

Foundation Investigation and Design Report

High Fill Embankments and Retaining Walls

Replacement of Twin Structures over CN and CP Rails QEW from 1.4 km North of Bowen Road Interchange Southerly to Gilmore Road Interchange, Town of Fort Erie, Niagara Region, Ontario, GWP 2116-16-00

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NSSP – Supply and Installation of Embankment Monitoring Equipment

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PART A

FOUNDATION INVESTIGATION REPORT
HIGH FILL EMBANKMENTS AND RETAINING WALLS
REPLACEMENT OF TWIN STRUCTURES OVER CN AND CP RAILS
QEW FROM 1.4 KM NORTH OF BOWEN ROAD INTERCHANGE SOUTHERLY
TO GILMORE ROAD INTERCHANGE
TOWN OF FORT ERIE, NIAGARA REGION, ONTARIO
GWP 2116-16-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with high fill embankments and retaining walls for the widening of the Queen Elizabeth Way (QEW) and replacement of twin structures over Canadian National (CN) and Canadian Pacific (CP) Rails and ancillary structures (Site Nos. 34-129-1 and 34-129-2) near Bowen Road in the Town of Fort Erie, Regional Municipality of Niagara, located approximately as shown on the Key Plan on Drawings 1 to 7, attached.

This report addresses the results of the foundation investigation carried out for the high fill embankments and retaining walls, and associated ramps. The purpose of this investigation is to establish the subsurface (soil, bedrock and groundwater) conditions at the high fill embankments and retaining wall locations by borehole drilling, rock coring and geotechnical and chemical analytical laboratory testing of selected soil and bedrock core samples.

The Terms of Reference for the foundation engineering services are outlined in MTO's Work Item Order No. 2016-E-0029-001, dated July 2017, and MTO's Work Item Order No. 2016-E-0029-008, dated March 2018, which form part of the Consultant's Assignment for the Central Region Large Value Retainer under Agreement No. 2016-E-0029-001 and 2016-E-0029-008.

2.0 SITE DESCRIPTION

For the purposes of the project and this report, the QEW at the site is oriented in a north-south direction.

The existing CN/CP Rails twin structures are located approximately 650 m north of the Bowen Road / Queen Elizabeth Way (QEW) interchange in the Town of Fort Erie, Ontario. Based on the information provided by AECOM, a grade raise and widening (realignment) of the existing north bound lanes (NBL) and south bound lanes (SBL) of the QEW is proposed between approximate highway Stations 13+255 and 14+600 (Bowen Road), including construction of three retaining walls identified as RW-1, RW-2 and RW-3 to facilitate construction within the limits of the available highway QEW right-of-way, and realignment of the Bowen Road/QEW E/W-S and E/W-N Ramps. The existing QEW through the area is two lane roadway in each direction and the proposed widening of the QEW in support of the new structures is planned to stretch from approximately 300 m north of the railway structures to Bowen Road, a distance of approximately 1.3 km, while the proposed grade raise stretches from the north project limit to approximately 200 m north of Bowen Road. The existing QEW highway grade varies from approximately Elevation 177 m near the north project limit to Elevation 189 m at the existing CN/CP twin structure locations, and from Elevation 183 m approximately 275 m north of Bowen Road to Elevation 186 m at Bowen Road. The existing QEW embankments near the north and south limits of the high fill area are approximately 1.5 m to 2 m high relative to the natural ground surface. At the existing CN/CP overhead structure, the existing QEW embankments rise to about 9 m above natural ground surface. The existing natural ground surface at the toes of the existing highway embankment varies from about Elevation 175 m at the north project limit to about Elevation 185 m at the south project limit near Bowen Road.

Retaining walls RW-1 and RW-2 will extend along the west property limit at or near the toe of the widened SBL embankment; RW-1 will extend between Stations 13+670 and 13+858; and RW-2 will extend between Stations 14+010 and 14+313. Both retaining walls RW-1 and RW-2 will conjoin with the proposed north and south abutment retaining walls of the SBL CN/CP overhead structure. Retaining wall RW-3 will extend along the existing east shoulder of the NBL between Stations 14+190 and 14+470.

3.0 INVESTIGATION PROCEDURES

Field work for the high fill embankment and retaining wall subsurface exploration was carried out between September 6, 2018 and January 26, 2019, during which time 38 boreholes (designated as Boreholes HF-1 through HF-7, HF-9 through HF-15, and R1-1 through R1-6 and R2-1 through R2-6 and RW4A, RW-5 through RW-7, RW-9 through RW-16,) were advanced at the site. The subsurface information of the current exploration is supplemented with information from: three boreholes advanced at the culvert at Station 14+273 crossing the QEW (Boreholes C1-1 through C1-3); one borehole advanced at the culvert under the Bowen Road/QEW EW-S Ramp (Borehole C3-2); and six boreholes advanced for the CN/CP twin structures site (Boreholes CN/CP1, CN/CP3, CN/CP9, CN/CP10, CN/CP12 and CN/CP13). The boreholes at the CN/CP twin structures were advanced between August 23 and 30, 2018 and on November 29, 2018, while the boreholes at the culvert sites were advanced on September 4, 2018 and 24, 2018, December 24, 2018, and January 8 and 26, 2019. The borehole locations are shown on Drawings 1 to 3.

Boreholes CN/CP1, CN/CP3, CN/CP10, CN/CP12, CN/CP13, C1-1, C1-3, HF-1, HF-3, HF-5, HF-7, HF-12, HF-14, RW-4A, RW-5, RW-7, RW-9, RW-10, RW-11, R1-1, R1-3 through R1-6, and R2-1 through R2-6 were drilled using 152 mm or 203 mm outer diameter hollow-stem augers by a CME 75 truck-mounted drilling rig. Boreholes CN/CP9 and C3-2 were advanced using 203 mm outer diameter hollow stem augers by a CME 55 track-mounted drilling rig. The CME 55 and CME 75 drill rigs were supplied and operated by Geo-Environmental Drilling Ltd. of Halton Hills, Ontario. Boreholes C1-2, HF-2, HF-9, HF-11, HF-13, HF-15, RW-6, RW-12 through RW-16 and R1-2 were drilled using 191 mm outer diameter hollow-stem augers by a CME 45 track-mounted drilling rig. Boreholes HF-4 and HF-6 were drilled using a portable tripod drill rig. The CME 45 and portable tripod drilling rigs were supplied and operated by OGS Inc. of Almonte, Ontario. The portable tripod drilling rig utilized wash boring methods to advance BW and AW casing through the overburden. Soil samples were obtained at 0.6 m, 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in all boreholes in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)¹. In situ field vane shear testing, using MTO standard “N”-sized and “B”-sized vanes, was carried out to measure the undrained shear strength of cohesive soils (ASTM D2573)². Bedrock core samples were obtained using an ‘HQ3’ size (96 mm OD) rock core barrel.

The groundwater conditions in the open boreholes were observed during and immediately following the drilling operations. Standpipe piezometers were installed in Boreholes RW-6, C1-2 and C1-3 to permit monitoring of the water level. The installed piezometers consist of a 50 mm diameter PVC pipe with a 1.5 m slotted screen positioned within a filter sand pack sealed within the near surface bedrock formation about 2.8 m above the bottom of the borehole. The borehole and annulus surrounding the piezometer pipes above the filter sand pack were backfilled to near ground surface with bentonite pellets and the upper 200 mm of Boreholes RW-6 and C1-3 were capped with a steel well casing to road surface, while Borehole C1-2 was capped with a stick-up casing. All other boreholes were backfilled to ground surface with bentonite in accordance with Ontario Regulation 903, Wells (as amended) and the upper 200 mm of Boreholes C1-1, C1-3, HF-1, HF-3, HF-5, HF-7, HF-12, HF-14, HF-15, RW-4A, RW-5, RW-6, RW-7, RW-9, RW-10, and RW-11 were sealed to the roadway surface with cold patch asphalt upon completion..

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

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

Field work was monitored on a full-time basis by members of Golder's technical staff who located the boreholes in the field, directed the sampling and in situ testing operations, logged the boreholes and examined the soil and rock samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further visual examination and for geotechnical laboratory testing on selected samples, consisting of natural moisture content, organic content determination, Atterberg limits and grain size distribution, conducted in accordance with MTO and / or ASTM Standards as applicable. Select soil samples were submitted to Maxxam Analytics in Mississauga, Ontario for analysis of parameters used to assess the potential corrosivity and deterioration of the site soil to steel and concrete.

Rock quality (i.e., Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD), weathering and strength index), discontinuity characteristics and classification data were recorded in the field based on visual inspection of the recovered rock cores upon extraction from the core barrel. The bedrock was sequentially photographed, packed and transported to Golder's Mississauga laboratory for further visual examination. Unconfined (uniaxial) compression (UC) testing was carried out on selected rock samples by Geomechanica in Oakville, Ontario. Point load testing was carried out on selected samples of the bedrock core. The remainder of the bedrock core samples were placed in wooden core boxes and kept in storage.

Classification of the rock mass quality of the bedrock with respect to the RQD is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006)³ while the strength of the bedrock core samples is based on Table 3.5 of CFEM, (2006)³. The degree of weathering of the bedrock core samples and the strength classification of the intact rock mass based on field identification are described in accordance with Table B.3 and Table B.6, respectively of the International Society of Rock Mechanics (ISRM, 1985)⁴ standard classification system.

The as-drilled borehole locations were surveyed by Callon Dietz, Ontario Land Surveyors, to an accuracy of 50 mm in the horizontal and vertical directions. The locations given in the Record of Borehole sheets and shown on Drawings 1 to 3 are positioned relative to MTM NAD 83 (Zone 10) CSRS CBNV6-ZD10.0 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, including in geographic (Latitude / Longitude) coordinates, the ground surface elevations and borehole drilled depths are summarized in Table A-1, included in Appendix A.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of the QEW is located in the Clay Plains subregion within the Haldimand Clay Plain physiographic region, as delineated in The Physiography of Southern Ontario (Chapman and Putnam, 1984)⁵. The Beaches and Limestone Plains, also within the Haldimand Clay Plain physiographic region, are located in close proximity to the site.

Generally, this section of Haldimand Clay Plain, located in the farthest southeast reach of the Niagara peninsula, consists of fine-textured glaciolacustrine deposits of silt and clay with minor amounts of sand and gravel. These

³ Canadian Foundation Engineering Manual. 2006. Fourth Edition, Canadian Geotechnical Society: Richmond, British Columbia.

⁴ 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.

⁵ Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

deposits range from massive to well-laminated. This area of the Haldimand Clay Plain can be considered a separate subregion, characterized by level topography and poor drainage.

The overburden in this area is underlain by dolomitic limestone and dolostone of the Bois Blanc and Salina Formations, specifically the Bertie Member of the Salina Formation. These limestone and dolostone units are typically characterized as medium strong to extremely strong, grey, crystalline and slightly argillaceous.

4.2 General Overview of Subsurface Conditions

The detailed subsurface soil, bedrock and groundwater conditions encountered in the boreholes of the investigation including piezometer installation details and water level readings, and the summary results of the in situ and laboratory tests are provided on the Record of Borehole Sheets in Appendix A. The results of the in-situ field tests (i.e., in-situ field vane and SPT “N”-values) as presented on the borehole records and values provided in Section 4 are uncorrected. The results of the geotechnical laboratory testing on soil samples are presented on the laboratory test figures in Appendix B. Photographs and laboratory test results of the rock core samples are provided in Appendix C. The results of the analytical testing are provided in Appendix D.

The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profiles on Drawings 4 through 7 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole records governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes advanced at the site consists of Highway QEW embankment fill (at the boreholes drilled from the highway grade) comprised of layers of non-cohesive and cohesive fill, underlain by cohesive soil deposits of clayey silt to silty clay to clay, and non-cohesive deposits of sandy silt to sand, silty sand to sand and gravel. Localized thin layers of fill materials were encountered at some locations at the toe of the existing highway embankment in portions of the SBL embankment widening area. Fills were also encountered at the locations of the proposed realigned E/W-N and E/W-S Ramps. It should be noted that the E/W-N Ramp area is currently an active construction zone, and fills in this area are likely to have been recently placed / reworked. Dolomitic limestone bedrock was encountered at and confirmed by coring in Boreholes CN/CP3, CN/CP9, CN/CP10, CN/CP12, C1-1, C1-2, C1-3, C3-2, HF-9, , HF-11, RW-6, RW-7, and RW-15, and inferred from auger and/or split spoon refusal in Boreholes HF-13, RW-16, R1-1 to R1-6 and R2-1 to R2-6. More detailed descriptions of the subsurface conditions for sections along the QEW are provided in the following sub-section of this report.

4.2.1 QEW Station 13+550 to Station 13+900 – North of CN/CP Twin Structure

Ten boreholes were advanced for the high fill area and retaining wall RW-1 between Stations 13+550 and 13+900 (HF-1 to HF-7 and RW-11 to RW-13), supplemented with two boreholes advanced for the CN and CP twin structures replacement (CN/CP1 and CN/CP3) to provide subsurface information at the south limits of the area, adjacent to the twin bridges north approach embankment. The borehole locations and stratigraphic profile for this high fill/retaining wall section are shown on Drawings 1 and 4, respectively.

4.2.1.1 Topsoil

An approximately 30 mm to 150 mm thick layer of topsoil was encountered immediately below ground surface in Boreholes HF-2, HF-4 and RW-12, advanced to the west of the QEW near the toe of the existing highway

embankment. Layers of topsoil and organic soils were encountered near the base of the fill (described below) at depths ranging from 2.7 m to 8.5 m below ground surface in Boreholes HF-1, HF-5, HF-7, CN/CP3, RW-11.

4.2.1.2 Asphalt/Sand to Sand and Gravel (Fill)

Boreholes CN/CP1, CN/CP3, HF-1, HF-3, HF-5, HF-7, and RW-11 were advanced through the existing pavement structure on the southbound lanes of the QEW. The pavement is comprised of an approximately 280 mm to 460 mm thick layer of asphalt, underlain by an approximately 0.5 m to 1.2 m thick layer of sand to sand and gravel fill. The measured Standard Penetration Test (SPT) “N”-values within the sand to sand and gravel fill range between 4 blows and 13 blows per 0.3 m of penetration, indicating a loose to compact compactness condition.

4.2.1.3 Clayey Silt to Silty Clay to Clay Fill

A 2.5 m to 7.7 m thick layer of cohesive fill comprised of clayey silt to silty clay to clay was encountered underlying the pavement structure granular fill in Boreholes CN/CP1, CN/CP3, HF-1, HF-3, HF-5, HF-7, and RW-11 advanced from the highway grade. This cohesive fill is associated with the existing Highway QEW embankment. The existing embankment fill extends to between Elevations from 179.7 m to 176.5 m. The fill contained trace organics, and in some instances, distinct layers of topsoil (as noted in Section 4.2.1.2).

An approximately 1.2 m thick layer of clay fill was encountered immediately below ground surface in Borehole HF-6 which was advanced at the toe of the existing embankment. This fill extends to Elevation 179.2 m.

The measured SPT “N”-values within the cohesive fill layer range from 4 blows to 15 blows per 0.3 m of penetration. In situ field vane tests carried out within this layer measured undrained shear strengths ranging from about 98 kPa to greater than 144 kPa (shearing did not occur), with sensitivities ranging from 1.8 to 2.8. The undrained shear strengths together with the SPT “N”-values suggest the cohesive fill is soft to very stiff in consistency and generally has a stiff to very stiff consistency.

The results of grain size distribution testing completed on seven (7) samples of the cohesive fill layer are presented on Figure B-1 in Appendix B. The organic content measured on one sample from the cohesive fill layer in Borehole CN/CP1 is 4.8 per cent.

The natural water content measured on eighteen (18) samples of the cohesive fill layer ranges from about 18 per cent to 28 per cent. Atterberg limits tests were carried out on nine (9) selected samples of the cohesive fill layer and measured plastic limits ranging from about 16 per cent to 24 per cent, liquid limits ranging from about 33 per cent to 60 per cent, and plasticity indices ranging from about 13 per cent to 36 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B-2A and B-2B in Appendix B, and indicate that the fill can be classified as clayey silt of low plasticity to clay of high plasticity.

4.2.1.4 Silty Clay to Clay

A 2.3 m to 5.3 m thick deposit of silty clay to clay was encountered underlying the cohesive fill layer in Boreholes CN/CP1, CN/CP3, HF-1, HF-3, HF-5, HF-6, HF-7 and RW-11, underlying the topsoil in Boreholes HF-2, HF-4, and RW-12 and immediately below ground surface in Borehole RW-13. The surface of the deposit was encountered between Elevations 179.4 m and 176.5 m, and the deposit extends to depths ranging from 3.0 m to 13.3 m below ground surface (Elevations 171.6 m to 175.0 m). Borehole CN/CP1 was terminated in this deposit, penetrating it for a thickness of 1.1 m.

The measured SPT “N”-values within the silty clay to clay deposit range from 4 blows to 35 blows per 0.3 m of penetration, and one value of to 71 blows per 0.3 m of penetration, but generally were greater than 15 blows per

0.3 m of penetration. In situ field vane tests carried out with this deposit measured undrained shear strengths ranging from about 54 kPa to greater than 144 kPa (shearing did not occur), with sensitivities ranging from 1.5 to 4.1. The undrained shear strengths, together with the SPT “N”-values, suggest that the deposit generally has a stiff to hard consistency. The lower portion of the deposit is considered to be of firm to stiff consistency in Borehole HF-2 (north of Station 13+725) where an SPT “N”-value of 7 and undrained shear strengths of about 54 kPa to 81 kPa were measured.

Grain size distribution testing was completed on twelve (12) samples of the silty clay to clay deposit and the test results are shown on Figures B-3A and B-3B in Appendix B.

The natural water content measured on twenty-two (22) samples of the silty clay to clay deposit ranges from about 13 per cent to 37 per cent. Atterberg limits tests were carried out on thirteen (13) selected samples of the silty clay to clay deposit and measured plastic limits ranging from about 17 per cent to 24 per cent, liquid limits ranging from about 36 per cent to 59 per cent, and plasticity indices ranging from about 19 per cent to 36 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figures B-4A and B-4B in Appendix B, and indicate that the deposit can be classified as silty clay of intermediate plasticity to clay of high plasticity.

A laboratory consolidation test (oedometer test) was carried out on one sample of the firm to stiff portion of the silty clay deposit from Borehole HF-2 and the test results are presented on Figures B-5 in Appendix B and summarized below.

Borehole/ Sample No.	Sample Depth/ Elevation	Unit Wt. (kN/m ³)	σ_{vo}' (kPa)	σ_p' (kPa)	$\sigma_p' - \sigma_{vo}'$ (kPa)	C_c	C_r	e_o	OCR
HF-2 / SA5	4.1 m / 172.9 m	19.5	55*	200	145	0.20	0.021	0.745	3.8

where: σ_{vo}' is the in situ vertical effective overburden stress in kPa
 σ_p' is the preconsolidation stress in kPa
 OCR is the over consolidation ratio
 C_c is the compression index
 C_r is the recompression index
 e_o is the initial void ratio
 * for an inferred groundwater level at 1.5 m depth (~Elev. 175.5 m)

Laboratory consolidated undrained triaxial test (CIU) with pore pressure measurement were carried out on one sample of the firm to stiff portion of the silty clay deposit from Borehole HF-2. In total, 1 set of 3 specimens (total of 3 tests) were tested. All tests were carried out on specimens trimmed from a relatively ‘undisturbed’ Shelby tube sample. The details of the test results are shown on Figures B-6 in Appendix B and the results are summarized below.

Borehole/Sample No.	Sample Depth/Elevation	Peak		Post-Peak / Softened	
		Effective Cohesion Intercept, c' (kPa)	Effective Angle of Internal Friction, ϕ' (degrees)	Effective Cohesion Intercept, c' (kPa)	Effective Angle of Internal Friction, ϕ' (degrees)
HF-2 / SA5	3.8 – 4.4 m / 173.2 – 172.6 m	0	26	0	23

Note: The assessed shear strength parameters are only valid over the range of stress conditions employed in the test.

4.2.1.5 Clayey Silt

A 2.0 m to 7.7 m thick deposit of clayey silt was encountered underlying the silty clay to clay deposit in Boreholes CN/CP3, HF-1 to HF-7, and RW-11 to RW-13. The surface of the deposit was encountered between Elevations 179.7 m and 171.6 m, and extended to depths ranging from 6.3 m to 21.0 m below ground surface (Elevations 166.8 m to 171.9 m). Boreholes HF-1, HF-2, HF-4, HF-6, and RW-13 were terminated in this deposit, penetrating it for thicknesses ranging from 2.9 m to 5.7 m.

The SPT “N”-values measured within the clayey silt deposit range from 0 blows (weight of the automatic hammer on the rods) to 46 blows per 0.3 m of penetration, one ‘N’-value of 100 blows for 0.29 m of penetration. In situ field vane tests carried out with this deposit measured undrained shear strengths ranging from about 36 kPa to greater than 144 kPa (shearing did not occur), with sensitivities ranging from 1.3 to 2.1. The undrained shear strengths, together with the SPT “N”-values, suggest that the deposit is very soft to hard and generally soft to hard in consistency. North of approximately Station 13+725 the upper portion of the deposit in Boreholes HF-1 to HF-3 and RW-12, is considered to be very soft to stiff in consistency where SPT “N”-values ranging from 0 blows to 4 blows per 0.3 m of penetration and undrained shear strengths ranging from about 36 kPa to 80 kPa were measured.

Grain size distribution testing was completed on eleven (11) samples of the clayey silt deposit and the test results are shown on Figures B-7A and B-7B in Appendix B.

The natural water content measured on twenty (20) samples of the clayey silt deposit ranges from about 12 per cent to about 23 per cent. Atterberg limits tests were carried out on thirteen (13) selected samples of the clayey silt deposit and measured plastic limits ranging from about 12 per cent to 15 per cent, liquid limits ranging from about 21 per cent to 29 per cent, and plasticity indices ranging from about 8 per cent to 16 per cent. These test results, which are plotted on the plasticity chart on Figure B-8A and B-8B in Appendix B, indicate that the deposit can be classified as clayey silt of low plasticity.

4.2.1.6 Sandy Silt to Sand

A 0.7 m to 2.2 m thick deposit of sandy silt to silt and sand to silty sand to sand was encountered below or interbedded with the clayey silt deposit in Boreholes CN/CP3, HF-7, RW-11, RW-12 and RW-13. The surface of the deposit was encountered between Elevations 173.4 m and 169.0 m, and the deposit extends to depths ranging from 5.6 m to 21.6 m below ground surface (Elevations 172.4 m to 166.8 m). Boreholes RW-11 and RW-12 terminated in this deposit, penetrating it to depths of 17.4 m and 8.2 m below ground surface (Elevations 169.3 m and 168.9 m), respectively.

The measured SPT “N”-values within the sandy silt to sand deposit range from 20 blows to 35 blows per 0.3 m of penetration, indicating that the deposit is a compact to dense compactness condition.

Grain size distribution testing was completed on four (4) samples of the sandy silt to sand deposit and the test results are shown on Figure B-9 in Appendix B.

The natural water content measured on four (4) samples of the sandy silt to sand deposit ranged from about 15 to 21 per cent.

4.2.1.7 Sand and Gravel

A deposit of silty sand and gravel to sand and gravel was encountered underlying the clayey silt deposit in Boreholes HF-3, HF-5, and HF-7 and underlying the sandy silt deposit in Borehole CN/CP3. The surface of the deposit was encountered between Elevations 168.1 m to 166.8 m. Boreholes HF-3, HF-5 and HF-7 were terminated in this deposit at depths ranging from 14.3 m to 22.9 m below ground surface (Elevations 167.8 m to 164.9 m), penetrating the deposit for thicknesses ranging from 0.3 m to 1.9 m. The sand and gravel deposit in Borehole CN/CP3 was measured to be 1.6 m thick, extending to a depth of 23.2 m below ground surface (Elevation 165.2 m).

The measured SPT “N”-values within the sand and gravel deposit range from 25 blows to 31 blows, per 0.3 m of penetration with one ‘N’-value of 155 blows per 0.2 m of penetration at the bedrock contact, indicating that the deposit is in a compact to very dense compactness condition.

Grain size distribution testing was completed on two (2) samples of the sand and gravel deposit and the test results are shown on Figure B-10 in Appendix B.

The natural water content measured on four (4) samples of the sand and gravel deposit ranges from about 7 per cent to 13 per cent.

4.2.1.8 Dolomitic Limestone (Bedrock)

Bedrock was encountered in Borehole CN/CP3 at a depth of 23.2 m below ground surface (Elevation 165.2 m) and was cored for a depth of 3.9 m.

Based on the review of the bedrock core samples, the bedrock consists of dolomitic limestone of the Bois Blanc Formation. The core samples are generally described as slightly weathered (W2), crystalline, grey, fine to medium grained, non-porous to faintly porous, medium strong (R3) dolomitic limestone as presented on the relevant Record of Drillhole sheet, and shown on the photographs of the recovered core samples on Figure C-1 in Appendix C.

The Total Core Recovery (TCR) and Solid Core Recovery (SCR) of samples recovered from Boreholes CN/CP3 are between 89 per cent and 100 per cent and between 70 per cent and 100 per cent; respectively. the RQD ranges from 51 per cent to 100 per cent, indicative of a rock mass of fair to excellent quality, per Table 3.10 in CFEM, (2006)³.

The majority of the logged discontinuities are joints or faults within the dolomitic limestone bedrock or contacts between siltstone/limestone interbeds. In general, the identified discontinuity surfaces are undulating, planar or curved in shape, with smooth to rough surface roughness. The surfaces of the identified discontinuities generally range from clean to slightly altered. A 110 mm thick seam or interbed of gypsum infill was noted present in Borehole CN/CP3 as noted on the Records of Drillhole sheet in Appendix A.

An unconfined compression test (UC) (ASTM D7012)⁶ was carried out on a core specimen of limestone bedrock and strength test results are as shown on Record of Drillhole sheet in Appendix A, detailed in the laboratory test reports contained in Appendix C, and summarized below.

Borehole No.	Depth From (m)	Depth To (m)	Density (g/cm ³)	UCS (Mpa)
CN/CP3	26.0	262.2	2.70	133

Point load strength tests (ASTM D5731)⁷ were carried out on selected core specimens of the bedrock and the axial and diametral point load strength indices ($I_{s(50)}$) are presented on Figure C-13 in Appendix C. One axial test on a core sample from Borehole CN/CP3 measured an $I_{s(50)}$ value of about 6.0 MPa. Two diametral tests measured $I_{s(50)}$ values of about 0.3 MPa and 2.0 MPa.

Based on the laboratory UC and Point Load test results, the bedrock is generally classified as medium strong to very strong (R3 to R5) in accordance with Table 3.5 of CFEM (2006)³.

4.2.1.9 Groundwater Conditions

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

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date	Comments
HF-1	179.8	Dry	-	Sep. 13, 2018	Open Borehole
HF-2	177.0	Dry	-	Jan. 16, 2019	Open Borehole
HF-3	182.1	6.2	175.9	Sep. 12, 2018	Note 1.
HF-4	177.6	N/A	N/A	Dec. 3, 2018	Note 2.
HF-5	185.1	12.0	173.1	Sep.12, 2018	Note 1.
HF-6	180.4	N/A	N/A	Nov. 30, 2018	Note 2.
HF-7	187.8	14.3	173.5	Sep. 19, 2018	Note 1.
CN/CP1	188.1	Dry	-	Aug.23, 2018	Open Borehole
CN/CP3	188.4	12.5	175.9	Aug.28, 2018	Note 3.
RW-11	186.7	13.8	172.9	Sep. 19, 2018	Note 1.
RW-12	177.1	7.2	169.9	Jan.16, 2019	Open Borehole
RW-13	178.0	0.0	178.0	Jan. 16, 2019	Open Borehole

Notes: 1. Inside H.S. auger upon completion of soil drilling.

⁶ ASTM D7012 - Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens

⁷ ASTM D5731 - Standard Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications

2. Not Recorded – used water for drilling.
3. Inside H.S. auger prior to bedrock coring.

As the water levels were measured during or immediately after completion of drilling and within low permeable fine grained soils, they may not represent the stabilized groundwater level at the site. However, in general, the groundwater level at the site is anticipated to range from approximately Elevations 178.0 m to 169.9 m. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.2.2 QEW Station 14+000 to Station 14+500 – South of CN/CP Twin Structure

Sixteen (16) boreholes were advanced for the high fill area and retaining walls RW-2 and RW-3 south of the CN/CP overhead structure, between Stations 14+000 and 14+500 (Boreholes HF-9 to HF-15 and RW-4A, RW-5 to RW-7, RW-9, RW-10, and RW-14 to RW-16). In addition, four boreholes advanced for the CN and CP twin structure replacement (Boreholes CN/CP9, CN/CP10, CN/CP12 and CN/CP13) and three boreholes advanced for a culvert replacement (Boreholes C1-1 to C1-3) were used to supplement the high Fill/retaining wall boreholes adjacent to the bridges south approach embankment and near the south limit of the high fill/retaining wall areas. The borehole locations and stratigraphic profile for this high fill/retaining walls section are shown on Drawing 1 and Drawings 5 and 6, respectively.

4.2.2.1 Topsoil

An approximately 200 mm to 700 mm thick layer of topsoil was encountered immediately below ground surface in Boreholes CN/CP9, HF-9, RW-14, RW-15 and RW-16, advanced along the west side of the QEW near the toe of the existing highway embankment.

4.2.2.2 Asphalt/Sand to Sandy Gravel (Fill)

Boreholes CN/CP10, CN/CP12, CN/CP13, HF-10, HF-12, C1-1 and C1-3 RW-4A to RW-7 and RW-9 to RW-11 which were advanced through the existing pavement structure of the northbound and southbound lanes of the QEW encountered an approximately 150 mm to 370 mm thick layer of asphalt, underlain by a 0.5 m to 1.9 m thick interlayers of granular fill materials comprised of sandy silt to silt and sand and sand to silty sand to sand and gravel to sandy gravel. A 0.4 m thick layer of clayey silt was encountered within the granular material in Borehole RW-10.

The measured Standard Penetration Test (SPT) “N”-values within the granular materials ranges from 5 blows to per 0.3 m of penetration and one ‘N’-value of 50 blows for 0.25 m of penetration, indicating a loose to very dense compactness condition.

4.2.2.3 Clayey Silt to Silty Clay Fill

A 0.8 m to 7.8 m thick layer of cohesive fill comprised of sandy clayey silt to silty clay was encountered underlying the pavement structure in all boreholes advanced from the highway grade (noted above), except in Borehole HF-14. The cohesive fill extends depth between 1.5 m and 812 m below ground/pavement surface, to between Elevations ranging 182.4 m to 179.2 m. The cohesive fill contains trace organics and wood fragments in places.

An approximately 0.4 m to 0.6 m thick layer of clayey silt fill was encountered immediately below ground surface in Boreholes HF-13, HF-15 and C1-2 which were advanced at the west toe of the existing embankment. This layer of cohesive fill extends to between Elevations from 182.4 m and 181.3 m.

The measured SPT “N”-values within the cohesive fill layer range from 4 blows to 24 blows per 0.3 m of penetration. Two in situ field vane tests carried out within this layer measured undrained shear strengths of about 125 kPa and greater than 144 kPa (shearing did not occur), with a sensitivity of 1.6. The vane undrained shear strengths together with the SPT “N”-values suggest that the cohesive fill is soft firm to very stiff in consistency.

Grain size distribution testing was completed on ten (10) samples of the cohesive fill layer and the test results are shown on Figures B-11A and B-11B in Appendix B. The organic content measured on one sample from the cohesive fill layer is 3.8 per cent.

The natural water content measured on twenty-six (26) samples of the cohesive fill layer ranges from about 11 per cent to 26 per cent. Atterberg limits tests were carried out on twelve (12) selected samples of the cohesive fill layer and measured plastic limits ranging from about 14 per cent to 20 per cent, liquid limits ranging from about 24 per cent to 43 per cent, and plasticity indices ranging from about 8 per cent to 24 per cent. These test results, which are plotted on the plasticity chart on Figures B-12A and B-12B in Appendix B, indicate that the deposit is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

4.2.2.4 Silt and Sand to Silty Sand Fill

A 1.8 m thick layer of silt and sand to silty sand fill was encountered from ground surface in Borehole HF-11 advanced at the west toe of the existing embankment which extended to Elevation 181.9 m. Dolostone fragments were noted within the fill. The measured SPT “N”-values within this layer of non-cohesive fill are 3 and 9 blows per 0.3 m of penetration, indicating a very loose to loose compactness condition. An SPT “N”-value of 50 blows for 0.1 m of penetration was measured near the bottom of the borehole at the depth that dolostone fragments were recovered.

Grain size distribution testing was completed on one sample of the silt and sand fill interlayer and the test result is shown on Figure B-13 in Appendix B. The natural water content measured on one sample of the silt and sand fill is about 19 per cent.

4.2.2.5 Silty Clay

A 2.1 m to 5.4 m thick deposit of silty clay was encountered underlying the topsoil in Boreholes CN/CP9, HF-9 and RW-10, and underlying the fill layers in Boreholes CN/CP10, CN/CP12 and CN/CP13. The surface of the deposit was encountered between Elevations from 179.2 m and 181.0 m, and the deposits extends to depths ranging from 3.7 m to 13.3 m below ground surface (Elevations 178.1 m to 174.5 m). Borehole CN/CP13 was terminated within this deposit, penetrating it for a thickness of 1.1 m.

An interlayer of silt and sand was encountered within the silty clay deposit in Borehole CN/CP10, as described in Section 4.2.2.7.

The measured SPT “N”-values within the silty clay deposit range from 9 blows to 23 blows per 0.3 m suggesting that the deposit is stiff to very stiff in consistency.

Grain size distribution testing was completed on five (5) samples of the silty clay deposit and the test results are shown on Figures B-14A and B-14B in Appendix B.

The natural water content measured on eleven (11) samples of the silty clay deposit range from about 13 per cent to about 27 per cent. Atterberg limits tests were carried out on five (5) selected samples of the silty clay deposit and measured plastic limits ranging from about 16 to 21 per cent, liquid limits ranging from about 36 to 44 per cent, and plasticity indices ranging from about 20 to 23 per cent. These test results, which are plotted on the plasticity

chart on Figures B-15A to B-15B in Appendix B, indicate that the deposit can be classified as silty clay of intermediate plasticity.

4.2.2.6 Clayey Silt

A 0.4 m to 4.6 m thick deposit of clayey silt was encountered underlying the topsoil in Boreholes RW-14, underlying the silty clay in Boreholes CN/CP9, CN/CP12, underlying the silt and sand to silty sand deposit in Boreholes CN/CP10, C1-1 and RW-15, and underlying the fill layers in Boreholes C1-3, HF-10, HF-12, RW-7, RW-9. The surface of the deposit was encountered between Elevations from 174.4 m and 182.4 m, and the deposit extends to depths ranging from 4.0 m to 16.3 m below ground surface (Elevations 179.6 m to 171.9 m). Borehole RW-14 was terminated within this deposit, penetrating for a thickness of 2.8 m.

Interlayers of sandy silt to silty sand and silty sand and gravel were encountered within the silty clay deposit in a number of boreholes, as described in Section 4.2.2.7.

The measured SPT “N”-values within the clayey silt to silty clay deposit range from 4 blows to 71 blows per 0.3 m of penetration, and up to 60 blows for 0.05 m of penetration, but generally greater than 8 blows per 0.3 m of penetration, suggesting that the deposit is generally stiff to hard in consistency.

Grain size distribution testing was completed on fourteen (14) samples of the clayey silt deposit and the test results are shown on Figures B-14A to B-14C in Appendix B.

The natural water content measured on seventeen (17) samples of the clayey silt deposit range from about 10 per cent to about 22 per cent. Atterberg limits tests were carried out on twelve (12) selected samples of the clayey silt deposit and measured plastic limits ranging from about 10 to 15 per cent, liquid limits ranging from about 18 to 30 per cent, and plasticity indices ranging from about 6 to 16 per cent. These test results, which are plotted on the plasticity chart on Figures B-15A to B-15C in Appendix B, indicate that the deposit can be classified as clayey silt of low plasticity.

4.2.2.7 Sandy Silt to Silty Sand to Silty Sand and Gravel

A 0.2 m to 2.6 m thick deposit of sandy silt to silt and sand to silty sand was encountered underlying the topsoil in Borehole RW-15, underlying the clayey silt to silty clay deposit in Boreholes HF-9 and RW-9 and underlying the fill layers in Boreholes C1-1, HF-14, RW-4A, RW-5 and RW-6. The surface of the deposit was encountered between Elevations 182.6 and 179.0 m and the deposit extends to depths ranging from 0.3 m to 6.1 m below ground surface (Elevations 182.1 m to 176.4 m).

In Borehole RW-7, a 0.7 m thick layer of silty sand and gravel layer was encountered within the clayey silt to silty clay deposit at a depth of 5.1 m below ground surface (Elevation 178.6 m).

In Boreholes CN/CP10, HF-12, and RW-14, sandy silt to silty sand deposits were encountered interlayered within the clayey silt and silty clay deposits. The elevations of the surface and based of the sandy silt to silty sand interlayers, and interlayer thickness as encountered in the boreholes, are summarized below.

Borehole ID	Depth to Surface of Interlayer (m)	Interlayer Surface Elevation (m)	Interlayer Thickness (m)	Interlayer Base Elevation (m)
CN/CP10	10.8	177.4	0.9	176.5
HF-12	3.0	181.2	1.7	179.5

Borehole ID	Depth to Surface of Interlayer (m)	Interlayer Surface Elevation (m)	Interlayer Thickness (m)	Interlayer Base Elevation (m)
RW-14	1.0	180.5	2.0	178.5

The measured SPT “N”-values within the sandy silt to silty sand deposit range from 3 blows to 29 blows per 0.3 m of penetration, and to 80 blows for 0.07 m of penetration, indicating that the deposit is in a very loose to very dense compactness condition, but generally is compact.

The natural water content measured on eleven (11) samples of the sandy silt to silty sand deposit range from about 7 per cent to about 21 per cent.

Grain size distribution testing was completed on nine (8) samples of the sandy silt to silty sand deposit and the test results are shown on Figure B-16A and B-16B in Appendix B.

4.2.2.8 Sand to Sand and Gravel

A deposit of sand to sand and gravel was encountered underlying the clayey silt to silty clay deposit in Boreholes CN/CP9, CN/CP10, CN/CP12, HF-10, HF-12, RW-7, RW-10, and RW-15 and underlying the silty sand to sand and silt to sandy silt deposit in Borehole HF-14, RW-4A, RW-5, RW-9. The surface of the deposit was encountered between Elevations 181.5 m and 170.4 m. Boreholes HF-10, HF-12, HF-14, RW-4A, RW-5, RW-7, RW-9, RW-10 and RW-15 were terminated within this deposit, penetrating it for thicknesses ranging from 0.6 m to 13.3 m. Where fully penetrated, the thickness of the deposit ranges from 6.9 m to 7.6 m and extends to depths ranging from 15.5 m to 23.3 m below ground surface (Elevations 165.3 m to 164.5 m). The deposit is noted to contain cobbles, boulders and rock fragments as inferred from grinding of the augers during drilling. In Borehole HF-12, a 0.7 m thick layer of sandy silt was encountered within the sand to sand and gravel deposit at a depth of 13.0 m below ground surface (Elevation 171.2 m).

The measured SPT “N”-values within the sand to sand and gravel deposit range from 11 blows to 69 blows per 0.3 m of penetration and up to 100 blows for 0.02 m of penetration, indicating that the deposit has a compact to very dense relative density.

Grain size distribution testing was completed on thirteen (13) samples of the sand to sand and gravel deposit and the test results are shown on Figure B-17A and B-17B in Appendix B.

The natural water content measured on twenty-five (25) samples of the sand to sand and gravel deposit range from about 3 per cent to 14 per cent, with one sample from a sand interlayer in Borehole CN/CP12 measuring 26 per cent. Atterberg limits testing was carried out on one sample of the sand and gravel portion of the deposit from Borehole CN/CP12 and measured a plastic limit of about 15 percent, a liquid limit of about 16 per cent, and a plasticity index of about 1 per cent. The test result, which is plotted on Figure B-18 in Appendix B, indicates that the finer material of the deposit may be classified as silt with slight plasticity.

4.2.2.9 Dolomitic Limestone (Bedrock)

Refusal to further split spoon penetration was recorded in Boreholes HF-10, RW-1 and RW-14 to RW-16 at depths ranging from 0.4 m to 11.6 m below ground surface, corresponding to Elevations 181.5 m to 174.6 m.

Bedrock was encountered and cored in Boreholes C1-1, C1-2, C1-3, HF-9, HF-11 and RW-6 between Elevations 181.9 m and 176.5 m, and in Boreholes CN/CP9, CN/CP10 and CN/CP12 between Elevations 165.3 m and

164.5 m. The upper 4.6 m depth of the weathered portion of the bedrock was penetrated by augering and recovered by split-spoon sampling in Borehole C1-1. The depths to bedrock, the corresponding bedrock surface elevations and the recovered core length are summarized below.

Borehole	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)	Cored Depth (m)
CN/CP9	15.5	164.5	3.1
CN/CP10	23.2	165.0	4.0
CN/CP12	23.3	165.3	3.9
C1-1	4.1	179.6	4.7 (below the augered upper 4.6 m depth)
C1-2	0.4	181.4	3.3
C1-3	7.6	176.5	1.5
HF-9	4.3	177.2	4.7
HF-10	11.6	174.6	Inferred from refusal to split spoon penetration
HF-11	1.8	181.9	4.4
RW-6	3.4	180.2	5.8

Based on the review of the bedrock core samples, the bedrock consists of dolomitic limestone of the Bois Blanc Formation. In general, the bedrock core samples are described as fresh to completely weathered (W1 to W5), crystalline, grey, fine to coarse grained, non-porous to slightly porous, weak to medium strong (R2 to R3) dolomitic limestone as presented on the relevant Record of Drillhole sheets, and shown on the photographs of recovered core samples on Figures C-2 through C-10 in Appendix C.

The RQD measured on core samples ranges from about 0 per cent to 84 per cent, indicative of a rock mass of very poor to good quality, as per Table 3.10 CFEM(2006)³. The TCR and SCR of samples recovered from Boreholes C1-1 to C1-3, HF-9, HF-11 and RW-6 are between 8 per cent and 100 per cent, and between 0 per cent and 94 per cent, respectively.

The bedrock core samples recovered from Boreholes CN/CP9, CN/CP10 and CN/CP 12 indicate TCR and SCR ranging between 94 per cent and 100 per cent, and between 75 per and 100 per cent, respectively. The RQD ranges from 69 per cent to 100 per cent, indicating a rock mass of fair to excellent quality CFEM (2006)³.

The majority of the logged discontinuities are joints or faults within the dolomitic limestone bedrock or contacts between siltstone/limestone interbeds. In general, the identified discontinuity surfaces are undulating, planar or curved in shape, with smooth to rough surface roughness. The surfaces of the identified discontinuities generally range from clean to slightly altered. Three occurrences of gypsum infills, or interbeds, were noted present in Borehole CN/CP9, as indicated on the Records of Drillhole sheet in Appendix A.

A grain size distribution test was completed on one split spoon sample of the upper weathered portion of the dolomitic limestone bedrock recovered in Borehole C1-1 and the test result is shown on Figure C-12 in Appendix C.

Two unconfined compression tests (UC) (ASTM D7012)⁶ were carried out on core specimens of limestone bedrock and strength test results are as shown on Record of Drillhole sheets in Appendix A, detailed in the laboratory test reports contained in Appendix C and are summarized below.

Borehole No.	Depth From (m)	Depth To (m)	Density (g/cm ³)	UCS (Mpa)
CN/CP9	16.0	16.1	2.75	97
CN/CP12	23.4	23.6	2.62	93

Point load strength tests (ASTM D5731)⁷ were carried out on selected core specimens. The axial and diametral point load strength index values ($I_{s(50)}$) are shown Figure C-13 in Appendix C. Nine axial tests measured $I_{s(50)}$ indices ranging from about 0.7 MPa to 7.7 MPa and an average of 4.1 MPa. Eleven diametral tests measured $I_{s(50)}$ indices ranging from about 0.1 MPa to 3.0 MPa, with an average of 0.5 MPa.

Based on the laboratory UC and Point Load Index tests, the bedrock is generally classified as weak to strong (R2 to R4) in accordance with Table 3.5 of CFEM (2006)³.

4.2.2.10 Groundwater Conditions

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

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date	Comments
C1-1	183.7	Dry	-	Sep. 5, 2018	Note 3.
C1-2	181.8	3.9	177.9	Jan. 13, 2019	Standpipe
		3.2	178.6	Feb. 8, 2019	
		3.8	178.0	Feb. 22, 2019	
C1-3	184.1	3.2	180.9	Feb. 8, 2019	Standpipe
		5.9	178.2	Feb. 22, 2019	
CN/CP9	180.0	7.9	172.1	Nov. 29, 2018	Note 2.
CN/CP10	188.2	12.5	175.7	Aug. 29, 2018	Note 1.
CN/CP12	188.6	12.2	176.4	Aug. 24, 2018	Note 1.
CN/CP13	187.9	Dry	-	Aug. 30, 2018	Note 1.
HF-9	181.5	Dry	-	Jan. 11, 2019	Note 3.

Borehole No.	Ground Surface Elevation (m)	Depth to Groundwater (m)	Groundwater Elevation (m)	Date	Comments
HF-10	186.2	9.7	176.5	Sep. 6 and 7, 2018	Note 1.
HF-11	183.7	Dry above 1.6	-	Jan. 12, 2019	Note 1.
HF-12	184.2	7.5	176.7	Sep. 6, 2018	Note 1.
HF-13	181.9	Dry	-	Jan. 12, 2019	Open Borehole
HF-14	183.3	6.8	176.5	Sep. 7, 2018	Note 1.
HF-15	183.0	Dry	-	Jan. 12, 2019	Open Borehole
RW-4A	184.5	Dry	-	Sep. 21, 2018	Note 1.
RW-5	184.2	Dry	-	Sep. 17, 2018	Note 1.
RW-6	183.6	4.9	178.7	Jan. 14, 2019	Note 3.
		6.6	177.0	January 15, 2019	Open Borehole
		3.3	180.3	Feb. 22, 2019	Standpipe
RW-7	183.7	7.3	176.4	Sep. 17, 2018	Note 1.
RW-9	185.1	5.5	179.6	Sep. 17, 2018	Note 1.
RW-10	186.6	10.7	175.9	Sep. 21, 2018	Note 1.
RW-14	181.5	N/A	N/A	Jan. 25, 2019	Not Recorded
RW-15	182.9	5.3	177.6	Jan. 25, 2019	Note 1.
RW-16	181.9	Dry	-	Jan. 26, 2019	Open Borehole

Notes: 1. Inside H.S. auger upon completion of soil drilling.

2. Not Recorded – used water for drilling.

3. Inside H.S. auger prior to bedrock coring.

As the water levels were measured during or immediately after completion of drilling and within low permeable fine grained soils, they may not represent the stabilized groundwater level at the site. However, in general, the groundwater level at the site is anticipated to range from approximately Elevations 180.3 m to 176.0 m. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.2.3 Bowen Road E/W-S and E/W-N Ramps

Twelve (12) boreholes were advanced for the realignment of ramp E/W-S (Boreholes R1-1 to R1-6) and ramp EW-S (Boreholes R2-1 to R2-6); supplemented with one borehole advanced for the culvert under ramp E/W-S

(Borehole C3-2) to provide additional subsurface information within the ramp area. The borehole locations at these high fill ramps are shown on Drawings 2 and 3 and the respective stratigraphic profiles are shown on Drawing 7.

It should be noted that the subsurface stratigraphy encountered within the boreholes advanced at the ramps as shown on the Record of Borehole sheets and on the stratigraphic profiles on Drawing 7 may change as there was active construction occurring at the time of the field investigation related to the realignment of the Bowen Road overpass. Local grading may impact the presence and/or thickness of the deposits that were encountered at the time of the investigation.

4.2.3.1 Topsoil

An approximately 75 mm to 180 mm thick layer of topsoil was encountered immediately below ground surface in Boreholes R1-2, R1-3, R1-4, and R1-5 at the E/W-S Ramp.

4.2.3.2 Asphalt/Sand (Fill)

Boreholes R1-1, R2-5 and R2-6 were advanced through the existing pavement structure of the existing ramps and penetrated an approximately 100 mm to 300 mm thick layer of asphalt, underlain by a 0.8 m to 1.3 m thick layer of granular fill comprised of an upper 0.8 m thick layer of sand or 0.9 m thick layer of sand and gravel and a lower 0.3 m to 0.4 m thick layer of sand. The measured Standard Penetration Test (SPT) "N"-values within the granular materials are 23 blows and 31 blows per 0.3 m of penetration, indicating a compact to dense level of compactness condition.

The natural water content measured on two samples of the granular material ranged from about 2 to 14 per cent.

4.2.3.3 Clayey Silt to Silty Clay (Fill)

A 0.2 m to 3.9 m thick layer of sandy clayey silt to clayey silt to silty clay fill was encountered underlying the granular fill in Borehole R1-1, underlying the topsoil in Borehole R1-2, underlying the sand fill in Borehole R1-5 and immediately below ground surface in Boreholes R1-6, R2-1, and R2-3. The cohesive fill extended to depths ranging from 1.1 m to 4.8 m auger and/or (Elevations 182.9 m and 185.8 m). Boreholes R1-1, R1-2 and R1-5 were terminated in the fill layer on split spoon and auger refusal below ground surface to further penetration.

The measured SPT "N"-values within the cohesive fill layer range from 2 blows to 30 blows per 0.3 m of penetration and up to 103 blows for 0.15 m of penetration. An in-situ field vane test carried out with this deposit measured an undrained shear strength greater than 144 kPa (shearing did not occur). The undrained shear strength together with the SPT "N"-values, suggest that the deposit generally has a soft to hard consistency.

Grain size distribution testing was completed on four (4) samples of the clayey silt to silty clay fill layers and the test results are shown on Figure B-19 in Appendix B.

The natural water content measured on six (6) samples of the clayey silt to silty clay fill range from about 12 per cent to 21 per cent. Atterberg limits testing was carried out on four (4) selected samples of the clayey silt to silty clay fill and measured plastic limits ranging from about 15 per cent to 19 per cent, liquid limits ranging from about 27 per cent to 40 per cent, and plasticity indices ranging from about 8 per cent to 22 per cent. These test results, which are plotted on the plasticity chart on Figure B-20 in Appendix B, indicate the cohesive fill can be classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

4.2.3.4 Sand to Sand and Gravel (Fill)

Layers of sand to silty sand and gravel to sand and gravel fill were encountered immediately the ground surface in borehole R2-2, below the topsoil in Borehole R1-5 and interlayered with the clayey silt to silty clay fill in Borehole R1-1. The non-cohesive fill layers range in thickness between about 0.3 m and 0.8 m and the interlayer in Borehole R1-1 was encountered at a depth of 2.2 m below ground surface (Elevation 187.6 m).

One SPT “N”-value measured within the non-cohesive fill is 29 blows per 0.3 m of penetration indicating a compact compactness condition.

4.2.3.5 Silt

A 0.7 m and 0.8 m thick deposit of silt to sandy silt was encountered underlying the topsoil in Boreholes R1-3 and R1-4. The surface of the silt deposit was encountered at Elevation 183.9 m and extends to depths of 0.9 m below ground surface (Elevation 183.2 m and 183.1 m) in the respective boreholes. Both boreholes were terminated in this deposit on auger and/or to split spoon and refusal to further penetration.

One SPT “N”-value within the silt deposit is 100 blows per 0.08 m of penetration, measured at the refusal depth.

4.2.3.6 Clayey Silt to Silty Clay

A 0.2 m to 4.1 m thick deposit of clayey silt with sand to clayey silt to silty clay was encountered immediately below ground surface in Borehole R2-4, underlying the pavement structure in Boreholes R2-5 and R2-6, and underlying the fill layers in Boreholes R1-6, and R2-1 to R2-3. The surface of the clayey silt to silty clay was encountered between Elevations 185.8 m and 184.1 m and the deposit extends to depths ranging from 1.5 m to 4.5 m (Elevations 184.5 m and 180.6 m). All seven boreholes were terminated within this deposit due to split spoon and/or auger refusal.

The measured SPT “N”-values within the clayey silt to silty clay deposit ranged from 10 blows to 33 blows per 0.3 m of penetration, and up to 100 blows for 0.3 m of penetration, suggesting a stiff to hard consistency within the deposit.

Grain size distribution testing was completed on five (5) samples of the clayey silt to silty clay deposit and the test results are shown on Figure B-21 in Appendix B.

The natural water content measured on thirteen (14) samples of the clayey silt to silty clay deposit range from about 6 to 21 per cent. Atterberg limits testing was carried out on five (5) selected samples of the clayey silt to silty clay deposit and measured plastic limits ranging from about 12 per cent to 19 per cent, liquid limits ranging from about 22 per cent to 43 per cent, and plasticity indices ranging from about 10 per cent to 24 per cent. These test results, which are plotted on the plasticity chart on Figure B-22 in Appendix B, indicate the deposit can be classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

4.2.3.7 Dolomitic Limestone (Bedrock)

Refusal to further split spoon and/or auger advancement was recorded in Boreholes R1-1 to R1-6 and R2 to R2-6 at depths between 1.1 m and 4.8 m below ground surface (between Elevations 185.0 m and 180.6 m).

Bedrock was encountered in Borehole C3-2 immediately at ground surface (outcrop) at Elevation 183.9 m and the bedrock was cored for 3.2 m depth.

Based on the review of the bedrock core samples, the bedrock consists of dolomitic limestone of the Bois Blanc Formation. In general, the bedrock core samples are described as moderately weathered (W3), crystalline, grey,

fine grained, non-porous, medium strong (R3) dolomitic limestone, as presented on the Record of Drillhole C3-2, and shown on the photographs of recovered core samples on Figure C-11 in Appendix C.

The RQD measured on core samples ranges from about 34 per cent to 71 per cent, indicative of a rock mass of poor to fair quality, as per Table 3.10 CFEM (2006)³. The TCR and SCR of the core samples recovered from Borehole C3-2 range between 71 per cent and 100 per cent and between 65 per cent and 80 per cent, respectively.

The majority of the logged discontinuities are faults within the dolomitic limestone bedrock or contacts between siltstone/limestone interbeds. In general, the identified discontinuity surfaces are undulating or planar in shape, with smooth to rough surface roughness. The surfaces of the identified discontinuities generally range from clean to partially coated. Where the surfaces were partially coated with infill, the material is generally clay or crushed rock.

Point load strength tests (ASTM D5731)⁷ were carried out on selected core specimens. The axial and diametral strength index point load strength index ($I_{s(50)}$) are shown Figure C-13 in Appendix C: one axial test measured an $I_{s(50)}$ value of about 2.3 MPa; and two diametral tests measured $I_{s(50)}$ values of about 0.3 MPa and 0.4 MPa.

Based on the laboratory Point Load tests, the bedrock is generally classified as weak to strong (R2 to R4) in accordance with Table 3.5 of CFEM (2006)³.

4.2.3.8 Groundwater Conditions

The groundwater conditions in the open boreholes were noted during drilling operations and all boreholes were noted as dry upon completion of drilling. Surface water was noted at the location of Borehole C3-2 prior to drilling.

As the water level observations were made during or immediately after completion of drilling, and within low permeable fine grained soils, the recorded dry conditions may not represent the stabilized groundwater level at the site. The groundwater level will be subject to seasonal fluctuations and should be expected to be higher during the spring season or during and following periods of heavy precipitation.

4.3 Analytical Testing Results

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

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Chlorides (µg/g)	Soluble Sulphates (µg/g)
RW-4A / 3	8.02	610	1,640	810	120
RW-5 / 8	7.71	2,100	483	200	81
RW-7 / 5B	7.84	3,300	302	95	<20*
RW-9 / 6	7.87	1,600	623	340	39
RW-10 / 7	7.89	710	1,400	660	88
RW-11 / 5	7.70	1,600	642	<20*	530

Borehole No. / Sample No.	pH	Resistivity (ohm-cm)	Electrical Conductivity (µmho/cm)	Chlorides (µg/g)	Soluble Sulphates (µg/g)
RW-12 / 4	7.84	1,000	1,000	<20*	1,400
RW-13 / 2	8.02	270	3,640	120	4,800
RW-14 / 6	7.82	3,100	323	58	100
RW-16 / 1A	7.22	4,400	227	26	<20*
C1-1 / AS1	8.06	2,000	504	150	110
CN/CP3 / 12	7.91	680	1,470	<20*	2,900
CN/CP9 / 4	7.86	300	3,300	310	7,400
CN/CP12 / 11	7.89	3,400	297	<20*	180

*Concentration is below Reportable detection limit

5.0 CLOSURE

This Foundation Investigation Report was prepared by Eric Naylor, an EIT with Golder, and Matt Soderman, P.Eng, a geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., an MTO Foundations Designated Contact and senior consultant with Golder, conducted an independent technical and quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
HIGH FILL EMBANKMENTS AND RETAINING WALLS IN SUPPORT OF
REPLACEMENT OF TWIN STRUCTURES OVER CN AND CP RAILS
SITE NOS. 34-129-1 AND 34-129-2
QEW FROM 1.4 KM NORTH OF BOWEN ROAD INTERCHANGE SOUTHERLY
TO GILMORE ROAD INTERCHANGE
TOWN OF FORT ERIE, NIAGARA REGION, ONTARIO
GWP 2116-16-00

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed grade raise and widening of high fill embankments, and three associated retaining walls in support of replacement of the twin structures over Canadian National (CN) and Canadian Pacific (CP) Rails, Site Nos. 34-129-1 and 34-129-2, along the QEW near the Town of Fort Erie, Regional Municipality of Niagara (Assignment No. 2016 E 0029-001). These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the 2018 and 2019 subsurface investigation at this site. The discussion and recommendations presented are intended to provide the designer with sufficient information to assess the feasible foundation alternatives and carry out the design of the proposed retaining walls and assess the requirements for stability and settlement of the raised and widened high fill embankments. Discussions and recommendations for the bridge approach embankments for the replaced twin structures and culvert replacement at approximately Station 14+273, which the retaining walls are associated with, are provided in separate Foundation Investigation and Design Reports.

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

For the purposes of the project and this report, the QEW at the site is considered to be aligned in a north-south direction. It is understood that a full replacement is proposed for the twin structures over CN and CP Rails, with the new alignment approximately 10 m west of the existing overheads. In order to accommodate the new, wider alignment, widening of the existing high fill embankments and construction of retaining walls will be required.

6.1.1 High Fill Embankments

The proposed construction of the replacement twin structures over CN and CP Rail lines requires a grade raise and widening/alignment shift (to the west) of the existing QEW. Based on the design drawings provided by AECOM dated January 2019, it is understood that the existing south bound lane (SBL) high fill embankment will be widened laterally westward by up to 12.0 m (distance from existing to proposed embankment crest/shoulder). The north bound lane (NBL) will not be widened eastward but will shift westward also by up to 12.4 m (relative to the existing embankment crest). The proposed grade of both the NBL and SBL will be raised by up to 4.0 m above the existing highway grade. This widening and grade raise will require placement of a vertical thickness of up to approximately 7.0 m of additional fill atop the existing embankment and side slopes. The maximum overall height of the new embankment fill within the high fill area will be up to 10.7 m. The widened and raised high fill embankment will be constructed with 2 horizontal to 1 vertical (2H:1V) slopes, where space allows. Where space is restricted by the right-of-way, retaining walls will be constructed with the embankment slope above the retaining walls constructed with 2H:1V and 4H:1V slopes along the SBL and NBL, respectively. A median sewer will be constructed within the high fill embankment, between the newly re-aligned NBL and SBL.

The existing high fill embankments in the area appear to have performed well (no indications of excessive settlements or instability) based on field observations of the embankment slopes and existing pavement during Golder's 2018/2019 subsurface investigation.

Historical data review of information from MTO GEOCRE No. 30L15-011 for "QEW and Michigan Central Railway" suggests that an embankment failure occurred at the NBL, north of the existing CN and CP overhead structures. The exact location and extents of the failure cannot be confirmed based on the available information. The available information consists of a drawing, dated August 1961, which presents a plan view and three sections depicting details of the failure including tension cracks at the crest and bulging material at the toe of the highway embankment. The drawing also illustrates a mid-slope stabilization berm which is approximately 11.3 m wide, by 3.0 to 3.5 m high, by at least 100 m long. One of the sections shows stratigraphy inferred from boreholes drilled post-failure indicating that the failure surface was contained within the embankment fill material (i.e., not a foundation failure). Review of electronic design files provided to Golder by AECOM reveal a mid-slope bench exists along the NBL embankment between approximately Stations 13+845 to 13+940 (north abutment). As previously noted, the embankment slope in this area appears stable at this time, however, it is understood that clayey embankment fills in this area are prone to surficial instability when constructed with slopes at or steeper than 2H:1V. This needs to be taken into consideration in the selection of appropriate fill type(s) and embankment slope geometry as part of the design of the embankment widening(s) for this assignment and is discussed further in Section 6.9.

6.1.2 Retaining Walls

Given the limited width of available right-of-way, the proposed grade raise and widening will require three retaining walls (identified as RW-1 (MTO Site No. 34X-0600/W0), RW-2 (MTO Site No. 34X-0601/W0), and RW-3 (MTO Site No. 34X-0602/W0)) in areas along the east and west extents of the QEW due to property line constraints. The following table summarizes the locations and extent of the proposed retaining walls that require foundation design within the high fill embankment areas.

Retaining Wall I.D.	Retaining Wall Location along QEW	Approximate Retaining Wall Limits (m)	Approximate Length of Wall (m)	Proposed Maximum Retaining Wall Height ¹ (m)
Retaining Wall 1 (RW-1)	SBL – West side	STA 13+670 to STA 13+858	180	9.1
Retaining Wall 2 (RW-2)	SBL – West side	STA 14+010 to STA 14+313	299	10.2
Retaining Wall 3 (RW-3)	NBL – East side	STA 14+190 to STA 14+470	153	3.6 ² 5.5 ³

Note:

1. The proposed maximum retaining wall height is based on profiles provided by AECOM and referenced from finished ground to the top of the finishing coping.
2. Over the majority of the length of Retaining Wall RW-3.
3. Near the culvert location (Station 14+273) only along Retaining Wall RW-3.

The retaining walls are proposed to be Retained Soil System (RSS) walls. Retaining walls RW-1 and RW-2 are continuous with the proposed RSS walls for the north and south abutments of the replaced twin CN and CP

overhead structures, respectively. The RSS walls along the western limits of the QEW SBL (RW-1 and RW-2) are proposed to be founded within the native ground at the toe of the existing embankment while the RSS wall along the eastern limit of the NBL (RW-3) is proposed to be founded primarily within the existing highway embankment fill at the location of the existing north shoulder / embankment crest (except adjacent to, and at the location of the culvert at Station 14+273 where the wall will be founded on native ground). The RSS walls are proposed to be founded a minimum depth of either 1.0 m below native final ground surface, or 2.6 m below the existing fill surface (RW-3 where founded in existing embankment fill).

6.1.3 Ramps E/W-S and E/W-N

QEW Highway ramps E/W-S and E/W-N will both be realigned as a result of the replacement of the CN/CP twin structures. The new E/W-S ramp will be shifted to approximately 40 m south of the existing ramp. Based on the design profiles and typical sections provided by AECOM, the new E/W-S ramp embankment will require placement of up to 3.3 m of fill and will have side slope grades ranging from 2H:1V to 3H:1V. The E/W-S ramp is not considered a high fill embankment as the overall height is less than 4.5 m. As such, the E/W-S ramp is not discussed further in this report. However, it is recommended that only fill meeting the requirements of OPSS.PROV 1010 (Aggregates) for Select Subgrade Material (SSM) or Granular 'B' Type I or Type II be utilized for construction.

The new EW-N ramp will be shifted to approximately 40 m north of the existing location and will require placement of up to 5.7 m of new fill. For the majority of the length of the new ramp, the side slopes will be graded at 3H:1V, except in the vicinity of two hydro poles located in the Bowen Rd – Ramp E/W-N quadrant where the north slope of the ramp will need to be steepened to provide clearance distance from the poles. The length of the steepened ramp slope is approximately 35 m. A reinforced soil slope system constructed at a grade of 1H:1V or an RSS retaining wall constructed at the toe of a slope graded at 2H:1V above the wall are proposed in the area of the hydro poles.

6.2 General Foundation Design Context

6.2.1 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the *Canadian Highway Bridge Design Code* CAN/CSA S6-14 (*CHBDC* (2014)) and its *Commentary*, the proposed high fill embankment grade raise and widening of the QEW highway NBL and SBL is expected to carry high traffic volumes and its performance may have potential impacts on other transportation corridors; hence, the proposed high fill embankment works have been assessed as having a “typical consequence level” associated with exceeding limits states design. Similarly, the proposed retaining walls and their foundation systems may be classified as a geotechnical system designed for application along a transportation corridor having large traffic volumes and as having potential impacts on other transportation corridors, resulting in a “typical consequence level” associated with exceeding limit states design.

Based on the level of foundation investigation carried out for the high fill area and proposed retaining walls in comparison to the degree of site understanding in Section 6.5 of *CHBDC* (2014), the level of confidence for design has been assessed as “typical degree of site and prediction model understanding”.

Accordingly, the appropriate corresponding consequence factor, Ψ , and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs} , from Tables 6.1 and 6.2 of the *CHBDC* have been used for analyses and design.

For a “typical degree of understanding”, *CHBDC* (2014) requires a minimum Factor of Safety of 1.33 for the short-term/temporary condition and 1.54 for the long-term/permanent condition for global slope stability of embankments. *CHBDC* (2014) does not provide guidance on the minimum Factors of Safety for the global stability of retaining walls, but for this site, the same Factors of Safety used for the global stability of embankments will be adopted.

6.2.2 Seismic Design

6.2.2.1 Seismic Site Classification

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

6.2.2.2 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.4 of the *CHBDC* (2014) and as obtained from NRC (2017) website, the peak ground acceleration (PGA), peak ground velocity (PGV) and design spectral acceleration (Sa) values for Site Class C are presented below.

Seismic Hazard Values	10% Exceedance in 50 years (475-year return period)	5% Exceedance in 50 years (975-year return period)	2% Exceedance in 50 years (2,475 return period)
PGA (g)	0.055	0.104	0.202
PGV (m/s)	0.035	0.062	0.118
Sa (0.2) (g)	0.088	0.163	0.313
Sa (0.5) (g)	0.048	0.081	0.152
Sa (1.0) (g)	0.025	0.040	0.070
Sa (2.0) (g)	0.011	0.018	0.032
Sa (5.0) (g)	0.002	0.004	0.007
Sa (10.0) (g)	0.001	0.002	0.003

6.2.2.3 Soil Liquefaction

Given the generally stiff to hard consistency and plastic nature of the cohesive soils; compact to very dense compactness condition of the non-cohesive soils; and the low seismic hazard classification for the site, the risk of potential soil liquefaction due to a seismic event at this site is considered to be low.

6.3 Foundations Options for Retaining Walls

The key issues for design and construction at the site are the relatively high embankment fill / retaining wall heights and associated foundation settlements as well as property boundary limitations. As discussed further in Section 6.5, the estimated settlements under the locations of the retaining walls typically range from 15 mm to 45 mm. North of approximately Station 13+725 estimated factored settlements are greater due to the presence of a limited zone of firm to stiff clayey silt to silty clay soil, and are expected to be up to 135 mm to 150 mm at the location of the embankment shoulder and up to 90 mm at the wall (including up to 55 mm of long-term post-construction

settlement). The selected wall type must be able to accommodate this post-construction settlement, or appropriate settlement mitigation measures must be implemented.

Based on the proposed high fill embankment and retaining wall geometries, together with settlement estimates based on the subsurface conditions at the site and the property limit restrictions, various wall types have been considered. It is noted that alternatives such as soldier pile and concrete panel walls which are most advantageous in “top-down” construction applications, i.e. as part of a cut-widening, rather than for an embankment widening, have not been considered for the retaining walls at this site. A summary of the advantages and disadvantages associated with each option is presented below and a comparison of the alternative foundation options based on advantages, disadvantages, constructability and relative costs is provided in Table 1 following the text of this report.

- **Retained Soil System (RSS) walls:** RSS walls are geotechnically feasible for the proposed retaining walls at the site. RSS walls are considered to be more settlement tolerant than concrete retaining walls, particularly if a two-stage RSS wall is adopted. It is noted that the use of a two-stage RSS wall system will require review and approval by the MTO RSS Committee during construction; an NSSP to address this requirement is provided in Appendix E. A two-stage RSS wall would be preferred for retaining wall RW-1 north of Station 13+725 due to the estimated magnitudes of the post-construction total and differential settlements, however a one-stage RSS wall system comprised of modular pre-cast concrete panels could be considered if the RSS wall designer can ensure the structure can tolerate the estimated settlements. The RSS walls are preferably founded within the native stiff to hard clayey silt to silty clay stratum, but could be founded within the existing firm to stiff clayey silt embankment fill where wall heights are low. Typically, RSS walls can be constructed with only a limited excavation footprint required beyond the limits of the wall which is advantageous where the MTO right-of-way limit is close to the limit of construction along the SBL (i.e., at retaining walls RW-1 and RW-2). RSS walls have the lowest relative construction cost when compared to concrete retaining walls, although this cost may be higher where two-stage walls are used.
- **Concrete retaining wall on shallow foundations:** Based on the subsurface conditions, a concrete retaining wall supported on shallow foundations founded on the native subsurface strata is geotechnically feasible for the walls south of Station 13+725 (i.e., retaining walls RW-2, and section of RW-1 south of 13+725). At the north end of RW-1 (north of 13+725), the foundations would be required to extend below the firm to stiff clayey silt to silty clay deposit which could be more than 14 m below the ground surface at the toe of the existing highway embankment which is not practical. At RW-3, the foundations would be required to be founded below the existing embankment fill and onto the native soil. The excavation footprint for conventional concrete retaining walls is expected to be greater than required for RSS walls which may require temporary easement beyond the MTO right-of-way.
- **Concrete retaining wall on deep foundations:** Concrete walls supported on deep foundations (driven piles or caissons) are considered feasible from a geotechnical/foundations perspective. Deep foundations would only be considered necessary for the section of retaining wall RW-1 north of Station 13+725, however the construction duration for this type of wall would be longer and more expensive compared to the RSS wall alternative.

