



January 10, 2018

FOUNDATION INVESTIGATION REPORT

**QEW-DIXIE ROAD UNDERPASS REPLACEMENT
STRUCTURE SITE No. 24-193,
QEW WIDENING FROM EAST OF CAWTHRA ROAD
TO THE EAST MALL,
CITIES OF MISSISSAUGA AND ETOBICOKE
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 2102-13-00 & 2432-13-00**

Submitted to:

AECOM
30 Leek Crescent
Richmond Hill, ON
L4B 4N4

REPORT

GEOCRES NO.: 30M11-272

Report Number: 1530382-1

Distribution:

1 PDF & 3 Copies	Ministry of Transportation, Ontario (Central Region)
1 PDF & 1 Copy	Ministry of Transportation, Ontario (Foundations Section)
1 PDF	AECOM
1 PDF	Golder Associates Ltd.



Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	1
3.1 Previous Investigation.....	1
3.2 Current Investigation.....	2
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	4
4.1 Regional Geology	4
4.2 Subsurface Conditions.....	4
4.2.1 Asphalt.....	4
4.2.2 Topsoil	5
4.2.3 Fill	5
4.2.4 Silt to Silty Sand to Sand to Sand and Gravel.....	5
4.2.5 Gravelly Silty Sand Till	5
4.2.6 Clayey Silt (Residual Soil).....	6
4.2.7 Shale Bedrock.....	6
4.2.8 Groundwater Conditions	7
4.2.9 Analytical Testing Results.....	8
5.0 CLOSURE	9

REFERENCES

DRAWINGS

Drawing 1	QEW-Dixie Road Underpass, Borehole Locations and Soil Strata
Drawing 2	QEW-Dixie Road Underpass, Soil Strata

FIGURES

Figure 1	QEW-Dixie Road Underpass, Approach Embankment Static Global Stability Analysis
----------	--------------------------------------------------------------------------------

APPENDICES

Appendix A	Borehole Records and Laboratory Test Results – Previous Investigation (GEOCRES 30M11-251)
-------------------	--------------------------------------------------------------------------------------------------

Boreholes DR 14-01 and DR 14-02 (from Thurber Engineering Ltd. Report No. 19-1351-219, dated July 13, 2015)



Appendix B Borehole and Drillhole Records – Current Investigation

Lists of Symbols and Abbreviations

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes NW6-1, NW6-2, NW4-3, HF-2, HF-3, DO-1, DO-2, DO-3, DO-4, DO-5, DO-6

Records of Drillholes DO-2, DO-3

**Appendix C Laboratory Test Results, Bedrock Core Photographs and Chemical Test Results –
Current Investigation**

Figure C1A and C1B Grain Size Distribution Test Results – Silty Sand to Sand to Gravelly Sand

Figure C2 Grain Size Distribution Test Results – Gravelly Silty Sand (Till)

Figure C3 Plasticity Chart – Gravelly Silty Sand (Till)

Figure C4 Plasticity Chart – Clayey Silt (Residual Soil)

Figure C5 Bedrock Core Photograph – DO-3

Rock Laboratory Testing Results Reports dated July 18, 2016 and September 15, 2016 – Geomechanica Inc.

Certificates of Analysis – Chemical Test Results



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 proposed realignment and replacement of the Queen Elizabeth Way (QEW) underpass at Dixie Road in the City of Mississauga, Regional Municipality of Peel.

The purpose of this investigation is to establish the subsurface soil and bedrock conditions at the proposed structure location, including the associated high fill and approach embankments, by borehole drilling, rock coring and laboratory testing on selected soil and rock core samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated January 2016, which forms part of the Consultant's Assignment Number (Number 2015-E-0001) for this project. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated June 6, 2016.

2.0 SITE DESCRIPTION

The existing QEW-Dixie Road underpass is located approximately 1.9 km east of the QEW-Cawthra Road interchange and 2.5 km west of the Highway 427-QEW interchange in the City of Mississauga. The QEW alignment in the project area is oriented generally in a southwest-northeast direction; for the purposes of this report, the QEW is described as being in an east – west orientation.

The existing underpass was constructed in 1953 and is approximately 62 m long by 18 m wide; is a three-span bridge with abutments and piers supported on spread footings founded at about Elevation 104.7 m. The existing approach embankments are about 5 m high relative to the surrounding grade. The natural ground surface in the vicinity of the underpass is at about Elevation 107 m; the QEW and Dixie Road in the vicinity of the underpass are at about Elevation 106 m and 112 m, respectively.

Land use in the northeast, northwest and southeast quadrants is primarily residential, and a large commercial development is located in the southwest quadrant.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

In August 2014, a preliminary foundation investigation for the QEW / Dixie Road bridge structure replacement, was carried out at the site by Thurber Engineering Ltd. (Thurber) during which time a total of two boreholes, designated as Boreholes DR 14-01 and DR 14-02, were advanced. The results of the Thurber investigation are contained in their report titled "Preliminary Foundation Investigation and Design Report, QEW/Dixie Road Interchange Structure, Mississauga, Ontario", Report No. 19-1351-219, dated July 13, 2015 (GEOCRE 30M11-251).

The locations of the boreholes advanced by Thurber are shown on Drawing 1, and the borehole records including a summary of the laboratory testing results from this investigation are presented in Appendix A.



3.2 Current Investigation

The field work for the current foundation investigation was carried out in September and October 2016 and June 2017, during which time a total of eleven sampled boreholes (designated as Boreholes NW6-1, NW6-2, NW4-3, HF-2, HF-3 and DO-1 to DO-6) were advanced near the location of the structure foundation footprints and high fill approach embankments as follows:

Foundation Element	Nearest Boreholes
North High Fill / Approach Embankment	NW4-3, HF-3, DO-1
North Abutment	DO-2
Center Pier	DO-3, DO-4
South Abutment	DO-6
South High Fill / Approach Embankment	NW6-2, DO-5, NW6-1, HF-2

The location of the boreholes are shown on Drawing 1 and the borehole and drillhole records are included in Appendix B.

The field borehole investigation was carried out using a truck-mounted CME 75 drill rig, supplied and operated by Davis Drilling of Milton, Ontario. The boreholes were advanced through the overburden using 150 mm or 108 mm outside diameter solid stem augers and NW casing. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-08)¹.

The boreholes were typically advanced to auger and/or sampler refusal (i.e. inferred bedrock), at depths ranging from about 2.9 m to 9.8 m below existing ground surface. Samples of the bedrock were obtained using an 'NQ'-size rock core barrel and coring techniques in Boreholes DO-2 and DO-3. Photographs of the recovered bedrock core samples are provided in Appendix C.

The groundwater conditions and water levels in the open boreholes were observed during the drilling operations. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples. Uniaxial unconfined compression strength (UCS) tests, Young's modulus and Poisson's ratio tests and core density determinations were carried out on selected specimens of the bedrock core samples by Geomechanics Inc., on behalf of Golder. The results of the geotechnical laboratory testing for the current investigation are included in Appendix C.

¹ ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the soil.



**FOUNDATION REPORT – QEW-DIXIE ROAD UNDERPASS REPLACEMENT,
GWP 2102-13-00 & 2432-13-00**

A selected bedrock core sample and two selected soil samples were submitted to Maxxam Analytics (Maxxam) a Standards Council of Canada (SCC) accredited laboratory of Mississauga, Ontario for chemical analysis. The sample of bedrock core, specifically collected from Borehole DO-2 Run 1 advanced at the north abutment, was crushed and homogenized by Maxxam prior to testing. The soil and crushed bedrock samples were analyzed for a suite of corrosivity parameters, including conductivity, resistivity, soluble chloride, soluble sulphate and pH. The results of the chemical analyses are presented in Appendix C.

The as-drilled borehole locations and the ground surface elevations were obtained using a GPS (Trimble XH 3.5G), having an accuracy of 0.1 m in the vertical and 0.1 m in the horizontal directions. The locations given in the borehole/drillhole records and shown on Drawing 1 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations and ground surface elevations are summarized below.

Borehole No.	Location (MTM NAD 83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude, °)	Easting (Longitude, °)		
NW6-1	4,828,491.3 (43.596336)	299,318.3 (-79.567893)	106.0	3.5
NW6-2	4,828,522.7 (43.596619)	299,296.8 (-79.568160)	106.3	2.9
NW4-3	4,828,683.3 (43.598063)	299,100.6 (-79.570592)	108.1	4.7
HF-2	4,828,441.3 (43.595886)	299,370.6 (-79.567245)	105.2	4.0
HF-3	4,828,621.9 (43.597511)	299,190.3 (-79.569480)	107.5	3.2
DO-1	4,828,582.4 (43.597155)	299,214.9 (-79.569175)	107.3	3.3
DO-2	4,828,567.2 (43.597019)	299,225.4 (-79.569044)	107.0	9.8*
DO-3	4,828,536.7 (43.596744)	299,241.7 (-79.568842)	106.5	7.6*
DO-4	4,828,556.5 (43.596923)	299,257.5 (-79.568648)	106.8	3.8
DO-5	4,828,517.1 (43.596569)	299,294.2 (-79.568192)	106.4	4.7
DO-6	4,828,525.6 (43.596645)	299,285.0 (-79.568306)	106.5	3.5

* includes bedrock core of between 3.5 m and 6.2 m lengths

The current investigation was supplemented with previous boreholes advanced by Thurber. In its report, Thurber does not indicate the coordinate system to which the borehole locations were referenced; however, it is deduced that they were referenced to the UTM coordinate system, and the borehole locations have been converted to MTM NAD 83 for this report. The northing and easting coordinates for these boreholes in addition to the boreholes advanced by Golder are shown in plan and tabulated on Drawing 1.



4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The project area is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putman, 1984)².

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.

The Georgian Bay Formation that underlies the study area consists mainly of blue-grey shale, containing siltstone, sandstone and limestone interbeds. Outcrops of this formation are commonly found along water courses on the west side of Toronto and in Mississauga, notably in the Humber River, Mimico Creek, Etobicoke Creek and Credit River valleys.

4.2 Subsurface Conditions

The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced during the current investigation and the results of the laboratory tests carried out on selected soil and bedrock core samples are presented on the borehole and drillhole records provided in Appendix B. The results of the in situ field tests (i.e. SPT “N” values) as presented on the borehole records and in sub-sections of Section 4.2 are uncorrected. The geotechnical laboratory testing plots are contained in Appendix C.

The stratigraphic boundaries shown on the borehole records and on the stratigraphic profile and cross-sections on Drawings 1 and 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole and drillhole records govern any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawings 1 and 2 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the proposed replacement structure consist of a layer of asphalt and granular fill (road base) or topsoil, underlain by a deposit of sand, underlain by deposits of silty clay residual soil at some borehole locations. The native soil deposits are underlain by shale bedrock. A more detailed description of the subsurface conditions encountered in the boreholes of the current and previous investigations is provided in the following sections.

4.2.1 Asphalt

Boreholes HF-2, DO-3 to DO-6, DR14-01 and DR14-02 were advanced through the roadway surface on the existing QEW or South Service Road and encountered a layer of asphalt varying in thickness from about 65 mm to 200 mm.

It is noted that in Borehole HF-2, a 255 mm thick layer of concrete was penetrated under the asphalt, and in Boreholes DO-6 and DO-5, a 100 mm to 230 mm thick layer of concrete was penetrated underlying the asphalt and granular fill.

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



4.2.2 Topsoil

In Boreholes NW6-1, NW6-2, NW4-3, HF-3, DO-1 and DO-2 a 0.2 m to 0.3 m thick layer of topsoil was encountered at the ground surface.

4.2.3 Fill

Fill was encountered underlying the asphalt or concrete, where present, (or between the asphalt and concrete in Boreholes DO-5 and DO-6) in all of the boreholes advanced through the roadways, and underlying the topsoil in Boreholes NW6-2 and DO-1. The fill varies in composition from sandy silt to sand to sand and gravel. The surface of the fill was encountered between about Elevation 104.8 m and 107.0 m and extends to depths of about 0.2 m to 1.7 m below ground surface (to between Elevation 104.7 m and 106.2 m).

The Standard Penetration Test (SPT) “N” values measured within the fill range from 8 blows to 22 blows per 0.3 m of penetration, indicating that the non-cohesive fill has a loose to compact relative density.

A grain size distribution test was carried out on a sample of the granular fill from Borehole DR14-02 and the results are included in Appendix A.

The water content measured on five samples of the granular fill ranges between 3 per cent and 18 per cent.

4.2.4 Silt to Silty Sand to Sand to Sand and Gravel

In all of the boreholes advanced at the site, a granular deposit consisting of silt to silty sand to sand to sand and gravel to gravelly sand was encountered underlying the topsoil and fill (where present). The surface of the granular deposit was encountered at depths of about 0.2 m to 1.7 m below ground surface (about Elevation 104.7 m to 107.9 m) and the thickness of the deposit was measured to be between about 1.0 m and 3.1 m (extending to between Elevation 102.5 m and 104.9 m). A 0.5 m thick layer of gravel was encountered within the sand to silty sand deposit in Borehole DO-6 at a depth of about 2.6 m below ground surface (Elevation 103.9 m).

The SPT “N” values measured within the granular deposit are between 0 blows (weight of hammer) and 53 blows per 0.3 m of penetration, indicating a very loose to very dense relative density.

The results of grain size distribution tests completed on two samples of the granular deposit from Boreholes DR14-01 and DR14-02 are included in Appendix A. Grain size distribution tests were carried out on ten selected samples of the granular deposit by Golder, and the results are shown on Figures C1A and C1B in Appendix C.

The natural water content measured on samples of the granular deposit are between 5 per cent and 25 per cent.

4.2.5 Gravelly Silty Sand Till

A 0.7 m thick till layer was encountered underlying the sand deposit in Borehole NW6-1 at a depth of about 2.5 m below ground surface (Elevation 103.5 m). The deposit is about 0.7 m thick at this location, extending to about Elevation 102.8 m. This non-cohesive till layer is comprised of gravelly silty sand and contains clayey silt pockets.

An SPT “N” value measured across the interface between the till deposit and the underlying bedrock is 54 blows for 0.25 m of penetration.

A grain size distribution test was carried out on a sample of the till deposit and the result is shown on Figure C2 in Appendix C. An Atterberg limits test was carried out on the fines portion of a sample of this till deposit and measured a liquid limit about of 16 per cent, a plastic limit of about 12 per cent, and a plasticity index of about 4 per cent. The test result, which is plotted on a plasticity chart on Figure C3 in Appendix C, indicates that the fines portion of the till deposit can be classified as a clayey silt of low plasticity.



The natural water content measured on a sample of the till is 13 per cent.

4.2.6 Clayey Silt (Residual Soil)

Underlying the native granular deposits in Boreholes HF-3, DO-1 to DO-3 and DO-5, a 0.1 m to 0.3 m thick deposit of residual soil was encountered at depths between about 2.7 m and 3.3 m below ground surface (between Elevation 103.3 m and 104.8 m). This deposit is interpreted to be derived from weathering of the underlying shale bedrock, and consists of clayey silt trace gravel to gravelly, some sand, containing varying amounts of shale fragments.

