FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 407/BROCK ROAD INTERCHANGE CONNECTION
STRUCTURE M-2 (SITE 3)
HIGHWAY 407 OVER BROUGHAM CREEK
Contract No: E2-2012

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of Structure M-2 which consists of 4 bridges crossing Brougham Creek, in The City of Pickering, Ontario. The four bridges are for the following components of the new Highway 407 – Brock Road Interchange: eastbound lanes (EBL), westbound lanes (WBL), NW ramp (on ramp), and W-N/S ramp (off ramp). The new bridges are planned as part of the Highway 407 east extension and are to be completed as part of the Highway 407/Brock Road Interchange Connection project.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and sections, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained during the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Highway 407 ETR Contract Number E2-2012 (Design).

2 SITE DESCRIPTION

The Structure M-2 site is located approximately 300 m east of the existing Brock Road and extends from the existing Highway 407 to 60 m north of the highway at Brougham Creek. The community of Brougham is located approximately 500 m northwest of the proposed bridge site.

At the location of the proposed bridges, Brougham Creek flows from north to south. The creek flows in a valley that is approximately 4 to 5 m below the existing highway grade. At the site of Structure M-2, this valley is well defined by the slope to the east and poorly defined to the west, where low lying areas extend away from the creek. Due to the presence of beaver dams and extensive beaver activity, the low lying area adjacent to the creek in the vicinity of the proposed bridges was flooded.

Lands surrounding the bridge site consist primarily of agricultural fields and undeveloped areas within the Highway 407 right-of-way.

The site is situated in the physiographic region known as the South Slope, which lies between the Oak Ridges Moraine and the Iroquois Plain and typically is characterized by overburden deposits consisting of sand and silt overlying glacial till sheets. 'Surficial Geology of Southern Ontario' published by The Ontario Geological Survey shows that the bridge site is located in an area covered by sandy silt to silty sand till.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this structure were carried out from December 5 to 18, 2012 and consisted of drilling and sampling a total of thirteen boreholes (identified as SM2-02, SM2-03, SM2-06 to SM2-09, and SM2-11 to SM2-17). Due to the flooded nature of the northern portion of the site, some boreholes (Boreholes SM2-02, SM2-03, and SM2-06 to SM2-08) were drilled at locations set back some 15 to 35 m from the proposed abutments. Four proposed boreholes (SM2-01, SM2-04, SM2-05, and SM2-10) could not be drilled due to the site conditions and access limitations created by the flooding caused by the beaver dams and beaver activity. The approximate locations of the boreholes that were drilled at this site are shown on the Borehole Locations and Soil Strata Drawings included in Appendix G. The boreholes were advanced to depths ranging from 9.2 to 16.9 m below the existing ground surface (Elevations 178.3 to 170.7 m). The Record of Borehole sheets are included in Appendix A.

Previous investigations, one by Peto MacCallum Limited in 1998 (Boreholes 401 to 418) and one by Golder Associates Limited in 2008 (Boreholes WM1-1 and WM2-1), were carried out in the vicinity of this site. The logs for the boreholes from these investigations are included in Appendix C. The locations of these boreholes are also shown on the drawings included in Appendix G. It should be noted that the borehole coordinates provided in the Peto report were converted in order to plot the boreholes on the current drawings.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. Double row silt fencing with straw bales was installed at each drilling location that was within the protected zone identified by MNR to prevent sediment laden water from entering Brougham Creek.

For the boreholes located off of the highway, drilling was carried out using a track mounted drill rig while a truck-mounted rig was used to drill the boreholes located on the existing highway. Hollow stem augers were typically used to advance the boreholes. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with the Standard Penetration Test (SPT).

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Where practical, groundwater conditions were observed in the open boreholes upon completion of the drilling operations. Five standpipe piezometers, one nested piezometer, and one vibrating wire piezometer (VWP) were installed at this site for long term monitoring of ground water levels. The standpipe piezometers generally consist of a 19 or 25 mm diameter PVC pipe with a 1.5 or 3.0 m long slotted screen encased with filter sand. The completion details of the piezometers and boreholes conducted in general accordance with O.Reg. 903 are summarized below in Table 3-1.

Table 3-1 Borehole Completion and Piezometer Installation Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Borehole Backfilling Details
SM2-02	7.6 / 178.4	Piezometer with 1.5 m slotted screen installed with sand filter to 5.8 m and bentonite from 5.8 m to surface.
SM2-03	5.2 / 180.0	Borehole caved to 5.2 m. Vibrating wire piezometer installed at 5.2 m. Borehole backfilled with grout to surface.
SM2-06	11.0 / 176.2	Piezometer with 3.0 m slotted screen installed with sand filter to 7.0 m and bentonite from 7.0 m to surface.
SM2-07	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.
SM2-08	10.7 / 176.1	Piezometer with 3.0 m slotted screen installed with sand filter to 6.4 m and bentonite from 6.4 m to surface.
SM2-09	None installed	Borehole backfilled with bentonite holeplug to surface.
SM2-11	3.1 / 180.9 8.2 / 175.8	Deep piezometer installed at 8.2 m with 1.5 m slotted screen with sand filter to 4.9 m and then bentonite from 4.9 to 3.4 m. Shallow piezometer installed at 3.1 m with 1.5 m slotted screen with sand filter to 1.5 m and bentonite from 1.5 m to surface.
SM2-12	None installed	Borehole backfilled with bentonite holeplug to surface.
SM2-13	None installed	Borehole backfilled with bentonite holeplug to 1.9 m, cuttings from 1.9 to 0.1 m and asphalt patch to surface.
SM2-14	None installed	Borehole backfilled with bentonite holeplug to 0.6 m, cuttings from 0.6 to 0.1 m and asphalt patch to surface.
SM2-15	None installed	Borehole backfilled with bentonite holeplug to 0.5 m, cuttings from 0.5 to 0.1 m and concrete to surface.
SM2-16	12.2 / 176.5	Piezometer with 1.5 m slotted screen installed with sand filter to 9.0 m, bentonite from 9.0 to 1.8 m, sand from 1.8 to 0.3 m, and concrete from 0.3 m to surface.
SM2-17	9.1 / 178.6	Piezometer with 1.5 m slotted screen installed with sand filter to 5.9 m, bentonite to 1.3 m, sand to 0.15 m, and asphalt to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing, where appropriate. The results of this testing program are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B. Four selected samples were also subjected to analytical pH and sulphate testing, the results of which are presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy near the proposed bridges are presented on the "Borehole Locations and Soil Strata" drawings included in Appendix G. An overall description of the stratigraphy encountered at this site is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

5.1 Topsoil / Organic Soil

A layer of topsoil or organic soil was encountered at surface in the eight boreholes that were drilled off of the existing highway (Boreholes SM2-02, SM2-03, SM2-06 to SM2-09, SM2-11, and SM2-12).

A thin layer of topsoil was encountered in the boreholes on the west side of the creek (SM2-02, SM2-03, SM2-09, and SM2-11). The topsoil generally contained silty sand and this layer was 175 to 200 mm thick.

In the boreholes drilled on the east side of the creek (Boreholes SM2-06 to SM2-08 and SM2-12), a layer or organic soil, 0.6 to 0.8 m thick, was encountered at the surface. This organic soil generally contained clayey silt to silty clay. SPT N-values of 2 blows for 0.3 m penetration were recorded in this layer, indicating a soft consistency.

Moisture contents of samples of the topsoil and organic soil ranged from 18 to 32%.

5.2 Asphalt and Concrete

A layer of asphalt was encountered at the surface in the five boreholes that were drilled on the existing Highway 407 (Boreholes SM2-13 to SM2-17).

The thickness of the asphalt ranged from 100 to 175 mm.

A layer of concrete, 300 mm thick was encountered below the asphalt in Borehole SM2-15 only.

5.3 Fill

A layer of sand fill was encountered below the asphalt (and concrete in Borehole SM2-15) in the boreholes drilled on the existing Highway 407 (Boreholes SM2-13 to SM2-17). The sand fill was brown in colour and contained trace silt to silty and trace to some gravel.

The thickness of the sand fill ranged from 1.6 to 2.9 m, with the lower boundary of the sand fill encountered at a depth of 1.8 to 3.0 m (Elevation 185.7 to 184.5 m).

SPT N-values recorded in the sand fill ranged from 10 to 49 blows for 0.3 m penetration, indicating a compact to very dense relative density. Measured moisture contents ranged from 1 to 11%

Three samples of the sand fill underwent laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure B1 in Appendix B.

Soil Particles	Percentage (%)
Gravel	4 to 13
Sand	57 to 67
Silt	20 to 21
Clay	7 to 9

In Borehole SM2-16 only, a 2.9 m thick layer of clayey silt and sand fill was encountered below the sand fill. The lower boundary of the clayey silt and sand fill was encountered at a depth of 5.9 m (Elevations 182.7 m). The clayey silt and sand fill was brown in colour and contained trace gravel.

SPT N-values of 5 and 11 were recorded in the clayey silt and sand fill, indicating a firm to stiff consistency. Moisture contents of 9 and 10% were measured on samples of the clayey silt and sand fill.

One sample of the clayey silt and sand fill was selected for laboratory grain size analysis testing, the results of which are summarized below. The grain size distribution curve for this sample is plotted on Figure B2 in Appendix B.

Soil Particles	Percentage (%)
Gravel	4
Sand	46
Silt	34
Clay	16

5.4 Silt to Silty Sand

A layer of silt to silty sand was encountered locally in Boreholes SM2-09, SM2-11 and SM2-16. In Boreholes SM2-09 and SM2-11, a layer of silty sand was encountered below the topsoil and in Borehole SM2-16 a layer of silt was encountered below the fill. The silt to silty sand was brown to grey in colour and contained some clay to clayey, trace gravel, and rootlets.

The thickness of the silt to silty sand ranged from 1.3 to 2.1 m, with the lower boundary of this layer encountered at depths of 1.5 to 7.3 m (Elevation 183.4 to 181.3 m).

SPT N-values recorded in this layer ranged from 3 to 12 blows for 0.3 m penetration, indicating a very loose to compact relative density. Moisture contents ranged from 11 to 32%.

5.5 Clayey Silt and Sand to Silty Sand Till

Clayey silt and sand to silty sand till was the dominant soil type encountered in the boreholes drilled at this site. The till was typically brown to grey with increasing depth and contained trace clay to clayey, trace to some gravel with occasional gravelly zones, and occasional inferred cobbles and/or boulders.

