



October 2012

## FOUNDATION INVESTIGATION REPORT

### Crown Hill Overpass Replacement Highway 400 NBL Rehabilitation, Highway 400- Highway 11 Interchange, Simcoe County GWP 2179-10-00

**Submitted to:**

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REPORT





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### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the detail design for the proposed replacement of the Crown Hill overpass associated with the overall interchange improvements, in the County of Simcoe, Ontario.

The initial terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) dated May 2008, and in Section 6.8 of MH's *Technical Proposal*. The original terms of reference and scope of work for this portion of the foundation investigation included a contingency item for widening of the existing Highway 400 Northbound Lanes (NBL) ramp structure. Subsequent to the RFP, MTO endorsed the replacement of the existing Highway 400 NBL overpass structure at the Crown Hill interchange on a new alignment. Amended Terms of Reference for the foundation engineering services were provided by MTO on February 22, 2012, and the scope of the revised foundation engineering services was outlined in Golder's letter dated March 2, 2012.

### 2.0 SITE DESCRIPTION

The existing overpass structure carrying Highway 400 NBL over Highway 11 is located about 3 km north of the Duckworth Street interchange in Barrie, Ontario. The proposed replacement overpass is located approximately 35 m (centerline to centerline) southwest of the existing overpass structure.

In general, the overall surface topography in the area is gently sloping, and the natural ground surface varies from approximately Elevation 230 m near the southern end of the site, to Elevation 242 m near the northern end of the structure site.

The Highway 400 NBL embankments at this site vary in height from approximately 5 m to 9 m relative to the natural ground surface. The pavement surface of the existing Highway 400 NBL is at approximately Elevation 242 m at the south end of the existing structure, and approximately Elevation 248 m beyond the north end of the existing structure. The existing embankment side slopes are generally oriented at about 2 horizontal to 1 vertical (2H:1V), with the slope faces generally well vegetated.

### 3.0 SUBSURFACE INVESTIGATION

#### 3.1 Previous Investigation

In March 2011 Golder completed a foundation investigation and design report entitled "Widening of Deep Cuts and High Fill Embankments, Highway 400 NBL Rehabilitation between Highway 11 and Highway 93, Simcoe County, G.W.P. 2039-06-00", March 2011. Several boreholes were advanced near the proposed alignment of the new overpass structure. Boreholes 09-F-6 and 09-F-10 have been included in Appendix A and are used in this report to supplement the information collected during the current investigation. The locations of these boreholes are shown on the Borehole Location and Soil Strata drawing contained in the Contract Documents.



### 3.2 Current Investigation

The field work for the subsurface investigation for the proposed Crown Hill overpass structure was carried out between March 28 and April 18, 2012, during which time nine boreholes were advanced using both track-mounted and truck-mounted drill rigs, supplied and operated by Canadian Soil Drilling of Midhurst, Ontario. Two boreholes were advanced at each of the north and south abutments (Boreholes 12-01, 12-02, 12-08, and 12-09, respectively), and one borehole was advanced near each of the north and south piers (Boreholes 12-04 and 12-06, respectively). A total of three boreholes were advanced between the abutments and piers to provide information for use by the Contractor for design of temporary falsework support (Boreholes 12-03, 12-05, and 12-07). Due to site access constraints associated with sloping ground conditions adjacent to the existing structure and its approach embankments, several of the boreholes had to be relocated outside of the footprints of the proposed foundation units to permit suitable and safe drilling access. The locations of Boreholes 12-01 to 12-09 are shown on the Borehole Location and Soil Strata drawing contained in the Contract Documents.

The boreholes were advanced to depths ranging from 6.6 m to 34.0 m below existing ground surface using hollow stem auger and mud rotary drilling methods. Soil samples were generally obtained in the boreholes at 0.75 m and 1.5 m intervals of depth (excluding one sample interval of 3.0 m in Borehole No. 12-09 at a depth of 30 m) using 50 mm outer diameter split-spoon samplers driven by a manual hammer, in accordance with the Standard Penetration Test (SPT) procedure.

Each of the foundation boreholes, excluding Borehole 12-09, was terminated after 'effective refusal', defined in the MTO Terms of Reference as 3 m of penetration into materials that have Standard Penetration Test (SPT) 'N'-values greater than 100 blows per 0.3 m of penetration. Borehole 12-09 was terminated at a depth of 34 m due to penetration into a wet, very dense sand and gravel layer that would not permit the drilling rods to be recovered if additional mud-rotary drilling was completed through this layer. The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations, and standpipe piezometers were installed in two boreholes (Boreholes 12-02 and 12-08). The piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within the borehole. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled to the ground surface with bentonite pellets. The piezometer installation details and water level readings are indicated on the borehole records contained in Appendix A. Although the groundwater conditions in Borehole 12-08 were not artesian during drilling, the water level was observed in late May 2012 to be above the ground surface at this borehole location (with a very slight trickle of clean water from the piezometer); Golder is arranging to have this borehole decommissioned in accordance with Ontario Regulation 903 (as amended), and details of this decommissioning will be provided in the final Foundation Investigation Report. All remaining boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended).

The field work was supervised on a full-time basis by a member of Golder's staff who observed the drilling, sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Barrie for further examination. Laboratory testing was completed in Golder's London office. Index and classification tests consisting of water content determinations, Atterberg limits and grain size distribution analyses were carried out on selected soil samples.



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The borehole locations were measured in the field relative to site features and survey staking, and the ground surface elevations were obtained from existing topographical drawings. The borehole locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to geodetic datum, are summarized below and are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

Borehole No.	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
12-01	4,921,041.5	292,822.3	246.8	18.8
12-02	4,921,022.8	292,796.3	237.3	14.0
12-03	4,921,008.7	292,814.8	235.1	6.6
12-04	4,920,996.4	292,832.8	237.2	15.7
12-05	4,920,973.3	292,840.8	237.0	6.6
12-06	4,920,947.6	292,845.8	236.3	24.8
12-07	4,920,922.0	292,859.9	234.0	8.1
12-08	4,920,906.8	292,853.8	233.5	26.4
12-09	4,920,896.1	292,893.8	241.8	34.0
09-F-6	4,920,849.8	292,830.3	232.0	12.7 + DCPT
09-F-10	4,921,092.7	292,763.1	248.0	21.7

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

This section of Highway 400 is located within the physiographic region known as the Simcoe Uplands, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984).

The general topography within the Simcoe Uplands consists of sloping till or moraine plains (Ontario Geological Society, 1991). The surficial soils in this region consist of sandy silt to sand and gravel, representing shoreline deposits of a former glacial lake that once flooded the area, overlying a glacial till deposit. Surficial deposits of clayey silt to silty clay are also present adjacent to current and former streams.

### 4.2 Overview of Subsurface Conditions

A summary of the subsurface conditions at the Crown Hill overpass site is provided below. Appendix A provides borehole records that show the detailed subsurface soil and groundwater conditions encountered in each borehole and the results of in situ and laboratory testing. Appendix B provides a summary of the geotechnical laboratory test reports.

The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic sections and profiles on the Borehole Location and Soil Strata drawings contained in the Contract Documents 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.



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In summary, the subsoils encountered in the boreholes consist of surficial topsoil and fill, which are in turn underlain by native deposits that are predominantly cohesionless (granular) in nature. These granular deposits are interlayered with variable tills and soft to hard (but predominantly firm to stiff) clayey silt to silty clay deposits,. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### 4.2.1 Topsoil

Approximately 100 mm to 200 mm of topsoil was encountered immediately below the existing ground surface in Boreholes 12-02, 12-03, 12-07, 12-08, and 09-F-6.

### 4.2.2 Fill

Each of the boreholes, excluding Boreholes 12-02, 12-03 and 09-F-6, encountered granular embankment fill. As the boreholes were advanced both at the Highway 400 NBL embankment level and at the Highway 11 level, the elevations of the surface of the fill materials are highly variable. The granular fill was encountered for a maximum thickness of 7.6 m (Elevation 240.4 m) in Borehole 09-F-10, which was advanced through the Highway 400 NBL embankment.

Borehole No.	Fill Surface Depth (m)	Fill Surface Elevation (m)	Fill Thickness (m)	Base of Fill Elevation (m)
12-01	0.0	246.8	5.7	241.1
12-02	Not encountered			
12-03	Not encountered			
12-04	0.0	237.2	2.9	234.3
12-05	0.0	237.0	1.4	235.6
12-06	0.0	236.3	2.1	234.2
12-07	0.2	233.8	1.2	232.6
12-08	0.2	233.3	1.9	231.4
12-09	0.0	241.8	5.6	236.2
09-F-6	Not encountered			
09-F-10	0.0	248.0	7.6	240.4

The fill materials vary in composition from sand containing trace silt and trace to some gravel, to silty sand containing trace to some clay and gravel. The results of grain size distribution tests completed on five selected samples of the fill are shown on Figure B1 in Appendix B.

The measured Standard Penetration Test (SPT) "N" values within the fill range from 7 to 44 blows per 0.3 m of penetration, indicative of a loose to dense relative density.





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### 4.2.3 Sand to Silt

An extensive cohesionless deposit of sand to sand and silt, although predominantly sand to silty sand, was encountered in all of the boreholes. The deposit was encountered below the fill materials in Boreholes 12-01, 12-04, 12-05, 12-06, 12-07, 12-08, 12-09, and 09-F-10; and below the topsoil in Boreholes 12-02, 12-03, and 09-F-6. The granular deposits are generally extensive and are interlayered with the till and clayey silt to silty clay deposits, as described in the following sections. Each of the boreholes, excluding Boreholes 12-07 and 12-09, were terminated in the cohesionless deposit. The elevations of the surface and base of this deposit and the deposit thickness as encountered in the boreholes are summarized below.

