



October 2012

## REPORT ON

### Foundation Investigation and Design High Fill Section and Lily Lake Road Culvert Extension Highway 7 from Fowlers Corners Southerly to County Road 28 Peterborough, Ontario W.P. 4149-11-01

**Submitted to:**

D.M. Wills Associates Limited  
150 Jameson Drive  
Peterborough, Ontario  
K9J 0B9



REPORT



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## **FOUNDATION INVESTIGATION**

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### **PART A**

**FOUNDATION INVESTIGATION REPORT  
HIGH FILL SECTION  
HIGHWAY 7 FROM FOWLERS CORNERS  
SOUTHERLY TO COUNTY ROAD 15  
PETERBOROUGH, ONTARIO  
W.P. 4149-11-01**



### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Limited on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with proposed highway operational improvements and future four laning of Highway 7 from Fowlers Corners Southerly to County Road 28 in Peterborough, Ontario.

The terms of reference for the scope of work are outlined in Golder's proposal P0-1121-0007, dated February 2010, that forms part of the consultant's agreement (GWP 4053-06-00/245-00-01/345-01-01/4149-11-01/4148-11-01). Detailed foundation investigation and design services are required for a total of four structures (i.e., Jackson Creek Bridge, CNR overhead site, and two structural culvert sites) and one high fill section in five separate reports for this project. This report addresses the detailed foundation investigation carried out for the proposed roadway high fill embankment construction between Stations 26+100 to about 27+370 along the proposed realignment of Highway 7 and between Station 9+750 to about 10+020 along Lily Lake Road as part of the Highway 7 improvement project.

The purpose of this investigation is to establish the subsurface conditions at the high fill section by borehole drilling, in situ testing and laboratory testing on selected samples. A plan drawing of the proposed embankment location was provided to Golder by D.M. Wills in July 2010.

The current investigation was supplemented with information from two previous investigations at or nearby this site, as follows:

- Golder's report titled "Foundation Investigation and Design, Preliminary Design, High Fill and Swamp Areas, Highway 7 from Fowlers Corners, Southerly to County Road 15, Peterborough, Ontario, G.W.P. 73-99-00, dated March 2008.
- Golder's report titled "Foundation Investigation and Design, Preliminary Design, Recreational Trail Culvert, Highway 7 from Fowlers Corners, Southerly to County Road 28, Peterborough, Ontario, G.W.P. 73-99-00, Site No. 26-35", dated June 2007.



### 2.0 SITE DESCRIPTION

The proposed high fill section is located generally east of the existing Highway 7, between Station 26+100 to about 27+370 and along existing Lily Lake Road from about Station 9+750 to about 10+020 in Peterborough, Ontario (see key plan on Drawings 1 through 5). The existing highway runs north-south in this area and consists of two lanes, one lane in each direction.

Within the existing MTO right-of-way, the site generally consists of the raised highway with grass covered embankment side-slopes (sloped at about 2H:1V to 3H:1V). The existing embankments showed no visible signs of significant global instabilities at the time of our investigation, however localized areas of erosion or distress could be present. Open grassy fields and low-lying areas generally consisting of various vegetation are present on the east side of the existing highway, where the proposed new alignment of Highway 7 will be located.

Based on the drawings provided by D.M. Wills November 2011, the proposed roadway surface elevations along the proposed Highway 7 realignment at the high fill section varies from about Elevation 270 m in the north, climbing to about Elevation 277.2 m at about 150 m north of Lily Lake Road and then descending to about Elevation 256 m in the low lying area east of Emily Manor Drive. Within the High Fill Embankment Section, the existing Lily Lake Road is valley-shaped with a high point at about Elevation 275.5 m at the intersection with the existing Highway 7 and a low point at about Elevation 270 m near the middle of the proposed high fill embankment at about Station 9+860 m. Based on these preliminary drawings, the embankment section of the realigned section of Highway 7 will require the grade to be raised by up to 8.5 m above the existing ground surface, but typically the fill height is about 5 to 7 m. Along Lily Lake Road the grade is to be raised by up to 4.5 m above the existing road surface.



### 3.0 INVESTIGATION PROCEDURES

#### 3.1 Previous Foundation Investigation

The field work for the previous investigations were carried out between July 10 and 31, 2006 during which time a total of four (4) boreholes were advanced; two boreholes along Lily Lake Road at the high fill embankment and two boreholes at the proposed Trans-Canada recreational trail structure. The boreholes, numbered 06-11 to 06-14 (inclusive), were advanced at the approximate locations shown in plan on Drawings 1 to 3.

The field investigation was carried out using a track-mounted CME-55 drill rig supplied and operated by Eastern Soil Investigation Limited of Courtice, Ontario. The boreholes were advanced using 101 mm outside diameter (O.D.) solid stem augers. Soil samples were obtained at intervals ranging from 0.75 m to 1.5 m in depth, using a 50 mm outer diameter (O.D.) split spoon sampler in accordance with Standard Penetration Test (SPT) procedures. The boreholes were advanced and sampled to depths of about 9.3 m to 12.3 m below ground surface.

The groundwater conditions in the open boreholes were observed during the drilling operations and piezometers were installed in boreholes 06-13 and 06-14 to permit monitoring of the groundwater level. The piezometers consisted of 50 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The boreholes and annulus surrounding the piezometer pipe were backfilled to the surface with bentonite pellets in accordance with Ontario Regulation (O.Reg.) 903 amended to O.Reg. 128/03 of the Ontario Water Resources Act. The piezometer installation details and water level readings are described on the Record of Borehole sheets that follow the text of this report.

The field work was supervised by a member of our engineering staff, who located the boreholes, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on select samples.

The borehole locations were staked in the field by Golder relative to on-site features. Upon completion of drilling operations, the borehole locations (i.e., MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) were surveyed by a licensed surveyor (i.e., Transenco Limited) and are summarized below and on Drawings 1 to 3.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
06-11	4907547.0	390222.4	265.7
06-12	4907501.9	390114.3	275.1
06-13	4907829.8	390031.5	268.4
06-14	4907829.5	389997.4	268.3



### 3.2 Current Foundation Investigation

The field work for the current investigation was carried out between September 8 and September 24, 2010 during which time a total of twenty three (23) boreholes were advanced along Highway 7 from Station 26+200 to Station 27+300, numbered 10-1 to 10-24 (excluding 10-20), at the approximate locations shown in plan on Drawings 1 and 2. Between September 20 and October 5, 2010 during which time a total of four (4) boreholes were advanced along Lily Lake Road from Station 9+800 to Station 10+000, numbered 10-26 to 10-29, at the approximate locations shown in plan on Drawing 4. Boreholes 10-20 and 10-25 were not drilled due to site access constraints and permission to entry.

The field investigation was carried out using a Diedrich D-50 track mounted drill rig supplied and operated by Walker Drilling Limited of Utopia, Ontario. The boreholes were advanced using 101 mm outside diameter (O.D.) hollow stem augers. Soil samples were obtained at intervals ranging from 0.75 m to 1.5 m in depth, using a 50 mm outer diameter (O.D.) split spoon sampler in accordance with Standard Penetration Test (SPT) procedures. The boreholes were advanced and sampled to depths of about 1.9 m to 10.4 m below ground surface.

The groundwater conditions in select open boreholes were observed during the drilling operations and piezometers were installed in boreholes 10-2, 10-16, 10-22, and 10-26 to permit monitoring of the groundwater level at the site. The piezometers consisted of 50 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. The boreholes and annulus surrounding the piezometer pipe were backfilled to the surface with bentonite pellets in accordance with Ontario Regulation (O.Reg.) 903 amended to O.Reg. 128/03 of the Ontario Water Resources Act. The piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A.

The field work was supervised by a member of our engineering staff, who located the boreholes, arranged for the clearance of underground services, supervised the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our geotechnical laboratories where the samples underwent further detailed visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on select samples.

The borehole locations were staked in the field by Golder using a Trimble R8 GPS survey unit. Upon completion of drilling operations, the borehole locations (i.e., MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) were surveyed by Golder using a Trimble R8 GPS survey unit and are summarized below and on Drawings 1 to 5.



## FOUNDATION INVESTIGATION

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
10-1	4907839.4	390028.7	268.0
10-2	4907824.3	390022.5	268.5
10-3	4907832.2	390016.0	267.9
10-4	4908039.5	389975.7	265.8
10-5	4907982.7	389972.2	265.7
10-6	4907948.4	390014.6	265.6
10-7	4907885.7	390004.2	266.7
10-8	4907832.7	390053.2	268.1
10-9	4907789.9	390035.6	269.4
10-10	4907752.6	390078.8	267.8
10-11	4907693.4	390071.0	271.5
10-12	4907657.0	390118.3	271.0
10-13	4907591.4	390107.0	272.9
10-14	4907457.0	390167.8	265.8
10-15	4907405.9	390166.9	266.5
10-16	4907368.7	390196.3	261.9
10-17	4907318.1	390194.1	262.8
10-18	4907275.1	390226.4	259.2
10-19	4907212.9	390218.3	262.7
10-21	4907122.9	390247.3	256.6
10-22	4907082.4	390288.5	250.1
10-23	4907026.9	390287.5	250.2
10-24	4906982.8	390329.2	253.8
10-26	4907572.6	390217.2	259.9
10-27	4907506.3	390202.6	261.2
10-28	4907530.4	390123.7	269.3
10-29	4907479.1	390107.4	274.6



## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

As delineated in The Physiography of Southern Ontario, the study area for this assignment lies within the physiographic region known as the Peterborough Drumlin Field.

The surficial soils in the Peterborough Drumlin Field consist of drumlinized till. Toward the southwestern portion of this physiographic region, near the Oak Ridges Moraine, the till is typically sandy. Some of the drumlins in this area have shallow coverings of silt and fine sand, between about 0.5 m and 2.5 m in thickness. "Wave-washed" drumlins, with exposed bouldery surfaces, are also present near the Simcoe Lowlands immediately south and east of Lake Simcoe.

### 4.2 Subsoil Conditions

The following sections discuss the findings of the borehole investigation carried out at the high fill embankment section along Highway 7 from approximately Station 26+200 to Station 27+400 as shown on Drawings 1 and 3. The high fill embankment section along Lily Lake Road from approximately station 9+800 to station 10+000 is shown on Drawings 4 and 5. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of the in situ and laboratory testing are given on the Record of Borehole Sheets and Figures in Appendices A and B following the text of this report. The stratigraphic boundaries shown on the borehole records are inferred from non continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the predominant subsoils at the high fill embankment areas consist of silty sand and sands and gravels overlying a deposit of silty sand till with varying amounts of gravel, cobbles and boulders. In low lying areas fine grained soil and organics were encountered along with fill materials. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### 4.2.1 Topsoil, Peat and Organic soils

Topsoil and silty sand with organics were encountered at the ground surface for most of the new alignment, excluding areas which fill had been placed or in low lying areas where peat and other soils containing organics were encountered. The topsoil varied in thickness from 100 to 600 mm, averaging 260 mm. In localized low lying areas, near boreholes 10-5, 10-10, and 10-23, peat was encountered at the surface or beneath fill. The thickness of the peat encountered varied from 300 to 700 mm.

#### 4.2.2 Fill

Fill was encountered along the new alignment section in previously low lying areas and as well as along existing Highway 7 and Lily Lake Road. The fill generally consists of sand and silty sand with varying amounts of gravel and trace amounts of clay and organics. Fill was encountered in boreholes 10-1, 10-2, 10-3, 10-8, 10-9, 10-12, 10-19, 10-21, and 10-29. The fill material extended to a depth ranging from 0.7 to 3.4 m depth. The thickness of the fill ranged from 0.5 to 2.3 m, averaging 1.2 m. A layer of topsoil generally underlies the fill material in the boreholes along the realignment section.



Standard Penetration Test (SPT) 'N' values recorded within the fill materials ranged between 2 blows to over 100 blows per 0.3 m of penetration, but typically below 25 blows per 0.3 m of penetration, which indicates a very loose to very dense relative density but generally was loose to compact.

The laboratory natural water content measured on select samples ranged from 10 to 15 percent. Grain size distributions were performed on select samples of the fill and are shown on Figure A1 in Appendix A and on Figure B1 in Appendix B.

### 4.2.3 Silty Clay to Clayey Silt

Limited extent of silty clay and clayey silt were encountered along the realignment section, north of Lily Lake Road primarily in low lying near the Trans-Canada recreational trail or previous low lying areas that have been filled. The silty clay and clayey silt were encountered below the fill, topsoil, peat, silty sand with organics in boreholes 06-13, 06-14, 10-1, 10-3, 10-5 and 10-8. The cohesive layer contained isolated sand and gravel seams. The top of the clayey silt to silty clay deposit was encountered at a depth of about 0.5 m and 2.3 m (Elevation 266.1 to 265.2 m) and the deposit ranged from about 0.2 to 2.0 m in thickness.

Standard Penetration Testing (SPT) 'N' values recorded within the silty clay deposit ranged between 10 blows and 27 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency.

The natural water content measured on select samples of the silty clay layer ranged from 10 to 31 percent. The results of Atterberg Limits testing carried out on these samples of silty clay deposit are illustrated on the plasticity chart on Figure A7 in Appendix A and clayey silt on Figure A1 in Appendix B. The test results are summarized below and indicate the silty clay is of low to medium plasticity.

Borehole	Sample	Elevation (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
06-13	4	264.8 – 265.4	15	9	6
06-14	2	266.2 – 266.8	25	17	8
10-1	2	266.5 – 265.9	40	21	19
10-5	1	264.9 – 264.3	46	24	22

### 4.2.4 Silty Sand and Sand and Gravel

Underlying the surficial materials (fill, topsoil, peat, silty clay, clayey silt), a layer of native silty sand and sand and gravel was encountered in all the boreholes, except boreholes 10-19 and 10-24. This stratum primarily consists of silty sand with varying amounts of gravel and clay. In the areas between the Trans-Canada recreational trail and Lily Lake Road a lense of sand and gravel was encountered in boreholes 10-9 through 10-13, inclusively. The top of this native granular layer was encountered at surface to a depth of 7.6 m below the existing ground surface. The thickness of this granular deposit ranges from 0.4 m to 7.7 m.

SPT 'N' values measured within the silty sand to silty sand and gravel layer range from 3 blows per 0.3 m of penetration to over 100 blows per 0.1 m of penetration, indicating a very loose to very dense relative density with an average SPT 'N' value of 32 blows per 0.3 m of penetration indicating generally a dense relative density. In



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the area along the realignment near Emily Manor Drive (boreholes 10-21, 10-22 and 10-23), the density within this deposit appears to be consistently lower than this deposit at higher elevations near Lily Lake Road and the Tran-Canada recreational trail.

The natural water content measured on samples of this deposit range from 6 percent and 22 percent. In Appendix A, Figures A2 to A4 and in Appendix B, Figure B2 shows the results of a grain size distributions performed on select samples of this deposit.

### 4.2.5 Glacial Till

Underlying the surficial soils and the silty sand, sand and gravel granular deposits, a silty sand till deposit was encountered in the boreholes. Borehole 10-24 encountered this till deposit at the existing ground surface. The glacial till deposit as recovered in the sampler was principally silty sand and contained trace to some gravel and trace to some clay. The drilling encountered some cobbles and boulders. The top of this layer was encountered at depths from 0.0 m to 8.0 m in all the boreholes. The till deposit was penetrated about 1.2 m to 10.4 m in depth and drilling was terminated at these depths within this deposit except for boreholes 10-5, 10-13, 10-18, 10-22, 10-24 and 10-28 which encountered refusal to augering at depths of ranging from 1.9 to 7.9 m.

SPT 'N' values measured within the silty sand till deposit ranged from 11 blows per 0.3 m of penetration to over 100 blows per 0.1 m of penetration at depth. The 'N' values indicate that the glacial till has a loose to very dense relative density. But, in general, this till deposit generally has a dense to very dense relative density.

The natural water content measured on samples of the till typically ranged between about 5 percent and 10 percent. Grain size distribution curves for selected samples of the till deposit are shown on in Appendix A, Figures A5 and A6 and various figures within Appendix B.

### 4.2.6 Groundwater Conditions

The water levels were noted within the open boreholes at the time of the drilling operations. Piezometers were installed in boreholes 06-13, 06-14, 10-2, 10-16, 10-22, and 10-26. The piezometers were sealed into the silty sand glacial till deposits below the silty sand to sand and gravel. Details of the piezometer installations are shown on the Record of Borehole Sheets following the text of this report. The water levels measured in the piezometers and open boreholes upon completion of drilling are summarized below.

Borehole	Installation	Ground Surface Elevation (m)	Depth to Water Level (m)	Water Level Elevation (m)	Date
06-11	Open Borehole	265.7	6.0	259.7	July 10, 2006
06-12	Open Borehole	275.1	7.9	267.2	July 31, 2006
06-13	Piezometer	268.4	8.7	259.7	July 10, 2006
			7.2	261.2	July 11, 2006
			1.7	266.7	July 31, 2006
			2.1	266.3	August 18, 2006



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Borehole	Installation	Ground Surface Elevation (m)	Depth to Water Level (m)	Water Level Elevation (m)	Date
06-14	Piezometer	268.3	7.3 1.6 1.8	261.0 266.7 266.5	July 11, 2006 July 31, 2006 August 18, 2006
10-2	Piezometer	268.5	2.1 2.1 2.0 2.0 1.6	266.4 266.4 266.5 266.5 266.9	September 24, 2010 October 6, 2010 October 16, 2010 December 13, 2010 April 26, 2011
10-4	Open Borehole	265.8	2.3	263.5	September 15, 2010
10-10	Open Borehole	267.8	1.2	266.6	September 15, 2010
10-16	Piezometer	261.9	3.3 4.0 3.0 1.5 1.1	258.6 257.9 258.9 260.4 260.8	September 24, 2010 October 6, 2010 October 16, 2010 December 13, 2010 April 26, 2011
10-22	Piezometer	250.1	0.3 0.3 Note 1 0.0	249.8 249.9 250.1 250.1	October 6, 2010 October 16, 2010 December 13, 2010 April 26, 2011
10-26	Piezometer	259.9	Dry 5.7 4.8 2.1 0.1	- 254.2 255.1 257.8 259.8	September 24, 2010 October 6, 2010 October 16, 2010 December 13, 2010 April 26, 2011

Note 1: Frozen at ground surface

The measured groundwater level typically ranged from elevation 263.5 m (2.3 m depth) at Station 26+200 to elevation 266.9 m (1.6 m depth) north of Lily Lake Road. South of Lily Lake Road, the groundwater levels typically ranged from 260.8 m (1.1 m depth) at Station 26+900 to elevation 250.1 (0.0 m depth) in the low lying area at Station 27+200.



### 5.0 CLOSURE

The field technician supervising the drilling program was Mr. Harold Cameron. This report was prepared by Mr. Bruce D. Goddard, P.Eng., a senior geotechnical engineer. Mr. Fintan J. Heffernan, Golder's Designated MTO Contact for this project, conducted a technical and independent quality control review of the report.

#### GOLDER ASSOCIATES LTD.

Bruce D. Goddard, P.Eng.  
Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.  
Designated MTO Contact



BDG/FJH/bg

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## FOUNDATION INVESTIGATION

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### PART B

FOUNDATION DESIGN REPORT  
HIGH FILL SECTION  
HIGHWAY 7 FROM FOWLERS CORNERS  
SOUTHERLY TO COUNTY ROAD 15  
PETERBOROUGH, ONTARIO  
W.P. 4149-11-01



### 6.0 ENGINEERING RECOMMENDATIONS

This section of the report provides engineering recommendations for the design of the proposed high fill embankments as part of the proposed highway operational improvements of Highway 7. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigations at this site. The interpretation and recommendations provided are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out design of the project. Where comments are made on construction they are provided in order to highlight those aspects which could affect the design of the project.

#### 6.1 General

Based on the plans, profiles and cross sections provide by D.M. Will in November 2011, the proposed Highway 7 realignment will be constructed east of the existing highway and fill height will reach up to 8.5 m. The following table summarizes the approximate existing ground surface and proposed roadway elevations and anticipated embankment heights for embankment fill areas.

26+100 to about 27+370 and along existing Lily Lake Road from about Station 9+750 to about 10+020 in.

Site	Approximate Station	Existing Road Grade or Ground Surface (m)	Proposed Road Grade (m)	Proposed Embankment Height (m)
New Highway 7 Alignment	26+100 to 26+300	266.0 to 265.7	270.2 to 274.4	0.5 to 6.5 m
	26+300 to 26+680	265.7 to 273.9	274.4 to 277.2	3.2 to 6.5 m
	26+680 to 37+370	272.9 to 250.0	276.7 to 256.0	0.5 to 8.5 m
Lily Lake Road	9+750 to 10+020	259.0 to 275.6	270.0 to 274.7	*4 m to 10 m

\* Existing high fill embankment is about 4 m to 7 m high.

At the Lily Lake Road high fill embankment location, it is understood that the new Highway 7 realignment will be lower than the existing Highway 7. However, the existing embankment along Lily Lake Road directly east of the proposed Highway 7 realignment is proposed to be nearing the intersection with Highway 7 as part of the construction. Associated with the grade raise along Lily Lake Road, the existing culvert near Station 9+865 will need to be extended on both sides of the existing embankment to accommodate the new width of the embankment. The length of the existing culvert is 40.8 m and it will be extended to a length of about 65.0 m. This extension will consist of 2400 mm diameter sections of corrugated steel pipe (CSP). The upstream invert elevation will be 259.53 m and the downstream invert elevation will be 258.77 m.

The borehole locations and interpreted soil strata at the three sites are shown on Drawings 1 through 5. The following sections discuss the preliminary design recommendations for each site in further detail and are summarized on Table 1.

#### 6.2 High Fill Embankment

The existing Highway 7 approach embankments on either side of the Former CNR overpass structure at the Trans Canada Recreational Trail measures up to about 9.5 m high and Lily Lake Road embankment (from about Station 9+750 to 10+000) presently measures up to about 7 m high. Both embankments have grass covered



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side slopes with profiles of approximately 2 horizontal to 1 vertical (2H:1V). The existing embankments showed no visible signs of significant global instability at the time of our investigation; however localized areas of erosion and distress may be present. Currently, these embankments do not have a mid-height bench.

Based on the borehole results, the existing embankment consists of up to about 7 m of sand and gravel fill containing trace organics. The fills were generally dense to very dense, however, loose to compact zones were generally encountered near the bottom third of the fill deposit. Below the fill, a compact silty sand and gravel layer was present that contained trace organics, underlain by compact to very dense silty sand till.

The existing embankment supporting Lily Lake road will require placement of up to about 6.1 m of new embankment fill above the existing road grade as shown on the section on Drawing 4. The existing ground surface at the toe of the existing embankment is at about Elevation 259 m (based on base of fill in borehole 06-11) and the proposed road grade in this area is about Elevation 272 m, the proposed embankment will be up to 13 m in height as shown on Drawing 5. At the east and west limits of the grade raise, the proposed road grade will tie into the existing Lily Lake Road and proposed Highway 7 grade, respectively. The extent of the "high fill" area extends from about Station 9+750 to 10+000 assuming a minimum 4.5 m high embankment in accordance with MTO typical terms of reference.

It is important to note that an existing corrugated steel pipe (CSP) runs beneath Lily Lake Road at about Station 9+865; which will need to be either replaced or extended as part of the construction. It is estimated that the existing culvert is currently located below about 7 m of existing embankment fill and after the proposed grade raise, will be located below about 14 m of embankment fill.

### 6.2.1 Fill Embankment Construction

Prior to the placement of any engineered fill for the new embankment construction and grade raise, all vegetation, topsoil or soils containing significant organics and/or deleterious material should be stripped from below the proposed embankment and grade raise footprint areas and wasted/reused for landscaping. The foundation footprint not only includes the area outside the toe of the existing embankment but also includes the areas where fill is to be placed on top of the existing embankment. In areas where fill is to be placed on top of the existing road surface, it is recommended that the existing asphalt pavement structure be pulverized (and recycled if possible) prior to any fill placement. All subgrade soils should be proof-rolled prior to fill placement and embankment fill should be placed in accordance with SP206S03. The following approximate areas are where the native subgrade should be subexcavated:

Stationing	Limits	Subexcavation Depth (m)
26+200 to 26+300	10 m Right to 20m Left	0.5
26+400 to 26+550	5 m Right to 20m Left	1.2 to 2.1
27+100 to 27+300	5 m Right to 20m Left	0.8

Benching into the existing embankment side slopes should be carried out as per OPSD 208.010 for construction of the embankment widening and grade raise to ensure adequate keying of the new fill into the existing fill.