An Atterberg limits test was carried out on one sample of the residual soil deposit and measured a liquid limit about of 29 per cent, a plastic limit of about 18 per cent, and a plasticity index of about 11 per cent. The test result, which is plotted on a plasticity chart on Figure C4 in Appendix C, indicates that the residual soil can be classified as a clayey silt of low plasticity.

The natural water content measured on a sample of the till is 14 per cent.

4.2.7 Shale Bedrock

Bedrock was encountered and confirmed by augering and sampling in Boreholes HF-2, HF-3, DO-1, DO-4, DO-5, DO-6, NW4-3, NW6-1 and NW6-2, while bedrock core samples were recovered in Boreholes DO-2, DO-3, DR14-01 and DR14-02. The depths to bedrock below ground surface, and the corresponding bedrock surface elevation are summarized below.

Foundation Element / Approach Embankment	Borehole	Depth to Bedrock Surface / Refusal (m)	Bedrock Surface / Refusal Elevation (m)	Comments
North High Fill / Approach Embankment	NW4-3	3.2	104.9	Split-Spoon Sample
	HF-3	2.8	104.7	Split-Spoon Sample
	DO-1	3.2	104.1	Split-Spoon Sample
North Abutment	DO-2	3.3	103.7	Bedrock Cored
	DR 14-02 ¹	3.0	103.7	Bedrock Cored
Center Pier	DO-3	3.4	103.1	Bedrock Cored
	DO-4	3.0	103.8	Split-Spoon Sample
South Abutment	DO-6	3.3	103.2	Split-Spoon Sample
South High Fill / Approach Embankment	NW6-2	2.5	103.8	Split-Spoon Sample
	DO-5	3.4	103.1	Split-Spoon Sample
	NW6-1	3.2	102.8	Split-Spoon Sample
	HF-2	2.7	102.5	Split-Spoon Sample
	DR 14-01 ¹	3.6	102.9	Bedrock Cored

Note:

1. Thurber Engineering Ltd. Report No. 19-1351-219, dated July 13, 2015, GEOCRE 30M11-251.

In general, the bedrock surface as encountered in the area of the proposed underpass replacement is relatively level to gently sloping towards the south.



Based on a review of the bedrock core samples from the current investigation, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock samples are described as highly to slightly weathered, thinly to very thinly laminated, very fine to fine grained, non-porous, weak, grey, with medium strong to strong limestone interbeds at varying intervals, as presented in the drillhole records in Appendix B, and shown on the photographs of the recovered core samples from Drillhole DO-3 on Figure C5 in Appendix C. The degree of weathering of the bedrock samples (i.e. fresh to slightly weathered – W1 to W2), and the strength classification of the intact rock mass based on field identification (i.e. strong to very strong – R4 to R5) are described in accordance with the International Society for Rock Mechanics (ISRM³) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples generally ranges from about 60 per cent to 100 per cent, except for an upper completely weathered zone in Borehole DO-3, indicating a rock mass of generally fair to excellent quality as per Table 3.10 of CFEM (2006)⁴. The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered are generally between 90 per cent and 100 per cent and between 40 per cent and 100 per cent, respectively.

Two Unconfined Compression (UC) tests (ASTM D7012)⁵ were carried out on selected core samples of the shale bedrock obtained in Boreholes DO-2 and DO-3 and measured compressive strengths of about 13.1 MPa and 5.5 MPa, as shown on the Rock Laboratory Test Result Reports from Geomechanica Inc. in Appendix C. The measured Young's moduli are 302 MPa and 1010 MPa.

Based on the laboratory UCS tests, in accordance with Table 3.5 in CFEM (2006)⁴, the shale bedrock is classified as weak (R2, 5 MPa < UCS < 25 MPa). As noted above, however, the shale contains medium strong to strong limestone interlayers.

4.2.8 Groundwater Conditions

The overburden samples obtained from the current investigation boreholes were generally moist to wet. The depths to the water level observed in the boreholes upon completion of drilling and prior to rock coring varied between about 1.5 m and 4.1 m (between Elevation 106.0 m and 103.6 m), to dry upon completion of drilling at depths between 3.4 m and 4.7 m below ground surface (between Elevations 103.1 and 101.2 m); however, these observations are not necessarily representative of the stabilized groundwater level at the site. Standpipe piezometers were installed in the boreholes advanced in the preliminary investigation by Thurber and the following summarizes the water levels recorded in the piezometers about one to two months after the 2014 borehole drilling:

Borehole	Nearest Foundation Unit	Stratum Sealed Into	Water Level Depth (m)	Water Elevation (m)	Date
DR 14-01	South Approach Embankment	Bedrock	3.8	102.7	September 29, 2014
			3.5	103.0	October 27, 2014
DR 14-02	North Abutment	Bedrock	3.4	103.3	September 29, 2014
			2.8	103.9	October 27, 2014

³ International Society for Rock Mechanics Commission on Test Methods, 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.

⁴ Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.

⁵ ASTM D7012 – Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens



It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.2.9 Analytical Testing Results

As discussed in Section 3.2, a bedrock core sample and two soil samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil and bedrock to steel and concrete. Detailed analytical test results are included in Appendix C and the following table summarizes the results of the testing:

Parameter	Borehole DO-2 Bedrock Run #1 (Elev. 102.9 m)	Borehole DO-4 Soil Sample 4 (Elev. 104.2 m)	Borehole DO-5 Soil Sample 2 (Elev. 104.5 m)
pH	8.02	8.14	8.10
Resistivity (ohm-cm)	3,500	1,200	440
Electrical Conductivity (umho/cm)	284	828	2,250
Chlorides (ug/g)	28	450	1,300
Soluble Sulphates (ug/g)	110	61	27



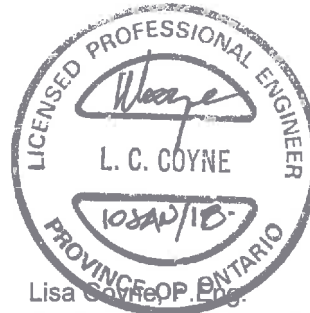
5.0 CLOSURE

This report was prepared by Mr. Matthew Kelly, P.Eng., a geotechnical engineer with Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundation Contact and Principal with Golder, conducted a technical and quality control review of the report.

GOLDER ASSOCIATES LTD.



Matthew Kelly, P. Eng.
Geotechnical Engineer



Lisa Coyne, P. Eng.
Designated MTO Foundation Contact, Principal

MWK/SMM/LCC/rbsm

[https://golderassociates.sharepoint.com/sites/19542g/1 foundations/9 - reports/3 - dixie underpass/final/1530382 2018-01-10 fir - dixie road.docx](https://golderassociates.sharepoint.com/sites/19542g/1%20foundations/9%20-%20reports/3%20-%20dixie%20underpass/final/1530382%202018-01-10%20fir%20-%20dixie%20road.docx)



REFERENCES

- Canadian Geotechnical Society. 1992. *Canadian Foundation Engineering Manual* (CFEM), 3rd Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.
- Canadian Geotechnical Society. 2006. *Canadian Foundation Engineering Manual* (CFEM), 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.
- Canadian Standards Association (CSA). 2014. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-14*. CSA Special Publication.
- Canadian Standards Association (CSA). 2006. *Canadian Highway Bridge Design Code and Commentary on CAN/CSA-S6-06*. CSA Special Publication, S6.1 06.
- 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.
- International Society for Rock Mechanics Commission on Test Methods. 1985. Int. J. Rock Mech.Min. Sci. & Geomech. Abstr. Vol 22, No. 2, pp. 51-60.
- Terzaghi, K., 1955. Evaluation of Coefficients of Subgrade Reaction. In *Geotechnique*, Vol. 5, No. 4, pp. 297-326. Discussion in Vol. 6, No. 2, pp. 94-98.
- Terzaghi, K. and Peck, R.B., 1967. *Soil Mechanics in Engineering Practice*, 2nd Edition, John Wiley and Sons, New York.
- Thurber Engineering Ltd, "Preliminary Foundation Investigation Report, QEW/Dixie Road Interchange Structure, Mississauga, Ontario", Report No. 19-1351-219, dated July 13, 2015 (GEOCRE 30M11-251).

ASTM International:

- | | |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| ASTM D1586 | Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils |
| ASTM D7012 | Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures |

Commercial Software:

- Slide (Version 6) by Rocscience Inc.

Ontario Provisional Standard Drawing:

- | | |
|---------------|-----------------------------------------------------------|
| OPSD 202.010 | Slope Flattening |
| OPSD 3000.100 | Foundation, Piles, Steel H-Pile Driving Shoe |
| OPSD 3000.100 | Foundation, Piles, Tube Pile Driving Shoe |
| OPSD 3090.101 | Foundation Frost Penetration Depths for Southern Ontario |
| OPSD 3101.150 | Walls, Abutments, Backfill, Minimum Granular Requirements |
| OPSD 3121.150 | Walls, Retaining, Backfill, Minimum Granular Requirements |
| OPSD 3190.100 | Walls, Retaining and Abutment, Wall Drain |



Ontario Provincial Standard Specification:

OPSS.PROV 501	Construction Specifications for Compacting
OPSS 511	Construction Specification for Rip Rap, Rock Protection and Granular Sheeting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

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

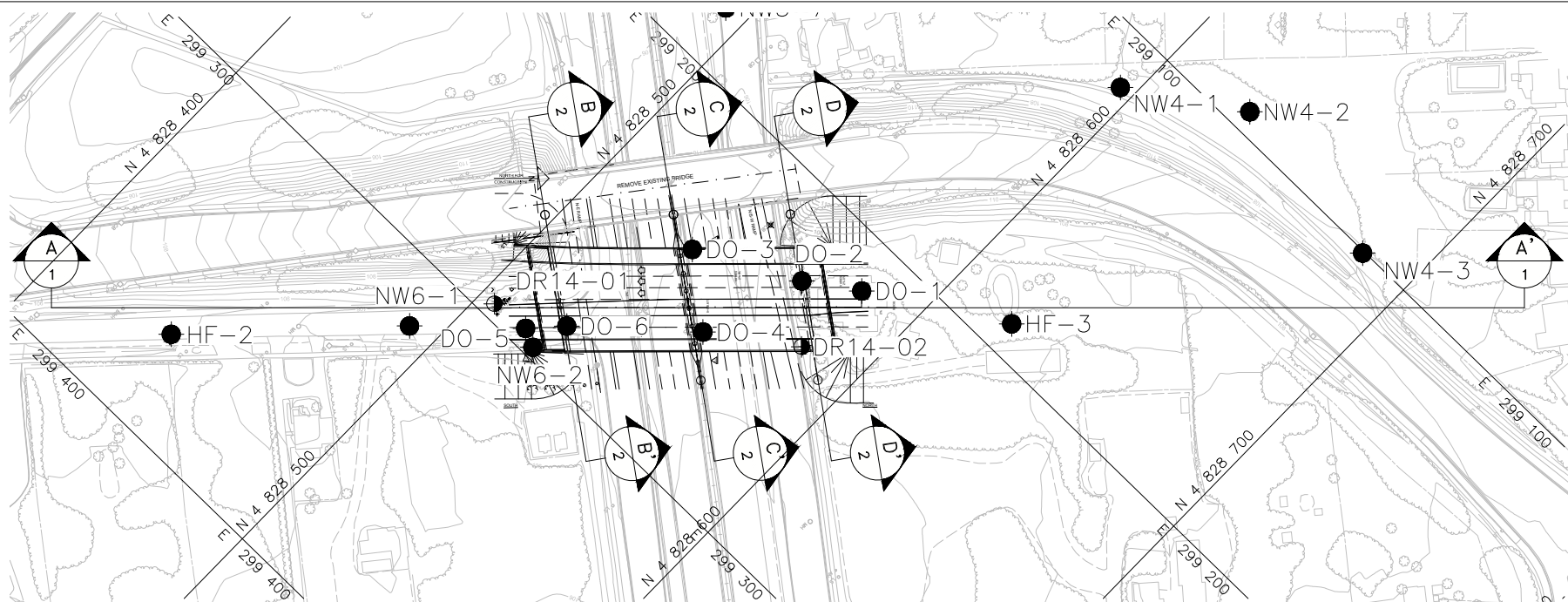
Structural Manual, Provincial Highways Management Division, Highway Standards Branch, Bridge Office, August 2014.

Ministry of Transportation Ontario. Structural Office Report SO-96-01. Integral Abutment Bridges.

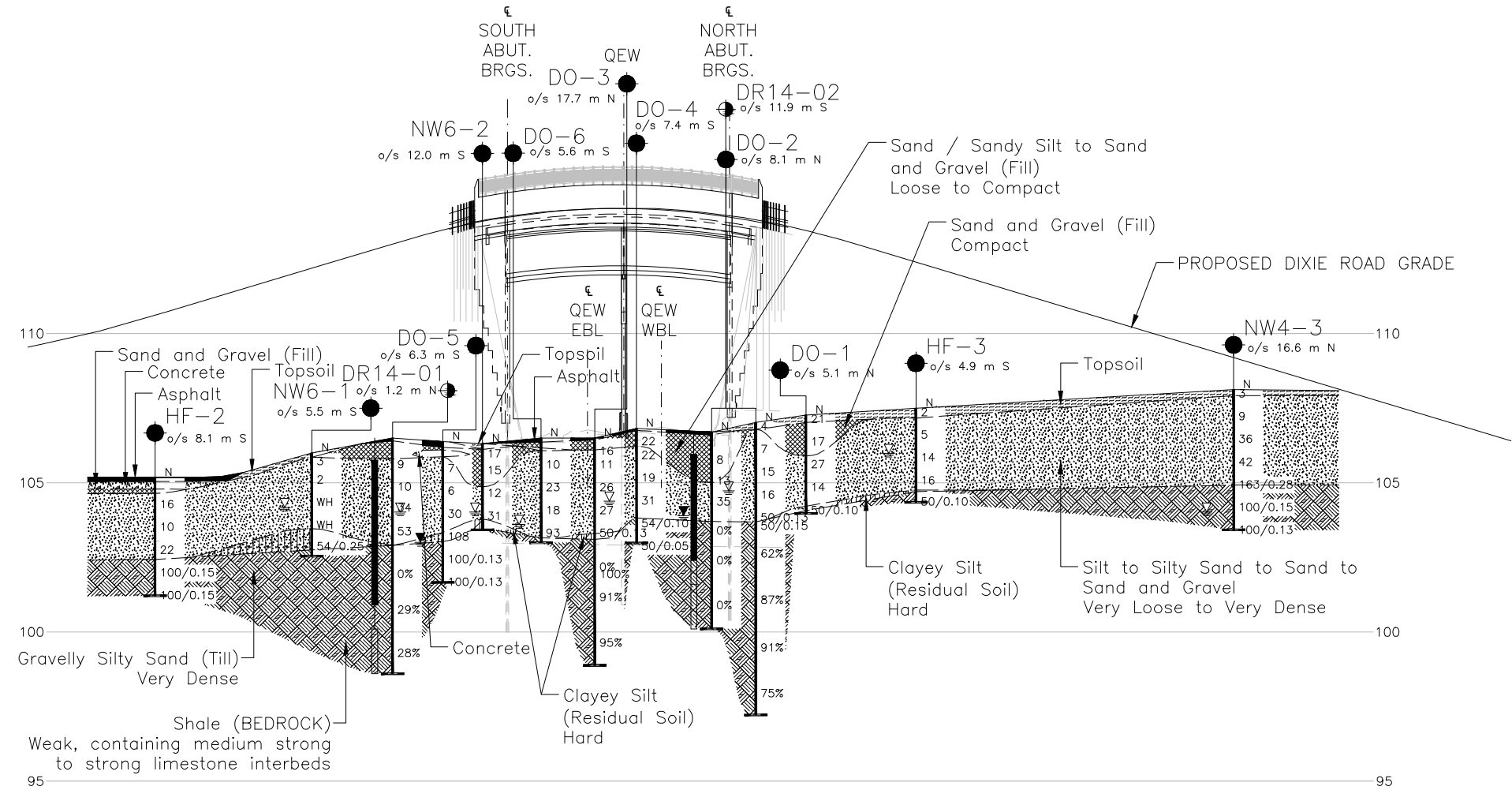
MTO Foundations Guideline, Embankment Settlement Criteria for Design, July 2010.



