REPORT

June 9, 2017

FOUNDATION INVESTIGATION REPORT

Highway 401 Structural Culvert - Site No. 22-438/C Rehabilitation/Replacement - Highway 35/115 and Highway 401
Ministry of Transportation, Ontario
W.P. 2242-14-00

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GEOCRES NO: 30M15-317

Report Number: 1540419-8

Distribution:

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TABLE OF CONTENTS

TABLES

DRAWINGS

APPENDICES

PART A

FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 STRUCTURAL CULVERT, SITE NO. 22-438/C
STRUCTURAL CULVERT REHABILITATION/REPLACEMENT
HIGHWAY 35/115 AND HIGHWAY 401
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Golder Associates

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. (D.M. Wills) on behalf of Ministry of Transportation, Ontario (MTO) to provide Foundation Engineering services for the rehabilitation and extension of a structural culvert at STA 14+714 on Highway 401 in the Town of Whitby, Regional Municipality of Durham, Ontario (MTO Structure Site No. 22-438/C) as shown on the Key Plan on Drawing 1.

The Terms of Reference and the Scope of Work for the foundation investigation are outlined in MTO's Request for Quotation, dated August 2015. Golder's proposal for the Foundation Engineering services associated with the rehabilitation/replacement of various culverts on Highway 35/115 and Highway 401 is contained in Section 3.5 of D.M. Wills' Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated December 1, 2016.

This report addresses the investigation carried out for the structural culvert at about STA 14+714 on Highway 401 (MTO Structure Site No. 22-438/C) which has been identified for potential rehabilitation and extension 8.9 m to the north and 5.1 m to the south. The foundation investigation and design associated with the other culverts, which forms part of the Foundation assignment are presented in separate reports. The current investigation was supplemented with information from a previous investigation for the Highway 401 and Pringle Creek area, as follows:

- **Golder Associates Report No. 13-1186-0419**: Geotechnical Investigation Report: Proposed Watermain Replacement Crossing Highway 401 Right-of-Way at Pringle Creek, Town of Whitby, Ontario" Dated 2015.

2.0 SITE DESCRIPTION

The structural culvert at Site No. 22-438/C (Culvert C8) requiring rehabilitation and extension or replacement, is located at approximately STA 14+714 on Highway 401 in the Town of Whitby, Regional Municipality of Durham, Ontario. The existing structural culvert is an open footing concrete structure and is 56.65 m long, 6.09 m wide by 3.5 m high. The structure is located within the highway embankment and has less than approximately 1 m of cover. Details of the culvert are summarized in Table 1 following the text of this report.

The overall surface topography in the vicinity of the site is generally flat-lying to gently sloping, with the natural ground surface at approximately Elevation 79 m. The Highway 401 grade over the culvert is at about Elevation 81.1 m. The existing Highway 401 embankment consist of earth fill, up to about 3.5 m high with side slopes inclined at approximately 2 horizontal to 1 vertical (2H:1V).

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigation

The fieldwork for the current investigation associated with structural culvert Site No. 22-438/C was carried out on July 28 and December 19, 2016, and January 16, 24 and 25, 2017 during which time a total of three boreholes, designated as Boreholes C8-1, C8-2 and C8-4, were advanced at, or in the immediate vicinity of the culvert alignment as shown in plan on Drawing 1.

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

Drilling Equipment	Supplied and Operated By
Truck-Mounted CME 75	AtCost Drilling Inc. of Gormley, Ontario
Track-Mounted Mini-Mole	Kodiak Drilling Inc. of Oakville, Ontario
Portable Equipment	Walker Drilling Ltd. of Utopia, Ontario

The boreholes drilled by the truck-mounted CME75 drill rig were advanced through the overburden using 208 mm outer diameter (O.D.) 108 mm inner diameter (I.D.) hollow stem augers. The boreholes drilled by the track-mounted Mini-Mole rig were advanced through the overburden using 102 mm diameter solid stem augers. The boreholes completed with the portable equipment were advanced through the overburden using BW size casing with wash boring techniques. Soil samples were obtained continuously at some borehole locations but generally at intervals of depth of about 0.75 m and 1.5 m using a 50 mm O.D. split-spoon sampler operated by an automatic hammer on the drill rigs, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586[1]). Borehole C8-1 advanced by portable equipment employed a 40.8 kilogram hammer lifted manually and dropped from the SPT height; the SPT 'N'-values shown on the Record of Borehole for C8-1 have been corrected to the 'N'-values expected to have been achieved when using a full weight hammer. Bedrock in Boreholes C8-1 and C8-2 was cored using wet diamond drilling techniques and BQ and NQ core sizes, respectively. At the location of Borehole C8-1, approximately 1 m of the bedrock was cored from Elevations 73.2 m to 72.2 m. At the location of Borehole C-8-2, approximately 4.2 m of the bedrock was cored from Elevations 73.2 m to 69.0 m.

A piezometer was installed in Borehole C8-4 to allow monitoring of the groundwater level at this site. The piezometer consists of a 25 mm diameter PVC pipe, with a slotted screen sealed within the sand and gravel to clayey silt deposits. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled with bentonite pellets to ground surface. The piezometer installation details and water level readings are noted on the Record of Borehole C8-4 in Appendix A. All other boreholes were backfilled with bentonite upon completion of drilling in accordance with Ontario Regulation 903 (Wells) (as amended). The groundwater soil sample conditions were noted as the samples were retrieved but the water levels in the open boreholes were not recorded immediately prior to start of coring operations nor following the drilling operations, after introduction of drilling water, as noted on the Record of Borehole sheets in Appendix A. The groundwater level in the piezometer in Borehole C8-4 was monitored immediately after installation and about eight months later (March 2017) and as noted on the Record of Borehole sheet and summarized in Section 4.2.11.

The fieldwork was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the soil and bedrock samples. The soil and bedrock samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were

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

carried out to MTO Laboratory and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected soil samples and strength testing (Unconfined Compression and Point Load) was carried out on selected samples of the cored bedrock. The results of the laboratory testing are summarized on the Record of Borehole and Record of Drillhole sheets in Appendix A and provided in Appendix B.

A soil sample obtained during the field investigation at about the culvert invert elevation, using appropriate sampling protocols, was submitted to a specialist analytical laboratory under chain of custody procedures for chemical analysis of conductivity / resistivity, pH, sulphate and chloride content and redox potential to assess the potential for the soil to cause corrosion to buried concrete and steel. The results of the analytical testing are presented in Appendix C and summarized in Section 4.3.

The as-drilled borehole locations were measured relative to existing site features and were subsequently converted into MTM NAD 83 coordinates in AutoCAD. The Geodetic elevation of the boreholes was obtained by plotting the borehole locations on the topographic mapping provided by D.M. Wills on January 20, 2016. The borehole locations given on the Record of Borehole and Record of Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (m)		Location (degrees)		Ground Surface Elevation (m)	Depth of Borehole (m)
	Northing	Easting	Lat.	Long.		
C8-1	4858601.8	350978.9	43.865944	-78.925481	78.8	6.6*
C8-2	4858584.5	350977.3	43.865800	-78.926000	81.0	12.0*
C8-4	4858535.8	350986.1	43.865349	-78.925399	79.1	5.5

*Includes 1.0 m and 4.2 m of bedrock coring, respectively.

3.2 Previous Investigation

The field work for the previous investigation was carried out between June 17 and July 3, 2015, during which time three boreholes (Boreholes 15-1 to 15-3) were drilled at the approximate locations shown on Drawing 1. The boreholes were advanced with track-mounted and truck-mounted drill rigs, supplied and operated by AtCost Drilling Inc. of Gormley, Ontario.

The boreholes were advanced through the overburden using 210 mm O.D. hollow stem augers. Soil samples were obtained continuously at some borehole locations but generally at intervals of depth of about 0.75 m using a 50 mm O.D. split-spoon sampler operated by an automatic hammer on the drill rigs, performed in accordance with SPT procedures. HQ coring was advanced within the bedrock in Borehole 15-1, between the depths of 6.3 m and 7.2 m, followed by hollow stem augering to carry out an SPT in the shale bedrock at this location as groundwater pressures affected the ability to continue rock coring operations.

Piezometers were installed in Boreholes 15-1 and 15-3 to allow monitoring of the groundwater level at this site. The piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed within the shale bedrock. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled with

bentonite pellets to ground surface. The piezometer installation details and water level readings are noted on the Record of Boreholes 15-1 and 15-3 in Appendix D. Boreholes 15-2 was backfilled with bentonite upon completion of drilling in accordance with Ontario Regulation 903 (Wells) (as amended). The groundwater conditions and water levels in the open boreholes were observed during and immediately following the drilling operations and are described on the Record of Borehole sheets in Appendix D.

The fieldwork at that time was observed by members of Golder's engineering and technical staff. Soil and bedrock samples were identified in the field, placed in appropriate containers, labelled and transported to our Whitby geotechnical laboratory where the samples underwent further visual examination and classification testing (water content, Atterberg limits and grain size distribution) of selected soil samples. The results of the laboratory testing are summarized on the Record of Borehole and Record of Drillhole sheets and laboratory test sheets in Appendix D.

The borehole locations given on the Record of Borehole and Record of Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are as follows:

Borehole	Location (m)		Ground Surface Elevation (m)	Depth of Borehole (m)
	Northing	Easting		
15-1	4858611.3	3510003.9	79.0	7.7*
15-2	4858562.5	351014.0	81.5	9.2
15-3	4858525.5	351015.5	79.2	7.7

*Includes 0.9 m of bedrock coring

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 and underlain by the black bituminous shale of the Whitby Formation.

4.2 General Overview of Local Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation as well as the previous investigation, together with the results of the laboratory tests carried out on

[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.

selected soil samples, are presented on the Record of Borehole and Drillhole sheets and the laboratory test sheets in Appendices A, B, and D. The stratigraphic boundaries shown on the Record of Boreholes and Record of Drillhole sheets and stratigraphic profile are inferred from non-continuous sampling, observations of drilling progress and in situ testing and are approximate. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations.

The stratigraphy at the locations of the current investigation and previous borehole locations at the culvert site consists of embankment fill materials which extend to between approximately Elevations 77.3 m and 79.6 m, except at Borehole C8-4 where no fill was encountered. From the ground surface at Borehole C8-4 and underlying the fill materials there are variable native deposits consisting of loose to dense gravelly sand, very soft to very stiff clayey silt and till-like materials, and glacial tills ranging in gradation from clayey silt, silty sand, gravelly sand to sand and gravel. Shale bedrock, which was found to be weathered and highly fractured, water-bearing and pressurized, was encountered at depths ranging from Elevation 73.9 m at the location of Borehole C8-2 to Elevation 74.7 at the location of Borehole 15-1. Sampler and auger refusal in Borehole C8-4 occurred at elevation 73.6 m.

A detailed description of the subsurface conditions at the culvert crossing is provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit or stratum.

4.2.1 Asphalt and Road Base

Boreholes C8-2 and 15-2 were advanced through the paved shoulder of the westbound Highway 401 and through the left (median) shoulder of eastbound Highway 401, respectively. These boreholes penetrated an asphalt layer between approximately 150 mm and 125 mm thick, respectively. The underlying layer of road base material consists of sand and gravel fill and is 600 mm and 715 mm thick at the respective boreholes.

The SPT ‘N’-values measured in this layer are 14 blows and 76 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

4.2.2 Topsoil

A 25 mm thick layer of topsoil was encountered at ground surface in Borehole C8-1. In Borehole 15-3, a topsoil sandy silt fill mixture extended from ground surface to a depth of 1.9 m below ground surface. In Borehole 15-2, an approximately 0.8 m thick layer of mixed topsoil and silty sand fill was encountered at the bottom of the embankment fill (described below).

The SPT ‘N’-values measured within the topsoil/topsoil-sandy silt fill mixture range from 4 blows to 11 blows per 0.3 m of penetration, indication a loose to compact relative density.

4.2.3 Embankment Fill

An embankment fill layer, approximately 0.7 m to 2.9 m thick was encountered in all boreholes, with the exception of Borehole C8-4, immediately below existing ground surface and underlying the topsoil or road base layer (where present). The embankment fill consists of various layers, thicknesses and composition, especially in Borehole 15-1. In Borehole C8-1, an approximately 0.7 m thick layer of silty sand, some gravel and containing trace topsoil inclusions was encountered below the surface topsoil layer. In Borehole C8-2, an approximately 0.6 m thick layer of sandy clayey silt with some gravel was encountered below the asphalt and road base material.

In Borehole 15-1, a 0.7 m thick layer of silt and sand with some gravel and organic inclusions was encountered below ground surface, underlain by an approximately 1 m thick layer of silty sand containing rootlets , organic inclusions and wood fragments.

In Borehole 15-2 underlying the asphalt and road base materials, the borehole penetrated an approximately 3.9 m tick deposit of fill comprised of a 0.9 m thick layer of silty sand with some clay and gravel, underlain by a 0.4 m thick layer of silty clay and some sand, and a 0.8 m thick layer of sandy clayey silt, underlain by the layer of topsoil and silty sand mixture (as described in previous section).

The SPT 'N'-values measured within the non-cohesive embankment fill layers range between 2 blows and 11 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The SPT 'N'-values measured in the cohesive embankment fill layers are 11 blows and 21 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The natural water content measured on three samples of the cohesive embankment fill from the current and previous investigations range from 10 per cent to 14 per cent.

The natural water content measured on eight samples of the non-cohesive embankment fill from the current and previous investigations range from 8 per cent to 32 per cent.

The result of a grain size distribution test completed on one sample of the silty sand fill encountered in Borehole 15-2 is shown on Figure D1 in Appendix D.

An Atterberg limits test carried out one sample of the sandy cohesive embankment fill measured a liquid limit of about 20 per cent, a plastic limit of about 13 per cent and a plasticity index of about 7 per cent. The test result, which is plotted on a plasticity chart on Figure B1 in Appendix B, indicates that the material is a clayey silt of low plasticity.

