REPORT

January, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

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

Submitted to:
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GEOCRES No. 30M15-154

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Golder Associates

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PART A

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CLARINGTON, ONTARIO
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Golder Associates

1.0 INTRODUCTION

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

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

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 2008-E-0059 dated March 2009 and associated clarifications, and in Section 6.8 of the URS *Technical Proposal* for this assignment.

2.0 SITE DESCRIPTION

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

Based on the General Arrangement (GA) drawing of the new Highway 401/Holt Road Interchange provided by URS on September 12, 2013, we understand that the existing bridge will be removed and a new Underpass bridge will be constructed about 30 m to the east of the existing structure.

In general, the terrain in the area of the proposed new bridge is relatively flat, with the natural ground surface in the vicinity of the structure site ranging between about Elevation 111 m and 114 m.

The Highway 401 grade in the vicinity of the existing and the new Holt Road Interchange is at about Elevation 111 m. The existing Holt Road Underpass approach embankments consist of earth fill, up to about 7.5 m high, with the Holt Road surface at about Elevation 118.5 m. The existing approach embankment side slopes are oriented at approximately 2 horizontal to 1 vertical (2H:1V), with no mid-height benches.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigation

Golder Associates completed a preliminary subsurface investigation for the new Interchange structure which was carried out on November 22, 2012, during which time two boreholes (Boreholes HR-1 and HR-2) were advanced at the proposed abutment locations as shown on Drawing 1. The results of the subsurface investigation are reported in Golder's Preliminary Foundation Investigation and Design Report (Golder, 2013). The borehole information from the preliminary investigation have been utilized to supplement the current investigation.

The field work for the current subsurface investigation was carried out between May and June 2013, during which time six boreholes (Boreholes 13-45 to 13-50) were advanced approximately at the locations shown on Drawing 1. Boreholes 13-45, 13-46, 13-49 and 13-50 were advanced using a track-mounted CME-45 drill rig, supplied and operated by KC Drilling of Innisfill, Ontario and Boreholes 13-47 and 13-48 were advanced using a truck-mounted CME-55 drill rig, supplied and operated by Strong Soil Search Inc. of Claremont, Ontario. All boreholes were drilled within the footprint of the proposed structure foundations with Boreholes 13-45 and 13-46 drilled at the north abutment and approach, respectively, Boreholes 13-47 and 13-48 drilled in the median of Highway 401 at the central pier and Boreholes 13-49 and 13-50 drilled at the south abutment and approach, respectively.

The boreholes were drilled using 120 mm diameter solid stem augers to depths ranging between 6.2 m and 9.2 m below ground surface. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth in the boreholes, using a 50 mm outside diameter split-spoon sampler driven in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586)[1].

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and are noted on the borehole records contained in Appendix A. A piezometer was installed in each of Boreholes 13-45 and 13-46 to monitor the groundwater levels at those locations. The piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled in accordance with Ontario Regulation 903 (as amended).

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

The as-drilled borehole locations and ground surface elevations were surveyed in the field by Callon-Dietz, a licensed surveyor. The borehole locations (referenced to the MTM NAD83 coordinate system) and ground surface elevations (referenced to geodetic datum) are summarized below and are shown on the Record of Borehole Sheets in Appendix A and on Drawing 1.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
13-45	4,860,779.0	367,273.0	113.8	6.2
13-46	4,860,802.0	367,275.0	114.1	9.2
13-47	4,860,744.0	367,287.0	112.3	8.1
13-48	4,860,749.0	367,304.0	111.8	6.4
13-49	4,860,714.0	367,319.0	110.9	6.2
13-50	4,860,695.0	367,316.0	110.9	9.2

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

3.2 Previous Investigation

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

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

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

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

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

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

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

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

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

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

4.2 Subsurface Conditions

The current and preliminary subsurface investigations entailed the advancement of six boreholes and two boreholes, respectively, at the proposed new Highway 401/Holt Road Underpass structure site. The borehole locations, ground surface elevations and interpreted stratigraphic conditions are shown on Drawings 1 and 2. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B6 contained in Appendix B. The stratigraphic boundaries shown on the Record of Boreholes and on the interpreted stratigraphic sections on Drawings 1 and 2 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsurface conditions encountered at the site consist of topsoil or asphalt underlain by a fill deposit comprised of sand and gravel to sandy silt to clayey silt between 0.8 m and 4.4 m thick, underlain by a dense to very dense sand and silt till deposit interlayered in places with very stiff to hard clayey silt till. A more detailed description of the soil deposits encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

A deposit of topsoil was encountered immediately below ground surface in Boreholes 13-45, 13-46, 13-49 and 13-50. The thickness of the deposit ranges between 0.4 m and 0.6 m.

The Standard Penetration Test (SPT) “N” values measured within the topsoil deposit range from 8 blows to 19 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The natural water content measured on one sample of the topsoil is 8 per cent.

4.2.2 Asphalt

An approximately 0.1 m thick layer of asphalt was encountered in Boreholes 13-47 and 13-48 at ground surface.

4.2.3 Sand and Gravel Fill

A fill deposit comprised of sand and gravel, trace to some silt was encountered below the asphalt in Boreholes 13-47 and 13-48. The surface of the granular fill deposit was encountered at Elevations 112.2 m and 111.7 m and the deposit is 0.7 m and 1.4 m thick in Boreholes 13-47 and 13-48, respectively.

The measured SPT “N” values within this deposit range from 20 blows to 25 blows per 0.3 m of penetration, indicating a compact relative density.

The natural water content measured on one sample of the granular fill is 5 per cent.

4.2.4 Clayey Silt Fill

A deposit of clayey silt fill was encountered below the sand and gravel fill in Borehole BH-47 and below the topsoil in Boreholes 13-49 and 13-50. The surface of the cohesive fill deposit was encountered between Elevation 111.5 m and 110.5 m and the thickness of the cohesive fill deposit is between 0.3 m and 0.7 m thick.

One measured SPT “N” value within this deposit is 16 blows per 0.3 m of penetration, suggesting a very stiff consistency.

The cohesive fill deposit consists of clayey silt with to some sand, trace to some gravel, trace organics. The results of a grain size distribution test completed on one selected sample of the clayey silt with sand fill is shown on Figure B1 in Appendix B.

Atterberg limits testing conducted on one selected sample of the clayey silt fill measured a plastic limit of about 14 per cent, a liquid limit of about 22 per cent and a plasticity index of about 8 per cent. This test result, which is plotted on a plasticity chart on Figure B2 in Appendix B, indicates that the deposit consists of clayey silt of low plasticity.

The natural water content measured on a sample of the clayey silt fill is 15 per cent.

4.2.5 Sandy Silt to Silty Sand Fill

A fill deposit comprised of sandy silt to silty sand was encountered at the ground surface in Boreholes HR-1 and HR-2, underlying the topsoil in Boreholes 13-45 and 13-46, and below the sand and gravel fill in Borehole 13-48. The surface of the sand and silt fill deposit was encountered up to 1.5 m below ground surface (Elevation 113.5 m to 110.4 m), and was measured to be between 0.7 m and 3.8 m thick.

The measured SPT “N” values within this deposit range from 7 blows to 87 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

This deposit is comprised of zones of sandy silt, sand and silt and silty sand, trace to some gravel, trace to some clay and trace organics. Increased organic content/wood fibres were present in some boreholes near the interface between the fill and underlying till soils. The results of grain size distribution tests completed on three selected samples of the sand and silt portion of the fill deposit are shown on Figure B3 in Appendix B.

The natural water content measured on eight selected samples of the sandy silt to silty sand fill deposit ranges from about 6 per cent to 18 per cent. One water content of 26 per cent was measured in 13-45 and is attributed to the greater organic content of the fill in this borehole.

4.2.6 Clayey Silt (Till)

A deposit of clayey silt till was encountered below the fill in Boreholes HR-1, 13-45, 13-46, 13-49 and 13-50, and within the upper portion of the sandy silt to sand and silt till deposit in Borehole HR-2. The surface of the clayey silt till was encountered at depths between 0.8 m and 4.4 m below ground surface, corresponding to Elevations 110.9 m to 109.4 m. The thickness of this till deposit ranges from about 0.6 m to 3.9 m in Boreholes HR-1, HR-2, 13-46 and 13-49,and from about 3.3 m to 8.4 m in Boreholes 13-45 and 13-50 where it was not fully penetrated.

The measured SPT “N” values within this deposit range from 28 blows per 0.3 m of penetration to 100 blows per 0.08 m of penetration, suggesting a very stiff to hard consistency.

The till deposit consists of clayey silt with sand to some sand, trace to some gravel and contains occasional silt seams at some locations. The presence of cobbles and boulders was inferred from grinding of the augers within this deposit as noted on the Record of Borehole sheets. The results of grain size distribution tests completed on eight selected samples of the clayey silt till are shown on Figure B4 and resemble the grain size distributions of the underlying sandy silt to sand and silt till, suggesting that the clayey silt till layer is likely a transition zone to the underlying more granular till deposit.

