Foundation Investigation 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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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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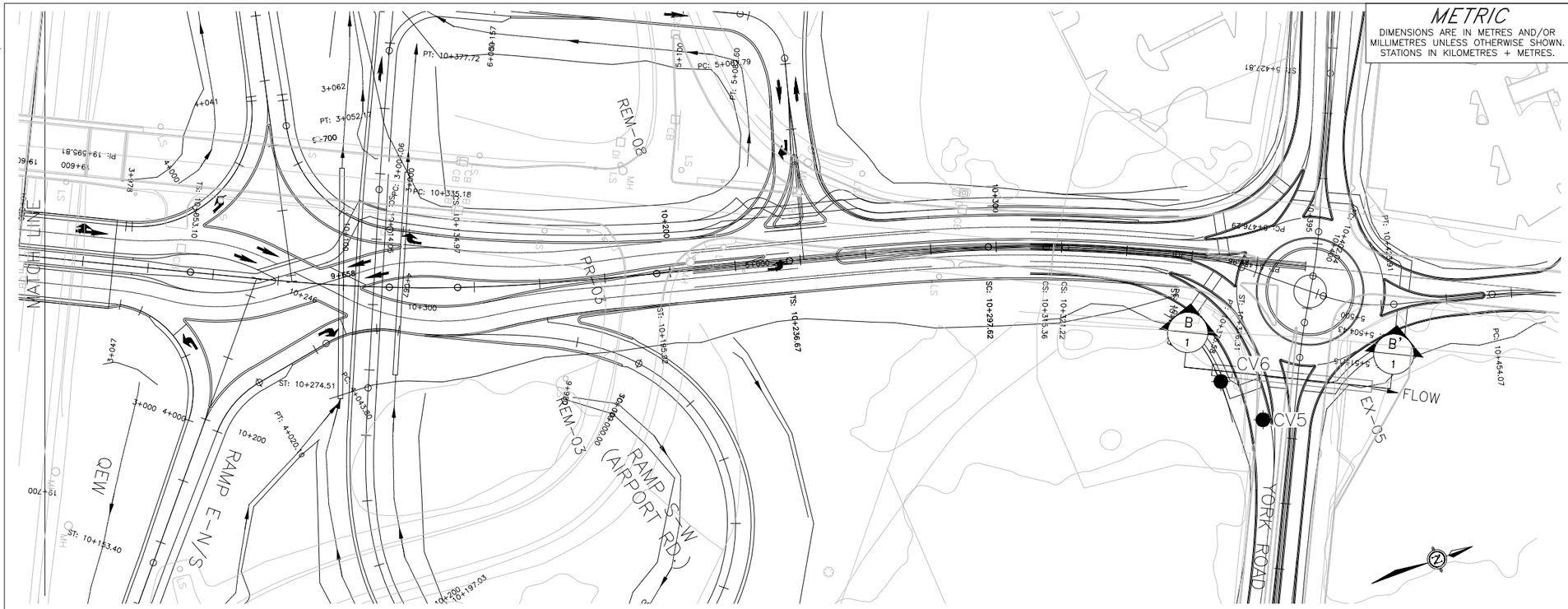
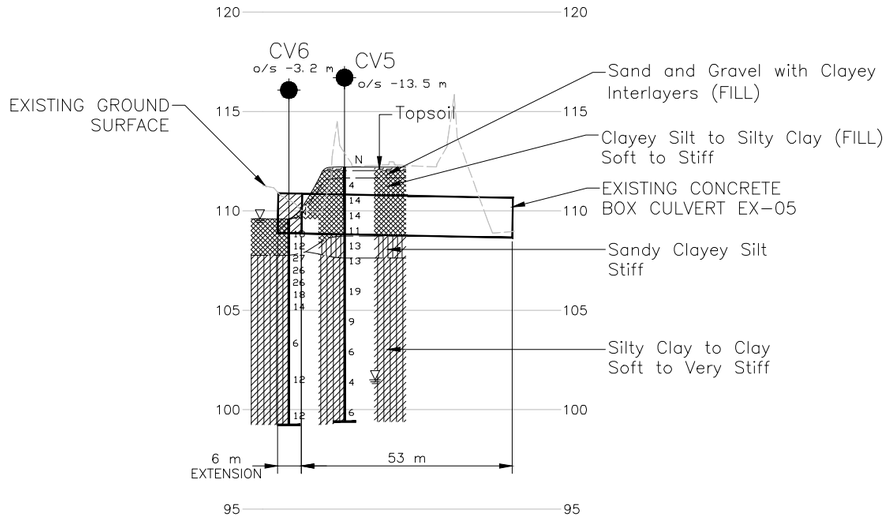
EN/MA/JMAC/en/rb

https://golderassociates.sharepoint.com/sites/15994g/6. deliverables/wo 002 - glendale interchange/foundations/3. culverts/3. fir\final/1671430 wo2 fnl03 2019april17 glendale ave culverts.docx

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN
SCALE
15 0 15 30 m



B-B' 1 CULVERT EX-05 PROFILE

VERTICAL SCALE
3 0 3 6 m

HORIZONTAL SCALE
15 0 15 30 m

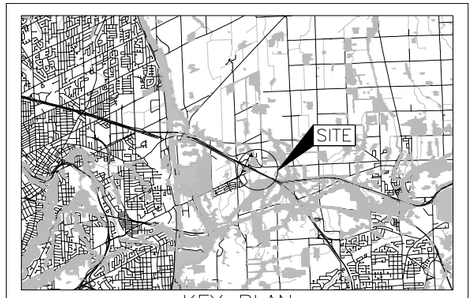
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2423-15-00

SHEET

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

GOLDER



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

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

PLOT DATE: April 17, 2019
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MINISTRY OF TRANSPORTATION, ONTARIO

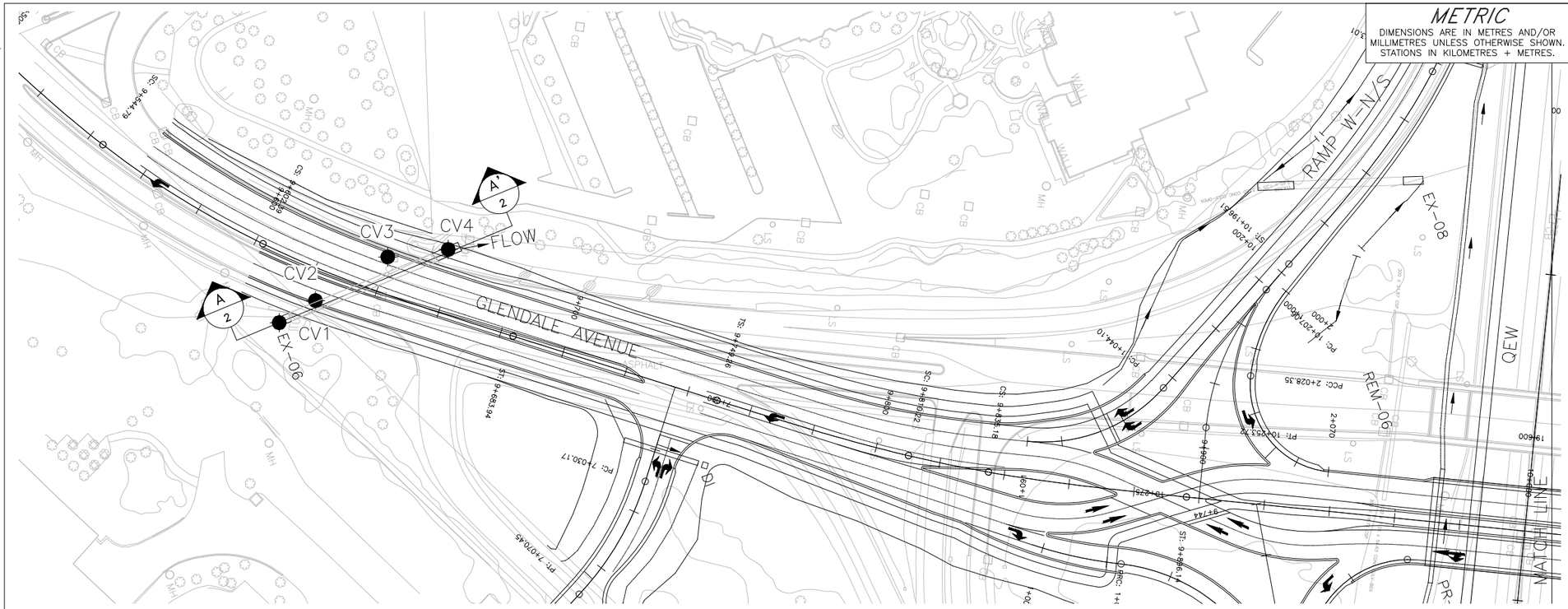
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2423-15-00

