



AUGUST 2009

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

**CULVERTS
HIGHWAY 427 EXTENSION (NBL AND SBL)
FROM HIGHWAY 7 TO MAJOR MACKENZIE DRIVE
MINISTRY OF TRANSPORTATION, ONTARIO
W.O. 05-20012**

Submitted to:
McCormick Rankin Corporation
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

REPORT

GEOCREs No: 30M13-176

Report Number: 06-1111-012-10

Distribution:

- 3 Copies - Ministry of Transportation, Ontario, Downsview, Ontario, (Central Region)
- 1 Copy - Ministry of Transportation, Ontario, Downsview, Ontario (Foundation Section)
- 2 Copies - McCormick Rankin Corporation, Mississauga, Ontario
- 2 Copies - Golder Associates Ltd. Mississauga, Ontario



**A world of
capabilities
delivered locally**





Table of Contents

PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
3.0 INVESTIGATION PROCEDURES	2
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	2
4.1 Regional Geology	2
4.2 Subsurface Conditions	3
4.2.1 Stream Crossings Immediately North of Highway 7	3
4.2.1.1 Topsoil / Asphalt / Fill	3
4.2.1.2 Surficial Silty Clay	4
4.2.1.3 Clayey Silt Till	4
4.2.1.4 Sand and Silt Till	4
4.2.1.5 Silt	5
4.2.1.6 Silty Clay to Clayey Silt	5
4.2.1.7 Clayey Silt Till (Lower Cohesive Till)	5
4.2.2 Culverts and Stream Crossings Between Langstaff Road and Major Mackenzie Drive	5
4.2.2.1 Topsoil	6
4.2.2.2 Surficial Silty Clay to Clayey Silt	6
4.2.2.3 Silty Clay to Clayey Silt Till	7
4.2.3 Groundwater Conditions	7
5.0 CLOSURE	8

PART B – PRELIMINARY FOUNDATION DESIGN REPORT

6.0 PRELIMINARY ENGINEERING RECOMMENDATIONS	9
6.1 Foundations for Culverts	9
6.1.1 Founding Elevations and Subexcavation Requirements	9
6.1.1.1 Open Footing Culvert and Retaining Walls	9
6.1.1.2 Box Culvert	11
6.1.2 Geotechnical Resistance	12



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

6.1.2.1	Open Footing Culvert and Retaining Walls	12
6.1.2.2	Box Culvert	12
6.1.3	Resistance to Lateral Loads / Sliding Resistance.....	12
6.1.4	Frost Protection	13
6.1.5	Stability.....	13
6.1.6	Settlement	14
6.2	Culvert Bedding, Backfill and Erosion Protection	14
6.3	Lateral Earth Pressures for Design	15
6.3.1	Seismic Considerations	16
6.4	Detail Design and Construction Considerations.....	17
6.4.1	Additional Investigation Requirements	17
6.4.2	Excavation.....	18
6.4.3	Groundwater and Surface Water Control for Foundation Excavation.....	18
6.4.4	Subgrade Preparation	18
7.0	CLOSURE	19

REFERENCES

LIST OF TABLES

Table 1	Open Footing Culvert Founding Elevations - Subexcavation Requirements and Geotechnical Resistances WO 05-20012
Table 2	Box Culvert Founding Elevations – Subexcavation Requirements and Geotechnical Resistance WO 05-20012

LIST OF DRAWINGS

Drawing 1	Highway 427 Extension – Stream Crossings at Stations 10+050 and 10+100 Borehole Locations and Soil Strata
Drawing 2	Highway 427 Extension – Culverts at Stations 13+025 and 13+560, Stream Crossings at Stations 13+300 and 13+640 – Borehole Locations
Drawing 3	Highway 427 Extension – Culverts at Stations 13+025 and 13+560, Stream Crossings at Stations 13+300 and 13+640– Soil Strata
Drawing 4	Highway 427 Extension – Culverts at Stations 14+480, Stream Crossings at Stations 14+280, 10+030, 14+850 and 14+925 – Borehole Locations
Drawing 5	Highway 427 Extension – Stream Crossings at Stations 14+280, 10+030, 14+850 and 14+925 – Soil Strata
Drawing 6	Highway 427 Extension – Culvert at Station 10+250 and Stream Crossing at Station 10+400 Borehole Locations and Soil Strata

LIST OF FIGURES

Figure 1	Highway 427 Extension- Site Location Plan, Proposed Culverts and Stream Crossings
----------	---



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

LIST OF APPENDICES

Appendix A Record of Boreholes

List of Symbols and Abbreviations
Record of Borehole Sheets C1 to C16 and C19 to C22

Appendix B Laboratory Test Results

Figure B1 Grain Size Distribution Test Results – Clayey Silt Till
Figure B2 Plasticity Chart – Clayey Silt Till
Figure B3 Grain Size Distribution Test Results – Sand and Silt Till
Figure B4 Grain Size Distribution Test Results – Silt
Figure B5 Grain Size Distribution Test Results – Silty Clay to Clayey Silt
Figure B6 Plasticity Chart – Clayey Silt to Silty Clay
Figure B7 Grain Size Distribution Test Results – Silty Clay to Clayey Silt
Figure B8 Plasticity Chart – Silty Clay to Clayey Silt
Figure B9-A Grain Size Distribution Test Results – Silty Clay to Clayey Silt Till
Figure B9-B Grain Size Distribution Test Results – Silty Clay to Clayey Silt Till
Figure B10-A Plasticity Chart – Silty Clay to Clayey Silt Till
Figure B10-B Plasticity Chart – Silty Clay to Clayey Silt Till

Appendix C Record of Boreholes for Culverts at Stations 11+125, 12+330 and 14+480

List of Symbols and Abbreviations
Record of Borehole Sheets E5, E6, E7, E19, S12, S13 and S14



**PRELIMINARY FOUNDATION REPORT
CULVERTS - HIGHWAY 427 EXTENSION**

PART A

PRELIMINARY FOUNDATION INVESTIGATION REPORT CULVERTS

HIGHWAY 427 EXTENSION

FROM HIGHWAY 7 TO MAJOR MACKENZIE DRIVE

W.O. 05-20012



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the proposed 6.6 km long extension of Highway 427 from Highway 7 northward to Major Mackenzie Drive in the City of Vaughan, Ontario. The terms of reference for the foundation engineering services are provided in the Request for Proposal for MTO Assignment No. 2005-E-0028, dated December 21, 2005.

This report addresses the preliminary foundation investigation carried out for the thirteen proposed culvert structures along the alignment of the Highway 427 Extension. At the beginning of this preliminary geotechnical investigation a total of thirteen culvert locations were identified. Two boreholes for the culvert proposed at Station 14+620 m were not drilled due to property access limitations. At the time of preparation of this report a total of six culverts were identified by MRC and design information for these culverts was provided to Golder. Three of these culvert locations coincide with three of the original proposed culvert locations, however, there are three new culverts identified where boreholes were not drilled during the preliminary geotechnical investigation. In this report the locations where design information was received are referred to as culverts and the other locations are referred to as stream crossings. The approximate location of the culvert and stream crossing sites along the Highway 427 Extension alignment are shown on Figure 1.

The work was carried out in accordance with Golder's Supplemental Speciality Quality Control Plan for foundation engineering services for this project dated April 4, 2006.

2.0 SITE DESCRIPTION

The proposed culverts are located along the Highway 427 Extension between Highway 7 to approximately 200 m north of Major Mackenzie Drive, in the City of Vaughan, Ontario. The proposed culverts at the south end of the alignment are located approximately 1.2 km east of Huntington Road, and follow the proposed alignment of Highway 427 Extension to the north end where the culverts are located approximately 200 m east of Huntington Road.

In general, the topography along the Highway 427 Extension alignment consists of flat-lying to gently sloping farm land and densely treed areas that are crossed by the valleys of Rainbow Creek and West Robinson Creek. Some residential, commercial and/or light industrial development is present along Zenway Boulevard, Langstaff Road and Rutherford Road.

Overall, the natural ground surface within the area addressed by this report slopes downward towards the south, from approximately Elevation 205 m near Major Mackenzie Drive to approximately Elevation 180 m near Highway 7. The proposed culverts/stream crossings near the proposed realigned Major Mackenzie Drive and north of Rutherford Road are in flat-lying agricultural fields, which have moderate tree cover around the perimeters of the fields. South of Rutherford Road and west of Robinson Creek, the proposed stream crossings at Station 13+640 and Station 13+560, are located within rolling hills which act as drainage for Robinson Creek. The valley area that forms Robinson Creek is about 4 m above the creek level and the creek is moderately treed. At the south limit of the project one culvert is proposed just north of Zenway Boulevard, one is proposed in a flat open field (west of the Highway 427 Interim Arterial Extension (Regional Road 99)), and the other transverses the existing Highway 427 Interim Arterial Extension (Regional Road 99) just north of Highway 7. There is an existing CSP culvert at this location. With the exception of the proposed culvert in vicinity of Regional Road 99, all the other culvert/stream crossing sites are generally low lying areas which are wet during the spring and fall and dry during the winter and summer.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

3.0 INVESTIGATION PROCEDURES

The borehole investigation for the culvert sites was carried out in March, April, and May 2009. At this time twenty boreholes (Boreholes C1 to C16 and C19 to C22) were advanced. The borehole locations are shown on Drawings 1, 2, 4 and 6.

The boreholes were drilled using a track-mounted, and truck-mounted drill rigs supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced using 200 mm outside diameter hollow-stem augers and 108 mm diameter solid-stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586-99).

The groundwater conditions in the open boreholes were observed during the drilling operations and standpipe piezometers were installed in Boreholes C3, C4, C6, C8, C10, C12, C15, C19, C21, and C22 to permit monitoring of the water levels at these locations. The piezometers consisted of 51 mm diameter PVC pipe, with a slotted screen sealed at a select depth within the borehole. A sand filter pack surrounds the screen and above the screen the boreholes and annulus surrounding the piezometer pipe were backfilled to the surface with bentonite pellets/grout. The piezometer installation details and water level readings are described on the Record of Borehole Sheets in Appendix A. The boreholes in which no standpipe piezometers were installed were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services through both public utility companies and a private utility locator, observed 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 Golder's Mississauga geotechnical laboratory where the samples underwent further detailed visual examination and geotechnical classification testing (water contents, Atterberg limits, and grain size distribution tests). All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

Prior to drilling, the boreholes were located in the field using the Highway 427 Extension alignment centreline stakes installed by MRC and a Global Positioning System unit (GPS). The as-drilled borehole locations and ground surface elevations were surveyed by MRC. The borehole locations shown on Drawing 1, 2, 4 and 6 and on the borehole records are given relative to MTM NAD 83 northing and easting coordinates, and the ground surface elevations are referenced to geodetic datum.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The Highway 427 Extension area lies within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario*¹. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys. The

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



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay. The study area is underlain by Ordovician shales of the Georgian Bay Formation.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced for this investigation and the results of the laboratory tests carried out on selected soil samples are provided in Appendices A and B, respectively. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change.

The interpreted stratigraphic conditions at the proposed culvert sites and stream crossings are shown on Drawings 1, 3, 5 and 6. These stratigraphic profiles represent a simplification of the subsurface conditions as encountered in the boreholes. Variation in the stratigraphic boundaries and properties of the soil deposits will occur between and beyond the borehole locations.

In general, the subsurface conditions in the area of the proposed stream crossings just north of Highway 7 consist of a surficial layer of topsoil/asphalt, underlain by either sand and gravel fill or surficial silty clay. The fill and surficial silty clay are underlain by a cohesive and cohesionless till deposit. The till deposits are underlain by a silt deposit, which in turn is underlain by a silty clay to clayey silt deposit. Between Langstaff Road and Major Mackenzie Drive the subsurface conditions in the area of the proposed culverts and stream crossings consist of topsoil underlain by surficial clayey silt which is in turn underlain by a silty clay to clayey silt till deposit.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections. The subsurface conditions are discussed in two separate sections as the subsurface conditions at the culverts immediately north of Highway 7 are different from those encountered north of Langstaff Road.

4.2.1 Stream Crossings Immediately North of Highway 7

The following sections describe the subsurface conditions encountered in the area of the two proposed stream crossings north of Highway 7. One stream crossing is proposed at approximately 50 m north of Highway 7 (Station 10+050) and is to be located beneath the proposed Highway 427 Extension. Boreholes C1 and C2 were drilled for this stream crossing and were located within the outside lane on NBL and SBL existing 427 Interim Arterial Extension (Regional Road 99). A second stream crossing is proposed beneath the proposed N-W Highway 427 off ramp at about Station 10+100 m (stationing along the ramp). Borehole C3 was drilled at the location of the second stream crossing. The subsurface conditions encountered at these two stream crossings are described in the following sections.

4.2.1.1 Topsoil / Asphalt / Fill

Approximately 600 mm of topsoil was encountered immediately below ground surface in Borehole C3 which was drilled at the location of a proposed stream crossing along the N-W Highway 427 off ramp.

Approximately 0.1 m of asphalt was encountered immediately below the ground surface in Boreholes C1 and C2 that were drilled through the outside lane on NBL and SBL existing 427 Interim Arterial Extension (Regional Road 99).



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

In Boreholes C1 and C2 the asphalt is underlain by a layer of sand and gravel fill that extended to a depth of 0.6 m. The base of the fill layer was encountered at Elevation 179.6 m and 179.3 m in Boreholes C1 and C2, respectively.

4.2.1.2 *Surficial Silty Clay*

The topsoil in Borehole C3 is underlain by a surficial silty clay deposit that extends to a depth of about 1.4 m below ground surface (Elevation 179.2 m). The surficial silty clay contains trace sand and trace gravel. The Standard Penetration Test (SPT) 'N' value in the surficial silty clay was 9 blows per 0.3 m of penetration, indicating that the surficial soil has a stiff consistency. A measured water content on a sample of the surficial silty clay was 21 percent.

4.2.1.3 *Clayey Silt Till*

The fill in Boreholes C1 and C2 is underlain by a clayey silt till deposit that extends to depths of 2.4 m and 3.8 m, respectively. The base of the cohesive till was encountered in Boreholes C1 and C2 at Elevation 177.8 m and 176.1 m, respectively.

The clayey silt till contains some to with sand, trace gravel and contains oxidation staining. Within the cohesive till deposit in Borehole C1 a 0.5 m thick silty sand stratum was encountered at a depth of 1.0 m below ground surface. Grain size distribution tests were completed on two selected samples of the cohesive till deposit and the results are presented on Figure B1 in Appendix B. Atterberg limits testing was carried out on two samples of the cohesive till deposit, and the plastic limits were 12 and 13 percent, the liquid limits were 22 and 25 percent and the plasticity indices were 9 and 13 percent. These results, which are plotted on a plasticity chart on Figure B2 in Appendix B, confirm that this portion of the till deposit is a clayey silt of low plasticity.

The SPT 'N' values measured within the cohesive till were 43, 46 and 57 blows per 0.3 m of penetration, indicative of a hard consistency. One measured SPT 'N' value of 100 blows per 0.1 m of penetration is likely indicative of the split spoon bouncing on a cobble or boulder.

4.2.1.4 *Sand and Silt Till*

The surficial silty clay in Borehole C3 is underlain by a sand and silt till deposit the surface of which was encountered at a depth of 1.4 m below ground surface (Elevation 179.2 m). The sand and silt till deposit extends to about 3.8 m depth (Elevation 176.8 m).

The sand and silt till deposit contains trace gravel and trace clay. The results of a grain size distribution test carried out one sample of the cohesionless till is provided on Figure B3 in Appendix B. Measured water contents on three selected samples of the cohesionless till were 8 and 9 percent.

The SPT 'N' values measured in the cohesionless till were 55 and greater than 100 blows per 0.3 m of penetration, indicating a very dense relative density.

Till deposits in southern Ontario typically contain cobbles and/or boulders. Although there was no evidence of cobbles and/or boulders during drilling by grinding of the augers, cobbles and/or boulders should be expected within the till deposit.



4.2.1.5 Silt

Beneath the cohesive till deposit in Boreholes C1 and C2 a silt deposit was encountered at depths of 2.4 m (Elevation 177.8 m) and 3.8 m (Elevation 176.1 m) in Boreholes C1 and C2, respectively. The base of the silt deposit was encountered at Elevations 174.6 and 174.3 m in Boreholes C1 and C2, respectively. This silt deposit was about 3.2 m thick in Borehole C1 and about 1.8 m thick in Borehole C2.

The silt deposit contains trace clay. The results of grain size distribution test completed on two samples of the silt are provided on Figure B4 in Appendix B. The measured SPT 'N' values within the silt varied from 35 to 101 blows per 0.3 m of penetration, indicative of a dense to very dense relative density.

4.2.1.6 Silty Clay to Clayey Silt

Underlying the silt deposit in Boreholes C1 and C2 and underlying the cohesionless till deposit in Borehole C3 a deposit of silty clay to clayey silt was encountered. Boreholes C1 and C3 terminated within this deposit at a depth of 9.8 m (between Elevation 170.5 m and 170.9 m); however Borehole C2 fully penetrated the cohesive deposit which was found to have a thickness of 3.9 m. Within the cohesive deposit an approximately 1.2 m thick layer of silty sand containing trace gravel and trace clay was encountered at a depth of about 5.5 m. This layer extended to a depth of about 6.7 m (Elevation 173.9 m).

The silty clay to clayey silt contains fine sand partings. The results of grain size distribution test completed on two samples of the clayey silt are provided on Figure B5 in Appendix B. Atterberg limits testing was carried out on three samples of the clayey silt deposit and two samples of the silty clay. The measured plastic limits of the clayey silt varied from 15 to 19 percent, the liquid limits varied from 27 to 32 percent, and the plasticity indices varied from 12 to 15 percent. These results, which are plotted on a plasticity chart on Figure B6 in Appendix B, confirm that the material is a clayey silt of low to medium plasticity. The measured plastic limits of the silty clay deposit were 17 and 21 percent, the liquid limits were 35 and 39 percent, and the plasticity indices were 18 percent. These results, which are plotted on a plasticity chart on Figure B6 in Appendix B, confirm that this material is a silty clay of medium plasticity. Measured water contents on four selected samples of the cohesive deposit varied from about 14 to 20 percent.

The SPT 'N' values within the cohesive deposit varied from 24 to 59 blows per 0.3 m of penetration, indicative of a very stiff to hard consistency. One measured SPT 'N' value within the silty sand layer was greater than 100 blows per 0.3 m of penetration, indicating that the silty sand layer has a very dense relative density.

4.2.1.7 Clayey Silt Till (Lower Cohesive Till)

Beneath the clayey silt deposit in Borehole C2 the base of the borehole just penetrated approximately 0.3 m into a clayey silt till deposit at a depth of 9.5 m (Elevation 170.5 m). The clayey silt till deposit contains trace sand and trace gravel. One measured SPT 'N' value in the lower cohesive till was 54 blows per 0.3 m of penetration, indicative of a hard consistency.

4.2.2 Culverts and Stream Crossings Between Langstaff Road and Major Mackenzie Drive

The following sections describe the subsurface conditions encountered in the area of the seven stream crossings and three culvert locations proposed between Langstaff Road and Major Mackenzie Drive.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

4.2.2.1 Topsoil

In all boreholes, with the exception of Boreholes C8, C10 and C11, topsoil varying in thickness from about 0.1 m to 0.6 m was encountered immediately below the ground surface.

4.2.2.2 Surficial Silty Clay to Clayey Silt

In Boreholes C8, C10 and C11 a surficial clayey silt deposit was encountered immediately below ground surface. In the remaining boreholes the surficial silty clay to clayey silt deposit was encountered underlying the topsoil, with the exception of Borehole C19 where it is was not encountered. The surficial deposit generally extends to depths of between about 0.5 m to 1.5 m below ground surface, except for Borehole C21, where it extended to 2.2 m below ground surface. The depth to and elevation of the base of the surficial silty clay to clayey silt is summarized in the table below:

Culvert / Stream Crossing	Station Location	Borehole No.	Depth of Base of Layer	Elevation of Base of Layer
Culvert	13+025	C4	1.5 m	188.6 m
		C5	0.7 m	189.3 m
Stream Crossing	13+300	C6	0.9 m	188.8 m
		C7	0.9 m	189.3 m
Culvert	13+560	C8	0.6 m	186.3 m
		C9	0.6 m	187.7 m
Stream Crossing	13+640	C10	0.6 m	188.0 m
		C11	0.7 m	190.4 m
Stream Crossing	14+280	C12	1.4 m	191.6 m
		C13	0.9 m	192.9 m
		C14	0.6 m	193.9 m
Stream Crossing	10+030 ¹	C15	0.9 m	194.3 m
Stream Crossing	14+925 ²	C16	0.9 m	194.8 m
Stream Crossing	14+850	C19	not present	not present
		C20	1.5 m	195.2 m
Stream Crossing	10+400 ³	C21	2.2 m	199.8 m
Culvert	10+250 ³	C22	0.9 m	201.3 m

1. Based on stationing along proposed E-S Highway 427 Extension Ramp.

2. Based on stationing along proposed S-W Highway 427 Extension Ramp.

3. Based on stationing along proposed realigned Major Mackenzie Drive.

On the borehole records in Appendix A, the surficial silty clay to clayey silt is also described as “reworked” as it appears that this material has been disturbed by previous agricultural activities. The surficial silty clay to clayey silt contains trace sand, trace gravel and also contains organics and rootlets at some locations. The results of grain size distribution tests carried out on two samples of the surficial silty clay to clayey silt is provided on Figure B7 in Appendix B. Atterberg limits testing was carried out on one sample of the surficial clayey silt, and the plastic limit was 23 percent, the liquid limit was 50 percent and the plasticity index was 27 percent. These results, which are plotted on a plasticity chart on Figure B8 in Appendix B, confirm that this portion of the surficial soil is a silty clay of medium plasticity. Atterberg limits testing was carried out on one sample of the surficial clayey silt, and the plastic limit was 20 percent, the liquid limit was 34 percent and the plasticity index was 14 percent. These results, which are plotted on a plasticity chart on Figure B8 in Appendix B, confirm that this portion of the surficial soil is a clayey silt of low to medium plasticity. Measured water content on samples of the



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

surficial silty clay to clayey silt ranged from 19 to 51 percent. The high measured water contents are likely due to the presence of organics in the surficial soils.

The SPT 'N' values in the surficial silty clay generally varied from 4 to 8 blows per 0.3 m of penetration, indicating that the surficial soils generally has a firm consistency. The exception to this was at Boreholes C12, C16 and C20 where SPT 'N' values of 10, 14 and 22 blows per 0.3 m of penetration was measured; indicating that the surficial soils at these locations has a stiff to very stiff consistency.

4.2.2.3 Silty Clay to Clayey Silt Till

In all boreholes drilled for this site the topsoil or surficial silty clay to clayey silt deposits are underlain by a silty clay to clayey silt till deposit. All of the boreholes drilled at the culvert/stream crossings terminated within the cohesive till deposit.

It is noted that till deposits in Southern Ontario typically contain cobbles and/or boulders. Cobbles and/or boulders have been inferred to be present within the till deposits at the boreholes drilled for the culvert/stream crossings, based on grinding of augers during borehole drilling, as summarized in the table below:

Culvert / Stream Crossing	Station Location	Borehole No.	Depth of Observed Auger grinding	Elevation of Inferred Cobbles/Boulders
Stream Crossing	13+300	C6	1.5 m	188.2 m
			3.5 m	186.2 m
			8.7 m	181.0 m
		C7	8.8 m	181.4 m
Culvert	13+560	C8	7.0 m	179.9 m
Stream Crossing	13+640	C10	1.5 m	187.1 m
			8.5 m	180.1 m
Stream Crossing	14+280	C12	4.5 m	188.5 m
Stream Crossing	10+030	C15	3.0 m	192.2 m
Stream Crossing	10+400 ¹	C21	3.5 m	198.5 m

1. Based on stationing along proposed realigned Major Mackenzie Drive

The silty clay to clayey silt till deposit contains trace sand, trace gravel and also contains seams of sandy silt to silty sand to sand to sand and gravel. The results of grain size distribution tests on eleven samples of the silty clay to clayey silt till deposit are shown on Figures B9-A and B9-B in Appendix B. Atterberg limits testing was conducted on four selected samples of the silty clay till deposit, and measured plastic limits of 20 to 25 per cent, liquid limits of 38 to 43 per cent, and plasticity indices of 17 to 20 per cent; these test results, which are plotted on a plasticity chart on Figure B10-A and B10-B, confirm that this portion of the till is a silty clay of medium plasticity. Atterberg limits testing was carried out on twenty-eight selected samples of the clayey silt till deposit, and measured plastic limits of 12 to 20 per cent, liquid limits of 18 to 33 per cent, and plasticity indices of 6 to 14 per cent; these test results, which are plotted on a plasticity chart on Figure B10-A and B10-B, confirm that this portion of the till is a clayey silt of low plasticity. Measured water content on samples of the cohesive till deposit ranged from 8 to 25 percent; the higher water contents were typically measured on samples of the silty clay till.