Atterberg limits testing was conducted on seven selected samples of the clayey silt till and measured plastic limits ranging from 10 per cent to 15 per cent, liquid limits ranging from 13 per cent to 33 per cent and plasticity indices ranging from 2 per cent to 18 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B5 and indicate that the material is a clayey silt of low plasticity with zones that may be classified as silt of slight plasticity.

The natural water content measured on samples of the clayey silt till deposit ranges from about 4 per cent to 15 per cent.

4.2.7 Sand and Silt (Till)

A deposit of sand and silt till was encountered underlying the fill deposit in Boreholes 13-47, 13-48 and HR-2 and underlying the clayey silt till deposit in Boreholes 13-46, 13-49 and HR-1. The surface of the sand and silt till deposit was encountered at depths ranging from 1.5 m to 8.3 m below ground surface, at between Elevations 110.9 m and 105.8 m. The boreholes were terminated within this till deposit at depths ranging between 6.2 m and 9.2 m below ground surface corresponding to between Elevations 105.5 m and 103.9 m.

The measured SPT “N” values within this deposit range from 42 blows per 0.3 m of penetration to greater than 50 blows per 0.03 m of penetration, indicating a dense to very dense (but typically very dense) relative density.

The glacial till deposit consists of sand and silt, trace to some clay, trace to some gravel, interlayered as noted above with clayey silt till in places. The presence of cobbles and boulders was inferred from grinding of the augers within this deposit as noted on the Record of Borehole sheets. The results of grain size distribution tests completed on seven selected samples of the sand and silt till from the current investigation are shown on Figure B6 in Appendix B.

Atterberg limits testing was conducted on five selected samples of the sand and silt till and measured plastic limits ranging from 10 per cent to 12 per cent, liquid limits of 13 per cent and plasticity indices ranging from 1 per cent to 3 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B7 and indicate that the fines portion of the material may be classified as silt of slight plasticity.

The natural water content measured on fifteen samples of the sand and silt till deposit ranges from about 4 per cent to 8 per cent.

4.3 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are summarized on the Record of Borehole sheets in Appendix A of this report. The water level in the open boreholes was measured at between 3.0 m and 7.3 m below ground surface corresponding to between Elevations 110.8 m and 105.0 m in Boreholes 13-45 to 13-47, 13-50, HR-1 and HR-2; Boreholes 13-48 and 13-49 were dry upon completion of drilling.

Standpipe piezometers were installed in Boreholes 13-45 and 13-46 to permit monitoring of the groundwater level at those locations. Details of the piezometer installations are shown on the Record of Borehole sheets in Appendix A. Groundwater levels measured in the piezometers are summarized below.

Borehole No.	Ground Surface Elevation	Depth to Groundwater Level	Groundwater Elevation	Date of Measurement
13-45	113.8 m	2.1 m	111.7 m	September 10, 2013
13-46	114.1 m	3.9 m	110.2 m	September 10, 2013

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

5.0 CLOSURE

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

GOLDER ASSOCIATES LTD.

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Geotechnical Engineer

Kevin Bentley, P.Eng.
Geotechnical Engineer, Associate

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

BM/MWK/KJB/JMAC/jl

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Department of Highways Ontario, 1961 *Darlington Twp. Bridge No. 8, Holt Road Underpass at Highway 401 Intersection, District No. 7.* GEOCRES No. BA851-E

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Ontario Water Resources Act. R.R.O. Regulation 903, *Wells* 1990

ASTM International

ASTM D1556 Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of Soils

MINISTRY OF TRANSPORTATION, ONTARIO

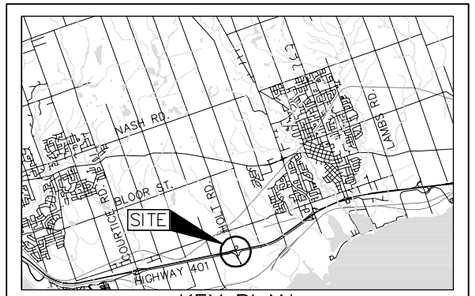
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2101-08-00

SHEET

HIGHWAY 401
HOLT ROAD INTERCHANGE STRUCTURE
BOREHOLE LOCATIONS AND SOIL STRATA

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



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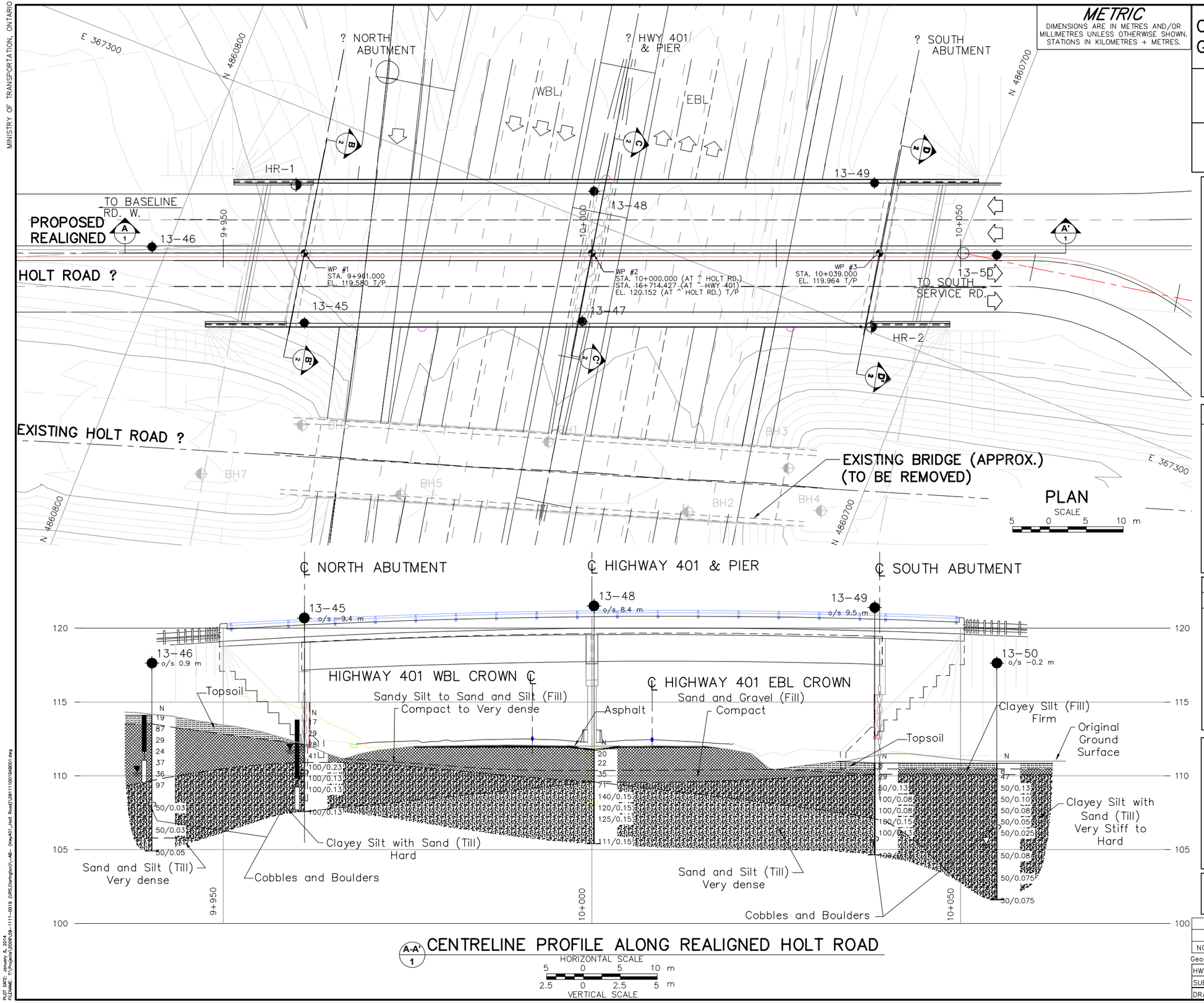


PLAN
SCALE
5 0 5 10 m

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

HORIZONTAL SCALE
5 0 5 10 m
VERTICAL SCALE
2.5 0 2.5 5 m

LEGEND

- Borehole – Current Investigation
- Borehole – Preliminary Investigation (Golder 2012)
- Borehole – Previous Investigation (1961)
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured in piezometer
- WL upon completion of drilling September 9, 2013

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
13-45	113.8	4860779.0	367273.0
13-46	114.1	4860802.0	367275.0
13-47	112.3	4860744.0	367287.0
13-48	111.8	4860749.0	367304.0
13-49	110.9	4860714.0	367319.0
13-50	110.9	4860695.0	367316.0
HR-1	111.7	4860786.9	367290.0
HR-2	111.7	4860707.2	367300.7

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

REFERENCE

Base plan provided in digital format by URS, drawing file no. 120921-X-Design_Holt Preferred_ACAD 2007.dwg, received January 3, 2013 and 01-HoltRd_GA_Dec 20 2013.dwg, received December 20, 2013.

