Foundation Investigation and Design Report

Sign Supports, High Mast Light and Closed Circuit Television (CCTV) Poles
Highway 410, Eglinton Avenue to Mayfield Road - Contract 2
Mississauga and Brampton, Ontario
Assignment No. 2016-E-0040, G.W.P. 2369-15-00

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detailed design of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road in the Cities of Mississauga and Brampton, Ontario (MTO Agreement No. 2016-E-0040).

This report addresses the foundation investigation carried out for the proposed overhead and variable message sign supports, high mast light (HML) and closed circuit television (CCTV) poles for the section of Highway 410 extending from approximately Highway 401 to Queen Street East, as shown on the key plan on Drawings 1 and 2. This report was developed based on information from the 2019 (current) investigation, supplemented with information from 1976 and 2012 (previous) foundation investigations, reported as follows:

- **MTO GEOCRES No. 30M12-122:** "Foundation Investigation and Design Report, From Steeles Avenue Southerly to Derry Road Culverts, W.P. 103-69-08, Highway 410, District 6, Toronto," by Ministry of Transportation, dated December 21, 1976.
- **MTO GEOCRES No. 30M12-361:** "Foundation Investigation Report for Culvert Extensions and Replacement, Highway 410 Widening From South of Highway 401 to Queen Street, Regional Municipality of Peel, G.W.P. 2144-07-00(i)" by Golder Associates, dated March 2013.

The Terms of Reference and Scope of Work for the foundation engineering services are outlined in MTO's Request for Proposal, dated November 25, 2016, which forms part of the Consultant Agreement (No. 2016-E-0040) for this project. The Scope of Work for the overhead and variable message sign supports, HML and CCTV poles is outlined in Golder's Change Request dated February 15, 2018. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for this project, dated May 2017.

2.0 SITE DESCRIPTION

The proposed sign supports, HML and CCTV poles are located within the Highway 410 corridor from approximately 630 m south of the Courtneypark Drive underpass, to approximately 30 m north of the Queen Street East underpass in the Cities of Mississauga and Brampton, respectively, within the Regional Municipality of Peel. The natural ground surface in the Highway 410 corridor rises from approximately Elevation 184 m near the south limit, to about Elevation 216 m near the north limit.

Highway 410 has generally been constructed on embankment fill, with the embankment height varying from less than 1 m to 2 m, to on the order of 6 m to 8 m adjacent to overpass structures. Highway 410 has been constructed in a cut in the vicinity of the Steeles Avenue overpass structure, extending northward to beyond the Queen Street East underpass.

3.0 INVESTIGATION PROCEDURES

3.1 1976 Investigation

One borehole from the 1976 investigation (designated as Borehole 3(2)) was advanced approximately 1 km north of the Highway 407 overpass as part of a culvert investigation (GEOCRES No. 30M12-122). The 1976 borehole has been renamed to show the MTO GEOCRES reference number followed by the original borehole designation.

The borehole record from the investigation (referenced herein as Borehole 122-3(2)) is presented in Appendix A. The borehole was advanced at the location shown on Drawing 1; this location has been developed based on plotting the station and offset as shown on the 1976 borehole records and drawings, adjusting based on the site features shown on the drawings and converting these to geographic coordinates based on MTM NAD83 (Zone 10). The borehole location, ground surface elevation (referenced to geodetic datum), and drilled depth are summarized below.

Borehole No.	MTM NAD 83 (Zone 10)		Borehole Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
122-3(2)	4,837,513.3	288,255.4	192.0	8.1

The Standard Penetration Test (SPT) “N” values in the 1976 investigation were obtained using a manual hammer, consisting of a 63.5 kg (140 pound) hammer falling over a distance of 760 mm (30 inches).

Geotechnical laboratory index and classification testing, consisting of water content, grain size distributions and Atterberg limits, was conducted on selected samples as part of the 1976 investigation. The test results are presented on the borehole record contained in Appendix A.

3.2 2012 Investigation

One borehole from the 2012 investigation (designated as Borehole C4-1) was advanced approximately 300 m north of the Courtneypark Drive underpass as part of a culvert rehabilitation investigation (GEOCRES No. 30M12-361). The borehole record from the 2012 investigation is presented in Appendix A. The borehole was advanced at the location shown on Drawing 2. The borehole location and ground surface elevation (referenced to geodetic datum) were obtained from the original borehole record, as summarized below.

Borehole No.	MTM NAD 83 (Zone 10)		Borehole Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
C4-1	4,834,903.6	290,226.0	185.1	10.9

Geotechnical laboratory index and classification testing, consisting of water content, grain size distributions and Atterberg limits was conducted on selected samples as part of the 2012 investigation. The grain size distribution and Atterberg limits test results from this investigation are presented in Appendix A.

3.3 2019 Investigation

The 2019 foundation investigation for the sign supports, HML and CCTV poles was carried out between March 5 and March 25, 2019, during which time 14 boreholes (designated as Boreholes CCTV1, CCTV-3 to CCTV-6, HML-1, OH-1 to OH-6, VMS-1 and VMS-2) were advanced near the proposed foundation elements, as shown on Drawings 1 and 2. The borehole records are contained in Appendix B.

The borehole investigation was carried out using a CME-55 track-mounted drill rig, supplied and operated by Geo-Environmental Drilling Inc. of Halton Hills, Ontario. The boreholes were advanced through the overburden using

152 mm or 203 mm outside diameter hollow stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1]. Considering the inside diameter of the split-spoon samplers, soil particles larger than 35 mm cannot be retrieved. The results of the in-situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4.0 are uncorrected.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. The boreholes were backfilled to ground surface with bentonite, in accordance with Ontario Regulation 903 (Wells, as amended), and the boreholes advanced through asphalt were sealed at ground surface with cold patch asphalt.

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual review. Geotechnical laboratory index and classification testing, consisting of natural moisture contents, grain size distributions and Atterberg limits, was conducted on selected samples in accordance with MTO and / or ASTM Standards, as applicable. The geotechnical laboratory results are presented in Appendix C.

Seven selected soil samples, obtained using appropriate sampling protocols, were submitted to a specialist analytical laboratory under chain of custody procedures for testing of conductivity / resistivity, pH and chemical analysis of sulphate and chloride content, to assess the potential for the soil to cause deterioration to buried concrete and corrosion to steel. The analytical laboratory results are presented in Appendix D.

The as-drilled borehole locations were surveyed by Callon Dietz, Ontario Land Surveyors, or by Golder personnel using a handheld GPS device to a horizontal accuracy of 0.1 m and a vertical accuracy of 0.1 m. The locations provided on the borehole records and shown on Drawings 1 and 2 are positioned relative to MTM NAD 83 (Zone 10) coordinates and the ground surface elevations are referenced to geodetic datum. The borehole locations (including in geographic coordinates of latitude and longitude), ground surface elevations, and drilled depths are summarized below.

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude,°)	Easting (m) (Longitude,°)		
CCTV-1	4,840,702.0 (43.706029)	285,577.9 (-79.738523)	216.2	7.8
CCTV-3	4,836,539.6 (43.668635)	288,731.1 (-79.699269)	194.6	6.5
CCTV-4	4,835,152.1 (43.656178)	290,066.5 (-79.682667)	185.1	8.2
CCTV-5	4,834,657.9 (43.651737)	290,565.8 (-79.676462)	185.2	8.2

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

Borehole No.	MTM NAD83 (Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m) (Latitude,°)	Easting (m) (Longitude,°)		
CCTV-6	4,834,246.7 (43.648042)	290,957.8 (-79.671594)	184.0	7.8
HML-1	4,834,776.0 (43.652794)	290,272.9 (-79.680096)	185.5	8.2
OH-1	4,836,154.2 (43.665173)	288,961.7 (-79.696392)	189.3	7.6
OH-2	4,835,887.2 (43.662774)	289,161.2 (-79.693910)	188.3	7.7
OH-3	4,835,459.0 (43.658930)	289,662.0 (-79.687689)	185.7	8.2
OH-4	4,835,139.5 (43.656061)	290,000.4 (-79.683485)	185.0	8.1
OH-5	4,834,600.2 (43.651211)	290,262.0 (-79.680227)	187.9	7.5
OH-6	4,834,615.7 (43.651351)	290,287.5 (-79.679911)	192.7	8.2
VMS-1	4,838,493.1 (43.686192)	287,654.8 (-79.712675)	196.4	8.0
VMS-2	4,834,872.8 (43.653668)	290,337.4 (-79.679306)	186.3	8.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 410 is located within the physiographic region known as the South Slope, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[2].

The South Slope region is comprised of calcareous clay till with lacustrine clay and silt reworked by glaciers, with numerous scattered drumlins and deep valley cuts caused by streams flowing towards Lake Ontario. The surface topography slopes gradually and uniformly southwards towards Lake Ontario. The overburden within the majority of the South Slope area is underlain by shale bedrock of the Queenston and Georgian Bay Formations, which contain limestone interlayers.

[2] Chapman, L.J. and Putman, D.F., 1984, The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the 1976 and 2012 investigations, and the 2019 investigation, are presented on the borehole records in Appendices A and B, respectively. The results of the geotechnical laboratory tests carried out as part of the 2019 investigation are presented in Appendices C. The results of the analytical laboratory tests carried out as part of 2019 investigation are presented in Appendix D.

The results of the in situ field tests (i.e., SPT "N"-values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Variation in the stratigraphic boundaries between and beyond boreholes exists and is to be expected.

In general, the subsurface conditions encountered at the site consist of a road pavement structure underlain by sand and gravel fill and variable embankment fill (for those boreholes drilled through the Highway 410 lanes or shoulder), or topsoil typically underlain by clayey silt fill (for those boreholes drilled outside of the embankment footprint). A till deposit, grading in composition from clayey silt to silt and sand, was encountered underlying the fill, and this represents the predominant soil deposit throughout the site. Clayey silt layers are present above the till or as interlayers within till in some of the boreholes. Residual soil / possible bedrock was encountered underlying the till deposit at some locations. At the north limit of the proposed installations, the subsurface conditions encountered in Borehole CCTV-1 differ and consist of a pavement structure and embankment fill material, underlain by deposits of silt and silty sand.

A more detailed description of the subsurface conditions throughout the site is provided in the following sections of this report. However, reference should be made to the closest borehole to any given sign support, HML or CCTV pole location to interpret the conditions at the applicable foundation element, recognizing the potential for variation between and beyond borehole locations.

4.2.1 Topsoil

An approximately 50 mm thick layer of topsoil was encountered at ground surface in Boreholes CCTV-5 and OH-5, and an approximately 200 mm thick layer of topsoil was encountered at ground surface in Borehole HML-1.

4.2.2 Asphalt

An approximately 130 mm to 330 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes CCTV-1, CCTV-3, CCTV-4, CCTV-6, OH-1 through OH-4, OH-6, VMS-1 and VMS-2.

4.2.3 Fill

Fill was encountered in all the boreholes except Boreholes CCTV-5 and 122-3(2); in general, sand and gravel fill was encountered immediately below the asphalt, and cohesive fill was encountered below the granular fill, or below topsoil, as follows:

Borehole No.	Approximate Fill Thickness (m)	Elevation of Base of Fill (m)	Fill Description
C4-1	4.7	180.4	0.9 m of loose sand and gravel fill immediately below ground surface, underlain by firm to stiff clayey silt fill
CCTV-1	2.7	213.2	Stiff to hard sandy clayey silt fill below asphalt; plastic refuse was encountered within the fill at a depth of 2.3 m
CCTV-3	1.2	193.2	Dense sand and gravel fill below asphalt
CCTV-4	1.2	183.7	0.5 m of very dense sand and gravel fill below asphalt, underlain by 0.7 m of stiff sandy gravelling clayey silt fill
CCTV-6	0.9	182.8	Very dense sand and gravel fill below asphalt
HML-1	1.3	184.1	Very stiff clayey silt fill below topsoil
OH-1	0.5	188.7	Very dense sand and gravel fill below asphalt
OH-2	0.7	187.5	Very dense sand and gravel fill below asphalt
OH-3	0.7	184.8	Very dense sand and gravel fill below asphalt
OH-4	0.6	184.1	Compact sand and gravel fill below asphalt
OH-5	0.6	187.2	Firm clayey silt fill below topsoil
OH-6	4.2	188.2	0.6 m of very dense sand and gravel fill below asphalt, underlain by 3.6 m of stiff to very stiff gravelly sandy silty clay fill
VMS-1	0.9	195.2	Compact to dense sand and gravel fill below asphalt
VMS-2	1.9	184.1	1.0 m of compact to very dense sand and gravel fill, underlain by 0.9 m of stiff gravelly clayey silt

The Standard Penetration Test (SPT) “N”-values measured within the sand and gravel fill layers range from 13 blows to 110 blows per 0.3 m of penetration, indicating a compact to very dense level of compactness. The SPT “N”-values measured within the cohesive fill range from 4 blows to 38 blows per 0.3 m of penetration, suggesting a firm to hard consistency.

Grain size distribution testing was carried out on two samples of the cohesive fill as part of the 2019 investigation and the results are presented on Figure C-1 in Appendix C. Grain size distribution testing was carried out on one sample of the cohesive fill as part of the 2012 investigation and the results are presented in Appendix A.

Atterberg limits testing was carried out on one sample of the cohesive fill as part of the 2019 investigation and on one sample of the cohesive fill as part of the 2012 investigation. The testing measured liquid limits of 35 and

31 per cent, plastic limits of 21 and 17 per cent, and plasticity indices of about 14 per cent. The Atterberg limits testing results from the 2019 investigation are presented on Figure C-2 in Appendix C and indicate that the fill layer in this borehole is comprised of silty clay of intermediate plasticity. The Atterberg limits testing results from the 2012 investigation are contained in Appendix A and indicate that the fill layer in this borehole is comprised of clayey silt of low plasticity. The natural water content measured on selected samples of the cohesive fill range from about 2 per cent to about 17 per cent. The natural water content measured on selected samples of the non-cohesive fill range from about 3 per cent to about 6 per cent.

4.2.4 Silt to Gravelly Silty Sand

A 2.6 m thick deposit of silt was encountered underlying the cohesive fill in Borehole CCTV-1 at a depth of 3.0 m, corresponding to Elevation 213.2 m. The silt is underlain in this borehole by a deposit of gravelly silty sand, the surface of which was encountered at a depth of 5.6 m, corresponding to Elevation 210.6 m. The borehole was terminated within the gravelly silty sand, penetrating it for a thickness of 2.2 m.

The SPT "N"-values measured within the silt deposit ranged from 21 blows to 121 blows per 0.3 m of penetration, increasing with depth, indicating a compact to very dense state of compactness. The SPT "N"-values measured within the gravelly silty sand deposit were 100 blows per 0.15 m of penetration and 100 blows per 0.05 m of penetration, indicating a very dense state of compactness. Auger grinding was observed during drilling in the gravelly silty sand deposit, suggesting the presence of cobbles and/or boulders.

Grain size distribution testing was carried out on a sample of the silt deposit; the results are presented on Figure C-3 in Appendix C. Atterberg limits testing was carried out on one sample silt deposit; the deposit was determined to be non-plastic. The water content measured on selected samples of the silt deposit ranges from about 18 per cent to about 23 per cent.

4.2.5 Clayey Silt

Layers of clayey silt were encountered underlying the cohesive fill on top of the till deposit in Borehole CCTV-4, and interlayered within the till deposit in Boreholes C4-1, CCTV-5 and OH-4. The surface of the clayey silt layers was encountered between depths of 1.5 m and 10.2 m (Elevations 174.9 m and 183.7 m). Boreholes OH-4 and C4-1 were terminated within this layer, penetrating it for a thickness of 2.5 m and 0.7 m, respectively. The clayey silt layers are 1.5 m and 1.6 m thick in Boreholes CCTV-4 and CCTV-5, respectively, where they were fully penetrated.

The SPT "N"-values measured within the clayey silt layers range from 9 blows per 0.3 m of penetration to 60 blows per 0.08 m of penetration, suggesting a stiff to hard consistency.

Grain size distribution testing was carried out on three samples of the clayey silt deposit as part of the 2019 investigation; the results are presented on Figure C-4 in Appendix C. Grain size distribution testing was also carried out on one sample of the clayey silt as part of the 2012 investigation and the results are presented in Appendix A.

Atterberg limits testing was carried out on three samples of the clayey silt deposit as part of the 2019 investigation and one sample from the 2012 investigation, and measured liquid limits ranging from 20 per cent to 34 per cent, plastic limits ranging from 13 per cent to 19 per cent, and plasticity indices ranging from about 6 per cent to 15 per cent. The Atterberg limits testing results from the 2019 investigation are presented on Figure C-5 in Appendix C, and the results from the 2012 investigation are contained in Appendix A; these results indicate the deposit is comprised of clayey silt of low plasticity. The water content measured on selected samples of the clayey silt deposit range from approximately 11 per cent to 21 per cent, typically near the plastic limit for the material.

4.2.6 Clayey Silt Till to Silt and Sand Till

A till deposit was encountered in all boreholes except Borehole CCTV-1, as follows:

- immediately below the then-existing ground surface in Borehole 122-3(2);
- underlying the topsoil in Borehole CCTV-5;
- underlying the sand and gravel fill in Boreholes CCTV-3, CCTV-6, OH-1 to OH-4, and VMS-1;
- underlying the cohesive fill in Boreholes C4-1, HML-1, OH-5, OH-6, and VMS-2; and
- underlying the surficial clayey silt in Borehole CCTV-4.

Boreholes OH-3, OH-5, OH-6, CCTV-4, CCTV-5, CCTV-6, VMS-1, VMS-2, HML-1 and 122-3(2) were terminated in this deposit, penetrating it for a thickness of 3.7 m to 8.1 m. Where fully penetrated, the till deposit is 4.7 m to 6.6 m thick.

The till deposit is generally comprised of clayey silt, some sand to clayey silt with sand, trace to some gravel. However, the till does vary in composition, and grades to a silt and sand till at depth in some of the boreholes (Boreholes CCTV-4, CCTV-6, OH-1, OH-4, and VMS-2). A 0.4 m thick layer of wet silt and sand was encountered within the till deposit in Borehole VMS-1 at a depth of 6.3 m (Elevation 190.1 m); although not specifically encountered in the samples in other boreholes, similar thin interlayers or lenses or water-bearing sand/silt/gravel soils should be expected within this deposit. Auger grinding was observed during drilling in the till deposit in the majority of the boreholes, and auger refusal was encountered in Boreholes HML-1 (at a depth of 8.2 m corresponding to Elevation 177.3 m), OH-2 (5.6 m/Elevation 182.7 m), OH-3 (5.2 m/Elevation 180.5 m) and OH-5 (7.5 m/Elevation 180.4 m), suggesting the presence of cobbles and/or boulders, which are commonly encountered in glacially derived materials and should be expected within this deposit. Shale fragments were encountered within the till deposit in Boreholes CCTV-1, CCTV-6, OH-1 and OH-3.

The SPT "N"-values measured within the cohesive portions of the till deposit range from 13 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, suggesting a stiff to hard consistency. The SPT "N"-values measured within the non-cohesive portions of the till deposit range from 26 blows per 0.3 m of penetration to 100 blows per 0.15 m of penetration, indicating a compact to very dense state of compactness. In general, the SPT "N"-values increase with depth in both the cohesive and non-cohesive portions of the till deposit.

Grain size distribution testing was carried out on twenty-two samples of the cohesive till deposit and three samples of the non-cohesive till deposit as part of the 2019 investigation and the results are presented on Figures C-6A to C-6D in Appendix C. Grain size distribution testing was carried out on two samples of the till deposit as part of the 2012 investigation and the results are presented in Appendix A.

Atterberg limits testing was carried out on twenty samples of the cohesive till deposit and one sample of the non-cohesive till deposit as part of the 2019 investigation, as well as one sample of the cohesive fill as part of the 2012 investigation. The Atterberg limits tests on the cohesive till deposit measured liquid limits ranging from 17 per cent to 41 per cent, plastic limits ranging from 12 per cent to 22 per cent, and plasticity indices ranging from about 5 per cent to about 19 per cent. Atterberg limits testing was carried out on one sample silt deposit; the deposit was determined to be non-plastic. The Atterberg limits testing results from the 2019 investigation are presented on Figures C-7A to C-7C in Appendix C and the results from the 2012 investigation are contained in Appendix A; these results indicate the cohesive portion of the till deposit is comprised of clayey silt of low plasticity, although one sample is classified as silty clay of intermediate plasticity. The water content measured on selected samples of the till deposit ranges from 7 per cent to 19 per cent, generally near or below the plastic limit for the material.

4.2.7 Residual Soil and Shale Bedrock

A highly weathered shale, or residual soil, was encountered in Borehole OH-2 at a depth of 5.6 m (Elevation 182.7 m) and penetrated to a depth of 7.7 m (Elevation 180.6 m) before termination of the borehole. Fragments of highly weathered shale bedrock were found in Boreholes OH-1 and CCTV-3, encountering split-spoon refusal at a depth of 7.6 m (Elevation 181.7 m) and auger refusal at a depth of 6.5 m (Elevation 188.1 m), respectively.

4.3 Groundwater Conditions

Details of the groundwater levels measured in the open boreholes on completion of drilling are presented on the borehole records in Appendices A and B and presented below. It is emphasized that these water levels do not represent the stabilized groundwater level at the site; typically, the stabilized groundwater level will be higher than that encountered in open boreholes where cohesive till soils are present.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date
C4-1	185.1	Dry	-	August 22, 2012
122-3(2)	192.0	3.8	188.2	July 22, 1976
CCTV-1	216.2	2.6	213.6	March 18, 2019
CCTV-3	194.6	4.0	190.6	March 21, 2019
CCTV-4	185.1	Dry	-	March 25, 2019
CCTV-5	185.2	Dry	-	March 15, 2019
CCTV-6	184.0	7.8	176.2	March 21, 2019
HML-1	185.5	Dry	-	March 6, 2019
OH-1	189.3	Dry	-	March 12, 2019
OH-2	188.3	Dry	-	March 11, 2019
OH-3	185.7	Dry	-	March 10, 2019
OH-4	185.0	6.8	178.4	March 10, 2019
OH-5	187.9	Dry	-	March 6, 2019
OH-6	192.7	Dry	-	March 11, 2019
VMS-1	196.4	7.5	188.9	March 19, 2019
VMS-2	186.3	Dry	-	March 25, 2019

Based on the soil moisture contents and the observed oxidized zone (i.e. soil colour), together with measurements in piezometers for structure sites along this corridor, the groundwater level within the upper portion of the till deposit is inferred to be at about Elevation 181 m in the vicinity of Courtneypark Drive and Derry Road, rising to Elevation 213 m near Queen Street.