In the boreholes drilled near the west abutment of the on ramp and WBL bridges (Boreholes SM2-02, SM2-03, SM2-09, and SM2-11), an upper and lower layer of till were encountered, except in Borehole SM2-11 where the upper layer was not encountered. The upper layer of till was encountered below the topsoil in Boreholes SM2-02 and SM2-03 and below a layer of localized silty sand in Borehole SM2-09. The lower till was encountered below a layer of sand to gravelly sand.

The upper till layer was 1.3 to 2.5 m thick, with the lower boundary encountered at depths of 1.5 to 3.0 m (Elevation 184.4 to 181.9 m). The lower till layer was fully penetrated in Borehole SM2-09 and SM2-11 only. The thickness of the lower till in these boreholes was 4.2 and 4.3 m, with the lower boundary encountered at depths of 8.8 and 7.3 m, respectively

(Elevation 176.1and 176.7 m). Boreholes SM2-02 and SM2-03 were terminated at depths of 9.3 and 9.2 m, respectively (Elevation 176.6 and 176.0 m), within the lower till.

In all other boreholes, a single till deposit was encountered, typically below a surficial organic layer (Boreholes SM2-06 to SM2-08 and SM2-12) or below the sand fill (Boreholes SM2-13 to SM2-17). Where fully penetrated (Boreholes SM2-06, SM2-08, SM2-12, and SM2-14 to SM2-16), the thickness of the till ranged from 4.9 to 11.2 m with the lower boundary of the till encountered at depths of 10.2 to 12.2 m (Elevation 177.4 to 174.7 m).

Where not fully penetrated (Boreholes SM2-07, SM2-13, and SM2-17), the boreholes were terminated at depths of 9.4 to 12.5 m (Elevation 178.3 to 174.5 m).

SPT N-values recorded in the till ranged from 3 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a variable relative density ranging from very loose to very dense. In general, SPT N-values increased with depth and were typically greater than 30 (dense) below approximately 3 m depth. Measured moisture contents ranged from 4 to 32%, typically less than 20%.

Nineteen samples of the till underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figures B3 to B6, Appendix B.

Soil Particles	Percentage (%)
Gravel	1 to 18
Sand	33 to 52
Silt	27 to 42
Clay	6 to 25
Silt and Clay	30

Two samples exhibited sufficient plasticity for Atterberg Limits testing.

Index Property	Percentage (%)
Liquid Limit	16 to 26
Plastic Limit	9 to 14
Plasticity Index	7 to 12

The results of the Atterberg Limits testing indicate that the till has occasional low plastic zones with a group symbol of CL-ML to CL as plotted on Figure B10 of Appendix B.

Glacial tills inherently contain cobbles and boulders.

5.6 Upper Sand to Sand and Gravel

A layer of sand to sand and gravel was encountered between the upper and lower till deposits in the boreholes drilled near the west abutment of the on ramp and WBL bridges (Boreholes SM2-02, SM2-03, SM2-09, and SM2-11). The sand to sand and gravel was typically grey in colour and contained trace to some silt.

The thickness of this layer ranged from 0.7 to 4.6 m, with the lower boundary of the sand to sand and gravel layer encountered at a depth of 3.0 to 6.1 m (Elevation 181.0 to 179.1 m). In general, the thickness of this layer was observed to decrease from the north end of the site to the south end of the site.

SPT N-values recorded in this layer ranged from 17 to 105 blows for 0.3 m penetration, indicating a compact to very dense relative density. Typically, SPT N-values were 30 or greater (dense to very dense). Measured moisture contents ranged from 7 to 14 %.

Two samples of the sand and gravel were selected for laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figure B7 in Appendix B.

Soil Particles	Percentage (%)
Gravel	34 to 62
Sand	30 to 59
Silt and Clay	7 to 8

Localized layers of sand were also encountered within the till in Boreholes SM2-07 and SM2-012, located near the east abutment of the on ramp and WBL structures. The sand was brown and grey in colour and contained some silt and trace gravel.

These sand layers were 1.4 and 0.9 m thick, respectively, with the lower boundary of the sand layer encountered at depths of 7.5 and 8.5 m (Elevations 179.6 and 177.5 m).

SPT N-values of 57 and 103 blows for 0.3 m penetration were recorded in these sand layers, indicating a very dense relative density. Moisture contents of 7 and 14% were measured in samples of the sand.

5.7 Lower Sand to Sand and Gravel

A lower deposit of sand to sand and gravel was encountered below the till in Boreholes SM2-06, SM2-08, SM2-09, SM2-11, SM2-12, SM2-14, SM2-15, and SM2-16. The sand to sand and gravel was grey in colour and contained trace silt to silty and occasional cobbles and boulders which were inferred during drilling. In Borehole SM2-06, a localized layer of very dense sandy silt (1.5 m thick) was encountered between the till and lower sand layer.

The sand to sand and gravel layer was generally encountered near the completion depth of the borehole and was therefore not fully penetrated in any of the boreholes. The boreholes typically only penetrated 0.3 to 1.9 m through this layer, except for in Boreholes SM2-11 and SM2-14 where 3.6 and 6.7 m of sand was penetrated before the boreholes was terminated at depths of 10.9 and 16.9 m, respectively (Elevation 173.1 and 170.7 m).

SPT N-values recorded in this layer ranged from 64 blows for 0.3 m penetration to 100 blows for less than 0.3 m penetration, indicating a very dense relative density. Measured moisture contents ranged from 6 to 18 %.

Five samples of the lower sand to sand and gravel (as well as a sample of the sandy silt from Borehole SM2-06) were selected for laboratory grain size analysis testing. The results of these tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are plotted on Figures B8 and B9 of Appendix B.

Soil Particles	Sandy Silt to Silty Sand Fig. B8	Sand and Gravel Fig. B9
Gravel	3 to 13	30 to 41
Sand	27 to 68	45 to 55
Silt and Clay	19	9 to 22
Silt	26 to 59	-
Clay	3 to 11	-

5.8 Groundwater Levels

Groundwater levels were observed in the open boreholes upon completion of the drilling. Standpipe piezometers were installed in selected boreholes to monitor groundwater levels. The measured groundwater levels are summarized in Table 5-1.

Table 5-1 Measured Groundwater Levels

Borehole	Date	Groundwater Level (m)		Comment
		Depth (m)	Elevation (m)	
SM2-02	Dec. 17, 2012	0.3	185.6	Open borehole
	Dec. 18, 2012	0.4	185.5	Piezometer
	Dec. 19, 2012	0.3*	186.2	Piezometer
	Jan. 2, 2013	0.2* (frozen)	186.1	Piezometer
SM2-03	Dec. 18, 2012	0.1	185.1	Vibrating Wire
	Jan. 3, 2012	0.05*	185.25	
	Jan. 9, 2012	0.0	185.2	
SM2-06	Dec. 7, 2012	6.1	181.1	Open borehole
	Dec. 18, 2012	4.3	182.9	Piezometer
	Dec. 19, 2012	3.8	183.4	Piezometer
	Jan. 2, 2013	3.9	183.3	Piezometer
SM2-07	Dec. 10, 2012	7.6	179.4	Open borehole
SM2-08	Dec. 10, 2012	9.1	177.7	Open borehole
	Dec. 18, 2012	4.4	182.4	Piezometer
	Dec. 19, 2012	3.9	182.9	Piezometer
	Jan. 2, 2013	3.9	182.9	Piezometer
SM2-11 (Shallow)	Dec. 18, 2012	1.4	182.6	Piezometer
	Dec. 19, 2012	0.8	183.2	Piezometer
	Jan. 2, 2013	0.8	183.2	Piezometer
SM2-11 (Deep)	Dec. 18, 2012	1.5	182.5	Piezometer
	Dec. 19, 2012	0.8	183.2	Piezometer
	Jan. 2, 2013	1.0	183.0	Piezometer
SM2-12	Dec. 11, 2012	7.6	178.4	Open borehole
SM2-13	Dec. 5, 2012	8.5	178.2	Open borehole
SM2-16	Dec. 18, 2012	5.3	183.4	Piezometer
	Jan. 2, 2013	5.0	183.7	
SM2-17	Dec. 18, 2012	6.1	181.6	Piezometer
	Jan. 2, 2013	4.5	183.2	

** Artesian condition. Water level is above ground surface.*

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level is expected to be higher during high creek water level, after the spring snowmelt or after periods of heavy precipitation.

6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field using the Trimble Pathfinder ProXRT differential GPS. The co-ordinates and ground surface elevations at the boreholes were surveyed by MMM upon completion of drilling.

Thurber obtained utility clearances for the borehole locations prior to drilling.

DBW Drilling of Ajax, Ontario and Walker Drilling Ltd. of Utopia, Ontario supplied the drill rigs for this site and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised by Mr. Alistair Hall, Mr. Stephane Loranger, Mr. George Azzopardi, and Ms. Katrina Young of Thurber. Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall supervision of the field program was conducted by Ms. Lindsey Blaine, E.I.T. Interpretation of the data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T and Mr. Alastair Gorman, P.Eng.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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FOUNDATION INVESTIGATION AND DESIGN REPORT
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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data presented in the foregoing section, and also presents geotechnical recommendations for design of the Highway 407 crossing of Brougham Creek based on the factual information as well as our understanding of the project. The plans and profiles and GA drawings used for preparation of this report were provided by MMM Group Limited.

Based on the GA drawings, there will be four individual structures which will carry: the N-W Ramp, WBL, EBL and the W-N/S Ramp and the approximate structure ultimate widths are: 9.3 m, 29.0 m, 26.1 m and 12.1 m, respectively. Each of the structures will be single-span, CPCI construction. Armour stone retaining walls will be constructed on the east and west sides of the creek to the north and the south of the W-N/S Ramp structure. The existing structure carrying Highway 407 over Brougham Creek will be removed.

The approach fill heights will be as shown in Table 7.1.

