Foundation Investigation and Design Report

Culvert Extensions, QEW / Glendale Avenue Interchange Improvements Niagara-on-the-Lake, Ontario, Ministry of Transportation, Ontario, GWP 2423-15-00

Submitted to:

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PART A

FOUNDATION INVESTIGATION REPORT
CULVERT EXTENSIONS
QEW / GLENDALE AVENUE INTERCHANGE IMPROVEMENTS
NIAGARA-ON-THE-LAKE, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2423-15-00

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 replacement of the Glendale Avenue Underpass and extensions of existing culverts in the Town of Niagara-on-the-Lake, Regional Municipality of Niagara, located as shown on the attached Key Plan on Drawing 1.

This report addresses the foundation investigation carried out between September 18 and November 28, 2018 at two culvert extension sites crossing York Road and Glendale Avenue.

The Terms of Reference for the foundation engineering services are outlined in MTO's Work Item Order No. 2016-E-0029-002, dated July 2017, which forms part of the Consultant's Assignment for the Central Region Retainer under Agreement No. 2016-E-0029-002.

2.0 SITE DESCRIPTION

Based on the preliminary Class EA study, the area of the QEW within the project limits receives surface runoff from four main watersheds which discharge into various outfalls. These Outfalls ultimately drain into Six Mile Creek which continues as a municipal drain to its final discharge point. The existing culverts convey surface water runoff northerly to ditches which discharges to the Outfalls.

2.1 Culvert EX-05 Extension

Culvert EX-05 crosses under York Road approximately 30 m east of Glendale Avenue in Niagara-on-the-Lake, Ontario, at approximately the location shown on the Key Plan location on Drawing 2. The property lots to the north and south of the culvert are undeveloped, primarily heavily treed to the north and grass-covered to the south. The roadway grade of York Road at the culvert site is approximately Elevation 112 m, and the existing ground surface grade at the south toe of the road embankment is approximately Elevation 109.5 m.

The existing culvert is a 3.5 m wide by 2 m high reinforced cast-in-place concrete box with a length of 53 m, oriented north-south under York Road.

2.2 Culvert EX-06 Extension

Culvert EX-06 crosses under Glendale Avenue approximately 350 m southwest of Queen Elizabeth Way (QEW) in Niagara-on-the-Lake, Ontario, at approximately the location shown on the Key Plan on Drawing 1. Commercial buildings surround the site. The Glendale Avenue road grade at the culvert site is approximately Elevation 119 m and existing ground surface grade at the culvert site is approximately Elevation 116 m.

The existing culvert is a 2.3 m wide by 1 m high reinforced cast-in-place concrete box with a length of 61 m, oriented northwest (west for the purposes of this report) to -southeast (east for the purposes of this report) under Glendale Avenue.

3.0 INVESTIGATION PROCEDURES

Field work for the foundation investigation at the culvert extension areas was carried out between September 18 and November 28, 2018, during this time a total of six boreholes (designated as Boreholes CV5 and CV6 at the York Road site and Boreholes CV1 to CV4 at the Glendale Avenue site) were advanced at the sites. Boreholes CV2, CV3 and CV5 were advanced from existing road grade of Glendale Avenue and York Road and

Boreholes CV1, CV4 and CV6 were advanced adjacent to the existing culvert edges below road grade. The approximate locations of the boreholes at Culvert EX-05 crossing York Road and at Culvert EX-06 crossing Glendale Avenue are shown on Drawings 1 and 2, respectively.

Boreholes CV2, CV3 and CV 5 were drilled using 178 mm outer diameter hollow-stem augers by a CME 75 truck-mounted drill rig, supplied and operated by Geo-Environmental Drilling Ltd. of Halton Hills, Ontario. Boreholes CV1, CV4 and CV6 were advanced using 63.5 mm casing and wash boring methods by a Hilti DD 250E Portable drill rig, supplied and operated by OGS Drilling of Almonte, Ontario. 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 all boreholes in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)[1]. In situ field vane shear testing, using MTO standard "N"-sized and "B"-sized vanes, was carried out to measure the undrained shear strength of cohesive soils (ASTM D2573)[2]. Dynamic cone penetration tests (DCPT) were advanced from the bottom of Boreholes CV1 and CV4 at depths ranging from 11.9 m to 4.3 m below ground surface, respectively.

Groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. All boreholes were backfilled to or near to the ground surface with bentonite, in accordance with Ontario Regulation 903, Wells (as amended). The upper 200 mm of Boreholes CV2 and CV3 were sealed to the roadway surface with cold patch asphalt upon completion.

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 and geotechnical laboratory testing on selected samples, consisting of natural moisture content, Atterberg limits and grain size distribution, conducted in accordance with MTO and / or ASTM Standards as applicable.

The borehole locations were marked in the field by Golder personnel relative to the existing guiderails and other fixed identifiable site features. The locations given in the Record of Borehole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) CSRS CBNV6-2010.0 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including geographic (Latitude / Longitude) coordinates, the ground surface elevations and borehole drilled depths are summarized below:

Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole/DCPT Depth (m)
	Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
CV1	4,779,405.5 (43.154018)	331,924.2 (-79.166491)	116.6	7.0 / 11.9
CV2	4,779,418.2 (43.154133)	331,921.7 (-79.166521)	119.6	13.1

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

[2] ASTM D2573 - Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole/DCPT Depth (m)
	Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
CV3	4,779,443.5 (43.154361)	331,916.8 (-79.166580)	118.4	12.8
CV4	4,779,461.7 (43.154524)	331,921.0 (-79.166527)	116.3	4.3 / 7.3
CV5	4,780,080.4 (43.160080)	332,294.2 (-79.161908)	112.2	12.8
CV6	4,780,072.3 (43.160009)	332,278.8 (-79.162105)	109.6	10.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of QEW Highway is located in the Iroquois Plain physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)[3]. The glacial Iroquois Plain stretches along the northern shoreline of Lake Ontario, extending from the Niagara Escarpment in the west to the Scarborough Bluffs in the east. The Iroquois Plain soils consist of glaciolacustrine sediments deposited in Lake Iroquois, primarily sands, silts and gravels, with a shallow cover of till remaining over the bedrock.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes of this investigation, including notes on groundwater conditions and water level readings, and the results of the in situ and laboratory tests are provided on the Record of Borehole sheets in Appendix A. The results of the in-situ field tests (i.e., SPT "N"-values, DCPT values and field vane undrained shear strength) as presented on the borehole records and provided in Section 4 are uncorrected. The results of the geotechnical laboratory testing on soil samples are presented on the laboratory test Figures B-1 to B-12 included in Appendix B. The detailed results of the analytical testing are provided in Appendix C.

4.2.1 Culvert EX-05

4.2.1.1 Fill

Boreholes CV5 and CV6 were advanced in the close vicinity of existing culvert EX-05. Borehole CV5 was advanced through the shoulder of York Road adjacent to the south end(inlet) of existing culvert EX-05, penetrated surficial layers of fill comprised of silty topsoil, clayey silt, and sand and gravel to a depth of 0.8 m (Elevation 111.4 m), underlain by a 2.7 m thick layer of clayey silt fill (cohesive fill) extending to a depth of 3.5 m (Elevation 108.7 m).

[3] Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

Borehole CV6 was advanced near the south end of the existing culvert and penetrated a surface layer of silty clay fill (cohesive fill) extending to a depth of 1.8 m (Elevation 107.8 m).

The measured SPT "N"-values within the layers of cohesive fill range from 4 blows to 14 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

The natural water content measured on two samples of the clayey silt to silty clay fill range between about 22 per cent and about 26 per cent. An Atterberg limits test was carried out on one selected sample of the cohesive fill and measured a plastic limit of about 19 per cent, a liquid limit of about 40 per cent, and a plasticity index of about 21 per cent. This test result, which is plotted on the plasticity chart on Figure B-1 in Appendix B, confirms that this layer of cohesive fill is classified as silty clay fill of intermediate plasticity.

Grain size distribution testing was completed on one sample of the silty clay fill and the test result is shown on Figure B-2 in Appendix B.

4.2.1.2 Clayey Silt

A 1.1 m thick deposit of sandy clayey silt was encountered underlying the clayey silt fill in Borehole CV5, extending to a depth of 4.6 m (Elevation 107.6 m). The clayey silt deposit also contains silty sand seams and trace rootlets. The measured SPT "N"-values within the clayey silt deposit are 11 blows and 13 blows per 0.3 m of penetration, suggesting a stiff consistency.

The natural water content measured on two samples of the clayey silt deposit is about 18 per cent and about 23 per cent. An Atterberg limits test was carried out on one selected sample of the clayey silt deposit and measured a plastic limit of about 17 per cent, a liquid limit of about 33 per cent, and a plasticity index of about 17 per cent. This test result, which is plotted on the plasticity chart on Figure B-3 in Appendix B, confirms the cohesive deposit is classified as clayey silt of low plasticity.

Grain size distribution testing was completed on one sample of the clayey silt deposit and the test result is shown on Figure B-4 in Appendix B.

4.2.1.3 Silty Clay to Clay

Underlying the clayey silt deposit in Borehole CV5 and underlying the cohesive fill in Borehole CV6, an 8.2 m and 8.6 m thick deposit of brown to grey silty clay to clay, trace sand and trace gravel was encountered. Both boreholes were terminated in this deposit, penetrating it to depths of 12.8 m and 10.4 m below ground surface (Elevations 99.4 m and 99.2 m) in Boreholes CV5 and CV6, respectively.

The measured SPT "N"-values within the silty clay to clay deposit range from 4 blows to 27 blows per 0.3 m of penetration. In situ field vane tests carried out with this deposit measured undrained shear strengths ranging from about 57 kPa to greater than 144 kPa, with sensitivities ranging from 2 to 3. The undrained shear strengths together with the SPT "N"-values, suggest that the deposit is soft to very stiff in consistency.

The natural water content measured on seven samples of the silty clay to clay deposit range from about 24 per cent to about 36 per cent. Atterberg limits tests were carried out on four selected samples of the silty clay to clay deposit and measured plastic limits ranging between about 21 per cent and about 22 per cent, liquid limits ranging between about 47 per cent and about 55 per cent, and plasticity indices ranging between about 27 per cent and about 33 per cent. These test results, which are plotted on the plasticity chart on Figure B-5 in Appendix B, confirm the deposit is classified as silty clay of intermediate plasticity to clay of high plasticity.

Grain size distribution testing was completed on four samples of the silty clay to clay deposit and the test results are shown on Figure B-6 in Appendix B.

4.2.2 Culvert EX-06 East Extension

Boreholes CV1 and CV2 were advanced near the east end of the existing culvert EX-06 inlet. Borehole CV2 was advanced through the northbound lanes/roadway embankment at Glendale Avenue; Borehole CV1 was advanced at the east toe of the embankment near the outlet of the existing culvert.

4.2.2.1 Asphalt/Fill

An approximately 150 mm thick layer of asphalt pavement was encountered in Borehole CV2. An approximately 1.2 m thick stratum of fill, comprised of an upper 0.4 m thick layer of organic silt and a lower 0.8 m thick layer of sandy silty clay (cohesive fill), was encountered from the surface in Borehole CV1 (at Elevation 116.6 m). Underlying the asphalt pavement in Borehole CV2, an approximately 0.8 m thick layer of sand and gravel fill (non-cohesive fill) was encountered at Elevation 119.5 m, which is in turn underlain by a 2.5 m thick layer of clayey silt to sandy clayey silt fill (cohesive fill), extending to a depth of 3.4 m (Elevation 116.2 m).

The measured SPT "N"-value within the sand and gravel fill (non-cohesive fill) is 13 blows per 0.3 m of penetration, indicating a compact state of compactness. The measured SPT "N"-values within the organic silt/ sandy silty clay to clayey silt fill (cohesive fill) range from 6 blows to 13 blows per 0.3 m of penetration, suggesting a firm to stiff consistency.

The natural water content measured on two samples of the sandy clayey silt to silty clay fill are about 22 per cent and about 23 per cent. An Atterberg limits test was carried out on one selected sample of the silty clay fill from Borehole CV1 and measured a plastic limit of about 20 per cent, a liquid limit of about 43 per cent, and a plasticity index of about 23 per cent. The test result, which is plotted on the plasticity chart on Figure B-7 in Appendix B, confirms that the fill is classified as silty clay.

Grain size distribution testing was completed on one sample of the silty clay fill and the test result is shown on Figure B-8 in Appendix B.

4.2.2.2 Silty Clay to Clay

Underlying the cohesive fill in Boreholes CV1 and CV2, a deposit of silty clay to clay was encountered to the termination depth in both, penetrating the deposit to depths of 7.0 m and 13.1 m (Elevations 109.6 m and 106.5 m) in the respective boreholes. The silty clay deposit is brown to light-grey and contains trace sand and a silt seam in Borehole CV2.

The measured SPT "N"-values within the silty clay to clay deposit in Boreholes CV1 and CV2 range from 3 blows to 62 blows per 0.3 m of penetration. In situ field vane tests carried out with this deposit in Borehole CV2 measured undrained shear strengths ranging between 85 kPa and greater than 96 kPa, with sensitivities of about 2.0. The SPT "N"-values together with the in-situ vane shear strengths measured in this deposit suggest that the deposit is soft to hard in consistency. A dynamic cone penetration test (DCPT) was driven from the bottom of Borehole CV1 from a depth of 7.0 m below ground surface (Elevation 109.6 m) to practical refusal at a depth of about 11.9 m below ground surface (Elevation 104.7 m).

The natural water content measured on seven samples of the silty clay to clay deposit ranges from about 24 per cent to about 35 per cent. Atterberg limits tests were carried out on five selected samples of the silty clay to clay deposit and measured plastic limits ranging between about 20 per cent and about 23 per cent, liquid limits ranging between about 42 per cent and about 56 per cent, and plasticity indices ranging between about 23 per cent and about 33 per cent. These test results, which are plotted on the plasticity chart on Figures B-9A and B-9B in Appendix B, confirm the deposit is classified as silty clay of intermediate plasticity to clay of high plasticity.

Grain size distribution testing was completed on five samples of the silty clay to clay deposit and the test results are shown on Figures B-10A and B-10B in Appendix B.

4.2.3 Culvert EX-06 West Extension

Boreholes CV3 and CV4 were advanced near the west end (outlet) of the existing culvert EX-06. Borehole CV3 was advanced through the southbound lanes/roadway embankment at Glendale Avenue; and Borehole CV4 was advanced at the west toe of the embankment near the outlet of the existing culvert.

4.2.3.1 Asphalt/Fill

A 250 mm thick layer of asphalt was encountered at the surface of Borehole CV3. Borehole CV3 encountered a 0.9 m thick layer of sand and gravel fill (non-cohesive fill) underneath the asphalt layer, in turn underlain by a 0.8 m thick layer of clayey silt fill (cohesive fill), extending to a depth of 2.0 m below ground surface (Elevation 116.4 m). Borehole CV4 encountered a 0.6 m thick layer of crushed gravel fill at ground surface underlain by a 0.6 m thick layer of silty clay fill (cohesive fill), extending to a depth of 1.2 m below ground surface (Elevation 115.1 m).

The measured SPT “N”-value within the sand and gravel fill (non-cohesive fill) is 9 blows per 0.3 m of penetration, indicating a loose state of compactness. The measured SPT “N”-values within the silty clay fill and clayey silt fill (cohesive fill) are 4 blows and 17 blows per 0.3 m of penetration, suggesting a soft to stiff consistency.

The natural water content measured on one sample of the clayey silt fill is about 24 per cent.

4.2.3.2 Clayey Silt

A 5.2 m thick deposit of clayey silt was encountered underlying the clayey silt fill in Borehole CV3, extending to a depth of 7.2 m below ground surface (Elevation 111.2 m). The clayey silt deposit contains trace to some sand, some silt seams. The measured SPT “N”-values within the clayey silt deposit range from 16 blows to 23 blows per 0.3 m of penetration; and In situ field vane tests carried out with this deposit measured undrained shear strengths greater than 144 kPa, with a sensitivity of about 2.0. The SPT “N”-values together with the in-situ vane shear strengths suggest that the clayey silt deposit is very stiff in consistency.

The natural water content measured on two samples of the clayey silt deposit is about 19 per cent and 27 per cent. An Atterberg limits test carried out on one selected sample of the clayey silt deposit measured a plastic limit of about 18 per cent, a liquid limit of about 33 per cent, and a plasticity index of about 16 per cent. This test result, which is plotted on the plasticity chart on Figure B-11 in Appendix B, confirms the deposit is classified as clayey silt of low plasticity.

Grain size distribution testing was completed on one sample of the clayey silt deposit and the test result is shown on Figure B-12 in Appendix B.