As noted in Section 6.1.2, the preferred retaining wall / foundation type for retaining walls RW-1 to RW-3 as selected by AECOM is RSS walls. Based on the above considerations, from a geotechnical/foundations perspective, RSS walls (incorporating a two-stage system if necessary and where applicable) are considered to be the most practicable and cost-effective option for all new retaining walls at this site. As presented in Section 6.5, the preferred

settlement mitigation measure in the area north of Station 13+725 is either a one-stage RSS wall with modular facing panels properly designed to accommodate the estimated total and differential settlements or a two-stage RSS wall with installation of the facing panels after a preload period of at least 3 months.

6.4 Foundation Options for EW-N Ramp Slope Steepening

Steepening of the approximately 35 m long section of the new E/W-N ramp slope to avoid hydro poles is required and can be achieved by construction of an RSS wall or reinforced soil slope system, as proposed by AECOM. Based on the design model snapshots provided by AECOM by email on May 2, 2019, the proposed RSS wall would range from 1.8 m to 2.9 m in height. The reinforced soil slope, which would consist of a geogrid and erosion control matting wrapped face with a geogrid reinforcement zone extending back into the slope, would be constructed with the toe of the 1H:1V graded slope at approximately the same location as the RSS wall thus providing similar clearance from the hydro poles. The estimated settlements resulting from new fill for the ramp construction in this area are estimated to be less than 25 mm and would occur during or shortly after construction (i.e. immediate settlement).

It is understood that the preferred option for steepening the E/W-N ramp slope as selected by AECOM is a reinforced soil slope. From a geotechnical/foundations perspective, both an RSS wall and reinforced soil slope are feasible options for steepening the ramp slope. There are no clear technical advantages or disadvantages to one alternative over the other as both options provide practicable and cost-effective solutions. However, a reinforced soil slope may be less expensive than an RSS wall and be simpler to construct. Recommendations and global stability requirements for both a reinforced soil slope and an RSS wall at the E/W-N ramp are provided in Sections 6.6 to 6.8.

6.5 Settlement Under New High Fill Embankment and Retaining Wall Construction

Based on the design cross-sections provided by AECOM, the highway QEW alignment will be shifted by up to 12.4 m westerly which will require widening of the SBL embankment to the west. The proposed grade of the NBL and SBL embankments will also be raised by up to 4.0 m above the existing highway grade. This widening and grade raise will require placement of a vertical thickness of up to approximately 7.5 m of additional fill atop the existing embankment side slopes and native ground at the toe.

The new RSS retaining walls along the SBL, i.e. RW-1 and RW-2, are proposed to be located approximately at the toe of the existing highway embankment to up to 10 m west of the existing embankment toe. Retaining wall RW-3 along the NBL is proposed to be constructed at the eastern crest / shoulder of the existing embankment and be founded within the existing embankment fill. Given that the RSS walls are to be constructed as part of the overall high fill embankment grade raise and widening system, settlements of the RSS wall systems will be coupled with those induced by the immediately adjacent new fills.

The realignment of ramp EW-N will require up to 5.7 m of new fill. The highest fill thickness will be placed in the area where the existing ramp is being widened between approximately Stations 9+829 m to 9+900 m.

The following sub-sections outline the methodology used to carry out the settlement analyses due to the new fill/RSS wall construction, the predicted magnitude of settlement under the new E/W-N ramp fill and under the raised and widened QEW high fill embankments including under and behind the RSS walls, the duration of settlements, and settlement mitigation measures, where required.

6.5.1 Method of Analysis

To estimate the magnitude and duration of expected settlement(s), analyses were carried out at various sections of the proposed RSS walls and high fill areas. The representative sections were selected at approximately 50 m to 120 m intervals along the highway QEW alignment to provide a comprehensive settlement estimation accounting for varying foundation soil conditions, locations and heights of the retaining walls, and high fill embankment heights and geometry. Additionally, one representative section for the EW-N ramp was selected for analysis. The stratigraphy at each of the sections was simplified based on the nearest adjacent boreholes. The settlement analyses assume that all topsoil and any surficial deposits containing organics or any other deleterious and weak materials have been removed and replaced with either OPSS.PROV 1010 Select Subgrade Material (SSM) or Granular A or B fill. The settlement analyses were carried out using the commercially available program Settle^{3D} (Version 4.0), developed by Rocscience Inc. The stress distribution calculations used in the settlement analyses were based on the Boussinesq solution.

The sources of settlement are considered to include:

- Immediate (elastic) settlement of the cohesionless soils and generally very stiff to hard cohesive deposits (short-term);
- Primary and secondary (creep), time-dependant consolidation settlement of a 2.0 m to 5.7 m thick zone of firm to stiff clayey silt to silty clay encountered north of Station 13+725 (between elevations 174.2 m and 168.5 m in Boreholes HF-1 to HF-3 and RW-12) (long-term); and,
- Compression of the existing and new highway embankment fill itself due to the grade raise and widening (during and shortly after completion of construction).

As noted above, settlements will vary along the length of the high fill embankments, RSS wall alignments and ramp based on varying subsurface conditions and new fill heights/geometry. However, given that the analyses were carried out at several sections of the high fill area which included critical sections representing “worst-case” foundation stratigraphy and greatest fill height, the settlements estimated will generally represent a range which includes the maximum estimated values along a given section of the alignment. Secondary consolidation of the fills is anticipated to be negligible.

6.5.2 Settlement Performance Requirements

The settlement performance criterion for design of embankment widenings within the high fill area is outlined in MTO's Guideline titled, “Embankment Settlement Criteria for Design”, dated July 2010. The allowable total post-construction settlement and differential settlement limits for freeway embankment widenings is 50 mm and 200:1, respectively, over a 20-year period following completion of construction for a King's highway.

The settlement performance criteria for design of RSS walls is defined in TAC (2017). The ranges of allowable total and differential settlements for the different RSS wall types are summarized below. It is noted that for RSS walls designed and constructed without any special considerations, the allowable settlements must be limited to the low end of the range(s) indicated. Where settlements are anticipated to be in the middle or high end of the ranges, specific design checks to ensure that the RSS wall can accommodate the settlements and/or approval from the RSS wall designer would be required.

- Single-stage walls with full-height precast concrete panels: ≤ 25 mm to 65 mm (total), ≤ 20 mm to 50 mm (differential);

- Single-stage walls with modular precast concrete panels: ≤ 50 mm to 100 mm, ≤ 40 mm to 75 mm (differential);
- Flexible face walls and two-stage walls: ≤ 100 mm to 300 mm, ≤ 75 mm to 230 mm (differential);

6.5.3 Settlement Parameter Selection

The majority of the soils encountered at the site consist of non-cohesive soils and very stiff to hard cohesive soils. The immediate compression of these deposits were modelled by estimating an elastic modulus of deformation based on the SPT “N”-values and using correlations proposed by Bowles (1984), Kulhawy and Mayne (1990), and Peck et al. (1974) as well engineering judgement from experience with similar soils in this region of Ontario.

The consolidation settlement of the firm to stiff clayey silt to silty clay encountered north of Station 13+725 was assessed using the results of the laboratory consolidation test, and in-situ field vane tests, where appropriate, to estimate the stress history and deformation parameters for this zone. In addition, the results of the laboratory index tests were employed to further assess deformation parameters (i.e., compression and recompression indices) using empirical correlations proposed in literature by Nakase et al. (1988) and Nagaraj et al. (1985).

The following correlation relating in-situ undrained shear strength to preconsolidation stress (Mesri, 1975) was employed:

$$\sigma'_p = \frac{s_{u(mob)}}{0.22}$$

where:

$$\begin{aligned} \sigma'_p &= \text{preconsolidation stress (kPa); and,} \\ s_{u(mob)} &= \mu s_{u(FV)} \text{ (after Bjerrum, 1973), where } s_{u(mob)} = \text{average mobilized undrained shear strength (kPa)} \\ s_{u(FV)} &= \text{undrained shear strength from field vane test (kPa)} \\ \mu &= \text{Bjerrum's correction factor based on Plasticity Index} \end{aligned}$$

The parameters associated with the firm to stiff clayey silt to silty clay deposit north of Station 13+725 are presented on Figure 1.

In addition to primary consolidation within the firm to stiff clayey silt to silty clay deposit north of Station 13+725, secondary compression may also occur. Secondary compression or creep settlement occurs over a long period of time, after full dissipation of excess pore pressure under a constant stress. The following relationship has been employed for estimating the magnitude of creep settlement over the life of the embankments following the completion of primary settlement:

$$S_c = H C_{\alpha\epsilon} \log\left(\frac{t}{t_{EOP}}\right)$$

where:

$$\begin{aligned} S_c &= \text{secondary consolidation (creep) settlement (mm)} \\ C_{\alpha\epsilon} &= \text{modified secondary compression index as estimated from laboratory consolidation tests and correlation by Mesri (1973)} \\ H &= \text{initial thickness of compressible clay deposit (mm)} \\ t &= \text{post-construction period of interest (20 years)} \\ t_{EOP} &= \text{time to reach end of primary consolidation (years)} \end{aligned}$$

The coefficient of consolidation, c_v (cm^2/s), required in the time-rate settlement analysis of the firm to stiff clayey silt to silty clay, was established using the results of the laboratory consolidation test, checked using the U.S. Navy (1986) correlation with liquid limit, and tempered based on experience using settlement monitoring data from fill embankments constructed on similar clay deposits in the area of the site, as applicable.

A bulk unit weight of 21 kN/m^3 was employed for the proposed embankment widening and RSS wall fill in calculating the loading of the new fill on the subgrade subsoils.

A summary of the parameters used for carrying out the settlement analyses for the simplified representative stratigraphies under the new EW-N ramp, high fill embankments and RSS wall construction are summarized below. Given the lengths of the retaining walls and high fill areas, and the variability in the subsurface conditions, several sections have been analysed for each which is why a range of parameters has been indicated in the summary table below for some soil layers.

Area	Soil Deposits used in Analyses at Simplified Representative Sections	Bulk Unit Weight (kN/m ³)	Elastic Modulus (MPa)	σ'_p (kPa)	e_o	C_c	C_r
North of CN/CP Twin Structure (North of Station 13+875, including RSS Wall RW-1)	Clayey Silt to Silty Clay to Clay – Stiff to Hard	19.5	25 - 40	-	-	-	-
	Clayey Silt to Silty Clay – Firm to Stiff	19.5	-	Refer to Figure 1			
	Sandy Silt to Sand – Compact to Dense	20	50	-	-	-	-
	Sand and Gravel – Compact to Very Dense	21	50	-	-	-	-
South of CN/CP Twin Structure (Station 14+010 to 14+313, including RSS Wall RW-2)	Clayey Silt – Stiff to Very Stiff	19.5	15 - 25	-	-	-	-
	Silt and Sand – Loose to Compact	20	25 - 35	-	-	-	-
	Sand and Gravel to Gravelly Sand – Compact to Very Dense	21	50 - 70	-	-	-	-
	Sand and Gravel (containing rock fragments) – Very Dense	21	70	-	-	-	-
South of CN/CP Twin Structure – (Station 14+190 to 14+470, NBL only including RSS Wall RW-3)	Clayey Silt Fill – Stiff	19	8	-	-	-	-
	Clayey Silt – Stiff to Very Stiff	19.5	20 - 25	-	-	-	-
	Silty Sand to Gravelly Sand – Compact to Very Dense	21	35 - 50	-	-	-	-
	Sand and Gravel (containing rock fragments) – Very Dense	21	70	-	-	-	-
Ramp EW-N	Clayey Silt to Silty Clay – Stiff to Hard	19.5	15 - 30	-	-	-	-

6.5.4 Magnitude

Settlement of new fill that is properly placed and compacted for construction of the embankment widening(s) will occur during construction. Provided that the embankment grade raise and widening material consists of SSM or granular fill, the settlement of the new embankment fill itself is expected to be less than approximately 25 mm under the travelled portion of the highway (i.e. inside of shoulder) for the proposed widenings and grade raise. There will also be settlement of the existing clayey embankment fill under the loading from the grade raises; however, it is estimated that the magnitude of the settlement of the existing clayey fills will be less than 50 mm and that the majority of this settlement will happen during construction of the grade raise(s).

The use of granular fill is preferred for the new embankment construction because this would reduce the magnitude of settlement, since the majority of settlement of granular fills will occur during, or immediately following construction.

Based on the settlement analyses, the estimated total factored settlement of the foundation soils under the proposed high fill embankment areas where the maximum thickness of new fill is located (generally corresponding to the shoulders/crest of the embankment) and behind the RSS walls is summarized as follows, assuming the use of granular fill for the RSS wall construction:

Area	Highway Stationing Location	Estimated Factored Total Settlement (mm)	Estimated Factored Immediate/Elastic Settlement (mm)	Estimated Factored Consolidation Settlement (mm)
North of CN/CP Twin Structure - SBL (including RSS Wall RW-1)	SBL - North of Station 13+725	Shoulder: 135 – 150 RSS RW-1: 85 - 90	Shoulder: 35 – 45 RSS RW-1: 30	Shoulder: 100 to 115 RSS RW-1: 55 (including 10 mm to 15 mm of creep)
	SBL - Between Stations 13+725 and 13+875	Shoulder: 60 - 80 RSS RW-1: 45 - 50	Shoulder: 60 - 80 RSS RW-1: 45 - 50	-
South of CN/CP Twin Structure - SBL (including RSS Wall RW-2)	SBL - Between Stations 14+010 and 14+313	Shoulder: 80 - 105 RSS RW-2: 0* - 60	Shoulder: 80 - 105 RSS RW-2: 0* - 60	-
South of CN/CP Twin Structure - NBL (including RSS Wall RW-3)	NBL - Between Stations 14+190 and 14+470	Shoulder: 35 - 55 RSS RW-3: 30 - 35	Shoulder: 35 - 55 RSS RW-3: 30 - 35	-
Ramp EW-N	9+829 to 10+000	Shoulder: 15 - 20	Shoulder: 15 - 20	-

Note: * Bedrock was encountered below topsoil at the toe of the existing SBL high fill embankment in Borehole RW-16.

The expected factored settlements of the foundation soils below the median and NBL are estimated to be much less than under the widened portion of the SBL due to the lower height of additional fill required for the grade raise. Settlements under all portions of the proposed construction (i.e. NBL and SBL) south of approximately Station 14+313 are estimated to be less than 25 mm due to relatively low proposed embankment heights and geotechnically favourable subsurface conditions.

6.5.5 Rate of Consolidation Settlement

The immediate (elastic) settlements of the non-cohesive soils and stiff to hard cohesive soils which underly the majority of the site area is expected to occur essentially during embankment and RSS wall construction.

Where post construction settlements are predicted north of approximately Station 13+725, it is estimated that the time to complete about ninety percent of the primary consolidation settlement under the SBL shoulder (location of greatest thickness of new fill placement) will be approximately 1 year following the completion of the new embankment and RSS wall fill based on an estimated co-efficient of consolidation (c_v) of $2 \times 10^{-3} \text{ cm}^2/\text{s}$ for the firm to stiff clayey silt to silty clay (and the imposed loading conditions, and assuming two-way drainage of the deposit). It is estimated that less than 50 mm of settlement will remain approximately 3 months after placement of the new fill.

6.5.6 Settlement Mitigation Options

For areas south of Station 13+725, the foundation settlements are expected to be predominantly immediate and occur during and shortly after construction of the new embankment fills and RSS walls. The maximum predicted magnitudes of the settlements under the thickest fill at the new SBL shoulder of the highway and at the location of the RSS walls are about 85 mm and 50 mm, respectively. Typically, estimated settlements at the RSS wall locations are less than 35 mm. Given that the settlements are expected to occur during and shortly after construction, the MTO's post-construction performance criteria outlined in Section 6.5.2 will be achieved (i.e., no long-term, post-construction settlements anticipated). Additionally, a conventional RSS wall with modular facing panels will be able to tolerate the magnitudes of settlement predicted for this area (TAC, 2017). However, it is recommended that the median sewer construction and paving should be delayed for approximately 4 weeks after completion of fill placement in order to ensure the settlements are completed.

North of Station 13+725, both the duration and magnitude of settlements predicted require mitigation in order to meet the MTO's settlement criterion. The total settlement estimated under the new SBL shoulders is up to 120 mm with up to 90 mm of long-term, post-construction settlement. The total settlement estimated at the location of RSS wall RW-1 in this area is up to 70 mm, including up to 45 mm of long-term, post-construction settlement, and a conventional RSS wall may not be able to tolerate this magnitude of settlement and the resulting differential settlement. However, the flexible wall facing and reinforced soil mass of a two-stage RSS wall system should be able to tolerate this magnitude of total settlement and the accompanying differential settlement that will occur along the wall length (TAC, 2017). Typical options for settlement mitigation (preloading with or without surcharging, potentially in conjunction with wick drains) are constrained by the limits of the existing right of way; there is limited space for over-constructing embankments. Another alternative would be to use lightweight fill (such as cellular concrete, or ultra-lightweight slag fill with appropriate geosynthetic reinforcement) for the reinforced soil mass, and this could be considered but would require submission of the design and approval by the MTO RSS Committee. As discussed in Section 6.5.5, it is estimated that less than 50 mm of post-construction settlement will remain following a preload period of about 3 months after placement of the new fill.

For the RSS wall north of Station 13+725, based on settlement criteria outlined in Section 6.5.2, the following options are considered suitable:

- **A single-stage RSS wall with modular facing panels:** However, the RSS designer must confirm that the structure, including the facing panels, can tolerate the estimated total and differential settlements outlined above and meet specified performance levels. If lightweight fill is to be considered for use within the reinforced soil mass, the Contractor will need to submit the proposed RSS wall system design for review and approval

by the MTO RSS Committee; an NSSP has been included in Appendix E outlining this requirement, for inclusion in the Contract Documents.

- **A two-stage RSS wall with the facing panels added after the recommended minimum 3 month preload period (subject to monitoring) for this section of the project:** Two-stage RSS wall types are currently not listed on the MTO Designated Sources of Material (DSM) list, and the Contractor will need to submit the proposed RSS wall system design for review and approval by the MTO RSS Committee; an NSSP has been included in Appendix E outlining this requirement, for inclusion in the Contract Documents.

From a foundations perspective, a two-stage RSS wall is preferred as it minimizes the risk associated with poor long-term performance of the wall. However, a single-stage RSS wall with facing panels appropriately designed by the proprietary designer to accommodate the expected total and differential settlements could be considered. For either wall option, preloading is recommended prior to construction of the pavement structure and installation of the median sewer. Following discussions with AECOM, it is understood that there is sufficient time available during construction to allow for a minimum 3 month preload period before final paving and RSS wall facing panel installation (should a two-stage wall be implemented). It should be noted that the median sewer installation and paving should also be delayed in this area until the preload period is completed to mitigate the potential effects of differential settlements.

An NSSP for two-stage RSS walls has been developed and is included in Appendix E, for inclusion in the Contract Documents. An Operational Constraint has been developed for inclusion in the contract documents to address the preload timing requirement, delay of paving, and delay of installation of the two-stage facing panels and is included in Appendix E. Monitoring of the settlement in the area north of Station 13+725 during the construction and preloading period is recommended, as discussed further in Section 6.5.7.

The preload for the high fill area should be constructed up to the top of the granular sub-base. After the preload period, it is recommended that additional sub-base fill be placed to achieve the final subgrade level prior to placement of the pavement structure.

6.5.7 Instrumentation and Settlement Monitoring

It is recommended that settlement monitoring be carried out for the embankment and RSS wall construction north of Station 13+725, to monitor the magnitude and rate of settlement during the construction of the new embankment fill / first stage of the RSS wall and for a period of at least three months following completion of the fill placement, to confirm that the remaining post-construction settlement is less than MTO's permitted settlement of 50 mm before installing the final pavement structure, the median sewer, and, if a two-stage wall is adopted, the RSS wall facing panels.

A monitoring program has been developed, consisting of the following:

- Settlement plates installed on the ground surface at the toe of and on the slope of the existing high fill embankment prior to construction of the new embankment fill placement and RSS wall construction; and,
- Settlement nail pins installed within concrete along the new shoulder of the widened high fill embankment at the beginning of the preload period.

The nail pins and settlement plates would be surveyed at regular intervals for the duration of the preloading period. Instrumentation and monitoring plans (See Drawings 8 and 9) and an NSSP for settlement monitoring are included in Appendix E, for inclusion in the Contract Documents.

6.6 Global Stability of High Fill Embankment and Retaining Walls

The following sub-sections outline the method and parameters used to evaluate static global stability of the proposed RSS walls and high fill embankment grade raise(s) and widening(s).

6.6.1 Method of Analysis

Two-dimensional limit equilibrium slope stability analyses were performed using the commercially available program SLIDE 2018, developed by Rocscience Inc., employing the Morgenstern Price method of analysis. Morgenstern Price is a general method of slices which is based on equilibrium of forces and moments acting on each slice of soil mass above the potential failure surface. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed in order to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. For the purpose of the stability analysis, the Factor of Safety is equal to the inverse of the product of the consequence factor, Ψ , and the geotechnical resistance factor, ϕ_{gu} (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$). Accordingly, minimum Factors of Safety of 1.33 and 1.54 have been used for the design of the embankments and retaining walls for consideration of the global stability under short term/temporary and long term/permanent static conditions, as per Tables 6.1 and 6.2 of CHBDC (2014).

Similar to the settlement analysis, the stability analyses have been completed for various representative sections within the proposed RSS wall and high fill areas. Soil stratigraphies were simplified to represent the subsurface conditions encountered in the surrounding boreholes within the area. The typical representative sections were selected based on the highest embankment height and the weakest soil conditions encountered within the high fill embankment areas. With the exception of within the limits of RSS wall RW-3, the analysis was primarily focused on the west slope of the SBL due to the proposed widening and steepening of the existing high fill embankment, however a review of the global stability of the east limit of the NBL was also carried out to confirm stability.

The widened embankment geometry is based on the typical cross sections provided by AECOM with an assumed maximum final embankment height of 10.7 m. The widened and raised high fill embankment(s) are proposed to be constructed with 2H:1V slopes. Where retaining walls are present, the embankment slope above the wall are to be constructed with 2H:1V and 4H:1V slopes along the SBL and NBL, respectively.

The piezometric groundwater level used in the analyses was interpreted to be at approximately 1.5 m below ground surface. It is assumed for the analysis that all topsoil and any other unsuitable surficial material will be removed from the footprint of the high fill embankment widening / RSS walls during foundation preparation prior to construction.

6.6.2 Soil Shear Strength Parameters

For the non-cohesive soils present at the site, the effective stress parameters employed in the analyses were estimated from empirical correlations based on the results of the in-situ Standard Penetration Tests (SPT). The correlations proposed by Peck et al (1974) and U.S. Navy (1986) were employed and the results were adjusted by engineering judgment based on precedent experience in similar soil conditions.

For the cohesive deposits, total stress parameters were employed in the analyses of the short-term, undrained conditions (i.e., temporary conditions). The total stress parameters (i.e., average mobilized undrained shear strength – s_u) for the cohesive soils were estimated from corrected field vane tests (based on Bjerrum's correction method), from the lab oedometer test (following the correlation proposed by Mesri, (1975) as outlined in Section 6.5.3) and from correlations with the SPT results, where appropriate. A plot of the undrained shear strength versus elevation for the firm to stiff clayey silt to silty clay north of Station 13+725 is shown on Figure 1. Effective stress

parameters were also assigned to the cohesive deposits to evaluate the stability for the long-term, drained conditions (i.e., permanent conditions). The effective stress parameters (i.e., effective cohesion (c') and effective friction angle (ϕ')) for the cohesive deposits were estimated based on the results of the laboratory CIU triaxial test as well as empirical correlations based on the plasticity index. The empirical correlations proposed by Mitchell (1993), Kulhawy and Mayne (1990), and Ladd et al. (1977) were employed to check the parameters from the CIU triaxial test. In addition, the results of triaxial testing carried out on samples of the clayey soils from other MTO projects in the St. Catherine's area were reviewed and the results adjusted using engineering judgment, if necessary.

For the existing clayey embankment fill, effective stress parameters were employed in the analysis for both the short-term and long-term conditions. The effective stress parameters (i.e., effective cohesion (c') and effective friction angle (ϕ')) for the cohesive fill were estimated based on the results of the laboratory CIU triaxial test (considered the post-peak, softened condition) as well as the results of triaxial and direct shear testing carried out on samples of the clayey embankment fills from other MTO projects in the Welland/Port Colborne area.

For assessment of global stability, the reinforced zone behind RSS walls was modelled as a material with "infinite strength".

Summarized below are the simplified stratigraphy and the associated strengths and unit weights employed for the different soil types in the proposed high fill embankment widening areas / RSS wall locations. For reference, the figure numbers presenting the corresponding stability analysis results for each area are included. The results of the stability analyses are discussed in Section 6.6.3.

Typical Representative Section Location	Stability Results Figures	Soil Deposits used in Analyses at Simplified Representative Sections	Bulk Unit Weight, γ (kN/m ³)	Effective Friction Angle, ϕ' (°)	Cohesion, c' (kPa)	Undrained Shear Strength, s_u (kPa)
North of CN/CP Twin Structure SBL (including RSS Wall RW-1)	2 to 5	New embankment fill (compacted SSM or Granular)	21	33		-
		Existing clayey embankment fill	20	23	0	-
		Clayey Silt to Silty Clay to Clay – Stiff to Hard	19.5	22 ¹	10 ¹	100
		Clayey Silt to Silty Clay – Firm to Stiff	19.5	26	0	35
		Sandy Silt to Sand – Compact to Dense	20	33	-	-
		Sand and Gravel – Compact to Very Dense	21	35	-	
South of CN/CP Twin Structure - SBL (including RSS Wall RW-2)	6 to 9	New embankment fill (SSM or Granular)	21	33	-	-
		Existing clayey embankment fill	20	23	0	-
		Clayey Silt to Silty Clay – Stiff to Very Stiff	19.5	22 ¹	10 ¹	75
		Clayey Silt to Silty Clay – Firm to Stiff	19.5	26	0	50
		Sand and Gravel to Gravelly Sand – Compact to Very Dense	21	35	-	-
		Sand and Gravel (containing rock fragments) – Very Dense	21	36	-	-
South of CN/CP Twin Structure - NBL (including RSS Wall RW-3)	10 and 11	Clayey Silt – Very Stiff	19.5	22 ¹	10 ¹	75 to 80
		Silty Sand to Gravelly Sand – Compact to Very Dense	21	33	-	-
Ramp EW-N	12 to 15	New embankment fill (SSM or Granular)	21	33	-	-
		Existing clayey embankment fill	20	23	0	-
		Clayey Silt to Silty Clay – Stiff to Hard	19.5	22 ¹	10 ¹	75
		Reinforced soil slope zone	21	45 ²	100 ²	-

Note(s): 1. Stiff to hard cohesive deposits encountered at the site are expected to remain in the over-consolidated state.

2. Parameters selected only to force failure surface outside of the reinforce soil zone for global stability assessment. Internal stability of the reinforced zone must be checked by the designer.

6.6.3 Stability Analysis Results

Assuming that the RSS walls at RW-1 and RW-2 are founded a minimum 1 m below the final ground surface in front of the wall(s), the minimum global stability target Factors of Safety of 1.33 for short term/temporary (undrained conditions) and 1.54 for long term/permanent (drained conditions) static conditions (in accordance with CHBDC, 2014) are satisfied for the proposed wall heights and geometries provided the minimum reinforcing strip lengths summarized below are employed. However, for RSS wall RW-3, which is proposed to be founded primarily within the side slope of the existing clayey embankment fill, the wall will need be founded at a deeper depth (i.e., at 2.6 m below the final adjacent ground surface) in order to satisfy the globally stability requirements and to provide a suitable value for the factored ultimate geotechnical resistance (as discussed in Section 6.7.2). Stability analysis results for the section of RW-3 founded on native ground at, and adjacent to the culvert at Station 14+273 are provided under in a separate Foundation Investigation and Design Report (GEOCRE No. 30L15-17).

RSS Retaining Wall	Approximate Limits	Minimum Reinforcing Strip Length (as a ratio of wall height) ¹
RW-1	13+670 to 13+845	0.67
	13+845 to 13+858 (or junction with north abutment bridge RSS wall)	1.0
RW-2	14+010 (or junction with south abutment RSS wall) to 14+100	1.3
	14+100 to 14+313	0.67
RW-3	14+190 to 14+470	2.5 ²
Ramp E/W-N	9+829 to 9+900	1.0

Note: 1. Analyses assume ground surface in front of RSS walls RW-1 and RW-2 graded is flat.

2. A greater length of reinforcing strips is required for RSS wall RW-3 where founded in the existing embankment fill due to sloping ground in front of the wall.

Furthermore, where RSS retaining walls are not present, the stability analyses indicate that the proposed raised and widened high fill embankments with side slopes inclined no steeper than 2H:1V (with the inclusion of 2 m wide mid-slope benches where the uninterrupted slope height is 8 m or greater (discussed further in Section 6.9.3)) will have a FoS of greater than 1.33 and 1.54 against global instability for the short-term (undrained) and long-term (drained) conditions, respectively.

Finally, should a reinforced soil slope be utilized to steepen the slope of the E/W-N ramp instead of a RSS wall, the width of the reinforced soil zone should extend into the slope a distance equal to the slope height (or greater) in order to meet the required minimum FoS against global instability as shown on Figures 14 and 15.

The results of the limit equilibrium, static global stability analyses for the short-term and long-term conditions for various critical typical representative sections are provided on Figures 2 through 15.

It is noted that surficial stability of the high fill embankment sides slopes is less than the factored global FoS of 1.54 at some locations. In the steeper areas of the existing fill slopes, the calculated FoS is less than 1.3. Erosion

protection and on-going maintenance of the slopes may be required, depending on the selected embankment fill type. Further discussion on these aspects is provided in Section 6.9.3.

6.7 Retained Soil System (RSS) Walls

RSS walls are the preferred option for the proposed retaining walls along the QEW at this site. The majority of the wall lengths will be constructed of conventional single stage RSS walls, while a two-stage wall is preferred at the north limit of RSS wall RW-1 (north of Station 13+725) in order to accommodate the estimated post-construction settlements. RSS walls RW-1 and RW-2 will conjoin with the bridge RSS walls at the north and south abutments/approach areas of the SBL CN and CP overhead structure, respectively.

It is noted that the use of a two-stage RSS wall system will require review and approval by the MTO RSS Committee during construction; an NSSP to address this requirement is provided in Appendix E.

The use of a RSS wall for steepening the 35 m long section of the E/W-N ramp slope to avoid hydro poles is a technically feasible option although may not be preferred.

6.7.1 Founding Elevations

RSS walls RW-1 and RW-2 are proposed to be founded within the predominantly stiff to hard native cohesive soils at the toe of the existing embankment. RSS wall RW-3 is proposed to be founded primarily within the existing embankment fill generally comprised of stiff to very stiff clayey silt to silty clay except at, and adjacent to the culvert at Station 14+273, where it is proposed to be founded on native ground. Should a RSS wall be constructed for the E/W-N ramp steepening, it should be founded within the stiff to hard native clayey silt to silty clay. A typical RSS wall has a front facing supported on a strip footing placed at shallow depth below the ground surface in front of the wall. The RSS wall facing should be founded a minimum of 1.0 m below the finished ground surface where founded in native ground. The length of RSS wall RW-3 which is founded within the existing embankment fill should be founded a minimum of 2.6 m below the final adjacent ground surface in front of the wall to satisfy global stability requirements, as discussed in Section 6.6.3.

The facing footing should be placed on a minimum 300 mm thick layer of compacted OPSS.PROV 1010 (*Aggregates*) Granular 'A', as shown in Figure 5.2 in the *MTO RSS Wall Design Guidelines* (September 2008). The compacted granular pad should extend at least 1.0 m beyond the outside edge of the facing footing, then downward at 1H:1V. Where sub-excavation of fill and unsuitable soils has been carried out, the Granular 'A' pad and the reinforced soil mass can be constructed immediately on top of the proof-rolled native subgrade, such as the stiff to hard native cohesive soils. Alternatively, the thickness of the granular pad can be increased to raise the grade after sub-excavation and the facing footing and reinforced soil mass founded at a higher elevation. It is recommended that the foundation subgrade for any RSS walls placed on existing embankment fill (i.e. retaining wall RW-3) be inspected such that any unsuitable soils (i.e. soft soils or soils containing excessive organics) are sub-excavated and replaced with suitable engineered fill.

Where applicable, the compacted Granular 'A' pad and the reinforced soil mass should be keyed into the existing embankment fills by benching into the embankment fill, similar to OPSD 208.010 (*Benching of Earth Slopes*).

6.7.2 Geotechnical Resistances

For the reinforced soil mass, the factored ultimate and serviceability geotechnical resistances given below may be used for design of the reinforced soil mass. These values assume that the reinforced soil mass acts as a unit and bears uniformly over the full width of the reinforced soil mass (which can be taken as approximately the wall

height multiplied by the strip length ratio listed in the table in Section 6.6.3 for design purposes; actual required strip length to be confirmed by the RSS wall designer).

RSS Retaining Wall	Approximate Limits	Estimated Maximum Wall height (m)	Assumed Reinforced Width (m)	Factored Ultimate Geotechnical Resistance (kPa)	Factored Serviceability Geotechnical Resistance for 25 mm of settlement (kPa)
RW-1 ¹ .	13+670 to 13+845	5.7	3.8	200	35
	13+845 to 13+858 (or junction with north abutment bridge RSS wall)	9.1	9.1	250	85
RW-2 ¹ .	14+010 (or junction with south abutment RSS wall) to 14+060	10.2	13.3	275	80
	14+060 to 14+200	5.7	3.8	200	80
RW-3 ² .	14+190 to 14+470	3.6	9.0	150 ³ .	45
Ramp E/W-N ¹ .	9+829 to 9+900	2.9	2.6	200	80

Note(s): 1. RSS wall founded a minimum of 1 m below final adjacent ground surface on very stiff to hard native clayey subgrade.

2. RSS wall founded a minimum of 2.6 m below final adjacent ground surface on stiff to very stiff clayey embankment fill.

3. Geotechnical resistance for RW-3 is reduced due to sloping ground in front of wall.

6.7.3 Static Lateral Earth Pressures for RSS Design

The lateral earth pressures acting on the rear face of the reinforced zone of soil will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, and the magnitude of surcharge including construction loadings.

The following recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressure coefficients provided are based on the ground above the wall being either flat or sloping at a maximum of 2H:1V.

Material	Existing Cohesive/ Non-Cohesive Fill	SSM or Granular
Soil Unit Weight:	20 kN/m ³	21 kN/m ³
Friction Angle	23°	33°
Coefficients of static lateral earth pressure: Active, K _a (for flat ground surface adjacent to RSS) Active, K _a (for 2H:1V slope above RSS)	0.44 Note 1.	0.29 0.44

Note: 1. It is assumed that slopes above RSS walls will be constructed with either new SSM or Granular fill.

Depending on the Seismic Performance Category for RSS wall structures, seismic (earthquake) loading may also have to be taken into account in the design. We understand that based on the location of the site, the new RSS walls would be classified as being in Seismic Performance Category 1 and as such seismic design is not required.

6.8 Reinforced Soil Slope

A reinforced soil slope for steepening the 35 m long section of the E/W-N ramp slope to avoid conflicts with the existing hydro poles is a feasible option and is likely the preferred alternative from a cost perspective. Based on a typical section for a reinforced soil slope provided by AECOM, it is assumed that the base of the reinforcement zone would be a minimum of 600 mm below existing ground surface and constructed upon a prepared and inspected native, very stiff to hard native clayey subgrade.

For the design of the reinforced soil mass, the factored ultimate and serviceability geotechnical resistances indicated in Section 6.7 for the E/W-N Ramp may be used for design of the reinforced soil mass. These values assume that the reinforced soil mass acts as a unit and bears uniformly over the full width of the reinforced soil mass (which can be taken as approximately equivalent to the wall height) as recommended in Section 6.6.3 for design purposes.

The internal stability of the reinforced slope (i.e. bulging at the face, geogrid pullout / tearing, internal sliding, etc.) has not been analyzed by Golder and is required to be carried out by the proprietary designer / manufacturer of the reinforced soil slope system. The parameters listed in Section 6.7.3 may be used to calculate the static lateral earth pressures acting on the rear face of the reinforced soil zone.

The compacted reinforced soil mass should be keyed into the existing embankment fills by benching into the embankment fill, similar to OPSP 208.010 (*Benching of Earth Slopes*).

6.9 Construction Considerations

The following sections discuss general aspects of subgrade preparation and embankment construction for the high fill embankment widening(s).

6.9.1 Temporary Excavations

Temporary excavations through the existing cohesive embankment fill will be required to construct the reinforced soil mass for the new RSS walls and to install the median sewer.

Open-cut excavations must be carried out in accordance with the guidelines outlined in the most recent version of the Occupational Health and Safety Act and Regulation for Construction Activities. The existing fill materials are classified as Type 3 soils, while the native cohesive firm to very stiff deposits are generally classified as Type 2 soils, according to the OHSA. Temporary excavations (i.e. those that are open for a relatively short period of time) should be made with side slopes no steeper than 1H:1V. Localized zones of softer cohesive fill may be encountered and would be classified as Type 4 soils. If these soft areas are encountered, temporary excavation side slopes will need to be flattened to 3H:1V.

Temporary excavations are generally expected to be confined to the fill and near surface deposits, and as such, the base of any excavations will be made above the groundwater level at the site. Surface water seepage into the excavations should be expected and will be heavier during periods of sustained precipitation; all surface water should be directed away from the excavations.

6.9.2 Subgrade Preparation Requirements

Based on the information from the boreholes advanced during the field investigation, the thickness of organic deposits (mainly topsoil) generally ranges from about 0.2 m to 0.6 m. After clearing and grubbing of the high fill widening, RSS wall and reinforced slope areas, and prior to the placement of any fill for new construction, it is recommended that all surficial and near surface layers of topsoil, organic soils, and any deposits containing deleterious materials be stripped from the plan limits of the proposed works regardless of height in accordance with OPSS.PROV 206 (*Grading*).

The exposed subgrade soils in the stripped area should be proof-rolled and inspected by a geotechnical engineer to confirm that the foundation soils meet the intent of the design prior to fill placement in accordance with the applicable specifications. Any unsuitable subgrade materials encountered during proof-roll operations should be sub-excavated and backfilled with approved material and compacted.

6.9.3 Embankment Construction

Non-cohesive fill (and not earth borrow) is recommended for the construction of the embankment grade raise(s) and widening(s), as settlement within non-cohesive embankment fill will essentially occur during placement and compaction, whereas some nominal post-construction settlement of cohesive fill could occur.

Placement of Select Subgrade Material (SSM) as per OPSS.PROV 1010 (*Aggregates*) or granular fill (satisfying OPSS.PROV 1010 Granular 'B' Type I or Type II requirements) above the water table for construction of the high fill embankment widening(s) (including backfilling operations) should be carried out in accordance with the requirements as outlined in OPSS.PROV 206 (*Grading*). Benching of the existing embankment side slopes should be carried out to "key in" the new fill materials for the widening(s), in accordance with OPSD 208.010 (*Benching of Earth Slopes*).

The SSM or granular fill should be compacted in accordance with OPSS.PROV 501 (*Compacting*). Inspection and field testing should be carried out by qualified personnel during construction to confirm that appropriate materials are being utilized and that adequate levels of compaction are being achieved. Side slopes for the SSM or granular fill roadway embankment should be no steeper than 2H:1V. The embankment side slopes should also include a minimum 2 m wide bench at mid height for all fill heights greater than 8 m as suggested in OPSD 202.010 (*Slope Flattening*).

To reduce surface water erosion on the granular embankment side slopes, topsoil and seeding as per OPSS 802 (Topsoil) and OPSS.PROV 804 (Seed and Cover) should be carried out as soon as possible after construction of the embankments. If this slope protection is not in place before winter, then alternate protection measures, such as covering the slope with straw, or gravel sheeting as per OPSS 511 (Rip Rap, Rock Protection and Granular Sheeting), and OPSS.PROV 1004 (Aggregates – Miscellaneous) will be required to reduce the potential for erosion and to reduce the potential for the requirement of remedial works on the side slopes in the spring prior to topsoil dressing and seeding.

6.9.4 Surficial Embankment Stability and Erosion Protection

The existing highway embankments at the project site are required to be raised and widened to accommodate the re-aligned and widened QEW and associated ramps. It is understood that different fill materials are being considered for the embankment widening construction, including: OPSS.PROV 1010 (Aggregates) Granular 'A': Granular 'B' Type I or Type II; and Select Subgrade Material (SSM). It is noted that compacted earth meeting the requirements of OPSS.PROV 212 (Earth Borrow) is not recommended to be used on this project.

Section 6.6 provides design recommendations for side slope geometry to achieve a factored Factor of Safety (FoS) that satisfies the requirements of the CHBDC (2014) with respect to global stability for temporary and permanent conditions. However, depending on the selected embankment fill material type as well as the existing embankment fill material type, slope geometry, surface treatment and weather (i.e. precipitation, cycles of wetting-drying and/or freezing-thawing), surficial instability of the embankment side slopes may occur, which could include localized sloughing and erosion. As such, in order to maintain the integrity of the new and existing embankments, erosion protection measures may be required depending on the fill type selected for construction.

The potential for erosion of embankment fill types can be estimated using the Wischmeier Nomograph (1978). The silt, sand and organic content of the fill material, as well as the soil structure and permeability, influence the erosion potential of a soil. The Wischmeier Nomograph generates a 'K' Factor between 0 and 1.0, which categorizes the erodibility of the soil. The higher the K value, the greater the erodibility; for example, highly erodible silty soils may have a K factor exceeding 0.6, while relatively non-erodible soils may have a K factor less than 0.2.

Based on the specified gradation, granular fill such as OPSS.PROV 1010 (Aggregates) Granular 'A', or Granular 'B' Type I or Type II, have a low potential for erosion. For embankments constructed of granular fill, erosion control can be limited to hydro-seeding and vegetation. On-going maintenance for embankments constructed of this material is not expected to be required.

The specification for OPSS.PROV 1010 (Aggregates) SSM allows for much more variation in the gradation of the material (as compared to Granular 'A', or Granular 'B' Type I or Type II), and therefore has the potential to be low-erodible to moderate-erodible. Erosion protection for slopes constructed of SSM should consist of erosion control blankets and hydro-seeding. Slopes constructed of SSM and properly protected from erosion (as discussed in Section 6.9.2) should require limited on-going maintenance.

The specification for earth borrow as provided in OPSS.PROV 212 (Earth Borrow) allows for a wide variability of soil types with a wide range of gradations. As such, the potential for surficial instability and erosion of earth borrow material may range from low- to severe-erodibility depending on the soil type. Based on the potential range in gradations, and variability and uncertainty in soil types, for embankments constructed of earth borrow, flattening of side slopes (i.e., flatter than 2H:1V) or construction of berms may be required and robust erosion protection such as the application of a minimum 300 mm thick layer of granular sheeting meeting the specification in OPSS.PROV 1004 (Aggregates – Miscellaneous) is recommended to be placed on the slopes. Even with appropriate erosion protection, on-going maintenance of embankment slopes constructed of earth borrow may be required depending on the side slope geometry as well as the final gradation and soil type of the earth borrow used for construction. In some cases, in particular for clayey earth borrow with intermediate to high plasticity, flatter side slopes than 2.75H:1V will be necessary to maintain surficial stability. It is for this reason that the use of earth borrow for construction of the embankment grade raises and widenings is not recommended at this site. Further, as discussed in Section 6.1.1, a failure of the NBL side slope of the clayey embankment fill located north of the CN/CP bridge occurred in the early 1960s at the site. It is speculated that this is a result of the use of intermediate to high plasticity clayey fills (as used for earth borrow) which are prevalent locally in this area of Ontario. Given this, there is a risk that surficial instability of the existing clayey fill embankment side slopes may still occur in the future requiring on-going maintenance; as such, erosion control measures should be implemented or replaced on the existing embankment side slopes in any areas disturbed as part of the new construction.

6.9.5 Temporary Protection Systems

To facilitate the construction of the grade raise(s) in stages in order to maintain traffic flow, temporary protection systems are expected to be required between the live QEW highway traffic lanes (shifted at various stages) and the active work zone.

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*). The lateral movement of the temporary protections systems within the Highway QEW alignment should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent structures or utilities can tolerate this magnitude of deformation.

Although the selection and design of the protection systems will be the responsibility of the contractor, it is considered that it may be difficult to install a driven, interlocking sheet pile system at this site due to the dense to very dense / very stiff to hard nature of the soils at relatively shallow depth below the fills. In this case, a soldier pile and lagging system may be required. Although groundwater seepage is anticipated to be minor, it would be necessary to control seepage or include measures to mitigate loss of soil particles through the lagging boards. The sheet piles or soldier piles would have to be driven or socketted to sufficient depth to provide the necessary passive resistance for the retained soil height, including any surcharge loads behind the protection system within at least a 1H:1V zone relative to the base of the fill / adjacent active QEW lane grade level. Lateral support to the sheet piles or soldier piles could be provided in the form of struts, rakers or temporary anchors where space permits.

7.0 CLOSURE

This Foundation Investigation Report was prepared by Matt Soderman, P.Eng, a geotechnical engineer with Golder. Mr. Paul Dittrich, P.Eng., an MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

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ASTM International:

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

Commercial Software:

Settle3D (Version 4.0) by Rocscience Inc.

Slide (Version 2018) by Rocscience Inc.

Ontario Provisional Standard Drawing:

OPSD 202.010 Slope Flattening

OPSD 208.010 Benching of Earth Slopes

OPSD 3090.101 Foundation Frost Penetration Depths for Southern Ontario

Ontario Provincial Standard Specification:

OPSS.PROV 206 Construction Specification for Grading

OPSS.PROV 501 Construction Specification for Compacting

OPSS.PROV 511 Construction Specification for Rip Rap, Rock Protection and Granular Sheeting

OPSS.PROV 539 Construction Specification for Temporary Protection Systems

OPSS 802 Construction Specification for Topsoil

OPSS.PROV 804 Construction Specification for Seed and Cover

OPSS.PROV 1004 Material Specification for Aggregates – Miscellaneous

OPSS.PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

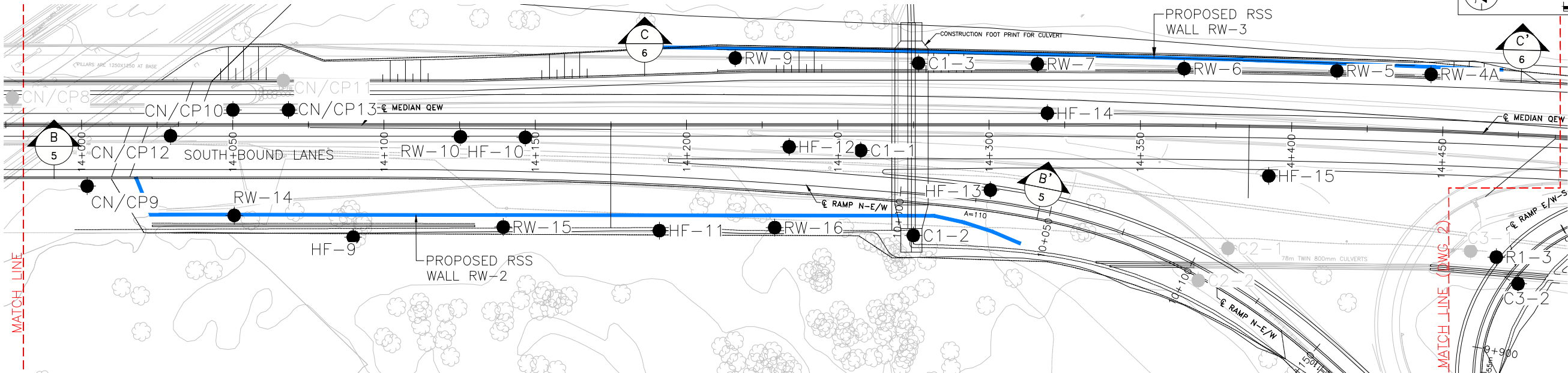
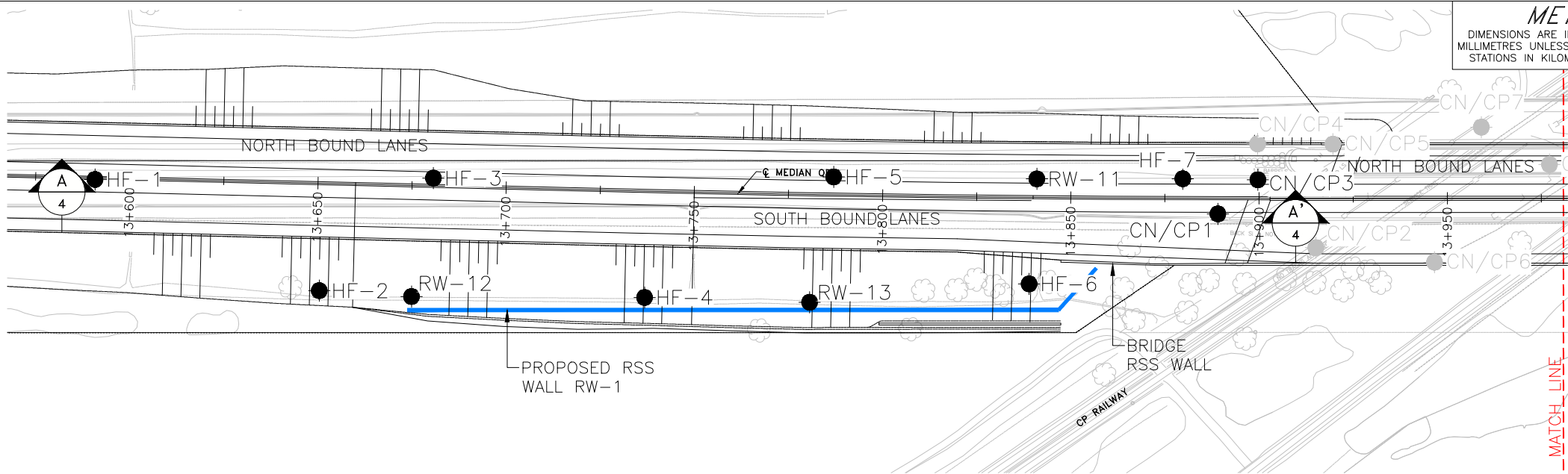
Ontario Regulation 213/91 Construction Projects (as amended)

Ministry of Transportation, Ontario

RSS Design Guidelines, Ministry of Transportation Engineering Standards Branch, September 2008

TABLE 1 – COMPARISON OF RETAINING WALL TYPES AND FOUNDATION ALTERNATIVES

Wall Type and Foundation Option	Feasibility	Advantages	Disadvantages	Constructability	Estimated Costs
RSS Walls	<ul style="list-style-type: none">Feasible.	<ul style="list-style-type: none">More tolerable to total and differential settlements, especially if a two-stage wall is constructed.Smaller excavation footprint required beyond wall limits (towards property boundary) to install foundation along SBL for walls RW-1 and RW-2.Lowest cost alternative.	<ul style="list-style-type: none">Potentially larger amount of existing embankment fill excavation required to install reinforcing strips where wall heights are relatively high.Should conventional (single-stage) modular RSS walls be constructed north of STA 13+725, RSS designer must confirm that the structure, including the facing panels, can tolerate the estimated total and differential settlements	<ul style="list-style-type: none">Conventional construction techniques.Two-stage walls are preferred for RW-1 north of STA 13+725 to accommodate post construction settlements.	<ul style="list-style-type: none">Lower cost than concrete retaining walls, two-stage RSS wall more expensive than conventional (single stage) RSS wall
Concrete retaining walls on shallow foundations	<ul style="list-style-type: none">Feasible for retaining walls RW-2, RW-3 and RW-1 south of STA 13+725.Not feasible for RW-1 north of STA 13+725.	<ul style="list-style-type: none">	<ul style="list-style-type: none">Less-tolerable to immediate and post-construction settlements.Cannot be used for north limit of wall RW-1 due to estimated magnitude of post-construction settlements north of STA 13+725.Requires larger excavation footprint beyond wall limits (towards property boundary) along SBL for walls RW-1 and RW-2.	<ul style="list-style-type: none">Conventional construction techniques.Encroachment beyond property boundary may be required for walls RW-1 and RW-2.	<ul style="list-style-type: none">Lower cost than concrete retaining walls supported on deep foundations.More expensive than RSS walls.
Concrete retaining walls on deep foundations	<ul style="list-style-type: none">Feasible.	<ul style="list-style-type: none">Limited settlement of wall.	<ul style="list-style-type: none">Will still have settlements of soils behind wall.Requires largest construction footprint beyond limit of wall (towards property boundary).Highest cost alternative.	<ul style="list-style-type: none">Conventional excavation and construction techniques, although installation of deep foundations required.Relatively long construction time compared to most wall alternatives.Encroachment beyond property boundary may be required for walls RW-1 and RW-2.	<ul style="list-style-type: none">Highest cost relative to other options.
Solder pile and concrete panel walls	<ul style="list-style-type: none">Feasible, but not considered appropriate given the height of retained fill required at this site.	<ul style="list-style-type: none">	<ul style="list-style-type: none">Most advantageous in “top-down” construction applications, i.e. as part of a cut-widening, rather than for an embankment widening.For soldier pile and panel wall heights required at his site, some form of lateral support likely required; anticipated that deadman anchors would be necessary which will increase costs.	<ul style="list-style-type: none">Conventional excavation and construction techniques although additional step of constructing deadman anchors required.Relatively long construction time compared to most wall alternatives	<ul style="list-style-type: none">Higher cost than RSS wall or concrete wall on shallow foundation, but likely lower cost than concrete wall on deep foundation.



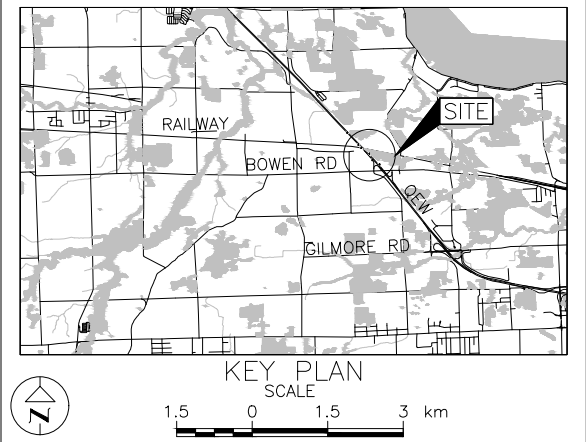
BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C1-1	183.7	4755249.3	346719.3
C1-2	181.8	4755217.3	346711.3
C1-3	184.1	4755255.7	346753.2
CN/CP1	188.1	4755516.6	346465.5
CN/CP3	188.4	4755515.3	346479.4
CN/CP9	180.0	4755424.5	346532.6
CN/CP10	188.2	4755407.5	346584.2
CN/CP12	188.6	4755416.3	346563.7
CN/CP13	187.9	4755394.3	346597.0
HF-1	179.8	4755736.8	346264.2
HF-2	177.0	4755673.5	346284.5
HF-3	182.1	4755672.6	346327.1

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
HF-4	177.6	4755610.3	346343.4
HF-5	185.1	4755596.6	346401.4
HF-6	180.4	4755539.6	346417.2
HF-7	187.8	4755529.8	346465.7
HF-9	181.5	4755349.7	346581.8
HF-10	186.2	4755331.9	346645.1
HF-11	183.7	4755278.6	346653.9
HF-12	184.2	4755267.2	346703.6
HF-13	181.9	4755209.5	346739.8
HF-14	183.3	4755213.7	346771.1
HF-15	183.0	4755146.8	346807.2
RW-4A	184.5	4755131.7	346868.7

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
RW-5	184.2	4755154.8	346847.8
RW-6	183.6	4755191.5	346813.2
RW-7	183.7	4755227.4	346780.4
RW-9	185.1	4755300.4	346712.2
RW-10	186.6	4755347.4	346630.3
RW-11	186.7	4755557.6	346438.6
RW-12	177.1	4755654.9	346300.5
RW-13	178.0	4755578.0	346373.1
RW-14	181.5	4755382.9	346559.5
RW-15	182.9	4755316.5	346618.8
RW-16	181.9	4755252.0	346681.2

CONT No.
GWP No.2116-16-00

QEW
RETAINING WALLS AND HIGH FILLS
BOREHOLE LOCATIONS



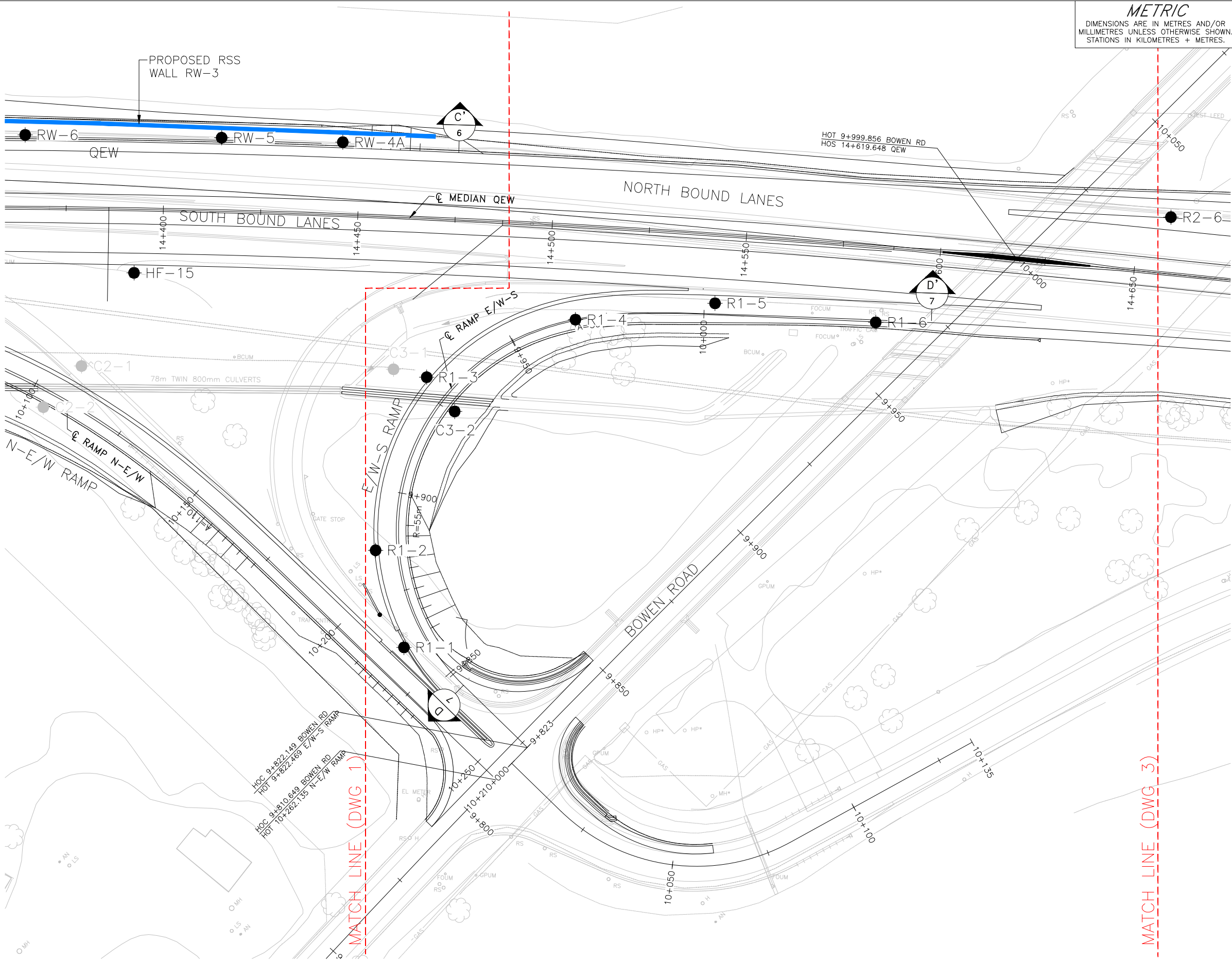
LEGEND	
	Borehole - 2018/2019 Investigation

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

REFERENCE	
Base plan provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018, X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Bert Alignment_2019Jan03mw.dwg, received January 08, 2019. Retaining wall plans provided in digital format by Aecom, drawing file nos. XX-60581660--RETAINING WALL_13+670-13+858.dwg, XX-60581660--RETAINING WALL_14+010-14+313 and XX-60581660--RETAINING WALL_14+190-14+470.dwg, received January 28, 2019.	



NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW		PROJECT NO. 1671430	
SUBM'D. MAS		DATE: 2019-05-23	
DRAWN: DD		APPD. JMAC	
CHKD. MAS		DIST. .	
		SITE: .	
		DWG. 1	



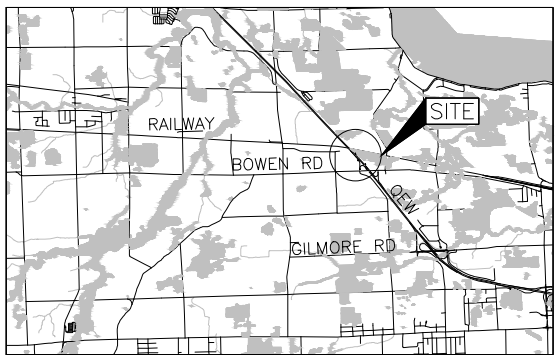
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2116-16-00

QEW RAMP E/W-S
RETAINING WALLS AND HIGH FILLS

BOREHOLE LOCATIONS

SHEET



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND	
	Borehole - 2018/2019 Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
C3-2	183.9	4755062.9	346839.2
R1-1	189.8	4755030.0	346786.6
R1-2	185.6	4755052.6	346799.4
R1-3	184.0	4755074.2	346840.4
R1-4	184.0	4755057.1	346877.7
R1-5	184.7	4755034.3	346905.7
R1-6	186.0	4755001.3	346931.0

NOTES
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PLAN
SCALE
10 0 10 20 m

MATCH LINE (DWG 3)

REFERENCE
Base plan provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018, X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Berti Alignments_2019Jan03mw.dwg, received January 08, 2019. Retaining wall plans provided in digital format by Aecom, drawing file nos. XX-60581660--RETAINING WALL_13+670-13+858.dwg, XX-60581660--RETAINING WALL_14+010-14+313 and XX-60581660--RETAINING WALL_14+190-14+470.dwg, received January 28, 2019.

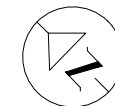
NO.	DATE	BY	REVISION

Geocres No. 30L15-19

HWY. QEW	PROJECT NO. 1671430	DIST. .
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019
DRAWN: DD	CHKD. MAS	APPD. JMAC
		DWG. 2

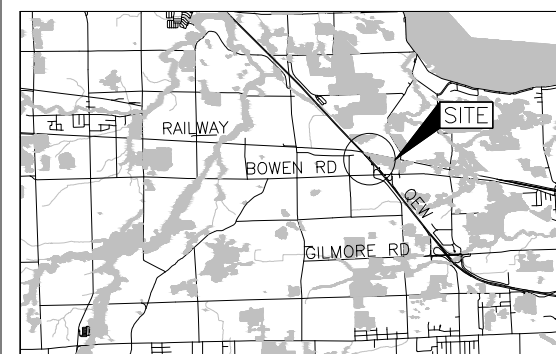


CONT No.
GWP No.2116-16-00



QEW RAMP E/W-N
RETAINING WALLS AND HIGH FILLS
BOREHOLE LOCATIONS

SHEET



KEY PLAN
SCALE

1.5 0 1.5 3 km

LEGEND

Borehole – 2018/2019 Investigation

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
R2-1	185.2	4754977.0	347137.7
R2-2	184.4	4754939.4	347121.1
R2-3	186.0	4754920.6	347097.9
R2-4	184.7	4754921.4	347063.8
R2-5	186.6	4754944.2	347021.9
R2-6	186.2	4754965.7	347003.2

REFERENCE

Base plan provided in digital format by Aecom, drawing file nos.
 XX-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018,
 XX-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW
 Berti_Alignments_2019Jan03rmw.dwg, received January 08, 2019.
 Retaining wall plans provided in digital format by Aecom, drawing file nos.
 XX-60581660--RETAINING WALL_13-670--13-858.dwg,
 XX-60581660--RETAINING WALL_14-010--14-313.dwg,
 XX-60581660--RETAINING WALL_14-190--14-470.dwg, received January
 28, 2019.

NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW		PROJECT NO. 1671430	DIST. .
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019	SITE: .
DRAWN: SW	CHKD. MAS	APPD. JMAM	DWG. 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.

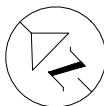
PLAN

SCALE

10 0 10 20 m



CONT No.
GWP No. 2116-16-00



QEW
RETAINING WALLS AND HIGH FILLS
SOIL STRATA








KEY PLAN
SCALE



1.5 0 1.5 3 km

LEGEND

- | | |
|---|--|
|  | Borehole – Current Investigation |
|  | Seal |
|  | Piezometer |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
| 100% | Rock Quality Designation (RQD) |
| REC | Recovery % |
|  | WL in piezometer, measured on MMM DD, YYYY |
|  | WL upon completion of drilling |

Refer to Drawing 1 for Borehole Location Coordinates and Ground Surface Elevation Coordinates.

NOTES

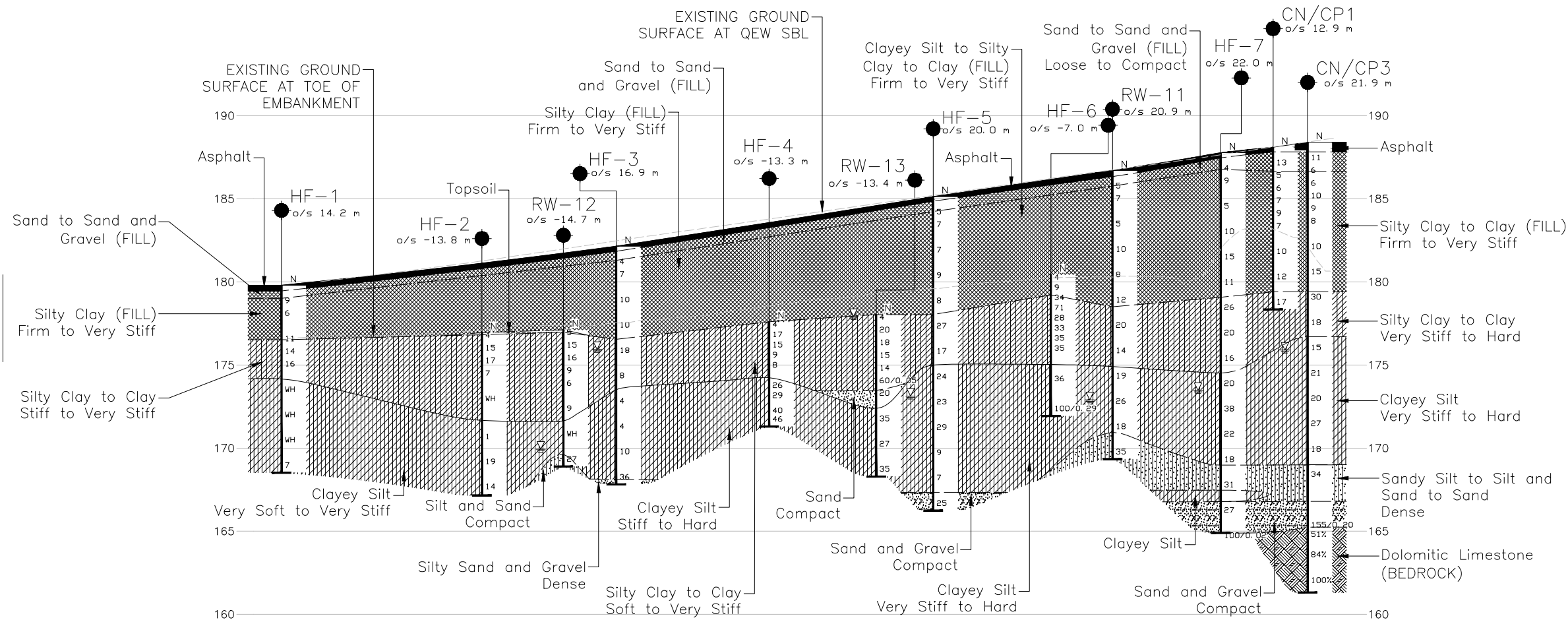
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The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

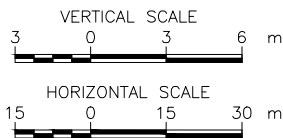
REFERENCE

Base plan provided in digital format by Aecom, drawing file nos.
X-605811660-C-CNCP-QEW-DES.dwg, received November 15, 2018,
X-605811660-C-CNCP-QEW-BASE.dwg and 60581660 QEW
Berti_Alignments-2019Jan03mw.dwg, received January 08, 2019.
Retaining wall plans provided in digital format by Aecom, drawing file nos.
X-605811660-RETAINING WALL_14+010-14+858.dwg, received January
XX-60581660-RETAINING WALL_14+010-14+313 and
XX-60581660-RETAINING WALL_14+190-14+470.dwg, received January
28, 2019.

