



March 13, 2019

FOUNDATION INVESTIGATION REPORT REVISION 1

**Proposed Culvert Replacement / Rehabilitation
Site 22-415/C on Highway 7A, Port Perry, Ontario and
Site 21-13/C on Highway 7A near Blackstock, Ontario
GWP 2248-14-00**

Submitted to:

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REPORT





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LISTS OF ABBREVIATIONS AND SYMBOLS

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Drawing 2	Highway 7A – Port Perry Culvert (Site No. 22-415C) – Soil Strata
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Records of Boreholes 18, 20, 21, 33, 34, 35

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by CIMA+ Canada Inc. (CIMA+) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detailed foundation engineering services for the following:

- Site 22-415C: Replacement of existing culvert and endwall / retaining wall (at culvert outlet); and
- Site 21-13C: Rehabilitation of wingwalls / headwall at existing culvert inlet.

The purpose of this investigation is to establish the subsurface soil and shallow groundwater conditions at the culvert replacement / rehabilitation locations by borehole drilling and laboratory testing on selected soil samples.

The Terms of Reference (TOR) and the scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated June 3, 2015 and Golder's scope change letter dated April 10, 2017.

2.0 SITE DESCRIPTION

2.1 Site 22-415C

Site 22-415C is located on Highway 7A, about 80 m west of the intersection with Queen Street / Scugog Line 6 in Port Perry, Ontario. The culvert crosses under Highway 7A and the watercourse flows through the culvert from south to north at approximately Station 12+710. The upstream and downstream area consists of a well vegetated confined valley with dense trees. A commercial retail area is located to the northwest of the culvert, while residential land is present at the northeast, southwest and southeast quadrants. The Highway 7A grade at the culvert site is at approximately Elevation 271.5 m, and the road grade increases in elevation in both the east and west directions away from the low point. The toe of the embankment is at about Elevation 266.5 m, resulting in an embankment height up to about 5 m.

The culvert consists of an original non-rigid frame open footing cast-in-place concrete culvert with three extensions added over the years. Each extension consists of a rigid frame open footing cast-in-place concrete culvert. The original culvert has a span of 2.6 m, a rise of 2.1 m and a length of 12.0 m; the extensions have a span of 3.0 m, a rise of 2.1 m, and lengths of 6.7 m, 3.7 m and 5.7 m. The founding elevation of the existing open footing culvert and associated culvert extensions are not known. There is an existing concrete endwall / retaining wall located parallel to Highway 7A at the culvert outlet. The existing retaining wall is about 12 m long and up to about 3.5 m high; existing details for the retaining wall foundation were not available at the time this report was prepared.

Golder visited the site in the Spring / Summer of 2017. The existing embankment slopes were observed to be stable and there were no visual signs of instability or excessive settlement near the existing culvert inlet (see Photograph 1). The existing endwall / retaining wall is shown in Photograph 2 and water seepage was observed to be emanating through cracks in the headwall near the top of the culvert opening.



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Photograph 1 – Site 22-415C (looking north from inlet side)



Photograph 2 – Site 22-415C (looking southeast at endwall from outlet side)

2.2 Site 21-13C

Site 21-13C is located on Highway 7A, about 200 m east of Durham Regional Road 57 along a bend in the highway near Blackstock, Ontario. The culvert crosses under the Highway 7A embankment and Blackstock Creek flows through the culvert from southeast (inlet) to northwest (outlet). Two residences are located approximately 150 m to the southwest of Culvert 21-13C, one along Highway 7A and one along Regional Road 57. The Highway 7A grade at the site is at approximately Elevation 263 m, increasing in elevation away from the low point to the northeast and southwest. The embankment is about 3 m high near the culvert location.



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The existing culvert consists of a rigid frame cast-in-place concrete box culvert with a span of 6.1 m, a rise of 2.2 m and a length of 22.0 m. The base of the culvert is at about Elevation 259.2 m and the inlet consists of flared concrete headwall founded at the same level.

Golder visited the site on several occasions (Summer and Fall 2017) and observed the existing concrete headwall was distressed/delaminating (see Photograph 3). Referring to Photographs 4 and 5, the existing pavement structure above the culvert was observed to be eroding due to the close proximity of the guardrail and edge of pavement to the limit of the headwall, and there was also active erosion of the granular pavement base / subbase on both sides of the culvert inlet (adjacent and above the flared headwalls). Water seepage was observed to be flowing over the flared headwall at about the mid-height of the embankment.



Photograph 3 – Site 21-13 (looking northwest at headwall)



Photograph 4 – Site 21-13C (looking West)



Photograph 5 – Site 21-13C (looking East)



3.0 INVESTIGATION PROCEDURES

The field work for the foundation investigations for the culvert rehabilitation / replacement was carried out between July 5 and August 17, 2017, during which time six foundation boreholes were advanced at Culvert 22-415C (designated as Boreholes 18, 20, 21, 33, 34 and 35) and three foundation boreholes were advanced at Culvert 21-13C (designated as Boreholes 17-18, 17-20 and 17-36), at the locations shown on Drawings 1 and 2, respectively. Three pavement boreholes (designated 13, 15, and 32) advanced by Golder as part of the pavement investigation for this project are referenced and shown on Drawing 1 to supplement the foundation investigation program. The Record of Boreholes are provided in Appendices A and B, along with copies of the supplementary pavement borehole information.

The foundation borehole investigation was carried out using a D-50 truck mounted drill rig and a CME-55 track mounted drill rig, supplied and operated by Tri-phase Group of Mississauga, Ontario. The boreholes were advanced through the overburden using 210 mm outside diameter (O.D.) hollow stem power augers to depths of between about 9.2 m and 15.5 m below ground surface at Culvert 22-415C and to depths between about 2.4 m and 9.6 m below ground surface at Culvert 21-13C. Portable equipment (continuous split-spoon sampling) was required for one borehole (17-36) advanced at Site 21-13C due to wet, soft ground conditions.

Soil samples were typically obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586)¹. For borehole 17-36, continuous sampling using the 50 mm split-spoon sampler was performed by driving with a half-weight (32 kg) manual hammer. As a result, the recorded blow count per 0.3 m of penetration was divided in half to represent the equivalent SPT "N"-value (using standard hammer weight) as presented on the Record of Borehole.

The groundwater conditions and water levels in the open boreholes were observed in the boreholes during drilling operations. One standpipe piezometer was installed in Borehole 35 to permit monitoring of the water level pertinent to the culvert replacement at Site 22-415C. The installed piezometer consisted of 50 mm diameter PVC pipe, with a 1.5 m machine slotted screen sealed within a filter sand pack at a selected depth within the borehole. The annulus surrounding the piezometer pipe above the filter sand pack was backfilled to ground surface with bentonite pellets. Piezometer installation details and water level readings are described on the Record of Borehole sheet included in Appendix A. All other boreholes were backfilled to ground surface with bentonite upon completion, in accordance with Ontario Regulation 903, Wells (as amended) and a 0.1 m to 0.2 m thick asphalt cap was placed at roadway surface in the boreholes drilled on roadways/shoulders.

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, directed the sampling and in situ testing operations, logged the boreholes and examined the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Whitby for further visual review and geotechnical laboratory testing on selected samples. The geotechnical laboratory index and classification testing; consisting of natural moisture content, Atterberg limits and grain size distribution was conducted in accordance with MTO and / or ASTM Standards as applicable. One soil sample obtained during the field investigation was submitted for testing of organic content.

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



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The borehole locations were marked in the field by Golder personnel relative to existing road features and pre-selected coordinates using a hand-held GPS. The locations given on the Record of Boreholes and shown on the Drawings are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum based on interpolation from the digital terrain model provided by CIMA+. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole No.	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude)	Easting (Longitude)		
18	4,884,173.8 (44.096291)	348,010.4 (-78.960334)	271.3	9.2
20	4,884,180.1 (44.096347)	348,033.0 (-78.960052)	271.8	9.6
21	4,884,178.5 (44.096332)	348,035.0 (-78.960027)	271.7	9.6
33	4,884,160.3 (44.096170)	347,998.7 (-78.960482)	271.9	15.5
34	4,884,153.5 (44.096109)	348,005.6 (-78.960396)	271.9	15.5
35	4,884,143.3 (44.096016)	348,016.8 (-78.960257)	267.2	9.2
17-18	4,888,201.9 (44.131829)	358,670.1 (-78.826786)	263.2	9.6
17-20	4,888,211.3 (44.131921)	358,681.6 (-78.826654)	263.1	9.6
17-36	4,888,204.2 (44.131854)	358,686.5 (-78.826536)	261.0	2.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

4.1.1 Site 22-415C

This section of Highway 7A is located near the interface of several physiographic regions including the Schomberg Clay Plains, Oak Ridges Moraine, and Peterborough Drumlin Field, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)².

Three large areas, located near Schomberg, Newmarket and Lake Scugog, are included in the Schomberg Clay Plains. They are composed of a number of topographic basins along the northern slopes of the Oak Ridges Moraine that contain deep deposits of stratified clay and silt. This investigation is located in the third area, near Lake Scugog, where the surface under the clay is that of a flat till plain, with few drumlins occurring.

² 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.



4.1.2 Site 21-13C

This section of Highway 7A is located in the Peterborough Drumlin Field physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)².

The Peterborough Drumlin Field is a rolling till plain. The drumlins throughout are composed of highly calcareous till with local differences. In some areas deposits of clay lie between the drumlins, in places flooded by the old glacial lakes. In other places such as to the south of Lake Simcoe there are drumlins rising from sand plains. The Peterborough Drumlin Field is also notable for its eskers / gravel ridges.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the current investigation and the results of the geotechnical laboratory tests carried out on selected soil samples are presented on the Record of Borehole sheets provided in Appendices A and B for Culverts 22-415C and 21-13C, respectively. The results of the in situ field tests (i.e., SPT "N"-values) as presented on the Record of Borehole sheets and in Section 4.2 are uncorrected. The results of laboratory grain size distribution tests and Atterberg Limits tests are also presented in Appendices A and B, for Culverts 22-415C and 21-13/C, respectively.

The stratigraphic boundaries shown on the Record of Borehole sheets 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 Record of Borehole sheets governs any interpretation of the site conditions.