Table 7.1 – Fill Heights

Structure	Abutment	Highway Grade	Ground Elevation	Height of Fill (m)
N-W Ramp	West	189.4	184.5±	4.9
	East	189.3	184.5±	4.8
WBL	West	190.2	184.0±	6.2
	East	189.9	184.0±	5.9
EBL	West	190.2	182.0±	8.2
	East	189.9	187.0±	2.9
W-N/S Ramp	West	190.7	183.0±	7.7
	East	190.2	188.5±	1.7

8 STRUCTURE FOUNDATIONS

In general terms, the site was found to be underlain by a veneer of organic soil in the undeveloped areas, embankment fill at the existing highway and then by loose to compact sands and followed by dense to very dense silty sand till and sand. The piezometric level at the site was measured at values ranging from 0.2 m above ground to 4.5 m below ground, corresponding to Elevation 186.2 to 183.2, respectively.

Consideration was given to the following foundation types:

- Spread footings:
  - bearing on native soil
  - bearing on compacted Granular A pad
- Augered caissons (drilled shafts)
- Driven steel H-piles

A comparison of the foundation alternatives, with advantages and disadvantages of each, are included in Appendix D.

8.1 Spread Footings Bearing on Native Soil

Spread footings may be founded on undisturbed, dense or very dense native soil. The existing fill encountered on site, in particular the existing highway embankment, is not suitable for founding spread footings..

The design of spread footings must be in accordance with the elevations and factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) as provided in Table 8-1.

Table 8-1. Founding Elevation and Bearing Resistances for Spread Footings

Locations	Founding Elevation (m)	Factored ULS Resistance (kPa)	SLS Resistance (kPa)	Comments
N-W Ramp West Abutment (SM2-02, SM2-03)	183.0	500	350	Excavation 3.4m below GWL, not recommended.
N-W Ramp East Abutment (SM2-06, SM2-07)	184.0	500	350	Excavation 3.0m below existing ground and into GWL, not recommended.
WBL West Abutment (SM2-03, SM2-09)	180.4	500	350	Excavation 4.8m below ground surface and GWL, not recommended.
WBL East Abutment (SM2-07)	181.0	500	350	Excavation 3.9m below ground surface, not recommended.

Locations	Founding Elevation (m)	Factored ULS Resistance (kPa)	SLS Resistance (kPa)	Comments
EBL West Abutment (SM2-11, SM2-14, 406)	181.0	500	350	Excavation 4.0m below original ground surface, plus existing highway fill, 2.2m below GWL, not recommended.
EBL East Abutment (SM2-12, SM2-13)	184.0	450	300	Excavation 2.0 to 3.0m below existing ground surface and into GWL, not recommended.
W-N/S Ramp West Abutment SM2-16, 406)	181.0	600	400	Excavation approximately 2.0m below original ground surface plus 5m existing embankment and below the GWL, not recommended.
W-N/S Ramp East Abutment (SM2-15, SM2-17, 415)	183.5	450	300	Excavation approximately 1.0 to 1.5m below original ground surface plus 3m existing embankment and below the GWL, not recommended.

The bearing resistances in Table 8-1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure.

Founding elevations presented in Table 8-1 are near or below the groundwater level observed during the investigation. If temporary excavations required to construct these footings extend below the water table, local groundwater control will be required to construct the footing in the dry and to prevent disturbance of the footing base

Resistance to sliding between the cast-in-place footing concrete and the very dense, undisturbed sand and silt subgrade can be evaluated using an ultimate coefficient of friction of 0.5 at the interface.

8.2 Spread Footings Bearing on Engineered Fill

Founding spread footings on Granular A engineered fill can be considered at this site.

If an engineered fill pad is used, all organics or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. At this site, it is recommended that the engineered fill pad be at least 2.0 m thick and conform to the geometry illustrated in Figure 1 at the end of the text. The footings may then be designed on the basis of the following bearing resistances:

$ULS_f = 750$ kPa

SLS = 350 kPa

The engineered fill must bear on native compact to very dense sand and silt till and the highest permitted base elevations, at which engineered fill pads may be founded, are giving in Table 8-2.

Table 8-2. Founding Elevation and Bearing Resistances of Engineered Fill Pads

Locations	Base Elevation for Engineered Fill (m)	Comments
N-W Ramp West Abutment (SM2-02, SM2-03)	183.5	Excavation 2.8m below GWL, not recommended.
N-W Ramp East Abutment (SM2-06, SM2-07)	185.0	Excavation 2.0m below existing ground and into GWL, not recommended.
WBL West Abutment (SM2-03, SM2-09)	182.5	Excavation 2.5m below ground surface and below GWL, not recommended.
WBL East Abutment (SM2-07)	184.5	Excavation 2.5m below ground surface, not recommended.
EBL West Abutment (SM2-11, SM2-14, 406)	181.5	Excavation 2.5m below original ground surface, plus existing highway fill, 1.7m below GWL, not recommended.
EBL East Abutment (SM2-12, SM2-13)	184.0	Excavation 2.0 to 3.0m below existing ground surface and into GWL, not recommended.
W-N/S Ramp West Abutment SM2-16, 406)	181.5	Excavation approximately 1.5 below original ground surface plus 6m existing embankment and below the GWL, not recommended.
W-N/S Ramp East Abutment (SM2-15, SM2-17, 415)	184.0	Excavation approximately 1.0m below original ground surface plus 3.0m existing embankment and below the GWL, not recommended.

The geotechnical resistances shown in Table 8-2 are based on a minimum 2.0 m thick layer of engineered granular fill. Additionally, the resistance values shown are for concentric, vertical loads only. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure.

The Granular A fill must be placed in 150 mm thick lifts and be compacted to 100% of Standard Proctor maximum dry density (SPMDD) at optimum moisture ±2%.

8.3 Caissons

The use of caissons is not recommended in the soil and groundwater conditions encountered at this site.

8.4 Steel H-pile Foundations

The soil stratigraphy encountered at this site is considered to be suitable for the support of foundations on driven steel piles. Steel HP 310x110 piles driven to refusal in the very dense silty sand till may be designed for geotechnical resistances of:

ULS_f = 1,600 kN

SLS = 1,400 kN

Table 8-4 presents the anticipated tip elevations at which the piles will achieve the design resistance and these are the elevations that should be used for estimating. In order to develop these resistances, the piles must achieve certain penetration below the pile cap or into very dense soil. Where applicable, Table 8-4 also shows the elevation below which the piles must be driven. These elevations must be shown on the foundation drawings and the contract documents must contain instructions that pre-augering must be used where necessary in order to achieve the minimum penetration and to conform to the requirements of integral abutment design.

Table 8-3. Recommended Tip Elevations and Axial Resistances for Steel H-piles

Locations	Anticipated Pile Tip Elevation	Highest Recommended Pile Tip Elevation	Comments
N-W Ramp West Abutment (SM2-02, SM2-03)	177.0	177.0	Pre-augering may be required.
N-W Ramp East Abutment (SM2-06, SM2-07)	176.0	177.0	Pre-auger only if piles cannot reach El. 177.0
WBL West Abutment (SM2-03, SM2-09)	177.0	177.0	Pre-auger only if piles cannot reach El. 177.0

Locations	Anticipated Pile Tip Elevation	Highest Recommended Pile Tip Elevation	Comments
WBL East Abutment (SM2-07)	176.0	177.0	-
EBL West Abutment (SM2-11, SM2-14, 406)	175.0	176.0	-
EBL East Abutment (SM2-12, SM2-13)	176.0	176.0	Pre-augering may be required.
W-N/S Ramp West Abutment SM2-16, 406)	177.0	177.0	Pre-augering may be required
W-N/S Ramp East Abutment (SM2-15, SM2-17, 415)	177.0	177.0	-

Where pre-augering is carried out, it must not extend deeper than 2.5 m above the anticipated tip elevation. A note to this effect must be added to the foundation drawing.

The structural resistance of the pile must be checked by the structural designer and pile installation should be in accordance with OPSS 903.

8.4.1 Pile Tips

Due to the probable presence of cobbles and/or boulders, the tips of all piles must be reinforced. This can be achieved by fitting the piles with steel H-piles driving shoes in accordance with OPSD 3000.100.

8.4.2 Pile Driving

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance should be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles are within 2.0 m of the bearing stratum. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile. "R" must have a minimum value of twice the factored design load at ULS but must not exceed 3,200 kN.

As boreholes encountered SPT refusal within the silty sand to sand and silt till and noted the presence of cobbles and/or boulders, an NSSP should require the QVE to terminate driving before the pile is damaged by overdriving. Suggested texts for NSSPs are included in Appendix E.

Pile driving at this site could induce vibration that could result in adverse effects on the adjacent Highway 407 bridge. However, it is understood that this bridge will be removed

but monitoring must be carried out to confirm its continuing serviceability while it is still carrying traffic.

8.4.3 Downdrag

Downdrag on the piles is not considered to be an issue at this site, since the till and the sands and silts are in a very dense state with low clay content.

8.4.4 Abutment Type

The subsurface conditions at this site are considered suitable for integral, semi-integral or conventional abutment design. The use of H-piles at the abutments allows for the design of an integral abutment structure as shown on the GA drawing.

For an integral abutment design, the piles must be placed in CSPs as described in the requirements for an MTO integral abutment design.

It must be noted that installation of the CSPs will involve augering into cohesionless soils below the groundwater level.

8.4.5 Pile Lateral Resistance

The geotechnical lateral resistance of an H-pile embedded in the silty sand to sand and silt till may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (kN/m^3)$$

$$p_{ult} = 3 \gamma z K_p \quad (kPa)$$

Where
- z = depth of embedment of pile in metres
- D = pile width in metres
- n_h = coefficient of horizontal subgrade reaction
  - = 10,000 kN/m^3 (in dense to very dense soils)
- γ = 21 kN/m^3 (total unit weight)
- γ_w = 11 kN/m^3 (submerged unit weight below water table)
- K_p = passive earth pressure coefficient
  - = 3.7 (for dense to very dense soils)

The above equations and recommended parameters may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

The spring constant, k_s, for analysis may be obtained by the expression, $k_s = k_s \times L \times D$ (kN/m), where L is the length (m) of the pile segment or element used in the analysis and the remaining variables are as defined earlier. The ultimate lateral resistance, p_{ult}, may be

obtained from the expression, $p_{ult} = p_{ult} \times L \times D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance assumed in one pile be limited to no more than 120 kN at ULSf and 50 kN at SLS.

The modulus of subgrade reaction may have to be reduced due to pile interaction, based on the centre-to-centre pile spacing. The reduction factors to be used for a pile group oriented perpendicular and/or parallel to the direction of loading are provided in Table 8-5 with intermediate values obtained by linear interpolation. Alternatively, horizontal loads may be resisted by means of battered piles.

