holt Road in Clarington, Ontario, the location of which is shown on the Key Plan on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Quotation, dated August 2015. Golder's proposal for the foundation engineering services associated with the culvert replacements is contained in Section 3.5 of D.M. Wills' Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated December 1, 2016.

This report addresses the investigation carried out for the structural culvert at about STA 17+730 on Highway 401 (MTO Structure Site No. 21-489/C) which has been identified for rehabilitation and construction of a relief culvert to the east of the existing culvert. The foundation investigation associated with the other culverts, which forms part of the Foundation assignment for this project are presented in separate reports.

2.0 SITE DESCRIPTION

The existing structural culvert at Site No. 21-489/C is 92.7 m in total length, and consists of a 75 m long central section concrete box which is 4.3 m wide by 2.4 m high. The north and south extensions, which are 12.8 m and 4.9 m long, respectively, are both 4.3 m wide and 2.4 m high. The structure is located within an approximately 7.5 m to 10.5 m high fill embankment and has approximately 6.1 m of soil cover. Details of the culvert are summarized in Table 1 following the text of this report.

In general, the topography in the area of the culvert consists of a relatively flat lacustrine plain used for agricultural purposes with clusters of trees and brush present along the ditch line and Darlington Creek. The natural ground surface in the vicinity of the culvert is at about Elevation 87.0 m. The Highway 401 grade in the vicinity of the culvert is at about Elevation 94 m. The existing Highway 401 embankment consists of earth fill, with side slopes inclined at approximately 2 horizontal to 1 vertical (2H:1V). The ground surface at the borehole locations advanced for the culvert investigation, including through the existing Highway 401 embankment, varies between about Elevation 85.2 m and 94.2 m, referenced to Geodetic datum.

3.0 INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation associated with structural culvert Site No. 21-489/C was carried out between July 27, and September 6, 2016 in which a total of four boreholes were advanced at, or in the immediate vicinity of the culvert alignment, as shown in plan on Drawing 1.

The field investigation was carried out using a variety of drilling equipment as a result of the accessibility and restrictions associated with the terrain at the culvert site. The details of the drilling equipment and suppliers are listed below.



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Drilling Equipment	Supplied and Operated By
Truck-Mounted CME 75	Atcost Drilling Inc. of Gormley, Ontario
Track-Mounted Mini-Mole	Kodiak Drilling of Oakville, Ontario
Portable Equipment	OGS Drilling Inc. of Almonte, Ontario

The boreholes drilled by the truck-mounted CME75 drill rig were advanced through the overburden using 203 mm outer diameter (O.D.), 108 mm inner diameter (I.D.) hollow stem augers. The boreholes drilled by the track-mounted Mini-Mole rig were advanced through the overburden using 102 mm diameter solid stem augers. The boreholes completed with the portable equipment were advanced through the overburden using BQ and NQ sized casing with wash boring techniques. Soil samples were obtained continuously at some borehole locations but generally at intervals of depth of about 0.75 m and 1.5 m using a 50 mm O.D. split-spoon sampler operated by an automatic hammer on the drill rigs, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586¹). Boreholes advanced by portable equipment employed a full-weight hammer lifted manually and dropped from the SPT height.

The results of the SPT testing as presented on the Record of Borehole sheets are uncorrected (not standardized for hammer efficiency, borehole diameter, rod length, etc.). The samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore particles that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. For the site stratigraphy, these larger sized particles may include cobbles and boulders.

A piezometer was installed in Borehole C3-4 to allow monitoring of the groundwater level at this site. The piezometer consists of a 25 mm diameter PVC pipe, with a slotted screen sealed within the silt and sand till deposit. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled with bentonite pellets to ground surface. The piezometer installation details and water level readings are noted on the Record of Borehole C3-4 in Appendix A. The other boreholes were backfilled with bentonite upon completion of drilling in accordance with Ontario Regulation 903 (Wells) (as amended). The groundwater conditions and water levels in the open boreholes were observed during and immediately following the drilling operations and are described on the Record of Borehole sheets in Appendix A.

The fieldwork was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the soil samples. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO Laboratory and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and provided in Appendix B.

A soil sample obtained during the field investigation in Borehole C3-2 at about the culvert invert elevation, using appropriate sampling protocols, was submitted to a specialist analytical laboratory under chain of custody

¹ ASTM D1586-11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2011



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procedures for chemical analysis of conductivity / resistivity, pH and sulphate, and chloride content to assess the potential for the soil to cause corrosion to buried concrete and steel. The results of the analytical testing are discussed in Section 4.4 and are provided in Appendix C. Borehole locations were surveyed in the field relative to a fixed location on site. The as-drilled borehole locations were measured relative to existing site features and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The Geodetic elevation of the boreholes were obtained using the borehole locations and topographic information provided by D.M. Wills on January 20, 2016. The borehole locations given on the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 Zone 10 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and depths drilled are as follows:

Culvert Location	Borehole	Location (m)		Ground Surface Elevation (m)	Depth of Borehole (m)
		Northing (Latitude)	Easting (Longitude)		
STA 17+730 (Town of Clarington)	C3-1	4860965.6 (-78.7102389797)	368258.7 (43.8859352057)	87.7	8.7
	C3-2	4860950.2 (-78.71013556)	368267.1 (43.8857957051)	94.2	17.2
	C3-3	4860928.8 (-78.7095213623)	368316.7 (43.8855987476)	94.0	17.0
	C3-4	4860913.3 (-78.7092701443)	368337.0 (43.8854577017)	85.2	12.5

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*² and *Urban Geology of Canadian Cities*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 underlying bedrock surface is mapped at a depth of about 22 m at the site. The bedrock is described as limestone, dolostone, shale, arkose, sandstone of the Ottawa Group, Simcoe Group, and Shadow Lake formation.

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.



4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets and the laboratory test sheets in Appendices A and B, respectively. The stratigraphic boundaries shown on the Record of Boreholes sheets and stratigraphic cross sections are inferred from non-continuous sampling, observations of drilling progress and in situ testing and are approximate. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The stratigraphy at the borehole locations at culvert Site No. 21-489/C consists of surficial layers of topsoil or asphalt as the roadway platform, underlain by non-cohesive and cohesive layer of embankment fill, in turn underlain by layers/deposits of hard clayey silt, firm clayey silt with sand, and pockets of loose to dense sand in places. The cohesive deposits are underlain by a till deposit which is comprised of compact to very dense silt and sand, sandy silt and silt. A detailed description of the subsurface conditions at the culvert crossing is provided in the following section of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

4.2.1 Asphalt

In Boreholes C3-2 and C3-3 advanced at the Highway 401 grade, an approximately 150 mm thick layer of asphalt was encountered.

4.2.2 Topsoil

A 50 mm thick layer of topsoil was encountered at ground surface in Borehole B3-1.

4.2.3 Embankment Fill

Embankment fill approximately 7.8 m and 10.1 m thick was encountered below the asphalt in Boreholes C3-2 and C3-3 extending from Elevations 94.0 m and 93.8 m, respectively. The embankment fill consists of an upper granular layer approximately 0.6 m and 1.1 m thick consisting of gravelly sand to sand and gravel, and a lower cohesive layer consisting primarily of clayey silt, approximately 7.2 m and 8.9 m thick. Grinding of the augers was observed in Borehole C3-2 in the clayey silt fill at Elevations 89.9 m and 87.8 m and in the gravelly clayey silt fill between Elevations 92.5 m and 91.9 m, inferring the presence of cobbles. Our recent experience with trenchless crossings of major MTO highways suggests that there could be debris consisting of abandoned temporary works associated with the original culvert construction. This debris in the fill may consist of logs, stumps, and brush from the clearing and grubbing operations, and cobbles and/or boulders.

The SPT 'N'-values measured within the non-cohesive embankment fill generally range from 29 blows to 51 blows per 0.3 m of penetration, indicating a compact to very dense relative density. The SPT 'N'-values measured in the cohesive embankment fill range from 4 blows to 19 blows per 0.3 m of penetration, suggesting firm to very stiff consistency.

The natural water content measured on a sample of the non-cohesive embankment fill is about 7 per cent. The natural water content measured on seven samples of cohesive embankment fill ranges between about 9 and 21 per cent.



The results of grain size distribution tests completed on four samples of the fill are shown on Figure B1 in Appendix B.

Atterberg limits tests were carried out on three samples of the cohesive embankment fill. On two samples from Borehole 3-2, the tests measured a liquid limit of about 15 and 16 per cent, a plastic limit of about 11 per cent and a plasticity indices of about 4 and 5 per cent. The test results, which are plotted on a plasticity chart on Figure B2 in Appendix B, indicate that the material tested is comprised of clayey silt to silt of low plasticity. On the samples from Borehole 3-3, the test measured a liquid limit of about 31 per cent, a plastic limit of about 14 per cent and a plasticity index of about 17 percent, indicating that the material tested is a clayey silt of low plasticity as shown on Figure B2.

4.2.4 Clayey Silt

The topsoil in Borehole C3-1 is underlain at Elevation 87.6 m by a 2.8 m thick layer of clayey silt to sandy clayey silt containing trace organics. A gravel layer was encountered near the bottom of the deposit at approximate Elevation 85 m.

