Foundation Investigation Report

Sanitary Sewer Installation at Station 16+560, QEW Widening from West of Mississauga Road to West of Hurontario Street, Mississauga, Ontario
Ministry of Transportation, Ontario, GWP 2002-13-00

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the sanitary sewer installation at Station 16+560, associated with the widening of the Queen Elizabeth Way (QEW) from Knareswood Drive to the north side of the QEW (south of Mississauga Crescent), at the location shown on the Key Plan Drawing 1.

The purpose of the foundation investigation is to explore the subsurface soil, bedrock and groundwater conditions along the alignment of the proposed sanitary sewer installation by borehole drilling, bedrock coring, geotechnical laboratory testing and analytical chemistry laboratory testing on selected soil and bedrock samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated July 2016, and the approved Change Request letters, which form part of the Consultant's Assignment Number (2015-E-0033) 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 February 3, 2017.

2.0 SITE DESCRIPTION

The proposed sanitary sewer installation at Station 16+560 is located approximately 300 m east of the Mississauga Rd. underpass, and 250 m west of the Credit River in the City of Mississauga, Ontario (see Drawing 1). The sanitary sewer installation extends from approximately 50 m north of the existing QEW noise barrier wall, north of the QEW to approximately 20 m south of the Kedleston Way and Knarewood Dr. intersection south of the QEW. The QEW is oriented in a northeast-southwest direction at this location which, for the purpose of this report, is referred to as west-east orientation.

The QEW consists of three eastbound lanes (to Toronto) and three westbound lanes (to Hamilton), while Kedleston Way and Knareswood Drive consists of one lane in each direction. Residential areas are located on the south side of the QEW and at Mississauga Crescent located north of the QEW, and at Kedleston Way and Knareswood Drive, located south of the QEW. The existing ground surface along the alignment of the sanitary sewer varies from about Elevation 97.2 m at the north end, about Elevation 94.3 m at the Multi-Use Path, and between about Elevations 96.5 m and 96.0 m from the north side of the proposed QEW westbound lanes to the south side of the existing QEW.

3.0 INVESTIGATION PROCEDURES

Field work was carried out between February 20 to March 1, 2019, during which time a total of four sampled boreholes, designated as Boreholes C3-1, C3-2, C3-3 and C3-4, were advanced along or adjacent to the proposed sanitary sewer alignment approximately at the locations shown on Drawing 1. This information was supplemented with Boreholes NW5-4 and OHS-4 which were advanced on July 12 and September 6, 2018, respectively. Borehole NW5-4 was advanced for the proposed Noise Barrier Wall, and OHS-4 was advanced near a proposed overhead sign support.

Field drilling was carried out using a truck-mounted CME 75 drilling rig and a track-mounted CME 55 drilling rig supplied and operated by Davis Drilling Ltd., of Milton, Ontario, a truck-mounted CME 75 drilling rig supplied and operated by Geo-Environmental Drilling Inc., of Halton Hills, Ontario, and a truck-mounted CME 55 drilling rig

supplied and operated by Aardvark Drilling Inc., of Guelph, Ontario. Borehole OHS-4 was advanced using a Portable Tripod drilling rig and a manual hammer drive system supplied and operated by Walker Drilling Ltd., of Utopia, Ontario. With the exception of Borehole OHS-4, the boreholes were advanced through the overburden using 83 mm, 114 mm and 108 mm inside diameter (I.D.) hollow-stem augers. Borehole OHS-4 was advanced with NW-size casing throughout the overburden and a NQ core barrel through the bedrock. Soil samples were obtained at 0.60 m, 0.75 m and 1.5 m intervals of depth, using a 50 mm O.D. split-spoon sampler driven by an automatic hammer (in Boreholes C3-1 to C3-4 and NW5-4) or a manual hammer (in Borehole OHS-4) in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-11)[1]. Samples of the bedrock were obtained using an 'HQ' size rock core barrel and coring techniques in all boreholes, with the exception of Borehole OHS-4, in which samples of bedrock were obtained using an 'NQ' size rock core barrel. The boreholes were advanced to depths between 5.6 m and 9.4 m below existing ground surface, including coring of bedrock for core lengths of between 3.6 m and 7.2 m in Boreholes C3-1 to C3-4, OHS-4 and NW5-4.

Groundwater conditions and water levels in the open boreholes were observed during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole C3-3 to permit monitoring of the water level at the borehole location. The installed piezometer consists of a 50 mm diameter PVC pipe, with a slotted screen. The annulus surrounding the piezometer screen was backfilled with a filter sand pack. The section of the borehole below the standpipe piezometer screen was backfilled with bentonite to the underside of the sand pack level, and the remainder of the borehole above the sand pack was backfilled with bentonite to near the ground surface and topped with cold patch asphalt or sand and gravel to match the adjacent ground surface material. All boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903 Wells (as amended).

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, logged the boreholes, and examined and cared for the soil and rock samples. 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 soil laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits, grain size distribution and organic content) was carried out on selected soil samples.

Selected bedrock core samples were submitted to Geomechanica Inc. of Toronto, Ontario for Unconfined Compression (UC) testing, assessment of Young's modulus and bulk density, as well as Cerchar abrasivity testing and slake durability testing. Rock core specimens were also submitted to Western University in London, Ontario for a suite of swell testing, which includes free swell, null swell and semi-confined, with accompanying moisture, salt, and calcite content testing; however, due to the long duration of the test(s), the results are not available for this reporting stage.

Selected bedrock core samples were submitted to Maxxam Analytics (Maxxam) of Mississauga, Ontario which is a Standards Council of Canada (SCC) accredited laboratory, for chemical analysis of a suite of characteristics including Petroleum Hydrocarbons, CCME F1 and BTEX. Additional bedrock core samples were also analyzed by Maxxam for a suite of characteristics that indicate corrosivity potential including pH, resistivity, conductivity, chloride content and sulphate content.

[1] ASTM D1586-11 – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the soil.

The as-drilled borehole locations and the ground surface elevations were obtained using a GPS (Trimble Geo 7X), having an accuracy of approximately 0.1 m in the vertical and 0.1 m in the horizontal directions. The locations given on the Record of Borehole/Drillhole sheets and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) CSRS CBNV6-2010.0 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, geographic coordinates, ground surface elevations and drilled depths are summarized below.

Borehole No.	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude)	Easting (Longitude)		
C3-1	4,823,858.0 (43.554603)	295,751.1 (-79.612001)	96.6	9.0 (including 6.23 m of bedrock core)
C3-2	4,823,846.8 (43.554503)	295,790.1 (-79.611518)	96.6	9.3 (including 7.17 m of bedrock core)
C3-3	4,823,854.5 (43.554573)	295,834.5 (-79.610969)	95.7	9.4 (including 6.69 m of bedrock core)
C3-4	4,823,830.8 (43.554358)	295,725.0 (-79.612324)	95.4	7.0 (including 5.43 m of bedrock core)
OHS-4	4,823,828.9 (43.554333)	295,734.3 (-79.612205)	97.3	5.6 (including 3.83 m of bedrock core)
NW5-4	4,823,869.2 (43.554705)	295,818.3 (-79.611169)	96.3	6.8 (including 3.63 m of bedrock core)

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 sand, silt and gravel, with a shallow cover of till remaining over the bedrock.

The Georgian Bay Formation bedrock, which 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.

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

4.2 Subsurface Conditions

Subsurface soil, bedrock and groundwater conditions as encountered in the boreholes, details of the piezometer installation and water level readings, and the results of the geotechnical laboratory tests carried out on selected soil and bedrock core samples are presented on the Record of Borehole and Drillhole sheets provided in Appendix A. Photographs of the recovered bedrock core samples are presented on Figures A-1 to A-6, in Appendix A. The results of in-situ field tests (i.e., SPT “N”-values) as presented on the Record of Borehole sheets and in sub-sections of Section 4.2 are uncorrected. Lists on abbreviations and symbols and lithological, geotechnical rock description terminology, field estimation of rock hardness and rock weathering classification are also included in Appendix A to assist in the interpretation of the borehole and drillhole records. The results of the geotechnical laboratory testing on the soil and bedrock samples are presented in Appendix B. The analytical laboratory test report is included in Appendix C and the test results are summarized in Section 4.2.8.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profile on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of the 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 governs any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

In general, the stratigraphy encountered at the various borehole locations typically consists of surficial layers of asphalt / concrete pavement or topsoil underlain by fill, underlain by a cohesive clayey silt to sandy silty clay to silty clay deposit, in turn underlain by shale bedrock. Detailed descriptions of the subsurface conditions are provided in the following sections of this report. Where relatively significant thicknesses of overburden were encountered, the various soil types are described in detail for each main deposit.

4.2.1 Asphalt / Concrete Pavement

An approximately 340 mm thick layer of asphalt pavement was encountered at ground surface in Borehole C3-2. A 220 mm thick layer of concrete was encountered underlying the asphalt pavement at Borehole C3-2, and a 610 mm thick layer of concrete was encountered at ground surface in Borehole NW5-4.

4.2.2 Topsoil

An approximately 300 mm and 690 mm thick layer of topsoil was encountered at ground surface in Boreholes OHS-4 and C3-1, respectively. A Standard Penetration Test (SPT) “N”-values measured within the topsoil in Borehole C3-1 was 5 blows per 0.3 m of penetration, suggesting a firm consistency.

4.2.3 Fill

An approximately 0.3 m to 1.2 m thick layer of fill comprised of silt and sand to sand to gravelly sand to gravel, containing trace to some silt, trace to some clay, was encountered at ground surface in Boreholes C3-3 and C3-4, underlying the topsoil in Borehole OHS-4, and underlying the asphalt and/or concrete in Boreholes C3-2 and NW5-4 at depths of between ground surface and 0.6 m below ground surface (between Elevation 97.0 m and Elevation 95.4 m). The fill extends to depths of between about 0.7 m to 1.7 m below ground surface (between Elevations 96.6 m to 94.4 m). Within the fill layer in Borehole C3-2 a hydrocarbon odour was noted.

The Standard Penetration Test (SPT) “N”-values measured within the fill layer range from 6 blows per 0.3 m to penetration to 82 blows per 0.25 m of penetration, suggesting a loose to very dense compactness condition.

Grain size distribution testing was carried out on three samples of the fill layers and the results are shown on Figure B-1 in Appendix B.

The water content measured on five samples of the fill ranges from about 6 per cent to about 21 per cent.

4.2.4 Silt and Sand

A 0.7 m thick deposit of silt and sand containing trace clay and trace organics was encountered underlying the fill in Borehole C3-2 at a depth of about 0.9 m below ground surface (Elevation 95.7 m) and extends to Elevation 95.0 m.

The SPT “N”-value measured within the silt and sand deposit is 7 blows per 0.3 m of penetration, indicating a loose compactness condition.

Grain size distribution testing was carried out on one sample of the deposit and the results are shown on Figure B-2 in Appendix B.

The water content measured on one sample of the deposit was about 27 per cent. Organic content testing was carried out on a sample of the silt and sand deposit and measured an organic content of about 3.0 per cent.

4.2.5 Clayey Silt to Silty Clay

An approximately 0.5 m to 0.6 m thick cohesive deposit comprised of clayey silt to sandy silty clay to silty clay, some sand, trace to some gravel was encountered underlying the topsoil in Borehole C3-1 and the fill in Boreholes C3-3 and NW5-4. Trace organics were encountered within the till deposit in Borehole NW5-4. The surface of the deposit was encountered at depths of between 0.7 m and 1.7 m below ground surface (between Elevations 95.9 m and 94.5 m) and extends to depths of between 1.2 m and 2.3 m below ground surface (between Elevations 95.4 m and 93.9 m).

The SPT “N”-values measured within the cohesive deposit range from 6 blows to 18 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

Grain size distribution testing was carried out on three samples of the cohesive deposit and the results are shown on Figure B-3 in Appendix B. Atterberg testing was carried out on three samples of the cohesive deposit and measured liquid limits between about 32 per cent and 43 per cent, plastic limits between about 19 per cent and 20 per cent, and plasticity indices between about 12 per cent and 22 per cent. These results, which are plotted on a plasticity chart on Figure B-4 in Appendix B, indicate that the cohesive deposit consists of clayey silt of low plasticity to silty clay of medium plasticity.

The water content measured on four samples of the cohesive deposit ranges between about 12 per cent and 22 per cent.

4.2.6 Shale Bedrock

The upper portion of the bedrock was sampled by split-spoon and the bedrock was confirmed coring in Boreholes C3-1 to C3-4, OHS-4 and NW5-4. The length of bedrock sampled by split-spooning and by coring and the depths to, and corresponding elevations of, the completely to moderately weathered shale bedrock and the depths to, and corresponding elevations of, the slightly weathered to fresh shale bedrock are summarized below.

Borehole No.	Completely to Moderately Weathered Bedrock		Length of Bedrock Split-Spoon Sampled (m)	Slightly Weathered to Fresh Bedrock		Length of Bedrock Cored (m)
	Depth (m)	Elevation (m)		Depth (m)	Elevation (m)	
C3-1	1.2 – 3.6	95.4 – 93.0	1.5	3.61 – 8.98	92.99 – 87.62	6.23
C3-2	1.6 – 3.9	95.0 – 92.7	0.6	3.86 – 9.33	92.74 – 87.27	7.17
C3-3	1.8 – 3.2	93.9 – 92.5	1.1	3.20 – 9.43	92.50 – 86.27	6.69
C3-4	1.0 – 1.9	94.4 – 93.5	0.6	1.89 – 6.95	93.51 – 88.45	5.43
OHS-4	0.7 – 3.2	96.6 – 94.1	1.0	3.15 – 5.56	94.15 – 91.77	3.83
NW5-4	2.3 - 2.7	94.0 – 93.6	0.9	3.15 – 6.78	93.19 – 89.56	3.63

Inferred Completely to Moderately Weathered Shale

Inferred completely to moderately weathered shale bedrock was encountered at depths ranging from 0.7 m to 2.3 m below ground surface (Elevations 96.6 m to 93.9 m) as inferred based on drilling behaviour, observations of drilling cuttings and split-spoon sampling. The thickness of completely to moderately weathered bedrock is inferred to range from about 0.4 m to 2.5 m.

The SPT “N”-values measured within the the inferred completely to moderately weathered shale bedrock range from 17 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, suggesting a very stiff to hard consistency and blockages of sampling equipment by fragments of rock.

Grain size distribution testing was carried out on one sample of the inferred completely to moderately weathered bedrock obtained by split-spoon sampling and the result is shown on Figure B-5 in Appendix B. The split-spoon samples obtained from within the inferred completely to moderately weathered bedrock do not contain larger fragments of rock due to the sampler size and sampling method. Larger fragments of unweathered shale bedrock may be present in-situ. In addition, the percentage of gravel sized particles may include completely to moderately weathered shale fragments that either remained intact after or were broken during sampling and sample preparation. Therefore, the results of the grain size distribution testing may not be representative of the bulk grain size distribution or behavior of the in-situ or excavated completely to moderately weathered shale bedrock.

Atterberg limits testing was carried out on the finer fractions of one sample of the inferred completely to moderately weathered bedrock and the measured liquid limit was 39 per cent, the plastic limit was 20 per cent, and the corresponding plasticity index was measured at 19 per cent. This result, which is plotted on a plasticity chart on Figure B-6 in Appendix B, indicates that the finer fraction of the inferred completely to moderately weathered shale bedrock, when broken down to a soil consists of silty clay of medium plasticity.

The water content measured on five samples of the inferred completely to moderately weathered shale bedrock range between about 8 per cent and 16 per cent.

Moderately Weathered to Fresh Shale

Based on a review of the recovered bedrock core samples, the bedrock consists of shale of the Georgian Bay Formation. In general, the bedrock core samples are described as moderately weathered to fresh, thinly laminated to medium bedded, very fine to fine grained, faintly porous, very weak to weak, grey, shale with slightly

weathered to fresh, laminated to medium bedded, grey, fine grained, medium strong to very strong limestone interbeds at varying intervals of depth as presented on the drillhole records. The strong limestone layers within the moderately weathered to fresh shale range in thickness from about 10 mm to 430 mm, with an average thickness of about 70 mm. The rock core samples obtained during the drilling investigation contain less than 5 per cent to up to 60 per cent stronger limestone layers (based on the percentage of limestone in a core run). Details of the bedrock descriptions are presented on the drillhole records and a photograph of the recovered bedrock core samples is presented on Figures A-1 to A-6 in Appendix A. The degree of weathering of the bedrock core samples (i.e., fresh to moderately weathered – W1 to W3), and the strength classification of the intact rock mass based on field identification (i.e., very weak to weak – R1 to R2) are described in accordance with the International Society for Rock Mechanics (ISRM[3]) standard classification system.

The Rock Quality Designation (RQD) measured on the core samples ranges from about 50 per cent to 100 per cent, indicating that the moderately weathered to fresh portion of the rock mass consists of fair to excellent quality as per Table 3.10 of CFEM (2006)[4], with the exception of Run #1 in Borehole C3-3 and Runs #1 to #4 in Borehole OHS-4, in which the RQD measured on the core samples ranges from 0 per cent to 35 percent, indicating a rock mass of very poor to poor quality (CFEM, 2006). The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered range between 43 per cent and 100 per cent and between 0 per cent and 100 per cent, respectively.

Unconfined Compression (UC) testing (ASTM D7012)[5] was carried out on three selected core samples of the shale bedrock and the uniaxial compressive strength (UCS), bulk density and Young's moduli of the intact samples are summarized below and the details are presented in the Rock Laboratory Test Results report from Geomechanica in Appendix B. The UCS of intact shale rock specimens ranges from 16.6 MPa to 17.6 MPa, with an average of about 17.2 MPa. A single limestone bedrock core specimen was also tested with a UCS test results of 196 MPa which is classified as very strong rock (R5, 100 MPa < UCS < 250 MPa). Based on the range of laboratory UCS test results on the shale bedrock core samples, in accordance with Table 3.5 in CFEM (2006)[4], the shale bedrock is classified as weak rock (R2, 5 MPa < UCS < 25 MPa).

Borehole No. / Sample No.*	Sample Depth (m)	Sample Elevation (m)	UCS (MPa)	Young's Modulus, E at 2.5 MPa (GPa)	Young's Modulus, E at 50% UCS (GPa)	Density (g/cm^3)	Rock Type
C3-3 / SA-02	6.18 – 6.38	89.52 – 89.32	16.6	1.7	0.8	2.598	Shale
C3-4 / SA-01	3.09 – 3.41	92.31 – 91.99	17.6	1.9	0.8	2.601	Shale
C3-4 / SA-02	3.41 – 3.77	91.99 – 91.63	17.3	2.0	0.8	2.594	Shale
NW5-4 / SA-01	5.47 – 5.61	90.23 – 89.19	196.3	--	60.84	2.732	Limestone

NOTE:
* The sample numbers listed above and in the two tables below are related to the samples selected from the rock core and do not correspond to the run number shown on the drillhole sheets.

[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

The results of the slake durability testing carried out on one selected core sample of the shale bedrock obtained in Borehole C3-1 are presented below and in Appendix B.

Borehole No. / Sample No.	Sample Depth (m)	Sample Elevation (m)	Moisture Content (%)	Slake Durability Index (1st Cycle) *Id*1 (%)	Slake Durability Index (2nd Cycle) *Id*2 (%)
C3-1 / SA-01	4.50 – 4.69	92.10 – 91.91	0.82	87.4	74.5

The results of the CERCHAR abrasivity index (CAI) testing carried out on two selected core samples of the shale bedrock obtained in Boreholes C3-2 and C3-3 are presented below and in Appendix B.

Borehole No. / Sample No.	Sample Depth (m)	Sample Elevation (m)	Mean Wear (mm)	CAI	Standard Deviation of CAI	ASTM Classification
C3-2 / SA-03	7.55 – 7.68	89.02 – 88.92	0.023	0.23	0.13	< Very Low
C3-3 / SA-04	7.03 – 7.18	88.67 – 88.52	0.033	0.33	0.17	< Very Low

The swelling potential of the shale bedrock was investigated by conducting a suite of swell tests at Western University (K.Y. Lo Inc.) of London, Ontario. The samples were subjected to either free swell (samples with no applied pressure), semi-confined (confining pressure applied to samples in the direction of the sample axis) or null swell conditions (swelling in the direction of the sample axis was fully restricted and the pressure applied to suppress swelling was measured), in either vertical and horizontal orientations (sample axis perpendicular and along the bedding plane respectively), with accompanying moisture, salt, and calcite content testing.

The tests assessing the swell potential are still underway at the time of this report and will be issued to the MTO under a separate cover.

4.2.7 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are presented on the Records of Boreholes in Appendix A. A standpipe piezometer was installed in Borehole C3-3 to monitor the groundwater level at the borehole location. The water levels measured in the open boreholes and the piezometer are summarized below. 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.

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
C3-1	96.6	Dry	-	March 1, 2019	Dry prior to bedrock coring
C3-2	96.6	Dry	-	February 28, 2019	Dry prior to bedrock coring
C3-3	95.7	4.8	90.9	February 20, 2019	Piezometer sealed into bedrock
		4.7	91.0	March 13, 2019	

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
		4.7	91.0	March 21, 2019	
C3-4	95.4	Dry	-	February 28, 2019	Dry prior to bedrock coring
OHS-4	97.3	Dry	-	September 6, 2018	Dry prior to bedrock coring
NW5-4	96.3	Dry	-	July 12, 2018	Dry prior to bedrock coring

4.2.8 Analytical Testing Results

Selected specimens of the rock core samples from Borehole C3-2 were submitted to Maxxam Analytics (Maxxam), a Standards Council of Canada (SCC) accredited laboratory, of Mississauga, Ontario for chemical analysis of the following parameters: Petroleum Hydrocarbons, CCME F1 and BTEX. As described on the Record of Borehole sheet for Borehole C3-2, a hydrocarbon odour was noted within the fill material.

Borehole No. / Sample No. (Elev., m)	Analyzed Parameters
C3-2 / SA-01 (93.37 – 93.26 m)	Petroleum Hydrocarbons, CCME F1 and BTEX

Two specimens from the bedrock core samples were submitted for analysis of parameters used to assess the potential corrosivity of the site soil to steel and concrete. The Maxxam report is provided in Appendix C and summarized below.

Borehole No.	Borehole C3-1 Run#2 Specimen at Elev. 92.9 m	Borehole C3-3 Run #2 Specimen at Elev. 91.4 m
pH	8.19	8.19
Resistivity (ohm-cm)	3,700	3,800
Electrical Conductivity (umho/cm)	274	266
Chlorides (ug/g)	<20*	<20*
Soluble Sulphates (ug/g)	35	51

Notes:
* Lower than Reportable Detection Limit

5.0 CLOSURE

This report was prepared by Ms. Katelyn Nero, a geotechnical Engineer-In-Training with Golder and reviewed by Ms. Sandra McGaghran, M.Eng., P.Eng., an Associate and Senior Geotechnical Engineer with Golder. Mr. Paul Dittrich, Ph.D., P.Eng., an MTO Foundations Designated Contact and Principal with Golder, conducted a technical and quality control review of the report.