The groundwater level at the site will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation. Further, perched groundwater levels should be expected within non-cohesive fill materials or interlayers.

4.4 Analytical Testing Results

Seven soil samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. Detailed analytical test results are included in Appendix D and the test results are summarized below.

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (umho/cm)	Chlorides (ug/g)	Soluble Sulphates (ug/g)
OH-1 / 5	7.87	1,700	579	<20*	590
OH-2 / 2	7.84	480	2,100	770	1,100
OH-3 / 4	7.85	3,900	255	44	51
OH-4 / 3	7.85	1,200	869	430	61
OH-6 / 4	7.44	570	1,760	820	440
VMS-1 / 3	7.84	2,400	412	100	140
VMS-2 / 6	7.69	4,700	214	30	50

* Reportable Detection Limit

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Eric Naylor, EIT, and reviewed by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

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PART B

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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation recommendations for the design of foundations for the overhead sign (OHS) and variable message sign (VMS) supports, high mast light pole (HML) and closed circuit television (CCTV) poles as part of the rehabilitation of Highway 410 from Eglinton Avenue to Mayfield Road in the cities of Mississauga and Brampton, Ontario. These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the 2019 subsurface investigation at this site, supplemented with data from the 1976 and 2012 investigations.

The discussion and recommendations presented are intended to provide the designer with sufficient information to carry out the design of the OHS and VMS supports, HML and CCTV pole foundations. The Foundation Investigation Report, discussions and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO), and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in the Foundation Investigation (Part A) of this report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

6.2 Design of Sign Support Foundations

Caisson foundations for sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual* (MTO, 2019). The *Sign Support Manual* includes standard caisson foundation designs for each sign type as follows:

- **Steel Column Signs**: Steel Column Sign Supports have been removed from the 2019 *Sign Support Manual*; however, Standard Drawing SS118-30 is still available.
- **Cantilever Signs:** Cantilever Static Sign Supports, Section 3 and Standard Drawings SS118-3, SS118-4 and SS118-5.
- **Trichord Overhead Signs:** Tri-Chord Static Sign Supports, including those for Pole-Mounted Variable Message Signs, Section 4 and Section 8, respectively, and Standard Drawings SS118-3, SS118-4, SS118-5, and SS118-11.
- **Monotube Signs:** Overhead Monotube Sign Supports, Section 7 and Standard Drawing SS118-40, SS118-41 and SS118-42.

6.2.1 Steel Column Breakaway Signs

As per the 2019 *Sign Support Manual*, a standard caisson foundation design for a steel column breakaway sign is not available and a site-specific design is required. The geotechnical parameters required for the site-specific design for Roadside Sign G322-B at Station 6+630.00 are included in Table 1. It should be noted that the new and existing fill extends to a depth of approximately 4.4 m to 4.9 m below ground surface, and a site-specific design would have been required under the 2015 *Sign Support Manual*.

6.2.2 Cantilever and Trichord Overhead Signs

In the standard caisson foundation design for cantilever and trichord (including variable message) overhead signs, the caisson is extended 5 m to 6.5 m below the design frost depth. The design frost depth can be taken as 1.2 m for this site, as interpreted from OPSD 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario),* resulting in a total foundation length of 6.2 m to 7.7 m below final grade depending on the sign class and corresponding caisson diameter. The standard sign foundation designs presented in MTO's *Sign Support Manual* have been developed based on the minimum soil conditions given below.

- **Case 1 (Non-Cohesive Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials looser or softer than those of Case 1 or Case 2 are present. The standard foundation design is also not applicable where bedrock is encountered within the standard foundation depth. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the subsurface conditions at the proposed sign locations have been compared to the standard design requirements to assess whether a standard or site-specific design is required. The requirement for either a standard or site-specific design is summarized in Table 1, following the text of this report, along with geotechnical parameters for design. Based on the borehole results, all of the subsurface conditions meet or exceed the minimum values required for standard trichord overhead sign foundations, provided that the other aspects of the signs (e.g., sign board surface area) also meet the standard requirements. If larger sign boards are adopted, site-specific foundation designs will be required.

6.2.3 Monotube Signs

In the standard caisson foundation design for monotube signs, the caisson is 3 m long, and is placed with its finished grade 75 mm to 200 mm above ground surface for safety reasons. The standard sign foundation designs presented in the MTO's Sign Support Manual have been developed based on the minimum soil conditions given below.

- **Case 1 (Non-Cohesive Soils):** Non-cohesive soils with a minimum angle of internal friction of 30 degrees surrounding the caisson.
- **Case 2 (Cohesive Soils):** Cohesive soils with a minimum undrained shear strength of 50 kPa surrounding the caisson.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials looser or softer than those of Case 1 or Case 2 are present. The standard foundation design is also not applicable where bedrock is encountered within the standard foundation depth. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the subsurface conditions at the proposed sign locations have been compared to the standard design requirements to assess whether a standard or site-specific design is required. The requirement for either a standard or site-specific design is summarized in Table 1, following the text of this report, along with geotechnical parameters to be used for design. Based on the borehole results, all of the subsurface conditions meet or exceed the minimum values required for standard monotube sign foundations, provided that the other aspects of the signs (e.g., sign board surface area) also meet the standard requirements. If larger sign boards are adopted, site-specific foundation designs will be required.

6.2.4 Site-Specific Caisson Foundation Design in Soil

A site-specific caisson foundation design may be carried out by the structural engineer to optimize the standard foundation design using the geotechnical design parameters given in Table 1 following the text of this report. Where both undrained shear strength and effective stress parameters are provided, the structural assessment should be completed for both cohesive and non-cohesive soil cases, and the more conservative approach adopted. In the design of cantilever, trichord and monotube sign foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit State (ULS).

The current General Arrangement drawings indicate that the sign support foundations will be constructed in areas of relatively flat ground, and all boreholes penetrated interlayers of non-cohesive and cohesive soils of variable thickness and variable compactness condition/consistency. In cases where the sign foundations are located on the highway embankment side slope or within approximately two caisson foundation diameters of the crest of the slope in the direction of loading, there will be unbalanced earth pressures around the foundation due to its being located within sloping ground (assumed 2H:1V embankment). For this case, the passive earth pressure coefficient ($K_{p\ 2:1}$), calculated in accordance with Figure C6.18 of the Canadian Highway Bridge Design Code and its Commentary (CHBDC (2014)), to be used in the foundation design is also included in Table 1, attached.

6.3 Design of High Mast Light Pole Foundations

Caisson foundations for HML poles should be designed in accordance with the requirements in MTO's *Guidelines for the Design of High Mast Pole Foundations* (MTO, 2004), based on the stratigraphy and geotechnical design parameters given in Table 2 following the text of this report. Where both undrained shear strength and effective stress parameters are provided, the structural assessment should be completed for both cohesive and non-cohesive soil cases, and the more conservative approach adopted. In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action.

The current General Arrangement drawings indicate that the HML pole will be constructed in an area of relatively flat ground; however, if the HML pole is relocated onto a highway embankment slope or within about two diameters of the crest of the slope, there would be unbalanced earth pressures around the HML pole foundation due to its foundation being located within sloping ground (assumed 2H:1V embankment). For this case, the passive earth pressure coefficient ($K_{p2:1}$), to be used in the foundation design is also included in Table 2.

6.4 Design of CCTV Pole Foundations

It is understood that a standard MTO design for new CCTV poles is not yet available and a detailed analysis is needed to estimate lateral deflections of the proposed CCTV poles to ensure they are within a specified serviceability limit criterion. Table 2 presents a summary of the estimated geotechnical soil and groundwater parameters to support the lateral analysis of the poles to meet serviceability limits for lateral deflection. It is important to note that the "buried" portion of the concrete poles must be in intimate contact with the surrounding ‘undisturbed’ soil, similar to a caisson or driven pile installation, in order for the soil resistance values provided in this report to be valid and representative. If there is a ‘void’ or ‘loosened’ backfill material in the annulus between the buried concrete pole and surrounding soils, this must be taken into consideration during design.

6.4.1 Axial Capacity of Direct Buried Concrete Poles

The design for the CCTV poles will be governed by the lateral resistance requirements; axial geotechnical resistance is not considered to be a concern given that negligible axial loads are to be applied (other than self-weight of the hollow concrete poles) and given the relatively competent soils throughout this site.

6.4.2 Lateral Resistance of Direct Buried Concrete Poles

The resistance to lateral loading of vertical buried concrete poles may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction (k_h in kPa/m) is determined based on the equations given below:

For cohesionless soils:

$$k_h = \frac{n_h z}{B}$$

where n_h is the constant of horizontal subgrade reaction (kPa/m);
z is the depth (m); and
B is the buried concrete or caisson diameter (m)

For cohesive soils:

$$k_h = \frac{67 S_u}{B}$$

where S_u is the undrained shear strength of the soil (kPa); and
B is the buried concrete or caisson diameter (m)

The above equations and recommended parameters may be used to analyse the interaction between a buried concrete pole or caisson and the surrounding soil (i.e., for serviceability limit state (SLS) design) provided that lateral displacements within the soil do not exceed approximately 10 mm. If deflections exceed 10 mm, a non-linear analysis method should be used to model the behaviour of the soil (e.g. p-y curves). The upper 1.2 m of soil resistance should not be included in the design to account for frost action.

The spring constant, K, for analysis may be obtained by the expression, K = k_h x L x B (kN/m), where k_h is the coefficient of horizontal subgrade reaction (kPa/m), B is the buried concrete pole or caisson diameter (m) and L is the length (m) of the buried concrete pole or caisson segment used in the analysis. Table 2 provides the recommended geotechnical parameters for use in the design approach outlined above. The current General Arrangement drawings indicate that the CCTV poles will be constructed in areas of relatively flat ground; however, in the event that the CCTV poles are located on the highway embankment slope or within about two diameters of the crest of a slope, there would be unbalanced earth pressures around the CCTV foundation due to its foundation being located within sloping ground (assumed 2H:1V embankment). For this case, the passive earth pressure coefficient ($K_{p2:1}$), to be used in the foundation design is also included in Table 2.

Considering this is a non-standard MTO design, it is understood that a detailed soil-structure analysis will be carried out by the proprietary CCTV pole designer to meet the specified deflection tolerances and provide associated details on foundation design / embedment and installation procedures to meet the requirements in Special Provision SP682S30.

The lateral pressures obtained from the analysis must not exceed the ultimate lateral geotechnical resistance or the factored structural flexural shear resistance and/or bending moment of the buried concrete pole / caisson. The ultimate resistance should be checked by the structural engineer and the ultimate lateral geotechnical resistance can be checked using the conventional Broms' equation, based on the stratigraphy and geotechnical design parameters given in Table 2 following the text of this technical memorandum.

Alternatively, the unfactored lateral geotechnical resistance can be calculated using passive lateral earth pressure, P_p (kPa) as defined below, distributed along the length of the caisson/buried pole based on the stratigraphy and geotechnical design parameters given in Table 2.

$P_p = K_p \gamma d_w$ above the groundwater table (kPa), and

$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w)$ below the groundwater table (kPa)

where Kp is the passive earth pressure coefficient;

γ is the bulk unit weight (kN/m^3);

γ' is the effective unit weight below the groundwater level (kN/m^3);

d is the depth below the ground surface (m); and

d_w is the depth to the groundwater level (m).

The unfactored lateral resistance, p_{ult} (kN) for non-cohesive soils should be calculated assuming an equivalent width equal to three times the caisson/buried pole diameter, and an equivalent length equal to six times the caisson/buried pole diameter (Section C6.8.7.1 of CHBDC (2006)), as outlined below:

$p_{ult} = P_p A_e$ (kN)

where A_e is the equivalent area equal to $3D \cdot 6D = 18D^2$ (m^2)

D is the caisson/buried pole diameter (m)

Where an undrained shear strength, S_u, is provided for a cohesive soil layer in Table 2, the undrained capacity of the caisson/buried pole should also be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson/buried pole within the cohesive soil should be calculated assuming an internal angle of friction, $\Phi' = 0$ degrees, and an unfactored passive lateral pressure distribution varying from 2 S_u at ground surface and increase linearly to 9 S_u at and below a depth equivalent to three caisson/buried pole diameters, acting over the actual width of the caisson/buried pole (Section C6.8.7.1 of CHBDC (2006)), as outlined below.

$p_{ult} = P_p A_e$ (kN)

where P_p = 2 S_u at ground surface to 9 S_u at and below a depth equivalent to 3D (kPa)

A_e is the equivalent area equal to L x D (m^2)

L is the caisson/buried pole length (m)

D is the caisson/buried pole diameter (m)

In accordance with CHBDC (2014), the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu} should be applied to this unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (p_{ULS}) as shown below.

$$p_{ULS} = p_{ult} \cdot \Psi \cdot \phi_{gu} \text{ (kN)}$$

where Ψ = 1 – 1.15 (typical to low consequence factor as per Table 6.1 in CHBDC (2014)

ϕ_{gu} = 0.5 (passive resistance factor for typical degree of understanding, as per Table 6.2 in CHBDC (2014)

6.5 Corrosion Assessment and Protection

The results of analytical testing on a soil samples from each of the OH-series boreholes advanced near the sign support locations are summarized in Section 4.4 and the analytical laboratory test report is included in Appendix D. The analytical test results were compared to CSA A23.1 Table 3 *("Additional requirements for concrete subjected to sulphate attack")* for potential sulphate attack on concrete. The sulphate concentration measured in the tested samples (ranging between 0.005% and 0.11%) is generally below or within the low boundaries of the exposure class of S-3 (Moderate) and is considered negligible according to MTO *Gravity Pipe Design Guidelines* (2014). Therefore, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

The analytical test results of the soil samples were also compared to the MTO *Gravity Pipe Design Guidelines* (2014) for the potential attack on buried steel and the pH is not considered detrimental to the steel durability. The resistivity measured in the tested soil samples (ranging between 480 ohm-cm and 3,900 ohm-cm) indicates that the soil corrosiveness is "moderate" (4,500 > R > 2,000 ohm-cm) to "severe" (R < 2,000 ohm-cm), as per Table 3.2 of the *Gravity Pipe Design Guidelines* (MTO, 2014), and some level of corrosion protection should be applied to the foundation element / materials. Based on the results of the samples tested and given that the structure will be exposed to de-icing salt, consideration should be given by the designer to designing for a "C" type exposure class as defined by CSA A23.1 Table 1.

It is ultimately up to the structural designer to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 "Durability Requirements" are followed.

6.6 Construction Considerations

6.6.1 Control of Soil and Groundwater

The water-bearing non-cohesive soils at this site should be expected to run or flow into the caisson holes during or after drilling of the caisson foundations for the sign supports, HML or CCTV poles. Therefore, appropriate equipment and procedures will be required to minimize ground loss during drilling and concrete placement. This could include the use of temporary caisson liners, and/or the use of drilling mud. Foundations for the sign supports, HML and CCTV poles should be constructed consistent with OPSS 915 (Sign Support Structures) and OPSS 903 (Deep Foundations), respectively. It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of this condition; such an NSSP is provided in Appendix E.

6.6.2 Obstructions

Cobbles and/or boulders were encountered and inferred due to difficult drilling and auger grinding at varying depths in the boreholes drilled during the current subsurface investigation at the proposed overhead and variable sign locations and HML and CCTV pole locations. Additionally, auger refusal was encountered in the boreholes at a number of the sign and pole locations within hard/very dense till deposit, residual soils or on possible bedrock, as follows:

- CCTV: 410TW0050TNS (Borehole CCTV-3), Approx. Station 8+950: Refusal encountered at approximately Elevation 188.1 m on inferred shale bedrock;
- HML - Courtneypark Ramp S-E/W (Borehole HML-1), Approx. Station 10+400: Refusal encountered at approximately Elevation 177.3 m within clayey silt till;
- OHS No. 4 (Borehole OH-1), Approx. Station 8+777: Refusal encountered at approximately Elevation 181.7 m within shale bedrock;
- OHS No. 1 (Borehole OH-2), Approx. Station 9+438: Refusal encountered at approximately Elevation 182.7 m within clayey silt residual soil; and,
- OHS No. 2 (Borehole OH-3), Approx. Station 9+438: Refusal encountered at approximately Elevation 180.5 m within clayey silt till.

It is recommended that a paragraph be added into the NSSP described in Section 6.6.1 be included in the Contract Documents to warn the Contractor of the presence of cobbles and/or boulders within the overburden soils, as well as refusal conditions; an example of the NSSP is provided in Appendix E.

6.6.3 CCTV Poles

We understand the CCTV poles will be "direct buried". According to SP682S30, the concrete pole will be inserted directly into a steel lined auger hole and the annulus surrounding the concrete poles will be filled with grout / concrete to form the foundation that is to be in intimate contact with the surrounding soils.

The CCTV poles are to be designed and constructed in accordance with OPSS 615 (*Construction Specification for Erection of Poles*) and Special Provision 682S30 (*Concrete Poles, Direct Buried in Earth with Camera Raising and Lowering System*). The foundation diameter and embedment depth will be designed by the proprietary CCTV pole designer to ensure that deflection limits (i.e., 25 mm for poles up to 21.3 m high, and 30 mm for poles up to 24.2 m high) specified in SP682S30 are achieved.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Eric Naylor, EIT, and reviewed by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

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ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

Ontario Provisional Standard Drawings:

OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specifications:

OPSS 615	Construction Specification for Erection of Poles
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 915	Construction Specification for Sign Support Structures
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
SP 682S30	Concrete Poles, Direct Buried in Earth with Camera Raising and Lowering System

Ontario Water Resources Act:

Ontario Regulation 903	Wells (as amended)

Ministry of Transportation, Ontario

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Sign Support Manual. Provincial Highways Management Division, Highway Standards Branch, Bridge Office. February 2019.

TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR OVERHEAD AND VARIABLE MESSAGE SIGN FOUNDATIONS

Overhead Sign ID (Location)	Reference Borehole (Station)	Ground Surface Elevation at Reference Borehole (m)	Average Finished Ground Surface Elevation at Sign Location (m)	Sign Type	Standard or Site-Specific Foundation Design	Stratum	Depth Relative to Proposed Ground Surface (m)[1]	Elevation in Reference Borehole (m)	Design Groundwater Elevation (m)	Design Parameters[2, 3]					
										S_u (kPa)	Φ'	γ (kN/m^3)	γ' (kN/m^3)	K_p	$K_{p2:1}$
OHS No. 1 (Sta. 8+776.66)	OH-2	188.3	Left - 187.4 Right - 187.5	Tri-chord Static Sign Support	Standard	Very dense sand and gravel fill	-	188.3 - 187.5	185.5	-	28	20	10	2.77	0.99
						Firm to stiff sandy silty clay till	0.0-2.8	187.5 - 184.6		75	30	20	10	3.00	1.12
						Hard clayey silt till	2.8-4.7	184.6 - 182.7		-	34	21	11	3.54	1.34
						Hard residual soil	Below 4.7	Below 182.7		-	36	21	11	3.85	1.45
OHS No. 2 (Sta. 9+438.20)	OH-3	185.7	Left - 187.4	Tri-chord Static Sign Support	Standard	New fill and existing very dense sand and gravel fill	0-2.6	187.4 - 184.8	183.0	-	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	2.6-9.9	184.8 - 177.5		-	34	21	11	3.54	1.34
			Right - 187.0			New fill and existing very dense sand and gravel fill	0-2.2	187.0 - 184.8	183.0	-	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	2.2-9.5	184.8 - 177.5		-	34	21	11	3.54	1.34
OHS No. 3 (Sta. 9+899.27)	OH-4	185.0	Left - 184.8	Tri-chord Static Sign Support	Standard	Compact sand and gravel fill	0.0-0.7	184.8 - 184.1	181.5	-	28	20	10	2.77	0.99
						Very stiff to hard / dense to very dense clayey silt to silt and sand till	0.7-7.9	184.1 - 176.9		-	34	21	11	3.54	1.34
			Right - 184.2			Dense sand and gravel fill	0.0-0.1	184.2 - 184.1	181.5	-	28	20	10	2.77	0.99
						Very stiff to hard / dense to very dense clayey silt to silt and sand till	0.1-7.3	184.1 - 176.9		-	34	21	11	3.54	1.34
OHS No. 4 (Sta. 10+194.97)	OH-1	189.3	189.3	Cantilever Static Overhead Sign Support	Standard	Very dense sand and gravel fill	0.0-0.6	189.3 - 188.7	187.0	-	28	20	10	2.77	0.99
						Very stiff to hard clayey silt/clayey silt till	0.6-4.3	188.7 - 185.0		-	34	21	11	3.54	1.34
						Very dense silt and sand till	4.3-7.2	185.0 - 182.1		-	34	21	11	3.54	1.34
						Shale Bedrock	Below 7.2	Below 182.1		-	36	21	11	3.85	1.45
Roadside Sign G322-B (Sta. 6+630.00)	C4-1 (Golder 2012)	185.1	Left - 185.3	Steel Column Breakaway Sign Support	Site Specific	New fill and existing loose sand and gravel fill	0.0-1.1	185.3 - 184.2	179.5	-	28	20	10	2.77	0.99
						Firm to stiff clayey silt fill	1.1-4.9	184.2 - 180.4		50	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	4.9-10.4	180.4 - 174.9		-	34	21	11	3.54	1.34
						Hard clayey silt	10.4-11.1	174.9 - 174.2		-	34	20	10	3.54	1.34
			Right - 184.8			Loose sand and gravel fill	0.0-0.6	184.8 - 184.2	179.5	-	28	20	10	2.77	0.99
						Firm to stiff clayey silt fill	0.6-4.4	184.2 - 180.4		50	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	4.4-9.9	180.4 - 174.9		-	34	21	11	3.54	1.34
						Hard clayey silt	9.9-10.6	174.9 - 174.2		-	34	20	10	3.54	1.34
OHS No. 5 (Sta. 10+403.00)	HML-1	185.5	Left - 187.3	Steel Monotube Sign Support - Type 1	Standard	New engineered fill	0.0-1.8	Above 185.5	181.5	-	28	20	10	2.77	0.99
						Very stiff clayey silt fill	1.8-3.3	185.5 - 184.0		75	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	3.3-10.0	184.0 - 177.3		-	34	21	11	3.54	1.34
			Right - 187.0			New engineered fill	0.0-1.5	Above 185.5		-	28	20	10	2.77	0.99
						Very stiff clayey silt fill	1.5-3.0	185.5 - 184.0		75	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till	3.0-10.0	184.0 - 177.3		-	34	21	11	3.54	1.34
OHS No. 6 (VMS) (SBL Sta. 11+184)	VMS-1	196.4	196.2	Pole Mounted Variable Message Sign	Standard	Compact sand and gravel fill	0.0-1.0	196.2 - 195.2	193.5	-	28	20	10	2.77	0.99
						Very stiff to hard clayey silt till including interlayers	1.0-7.8	195.2 - 188.4		-	34	21	11	3.54	1.34
OHS No. 7 (VMS) (NBL Sta. 6+573)	VMS-2	186.3	186.3	Pole Mounted Variable Message Sign	Standard	Compact to very dense sand and gravel fill	0.0-1.3	186.3 - 185.0	181.0	-	28	20	10	2.77	0.99
						Stiff clayey silt fill	1.3-2.2	185.0 - 184.1		75	28	20	10	2.77	0.99
						Very stiff to hard clayey silt with sand	2.2-5.6	184.1 - 180.7		-	32	20	10	3.25	1.23
						Dense to very dense silt and sand till	5.6-8.2	180.7 - 178.1		-	34	20	10	3.54	1.34

NOTES:

1. Depths are given at the proposed sign support locations relative to the proposed average ground surface following construction. Although Su, ϕ' and Kp parameters are given for the full depth of the soil, the passive resistance in the upper 1.2 m should be neglected in the design to account for frost action.