## FOUNDATION INVESTIGATION

Based on the existing subsoil conditions, either earth fill or rock fill embankment options may be considered. The different fill alternatives (i.e., earth fill and rock fill) provide relative advantages and disadvantages in terms of weight (i.e., driving force and applied load to founding subsoils / bedrock), construction cost and time, and ease of construction / availability. Earth fill has typically been used in this area in the past; however, if rock fill is being considered, more details are provided below.

Construction of an earth fill embankment above the prepared subgrade may be carried out using Select Subgrade Material (SSM) meeting OPSS 1010. All embankment fill should be placed in regular loose lifts not exceeding 300 mm, and compacted to at least 95 percent of the material Standard Proctor maximum dry density. The final lift prior to placement of the granular subbase or base course should be compacted to 100 percent of the SPMDD. Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

Construction of a rock fill embankment above the prepared subgrade shall be construction in accordance with OPSS 206. It is understood that rock borrow is not readily available near the project location, therefore this type of embankment material is most likely not cost efficient.

To reduce surface water erosion on the embankment side slopes, topsoil and seeding should be placed as soon as possible in accordance with OPSS 572.

### 6.2.2 Embankment Stability

Limit equilibrium slope stability analyses were performed using the commercially available program SLOPE/W (produced by Geo-Slope International Ltd.), employing the Morgenstern-Price method of analyses, to check that a minimum factor of safety of 1.3 is achieved against deep-seated, global type failures that would impact the operation of the roadway.

Static slope stability analyses that examine the global stability for the high fill embankment was carried out using the following parameters based on field and laboratory test data and accepted correlations:

Soil Layer / Deposit	Bulk Unit Weight (kN/m <sup>3</sup> )	Effective Friction Angle, $\phi'$ (degrees)
New Highway 7 Embankment		
New Embankment Fill	22	32
Compact to very dense silty Sand to Sand and Gravel	21	32
Compact to very dense, gravelly silty Sand Till	22	36
Lily Lake Road Embankment		
New Embankment Fill	22	32
Existing Embankment Fill	21	32
Loose to dense silty Sand to Sand and Gravel	20	30
Compact to very dense silty Sand Till	22	36



## FOUNDATION INVESTIGATION

For the purpose of the analyses, it was assumed that the subgrade was properly prepared and proper placement and compaction of the engineered fill embankment was performed. Select Subgrade Material (i.e., granular earth fill) was assumed to be used for the engineered fill for the construction of the proposed high fill embankment. The piezometric conditions used in the analyses were based on the groundwater levels noted during drilling in the boreholes in this area which resulted in a water level located at the base of the fill.

A maximum embankment height of 10 m for Highway 7 realignment and 13 m (i.e., up to 7 m grade raise) for Lily Lake Road were analyzed for slope global stability. Both embankments were analyzed with side slopes at 2H:1V with no benching. For both embankments, a Factor of Safety of 1.3 or greater was calculated against static deep-seated slope instability.

Pseudo-static seismic slope stability analysis for the above configurations also indicates that the roadway embankment side slopes will have a factor of safety greater than 1.1 against deep-seated slope instability based on an acceleration of 0.1g.

For granular earth fill, the incorporation of a 2 m wide mid-height bench (berm) into the uniform side slope profile is required wherever the embankment will exceed a height of 8 m (as per OPSD 202.010). The incorporation of a bench will further increase the Factor of Safety against instability.

Granular fills are susceptible to erosion and surficial slides due to the nature of the loose and unravelling surface of the granular soils. To reduce this risk, the side slopes should be top dressed and hydro seeded soon after construction. The side slopes should be tracked with the cleats of a dozer creating parallel furrows along the granular side slopes allowing the surficial topsoil to have a good rough interface with the granular embankment to reduce the surficial slides along the upper soils. The application of liquid asphalt or emulsified asphalt in accordance with OPSS 305 on the granular shoulders along the breakpoint of the embankment will reduce the potential for surface erosion and gullies along the side slopes of the embankment.

In addition to cleating the embankment surface prior to placing the topsoil, placing a turf reinforcement mats or blanket (TRM) would also increase the surficial stability of the embankment. A TRM can be temporary, which is comprised of biodegradable materials and is intended for construction use. A TRM can also be permanent, which is comprised of more durable materials and is intended for known areas of surficial instability.

During construction, if areas of shallow instability are observed a temporary TRM, such as Woven Jute or Biomac TRM's (Maccaferri products) or equivalent could be placed along these sections of the embankment after the side slope has been regraded. This will help protect the slope from erosion and shallow surficial instabilities while the vegetation is being re-established.

If after construction an area continues to show signs of erosion and shallow surficial instability, the slope can be reinforced with a MacMar-R or Armater (Maccaferri products) or equivalent TRM that can be staked or in more severe cases soil nailed to the embankment slope.

### 6.2.3 Embankment Settlement

Settlement analyses were carried out for the new high fill embankment along the realignment of Highway 7 and the grade raise along Lily Lake Road using the results from the boreholes, in situ field test data (SPT), and laboratory tests to estimate the deformation parameters of the subsoils. A settlement analysis was performed using the commercially available program SETTLE 3D (Version 2.011) produced by Rocscience Inc. For these analyses, the critical sections are assumed to correspond to the greatest new embankment height of 8.5 m



## FOUNDATION INVESTIGATION

above existing ground surface located at about Station 27+220 for the Highway 7 realignment and a grade raise of about 7 m above the existing ground surface located at about Station 9+855 for the Lily Lake Road. The subsurface profiles for the embankment fills described in the previous slope stability section were employed in the analyses. The total net loading on the foundation soils (after stripping, backfilling and embankment fill construction) was estimated to be about 190 kPa for Highway 7 and about 152 kPa for Lily Lake Road. The following is a summary of engineering properties used for this settlement analysis.

Soil Layer / Deposit	Bulk Unit Weight (kN/m <sup>3</sup> )	Poisson Ratio	Modulus of Elasticity, E <sub>s</sub> (MPa)
New Highway 7 Embankment			
New Embankment Fill	22	0.35	40
Compact to very dense silty Sand to Sand and Gravel	21	0.3	20
Compact to very dense, gravelly silty Sand Till	22	0.4	100
Lily Lake Road Embankment			
New Embankment Fill	22	0.35	40
Existing Embankment Fill	21	0.35	40
Compact to dense silty Sand to Sand and Gravel	20	0.3	35
Compact to very dense silty Sand Till	22	0.4	100

As noted previously, the subsoils encountered within the limits of the project site generally consist of silty sand and sand and gravel fill overlying a layer of silty sand and gravel, underlain by a silty sand till deposit. The sand and gravel fills and silty sand and gravel layer contained trace organics within the boreholes. Based on the results of the boreholes, settlement of the cohesionless foundation and embankment soils is expected to occur during or shortly after construction. Settlement of the new embankments will also occur due to compression of the engineered fill itself.

It is predicted that immediate settlement due to compression of the existing cohesionless embankment and foundation soil layers will be less than 55 mm for the new Highway 7 embankment and will be less than 25 mm for the grade raise along Lily Lake Road. Provided that the new embankment fill material consists of granular earth fill, the settlement of the new embankment fill itself is expected be less than 25 mm. Therefore, the total settlement of the high fill embankment for the new Highway 7 is estimated to be less than 80 mm and the total settlement along Lily Lake Road will be less than 50 mm. These settlements are expected to occur rapidly (i.e., during or shortly after construction) in response to the filling based on the granular nature of the native and fill soils.

It is noted that these settlements are conditional based on the actual composition and consistency of the proposed embankment fill materials.

Considering the embankments are underlain by a relatively thin layer of compact silty sand and gravel and compact to very dense silty sand till soils containing cobbles and boulders, liquefaction is not considered to be a significant concern.



### 6.3 Lily Lake Road Culvert – Station 9+865

The soil conditions at this existing culvert are shown on Section C-C on Drawing 5. Borehole 06-11 put down through the existing embankment encountered compact to very dense sand and gravel to elevation 259.9 (5.8 m depth). The embankment fill is underlain by compact sand and gravel (N value of 13 blows per 0.3 m) to elevation 258.4 followed by compact to very dense silty sand till. Boreholes 10-26 and 10-27 near the toe of the proposed embankment encountered compact silty sand, some gravel, with N values generally ranging from 12 to 18 blows per 0.3 m. A piezometer installed in borehole 10-26 measured water levels at about elevation 255 in the fall of 2010 and near ground surface at elevation 259.8 in April 2011.

It is understood that the existing culvert invert is at about elevation 260 and, as such, is probably founded on compact silty sand. If the CSP is left in place and lengthened, any embankment fill existing at invert level should be subexcavated to the native silty sand, some gravel and replaced with Granular A material. The Granular A bedding should be of 200 mm minimum thickness.

The factored geotechnical resistance at ULS may be taken as 450 kPa and the geotechnical resistance at SLS as 300 kPa. The settlement of the extended sections under the raised embankment loading is estimated to be 25 mm. With this minor differential settlement, the flow in the culvert should not be affected.

We understand that consideration is being given to replacing the CSP culvert with a concrete culvert, either box culvert or open footing culvert. A box culvert is the preferred culvert type from a foundation's perspective, as it would require less excavation and the spring groundwater level (in Borehole 10-26) is near the invert level. Where embankment fill exists at subgrade level, it should be subexcavated to reach the compact silty sand, placed on 200 mm of Granular A bedding, and designed for a ULS of 450 kPa and a SLS of 300 kPa. For a precast box culvert, OPSS 422 would apply and for cast-in-place box culvert, OPSS 902 would apply.

Resistance to lateral forces between the base of the concrete culvert foundation and the undisturbed native materials should be calculated in accordance with Section 6.7.5 of the CHBDC. For the concrete box option, assuming the culvert is precast concrete and is placed on compacted granular bedding, a coefficient of 0.55 can be used in design. The coefficient of friction value for this option can be increased to 0.58 if cast-in-place concrete is placed on compacted granular bedding.

The design frost protection depth in the area of the proposed culvert is 1.6 m. All shallow foundations should be provided with a minimum of 1.6 m of soil cover for frost protection.

The silty sand foundation soils are susceptible to groundwater seepage and construction traffic. Depending on the time of year that construction is carried out, dewatering of the foundation soils may be required. A Non Standard Special Provision (NSSP) for dewatering is included in Appendix C.

At the culvert inlet and outlet locations, if the anticipated water flow velocities are sufficiently high, provision should be made for scour and erosion protection. In order to prevent water from flowing either beneath the culvert (potentially causing undermining and scouring for box culverts) or around the culvert (creating seepage through the embankment fill and potentially causing erosion and loss of fine particles), a clay seal or cut-off headwall should be provided at both ends of the culvert. If cut-off headwalls are used, the backfill around these headwalls should consist of fine grained cohesive soils with low permeability, such as clay or silty clay.

Erosion protection should be provided upstream and downstream of the culvert as appropriate. Consideration could be given to the use of suitable non-woven geotextiles and rip-rap to provide erosion protection based on hydraulic requirements.



### 6.4 Other Considerations for Embankment Construction

#### 6.4.1 Backfill

As previously mentioned, subexcavation of unsuitable soils of up to about 2.1 m is anticipated in certain locations along the highway realignment. As a result, the subgrade will require placement of engineered fill (i.e., backfill) to raise grades to the existing surface elevations prior to embankment construction. This can be achieved by placing additional lifts of the properly placed and compacted embankment fill material (i.e., OPSS Select Subgrade Material or Granular 'B' Type II / rock fill in wet ground conditions). If Granular 'B' Type II or rock fill is used, the placement of a geotextile filter between the bottom of the backfill and native soils may be required depending on the actual in situ ground conditions.

Following proof-rolling and/or approval of the subgrade, the backfill should be placed in maximum 300 mm thick loose lifts and be uniformly compacted to 95 percent of the SPMDD. Placement of backfill for the new embankment should be carried out in accordance with Special Provision SP206S03 and compacted in accordance with OPSS 539.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

#### 6.4.2 Groundwater and Surface Water Control

Based on the borehole information, excessive groundwater inflow is not anticipated to be encountered during construction of the high fill embankment, except in the areas of subexcavation. Any seepage or surface water should be able to be handled by pumping from filtered sumps and/or filtered drains.

#### 6.4.3 Subexcavations

Based on the boreholes, it is anticipated that subexcavations up to about 0.5 m and 2.1 m below the existing ground surface within certain areas along Highway 7 realignment, will be required to remove the topsoil, peat, and soils containing excessive organics to expose the native clayey silt and silty sand soils.

It is noted that the soils in which the excavations will be formed are susceptible to disturbance due to the highly organic peat, groundwater seepage, upwellings from artesian water conditions, and construction traffic. Groundwater and surface water control will be required as discussed in the previous section.

Subexcavation works should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities, and follow the guidelines outlined in OPSP 203.010.

For typical subexcavations through dewatered topsoil and peat soils, these organic soils may be classified as Type 3 and 4 soils under the OHSA, as such, it is recommended that temporary open-cut slopes be maintained no steeper than 2H:1V. At the high fill embankment area, the existing compact to dense sand and gravel embankment soils and underlying native silty sand and gravel containing trace organics would be classified as Type 2 soil under the guidelines, as such, it is recommended that temporary open-cut slopes be maintained no steeper than 1H:1V.



## FOUNDATION INVESTIGATION

For typical subaqueous subexcavations, and in accordance with OPSD 203.010, the side-slopes of the excavated material (i.e., peat) should be equal to the angle of repose of the excavated material. It is anticipated that submerged side-slopes of about 2H:1V will be required to maintain stability and prevent sloughing of the unsuitable soils onto the embankment foundation footprint.

Depending on construction staging, the final sub-excavation depths and embankment footprint (after detailed design), and property constraints, some areas may require temporary support. In general, temporary support systems, if being considered, should be designed to Performance Level 3 as defined SP 105S19. If the temporary excavation support system is required for existing roadway or utility protection, then the temporary shoring system should meet Performance Level 2 as specified in OPSS 539.

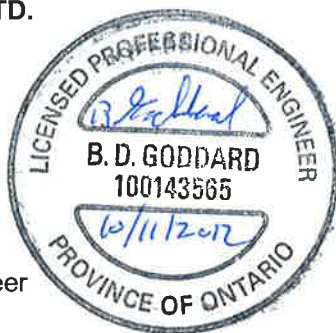


### 7.0 CLOSURE

This report was prepared by Mr. Bruce Goddard, P.Eng., a senior geotechnical engineer. Mr. Fintan J. Heffernan, P.Eng., a Designated MTO Contact with Golder, reviewed the technical aspects and conducted a quality control review of the report.

#### GOLDER ASSOCIATES LTD.

Bruce D. Goddard, P.Eng.  
Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.  
Designated MTO Contact



BDG/FJH/bg

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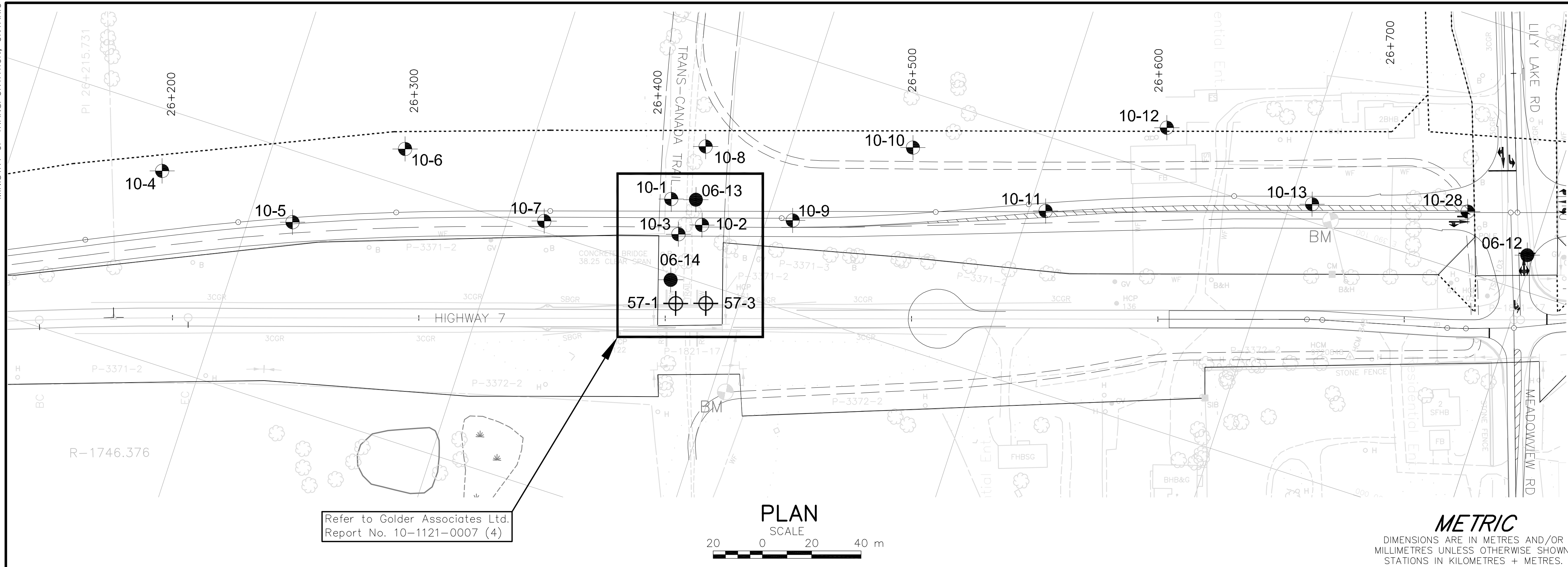


## FOUNDATION INVESTIGATION

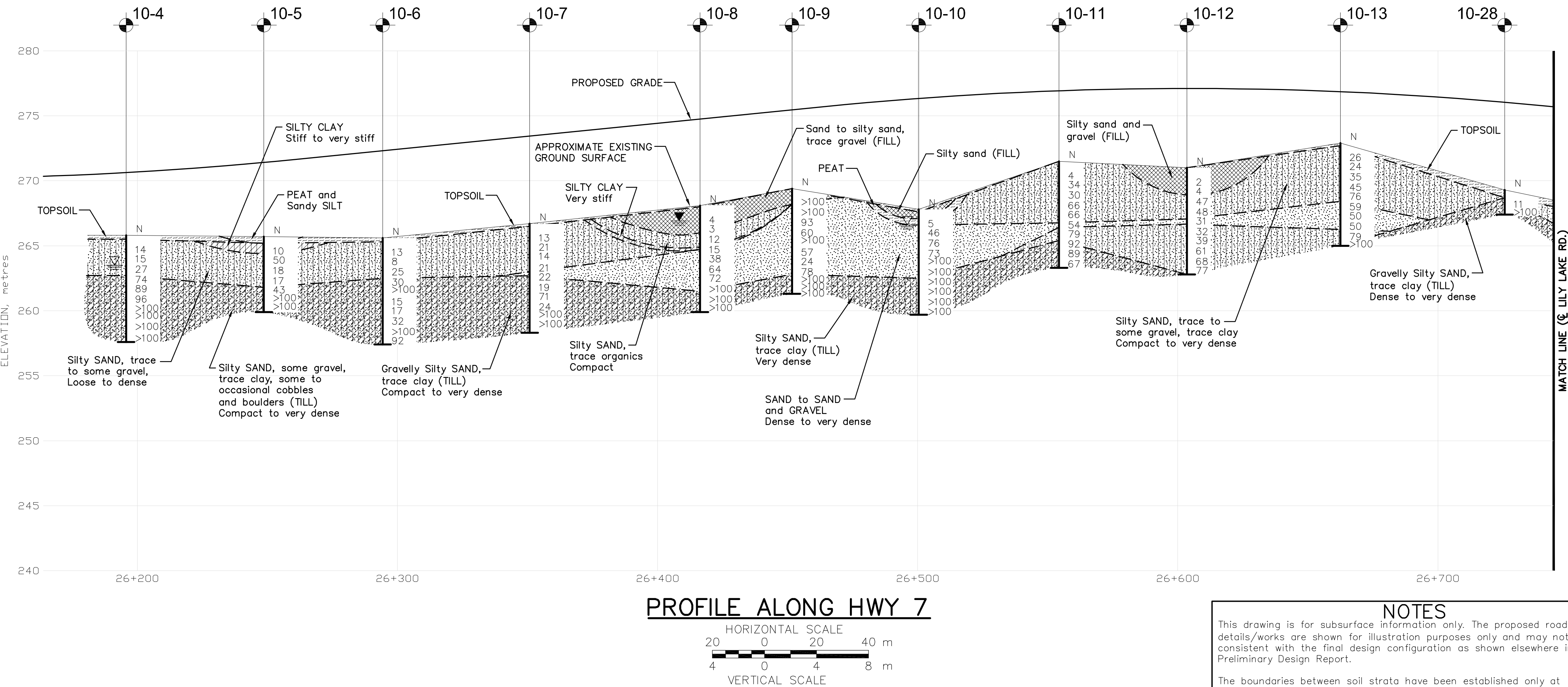
**TABLE 1**  
**SUMMARY OF RECOMMENDATIONS AT HIGH FILL LOCATIONS**  
**HIGHWAY 7, PETERBOROUGH**  
**W.P. 245-00-01**

Location	Approx. Station	Boreholes	Proposed Works	Surface Conditions	Recommended Embankment Fill Type	Organics Encountered along Alignment	Recommended Embankment Side Slope	*Estimated Post-Construction Settlements (d) and Mitigation Measures
Highway 7 Realignment	26+100 to 27+370	10-4 to 10-24 and 06-13	High Fill (up to 8.5 m high)	Topsoil, localized area of peat and fill overlaying silty sand and glacial till.	OPSS Select Subgrade Material	<ul style="list-style-type: none"> <li>Peat was encountered between 26+200 to 26+300</li> <li>Buried peat was encountered between 26+400 to 26+550</li> <li>Topsoil and peat encountered between 27+100 to 27+300</li> </ul>	2H : 1V 2 m wide bench required where embankment height exceeds 8 m.	$\delta_{\max} < 25 \text{ mm}$  No mitigation measures required.
Lily Lake Road	9+750 to 10+000	10-26 to 10-29, 06-11 and 06-12	High Fill (up to 10 m high)	Asphalt Road Surface and existing embankment up to 6 m high.	OPSS Select Subgrade Material	Topsoil ranging from 200 to 600 mm was encountered in the boreholes along the toe of the existing slopes.	2H : 1V 2 m wide bench required where embankment height exceeds 8 m.	$\delta_{\max} < 25 \text{ mm}$  No mitigation measures required.

\* Refers to settlement expected from cohesive foundation soils only. Short-term settlements (including shortly after construction) are not included.



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**PROFILE ALONG HWY 7**

**NOTES**

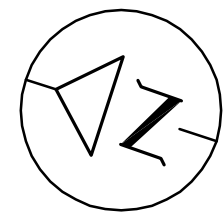
This drawing is for subsurface information only. The proposed roadway details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Preliminary Design Report.

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

The complete Preliminary Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

**REFERENCE**  
Base plans provided in digital format by D.M. WILLS (Drawing File No. "73-99-00 PR-2 Property Request Part B.dwg", received July 13, 2010).