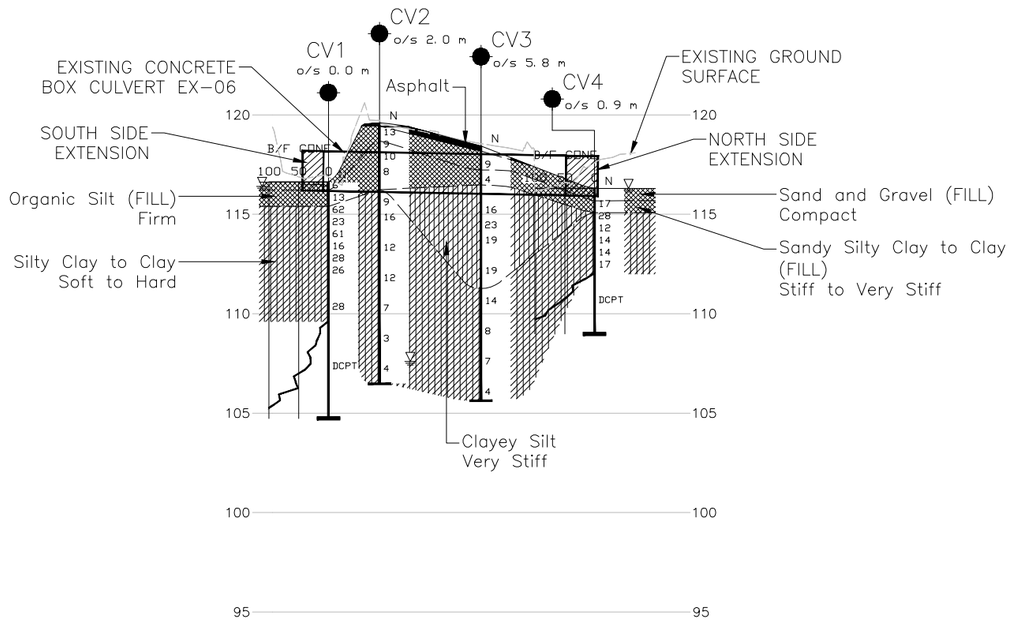
SHEET

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

GOLDER



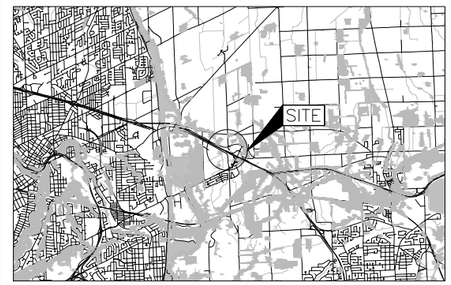
PLAN
SCALE
15 0 15 30 m



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.

NO.	DATE	BY	REVISION
.	.	.	.

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

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

PLOT DATE: April 17, 2019
FILENAME: S:\Clients\MTO\QEW-Glendale\99_PRO\1\1671430\40_PROD\0007_Culverts\1671430-0007-BE-0002.dwg

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (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

RECORD OF BOREHOLE No CV1

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4779405.5; E 331924.2 MTM NAD 83 ZONE 10 (LAT. 43.154018; LONG. -79.166491)
BOREHOLE TYPE Hilti PD 250E Portable Drill Rig, 63.5 mm Casing Wash Boring
DATE November 12, 2018

ORIGINATED BY LK
COMPILED BY EN
CHECKED BY MA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
116.6	GROUND SURFACE					
0.0 / 116.2	Organic silt, some clay, trace sand, trace gravel, some roots/organic (FILL) Firm Grey-black Wet		1A / 1B	SS	6	▽
0.4 / 115.4	Sandy silty clay, trace gravel (FILL) Stiff Grey-brown Moist		2	SS	13	
1.2	CLAY, trace sand Very stiff to hard Brown to grey, black starting from at depth of 3.7 m to 4.1 m Moist		3	SS	62	
			4	SS	23	
			5	SS	61	
			6	SS	16	
			7	SS	28	
			8	SS	26	
			9	SS	28	
109.6						
7.0	Start of Dynamic Cone Penetration Test (DCPT)					
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.					

ELEVATION SCALE: 116, 115, 114, 113, 112, 111, 110, 109, 108, 107, 106, 105

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
135

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
43
52
53

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	1	21	39	39
	0	3	33	64
	0	2	35	63

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

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GOLDER

PROJECT 1671430 WO2

RECORD OF BOREHOLE No CV2

SHEET 1 OF 1

METRIC

G.W.P. 2423-15-00 LOCATION N 4779418.2; E 331921.7 MTM NAD 83 ZONE 10 (LAT. 43.154133; LONG. -79.166521) ORIGINATED BY KN

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

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
119.6	GROUND SURFACE										
0.0	ASPHALT (150 mm)										
	Sand and gravel (FILL) Compact Brown-red		1	SS	13		119				
118.7	Dry to moist										
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		118				
			4	SS	8		117	2.0 + >95.8 +			
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		116		56		0 2 33 65
			6	SS	16		115				
			7	SS	12		114		51		0 2 36 62
			8	SS	12		113				
	Silt seams at a depth between 9.1 m and 9.8 m below ground surface.		9	SS	7		112				
			10	SS	3	▽	111	>95.8 +			
			11	SS	4		110	2.0 + >95.8 +			
106.5							109		42		0 3 39 58
13.1	END OF BOREHOLE						108				
	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.						107	>95.8 +			

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

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GOLDER

RECORD OF BOREHOLE No CV3

SHEET 1 OF 1 **METRIC**

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

LOCATION N 4779443.5; E 331916.8 MTM NAD 83 ZONE 10 (LAT. 43.154361; LONG. -79.166580) ORIGINATED BY MA
BOREHOLE TYPE 178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig COMPILED BY KG
DATE September 28, 2018 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.4	GROUND SURFACE										
0.0	ASPHALT (250 mm)										
0.3	Sand and gravel, some silt, some clayey silt layers (FILL) Loose Brown Moist						118				
117.2			1	SS	9						
1.2	Clayey silt, trace sand, trace gravel, trace topsoil (FILL) Firm to stiff Brown Moist						117				
116.4			2	SS	4						
2.0	CLAYEY SILT, trace to some sand, contains some silt seams and partings Very stiff Brown Moist						116	>143.6	2.0		
			3	SS	16		115				
			4	SS	23						0 5 62 33
			5	SS	19		114				
			6	SS	19		113				
111.2							112				
7.2	SILTY CLAY, trace sand, some silt seams and partings Soft to stiff Brown to grey below 11.6 m Moist		7	SS	14		111		49		0 4 37 59
			8	SS	8		110				
			9	SS	7		109	>143.6	50		0 3 36 61
			10	SS	4		108				
105.6							107	>143.6			
12.8	END OF BOREHOLE						106				

NOTES:

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

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

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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	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.3	GROUND SURFACE										
0.0 / 115.7	Crushed gravel, some clay pockets (FILL) Black										
0.6 / 115.1	Silty clay, trace sand, trace organic (FILL) Very stiff Brown-grey Moist		1	SS	17						
1.2	SILTY CLAY to CLAY, trace sand Stiff to very stiff Brown to brown grey Moist		2	SS	28				52		0 3 35 62
			3	SS	12						
			4	SS	14						
			5	SS	14						
112.0			6	SS	17				50		0 2 35 63
4.3	Start of Dynamic Cone Penetration Test (DCPT)							138			
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.

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

GOLDER

RECORD OF BOREHOLE No CV5

SHEET 1 OF 2 **METRIC**

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

LOCATION N 4780080.4; E 332294.2 MTM NAD 83 ZONE 10 (LAT. 43.160080; LONG. -79.161908)
BOREHOLE TYPE 178 mm O.D. Hollow Stem Augers; CME 75 Track Mounted Drill Rig
DATE September 18, 2018

ORIGINATED BY MA
COMPILED BY KG/EN
CHECKED BY

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
112.2	GROUND SURFACE				
0.0	Silty topsoil, some sand (FILL) Brown				
111.7	Clayey silt, some sand, trace gravel (FILL) Brown				
111.4	Sand and gravel, trace silt (FILL) Brown Moist	1	SS	4	
0.8	Clayey silt, trace sand, trace gravel, trace topsoil, trace wood fragments, trace rootlets (FILL) Soft to stiff Brown to black Moist	2	SS	14	
		3	SS	14	
108.7		4	SS	11	
3.5	Sandy CLAYEY SILT, trace rootlets, silty sand seams at 3.8 m bgs Stiff Brown Moist	5	SS	13	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	0 4 36 60
		7	SS	19	
		8	SS	9	
		9	SS	6	1 3 33 63
		10	SS	4	
		11	SS	6	
99.4					
12.8	END OF BOREHOLE				

GROUND WATER CONDITIONS: ▽

ELEVATION SCALE: 112, 111, 110, 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

>143.6
2.0
2.0
54
48

Continued Next Page

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

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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 ○ 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.										