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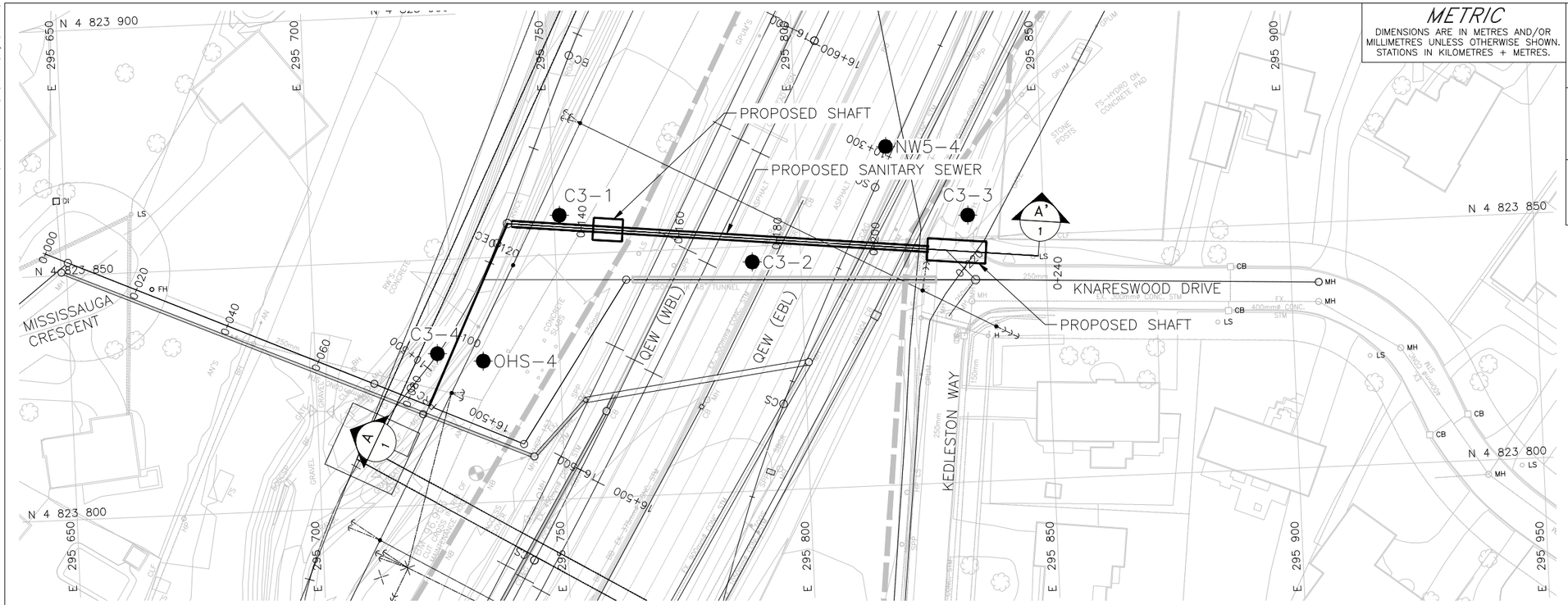
MINISTRY OF TRANSPORTATION, ONTARIO



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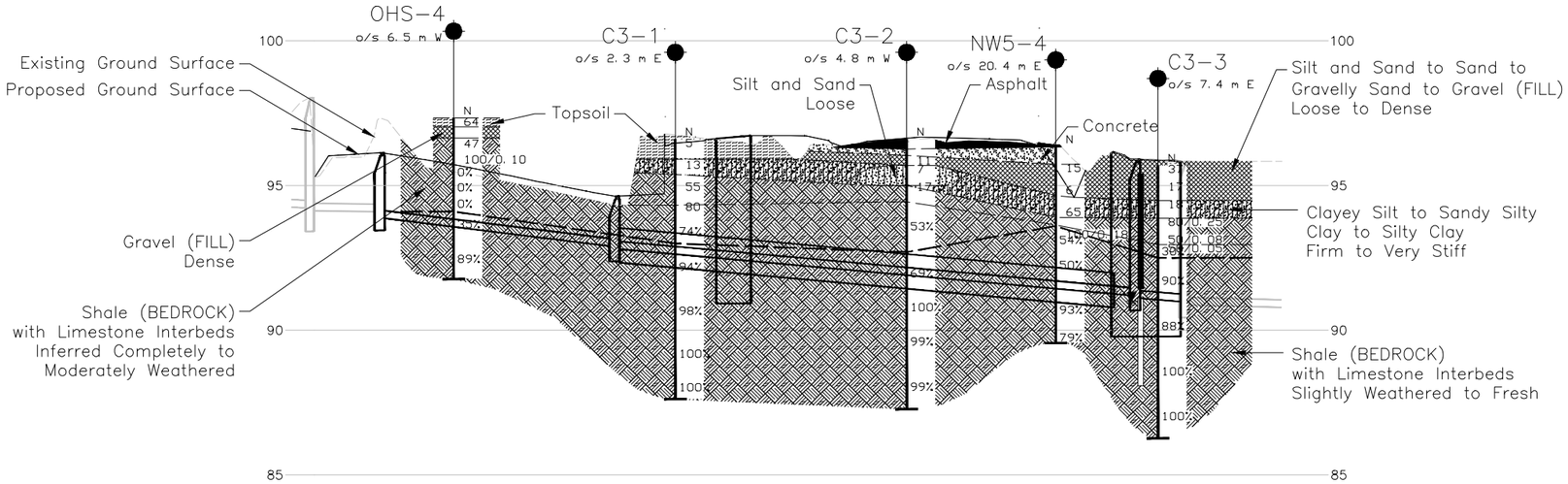
SCALE
10 0 10 20 m



A-A' PROFILE A-A' – SANITARY SEWER STATION 16+560

VERTICAL SCALE
10 0 10 20 m

HORIZONTAL SCALE
10 0 10 20 m

METRIC

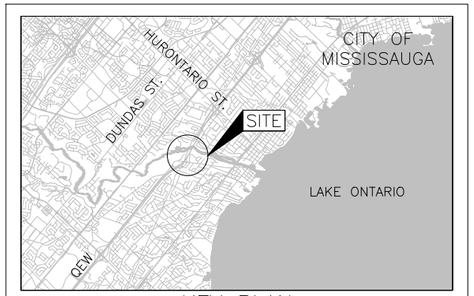
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2002-13-00

QEW WIDENING – MISISSAUGA RD TO HURONTARIO ST
SANITARY SEWER INSTALLATION STATION 16+560
BOREHOLE LOCATIONS PLAN AND SOIL STRATA

SHEET

GOLDER



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole
- 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 MAR 21, 2019
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
C3-1	96.6	4823858.0	295751.1
C3-2	96.6	4823846.8	295790.1
C3-3	95.7	4823854.5	295834.5
C3-4	95.4	4823830.8	295725.0
NW5-4	96.3	4823869.2	295818.3
OHS-4	97.3	4823828.9	295734.3

NOTES

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

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

Borehole C3-4 was advanced through the existing West Multi-Use Trail and is therefore not presented on the soil strata as the trail was cut into the bedrock.

REFERENCE

Base plans provided in digital format by MH, drawing file nos. X11609340Base.dwg, X-Final Merged Util.dwg, X-PROP-UTIL.dwg, Existing Property.dwg, 11609340 – QEW Prop Util-Dickson & Lynchmere – C3D 2017.dwg, 11609340 – QEW Prop Util-IndianGroveAve – C3D 2017.dwg, 11609340 – QEW Prop Util-Stavebank Rd – C3D 2017.dwg, 11609340 – QEW Prop Util-Knareswood Dr – C3D 2017.dwg, and x1160934_Align.dwg, received March 25, 2019.

LICENSED PROFESSIONAL ENGINEER J.P. DITTRICH Jul. 16, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S. McGaghran Jul. 16, 2019 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 30M12-449

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. AB/EJ	CHKD. DM	DATE: 07/31/2019	SITE: .
DRAWN: DD	CHKD. SMM	APPD. JPD	DWG. 1

PLOT DATE: July 31, 2019
FILENAME: S:\Clients\MTO\GEW-Credit_River\PR_PROJ\1662333_MH_P&P\4A_PROD\0022_SS_Relocation_Crossing_2\1662333-0022-BD-0001.dwg

APPENDIX A

Record of Borehole and Drillhole Sheets and Bedrock Core Photographs

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d:

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

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

Description	Bedding Plane Spacing
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

Description	Spacing
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

Term	Size*
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^{o} 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		

FIELD ESTIMATION OF ROCK HARDNESS

Grade	Description	Field Identification	Approx. Range of UCS (MPa)
R0	Extremely Weak Rock	Indented by thumbnail	0.25 - 1
R1	Very Weak Rock	Material can be peeled or shaped with a knife. Crumbles under firm blows from geological hammer.	1 - 5
R2	Weak Rock	Knife cuts material but too hard to shape into triaxial specimens or material can be peeled with a knife with difficulty. Shallow (<5mm) indentations made by firm blows from pick of a geological hammer.	5 - 25
R3	Moderately Strong Rock	Cannot be peeled or scraped with a knife. Hand held specimens can be fractured with single firm blow of geological hammer.	25 - 50
R4	Strong Rock	Hand held specimen requires more than one blow of geological hammer to fracture.	50 - 100
R5	Very Strong Rock	Hand held specimen requires many blows of geological hammer to fracture.	100 - 250
R6	Extremely Strong Rock	Specimen can only be chipped under repeated hammer blows, rings when hit.	> 250

Notes:

1. Hand held specimens should have height approximately 2 times the diameter.
2. Materials having a uniaxial compressive strength of less than approximately 0.5 MPa and cohesionless materials should be classified using soil classification systems.
3. Rocks with a uniaxial compressive strength below 25 MPa (i.e. below R2) are likely to yield highly ambiguous results under point load testing.

Reference:

Brown, 1981. "Suggested Methods for Rock Characterization Testing and Monitoring", International Society for Rock Mechanics.

Hoek, E., Kaiser, P.K., Bawden, W.F., 1995. "Support of Underground Excavations in Hard Rock", Balkema, Rotterdam.

ROCK WEATHERING CLASSIFICATION

Term	Symbol	Description	Discoloration Extent	Fracture Condition	Surface Characteristics
Residual soil	W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	Throughout	N/A	Resembles soil
Completely weathered	W5	100% of rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	Throughout	Filled with alteration minerals	Resembles soil
Highly weathered	W4	More than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.	Throughout	Filled with alteration minerals	Friable and possibly pitted
Moderately weathered	W3	Less than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones. Visible texture of the host rock still preserved. Surface planes are weathered (oxidized or carbonate filling) even when breaking the “intact rock”.	>20% of fracture spacing on both sides of fracture	Discoloured, may contain thick filling	Partial to complete discoloration, not friable except poorly cemented rocks
Slightly weathered	W2	Discoloration indicates weathering of rock material on discontinuity surfaces (usually oxidized). Less than 5% of rock mass altered.	<20% of fracture spacing on both sides of fracture	Discoloured, may contain thin filling	Partial discoloration
Fresh	W1	No visible sign of rock material weathering.	None	Closed or discoloured	Unchanged

Reference:

Brown, 1981. "Suggested Methods for Rock Characterization Testing and Monitoring", International Society for Rock Mechanics.

GOLDER

RECORD OF BOREHOLE No C3-1

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823858.0; E 295751.1 MTM NAD ZONE 10 (LAT. 43.554603; LONG. -79.612001)
BOREHOLE TYPE CME 55 83 mm I.D. Hollow Stem Augers
DATE March 1, 2019

ORIGINATED BY EJ
COMPILED BY ACM
CHECKED BY SEMP/SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.6	GROUND SURFACE										
0.0 / 95.9	TOPSOIL (690 mm)		1	SS	5		96				
0.7 / 95.4	SILTY CLAY, some sand, trace gravel Stiff		2A 2B	SS	13				43		2 12 50 36
1.2	Mottled brown-grey Moist						95		○		
94.3	Inferred completely to moderately weathered, brown to grey, extremely weak to weak SHALE (Georgian Bay Formation)		3	SS	55						
2.3	SHALE (BEDROCK) Grey Moderately weathered to 3.6 m depth to slightly weathered to fresh below 3.6 m depth - Heavy auger grinding at 2.7 m Bedrock cored from a depth of 2.8 m to 9.0 m. For bedrock coring details, refer to Record of Drillhole C3-1.		4A 4B	SS	80		94				
			1	RC	REC 100%						RQD = 74%
			2	RC	REC 100%		93				RQD = 94%
			3	RC	REC 100%		92				RQD = 98%
			4	RC	REC 100%		91				RQD = 100%
			5	RC	REC 100%		90				RQD = 100%
87.6							89				
9.0	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of soil drilling prior to rock coring.						88				

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

PROJECT: 1662333

RECORD OF DRILLHOLE: C3-1

SHEET 1 OF 1

LOCATION: N 4823858.0 ;E 295751.1

DRILLING DATE: March 1, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Davis Drilling Inc.

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole C3-1		93.85															
3		Moderately weathered, very thinly to thinly laminated, grey, fine grained, faintly porous, weak, SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		2.75	1							BD,UN,SM BD,PL,SM BD,UN,SM	2 1 2	1 1 1					
				92.99								BD,UN,SM SA	2	2					
4		Slightly weathered to fresh, very thinly to thinly laminated, grey, fine grained, faintly porous, weak , SHALE (Georgian Bay Formation) with LIMESTONE interbeds		3.61	2							BD,UN,SM BD,UN,SM SA	2 2	1 2					
												BD,UN,SM	2	1					
5												BD,PL,RO BD,UN,SM	1.5 2	1 1					
												BD,PL,SM BD,CU,SM	1 2	1 1					
6					3							JN,PL,RO PC,FE, 1 mm BD,UN,SM PC,CL, 1 mm BD,UN,SM CC,CL, 2 mm	1.5 2 2	3 4 4					
7					4														
8																			
					5														
9				87.62															
		END OF DRILLHOLE		8.98															
10																			
11																			

FEATURES LEGEND

BROKEN CORE CLAY SEAM LIMESTONE LOST CORE

DEPTH SCALE
1 : 50

GOLDER

LOGGED: EJ
CHECKED: AC

GTA-RCK 054 S:\CLIENTS\MTO\QEW-CREDIT_RIVER\02_DATA\GINT\QEW-CREDIT_RIVER.GPJ GAL-MISS.GDT 07/29/19

GOLDER

RECORD OF BOREHOLE No C3-2

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823846.8; E 295790.1 MTM NAD ZONE 10 (LAT. 43.554503; LONG. -79.611518)
BOREHOLE TYPE CME 75, 108 mm I.D. Hollow Stem Augers, HQ Casing
DATE February 28, 2019

ORIGINATED BY AB
COMPILED BY ACM
CHECKED BY SEMP/SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.6	GROUND SURFACE										
0.0 / 96.3	ASPHALT (340 mm)										
	CONCRETE (220 mm)										
95.7	Gravelly sand, some silt (FILL) Compact Brown-black Moist - Hydrocarbon odour		1	SS	11		96				
0.9			2	SS	7				○	OC = 3.0%	0 61 34 5
95.0	SILT and SAND, trace clay, trace organics Loose Black-grey-brown Moist to wet at 1.4 - Organic silt layers present		3A 3B	SS	17		95		○		
1.6 / 94.4	Inferred completely weathered, brown to grey, extremely weak to weak SHALE (Georgian Bay Formation)		1	RC	REC 100%		94				RQD = 53%
2.2	SHALE (BEDROCK) Grey Moderately weathered to 3.9 m depth to slightly weathered to fresh below 3.9 m depth Auger refusal at 2.2 m Bedrock cored from a depth of 2.2 m to 9.3 m. For bedrock coring details, refer to Record of Drillhole C3-2.		2	RC	REC 100%		93				RQD = 69%
			3	RC	REC 100%		92				RQD = 100%
			4	RC	REC 100%		91				RQD = 99%
			5	RC	REC 100%		90				RQD = 99%
87.3							89				
9.3	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of soil drilling prior to rock coring.						88				

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

PROJECT: 1662333

RECORD OF DRILLHOLE: C3-2

SHEET 1 OF 1

LOCATION: N 4823846.8 ;E 295790.1

DRILLING DATE: February 28 and March 1, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Truck

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate | BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage | PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular | PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break | BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX R4	R3	R2	R1	WEATHERING INDEX W1	W2	W3	W4	W5	W6	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole C3-2		94.44																						
		Moderately weathered, very thinly bedded, grey, very fine grained, faintly porous, very weak, SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		2.16	1							BD,UN,RO CC,CL	3	4												
												BD,IR,RO PC,CL	3	4												
				92.74																						
		Slightly weathered to fresh, very thinly bedded, grey, very fine grained, faintly porous, weak, SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		3.86	2							BD,UN,SM IN,CL, 8 mm	3	6												
												BD,UN,RO SA	3	2												
												BD,UN,SM SA	2	2												
												BD,UN,RO SA	3	2												
												BD,UN,SM SA	2	2												
												BD,IR,SM SA	2	2												
					3							BD,,SM SA	2	2												
																									R1	
					4							BD,,SM SA	2	2												
												BD,,SM SA	1	2												
												BD,PL,RO SA	1.5	2												
												BD,UN,RO SA	3	2												
					5							BD,ST,SM PC,CL	2	4												
												BD,IR,RO SA	3	2												
				87.27								BD,PL,RO SA	15	2												
		END OF DRILLHOLE		9.33																						
		NOTE:																								
		1. After the first two runs the Drillhole was backfilled due to too much water on the highway and the remaining three runs were drilled at a new location 0.83 m North (towards the median).																								

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: AB

CHECKED: AC

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GOLDER

RECORD OF BOREHOLE No C3-3

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823854.5; E 295834.5 MTM NAD ZONE 10 (LAT. 43.554573; LONG. -79.610969)
BOREHOLE TYPE CME 55, 83 mm I.D. Hollow Stem Augers, HQ Casing
DATE February 20, 2019

ORIGINATED BY EJ
COMPILED BY KN
CHECKED BY SEMP/SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.7	GROUND SURFACE										
0.0	Sand, some silt, trace to some gravel, trace clay, trace rootlets (FILL) Compact to dense Brown Moist		1	SS	37				○		
94.5			2	SS	17		95		○		11 64 20 5
1.2	Sandy SILTY CLAY, some gravel Very stiff Grey to brown Moist		3	SS	18				○ — ●		14 23 35 28
93.9							94				
1.8	Inferred highly weathered, brown to grey, extremely weak to weak SHALE (Georgian Bay Formation)		4	SS	80/0.25				○		
93.0			5	SS	50/0.08		93				
2.7	SHALE (BEDROCK) Grey Moderately weathered to 3.2 m depth to slightly weathered to fresh below 3.2 m depth Bedrock cored from a depth of 2.7 m to 9.4 m. For bedrock coring details, refer to Record of Drillhole C3-3.		6	SS	50/0.05						
			1	RC	REC 100%						RQD = 30%
			2	RC	REC 100%		92				RQD = 90%
			3	RC	REC 100%		91				RQD = 88%
			4	RC	REC 100%		90				RQD = 100%
			5	RC	REC 100%		89				RQD = 100%
86.3							88				
9.4	END OF BOREHOLE NOTE: 1. Open borehole dry upon completion of soil drilling prior to bedrock coring. 2. Water level measured at 4.8 m depth below ground surface (Elev. 90.9 m) after piezometer installation. 3. Water level measured at 4.7 m depth below ground surface (Elev. 91.0 m) on March 13, 2019 and on March 21, 2019.						87				

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

PROJECT: 1662333

RECORD OF DRILLHOLE: C3-3

SHEET 1 OF 1

LOCATION: N 4823854.5 ;E 295834.5

DRILLING DATE: February 20, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75 Truck

DRILLING CONTRACTOR: Davis Drilling Ltd.

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate

BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage

PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular

PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole C3-3		92.96															
3		Moderately weathered, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		2.74	1							JN,IR,SM BD,PL,SM	2 1	1 1					Bentonite
				92.50								BD,PL,SM	1	1					
		Slightly weathered to fresh, grey, fine grained, faintly porous, weak, SHALE (Georgian Bay Formation) with LIMESTONE interbeds		3.20								CO,UN,SM CO,UN,SM	2 2	1 1					
4					2							JN,UN,SM BD,PL,SM BD,UN,SM	2 1 2	1 1 1					Sand
5					3							CO,UN,SM PC,FE, 1 mm JN,IR,RO CC,FE, 1 mm CO,IR,SM IN,CL, 5 mm	2 3 1	3 3 8					
6																			Screen UCS = 16.6 MPa
7					4													R1	
8												BD,IR,RO	3	1					Sand
9					5														Bentonite
				86.27								JN,UN,SM	2	1					
10		END OF DRILLHOLE		9.43															
11																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: EJ

CHECKED: AC

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GOLDER

RECORD OF BOREHOLE No C3-4

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823830.8; E 295725.0 MTM NAD ZONE 10 (LAT. 43.554358; LONG. -79.612324)
BOREHOLE TYPE CME 55 83 mm I.D. Hollow Stem Augers
DATE February 28, 2019

ORIGINATED BY EJ
COMPILED BY ACM
CHECKED BY SEMP/SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.4	GROUND SURFACE										
0.0	Gravel, some sand, some silt, trace clay (FILL) Very dense Grey to brown Wet		1	SS	50/0.13		95		○ ○		57 20 18 5
94.4	- Auger grinding from 0.0 m to 0.6 m		2A 2B	SS	82/0.25						
1.0	SHALE (BEDROCK) Grey Moderately weathered to 1.9 m depth to slightly weathered to fresh below 1.9 m depth Bedrock cored from a depth of 1.5 m to 7.0 m. For bedrock coring details, refer to Record of Drillhole C3-4.		3 1	SS RC	50/0.08 REC 100%		94				RQD = 41%
			2	RC	REC 100%		93				RQD = 100%
			3	RC	REC 100%		92				RQD = 100%
			4	RC	REC 100%		91				RQD = 100%
							90				
			5	RC	REC 100%		89				RQD = 100%
88.4											
7.0	END OF BOREHOLE NOTE: 1. Borehole dry upon completion of soil drilling prior to rock coring.										

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

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

PROJECT: 1662333

RECORD OF DRILLHOLE: C3-4

SHEET 1 OF 1

LOCATION: N 4823830.8 ;E 295725.0

DRILLING DATE: February 28, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track

DRILLING CONTRACTOR: Davis Drilling Ltd.