CONT No.  
WP No. 4149-11-01

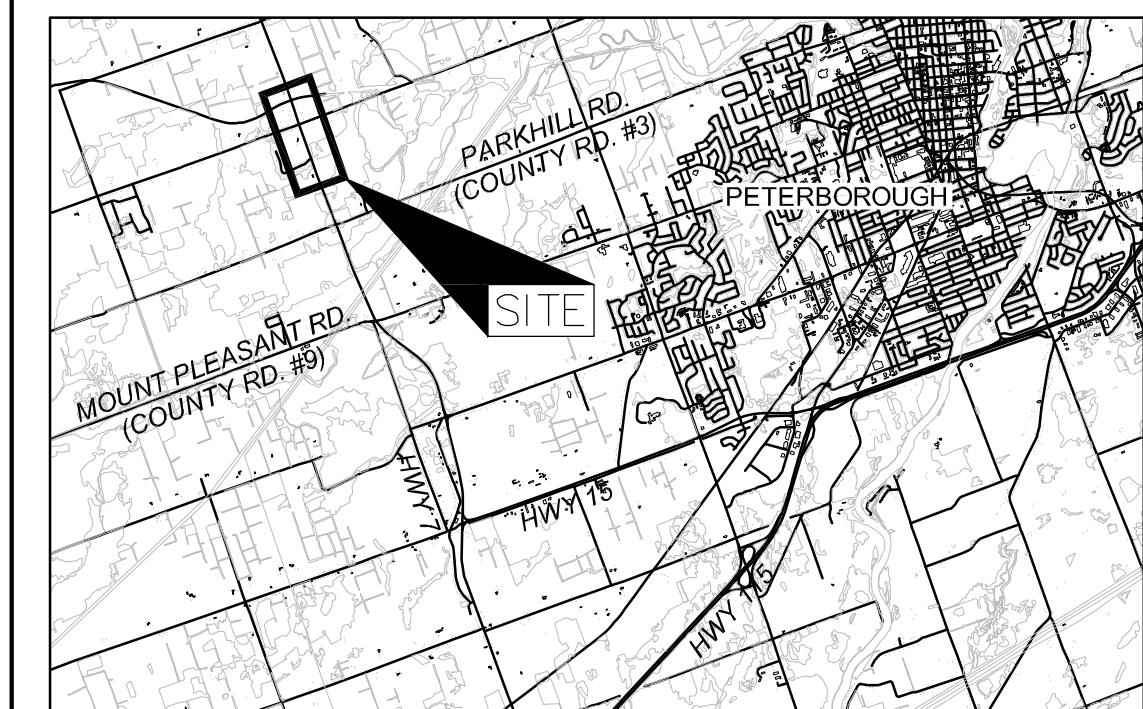


HIGHWAY 7  
HIGH FILL EMBANKMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



**Golder Associates Ltd.**  
OTTAWA, ONTARIO, CANADA



**KEY PLAN**  
SCALE  
2 0 2 4 km

**LEGEND**

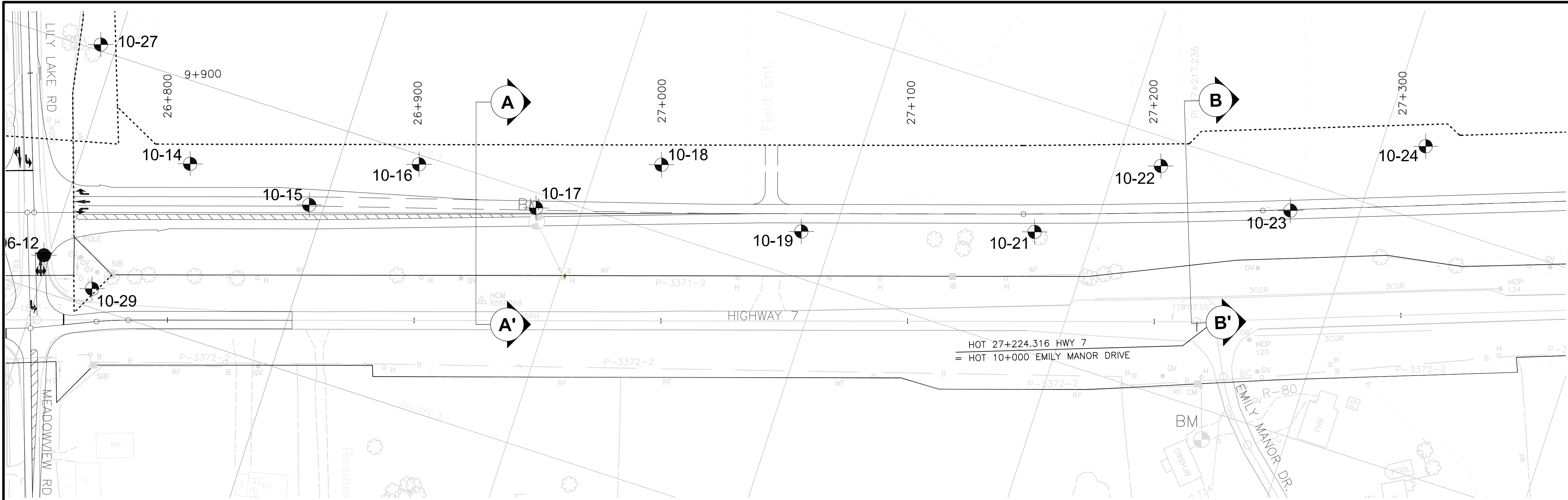
- Borehole - Current Investigation
- Borehole - Previous MTO Investigation (Geocres No. 31D-428)
- Borehole - Previous Investigation by Racey, MacCallum and Associates (1957)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Seal
- Piezometer
- WL in piezometer
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
10-1	268.0	4907839.4	390028.7
10-2	268.5	4907824.3	390022.5
10-3	267.9	4907832.2	390016.0
10-4	265.8	4908039.5	389975.7
10-5	265.7	4907982.7	389972.2
10-6	265.6	4907948.4	390014.6
10-7	266.7	4907885.7	390004.2
10-8	268.1	4907832.7	390053.2
10-9	269.4	4907789.9	390035.6
10-10	267.8	4907752.6	390078.8
10-11	271.5	4907693.4	390071.0
10-12	271.0	4907657.0	390118.3
10-13	272.9	4907591.4	390107.0
10-14	265.8	4907457.0	390167.8
10-15	266.5	4907405.9	390166.9
10-16	261.9	4907368.7	390196.3
10-17	262.8	4907318.1	390194.1
10-18	259.2	4907275.1	390226.4
10-19	262.7	4907212.9	390218.3
10-21	256.6	4907122.9	390247.3
10-22	250.1	4907082.4	390288.5
10-23	250.2	4907026.0	390287.5
10-24	253.8	4906982.8	390329.2
10-26	259.9	4907572.6	390217.2
10-27	261.2	4907506.3	390202.6
10-28	269.3	4907530.4	390123.7
10-29	274.6	4907479.1	390107.4
06-11	265.7	4907547.0	390222.4
06-12	275.1	4907501.9	390114.3
06-13	268.4	4907829.8	390031.5
06-14	268.3	4907829.5	389997.4
57-1	268.5	4907824.6	389988.9
57-3	268.4	4907813.0	389992.7

NO.	DATE	BY	REVISION
Geocres No. 31D-542			
HWY. 7		PROJECT NO. 10-1121-0007	DIST. 43
SUBM'D. BDG	CHKD. BDG	DATE: SEPT. 2012	SITE:
DRAWN: JM	CHKD. BDG	APPD. FJH	DWG. 1

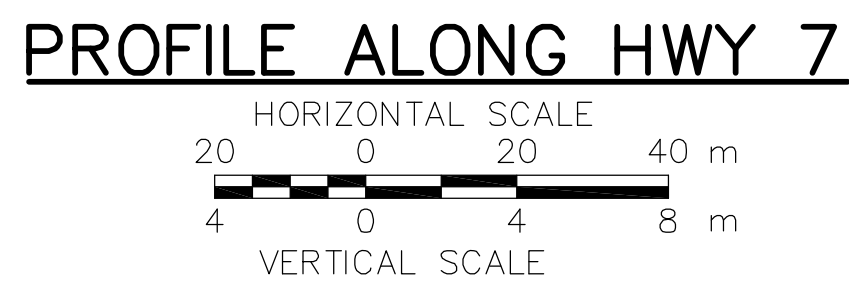
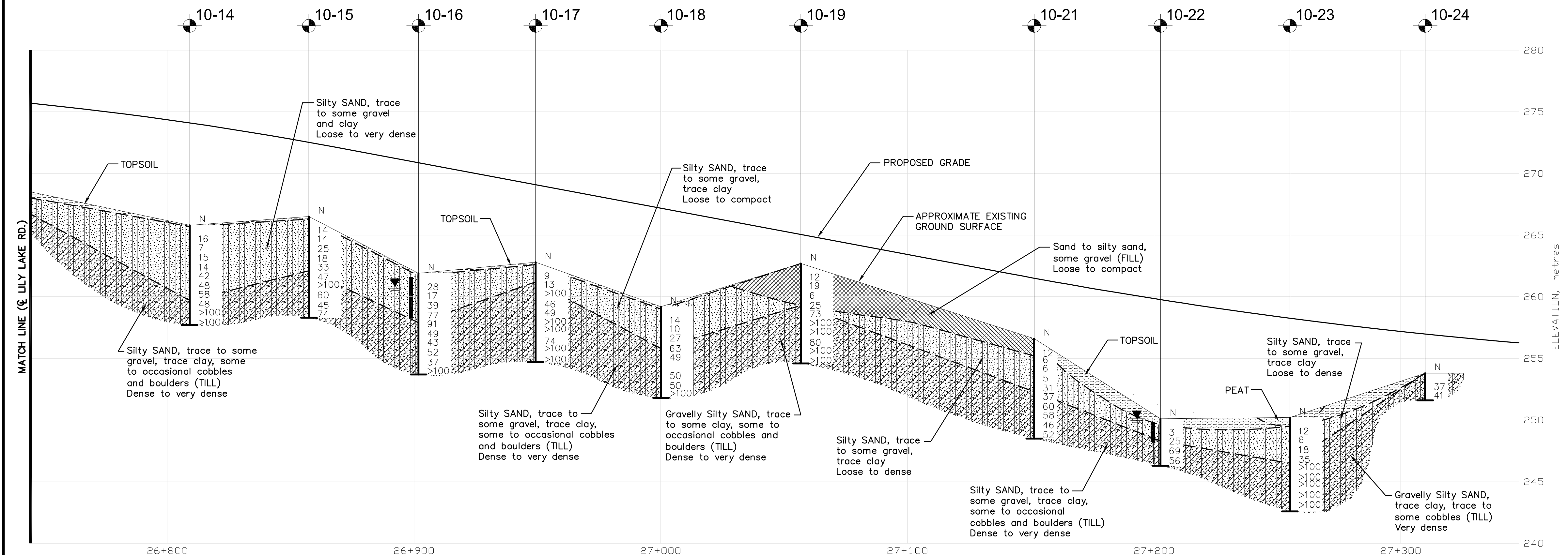
MINISTRY OF TRANSPORTATION, ONTARIO

PLOT DATE: October 11, 2012  
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STATIONS IN KILOMETRES + METRES.



**NOTES**

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**REFERENCE**

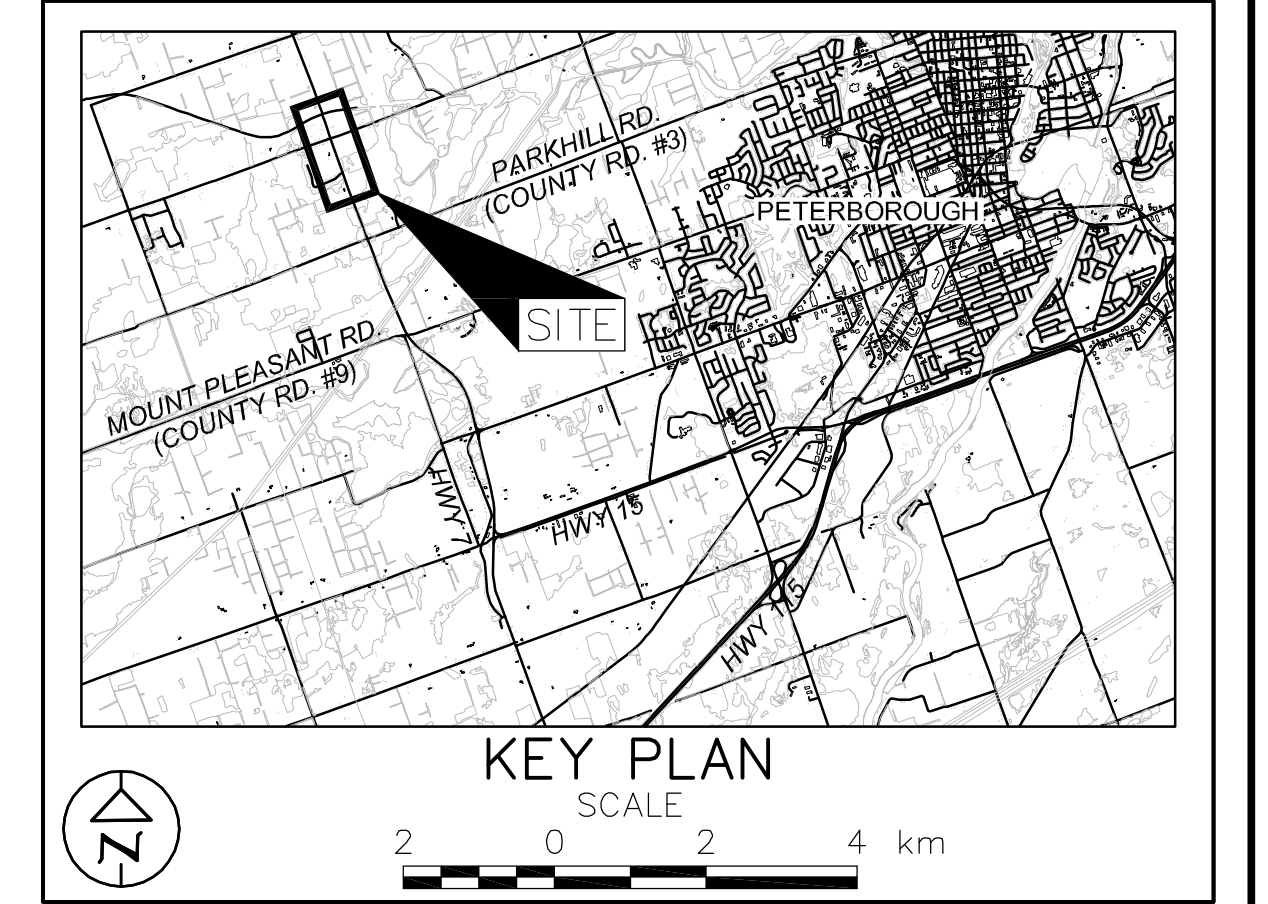
Base plans provided in digital format by D.M. WILLS (Drawing File No. "73-99-00 PR-2 Property Request Part B.dwg", received July 13, 2010).

CONT No.  
WP No. 4149-11-01

HIGHWAY 7  
HIGH FILL EMBANKMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

**Golder Associates Ltd.**  
OTTAWA, ONTARIO, CANADA



- LEGEND**
- Borehole - Current Investigation
  - Borehole - Previous MTO Investigation (Geocres No. 31D-428)
  - Borehole - Previous Investigation by Racey, MacCallum and Associates (1957)
  - N Standard Penetration Test Value
  - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
  - Seal
  - Piezometer
  - WL in piezometer
  - WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
10-1	268.0	4907839.4	390028.7
10-2	268.5	4907824.3	390022.5
10-3	267.9	4907832.2	390016.0
10-4	265.8	4908039.5	389975.7
10-5	265.7	4907982.7	389972.2
10-6	265.6	4907948.4	390014.6
10-7	266.7	4907885.7	390004.2
10-8	268.1	4907832.7	390053.2
10-9	269.4	4907789.9	390035.6
10-10	267.8	4907752.6	390078.8
10-11	271.5	4907693.4	390071.0
10-12	271.0	4907657.0	390118.3
10-13	272.9	4907591.4	390167.8
10-14	265.8	4907457.0	390167.8
10-15	266.5	4907405.9	390166.0
10-16	261.9	4907368.7	390196.3
10-17	262.8	4907318.1	390194.1
10-18	259.2	4907275.1	390226.4
10-19	262.7	4907212.9	390218.3
10-21	256.6	4907122.9	390247.3
10-22	250.1	4907082.4	390288.5
10-23	250.2	4907026.0	390287.5
10-24	253.8	4906982.8	390329.2
10-26	259.9	4907572.6	390217.2
10-27	261.2	4907506.3	390202.6
10-28	269.3	4907530.4	390123.7
10-29	274.6	4907479.1	390107.4
06-11	265.7	4907547.0	390222.4
06-12	275.1	4907501.9	390114.3
06-13	268.4	4907829.8	390031.5
06-14	268.3	4907829.5	389997.4
57-1	268.5	4907824.6	389988.9
57-3	268.4	4907813.0	389992.7

NO.	DATE	BY	REVISION
Geocres No. 31D-542			
HWY. 7		PROJECT NO. 10-1121-0007	DIST. 43
SUBM'D. BDG	CHKD. BDG	DATE: SEPT. 2012	SITE:
DRAWN: JM	CHKD. BDG	APPD. FJH	DWG. 2

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

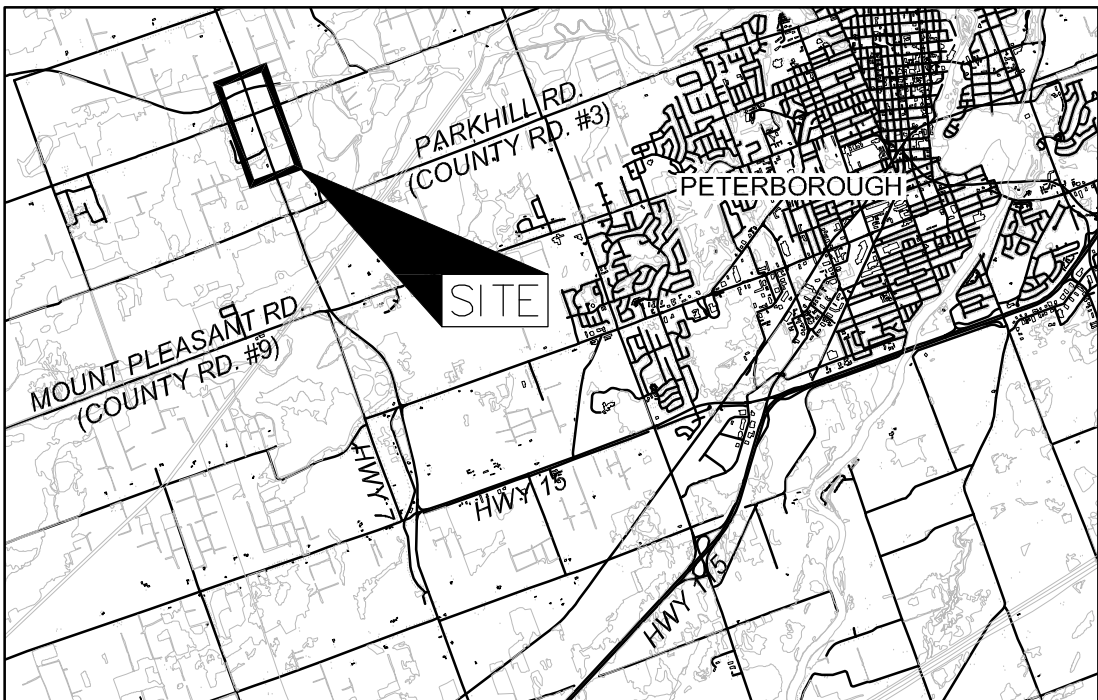
CONT No.  
WP No.4149-11-01

HIGHWAY 7  
HIGH FILL EMBANKMENT  
SOIL STRATA

SHEET



**Golder Associates Ltd.**  
OTTAWA, ONTARIO, CANADA



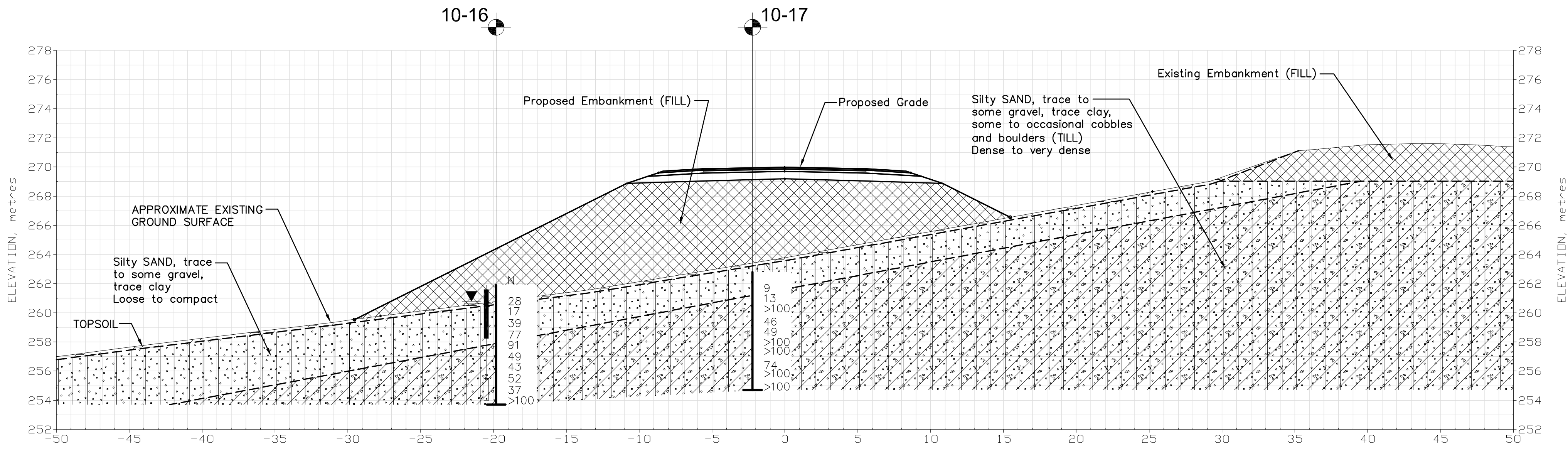
KEY PLAN



SCALE  
2 0 2 4 km

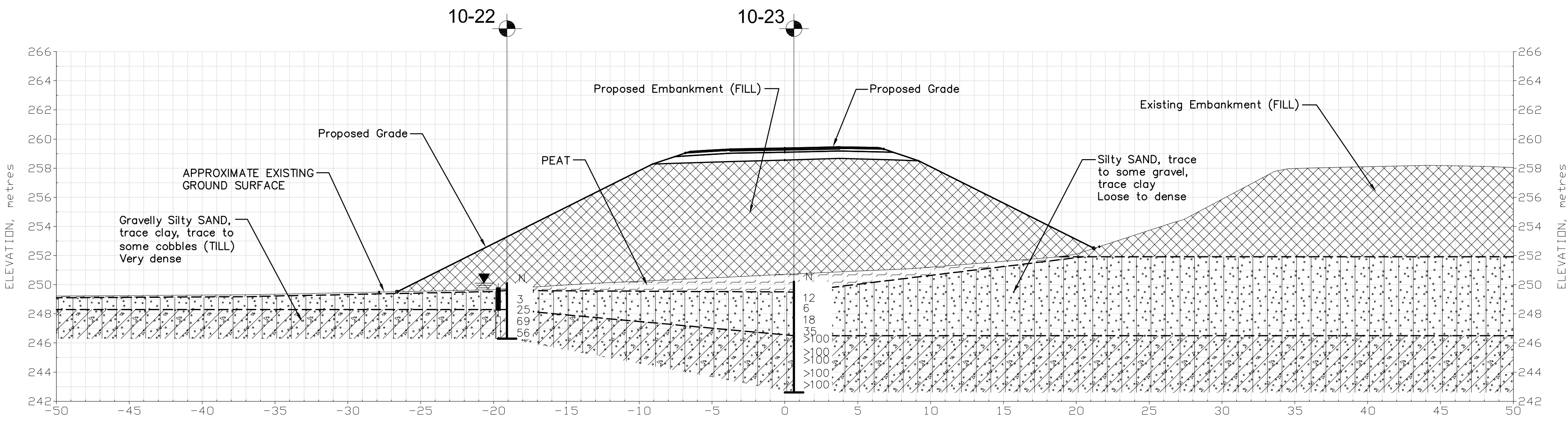
LEGEND

- Borehole - Current Investigation
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- Seal
- Piezometer
- WL in piezometer
- WL upon completion of drilling



CROSS-SECTION A-A'

HORIZONTAL SCALE  
4 0 4 8 m  
VERTICAL SCALE  
4 0 4 8 m



CROSS-SECTION B-B'

