August 2011

REVISED DRAFT SUBSURFACE INVESTIGATION AND DESIGN REPORT

Horizontal Directional Drilling Utility Installation - Highway 400 - Duckworth Street Interchange, Simcoe County G.W.P 2010-20T-82

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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the City of Barrie (Barrie) to provide geotechnical engineering services associated with the proposed trenchless installation of separate Hydro and Bell utilities beneath the Highway 400 - Duckworth Street Interchange, in the City of Barrie. The Hydro and Bell utility installations crossing Highway 400 within the approach embankments paralleling both sides of Duckworth Street are part of the proposed improvements to the Highway 400 and Duckworth Street Interchange. Based on correspondence with both the Hydro (Powerstream) and Bell (Prestige Telecom) representatives, the preferred embankment crossing method for installation of the utilities is Horizontal Directional Drilling (HDD).

The purpose of the investigation is to address the Ministry of Transportation (MTO) requirements for determining the local subsurface soil and groundwater conditions, to provide site specific geotechnical engineering recommendations for the proposed installations at the Highway 400 crossing locations, and to provide comments regarding ground displacement monitoring at the site. Project specific Terms of Reference were not provided to us, therefore the subsurface investigation program developed for the utilities installations is based on the requirements noted in the Ministry of Transportation, Ontario (MTO) "Guidelines for Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application (April 3, 2008)". Furthermore, as subsurface investigations have recently been carried out at the site for the Highway 400 – Duckworth Street Overpass structures and associated retaining walls, this available subsurface information has been supplemented with limited additional new borehole information, to develop the subsurface models for the crossings by the HDD method.

This report addresses the geotechnical issues associated with the crossing of Highway 400 only and should be read in conjunction with the "Important Information and Limitations of this Report" following the text of the report. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 SITE DESCRIPTION

For consistency with the overall orientation of the site relative to Highway 400, given that Duckworth Street crosses under the highway on a skew but at an essentially north to south direction, all directions in this report are relative to Highway 400 being oriented North-South.

The existing overpass structure carrying Highway 400 over Duckworth Street is located about 2.5 km north of the Bayfield Street (Highway 26) interchange and 2.5 km south of the Highway 11 interchange in Barrie, Ontario at the location shown on the Key Plan on Drawing 1. At the site, Duckworth Street is two lanes wide where it passes beneath Highway 400, and is constructed in a cut. The Duckworth Street grade varies between about Elevations 257 m and 259 m under the highway and slopes down from the south towards the north. The Highway 400 grade is at about Elevation 264 m.

The site of the proposed Hydro utility crossing commences east of the Highway 400 North Bound Lanes (NBL), within the southeast quadrant of the Highway 400 and Duckworth Street interchange area, and extends westerly to beyond the proposed Southbound Lanes (SBL). The proposed Hydro utility crossing runs roughly parallel to, and south of Duckworth Street, and will have an approximate length of 120 m. The Hydro utility crossing will consist of a bundle of 15 ducts, each 100 mm in diameter. Based on the drawing provided to our office by MH on behalf of Powerstream, the minimum depth of cover directly below the travelled surface of Highway 400 will be about 9 m, and increases in depth westward.

The site of the Bell utility crossing commences east of the Highway 400 NBL, within the northeast quadrant of the Highway 400 and Duckworth Street Interchange area, and extends westerly to beyond the proposed SBL. The Bell utility crossing runs parallel to, and north of, Duckworth Street. The Bell utility crossing originally proposed to be constructed beneath the proposed location of the north abutments of the NBL and SBL bridges as part of the interchange improvements has now been relocated a distance of about 12 m to the north of the proposed abutments. Based on the utility drawings provided to us by MH on behalf of Prestige Telecom (Prestige), the utility line will then extend beneath the E-S Ramp to provide a connection to the tie-in point located near the intersection of Duckworth Street and Cundles Road. The utility crossing will consist of a bundle of 4 ducts, each 100 mm in diameter. The proposed Highway 400 crossing will have an approximate length of 165 m and the proposed E-S Ramp crossing will have an approximate length of 24 m. The minimum depth of cover directly below the travelled surface of Highway 400 will be about 7 m, and increases in depth westward, whereas the minimum depth of cover below the E-S Ramp surface will be about 3 m.

3.0 SUBSURFACE INVESTIGATION

3.1 Current Investigation

The field work specifically for the subsurface investigation for the proposed directional drilling was carried out on March 15 and 16, 2011, during which time a total of three boreholes were advanced using a track-mounted drill rig, supplied and operated by Walker Drilling, of Utopia, Ontario. The boreholes advanced as part of the directional drilling investigation are designated as Boreholes 11-1, 11-2 and 11-3. The borehole locations are shown on Drawing 1.

In conjunction with the three boreholes advanced for the directional drilling investigation, in 2010 several boreholes were advanced in the area of the Highway 400 – Duckworth Street interchange for the proposed interchange improvements. Boreholes from the 2010 investigation which are considered relevant for the Hydro / Bell utility works are shown on Drawing 1 and are designated as Boreholes 10-05 to 10-08, 10-10 to 10-12, 10-EMB-01, and 10-EMB-02. In addition, Boreholes 19 and 21, advanced during an investigation conducted by Terraprobe in 2006, presented in the Terraprobe report entitled “Preliminary Geotechnical Investigation – Duckworth Street Widening from Cundles Road to Rose Street / Bernick Drive” dated March 30, 2007, have also been included to provide supplemental information for the utility crossings.

The boreholes were advanced to depths ranging from 7.9 m to 31.1 m below existing ground surface using hollow stem auger drilling methods. Soil samples were obtained in the boreholes at about 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by either an automatic hammer (Boreholes 11-1, 11-2, and 11-3), or a manual hammer (the remainder of the boreholes), in accordance with the Standard Penetration Test (SPT) procedure. It is unknown which hammer method was utilized for the boreholes advanced by Terraprobe in 2006. Each of the boreholes was terminated in very dense cohesionless strata or very stiff to hard cohesive strata.

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations. A standpipe piezometer was installed in Borehole 11-3 and, as part of the investigations conducted in 2010, standpipe piezometers were installed in Boreholes 10-05, 10-08, 10-10 and 10-11, to permit monitoring of the groundwater levels at these locations. The piezometers consist of 50 mm diameter PVC pipe, with a slotted screen sealed within a sand filter pack at a selected depth interval within the borehole. Above the sand filter pack and piezometer screen, the annulus surrounding the piezometer pipe was backfilled to the ground surface with bentonite pellets or layers of bentonite pellets and soil cuttings. The piezometer installation details and water level readings are indicated on the borehole records included in Appendix A. All remaining boreholes were backfilled with bentonite upon completion, in accordance with Ontario Regulation 903 (as amended by Ontario Regulation 372).

The field work was observed on a full-time basis by a member of Golder's staff who observed the drilling, sampling and in situ testing operations, and logged the subsurface conditions encountered in the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests consisting of water content determinations, Atterberg limits and grain size distribution analyses were carried out on selected soil samples.

The borehole locations and ground surface elevations were determined by MH. The borehole locations, including MTM NAD83 and UTM NAD83 northing and easting coordinates, ground surface elevations referenced to geodetic datum and depths drilled are summarized below and the locations and ground surface elevations are shown/presented on Drawing 1. The coordinates for the Terraprobe boreholes have been interpreted based on the site plan provided in the Terraprobe report.

Borehole Number	MTM NAD83 Zone 10 Coordinates		UTM NAD83 Zone 17 Coordinates		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)	Northing (m)	Easting (m)		
11-1	4,919,464.4	291,065.0	4,918,831.0	605,689.0	255.1	11.0
11-2	4,919,490.5	291,061.5	4,918,857.0	605,685.0	252.8	8.1
11-3	4,919,511.7	291,051.9	4,918,878.0	605,675.0	252.8	8.1
10-05	4,919,399.4	291,048.1	4,918,765.6	605,673.3	259.0	14.2
10-06	4,919,379.9	291,051.4	4918746.2	605676.9	263.4	12.5
10-07	4,919,331.3	290,992.4	4,918,696.5	605,618.8	264.7	12.5
10-08	4,919,308.2	291,005.8	4,918,673.7	605,632.6	259.7	7.9
10-10	4,919,316.7	291,030.4	4,918,682.6	605,657.0	262.5	31.1
10-11	4,919,351.5	291,043.9	4,918,717.7	605,669.9	263.9	18.7
10-12	4,919,328.7	291,040.3	4,918,694.8	605,666.8	264.1	14.2
10-EMB-01	4,919,368.2	290,990.1	4,918,733.4	605,615.8	259.7	9.6
10-EMB-02	4,919406.4	291,064.6	4,918772.9	605,689.6	258.3	9.6
19*	4,919316.6	291,049.8	4,918682.9	605,676.5	264.0	15.7
21*	4,919,391.3	290,997.2	4.918.756.6	605.622.5	258.8	12.5

* Terraprobe Boreholes

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 400 lies within the Simcoe Uplands, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, Third Edition, 1984). The Simcoe Uplands extend north from about 1 km north of Dunlop Street, including Duckworth Street, and extend beyond the northern limit of the project site.

The surficial soils in the Simcoe Uplands physiographic region, in which the Duckworth Street site and the Hydro/Bell utility crossings are located, consist primarily of sandy silt till deposits, known to contain boulders. Low-lying areas may be infilled with shallow sand and gravel deposits, which are shoreline deposits of a former glacial lake that once flooded the area.

4.2 Subsurface Conditions

Three (3) boreholes, in addition to the nine (9) pertinent boreholes advanced in 2010 (as well as the two (2) Terraprobe boreholes advanced in 2006), were drilled along the proposed alignment of the Hydro and Bell utility crossing and, at/near entry/exit pits required for the proposed HDD crossings. These borehole locations are shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are summarized on the Record of Borehole sheets in Appendix A.

The results of laboratory testing carried out on selected samples from these boreholes are shown on Figures B1 to B112 in Appendix B. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoils encountered in the boreholes consist of topsoil underlain by fill materials which are in turn underlain by interlayered native strata comprised of silt, sand, clayey silt, and clayey silt till.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Topsoil

Approximately 100 mm to 900 mm of topsoil was encountered at the existing ground surface in each of the boreholes. The thickest topsoil layer was encountered in Borehole 11-2, which was advanced within the embankment fill of the East-South Ramp.

4.2.2 Fill

Each of the boreholes encountered fill materials of variable composition and thickness. As the boreholes were advanced at the Highway 400 embankment level, as well as at the Duckworth Street level, the elevations of the surface of the fill materials are highly variable. The elevations of the surface and the thickness of the fill deposit as encountered in the boreholes are summarized below.

Borehole No.	Fill Surface Depth	Fill Surface Elevation	Fill Thickness
11-1	0.2 m	254.9 m	1.9 m
11-2	0.9 m	251.9 m	1.2 m
11-3	0.2 m	252.6 m	1.9 m
10-05	0.4 m	258.6 m	3.0 m
10-06	0.1 m	263.3 m	5.4 m
10-07	0.1 m	264.6 m	5.1 m
10-08	0.2 m	259.5 m	0.5 m
10-10	0.2 m	262.3 m	2.1 m
10-11	0.1 m	263.8 m	3.6 m
10-12	0.1 m	264.0 m	3.6 m
10-EMB-01	0.3 m	259.4 m	1.1 m
10-EMB-02	0.3 m	258.0 m	2.6 m

The measured Standard Penetration Test (SPT) "N"-values of the cohesionless fill range from 10 blows to 39 blows per 0.3 m of penetration, indicative of a compact to dense relative density, while the measured SPT "N- values of the cohesive fill range from 2 blows to 42 blows per 0.3 m of penetration, suggestive of a very soft to hard (but typically stiff to very stiff) consistency. The SPT "N"-values in Borehole 10-07 from 2.9 m to 5.2 m are generally lower than the SPT-"N"-values in cohesive fill layers in other boreholes and therefore field vane testing was conducted within this cohesive fill. The measured undrained shear strength is approximately 22 kPa and 105 kPa indicating a soft to very stiff consistency.

The fill materials encountered in the boreholes frilled for the current investigation vary in composition from silt and sand to clayey silt. Re-examination of the grain size distribution test results of the fill samples tested during the 2010 subsurface investigation further suggest that the fill materials are quite variable in composition ranging from sand and gravel containing trace silt, to clayey silt with sand containing trace to some gravel, and trace organic matter. Auger grinding was noted in Borehole 10-05 at a depth of 2.3 m below existing grade suggesting the presence of cobbles, boulders or debris materials within the fill. The results of grain size distribution tests completed on seven selected samples of the fill are shown on Figures B1 and B2.

Atterberg limits tests carried out on six selected samples of the cohesive fill material measured plastic limits between 10 and 13 percent, liquid limits between 14 and 27 percent and plasticity indices between 3 and 15 percent. These results, which are plotted on a plasticity chart on Figure B3, confirm that the cohesive portion of the fill is typically comprised of clayey silt of low plasticity, with the exception of Sample 3 from Borehole 11-1, which is comprised of a silty sand of slight plasticity.

Borehole 21 advanced by Terraprobe in 2006 encountered a 1.4 m thick layer of clayey silt fill containing trace sand and trace gravel. The measured SPT "N"-values are 5 blows and 8 blows per 0.3 m of penetration, suggestive of a firm consistency.

The natural water contents measured in samples of the fill are between 3 percent and 19 percent.

4.2.3 Clayey Silt to Silty Clay Till

A clayey silt till to silty clay deposit was encountered underlying the fill materials in Boreholes 11-1, 11-2, 10-05, 10-07, 10-11, 10-12, 10-EMB-01 and below a sandy silt to silt deposit in Borehole 10-10. A lower deposit of clayey silt till was also encountered below a silt deposit in Boreholes 10-05, 10-11, 10-12, and 10-EMB-02. Borehole 10-EMB-02 was terminated in the till deposit. The elevations of the surface of the till and the deposit thickness encountered at the borehole locations are summarized below.

Borehole No.	Till Surface Depth	Till Surface Elevation	Till Thickness
11-1	2.1 m	253.0 m	3.5 m
11-2	2.1 m	250.7 m	1.6 m
10-05	3.4 m	255.6 m	1.9 m
	7.5 m	251.5 m	4.2 m
10-07	5.2 m	259.5 m	1.9 m
10-10	10.1 m	252.4 m	2.1 m
10-11	3.7 m	260.2 m	3.4 m
	11.6 m	252.3 m	2.2 m
10-12	3.7 m	260.4 m	1.9 m
	11.3 m	252.8 m	0.7 m
10-EMB-01	1.4 m	258.3 m	2.6 m
10-EMB-02	2.9 m	255.4 m	2.6 m
	8.6 m	249.7 m	>1.0 m

The measured SPT “N”-values within the clayey silt till deposit range from 7 blows to greater than 100 blows per 0.3 m of penetration, suggestive of a firm to hard consistency. However, the majority of the SPT “N”-values measured within the till are greater than 15 blows per 0.3 m of penetration suggesting a very stiff to hard consistency.

The till deposit typically is comprised of clayey silt with sand to clayey silt containing some sand, and trace to some gravel, and silty clay containing trace to some gravel and trace sand. The results of grain size distribution tests completed on six selected samples of the clayey silt till deposits are shown on Figure B4. Auger grinding, indicative of boulders and/or cobbles, was encountered in the lower till stratum in Borehole 10-05. Based on the auger grinding and general knowledge of the till deposits in Ontario, cobbles and boulders are anticipated to be present throughout the till deposits at this site.

Atterberg limits testing carried out on five selected samples of the deposit measured plastic limits ranging between 10 and 15 percent, liquid limits ranging between 15 and 34 percent and plasticity indices ranging between 5 and 19 percent. These results, which are plotted on a plasticity chart on Figure B5, indicates that the till deposit consists of clayey silt of low plasticity.

The natural water content measured in samples of the clayey silt to silty clay till are between 5 percent and 20 percent.

4.2.4 Silt

A deposit of silt was encountered underlying a silty sand to sand deposit in Boreholes 10-05 and 10-06, below the fill materials in Boreholes 10-08 and 10-10, and below the clayey silt till deposit in Boreholes 10-07, 10-11, 10-12, 10-EMB-01 and 10-EMB-02. Boreholes 10-06, 10-07 and 10-08 were terminated in the silt deposit. The elevations of the surface of the silt deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Silt Surface Depth	Silt Surface Elevation	Silt Thickness
10-05	6.3 m	252.7 m	1.2 m
10-06	5.5 m	257.9 m	>7.0 m
10-07	7.1 m	257.6 m	>5.4 m
10-08	0.7 m	259.0 m	>7.2 m
10-10	2.3 m	260.2 m	7.8 m
10-11	7.1 m	256.8 m	4.5 m
10-12	5.6 m	258.5 m	5.7 m
10-EMB-01	4.0 m	255.7 m	3.0 m
10-EMB-02	5.5 m	252.8 m	3.1 m

The measured SPT "N"-values in the silt deposit range from 53 blows per 0.3 m of penetration to greater than 100 blows per 0.3 m of penetration, indicating that this deposit is very dense.

The silt deposit contains trace to some sand, trace to some gravel, and trace clay, and in Borehole 10-10 visual examination of the same samples indicate a slightly coarser gradation. Cobbles or boulders were encountered within this deposit in Borehole 10-10 at a depth of about 3.8 m below existing grade (corresponding to Elevation 258.7 m). Lenses of clayey silt were encountered in the silt deposit in Borehole 10-EMB-01. The results of grain size distribution tests carried out on fourteen selected samples of the silt deposit are shown on Figures B6, B7, and B8.