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

GOLDER

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) ORIGINATED BY SE
BOREHOLE TYPE Hilti PD 250E Portable Drill Rig, 63.5 mm Casing Wash Boring COMPILED BY EN
DATE November 27, 28, 2018 CHECKED BY MA

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.6	GROUND SURFACE							20 40 60 80 100	10 20 30		
0.0	Silty clay, trace to some sand, trace to some gravel, some organics to 0.6 m (FILL) Stiff Brown Moist		1	SS	10		109		40		7 11 40 42
			2	SS	12		108				
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		3	SS	27		107		55		0 2 34 64
			4	SS	26						
	- No recovery in samples 4 and 6.		5	SS	26		106				
			6	SS	18						
			7	SS	14		105				
							104				
			8	SS	6				50		1 2 31 66
							103	3.0 2.0			
							102				
			9	SS	12						
							101				
							100				
99.2			10	SS	12						
10.4	END OF BOREHOLE										

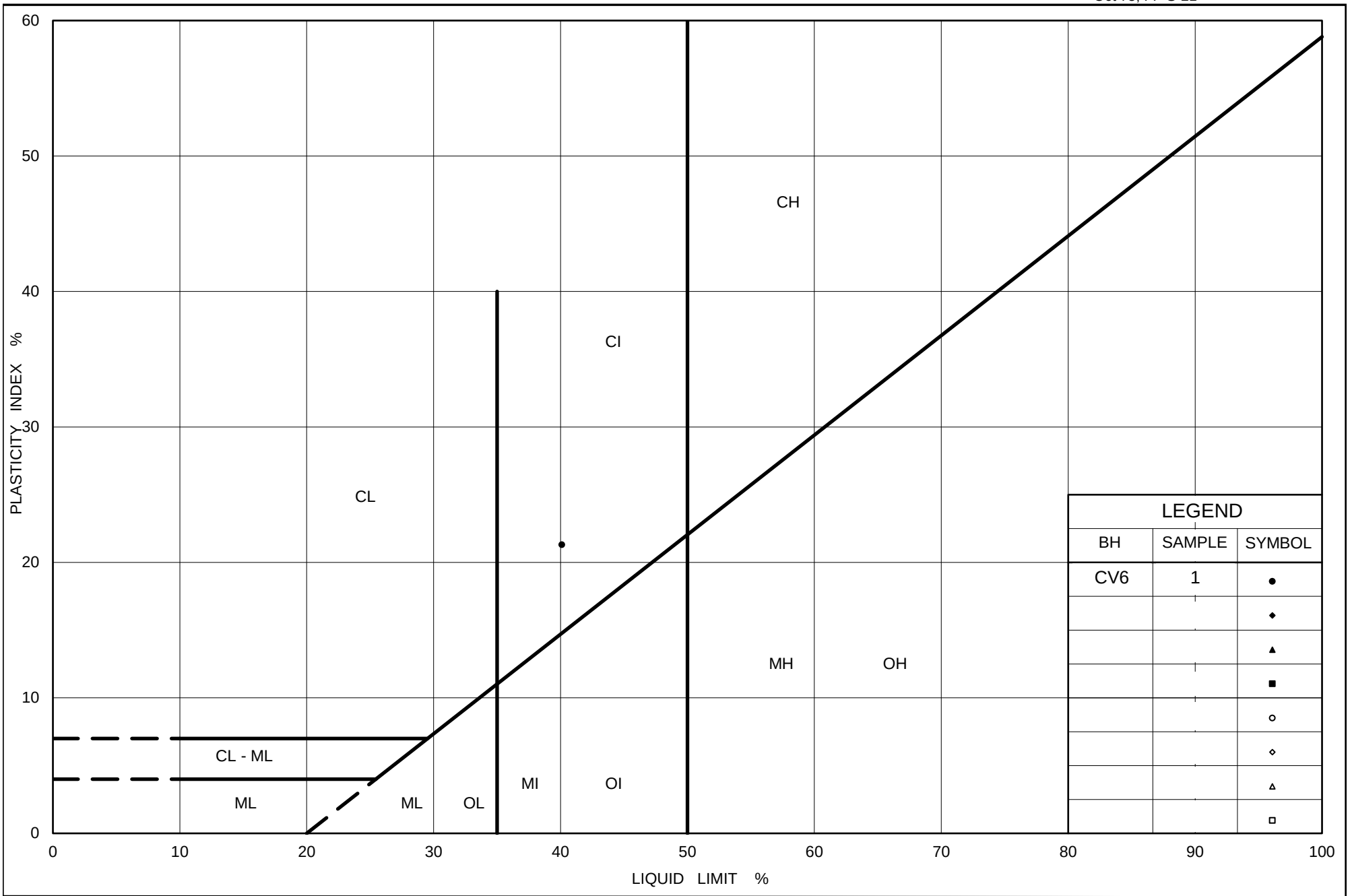
NOTE:

1. Water level in open borehole at ground surface (Elev. 109.6 m) on completion of drilling.

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

APPENDIX B

Geotechnical Laboratory Test Results



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay (Fill)

(Culvert EX-05)

Figure No. B-1

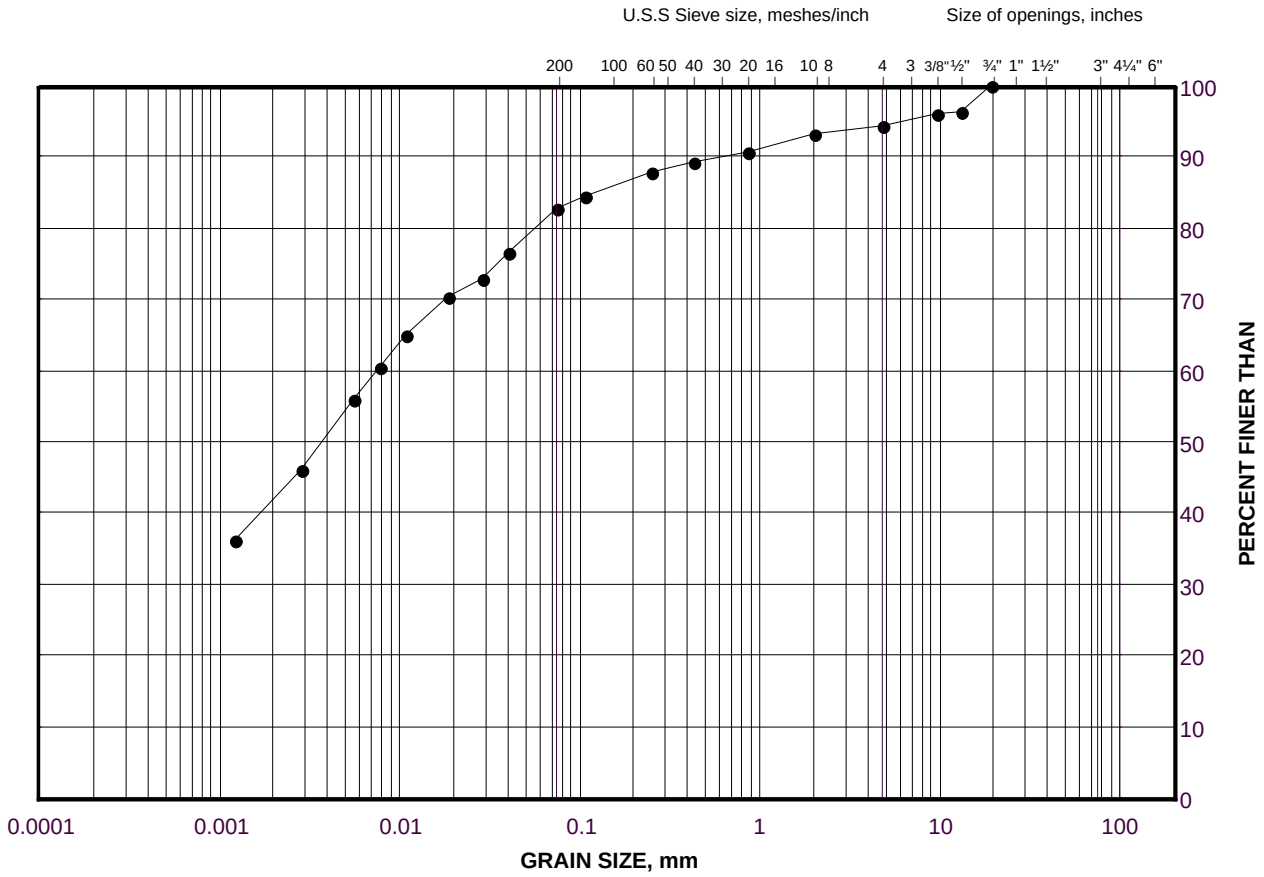
Project No. 1671430 (WO 002)

Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay (Fill)
(Culvert EX-05)