4.2.3.3 Silty Clay to Clay

Underlying the clayey silt deposit in Borehole CV3 and the cohesive fill in Borehole CV4, is a deposit of silty clay to clay to the termination depths in both boreholes, penetrating the deposit to depths of 12.8 m and 4.3 m (Elevations 105.6 m and 112.0 m), respectively.

The measured SPT "N"-values within the silty clay to clay deposit range between 4 blows and 28 blows per 0.3 m of penetration; in situ field vane tests carried out with this deposit measured undrained shear strengths greater than 144 kPa. The measure SPT "N"-values together with the in-situ vane undrained shear strength, suggest that the deposit is soft to very stiff in consistency.

A dynamic cone penetration test (DCPT) was driven from the bottom of Borehole CV4, from a depth of 4.3 m below ground surface (Elevation 112.0 m) to practical refusal at a depth of 7.3 m below ground surface (Elevation 109.0 m).

The natural water content measured on five samples of the silty clay to clay deposit range from about 25 per cent to about 32 per cent. Atterberg limits tests were carried out on four selected samples of the silty clay to clay deposit and measured plastic limits ranging between about 21 per cent and about 22 per cent, liquid limits ranging between about 49 per cent and about 52 per cent, and plasticity indices ranging between about 29 per cent and about 30 per cent. These test results, which are plotted on the plasticity chart on Figures B-9A and B-9B in Appendix B, confirm the deposit is classified as silty clay of intermediate plasticity to clay of high plasticity.

Grain size distribution testing was completed on four samples of the silty clay to clay deposit and the test results are shown on Figures B-10A and B-10B in Appendix B.

4.3 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations, at the depths summarized below.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date
CV1	116.6	0.2	116.4	November 12, 2018
CV2	119.6	12.0	107.6	September 28, 2018
CV3	118.4	Dry	-	September 28, 2018
CV4	116.3	0.0	116.3	November 14, 2018
CV5	112.2	10.7	101.5	September 18, 2018
CV6	109.6	0.0	109.6	November 28, 2018

As the water levels were measured immediately after completion of drilling, they may not represent the stabilized groundwater level at the site. The groundwater level 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.

4.4 Analytical Testing Results

Three 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 C and the test results are summarized below.

Borehole No. / Sample No. (Soil Description)	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Chlorides (µg/g)	Soluble Sulphates (µg/g)
CV2 / 3 (Clayey Silt Fill)	7.84	840	1,180	580	250
CV3 / 5 (Clayey Silt)	7.88	2,200	458	120	190
CV5 / 2 (Clayey Silt Fill)	7.62	1,300	763	160	390

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Eric Naylor, EIT, and reviewed by Ms. Manisha Ahuja, P.Eng., P.E. Mr. Jorge Costa, P.Eng., Senior Consultant and an MTO Foundations Designated Contact of Golder, conducted an independent technical and quality control review of this report.

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https://golderassociates.sharepoint.com/sites/15994g/6. deliverables/wo 002 - glendale interchange/foundations/3. culverts/3. final/1671430 wo2 fidrfnl03 2019april17 glendale ave culverts.docx

PART B

FOUNDATION DESIGN REPORT
CULVERT EXTENSIONS
QEW / GLENDALE AVENUE INTERCHANGE IMPROVEMENTS
NIAGARA-ON-THE-LAKE, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation recommendations for the design of the proposed extensions to existing Culverts EX-05 and EX-06, crossing York Road and Glendale Avenue, respectively, in the Town of Niagara-On-Lake, Regional Municipality of Niagara (Assignment No. 2016-E-0029-002). These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation at this site. The discussions and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out detail design of the culvert 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 Part A (Foundation Investigation) of the 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 aspects of construction should 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 General Foundation Design Context

6.2.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* and its *Commentary* (CHBDC (2014)), the proposed Glendale Avenue underpass and its foundation system and adjacent ancillary structures may be classified as having medium to high traffic volumes and their performance as having potential impacts on other transportation corridors, hence having a “typical consequence level” associated with exceeding limit states design. In addition, based on the level of foundation investigation completed at this site as presented in Sections 3 and 4, in comparison to the degree of site understanding in Section 6.5 of *CHBDC (2014)*, the level of confidence for design for the culvert extensions is considered to be a “typical degree of site and prediction model understanding”.

Accordingly, the appropriate corresponding Ultimate Limit States (ULS) and Serviceability Limit States (SLS) consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the *CHBDC (2014)* have been used for the design.

6.2.2 Seismic Design

6.2.2.1 Seismic Site Classification

The subsurface conditions for seismic site characterization were assessed based on the results of the field investigation and laboratory testing. The SPT “N”-values measured in the soil layers and the interpreted shear wave velocity of soils up to 30 m below founding level were used to define the seismic site classification in accordance with Table 4.1 of the *CHBDC (2014)*. Based on this methodology, it is considered that a Site Class D would be applicable for the design of the culvert extensions.

6.2.2.2 Spectral Response Values and Seismic Performance Category

The CHBDC (2014) states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC).

The GSC has developed a new set of seismic hazard maps (referred to as the 5th generation seismic hazard maps) that were made available for public use in December 2015, through the Natural Resources Canada (2017) website.

In accordance with Section 7.5.5.1 of the *CHBDC (2014*), buried structures should be designed to resist inertial forces associated with a seismic event having a 2% exceedance in 50 years (i.e., a 2,475 year return period), where the horizontal ground acceleration ratio A_H is equal to the peak ground acceleration, PGA, as specified in Section 4.4.3 of *CHBDC (2014*). Therefore, based on Section 4.4.3 of the *CHBDC (2014*) and the general site location of the culverts (approximately Latitude 43.154400 and Longitude -79.166491), the reference Site Class D PGA value, which corresponds to the site-specific PGA value, based on the 5th generation seismic hazard maps published by the GSC is as follows:

Seismic Hazard Values (Site Class D)	2% Exceedance in 50 years (2,475 years return period)
PGA (g)	0.240

6.3 Culvert Extensions

It is understood that Culvert EX-05 requires a southerly extension associated with the widening of York Road and construction of a roundabout intersection at York Road and Glendale Avenue; and Culvert EX-06 requires both west and east end extensions associated with the widening and realignment of Glendale Avenue. Details regarding the existing culverts are:

- Culvert EX-05 (3.5m wide x 2m high box culvert) – 6m extension at the south end (invert Elevation 108.9 m).
- Culvert EX-06 (2.3m wide x 1.2m high box culvert) – 8m extension at the west end (invert Elevation 115.9 m) and 5m extension at the east end (invert Elevation 116.2 m)

6.4 Foundations Options for Box Culvert Extensions

6.4.1 Founding Elevations

The box culvert extensions will not necessary be founded at the standard depth for frost protection purposes, as the box structures are tolerant of small magnitudes of movement related to freeze-thaw cycles, should these occur. Box culvert extensions should, however, be founded below any existing fill and surficial organic materials. Provided below are recommended founding elevations and sub-excavation requirements for box culvert extensions, based on an assumed base slab thickness of 300 mm. In addition, it is recommended that the box culvert extension segments be placed on a minimum 300 mm thick layer of granular bedding meeting Ontario Provincial Standard Specification Provincial Oriented (OPSS.PROV) 1010 (Aggregates) Granular ‘A’ or Granular ‘B’ Type II material.

Culvert	Approximate Culvert Invert Elevation	Subexcavation required?	Highest Base Slab Founding Elevation	Founding Stratum
EX-05	108.9 m	Yes, to Elev. 107.8 m	108.6 m	Granular Bedding on Native Sandy Clayey Silt to Silty Clay to Clay
EX-06 West end	115.9 m	Yes, to Elev. 115.4 m	115.6 m	Granular Bedding on Native Clayey Silt to Clay
EX-06 East end	116.2 m	Yes, to Elev. 115.1 m	115.9 m	Granular Bedding on Native Silty Clay to Clay

Based on the founding levels and subsurface conditions at the culvert sites, sub-excavation of the fill layers and zones of the soft silty clay to clay deposit is recommended to the levels noted above. However, sub-excavation of the material immediately adjacent to the ends of the existing culverts is not recommended, as such excavation would extend to below the founding level of the existing culverts and would likely require a protection system to prevent undermining of the existing culvert ends. It is therefore recommended that the sub-excavation be maintained 0.3 m beyond the ends of the existing culverts.

6.4.2 Geotechnical Resistance

The design for box culvert extensions placed on the properly prepared subgrade (removing the existing fill and soft native clay and placing granular fill), at or below the founding elevation identified above, should be based on the following factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical reaction at Serviceability Limit States (SLS):

Culvert	Culvert Span	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance
EX-05	3.5 m	140 kPa	N/A*
EX-06 West Extension	2.3 m	180 kPa	N/A*
EX-06 East Extension	2.3 m	160 kPa	N/A*

*The factored serviceability geotechnical resistance for 25 mm of settlement for the given base width is greater than the factored ultimate geotechnical resistance, and so does not govern the design.

The geotechnical resistances/reactions provided above should be reviewed if the selected box culvert width does not match the existing culvert dimensions, or if the founding elevations differs significantly from those given in Section 6.3.

6.4.3 Resistance to Lateral Loading/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base slab of pre-cast culvert extensions and the granular bedding should be calculated in accordance with Section 6.10.5 of the *CHBDC (2014)*. For pre-cast concrete box culvert segments placed on compacted granular bedding, the coefficient of friction, tan δ, can be taken as 0.50, as interpreted from NAVFAC (1986).

6.5 Open Footing Culvert Extensions and Shallow Foundations for Wingwalls/Retaining Walls

6.5.1 Founding Elevations

Strip footings for open footing culvert extensions, and/or for any concrete wingwalls/retaining walls that may be required immediately adjacent to the culvert extensions, should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration, as interpreted from OPSD 3090.101 (Foundation Frost Depths for Southern Ontario). In addition, the footings should extend below any existing fill, surficial organic materials, loose or soft soils, where present. The recommended founding elevations for strip footings for the open footing culvert extensions are as follows:

Culvert	Approximate Culvert invert Elevation	Subexcavation Required?	Highest Footing Founding Elevation	Founding Stratum
EX-05	108.9 m	Yes, to 107.8 m	107.8 m	Granular Fill/ Unshrinkable Fill, or Stiff to very Stiff Sandy Clayey Silt/ Silty Clay to Clay
EX-06 West End	115.9 m	Yes, to 115.1 m	115.1 m	Stiff to Very Stiff Clayey Silt/ Silty Clay to Clay
EX-06 East End	116.2 m	Yes, to 115.4 m	115.4 m	Stiff to Very Stiff Silty Clay to Clay

Based on the footing founding levels and subsurface conditions encountered in the boreholes at the culvert extension sites, approximately 1.8 m and 1.4 m of sub-excavation has been identified required at the Culvert EX-05 and EX-06 sites, respectively if an open footing culvert extension is adopted. Excavation and backfilling for open footing culvert construction should be carried out in accordance with OPSS 902 (Excavation and Backfilling – Structures). If the excavations extend below the design founding level, as may be required to remove soft/organic/unsuitable soil, the sub-excavated area could be backfilled with compacted OPSS.PROV 1010 Granular ‘A’ or Granular ‘B’ Type II material to raise the subgrade to the founding level.

Temporary excavation support is required at the ends of the existing box culvert to prevent loss of bedding material and/or native soils from below the existing box culvert during excavation/sub-excavation activities.

6.5.2 Geotechnical Resistance

Strip footings placed on the properly prepared subgrade, at or below the founding elevation identified above, should be designed based on the following factored geotechnical resistances at ULS and geotechnical reactions at SLS:

Culvert	Founding Stratum	Footing Width	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance*
EX-05	Stiff Sandy Clayey Silt to Stiff to Very Stiff Silty Clay to Clay	1.0 m	170 kPa	N/A
EX-06 East Extension	Very Stiff Clayey Silt to Stiff to Very Stiff Silty Clay to Clay	1.0 m	135 kPa	N/A
EX-06 West Extension	Stiff to Hard Silty Clay to Clay	1.0 m	250 kPa	N/A

*The factored serviceability geotechnical resistance for 25 mm of settlement for the given footing width is greater than the factored ultimate geotechnical resistance, and so does not govern the design.

The geotechnical resistances/reactions provided above should be reviewed if the selected footing width or founding elevation differs significantly from those given above. In addition, these geotechnical resistances are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with Section 6.10.4 of the *CHBDC (2014)*.

6.5.3 Resistance to Lateral Loading/Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings for the culvert extensions and the subgrade should be calculated in accordance with Section 6.10.5 of the *CHBDC (2014)*. For cast-in-place concrete (either the footing itself, or a concrete working slab), the coefficient of friction, tan δ or tan ϕ', can be taken as follows:

- Cast-in-place footing or working slab to clayey silt/silty clay: tan ϕ' = 0.35
- Cast-in-place footing to concrete working slab: tan δ = 0.7

6.5.4 Groundwater Conditions

Groundwater and/or surface water control will be required for excavation and construction of open footing culvert extensions. Assuming that surface water within the creek or drainage channel is controlled by means of a cofferdam and bypass pumping, the groundwater seepage from the predominantly cohesive soils into the excavation is expected to be relatively minor and should be able to be controlled by pumping from properly filtered sumps. As discussed further in Section 6.10 (Construction Considerations), it is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to address groundwater control requirements for the culvert sites, a copy of which is included in Appendix D.

6.6 Lateral Earth Pressures for Design

The lateral earth pressures acting on the culvert walls, and on any associated headwalls, wingwalls or retaining walls that may be required immediately adjacent to the culvert extensions will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of the surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the retaining walls. These design recommendations and parameters assume levelled (horizontal at the surface) backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free-draining granular fill meeting the specifications of OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II material should be used as backfill behind the walls.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the culvert walls, in accordance with *CHBDC* Section 6.12.3 and Figure 6.6. Compaction equipment should be used in accordance with OPSS.PROV 501 (Compacting). Other surcharge loadings should be accounted for in the design, as required.
- For a restrained wall, the granular fill may be placed in a zone with the width equal to at least 1.2 m behind the back of the walls (see Case A in Figure C6.20 of the *Commentary* to the *CHBDC*).
- For an unrestrained wall, the granular fill should be placed within the wedge-shaped zone defined by a line drawn flatter than 1 horizontal to 1 vertical (<1H:1V) extending up and back from the rear face of the footing (see Case B in Figure C6.20 of the *Commentary* to the *CHBDC*).
- For Case A - restrained wall, the pressures are based on the existing embankment fill materials and the existing overburden soils and the following parameters (unfactored) may be used:

Material	Existing Cohesive/Non-Cohesive Fill	Granular B Type I, II or SSM
Soil Unit Weight:	20 kN/m^3	21 kN/m^3
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	 0.35 0.52	 0.31 0.47

- For Case B - unrestrained wall, the pressures are based on the engineered granular fill within the backfill zone, and the following parameters (unfactored) may be used:

Material	Granular 'A'	Granular 'B' Type II
Soil Unit Weight:	22 kN/m^3	21 kN/m^3
Coefficients of static lateral earth pressure: Active, K_a At rest, K_o	 0.27 0.43	 0.27 0.43

Where the culvert wall support does not allow lateral yielding, at-rest earth pressures should be assumed for the geotechnical design. Where culvert wing walls or retaining walls are required and their support allows lateral yielding of the stem, active earth pressures should be used in the geotechnical design of the wall structure(s). The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the *Commentary* to the *CHBDC (2014)*.

6.6.1 Seismic Considerations

For concrete culvert walls, wingwalls or retaining walls, seismic (earthquake) loading must be considered in the design in accordance with Section 4.6.5 of *CHBDC (2014),* as significant seismic loading will result in increased lateral earth pressures acting on the walls. Concrete culvert walls, wing walls or retaining walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the applicable earthquake-induced dynamic earth pressure.

In accordance with Sections 4.6.5 and C.4.6.5 of the *CHBDC (2014)* and its Commentary, for structures which allow lateral yielding, the horizontal seismic coefficient, k_h, used in the calculation of the seismic active pressure coefficient, is taken as 0.5 times the site-specific PGA. For structures that do not allow lateral yielding, k_h is taken as equal to the site-specific PGA. For both cases the value of the vertical seismic coefficient k_v is taken as zero.