The natural water content measured in samples of the silt are between 12 percent and 35 percent.

4.2.5 Clayey Silt

A deposit of clayey silt was encountered underlying the fill in Borehole 11-3, underlying the sand deposit in Boreholes 10-05 and 10-12, and underlying the clayey silt till in Boreholes 11-1, 11-2 and 10-10. Each of the boreholes was terminated in this deposit. The elevations of the surface of the deposit and the thickness of the clayey silt stratum as encountered in the boreholes are summarized below.

Borehole No.	Clayey Silt Surface Depth	Clayey Silt Surface Elevation	Clayey Silt Thickness
11-1	5.6 m	249.5 m	>5.4 m
11-2	3.7 m	249.1 m	>4.4 m
11-3	2.1 m	250.7 m	>6.0 m
10-05	13.2 m	245.8 m	>1.0 m
10-10	12.2 m	250.3 m	>18.9 m
10-12	13.2 m	250.9 m	>1.0 m

The measured SPT "N"-values within the clayey silt deposit range from 30 blows to greater than 100 blows per 0.3 m of penetration, suggestive of a hard consistency.

The clayey silt deposit contains trace to some sand and trace gravel. The results of grain size distribution tests completed on five selected samples of the clayey silt deposit are shown on Figure B9.

Atterberg limits testing carried out on four selected samples of the deposit measured plastic limits ranging between 12 and 18 percent, liquid limits ranging between 22 and 30 percent and plasticity indices ranging between 6 and 16 percent. These results, which are plotted on the plasticity chart on Figure B10, indicate that the deposit consists of clayey silt of low plasticity.

The natural water content measured in samples of the clayey silt are between 17 percent and 23 percent.

A deposit of clayey silt was also encountered underlying the fill in Borehole 21 advanced by Terraprobe. The deposit was encountered at a depth of 1.4 m below ground surface, corresponding to Elevation 257.4 m, and the deposit is 7.1 m thick. The measured SPT "N"-values ranged from 15 blows to greater than 100 per 0.3 m of penetration, suggestive of a stiff to hard consistency.

4.2.6 Silt and Sand to Sand and Gravel

A deposit of silty sand to sand and gravel containing varying amounts of silt was encountered underlying the clayey silt till in Boreholes 10-05, 10-11, and 10-12, and below the silt deposit in Borehole 10-EMB-01. A lower sand deposit was encountered below the lower clayey silt till deposit in Borehole 10-05. Boreholes 10-11 and 10-EMB-01 were terminated in the sand deposit. The elevations of the surface and base of the deposit and the deposit thickness as encountered in the boreholes are summarized below.

Borehole No.	Sand Surface Depth	Sand Surface Elevation	Sand Thickness
10-05	5.3 m	253.7 m	1.0 m
	11.7 m	247.3 m	1.5 m
10-11	13.8 m	250.1 m	>4.9 m
10-12	12.0 m	252.1 m	1.2 m
10-EMB-01	7.0 m	252.7 m	>2.6 m

The measured SPT "N"-values in the sand deposit range from 23 blows to greater than 100 blows per 0.3 m of penetration indicative of a compact to very dense relative density, with the exception of the upper sample in Borehole 10-11 at the contact with the overlying clayey silt till, which indicated an "N"-value of 2 blows per 0.3 m of penetration (indicative of a very loose relative density). The low SPT "N"-value measured in Borehole 10-11 at a depth of 13.8 m below existing grade is considered to be the result of soil disturbance during drilling operations.

The sand deposit varies in composition from silt and sand to sand and gravel, containing lenses of clayey silt. The results of grain size distribution tests carried out on selected samples of the sand and sand and gravel portions of the deposit are shown on Figure B11.

The natural water content measured in samples of the silt and sand to sand and gravel was between 8 percent and 26 percent.

A deposit of silty fine sand was encountered underlying the clayey silt deposit in Borehole 21 advanced by Terraprobe. The deposit was encountered at a depth of 8.5 m, corresponding to Elevation 250.3 m, and the deposit extends to a depth of 12.5 m below existing grade, at which point the borehole was terminated. The measured SPT "N"-values range from 79 blows to greater than 100 per 0.3 m of penetration, indicating a very dense relative density.

4.3 Groundwater Conditions

The observed water levels in the open boreholes following completion of drilling, and the water levels measured in the piezometers to date, are summarized as follows:

Borehole No.	Ground Surface Elevation	Groundwater Elevation	Date of Measurement	Notes
11-1	255.1 m	Dry	March 16, 2011	Open Borehole
11-2	252.8 m	250.5 m	March 15, 2011	Open Borehole
11-3	252.8 m	247.8 m 250.0 m	March 15, 2011 April 4, 2011	Open Borehole Piezometer
10-05	259.0 m	253.6 m 256.6 m	June 9, 2010 June 16, 2010	Open Borehole Piezometer
10-06	263.4 m	256.3 m	June 10, 2010	Open Borehole
10-07	264.7 m	256.5 m	June 16, 2010	Open Borehole
10-08	259.7 m	258.3 m 256.7 m	June 3, 2010 June 16, 2010	Open Borehole Piezometer
10-10	262.5 m	257.9 m 257.7 m 258.3 m	June 4, 2010 June 16, 2010 March 16, 2011	Open Borehole Piezometer Piezometer
10-11	263.9 m	256.8 m 256.9 m	June 14, 2010 June 16, 2010	Open Borehole Piezometer
10-12	264.1 m	258.5 m	June 17, 2010	Open Borehole
10-EMB-01	259.7 m	252.7 m	June 2, 2010	Open Borehole
10-EMB-02	258.3 m	252.8 m	June 9, 2010	Open Borehole

Borehole No.	Ground Surface Elevation	Groundwater Elevation	Date of Measurement	Notes
		257.8 m	June 16, 2010	Piezometer
19*	264.0 m	258.5 m 260.5 m	October 27, 2006 January 4, 2007	Open Borehole Piezometer
21*	258.8 m	249.4 m 254.8 m	November 2, 2006 January 4, 2007	Open Borehole Piezometer

* Terraprobe Borehole

These water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt, and are expected to be higher during the spring season.

5.0 CLOSURE

This Geotechnical Investigation Report was prepared by Mr. Nick La Posta, P.Eng. The report was reviewed by Mr. Jorge M.A. Costa, P.Eng., a Principal of Golder. Mr. Costa, a designated MTO Contact for Golder, also carried out a quality control audit of the report.

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PART B

DESIGN REPORT
HORIZONTAL DIRECTIONAL DRILLING UTILITY INSTALLATION
HIGHWAY 400 - DUCKWORTH STREET INTERCHANGE
SIMCOE COUNTY
G.W.P. 2010-20T-82

6.0 DISCUSSION OF PROPOSED INSTALLATION

This section of the report provides an assessment of the subsurface conditions and recommendations related to the geotechnical design of the proposed installation of the Hydro and Bell utility lines to be installed beneath the Highway 400 Right-of-Way (ROW) at the Duckworth Street Interchange. For consistency with the overall orientation of the site relative to Highway 400, all directions in this report are relative to Highway 400 being oriented North-South.

The Hydro utility crossing Highway 400 will be installed parallel to, and on the south side, of Duckworth Street, and will extend west into the southwest quadrant of the interchange. The Bell utility that will cross Highway 400 will be installed parallel to and on the north side of Duckworth Street, about 12 m north of the proposed Highway 400 NBL and SBL bridge abutments proposed as part of the interchange improvements. The Bell utility will extend from the northeast to the northwest quadrant of the interchange and then south-westerly under the E-S Ramp.

The recommendations are based on interpretation of the factual geotechnical data obtained from the boreholes advanced during subsurface investigations at the site. Based on the drawings submitted to us, it is understood that the proposed invert of the Hydro utility will be installed on a downward grade between approximately 4 m and 9 m below the existing Highway 400 embankment, increasing in depth westerly. The proposed invert of the Bell utility will be installed on a downward grade between about 7 m and 9 m below the highway embankment and between about 7 m and 3 m below ground surface in the area extending from the west side of the SBL to the west side of the E-S Ramp.

Traditional open trench construction is not considered feasible for the crossings of Highway 400, as significant disruptions to traffic flow along the highway and ramp would occur if this construction method is used.

Pipe ramming and/or pipe jacking is also not considered feasible for this crossing due to the length of the crossing, the very dense / hard relative density / consistency of the subsurface soil strata and potential presence of cobbles or boulders in the till units, as well as the sloped configuration of the embankments adjacent to the Highway and the lack of suitable staging areas at several of the entry and exit pit locations.

Conventional tunnelling is not considered appropriate for crossing of the highway corridor as the size of the tunnelling equipment required to allow for human access into the tunnel would necessitate a tunnel much larger in diameter than is required for the utility installations. In addition, dewatering works could be required if conventional open-face shields were to be used. Micro-tunnelling is also considered impractical and uneconomical due to a lack of local experience and appropriately equipped local contractors which would result in very high mobilization costs for a relatively short tunnel section.

Based on the above constraints, the installation of the Hydro and Bell utilities using horizontal directional drilling (HDD) methods as proposed by both Powerstream and Prestige Telecom is considered the most appropriate option for installation of the utilities. The use of HDD methods will allow the proposed crossings to be carried out in a continuous operation, provides fluid pressure support to the hole, and eliminates the need for deep shaft construction.

The following sections of this report provide a discussion on the construction issues that will need to be addressed and managed by contractors experienced in the use of HDD installation techniques. Where comments are made on construction, they are provided only in order to highlight aspects of construction that could affect the design of the project (e.g. how the site features and subsurface conditions could affect the design and specifications for installation of the Hydro and Bell utilities at the crossing locations using HDD methods). Since not all potential aspects relating to the specific equipment and installation methods selected by the installation contractor can be identified at this time, it should be clearly understood that contractors bidding on the project will be solely responsible for independently reviewing and confirming the feasibility of the installation using the proposed HDD installation method and confirming the suitability of the contractor's equipment and proposed construction procedures for this purpose and for the ground conditions that are documented for the site.

The professional services for this assignment address only the geotechnical aspects of design and installation of the proposed HDD utilities installation. The interpretation and recommendations provided are intended to provide the designers with information to assess and specify the construction methodology and equipment. This report does not assess other aspects of the design of the HDD crossing (e.g. identifying staging areas and confirming that pulling forces associated with the pullback installation will not damage the lines, etc.). Furthermore, the installations should be carried out in general accordance with all applicable municipal and provincial regulations/guidelines, including OPSS 450 (Pipeline and Utility Installation in Soil by Horizontal Directional Drilling).

6.1 General HDD Considerations

The HDD process involves the drilling of an initial pilot hole from an entry/sending pit to an exit/receiving pit using drilling mud to support the sidewalls of the drillhole. Following completion of the pilot hole, the drillhole is reamed successively in increasing diameters until the drillhole is of sufficient size to permit the installation of the bundles of ducts. The bundles are then typically installed by attaching them to the drill rods and pulling them back through the drillhole from the exit/receiving pit to the entry/sending pit.

The final HDD alignment should be selected such that the radii of curvature in all sections of the alignment, including those which may involve complex curves, are sufficiently large such that the HDD drill rods can readily accommodate the proposed alignment, and that the bundles can be installed/pulled along the proposed alignment without being overstressed. Generally, HDD installations are advanced from the higher elevations to lower elevations (downhill) to minimize drilling mud flowing back toward the pilot hole. As such at this site it is anticipated that the direction of the HDD installations will be from east to west.

Typically, the entire length of the proposed duct bundles to be installed using HDD techniques is assembled and laid out in a single section to minimize the time it takes to install/pull the duct bundles into the drillhole and, thereby, reduce the potential for instability of the drillhole. Minimizing the time that the final drillhole is required to stay open is an important consideration for a HDD operation, particularly at sites where the alignment will pass through cohesionless soils (e.g. sandy soils). Therefore, it is recommended that the final alignments and temporary staging areas be selected to permit sufficient space for assembly of the duct bundles in a single section, if possible. However, it should be noted that working space is limited within the 'upstream' east side of the Highway embankment, particularly within the southeast quadrant.

The contractor undertaking the work should submit a detailed and comprehensive drilling plan addressing all aspects of the drilling operations providing the proposed installation method, equipment, drilling fluids and construction methods for review prior to construction.

6.2 HDD Profile and Installation Considerations

Based on the crossing alignment information provided to us by MH, on behalf of Powerstream (for the Hydro line) and Prestige Telecom (for the Bell line), the entry/exit pits for the HDD operations are planned to be located as follows:

- For the Hydro utility line, the entry/exit pits will be located within the southeast and southwest landscaped quadrants of the interchange (in the vicinity of Boreholes 10-08 and BH 21, respectively). As the new alignment of the Highway 400 SBL lanes will be shifted westerly, the pit in this quadrant will be located beyond the footprint of the future Highway 400 SBL embankment.
- For the Bell utility line, the entry/exit pits for the Highway 400 crossing will be located within the northeast and northwest landscaped quadrants of the Highway interchange (in the vicinity of Boreholes 10-10 / BH 19 and Borehole 11-1, respectively). The entry/exit pits for the crossing of the E-S Ramp are to be located in the northwest quadrant of the interchange in the vicinity of Boreholes 11-2 and 11-3.

Based on the drawings provided to us showing the proposed Hydro utility alignment and profile, the HDD drillhole will be advanced through the surficial clayey silt / sand fill materials and within the predominantly cohesionless, very dense silt deposit (assuming the HDD drillhole is advanced from the east quadrant of the interchange) as encountered in Boreholes 10-07 and 10-EMB-01, and then within the cohesive, very stiff to hard clayey silt deposit (at the west quadrant of the interchange), as encountered in Borehole 21 advanced by Terraprobe in 2006.

Based on the updated drawings provided to us showing the proposed Bell utility alignment and profile, the HDD drillhole will be advanced through the surficial sandy silt/clayey silt fill materials and will encounter the predominantly cohesionless, very dense sandy silt to silt deposit (assuming the HDD drillhole is advanced from the east quadrant) as encountered in Boreholes 10-10, 10-12, 10-11, 10-02, 10-05, and 10-EMB-02, a layer of sand and gravel in Borehole 10-05, and through the firm to hard clayey silt till and clayey silt deposits as encountered in Borehole 11-1.

The HDD drillhole for the westerly extension of the Bell utility line crossing beneath the E-S Ramp will be advanced through the surficial embankment fill material as encountered in Boreholes 11-2 and 11-3, and extend through the hard clayey silt till and clayey silt deposits as encountered in Boreholes 11-2 and 11-3, respectively.

It is noted that the Bell utility alignment, as noted above, has been relocated northward to avoid conflict with the proposed locations of the north abutments for the new NBL and SBL bridges to be constructed as part of the interchange improvements. As indicated in the geotechnical design report for the SBL structure, entitled "Highway 400 Southbound Lanes – Overpass at Duckworth Street" and dated May 2011, the recommended foundation alternative for the bridge abutments is spread footings, as well as for the adjoining retaining / wing walls extending north of the abutments. As such, it should be confirmed by the designer that the Bell utility alignment is located outside of the zone of influence of both the proposed bridge abutment foundations, and the retaining / wing wall foundations. The zone of influence may be taken as extending downward and outward from the outside edge of any footing at a slope of one horizontal to one vertical from a point one metre beyond the perimeter of the structure foundation.

Localized sand zones were encountered in two boreholes, in particular a 1.0 m thick compact silty sand to sand and gravel zone in Borehole 10-05. As summarized in ASTM Designation F1962-05, the hard clay soils and dense to very dense silts below the groundwater table are generally suitable for HDD installations, however HDD advancement through sand and gravel zones (30 percent to 50 percent gravel by weight) may encounter difficulties.

Maintaining the stability of an HDD drillhole within, and installing the Hydro and Bell utilities through the above noted materials using HDD methods is considered feasible. However, the HDD contractor will have to carefully select and control the properties of the drilling fluid and drilling fluid pressures in order to deal with the issues associated with the variability of the site soils (e.g. selecting the viscosity/thixotropic properties of the drilling fluid such that they are capable of maintaining the stability of the HDD drillhole, while being able to transport variable cuttings out of the HDD drillhole). If the drill fluid properties and drilling pressures are not carefully monitored/controlled, there is a greater potential for 'over-cutting' (i.e. enlarging) of materials from the sidewall of portions of the HDD drillhole, leading to the potential for increased settlement above the HDD alignment.

Based on the interpreted stratigraphy, the alignments will be located in close proximity and/or pass through soil interfaces. The Bell utility alignment is anticipated to penetrate through the 1 m thick silty sand to sand and gravel zone encountered in Borehole 10-05 at between about Elevation 253.7 m and 252.7 m. In order to reduce potential construction related issues associated with installing the utility line through this deposit, consideration should be given to adjusting (deepening) the alignment to avoid drilling through this zone of silty sand to sand and gravel. In addition, both proposed alignments will be advanced through a transition zone from the cohesionless silts into cohesive clayey silt. Particular attention to alignment control will be required when advancing through these transitions.

Sidewalls of the HDD drillhole formed within cohesionless soils are considered to be susceptible to erosion when subjected to ongoing exposure to drilling fluid action. In this regard, the time that the drillhole remains open should be minimized (particularly at the final drillhole diameter) in order to maintain drillhole stability.

In addition, cobbles and/or boulders are expected to be present in the clayey silt till deposits at the site. The presence of these materials can obstruct the drilling process causing delay, increased wear-and-tear of tools, misalignment, and possible additional cost and/or the need to alter the drill path to avoid large obstructions such as boulders.