Table 8-4 Reduction Factor for Coefficient of Lateral Subgrade Reaction

Condition	Pile spacing, Centre to centre*	Reduction factor
Pile group oriented **perpendicular** to direction of loading	4D	1.0
	1D	0.5
Pile group oriented ***parallel*** to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

Note: D is the pile width

8.5 Frost cover

The depth of frost penetration at this site is 1.2 m. The base of all pile caps, caissons caps or spread footings, must be provided with a minimum of 1.2 m of earth cover as protection against frost action.

8.6 Recommended Foundation

From a geotechnical perspective and based on current information, the recommended abutment foundation consists of steel H-piles driven into the very dense sand or silty sand till for supporting the integral abutments.

9 BRIDGE APPROACHES AND EMBANKMENTS

Placement of new fill in the creek valley will be required to construct the bridge approaches and embankments. The GAs for the EBL and W-N/S Ramp structures indicate that armour stone retaining walls will be used to steepen the slopes adjacent to these structures and to provide erosion protection.

Based on the information obtained from the boreholes, there is 200 to 800 mm of topsoil or organics overlying the valley floor and these soils must be stripped prior to construction of the embankments.

The groundwater levels in the boreholes were close to or slightly above the ground surface in some boreholes. Two small springs were reported in the area of the north flank of the west approach fill. In view of the potential groundwater seepage into the base of the embankment fill, it is recommended that a drainage blanket be constructed on the stripped surface and below the remainder of the fill. The drainage blanket must consist of a minimum 1.0 m thickness of Granular "O".

The embankment above the drainage blanket may be constructed using either Granular or SSM fill. Since the backfill to the abutments will be Granular "B" Type II, it is acceptable to use this material for the entire approach fill above the drainage blanket, if that simplifies construction and is cost-effective. These embankments will be stable if constructed with side slopes no steeper than 2H:1V. Based on the non-cohesive composition of the soils below the approaches, settlement under the embankments will be immediate in nature and will be essentially completed at the end of embankment construction.

The completed embankment slopes must be protected from erosion in accordance with OPSS 804.

Where armour stone walls are required, it is recommended that these be specified in the same manner as other RSS walls, as an approved block wall system in the DSM. The design of the wall must be completed by the supplier.

10 EXCAVATION AND GROUNDWATER CONTROL

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the existing fill and surficial native soils can be classified as Type 3 soils. The underlying "100-blow" sandy silt, silty sand to sand and silt till may be classified as Type 2 soils. After removal of surface vegetation on the valley slopes, excavation of topsoil, organics, fill and surficial disturbed native soils will likely be required to reach competent native soils prior to placing new fill.

Based on the integral abutments shown on the GA drawing, excavation below the groundwater level is not likely to exceed approximately 1.0 to 2.0 m. It should be possible to achieve effective dewatering by pumping from sumps in the excavations, though this may be dependent on the time of year and level of water in the stream. The contract documents should alert the contractor to the risk associated with fluctuations in the stream level and require him to make his own assessment of the requirements for dewatering, cofferdams, etc., taking account of his intended construction methods, schedule and the presence of sand and gravel zones near the ground surface.

With respect to the CSPs to be installed below the existing ground surface, it must be noted that some of the preaugering will be carried out in cohesionless soils below the groundwater level. These holes may be prone to collapse before the CSP can be installed and the contract documents must contain a note warning the contractor that it may be necessary to use a temporary, over-size liner in order to install the CSP.

The design of a dewatering system, if required, is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. The Contractor should also be prepared to pump from sumps to remove any remaining seepage water or surface water collecting in an excavation. Placement of concrete must be done in the dry. Dewatering must remain operational and effective until the foundation is installed and backfilled.

Furthermore, the excavation and backfilling for foundations must be carried out in accordance with OPSS 902.

11 BACKFILL TO ABUTMENTS

The recommended backfill to the abutment walls is Granular B Type II material meeting the requirements of Special Provisions 110S13 "Amendment to OPSS 1010, April 2004". The backfill must be in accordance with OPSS 902 and placed to the extent shown in OPSD 3101.150.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with OPSS 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3101.150.

12 EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the following expression:

$$p_h = K(\gamma h + q) \quad (kN/m^3)$$

where
p_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see table below)
γ = unit weight of retained soil (see table below)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of the fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the embankment wall are dependent on the material used as backfill. Typical values are shown in Table 12-1.

The factors in Table 12-1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to be used in design can be estimated from Figure C6.16 in the Commentary to the CHBDC.

Table 12-1. Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		Existing Sand Fill or OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active	0.27	0.40	0.31	0.48
Passive	3.7	-	3.3	-
At Rest	0.43	-	0.47	-

13 SEISMIC CONSIDERATIONS

13.1 Seismic Design Parameters

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.08

The soil profile type at this site has been classified as Type II. Therefore, according to Table 4.4 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.2 should be used in seismic design.

13.2 Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 13-1 may be used:

Table 13-1. Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		Existing Sand Fill or OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.3	0.47	0.34	0.58
Passive (K_{PE})	3.6	-	3.2	-
At Rest (K_{OE})**	0.53	-	0.58	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

13.3 Liquefaction Potential

The potential for liquefaction of the foundation soils was assessed using the Seed and Idriss (1971) method. Using this method, it is estimated that under the existing conditions the foundation soils are not prone to liquefaction.

The approach embankments are above the groundwater level and are not considered to be in danger of undergoing liquefaction. Some toe failure may occur but it is expected to be of limited nature and readily repairable.

14 ROADWAY PROTECTION

Roadway protection may be required to support the existing Highway 407 embankment adjacent to the excavations. The roadway protection must be implemented in accordance with OPSS 539 and designed for Performance Level 2.

Conventional steel soldier piles and timber lagging walls is one option to provide temporary support to the soils during excavation. Timber lagging boards should be installed as soon as the soil face is exposed and properly prepared.

The following parameters apply for design of the temporary shoring system.

γ	=	20 kN/m^3	(bulk soil unit weight)
γ_w	=	10 kN/m^3	(submerged soil unit weight under groundwater table)
K_a	=	0.33	(active pressure coefficient for road embankment fill)
	=	0.27	(active pressure coefficient for dense to very dense native soils)

K_p	=	3.0	(Passive pressure coefficient for road embankment fill)
	=	3.7	(Passive pressure coefficient for dense to very dense native soils)
h_w	=	186.2 m	(elevation for hydrostatic pressure behind the temporary shoring)

The design of roadway protection should be the responsibility of the Contractor. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

15 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- **High Pile Driving Resistance.** In some locations, it may be necessary to employ pre-augering in order to drive the pile tips to the sufficient depth, i.e. below the highest permitted elevation. Preaugering must not extend deeper than 2.5 m above the anticipated pile tip elevation.
- **Dewatering and Surface Water Control.** If abutment construction is carried out at drier times of the year, it may be possible to effect sufficient dewatering by pumping from sumps. However, at wetter times of year, more elaborate dewatering may be required and cofferdams (e.g. sandbags) may be required to control surface inflow from the creek.

The successful performance of the overpass will depend largely depend upon good workmanship and quality control during construction. Pile driving supervision, subgrade inspection and field density testing should be carried out by qualified personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications met. Vibration monitoring during pile driving should be carried out by specialists in this field. The adjacent bridge must be monitored during pile driving.

16 CLOSURE

Engineering analysis and preparation of the report was carried out by Mr. Alastair Gorman, P.Eng.

The report was reviewed by Dr. P.K. Chatterji, P.Eng. who is a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

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Review Principal

Appendix A

Record of Borehole Sheets
(Current Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[1] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS Split Spoon Sample WS Wash Sample AS Auger (Grab) Sample
TW Thin Wall Shelby Tube Sample TP Thin Wall Piston Sample
PH Sampler Advanced by Hydraulic Pressure PM Sampler Advanced by Manual Pressure
WH Sampler Advanced by Self Static Weight RC Rock Core SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

$\blacktriangledown$ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

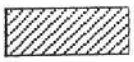
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

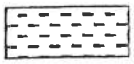
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

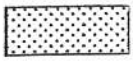
SYMBOLS



CLAYSTONE



SILTSTONE



SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-02 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 073.3 E 336 764.2 ORIGINATED BY GA
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.17 - 2012.12.17 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.9								
0.0	**TOPSOIL:** (175mm)							
0.2	Silty **SAND**, some clay to clayey, trace gravel Loose to Compact Brown Wet (TILL)		1	SS	5			
			2	SS	18		185	
184.4								
1.5	**SAND** and **GRAVEL**, trace silt Dense to Very Dense Brown Wet		3	SS	41		184	
			4	SS	104			
	Grey						183	
			5	SS	85			62 30 8 (SI+CL)
							182	
			6	SS	105		181	
179.8								
6.1	Silty **SAND**, trace clay, trace to some gravel Very Dense Grey Wet (TILL)		7	SS	61/ 0.150		180	13 45 35 7
							179	
			8	SS	55/ 0.150		178	
176.6							177	
			9	SS	109/ 0.150			
9.3	END OF BOREHOLE AT 9.3m. WATER LEVEL AT 0.3m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe							

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

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

(%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-02 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 073.3 E 336 764.2 ORIGINATED BY GA
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.17 - 2012.12.17 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	with a 1.52m slotted screen.										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 18/12 0.4 185.6 Dec. 19/12 0.3* 186.3 Jan. 02/13 0.2* 186.4										
	* Above ground surface (Artesian Condition)										

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

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-03 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 079.1 E 336 787.4 ORIGINATED BY KMY
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.14 - 2012.12.14 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
185.2								
0.0	**TOPSOIL**, silty sand with rootlets:		1	GS				
0.2	(175mm)							
	Silty **SAND**, some clay, trace to some gravel Loose to Compact Grey Moist (TILL)		1	SS	7			4 47 34 15
			2	SS	13			
			3	SS	33			
182.4	Gravelly							
2.7	Wet							
	Gravelly **SAND**, trace to some silt Dense Grey Wet		4	SS	36			34 59 7 (SI+CL)
			5	SS	35			
179.1								
6.1	Silty **SAND**, trace clay, trace gravel Very Dense Grey Damp to Wet (TILL)		6	SS	50/ 0.100			
			7	SS	124/ 0.150			
175.9			8	SS	100/ 0.100			
9.2	END OF BOREHOLE AT 9.2m. VIBRATING WIRE PIEZOMETER INSTALLED AT 5.2m.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) (20 40 60)