FIGURE B-2



LEGEND

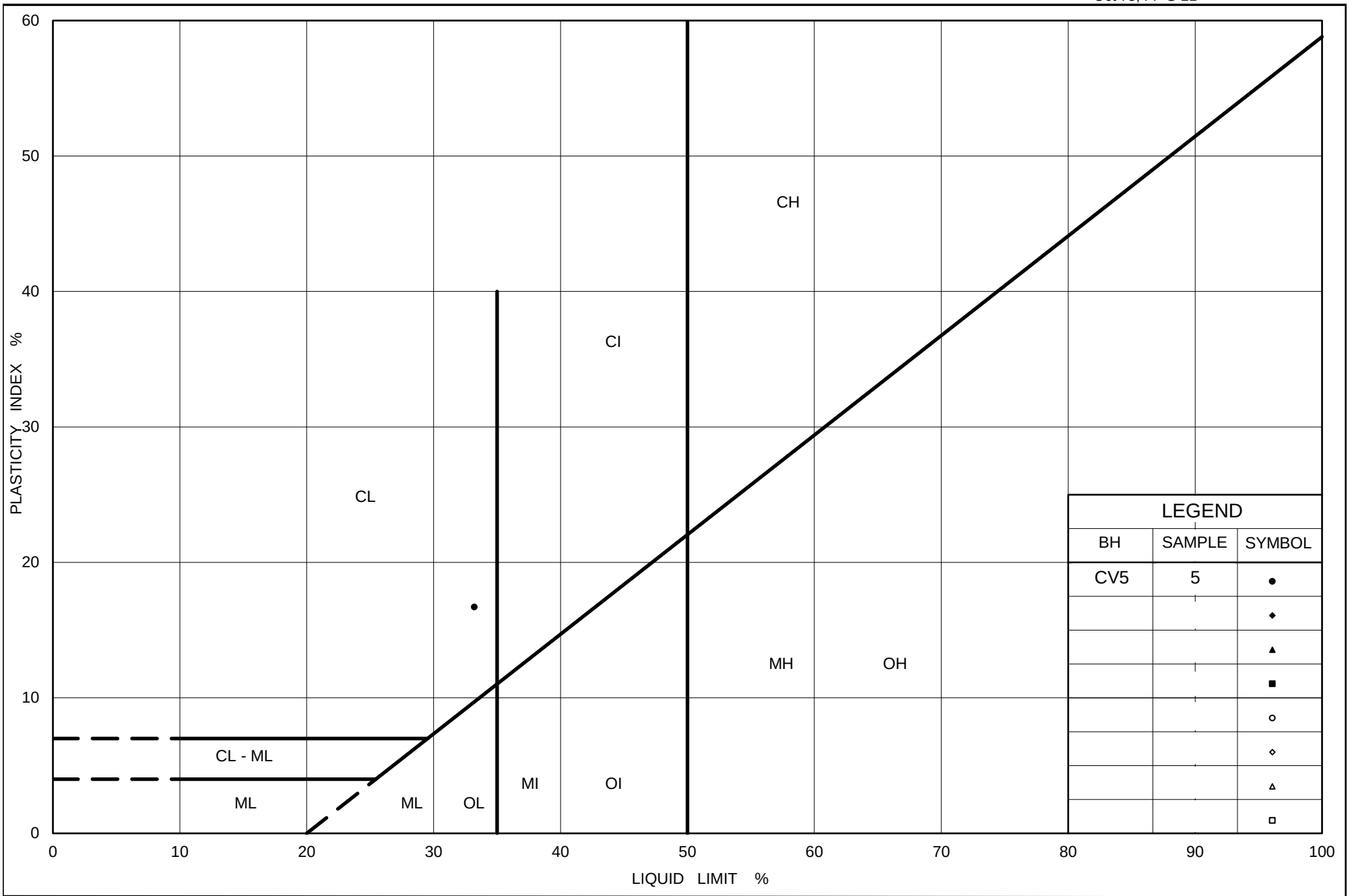
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV6	1	108.7

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

(Culvert EX-05)

Figure No. B-3

Project No. 1671430 (WO 002)

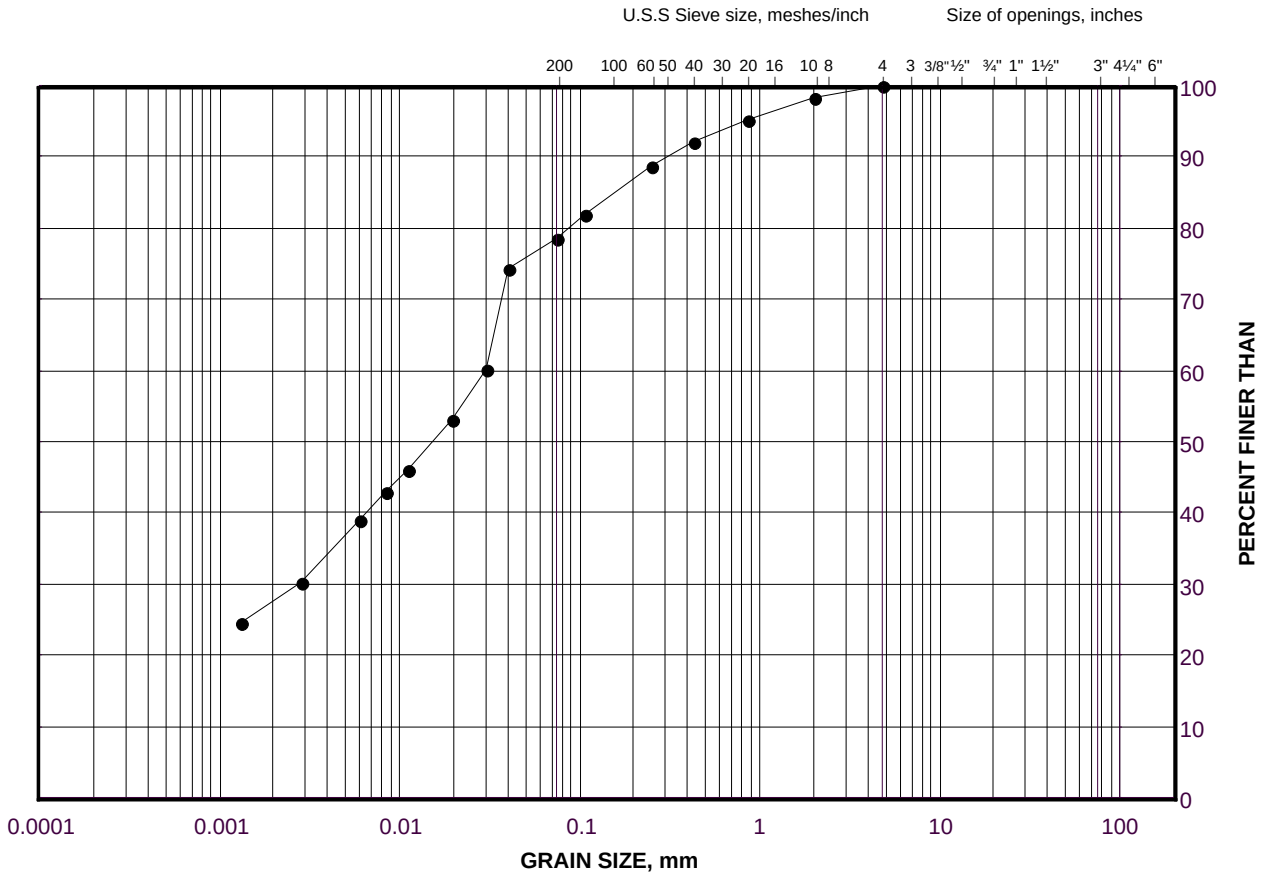
Checked By: MA

GRAIN SIZE DISTRIBUTION

Clayey Silt

(Culvert EX-05)

FIGURE B-4



LEGEND

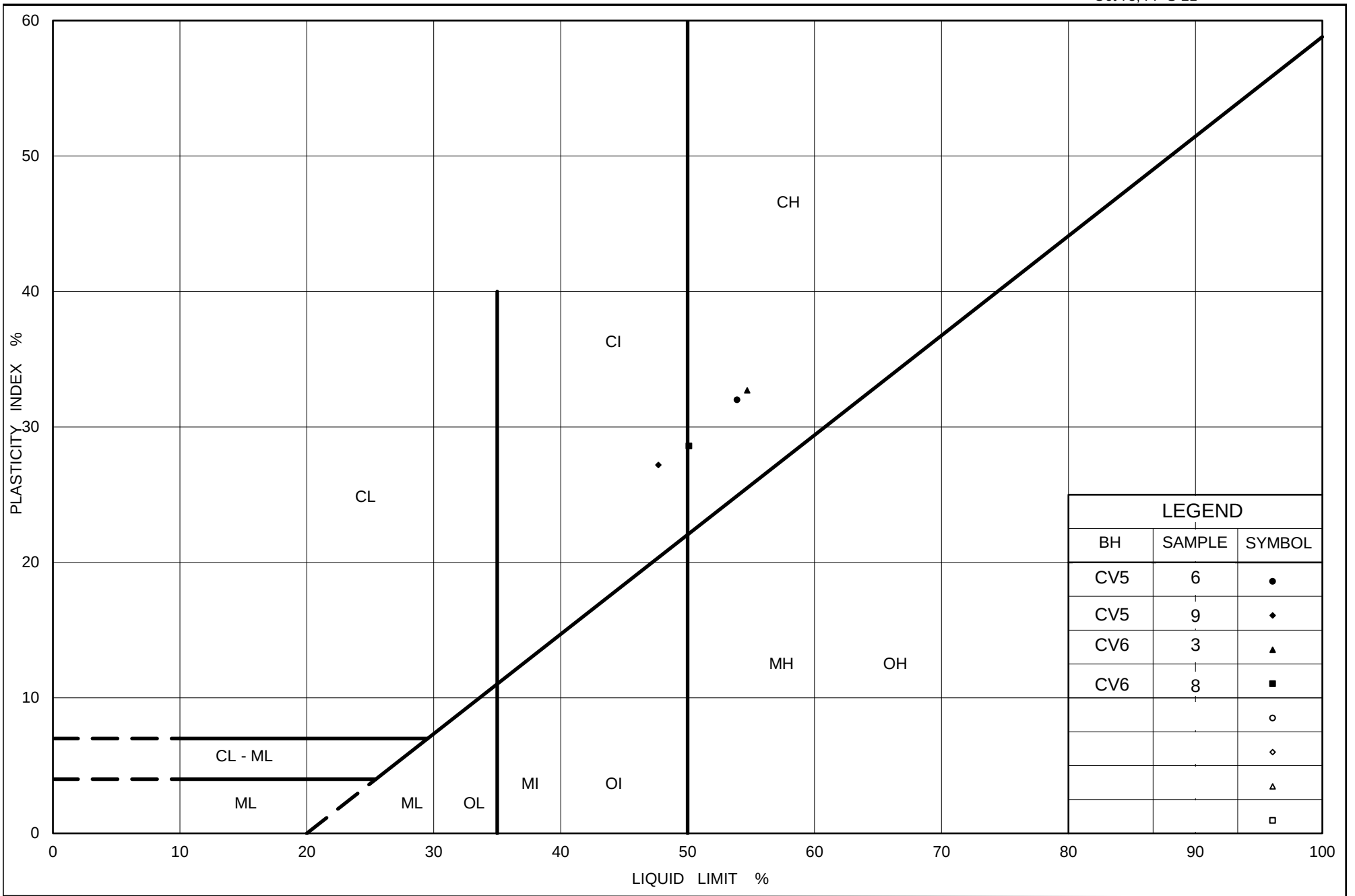
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV5	5	108.1