6.2.1 Hydraulic Fracture ("Frac-out") Potential

For assessment of the HDD installation, a number of issues must be considered, such as hydraulic fracture (typically referred to as "frac-out"), methods for settlement reduction and maintaining surface stability. Latorre et al (2002) provides some guidance relating to the recommended minimum depth of cover for various pipe diameters as reproduced below.

Pipe Diameter	Depth of Cover
50 mm (2 in.) to 150 mm (6 in.)	1.2 m (4 ft)
200 mm (8 in.) to 350 mm (14 in.)	1.8 m (6 ft)
375 mm (15 in.) to 600 mm (24 in.)	3.0 m (10 ft)
625 mm (25 in.) to 1,200 mm (48 in.)	4.5 m (15 ft)

Based on the utility cross sectional configurations presented in the drawings provided to us by MH, it is anticipated that the Hydro utility arrangement will be about 0.8 m in diameter (15 ducts 100 mm each in diameter), and the Bell utility arrangement will have a total diameter of about 0.3 m (4 ducts 100 mm each in diameter). The Hydro utility crossing will be installed at a depth of about 4 m and 9 m beneath the Highway 400 embankment, whereas the Bell utility mainline crossing will be installed at a depth of between about 7 m and 4 m below the Highway 400 embankment and about 3 m below the top of the E-S Ramp embankment. These depths are about the same as or greater than the minimum depth of cover suggested by Latorre et al. (i.e. 3.0 m to 4.5 m). The depth of the HDD drillhole is 3 m below the existing ground surface at / near the toe of the Highway embankment at the Hydro utility alignment.

Based on the proposed depth of the alignments, the overlying soil conditions, and our experience with similar HDD installations, the potential for frac-out is considered to be low, however, the potential for frac-out is dependent on the type of drilling equipment, drilling and reaming methodology, down-hole drilling fluid properties (density, viscosity, etc.), drillhole path geometry (particularly the elevation of entry and exit pits in relation to the HDD hole profile elevation and depth of cover beneath the right-of-way) and drilling fluid pressures used by the contractor. Installation variables should be assessed by an experienced contractor with reference to the actual soil conditions and HDD drillhole geometry to assess the depth of cover and to minimize the risk of frac-out and prevent settlement of the ground along the alignment, especially in areas of lesser cover such as at and beyond the embankment toe areas within the Highway ROW. In this regard, consideration should be given to lowering the Bell utility line between Boreholes 10-05 and 11-1, and especially in the area of Borehole 11-1 where the surficial soft clayey silt fill encountered is soft in consistency and may be susceptible to frac-out.

The drilling fluid pressures that will develop within the drillhole may not exceed the static confining stresses in the soils encountered below the highway. As part of the mitigation measures to prevent frac-out from occurring during drilling, pressure relief pits (or “burp holes”) could be installed on either side of the highway to dissipate high fluid pressures that may develop during drilling. The installation of pressure relief pits will also minimize the potential for “hydro lock”, which is a condition where circulation from the bore is lost due to cuttings inhibiting mud circulation which then allows pressure build-up ahead of the advancing pipe, creating a hydraulic cylinder in the ground. The risk of hydro lock is increased when drilling in dense to very dense or hard soils encountered along the proposed drill path. In this regard, the specifications should require incorporating pressure relief pits as part of the HDD operations in addition to the design and construction considerations noted above.

Boreholes advanced as part of the geotechnical investigations were located in close proximity to the proposed HDD pipeline alignment and monitoring wells were installed in several of the boreholes. The HDD drill fluids will take the path of least resistance and may potentially migrate to the ground surface through the standpipe piezometers at these borehole locations. Prior to installation of the pipeline, all standpipe piezometers should be decommissioned / grouted in order to limit the potential for upward fluid migration. The remaining boreholes were typically sealed with bentonite; however, as the HDD drill fluids will take the path of least resistance, there is a potential for migration of the drill fluids through the softer backfill in the boreholes. Visual monitoring of the borehole locations for signs of drill fluid migration should be carried out on a regular basis during the HDD operations. It is also recommended that the contractor should be required to have contingency/mitigation plans in place to control/reduce drill fluid pressures and to clean up any drill fluid in the event that drilling fluid migration takes place.

6.3 Settlement and Settlement Monitoring

The installation of the proposed Hydro and Bell utilities using HDD methods may result in ground displacements of the soils above and adjacent to the annulus between the duct bundles and the drillhole walls. The magnitude of such displacements is highly dependent on the construction procedures utilized (i.e. final reamer size, depth of installation, drilling fluid etc.). During the proposed HDD installation, provision for monitoring should be required in the contract documents as per MTO's document "Guideline for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application" (April, 2008).

Ground surface displacements at the proposed Highway 400 crossing are not expected to affect the safe operations of highway traffic as the intended alignments will have 7 m to 9 m of soil cover directly below the traffic lanes of the highway, and about 3 m of cover below the traffic lane of the E-S Ramp.

Provided that appropriate construction procedures are specified and implemented, the potential ground displacement at the ground surface during the Hydro and Bell utilities installations, above the proposed crossings, is estimated to be less than 10 mm (the Review Level as described below) at both the Highway and E-S Ramp locations. However, long-term settlement can occur after the installations are completed due to consolidation of the mud slurry and progressive collapse of the oversized drillhole between the ground and the ducts. Based on an assumed ream size, the maximum amount of settlement from this mechanism is estimated to be less than 20 mm below Highway 400 and less than 10 mm below Highway 400 and the E-S Ramp for the Hydro crossing. If this settlement occurs it would be over a period of several years as the drillhole, and material above it, compresses. As a result of the potential settlement that may occur at the Hydro crossing location (due to the relatively large drillhole diameter required to contain the fifteen 100 mm ducts), it is recommended that the annulus between the duct bundle and the HDD drillhole be grouted following the installation of the duct bundle to reduce the potential of the long-term settlement.

An inspection, instrumentation and ground monitoring program is necessary on this project to:

- document the effects of the HDD installation on the overlying highway;
- obtain prior warning of ground movements that could occur due to the construction methods and equipment or unforeseen ground conditions;
- verify the contractor's compliance with the ground movement limits imposed in the Contract; and
- allow adjustments to be made to the HDD methods such that the ground movement limits established are not exceeded.

The proposed monitoring program for the two crossings of Highway 400 is consistent with the "Appendix – Settlement Monitoring Guideline-Tunneling" included in the above noted MTO Guideline (2008) and is summarized below:

- A series of surface monitoring points (reflectors) should be installed along the intended HDD alignments, at spacings of not more than 5 m, under the travelled portion of the Highway (including the E-S Ramp). The surface monitoring points should be installed directly over the alignments along the centreline of the crossings.

- In-ground monitoring points should extend to a depth of about 1.8 m below existing grade (below frost depth). These monitoring points should be installed on the outside shoulders of Highway 400 and the E-S Ramp and at the toes of the embankments (at about 5 m spacing from the shoulder monitors). The in-ground monitoring points should also be installed directly over the alignment along the centreline of the crossings.
- Prior to the start of construction all monitoring points should be read a minimum of two times to provide a baseline, and in addition, a condition survey of the pavement prior to and after the HDD operations should be conducted.
- The monitoring points should be surveyed a minimum of three times per day during installation of the pilot hole and reaming activities, while drilling within the limits of, or approaching the limits of the highway, including during shut-down periods and weekends. An allowance should be made for more frequent monitoring (up to every four hours) should observations dictate.
- The surface monitoring points should be read and recorded during the construction period and after construction for a period of at least two weeks, provided that further settlement has ceased.

Monitoring of the instrumentation on this project will be constrained by the continuous and high traffic volume and the limited periods during which access to the Highway can be obtained. The elevation of the top of the monitoring points would have to be read using conventional precision levelling equipment. By necessity, monitoring points on the road must be read remotely and the use of EDM equipment reading reflectors installed on the highway is suggested. A specialist surveying firm should be retained to confirm the set-up and to carry out the monitoring during construction; their equipment and procedures must be capable of surveying the settlement point elevation to within ± 2 mm of the actual elevation.

The following procedure should be followed if settlements of 10 mm (Review Level) and 15 mm (Alert Level) are reached:

- If the Review Level is reached the contractor should be required to provide a formal plan that states what is going to be done to ensure that the Alert Level is not reached
- If the Alert Level is reached, the contractor shall stop drilling and MTO would have the authority to order that the contractor alter the drilling methods prior to continuing with the installation.

In addition to ground movement monitoring, the HDD alignments (line and grade) should be carefully monitored using a downhole tracking system during installation of the pilot hole and the as-drilled pilot hole alignment should be submitted to the owner for approval.

6.4 Need for PTTW

In regard to the Hydro crossing, the entry and exit pits for the directional drilling will be excavated to depths of approximately 1 m to 2 m in the vicinity of Boreholes 10-08 and 21 (east and west sides of the Highway, respectively). The subsurface conditions anticipated to be encountered at the pit locations consist of very dense silt and stiff to hard clayey silt. Groundwater was encountered at a depth of 3 m and 4 m below ground surface (Elevation 256.7 m and 254.8 m) in the above noted boreholes respectively.

In regard to the Bell utility crossing, it is assumed that the entry and exit pits for the directional drilling will be excavated to a depth of about 3 m and 6 m in the vicinity of Boreholes 10-10 / BH 19 and 11-1, respectively, and to a depth of about 3 m for the E-S Ramp crossing in the vicinity of Boreholes 11-2 and 11-3. The subsurface conditions anticipated to be encountered at the pit locations range from very dense silty sand and firm to hard clayey silt till to hard clayey silt. The highest groundwater level encountered for the primary crossing beneath Highway 400 was at a depth of 3.5 m (BH 19), whereas the highest groundwater level noted for the E-S Ramp crossing was at a depth of 2.3 m (Elevation 250.5 m) in Borehole 11-2.

Given the anticipated depths of the pit locations compared to the measured groundwater levels, it is anticipated that only localized dewatering from perched groundwater will be required for the entry and exit pits. As such, we do not expect that dewatering of the excavations will be required to an extent that a Permit to Take Water would be required (i.e. >50,000 L per day).

6.5 Additional Investigation Work, Review of Methodology and Construction Inspection

The potential for the HDD drillhole to become larger than the design drillhole diameter due to loss of ground into the drillhole and the associated potential for ground surface movements above the HDD crossings are largely dependent upon the construction procedures and techniques utilized. In this regard, a qualified contractor experienced in this type of work should carry out the work. A geotechnical engineer retained by the owner should review the contractor's proposed methodology prior to construction. During construction, the geotechnical engineer should monitor the HDD operations including measuring approximate volumes of soil/slurry/cuttings removed per unit of drillhole advance. Where the utilities cross below the Highway, the implementation of a ground monitoring program as defined above should be carried out to confirm that ground movements are within tolerable limits. Monitoring points should be established and surveyed prior to construction and throughout the HDD operations to determine if the installation methods are adequately controlling ground movement.

7.0 CLOSURE

This Design Report was prepared by Mr. Nick La Posta, P.Eng. The report was reviewed by Mr. Jorge M.A. Costa, P.Eng., a Principal of Golder, as well as Mr. John Westland, P. Eng., a Principal of Golder and the RAQS tunnelling specialist. Mr. Costa, a designated MTO Contact for Golder, also carried out a quality control audit of this report.

GOLDER ASSOCIATES LTD.

DRAFT	DRAFT
Nick La Posta, P.Eng. Geotechnical Engineer	Jorge Costa, P.Eng. Designated MTO Contact, Principal

DRAFT

John Westland, P.Eng.
Principal

NLP/JMAC/plc

n:\active\2008\5000 files\08-1170-5040 mh duckworth st barrie\report\6 - reports\hwy 400 hdd utility\revised draft\08-1170-5040 rep duckworth overpass - directional boring (revised draft).docx

REFERENCES

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

Ministry of Transportation, Ontario, 2008. Guidelines for Foundation Engineering – Tunnelling Specialty For Corridor Encroachment Permit Application.

ASTM, Designation: F 1962-05. Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings.

Latorre, Carlos, A., Wakeley, Lillian D., Conroy, Patrick J., 2002. Guidelines for Installation of Utilities Beneath Corp of Engineers Levees Using Horizontal Directional Drilling. US Army Corp of Engineers – Engineering Research and Development Center ERDC/GSL TR-02-9. 43 pgs.

Ontario Provincial Standard Specifications and Drawings (OPSS and OPSD):

- OPSS 450, “Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling
- OPSS 572 - Construction Specification for Seed and Cover

MINISTRY OF TRANSPORTATION, ONTARIO

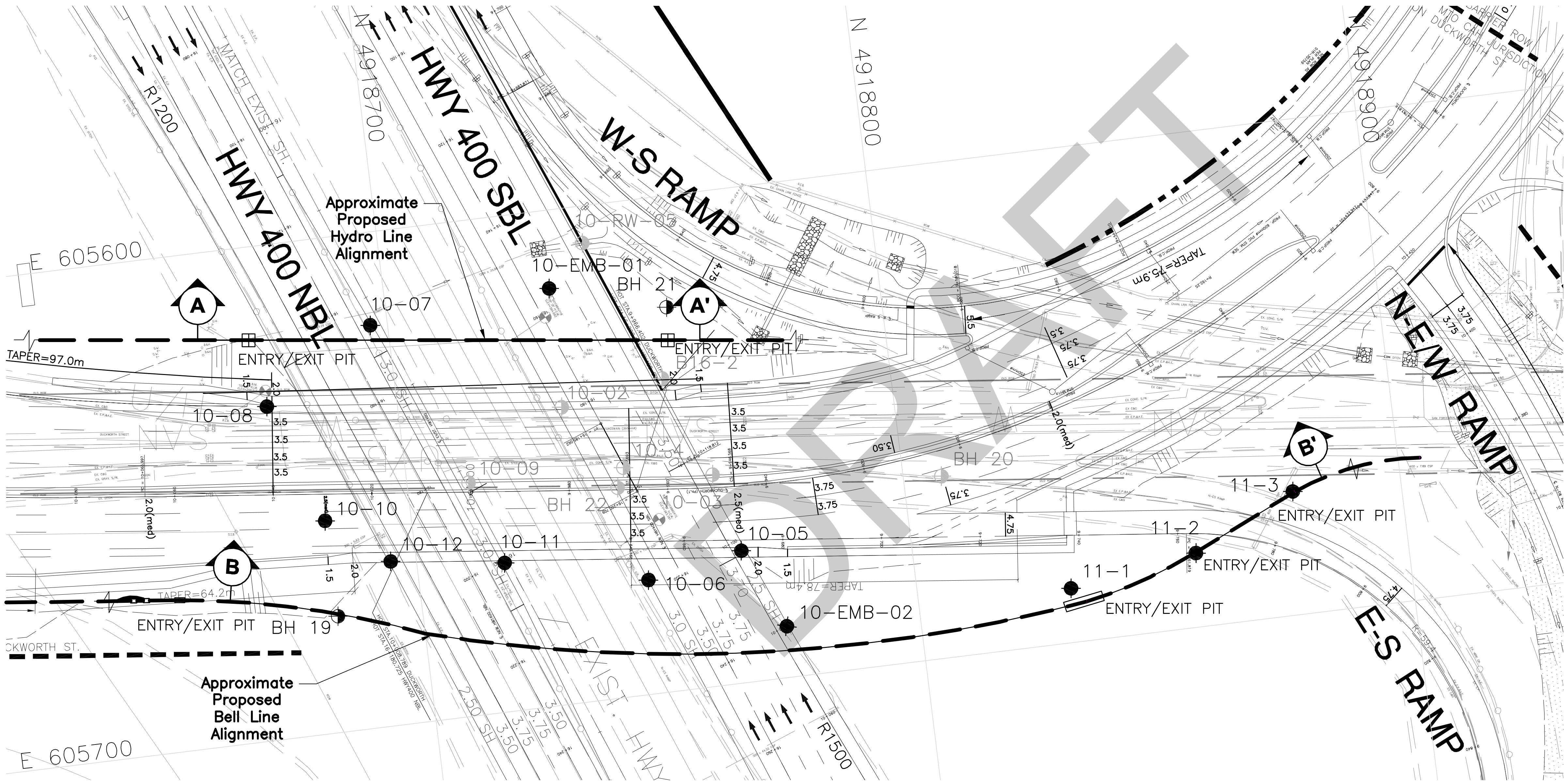
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2010-20T-82

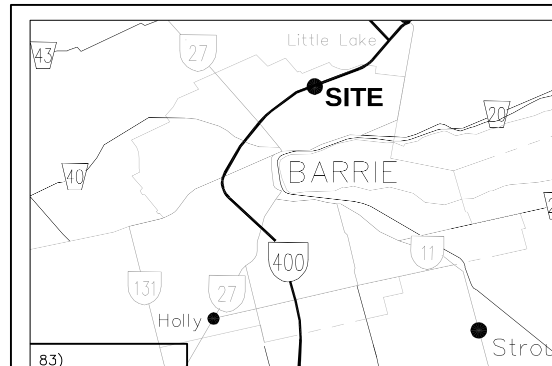
SHEET

HIGHWAY 400
DUCKWORTH STREET INTERCHANGE
HYDRO AND BELL UTILITY INSTALLATION
BOREHOLE LOCATIONS

Golder Associates Ltd.
BARRIE, ONTARIO, CANADA



PLAN
SCALE
10 0 10 20 m



KEY PLAN
SCALE 3 0 3 6 KM

LEGEND

- Borehole – Current and Previous Investigation
- Borehole – Previous Investigation
- Borehole – Previous Investigation (Teraprobe 2006)

BOREHOLE CO-ORDINATES (MTM NAD 83)

No.	ELEVATION	NORTHING	EASTING
10-05	259.0	4918765.6	605673.3
10-07	264.7	4918696.5	605618.8
10-08	259.7	4918673.7	605632.6
10-10	262.5	4918682.6	605657.0
10-11	263.9	4918717.7	605669.9
10-12	264.1	4918694.8	605666.8
10-EMB-01	259.7	4918733.4	605615.8
10-EMB-02	258.3	4918772.9	605689.6
11-1	255.1	4918831.0	605689.0
11-2	252.8	4918857.0	605685.0
11-3	252.8	4918878.0	605675.0
BH 19	264.0	4918682.9*	605676.5*
BH 21	258.8	4918756.6*	605622.5*

* Estimated from Digital Terrain Map

NOTES

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

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

REFERENCE

Base plans provided in digital format by MH file nos. x84059base.dwg, and x84059Align.dwg, received July 26, 2010 and x84059design Duckworth.dwg and x84059design Hwy 400.dwg received August 3, 2010.