The SPT 'N' values measured within the clayey silt deposit range between 8 and 98 blows per 0.3 metres suggesting a firm to hard consistency.

The natural water content measured on a sample of the clayey silt deposit is 10 per cent.

An Atterberg limit test was also carried out on a sample of the clayey silt deposit and measured a liquid limit of about 34 per cent, a plastic limit of 19 per cent and a plasticity index of 15 per cent indicating a clayey silt of low plasticity, as presented on Figure B3 in Appendix B.

4.2.5 Silty Sand

A 2.3 m thick layer of silty sand was encountered at the ground surface in Borehole C3-4. The measured SPT 'N' values within the silty sand deposit range from 7 to 31 blows per 0.3 m indicating a loose to dense relative density. The silty sand deposit is classified as non-plastic based on the results of an Atterberg Limit test on the sample tested. The water content of the Atterberg Limits tested sample is 18 per cent. The result of a grain size analyses carried out on a sample of silty sand is presented on Figure B4.

4.2.6 Clayey Silt with Sand

A 0.8 m thick deposit of clayey silt with sand containing trace organics was encountered in Boreholes C3-1 and C3-2 at Elevations 84.8 m and 86.3 m. The deposit in Borehole C3-1 is gravelly.

The SPT 'N'-values measured within the clayey silt with sand deposit are 8 blows and 9 blows per 0.3 m of penetration, suggesting a stiff consistency.

The natural water content measured on a sample of the clayey silt with sand deposit is about 11 per cent.

The result of a grain size distribution test completed on a sample of the deposit is shown on Figure B5 in Appendix B.

An Atterberg limits test was carried out on a sample of the cohesive deposit in C3-1 and measured a liquid limit of about 19 per cent, a plastic limit of about 12 per cent and a plasticity index of about 7 per cent. The test result,



which is plotted on a plasticity chart on Figure B6 in Appendix B, indicate that the material tested is a clayey silt of low plasticity.

4.2.7 Sand

A 0.9 m and 0.7 m thick layer of sand was encountered below the clayey silt with sand deposit in Borehole C3-2 at Elevation 85.5 m, and below the silt and sand till deposit (discussed below) in Borehole C3-1 at Elevation 79.7 m. Borehole C3-1 was terminated in the sand deposit.

SPT 'N'-values measured in the sand layers are 67 blows and 109 blows per 0.3 m, in the respectively boreholes, indicating a very dense relative density.

The natural water content measured on a sample of the sand layer in Borehole C3-1 is about 11 per cent.

4.2.8 Silt to Silt and Sand Till

A glacial till deposit consisting primarily of silt and sand was encountered below the clayey silt, sand, fill and silty sand deposits/layers described above in all boreholes between about Elevations 84.6 m and 82.9 m. The silt and sand till deposit also encompasses materials described as gravelly sandy silt, silty sand and silt. The silt and sand till deposit is 4.3 m thick in Borehole C3-1, and in the remaining boreholes the deposit was penetrated to thicknesses ranging between 6.8 m to 10.2 m and terminated within the deposit. Although cobbles and boulders were not specifically encountered within the silt and sand till at the borehole locations, their presence should be anticipated given the depositional history of the glacial till, and as inferred by auger grinding within the gravelly sandy silt till deposit in Borehole C3-1, within the silt and sand to silty sand till deposit in Borehole C3-2 and within the silt and sand till in Borehole C3-4, at various depths.

The SPT 'N'-values measured within the silt and sand till deposit range between 25 blows and 117 blows per 0.3 m of penetration, and numerous 'N'-values greater than 100 blows for less than 0.3 m of penetration, indicating a compact to very dense relative density. .

The natural water content measured on thirteen samples of the silt and sand till deposit range between about 5 per cent and 12 per cent.

The results of grain size distribution tests completed on five samples of the silt and sand portion of the till deposit are shown on Figure B7 in Appendix B.

Atterberg limits tests were carried out on five samples of the silt and sand till and silt till portion of the deposit. Four of the samples measured liquid limits between about 11 per cent and 12 per cent, plastic limits between about 10 per cent and 11 per cent and plasticity indices between about 1 per cent and 2 per cent. The test results, which are plotted on a plasticity chart on Figures B8 and B9 in Appendix B, indicate that the fines portion of the material tested is silt of slight plasticity. One test on a sample from Borehole C3-2 of the silt and sand till portion of the deposit indicates the material as being non-plastic.

4.3 Groundwater Conditions

The groundwater level in Borehole C3-1 was not established due to the use of wash-boring techniques to advance the borehole. The groundwater level was measured in the remaining boreholes upon completion of drilling operations at depths between 4.6 m and 12.2 m below ground surface, at between Elevations 84.9 m and 80.6 m.



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However, the water level observed in the open boreholes during and/or upon completion of drilling may not represent the longer-term, stabilized groundwater level at the site.

A standpipe piezometer was installed in Borehole C3-4 on the south side of Highway 401. The observed groundwater level in the monitoring well is shown on the Record of Borehole sheets and is summarized below.

Borehole	Depth to Water Level (m)	Groundwater Elevation (m)	Date of Measurement
C3-4	4.6	80.6	On Completion (July 27, 2016)
	0.5	84.7	March 28, 2017

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 and periods of precipitation.

4.4 Analytical Testing of Soil Sample

Analytical testing was carried out on a composite soil sample constituted from Samples 8 to 10 from Borehole C3-2, from depths between 7.9 m and 10.7 m below ground surface (between Elevations 86.3 m and 83.5 m). The testing was carried out to assess the corrosivity and concrete degradation potential of the soils against the new culvert structure. The analytical test results from the specialist analytical laboratory are presented in Appendix C and are summarized below.

Parameter	Test Results
Soil Resistivity	1300 ohm-cm
Soil Conductivity	798 μ mho/cm
Sulphate Concentration	<20 μ g/g
Chloride Concentration	410 μ g/g
Soil pH	7.63

5.0 CLOSURE

Messrs. Pat Speirs and Michael Bentley, supervised the borehole investigation program. This report was prepared by Ms. Amelia Jewiston, B.A.Sc., and was reviewed by Ms. Dirka U. Prout, P.Eng., a senior geotechnical engineer with Golder. Mr. Jorge M.A. Costa, P.Eng., a Senior Consultant with Golder and Designated MTO Contact conducted an independent quality control review of this report.



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Report Signature Page

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REFERENCES

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.

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.

Ontario Water Resources Act:

Ontario Regulation 372/9 Amendment to Ontario Regulation 903



TABLES



FOUNDATION REPORT - STRUCTURAL CULVERT REPLACEMENT - HIGHWAY 401, SITE NO. 21-489/C

Table 1: Summary of Existing Culvert Details

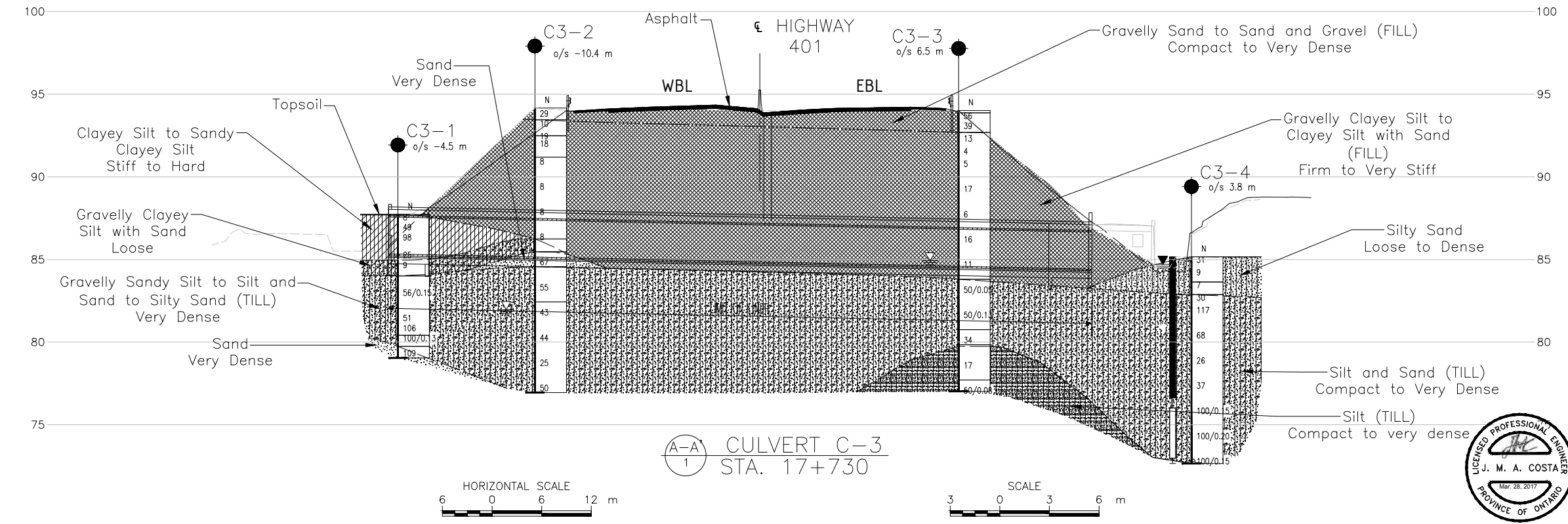
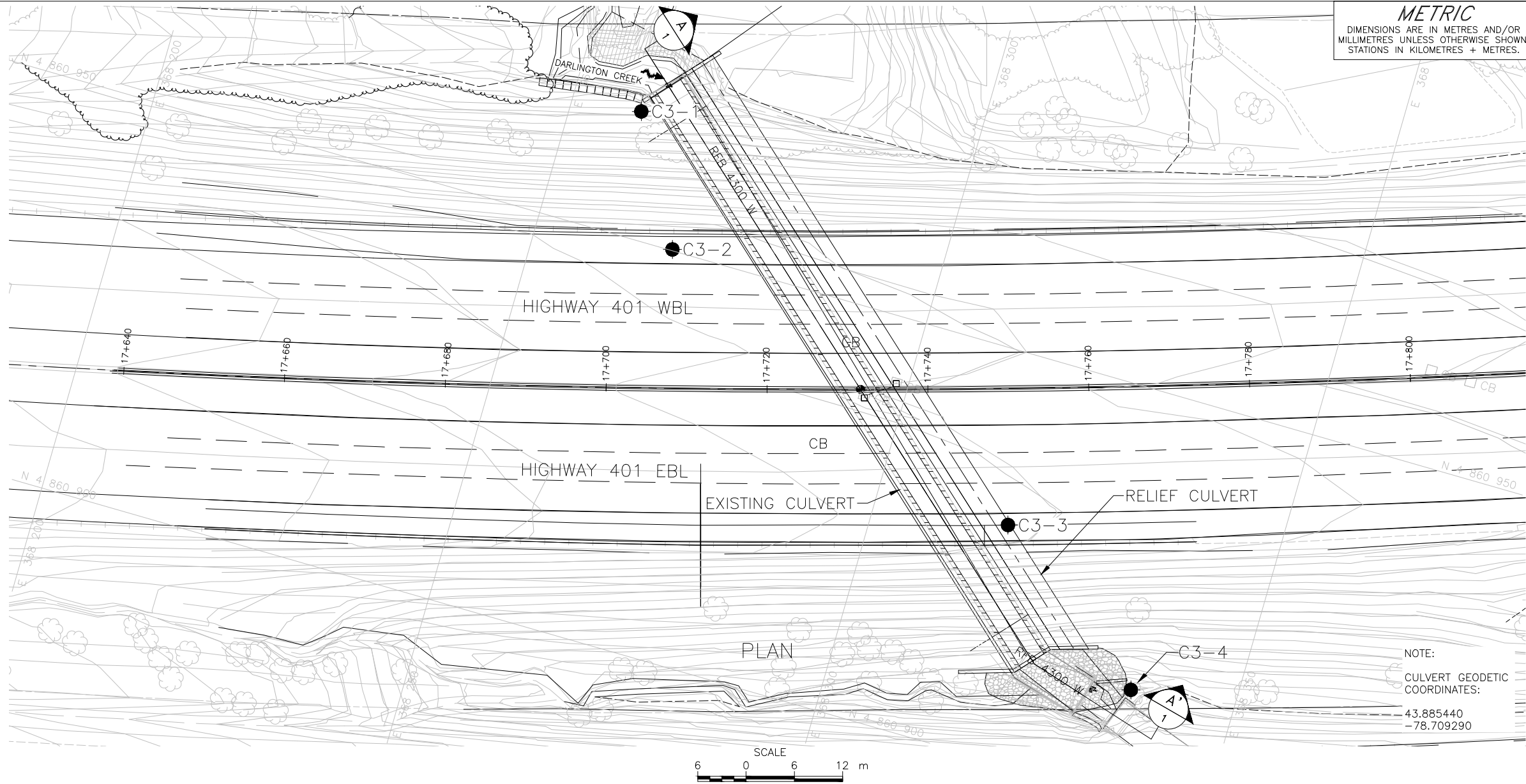
Culvert Location (Township)	Culvert ID / Site No.	Approximate Height of Embankment / Cover ¹	Existing Culvert			Approximate Invert Elevation ²		Boreholes
			Type	Approximate Dimension	Approximate Length	Upstream	Downstream	
STA 17+732 (Clarington)	C3	Up to about 10.5 m	Box Culvert	4.3 m x 24 m	92.7 m	85.22 m	84.16 m	4 Boreholes (C3-1 to C3-4)

Notes: 1. Embankment height is relative to existing ground surface level at the toe of embankment adjacent to the culvert and the thickness of culvert cover is based on drawings provided by D.M. Wills dated November 24, 2016

2. Culvert invert elevations are based on drawings provided by D.M. Wills dated November 24, 2016.



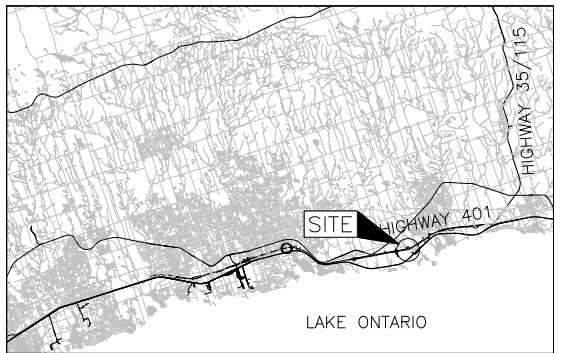
DRAWINGS



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

CONT No. 2186-15-00
WP No. 2186-15-00

HIGHWAY 401
DARLINGTON CREEK CULVERT STA 17+730
BOREHOLE LOCATIONS AND
SOIL STRATA



KEY PLAN
SCALE
0 6 12 km

LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C3-1	87.7	4860965.6	368258.7
C3-2	94.2	4860950.2	368267.1
C3-3	94.0	4860928.8	368316.7
C3-4	85.2	4860913.3	368337.0

NOTES
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE
Base Plan and Contours provided in digital format by DM Wills, drawing file nos. 132306.dwg and 132307.dwg, received Jan. 20, 2016. Design Plan and Section provided in digital format by DM Wills, drawing file no. 4561-C2 GA.dwg, received Aug. 22, 2016.



NO.	DATE	BY	REVISION
1	8/23/2016	MR	Initial

HWY. 401	PROJECT NO. 1540419	DIST. .
SUBM'D. MCK	CHKD. MCK	DATE: 8/23/2016
DRAWN: MR	CHKD. MK	APPD. JMAC



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

* 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 = $\tan \delta$
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

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 Soils

Density Index	N
Relative Density	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	
0 to 5	Trace
5 to 12	Trace to Some (or Little)
12 to 20	Some
20 to 30	(ey) or (y)
over 30	And (non-cohesive (cohesionless)) or With (cohesive)

Example

Trace sand
Trace to some sand
Some sand
Sandy
Sand and Gravel
Silty Clay with sand / Clayey Silt with sand

PROJECT 1540419			RECORD OF BOREHOLE No C3-1			SHEET 1 OF 1			METRIC					
W.P. 2186-15-00			LOCATION N 4860965.6; E 368258.7 MTM ZONE (LAT. 43.885944; LONG. -78.710242)			ORIGINATED BY MB								
DIST HWY 401			BOREHOLE TYPE Portable Equipment, BW Casing Washboring (Manual Hammer)			COMPILED BY SZ/MR								
DATUM Geodetic			DATE August 30 to September 1, 2016			CHECKED BY MCK								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
87.7	GROUND SURFACE													
87.9	TOPSOIL		1	SS	8									
	CLAYEY SILT to sandy CLAYEY SILT, trace organics Stiff to hard Brown becoming grey at a depth of 2.3 m Moist to wet		2	SS	49									
			3	SS	98*									
	- Gravel layer encountered between depths of 2.3 m and 2.9 m (Elev. 85.4 m and 84.8 m)		4	SS	25									
84.8														
2.9	Gravelly CLAYEY SILT with SAND Firm Grey Wet		5	SS	9									
84.0														
3.7	Gravelly Sandy SILT (TILL) Very dense Grey Wet													
	- Casing grinding at a depth of 4.3 m (Elev. 83.4 m)		6	SS	56/0.15									
81.3			7	SS	51									
6.4	SILT and SAND, trace to some gravel, trace to some clay (TILL) Very dense Grey Wet		8	SS	106									
			9	SS	147/0.28									
79.7														
8.0	SAND, some gravel Very dense Grey Wet		10	SS	109									
79.0														
8.7	END OF BOREHOLE													
	* Sampler Bouncing													
	NOTE: 1. Water level not established as water was introduced into the borehole during wash boring.													