4.2.4 Silty Sand to Sand

A 1.6 m thick deposit of silty sand and a 2.3 m thick deposit of sand was encountered below the fill materials in Borehole C8-2 and from ground surface in Borehole C8-4 at Elevation 79.6 m and 79.1 m respectively.

SPT "N"-values ranging from 5 blows to 21 blows per 0.3m of penetration were measured within this layer, indicating a loose to compact relative density.

The natural water contents of two samples of the silty sand to sand are 9 per cent and 13 per cent. A grain size distribution curve for one sample the sand portion of the deposit is shown on Figure B2 in Appendix B

4.2.5 Gravelly Sand

A deposit of gravelly sand was encountered below the fill materials in Borehole 15-2 at Elevation 77.8 m and extended to a depth of about 5.5 m below existing ground surface. In Borehole C8-2 a 4.1 m thick deposit of gravelly sand was encountered below the silty sand deposit at Elevation 78.0 m.

SPT "N"-values ranging from 8 blows to 15 blows per 0.3 m of penetration were measured within this deposit, indicating a loose to compact relative density.

The natural water content of the samples of the gravelly sand ranged from about 5 per cent to 28 per cent. The results of four grain size distribution curves for the samples of gravelly sand are shown on Figure B3 in Appendix

B and Figure D2 in Appendix D. An Atterberg Limits test carried out on a sample of the gravelly sand deposit indicates a plastic limit of about 15 per cent, a liquid limit of about 22 per cent and a plasticity index of about 7 per cent, indicating that the fines material of the deposit is a silty clay of low plasticity as shown on Figure B4 in Appendix B.

4.2.6 Clayey Silt to Sandy Clayey Silt

A 1.2 m and 0.5 m thick deposit of clayey silt to sandy clayey silt was encountered below the fill deposits in Boreholes 15-1 and 15-3 at Elevation 77.3 m; and a 1.8 m thick deposit of clayey silt was encountered below the sand and gravel (till-like) deposit (described below) in Borehole C8-4 at Elevation 75.0 m. SPT "N"-values of 1 blow to 2 blows per 0.3 m of penetration, and 70 blows for 0.15 m of penetration, were measured in this deposit, suggesting a very soft to hard consistency. The harder 'N'-values are likely due to the presence of shell fragments in this portion of the deposits.

The natural water contents of the samples of the clayey silt to sandy clayey silt range from about 9 per cent to 26 per cent. The grain size distribution curve for a sample of the sandy clayey silt is shown on Figure D3 in Appendix D. Atterberg limits testing carried out on two samples of sandy clayey silt to clayey silt yielded liquid limits of about 24 per cent, plastic limits of about 12 per cent and 17 per cent, and plasticity indices of about 12 per cent and 7 per cent, indicating a clayey silt of low plasticity, as shown on the plasticity chart on Figure D4 in Appendix D and Figure B in Appendix B.

4.2.7 Silty Sand and Gravel to Sand and Gravel (Till-Like)

A 1.4 m thick till-like deposit of silty sand and gravel to sand and gravel was encountered below the sandy clayey silt deposit in Borehole 15-1 at Elevation 76.1 m. In Boreholes C8-1 and C8-4, a silty sand deposit grading to a till-like sand and gravel deposit was encountered below the silty sand till layer and below the sand deposit, respectively. The deposit was encountered at Elevations 78.0 m and 76.8 m in the respective boreholes and the layers are 1.5 m and 2.1 m thick in Borehole C8-1 and C8-4.

SPT "N"-values measured within the till-like layers range from 7 blows to 76 blows per 0.3 m of penetration, and 90 blows for 0.08 m of penetration, indicating a loose to very dense relative density.

Grain size distribution test results of four samples of the till-like silty sand and gravel are shown on Figure B6 and D5 in Appendices B and D, respectively.

An Atterberg limits test carried out on a sample of the silty sand (till-like) deposit and measured a plastic limit of about 23 per cent, a liquid limit of about 15 per cent corresponding to a plasticity index of about 8 per cent, indicating that the fines portion of the till-like deposit is a silt of slight plasticity as shown on Figure B7 in Appendix B.

4.2.8 Clayey Silt Till to Clayey Silty Sand Till

A till deposit comprised of clayey silt to clayey silty sand was encountered below the clayey silt deposit in Borehole 15-3 at Elevation 76.8 m and is 2.0 m thick.

SPT "N"-values of 57 blows per 0.3 m of penetration and 50 blows per 0.13 m of penetration were measured within the till, indicating a hard consistency. The till deposits of the Greater Toronto Area known to contain cobbles and boulders, and these materials are anticipated to be present within the till deposits at this site as inferred from auger grinding in this borehole.

The measured water contents of the samples of the clayey tills ranged between about 6 per cent and 7 per cent. A grain size distribution test on a sample of clayey silty sand till is shown on Figure D6 in Appendix D. An Atterberg limits test carried out on a samples of the cohesive till measured a liquid limit of about 21 per cent, a plastic limit of 12 per cent, and a plasticity index of about 9 per cent, indicating a clayey silt of low plasticity, as shown on the plasticity chart on Figure D7 in Appendix D.

4.2.9 Silty Sand Till to Gravelly Silty Sand Till

A 2.0 m thick and 0.8 m thick deposit of silty sand to gravelly silty sand till was encountered in Boreholes 15-2 and 15-3 at Elevations 76.0 m and 74.8 m, respectively.

Standard Penetration Tests carried out within the silty sand till to gravelly silty sand till measured SPT “N”-values ranging from 34 blows to 42 blows per 0.3 m of penetration and 95 blows for 0.28 m of penetration, indicating a dense to very dense relative density.

The measured water contents of the samples of the silty sand to gravelly silty sand till range from about 6 per cent to 10 per cent. The grain size distribution test results for one sample of the silty sand till and one sample of gravelly silty sand till portions of the deposit are shown on Figure D8 in Appendix D.

4.2.10 Shale Bedrock

Shale bedrock was encountered in Boreholes C8-1, C8-2, 15-1, 15-2, and 15-3 at depths ranging from approximately 4.3 m and 7.5 m below ground surface (between Elevations 74.7 m and 73.9 m). The upper 0.7 m to 2.0 m of the bedrock is inferred to be highly weathered to moderately weathered, fractured and water-bearing based on various SPT samples and examination and the groundwater conditions observed during drilling of the boreholes. The SPT “n”-values in the weathered shale portion of the bedrock are 55 blows and 63 blows per 0.3 m of penetration and range from 32 blows for 0.1 m of penetration to 50 blows for no penetration (spoon bouncing) suggesting the variability in the weathered nature of the upper portion of the bedrock. The shale is also bituminous in nature as inferred from the hydrocarbon-like odour observed in the shale bedrock in Borehole 15-1.

At the location of Borehole 15-1, approximately 0.9 m of the bedrock was cored using wet diamond drilling techniques (HQ core size) from Elevation 72.7.

The bedrock in Boreholes C8-1 and C8-2 was cored using wet diamond drilling technical and BQ and NQ core sizes, respectively. At the location of Borehole C8-1, approximately 1 m of the bedrock was cored from Elevation 73.2 m and in Borehole C8-2, approximately 4.2 m of the bedrock was cored from Elevation 73.2 m.

The Total Core Recovery (TCR) of the cored bedrock ranges between about 77 per cent and 100 per cent, the Solid Core Recovery (SCR) ranges between about 60 per cent and 100 per cent. The Rock Quality Designation (RQD) ranges between about 0 per cent and 32 per cent with core runs of up to 100 per cent, indicating rock of very poor to excellent quality as per Table 3.10 of CFEM (2006).

Based on a review of the recovered bedrock core samples, the bedrock consists of black, moderately weathered shale. Detailed descriptions of the bedrock are presented on the Record of Drillhole sheets in Appendix A.

An Unconfined Compressive Strength (UCS) test carried out on one sample of the shale bedrock from Borehole C8-2 measured a uniaxial compressive strength of about 45 MPa. The test result which is shown on the Record of Drillhole sheet in Appendix A and summarised in Table B1 in Appendix B, indicates that the bedrock is medium strong (R3) as per Table 3.5 of CFEM (2006).

Axial point load index tests were performed on eight selected samples of the rock core recovered from Boreholes C8-1 and C8-2 at this site and the strength index values are presented on the Record of Drillhole Sheets in Appendix A and detailed in Table B2 in Appendix B. The point load index (Is_{50}) results of core samples of the shale bedrock range from approximately 1.8 MPa to 3.9 MPa. These index values correspond to UCS values ranging between about 28 MPa and 62 MPa, based on a relationship between Is_{50} and UCS which is given by a correlation factor (C), estimated to be equal to 15.9 for this site, and calculated as the ratio of the laboratory UCS and average corresponding point load test index value from all of the drillholes at this site. These values have been given for comparison only and should be interpreted together with the results of the UCS tests.

Based on the laboratory UCS tests and point load testing results, the estimated intact strength of the shale bedrock generally ranges from medium strong (R3, 25 MPa < UCS < 50 MPa) to strong (R4, 50 MPa < UCS < 100 MPa); (Table 3.5 of CFEM, 2006).

4.2.11 Groundwater Conditions

The water level was not recorded in Boreholes C8-1 and C8-2 prior to bedrock coring.

A standpipe piezometer had been installed in Borehole C8-4 west of the existing culvert outlet. Standpipe piezometers previously installed in Boreholes 15-1 and 15-3 were monitored at the time of the previous investigation. The observed groundwater levels are shown on the Record of Borehole sheets and summarized below.

Borehole	Depth to Water Level (m)	Groundwater Elevation	Date of Measurement
C8-4	4.6	74.5	July 28, 2016
	1.1	78.0	March 28, 2017
15-1	0.3	78.7	July 8, 2015
	0.5	78.5	July 13, 2015
	0.6	78.4	July 15, 2015
15-3	0.9	78.3	July 8, 2015
	1.1	78.1	July 13, 2015
	1.1	78.1	July 15, 2015

The water level observed in the boreholes during and/or upon completion of drilling may not represent the longer-term, stabilized groundwater level at the site. The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

4.3 Analytical Testing of Soil Sample

Analytical testing was carried out on a composite soil sample constituted from the SPT samples recovered from near the culvert invert elevation at Borehole C8-1. The analytical parameters include conductivity / resistivity, pH sulphate and chloride to allow for the assessment of the potential for the soil to cause deterioration of concrete and corrosion of steel. The laboratory test results are included in Appendix D and are summarized below.

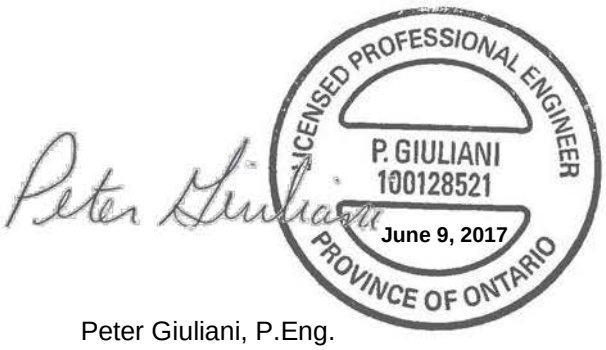
Parameter	Test Result
Soil Resistivity	1800 ohm-cm
Soil Conductivity	550 umho/cm
Sulphate Concentration	160 ug/g
Chloride Concentration	180 ug/g
PH	7.9

5.0 CLOSURE

Messrs. Pat Speirs and Michael Bentley, and Ms. Amelia Jewison supervised the borehole investigation program. This report was prepared by Mr. Peter Giuliani, P.Eng., a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., Senior Consultant with Golder and Designated MTO Foundations Contact conducted an independent quality control review of this report.

Report Signature Page

GOLDER ASSOCIATES LTD.



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Designated MTO Foundations Contact, Senior Consultant

PG/MWK/JMAC/mck

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TABLES

Table 1: Summary of Existing Culvert Details

Culvert Location (Township)	Culvert ID	Approximate Height of Embankment [1]	Existing Culvert			Approximate Invert Elevation [2]		Boreholes	Previous Investigation Boreholes
			Type	Approximate Dimension	Approximate Length	North End of Culvert	South End of Culvert		
STA 14+417 (Whitby)	C8	Up to about 3.7 m	Open Footing	6.1 m x 3.5 m	56.65 m	76.37 m	76.40 m	3 Boreholes (C8-1, C8-2 and C8-4)	3 Boreholes (15-1, 15-2 and 15-3)

Notes: 1. Embankment height is relative to existing ground surface level at the toe of embankment adjacent to the culvert.