2. Design parameters:
   - s_u = undrained shear strength (kPa);
   - φ' = effective friction angle (degrees);
   - γ = bulk unit weight (kN/m3);
   - γ' = effective unit weight below the groundwater level (kN/m3);
   - K_p = passive earth pressure coefficient; and
   - $K_{p2:1}$ = passive earth pressure coefficient adjusted to account for 2H:1V sloping ground within two caisson diameters of the foundation element.

3. Where both undrained shear strength and effective friction angle parameters are provided for cohesive materials, the structural assessment should be completed for both undrained and drained conditions, and the selected design should be based on the more conservative approach.

TABLE 2
GEOTECHNICAL DESIGN PARAMETERS FOR HIGH MAST LIGHT AND CLOSED CIRCUIT TELEVISION POLE FOUNDATIONS

Overhead Sign ID (Location)	Reference Borehole (Station)	Ground Surface Elevation at Reference Borehole (m)	Average Finished Ground Surface Elevation at Pole Location (m)	Stratum	Depth Relative to Proposed Finished Ground Surface (m)[1]	Elevation in Reference Borehole (m)	Design Groundwater Elevation (m)	Design Parameters[2, 3]						
								S_u (kPa)	ϕ'	γ (kN/m^3)	γ' (kN/m^3)	n_h (kPa/m)	K_p	$K_{p2:1}$
CCTV: 410TW0090TNS (Sta. 14+200)	CCTV-1	216.2	216.2	Stiff to hard sandy clayey silt fill	0.0-3.0	216.2 - 213.2	214.0	50	28	20	10	-	2.77	0.99
				Compact to very dense silt	3.0-5.6	213.2 - 210.6		-	33	20	10	15,000	3.39	1.29
				Very dense gravelly silty sand	5.6-7.8	210.6 - 208.4		-	35	21	11	25,000	3.69	1.40
CCTV: 410TW0060TNS ~(Sta. 9+950)	122-3(2) (MTO 1976)	192.0	192.0	Hard clayey silt till	0.0-8.1	192.0 - 183.9	188.5	-	34	21	11	20,000	3.54	1.34
CCTV: 410TW0050TNS (Sta. 8+950)	CCTV-3	194.6	193.5	Dense sand and gravel fill	0.0-0.4	194.6 - 193.1	191.0	-	28	20	10	5,000	2.77	0.99
				Stiff to hard clayey silt till	0.4-5.0	193.1 - 188.5		100	34	21	11	20,000	3.54	1.34
				Shale Bedrock	Below 5.0	Below 188.5		-	36	21	11	N/A	3.85	1.45
CCTV: 410TW0030TNS (Sta. 9+920)	CCTV-4	185.1	184.6	Stiff sandy gravelly clayey silt fill	0.0-0.9	184.6 - 183.7	183.0	75	28	20	10	-	2.77	0.99
				Stiff to very stiff clayey silt	0.9-2.5	183.7 - 182.1		100	30	20	10	-	3.00	1.12
				Hard clayey silt till/Compact to very dense silt and sand till	2.5-7.7	182.1 - 176.9		-	34	20	10	20,000	3.54	1.34
CCTV: 410TW0020TNS (Sta. 10+050)	CCTV-5	185.2	187.1	New engineered fill	0.0-1.9	187.1 - 185.2	181.5	-	28	20	10	5,000	2.77	0.99
				Very stiff to hard clayey silt till	1.9-7.5	185.2 - 179.6		-	34	21	11	20,000	3.54	1.34
				Stiff clayey silt	7.5-9.1	179.6 - 178.0		75	32	20	10	-	3.25	1.23
				Hard clayey silt with sand till	9.1-10.1	178.0 - 177.0		-	34	21	11	20,000	3.54	1.34
CCTV: 410TW0010TNS (Sta. 5+730)	CCTV-6	184.0	184.0	Compact sand and gravel fill	0.0-1.2	184.0 - 182.8	180.0	-	28	20	10	5,000	2.77	0.99
				Very stiff to hard clayey silt till/very dense silt and sand till	1.2-7.8	182.8 - 176.2		-	34	21	11	20,000	3.54	1.34
HML - Courtneypark Ramp S-E/W (Sta. 10+400.00)	HML-1	185.5	187.1	New engineered fill	0.0-1.6	187.1 - 185.5	181.0	-	28	20	10	N/A	2.77	0.99
				Very stiff clayey silt fill	1.6-3.1	185.5 - 184.0		75	28	20	10	N/A	2.77	0.99
				Very stiff to hard clayey silt till	3.1-9.8	184.0 - 177.3		-	34	21	11	N/A	3.54	1.34

NOTES:

1. Depths are given at the existing borehole location or proposed pole locations relative to the estimated proposed ground surface following construction, including any regrading. Although Su, ϕ' and Kp parameters are given for the full depth of the soil, the passive resistance in the upper 1.2 m should be neglected in the high mast light pole design to account for frost action.

2. Design parameters:
   - s_u = undrained shear strength (kPa);
   - φ' = effective friction angle (degrees);
   - γ = bulk unit weight (kN/m3);
   - γ' = effective unit weight below the groundwater level (kN/m3);
   - n_h = constant of horizontal subgrade reaction (kPa/m);
   - K_p = passive earth pressure coefficient; and
   - $K_{p2:1}$ = passive earth pressure coefficient adjusted to account for 2H:1V sloping ground within two caisson diameters of the foundation element.

3. Where both undrained shear strength and effective friction angle parameters are provided for cohesive materials, the structural assessment should be completed for both undrained and drained conditions, and the selected design should be based on the more conservative approach.

MINISTRY OF TRANSPORTATION, ONTARIO

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

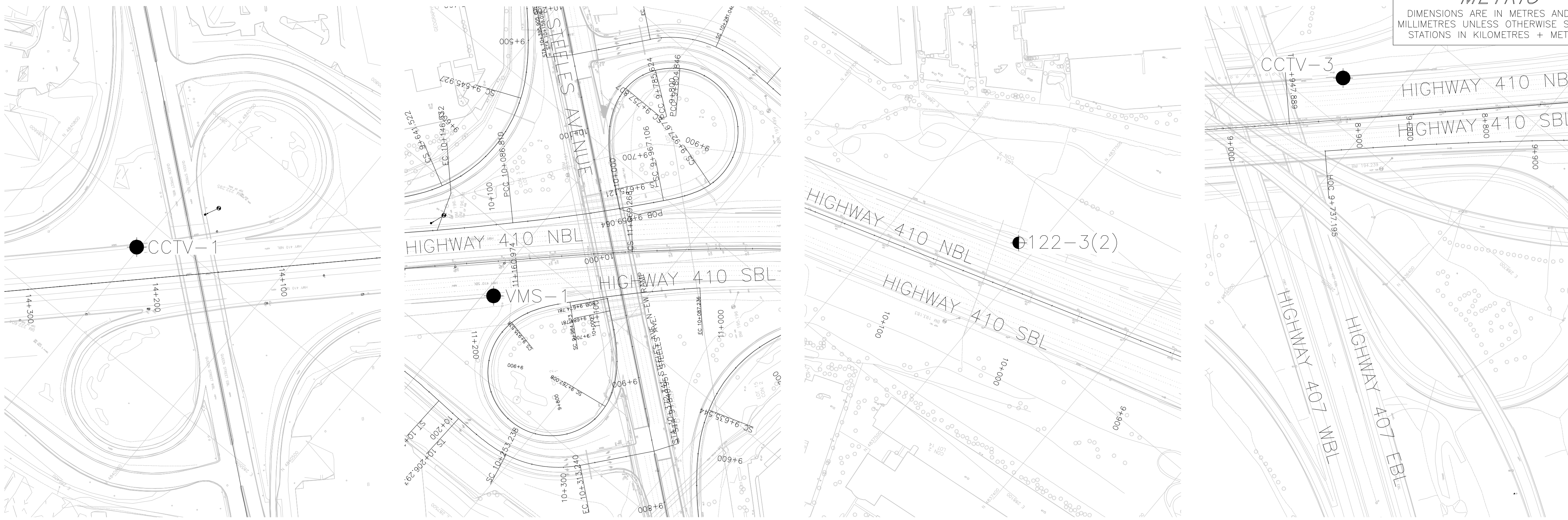
CONT No. 2019–2014
GWP No. 2369–15–00

SHEET

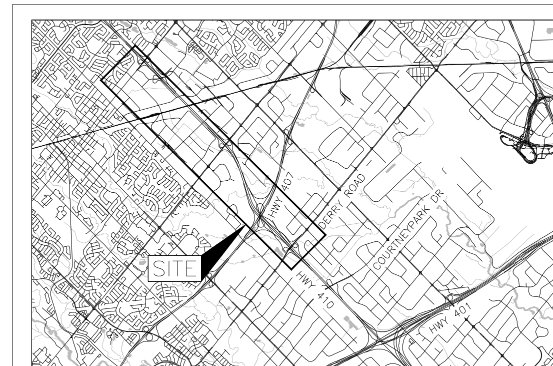
HIGHWAY 410
OHS, VMS, HML & CCTV POLES

BOREHOLE LOCATIONS

GOLDER



PLAN
SCALE
40 0 40 80 m



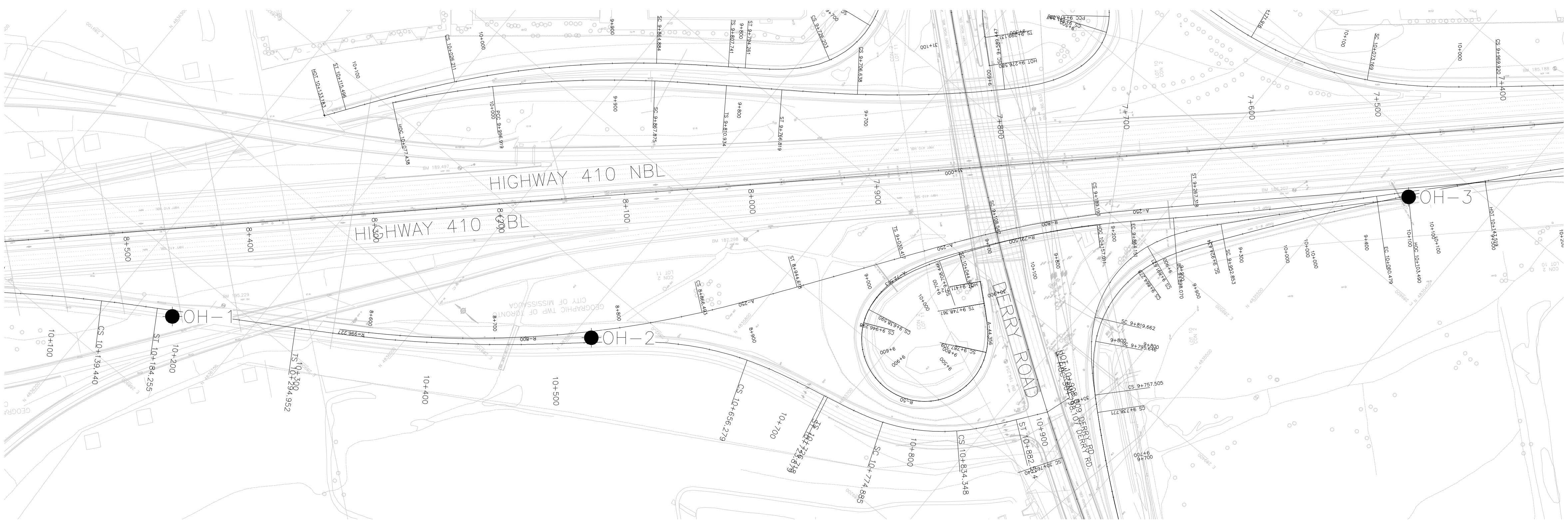
KEY PLAN
SCALE
40 0 40 80 m

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation (GEOCRES. No. 30M12–122)

BOREHOLE CO–ORDINATES

No.	ELEVATION	NORTHING	EASTING
122–3(2)	192.0	4837513.3	288255.4
CCTV–1	216.2	4840702.0	285577.9
CCTV–3	194.6	4836539.6	288731.1
OH–1	191.5	4836154.2	288961.7
OH–2	188.3	4835887.2	289161.2
OH–3	185.7	4835459.0	289662.0
VMS–1	196.4	4838493.1	287654.8



PLAN
SCALE
40 0 40 80 m

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.

REFERENCE

General arrangement plan provided in digital format by AECOM, drawing file nos. ACAD_X–60543038–C–ALI–HWY 410.dwg, X–60543038–C–Courtneypark–NC – Addendum.dwg, received April 04, 2019 and ACAD–X–60543038–C–Base.dwg, received April, 12, 2019.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE May 09, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 May 09, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M12–445

HWY. 410	PROJECT NO. 1669996		DIST. CENTRAL
SUBM'D. NK	CHKD. NK	DATE: 05/09/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. LCC	DWG. 1

PLOT DATE: May 9, 2019
FILENAME: S:\Clients\MTO\Hwy_410_courtneypark\99_PROJ\1669996\40_PROD\0005_OHS_VMS_CCTV_&_HML\1669996-0005-BG-0001.dwg

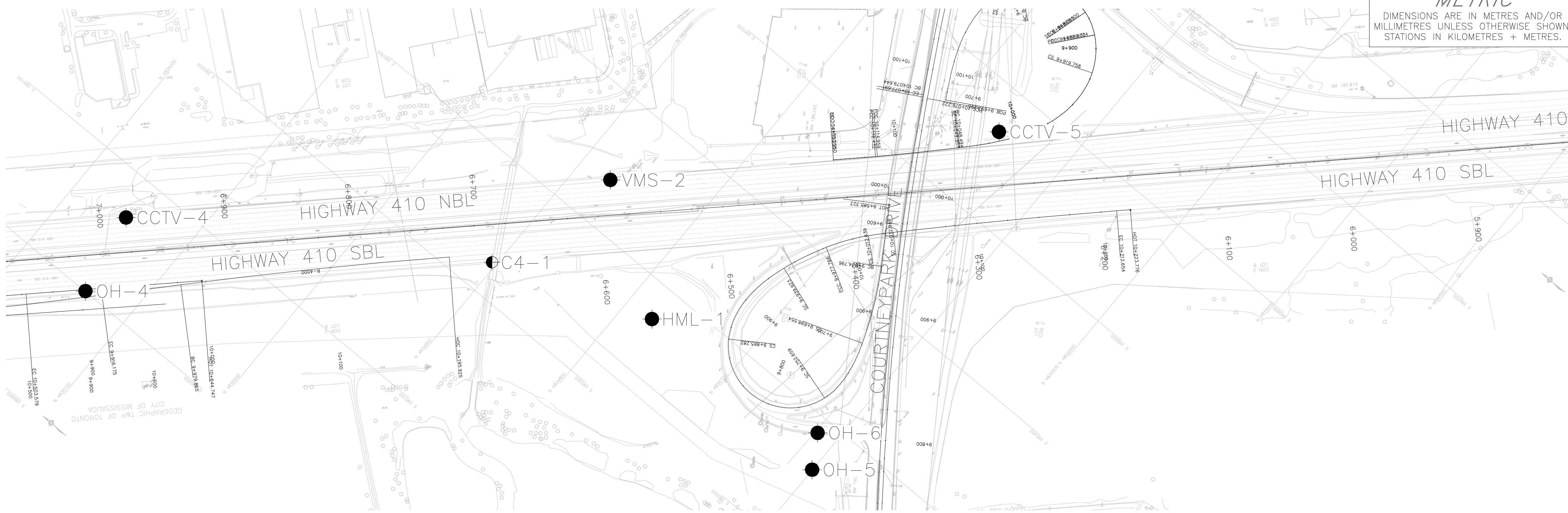
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2019-2014
GWP No. 2369-15-00

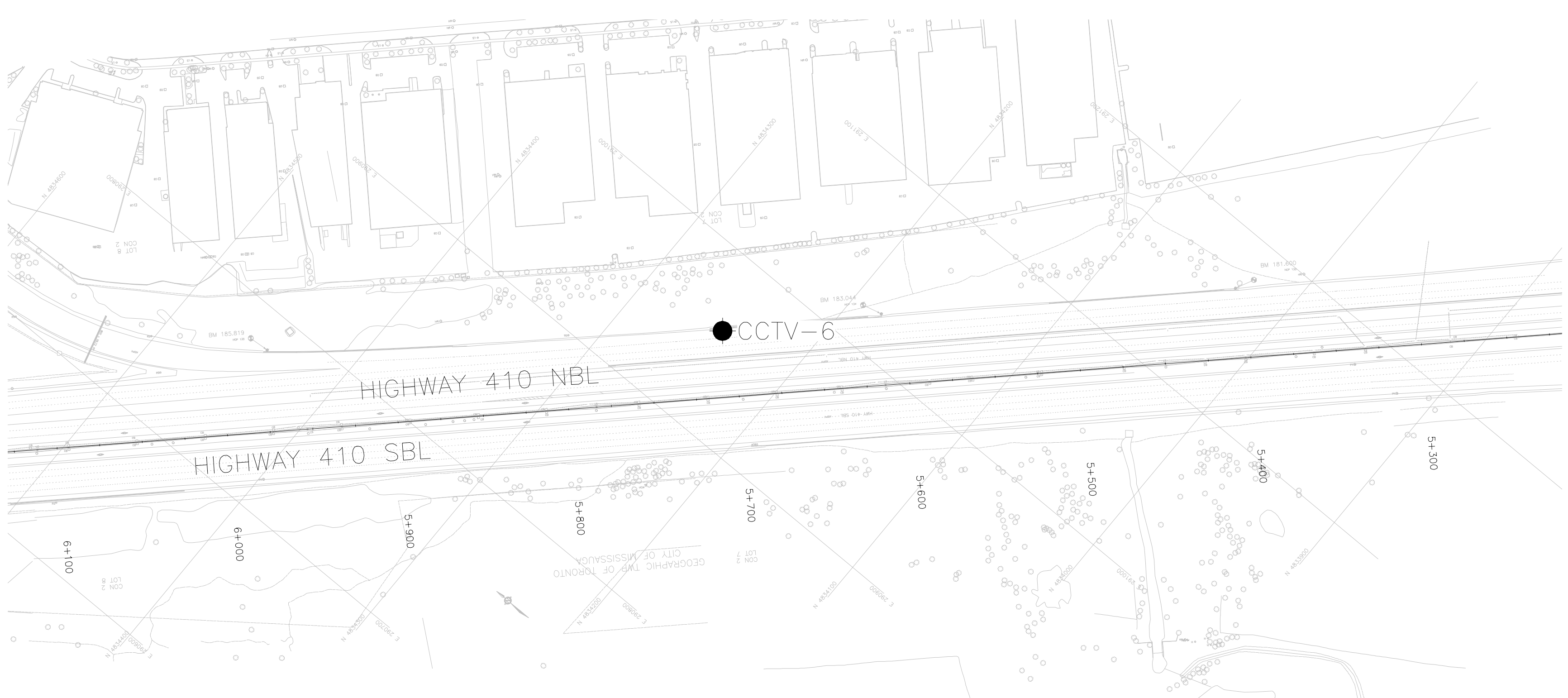
SHEET

HIGHWAY 410
OHS, VMS, HML & CCTV POLES
BOREHOLE LOCATIONS

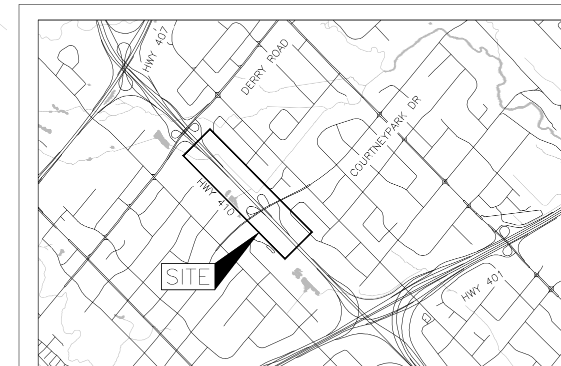
GOLDER



PLAN
SCALE
40 0 40 80 m



PLAN
SCALE
40 0 40 80 m



KEY PLAN
SCALE
1 0 1 2 km

LEGEND

- Borehole – Current Investigation
- Borehole – Previous Investigation (GEOCRES. No. 30M12-361)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C4-1	185.1	4834903.6	290226.0
CCTV-4	185.1	4835152.1	290066.5
CCTV-5	185.2	4834657.9	290565.8
CCTV-6	184.0	4834246.7	290957.8
HML-1	185.5	4834776.0	290272.9
OH-4	185.0	4835139.5	290000.4
OH-5	187.9	4834600.2	290262.0
OH-6	192.7	4834615.7	290287.5
VMS-2	186.3	4834872.8	290337.4

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.