4.2.3 Groundwater Conditions

The water level in the boreholes were noted during and upon completion of drilling in all boreholes completed for the proposed culverts / stream crossings. Standpipe piezometers were installed in ten boreholes to permit monitoring of the water levels at this site. Details of the piezometer installations are shown the Record of



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

Borehole Sheets in Appendix A. The groundwater levels measured in the piezometer installations on July 9, 2009 are summarised below.

General Location	Station Location	Borehole Number	Groundwater Depth	Groundwater Elevation
North of Highway 7	10+100	C3	0.6 m	179.9 m
South of Rutherford Road	13+025	C4	0.7 m	188.4 m
	13+300	C6	0.4 m	188.7 m
	13+560	C8	2.2 m	184.7 m
	13+640	C10	7.6 m	181.0 m
North of Rutherford Road	14+280	C12	1.9 m	191.1 m
	10+030	C15	1.8 m	193.4 m
	14+850	C19	2.6 m	194.5 m
Realigned Major Mackenzie Drive	10+400 ¹	C21	3.1 m	198.9 m
	10+250 ¹	C22	1.9 m	200.3 m

1. Based on stationing along proposed realigned Major Mackenzie Drive

It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events, and will be higher during wet periods of the year (for example, during spring conditions).

5.0 CLOSURE

The field technicians directing the drilling program were Messrs. Jordan Black, Chris Radway and Ted Beadle. This report was prepared by Ms. Sandra McGaghran, P.Eng. a geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Contact for this project, conducted an independent quality control review of the report.




Sandra McGaghran, P.Eng.
Geotechnical Engineer




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

JEB/SMM/FJH/jl

n:\active\2006\1111\06-1111-012 mrc hwy 427 extension\5 - reports\foundation\final reports\06-1111-012-10 final rpt 09aug july highway 427 culverts.docx



**PRELIMINARY FOUNDATION REPORT
CULVERTS - HIGHWAY 427 EXTENSION**

PART B

PRELIMINARY FOUNDATION DESIGN REPORT

CULVERTS

HIGHWAY 427 EXTENSION

FROM HIGHWAY 7 TO MAJOR MACKENZIE DRIVE

W.O. 05-20012



6.0 PRELIMINARY ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the preliminary design of the proposed culverts along the Highway 427 Extension NBL and SBL mainline alignment and along the realigned Major Mackenzie Drive for which design information was provided to us. The preliminary recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the preliminary subsurface investigation for these culvert sites. The interpretation and recommendations are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to design the foundations for the proposed culvert sites. Where comments are made on construction, they are provided to highlight those aspects that could affect the preliminary design of the project, and for which special provisions are expected to be required as the project proceeds through detail design and into contract preparation. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

Further borehole investigation and analysis will be required during the detail design phase of the project, once the location of the proposed culverts are finalized, to confirm and expand on the preliminary foundation recommendations provided in this report.

6.1 Foundations for Culverts

This section of the report provides the foundation options for each of the proposed culverts. Prior to commencing the geotechnical investigation for the proposed culverts a total of thirteen culvert locations were identified and borehole drilling was carried out at twelve of these locations; two boreholes were not completed at one of the locations due to restrictions with property access. On June 2, 2009 invert elevations and approximate dimensions for six box culverts was received from MRC. Three of the locations are new and therefore no drilling was completed at these locations (Station 11+125, 12+330 and 14+480). The culverts for which there is invert elevations are shown on Figure 1 and are identified as Culvert Crossings. Those for which borehole drilling was completed, are identified as Stream Crossings (see Figure 1 for locations). Preliminary foundation recommendations are provided for the culvert locations only. For the three culverts where borehole drilling was not planned, preliminary recommendations are provided based on the closest borehole. These recommendations will have to be confirmed at detail design.

All the proposed culvert locations are located in low-lying terrain, which is generally dry during the winter and summer and wet with ponded/flowing water during the spring and the fall.

Either open footing or box culvert is feasible from a foundations perspective for all of the culvert sites. Deep foundations are not required for any of the culvert sites since shallow foundations will provide sufficient bearing resistance and satisfactory settlement performance under the embankment loading.

From a foundations perspective, a box culvert is generally preferred as this option generally minimizes the depth of excavation and the groundwater control requirements compared with open footings.

6.1.1 Founding Elevations and Subexcavation Requirements

6.1.1.1 Open Footing Culvert and Retaining Walls

Strip footings for proposed open footing culverts, and for any associated concrete wing walls/retaining walls, should be founded at a minimum depth of 1.4 m below the lowest surrounding grade, to provide adequate protection against frost penetration (OPSD 3090.101), and extend below any existing fill and surficial organic



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

materials, where present. Table 1, following the text of the report, provides recommended founding elevations for strip footings for the proposed culverts.

The anticipated soil conditions at the maximum founding elevation for strip footings is summarized in the table below:

Station / Culvert	Reference Borehole(s)	Maximum Footing Founding Elevation	Anticipated Soil Conditions	Groundwater Conditions
Station 11+125 Rain-1	E5, E6 & E7	179.1 to 178.6 m	Very Stiff to Hard Clayey Silt Till ¹	Below the footing excavation
Station 12+330 Creek-2	S12, S13 & S14	185.3 to 184.9 m	Very Stiff to Hard Clayey Silt Till ¹	Below the footing excavation
Station 13+025 Rob-1	C4 & C5	187.7 to 187.5 m	Stiff to Very Stiff Clayey Silt Till	Elevation 188.4 m; about 0.9 m above the footing excavation.
Station 13+560 Rob-2	C8 & C9	187.8 to 183.5 m	Hard Clayey Silt Till	Elevation 184.7 m at outlet (2.2 m depth); about 1.2 m above the footing excavation.
Station 14+480 Rob-3	C15, C16 & E19	192.9 to 190.8 m	Very Stiff Clayey Silt Till ¹	Water level in Borehole C15 is at 2.8 m depth; anticipate that excavations will be above groundwater.
Station 10+250 Rob-7	C22	200.4 to 200.1 m	Very Stiff Silty Clay Till	Elevation 200.3 m; just above the base of the excavation for the footing.

1. Soil conditions based on nearest borehole which is generally about 200 m away.

As discussed in Section 6.1 three are new and therefore no drilling was completed at these locations (Station 11+125, 12+330 and 14+480). The closest borehole to these proposed culverts is noted above and the borehole records for these culverts are included in Appendix C of this report. Based on these boreholes it is anticipated that the soil conditions at the proposed culverts will consist of very stiff to hard clayey silt till.

Based on the subsoil conditions encountered in the boreholes drilled at the culvert locations, it is anticipated that the spread footings would generally be founded on stiff to hard clayey silt to silty clay till. At the culvert locations where boreholes were drilled it is anticipated that no subexcavation would be required, however at the culvert locations where no borehole drilling was carried out subexcavation requirements will have to be assessed at detail design following borehole drilling.

It is anticipated that groundwater control may be required for excavation and construction of strip footings for culverts at Station 13+025 (Rob-1) and Station 13+560 (Rob-2). However, considering that the boreholes drilled for these two sites were dry upon completion of drilling and also the low permeability of the clayey silt till, it is anticipated that groundwater inflow into the excavation can be handled by pumping from well filtered sumps along the perimeter of the excavation.

The footing subgrade should be inspected following excavation to ensure that all existing fill and surficial organic soils or other unsuitable material have been removed, any subexcavated areas should be backfilled with



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

granular material meeting Ontario Provincial Standard Specification (OPSS) 1010 Granular 'A' or Granular 'B Type II', that is placed and compacted in accordance with the requirements of MTO's Special Provision SP105S10. It is recommended that at culvert sites where groundwater is present that Granular 'B Type II' be used for raising the subexcavated area to the footing level as it is easier to compact this material in 'wet' conditions compared to Granular 'A'.

The footing subgrade will be susceptible to loosening and degradation on exposure to water and construction traffic. As discussed further in Section 6.4.4, it is recommended that a 100 mm thick layer of lean mix concrete (mud slab) or mass concrete be placed on the inspected and approved footing subgrade, to protect the subgrade from degradation and to form a working mat for construction of the proposed culverts.

6.1.1.2 Box Culvert

The proposed box culverts should be founded below any existing fill and surficial organic materials. Table 2, following the text of the report, provides recommended maximum founding elevations and subexcavation requirements for the proposed box culverts, based on an assumed base slab thickness of 250 mm.

At the proposed culvert at Station 13+025 firm clayey silt was encountered to a depth of 1.5 m below ground surface; which is about 0.7 m to 0.9 m below the base slab of the box culvert for the invert elevations proposed. Geotechnical resistances are provided for the option of leaving this firm material in place. For this option it is estimated that approximately 30 mm of settlement will occur under the loading from the proposed embankment around the culvert at Station 13+025, primarily in the firm clayey silt. It will be necessary to preload the area of the proposed embankment around the culvert before construction of the overlying pavement structure for Highway 427 Extension to mitigate settlement at the culvert and pavement structure. It is estimated that this would take about three months to complete 70 percent of this predicted settlement. Further details regarding design assumptions and soil parameters used in the analysis are discussed in Section 6.1.6.

To achieve higher geotechnical resistances this material should be subexcavated to about Elevation 187.7 m. The width of the required subexcavation should be defined by lines extending from the outside edges of the proposed culvert base slab outward and downward at 1H:1V.

If the option of subexcavation of between 0.7 m and 0.9 m of firm clayey silt is considered at the proposed culvert at Station 13+025 (Rob-1) then this subexcavation will extend about 0.7 m below the groundwater level measured in the monitoring well in Borehole C4. Groundwater control can be handled by pumping from well filtered sumps at the perimeter of the excavation. It is anticipated that excavations for the remaining culvert site will be above the groundwater level.

The box culvert subgrade should be inspected following subexcavation to ensure that all existing fill and surficial organic soils or other unsuitable material have been removed, then for precast culverts the subexcavated area should be backfilled with granular material meeting OPSS 1010 Granular 'A' or Granular 'B' Type II, that is placed and compacted in accordance with the requirements of MTO's Special Provision SP105S10. As noted in the previous section, at culvert sites where groundwater is present it is suggested that Granular 'B Type II' be used as it is easier to compact this material in 'wet' conditions compared to Granular 'A'.

The subgrade for the proposed cast in place box culverts will be susceptible to loosening and degradation on exposure to water and construction traffic. As discussed further in Section 6.4.4, it is recommended that a 100 mm thick layer of lean mix concrete (mud slab) or mass concrete be placed on the inspected and approved subgrade, to protect the subgrade from this degradation and form a working mat for construction of the proposed culverts. Where pre-cast box culverts are used, it is recommended that a 150 mm thick levelling pad of Granular



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

'A' or concrete fine aggregate (meeting the gradation requirements in OPSS 1002) be provided on top of the lean concrete mat, to facilitate positioning and seating of the culvert segment(s).

6.1.2 Geotechnical Resistance

Tables 1 and 2, following the text of this report, provide factored geotechnical resistances at Ultimate Limit State (ULS) and geotechnical resistances at Serviceability Limit State (SLS) for proposed open footing culverts and proposed box culverts at each site. It is noted that for culvert sites where no borehole drilling was carried the geotechnical resistances are based on the soil conditions encountered in the closest boreholes, which were about 200 m away, therefore these geotechnical resistances are preliminary and will need to be confirmed at detail design following additional borehole drilling.

6.1.2.1 Open Footing Culvert and Retaining Walls

Strip footings placed on the properly prepared subgrade, at or below the maximum founding elevations recommended in Table 1, should be designed based on the factored geotechnical resistances at ULS and the geotechnical resistances at SLS (for 25 mm of settlement) as given in Table 1. These recommendations are based on an assumed footing width of 0.6 m.

The geotechnical resistances provided are given under the assumption that the loads will be applied perpendicular to the surface of the footings. Where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with the *Canadian Highway Bridge Design Code (CHBDC)*.

6.1.2.2 Box Culvert

Box culvert placed on the properly prepared subgrade, at or below the maximum founding elevations recommended in Table 2, should be designed based on the recommended factored geotechnical resistances at ULS and the geotechnical resistances at SLS (for 25 mm of settlement) as given in Table 2. These recommendations are based on the box culvert span as given in Table 2. It is noted that for the option of leaving the firm clayey silt in place at the proposed culvert at Station 13+025 there is an increase risk of differential settlement.

The geotechnical resistances provided are given under the assumption that the loads will be applied perpendicular to the surface of the footings/culvert base. Where the load is not applied perpendicular to the surface of the footings/base, inclination of the load should be taken into account in accordance with the *CHBDC*.

6.1.3 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces / sliding resistance between the concrete footings or base slab for the proposed culverts and the subgrade should be calculated in accordance with Section 6.7.5 of the *CHBDC*. The following summarises the coefficient of friction, $\tan \delta$, for the various interface materials.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

Culvert Types	Interfaces Materials	Coefficient of Friction ($\tan \delta$)
Cast-in-place Strip Footing	Concrete footing on Stiff to Hard Native Clayey Silt to Silty Clay Till	0.58
Box Culvert	Concrete footing on Compacted Granular 'A'	0.50

These values represent unfactored values; in accordance with the *CHBDC*, a factor of 0.8 is to be applied in calculating horizontal resistance.

6.1.4 Frost Protection

All strip footings founded on the native clayey silt to silty clay till should be provided with a minimum of 1.4 m of soil cover for frost protection (OPSD 3090.101).

6.1.5 Stability

The proposed culverts are located outside of the high embankment areas therefore, considering that the culverts are between 1.2 m and 1.5 m in height, the road structure for Highway 427 Extension will likely be in the order of 1 m and also depending on the grade of the highway it is anticipated that up to about 4 m of fill may be placed at the culvert locations.

Static and seismic slope stability analyses of the proposed fill loading at the culverts were carried out with the commercially available program SLOPE/W (produced by Geo-Slope International Ltd.) to check that the target minimum factor of safety was achieved for the proposed fill loading. The factor of safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. A target minimum factor of safety of 1.3 is normally used in the design of fill slopes under static conditions. This factor of safety is considered adequate for the fill loadings at the culvert sites.

The soil parameters used in the analysis, as given in the following table, were estimated from empirical correlations using the results of in situ Standard Penetration Tests (SPT) and geotechnical classification testing.

Soil Type	Unit Weight (kN/m^3)	Undrained Shear Strength (kPa)	Cohesion, c' (kPa)	Angle of Internal Friction, ϕ' (degrees)
New Earth or Granular Fill	21	--	--	35
Firm to Stiff Clayey Silt	19	50 kPa	--	28
Very Stiff to Hard Clayey Silt to Silty Clay Till	21	150 kPa	--	34
Hard Clayey Silt	21	200 kPa	--	34

With appropriate subgrade preparation and proper placement and compaction of fill materials, the proposed 4 m high fills with side slopes maintained at 2H:1V will have a factor of safety of greater than 1.3 against deep-seated



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

slope instability. Under seismic loading conditions with a horizontal peak ground acceleration (HPGA) equal to 0.067g, the factor of safety is greater than 1.2.

6.1.6 Settlement

As discussed in Section 6.1.5 it is anticipated that up to about 4 m of fill may be placed at the culvert locations. This fill will induce some settlement in the foundations soils beneath the culvert area.

The magnitude of settlement under the loading of fill at each culvert site was estimated using the commercially available program Settle 3D, 2008 (Version 2.0) produced by Rocscience Inc. The settlement of the founding soils under the loading of fill has been estimated using the elastic deformation moduli given below, based on correlations with the SPT 'N' values and Atterberg limits.

Soil Deposit	Bulk Unit Weight	Elastic Modulus	Consolidation Parameters
Fill (range of parameters assumed for earth fill and granular fill)	20 – 22 kN/m ³	--	--
Firm Clayey Silt	20 kN/m ³	10 MPa	--
Very Stiff to Hard Clayey Silt Till	21 kN/m ³	75 MPa	--

Settlement of the approach embankments at the site will occur due to compression of the new embankment fill itself, as well as compression of the underlying native soils. Provided that the embankment material consists of clean earth fill or granular fill, the settlement of the 4 m high approach embankment fill itself is expected to be up to 25 mm, and this settlement will occur relatively quickly during and immediately following construction. The settlement of the foundation soils under the fill loading is anticipated to be between 10 mm and 15 mm; the majority of this settlement will occur during or immediately following construction of the culvert embankments.

If consideration is given to leaving the firm clayey silt in place at station 13+025, then it is estimated that about 30 mm of settlement will occur under the embankment loading, primarily in the firm clayey silt. It is estimated that this would take about three months to complete 70 percent of this predicted settlement. Provided there is time in the construction schedule, the simplest and most economical mitigation measure would be preloading the embankment area for a period of about three months. If there is insufficient time available, the embankment area could be preloaded and surcharged with an addition 1m to 2 m of fill, to shorten the preloading period.

Further examination of the predicted magnitude and time rate of settlement and the proposed mitigation measures will be required during detail design.

6.2 Culvert Bedding, Backfill and Erosion Protection

For box culverts, the bedding levelling pad and backfill requirements should be in accordance with OPSS 422 for pre-cast rigid frame culverts.

Backfill to the culvert walls should consist of granular fill meeting the requirements of OPSS 1010 Granular 'A' or Granular 'B' Type II, but with less than 5 per cent passing the No. 200 sieve. The backfill should be placed and compacted in accordance with MTO's Special Provision SP105S10. The fill depth during placement should be maintained equal on both sides of the culvert walls, with one side not exceeding the other by more than 500 mm. The culvert should be designed for the full overburden pressure and live load, assuming an embankment fill unit



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

weight of 22 kN/m^3 for Granular 'A', 21 kN/m^3 for Granular 'B' Type II, and 20 kN/m^3 for earth backfill above and/or surrounding the culvert.

If the streams flow velocities are sufficiently high, provision should be made for scour and erosion protection. To prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided at the culverts at the upstream end. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205, and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet openings, and a minimum vertical height equivalent to the high water level including treatment of adjacent side slopes. Alternatively, a clay blanket may be constructed, extending upstream to a distance equal to three times the culvert height, and extending along the adjacent side slopes to a height of two times the culvert height or the high water level, whichever is higher.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulic design engineer. As a minimum, rip-rap treatment for the inlet and outlet of the culvert should be consistent with the standard presented in OPSD 810.010 Rip-Rap Treatment Type A, with the rip-rap placed to above the high water level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket, including the creek side slopes and embankment fill slope adjacent to the culverts.

6.3 Lateral Earth Pressures for Design

The lateral earth pressures acting on the culvert walls and any associated wing walls/retaining walls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the walls. These design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) 1010 Granular 'A' or Granular 'B' Type II but with less than 5 percent passing the 200 sieve should be used as backfill behind the walls. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill. Other aspects of the granular backfill requirements with respect to sub drains and frost taper should be in accordance with OPSD 3101.150 and OPSD 3121.150.
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the wall stem, in accordance with CHBDC Section 6.9.3 and Figure 6.6. Compaction equipment should be used in accordance with MTO's Special Provision SP105S10. Other surcharge loadings should be accounted for in the design as required.
- The granular fill may be placed either in a zone with the width equal to at least 1.4 m behind the back of the walls (see Case A in Figure C6.20(a) of the *Commentary* to the CHBDC), or within the wedge shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing (see Case B in Figure C6.20(b) of the *Commentary* to the CHBDC).



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

- For Case A, the pressures are based on the proposed embankment fill materials and the existing overburden soils and the following parameters (unfactored) may be used assuming the use of earth fill :

	Earth Fill
Soil unit weight:	20 kN/m ³
Coefficients of static lateral earth pressure:	
Active, K_a	0.33
At rest, K_o	0.50

- For Case B, where the pressures are based on OPSS 1010 granular fill behind the wall, the following parameters (unfactored) may be assumed:

	Granular 'A'	Granular 'B' Type II
Soil unit weight:	22 kN/m ³	21 kN/m ³
Coefficients of static lateral earth pressure:		
Active, K_a	0.27	0.27
At rest, K_o	0.43	0.43

If the wall support allow lateral yielding of the stem, active earth pressures should be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.9.1 and Table C6.6 of the *Commentary* to the *CHBDC*.

A restrained structure is typically concrete box culverts or rigid frame bridge structures where the rotational and/or horizontal movement is not sufficient to mobilize the active pressure condition. For this condition, an at-rest pressure plus any compaction surcharge should be included in the design of the structure.

6.3.1 Seismic Considerations

Seismic (earthquake) loading must also be taken into account in the design in accordance with Section 4.6 of the *CHBDC*. Seismic (earthquake) loading must be considered in the design in accordance with Section 4.6.4 of *CHBDC*, as significant seismic loading will result in increased lateral earth pressures acting on the culvert wall and retaining walls. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the applicable earthquake-induced dynamic earth pressure. The earthquake-induced dynamic pressure distribution is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e. an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

$$P = K \gamma' d + (K_{AE} - K) \gamma' H$$

Where	K	is either the static active earth pressure coefficient (K_a) or the static at rest earth pressure coefficient (K_o);
	K_{AE}	is the seismic active earth pressure coefficient;
	γ'	is the effective unit weight of the soil (kN/m^3)
		<ul style="list-style-type: none"> taken as soil unit weights given above for fill materials taken as 20 kN/m^3 for the native materials
	d	is the depth below the top of the wall (m); and
	H	is the height of the wall above the toe (m).

According to Table C4.2 of the *Commentary* to the *CHBDC*, this site is located in Seismic Zone 1, and the site specific zonal acceleration ratio for the Vaughan area is 0.05. For the thicknesses and type of competent overburden soils at this site, a site coefficient of 1.0 and) an amplification factor of 1.33 are recommended. Therefore, the recommended ground surface acceleration is $0.067g$.

The seismic lateral earth pressure coefficients given below have been derived based on a design zonal acceleration ratio of $A = 0.067$. These coefficients have been determined in accordance with Sections 4.6.4 and C4.6.4 of the *CHBDC* and its *Commentary*, and assume that the back of the wall is vertical and the ground surface behind the wall is essentially flat.

SEISMIC ACTIVE PRESSURE COEFFICIENTS, K_{AE}

	CASE A	CASE B	
	Earth Fill	Granular 'A'	Granular 'B' Type II
Yielding Wall	0.29	0.26	0.26
Non-Yielding Wall	0.33	0.29	0.29

Note : These *CHBDC* seismic K_{AE} values include the effect of wall friction ($\delta=\phi'/2$) and are not greater than the static values of K_a and K_o reported above for the very low zonal acceleration ratio for this site.

6.4 Detail Design and Construction Considerations

6.4.1 Additional Investigation Requirements

As noted previously, additional borehole investigation, laboratory testing and analysis will be required during detail design, once the layout of the proposed culverts is finalized, to confirm preliminary foundation recommendations presented herein, including founding elevations and any subexcavation requirements, geotechnical resistances, settlement and dewatering.

In particular, it is recommended that a geotechnical investigation be completed at the proposed culverts where no borehole drilling was completed. In addition, it is recommended that the surficial clayey silt, particularly at the proposed culvert at Station 13+025 be further characterized by carrying out field vane tests to measure the undrained shear strength of the soil and complete Atterberg limit tests for strength and settlement correlation purposes.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

6.4.2 Excavation

Temporary excavations for the culverts will be made through firm clayey silt soils, generally terminating in stiff to hard clayey silt to silty clay till soils. Excavation works must be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and Regulations for Construction Projects. The weaker portions of the clayey silt would be classified as Type 3 soil, according to the OHSA. Where space permits, and provided that proper groundwater control is in place where needed, temporary open-cut excavations through these materials should be made with side slopes formed no steeper than 1H:1V.

6.4.3 Groundwater and Surface Water Control for Foundation Excavation

The culverts at Station 13+025, 13+560 and 10+250 (realigned Major Mackenzie Drive) are located in low-lying terrain, which typically contains standing or flowing water in the spring and fall and is dry during the winter and summer. Depending on the time of year that the culvert is constructed, control of surface water may be necessary at the culvert sites to allow for excavation and foundation construction to be carried out in dry conditions.

Depending on the stream crossing flow at the time of construction, the surface water flow could be passed through the culvert area by means of a temporary pipe, or diverted by pumping from behind a temporary cofferdam. Surface water should be directed away from the excavation areas, to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade; further discussion on this aspect is provided in Section 6.4.4.

As discussed in Section 6.1.1.1 and 6.1.1.2, groundwater control will be required, as the foundation excavations are expected to extend below the groundwater level at some of the culvert sites. Where the excavation will be advanced through existing fill and cohesive soils to terminate within cohesive soils (i.e. no excavation through water-bearing granular soils), seepage into the excavation should be adequately controlled by pumping from properly filtered sumps.