Detailed descriptions of the subsurface conditions encountered at each culvert site are provided in the following sections of this report.

4.2.1 Site 22-415C

The plan and profile drawings at the existing / proposed culvert replacement and retaining wall location showing the borehole locations and interpreted stratigraphy are shown on Drawings 1 and 2. The Record of Borehole sheets (Boreholes 18, 20, 21, and 33 to 35) and the laboratory test results are presented in Appendix A.

In general, the soil conditions at the area of the proposed culvert and retaining wall replacement consist of surficial asphalt, topsoil or sand and gravel fill, underlain by a silty sand to silt and sand (fill). The fill was underlain by a sandy silt to silt and sand deposit in Boreholes 18, 33 and 34 and by a silt and sand till deposit in Boreholes 20, 21 and 35. In the boreholes where the sandy silt to silt and sand deposit was encountered, it was immediately underlain by the silt and sand till. Interlayers of sand were observed in the silt and sand till deposit in Boreholes 20 and 35.

4.2.1.1 Asphalt

An approximately 200 mm thick layer of asphalt was encountered immediately below ground surface in Borehole 20.

4.2.1.2 Topsoil

An approximately 300 mm thick layer of topsoil was encountered immediately below ground surface in Borehole 35, which was advanced near the inlet on the south side of Highway 7A. The pavement borehole 32



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located near the outlet on the north side of Highway 7A also encountered 300 mm of topsoil and the pavement borehole 15 located near the toe of the embankment west of the culvert encountered about 200 mm of topsoil.

4.2.1.3 *Fill*

A 0.4 m to 4.0 m thick layer of fill was encountered underlying the asphalt pavement in Borehole 20, underlying the topsoil in Borehole 35, and at ground surface in the remaining four boreholes (18, 21, 33, and 34). The surface of the fill layer was encountered between Elevations 271.9 m and 266.9 m, and the base of the fill layer was encountered between Elevations 269.7 m and 266.5 m.

The fill is variable in composition but is mainly non-cohesive and is comprised of silt and sand to sandy silt. The boreholes advanced on Highway 7A typically encountered a gravelly sand to sand and gravel layer near the road / shoulder surface that transitioned into silt and sand at depth. A 0.4 m thick layer of cohesive fill was encountered in Borehole 20 and is comprised of silty clay with gravel containing trace sand. Trace organics were noted within the fill in Boreholes 18, 20, and 35.

The Standard Penetration Test (SPT) "N"-values measured within the non-cohesive fill deposit range from 3 blows to 32 blows per 0.3 m of penetration, indicating a very loose to dense level of compactness. SPT "N"-values were not measured within the cohesive fill.

Atterberg limits testing was carried out on one sample of the non-cohesive fill and indicated that the fill was non-plastic. The natural water content measured on selected samples of the non-cohesive fill ranges from about 5 per cent to 25 per cent.

The supplementary pavement borehole 13, located on the Highway 7A shoulder west of the culvert, indicates that the embankment fill consists of gravelly sand near the surface and transitions to a silty clay with sand at a depth of about 1.1 m and extends to the termination of the pavement hole at about Elevation 269.9 m. An SPT "N"-value measured 5 blows per 0.3 m of penetration at the pavement borehole 13, suggesting the gravelly sand to silty clay with sand fill has a loose to firm consistency.

4.2.1.4 *Sandy Silt to Silt and Sand*

A 1.1 m to 1.6 m thick deposit of sandy silt to silt and sand was encountered underlying the fill in Boreholes 18, 33, and 34. The surface of the sandy silt to silt and sand was encountered between Elevations 269.0 m and 267.9 m. The deposit consisted of varying amounts of sand and silt containing trace to some gravel and clay.

The SPT "N"-values measured within sandy silt to silt and sand deposit range from 2 blows to 21 blows per 0.3 m of penetration, indicating a very loose to compact level of compactness.

Grain size distribution testing was carried out on two selected samples of the sandy silt to silt and sand and the results are shown on Figure A-1 in Appendix A. Atterberg limits testing was carried out on two selected samples of the sandy silt to silt and sand deposit, both tests indicated a non-plastic material. The natural water content measured on one selected sample of the sandy silt to silt and sand indicated a water content of about 18 per cent.

4.2.1.5 *Silt and Sand to Sandy Silt (Till)*

A silt and sand to sandy silt till deposit was encountered underlying the fill or sandy silt to silt and sand deposit in all boreholes (18, 20, 21, 33, 34, and 35). The boreholes were terminated within the silt and sand to sandy silt till deposit, penetrating the deposit between about 5.2 m and 11.5 m. The surface of the silt and sand to sandy silt



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till deposit was encountered between Elevations 269.7 m and 266.3 m. The till deposit consisted of silt and sand to silty sand containing trace to some gravel and clay. Although not encountered during the current investigation, cobbles and boulders are known to be present within glacial till soils in Southern Ontario and should be expected within this soil deposit.

The SPT “N”-values measured within the silt and sand to sandy silt till deposit ranged from 11 blows per 0.3 m of penetration to 50 blows per 0.08 m of penetration, indicating a compact to very dense level of compactness.

Grain size distribution testing was carried out on thirteen selected samples of the silt and sand to sandy silt till and the results are shown on Figures A-2A and A-2B in Appendix A. Atterberg limits testing was carried out on four selected samples of the silt and sand to sandy silt till deposit, all tests indicated a non-plastic material. The natural water content measured on selected samples of the silt and sand to sandy silt till deposit range between about 6 per cent and 23 per cent.

4.2.1.6 Sand

A 1.5 m and 2.9 m thick sand layer was encountered within the silt and sand till deposit in Boreholes 20 and 35, respectively. The sand layer contained trace to some silt and trace gravel and clay.

The SPT “N”-values measured within the sand interlayer ranged from 19 blows per 0.3 m of penetration to 84 blows per 0.28 m of penetration, indicating a compact to very dense level of compactness. A grain size distribution test was conducted on one sample of the sand and is shown on Figure A-3 in Appendix A. The natural water content measured on one selected sample of the sand interlayer is about 21 per cent.

4.2.1.7 Groundwater Conditions

Details of the water levels observed in the open boreholes at the time of drilling are shown on the Record of Borehole sheets for Boreholes 18, 20, 21, and 33 to 35 in Appendix A. A standpipe piezometer was installed in Borehole 35 to monitor the groundwater level at the site. The water levels measured in the open boreholes and the piezometers are summarized below:

Borehole No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
18	271.3	3.1	268.2	13-Jul-17	Open borehole - on completion of drilling
20	271.8	wet at 5.6 m	wet at 266.2	13-Jul-17	Borehole caved to 5.2 m depth upon completion of drilling
21	271.7	wet at 2.4 m	wet at 269.3	11-Jul-17	Borehole caved to 2.4 m depth upon completion of drilling
33	271.9	-	-	11-Jul-17	Open borehole - on completion of drilling
34	271.9	2.4	269.5	10-Jul-17	Open borehole - on completion of drilling
35	267.2	4.3	262.9	20-Jul-17	Open borehole - on completion of drilling
		(-0.6)*	267.8	24-Aug-17	Piezometer



***Artesian Conditions**

The creek level, as shown on the 60% design drawings, is at about Elevation 266.49 m. It is noted that artesian groundwater conditions were measured in the piezometer installed in Borehole 35 when measured in August 2017, about one month after initial installation. The piezometer was screened within the sand interlayer present within the silt and sand till deposit.

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

4.2.2 Site 21-13C

The plan and profile of the culvert inlet headwall / wingwall location at Culvert 21-13C showing the borehole locations and interpreted soil stratigraphy are shown on Drawing 3. The Record of Borehole sheets (Boreholes 17-18, 17-20, and 17-36) and the laboratory test results for this site are provided in Appendix B.

In general, the subsurface conditions from the surface of Highway 7A near the culvert inlet and proposed headwall / wingwall rehabilitation consist of roadway granular fill (i.e. gravelly sand) underlain by silt and sand fill that was used to construct the existing Highway 7A embankment. The fill soils are underlain by cohesionless deposits of native gravel to sand and gravel to sand. Adjacent to the road embankment and near the end of the existing wing walls, a surficial layer of topsoil was encountered underlain by silty sand containing variable amounts of organics.

4.2.2.1 Topsoil

An approximately 500 mm thick layer of topsoil was encountered immediately below ground surface in Borehole 17-36, which was advanced near the culvert inlet on the south side of Highway 7A.

4.2.2.2 Fill

A 1.4 m thick layer of gravelly sand fill was encountered at ground surface in Boreholes 17-18 and 17-20, advanced at the shoulder of the Highway 7A eastbound lane. The roadway granular soil was underlain by a 4.2 m thick layer of silt and sand fill at both borehole locations. The bottom of the fill layer was encountered at Elevation 257.6 m and 257.5 m at Boreholes 17-18 and 17-20 respectively.

The gravelly sand fill contained trace to some silt and the silt and sand fill was more variable but typically contained trace to some clay, trace gravel. Trace brick fragments and organic inclusions were encountered near the bottom of the silt and sand fill in Borehole 17-20. A laboratory organic content test was conducted on one selected sample of the bottom of the silt and sand fill and measured an organic content of about 6 per cent.

The SPT "N"-values measured within the non-cohesive fill deposit range from 4 blows to 14 blows per 0.3 m of penetration, indicating a very loose to compact level of compactness.

Grain size distribution testing was carried out on two selected samples of the non-cohesive silt and sand fill and the results are shown on Figure B-1 in Appendix B. Atterberg limits testing was carried out on one sample of the silt and sand fill and indicated that the soil was non-plastic. The natural water content measured on selected samples of the non-cohesive fill ranges from about 10 per cent to about 39 per cent, but is generally between about 10 per cent and 13 per cent. The high water content value of 39 per cent was measured on a sample of the fill that contained organics in Borehole 17-20, Sample 5.



4.2.2.3 Gravel

A 1.5 m thick gravel deposit was encountered underlying the fill in Borehole 17-18. The surface of the gravel was encountered at Elevation 257.6 m. The gravel contained trace to some sand and trace amounts of silt.

The SPT “N”-value measured within the gravel deposit was 12 blows per 0.3 m of penetration, indicating a compact level of compactness. The natural water content measured on a selected sample of the gravel deposit is about 3 per cent.