NO.	DATE	BY	REVISION

Geocres No.

HWY. 400		PROJECT NO. 08-1170-5040	DIST.
SUBM'D. NL	CHKD. NL	DATE: June 1, 11	SITE:
DRAWN: JJL/DD	CHKD. JMAC	APPD. NL	DWG. 1

PLOT DATE: August 31, 2011

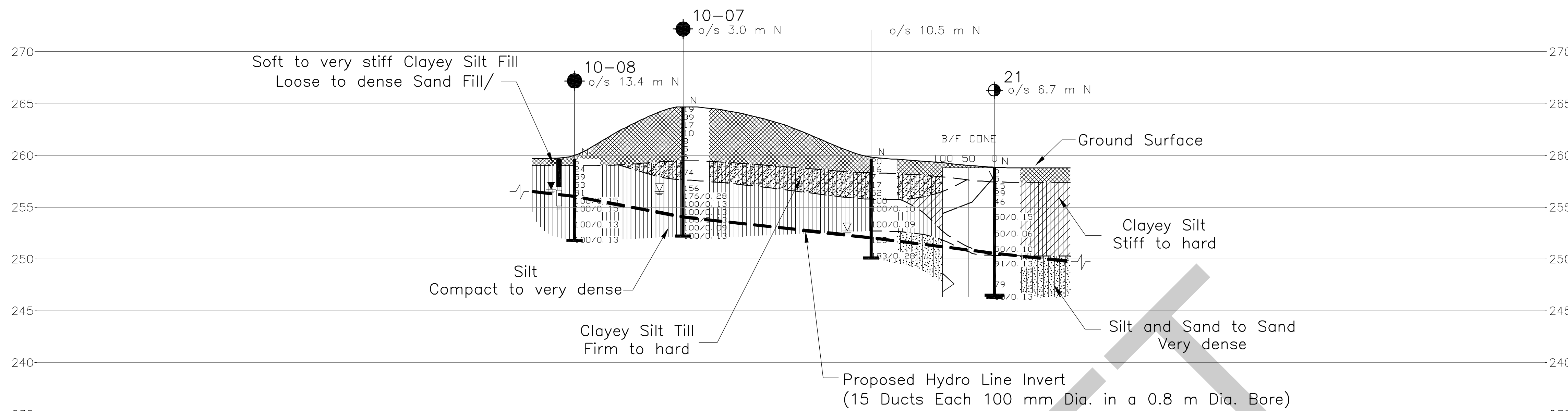
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 2010–20T–82

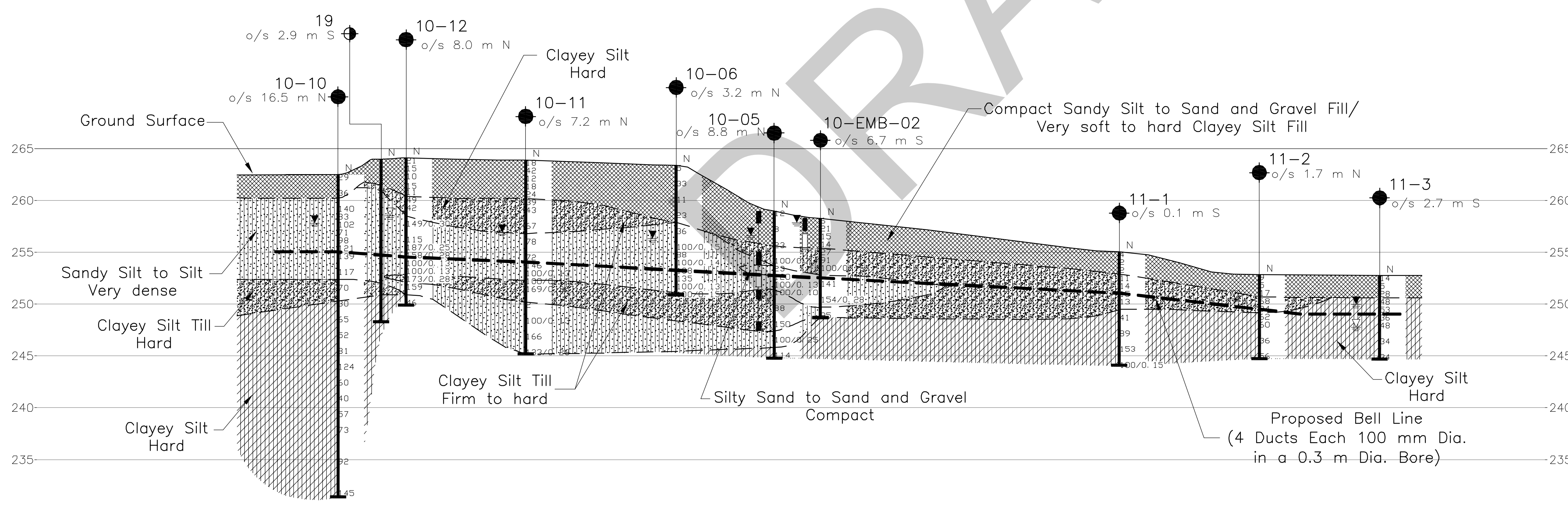
SHEET

HIGHWAY 400
DUCKWORTH STREET INTERCHANGE
HYDRO AND BELL UTILITY INSTALLATION
SOIL STRATA

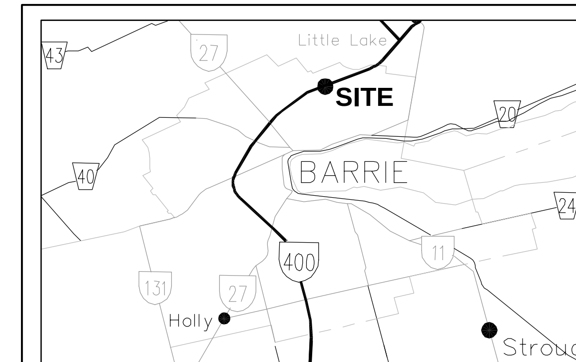
Golder Associates Ltd.
BARRIE, ONTARIO, CANADA



PROFILE A–A'
HYDRO UTILITY LINE
HORIZONTAL SCALE 10 0 10 20 m
4 0 4 8 m VERTICAL SCALE



PROFILE B–B'
BELL UTILITY LINE
HORIZONTAL SCALE 10 0 10 20 m
4 0 4 8 m VERTICAL SCALE



KEY PLAN

LEGEND

- Borehole – Current and Previous Investigation
- Borehole – Previous Investigation (Teraprobe 2006)
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD 83)

No.	ELEVATION	NORTHING	EASTING
10–05	259.0	4918765.6	605673.3
10–07	264.7	4918696.5	605618.8
10–08	259.7	4918673.7	605632.6
10–10	262.5	4918682.6	605657.0
10–11	263.9	4918717.7	605669.9
10–12	264.1	4918694.8	605666.8
10–EMB–01	259.7	4918733.4	605615.8
10–EMB–02	258.3	4918772.9	605689.6
11–1	255.1	4918831.0	605689.0
11–2	252.8	4918857.0	605685.0
11–3	252.8	4918878.0	605675.0
BH 19	264.0	4918682.9*	605676.5*
BH 21	258.8	4918756.6*	605622.5*

* Estimated from Digital Terrain Map

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

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NO.	DATE	BY	REVISION

Geocres No.

HWY. 400	PROJECT NO. 08–1170–5040		DIST.
SUBM'D. NL	CHKD. NL	DATE: June 1, 11	SITE:
DRAWN: JJL/DD	CHKD. JMAC	APPD. NL	DWG. 2

APPENDIX A

Record of Boreholes

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

I. GENERAL

π	3.1416
in x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety
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
υ	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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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, 60º cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

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

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

III. SOIL DESCRIPTION

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

IV. SOIL TESTS

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

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

V. MINOR SOIL CONSTITUENTS

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

Golder Associates

RECORD OF BOREHOLE No 11-1

 METRIC

PROJECT 08-1170-5040
W.P. 2010-20T-82
LOCATION N 4918831.0 ;E 605689.0
ORIGINATED BY DD
DIST Central HWY 400
BOREHOLE TYPE 200 mm Hollow Stem Augers
COMPILED BY NLP
DATUM Geodetic
DATE March 16, 2011
CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
255.1	GROUND SURFACE									
0.0	TOPSOIL									
0.2	Silty sand to clayey silt, with sand, trace gravel (FILL) Loose/Very soft to soft Brown Moist to wet	1	SS	4						
		2	SS	2	254					
		3	SS	2		w with Wp plotted	13	52	28	7
253.0 / 2.1	CLAYEY SILT some to with sand, trace to some gravel (TILL) Stiff Brown Moist	4	SS	11	253					
		5	SS	14	252	w plotted				
		6	SS	15	251					
		7	SS	13	250	w plotted				
249.5 / 5.6	CLAYEY SILT, trace to some sand Hard Brown Moist	8	SS	41	249					
					248					
		9	SS	89	247	Wp–w–WL plotted	0	7	73	20
					246					
		10	SS	153	245					
244.1 / 11.0	END OF BOREHOLE	11	SS	100/0.15		w plotted				

NOTE:

1. Borehole dry upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) 10, 20, 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%); GROUND WATER CONDITIONS; STRAT PLOT.

DRAFT

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

Golder Associates

RECORD OF BOREHOLE No 11-2

 METRIC

PROJECT 08-1170-5040			
W.P. 2010-20T-82	LOCATION N 4918857.0 ;E 605685.0		ORIGINATED BY DD
DIST Central HWY 400	BOREHOLE TYPE 200 mm Hollow Stem Augers		COMPILED BY NLP
DATUM Geodetic	DATE March 15, 2011		CHECKED BY JMAC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.8	GROUND SURFACE					
0.0	TOPSOIL	1	SS	9		
251.9 / 0.9	Clayey silt, trace to with sand, trace gravel (FILL) Firm to very stiff Brown Moist Auger grinding from 1.8 m to 2.1 m depth	2	SS	5		
		3	SS	17		
250.7 / 2.1	CLAYEY SILT, with sand, trace to some gravel (TILL) Hard Brown Moist	4	SS	68	∇	
		5	SS	34		13 37 40 10
249.1 / 3.7	CLAYEY SILT, trace sand Hard Brown to grey Moist	6	SS	62		
		7	SS	60		0 1 86 13
		8	SS	36		
		9	SS	56		
244.7 / 8.1	END OF BOREHOLE					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; ELEVATION SCALE (252, 251, 250, 249, 248, 247, 246, 245); DYNAMIC CONE PENETRATION RESISTANCE PLOT 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³.

NOTE:

1. Water level in open borehole at a depth of 2.3 m (Elev. 250.53 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 11-3

 METRIC

PROJECT	08-1170-5040		
W.P.	2010-20T-82	LOCATION	N 4918878.0 ;E 605675.0
DIST	Central HWY 400	BOREHOLE TYPE	200 mm Hollow Stem Augers
DATUM	Geodetic	DATE	March 15, 2011
ORIGINATED BY	DD	COMPILED BY	NLP
CHECKED BY	JMAC		

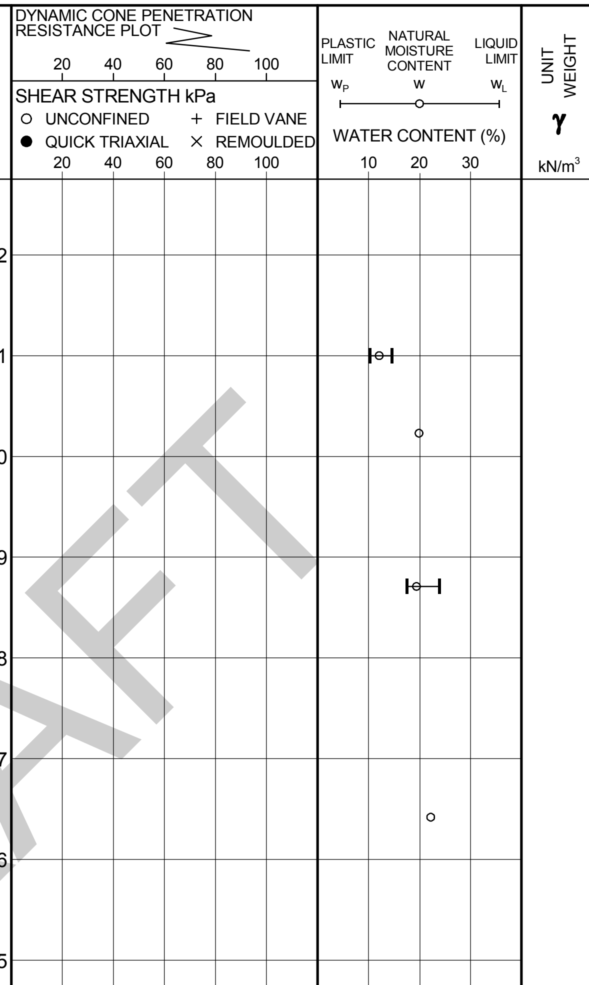
SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
252.8	GROUND SURFACE
0.0	TOPSOIL
0.2	Silt and sand to clayey silt, with trace gravel (FILL) Firm to very stiff Brown Becoming very stiff below 0.5 m depth
250.7 / 2.1	CLAYEY SILT, trace sand, trace gravel Hard Brown Sandy silt interlayers from 5.0 m to 8.1 m depth Becoming grey below 6.1 m depth
244.7 / 8.1	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	14	
2	SS	5	
3	SS	28	2 53 35 10
4	SS	48	
5	SS	53	
6	SS	36	2 1 80 17
7	SS	48	
8	SS	34	
9	SS	34	

ELEVATION SCALE: 252, 251, 250, 249, 248, 247, 246, 245



NOTES:

1. Water level in open borehole at a depth of 5.0 m (Elev. 247.8 m) upon completion of drilling.

2. Water level in piezometer measured at a depth of 2.8 m (Elev. 250.0 m) on April 4, 2011.

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

Golder Associates

RECORD OF BOREHOLE No 10-05

 METRIC

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
LOCATION N 4919399.4 ;E 291048.1
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
COMPILED BY NLP
DATUM Geodetic
DATE June 9, 2010
CHECKED BY KN

SOIL PROFILE

ELEV / DEPTH (m)	DESCRIPTION
259.0	GROUND SURFACE
0.0	TOPSOIL
258.6 / 0.4	Clayey silt, some to with sand, trace to some gravel, trace organic matter to 1.1 m (FILL) Stiff to very stiff Brown Moist Augers grinding at 2.3 m depth
255.6 / 3.4	CLAYEY SILT, some sand to sandy, trace gravel (TILL) Hard Brown Moist to wet
253.7 / 5.3	Silty SAND to SAND and GRAVEL, some silt Compact to very dense Brown Wet
252.7 / 6.3	SILT, trace sand, trace to some gravel Very dense Grey Wet
251.5 / 7.5	CLAYEY SILT, some sand, trace to some gravel, contains cobbles and/or boulders (TILL) Hard Grey Moist Auger grinding noted from 7.5 m to 11.7 m
247.3 / 11.7	SAND, trace silt to SAND and GRAVEL, trace silt Very dense Brown Wet
245.8 / 13.2	CLAYEY SILT Hard Grey Wet
244.8 / 14.2	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	12				
2	SS	8	5	55	33	7
3	SS	23				
4	SS	100/0.14	5	24	55	16
5A 5B	SS	23	50	37	12	1
6	SS	120				
7	SS	100/0.13	1	4	89	6
8	SS	100/0.10				
9	SS	88				
10	SS	150				
11	SS	100/0.25				
12	SS	114				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 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 (%): 10 20 30
UNIT WEIGHT γ kN/m³
ELEVATION SCALE: 258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245

Continued Next Page

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

RECORD OF BOREHOLE No 10-05 — 2 OF 2 — **METRIC**

PROJECT 08-1170-5040

G.W.P. 2010-20T-82 — LOCATION N 4919399.4 ;E 291048.1 — ORIGINATED BY AB

DIST Central HWY 400 — BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger — COMPILED BY NLP

DATUM Geodetic — DATE June 9, 2010 — CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 5.4 m (Elevation 253.6 m) upon completion of drilling. 2. Water level in piezometer at a depth of 2.4 m (Elevation 256.6 m) on June 16, 2010.										