DRAWINGS



PLAN SCALE 20 0 20 40 m



DIXIE ROAD CENTRELINE PROFILE

HORIZONTAL SCALE 20 0 20 40 m

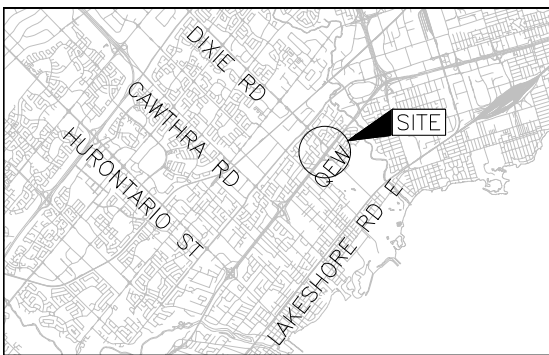
VERTICAL SCALE 2 0 2 4 m

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DO-1	107.3	4828582.4	299214.9
DO-2	107.0	4828567.2	299225.4
DO-3	106.5	4828536.7	299241.7
DO-4	106.8	4828556.5	299257.5
DO-5	106.4	4828517.1	299294.2
DO-6	106.5	4828525.6	299285.0
DR14-01	106.5	4828505.1	299295.5
DR14-02	106.7	4828581.1	299239.8
HF-2	105.2	4828441.3	299370.6
HF-3	107.5	4828621.9	299190.3
NW4-3	108.1	4828683.3	299100.6
NW6-1	106.0	4828491.3	299318.3
NW6-2	106.3	4828522.7	299296.8

CONT No. GWP No. 2012-13-00 & 2432-13-00

QEW DIXIE ROAD UNDERPASS
BOREHOLE LOCATIONS AND
SOIL STRATA



KEY PLAN SCALE 2 0 2 4 km

LEGEND

- Borehole - Current Investigation
- Borehole - 2014 Investigation (Geocres No. 30M11-251)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL in piezometer, measured on March 31, 2015
- WL upon completion of drilling
- R Refusal

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 the borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Boreholes 155 to 167 from Geocres 30M11-20, dated September 23, 1966 were overlaid onto this drawing and the borehole coordinates were interpreted from the coordinate system superimposed on the plan.

The coordinates for Boreholes EC 14-01 to EC 14-04 were recorded by Thurber in UTM coordinates. Golder converted the UTM coordinates to MTM coordinates.

REFERENCE

Base plans provided in digital format by AECOM, drawing file nos. QEW_DixieC_base.dwg and QEW_DixieC_plan.dwg, dated July 20, 2016, received Dec. 06, 2016.

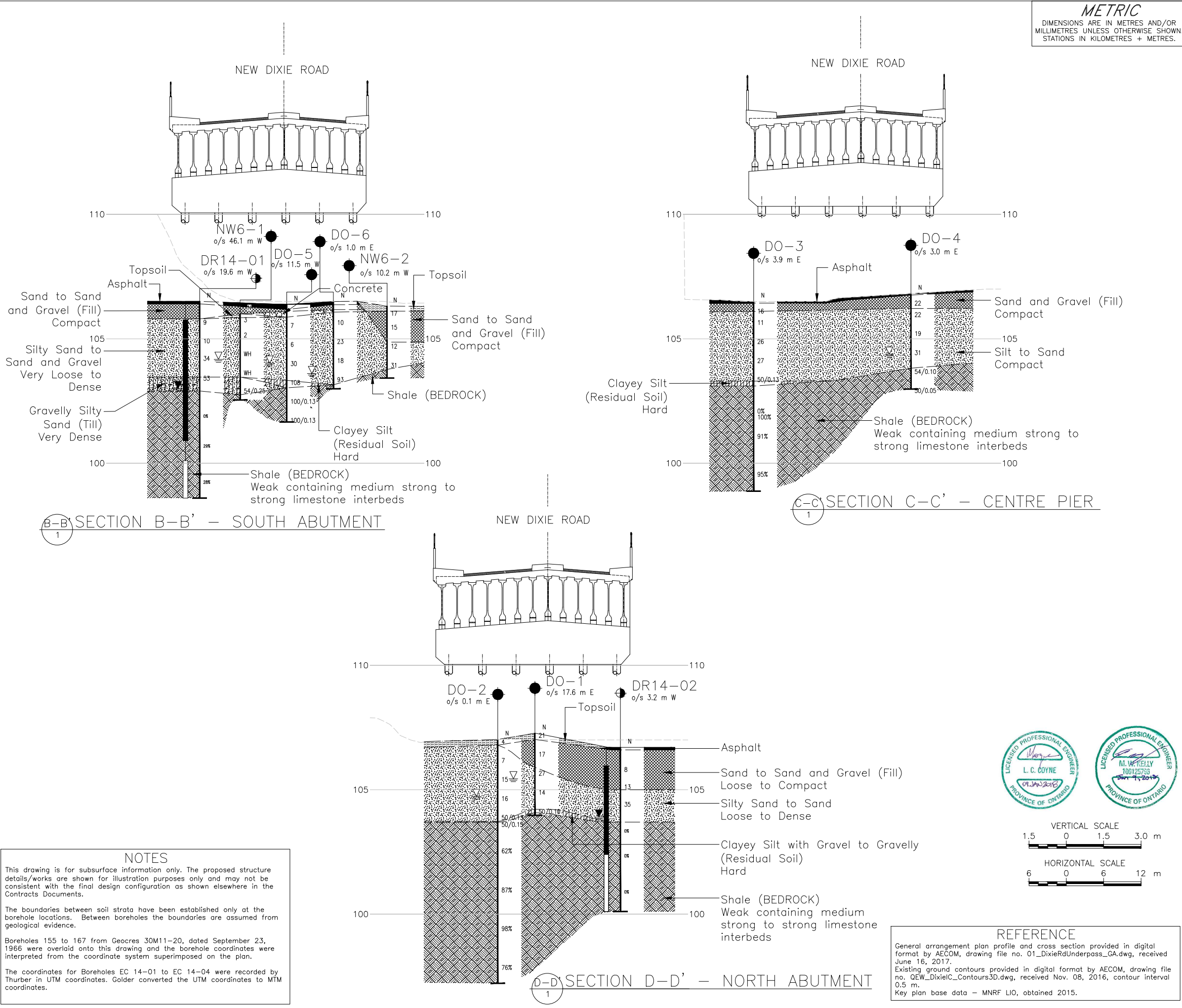
General arrangement plan profile and cross section plan provided in digital format by AECOM, drawing file no. 01_DixieRdUnderpass_GA.dwg, received June 16, 2017.

Existing ground contours provided in digital format by AECOM, drawing file no. QEW_DixieC_Contours3D.dwg, received Nov. 08, 2016, contour interval 0.5 m.

Dixie Road Profile (shown as approximate) based on PDF file of 30% Executive Review Submission, provided by AECOM, Dated January 10, 2017. Key plan base data - MNRF LIO, obtained 2015.

NO.	DATE	BY	REVISION
Geocres No. 30M11-272			
HWY. QEW	PROJECT NO. 1530382	DIST. CENTRAL	
SUBM'D. SMM	CHKD. MWK	DATE: 10/01/2018	SITE:
DRAWN: MR/DD	CHKD. SMM	APPD. LCC	DWG. 1





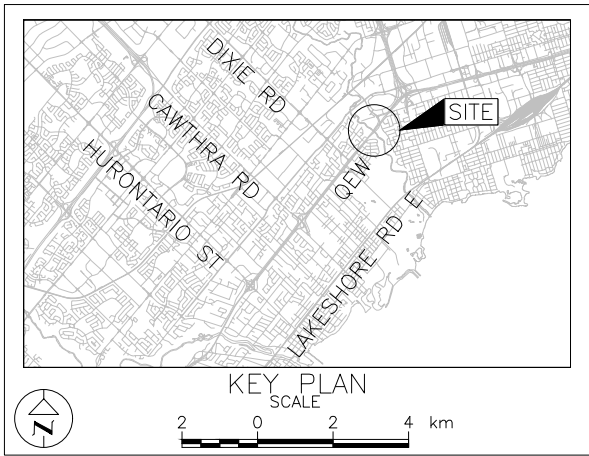
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. _____
GWP No. 2012-13-00 & 2432-13-00

QEW DIXIE ROAD UNDERPASS

SOIL STRATA

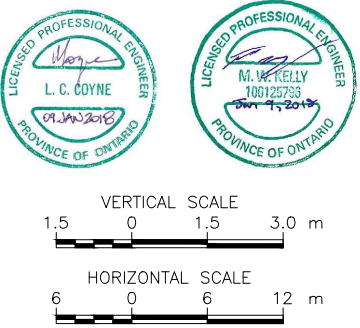
SHEET



LEGEND

- Borehole - Current Investigation
- Borehole - 1966 Investigation (Geocres No. 30M11-20)
- Borehole - 2014 Investigation (Geocres No. 30M11-252)
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on March 31, 2015
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
DO-1	107.3	4828582.4	299214.9
DO-2	107.0	4828567.2	299225.4
DO-3	106.5	4828536.7	299241.7
DO-4	106.8	4828556.5	299257.5
DO-5	106.4	4828517.1	299294.2
DO-6	106.5	4828525.6	299285.0
DR14-01	106.5	4828505.1	299295.5
DR14-02	106.7	4828581.1	299239.8
HF-3	107.5	4828621.9	299190.3
NW6-1	106.0	4828491.3	299318.3
NW6-2	106.3	4828522.7	299296.8



REFERENCE

General arrangement plan profile and cross section provided in digital format by AECOM, drawing file no. 01_DixieRdUnderpass_GA.dwg, received June 16, 2017.

Existing ground contours provided in digital format by AECOM, drawing file no. QEW_DixieRdContours3D.dwg, received Nov. 08, 2016, contour interval 0.5 m.

Key plan base data - MNRF LIO, obtained 2015.

NO.	DATE	BY	REVISION
Geocres No. 30M11-272			
HWY. QEW	PROJECT NO. 1530382		DIST. CENTRAL
SUBM'D. SMM	CHKD. MWK	DATE: 1/10/2018	SITE:
DRAWN: MR	CHKD. SMM	APPD. LCC	DWG. 2

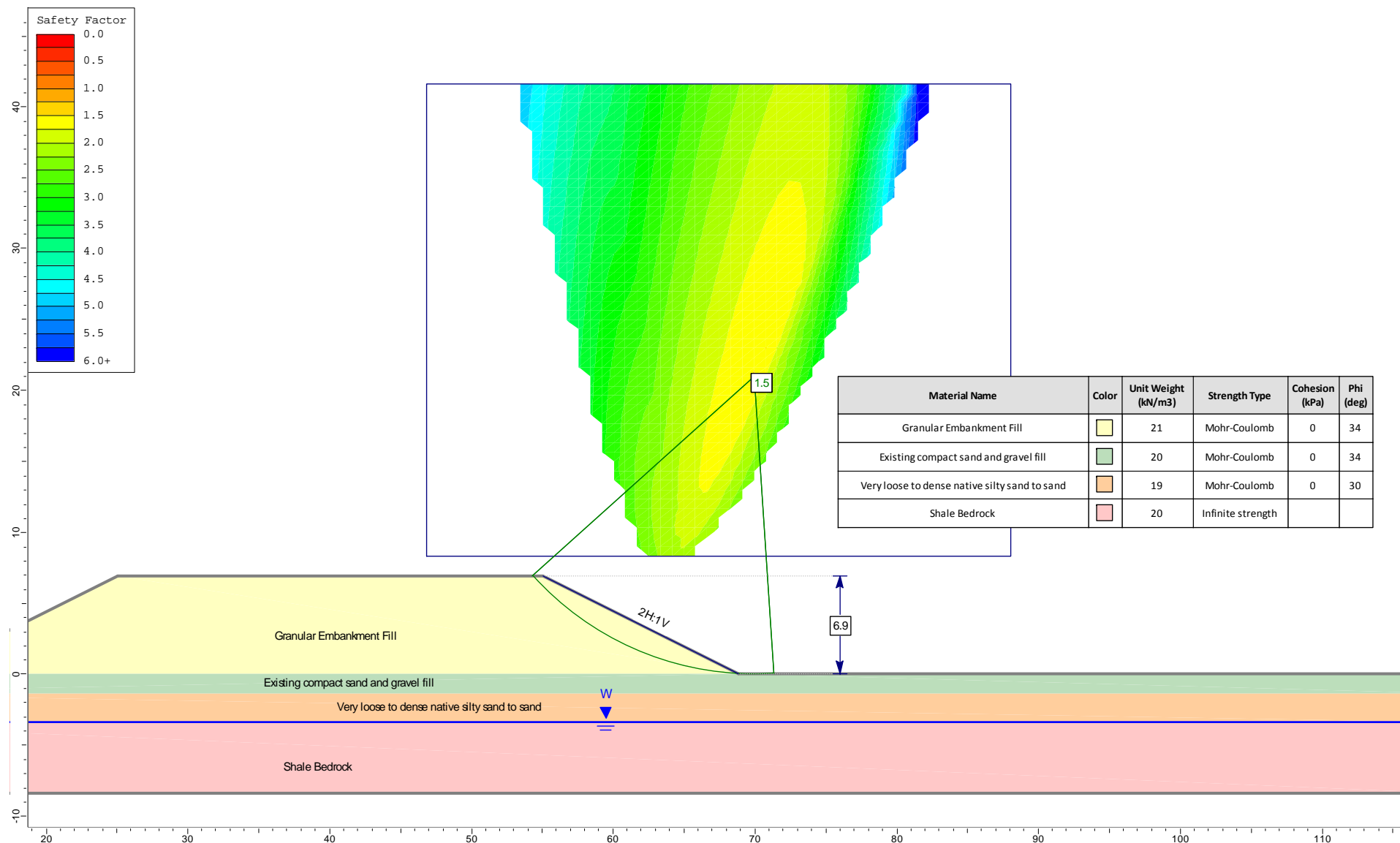


FIGURES



QEW – Dixie Road Underpass Replacement Approach Embankment Static Global Stability Analysis