4.2.2.4 Sand

A sand deposit was encountered underlying the gravel in Borehole 17-18. Borehole 17-18 was terminated within the sand, penetrating the sand deposit for 2.5 m. The surface of the sand deposit was encountered at Elevation 256.1 m and the sand deposit contained trace to some silt and trace amounts of gravel.

The SPT “N”- values measured within the sand deposit were 23 blows and 36 blows per 0.3 m of penetration, indicating a compact to dense level of compactness.

Grain size distribution testing was carried out on one selected sample of the sand deposit and the result is shown on Figure B-2 in Appendix B. The natural water content measured on a selected sample of the sand deposit is about 14 per cent.

4.2.2.5 Sand and Gravel

A sand and gravel deposit was encountered underlying the fill in Borehole 17-20. Borehole 17-20 was terminated within the sand and gravel, penetrating the deposit for about 4.0 m. The surface of the sand and gravel deposit was encountered at Elevation 257.5 m. The sand and gravel deposit contained trace to some silt and trace amounts of clay.

The SPT “N”-values measured within the sand and gravel deposit range from 10 blows to 35 blows per 0.3 m of penetration, indicating a compact to dense level of compactness.

Grain size distribution testing was carried out on one selected sample of the sand and gravel deposit and the result is shown on Figure B-3 in Appendix B. The natural water content measured on selected samples of the sand and gravel deposit were 8 per cent and 18 per cent.

4.2.2.6 Silty Sand

A silty sand deposit was encountered underlying the topsoil in Borehole 17-36. Borehole 17-36 was terminated within the silty sand, penetrating the deposit for about 1.9 m. The surface of the silty sand deposit was encountered at Elevation 260.5 m. The silty sand contained trace clay and trace to some organics.

The SPT “N”-values measured within the silty sand deposit range from 6 blows to 21 blows per 0.3 m of penetration, indicating a loose to compact level of compactness.

Grain size distribution testing was carried out on one selected sample of the silty sand deposit and the result is shown on Figure B-4 in Appendix B. The natural water content measured on selected samples of the silty sand deposit range from about 25 per cent and 33 per cent.



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4.2.2.7 Groundwater Conditions

The groundwater levels in the open boreholes were measured upon completion of drilling operations. Upon completion of Boreholes 17-18 and 17-20, the water level was measured to be at a depth of about 1.2 m below ground surface (corresponding to Elevation 262.0 m and 261.9 m, respectively); however, it should be noted that these boreholes progressively caved soon after the augers were removed and may have influenced the observed water level. Borehole 17-36 was observed to be dry upon completion of drilling, although wet soil samples were noted below a depth of 1.8 m (Elevation 259.2 m).

The creek water level was measured at Elevation 260.0 m in December 2015, as shown on the 60% design drawings.

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

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Kevin Wallin, and was reviewed by Ms. Nikol Kochmanová, P.Eng., a geotechnical engineer with Golder. Mr. Kevin Bentley, P.Eng., an Associate and MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of this report.

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KAW/NK/KJB/sm

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\\golder.gds\gal\whitby\active\2015\3 proj\1533653 cima hwy 26 & 7a mto central region\2000 - foundations\hwy 7a\report\5. revised final fidr\1533653 fir rev1 2019\march13 cima hwy 7a culvert replacement-rehab.docx



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

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



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

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

(b) Cohesive Soils Consistency

	c_u, s_u kPa	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

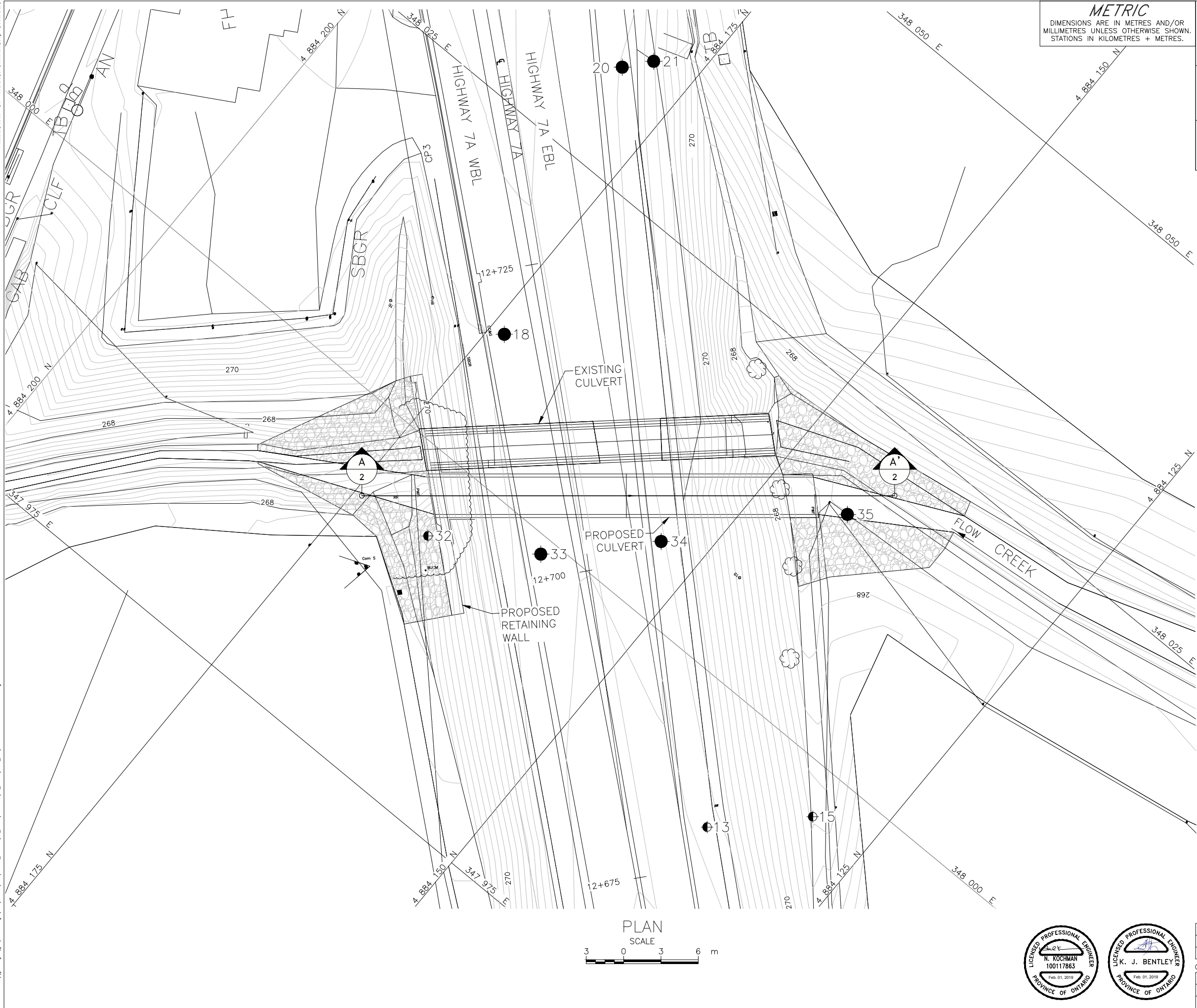
IV. SOIL TESTS

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

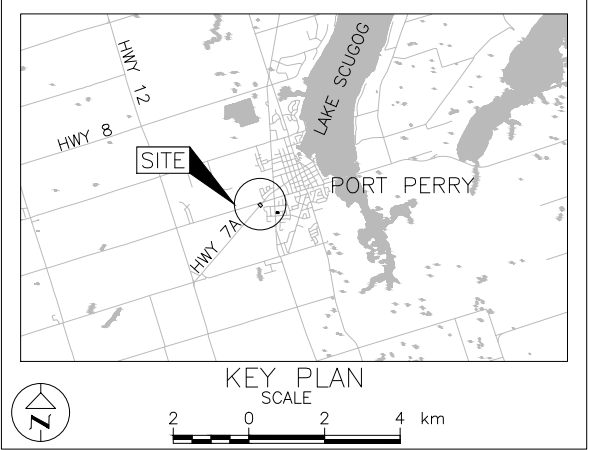
Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



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

CONT No.
GWP No.2248-14-00

HIGHWAY 7A
PORT PERRY CULVERT (SITE NO. 22-415C)
BOREHOLE LOCATIONS



LEGEND

- Borehole - Current Investigation
- Borehole - Pavement Investigation

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)			
No.	ELEVATION	NORTHING	EASTING
13	271.9	4884136.0	347990.3
15	268.8	4884130.0	347996.3
18	271.3	4884173.8	348010.4
20	271.8	4884180.1	348033.0
21	271.7	4884178.5	348035.0
32	269.0	4884168.2	347994.0
33	271.9	4884160.3	347998.7
34	271.9	4884153.5	348005.6
35	267.2	4884143.3	348016.8

NOTES

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

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

REFERENCE

Base plans provided in digital format by CIMA+, drawing file nos. site 22-415C highway 7A.DWG, received July 25, 2017.