6.4.4 Subgrade Preparation

Where clayey or silty soils are exposed at the footing subgrade level, they will be susceptible to disturbance from construction traffic and/or ponded water. To limit this degradation, it is recommended that a working mat of lean concrete or mass concrete be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

7.0 CLOSURE

This report was prepared by Ms. Sandra McGaghran, P.Eng. a geotechnical engineer with Golder. Mr. Fintan Heffernan, P.Eng., Golder's Designated MTO Contact for this project, conducted an independent quality control review of the report.



Sandra McGaghran, P.Eng.
Geotechnical Engineer



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

JEB/SMM/FJH/jl

n:\active\2006\1111\06-1111-012 mrc hwy 427 extension\5 - reports\foundation\final reports\06-1111-012-10 final rpt 09aug july highway 427 culverts.DOCX



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

REFERENCES

Bowles, J.E. 1984. Physical and Geotechnical Properties of Soils, Second Edition. McGraw Hill Book Company, New York.

Canadian Geotechnical Society. 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society c/o BiTech Publisher Ltd, British Columbia.

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6 06. 2006. CSA Special Publication, S6.1 06. Canadian Standard Association.

Chapman, L.J., and Putnam, D.F. 1984. The Physiography of Southern, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Geology of Ontario. 1991. Ontario Geological Society, Special Volume 4, Part 1. Eds. P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott. Ministry of Northern Development and Mines, Ontario.

Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.

NAVFAC Design Manual DM 7.2. Soil Mechanics, Foundation and Earth Structures. U.S. Navy. 1982. Alexandria, Virginia.

Peck, R.B., Hanson, W.E., and Thornburn, T.H. 1974. Foundation Engineering, Second Edition, John Wiley and Sons, New York.



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

TABLE 1
OPEN FOOTING CULVERT FOUNDING ELEVATIONS,
SUBEXCAVATION REQUIREMENTS AND GEOTECHNICAL RESISTANCES
WO 05-20012

<i>Station / Culvert</i>	<i>Reference Borehole(s)</i>	<i>Proposed Culvert Invert Elevation</i>	<i>Subexcavation Required?</i>	<i>Maximum Footing Founding Elevation</i>	<i>Factored Geotechnical Resistance at ULS</i>	<i>Geotechnical Resistance at SLS</i>
Station 11+125 Rain - 1	E5, E6, E7	180.5 m (inlet) 180.0 m (outlet)	To be determined at detail design	179.1 m (inlet) ¹ 178.6 m (outlet) ¹	300 kPa	200 kPa
Station 12+330 Creek-2	S12, S13, S14	186.7 m (inlet) 186.3 m (outlet)	To be determined at detail design	185.3 m (inlet) ¹ 184.9 m (outlet) ¹	300 kPa	200 kPa
Station 13+025 Rob-1	C5 C4	189.1 m (inlet) 188.9 m (outlet)	--	187.7 m (inlet) 187.5 m (outlet)	300 kPa	200 kPa
Station 13+560 Rob-2	C9 C8	189.2 m (inlet) 184.9 (outlet)	--	187.8 m (inlet) 183.5 m (outlet)	300 kPa	200 kPa
Station 14+480 Rob-3	E19, C16	194.3 m (inlet) 192.2 m (outlet)	To be determined at detail design	192.9 m (inlet) ¹ 190.8 m (outlet) ¹	350 kPa	250 kPa
Station 10+250 Rob-7	C22	201.8 m (inlet) 201.5 m (outlet)	--	200.4 m (inlet) 200.1 m (outlet)	250 kPa	175 kPa

1. Maximum Founding Elevation based on frost protection, at detail design drilling should be carried out to confirm whether any subexcavation is required.
2. Based on Borehole C9.

Prepared By: J. Black

Reviewed By: 

PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

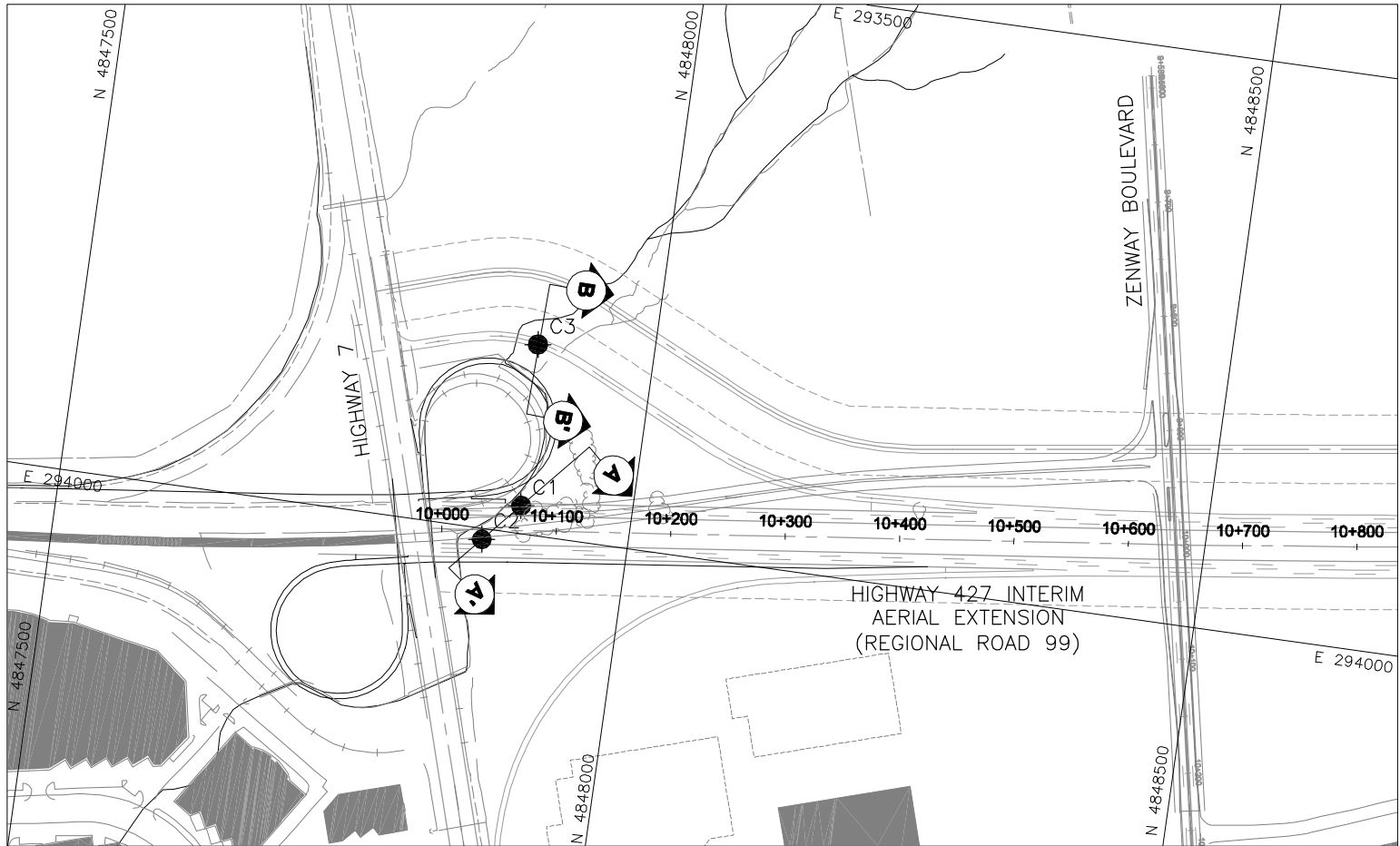
TABLE 2
BOX CULVERT FOUNDING ELEVATIONS,
SUBEXCAVATION REQUIREMENTS AND GEOTECHNICAL RESISTANCES
WO 05-20012

Station / Culvert	Reference Borehole(s)	Proposed Culvert Invert Elevation	Culvert Span	Subexcavation Required?	Maximum Footing Founding Elevation	Factored Geotechnical Resistance at ULS	Geotechnical Resistance at SLS
Station 11+125 Rain - 1	E5, E6, E7	180.5 m (inlet) 180.0 m (outlet)	2.7 m	To be determined at detail design	180.1 m (inlet) ¹ 179.6 m (outlet) ¹	300 kPa	200 kPa
Station 12+330 Creek-2	S12, S13, S14	186.7 m (inlet) 186.3 m (outlet)	2.1 m	To be determined at detail design	186.3 m (inlet) ¹ 185.9 m (outlet) ¹	275 kPa	175 kPa
Station 13+025 Rob-1	C5 C4	189.1 m (inlet) 188.9 m (outlet)	2.4 m	Yes, additional 0.9 m (inlet) Yes, additional 0.7 m (outlet)	187.7 m (inlet) 187.7 m (outlet)	275 kPa	175 kPa
				--		200 kPa	125 kPa
Station 13+560 Rob-2	C9 C8	189.2 m (inlet) 184.9 m (outlet)	3.0 m	--	188.8 m (inlet) ² 184.5 m (outlet)	300 kPa	200 kPa
Station 14+480 Rob-3	E19, C16	194.3 m (inlet) 192.2 m (outlet)	2.1 m	To be determined at detail design	193.9 m (inlet) ¹ 191.8 m (outlet) ¹	300 kPa	200 kPa
Station 10+250 Rob-7	C22	201.8 m (inlet) 201.5 m (outlet)	6.0 m	--	201.4 m (inlet) 201.1 m (outlet)	400 kPa	275 kPa

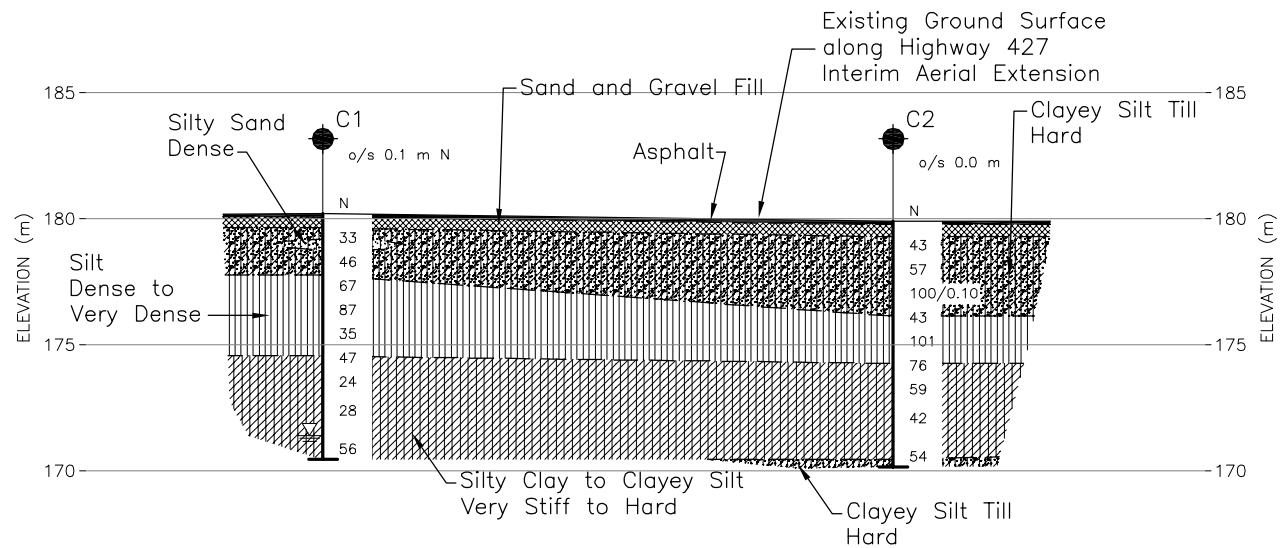
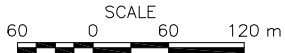
1. Maximum Footing Elevation based on base slab and granular thickness of 0.5 m, at detail design drilling should be carried out to confirm whether any subexcavation is required.
3. Based on Borehole C9.

Prepared By: J. Black

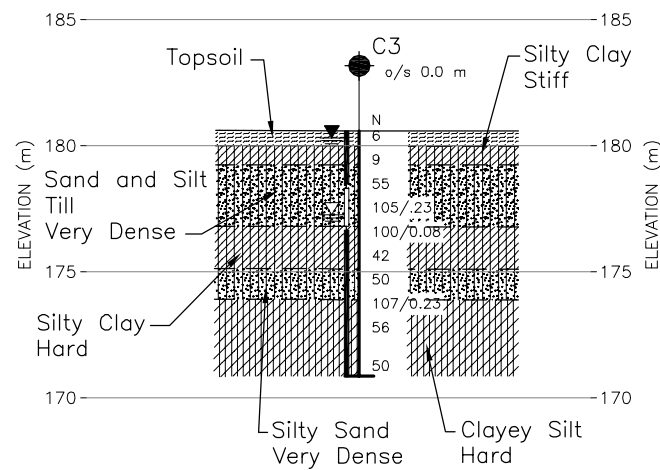
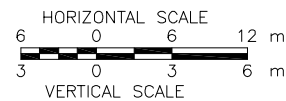
Reviewed By: 



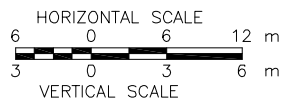
PLAN



SECTION A-A' STREAM CROSSING STATION 10+050



SECTION B-B' STREAM CROSSING STATION 10+100



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

CONT No.
WO No. 05-20012

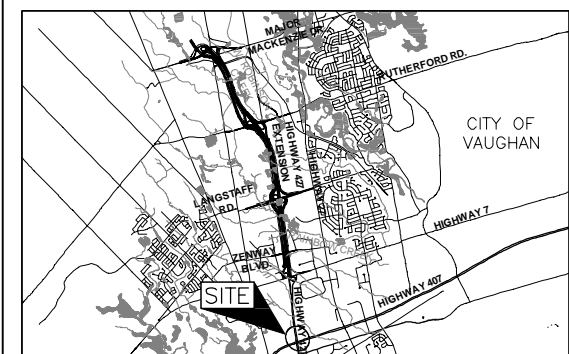


HIGHWAY 427 EXTENSION
STREAM CROSSING AT STATIONS
10+050 and 10+100
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on May 21, 2009
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C1	180.2	4847903.2	293975.6
C2	179.9	4847873.3	294009.6
C3	180.6	4847898.4	293834.2

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the 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 MRC, (Drawing file nos. "P6450-XPB-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).



NO.	DATE	BY	REVISION
Geocres No. 30M13-176			
HWY. 427	PROJECT NO. 06-1111-012-10		
SUBM'D. TB/JEB	CHKD. SMM	DATE: 5-Aug-2009	SITE:
DRAWN: JFC	CHKD. SMM	APPD. LCC	DWG. 1

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

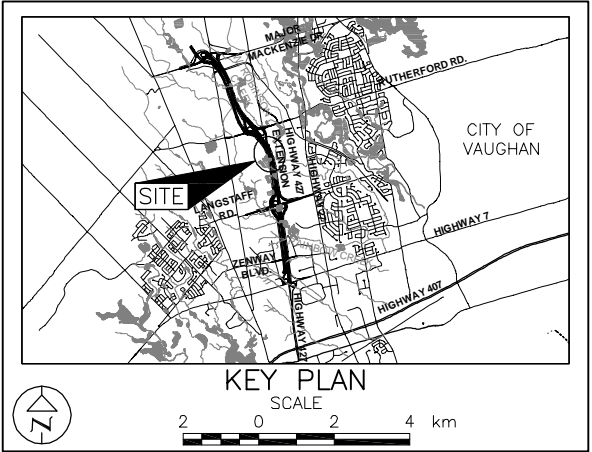
CONT No.
WO No. 05-20012










HIGHWAY 427 EXTENSION
CULVERT AT STATIONS 13+025 and 13+560
STREAM CROSSING AT STATIONS 13+300 and 13+640
BOREHOLE LOCATIONS

SHEET

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



LEGEND

-  Borehole - Current Investigation
-  Seal
-  Piezometer
-  N Standard Penetration Test Value
-  16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
-  WL in piezometer, measured on May 13, 2009
-  WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C4	189.1	4850789.6	293627.7
C5	189.3	4850807.0	293585.8
C6	189.7	4851082.9	293567.1
C7	190.2	4851098.8	293520.6
C8	186.9	4851323.3	293481.9
C9	188.3	4851338.9	293427.6
C10	188.6	4851421.5	293435.4
C11	191.1	4851412.1	293389.7

NOTES

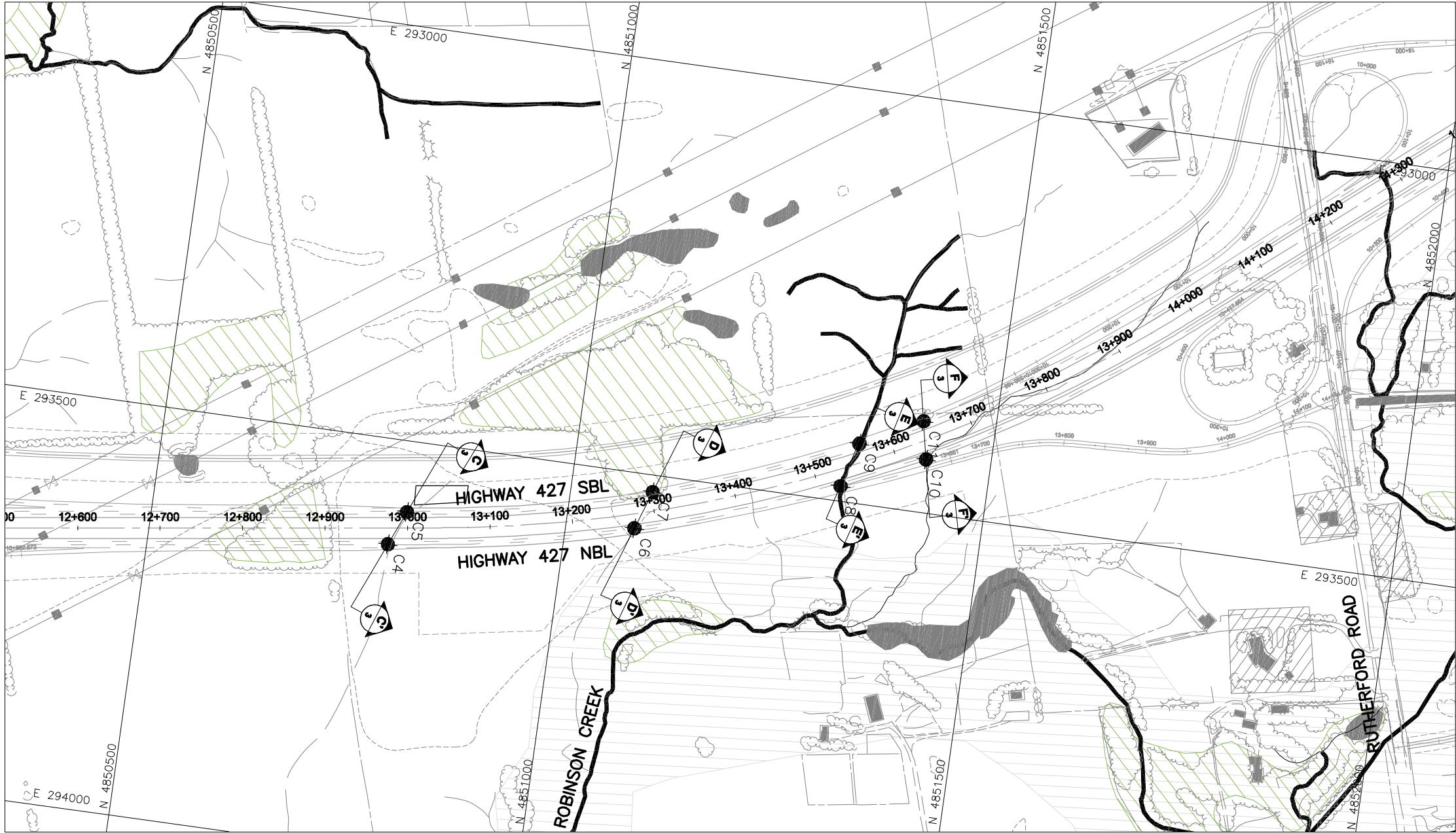
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Preliminary Design Report.

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 MRC, (Drawing file nos. "P6450-XPD-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).



**F. J. HEFFERNAN**
Aug. 5, 2009
PROVINCE OF ONTARIO

**S.M. MCGAGHRAN**
Aug. 5, 2009
PROVINCE OF ONTARIO

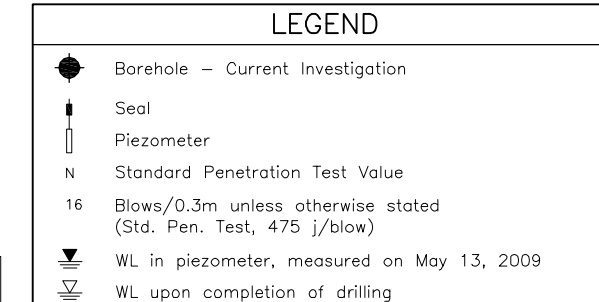
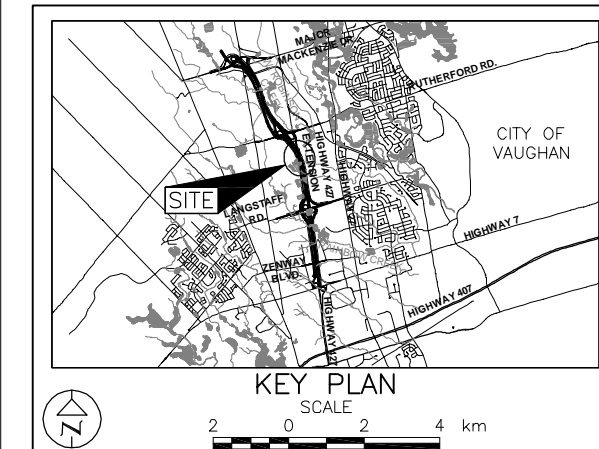
NO.	DATE	BY	REVISION
Geocres No. 30M13-176			
HWY. 427	PROJECT NO. 06-1111-012-10		DIST.
SUBM'D. JEB	CHKD. SMM	DATE: 4-Aug-2009	SITE:
DRAWN: JFC	CHKD. SMM	APPD. LCC	DWG. 2

CONT No.
WO No. 05-20012

HIGHWAY 427 EXTENSION
CULVERT AT STATIONS 13+025 and 13+560
STREAM CROSSING AT STATIONS 13+300 and 13+640
SOIL STRATA



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



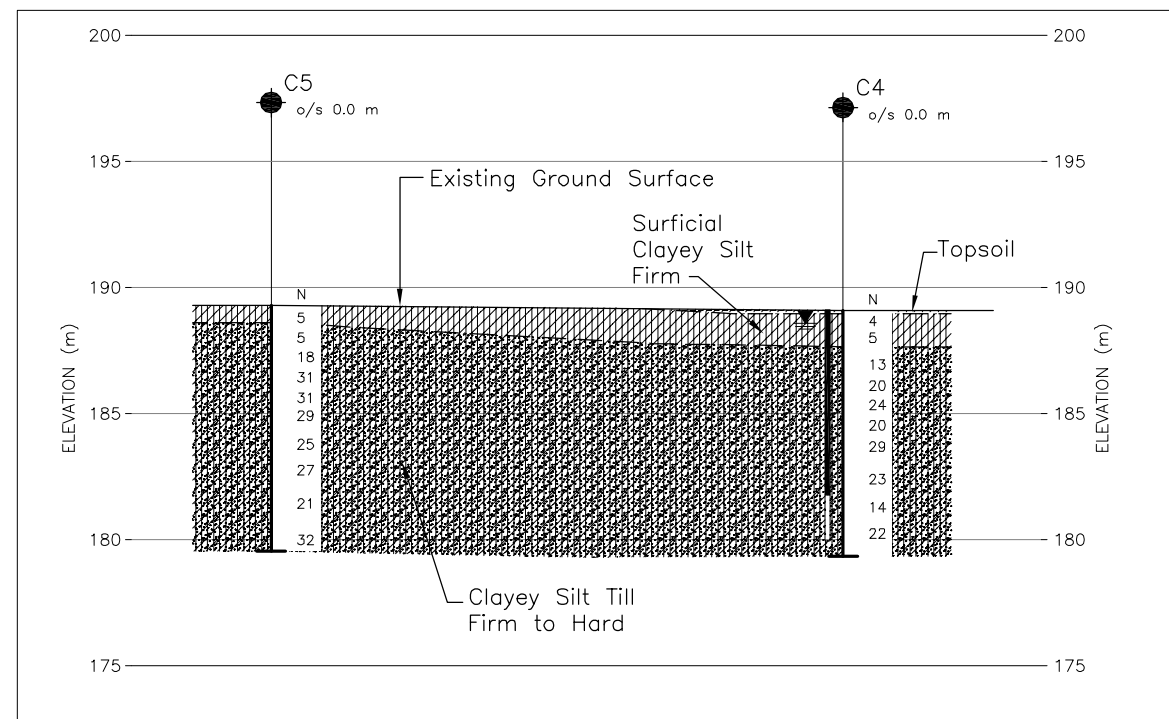
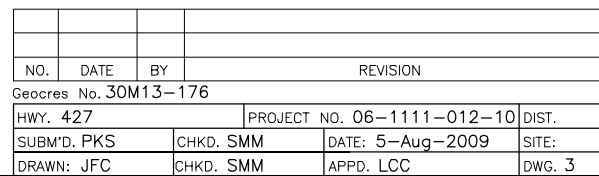
No.	ELEVATION	CO—ORDINATES	
		NORTHING	EASTING
C4	189.1	4850789.6	293627.
C5	189.2	4850807.0	293585.
C6	189.7	4851082.9	293567.
C7	190.2	4851098.8	293520.
C8	186.9	4851323.3	293481.
C9	188.3	4851338.9	293427.
C10	188.6	4851421.5	293435.
C11	191.1	4851412.1	293389.