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

Golder Associates

RECORD OF BOREHOLE No 10-06

 METRIC

PROJECT: 08-1170-5040			
W.P.: 2010-20T-82	LOCATION: N 4919379.9 ;E 291051.4	ORIGINATED BY: AB
DIST: Central HWY: 400	BOREHOLE TYPE: D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger	COMPILED BY: NLP
DATUM: Geodetic	DATE: June 10, 2010	CHECKED BY: KN

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
263.4	GROUND SURFACE							
0.0	TOPSOIL							
0.1	Sand, trace gravel, trace silt (FILL) Loose Brown Moist	1	SS	5		263		
262.3 / 1.1	Clayey silt, some to with sand, trace to some gravel, trace organic matter (FILL) Stiff to hard Brown Moist	2	SS	33		262	~12	
		3	SS	11		261, 260		
		4	SS	23		259	~10	10 51 33 6
257.9 / 5.5	SILT and SAND, trace to some gravel, trace to some clay Dense to very dense Brown Moist to wet	5	SS	36		258, 257		
					▽ (256.3)	256		
		6	SS	100/0.15			~13 (H)	1 35 58 6
255.2 / 8.2	SILT, trace sand, trace gravel, trace clay Very dense Brown Wet	7	SS	88		255	~22	0 1 99 0
		8	SS	100/0.14		254		
		9	SS	138		253	~19	
		10	SS	135		252	~25	2 4 93 1
		11	SS	100/0.13				
250.9 / 12.5		12	SS	100/0.15		251	~18	
	END OF BOREHOLE							

NOTES:

1. Water level in open borehole at a depth of 7.1 m (Elevation 256.3 m) upon completion of drilling.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) 10 20 30; UNIT WEIGHT γ kN/m³.

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

DRAFT

Golder Associates

RECORD OF BOREHOLE No 10-07

 METRIC

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4919331.3 ;E 290992.4
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Augers
DATE June 16, 2010

ORIGINATED BY AB
COMPILED BY NLP
CHECKED BY KN

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
264.7	GROUND SURFACE
0.0	TOPSOIL
0.1	Sand, trace to some gravel, to sand and gravel, trace silt, trace organic matter and wood pieces, contains pockets of clayey silt (FILL) Compact to dense Brown Moist
261.8 / 2.9	Clayey silt with sand, trace to some organic matter, trace gravel (FILL) Soft to firm Grey / black Moist
259.5 / 5.2	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist
257.6 / 7.1	SILT, trace to some sand, trace clay Very dense Brown to grey Moist to wet
252.2 / 12.5	END OF BOREHOLE

NOTES:

1. Water level in open borehole at a depth of 8.2 m below ground surface (Elevation 256.5 m) upon completion of drilling.

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	SHEAR STRENGTH kPa	WATER CONTENT (%)	GR	SA	SI	CL
1	SS	19							
2	SS	39			~4				
3	SS	17							
4	SS	10			~10	17	71	11	1
5	SS	8							
6	SS	5		Field vane ~20 (sensitivity 1.3)	~18 (wP ~11, wL ~20)	0	52	36	12
7	SS	6		Remoulded ~0; field vane ~105					
8	SS	74			~13				
9	SS	156	▽ (water level)		~11	0	20	80	0
10	SS	176/0.28			~21	0	5	94	1
11	SS	100/0.13							
12	SS	100/0.13			~20				
13	SS	100/0.13							
14	SS	100/0.09			~20				
15	SS	100/0.13							

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; ELEVATION SCALE 264 to 253.

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

Golder Associates

RECORD OF BOREHOLE No 10-08

 METRIC

PROJECT 08-1170-5040

G.W.P. 2010-20T-82

LOCATION N 4919308.2 ;E 291005.8

ORIGINATED BY AB

DIST Central HWY 400

BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger

COMPILED BY NLP

DATUM Geodetic

DATE June 3, 2010

CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
259.7	GROUND SURFACE									
0.0	TOPSOIL									
0.2	Sand, trace to some silt, trace organic matter (FILL) Loose Brown to black Moist	1	SS	6						
259.0 / 0.7	SILT, trace to some sand, trace clay Compact to very dense Brown to grey Moist to wet	2	SS	24	259					
		3	SS	59	258	o	0	4	96	0
		4	SS	53	257					
		5	SS	81		o	0	2	96	2
		6	SS	100/0.15	256					
		7	SS	100/0.15	255	o	0	4	95	1
		8	SS	100/0.13	254, 253					
251.8		9	SS	100/0.13	252	o				
7.9	END OF BOREHOLE									

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O 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); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTES:

1. Water level in open borehole at a depth of 1.4 m below ground surface (Elevation 258.3 m) upon completion of drilling.

2. Water level in piezometer at a depth of 3.0 m below ground surface(Elevation 256.7 m) on June 16, 2010.

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

O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 10-10

 METRIC

PROJECT 08-1170-5040			ORIGINATED BY DD
W.P. 2010-20T-82	LOCATION N 4919316.7 ;E 291030.4		
DIST Central HWY 400	BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger		COMPILED BY NLP
DATUM Geodetic	DATE June 4, 2010		CHECKED BY KN

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV DEPTH	DESCRIPTION
262.5	GROUND SURFACE
0.0	TOPSOIL
0.2	Sandy silt, trace gravel, trace clay (FILL) Compact Brown Moist
261.7 0.8	Clayey silt, trace gravel (FILL) Hard Brown Moist
260.2 2.3	Augers grinding at 2.3 m depth Sandy SILT to SILT, trace to some sand, trace gravel Very dense Brown Moist to wet Spoon advanced through boulder/cobble at 3.8 m depth
252.4 10.1	CLAYEY SILT with sand and gravel (TILL) Hard Grey Wet
250.3 12.2	CLAYEY SILT, trace sand Hard Grey Moist

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	29				
2	SS	36				
3	SS	140				
4	SS	83				
5	SS	102				
6	SS	71	0	6	93	1
7	SS	98				
8	SS	121	2	4	92	2
9	SS	139				
10	SS	117				
11	SS	70	24	50	20	6
12	SS	30				
13	SS	65				

Elevation scale: 262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248

DRAFT

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 10-10

 METRIC

PROJECT 08-1170-5040			
W.P. 2010-20T-82	LOCATION N 4919316.7 ;E 291030.4	ORIGINATED BY DD	
DIST Central HWY 400	BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger	COMPILED BY NLP	
DATUM Geodetic	DATE June 4, 2010	CHECKED BY KN	

--- CONTINUED FROM PREVIOUS PAGE ---

SOIL PROFILE: CLAYEY SILT, trace sand, Hard, Grey, Moist

SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
14	SS	52	
15	SS	81	0 3 61 36
16	SS	124	
17	SS	60	
18	SS	40	
19	SS	57	0 1 60 39
20	SS	73	
21	SS	92	

Elevation scale: 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235, 234, 233

Column headings: ELEV DEPTH; DESCRIPTION; STRAT PLOT; NUMBER; TYPE; "N" VALUES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + 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; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No 10-10

 METRIC

PROJECT 08-1170-5040
W.P. 2010-20T-82 LOCATION N 4919316.7 ;E 291030.4 ORIGINATED BY DD
DIST Central HWY 400 BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger COMPILED BY NLP
DATUM Geodetic DATE June 4, 2010 CHECKED BY KN

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace sand Hard Grey Moist		22	SS	145		232	149			
231.4 31.1	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 4.6 m below ground surface (Elevation 257.9 m) upon completion of drilling. 2. Water level in piezometer at a depth of 4.7 m below ground surface (Elevation 257.7 m) on June 16, 2010, and 4.2 m below ground surface (Elevation 258.3 m) on March 16, 2011.							241 405			

Shear strength legend: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED. Plastic limit W_P, natural moisture content W, liquid limit W_L.

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

Golder Associates

RECORD OF BOREHOLE No 10-11

 METRIC

PROJECT 08-1170-5040			
G.W.P. 2010-20T-82	LOCATION N 4919351.5 ;E 291043.9		ORIGINATED BY AB
DIST Central HWY 400	BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger		COMPILED BY NLP
DATUM Geodetic	DATE June 14, 2010		CHECKED BY KN

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
263.9	GROUND SURFACE
0.0 / 0.1	TOPSOIL
	Clayey silt, trace to some sand, trace gravel to sand, trace silt, trace gravel, trace organic matter (FILL) Compact / stiff Brown Moist
260.2 / 3.7	CLAYEY SILT with sand, trace to some gravel (TILL) Hard Brown Moist
256.8 / 7.1	SILT, trace to some sand, trace gravel Very dense Brown Wet
252.3 / 11.6	CLAYEY SILT, trace to some gravel, trace to some sand (TILL) Hard Brown to grey Moist 150 mm thick seam of grey, silty clay encountered at 17.1 m depth
250.1 / 13.8	Low SPT "N" value for Sample 15 due to sample disturbance

SAMPLES AND REMARKS

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	18				
2	SS	42				
3	SS	12				
4	SS	18				
5	SS	24	28	35	23	14
6	SS	39	5	48	37	10
7	SS	43				
8	SS	67				
9	SS	78	0	10	90	0
10	SS	72	2	4	94	0
11	SS	146				
12	SS	100/0.13				
13	SS	100/0.13				
14	SS	169/0.30				
15	SS	2	2	80	15	3

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (263, 262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250, 249); DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 10-11

 METRIC

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
LOCATION N 4919351.5 ;E 291043.9
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
COMPILED BY NLP
DATUM Geodetic
DATE June 14, 2010
CHECKED BY KN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND, some silt, trace gravel, trace clay Very loose (13.8 m to 14.8 m) to very dense Brown Wet		16	SS	100/0.13						
							248				
			17	SS	166		247		○		
							246				
245.2			18	SS	133/0.28				○		
18.7	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 7.1 m below ground surface (Elevation 256.8 m) upon completion of drilling. 2. Water level in piezometer at a depth of 7.0 m below ground surface (Elevation 256.9 m) on June 16, 2010.										

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 10-12

 METRIC

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
LOCATION N 4919328.7 ;E 291040.3
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
COMPILED BY NLP
DATUM Geodetic
DATE June 17, 2010
CHECKED BY KN

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
264.1	GROUND SURFACE
0.0	TOPSOIL
0.1	Sand and gravel, trace silt (FILL) Compact Brown Moist
263.1 / 1.0	Clayey silt with sand, trace to some gravel (FILL) Stiff Brown to black Moist
260.4 / 3.7	CLAYEY SILT to SILTY CLAY, some gravel, some sand (TILL) Hard Brown Moist
258.5 / 5.6	SILT, trace sand, trace to some gravel, trace clay Very dense Brown Wet. Interlayer of CLAYEY SILT TILL from 9.6 m to 10.5 m depth (Auger grinding)
252.8 / 11.3	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist
252.1 / 12.0	SAND, some gravel, trace silt Very dense Brown Wet
250.9 / 13.2	CLAYEY SILT, trace sand Hard Brown Moist
249.9 / 14.2	

Groundwater level symbol (∇) at approx. elev. 258.5.

SAMPLES

NUMBER	TYPE	"N" VALUES	Water content	GR	SA	SI	CL
1	SS	21					
2	SS	15					
3	SS	10	w with w_P–w_L range	0	55	35	10
4	SS	15					
5	SS	11	o				
6	SS	49					
7	SS	42	o				
8	SS	149/0.30	o	0	6	94	0
9	SS	115					
10	SS	187/0.25	o	2	2	93	3
11	SS	158/0.28					
12	SS	100/0.13	o				
13	SS	100/0.13	o	9	2	87	2
14	SS	173/0.28	w with w_P–w_L range	6	16	65	13
15	SS	159	o				
16	SS	46					

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (264 to 250); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

DRAFT

Continued Next Page

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

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RECORD OF BOREHOLE No 10-12

 METRIC

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
LOCATION N 4919328.7 ;E 291040.3
ORIGINATED BY AB
DIST Central HWY 400
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
COMPILED BY NLP
DATUM Geodetic
DATE June 17, 2010
CHECKED BY KN

SOIL PROFILE		SAMPLES									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + 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)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE NOTES: 1. Water level in open borehole at a depth of 5.6 m below ground surface (Elev. 258.5 m) upon completion of drilling.										

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

RECORD OF BOREHOLE No 10-EMB-01

1 OF 1 **METRIC**

PROJECT 08-1170-5040
G.W.P. 2010-20T-82
DIST Central HWY 400
DATUM Geodetic

LOCATION N 4918733.4 ;E 605615.8
BOREHOLE TYPE D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
DATE June 2, 2010

ORIGINATED BY AB
COMPILED BY NLP
CHECKED BY KN

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.7	GROUND SURFACE				
259.4 / 0.0	TOPSOIL	1	SS	20	
0.3	Clayey silt, trace to some sand, trace to some gravel (FILL) Very stiff Brown Moist	2	SS	16	
258.3 / 1.4	CLAYEY SILT, with sand, trace to some gravel (TILL) Firm to hard Brown Moist	3	SS	7	7 35 33 25
		4	SS	17	
		5	SS	52	
255.7	150 mm silt seam encountered at 3.8 m depth	6	SS	100	
4.0	SILT, trace sand, contains clayey silt lenses Very dense Brown to grey Moist	7	SS	100/0.10	0 3 83 14
	Becoming grey at 5.5 m depth	8	SS	100/0.09	
252.7 / 7.0	SAND, some silt to SILT and SAND Very dense Brown to grey Wet	9	SS	125	
		10	SS	183/0.28	
250.1 / 9.6	END OF BOREHOLE				

Elevation scale: 259, 258, 257, 256, 255, 254, 253, 252, 251

Ground water: water level symbol at approx. elevation 252.7

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 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 (%) 10 20 30

UNIT WEIGHT γ kN/m³

NOTES:

1. Water level in open borehole at a depth of 7.0 m (Elevation 252.7 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No 10-EMB-02

 METRIC

PROJECT	08-1170-5040		
G.W.P.	2010-20T-82	LOCATION	N 4198772.9 ;E 605689.6
DIST	Central HWY 400	BOREHOLE TYPE	D-50 Turbo Track Mount, 200 mm Diameter Hollow Stem Auger
DATUM	Geodetic	DATE	June 9, 2010
ORIGINATED BY	AB	COMPILED BY	NLP
CHECKED BY	KN		

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
258.3	GROUND SURFACE
258.0 / 0.0	TOPSOIL
256.9 / 0.3	Silty sand, some gravel, trace clay, containing pockets of topsoil (FILL) Loose to compact Brown Moist
255.4 / 1.4	Clayey silt with sand, trace to some gravel (FILL) Stiff to very stiff Brown Moist
252.8 / 2.9	CLAYEY SILT with sand, trace to some gravel (TILL) Very stiff to hard Brown to grey Moist
249.7 / 5.5	SILT, trace to some sand, trace clay Very dense Brown Wet
248.7 / 8.6	CLAYEY SILT, trace to some sand, trace to some gravel (TILL) Hard Grey Moist
9.6	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	6				
2	SS	21				
3	SS	15	4	50	35	11
4	SS	14				
5	SS	27	10	45	35	10
6	SS	91				
7	SS	100/0.15				
8	SS	141				
9	SS	154/0.28				
10	SS	95				

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (258 to 249); DYNAMIC CONE PENETRATION RESISTANCE PLOT (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 (%) (10, 20, 30); UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

NOTES:

1. Water level in open borehole at a depth of 5.5 m (Elevation 252.8 m) upon completion of drilling.

2. Water level in piezometer at a depth of 0.5 m (Elevation 257.8 m) on June 16, 2010.

3. A borehole was advanced adjacent to BH 10-EMB-02 to a depth of 1.5 m and field vane tests are conducte at a depth of 1.8 m and 2.1 m

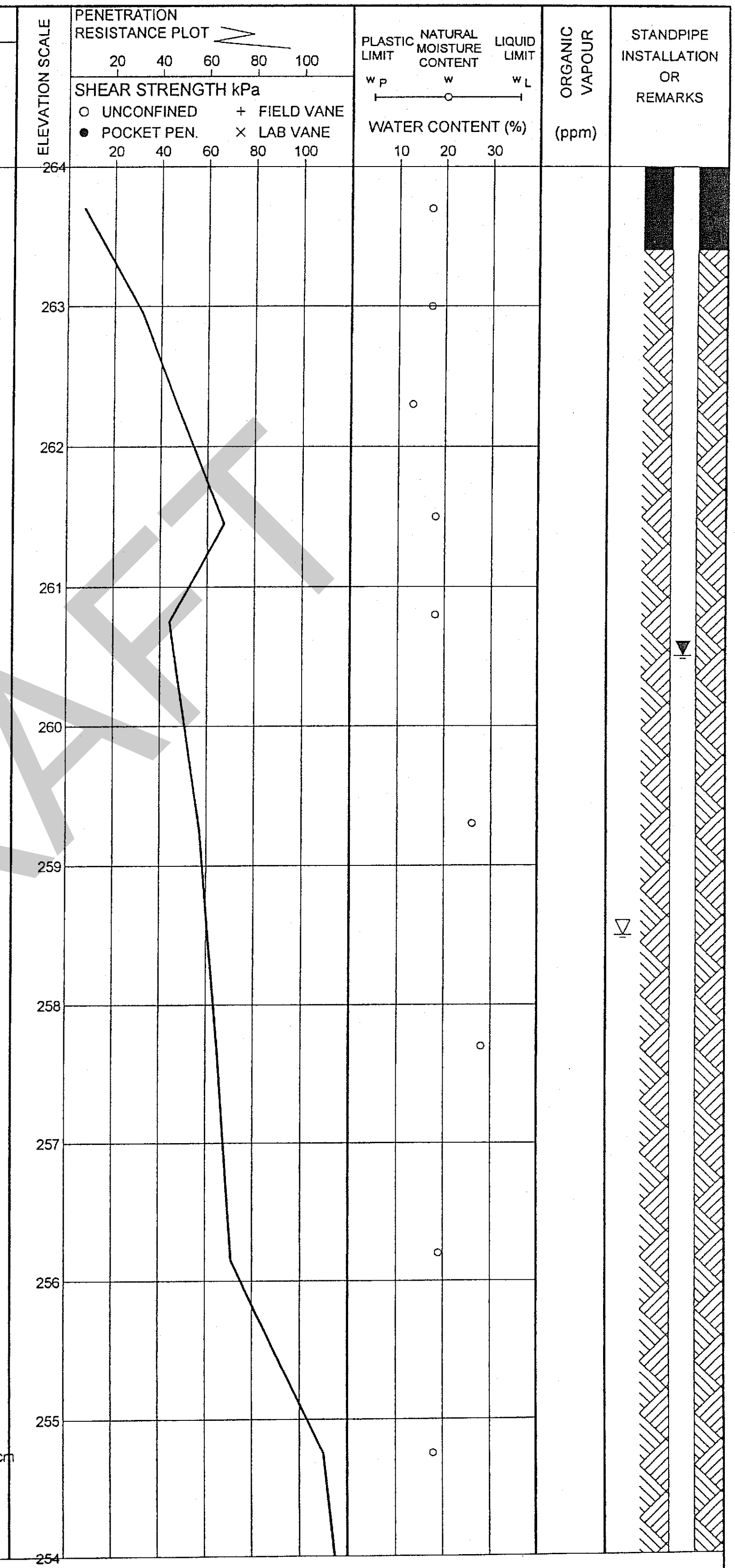
+ ^{3}, × ^{3}: Numbers refer to Sensitivity   ○ $^{3\%}$ STRAIN AT FAILURE