ELEVATION SCALE: 185 184 183 182 181 180 179 178 177 176

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/25/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-03 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 079.1 E 336 787.4 ORIGINATED BY KMY

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.14 - 2012.12.14 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	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										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 18/12 0.1 185.1 Jan. 03/13 0.05* 185.25 Jan. 09/13 0.05* 185.25 * Above Ground Surface (Artesian Condition)										

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/24/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-06 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 131.0 E 336 829.3 ORIGINATED BY AH
HWY 407 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 2012.12.07 - 2012.12.07 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
187.2								
0.0	**ORGANICS**, silty clay, trace sand, trace roots Soft Dark Brown Moist	1	SS	2				
186.6								
0.6	Clayey **SILT** and **SAND**, trace gravel, trace roots Stiff Light Brown Moist (TILL)	2	SS	9	4	33	38	25
185.9								
1.4	Silty **SAND**, some clay, trace gravel Compact to Dense Grey/Brown Moist (TILL)	3	SS	14				
		4	SS	25				
		5	SS	41				
		6	SS	50	2	45	35	18
	Some gravel to gravelly	7	SS	33				
	Very Dense	8	SS	88				
		9	SS	127				

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEVATION SCALE: 187, 186, 185, 184, 183, 182, 181, 180, 179, 178

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

20 / 15 / 10 / 5 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-06 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 131.0 E 336 829.3 ORIGINATED BY AH

HWY 407 BOREHOLE TYPE COMPILED BY AN

DATUM Geodetic DATE 2012.12.07 - 2012.12.07 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
176.9							177				
10.4	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey		10	SS	103/ 0.150				C		3 27 59 11
175.4							176				
11.9	**SAND**, coarse grained, some silt, trace gravel										
174.9	Very Dense Grey Wet		11	SS	102/ 0.150		175		C		
12.3	END OF BOREHOLE AT 12.3m. WATER LEVEL AT 6.1m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Dec. 18/12	4.3	182.9
Dec. 19/12	3.8	183.4
Jan. 02/13	3.9	183.3

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

$15 \oplus^{20}_{10} 5$ (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-07

1 OF 2

METRIC

WP# E2-2012 | LOCATION N 4 864 116.2 E 336 843.1 | ORIGINATED BY AH

HWY 407 | BOREHOLE TYPE | COMPILED BY AN

DATUM Geodetic | DATE 2012.12.10 - 2012.12.10 | CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.0							187				
0.0	**ORGANICS**, silty clay, trace sand Soft Brown Moist		1	SS	2				○		
186.3							186				
0.8	Clayey **SILT** and **SAND**, trace gravel Soft to Hard Brown Moist to Damp (TILL)		2	SS	3				○		
			3	SS	12		185		○		5 34 38 23
			4	SS	21				○		
			5	SS	36		184		○		
							183				
			6	SS	38				○		
180.9							182				
6.1	**SAND**, coarse grained, some silt, trace gravel Very Dense Brown Damp		7	SS	103				○		
179.6							181				
7.5	Silty **SAND**, some gravel, trace clay Very Dense Grey Moist (TILL)		8	SS	62	▽	180		○		15 49 27 9
							179				
			9	SS	124		178		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-07 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 116.2 E 336 843.1 ORIGINATED BY AH

HWY 407 BOREHOLE TYPE COMPILED BY AN

DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page						177				
			10	SS	73/ 0.150		176		C		
							175				
174.5	Gravelly		11	SS	98/ 0.150				C		
12.5	END OF BOREHOLE AT 12.5m. WATER LEVEL AT 7.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-08 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 101.5 E 336 851.6 ORIGINATED BY AH

HWY 407 BOREHOLE TYPE COMPILED BY AN

DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.8											
0.0	**ORGANICS**, clayey silt, trace sand, some roots Soft Brown		1	SS	2				○		
186.0	Moist										
0.8	Clayey **SILT** and **SAND**, trace gravel Stiff to Hard Light Brown Moist (TILL)		2	SS	11		186		○		
			3	SS	22		185		○		
			4	SS	32				○		2 38 38 22
			5	SS	40		184		○		
						▼	183				
			6	SS	45		182		○		
			7	SS	114/ 0.150		181		○		
179.8							180				
7.0	Silty **SAND**, trace to some clay, trace to some gravel Very Dense Grey Moist (TILL)		8	SS	64		179		○		11 48 30 11
							178				
			9	SS	111		177		○		

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-08 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 101.5 E 336 851.6 ORIGINATED BY AH
HWY 407 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

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 (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
			10	SS	156/ 0.150		176				
							175				
174.7 12.0	**SAND**, some silt, trace to some gravel Very Dense Grey		11	SS	183				○		13 68 19 (SI+CL)
174.1 12.6	END OF BOREHOLE AT 12.6m. WATER LEVEL AT 9.1m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Dec. 18/12	4.4	182.4
Dec. 19/12	3.9	182.9
Jan. 02/13	3.9	182.9

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-09 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 078.5 E 336 803.7 ORIGINATED BY KMY
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.13 - 2012.12.13 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.9											
0.0	**TOPSOIL**, silty sand with rootlets: (175mm)		1	GS							
0.2	Silty **SAND**, some clay, with rootlets, trace gravel Compact Light Brown Moist to Wet		1	SS	12		184		C		
183.3											
1.5	Silty **SAND**, trace gravel, trace to some clay Loose to Compact Grey Moist (TILL)		2	SS	9		183		C		5 46 36 13
			3	SS	27				C		
181.8	Wet						182				
3.0	**SAND**, trace silt, trace gravel Compact Grey Wet		4	SS	17				○		
180.3							181				
4.6	Silty **SAND**, some gravel, trace clay Very Dense Grey Moist (TILL)		5	SS	50/ 0.125		180		○		
			6	SS	88/ 0.250		179		○		
			7	SS	56/ 0.150		178				
176.0							177		○		
8.8	Silty **SAND**, trace to some gravel Very Dense Grey Wet		8	SS	82		176		○		10 61 26 3
175.1											
9.8	END OF BOREHOLE AT 9.8m.										

Continued Next Page

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-09 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 078.5 E 336 803.7 ORIGINATED BY KMY

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.13 - 2012.12.13 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60	kN/m^3	GR SA SI CL
	Continued From Previous Page										
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

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

$15 \overset{20}{\oplus} 5$ 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-11 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 059.6 E 336 820.7 ORIGINATED BY KMY
HWY 407 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 2012.12.12 - 2012.12.12 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.0									
0.0	**TOPSOIL**, silty sand with rootlets:		1	GS			184		
0.2	(200mm)								
	Silty **SAND**, with rootlets, some clay to clayey Very Loose Brown/Grey Moist		1	SS	3		183		
	Trace gravel		2	SS	4		182		
181.7									
2.3	**SAND** and **GRAVEL**, some silt Compact Grey Wet		3	SS	30				
181.0							181		
3.0	Silty **SAND**, some gravel, trace clay, occasional cobbles Very Dense Greyish Brown Wet (TILL)		4	SS	100		180		
			5	SS	55		179		18 52 30 (SI+CL)
			6	SS	61		178		
176.7							177		
7.3	Gravelly **SAND**, some silt to silty Very Dense Grey Wet to Saturated		7	SS	50/ 0.100		176		
			8	SS	50/ 0.075		175		30 48 22 (SI+CL)

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+ ³, × ³: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No SM2-11 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 059.6 E 336 820.7 ORIGINATED BY KMY

HWY 407 BOREHOLE TYPE COMPILED BY AN

DATUM Geodetic DATE 2012.12.12 - 2012.12.12 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Gravelly **SAND**, some silt to silty Very Dense Grey Wet to Saturated						174				
173.1			9	SS	50/				C		
10.9	END OF BOREHOLE AT 10.9m. Well installation consists of two 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				0.075						

DEEP WELL:
WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Dec. 18/12	1.5	182.5
Dec. 19/12	0.8	183.2
Jan. 02/13	1.0	183.0

SHALLOW WELL:
WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Dec. 18/12	1.4	182.6
Dec. 19/12	0.8	183.2
Jan. 02/13	0.8	183.2

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

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-12 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 085.4 E 336 855.8 ORIGINATED BY AH

HWY 407 BOREHOLE TYPE COMPILED BY AN

DATUM Geodetic DATE 12/11/12/ - 2012.12.11 CHECKED BY LRB

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.0							186				
0.0	**ORGANIC**, clayey silt, trace sand, roots Very Soft Brown		1	SS	2				○		
185.4							185		○		1 35 42 22
0.6	**SILT** and **SAND**, some clay to clayey, trace gravel Loose to Compact Light Brown Moist (TILL)		2	SS	11						
			3	SS	12		184		○		
			4	SS	26				○		
			5	SS	35		183		○		
	Grey		6	SS	25		182		○		7 43 33 17
	Dense		7	SS	89		181				
178.4						▽	180		○		
7.6	**SAND**, some silt Very Dense Grey Wet		8	SS	57		179				
177.5							178		○		
8.5	Silty **SAND**, some clay, some gravel Very Dense Grey Wet (TILL)		9	SS	148/ 0.150		177		○		

Continued Next Page

+ ^{3}, × ^{3} : Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-12 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 085.4 E 336 855.8 ORIGINATED BY AH
HWY 407 BOREHOLE TYPE COMPILED BY AN
DATUM Geodetic DATE 12/11/12/ - 2012.12.11 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page						176				
175.4											
10.7	**SAND** and **GRAVEL**, some silt Very Dense Grey Wet		10	SS	105/ 0.150		175		○		41 45 14 (SI+CL)
							174				
173.4			11	SS	134				○		
12.6	END OF BOREHOLE AT 12.6m. WATER LEVEL AT 7.6m UPON COMPLETION.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

ONTMT4S 1130A.GPJ 1/4/13

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Ontario

THURBER

RECORD OF BOREHOLE No SM2-13 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 075.8 E 336 858.8 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.05 - 2012.12.05 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
186.7											
0.0	**ASPHALT:** (175mm)										
0.2	Silty **SAND**, trace to some gravel Dense Brown Moist (FILL)		1	GS							
			2	GS							
			3	SS	39		186				13 57 21 9
184.9			4	SS	34		185				
1.8	**SILT** and **SAND**, some clay to clayey, trace gravel Dense Brown Moist (TILL)		5	SS	39						4 46 34 16
			6	SS	37		184				
							183				
	Grey		7	SS	47		182				
			8	SS	100/0.250		181				
							180				
			9	SS	100	▽	179				5 47 37 11
177.3	Moist to Wet		10	SS	100/0.100		178				
9.4	END OF BOREHOLE AT 9.4m. BOREHOLE OPEN AND WATER LEVEL AT 8.5m UPON COMPLETION.										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No SM2-13 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 075.8 E 336 858.8 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.05 - 2012.12.05 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60	kN/m^3	GR SA SI CL
	Continued From Previous Page										
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.9m, CUTTINGS TO 0.1m THEN ASPHALT TO SURFACE.										