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

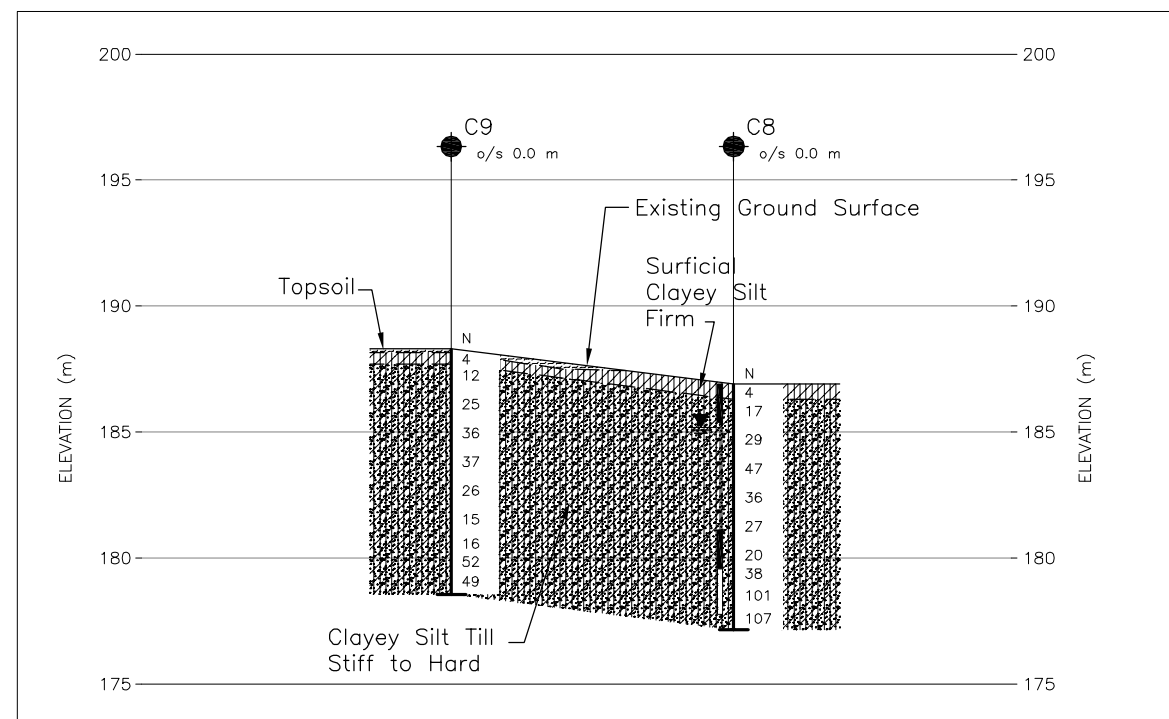
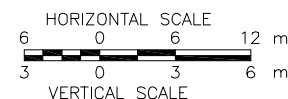
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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.

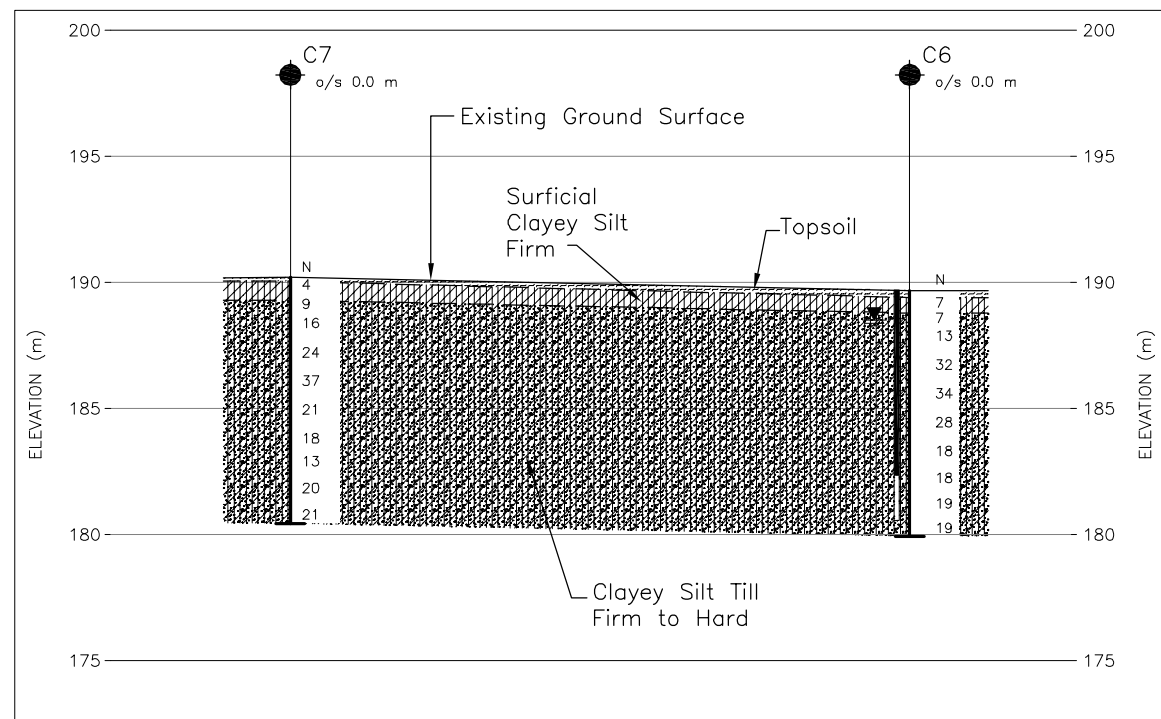
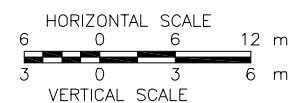
Base plans provided in digital format by MRC, (Drawing file nos. "P6450-XPD-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).



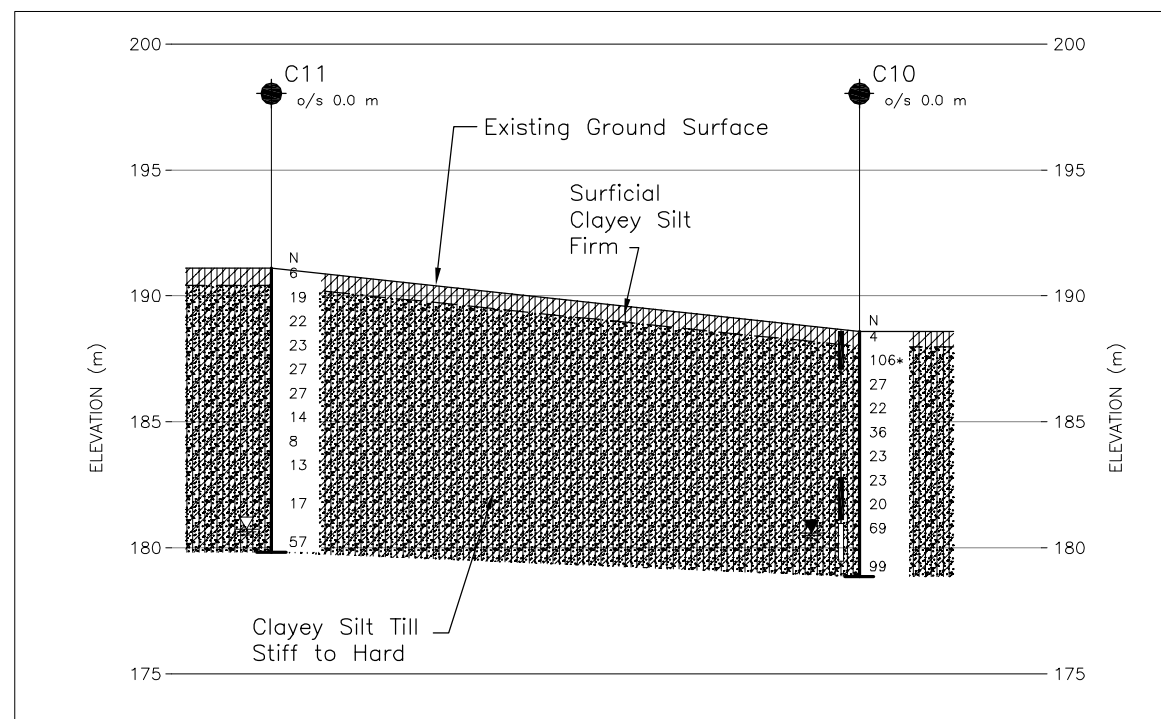
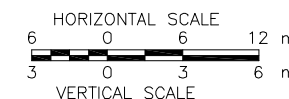
SECTION C-C' CULVERT STATION 13+025



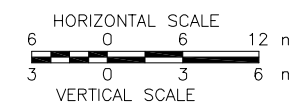
SECTION E-E' CULVERT STATION 13+560



SECTION D-D' STREAM CROSSING STATION 13+300



SECTION F-F' STREAM CROSSING STATION 13+640



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

CONT No.
WO No. 05-20012

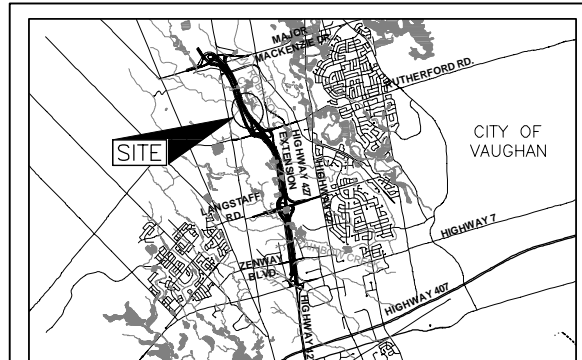


HIGHWAY 427 EXTENSION
CULVERT AT STATION 14+480 AND STREAM CROSSING
AT STATIONS 14+280, 10+030, 14+925 and 14+850
BOREHOLE LOCATIONS

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN

SCALE

2 0 2 4 km



LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on May 13, 2009
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C12	193.0	4851938.9	293098.1
C13	193.8	4851936.1	293054.4
C14	194.5	4851913.5	293008.0
C15	195.2	4851914.4	292897.6
C16	195.7	4852007.7	292849.4
C19	197.1	4852360.0	292668.5
C20	196.7	4852380.5	292705.2

NOTES

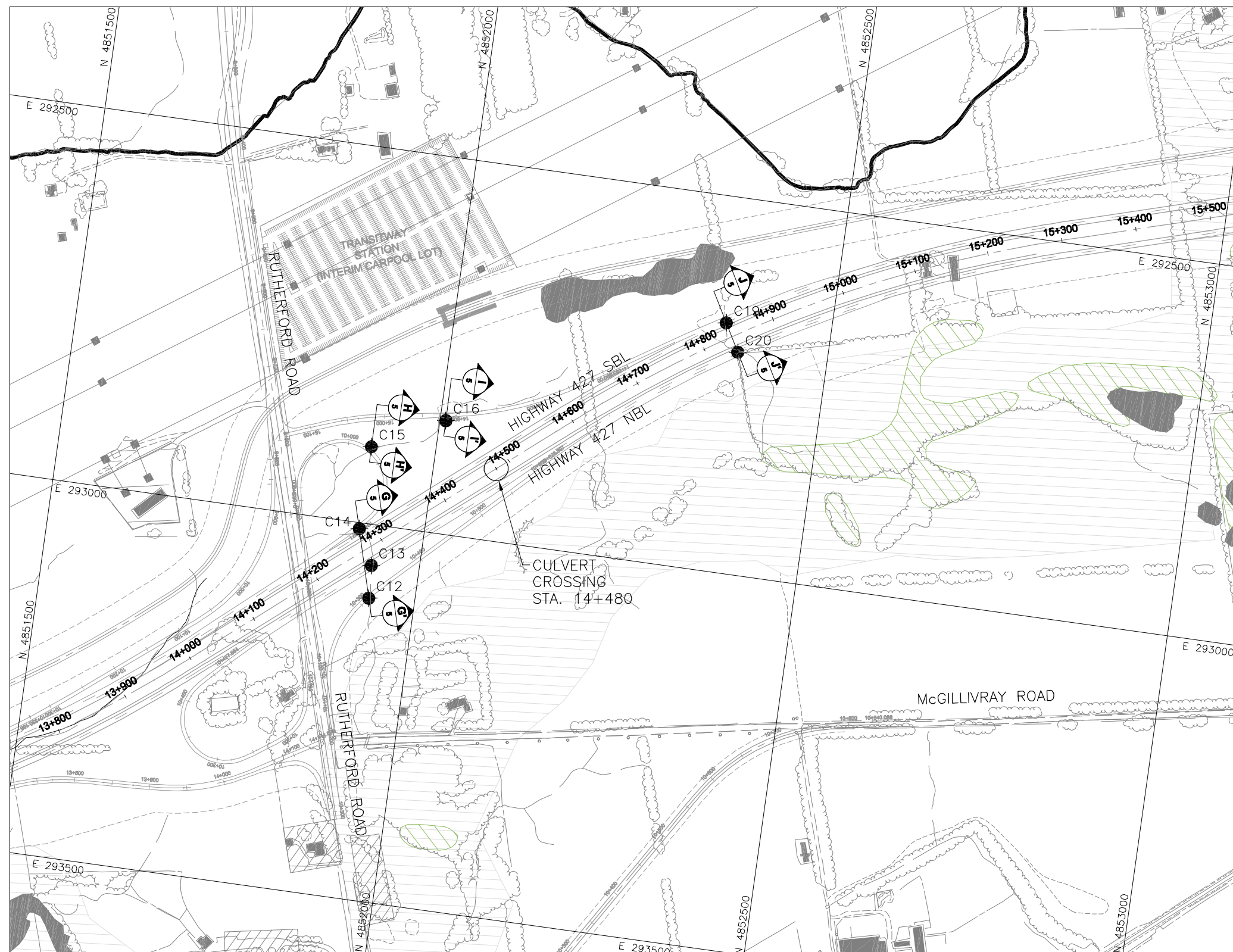
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Preliminary Design Report.

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 MRC, (Drawing file nos. "P6450-XP0-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).



PLAN

SCALE

60 0 60 120 m



NO.	DATE	BY	REVISION
Geocres No. 30M13-176			
HWY. 427	PROJECT NO. 06-1111-012-10		
SUBM'D. JEB	CHKD. SMM	DATE: 4-Aug-2009	SITE:
DRAWN: JFC	CHKD. SMM	APPD. LCC	DWG. 4

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

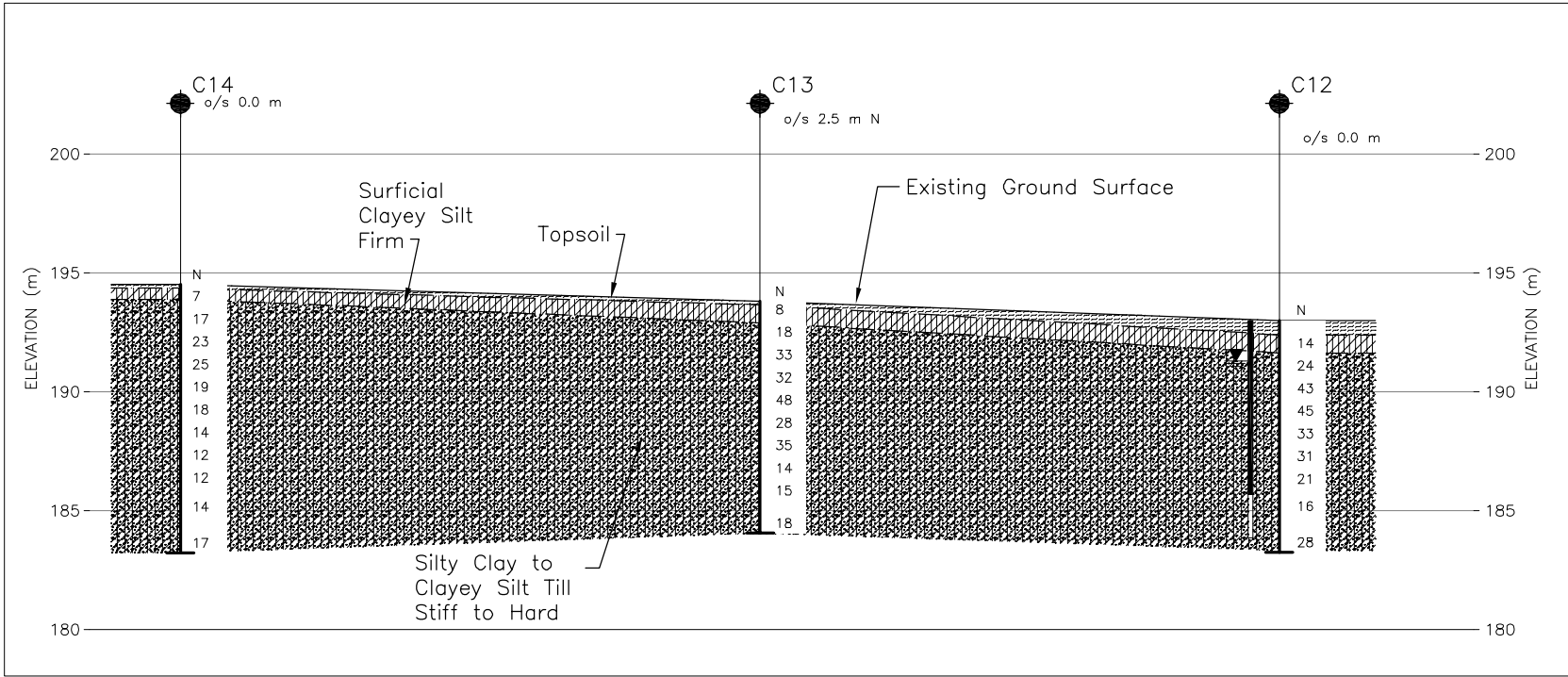
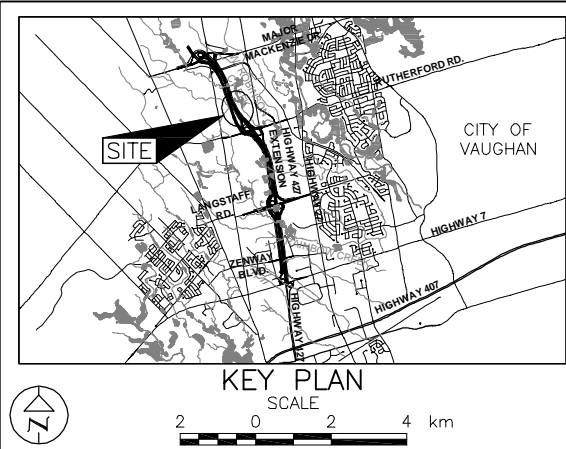
CONT No.
WO No. 05-20012

HIGHWAY 427 EXTENSION
STREAM CROSSING AT STATIONS 14+280, 10+030,
14+925 and 14+850
SOIL STRATA

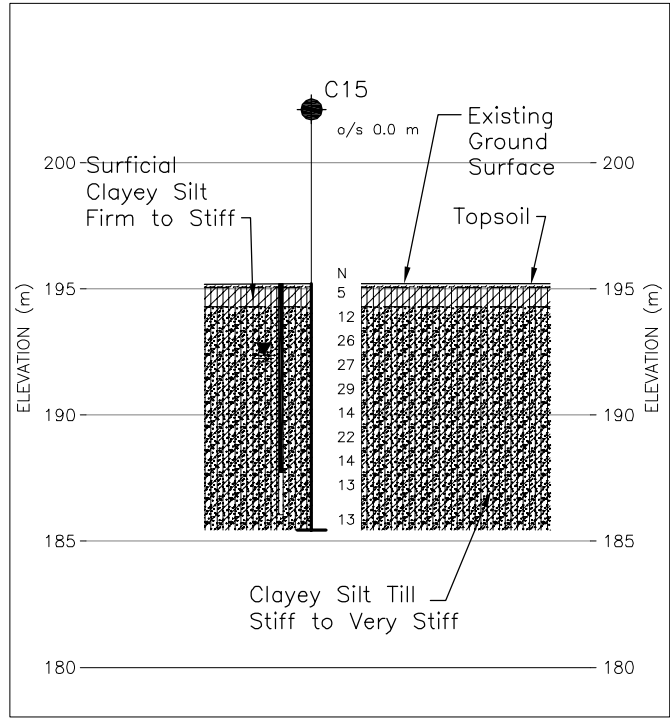
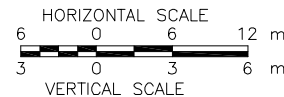
SHEET



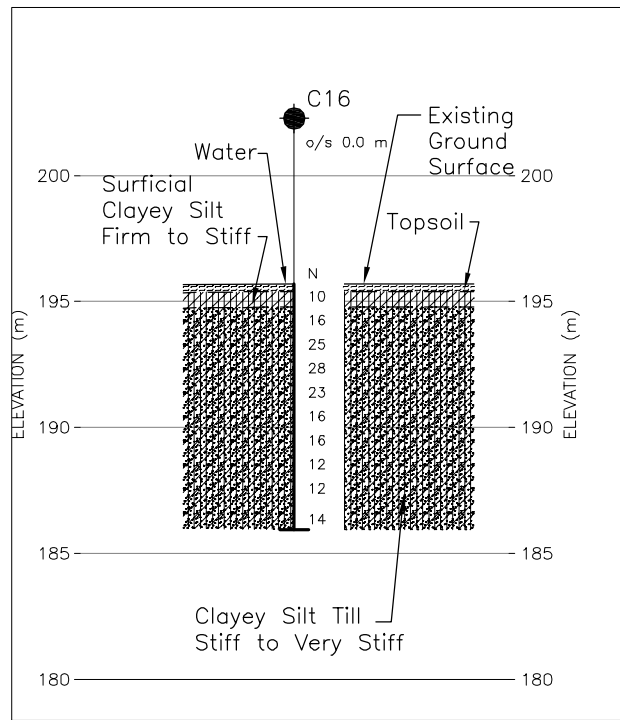
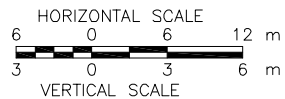
Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



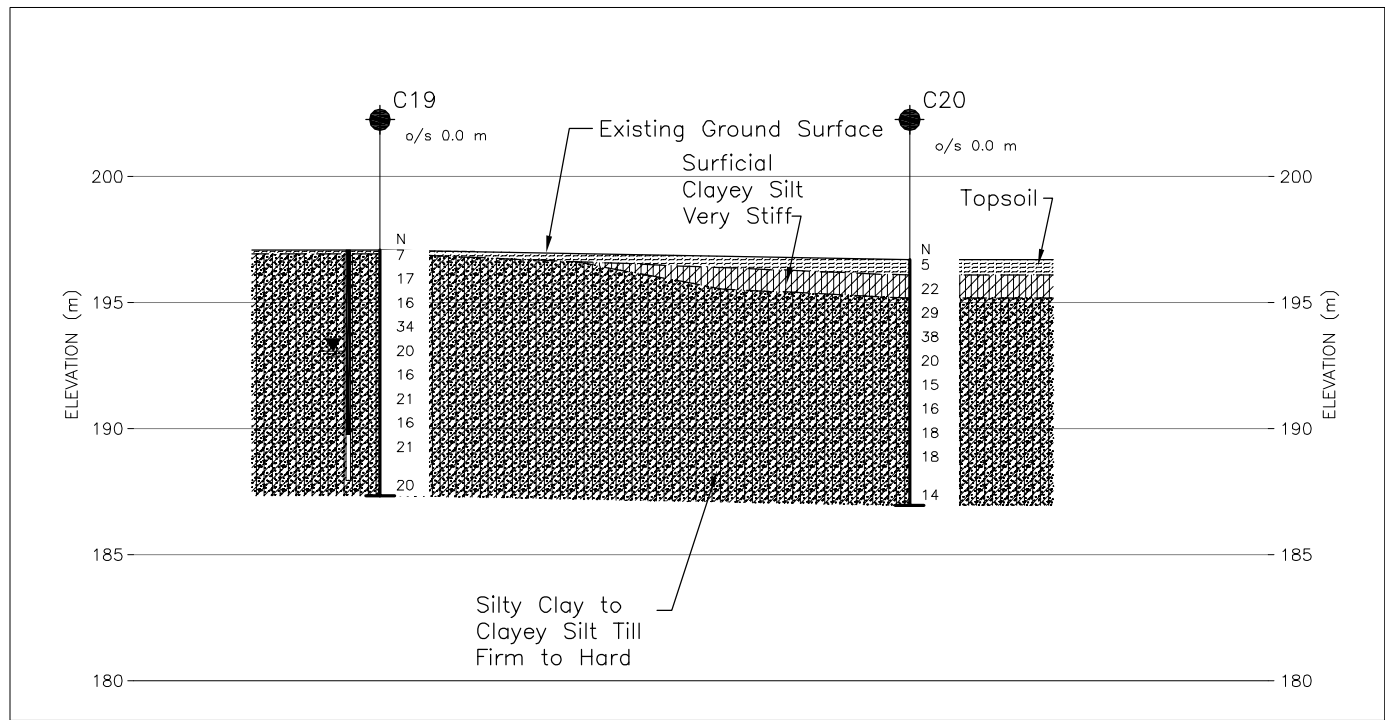
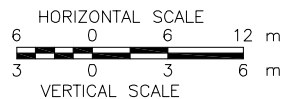
SECTION G-G' STREAM CROSSING STATION 14+280