JN - Joint, FLT - Fault, SHR- Shear, VN - Vein, CJ - Conjugate | BD- Bedding, FO- Foliation, CO- Contact, OR- Orthogonal, CL - Cleavage | PL - Planar, CU- Curved, UN- Undulating, ST - Stepped, IR - Irregular | PO- Polished, K - Slickensided, SM- Smooth, Ro - Rough, MB- Mechanical Break | BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX R4	R3	R2	R1	WEATHERING INDEX W1	W2	W3	W4	W5	W6	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Record of Borehole C3-4		93.88																						
2		Moderately weathered, very thinly to thinly laminated, grey, fine grained, faintly porous, weak, SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		1.52 / 93.51	1							BD,PL,SM IN,CL, 5 mm BD,PL,SM BD,UN,SM BD,UN,SM BD,UN,SM BD,UN,SM	1 1 2 2 2 2 2	8 1 1 1 1 1 1													
3		Slightly weathered to fresh, very thinly to thinly laminated, grey, fine grained, faintly porous, weak , SHALE (Georgian Bay Formation) with LIMESTONE interbeds		1.89	2							BD,CU,SM SA	2	2													UCS = 17.6 MPa
4					3							BD,PL,SM	1	1													UCS = 17.3 MPa
5		- Vuggy porosity visible from 4.93 m - 4.95 m										BD,UN,SM	2	1													
6					4																						
7				88.45	5							BD,PL,SM														
		END OF DRILLHOLE		6.95																						
8																										
9																										
10																										

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: EJ

CHECKED: AC

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GOLDER

RECORD OF BOREHOLE No NW5-4

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823869.2; E 295818.3 MTM NAD 83 ZONE 10 (LAT. 43.554705; LONG. -79.611169)
BOREHOLE TYPE CME 55, 114 mm I.D., Hollow Stem Augers
DATE July 12, 2018

ORIGINATED BY ACM
COMPILED BY SK
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.3	GROUND SURFACE										
0.0 / 95.7	CONCRETE (610 mm)						96				
95.4 / 0.9	Gravelly sand, trace to some silt (FILL) Compact Brown Moist		1A 1B	SS	15						
94.6 / 1.7	Silt and sand, trace to some clay (FILL) Loose to compact Brown Moist		2A 2B	SS	6		95				1 49 40 10
94.0 / 93.6 / 2.7	CLAYEY SILT, some sand, some gravel Firm Grey to brown Moist - Trace organics encountered between depths of about 1.7 m and 1.8 m		3A 3B	SS	65		94				16 15 46 23
			4	SS	100/0.1						
			1	RC	REC 100%						RQD = 54%
	Inferred highly to moderately weathered, brown to grey, extremely weak to weak SHALE (Georgian Bay Formation)		2	RC	REC 86%		93				RQD = 50%
	SHALE (BEDROCK) Grey Slightly weathered - Auger grinding from 2.7 m to 2.9 m Bedrock cored from a depth of 3.2 m to 6.8 m. For bedrock coring details, refer to Record of Drillhole NW5-4.		3	RC	REC 97%		92 / 91				RQD = 93%
89.5			4	RC	REC 79%		90				RQD = 79%
6.8	END OF BOREHOLE										

NOTE:

1. Open borehole dry upon completion of soil drilling.

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

PROJECT: 1662333

RECORD OF DRILLHOLE: NW5-4

SHEET 1 OF 1

LOCATION: N 4823869.2 ;E 295818.3

DRILLING DATE: July 12, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Aardvark Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		Continued from Borehole NW5-4		93.19															
4	HQ Core	Slightly weathered, thinly laminated to medium bedded, grey, very fine to fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		3.15	1														
					2							BD,UN,SM SO	2	1					
												BD,UN,SM Sa	2	2					
												BD,UN,SM Sa	2	2					
												BD,UN,SM Sa	2	2					R1
												BD,UN,SM PC, Cl	2	3					
												BD,UN,SM PC, Cl	2	3					
5																			
												BD,IR,SM PC, Cl	2	3					
					3							BD,UN,SM SO	2	1					UCS = 196.3 MPa
												BD,UN,SM SO	2	1					
6																			
				89.56	4														
		END OF DRILLHOLE		6.78															
7																			
8																			
9																			
10																			
11																			
12																			

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ACM

CHECKED: AB

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GOLDER

RECORD OF BOREHOLE No OHS-4

SHEET 1 OF 1 **METRIC**

PROJECT 1662333
G.W.P. 2002-13-00
DIST Central HWY QEW
DATUM Geodetic

LOCATION N 4823828.9; E 295734.3 MTM NAD 83 ZONE 10 (LAT. 43.554333; LONG. -79.612205)
BOREHOLE TYPE Portable Tripod
DATE September 6, 2018

ORIGINATED BY ACM
COMPILED BY DH
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
97.3	GROUND SURFACE										
0.0 / 97.0	TOPSOIL (300mm)										
96.6	Gravel, some sand, some silt (FILL)		1	SS	64		97				
0.7	Dense Brown Moist		2	SS	47						
	Inferred completely to moderately weathered, brown to grey, extremely weak to weak SHALE (Georgian Bay Formation)						96				
95.6			3	SS	100/0.10				○		5 14 49 32
1.7	SHALE (BEDROCK) Grey Moderately weathered to 3.2 m depth to slightly weathered to fresh below 3.2 m depth		1	RC	REC 100%						RQD = 0%
			2	RC	REC 43%		95				RQD = 0%
			3	RC	REC 53%						RQD = 0%
	Bedrock cored from a depth of 1.7 m to 5.6 m For bedrock coring details, refer to Record of Drillhole OHS-4		4	RC	REC 82%		94				RQD = 35%
			5	RC	REC 92%		93				RQD = 89%
91.7							92				
5.6	END OF BOREHOLE NOTES: 1. Borehole dry prior to rock coring.										

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

PROJECT: 1662333

RECORD OF DRILLHOLE: OHS-4

SHEET 1 OF 1

LOCATION: N 4823828.9 ;E 295734.3

DRILLING DATE: September 6, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: Portable Tripod

DRILLING CONTRACTOR: Walker Drilling

JN - Joint; FLT - Fault; SHR- Shear; VN - Vein; CJ - Conjugate
BD- Bedding; FO- Foliation; CO- Contact; OR- Orthogonal; CL - Cleavage
PL - Planar; CU- Curved; UN- Undulating; ST - Stepped; IR - Irregular
PO- Polished; K - Slickensided; SM- Smooth; Ro - Rough; MB- Mechanical Break
BR - Broken Rock
NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA: B Angle	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA: Jr	DISCONTINUITY DATA: Ja	ROCK STRENGTH INDEX: R4	ROCK STRENGTH INDEX: R3	ROCK STRENGTH INDEX: R2	ROCK STRENGTH INDEX: R1	WEATH-ERING INDEX: W1	WEATH-ERING INDEX: W2	WEATH-ERING INDEX: W3	WEATH-ERING INDEX: W4	WEATH-ERING INDEX: W5	WEATH-ERING INDEX: W6	FEATURES	R0/R1 ZONES	NOTES WATER LEVELS INSTRUMENTATION
		GROUND SURFACE		95.60																							
2	NQ Core	Moderately weathered, thinly bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		1.73	1							CO,PL,SM CC CL CO,UN,SM CC CL JN,UN,RO SA HE CO,UN,RO CC CL CO,PL,SM CC CL JN,UN,RO SA HE CO,UN,SM CC CL BD,PL,SM SA HE	1 2 3 3 1 3 2 1 2	4 2 4 4 2 4 2 1											
3					2																						
3				94.18	3								1 2 2 3	4 1 1 1													
4		Slightly weathered to fresh, thinly bedded, grey, fine grained, faintly porous, weak SHALE (Georgian Bay Formation) with slightly weathered to fresh, grey, fine grained, strong to very strong LIMESTONE interbeds		3.15	4							BD,UN,SM SO BD,PL,SM SO CO,UN,SM CC CL BD,UN,SM SO BD,UN,RO SO BD,ST,SM SO JN,PL,RO SA HE JN,UN,RO SA HE	2 1.5 3	1 2 2											
5					5																						
				91.77																							
		END OF DRILLHOLE		5.56																							
6																											
7																											
8																											
9																											
10																											

FEATURES LEGEND

BROKEN CORE | CLAY SEAM | LIMESTONE | LOST CORE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ACM

CHECKED: AB

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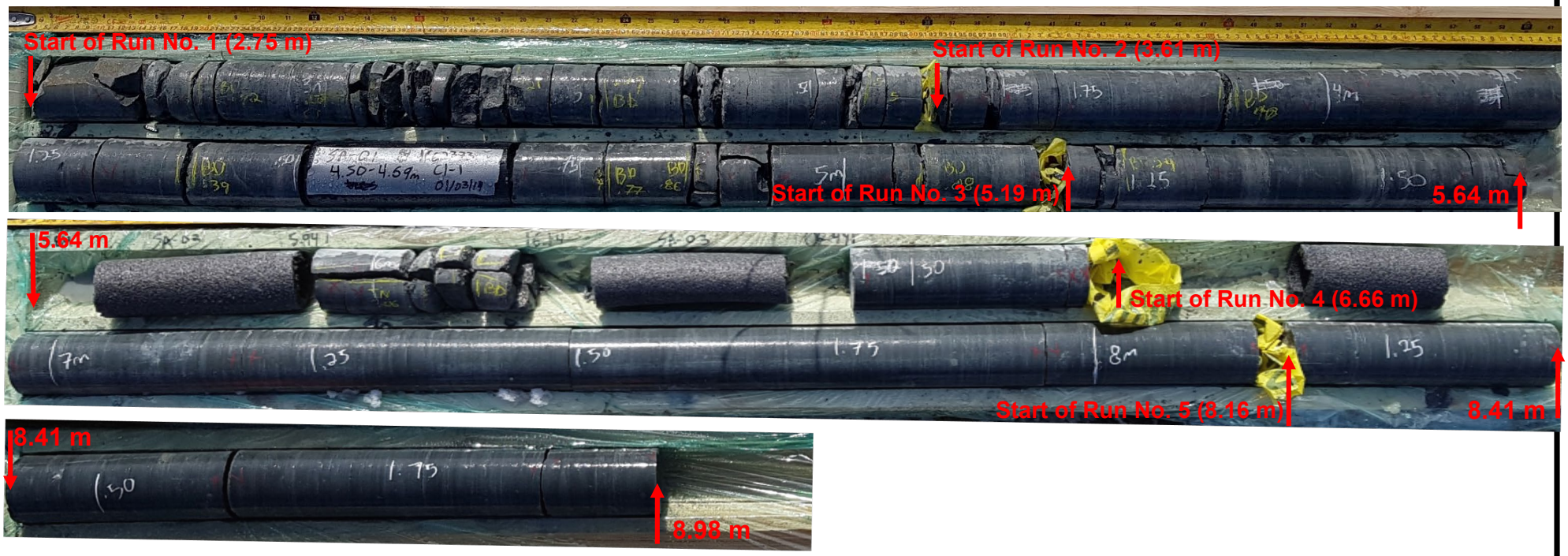


0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

TITLE

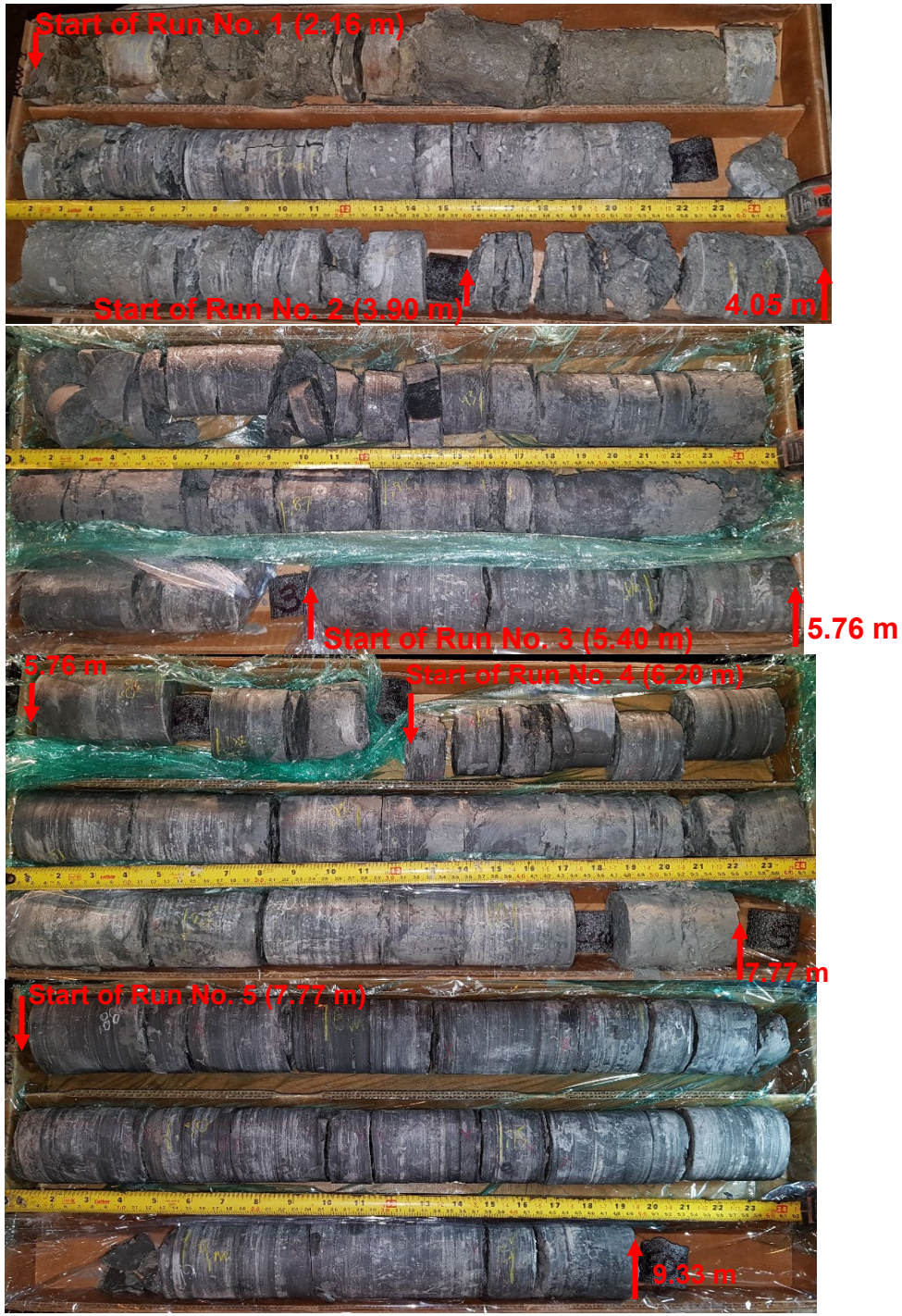
Bedrock Core Photograph
Borehole C3-1 (2.75 m to 8.98 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329			
REVIEW	JAMC	201803--			

FIGURE A-1

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333



0 m 0.25 m 0.5 m

0 ft 1 ft 2 ft

Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

TITLE

Bedrock Core Photograph
Borehole C3-2 (2.16 m to 9.33 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329	**FIGURE A-2**		
REVIEW	JAMC	201803--			

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333

0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m

0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

TITLE

Bedrock Core Photograph
Borehole C3-3 (2.74 m to 9.43 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329			
REVIEW	JAMC	201803--			

FIGURE A-3

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333

0 m 0.25 m 0.5 m 0.75 m 1.0 m 1.25 m 1.5 m

0 ft 1 ft 2 ft 3 ft 4 ft 5 ft

Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

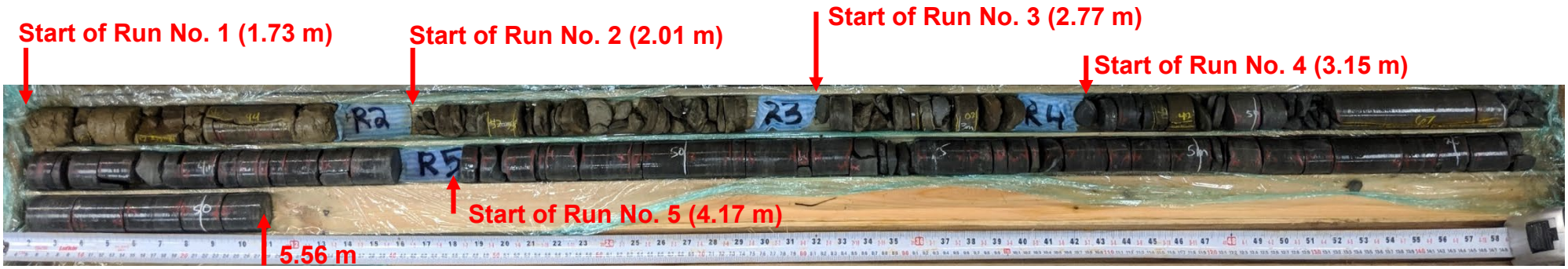
TITLE

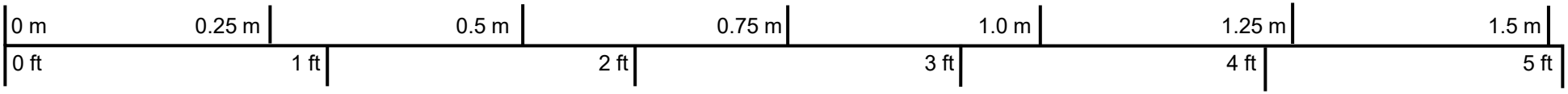
Bedrock Core Photograph
Borehole C3-4 (1.52 m to 6.95 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329	**FIGURE A-4**		
REVIEW	JAMC	201803--			

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333





Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

TITLE

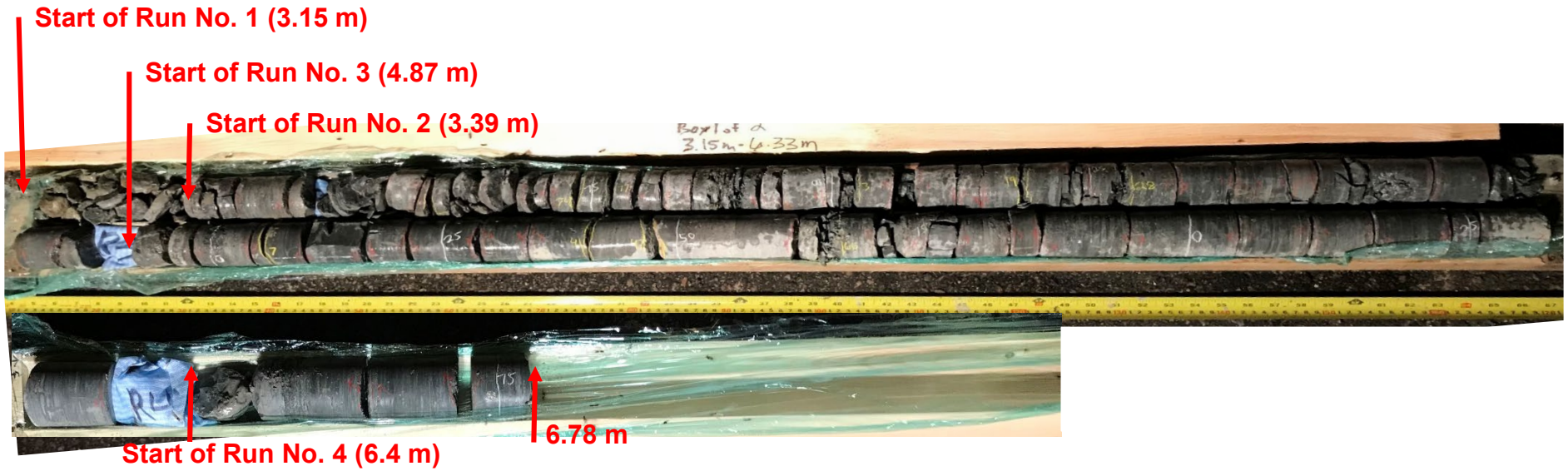
Bedrock Core Photograph
Borehole OHS-4 (1.73 m to 5.56 m)

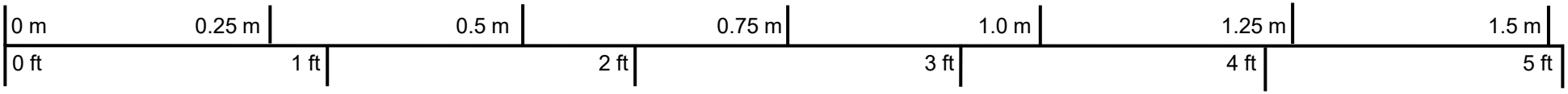
GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329			
REVIEW	JAMC	201803--			

FIGURE A-5

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333





Scale

PROJECT

MTO Assignment 2015-E-0033
Sanitary Sewer Installation Station 16+560
Mississauga Road to Hurontario Way

TITLE

Bedrock Core Photograph
Borehole NW5-4 (3.15 m to 6.78 m)

GOLDER

PROJECT No. 1662333			FILE No. ----		
DRAFT	JMP	20180326	SCALE	AS SHOWN	VER. 1.
CADD	--				
CHECK	SMM	20180329			
REVIEW	JAMC	201803--			

FIGURE A-6

REVISION DATE: March 26, 2019 BY: JMP Project: 1662333

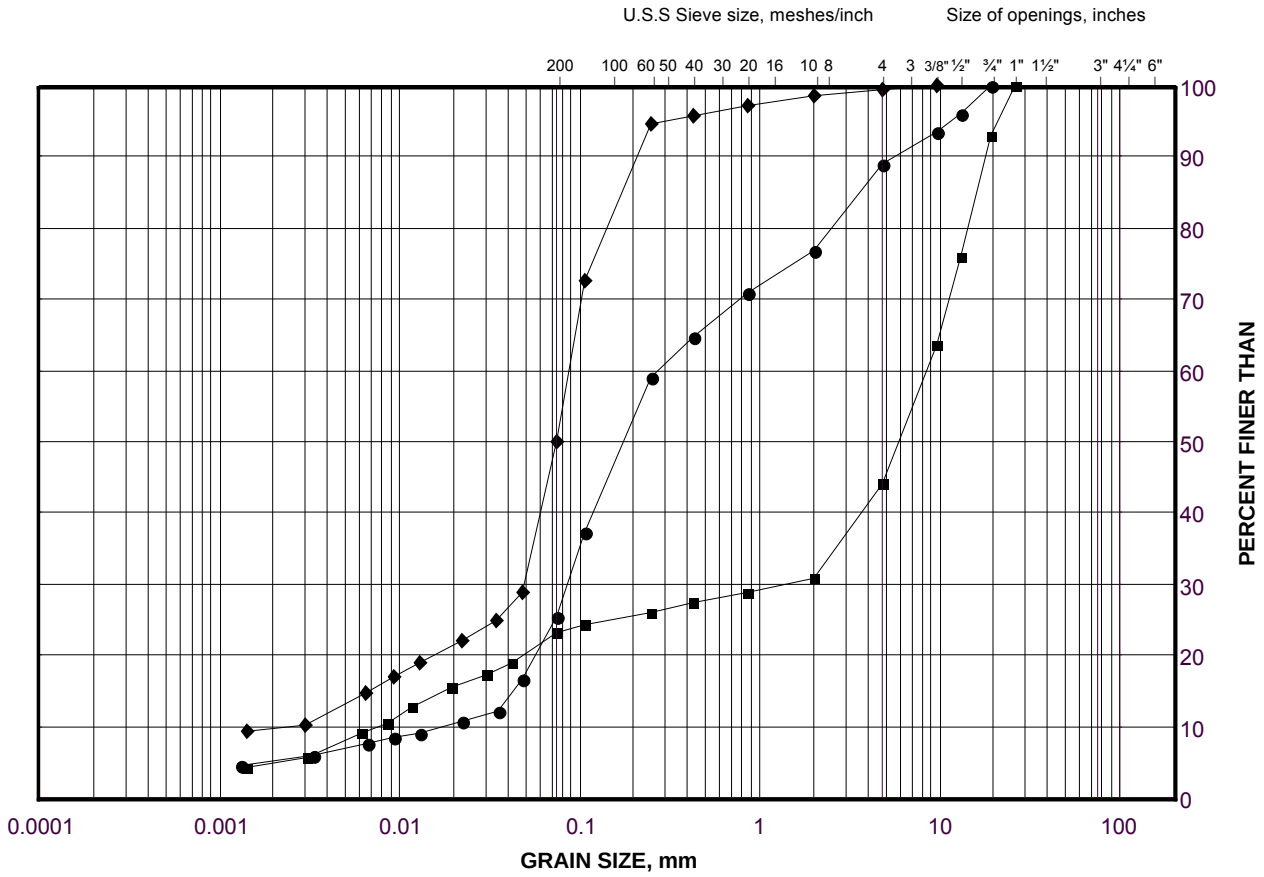
APPENDIX B

Geotechnical Laboratory Test Results (incl. Geomechanica Test Results on Rock)