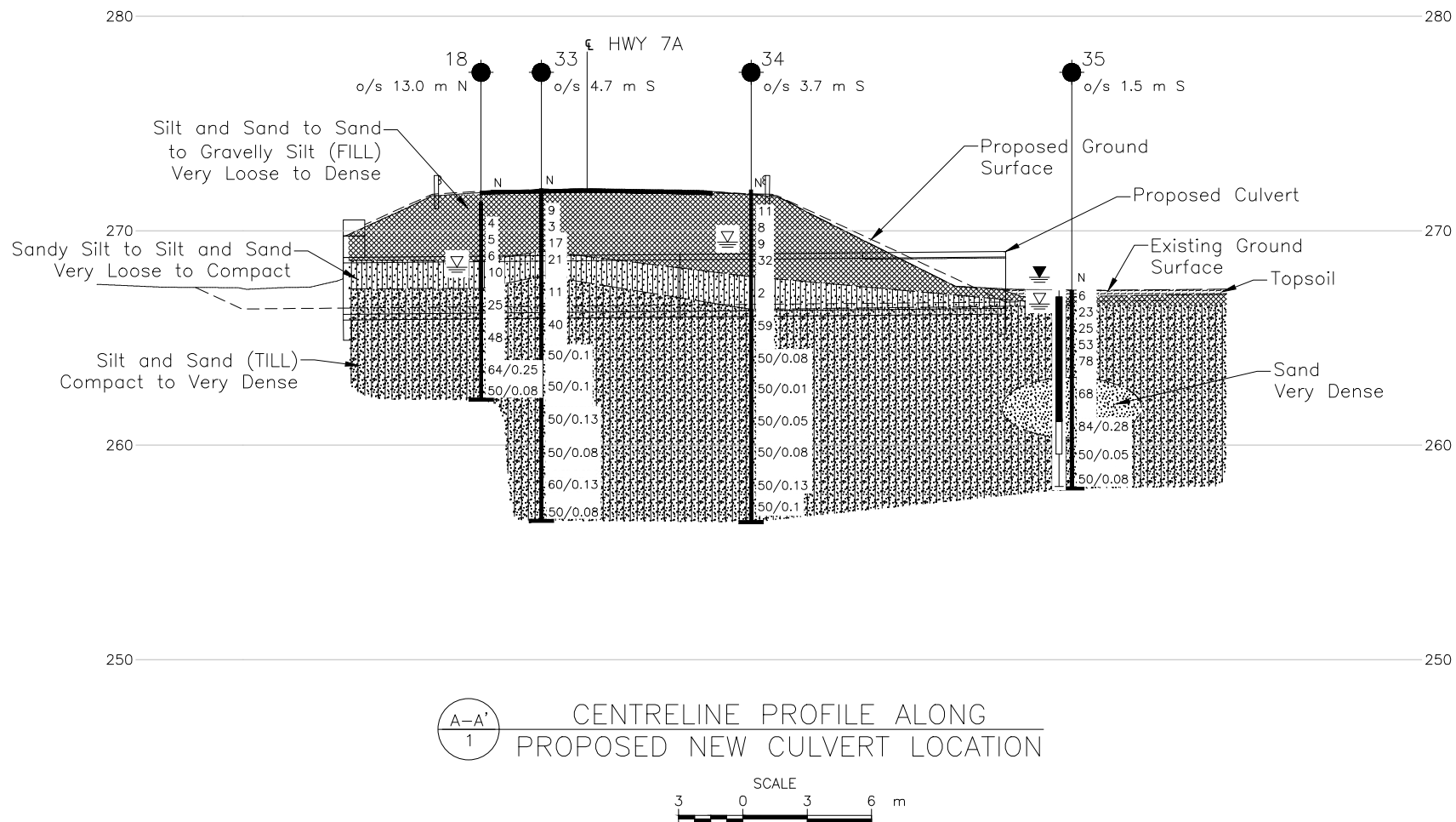


NO.	DATE	BY	REVISION
Geocres No. 31D-706			
HWY. 7A	PROJECT NO. 1533653		DIST. .
SUBM'D.	CHKD.	DATE: 2/1/2019	SITE: 22-415C
DRAWN: TR	CHKD. NK	APPD. KJB	DWG. 1








CONT No.
GWP No.2248-14-00

HIGHWAY 7A
PORT PERRY CULVERT (SITE NO. 22-415C)
SOIL STRATA

SHEET



LEGEND

-  Borehole — Current Investigation
 Seal
 Piezometer
 Standard Penetration Test Value
 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 WL in piezometer, measured on AUG 24, 2017
 WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
18	271.3	4884173.8	348010.4
33	271.9	4884160.3	347998.7
34	271.9	4884153.5	348005.6
35	267.2	4884143.3	348016.8

NOTES

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

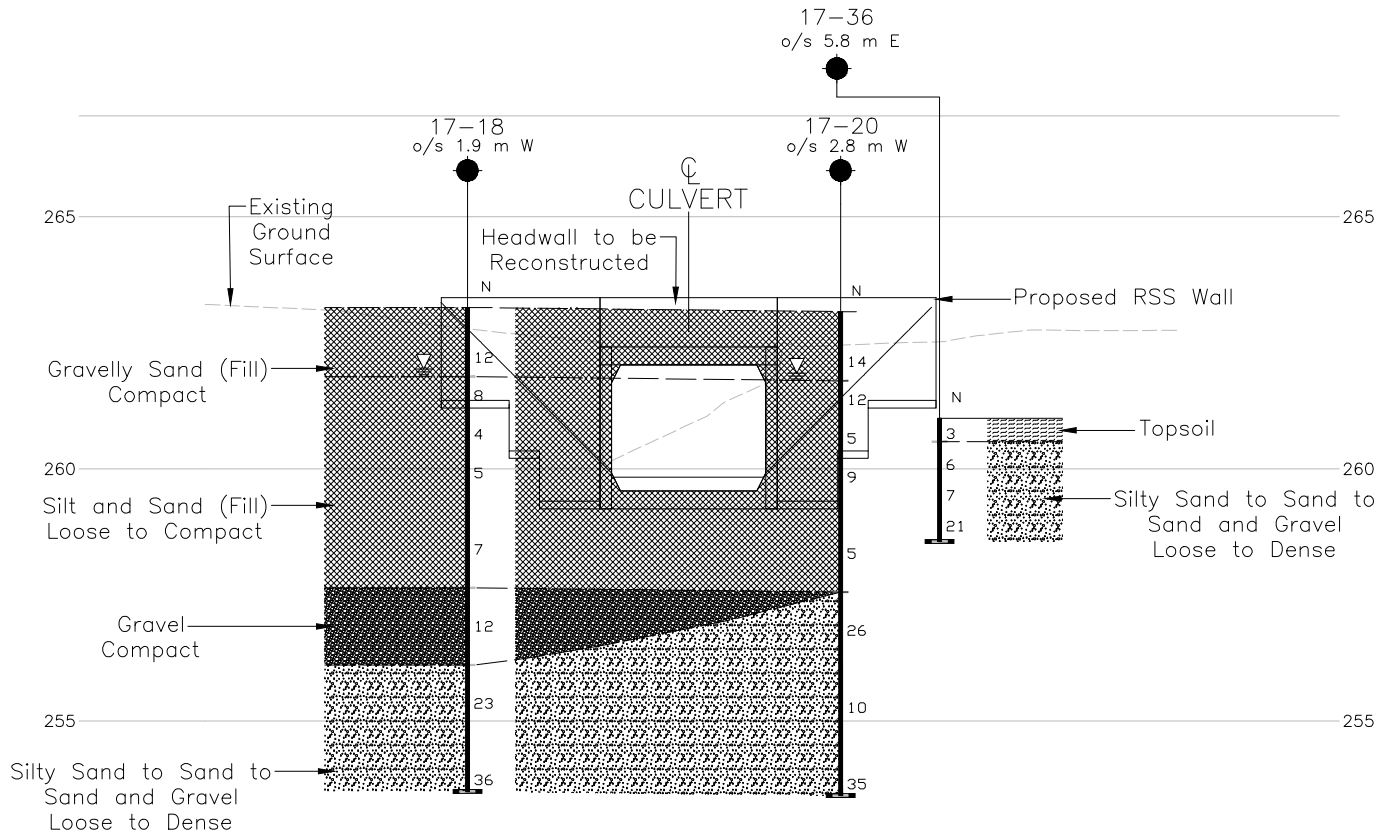
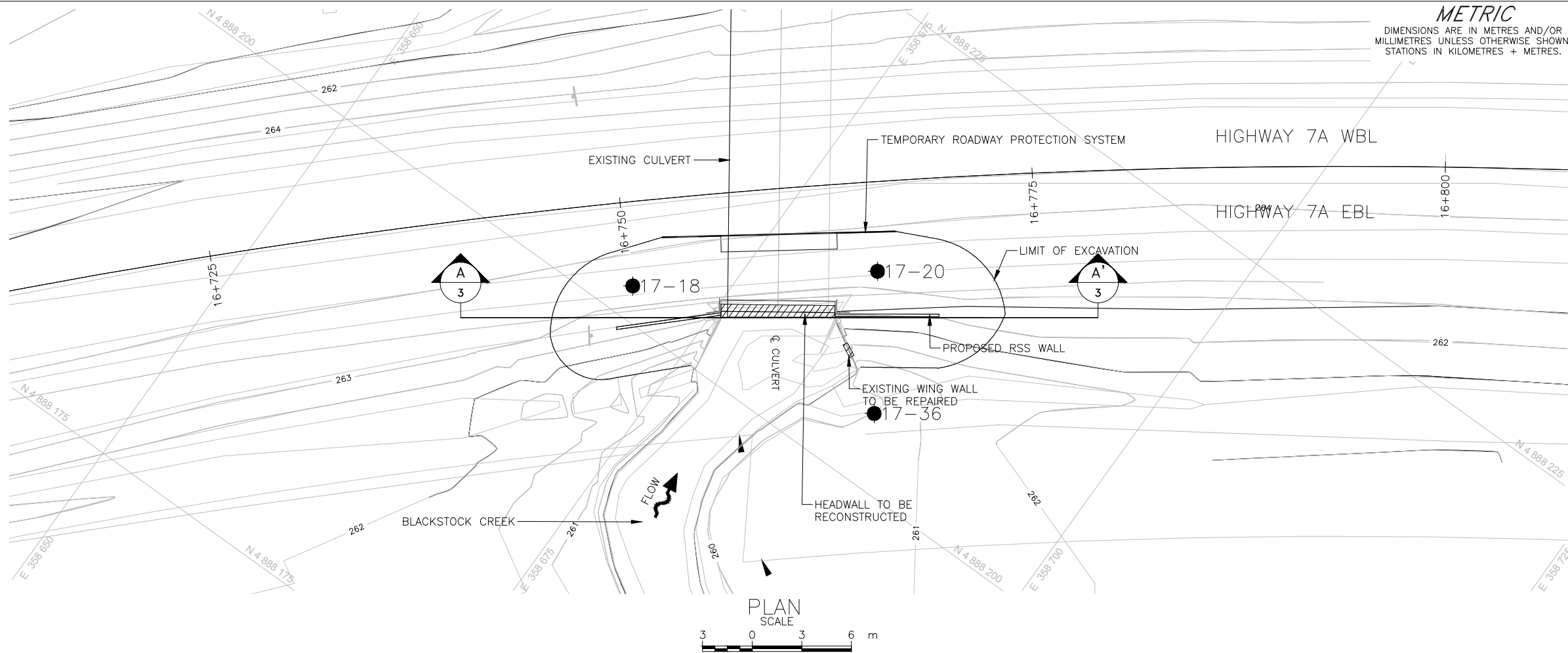
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by CIMA+, drawing file nos. site 22-415C highway 7A.DWG, received July 25, 2017.