HORIZONTAL SCALE  
4 0 4 8 m  
VERTICAL SCALE  
4 0 4 8 m

NOTES

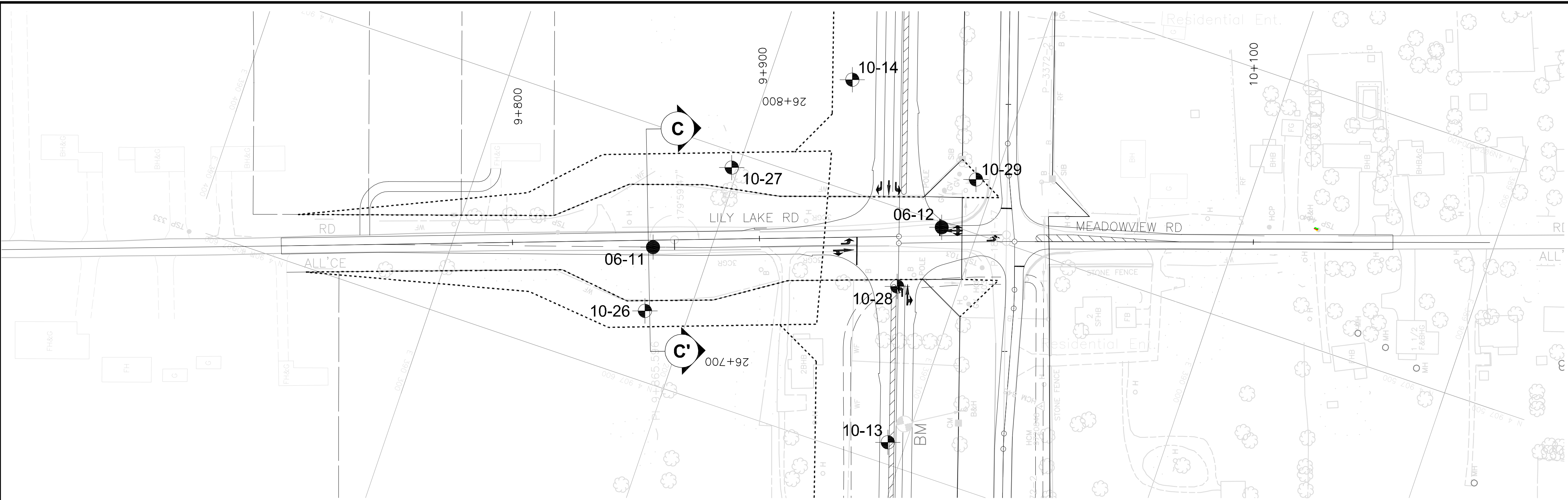
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No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
10-1	268.0	4907839.4	390028.7
10-2	268.5	4907824.3	390022.5
10-3	267.9	4907832.2	390016.0
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10-6	265.6	4907948.4	390014.6
10-7	266.1	4907885.7	390004.2
10-8	268.1	4907832.7	390053.2
10-9	269.4	4907789.9	390035.6
10-10	267.8	4907752.6	390078.8
10-11	271.5	4907693.4	390071.0
10-12	271.0	4907657.0	390118.3
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06-13	268.5	4907824.6	389988.9
06-14	268.4	4907813.0	389992.7

NO.	DATE	BY	REVISION
Geocres No. 31D-542			
HWY. 7	PROJECT NO. 10-1121-0007		DIST. 43
SUBM'D. BDG	CHKD. BDG	DATE: SEPT. 2012	SITE:
DRAWN: JM	CHKD. BDG	APPD. FJH	DWG. 3



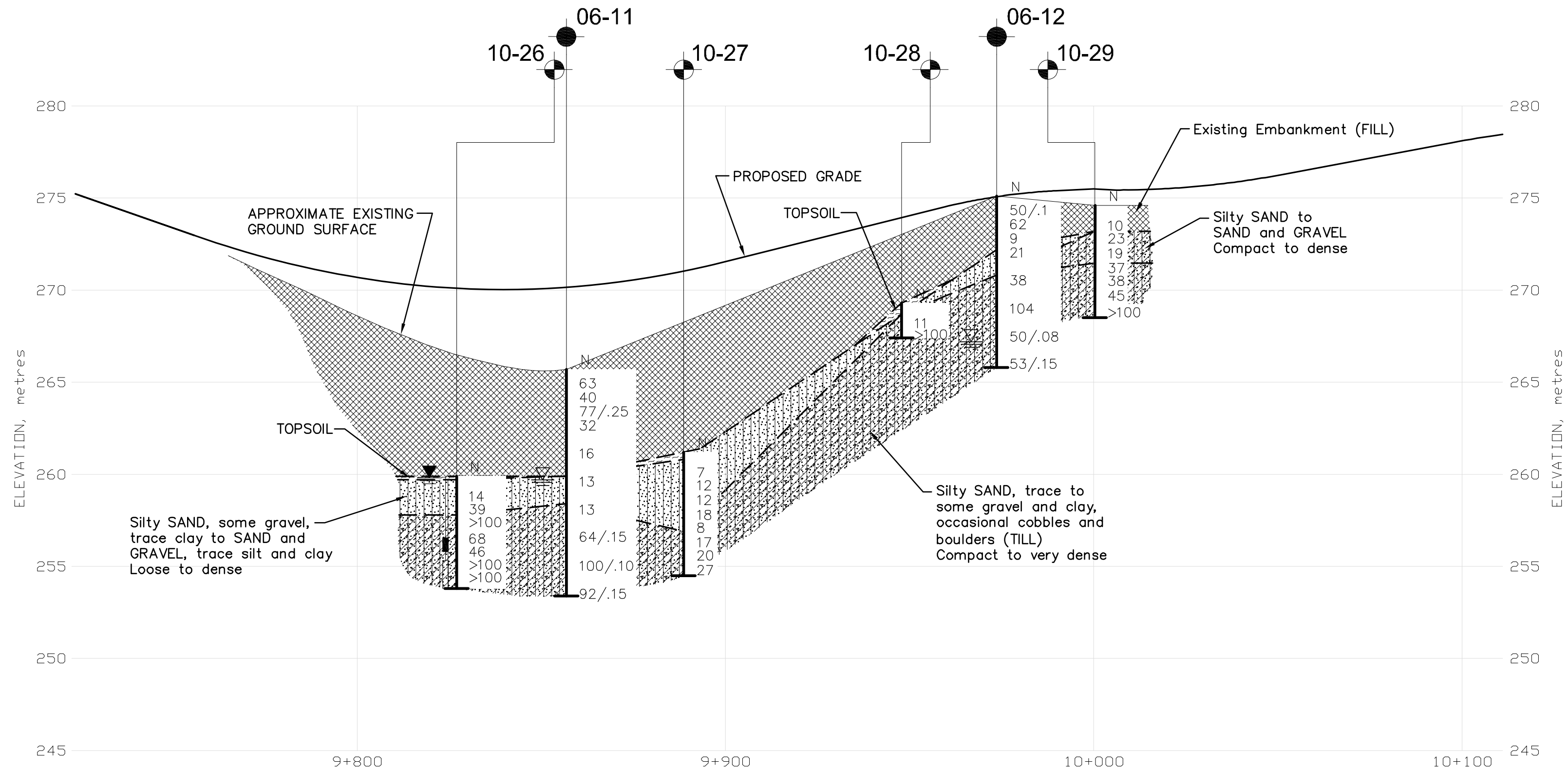
PLAN

SCALE

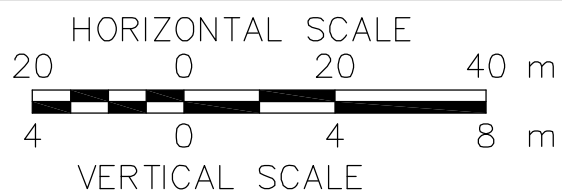


METRIC

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



PROFILE ALONG LILY LAKE RD.



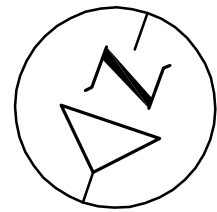
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CONT No.  
WP No. 4149-11-01

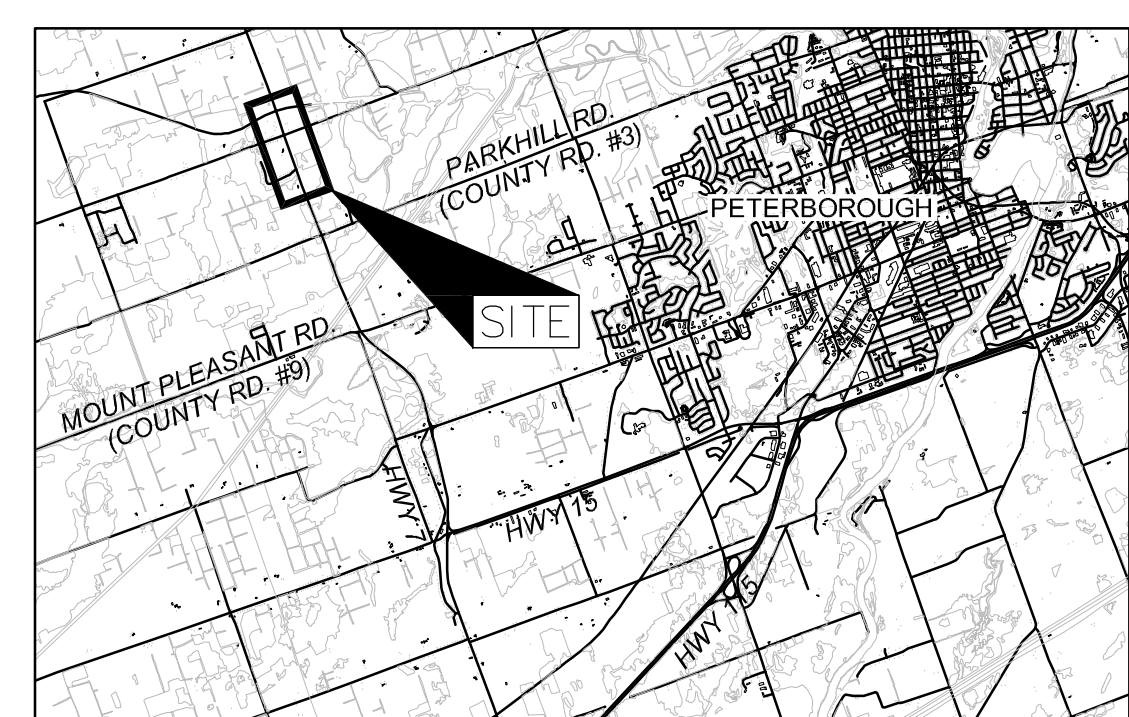


HIGHWAY 7  
HIGH FILL EMBANKMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.  
OTTAWA, ONTARIO, CANADA



KEY PLAN

SCALE



LEGEND

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- WL in piezometer
- WL upon completion of drilling

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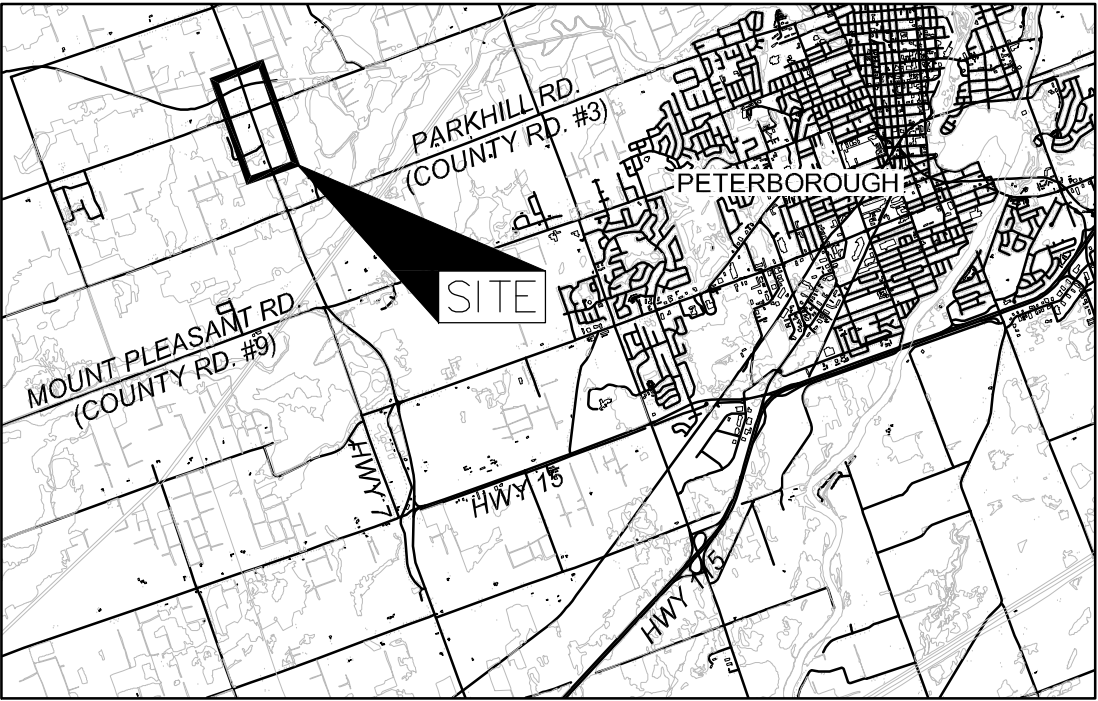
CONT No.  
WP No.4149-11-01

HIGHWAY 7  
HIGH FILL EMBANKMENT  
SOIL STRATA

SHEET



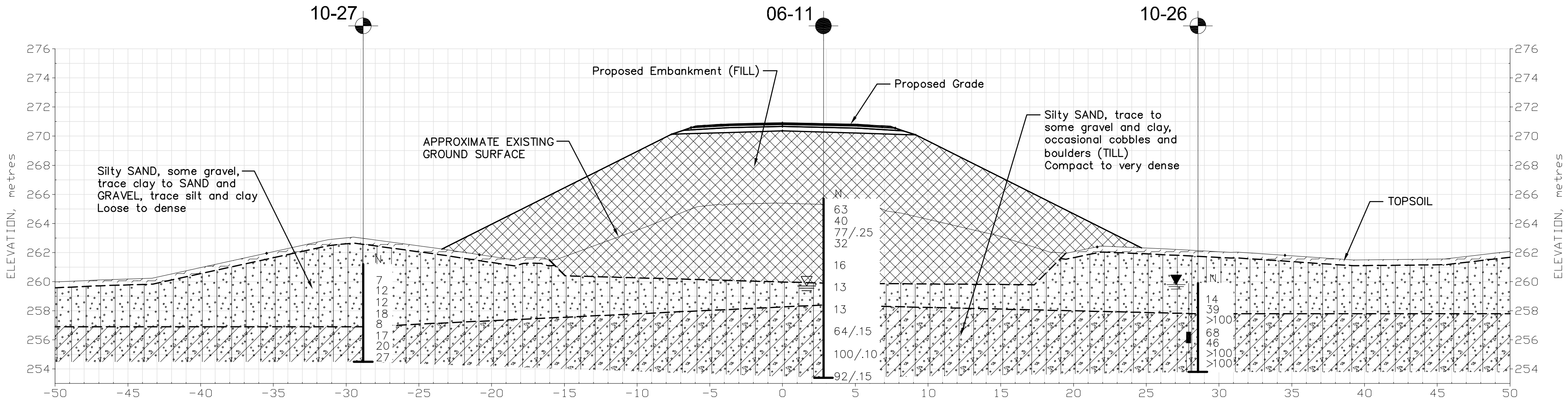
**Golder Associates Ltd.**  
OTTAWA, ONTARIO, CANADA



**KEY PLAN**  
SCALE  
2 0 2 4 km

**LEGEND**

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**CROSS-SECTION C-C'**

HORIZONTAL SCALE  
4 0 4 8 m  
4 0 4 8 m  
VERTICAL SCALE

**NOTES**

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06-11	265.7	4907547.0	390222.4
06-12	275.1	4907501.9	390114.3
06-13	268.4	4907829.8	390031.5
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57-1	268.5	4907824.6	389988.9
57-3	268.4	4907813.0	389992.7

NO.	DATE	BY	REVISION
Geocres No. 31D-542			
HWY. 7	PROJECT NO. 10-1121-0007		DIST. 43
SUBM'D. BDG	CHKD. BDG	DATE: SEPT. 2012	SITE:
DRAWN: JM	CHKD. BDG	APPD. FJH	DWG. 5



# APPENDIX A

List of Abbreviations and Symbols  
Record of Borehole Sheets and Detailed Laboratory Test Results,  
Present Investigation

## 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		III. SOIL DESCRIPTION	
AS	Auger sample	(a)	Cohesionless Soils
BS	Block sample		
CS	Chunk sample		
DO	Drive open	Density Index	N
DS	Denison type sample	(Relative Density)	Blows/300 mm
FS	Foil sample		Or Blows/ft.
RC	Rock core	Very loose	0 to 4
SC	Soil core	Loose	4 to 10
ST	Slotted tube	Compact	10 to 30
TO	Thin-walled, open	Dense	30 to 50
TP	Thin-walled, piston	Very dense	over 50
WS	Wash sample	(b)	Cohesive Soils
DT	Dual Tube sample	Consistency	C <sub>u</sub> or S <sub>u</sub>
II. PENETRATION RESISTANCE			
<b>Standard Penetration Resistance (SPT), N:</b>		<u>Kpa</u>	<u>Psf</u>
The number of blows by a 63.5 kg. (140 lb.)		Very soft	0 to 12
hammer dropped 760 mm (30 in.) required		Soft	12 to 25
to drive a 50 mm (2 in.) drive open		Firm	25 to 50
Sampler for a distance of 300 mm (12 in.)		Stiff	50 to 100
DD- Diamond Drilling		Very stiff	100 to 200
Hard		Hard	Over 200
<b>Dynamic Penetration Resistance; N<sub>d</sub>:</b>			
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.).			
<b>PH:</b>	Sampler advanced by hydraulic pressure	IV. SOIL TESTS	
<b>PM:</b>	Sampler advanced by manual pressure	w	water content
<b>WH:</b>	Sampler advanced by static weight of hammer	w <sub>p</sub>	plastic limited
<b>WR:</b>	Sampler advanced by weight of sampler and rod	w <sub>l</sub>	liquid limit
		C	consolidation (oedometer) test
		CHEM	chemical analysis (refer to text)
		CID	consolidated isotropically drained triaxial test <sup>1</sup>
		CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
		D <sub>R</sub>	relative density (specific gravity, G <sub>s</sub> )
		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 <sub>4</sub>	concentration of water-soluble sulphates
		UC	unconfined compression test
		UU	unconsolidated undrained triaxial test
		V	field vane test (LV-laboratory vane test)
		γ	unit weight

Note:

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

# LIST OF SYMBOLS

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

## I. GENERAL

$\pi$	= 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
$F$	factor of safety
$V$	volume
$W$	weight

## II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma'$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1 \sigma_2 \sigma_3$	principal stresses (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = p_s/p_w$ ) formerly ( $G_s$ )
$e$	void ratio
$n$	porosity
$S$	degree of saturation
*	Density symbol is $p$ . Unit weight symbol is $\gamma$ where $\gamma = pg$ (i.e. mass density x acceleration due to gravity)

### (a) Index Properties (cont'd.)

$w$	water content
$w_L$	liquid limit
$w_p$	plastic limit
$I_p$	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 (overconsolidated range)
$C_s$	swelling index
$C_a$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation
$T_v$	time factor (vertical direction)
$U$	degree of consolidation
$\sigma'_p$	pre-consolidation pressure
OCR	Overconsolidation ratio = $\sigma'_p/\sigma'_{vo}$

### (d) Shear Strength

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

Notes: 1.  $\tau = c' + \sigma' \tan \phi'$   
2. Shear strength = (Compressive strength)/2



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

MIS-MTO 001 1011210007-245-00-01.GPJ GAL-MISS.GDT 09/21/12 JM

PROJECT		10-1121-0007		RECORD OF BOREHOLE No 10-2		1 OF 2 METRIC											
G.W.P.		4149-11-01		LOCATION		N 4907824.3 ; E 390022.5											
DIST		43 HWY 7		BOREHOLE TYPE		Power Auger, 105mm Diam. Solid Stem											
DATUM		Geodetic		DATE		Sept. 9, 2010											
						ORIGINATED BY HEC											
						COMPILED BY JM											
						CHECKED BY NRL											
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	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	25 50 75	γ	GR SA SI CL				
268.5	GROUND SURFACE																
0.0 268.3	Sand, with organic matter (TOPSOIL)																
0.2	Dark brown to black Sand to silty sand, some gravel and cobbles, trace clay (FILL) Loose to compact Brown Moist		1	SS	11		268						9 56 30 5				
267.0																	
1.5 266.6	SAND, some silt, with organic matter Compact Dark brown Moist		2	SS	16		267										
1.9	SAND, trace silt Compact Brown Moist												1 78 18 3				
			3	SS	15		266										
265.4																	
3.1	Silty SAND, some gravel Compact Grey-brown to brown Wet		4	SS	11		265										
264.5			5	SS	>100												
4.0	Silty SAND, trace gravel, some cobbles, occasional boulder (TILL) Dense Grey-brown Wet						264										
263.6			6	SS	35												
4.9	Silty SAND and GRAVEL, some clay, occasional cobble and small boulder (TILL) Very dense Grey Wet		7	SS	80		263										
			8	SS	83		262										
			9	SS	>100								14 42 29 15				
			10	SS	>100		261										
			11	SS	>100		260										
			12	SS	49		259										

PROJECT <u>10-1121-0007</u>		<b>RECORD OF BOREHOLE No 10-2</b>				2 OF 2 <b>METRIC</b>											
G.W.P. <u>4149-11-01</u>		LOCATION <u>N 4907824.3 ; E 390022.5</u>				ORIGINATED BY <u>HEC</u>											
DIST <u>43</u> HWY <u>7</u>		BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>											
DATUM <u>Geodetic</u>		DATE <u>Sept. 9, 2010</u>				CHECKED BY <u>NRL</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>
	--- CONTINUED FROM PREVIOUS PAGE ---																
258.1 10.4	End of Borehole  Note: 1. Water level in well screen at 2.1 m depth (Elev. 266.4 m) below ground surface on Sept. 24, 2010.  2. Water level in well screen at 2.0 m depth (Elev. 266.5 m) below ground surface on Dec. 13, 2010.  3. Water level in well screen at 1.6 m depth (Elev. 266.9 m) below ground surface on Apr. 26, 2011.		13	SS	84												22 48 22 8

PROJECT 10-1121-0007				<b>RECORD OF BOREHOLE No 10-3</b>				1 OF 2 <b>METRIC</b>									
G.W.P. 4149-11-01				LOCATION N 4907832.2 ; E 390016.0				ORIGINATED BY HEC									
DIST 43 HWY 7				BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM									
DATUM Geodetic				DATE Sept. 10, 2010				CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
267.9	GROUND SURFACE																
0.0	Sand, with organic matter (TOPSOIL)																
267.6	Dark brown to black																
0.3	Sand, trace gravel (FILL)																
	Compact																
	Brown to grey-brown																
	Moist																
267.0																	
0.9	Silty SAND (Possible Fill)		1	SS	12		267										
	Compact																
	Brown to grey-brown																
	Moist																
266.4																	
1.5	SILTY CLAY																
	Stiff to very stiff																
266.1	Grey-brown		2	SS	27		266										
	Moist																
1.8	Silty SAND, some gravel																
	Compact																
	Brown																
	Moist to wet																
			3	SS	30		265										
			4	SS	23												
263.8							264										
4.1	Silty SAND, some gravel and clay, occasional cobble (TILL)		5	SS	48												
	Very dense																
	Grey																
	Wet																
			6	SS	82		263										
			7	SS	111		262										14 46 26 14
261.8																	
6.1	Silty SAND, some gravel and clay, numerous cobbles, occasional small boulder (TILL)		8	SS	>100												
	Very dense																
	Grey																
	Wet																
			9	SS	>100		261										
			10	SS	>100		260										
			11	SS	138		259										15 47 25 13
			12	SS	78												
							258										

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

MIS-MTO.001 1011210007-245-00-01.GPJ GAL-MISS.GDT 09/21/12 JM



## 2 OF 2 METRIC

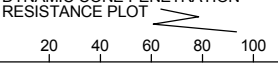
PROJECT		10-1121-0007		RECORD OF BOREHOLE NO 10-3		2 OF 2		METRIC			
G.W.P.		4149-11-01		LOCATION		N 4907832.2 ; E 390016.0		ORIGINATED BY		HEC	
DIST		43		HWY		7		BOREHOLE TYPE		Power Auger, 105mm Diam. Solid Stem	
DATALOG		Geodetic		DATE		Sept. 10, 2010		CHECKED BY		NRL	