A deposit of silt was encountered within the extensive sand to sand and silt deposit in Boreholes 12-06, 12-07, and 09-F-6. The silt deposit was encountered immediately below sand to silty sand in Boreholes 12-06 and 12-07, and below a clayey silt layer in Borehole 09-F-6. The silt was penetrated in each of the boreholes and has a maximum thickness of 5.9 m in Borehole 12-06. The elevations of the surface and base of this deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Sand to Silty Sand Surface Depth (m)	Sand to Silty Sand Surface Elevation (m)	Sand to Silty Sand Thickness (m)	Sand to Silt Base Elevation (m)
12-01	5.7	241.1	3.1	238.0
	10.3	236.5	> 8.4	Below 228.1
12-02	0.1	237.2	2.0	235.2
	4.0	233.3	> 10.0	Below 223.3
12-03	0.1	235.0	> 6.4	Below 228.6
12-04	2.9	234.3	> 12.8	Below 221.5
12-05	1.4	235.6	> 5.1	Below 230.5
12-06	2.1	234.2	12.6	221.6
	17.8	218.5	> 7.0	Below 211.5
12-07	1.4	232.6	5.7	226.9
12-08	2.1	231.4	0.8	230.6
	5.6	227.9	2.3	225.6
	8.6	224.9	4.6	220.3
	17.8	215.7	3.0	212.7
	22.3	211.2	> 4.1	Below 207.1
12-09	5.6	236.2	7.6	228.6
	14.7	227.1	9.1	218.0
09-F-6	0.1	231.9	0.6	231.3
	2.9	229.1	5.8	223.3
	10.1	221.9	> 2.6	Below 219.3
09-F-10	7.6	240.4	3.2	237.2
	16.8	231.2	> 4.9	Below 226.3



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The deposit typically is comprised of sand containing trace to some silt, trace to some gravel, and trace to some clay, to silty sand containing variable amounts gravel and clay, to sand and silt, to silt containing some sand and trace to some clay. Lenses of clayey silt were encountered in the sand deposit in several of the boreholes. In addition, organics (such as topsoil, rootlets or wood fragments) were noted in several of the boreholes on the northern half of the site. Auger grinding, indicative of boulders and cobbles, was noted within the deposit at various depths; additional details in regard to the above noted items are shown on the borehole in Appendix A.

The results of grain size distribution tests carried out on eighteen selected samples of the sand to silt deposit are shown on Figures B2 to B4 in Appendix B. Laboratory testing of two samples containing visible organic matter from Borehole 12-03 indicated that the tested samples had organic contents of approximately 1 per cent and 3 per cent expressed as a percentage of the dry weight of the soil.

The measured SPT "N" values in the sand to silt deposit range from 1 blow per 0.3 m of penetration to 172 blows per 0.23 m of penetration, although the values of less than about 5 blows per 0.3 m of penetration are considered to have been affected by sample disturbance due to groundwater inflow to the borehole. These results indicate this deposit has a loose to very dense relative density, but that it is typically compact to very dense. The SPT "N" values generally increase with depth.

### 4.2.4 Gravelly Sand to Sand and Gravel

A deposit of gravelly sand to sand and gravel was encountered in Boreholes 12-02, 12-08, 12-09, 09-F-6, and 09-F-10. Borehole 12-09 was terminated in the deposit at a depth of 34.0 m (Elevation 207.8 m). The elevations of the surface and base of this deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Gravelly Sand to Sand and Gravel Surface Depth (m)	Gravelly Sand to Sand and Gravel Surface Elevation (m)	Gravelly Sand to Sand and Gravel Thickness (m)	Gravelly Sand to Sand and Gravel Base Elevation (m)
12-02	2.1	235.2	0.8	234.4
12-08	20.8	212.7	1.5	211.2
12-09	26.9	214.9	3.0	211.9
	32.2	209.6	> 1.8	Below 207.8
09-F-6	8.7	223.3	1.4	221.9
09-F-10	10.9	237.2	2.8	234.3

The gravelly sand to sand and gravel deposit contains trace to some silt and clay. The results of a grain size distribution test carried out on one selected sample of the deposit are shown on Figure B5 in Appendix B.





The measured SPT “N” values within the gravelly sand to sand and gravel range from weight of hammer to 125 blows per 0.15 m of penetration, indicative of a very loose to very dense relative density. However, the lower SPT “N” values are considered to be affected by sample disturbance due to groundwater inflow into the borehole, and the deposit is therefore considered to have a compact to very dense relative density.

### 4.2.5 Clayey Silt Till to Silty Sand Till

A till deposit was encountered in Boreholes 12-01, 12-02, and 12-09. The till was encountered underlying the sand deposit in Boreholes 12-01 and 12-02, and below the gravelly sand in Borehole 12-09. The till deposits are relatively thin, with a maximum thickness of 2.2 m.

The till deposit is variable in composition and ranges from clayey silt with sand and trace to some gravel, to silty sand containing some gravel, and trace to some clay. The results of grain size distribution tests carried out on two selected samples of the till are shown on Figure B6 in Appendix B.

Atterberg limits testing carried out on two selected samples of the till deposit measured plastic limits of 9 per cent and 11 per cent, liquid limits of 15 per cent and 19 per cent and plasticity indices of 6 per cent and 8 per cent. These results, which are plotted on the plasticity chart on Figure B7 in Appendix B, confirm that the cohesive till deposit consists of clayey silt of low plasticity.

One SPT “N” value of 42 blows per 0.3 m of penetration was measured within the silty sand till, indicative of a dense relative density. The measured SPT “N” values within the clayey silt till deposit range from 14 blows to 22 blows per 0.3 m of penetration, suggestive of a stiff to very stiff consistency.

### 4.2.6 Clayey Silt to Silty Clay

A clayey silt to silty clay deposit was encountered in Boreholes 12-06, 12-08, 12-09, and 09-F-6 underlying the silty sand to sand deposit; in Borehole 12-07 underlying the silt deposit; and in Borehole 09-F-10 underlying the sand and gravel deposit. Borehole 12-07 was terminated in the clayey silt to silty clay deposit at a depth of 8.1 m (Elevation 225.9 m). The elevations of the surface and base of the clayey silt to silty clay deposits and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Clayey Silt to Silty Clay Surface Depth (m)	Clayey Silt to Silty Clay Surface Elevation (m)	Clayey Silt to Silty Clay Thickness (m)	Clayey Silt to Silty Clay Base Elevation (m)
12-06	14.7	221.6	3.0	218.6
12-07	7.1	226.9	> 1.0	Below 225.9
12-08	2.9	230.6	2.7	227.9
	7.9	225.6	0.7	224.9
	13.2	220.3	4.5	215.8
12-09	13.2	228.6	1.5	227.1
	23.9	217.9	3.0	214.9
09-F-6	0.7	231.3	2.2	229.1



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Borehole No.	Clayey Silt to Silty Clay Surface Depth (m)	Clayey Silt to Silty Clay Surface Elevation (m)	Clayey Silt to Silty Clay Thickness (m)	Clayey Silt to Silty Clay Base Elevation (m)
09-F-10	13.7	234.3	3.1	231.2

The deposit is comprised of clayey silt to silty clay containing some sand and gravel in Borehole 12-06, and typically containing sand seams or layers. Cobbles were noted within the deposit in Borehole 09-F-10. The results of grain size distribution tests completed on eight selected samples of the clayey silt to silty clay deposits are shown on Figures B8 and B9 in Appendix B.

Atterberg limits testing was carried out on four selected samples of the deposit and measured plastic limits between 12 per cent and 20 per cent, liquid limits between 22 per cent and 45 per cent, and plasticity indices between 9 per cent and 25 per cent. These results, which are plotted on the plasticity chart on Figure B10, confirm that the deposit consists of clayey silt of low plasticity to silty clay of intermediate plasticity.

The natural water contents measured on samples of the clayey silt to silty clay were between 13 per cent and 42 per cent.

The measured SPT "N" values within the clayey silt to silty clay deposits were variable and ranged from 2 blows to 48 blows per 0.3 m of penetration, suggestive of a soft to hard consistency. In situ vane shear strength testing was carried out in Borehole 09-F-6 and measured an undrained shear strength of approximately 80 kPa.

### 4.3 Groundwater Conditions

The observed water levels in the each of the open boreholes following completion of drilling are indicated on the borehole records in Appendix A. The water levels measured in the open boreholes and in the two standpipe piezometers are summarized below.

Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement	Notes
North Approach Embankment	09-F-10	248.0	237.9	August 10, 2010	Open Borehole
North Abutment	12-01	246.8	236.1	March 28, 2012	Open Borehole
	12-02	237.3	232.7 236.7	April 17, 2012 May 28, 2012	Open Borehole Piezometer
Piers	12-04	237.2	231.1	April 11, 2012	Open Borehole
	12-06	236.3	231.7	April 12, 2012	Open Borehole
South Abutment	12-08	233.5	228.9 > 234.5	April 18, 2012 May 28, 2012	Open Borehole Piezometer
	12-09	241.8	231.8	March 29, 2012	Open Borehole



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Foundation Element	Borehole No.	Ground Surface Elevation (m)	Groundwater Elevation (m)	Date of Measurement	Notes
South Approach Embankment	09-F-6	232.0	230.2	August 5, 2012	Open Borehole



It is noted that artesian groundwater levels were observed in Borehole 12-08 in the vicinity of the proposed south abutment, associated with the deeper portion of the cohesionless soil deposit (below some confining layers of clayey silt to silty clay). The artesian conditions were not observed during drilling, but were measured on a subsequent site visit once the water level had had time to equilibrate. Based on observations during drilling, sample moisture conditions, the colour change from brown to grey, and the water levels measured in the piezometers, it is anticipated that the "shallow" groundwater level associated with the near-surface cohesionless soil deposits will vary from about Elevation 232 m near the south abutment and south pier, to about Elevation 236.5 m near the north abutment.