NO.	DATE	BY	REVISION	
Geocres No. 31D-706				
HWY. 7A		PROJECT NO.		DIST.
SUBM'D.	CHKD.	DATE: 2/1/2019		SITE: 22-415C
DRAWN: TR	CHKD. NK	APPD. KJB		DWG. 2

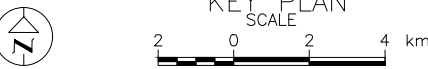
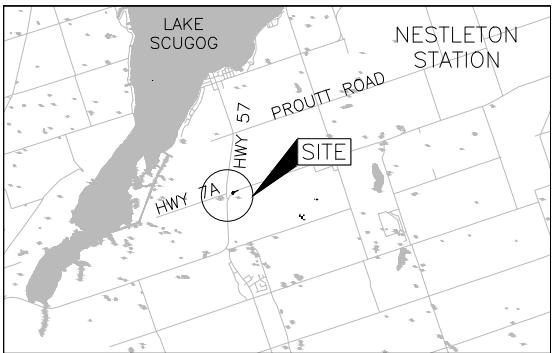




PROFILE ALONG PROPOSED HEADWALL / RETAINING WALL

CONT No.
GWP No. 2248-14-00

HIGHWAY 7A
BLACKSTOCK CULVERT (SITE NO. 21-13C)
BOREHOLE LOCATIONS AND SOIL STRATA



LEGEND

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

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
17-18	263.2	4888201.9	358670.1
17-20	263.1	4888211.3	358681.6
17-36	261.0	4888204.2	358686.5

NOTES

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

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

REFERENCE

Base plans provided in digital format by client, drawing file no. "GA_X-21-13c S1.dwg, and GA_X-21-13c S2.dwg, and GA_X-21-13c S3.dwg", dated Feb. 27, 2017, received Feb. 2018.



NO.	DATE	BY	REVISION
Geocres No. 31D-706			
HWY. 7A	PROJECT NO. 1533653		DIST. .
SUBM'D. NK	CHKD. NK	DATE: 2/1/2019	SITE: 21-13C
DRAWN: SMD/DD	CHKD. KJB	APPD. KJB	DWG. 3



APPENDIX A

Site 22-415/C

Record of Borehole Sheets
Laboratory Test Results



S:\CLIENTS\MTO\001 S:\CLIENTS\MTO\CENTRAL_ONTARIO\02 DATA\GIN\1533653 NEW.GPJ GAL-GTA.GDT 02/04/19 MK Mar. 2018

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

PROJECT 1533653		RECORD OF BOREHOLE No 20		SHEET 1 OF 1		METRIC																	
G.W.P. 2248-14-00		LOCATION N 4884180.1; E 348033.0 MTM NAD 83 ZONE 10 (LAT. 44.096347; LONG. -78.960052)		ORIGINATED BY LP																			
DIST Central HWY 7A		BOREHOLE TYPE 210 mm Diameter Hollow Stem Power Augers		COMPILED BY AMP																			
DATUM Geodetic		DATE July 13, 2017		CHECKED BY KJB																			
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL				
271.8	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L 10 20 30			kN/m ³							
0.0	ASPHALT																						
0.4	Crushed granular (FILL) Brown																						
270.7	Sand, fine to medium, with gravel, trace silt (FILL) Brown						271																
1.1	Moist																						
270.3	Silty clay, with gravel, trace sand (FILL) Grey		1	SS	6		270																
1.5	Moist																						
269.7	Silt and sand, trace to some gravel, trace to some clay, trace rootlets (FILL) Loose Dark brown Moist		2	SS	32		269												NP	11	53	30	6
2.1	SILT and SAND, trace to some gravel, trace to some clay, oxidation staining (TILL) Dense to very dense Brown Moist		3	SS	40		268																
							267												NP	3	37	49	11
			4	SS	59		266																
266.2	SAND, trace to some silt, trace gravel, trace clay Compact Brown Wet		5	SS	19		265																
264.7	SILT and SAND, trace to some gravel, trace clay (TILL) Very dense Brown to grey Moist		6	SS	79		264																
262.2	END OF BOREHOLE		7	SS	76		263																
9.6	Notes: 1. Borehole caved to a depth of about 5.18 m below ground surface upon completion of drilling.																						

PROJECT 1533653		RECORD OF BOREHOLE No 21				SHEET 1 OF 1		METRIC									
G.W.P. 2248-14-00		LOCATION N 4884178.5; E 348035.0 MTM NAD 83 ZONE 10 (LAT. 44.096332; LONG. -78.960027)				ORIGINATED BY LP											
DIST Central HWY 7A		BOREHOLE TYPE 210 mm Diameter Hollow Stem Power Augers				COMPILED BY AMP											
DATUM Geodetic		DATE July 11, 2017				CHECKED BY KJB											
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									
271.7	GROUND SURFACE																
0.0	Gravelly sand (FILL) Compact Brown Moist																
270.6			1A	SS	16												
1.1	Silt and sand, trace to some gravel, trace to some clay (FILL) Very loose to compact Black to brown Moist to wet		1B														
			2	SS	3												
			3	SS	20												
268.8																	
2.9	SILT and SAND, trace to some gravel, trace to some clay (TILL) Dense to very dense Brown to grey Moist		4	SS	49												
			5	SS	44												
			6	SS	41												
			7	SS	96/0.23												
	- Becoming grey at a depth of about 8.6 m																
262.1	- 50 mm sand seam at a depth of about 9.2 m		8	SS	53												
9.6	END OF BOREHOLE																
	Note: 1. Borehole caved to a depth of about 2.4 m below ground surface upon completion of drilling.																



S:\CLIENTS\MTO\001 S:\CLIENTS\MTO\CENTRAL ONTARIO\02 DATA\GIN\1533653 NEW.GPJ GAL-GTA.GDT 02/04/19 MK Mar. 2018

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



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




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Continued Next Page

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

PROJECT <u>1533653</u>		RECORD OF BOREHOLE No 34				SHEET 2 OF 2		METRIC	
G.W.P. <u>2248-14-00</u>		LOCATION <u>N 4884153.5; E 348005.6 MTM NAD 83 ZONE 10 (LAT. 44.096109; LONG. -78.960396)</u>				ORIGINATED BY <u>LP</u>			
DIST <u>Central</u> HWY <u>7A</u>		BOREHOLE TYPE <u>210 mm Diameter Hollow Stem Power Augers</u>				COMPILED BY <u>AMP</u>			
DATUM <u>Geodetic</u>		DATE <u>July 10, 2017</u>				CHECKED BY <u>KJB</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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _p	W		
256.4	<div style="text-align: center;">--- CONTINUED FROM PREVIOUS PAGE ---</div> END OF BOREHOLE Notes: 1. Water level measured at a depth of 2.44 m below ground surface upon completion of drilling.		12	SS	50/0.1											
15.5																

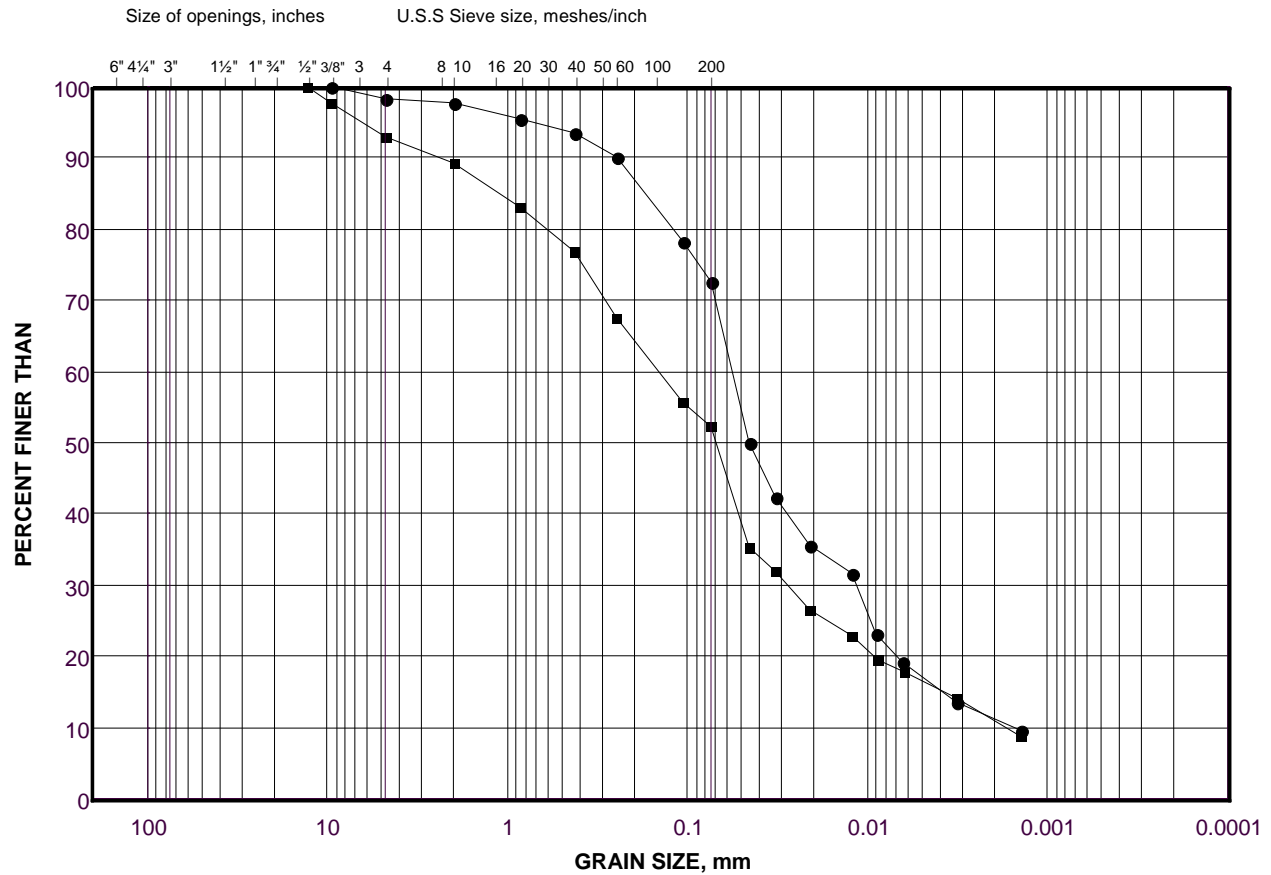
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PROJECT 1533653		RECORD OF BOREHOLE No 35		SHEET 1 OF 1		METRIC															
G.W.P. 2248-14-00		LOCATION N 4884143.3; E 348016.8 MTM NAD 83 ZONE 10 (LAT. 44.096016; LONG. -78.960257)		ORIGINATED BY JS																	
DIST Central HWY 7A		BOREHOLE TYPE 210 mm Diameter Hollow Stem Power Augers		COMPILED BY AMP																	
DATUM Geodetic		DATE July 20, 2017		CHECKED BY KJB																	
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL		
267.2	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p — W — W _L 10 20 30			kN/m ³					
0.0	TOPSOIL		1	SS	6		267														
0.3	Silt and sand, trace to some clay, trace gravel, organic inclusions (FILL)		2	SS	23		266														
0.7	Loose Dark brown Moist		3	SS	25		265														
	SILT and SAND, trace gravel, trace clay, some oxidation staining (TILL)		4	SS	53		264														
	Compact to very dense Brown Moist		5	SS	78		263														
263.2			6	SS	68		262														
4.0	SAND, trace to some silt, trace gravel		7	SS	84/0.28		261														
	Very dense Brown Wet		8	SS	50/0.06		260														
260.3			9	SS	50/0.08		259														
6.9	SILT and SAND, trace to some clay, trace gravel (TILL)						258														
	Very dense Grey Moist																				
258.0	END OF BOREHOLE																				
9.2	Notes: 1. Water level measured at a depth of about 4.27 m below ground surface upon completion of drilling. 2. Water level measured in piezometer at 0.63 m above ground surface on August 24, 2017.																				