REFERENCE

General arrangement plan provided in digital format by AECOM, drawing file nos. ACAD_X-60543038-C-ALI-HWY 410.dwg, X-60543038-C-Courtneypark-NC – Addendum.dwg, received April 04, 2019 and ACAD-X-60543038-C-Base.dwg, received April, 12, 2019.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE May 09, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 May 09, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M12-445

HWY. 410		PROJECT NO. 1669996	DIST. CENTRAL
SUBM'D. NK	CHKD. NK	DATE: 05/09/2019	SITE:
DRAWN: DD	CHKD. NK	APPD. LCC	DWG. 2

PLOT DATE: May 9, 2019
FILENAME: S:\Clients\MTO\Hwy_410_courtneypark\99_PROJ\1669996\40_PROD\0005_OHS_VMS_CCTV_&_HML\1669996-0005-BG-0002.dwg

APPENDIX A

Borehole Records and Laboratory Testing from 1976 and 2012 Investigations (GEOCRES No. 30M12-122 and 30M12-361)

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE—SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 3(2) (Culvert 3)

WP 103-69-08 LOCATION Co-ords. N 15,870,376; E 945,660 ORIGINATED BY VK

DIST 6 HWY 410 BORING DATE July 22, 1976 COMPILED BY VK

DATUM Geodetic BOREHOLE TYPE C.?.E. 5.1 (1) M.V.H.S. CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	REMARKS % GR SA SI CL
630.0	Ground Level					
0.0	Brown	1	SS	43		8 22 49 21
	Grey	2	SS	129		25 32 29 14
	Het. mixture of clayey silt, sand and gravel	3	SS	50	620	
	(Glacial Till)	4	SS	120		9 33 56 2
	Hard	5	SS	137/6"		
		6	SS	100/6"	610	
603.5		7	SS	160		12 23 46 19
26.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT — w_L; PLASTIC LIMIT — w_P; WATER CONTENT — w

WATER CONTENT %: 10 20 30

UNIT WEIGHT γ

20 / 15 ⌖ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No C4-1

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0083
G.W.P. 2144-07-00 LOCATION N 4834903.6 ;E 290226.0 ORIGINATED BY TWB
DIST Central HWY 410 BOREHOLE TYPE CME-55 Track-mount, 152 mm Solid Stem Augers COMPILED BY MS/NK
DATUM Geodetic DATE August 22, 2012 CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.1	GROUND SURFACE					
0.0	Sand and gravel, some silt, trace clay (FILL) Loose Brown Moist					
184.2 / 0.9	Clayey silt, with to some sand, trace gravel, containing rootlets (FILL) Firm to stiff Brown and grey with oxidation stains Moist	1	SS	7		
		2	SS	5		
		3	SS	8		
		4	SS	12		1 28 37 34
		5	SS	6		
180.4 / 4.7	CLAYEY SILT, trace to some sand, trace gravel, containing cobbles and boulders (TILL) Very stiff to hard Brown with oxidation stains, becoming grey below 5.6 m Moist	6	SS	18		
		7	SS	26		
		8	SS	64		1 8 79 12
		9	SS	36		
174.9 / 10.2	CLAYEY SILT, trace to some sand, trace gravel Hard Grey Moist	10	SS	60/0.08		1 12 70 17
174.2 / 10.9	END OF BOREHOLE					

NOTES:

1. Borehole dry on completion of drilling.

Legend: 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; UNIT WEIGHT γ kN/m³; GROUND WATER CONDITIONS; ELEVATION SCALE 185–175.

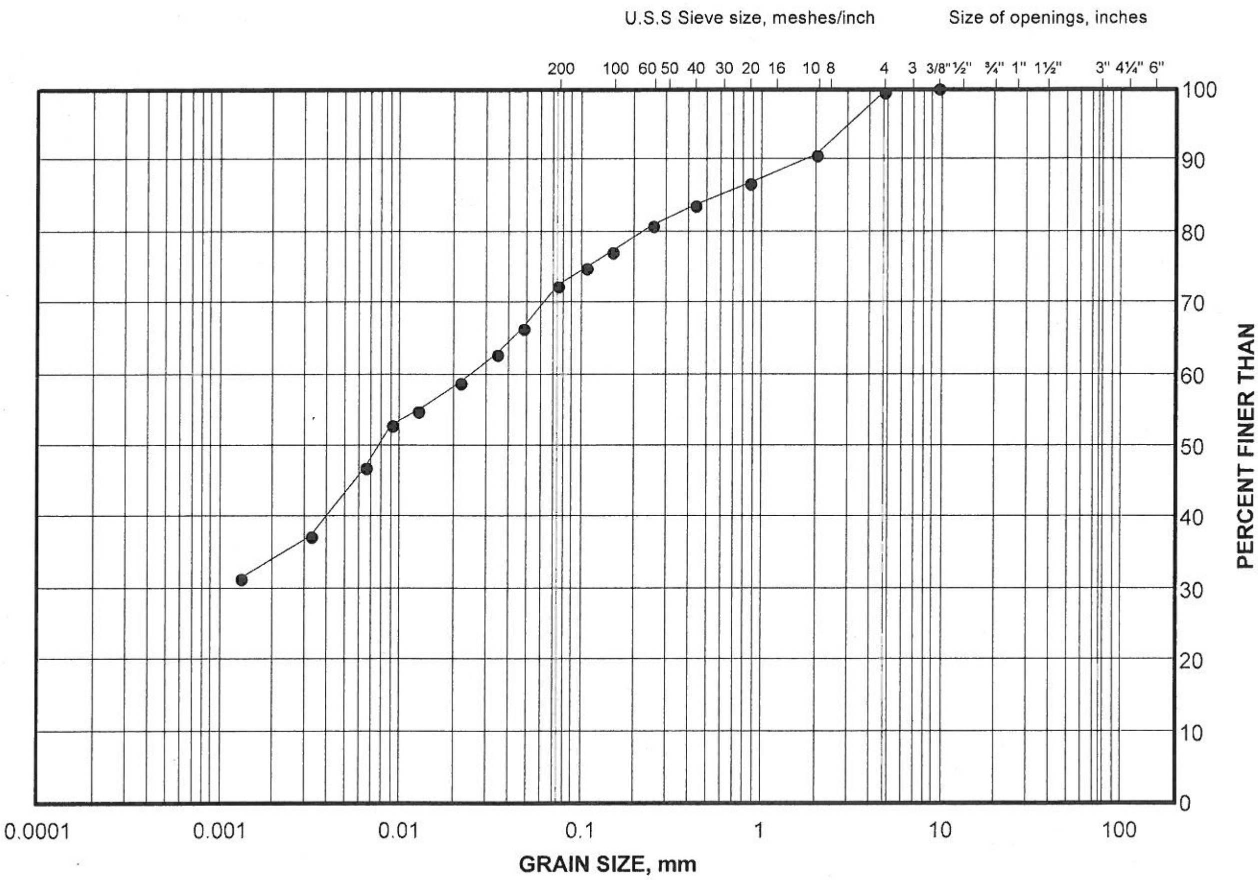
+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

GRAIN SIZE DISTRIBUTION TEST RESULTS

Culvert 4

Clayey Silt Fill

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C4-1	4	181.7

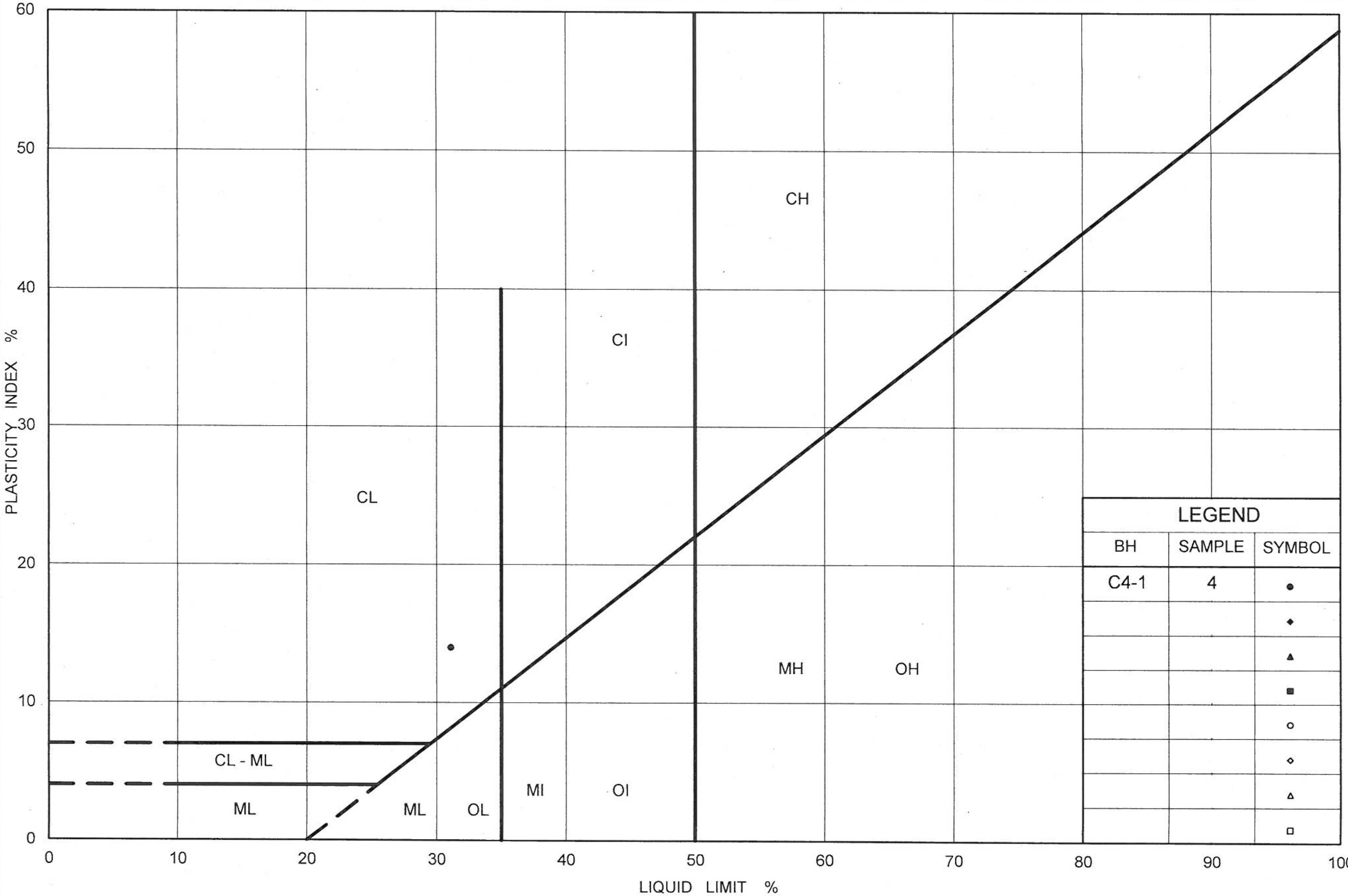
Project Number: 11-1111-0083

Checked By: LCC

Golder Associates

Date: 12-Feb-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Culvert 4 - Clayey Silt Fill

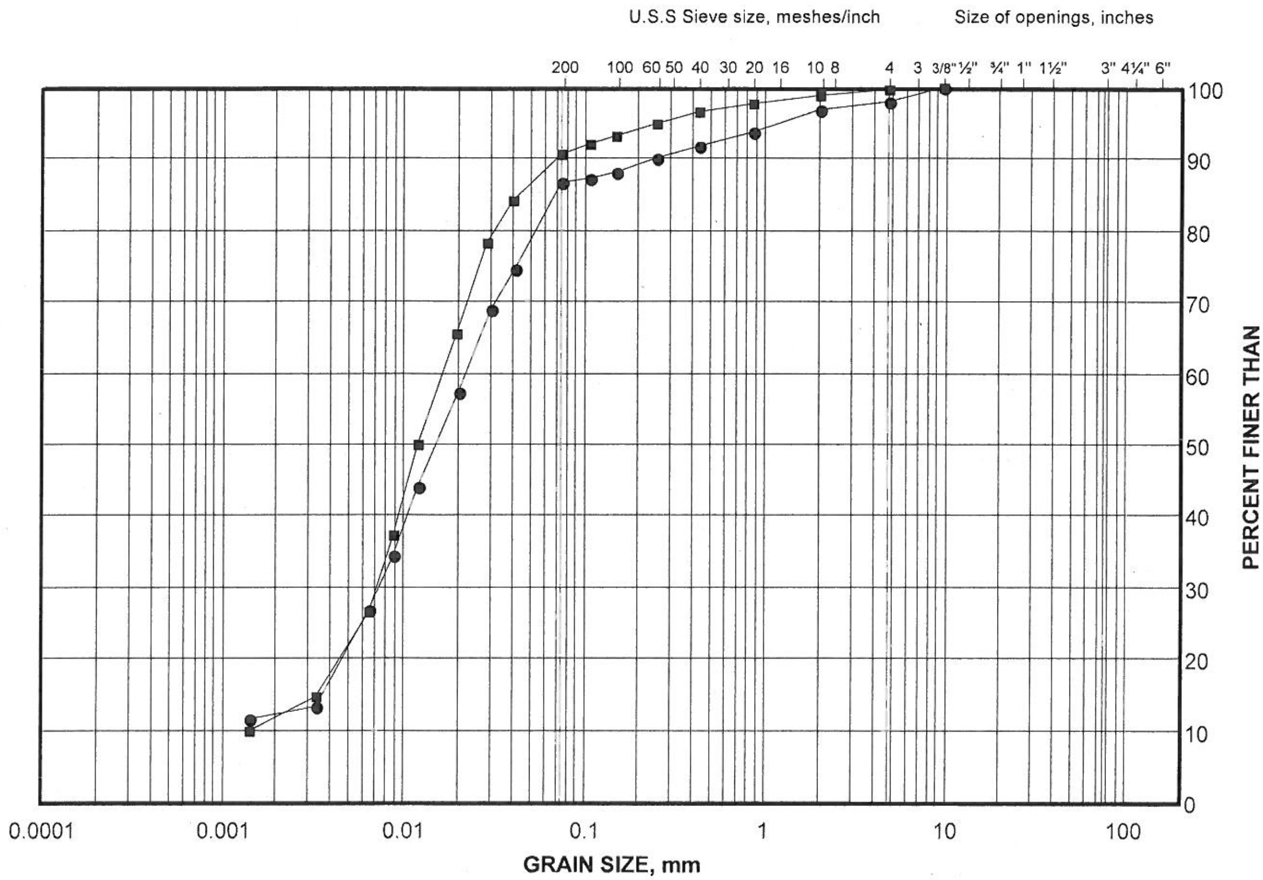
Figure No. B2

Project No. 11-1111-0083

Checked By: LCC

GRAIN SIZE DISTRIBUTION TEST RESULTS
Culvert 4
Clayey Silt to Silt Till

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C4-2	7	177.3
■	C4-1	8	177.2

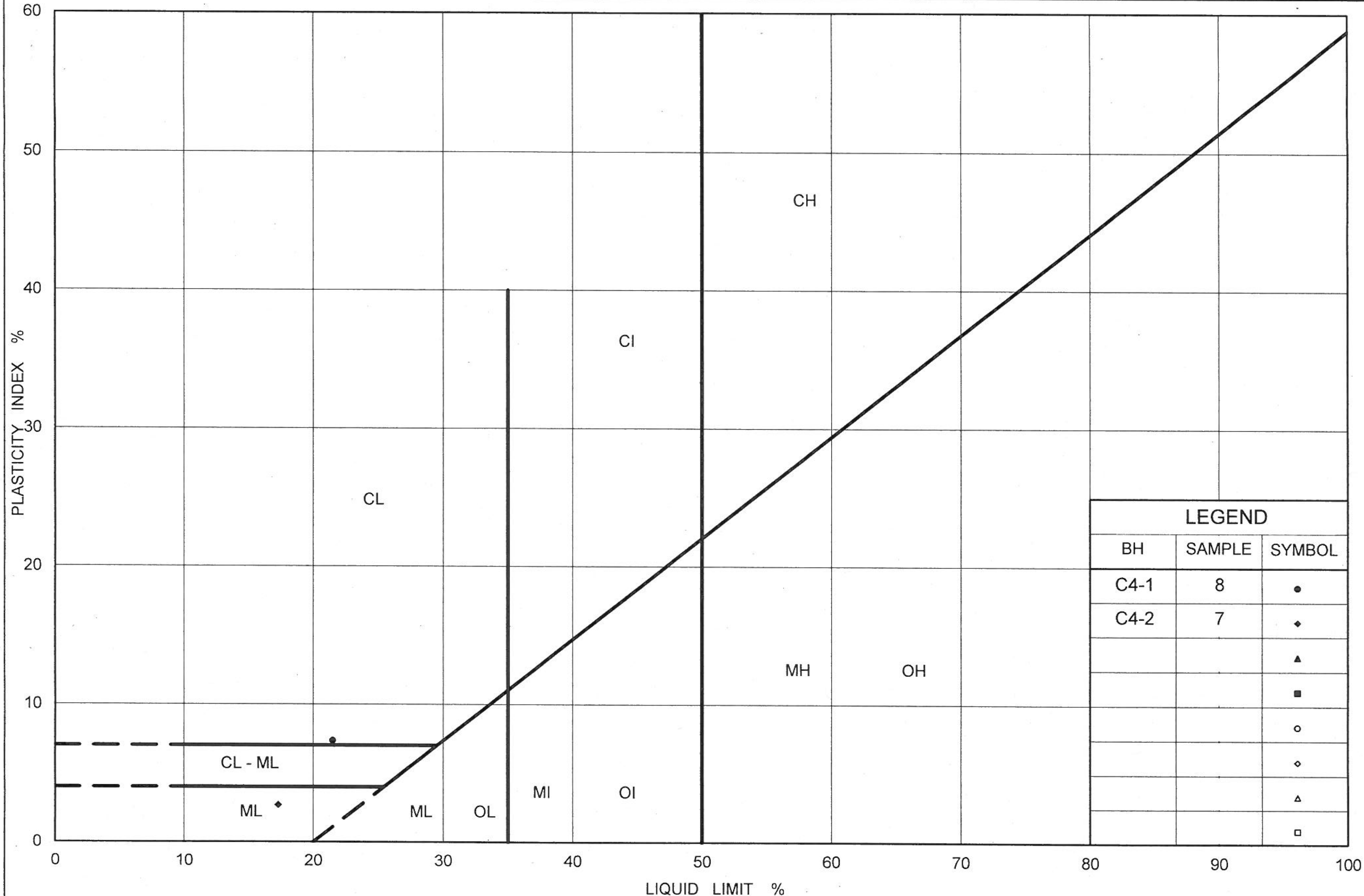
Project Number: 11-1111-0083

Checked By: LCC

Golder Associates

Date: 12-Feb-13

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Culvert 4 - Clayey Silt to Silt Till