The water levels at the abutment and pier sites are expected to fluctuate seasonally in response to changes in precipitation and snow melt, and are expected to be higher during the spring season.

### 5.0 CLOSURE

This Foundation Investigation Report was prepared by Nick La Posta, P.Eng., and reviewed by Lisa Coyne, P.Eng., a senior geotechnical engineer and Principal with Golder. Fin Heffernan, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent quality control review of this report.

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# **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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	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<sup>2</sup> 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	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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	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

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

#### (a) Index Properties (continued)

w	water content
$w_l$ or LL	liquid limit
$w_p$ or PL	plastic limit
$I_p$ or PI	plasticity index = $(w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index = $(w - w_p) / I_p$
$I_C$	consistency index = $(w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_\alpha$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$C_u, S_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

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

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$

PROJECT 09-1111-0022		<b>RECORD OF BOREHOLE No 09-F-6</b>		SHEET 1 OF 2		<b>METRIC</b>	
G.W.P. 2179-10-00		LOCATION N 4920849.8 ; E 292830.3		ORIGINATED BY AB			
DIST Central HWY 400		BOREHOLE TYPE CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger		COMPILED BY MS/NK			
DATUM Geodetic		DATE August 5, 2010		CHECKED BY LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
232.0	GROUND SURFACE													
0.0	TOPSOIL		1	SS	7									
231.3	SAND, some silt Loose Brown Moist		2	SS	2									
0.7	CLAYEY SILT, trace to some sand, containing silty sand seams and layers Firm to stiff Brown Moist to wet		3	SS	9			3.2						
			4	SS	5									
229.1	SILT, some sand Very loose Grey Wet		5	SS	2									
228.0	Sandy SILT, trace to some clay, containing silt seams Compact Brown Wet		6	SS	11					H				
226.4	SAND, trace silt, clay and gravel, containing clayey silt layers Very loose to loose Brown Wet		7	SS	9									
5.6			8	SS	2*									
223.3	SAND and GRAVEL, trace silt, containing clayey silt layers Compact Grey Wet		9	SS	13*									
221.9	SAND, some silt, trace clay, containing clayey silt layers Compact Brown Wet		10	SS	16									
219.3	END OF BOREHOLE		11	SS	3*									
12.7	Dynamic Cone Penetration Test													




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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC


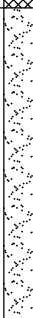


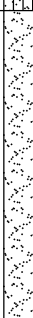
PROJECT		09-1111-0022		RECORD OF BOREHOLE No 09-F-6		SHEET 2 OF 2		METRIC									
G.W.P.		2179-10-00		LOCATION		N 4920849.8 ; E 292830.3		ORIGINATED BY									
DIST		Central HWY 400		BOREHOLE TYPE		CME 55 Track-Mount, 108 mm Diameter Hollow Stem Auger		COMPILED BY									
DATUM		Geodetic		DATE		August 5, 2010		CHECKED BY									
LCC																	
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100						
	END OF BOREHOLE																
	Dynamic Cone Penetration Test																
214.6							216										
17.4							215										
	END OF DCPT																
	Notes:																
	*SPT "N" value considered to be affected by sample disturbance due to groundwater inflow to borehole.																
	1. Water level in open borehole at a depth of 1.8 m (Elevation 230.2 m) on completion of drilling.																

PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 09-F-10</b>		SHEET 1 OF 2		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4921092.7 ; E 292763.1</u>		ORIGINATED BY <u>AB</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers</u>		COMPILED BY <u>NK</u>			
DATUM <u>Geodetic</u>		DATE <u>August 10, 2010</u>		CHECKED BY <u>LCC</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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	w <sub>p</sub>	w	w <sub>L</sub>						
248.0	GROUND SURFACE																				
0.0	Sand and gravel, trace to some silt (FILL)		1	SS	42																
247.4	Dense Brown																				
0.6	Moist																				
	Sand, some silt, some gravel (FILL)																				
	Dense to compact Brown																				
	Moist																				
			2	SS	42																
			3	SS	29																
			4	SS	15																
241.9																					
6.1	Sand and gravel, some silt (FILL)		5	SS	15																
	Compact Brown Moist																				
240.4																					
7.6	SAND, some silt, trace to some gravel, containing clayey silt lenses		6	SS	53																
	Very dense to compact Brown Moist to wet																				
					</																

PROJECT		RECORD OF BOREHOLE		No 09-F-10		SHEET 2 OF 2		METRIC								
G.W.P. 09-1111-0022		LOCATION		N 4921092.7 ; E 292763.1		ORIGINATED BY		AB								
DIST Central HWY 400		BOREHOLE TYPE		CME 75 Truck-Mounted, 200 mm Diameter Hollow Stem Augers		COMPILED BY		NK								
DATUM Geodetic		DATE		August 10, 2010		CHECKED BY		LCC								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100				
231.2	SILTY CLAY, trace sand and gravel, containing cobbles Hard Grey Moist		13	SS	48											
16.8	SAND, trace to some silt, trace gravel, trace clay Compact to very dense Brown Wet		14	SS	19											0 78 20 2
			15	SS	141											
			16	SS	59*											
226.3			17	SS	172/0.23											3 89 6 2
21.7	END OF BOREHOLE  Notes:  *SPT "N" values considered to be affected by sample disturbance due to groundwater inflow to borehole.  1. Water level in open borehole at a depth of 10.1 m (Elevation 237.9 m) on completion of drilling.															

PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 12-01</b>		SHEET 1 OF 2		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4921041.5 ; E 292822.3</u>		ORIGINATED BY <u>DD</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Truck Mount Power Auger</u>		COMPILED BY <u>NLP</u>			
DATUM <u>Geodetic</u>		DATE <u>March 28, 2012</u>		CHECKED BY <u>LCC</u>			

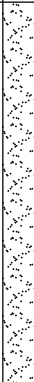
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w <sub>p</sub>	w	w <sub>L</sub>		WATER CONTENT (%)	GR	SA	SI	CL
								20	40	60	80	100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
246.8	GROUND SURFACE																				
0.0	Sand, trace to some silt, trace clay, trace gravel (FILL) Loose to dense Brown Moist		1	SS	43																
			2	SS	28																
			3	SS	15																
			4	SS	21																
			5	SS	28																
			6	SS	7																
			7	SS	31																
241.1																					
5.7	SAND, trace to some gravel, some silt, containing interlayers of silty sand at a depth of 7.6 m Dense to very dense Brown Moist		8A	SS	36																
			8B	SS	32																
			9	SS	59																
238.0																					
8.8	Silty SAND, some gravel, trace to some clay (TILL) Dense Brown Moist		10	SS	42																
236.5																					
10.3	Silty SAND, some gravel, containing organics and wood fragments Very dense Grey Moist to wet Auger grinding noted from 10.7 m to 12.2 m		11	SS	60/0.15																
235.0																					
11.8	SAND, trace to some silt, some gravel, trace clay, containing seams or lenses of clayey silt in Sample 13 Compact to dense Grey Wet  Auger grinding noted from 12.2 m to 15.2 m		12	SS	20																
			13	SS	46																
231.9																					
					</																

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC



PROJECT		09-1111-0022		RECORD OF BOREHOLE No 12-01		SHEET 2 OF 2		METRIC										
G.W.P.		2179-10-00		LOCATION		N 4921041.5 ; E 292822.3		ORIGINATED BY										
DIST		Central HWY 400		BOREHOLE TYPE		Truck Mount Power Auger		COMPILED BY										
DATUM		Geodetic		DATE		March 28, 2012		CHECKED BY										
								LCC										
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	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					W <sub>p</sub> W W <sub>L</sub> WATER CONTENT (%) 10 20 30			γ kN/m <sup>3</sup>	GR SA SI CL	
--- CONTINUED FROM PREVIOUS PAGE ---																		
14.9	SAND, trace to some silt, trace clay Very dense Brown Wet		14	SS	137		231											
								230										
				15	SS	153		229										
228.0 18.8	END OF BOREHOLE  NOTE:  1. Water level in open borehole at a depth of 10.7 m (Elev. 236.1 m) upon completion of drilling.		16	SS	186		228											

PROJECT 09-1111-0022

G.W.P.	2179-10-00	LOCATION	N 4921022.8 ; E 292796.3	ORIGINATED BY	DD
DIST	Central	HWY	400	BOREHOLE TYPE	Track Mount Power Auger
DATUM	Geodetic	DATE	April 17, 2012	COMPILED BY	NLP
				CHECKED BY	LCC

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

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC

PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 12-02</b>		SHEET 2 OF 2		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4921022.8 ; E 292796.3</u>		ORIGINATED BY <u>DD</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Track Mount Power Auger</u>		COMPILED BY <u>NLP</u>			
DATUM <u>Geodetic</u>		DATE <u>April 17, 2012</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	10	20	30						
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	END OF BOREHOLE																				
	NOTES:  1. Water level in open borehole at a depth of 4.6 m (Elev. 232.7 m) upon completion of drilling  2. Water level in piezometer at a depth of 0.6 m (Elev. 236.7 m) on May 28, 2012																				

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC

PROJECT 09-1111-0022			RECORD OF BOREHOLE No 12-03			SHEET 1 OF 1			METRIC								
G.W.P. 2179-10-00			LOCATION N 4921008.7 ; E 292814.8			ORIGINATED BY DD											
DIST Central HWY 400			BOREHOLE TYPE Track Mount Power Auger			COMPILED BY NLP											
DATUM Geodetic			DATE April 17, 2012			CHECKED BY LCC											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
235.1	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL		1	SS	7		235										
	SAND, trace to some gravel, trace to some silt, trace clay, containing organics below 1.5 m Loose to compact Brown to grey Moist		2	SS	14		234										
			3	SS	10		233										
233.0			4	SS	7		232										
2.1	Silty SAND TO SAND, trace to some silt, trace gravel, containing trace organics at 4.6 m Loose to very dense Grey to brown Moist		5	SS	21		231										
			6	SS	11		230										
			7	SS	123		229										
228.5	END OF BOREHOLE																
6.6	NOTE:  1. Water level in open borehole at a depth of 4.6 m (Elev. 230.5 m) upon completion of drilling																




GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 12-04</b>		SHEET 2 OF 2		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4920996.4 ; E 292832.8</u>		ORIGINATED BY <u>DD</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Track Mount Power Auger</u>		COMPILED BY <u>NLP</u>			
DATUM <u>Geodetic</u>		DATE <u>April 11, 2012</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED									
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
221.5			13	SS	134		222										
15.7	END OF BOREHOLE  NOTE:  1. Water level in open borehole at a depth of 6.1 m (Elev. 231.1 m) upon completion of drilling																



PROJECT		RECORD OF BOREHOLE		No 12-05		SHEET 1 OF 1		METRIC							
G.W.P.		LOCATION		ORIGINATED BY		DIST		BOREHOLE TYPE		COMPILED BY		DATE		CHECKED BY	
09-1111-0022		N 4920973.3 ; E 292840.8		DD		Central		Track Mount Power Auger		NLP		April 11, 2012		LCC	
Geodetic															

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
							20	40	60	80	100						
237.0	GROUND SURFACE																
0.0	Sand, trace gravel, trace silt (FILL) Compact Brown Moist		1	SS	16												
			2	SS	22												
235.6																	
1.4	Silty SAND, trace to some gravel, trace to some clay, containing clayey silt seams Dense Brown Moist		3	SS	41												
			4	SS	36												
234.1																	
2.9	Sandy SILT to silty SAND, trace to some gravel, trace clay, containing organics (wood fragments) in Sample 6 at 4.6 m Compact Brown to dark grey Moist to wet		5	SS	22												
			6	SS	17												
230.4			7	SS	17												
6.6	END OF BOREHOLE																
	NOTE:  1. Water level in open borehole at a depth of 6.1 m (Elev. 230.9 m) upon completion of drilling																

<b>PROJECT</b> 09-1111-0022		<b>RECORD OF BOREHOLE No 12-06</b>		SHEET 1 OF 2		<b>METRIC</b>	
<b>G.W.P.</b> 2179-10-00		<b>LOCATION</b> N 4920947.6 ; E 292845.8		<b>ORIGINATED BY</b> DD			
<b>DIST</b> Central HWY 400		<b>BOREHOLE TYPE</b> Track Mount Power Auger		<b>COMPILED BY</b> NLP			
<b>DATUM</b> Geodetic		<b>DATE</b> April 12, 2012		<b>CHECKED BY</b> LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL	
								20	40	60	80	100	W <sub>p</sub>		W					W <sub>L</sub>
236.3	GROUND SURFACE																			
0.0	Sand, some gravel, trace silt and clay (FILL) Dense Brown Moist		1	SS	35															
235.6			2	SS	31															
0.7	Silty sand, trace to some gravel, trace to some silt (FILL) Dense Brown Moist		3	SS	33															
234.2																				
2.1	Silty SAND, trace gravel, trace clay Compact to very dense Brown Moist		4	SS	50/0.08															
			5	SS	18															
232.1																				
4.2	SILT, some sand, trace gravel, trace to some clay, containing clayey silt to silty clay lenses or seams Loose to compact Brown to grey Moist to wet		6	SS	12															
			7	SS	8															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

PROJECT 09-1111-0022		<b>RECORD OF BOREHOLE No 12-07</b>		SHEET 1 OF 1		<b>METRIC</b>	
G.W.P. 2179-10-00		LOCATION N 4920922.0 ; E 292859.9		ORIGINATED BY DD			
DIST Central HWY 400		BOREHOLE TYPE Track Mounted Power Auger		COMPILED BY NLP			
DATUM Geodetic		DATE April 18, 2012		CHECKED BY LCC			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
													20	40	60		80	100	W <sub>p</sub>	W
234.0	GROUND SURFACE																			
0.0	TOPSOIL																			
0.2	Sand, some silt, trace gravel, trace clay (FILL) Compact to dense Brown Moist		1	SS	25	$\nabla$	233													
			2	SS	31		232													
232.6																				
1.4	Silty SAND, trace clay, trace gravel Loose to compact Brown Moist		3	SS	15															
			4	SS	5															
231.1							231													
2.9	SILT, trace sand to SAND and SILT, trace clay, trace gravel, containing clayey silt to silty clay lenses or seams Loose Grey Moist to wet		5	SS	8															
							230													
			6	SS	6	229														
						228														
			7	SS	1*															
226.9						227														
7.1	CLAYEY SILT, trace sand, containing silty sand seams Very stiff Grey Moist		8	SS	19	226														
225.9																				
8.1	END OF BOREHOLE																			
	NOTE:  1. Water level in open borehole at a depth of 4.6 m, (Elev. 229.4 m) upon completion of drilling  * SPT "N" values considered to have been affected by sample disturbance due to groundwater inflow to borehole																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE



## METRIC

CHECKED BY           LCC          

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE


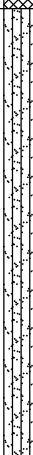
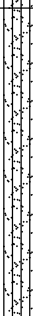

GT-A-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC

PROJECT		09-1111-0022		RECORD OF BOREHOLE No 12-08		SHEET 2 OF 2		METRIC				
G.W.P.		2179-10-00		LOCATION		N 4920906.8 ; E 292853.8		ORIGINATED BY				
DIST		Central HWY 400		BOREHOLE TYPE		Track Mount Power Auger		COMPILED BY				
DATUM		Geodetic		DATE		April 18, 2012		CHECKED BY				
								LCC				
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL
--- CONTINUED FROM PREVIOUS PAGE ---												
215.7	CLAYEY SILT to SILTY CLAY, trace to some sand, trace gravel Firm to stiff Grey Moist to wet		13	SS	8		218				45	0 9 22 69
			14	SS	6		217					
17.8	Silty SAND, trace gravel, trace clay Dense to very dense Brown to grey Moist to wet		15	SS	38		215					
			16	SS	139		214					
212.7	Gravelly SAND, trace silt, trace clay Very dense Grey Wet		17	SS	125/0.15		212					1 64 28 7
20.8							213					
211.2	SAND, trace silt to silty SAND, trace clay Very dense Grey Wet		18	SS	155		211					
22.3							210					
							209					
							208					
207.1			19	SS	157							
26.4	END OF BOREHOLE											
NOTES: 1. Water level in open borehole at a depth of 4.6 m, (Elev. 228.9 m) upon completion of drilling 2. Water level in piezometer measured at 1.0 m above ground surface (Elev. 234.5 m) on May 28, 2012 * SPT "N" values considered to have been affected by sample disturbance due to groundwater inflow to borehole												

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC



PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 12-09</b>		SHEET 1 OF 3		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4920896.1 ; E 292893.8</u>		ORIGINATED BY <u>DD</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Track Mount Power Auger</u>		COMPILED BY <u>NLP</u>			
DATUM <u>Geodetic</u>		DATE <u>March 29, 2012</u>		CHECKED BY <u>LCC</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
241.8	GROUND SURFACE																
0.0	Sand, some gravel, trace silt (FILL)		1	SS	13												
241.1	Compact Brown Moist		2	SS	18												
0.7	Silty sand to sand, trace gravel, trace to some silt, trace clay (FILL)		3	SS	24												
	Compact to dense Brown Moist		4	SS	40												
			5	SS	36												
			6	SS	28												
			7	SS	44												
236.2																	
5.6	SAND and SILT to SAND, trace to some silt, trace clay, trace to some gravel, containing clayey silt layers		8	SS	20												
	Compact to very dense Brown to grey Moist																
			9	SS	62												
231.7																	
10.1	SAND and SILT, trace gravel, trace to some clay, containing clayey silt layers		11	SS	8												
	Loose to compact Grey Moist to wet																
			12	SS	14												
228.6																	
13.2	CLAYEY SILT, trace sand																
	Stiff Grey Moist to wet		13	SS	9												
227.1																	
14.7																	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-0022.GPJ GAL-MASS.GDT 7/10/12 DD/SAC


PROJECT <u>09-1111-0022</u>		<b>RECORD OF BOREHOLE No 12-09</b>		SHEET 2 OF 3		<b>METRIC</b>	
G.W.P. <u>2179-10-00</u>		LOCATION <u>N 4920896.1 ; E 292893.8</u>		ORIGINATED BY <u>DD</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Track Mount Power Auger</u>		COMPILED BY <u>NLP</u>			
DATUM <u>Geodetic</u>		DATE <u>March 29, 2012</u>		CHECKED BY <u>LCC</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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED								
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100								
	Silty SAND to SAND, trace to some silt, trace clay, trace gravel, containing silty clay layers from 15.2 m to 15.7 m Compact to dense Brown to grey Moist to wet		14	SS	14		226									
							225				○					
			15	SS	30		224									
							223				○			0 83 10 7		
			16	SS	24		222									
							221									
			17	SS	17		220				○					
							219									
			18	SS	21		218									
							217				┌───┐ ○			0 26 42 32		
			19	SS	34		216									
							215									
			20	SS	12		214				○					
							213									
			21	SS	9		212									
			22	SS	2*											
			23	SS	WH*											