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)

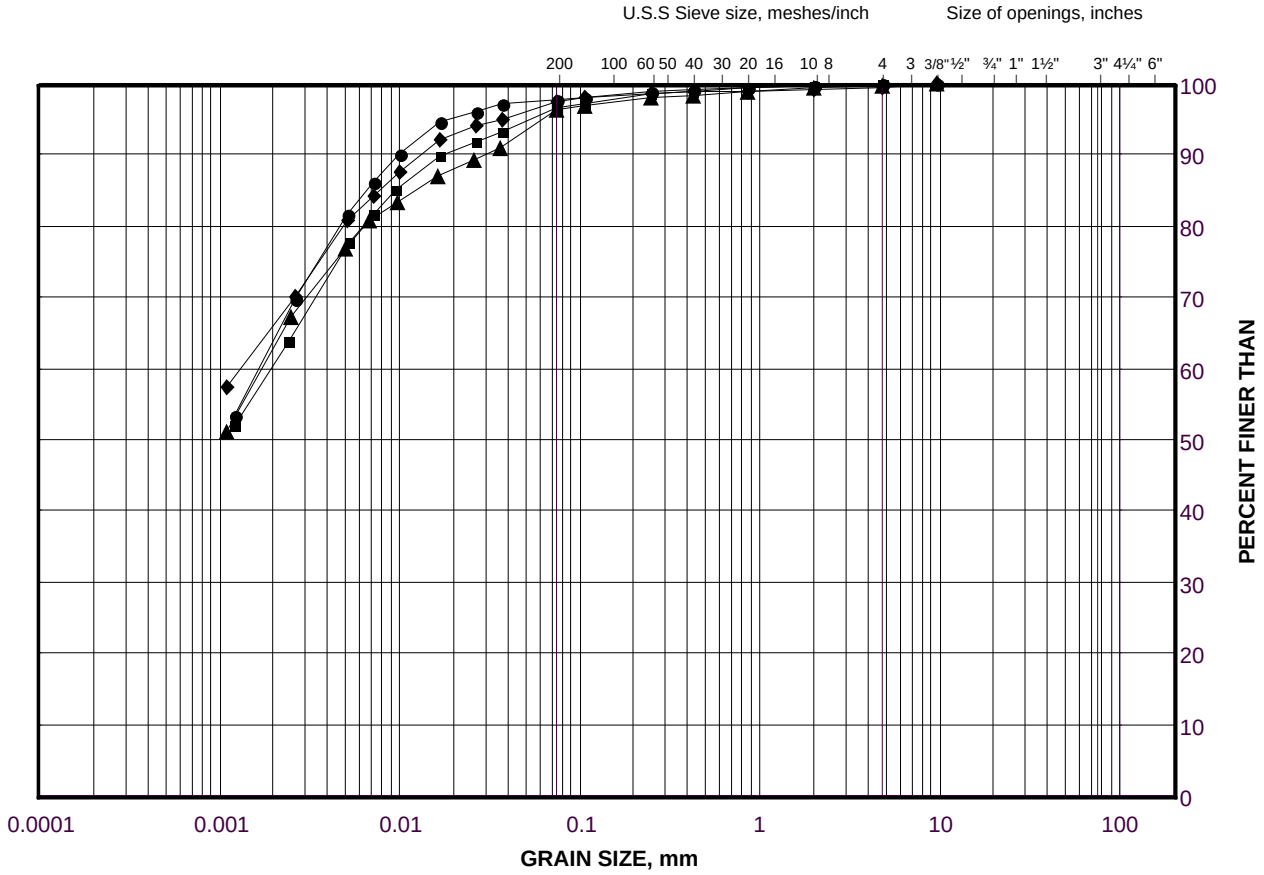
Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

(Culvert EX-05)

FIGURE B-6



LEGEND

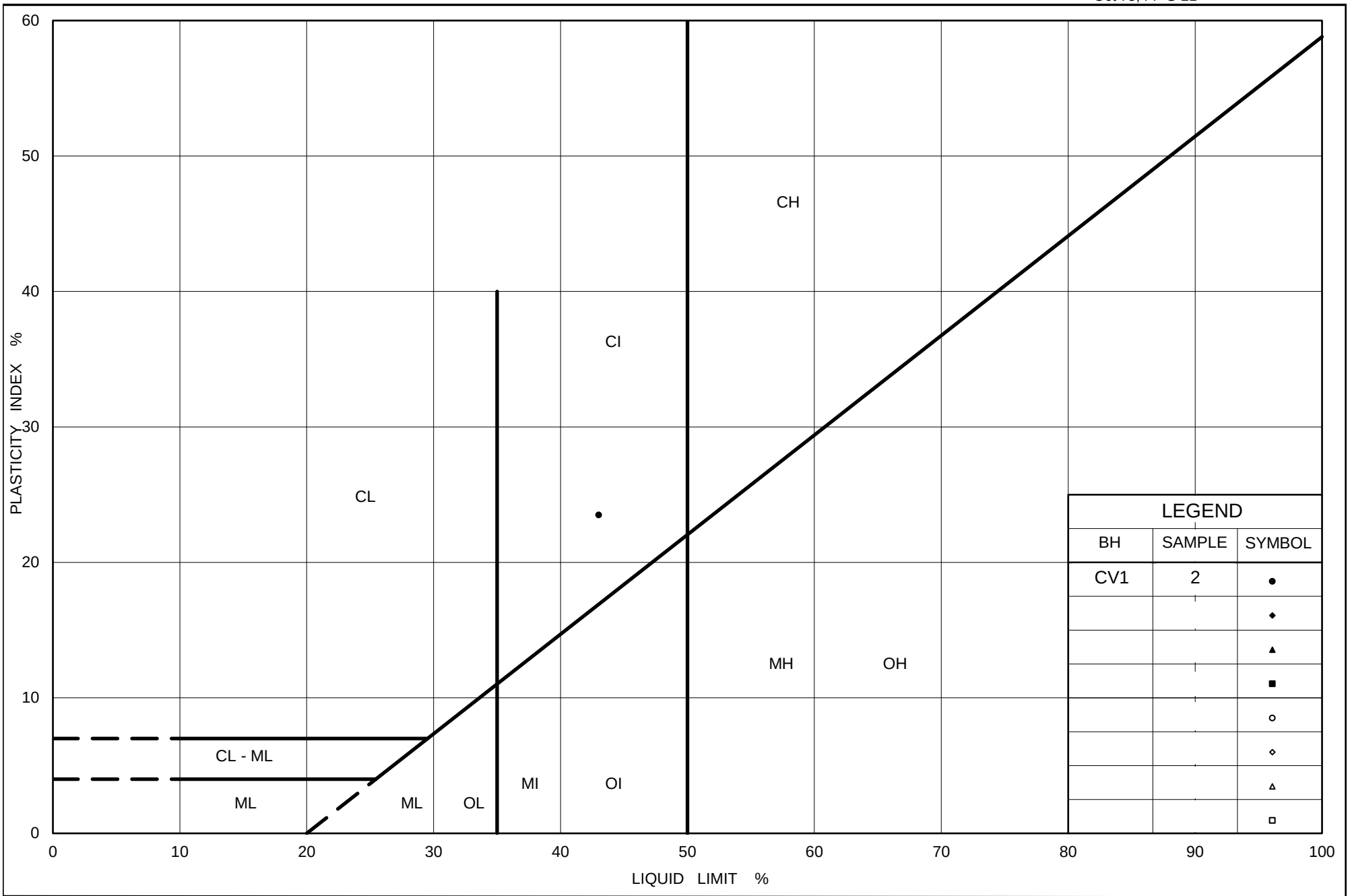
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV6	3	107.5
■	CV5	6	107.3
◆	CV6	8	103.2
▲	CV5	9	102.8

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay (Fill)

(Culvert EX-06)

Figure No. B-7

Project No. 1671430 (WO 002)