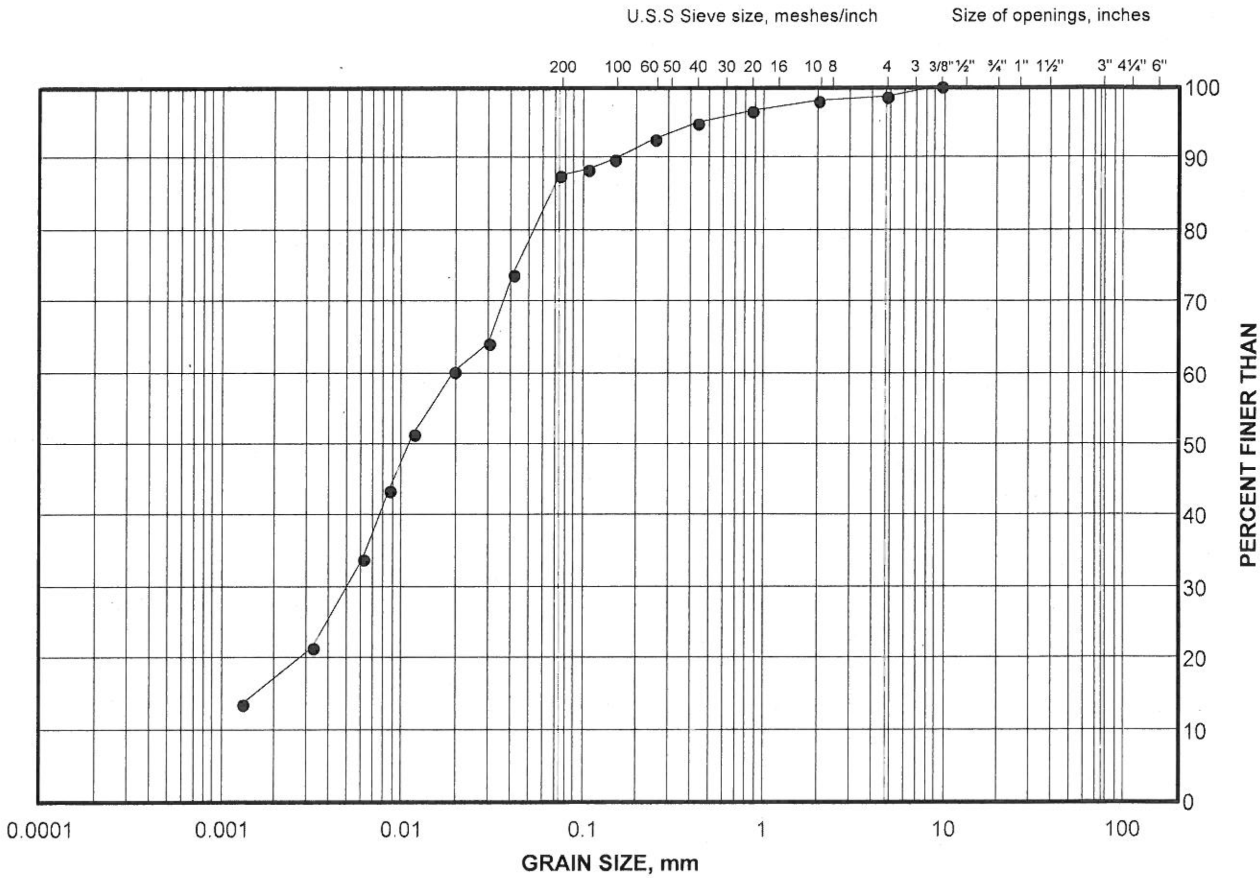
Figure No. B6

Project No. 11-1111-0083

Checked By: LCC

GRAIN SIZE DISTRIBUTION TEST RESULTS
Culvert 4
Lower Clayey Silt

FIGURE B7



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

LEGEND

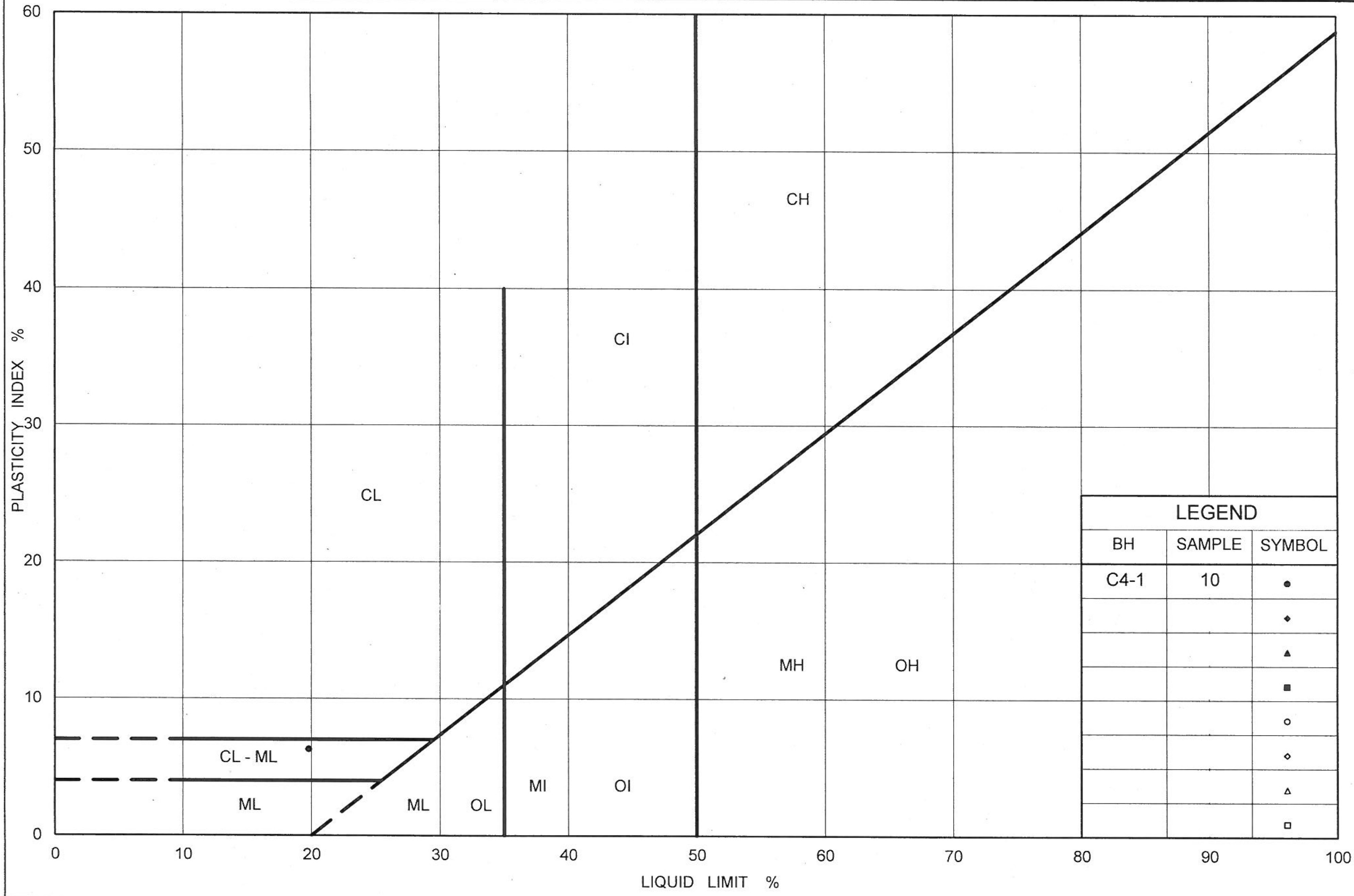
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C4-1	10	174.3

Project Number: 11-1111-0083

Checked By: LCC

Golder Associates

Date: 12-Feb-13



BH	SAMPLE	SYMBOL
C4-1	10	●
		◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Culvert 4 - Lower Clayey Silt

Figure No. B8

Project No. 11-1111-0083

Checked By: LCC

APPENDIX B

Borehole Records from 2019 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
$\sigma_1, \sigma_2, \sigma_3$	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 $= \sigma'_p / \sigma'_{vo}$

(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

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

Compactness Condition	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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CCTV-1

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00 LOCATION N 4840702.0; E 285577.9 MTM NAD ZONE (LAT. 43.706029; LONG. -79.738523) ORIGINATED BY SE

DIST Central HWY 410 BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig COMPILED BY EN

DATUM Geodetic DATE March 18, 2019 CHECKED BY NK

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
216.2	GROUND SURFACE							
0.0 / 215.9	ASPHALT (280 mm)							
0.3	Sandy clayey silt, some gravel (FILL), Stiff to hard, Brown, Moist	-	SS	13				
		1	SS	26				
		2	SS	8		~11		
	- Plastic refuse encountered at 2.3 m, no sample recovered	3	SS	38	▽ (213.6)			
213.2 / 3.0	SILT, some sand, some gravel, trace clay, Compact to very dense, Grey, Wet	4	SS	21		~21		
		5	SS	59		~23		
		6	SS	121		~19	NP	17 15 65 3
210.6 / 5.6	Gravelly Silty SAND, shale fragments at 5.2 m, Very dense, Grey, Moist, - Auger grinding at 6.1 m to 7.6 m	7	SS	100/0.05				
208.4 / 7.8	END OF BOREHOLE	8	SS	100/0.15				

NOTES:

1. Borehole caved to 3.0 m on removal of augers.
2. Water level in open borehole at 2.6 m below ground surface on removal of augers.

Elevation scale: 216, 215, 214, 213, 212, 211, 210, 209

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

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

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RECORD OF BOREHOLE No CCTV-3

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4836539.6; E 288731.1 MTM NAD ZONE (LAT. 43.668635; LONG. -79.699269)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 19 and 21, 2019

CHECKED BY NK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	W (%)	GR	SA	SI	CL
194.6	GROUND SURFACE									
194.3 / 0.0	ASPHALT (280 mm)									
0.3	Sand and gravel, some silt (FILL) Dense Brow Moist	-	SS	41						
		1	SS	31						
193.2 / 1.5	CLAYEY SILT, some sand to Sandy CLAYEY SILT, trace to some gravel (TILL) Stiff to hard Brown Moist	2	SS	14		o	5	22	46	27
		3	SS	15						
		4	SS	20		o				
		5	SS	118/0.25	∇	o	13	19	45	23
	- Auger grinding at 4.4 m	6	SS	127/0.23						
	- Auger grinding at 5.0 m									
188.5	- Auger grinding at 6.1 m	7	SS	100/0.03						
188.1 / 6.5	SHALE (BEDROCK) - Auger grinding from 6.1 m to 6.5 m									
	AUGER REFUSAL END OF BOREHOLE									

Elevation scale: 194, 193, 192, 191, 190, 189

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O 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

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

NOTES:

1. Water level at a depth of 3.96 m below ground surface (Elev. 190.6 m) on completion of drilling (left overnight).

2. Borehole caved to a depth of 6.2 m below ground surface on removal of augers.

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

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CCTV-4 SHEET 1 OF 1 METRIC

PROJECT 1669996

G.W.P. 2369-15-00 LOCATION N 4835152.1; E 290066.5 MTM NAD ZONE (LAT. 43.656178; LONG. -79.682667) ORIGINATED BY JP

DIST Central HWY 410 BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig COMPILED BY EN

DATUM Geodetic DATE March 25, 2019 CHECKED BY NK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
185.1	GROUND SURFACE								
0.0 / 184.8	ASPHALT (330 mm)								
0.3 / 184.3	Sand and gravel, some silt (FILL) Very dense Brown/black Moist	-	SS	99					
0.8 / 183.7	Sandy gravelly clayey silt, some clay pocket (FILL) Stiff Mottled brown and grey Moist	1	SS	12					
1.5 / 182.1	CLAYEY SILT, some sand, trace gravel Stiff to very stiff Mottled brown and grey Moist	2	SS	13	○				
		3	SS	22	wP–wL	2	15	49	34
3.0 / 180.6	Sandy CLAYEY SILT, some gravel (TILL) Hard Grey Moist - Auger grinding at 3.8 m	4	SS	69					
		5	SS	27	○	9	19	53	19
4.5 / 176.9	SILT and SAND, trace to some clay, trace to some gravel (TILL) Compact to very dense Grey Moist	6	SS	26					
		7	SS	35	○	3	49	40	8
		8	SS	79					
8.2	END OF BOREHOLE								

Elevation scale: 185, 184, 183, 182, 181, 180, 179, 178, 177

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; 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; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Borehole caved to a depth of 7.0 m below ground surface on removal of augers.

2. Open borehole dry on completion of drilling and removal of augers.

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CCTV-5

SHEET 1 OF 1

METRIC

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4834657.9; E 290565.8 MTM NAD ZONE (LAT. 43.651737; LONG. -79.676462)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 15, 2019

CHECKED BY NK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.2	GROUND SURFACE						
0.0	TOPSOIL (50 mm)				185		
0.1	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace to some gravel (TILL) Stiff to hard Mottled brown to grey below 4.0 m Moist	-	SS	8			
		1	SS	22	184		
		2	SS	23	183	w	
		3	SS	37			
		4	SS	34	182	w, wP–wL	8 26 46 20
		5	SS	23	181		
		6	SS	17	180		
179.6 / 5.6	CLAYEY SILT, some sand, trace gravel Stiff Grey Moist	7	SS	9	179	wP–w–wL	2 18 39 43
178.0 / 7.2	CLAYEY SILT with SAND, trace gravel (TILL) Hard Grey Moist	8A	SS	36	178	w, wP–wL	5 34 45 16
177.0		8B			177	w	
8.2	END OF BOREHOLE						

NOTE:

1. Open borehole dry upon completion of drilling and removal of augers.

Column headings: SOIL PROFILE (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 + 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; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

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GOLDER

Foundation Design

RECORD OF BOREHOLE No CCTV-6

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4834246.7; E 290957.8 MTM NAD ZONE (LAT. 43.648042; LONG. -79.671594)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 21, 2019

CHECKED BY NK

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.0	GROUND SURFACE						
0.0	ASPHALT (250 mm)						
0.3	Sand and gravel, some silt (FILL) Very dense to compact Brown Moist - Contains asphalt and brick fragments - Slight hydrocarbon odour	-	SS	86			
		1A	SS	15		183	
182.8 / 1.2	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace gravel to gravelly (TILL) Very stiff to hard Brown to grey below 4.4 m Moist	1B					
		2	SS	25		182	
		3	SS	46			27 21 35 17
		4	SS	45		181	
		5	SS	64		180	
		6	SS	26		179	
		7	SS	19		178	8 33 42 17
	- Auger grinding at 7.0 m					177	
176.4 / 7.8	SILT and SAND, some clay, some gravel, contains shale fragments (TILL) Very dense Grey Moist	8	SS	100/0.15	▽		
	END OF BOREHOLE						

NOTES:

1. Water level in the open borehole at a depth of 7.8 m below ground surface on removal of augers.

2. Borehole caved to a depth of 6.5 m below ground surface on removal of augers.

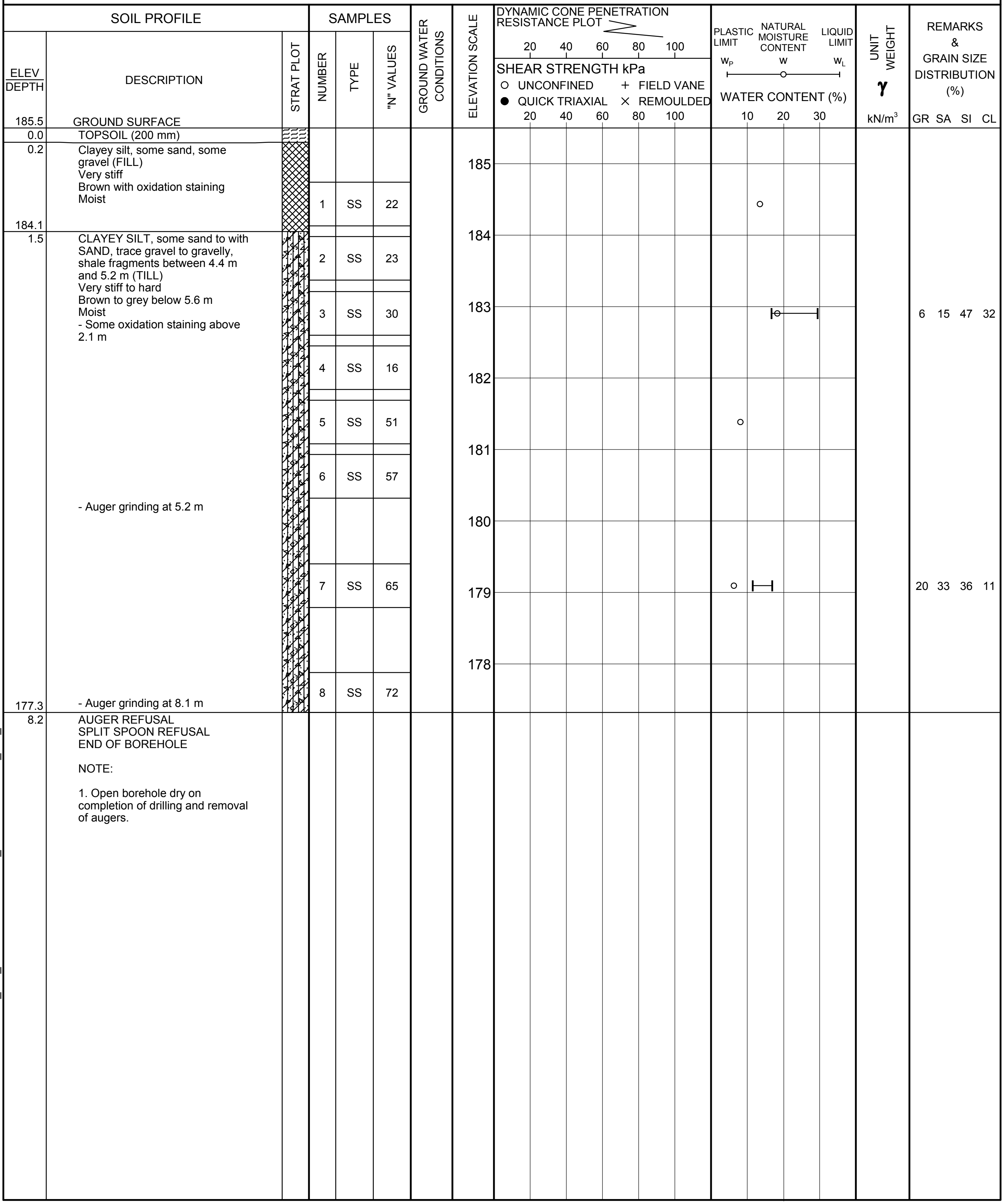
Plot legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No HML-1 SHEET 1 OF 1 METRIC

PROJECT 1669996
G.W.P. 2369-15-00
DIST Central HWY 410
DATUM Geodetic
LOCATION N 4834776.0; E 290272.9 MTM NAD ZONE (LAT. 43.652794; LONG. -79.680096)
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
DATE March 6, 2019
ORIGINATED BY SE
COMPILED BY EN
CHECKED BY NK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
185.5	GROUND SURFACE							
0.0	TOPSOIL (200 mm)							
184.1 0.2	Clayey silt, some sand, some gravel (FILL) Very stiff Brown with oxidation staining Moist	1	SS	22				
1.5	CLAYEY SILT, some sand to with SAND, trace gravel to gravelly, shale fragments between 4.4 m and 5.2 m (TILL) Very stiff to hard Brown to grey below 5.6 m Moist - Some oxidation staining above 2.1 m	2	SS	23				
		3	SS	30	6	15	47	32
		4	SS	16				
		5	SS	51				
		6	SS	57				
	- Auger grinding at 5.2 m							
		7	SS	65	20	33	36	11
177.3	- Auger grinding at 8.1 m	8	SS	72				
8.2	AUGER REFUSAL SPLIT SPOON REFUSAL END OF BOREHOLE NOTE: 1. Open borehole dry on completion of drilling and removal of augers.							



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

GOLDER

RECORD OF BOREHOLE No OH-1

SHEET 1 OF 1

METRIC

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4836154.2; E 228961.7 MTM NAD ZONE (LAT. 43.665173; LONG. -79.696392)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 12, 2019

CHECKED BY NK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
189.3	GROUND SURFACE										
0.0	ASPHALT (130 mm)										
0.1	Sand and gravel (FILL) Very dense Brown Dry	1A	SS	106	189						
188.7 0.6		1B									
	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff to hard Brown to grey below 2.9 m Moist	2	SS	27	188						
		3	SS	37	187						
		4	SS	39							
		5	SS	113/0.28	186			9	31	43	17
	- Auger grinding at 4.0 m	6	SS	100/0.13							
185.0 4.3	SILT and SAND, trace to some clay, trace to some gravel, contains shale fragments below 6.1 m (TILL) Very dense Grey Dry - Auger grinding at 5.2 m to 6.1 m	7	SS	100/0.15	185		NP	6	41	43	10
					184						
		8	SS	100/0.15	183						
182.1 7.2	SHALE (BEDROCK) - Auger grinding at 7.6 m				182						
181.7 7.6	END OF BOREHOLE	9	SS	100/0.03							

NOTES:

1. Borehole caved to depth of 5.9 m below ground surface on removal of augers.

2. Open borehole dry on completion of drilling and removal of augers.

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

GOLDER

RECORD OF BOREHOLE No OH-2

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4835887.2; E 289161.2 MTM NAD ZONE (LAT. 43.662774; LONG. -79.693910)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. 70 mm I.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 11, 2019

CHECKED BY NK

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.3	GROUND SURFACE					
0.0	ASPHALT (130 mm)					
0.1	Sand and gravel, some silt (FILL) Very dense Brown Moist	1	SS	110		
187.5 / 0.8	Sandy SILTY CLAY, trace gravel (TILL) Firm to stiff Brown Moist	2	SS	5		
		3	SS	9		
		4	SS	11		
	- Black clay pockets between 3.0 m and 3.7 m - Oxidation stains from 3.0 m to 5.2 m	5	SS	8	41	5 21 44 30
184.6 / 3.7	Gravelly Sandy CLAYEY SILT (TILL) Hard Brown Moist - Auger grinding at 4.0 m and 5.2 m	6	SS	100/0.10		
		7	SS	40		20 25 38 14
182.7 / 5.6	CLAYEY SILT (RESIDUAL SOIL) - Auger grinding at 5.6 m and 6.1 m - Auger refusal and split spoon refusal encountered at 5.6 m; borehole moved 2 m north and drilling continued. - Auger grinding at 7.2 m and 7.6 m	8	SS	100/0.10		
180.6 / 7.7	END OF BOREHOLE	9	SS	100/0.10		

Elevation scale: 188, 187, 186, 185, 184, 183, 182, 181

Dynamic cone penetration resistance plot: 20, 40, 60, 80, 100. Shear strength kPa: ○ Unconfined, + Field Vane, ● Quick Triaxial, × Remoulded. Plastic limit W_P, natural moisture content W, liquid limit W_L; water content (%) 10, 20, 30. Unit weight γ kN/m³.

NOTES:

1.Borehole OH-2B advanced 2 m north of OH-2 due to auger refusal on inferred boulder.

2. Open borehole dry upon completion of drilling and removal of augers.

3. Open borehole caved to 6.3 m on removal of augers.

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

GOLDER

RECORD OF BOREHOLE No OH-3

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00

LOCATION N 4835459.0; E 289662.0 MTM NAD ZONE (LAT. 43.658930; LONG. -79.687689)

ORIGINATED BY SE

DIST Central HWY 410

BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig

COMPILED BY EN

DATUM Geodetic

DATE March 10, 2019

CHECKED BY NK

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.7	GROUND SURFACE					
0.0	ASPHALT (230 mm)					
0.2	Sand and gravel, some silt (FILL) Very dense Brown Moist	-	SS	56		
184.8 0.9	CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff to hard Brown to grey below 3.8 m Moist	1A 1B	SS	17	w with w_P–w_L range plotted	
		2	SS	31		
		3	SS	38	plotted	
		4	SS	52	plotted	
	- Shale fragments below 3.8 m - Oxidation staining between 3.8 m and 4.4 m	5	SS	56	w with w_P–w_L range plotted	10 30 43 17
		6	SS	64		
	- Auger refusal encountered at 5.2 m; borehole moved 2 m north and drilling continued. - Auger grinding at 5.4 m - Auger grinding between 5.5 m and 5.8 m	7	SS	100/0.15	plotted	13 40 39 8
		8	SS	88		
177.5 8.2	END OF BOREHOLE					

Elevation scale: 185, 184, 183, 182, 181, 180, 179, 178

NOTES:

1.Borehole OH-3B advanced 2 m north of OH-3 due to auger refusal on inferred boulder.