The following seismic active pressure coefficients (K_{AE}) may be used in design; these coefficients reflect the maximum K_{AE} obtained for each of the earthquake design periods and backfill conditions. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is level. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

Wall Type	Design Earthquake	Site PGA	Seismic Active Pressure Coefficients, K_{AE}		
			Granular A	Granular B Type II	Earth Fill
Yielding Wall (Unrestrained Wall)	**475-Yr**	0.074g	0.27	0.27	0.32
	975-Yr	0.138g	0.29	0.29	0.35
	2,475 Yr	0.240g	0.32	0.32	0.38
Non-Yielding Wall (Restrained Wall)	**475-Yr**	0.074g	0.29	0.29	0.35
	975-Yr	0.138g	0.33	0.33	0.40
	2,475 Yr	0.240g	0.41	0.41	0.49

- The K_{AE} value for a yielding wall is applicable provided that the wall can move up to 250k_h mm, where k_h is the site-specific PGA as given in the table above. This corresponds to displacements of 18 mm, 35 mm, and 60 mm for the 475-year, 975-year, and 2,475-year design earthquakes at this site.
- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined per Section C4.6.5 of the *Commentary* to *CHBDC (2014).*

6.7 Settlement

The existing Glendale Avenue and York Road embankments are about 2 m to 3 m high at the culvert sites. The roadway embankments will be widened at both culvert sites, which will require placement of an approximately 1 m to 2 m thick zone of additional fill on top of the existing embankment side slopes, and an approximately 2 m to 3 m thick zone of fill on top of the ground surface beyond the existing toes of the highway embankments. These additional fill loadings will induce some settlement in the soils beneath the embankment widening areas.

Analysis of the magnitude of settlement of the subgrade strata below the present existing embankment slope surfaces and ground surface under the widening footprint at and adjacent to the culverts was carried out by hand calculations, using estimated elastic deformation moduli as given below, as estimated from correlations with the SPT 'N'-values (Bowles, 1984; Kulhawy and Mayne, 1990; Terzaghi, 1955) and engineering judgement from experience with similar soils in this region of Ontario. The consolidation parameters utilized for cohesive deposits were derived from correlation with water content/liquid limits/plasticity indices obtained from published literature (Mesri, 1973; Djoenaidi 1985)

Soil Deposit	Bulk Unit Weight	Elastic Modulus	P_c'	e_o	C_c	C_r
Existing (Interlayered) Embankment Fill (Compact/Stiff)	21 kN/m^3	25 MPa	-	-	-	-
Stiff to Very Stiff Clayey Silt	20 kN/m^3	25 MPa	75 kPa	0.60	0.25	0.05
Stiff to Very Stiff Silty Clay to Clay	19 kN/m^3	20 MPa	-	0.80	0.35	0.07
(Soft to) Stiff Silty Clay to Clay	19 kN/m^3	10 MPa	-	0.90	0.40	0.08

The settlement of the foundation soils under the approximately 2 m to 3 m thickness of additional fill that will be placed beyond the existing embankments toes for the embankment widening is estimated to be less than 20 mm and 25 mm in the area of the Culverts EX-06 and EX-05 extensions, respectively, decreasing to less than 10 mm and 12 mm under the existing embankment side slopes, at the respective culvert sites, corresponding to differential settlements of about 10 mm and 13 mm, which are considered acceptable for culvert structures.

6.8 Culvert Bedding, Backfill and Erosion Protection

Backfill and cover for the concrete box culverts should be completed consistent with the elements shown on OPSD 803.010 (Backfill and Cover for Concrete Culverts) and the bedding levelling pad and backfill should be completed in accordance with OPSS 422 (Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut).

The box culvert extensions should be provided with at least 300 mm of OPSS.PROV 1010 Granular 'A' material for bedding purposes and backfill to the culvert walls should consist of granular fill meeting the requirements of OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II. The backfill and bedding should be placed and compacted in accordance with OPSS.PROV 501. The culvert extensions should be designed for the full overburden pressure and live load, assuming that the embankment fill has a unit weight of 22 kN/m^3 for Granular 'A', and 21 kN/m^3 for

Granular 'B' Type II or select subgrade material (SSM) or earth fill above and/or surrounding the culvert bedding/cover zones.

To prevent surface water from flowing either beneath the culvert extensions (potentially causing undermining and scouring) or around the culvert extensions (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a concrete cut-off wall should be provided at the upstream end of box culvert extensions, whereas a clay seal should be provided at the upstream end of open footing culvert extensions. Clay seals should also be placed adjacent to the culvert inlet opening for both box culvert and open footing structure types. The clay material should meet the requirements of OPSS.PROV 1205 (Clay Seal). The clay seal should have a thickness of 1 m, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high-water level including treatment of the adjacent side slopes.

Provision should also be made for scour and erosion protection at the culvert inlet and outlet, including in front of any wing walls/retaining walls adjacent to the creek channel. The requirements for and design of erosion protection measures for the culvert inlet should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the culvert outlet should be consistent with the standard Treatment Type A presented in OPSD 810.010 (Rip-Rap Layout for Sewer and Culvert Outlets), with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket if adopted, including the channel/ditch bottom similar to that at the culvert outlet, as well as on the side slopes and embankment fill slope adjacent to the culverts.

6.9 Corrosion Assessment and Protection

Soil corrosivity may affect the concrete foundations and reinforced steel and other concrete elements buried in the soil. The long-term performance and durability of the foundations are directly related to their respective corrosion resistance. Generally, the degree of corrosivity potential of a structure depends on the soil resistivity, hydrogen ion concentration and salts (chloride and sulphate concentrations). The analytical results for the samples submitted for testing are summarized in Section 4.4 and the analytical laboratory test report is included in Appendix C.

6.9.1 Potential for Sulphate Attack

The analytical test results were compared to CSA Standard, CAN/CSA-A23.1-14 Table 3 *("Additional requirements for concrete subjected to sulphate attack")* for potential sulphate attack on concrete. The sulphate concentrations measured in the samples are less than 0.039 per cent, which is lower than the exposure class of Moderate and the relative degree of sulphate attack is considered "negligible", according to the Gravity Pipe Design Guidelines (2014). Therefore, based on the test results of the three soil samples from the boreholes obtained at the locations of the culvert extensions the effects of sulphates from within the existing native clayey silt fill and clayey silt to silty clay deposit may not need to be considered.

6.9.2 Potential for Corrosion

The soil has a pH between about 7.6 and 7.9 and a resistivity between about 840 ohm-cm and 2,200 ohm-cm. According to the Gravity Pipe Design Guidelines (MTO, 2014), the pH is not considered detrimental to concrete durability (pH values between 5.5 and 8.5). However, the resistivity is less than 2,000 ohm-cm, which indicates that the soil corrosiveness is severe ($R < 2{,}000$ ohm-cm), as per Table 3.2 of Gravity Pipe Design Guidelines (2014). Based on the resistivity test results, some level of protection should be provided to the reinforcing elements. Further, given that the culvert extensions are located adjacent to the roadway shoulder and will likely be exposed to de-icing salt, consideration should be given to selection of a "C" type exposure class as defined by CSA A23.1 Table 1.

It is ultimately up to the 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.

6.10 Construction Considerations

6.10.1 Surface Water and Groundwater Control

Control of the surface water and groundwater will be necessary for the construction of the culvert extensions, to allow excavation and foundation construction to be carried out in dry conditions. Depending on the channel/ditch flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe or diverted by pumping from behind a temporary cofferdam. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the subgrade soils; further discussion on this aspect is provided in Section 6.10.3.

The foundation excavations for the culvert extensions are expected to extend near to or below the groundwater level as the water levels observed at the three borehole locations were essentially at ground surface; but three boreholes were observed to have collect groundwater up to a level of about 11 m below ground surface. Excavations for construction of the culvert extensions are expected to be advanced through existing interlayered cohesive and non-cohesive fill to terminate within native cohesive soils and therefore seepage into the excavation should be adequately controlled by pumping from properly filtered sumps.

An NSSP is provided in Appendix D for inclusion in the Contract Documents, to address groundwater control for culvert sites.

6.10.2 Excavation and Temporary Protection Systems

Temporary excavations for the culvert extensions will be made through the existing interlayered cohesive and non-cohesive fill and extend into the very stiff clayey silt deposit and stiff to very stiff silty clay to clay deposit. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects (Ont. Reg. 213/91). The existing fill and stiff to very stiff clayey silt and stiff to very stiff silty clay to clay deposits are classified as Type 3 soil according to the OHSA. Where space permits, temporary open-cut excavations through these materials should be made with side slopes formed no steeper than 1H:1V, assuming proper groundwater and surface water control is in place.

It is expected that temporary protection systems may be required for the culvert extension work, installed perpendicular to Glendale Avenue and York Road to allow excavation into the existing embankment side slopes, or parallel to the creek/drainage channel to form a cut-off to facilitate foundation excavation. The temporary excavation support systems for the culvert extension work should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any adjacent utilities can tolerate this magnitude of deformation.

The protection system may be required to allow for excavation to be made to depths between approximately 2 m and 4 m below adjacent ground surface at the culvert ends. Although the selection and design of the protection system will be the responsibility of the contractor, it is considered that either a driven, interlocking sheetpile system or a soldier pile and timber lagging system would be suitable for the roadway protection at these culvert sites, based on the subsurface soil and groundwater conditions. An interlocking sheetpile system would contribute to both ground and groundwater/surface water control, which is considered to be suitable and advantageous for both the culvert extension sites. While cobbles and boulders were not encountered in the boreholes advanced at the sites of the culvert extensions, such materials are inferred to be present in glacial deposits, and sheetpile sections may encounter such obstructions or refusal during driving.

The sheetpiles or soldier piles would have to be socketed to sufficient depth to provide the necessary passive resistance for the retained soil height of up to approximately 4 m. Lateral support to the sheetpiles or soldier piles could be provided in the form of rakers or temporary anchors.

6.10.3 Subgrade Protection

If open footing culvert extensions are adopted, the subgrade soils will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade if the footings are not constructed within four hours after preparation, inspection and approval of the footing subgrade. This requirement can be addressed with a note on the General Arrangement drawing and/or with an NSSP.

An NSSP is provided in Appendix D for inclusion in the Contract Documents.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Eric Naylor, EIT, and Ms. Manisha Ahuja, P.Eng., P.E. Mr. Jorge Costa, P.Eng., Senior Consultant and MTO Foundations Designated Contact of Golder, conducted an independent technical and quality control review of this report.

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EN/MA/JMAC/en/rb

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ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587	Standard Test Method for Thin Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
ASTM D2573	Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Canadian Standards Association (CSA):

CAN/CSA A23.1-14	Concrete Materials and Methods of Concrete Construction

Ontario Provisional Standard Drawing:

OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario
OPSD 803.010	Backfill and Cover for Concrete Culverts with Span Less Than or Equal to 3.0 m
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets

Ontario Provincial Standard Specification:

OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specifications for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems

OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS 902	Excavation and Backfilling - Structures

Ontario Water Resources Act:

Ontario Regulation 903	Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91	Construction Projects (as amended)

Ministry of Transportation, Ontario

MTO Gravity Pipe Design Guidelines, Circular Culverts and Storm sewers, April 2014

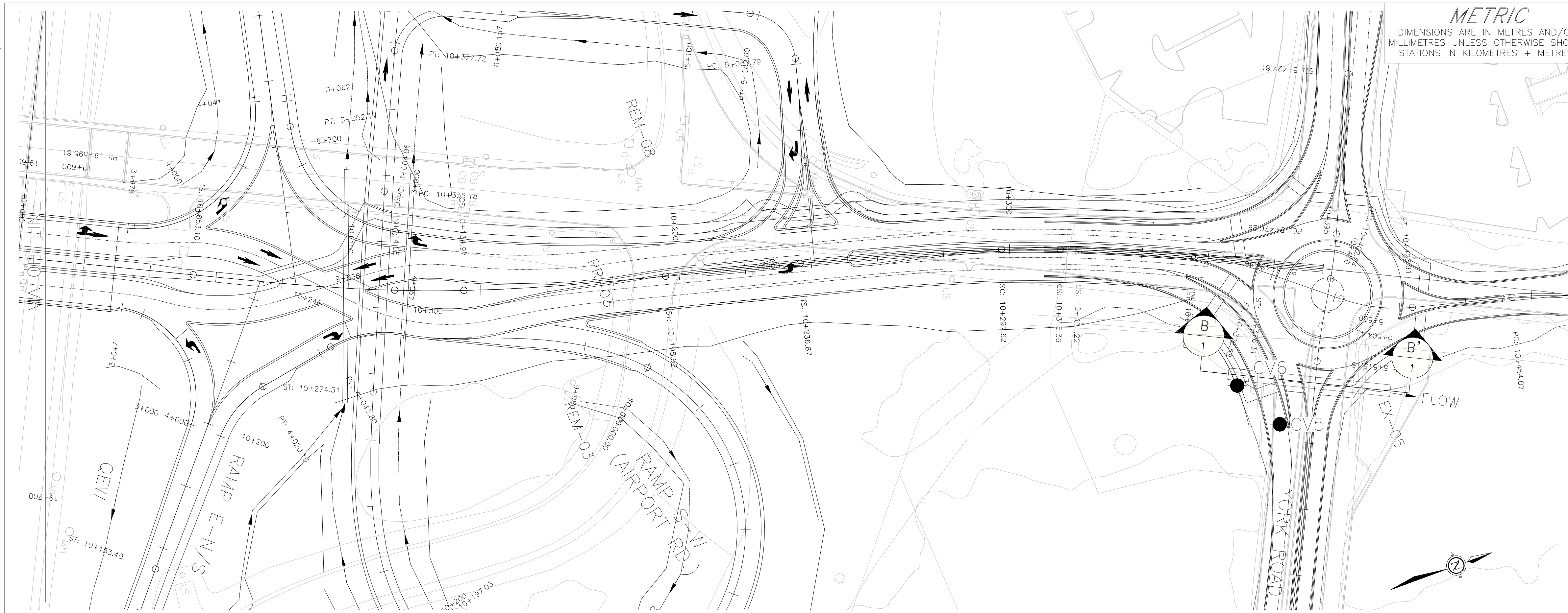
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2423-15-00

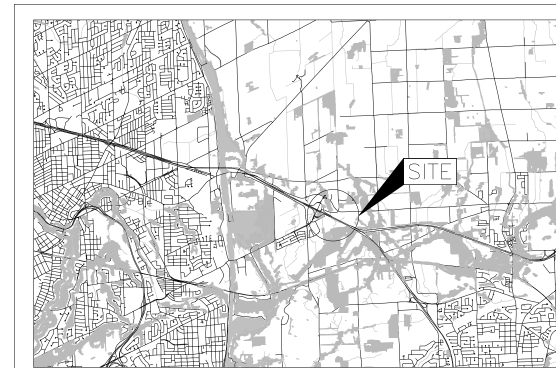
SHEET

QEW/GLENDALE AVENUE INTERCHANGE IMPROVEMENTS
CULVERT EX-05 EXTENSION
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER



PLAN
SCALE
15 0 15 30 m



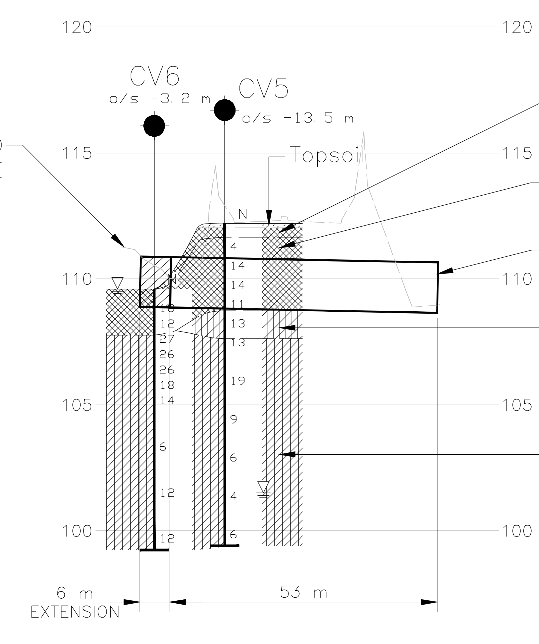
KEY PLAN
SCALE
2 0 2 4 km

LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
CV5	112.2	4780080.4	332294.2
CV6	109.6	4780072.3	332278.8



B-B 1 CULVERT EX-05 PROFILE

VERTICAL SCALE
3 0 3 6 m

HORIZONTAL SCALE
15 0 15 30 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.

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

REFERENCE

Base plans provided in digital format by Aecom, drawing file nos. X_Base.dwg, X_Property.dwg, York Roundabout_1 Lane.dwg, Diverging Diamond.dwg and Diverging Diamond with Airport Rd connection.dwg, received October 23, 2018.