Figure 1





APPENDIX A

Borehole Records and Laboratory Test Results – Previous Investigation (GEOCRES 30M11-251)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS


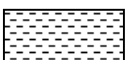

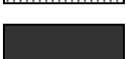

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No DR 14-01

1 OF 1

METRIC

W.P. 09-20003 LOCATION Dixie Rd. Underpass N 4 828 505.1 E 299 295.5 ORIGINATED BY SLL
 HWY QEW BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.08.08 - 2014.08.08 CHECKED BY MW

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%)							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
							W P W W L							
							20 40 60 80 100							
							20 40 60 80 100							
106.5	GROUND SURFACE													
0.0	ASPHALT: (113mm)													
0.1	SAND, trace gravel, trace silt, occasional cobbles		1	GS										
105.8	Brown Moist (FILL)													
0.7	Silty SAND, trace clay, trace gravel, trace rootlets Loose to Dense Brown Moist		2	SS	9									
			3	SS	10								5 67 25 3	
			4	SS	34									
			5	SS	53									
102.9														
3.6	SHALE, highly to moderately weathered, fine grained, thinly bedded, grey, weak to medium strong, with strong limestone interbeds: (Georgian Bay Formation)													
	Highly broken zone (125mm) at 4.2m		1	RUN									RUN #1 TCR=94% SCR=83% RQD=0%	
	Highly broken zone (75mm) at 5.5m		2	RUN									RUN #2 TCR=100% SCR=95% RQD=29% UCS=22.4MPa UCS=17.4 MPa	
	Thin clay seam (less than 25mm) from 6.8m to 7.0m		3	RUN									RUN #3 TCR=100% SCR=96% RQD=28% UCS=30.8MPa UCS=11.9 MPa	
98.6														
7.9	END OF BOREHOLE AT 7.9m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep 29, 14 3.8 102.7 Oct 27, 14 3.5 103.0													

ONTMT4S 1219.GPJ 2012TEMPLATE(MTO).GDT 12/9/14

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No DR 14-02

1 OF 1

METRIC

W.P. 09-20003 LOCATION Dixie Rd. Underpass N 4 828 581.1 E 299 239.8 ORIGINATED BY SLL
 HWY QEW BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.08.08 - 2014.08.08 CHECKED BY MW

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
106.7	GROUND SURFACE							20	40	60	80	100						
0.0 0.1	ASPHALT: (125mm) SAND, trace gravel, trace silt and clay Loose Brown Moist (FILL)		1	GS														
			2	SS	8												3 84 10 3	
105.0																		
1.7	SAND, trace gravel, trace silt, trace rootlets Compact to Dense Brown Moist		3	SS	13													
			4	SS	35												7 80 13 (SI+CL)	
103.7																		
3.0	SHALE, highly to moderately weathered, fine grained, thinly bedded, grey, weak to medium strong, with very strong limestone interbeds: (Georgian Bay Formation) Clay seam (25mm) at 3.6m Highly broken zone at: 50mm at 4.1m 100mm at 4.3m 100mm at 4.5m Vertical joint (125mm) at 4.9m Highly broken zone at: 50mm at 5.1m 50mm at 5.5m 75mm at 6.1m Limestone interbeds		1	RUN													RUN #1 TCR=100% SCR=63% RQD=0%	
			2	RUN													RUN #2 TCR=100% SCR=69% RQD=0%	
			3	RUN													RUN #3 TCR=100% SCR=84% RQD=0% UCS=25.3MPa UCS=133.6 MPa	
100.1																		
6.6	END OF BOREHOLE AT 6.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Sep 29, 14 3.4 103.3 Oct 27, 14 2.8 103.9																	

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

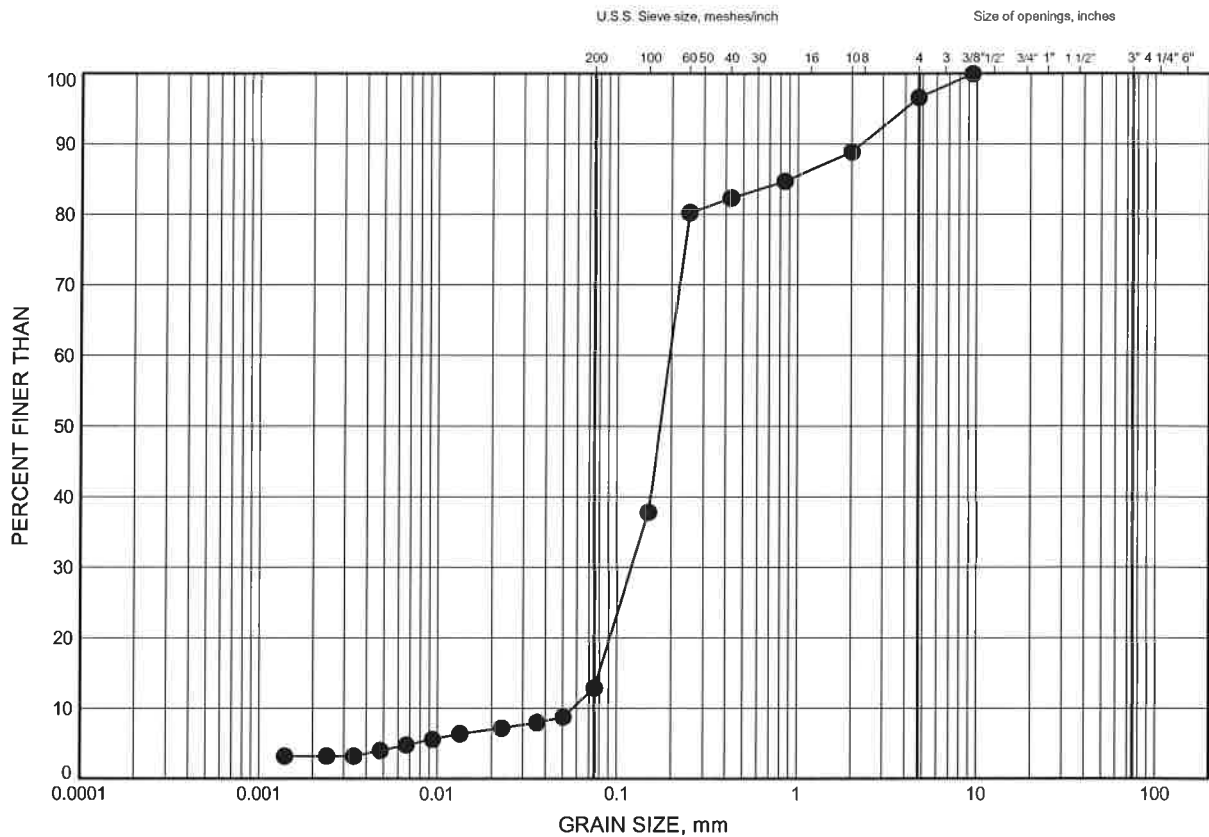
Appendix B
Laboratory Test Results

QEW Cawthra Road

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	DR 14-02	1.07	105.63

Date December 2014
W.P. 09-20003

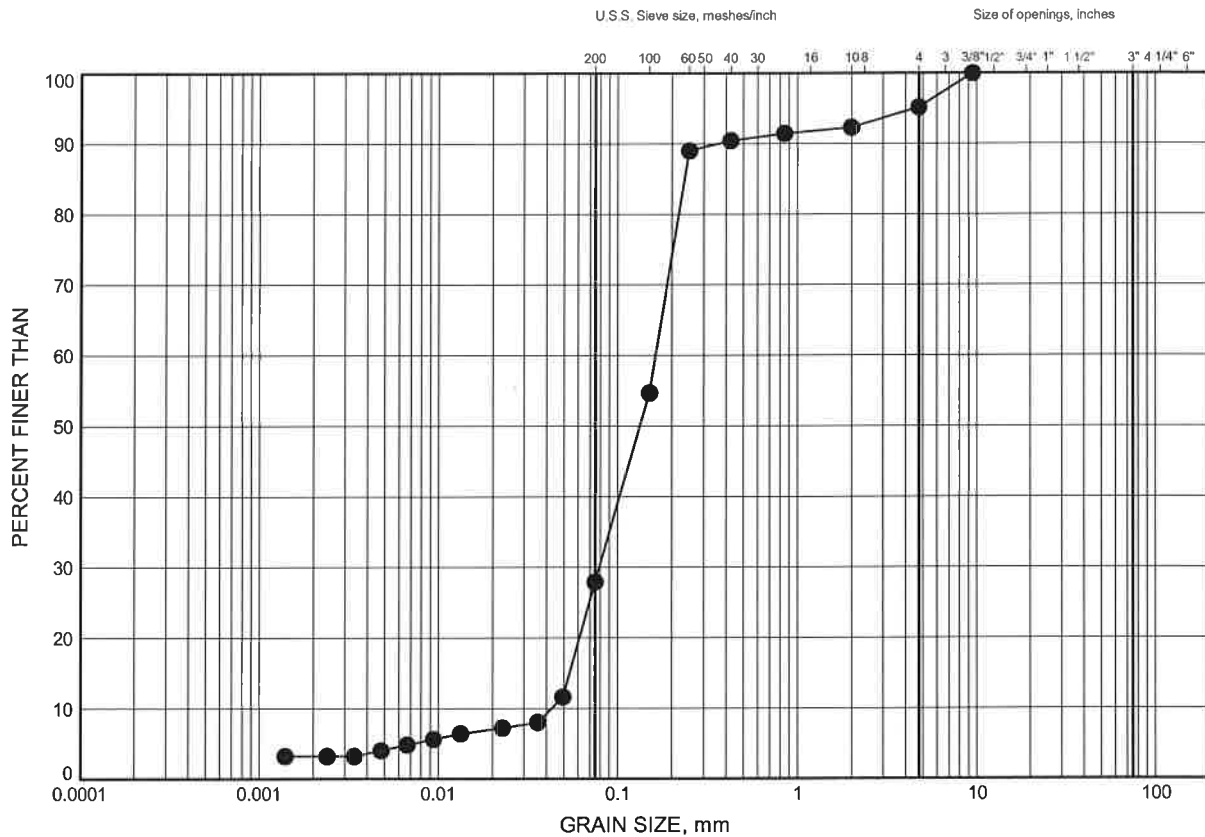


Prep'd AN
Chkd. AP

QEW Cawthra Road
GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	DR 14-01	1.83	104.67

Date December 2014
W.P. 09-20003

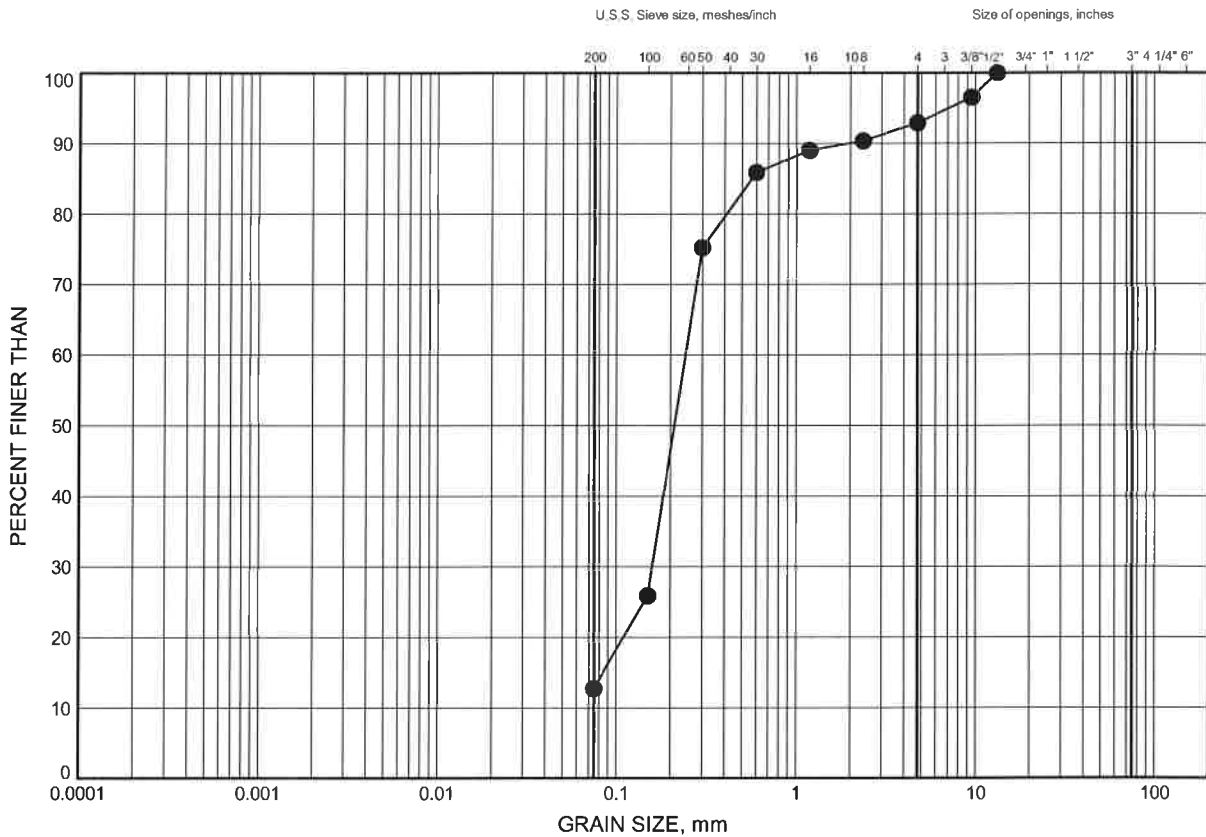


Prep'd AN
Chkd. AP

QEW Cawthra Road
GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	DR 14-02	2.51	104.19

Date December 2014
W.P. 09-20003



Prep'd AN
Chkd. AP

Appendix C

Point load Test Results and Rock Core Photographs



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No : 19-1351-219 Client : MMM Group
Date Drilled : 08-Aug-14
Project Name : QEW CAWTHRA ROAD Date Tested : 08-Aug-14
Core Size : NQ BH No : DR14-01 Tester : GAZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	2	5.8	A	3.0	47.1	54.3	22.4	Shale	Weak
2	2	6.0	A	2.2	47.0	50.2	17.4	Shale	Weak
3	3	7.3	A	4.0	47.0	51.2	30.8	Shale	Medium Strong
4	3	7.9	D	1.2	46.9	long	11.9	Shale	Weak
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

Last Modified: August 15, 2013



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

Job No : 19-1351-219

Client : MMM Group

Date Drilled : 08-Aug-14

Project Name : QEW CAWTHRA ROAD

Date Tested : 08-Aug-14

Core Size : NQ BH No : DR14-02

Tester : GAZ

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	UCS (MPa)	Rock Type	Notes
1	3	6.1	D	2.5	47.0	84.9	25.3	Shale	Medium Strong
2	3	6.4	A	21.2	47.0	66.9	133.6	Limestone	Very Strong
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

Last Modified: August 15, 2013



Photograph 1. Rock cores recovered from Borehole DR14-01



Photograph 2. Rock cores recovered from Borehole DR14-02



APPENDIX B

Borehole and Drillhole Records – Current Investigation



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
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, 60° 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 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

Density Index	N
Relative Density	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	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) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		1530382		RECORD OF BOREHOLE No NW6-1		SHEET 1 OF 1		METRIC								
G.W.P.		2102-13-00; 2432-13-00		LOCATION		N 4828491.3; E 299318.3 MTM NAD 83 ZONE 10 (LAT. 43.596336; LONG. -79.567893)		ORIGINATED BY ML								
DIST		Central HWY QEW		BOREHOLE TYPE		150 mm O.D. Solid Stem Augers		COMPILED BY								
DATUM		Geodetic		DATE		June 28, 2017		CHECKED BY								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
106.0	GROUND SURFACE															
0.0	TOPSOIL															
0.2	SAND, trace to some silt, some gravel Very loose Brown Moist to wet		1	SS	3											
			2	SS	2											
			3	SS	WH											
103.5	Gravelly Silty SAND, containing clayey silt pockets (TILL) Very dense Grey Wet		4A	SS	WH											
2.5			4B	SS	WH											
102.8	SHALE (BEDROCK)		5A	SS	54/0.25											
102.5			5B													
3.5	END OF BOREHOLE															
	NOTE: 1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 104.2 m) upon completion of overburden drilling.															