GTA-MTO 001 S:\CLIENTS\MTOWHY_401 & HWY35-11502_DATA\GINTHWY_401_AJAX_TO_NEWTONVILLE_WITH_LAT_AND_LONGS.GPJ GAL-GTA-GDT 3/28/17



SHEET 1 OF 2

METRIC

CHECKED BY MCK

GTA-MTO 001 S:\CLIENTS\MT\HWY_401 & HWY35-11502_DATA\GINT\HWY_401 AJAX TO NEWTONVILLE WITH LAT AND LONGS.GPJ GAL-GTA.GDT 3/28/17

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

PROJECT <u>1540419</u>		RECORD OF BOREHOLE No C3-2				SHEET 2 OF 2		METRIC										
W.P. <u>2186-15-00</u>		LOCATION <u>N 4860950.2; E 368267.1 MTM ZONE (LAT. 43.885804; LONG. -78.710139)</u>				ORIGINATED BY <u>MK</u>												
DIST <u> </u> HWY <u>401</u>		BOREHOLE TYPE <u>CME 75, 203 mm O.D., 108 mm I.D. Hollow Stem Augers (Auto Hammer)</u>				COMPILED BY <u>SZ/MR</u>												
DATUM <u>Geodetic</u>		DATE <u>August 28, 2016</u>				CHECKED BY <u>MCK</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p W W _L					
	--- CONTINUED FROM PREVIOUS PAGE ---						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					10 20 30 WATER CONTENT (%)						
	SILT and SAND to Silty SAND, trace to some clay, some gravel (TILL) Compact to very dense Grey Moist	[Pattern]	13	SS	25		79								○			
		[Pattern]					78											
77.0		[Pattern]	14	SS	50		77											
17.2	END OF BOREHOLE																	
	NOTE: 1. Water level in open borehole at a depth of 12.2 m below ground surface (Elev. 82.0 m) upon completion of drilling.																	

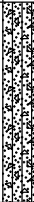
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PROJECT		1540419		RECORD OF BOREHOLE No C3-3		SHEET 1 OF 2		METRIC								
W.P.		2186-15-00		LOCATION		N 4860928.8; E 368316.7 MTM ZONE (LAT. 43.885607; LONG. -78.709525)		ORIGINATED BY MB								
DIST		HWY 401		BOREHOLE TYPE		CME 75, 203 mm O.D., 108 mm I.D. Hollow Stem Augers (Auto Hammer)		COMPILED BY SZ/MR								
DATUM		Geodetic		DATE		September 6, 2016		CHECKED BY MCK								
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 (%)
94.0	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT (150 mm)															
0.2	Gravelly sand (FILL) Dense to very dense Brown Dry		1	SS	51											
92.7			2	SS	39		93									
1.3	Clayey silt, trace to some sand, some gravel (FILL) Firm to very stiff Brown to grey Moist to wet		3	SS	13		92									
			4	SS	4		91									20 7 48 25
			5	SS	5		90									
			6	SS	17		89									11 41 36 12
			7	SS	6		88									
			8	SS	16		86									
			9	SS	11		85									
83.8							84									
10.2	SILT and SAND, trace to some clay, some gravel (TILL) Dense to very dense Grey Moist		10	SS	50/0.05		83									
	- Augers grinding at a depth of 11.6 m (Elev. 82.4 m)		11	SS	98/0.28		82									
			12	SS	34		80									19 41 32 8
79.2																
14.8	- Augers grinding at a depth of 14.6 m (Elev. 79.4 m)															

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\MTOWHY_401 & HWY35-11502_DATA\GINTHWY_401_AJAX_TO_NEWTONVILLE_WITH_LAT_AND_LONGS.GPJ GAL-GTA.GDT 3/28/17

PROJECT 1540419		RECORD OF BOREHOLE No C3-3				SHEET 2 OF 2		METRIC								
W.P. 2186-15-00		LOCATION N 4860928.8; E 368316.7 MTM ZONE (LAT. 43.885607; LONG. -78.709525)				ORIGINATED BY MB										
DIST _____ HWY 401		BOREHOLE TYPE CME 75, 203 mm O.D., 108 mm I.D. Hollow Stem Augers (Auto Hammer)				COMPILED BY SZ/MR										
DATUM Geodetic		DATE September 6, 2016				CHECKED BY MCK										
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 ---															
	SILT, some gravel, trace to some sand (TILL) Compact to very dense Grey Moist to wet		13	SS	17											
77.0						78										
17.0	END OF BOREHOLE		14	SS	50/0.08											
	NOTE: 1. Water level in open borehole at a depth of 9.1 m below ground surface (Elev. 84.9 m) upon completion of drilling.															

GTA-MTO 001 S:\CLIENTS\MTOWHY_401_& HWY35-11502_DATA\GINTHWY_401 AJAX TO NEWTONVILLE WITH LAT AND LONGS.GPJ GAL-GTA.GDT 3/28/17

PROJECT 1540419		RECORD OF BOREHOLE No C3-4		SHEET 1 OF 1		METRIC															
W.P. 2186-15-00		LOCATION N 4860913.3; E 368337.0 MTM ZONE (LAT. 43.885466; LONG. -78.709273)		ORIGINATED BY PKS																	
DIST _____ HWY 401		BOREHOLE TYPE Mini Mole, 102 mm O.D. Solid Stem Augers (Auto Hammer)		COMPILED BY ZMR																	
DATUM Geodetic		DATE July 27, 2016		CHECKED BY MCK																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
85.2	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	10 20 30											
0.0	Silty SAND, some gravel, trace to some clay Loose to dense Brown Moist		1	SS	31		85														
			2	SS	9		84														
			3	SS	7		83														
82.9							83														
2.3	SILT and SAND, trace to some gravel, trace to some clay (TILL) Compact to very dense Grey Moist to wet		4	SS	30		82														
			5	SS	117		81														
			6	SS	68		80														
			7	SS	26		79														
			8	SS	37		78														
	- Inferred cobbles between depths of 7.6 m and 9.1 m (Elev. 77.6 m and 76.1 m)		9	SS	100/0.1		77														
			10	SS	100/0.2		76														
			11	SS	100/0.1		75														
72.7							74														
12.5	END OF BOREHOLE						73														
	NOTE: 1. Water level in open borehole at a depth of 4.6 m below ground surface (Elev. 80.6 m) upon completion of drilling. 2. Water level measurement in piezometer: Date 09/28/2017 Depth 0.5m Elev. 84.7m																				



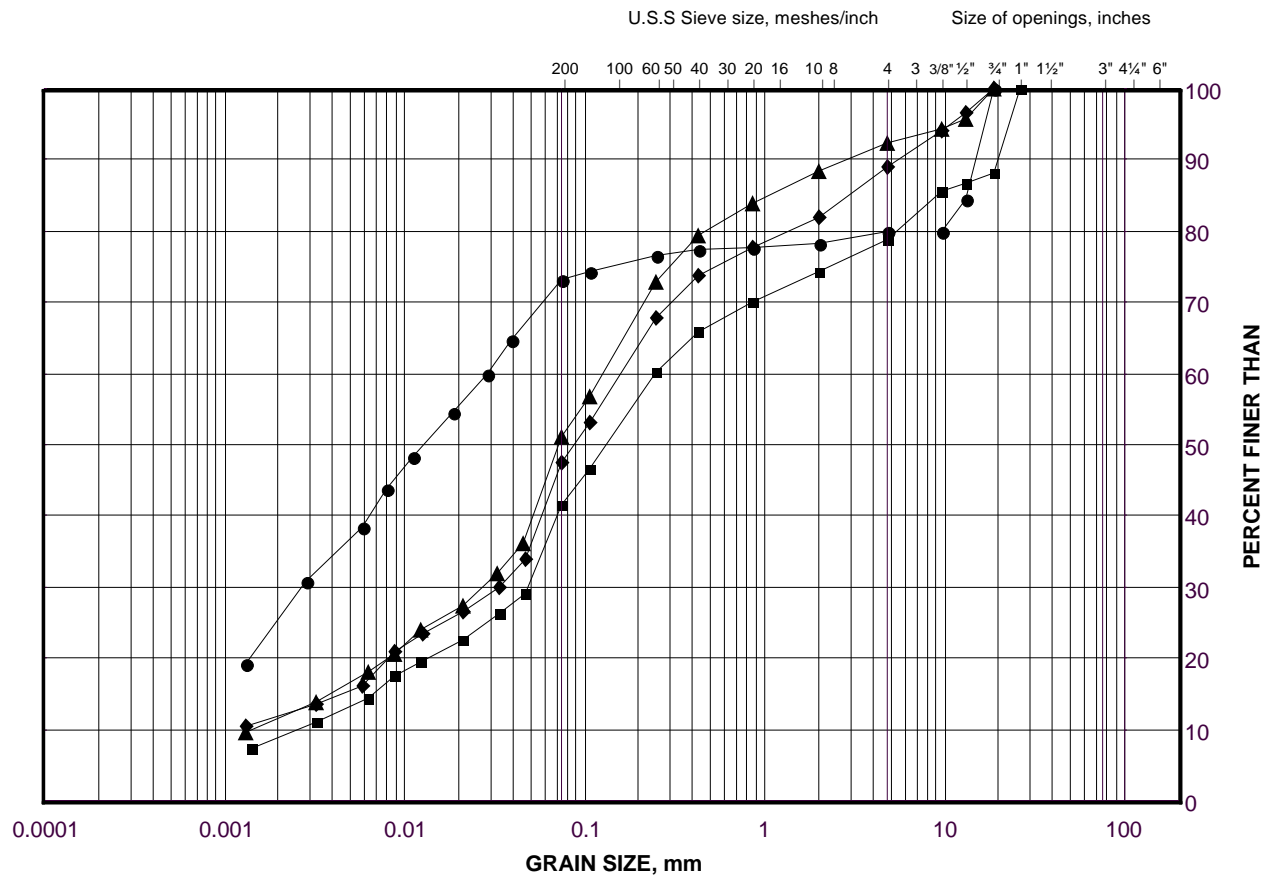
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Clayey Silt (FIL)L