NO.	DATE	BY	REVISION		
Geocres No. 30L15-19					
HWY. QEW		PROJECT NO. 1671430		DIST. .	
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019		SITE:	
DRAWN: SW	CHKD. MAS	APPD. JMAM		DWG. 4	

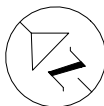


PROFILE - HIGH FILL/RETAINING WALL 1



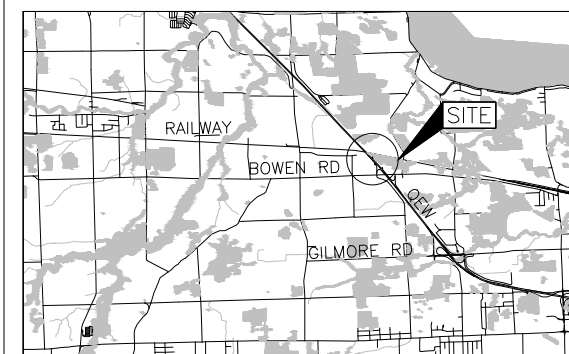
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2116-16-00



QEW
RETAINING WALLS AND HIGH FILLS
SOIL STRATA

SHEET



KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- ⬮ Seal
- ⬮ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- REC Recovery %
- ⬮ WL in piezometer, measured on MMM DD, YYYY
- ⬮ WL upon completion of drilling

Refer to Drawing 1 for Borehole Location Coordinates and Ground Surface Elevation Coordinates.

NOTES

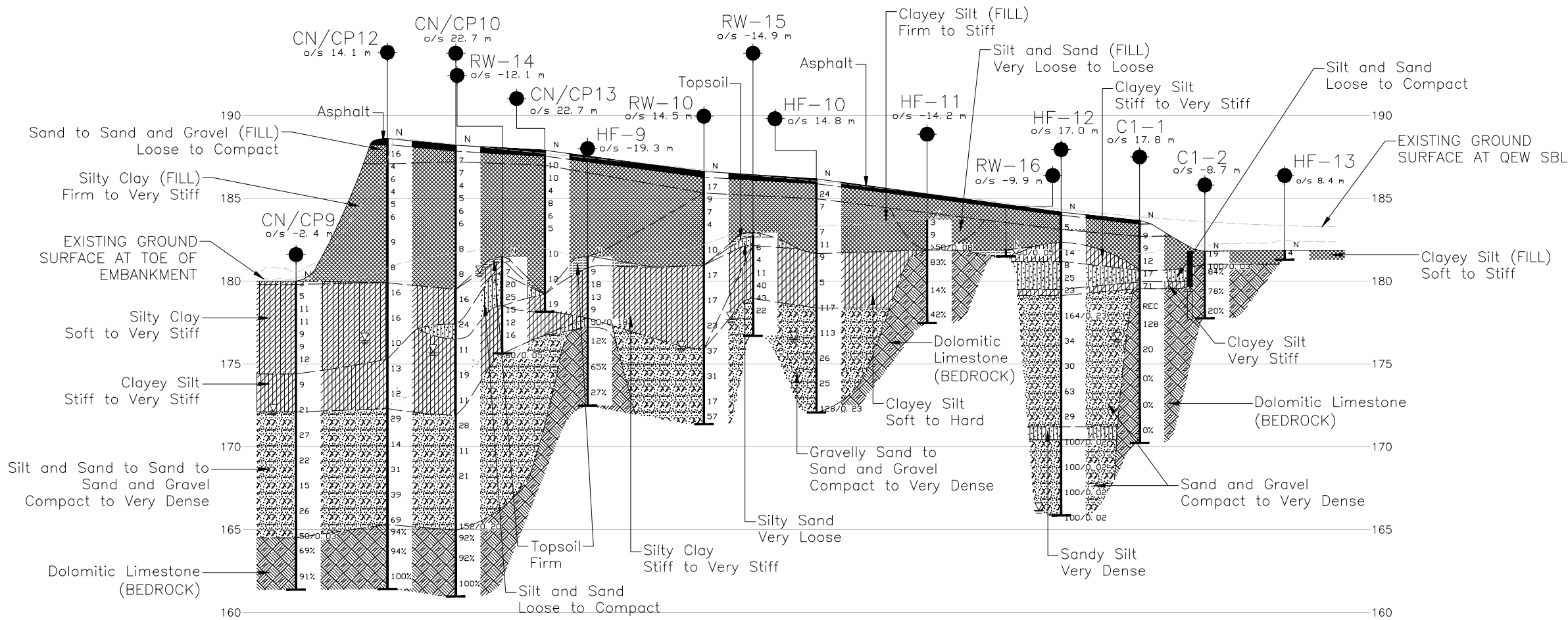
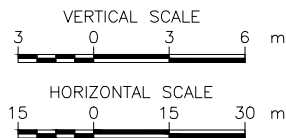
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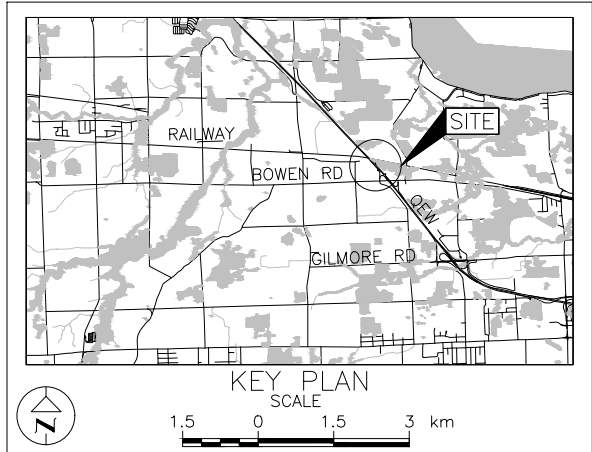
REFERENCE

Base plan provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018, X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Berti Alignments_2019Jan03mw.dwg, received January 08, 2019. Retaining wall plans provided in digital format by Aecom, drawing file nos. XX-60581660--RETAINING WALL_13+670-13+858.dwg, XX-60581660--RETAINING WALL_14+010-14+313 and XX-60581660--RETAINING WALL_14+190-14+470.dwg, received January 28, 2019.

B-B PROFILE - HIGH FILL/RETAINING WALL 2

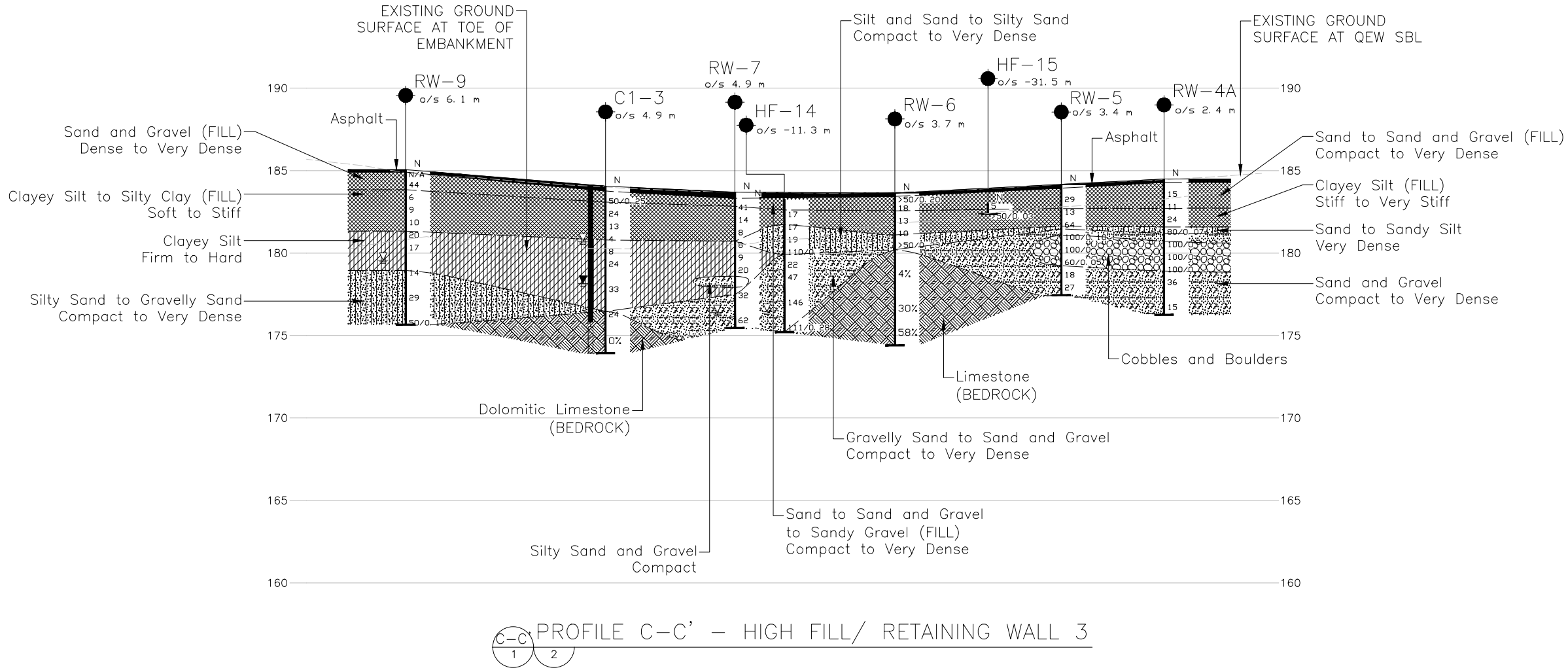


NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW	PROJECT NO. 1671430		DIST. .
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019	SITE: .
DRAWN: SW	CHKD. MAS	APPD. JMAC	DWG. 5



LEGEND	
	Borehole - Current Investigation
	Seal
	Piezometer
	N Standard Penetration Test Value
	16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
	100% Rock Quality Designation (RQD)
	WL in piezometer, measured on MMM DD, YYYY
	WL upon completion of drilling

Refer to Drawing 2 for Borehole Location Coordinates and Ground Surface Elevation Coordinates.



NOTES

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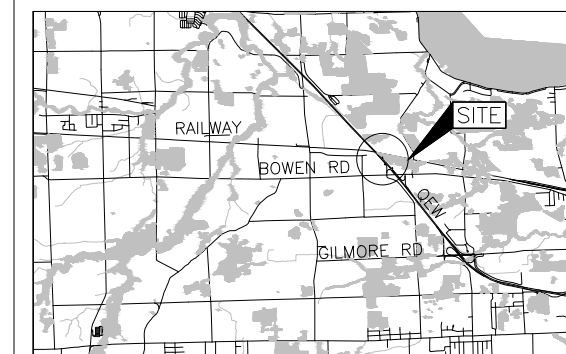
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REFERENCE

Base plan provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018, X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Berti Alignments_2019Jan03mw.dwg, received January 08, 2019. Retaining wall plans provided in digital format by Aecom, drawing file nos. XX-60581660--RETAINING WALL_13+670-13+858.dwg, XX-60581660--RETAINING WALL_14+010-14+313 and XX-60581660--RETAINING WALL_14+190-14+470.dwg, received January 28, 2019.

NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW		PROJECT NO. 1671430	
SUBM'D. MAS		CHKD. MAS	DATE: 05/23/2019
DRAWN: SW		APPD. JMAC	SITE: .
			DWG. 6





KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on MMM DD, YYYY
- ≡ WL upon completion of drilling

Refer to Drawing 2 and 3 for Borehole Location
Coordinates and Ground Surface Elevation Coordinates.

NOTES

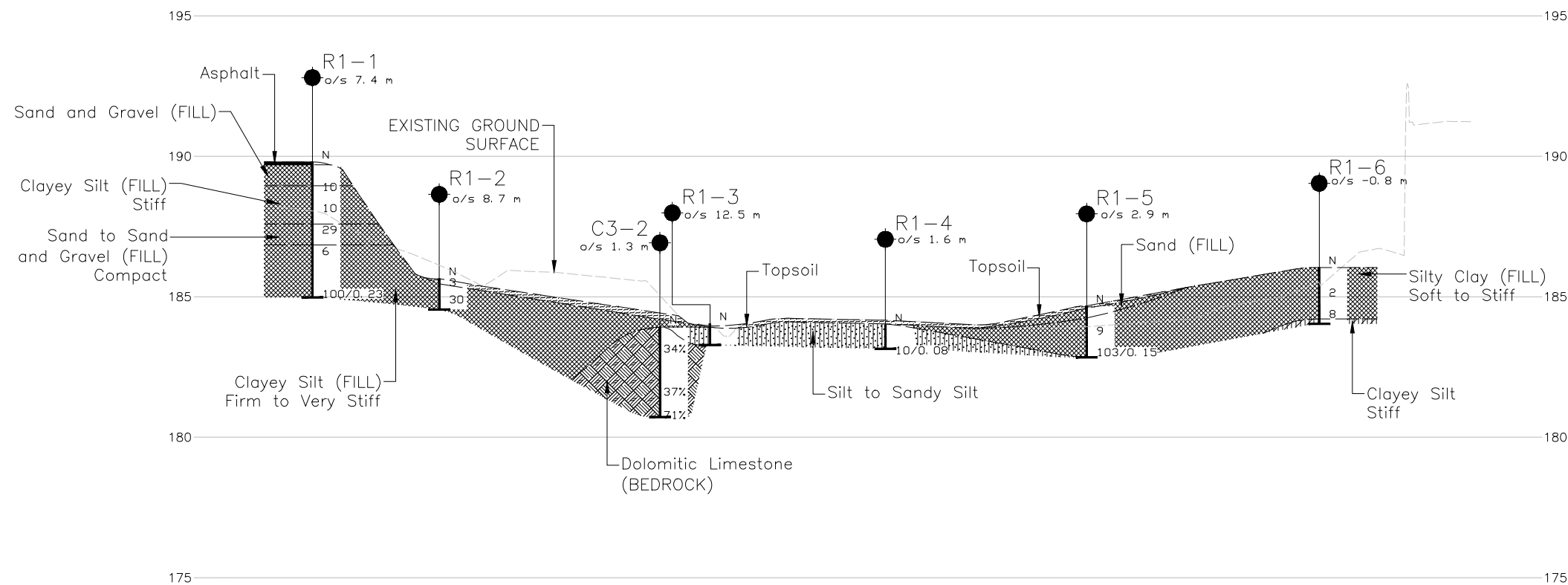
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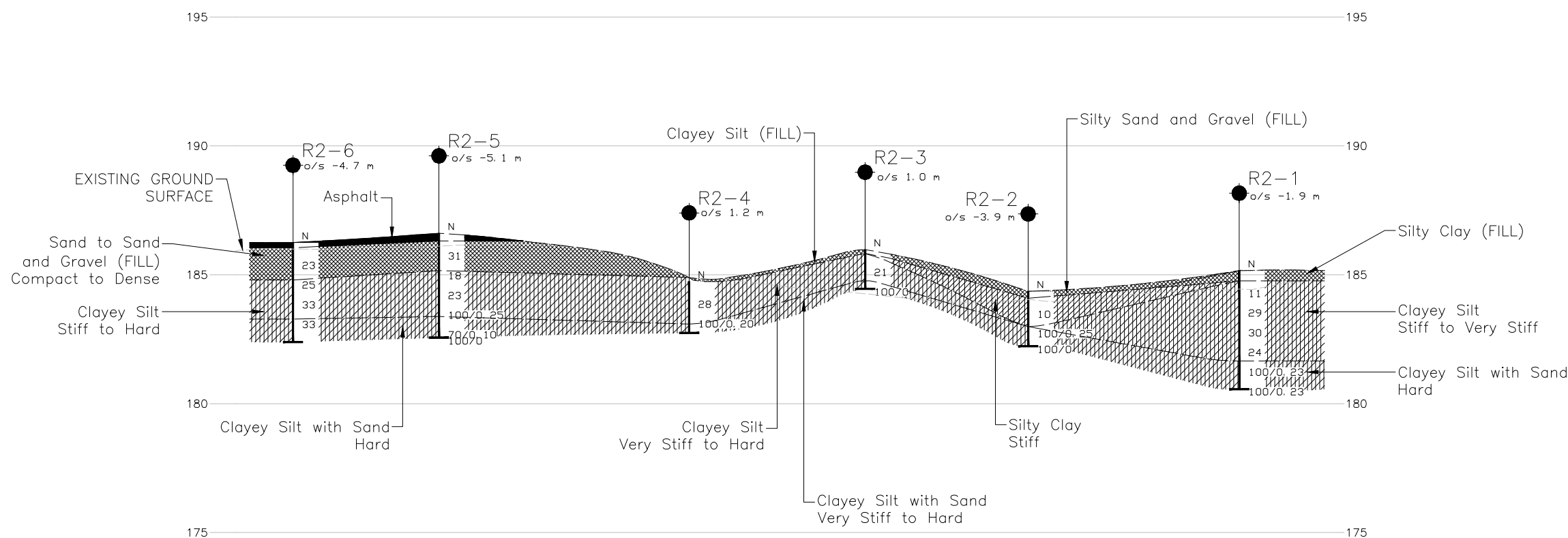
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Base plan provided in digital format by Aecom, drawing file nos. X-60581660-C-CNCP-QEW-DES.dwg, received November 15, 2018, X-60581660-C-CNCP-QEW-BASE.dwg and 60581660 QEW Berti Alignments_2019Jan03mw.dwg, received January 08, 2019. Retaining wall plans provided in digital format by Aecom, drawing file nos. XX-60581660--RETAINING WALL_13+670-13+858.dwg, XX-60581660--RETAINING WALL_14+010-14+313 and XX-60581660--RETAINING WALL_14+190-14+470.dwg, received January 28, 2019.

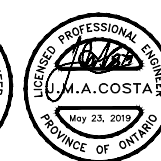
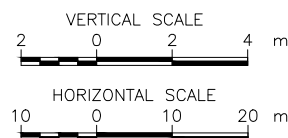
NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW	PROJECT NO. 1671430		DIST. .
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019	SITE: .
DRAWN: SW	CHKD. MAS	APPD. JMAC	DWG. 7



D-D PROFILE - BOWEN ROAD E/W-QEW S RAMP

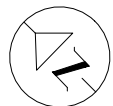


E-E PROFILE - BOWEN ROAD E/W-QEW N RAMP



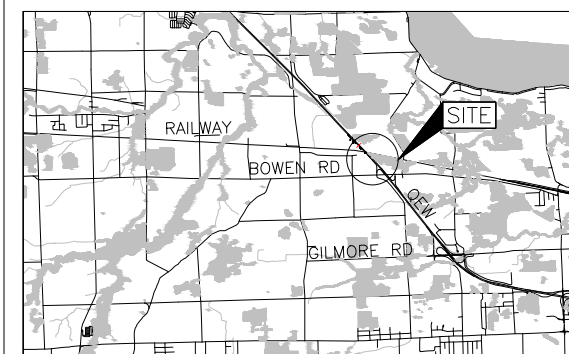
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2116-16-00



QEW
RETAINING WALLS AND HIGH FILLS
EMBANKMENT MONITORING PROGRAM
LOCATION PLAN

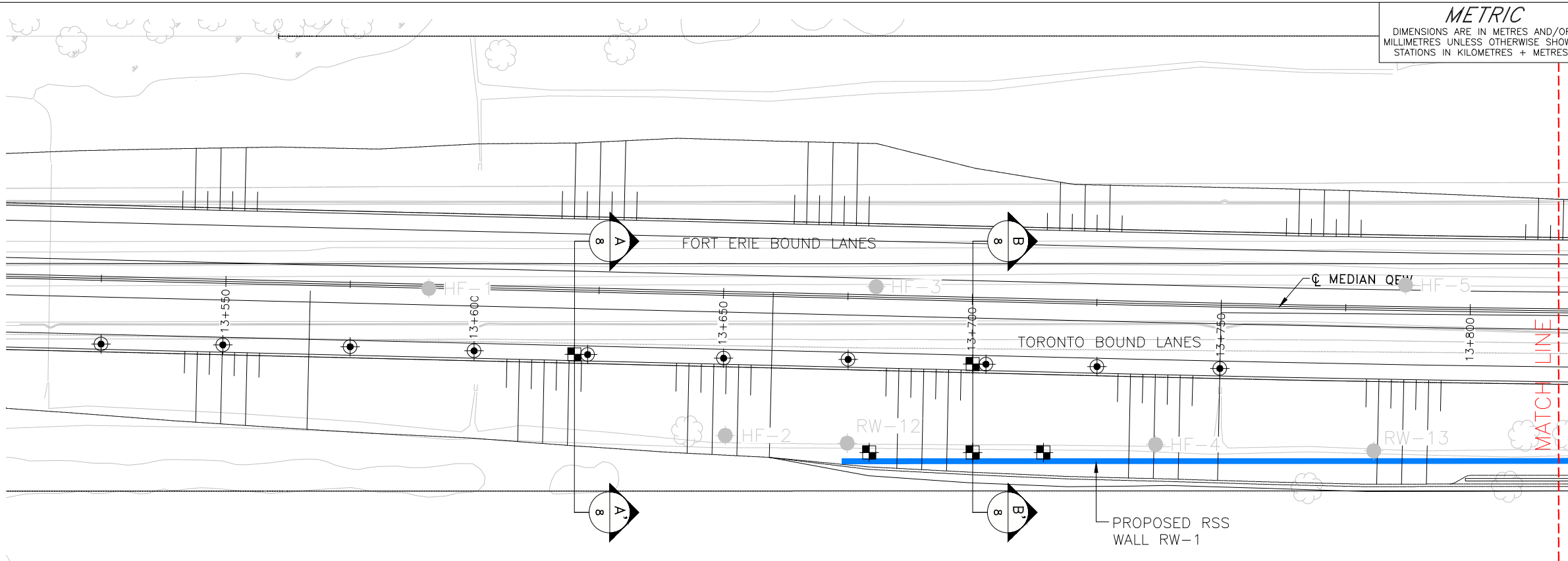
SHEET



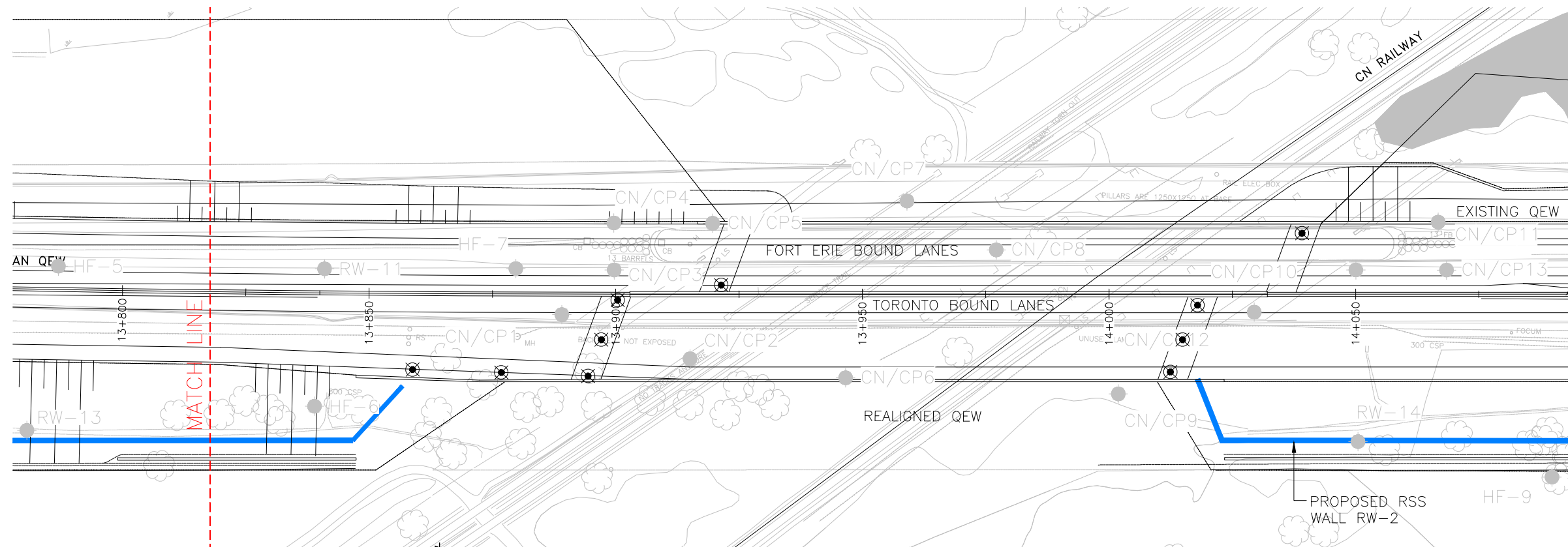
KEY PLAN
SCALE
1.5 0 1.5 3 km

LEGEND

- Borehole - Current Investigation
- Settlement Plate (SP)
- Nail Pin (NP)
- Instrumentation Section



PLAN
SCALE
10 0 10 20 m



PLAN
SCALE
10 0 10 20 m

NOTES

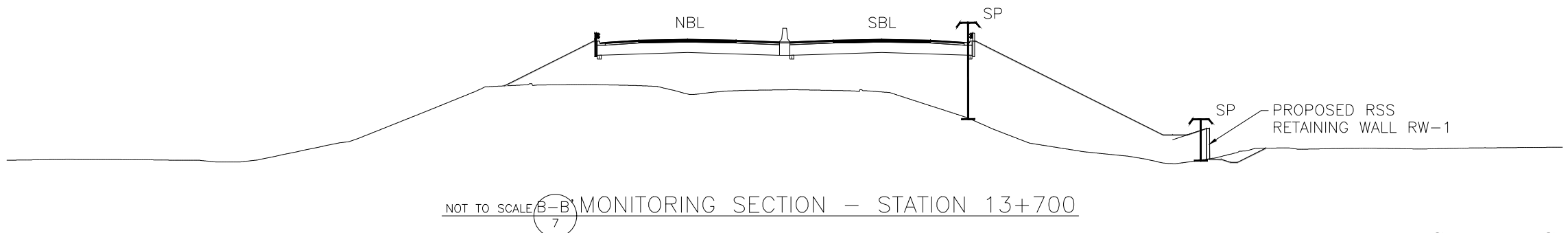
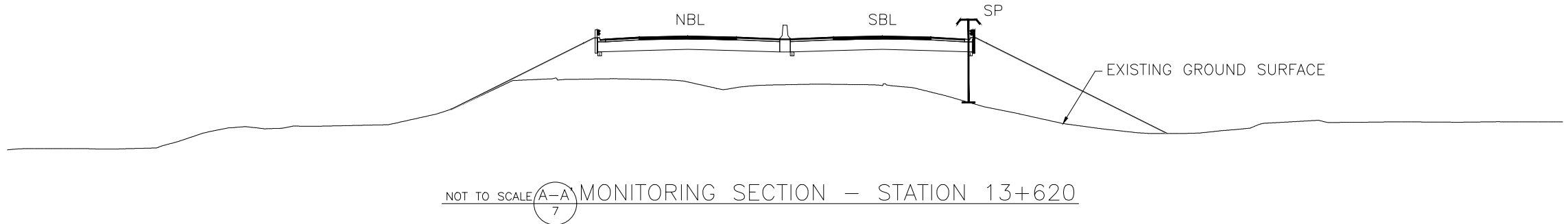
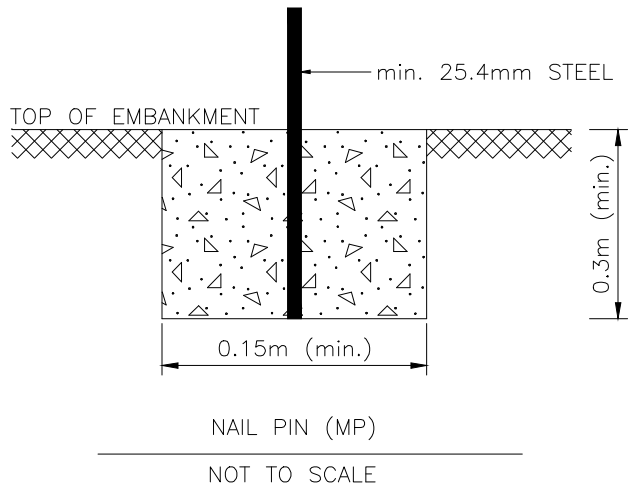
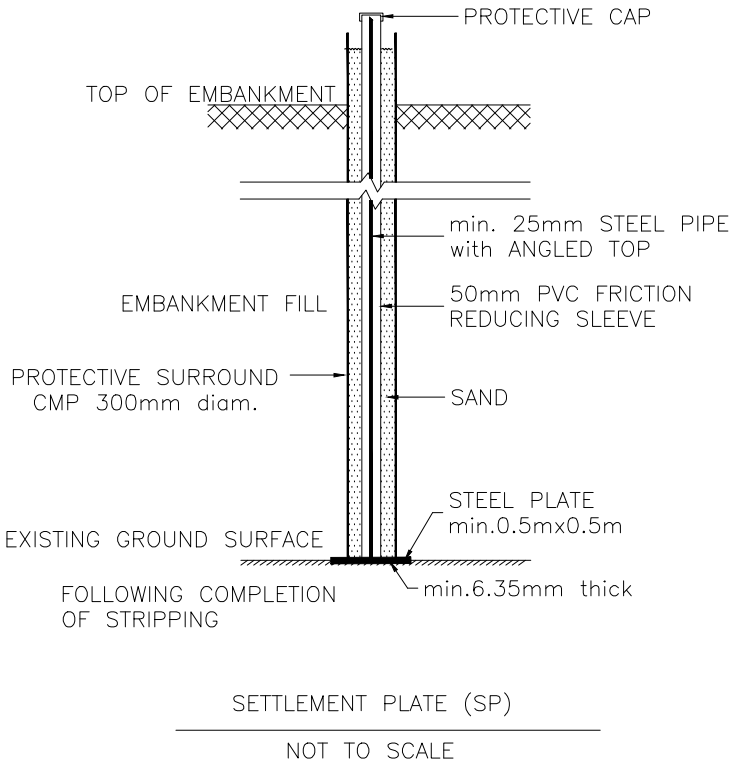
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NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY. QEW	PROJECT NO. 1671430		DIST. .
SUBM'D. MAS	CHKD. MAS	DATE: 05/23/2019	SITE: .
DRAWN: DD	CHKD. MAS	APPD. JPD	DWG. 8



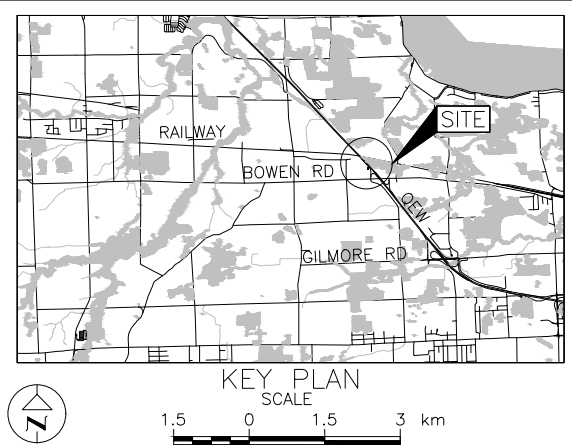


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.2116-16-00

QEW
RETAINING WALLS AND HIGH FILLS
MONITORING TYPICAL SECTIONS AND
INSTRUMENTATION INSTALLATION DETAILS

SHEET



LEGEND	
	Settlement Plate (SP)

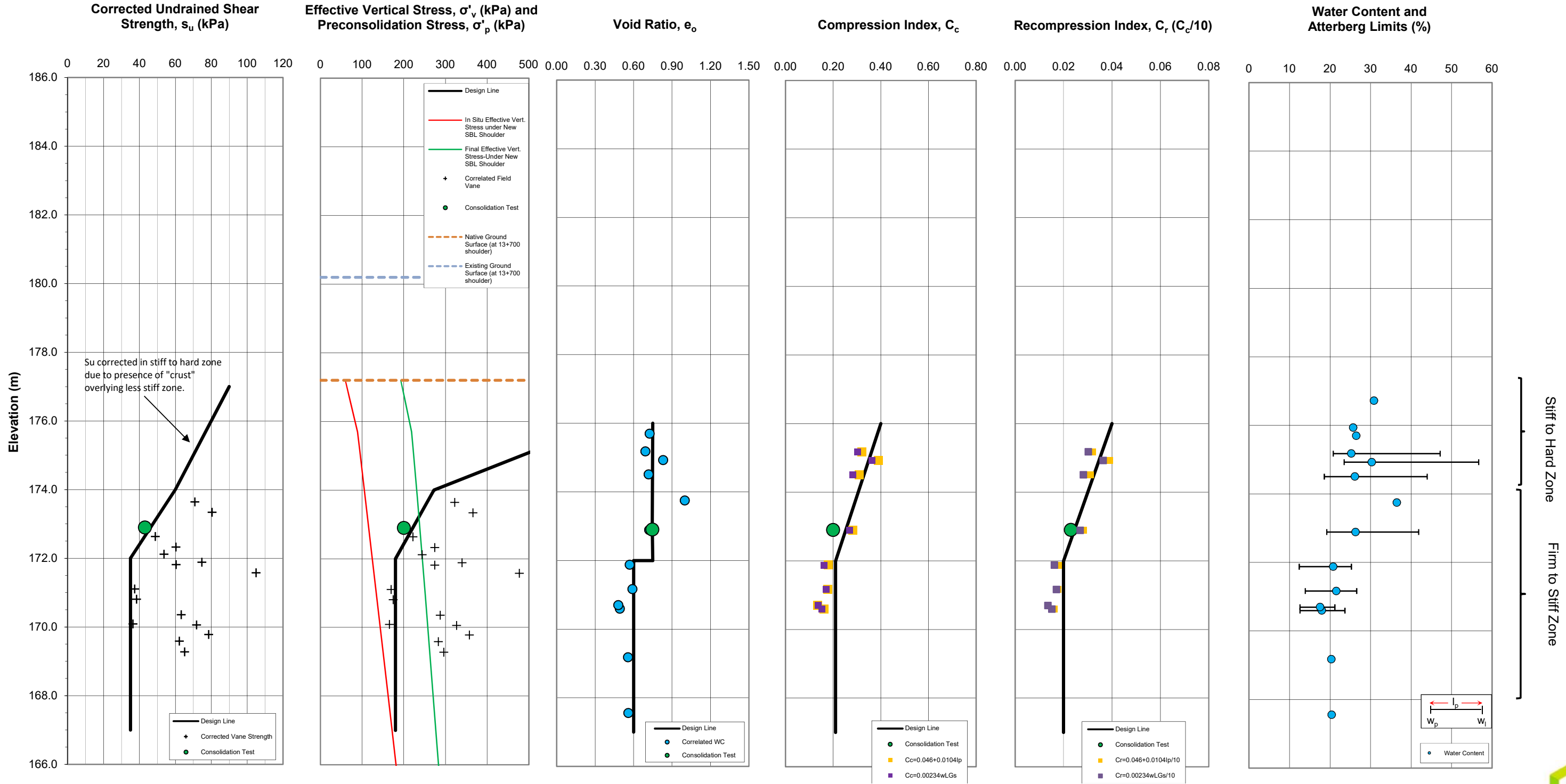


NO.	DATE	BY	REVISION
Geocres No. 30L15-19			
HWY.	QEW	PROJECT NO.	1671430
SUBM'D.	MAS	CHKD.	MAS
DATE:	05/23/2019	SITE:	
DRAWN:	DD	CHKD.	MAS
APPD.	JPD	DWG.	9

C:\Users\msoderman\Golder Associates\1671430 - AECOM MTO Mega Retainer 2016\0029 - Fdms2 - Analysis\Parameters\1671430 WO8 Parameters of Native Cohesive Deposits.xlsx[FIG 1-BERTIE HF RW 13+700

SUMMARY PLOT OF ENGINEERING PARAMETERS FOR
COHESIVE SOILS NORTH OF STA. 13+725
QEW Bertie - High Fills and Retaining Walls

FIGURE 1

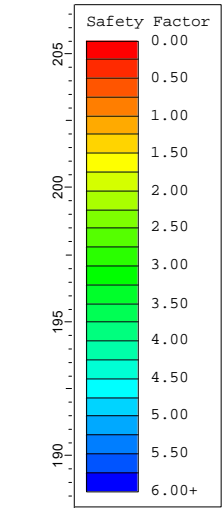


Golder Associates Ltd.

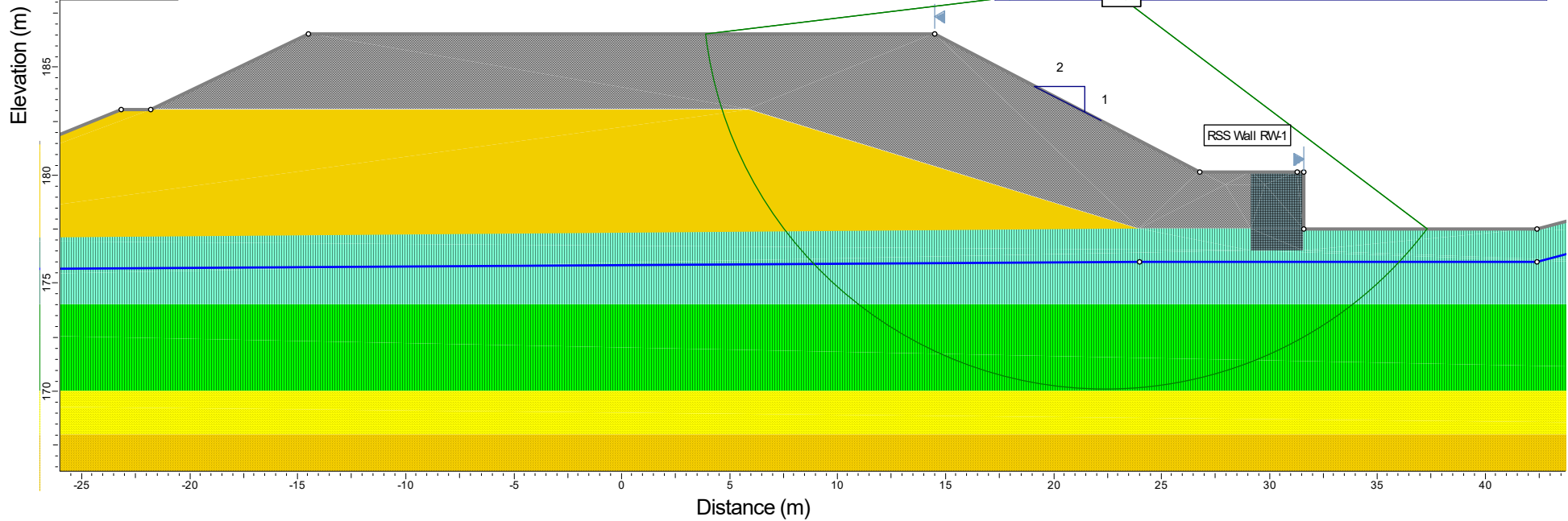
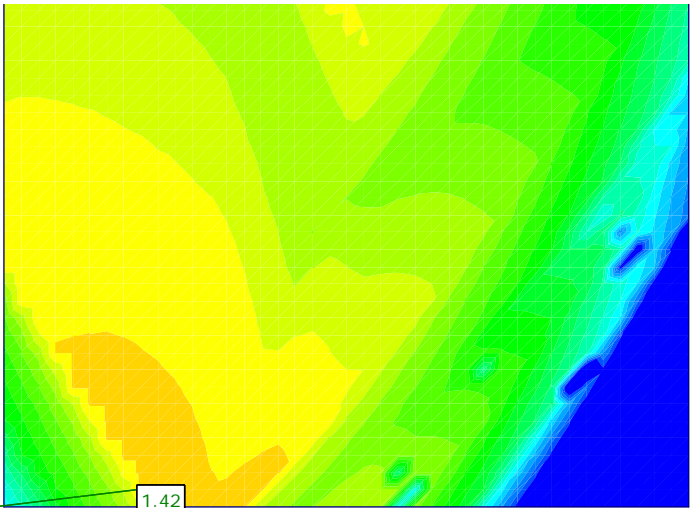
Date: May 2019
Project No: 1671430

Prepared By: MAS
Checked By: JPD





Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Cohesion Change (kPa/m)	Cutoff (kPa)
New Embankment Fill (Granular or SSM)		21	Mohr-Coulomb	0	33			
Existing Clayey Embankment Fill		19	Mohr-Coulomb	0	23			
Clayey Silt to Silty Clay to Clay (Stiff to Hard)		19.5	Undrained	90		FDepth	-10.57	35
Clayey Silt to Silty Clay (firm to stiff)		19.5	Undrained	35		Constant		
Sandy Silt to Sand (Compact to V. Dense)		20	Mohr-Coulomb	0	33			
Sand and Gravel (Compact to V. Dense)		21	Mohr-Coulomb	0	35			
RSS Wall		20	Infinite strength					



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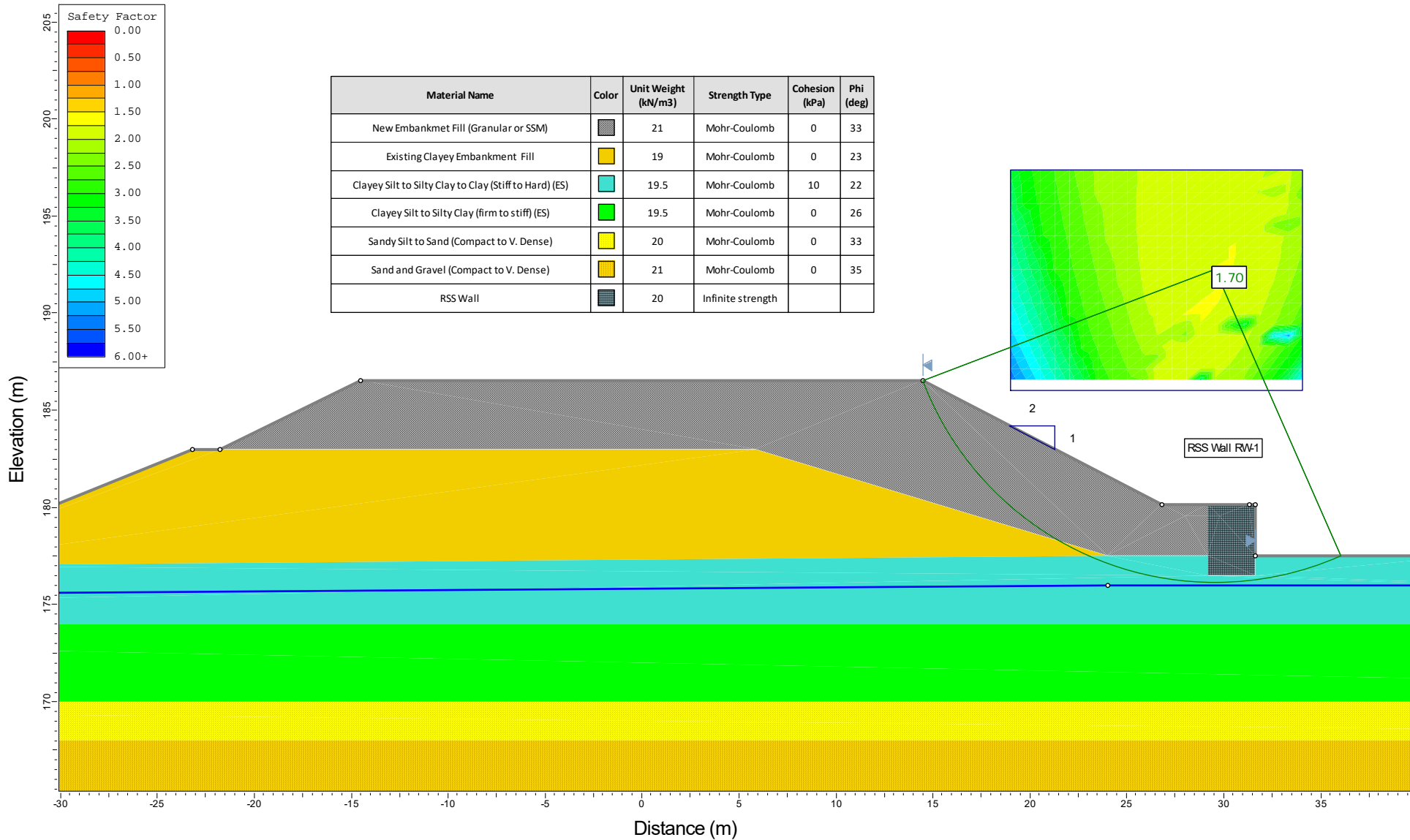


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APPROVED LCC

PROJECT
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TITLE
STATIC GLOBAL STABILITY ANALYSIS – APPROX STA. 13+700
SHORT-TERM CONDITIONS (UNDRAINED)

PROJECT No.
1671430



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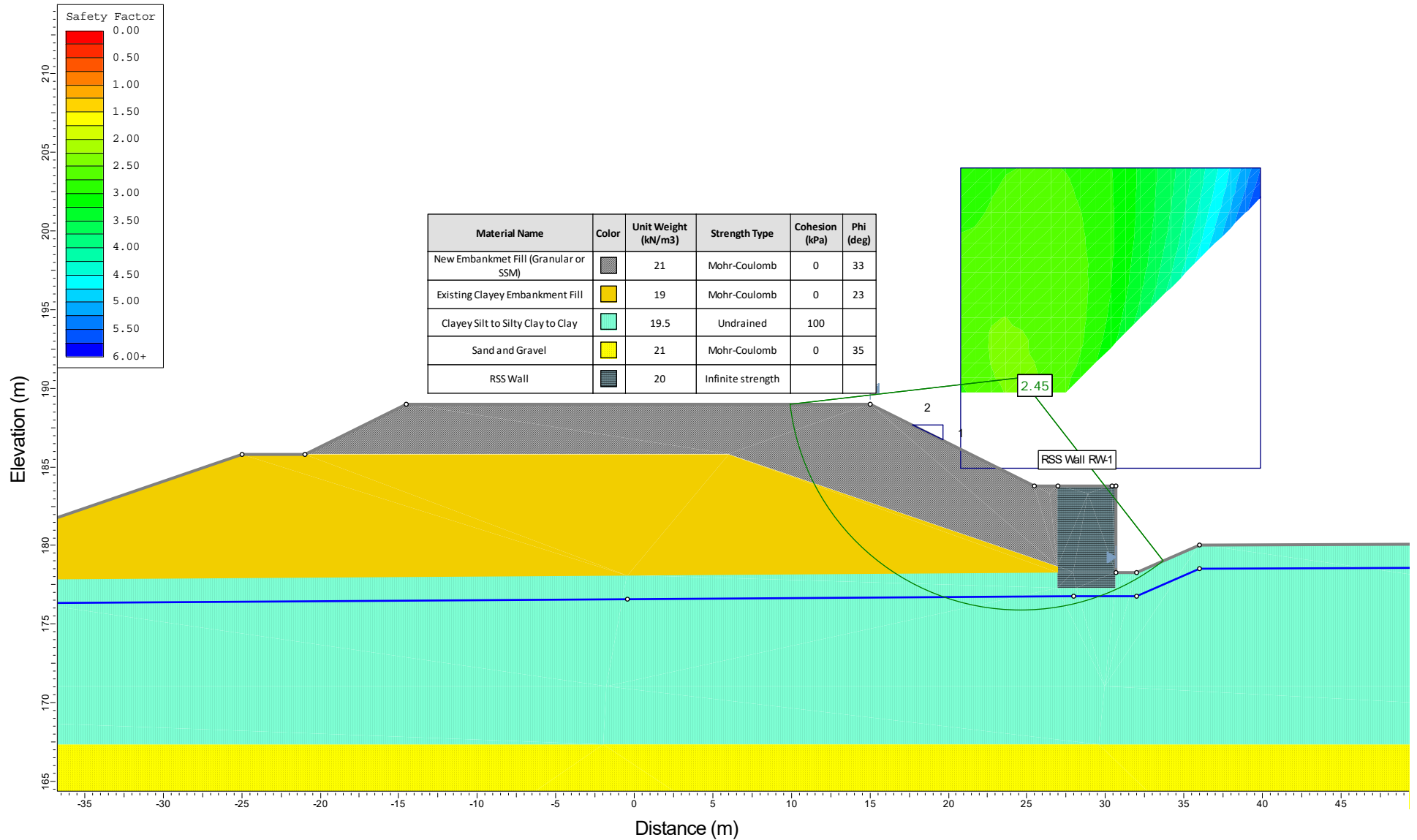


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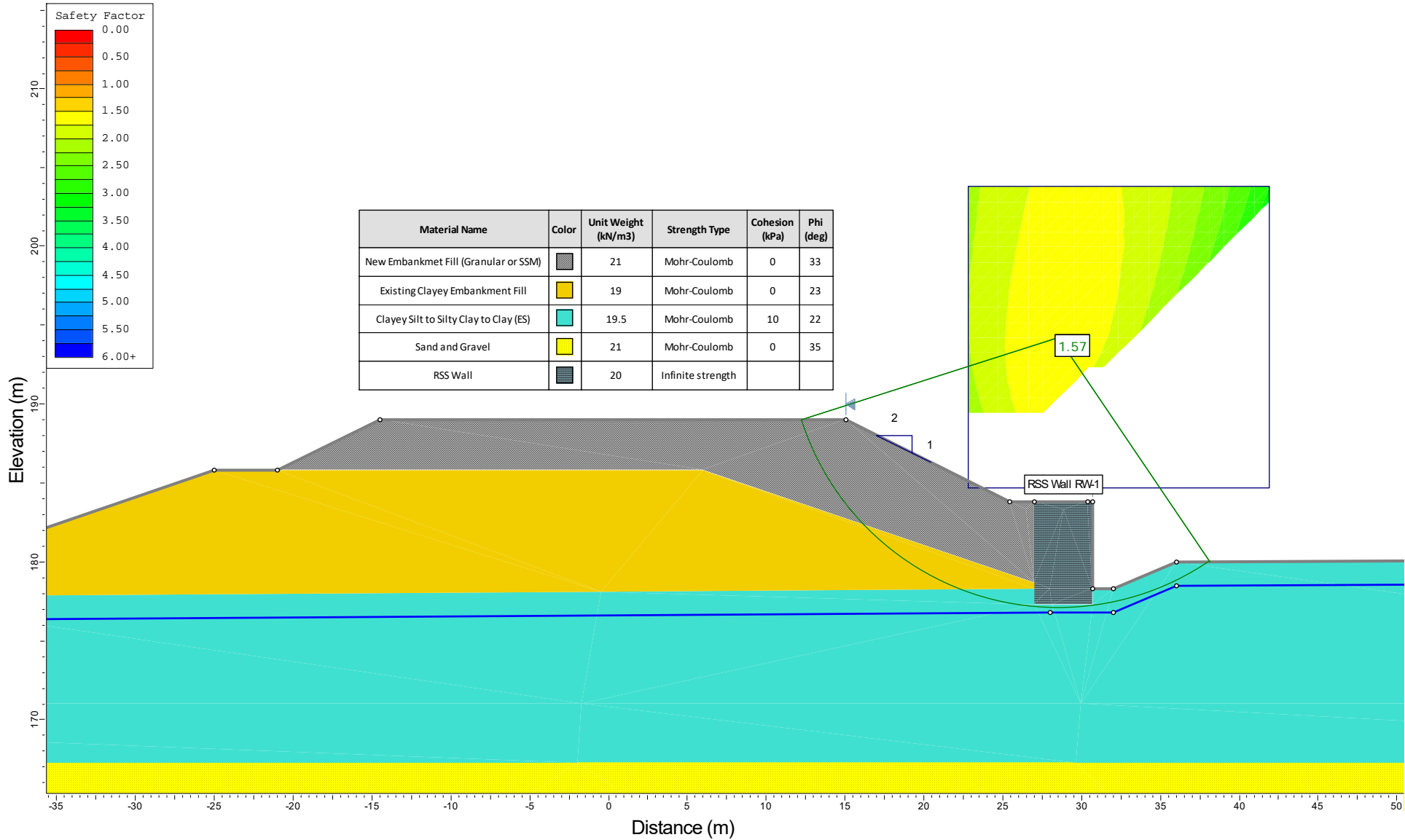
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STATIC GLOBAL STABILITY ANALYSIS – APPROX STA. 13+800
SHORT-TERM CONDITIONS (UNDRAINED)

PROJECT No.

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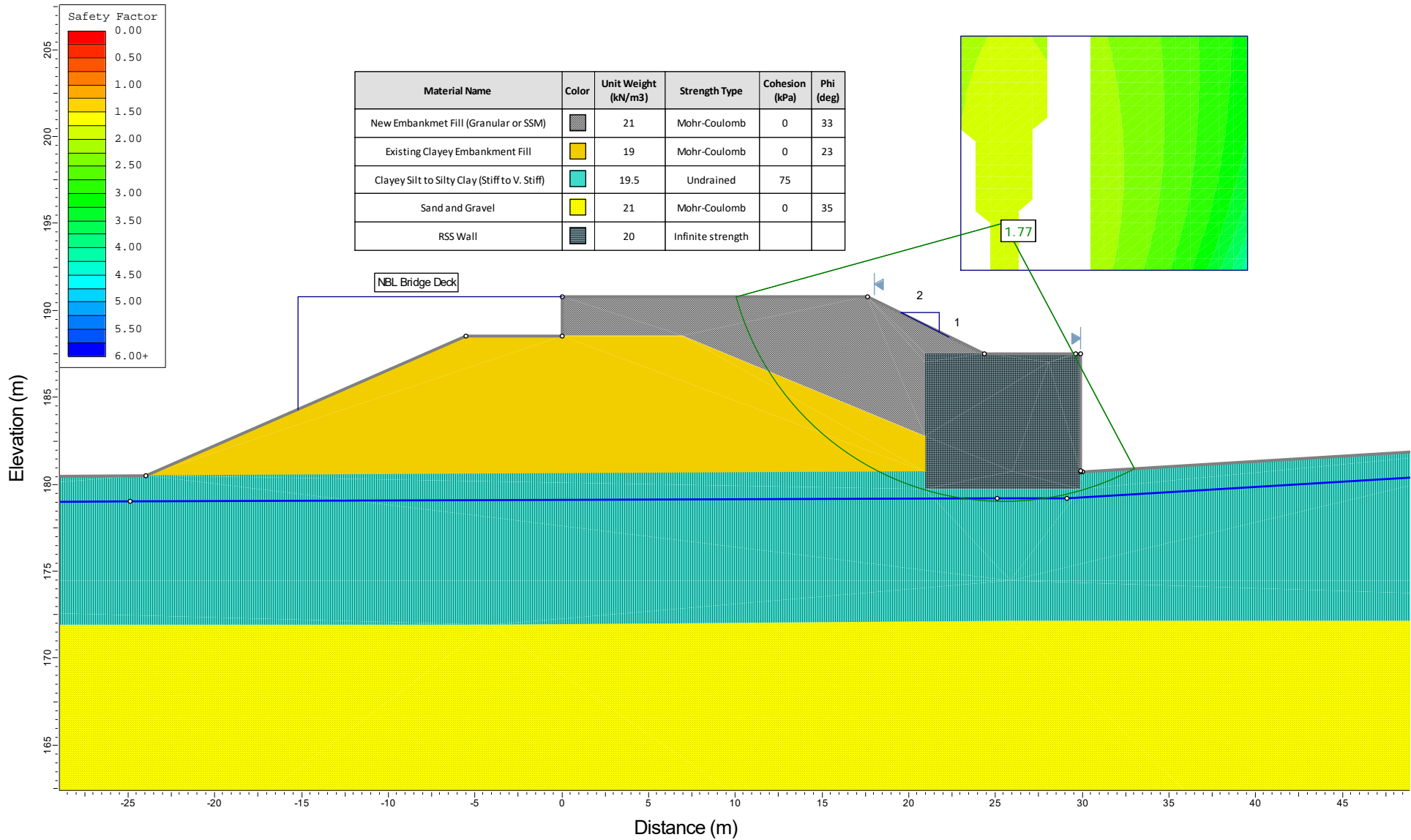


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Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
New Embankmet FILL (Granular or SSM)		21	Mohr-Coulomb	0	33
Existing Clayey Embankment Fill		19	Mohr-Coulomb	0	23
Clayey Silt to Silty Clay (Stiff to V. Stiff)		19.5	Undrained	75	
Sand and Gravel		21	Mohr-Coulomb	0	35
RSS Wall		20	Infinite strength		

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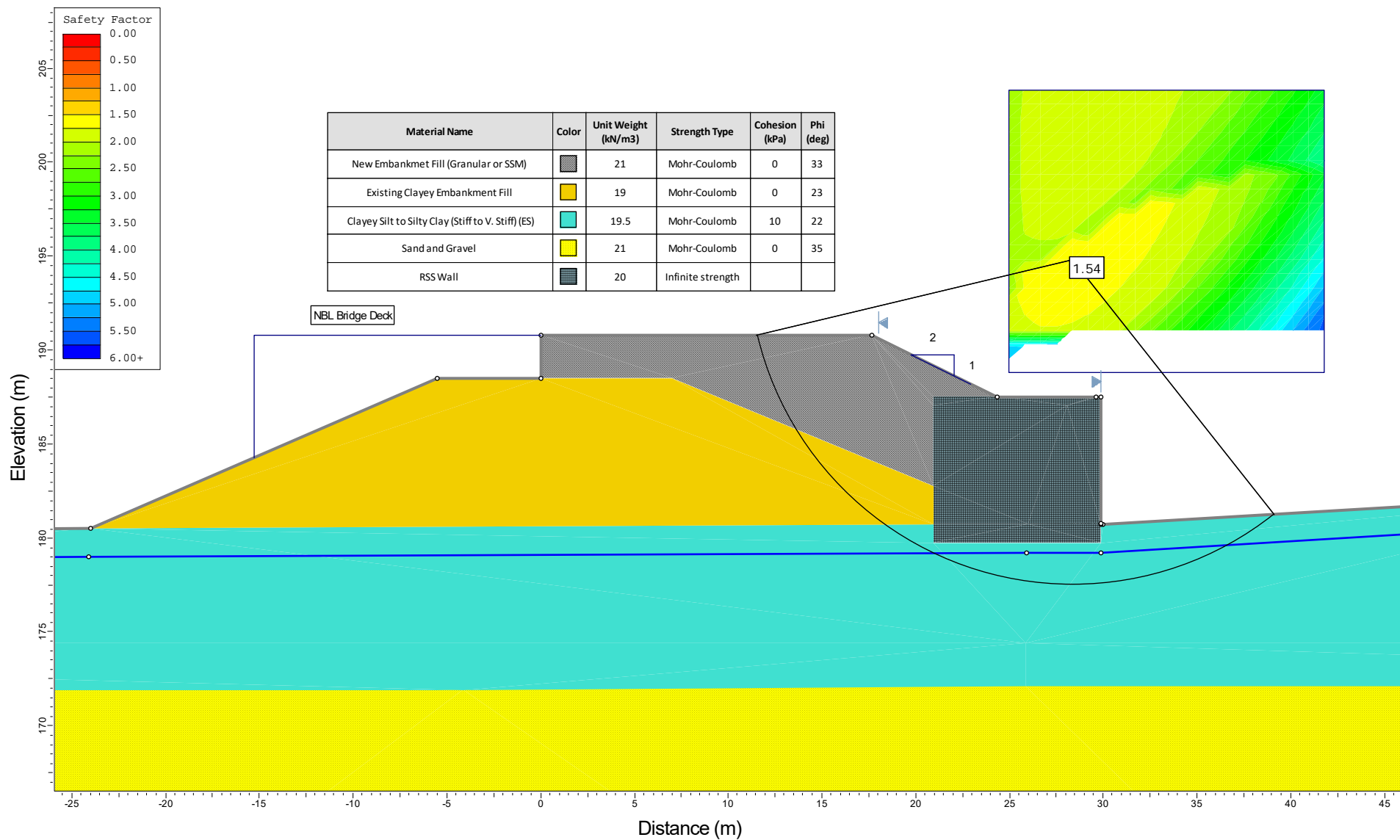
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STATIC GLOBAL STABILITY ANALYSIS – APPROX STA. 14+040
SHORT-TERM CONDITIONS (UNDRAINED)

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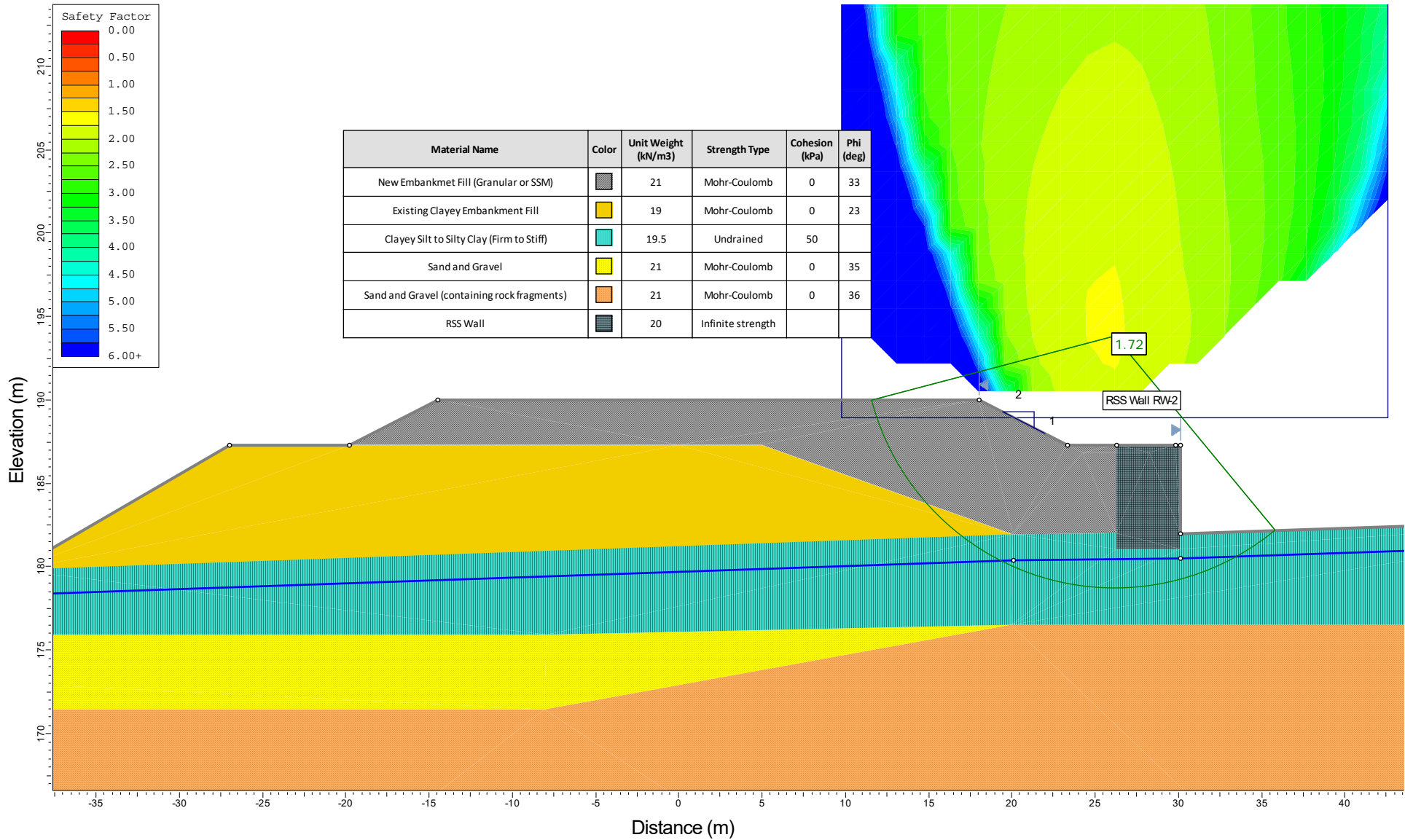
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TITLE

STATIC GLOBAL STABILITY ANALYSIS – APPROX STA. 14+040
LONG-TERM CONDITIONS (DRAINED)

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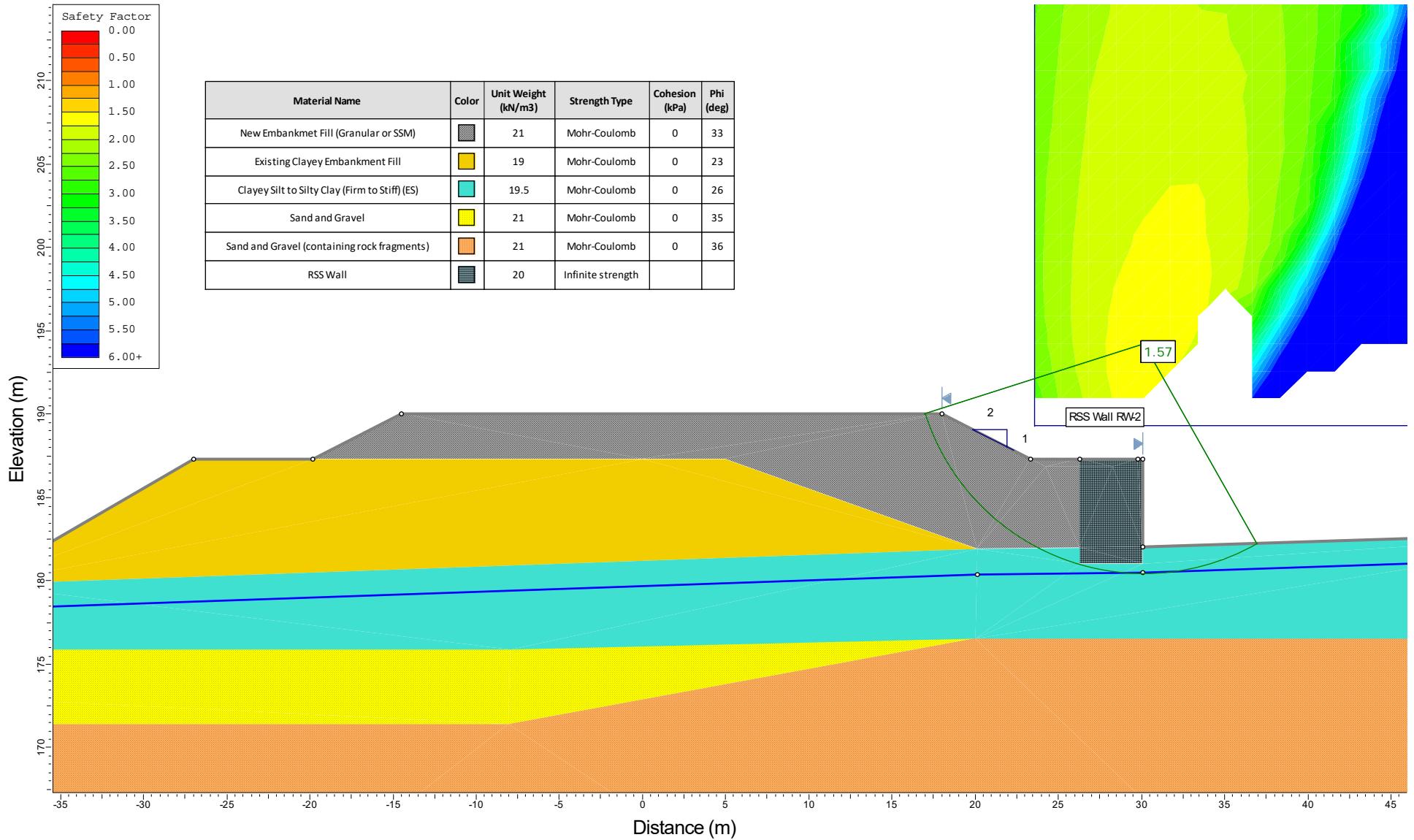


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SHORT-TERM CONDITIONS (UNDRAINED)

PROJECT No.
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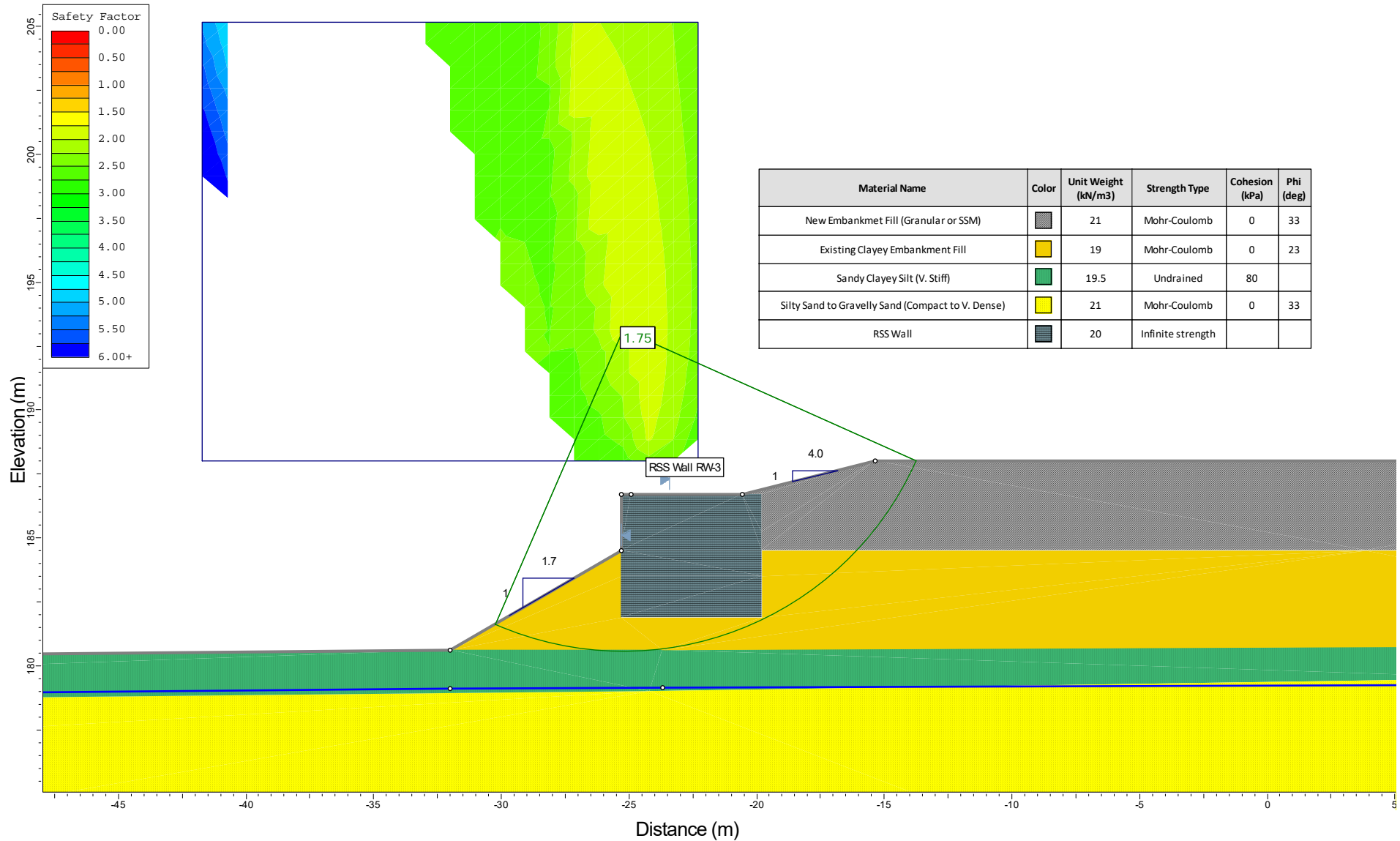