2. Open borehole dry upon completion of drilling.

Legend: 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; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No OH-4

SHEET 1 OF 1 **METRIC**

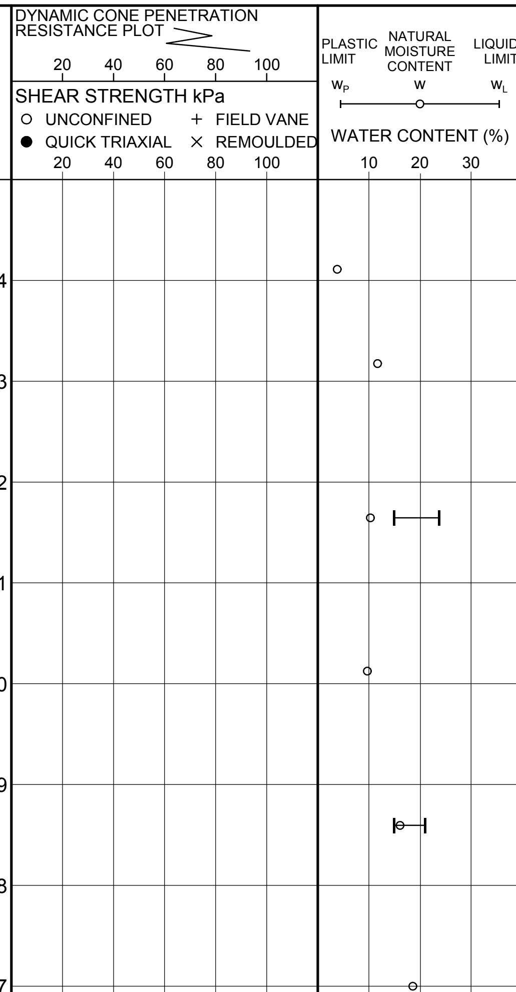
PROJECT 1669996
G.W.P. 2369-15-00
LOCATION N 4835139.5; E 290000.4 MTM NAD ZONE (LAT. 43.656061; LONG. -79.683485)
ORIGINATED BY SE
DIST Central HWY 410
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
COMPILED BY EN
DATUM Geodetic
DATE March 10, 2019
CHECKED BY NK

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.0	GROUND SURFACE					
0.0 / 184.7	ASPHALT (330 mm)					
0.3	Sand and gravel, some silt (FILL), Compact, Brown, Moist	1A / 1B	SS	13		
184.1 / 0.9	CLAYEY SILT with SAND, some gravel (TILL), Stiff to hard, Brown with oxidation staining, Moist	2	SS	28		
		3	SS	28		
		4	SS	30		17 30 40 13
181.3 / 3.7	SILT and SAND, trace to some clay, trace gravel (TILL), Dense to very dense, Grey, Moist	5	SS	53		
		6	SS	41		5 37 47 11
179.4 / 5.6	CLAYEY SILT, some sand, Hard, Grey, Moist	7	SS	33	Water level (Elev. 178.4 m)	0 12 67 21
		8A / 8B	SS	35		
176.9 / 8.1	END OF BOREHOLE					

NOTES:

1. Borehole caved to depth of 6.9 m on removal of augers.

2. Water level in open borehole at a depth of 6.8 m below ground surface (Elev. 178.4 m) on completion of soil drilling.



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

GOLDER

Foundation Design

RECORD OF BOREHOLE No OH-5

SHEET 1 OF 1 **METRIC**

PROJECT 1669996

G.W.P. 2369-15-00 LOCATION N 4834600.2; E 290262.0 MTM NAD ZONE (LAT. 43.651211; LONG. -79.680227) ORIGINATED BY SE

DIST Central HWY 410 BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig COMPILED BY EN

DATUM Geodetic DATE March 5 and 6, 2019 CHECKED BY NK

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.9	GROUND SURFACE						
0.0 / 0.1	TOPSOIL (50 mm)						
	Clayey silt, some sand, some organics (FILL) Firm Brown Moist	1	SS	4			
187.2 / 0.7	Sandy CLAYEY SILT, trace to some gravel (TILL) Very stiff to hard Brown to grey below 4.5 m Moist	2	SS	17	187		
		3	SS	27	186		
		4	SS	41	185		3 22 52 23
		5	SS	52	184		
		6	SS	30			
		7	SS	18	183		
		8	SS	23	182		18 23 42 17
	- Auger grinding at 7.3 m - Water seepage at 7.3 m				181		
180.4 / 7.5	AUGER REFUSAL SPLIT SPOON REFUSAL END OF BOREHOLE						

NOTES:

1. Borehole caved to 6.4 m on removal of augers.

2. Open borehole dry on completion of drilling.

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; UNIT WEIGHT γ kN/m³

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY_410_COURTNEYPARK\02_DATA\GINT\HWY_410_COURTNEYPARK.GPJ GAL-GTA.GDT 04/25/19

RECORD OF BOREHOLE No OH-6

SHEET 1 OF 1 **METRIC**

PROJECT 1669996
G.W.P. 2369-15-00
DIST Central HWY 410
DATUM Geodetic

LOCATION N 4834615.7; E 290287.5 MTM NAD ZONE (LAT. 43.651351; LONG. -79.679911)
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
DATE March 11, 2019

ORIGINATED BY SE
COMPILED BY EN
CHECKED BY NK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
192.7	GROUND SURFACE							
0.0 / 192.4	ASPHALT (305 mm)							
0.3	Sand and gravel, some silt (FILL) Very dense Brown Moist	1	SS	87				
191.8 / 0.9	Gravelly sandy silty clay (FILL) Stiff to very stiff Grey to mottled brown Moist	2	SS	14	33	17	37	13
		3	SS	13				
		4	SS	10	30	23	32	15
		5	SS	28				
	- Auger grinding at 3.7 m	6	SS	13				
188.2	- Auger grinding at 4.4 m							
4.5	Sandy CLAYEY SILT, trace to some gravel, trace rootlets to 5.1 m (TILL) Stiff to hard Brown to grey below 7.2 m Moist	7	SS	14				
		8	SS	41				
184.5		9	SS	27	10	28	39	23
8.2	END OF BOREHOLE							

NOTES:

1. Borehole caved to a depth of 6.7 m below ground surface on removal of augers.

2. Open borehole dry on completion of drilling and removal of augers.

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (192, 191, 190, 189, 188, 187, 186, 185); 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); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

GOLDER

RECORD OF BOREHOLE No VMS-1

SHEET 1 OF 1 **METRIC**

PROJECT 1669996
G.W.P. 2369-15-00
LOCATION N 4838493.1; E 287654.8 MTM NAD ZONE (LAT. 43.686192; LONG. -79.712675)
ORIGINATED BY SE
DIST Central HWY 410
BOREHOLE TYPE 152 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
COMPILED BY EN
DATUM Geodetic
DATE March 19, 2019
CHECKED BY NK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
196.4	GROUND SURFACE									
0.0 / 196.1	ASPHALT (300 mm)									
0.3	Sand and gravel, some silt (FILL) Compact to dense Brown Moist	-	SS	39						
195.2		1A / 1B	SS	21						
1.2	Sandy CLAYEY SILT, trace to some gravel (TILL) Very stiff to hard Brown to grey below 3.9 m Moist	2	SS	33		plotted	8	30	42	20
		3	SS	43						
		4	SS	40		plotted				
		5	SS	53						
		6	SS	61		plotted	34	26	30	10
190.1	SILT and SAND Very dense Grey Wet	7A / 7B	SS	68		plotted				
189.7 / 6.7	Sandy CLAYEY SILT, trace to some gravel (TILL) Very stiff to hard Brown to grey below 3.9 m Moist				▽ (189)					
188.4		8	SS	142/0.25						
8.0	END OF BOREHOLE									

NOTES:

1. Borehole caved to depth of 6.1 m on removal of augers.

2. Water level in open borehole at a depth of 7.5 m below ground surface (Elev. 188.9 m) on completion of drilling.

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

RECORD OF BOREHOLE No VMS-2

SHEET 1 OF 1 **METRIC**

PROJECT 1669996
G.W.P. 2369-15-00
LOCATION N 4834872.8; E 290337.4 MTM NAD ZONE (LAT. 43.653668; LONG. -79.679306)
ORIGINATED BY JNP
DIST Central HWY 410
BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers; CME 55 Track Mounted Drill Rig
COMPILED BY EN
DATUM Geodetic
DATE March 24 and 25, 2019
CHECKED BY NK

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.3	GROUND SURFACE					
186.0 / 0.0	ASPHALT (300 mm)					
0.3	Sand and gravel, some silt (FILL) Compact to very dense Brown Moist	1	SS	63		
		2	SS	16	○	
185.0 / 1.3	Gravelly clayey silt, some sand (FILL) Stiff Brown Moist	3	SS	10	○	
184.1 / 2.2	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace to some gravel (TILL) Very stiff to hard Brown Moist - Trace sand pockets below 3.8 m	4	SS	30		
		5	SS	24	○ (with plastic and liquid limits)	7 22 44 27
		6	SS	17		
		7	SS	59	○ (with plastic and liquid limits)	11 39 37 13
180.7 / 5.6	SILT and SAND, trace gravel, trace clay (TILL) Dense to very dense Grey Moist	8	SS	34		
		9	SS	67	○	
178.1 / 8.2	END OF BOREHOLE					

NOTES:

1. Borehole caved to a depth of 6.9 m on removal of augers.

2. Borehole dry on completion of drilling and removal of augers.

Elevation scale: 186, 185, 184, 183, 182, 181, 180, 179

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
Unit weight γ kN/m³

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

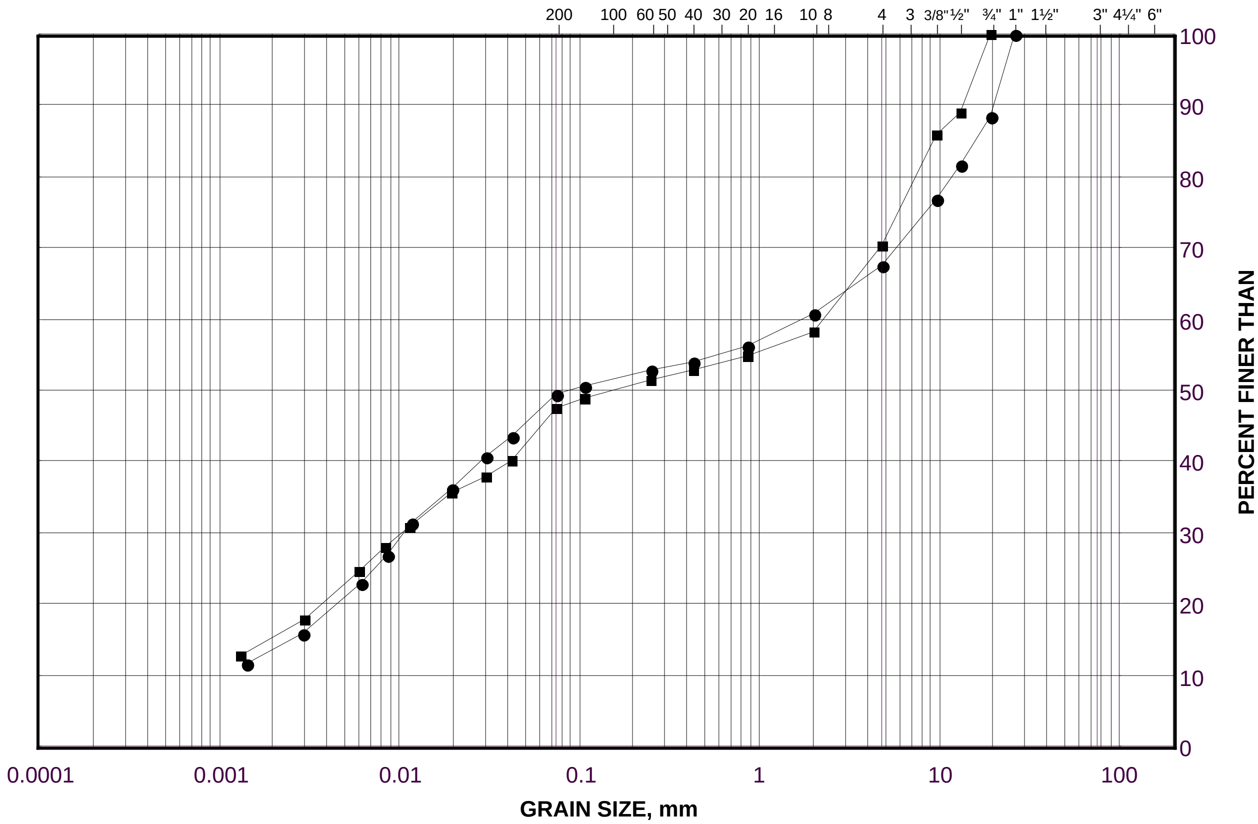
APPENDIX C

Geotechnical Laboratory Test Results from 2019 Investigation

GRAIN SIZE DISTRIBUTION

Gravelly Sandy Silty Clay Fill

FIGURE C-1



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OH-6	2	191.5
■	OH-6	4	190.1

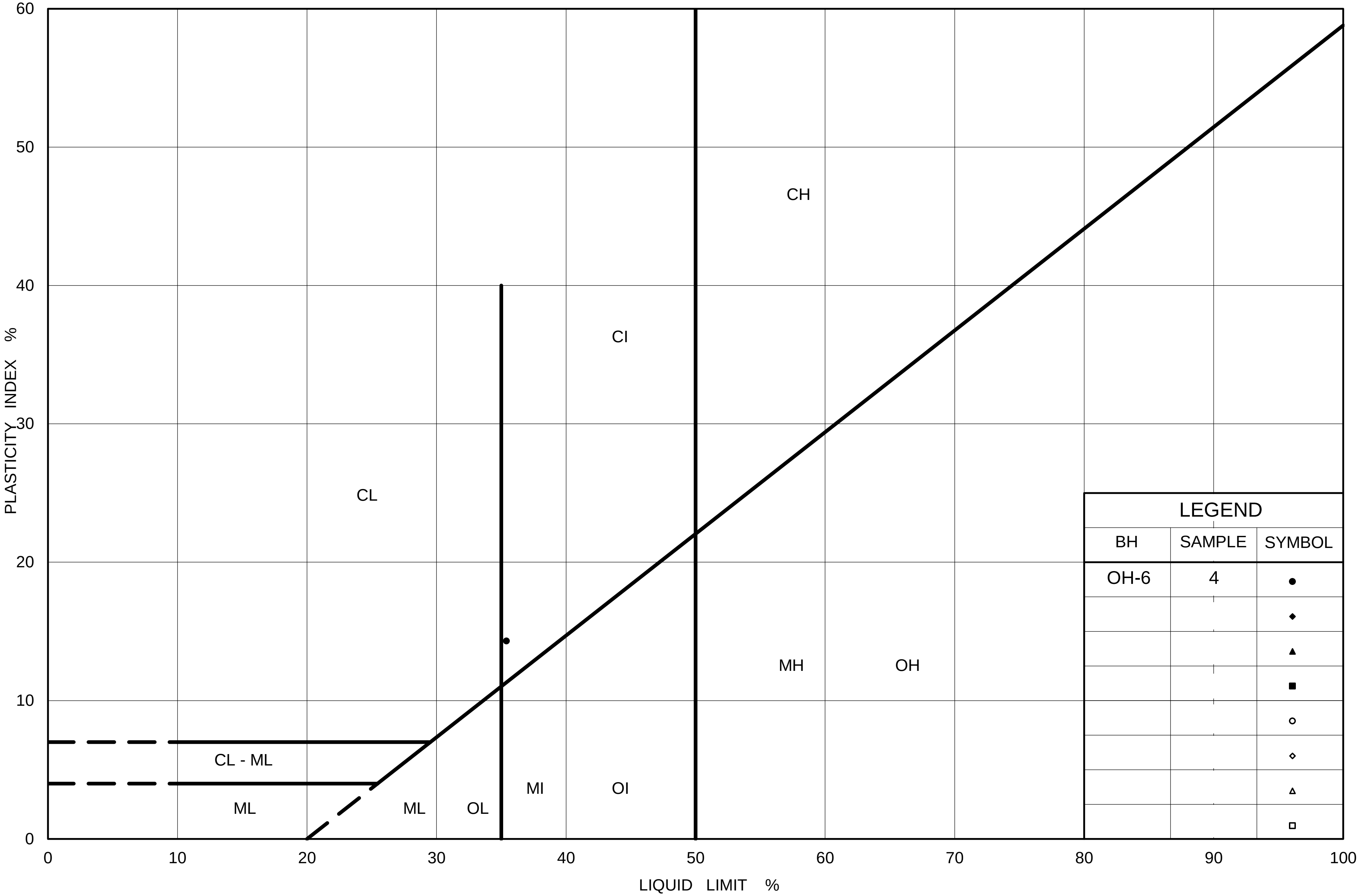
Project Number: 1669996

Checked By: NK

Golder Associates

Date: 24-Apr-19

Oct 75, FF-S-21



Ministry of Transportation

Ontario

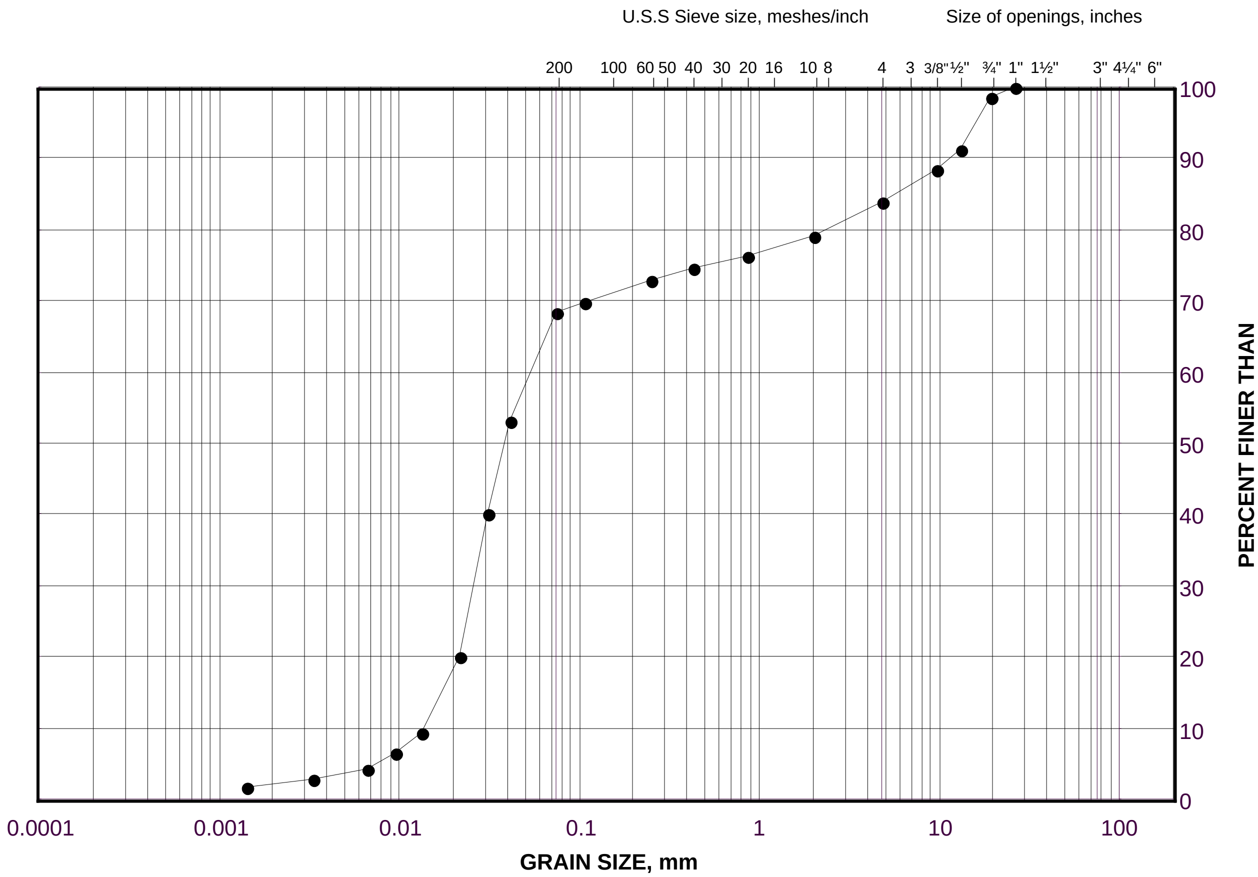
PLASTICITY CHART
Gravelly Sandy Silty Clay Fill

Figure No. C-2

Project No. 1669996 (2200)