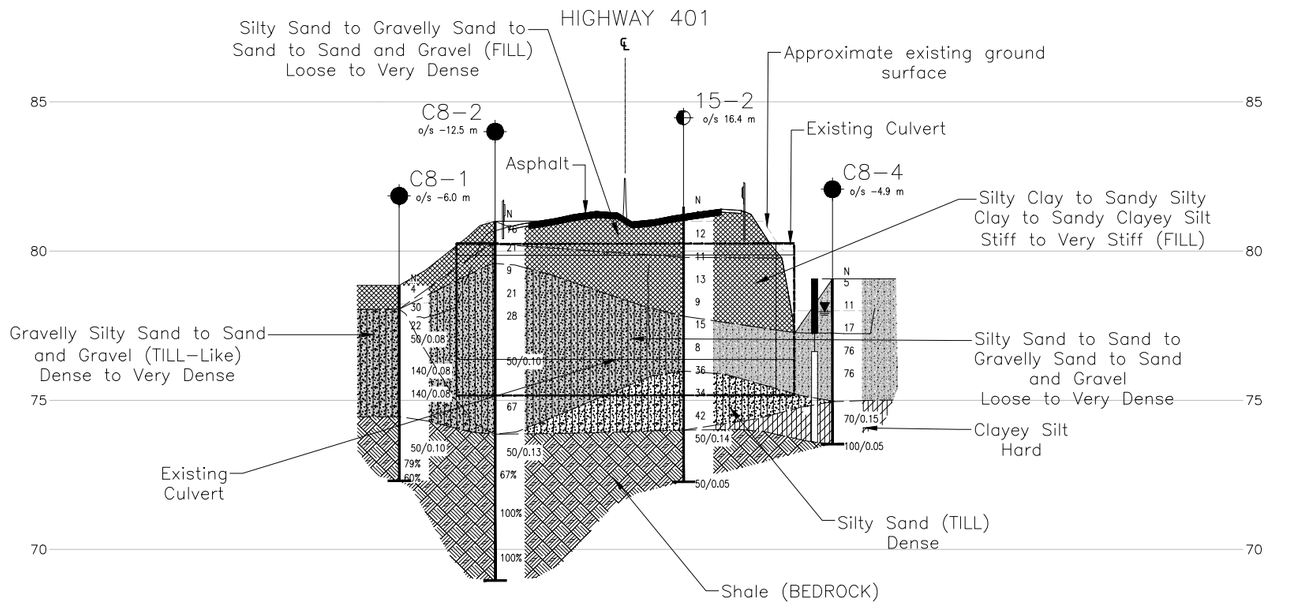
2. Culvert invert elevations are estimated based on the top of culvert surveys and culvert dimensions provided by MTO.

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

PLAN

SCALE
10 0 10 20 m



HORIZONTAL SCALE
10 0 10 20 m

A-A' / 1 CULVERT C8 STA. 14+714

VERTICAL SCALE
2 0 2 4 m

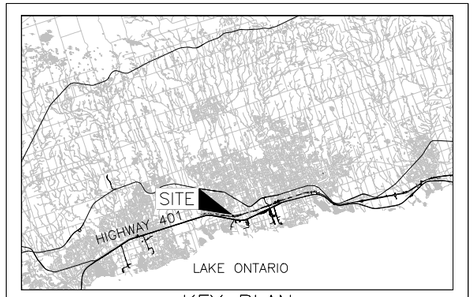
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. 2017-2016
WP No. 2242-14-00

HIGHWAY 401
STRUCTURAL CULVERT STA. 14+714
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 18

Golder Associates



KEY PLAN
SCALE
6 0 6 12 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)*
- WL in piezometer, measured on SEP 13, 2016

BOREHOLE NOTE

* Borehole C8-1 SPT N-Values corrected for ⅔ Weight Hammer.

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
15-1	79.0	4858611.3	351003.9
15-2	81.5	4858562.5	351014.0
15-3	79.2	4858525.5	351015.5
C8-1	78.8	4858601.8	350978.9
C8-2	81.0	4858584.5	350977.3
C8-4	79.1	4858535.8	350986.1

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.

Geographic Coordinates of Culvert: Latitude 43.865380; Longitude -78.925308

REFERENCE

Base Plan and Contours provided in digital format by DM Wills, drawing file nos. 123019.dwg, received Jan. 20, 2016. Design Plan and Section provided in digital format by DM Wills, drawing file no. 4561-C8 GA.dwg, received Jan. 3, 2017.

LICENSED PROFESSIONAL ENGINEER P. GIULIANI 100128521 June 9, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J. M. A. COSTA June 9, 2017 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M15-317

HWY. 401		PROJECT NO. 1540419	DIST.
SUBM'D. MCK	CHKD. MCK	DATE: 5/30/2017	SITE: 22-438/C
DRAWN: SMD/MR	CHKD. MWK	APPD. JMAC	DWG. 1

PLOT DATE: June 9, 2017
FILENAME: S:\Clients\MTO\Hwy_401_&_Hwy35-115\99_PROJ\1540419_DMWills_CulvRep\40_PROD\0008_CB_Foundations\1540419-0008-BD-0001.dwg

APPENDIX A

Record of Boreholes ï Current Investigation

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
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

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

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RECORD OF BOREHOLE No C8-1

SHEET 1 OF 1 **METRIC**

PROJECT 1540419
W.P. 2242-14-00
DIST HWY 401
DATUM Geodetic
LOCATION N 4858601.8; E 350979.0 MTM ZONE 10 (LAT. 43.865944; LONG. -78.925481)
BOREHOLE TYPE Portable Equipment, BW Casing, Washboring (Manual Hammer)
DATE January 16 to 25, 2017
ORIGINATED BY MB
COMPILED BY SMD
CHECKED BY MCK

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
78.8	GROUND SURFACE										
0.0	TOPSOIL										
0.1	Silty sand, some gravel, trace organic inclusions (FILL) Very loose Dark brown Wet		1	SS	3				○		
78.0			2	SS	19		78		○		
0.8	SAND and GRAVEL, some silt, trace clay (TILL-LIKE) Compact to dense Grey Moist		3	SS	14				○		31 53 14 2
			4	SS	32		77				
76.5											
2.3	Gravelly SILTY SAND, trace clay (TILL-LIKE) Very dense Grey Moist to wet		5	SS	90		76		○		19 47 30 4
			6	SS	90						
							75				
74.4			7	SS	32						
4.4	Weathered SHALE (BEDROCK)						74				
73.2			8	SS	32						
5.6	Shale (BEDROCK) Bedrock cored from depths of 5.6 m to 6.6 m		1	RC	REC 100%		73				RQD = 32%
72.2	For bedrock coring details, refer to Record of Drillhole C8-1.		2	RC	REC 100%						RQD = 0%
6.6	END OF BOREHOLE										

NOTE:

1. Water level in borehole not recorded prior to rock coring.

2. Borehole advanced with 2/3 weight hammer; SPT N-Values have been corrected to the values expected if using full weight hammer.

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

PROJECT: 1540419

RECORD OF DRILLHOLE: C8-1

SHEET 1 OF 1

LOCATION: N 4858601.77 ;E 350978.95

DRILLING DATE: January 24 and 25, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Equipment

DRILLING CONTRACTOR: Walker Drilling

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	WEATHERING INDEX	Axial Point Load Index (MPa)	FEATURES	PIEZOMETER
		GROUND SURFACE		73.26															
6	35mm Dia. BQ Core Jan. 25, 2017	Moderately weathered, thinly bedded, black, fine grained, non-porous, weak SHALE (Whitby formation)		5.59	1		80 60 40 20	80 60 40 20	80 60 40 20	5 10 15 20	0 30 60 90	BD,PL,SM BD,PL,SM	1 1	1 1	16 16	W1 W2 W3 W4 W5 W6	2 4 6	BC	Axial Axial Axial Axial Axial
				72.25	2							BD,PL,SM	1	1	16			BC	
		END OF DRILLHOLE		6.60															

DEPTH SCALE
1 : 50

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LOGGED: MB
CHECKED: MWK

GTA-RCK 049 S:\CLIENTS\MTO\HWY_401_&_HWY35-115\02_DATA\GINT\HWY_401_AJAX_TO_NEWTONVILLE.GPJ GAL-MISS.GDT 06/09/17

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RECORD OF BOREHOLE No C8-2

SHEET 1 OF 1

METRIC

PROJECT 1540419

W.P. 2242-14-00 LOCATION N 4858584.5; E 350977.3 MTM ZONE 10 (LAT. 43.8658; LONG. -78.926) ORIGINATED BY AJ

DIST HWY 401 BOREHOLE TYPE CME 75, 208 mm O.D., 108 mm I.D. Hollow Stem Augers COMPILED BY SMD

DATUM Geodetic DATE December 19, 2016 CHECKED BY MCK

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
81.0	GROUND SURFACE										
0.0	ASPHALT										
0.2	Sand and gravel (FILL) Very dense Brown Moist		1	SS	76						
80.2							80				
0.8	Sandy clayey silt, some gravel (FILL) Very stiff Brown Moist		2	SS	21						
79.6											
1.4	SILTY SAND, some gravel, trace clay Loose to compact Brown Moist		3	SS	9		79				
			4	SS	21						
78.0							78				
3.0	Gravelly SAND, some silt, trace clay, trace shale fragments Compact to hard Brown to grey Moist to wet - Augers grinding between depths of 3.6 m and 4.6 m		5	SS	28						25 53 18 4
			6	SS	50/0.10		77				
75.5							76				
5.5	Gravelly CLAYEY SILT with SAND Hard Grey Moist		7	SS	67		75				29 53 16 2
73.9							74				
7.1	Weathered SHALE (BEDROCK)		8	SS	50/0.13						
73.2							73				
7.8	Shale (BEDROCK) Bedrock cored from depths of 8.0 m to 12.0 m For bedrock coring details, refer to Record of Drillhole C8-2.		1	RC	REC 77%						RQD = 0%
			2	RC	REC 100%		72				RQD = 100%
							71				
			3	RC	REC 100%		70				RQD = 100%
69.0							69				
12.0	END OF BOREHOLE NOTE: 1. Water level in borehole not recorded prior to rock coring.										

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

PROJECT: 1540419

RECORD OF DRILLHOLE: C8-2

SHEET 1 OF 1

LOCATION: N 4858584.51 ;E 350977.29

DRILLING DATE: December 19, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: At Cost Drilling Inc.

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	WEATHERING INDEX	Axial Point Load Index (MPa)	FEATURES	PIEZOMETER
		GROUND SURFACE		73.05															
8	NQ Rock Core December 19, 2016	Slightly weathered to fresh bedded, dark grey, fine grained, weak SHALE		7.95	1							BD,PL,SM BD,IR,SM BD,UN,SM BD,PL,SM BD,CU,SM BD,PL,SM BD,UN,SM BD,UN,SM BD,UN,SM BD,UN,SM BD,UN,SM BD,PL,SM BD,IR,SM BD,CU,RO BD,IR,SM BD,UN,SM BD,UN,SM BD,PL,SM BD,IR,SM BD,CU,SM BD,UN,SM							UCS = 45 MPa
9																			
10					2														
11					3														
12				68.96															
		END OF DRILLHOLE		12.04															
13																			
14																			
15																			
16																			
17																			

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: AJ
CHECKED: MWK

GTA-RCK 049 S:\CLIENTS\MTO\HWY_401_&_HWY35-115\02_DATA\GINT\HWY_401_AJAX_TO_NEWTONVILLE.GPJ GAL-MISS.GDT 06/09/17

Golder Associates

RECORD OF BOREHOLE No C8-4

SHEET 1 OF 1

METRIC

PROJECT 1540419

W.P. 2242-14-00

LOCATION N 4858535.8; E 350986.1 MTM ZONE 10 (LAT. 43.865349; LONG. -78.925399)

ORIGINATED BY PKS

DIST HWY 401

BOREHOLE TYPE Mini-Mole 102 mm O.D. Continuous Flight Solid Stem Augers

COMPILED BY ZMR/MR

DATUM Geodetic

DATE July 28, 2016

CHECKED BY MCK

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
79.1	GROUND SURFACE										
0.0	SAND, some silt, some gravel, trace clay Loose to compact Brown Moist		1	SS	5						
			2	SS	11	▼	78		○		19 57 16 8
	- Becoming wet below a depth of 2.1 m		3	SS	17		77				
76.8											
2.3	SAND and GRAVEL, trace to some silt, trace clay, trace black shale fragments (TILL-LIKE) Very dense Grey to brown Wet		4	SS	76				○		50 36 11 3
	- Augers grinding at a depth of 2.3 m (Elev. 76.8 m)		5	SS	76		76				
75.0							75				
4.1	CLAYEY SILT, some black shale fragments Hard Grey Wet		6	SS	70/0.15				○ ⊢		
73.6			7	SS	100/0.05		74				
5.5	END OF BOREHOLE SAMPLER REFUSAL AUGER REFUSAL										

NOTE:

1. Water level measured in piezometer:

Date	Depth (m)	Elev. (m)
07/28/16	4.6	74.5
03/28/17	1.1	78.0

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

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

APPENDIX B

Laboratory Test Results

UNCONFINED COMPRESSION TEST (UC) TABLE B1

ASTM D 7012-04

SAMPLE IDENTIFICATION

PROJECT NUMBER	1540419	SAMPLE NUMBER	Run2
BOREHOLE NUMBER	C8-2	SAMPLE DEPTH, m	1.025-1.192

TEST CONDITIONS

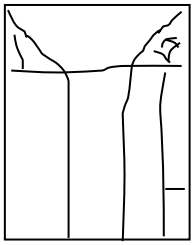
MACHINE SPEED, mm/min	-	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.37

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	11.23	WATER CONTENT, (specimen) %	0.53
SAMPLE DIAMETER, cm	4.73	UNIT WEIGHT, kN/m^3	24.46
SAMPLE AREA, cm^2	17.58	DRY UNIT WT., kN/m^3	24.33
SAMPLE VOLUME, cm^3	197.45	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	492.63	VOID RATIO	0.09
DRY WEIGHT, g	490.03		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	-	COMPRESSIVE STRESS, MPa	45.0

REMARKS:

DATE: 1/16/2017

POINT LOAD TESTS ON ROCK SAMPLES — TABLE B2

PROJECT NO. 1540419
TITLE DM Wills/Culverts Hwy35/ON
DATE September, 2016

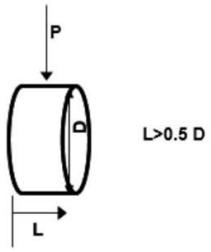
Borehole Number	Sample Number	Sample Depth (m)	Test Type	Core Length (mm)	Core Diameter (mm)	Equivalent Diameter (mm)	Is Axial (MPa)	Is Diametral (MPa)	**Is (50mm)** (MPa)	**Approx. (1) UCS** (MPa)
C8-2	Run 2	9.14 - 9.21	A	25.02	47.32	38.83	4.038	-	3.603	57
C8-2	Run 1	8.56 - 8.59	A	29.21	47.14	41.87	1.936	-	1.787	28
C8-2	Run 3	8.04 - 8.08	A	23.87	47.20	37.87	4.401	-	3.884	62
C8-1	PLT1	5.96-5.99	A	21.47	36.00	31.37	3.361	-	2.725	43
C8-1	PLT2	6.045-6.075	A	18.34	35.99	28.99	3.383	-	2.647	42
C8-1	PLT3	6.125-6.155	A	21.41	36.03	31.34	2.403	-	1.947	31
C8-1	PLT4	6.21-6.24	A	19.19	35.98	29.65	4.665	-	3.687	59
C8-1	PLT5	6.26-6.29	A	23.94	35.97	33.11	2.787	-	2.316	37