NO.	DATE	BY	REVISION

Geocres No. 30M15-154

HWY. 401	PROJECT NO. 09-1111-0019		DIST.
SUBM'D. MWK	CHKD. MWK	DATE: Dec. 2013	SITE: 21-159
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 1

PLOT DATE: January 9, 2014
FILENAME: I:\Projects\2009\09-1111-0019 (URS Donington)_KB_ (Hwy401_Holt Road)\09111101948201.dwg

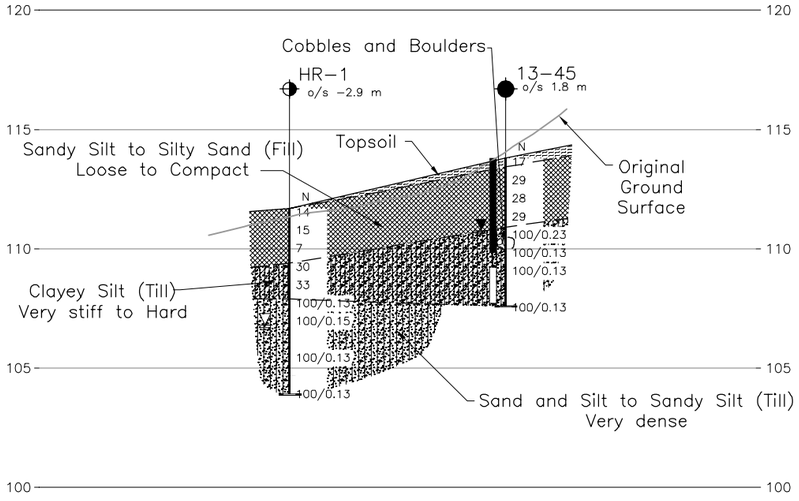
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2101-08-00

HIGHWAY 401
HOLT ROAD INTERCHANGE STRUCTURE
SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



B-B'
1

CROSS-SECTION (NORTH ABUTMENT)
STATION 9+961

HORIZONTAL SCALE
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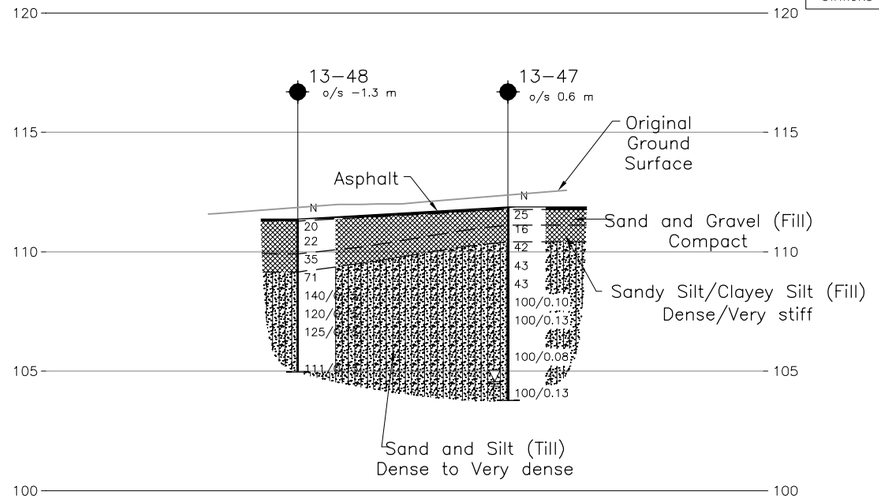
2.5 0 2.5 5 m
VERTICAL SCALE



C-C'
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CROSS-SECTION (PIER)
STATION 10+000

HORIZONTAL SCALE
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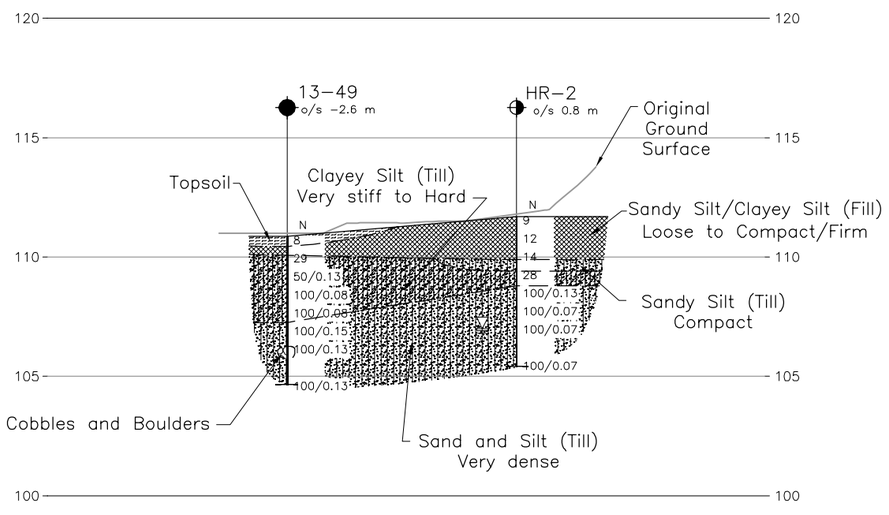
2.5 0 2.5 5 m
VERTICAL SCALE



D-D'
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CROSS-SECTION (SOUTH ABUTMENT)
STATION 10+039

HORIZONTAL SCALE
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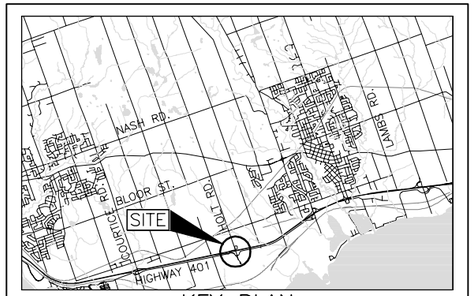
VERTICAL SCALE



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- Borehole – Preliminary Investigation (Golder 2012)
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL measured in piezometer
- WL upon completion of drilling September 9, 2013

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
13-45	113.8	4860779.0	367273.0
13-47	112.3	4860744.0	367287.0
13-48	111.8	4860749.0	367304.0
13-49	110.9	4860714.0	367319.0
BH HR-1	111.7	4860786.9	367290.0
BH HR-2	111.7	4860707.2	367300.7

NOTES

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Geocres No. 30M15-154

HWY. 401	PROJECT NO. 09-1111-0019		DIST.
SUBM'D. MWK	CHK'D. MWK	DATE: Dec. 2013	SITE: 21-159
DRAWN: JFC	CHK'D. KJB	APP'D. JMAC	DWG. 2

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index / Relative Density	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel / Silty Clay with sand / Clayey Silt with sand

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
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
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 $\tau = c' + \sigma' \tan\phi'$

2 shear strength = (compressive strength)/2

Golder Associates

RECORD OF BOREHOLE No 13-45

SHEET 1 OF 1 **METRIC**

PROJECT 09-1111-0019 | G.W.P. 2101-08-00 | LOCATION N 4860779.0 ;E 367273.0 | ORIGINATED BY JLC

DIST | HWY 401 | BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger | COMPILED BY BM

DATUM Geodetic | DATE May 28, 2013 | CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
113.8	GROUND SURFACE						
0.0 / 113.4	TOPSOIL	1	SS	17			
0.4	Sand and silt, trace to some gravel, some clay, trace organics (FILL) Compact Grey to dark brown Moist	2	SS	29	113		
	Pockets of organics below a depth of 1.8 m (Elev. 112.0 m)	3	SS	28	112		8 42 37 13
110.9		4	SS	41	111		15 37 33 15
2.9	CLAYEY SILT with SAND, trace gravel (TILL) Hard Brown to grey Moist	5	SS	100/0.23			
	Auger grinding on possible cobbles and boulders below 3.0 m depth	6	SS	100/0.13	110		
		7	SS	100/0.13	109		3 40 42 15
107.6		8	SS	100/0.13	108		
6.2	END OF BOREHOLE						

NOTES:

1. Borehole caved at a depth of 5.8 m below ground surface (Elev. 108.0 m) upon completion of drilling.

2. Water level at 3.0 m below ground surface (Elev. 110.8 m) upon completion of drilling.

3. Water level measurements in Piezometer:

Date	Depth (m)	Elev. (m)
05/29/13	3.0	110.8
09/10/13	2.1	111.7

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

WATER CONTENT (%) (10 20 30)