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

MIS-MTO 001 1011210007-245-00-01.GPJ GAL-MISS.GDT 09/21/12 JM

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

PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-5			1 OF 1 METRIC					
G.W.P. 4149-11-01			LOCATION N 4907982.7 ; E 389972.2			ORIGINATED BY HEC					
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem			COMPILED BY JM					
DATUM Geodetic			DATE Sept. 14, 2010			CHECKED BY NRL					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT  SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
265.7	GROUND SURFACE										
0.0	Sand, with organic matter (PEAT) Dark brown to black										
265.4	Sandy silt (ALLUVIUM) Grey										
265.2	SILTY CLAY Stiff to very stiff Grey Moist										
0.5			1	SS	10						
264.4	Silty SAND, trace gravel and clay Compact to dense Brown Moist to wet										
1.3			2	SS	50						
			3	SS	18						
			4	SS	17						
261.8	Silty SAND, some gravel, trace clay, some cobbles, occasional to some boulders (TILL) Dense to very dense Grey Wet										
3.9			5	SS	43						
			6	SS	>100						
			7	SS	>100						
259.9	End of Borehole Auger Refusal										
5.8											

**RECORD OF BOREHOLE No 10-6**

1 OF 1 **METRIC**

PROJECT 10-1121-0007

G.W.P. 4149-11-01

LOCATION N 4907948.4 ; E 390014.6

ORIGINATED BY HEC

DIST 43 HWY 7

BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem

COMPILED BY JM

DATUM Geodetic

DATE Sept. 13, 2010

CHECKED BY NRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
265.6	GROUND SURFACE							20	40	60	80	100					
0.0	Silty sand, with organic matter (TOPSOIL)																
265.3	Dark brown to black																
265.1	Silty SAND, some gravel Brown																
0.6	SAND and GRAVEL Brown						265										
	Silty SAND, some gravel, trace clay, occasional cobble		1	SS	13												
	Compact to loose																
	Grey-brown																
	Moist to wet																
			2	SS	8		264										
			3	SS	25		263										
262.5																	
3.1	Silty SAND, some gravel, clay and cobbles (TILL)		4	SS	30		262										
	Compact																
	Grey		5	SS	>100												
	Wet																
			6	SS	15		261						○				14 46 26 14
			7	SS	17		260										
259.5																	
6.1	Silty SAND, trace gravel and clay, trace to some cobbles (TILL)		8	SS	32		259										
	Dense to very dense																
	Grey																
	Wet		9	SS	>100								○				
							258										
			10	SS	92												
257.4																	
8.2	End of Borehole																


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-7			1 OF 1 METRIC											
G.W.P. 4149-11-01			LOCATION N 4907885.7 ; E 390004.2			ORIGINATED BY HEC											
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem			COMPILED BY JM											
DATUM Geodetic			DATE Sept. 13, 2010			CHECKED BY NRL											
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 kN/m <sup>3</sup>	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W <sub>p</sub> W W <sub>L</sub>	25 50 75						
266.7	GROUND SURFACE																
0.0	Silty sand, with organic matter (TOPSOIL)																
266.5	Dark brown																
0.2	Silty SAND, trace clay and gravel, occasional cobble																
	Compact																
	Brown																
	Moist																
			1	SS	13		266										
			2	SS	21		265										
			3	SS	14		264										
264.0																	
2.7	Silty SAND, some gravel, trace clay and cobbles																
	Compact																
	Grey																
	Wet																
			4	SS	21		263										
263.0																	
3.7	SAND																
	Compact																
	Grey																
	Wet																
262.7																	
4.0	Silty SAND, some gravel, trace cobbles and clay (TILL)																
	Compact																
	Grey																
	Wet																
			5	SS	22		262										
			6	SS	19		261										
261.5																	
5.2	Gravelly Silty SAND, trace clay, some cobbles and small boulders (TILL)																
	Dense to very dense																
	Grey																
	Wet																
			7	SS	71		260										
			8	SS	24		259										
			9	SS	>100												
			10	SS	>100												
258.3																	
8.4	End of Borehole																

MIS-MTO 001 1011210007-245-00-01.GPJ GAL-MISS.GDT 09/21/12 JM

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

PROJECT <u>10-1121-0007</u>		<b>RECORD OF BOREHOLE No 10-9</b>				1 OF 1 <b>METRIC</b>											
G.W.P. <u>4149-11-01</u>		LOCATION <u>N 4907789.9 ; E 390035.6</u>				ORIGINATED BY <u>HEC</u>											
DIST <u>43</u> HWY <u>7</u>		BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>											
DATUM <u>Geodetic</u>		DATE <u>Sept. 14-15, 2010</u>				CHECKED BY <u>NRL</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
269.4 0.0	GROUND SURFACE Silty sand and gravel, occasional cobble, trace boulders (Possibly FILL) Compact to very dense Brown Moist						269										
			1	SS	>100												
268.2 1.2	SAND, some gravel and cobbles Very dense Brown Moist		2	SS	>100		268										
267.1 2.3	SAND and GRAVEL Very dense Grey-brown Moist to wet		3	SS	93		267										
266.0 3.4	Silty SAND, some gravel, occasional cobble Very dense Grey-brown Wet		4	SS	60		266										
			5	SS	>100		265										
264.5 4.9	SAND and GRAVEL Very dense to compact Brown Wet		6	SS	57		264										
			7	SS	24												
262.8 6.6	SAND, trace gravel, silt and clay (TILL) Very dense Brown Wet		8	SS	78		263										
			9	SS	>100												
			10	SS	>100		262										
			11	SS	>100												
261.3 8.1	End of Borehole																

MIS-MTO-001 1011210007-245-00-01.GPJ GAL-MISS.GDT 09/21/12 JM

PROJECT 10-1121-0007				<b>RECORD OF BOREHOLE No 10-10</b>				1 OF 1 <b>METRIC</b>									
G.W.P. 4149-11-01				LOCATION N 4907752.6 ;E 390078.8				ORIGINATED BY HEC									
DIST 43 HWY 7				BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM									
DATUM Geodetic				DATE Sept. 15, 2010				CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
267.8	GROUND SURFACE																
0.0	Silty sand, trace organic matter (TOPSOIL)																
267.6	Brown																
0.2	Silty sand, with organic silt (FILL)																
267.1	Grey																
0.7	Silty sand, abundant organic matter (PEAT)																
266.6	Loose Dark brown to black		1	SS	5												
1.2	Moist																
266.3	Silty SAND, some gravel																
1.5	Compact Brown																
	Moist SAND		2	SS	46												
	Dense to very dense																
	Brown																
	Wet																
			3	SS	76												
			4	SS	73												
			5	SS	>100												
263.1																	
4.7	Silty SAND, trace gravel		6	SS	>100												
	Very dense																
	Light brown to grey-brown																
	Wet																
262.5																	
5.3	Silty SAND, trace to some gravel, occasional cobble (TILL)		7	SS	>100												
	Very dense																
	Grey																
	Wet																
			8	SS	>100												
			9	SS	>100												
			10	SS	>100												
259.7																	
8.1	End of Borehole																
	Note: Water level in open borehole at 1.2 m depth (Elev. 266.6 m) below ground surface on Sept. 15, 2010.																

PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-11			1 OF 1 METRIC											
G.W.P. 4149-11-01			LOCATION N 4907693.4 ; E 390071.0			ORIGINATED BY HEC											
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem			COMPILED BY JM											
DATUM Geodetic			DATE Sept. 15, 2010			CHECKED BY NRL											
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 kN/m³	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W <sub>p</sub> W W <sub>L</sub>	25 50 75						
271.5 0.0	GROUND SURFACE Silty SAND, trace gravel Loose Brown Moist						271										
270.1 1.4	Silty SAND, some gravel, trace clay Compact to very dense Brown Moist to wet		1	SS	4		270										
			2	SS	34		269										
			3	SS	30		268										
			4	SS	66		267										
			5	SS	66												
266.7 5.0	SAND Very dense Brown Wet		6	SS	54		266										
	Silty SAND, trace gravel Very dense Brown Wet		7	SS	79		265										
265.4 6.1	Silty SAND, some gravel, trace cobbles (TILL) Very dense Brown Wet		8	SS	92		264										
			9	SS	89												
263.9 7.6	SAND, trace silt (TILL) Very dense Brown Wet		10	SS	67												
263.3 8.2	End of Borehole																

PROJECT		10-1121-0007		<b>RECORD OF BOREHOLE No 10-12</b>				1 OF 1 <b>METRIC</b>									
G.W.P.		4149-11-01		LOCATION		N 4907657.0 ; E 390118.3		ORIGINATED BY HEC									
DIST		43 HWY 7		BOREHOLE TYPE		Power Auger, 105mm Diam. Solid Stem		COMPILED BY JM									
DATUM		Geodetic		DATE		Sept. 17, 2010		CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
271.0 0.0	GROUND SURFACE Silty sand (FILL) Grey							20	40	60	80	100					
270.2 0.8	Silty sand and gravel, trace wood (FILL) Very loose Grey-brown Moist		1	SS	2		270										
268.9 2.1	Silty SAND, some gravel, occasional cobble Dense Brown Moist		2	SS	4		269										
267.2 3.8	SAND Dense Brown Moist to wet		3	SS	47		268										
266.8 4.2	Silty SAND, trace to some gravel, trace clay Dense to very dense Grey-brown Wet		4	SS	48		267										
			5	SS	31		266										
			6	SS	32		265										
			7	SS	39		264										
			8	SS	61		263										
			9	SS	68												
			10	SS	77												
262.8 8.2	End of Borehole																

PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-13				1 OF 1 METRIC										
G.W.P. 4149-11-01			LOCATION N 4907591.4 ; E 390107.0				ORIGINATED BY HEC										
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM										
DATUM Geodetic			DATE Sept. 17, 2010				CHECKED BY NRL										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
272.9	GROUND SURFACE																
0.0	Silty sand, with organic matter (TOPSOIL)																
0.2	Silty SAND, trace to some gravel, trace clay, occasional cobble, trace boulders Compact to dense Brown Moist		1	SS	26												
			2	SS	24												10 50 30 10
			3	SS	35												
269.8																	
3.1	Silty SAND, trace gravel Dense to very dense Brown Moist		4	SS	45												
			5	SS	76												
268.2																	
4.7	SAND, trace silt, occasional brown sand seam Very dense Brown Moist to wet		6	SS	59												2 86 9 3
267.3			7	SS	50												
5.6	Silty SAND, trace to some gravel Dense Grey-brown Wet																
266.6			8	SS	50												
6.3	SAND Dense Brown Wet																
266.2			9	SS	79												
6.7	Silty SAND, trace gravel Dense to very dense Brown to grey-brown Wet																
265.0			10	SS	>100												
7.9	End of Borehole Auger Refusal																

PROJECT 10-1121-0007			<b>RECORD OF BOREHOLE No 10-14</b>				1 OF 1 <b>METRIC</b>									
G.W.P. 4149-11-01		LOCATION N 4907457.0 ; E 390167.8				ORIGINATED BY HEC										
DIST 43 HWY 7		BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM										
DATUM Geodetic		DATE Sept. 22, 2010				CHECKED BY NRL										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
265.8	GROUND SURFACE															
0.0	Silty sand, some organic matter (TOPSOIL)															
0.1	Dark brown to black															
	Silty SAND, trace gravel															
	Brown to medium brown															
265.0							265									
0.8	Silty SAND, trace to some clay and gravel		1	SS	16											
	Loose to compact															
	Grey-brown															
	Moist															
			2	SS	7		264									
			3	SS	15		263									
			4	SS	14											
262.0							262									
3.8	Silty SAND, trace clay, trace to some gravel		5	SS	42											
	Dense to very dense															
	Grey-brown to brown															
	Moist to wet															
			6	SS	48		261									
			7	SS	58		260									
259.7																
6.1	Silty SAND, trace gravel and cobbles (TILL)		8	SS	48		259									
	Dense to very dense															
	Brown															
	Wet															
			9	SS	>100											
			10	SS	>100		258									
257.7																
8.1	End of Borehole															

PROJECT <u>10-1121-0007</u>				<b>RECORD OF BOREHOLE No 10-15</b>				1 OF 1 <b>METRIC</b>									
G.W.P. <u>4149-11-01</u>				LOCATION <u>N 4907405.9 ; E 390166.9</u>				ORIGINATED BY <u>HEC</u>									
DIST <u>43</u> HWY <u>7</u>				BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>									
DATUM <u>Geodetic</u>				DATE <u>Sept. 22, 2010</u>				CHECKED BY <u>NRL</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
266.5	GROUND SURFACE																
0.0	Silty sand, some organic matter (TOPSOIL)																
266.3	Dark brown to black																
0.2	Silty SAND, some gravel and clay Compact to dense Brown Moist																
			1	SS	14												
			2	SS	14												
			3	SS	25												
			4	SS	18												
			5	SS	33												
262.1	Silty SAND, some gravel and cobbles, occasional small boulder (TILL) Dense to very dense Brown to grey-brown Moist to wet		6	SS	47												
4.4			7	SS	>100												
			8	SS	60												
259.6	Silty SAND, some gravel, occasional cobble, and boulder (TILL) Dense to very dense		9	SS	45												
6.9			10	SS	74												
258.3	End of Borehole																
8.2																	

**RECORD OF BOREHOLE No 10-16**

1 OF 2 **METRIC**

PROJECT 10-1121-0007  
 G.W.P. 4149-11-01 LOCATION N 4907368.7 ; E 390196.3 ORIGINATED BY HEC  
 DIST 43 HWY 7 BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem COMPILED BY JM  
 DATUM Geodetic DATE Sept. 21, 2010 CHECKED BY NRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED												
261.9	GROUND SURFACE							20	40	60	80	100								
0.0	Silty sand, trace organic matter (TOPSOIL)																			
261.7	Dark brown																			
0.2	Silty SAND, trace gravel																			
	Compact																			
	Brown																			
	Moist																			
260.5			1	SS	28		261													
1.4	Silty SAND, trace gravel																			
	Compact to very dense																			
	Grey-brown		2	SS	17		260													
	Moist																			
			3	SS	39		259													
			4	SS	77		258													
257.9																				
4.0	Silty SAND, some gravel and cobbles, trace small boulders and clay (TILL)		5	SS	91		257													
	Dense to very dense																			
	Grey-brown																			
	Moist		6	SS	49		256													
256.6																				
5.3	Silty SAND, some gravel, clay and cobbles, occasional boulder (TILL)		7	SS	43		255													
	Dense to very dense																			
	Grey																			
	Moist to wet		8	SS	52		254													
			9	SS	37												18 45 25 12			
			10	SS	>100															
253.7																				
8.2																				

Continued Next Page

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

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PROJECT <u>10-1121-0007</u>	<b>RECORD OF BOREHOLE No 10-16</b>	2 OF 2 <b>METRIC</b>
G.W.P. <u>4149-11-01</u>	LOCATION <u>N 4907368.7 ; E 390196.3</u>	ORIGINATED BY <u>HEC</u>
DIST <u>43</u> HWY <u>7</u>	BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>	COMPILED BY <u>JM</u>
DATUM <u>Geodetic</u>	DATE <u>Sept. 21, 2010</u>	CHECKED BY <u>NRL</u>

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE   LIQUID CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE	REMOULDED	W <sub>p</sub>	W		W <sub>L</sub>				
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	End of Borehole																				
	Note: 1. Water level in well screen at 3.3 m depth (Elev. 258.6 m) below ground surface on Sept. 24, 2010.  2. Water level in well screen at 3.0 m depth (Elev. 258.9 m) below ground surface on Oct. 16, 2010.  3. Water level in well screen at 1.5 m depth (Elev. 260.4 m) below ground surface on Dec. 13, 2010.  4. Water level in well screen at 1.1 m depth (Elev. 260.8 m) below ground surface on Apr. 26, 2011.																				

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PROJECT <u>10-1121-0007</u>				<b>RECORD OF BOREHOLE No 10-17</b>				1 OF 1 <b>METRIC</b>									
G.W.P. <u>4149-11-01</u>				LOCATION <u>N 4907318.1 ; E 390194.1</u>				ORIGINATED BY <u>HEC</u>									
DIST <u>43</u> HWY <u>7</u>				BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>									
DATUM <u>Geodetic</u>				DATE <u>Sept. 21, 2010</u>				CHECKED BY <u>NRL</u>									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
262.8	GROUND SURFACE						20	40	60	80	100						
0.0	Silty sand, with organic matter (TOPSOIL)																
262.6	Dark brown to black																
0.2	Silty SAND, trace gravel																
	Loose																
	Brown																
	Moist																
261.2			1	SS	9												
261.2	Silty SAND, some gravel, occasional cobble (TILL)																
1.6	Compact to very dense																
	Brown to grey-brown																
	Moist																
260.1			2	SS	13												
260.1	Silty SAND, some gravel, occasional cobble (TILL)																
2.7	Dense																
	Grey-brown																
	Moist																
258.5			3	SS	>100												
258.5	Silty SAND, some gravel, occasional cobble (TILL)																
4.3	Dense																
	Grey																
	Moist to wet																
255.7			4	SS	46												
255.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
4.3	Very dense																
	Grey																
	Moist to wet																
254.7			5	SS	49												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7			6	SS	>100												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7			7	SS	>100												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7			8	SS	74												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7			9	SS	>100												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7			10	SS	>100												
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																
	Moist to wet																
254.7																	
254.7	Silty SAND, some gravel and clay, some cobbles, occasional small boulders (TILL)																
8.1	Very dense																
	Grey																





<b>PROJECT</b> 10-1121-0007		<b>RECORD OF BOREHOLE No 10-18</b>		1 OF 1 <b>METRIC</b>	
<b>G.W.P.</b> 4149-11-01		<b>LOCATION</b> N 4907275.1 ; E 390226.4		<b>ORIGINATED BY</b> HEC	
<b>DIST</b> 43 <b>HWY</b> 7		<b>BOREHOLE TYPE</b> Power Auger, 105mm Diam. Solid Stem		<b>COMPILED BY</b> JM	
<b>DATUM</b> Geodetic		<b>DATE</b> Sept. 21, 2010		<b>CHECKED BY</b> NRL	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20 40 60 80 100					W <sub>p</sub> W W <sub>L</sub>				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED									
259.2	GROUND SURFACE																
0.0 259.0 0.2	Silty sand, some organic matter (TOPSOIL) Dark brown to black Silty SAND, trace gravel and clay Compact Brown Moist						259										
			1	SS	14												
							258										
			2	SS	10												
							257										
			3	SS	27												
256.4																	
2.8	Silty SAND, trace gravel Dense to very dense Brown Moist						256										
255.8			4	SS	63												
3.4	Silty SAND, some gravel, occasional cobble (TILL) Very dense to dense Grey-brown Moist						255										
			5	SS	49												
254.6																	
4.6	Silty SAND, some gravel and cobbles, trace clay, occasional boulder (TILL) Dense to very dense Grey Moist to wet						254										
			6	SS	50												
							253										
			7	SS	50												
			8	SS	>100												
							252										
251.8																	
7.4	End of Borehole Auger Refusal																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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PROJECT 10-1121-0007				RECORD OF BOREHOLE No 10-19				1 OF 1 METRIC									
G.W.P. 4149-11-01				LOCATION N 4907212.9 ; E 390218.3				ORIGINATED BY HEC									
DIST 43 HWY 7				BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM									
DATUM Geodetic				DATE Sept. 23, 2010				CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
262.7	GROUND SURFACE							20	40	60	80	100					
0.0	Sand, trace silt, some gravel, trace cobbles (FILL) Brown																
261.9							262										
0.8	Silty sand (FILL) Compact Grey-brown Moist		1	SS	12												
			2	SS	19		261										
260.4																	
2.3	Silty sand to sandy silt, some clay, trace gravel and cobbles (FILL) Loose to compact Grey-brown Moist		3	SS	6		260										
259.3																	
3.4	Gravelly Silty SAND, trace to some clay, occasional cobble (TILL) Very dense Grey-brown Moist		4	SS	25		259										
			5	SS	73												
			6	SS	>100		258										
257.2			7	SS	>100		257										
5.5	Silty SAND, some gravel, trace to some cobbles, occasional small boulder (TILL) Very dense Moist to wet		8	SS	80												
			9	SS	>100		256										
			10	SS	>100		255										
254.6																	
8.1	End of Borehole																

PROJECT <u>10-1121-0007</u>		<b>RECORD OF BOREHOLE No 10-21</b>		1 OF 1 <b>METRIC</b>														
G.W.P. <u>4149-11-01</u>		LOCATION <u>N 4907122.9 ; E 390247.3</u>		ORIGINATED BY <u>HEC</u>														
DIST <u>43</u> HWY <u>7</u>		BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>		COMPILED BY <u>JM</u>														
DATUM <u>Geodetic</u>		DATE <u>Sept. 23, 2010</u>		CHECKED BY <u>NRL</u>														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
256.6 0.0	GROUND SURFACE Silty sand, trace to some organic matter (FILL) Loose to compact Dark brown Moist																	
			1	SS	12													
255.2 1.4	SAND and SILT, trace gravel and clay Loose Dark brown Moist		2	SS	6													
			3	SS	6													
			4	SS	5													
253.1 3.5	SAND, trace gravel Dense Brown Moist		5	SS	31													
252.3 4.3	Silty SAND, some gravel and cobbles (TILL) Dense to very dense Brown to grey-brown Moist		6	SS	37													
			7	SS	60													
			8	SS	58													
249.9 6.7	Silty SAND, trace clay, trace to some gravel, occasional cobble and boulder (TILL) Dense to very dense Grey Moist to wet		9	SS	46													
			10	SS	52													
248.5 8.1	End of Borehole																	


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

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PROJECT		10-1121-0007		<b>RECORD OF BOREHOLE No 10-22</b>		1 OF 1 <b>METRIC</b>											
G.W.P.		4149-11-01		LOCATION		N 4907082.4 ; E 390288.5											
DIST		43 HWY 7		BOREHOLE TYPE		Power Auger, 105mm Diam. Solid Stem											
DATUM		Geodetic		DATE		Sept. 24, 2010											
				ORIGINATED BY		HEC											
				COMPILED BY		JM											
				CHECKED BY		NRL											
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 kN/m³	GR SA SI CL
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	25 50 75				
250.1	GROUND SURFACE						250										
0.0	Clayey silt, trace cobbles, with organic matter (TOPSOIL)																
249.6																	
0.5	Silty SAND, trace gravel Very loose to compact Grey-brown Wet		1	SS	3		249										
248.3			2	SS	25		248										
1.8	Silty SAND, trace to some gravel, trace clay, some cobbles (TILL) Very dense Grey Wet																
			3	SS	69												
			4	SS	56		247										
246.3																	
3.8	End of Borehole Auger Refusal																
	1. Water level in well screen at 0.3 m depth (Elev. 249.8 m) below ground surface on Oct. 6, 2010.																
	2. Water level in well screen at 0.3 m depth (Elev. 249.8 m) below ground surface on Oct. 16, 2010.																
	3. Water level in well screen at ground surface (Elev. 250.1 m) on Apr. 26, 2011.																

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

PROJECT <u>10-1121-0007</u>		<b>RECORD OF BOREHOLE No 10-24</b>				1 OF 1 <b>METRIC</b>											
G.W.P. <u>4149-11-01</u>		LOCATION <u>N 4906982.8 ; E 390329.2</u>				ORIGINATED BY <u>HEC</u>											
DIST <u>43</u> HWY <u>7</u>		BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>				COMPILED BY <u>JM</u>											
DATUM <u>Geodetic</u>		DATE <u>Sept. 23, 2010</u>				CHECKED BY <u>NRL</u>											
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)				
253.8 0.0	GROUND SURFACE Silty SAND and GRAVEL, some cobbles and boulders (TILL) Dense Brown Moist		1	SS	37	253											
			2	SS	41	252											
251.6 2.2	End of Borehole Auger Refusal																

PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-26			1 OF 1 METRIC											
G.W.P. 4149-11-01			LOCATION N 4907572.6 ; E 390217.2			ORIGINATED BY HEC											
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem			COMPILED BY JM											
DATUM Geodetic			DATE Sept. 20, 2010			CHECKED BY NRL											
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 kN/m³	GR SA SI CL
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W <sub>p</sub> W W <sub>L</sub>	25 50 75						
259.9	GROUND SURFACE																
0.0	Silty sand, with organic matter (TOPSOIL)																
0.2	Dark brown to black																
	Silty SAND, some gravel, trace clay																
	Compact to dense																
	Brown to grey-brown																
	Moist to wet																
259.7			1	SS	14		259										
			2	SS	39		258										
257.8																	
2.1	Silty SAND, some gravel, trace clay and cobbles (TILL)																
	Very dense																
	Grey-brown to brown		3	SS	>100		257										
	Wet																
256.8																	
3.1	Silty SAND, some gravel, trace clay, occasional cobble and small boulder (TILL)																
	Dense to very dense																
	Grey		4	SS	68		256										
	Wet																
			5	SS	46												
			6	SS	>100		255										
			7	SS	>100												
253.8							254										
6.1	End of Borehole																
	Note:																
	1. Well screen dry on Sept. 24, 2010.																
	2. Water level in well screen at 5.7 m depth (Elev. 254.2 m) below ground surface on Oct. 6, 2010.																
	3. Water level in well screen at 4.8 m depth (Elev. 255.1 m) below ground surface on Dec. 13, 2010.																
	4. Water level in well screen at 0.1 m depth (Elev. 259.8 m) below ground surface on Apr. 26, 2011.																