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand to Gravel (Fill)

FIGURE B-1



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C3-3	2	94.8
■	C3-4	2A	94.5
◆	NW5-4	2A	94.8

Project Number: 1662333

Checked By: SMM

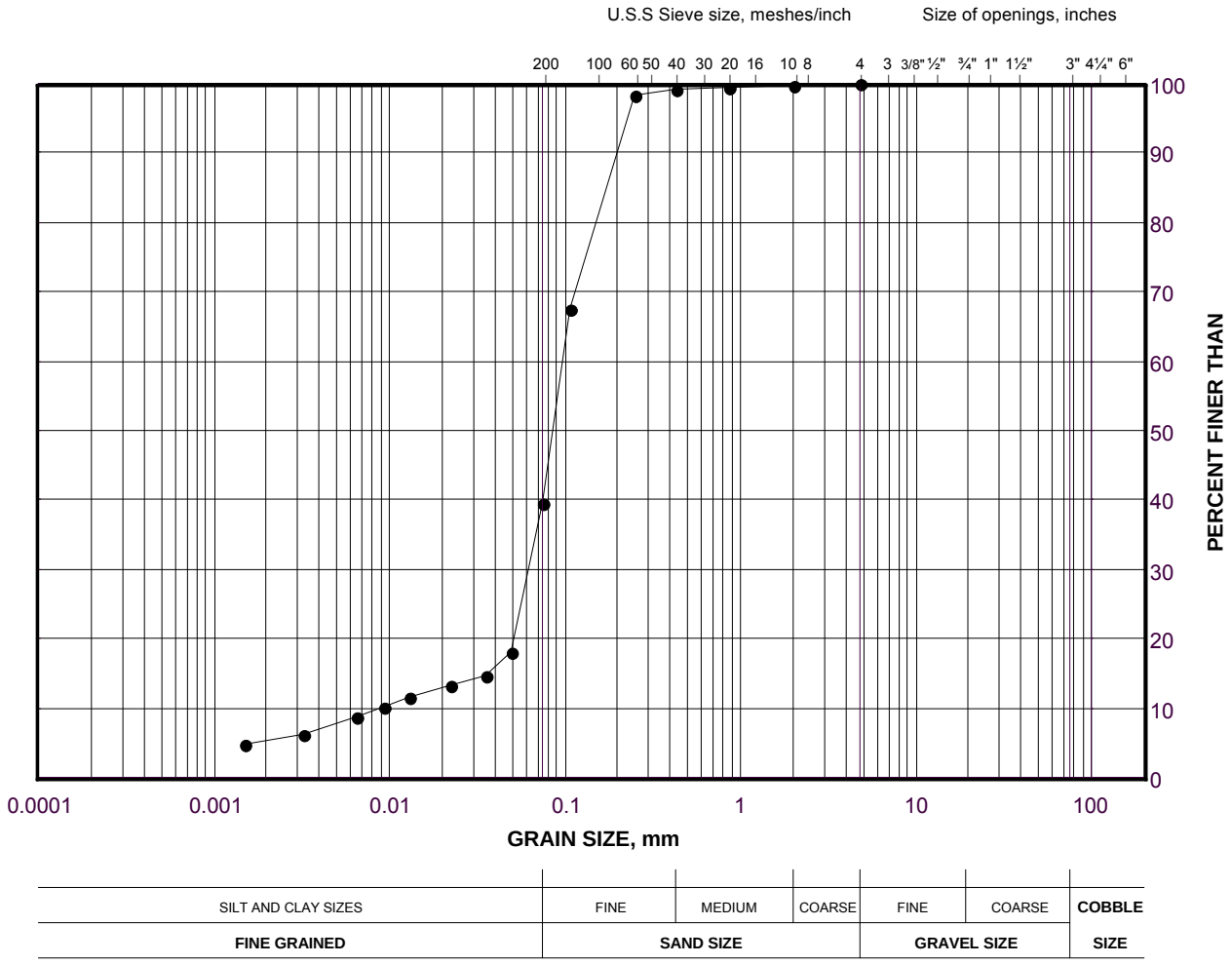
Golder Associates

Date: 18-Apr-19

GRAIN SIZE DISTRIBUTION

Silt and Sand

FIGURE B-2



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C3-2	2	95.4

Project Number: 1662333

Checked By: SMM

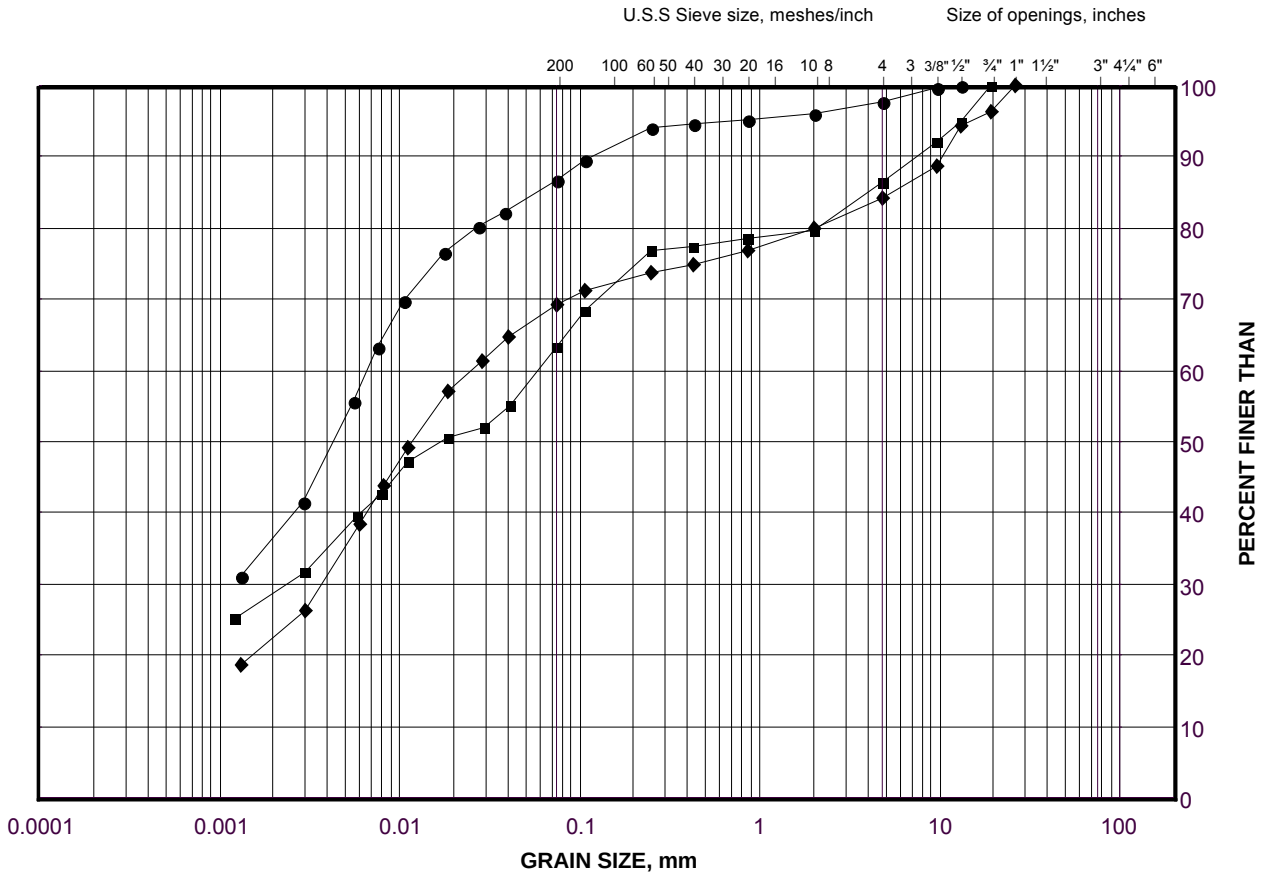
Golder Associates

Date: 18-Apr-19

GRAIN SIZE DISTRIBUTION

Clayey Silt to Sandy Silty Clay to Silty Clay

FIGURE B-3



LEGEND

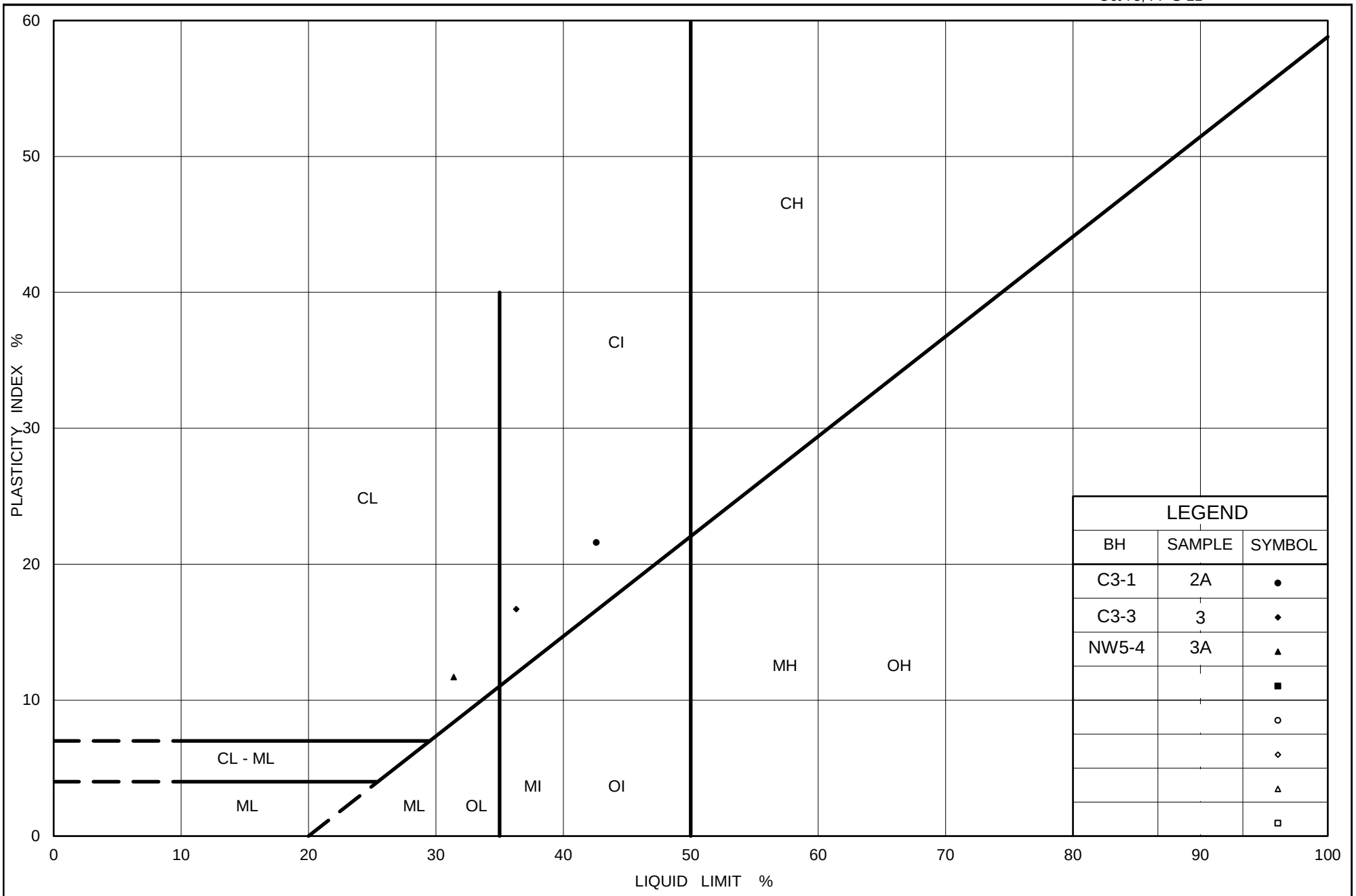
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C3-1	2A	95.6
■	C3-3	3	94.2
◆	NW5-4	3A	94.1

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 18-Apr-19



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt to Sandy Silty Clay to Silty Clay

Figure No. B-4

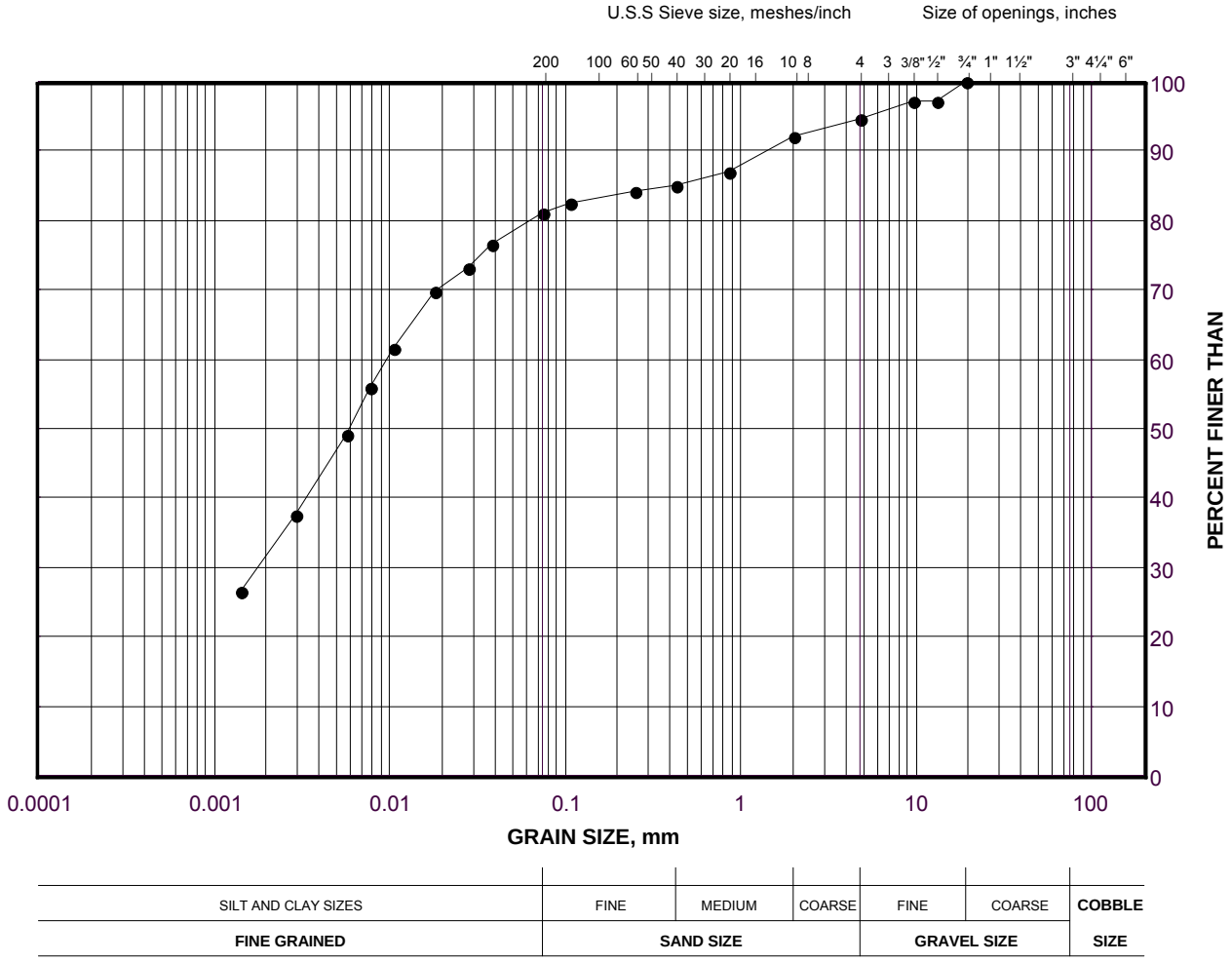
Project No. 1662333

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Inferred Completely to Moderately Weathered Shale (Bedrock)

FIGURE B-5



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	OHS-4	3	95.8

NOTES:

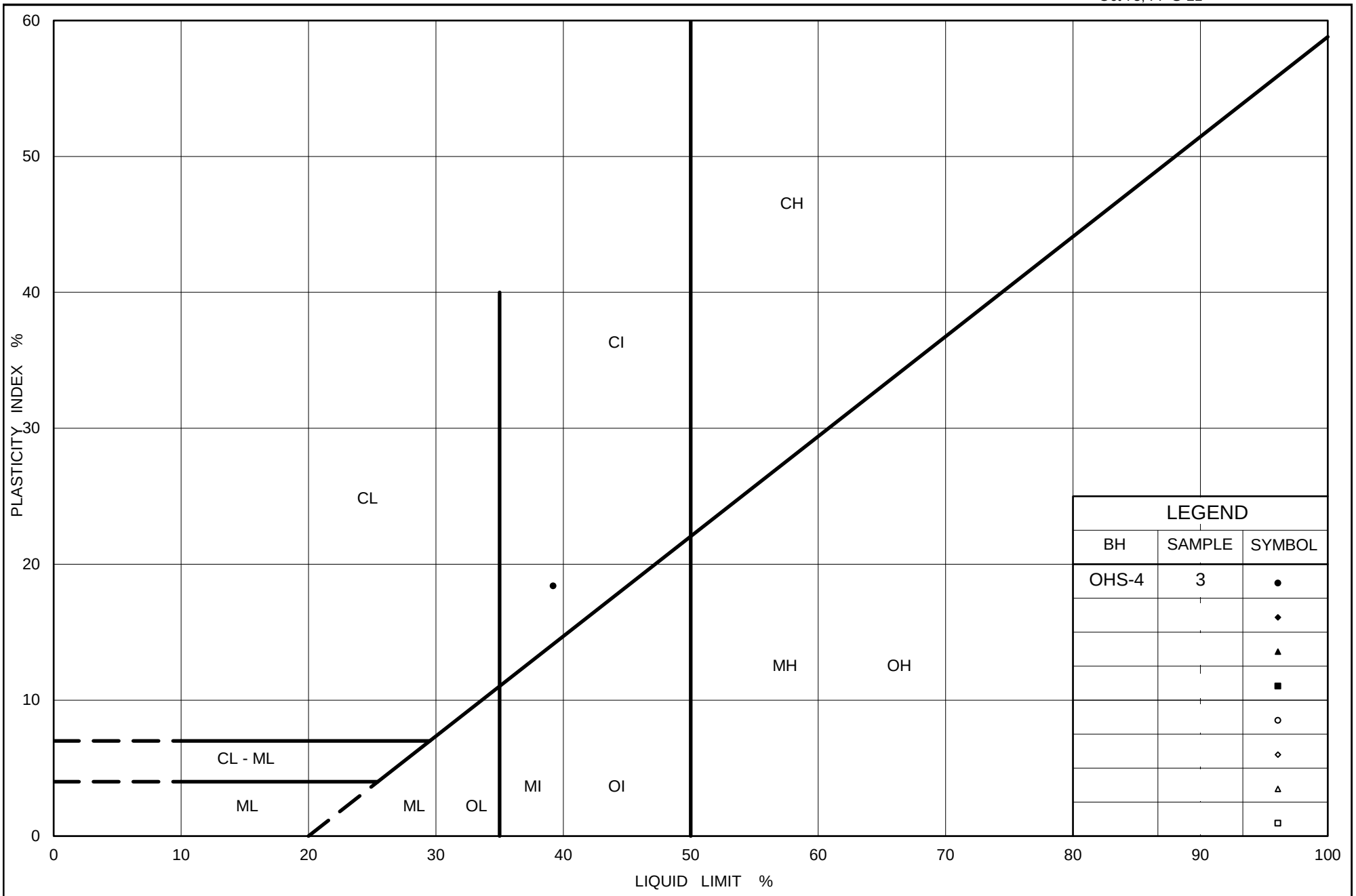
1. The sample of inferred completely to moderately weathered bedrock was obtained by split-spoon sampling, and as such, the particle size(s) are effected by the sampling method and are limited to the size of the sampler. Larger fragments of shale bedrock may be present in-situ.
2. The percentage of gravel size particles may include shale fragments that either remained intact after or were broken during sampling and sample preparation. Therefore, the results of the grain size distribution testing may not be representative of the bulk grain size distribution or behavior of the in-situ or excavated completely to moderately weathered shale bedrock.

Project Number: 1662333

Checked By: SMM

Golder Associates

Date: 18-Apr-19



Ministry of Transportation

Ontario

PLASTICITY CHART

Inferred Completely to Moderately Weathered Shale (Bedrock)

Figure No. B-6

Project No. 1662333

Checked By: SMM

Geomechanica Inc.
Suite 900 – 390 Bay St.
Toronto Ontario
Canada M5H 2Y2

August 27, 2018

Mr. David Marmor
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS only and UCS + E testing
(Golder Project No. 1662333)

Dear Mr. Marmor:

On July 31, 2018 and August 17, 2018 seven (7) and six (6) HQ-sized core samples were received by Geomechanica Inc. via drop-off by Golder personnel, respectively. These samples were identified as being from boreholes drilled as part of Golder project 1662333. A total of 13 uniaxial compressive strength (UCS) specimens were prepared and tested from these samples. The tangent elastic modulus was measured for 5 of these 13 tests.

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

Sincerely,

Bryan Tatone Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: bryan.tatone@geomechanica.com

GEOMECHANICA

Rock Laboratory Testing Results

A report submitted to:

David Marmor
Golder Associates Limited
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

Bryan Tatone, PhD, PEng
Omid Mahabadi, PhD, PEng

Geomechanica Inc
#900-390 Bay St
Toronto ON
M5H 2Y2 Canada
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August 27, 2018
Project number: 1662333

Abstract

This document summarizes the results of rock laboratory testing of 13 uniaxial compressive strength (UCS) tests. Results, including uniaxial compressive strength (UCS) and Young's modulus (for select samples) along with photographs of samples before and after testing are presented. Additional specimen information is included in an accompaning summary spreadsheet.

In this document:

1 Uniaxial Compressive Strength (UCS) testing

This report summarizes the results of 13 uniaxial compressive strength (UCS) tests. The testing was performed in Geomechanica's rock testing laboratory using a 150 ton (1.3 MN) Forney loading frame equipped with pressure-compensated control valve to maintain an axial displacement rate of approximately 0.15 mm/min for shale and and 0.075 mm/min for limestone samples (Figure 1). This displacement rate was selected to target specimen failure to occur within 2 - 15 minutes.

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 minimize exposure to moisture during subsequent specimen preparation.
2. Diamond cutting of core sample to obtain a cylindrical specimen with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Diamond grinding of specimen to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).
4. Placement of the specimen into the loading frame, applying a 1 kN axial load, and removing the electrical tape.
5. Axial loading to rupture while continuously recording axial force and axial deformation to determine the peak strength (UCS) and (tangent) Young's modulus (E) mfor select samples.

Figure 1: UCS test setup.

1.1 Results

The results of the tests are summarized in Table 1. The corresponding stress-strain curves for the uniaxial compression tests are presented in Figure 2 and 3. Young's modulus is the tangent modulus, calculated as the slope of the best fit line through ± 300 data points on either side of the point representing 50.0% of the peak strength. Additional specimen information is included in the accompaning summary spreadsheet.