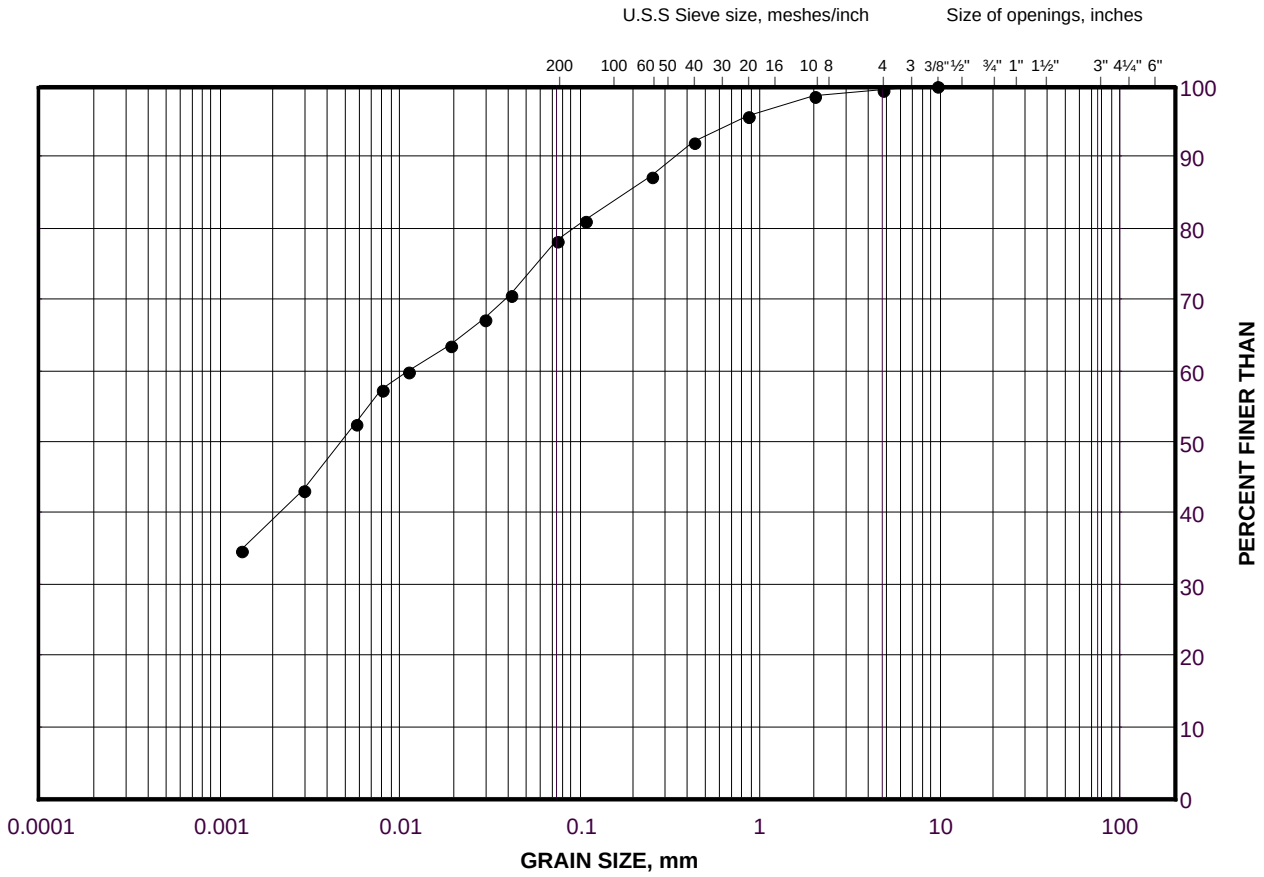
Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay (Fill)

(Culvert EX-06)

FIGURE B-8



LEGEND

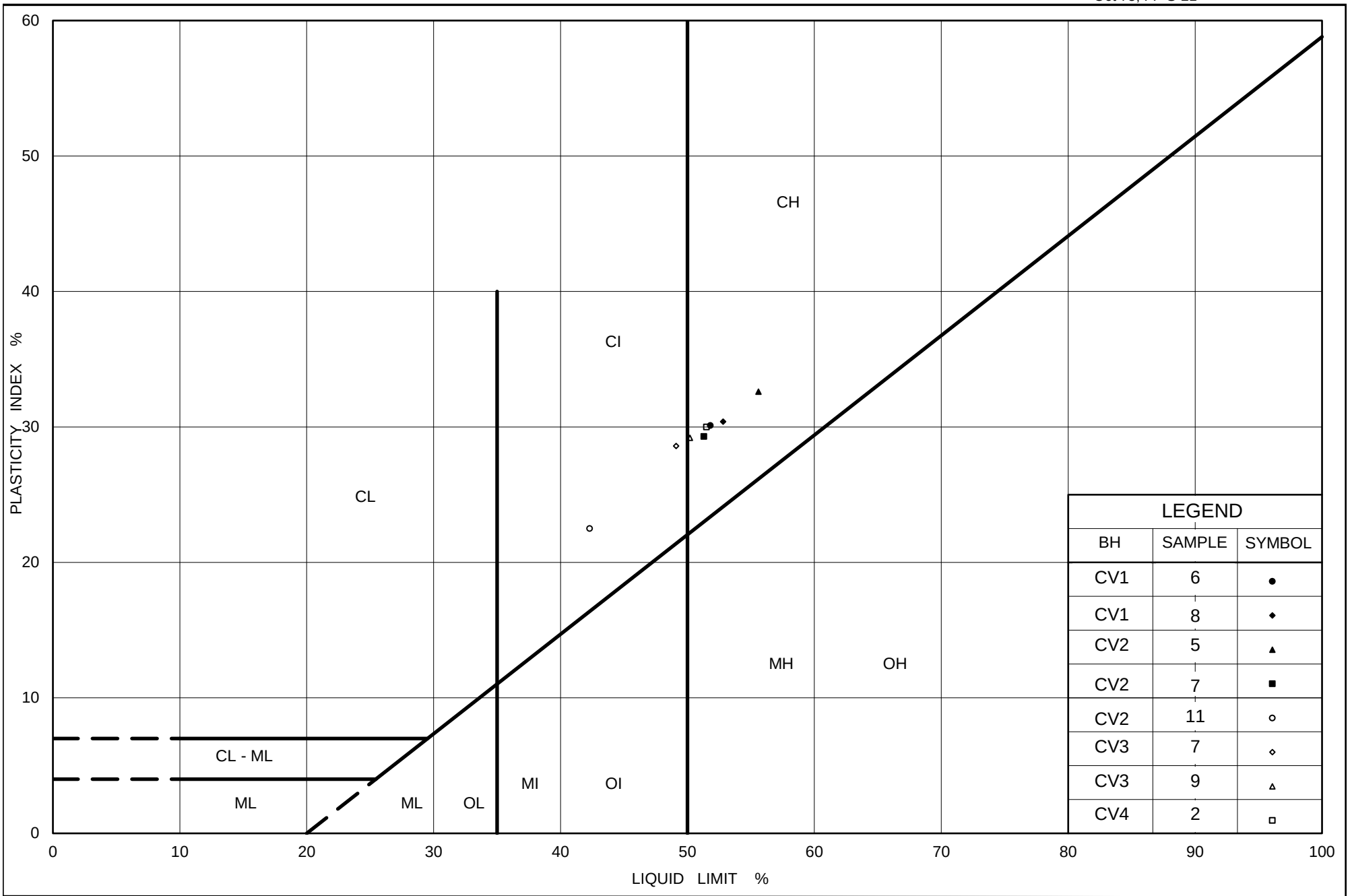
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV1	2	115.7