GRAIN SIZE DISTRIBUTION

Sandy Silt to Silt and Sand

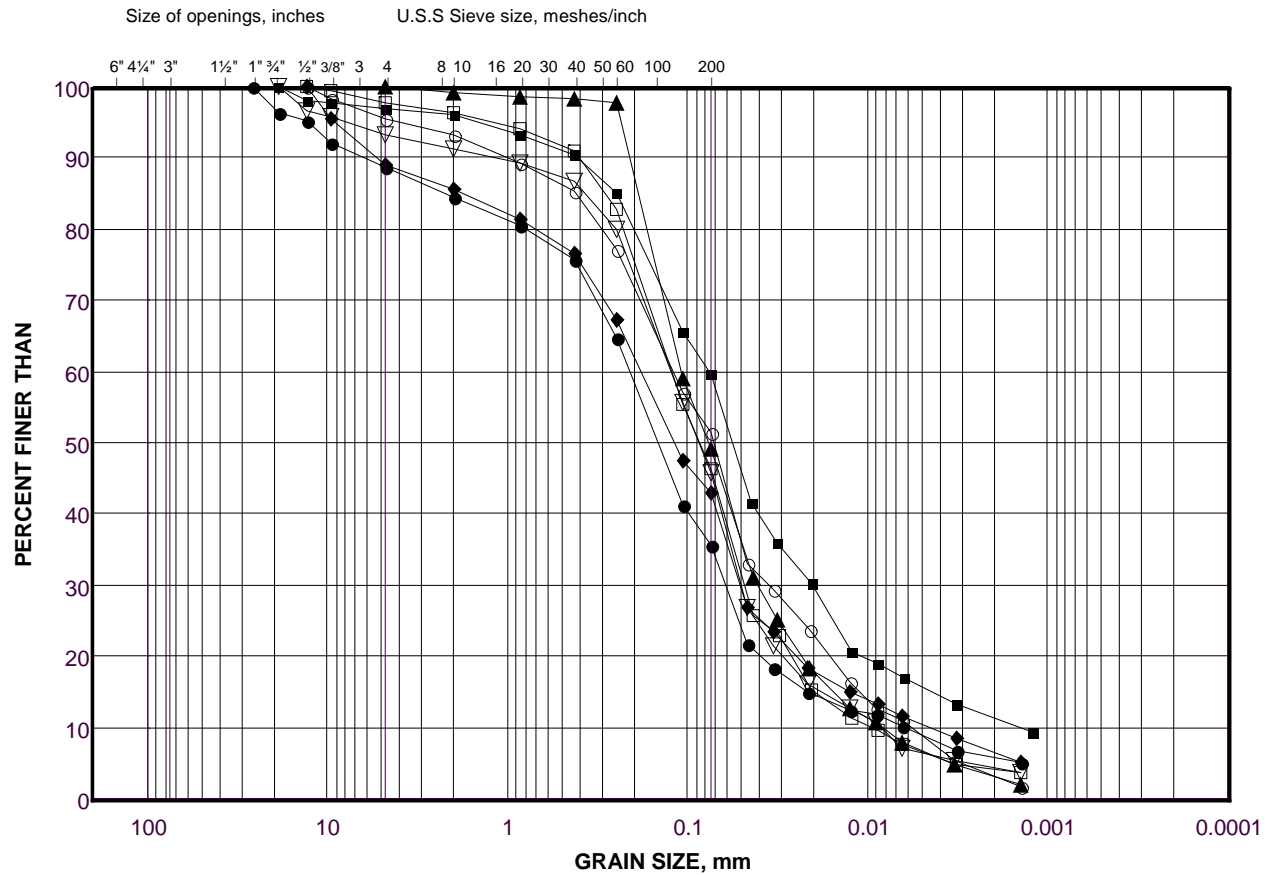
FIGURE A-1



GRAIN SIZE DISTRIBUTION

Silt and Sand Till

FIGURE A-2A



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	20	2	269.5
■	20	4	267.2
◆	21	4	268.7
▲	18	6	265.2
▽	20	6	264.2
○	18	8	262.2
□	21	8	262.6

Project Number: 1533653

Checked By: KJB

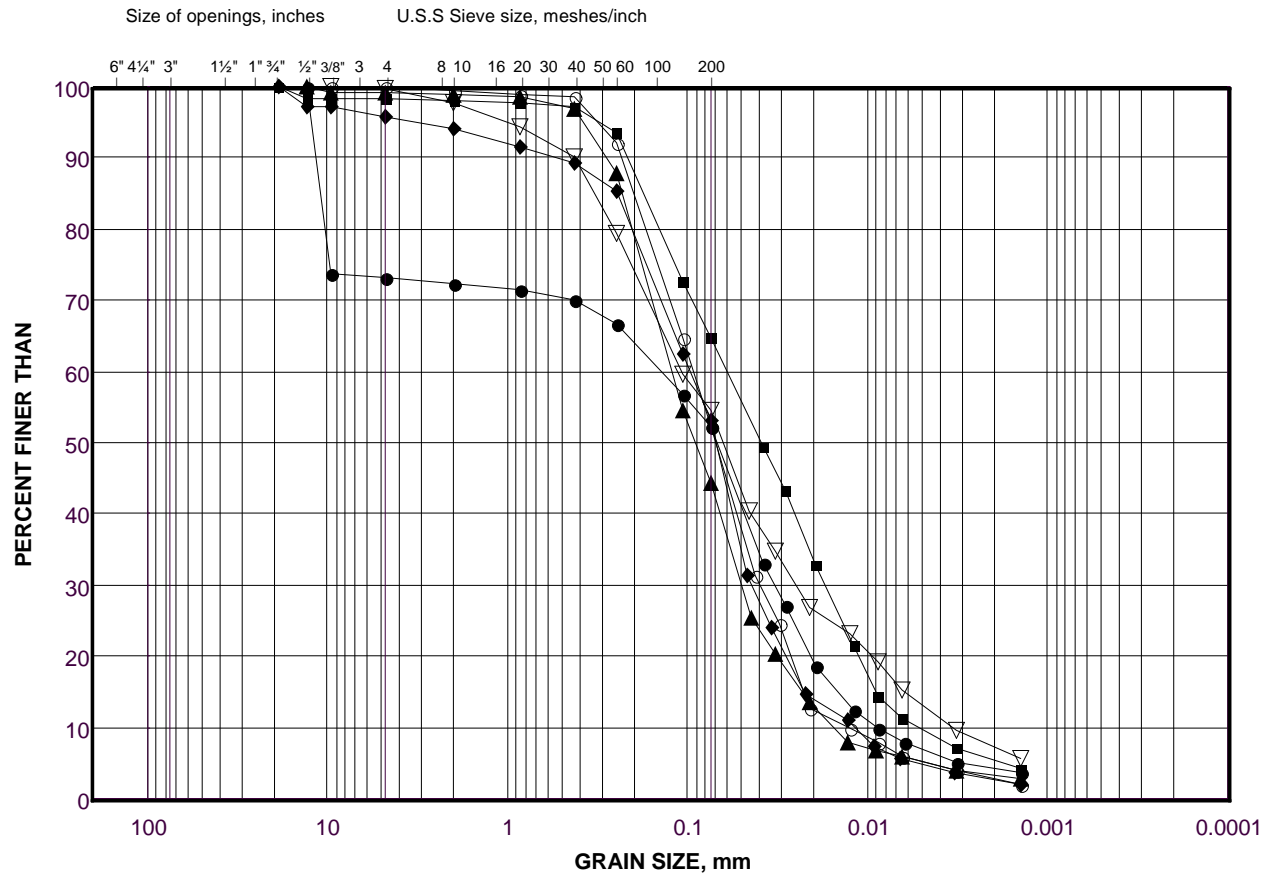
Golder Associates

Date: 01-Jun-18

GRAIN SIZE DISTRIBUTION

Silt and Sand Till

FIGURE A-2B



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	34	11	258.2
■	33	12	256.7
◆	35	4	264.9
▲	33	7	264.3
▽	35	8	259.6
○	34	8	262.8