LICENSED PROFESSIONAL ENGINEER M. AHUJA 100515144 April 15, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER J.M.A.COSTA April 15, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M3-308

HWY. QEW		PROJECT NO. 1671430	DIST. CENTRAL
SUBM'D. NK	CHKD.	DATE: 4/15/2019	SITE:
DRAWN: DD	CHKD. MA	APPD. JMAC	DWG. 1

MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: April 17, 2019

MINISTRY OF TRANSPORTATION, ONTARIO

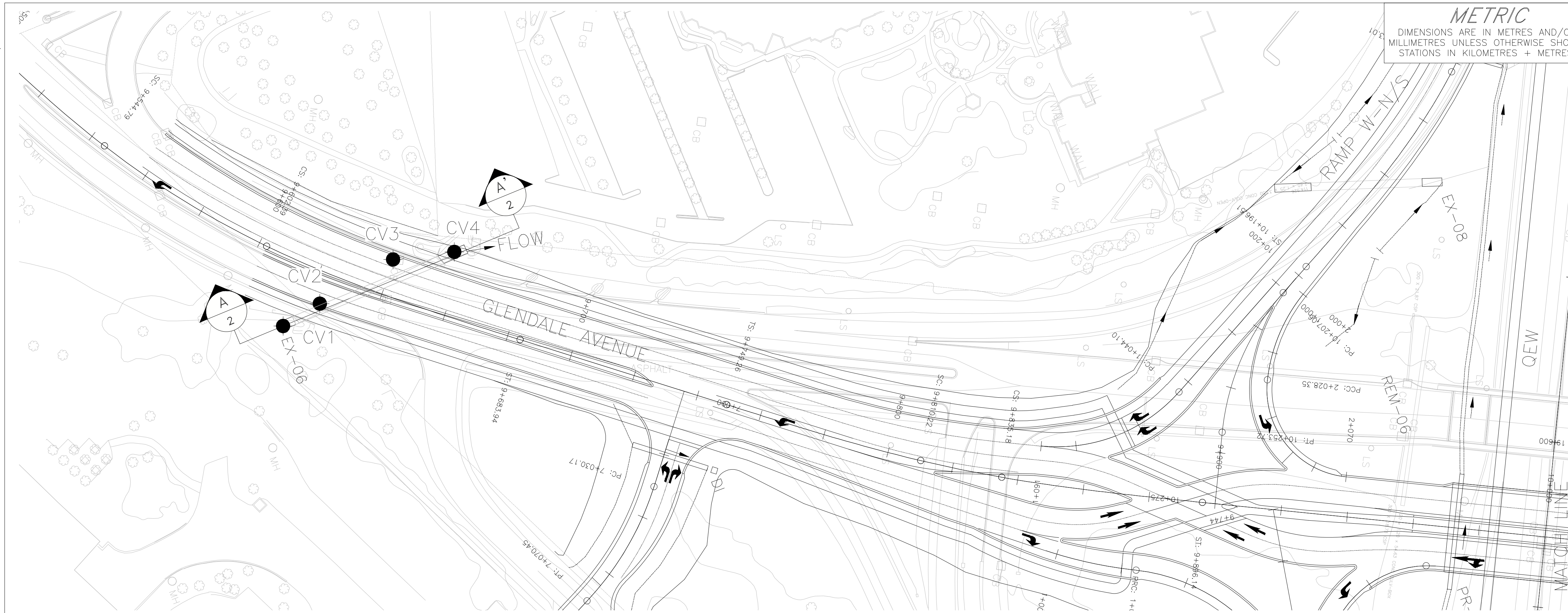
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2423-15-00

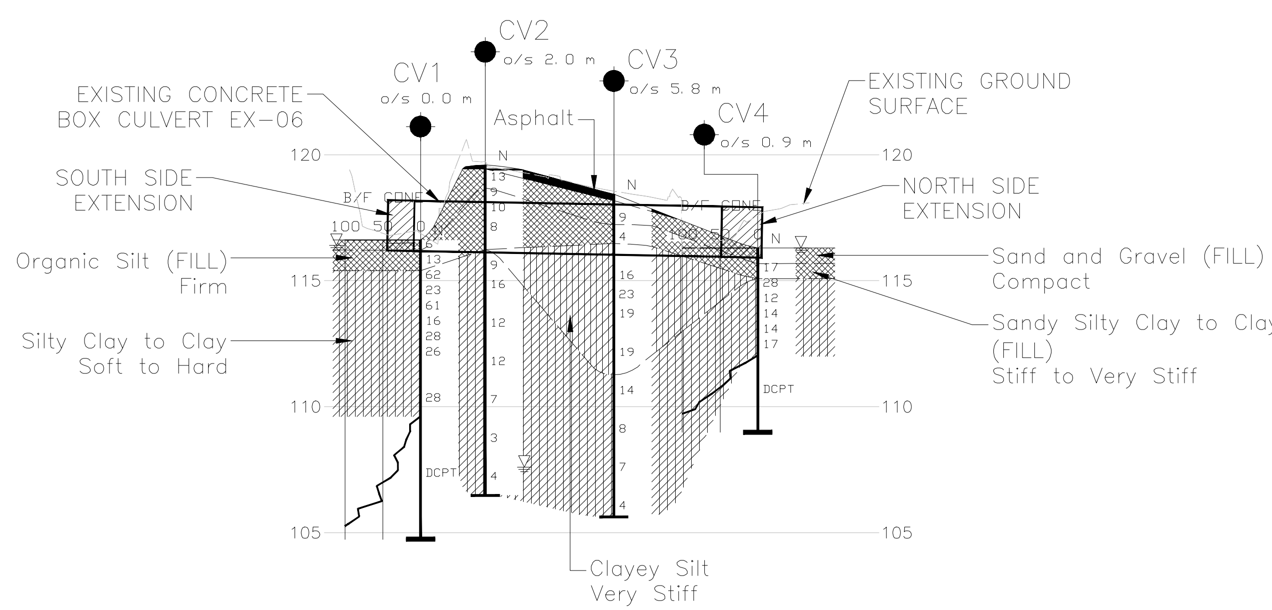
SHEET

QEW/GLENDALE AVENUE INTERCHANGE IMPROVEMENTS
CULVERT EX-06 EXTENSION
BOREHOLE LOCATIONS AND SOIL STRATA

GOLDER



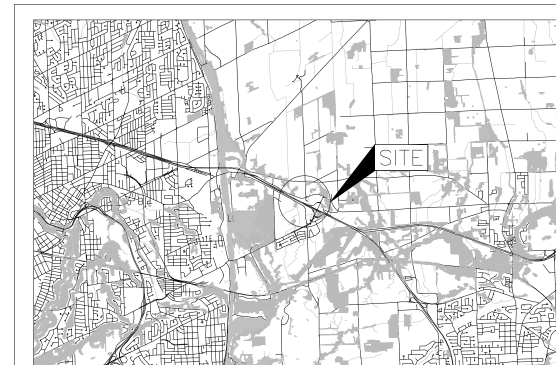
PLAN
SCALE
15 0 15 30 m



A-A / 2 CULVERT EX-06 PROFILE

VERTICAL SCALE
3 0 3 6 m

HORIZONTAL SCALE
15 0 15 30 m



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

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

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
CV1	116.6	4779405.5	331924.2
CV2	119.6	4779418.2	331921.7
CV3	118.4	4779443.5	331916.8
CV4	116.3	4779461.7	331921.0

NOTES

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

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

REFERENCE

Base plans provided in digital format by Aecom, drawing file nos. X_Base.dwg, X_Property.dwg, York Roundabout_1 Lane.dwg, Diverging Diamond.dwg and Diverging Diamond with Airport Rd connection.dwg, received October 23, 2018.

LICENSED PROFESSIONAL ENGINEER — M. AHUJA 100515144 — April 15, 2019 — PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER — J.M.A.COSTA — April 15, 2019 — PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 30M3-308

HWY. QEW	PROJECT NO. 1671430		DIST. CENTRAL
SUBM'D. NK	CHKD. EN	DATE: 2019-03-22	SITE:
DRAWN: DD	CHKD. MA	APPD. JMAC	DWG. 2

APPENDIX A

Borehole Records

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

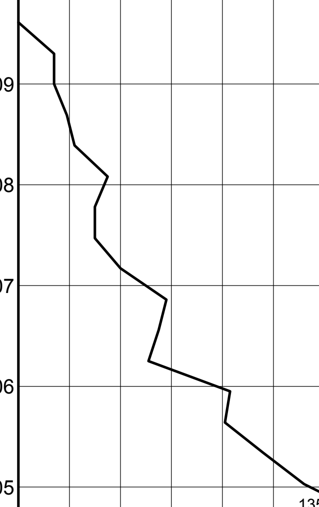
RECORD OF BOREHOLE No CV1

SHEET 1 OF 1 **METRIC**

PROJECT 1671430 WO2
G.W.P. 2423-15-00
LOCATION N 4779405.5; E 331924.2 MTM NAD 83 ZONE 10 (LAT. 43.154018; LONG. -79.166491)
ORIGINATED BY LK
DIST Central HWY QEW
BOREHOLE TYPE Hilti PD 250E Portable Drill Rig, 63.5 mm Casing Wash Boring
COMPILED BY EN
DATUM Geodetic
DATE November 12, 2018
CHECKED BY MA

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (w_P – w – w_L)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
116.6	GROUND SURFACE											
0.0	Organic silt, some clay, trace sand, trace gravel, some roots/organic (FILL)	1A	SS	6	∇							
116.2 / 0.4	Firm, Grey-black, Wet	1B				116						
		2	SS	13			w_L = 43		1	21	39	39
115.4 / 1.2	Sandy silty clay, trace gravel (FILL), Stiff, Grey-brown, Moist	3	SS	62		115						
	CLAY, trace sand, Very stiff to hard, Brown to grey, black starting from at depth of 3.7 m to 4.1 m, Moist	4	SS	23								
		5	SS	61		114						
		6	SS	16			w_L = 52		0	3	33	64
		7	SS	28		113						
		8	SS	26		112	w_L = 53		0	2	35	63
						111						
		9	SS	28		110						
109.6 / 7.0	Start of Dynamic Cone Penetration Test (DCPT)					109, 108, 107, 106, 105						
104.7 / 11.9	END OF DCPT END OF BOREHOLE NOTE: 1. Water level measured in open borehole at a depth of 0.2 m below ground surface (Elev. 116.4 m) upon 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)



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

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GOLDER

Foundation Design

RECORD OF BOREHOLE No CV2

SHEET 1 OF 1 — **METRIC**

PROJECT: 1671430 WO2
G.W.P.: 2423-15-00
DIST: Central HWY: QEW
DATUM: Geodetic

LOCATION: N 4779418.2; E 331921.7 MTM NAD 83 ZONE 10 (LAT. 43.154133; LONG. -79.166521)
BOREHOLE TYPE: 178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig
DATE: September 28, 2018

ORIGINATED BY: KN
COMPILED BY: KG
CHECKED BY:

Soil Profile and Samples

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
119.6	GROUND SURFACE				
0.0	ASPHALT (150 mm)				
	Sand and gravel (FILL) Compact Brown-red Dry to moist	1	SS	13	
118.7 / 0.9	Sandy clayey silt to clayey silt, trace to some sand, trace to some gravel (FILL) Stiff Brown Moist	2	SS	9	
		3	SS	10	
		4	SS	8	
116.2 / 3.4	SILTY CLAY to CLAY, trace sand Soft to very stiff Brown to grey-brown below 10.2 m Moist to wet below 10.2 m	5	SS	9	0 2 33 65
		6	SS	16	
		7	SS	12	0 2 36 62
		8	SS	12	
	Silt seams at a depth between 9.1 m and 9.8 m below ground surface.	9	SS	7	
		10	SS	3	
		11	SS	4	0 3 39 58
106.5 / 13.1	END OF BOREHOLE				

NOTES:

1. Borehole caved to 12.1 m on removal of augers.

2. Water level at a depth of 12 m below ground surface (Elev.107.6 m) on completion of drilling.

Ground water conditions: ∇ at approx. Elev. 107.6 m

Elevation scale: 119, 118, 117, 116, 115, 114, 113, 112, 111, 110, 109, 108, 107

Dynamic Cone Penetration Resistance Plot (20, 40, 60, 80, 100)

Shear Strength kPa (20, 40, 60, 80, 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED

Field vane results: near Elev. 116.4: + (sensitivity 2.0), >95.8 +; near Elev. 109.6: >95.8 +; near Elev. 108.4: + (sensitivity 2.0), >95.8 +; near Elev. 106.5: >95.8 +

Plastic limit W_P, Natural moisture content W, Liquid limit W_L — Water content (%) (10, 20, 30)

Liquid limit values plotted: 56 (Sample 5), 51 (Sample 7), 42 (Sample 11)

Unit weight γ kN/m³

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CV3

SHEET 1 OF 1 **METRIC**

PROJECT	1671430 WO2
G.W.P.	2423-15-00
LOCATION	N 4779443.5; E 331916.8 MTM NAD 83 ZONE 10 (LAT. 43.154361; LONG. -79.166580)
ORIGINATED BY	MA
DIST	Central
HWY	QEW
BOREHOLE TYPE	178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig
COMPILED BY	KG
DATUM	Geodetic
DATE	September 28, 2018
CHECKED BY	

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
118.4	GROUND SURFACE
0.0	ASPHALT (250 mm)
0.3	Sand and gravel, some silt, some clayey silt layers (FILL) Loose Brown Moist
117.2 / 1.2	Clayey silt, trace sand, trace gravel, trace topsoil (FILL) Firm to stiff Brown Moist
116.4 / 2.0	CLAYEY SILT, trace to some sand, contains some silt seams and partings Very stiff Brown Moist
111.2 / 7.2	SILTY CLAY, trace sand, some silt seams and partings Soft to stiff Brown to grey below 11.6 m Moist
105.6 / 12.8	END OF BOREHOLE NOTES: 1. Open borehole dry on completion of drilling and removal of augers.

SAMPLES

NUMBER	TYPE	"N" VALUES	Water content / limits (%)	GR	SA	SI	CL
1	SS	9					
2	SS	4	w ≈ 23				
3	SS	16					
4	SS	23	w_P ≈ 18, w ≈ 18, w_L ≈ 33	0	5	62	33
5	SS	19					
6	SS	19	w ≈ 27				
7	SS	14	w_P ≈ 20, w ≈ 25, w_L 49	0	4	37	59
8	SS	8					
9	SS	7	w_P ≈ 21, w ≈ 32, w_L 50	0	3	36	61
10	SS	4					

Elevation scale: 118, 117, 116, 115, 114, 113, 112, 111, 110, 109, 108, 107, 106

Column headings: 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

Shear strength (field vane) values plotted: 2.0 (near elev. 116); >143.6 (near elev. 115.6); >143.6 (near elev. 108.3); >143.6 (near elev. 106.8)

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

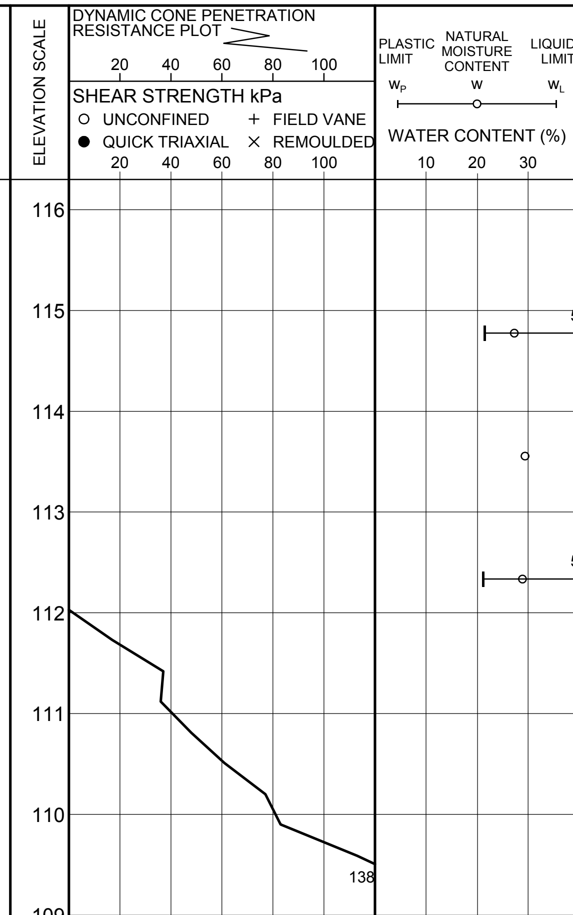
GOLDER

RECORD OF BOREHOLE No CV4

SHEET 1 OF 1 **METRIC**

PROJECT	1671430 WO2
G.W.P.	2423-15-00
LOCATION	N 4779461.7; E 331921.0 MTM NAD 83 ZONE 10 (LAT. 43.154524; LONG. -79.166527)
ORIGINATED BY	LK
DIST	Central
HWY	QEW
BOREHOLE TYPE	Hilti PD 250E Portable Drill Rig, 63.5 mm Casing Wash Boring
COMPILED BY	EN
DATUM	Geodetic
DATE	November 14, 2018
CHECKED BY	MA

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.3	GROUND SURFACE					
0.0	Crushed gravel, some clay pockets (FILL) Black					
115.7 0.6	Silty clay, trace sand, trace organic (FILL) Very stiff Brown-grey Moist	1	SS	17		
115.1 1.2	SILTY CLAY to CLAY, trace sand Stiff to very stiff Brown to brown grey Moist	2	SS	28	w_L = 52	0 3 35 62
		3	SS	12		
		4	SS	14		
		5	SS	14		
		6	SS	17	w_L = 50	0 2 35 63
112.0 4.3	Start of Dynamic Cone Penetration Test (DCPT)					
109.0 7.3	END OF DCPT END OF BOREHOLE NOTE: 1. Water level measured in open borehole at ground surface (Elev. 116.3 m) upon completion of drilling.					