(1) Is_{50} x C, from ISRM "Suggested Methods for Determining Point Load Strength", International Society for Rock Mechanics Comm
Methods, Int. J. Rock. Mech. Min. Sci. and Geomechanical Abstr., Vol 22, No. 2 1985, pp. 51-60.
C=15.9, calculated from Is50 average (3 tests) equal to 2.825 MPa on axial orientation and UCS equal to 45 MPa (1 test)

DIAMETRAL SPECIMEN SHAPE REQUIREMENTS

note: Diametral tests are perpendicular to core axis

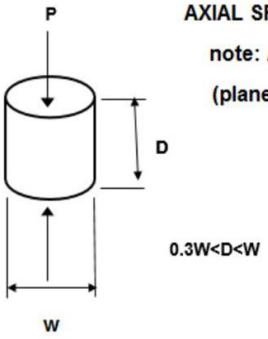
(planes of weakness)



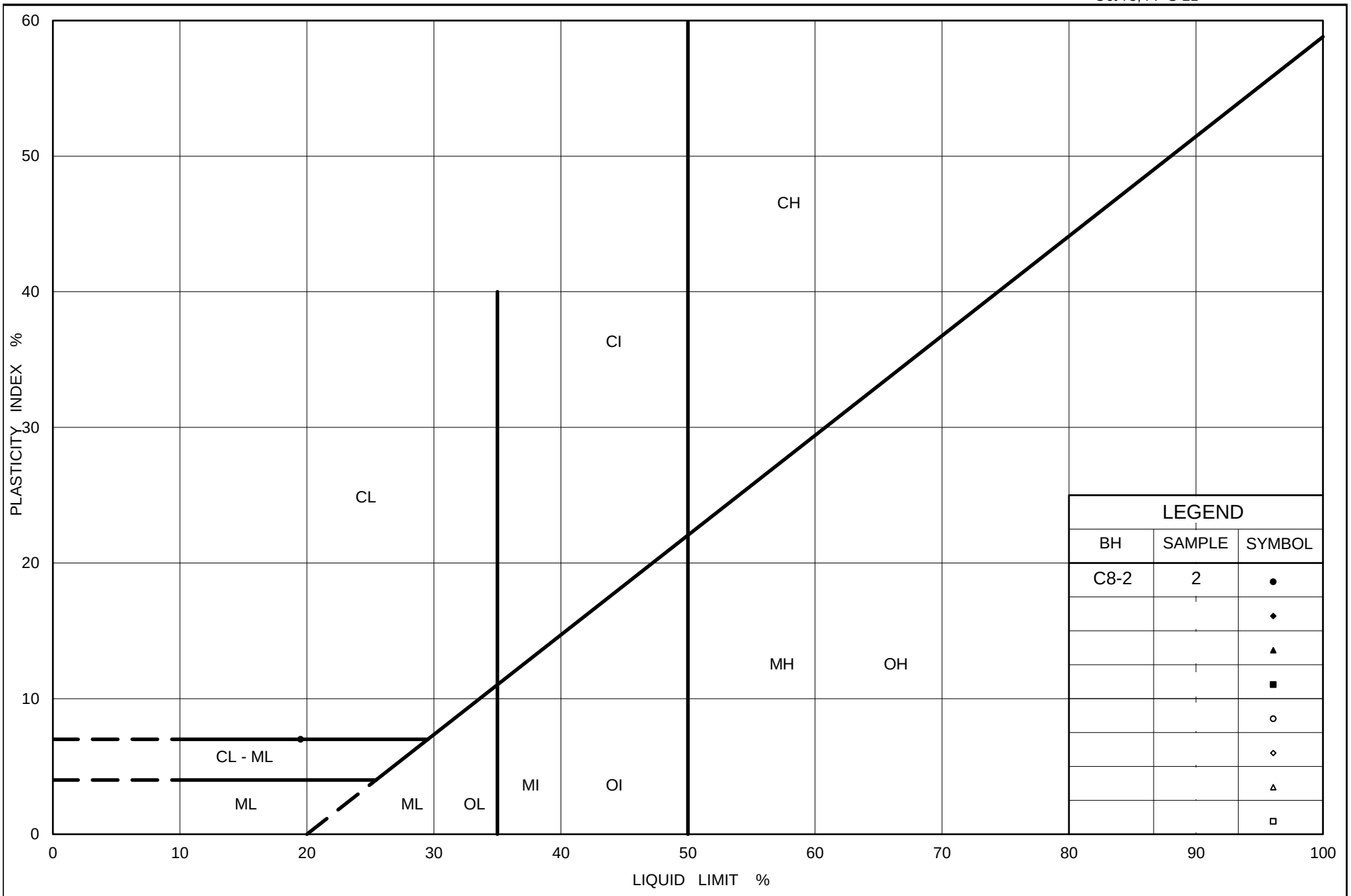
AXIAL SPECIMEN SHAPE REQUIREMENTS

note: Axial tests are parallel to core axis

(planes of weakness)



Checked By:



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B1

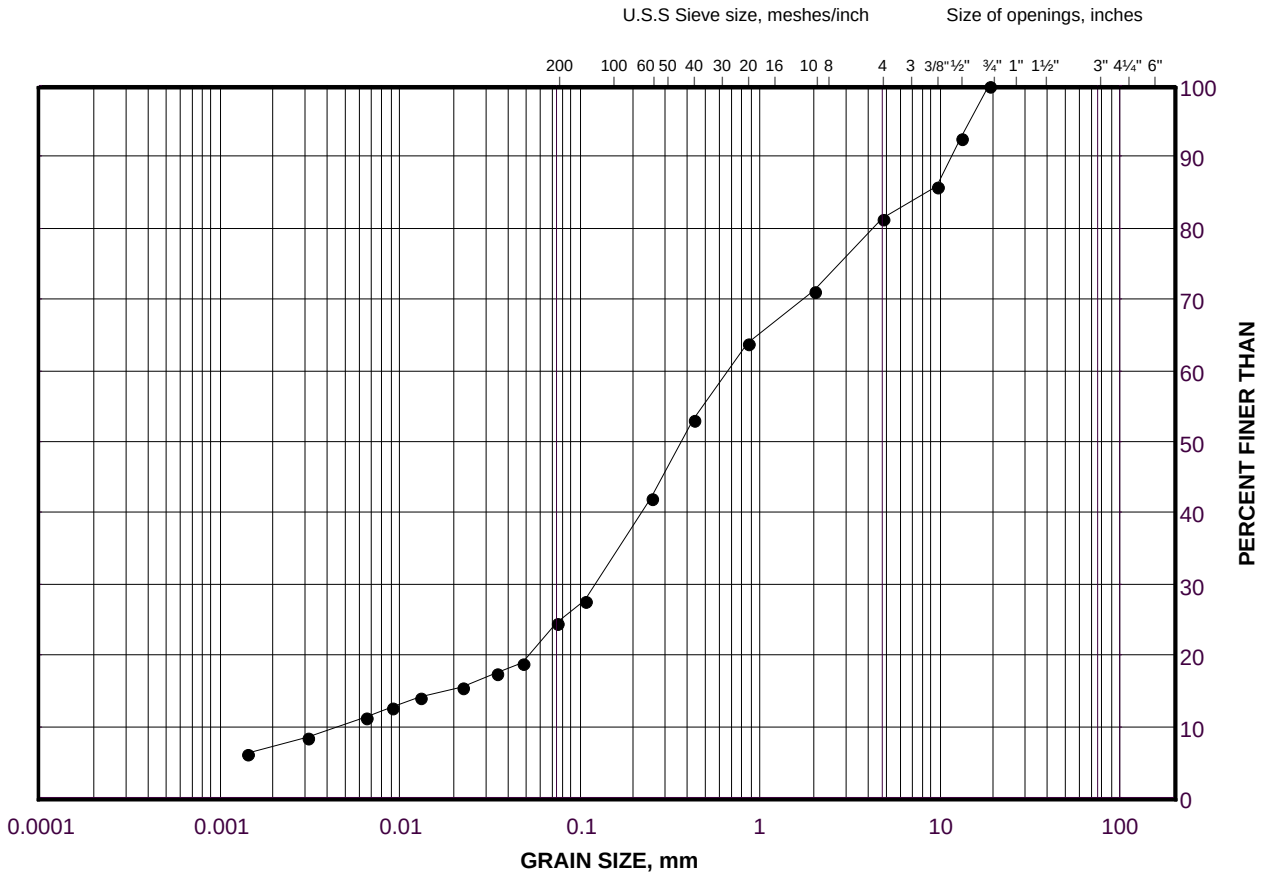
Project No. 1540419

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Sand

FIGURE B2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C8-4	2	78.0

Project Number: 1540419

Checked By: MWK

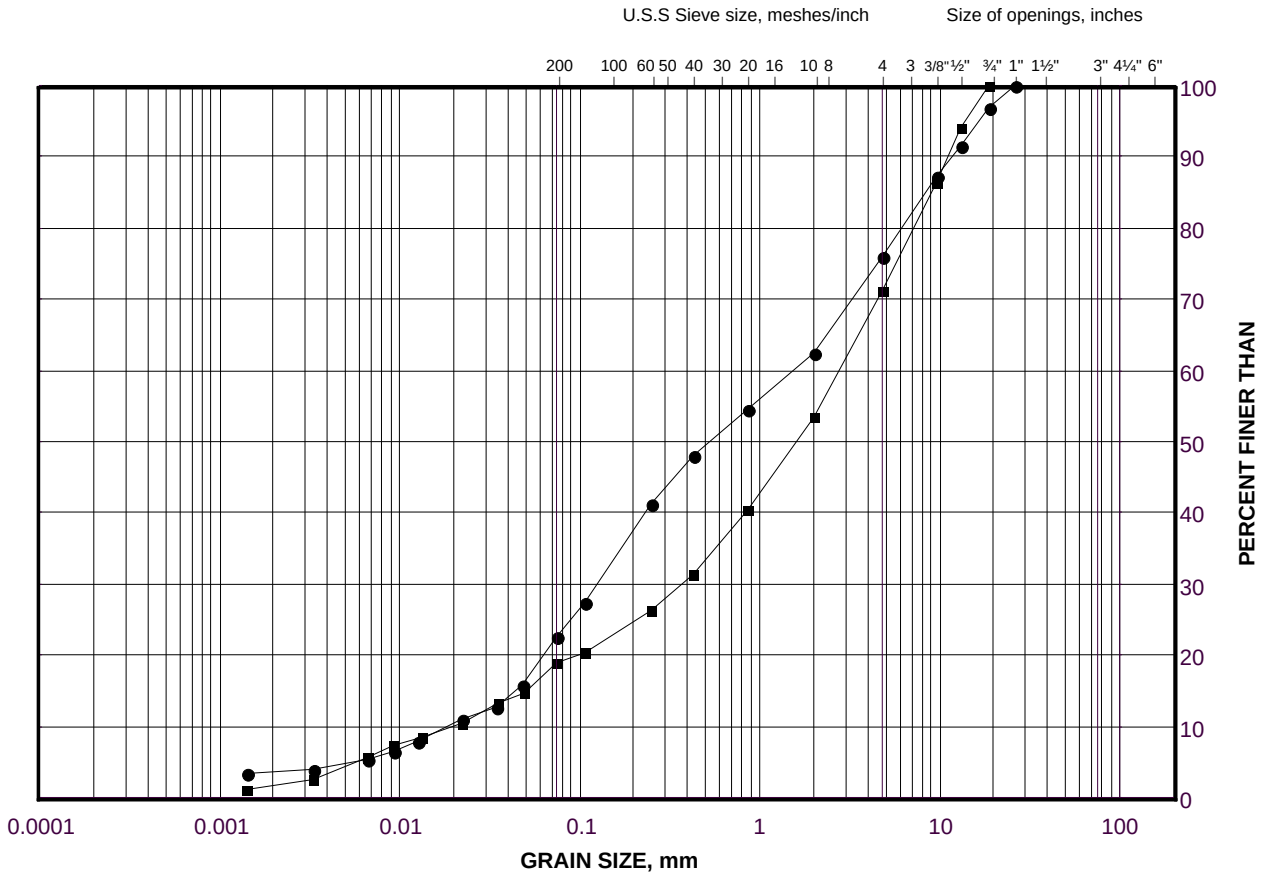
Golder Associates

Date: 26-Apr-17

GRAIN SIZE DISTRIBUTION

Gravelly Sand

FIGURE B3



LEGEND

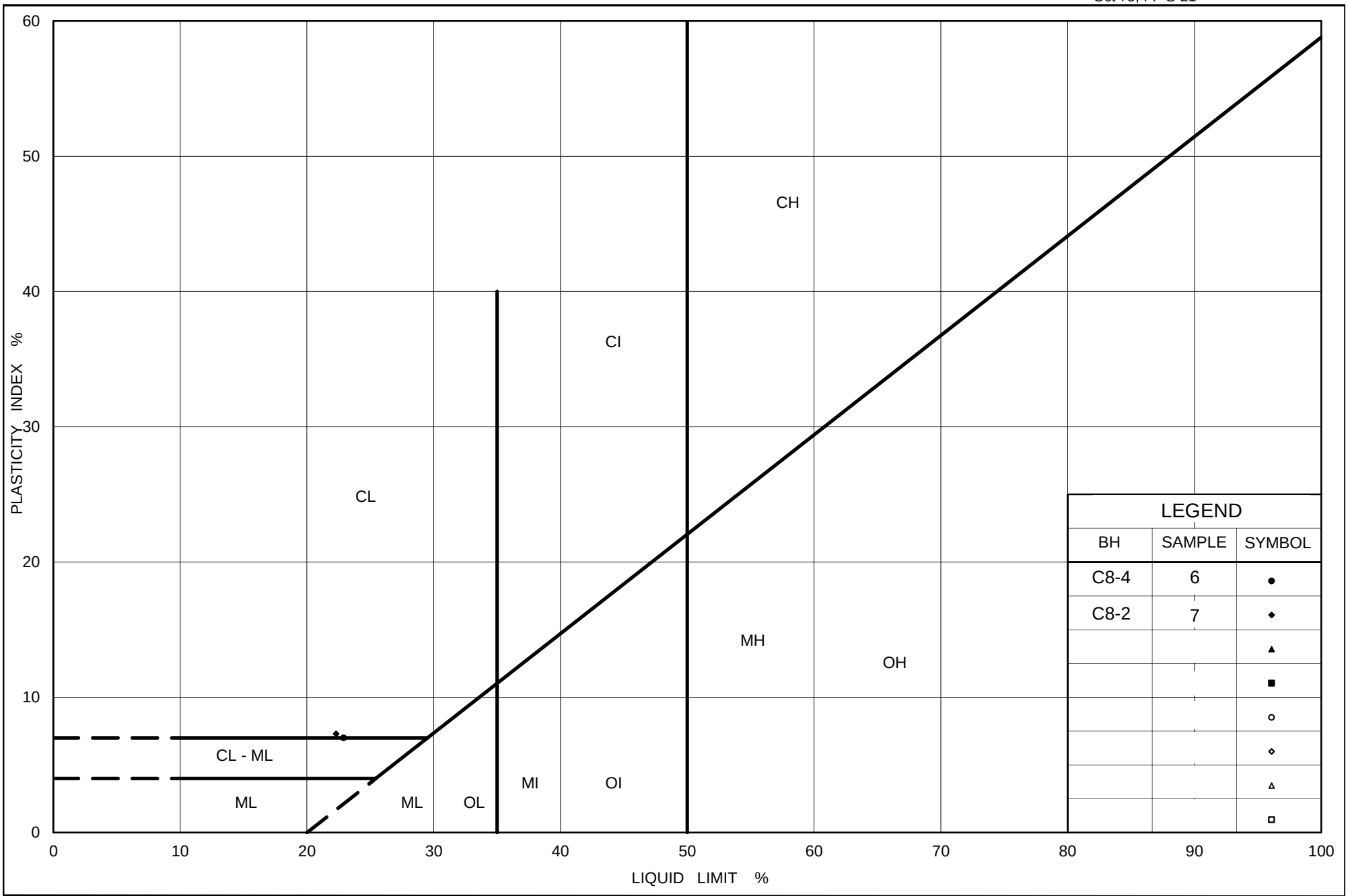
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C8-2	5	77.6
■	C8-2	7	74.6

Project Number: 1540419

Checked By: MWK

Golder Associates

Date: 26-Apr-17



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B4

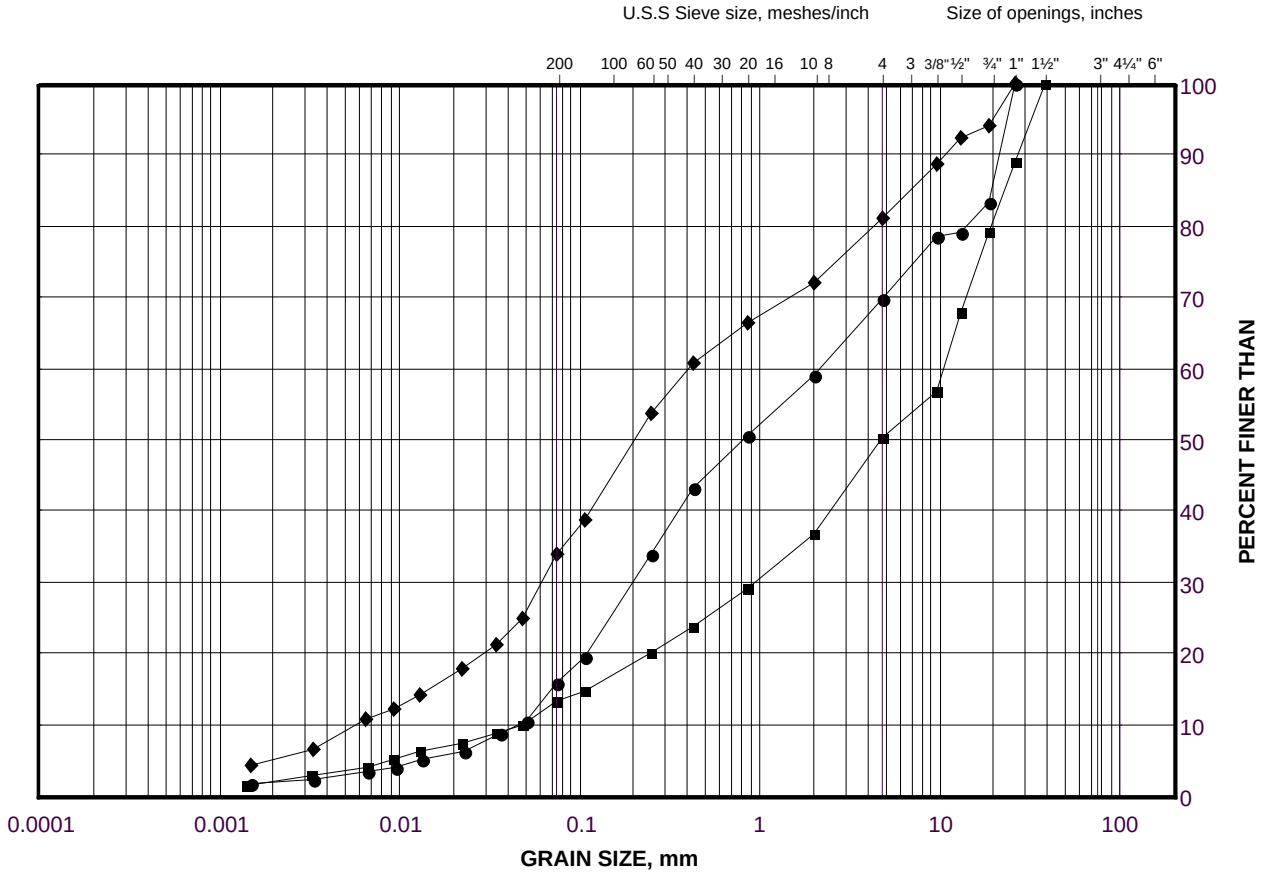
Project No. 1540419

Checked By: MWK

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand and Gravel (Till-Like)

FIGURE B5



LEGEND

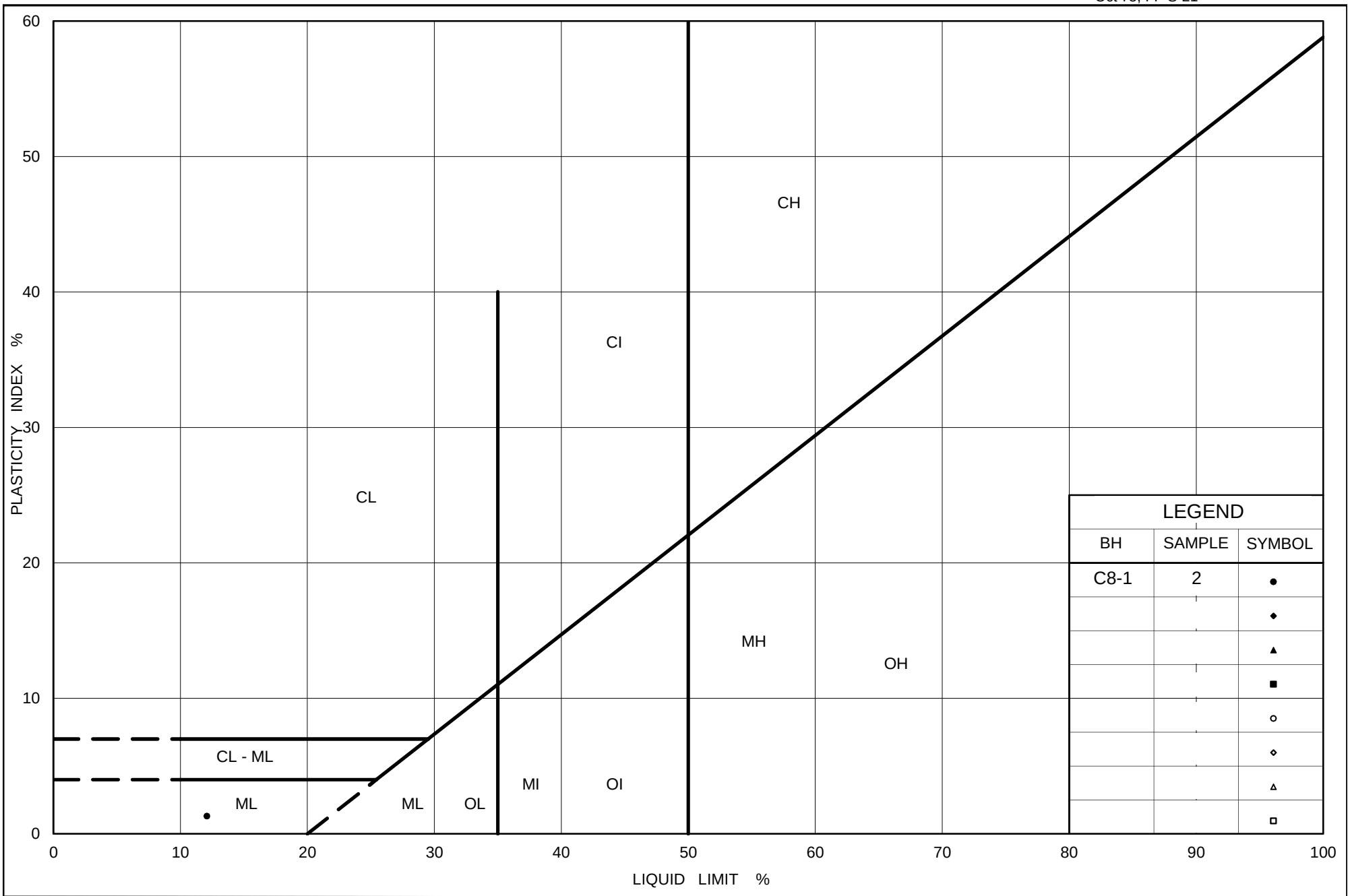
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	C8-1	3	77.5
■	C8-4	4	76.5
◆	C8-1	5	76

Project Number: 1540419

Checked By: MWK

Golder Associates

Date: 17-May-17



Ministry of Transportation

Ontario

PLASTICITY CHART
Silt and Sand (Till)

Figure No. B6

Project No. 1540419

Checked By: MWK

APPENDIX C

Analytical Test Results

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

Attention:Matt Kelly

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

Report Date: 2017/01/19
Report #: R4329708
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B708468
Received: 2017/01/13, 16:11

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	1	N/A	2017/01/18	CAM SOP-00463	EPA 325.2 m
Conductivity	1	N/A	2017/01/17	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2017/01/16	2017/01/16	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2017/01/13	2017/01/17	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	1	N/A	2017/01/18	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods. Results relate to samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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

Attention:Matt Kelly

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

Report Date: 2017/01/19
Report #: R4329708
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B708468
Received: 2017/01/13, 16:11

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

==========

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

Maxxam Job #: B708468
Report Date: 2017/01/19

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

RESULTS OF ANALYSES OF SOIL

Maxxam ID		DTH264	DTH264		
Sampling Date		2016/12/19 14:30	2016/12/19 14:30		
COC Number		573330-01-01	573330-01-01		
	UNITS	**C8**	**C8 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters					
Resistivity	ohm-cm	1800			4825290
Inorganics					
Soluble (20:1) Chloride (Cl)	ug/g	180	180	20	4828244
Conductivity	umho/cm	550		2	4826709
Available (CaCl2) pH	pH	7.90			4826275
Soluble (20:1) Sulphate (SO4)	ug/g	160	150	20	4828235

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

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

Maxxam Job #: B708468
Report Date: 2017/01/19

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

TEST SUMMARY

Maxxam ID: DTH264
Sample ID: C8
Matrix: Soil

Collected: 2016/12/19
Shipped:
Received: 2017/01/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4828244	N/A	2017/01/18	Alina Dobreanu
Conductivity	AT	4826709	N/A	2017/01/17	Tahir Anwar
pH CaCl2 EXTRACT	AT	4826275	2017/01/16	2017/01/16	Neil Dassanayake
Resistivity of Soil		4825290	2017/01/17	2017/01/17	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4828235	N/A	2017/01/18	Alina Dobreanu

Maxxam ID: DTH264 Dup
Sample ID: C8
Matrix: Soil

Collected: 2016/12/19
Shipped:
Received: 2017/01/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4828244	N/A	2017/01/18	Alina Dobreanu
Sulphate (20:1 Extract)	KONE/EC	4828235	N/A	2017/01/18	Alina Dobreanu

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Maxxam Job #: B708468
Report Date: 2017/01/19

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

GENERAL COMMENTS

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

Package 1	6.0°C

Results relate only to the items tested.