Table 1: Summary of laboratory test results.

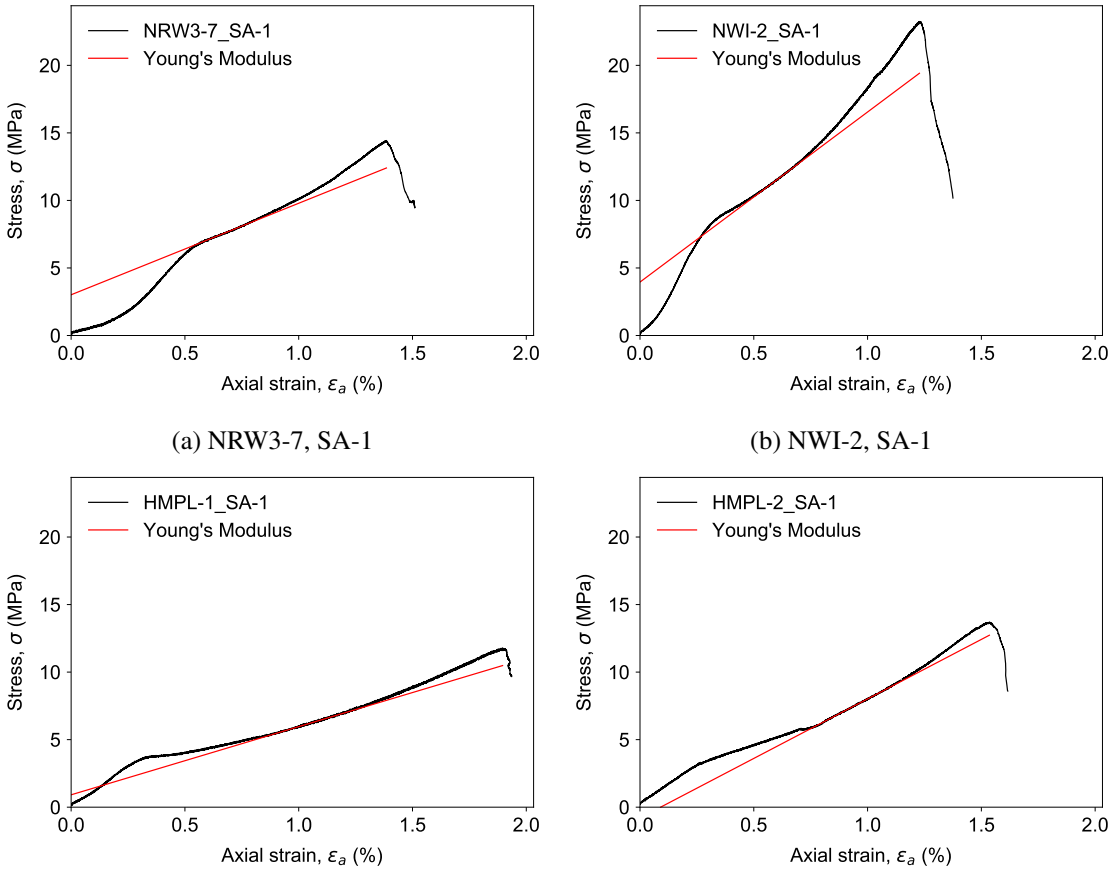
Sample	Depth (m)	Lithology description	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's Modulus E (GPa)	Failure description
NRW3-7, SA-1	9.57 - 9.71	Georgian Bay Formation - Shale	2.596	14.4	0.68	Axial splitting [1, 2]
NWI-2, SA-1	5.06 - 5.31	Georgian Bay Formation - Shale	2.619	23.3	1.26	Inclined shear fracture [2]
NWI-3, SA-1	4.29 - 4.44	Georgian Bay Formation - Shale with several limestone lenses $<$ 5 mm	2.601	16.8	-	Localized crushing [2]
NW5-4, SA-1	5.47 - 5.61	Georgian Bay Formation - Limestone	2.732	196.3	60.84	Inclined shear fracture
OHS-1, SA-1	5.26 - 5.44	Georgian Bay Formation - Shale	2.591	13.0	-	Inclined shear fracture [2]
OHS-2, SA-1	5.38 - 5.49	Georgian Bay Formation - Shale with 2 limestone layers $\approx$5 mm thick	2.449	23.4	-	Hourglass failure [1, 2]
OHS-5, SA-1	6.13 - 6.27	Georgian Bay Formation - Shale	2.603	16.7	-	Axial splitting [2]
AR-2, SA-1	5.92 - 6.12	Georgian Bay Formation - Shale	2.574	9.1	-	Axial splitting [2]
AR-2, SA-2	8.60 - 8.82	Georgian Bay Formation - Shale	2.588	11.5	-	Axial splitting [2]
NW5-1, SA-1	4.29 - 4.45	Georgian Bay Formation - Shale	2.593	13.6	-	Hourglass failure [2]
SWME-4, SA-1	10.40 - 10.54	Georgian Bay Formation - Shale	2.586	13.5	-	Axial splitting [2]
HMPL-1, SA-1	4.81 - 4.96	Georgian Bay Formation - Shale	2.573	11.8	0.50	Localized crushing [2]
HMPL-2, SA-1	3.70 - 3.85	Georgian Bay Formation - Shale	2.594	13.7	0.88	Axial splitting [2]

[1] Specimen Length:Diameter ratio $<$ 2 due to short sample length

[2] Specimen emitted pore water upon loading

1.2 Specimen photographs

Photographs of the specimens before and after testing are presented in Figures 4 to 6.



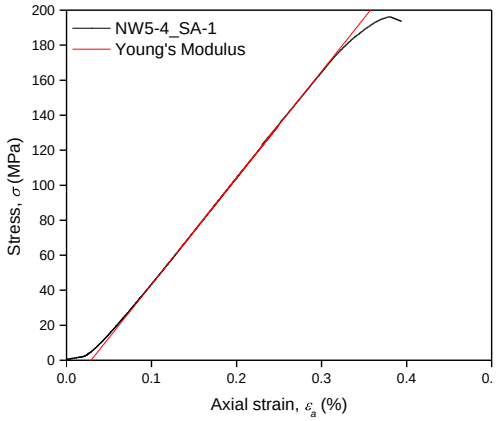
(a) NRW3-7, SA-1

(b) NWI-2, SA-1

(c) HMPL-1, SA-1

(d) HMPL-2, SA-1

Figure 2: Measured stress-strain curves for shale samples.



(a) NRW5-4, SA-1

Figure 3: Measured stress-strain curves for limestone samples.

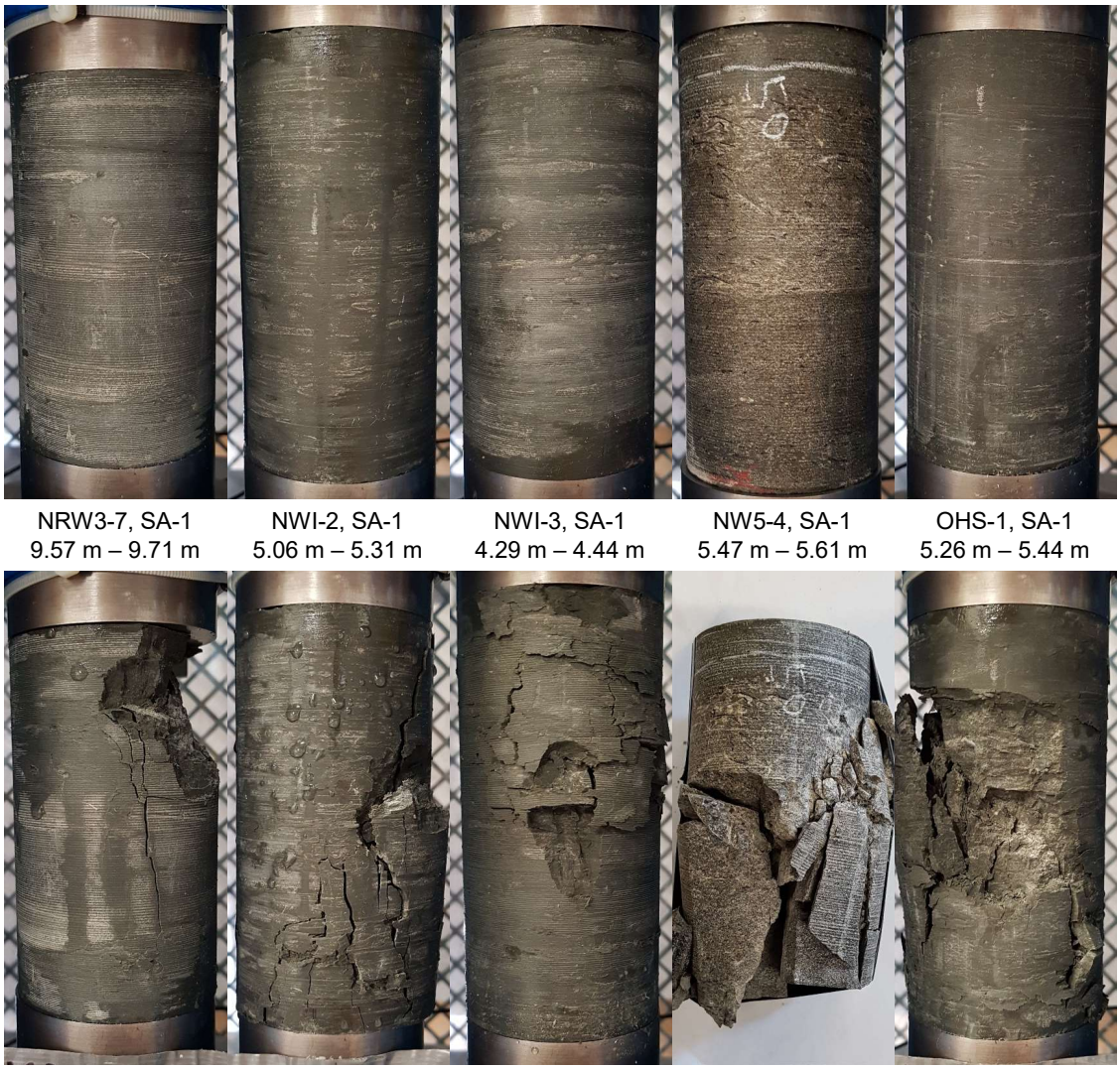


Figure 4: Photographs of specimens before and after testing.

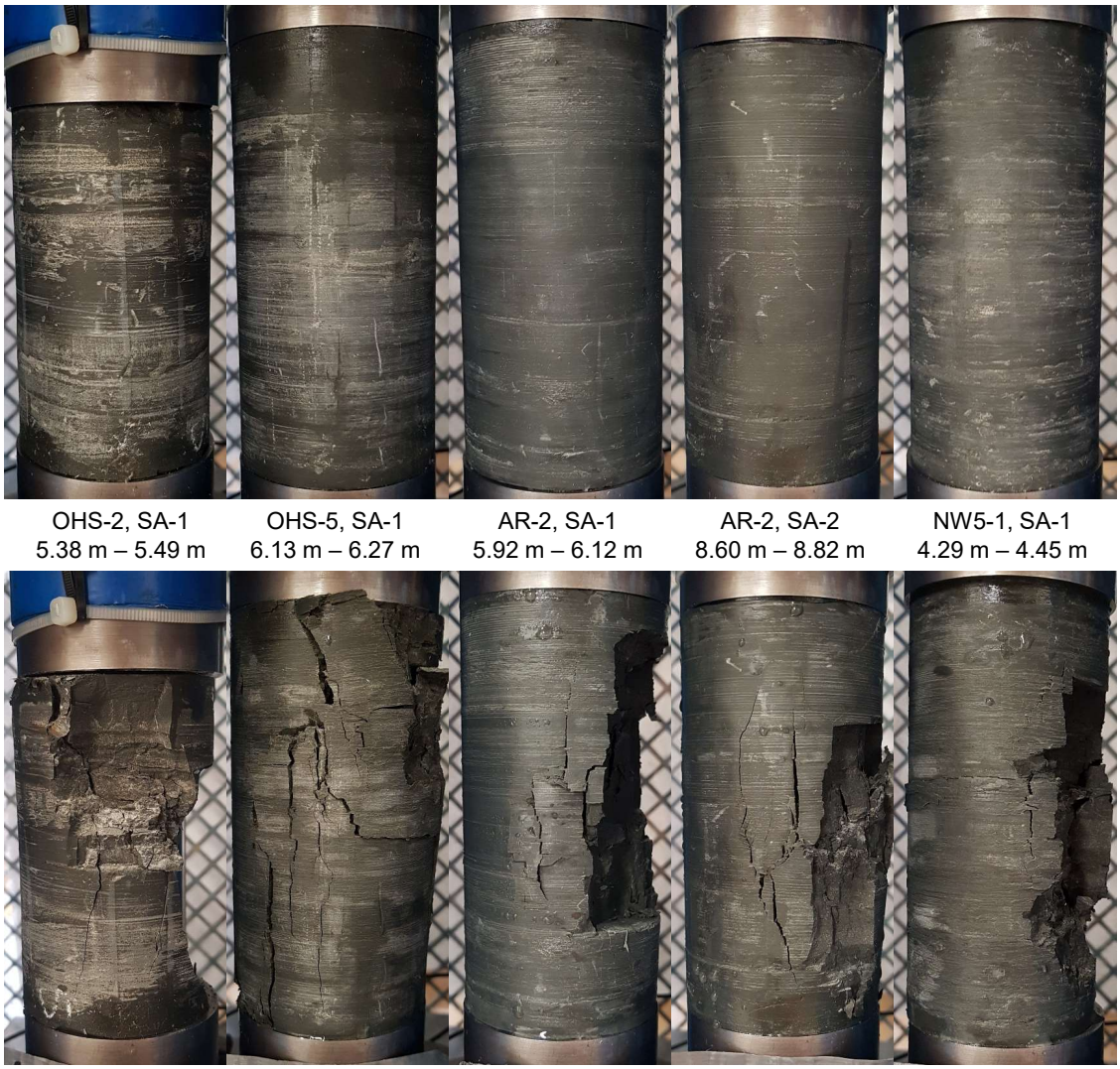


Figure 5: Photographs of failed specimens before and after testing (continued).

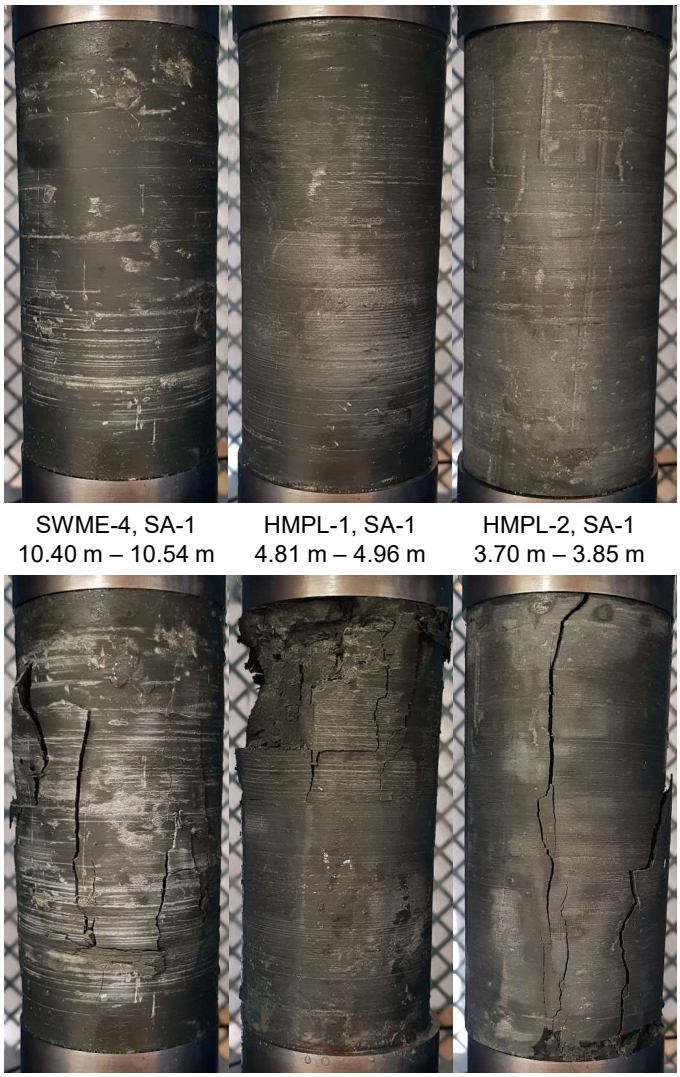


Figure 6: Photographs of failed specimens before and after testing (continued).

Geomechanica Inc.
Suite 900 – 390 Bay St.
Toronto Ontario
Canada M5H 2Y2

March 15, 2019

Mr. David Marmor
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Re: UCS, Slake, and CERCHAR testing
(Golder Project No. 1662333)

Dear Mr. Marmor:

On March 8, 2019 and March 12, 2019 eighteen (18) and two (2) HQ-sized core samples were received by Geomechanica Inc. via drop-off by Golder personnel, respectively. These samples were identified as being from boreholes drilled as part of Golder project 1662333. A total of 14 uniaxial compressive strength (UCS) tests, 2 slake durability tests, and 4 CERCHAR tests were performed using these samples.

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

Sincerely,

Bryan Tatone Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
Email: bryan.tatone@geomechanica.com

GEOMECHANICA

Rock Laboratory Testing Results

A report submitted to:

David Marmor
Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario
Canada L5N 7K2

Prepared by:

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Toronto ON
M5H 2Y2 Canada
Tel: +1-647-478-9767
lab@geomechanica.com

March 15, 2019
Project number: 1662333

Abstract

This document summarizes the results of rock laboratory testing, including the results of Uniaxial Compressive Strength (UCS), Slake durability, and CERCHAR abrasivity testing. The results of each test type are presented in separate sub-sections herein.

In this document:

1 Uniaxial Compressive Strength Tests

1.1 Overview

This section summarizes the results of uniaxial compressive strength (UCS) testing of HQ3-sized specimens. The testing was performed in Geomechanica's rock testing laboratory using a 150 ton (1.3 MN) Forney loading frame equipped with pressure-compensated control valve to maintain an axial displacement rate of approximately 0.150 mm/min and 0.100 mm/min for shale and limestone specimens, respectively (Figure 1). The preparation and testing of each specimen included the following:

1. Unwrapping of the core sample, inspecting it for damage, and re-wrapping it in electrical tape to minimize exposure to moisture during subsequent specimen preparation.
2. Diamond cutting of core sample to obtain cylindrical specimens with an appropriate length (length:diameter = 2:1) and nearly parallel end faces.
3. Diamond grinding of specimen to obtain flat (within ± 0.025 mm) and parallel end faces (within 0.25°).
4. Placing specimen into the loading frame, applying a 1 kN axial load, and removing the electrical tape.
5. Axially loading the specimens to rupture while continuously recording axial force, axial deformation, radial deformation (for select samples) to determine the peak strength (UCS), tangent Young's modulus, and Poisson's ratio (for select samples).

Using a precision V-block mounted on the magnetic chuck of the surface grinder, test specimens met the end flatness, end parallelism, and perpendicularity criteria set out in ASTM D4543-08. The side straightness criteria, as checked with a 0.5 mm feeler gauge, was met for all samples and the minimum length:diameter criteria was met for all specimens unless noted otherwise in Table 3. Testing of the specimens followed ASTM D7012-14 with the following exceptions:

- Rather than a spherical seat diameter equal to 1 to 2 times the specimen diameter, the setup used here employed a 25.4 mm diameter high precision ball bearing and seat. Despite the smaller diameter, this seat could move freely to accommodate small angular rotations in any direction, as needed, and therefore did not appreciably influence the results.
- Some tests included measurement of the UCS and tangent Young's (elastic) modulus, but not the Poisson's ratio. This represents a hybrid between Methods C and D of ASTM D7012-14.

Figure 1: Forney loading frame setup for uniaxial compression testing.

1.2 Quantifying Poisson's ratio

To quantify the Poisson's ratio, the radial strain during UCS testing was recorded using a specially designed sensor consisting of a radial spring and non-contact displacement transducer (Figure 2). This sensor was calibrated by axially loading an aluminum cylinder with known elastic modulus and Poisson's ratio and having the same dimensions as the test specimens. By doing so, the output of the non-contact displacement transducer could be calibrated directly to the radial strain of the cylinder. Poisson's ratio was measured over the same range of stresses as the tangent Young's modulus.

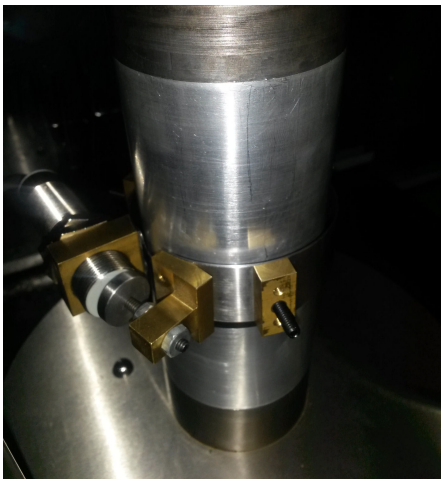


Figure 2: Radial strain sensor comprised of a radial spring and non-contact displacement transducer positioned on the aluminum calibration cylinder.

1.3 Results

The results of UCS testing are summarized in Table 1. The corresponding stress-strain curves are presented in Figures 3 - 5. Please note that additional details and measurements for each test specimen are included in the summary spreadsheet that accompanies this report. The Young's modulus, E, is the tangent modulus, calculated as the slope of the best-fit line through $\pm$300 axial strain data points and the Poisson's ratio, ν, is defined as the ratio of the slope of the best-fit line through $\pm$300 radial strain data points divided by the Young's modulus. For this project, the moduli have been defined at stress levels corresponding to both 50% of the UCS strength and at a stress level of 2.5 MPa (for shale samples only). Definition of the moduli at 50% of the UCS is the conventional approach, however the shale samples tested display non-linear behaviour at this stress level. Therefore, the moduli have also been defined at an alternative stress level where the stress-strain response displays a more linear response.