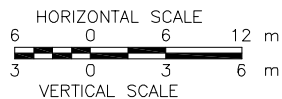
SECTION H-H' STREAM CROSSING STATION 10+030



SECTION I-I' STREAM CROSSING STATION 14+925



SECTION J-J' STREAM CROSSING STATION 14+850



LEGEND

- Borehole - Current Investigation
- ⊥ Seal
- ⊥ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL in piezometer, measured on May 13, 2009
- ≡ WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C12	193.0	4851938.9	293098.1
C13	193.8	4851936.1	293054.4
C14	194.5	4851913.5	293008.0
C15	195.2	4851914.4	292897.6
C16	195.7	4852007.7	292849.4
C19	197.1	4852360.0	292668.5
C20	196.7	4852380.5	292705.2

NOTES

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

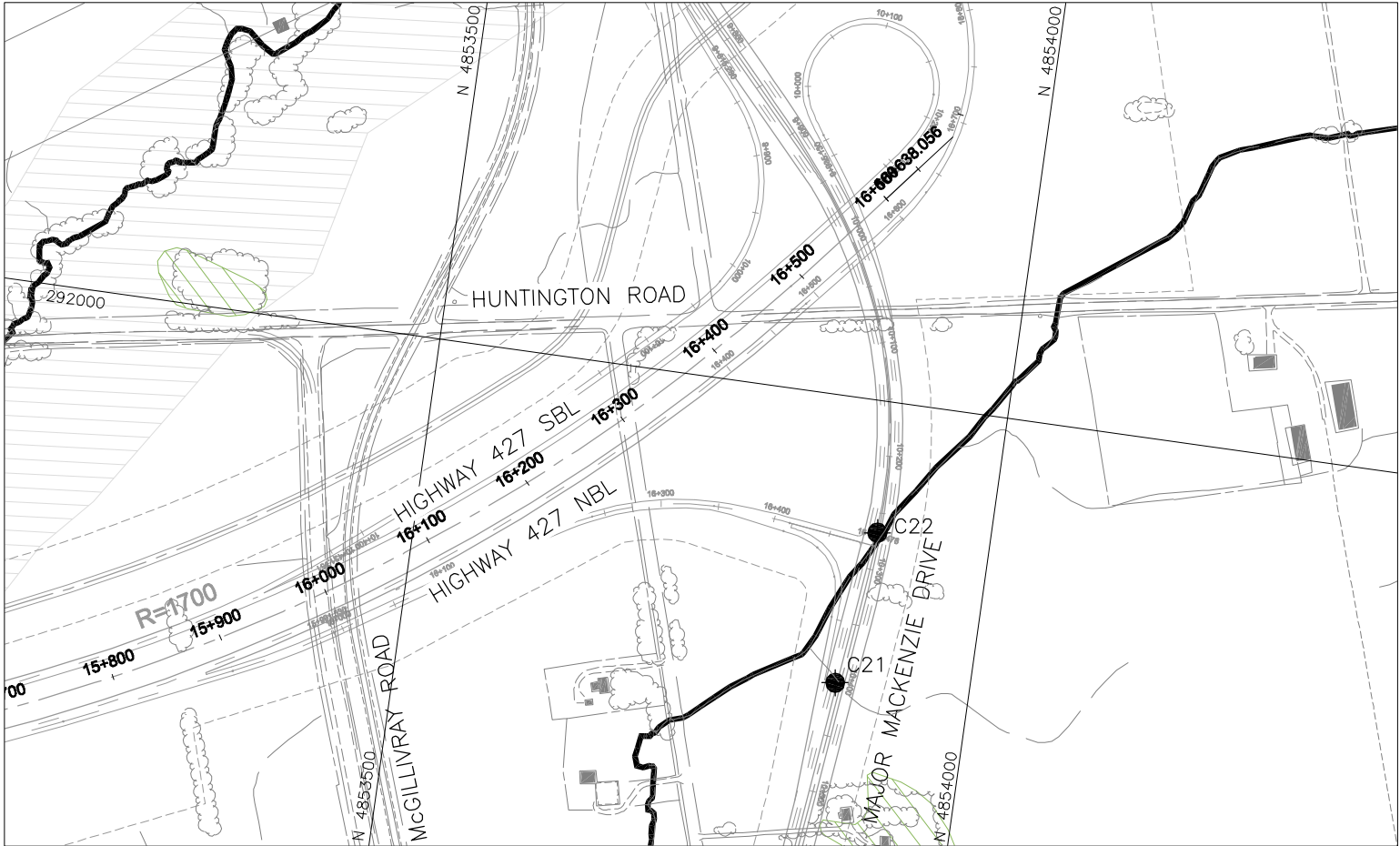
Base plans provided in digital format by MRC, (Drawing file nos. "P6450-XP0-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).

NO.	DATE	BY	REVISION

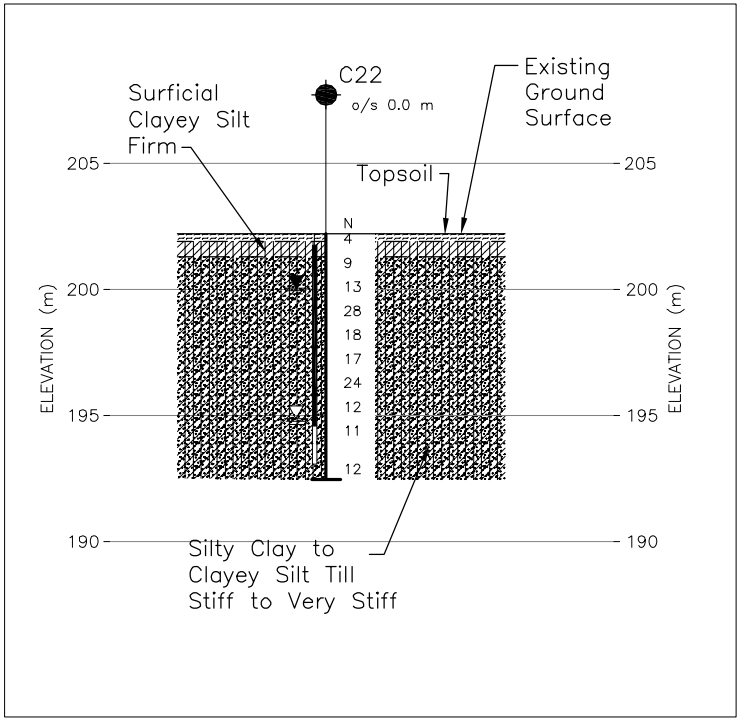
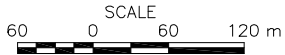
Geocres No. 30M13-176

HWY. 427	PROJECT NO. 06-1111-012-10	DIST.
SUBM'D. JEB	CHKD. SMM	DATE: 4-Aug-2009
DRAWN: JFC	CHKD. SMM	APPD. LCC
		DWG. 5

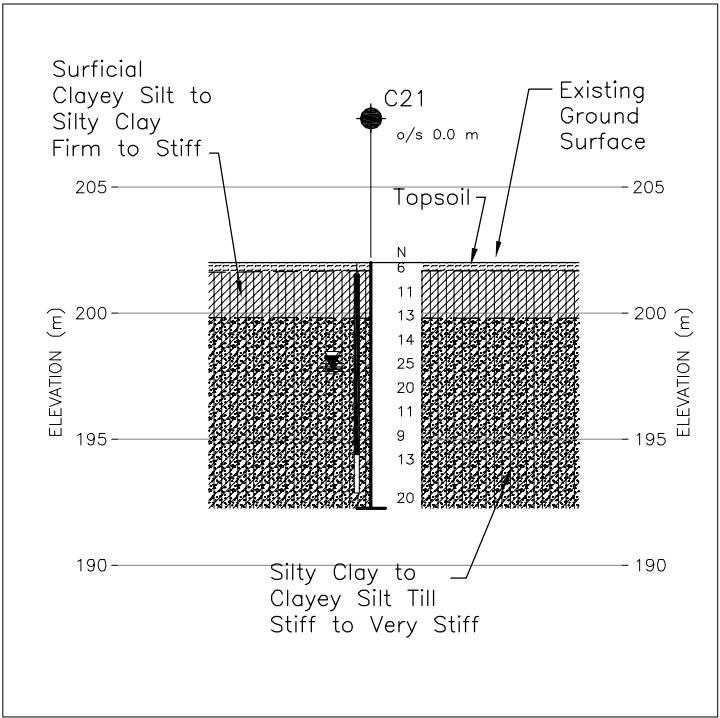
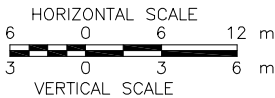




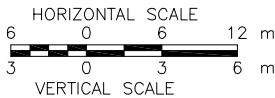
PLAN



SECTION K-K' CULVERT STATION 10+250



SECTION L-L' STREAM CROSSING STATION 10+400



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

CONT No.
WO No. 05-20012

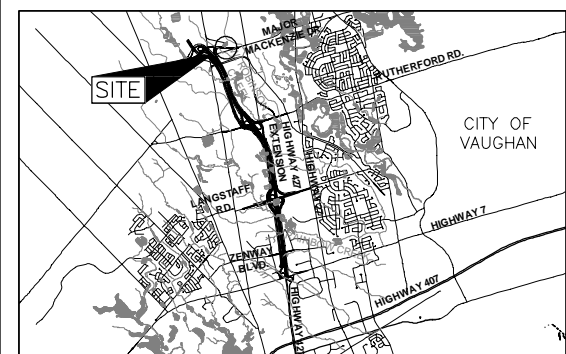


HIGHWAY 427 EXTENSION
CULVERT AT STATION 10+250 and
STREAM CROSSING AT STATION 10+400
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on May 21, 2009
- WL upon completion of drilling

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
C21	202.0	4853883.0	292249.3
C22	202.4	4853901.4	292114.6

NOTES

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

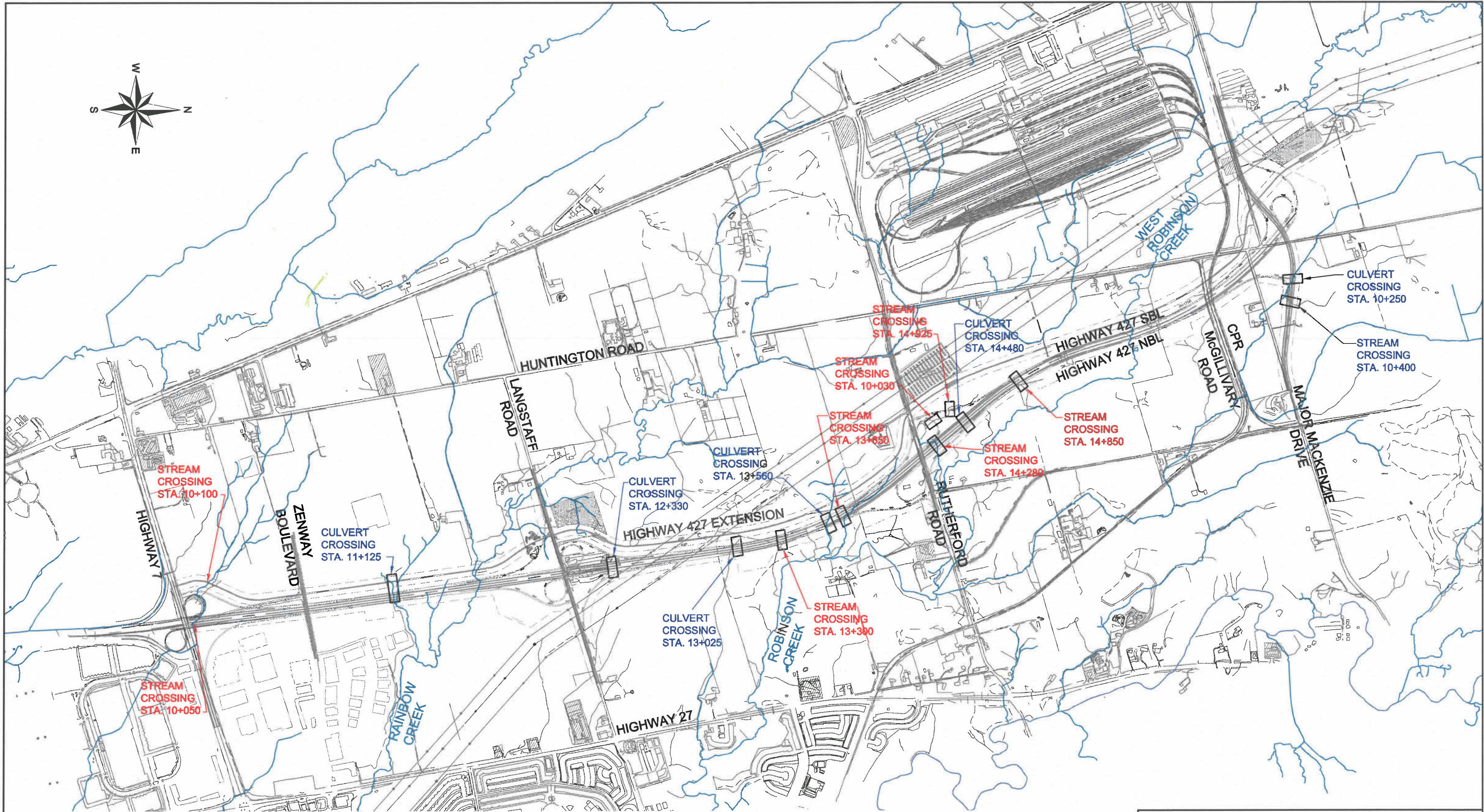
REFERENCE

Base plans provided in digital format by MRC, (Drawing file nos. "P6450-XP0-427Extension1.dwg", "P6450-XB08-Hatch.dwg", "P6450-XB06-Environmental Features.dwg", "P6450-XB01-Base Mapping.dwg", received April 16, 2009).




NO.	DATE	BY	REVISION
Geocres No. 30M13-176			
HWY. 427	PROJECT NO. 06-1111-012-10		
SUBM'D. CR	CHKD. SMM	DATE: 4-Aug-2009	SITE:
DRAWN: JFC	CHKD. SMM	APPD. LCC	DWG. 6

PLOT DATE: August 5, 2009
FILENAME: T:\Projects\2006\06-1111-012 (MRC, Vaughan)\-MB- (CULVERTS)\061111012MAF001.dwg



PROJECT				HIGHWAY 427 EXTENSION			
TITLE				SITE LOCATION PLAN PROPOSED CULVERTS AND STREAM CROSSINGS			
PROJECT No.		06-1111-012		FILE No.		061111012MAF001.dwg	
DESIGN	JFC	5-Aug-2009	SCALE	AS SHOWN	REV.	B	
CAD	JFC	5-Aug-2009	FIGURE	1			
CHECK	SMM	5-Aug-2009					
REVIEW	LCC	5-Aug-2009					



Golder Associates
Mississauga, Ontario, Canada



PRELIMINARY FOUNDATION REPORT CULVERTS - HIGHWAY 427 EXTENSION

APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_L	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 (over-consolidated 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
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2



LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

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

Piezo-Cone Penetration Test (CPT)

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

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

IV. SOIL TESTS

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

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

PROJECT 06-1111-012		RECORD OF BOREHOLE No C1		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4847903.2 :E 293975.6		ORIGINATED BY TB	
DIST Central HWY 427		BOREHOLE TYPE 108 mm Diameter Solid Stem Augers		COMPILED BY JEB	
DATUM Geodetic		DATE May 13, 2009		CHECKED BY SMM <i>SMM</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
180.2	GROUND SURFACE													
0.0	ASPHALT													
0.1	Sand and gravel (FILL)													
179.6														
0.6	CLAYEY SILT, with sand, trace gravel (TILL), containing oxidation staining		1	SS	33									
179.2	Hard Brown Moist													
1.0														
178.8	Silty SAND, trace clay Dense Brown Moist		2	SS	46									
1.5														
177.8	CLAYEY SILT, with sand, trace gravel (TILL), containing oxidation staining		3	SS	67									
2.4	Hard Brown Moist		4	SS	87									
	SILT, trace clay Dense to very dense Grey Moist		5	SS	35									
			6	SS	47									
174.6														
5.6	SILTY CLAY, trace sand, containing layers of sand and silt Very stiff to hard Grey Moist		7	SS	24									
			8	SS	28									
			9	SS	56									
170.5														
9.8	END OF BOREHOLE													
	NOTES: 1. Water level in open borehole at a depth of 8.8 m below ground surface (Elev. 171.4 m) upon completion of drilling. 2. Borehole backfilled with bentonite.													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012

RECORD OF BOREHOLE No C2

1 OF 1 **METRIC**

W.O. 05-20012

LOCATION N 4847873.3 :E 294009.6

ORIGINATED BY TB

DIST Central HWY 427

BOREHOLE TYPE 108 mm Diameter Solid Stem Augers

COMPILED BY JEB

DATUM Geodetic

DATE May 13, 2009

CHECKED BY SMM *SMM*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE							w _p w w _L				
								● QUICK TRIAXIAL × REMOULDED											
179.9	GROUND SURFACE						20	40	60	80	100								
0.0	ASPHALT																		
0.1	Sand and gravel (FILL)																		
179.3																			
0.6	CLAYEY SILT, some sand, trace gravel (TILL), containing oxidation staining Hard Brown Moist		1	SS	43		179												
			2	SS	57		178							7	19	56	18		
			3	SS	100/0.10		177												
			4	SS	43														
176.1							176												
3.8	SILT, trace clay Very dense Grey Moist		5	SS	101														
			6	SS	76		175							0	0	94	6		
174.3							174												
5.6	CLAYEY SILT Hard Grey Moist		7	SS	59		173												
							172							0	0	64	36		
			8	SS	42														
	Stratified with layers of sand and silt						171												
170.5			9	SS	54														
170.2	CLAYEY SILT, trace sand, trace gravel (TILL) Hard Greenish brown Moist																		
9.8	END OF BOREHOLE																		
NOTES: 1. Borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.																			

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C3		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4847898.4 E 293834.2		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 108 mm Diameter Solid Stem Augers		COMPILED BY PKS	
DATUM Geodetic		DATE April 30, 2009		CHECKED BY SMM	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
180.6 0.0	GROUND SURFACE TOPSOIL		1	SS	6										
180.0 0.6	SILTY CLAY, trace sand, trace gravel Stiff Brown grey Moist		2	SS	9										
179.2 1.4	SAND and SILT, trace gravel, trace clay (TILL) Very dense Moist Brown		3	SS	55									3 41 52 4	
			4	SS	105/23										
			5	SS	100/0.0										
176.8 3.8	SILTY CLAY, containing fine sand partings Hard Grey Moist		6	SS	42										
			7	SS	50										
175.1 5.5	Silty SAND, trace gravel, trace clay Very dense Grey Wet		8	SS	107/0.2										
173.9 6.7	CLAYEY SILT, containing fine sand partings Hard Grey Moist		9	SS	56										
			10	SS	50										
170.9 9.8	END OF BOREHOLE														
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 3.8 m (Elev. 176.8 m). Water level measurements Date Depth Elev. On Completion 3.3 m 177.3 m May 13, 2009 0.3 m 180.3 m June 15, 2009 0.8 m 179.7 m July 09, 2009 0.6 m 179.9 m															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C4		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4850789.6 E 293627.7		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY TBVA	
DATUM Geodetic		DATE April 1, 2009		CHECKED BY SMM <i>SM</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										

189.1	GROUND SURFACE													
0.0	TOPSOIL													
0.2	CLAYEY SILT, trace to some sand, containing organics and rootlets to a depth of 0.6 m Firm Brown Moist		1	SS	4									
			2	SS	5									0 11 52 37
187.7	CLAYEY SILT, some sand, trace gravel (TILL), containing thin sand and silty sand layers Stiff to very stiff Brown to grey Moist		3	SS	13									
1.5			4	SS	20									
	Becoming grey below a depth of 3.1 m		5	SS	24									4 19 58 19
			6	SS	20									
			7	SS	29									
			8	SS	23									
	Containing about 25 mm thick layer of sand at a depth of 6.4 m		9	SS	14									
	Containing about 100 mm thick layer of silty sand at a depth of 7.9 m		10	SS	22									
179.4	END OF BOREHOLE													
9.8	NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 180.0 m). Water level measurements Date Depth Elev. On Completion Dry April 24, 2009 1.1 m 188.0 m May 13, 2009 0.5 m 188.6 m May 21, 2009 0.5 m 188.6 m June 15, 2009 0.9 m 188.2 m July 09, 2009 0.7 m 188.4 m													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C5		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4850807.0 ; E 293585.8		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY PKS/VA	
DATUM Geodetic		DATE March 31, 2009		CHECKED BY SMM <i>[Signature]</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						

189.3	GROUND SURFACE													
0.9	TOPSOIL		1	SS	5		189							
188.6	CLAYEY SILT, trace gravel, trace sand, containing rootlets (Reworked)		2	SS	5		188							4 14 56 26
0.7	Firm Brown Moist													
	CLAYEY SILT, some sand, trace gravel, containing sand seams (TILL)		3	SS	18		187							
	Firm to hard Brown Moist		4	SS	31					○	—	—		
			5	SS	31		186							
	Becoming grey below a depth of 4.1 m		6	SS	29		185			○	—	—		
			7	SS	25		184							
							183							
			8	SS	27		182							
							181							
	Containing sand seams between depths of 7.6 m and 8.2 m		9	SS	21		180							
			10	SS	32									
179.6	END OF BOREHOLE													
9.8	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C6		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4851082.9 E 293567.1		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY PKS/VA	
DATUM Geodetic		DATE March 31, 2009		CHECKED BY SMM <i>SM</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
189.7	GROUND SURFACE														
0.0 189.4	TOPSOIL														
0.3	CLAYEY SILT, trace gravel, trace sand (Reworked) Firm Brown Moist		1	SS	7										
188.8			2	SS	7										
0.9	CLAYEY SILT, some sand, trace gravel (TILL), containing sand seams Firm to hard Grey Moist		3	SS	13										
			4	SS	32									4 19 51 26	
			5	SS	34										
	Augers grinding at 1.5 m and 3.5 m depth Becoming grey below a depth of 3.8 m		6	SS	28										
			7	SS	18										
			8	SS	18										
			9	SS	19										
	Augers grinding at a depth of 8.7 m		10	SS	19										
180.0 9.8	END OF BOREHOLE														
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 180.6 m). Water level measurements Date Depth Elev. On Completion Dry April 24, 2009 0.3 m 189.4 m May 13, 2009 1.2 m 188.5 m May 21, 2009 1.1 m 188.6 m June 15, 2009 1.0 m 188.7 m July 09, 2009 0.4 m 189.3 m															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT <u>06-1111-012</u>		RECORD OF BOREHOLE No C7		1 OF 1 METRIC	
W.O. <u>05-20012</u>	LOCATION <u>N 4851098.8 ; E 293520.6</u>	ORIGINATED BY <u>JEB</u>			
DIST <u>Central</u> HWY <u>427</u>	BOREHOLE TYPE <u>200 mm Outside Diameter Hollow Stem Augers</u>	COMPILED BY <u>PKS/VA</u>			
DATUM <u>Geodetic</u>	DATE <u>March 31, 2009</u>	CHECKED BY <u>SMM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
190.2	GROUND SURFACE													
0.0	TOPSOIL													
0.2	CLAYEY SILT, trace gravel, trace sand, containing rootlets (Reworked)		1	SS	4		190							
189.3	Firm Black and brown Moist		2	SS	9		189							
0.9	CLAYEY SILT, some sand, trace gravel, containing sand seams and cobbles (TILL) Stiff to hard Brown Moist		3	SS	16		188							
			4	SS	24		187							
			5	SS	37		186							
	Becoming grey below a depth of 3.8 m		6	SS	21		185							
	Containing sand seams between depths of 4.6 m and 5.2m		7	SS	18		184							
			8	SS	13		183							
	Containing sand seams between depths of 6.1 m and 6.7 m		9	SS	20		182							
			10	SS	21		181							
	Augers grinding at a depth of 8.8 m													
180.5	END OF BOREHOLE													
9.8	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012 **RECORD OF BOREHOLE No C8** 1 OF 1 **METRIC**
 W.O. 05-20012 LOCATION N 4851323.3 , E 293481.9 ORIGINATED BY JEB
 DIST Central HWY 427 BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers COMPILED BY PKS/VA
 DATUM Geodetic DATE March 30, 2009 CHECKED BY SMN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
186.9	GROUND SURFACE													
0.0	CLAYEY SILT, trace gravel, trace sand, containing rootlets		1	SS	4									
186.3	Firm													
0.6	Brown Moist													
	CLAYEY SILT, some sand, trace gravel, containing sand seams and cobbles (TILL)		2	SS	17		186							1 13 62 24
	Very stiff to hard													
	Brown to grey		3	SS	29		185							
	Moist													
	Containing sand seams between depths of 3.0 m and 3.7 m		4	SS	47		184							
	Becoming grey below a depth of 3.8 m		5	SS	36		183							
			6	SS	27		182							
			7	SS	20		181							
			8	SS	38		180							
	Cobbles encountered at a depth of 7.0 m													
			9	SS	101		179							
			10	SS	107		178							
177.2	END OF BOREHOLE													
9.8	NOTES:													
	1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 177.8 m).													
	Water level measurements													
	Date Depth Elev.													
	On Completion Dry													
	April 24, 2009 1.7 m 185.2 m													
	May 21, 2009 2.5 m 184.4 m													
	June 15, 2009 2.3 m 184.6 m													
	July 09, 2009 2.2 m 184.7 m													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012

RECORD OF BOREHOLE No C9

1 OF 1 **METRIC**

W.O. 05-20012

LOCATION N 4851338.9 ; E 293427.6

ORIGINATED BY JEB

DIST Central HWY 427

BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers

COMPILED BY PKS/VA

DATUM Geodetic

DATE March 27, 2009

CHECKED BY SMW *SMW*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× REMOULDED	W _p	W
188.3	GROUND SURFACE						20	40	60	80	100							
0.0	TOPSOIL																	
0.2	CLAYEY SILT, trace gravel, trace sand, containing rootlets (Reworked)		1	SS	4													
187.7	Firm Brown Moist		2	SS	12													
0.6	CLAYEY SILT, some sand, trace gravel (TILL)		3	SS	25													
	Stiff to hard Brown to grey Moist		4	SS	36													
			5	SS	37													
	Becoming grey below a depth of 3.8 m		6	SS	26													
			7	SS	15													
			8	SS	16													
	Containing sand partings at a depth of 7.5 m		9	SS	52													
			10	SS	49													
178.6	END OF BOREHOLE																	
9.8	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.																	