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19



Ministry of Transportation

Ontario

PLASTICITY CHART

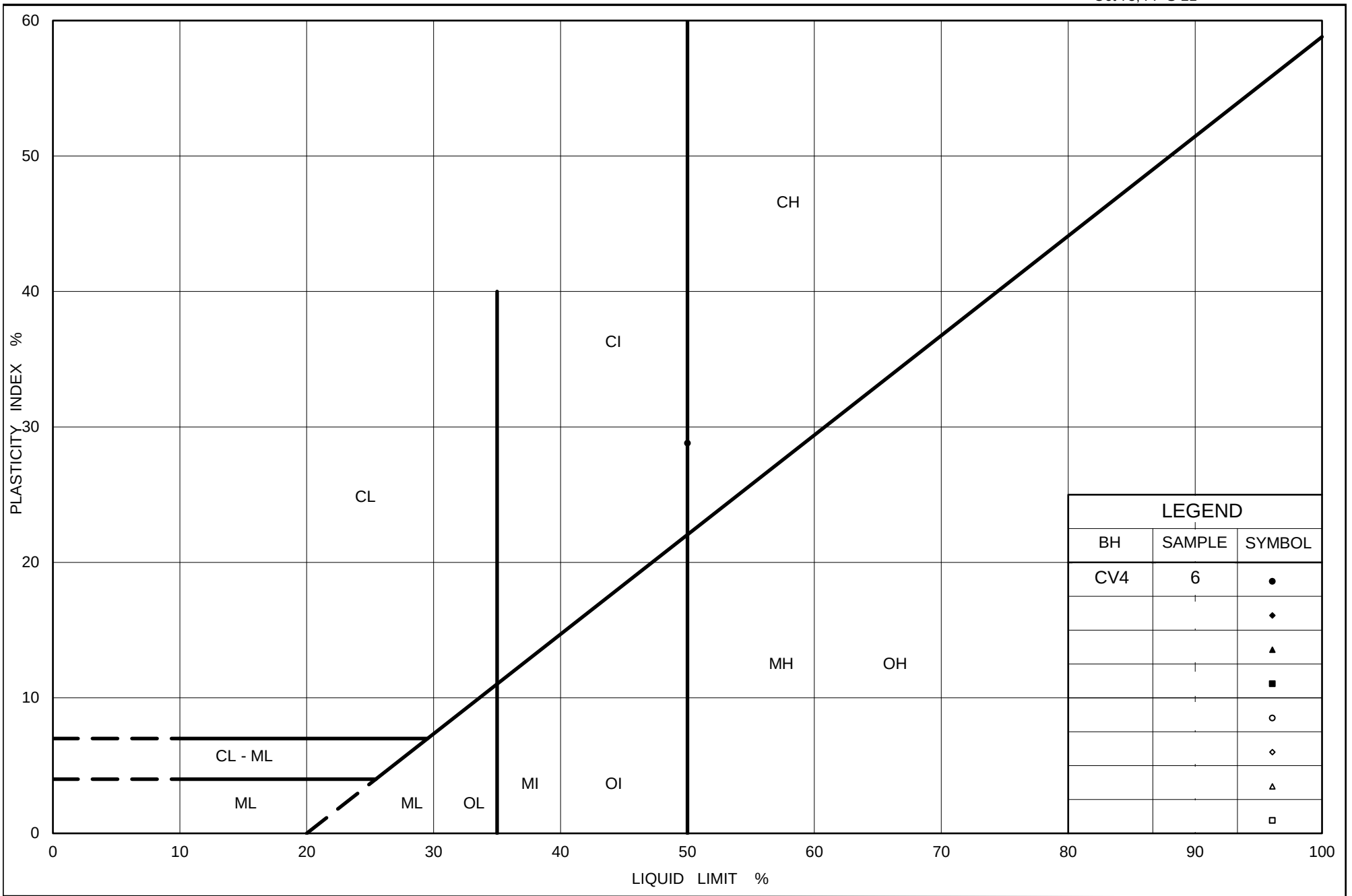
Silty Clay to Clay

(Culvert EX-06)

Figure No. B-9A

Project No. 1671430 (WO 002)

Checked By: MA



Ministry of Transportation

Ontario

PLASTICITY CHART

Silty Clay

(Culvert EX-06)

Figure No. B-9B

Project No. 1671430 (WO 002)

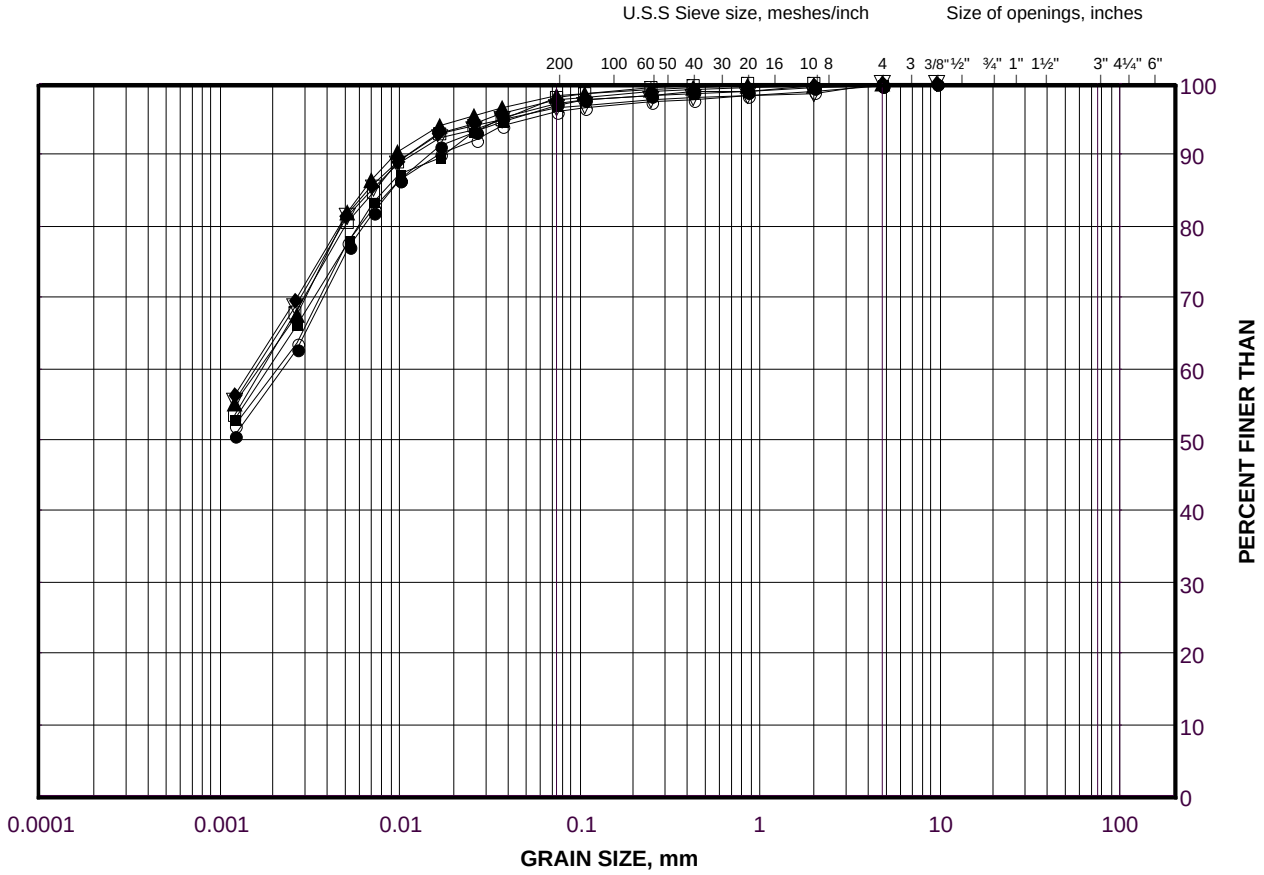
Checked By: MA

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

(Culvert EX-06)

FIGURE B-10A



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

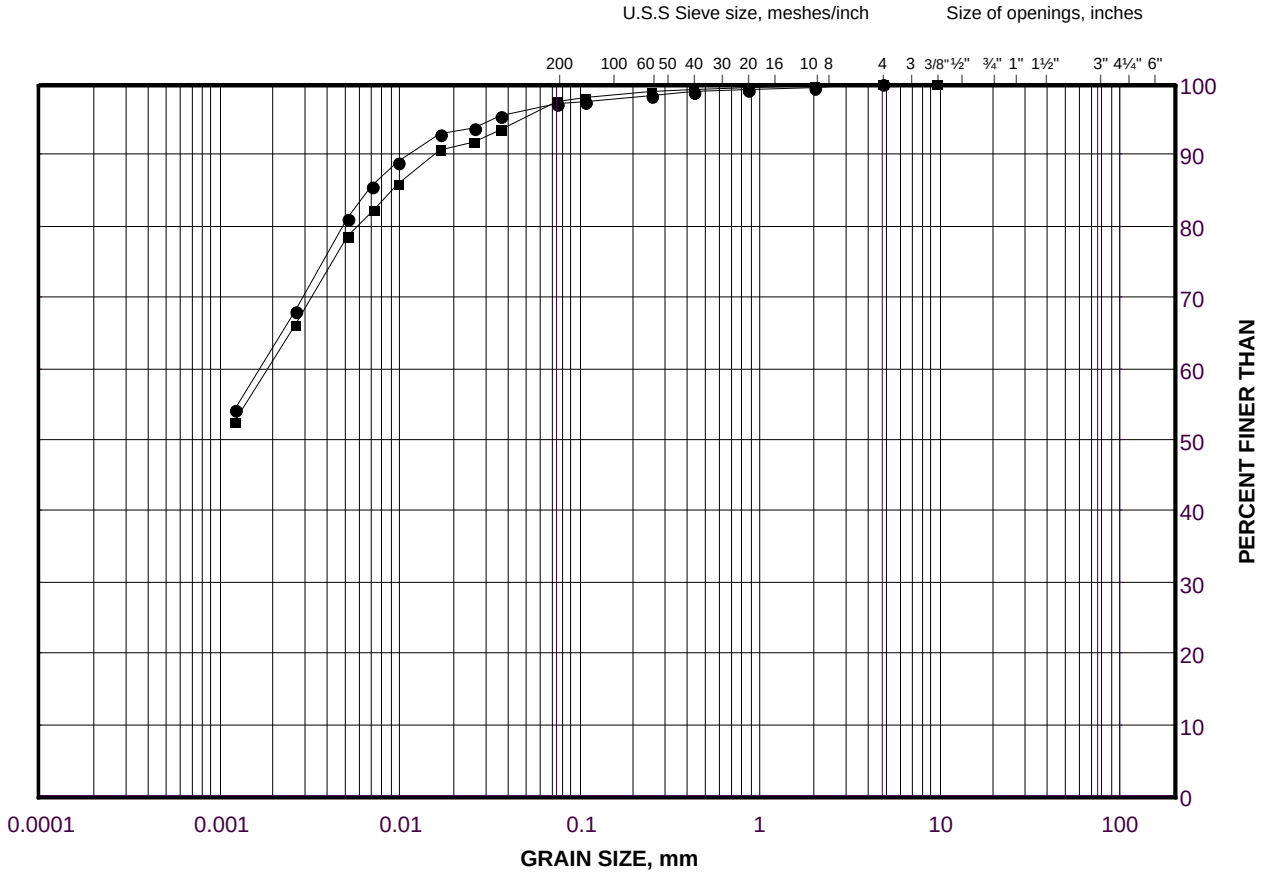
Date: 19-Mar-19

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

(Culvert EX-06)