PROJECT		1530382		RECORD OF BOREHOLE		No NW6-2		SHEET 1 OF 1		METRIC							
G.W.P.		2102-13-00; 2432-13-00		LOCATION		N 4828522.7; E 299296.8 MTM NAD 83 ZONE 10 (LAT. 43.596619; LONG. -79.568160)		ORIGINATED BY		EN							
DIST		Central HWY QEWE		BOREHOLE TYPE		150 mm O.D. Solid Stem Augers		COMPILED BY									
DATUM		Geodetic		DATE		June 28, 2017		CHECKED BY									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
106.3	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL																
0.2	Sand, some silt, trace gravel to gravelly, trace organics (FILL) Compact Black to brown Moist		1A	SS	17		106										
			1B	SS													
			2	SS	15												
104.9							105										
1.5	SAND, some silt, trace clay Compact Brown Wet		3	SS	12												
103.8			4A				104										
2.5	SHALE (BEDROCK)		4B	SS	31												
103.4																	
2.9	END OF BOREHOLE																
	NOTE: 1. Water level in open borehole at a depth of 2.3 m below ground surface (Elev. 104.0 m) upon completion of overburden drilling.																

PROJECT 1530382		RECORD OF BOREHOLE No NW4-3		SHEET 1 OF 1		METRIC	
G.W.P. 2102-13-00; 2432-13-00		LOCATION N 4828683.3; E 299100.6 MTM NAD 83 ZONE 10 (LAT. 43.598063; LONG. -79.570592)		ORIGINATED BY PKS			
DIST Central HWY QEW		BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY ACK			
DATUM Geodetic		DATE October 6, 2016		CHECKED BY SMM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						WATER CONTENT (%)			
108.1	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL																
0.2	SAND, some silt Very loose to dense Brown to grey Moist		1	SS	3		108										
			2	SS	9		107										
			3	SS	36		106							○		0	83 17 0
	- Becoming wet below 2.1 m depth																
			4	SS	42												
104.9	SHALE (BEDROCK)		5	SS	163/0.28		105										
3.2																	
			6	SS	100/0.15												
							104										
103.4	END OF BOREHOLE		7	SS	100/0.13												
4.7	NOTE: 1. Water level in open borehole at a depth of 4.1 m below ground surface (Elev. 104.0 m) upon completion of drilling.																

PROJECT		1530382		RECORD OF BOREHOLE		No HF-2		SHEET 1 OF 1		METRIC								
G.W.P.		2102-13-00; 2432-13-00		LOCATION		N 4828441.3; E 299370.6 MTM NAD 83 ZONE 10 (LAT. 43.595886; LONG. -79.567245)		ORIGINATED BY		PKS								
DIST		Central HWY QEW		BOREHOLE TYPE		108 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY		ACK								
DATUM		Geodetic		DATE		October 13, 2016		CHECKED BY		SMM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
105.2	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT (130 mm)																	
104.8	CONCRETE (255 mm)																	
0.5	Sand and gravel (FILL) Brown Moist SAND, trace silt, trace gravel Compact Brown Moist		1	SS	16													
			2	SS	10													
103.1	Gravelly SAND, trace to some silt, trace clay Compact Brown Wet		3A	SS	22													
102.5	SHALE (BEDROCK)		3B															
			4	SS	100/0.15													
101.2	END OF BOREHOLE		5	SS	100/0.15													
4.0	NOTE: 1. Open borehole dry upon completion of drilling.																	






PROJECT <u>1530382</u>		RECORD OF BOREHOLE No HF-3		SHEET 1 OF 1		METRIC	
G.W.P. <u>2102-13-00; 2432-13-00</u>		LOCATION <u>N 4828621.9; E 299190.3 MTM NAD 83 ZONE 10 (LAT. 43.597511; LONG. -79.569480)</u>		ORIGINATED BY <u>KG</u>			
DIST <u>Central</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>CME 75, 150 mm O.D. Solid Stem Augers</u>		COMPILED BY _____			
DATUM <u>Geodetic</u>		DATE <u>June 15, 2017</u>		CHECKED BY <u>MWK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _p	W	W _L						
107.5	GROUND SURFACE																				
0.0	TOPSOIL																				
107.2			1	SS	2	▽															
0.3	SAND, trace to some silt Loose to compact Brown, oxidation staining present Moist to wet																				
			2	SS	5																
			3	SS	14																
			4	SS	16																
104.8																					
2.8	Gravelly CLAYEY SILT, some shale fragments (RESIDUAL SOIL) Very stiff Grey Moist																				
104.3			5	SS	50/0.10																
3.2	SHALE (BEDROCK) END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 1.5 m below ground surface (Elev. 106.0 m) upon completion of overburden drilling.																				

NOTE:

1. Water level in open borehole at
a depth of 1.5 m below ground
surface (Elev. 106.0 m) upon
completion of overburden drilling.

PROJECT 1530382		RECORD OF BOREHOLE No DO-1		SHEET 1 OF 1		METRIC	
G.W.P. 2102-13-00; 2432-13-00		LOCATION N 4828582.4; E 299214.9 MTM NAD 83 ZONE 10 (LAT. 43.597155; LONG. -79.569175)		ORIGINATED BY KG			
DIST Central HWY QEW		BOREHOLE TYPE CME 55, 150 mm O.D. Solid Stem Augers		COMPILED BY			
DATUM Geodetic		DATE June 15, 2017		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE	20	40	60	80	100	● QUICK TRIAXIAL × REMOULDED	W _p		
107.3	GROUND SURFACE																
0.0	TOPSOIL																
107.0			1	SS	21												
0.3	Sand and gravel (FILL) Compact Grey Moist																
			2	SS	17												
105.9																	
1.4	SAND, trace to some silt Compact Brown Moist to wet - Becoming wet below 1.8 m																
			3	SS	27												
			4	SS	14												
104.2																	
	CLAYEY SILT with GRAVEL, some shale fragments (RESIDUAL SOIL) Hard Grey Moist		5	SS	50/0.10												
	SHALE (BEDROCK) END OF BOREHOLE																
3.3																	
	NOTE: 1. Water level in open borehole at a depth of 1.8 m below ground surface (Elev. 105.5 m) upon completion of overburden drilling.																

PROJECT 1530382		RECORD OF BOREHOLE No DO-2		SHEET 1 OF 2		METRIC	
G.W.P. 2102-13-00; 2432-13-00		LOCATION N 4828567.2; E 299225.4 MTM NAD 83 ZONE 10 (LAT. 43.597019; LONG. -79.569044)		ORIGINATED BY KG			
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 150 mm O.D. Solid Stem Augers		COMPILED BY			
DATUM Geodetic		DATE June 15, 2017		CHECKED BY MWK			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	20	40	60	80	100	w _p	w		w _L			
107.0	GROUND SURFACE																			
0.0	TOPSOIL																			
106.8																				
0.2	Silty SAND to SAND, some silt, trace rootlets Loose to compact Brown Moist		1	SS	4															
			2	SS	7															
			3	SS	15															
	- Becoming wet below 2.3 m		4	SS	16															
103.7			5	SS	50/0.13															
3.3	CLAYEY SILT with GRAVEL (RESIDUAL SOIL) Hard Grey Moist SHALES (BEDROCK) Bedrock cored from depths of 3.6 m to 9.8 m. For bedrock coring details refer to Record of Drillhole DO-2.		6	SS	50/0.15															
			1	RC	REC 92%															
			2	RC	REC 100%															
			3	RC	REC 100%															
			4	RC	REC 100%															
97.2																				
9.8	END OF BOREHOLE																			

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\MTQ\QEW-DIXIE\GPJ GAL-GTA.GDT 01/10/18 GPJ



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

SHEET 1 OF 1

DATUM: Geodetic

DRILLING CONTRACTOR: Davis Drilling Ltd.

[illegible]

BROKEN CORE



CLAY SEAM



LIMESTONE



LOST CORE

DEPTH SCALE

1 : 50


**Golder
Associates**

LOGGED:

CHECKED:

STA-RCK 054 S:\CLIENTS\MTQ\QEW-DIXIE\02 DATA\GINT\QEW-DIXIE.GPJ GAL-MISS.GDT 01/10/18 GPK

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

PROJECT: 1530382

RECORD OF DRILLHOLE: DO-3

SHEET 1 OF 1

LOCATION: N 4828536.7 ; E 299241.7

DRILLING DATE: September 6 and 7, 2016

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 (Truck Mounted)

DRILLING CONTRACTOR: Davis Drilling Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	SYMBOLIC LOG																		FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				ELEV. DEPTH (m)	RUN No.	RECOVERY			R.Q.D. %	FRACT. INDEX PER Meter	B Angle °	DIP W/L CORE AXIS °	DISCONTINUITY DATA		ROCK STRENGTH INDEX			WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
						TOTAL CORE %	SOLID CORE %	TYPE AND SURFACE DESCRIPTION					Jr	Ja	R4	R3	R2	R1	W1	W2	W3				W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
		Continued from Record of Borehole DO-3		102.41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

FEATURES LEGEND



BROKEN CORE



CLAY SEAM



LIMESTONE



LOST CORE

DEPTH SCALE

1 : 50



LOGGED: MK

CHECKED: KG/AB

GTA-RCK 054 S:\CLIENTS\MTQ\QEW-DIXIE\02_DATA\GINTQEW-DIXIE.GPJ GAL-MISS.GDT 01/10/18 GPK

PROJECT 1530382		RECORD OF BOREHOLE No DO-4		SHEET 1 OF 1		METRIC	
G.W.P. 2102-13-00; 2432-13-00		LOCATION N 4828556.5; E 299257.5 MTM NAD 83 ZONE 10 (LAT. 43.596923; LONG. -79.568648)		ORIGINATED BY MK			
DIST Central HWY QEW		BOREHOLE TYPE CME 75, 108 mm O.D. Solid Stem Augers		COMPILED BY FRC			
DATUM Geodetic		DATE September 7, 2016		CHECKED BY SMM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		
							20	40	60	80	100						
106.8	GROUND SURFACE																
0.0	ASPHALT (65 mm)																
106.4	Sand and gravel (FILL)																
0.6	Brown Moist		1	SS	22												
106.2	Sandy silt, trace gravel (FILL)																
0.6	Compact Grey Moist																
	SAND, some silt, trace gravel, trace clay		2	SS	22												
	Compact to dense Brown Moist to wet																
			3	SS	19												
			4	SS	31												
103.8	SHALE (BEDROCK)		5	SS	54/0.10												
3.0																	
103.0	END OF BOREHOLE		6	SS	50/0.05												
3.8																	
	NOTE: 1. Water level in open borehole at a depth of 2.4 m below ground surface (Elev. 104.4 m) upon completion of drilling.																

GTA-MTO 001 S:\CLIENTS\MTQ\QEW-DIXIE02_DATAGINT\QEW-DIXIE.GPJ GAL-GTA.GDT 01/10/18 GPK

PROJECT		2102-13-00; 2432-13-00		LOCATION		N 4828517.1; E 299294.2 MTM NAD 83 ZONE 10 (LAT. 43.596569; LONG. -79.568192)		SHEET 1 OF 1		METRIC							
G.W.P.		2102-13-00; 2432-13-00		BOREHOLE TYPE		108 mm O.D. Continuous Flight Solid Stem Augers		ORIGINATED BY		PKS							
DIST		Central HWY QEW		COMPILED BY		ACK		DATE		October 13, 2016							
DATUM		Geodetic		CHECKED BY		SMM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
106.4	GROUND SURFACE																
0.0	ASPHALT (200 mm)																
105.9	Sand and gravel (FILL) Brown Moist																
0.5	CONCRETE (230 mm)																
	SAND, some silt, trace clay Loose to compact Brown Moist to wet below 2.3 m depth		1	SS	7												
			2	SS	6												
			3	SS	30												
103.4	CLAYEY SILT, some sand, trace gravel, trace shale fragments (RESIDUAL SOIL)		4	SS	108												
3.1	Hard Grey Wet																
103.1	SHALE (BEDROCK)		5	SS	100/0.13												
3.4																	
			6	SS	100/0.13												
101.7	END OF BOREHOLE																
4.7	NOTE: 1. Open borehole dry upon completion of drilling.																