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Maxxam Job #: B708468
Report Date: 2017/01/19

QUALITY ASSURANCE REPORT

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

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4826275	Available (CaCl2) pH	2017/01/16			99	97 - 103			2.2	N/A
4826709	Conductivity	2017/01/17			100	90 - 110	<2	umho/cm	1.6	10
4828235	Soluble (20:1) Sulphate (SO4)	2017/01/18	NC	70 - 130	109	70 - 130	<20	ug/g	4.9	35
4828244	Soluble (20:1) Chloride (Cl)	2017/01/18	NC	70 - 130	104	70 - 130	<20	ug/g	0.081	35

N/A = Not Applicable

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

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

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

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

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

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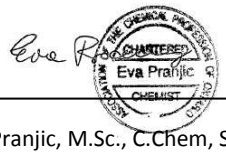
Maxxam Job #: B708468
Report Date: 2017/01/19

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

VALIDATION SIGNATURE PAGE

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



Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist

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

CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:

Company Name: #1326 Golder Associates Ltd
Attention: Central Acct:1112, 1113, 1118
Address: 6925 Century Ave Suite 100, Mississauga ON L5N 7K2
Tel: (905) 567-4444 Fax: (905) 567-6561
Email: Catherine_Guiao@golder.com, Rachel_Benjamin@gol

REPORT TO:

Company Name: Golder Associates Ltd.
Attention: Matt Kelly
Address:
Tel: Fax:
Email: Matthew_Kelly@golder.com, Madkennedy@golder.com

PROJECT INFORMATION:

Quotation #: B63104
P.O. #:
Project: 1540419
Project Name:
Site #:
Sampled By:

Laboratory Use Only:

Maxxam Job #:
Bottle Order #: 573330
COC #: C#573330-03-01
Project Manager: Ema Gitej

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

Regulation 153 (2011)

- [ ] Table 1 [ ] Res/Park [ ] Medium/Fine
- [ ] Table 2 [ ] Ind/Comm [ ] Coarse
- [ ] Table 3 [ ] Agri/Other [ ] For RSC
- [ ] Table ___

Other Regulations

- [ ] CCME [ ] Sanitary Sewer Bylaw
- [ ] Reg 558 [ ] Storm Sewer Bylaw
- [ ] MISA Municipality ___
- [ ] PWQO
- [ ] Other ___

Special Instructions

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT:

(will be applied if Rush TAT is not specified):

Standard TAT = 5-7 Working days for most tests.

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

Job Specific Rush TAT (if applies to entire submission)

Date Required: ___ Time Required: ___

Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Corrosivity pkg (Cl, SO4, EC, Resistivity, pH)	# of Bottles	Comments
1		C8	Dec 19, 2016	2:30pm	Soil		X	1	
2									
3									
4									
5									
6									
7									
8									
9									
10									

13-Jan-17 16:11
Ema Gitej
B708468
GK1 ENV-676

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
MADISON KENNEDY	17/01/13	4:10pm	[illegible]	17/01/13	16:11	

Laboratory Use Only				
Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	6/6/6	Present		✓
		Intact		✓

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

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

White: Maxxam Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX D

Record of Boreholes and Laboratory Test Results from Previous Investigation

Golder Associates

RECORD OF BOREHOLE No 15-1

SHEET 1 OF 1 **METRIC**

PROJECT 13-1186-0419 LOCATION N 4858611.3 ;E 351003.9 ORIGINATED BY EW

DIST Central HWY 401 BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers COMPILED BY EW

DATUM Geodetic DATE June 22, 2015 CHECKED BY AM/DUP

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
79.0	GROUND SURFACE										
0.0 / 78.3	Silt and sand, some gravel, organic inclusions (FILL) Very soft, loose Brown		1	SS	2						
0.7 / 77.3	Silty sand, rootlets, oxidation staining, organic inclusions, wood fragments (FILL) Loose to very loose Grey Moist to wet		2	SS	6		78				
			3	SS	2		77				
1.7 / 76.1	Sandy CLAYEY SILT, trace gravel Very soft Grey		4	SS	1						2 20 39 39
2.9 / 74.7	SILTY SAND and GRAVEL, trace to some clay (TILL-LIKE) Loose Grey		5	SS	7		76				40 30 22 8
4.3 / 72.7	Weathered shale (BEDROCK) with sandy silt, sulphur odour; black (~70%), grey (~30%)		6	SS	55		75				
			7	SS	63		74				
			8	SS	50/0.03		73				
6.3 / 71.8	See Drillhole Log 15-1		1	RC	REC 85.4%		72				RQD = 19.6%
7.2 / 71.3	Shale (BEDROCK), hydrocarbon-like odour		9	SS	50/0.03						
7.7	END OF BOREHOLE										

NOTES:

1. Water encountered during drilling at a depth of 2.3 m (Elev. 76.7 m) on June 22, 2015

2. Water level in monitoring well at a depth of 0.34 m (Elev. 78.70 m) on July 8, 2015

3. Water level in monitoring well at a depth of 0.5 m (Elev. 78.5 m) on July 13, 2015

4. Water level in monitoring well at a depth of 0.6 m (Elev. 78.4 m) on July 15, 2015

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

PROJECT: 13-1186-0419

RECORD OF DRILLHOLE: 15-1

SHEET 1 OF 1

LOCATION: N 4858611.3 ;E 351003.9

DRILLING DATE: June 22, 2015

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Track Mount CME-55

DRILLING CONTRACTOR:

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % (80 60 40 20)	RECOVERY SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX (R5 R4 R3 R2 R1)	WEATH-ERING INDEX (W1 W2 W3 W4 W5 W6)	FEATURES	PIEZOMETER
		Continued from Borehole 15-1		72.76														
7	Track-Mounted Power Augers / Hollow Stem Augers (Automatic Hammer)	Weathered shale (BEDROCK)		6.28	1							FR						Screen
				71.36														
8	200 mm O.D.	END OF DRILLHOLE		7.68														
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: EW
CHECKED: AM

GTA-RCK 043 S:\CLIENTS\DURHAM_REGION\401_WATERMAIN_CROSSING\02_DATA\GINT\1311860419MTO.GPJ GAL-MISS.GDT 11/9/15 MK July 2015

Golder Associates

RECORD OF BOREHOLE No 15-2

SHEET 1 OF 1 **METRIC**

PROJECT 13-1186-0419

LOCATION N 4858562.5 ;E 351014.0

ORIGINATED BY EW

DIST Central HWY 401

BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers

COMPILED BY EW

DATUM Geodetic

DATE July 3, 2015

CHECKED BY AM/DUP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
81.5	GROUND SURFACE								
0.0	ASPHALT								
0.3	Gravelly sand, Granular Base (FILL) Compact Brown		1	SS	14		81		
80.7									
0.8	Sand, some gravel, Granular Subbase (FILL) Compact Brown		2	SS	12				
79.8							80		
1.7	Silty sand, some clay, some gravel, zones of clayey silt, organic inclusions (FILL)		3	SS	11				
79.4									
2.1	Stiff Dark brown		4	SS	13		79		13 45 28 14
	Silty clay, some sand, zones of silt, in varved 60 mm layers (FILL)								
78.6									
2.9	Stiff Grey		5	SS	9		78		
	Sandy clayey silt, some gravel (FILL)								
77.8									
3.7	Stiff Grey		6	SS	15				29 57 11 3
	Topsoil and silty sand mix (FILL) Black								
	Gravelly SAND, coarse, some silt, rootlets Loose to dense Grey		7	SS	8		77		
76.0									
5.5	SILTY SAND, some gravel, some clay (TILL) Dense Grey		8	SS	36		76		21 65 12 2
			9	SS	34		75		11 52 28 9
	-Shale fragments at Elev. 74.5 m		10	SS	42				
74.0							74		
7.5	Weathered shale (BEDROCK), containing silt in fractures/discontinuities Black Wet		11	SS	50/0.14				
	-Becoming less weathered at Elev. 72.6 m						73		
72.3			12	SS	50/0.05				
9.2	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

NOTES:

1. Water level encountered during drilling at a depth of 3.8 m (Elev. 77.7 m), July 3, 2015
2. Borehole caved to a depth of 5.5 m (Elev. 76.0 m), upon completion of drilling, July 3, 2015
3. Water level in open portion of borehole at a depth of 3.8 m (Elev. 77.7 m), upon completion of drilling, July 3, 2015

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

GTA-MTO 001 S:\CLIENTS\DURHAM_REGION\401_WATERMAIN_CROSSING\02_DATA\GINT\1311186041 9MTO.GPJ GAL-GTA.GDT 11/9/15 MK July 2015

Golder Associates

PROJECT 13-1186-0419

RECORD OF BOREHOLE No 15-3

SHEET 1 OF 1

METRIC

LOCATION N 4858525.5 ;E 351015.5

ORIGINATED BY EW

DIST Central HWY 401

BOREHOLE TYPE 210 mm Diameter Hollow Stem Augers

COMPILED BY EW

DATUM Geodetic

DATE June 17, 2015

CHECKED BY AM/DUP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
79.2	GROUND SURFACE								
0.0	Topsoil and sandy silt, some clay (FILL) Compact to loose Dark brown to black		1	SS	9		79		
			2	SS	11		78		
77.3			3	SS	4				
1.9	CLAYEY SILT, trace to some sand, varved						77		
76.8	Soft to firm								
2.4	Grey and brown								
	CLAYEY SILT to CLAYEY SILTY SAND, some gravel, cobbles and boulders, shale fragments (TILL) Hard Grey -Auger grinding on inferred cobble or boulder 2.44 m to 2.52 m		4	SS	50/.013		76		
			5	SS	57		75		18 42 26 14
74.8									
4.4	Gravelly SILTY SAND, trace to some clay, cobbles and boulders, shale fragments (TILL) Very dense Grey		6	SS	95/0.28				31 48 16 5
74.0							74		
5.2	Weathered shale (BEDROCK), some silt, sulphur odour Black		7	SS	50/0.10				
			8	SS	50/0.13		73		
			9	SS	50/0.13				
71.5			10	SS	50/0.13		72		
7.7	END OF BOREHOLE								

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

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

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

WATER CONTENT (%)
10 20 30

52.5

NOTES:

1. Water encountered during drilling at depths of 2.4 m and 5.3 m (Elev. 76.8 m and 73.9 m), June 17, 2015

2. Water level at ground surface, upon completion of drilling (Elev. 79.2 m), June 17, 2015

3. Water level in monitoring well at a depth of 0.9 m (Elev. 78.3 m), July 8, 2015

4. Water level in monitoring well at a depth of 1.1 m (Elev. 78.1 m), July 13, 2015

5. Water level in monitoring well at a depth of 1.1 m (Elev. 78.1 m), July 15, 2015

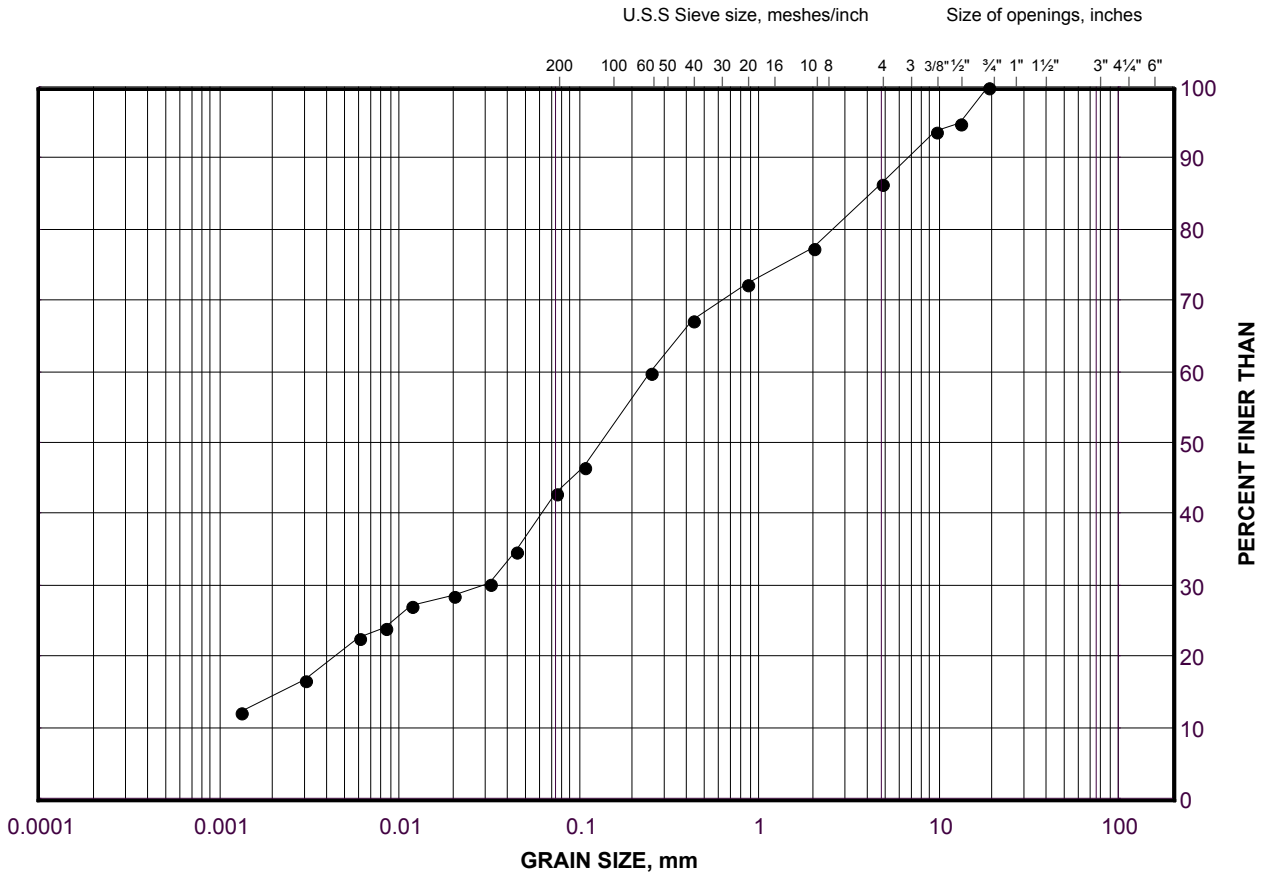
$+^3, \times^3$: Numbers refer to Sensitivity