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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CV5

SHEET 1 OF 2

METRIC

PROJECT 1671430 WO2

G.W.P. 2423-15-00

LOCATION N 4780080.4; E 332294.2 MTM NAD 83 ZONE 10 (LAT. 43.160080; LONG. -79.161908)

ORIGINATED BY MA

DIST Central HWY QEW

BOREHOLE TYPE 178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig

COMPILED BY KG/EN

DATUM Geodetic

DATE September 18, 2018

CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
112.2	GROUND SURFACE													
0.0	Silty topsoil, some sand (FILL) Brown						112							
111.7	Clayey silt, some sand, trace gravel (FILL) Brown													
111.4 / 0.8	Sand and gravel, trace silt (FILL) Brown Moist		1	SS	4		111							
	Clayey silt, trace sand, trace gravel, trace topsoil, trace wood fragments, trace rootlets (FILL) Soft to stiff Brown to black Moist		2	SS	14		110							
			3	SS	14									
108.7 / 3.5	Sandy CLAYEY SILT, trace rootlets, silty sand seams at 3.8 m bgs Stiff Brown Moist		4	SS	11		109							
			5	SS	13		108				0	22	51	27
107.6 / 4.6	SILTY CLAY to CLAY, trace sand, trace gravel, some silt seams Soft to very stiff Brown to grey below 7.3 m Moist		6	SS	13		107		54		0	4	36	60
			7	SS	19		106							
							105							
			8	SS	9		104	>143.6						
			9	SS	6		103		48		1	3	33	63
						∇	102	+ 2.0						
			10	SS	4		101	+ 2.0						
			11	SS	6		100							
99.4 / 12.8	END OF BOREHOLE													

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No CV5

SHEET 2 OF 2 **METRIC**

PROJECT 1671430 WO2

G.W.P. 2423-15-00

LOCATION N 4780080.4; E 332294.2 MTM NAD 83 ZONE 10 (LAT. 43.160080; LONG. -79.161908)

ORIGINATED BY MA

DIST Central HWY QEW

BOREHOLE TYPE 178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig

COMPILED BY KG/EN

DATUM Geodetic

DATE September 18, 2018

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	NOTES: 1. Open borehole dry during drilling. 2. Borehole caved to 11.6 m on removal of augers. 3. Water level in open borehole at a depth of 10.7 m below ground surface (Elev. 101.5 m) on removal of augers.										

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

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

GOLDER

Foundation Design

RECORD OF BOREHOLE No CV6

SHEET 1 OF 1 **METRIC**

PROJECT 1671430 WO2
G.W.P. 2423-15-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4780072.3; E 332278.8 MTM NAD 83 ZONE 10 (LAT. 43.160009; LONG. -79.162105)
BOREHOLE TYPE Hilti PD 250E Portable Drill Rig, 63.5 mm Casing Wash Boring
DATE November 27, 28, 2018

ORIGINATED BY SE
COMPILED BY EN
CHECKED BY MA

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
109.6	GROUND SURFACE
0.0	Silty clay, trace to some sand, trace to some gravel, some organics to 0.6 m (FILL) Stiff Brown Moist
107.8 / 1.8	SILTY CLAY to CLAY, trace sand, trace gravel Firm to very stiff Brown becoming grey below 5.6 m Moist becoming wet below 3.0 m - No recovery in samples 4 and 6.
99.2 / 10.4	END OF BOREHOLE NOTE: 1. Water level in open borehole at ground surface (Elev. 109.6 m) on completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	Liquid limit (plotted label)	Field vane (plotted labels)	GR	SA	SI	CL
1	SS	10	40		7	11	40	42
2	SS	12						
3	SS	27	55		0	2	34	64
4	SS	26						
5	SS	26						
6	SS	18						
7	SS	14						
8	SS	6	50		1	2	31	66
				3.0, 2.0				
9	SS	12						
10	SS	12						

ELEVATION SCALE: 109, 108, 107, 106, 105, 104, 103, 102, 101, 100

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

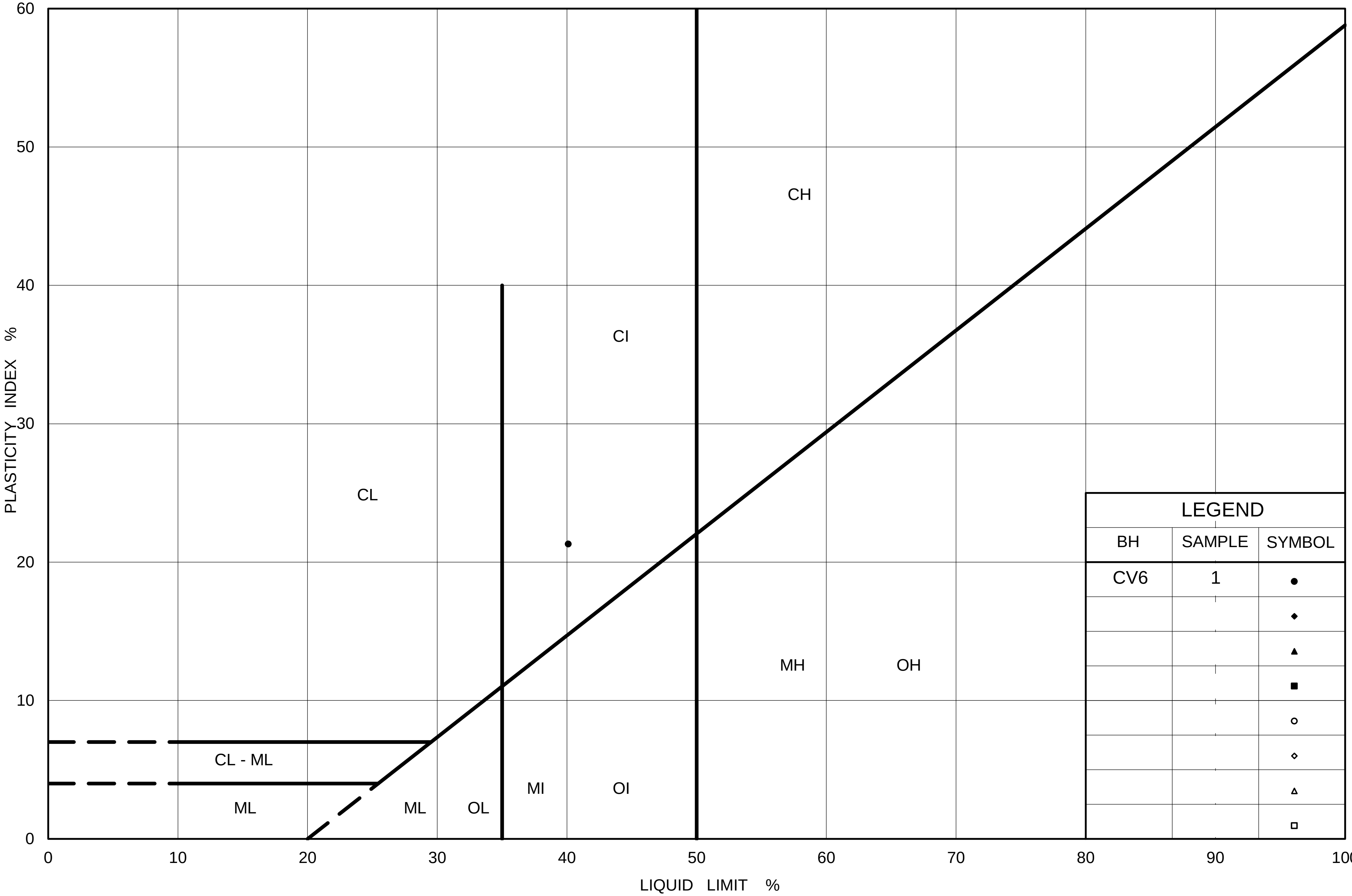
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 S:\CLIENTS\MTO\QEW-GLENDALE\02_DATA\GINT\QEW-GLENDALE.GPJ GAL-GTA.GDT 04/17/19

APPENDIX B

Geotechnical Laboratory Test Results

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay (Fill)

(Culvert EX-05)

Figure No. B-1

Project No. 1671430 (WO 002)

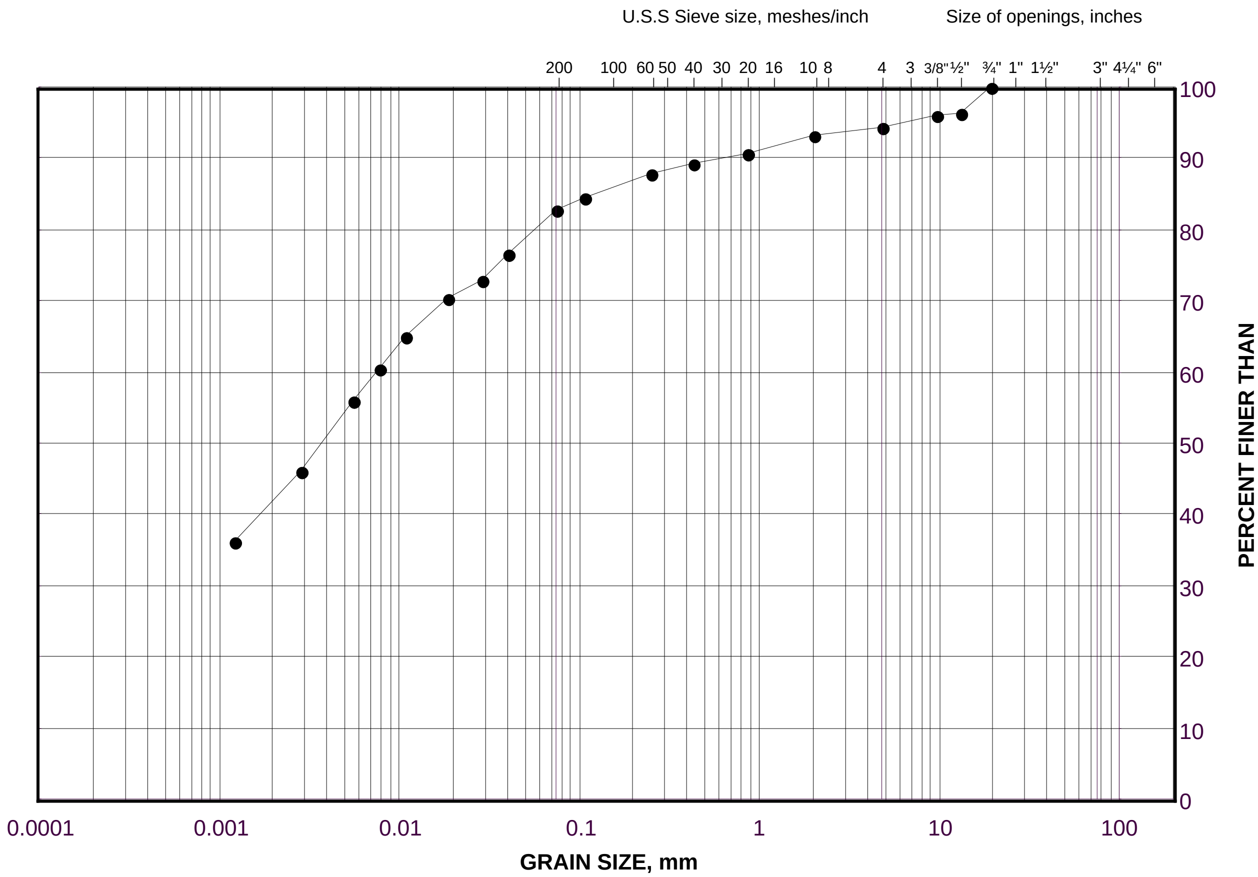
Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay (Fill)

(Culvert EX-05)

FIGURE B-2



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV6	1	108.7

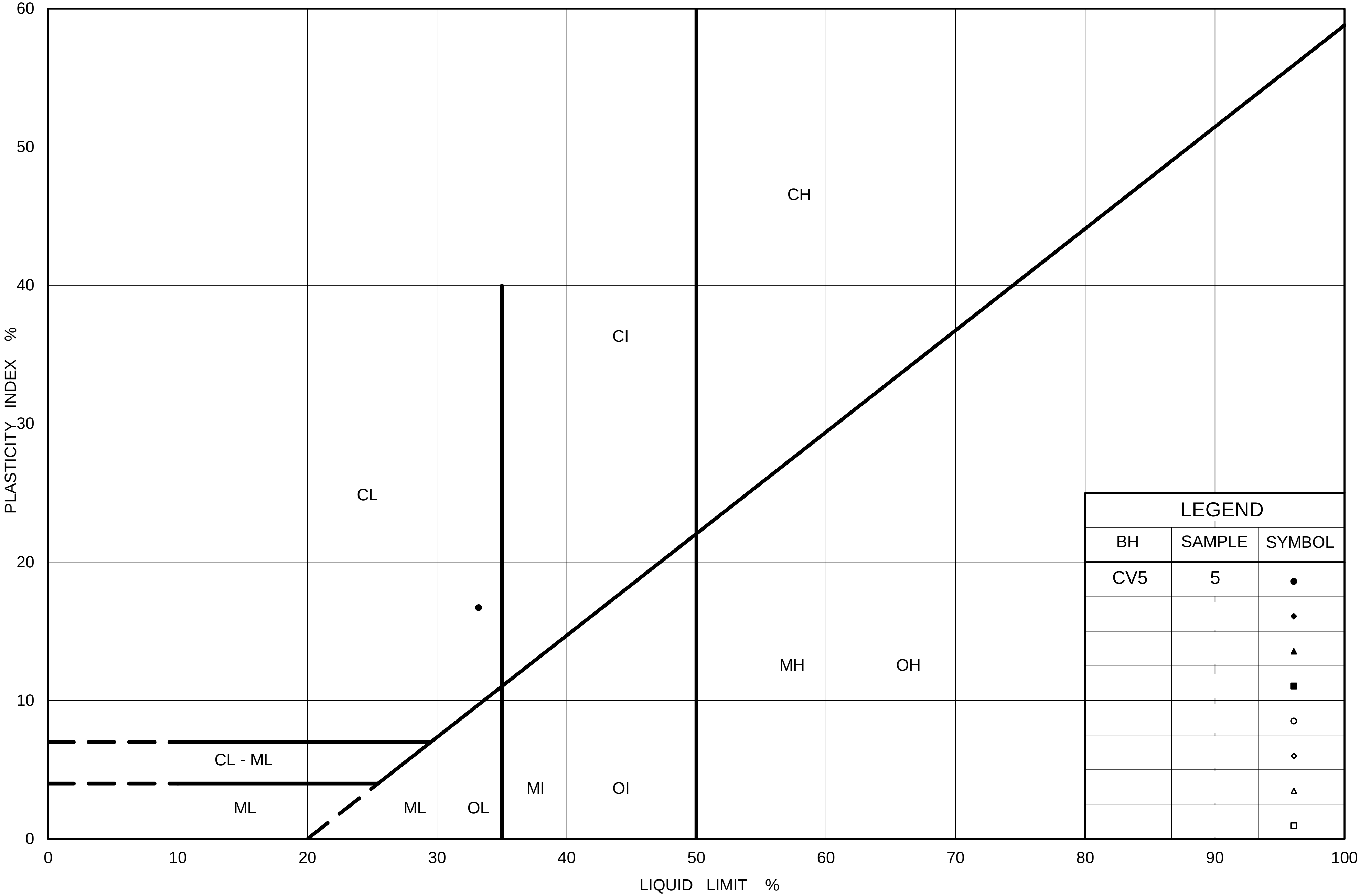
Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt
(Culvert EX-05)

Figure No. B-3

Project No. 1671430 (WO 002)