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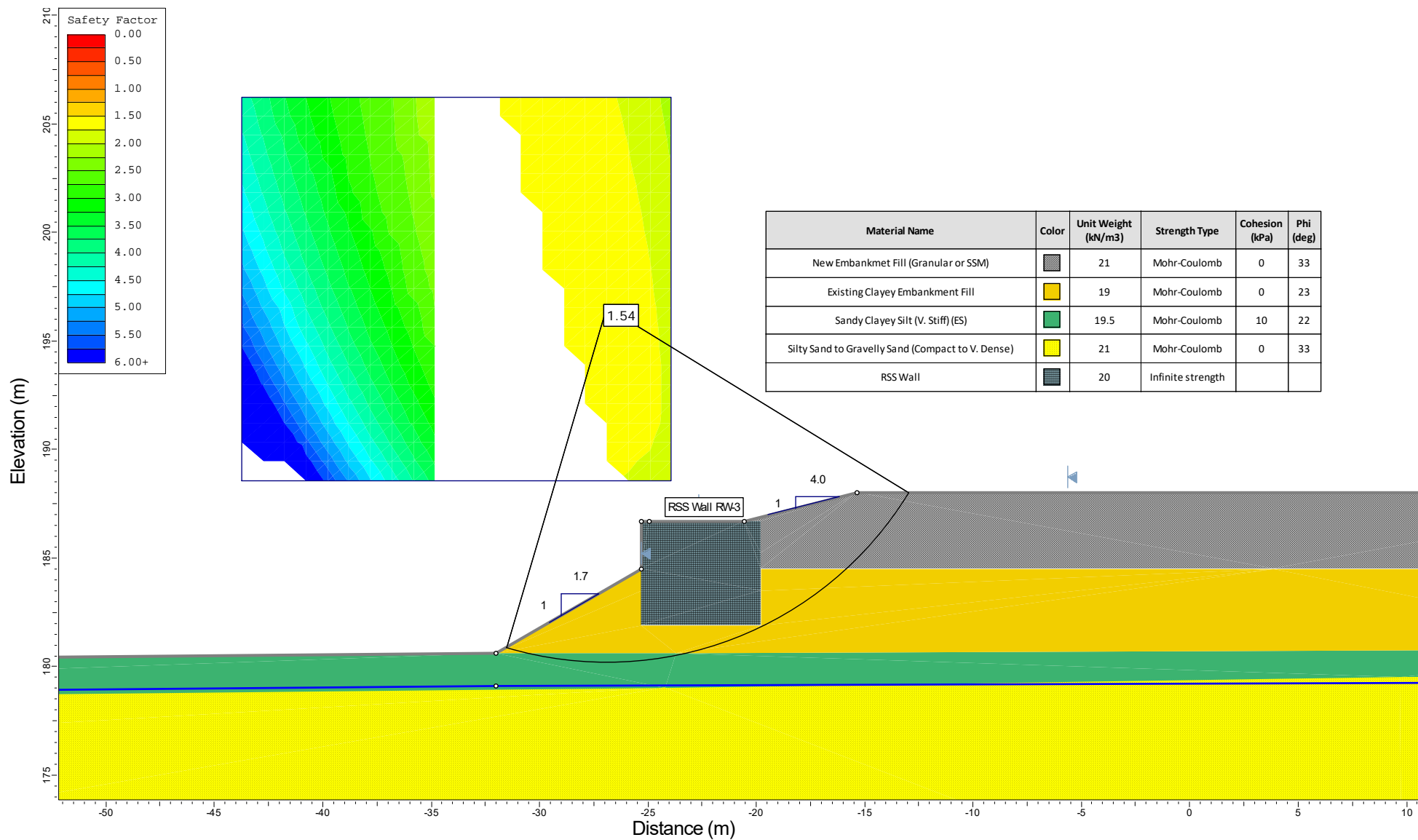
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TITLE

STATIC GLOBAL STABILITY ANALYSIS – APPROX STA. 14+240
SHORT-TERM CONDITIONS (UNDRAINED)

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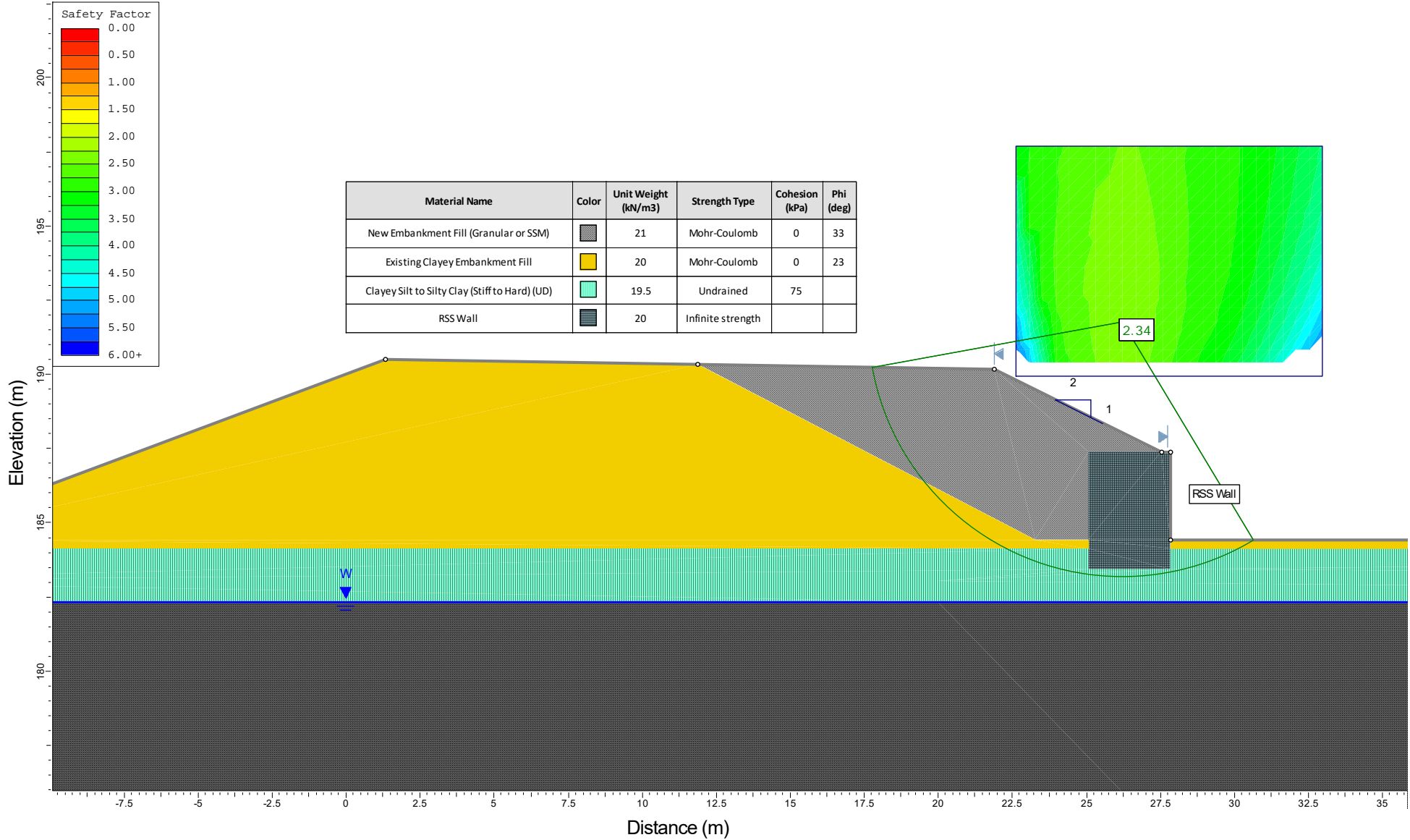
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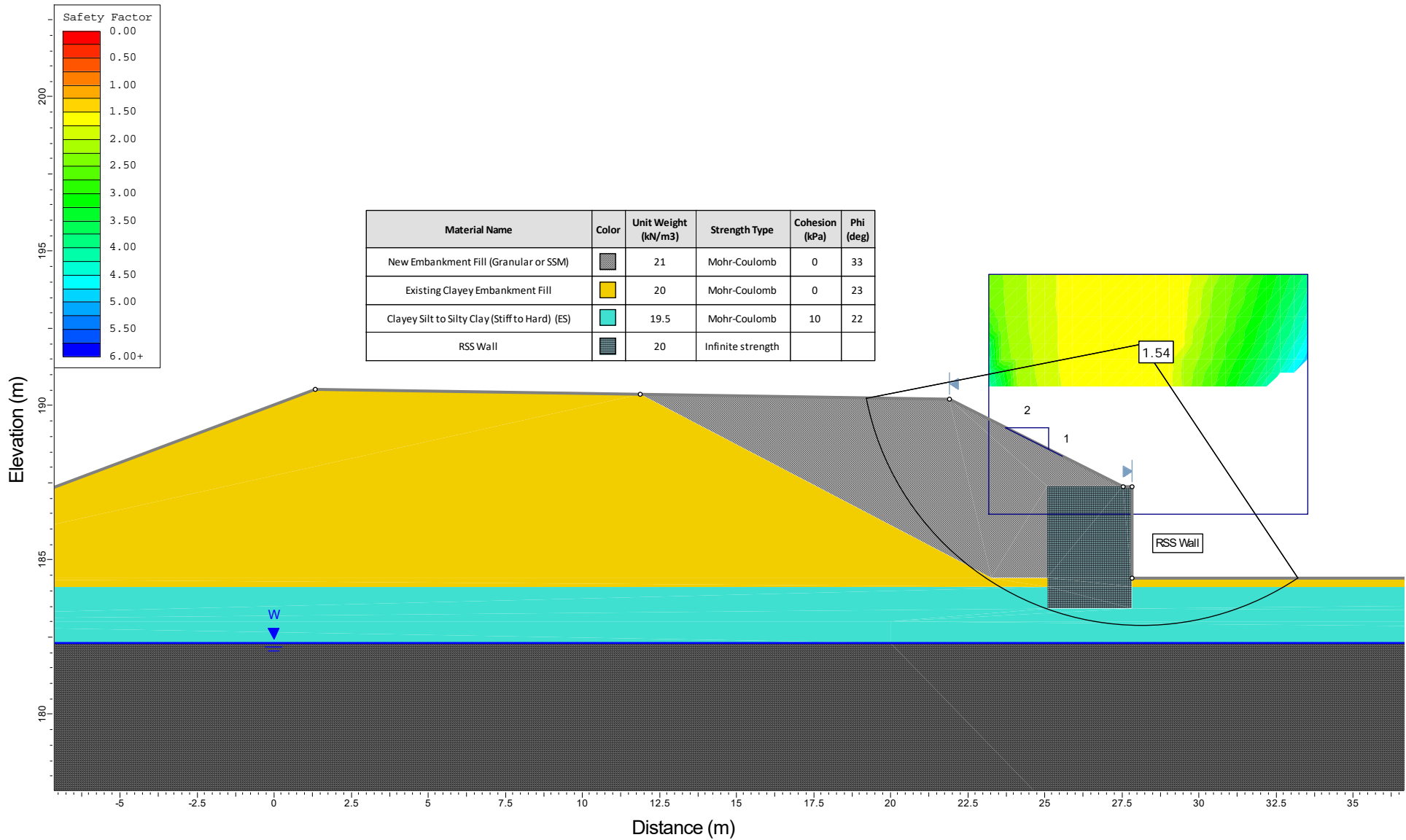


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TITLE
STATIC GLOBAL STABILITY ANALYSIS – RAMP EW-N RSS WALL
APPROX STA. 9+875
SHORT-TERM CONDITIONS (UNDRAINED)

PROJECT No.
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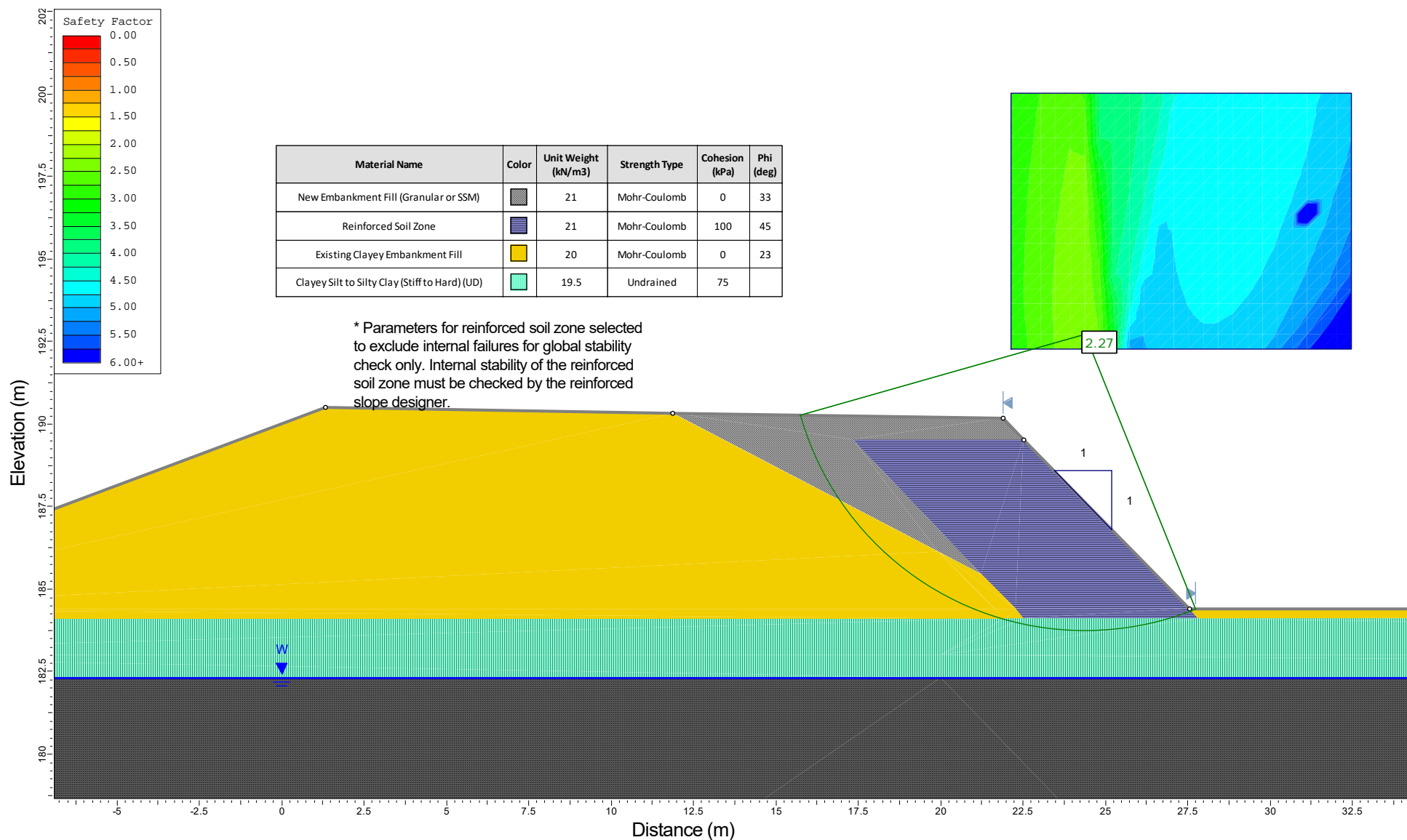


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APPROX STA. 9+875
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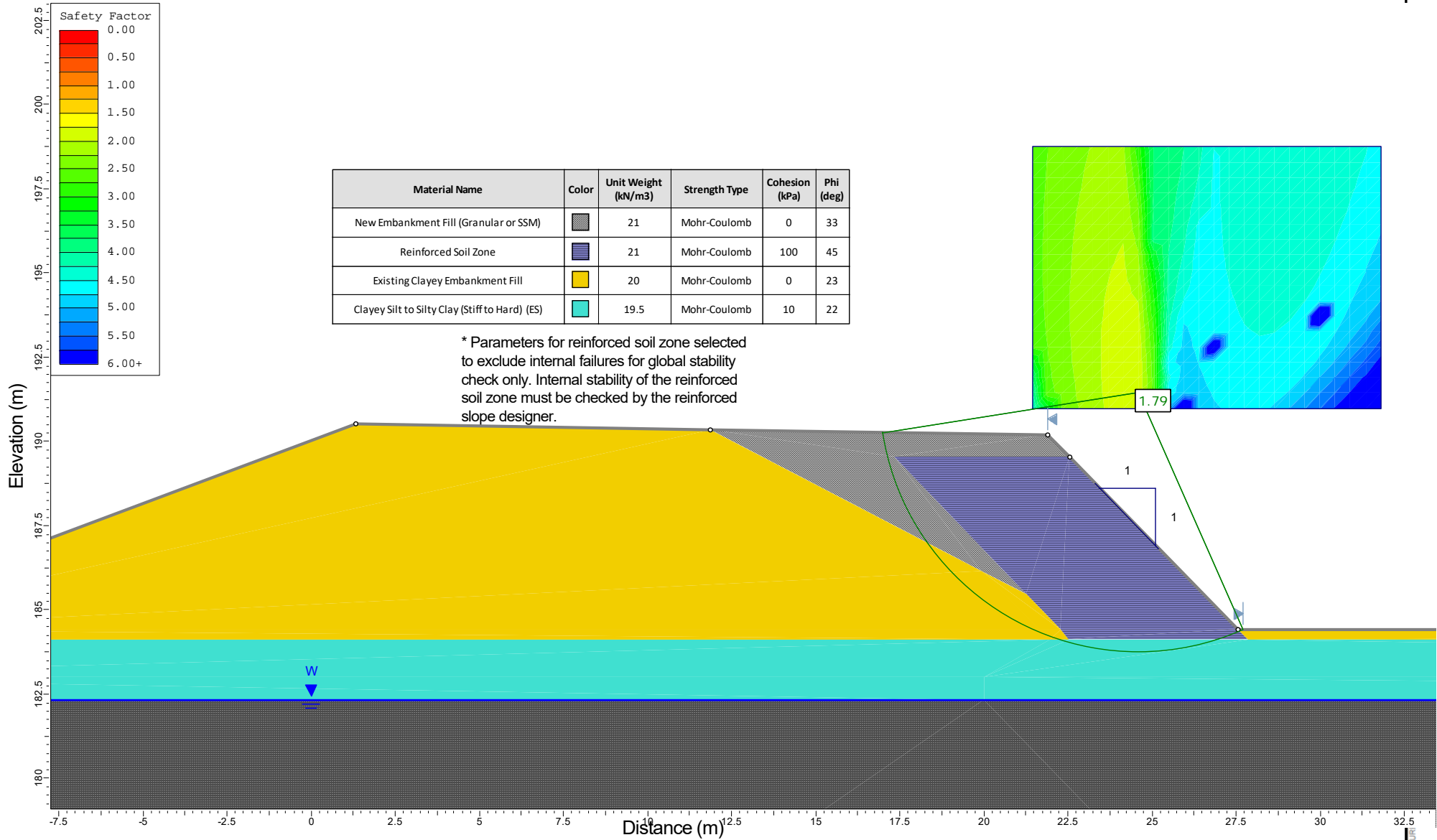
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TITLE

STATIC GLOBAL STABILITY ANALYSIS – RAMP EW-N
APPROX STA. 9+875 REINFORCED SOIL SLOPE
SHORT-TERM CONDITIONS (UNDRAINED)

PROJECT No.

1671430



CLIENT
Ministry of Transportation Ontario (MTO)

CONSULTANT



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TITLE
STATIC GLOBAL STABILITY ANALYSIS – RAMP EW-N
APPROX STA. 9+875 - REINFORCED SOIL SLOPE
LONG-TERM CONDITIONS (DRAINED)

PROJECT No.
1671430

APPENDIX A

Borehole and Drillhole Records

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

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

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (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° 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	

Table A-1: Summary of Borehole Locations, Ground Surface Elevations and Drilled Depths

Area	Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
North of CN/CP Twin Structure - SBL (including RSS Wall RW-1)	HF-1	4,755,736.8 (42.936639)	346,264.2 (-78.987300)	179.8	11.3
	HF-2	4,755,673.5 (42.939733)	346,284.5 (-78.991693)	177.0	9.8
	RW-12	4,755,654.9 (42.939564)	346,300.5 (-78.991499)	177.1	8.2
	HF-3	4,755,672.6 (42.939722)	346,327.1 (-78.991171)	182.1	14.3
	HF-4	4,755,610.3 (42.939161)	346,343.4 (-78.990975)	177.6	6.3
	RW-13	4,755,578.0 (42.938868)	346,373.1 (-78.990615)	178.0	9.8
	HF-5	4,755,596.6 (42.939034)	346,401.4 (-78.990266)	185.1	18.9
	HF-6	4,755,539.6 (42.938520)	346,417.2 (-78.990077)	180.4	8.5
	RW-11	4,755,557.6 (42.938681)	346,438.6 (-78.989813)	186.7	17.4
	HF-7	4,755,529.8 (42.938429)	346,465.7 (-78.989483)	187.8	22.9
	CN/CP1	4,755,516.6 (42.938311)	346,465.5 (-78.989487)	188.1	9.8
	CN/CP3	4,755,515.3 (42.938298)	346,479.4 (-78.989317)	188.4	27.1
South of CN/CP Twin Structure - SBL (including RSS Wall RW-2)	CN/CP9	4,755,424.5 (42.937469)	346,532.6 (-78.988668)	180.0	18.6
	CN/CP12	4,755,416.3 (42.937402)	346,563.7 (-78.988291)	188.6	27.2

Area	Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
	CN/CP10	4,755,407.5 (42.937321)	346,584.2 (-78.988041)	188.2	27.2
	RW-14	4,755,382.9 (42.937102)	346,559.5 (-78.988345)	181.5	5.8
	CN/CP13	4,755,394.3 (42.937202)	346,597.0 (-78.987885)	187.9	9.8
	HF-9	4,755,349.7 (42.936802)	346,581.9 (-78.988074)	181.5	9.0
	RW-10	4,755,347.4 (42.936778)	346,630.3 (-78.987481)	186.6	15.2
	RW-15	4,755,316.5 (42.936501)	346,618.8 (-78.987624)	182.9	6.3
	HF-10	4,755,331.9 (42.936638)	346,645.1 (-78.987300)	186.2	14.1
	HF-11	4,755,278.6 (42.936158)	346,653.9 (-78.987197)	183.7	6.2
	RW-16	4,755,252.0 (42.935917)	346,681.2 (-78.986864)	181.9	0.4
	HF-12	4,755,267.2 (42.936052)	346,703.6 (-78.986588)	184.2	18.3
	C1-1	4,755,249.3 (42.935891)	346,719.3 (-78.986398)	183.7	13.4
	C1-2	4,755,217.3 (42.935603)	346,711.3 (-78.986498)	181.8	4.1
	HF-13	4,755,209.5 (42.935531)	346,739.8 (-78.986150)	181.9	0.6
South of CN/CP Twin Structure -	RW-9	4,755,300.4 (42.936351)	346,712.2 (-78.986480)	185.1	9.4
	C1-3	4,755,255.7	346,753.3	184.1	10.1

Area	Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
NBL (including RSS Wall RW-3)		(42.935947)	(-78.985981)		
	RW-7	4,755,227.4 (42.935690)	346,780.4 (-78.985650)	183.7	8.2
	HF-14	4,755,213.7 (42.935567)	346,771.1 (-78.985765)	183.3	8.1
	RW-6	4,755,191.5 (42.935365)	346,813.2 (-78.985252)	183.6	9.2
	HF-15	4,755,146.8 (42.934963)	346,807.2 (-78.985327)	183.0	0.6
	RW-5	4,755,154.8 (42.935033)	346,847.8 (-78.984830)	184.2	6.7
	RW-4A	4,755,131.7 (42.934824)	346,868.7 (-78.984576)	184.5	8.2
Ramp E/W-S	R1-1	4,755,030.0 (42.933912)	346,786.6 (-78.985589)	189.8	4.8
	R1-2	4,755,052.6 (42.934115)	346,799.4 (-78.985430)	185.6	1.1
	C3-2	4,755,062.9 (42.934206)	346,839.2 (-78.984942)	183.9	3.2
	R1-3	4,755,074.2 (42.934307)	346,840.4 (-78.984927)	184.0	0.8
	R1-4	4,755,057.1 (42.934151)	346,877.7 (-78.984471)	184.0	0.9
	R1-5	4,755,034.3 (42.933945)	346,905.7 (-78.984130)	184.7	1.8
	R1-6	4,755,001.3 (42.933646)	346,931.0 (-78.983822)	186.0	2.0
Ramp E/W-N	R2-1	4,754,977.0 (42.933416)	347,137.7 (-78.981292)	185.2	4.6

Area	Borehole No.	MTM NAD83 Zone 10		Ground Surface Elevation (m)	Borehole Depth (m)
		Northing (m) (Latitude (°))	Easting (m) (Longitude (°))		
	R2-2	4,754,939.4 (42.933079)	347,121.1 (-78.981498)	184.4	2.1
	R2-3	4,754,920.6 (42.932910)	347,097.9 (-78.981783)	186.0	1.5
	R2-4	4,754,921.4 (42.932919)	347,063.8 (-78.982201)	184.7	2.0
	R2-5	4,754,944.2 (42.933127)	347,021.9 (-78.982713)	186.6	4.1
	R2-6	4,754,965.7 (42.933322)	347,003.2 (-78.982940)	186.2	3.9

Note: Boreholes listed by area and in order of location along alignment from north to south.

PROJECT		RECORD OF BOREHOLE				No HF-1		SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755736.8; E 346264.2 MTM NAD 83 ZONE 10 (LAT. 42.936639; LONG. -78.987300)				ORIGINATED BY		MA					
DIST		Central		HWY		QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY		EN/KN	
DATUM		Geodetic		DATE		September 13, 2018				CHECKED BY		MAS					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								<div><div></div><div></div><div></div><div></div><div></div></div>									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × REMOULDED									
								<div><div></div><div></div><div></div><div></div><div></div></div>									
179.8	GROUND SURFACE																
0.0	ASPHALT (340 mm)																
179.5																	
179.1	Sand and gravel, some silt (FILL) Brown Moist																
0.8	Sand, trace silt (FILL) Brown Moist		1	SS	9		179										
	Silty clay, trace to some sand, trace gravel, some silty sand layers, trace organics and topsoil (FILL) Firm to very stiff Brown Moist - 150 mm layer of topsoil encountered at 2.7 m		2	SS	6		178										
176.5			3A	SS	11		177										
3.3	SILTY CLAY to CLAY, trace sand, silt partings Stiff to very stiff Brown Moist		3B														
			4	SS	14		176										
			5	SS	16		175										
174.2																	
5.6	CLAYEY SILT, some sand, trace to some gravel Firm to stiff Brown Moist to wet below 7.1 m		6	SS	WH		174										
													</				



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

PROJECT		1671430 WO8F		RECORD OF BOREHOLE No RW-12				SHEET 1 OF 1		METRIC						
G.W.P.				LOCATION		N 4755654.9; E 346300.5 MTM NAD 83 ZONE 10 (LAT. 42.939564; LONG. -78.991499)		ORIGINATED BY		LK						
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY		JMP						
DATUM		Geodetic		DATE		January 16, 2019		CHECKED BY		MAS						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
177.1	GROUND SURFACE															
0.0	TOPSOIL (150 mm)															
0.2	SILTY CLAY, trace gravel, trace sand, trace rootlet, trace organics Firm to stiff Mottled brown Moist		1	SS	5											
			2	SS	15											
175.7																
1.4	SILTY CLAY, trace to some sand, trace gravel Stiff to very stiff Mottled greyish brown Moist - Coarser sand pockets at a depth of 1.5 m - 2.1 m - Finer sand pockets at a depth of 2.3 m - 2.9 m		3	SS	16											
			4	SS	9											
			5	SS	6											
			6	SS	9											
171.6																
5.5	CLAYEY SILT, some sand, trace gravel Firm to stiff Brown Moist		7	SS	WH											
169.6																
7.5	SILT and SAND, trace clay Compact Grey Moist		8	SS	27											
168.9																
8.2	END OF BOREHOLE															
	NOTE: 1. Water level in open borehole at a depth 7.2 m below ground surface (Elev. 169.9 m) upon completion of drilling.															

PROJECT		1671430 WO8		RECORD OF BOREHOLE No HF-3				SHEET 1 OF 2		METRIC			
G.W.P.		2116-16-00		LOCATION				N 4755672.6; E 346327.1 MTM NAD 83 ZONE 10 (LAT. 42.939722; LONG. -78.991171)		ORIGINATED BY		MA	
DIST		Central HWY QEW		BOREHOLE TYPE				178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY		EN/KN	
DATUM		Geodetic		DATE				September 12, 2018		CHECKED BY		MAS	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	WATER CONTENT (%)		
182.1	GROUND SURFACE						182						
0.0	ASPHALT (300 mm)												
181.8													
181.5	Sand and gravel, some silt (FILL) Brown Moist												
181.2	Sand, trace silt (FILL) Brown Moist		1	SS	4		181						
0.9	Silty clay, some sand to with sand, some silty topsoil seams (FILL) Soft to very stiff Brown Moist		2	SS	7		180						
			3	SS	10		179		2.3 + >143.6		42		0 17 30 53
							178		>143.6				
			4A 4B	SS	10		177				45		0 46 16 38
176.5													
5.6	SILTY CLAY, trace sand Firm to very stiff Brown Moist		5	SS	18		176						
							175						
			6	SS	8		174						
173.5							173		1.9 1.4				
8.6	CLAYEY SILT, trace sand Stiff to very stiff Brown Moist		7	SS	4		172		1.4 + 1.4 +				
			8	SS	4		171						0 4 61 35
							170		1.5 + 1.3 +				
			9A 9B	SS	10		169						
168.1			10A	SS	36		168						
167.8	Silty SAND and GRAVEL Dense Brown Wet		10B										
14.3													

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

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PROJECT <u>1671430 WO8</u>		RECORD OF BOREHOLE No HF-3				SHEET 2 OF 2		METRIC	
G.W.P. <u>2116-16-00</u>		LOCATION <u>N 4755672.6; E 346327.1 MTM NAD 83 ZONE 10 (LAT. 42.939722; LONG. -78.991171)</u>				ORIGINATED BY <u>MA</u>			
DIST <u>Central</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig</u>				COMPILED BY <u>EN/KN</u>			
DATUM <u>Geodetic</u>		DATE <u>September 12, 2018</u>				CHECKED BY <u>MAS</u>			

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W _p	W		
						20	40	60	80	100						
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 6.2 m below ground surface (Elev. 175.9 m) on completion of drilling. 2. Borehole caved to 13.1 m on removal of augers. 3. Water level in open borehole at a depth of 8.5 m (Elev. 173.6 m) on removal of augers.															

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No HF-4				SHEET 1 OF 1		METRIC					
G.W.P.		2116-16-00		LOCATION		N 4755610.3; E 346343.4 MTM NAD 83 ZONE 10 (LAT. 42.939161; LONG. -78.990975)				ORIGINATED BY					
DIST		Central		HWY		QEW		BOREHOLE TYPE		Manual Tripod, BW & AW Casings					
COMPILED BY		JMP		DATE		December 11-13, 2018		CHECKED BY		MAS					
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES										
177.6	GROUND SURFACE														
0.0	TOPSOIL (30 mm)														
	CLAY, trace rootlets, trace organics, trace sand with grey sand pockets from 1.2 m to 3.1 m, trace gravel Soft to very stiff Mottled grayish brown Moist		1	SS	4										
			2	SS	17										
			3	SS	15										
			4	SS	9										
			5	SS	8										
174.2															
3.4	CLAYEY SILT, trace to some sand, trace to some gravel Very stiff to hard Dark brown Moist		6	SS	26										
			7	SS	29										
			8	SS	40										
			9	SS	46										
171.3	END OF BOREHOLE														
6.3	NOTE: 1. Water level not measured due to addition of water during drilling.														

PROJECT		RECORD OF BOREHOLE				No RW-13		SHEET 1 OF 1		METRIC		
G.W.P.		2116-16-00		LOCATION		N 4755578.0; E 346373.1 MTM NAD 83 ZONE 10 (LAT. 42.938868; LONG. -78.990615)		ORIGINATED BY		LK		
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY		EN		
DATUM		Geodetic		DATE		January 16, 2019		CHECKED BY		MAS		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
178.0	GROUND SURFACE											
0.0	Organic SILTY CLAY, trace sand, trace gravel with roots		1	SS	4							
177.3	Soft Brown Moist											
0.7	SILTY CLAY to CLAY, trace sand		2	SS	20		177					
	Stiff to very stiff											
	Mottled greyish brown		3	SS	18		176					
	Moist											
			4	SS	15							
175.0	CLAYEY SILT, trace to some sand, trace gravel		5	SS	14		175					
3.0	Stiff to hard Brown Moist		6	SS	60/0.05		174					
	- Sample spoon bouncing at a depth of 4.0 m on inferred cobbles/boulder											
173.4	SAND, some silt, trace clay		7	SS	20		173					
4.6	Compact Greyish brown											
172.4	CLAYEY SILT, trace to some sand		8	SS	35		172					
5.6	Very stiff to hard Grey Moist											
							171					
			9	SS	27		170					
							169					
168.2	END OF BOREHOLE		10	SS	35							
9.8	NOTE: 1. Water level in open borehole at a ground surface (Elev. 178.0 m) on completion of drilling.											






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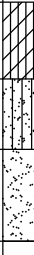
+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE



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

PROJECT		1671430 WO8		RECORD OF BOREHOLE No HF-6				SHEET 1 OF 1		METRIC					
G.W.P.		2116-16-00		LOCATION		N 4755539.6; E 346417.2 MTM NAD 83 ZONE 10 (LAT. 42.938520; LONG. -78.990077)		ORIGINATED BY		SE					
DIST		Central HWY QEW		BOREHOLE TYPE		Manual Tripod, BW & AW Casings		COMPILED BY		EN					
DATUM		Geodetic		DATE		November 29-30, 2018		CHECKED BY		MAS					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p W W _L				WATER CONTENT (%)	
180.4 0.0	GROUND SURFACE Clay, some sand (FILL) Soft to stiff Brown-red Moist		1	SS	4		180								
			2	SS	9										
179.2 1.2	SILTY CLAY to CLAY, trace to some sand, trace gravel Very stiff to hard Brown-red Moist		3	SS	34		179								
			4	SS	71										
			5	SS	28		178								
			6	SS	33										
			7	SS	35		177								
			8	SS	35		176								
175.0 5.4	CLAYEY SILT, some sand, trace gravel Hard Brown to red Wet		9	SS	36		174								
			10	SS	100/0.29	173									
171.9 8.5	END OF BOREHOLE NOTE: 1. Water level was not measured due to added water during drilling.					172									


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

PROJECT		RECORD OF BOREHOLE No RW-11				SHEET 2 OF 2		METRIC									
G.W.P. 2116-16-00		LOCATION N 4755557.6; E 346438.6 MTM NAD 83 ZONE 10 (LAT. 42.938681; LONG. -78.989813)				ORIGINATED BY MA											
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY EN/KN											
DATUM Geodetic		DATE September 19, 2018				CHECKED BY MAS											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
170.9	CLAYEY SILT, trace to some sand, trace to some gravel		11A	SS	18												
15.8	Very stiff Brown Moist		11B														
170.2	Sandy SILT, some gravel, trace clay																
16.5	Grey Moist																
169.3	SAND, some silt, contains some sandy silt layers		12	SS	35												
17.4	Dense Grey Wet																
	END OF BOREHOLE																
	NOTES:																
	1. Water level in open borehole at a depth of 13.8 m below ground surface (Elev. 172.9 m) on completion of drilling.																
	2. Borehole caved to a depth of 4.3 m on removal of augers.																



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

PROJECT		RECORD OF BOREHOLE				No HF-7		SHEET 2 OF 2		METRIC							
G.W.P. 2116-16-00		LOCATION		N 4755529.8; E 346465.7 MTM NAD 83 ZONE 10 (LAT. 42.938429; LONG. -78.989483)				ORIGINATED BY		MA							
DIST Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY		EN/KN							
DATUM Geodetic		DATE		September 11 and 19, 2018				CHECKED BY		MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
169.0	CLAYEY SILT, trace to some sand Very stiff to hard Brown Moist		11	SS	38												
168.8	SILT and SAND, trace to some clay Dense Brown Wet		12	SS	22												
167.5	SANDY CLAYEY SILT, contains some sandy silt seams Brown Wet		13A	SS	18												
			13B														
166.8	SANDY CLAYEY SILT, contains some sandy silt seams Brown Wet		14A	SS	31												
			14B														
166.8	SAND and GRAVEL, trace silt Compact to very dense Grey Wet		15	SS	27												
164.9	END OF BOREHOLE SPLIT-SPOON REFUSAL		16	SS	100/0.02												
22.9	NOTES: 1. Borehole HF-7A was advanced 1.4 m south and 0.3 m west of Borehole HF-7. 2. Water level in open borehole at a depth of 14.3 m below ground surface (Elev. 173.5 m) on completion of drilling. 3. Borehole caved to 20.4 m on removal of augers. 4. Water level in open borehole at a depth of 8.2 m (Elev. 179.6 m) on removal of augers.																



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

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PROJECT		1671430 WO1		RECORD OF BOREHOLE No CN/CP3		SHEET 2 OF 3		METRIC									
G.W.P.		2116-16-00		LOCATION		N 4755515.3; E 346479.4 MTM NAD 83 ZONE 10 (LAT. 42.938298; LONG. -78.989317)		ORIGINATED BY JK									
DIST		Central HWY QEW		BOREHOLE TYPE		203 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN									
DATUM		Geodetic		DATE		August 27 and 28, 2018		CHECKED BY NK									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
--- CONTINUED FROM PREVIOUS PAGE ---																	
169.0	CLAYEY SILT, trace sand to sandy, trace to some gravel Stiff to very stiff Red to brown Moist - Auger grinding on inferred cobbles at 15.8 m		13	SS	20												
169.4	Sandy SILT, trace to some clay, trace gravel Dense Red-brown Moist - Seepage noted at 19.8 m		14	SS	27												
166.8	SAND and GRAVEL, some silt, trace clay Very dense Grey Moist		15	SS	18												
165.2	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 23.2 m to 27.1 m. For rock coring details refer to Record of Drillhole CN/CP3.		16	SS	34												
165.2			17	SS	155/0.20												
23.2			1	RC	REC 93%												
			2	RC	REC 89%												
			3	RC	REC 100%												
161.3	END OF BOREHOLE																
27.1	NOTES: 1. Water level at a depth of 12.5 m below ground surface (Elev. 175.9 m) prior to rock coring. 2. Water level at a depth of 12.3 m (Elev. 176.1 m) after rock coring.																

GTA-MTO 001 S:\CLIENTS\MTQEW-BERTIE\02_DATAGINT\QEW-BERTIE.GPJ GAL-GTA.GDT 19-5-22

PROJECT: 1671430 W01

RECORD OF DRILLHOLE: CN/CP3

SHEET 3 OF 3

LOCATION: N 4755515.30 ;E 346479.40

DRILLING DATE: August 28, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY															FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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DEPTH SCALE

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LOGGED: JK/EN

CHECKED: EN


GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02_DATA\GINT\QEW-BERTIE.GPJ GAL-MISS.GDT 19-5-22

PROJECT 1671430		RECORD OF BOREHOLE No CN/CP9		SHEET 1 OF 2		METRIC													
G.W.P. 2116-16-00		LOCATION N 4755424.5; E 346532.6 MTM NAD 83 ZONE 10 (LAT. 42.937469; LONG. -78.988668)		ORIGINATED BY LK															
DIST Central HWY QEW		BOREHOLE TYPE 203 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig		COMPILED BY EN															
DATUM Geodetic		DATE November 29, 2018		CHECKED BY NK															
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40
180.0	GROUND SURFACE																		
0.0	TOPSOIL (200 mm)																		
0.2	SILTY CLAY, trace to some sand, trace gravel, trace rootlets to a depth of 1.4 m Soft to stiff Mottled grey-brown Moist		1A	SS	3														
			1B																
			2	SS	5														
			3	SS	11														
			4	SS	11														
			5	SS	9														
			6	SS	9														
			7	SS	12														
174.4																			
5.6	Gravelly Sandy CLAYEY SILT Stiff to very stiff Brown Moist		8	SS	9														
172.1			9A	SS	21														
7.9	SAND and GRAVEL, trace to some silt, trace clay Compact Grey Wet		9B																
			10	SS	27														
			11	SS	22														
			12	SS	15														
			13	SS	26														

Continued Next Page

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

GTA-MTO 001 S:\CLIENTS\MTQ\QEW-BERTIE\02_DATA\GINT\QEW-BERTIE.GPJ GAL-GTA.GDT 19-5-22

PROJECT		RECORD OF BOREHOLE				No CN/CP9		SHEET 2 OF 2		METRIC							
G.W.P. 2116-16-00		LOCATION				N 4755424.5; E 346532.6 MTM NAD 83 ZONE 10 (LAT. 42.937469; LONG. -78.988668)				ORIGINATED BY LK							
DIST Central HWY QEW		BOREHOLE TYPE				203 mm O.D Hollow Stem Augers; CME 55 Track-mounted Drill Rig				COMPILED BY EN							
DATUM Geodetic		DATE				November 29, 2018				CHECKED BY NK							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---																
164.5	DOLOMITIC LIMESTONE (BEDROCK) Bedrock cored from 15.5 m to 18.6 m. For coring details refer to Record of Drillhole CN/CP9		14	SS	50/0.03												
15.5			1	RC	REC 100%												RQD = 69%
			2	RC	REC 100%												RQD = 91%
161.4	END OF BOREHOLE																
18.6	NOTES: 1. Water level at a depth of 7.9 m below ground surface (Elev. 172.1 m) in hollow stem augers on completion of drilling and prior to rock coring.																

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PROJECT: 1671430

RECORD OF DRILLHOLE: CN/CP9

SHEET 1 OF 1

LOCATION: N 4755424.50 ;E 346532.60

DRILLING DATE: November 29, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY												FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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DEPTH SCALE

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LOGGED: LK/JL

CHECKED: EN

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

PROJECT		RECORD OF BOREHOLE				No CN/CP12		SHEET 2 OF 2		METRIC							
G.W.P. 2116-16-00		LOCATION		N 4755416.3; E 346563.7 MTM NAD 83 ZONE 10 (LAT. 42.937402; LONG. -78.988291)				ORIGINATED BY		JK							
DIST Central HWY QEW		BOREHOLE TYPE		203 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY		EN							
DATUM Geodetic		DATE		August 23 and 24, 2018				CHECKED BY		NK							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
172.3	CLAYEY SILT, trace sand to sandy, trace to some gravel Stiff Red-brown Moist		13	SS	12												
16.3	SAND and GRAVEL, trace to some silt, trace clay Compact to very dense Grey Wet		14	SS	29												30 59 9 2
	- 0.1 m sand layer at 19.8 m		16A	SS	31												
			16B	SS	31												
	- Augers grinding on inferred cobbles at 20.7 m and between 21.6 m and 22.9 m																
			17	SS	39												
165.3			18	SS	69												
23.3	DOLOMITIC LIMESTONE (BEDROCK)																
	Bedrock cored from 23.3 m to 27.2 m.		1	RC	REC 94%												RQD = 94%
	For rock coring details refer to Record of Drillhole CN/CP12.		2	RC	REC 100%												RQD = 94%
			3	RC	REC 100%												RQD = 100%
161.4																	
27.2	END OF BOREHOLE																
	NOTES: 1. Water level at a depth of 12.2 m below ground surface (Elev. 176.4 m) prior to rock coring.																

PROJECT: 1671430 W01

RECORD OF DRILLHOLE: CN/CP12

SHEET 1 OF 1

LOCATION: N 4755416.30 ;E 346563.70

DRILLING DATE: August 24, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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DEPTH SCALE

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LOGGED: JK/EN

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GTA-MTO 001 S:\CLIENTS\IMTO\QEW-BERTIE\02 DATA\GINT\QEW-BERTIE.GPJ GAL-GTA.GDT 19-5-22

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



GTA-MTO 001 S:\CLIENTS\IMTO\QEW-BERTIE\02 DATA\GINT\QEW-BERTIE.GPJ GAL-GTA.GDT 19-5-22

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



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

PROJECT: 1671430 W01

RECORD OF DRILLHOLE: CN/CP10

SHEET 3 OF 3

LOCATION: N 4755407.50 ;E 346584.20

DRILLING DATE: August 29, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY													FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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DEPTH SCALE

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LOGGED: JK/EN

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No RW-14				SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755382.9; E 346559.5 MTM NAD 83 ZONE 10 (LAT. 42.937102; LONG. -78.988345)		ORIGINATED BY		LK							
DIST		Central HWY QEWS		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY		EN							
DATUM		Geodetic		DATE		January 25, 2019		CHECKED BY		MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
181.5	GROUND SURFACE																
0.0	TOPSOIL (300 mm)		1A	SS	5												
0.3	CLAYEY SILT with SAND, trace gravel Firm Mottled greyish-brown Moist		1B														
180.5			2A	SS	7												4 30 43 23
1.0	SILT and SAND, trace clay, trace gravel Loose to compact Brown Moist to wet		2B														
			3	SS	20												2 62 32 4
			4	SS	25												
178.5																	
3.0	Sandy CLAYEY SILT, trace to some gravel Stiff to very stiff Grey Moist		5	SS	15												
			6	SS	12												10 24 43 23
			7	SS	16												
175.7																	
5.8	SPLIT SPOON REFUSAL END OF BOREHOLE		8	SS	80/0.05												
	NOTE: 1. Water level in open borehole not recorded.																

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PROJECT		1671430 WO1		RECORD OF BOREHOLE No CN/CP13				SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755394.3; E 346597.0 MTM NAD 83 ZONE 10 (LAT. 42.937202; LONG. -78.987885)				ORIGINATED BY		JK					
DIST		Central HWY QEWE		BOREHOLE TYPE		152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY		EN					
DATUM		Geodetic		DATE		August 30, 2018				CHECKED BY		NK					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
187.9	GROUND SURFACE																
0.0	ASPHALT (360 mm)																
187.5																	
187.1	Sand and gravel (FILL) Brown Moist		1A														
0.9	Sand (FILL) Red-brown Moist		1B	SS	10												
	Silty clay, trace sand to sandy, trace gravel, trace organics to 8.4 m (FILL) Soft to stiff Red-brown Moist		2	SS	10												
			3	SS	4												
			4	SS	8												
			5	SS	6												
			6	SS	5												
			7	SS	10												
			8	SS	12												
179.2	Sandy SILTY CLAY, trace gravel Very stiff Red-brown Moist																
8.7																	
178.1			9	SS	19												
9.8	END OF BOREHOLE																
	NOTE: 1. Open borehole dry on completion of drilling.																

PROJECT		1671430 WO8		RECORD OF BOREHOLE No HF-9		SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755349.7; E 346581.9 MTM NAD 83 ZONE 10 (LAT. 42.936802; LONG. -78.988074)		ORIGINATED BY							
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY							
DATUM		Geodetic		DATE		January 10-11, 2019		CHECKED BY							
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES										
181.5	GROUND SURFACE														
0.0	TOPSOIL (700 mm) Firm Dark brown		1	SS	7										
180.8															
0.7	Sandy SILTY CLAY, trace to some gravel Stiff to very stiff Mottled greyish brown		2	SS	9										
			3	SS	18										
			4	SS	13										
			5	SS	9										
177.8															
3.7	SILT and SAND, trace clay Very dense Greyish to brown		6A	SS	50/0.18										
177.2			6B	SS											
4.3	Moist LIMESTONE (BEDROCK)														
	Bedrock cored from 4.3 m to 9.0 m. For rock coring details refer to Record of Drillhole HF-9.		1	RC	REC 53%										
			2	RC	REC 67%										
			3	RC	REC 38%										
172.5															
9.0	END OF BOREHOLE														
	NOTE: 1. Borehole dry prior to rock coring.														

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: HF-9

SHEET 1 OF 1

LOCATION: N 4755349.69 ;E 346581.86

DRILLING DATE:

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45 Track-Mounted Drill Rig

DRILLING CONTRACTOR: OGS Drilling Rig

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY															FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	EXP w.r.t. CORE AXIS	DISCONTINUITY DATA					WEATH- ERING INDEX							Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcom	W1	W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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DEPTH SCALE

1 : 50



LOGGED:

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PROJECT 1671430 WO8		RECORD OF BOREHOLE No RW-10		SHEET 1 OF 2		METRIC	
G.W.P. 2116-16-00		LOCATION N 4755347.4; E 346630.3 MTM NAD 83 ZONE 10 (LAT. 42.936778; LONG. -78.987481)		ORIGINATED BY MA			
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN/KN			
DATUM Geodetic		DATE September 21, 2018		CHECKED BY MAS			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED		WATER CONTENT (%) w _p w w _L				
186.6	GROUND SURFACE													
0.0	ASPHALT (340 mm)													
186.3														
0.3	Sand and gravel, some silt (FILL) Compact Brown Moist		1A 1B 1C	SS	17									
185.5														
1.3	Sand, trace silt (FILL) Compact Brown Moist		2A 2B	SS	9									
184.9														
1.7	Clayey silt, trace sand, trace gravel (FILL) Stiff Brown Moist		3	SS	7									
184.4														
2.2	Silty sand, trace topsoil, clayey silt layers (FILL) Loose Brown Moist		4	SS	4									
	Clayey silt, trace to some sand, trace to some gravel, trace topsoil, trace wood fragments (FILL) Soft to stiff Brown and grey Moist													
			5	SS	10									
181.0														
5.6	SILTY CLAY, some sand, trace to some gravel Very stiff Brown Moist to wet		6	SS	17									
			7	SS	17									
			8	SS	23									
175.9														
10.7	Gravelly SAND, some silt, trace clay Compact to very dense Grey Wet		9	SS	37									
			10	SS	31									
			11	SS	17									
			12	SS	57									

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

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

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

PROJECT 1671430 WO8		RECORD OF BOREHOLE No HF-10				SHEET 1 OF 2			METRIC				
G.W.P. 2116-16-00		LOCATION N 4755331.9; E 346645.1 MTM NAD 83 ZONE 10 (LAT. 42.936638; LONG. -78.987300)				ORIGINATED BY JK							
DIST Central HWY QEW		BOREHOLE TYPE 152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY EN/KN							
DATUM Geodetic		DATE September 6 and 7, 2018				CHECKED BY MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
186.2	GROUND SURFACE							20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
0.0	ASPHALT (280 mm)							20 40 60 80 100	WATER CONTENT (%)				
185.9													
0.3	Sand and gravel (FILL) Compact Brown Moist												
185.1			1	SS	24								
1.2	Sand (FILL) Compact Brown Moist												
	Sandy clayey silt, trace gravel, trace organics (FILL) Firm to very stiff Grey-brown Moist		2	SS	7								
			3	SS	7							3 21 46 30	
			4	SS	11								
181.7													
4.5	Sandy CLAYEY SILT to CLAYEY SILT with SAND, trace gravel Firm to stiff Grey Moist		5	SS	9							0 39 37 24	
			6A 6B	SS	5								
178.4			7A 7B	SS	117							2 25 52 21	
7.8	SAND and GRAVEL, some silt, trace clay, some rock fragments Compact to very dense Grey Moist to wet below 10.7 m												
			8	SS	113							37 46 13 4	
	- Augers grinding at 9.8 m and between 10.1 m and 10.7 m												
	- Seepage observed at a depth of 10.7 m		9	SS	26								
	- Augers grinding between 11.6 m and 12.2 m		10	SS	25								
172.1			11	SS	128/0.23								
14.1	END OF BOREHOLE												

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

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PROJECT 1671430 WO8		RECORD OF BOREHOLE No HF-10		SHEET 2 OF 2		METRIC	
G.W.P. 2116-16-00		LOCATION N 4755331.9; E 346645.1 MTM NAD 83 ZONE 10 (LAT. 42.936638; LONG. -78.987300)		ORIGINATED BY JK			
DIST Central HWY QEW		BOREHOLE TYPE 152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN/KN			
DATUM Geodetic		DATE September 6 and 7, 2018		CHECKED BY MAS			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _p	W	W _L						
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	NOTES: 1. Water level in open borehole at a depth of 9.7 m below ground surface (Elev. 176.5 m) on completion of drilling. 2. Borehole caved to 10.5 m depth on removal of augers. 3. Water level in open borehole at a depth of 9.0 m below ground surface (Elev. 177.2 m) on removal of augers.																				

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PROJECT		RECORD OF BOREHOLE				No HF-11		SHEET 1 OF 2		METRIC							
G.W.P. 2116-16-00		LOCATION		N 4755278.6; E 346653.9 MTM NAD 83 ZONE 10 (LAT. 42.936158; LONG. -78.987197)				ORIGINATED BY		LK							
DIST Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig				COMPILED BY		JMP							
DATUM Geodetic		DATE		January 12, 2019				CHECKED BY		MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
183.7	GROUND SURFACE																
183.4	Silty sand, trace organics, wood fragments (FILL) Very loose Black Moist		1	SS	3												GR SA SI CL
183.0	Silt and sand, trace to some clay (FILL) Very loose to loose Brown to reddish brown Moist		2	SS	9												0 35 56 9
181.9	- Dolostone fragments at a depth of 1.6 m		3	SS	250/10.0%												
181.8	LIMESTONE (BEDROCK)																
	Bedrock cored from 1.8 m to 6.2 m. For rock coring details refer to Record of Drillhole HF-11.		1	RC	REC 86%												RQD = 83%
			2	RC	REC 41%												RQD = 14%
			3	RC	REC 83%												RQD = 42%
177.5	END OF BOREHOLE																
6.2	NOTE: 1. Open borehole dry prior to rock coring.																

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: HF-11

SHEET 2 OF 2

LOCATION: N 4755278.63 ;E 346653.88

DRILLING DATE: January 12, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45 Track-Mounted Drill Rig

DRILLING CONTRACTOR: OGS Drilling Rig

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP wrt. CORE AXIS °	DISCONTINUITY DATA				WEATH- ERING INDEX				Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon	W1	W2	W3	W4		W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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DEPTH SCALE

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LOGGED: LK

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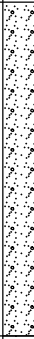
+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

PROJECT 1671430 WO8		RECORD OF BOREHOLE No HF-12				SHEET 1 OF 2		METRIC				
G.W.P. 2116-16-00		LOCATION N 4755267.2; E 346703.6 MTM NAD 83 ZONE 10 (LAT. 42.936052; LONG. -78.986588)				ORIGINATED BY JK						
DIST Central HWY QEW		BOREHOLE TYPE 152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY EN/KN						
DATUM Geodetic		DATE September 6, 2018				CHECKED BY MAS						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w		
184.2	GROUND SURFACE											
0.0	ASPHALT (180 mm)											
0.2	Sand and gravel (FILL)											
183.3	Brown-grey Moist											
1.0	Sand (FILL)		1	SS	5							
	Loose Brown-red Moist											
182.4	Sandy clayey silt (FILL)											
1.8	Firm Brown Moist											
	Sandy CLAYEY SILT, trace gravel		2	SS	14							
181.2	Stiff to very stiff Brown Moist											
3.0	SILT and SAND, trace to some clay		3	SS	8							
	Loose to compact Brown Moist											
			4	SS	25							
179.5												
179.2	Sandy CLAYEY SILT, trace gravel		5	SS	23							
5.0	Very stiff Brown Moist											
	SAND and GRAVEL, trace to some silt, trace clay, contains broken rock fragments											
	Compact to very dense Brown Moist to wet below 7.2 m		6	SS	164/0.23							
	- Augers grinding between a depth of 6.7 m and 7.6 m											
			7	SS	34							
	- Seepage observed at 8.2 m											
			8	SS	30							
	- Augers grinding between a depth of 10.2 m and 10.4 m											
			9	SS	63							
	- Augers grinding between a depth of 13.7 m and 14.5 m											
			10	SS	29							
171.2												
13.0	Sandy SILT, trace gravel											
	Very dense Grey Wet											
170.5			11	SS	100/0.02							
13.7	SAND and GRAVEL, trace to some silt, trace clay, contains broken rock fragments											
	Very dense Grey Wet											

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

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PROJECT		RECORD OF BOREHOLE No HF-12				SHEET 2 OF 2		METRIC									
G.W.P. 2116-16-00		LOCATION N 4755267.2; E 346703.6 MTM NAD 83 ZONE 10 (LAT. 42.936052; LONG. -78.986588)				ORIGINATED BY JK											
DIST Central HWY QEW		BOREHOLE TYPE 152 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig				COMPILED BY EN/KN											
DATUM Geodetic		DATE September 6, 2018				CHECKED BY MAS											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100						
	SAND and GRAVEL, trace to some silt, trace clay, contains broken rock fragments Very dense Grey Wet		12	SS	100/0.02												
	- Augers grinding at a depth of 17.1 m		13	SS	100/0.02												
165.9	END OF BOREHOLE		14	SS	100/0.02												
18.3	NOTES: 1. Water level in open borehole at a depth of 18.0 m below ground surface (Elev. 166.2 m) on completion of drilling. 2. Borehole caved to 13.3 m on removal of augers. 3. Water level in open borehole at a depth of 7.5 m below ground surface (Elev. 176.7 m) on removal of augers.																

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No C1-1		SHEET 1 OF 2		METRIC						
G.W.P.		2116-16-00		LOCATION		N 4755249.3; E 346719.3 MTM NAD 83 ZONE 10 (LAT. 42.935891; LONG. -78.986398)		ORIGINATED BY JK						
DIST		Central HWY QEW		BOREHOLE TYPE		203 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN/KN						
DATUM		Geodetic		DATE		September 4, 2018		CHECKED BY NK						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
183.7	GROUND SURFACE													
0.0	ASPHALT (200 mm)													
0.2	Sand and gravel (FILL) Brown													
182.9														
0.9	Sand (FILL) Loose Brown-red Moist		1A	SS	9									
			1B											
	Sandy clayey silt, trace gravel (FILL) Stiff Brown-grey Moist		2	SS	9									
			3	SS	12									
180.7														
3.0	SILT and SAND, some clay, trace gravel Compact Brown Moist		4	SS	17									2 40 44 14
180.0														
3.7	Sandy CLAYEY SILT, trace gravel Hard Brown Moist		5A	SS	71									
179.6			5B											
4.1	Dolomitic Limestone (BEDROCK)													
	- Augers grinding below a depth of 4.3 m													
	- Auger refusal at 4.5 m													
	- Cored from 4.5 m to 5.9 m													
			6	SS	128									
	- Auger grinding between depths of 6.9 m and 7.0 m, and at 8.2 m													
			7	SS	20									30 52 15 3
	- Auger refusal at 8.7 m													
	- Augered to 8.7 m		1	RC	REC 22%									RQD = 0%
	Bedrock cored from 8.7 m to 13.4 m.													
	For rock details refer to Record of Drillhole C1-1.		2	RC	REC 8%									RQD = 0%
			3	RC	REC 10%									RQD = 0%
170.3														
13.4	END OF BOREHOLE													
NOTES:														
1. Open borehole dry prior to rock coring.														

Continued Next Page

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

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

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C1-1

SHEET 1 OF 1

LOCATION: N 4755249.34 ;E 346719.27


DRILLING DATE: September 4, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	EXP w.r.t. CORE AXIS CORR	DISCONTINUITY DATA				WEATH- ERING INDEX	Diametral Point Load Index (MPa)					
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION		Jr	Ja			Jcom				
						000000	000000				000000	000000	000000	000000			000000	000000			
		Continued from Record of Borehole C1-1		174.96																	
9	Rotary Diamond Drill HQ Core	Highly weathered, medium to thickly bedded, grey, fine grained, slightly porous, medium strong, DOLOMITIC LIMESTONE (Bois Blanc Formation)		8.69																	
				1																	
10																					
11				2																	
12																					
13																					
		END OF DRILLHOLE		170.24 13.41																	
14																					
15																					
16																					
17																					
18																					

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: KN/JK

CHECKED: NK

GTA-RCK 046 S:\CLIENTS\MTQ\QEW-BERTIE\02_DATA\GINT\QEW-BERTIE.GPJ GAL-MISS.GDT 19-5-22

PROJECT		1671430 WO8F		RECORD OF BOREHOLE No C1-2		SHEET 1 OF 1		METRIC					
G.W.P.		2116-16-00		LOCATION		N 4755217.3; E 346711.3 MTM NAD 83 ZONE 10 (LAT. 42.935603; LONG. -78.986498)		ORIGINATED BY					
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY					
DATUM		Geodetic		DATE		January 8, 2019		CHECKED BY					
								NK					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p W W _L			
181.8	GROUND SURFACE												
0.0	Clayey silt with sand, trace to some gravel, organics (FILL)		1A	SS	19								8 32 42 18
181.4	Very stiff Brown Moist		1B	SS	19								
0.4	Dolomitic Limestone (BEDROCK)		2	SS	100/0.0								
	Bedrock cored from 0.8 m to 4.1 m.		1	RC	REC 94%								RQD = 84%
	For rock coring details refer to Record of Drillhole C1-2.		2	RC	REC 82%								RQD = 78%
			3	RC	REC 27%								RQD = 20%
177.7	END OF BOREHOLE												
4.1	NOTES:												
	1. Borehole dry prior to rock coring.												
	2. Water level in standpipe piezometer												
	Date Depth (m) Elev. (m)												
	Jan. 13. 2019 3.9 177.9												
	Feb. 08. 2019 3.2 178.6												
	Feb. 22. 2019 3.8 178.0												

PROJECT: 1671430 W08F

RECORD OF DRILLHOLE: C1-2

SHEET 1 OF 1

LOCATION: N 4755217.33 ;E 346711.26

DRILLING DATE: January 10, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45 Truck mounted Drill Rig

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY												FEATURES	PIEZOMETER							
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	EXP w.r.t. CORE AXIS	DISCONTINUITY DATA				WEATH- ERING INDEX					Diametral Point Load Index (MPa)						
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcom	W1	W2	W3				W4	W5	W6			
						000000	000000																			
1	Rotary Diamond Drill HQ Core	Continued from Record of Borehole C1-2		181.01	1									LC												
		Slightly to highly weathered, medium to thickly bedded, grey, fine grained, slightly porous, medium strong, DOLOMITIC LIMESTONE (Bois Blanc Formation)		0.79																						
2					2																					

PROJECT		RECORD OF BOREHOLE				No HF-13		SHEET 1 OF 1		METRIC							
G.W.P. 1671430 WO8		LOCATION		N 4755209.5; E 346739.8 MTM NAD 83 ZONE 10 (LAT. 42.935531; LONG. -78.986150)				ORIGINATED BY LK									
DIST Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig				COMPILED BY JMP									
DATUM Geodetic		DATE		January 12, 2019				CHECKED BY MAS									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
181.9	GROUND SURFACE																
0.0	Sandy clayey silt, trace gravel, trace organics, trace rootlets (FILL)		1A	SS	4												
181.3	Soft		1B														
0.6	Brown to brownish red to grey Moist END OF BOREHOLE SPLIT-SPOON REFUSAL																
NOTE: 1. Open borehole dry upon completion of drilling.																	

PROJECT		1671430 WO8		RECORD OF BOREHOLE		No RW-9		SHEET 1 OF 1		METRIC						
G.W.P.		2116-16-00		LOCATION		N 4755300.4; E 346712.2 MTM NAD 83 ZONE 10 (LAT. 42.936351; LONG. -78.986480)		ORIGINATED BY		EN						
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY		EN/KN						
DATUM		Geodetic		DATE		September 17, 2018		CHECKED BY		MAS						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
185.1	GROUND SURFACE															
0.0	ASPHALT (150 mm)															
0.2	Silty sand and gravel, trace asphalt (FILL) Dense Grey Moist		1	AS	-											
183.9			2A	SS	44											
1.2	Silty clay, some sand to sandy, trace gravel (FILL) Firm to stiff Brown Moist		2B													
			3	SS	6											
			4	SS	9											
			5	SS	10											
181.4																
3.7	Sandy CLAYEY SILT, trace to some gravel Very stiff Red-brown Moist		6	SS	20											
			7	SS	17											
179.0																
6.1	Silty SAND, trace to some clay, some clayey silt pockets Compact Brown Wet		8	SS	14											
			9	SS	29											
176.4																
8.7	Gravelly SAND, some silt, trace clay, contains shale fragments Very dense Brown Wet															
175.7			10	SS	50/0.10											
9.4	END OF BOREHOLE															
NOTES:																
1. Water level in open borehole at a depth of 5.5 m below ground surface (Elev. 179.6 m) on completion of drilling.																

PROJECT		1671430 W08		RECORD OF BOREHOLE No C1-3		SHEET 1 OF 1		METRIC																	
G.W.P.		2116-16-00		LOCATION		N 4755255.7; E 346753.3 MTM NAD 83 ZONE 10 (LAT. 42.935947; LONG. -78.985981)		ORIGINATED BY																	
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME45 Track/CME75 Truck mounted Drill Rigs		COMPILED BY																	
DATUM		Geodetic		DATE		January 26, 2019		CHECKED BY																	
								NK																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																			
184.1	0.0	GROUND SURFACE																							
183.8	0.3	ASPHALT (300 mm)																							
183.3	0.3	Sand and gravel to silty sand and gravel (FILL) Grey to dark grey		1	AS																				
183.3	1.0	Sand and gravel, trace silt to silty (FILL) Very dense Grey Dry		2	SS	50/0.25																			
183.3	1.0	Sandy clayey silt, trace gravel (FILL) Soft to very stiff Mottled grey brown Moist		3	SS	24																			
183.3	1.0			4	SS	13																			
183.3	1.0			5	SS	4																			
180.4	3.7	CLAYEY SILT, some sand, trace gravel Firm to hard Mottled grey-brown Moist to wet		6	SS	8																			
180.4	3.7	- Auger increased resistance between 5.3 m and 5.5 m		7	SS	24																			
180.4	3.7			8	SS	33																			
176.5	7.6	Dolomitic Limestone (BEDROCK)		9	SS	24																			
176.5	7.6	Bedrock cored from 8.6 m to 10.1 m. For rock coring details refer to Record of Drillhole C1-3.																							
176.5	7.6			1	RC	REC 39%																			
174.0	10.1	END OF BOREHOLE																							
174.0	10.1	NOTE: 1. Water level in borehole at a depth of 7.5 m (Elev. 176.6 m) below ground surface prior to rock coring. 2. Water level in standpipe piezometer Date Depth (m) Elev. (m) Feb. 08, 2019 3.2 180.9 Feb. 22, 2019 5.9 178.2																							

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C1-3

SHEET 1 OF 1

LOCATION: N 4755255.74 ;E 346753.25

DRILLING DATE: January 26, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 75 Truck Mounted Drill Rig

DRILLING CONTRACTOR: OGS

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				DEPTH (m)	ELEV.			RECOVERY		R.Q.D. %	FRACT. INDEX PER	EXP. W/L. CORE AXIS	DISCONTINUITY DATA				WEATH- ERING INDEX		Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
								TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcom	W1	W2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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DEPTH SCALE

1 : 50

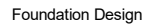
**GOLDER**

LOGGED: LK

CHECKED: NK

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PROJECT		RECORD OF BOREHOLE No RW-7				SHEET 1 OF 1		METRIC									
G.W.P. 1671430 WO8		LOCATION N 4755227.4; E 346780.4 MTM NAD 83 ZONE 10 (LAT. 42.935690; LONG. -78.985650)		ORIGINATED BY MA													
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY EN/KN													
DATUM Geodetic		DATE September 17, 2018		CHECKED BY MAS													
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
183.7	GROUND SURFACE																
0.0	ASPHALT (370 mm)																
183.3																	
182.9	Sand and gravel, some silt (FILL) Brown																
0.9	Sand, trace silt (FILL) Brown Moist		1	SS	41												
182.2	Sandy gravel, some silt, some asphalt (FILL) Dense Brown Moist		2	SS	14												
1.5																	
180.7	Clayey silt, trace to some organics/wood fragments, trace gravel, trace sand (FILL) Firm to stiff Brown Moist		3	SS	8												
3.0																	
	CLAYEY SILT with SAND, trace gravel Firm to very stiff Brown Moist		4	SS	8												
			5A	SS	9												
			5B														
			6A	SS	20												
178.6			6B														
5.1	Silty SAND and GRAVEL, trace clay Compact Brown Moist																
177.9																	
177.5	CLAYEY SILT, trace gravel, trace sand Brown Moist		7A	SS	32												
6.2			7B														
	Gravelly SAND, some silt, trace clay, some rock fragments Dense to very dense Brown Moist																
			8	SS	62												
175.5																	
8.2	END OF BOREHOLE																
NOTES:																	
1. Water level in open borehole at a depth of 7.3 m below ground surface (Elev. 176.4 m) on completion of drilling.																	
2. Borehole caved to a depth of 7.0 m on removal of augers.																	
3. Water level in open borehole at a depth of 6.9 m below ground surface (Elev. 176.8 m) on removal of augers.																	