PROJECT 1530382		RECORD OF BOREHOLE No DO-6		SHEET 1 OF 1		METRIC	
G.W.P. 2102-13-00; 2432-13-00		LOCATION N 4828525.6; E 299285.0 MTM NAD 83 ZONE 10 (LAT. 43.596645; LONG. -79.568306)		ORIGINATED BY PKS			
DIST Central HWY QEW		BOREHOLE TYPE 108 mm O.D. Continuous Flight Solid Stem Augers		COMPILED BY ACK			
DATUM Geodetic		DATE October 13, 2016		CHECKED BY SMM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					w _p w w _L				
106.5	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (150 mm)																
106.2	Sand and gravel (FILL) Brown Moist																
0.4	CONCRETE (100 mm)																
	SAND, some silt Compact Brown to grey Moist		1	SS	10												
	- Grey below a depth of 1.8 m		2	SS	23									○			0 85 15 0
	- Becoming wet below a depth of 2.1 m																
103.9																	
2.6	GRAVEL, some sand, trace silt Compact Brown Wet		3	SS	18									○			
103.5																	
3.1	Silty SAND Very dense Brown Wet																
103.2			4	SS	93												
3.5	SHALE (BEDROCK) END OF BOREHOLE																
	NOTE: 1. Water level in open borehole at a depth of 2.9 m below ground surface (Elev. 103.6 m) upon completion of drilling.																



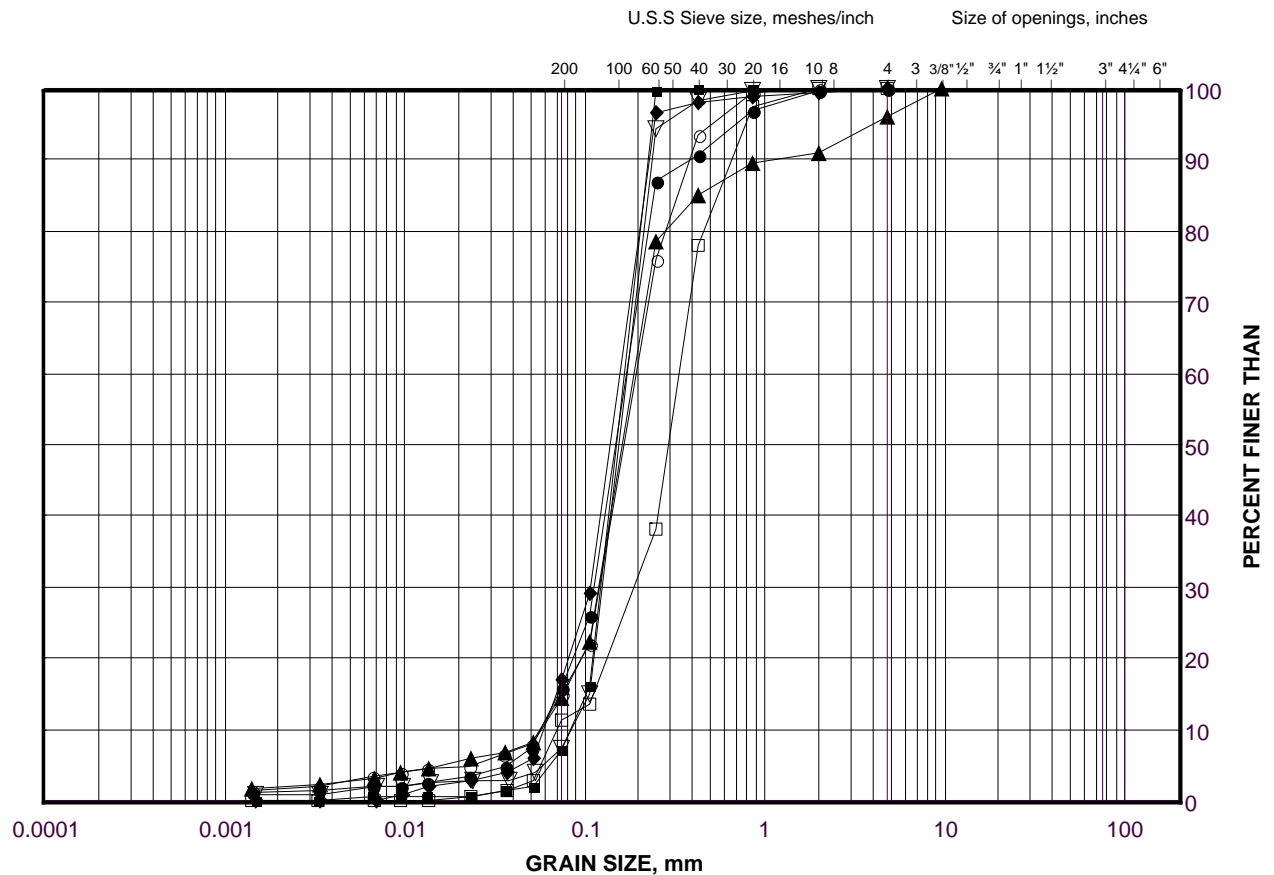
APPENDIX C

Laboratory Test Results, Bedrock Core Photographs and Chemical Test Results – Current Investigation

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand to Gravelly Sand

FIGURE C1-A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	NW6-2	3	104.5
■	HF-3	3	105.7
◆	NW 4-3	3	106.2
▲	DO -4	3	105.0
▽	DO -3	3	104.7
○	DO-2	4	104.4
□	DO-1	4	104.7

Project Number: 1530382

Checked By: MWK

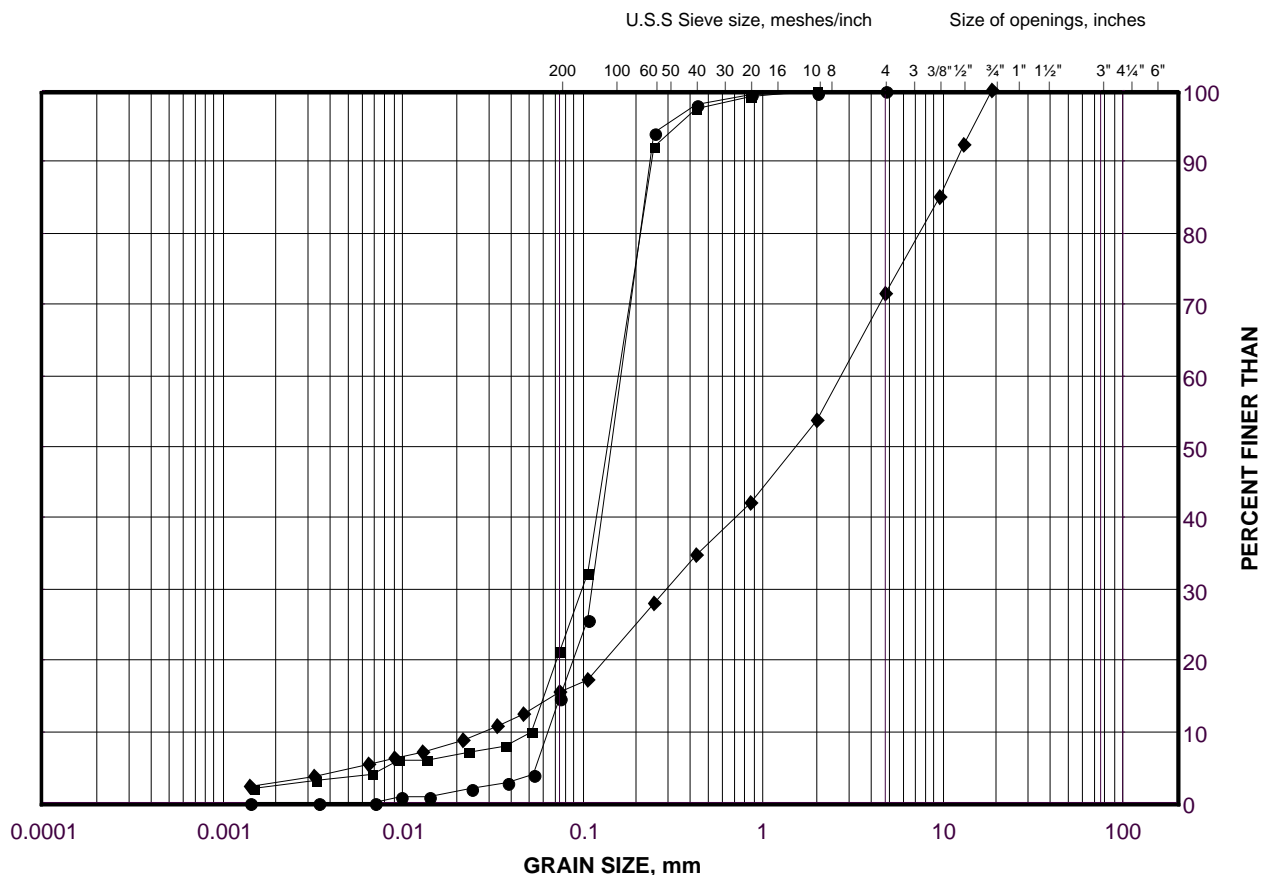
Golder Associates

Date: 16-Aug-17

GRAIN SIZE DISTRIBUTION

Silty Sand to Sand to Gravelly Sand

FIGURE C1-B



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	DO -6	2	104.7
■	DO -5	2	104.6
◆	HF -2	3A	102.7

Project Number: 1530382

Checked By: MWK

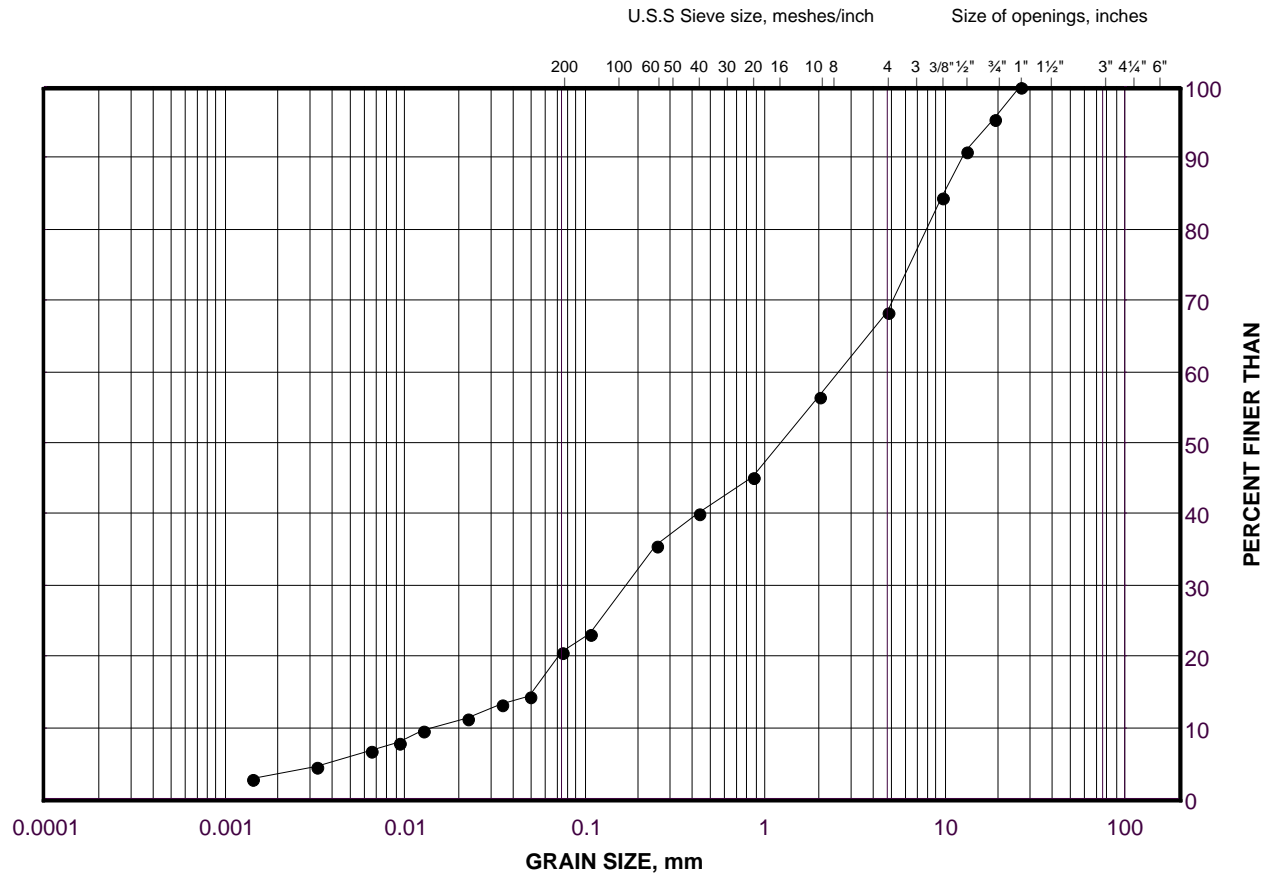
Golder Associates

Date: 16-Aug-17

GRAIN SIZE DISTRIBUTION

Gravelly Silty Sand (Till)

FIGURE C2



LEGEND

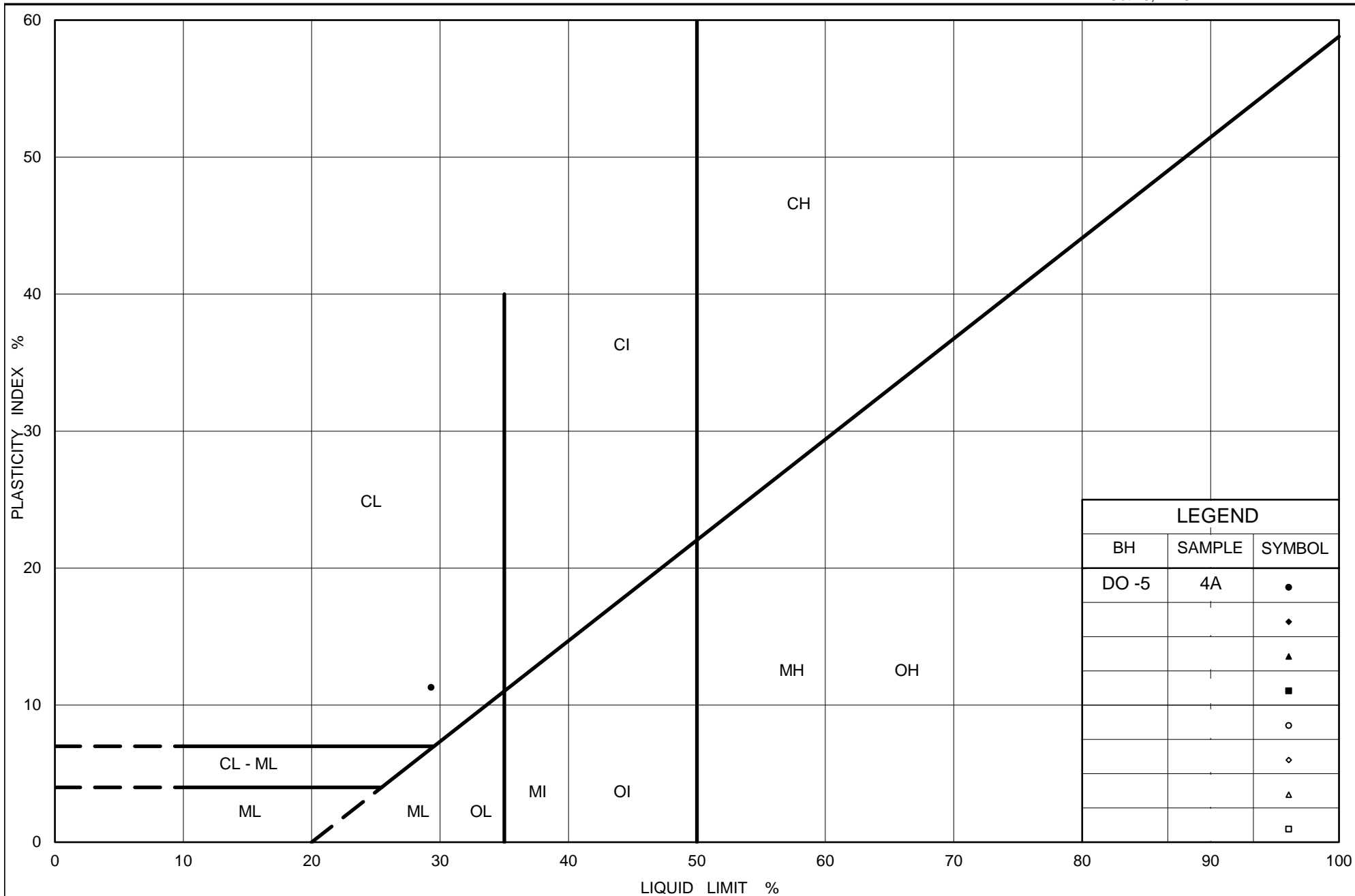
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	NW6-1	5A	102.9