GROUND WATER CONDITIONS

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

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

Golder Associates

RECORD OF BOREHOLE No 13-46

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4860802.0 ;E 367275.0 | BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger | DATE June 11, 2013

ORIGINATED BY JLC | COMPILED BY BM | CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
114.1	GROUND SURFACE				114		
0.0 / 113.5	TOPSOIL Compact Dark brown Moist	1	SS	19			
0.6	Sand and silt, some gravel, some clay, trace organics (FILL) Compact to very dense Grey to black Moist	2	SS	87	113		
		3	SS	29			
		4	SS	24	112		
	Pockets of wood fibres/rootlets below Elev. 111.0 m	5	SS	37	111		16 38 32 14
109.7		6	SS	36	110		
4.4	CLAYEY SILT with SAND, trace to some gravel (TILL) Hard Brown to grey Moist - - - - - - - - - - - - - - - Auger grinding on possible cobbles and boulders below 5.1 m depth	7	SS	97			10 39 36 15
		8	SS	50/0.03	109		
		9	SS	50/0.03	108		
105.8					107		
8.3	SAND and SILT, trace to some gravel, some clay (TILL) Very dense Grey				106		
104.9	Moist	10	SS	50/0.05	105		
9.2	END OF BOREHOLE						

NOTES:

1. Borehole caved at a depth of 8.7 m below ground surface (Elev. 105.4 m) upon completion of drilling.

2. Water level in caved borehole at a depth of 6.2 m below ground surface (Elev. 107.9 m) upon completion of drilling.

3. Water level measurements in Piezometer:

Date	Depth (m)	Elev. (m)
09/10/13	3.9	110.2

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%): 10 20 30

GROUND WATER CONDITIONS

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

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

Golder Associates

RECORD OF BOREHOLE No 13-47

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0019

G.W.P. 2101-08-00 LOCATION N 4860744.0 ;E 367287.0 ORIGINATED BY JLC

DIST HWY 401 BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger COMPILED BY BM

DATUM Geodetic DATE June 9, 2013 CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
112.3	GROUND SURFACE										
0.0	ASPHALT										
0.1	Sand and gravel, some silt (FILL) Compact Brown Moist		1	SS	25		112				
111.5											
0.8	Clayey silt, with sand, trace to some gravel, trace organics (FILL) Very stiff Brown Moist		2	SS	16						9 43 32 16
110.9							111				
1.5	SAND and SILT, some gravel, some clay (TILL) Dense to very dense Grey Moist		3	SS	42						
			4	SS	43		110		○ H		
			5	SS	43		109				
			6	SS	100/0.10				○		15 38 31 16
			7	SS	100/0.13		108				
							107				
			8	SS	100/0.08		106				
						▽	105				
			9	SS	100/0.13				○ H		
104.2											
8.1	END OF BOREHOLE										

NOTE:

1. Water level in open borehole at a depth of 7.3 m below ground surface (Elev. 105.0 m) upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 13-48

SHEET 1 OF 1

METRIC

PROJECT 09-1111-0019
G.W.P. 2101-08-00
DIST HWY 401
DATUM Geodetic
LOCATION N 4860749.0 ;E 367304.0
BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger
DATE June 9, 2013
ORIGINATED BY JLC
COMPILED BY BM
CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
111.8	GROUND SURFACE										
0.0	ASPHALT										
0.1	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	20		111		○		
110.4			2	SS	22						
1.5	Sandy silt, some gravel, trace clay, trace organics (FILL) Dense Brown to grey Moist		3	SS	35		110				
109.6											
2.2	SAND and SILT, trace to some gravel, some clay (TILL) Very dense Grey Moist		4	SS	71		109		○		22 35 30 13
			5	SS	140/0.15				○ H		
			6	SS	120/0.15		108		○		5 44 36 15
			7	SS	125/0.15		107				
							106				
105.4			8	SS	111/0.15				○		
6.4	END OF BOREHOLE NOTE: 1. Open borehole dry on completion of drilling.										

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

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

GTA-MTO 001 09-1111-0019.GPJ GAL-GTA.GDT 12/23/13

Golder Associates

RECORD OF BOREHOLE No 13-49

SHEET 1 OF 1

METRIC

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

LOCATION N 4860714.0 ;E 367319.0 | BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger | DATE May 27, 2013

ORIGINATED BY JLC | COMPILED BY BM | CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
111.0	GROUND SURFACE										
0.0 / 110.6	TOPSOIL Loose Dark brown Moist		1	SS	8						
110.2 / 0.8	Clayey silt, some sand, trace gravel, trace organics (FILL) Firm Dark brown Moist		2	SS	29		110				18 44 30 8
	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff to hard Brown to grey Moist		3	SS	50/0.13		109				
			4	SS	100/0.08						
107.4			5	SS	100/0.08		108				
3.6	SAND and SILT, trace to some gravel, trace to some clay (TILL) Very dense Grey Moist		6	SS	100/0.15		107				7 42 39 12
			7	SS	100/0.13						
	Auger grinding on probable cobbles or boulders at 4.9 m (Elev. 106.0 m)						106				
104.8			8	SS	100/0.13		105				
6.2	END OF BOREHOLE NOTE: 1. Open borehole dry on completion of drilling.										

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

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

Golder Associates

RECORD OF BOREHOLE No 13-50

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4860695.0 ;E 367316.0 | BOREHOLE TYPE 120 mm O.D. Continuous Flight Solid Stem Power Auger | DATE May 27, 2013

ORIGINATED BY JLC | COMPILED BY BM | CHECKED BY MWK

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
111.0	GROUND SURFACE										
0.0 / 110.6	TOPSOIL Loose Brown Moist		1	SS	8						
110.2 / 0.8	Clayey silt, some sand, trace gravel, trace organics (FILL) Dark brown Moist		2	SS	47		110				5 37 41 17
	CLAYEY SILT with SAND, trace to some gravel, occasional silt seams (TILL) Hard Brown to grey Moist		3	SS	50/0.13						2 39 44 15
			4	SS	50/0.10		109				
			5	SS	50/0.08		108				10 42 35 13
			6	SS	50/0.05		107				
	Auger grinding on inferred cobbles and boulders below 4.0 m depth		7	SS	50/0.03	▽	106				
			8	SS	50/0.06		105				
							104				
			9	SS	50/0.08		103				
101.8			10	SS	50/0.08		102				
9.2	END OF BOREHOLE										

NOTES:

1. Water level at a depth of 5.5 m below ground surface (Elev. 105.5 m) during drilling.

2. Borehole caved to a depth of 6.1 m below ground surface (Elev. 104.9 m) upon completion of drilling.

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

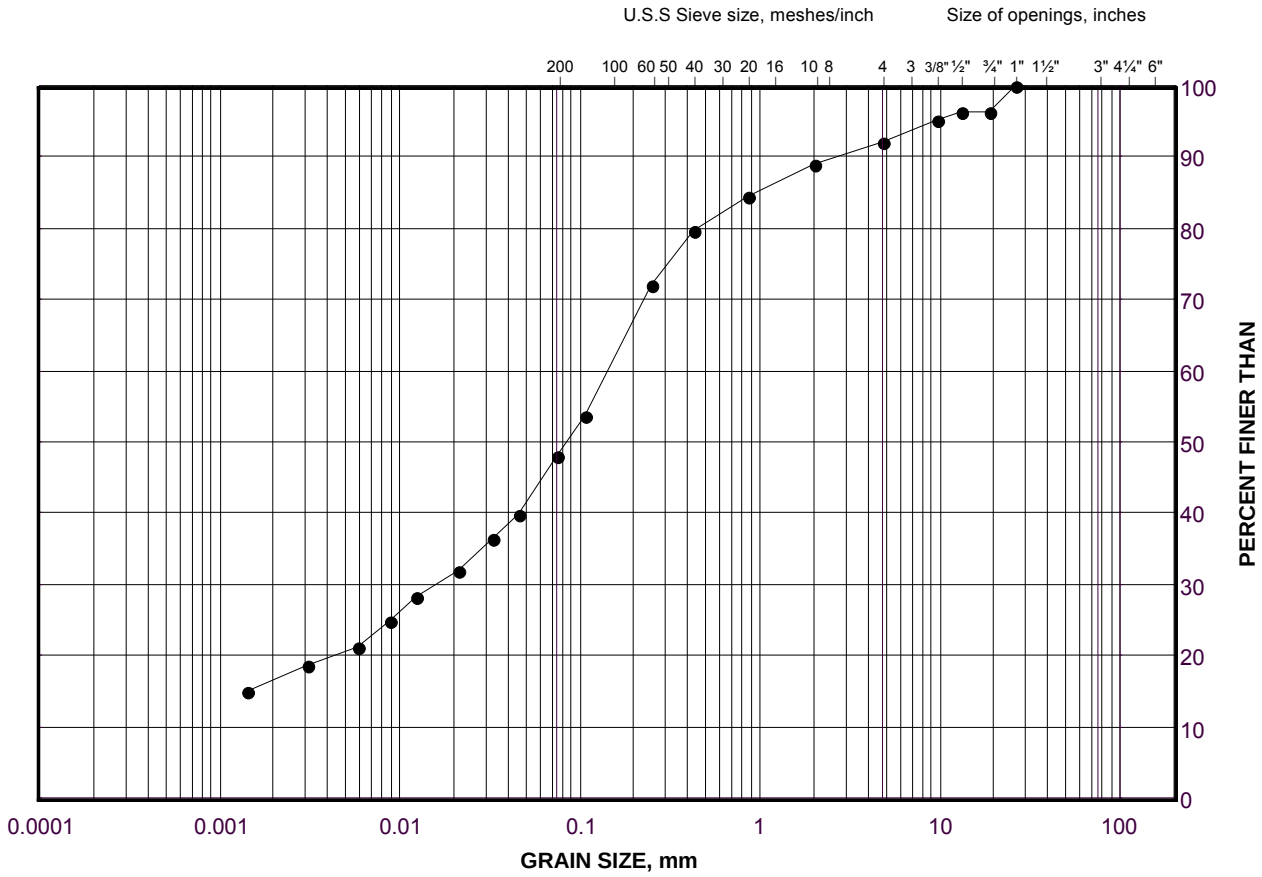
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand (FILL)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	BH-47	2	111.3