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

PROJECT 1671430 WO8		RECORD OF BOREHOLE No RW-6				SHEET 1 OF 2			METRIC						
G.W.P. 2116-16-00		LOCATION N 4755191.5; E 346813.2 MTM NAD 83 ZONE 10 (LAT. 42.935365; LONG. -78.985252)				ORIGINATED BY LK									
DIST Central HWY QEW		BOREHOLE TYPE 191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig				COMPILED BY JMP									
DATUM Geodetic		DATE January 14, 2019				CHECKED BY MAS									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
183.6	GROUND SURFACE														
0.0	ASPHALT (240 mm)														
183.0	Sand and gravel, trace asphalt pieces (FILL)		1A	SS	>50/0.2										
0.6	Very dense Grey Moist		1B												
182.5	Sand and gravel (FILL)		2A	SS	18										
1.1	Compact Grey Moist		2B												
	Sandy clayey silt, some gravel (FILL)		3	SS	13										
181.1	Stiff to very stiff Brown Moist		4A	SS	10										
2.5	Silty SAND, trace to some clay Compact to very dense Brown Moist		4B												
180.2	LIMESTONE (BEDROCK)		5	SS	>50/0.2										
3.4	Bedrock cored from 3.4 m to 9.2 m. For rock coring details refer to Record of Drillhole RW-6.		1	RC	REC 29%										
			2	RC	REC 54%										
			3	RC	REC 65%										
174.4	END OF BOREHOLE														
9.2	NOTE: 1. Water level at a depth of 4.9 m below ground surface (Elev. 178.7 m) prior to rock coring. 2. Water level at a depth of 6.6 m (Elev. 177.0 m) below ground surface measured on January 15, 2019 upon removal of augers and casing. 3. Water level in piezometer at a depth of 3.3 m below ground surface (Elev. 180.3 m) on February 22, 2019.														

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: RW-6

SHEET 2 OF 2

LOCATION: N 4755191.53 ;E 346813.16

DRILLING DATE: January 14, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: CME 45 Track-Mounted Drill Rig

DRILLING CONTRACTOR: OGS Drilling Rig

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY															FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA					WEATH- ERING INDEX	Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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DEPTH SCALE

1 : 50



LOGGED: LK

CHECKED: EN

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No HF-15		SHEET 1 OF 1		METRIC								
G.W.P.		2116-16-00		LOCATION		N 4755146.8; E 346807.2 MTM NAD 83 ZONE 10 (LAT. 42.934963; LONG. -78.985327)		ORIGINATED BY								
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY								
DATUM		Geodetic		DATE		January 12, 2019		CHECKED BY								
MAS																
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
183.0	GROUND SURFACE															
0.0	Clayey silt with sand, trace gravel, trace organics (FILL)		1A													
	Firm		1B	SS	5											
182.4	Dark brown to grey		2	SS	50/0.63											
0.6	Moist - Dolostone fragments, grey at a depth of 0.6 m															
	END OF BOREHOLE															
NOTE: 1. Open borehole dry upon completion of drilling.																

PROJECT		1671430 WO8		RECORD OF BOREHOLE No RW-5		SHEET 1 OF 1		METRIC								
G.W.P.		2116-16-00		LOCATION		N 4755154.8; E 346847.8 MTM NAD 83 ZONE 10 (LAT. 42.935033; LONG. -78.984830)		ORIGINATED BY								
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig		COMPILED BY								
DATUM		Geodetic		DATE		September 17, 2018		CHECKED BY								
								MAS								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
184.2	GROUND SURFACE															
0.0	ASPHALT (230 mm)															
0.2	Sand and gravel, some silt (FILL) Compact Brown Moist		1A	SS	29											
183.0			1B													
182.7	Sand, trace silt (FILL) Compact Brown-red Moist		2	SS	13											
1.5																
181.7	Sandy clayey silt, trace gravel (FILL) Stiff to hard Brown Moist		3A	SS	64											
			3B													
2.7	Sandy SILT, some gravel Very dense Brown Moist		4	SS	100/0.10											
	SAND and GRAVEL, trace to some silt, trace clay Compact to very dense Brown Moist		5	SS	100/0											
	- Containing dolostone cobbles and boulder between 2.7 m and 5.0 m depth		6	SS	60/0.05											
			7	SS	18											
			8	SS	27											
177.5																
6.7	END OF BOREHOLE															
NOTES:																
1. Open borehole dry on completion of drilling and on removal of augers.																

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No RW-4A		SHEET 1 OF 1		METRIC									
G.W.P.		2116-16-00		LOCATION		N 4755131.7; E 346868.7 MTM NAD 83 ZONE 10 (LAT. 42.934824; LONG. -78.984576)		ORIGINATED BY									
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Truck-mounted Drill Rig		COMPILED BY									
DATUM		Geodetic		DATE		September 21, 2018		CHECKED BY									
MAS																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
184.5	GROUND SURFACE																
0.0	ASPHALT (200 mm)																
0.2	Sand and gravel, some silt (FILL) Compact Brown Moist																
183.3			1A	SS	15												
1.2	Sand, trace silt (FILL) Compact Brown Moist		1B														
182.7			2A	SS	11												
1.8	Clayey silt, trace sand, trace gravel, sandy silt layers (FILL) Stiff to very stiff Brown Moist		2B														
181.6			3	SS	24												
181.3	Sandy SILT Very dense Brown Moist		4A	SS	80/0.07												
3.3			4B														
	SAND, some silt, trace gravel Very dense Brown Moist		5	SS	100/0												
			6	SS	100/0												
	SAND and GRAVEL, trace to some silt, trace clay Compact to very dense Brown Moist		7	SS	100/0												
	- Containing dolostone cobbles and boulder between 3.3 m and 5.5 m depth																
			8	SS	36												
			9	SS	15												
176.3																	
8.2	END OF BOREHOLE																
NOTES:																	
1. Open borehole dry during and on completion of drilling and on removal of augers.																	

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PROJECT		1671430 WO8		RECORD OF BOREHOLE No R1-1		SHEET 1 OF 1		METRIC						
G.W.P.		2116-16-00		LOCATION		N 4755030.0; E 346786.6 MTM NAD 83 ZONE 10 (LAT. 42.933912; LONG. -78.985589)		ORIGINATED BY						
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig		COMPILED BY						
DATUM		Geodetic		DATE		September 24, 2018		CHECKED BY						
								MAS						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
189.8	GROUND SURFACE													
0.0	ASPHALT (100 mm)													
188.9	Sand and gravel, some silt (FILL) Brown Moist													
0.9	Clayey silt, some sand, some gravel, trace topsoil seams (FILL) Stiff Brown Moist		1	SS	10									
187.6			2	SS	10									
2.2	Sand and gravel, some silt (FILL) Compact Brown Moist		3A	SS	29									
187.1			3B	SS	29									
186.8	Sand, trace silt (FILL) Compact Brown Moist		4	SS	6									
3.0	Clayey silt, some sand, trace to come gravel (FILL) Firm to very stiff Brown Moist													
185.0			5	SS	100/0.23									
4.8	END OF BOREHOLE AUGER REFUSAL													
NOTES: 1. Open borehole dry during and after completion of drilling and on removal of augers. 2. Borehole caved to 3.7 m on removal of augers.														

PROJECT		1671430 WO8		RECORD OF BOREHOLE No R1-2				SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4755052.6; E 346799.4 MTM NAD 83 ZONE 10 (LAT. 42.934115; LONG. -78.985430)		ORIGINATED BY		LK							
DIST		Central HWY QEW		BOREHOLE TYPE		191 mm O.D. Hollow Stem Augers; CME 45 Track-mounted Drill Rig		COMPILED BY		JMP							
DATUM		Geodetic		DATE		January 13, 2019		CHECKED BY		MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
185.6	GROUND SURFACE																
0.0	TOPSOIL (180 mm)																
0.2	Sandy clayey silt, trace to some gravel, trace organics (FILL) Soft to very stiff Brown Moist - Dolostone fragments at a depth of 1.1 m		1A	SS	3												8 29 44 19
184.5			1B														
1.1	END OF BOREHOLE SPLIT SPOON REFUSAL		2A	SS	30												
	NOTE: 1. Borehole dry upon completion of drilling.		2B														

PROJECT: 1671430 W08

RECORD OF DRILLHOLE: C3-2

SHEET 1 OF 1

LOCATION: N 4755062.89 ;E 346839.16

DRILLING DATE: September 24, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55 Track-Mounted Drill Rig

DRILLING CONTRACTOR: Geo-Environmental Drilling Inc.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES	PIEZOMETER																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS °	DISCONTINUITY DATA				WEATH- ERING INDEX							Diametral Point Load Index (MPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
						TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jzon	W1	W2	W3	W4	W5				W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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DEPTH SCALE

1 : 50



LOGGED: MA/EN

CHECKED: NK

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PROJECT		RECORD OF BOREHOLE				No R1-3		SHEET 1 OF 1		METRIC							
G.W.P. 2116-16-00		LOCATION				N 4755074.2; E 346840.4 MTM NAD 83 ZONE 10 (LAT. 42.934307; LONG. -78.984927)				ORIGINATED BY MA							
DIST Central HWY QEW		BOREHOLE TYPE				178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY EN/KN							
DATUM Geodetic		DATE				September 24, 2018				CHECKED BY MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
184.0	GROUND SURFACE																
0.0	TOPSOIL (130 mm)																
0.1	SILT, some clay, trace sand, trace gravel Brown																
183.2	END OF BOREHOLE AUGER REFUSAL																
0.8	NOTES: 1. Open borehole dry on completion of drilling.																

PROJECT		RECORD OF BOREHOLE				No R1-4		SHEET 1 OF 1		METRIC						
G.W.P. 2116-16-00		LOCATION		N 4755057.1; E 346877.7 MTM NAD 83 ZONE 10 (LAT. 42.934151; LONG. -78.984471)				ORIGINATED BY		MA						
DIST Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY		EN/KN						
DATUM Geodetic		DATE		September 24, 2018				CHECKED BY		MAS						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
184.0	GROUND SURFACE															
0.0	TOPSOIL (130 mm)															
0.1	Sandy SILT, some gravel Brown Moist															
183.1	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL															
0.9	NOTES: 1. Open borehole dry during and on completion of drilling.															

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PROJECT		RECORD OF BOREHOLE No R1-5				SHEET 1 OF 1		METRIC									
G.W.P. 2116-16-00		LOCATION N 4755034.3; E 346905.7 MTM NAD 83 ZONE 10 (LAT. 42.933945; LONG. -78.984130)				ORIGINATED BY MA											
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY EN/KN											
DATUM Geodetic		DATE September 24, 2018				CHECKED BY MAS											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
184.7	GROUND SURFACE																
0.0	TOPSOIL (75 mm)																
184.3	Sand, trace gravel, trace silt (FILL)																
0.4	Brown Silty clay, some sand, trace gravel (FILL)																
	Stiff Brown Moist		1A	SS	9												
			1B														
182.9			2	SS	103/0.15												
1.8	END OF BOREHOLE AUGER AND SPLIT SPOON REFUSAL																
NOTES:																	
1. Open borehole dry during and on completion of drilling and on removal of augers.																	

PROJECT		RECORD OF BOREHOLE				No R1-6		SHEET 1 OF 1		METRIC							
G.W.P. 2116-16-00		LOCATION				N 4755001.3; E 346931.0 MTM NAD 83 ZONE 10 (LAT. 42.933646; LONG. -78.983822)				ORIGINATED BY MA							
DIST Central HWY QEW		BOREHOLE TYPE				178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY EN/KN							
DATUM Geodetic		DATE				September 27, 2018				CHECKED BY MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
186.0	GROUND SURFACE																
0.0	Silty clay, some sand, trace to some gravel (FILL) Soft to stiff Brown Moist		1	SS	2		185										8 17 38 37
184.2	CLAYEY SILT, trace sand, trace gravel Stiff Brown Moist		2A 2B	SS	8												
2.0	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL NOTES: 1. Open borehole dry during and on completion of drilling.																

PROJECT		RECORD OF BOREHOLE				No R2-1		SHEET 1 OF 1		METRIC							
G.W.P. 1671430 WO8		LOCATION		N 4754977.0; E 347137.7 MTM NAD 83 ZONE 10 (LAT. 42.933416; LONG. -78.981292)				ORIGINATED BY		MA							
DIST Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY		EN/KN							
DATUM Geodetic		DATE		September 13, 2018				CHECKED BY		MAS							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
185.2	GROUND SURFACE																
0.0	Silty clay, trace sand, trace gravel, trace topsoil (FILL)																
184.8	Brown																
0.4	CLAYEY SILT, trace to some sand, trace gravel																
	Stiff to very stiff		1	SS	11												
	Brown																
	Moist		2	SS	29												
			3	SS	30												
			4A	SS	24												
181.7	CLAYEY SILT with SAND, some gravel		4B	SS	100/0.23												
3.5	Hard																
	Brown		5	SS	100/0.23												
	Moist																
180.7	POSSIBLE BEDROCK OR BOULDER		6	SS	100/0.03												
4.6	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL																
NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.																	

PROJECT		1671430 WO8		RECORD OF BOREHOLE No R2-2		SHEET 1 OF 1		METRIC										
G.W.P.		2116-16-00		LOCATION		N 4754939.4; E 347121.1 MTM NAD 83 ZONE 10 (LAT. 42.933079; LONG. -78.981498)		ORIGINATED BY										
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig		COMPILED BY										
DATUM		Geodetic		DATE		September 13, 2018		CHECKED BY										
MAS																		
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
184.4	GROUND SURFACE							20	40	60	80	100						
184.0	Silty sand and gravel, some clay (FILL) Brown						184											
184.1																		
0.3	SILTY CLAY, trace to some sand Stiff Brown Moist		1	SS	10													
183.0							183											
1.4	CLAYEY SILT with SAND, trace gravel Hard Brown Moist		2	SS	100/0.25													
182.3																		
2.1	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL		3	SS	100/0													
NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.																		

PROJECT		1671430 WO8		RECORD OF BOREHOLE No R2-3				SHEET 1 OF 1		METRIC							
G.W.P.		2116-16-00		LOCATION		N 4754920.6; E 347097.9 MTM NAD 83 ZONE 10 (LAT. 42.932910; LONG. -78.981783)				ORIGINATED BY							
DIST		Central HWY QEW		BOREHOLE TYPE		178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY							
DATUM		Geodetic		DATE		September 14, 2018				CHECKED BY							
MAS																	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
186.0	GROUND SURFACE																
0.0	Clayey silt, some sand, some gravel (FILL) Brown																
0.2	CLAYEY SILT, trace sand, trace gravel Very stiff Brown Moist		1A	SS	21												
184.8			1B														
184.5	CLAYEY SILT with SAND, some gravel Very stiff Brown Moist		2	SS	100/0												
1.5	END OF BOREHOLE AUGER REFUSAL																
NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.																	

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PROJECT <u>1671430 WO8</u>		RECORD OF BOREHOLE No R2-4		SHEET 1 OF 1		METRIC	
G.W.P. <u>2116-16-00</u>		LOCATION <u>N 4754921.4; E 347063.8 MTM NAD 83 ZONE 10 (LAT. 42.932919; LONG. -78.982201)</u>		ORIGINATED BY <u>MA</u>			
DIST <u>Central</u> HWY <u>QEW</u>		BOREHOLE TYPE <u>178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig</u>		COMPILED BY <u>EN/KN</u>			
DATUM <u>Geodetic</u>		DATE <u>September 14, 2018</u>		CHECKED BY <u>MAS</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L				WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE	20	40	60	80	100	● QUICK TRIAXIAL × REMOULDED						
184.7	GROUND SURFACE																			
0.0	CLAYEY SILT, trace gravel, trace sand Very stiff Brown Moist																			
			1	SS	28															
183.1																				
	CLAYEY SILT with SAND, some gravel Hard Brown Moist		2A 2B	SS	100/0.20															
182.7																				
2.0	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL																			
	NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.																			

PROJECT		RECORD OF BOREHOLE No R2-5				SHEET 1 OF 1		METRIC						
G.W.P. 2116-16-00		LOCATION N 4754944.2; E 347021.9 MTM NAD 83 ZONE 10 (LAT. 42.933127; LONG. -78.982713)				ORIGINATED BY MA								
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY EN/KN								
DATUM Geodetic		DATE September 14, 2018				CHECKED BY MAS								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
186.6	GROUND SURFACE													
0.0 186.3	ASPHALT (300 mm)													
0.3	Sand and gravel, some silt (FILL) Dense Brown Moist		1A	SS	31									
185.4	Sand, trace silt (FILL) Brown Moist		1B											
1.5	CLAYEY SILT, trace gravel, trace sand Very stiff Brown Moist		2	SS	18									
			3	SS	23									
183.4			4A 4B	SS	100/0.25									
3.2	CLAYEY SILT with SAND, trace to some gravel Hard Brown Moist		5	SS	70/0.10									
182.5			6	SS	100/0									
4.1	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL													
NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.														

PROJECT		RECORD OF BOREHOLE No R2-6				SHEET 1 OF 1		METRIC						
G.W.P. 2116-16-00		LOCATION N 4754965.7; E 347003.2 MTM NAD 83 ZONE 10 (LAT. 42.933322; LONG. -78.982940)				ORIGINATED BY MA								
DIST Central HWY QEW		BOREHOLE TYPE 178 mm O.D Hollow Stem Augers; CME 75 Track-mounted Drill Rig				COMPILED BY EN/KN								
DATUM Geodetic		DATE September 14, 2018				CHECKED BY MAS								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
186.2	GROUND SURFACE													
0.0	ASPHALT (200 mm)													
0.2	Sand and gravel, some silt (FILL) Compact Brown Moist													
185.1			1A	SS	23									
184.7	Sand, trace silt (FILL) Compact Brown Wet		1B											
1.5	Sandy CLAYEY SILT, trace gravel Very stiff to hard Brown Moist		2	SS	25									4 24 47 25
183.2			3	SS	33									
3.0	CLAYEY SILT with SAND, trace gravel Hard Brown Moist		4	SS	33									
182.3	- Augers grinding below a depth of 3.8 m													
3.9	END OF BOREHOLE SPLIT SPOON AND AUGER REFUSAL													
NOTES: 1. Open borehole dry during and on completion of drilling and on removal of augers.														

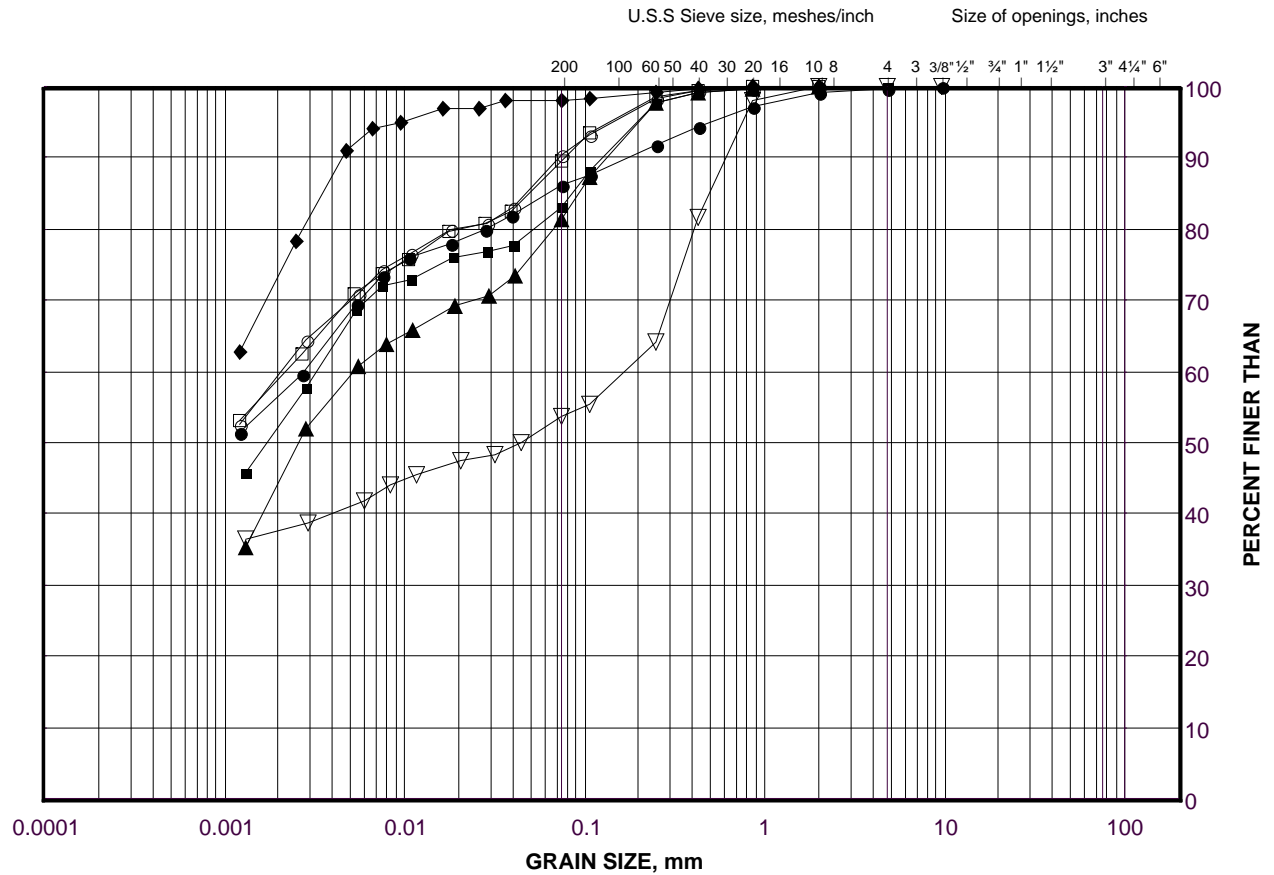
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Silty Clay with sand to Silty Clay to Clay (Fill)

FIGURE B-1



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

LEGEND

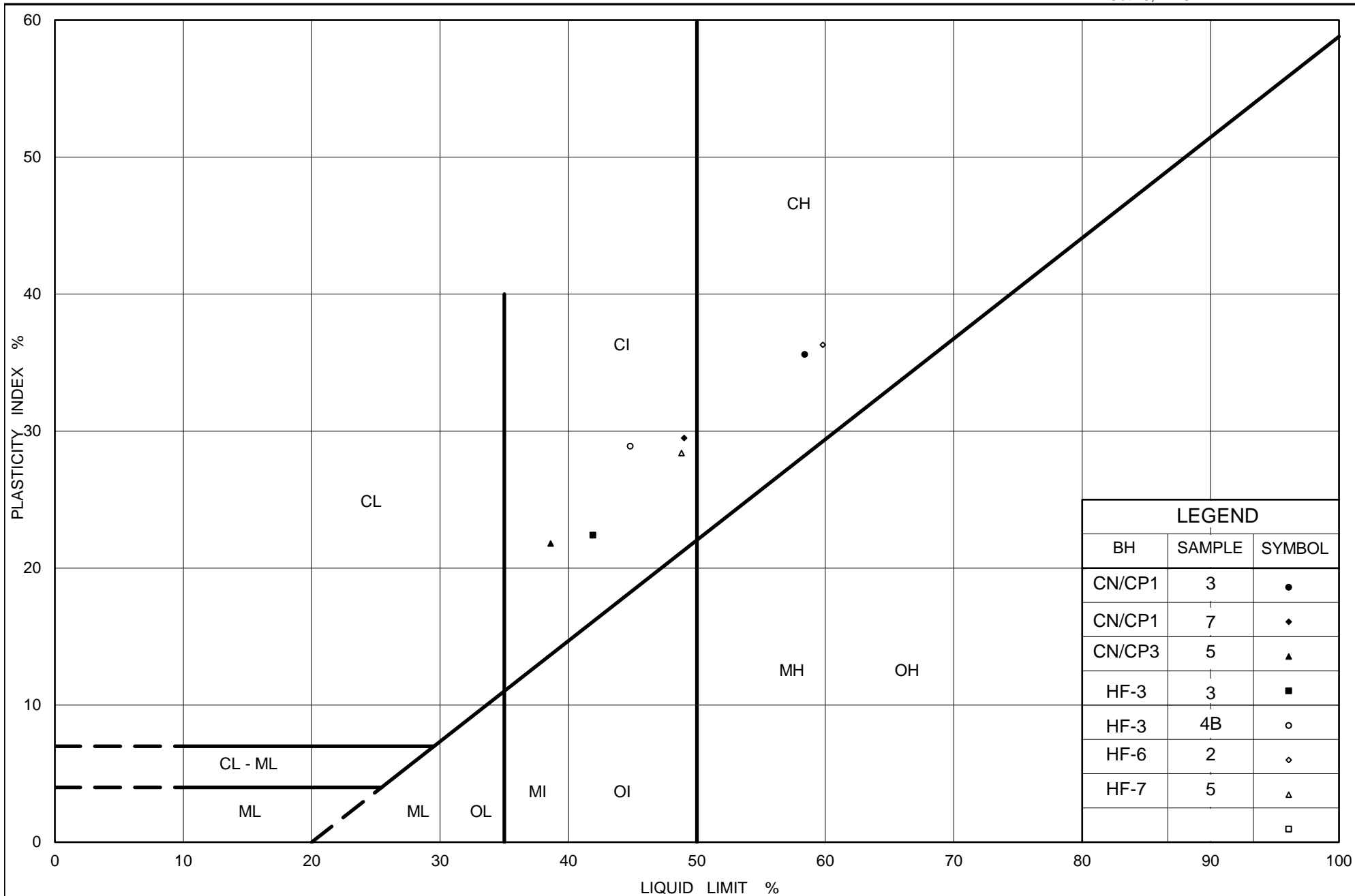
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-6	2	179.5
■	HF-3	3	178.8
◆	CN/CP1	3	185.5
▲	RW-11	4	181.8
▽	HF-3	4B	177.1
○	HF-7	5	181.4
□	CN/CP1	7	181.7

Project Number: 1671430

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Date: 01-May-19



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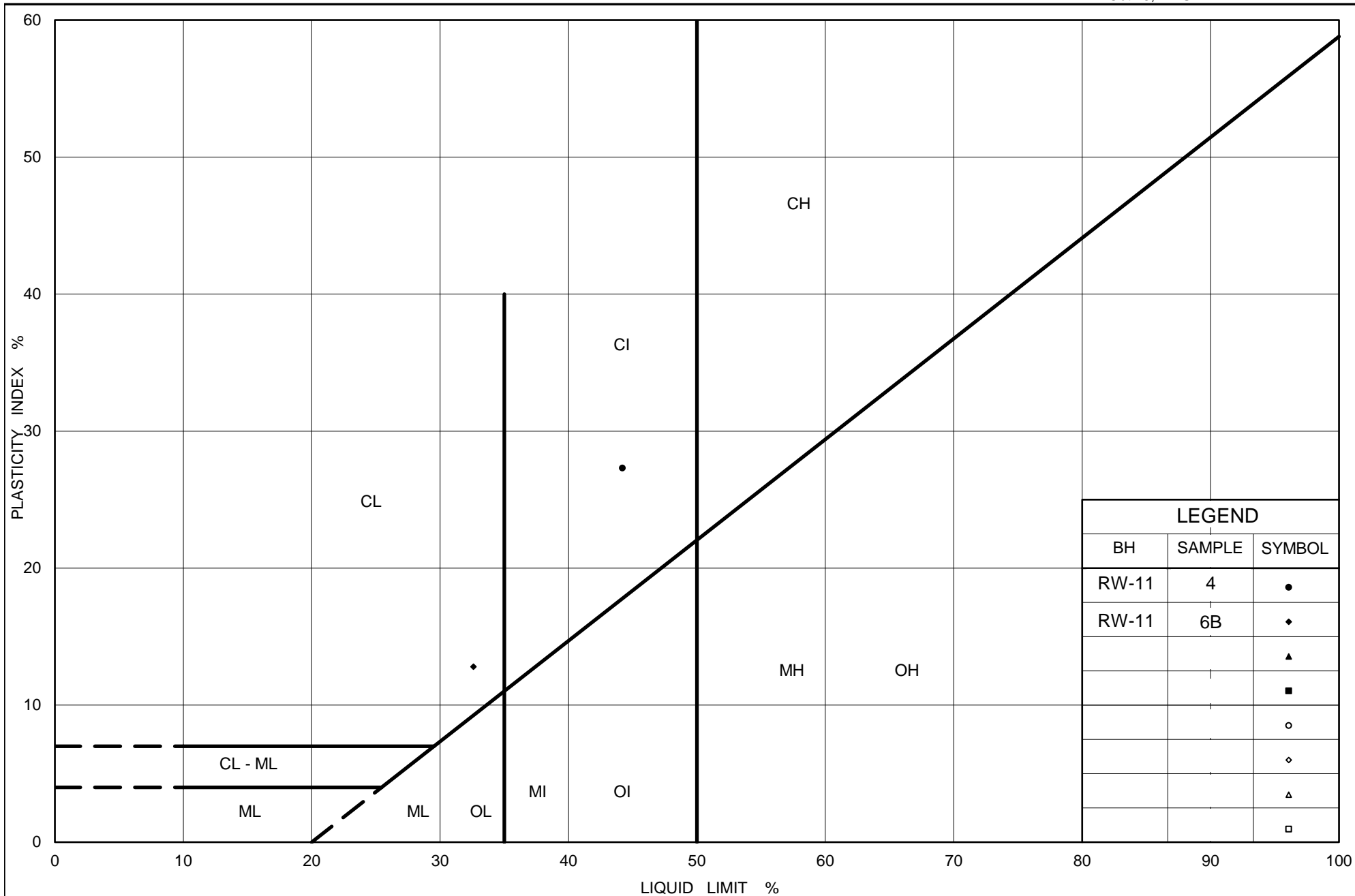
PLASTICITY CHART

Silty Clay to Clay (Fill)

Figure No. B-2A

Project No. 1671430 (WO 008)

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PLASTICITY CHART

Clayey Silt to Silty Clay (Fill)

Figure No. B-2B

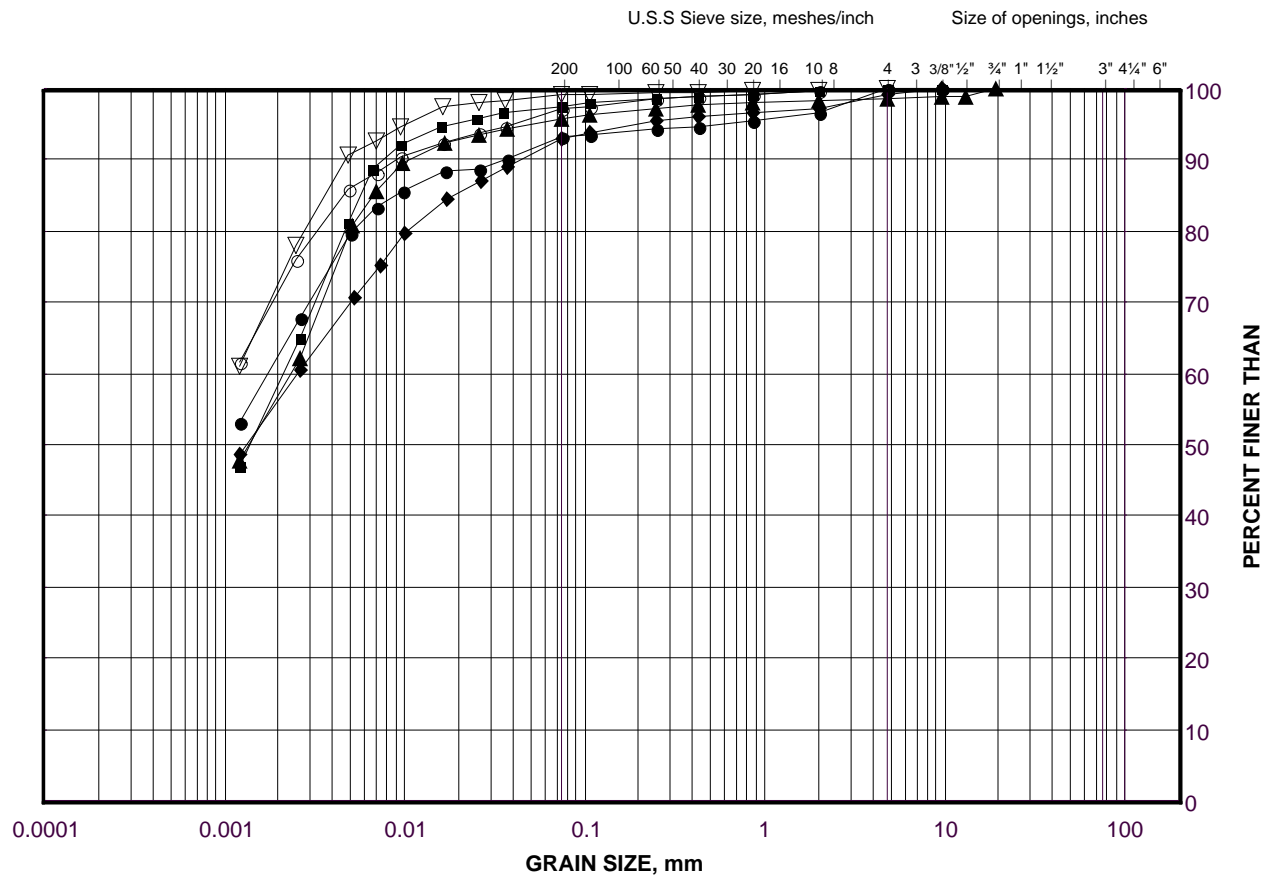
Project No. 1671430 (WO 008)

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GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE B-3A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-4	3	176.1
■	HF-2	3	175.1
◆	HF-2	5	172.9
▲	HF-4	5	174.8
▽	HF-1	5	174.9
○	HF-5	6	177.2

Project Number: 1671430

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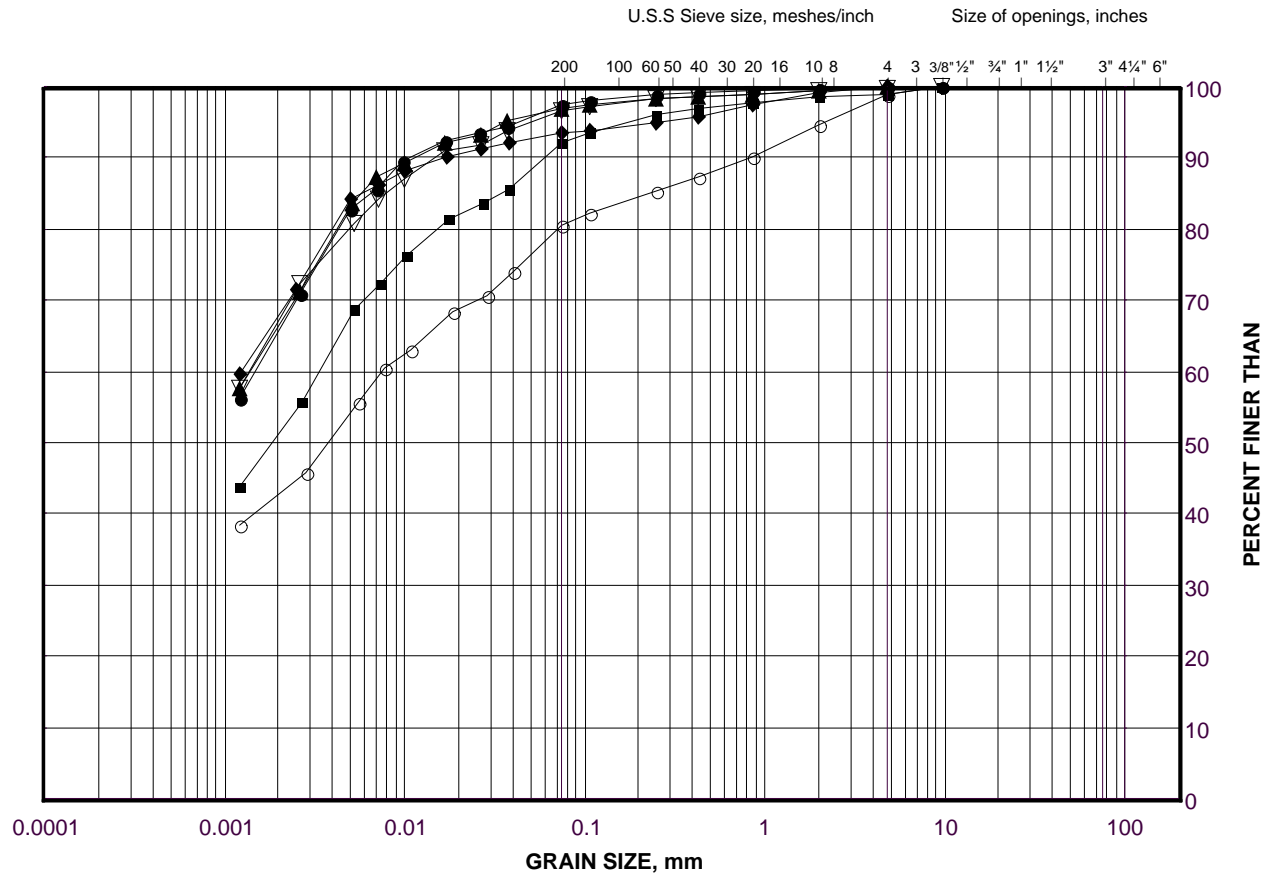
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Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Silty Clay to Clay

FIGURE B-3B



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

LEGEND

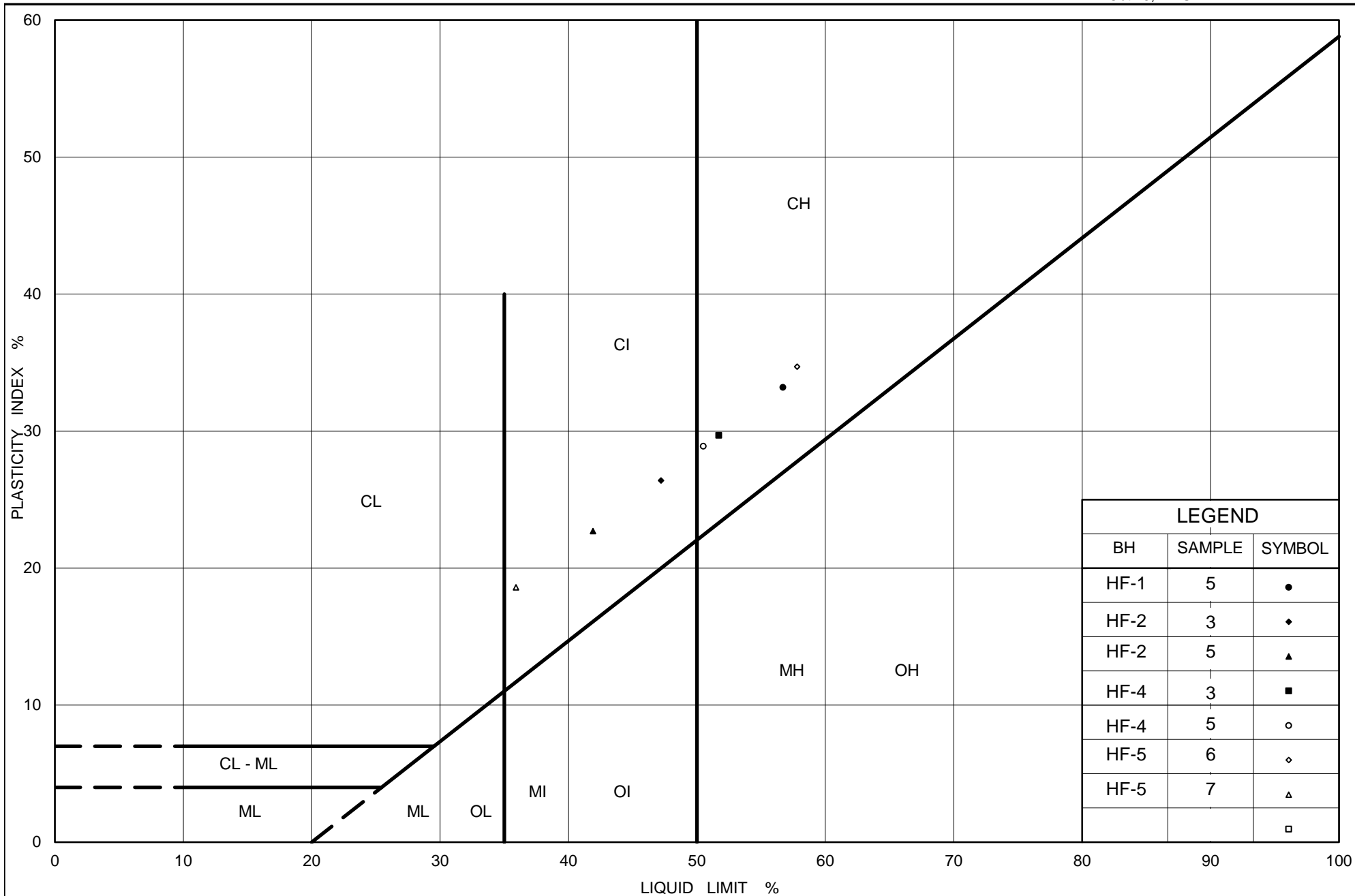
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	RW-13	3	176.2
■	RW-12	4	174.5
◆	HF-6	4	178.3
▲	RW-11	7	177.3
▽	HF-7	7	178.4
○	HF-6	8	175.8

Project Number: 1671430

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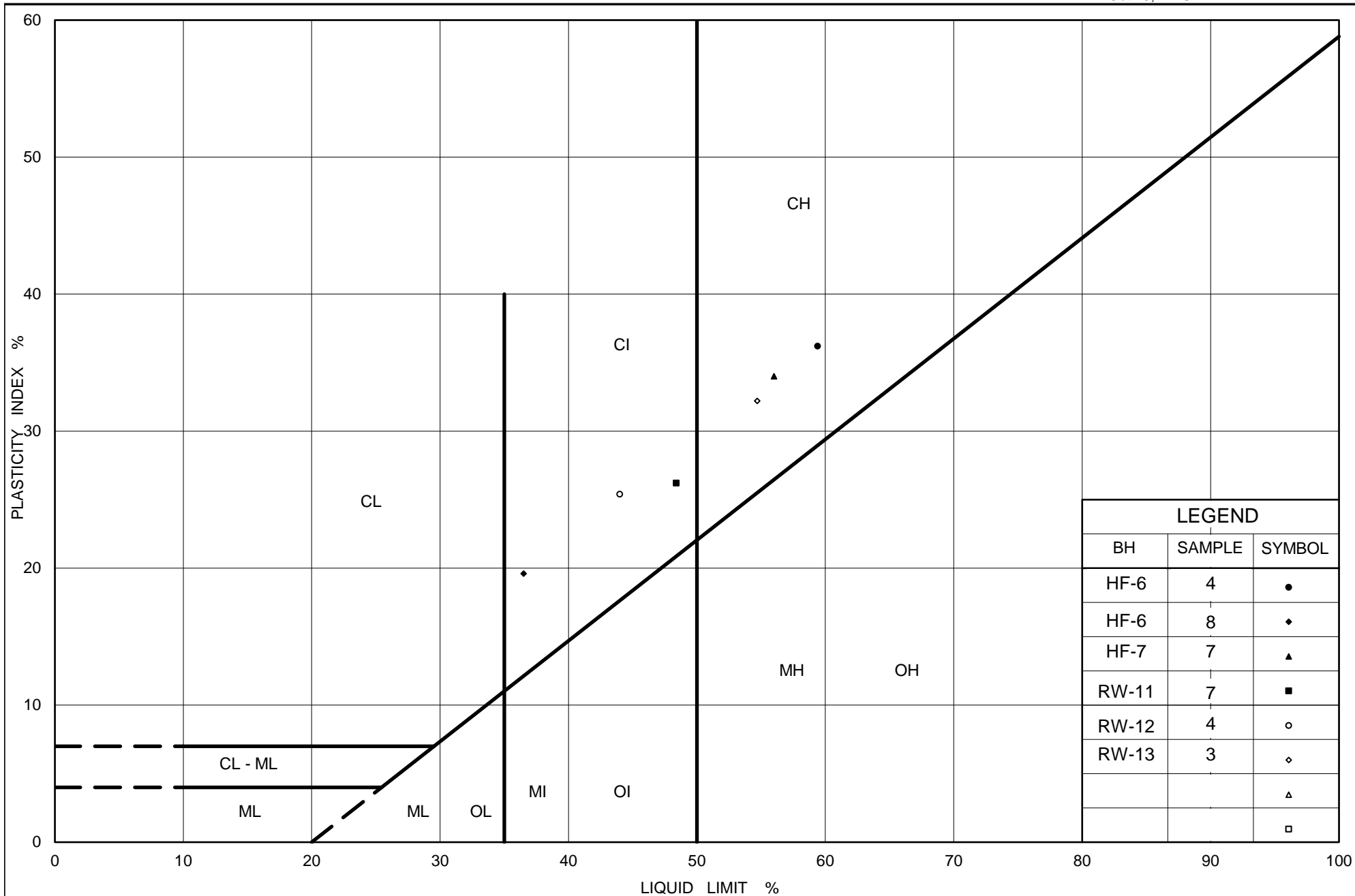
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PLASTICITY CHART **Silty Clay to Clay**

Figure No. B-4A

Project No. 1671430 (WO 008)

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PLASTICITY CHART Silty Clay to Clay

Figure No. B-4B

Project No. 1671430 (WO 008)

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CONSOLIDATION TEST SUMMARY**FIGURE B-5A****ASTM D2435/D2435M****SAMPLE IDENTIFICATION**

Project Number	1671430(W08)	Sample Number	5
Borehole Number	HF-2	Sample Depth, m	3.81-4.42

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	10		
Date Started	02/01/2019		
Date Completed	02/14/2019		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.53	Unit Weight, kN/m ³	19.45
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m ³	15.40
Area, cm ²	31.75	Specific Gravity, measured	2.74
Volume, cm ³	80.42	Solids Height, cm	1.451
Water Content, %	26.33	Volume of Solids, cm ³	46.08
Wet Mass, g	159.51	Volume of Voids, cm ³	34.34
Dry Mass, g	126.26	Degree of Saturation, %	96.8

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0.00	2.533	0.745	2.533				
5.93	2.529	0.743	2.531	7	1.94E-01	2.62E-04	4.97E-06
10.64	2.521	0.737	2.525	145	9.32E-03	6.62E-04	6.05E-07
20.33	2.507	0.727	2.514	437	3.07E-03	5.70E-04	1.71E-07
45.00	2.477	0.707	2.492	1058	1.24E-03	4.78E-04	5.84E-08
10.64	2.487	0.713	2.482				
45.00	2.475	0.705	2.481	406	3.21E-03	1.33E-04	4.20E-08
78.31	2.452	0.689	2.463	936	1.37E-03	2.77E-04	3.74E-08
155.31	2.404	0.656	2.428	1220	1.02E-03	2.46E-04	2.47E-08
309.55	2.341	0.613	2.373	653	1.83E-03	1.60E-04	2.87E-08
618.73	2.264	0.560	2.303	821	1.37E-03	9.82E-05	1.32E-08
1236.80	2.181	0.502	2.222	634	1.65E-03	5.34E-05	8.64E-09
2468.72	2.096	0.444	2.139	346	2.80E-03	2.70E-05	7.42E-09
618.73	2.120	0.461	2.108				
155.31	2.174	0.498	2.147				
45.00	2.221	0.530	2.198				
20.17	2.255	0.554	2.238				
5.96	2.306	0.589	2.280				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t₉₀ estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 0-9cm from bottom of the tube.

Specimen swelled under 5.93kPa

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	2.31	Unit Weight, kN/m ³	20.60
Sample Diameter, cm	6.36	Dry Unit Weight, kN/m ³	16.91
Area, cm ²	31.75	Specific Gravity, measured	2.74
Volume, cm ³	73.20	Solids Height, cm	1.451
Water Content, %	21.81	Volume of Solids, cm ³	46.08
Wet Mass, g	153.80	Volume of Voids, cm ³	27.12
Dry Mass, g	126.26		

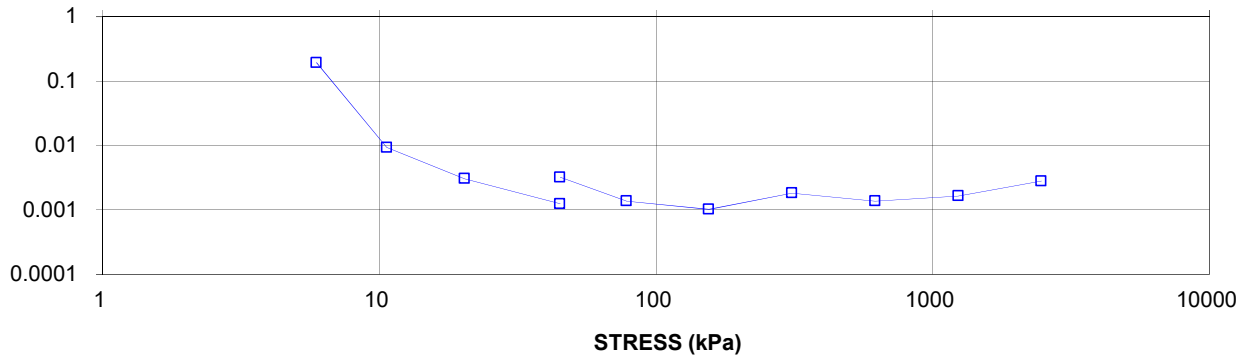
Prepared By: LH

Golder Associates

Checked By: MM

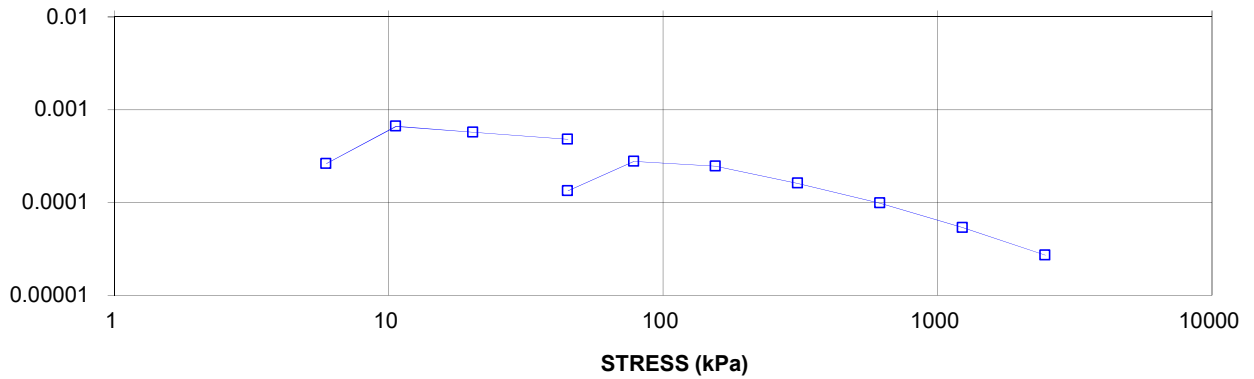
COEFFICIENT OF CONSOLIDATION,
cm²/s

CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
HF-2 SA 5



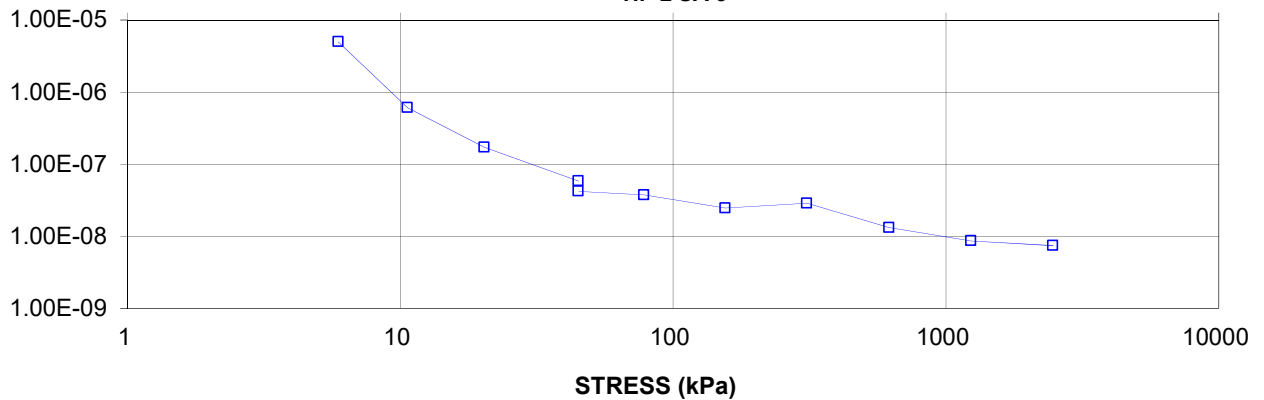
VOLUME COMPRESSIBILITY, m²/kN

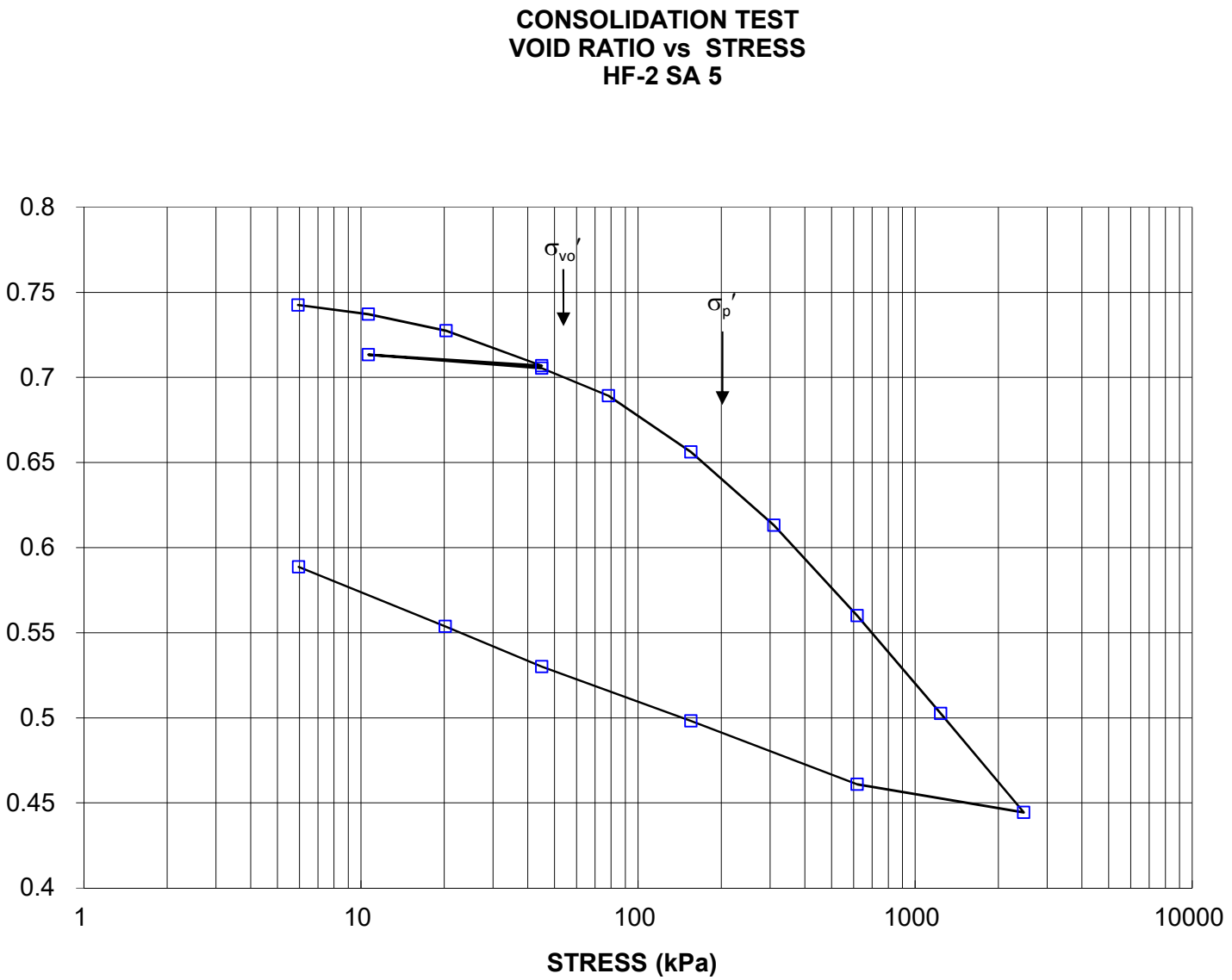
CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
HF-2 SA 5



HYDRAULIC CONDUCTIVITY,
cm/s

CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
HF-2 SA 5





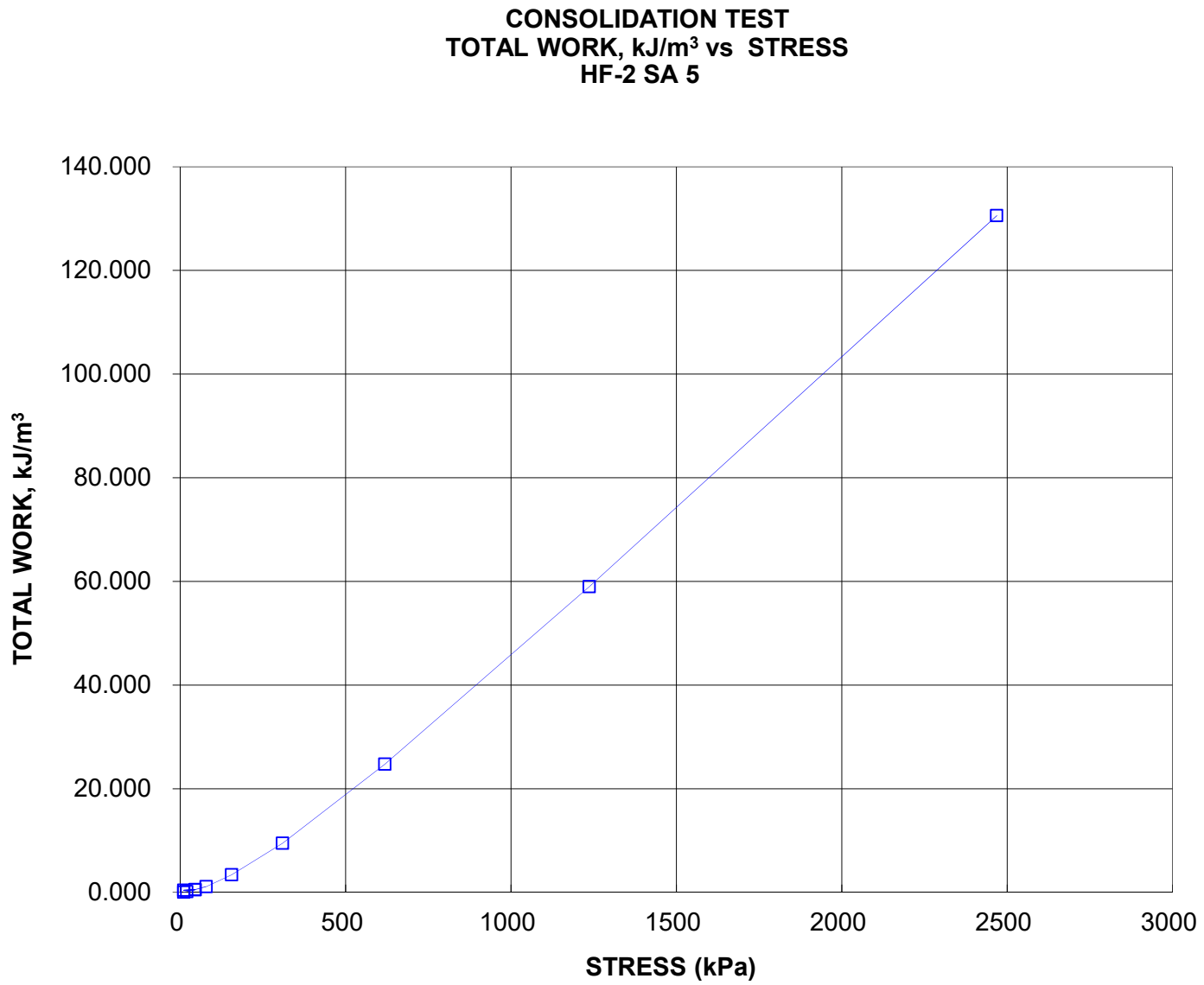
Project No. 167 1430(W08)

VOID RATIO

Prepared By: LH

Golder Associates

Checked By: MAS



**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 1 OF 4**

FIGURE B-6A

TEST STAGE	A	B	C
BOREHOLE NUMBER	HF-2		
SAMPLE	5		
DEPTH, m	3.81-4.42		
SPECIMEN DIAMETER, cm	4.99	5.04	5.00
SPECIMEN HEIGHT, cm	10.98	10.10	10.15
NATURAL WATER CONTENT, %	31.9	38.9	32.3
DRY DENSITY, Mg/m ³	1.36	1.34	1.45
WATER CONTENT AFTER SATURATION, %	32.8	39.1	32.7
CELL PRESSURE, σ_3 , kPa	175.0	220.0	310.0
BACK PRESSURE, kPa	130.0	130.0	130.0
PORE PRESSURE PARAMETER "B"	0.97	0.96	0.96
EFFECTIVE CONSOLIDATION STRESS, σ_c , kPa	45.0	90.0	180.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	1.7	8.0	5.8
WATER CONTENT AFTER CONSOLIDATION, %	31.4	33.1	28.6
AVERAGE RATE OF STRAIN, %/hr	0.5	0.5	0.5
TIME TO FAILURE, HOURS	15.4	11.8	10.0
WATER CONTENT AFTER TEST, %	31.8	38.0	30.8
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$, kPa	76.7	106.3	144.0
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ maximum, %	7.7	5.9	5.0
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1 / σ'_3) maximum	3.0	2.8	2.5
DEVIATOR STRESS AT (σ'_1 / σ'_3) maximum, kPa	69.4	102.2	143.9
AXIAL STRAIN AT (σ'_1 / σ'_3) maximum, %	3.5	3.7	5.3
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ maximum	0.04	0.26	0.57
PORE PRESSURE PARAMETER, Af, AT (σ'_1 / σ'_3) maximum	0.15	0.31	0.57
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES: <div style="margin-left: 40px;"> Effective consolidation stresses are assigned by the client. Specimen A taken 0-12 cm from top of tube. Specimen B taken 12-24 cm from top of tube. Specimen C taken 24-36 cm from top of tube. </div>			
FAILURE PLANE NUMBER	1.0	1.0	1.0
ANGLE OF FAILURE PLANE, DEGREES	70.0	50.0	50.0

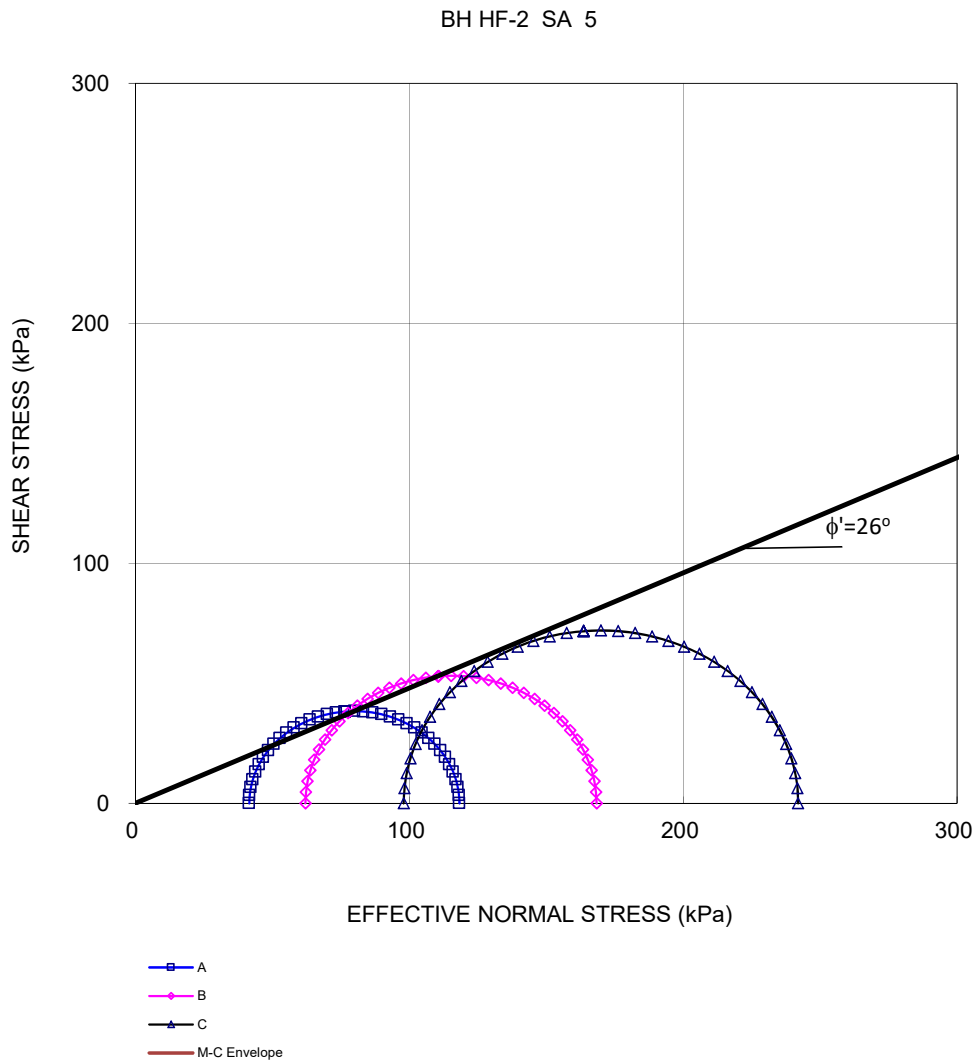
Date: 02/15/2019
Project No. 1671430(W08)

Golder Associates

Prepared By: LH
Checked By: MM

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 2 OF 4

FIGURE B-6B



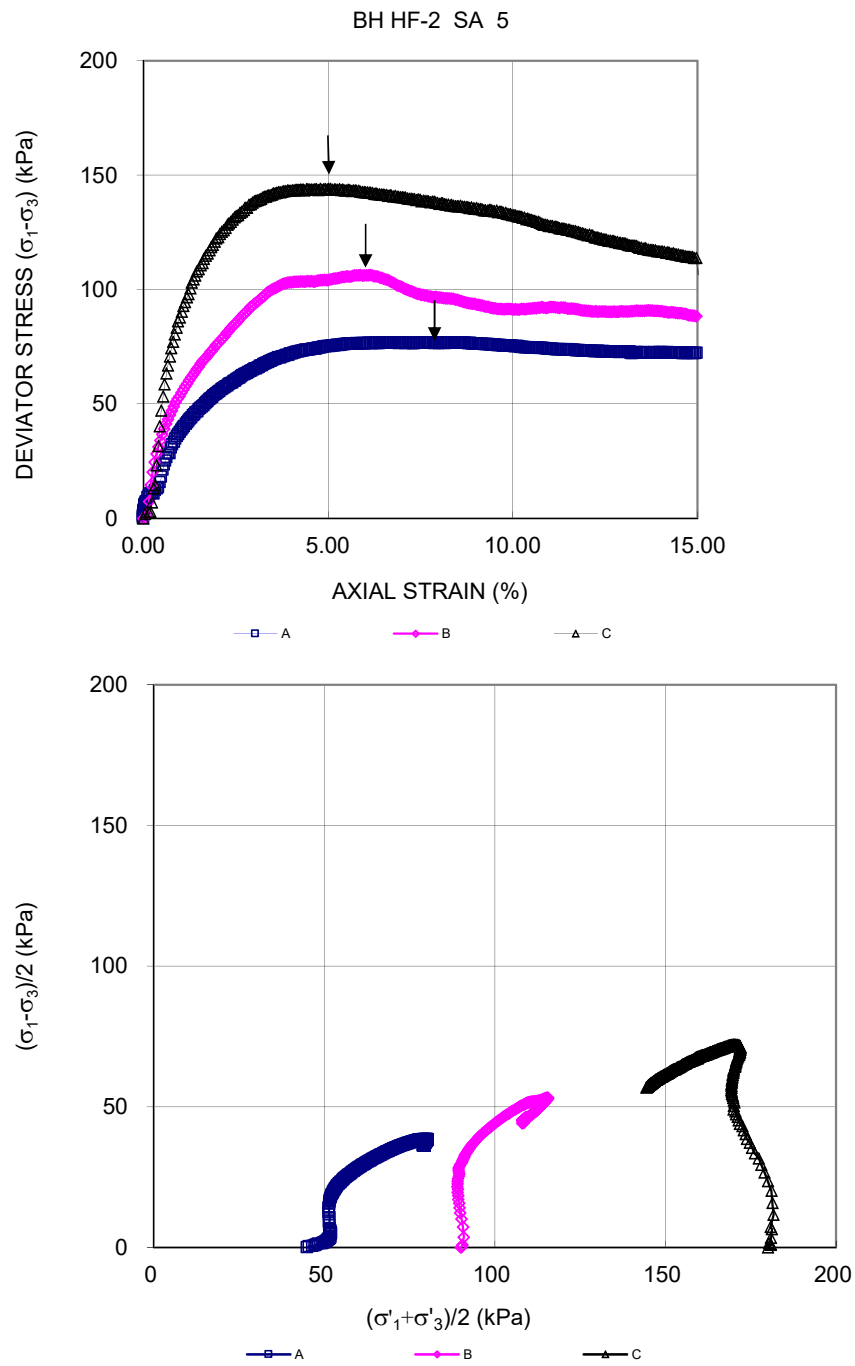
Date: 02/15/2019
Project No. 1671430(W08)