FIGURE B-10B



LEGEND

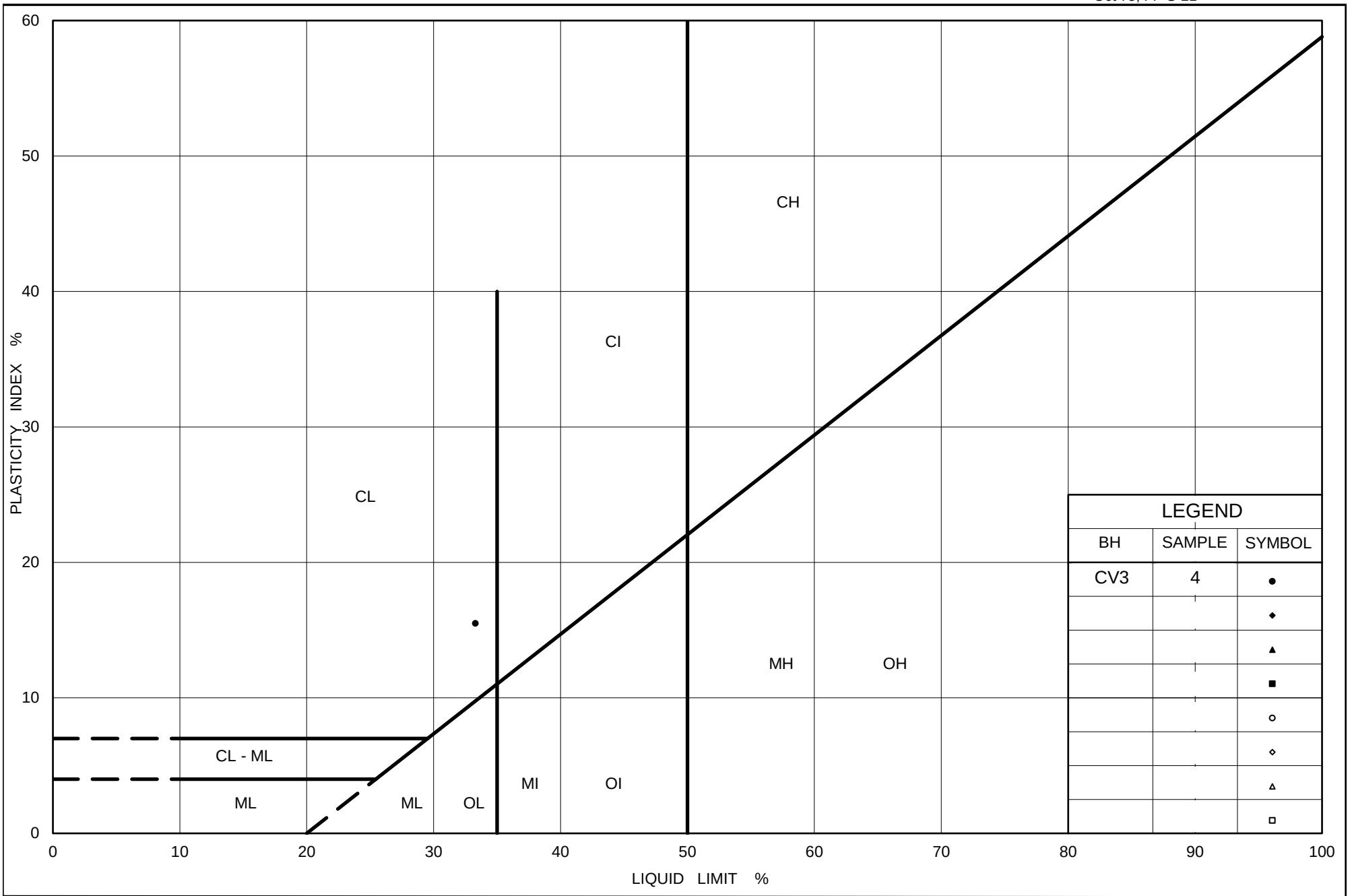
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CV1	8	112.0
■	CV3	9	107.4

Project Number: 1671430

Checked By: MA

Golder Associates

Date: 19-Mar-19



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

(Culvert EX-06)

Figure No. B-11

Project No. 1671430 (WO 002)

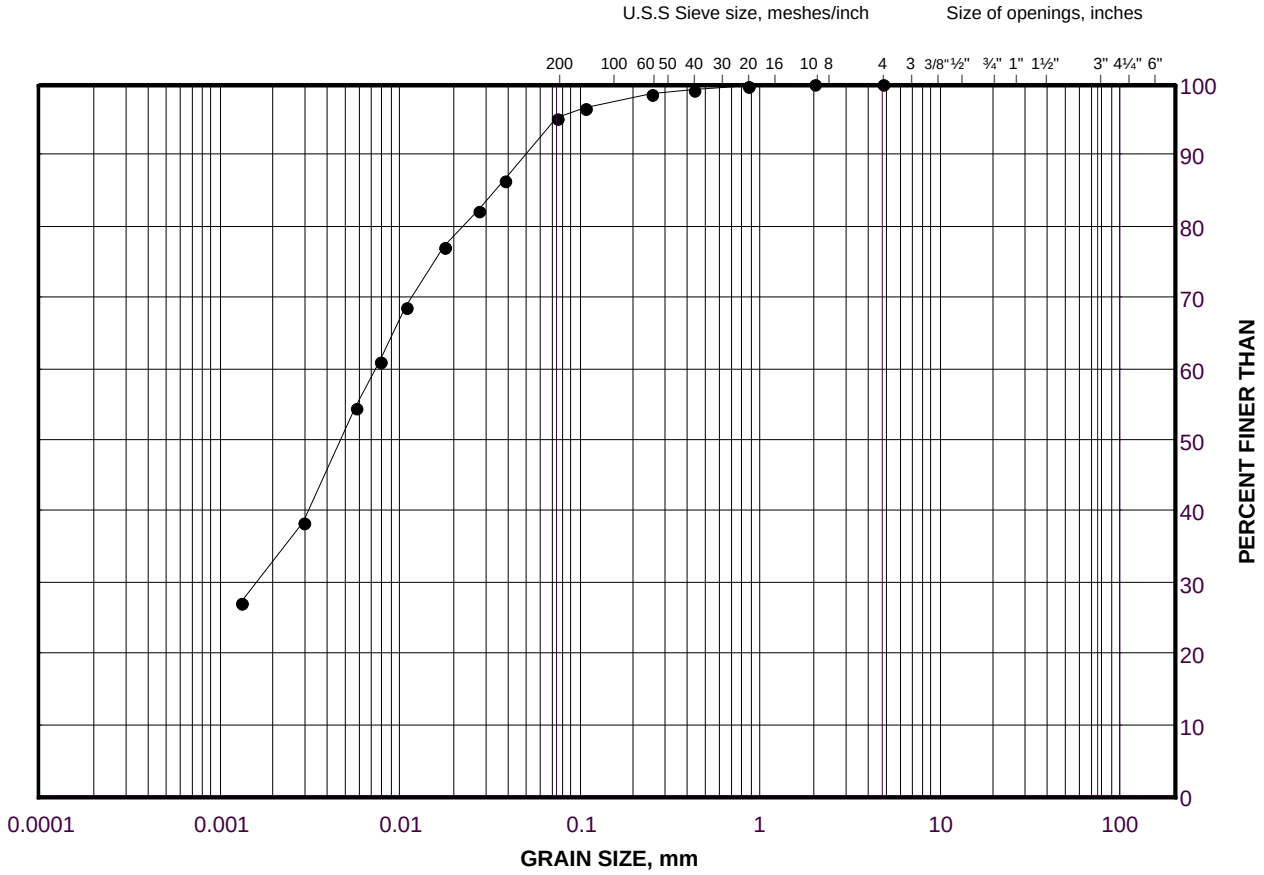
Checked By: MA

GRAIN SIZE DISTRIBUTION

Clayey Silt

(Culvert EX-06)

FIGURE B-12



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

Maxxam
A Bureau Veritas Group Company

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.

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

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

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.

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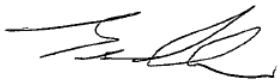
Maxxam Job #: B8W6769
Report Date: 2018/12/12

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

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

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CHAIN OF CUSTODY RECORD

IMMEDIATE

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	~~B80883~~	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	Nikol Kachmanová	P.O. #:			674002
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	~~08-1111-0039/3447~~ 1671430 W02	COC #:	Project Manager:
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	905 567 6100 x2134 Fax:	Project Name:	REM - Glendale	C#674002-03-01	Ema Gitej
Email:	AP_CustomerService@golder.com	Email:	nikol_kachmanova@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)	Other Regulations	Special Instructions
☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___	☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☐ PWQO ☐ Other ___	

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

Turnaround Time (TAT) Required:

Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___ ☐
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	ANALYSIS REQUESTED (PLEASE BE SPECIFIC): 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)							# of Bottles	Comments
1		CV2 SA3	Sept.18'18	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																	
7																	
8																	
9																	
10																	

06-Dec-18 12:29
Ema Gitej
B8W6769
URE ENV-1116

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
Eric Naylor	18/12/06	12:15	KVL — MATTHEW VAN CRUYNINGEN	2018/12/06	12:29	

Laboratory Use Only				
Time Sensitive	Temperature (°C) on Recei 8/3/5	Custody Seal Present	Yes	No ✓
		Intact		

* 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: Maxxa Yellow: Client

Maxxam Analytics International Corporation o/a Maxxam Analytics

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