Terraprobe

LOG OF BOREHOLE 19

PROJECT: Duckworth / 400 Interchange
LOCATION: Barrie, Ontario
CLIENT: The Corporation of the Cilty of Barrie
DATE: 27 October 2006
EQUIPMENT: Truck D25
ELEVATION DATUM: Geodetic
FILE: 3-06-2117

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES
264.0	Ground Surface			
0.0	FILL - Clayey Silt, trace sand, trace gravel, trace organics, firm to hard, dark brown / brown, damp to moist	1	SS	7
		2	SS	32
262.6 / 1.4	CLAYEY SILT some sand, trace gravel, hard, brown, damp to moist	3	SS	48
261.9 / 2.1	SILTY SAND trace gravel, dense to very dense, brown, moist	4	SS	67
		5	SS	44
		6	SS	57
		7	SS	65
		8	SS	71
255.5 / 8.5	SILT trace clay, trace sand, very dense, brown, damp to moist	9	SS	66/15cm



NOTES:
Borehole was open and water level at 5.5m upon completion of drilling. Water level in piezometer at 3.5m (Elev. 260.5m) on January 4, 2007.

Terraprobe

LOG OF BOREHOLE 19

PROJECT: Duckworth / 400 Interchange
DATE: 27 October 2006
LOCATION: Barrie, Ontario
EQUIPMENT: Truck D25
CLIENT: The Corporation of the Cilty of Barrie
ELEVATION DATUM: Geodetic
FILE: 3-06-2117

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (natural)
	SILT trace clay, trace sand, very dense, brown, damp to moist	10	SS	50/13cm	254, 253	o ~20
252.4 / 11.6	SILTY SAND very dense, brown, damp	11	SS	87	252	o ~9
250.9 / 13.1	CLAYEY SILT hard, grey, damp to moist	12	SS	95/25cm	251, 250	o ~16
		13	SS	83	249	o ~16
248.3 / 15.7	End of Borehole					

DRAFT

NOTES:
Borehole was open and water level at 5.5m upon completion of drilling. Water level in piezometer at 3.5m (Elev. 260.5m) on January 4, 2007.

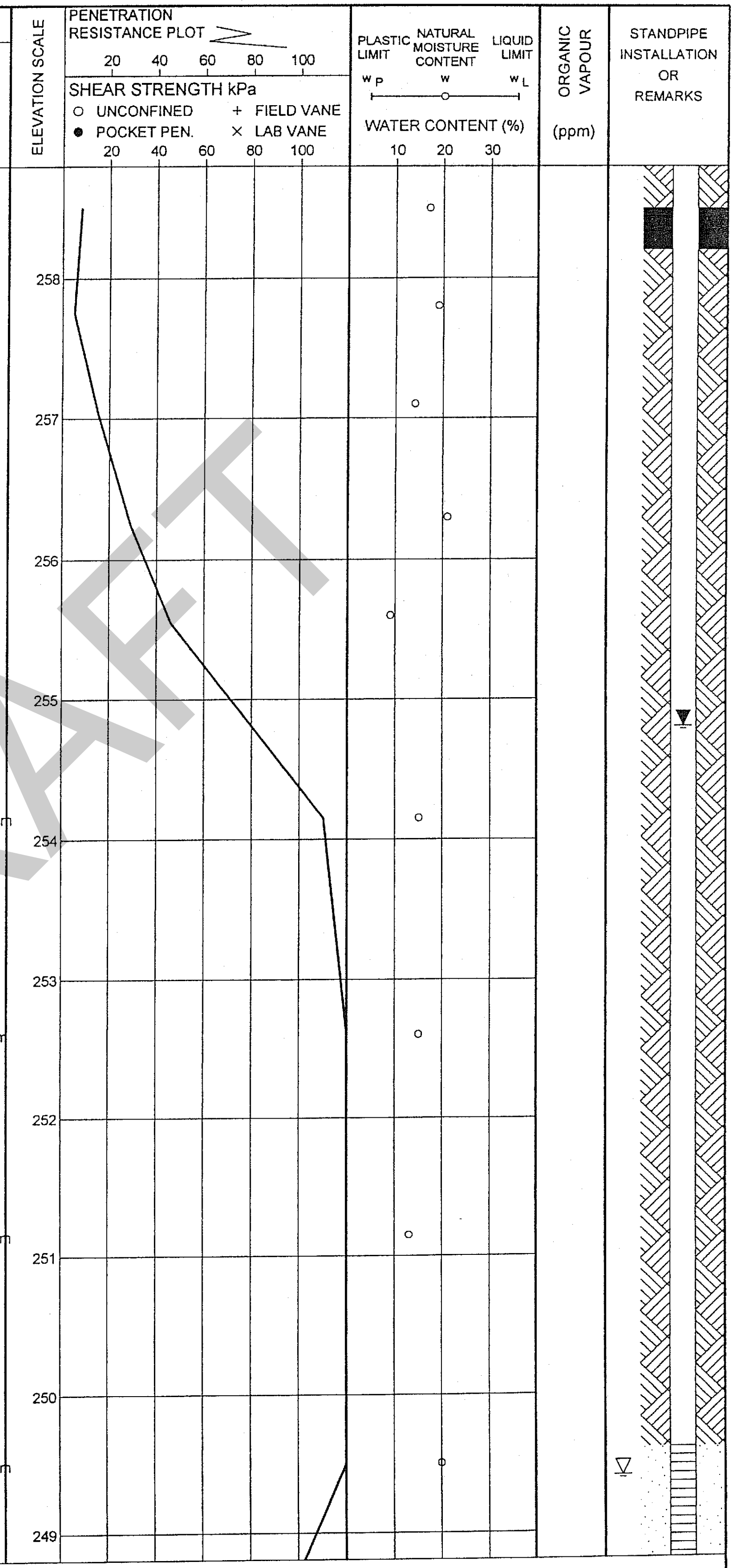
Terraprobe

LOG OF BOREHOLE 21

PROJECT: Duckworth / 400 Interchange
DATE: 02 November 2006
LOCATION: Barrie, Ontario
EQUIPMENT: Bombardier D50
CLIENT: The Corporation of the Cilty of Barrie
ELEVATION DATUM: Geodetic
FILE: 3-06-2117

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
258.8	Ground Surface	
0.0	FILL - Clayey Silt, trace topsoil, trace sand, trace gravel, firm, dark brown, damp to moist	
257.4 / 1.4	CLAYEY SILT trace to some silt, trace gravel, stiff to hard, brown, damp to moist ---- hard	
250.3 / 8.5	SILTY FINE SAND trace clay, very dense, brown, moist to wet	

SAMPLES NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	5
3	SS	15
4	SS	29
5	SS	46
6	SS	50/15cm
7	SS	50/6cm
8	SS	50/10cm
9	SS	91/25cm



NOTES:
Borehole was open and water level at 9.4m upon completion of drilling. Water level in piezometer at 4.0m (Elev. 254.8m) on January 4, 2007.

Terraprobe

LOG OF BOREHOLE 21

PROJECT: Duckworth / 400 Interchange
LOCATION: Barrie, Ontario
CLIENT: The Corporation of the Cilty of Barrie
DATE: 02 November 2006
EQUIPMENT: Bombardier D50
ELEVATION DATUM: Geodetic
FILE: 3-06-2117

SOIL PROFILE			SAMPLES			ELEVATION SCALE	PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● POCKET PEN., × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	ORGANIC VAPOUR (ppm)	STANDPIPE INSTALLATION OR REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES					
	SILTY FINE SAND trace clay, very dense, brown, moist to wet									
			10	SS	79	248				
						247				
246.3			11	SS	50/13cm					
12.5	End of Borehole									

NOTES:
Borehole was open and water level at 9.4m upon completion of drilling. Water level in piezometer at 4.0m (Elev. 254.8m) on January 4, 2007.

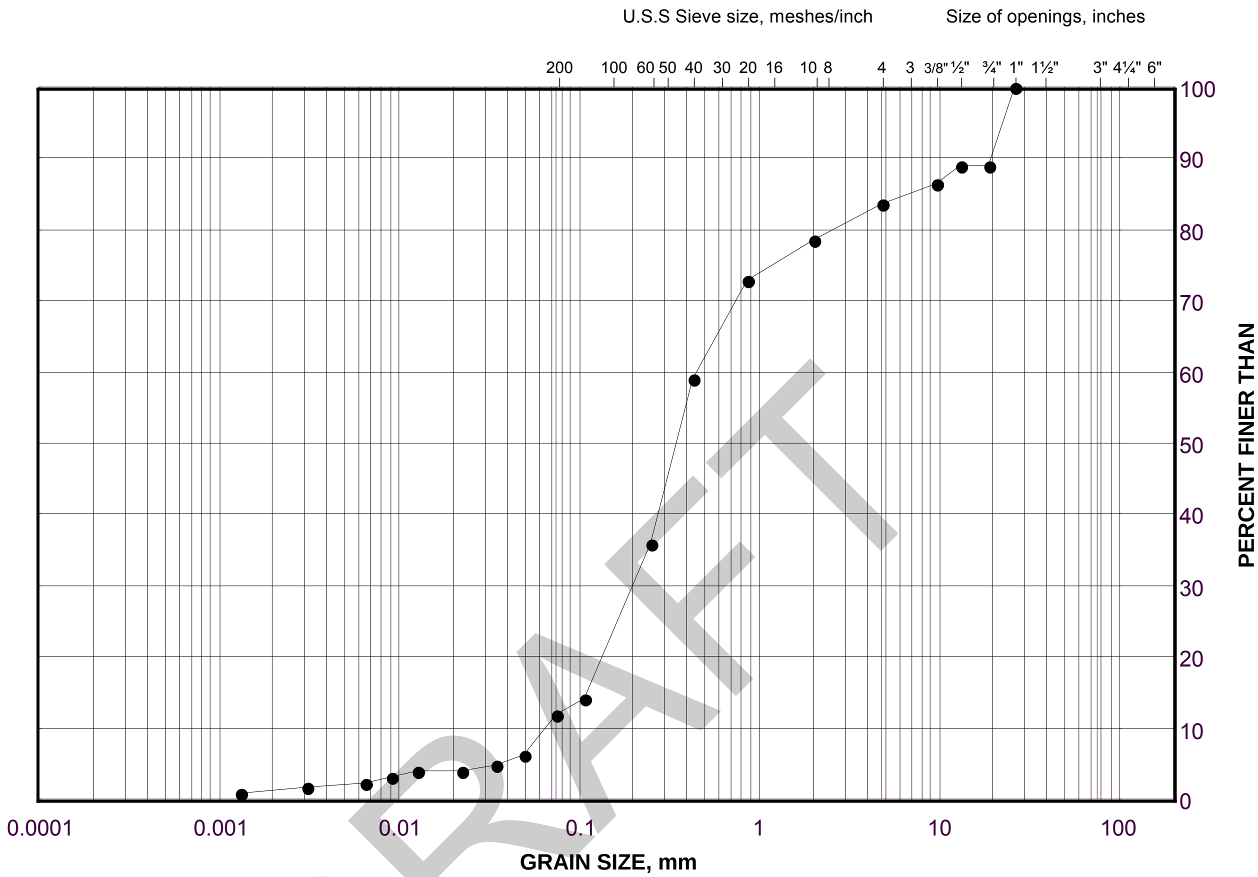
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Fill)

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-07	4	262.2

Project Number: 08-1170-5040

Checked By: ______________________

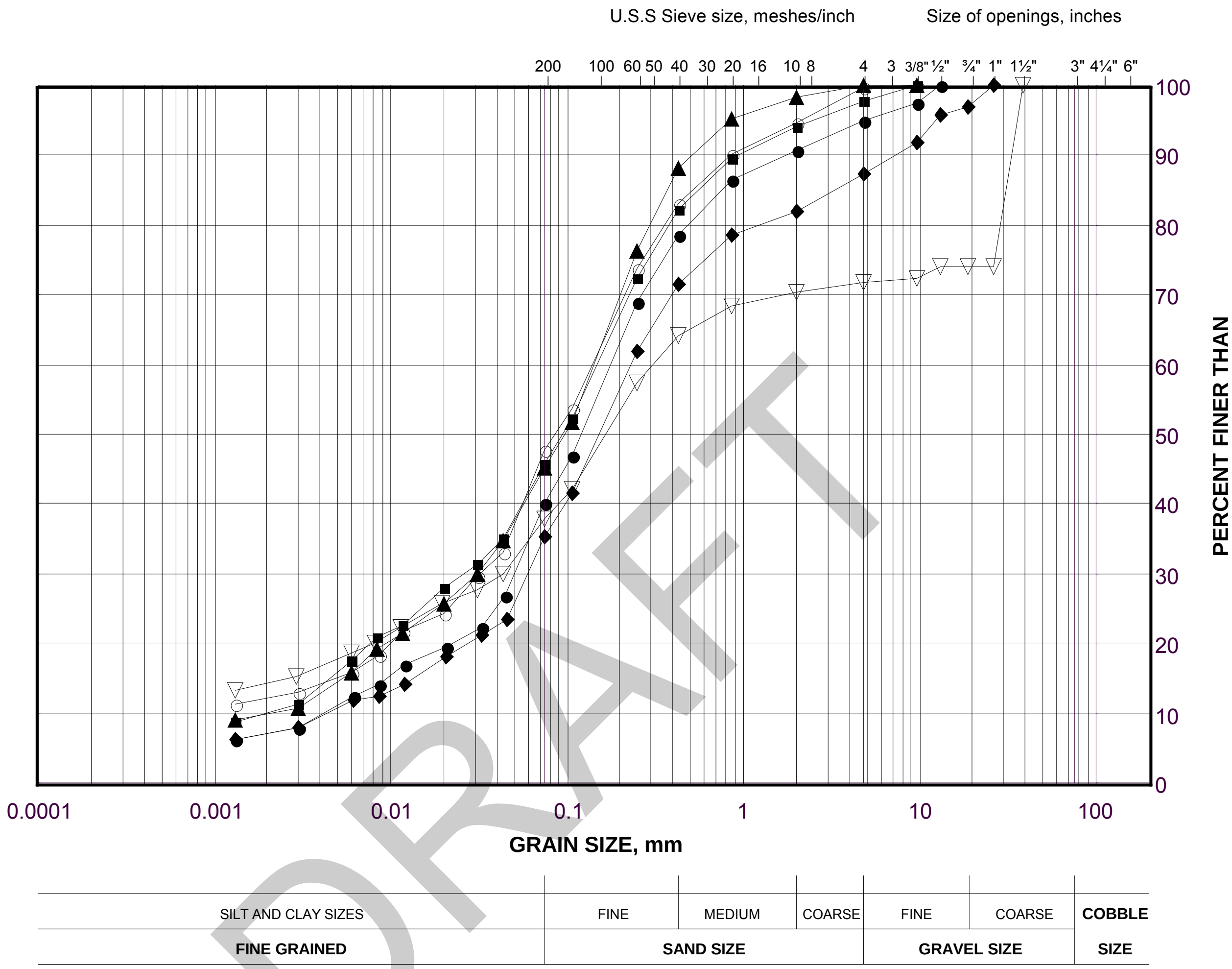
Golder Associates

Date: 17-May-11

GRAIN SIZE DISTRIBUTION

Silt to Clayey Silt (Fill)

FIGURE B2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-05	2	257.3
■	11-3	3	251.0
◆	11-1	3	253.3
▲	10-12	3	262.3
▽	10-11	5	260.7
❍	10-07	6	260.7