Golder Associates

Prepared By: LH
Checked By: MM

**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 3 OF 4**

FIGURE B-6C



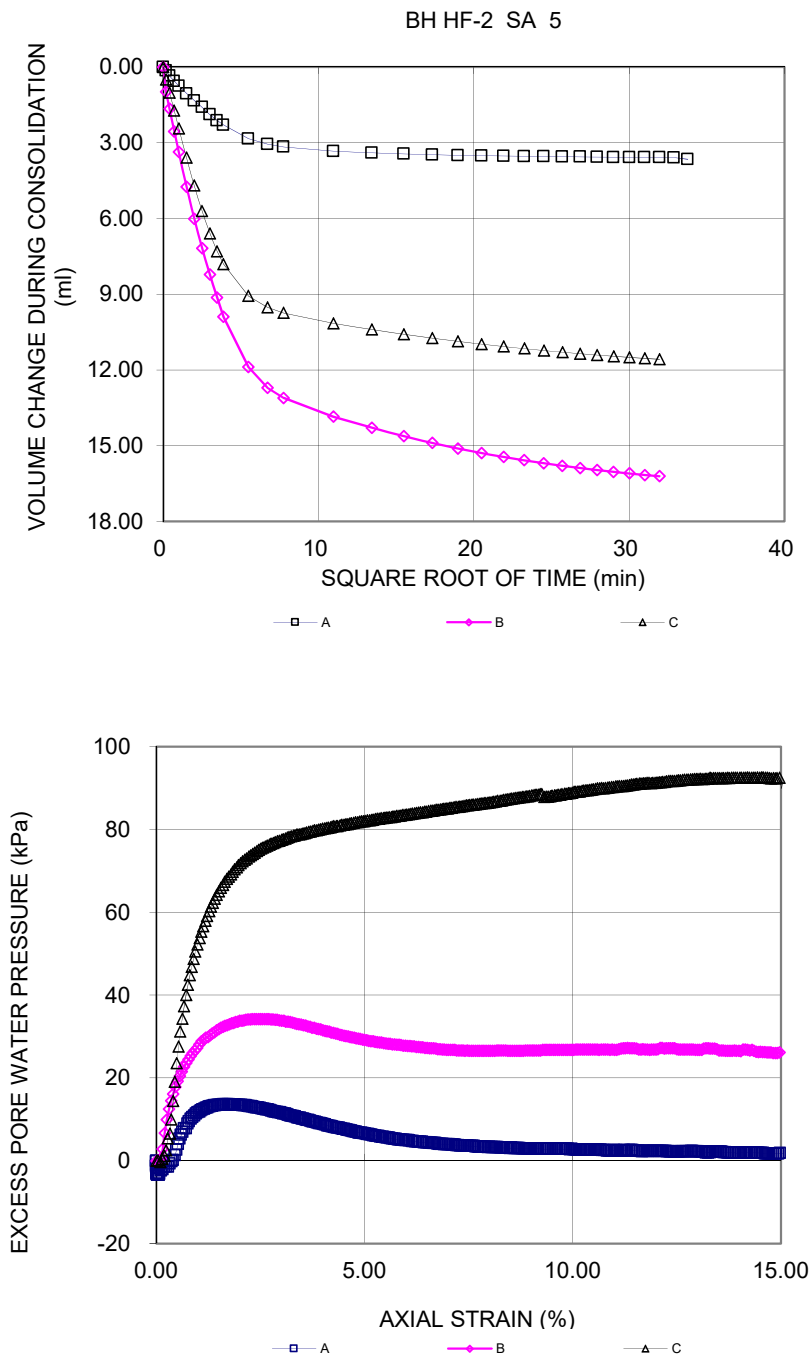
Date: 02/15/2019
Project No. 1671430(W08)

Golder Associates

Prepared By: LH
Checked By: MM

**CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 4 OF 4**

FIGURE B-6D



Date: 02/15/2019
Project No. 1671430(W08)

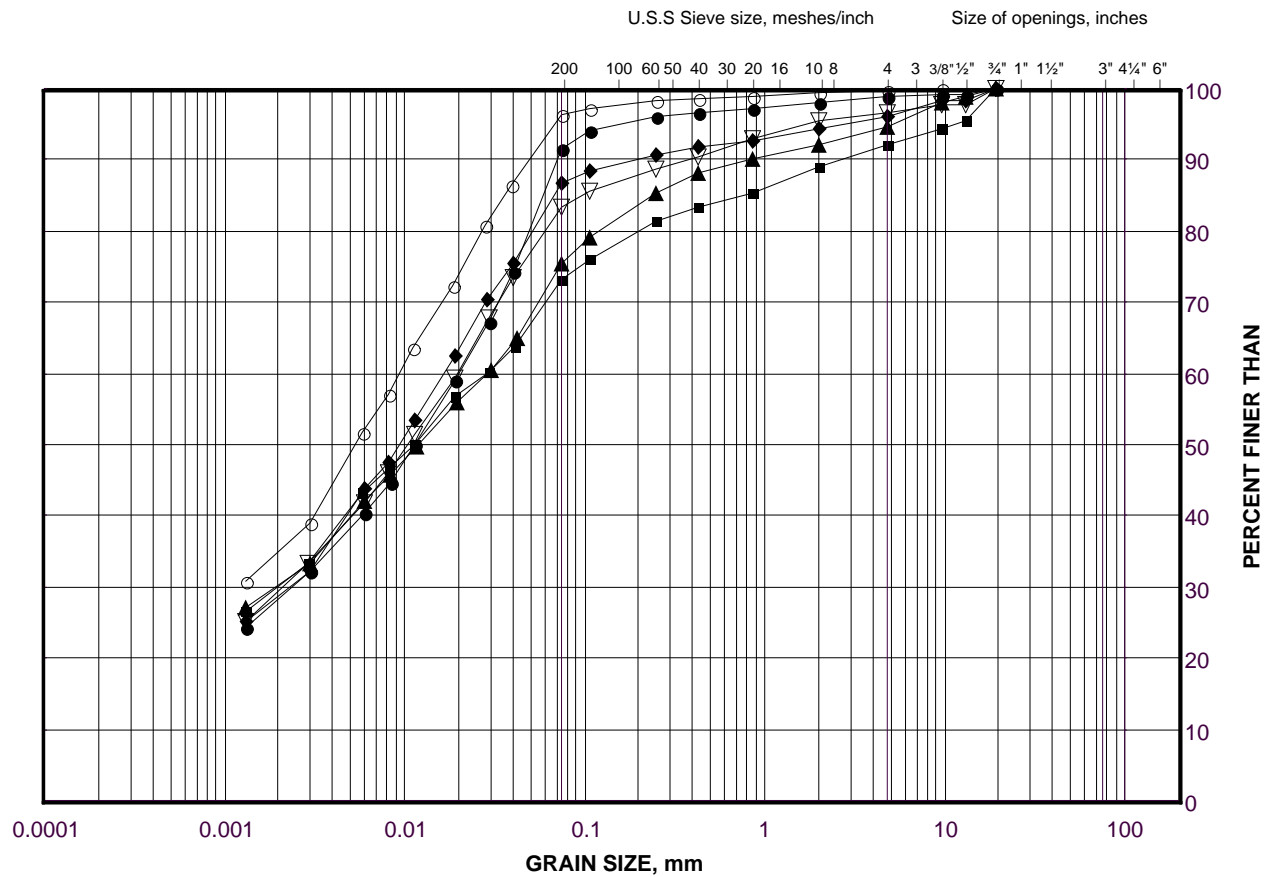
Golder Associates

Prepared By: LH
Checked By: MM

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B-7A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CN/CP3	11	175.9
■	CN/CP3	14	171.3
◆	HF-2	6	170.5
▲	HF-1	7	171.9
▽	HF-4	8	172.2
○	HF-3	8	171.2

Project Number: 1671430

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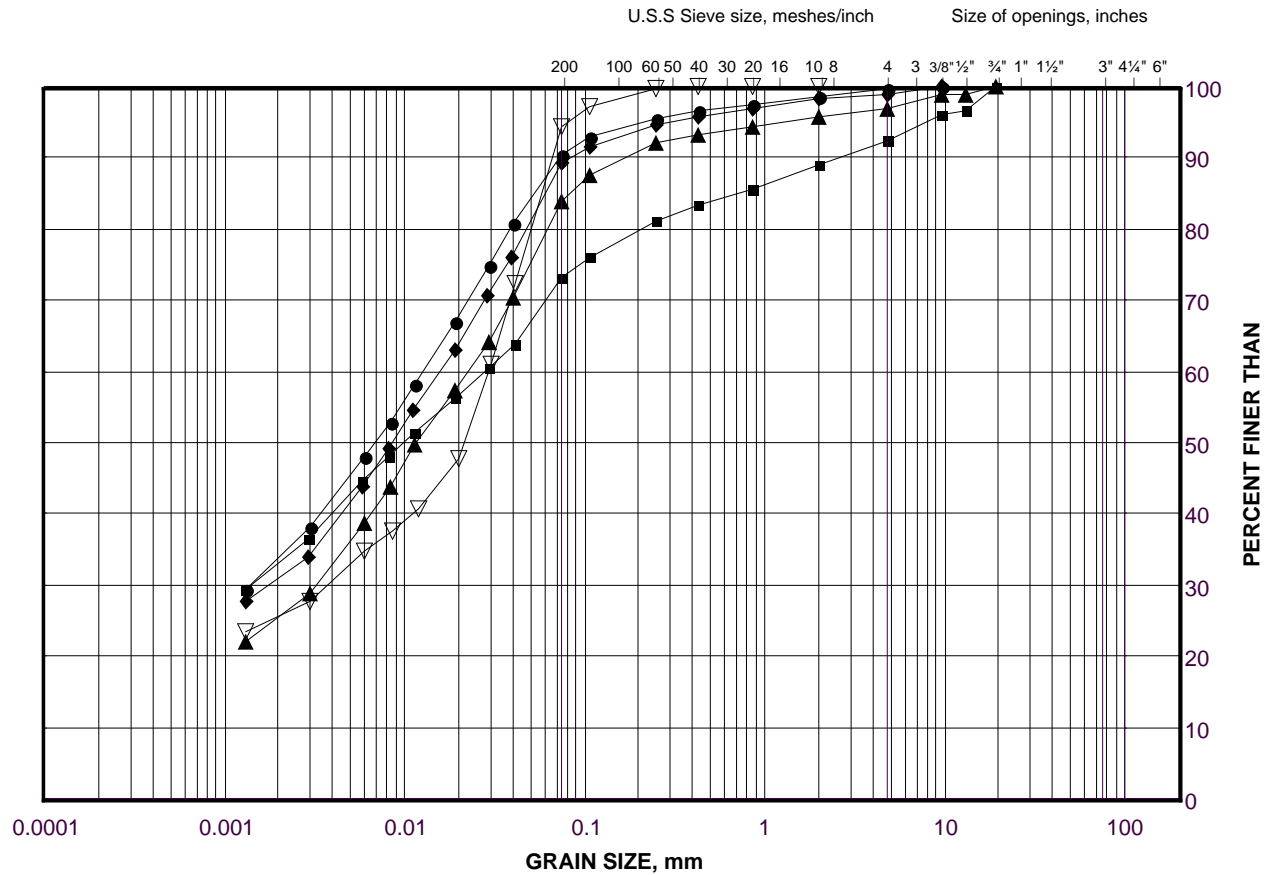
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Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B-7B



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

LEGEND

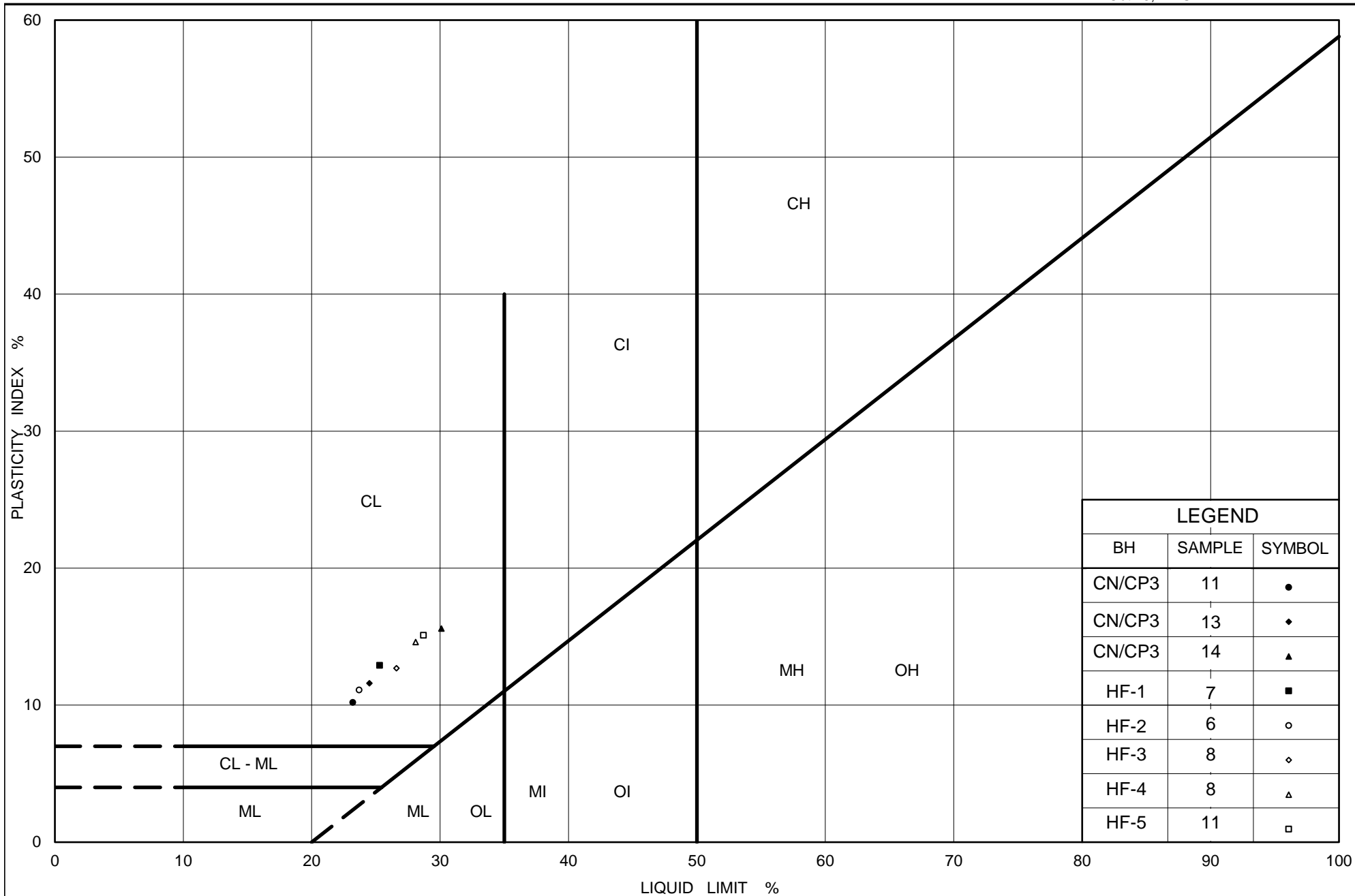
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-7	10	173.7
■	HF-5	11	169.6
◆	RW-13	5	174.7
▲	RW-12	7	170.7
▽	RW-13	9	170.1

Project Number: 1671430

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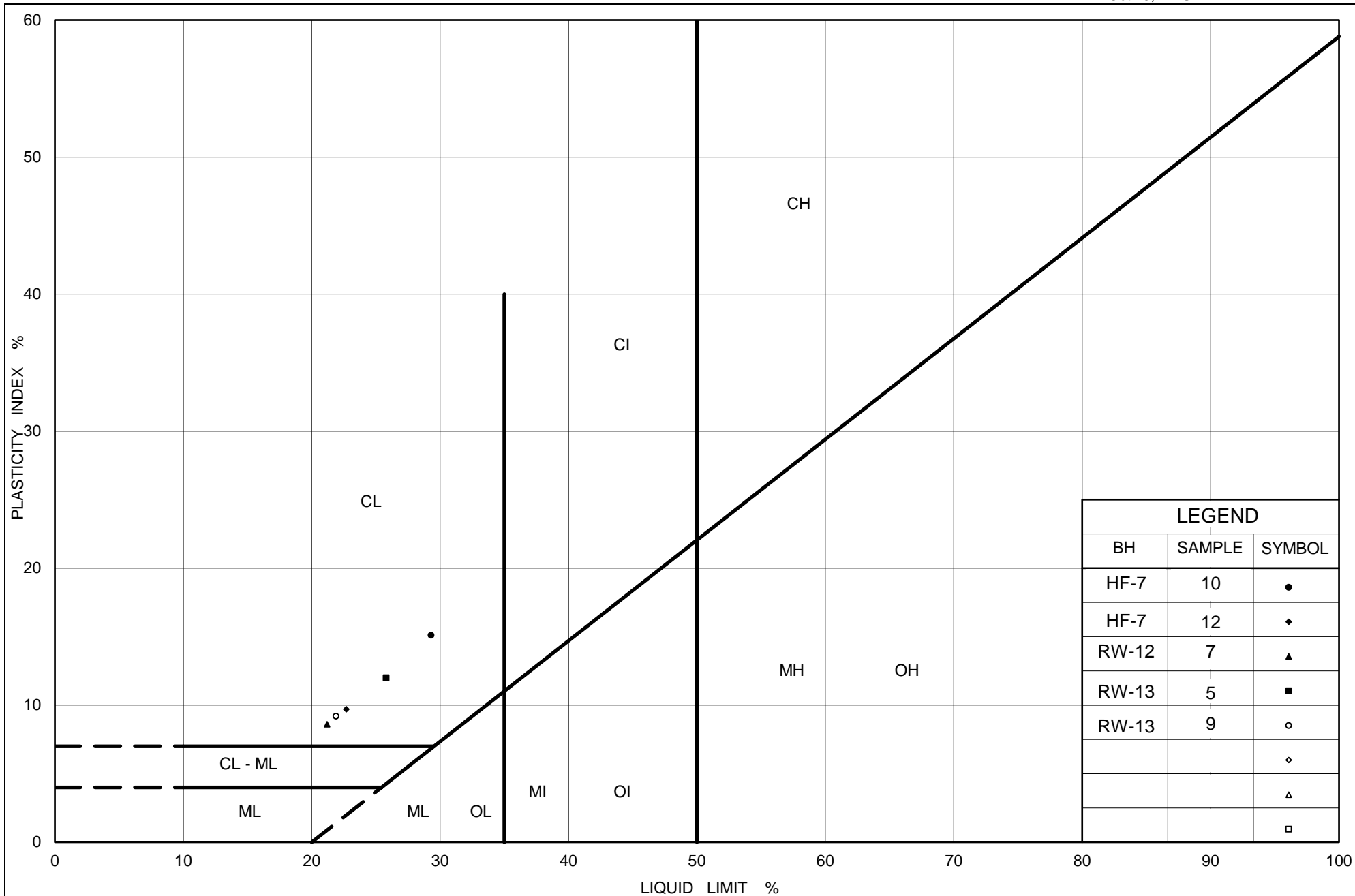
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PLASTICITY CHART Clayey Silt

Figure No. B-8A

Project No. 1671430 (WO 008)

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PLASTICITY CHART

Clayey Silt

Figure No. B-8B

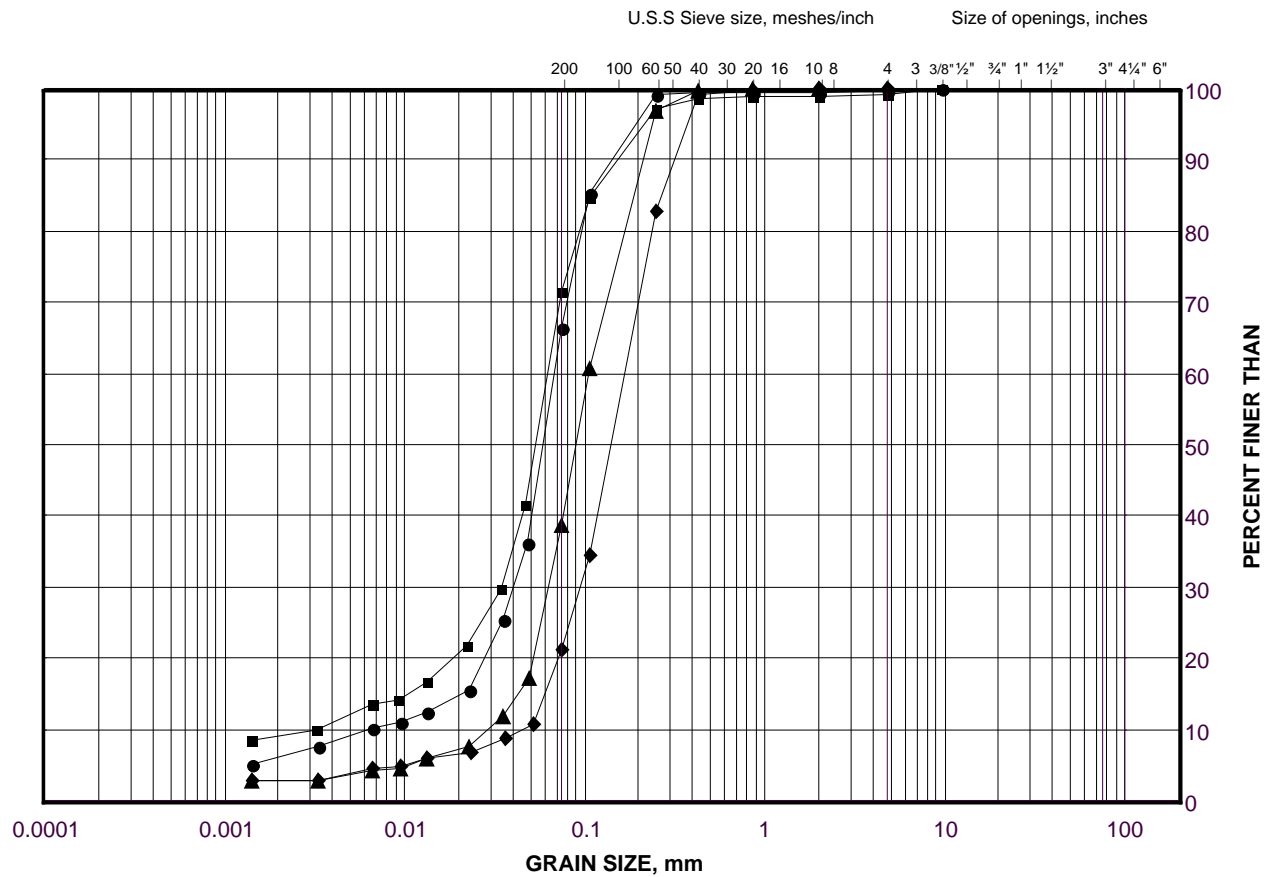
Project No. 1671430 (WO 008)

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GRAIN SIZE DISTRIBUTION

Sandy Silt to Sand

FIGURE B-9



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-7	14A	167.8
■	CN/CP3	16	168.3
◆	RW-13	7	173.2
▲	RW-12	8	169.2

Project Number: 1671430

Checked By: MAS

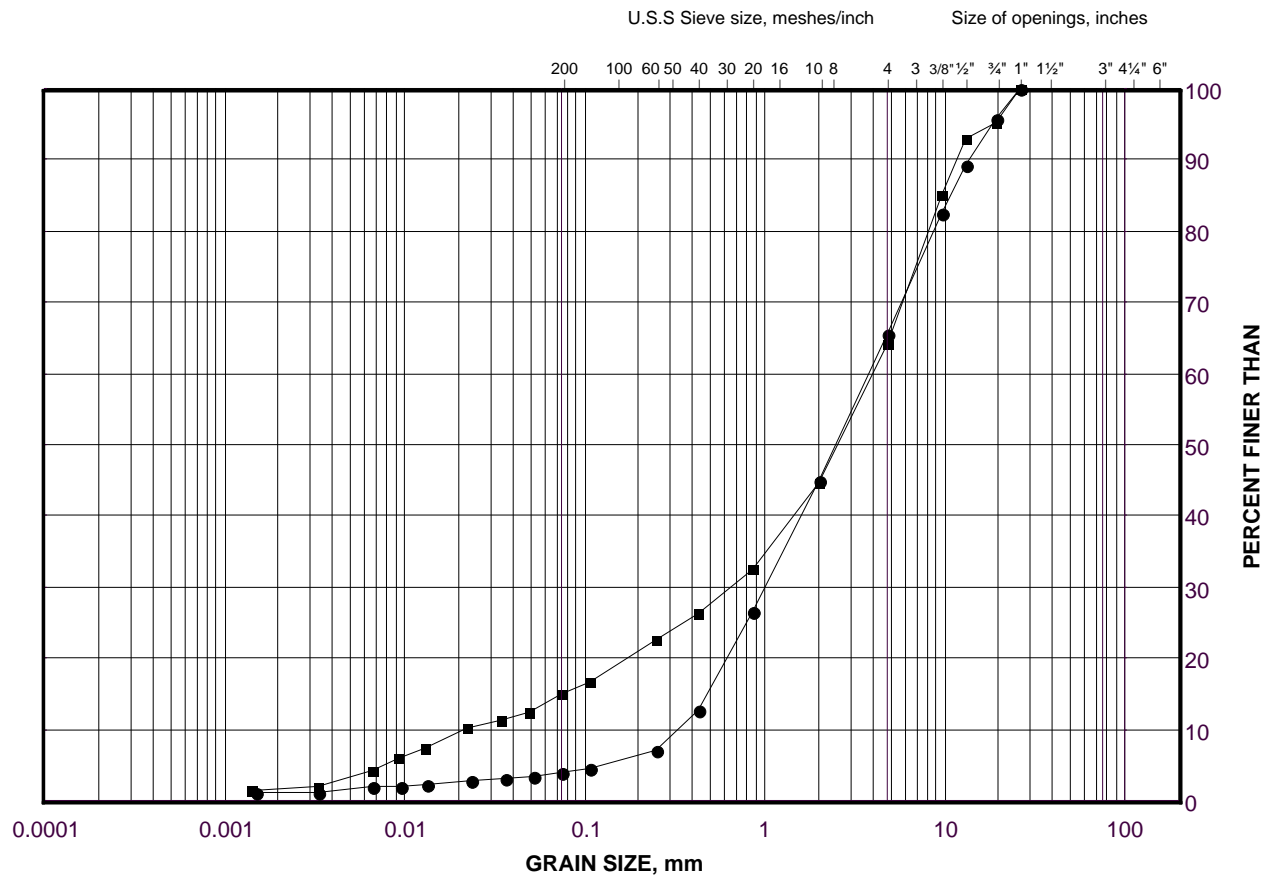
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Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B-10



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-5	13	166.5
■	CN/CP3	17	165.3

Project Number: 1671430

Checked By: MAS

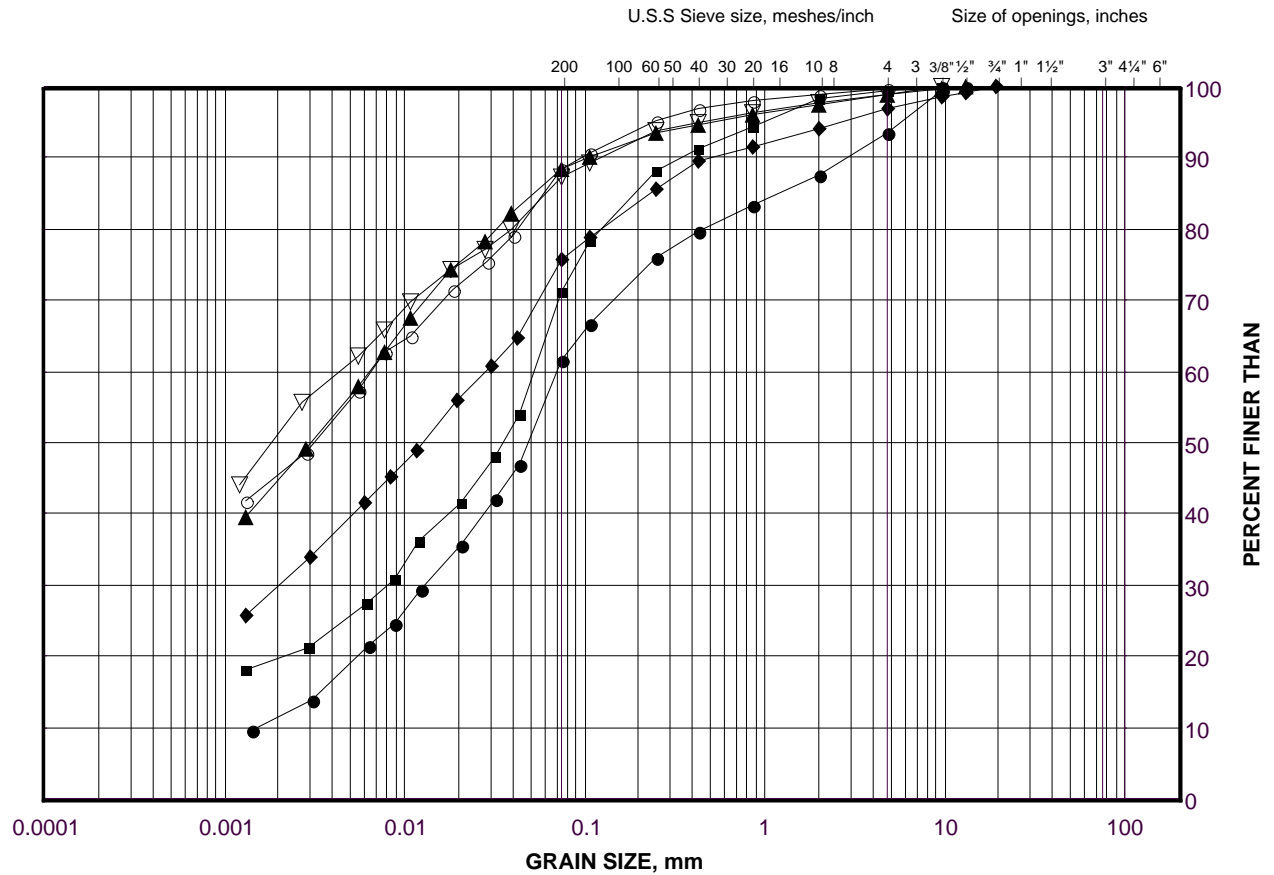
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GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay (Fill)

FIGURE B-11A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-15	1B	182.6
■	HF-13	1B	181.5
◆	HF-10	3	182.8
▲	CN/CP13	3	185.3
▽	CN/CP12	4	185.2
○	CN/CP13	7	181.5

Project Number: 1671430

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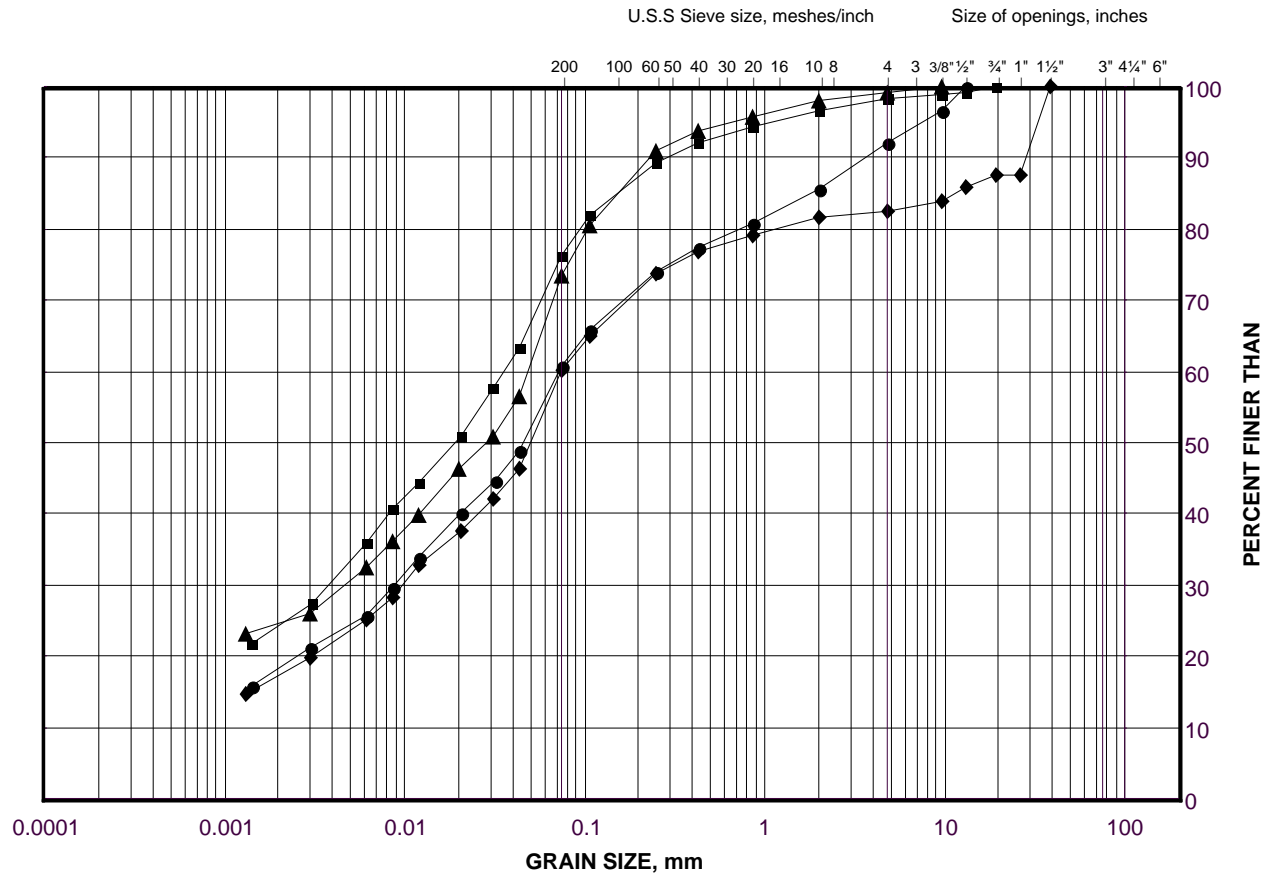
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GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt to Clayey Silt with Sand (Fill)

FIGURE B-11B



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

LEGEND

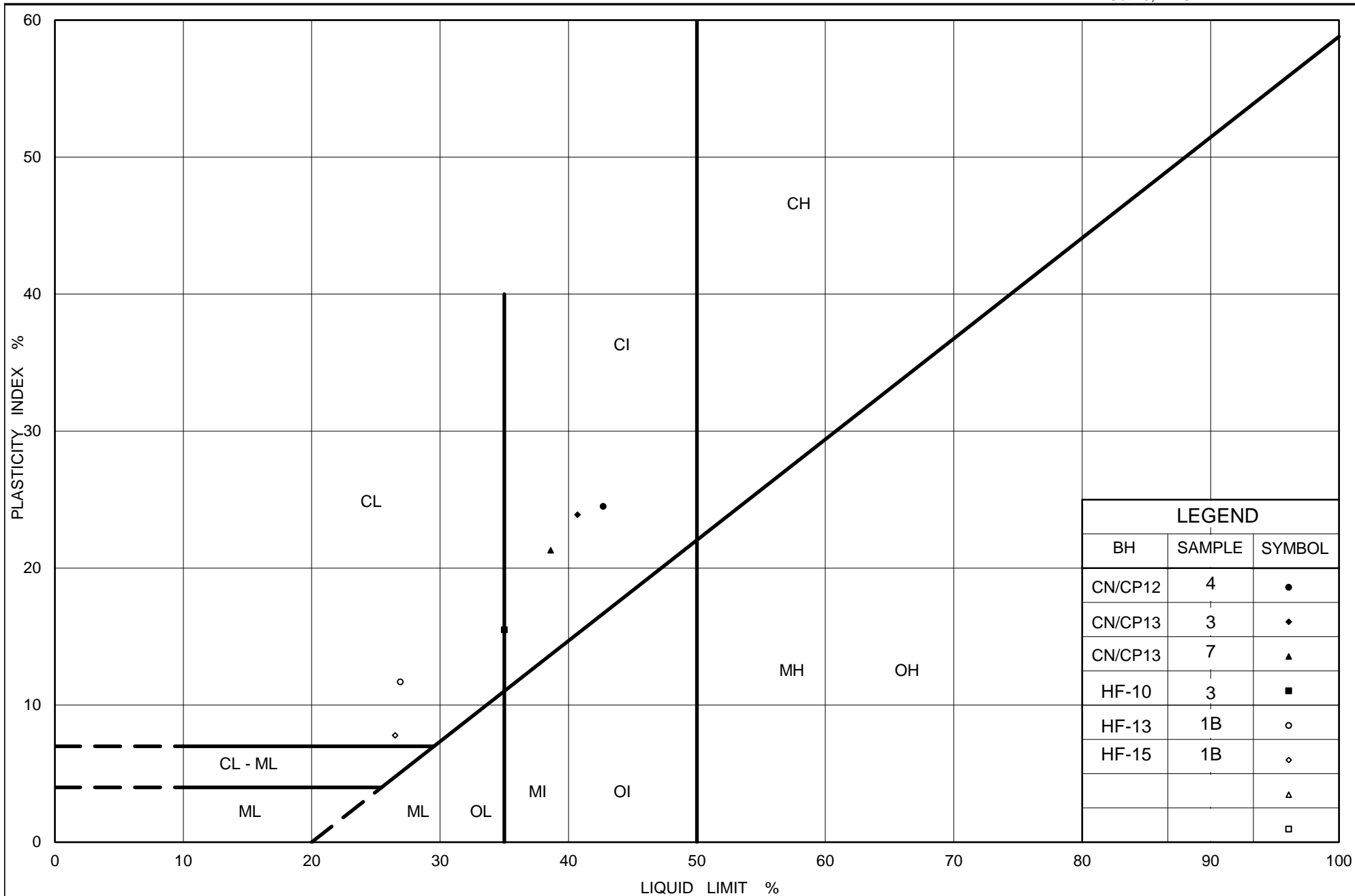
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	C1-2	1A	181.6
■	RW-5	2	182.3
◆	RW-6	3	181.8
▲	C1-3	4	181.4

Project Number: 1671430

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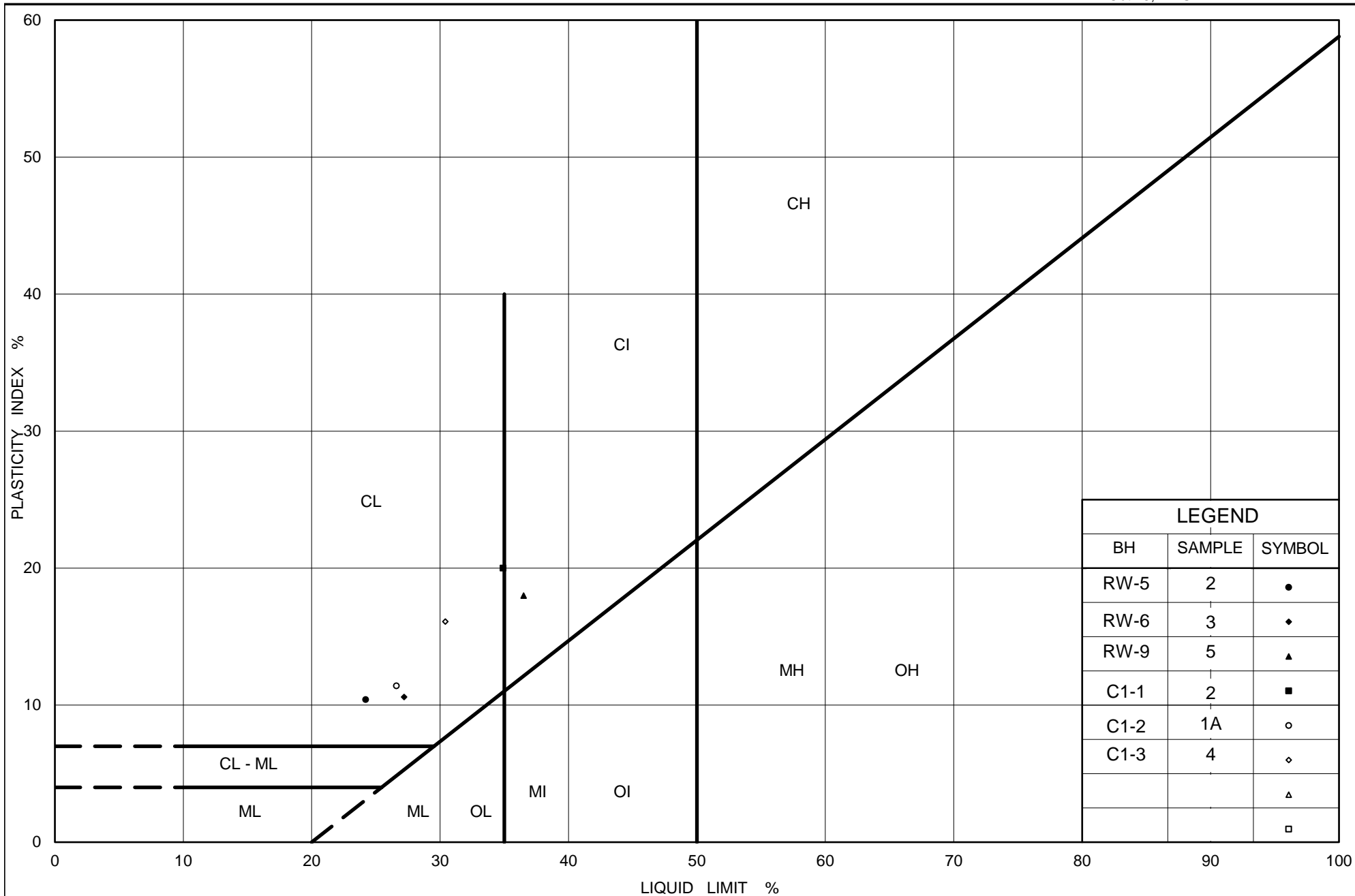
Ontario

PLASTICITY CHART Clayey Silt to Silty Clay Fill

Figure No. B-12A

Project No. 1671430 (WO 008)

Checked By: MAS



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PLASTICITY CHART Clayey Silt to Silty Clay Fill

Figure No. B-12B

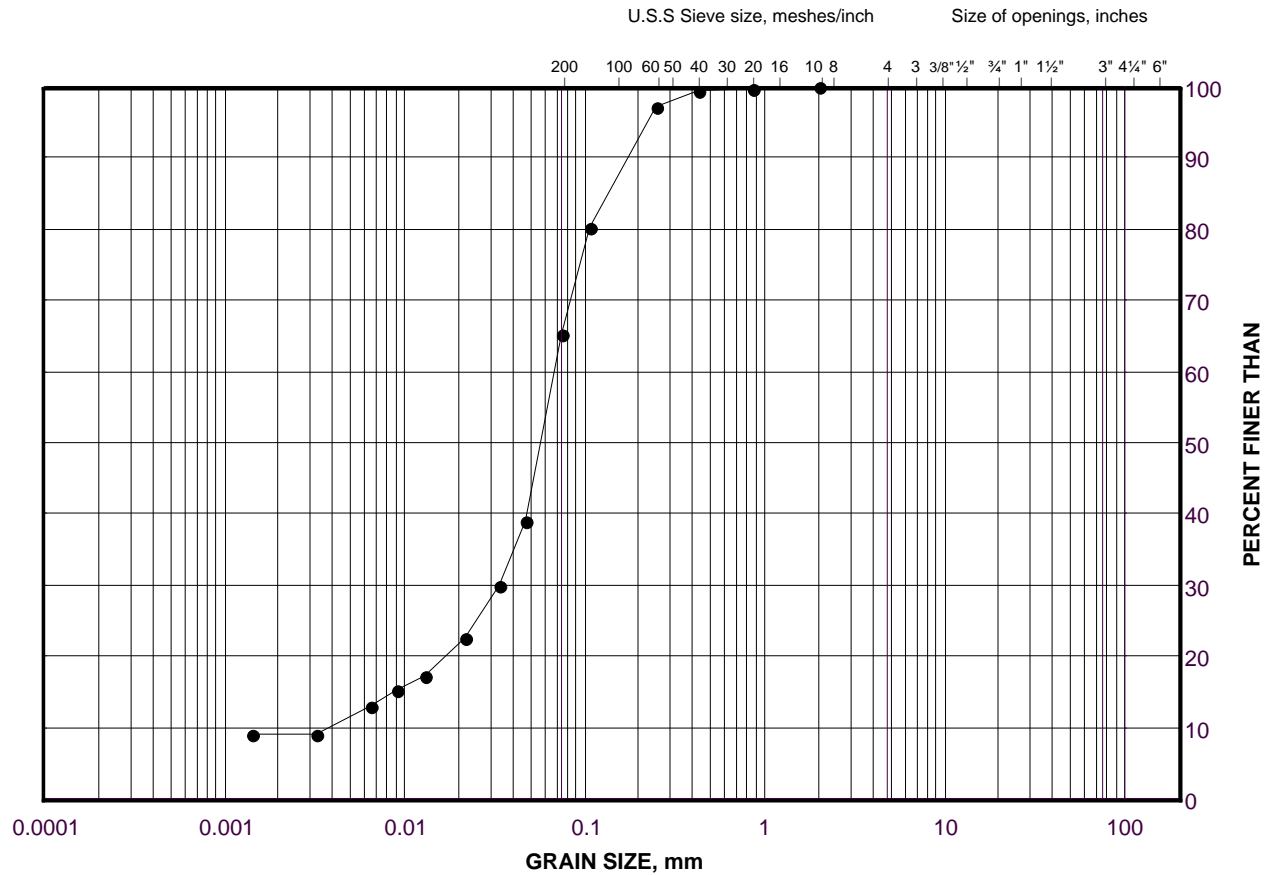
Project No. 1671430 (WO 008)

Checked By: MAS

GRAIN SIZE DISTRIBUTION

Silt and Sand (Fill)

FIGURE B-13



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	HF-11	2	182.6

Project Number: 1671430

Checked By: MAS

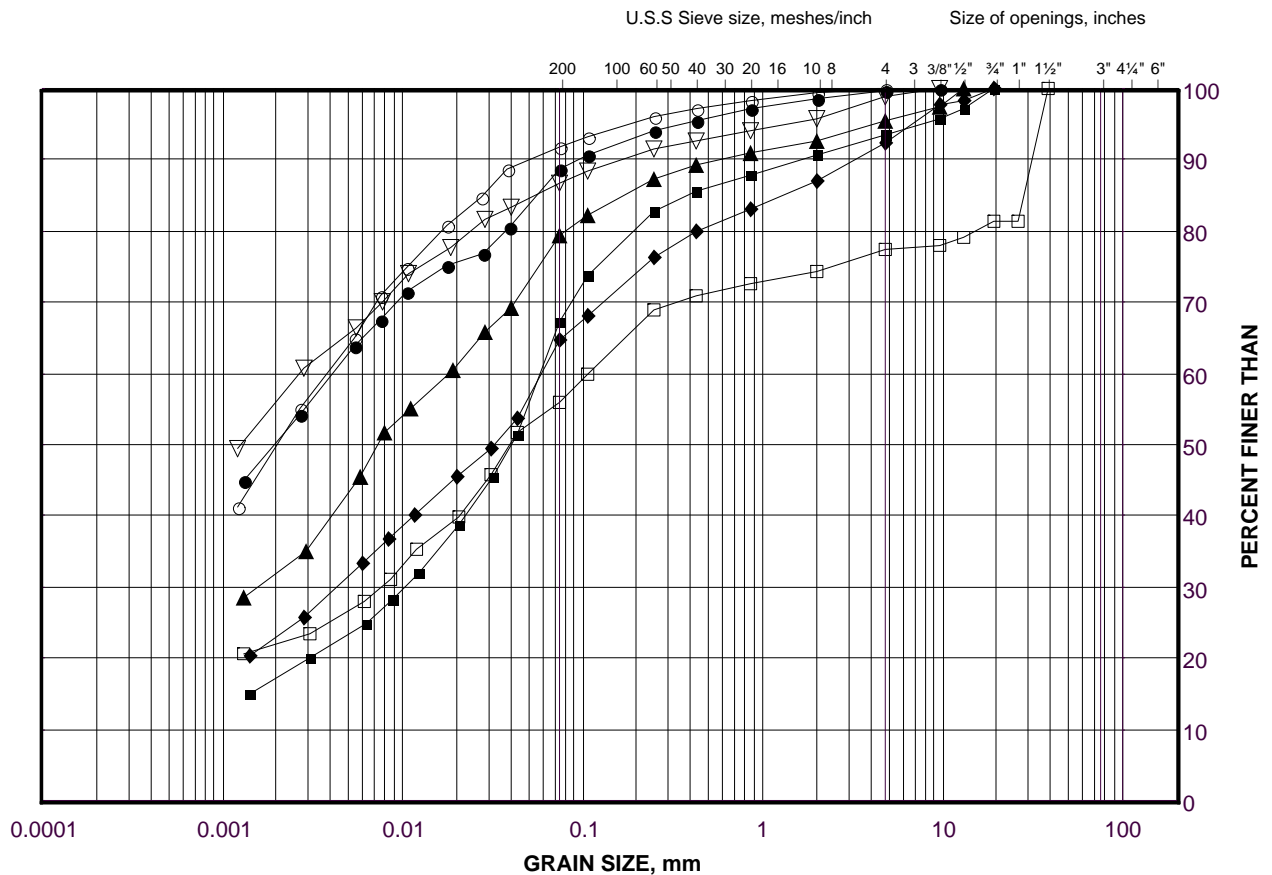
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Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE B-14A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CN/CP12	10	177.6
■	CN/CP10	11	175.7
◆	CN/CP12	12	174.6
▲	CN/CP10	13	172.7
▽	CN/CP9	1B	179.5
○	CN/CP9	5	176.6
□	CN/CP9	8	173.6

Project Number: 1671430

Checked By: MAS

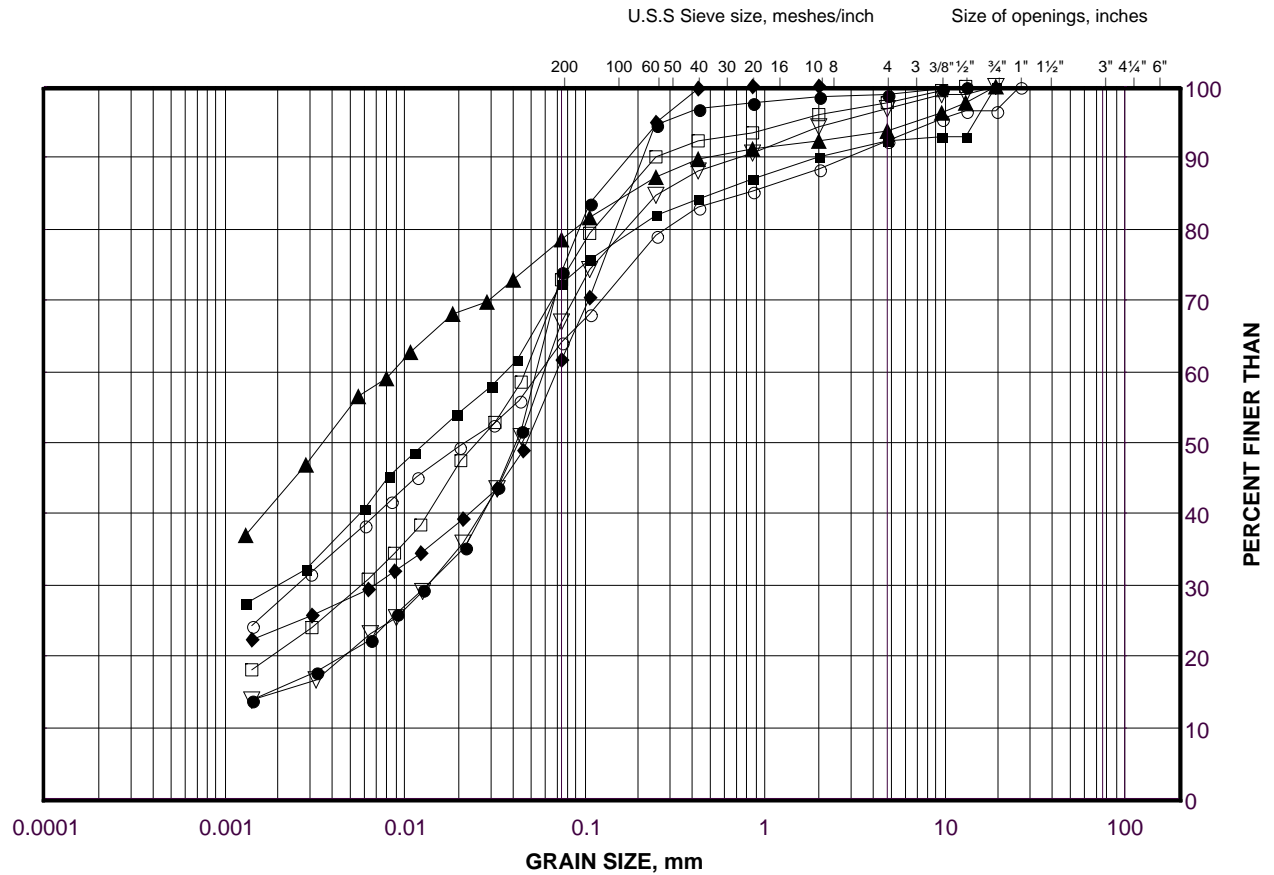
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Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand to Silty Clay

FIGURE B-14B



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-12	2	181.6
■	HF-9	4	178.9
◆	HF-10	5	181.2
▲	RW-10	6	180.2
▽	RW-7	6A	179.0
○	RW-9	7	180.2
□	HF-10	7A	178.4

Project Number: 1671430

Checked By: MAS

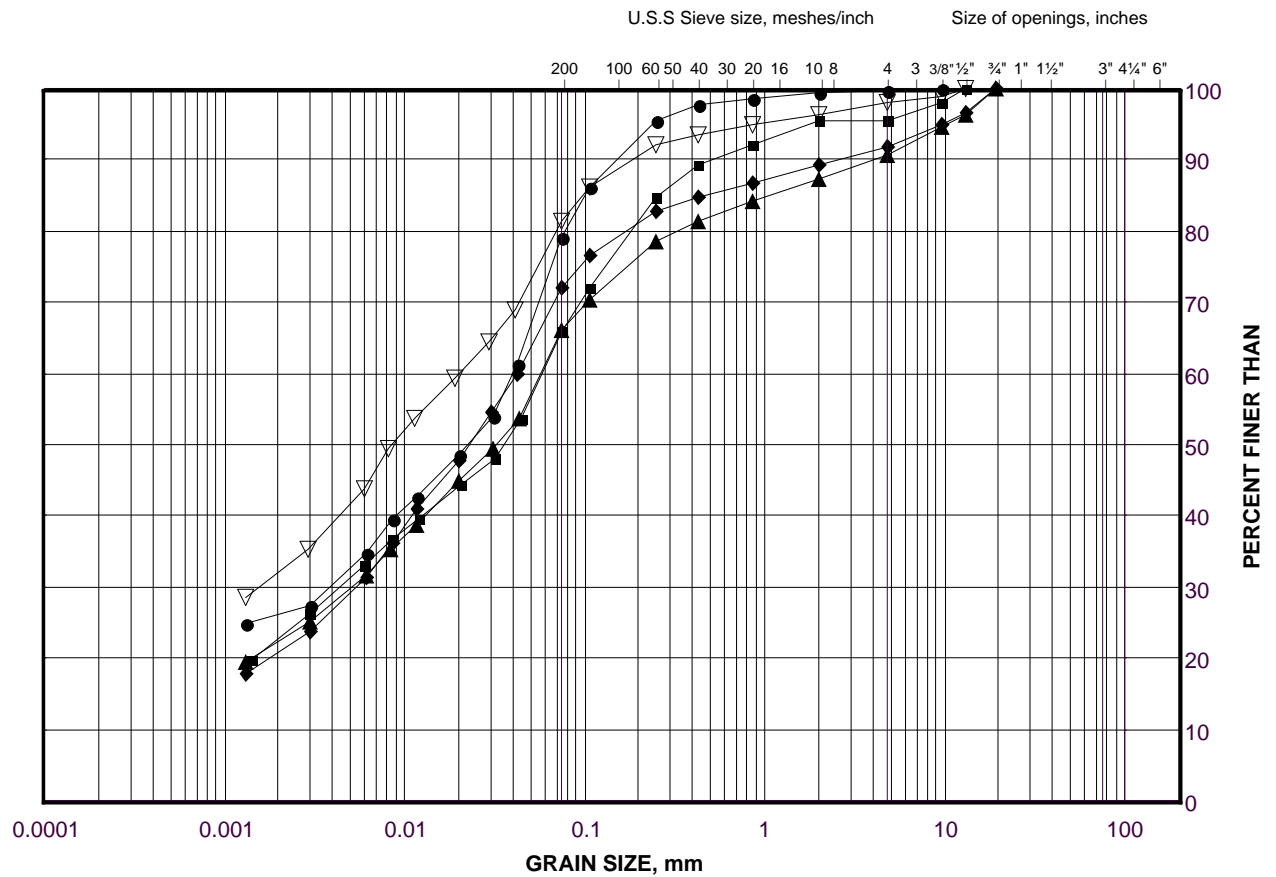
Golder Associates

Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand to Silty Clay

FIGURE B-14C



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

LEGEND

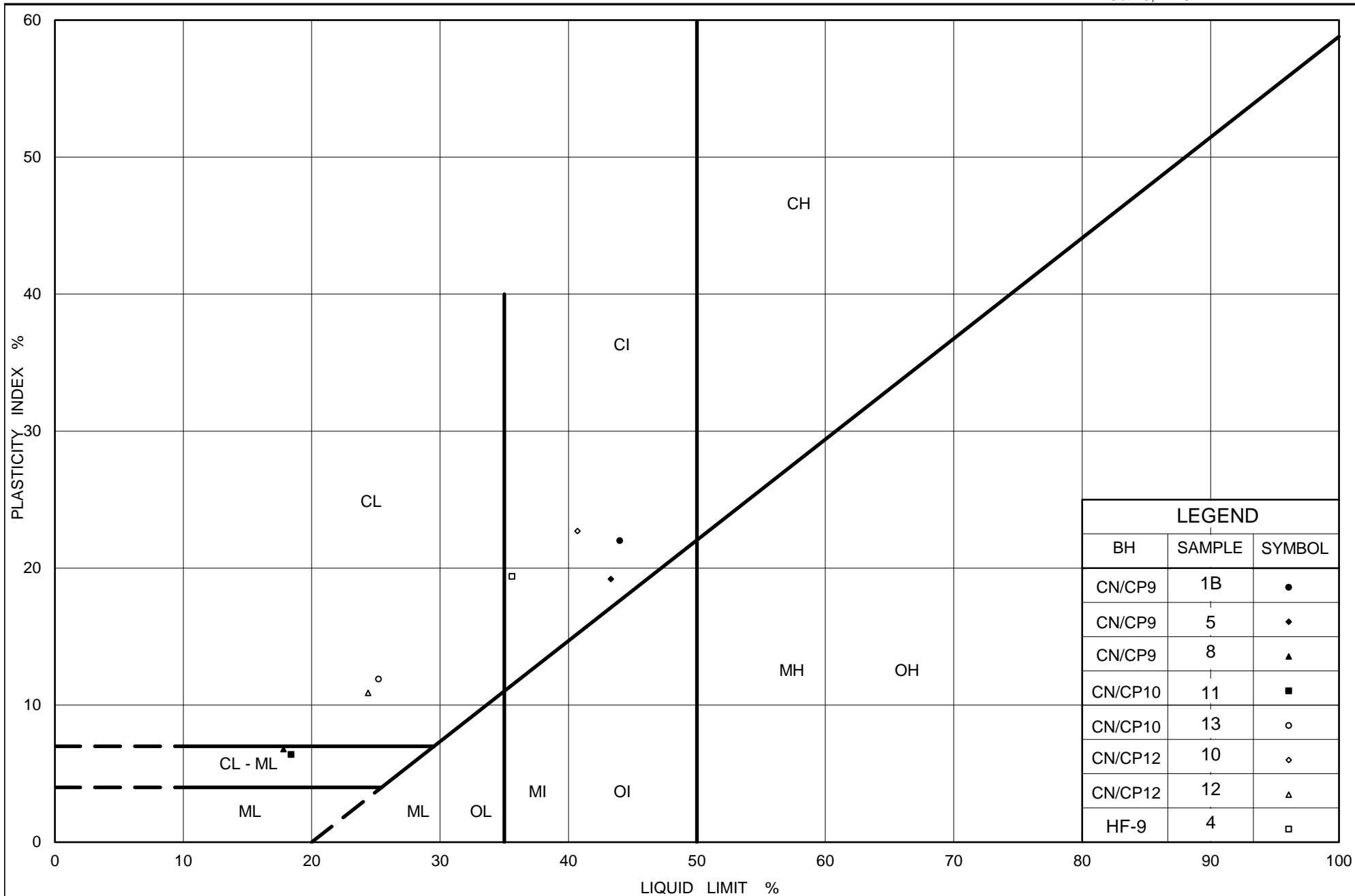
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	RW-15	2	181.9
■	RW-14	2A	180.6
◆	RW-15	5	179.6
▲	RW-14	6	177.3
▽	C1-3	7	179.2

Project Number: 1671430

Checked By: MAS

Golder Associates

Date: 01-May-19



Ministry of Transportation

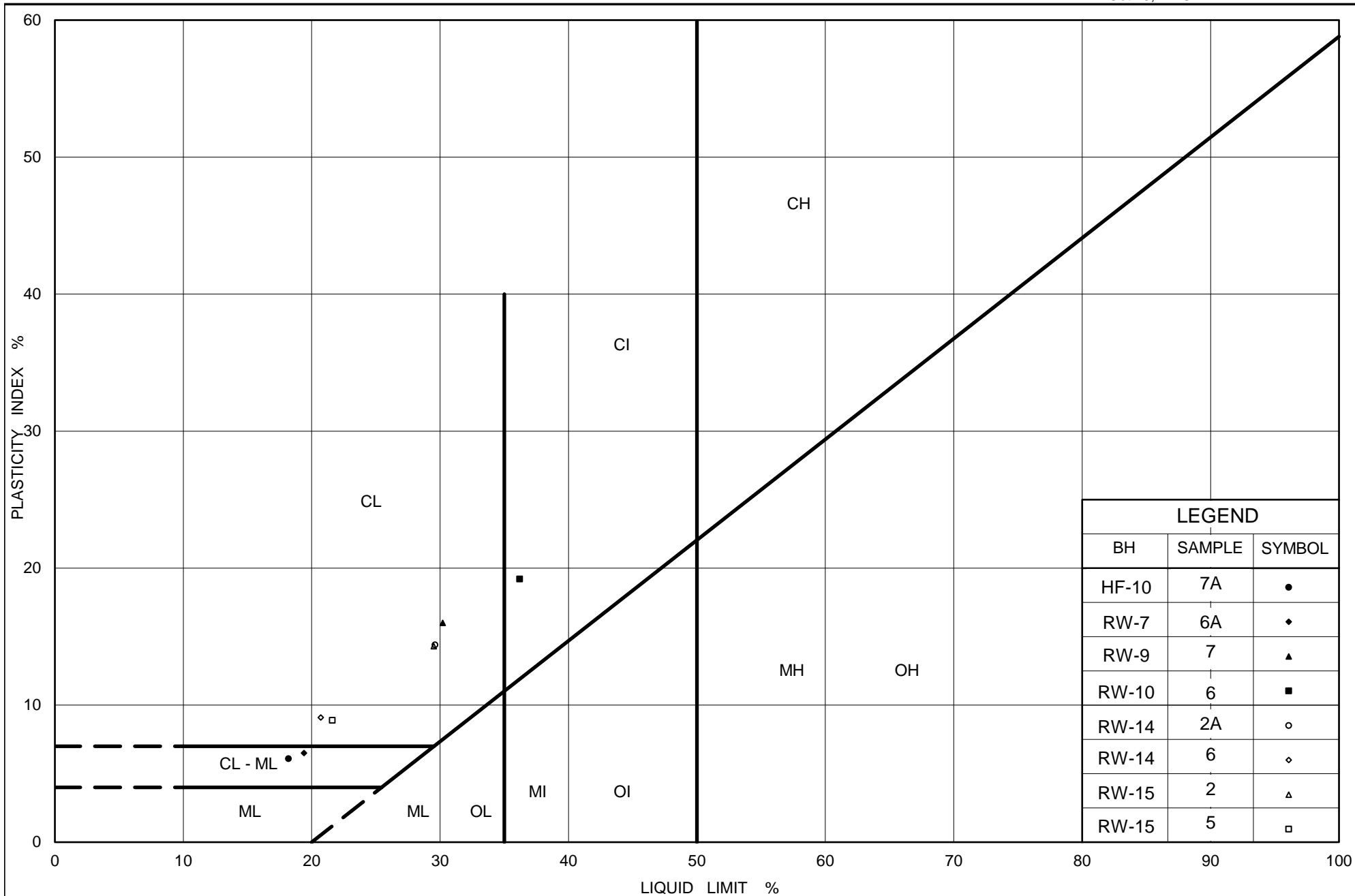
Ontario

PLASTICITY CHART Clayey Silt to Silty Clay

Figure No. B-15A

Project No. 1671430 (WO 008)

Checked By: MAS



Ministry of Transportation

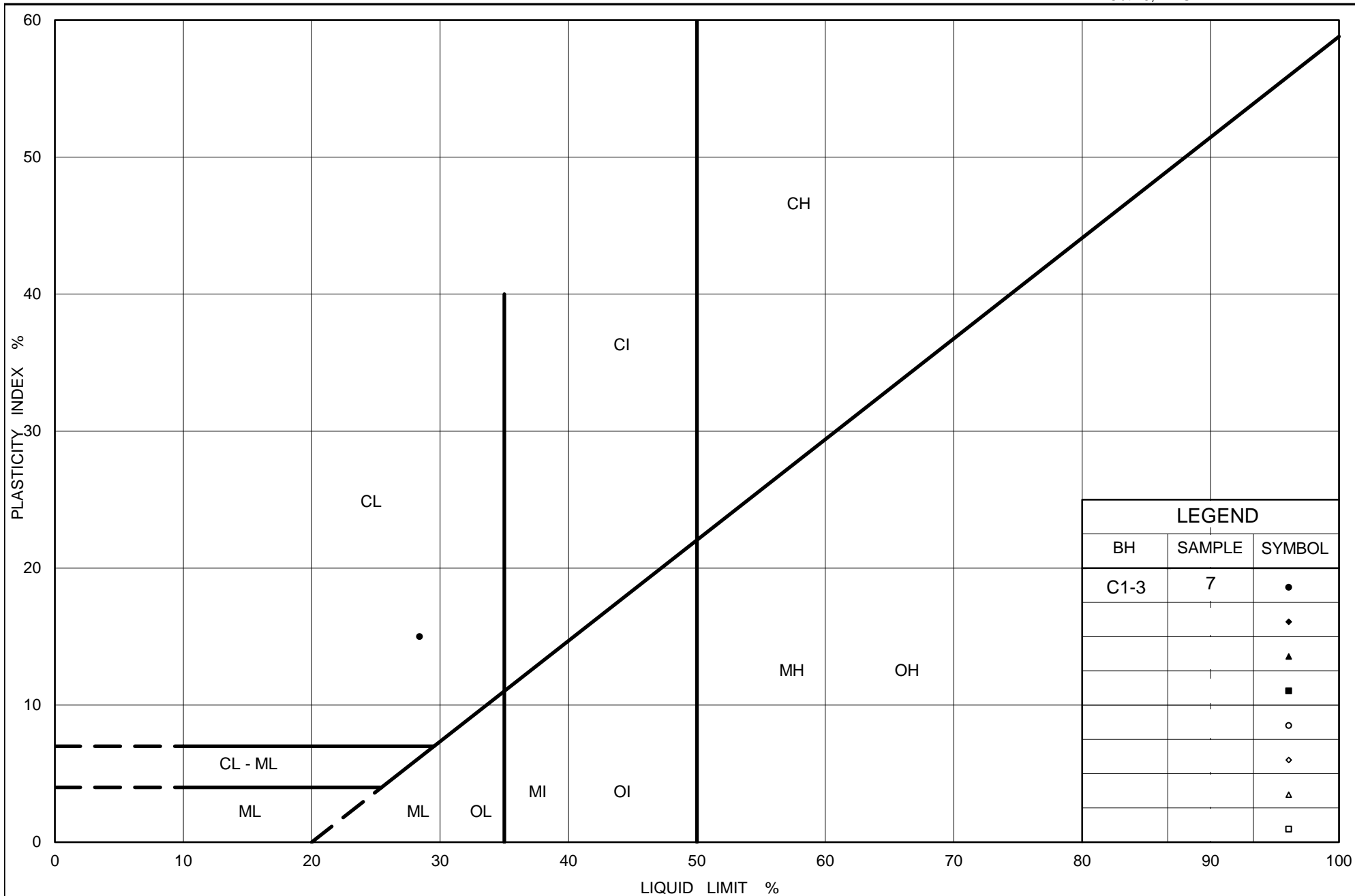
Ontario

PLASTICITY CHART Clayey Silt with Sand to Silty Clay

Figure No. B-15B

Project No. 1671430 (WO 008)