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 7/10/12 DD/SAC

PROJECT		09-1111-0022		RECORD OF BOREHOLE No 12-09		SHEET 3 OF 3		METRIC										
G.W.P.		2179-10-00		LOCATION		N 4920896.1 ; E 292893.8		ORIGINATED BY										
DIST		Central HWY 400		BOREHOLE TYPE		Track Mount Power Auger		COMPILED BY										
DATUM		Geodetic		DATE		March 29, 2012		CHECKED BY										
								LCC										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100						
30.0	CLAYEY SILT with sand, trace to some gravel, (TILL) Very stiff Grey Moist		24	SS	22		211											8 44 25 23
209.6							210											
32.2	SAND and GRAVEL, trace to some silt, trace clay Very dense Grey Wet						209											
207.8			25	SS	52		208											31 56 9 4
34.0	END OF BOREHOLE  NOTE:  1. Water level in open borehole at a depth of 10.0 m, (Elev. 231.8 m) upon completion of drilling  * SPT "N" values considered to have been affected by sample disturbance due to groundwater inflow to borehole																	



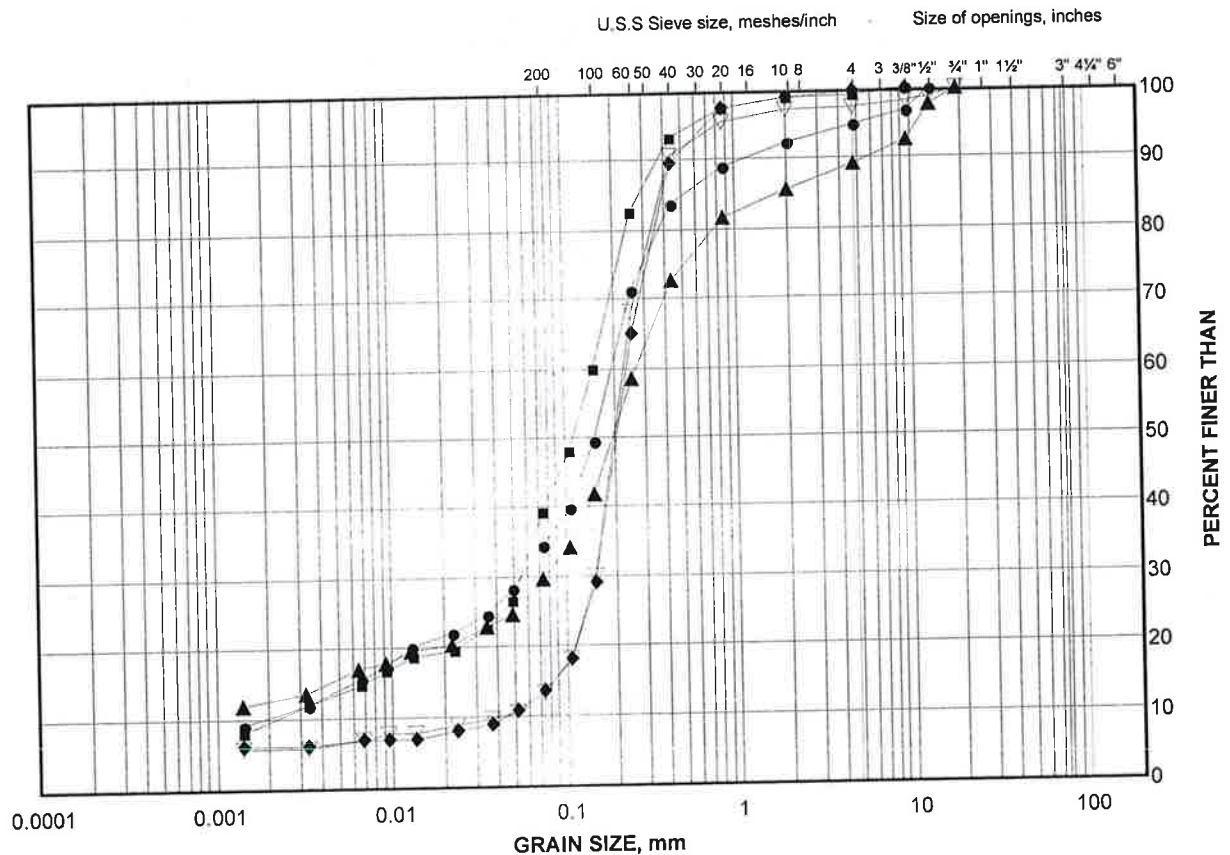
# **APPENDIX B**

## **Laboratory Test Results**

# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand (Fill)

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)
●	12-06	3	234.8
■	12-08	3	232
◆	12-09	4	239.5
▲	12-04	4	234.9
▽	12-01	6	243

Project Number: 09-1111-0022

Checked By: *[Signature]*

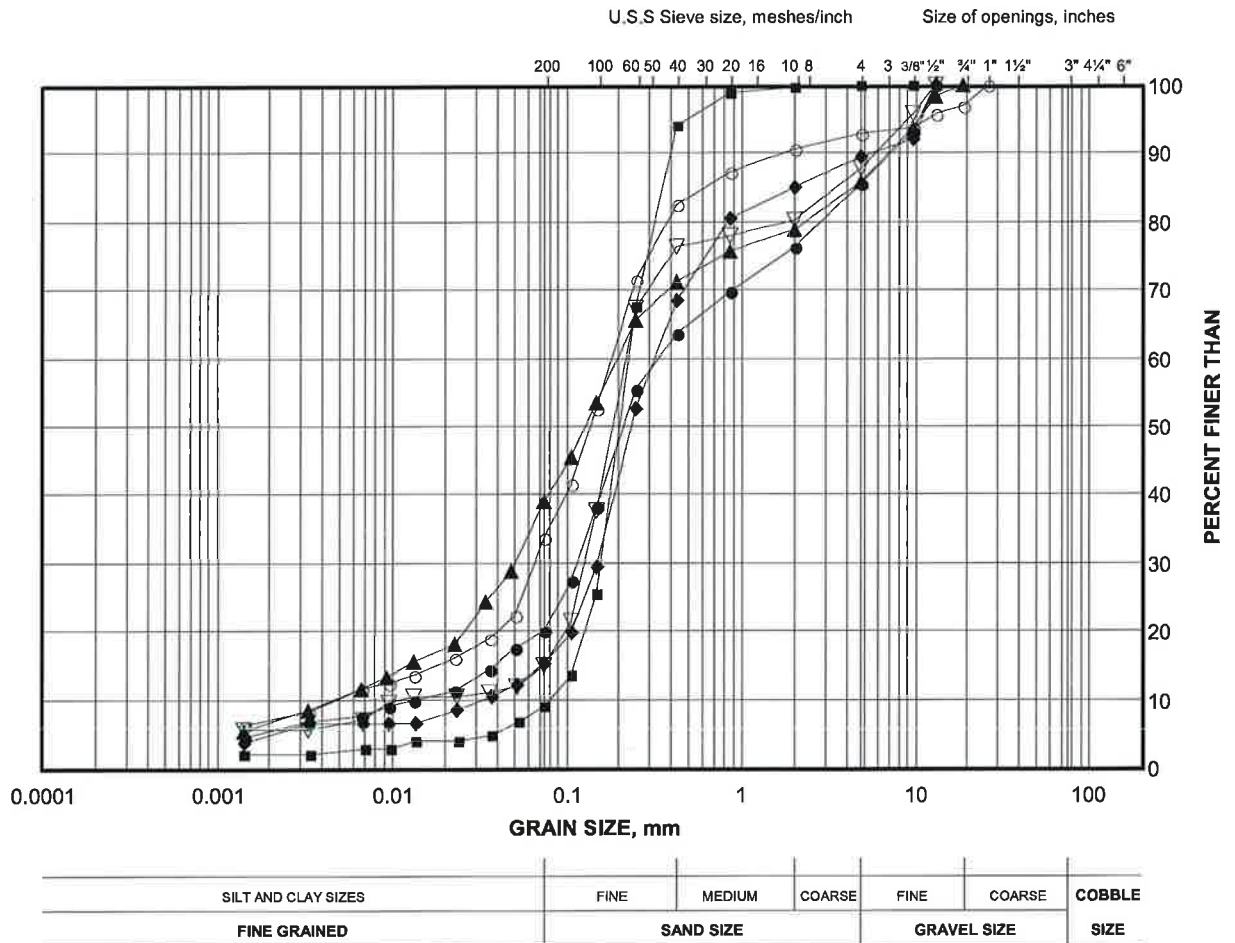
**Golder Associates**

Date: 12-Jun-12

# GRAIN SIZE DISTRIBUTION

Silty Sand to Sand

FIGURE B2



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-01	12	234.6
■	12-01	14	231.6
◆	12-03	3	233.6
▲	12-02	3	235.8
▽	12-02	7	231.2
○	12-01	9	239.2