Project Number: 1530382

Checked By: MWK

Golder Associates

Date: 16-Aug-17



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt (Residual Soil)

Figure No. C4

Project No. 1530382

Checked By: MWK

4.09 m




6.09 m

6.09 m



7.62 m

PROJECT		FOUNDATION REPORT	
		QEW - DIXIE ROAD UNDERPASS BRIDGE REPLACEMENT, GWP 2102-13-00 & 2432-13-00 SITE 24-193	
TITLE		BEDROCK CORE PHOTOGRAPHS – DO-3	
		PROJECT No. 1530382	FILE No. ----
		DESIGN MWK	SCALE NTS
		CADD --	REV.
		CHECK	
		REVIEW JMAC	FIGURE C5

September 15, 2016

Ms. Sandra McGaghran
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS Testing of shale sample - Golder Associates Project No. 1530382

Dear Ms. McGaghran:

On September 9, 2016 two (2) NQ-sized core samples were received by Geomechanica Inc. via drop-off. These samples were identified as shale from a drilling investigation near the QEW and Dixie Rd. in Mississauga, Ontario. One (1) uniaxial compressive strength (UCS) test specimen was prepared and tested from one of the two samples. The second sample was retained as a spare.

Details regarding the steps of specimen preparation and testing along with the test results and photographs of test specimen before and after testing are presented in the accompanying laboratory report.

Sincerely,



Giovanni Grasselli Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: giovanni.grasselli@geomechanica.com

Rock Laboratory Testing Results

A report submitted to:

Ms. Sandra McGaghran
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

Bryan Tatone, PhD
Omid Mahabadi, PhD
Giovanni Grasselli, PhD, PEng
Geomechanica Inc
#900-390 Bay St
Toronto ON
M5H 2Y2 Canada
Tel: +1-647-478-9767
info@geomechanica.com

September 15, 2016

Project number: 1530382

Abstract

This document summarizes the results of Uniaxial Compressive Strength (UCS) testing of 1 rock core sample for Golder Associates Ltd. (Golder Project No. 1530382). The sample was identified as shale from a drilling investigation near the QEW and Dixie Rd. in Mississauga Ontario. The results, including the tabulated values of the UCS, bulk density, and elastic modulus along with photos of the test specimen before and after testing, are presented herein.

In this document:

1	Uniaxial Compressive Strength (UCS) Testing	1
---	---------------------------------------------	---

1 Uniaxial Compressive Strength (UCS) Testing

1.1 Introduction

This section summarizes the results of UCS testing of a core sample of shale received by Geomechanica from Golder Associates Ltd. (Golder Project No. 1530382). The test was performed in Geomechanica's rock testing laboratory in Vaughan, Ontario using a 150 ton Forney loading frame equipped with pressure-compensated control valve to maintain an axial strain rate of approximately $1.3 \times 10^{-5} \text{ s}^{-1}$ (Figure 1). The specimen preparation and testing procedure included the following:

1. Unwrapping of the core sample, inspecting it for damage, and re-wrapping it in electrical tape to maintain the moisture content, avoid damage during handling, and minimize exposure to moisture during specimen preparation.
2. Diamond sawing the core sample to length such that a cylindrical specimen with a length:diameter ratio of approximately 2:1 and nearly parallel end faces was obtained.
3. Surface grinding of specimens to obtain flat and parallel end faces within $\pm 0.05 \text{ mm}$.
4. Loading the specimen into a stiff hydraulic loading frame and applying a small axial load of 0.1-0.2 kN to allow removal of the electrical tape and subsequently loading the specimen to rupture while recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E).



Figure 1: Equipment setup for measuring Uniaxial Compression Strength (UCS).

1.2 Results

The results of UCS testing are summarized in Table 1. The corresponding stress-strain curve is shown in Figure 2. The Young's modulus value presented in Table 1 represents the tangent modulus, calculated as the slope of the best fit line through ± 300 data points on either side of the point representing 50% of the UCS, unless noted otherwise.

Table 1: Summary of UCS test results.

Borehole	Depth	Bulk density, ρ (g/cm ³)	UCS (MPa)	Elastic modulus, E (MPa)
BH-DO-3	6.79 - 6.94	2.64	5.5	302

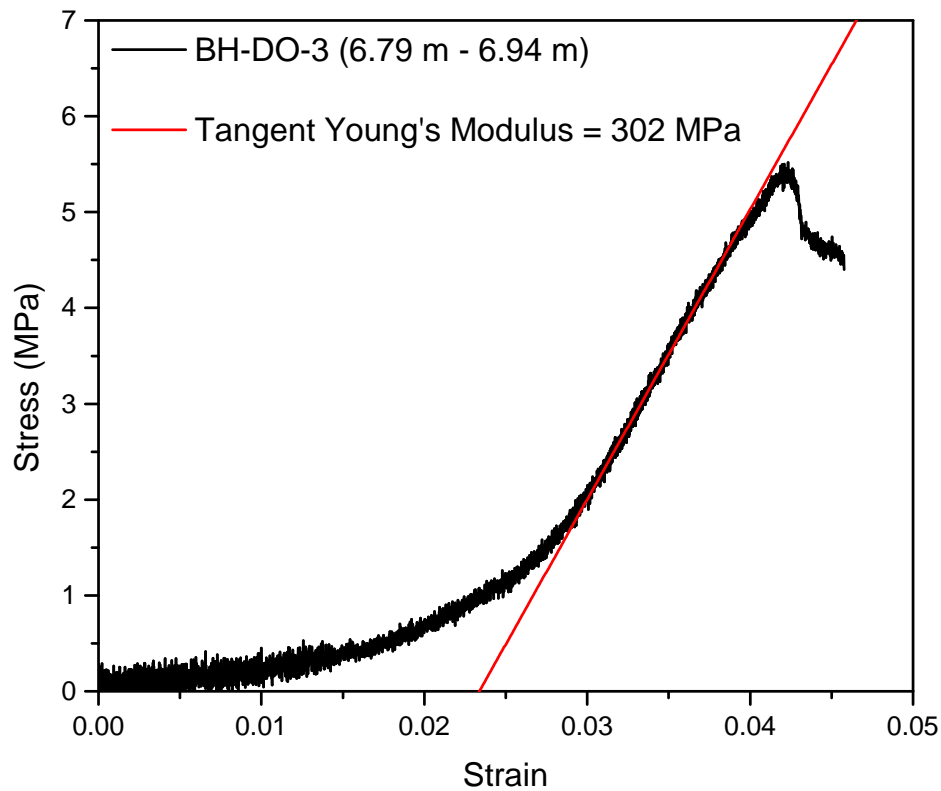
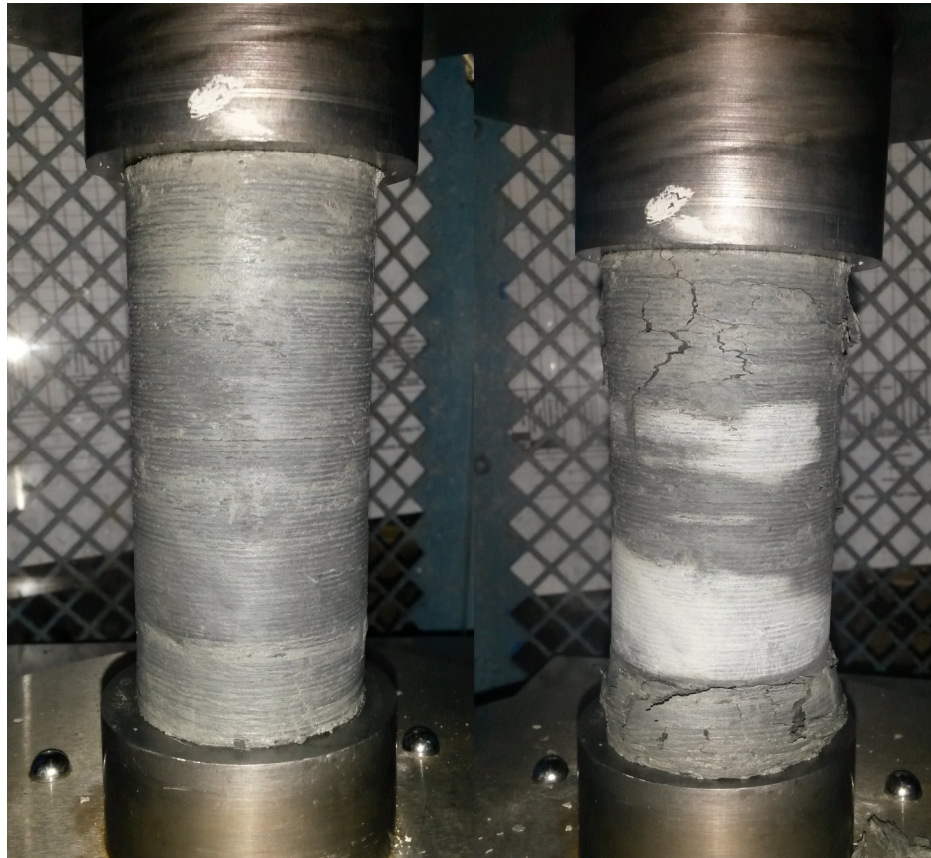


Figure 2: Measured stress-strain curve.

1.3 Specimen photographs

Photographs of the specimens before and after testing are presented in Figure 3.



BH-DO-3 6.79 m – 6.94 m
Pre-test

BH-DO-3 6.79 m – 6.94 m
Post-test

Figure 3: Photographs of UCS test specimen before and after testing. Note that the sub-horizontal lineations visible on the specimen are from the electrical tape used to protect the sample. That is, they do not reflect natural rock structure.

July 18, 2016

Ms. Sandra McGaghran
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS Testing of shale sample - Golder Associates Project No. 1530382

Dear Ms. McGaghran:

On July 12, 2017 one (1) HQ-sized core samples were received by Geomechanica Inc. via drop-off. These samples were identified as shale from a drilling investigation for Golder project 1530382 in Mississauga, Ontario. One (1) uniaxial compressive strength (UCS) test specimen was prepared and tested.

Details regarding the steps of specimen preparation and testing along with the test results and photographs of the test specimen before and after testing are presented in the accompanying laboratory report.

Sincerely,



Giovanni Grasselli Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: giovanni.grasselli@geomechanica.com

Rock Laboratory Testing Results

A report submitted to:

Ms. Sandra McGaghran
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

Bryan Tatone, PhD
Omid Mahabadi, PhD
Giovanni Grasselli, PhD, PEng
Geomechanica Inc
#900-390 Bay St
Toronto ON
M5H 2Y2 Canada
Tel: +1-647-478-9767
info@geomechanica.com

July 18, 2017

Project number: 1530382

Abstract

This document summarizes the results of Uniaxial Compressive Strength (UCS) testing of 1 rock core sample for Golder Associates Ltd. (Golder Project No. 1530382). The results, including the tabulated values of the UCS, bulk density, and elastic modulus along with photos of the test specimen before and after testing, are presented herein.

In this document:

1	Uniaxial Compressive Strength (UCS) Testing	1
---	---------------------------------------------	---

1 Uniaxial Compressive Strength (UCS) Testing

1.1 Introduction

This section summarizes the results of UCS testing of a core sample of shale received by Geomechanica from Golder Associates Ltd. (Golder Project No. 1530382). The test was performed in Geomechanica's rock testing laboratory in Oakville, Ontario using a 150 ton Forney loading frame equipped with pressure-compensated control valve to maintain an axial strain rate of approximately $1.5 \times 10^{-5} \text{ s}^{-1}$ (Figure 1). The specimen preparation and testing procedure included the following:

1. Unwrapping of the core sample, inspecting it for damage, and re-wrapping it in electrical tape to maintain the moisture content, avoid damage during handling, and minimize exposure to moisture during specimen preparation.
2. Diamond cutting of the core sample to length such that a cylindrical specimen with a length:diameter ratio of approximately 2:1 and nearly parallel end faces was obtained.
3. Surface grinding the specimens to obtain flat (within $\pm 0.025 \text{ mm}$) and parallel end faces (within 0.25°).
4. Loading the specimen into a stiff hydraulic loading frame and applying a small axial load of 0.5 kN to allow removal of the electrical tape and subsequently loading the specimen to rupture while recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E).

1.2 Results

The results of UCS testing are summarized in Table 1. The corresponding stress-strain curve is shown in Figure 2. The Young's modulus value presented in Table 1 represents the tangent modulus, calculated as the slope of the best fit line through ± 300 data points on either side of the point representing 50% of the UCS, unless noted otherwise.

Table 1: Summary of UCS test results.

Borehole	Depth	Bulk density, $\rho \text{ (g/cm}^3\text{)}$	UCS (MPa)	Elastic modulus, E (GPa)
BH-DO-2	9.13 - 9.27	2.59	13.1	1.01

1.3 Specimen photographs

Photographs of the test specimen before and after testing are shown in Figure 3.



Figure 1: Equipment setup for measuring Uniaxial Compression Strength (UCS).