Checked By: MAS



Ministry of Transportation

Ontario

PLASTICITY CHART

Clayey Silt

Figure No. B-15C

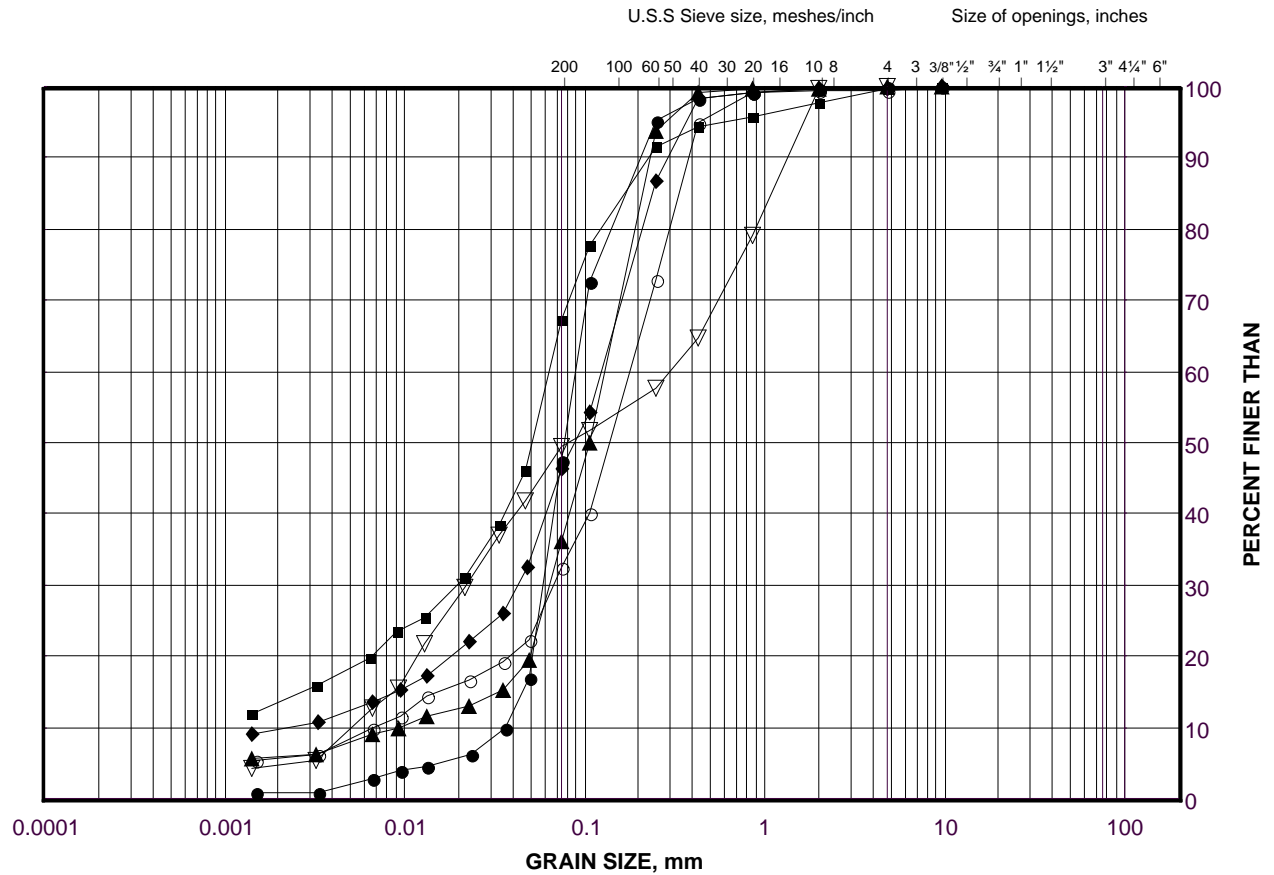
Project No. 1671430 (WO 008)

Checked By: MAS

GRAIN SIZE DISTRIBUTION

Silt and Sand to Silty Sand

FIGURE B-16A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	CN/CP10	10B	177.1
■	HF-14	2	181.4
◆	HF-12	3	180.8
▲	RW-6	4B	180.9
▽	HF-9	6A	177.7
○	RW-9	8	178.7

Project Number: 1671430

Checked By: MAS

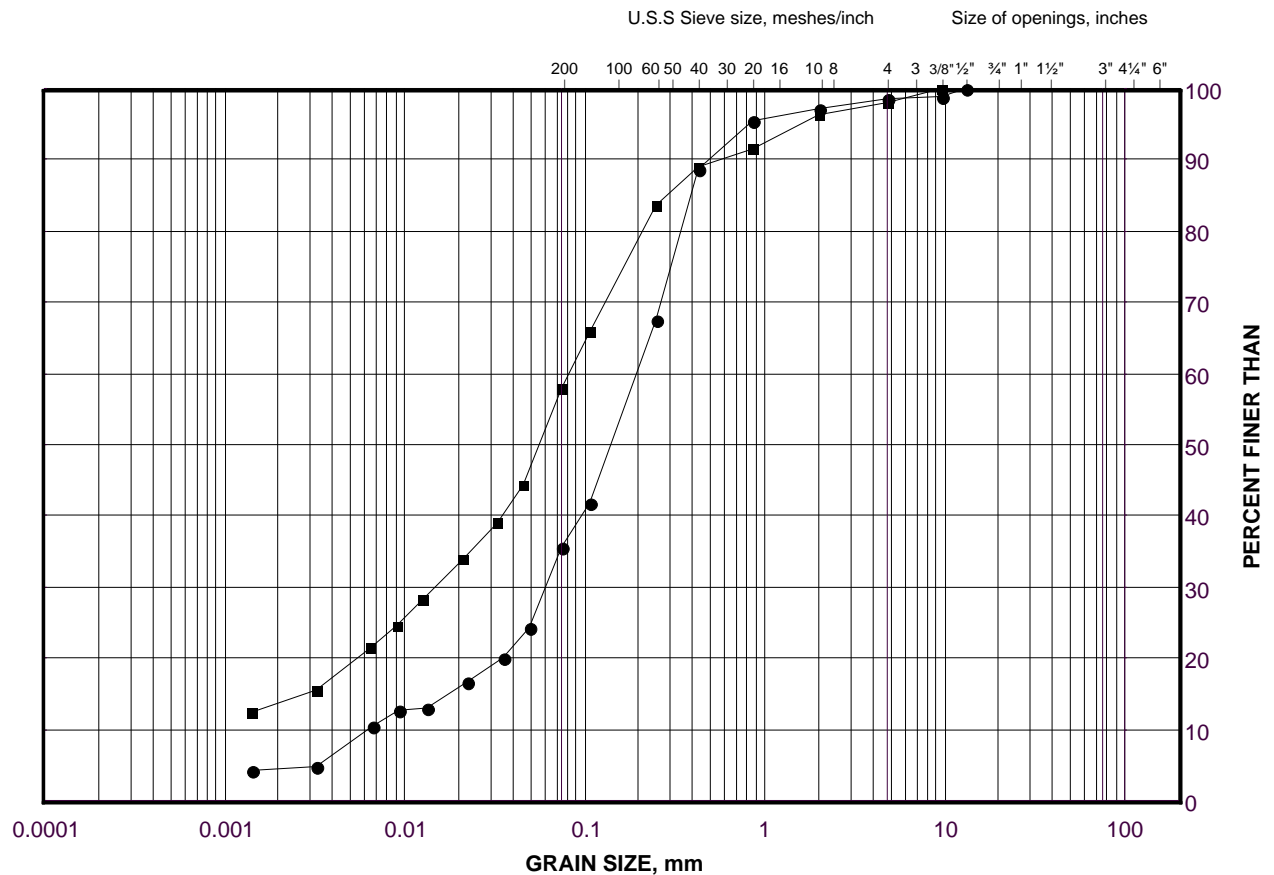
Golder Associates

Date: 06-May-19

GRAIN SIZE DISTRIBUTION

Sand to Silty Sand

FIGURE B-16B



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	RW-14	3	179.7
■	C1-1	4	180.3

Project Number: 1671430

Checked By: MAS

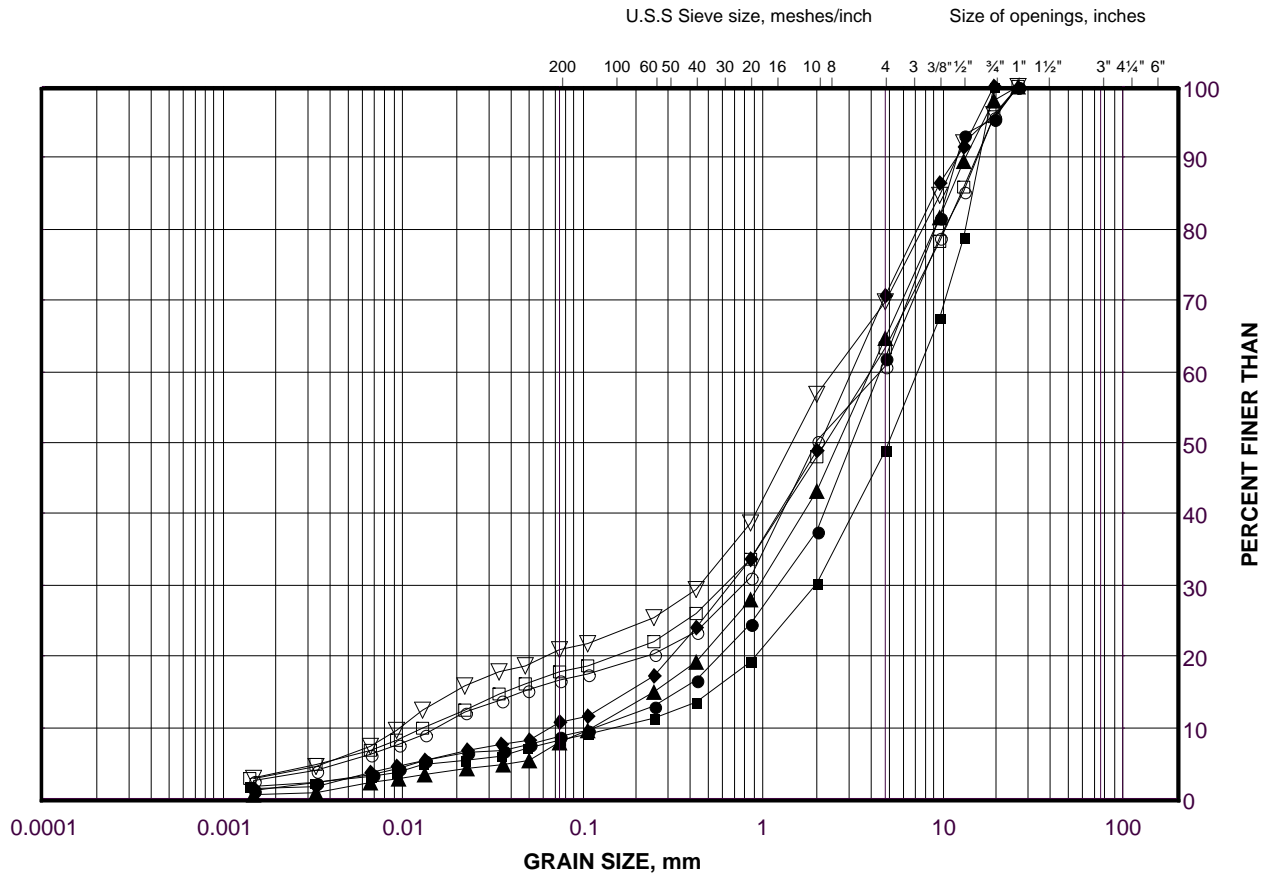
Golder Associates

Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B-17A



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	HF-12	10	171.7
■	CN/CP9	12	167.5
◆	CN/CP12	14	171.4
▲	CN/CP10	15	169.6
▽	HF-14	6	178.3
○	HF-12	7	176.2
□	HF-10	8	176.7

Project Number: 1671430

Checked By: MAS

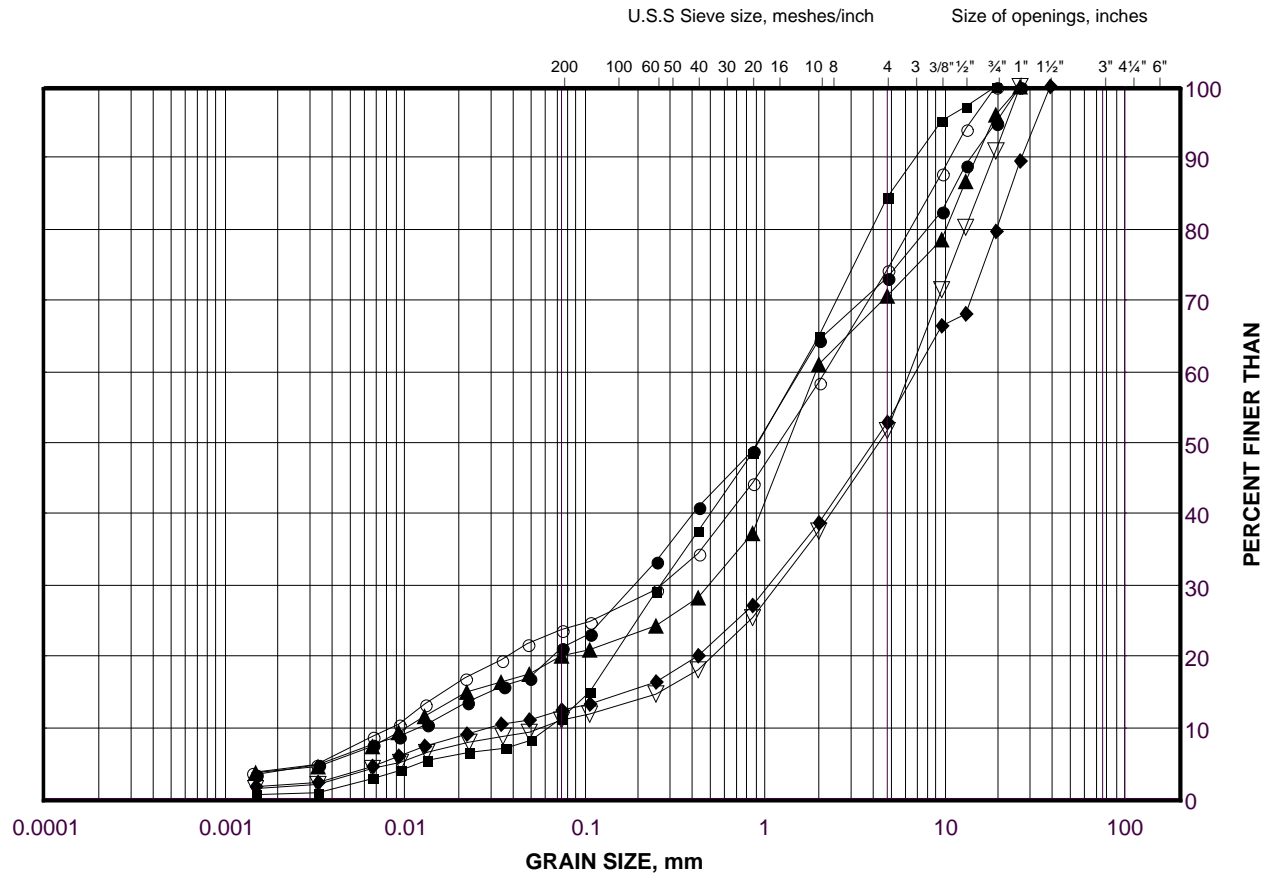
Golder Associates

Date: 01-May-19

GRAIN SIZE DISTRIBUTION

Sand to Gravelly Sand to Sand and Gravel

FIGURE B-17B



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

LEGEND

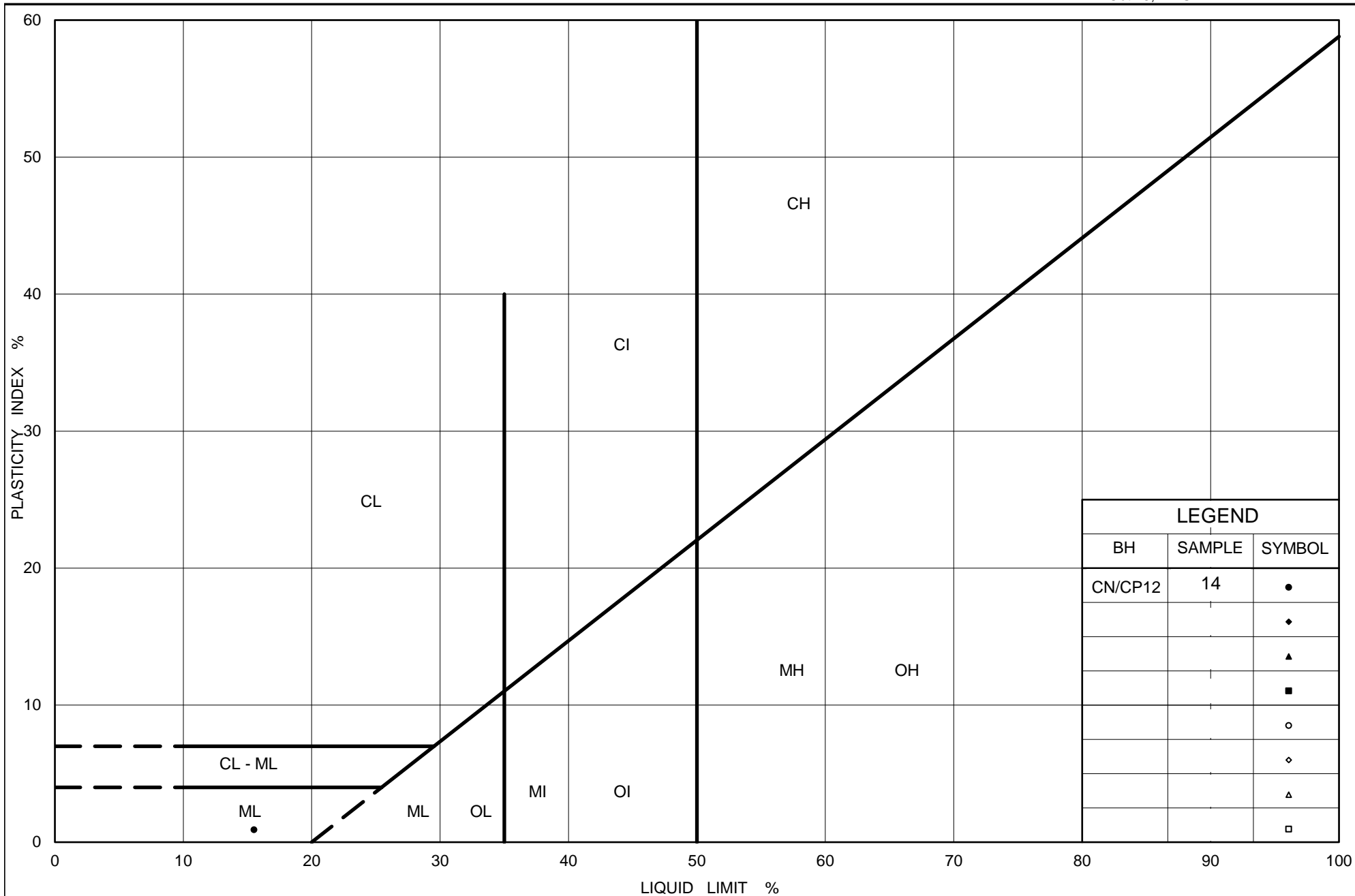
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	RW-9	10	175.8
■	CN/CP10	14	171.2
◆	RW-5	7	178.5
▲	RW-7	7B	177.0
▽	RW-4A	8	178.0
○	RW-10	9	175.6

Project Number: 1671430

Checked By: MAS

Golder Associates

Date: 06-May-19



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PLASTICITY CHART Sand and Gravel

Figure No. B-18

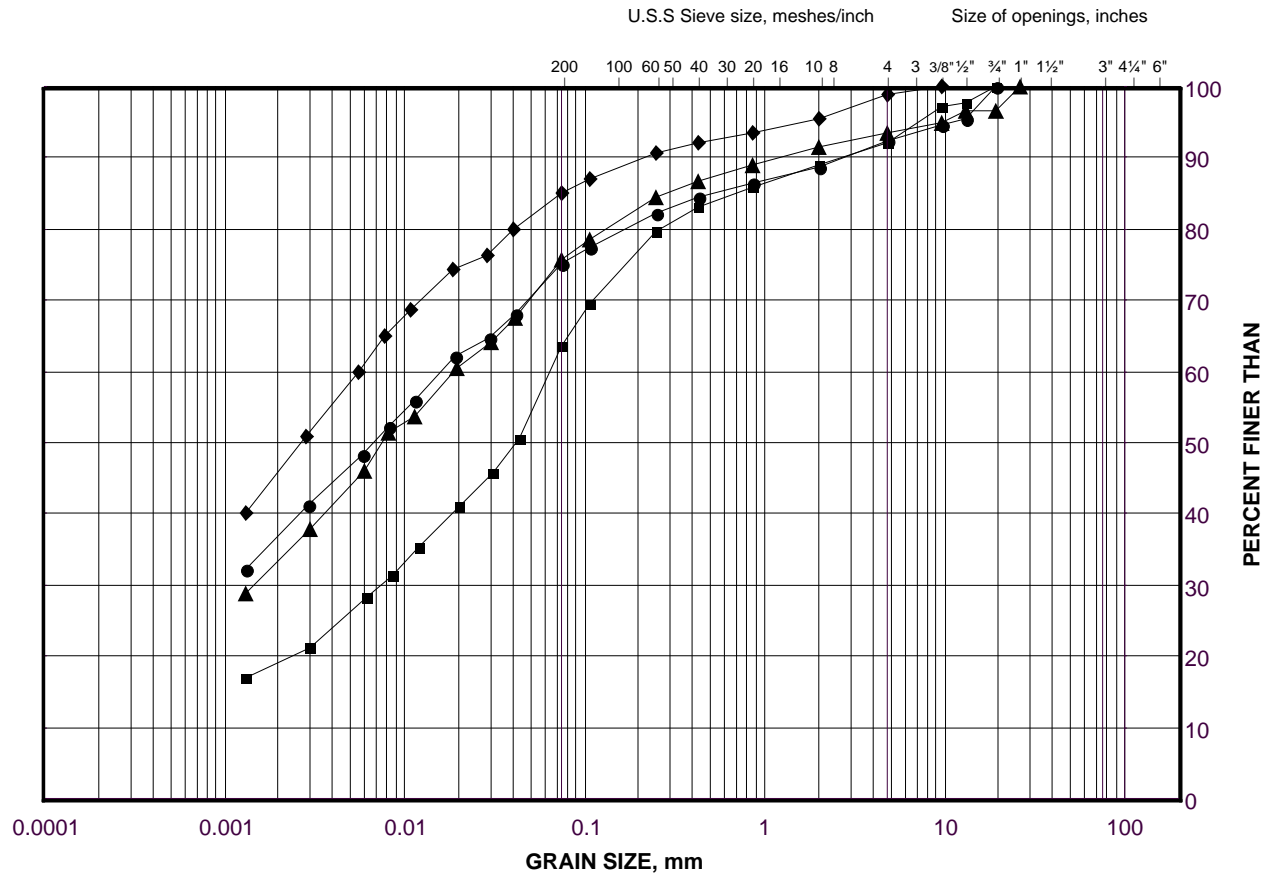
Project No. 1671430 (WO 008)

Checked By: MAS

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay Fill
(Bowen Road Ramps)

FIGURE B-19



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

LEGEND

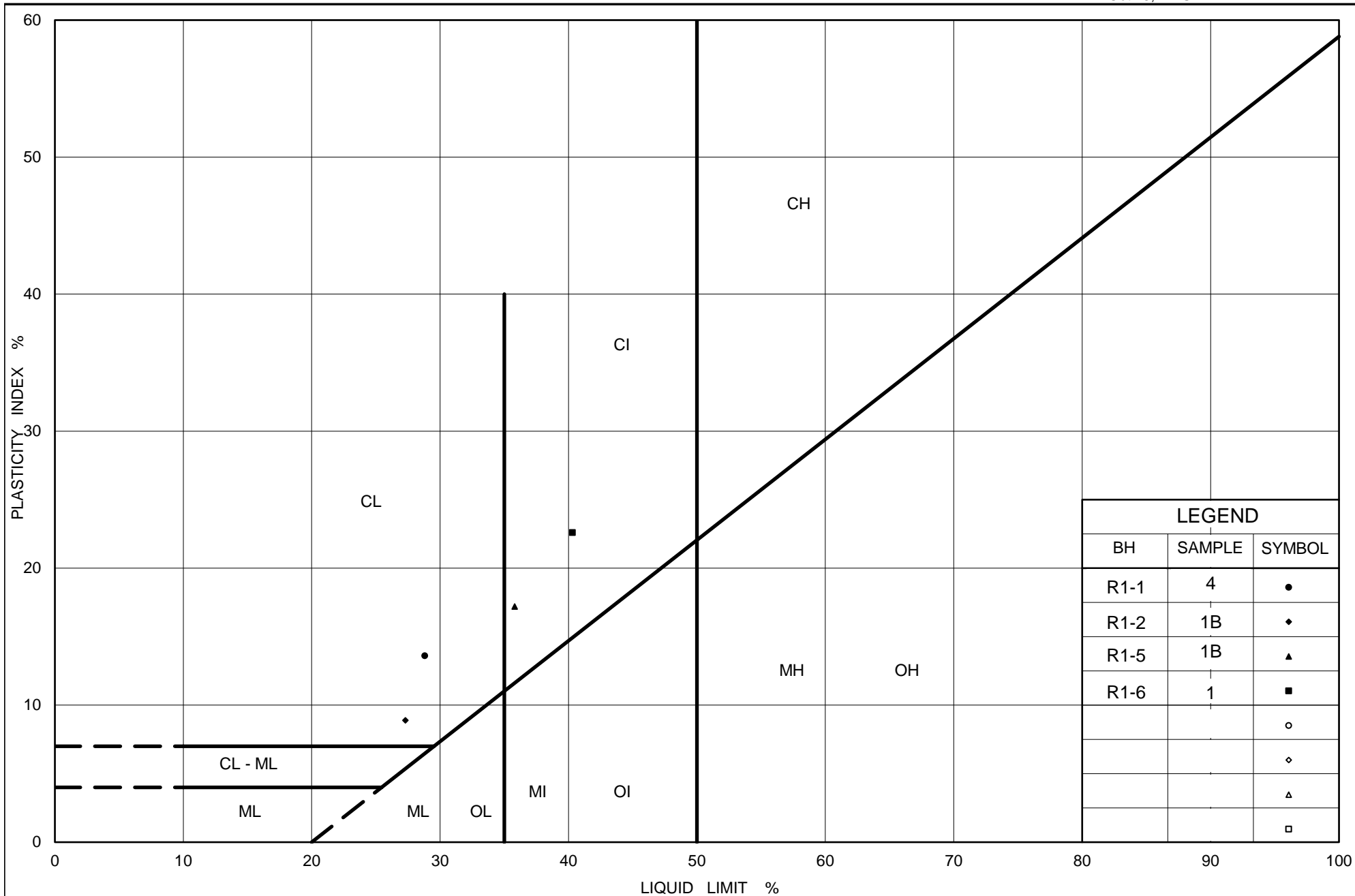
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	R1-6	1	185.0
■	R1-2	1B	185.2
◆	R1-5	1B	183.6
▲	R1-1	4	186.5

Project Number: 1671430

Checked By: MAS

Golder Associates

Date: 01-May-19



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt to Silty Clay Fill (Bowen Road Ramps)

Figure No. B-20

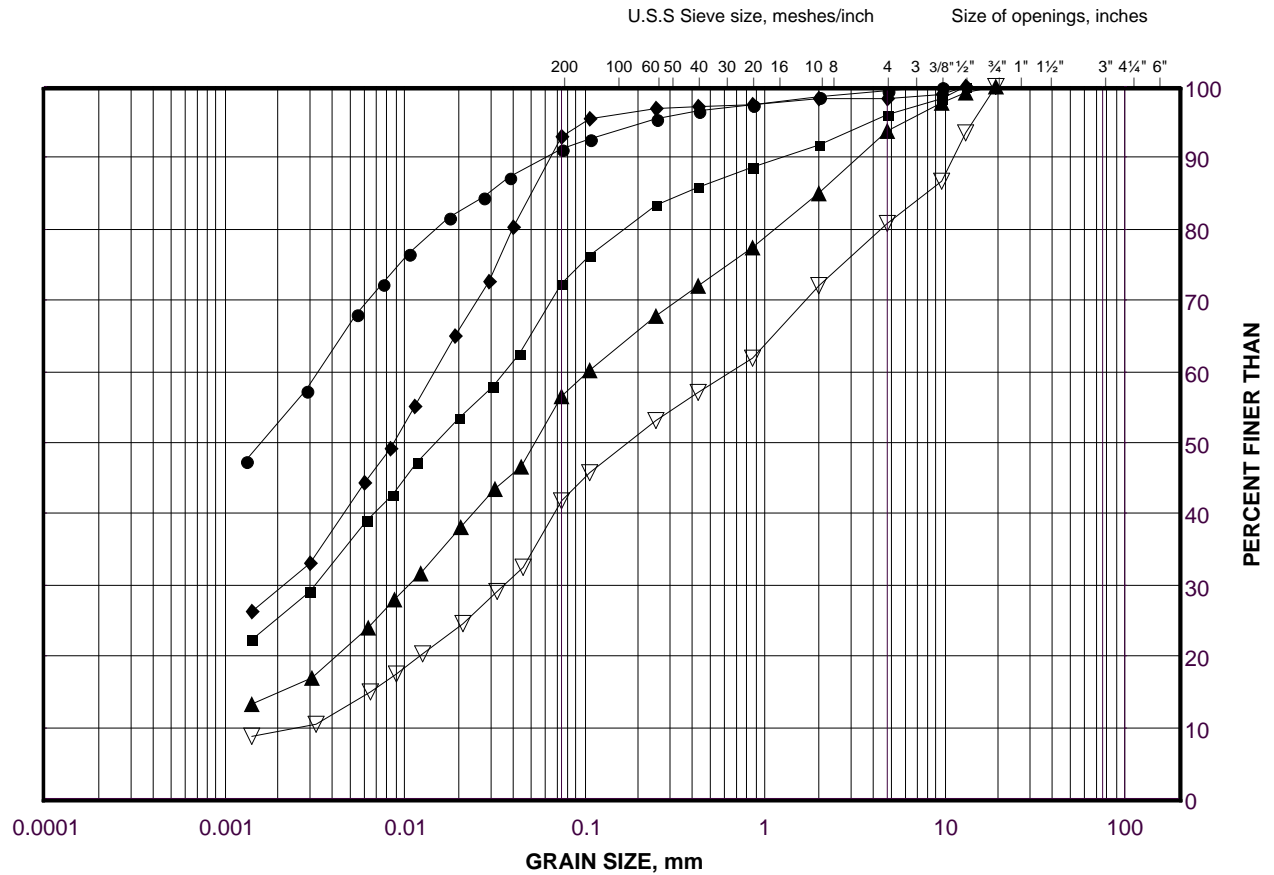
Project No. 1671430 (WO 008)

Checked By: MAS

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand to Silty Clay
(Bowen Road Ramps)

FIGURE B-21



LEGEND

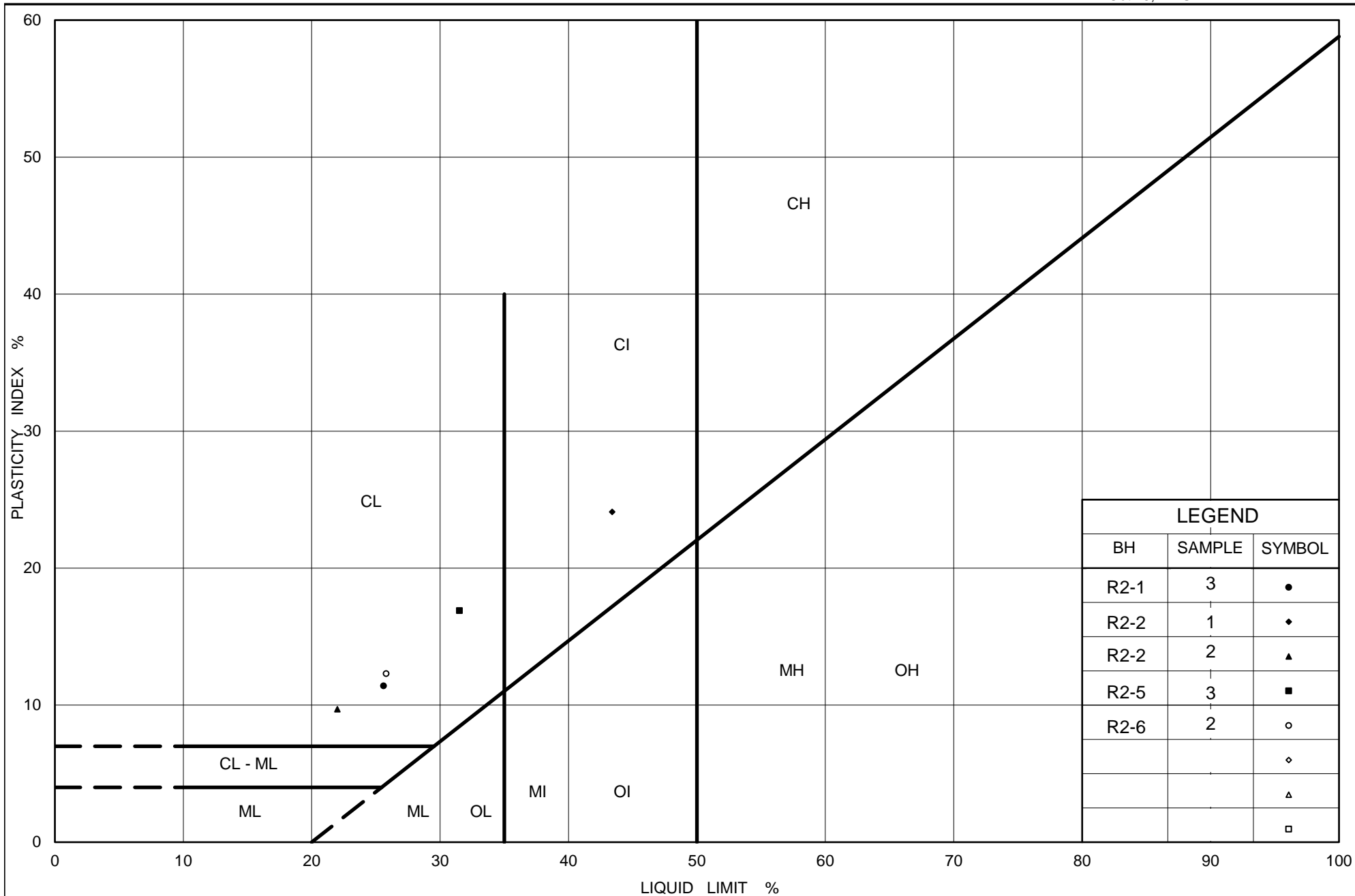
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	R2-2	1	183.3
■	R2-6	2	184.4
◆	R2-1	3	182.6
▲	R2-5	5	182.7
▽	R2-1	5	181.1

Project Number: 1671430

Checked By: MAS

Golder Associates

Date: 01-May-19



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt with Sand to Silty Clay (Bowen Road Ramps)

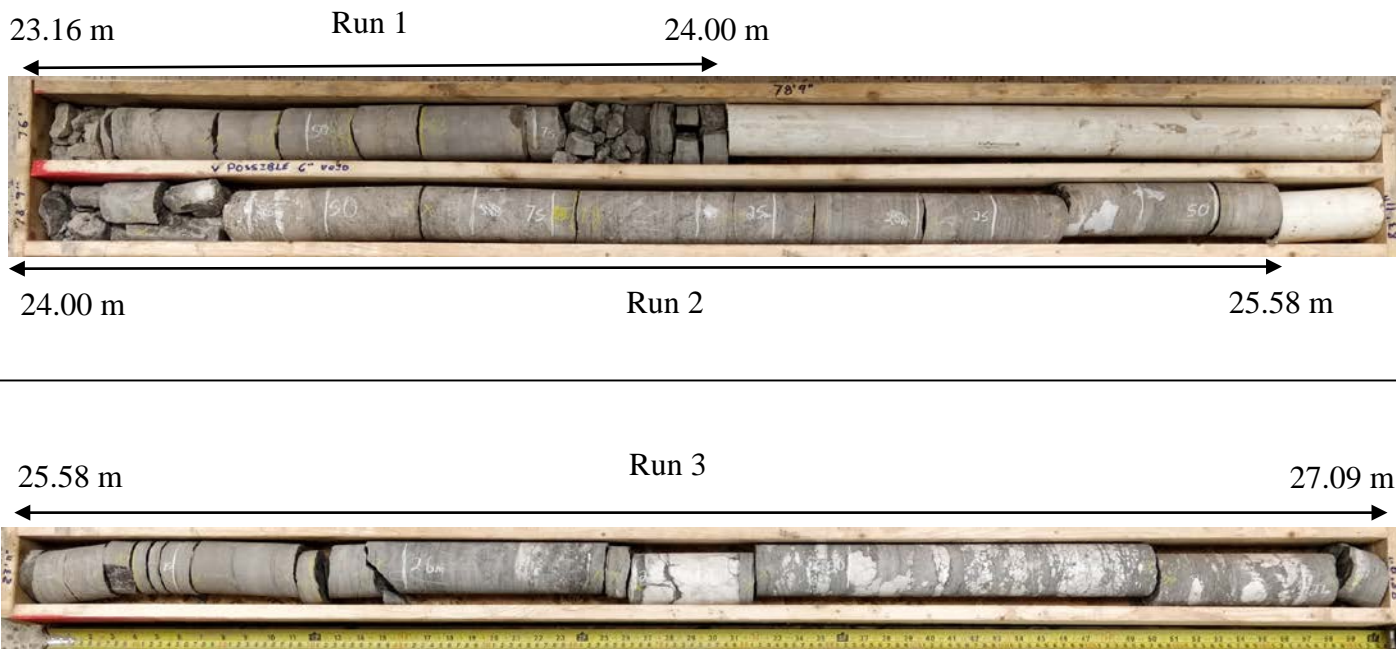
Figure No. B-22

Project No. 1671430 (WO 008)


Checked By: MAS

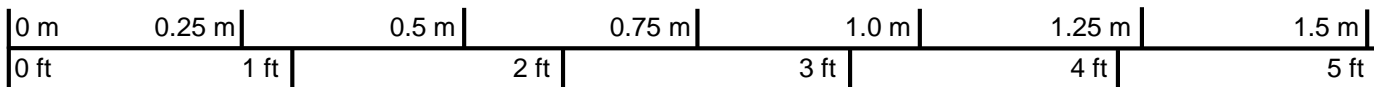
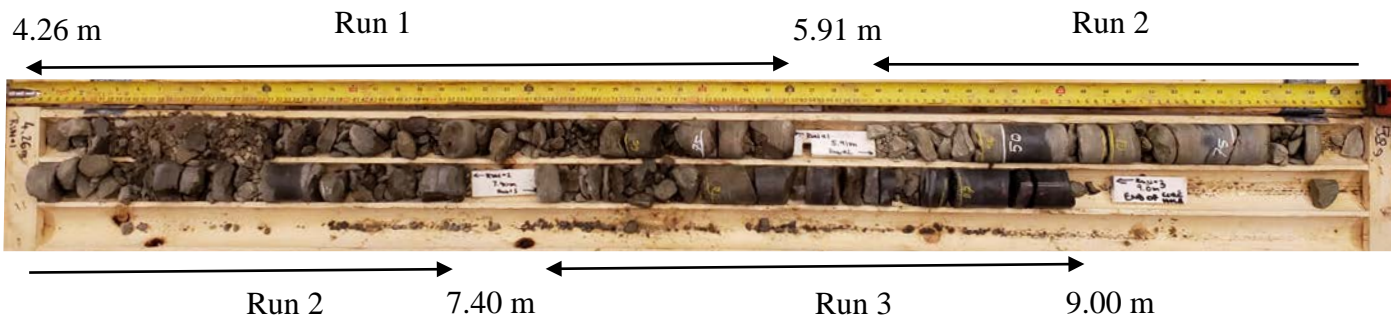
APPENDIX C

Bedrock Core Photographs and Laboratory Test Results



Scale

PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE CN/CP3			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			Figure C-1



Scale

PROJECT
HIGH FILL EMBANKMENTS AND RETAINING WALLS
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

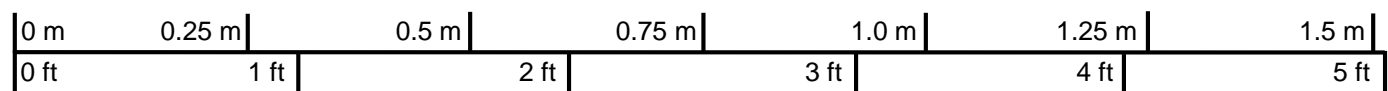
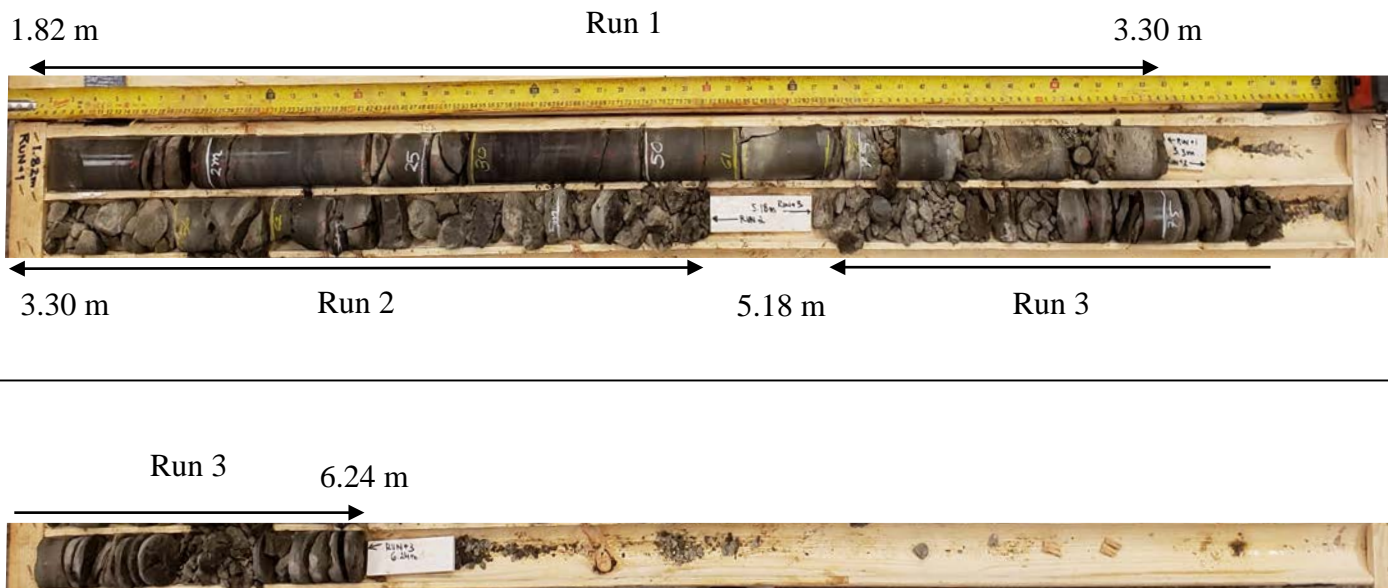
CLIENT
AECOM

TITLE
BEDROCK CORE PHOTOGRAPHS – BOREHOLE HF-9




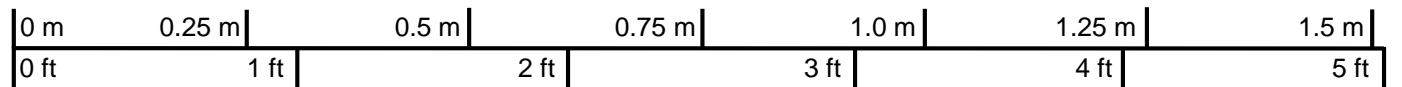
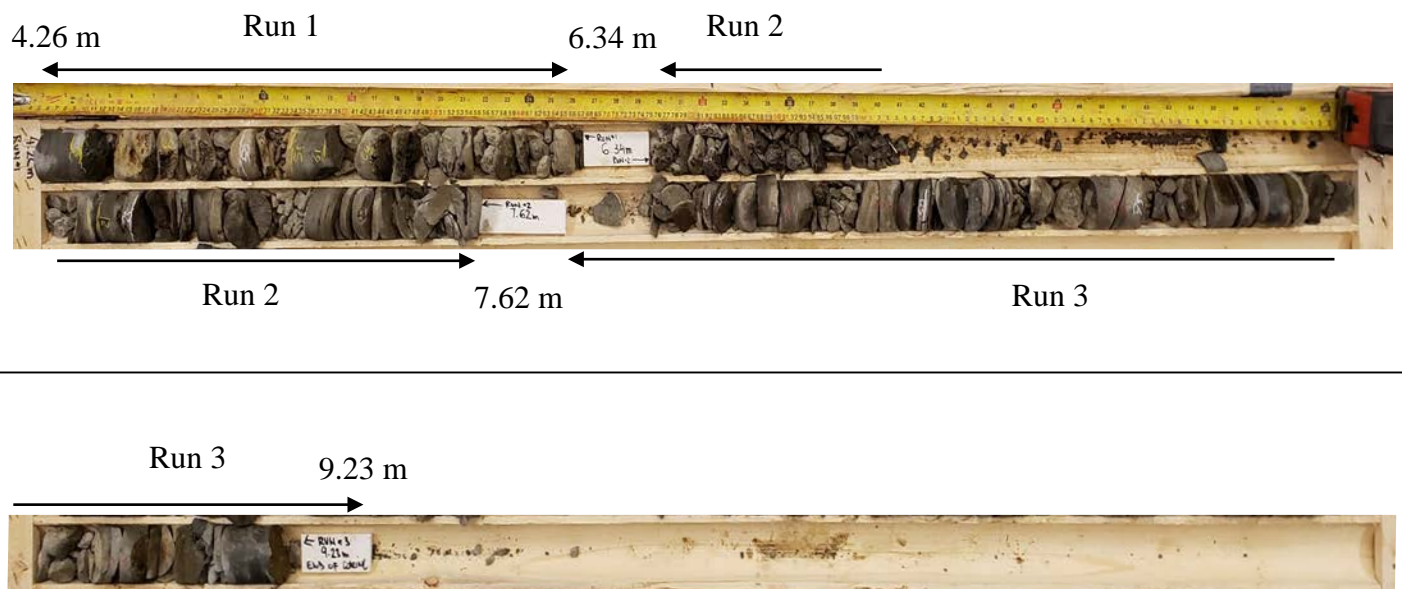
PROJECT NO.	1671430	PHASE	WO008
DESIGNED	SE	REV.	A
PREPARED	SE		
REVIEWED	EN		
APPROVED			

Figure C-2




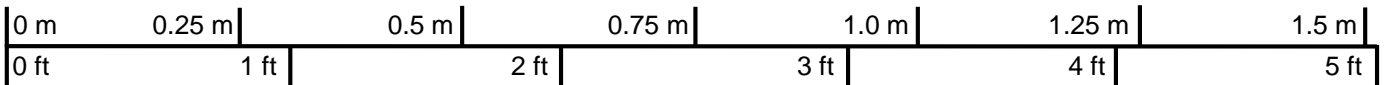
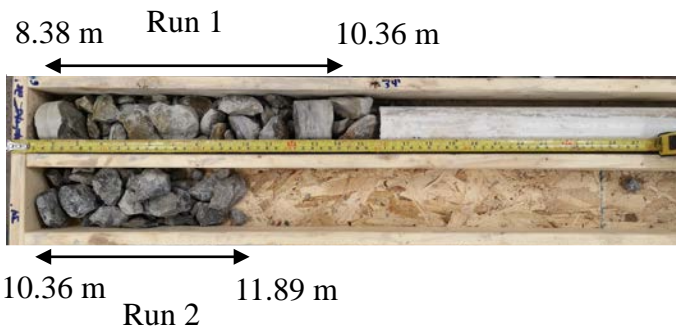
Scale

PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE HF-11			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			
Figure C-3			




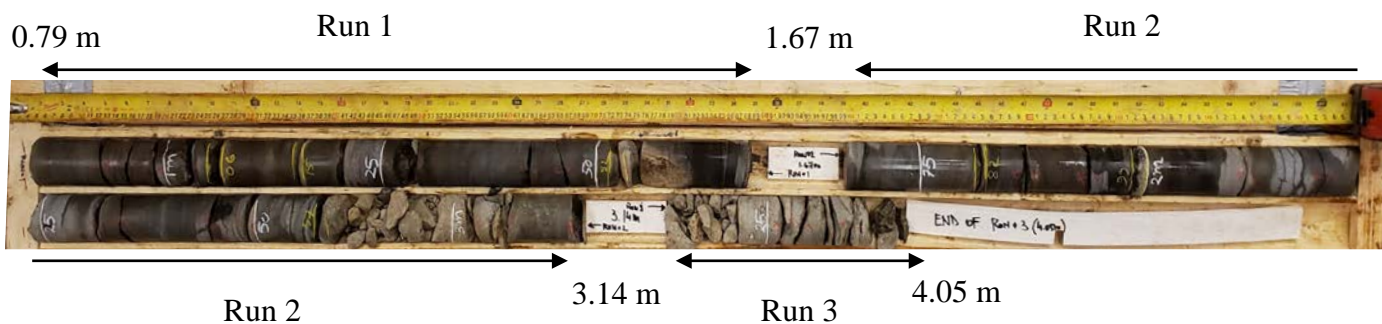
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PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE RW-6			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			Figure C-4



Scale

PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-1			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
	APPROVED		
Figure C-5			



Scale

PROJECT
HIGH FILL EMBANKMENTS AND RETAINING WALLS
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

CLIENT
AECOM

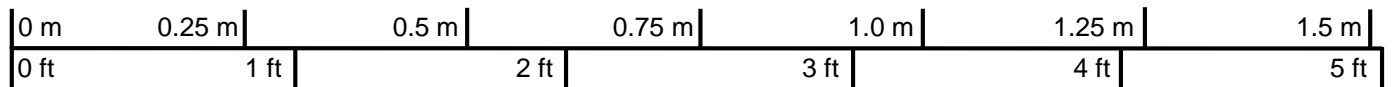
TITLE
BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-2



PROJECT NO.	1671430	PHASE	WO008
DESIGNED	SE	REV.	A
PREPARED	SE		
REVIEWED	EN		
APPROVED			

Figure C-6

8.61 m Run 1 10.14 m



Scale

PROJECT
HIGH FILL EMBANKMENTS AND RETAINING WALLS
QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS
MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00

CLIENT
AECOM

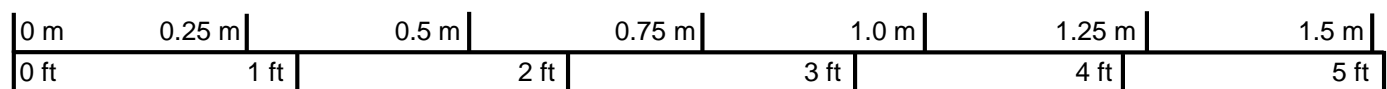
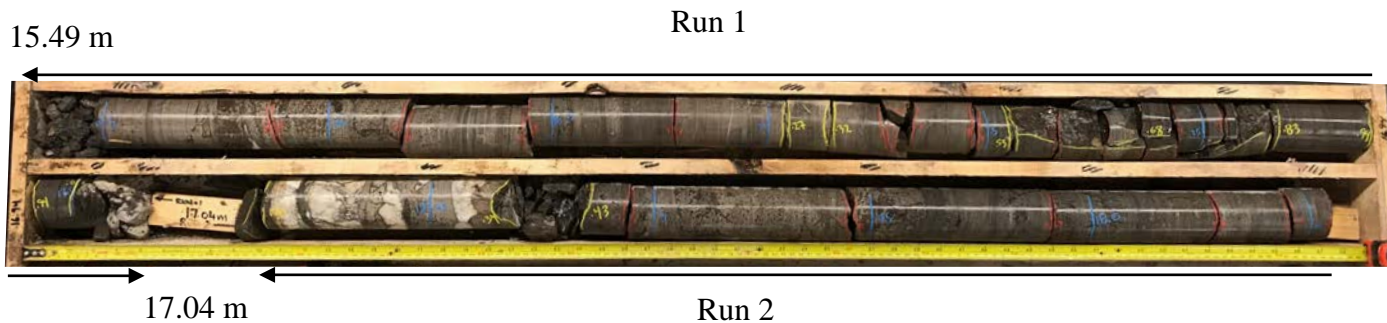
TITLE
BEDROCK CORE PHOTOGRAPHS – BOREHOLE C1-3




GOLDER

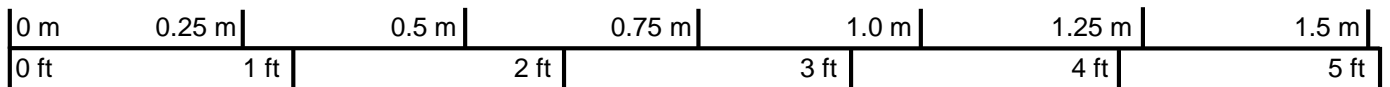
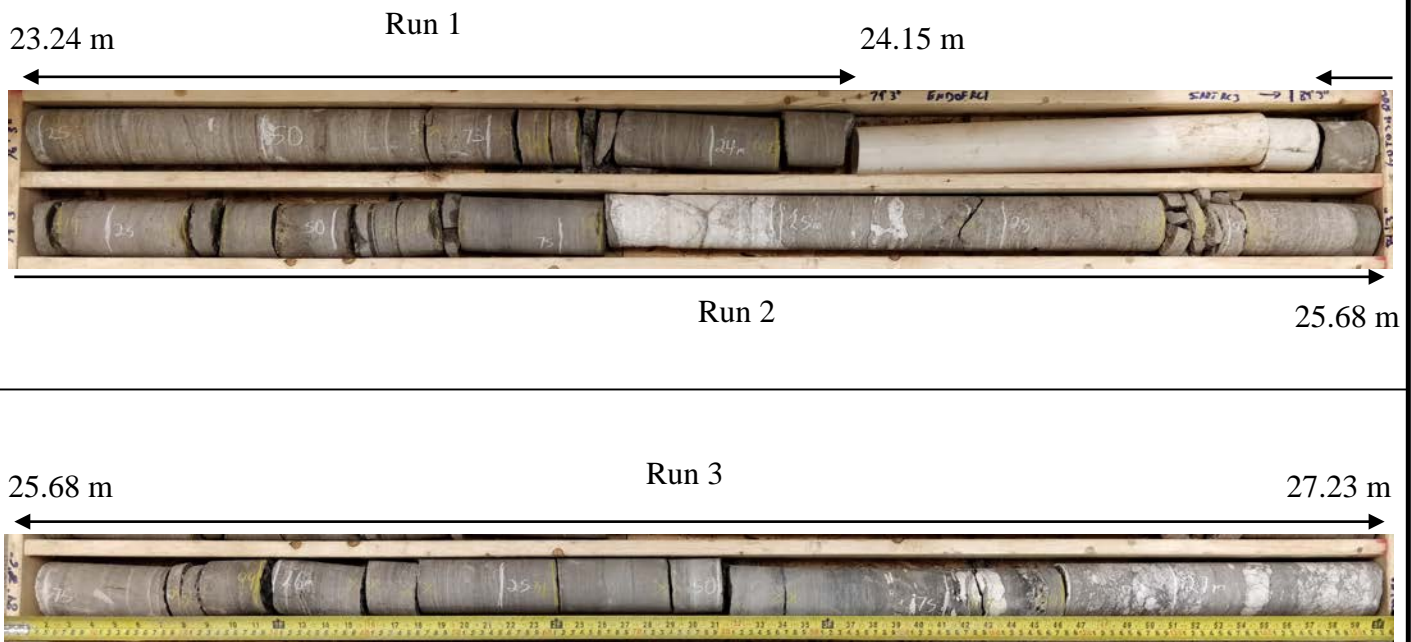
PROJECT NO. 1671430		PHASE WO008	
DESIGNED	SE		REV. A
PREPARED	SE		
REVIEWED	EN		
APPROVED			

Figure C-7




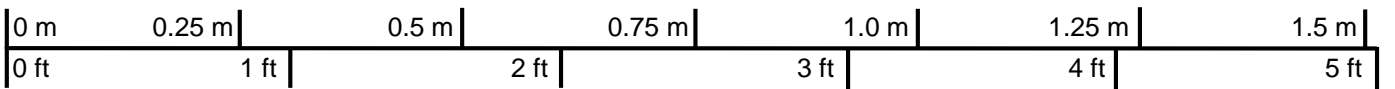
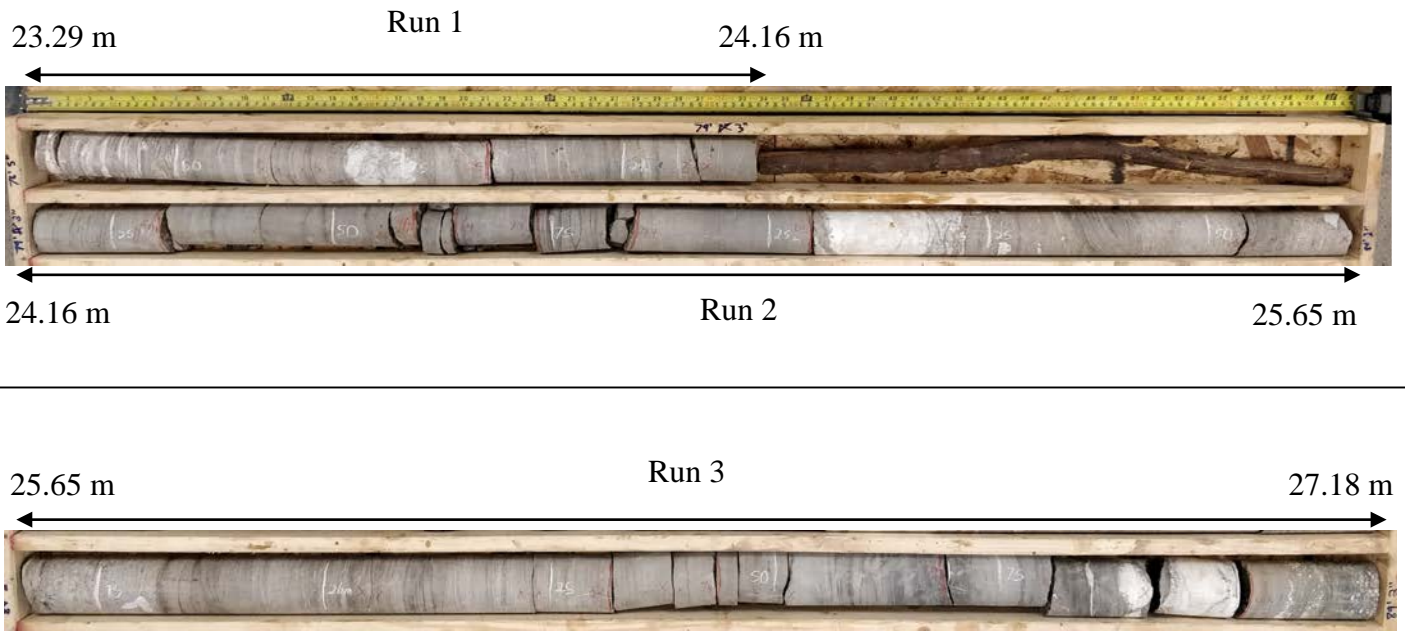
Scale

PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE CN/CP9			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			
Figure C-8			




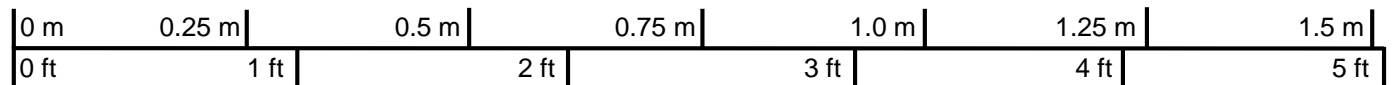
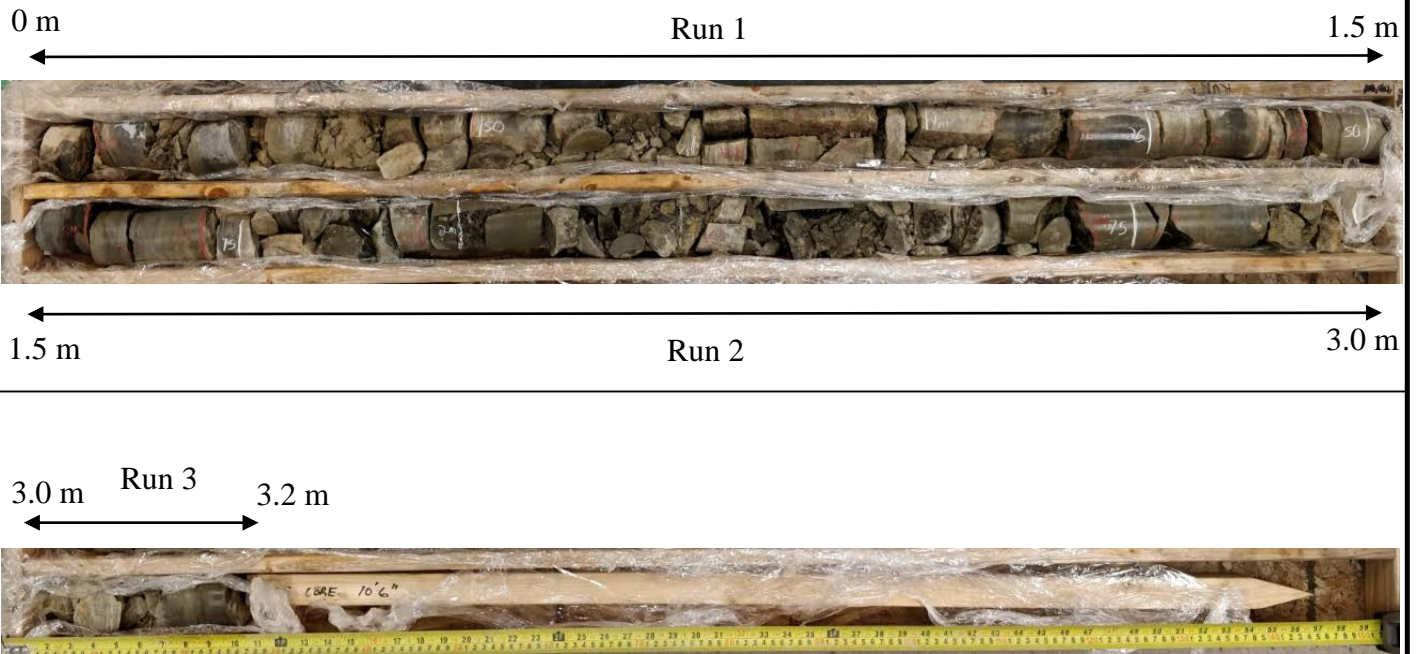
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PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE CN/CP10			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			Figure C-9




Scale

PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE CN/CP12			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
APPROVED			Figure C-10



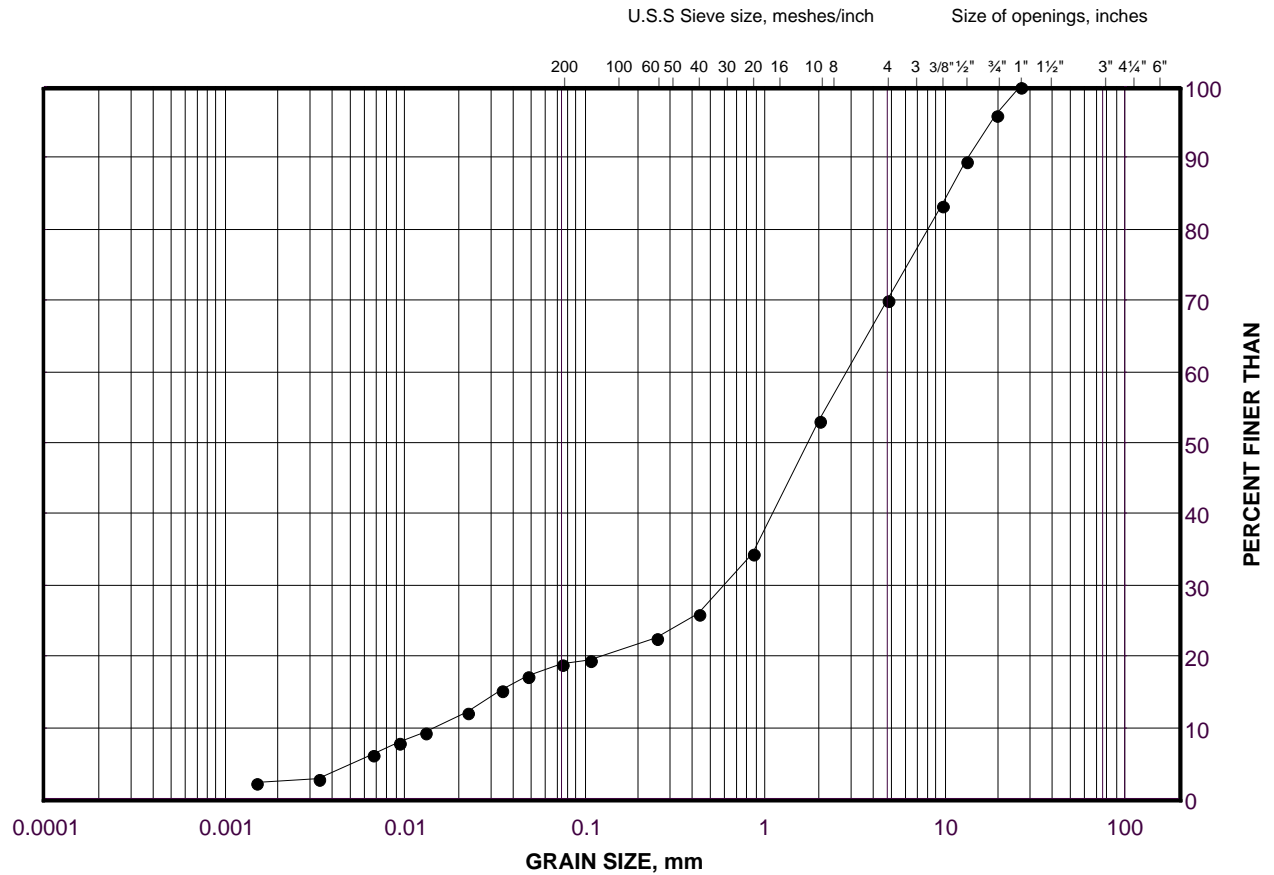
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PROJECT HIGH FILL EMBANKMENTS AND RETAINING WALLS QEW BRIDGE REPLACEMENT AND ASSOCIATED HIGHWAY IMPROVEMENTS MINISTRY OF TRANSPORTATION G.W.P. 2116-16-00			
CLIENT AECOM			
TITLE BEDROCK CORE PHOTOGRAPHS – BOREHOLE C3-2			
 GOLDER	PROJECT NO. 1671430		PHASE WO008
	DESIGNED	SE	REV. A
	PREPARED	SE	
	REVIEWED	EN	
	APPROVED		
Figure C-11			

GRAIN SIZE DISTRIBUTION

Dolomitic Limestone (Bedrock)

FIGURE C-12



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	C1-1	7	175.8

Project Number: 1671430

Checked By: _____

Golder Associates

Date: 02-May-19

POINT LOAD STRENGTH TEST (ISRM, 1985)

Min W (mm)

A Axial Test

19

D Diametral Test

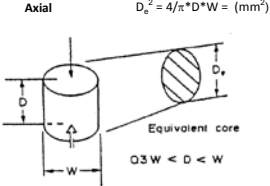
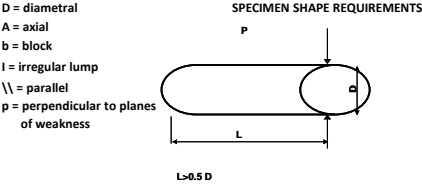
63

Test #	Borehole	Rock type	Depth (top)	W	D	Gauge Reading	Load P	D_e^2	$I_s = P/D_e^2$	$F = (D_e/50)^{0.45}$	$I_{s(50)}$	Type	Valid Test	Remarks
			m	mm	mm	Mpa	MN	mm ²	MPa		MPa			
1	C1-2	Limestone	2.50	75	46	0.36	0.00035	2116.0	0.16	0.963	0.16	D	Y	NX core
2	C1-2	Limestone	1.21	60	46	1.74	0.00168	2116.0	0.80	0.963	0.77	D	Y	NX core
3	C1-3	Limestone	8.80	46	45	2.52	0.00244	2635.6	0.92	1.012	0.94	A	Y	
4	C3-2	Limestone	1.32	63	55	9.14	0.00884	4411.8	2.00	1.136	2.28	A	Y	
5	C3-2	Limestone	1.63	90	63	1.02	0.00099	3969.0	0.25	1.110	0.28	D	Y	
6	C3-2	Limestone	2.79	100	63	1.44	0.00139	3969.0	0.35	1.110	0.39	D	Y	
7	CN/CP10	Limestone	26.44	63	60	9.76	0.00944	4812.8	1.96	1.159	2.27	A	Y	
8	CN/CP10	Limestone	24.68	95	63	0.86	0.00083	3969.0	0.21	1.110	0.23	D	Y	
9	CN/CP10	Limestone	25.34	70	63	1.16	0.00112	3969.0	0.28	1.110	0.31	D	Y	
10	CN/CP12	Limestone	24.58	63	25	16.78	0.01623	2005.4	8.09	0.952	7.70	A	Y	
11	CN/CP12	Limestone	26.44	63	25	14.58	0.01410	2005.4	7.03	0.952	6.69	A	Y	
12	CN/CP12	Limestone	25.55	110	63	0.18	0.00017	3969.0	0.04	1.110	0.05	D	Y	
13	CN/CP3	Limestone	23.39	63	40	18.94	0.01831	3208.6	5.71	1.058	6.04	A	Y	
14	CN/CP3	Limestone	24.95	100	63	7.28	0.00704	3969.0	1.77	1.110	1.97	D	Y	
15	CN/CP3	Limestone	26.39	60	63	1.02	0.00099	3969.0	0.25	1.110	0.28	D	Y	
16	CN/CP9	Limestone	17.47	110	63	11.12	0.01075	3969.0	2.71	1.110	3.01	D	Y	
17	CN/CP9	Limestone	18.40	63	30	18.84	0.01822	2406.4	7.57	0.991	7.51	A	Y	
18	CN/CP9	Limestone	16.48	63	45	12.30	0.01189	3609.6	3.30	1.086	3.58	A	Y	
19	HF-11	Limestone	1.95	30	46	0.30	0.00029	2116.0	0.14	0.963	0.13	D	Y	NX core
20	HF-11	Limestone	3.65	45	46	0.68	0.00066	2116.0	0.31	0.963	0.30	D	Y	NX core
21	HF-11	Limestone	6.01	46	20	4.90	0.00474	1171.4	4.05	0.843	3.41	A	Y	NX core
22	HF-9	Limestone	8.87	65	46	1.82	0.00176	2116.0	0.83	0.963	0.80	D	Y	NX core
23	HF-9	Limestone	7.18	70	46	4.86	0.00470	2116.0	2.22	0.963	2.14	D	Y	NX core
24	HF-9	Limestone	6.61	46	35	1.54	0.00149	2049.9	0.73	0.956	0.69	A	Y	NX core
25	RW-6	Limestone	9.12	85	46	0.38	0.00037	2116.0	0.17	0.963	0.17	D	Y	NX core
26	RW-6	Limestone	8.75	46	35	9.04	0.00874	2049.9	4.26	0.956	4.08	A	Y	NX core

$I_{s(50)}$ = Size Corrected Point Load Strength
 I_s = Uncorrected Point Load Strength
 $Ram Area = 9.67 E-04 m^2$

F = Size Correction Factor
 $F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
 $D_e^2 = D^2 (mm^2)$



PROJECT	1671430	PHASE	W0008
DESIGNED	EN	REV	A
PREPARED	EN		
REVIEWED			
APPROVED			
Figure C-13			

January 22, 2019

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

Re: UCS testing
(Golder Project No. 1671430 WO-1)

Dear Mr. Naylor:

On November 15, 2018 and January 10, 2019 four (4) and five (5) HQ-sized samples were received by Geomechanica Inc. via drop-off by Golder Personnel, respectively. These samples were identified as being from Golder project 1671430 WO-1 (QEW Bertie). From these samples, six (6) UCS tests were completed.