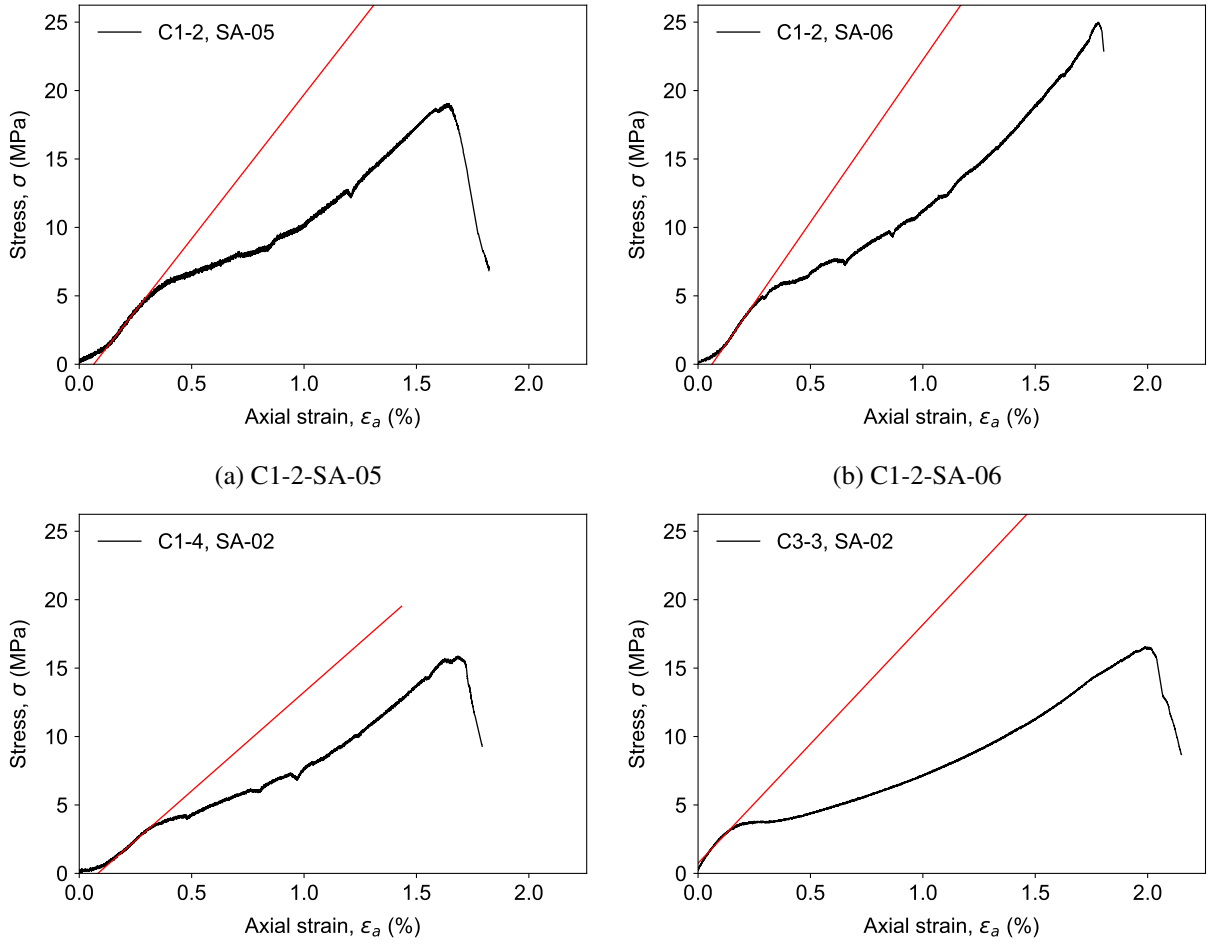
Table 1: Summary of Uniaxial Compression test results.

Sample	Depth (m)	Bulk density ρ (g/cm^3)	UCS (MPa)	Young's modulus E @ 2.5 MPa (GPa)	Poisson's ratio ν @ 2.5 MPa	Young's modulus E @ 50% UCS (GPa)	Poisson's ratio ν @ 50% UCS	Lithology	Failure description
C1-2, SA-05	8.13 - 8.32	2.600	19.1	2.1	-	0.7	-	Shale	1, 2
C1-2, SA-06	10.86 - 11.07	2.602	25.0	2.4	-	1.5	-	Shale	3, 2
C1-4, SA-02	7.49 - 7.81	2.603	15.9	1.4	-	1.0	-	Shale	3, 2
C3-3, SA-02	6.18 - 6.38	2.598	16.6	1.7	-	0.8	-	Shale	4, 5
C1-1, SA-02	5.25 - 5.55	2.607	19.3	1.8	0.54	1.0	0.06	Shale	1, 5
C1-1, SA-03	6.79 - 7.13	2.602	15.2	1.4	0.12	1.0	0.15	Inter-bedded limestone & shale	1, 2
C1-4, SA-03	7.15 - 7.38	2.585	11.0	0.9	0.19	0.5	0.13	Shale	6, 1, 2
C2-1, SA-01	4.60 - 4.85	2.591	17.1	1.5	0.19	0.8	0.05	Shale	3, 5
C2-1, SA-02	4.99 - 5.40	2.589	20.2	1.8	0.18	1.0	0.05	Shale	1, 3, 5
C2-2, SA-01	4.52 - 4.7	2.592	13.3	1.1	0.11	0.8	0.18	Shale	1, 5
C3-4, SA-01	3.09 - 3.41	2.601	17.6	1.9	0.13	0.8	0.14	Shale	1, 5
C3-4, SA-02	3.41 - 3.77	2.594	17.3	2.0	0.20	0.8	0.02	Shale	4, 5
C2-3, SA-05	8.29 - 8.49	2.602	23.2	1.9	0.27	1.4	0.06	Shale	4, 2
C1-3, SA-04	6.54 - 6.75	2.667	210.2	N/A	N/A	44.4	0.25	Limestone	7

[1] Axial splitting failure
[2] Specimen emitted saline pore water upon loading
[3] Partial hourglass failure
[4] Inclined shear band failure
[5] Specimen emitted pore water upon loading
[6] Localized crushing
[7] Hourglass failure

1.4 Specimen photographs

Photographs of the UCS specimens before and after testing are presented in the Appendix of this report.



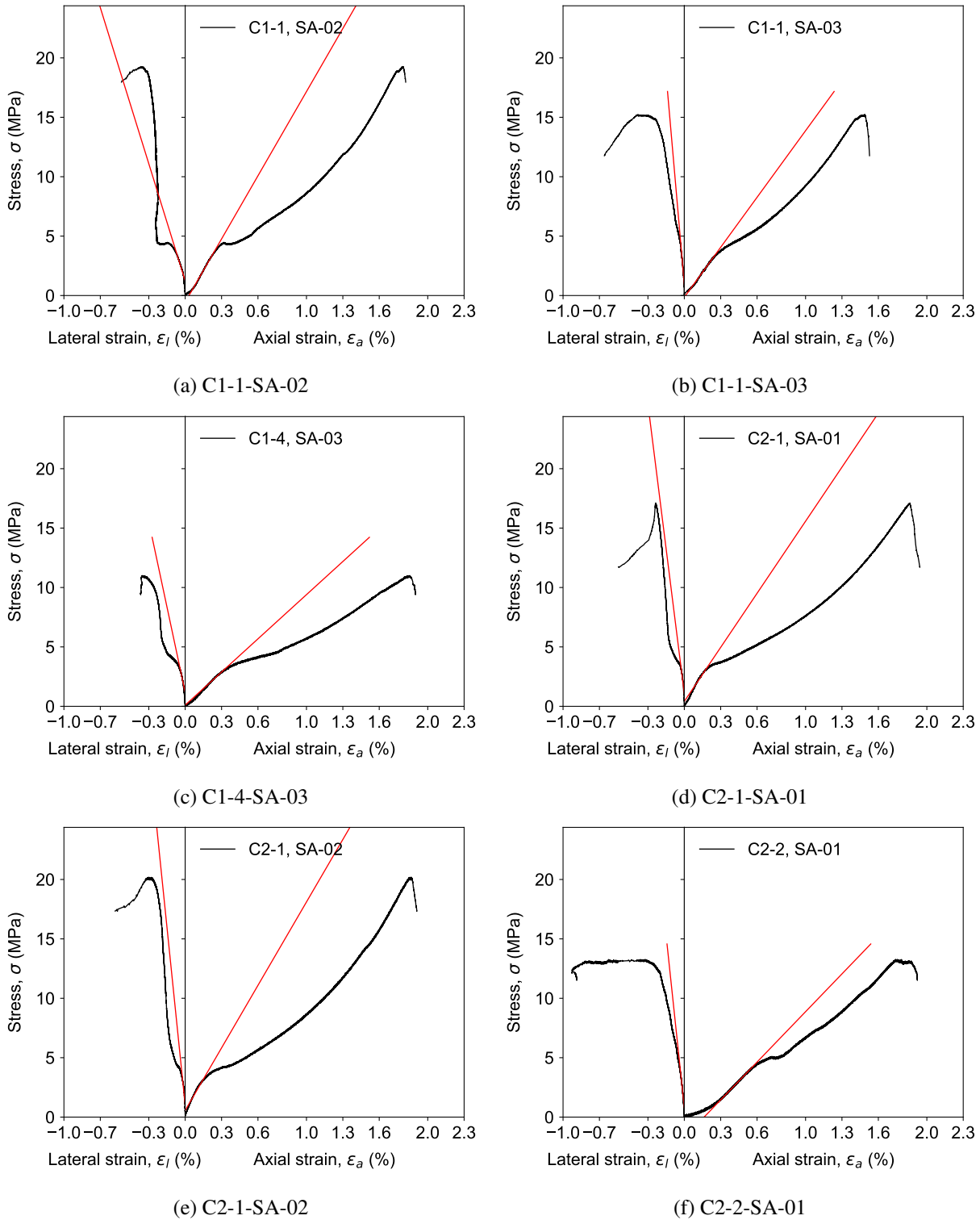
(a) C1-2-SA-05

(b) C1-2-SA-06

(c) C1-4-SA-02

(d) C3-3-SA-02

Figure 3: Measured stress-strain curves for specimens without radial strain measurement.



(a) C1-1-SA-02

(b) C1-1-SA-03

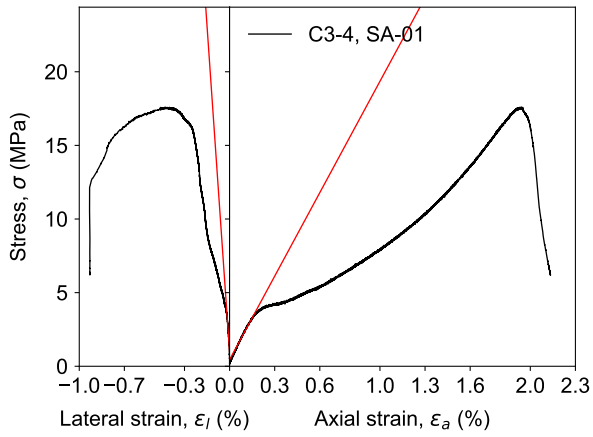
(c) C1-4-SA-03

(d) C2-1-SA-01

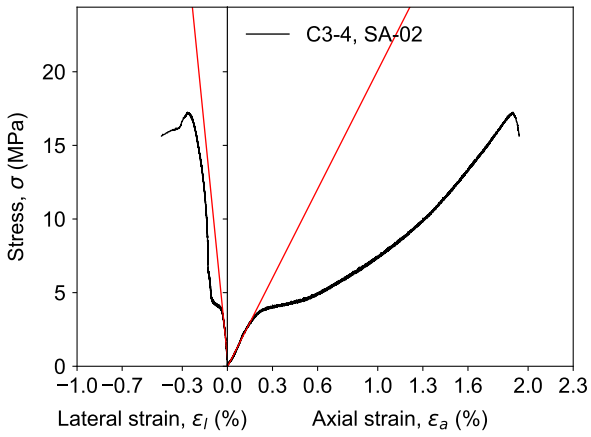
(e) C2-1-SA-02

(f) C2-2-SA-01

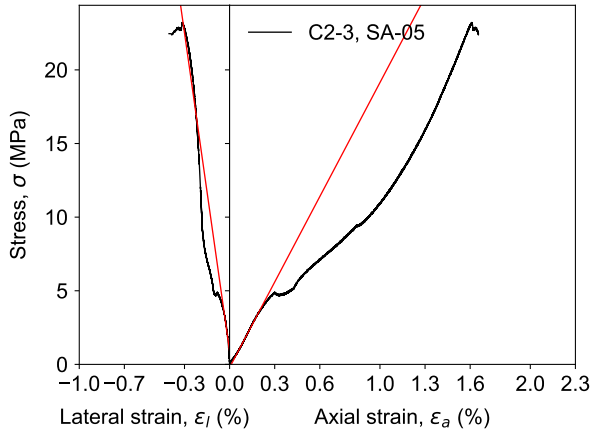
Figure 4: Measured stress-strain curves for specimens with axial and radial strain measurements.



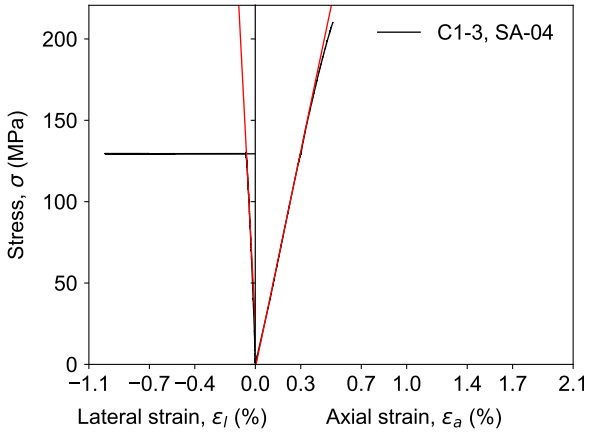
(a) C3-4-SA-01



(b) C3-4-SA-02



(c) C2-3-SA-05



(d) C1-3-SA-04 (limestone)

Figure 5: Measured stress-strain curves for specimens with axial and radial strain measurements (continued).

2 Slake Durability

2.1 Overview

This section summarizes the results of slake durability testing. The tests were performed using an M&L Testing Equipment Slake Durability apparatus capable of simultaneously performing four slake durability tests (Figure 6). The test was conducted using the following procedure:

1. The core was broken using a hammer and point load testing apparatus into 40-60 g lumps. The sharp edges of the lumps were removed by lightly hammering the edges.
2. Approximately 10 lumps weighing 450-550 g were inserted into the drum and dried in the oven at 110 °C until reaching a constant mass.
3. The drum was removed from the oven and allowed to cool to room temperature, weighed, and subsequently rotated in room temperature distilled water at 20 revolutions per minute for 10 minutes.
4. The drum was returned to the oven to dry for approximately one day and weighed again.
5. Steps 3 and 4 were then repeated for a second cycle.
6. The drum was thoroughly cleaned, dried, and weighed.

The above slake durability testing procedure adhered to ASTM D4644-16.

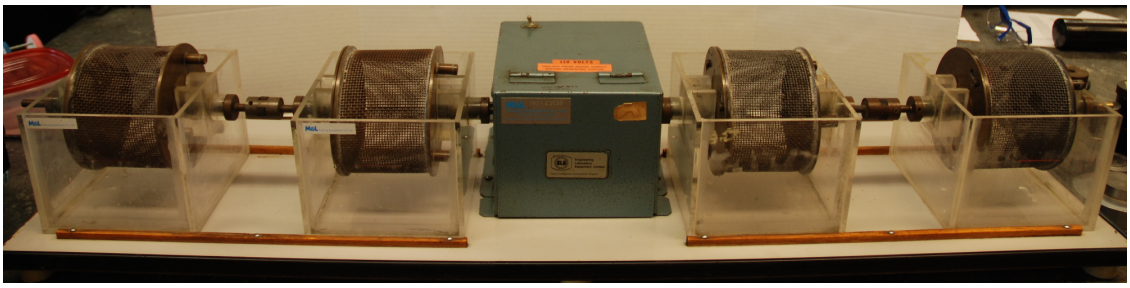


Figure 6: Test setup showing the slake durability apparatus.

2.2 Results

The results of the tests are summarized in Table 2. Additional measurements and sample descriptions are provided in the summary spreadsheet that accompanies this report. The slake durability index after one and two cycles was calculated as follows, respectively:

$$I_{d1} = \frac{B - D}{A - D} \times 100\% \quad (1)$$

$$I_{d2} = \frac{C - D}{A - D} \times 100\% \quad (2)$$

where A is the mass of the specimen and drum before the first test cycle, B is the mass of the specimen and drum after oven drying the first cycle, C is the mass of the specimen and drum after oven drying the second cycle and D is the mass of the drum.

Table 2: Summary of slake durability testing results.

Sample	Depth (m)	Moisture content (%)	Pre-First Cycle, A (g)	Post-First Cycle, B (g)	Post-Second Cycle, C (g)	Mass of Drum, D (g)	Slake Durability Index , (1st Cycle) I_{d1} (%)	Slake Durability Index (2nd Cycle), I_{d2} (%)	Lithology
C1-4, SA-01	6.27 - 6.47	0.90	2378.84	2286.94	2172.12	1897.46	80.9	57.1	Grey shale
C3-1, SA-01	4.50 - 4.69	0.82	2424.48	2365.03	2304.42	1952.74	87.4	74.5	Grey shale

2.3 Specimen Photographs

Photographs of the specimens before testing and after testing are shown in Figure 7.

Figure 7: Photographs of slake durability specimens before and after testing.

3 CERCHAR Abrasivity Tests

3.1 Overview

This section summarizes the results of CERCHAR abrasivity testing. The tests were performed using a Type-2 CERCHAR apparatus as shown in Figure 8a. The tips of the styluses were sharpened to a conical angle of 90° using the setup shown in Figure 8b. The styluses used to perform the tests are shown in Figure 8c-d (Rockwell hardness 55±1). A static force of 70 N was applied on top of the stylus by using a combination of weights. Details of the testing procedure are as follows:

1. The tips of the five styluses are sharpened using the grinding apparatus (Figure 8b).
2. The styluses are placed under a microscope (60x magnification) and three scaled photos (120° apart) are captured before the test is conducted to ensure the 90° point has been properly formed.
3. The test specimens are obtained by breaking core samples to expose a fresh fracture surface perpendicular to the core axis.
4. The specimen is secured in the cross-slide vise of the testing apparatus and the stylus is carefully lowered on to the surface of the rock.
5. A scratch measuring 10 mm in length is performed over a duration of 10 seconds. This process is repeated with all five styluses on undisturbed parts of the fracture surface (e.g., Figure 9a).
6. Lastly, the worn tips are re-examined under the microscope. From three scaled photos (120° apart), the wear flat, d, is measured (e.g., Figure 9c).

The length or the diameter of the wear flat, d, was measured from scaled microscope images using the image processing software Fiji (e.g., Figure 9b-c). The mean wear of the tip is calculated by taking the average d of all tests. The CERCHAR-Abrasivity-Index (CAI) of the sample is subsequently calculated by taking the mean wear and multiplying it by 10.

3.2 Results

The results of the CERCHAR abrasivity tests are summarized in Table 3. Additional measurements and sample descriptions are provided in the summary spreadsheet that accompanies this report.

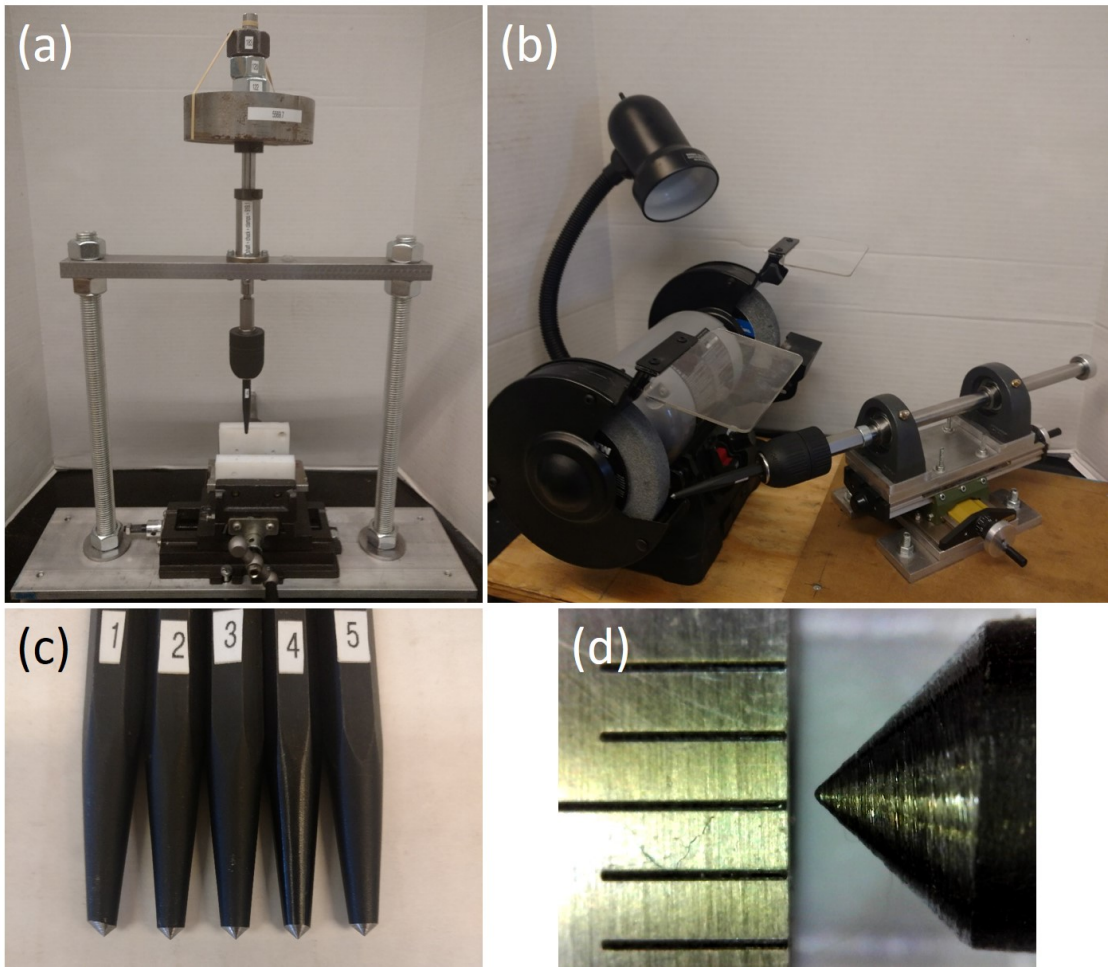


Figure 8: Photos showing (a) the CERCHAR apparatus, (b) tip sharpening setup, (c) the five styluses used to perform the test and (d) a microscope image of one of the stylus tips.

Table 3: Summary of CERCHAR abrasivity test results.