Project Number: 09-1111-0022

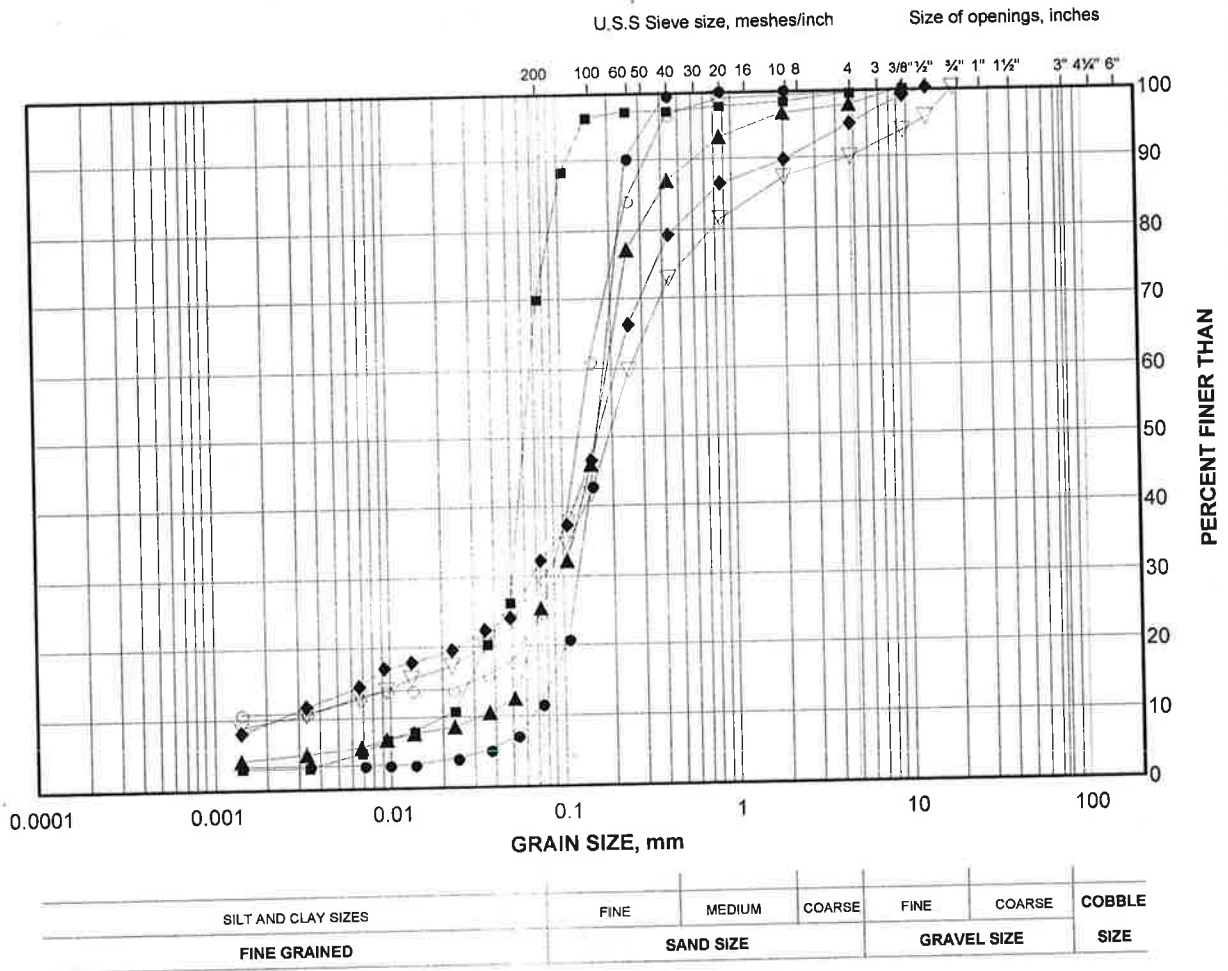
Checked By: *Maye*

Golder Associates

Date: 29-Jun-12

**Silty Sand to Sandy Silt**

FIGURE B3



## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-04	10	226.5
■	12-06	17	215
◆	12-05	3	233.9
▲	12-07	3	232.5
▽	12-04	6	232.6
○	12-08	7	227.4

Project Number: 09-111-0022

Checked By:

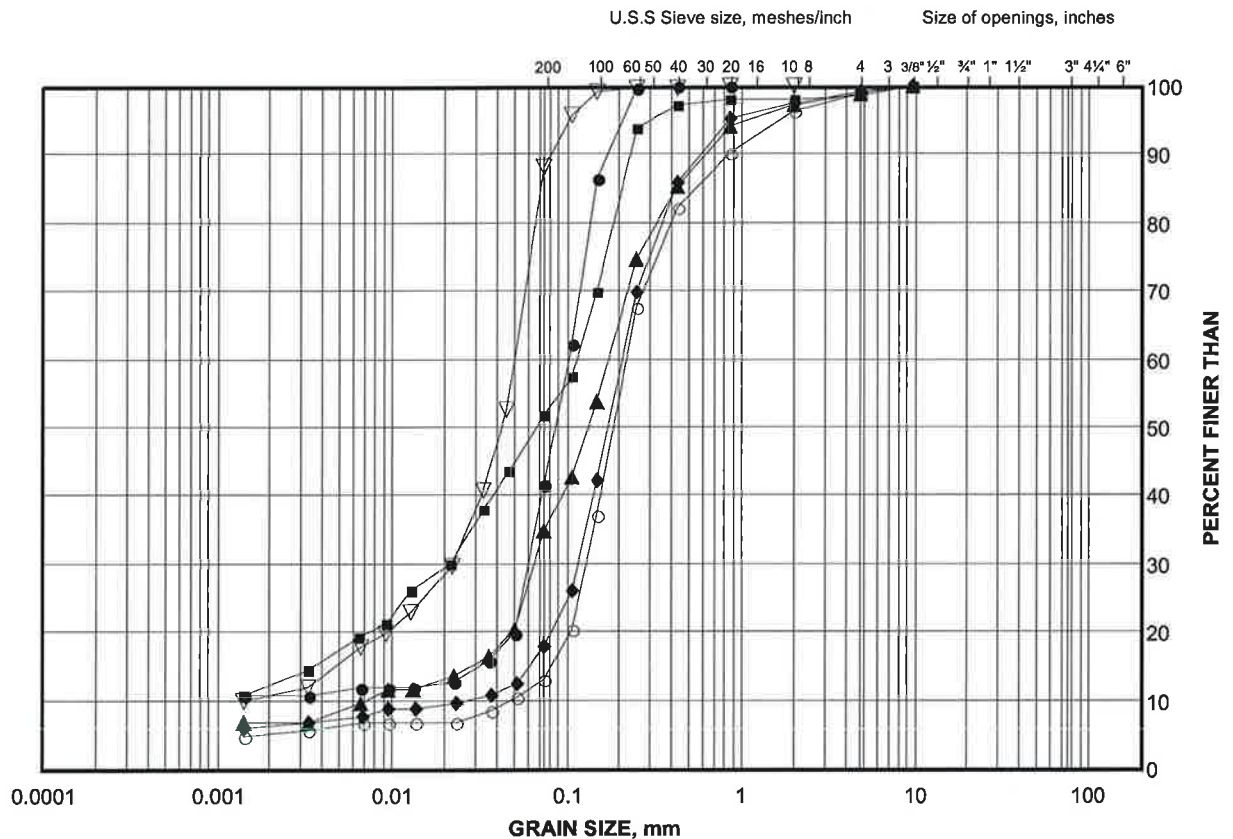
**Golder Associates**

Date: 12-Jun-12

# GRAIN SIZE DISTRIBUTION

Silty Sand to Silt

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)
●	12-08	11	221.3
■	12-09	12	229.6
◆	12-09	16	223.5
▲	12-08	16	213.7
▽	12-06	7	230.2
○	12-08	9	224.4

Project Number: 09-1111-0022

Checked By: *Wayne*

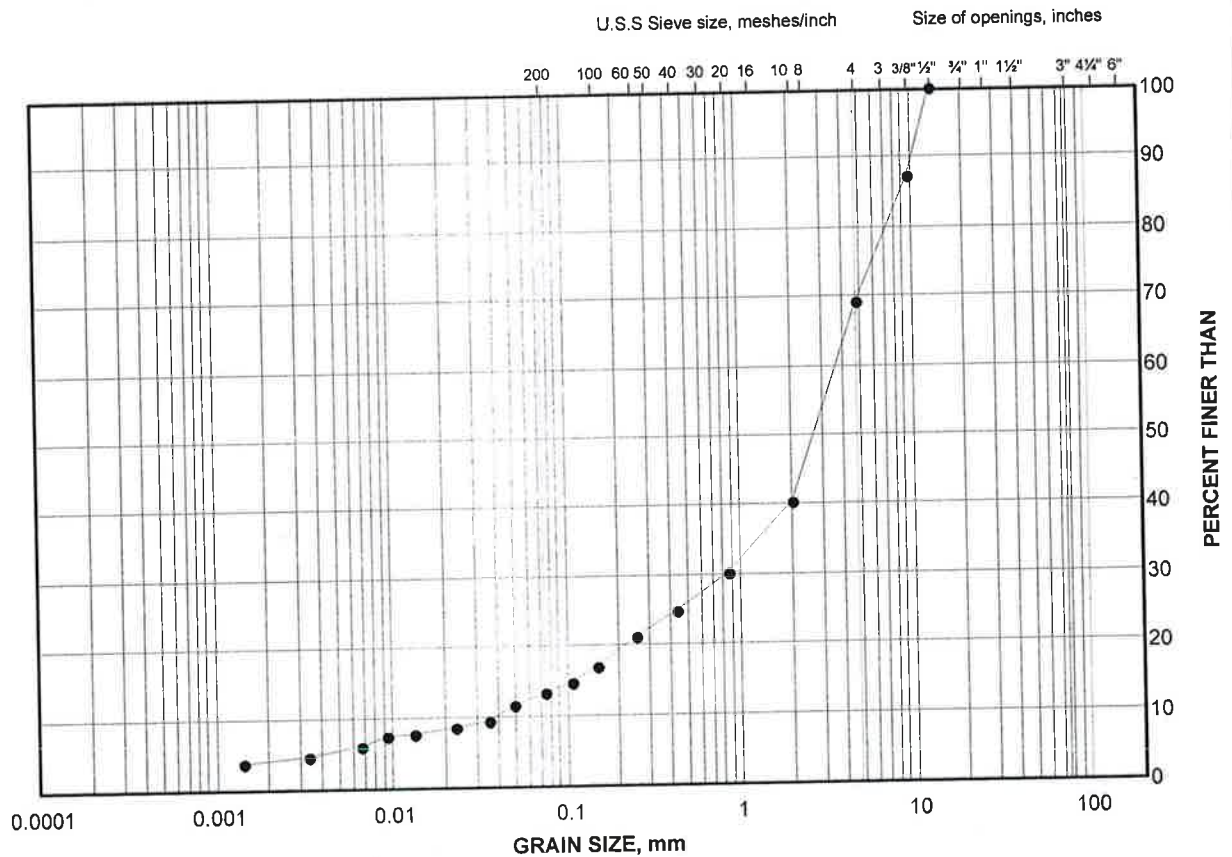
**Golder Associates**

Date: 29-Jun-12



## Sand and Gravel

FIGURE B5



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-09	25	208.3

Project Number: 09-1111-0022

Checked By:

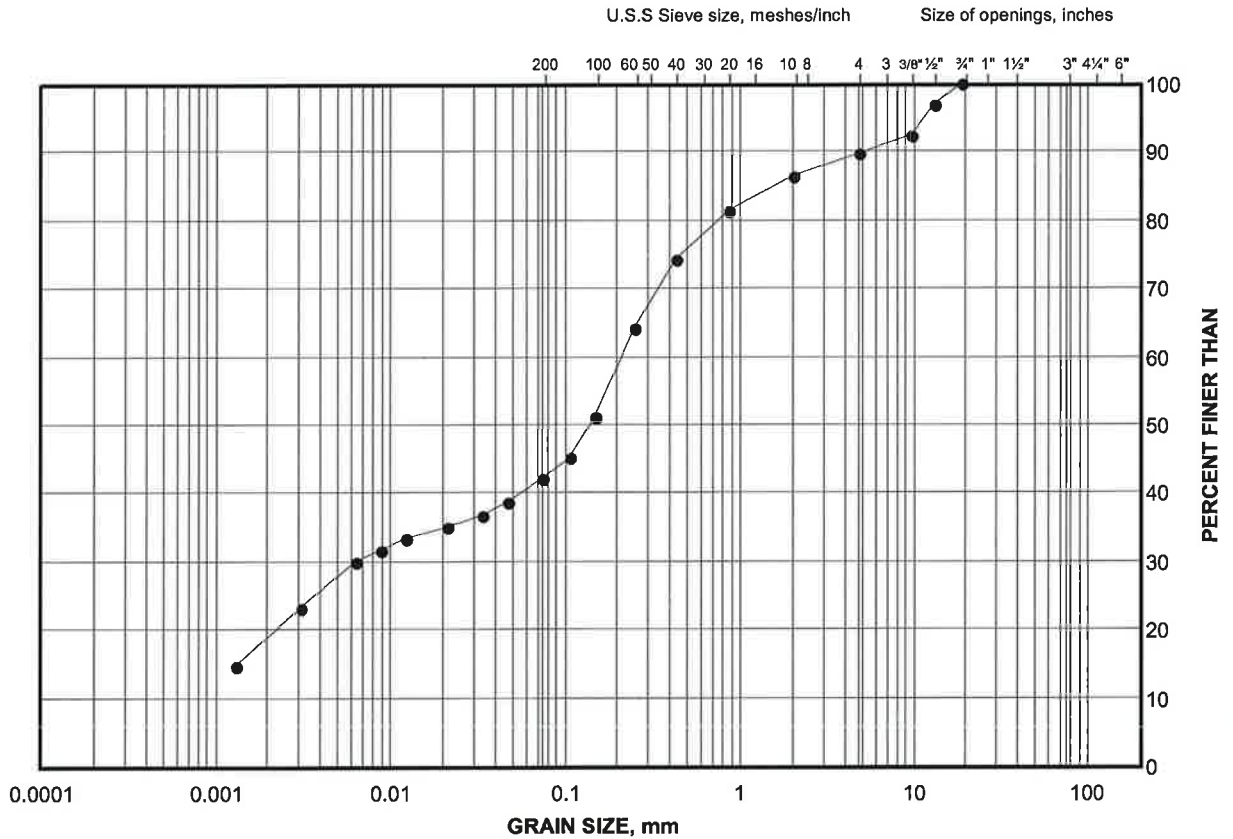
## Golder Associates

Date: 12-Jun-12

# GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B6



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

## LEGEND

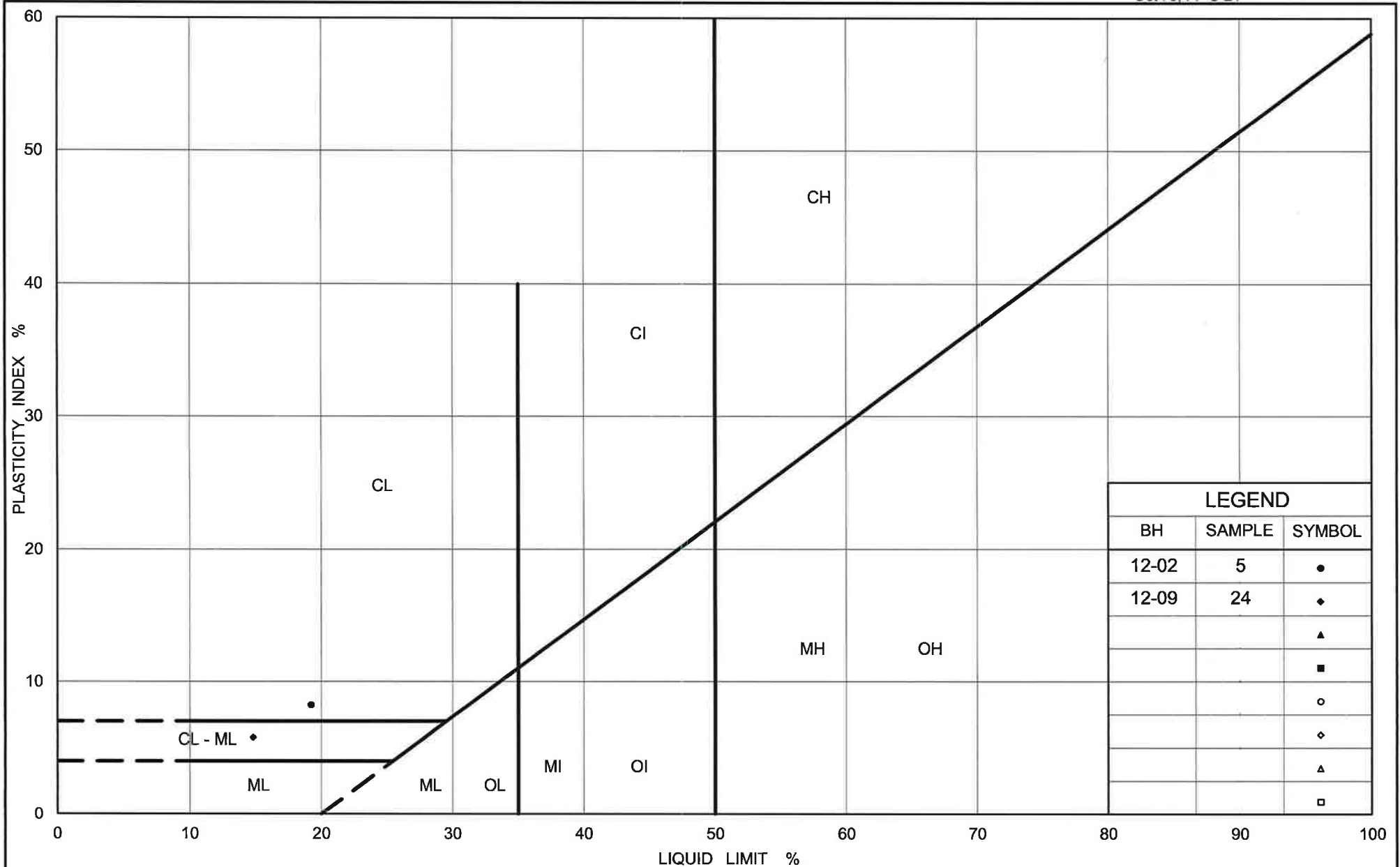
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	12-02	5	234.2