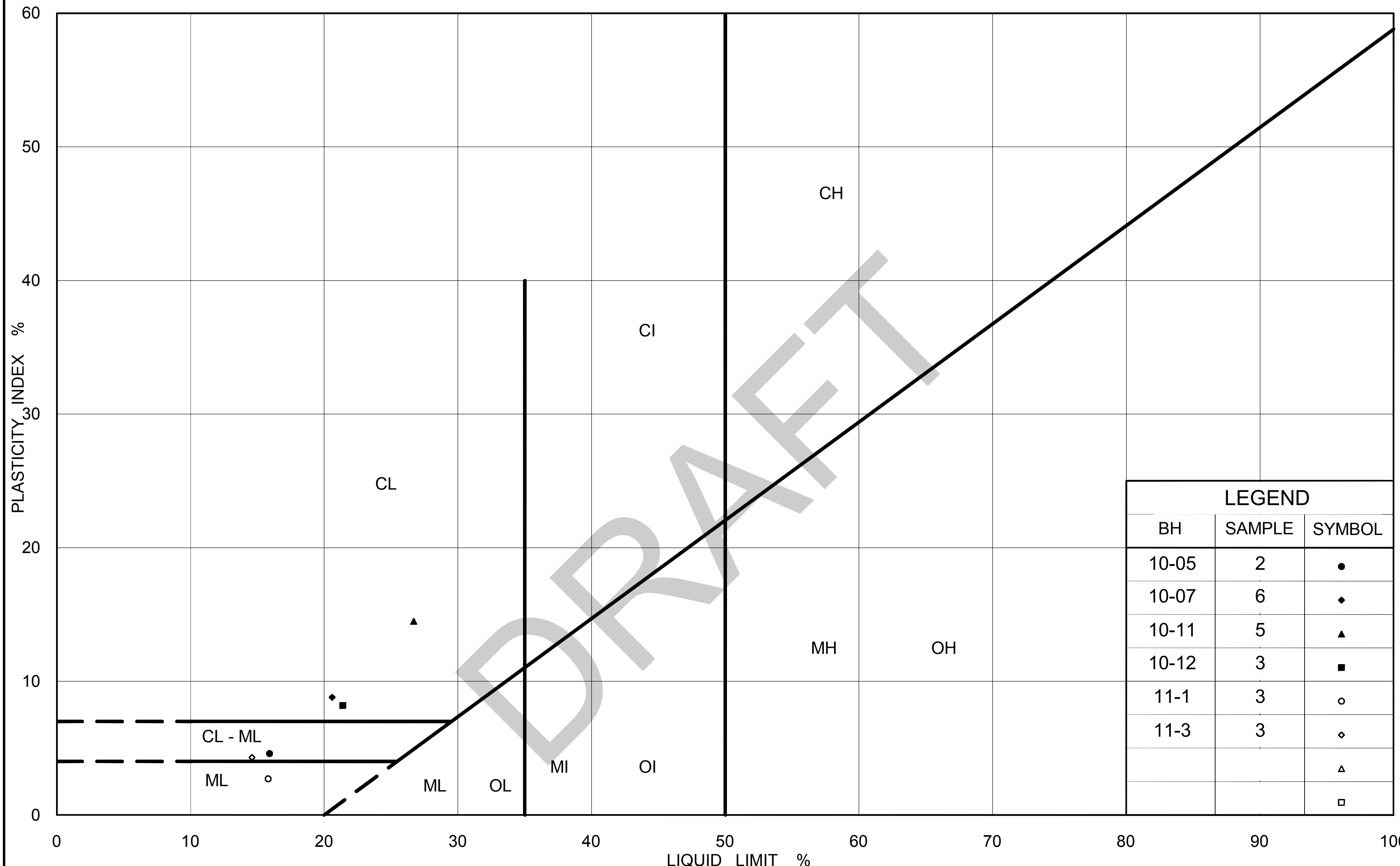
Project Number: 08-1170-5040

Checked By: ______________________

Golder Associates

Date: 30-May-11

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
10-05	2	●
10-07	6	◆
10-11	5	▲
10-12	3	■
11-1	3	○
11-3	3	◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Silt to Clayey Silt Fill

Figure No. B3

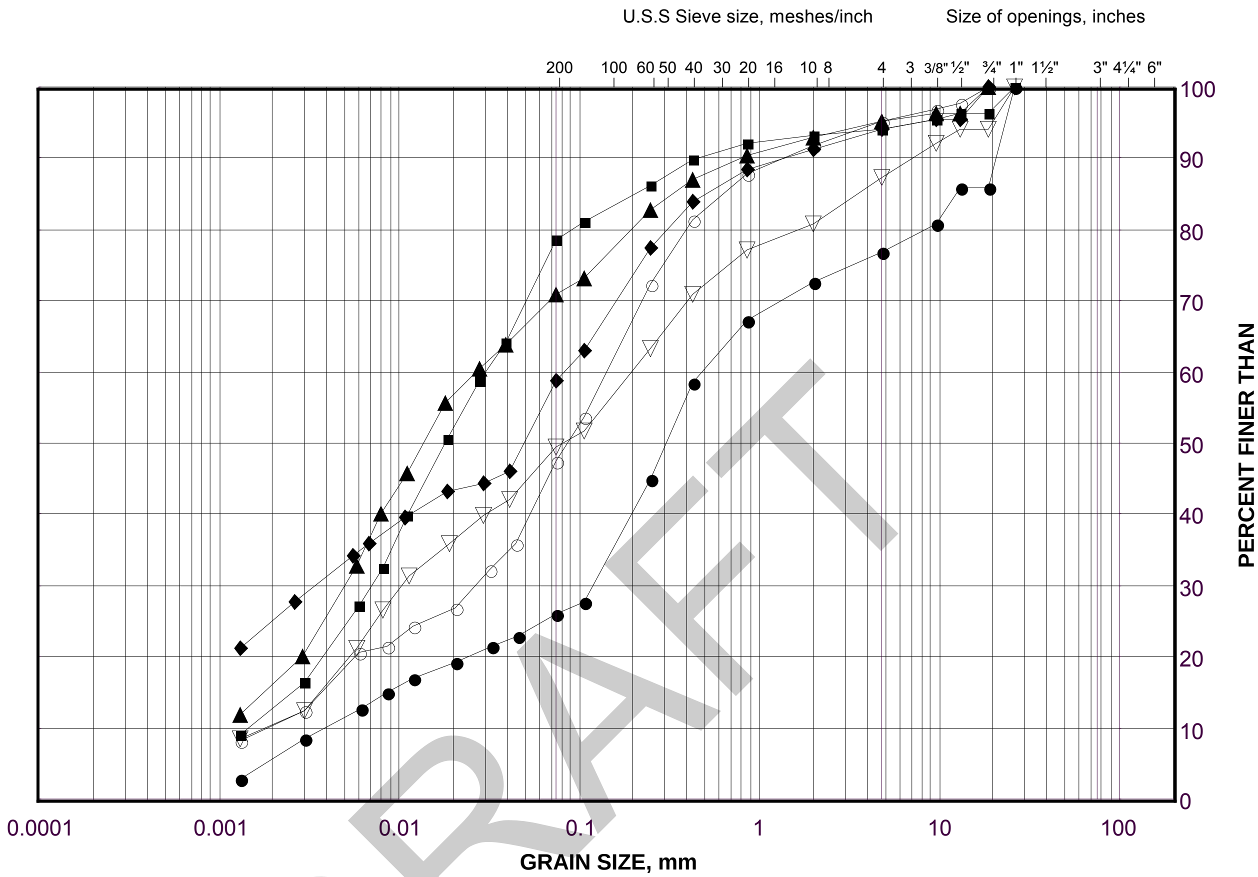
Project No. 08-1170-5040

Checked By:

GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)

FIGURE B4



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

LEGEND

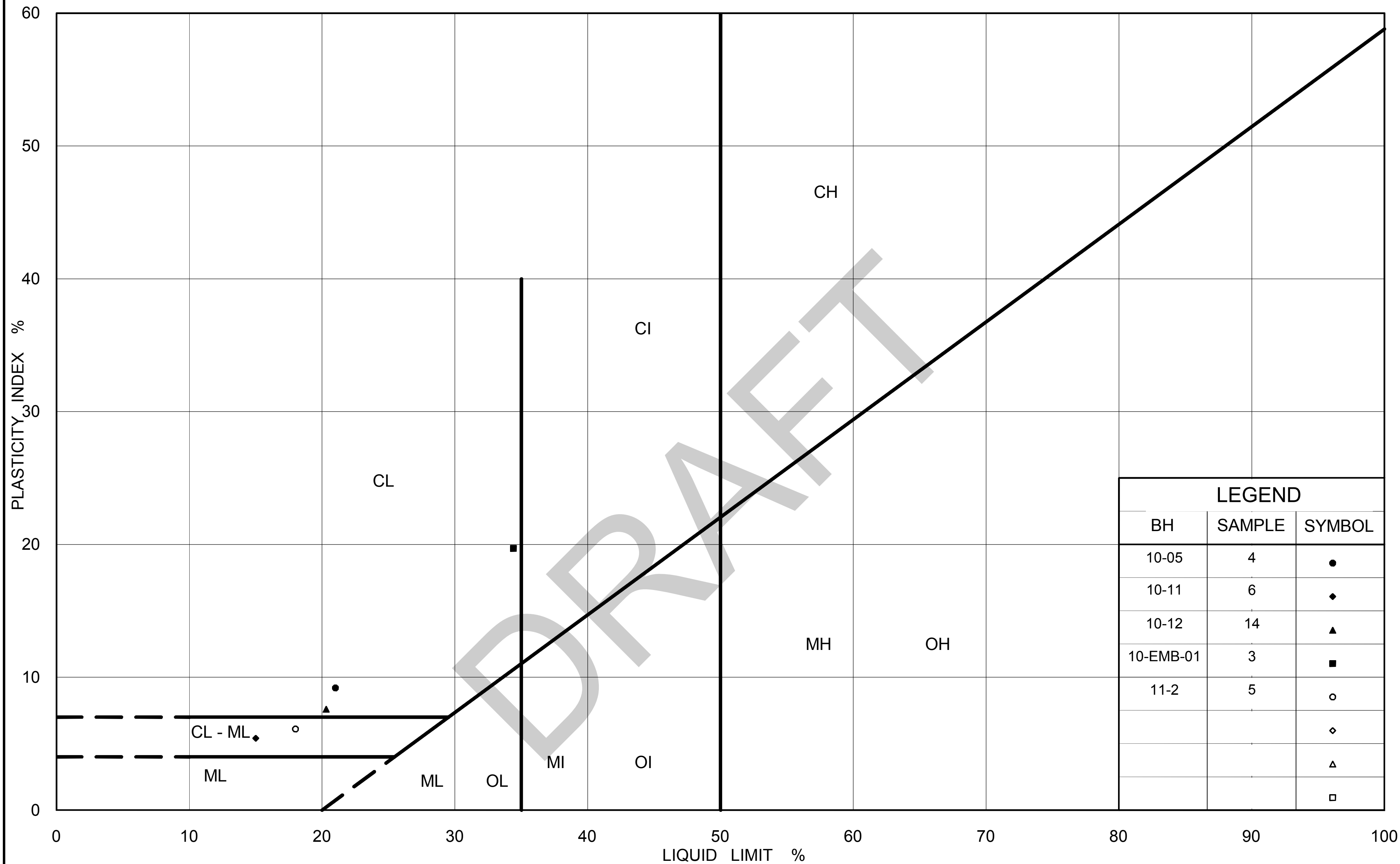
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-10	11	251.7
■	10-12	14	252.4
◆	10-EMB-01	3	257.9
▲	10-05	4	254.2
▽	11-2	5	249.5
❍	10-11	6	259.9

Project Number: 08-1170-5040

Checked By: ______________________

Golder Associates

Date: 30-May-11



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Till

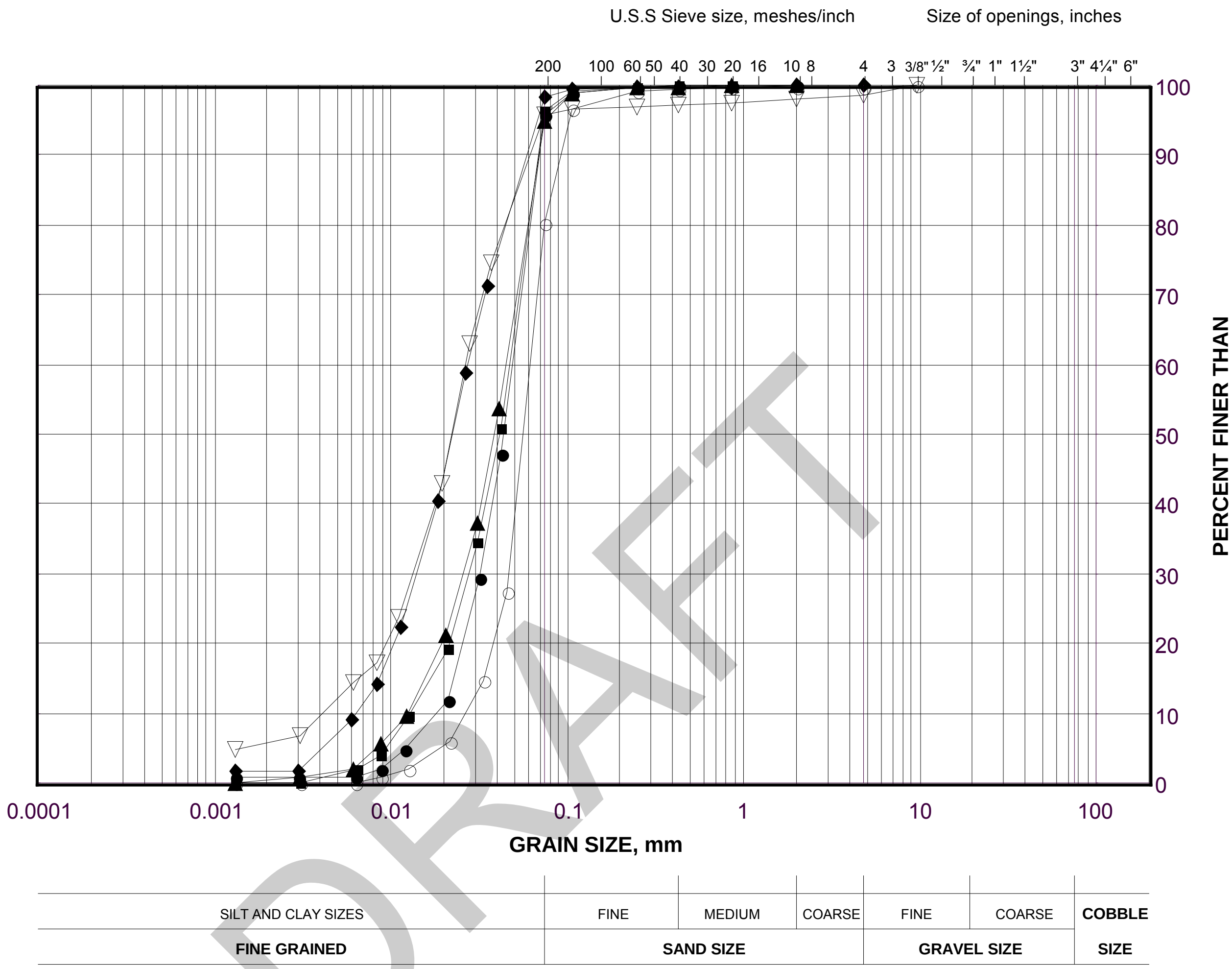
Figure No. B5

Project No. 08-1170-5040

Checked By:

GRAIN SIZE DISTRIBUTION
Silt

FIGURE B6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-07	10	256.1
■	10-08	3	258.9
◆	10-08	5	256.5
▲	10-08	7	255.9
▽	10-05	7	251.9
○	10-07	9	256.9

Project Number: 08-1170-5040

Checked By: ____________________

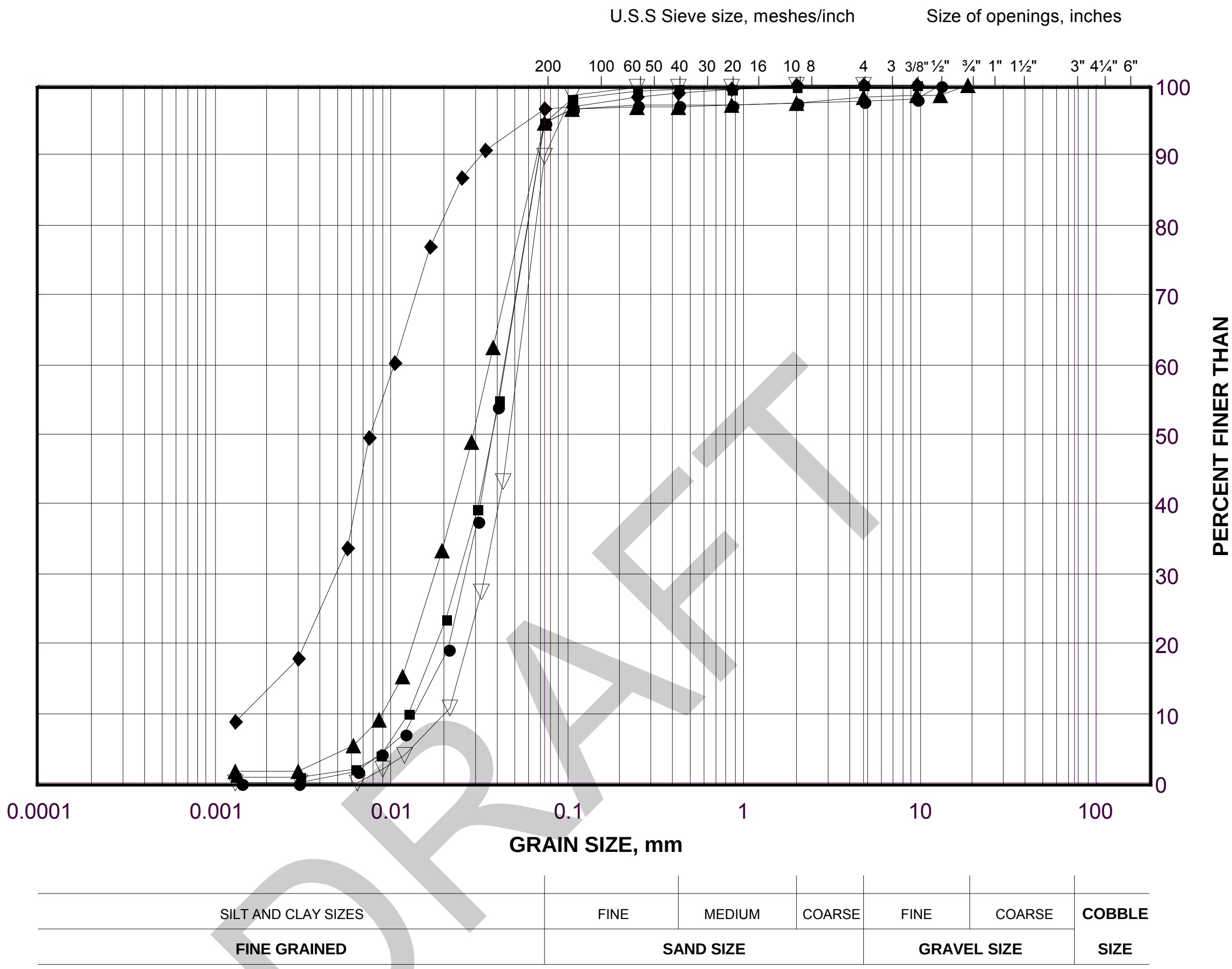
Golder Associates

Date: 17-May-11

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-11	10	254.5
■	10-10	6	256.9
◆	10-EMB-01	7	255.0
▲	10-10	8	255.4
▽	10-11	9	256.0