Sample	Depth (m)	Test 1 Mean (mm)	Test 2 Mean (mm)	Test 3 Mean (mm)	Test 4 Mean (mm)	Test 5 Mean (mm)	Mean Wear (mm)	CAI	Standard Deviation of CAI	ASTM Classification
C1-2, SA-02	4.78 - 4.91	0.019	0.022	0.035	0.024	0.026	0.025	0.25	0.06	< Very Low
C2-2, SA-02	7.20 - 7.29	0.026	0.015	0.033	0.045	0.015	0.027	0.27	0.12	< Very Low
C3-2, SA-03	7.55 - 7.68	0.027	0.042	0.008	0.022	0.015	0.023	0.23	0.13	< Very Low
C3-3, SA-04	7.03 - 7.18	0.015	0.025	0.060	0.032	0.033	0.033	0.33	0.17	< Very Low

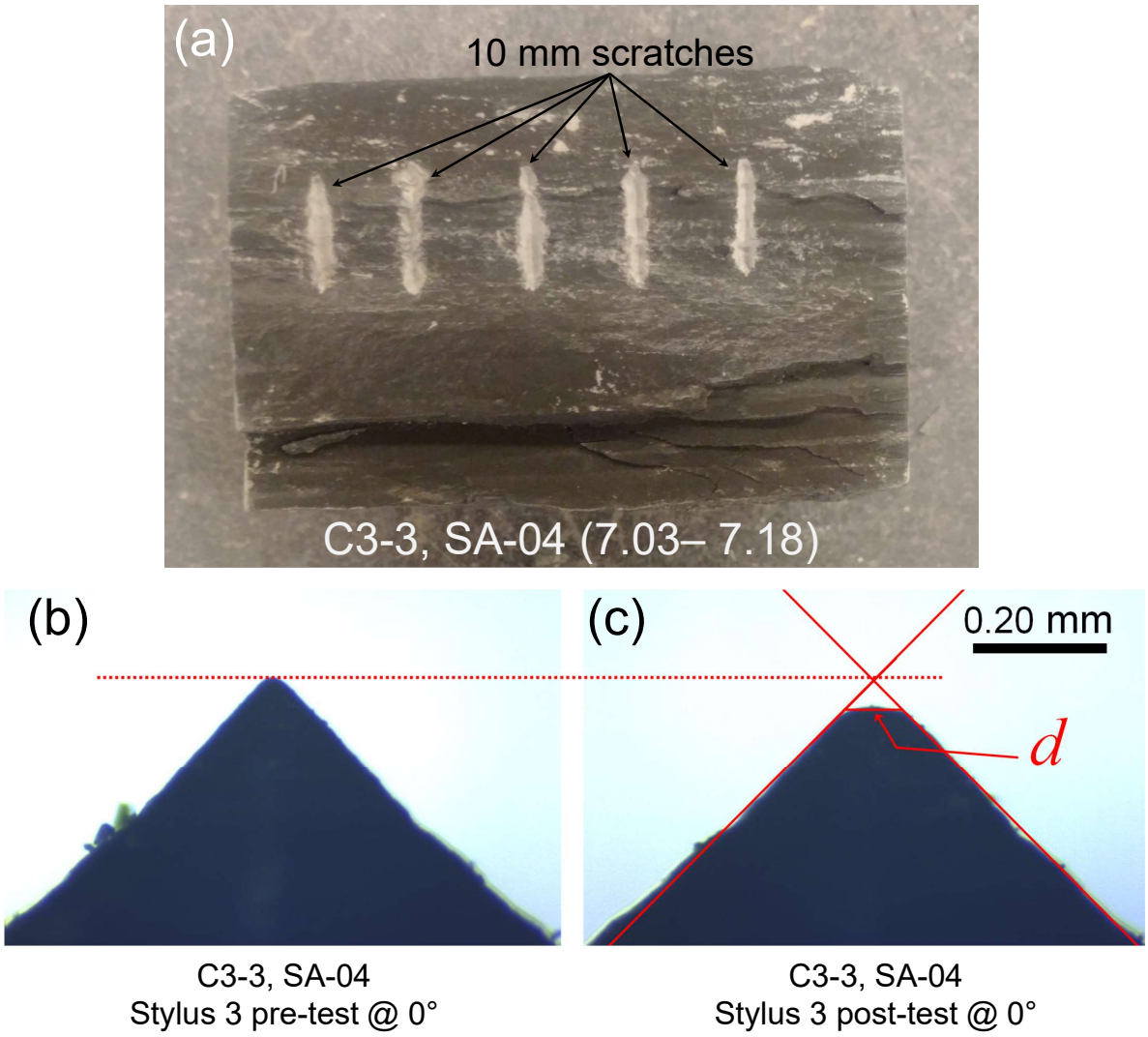


Figure 9: (a) Photograph showing an example of the five 10 mm scratches on a test specimen (b) microscope image of select stylus prior to testing at the noted position; and (c) microscope image of the same stylus at the same position following testing with the wear flat, d, denoted.

Appendices

A UCS specimen sheets

Tests without radial strain measurement

- C1-2, SA-05
- C1-2, SA-06
- C1-4, SA-02
- C3-3, SA-02

Tests with radial strain measurement

- C1-1, SA-02
- C1-1, SA-03
- C1-4, SA-03
- C2-1, SA-01
- C2-1, SA-02
- C2-2, SA-01
- C3-4, SA-01
- C3-4, SA-02
- C2-3, SA-05
- C1-3, SA-04

GEOMECHANICA

Uniaxial Compression Test

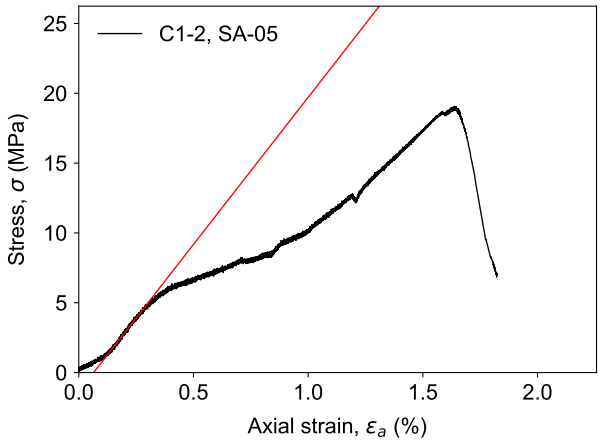
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-2, SA-05	**Depth**	8.13 - 8.32

Specimen parameters	
Diameter (mm) [a]	62.26
Length (mm) [a]	121.79
Bulk density ρ (g/cm^3)	2.600
UCS (MPa)	19.1
Young's modulus E (GPa) [b]	2.1
Lithology	Shale
Failure description [c]	1, 2

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 13.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [2] Specimen emitted saline pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-11

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Uniaxial Compression Test

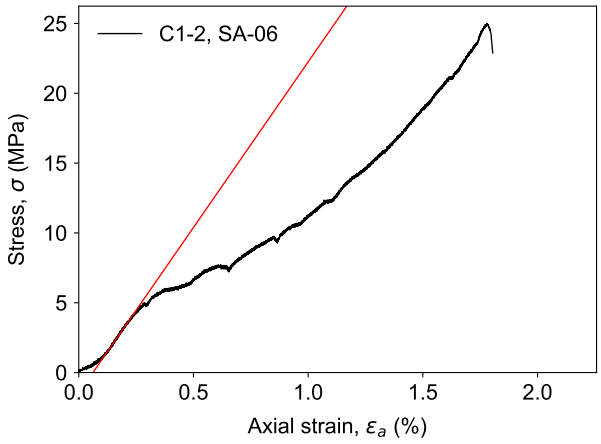
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-2, SA-06	**Depth**	10.86 - 11.07

Specimen parameters	
Diameter (mm) [a]	62.25
Length (mm) [a]	122.19
Bulk density ρ (g/cm^3)	2.602
UCS (MPa)	25.0
Young's modulus E (GPa) [b]	2.4
Lithology	Shale
Failure description [c]	3, 2

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 10.0% of the peak strength.
[c] Failure description: [3] Partial hourglass failure; [2] Specimen emitted saline pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-11

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Uniaxial Compression Test

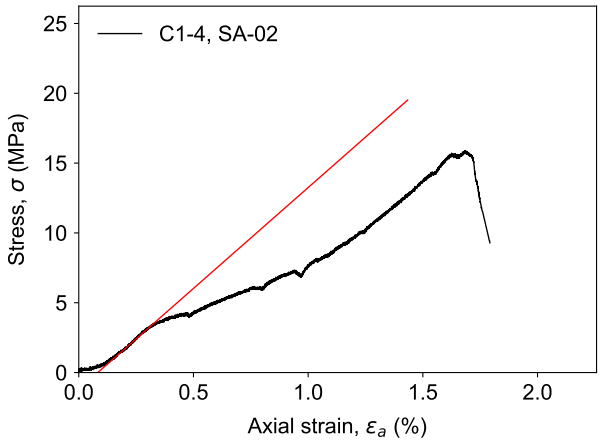
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-4, SA-02	**Depth**	7.49 - 7.81

Specimen parameters	
Diameter (mm) [a]	60.80
Length (mm) [a]	122.21
Bulk density ρ (g/cm^3)	2.603
UCS (MPa)	15.9
Young's modulus E (GPa) [b]	1.4
Lithology	Shale
Failure description [c]	3, 2

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 16.0% of the peak strength.
[c] Failure description: [3] Partial hourglass failure; [2] Specimen emitted saline pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-11

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Uniaxial Compression Test

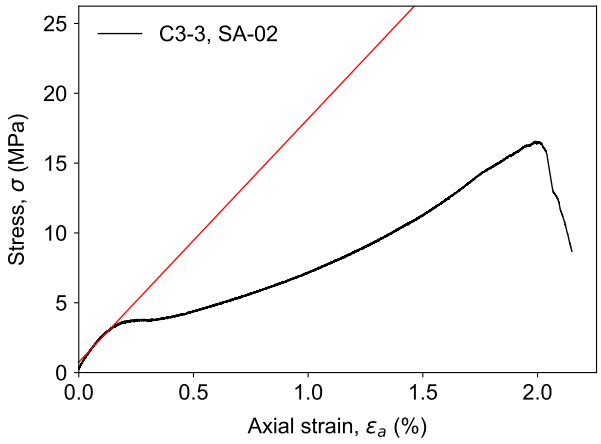
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C3-3, SA-02	**Depth**	6.18 - 6.38

Specimen parameters	
Diameter (mm) [a]	63.02
Length (mm) [a]	121.86
Bulk density ρ (g/cm^3)	2.598
UCS (MPa)	16.6
Young's modulus E (GPa) [b]	1.7
Lithology	Shale
Failure description [c]	4, 5

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 15.0% of the peak strength.
[c] Failure description: [4] Inclined shear band failure; [5] Specimen emitted pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-11

GEOMECHANICA

Uniaxial Compression Test

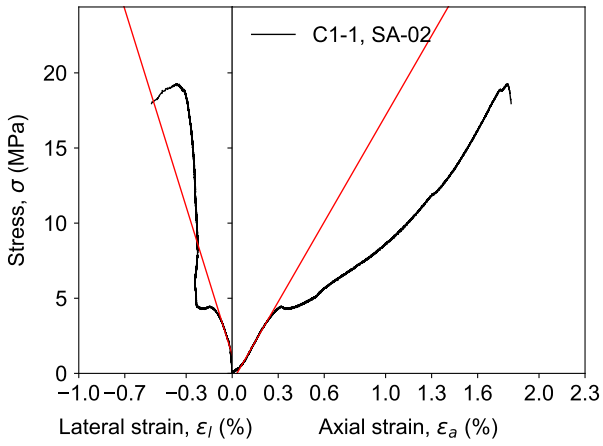
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-1, SA-02	**Depth**	5.25 - 5.55

Specimen parameters	
Diameter (mm) [a]	60.67
Length (mm) [a]	123.08
Bulk density ρ (g/cm^3)	2.607
UCS (MPa)	19.3
Young's modulus E (GPa) [b]	1.8
Poisson's ratio ν (-) [b]	0.54
Lithology	Shale
Failure description [c]	1, 5

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 13.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [5] Specimen emitted pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-11

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Uniaxial Compression Test

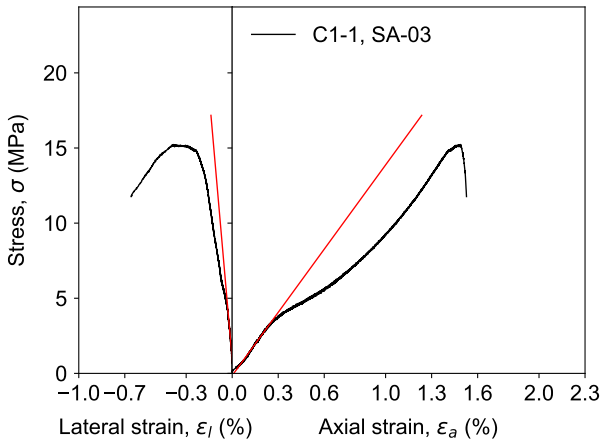
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-1, SA-03	**Depth**	6.79 - 7.13

Specimen parameters	
Diameter (mm) [a]	60.70
Length (mm) [a]	119.52
Bulk density ρ (g/cm^3)	2.602
UCS (MPa)	15.2
Young's modulus E (GPa) [b]	1.4
Poisson's ratio ν (-) [b]	0.12
Lithology	Inter-bedded limestone and s
Failure description [c]	1, 2

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 16.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [2] Specimen emitted saline pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-11

GEOMECHANICA

Uniaxial Compression Test

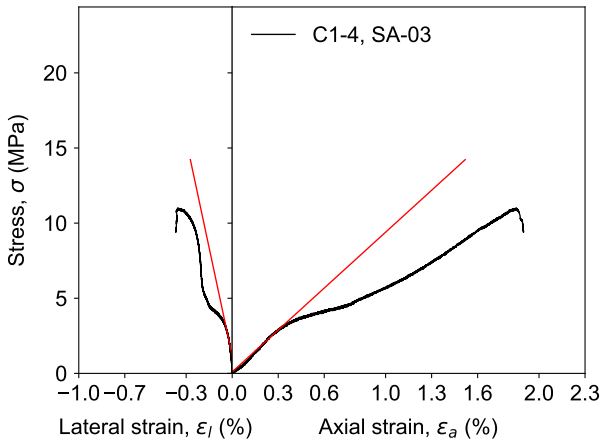
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-4, SA-03	**Depth**	7.15 - 7.38

Specimen parameters	
Diameter (mm) [a]	60.80
Length (mm) [a]	122.48
Bulk density ρ (g/cm^3)	2.585
UCS (MPa)	11.0
Young's modulus E (GPa) [b]	0.9
Poisson's ratio ν (-) [b]	0.19
Lithology	Shale
Failure description [c]	6, 1, 2

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 23.0% of the peak strength.
[c] Failure description: [6] Localized crushing; [1] Axial splitting failure; [2] Specimen emitted saline pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-11

GEOMECHANICA

Uniaxial Compression Test

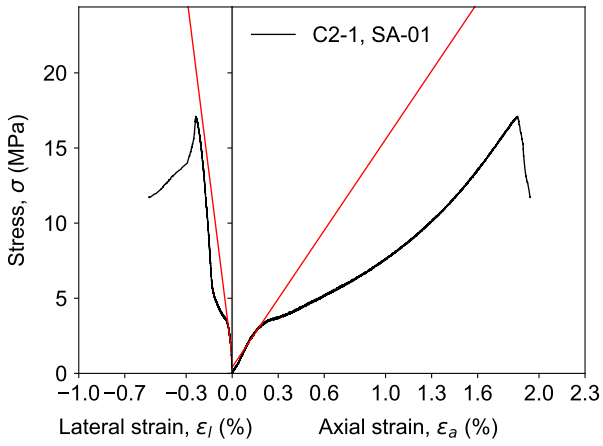
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C2-1, SA-01	**Depth**	4.60 - 4.85

Specimen parameters	
Diameter (mm) [a]	60.65
Length (mm) [a]	122.77
Bulk density ρ (g/cm^3)	2.591
UCS (MPa)	17.1
Young's modulus E (GPa) [b]	1.5
Poisson's ratio ν (-) [b]	0.19
Lithology	Shale
Failure description [c]	3, 5

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 15.0% of the peak strength.
[c] Failure description: [3] Partial hourglass failure; [5] Specimen emitted pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-11

GEOMECHANICA

Uniaxial Compression Test

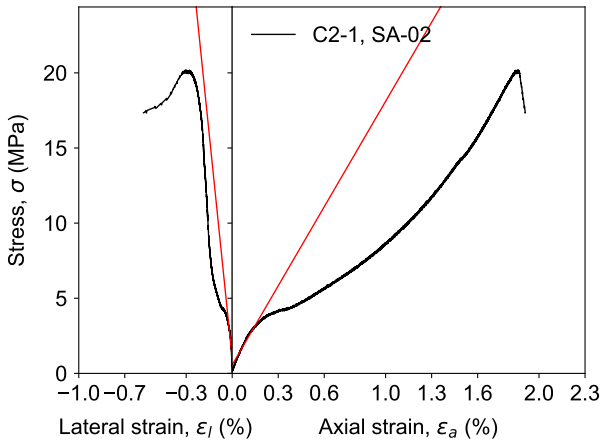
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C2-1, SA-02	**Depth**	4.99 - 5.40

Specimen parameters	
Diameter (mm) [a]	60.73
Length (mm) [a]	122.55
Bulk density ρ (g/cm^3)	2.589
UCS (MPa)	20.2
Young's modulus E (GPa) [b]	1.8
Poisson's ratio ν (-) [b]	0.18
Lithology	Shale
Failure description [c]	1, 3, 5

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 12.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [3] Partial hourglass failure; [5] Specimen emitted pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-12

GEOMECHANICA

Uniaxial Compression Test

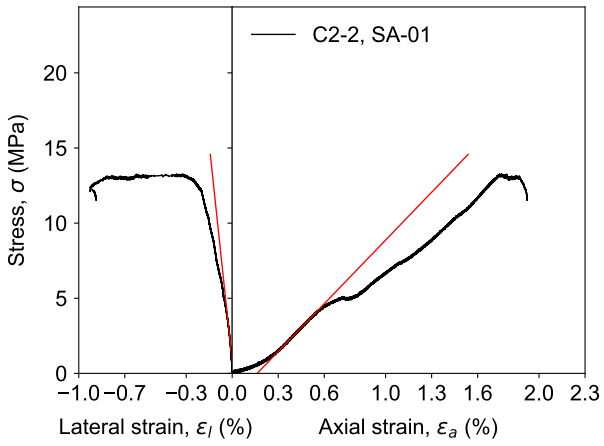
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C2-2, SA-01	**Depth**	4.52 - 4.7

Specimen parameters	
Diameter (mm) [a]	61.78
Length (mm) [a]	122.04
Bulk density ρ (g/cm^3)	2.592
UCS (MPa)	13.3
Young's modulus E (GPa) [b]	1.1
Poisson's ratio ν (-) [b]	0.11
Lithology	Shale
Failure description [c]	1, 5

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 19.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [5] Specimen emitted pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-12

GEOMECHANICA

Uniaxial Compression Test

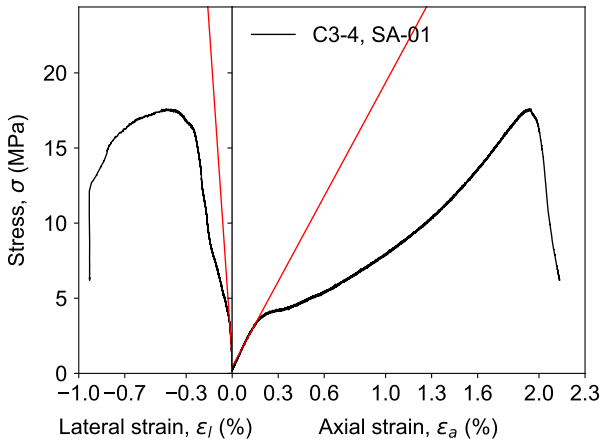
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C3-4, SA-01	**Depth**	3.09 - 3.41

Specimen parameters	
Diameter (mm) [a]	60.65
Length (mm) [a]	121.72
Bulk density ρ (g/cm^3)	2.601
UCS (MPa)	17.6
Young's modulus E (GPa) [b]	1.9
Poisson's ratio ν (-) [b]	0.13
Lithology	Shale
Failure description [c]	1, 5

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 14.0% of the peak strength.
[c] Failure description: [1] Axial splitting failure; [5] Specimen emitted pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-13

GEOMECHANICA

Uniaxial Compression Test

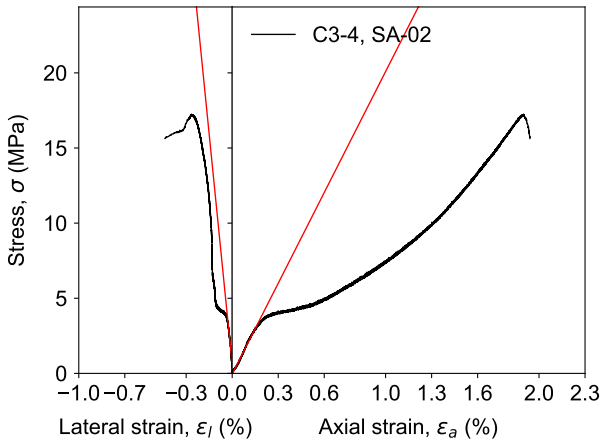
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C3-4, SA-02	**Depth**	3.41 - 3.77

Specimen parameters	
Diameter (mm) [a]	60.76
Length (mm) [a]	122.84
Bulk density ρ (g/cm^3)	2.594
UCS (MPa)	17.3
Young's modulus E (GPa) [b]	2.0
Poisson's ratio ν (-) [b]	0.20
Lithology	Shale
Failure description [c]	4, 5

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 14.0% of the peak strength.
[c] Failure description: [4] Inclined shear band failure; [5] Specimen emitted pore water upon loading;

Prior to testing

After testing



Remarks:

Performed by	BSAT	**Date**	2019-03-13

GEOMECHANICA

Uniaxial Compression Test

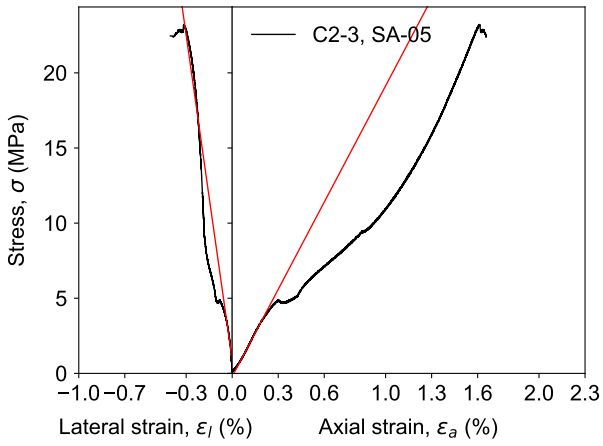
Client	Golder Associates Ltd.	**Project**	1662333
Sample	C2-3, SA-05	**Depth**	8.29 - 8.49

Specimen parameters	
Diameter (mm) [a]	62.29
Length (mm) [a]	124.74
Bulk density ρ (g/cm^3)	2.602
UCS (MPa)	23.2
Young's modulus E (GPa) [b]	1.9
Poisson's ratio ν (-) [b]	0.27
Lithology	Shale
Failure description [c]	4, 2

Prior to testing

After testing

[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through $\pm$300 data points on either side of the point representing 11.0% of the peak strength.
[c] Failure description: [4] Inclined shear band failure; [2] Specimen emitted saline pore water upon loading;



Remarks:

Performed by	BSAT	**Date**	2019-03-13

GEOMECHANICA

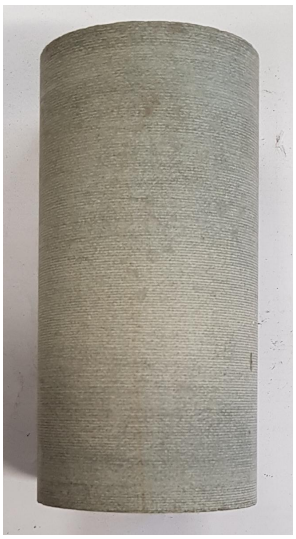
Uniaxial Compression Test

Client	Golder Associates Ltd.	**Project**	1662333
Sample	C1-3, SA-04	**Depth**	6.54 - 6.75

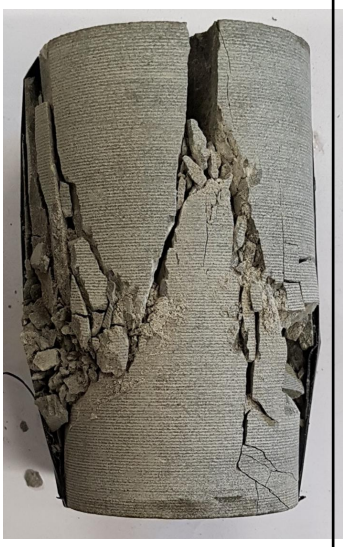
Specimen parameters	
Diameter (mm) [a]	62.34
Length (mm) [a]	125.90
Bulk density ρ (g/cm^3)	2.667
UCS (MPa)	210.2
Young's modulus E (GPa) [b]	44.4
Poisson's ratio ν (-) [b]	0.25
Lithology	Limestone
Failure description [c]	7

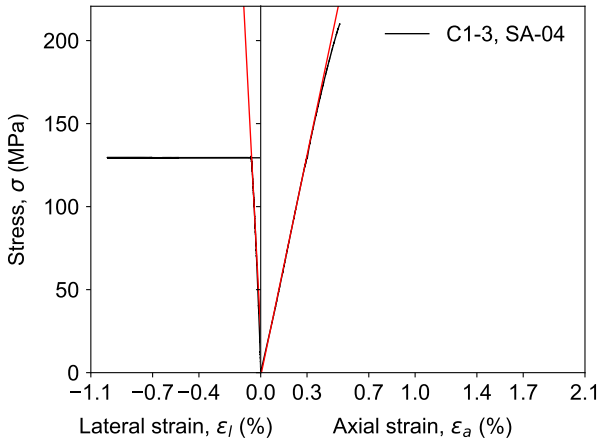
[a] Additional specimen measurement/details provides in accompanying summary spreadsheet.
[b] Tangent modulus, calculated as the slope of the best fit line through ±300 data points on either side of the point representing 50.0% of the peak strength.
[c] Failure description: [7] Hourglass failure;

Prior to testing



After testing





Remarks: Removed radial strain sensor prior to rupture to avoid possible damage.