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012

RECORD OF BOREHOLE No C10

1 OF 1 METRIC

W.O. 05-20012

LOCATION N 4851421.5 ; E 293435.4

ORIGINATED BY JEB

DIST Central HWY 427

BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers

COMPILED BY PKS/A

DATUM Geodetic

DATE March 30, 2009

CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
188.6	GROUND SURFACE													
0.0	CLAYEY SILT, trace sand, containing rootlets (Reworked) Firm Brown Moist		1	SS	4		188							
188.0	CLAYEY SILT, some sand, trace gravel, containing cobbles (TILL) Very stiff to hard Brown to grey Moist Augers grinding at a depth of 1.5 m		2	SS	106*									
0.6			3	SS	27		187							5 20 52 23
			4	SS	22		186							
			5	SS	36		185							
	Becoming grey below a depth of 3.8 m		6	SS	23		184							
			7	SS	23		183							
			8	SS	20		182							
			9	SS	69		181							
	Cobbles encountered at a depth of 8.5 m		10	SS	99		180							
178.9	END OF BOREHOLE						179							
9.8	NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 179.5 m). Water level measurements Date Depth Elev. On Completion Dry April 24, 2009 7.6 m 181.0 m May 13, 2009 8.0 m 180.6 m May 21, 2009 7.9 m 180.7 m June 15, 2009 7.9 m 180.7 m July 09, 2009 7.6 m 181.0 m * High SPT "N" value as a result of split spoon bouncing on cobbles													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT <u>06-1111-012</u>		RECORD OF BOREHOLE No C11		1 OF 1 METRIC	
W.O. <u>05-20012</u>		LOCATION <u>N 4851412.1 : E 293389.7</u>		ORIGINATED BY <u>JEB</u>	
DIST <u>Central</u> HWY <u>427</u>		BOREHOLE TYPE <u>200 mm Outside Diameter Hollow Stem Augers</u>		COMPILED BY <u>VA</u>	
DATUM <u>Geodetic</u>		DATE <u>March 27, 2009</u>		CHECKED BY <u>SMM</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
191.1	GROUND SURFACE													
0.0	CLAYEY SILT, trace sand (Reworked) Firm		1	SS	6		191							
190.4	Black and brown Moist													
0.7	CLAYEY SILT, some sand, trace gravel (TILL), containing oxidation zones to a depth of 2.1 m Stiff to very stiff Brown to grey Moist		2	SS	19		190							
			3	SS	22		189							
			4	SS	23		188							
			5	SS	27		187							
			6	SS	27		186							
	Becoming grey below a depth of 4.6 m		7	SS	14		185							
			8	SS	8		184							
			9	SS	13		183							
	Containing sand seams at a depth of 7.9 m		10	SS	17		182							
	Containing sand seams between depths of 9.1 m and 9.8 m						181							
180.7	CLAYEY SILT with sand, trace gravel, containing cobbles (TILL) Hard		11	SS	57		180							
10.4	Grey Moist													
179.8	END OF BOREHOLE													
11.3	NOTES: 1. Water level in open borehole at a depth of 10.3 m below ground surface (Elev. 180.8 m) upon completion of drilling. 2. Borehole backfilled with bentonite.													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C12		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4851938.9 ; E 293098.1		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY PKS	
DATUM Geodetic		DATE April 7, 2009		CHECKED BY SMM <i>[Signature]</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								● QUICK TRIAXIAL	× REMOULDED						
193.0	GROUND SURFACE														
0.0	TOPSOIL														
192.4															
0.6	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked) Stiff Brown Moist		1	SS	14										
191.6															
1.4	CLAYEY SILT, trace to some sand, trace to some gravel, containing cobbles (TILL) Very stiff to hard Brown to grey Moist		2	SS	24									7 12 44 37	
			3	SS	43										
			4	SS	45										
	Becoming grey at a depth of 3.8 m		5	SS	33										
	Augers grinding at a depth of 4.5 m		6	SS	31										
			7	SS	21										
			8	SS	16										
			9	SS	28										
183.3	END OF BOREHOLE														
9.8															
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 183.9 m). Water level measurements Date Depth Elev. On Completion Dry April 24, 2009 1.7 m 191.3 m May 21, 2009 1.9 m 191.1 m June 15, 2009 2.8 m 190.2 m July 09, 2009 1.9 m 191.1 m															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012			RECORD OF BOREHOLE No C13			1 OF 1 METRIC											
W.O. 05-20012			LOCATION N 4851936.1 E 293054.4			ORIGINATED BY JEB											
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY PKS											
DATUM Geodetic			DATE April 6, 2009			CHECKED BY SMM											
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 _P W W _L			γ	GR SA SI CL		
193.8	GROUND SURFACE																
0.0	TOPSOIL																
0.2	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked)		1	SS	8												
192.9	Stiff Brown Moist		2	SS	18		193										
0.9	SILTY CLAY, trace sand, trace gravel (TILL) Very stiff to hard Brown Moist		3	SS	33		192										
			4	SS	32		191										
			5	SS	48		190										
			6	SS	28		189										
189.2	CLAYEY SILT, trace to some sand, trace gravel (TILL) Stiff to hard Grey Moist		7	SS	35		188										
4.6			8	SS	14		187										
			9	SS	15		186										
			10	SS	18		185										
184.1	END OF BOREHOLE																
9.8	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.																

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012

RECORD OF BOREHOLE No C14

1 OF 1 **METRIC**

W.O. 05-20012

LOCATION N 4851913.5, E 293008.0

ORIGINATED BY JEB

DIST Central HWY 427

BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers

COMPILED BY PKS

DATUM Geodetic

DATE April 3, 2009

CHECKED BY SMM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED 20 40 60 80 100	+ FIELD VANE 20 40 60 80 100						
194.5	GROUND SURFACE														
0.0	TOPSOIL														
0.2	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked)		1	SS	7		194								
193.9	Firm Brown Moist		2	SS	17										
0.6	CLAYEY SILT, with sand, trace gravel (TILL) Stiff to very stiff Brown Moist		3	SS	23		193								
			4	SS	25		192								
			5	SS	19		191								
			6	SS	18		190								
			7	SS	14		189								
			8	SS	12		188								
			9	SS	12		187								
			10	SS	14		186								
	Containing sand seams below a depth of 9.14 m		11	SS	17		185								
183.2	END OF BOREHOLE						184								
11.3	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.														

MIS-MTQ 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C15		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4851914.4 ; E 292897.6		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY VA	
DATUM Geodetic		DATE April 2, 2009		CHECKED BY SMM <i>[Signature]</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
195.2	GROUND SURFACE																	
0.0	TOPSOIL																	
0.2	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked)		1	SS	5													
194.3	Firm to stiff Brown Moist		2	SS	12													
0.9	CLAYEY SILT, trace to some sand, trace gravel, containing cobbles (TILL)		3	SS	26													
	Stiff to very stiff Brown to grey Moist		4	SS	27													
	Augers grinding at a depth of 3.0 m		5	SS	29													
	Becoming grey at a depth of 3.8 m		6	SS	14													
			7	SS	22													
			8	SS	14													
			9	SS	13													
	Contains silty sand layers below a depth of 9.1 m		10	SS	13													
185.5	END OF BOREHOLE																	
9.8	NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 186.1 m). Water level measurements Date Depth Elev. On Completion Dry April 24, 2009 2.8 m 192.4 m May 21, 2009 1.9 m 193.3 m June 15, 2009 1.9 m 193.3 m July 09, 2009 1.8 m 193.4 m																	

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C16		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4852007.7 E 292849.4		ORIGINATED BY JEB	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY PKS/VA	
DATUM Geodetic		DATE April 2, 2009		CHECKED BY SMM	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								\circ UNCONFINED \bullet QUICK TRIAXIAL	$+$ FIELD VANE \times REMOULDED						
195.7	GROUND SURFACE														
0.0 195.4	TOPSOIL														
0.3	CLAYEY SILT, trace gravel, trace sand, containing rootlets (Reworked)		1	SS	10										
194.8 0.9	Stiff Brown Moist		2	SS	16										
	CLAYEY SILT, trace gravel, trace to some sand, containing sand seams (TILL)		3	SS	25										
	Stiff to very stiff Brown to grey Moist		4	SS	28										
	Becoming grey below a depth of 3.1 m		5	SS	23										
			6	SS	16										
	Containing sand seams between depths of 4.6 m and 5.2 m		7	SS	16										
			8	SS	12										
			9	SS	12										
	Containing sand and gravel seams at a depth of 8.1 m		10	SS	14										
186.0 9.8	END OF BOREHOLE														
	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.														

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT <u>06-1111-012</u>		RECORD OF BOREHOLE No C19		1 OF 1 METRIC	
W.O. <u>05-20012</u>	LOCATION <u>N 4852360.0 :E 292668.5</u>	ORIGINATED BY <u>JEB</u>			
DIST <u>Central</u> HWY <u>427</u>	BOREHOLE TYPE <u>108 mm Diameter Solid Stem Augers</u>	COMPILED BY <u>PKS</u>			
DATUM <u>Geodetic</u>	DATE <u>April 29, 2009</u>	CHECKED BY <u>SMM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED 20 40 60 80 100	+ FIELD VANE 20 40 60 80 100						
197.1	GROUND SURFACE														
0.0	TOPSOIL														
0.2	CLAYEY SILT, trace sand, trace gravel (TILL) Firm to hard Brown grey Moist		1	SS	7										
			2	SS	17										
			3	SS	16										
			4	SS	34										
194.1	SILTY CLAY, trace to some sand, trace gravel (TILL) Very stiff Grey Moist		5	SS	20										
3.0			6	SS	16										
192.5	CLAYEY SILT, trace sand, trace gravel (TILL) Very stiff Grey Moist		7	SS	21										
4.6			8	SS	16										
			9	SS	21										
			10	SS	20										
187.4	END OF BOREHOLE														
9.8	NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 188.0 m). Water level measurements Date Depth Elev. On Completion Dry May 13, 2009 4.0 m 193.1 m June 15, 2009 2.6 m 194.5 m July 09, 2009 2.5 m 194.6 m														

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT <u>06-1111-012</u>		RECORD OF BOREHOLE No C20		1 OF 1 METRIC	
W.O. <u>05-20012</u>		LOCATION <u>N 4852380.5 :E 292705.2</u>		ORIGINATED BY <u>JEB</u>	
DIST <u>Central</u> HWY <u>427</u>		BOREHOLE TYPE <u>108 mm Diameter Solid Stem Augers</u>		COMPILED BY <u>PKS</u>	
DATUM <u>Geodetic</u>		DATE <u>April 30, 2009</u>		CHECKED BY <u>SMM</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × REMOULDED						
196.7 0.0	GROUND SURFACE TOPSOIL		1	SS	5										
196.1 0.6	CLAYEY SILT, some sand, trace gravel, trace organics (Reworked) Very stiff Brown Moist		2	SS	22		196								
195.2 1.5	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Grey Moist		3	SS	29		195								
			4	SS	38		194								
	Becoming grey below a depth of 2.9 m		5	SS	20		193								
			6	SS	15		192								
	Sandy silt seam at a depth of 4.3 m		7	SS	16		191								
			8	SS	18		190								
			9	SS	18		189								
			10	SS	14		188								
187.0 9.8	END OF BOREHOLE						187								
NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite.															

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C21		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4853883.0 :E 292249.3		ORIGINATED BY CR	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY VA	
DATUM Geodetic		DATE March 16, 2009		CHECKED BY SMM <i>[Signature]</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED						
202.0	GROUND SURFACE													
0.0	TOPSOIL													
201.7														
0.3	CLAYEY SILT, trace sand, containing oxidation zones (Reworked)		1	SS	6									
201.2	Firm													
0.8	Brown		2	SS	11									
	Moist													
	SILTY CLAY, trace sand, containing oxidation zones and rootlets		3	SS	13									
199.8	Stiff													
2.2	Mottled brown and grey													
	SILTY CLAY, some sand, trace to some gravel, containing cobbles and boulders (TILL)		4	SS	14									
	Stiff to very stiff													
	Brown to grey		5	SS	25									
	Moist to wet													
	Augers grinding at a depth of 3.5 m													
	Becoming grey below a depth of 4.0 m		6	SS	20									
			7	SS	11									
			8	SS	9									
			9	SS	13									
193.3														
8.7	CLAYEY SILT, some gravel, some sand, containing cobbles (TILL)													
	Very stiff													
	Grey		10	SS	20									
192.3	Moist													
9.8	END OF BOREHOLE													
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev. 192.9 m). Water level measurements Date Depth Elev. On Completion 4.2 m 197.9 m May 21, 2009 4.0 m 198.0 m June 15, 2009 3.4 m 198.6 m July 09, 2009 3.1 m 198.9 m														

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012		RECORD OF BOREHOLE No C22		1 OF 1 METRIC	
W.O. 05-20012		LOCATION N 4853901.4 E 292114.6		ORIGINATED BY CR	
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers		COMPILED BY VA	
DATUM Geodetic		DATE March 17, 2009		CHECKED BY SMM <i>SMM</i>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
202.2	GROUND SURFACE													
0.0	TOPSOIL													
0.3	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked)		1	SS	4									
201.9	Firm Brown Moist		2	SS	9									
201.3	SILTY CLAY, trace to some sand, trace gravel, containing cobbles (TILL)		3	SS	13									
0.9	Stiff to very stiff Brown to grey Moist		4	SS	28									
	Becoming grey at a depth of 3.0 m		5	SS	18									
			6	SS	17									
			7	SS	24									
196.6	CLAYEY SILT, some sand, trace gravel (TILL)		8	SS	12									
5.6	Stiff Grey Wet													
			9	SS	11									
			10	SS	12									
192.5	END OF BOREHOLE													
9.8	NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 9.1 m (Elev.193.1 m). Water level measurements Date Depth Elev. On Completion 7.3 m 194.9 m April 24, 2009 2.1 m 200.1 m May 21, 2009 2.0 m 200.2 m June 15, 2009 2.0 m 200.2 m July 09, 2009 1.9 m 200.3 m													

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD



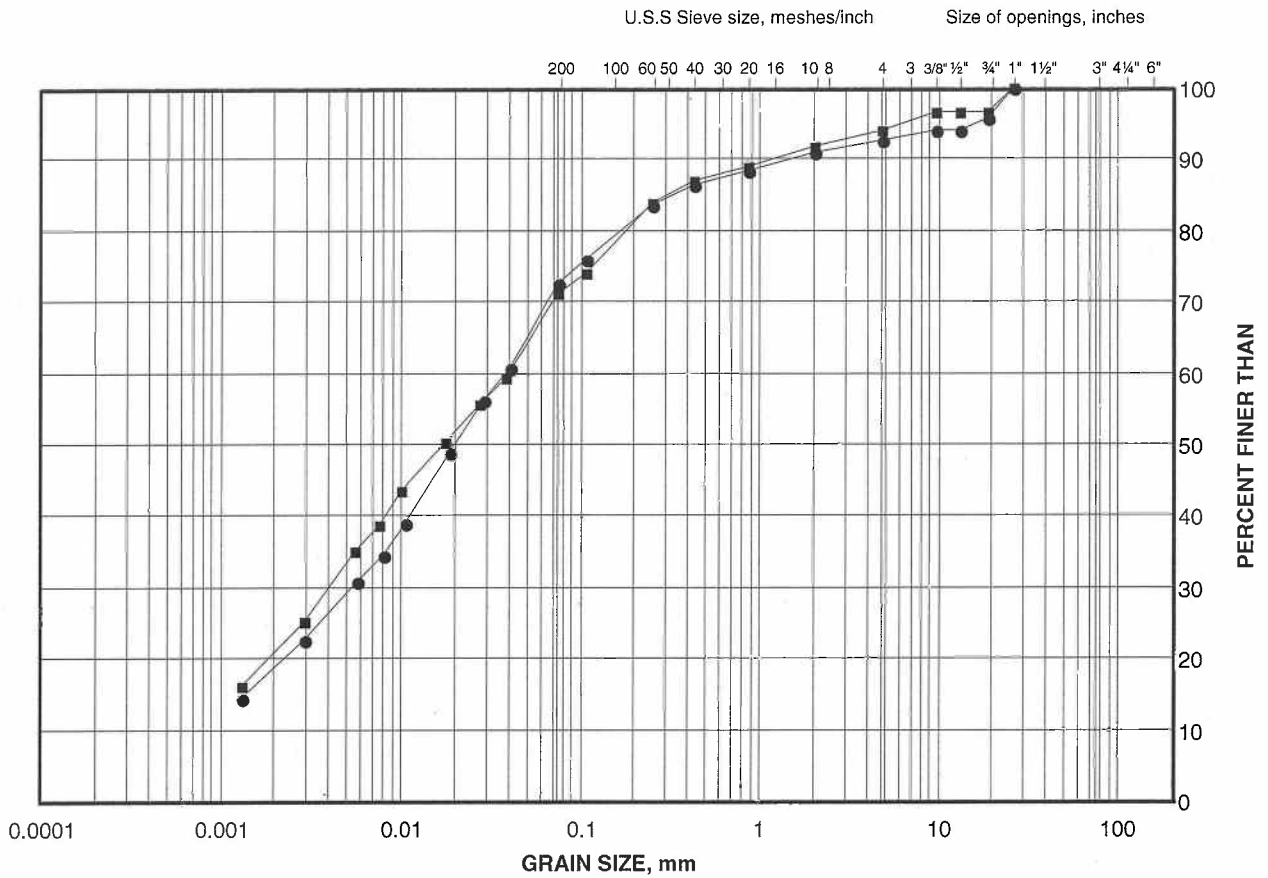
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Clayey Silt Till

FIGURE B1



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

LEGEND

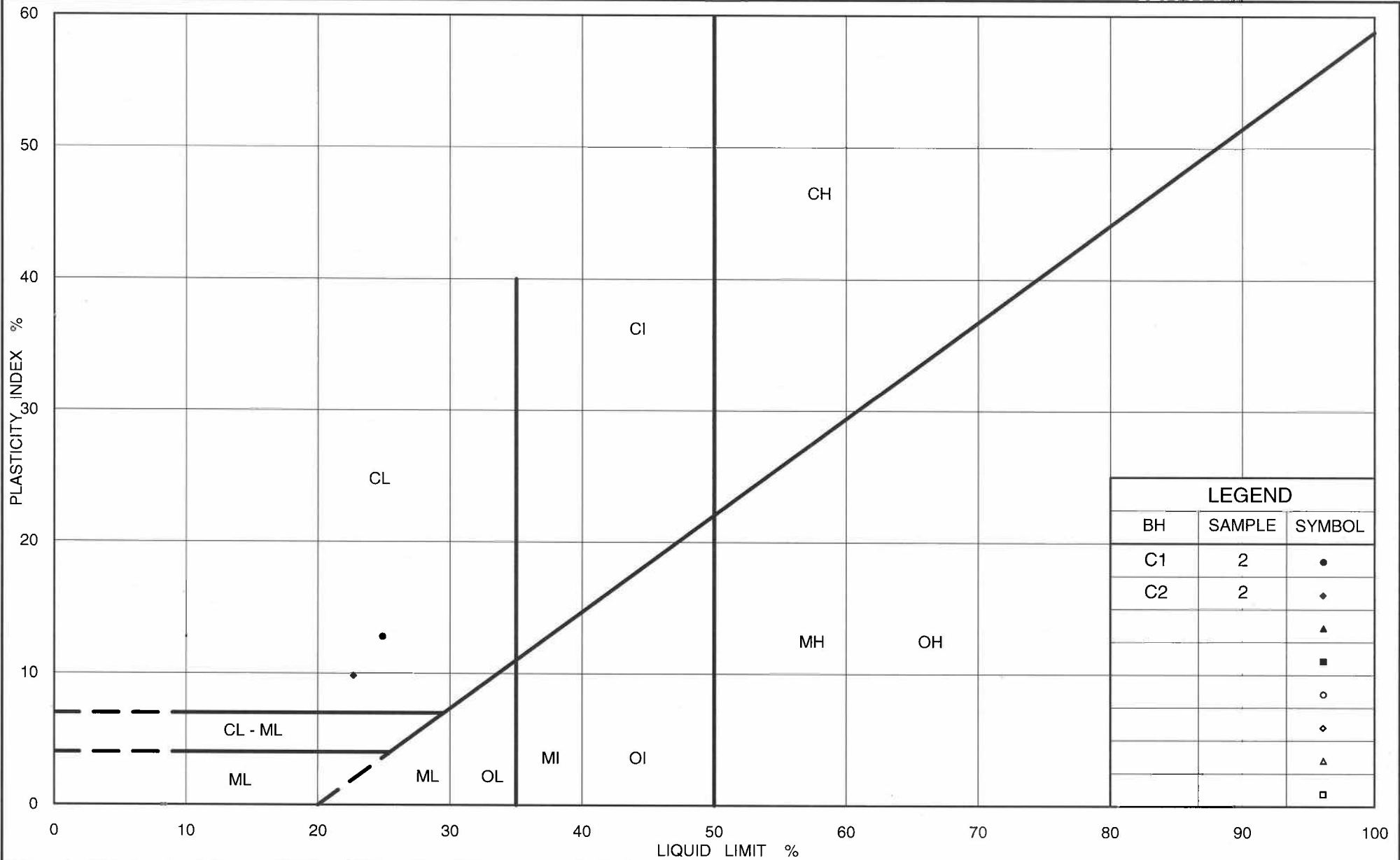
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C2	2	178.0
■	C1	2	178.4