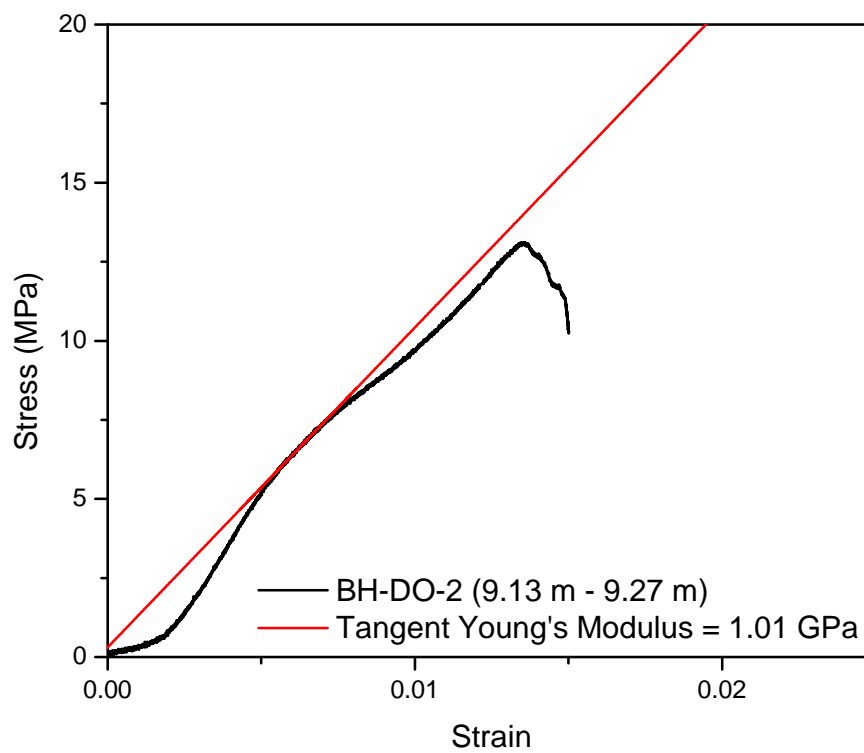


Figure 2: Measured stress-strain curve.

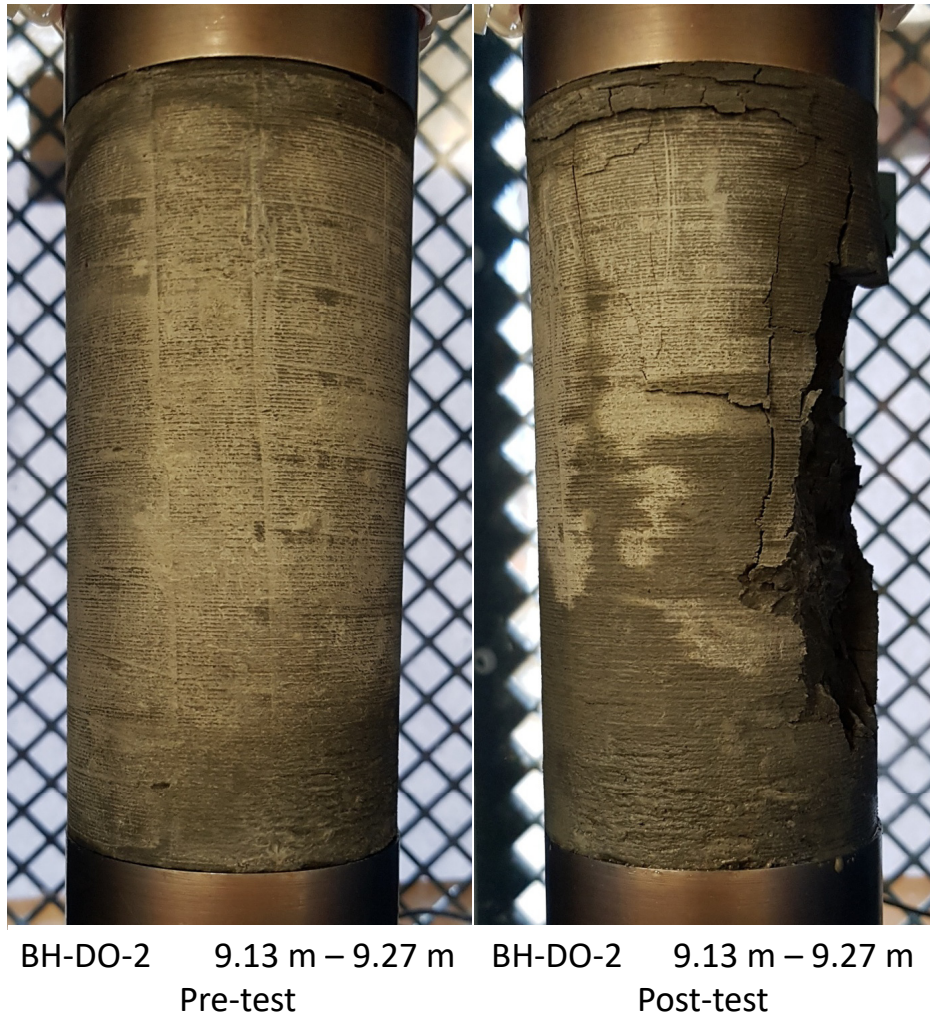


Figure 3: Photographs of UCS test specimen before and after testing. Note that the sub-horizontal lineations visible on the specimen are from the electrical tape used to protect the sample. That is, they do not reflect natural rock structure.

Your Project #: 1530382
Site Location: QEW/CAWTHRA
Your C.O.C. #: 76779

Attention: Alysha Kobylinski

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

Report Date: 2016/12/09
Report #: R4281717
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6Q3878
Received: 2016/12/03, 15:03

Sample Matrix: Soil
Samples Received: 2

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride (20:1 extract)	2	N/A	2016/12/09	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2016/12/09	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2016/12/07	2016/12/07	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2016/12/03	2016/12/09	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	2	N/A	2016/12/09	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

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.

Your Project #: 1530382
Site Location: QEW/CAWTHRA
Your C.O.C. #: 76779

Attention: Alysha Kobylinski

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

Report Date: 2016/12/09
Report #: R4281717
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B6Q3878
Received: 2016/12/03, 15:03

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

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

RESULTS OF ANALYSES OF SOIL

Maxxam ID		DOL198	DOL198		DOL199		
Sampling Date		2016/11/07	2016/11/07		2016/11/07		
COC Number		76779	76779		76779		
	UNITS	DO- 4 - SA4 -2.29M-2.90M	DO- 4 - SA4 -2.29M-2.90M Lab-Dup	RDL	DO-5- SA2 -1.52M-2.13M	RDL	QC Batch

Calculated Parameters							
Resistivity	ohm-cm	1200			440		4777837
Inorganics							
Soluble (20:1) Chloride (Cl)	ug/g	450	390	20	1300	40	4784297
Conductivity	umho/cm	828		2	2250	2	4784499
Available (CaCl2) pH	pH	8.14			8.10		4782348
Soluble (20:1) Sulphate (SO4)	ug/g	61	54	20	27	20	4784302
RDL = Reportable Detection Limit							
QC Batch = Quality Control Batch							
Lab-Dup = Laboratory Initiated Duplicate							

Maxxam Job #: B6Q3878
Report Date: 2016/12/09

Golder Associates Ltd
Client Project #: 1530382
Site Location: QEW/CAWTHRA
Sampler Initials: AK

TEST SUMMARY

Maxxam ID: DOL198
Sample ID: DO- 4 - SA4 -2.29M-2.90M
Matrix: Soil

Collected: 2016/11/07
Shipped:
Received: 2016/12/03

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4784297	N/A	2016/12/09	Deonarine Ramnarine
Conductivity	AT	4784499	N/A	2016/12/09	Tahir Anwar
pH CaCl2 EXTRACT	AT	4782348	2016/12/07	2016/12/07	Surinder Rai
Resistivity of Soil		4777837	2016/12/09	2016/12/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4784302	N/A	2016/12/09	Alina Dobreanu

Maxxam ID: DOL198 Dup
Sample ID: DO- 4 - SA4 -2.29M-2.90M
Matrix: Soil

Collected: 2016/11/07
Shipped:
Received: 2016/12/03

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4784297	N/A	2016/12/09	Deonarine Ramnarine
Sulphate (20:1 Extract)	KONE/EC	4784302	N/A	2016/12/09	Alina Dobreanu

Maxxam ID: DOL199
Sample ID: DO-5- SA2 -1.52M-2.13M
Matrix: Soil

Collected: 2016/11/07
Shipped:
Received: 2016/12/03

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	4784297	N/A	2016/12/09	Deonarine Ramnarine
Conductivity	AT	4784499	N/A	2016/12/09	Tahir Anwar
pH CaCl2 EXTRACT	AT	4782348	2016/12/07	2016/12/07	Surinder Rai
Resistivity of Soil		4777837	2016/12/09	2016/12/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	4784302	N/A	2016/12/09	Alina Dobreanu

GENERAL COMMENTS

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

Package 1	12.7°C
-----------	--------

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1530382
Site Location: QEW/CAWTHRA
Sampler Initials: AK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
4782348	Available (CaCl ₂) pH	2016/12/07			99	97 - 103			0.48	N/A
4784297	Soluble (20:1) Chloride (Cl)	2016/12/09	NC	70 - 130	103	70 - 130	<20	ug/g	14	35
4784302	Soluble (20:1) Sulphate (SO ₄)	2016/12/09	NC	70 - 130	105	70 - 130	<20	ug/g	NC	35
4784499	Conductivity	2016/12/09			100	90 - 110	<2	umho/cm	2.5	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.

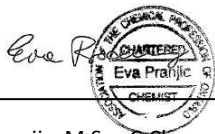
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of 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 (one or both samples < 5x RDL).

VALIDATION SIGNATURE PAGE

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



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

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

CHAIN OF CUSTODY RECORD

76779

Page 1 of 1

[illegible]

Your Project #: 1530382
Site Location: QEW/DIXIE
Your C.O.C. #: na

Attention: Sandra McGaghran

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

Report Date: 2017/07/13
Report #: R4596038
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7E2708

Received: 2017/07/06, 16:30

Sample Matrix: ROCK
Samples Received: 1

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride (20:1 extract)	1	N/A	2017/07/12	CAM SOP-00463	EPA 325.2 m
Conductivity	1	N/A	2017/07/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2017/07/12	2017/07/12	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2017/07/07	2017/07/12	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	1	N/A	2017/07/12	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

Results relate to samples tested.

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.

Your Project #: 1530382
Site Location: QEW/DIXIE
Your C.O.C. #: na

Attention:Sandra McGaghran

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

Report Date: 2017/07/13
Report #: R4596038
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7E2708
Received: 2017/07/06, 16:30

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

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

Maxxam Job #: B7E2708
Report Date: 2017/07/13

Golder Associates Ltd
Client Project #: 1530382
Site Location: QEW/DIXIE
Sampler Initials: AK

RESULTS OF ANALYSES OF ROCK

Maxxam ID		ERW232		
Sampling Date		2017/06/15		
COC Number		na		
	UNITS	DO-2-4.19M-4.30M	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	3500		5062825
Inorganics				
Soluble (20:1) Chloride (Cl)	ug/g	28	20	5066879
Conductivity	umho/cm	284	2	5068831
Available (CaCl2) pH	pH	8.02		5067289
Soluble (20:1) Sulphate (SO4)	ug/g	110	20	5066944
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				

Maxxam Job #: B7E2708
Report Date: 2017/07/13

Golder Associates Ltd
Client Project #: 1530382
Site Location: QEW/DIXIE
Sampler Initials: AK

TEST SUMMARY

Maxxam ID: ERW232
Sample ID: DO-2-4.19M-4.30M
Matrix: ROCK

Collected: 2017/06/15
Shipped:
Received: 2017/07/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5066879	N/A	2017/07/12	Deonarine Ramnarine
Conductivity	AT	5068831	N/A	2017/07/12	Xuanhong Qiu
pH CaCl2 EXTRACT	AT	5067289	2017/07/12	2017/07/12	Tahir Anwar
Resistivity of Soil		5062825	2017/07/12	2017/07/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5066944	N/A	2017/07/12	Deonarine Ramnarine

GENERAL COMMENTS

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

Package 1	7.0°C
-----------	-------

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1530382
Site Location: QEW/DIXIE
Sampler Initials: AK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5066879	Soluble (20:1) Chloride (Cl)	2017/07/12	107	70 - 130	103	70 - 130	<20	ug/g	NC	35
5066944	Soluble (20:1) Sulphate (SO4)	2017/07/12	NC	70 - 130	108	70 - 130	<20	ug/g	5.1	35
5067289	Available (CaCl2) pH	2017/07/12			100	97 - 103			0.27	N/A
5068831	Conductivity	2017/07/12			100	90 - 110	<2	umho/cm	2.2	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).

VALIDATION SIGNATURE PAGE

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

Cristina Carriere

Cristina Carriere, Scientific Services

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.

Invoice Information		Report Information (If differs from Invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required	
Company Name:	GOLDER ASSOCIATES	Company Name:	GOLDER ASSOCIATES	Quotation #:		<input checked="" type="checkbox"/> Regular TAT (5-7 days) Most analyses	
Contact Name:	Alysha Kobylinski	Contact Name:	SANDRA MCGAGHRAN	P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
Address:	6925 CENTURY AVE, SUITE #100 MISSISSAUGA, ON	Address:	6925 CENTURY AVE, SUITE #100 MISSISSAUGA, ON	Project #:	1530382	Rush TAT (Surcharges will be applied)	
Phone:	905 567 4444 Fax: 905 567 6561	Phone:	905 567 4444 Fax: 905 567 6561	Site Location:	QEW/DIXIE	<input type="checkbox"/> 1 Day <input type="checkbox"/> 2 Days <input type="checkbox"/> 3-4 Days	
Email:	akobylinski@golder.com	Email:	sandra.mcgaighran@golder.com	Site #:		Date Required:	
MCE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY				Sampled By:		Rush Confirmation #:	
Regulation 153 <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Med/ Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/ Other <input type="checkbox"/> Table _____ FOR RSC (PLEASE CIRCLE) Y / N		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> MISA <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> PWQO <input type="checkbox"/> Region <input type="checkbox"/> Other (Specify) <input type="checkbox"/> REG 558 (MIN. 3 DAY TAT REQUIRED)		Analysis Requested REFER TO BACK OF COC REG 153 METALS & INORGANICS REG 153 ICPMs METALS REG 153 METALS (Hg, Cr VI, ICPMs Metals, HWS, B) CORROSIVITY PACKAGE		LABORATORY USE ONLY CUSTODY SEAL Y / N Present Intact 7/7/7 COOLING MEDIA PRESENT: <input checked="" type="checkbox"/> Y / N	
Include Criteria on Certificate of Analysis: Y / N		SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM		HOLD- DO NOT ANALYZE		COMMENTS	
SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH-MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTX/ PHC F1	PHCS F2 - F4
1 DO-Z-4.19m-4.30m	2017/06/15	AM	ROCK	1			
2							
3							
4							
5							
6							
7							
8							
9							
10							
RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH-MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH-MM)		
Alysha Kobylinski	2017/07/06	4:10 AM	[Signature]	2017/07/06	16:30		

07-Jul-17 16:30

Ema Gitej



B7E2708

MNI ENV-1196

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario, L5N 7K2
Canada
T: +1 (905) 567 4444