PROJECT 10-1121-0007			RECORD OF BOREHOLE No 10-27			1 OF 1 METRIC											
G.W.P. 4149-11-01			LOCATION N 4907506.3 ; E 390202.6			ORIGINATED BY HEC											
DIST 43 HWY 7			BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem			COMPILED BY JM											
DATUM Geodetic			DATE Sept. 22, 2010			CHECKED BY NRL											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
261.2	GROUND SURFACE																
0.0	Silty sand, trace to some organic matter (TOPSOIL) Dark brown to black																
260.8																	
0.4	Silty SAND, trace gravel and cobbles Loose Brown to grey-brown Moist		1	SS	7												
259.8																	
1.4	Silty SAND, trace to some clay and gravel Compact to loose Grey-brown Moist		2	SS	12												
			3	SS	12												
			4	SS	18												
			5	SS	8												
256.9																	
4.3	Silty SAND, trace to some clay and gravel, occasional cobble (TILL) Compact Grey Wet		6	SS	17												
			7	SS	20												
			8	SS	27												
254.5																	
6.7	End of Borehole																

PROJECT <u>10-1121-0007</u>		<b>RECORD OF BOREHOLE No 10-28</b>		1 OF 1 <b>METRIC</b>	
G.W.P. <u>4149-11-01</u>		LOCATION <u>N 4907530.4 ; E 390123.7</u>		ORIGINATED BY <u>HEC</u>	
DIST <u>43</u> HWY <u>7</u>		BOREHOLE TYPE <u>Power Auger, 105mm Diam. Solid Stem</u>		COMPILED BY <u>JM</u>	
DATUM <u>Geodetic</u>		DATE <u>Sept. 20, 2010</u>		CHECKED BY <u>NRL</u>	

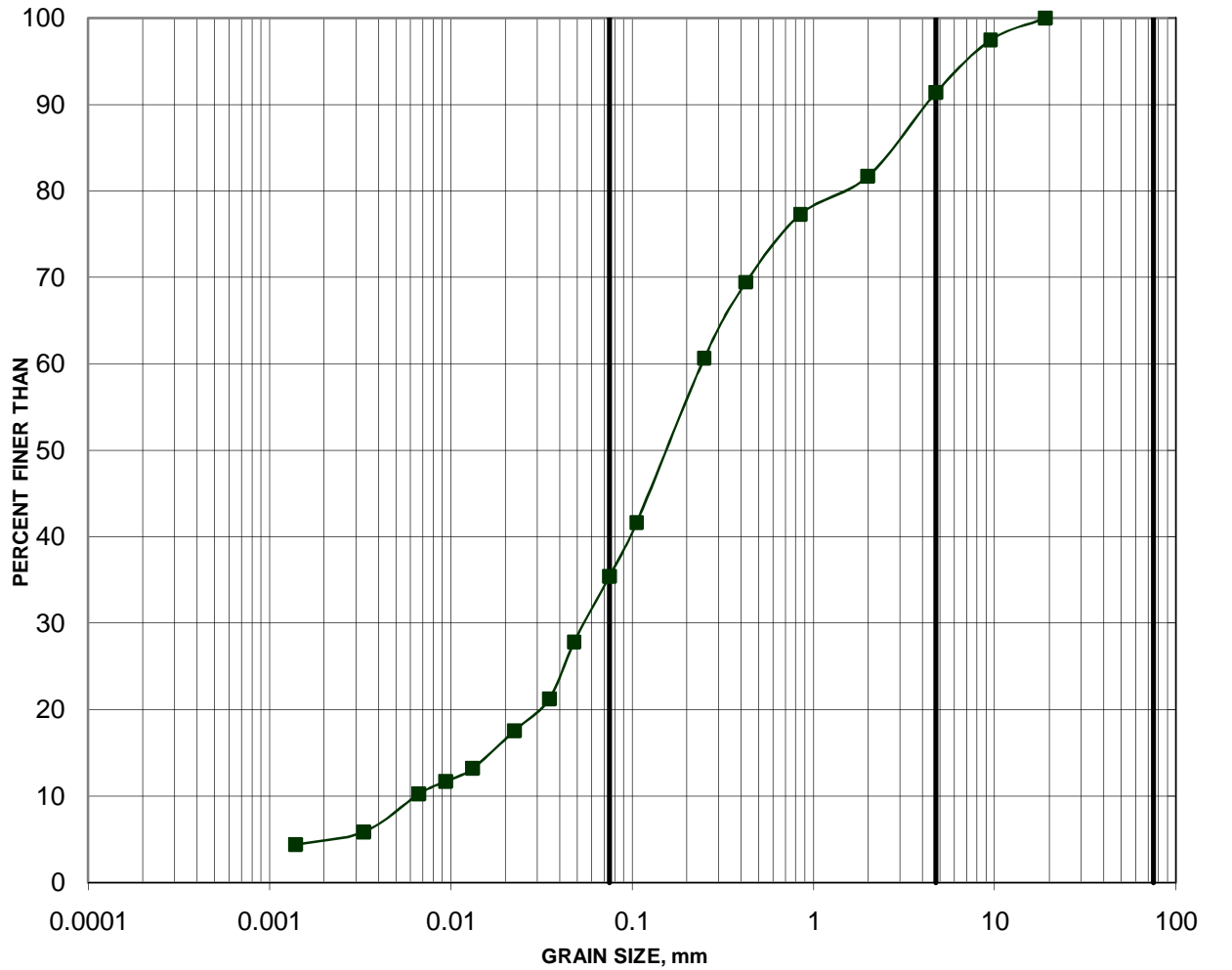
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	w <sub>p</sub>	w	w <sub>L</sub>						
269.3	GROUND SURFACE																				
0.0	Silty sand, with organic matter (TOPSOIL) Dark brown to black																				
268.7																					
0.6	Silty SAND, trace gravel, cobbles and boulders (TILL) Compact to very dense Brown Moist		1	SS	11																
			2	SS	>100																
267.4																					
1.9	End of Borehole Auger Refusal																				

PROJECT 10-1121-0007				RECORD OF BOREHOLE No 10-29				1 OF 1 METRIC									
G.W.P. 4149-11-01				LOCATION N 4907479.1 ; E 390107.4				ORIGINATED BY HEC									
DIST 43 HWY 7				BOREHOLE TYPE Power Auger, 105mm Diam. Solid Stem				COMPILED BY JM									
DATUM Geodetic				DATE Oct. 5, 2010				CHECKED BY NRL									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
274.6	GROUND SURFACE																
0.0	Silty sand, trace to some gravel (FILL) Brown																
273.8							274										
0.8	Gravelly silty sand, trace to some clay, trace organic matter (FILL) Compact Dark brown Moist		1	SS	10												
273.2																	
1.4	Gravelly Silty SAND, trace to some clay Compact Brown Moist		2	SS	23		273										
			3	SS	19		272										22 49 23 6
271.5																	
3.1	Silty SAND, some gravel, occasional cobble (TILL) Dense to very dense Brown Moist		4	SS	37		271										
			5	SS	38												
			6	SS	45		270										
			7	SS	>100		269										
268.5																	
6.1	End of Borehole																

# GRAIN SIZE DISTRIBUTION

FIGURE A1

## Silty Sand, trace gravel and clay (FILL)



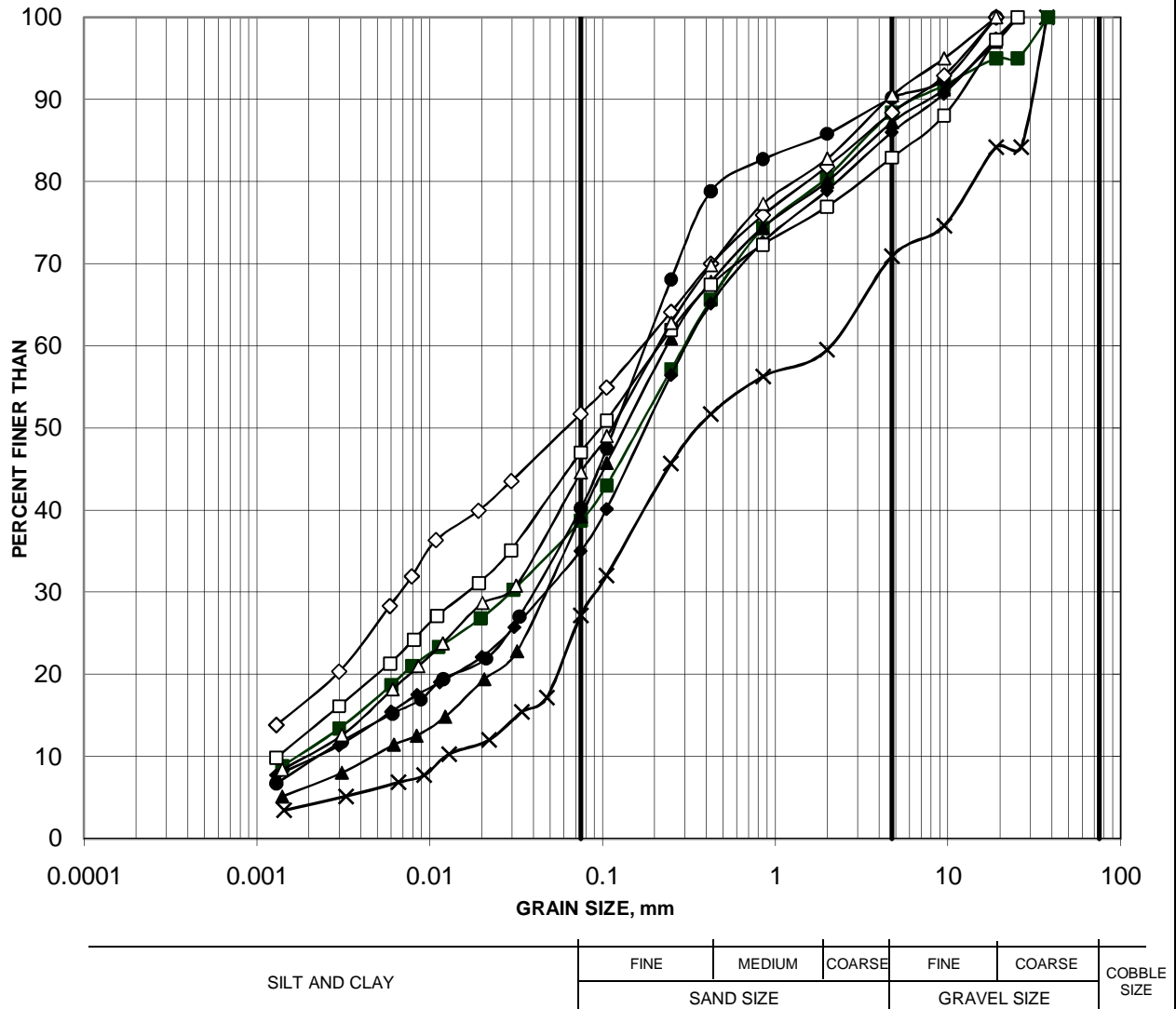
SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
10-2	1	0.76-1.37

# GRAIN SIZE DISTRIBUTION

FIGURE A2

**Silty SAND, trace to some gravel, trace clay**

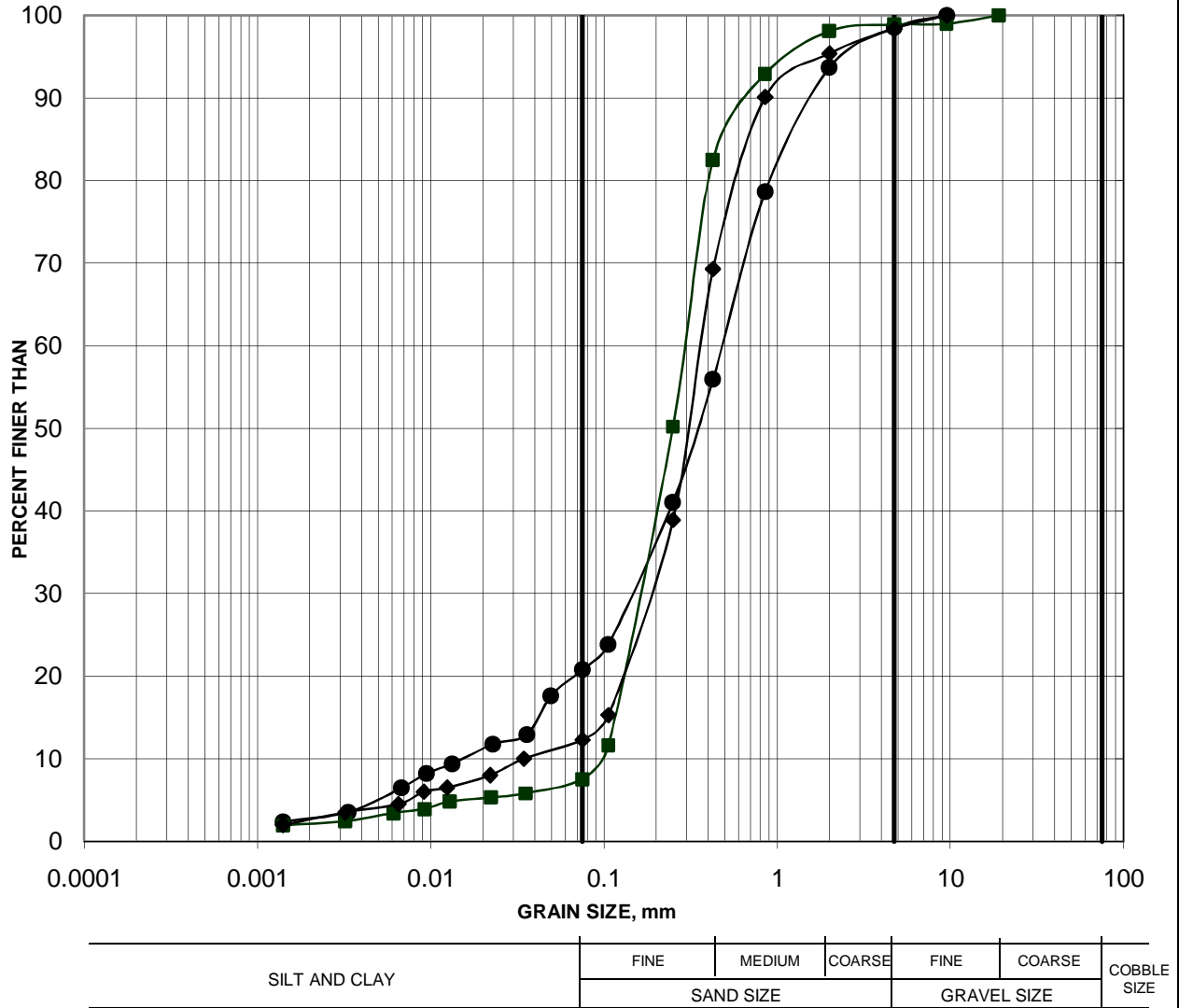


Borehole	Sample	Depth (m)
✕ 10-1	1	0.76-1.37
■ 10-4	1	0.76-1.37
◆ 10-11	3	2.29-2.90
▲ 10-12	9	6.86-7.47
● 10-13	2	1.50-2.10
□ 10-14	4	3.05-3.66
◇ 10-15	3	2.29-2.90
△ 10-27	2	1.52-2.13