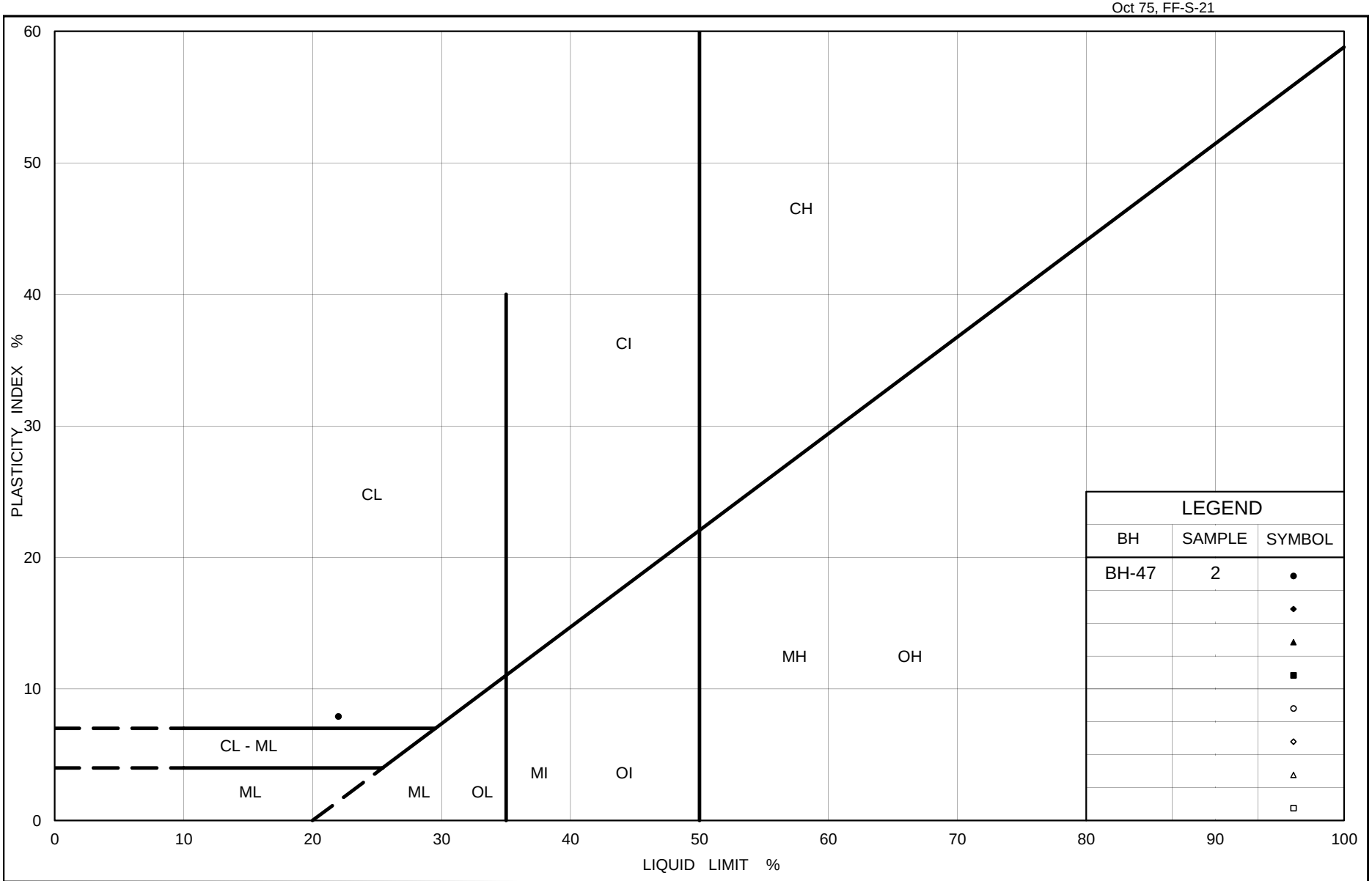
Project Number: 09-1111-0019

Checked By: KJB

Golder Associates

Date: 01-Oct-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt with Sand (FILL)

Figure No. B2

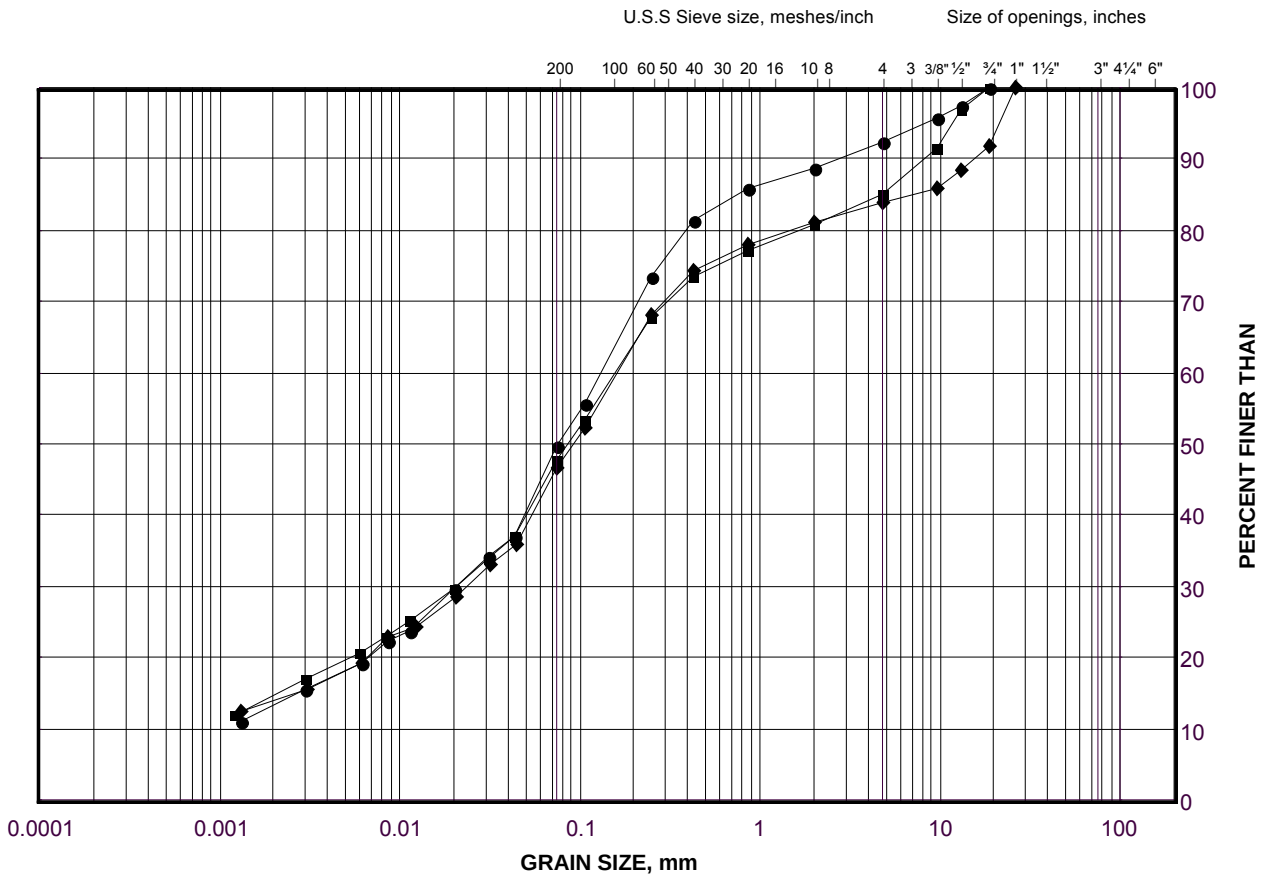
Project No. 09-1111-0019

Checked By: KJB

GRAIN SIZE DISTRIBUTION

Sand and Silt (FILL)