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-14 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 041.6 E 336 814.7 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2012.05.12 - 2012.06.12 CHECKED BY LRB

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.6											
0.0	**ASPHALT:** (175mm)										
0.2	**SAND**, trace gravel, trace silt Dense Brown Moist (FILL)		1	SS	45		187				
	Silty, some clay		2	SS	48		186				
185.4											
2.2	Silty **SAND**, some clay, trace gravel Compact Brown Moist (TILL)		3	SS	22		185				
			4	SS	16		184				7 46 31 16
183.3											
4.3	Clayey **SILT** and **SAND**, trace gravel Stiff Brown Moist (TILL)		5	SS	9		183				
181.7							182				
5.9	Silty **SAND**, some gravel, trace clay Very Dense Grey Moist (TILL)		6	SS	55		181				
	Moist to Wet		7	SS	100/ 0.200		180				13 48 31 8
							179				
			8	SS	74		178				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No SM2-14 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 041.6 E 336 814.7 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2012.05.12 - 2012.06.12 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
177.4											
10.2	**SAND**, some silt, some gravel, occasional cobbles Very Dense Grey Wet		9	SS	100/ 0.200		177		c		
	Auger refusal due to probable boulders at 11.4m. Borehole move 1.5m west						176				
	Some silt to silty, trace gravel Saturated		10	SS	64		175		c		
			11	SS	100/ 0.125		174		o		
	No sample recovery		12	SS	100/ 0.150		173				
							172				
170.7			13	SS	100/		171				
16.9	END OF BOREHOLE AT 16.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, CUTTINGS TO 0.1m THEN ASPHALT TO SURFACE.				0.125						

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-15 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 060.2 E 336 859.8 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.11 - 2012.12.11 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.5									
0.0	**ASPHALT:** (100mm)								
0.1									
187.1	**CONCRETE**								
0.4	**SAND**, some silt, some gravel Compact Brown Moist (FILL)		1	GS			187		
			2	SS	24				
			3	SS	15		186		10 63 20 7
			4	SS	10		185		
184.5									
3.0	Sandy **SILT**, some clay, trace gravel Compact Brown Moist (TILL)		5	SS	10		184		
183.5									
4.0	Silty **SAND**, some clay, trace gravel Very Dense Brown Moist (TILL)		6	SS	100/ 0.075		183		
	Auger refusal on probable boulder. Moved to 2.4m east						182		
			7	SS	54		181		5 44 32 19
	Grey								
			8	SS	65		180		
							179		
			9	SS	100/ 0.150		178		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

Continued Next Page

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

15 (20/10) 5 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-15 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 060.2 E 336 859.8 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.11 - 2012.12.11 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Silty **SAND**, some clay, trace gravel Very Dense Brown Moist (TILL)						177		C		
			10	SS	100/ 0.125						
175.8							176				
11.7	**SAND** and **GRAVEL**, trace silt Very Dense Grey Wet										
175.0			11	SS	100/ 0.125				C		36 55 9 (SI+CL)
12.5	END OF BOREHOLE AT 12.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.5m, CUTTINGS TO 0.1m THEN CONCRETE TO SURFACE.										

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-16 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 021.7 E 336 820.4 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.7											
0.0	**ASPHALT:** (130mm)										
0.1	**SAND**, some silt, some gravel Dense to Compact Brown Moist (FILL)		1	GS			188				
			2	SS	49						
			3	SS	27		187				
			4	SS	47		186				
185.7											
3.0	Clayey **SILT** and **SAND**, trace gravel Stiff to Firm Brown Moist (FILL)		5	SS	11		185				4 46 34 16
			6	SS	5		184				
182.7											
5.9	**SILT**, some sand, some clay, trace gravel, trace rootlets, topsoil stained Compact Dark Brown Moist		7	SS	10		183				
181.3							182				
7.3	**SILT** and **SAND**, trace to some gravel, trace clay Very Dense Grey Moist (TILL)		8	SS	100/ 0.250		181				
			9	SS	100/ 0.250		180				12 40 42 6
							179				

Continued Next Page

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 1130A.GPJ 1/4/13

Ministry of Transportation
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THURBER

RECORD OF BOREHOLE No SM2-16 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 021.7 E 336 820.4 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Cobbles and boulders from 10.2m to 10.6m		10	SS	100/ 0.125		178		○		
	Cobbles and boulders from 11.1m to 11.5m						177				
176.5	Cobbles and boulders from 11.8m to 12.1m								○		
12.2 / 176.1	**SAND**, some silt, trace to some gravel, occasional cobbles and boulders Very Dense Grey Moist to Wet		11	SS	100/ 0.175						
12.5	END OF BOREHOLE AT 12.5m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 18/12 5.3 183.4 Jan. 02/13 5.0 183.7										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM2-17 1 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 057.0 E 336 867.2 ORIGINATED BY SLL
HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.7									
0.0	**ASPHALT:** (150mm)								
0.2	**SAND**, some silt to silty,, trace to some gravel Compact Brown Moist (FILL)		1	SS	27		187		
			2	SS	30		186		4 67 21 8
			3	SS	19		185		
184.9									
2.8	**SILT** and **SAND**, some clay to clayey, trace gravel Dense to Compact Brown Moist (TILL)		4	SS	35		184		
			5	SS	27		183		3 46 34 17
			6	SS	100/ 0.200		182		
	Grey		7	SS	66		181		
							180		
178.3			8	SS	50/ 0.100		179		
9.4	END OF BOREHOLE AT 9.4m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

Continued Next Page

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No SM2-17 2 OF 2 METRIC

WP# E2-2012 LOCATION N 4 864 057.0 E 336 867.2 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.12.10 - 2012.12.10 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60		GR SA SI CL
	Continued From Previous Page										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec. 18/12 6.1 181.6 Jan. 02/13 4.5 183.2										

ONTMT4S 1130A.GPJ 1/4/13

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Appendix B

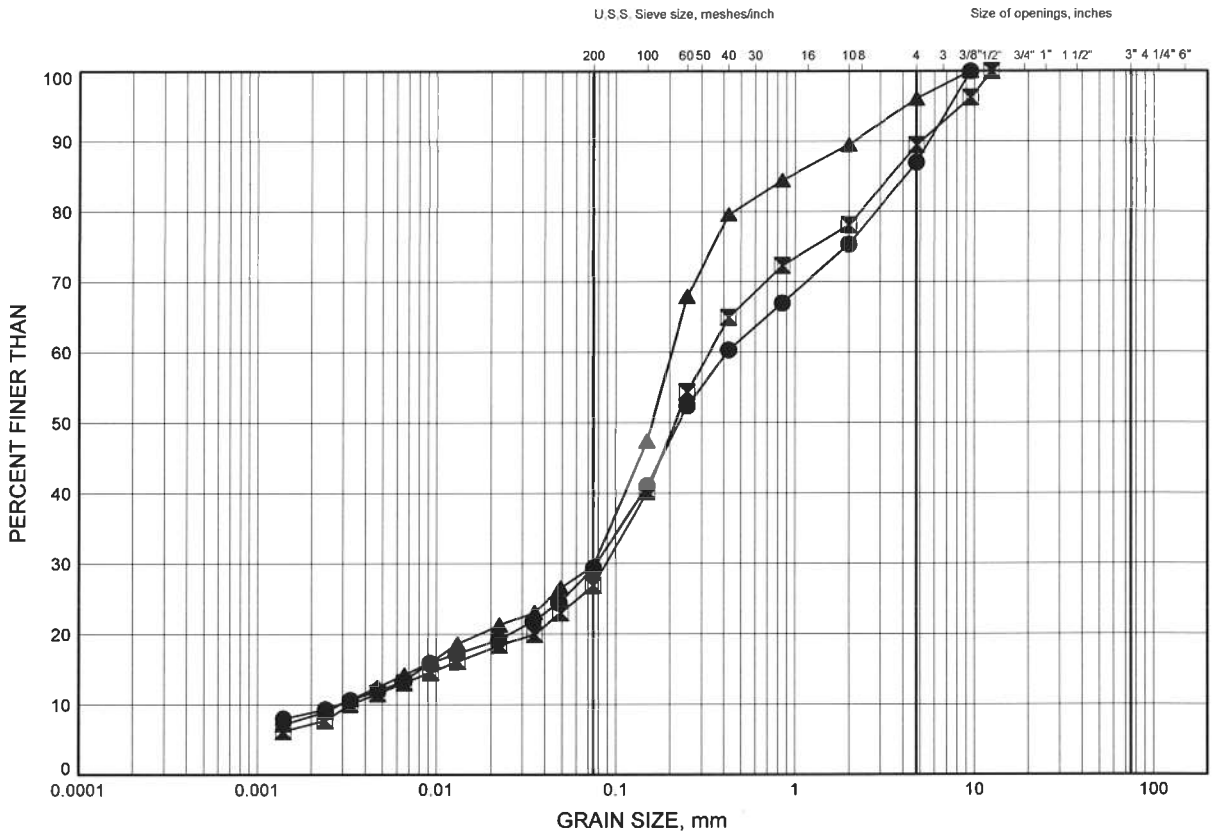
Laboratory Test Results
(Current Investigation)

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-13	0.99	185.74
⊠	SM2-15	1.83	185.66
▲	SM2-17	1.83	185.92