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

Sincerely,



Bryan Tatone Ph.D., P. Eng.

Geomechanica Inc.
Tel: (647) 478-9767
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Rock Laboratory Testing Results

A report submitted to:

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January 22, 2019

Project number: 1671430-WO1

Abstract

This document summarizes the results of rock laboratory testing, including the results of 6 Uniaxial Compressive Strength (UCS) tests. These samples are from a drilling investigation for the QEW Bertie Project (Golder Project No. 1671430-WO1). Results including uniaxial compressive strength (UCS) along with photographs of samples before and after testing are presented herein.

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1 Uniaxial Compressive Strength Tests

1.1 Overview

This section summarizes the results of uniaxial compressive strength (UCS) testing of HQ-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 0.100 mm/min (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 and axial deformation to determine the peak strength (UCS).



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

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 feeler gauge, was met for all samples and the minimum length:diameter criteria was met for all specimens unless noted otherwise in Table 1. Testing of the specimens followed ASTM D7012-14 Method C 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.

1.2 Results

The testing results are summarized in Table 1. Please note that additional specimen details and measurements are provided in the summary spreadsheet that accompanies this report.

Table 1: Summary of Uniaxial Compression test results.

Sample	Depth (m)	Bulk density ρ (g/cm ³)	UCS (MPa)	Lithology	Failure description
CN-CP3	25.96 - 26.22	2.703	133.2	Limestone	1
CN-CP5	25.03 - 25.39	2.540	62.9	Limestone	2
CN-CP12	23.37 - 23.62	2.615	92.5	Limestone	2
CN-CP6	17.88 - 18.08	2.696	136.9	Limestone	3
CN-CP9	15.97 - 16.14	2.745	96.8	Limestone	1
CN-CP8	16.18 - 16.37	2.794	215.6	Limestone	3
Average		2.682	123.0		
Standard deviation		0.084	48.5		

¹ Inclined shear band failure

² Axial splitting failure

³ Hourglass failure

1.3 Specimen photographs



Photographs of the specimens prior to and after testing are presented in the Appendix.

Appendices


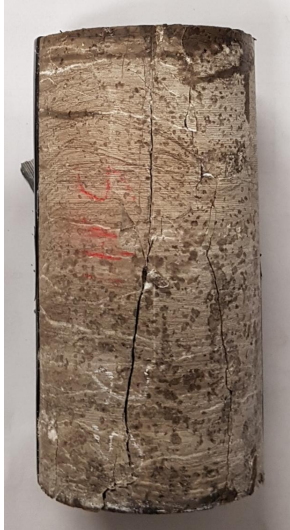
Specimen sheets

- CN-CP3
- CN-CP5
- CN-CP12
- CN-CP6
- CN-CP9
- CN-CP8



Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1														
Sample	CN-CP3	Depth	25.96 - 26.22														
<table><tr><th colspan="2">Specimen parameters</th></tr><tr><td>Diameter (mm) ^a</td><td>63.20</td></tr><tr><td>Length (mm) ^a</td><td>127.70</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.703</td></tr><tr><td>UCS (MPa)</td><td>133.2</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description ^b</td><td>1</td></tr></table>		Specimen parameters		Diameter (mm) ^a	63.20	Length (mm) ^a	127.70	Bulk density ρ (g/cm ³)	2.703	UCS (MPa)	133.2	Lithology	Limestone	Failure description ^b	1	<p>Prior to testing</p> 	<p>After testing</p> 
Specimen parameters																	
Diameter (mm) ^a	63.20																
Length (mm) ^a	127.70																
Bulk density ρ (g/cm ³)	2.703																
UCS (MPa)	133.2																
Lithology	Limestone																
Failure description ^b	1																
<p>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</p> <p>^b Failure description: ¹ Inclined shear band failure;</p>																	
Remarks:																	
Performed by	BSAT	Date	2018-12-18														



Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1												
Sample	CN-CP5	Depth	25.03 - 25.39												
<div><div>Specimen parameters</div><table><tr><td>Diameter (mm)^a</td><td>63.05</td></tr><tr><td>Length (mm)^a</td><td>127.90</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.540</td></tr><tr><td>UCS (MPa)</td><td>62.9</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description^b</td><td>2</td></tr></table></div>		Diameter (mm) ^a	63.05	Length (mm) ^a	127.90	Bulk density ρ (g/cm ³)	2.540	UCS (MPa)	62.9	Lithology	Limestone	Failure description ^b	2	<div>Prior to testing</div> 	<div>After testing</div> 
Diameter (mm) ^a	63.05														
Length (mm) ^a	127.90														
Bulk density ρ (g/cm ³)	2.540														
UCS (MPa)	62.9														
Lithology	Limestone														
Failure description ^b	2														
<div><div>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</div><div>^b Failure description: ² Axial splitting failure;</div></div>															
Remarks:															
Performed by	BSAT	Date	2018-12-18												



Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1														
Sample	CN-CP12	Depth	23.37 - 23.62														
<table><tr><th colspan="2">Specimen parameters</th></tr><tr><td>Diameter (mm) ^a</td><td>63.31</td></tr><tr><td>Length (mm) ^a</td><td>128.16</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.615</td></tr><tr><td>UCS (MPa)</td><td>92.5</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description ^b</td><td>2</td></tr></table>		Specimen parameters		Diameter (mm) ^a	63.31	Length (mm) ^a	128.16	Bulk density ρ (g/cm ³)	2.615	UCS (MPa)	92.5	Lithology	Limestone	Failure description ^b	2	<p>Prior to testing</p> 	<p>After testing</p> 
Specimen parameters																	
Diameter (mm) ^a	63.31																
Length (mm) ^a	128.16																
Bulk density ρ (g/cm ³)	2.615																
UCS (MPa)	92.5																
Lithology	Limestone																
Failure description ^b	2																
<p>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</p> <p>^b Failure description: ² Axial splitting failure;</p>																	
Remarks:																	
Performed by	BSAT	Date	2018-12-18														



Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1												
Sample	CN-CP6	Depth	17.88 - 18.08												
<div><div>Specimen parameters</div><table><tr><td>Diameter (mm)^a</td><td>63.38</td></tr><tr><td>Length (mm)^a</td><td>128.45</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.696</td></tr><tr><td>UCS (MPa)</td><td>136.9</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description^b</td><td>3</td></tr></table></div>		Diameter (mm) ^a	63.38	Length (mm) ^a	128.45	Bulk density ρ (g/cm ³)	2.696	UCS (MPa)	136.9	Lithology	Limestone	Failure description ^b	3	<div>Prior to testing</div> <div></div>	<div>After testing</div> <div></div>
Diameter (mm) ^a	63.38														
Length (mm) ^a	128.45														
Bulk density ρ (g/cm ³)	2.696														
UCS (MPa)	136.9														
Lithology	Limestone														
Failure description ^b	3														
<div><div>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</div><div>^b Failure description: ³ Hourglass failure;</div></div>															
Remarks:															
Performed by	BSAT	Date	2019-01-17												

Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1												
Sample	CN-CP9	Depth	15.97 - 16.14												
<div>Specimen parameters</div> <table><tr><td>Diameter (mm)^a</td><td>63.32</td></tr><tr><td>Length (mm)^a</td><td>127.37</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.745</td></tr><tr><td>UCS (MPa)</td><td>96.8</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description^b</td><td>1</td></tr></table>		Diameter (mm) ^a	63.32	Length (mm) ^a	127.37	Bulk density ρ (g/cm ³)	2.745	UCS (MPa)	96.8	Lithology	Limestone	Failure description ^b	1	<div>Prior to testing</div> 	<div>After testing</div> 
Diameter (mm) ^a	63.32														
Length (mm) ^a	127.37														
Bulk density ρ (g/cm ³)	2.745														
UCS (MPa)	96.8														
Lithology	Limestone														
Failure description ^b	1														
<div>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</div> <div>^b Failure description: ¹ Inclined shear band failure;</div>															
Remarks:															
Performed by	BSAT	Date	2019-01-17												

Uniaxial Compression Test

Client	Golder Associates Ltd.	Project	1671430-WO1												
Sample	CN-CP8	Depth	16.18 - 16.37												
<div>Specimen parameters</div> <table><tr><td>Diameter (mm) ^a</td><td>63.27</td></tr><tr><td>Length (mm) ^a</td><td>128.53</td></tr><tr><td>Bulk density ρ (g/cm³)</td><td>2.794</td></tr><tr><td>UCS (MPa)</td><td>215.6</td></tr><tr><td>Lithology</td><td>Limestone</td></tr><tr><td>Failure description ^b</td><td>3</td></tr></table>		Diameter (mm) ^a	63.27	Length (mm) ^a	128.53	Bulk density ρ (g/cm ³)	2.794	UCS (MPa)	215.6	Lithology	Limestone	Failure description ^b	3	<div>Prior to testing</div> 	<div>After testing</div> 
Diameter (mm) ^a	63.27														
Length (mm) ^a	128.53														
Bulk density ρ (g/cm ³)	2.794														
UCS (MPa)	215.6														
Lithology	Limestone														
Failure description ^b	3														
<div>^a Additional specimen measurement/details provides in accompanying summary spreadsheet.</div> <div>^b Failure description: ³ Hourglass failure;</div>															
Remarks:															
Performed by	BSAT	Date	2019-01-17												

APPENDIX D

Maxxam Certificate of Analysis

Your Project #: 1671430-W01
Site Location: BERTIC CNR
Your C.O.C. #: 654003-14-01

Attention: Nikol Kochmanova

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

Report Date: 2018/10/05
Report #: R5429894
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8P6311

Received: 2018/09/28, 19:45

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	4	N/A	2018/10/05	CAM SOP-00463	EPA 325.2 m
Conductivity	4	N/A	2018/10/04	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl ₂ EXTRACT	4	2018/10/03	2018/10/03	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	4	2018/10/02	2018/10/04	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	4	N/A	2018/10/05	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1671430-W01
Site Location: BERTIC CNR
Your C.O.C. #: 654003-14-01

Attention: Nikol Kochmanova

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

Report Date: 2018/10/05
Report #: R5429894
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8P6311

Received: 2018/09/28, 19:45

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.

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		HWS185		HWS186		HWS187		HWS187		
Sampling Date		2018/08/27		2018/08/23		2018/08/18		2018/08/18		
COC Number		654003-14-01		654003-14-01		654003-14-01		654003-14-01		
	UNITS	CNCP3-SA12	RDL	CNCP12-SA11	RDL	CNCP11-SA15	QC Batch	CNCP11-SA15 Lab-Dup	RDL	QC Batch

Calculated Parameters										
Resistivity	ohm-cm	680		3400		1600	5761982			
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	<20	20	<20	5766534	<20	20	5766534
Conductivity	umho/cm	1470	2	297	2	618	5765367	614	2	5765367
Available (CaCl2) pH	pH	7.91		7.89		7.91	5764259			
Soluble (20:1) Sulphate (SO4)	ug/g	2900	200	180	20	810	5766535	800	40	5766535
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										
Lab-Dup = Laboratory Initiated Duplicate										

Maxxam ID		HWS188		
Sampling Date		2018/08/21		
COC Number		654003-14-01		
	UNITS	CNCP5-SA5-AB	RDL	QC Batch

Calculated Parameters				
Resistivity	ohm-cm	730		5761982
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	39	20	5766534
Conductivity	umho/cm	1370	2	5765367
Available (CaCl2) pH	pH	7.46		5764259
Soluble (20:1) Sulphate (SO4)	ug/g	1400	60	5766535
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				

TEST SUMMARY

Maxxam ID: HWS185
Sample ID: CNCP3-SA12
Matrix: Soil

Collected: 2018/08/27
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5766534	N/A	2018/10/05	Deonarine Ramnarine
Conductivity	AT	5765367	N/A	2018/10/04	Barbara Kalbasi Esfahani
pH CaCl2 EXTRACT	AT	5764259	2018/10/03	2018/10/03	Gnana Thomas
Resistivity of Soil		5761982	2018/10/04	2018/10/04	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5766535	N/A	2018/10/05	Deonarine Ramnarine

Maxxam ID: HWS186
Sample ID: CNCP12-SA11
Matrix: Soil

Collected: 2018/08/23
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5766534	N/A	2018/10/05	Deonarine Ramnarine
Conductivity	AT	5765367	N/A	2018/10/04	Barbara Kalbasi Esfahani
pH CaCl2 EXTRACT	AT	5764259	2018/10/03	2018/10/03	Gnana Thomas
Resistivity of Soil		5761982	2018/10/04	2018/10/04	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5766535	N/A	2018/10/05	Deonarine Ramnarine

Maxxam ID: HWS187
Sample ID: CNCP11-SA15
Matrix: Soil

Collected: 2018/08/18
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5766534	N/A	2018/10/05	Deonarine Ramnarine
Conductivity	AT	5765367	N/A	2018/10/04	Barbara Kalbasi Esfahani
pH CaCl2 EXTRACT	AT	5764259	2018/10/03	2018/10/03	Gnana Thomas
Resistivity of Soil		5761982	2018/10/04	2018/10/04	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5766535	N/A	2018/10/05	Deonarine Ramnarine

Maxxam ID: HWS187 Dup
Sample ID: CNCP11-SA15
Matrix: Soil

Collected: 2018/08/18
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5766534	N/A	2018/10/05	Deonarine Ramnarine
Conductivity	AT	5765367	N/A	2018/10/04	Barbara Kalbasi Esfahani
Sulphate (20:1 Extract)	KONE/EC	5766535	N/A	2018/10/05	Deonarine Ramnarine

Maxxam ID: HWS188
Sample ID: CNCP5-SA5-AB
Matrix: Soil

Collected: 2018/08/21
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5766534	N/A	2018/10/05	Deonarine Ramnarine
Conductivity	AT	5765367	N/A	2018/10/04	Barbara Kalbasi Esfahani
pH CaCl2 EXTRACT	AT	5764259	2018/10/03	2018/10/03	Gnana Thomas

Maxxam Job #: B8P6311
Report Date: 2018/10/05

Golder Associates Ltd
Client Project #: 1671430-W01
Site Location: BERTIC CNR
Sampler Initials: CN

TEST SUMMARY

Maxxam ID: HWS188
Sample ID: CNCP5-SA5-AB
Matrix: Soil

Collected: 2018/08/21
Shipped:
Received: 2018/09/28

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Resistivity of Soil		5761982	2018/10/04	2018/10/04	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5766535	N/A	2018/10/05	Deonarine Ramnarine

GENERAL COMMENTS

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

Package 1	-0.7°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430-W01
Site Location: BERTIC CNR
Sampler Initials: CN

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5764259	Available (CaCl ₂) pH	2018/10/03			100	97 - 103			0.028	N/A
5765367	Conductivity	2018/10/04			104	90 - 110	<2	umho/cm	0.65	10
5766534	Soluble (20:1) Chloride (Cl ⁻)	2018/10/05	109	70 - 130	103	70 - 130	<20	ug/g	NC	35
5766535	Soluble (20:1) Sulphate (SO ₄)	2018/10/05	NC	70 - 130	104	70 - 130	<20	ug/g	0.39	35

N/A = Not Applicable

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

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

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

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

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

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

VALIDATION SIGNATURE PAGE

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

Cristina Carriere

Cristina Carriere, Scientific Service Specialist

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

CHAIN OF CUSTODY RECORD

Page 1 of 1

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY	ANALYSIS REQUESTED (PLEASE BE SPECIFIC)							Turnaround Time (TAT) Required
								Please provide advance notice for rush projects

Regulation 153 (2011)			Other Regulations		Special Instructions
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw	<p>Filtered (please circle)</p> <p>Details / Hg / Cr VI</p> <p>1 Metals & Inorganics Pkg</p> <p>2 Organic Pkg</p> <p>3 Volatiles Pkg</p> <p>4 PCBs Pkg</p> <p>5 Pesticides Pkg</p> <p>6 PCBs Pkg</p> <p>7 PCBs Pkg</p> <p>8 PCBs Pkg</p> <p>9 PCBs Pkg</p> <p>10 PCBs Pkg</p> <p>11 PCBs Pkg</p> <p>12 PCBs Pkg</p> <p>13 PCBs Pkg</p> <p>14 PCBs Pkg</p> <p>15 PCBs Pkg</p> <p>16 PCBs Pkg</p> <p>17 PCBs Pkg</p> <p>18 PCBs Pkg</p> <p>19 PCBs Pkg</p> <p>20 PCBs Pkg</p> <p>21 PCBs Pkg</p> <p>22 PCBs Pkg</p> <p>23 PCBs Pkg</p> <p>24 PCBs Pkg</p> <p>25 PCBs Pkg</p> <p>26 PCBs Pkg</p> <p>27 PCBs Pkg</p> <p>28 PCBs Pkg</p> <p>29 PCBs Pkg</p> <p>30 PCBs Pkg</p> <p>31 PCBs Pkg</p> <p>32 PCBs Pkg</p> <p>33 PCBs Pkg</p> <p>34 PCBs Pkg</p> <p>35 PCBs Pkg</p> <p>36 PCBs Pkg</p> <p>37 PCBs Pkg</p> <p>38 PCBs Pkg</p> <p>39 PCBs Pkg</p> <p>40 PCBs Pkg</p> <p>41 PCBs Pkg</p> <p>42 PCBs Pkg</p> <p>43 PCBs Pkg</p> <p>44 PCBs Pkg</p> <p>45 PCBs Pkg</p> <p>46 PCBs Pkg</p> <p>47 PCBs Pkg</p> <p>48 PCBs Pkg</p> <p>49 PCBs Pkg</p> <p>50 PCBs Pkg</p> <p>51 PCBs Pkg</p> <p>52 PCBs Pkg</p> <p>53 PCBs Pkg</p> <p>54 PCBs Pkg</p> <p>55 PCBs Pkg</p> <p>56 PCBs Pkg</p> <p>57 PCBs Pkg</p> <p>58 PCBs Pkg</p> <p>59 PCBs Pkg</p> <p>60 PCBs Pkg</p> <p>61 PCBs Pkg</p> <p>62 PCBs Pkg</p> <p>63 PCBs Pkg</p> <p>64 PCBs Pkg</p> <p>65 PCBs Pkg</p> <p>66 PCBs Pkg</p> <p>67 PCBs Pkg</p> <p>68 PCBs Pkg</p> <p>69 PCBs Pkg</p> <p>70 PCBs Pkg</p> <p>71 PCBs Pkg</p> <p>72 PCBs Pkg</p> <p>73 PCBs Pkg</p> <p>74 PCBs Pkg</p> <p>75 PCBs Pkg</p> <p>76 PCBs Pkg</p> <p>77 PCBs Pkg</p> <p>78 PCBs Pkg</p> <p>79 PCBs Pkg</p> <p>80 PCBs Pkg</p> <p>81 PCBs Pkg</p> <p>82 PCBs Pkg</p> <p>83 PCBs Pkg</p> <p>84 PCBs Pkg</p> <p>85 PCBs Pkg</p> <p>86 PCBs Pkg</p> <p>87 PCBs Pkg</p> <p>88 PCBs Pkg</p> <p>89 PCBs Pkg</p> <p>90 PCBs Pkg</p> <p>91 PCBs Pkg</p> <p>92 PCBs Pkg</p> <p>93 PCBs Pkg</p> <p>94 PCBs Pkg</p> <p>95 PCBs Pkg</p> <p>96 PCBs Pkg</p> <p>97 PCBs Pkg</p> <p>98 PCBs Pkg</p> <p>99 PCBs Pkg</p> <p>100 PCBs Pkg</p>
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw	
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other	<input type="checkbox"/> For RSC	<input type="checkbox"/> MISA	Municipality _____	
<input type="checkbox"/> Table _____			<input type="checkbox"/> PWQO	_____	
			<input type="checkbox"/> Other _____	_____	


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: _____

Include Criteria on Certificate of Analysis (Y/N)?						Field	M	O Reg 15 (Soil)	Corros (pH, S res)	Rush Confirmation Number	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	# of Bottles					Comments	
1	—	CNCP3-SA12	2018/08/27	PM	SOIL			X		1	Standard Corrosivity package ↓ ↓
2	—	CNCP12-SA11	2018/08/23	PM	SOIL			X		1	
3	—	CNCP11-SA15	2018/08/18	PM	SOIL			X		1	
4	—	CNCP5-SA5-AB	2018/08/21	AM	SOIL			X		1	
5											
6											
7											
8											
9											
10											

28-Sep-18 19:45

Ema Gitej



B8P6311

URE ENV-1151

* RELINQUISHED BY: (Signature/Print) <i>Sgt. Nino R. R. R.</i>	Date: (YY/MM/DD) <i>18/09/28</i>	Time <i>7:44 pm</i>	RECEIVED BY: (Signature/Print) <i>[Signature]</i>	Date: (YY/MM/DD) <i>20/09/20</i>	Time <i>19:45</i>	# Jars used and not submitted	Laboratory Use Only			
						Time Sensitive	Temperature (°C) on Receipt <i>-13/-12</i>	Custody Seal Intact	Yes	No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS AN 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](http://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF)

SAMPLES MUST BE KEPT COOL ($< 10^{\circ}\text{C}$) FROM TIME OF SAMPLING
UNTIL DELIVERY TO MAXXAM

White: Maxxa Yellow: Client

Your Project #: 1671430WO001
Site Location: QEW BERTIE
Your C.O.C. #: 641804-08-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522750
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6726

Received: 2018/12/06, 12:29

Sample Matrix: Soil
Samples Received: 5

Analyses	Date		Date Analyzed	Laboratory Method	Reference
	Quantity	Extracted			
Chloride (20:1 extract)	5	N/A	2018/12/12	CAM SOP-00463	EPA 325.2 m
Conductivity	5	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	5	2018/12/11	2018/12/11	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	5	2018/12/06	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	5	N/A	2018/12/12	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

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

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

Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

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

Your Project #: 1671430WO001
Site Location: QEW BERTIE
Your C.O.C. #: 641804-08-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522750
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6726

Received: 2018/12/06, 12:29

Email: EGitej@maxxam.ca

Phone# (905)817-5829

=====

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

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		IMF686		IMF687		IMF688	IMF689		IMF690		
Sampling Date		2018/11/20		2018/11/28		2018/11/22	2018/11/23		2018/11/29		
COC Number		641804-08-01		641804-08-01		641804-08-01	641804-08-01		641804-08-01		
	UNITS	CN/CP 2 SA6	RDL	CN/CP 6 SA5	RDL	CN/CP 7 SA2	CN/CP 8 SA3	RDL	CN/CP 9 SA4	RDL	QC Batch

Calculated Parameters

Resistivity	ohm-cm	870		420		980	1500		300		5875238
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Inorganics

Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	30	20	480	88	20	310	20	5882065
Conductivity	umho/cm	1150	2	2370	2	1020	667	2	3300	2	5882455
Available (CaCl2) pH	pH	8.00		7.83		7.75	7.78		7.86		5882163
Soluble (20:1) Sulphate (SO4)	ug/g	1300	60	2900	100	140	390	20	7400	200	5882077

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

Maxxam ID		IMF690	
Sampling Date		2018/11/29	
COC Number		641804-08-01	
	UNITS	CN/CP 9 SA4 Lab-Dup	QC Batch
Inorganics			
Available (CaCl2) pH	pH	7.70	5882163
QC Batch = Quality Control Batch			
Lab-Dup = Laboratory Initiated Duplicate			

TEST SUMMARY

Maxxam ID: IMF686
Sample ID: CN/CP 2 SA6
Matrix: Soil

Collected: 2018/11/20
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5882065	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5875238	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5882077	N/A	2018/12/12	Alina Dobreanu

Maxxam ID: IMF687
Sample ID: CN/CP 6 SA5
Matrix: Soil

Collected: 2018/11/28
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5882065	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5875238	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5882077	N/A	2018/12/12	Alina Dobreanu

Maxxam ID: IMF688
Sample ID: CN/CP 7 SA2
Matrix: Soil

Collected: 2018/11/22
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5882065	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5875238	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5882077	N/A	2018/12/12	Alina Dobreanu

Maxxam ID: IMF689
Sample ID: CN/CP 8 SA3
Matrix: Soil

Collected: 2018/11/23
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5882065	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5875238	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5882077	N/A	2018/12/12	Alina Dobreanu

Maxxam ID: IMF690
Sample ID: CN/CP 9 SA4
Matrix: Soil

Collected: 2018/11/29
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5882065	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5882455	N/A	2018/12/12	Kazzandra Adeva

Maxxam Job #: B8W6726
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430WO001
Site Location: QEW BERTIE
Sampler Initials: LKE

TEST SUMMARY

Maxxam ID: IMF690
Sample ID: CN/CP 9 SA4
Matrix: Soil

Collected: 2018/11/29
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas
Resistivity of Soil		5875238	2018/12/12	2018/12/12	Brad Newman
Sulphate (20:1 Extract)	KONE/EC	5882077	N/A	2018/12/12	Alina Dobreanu

Maxxam ID: IMF690 Dup
Sample ID: CN/CP 9 SA4
Matrix: Soil

Collected: 2018/11/29
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5882163	2018/12/11	2018/12/11	Gnana Thomas

GENERAL COMMENTS

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

Package 1	5.3°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430WO001
Site Location: QEW BERTIE
Sampler Initials: LKE

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5882065	Soluble (20:1) Chloride (Cl ⁻)	2018/12/12	NC	70 - 130	100	70 - 130	<20	ug/g	0.59	35
5882077	Soluble (20:1) Sulphate (SO ₄)	2018/12/12	NC	70 - 130	96	70 - 130	<20	ug/g	NC	35
5882163	Available (CaCl ₂) pH	2018/12/11			100	97 - 103			2.1	N/A
5882455	Conductivity	2018/12/12			104	90 - 110	<2	umho/cm	0.13	10

N/A = Not Applicable

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

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

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


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

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

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

VALIDATION SIGNATURE PAGE

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



Brad Newman, Scientific Service Specialist

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

Maxxam Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campbell Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca						CHAIN OF CUSTODY RECORD Page of																																																																																																																	
INVOICE TO:						REPORT TO:						PROJECT INFORMATION:						Laboratory Use Only:																																																																																																					
Company Name: #1326 Golder Associates Ltd Attention: Accounts Payable Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 Tel: (905) 567-4444 x Fax: (905) 567-6561 x Email: AP_CustomerService@golder.com						Company Name: N. Kol Kochmanova Attention: N. Kol Kochmanova Address: 905 567 6100 x 2134 Tel: 905 567 6100 x 2134 Email: n.kol.kochmanova@golder.com						Quotation #: B70916 P.O. #: 1671430 WD 001 Project: QEW Bertie Project Name: QEW Bertie Site #: LK/EN Sampled By: LK/EN						Maxxam Job #: 641804 Bottle Order #: 641804 COC #: 641804-08-01 Project Manager: Ema Gitej																																																																																																					
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY												ANALYSIS REQUESTED (PLEASE BE SPECIFIC)												Turnaround Time (TAT) Required: Please provide advance notice for rush projects																																																																																															
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Sample Barcode Label												Sample (Location) Identification												Date Sampled												Time Sampled												Matrix												Field Filtered (please circle): Metals / Hg / Cr VI Composite Package pH, Sulphate, Chlorides Resistivity, Conductivity												# of Bottles												Comments																																			
1												CN/ICP 2 SA6												Nov 20, 18												AM												Soil												X												1												Standard Corrosivity Package																																			
2												CN/ICP 6 SAS												Nov 28, 18												PM												↓												X												1																																															
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* RELINQUISHED BY: (Signature/Print) Eric Naylor												Date: (YY/MM/DD) 18/12/06												Time 12:15												RECEIVED BY: (Signature/Print) K. Van der Veen												Date: (YY/MM/DD) 20/12/06												Time 12:29												# jars used and not submitted												Laboratory Use Only Time Sensitive Temperature (°C) on Reel 2/3/5												Custody Seal Present Intact												Yes No											
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White: Maxxa Yellow: Client																																																																																																																							

Your Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Your C.O.C. #: 674002-02-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522878
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6738

Received: 2018/12/06, 12:29

Sample Matrix: ROCK
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	2	N/A	2018/12/12	CAM SOP-00463	EPA 325.2 m
Conductivity	2	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	2	2018/12/12	2018/12/12	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	2	2018/12/11	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	2	N/A	2018/12/12	CAM SOP-00464	EPA 375.4 m

Sample Matrix: Soil
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	7	N/A	2018/12/12	CAM SOP-00463	EPA 325.2 m
Conductivity	7	N/A	2018/12/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	7	2018/12/12	2018/12/12	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	7	2018/12/11	2018/12/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	7	N/A	2018/12/12	CAM SOP-00464	EPA 375.4 m

Remarks:

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

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

Your Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Your C.O.C. #: 674002-02-01

Attention: Nikol Kochmanova

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

Report Date: 2018/12/12
Report #: R5522878
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B8W6738

Received: 2018/12/06, 12:29

Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

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

Ema Gitej, Senior Project Manager

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.

SOIL CORROSIVITY PACKAGE (ROCK)

Maxxam ID		IMF770	IMF771		
Sampling Date		2018/09/05	2018/09/24		
COC Number		674002-02-01	674002-02-01		
	UNITS	C2-1	C3-1	RDL	QC Batch
Calculated Parameters					
Resistivity	ohm-cm	3800	5600		5882461
Inorganics					
Soluble (20:1) Chloride (Cl-)	ug/g	53	23	20	5883825
Conductivity	umho/cm	260	179	2	5883994
Available (CaCl2) pH	pH	8.22	7.94		5883840
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	5883826
RDL = Reportable Detection Limit					
QC Batch = Quality Control Batch					

SOIL CORROSIVITY PACKAGE (SOIL)

Maxxam ID		IMF764	IMF765	IMF766	IMF767	IMF768		
Sampling Date		2018/09/21	2018/09/19	2018/09/19	2018/09/19	2018/09/21		
COC Number		674002-02-01	674002-02-01	674002-02-01	674002-02-01	674002-02-01		
	UNITS	RW4A_SA3	RW5_SA8	RW7_SA5B	RW9_SA6	RW-10_SA7	RDL	QC Batch

Calculated Parameters								
Resistivity	ohm-cm	610	2100	3300	1600	710		5882461
Inorganics								
Soluble (20:1) Chloride (Cl-)	ug/g	810	200	95	340	660	20	5883825
Conductivity	umho/cm	1640	483	302	623	1400	2	5883994
Available (CaCl2) pH	pH	8.02	7.71	7.84	7.87	7.89		5883840
Soluble (20:1) Sulphate (SO4)	ug/g	120	81	<20	39	88	20	5883826
RDL = Reportable Detection Limit								
QC Batch = Quality Control Batch								

Maxxam ID		IMF768			IMF769	IMF772			IMF772	
Sampling Date		2018/09/21			2018/09/04	2018/09/27			2018/09/27	
COC Number		674002-02-01			674002-02-01	674002-02-01			674002-02-01	
	UNITS	RW-10_SA7 Lab-Dup	RDL	QC Batch	C1-1_AS1	C7-1 SA5	RDL	QC Batch	C7-1 SA5 Lab-Dup	QC Batch

Calculated Parameters										
Resistivity	ohm-cm				2000	1200		5882461		
Inorganics										
Soluble (20:1) Chloride (Cl-)	ug/g	650	20	5883825	150	330	20	5883825		
Conductivity	umho/cm	1390	2	5883994	504	858	2	5883994		
Available (CaCl2) pH	pH				8.06	7.92		5883840	8.02	5883840
Soluble (20:1) Sulphate (SO4)	ug/g				110	270	20	5883826		
RDL = Reportable Detection Limit										
QC Batch = Quality Control Batch										
Lab-Dup = Laboratory Initiated Duplicate										

TEST SUMMARY

Maxxam ID: IMF764
Sample ID: RW4A_SA3
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF765
Sample ID: RW5_SA8
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF766
Sample ID: RW7_SA5B
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF767
Sample ID: RW9_SA6
Matrix: Soil

Collected: 2018/09/19
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF768
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva

Maxxam Job #: B8W6738
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Sampler Initials: JK

TEST SUMMARY

Maxxam ID: IMF768
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF768 Dup
Sample ID: RW-10_SA7
Matrix: Soil

Collected: 2018/09/21
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva

Maxxam ID: IMF769
Sample ID: C1-1_AS1
Matrix: Soil

Collected: 2018/09/04
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF770
Sample ID: C2-1
Matrix: ROCK

Collected: 2018/09/05
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF771
Sample ID: C3-1
Matrix: ROCK

Collected: 2018/09/24
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam Job #: B8W6738
Report Date: 2018/12/12

Golder Associates Ltd
Client Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Sampler Initials: JK

TEST SUMMARY

Maxxam ID: IMF772
Sample ID: C7-1 SA5
Matrix: Soil

Collected: 2018/09/27
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5883825	N/A	2018/12/12	Deonarine Ramnarine
Conductivity	AT	5883994	N/A	2018/12/12	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas
Resistivity of Soil		5882461	2018/12/12	2018/12/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5883826	N/A	2018/12/12	Deonarine Ramnarine

Maxxam ID: IMF772 Dup
Sample ID: C7-1 SA5
Matrix: Soil

Collected: 2018/09/27
Shipped:
Received: 2018/12/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
pH CaCl2 EXTRACT	AT	5883840	2018/12/12	2018/12/12	Gnana Thomas

GENERAL COMMENTS

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

Package 1	5.3°C
-----------	-------

Conductivity Analysis: Analysis was performed past sample holding time. This may increase the variability associated with these results.

Sample IMF770 [C2-1] : Rock sample submitted, sample preparation completed by the lab as per client request.

Sample IMF771 [C3-1] : Rock sample submitted, sample preparation completed by the lab as per client request.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430-W08
Site Location: QEW BERTIE - DETAILED DESIGN
Sampler Initials: JK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5883825	Soluble (20:1) Chloride (Cl ⁻)	2018/12/12	NC	70 - 130	102	70 - 130	<20	ug/g	1.9	35
5883826	Soluble (20:1) Sulphate (SO ₄)	2018/12/12	NC	70 - 130	103	70 - 130	<20	ug/g	24	35
5883840	Available (CaCl ₂) pH	2018/12/12			101	97 - 103			1.3	N/A
5883994	Conductivity	2018/12/12			103	90 - 110	<2	umho/cm	0.65	10

N/A = Not Applicable

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

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


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

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

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

VALIDATION SIGNATURE PAGE

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



Brad Newman, Scientific Service Specialist

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

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campbell Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca		CHAIN OF CUSTODY RECORD Page of																																																								
IMMEDIATE Company Name: #1326 Golder Associates Ltd Attention: Accounts Payable Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 Tel: (905) 567-4444 Fax: (905) 567-6561 Email: AP_CustomerService@golder.com		REPORT TO: Company Name: <u>N. Kol Kochmarov</u> Attention: <u>N. Kol Kochmarov</u> Address: <u>905 567 6100 x2134</u> Tel: <u>905 567 6100 x2134</u> Fax: <u>905 567 6100 x2134</u> Email: <u>nkol.kochmarov@golder.com</u>																																																								
PROJECT INFORMATION: Quotation #: <u>B8W633</u> P.O. #: <u>08-144-0039/447-1671430-W08</u> Project: <u>QEW Bette - Detailed Design</u> Project Name: <u>QEW Bette - Detailed Design</u> Site #: <u>JK/MA/EN</u> Sampled By: <u>JK/MA/EN</u>		Laboratory Use Only: Maxxam Job #: <u>674002</u> Bottle Order #: <u>674002</u> COC #: <u>674002-02-01</u> Project Manager: <u>Ema Gitej</u>																																																								
MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY																																																										
Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____		Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWGO <input type="checkbox"/> Other _____																																																								
Special Instructions Include Criteria on Certificate of Analysis (Y/N)? _____		ANALYSIS REQUESTED (PLEASE BE SPECIFIC) Field Filtered (please circle): Metals / Hg / Cr / V O Reg 153 VOCs by HS & F1-F4 4-hydroxy-4-methyl-2-pentanone by SVOC Open Scan <u>Corrosivity Package</u> <u>pH, Sulphate, Chloride</u> <u>resistivity, conductivity</u>																																																								
<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th>Sample Barcode Label</th> <th>Sample (Location) Identification</th> <th>Date Sampled</th> <th>Time Sampled</th> <th>Matrix</th> </tr> </thead> <tbody> <tr><td>1</td><td>RW4A-SA3</td><td>Sept. 21, '18</td><td>AM</td><td>SOIL</td></tr> <tr><td>2</td><td>RWS-SA8</td><td>Sept. 19, '18</td><td>PM</td><td>SOIL</td></tr> <tr><td>3</td><td>RW7-SASB</td><td>Sept. 19, '18</td><td>AM</td><td>SOIL</td></tr> <tr><td>4</td><td>RW9-SA6</td><td>Sept. 19, '18</td><td>AM</td><td>SOIL</td></tr> <tr><td>5</td><td>RW-10-SA7</td><td>Sept. 21, '18</td><td>PM</td><td>SOIL</td></tr> <tr><td>6</td><td>C1-1-AS1</td><td>Sept. 4, '18</td><td>AM</td><td>SOIL</td></tr> <tr><td>7</td><td>C2-1</td><td>Sept. 5, '18</td><td>PM</td><td>ROCK</td></tr> <tr><td>8</td><td>C3-1</td><td>Sept. 24, '18</td><td>PM</td><td>ROCK</td></tr> <tr><td>9</td><td>C7-1 SAS</td><td>Sept. 27</td><td>AM</td><td>SOIL</td></tr> <tr><td>10</td><td></td><td></td><td></td><td></td></tr> </tbody> </table>		Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	1	RW4A-SA3	Sept. 21, '18	AM	SOIL	2	RWS-SA8	Sept. 19, '18	PM	SOIL	3	RW7-SASB	Sept. 19, '18	AM	SOIL	4	RW9-SA6	Sept. 19, '18	AM	SOIL	5	RW-10-SA7	Sept. 21, '18	PM	SOIL	6	C1-1-AS1	Sept. 4, '18	AM	SOIL	7	C2-1	Sept. 5, '18	PM	ROCK	8	C3-1	Sept. 24, '18	PM	ROCK	9	C7-1 SAS	Sept. 27	AM	SOIL	10					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. <input checked="" type="checkbox"/> Job Specific Rush TAT (if applies to entire submission) Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #) # of Bottles: _____ Comments: <u>Standard Corrosivity Package</u>	
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix																																																						
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10																																																										
* RELINQUISHED BY: (Signature/Print) <u>Ben Naylor Eric Naylor</u>		RECEIVED BY: (Signature/Print) <u>KATE VAN GRANSEN</u>																																																								
Date: (YY/MM/DD) <u>18/12/06</u> Time: <u>12:15</u>		Date: (YY/MM/DD) <u>12/29</u> Time: <u>2018/12/06</u>																																																								
# jars used and not submitted		Laboratory Use Only Time Sensitive: <u>8/3/5</u> Temperature (°C) on Reel: <u>8/3/5</u> Custody Seal: Present <input checked="" type="checkbox"/> Intact <input checked="" type="checkbox"/>																																																								
* 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/WWP-CONTENT/UPLOADS/ONTARIO-COC.PDF.																																																										
White: Maxxa Yellow: Client		SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM																																																								

Your Project #: 1671430 W01
Site Location: QEW BERTIE
Your C.O.C. #: 700485-03-01

Attention: Nikol Kochmanova

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

Report Date: 2019/01/23
Report #: R5568144
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B915679

Received: 2019/01/18, 10:35

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Reference
		Extracted	Analyzed		
Chloride (20:1 extract)	1	N/A	2019/01/23	CAM SOP-00463	EPA 325.2 m
Conductivity	1	N/A	2019/01/22	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2019/01/23	2019/01/23	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2019/01/19	2019/01/22	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	N/A	2019/01/23	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.

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This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1671430 W01
Site Location: QEW BERTIE
Your C.O.C. #: 700485-03-01

Attention: Nikol Kochmanova

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

Report Date: 2019/01/23
Report #: R5568144
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B915679
Received: 2019/01/18, 10:35

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

=====

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

RESULTS OF ANALYSES OF SOIL

Maxxam ID		IUD610		
Sampling Date		2018/09/20		
COC Number		700485-03-01		
	UNITS	RW 11 SA5	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	1600		5936840
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	5940294
Conductivity	umho/cm	642	2	5940019
Available (CaCl2) pH	pH	7.70		5941762
Soluble (20:1) Sulphate (SO4)	ug/g	530	20	5940279
RDL = Reportable Detection Limit				
QC Batch = Quality Control Batch				

Maxxam Job #: B915679
Report Date: 2019/01/23

Golder Associates Ltd
Client Project #: 1671430 W01
Site Location: QEW BERTIE
Sampler Initials: MA

TEST SUMMARY

Maxxam ID: IUD610
Sample ID: RW 11 SA5
Matrix: Soil

Collected: 2018/09/20
Shipped:
Received: 2019/01/18

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5940294	N/A	2019/01/23	Deonarine Ramnarine
Conductivity	AT	5940019	N/A	2019/01/22	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5941762	2019/01/23	2019/01/23	Gnana Thomas
Resistivity of Soil		5936840	2019/01/22	2019/01/22	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5940279	N/A	2019/01/23	Deonarine Ramnarine

GENERAL COMMENTS

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

Package 1	9.0°C
-----------	-------

pH, Chloride, Sulphate, Conductivity/Resistivity: Sample submitted and analyzed past the recommended sample hold time. This may increase the variability associated with these results.

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430 W01
Site Location: QEW BERTIE
Sampler Initials: MA

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5940019	Conductivity	2019/01/22			103	90 - 110	<2	umho/cm	0.68	10
5940279	Soluble (20:1) Sulphate (SO ₄)	2019/01/23	117	70 - 130	108	70 - 130	<20	ug/g	NC	35
5940294	Soluble (20:1) Chloride (Cl ⁻)	2019/01/23	112	70 - 130	103	70 - 130	<20	ug/g	NC	35
5941762	Available (CaCl ₂) pH	2019/01/23			100	97 - 103			0.44	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).

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.

Maxxam <small>A Maxxam Analytics International Corporation</small>		Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campbell Road, Mississauga, Ontario Canada L5N 2L8 Tel: (905) 817-5700 Toll-free 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca		CHAIN OF CUSTODY RECORD																																																																																																															
INVOICE TO: Company Name: #1326 Golder Associates Ltd Attention: Accounts Payable Address: 6925 Century Ave Suite 100 Mississauga ON L5N 7K2 Tel: (905) 567-4444 Fax: (905) 567-6561 Email: AP_CustomerService@golder.com		REPORT TO: Company Name: <u>Nikol Kochmanova</u> Attention: <u>Nikol Kochmanova</u> Address: <u>"</u> Tel: <u>"</u> Fax: <u>"</u> Email: <u>nikol.kochmanova@golder.com</u>		PROJECT INFORMATION: Quotation #: B80683 P.O. #: <u>1671430 WOI</u> Project: <u>NEW Bette</u> Project Name: <u>"</u> Site #: <u>MA</u> Sampled By: <u>MA</u>																																																																																																															
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* RELINQUISHED BY: (Signature/Print) <u>Eric Naylor</u>		RECEIVED BY: (Signature/Print) <u>DAID W</u>		18-Jan-19 10:35 Ema Gitej B915679 CA2 ENV-835																																																																																																															
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White: Maxxa		Yellow: Client		SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM																																																																																																															

Your Project #: 1671430 W08
Site Location: QEW BERTIE
Your C.O.C. #: 702394-02-01

Attention: Matt Saderman

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

Report Date: 2019/02/07
Report #: R5586082
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B928404

Received: 2019/02/01, 09:34

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	4	N/A	2019/02/06	CAM SOP-00463	EPA 325.2 m
Conductivity	4	N/A	2019/02/06	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	4	2019/02/05	2019/02/05	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	4	2019/02/01	2019/02/07	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	4	N/A	2019/02/06	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.

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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.

Your Project #: 1671430 W08
Site Location: QEW BERTIE
Your C.O.C. #: 702394-02-01

Attention: Matt Saderman

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

Report Date: 2019/02/07
Report #: R5586082
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B928404
Received: 2019/02/01, 09:34

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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RESULTS OF ANALYSES OF SOIL

Maxxam ID		IWV487		IWV488		IWV488			IWV489		
Sampling Date		2019/01/16		2019/01/16		2019/01/16			2019/01/25		
COC Number		702394-02-01		702394-02-01		702394-02-01			702394-02-01		
	UNITS	RW12 SA4	RDL	RW13 SA2	QC Batch	RW13 SA2 Lab-Dup	RDL	QC Batch	RW14 SA6	RDL	QC Batch

Calculated Parameters

Resistivity	ohm-cm	1000		270	5957440				3100		5957440
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Inorganics

Soluble (20:1) Chloride (Cl-)	ug/g	<20	20	120	5960699	120	20	5960699	58	20	5960699
Conductivity	umho/cm	1000	2	3640	5962188	3770	2	5962188	323	2	5962188
Available (CaCl2) pH	pH	7.84		8.02	5960350				7.82		5960350
Soluble (20:1) Sulphate (SO4)	ug/g	1400	80	4800	5960713	5100	200	5960713	100	20	5960713

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

Maxxam ID		IWV490		
Sampling Date		2019/01/26		
COC Number		702394-02-01		
	UNITS	RW16 SA1A	RDL	QC Batch

Calculated Parameters

Resistivity	ohm-cm	4400		5957440
-------------	--------	------	--	---------

Inorganics

Soluble (20:1) Chloride (Cl-)	ug/g	26	20	5960699
Conductivity	umho/cm	227	2	5962188
Available (CaCl2) pH	pH	7.22		5960350
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	5960713

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

TEST SUMMARY

Maxxam ID: IWV487
Sample ID: RW12 SA4
Matrix: Soil

Collected: 2019/01/16
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5960699	N/A	2019/02/06	Alina Dobreanu
Conductivity	AT	5962188	N/A	2019/02/06	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5960350	2019/02/05	2019/02/05	Gnana Thomas
Resistivity of Soil		5957440	2019/02/07	2019/02/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5960713	N/A	2019/02/06	Alina Dobreanu

Maxxam ID: IWV488
Sample ID: RW13 SA2
Matrix: Soil

Collected: 2019/01/16
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5960699	N/A	2019/02/06	Alina Dobreanu
Conductivity	AT	5962188	N/A	2019/02/06	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5960350	2019/02/05	2019/02/05	Gnana Thomas
Resistivity of Soil		5957440	2019/02/07	2019/02/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5960713	N/A	2019/02/06	Alina Dobreanu

Maxxam ID: IWV488 Dup
Sample ID: RW13 SA2
Matrix: Soil

Collected: 2019/01/16
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5960699	N/A	2019/02/06	Alina Dobreanu
Conductivity	AT	5962188	N/A	2019/02/06	Kazzandra Adeva
Sulphate (20:1 Extract)	KONE/EC	5960713	N/A	2019/02/06	Alina Dobreanu

Maxxam ID: IWV489
Sample ID: RW14 SA6
Matrix: Soil

Collected: 2019/01/25
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5960699	N/A	2019/02/06	Alina Dobreanu
Conductivity	AT	5962188	N/A	2019/02/06	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5960350	2019/02/05	2019/02/05	Gnana Thomas
Resistivity of Soil		5957440	2019/02/07	2019/02/07	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5960713	N/A	2019/02/06	Alina Dobreanu

Maxxam ID: IWV490
Sample ID: RW16 SA1A
Matrix: Soil

Collected: 2019/01/26
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5960699	N/A	2019/02/06	Alina Dobreanu
Conductivity	AT	5962188	N/A	2019/02/06	Kazzandra Adeva
pH CaCl2 EXTRACT	AT	5960350	2019/02/05	2019/02/05	Gnana Thomas
Resistivity of Soil		5957440	2019/02/07	2019/02/07	Automated Statchk

Maxxam Job #: B928404
Report Date: 2019/02/07

Golder Associates Ltd
Client Project #: 1671430 W08
Site Location: QEW BERTIE
Sampler Initials: LK

TEST SUMMARY

Maxxam ID: IWV490
Sample ID: RW16 SA1A
Matrix: Soil

Collected: 2019/01/26
Shipped:
Received: 2019/02/01

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate (20:1 Extract)	KONE/EC	5960713	N/A	2019/02/06	Alina Dobreanu

GENERAL COMMENTS

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

Package 1	12.7°C
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Results relate only to the items tested.

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1671430 WO8
Site Location: QEW BERTIE
Sampler Initials: LK

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5960350	Available (CaCl ₂) pH	2019/02/05			100	97 - 103			0.34	N/A
5960699	Soluble (20:1) Chloride (Cl ⁻)	2019/02/06	NC	70 - 130	101	70 - 130	<20	ug/g	0.23	35
5960713	Soluble (20:1) Sulphate (SO ₄)	2019/02/06	NC	70 - 130	101	70 - 130	<20	ug/g	5.8	35
5962188	Conductivity	2019/02/06			102	90 - 110	<2	umho/cm	3.6	10

N/A = Not Applicable

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

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

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

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

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

VALIDATION SIGNATURE PAGE

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







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

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

J L ENV-1363

Ema Gitej

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		 B928404 		y:	
Company Name: #1326 Golder Associates Ltd		Company Name:		Quotation #: B80683				Bottle Order #:	
Attention: Accounts Payable		Attention: <u>Matt Soderman</u>		P.O. #:				 702394	
Address: 6925 Century Ave Suite 100		Address:		Project: 1671430 WO8		J_L ENV-1363		Project Manager:	
Mississauga ON L5N 7K2				Project Name: <u>DEU Bertie</u>					
Tel: (905) 567-4444 Fax: (905) 567-6561		Tel:		Site #:				 C#702394-02-01	
Email: AP_CustomerService@golder.com		Email: <u>Matt_soderman@golder.com</u>		Sampled By: <u>LK IEN</u>				Ema Gitej	

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

Regulation 153 (2011) <input type="checkbox"/> Table 1 <input type="checkbox"/> Res/Park <input type="checkbox"/> Medium/Fine <input type="checkbox"/> Table 2 <input type="checkbox"/> Ind/Comm <input type="checkbox"/> Coarse <input type="checkbox"/> Table 3 <input type="checkbox"/> Agri/Other <input type="checkbox"/> For RSC <input type="checkbox"/> Table _____			Other Regulations <input type="checkbox"/> CCME <input type="checkbox"/> Sanitary Sewer Bylaw <input type="checkbox"/> Reg 558 <input type="checkbox"/> Storm Sewer Bylaw <input type="checkbox"/> MISA Municipality _____ <input type="checkbox"/> PWQO <input type="checkbox"/> Other _____			Special Instructions		
Include Criteria on Certificate of Analysis (Y/N)?			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 #)					

[illegible]

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# Jars used and not submitted	Laboratory Use Only				
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APPENDIX E

Non-Standard Special Provisions

TWO-STAGE RETAINED SOIL SYSTEM - Item No.

Non-Standard Special Provision

Amendment to SP 599S22 (March 2018), Section 4.0 Design and Submission Requirements

The following Section 4.01.06 is to be added:

Section 4.01.06 Two-Stage RSS Walls

Two-stage Retained Soil System (RSS) wall types are currently not listed on the Ministry of Transportation, Ontario (MTO) Designated Sources of Material (DSM). For the two-stage RSS wall sections along the QEW, the Contractor shall submit the proposed RSS wall system design to the Contract Administrator who will provide the MTO RSS Committee for review and approval. The Contractor shall allow for a minimum of eight (8) weeks of review time by the MTO RSS Committee.

The proposed wall system shall be designed in accordance with the Design, Construction, Maintenance and Inspection Guide for Mechanically Stabilized Earth Walls (TAC – July 2017) and suitable for the anticipated settlements due to the realignment of the QEW.

The submission shall include working drawings, supporting design documentation and commentary which specifically address the proposed design.

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT –
Item No.

Non-Standard Special Provision

1.0 SCOPE

This Special Provision contains the requirements for the supply and installation of instrumentation to monitor settlements in the foundation soils and at the top of the embankments during construction of the QEW westward embankment widening and grade raise between STA 13+475 and STA 13+725, based on the presence of a compressible cohesive soil layer north of Station 13+725. Settlement instrumentation and monitoring is also required at the RSS walls in front of and adjacent to the CN/CP bridge abutments.

The Contractor shall retain a Foundation Engineering consultant registered in MTO's Consultant Registry, Appraisal and Qualifications System (RAQS) for "Geotechnical Specialty – Medium Complexity", to undertake the supply and installation of geotechnical settlement monitoring instrumentation (settlement plates, settlement rods and temporary benchmarks) and for providing appropriate recommendations based on the measurement readings.

The Contractor shall also implement an embankment monitoring program to take, record and distribute all appropriate and timely measurements and transmit recommendations from the Foundation Engineering consultants to the Contract Administrator.

1.1 General Scope

This general special provision and the other item-specific special provisions contain the requirements for the supply and installation of the following geotechnical monitoring instrumentation:

- Settlement Plates (SP); and
- Nail Pins (NP).

This general special provision also contains the requirements for the supply and installation of temporary survey benchmarks (TBM) related to the geotechnical monitoring instrumentation.

1.2 Purpose

The purpose of the SPs and NPs is to monitor settlements at approximately the existing ground surface elevation behind the two-stage RSS wall and under the west shoulder of the raised and widened high fill embankment, as well as in the immediate vicinity of the bridge abutments. Settlement is measured by survey of the top of the rod (SPs) or nail head (NPs) with reference to stable, non-settling TBMs.

The SPs and NPs are required to be installed prior to, and immediately following the construction of the embankment grade raise and widening fill placement, respectively. The settlement readings are intended to confirm that the preload period(s) for the delay of paving, sewer installation, facing panels of the two-stage RSS walls, and/or installation of barriers on top of RSS walls in these sections of the highway are adequate. The completed preloaded embankments shall remain

undisturbed until such time as the monitoring indicates that a sufficient degree of compression of the foundation soil has been achieved.

2.0 REFERENCES

2.1 General

When the Contract Documents indicate that provincial oriented specifications are to be used and there is a provincial oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a municipal oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Construction

OPSS 905 Steel Reinforcement for Concrete

Ontario Provincial Standards Specifications, Material

OPSS1010 Aggregates – Base, Subbase, Select Subgrade and Backfill Material

OPSS.PROV 1350 Concrete – Materials and Production

OPSS 1205 Clay Seal

OPSS 1301 Cementing Materials

OPSS 1801 Corrugated Steel Pipe (CSP) Products

Ontario Water Resources Act RRO 1990:

Regulation 903 Wells

2.2 Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Reports for this Contract.

Foundation Investigation Report – High Fill Embankment and Retaining Walls in Support of Replacement of Twin Structures over CN and CP Rails, Site Nos 34-129-1 and 34-129-2, QEW from 1.4 km North of Bowen Road Interchange Southerly to Gilmore Road Interchange, QEW Town of Fort Erie, Niagara Region, Ontario, G.W.P. 2116-16-00

Foundation Investigation Report - Replacement of Twin Structures over CN and CP Rails, Site Nos 34-129-1 and 34-129-2, QEW from 1.4 km North of Bowen

3.0 DEFINITIONS

Contractor means the Contractor and his Geotechnical Consultant.

Geotechnical Engineering Consultant means a consultant with MTO classification of “Geotechnical (Structures and Embankments) - High Complexity”, to undertake the supply and installation of geotechnical instruments.

Temporary Benchmark (TBM) means a non-yielding, deep-seated survey reference point. The temporary survey benchmark location shall be selected by the Contractor at location(s) that do not interfere with their construction activities. The Temporary Survey Benchmarks shall be installed to the bedrock surface.

Monitoring Program means the monitoring readings conducted by others as part of the Contract Administration Assignment.

Settlement Plate means a plate installed at the defined level with a series of rods attached to a plate for the purposes of settlement monitoring.

Nail Pin means a survey nail installed at the defined location for the purposes of settlement monitoring.

Equal shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Design Requirements

4.01.01 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing temporary survey Benchmarks. Any damage to underground utilities caused by the Contractor’s work shall be repaired by the Contractor at no cost to the Owner or Contract Administrator.

4.01.02 Boreholes

If applicable, the Contractor shall make a basic stratigraphic log of boreholes as they are being drilled. In situ or laboratory testing is not required.

Boreholes for the TBM shall be advanced using conventional drilling methods and shall be as vertical as practical.

4.01.03 Marking and Labelling

The location of any above-ground monitoring fixtures shall be made clearly visible to nearby traffic before, during and after embankment construction. Markings shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for the duration of the preload period.

4.01.04 Protection of Instruments

The Contractor shall adequately protect all instruments such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at no cost to the Owner or Contract Administrator.

4.02 Submission Requirements

4.02.01 Notification

The Contract Administrator shall be notified a minimum of fifteen (15) working days in advance of commencing the installation of instruments.

4.02.02 Installation Methods

The Contractor shall submit details of the proposed installation methods including locations and types of the monitoring equipment, protections systems, temporary benchmarks and installation schedule, to the Contract Administrator, a minimum of fifteen (15) working days before the start of instrument installation.

5.0 MATERIALS

5.01 General

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

5.02 Temporary Benchmarks (TBM)

5.02.01 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Section 7.03.03.

The top end of each length of TBM rod shall be threaded to receive a cap or to allow for connection of successive lengths of rods. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.02.02 Sand

The Contractor shall supply clean, washed sand. The sand shall be Sakcrete washed general-purpose sand – or equal.

5.02.03 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.02.04 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type GU – OPSS 1301).

5.02.05 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve for the full length of rod consisting of Schedule 40 – 50.8 mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

5.03 Settlement Plates (SP)

5.03.01 Plate

The Contractor shall supply a steel plate with a thickness of at least 6.35 mm. The plate shall be at least 0.5 m wide by 0.5 m long.

5.03.02 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4 mm, supplied in lengths as required to complete the installation as described in Section 7.03.04.

The top end of the full length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.03.03 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 – 50.8 mm O.D. PVC pipe cut perpendicular to the axis of the pipe.

5.03.04 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP – OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reduction Sleeve (PVC pipe) shall be filled with medium to coarse sand.

5.04 Nail Pins (NP)

5.04.01 Pin

The Contractor shall supply a 25.4 mm minimum diameter reinforcing steel bar (OPSS 905) cut 0.15 m long or equivalent.

The top of the reinforcing steel bar shall be angled or rounded in such a way that a single survey point can be clearly identified and repeated.

5.04.02 Concrete

The Contractor shall supply concrete (OPSS.Prov 1350) of minimum 25 MPa compressive strength and set time sufficient to secure the NP within two (2) days of pouring.

6.0 EQUIPMENT

6.01 Equipment Operations and Weather Conditions

All installation and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range during the preload period.

7.0 CONSTRUCTION

7.01 Drawings

Reference shall be made to the following drawings that are contained elsewhere in the Contract:

- Embankment Monitoring Program Location Plan;
- Monitoring Typical Sections and Instrumentation Installation Details.

7.03 Instrumentation Installation

7.03.01 Instrument Locations

The quantity and location of instruments are as shown in the Contract Documents and in Table 1A below and are shown on the Contract Drawings.

Table 1A – Instrument Quantities and Locations

Monitoring Section		Quantities		
<i>Approx. QEW Station</i>	<i>Approx. Offset^{1, 2}</i>	<i>TBM</i>	<i>SP</i>	<i>NP</i>
NBL – South Abutment – 14+028	30	0	0	1
NBL – North Abutment – 13+922	19	0	0	1
SBL – South Abutment – 14+017	15	0	0	1
SBL – South Abutment – 14+014	8	0	0	1

SBL – South Abutment – 14+011	0	0	0	1
SBL – North Abutment – 13+902	15	0	0	1
SBL – North Abutment – 13+899	8	0	0	1
SBL – North Abutment – 13+896	0	0	0	1
13+878	0	0	0	1
13+860	0	0	0	1
13+750	0	0	0	1
13+725	0	0	0	1
13+715	17	0	1	0
13+700	0	0	1	0
13+700	17 ^{3.}	0	1	1
13+680	17	0	1	0
13+675	0	0	0	1
13+650	0	0	0	1
13+625	0	0	1	1
13+600	0	0	0	1
13+575	0	0	0	1
13+550	0	0	0	1
13+525	0	0	0	1
Location(s) Selected by Contractor	-	1 to 2 to meet sight line requirements	0	0
TOTAL		2	5	20

NOTES: 1. Offset distance relative to crest of widened SBL embankment.
2. Alternate locations may be selected by the Contractor upon approval of the Contract Administrator.
3. Location behind RSS Wall facing, within the reinforced fill zone.

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground surface elevation at each instrument location.

The locations of the monitoring instruments and temporary benchmarks should be adjusted in the field such that they will not be damaged by any stripping or sub-excavation procedures for the embankment widening, or by earth moving or compaction equipment.

7.03.02 Installation Program

SP and TBM installation shall be completed before any embankment widening construction. NP installation shall be completed immediately following completion of the embankment grade raise and widening fill has been placed.

7.03.03 Temporary Survey Benchmarks

7.03.03.01 General

TBM locations shall be selected by the Contractor to be more than 20 m from fill placement locations, fit in the field to be compatible with the Contractor's operations. The TBMs shall be

installed prior to embankment raising and widening construction. The TBMs shall consist of a steel rod anchored to the bottom of a borehole on the dolomitic limestone bedrock, or in soil having Standard Penetration Test (SPT) “N” values of greater than 100 blows per 0.3 m of penetration.

The number and locations of TBMs shall be such that direct sighting is possible from all geotechnical instruments to at least one (1) TBM. The location of the TBMs shall be determined prior to instrument installation. The Contractor shall establish the geodetic elevation of each such TBM.

7.03.03.02 Borehole Installation

The borehole shall be advanced to the bedrock or into 100-blow soils using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction reducing sleeve and rod anchor grout. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

7.03.03.03 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.03.03.04 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole using the rod anchor grout mix to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour clean sand in the lower 0.5 m length of the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

7.03.03.05 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod above the rod anchor and sand.

7.03.03.06 Installation Details

The elevation, easting and northing of the top of the Benchmark rod shall be surveyed.

7.03.04 Settlement Plates

7.03.04.01 General

The locations of the SPs are shown on the Contract Drawings and are given in Table 1A. As embankment grade raise widening construction proceeds, the rods shall be extended above the new top of embankment. Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

The SPs shall be placed on undisturbed native soil or existing embankment fill just below the existing ground surface (i.e. where sub-excavation of disturbed/unsuitable soil deposits is not required) or on top of the backfill after sub-excavation and replacement of disturbed/unsuitable deposits, where required.

The elevation, easting and northing of the centre of the base of the plate and top of the rod shall be surveyed after installation.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

7.03.04.02 Plate

The settlement plate shall be installed horizontally (level) on the undisturbed native soil or existing embankment fill just below the existing ground surface.

7.03.04.03 Rod

The SP rod shall be fixed to the centre of the plate and perpendicular to the plate. The coupling of the rods shall be such that all sections have the same axis and that no separation or contraction will occur at the couplings.

7.03.04.04 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the SP rod shall extend 25 mm above the top of the friction sleeve at all times.

7.03.04.05 Extension of Rod

The SP rods shall be extended upwards as the embankment widening is constructed so that the top of the rod is always at least 0.3 m but not more than 2 m above the surrounding fill.

7.03.04.06 Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended concurrent with the rods. The SP rod shall be in the centre of the CSP and friction-reducing sleeve. The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

7.03.06 Nail Pins

7.03.06.01 General

The locations of the NPs are as shown in the Contract Documents and in Table 1A. The NPs shall be installed in the west shoulder of the new Highway QEW Toronto Bound Lane, on the top of the embankment fill when the bottom of pavement grade elevation is reached.

7.03.06.02 Pin Installation

The Contractor shall install NPs within the wet concrete (prior to set) poured in a minimum 0.15 m diameter by 0.3 m deep hole. The top of the reinforcing bars shall protrude above the concrete such that an accurate single survey point can be clearly identified and repeated.

7.04 Coordination with Monitoring Program

7.04.01 Notification

The Contractor shall notify the Contract Administrator no later than three (3) days the completion of installation of TBMs, SPs, and NPs.

7.04.02 Reporting

The Contractor shall supply the information outlined in the following sections to the Contract Administrator within three (3) days of completion of installation of each instrument.

7.04.02.01 Temporary Survey Benchmarks

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- TBM Northing and Easting in MTM NAD 83 coordinates;
- Elevation of the rod anchor bottom, rod anchor length, and top of rod in Geodetic datum;
- Date of installation;
- Stratigraphic log of subsurface conditions at the TBMs, including notes on drilling method obstructions it encountered;
- Installation notes/sketches; and,
- Description of TBM (rod), sleeves and rod anchors.

7.04.02.02 Settlement Plates

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- SP Northing and Easting in MTM NAD 83 coordinates;
- Elevation of base of plate and top of rod in Geodetic datum;
- Date of installation;
- Installation notes/sketches; and,
- Description of SP rods, sleeves and plates.

Adjustments in the length of any SP rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

7.04.02.03 Nail Pins

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- NP Northings and Eastings in MTM NAD 83 coordinates;
- Elevation of pin in Geodetic datum;
- Dates of installation; and,
- Installation notes / sketches.

7.04.03 Monitoring

The Contractor shall meet with the Contract Administrator and staff responsible for the ongoing monitoring immediately after installation of the instruments. At this meeting, the Contractor shall hand over to the Contract Administrator all records pertaining to the installation of the instruments, and all equipment to be supplied by the Contractor, as identified in the item-specific special provisions.

Monitoring by the Contract Administrator's representative for the baseline readings shall commence within seven working days after the hand-over meeting. The monitoring shall continue on a schedule to be determined by the Contract Administrator throughout the construction of the embankments, and for up to approximately six (6) weeks (at the abutments) to three (3) months (north of Station 13+725) following the completion of construction to the preload grade.

7.04.03.01 Survey Personnel

Surveying to establish the benchmarks and other elevations shall be carried out by a registered surveyor with appropriate equipment. The surveyor shall be retained by the Contractor.

7.04.03.02 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

7.04.03.03 Temporary Survey Benchmarks

Monitoring of settlements with reference to the TBMs shall be done by others. Monitoring shall be conducted during the embankment grade raise and widening construction and during the pre-load period. The Contractor shall provide installation information as specified above and provide access to the TBMs for monitoring including, but not limited to, snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed.

7.04.03.04 Settlement Plates

Monitoring of the SPs shall be done by others. Monitoring shall be conducted during the embankment grade raise and widening construction and during the pre-load period. The Contractor shall provide installation information as specified above and provide access to the SPs for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed for reading the instruments.

7.04.03.05 Nail Pins

Monitoring of the NPs shall be done by others. Monitoring shall be conducted during the preload period. The Contractor shall provide installation information as specified above and provide access to the NPs for monitoring.

7.05 Decommissioning of Instruments

7.05.01 General

The Contractor shall decommission all the TBMs, SPs and NPs at the end of the monitoring program unless advised otherwise by the Contract Administrator. Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

8.0 PAYMENT

8.0.1 Measurement for Payment

Measurement for Payment will be made on the basis of the number of units of survey TBMs, SPs, and NPs installed.

8.02 Basis of Payment

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, monitoring equipment and material to do the work.

PRELOADING AND DELAY OF SEWER INSTALLATION, PAVING, INSTALLATION OF TWO-STAGE RSS WALL FACING PANELS, AND INSTALLATION OF BARRIERS ON TOP OF RSS WALLS ADJACENT TO BRIDGE ABUTMENTS

Operational Constraint

The QEW high fill embankment widening and grade raise between Station 13+260 and 14+600, and the associated single-stage and two-stage RSS walls within these limits, shall be completed to the top of the granular sub-base. The following preload periods apply before paving, and where applicable, before installation of sewers, installation of the facing panels on sections of two-stage RSS walls, and installation of concrete cap / barrier walls on top of RSS walls adjacent to the bridge abutments:

Location	Sewer Installation	Paving and Concrete Cap / Barrier Walls	Installation of Facing Panels on Two-Stage RSS Wall Segments
South of Station 13+725	Six (6) weeks	Six (6) weeks	Six (6) weeks ^{1.}
Station 13+725 to 13+670	Three (3) months	Three (3) months	Three (3) months
Station 13+670 to 13+475	Three (3) months	Three (3) months	N/A

Notes:

^{1.} If single-stage RSS walls are considered at the bridge abutments, facing panels must be designed to tolerate predicted settlements as outlined by the criteria specified in the “Design, Construction, Maintenance and Inspection Guide for Mechanically Stabilized Earth Walls” (Transportation Association of Canada, 2017) whilst maintaining the specified performance level.

The Contract Administrator shall confirm the end of the preload period based on the results of the settlement monitoring program as set out elsewhere in the Contract Documents. The Contractor shall not proceed with sewer installation, final granular placement and paving, two-stage RSS panel installation, or installation of concrete cap / barriers on top of RSS walls until approval has been given by the Contract Administrator.

Prior to placement of the pavement structure granular base material and paving, the Contractor shall conduct a survey to determine the elevation of the top of the granular sub-base material, and shall place additional granular sub-base material as and where required to achieve the pavement design sub-base elevation.



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