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	BH-45	3	112.1
■	BH-45	4	111.3
◆	BH-46	5	110.9

Project Number: 09-1111-0019

Checked By: KJB

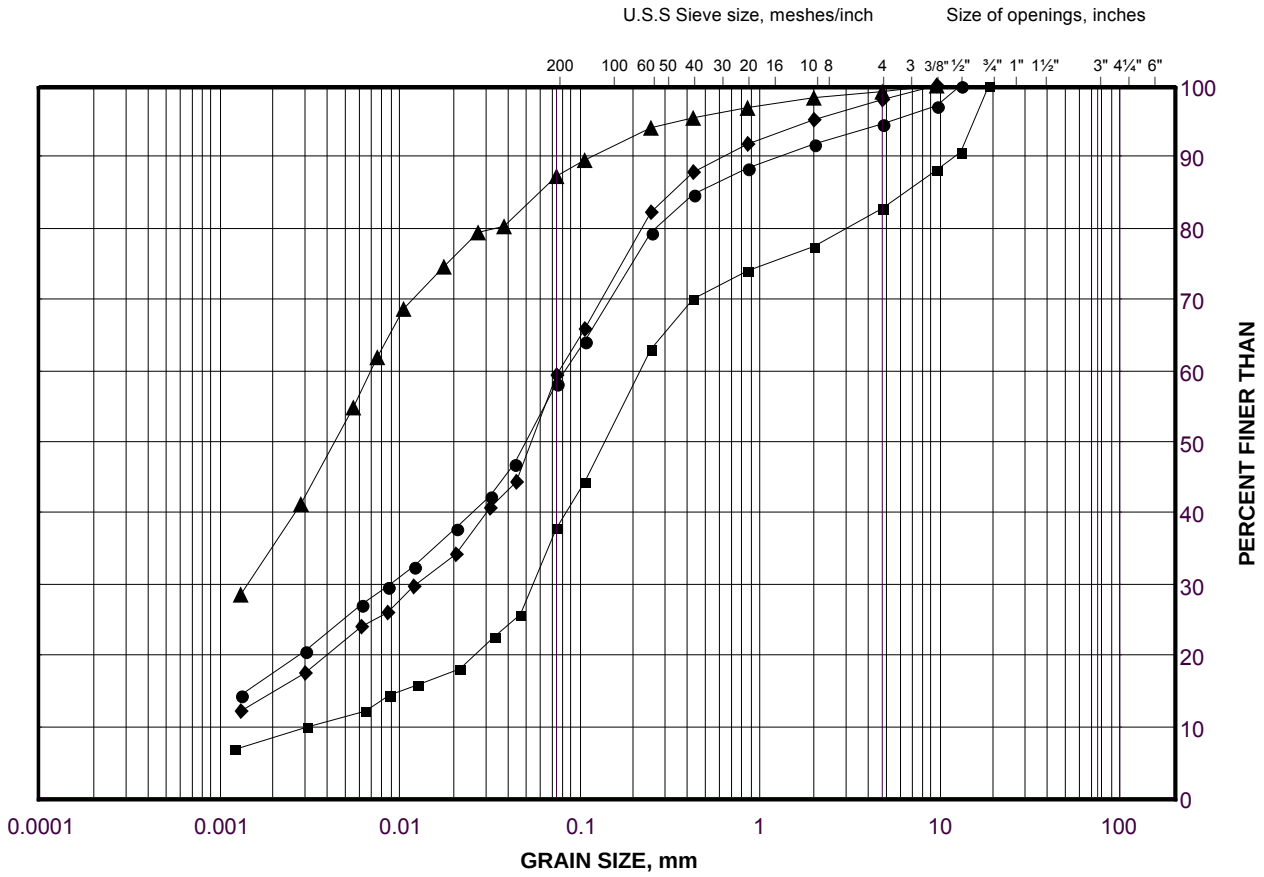
Golder Associates

Date: 01-Oct-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (TILL)

FIGURE B4A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-50	2	109.8
■	13-49	2	109.9
◆	13-50	3	109.3
▲	HR-2	4	109.1

Project Number: 09-1111-0019

Checked By: MWK

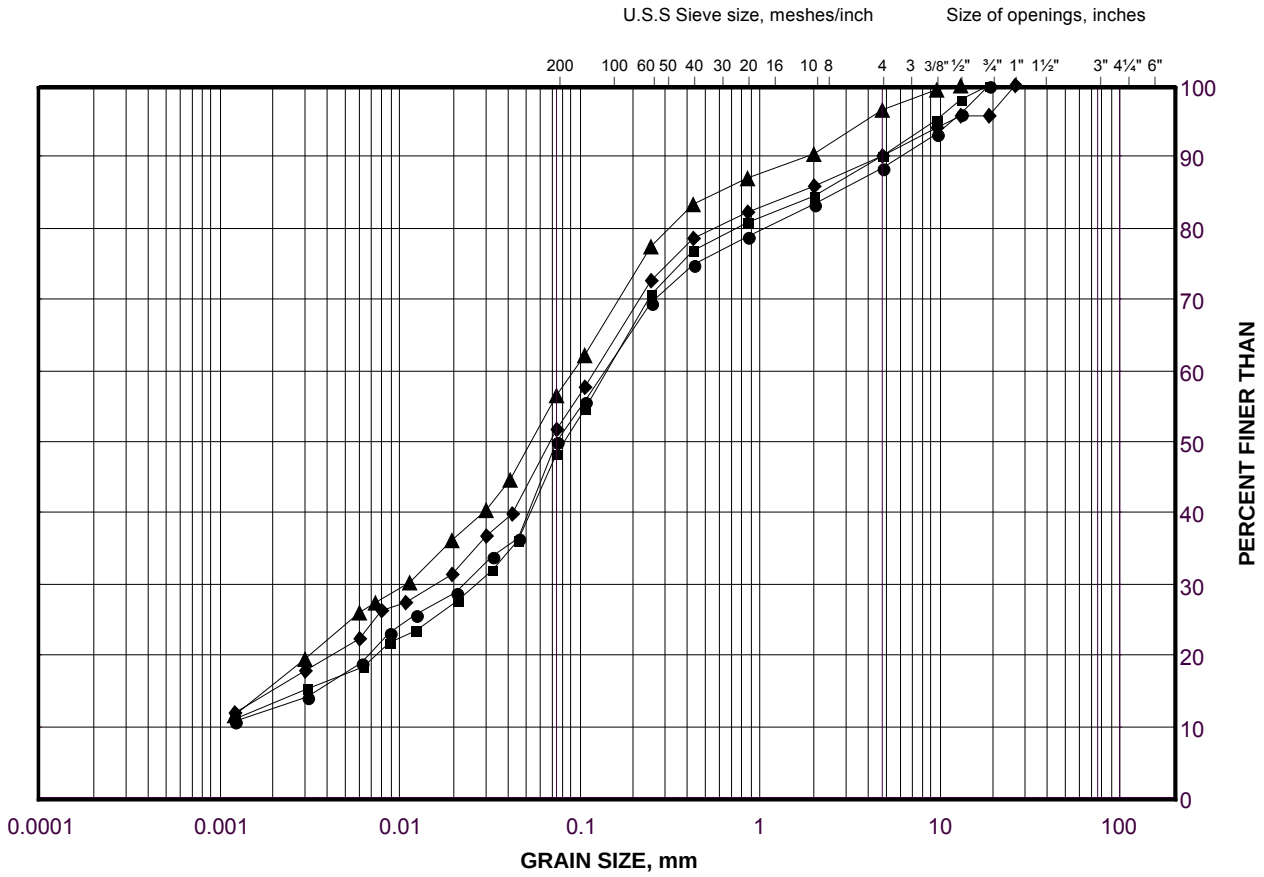
Golder Associates

Date: 12-Dec-13

GRAIN SIZE DISTRIBUTION

Clayey Silt (TILL)

FIGURE B4B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HR-1	4	109.1
■	13-50	5	107.9
◆	13-46	7	109.3
▲	13-45	7	109.2