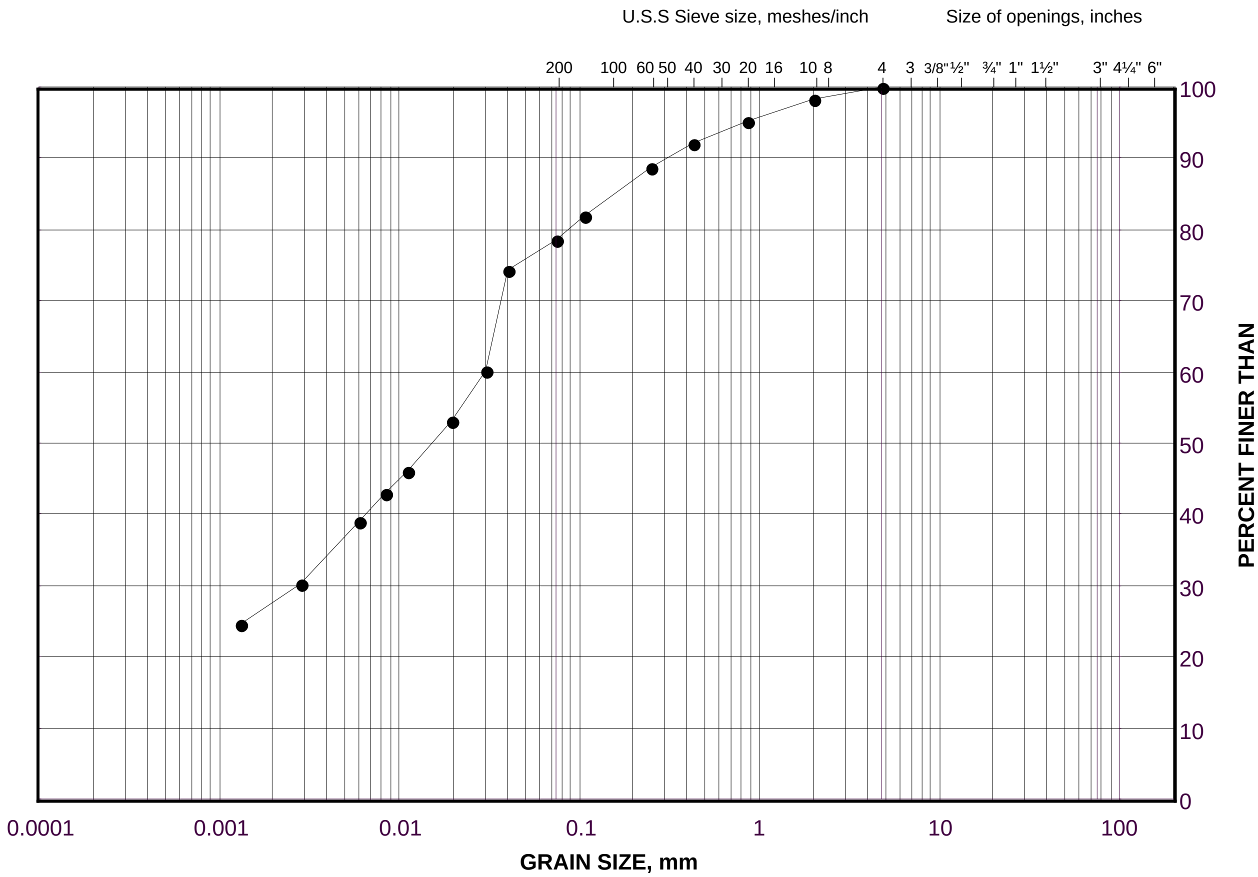
Checked By: MA

GRAIN SIZE DISTRIBUTION

Clayey Silt

(Culvert EX-05)

FIGURE B-4



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

LEGEND

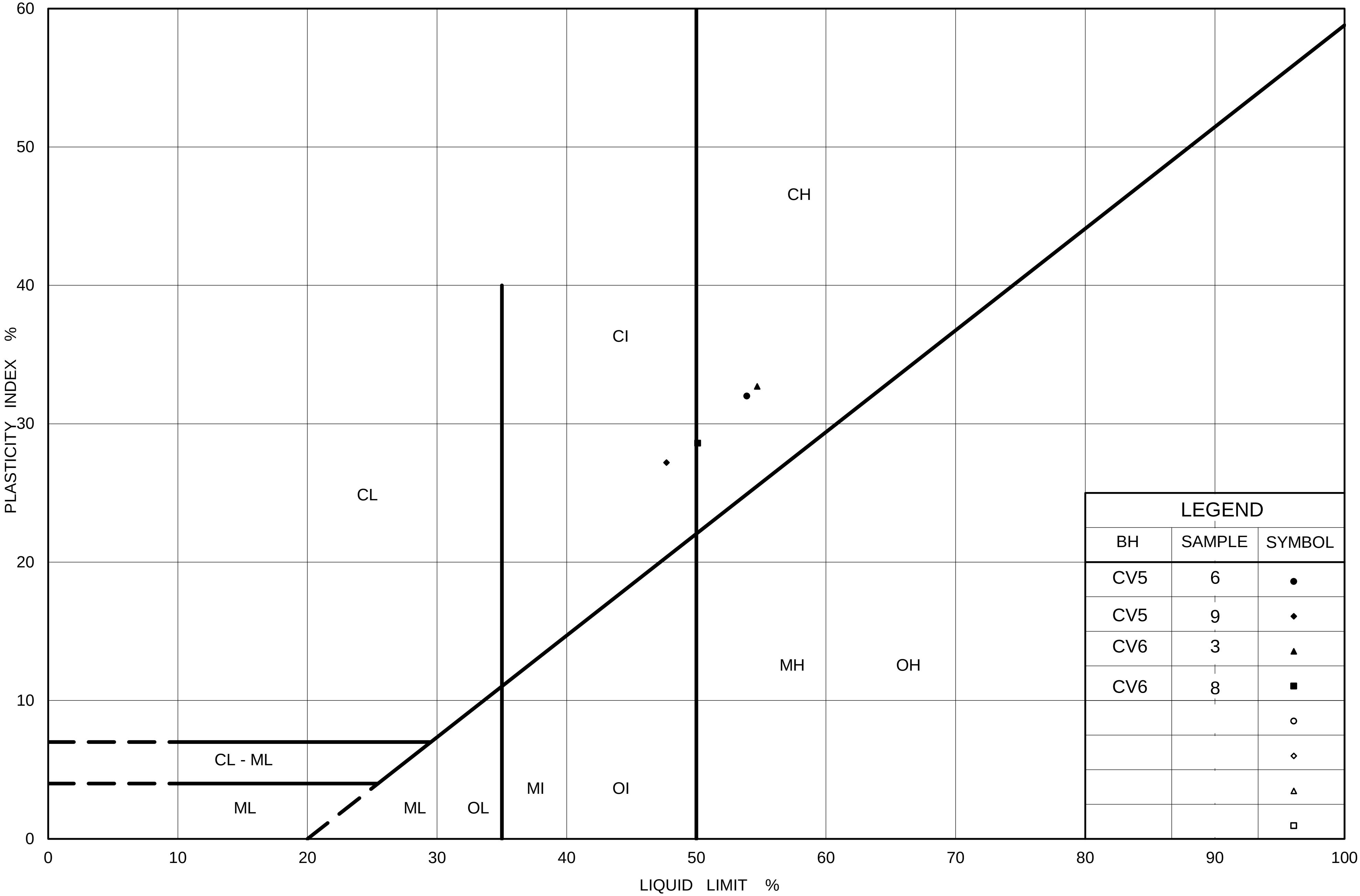
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV5	5	108.1

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19



Ministry of Transportation

Ontario

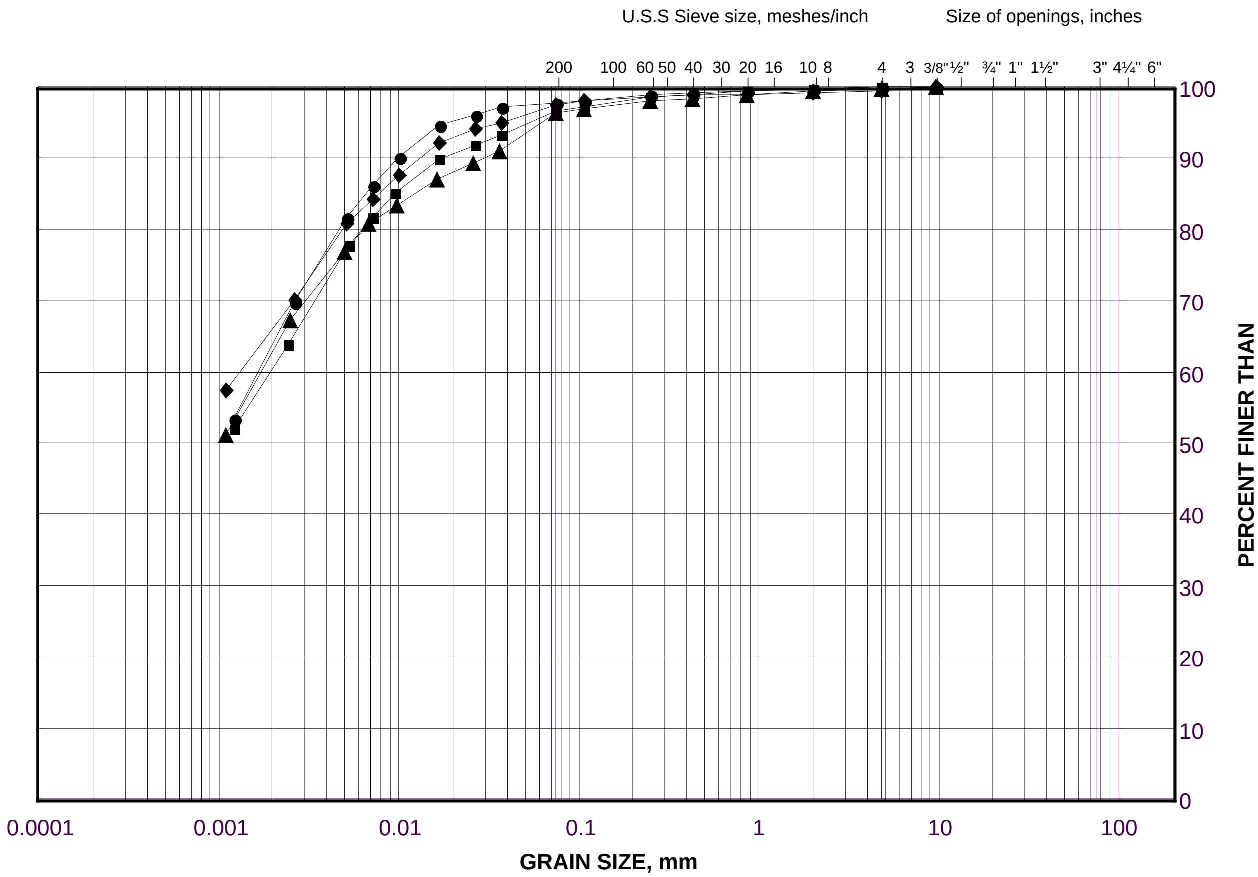
PLASTICITY CHART
Silty Clay to Clay
(Culvert EX-05)

Figure No. B-5

Project No. 1671430 (WO 002)

Checked By: MA

GRAIN SIZE DISTRIBUTION Silty Clay to Clay (Culvert EX-05)	FIGURE B-6



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV6	3	107.5
■	CV5	6	107.3
◆	CV6	8	103.2
▲	CV5	9	102.8

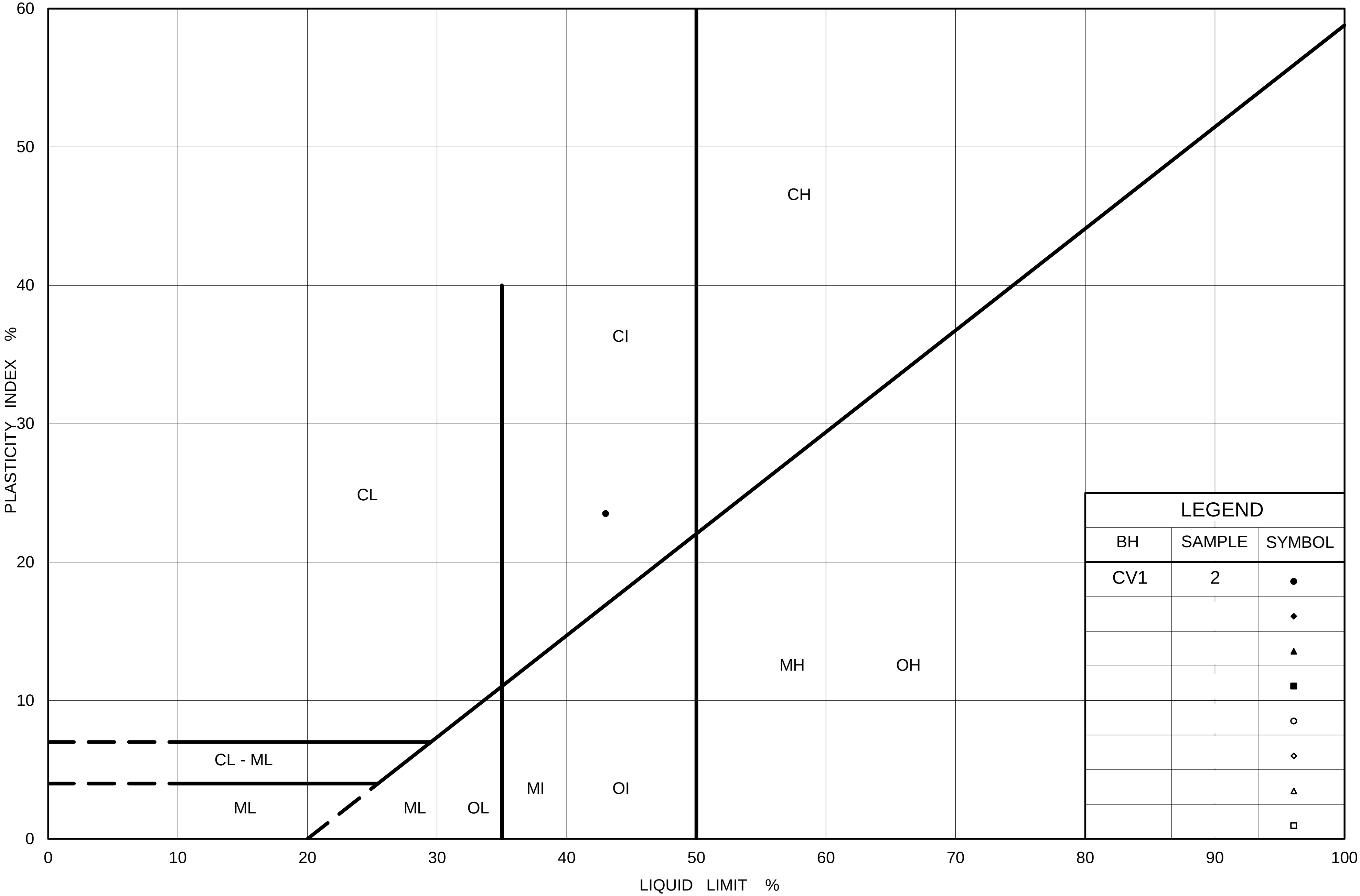
Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19

Oct 75, FF-S-21



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Ontario

PLASTICITY CHART
Silty Clay (Fill)
(Culvert EX-06)