Date January 2013

WP# E2-2012

THURBER

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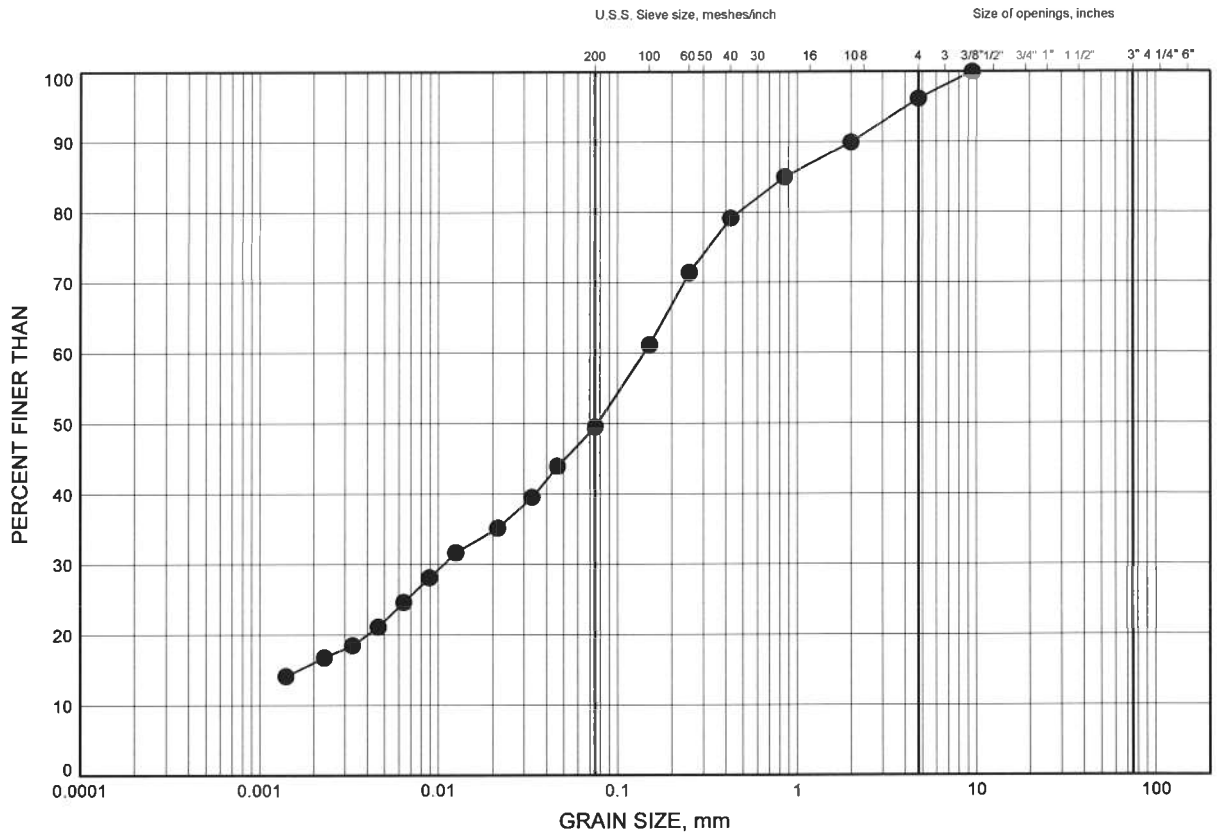
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2

CLAYEY SILT & SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-16	3.35	185.30

Date January 2013

WP# E2-2012

THURBER

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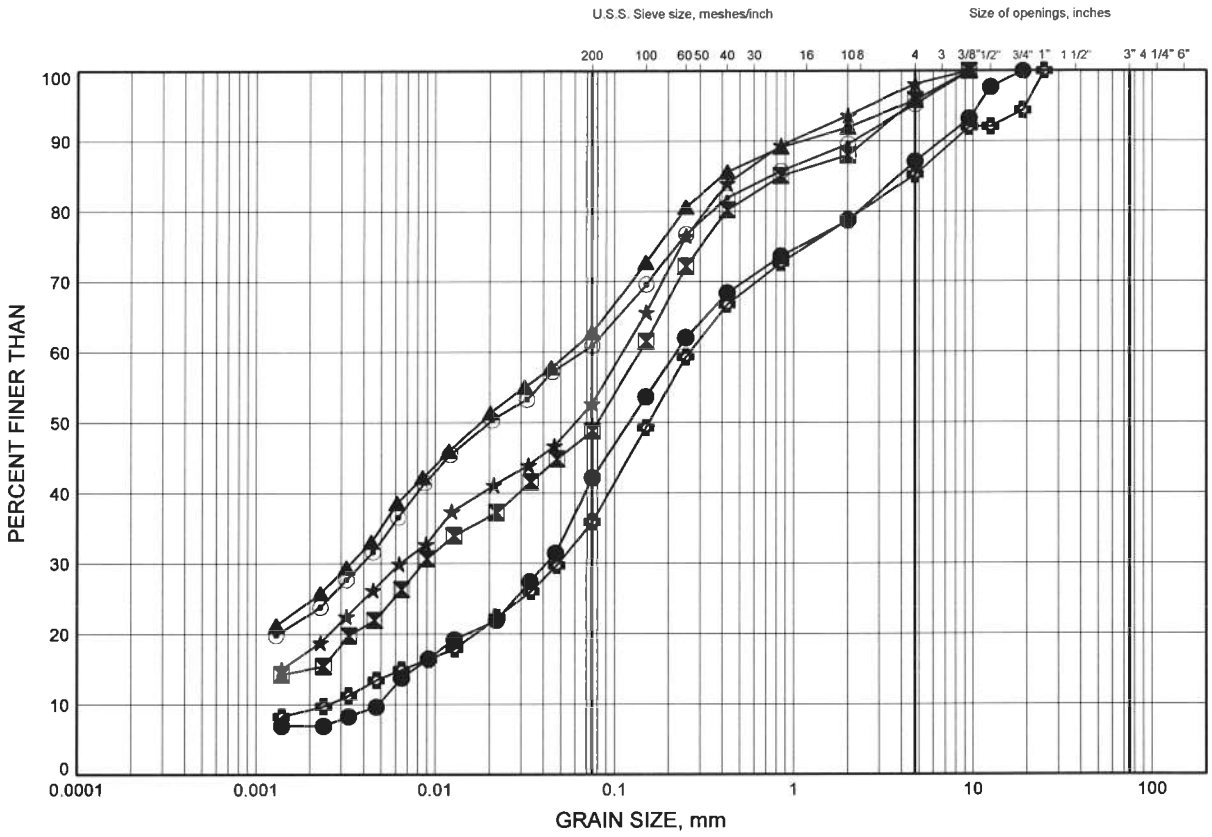
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3

CLAYEY SILT & SAND to SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-02	6.40	179.54
⊠	SM2-03	1.07	184.12
▲	SM2-06	1.07	186.18
★	SM2-06	4.88	182.37
⊙	SM2-07	1.83	185.20
✿	SM2-07	7.92	179.10

Date January 2013

WP# E2-2012

THURBER

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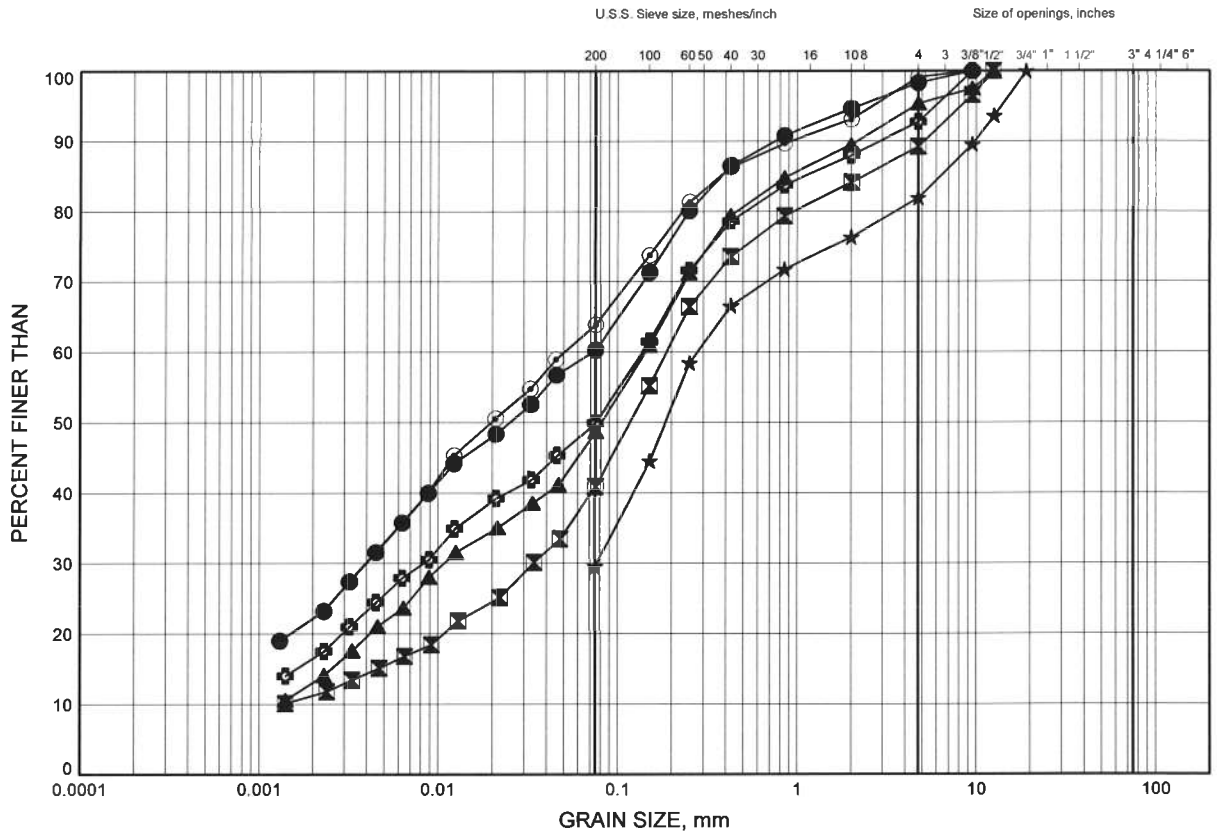
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B4

CLAYEY SILT & SAND to SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-08	2.59	184.19
⊠	SM2-08	7.92	178.86
▲	SM2-09	1.83	183.03
★	SM2-11	4.88	179.14
⊙	SM2-12	1.07	184.98
✿	SM2-12	4.88	181.17