Project Number: 06-1111-012-10

Checked By: SM

Golder Associates

Date: 07-Jul-09



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt Till

Figure No. B2

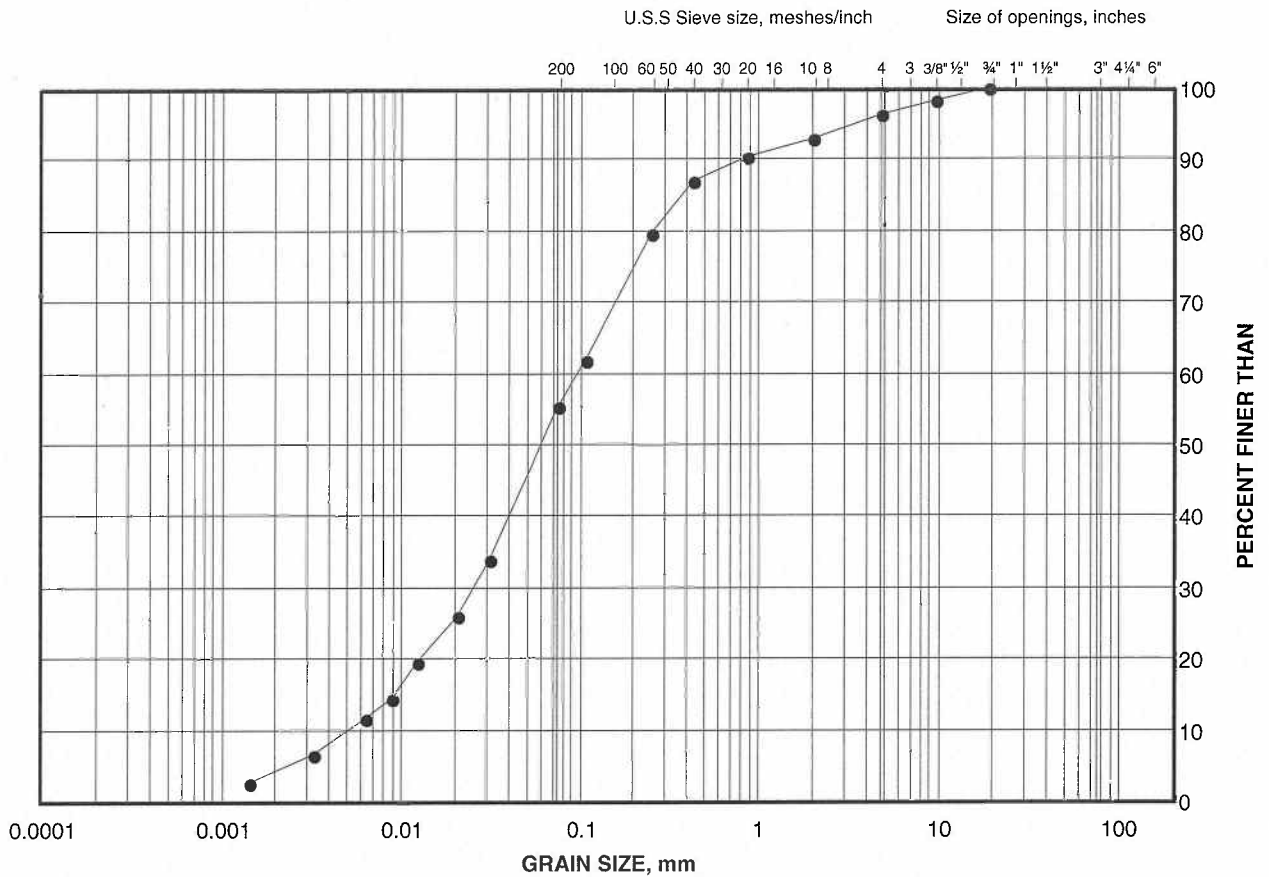
Project No. 06-1111-012-10

Checked By: *SM*

GRAIN SIZE DISTRIBUTION TEST RESULT

Sand and Silt 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)
•	C3	3	178.7

Project Number: 06-1111-012-10

Checked By: SM

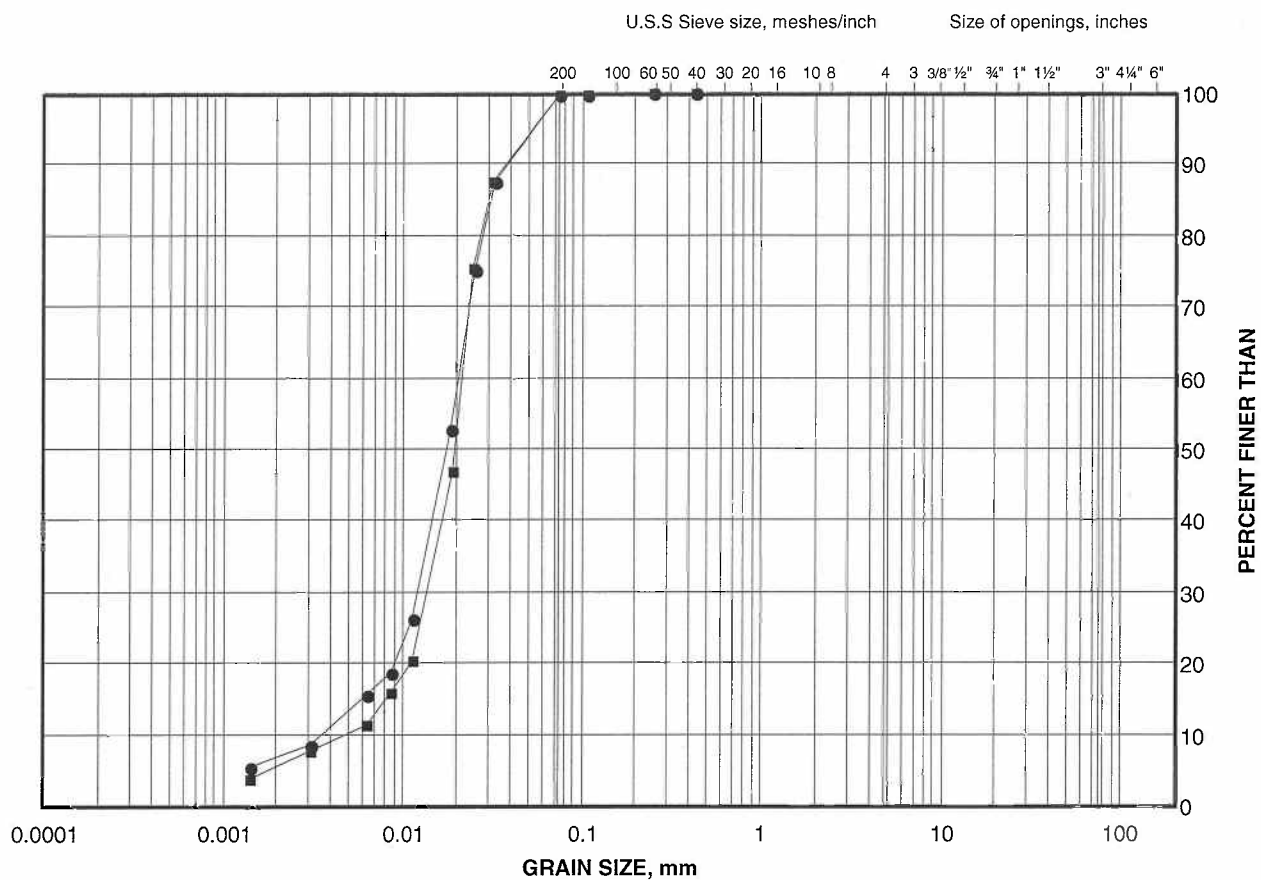
Golder Associates

Date: 07-Jul-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silt

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C1	4	176.9
■	C2	6	175.0

Project Number: 06-1111-012-10

Checked By: SM

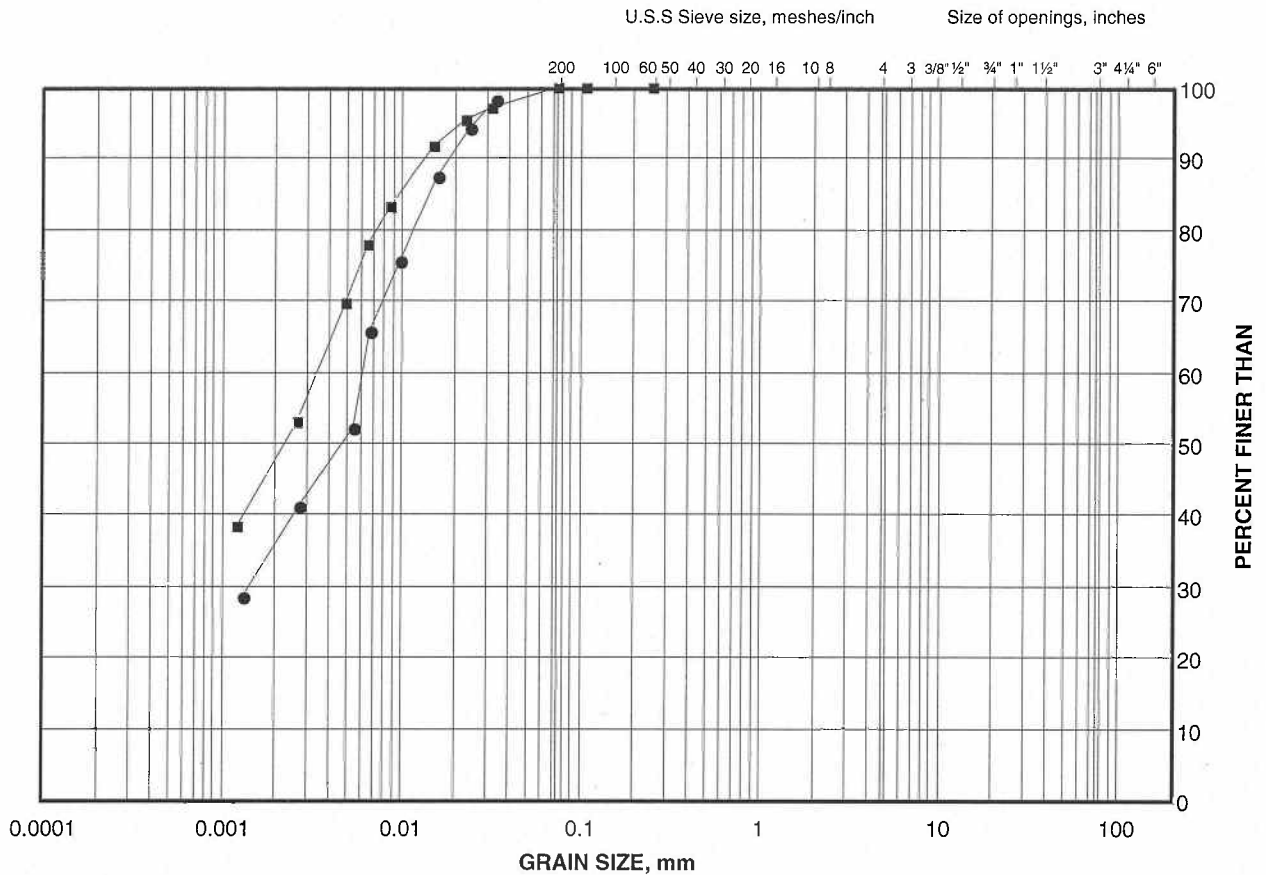
Golder Associates

Date: 07-Jul-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clayey Silt

FIGURE B5



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

LEGEND

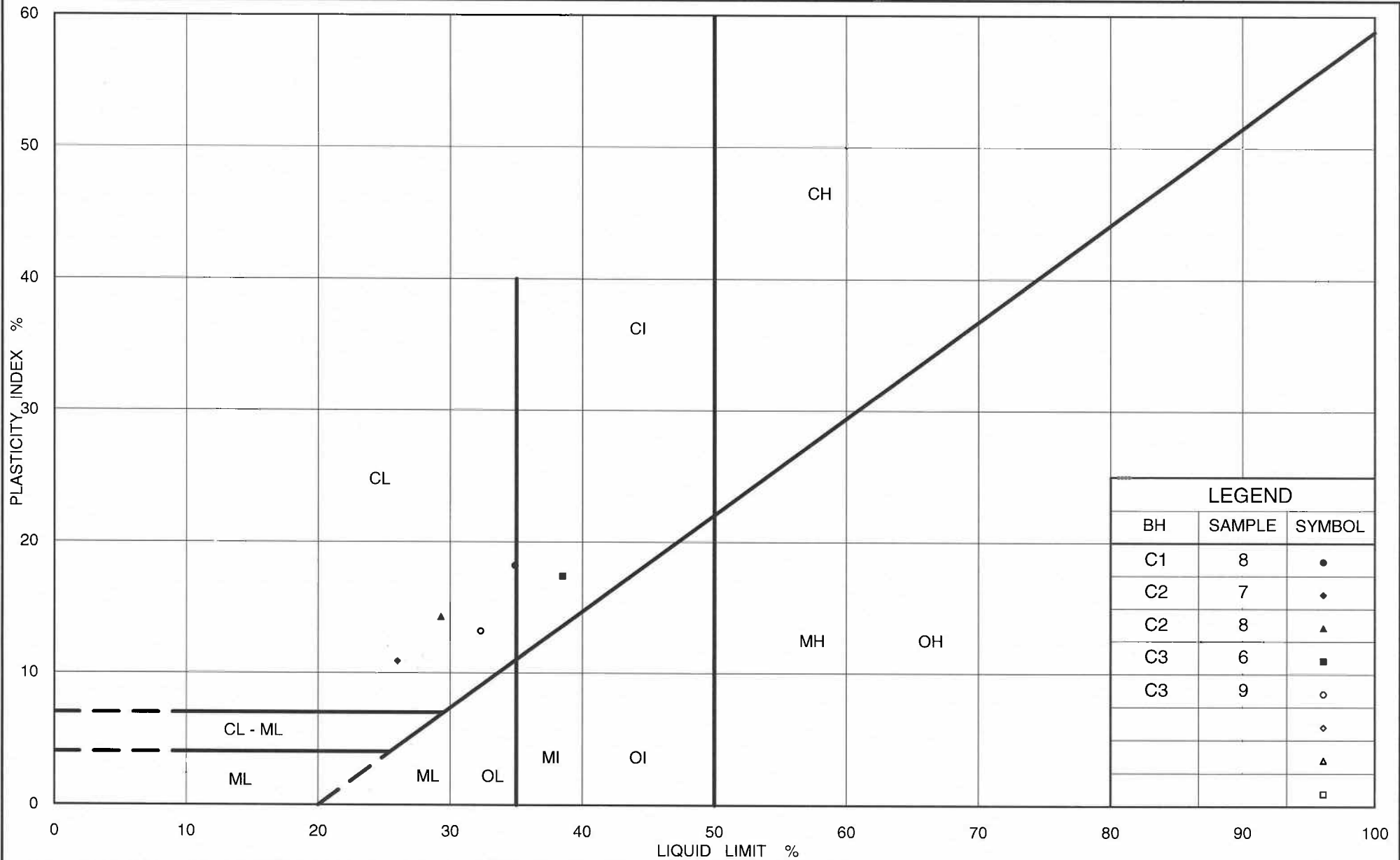
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C2	8	172.0
■	C1	8	172.3

Project Number: 06-1111-012-10

Checked By: SM

Golder Associates

Date: 07-Jul-09



Ministry of Transportation

Ontario

PLASTICITY CHART Clayey Silt and Silty Clay

Figure No. B6

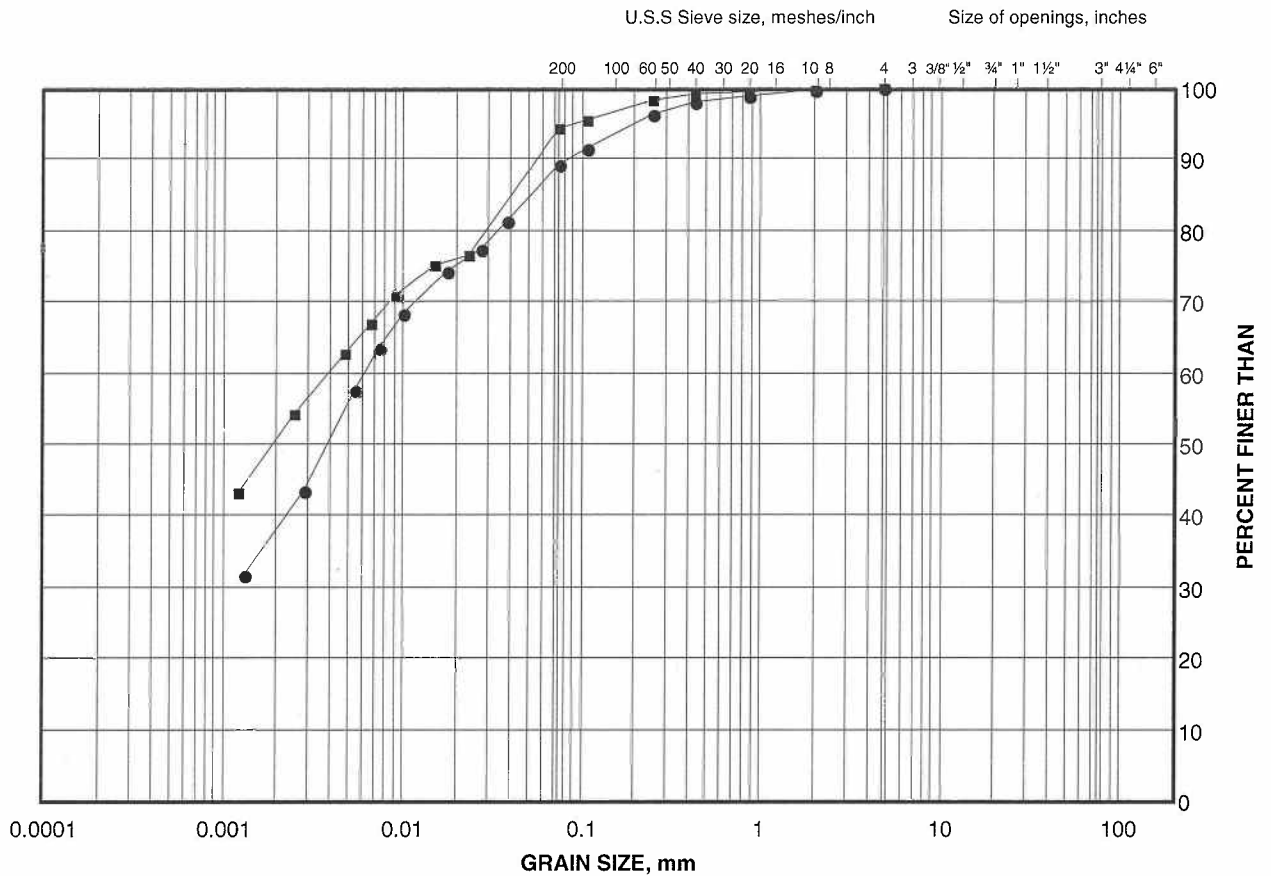
Project No. 06-1111-012-10

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clayey Silt

FIGURE B7



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

LEGEND

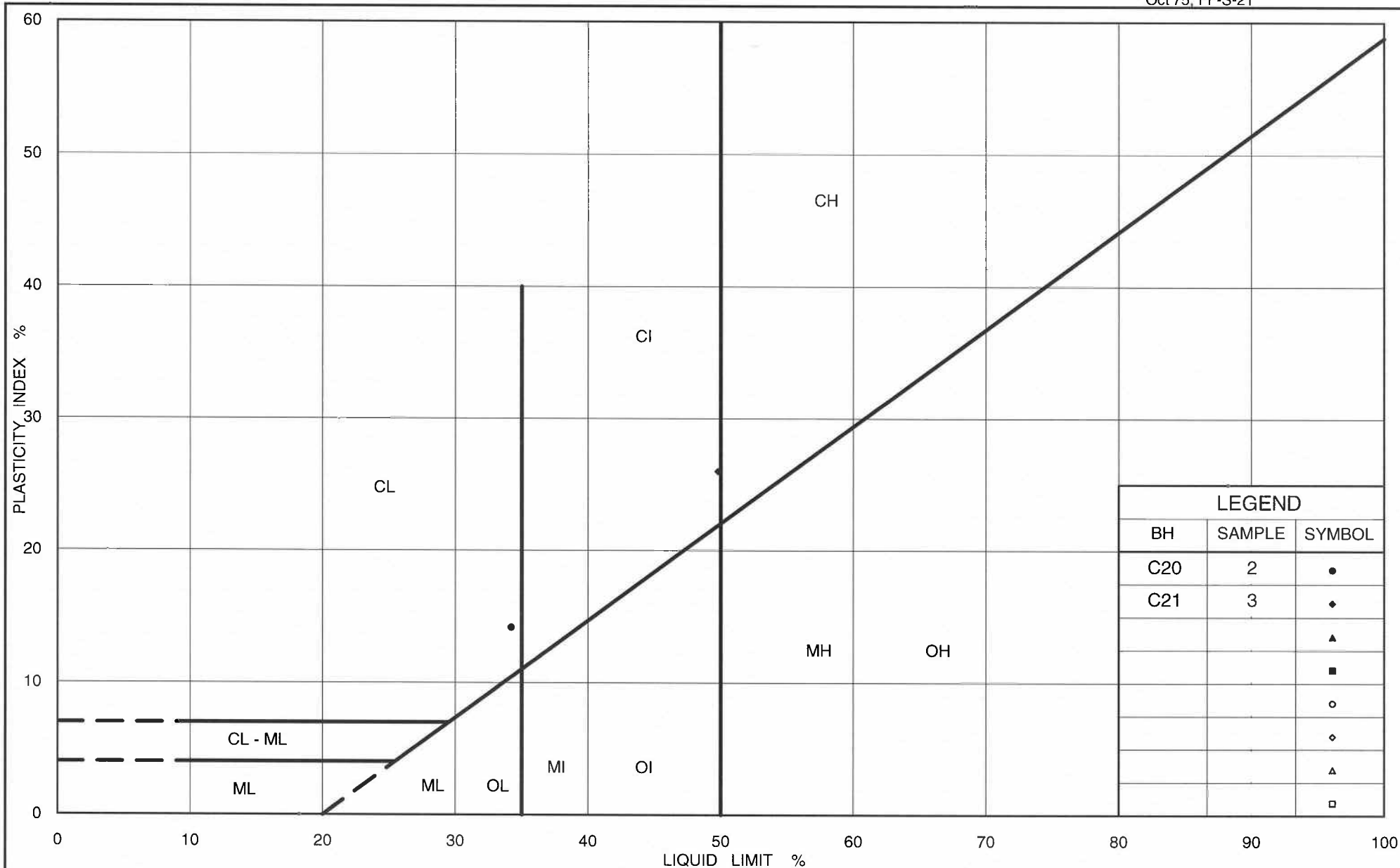
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C4	2	188.0
■	C21	3	200.2

Project Number: 06-1111-012-10

Checked By: *SM*

Golder Associates

Date: 04-Aug-09



Ministry of Transportation

Ontario

PLASTICITY CHART Silty Clay to Clayey Silt

Figure No. B8

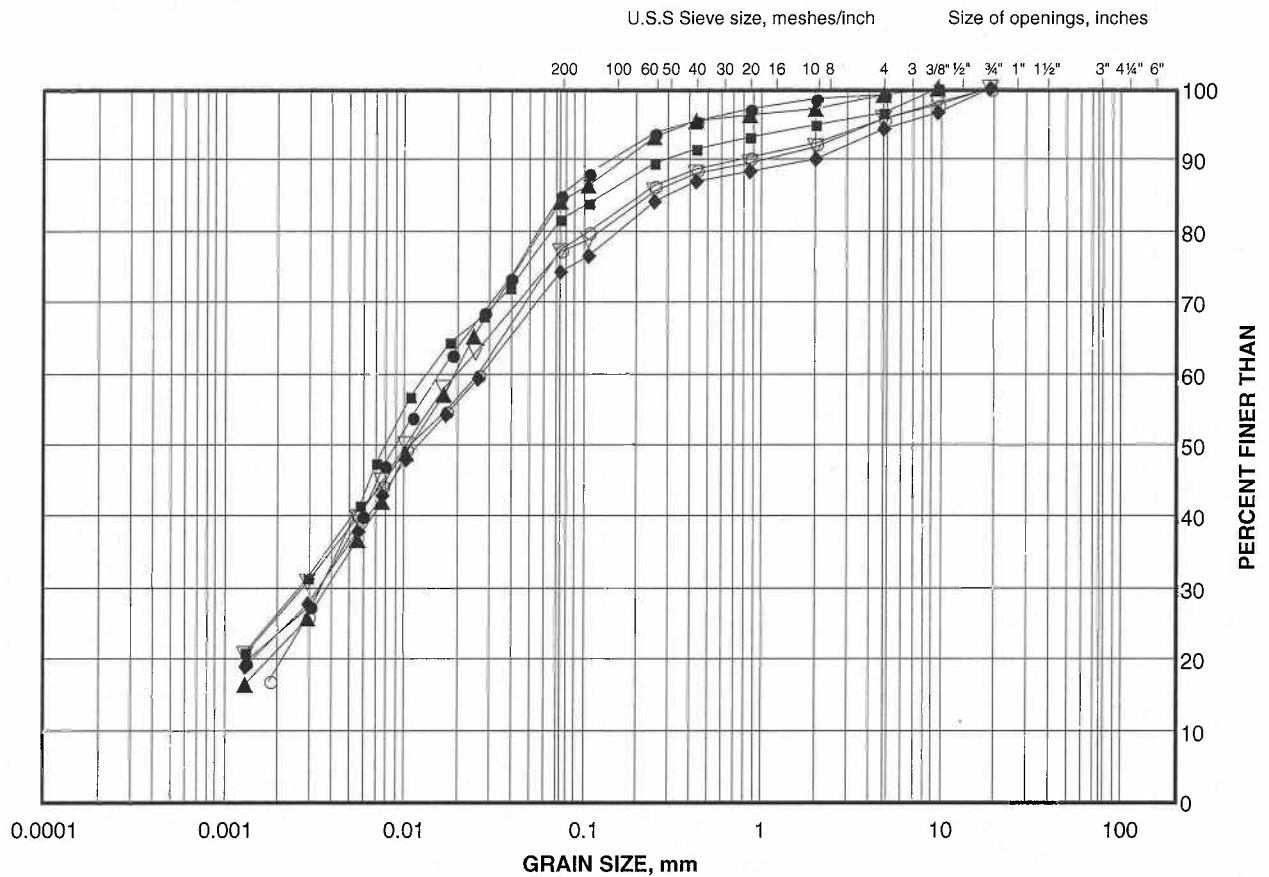
Project No. 06-1111-012-10

Checked By: *8m*

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clayey Silt Till

FIGURE B9-A



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C8	2	185.8
■	C5	2	188.2
◆	C10	3	186.8
▲	C9	3	186.5
▽	C6	4	187.1
○	C4	5	185.7