Project Number: 1533653

Checked By: KJB

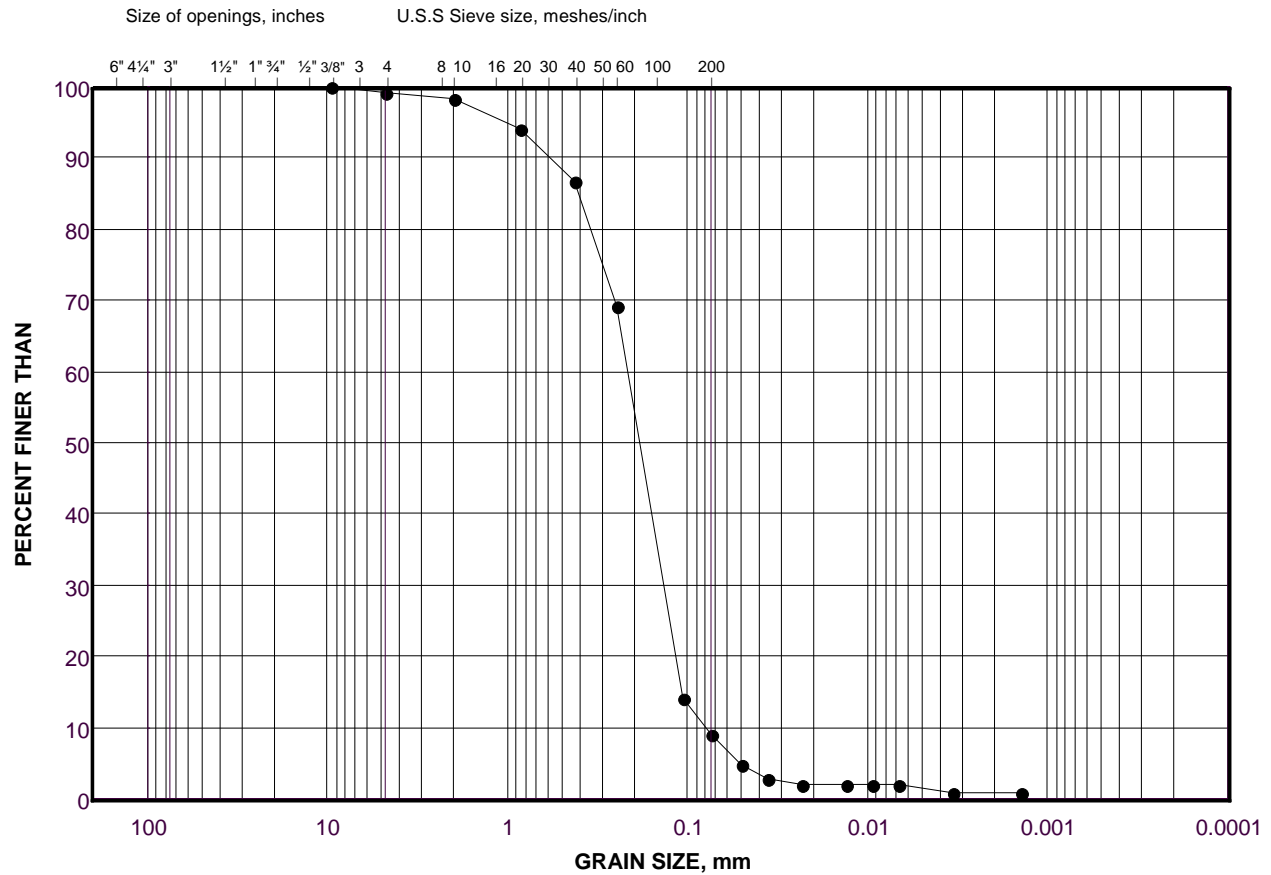
Golder Associates

Date: 01-Jun-18

GRAIN SIZE DISTRIBUTION

Sand

FIGURE A-3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	17-20	5	265.7

Project Number: 1533653

Checked By: KJB

Golder Associates

Date: 01-Jun-18






**FOUNDATION REPORT - REVISION 1
CULVERT REPLACEMENT / REHABILITATION AT SITE NOS. 22-
415/C AND 21-13/C**

APPENDIX B

Site 21-13/C

**Record of Borehole Sheets
Laboratory Test Results**

PROJECT 1533653		RECORD OF BOREHOLE No 17-18		SHEET 1 OF 1		METRIC																	
G.W.P. 2248-14-00		LOCATION N 4888201.9; E 358670.1 MTM NAD 83 ZONE 10 (LAT. 44.131838; LONG. -78.826799)		ORIGINATED BY JS																			
DIST Central HWY 7A		BOREHOLE TYPE 210 mm Diameter Hollow Stem Power Augers		COMPILED BY AMP																			
DATUM Geodetic		DATE July 5, 2017		CHECKED BY KJB																			
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		ELEVATION	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ							
263.2	GROUND SURFACE						263	20	40	60	80	100	10	20	30		GR	SA	SI	CL			
0.0	Gravelly sand, trace silt (FILL) Compact Brown Moist to wet		1	SS	12		262																
261.8	Silt and sand, trace to some clay, trace gravel (FILL) Brown to grey Loose Moist to wet - Wet at 2.3 m depth		2	SS	8		261																
1.4			3	SS	4		260																
			4	SS	5		259																
			5	SS	7		258																
257.6	- Auger grinding at 5.2 m depth						257																
5.6	Gravel, trace to some sand, trace to some silt Compact Brown Wet		6	SS	12		256																
256.1	Sand, trace to some silt, trace gravel Compact to dense Brown Wet		7	SS	23	255																	
			8	SS	36	254																	
253.6	END OF BOREHOLE																						
9.6	Notes: 1. Borehole caved to a depth of about 0.61 m below ground surface upon completion of drilling. 2. Water level measured at a depth of about 1.22 m below ground surface upon completion of drilling.																						

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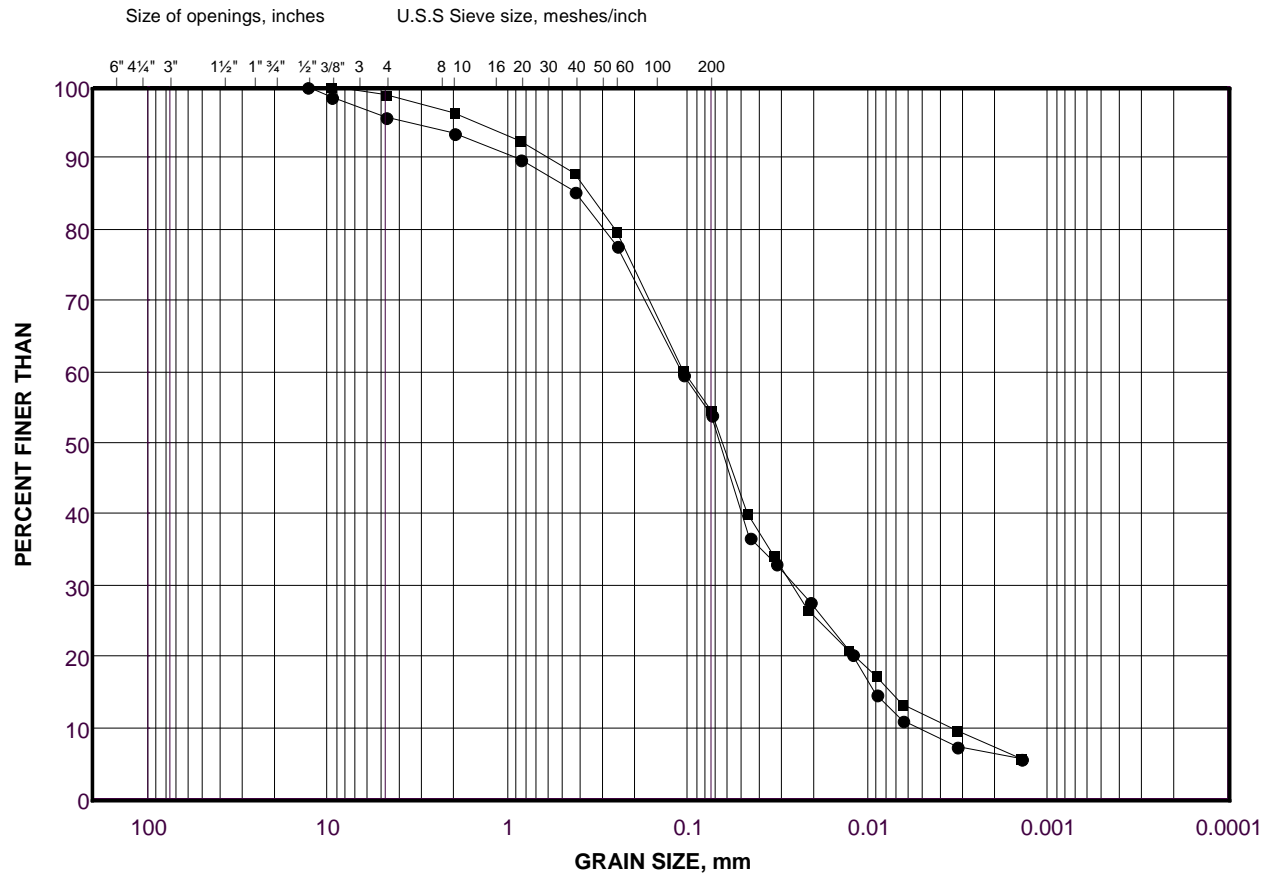
PROJECT 1533653		RECORD OF BOREHOLE No 17-20		SHEET 1 OF 1		METRIC											
G.W.P. 2248-14-00		LOCATION N 4888211.3; E 358681.6 MTM NAD 83 ZONE 10 (LAT. 44.131921; LONG. -78.826654)		ORIGINATED BY JS													
DIST Central HWY 7A		BOREHOLE TYPE 210 mm Diameter Hollow Stem Power Augers		COMPILED BY AMP													
DATUM Geodetic		DATE July 5, 2017		CHECKED BY KJB													
SOIL PROFILE			SAMPLES			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	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	20 40 60 80 100	10 20 30	OC=6.1%		
263.1	GROUND SURFACE						263										
0.0	Gravelly sand, trace to some silt (FILL) Compact Brown Moist		1	SS	14		262										
261.7	Silt and sand, trace to some clay, trace gravel (FILL) Loose to compact Brown Moist to wet		2	SS	12		261										
1.4			3	SS	5		260										
			4	SS	9		259										
	- Auger grinding at 3.7 m depth						258										
	- Trace brick fragments, organic inclusions		5	SS	5		257										
257.5	SAND and GRAVEL, trace to some silt, trace clay Compact to dense Grey Wet		6	SS	26		256										
5.6			7	SS	10		255										
			8	SS	35		254										
253.5	END OF BOREHOLE																
9.6	Notes: 1. Borehole caved to a depth of about 4.27 m below ground surface upon completion of drilling. 2. Water level measured at a depth of about 1.22 m below ground surface upon completion of drilling.																