Project Number: 09-1111-0022

Checked By: *Woyce*

**Golder Associates**

Date: 29-Jun-12



Ministry of Transportation

Ontario

## PLASTICITY CHART

### Clayey Silt Till

Figure No. B7

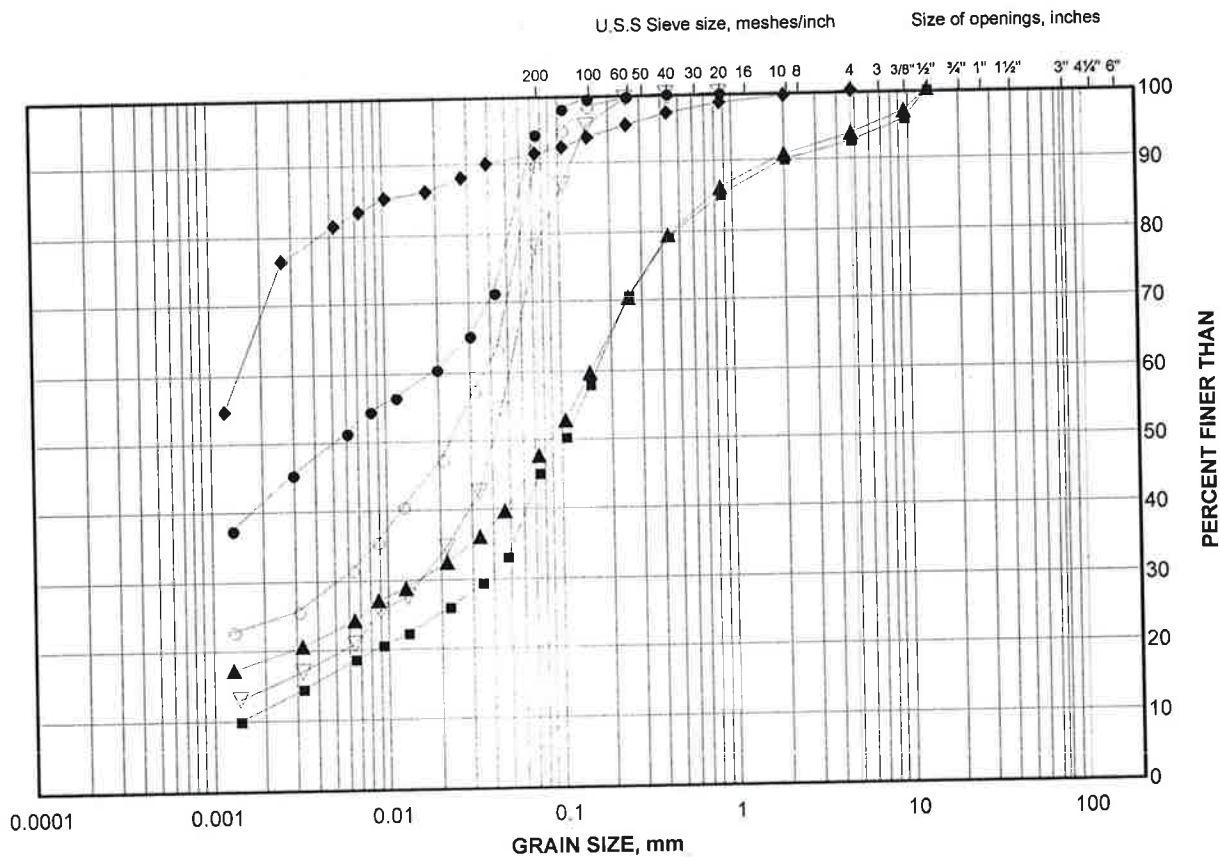
Project No. 09-1111-0022

Checked By: *Woyce*

# GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B8



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-08	12	219.8
■	12-06	13	221.1
◆	12-08	13	218.3
▲	12-06	14	219.5
▽	12-08	5	230.4
○	12-08	6	228.9

Project Number: 09-1111-0022

Checked By: *W. J. [Signature]*

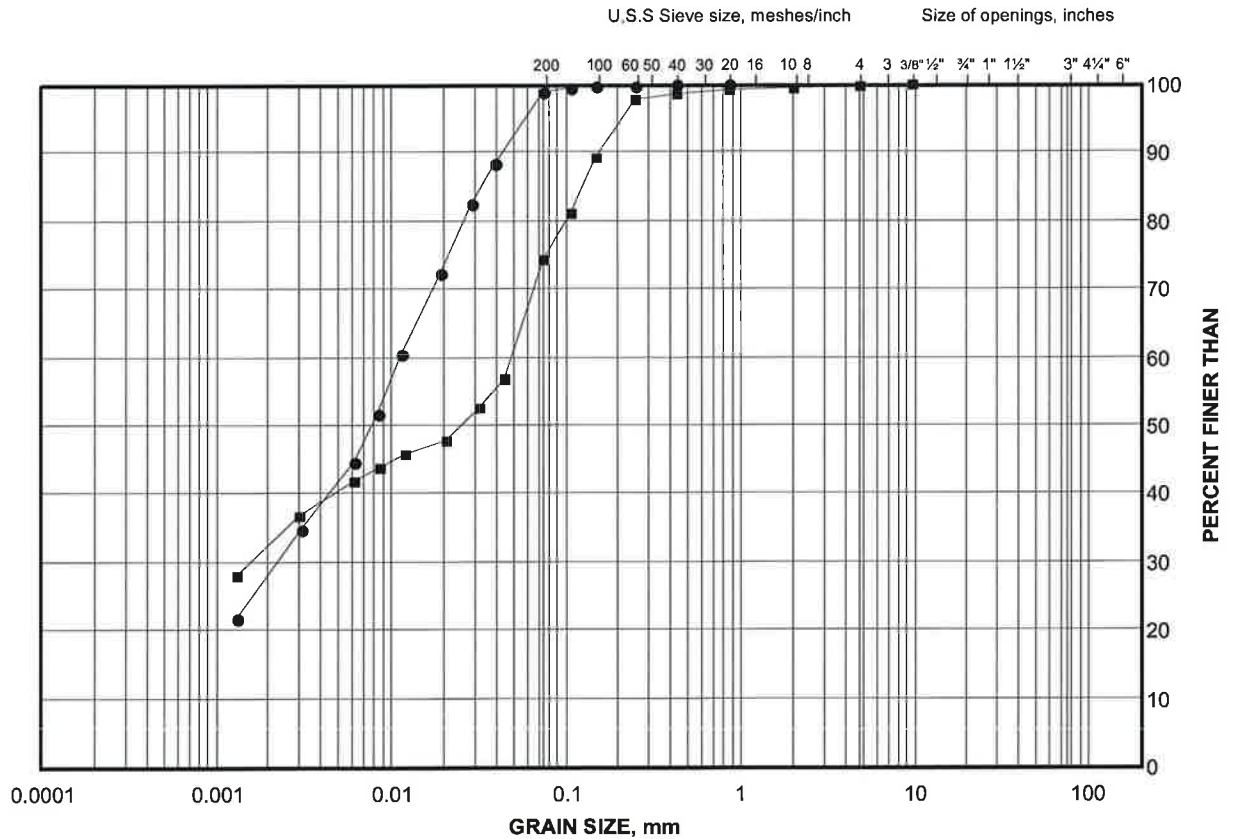
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Date: 12-Jun-12

# GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B9



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

## LEGEND

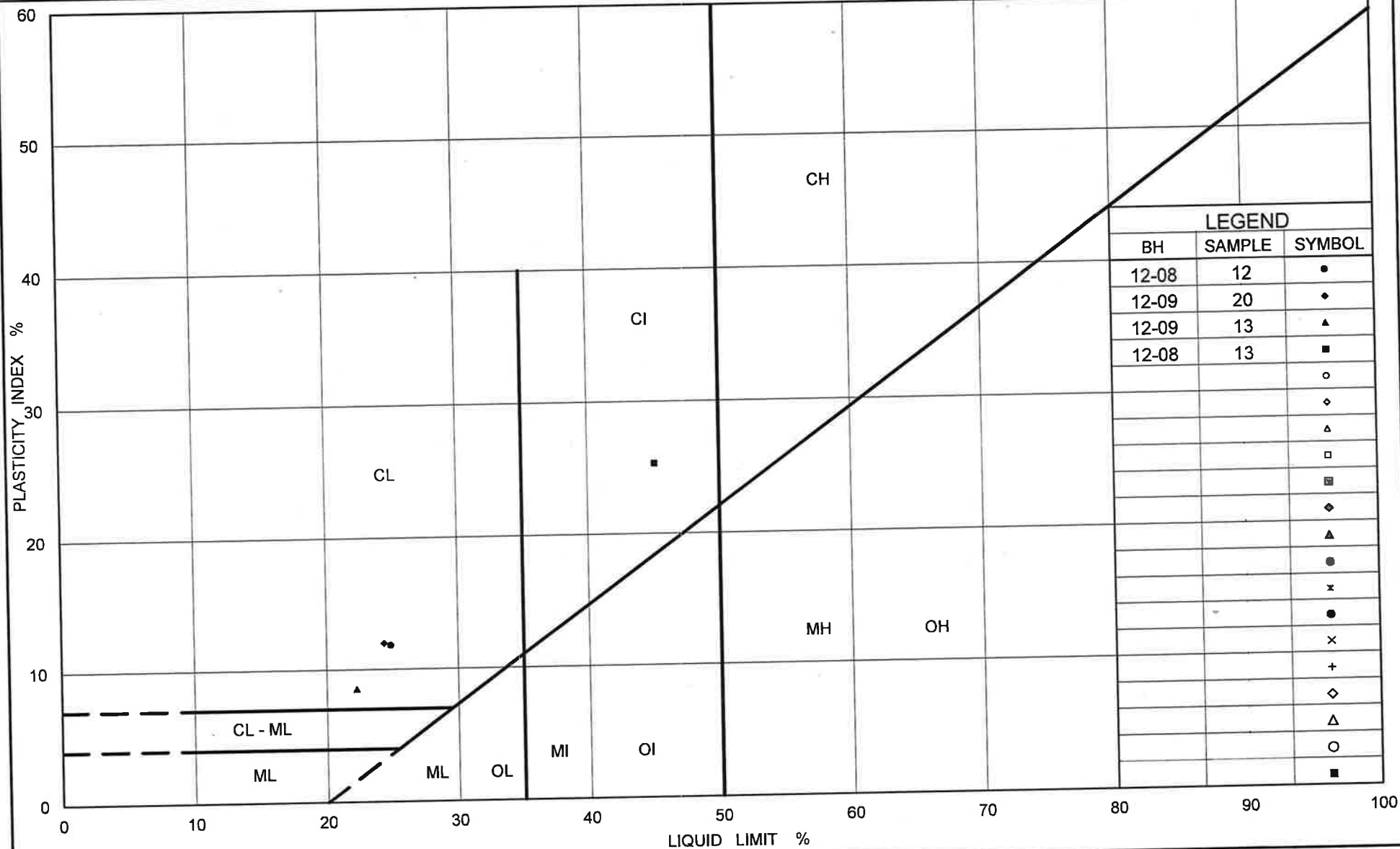
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	12-09	13	228.1
■	12-09	20	217.4

Project Number: 09-1111-0022

Checked By: *[Signature]*

**Golder Associates**

Date: 29-Jun-12



Ontario

Ministry of  
Transportation

# PLASTICITY CHART Clayey Silt to Silty Clay

Figure No. B10

Project No. 09-1111-0022

Checked By: CMS

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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Europe	+ 356 21 42 30 20
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