Performed by	BSAT	**Date**	2019-03-14

APPENDIX C

Analytical Laboratory Testing Results (Maxxam Analytics)

Maxxam
A Bureau Veritas Group Company

Your C.O.C. #: 125152

Attention: David Marmor

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

Report Date: 2019/03/12
Report #: R5625381
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B958559
Received: 2019/03/06, 15:01

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Petroleum Hydro. CCME F1 & BTEX in Soil (1)	2	N/A	2019/03/08	CAM SOP-00315	CCME PHC-CWS m
Moisture	2	N/A	2019/03/06	CAM SOP-00445	Carter 2nd ed 51.2 m

Remarks:

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

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

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

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) No lab extraction date is given for F1BTEX & VOC samples that are field preserved with methanol. Extraction date is the date sampled unless otherwise stated.

Your C.O.C. #: 125152

Attention: David Marmor

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

Report Date: 2019/03/12
Report #: R5625381
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B958559
Received: 2019/03/06, 15:01

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 #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

RESULTS OF ANALYSES OF SOIL

Maxxam ID		JDC559	JDC560		
Sampling Date		2019/03/05 15:15	2019/03/01 14:40		
COC Number		125152	125152		
	UNITS	BHC2-2 SA-03	BHC3-2 SA-01	RDL	QC Batch
Inorganics					
Moisture	%	5.0	6.4	1.0	6006016

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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

Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

PETROLEUM HYDROCARBONS (CCME)

Maxxam ID		JDC559	JDC560		
Sampling Date		2019/03/05 15:15	2019/03/01 14:40		
COC Number		125152	125152		
	UNITS	BHC2-2 SA-03	BHC3-2 SA-01	RDL	QC Batch
BTEX & F1 Hydrocarbons					
Benzene	ug/g	0.21	<0.020	0.020	6008322
Toluene	ug/g	0.072	<0.020	0.020	6008322
Ethylbenzene	ug/g	<0.020	<0.020	0.020	6008322
o-Xylene	ug/g	<0.020	<0.020	0.020	6008322
p+m-Xylene	ug/g	<0.040	<0.040	0.040	6008322
Total Xylenes	ug/g	<0.040	<0.040	0.040	6008322
F1 (C6-C10)	ug/g	<10	<10	10	6008322
F1 (C6-C10) - BTEX	ug/g	<10	<10	10	6008322
Surrogate Recovery (%)					
1,4-Difluorobenzene	%	100	102		6008322
4-Bromofluorobenzene	%	98	98		6008322
D10-Ethylbenzene	%	96	92		6008322
D4-1,2-Dichloroethane	%	101	102		6008322

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

TEST SUMMARY

Maxxam ID: JDC559
Sample ID: BHC2-2 SA-03
Matrix: Soil

Collected: 2019/03/05
Shipped:
Received: 2019/03/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Soil	HSGC/MSFD	6008322	N/A	2019/03/08	Ravinder Gaidhu
Moisture	BAL	6006016	N/A	2019/03/06	Min Yang

Maxxam ID: JDC560
Sample ID: BHC3-2 SA-01
Matrix: Soil

Collected: 2019/03/01
Shipped:
Received: 2019/03/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Soil	HSGC/MSFD	6008322	N/A	2019/03/08	Ravinder Gaidhu
Moisture	BAL	6006016	N/A	2019/03/06	Min Yang

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

Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

GENERAL COMMENTS

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

Package 1	3.7°C

Rock sample submitted, sample has been crushed and preserved at the lab prior to analysis as per client request.

Results relate only to the items tested.

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Maxxam Job #: B958559
Report Date: 2019/03/12

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Sampler Initials: AM

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
6008322	1,4-Difluorobenzene	2019/03/08	100	60 - 140	101	60 - 140	101	%		
6008322	4-Bromofluorobenzene	2019/03/08	99	60 - 140	99	60 - 140	98	%		
6008322	D10-Ethylbenzene	2019/03/08	91	60 - 140	82	60 - 140	84	%		
6008322	D4-1,2-Dichloroethane	2019/03/08	100	60 - 140	101	60 - 140	100	%		
6006016	Moisture	2019/03/06							3.4	20
6008322	Benzene	2019/03/08	83	60 - 140	83	60 - 140	<0.020	ug/g		
6008322	Ethylbenzene	2019/03/08	88	60 - 140	87	60 - 140	<0.020	ug/g		
6008322	F1 (C6-C10) - BTEX	2019/03/08					<10	ug/g	NC	30
6008322	F1 (C6-C10)	2019/03/08	94	60 - 140	89	80 - 120	<10	ug/g	NC	30
6008322	o-Xylene	2019/03/08	89	60 - 140	87	60 - 140	<0.020	ug/g		
6008322	p+m-Xylene	2019/03/08	89	60 - 140	87	60 - 140	<0.040	ug/g		
6008322	Toluene	2019/03/08	91	60 - 140	90	60 - 140	<0.020	ug/g		
6008322	Total Xylenes	2019/03/08					<0.040	ug/g		

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.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

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

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

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Maxxam
A Bureau Veritas Group Company

6740 Campobello Road, Mississauga, Ontario L5N 2L8
Phone: 905-817-5700 Fax: 905-817-5779 Toll Free: 800-563-6266
CAM FCD-01191/4

CHAIN OF CUSTODY RECORD 125152

Page 1 of 1

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: Golder Associates	Company Name:	Quotation #:	☒ Regular TAT (5-7 days) Most analyses
Contact Name: David Marmor	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: 6925 Century Avenue Suite #6 Mississauga, ON L5N 7K2	Address:	Project #:	Rush TAT (Surcharges will be applied) ☐ 1 Day ☐ 2 Day ☐ 3-4 Days
Phone: 905-567-4444 Fax: 905-567-6561	Phone: Fax:	Site Location:	
Email: dmarmor@golder.com	Email:	Site #:	Date Required:
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY		Site Location Province:	Rush Confirmation #:
		Sampled By:	

Regulation 153	Other Regulations
☐ Table 1 ☐ Res/Park ☐ Med/ Fine	☐ CCME ☐ Sanitary Sewer Bylaw
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ MISA ☐ Storm Sewer Bylaw
☐ Table 3 ☐ Agri/ Other	☐ PWQO Region
☐ Table ____	☐ Other (Specify)
FOR RSC (PLEASE CIRCLE) Y / N	☐ REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

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

Analysis Requested

LABORATORY USE ONLY

CUSTODY SEAL Y / N (Present / Intact)

COOLER TEMPERATURES: 2 | 8 | 1

COOLING MEDIA PRESENT: (Y) / N

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	HOLD - DO NOT ANALYZE	COMMENTS
1	BHC2-2 SA-03	2019/03/05	03:15	Rock	1 Jar 2 vials		X							
2	BH C3-2 SA-01	2019/03/01	02:40	Rock	1 Jar 2 vials		X							
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)
Alex MacMillan	2019/03/06	15:00	[signature]	2019/03/06	1501

06-Mar-19 15:01
Ema Gitej
B958559
KVG env-1302

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Maxxam's standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms w
Sample container, preservation, hold time and packages information can be viewed at http://maxxam.ca/wp-content/uploads/Ontario-COC.pdf.

COC-1004 (01/19)

White: Maxxam ~ Yellow: Client

Maxxam
A Bureau Veritas Group Company

Your C.O.C. #: 125152

Attention: David Marmor

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

Report Date: 2019/03/12
Report #: R5625381
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B958559
Received: 2019/03/06, 15:01

Sample Matrix: Soil
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Petroleum Hydro. CCME F1 & BTEX in Soil (1)	2	N/A	2019/03/08	CAM SOP-00315	CCME PHC-CWS m
Moisture	2	N/A	2019/03/06	CAM SOP-00445	Carter 2nd ed 51.2 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.

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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.
(1) No lab extraction date is given for F1BTEX & VOC samples that are field preserved with methanol. Extraction date is the date sampled unless otherwise stated.

Your C.O.C. #: 125152

Attention: David Marmor

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Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/03/12
Report #: R5625381
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CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B958559
Received: 2019/03/06, 15:01

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
==========
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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

RESULTS OF ANALYSES OF SOIL

Maxxam ID		JDC559	JDC560		
Sampling Date		2019/03/05 15:15	2019/03/01 14:40		
COC Number		125152	125152		
	UNITS	BHC2-2 SA-03	BHC3-2 SA-01	RDL	QC Batch
Inorganics					
Moisture	%	5.0	6.4	1.0	6006016

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

PETROLEUM HYDROCARBONS (CCME)

Maxxam ID		JDC559	JDC560		
Sampling Date		2019/03/05 15:15	2019/03/01 14:40		
COC Number		125152	125152		
	UNITS	BHC2-2 SA-03	BHC3-2 SA-01	RDL	QC Batch
BTEX & F1 Hydrocarbons					
Benzene	ug/g	0.21	<0.020	0.020	6008322
Toluene	ug/g	0.072	<0.020	0.020	6008322
Ethylbenzene	ug/g	<0.020	<0.020	0.020	6008322
o-Xylene	ug/g	<0.020	<0.020	0.020	6008322
p+m-Xylene	ug/g	<0.040	<0.040	0.040	6008322
Total Xylenes	ug/g	<0.040	<0.040	0.040	6008322
F1 (C6-C10)	ug/g	<10	<10	10	6008322
F1 (C6-C10) - BTEX	ug/g	<10	<10	10	6008322
Surrogate Recovery (%)					
1,4-Difluorobenzene	%	100	102		6008322
4-Bromofluorobenzene	%	98	98		6008322
D10-Ethylbenzene	%	96	92		6008322
D4-1,2-Dichloroethane	%	101	102		6008322

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

TEST SUMMARY

Maxxam ID: JDC559
Sample ID: BHC2-2 SA-03
Matrix: Soil

Collected: 2019/03/05
Shipped:
Received: 2019/03/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Soil	HSGC/MSFD	6008322	N/A	2019/03/08	Ravinder Gaidhu
Moisture	BAL	6006016	N/A	2019/03/06	Min Yang

Maxxam ID: JDC560
Sample ID: BHC3-2 SA-01
Matrix: Soil

Collected: 2019/03/01
Shipped:
Received: 2019/03/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Soil	HSGC/MSFD	6008322	N/A	2019/03/08	Ravinder Gaidhu
Moisture	BAL	6006016	N/A	2019/03/06	Min Yang

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

GENERAL COMMENTS

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

Package 1	3.7°C

Rock sample submitted, sample has been crushed and preserved at the lab prior to analysis as per client request.

Results relate only to the items tested.

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Maxxam Job #: B958559
Report Date: 2019/03/12

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Sampler Initials: AM

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
6008322	1,4-Difluorobenzene	2019/03/08	100	60 - 140	101	60 - 140	101	%		
6008322	4-Bromofluorobenzene	2019/03/08	99	60 - 140	99	60 - 140	98	%		
6008322	D10-Ethylbenzene	2019/03/08	91	60 - 140	82	60 - 140	84	%		
6008322	D4-1,2-Dichloroethane	2019/03/08	100	60 - 140	101	60 - 140	100	%		
6006016	Moisture	2019/03/06							3.4	20
6008322	Benzene	2019/03/08	83	60 - 140	83	60 - 140	<0.020	ug/g		
6008322	Ethylbenzene	2019/03/08	88	60 - 140	87	60 - 140	<0.020	ug/g		
6008322	F1 (C6-C10) - BTEX	2019/03/08					<10	ug/g	NC	30
6008322	F1 (C6-C10)	2019/03/08	94	60 - 140	89	80 - 120	<10	ug/g	NC	30
6008322	o-Xylene	2019/03/08	89	60 - 140	87	60 - 140	<0.020	ug/g		
6008322	p+m-Xylene	2019/03/08	89	60 - 140	87	60 - 140	<0.040	ug/g		
6008322	Toluene	2019/03/08	91	60 - 140	90	60 - 140	<0.020	ug/g		
6008322	Total Xylenes	2019/03/08					<0.040	ug/g		

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.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

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

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Maxxam Job #: B958559
Report Date: 2019/03/12

Golder Associates Ltd
Sampler Initials: AM

VALIDATION SIGNATURE PAGE

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

Anastassia Hamanov, Scientific Specialist

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

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CAM FCD-01191/4

CHAIN OF CUSTODY RECORD 125152

Page 1 of 1

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: Golder Associates	Company Name:	Quotation #:	☒ Regular TAT (5-7 days) Most analyses
Contact Name: David Marmor	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: 6925 Century Avenue Suite #6 Mississauga, ON L5N 7K2	Address:	Project #:	Rush TAT (Surcharges will be applied) ☐ 1 Day ☐ 2 Day ☐ 3-4 Days
Phone: 905-567-4444 Fax: 905-567-6561	Phone: Fax:	Site Location:	
Email: dmarmor@golder.com	Email:	Site #:	Date Required:
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY		Site Location Province:	Rush Confirmation #:
		Sampled By:	

Regulation 153	Other Regulations
☐ Table 1 ☐ Res/Park ☐ Med/ Fine	☐ CCME ☐ Sanitary Sewer Bylaw
☐ Table 2 ☐ Ind/Comm ☐ Coarse	☐ MISA ☐ Storm Sewer Bylaw
☐ Table 3 ☐ Agri/ Other	☐ PWQO Region
☐ Table ____	☐ Other (Specify)
FOR RSC (PLEASE CIRCLE) Y / N	☐ REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

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

Analysis Requested

LABORATORY USE ONLY

CUSTODY SEAL Y / N (Present / Intact)

COOLER TEMPERATURES: 2 | 8 | 1

COOLING MEDIA PRESENT: (Y) / N

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	HOLD - DO NOT ANALYZE	COMMENTS
1	BHC2-2 SA-03	2019/03/05	03:15	Rock	1 Jar 2 vials		X							
2	BH C3-2 SA-01	2019/03/01	02:40	Rock	1 Jar 2 vials		X							
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)
Alex MacMillan	2019/03/06	15:00	[signature]	2019/03/06	1501

06-Mar-19 15:01
Ema Gitej
B958559
KVG env-1302

Unless otherwise agreed to in writing, work submitted on this Chain of Custody is subject to Maxxam's standard Terms and Conditions. Signing of this Chain of Custody document is acknowledgment and acceptance of our terms w
Sample container, preservation, hold time and packages information can be viewed at http://maxxam.ca/wp-content/uploads/Ontario-COC.pdf.

COC-1004 (01/19)

White: Maxxam ~ Yellow: Client

Maxxam
A Bureau Veritas Group Company

Your Project #: 1662333
Your C.O.C. #: 709061-01-01

Attention: David Marmor

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

Report Date: 2019/03/26
Report #: R5644475
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B974455
Received: 2019/03/21, 16:07

Sample Matrix: Rock
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	10	2019/03/25	2019/03/26	CAM SOP-00463	EPA 325.2 m
Conductivity	10	2019/03/25	2019/03/25	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	10	2019/03/25	2019/03/25	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	10	2019/03/22	2019/03/26	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	10	2019/03/25	2019/03/26	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

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

Your Project #: 1662333
Your C.O.C. #: 709061-01-01

Attention: David Marmor

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

Report Date: 2019/03/26
Report #: R5644475
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B974455
Received: 2019/03/21, 16:07

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
==========
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Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

RESULTS OF ANALYSES OF ROCK

Maxxam ID		JGK384	JGK385	JGK386	JGK387	JGK388	JGK389		
Sampling Date		2019/03/21 01:30	2019/03/21 01:30	2019/03/21 01:30	2019/03/21 01:30	2019/03/21 01:30	2019/03/21 01:30		
COC Number		709061-01-01	709061-01-01	709061-01-01	709061-01-01	709061-01-01	709061-01-01		
	UNITS	1662333 C1-2	1662333 C1-1	1662333 C2-2	1662333 C2-3	1662333 C3-3	1662333 C3-1	RDL	QC Batch
Calculated Parameters									
Resistivity	ohm-cm	2100	1700	2500	2600	3800	3700		6032288
Inorganics									
Soluble (20:1) Chloride (Cl-)	ug/g	32	37	<20	71	<20	<20	20	6035188
Conductivity	umho/cm	469	583	407	391	266	274	2	6035037
Available (CaCl2) pH	pH	8.19	8.02	8.08	8.14	8.19	8.19		6035215
Soluble (20:1) Sulphate (SO4)	ug/g	160	350	190	72	51	35	20	6035189

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		JGK390	JGK391	JGK392	JGK393		
Sampling Date		2019/03/20 04:30	2019/03/20 04:30	2019/03/20 04:30	2019/03/20 04:30		
COC Number		709061-01-01	709061-01-01	709061-01-01	709061-01-01		
	UNITS	1662333 C4-2	1662333 C4-3	1662333 C5-2	1662333 C5-1	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	1500	1000	1700	3100		6032288
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	250	410	240	<20	20	6035188
Conductivity	umho/cm	670	991	578	323	2	6035037
Available (CaCl2) pH	pH	7.77	7.77	7.85	7.78		6035215
Soluble (20:1) Sulphate (SO4)	ug/g	130	190	130	220	20	6035189

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

TEST SUMMARY

Maxxam ID: JGK384 **Collected:** 2019/03/21
Sample ID: 1662333 C1-2 **Shipped:**
Matrix: Rock **Received:** 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK385 **Collected:** 2019/03/21
Sample ID: 1662333 C1-1 **Shipped:**
Matrix: Rock **Received:** 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK386 **Collected:** 2019/03/21
Sample ID: 1662333 C2-2 **Shipped:**
Matrix: Rock **Received:** 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK387 **Collected:** 2019/03/21
Sample ID: 1662333 C2-3 **Shipped:**
Matrix: Rock **Received:** 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK388 **Collected:** 2019/03/21
Sample ID: 1662333 C3-3 **Shipped:**
Matrix: Rock **Received:** 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas

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Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

TEST SUMMARY

Maxxam ID: JGK388
Sample ID: 1662333 C3-3
Matrix: Rock

Collected: 2019/03/21
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK389
Sample ID: 1662333 C3-1
Matrix: Rock

Collected: 2019/03/21
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK390
Sample ID: 1662333 C4-2
Matrix: Rock

Collected: 2019/03/20
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK391
Sample ID: 1662333 C4-3
Matrix: Rock

Collected: 2019/03/20
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

Maxxam ID: JGK392
Sample ID: 1662333 C5-2
Matrix: Rock

Collected: 2019/03/20
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

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Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

TEST SUMMARY

Maxxam ID: JGK393
Sample ID: 1662333 C5-1
Matrix: Rock

Collected: 2019/03/20
Shipped:
Received: 2019/03/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	6035188	2019/03/25	2019/03/26	Deonarine Ramnarine
Conductivity	AT	6035037	2019/03/25	2019/03/25	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	6035215	2019/03/25	2019/03/25	Gnana Thomas
Resistivity of Soil		6032288	2019/03/26	2019/03/26	Anastassia Hamanov
Sulphate (20:1 Extract)	KONE/EC	6035189	2019/03/25	2019/03/26	Alina Dobreanu

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Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

GENERAL COMMENTS

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

Package 1	-2.0°C

Results relate only to the items tested.

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Maxxam Job #: B974455
Report Date: 2019/03/26

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
6035037	Conductivity	2019/03/25			102	90 - 110	<2	umho/cm	0.40	10
6035188	Soluble (20:1) Chloride (Cl-)	2019/03/26	108	70 - 130	103	70 - 130	<20	ug/g	NC	35
6035189	Soluble (20:1) Sulphate (SO4)	2019/03/26	115	70 - 130	109	70 - 130	<20	ug/g	3.8	35
6035215	Available (CaCl2) pH	2019/03/25			100	97 - 103			0.39	N/A

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

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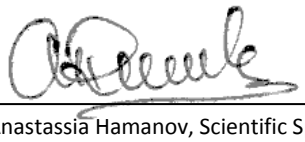
Maxxam Job #: B974455
Report Date: 2019/03/26

Golder Associates Ltd
Client Project #: 1662333
Sampler Initials: JP

VALIDATION SIGNATURE PAGE

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



Anastassia Hamanov, Scientific Specialist

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CHAIN OF CUSTODY RECORD

Page of

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B80683	Maxxam Job #:	Bottle Order #:
Attention:	Accounts Payable	Attention:	David Marmor	P.O. #:			709061
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	1662333	COC #:	Project Manager:
Tel:	(905) 567-4444 Fax: (905) 567-6561	Tel:	Fax:	Project Name:		C#709061-01-01	Ema Gitej
Email:	AP_CustomerService@golder.com	Email:	David_Marmor@golder.com	Site #:			
				Sampled By:			

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

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

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

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Corrosivity pkg (Cl, SO4, pH, EC/Resistivity)	# of Bottles	Comments
1		1662333 C1-2	21/3/2019	1:30	Rock		X		
2		1662333 C1-1	21/3/2019	1:30	Rock		X		
3		1662333 C2-2	21/3/2019	1:30	Rock		X		
4		1662333 C2-3	21/3/2019	1:30	Rock		X		
5		1662333 C3-3	21/3/2019	1:30	Rock		X		
6		1662333 C3-1	21/3/2019	1:30	Rock		X		
7		1662333 C4-2	20/3/2019	4:30	Soil		X		
8		1662333 C4-3	20/3/2019	4:30	Soil		X		
9		1662333 C5-2	20/3/2019	4:30	Soil		X		
10		1662333 C5-1	20/3/2019	4:30	Soil		X		

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

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

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

21-Mar-19 16:07
Ema Gitej
B974455
URE ENV-1222

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
JANE PETER (Jane)	2019/03/21	3:00pm	[illegible]	19/03/21	16:57	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Recei	Custody Seal	Yes	No
	-3/-2/-1	Present Intact	✓	

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

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

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

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

White: Maxxa Yellow: Client

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