Figure No. B-7

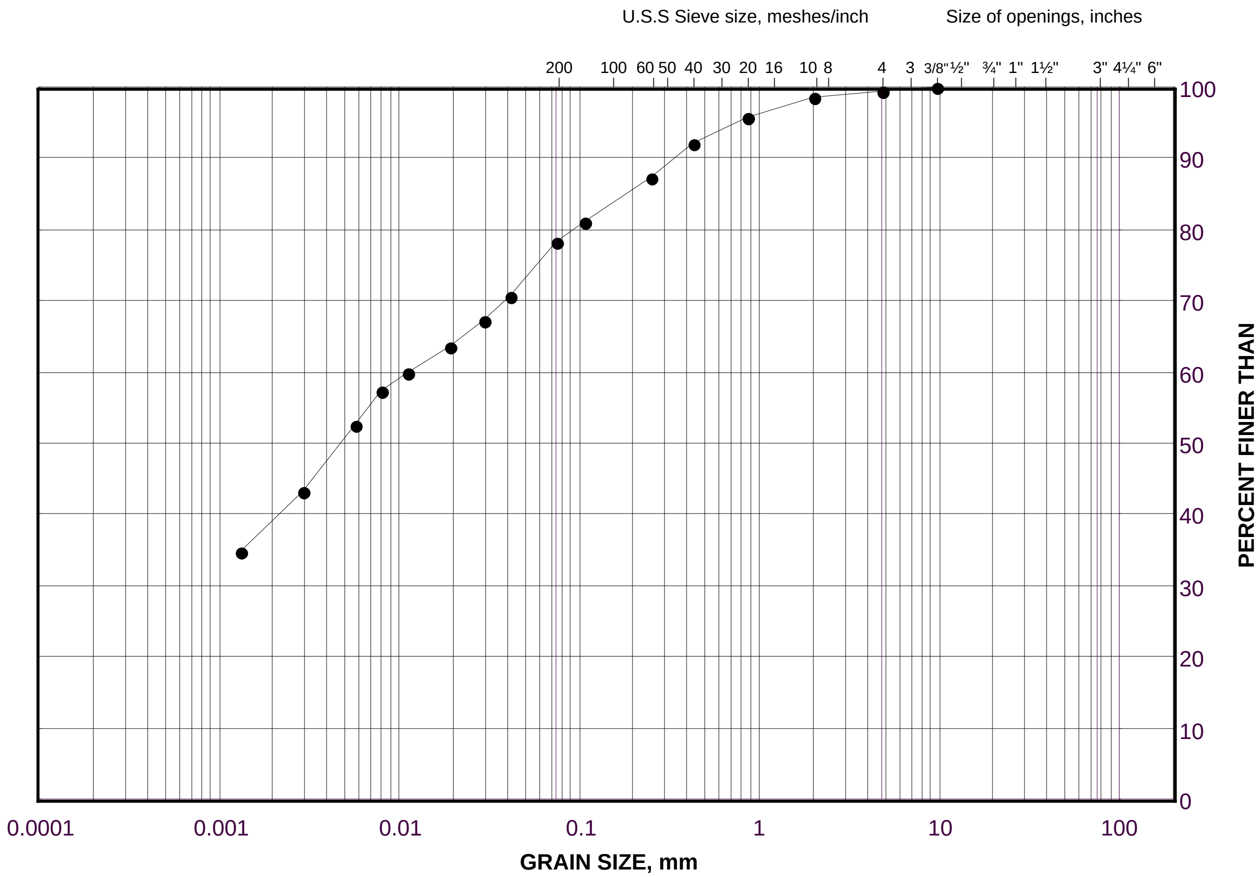
Project No. 1671430 (WO 002)

Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay (Fill)
(Culvert EX-06)

FIGURE B-8



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV1	2	115.7

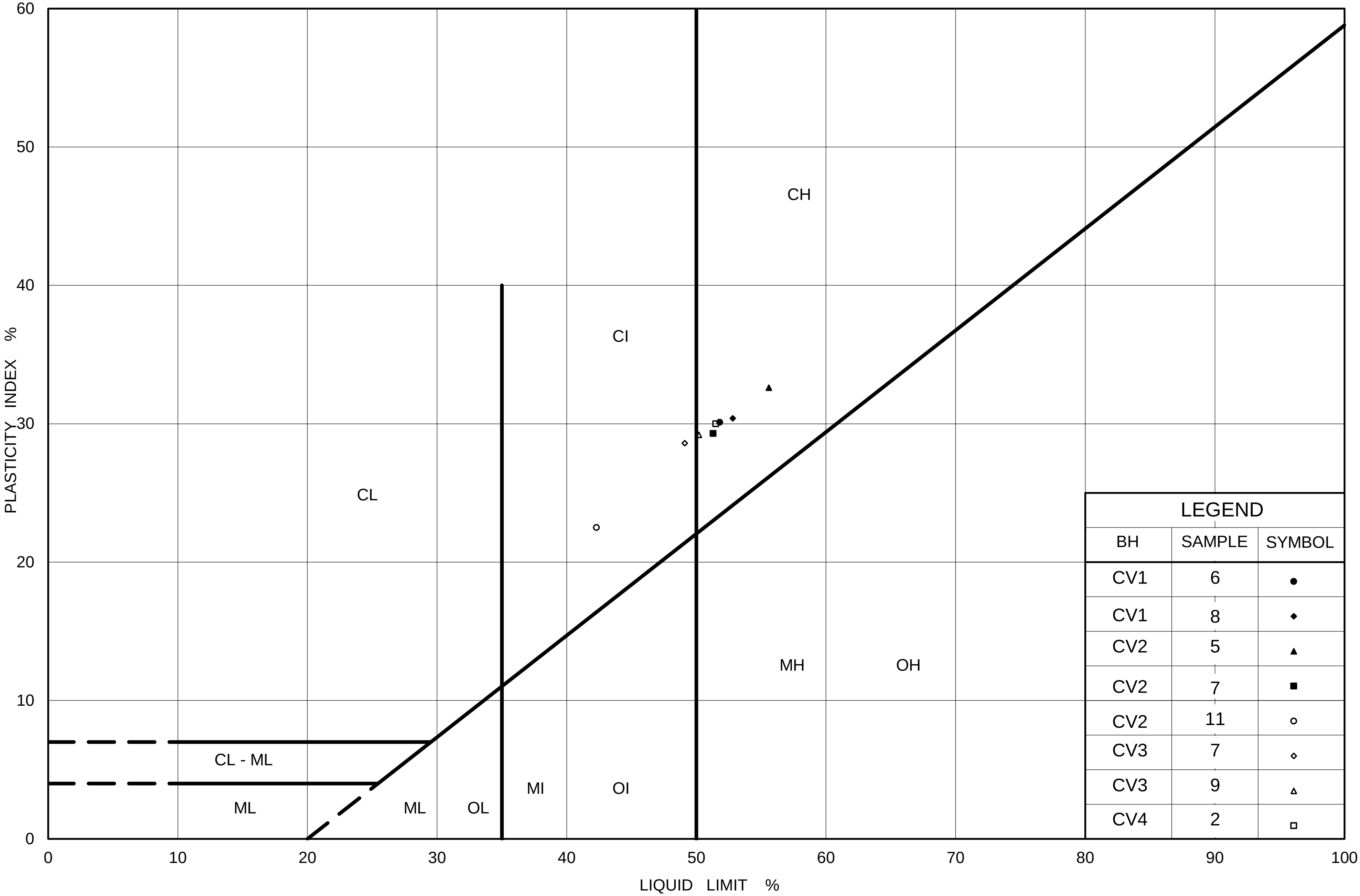
Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19

Oct 75, FF-S-21



BH	SAMPLE	SYMBOL
CV1	6	●
CV1	8	◆
CV2	5	▲
CV2	7	■
CV2	11	○
CV3	7	◇
CV3	9	△
CV4	2	□

Ministry of Transportation

Ontario

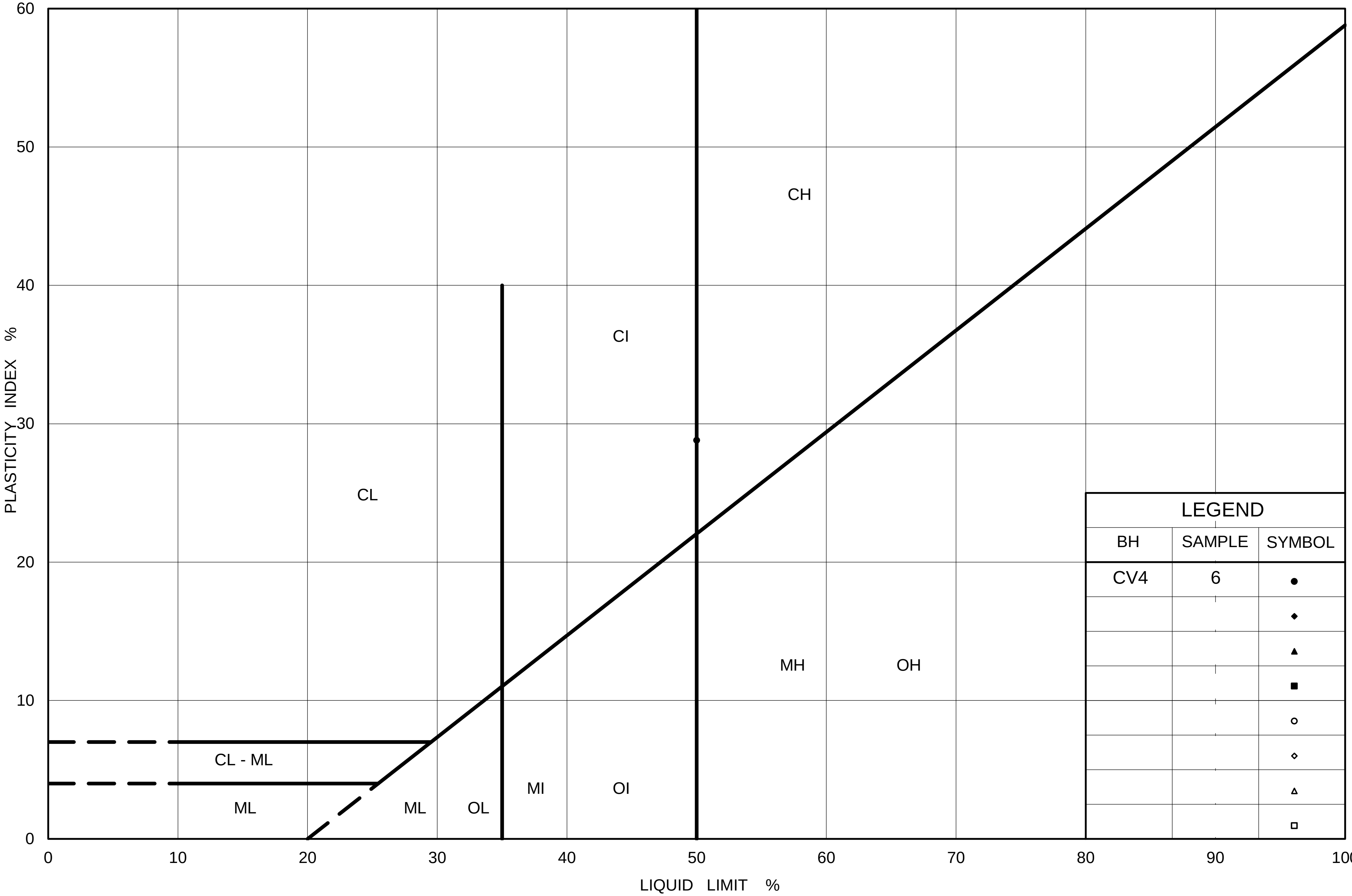
PLASTICITY CHART
Silty Clay to Clay
(Culvert EX-06)

Figure No. B-9A

Project No. 1671430 (WO 002)

Checked By: MA

Oct 75, FF-S-21



LEGEND		
BH	SAMPLE	SYMBOL
CV4	6	●
		◆
		▲
		■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay

(Culvert EX-06)

Figure No. B-9B

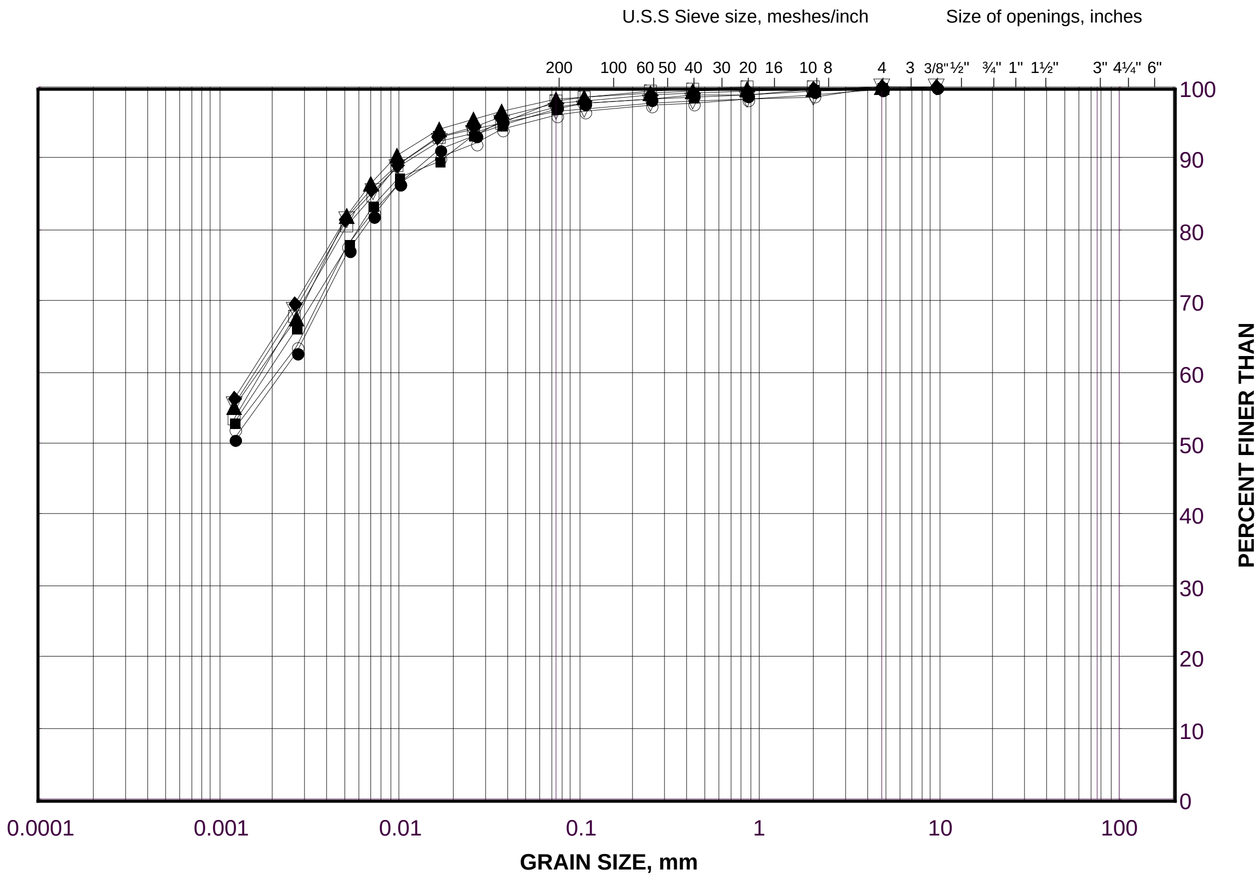
Project No. 1671430 (WO 002)

Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay
(Culvert EX-06)

FIGURE B-10A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV2	11	107.1
■	CV4	2	114.8
◆	CV2	5	115.5
▲	CV4	6	112.3
▽	CV1	6	113.2
❍	CV3	7	110.5
☐	CV2	7	113.2

Project Number: 1671430

Checked By: MA

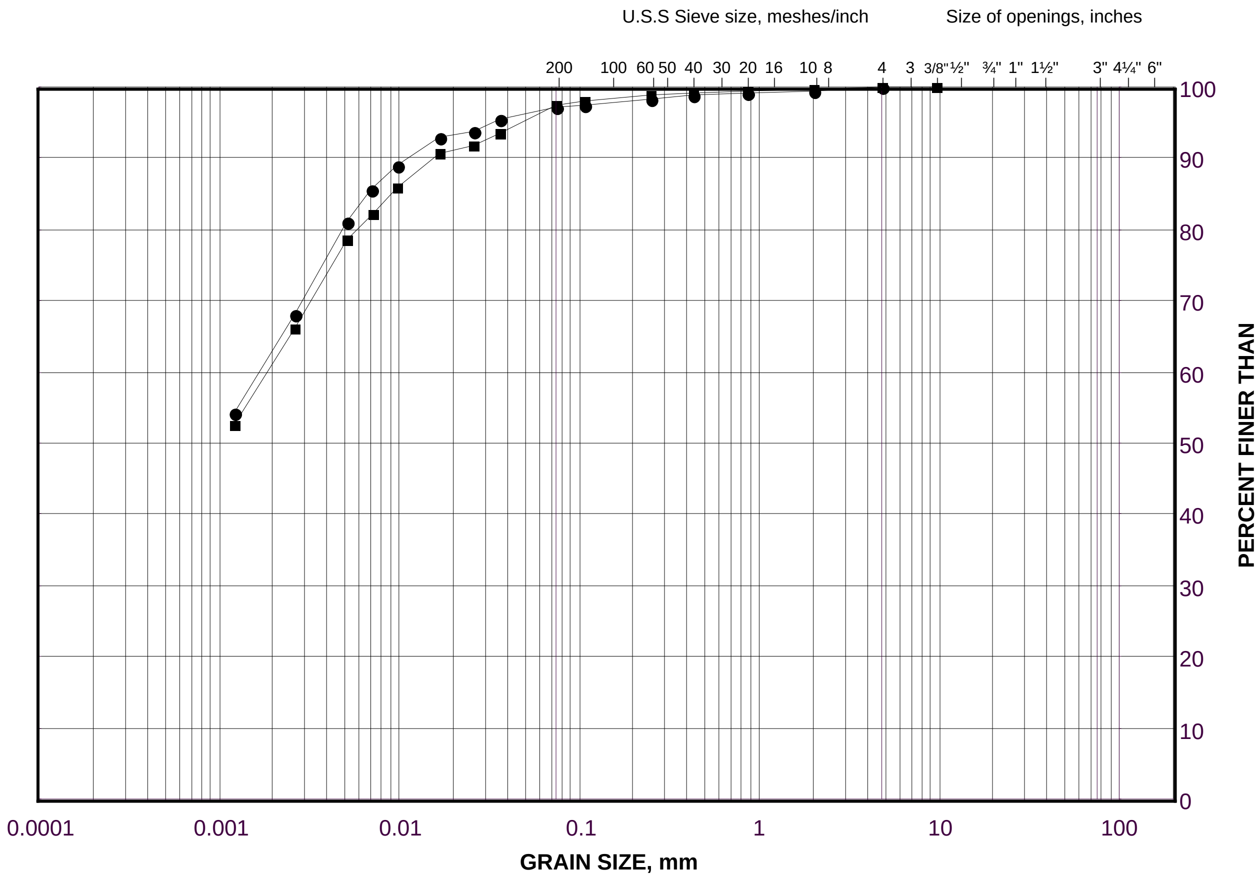
Golder Associates

Date: 19-Mar-19

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay
(Culvert EX-06)