FIGURE B1



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

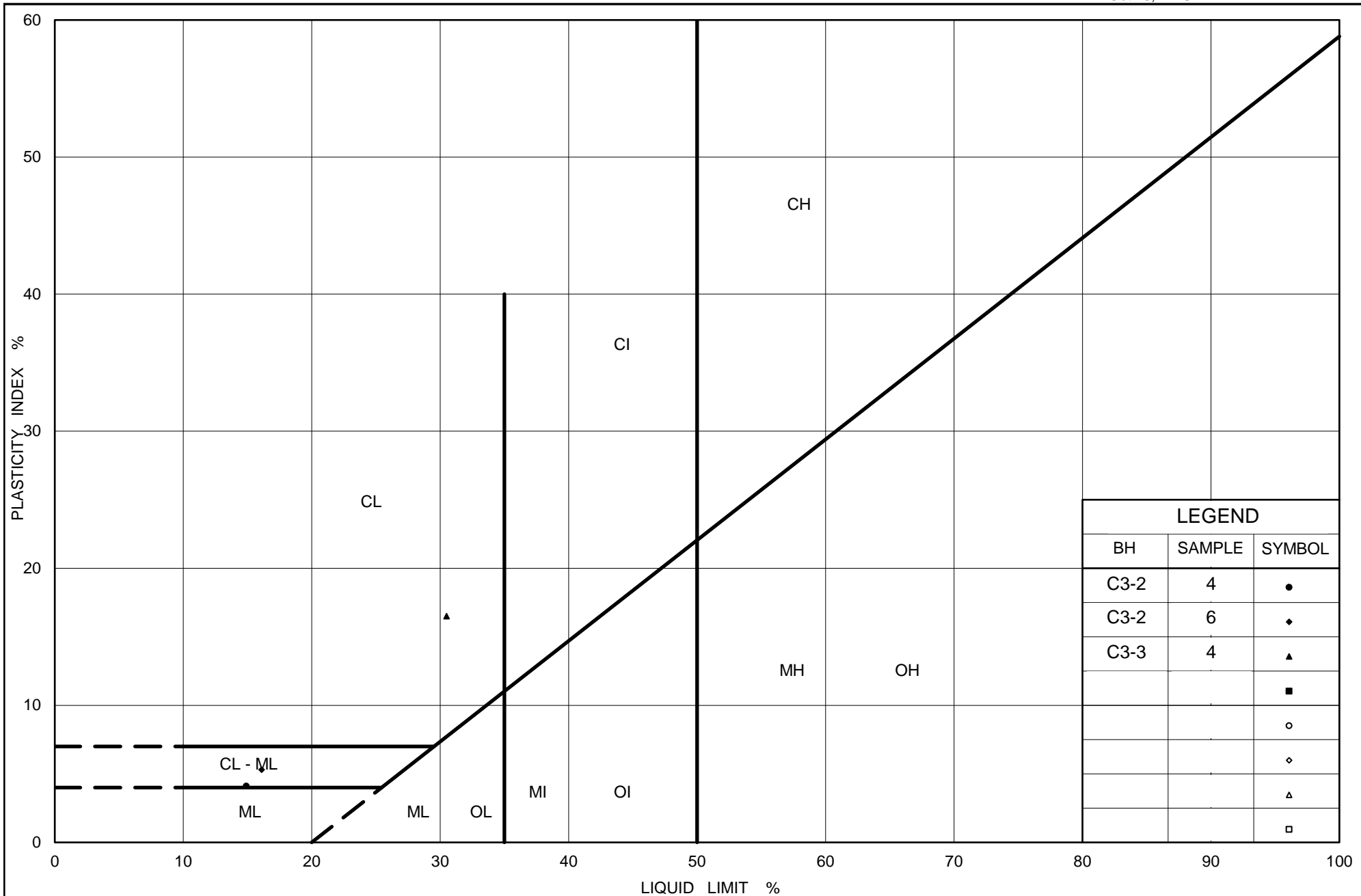
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C3-3	4	91.5
■	C3-2	4	91.6
◆	C3-3	6	89.1
▲	C3-2	7	87.8

Project Number: 1540419

Checked By: _____

Golder Associates

Date: 18-Oct-16



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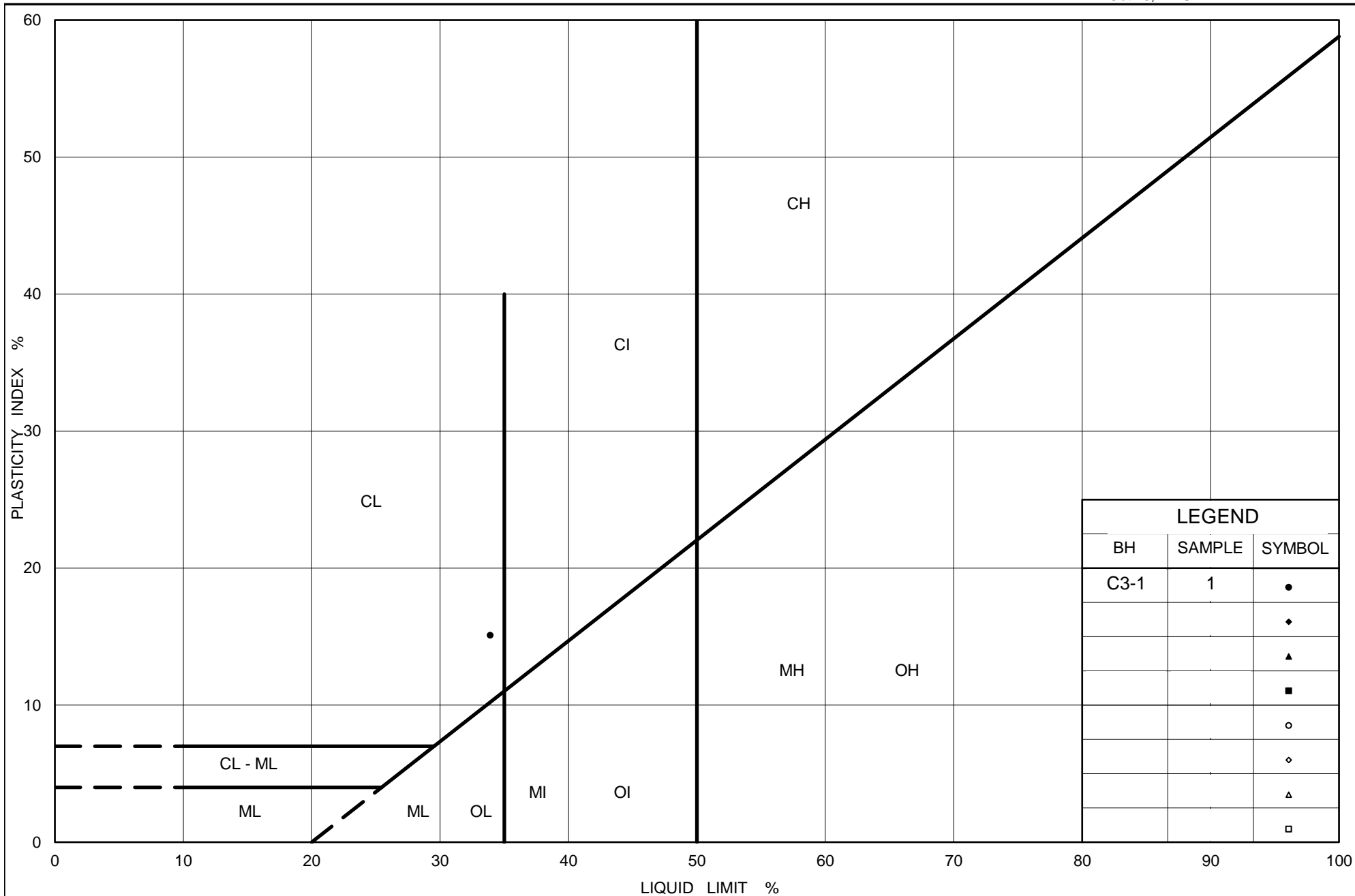
PLASTICITY CHART

Clayey Silt (FILL)

Figure No. B2

Project No. 1540419

Checked By:



Ministry of Transportation

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PLASTICITY CHART

Clayey Silt

Figure No. B3

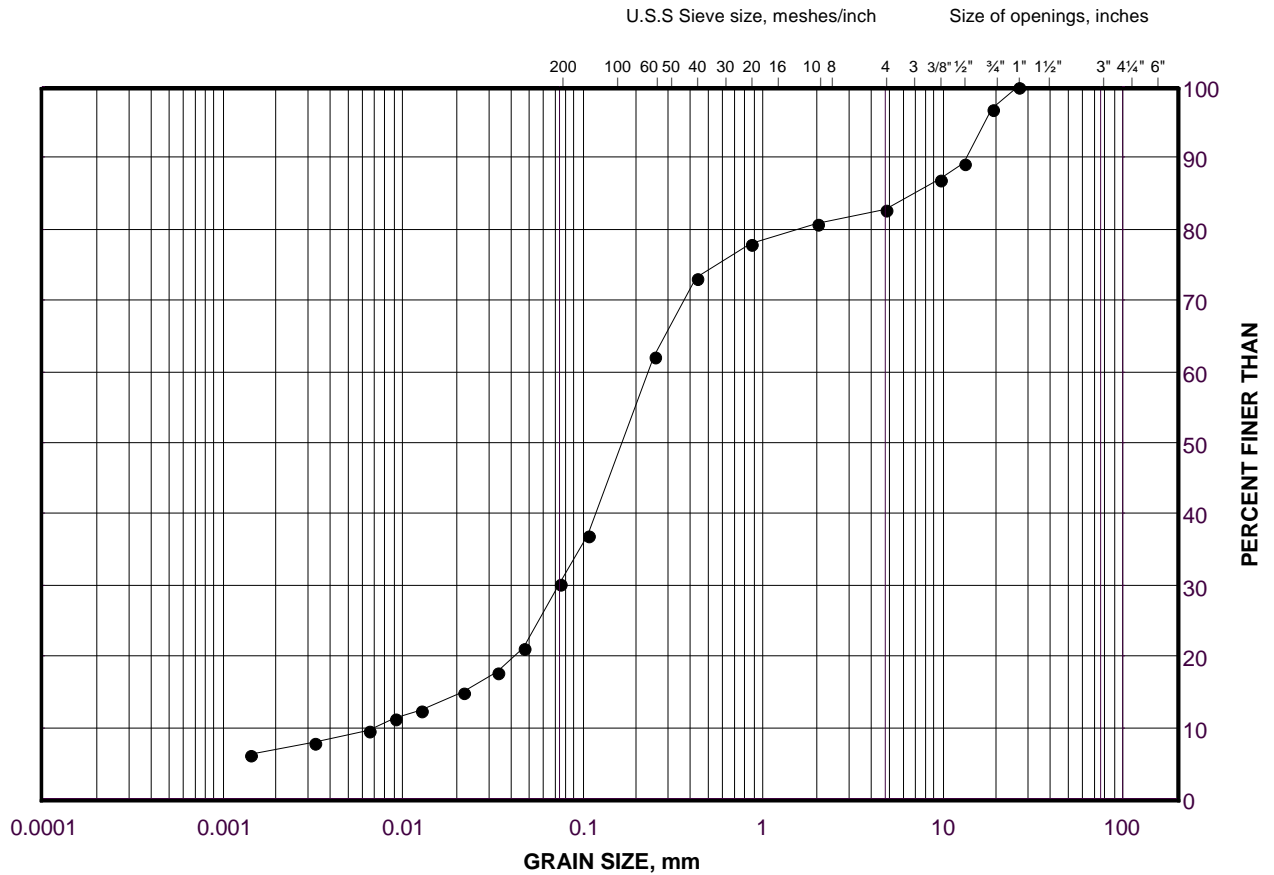
Project No. 1540419

Checked By:

GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE B4



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C3-4	3	83.4

Project Number: 1540419

Checked By: _____

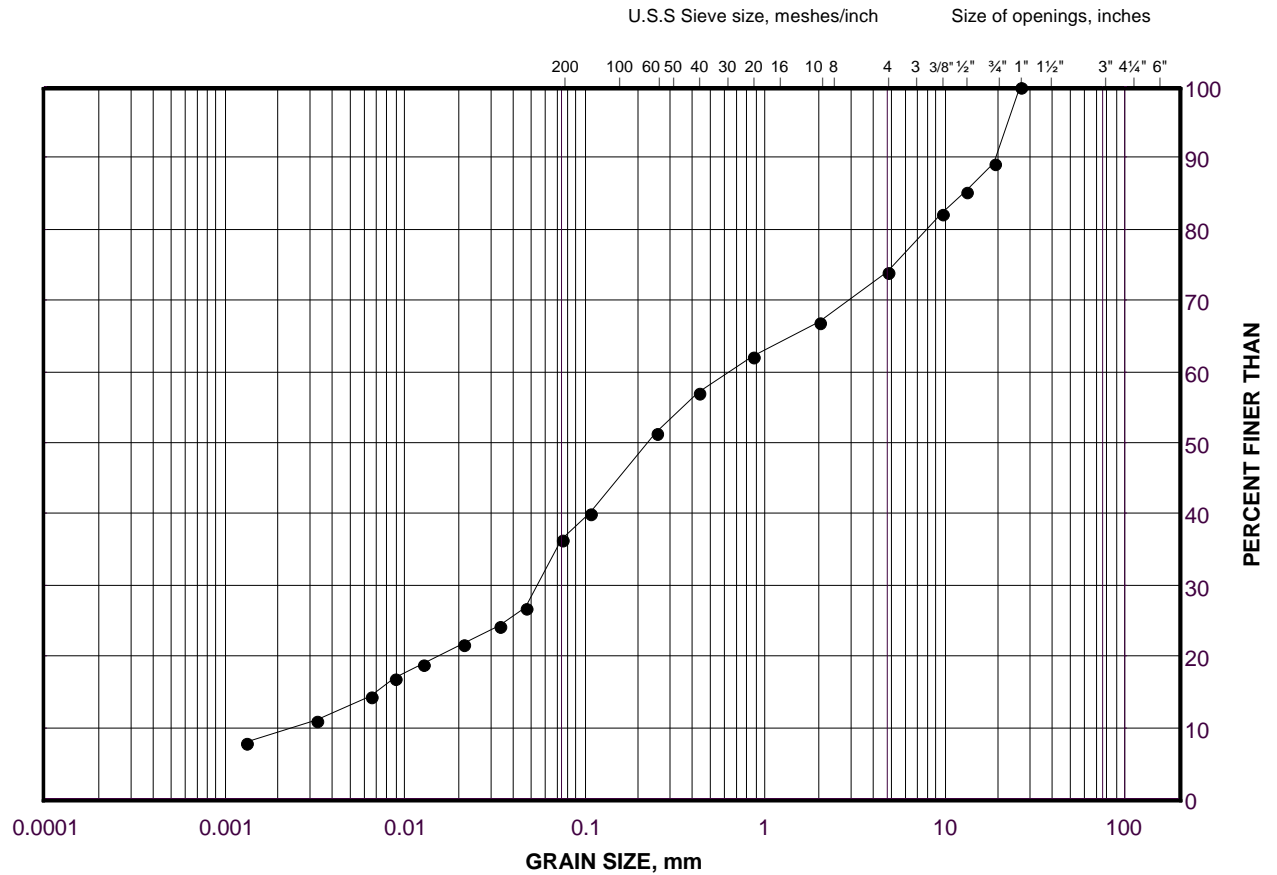
Golder Associates

Date: 18-Oct-16

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand

FIGURE B5



SILT AND CLAY SIZES				FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED				SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