Project Number: 06-1111-012-10

Checked By: *SM*

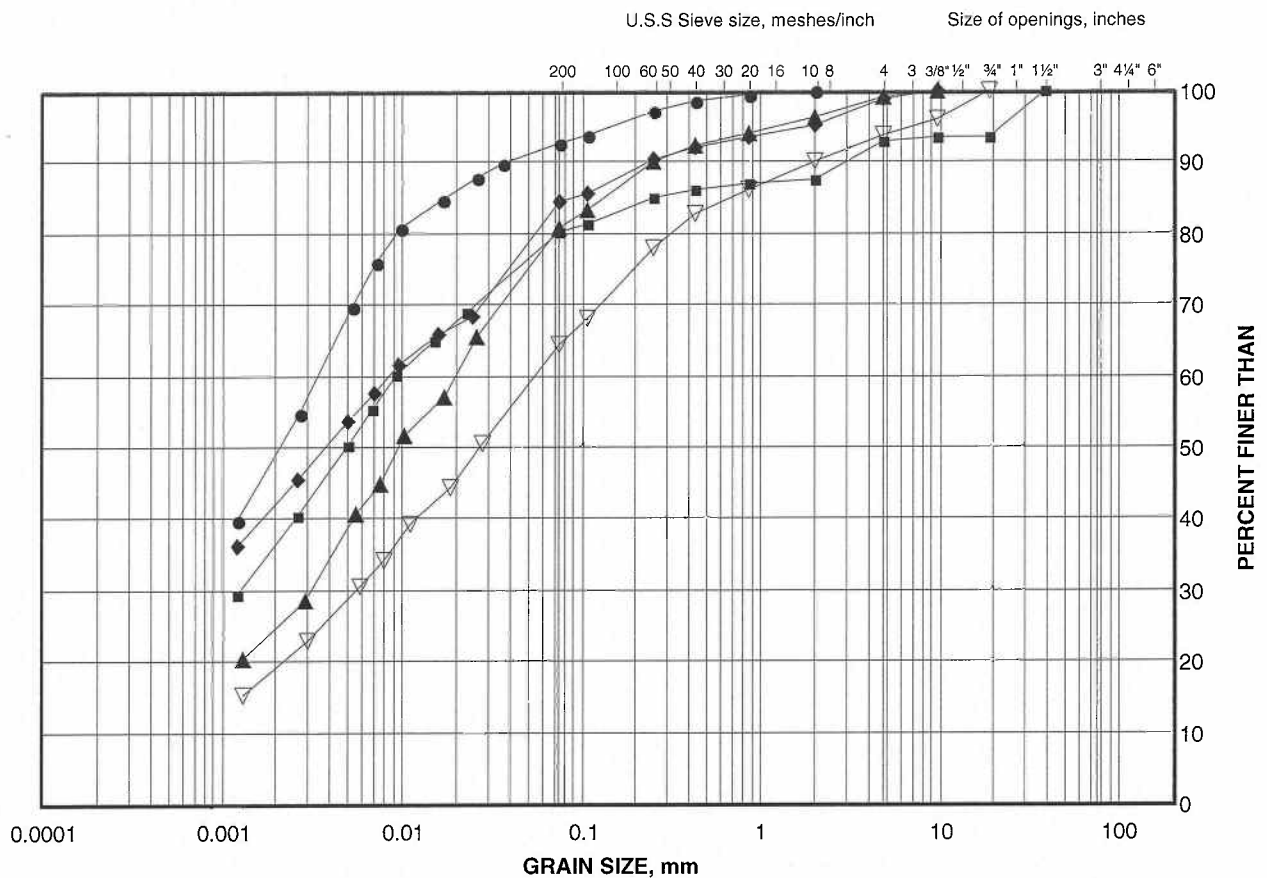
Golder Associates

Date: 04-Aug-09

GRAIN SIZE DISTRIBUTION TEST RESULTS

Silty Clay to Clayey Silt Till

FIGURE B9-B



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

LEGEND

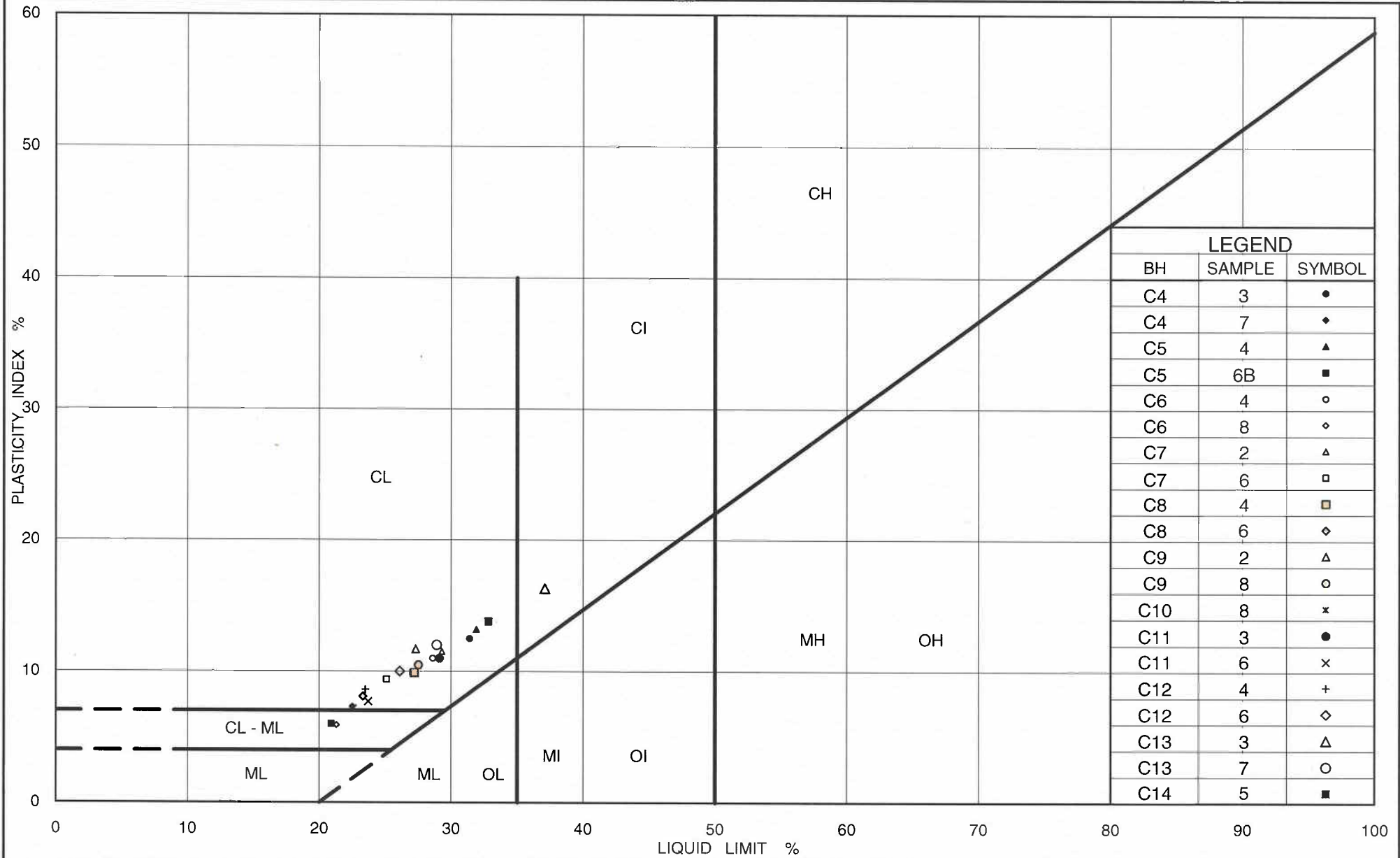
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	C22	2	201.1
■	C12	2	191.2
◆	C15	4	192.6
▲	C11	6	187.0
▽	C14	8	189.6

Project Number: 06-1111-012-10

Checked By: SM

Golder Associates

Date: 04-Aug-09



Ontario

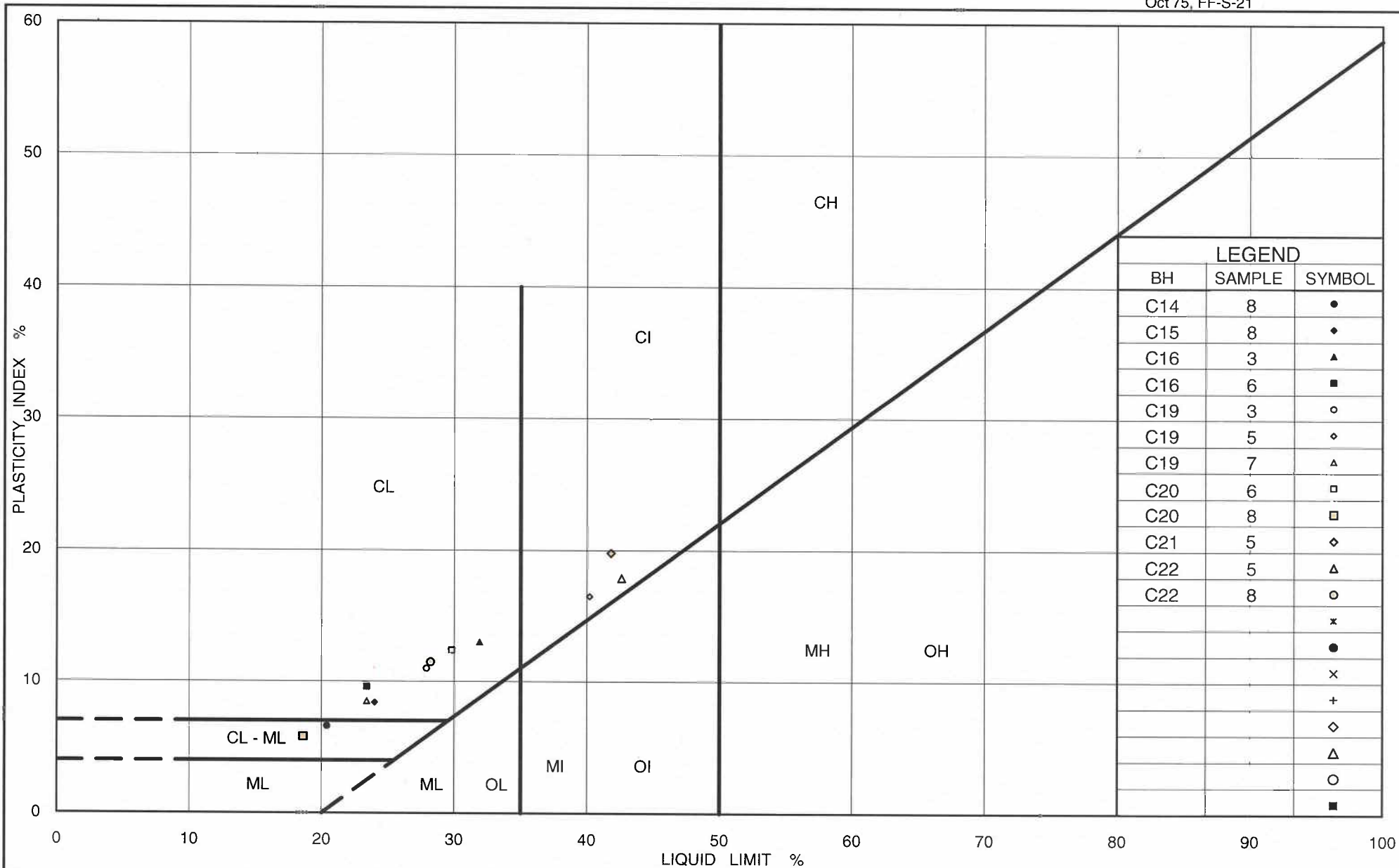
Ministry of
Transportation

PLASTICITY CHART Silty Clay Till to Clayey Silt Till

Figure No. B10-A

Project No. 06-1111-012-10

Checked By: *SM*



Ontario

Ministry of
Transportation

PLASTICITY CHART Silty Clay to Clayey Silt Till

Figure No. B10-B

Project No. 06-1111-012-10

Checked By: *SM*



APPENDIX C

Record of Boreholes for Culverts at Stations 11+125, 12+330 and 14+480



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_L	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 (over-consolidated 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
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2



LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

w	water content
w_L	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 (over-consolidated 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
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

PROJECT 06-1111-012		RECORD OF BOREHOLE No E5				1 OF 1 METRIC										
W.O. 05-20012		LOCATION N 4848694.6 ; E 293894.9				ORIGINATED BY JEB										
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY PKS/VA										
DATUM Geodetic		DATE April 7, 2009				CHECKED BY SMM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
183.2	GROUND SURFACE															
0.0	TOPSOIL															
0.2	CLAYEY SILT, trace sand, trace gravel, containing rootlets (Reworked)		1	SS	11											
182.4	Stiff Brown Moist		2	SS	14											
0.8	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Brown to grey Moist		3	SS	20											
			4	SS	27											
			5	SS	21											
	Becoming grey at a depth of 3.8 m		6	SS	23											
			7	SS	22											
	Containing sand layer between depths of 4.9 m and 5.0 m															
			8	SS	20											
176.5	END OF BOREHOLE															
6.7	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite															

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

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT		06-1111-012		RECORD OF BOREHOLE No E7		1 OF 1 METRIC											
W.O.		05-20012		LOCATION		N 4849217.1 ; E 293850.2											
DIST		Central HWY 427		BOREHOLE TYPE		200 mm Outside Diameter Hollow Stem Augers											
DATUM		Geodetic		DATE		March 2, 2009											
				ORIGINATED BY		DD											
				COMPILED BY		VA											
				CHECKED BY		SMM											
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 _p	W	W _L	γ	GR	SA	SI	CL
178.3	GROUND SURFACE																
0.0	TOPSOIL																
	CLAYEY SILT, trace sand, trace gravel (TILL), containing rootlets to a depth of 0.6 m Firm to hard Brown to grey Moist		1	SS	4		178										
			2	SS	19		177										
			3	SS	43		176										
			4	SS	40		175										
	Becoming grey below a depth of 3.0 m		5	SS	14		174										
			6	SS	11												
	Containing thin sand layer at a depth of 5.1 m		7	SS	16												
173.2	END OF BOREHOLE																
5.2	NOTES: 1. Open borehole dry upon completion of drilling. 2. Borehole backfilled with bentonite hole plug.																

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SACDD

PROJECT 06-1111-012			RECORD OF BOREHOLE No E19			1 OF 1 METRIC		
W.O. 05-20012			LOCATION N 4852013.6 ; E 292935.7			ORIGINATED BY JEB		
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY TB/VA		
DATUM Geodetic			DATE April 1, 2009			CHECKED BY SMM		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)
195.3	GROUND SURFACE							
0.0	SILTY CLAY, trace to some sand, trace gravel, containing rootlets to a depth of 0.6 m and organics Firm to stiff Brown, becoming dark brown at a depth of 0.3 m Moist		1	SS	7		195	
			2	SS	12		194	42
193.9								
1.4	SILTY CLAY, trace to some sand, trace gravel (TILL) Stiff to very stiff Brown to grey Moist		3	SS	15		193	
			4	SS	25		192	
			5	SS	21		191	
			6	SS	14		190	
			7	SS	13		189	
							188	
189.5							187	
5.8	CLAYEY SILT, some sand, trace gravel (TILL) Firm to stiff Grey Moist		8	SS	9		186	
			9	SS	7			
186.2								
9.1	Silty SAND, trace gravel, trace clay Compact Grey Wet		10	SS	18			
185.6								
9.8	END OF BOREHOLE							
NOTES: 1. Water level in open borehole at a depth of 7.9 m below ground surface (Elev. 187.4 m) upon completion of drilling. 2. Borehole backfilled with bentonite.								

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012			RECORD OF BOREHOLE No S12			1 OF 2 METRIC		
W.O. 05-20012			LOCATION N 4849869.7 ; E 293699.8			ORIGINATED BY CR		
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY PKS/VA		
DATUM Geodetic			DATE March 26, 2009			CHECKED BY SMM		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
187.5	GROUND SURFACE							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L WATER CONTENT (%)
0.0	ASPHALT							
0.4	Silty sand, some gravel (FILL) Compact Brown to grey Moist		1	SS	29		187	○
186.1	Clayey silt, trace gravel, trace sand, containing rootlets (FILL) Stiff to very stiff Brown Moist		2	SS	13		186	○
1.5	SILTY CLAY, trace gravel, trace sand (TILL) Hard Brown Moist		3	SS	32		185	○
			4	SS	30		184	○
			5	SS	32		183	○
			6	SS	37		182	○
182.9	CLAYEY SILT, some sand, trace gravel, containing cobbles (TILL) Very stiff to hard Grey Moist		7	SS	25		181	○
4.6			8	SS	22		180	○
			9	SS	26		179	○
			10	SS	42		178	○
			11	SS	31		177	○
			12	SS	51		176	○
			13	SS	35		175	○
							174	○
							173	○

Augers grinding at 11.4 m depth

1 18 58 23

Continued Next Page

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

PROJECT 06-1111-012		RECORD OF BOREHOLE No S12				2 OF 2 METRIC											
W.O. 05-20012		LOCATION N 4849869.7 ; E 293699.8				ORIGINATED BY CR											
DIST Central HWY 427		BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers				COMPILED BY PKS/VA											
DATUM Geodetic		DATE March 26, 2009				CHECKED BY SMM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ	GR SA SI CL		
							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	10 20 30	kN/m ³				
170.1	CLAYEY SILT, some sand, trace gravel, containing cobbles (TILL) Very stiff to hard Grey Moist		14	SS	39		172										
17.4	SAND, trace gravel, trace silt, trace clay Compact Grey Wet Augers grinding between 17.6 m and 18.0 m depth		15	SS	12		170										
168.6	SILTY CLAY, some sand, trace gravel (TILL) Hard Grey Wet		16	SS	155		169										
18.9			17	SS	112		168										
166.6	CLAYEY SILT, trace gravel, trace sand, containing cobbles (TILL) Hard Grey Wet Augers grinding between 22.1 m and 22.5 m depth		18	SS	102		166										
164.4			19	SS	100/0.1		165										
23.1	END OF BOREHOLE																
NOTES: 1. A 50 mm diameter monitoring well was installed at a depth of 18.9 m (Elev. 168.6 m). Water level measurements Date Depth Elev. On Completion 5.2 m 182.3 m May 13, 2009 6.9 m 180.6 m June 15, 2009 6.7 m 180.8 m July 09, 2009 6.3 m 181.3 m 2. At 18.3 m depth (Elev. 169.2 m) 1.2 m of sand was up inside the augers during drilling due to "blowing" sands.																	

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

Continued Next Page

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

PROJECT		06-1111-012		RECORD OF BOREHOLE No S13		2 OF 3 METRIC																	
W.O.		05-20012		LOCATION		N 4849885.0 ; E 293730.1																	
DIST		Central HWY 427		BOREHOLE TYPE		200 mm Outside Diameter Hollow Stem Augers																	
DATUM		Geodetic		DATE		March 30 & 31, 2009																	
				ORIGINATED BY		CR																	
				COMPILED BY		PKS/VA																	
				CHECKED BY		SMM																	
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20						40	60	80	100	20	40	60	80	100	10
172.5	15.2	CLAYEY SILT, some sand, trace gravel (TILL) Very stiff Grey Wet		14	SS	28																	
170.0	17.7	SAND, trace to some silt, trace gravel Compact Grey Wet		15	SS	22																	
167.9	19.8	CLAYEY SILT, some sand, trace gravel (TILL) Hard Grey Wet																					
		Augers grinding at 21.0 m depth																					
		Augers grinding at 22.0 m depth																					
				16	SS	199																	
				17	SS	80																	
163.9	23.8	SHALE (BEDROCK) Grey																					
				18	SS	50/0.10																	
				19	SS	50/0.05																	
160.2	27.5	END OF BOREHOLE		20	SS	100/0.03																	

Continued Next Page

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

MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD



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



MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SAC/DD

PROJECT 06-1111-012			RECORD OF BOREHOLE No S14			1 OF 2 METRIC		
W.O. 05-20012			LOCATION N 4849893.4 ; E 293775.6			ORIGINATED BY CR		
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY PKS/VA		
DATUM Geodetic			DATE April 2, 2009			CHECKED BY SMM		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100 PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30
187.7	GROUND SURFACE							
-0.6	ASPHALT							
0.3	Silty sand, some gravel (FILL)		1	SS	41		187	
186.9	Dense Brown Moist		2	SS	16			
0.8	Clayey silt, some sand, trace gravel (FILL)		3	SS	18		186	
	Hard Brown Moist		4	SS	24			
	CLAYEY SILT, some sand, trace gravel (TILL)		5	SS	30		185	
	Stiff to hard Brown Moist		6	SS	17			
			7	SS	19		184	
			8	SS	24			
			9	SS	30		183	
			10	SS	41			
			11	SS	30		182	
			12	SS	21			
			13	SS	38		181	
							180	
							179	
							178	
							177	
							176	
							175	
							174	
							173	

Continued Next Page

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

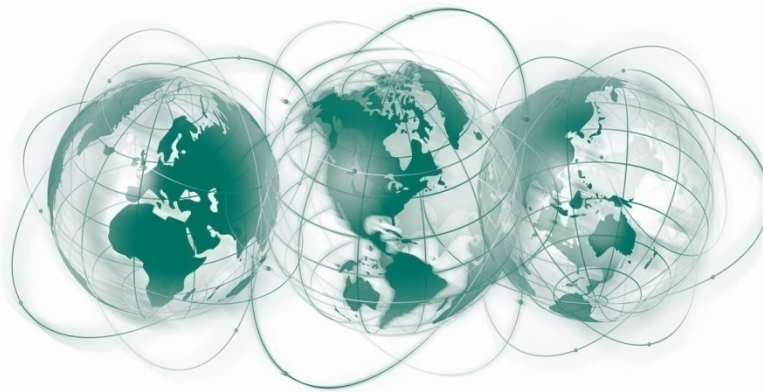
MIS-MTO 001 06-1111-012.GPJ GAL-MISS.GDT 8/5/09 SACDD

PROJECT 06-1111-012			RECORD OF BOREHOLE No S14			2 OF 2 METRIC		
W.O. 05-20012			LOCATION N 4849893.4 ; E 293775.6			ORIGINATED BY CR		
DIST Central HWY 427			BOREHOLE TYPE 200 mm Outside Diameter Hollow Stem Augers			COMPILED BY PKS/VA		
DATUM Geodetic			DATE April 2, 2009			CHECKED BY SMM		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100
--- CONTINUED FROM PREVIOUS PAGE ---								
170.0	CLAYEY SILT, some sand, trace gravel (TILL) Stiff to hard Brown Moist		14	SS	12		172	
17.7	Silty SAND, trace to some silt, trace gravel, trace clay Dense Grey Wet						171	
169.3							170	
18.4	SILTY CLAY, some sand, trace gravel (TILL) Hard Grey Wet		15	SS	46		169	
168.8	END OF BOREHOLE							
18.9	NOTES: 1. Water level in open borehole at a depth of 17.7 m below ground surface (Elev. 170.0 m) upon completion of drilling. 2. An additional borehole was drilled adjacent to Borehole S14; See Record of Borehole S14A for details. 3. Borehole backfilled with bentonite.							

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com



Golder Associates Ltd.
2390 Argentia Road
Mississauga, Ontario, L5N 5Z7
Canada
T: +1 (905) 567 4444