Project Number: 08-1170-5040

Checked By: ______________________

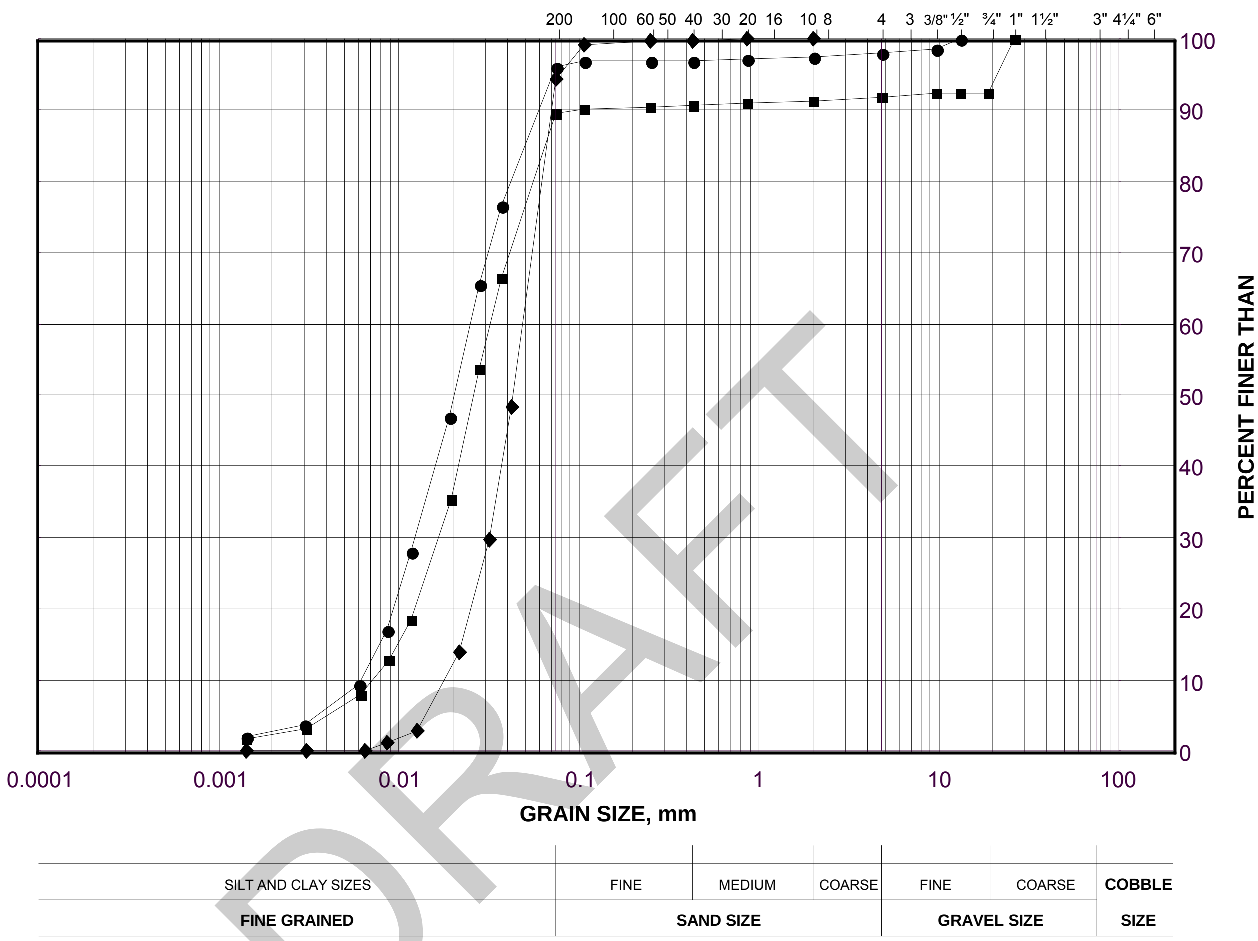
Golder Associates

Date: 17-May-11

GRAIN SIZE DISTRIBUTION

Silt

FIGURE B8



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-12	10	255.6
■	10-12	13	253.1
◆	10-12	8	257.8

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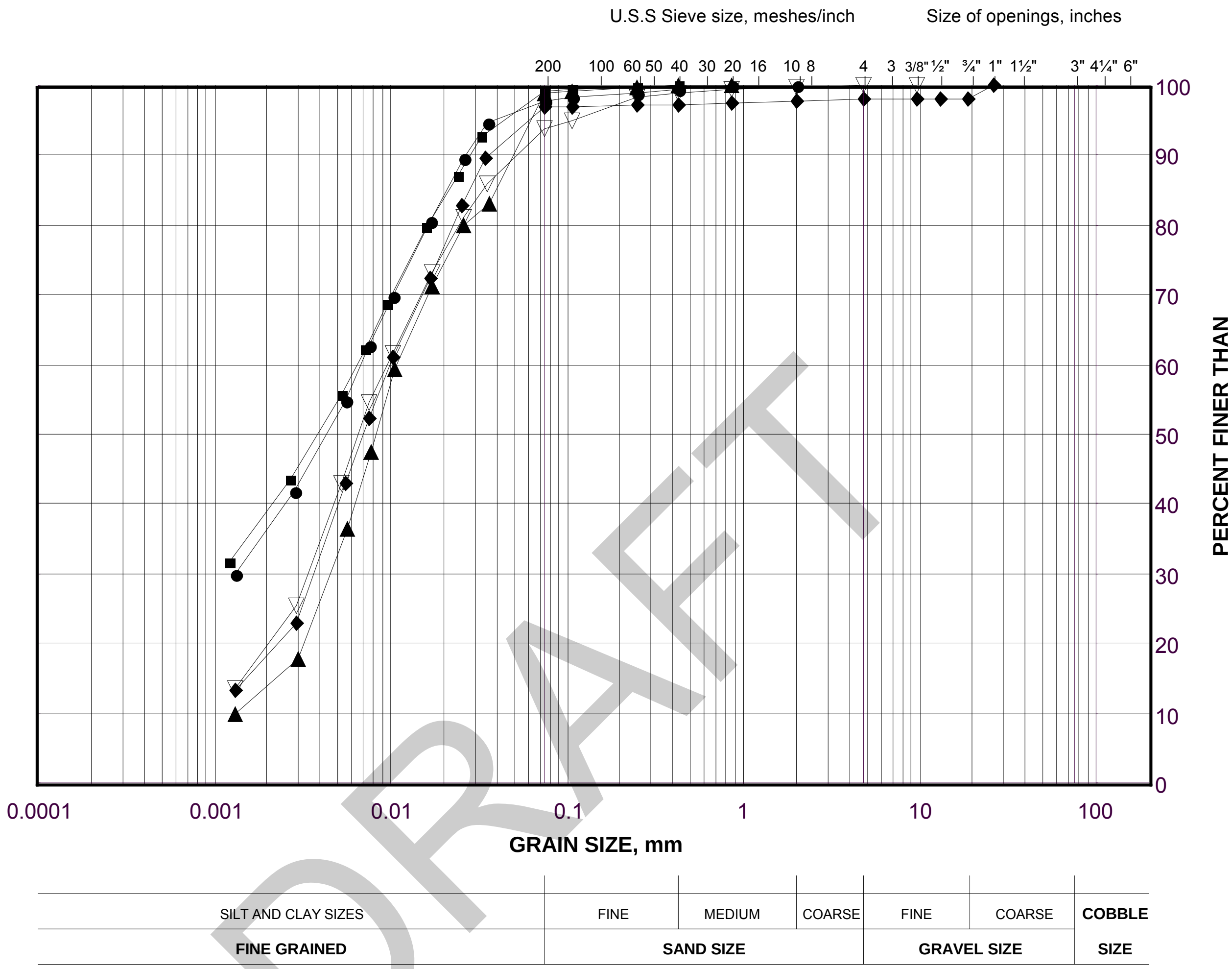
GRAIN SIZE DISTRIBUTION
Clayey Silt

FIGURE B9



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-10	15	245.6
■	10-10	19	239.4
◆	11-3	6	248.7
▲	11-2	7	248.1
▽	11-1	9	247.2

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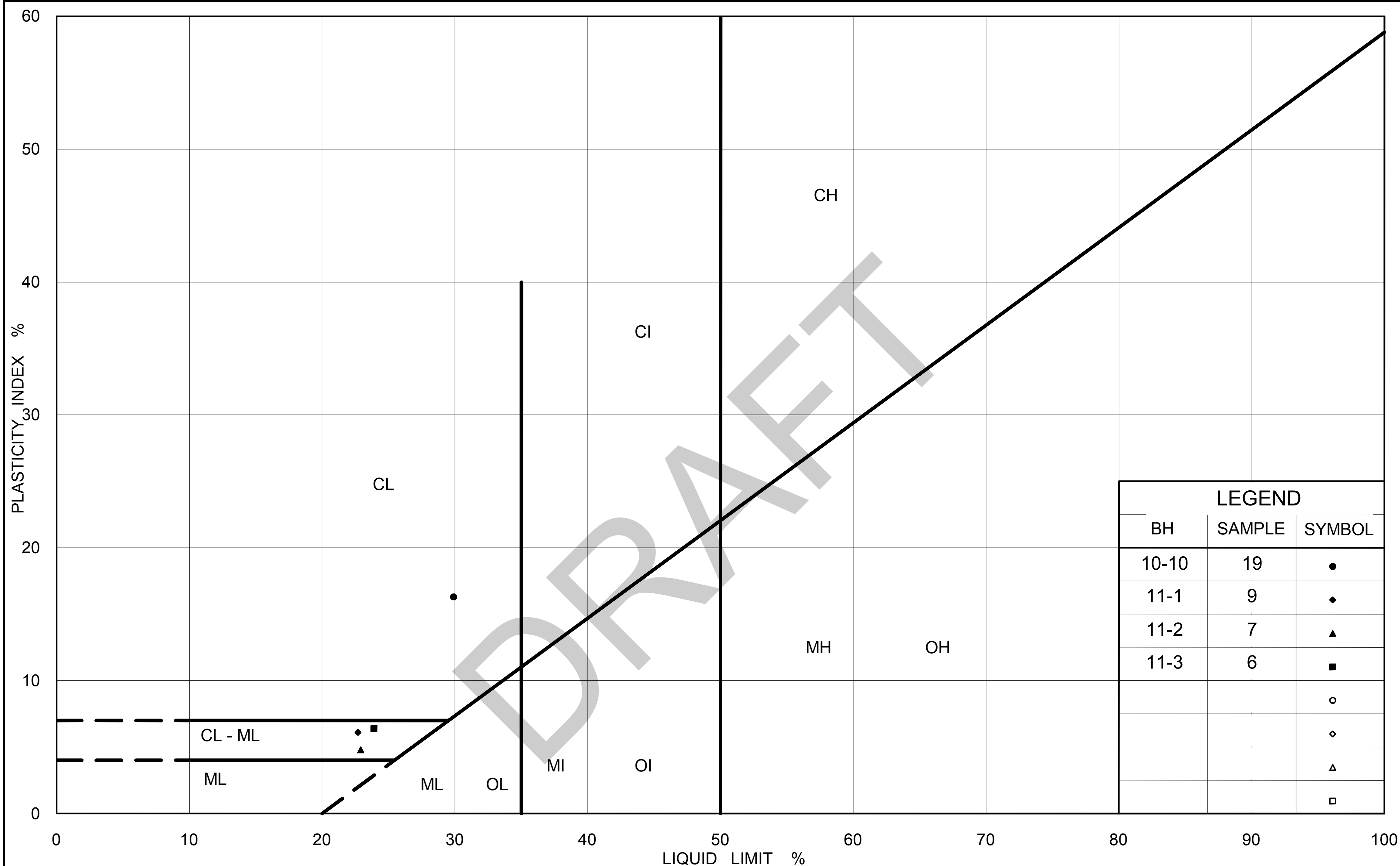
Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
10-10	19	●
11-1	9	◆
11-2	7	▲
11-3	6	■
		○
		◇
		△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B10

Project No. 08-1170-5040

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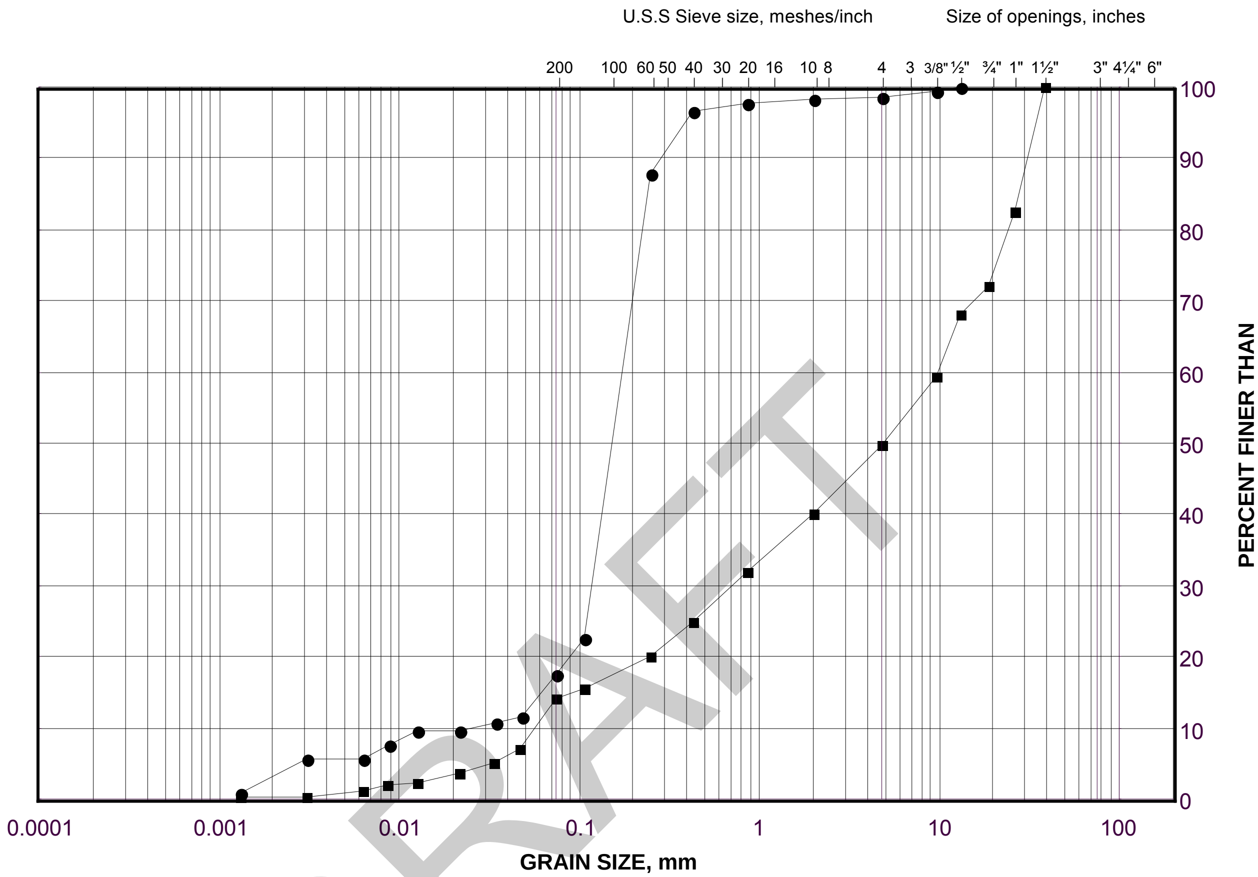
GRAIN SIZE DISTRIBUTION

Sand to Sand and Gravel

FIGURE B11



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	10-11	15	249.9
■	10-05	5A	253.6

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Date: 17-May-11

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.

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