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

GRAIN SIZE DISTRIBUTION

Silty Sand FILL

FIGURE D1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-2	4	79.0

Project Number: 13-1186-0419

Checked By: AM

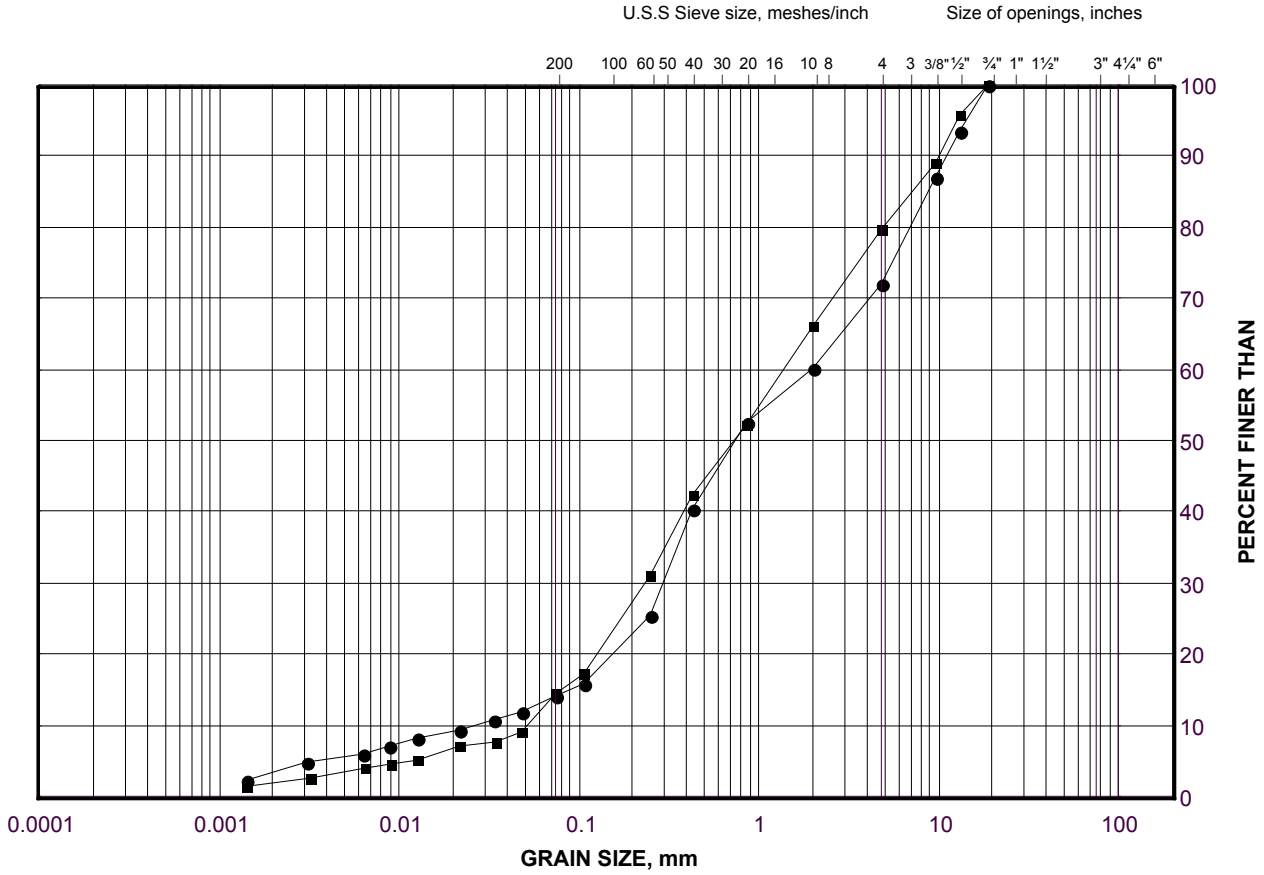
Golder Associates

Date: 04-Aug-15

GRAIN SIZE DISTRIBUTION

Gravelly SAND

FIGURE D2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-2	6	77.5
■	15-2	8A	75.9

Project Number: 13-1186-0419

Checked By: AM

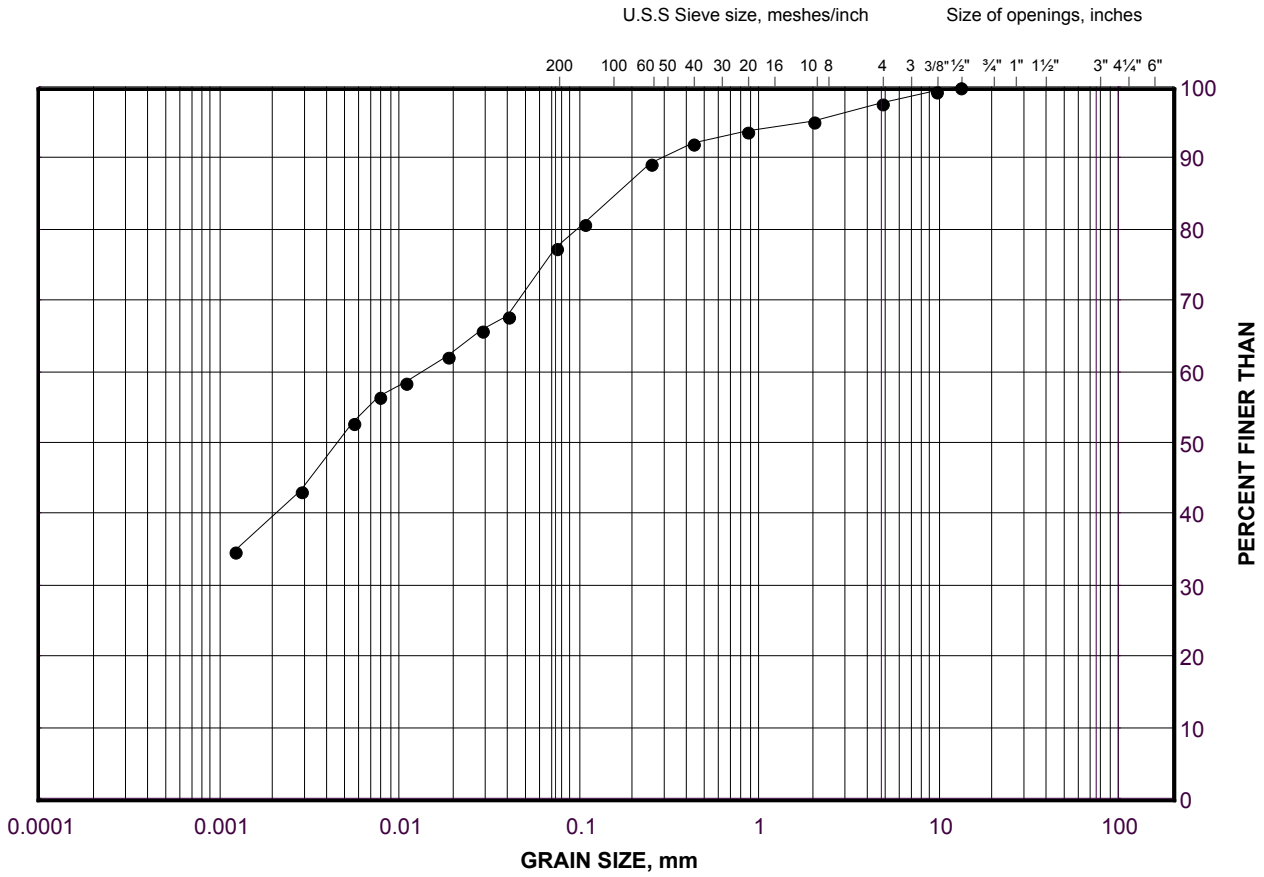
Golder Associates

Date: 04-Aug-15

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT

FIGURE D3



LEGEND

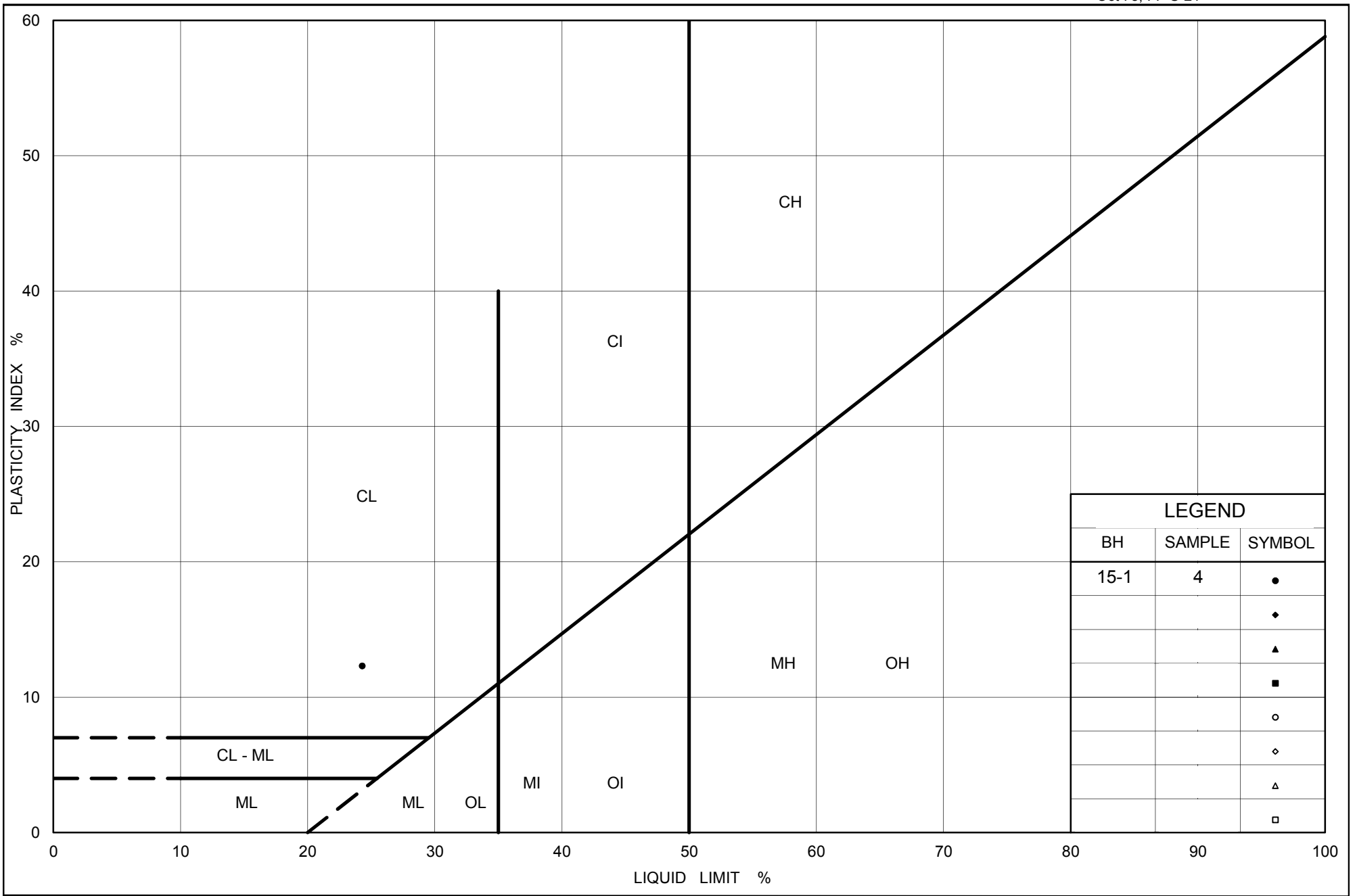
SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-1	4	76.6

Project Number: 13-1186-0419

Checked By: AM

Golder Associates

Date: 04-Aug-15



Ministry of Transportation

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PLASTICITY CHART
CLAYEY SILT