PROJECT 1533653		RECORD OF BOREHOLE No 17-36				SHEET 1 OF 1		METRIC									
G.W.P. 2248-14-00		LOCATION N 4888204.2; E 358686.5 MTM NAD 83 ZONE 10 (LAT. 44.131857; LONG. -78.826594)				ORIGINATED BY JS											
DIST Central HWY 7A		BOREHOLE TYPE Portable Equipment Using Continuous SPT				COMPILED BY NK											
DATUM Geodetic		DATE August 17, 2017				CHECKED BY KJB											
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									
261.0	GROUND SURFACE																
0.0	TOPSOIL		1	SS	3												
260.5	Silty SAND, trace clay, trace to some organics Loose to compact below 1.83 m Blackish brown Moist to wet below 1.83 m		2	SS	6												
0.5			3	SS	7												
			4	SS	21												
258.6																	
2.4	END OF BOREHOLE																
Notes: 1. Borehole dry upon completion of drilling. 2. SPT "N" values have been corrected to account for half-weight hammer used to drive split-spoon sampler.																	

GRAIN SIZE DISTRIBUTION

Silt and Sand Fill

FIGURE B-1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-18	2	261.7
■	17-20	3	260.8

Project Number: 1533653

Checked By: KJB

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Date: 01-Jun-18

Sand

Size of openings, inches

U.S.S Sieve size, meshes/inch

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer (%)
10	100
4.75	100
2.0	98
0.85	96
0.425	94
0.25	71
0.075	11
0.06	6
0.0475	4
0.03	2
0.025	2
0.02	2
0.015	2
0.0125	1
0.01	1
0.0075	0.5

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

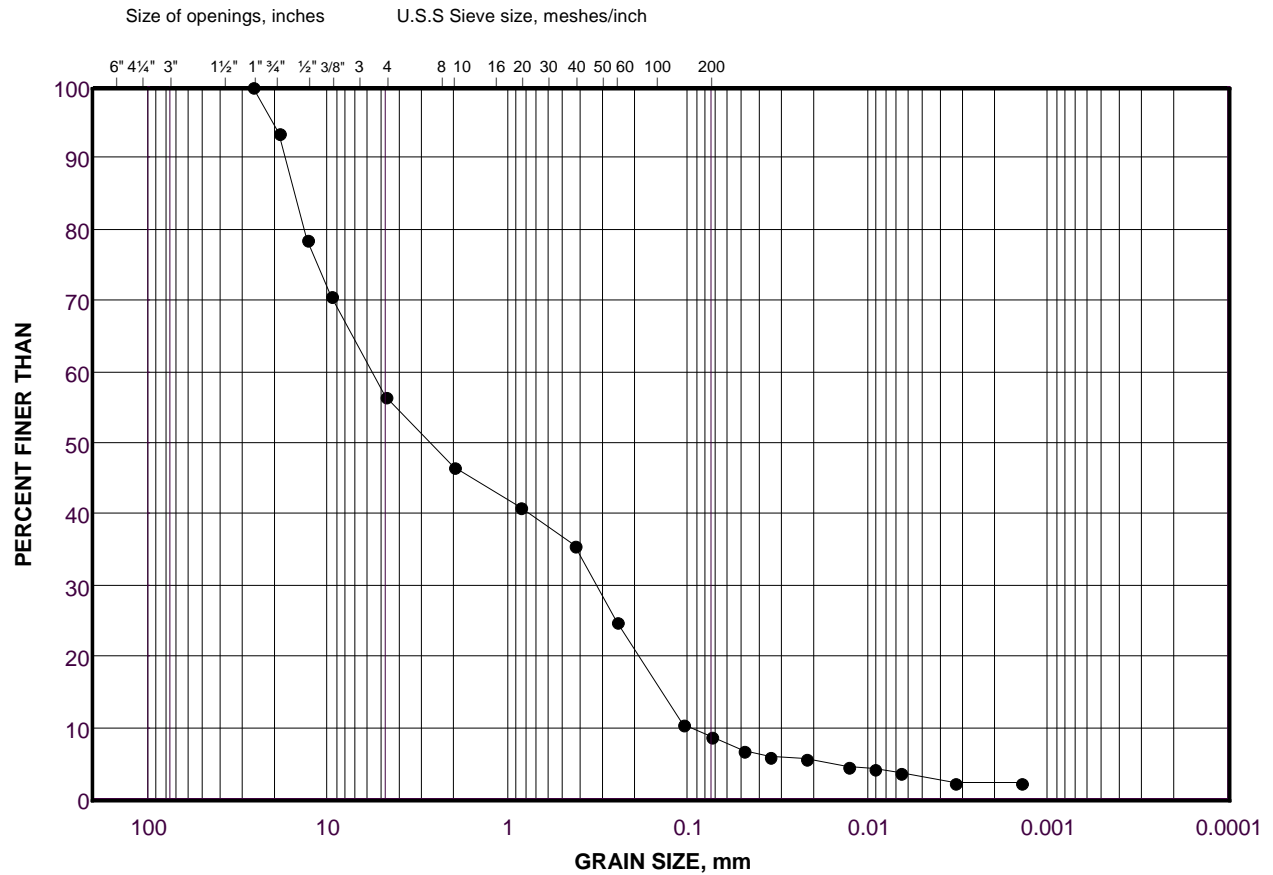
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-18	7	255.5

Date: 01-Jun-18

GRAIN SIZE DISTRIBUTION

Sand and Gravel

FIGURE B-3



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	17-20	6	257.0

Project Number: 1533653

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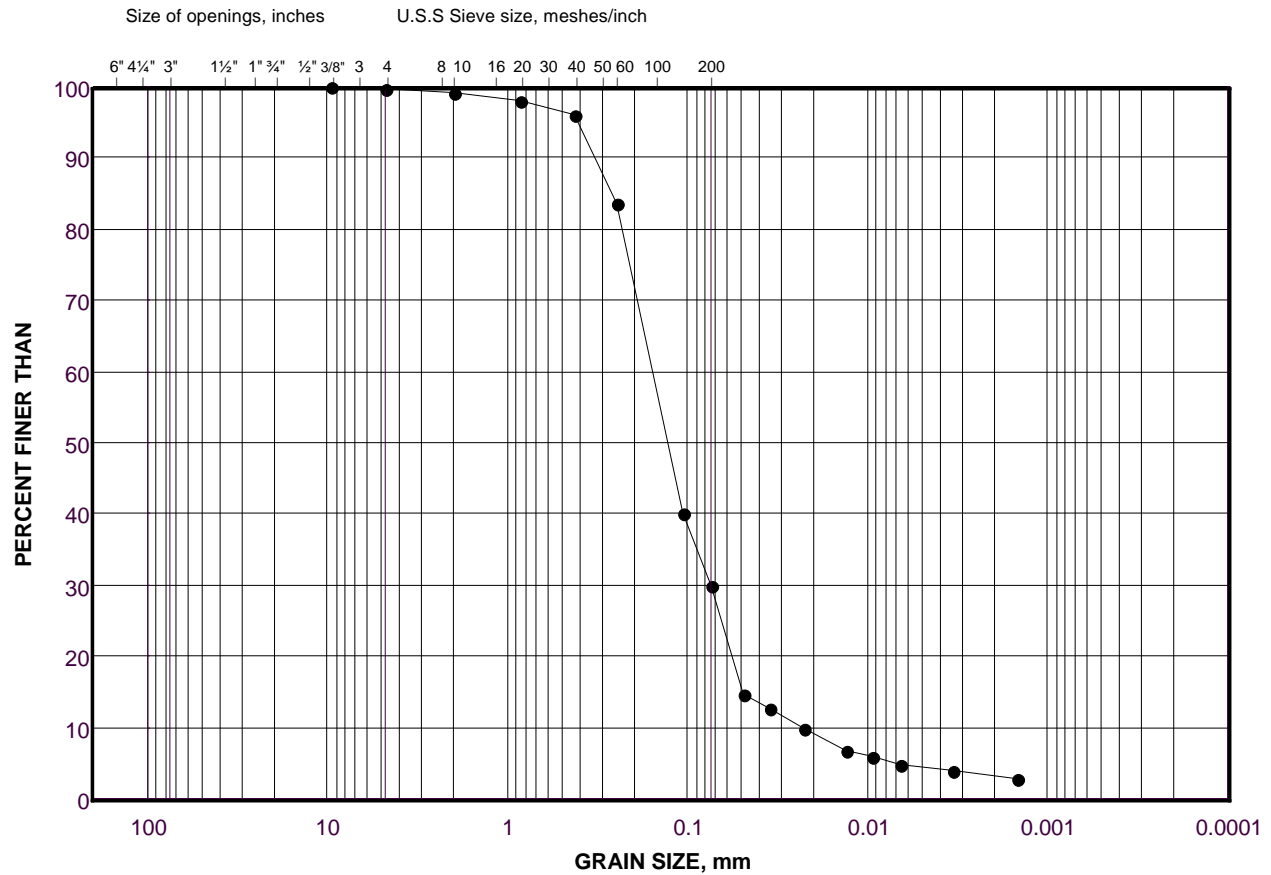
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Date: 01-Jun-18

GRAIN SIZE DISTRIBUTION

Silty Sand

FIGURE B-4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	17-36	3	257.9

Project Number: 1533653

Checked By: KJB

Golder Associates

Date: 01-Jun-18

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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