# GRAIN SIZE DISTRIBUTION

FIGURE A3

**SAND, trace to some silt, trace gravel and clay**

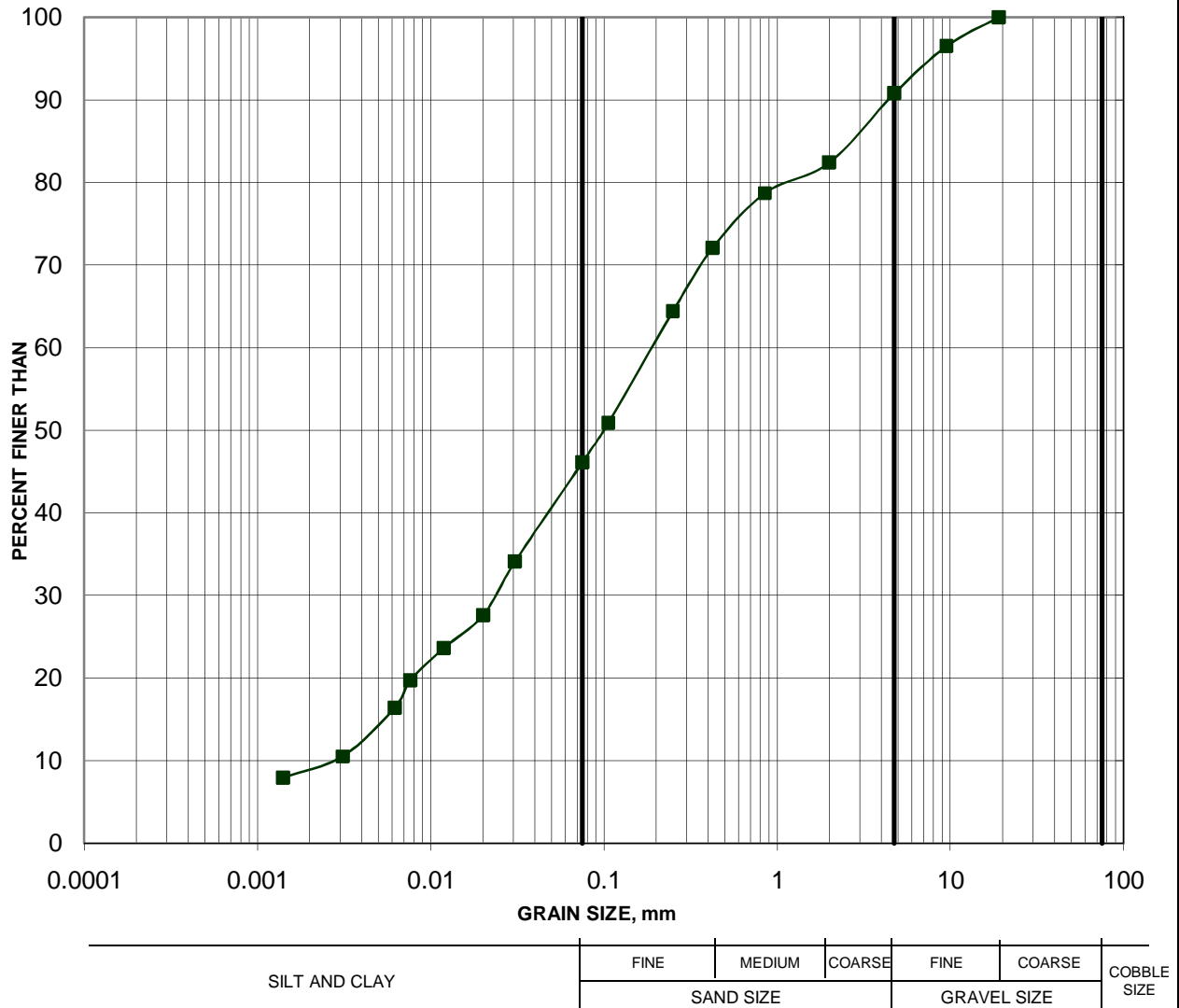


Borehole	Sample	Depth (m)
10-2	2A	1.88-2.13
10-9	8	6.10-6.71
10-13	6	4.57-5.18

# GRAIN SIZE DISTRIBUTION

FIGURE A4

## SAND and SILT, trace gravel and clay

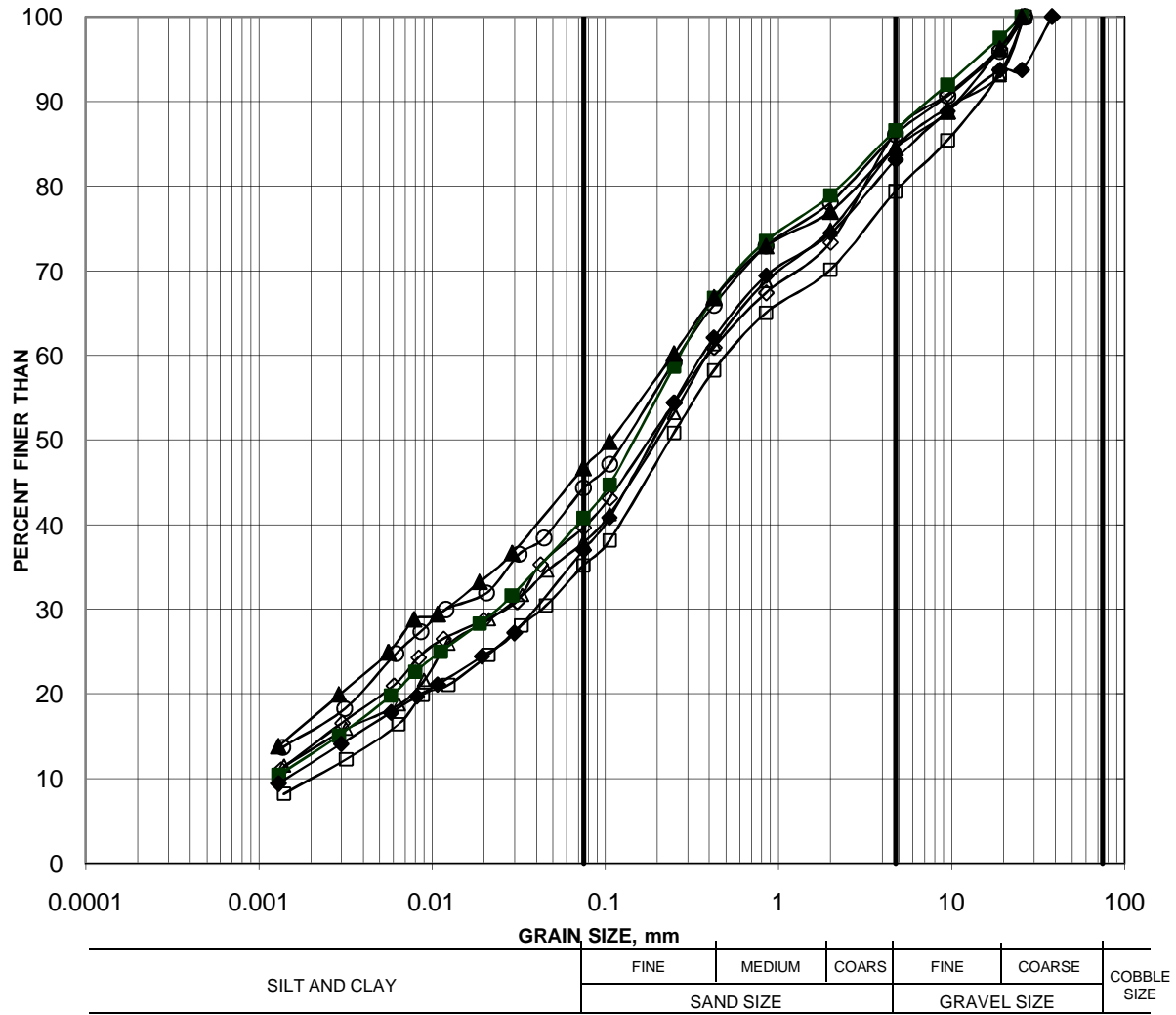


Borehole	Sample	Depth (m)
10-21	3	2.13-2.74

# GRAIN SIZE DISTRIBUTION

FIGURE A5

## Silty SAND, some gravel and clay (TILL)

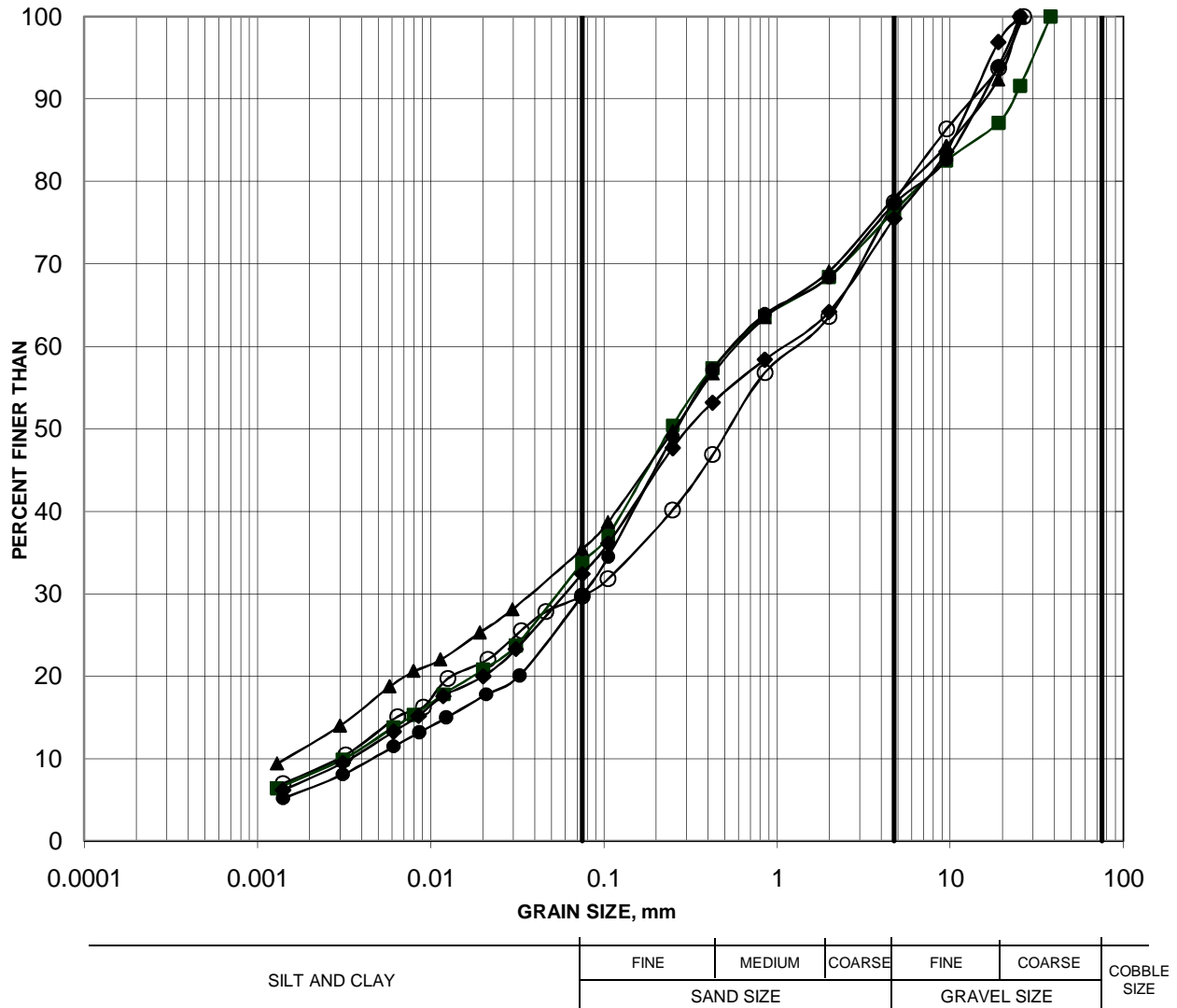


Borehole	Sample	Depth (m)
□ 10-1	6	4.57-5.18
○ 10-2	9	6.86-7.47
◇ 10-3	7	5.34-5.95
△ 10-3	11	8.38-8.69
■ 10-6	6	4.57-5.18
◆ 10-16	9	6.86-7.47
▲ 10-17	5	3.81-4.42

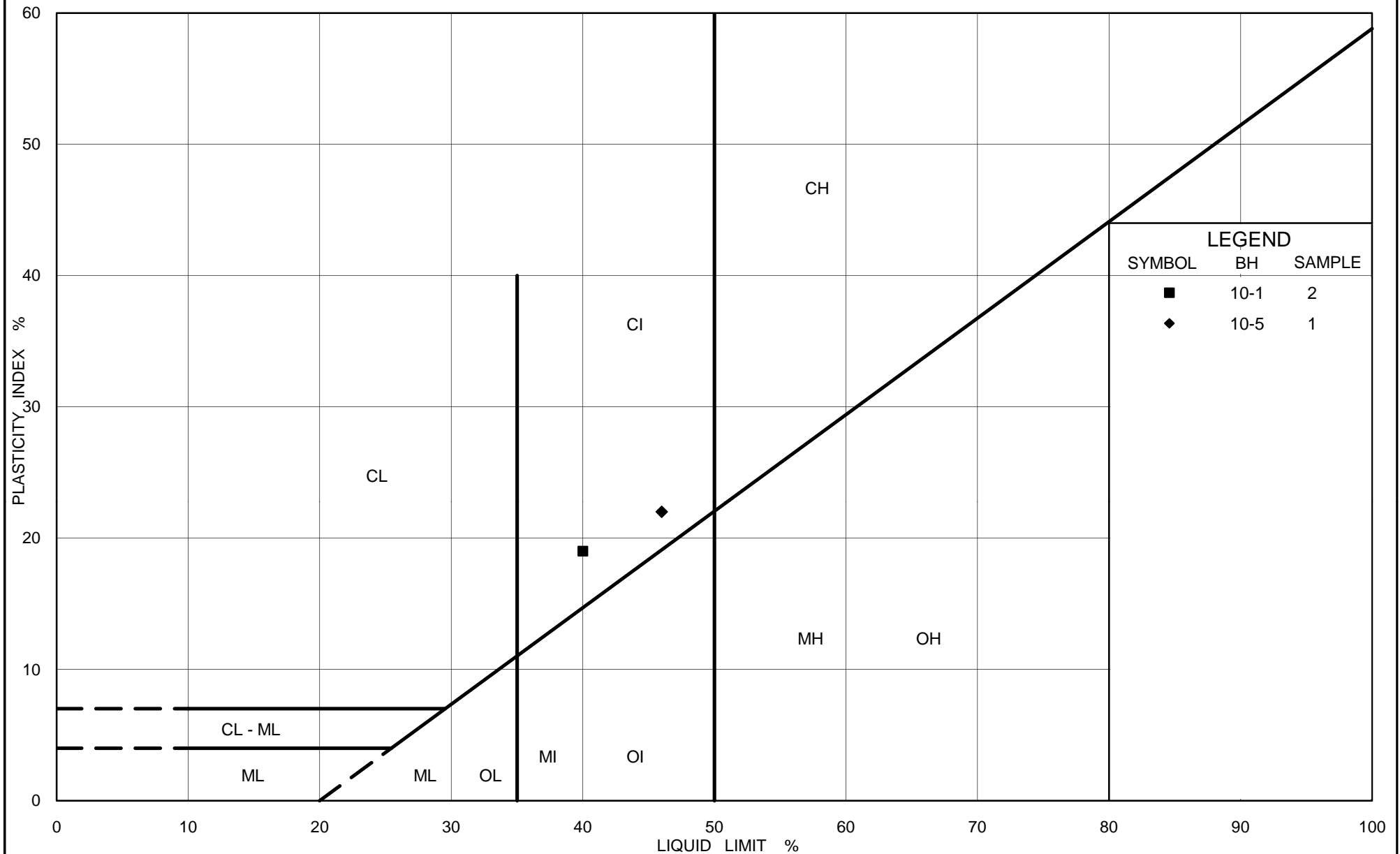
# GRAIN SIZE DISTRIBUTION

FIGURE A6

## Gravelly Silty SAND, trace clay (TILL)



Borehole	Sample	Depth (m)
—○— 10-2	13	9.91-10.37
—■— 10-7	7	5.33-5.94
—▲— 10-19	5	3.81-4.42
—◆— 10-23	6	4.57-5.03
—●— 10-29	3	2.29-2.90



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## PLASTICITY CHART

### Silty Clay

FIG No. A7

Project No. 10-1121-0007-3

Chk by : CNM



# APPENDIX B

## Record of Borehole Sheets and Detailed Laboratory Test Results, Previous Investigations



## **GOLDER ASSOCIATES**

**Foundation Investigation and Design, Preliminary Design,  
High Fill and Swamp Areas, Highway 7 from Fowlers Corners,  
Southerly to County Road 15, Peterborough, Ontario,  
G.W.P. 73-99-00, dated March 2008  
Project # 04-1111-024E**

PROJECT 04-1111-024E			RECORD OF BOREHOLE No 06-11			1 OF 2 METRIC														
W.P. 73-99-00			LOCATION N 4907547.0 ; E 390222.4			ORIGINATED BY SB														
DIST _____ HWY 7			BOREHOLE TYPE Power Auger, 101 mm O.D. Solid Stem Augers			COMPILED BY DD														
DATUM Geodetic			DATE July 10, 2006			CHECKED BY SLP														
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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>			γ	GR	SA	SI	CL
265.7	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT																			
	Sand and gravel, trace to some silt, trace clay (FILL) Compact to very dense Brown Moist		1	SS	63		265													
	Obstruction (inferred boulder) at 2.7m depth		2	SS	40		264													
			3	SS	77/25		263						○							
			4	SS	32		262													
			5	SS	16		261						○							
259.9	SAND and GRAVEL, trace silt, trace organics Compact Grey to black Wet		6	SS	13		260							○						
5.8							259													
258.4	SILTY SAND, some gravel, trace to some clay, contains cobbles and boulders (TILL) Compact to very dense Grey Moist to wet		7	SS	13		258							○						
7.3			8	SS	64/15		257													
			9	SS	100/10		256						○							
			10	SS	92/15		255													
253.4							254													
12.3													○							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 04-1111-024.GPJ GAL-MISS.GDT 3/7/08 DD



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3</sup>% STRAIN AT FAILURE

MIS-MTO 001 04-1111-024.GPJ GAL-MISS.GDT 3/7/08 DD

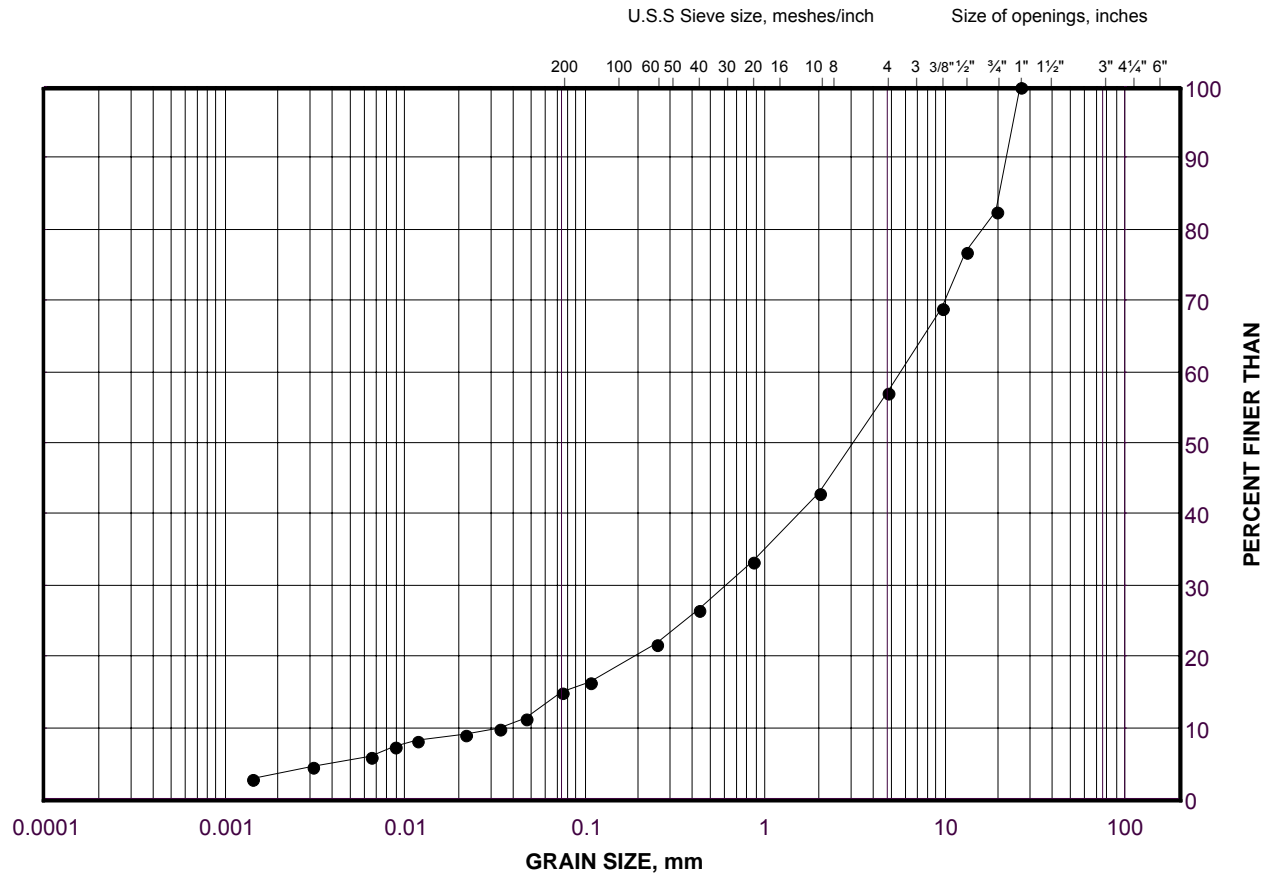
PROJECT 04-1111-024E			RECORD OF BOREHOLE No 06-12			1 OF 1 METRIC																						
W.P. 73-99-00			LOCATION N 4907501.9; E 390114.3			ORIGINATED BY SB																						
DIST _____ HWY 7			BOREHOLE TYPE Power Auger, 101 mm O.D. Solid Stem Augers			COMPILED BY DD																						
DATUM Geodetic			DATE July 31, 2006			CHECKED BY SLP																						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	20	40	60	80	100	10	20	30	γ	GR	SA	SI	CL
275.1	GROUND SURFACE																											
8.9	ASPHALT						275																					
	Sand with gravel, some silt, trace organics (FILL) Loose to very dense Brown Moist		1	SS	50/1		274																					
			2	SS	62		273																					
			3	SS	9		272																					
272.2	SILTY SAND and GRAVEL, trace to some clay, trace organics Compact Brown Moist		4	SS	21		271																					
2.9							270																					
270.8	SILTY SAND, trace to some gravel, trace to some clay, contains sand and gravel interlayers, cobbles and boulders (TILL) Dense to very dense Brown Moist to wet		5	SS	38		269																					
4.3			6	SS	104		268																					
			7	SS	50/08		267																					
			8	SS	53/15		266																					
265.8	End of Borehole																											
9.3	Notes:  1. Water first encountered during drilling at 9.1 m depth (Elevation 266.0 m).  2. Borehole caved to 8.1 m depth and water level measured at 7.9 m depth (Elevation 267.2 m) upon completion of drilling.																											

MIS-MTO 001 04-1111-024.GPJ GAL-MISS.GDT 3/7/08 DD

# GRAIN SIZE DISTRIBUTION

Sand and Gravel (Fill)

FIGURE B1



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	06-11	4	262.3

Project Number: 04-1111-024E

Checked By: \_\_\_\_\_

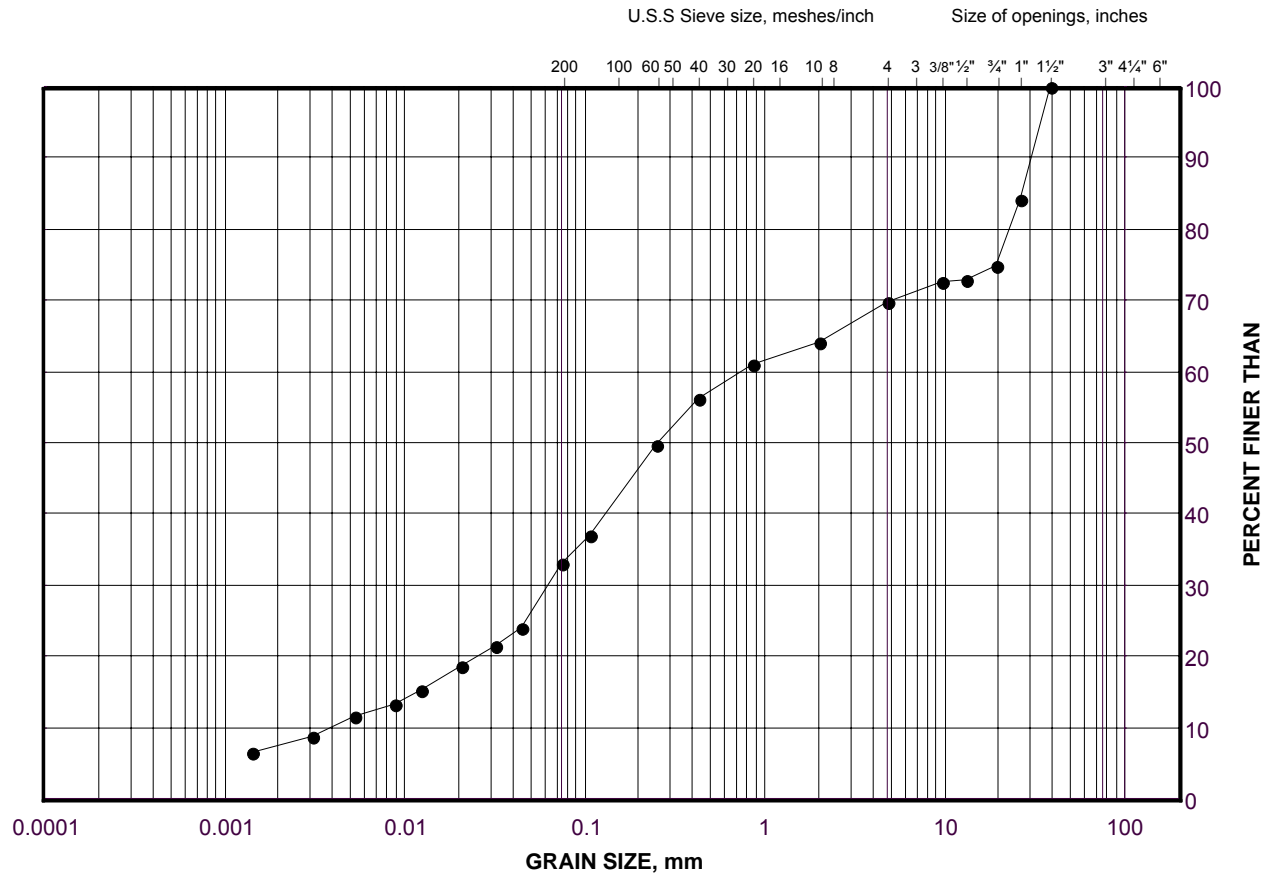
**Golder Associates**

Date: 12-Dec-11

# GRAIN SIZE DISTRIBUTION

Silty Sand and Gravel

FIGURE B2



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	06-12	4	268.7

Project Number: 04-1111-024E

Checked By: \_\_\_\_\_

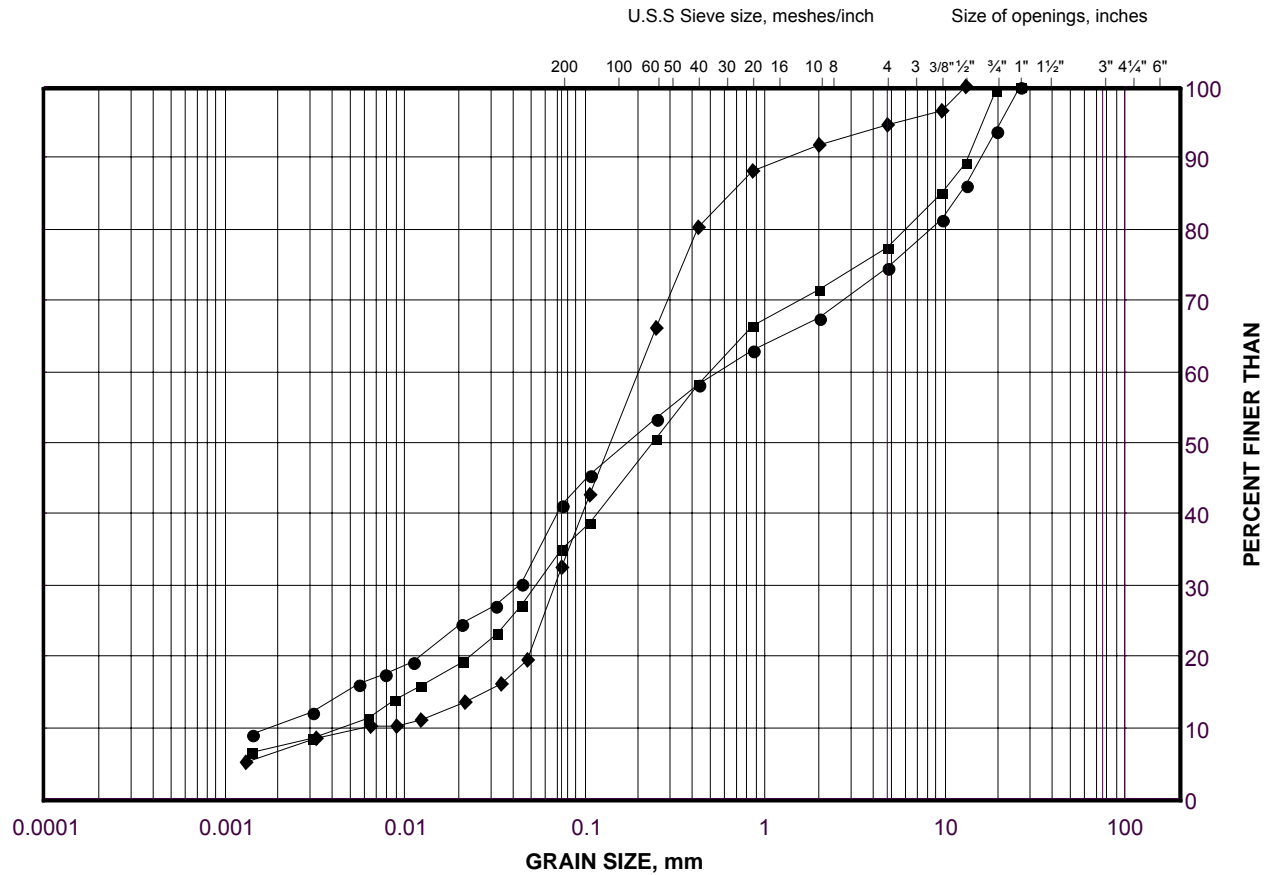
**Golder Associates**

Date: 12-Dec-11

# GRAIN SIZE DISTRIBUTION

Silty Sand (Till)

FIGURE B3



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	06-12	6	265.9
■	06-11	7	257.8
◆	06-12	8	263.1

Project Number: 04-1111-024E

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 12-Dec-11



## **GOLDER ASSOCIATES**

**Foundation Investigation and Design, Preliminary Design,  
Recreational Trail Culvert, Highway 7 from Fowlers Corners,  
Southerly to County Road 28, Peterborough, Ontario,  
G.W.P. 73-99-00, Site No. 26-35", dated June 2007  
Project # 04-1111-024B**

PROJECT 04-1111-024B			RECORD OF BOREHOLE No 06-13			1 OF 1 METRIC											
W.P. 73-99-00			LOCATION N 4907829.8 ; E 390031.5			ORIGINATED BY SB											
DIST HWY 7			BOREHOLE TYPE Power Auger, 107 mm O.D. Solid Stem Augers			COMPILED BY DD											
DATUM Geodetic			DATE July 10, 2006			CHECKED BY SLP											
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 kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	Wp	W	WL	20 40 60 80 100	10 20 30				
268.4	GROUND SURFACE																
0.0	Sand, trace gravel (FILL) Very loose Brown Moist		1	SS	3		268										
266.9							267										
1.5	CLAYEY SILT, trace organics AND FIBROUS PEAT, trace sand Very soft Brown and grey to black Moist		2	SS	WH												
266.1							266										
2.3	CLAYEY SILT, trace to some sand and gravel Stiff Brown and grey Moist		3	SS	10												
			4	SS	9		265										
264.1							264										
4.3	SILTY SAND, some gravel Compact Brown Wet		5	SS	10												
							263										
262.6							262										
5.8	SILTY SAND, trace to some clay and gravel, contains sand and gravel interlayers, cobbles and boulders (TILL) Very dense Grey Moist		6	SS	80												
							261										
			7	SS	55												
							260										
259.1			8	SS	65/0.15												
9.3	End of Borehole																
Notes:																	
1. Water level measured in piezometer at 8.7 m depth (Elevation 259.7 m) upon completion of installation.																	
2. Water level measured in piezometer at 7.2 m depth (Elevation 261.2 m) on July 11, 2006.																	
3. Water level measured in piezometer at 1.7 m depth (Elevation 266.7 m) on July 31, 2006.																	
4. Water level measured in piezometer at 2.1 m depth (Elevation 266.3 m) on August 18, 2006.																	