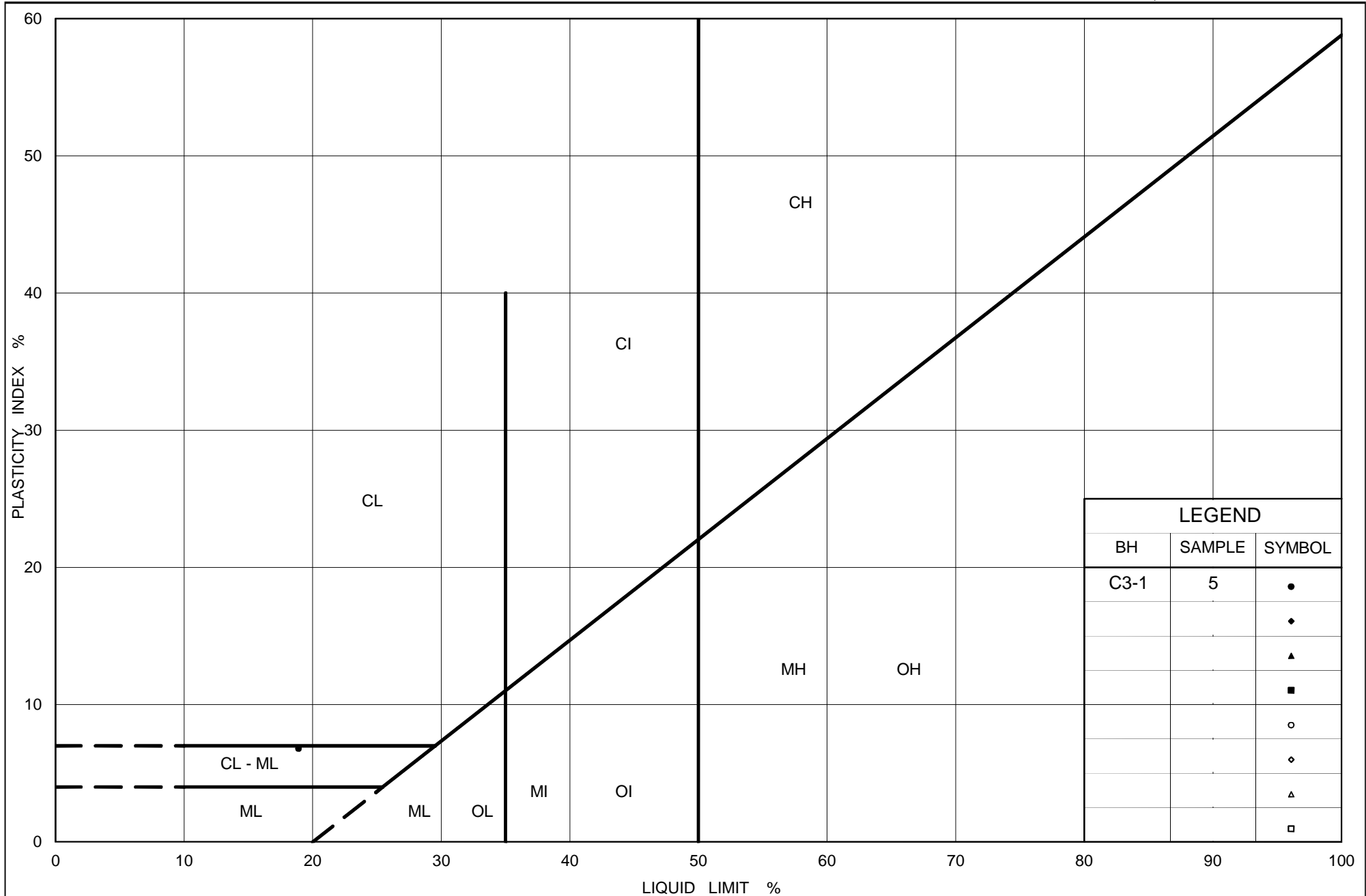
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	C3-1	5	84.5

Project Number: 1540419

Checked By: _____

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Date: 18-Oct-16



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PLASTICITY CHART Clayey Silt with Sand

Figure No. B6

Project No. 1540419

Checked By:

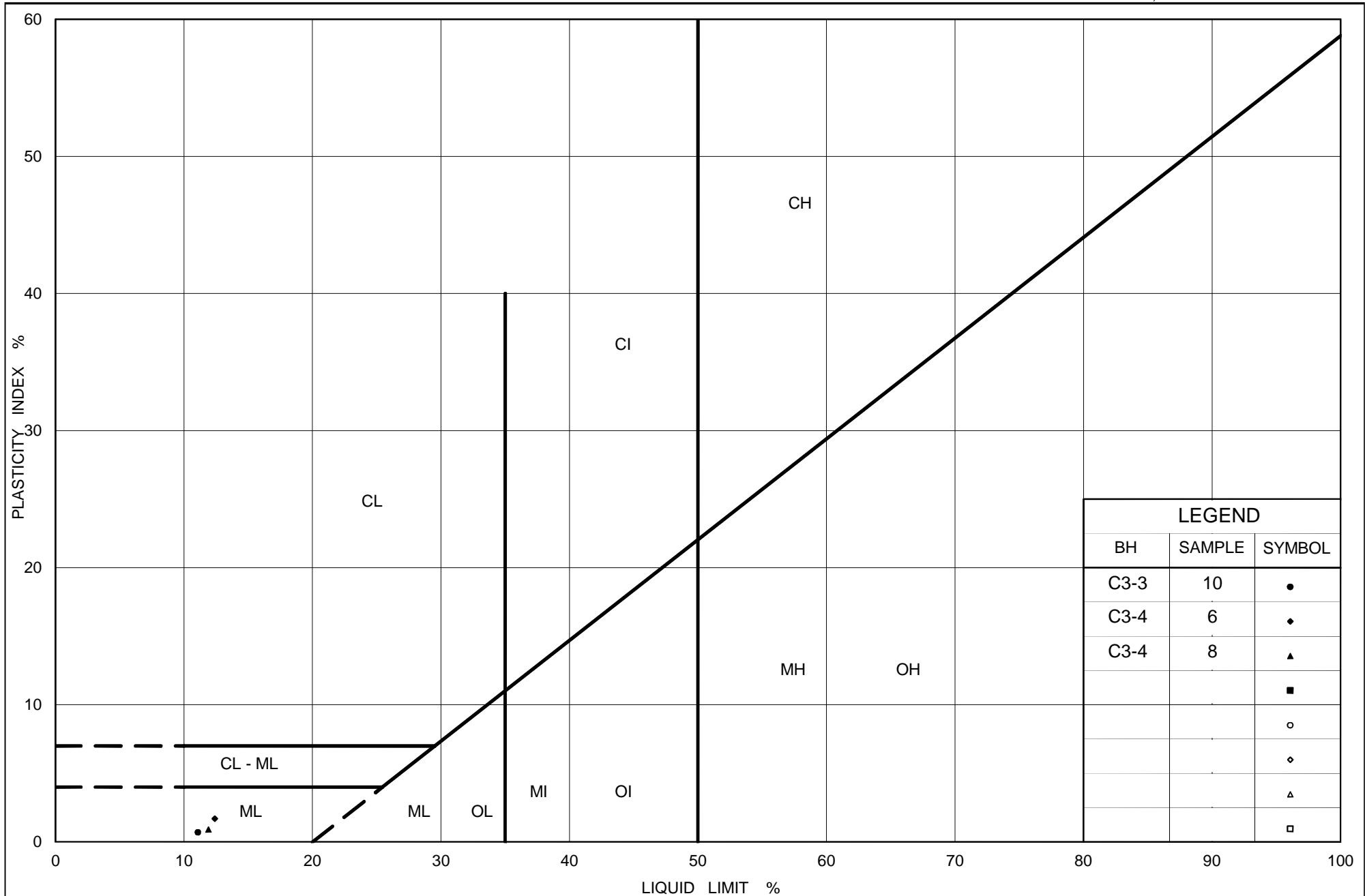
Silt and Sand (Till)

FIGURE B7



SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C3-3	12	80.0
■	C3-2	12	80.2
◆	C3-4	6	80.3
▲	C3-1	8	80.7
▽	C3-4	8	77.2

Date: 18-Oct-16



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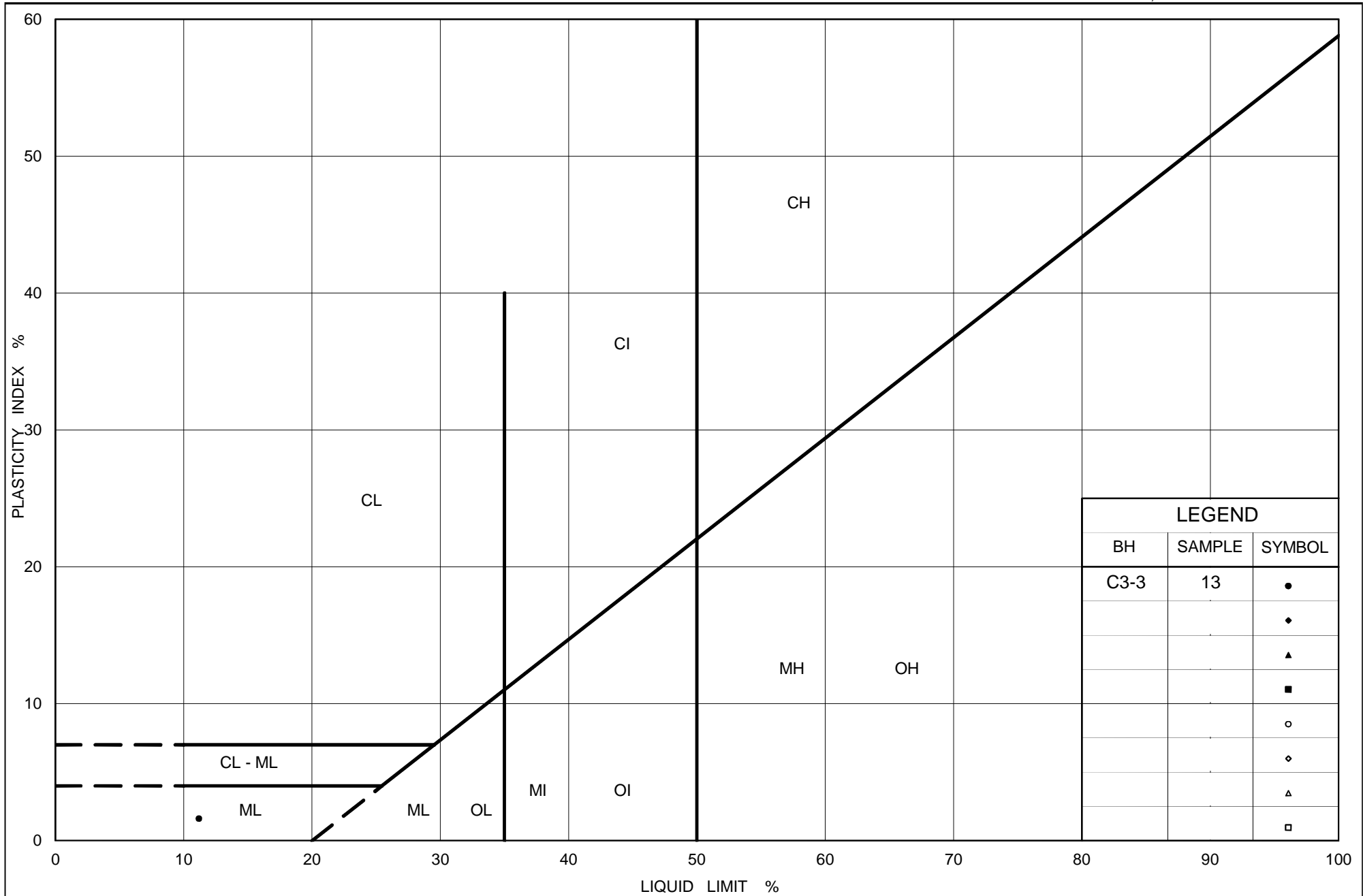
Ontario