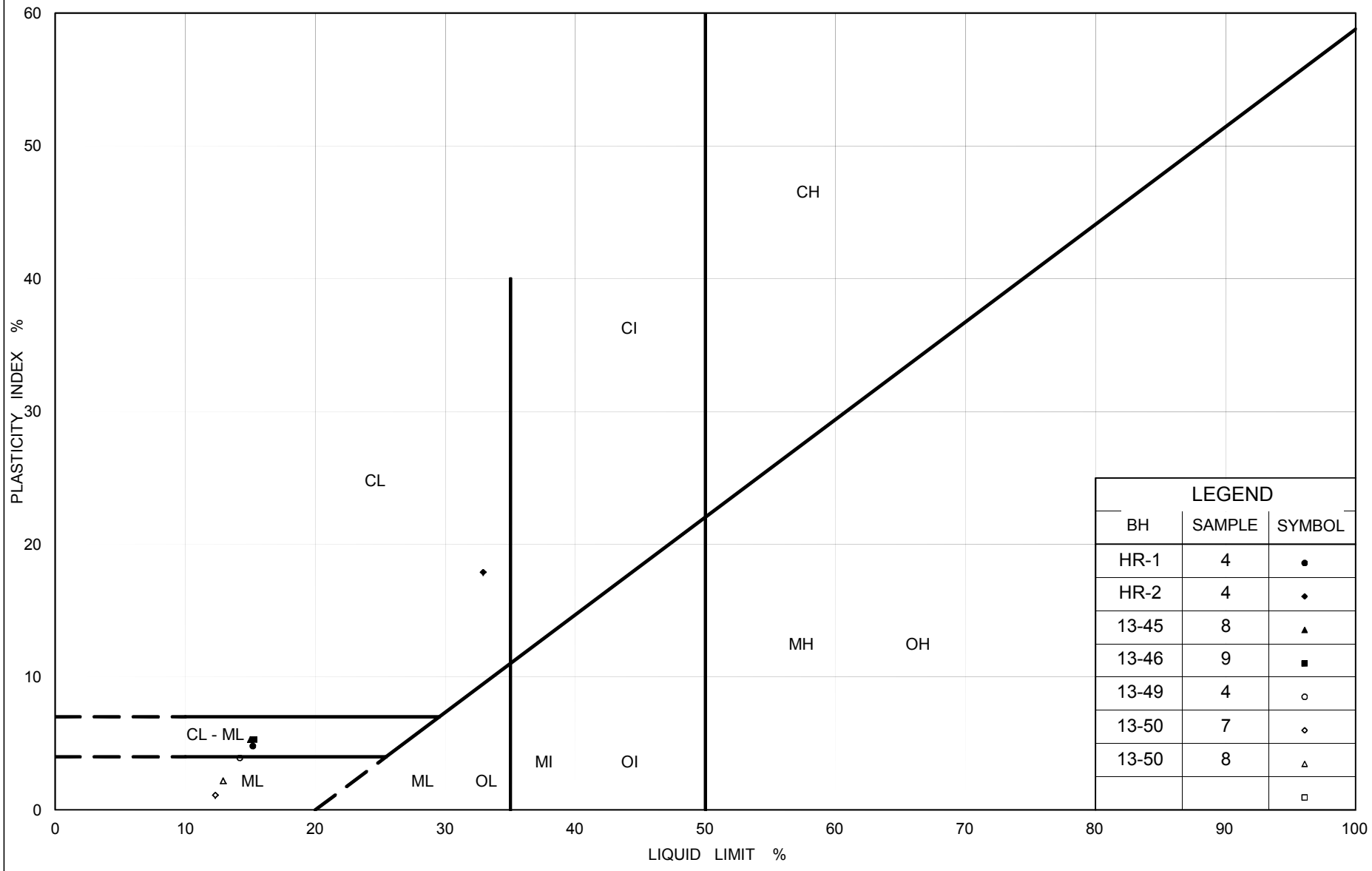
Project Number: 09-1111-0019

Checked By: MWK

Golder Associates

Date: 12-Dec-13

Oct 75, FF-S-21



Ministry of Transportation

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PLASTICITY CHART
Clayey Silt (TILL)

Figure No. B5

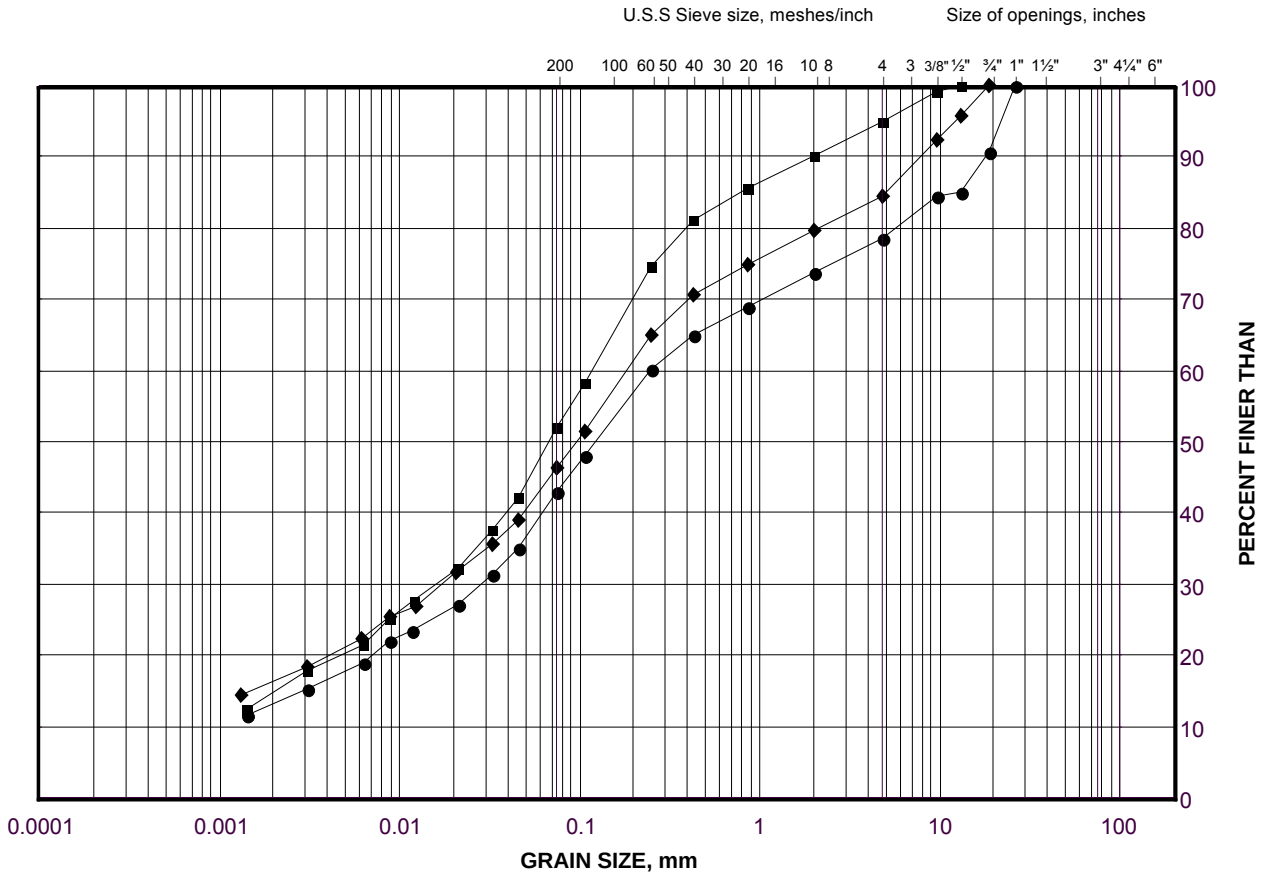
Project No. 09-1111-0019

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Sand and Silt (TILL)

FIGURE B6A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-48	4	109.2
■	13-48	6	107.9
◆	13-47	6	108.4