MIS-MTO 001 04-1111-024.GPJ GAL-MISS.GDT 6/12/07 DD

PROJECT 04-1111-024B			RECORD OF BOREHOLE No 06-14			1 OF 1 METRIC																	
W.P. 73-99-00			LOCATION N 4907829.5 ; E 389997.4			ORIGINATED BY SB																	
DIST _____ HWY 7			BOREHOLE TYPE Power Auger, 107 mm O.D. Solid Stem Augers			COMPILED BY DD																	
DATUM Geodetic			DATE July 11, 2006			CHECKED BY SLP																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	20 40 60 80 100	20 40 60 80 100	10 20 30	γ	GR SA SI CL						
268.3	GROUND SURFACE																						
0.0	Sand, trace gravel and silt (FILL) Loose to compact Brown Moist		1	SS	10		268																
266.8	CLAYEY SILT, some sand, trace gravel Soft to stiff Brown and grey Moist to wet		2	SS	4		267																
1.5			3	SS	11		266																
265.3	SILTY SAND, trace to some gravel and clay Loose Brown and grey Moist to wet		4	SS	8		265																
3.1							264																
263.7	SILTY SAND, some gravel contains cobbles and boulders (TILL) Very dense Brown and grey Moist		5	SS	70		263										29 32 32 7						
4.6							262																
262.2	CLAYEY SILT, with sand, trace gravel, contains cobbles and boulders (TILL) Hard Grey Moist		6	SS	76/0.15		261																
6.1			7	SS	70/0.15		260										4 47 32 17						
259.0	End of Borehole		8	SS	80/0.15																		
9.3	Notes:  1. Water level measured in piezometer at 7.3 m depth (Elevation 261.0 m) on upon completion of installation.  2. Water level measured in piezometer at 1.6 m depth (Elevation 266.7 m) on July 31, 2006.  3. Water level measured in piezometer at 1.8 m depth (Elevation 266.5 m) on August 18, 2006.																						

MIS-MTO 001 04-1111-024.GPJ GAL-MISS.GDT 6/12/07 DD

Order No.: S-500/T-852 RACEY, MACCALLUM AND ASSOCIATES

LIMITED

Barley  
Driller

Hole Begun \_\_\_\_\_ Foundation Engineering Division

Hole Ended \_\_\_\_\_ Engineering Data Sheet for Borehole: 57-1

Helper

Job Name: C.N.R. Overhead

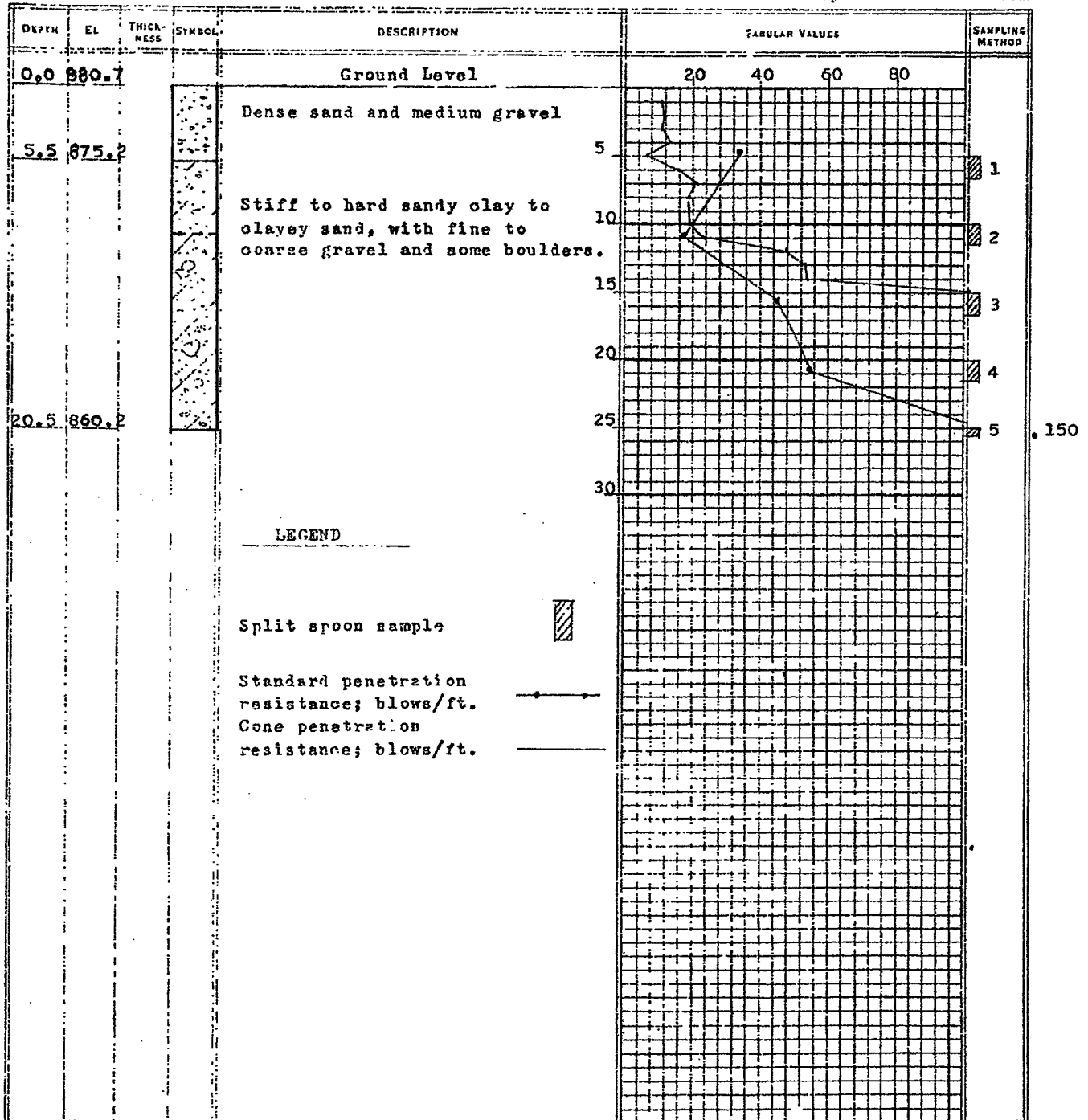
J.S.

Job Located: Highway 133, Peterborough, Ontario

Checked by

Hole Located: See enclosure No. 1

Hole Elevation: 880.7 Datum: M.S.L.

3 9 57  
Day Month Year

Order No.: E-500/T-652 RACEY, MACCALLUM AND ASSOCIATES  
LIMITED

Vidal

Driller

Hole Begun \_\_\_\_\_ Foundation Engineering Division

Hole Ended \_\_\_\_\_ Engineering Data Sheet for Borehole: 57-3

Helper

Job Name: C.N.R. Overhead

J.S.

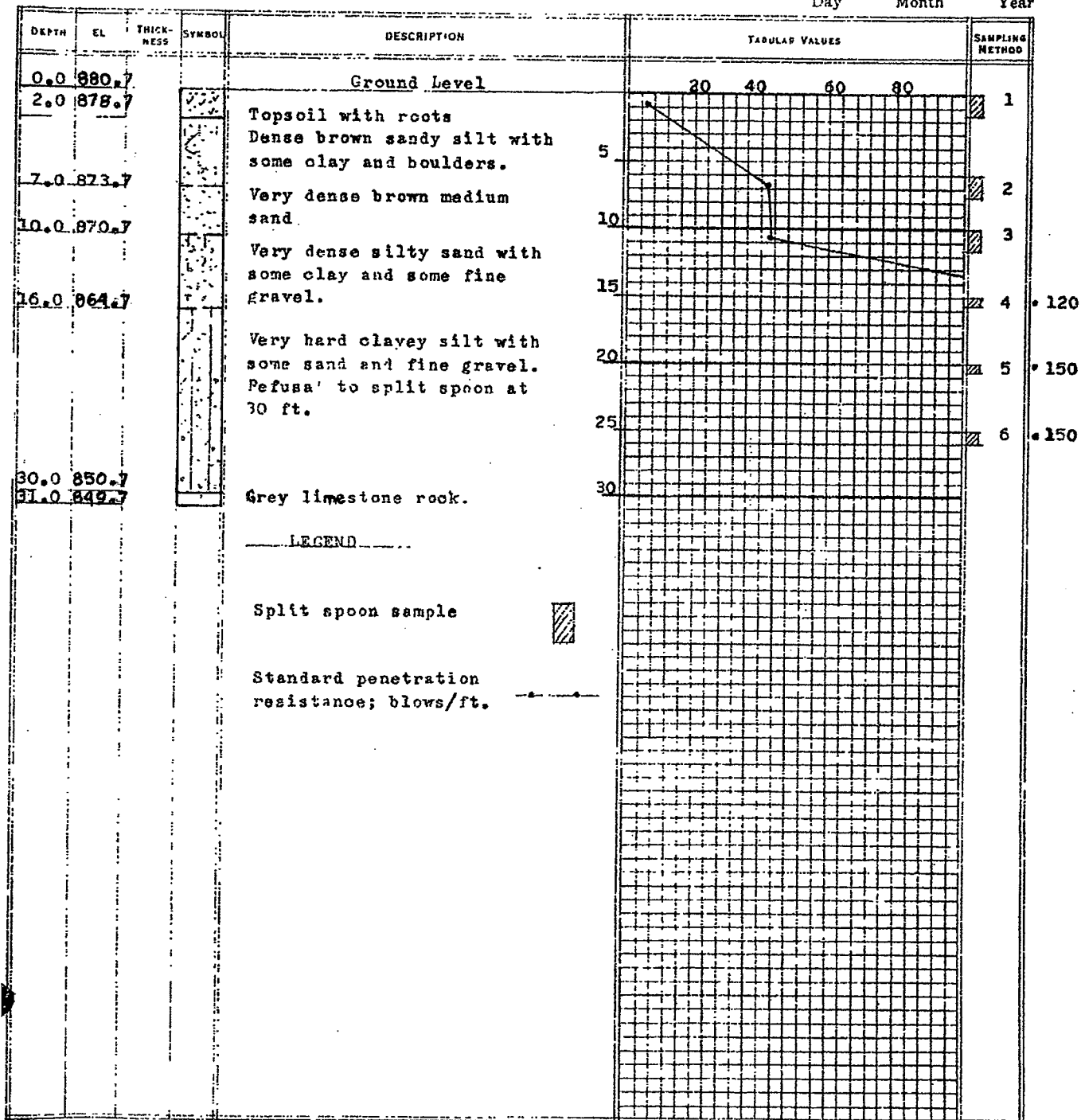
Job Located: Highway 133, Peterborough, Ontario

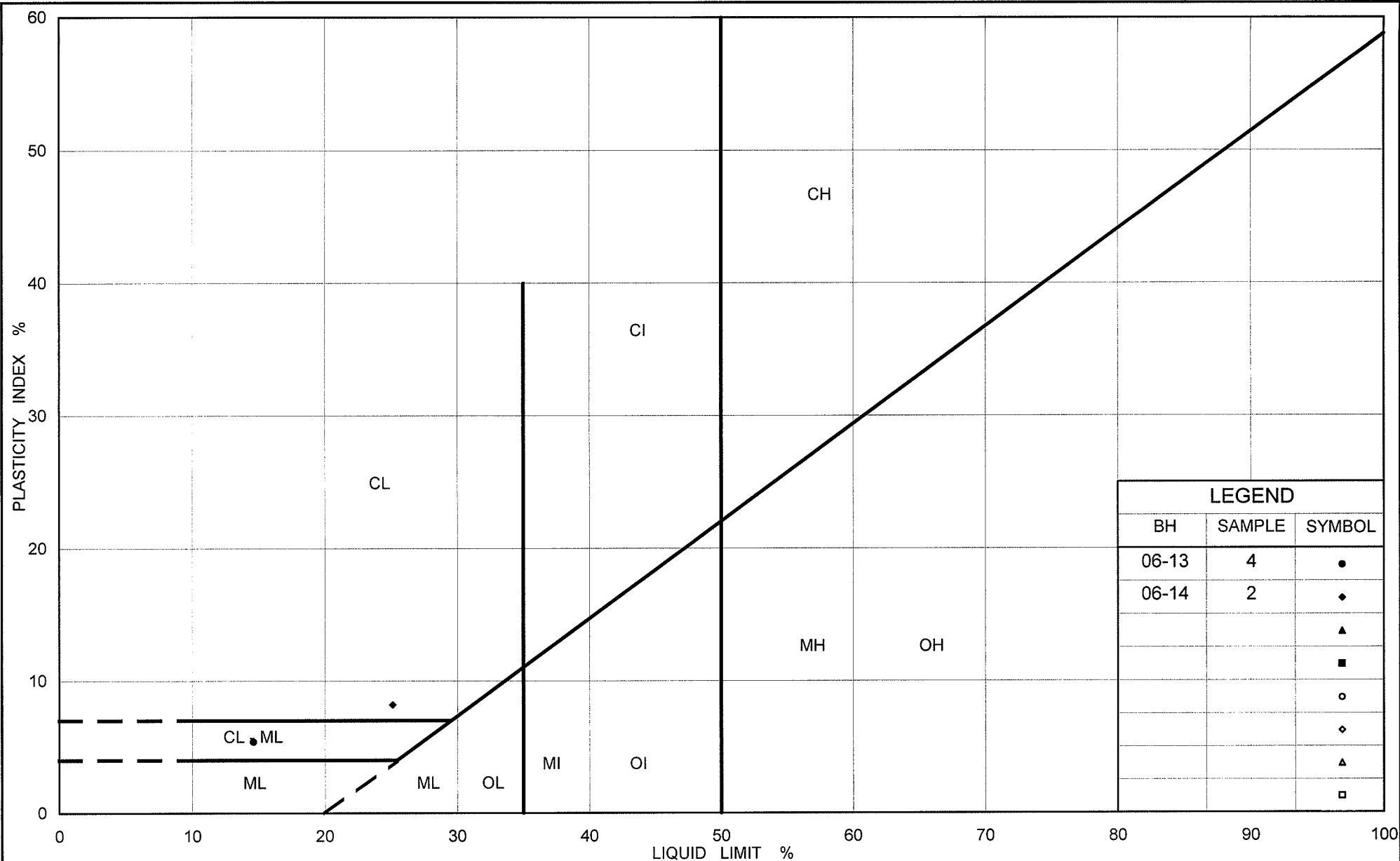
Checked by

Hole Located: See enclosure No. 1

Hole Elevation: 880.7 Datum: M.S.L.

3 9 57  
Day Month Year





Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt

FIG No. A1

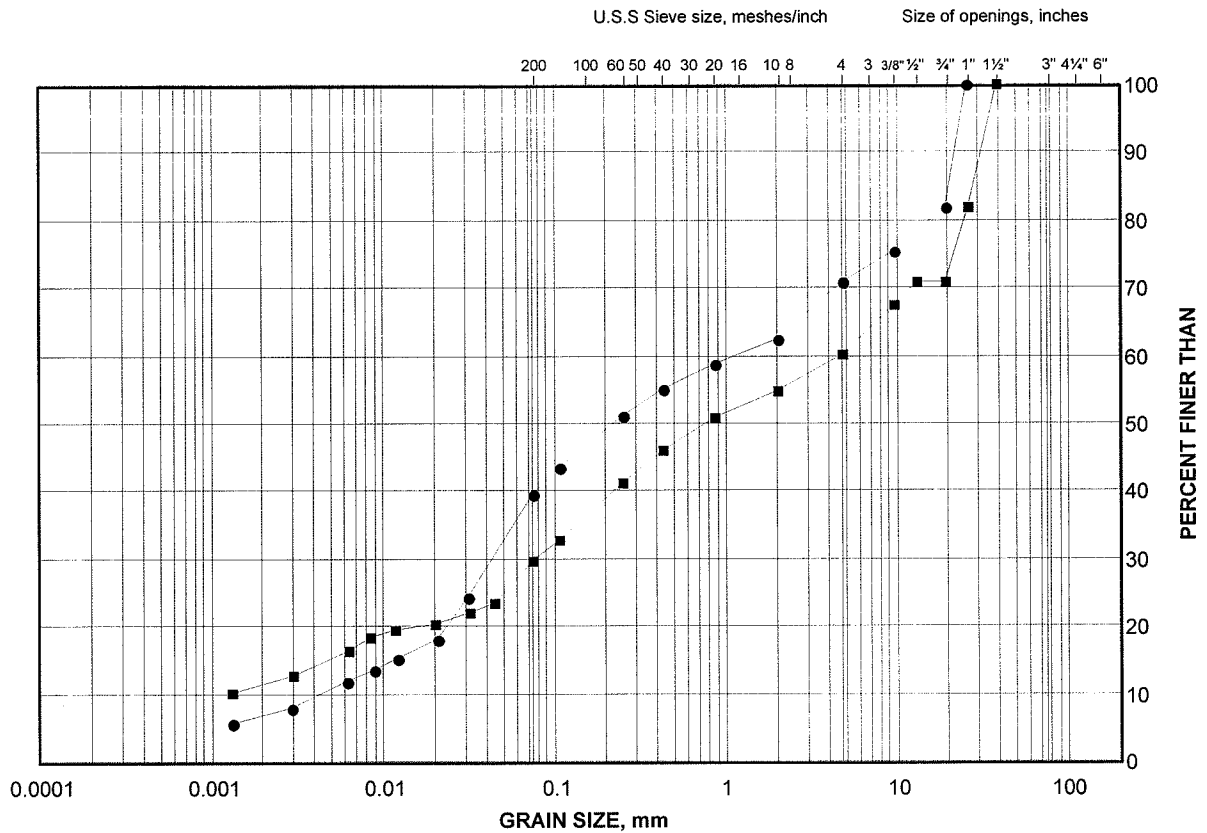
Project No. 04-1111-024B

Checked by: *ASB*

# GRAIN SIZE DISTRIBUTION

Silty Sand (Till)

FIGURE A2



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	06-14	5	263.4
■	06-13	6	262.0

Project Number: 04-1111-024B

Checked By: KTB

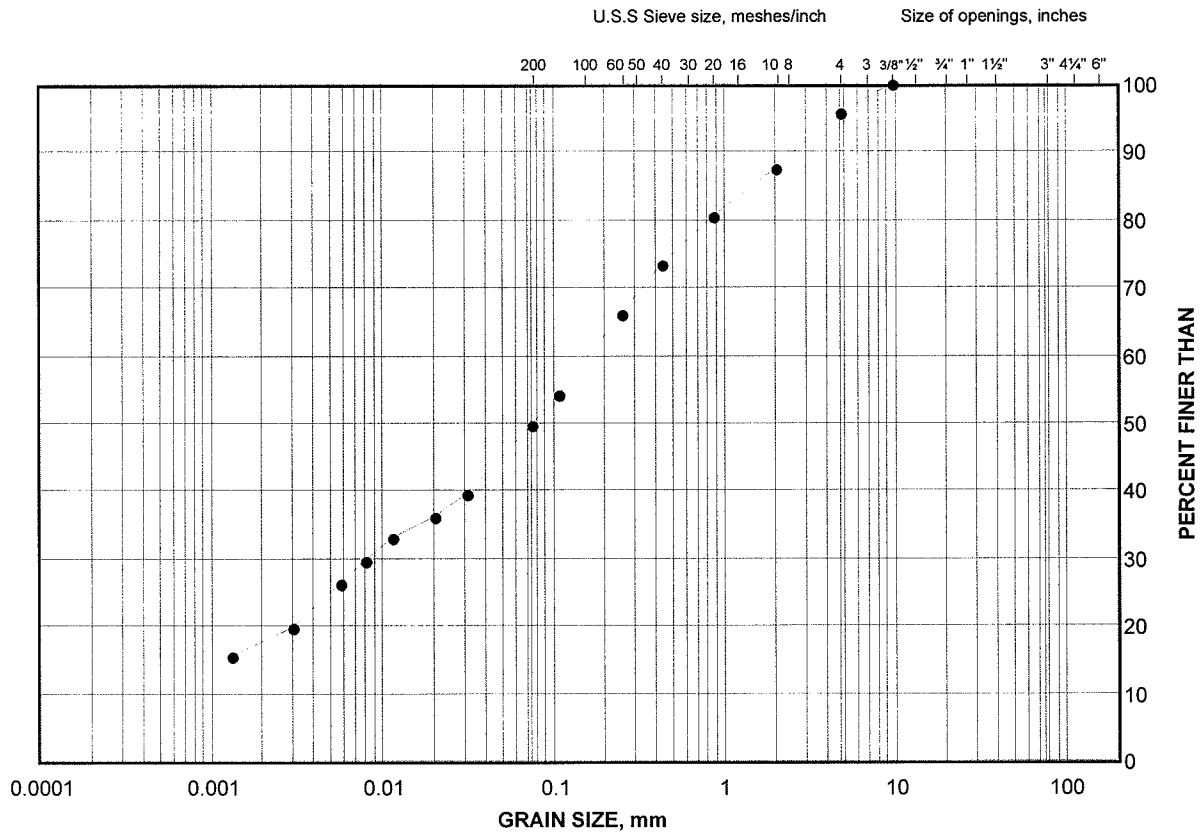
Golder Associates

Date: 19-Feb-07

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)

FIGURE A3



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

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	06-14	7	260.7

Project Number: 04-1111-024B

Checked By: *KTB*

Golder Associates

Date: 19-Feb-07



# APPENDIX C

## Non-Standard Special Provision



### DEWATERING

---

Non-Standard Special Provision

---

#### Scope

Excavations for the new culvert extensions for the existing culvert near Station 9+865 along Lily Lake Road could extend below the surficial groundwater level at the site. Cohesionless (sand to silty sand) soils that are present below the groundwater table could slough, run or cave in to the excavation unless appropriate groundwater control is in place. Depending on where the surficial groundwater level is at with respect to the depth of excavation at the time of construction, unwatering will be required during the construction of the culvert to minimize groundwater inflow into the excavation and construction area as well as to ensure construction is carried out in dry conditions. The Contractor is to design and install an appropriate unwatering system for the culvert site to prevent disturbance of the founding soils and enable construction in dry conditions.

#### References

OPSS 517 Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation

OPSS 518 Construction Specification for Control of Water from Dewatering Operations

#### Submission and Design Requirements

A dewatering plan providing written details and shop drawings for the proposed dewatering system shall be submitted to the Contract Administrator for information purposes. This dewatering plan shall be submitted to the Contract Administrator a minimum of ten business days prior to commencing dewatering operations. The Contractor shall reference borehole logs included in the contract documents as a guide in determining requirements.

#### Construction

##### Dewatering System

The Contractor is responsible for the design, installation, operation, and maintenance of temporary dewatering systems to lower the groundwater level in the underlying silty sand stratum to at least 0.5 m below the bottom of the excavations to allow excavation, foundation subgrade preparation, and foundation construction to be carried out in a safe condition.

Water pumped from the system should be discharged in a manner that is not injurious to public health or safety, to property, to the environment, or to any part of the work already completed or under construction.

##### Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment, and materials for completion of the work.

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

[solutions@golder.com](mailto:solutions@golder.com)  
[www.golder.com](http://www.golder.com)

**Golder Associates Ltd.**  
**32 Steacie Drive**  
**Kanata, Ontario, K2K 2A9**  
**Canada**  
**T: +1 (613) 592 9600**