PLASTICITY CHART Silt and Sand (Till)

Figure No. B8

Project No. 1540419

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PLASTICITY CHART Silt (Till)

Figure No. B9

Project No. 1540419

Checked By:



APPENDIX C

Analytical Test Results

Your Project #: 1540419
Your C.O.C. #: 573330-01-01

Attention: Matt Kelly

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2016/09/29
Report #: R4184963
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6K5174

Received: 2016/09/23, 12:57

Sample Matrix: Soil
Samples Received: 5

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride (20:1 extract)	5	N/A	2016/09/29	CAM SOP-00463	EPA 325.2 m
Conductivity	5	N/A	2016/09/29	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	5	2016/09/28	2016/09/28	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	5	2016/09/23	2016/09/29	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	5	N/A	2016/09/29	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics has performed all analytical testing herein in accordance with ISO 17025 and the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. All methodologies comply with this document and are validated for use in the laboratory. The methods and techniques employed in this analysis conform to the performance criteria (detection limits, accuracy and precision) as outlined in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act.

Maxxam Analytics is accredited for all specific parameters as required by Ontario Regulation 153/04. Maxxam Analytics is limited in liability to the actual cost of analysis unless otherwise agreed in writing. There is no other warranty expressed or implied. Samples will be retained at Maxxam Analytics for three weeks from receipt of data or as per contract.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

RESULTS OF ANALYSES OF SOIL

Maxxam ID		DCX431	DCX432	DCX433	DCX434	DCX435		
Sampling Date		2016/08/23 10:00	2016/08/27 13:00	2016/08/28 13:00	2016/08/31 11:00	2016/09/08 02:00		
COC Number		573330-01-01	573330-01-01	573330-01-01	573330-01-01	573330-01-01		
	UNITS	C1	C2	C3	C4	C9	RDL	QC Batch
Calculated Parameters								
Resistivity	ohm-cm	1800	1900	1300	1500	880		4673817
Inorganics								
Soluble (20:1) Chloride (Cl)	ug/g	190	280	410	360	570	20	4681464
Conductivity	umho/cm	557	540	798	687	1130	2	4681504
Available (CaCl2) pH	pH	7.57	7.77	7.63	7.61	7.42		4679490
Soluble (20:1) Sulphate (SO4)	ug/g	200	26	<20	<20	<20	20	4681465
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								

TEST SUMMARY

Maxxam ID: DCX431
Sample ID: C1
Matrix: Soil

Collected: 2016/08/23
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4681464	N/A	2016/09/29	Alina Dobreanu
Conductivity	AT	4681504	N/A	2016/09/29	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4679490	2016/09/28	2016/09/28	Neil Dassanayake
Resistivity of Soil		4673817	2016/09/29	2016/09/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4681465	N/A	2016/09/29	Alina Dobreanu

Maxxam ID: DCX432
Sample ID: C2
Matrix: Soil

Collected: 2016/08/27
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4681464	N/A	2016/09/29	Alina Dobreanu
Conductivity	AT	4681504	N/A	2016/09/29	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4679490	2016/09/28	2016/09/28	Neil Dassanayake
Resistivity of Soil		4673817	2016/09/29	2016/09/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4681465	N/A	2016/09/29	Alina Dobreanu

Maxxam ID: DCX433
Sample ID: C3
Matrix: Soil

Collected: 2016/08/28
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4681464	N/A	2016/09/29	Alina Dobreanu
Conductivity	AT	4681504	N/A	2016/09/29	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4679490	2016/09/28	2016/09/28	Neil Dassanayake
Resistivity of Soil		4673817	2016/09/29	2016/09/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4681465	N/A	2016/09/29	Alina Dobreanu

Maxxam ID: DCX434
Sample ID: C4
Matrix: Soil

Collected: 2016/08/31
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4681464	N/A	2016/09/29	Alina Dobreanu
Conductivity	AT	4681504	N/A	2016/09/29	Neil Dassanayake
pH CaCl2 EXTRACT	AT	4679490	2016/09/28	2016/09/28	Neil Dassanayake
Resistivity of Soil		4673817	2016/09/29	2016/09/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4681465	N/A	2016/09/29	Alina Dobreanu

Maxxam ID: DCX435
Sample ID: C9
Matrix: Soil

Collected: 2016/09/08
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4681464	N/A	2016/09/29	Alina Dobreanu
Conductivity	AT	4681504	N/A	2016/09/29	Neil Dassanayake

Maxxam Job #: B6K5174
Report Date: 2016/09/29

Golder Associates Ltd
Client Project #: 1540419
Sampler Initials: MK

TEST SUMMARY

Maxxam ID: DCX435
Sample ID: C9
Matrix: Soil

Collected: 2016/09/08
Shipped:
Received: 2016/09/23

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	4679490	2016/09/28	2016/09/28	Neil Dassanayake
Resistivity of Soil		4673817	2016/09/29	2016/09/29	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4681465	N/A	2016/09/29	Alina Dobreanu

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.7°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4679490	Available (CaCl ₂) pH	2016/09/28			99	97 - 103			0.48	N/A
4681464	Soluble (20:1) Chloride (Cl)	2016/09/29	NC	70 - 130	109	70 - 130	<20	ug/g	NC	35
4681465	Soluble (20:1) Sulphate (SO ₄)	2016/09/29	NC	70 - 130	107	70 - 130	<20	ug/g	NC	35
4681504	Conductivity	2016/09/29			99	90 - 110	<2	umho/cm	2.9	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Services

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



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23-Sep-16 12:57

Ema Gitej
B6K5174

Page of

Only:

Bottle Order #:

579330

Project Manager:

Ema Gitej

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:	Golder Associates Ltd	Quotation #:	B63104
Attention:	Central Acct:1112, 1113, 1118	Attention:	Matt Kelly / Madison Kennedy	P.O. #:	
Address:	6925 Century Ave Suite 100	Address:		Project:	1540419
	Mississauga ON L5N 7K2			Project Name:	
Tel:	(905) 567-4444	Tel:		Site #:	
Fax:	(905) 567-6561	Fax:		Sampled By:	
Email:	Catherine_Guiao@golder.com, Rachel_Benjamin@gol	Email:	Matthew_Kelly@golder.com, MadKennedy@golder.com		

JFU

ENV-107

COC #:



CM573330-01-01

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011)		Other Regulations		Special Instructions
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw	
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw	
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other	<input type="checkbox"/> MISA	Municipality	
<input type="checkbox"/> Table	<input type="checkbox"/> For RSC	<input type="checkbox"/> PWQO		
		<input type="checkbox"/> Other		

Include Criteria on Certificate of Analysis (Y/N)?

Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix
1	C1	2016/08/23	10:00am	Soil
2	C2	2016/08/27	1:00pm	Soil
3	C3	2016/08/28	1:00pm	Soil
4	C4	2016/08/31	11:00am	Soil
5	C9	2016/09/06	2:00am	Soil
6				
7				
8				
9				
10				

Field Filtered (please circle):

Metals / Hg / Cr VI

Corrosivity pkg (CI, SO4, EC, Resistivity, pH)

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:

(will be applied if Rush TAT is not specified)

Standard TAT = 5-7 Working days for most tests

Please note: Standard TAT for certain tests such as BOD and Dioxin/Furans are > 5 days - contact your Project Manager for details

Job Specific Rush TAT (if applies to entire submission)

Date Required:

Time Required:

Rush Confirmation Number:

(call lab for it)

of Bottles

Comments

RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	# Jars used and not submitted	Laboratory Use Only				
Madison Kennedy		26/09/23	12:57	Tanvir By Tanvir RST		2016/09/23	12:57		Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
										7/6/7	Present		c
											Intact		✓

* IT IS THE RESPONSIBILITY OF THE RELINQUISHING PARTY TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

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