Checked By: NK

GRAIN SIZE DISTRIBUTION Silt	FIGURE C-3



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CCTV-1	6	211.4

Project Number: 1669996

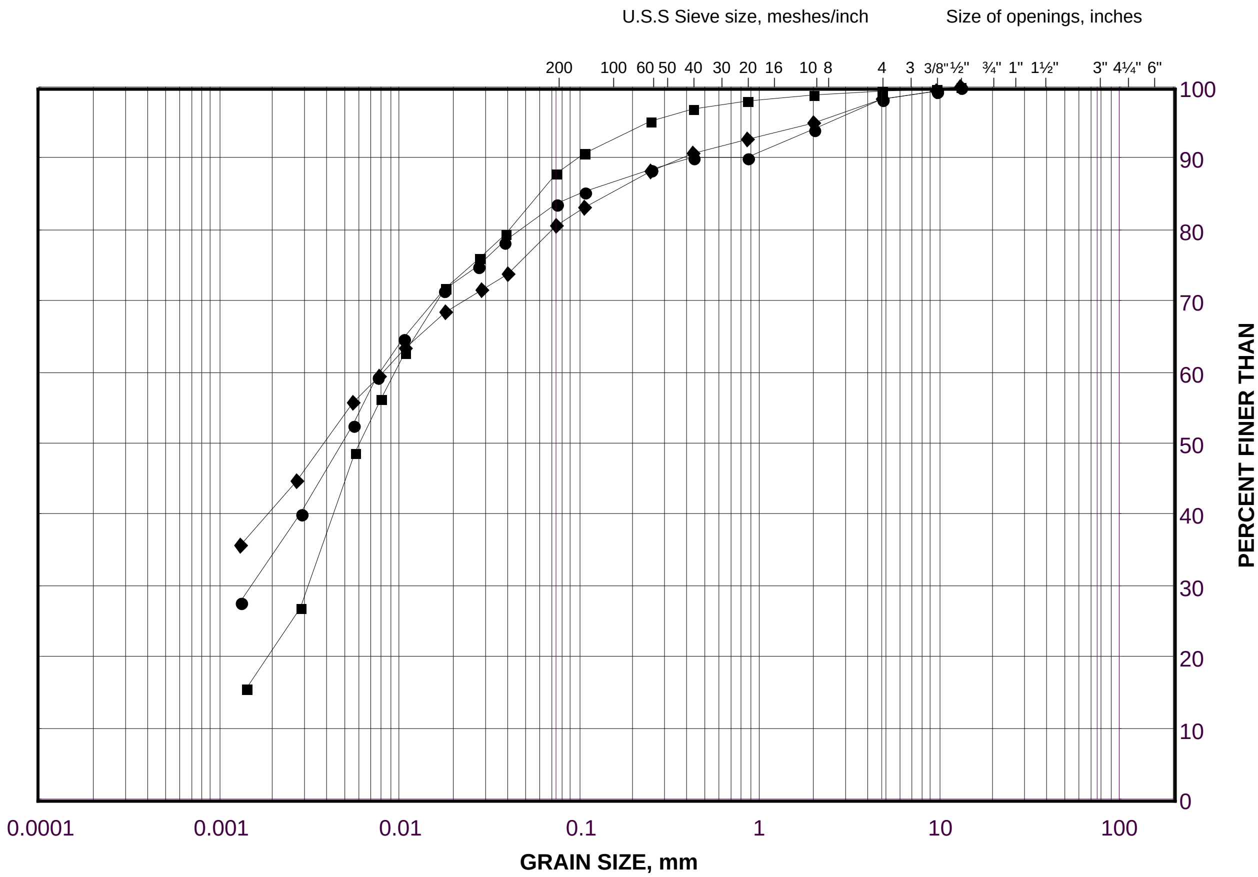
Checked By: NK

Golder Associates

Date: 24-Apr-19

GRAIN SIZE DISTRIBUTION
Clayey Silt

FIGURE C-4



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CCTV-4	3	182.5
■	OH-4	7	178.6
◆	CCTV-5	7	178.8

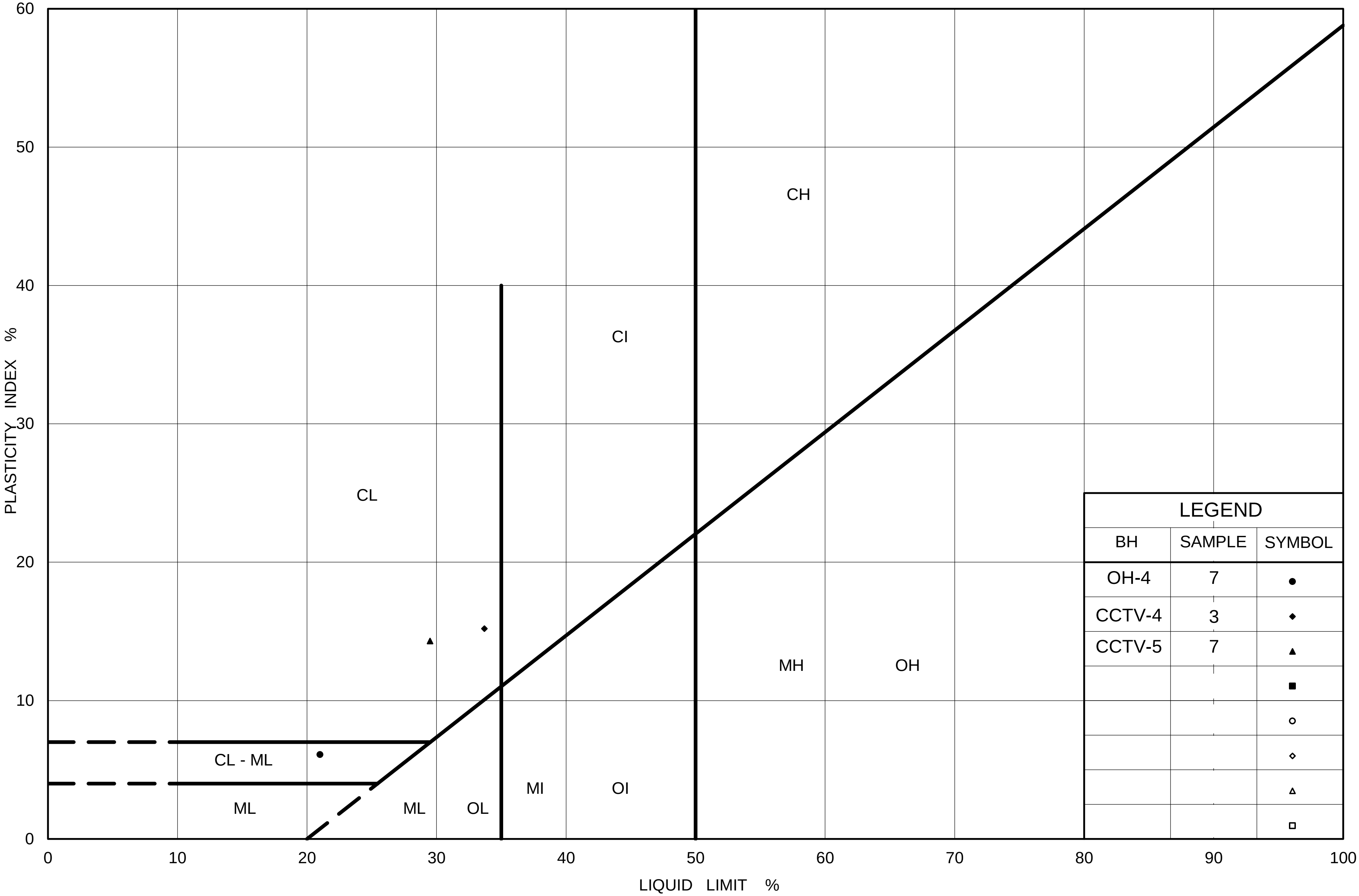
Project Number: 1669996

Checked By: NK

Golder Associates

Date: 24-Apr-19

Oct 75, FF-S-21



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PLASTICITY CHART
Clayey Silt

Figure No. C-5

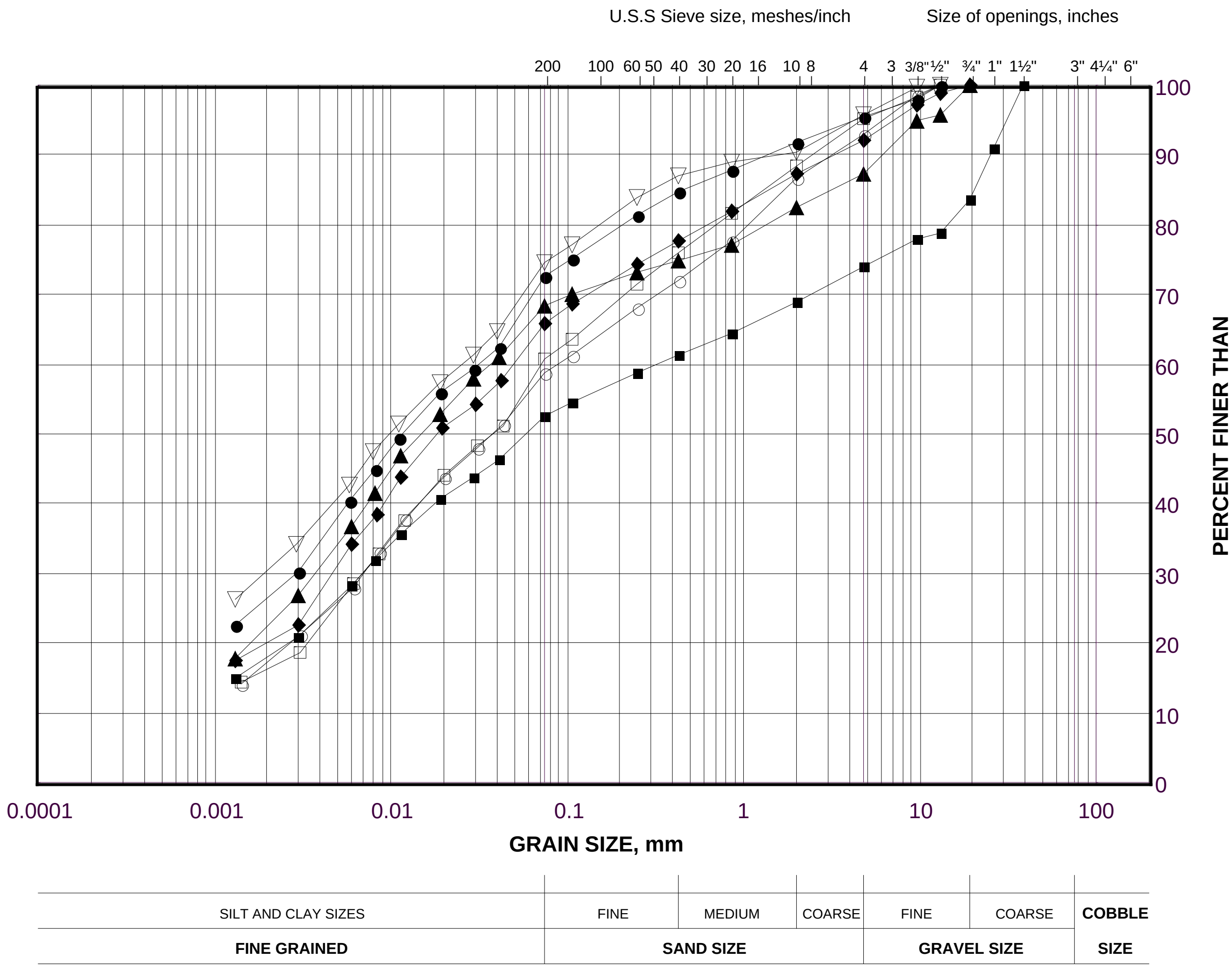
Project No. 1669996 (2200)

Checked By: NK

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand Till

FIGURE C-6A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CCTV-3	2	192.8
■	CCTV-6	3	181.4
◆	CCTV-5	4	181.8
▲	CCTV-3	5	190.6
▽	OH-2	5	184.9
❍	CCTV-6	7	177.6
☐	CCTV-5	8A	177.4

Project Number: 1669996

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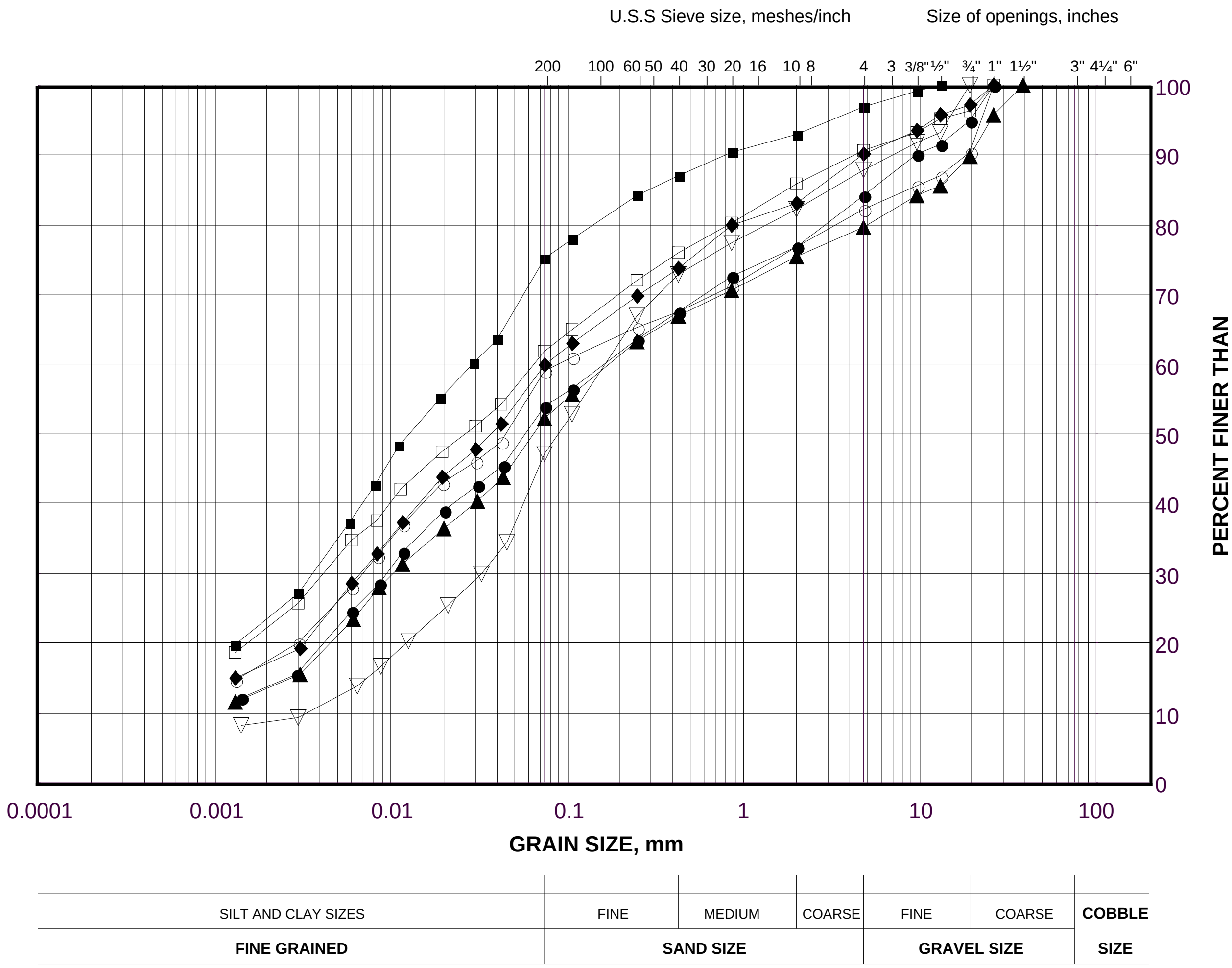
Date: 24-Apr-19

GRAIN SIZE DISTRIBUTION

Silty Clay to Clayey Silt with Sand Till

FIGURE C-6B



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OH-4	4	181.6
■	OH-5	4	185.3
◆	OH-3	5	181.6
▲	OH-2	7	183.4
▽	OH-3	7	179.5
❍	OH-5	8	181.5
□	OH-6	9	184.8

Project Number: 1669996

Checked By: NK

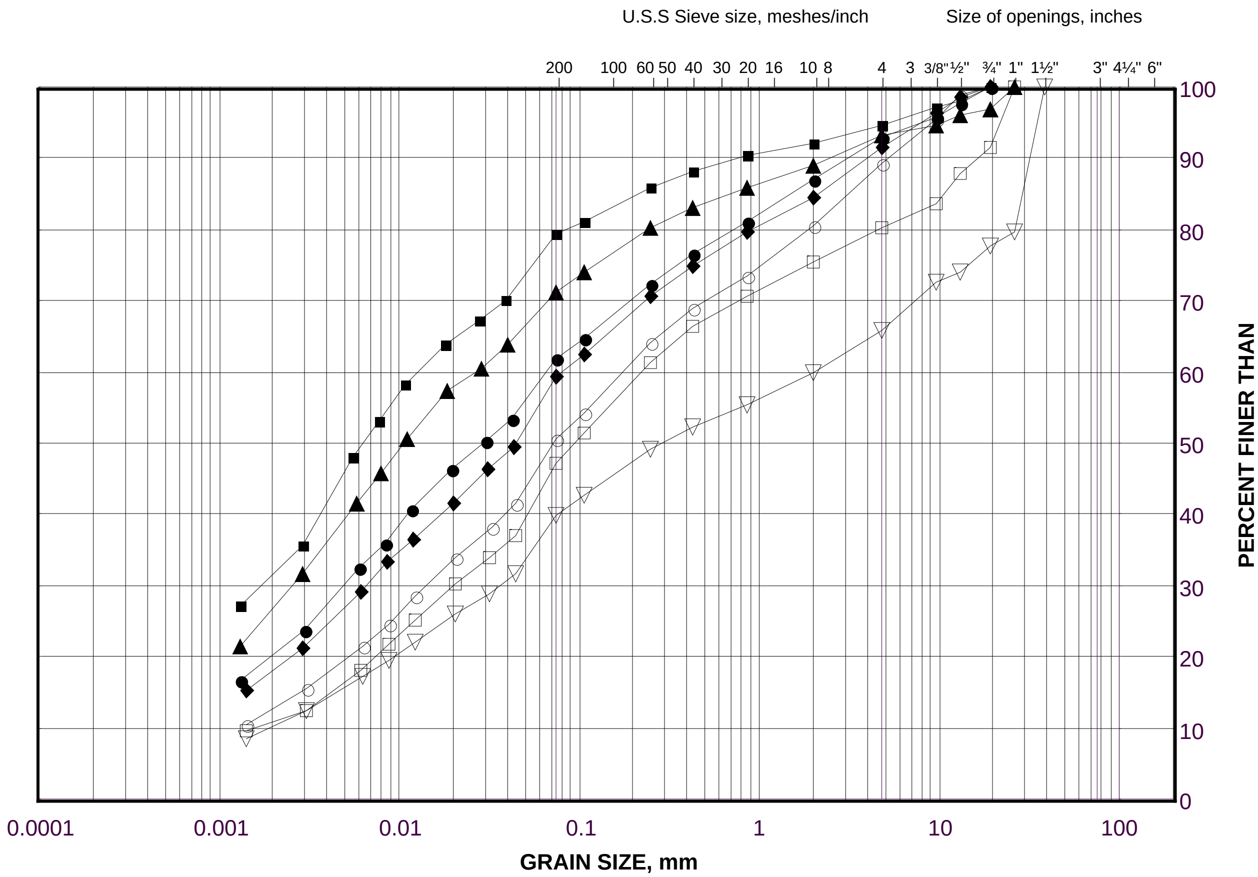
Golder Associates

Date: 24-Apr-19

GRAIN SIZE DISTRIBUTION

Clayey Silt to Clayey Silt with Sand Till

FIGURE C-6C



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	VMS-1	2	194.6
■	HML-1	3	182.9
◆	OH-1	5	186.1
▲	VMS-2	5	182.9
▽	VMS-1	6	191.5
○	VMS-2	7	181.4
□	HML-1	7	179.1