Figure No. D4

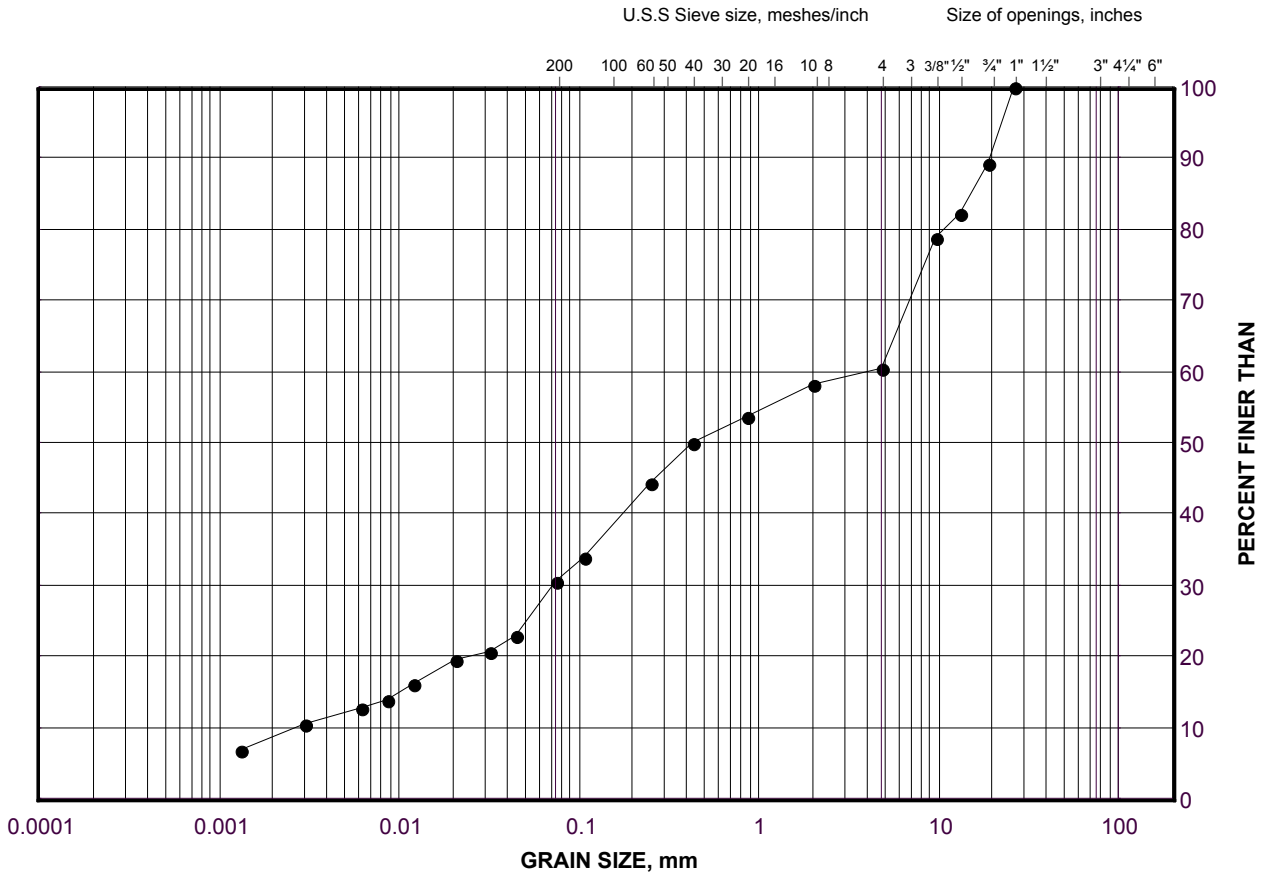
Project No. 13-1186-0419

Checked By: AM

GRAIN SIZE DISTRIBUTION

SILTY SAND and GRAVEL (TILL-LIKE)

FIGURE D5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-1	5	75.6

Project Number: 13-1186-0419

Checked By: AM

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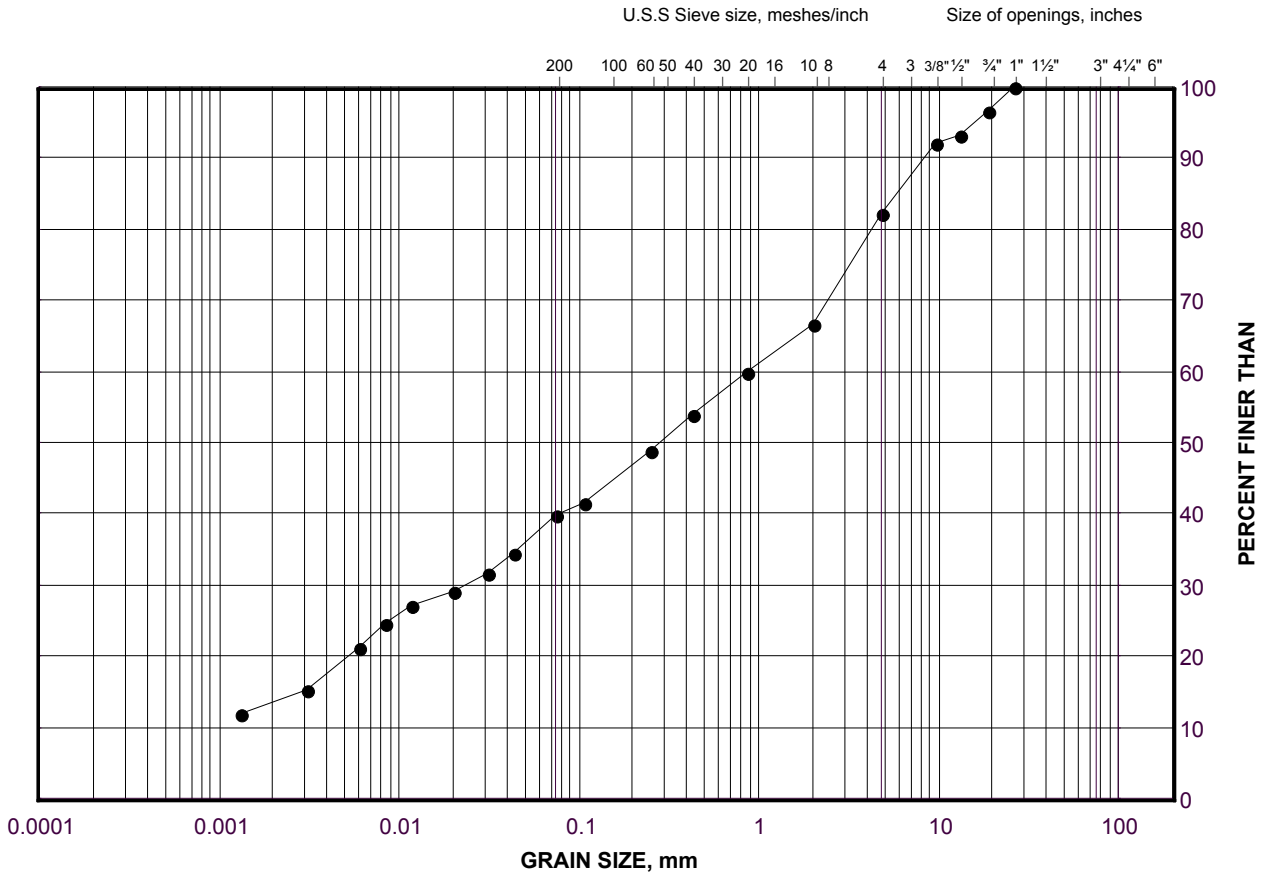
Date: 04-Aug-15

GRAIN SIZE DISTRIBUTION

CLAYEY SILTY SAND TILL

FIGURE D6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-3	5	75.2

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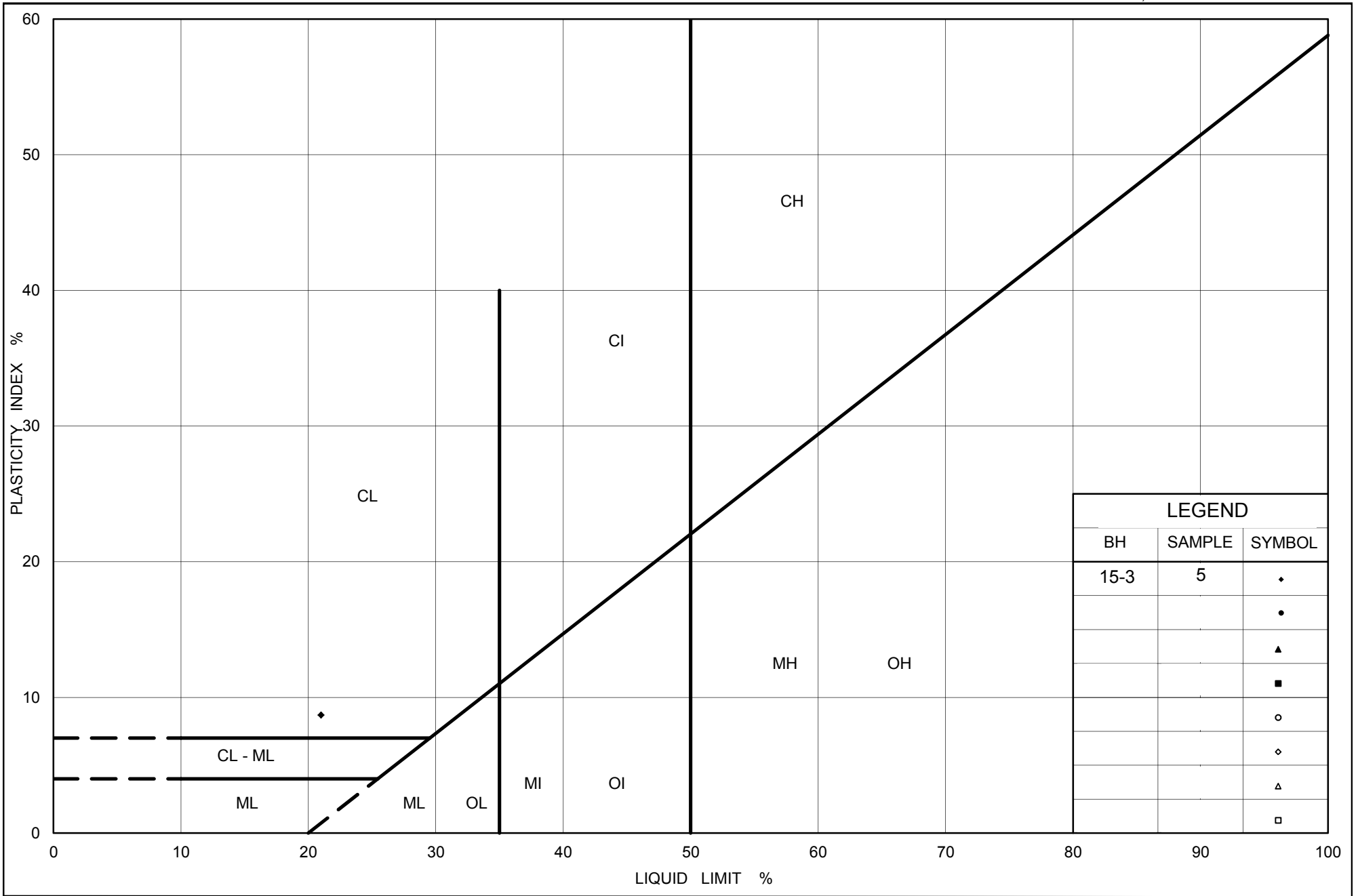

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PLASTICITY CHART
CLAYEY SILT TILL

Figure No. D7

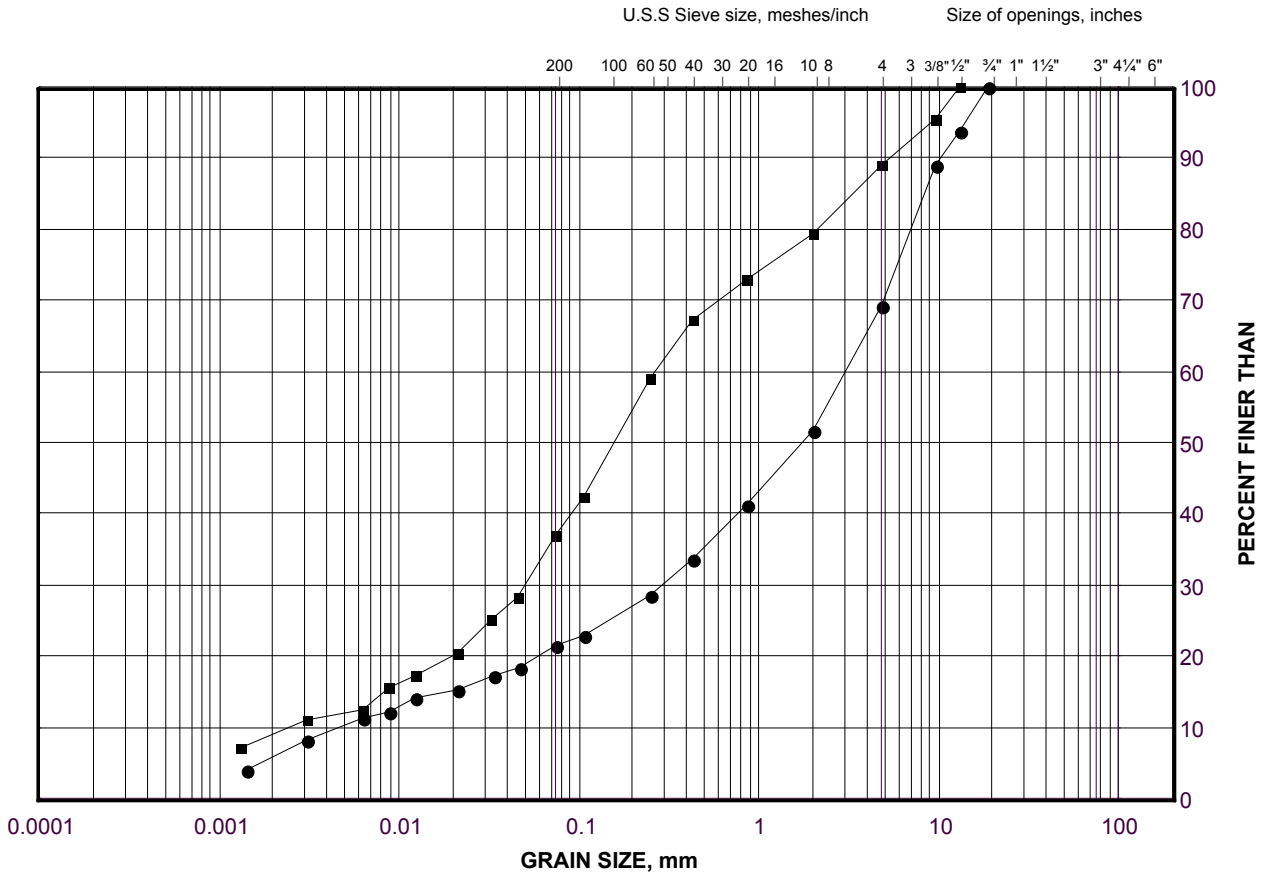
Project No. 13-1186-0419

Checked By: AM

GRAIN SIZE DISTRIBUTION

SILTY SAND TILL to Gravelly SILTY SAND TILL

FIGURE D8



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	15-3	6	74.3
■	15-2	9	75.2

Project Number: 13-1186-0419

Checked By: AM

Golder Associates

Date: 04-Aug-15

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