FIGURE B-10B



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV1	8	112.0
■	CV3	9	107.4

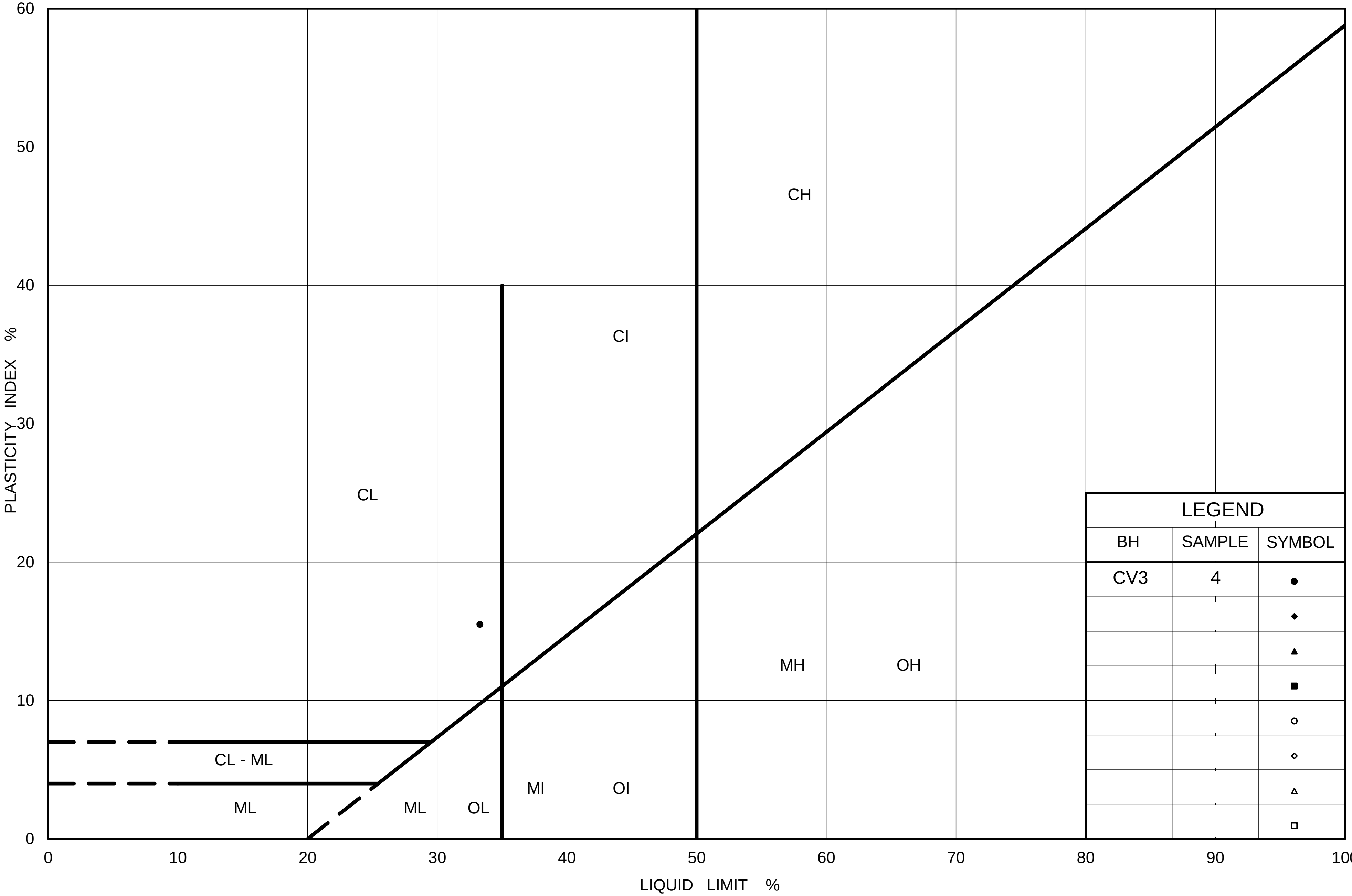
Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt
(Culvert EX-06)

Figure No. B-11

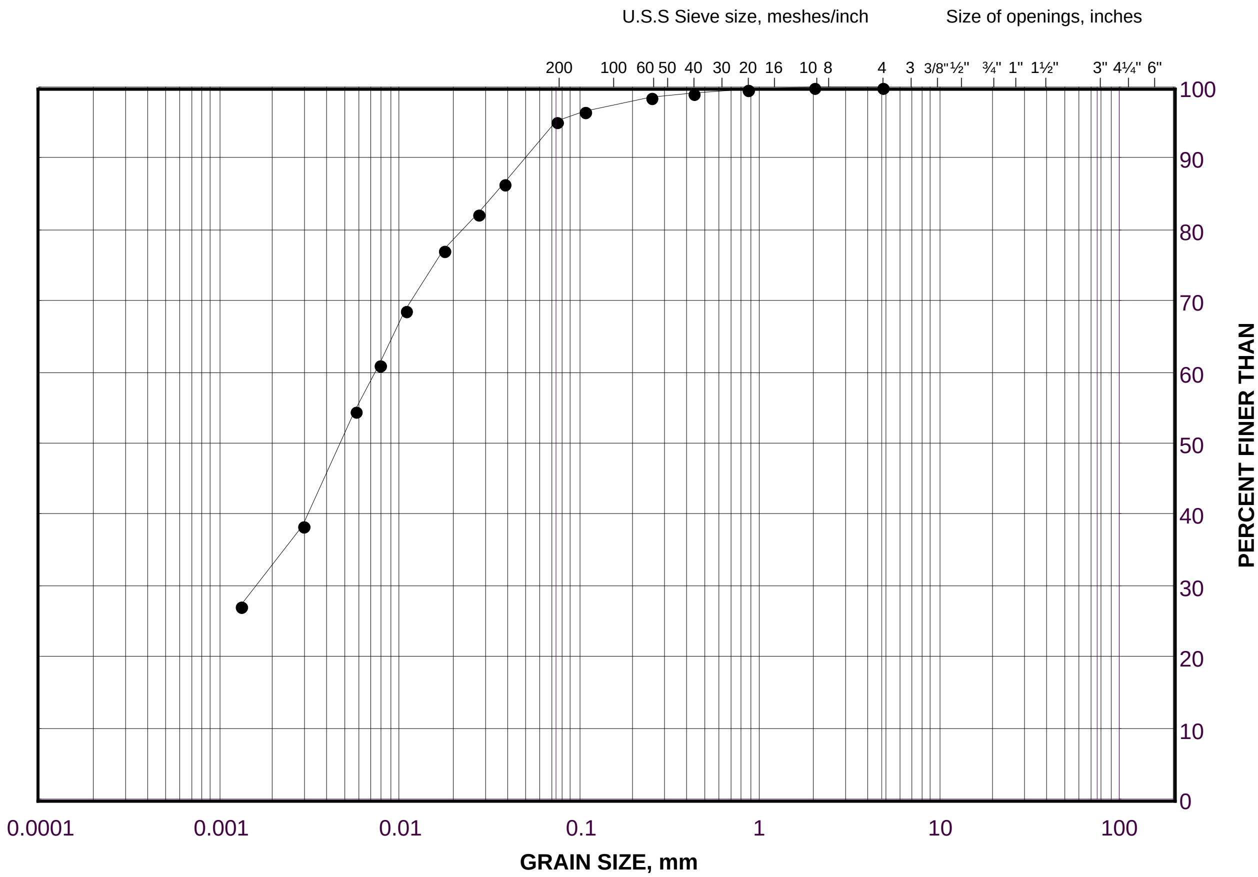
Project No. 1671430 (WO 002)

Checked By: MA

GRAIN SIZE DISTRIBUTION

Clayey Silt
(Culvert EX-06)

FIGURE B-12



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV3	4	114.3

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19

APPENDIX C

Analytical Laboratory Test Results

Your Project #: 1671430-W02
Site Location: QEW-GLENDALE
Your C.O.C. #: 674002-03-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522748
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6769
Received: 2018/12/06, 12:29

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	3	N/A	2018/12/11	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	3	2018/12/11	2018/12/11	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2018/12/07	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	3	N/A	2018/12/11	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.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager

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 #: 1671430-W02
Site Location: QEW-GLENDALE
Your C.O.C. #: 674002-03-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522748
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6769
Received: 2018/12/06, 12:29
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B8W6769
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430-W02
Site Location: QEW-GLENDALE
Sampler Initials: MAS

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		IMG025	IMG026	IMG027			IMG027		
Sampling Date		2018/09/28	2018/09/18	2018/09/18			2018/09/18		
COC Number		674002-03-01	674002-03-01	674002-03-01			674002-03-01		
	UNITS	**CV2 SA3**	**CV3 SA5**	**CV5 SA2**	**RDL**	**QC Batch**	**CV5 SA2 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters									
Resistivity	ohm-cm	840	2200	1300		5876242			
Inorganics									
Soluble (20:1) Chloride (Cl-)	ug/g	580	120	160	20	5879728			
Conductivity	umho/cm	1180	458	763	2	5882455	764	2	5882455
Available (CaCl2) pH	pH	7.84	7.88	7.62		5881791			
Soluble (20:1) Sulphate (SO4)	ug/g	250	190	390	20	5879732			

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

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Maxxam Job #: B8W6769
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430-W02
Site Location: QEW-GLENDALE
Sampler Initials: MAS

TEST SUMMARY

Maxxam ID: IMG025
Sample ID: CV2 SA3
Matrix: Soil

Collected: 2018/09/28
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5879728	N/A	2018/12/11	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5881791	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5876242	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5879732	N/A	2018/12/11	Alina Dobreanu

Maxxam ID: IMG026
Sample ID: CV3 SA5
Matrix: Soil

Collected: 2018/09/18
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5879728	N/A	2018/12/11	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5881791	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5876242	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5879732	N/A	2018/12/11	Alina Dobreanu

Maxxam ID: IMG027
Sample ID: CV5 SA2
Matrix: Soil

Collected: 2018/09/18
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5879728	N/A	2018/12/11	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5881791	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5876242	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5879732	N/A	2018/12/11	Alina Dobreanu

Maxxam ID: IMG027 Dup
Sample ID: CV5 SA2
Matrix: Soil

Collected: 2018/09/18
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva

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GENERAL COMMENTS

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

Package 1	5.3°C

Results relate only to the items tested.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B8W6769
Report Date: 2018/12/12

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430-W02
Site Location: QEW-GLENDALE
Sampler Initials: MAS

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5879728	Soluble (20:1) Chloride (Cl-)	2018/12/11	NC	70 - 130	103	70 - 130	<20	ug/g	6.4	35
5879732	Soluble (20:1) Sulphate (SO4)	2018/12/11	110	70 - 130	109	70 - 130	<20	ug/g	NC	35
5881791	Available (CaCl2) pH	2018/12/11			100	97 - 103			0.16	N/A
5882455	Conductivity	2018/12/12			104	90 - 110	<2	umho/cm	0.13	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)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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VALIDATION SIGNATURE PAGE

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

Brad Newman, Scientific Service 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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IMMEDIATE

CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80083	Maxxam Job #:	Bottle Order #: 674002
Attention:	Accounts Payable	Attention:	N. kol Kochmanová	P.O. #:			
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	~~08-1111-0039/34/47~~ 1671430 W02	COC #:	Project Manager:
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	905 567 6100 x2134 Fax:	Project Name:	QEW - Glendale	C#674002-03-01	Ema Gitej
Email:	AP_CustomerService@golder.com	Email:	nikol_kochmanova@golder.com	Site #: / Sampled By:	MA/SE		

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

Regulation 153 (2011): Table 1, Table 2, Table 3, Table ___; Res/Park, Ind/Comm, Agri/Other, Medium/Fine, Coarse, For RSC

Other Regulations: CCME, Reg 558, MISA, PWQO, Other; Sanitary Sewer Bylaw, Storm Sewer Bylaw, Municipality

Special Instructions

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; O.Reg 153 VOCs by HS & F1-F4; 4-hydroxy-4-methyl-2-Pentanone by SVOC Open Scan; Corrosivity Package (pH, Sulphate, Chloride, conductivity, resistivity)

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 / Metals	O.Reg 153 VOCs	4-hydroxy-4-methyl-2-Pentanone	Corrosivity Package	# of Bottles	Comments
1		CV2 SA3	Sept.28'18	AM	SOIL				X	1	Standard Corrosivity Package
2		CV3 SA5	Sept.18,'18	PM	SOIL				X	1	↓
3		CV5 SA2	Sept.18,'18	AM	SOIL				X	1	↓
4											
5											
6											06-Dec-18 12:29
7											Ema Gitej
8											B8W6769
9											URE ENV-1116
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	Laboratory Use Only
Eric Naylor	18/12/06	12:15	MARTIN VAN CRUIJSSEN	2018/12/06	12:29			Temperature (°C) on Receipt: 3/3/3; Custody Seal Present / Intact: Yes / No ✓

* 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 D

Non-Standard Special Provisions

WORKING SLAB - Item No.

Special Provision

1.0 SCOPE

This Special Provision covers the requirements for the supply and placement of a concrete working slab under structure foundations.

2.0 REFERENCES

This Special Provision refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 902 Excavating and Backfilling - Structures

3.0 DEFINITIONS - Not Used

4.0 DESIGN AND SUBMISSION REQUIREMENTS - Not Used

5.0 MATERIALS

Concrete for working slabs shall have a minimum 28 day strength of 20 MPa.

6.0 EQUIPMENT - Not Used

7.0 CONSTRUCTION

7.01 Excavation

Excavation for the working slab shall be according to OPSS 902.

7.02 Protection of Founding Soil

Following inspection and approval of the prepared subgrade, a working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade as specified in the Contract Documents.

7.03 Protection of Founding Bedrock

The surface of the footing founding rock shall be exposed, cleaned and any loose or fractured parts removed so that sound rock is exposed. The working slab shall be placed on the exposed cleaned sound founding rock surface as specified in the Contract Documents.

Thickness of the mass concrete pad shall depend on the slope and irregularities in the exposed founding rock surface. A nominal thickness and a footprint plan view area has been specified on the Contract Documents

7.04 Dewatering

Dewatering shall be carried out according to OPSS 902.

8.0 QUALITY ASSURANCE - Not Used

9.0 MEASUREMENT FOR PAYMENT - Not Used

10.0 BASIS OF PAYMENT

10.01 Working Slab - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment and Material to do the work.

DEWATERING – Item No.

Non-Standard Special Provision

SCOPE

The work under this item includes the design, installation, operation, maintenance and removal of temporary dewatering systems to facilitate the culvert extension.

Foundations for the temporary support system for culvert extension may require excavation below the groundwater level.

REFERENCES

OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation, as amended by SP517F01

OPSS 518 Construction Specification for Control of Water from Dewatering Operations

SUBMISSION AND DESIGN REQUIREMENTS

Written details for the proposed dewatering system shall be submitted to the Contract Administrator for information purposes a minimum of ten business days prior to commencing dewatering operations. The Contractor shall reference borehole logs included in the Contract Documents as a guide in determining requirements.

CONSTRUCTION

Dewatering System

The Contractor is responsible for the design, installation, operation and maintenance of an adequate dewatering system to lower the groundwater level to at least 0.3 m below the founding level for the culvert extension, to allow excavation, subgrade preparation and construction in dry conditions.

Operation

A continuous dewatering operation shall be provided to facilitate the installation of the culvert extension at all times during the work. All components of the dewatering system shall be maintained in an effective, functioning and stable condition at all times during the work. Notwithstanding the above, the work shall be completed in accordance with the environmental and operational constraints specified elsewhere in the contract.

Restoration

All equipment and materials placed shall be removed from the right-of-way upon the completion of the work and all areas disturbed as part of this work shall be restored to their preconstruction conditions, unless specified otherwise.

BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

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