Project Number: 1669996

Checked By: NK

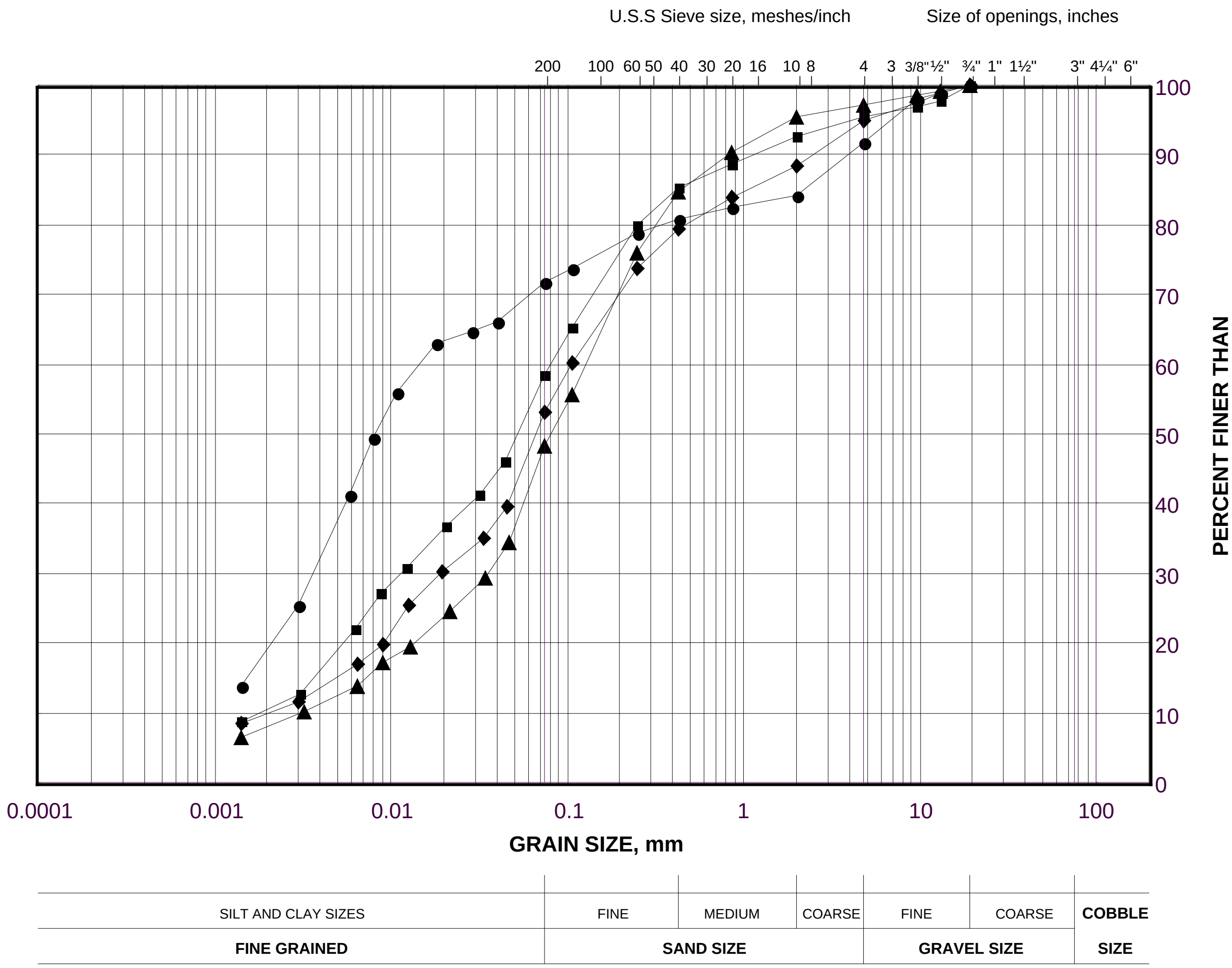
Golder Associates

Date: 24-Apr-19

GRAIN SIZE DISTRIBUTION

Clayey Silt Till to Silt and Sand Till

FIGURE C-6D



LEGEND

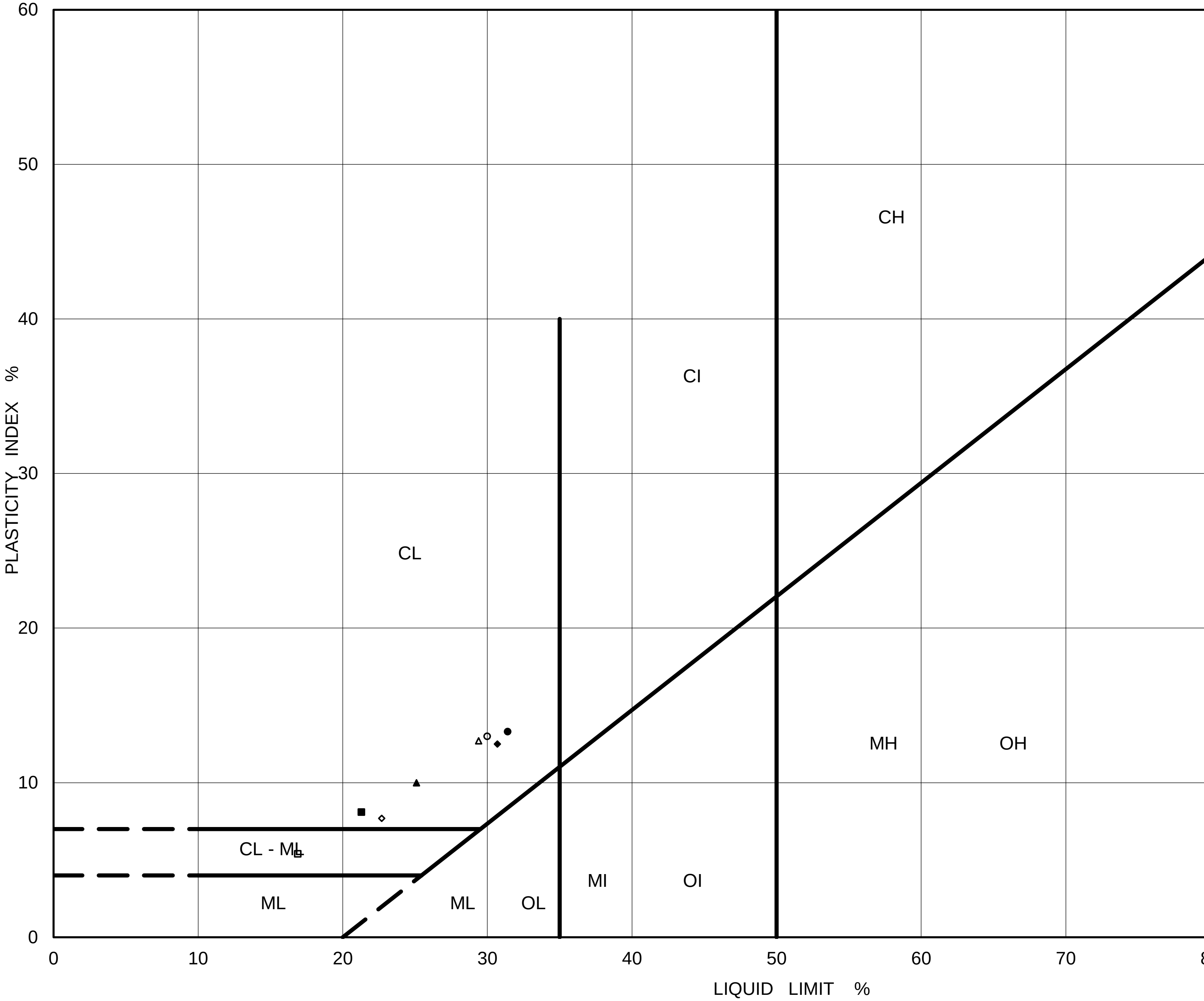
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CCTV-4	5	181.0
■	OH-4	6	180.1
◆	OH-1	7	184.7
▲	CCTV-4	7	178.7

Project Number: 1669996

Checked By: NK

Golder Associates

Date: 24-Apr-19



LEGEND

BH	SAMPLE	SYMBOL
CCTV-3	2	●
CCTV-3	5	◆
CCTV-5	4	▲
CCTV-5	8A	■
CCTV-6	3	○
CCTV-6	7	◇
HML-1	3	△
HML-1	7	□

Ministry of Transportation

Ontario

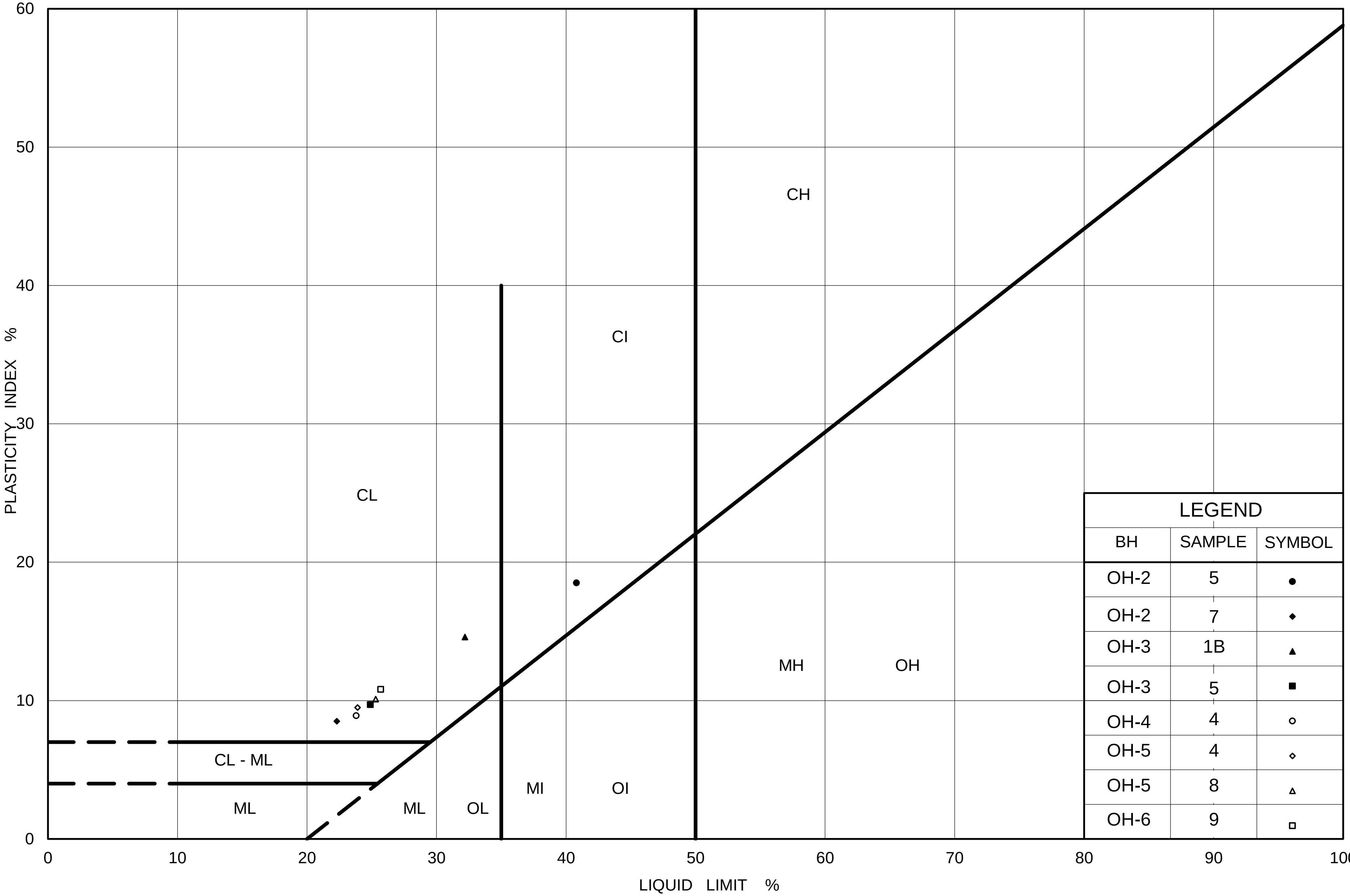
PLASTICITY CHART
Clayey Silt to Clayey Silt with Sand Till

Figure No. C-7A

Project No. 1669996 (2200)

Checked By: NK

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
OH-2	5	●
OH-2	7	◆
OH-3	1B	▲
OH-3	5	■
OH-4	4	○
OH-5	4	◇
OH-5	8	△
OH-6	9	□

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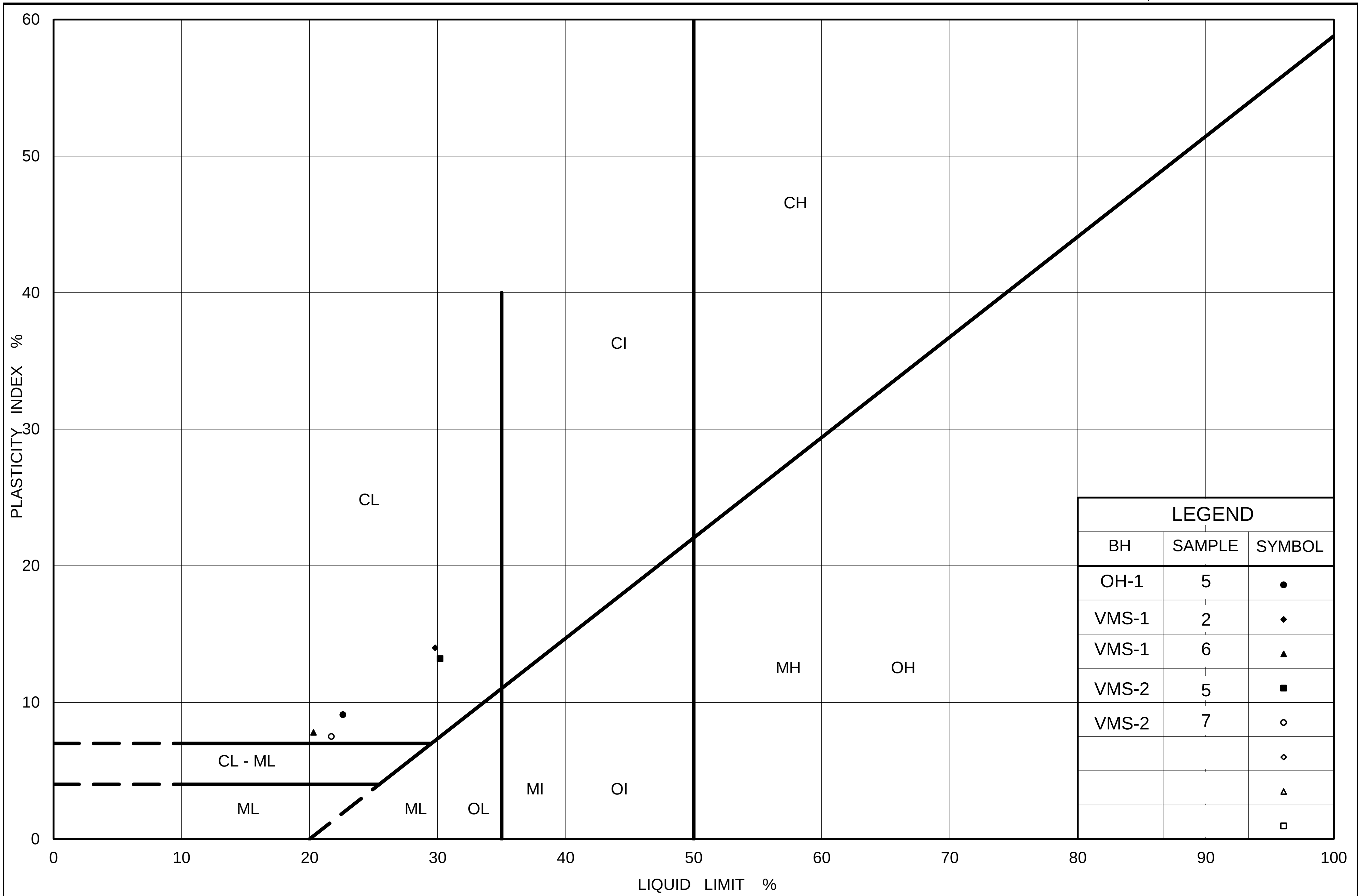
PLASTICITY CHART
Silty Clay to Clayey Silt with Sand Till

Figure No. C-7B

Project No. 1669996 (2200)

Checked By: NK

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy Clayey Silt to Clayey Silt with Sand Till

Figure No. C-7C	
Project No. 1669996 (2200)	
Checked By: NK	

APPENDIX D

Analytical Chemical Test Results

Maxxam
A Bureau Veritas Group Company

Your Project #: 1669996
Site Location: HIGHWAY 410
Your C.O.C. #: 711260-01-01

Attention: Nikol Kochmanova

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

Report Date: 2019/04/06
Report #: R5659885
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B984871
Received: 2019/04/02, 10:06

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	8	2019/04/04	2019/04/05	CAM SOP-00463	SM 4500-Cl E m
Conductivity	8	2019/04/05	2019/04/05	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	8	2019/04/04	2019/04/04	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	8	2019/04/02	2019/04/05	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	8	2019/04/04	2019/04/05	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. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

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. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

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. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
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.

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

Your Project #: 1669996
Site Location: HIGHWAY 410
Your C.O.C. #: 711260-01-01

Attention: Nikol Kochmanova

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

Report Date: 2019/04/06
Report #: R5659885
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B984871
Received: 2019/04/02, 10:06

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 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
A Bureau Veritas Group Company

Maxxam Job #: B984871
Report Date: 2019/04/06

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

RESULTS OF ANALYSES OF SOIL

Maxxam ID		JIO278		JIO279		JIO280	JIO281	JIO282		
Sampling Date		2019/03/12		2019/03/11		2019/03/10	2019/03/10	2019/03/11		
COC Number		711260-01-01		711260-01-01		711260-01-01	711260-01-01	711260-01-01		
	UNITS	**OH-1 SA5**	**RDL**	**OH-2 SA2**	**RDL**	**OH-3 SA4**	**OH-4 SA3**	**OH-6 SA4**	**RDL**	**QC Batch**
Calculated Parameters										
Resistivity	ohm-cm	1700		480		3900	1200	570		6050148
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	770	20	44	430	820	20	6053319
Conductivity	umho/cm	579	2	2100	2	255	869	1760	2	6055159
Available (CaCl2) pH	pH	7.87		7.84		7.85	7.85	7.44		6051675
Soluble (20:1) Sulphate (SO4)	ug/g	590	20	1100	60	51	61	440	20	6053340

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		JIO283	JIO284	JIO285			JIO285	
Sampling Date		2019/03/17	2019/03/19	2019/03/24			2019/03/24	
COC Number		711260-01-01	711260-01-01	711260-01-01			711260-01-01	
	UNITS	**CV-1 SA3**	**VMS-1 SA3**	**VMS-2 SA6**	**RDL**	**QC Batch**	**VMS-2 SA6 Lab-Dup**	**QC Batch**
Calculated Parameters								
Resistivity	ohm-cm	1700	2400	4700		6050148		
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	35	100	30	20	6053319		
Conductivity	umho/cm	591	412	214	2	6055159		
Available (CaCl2) pH	pH	7.88	7.84	7.69		6051675	7.68	6051675
Soluble (20:1) Sulphate (SO4)	ug/g	480	140	50	20	6053340		

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

Maxxam Job #: B984871
Report Date: 2019/04/06

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

TEST SUMMARY

Maxxam ID: JIO278
Sample ID: OH-1 SA5
Matrix: Soil

Collected: 2019/03/12
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO279
Sample ID: OH-2 SA2
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO280
Sample ID: OH-3 SA4
Matrix: Soil

Collected: 2019/03/10
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO281
Sample ID: OH-4 SA3
Matrix: Soil

Collected: 2019/03/10
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO282
Sample ID: OH-6 SA4
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva

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A Bureau Veritas Group Company

Maxxam Job #: B984871
Report Date: 2019/04/06

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

TEST SUMMARY

Maxxam ID: JIO282
Sample ID: OH-6 SA4
Matrix: Soil

Collected: 2019/03/11
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO283
Sample ID: CV-1 SA3
Matrix: Soil

Collected: 2019/03/17
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO284
Sample ID: VMS-1 SA3
Matrix: Soil

Collected: 2019/03/19
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO285
Sample ID: VMS-2 SA6
Matrix: Soil

Collected: 2019/03/24
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6053319	2019/04/04	2019/04/05	Deonarine Ramnarine
Conductivity	AT	6055159	2019/04/05	2019/04/05	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas
Resistivity of Soil		6050148	2019/04/05	2019/04/05	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	6053340	2019/04/04	2019/04/05	Deonarine Ramnarine

Maxxam ID: JIO285 Dup
Sample ID: VMS-2 SA6
Matrix: Soil

Collected: 2019/03/24
Shipped:
Received: 2019/04/02

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	6051675	2019/04/04	2019/04/04	Gnana Thomas

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GENERAL COMMENTS

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

Package 1	1.3°C

Results relate only to the items tested.

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Maxxam Job #: B984871
Report Date: 2019/04/06

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
6051675	Available (CaCl2) pH	2019/04/04			100	97 - 103			0.16	N/A
6053319	Soluble (20:1) Chloride (Cl-)	2019/04/05	NC	70 - 130	103	70 - 130	<20	ug/g	3.0	35
6053340	Soluble (20:1) Sulphate (SO4)	2019/04/05	NC	70 - 130	106	70 - 130	<20	ug/g	12	35
6055159	Conductivity	2019/04/05			102	90 - 110	<2	umho/cm	2.3	10

N/A = Not Applicable

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

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

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

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

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

Maxxam Job #: B984871
Report Date: 2019/04/06

Golder Associates Ltd
Client Project #: 1669996
Site Location: HIGHWAY 410
Sampler Initials: SE

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

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CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	Nikol Kochmanová	P.O. #:			711260
Address:	6925 Century Ave Suite 100	Address:		Project:	1668996	COC #:	Project Manager:
	Mississauga ON L5N 7K2			Project Name:	Highway 410	C#711260-01-01	Ema Gitej
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	Fax:	Site #:			
Email:	AP_CustomerService@golder.com	Email:	nikol_kochmanova@golder.com	Sampled By:	SE / JMP		

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

Regulation 153 (2011)	Other Regulations	Special Instructions
☐ Table 1 ☐ Res/Park ☐ Medium/Fine	☐ CCME ☐ Sanitary Sewer Bylaw	
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ Reg 558 ☐ Storm Sewer Bylaw	
☐ Table 3 ☐ Agri/Other ☐ For RSC	☐ MISA Municipality	
☐ Table	☐ PWQO	
	☐ Other	

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 (pH, Cl, SO4, EC/Resistivity)	# of Bottles	Comments
1		OH-1 SA5	Mar 12,'19	PM	Soil		✓	1	
2		OH-2 SA2	Mar 11,'19	PM	Soil		✓	1	
3		OH-3 SA4	Mar 10,'19	PM	Soil		✓	1	
4		OH-4 SA3	Mar 10,'19	PM	Soil		✓	1	
5		OH-6 SA4	Mar 11,'19	PM	Soil		✓	1	
6		CV-1 SA3	Mar 17,'19	PM	Soil		✓	1	02-Apr-19 10:06
7		VMS-1 SA3	Mar 19,'19	PM	Soil		✓	1	Ema Gitej
8		VMS-2 SA6	Mar 24,'19	PM	Soil		✓	1	B984871
9									CA2 ENV-1089
10									

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
Eric Naylor	19/04/02	10:05	[signature]	19/04/02	10:06			2/1/1	Present		✓
									Intact		✓

Laboratory Use Only

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* 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.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

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 E

Non-Standard Special Provision and Notice to Contractor

CONTROL OF OVERBURDEN SOILS DURING EXCAVATION FOR OVERHEAD AND VARIABLE MESSAGE SIGN SUPPORTS, HIGH MAST LIGHT AND CLOSED CIRCUIT TELEVISION POLE FOUNDATIONS - Item No.

Special Provision

The Contractor shall construct sign support and pole foundations in conformance with the design and at the locations indicated in the Contract Documents.

The Contractor shall construct the sign support and pole foundations against undisturbed bases and sides of excavations. The bases of caisson excavations shall be cleaned of loosened and/or softened materials prior to pouring concrete for the foundation. The construction methods and techniques shall be the responsibility of the Contactor. Consideration shall be given to using temporary liners or tremie concreting techniques where conditions warrant.

The Contractor is advised that excavations will be advanced through granular fill materials (where present), various interlayers of granular and native material through/into cohesive soils which may contain lenses or layers of potentially saturated cohesionless soils. The granular soils could slough (if dry) or flow (if water-bearing) into unsupported auger holes during caissons installation. Appropriate construction procedures and equipment shall be implemented to eliminate ground loss during drilling, caisson installation and concrete placement.

The contractor is also advised that the soils throughout the project area are glacially-derived and contain cobbles and boulders. Appropriate equipment and procedures shall be implemented for construction of foundations to penetrate obstructions (cobbles and boulders), and into the hard/very dense till deposit, residual soil and shale bedrock to depths/elevations specified in the contract.

Basis of Payment

Payment at the lump sum contract price for this tender item shall include full compensation for all labour, equipment and materials for completion of the work.

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