Project Number: 09-1111-0019

Checked By: MWK

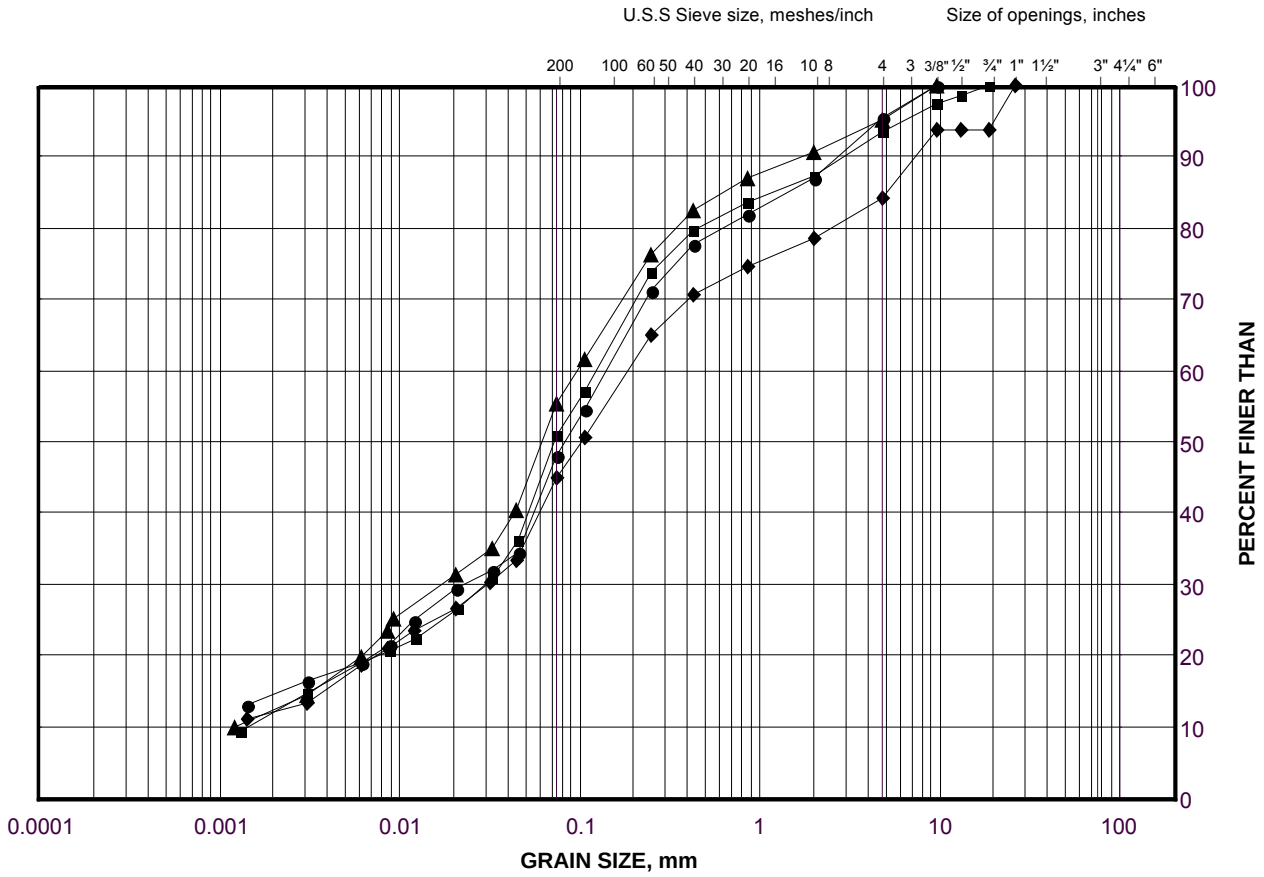
Golder Associates

Date: 12-Dec-13

GRAIN SIZE DISTRIBUTION

Sand and Silt (TILL)

FIGURE B6B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	HR-2	5	108.6
■	13-49	6	107.0
◆	HR-1	6	107.8
▲	HR-1	8	105.5

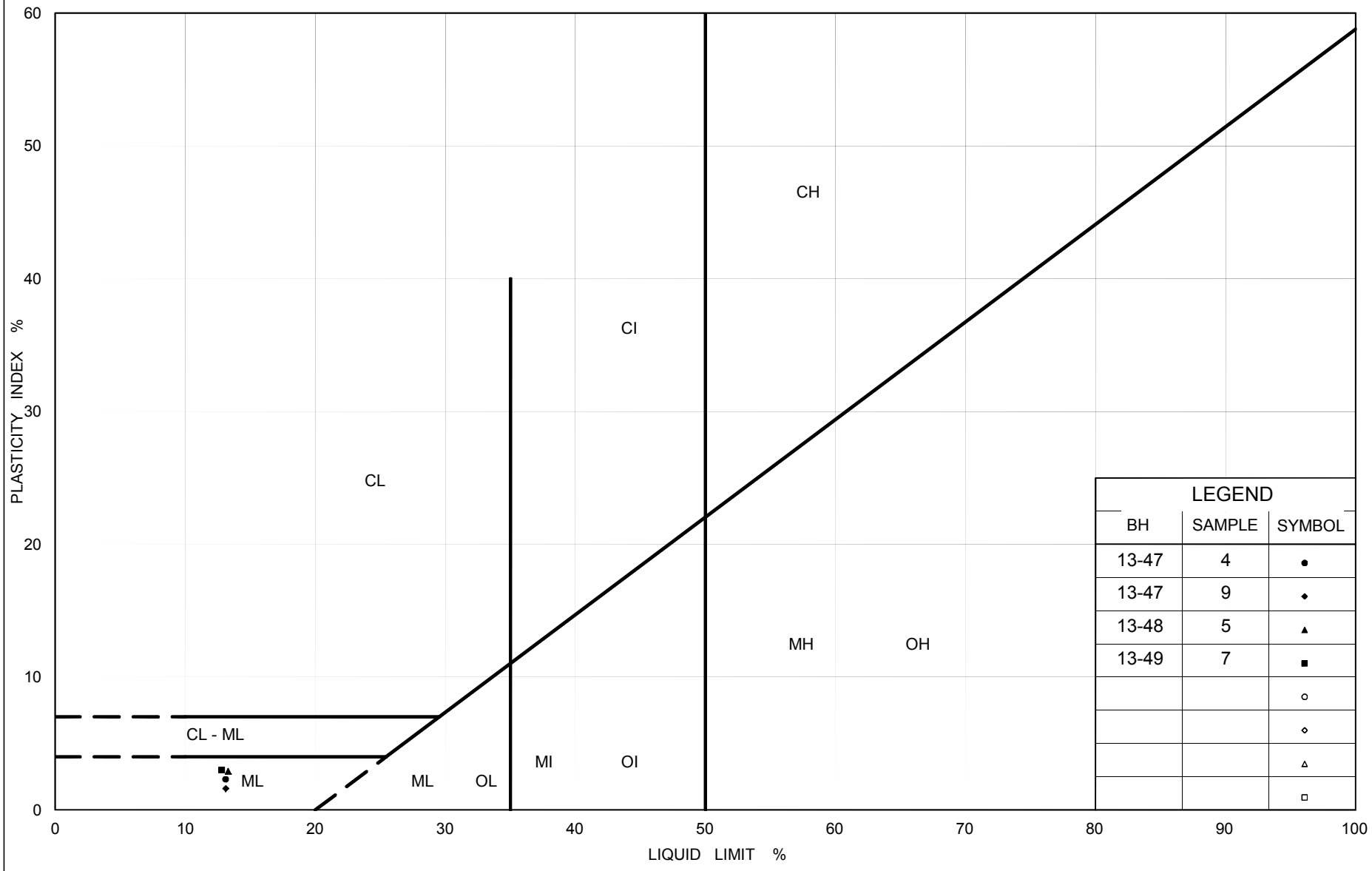
Project Number: 09-1111-0019

Checked By: MWK

Golder Associates

Date: 12-Dec-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sand and Silt (TILL)

Figure No. B7

Project No. 09-1111-0019

Checked By: MWK

APPENDIX C

Borehole Logs – Previous Investigation

OFFICE REPORT OF SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See drawing

DATUM 370.0' COMPILED BY B.K.

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

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

LEGEND

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

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

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200

CONSISTENCY

MOIST. CONTENT - % DRY WT.

10 20 30

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

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See Drawing

DATUM 369.0' COMPILED BY B.K.

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

LEGEND

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

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

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

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

CONSISTENCY
MOIST. CONTENT % DRY WT.
10 20 30

SAMPLE NATURAL UNIT WT. P.C.F.

S1 –
S2 –
S3 –
S4 –

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-P-15 STATION See Drawing

DATUM 367.0' COMPILED BY B.K.

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

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

LEGEND

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

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

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 BLOWS/FT. 200

CONSISTENCY

MOIST. CONTENT - % DRY WT.

SAMPLE

NATURAL UNIT WT. P.C.F.

S1 -
S2 -
S3 -
S4 -
S5 -

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See Drawing

DATUM 367.0' COMPILED BY B.K.

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

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

LEGEND

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

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

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

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

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

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

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See Drawing

DATUM 369.0' COMPILED BY B.K.

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

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

LEGEND

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

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

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 BLOWS/FT

CONSISTENCY

MOIST. CONTENT % DRY WT.

10 20 30

SAMPLE

S1
S2
S3
S4

NATURAL UNIT WT. P.C.F.

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See Drawing

DATUM 366.0' COMPILED BY B.K.

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

LEGEND

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

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

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

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 P.S.F.

CONSISTENCY

MOIST. CONTENT % DRY WT

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

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

JOB 61-F-15 STATION See Drawing

DATUM 365.5' COMPILED BY B.E.

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

LEGEND

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

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

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

STRENGTH AND PENETRATION RESISTANCE P.S.F.

50 100 150 200 P.S.F.

0
10
20
30
40

CONSISTENCY

MOIST. CONTENT - % DRY WT.

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

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

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