Date January 2013

WP# E2-2012

THURBER

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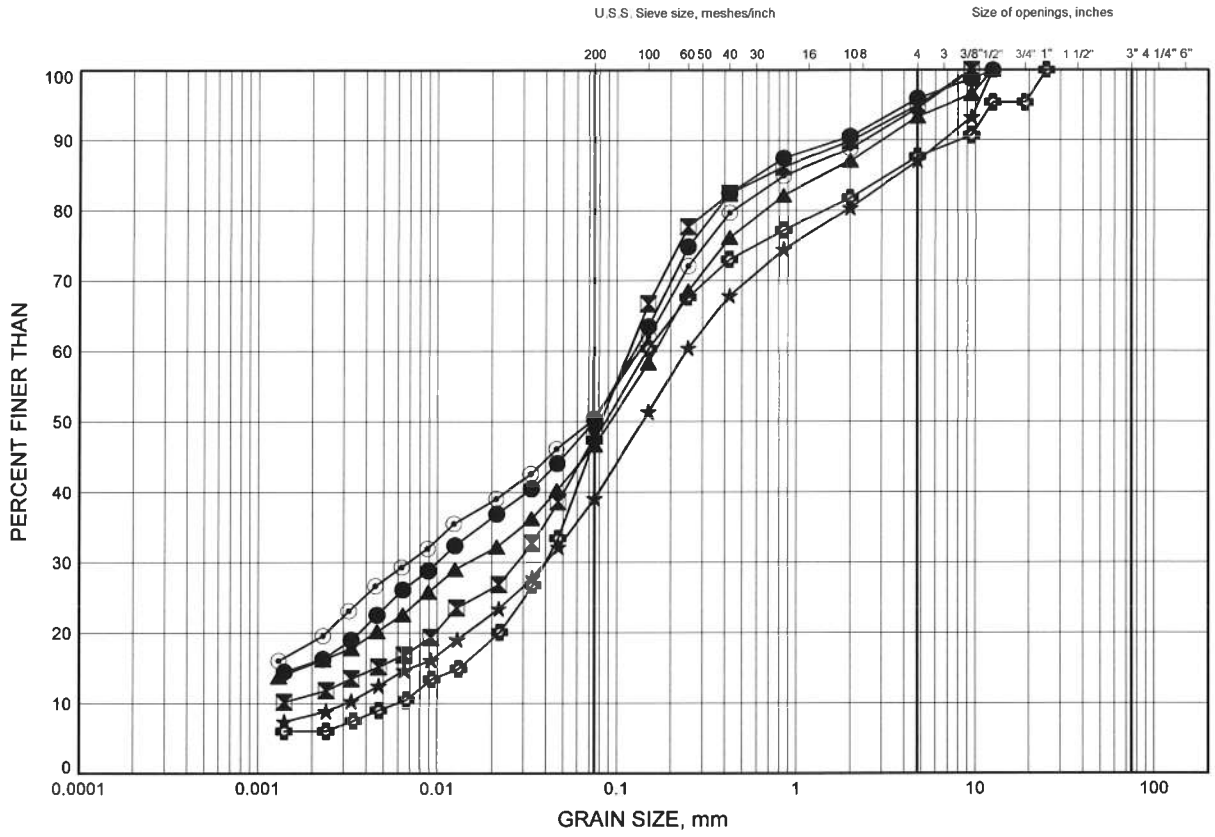
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B5

CLAYEY SILT & SAND to SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-13	2.59	184.14
⊠	SM2-13	7.85	178.88
▲	SM2-14	3.35	184.22
★	SM2-14	7.72	179.85
⊙	SM2-15	6.40	181.09
✿	SM2-16	9.35	179.31

Date January 2013

WP# E2-2012

THURBER

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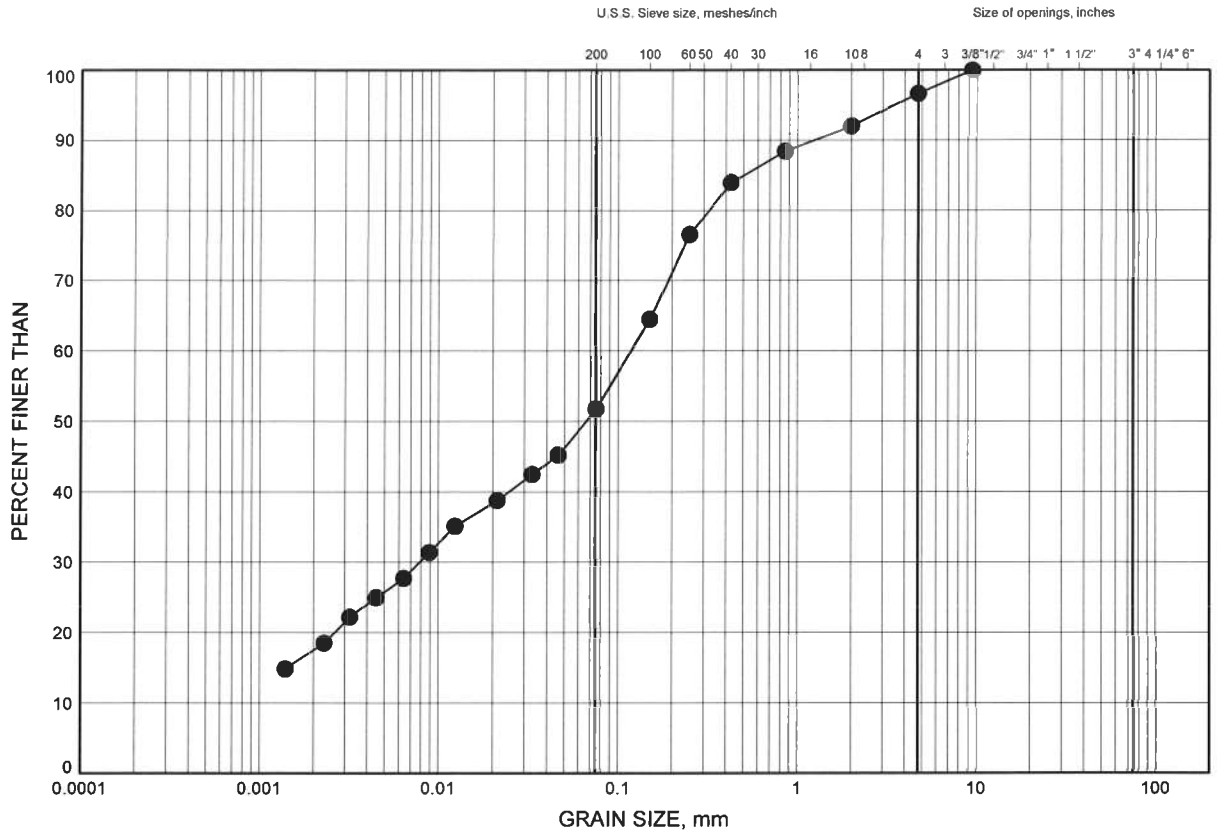
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT & SAND to SILTY SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-17	4.88	182.87

Date January 2013

WP# E2-2012

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Chkd. LRB

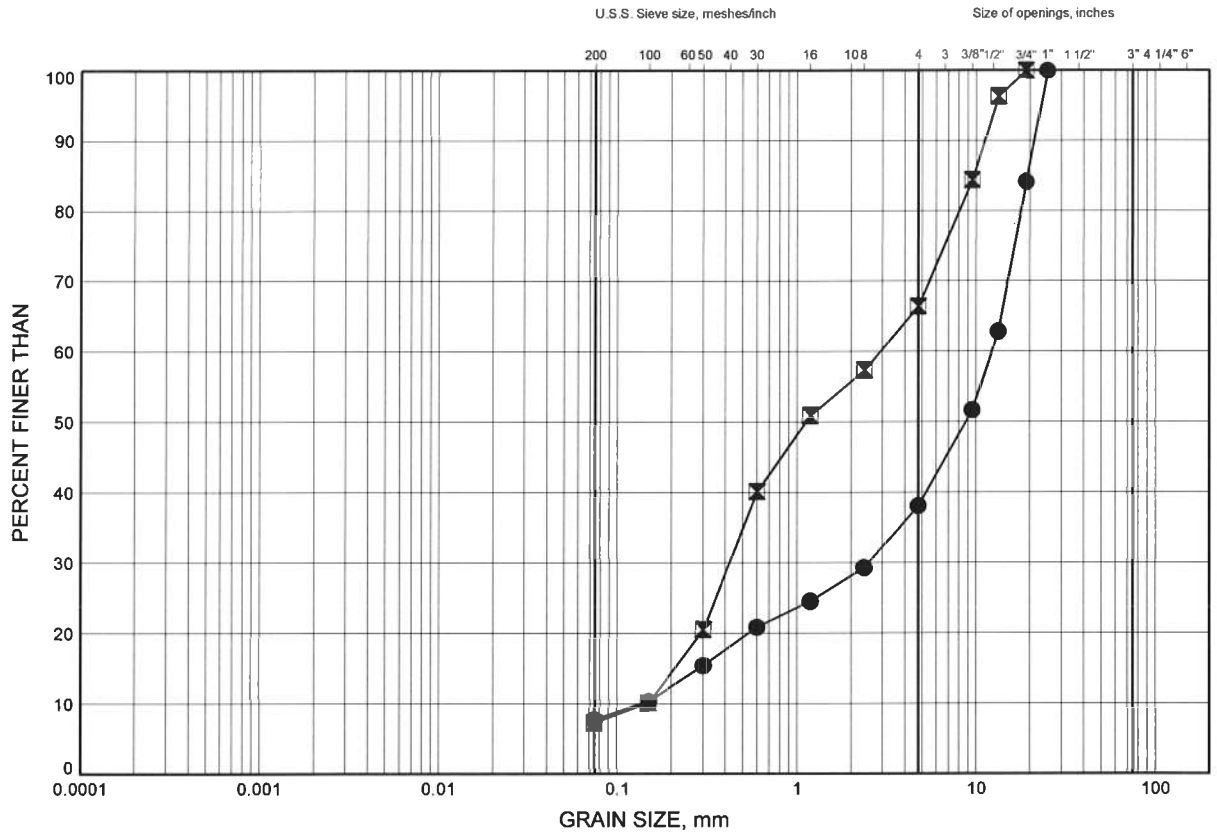
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B7

Upper SAND & GRAVEL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-02	3.35	182.59
⊠	SM2-03	3.35	181.83

Date January 2013

WP# E2-2012

THURBER

Prep'd AN

Chkd. LRB

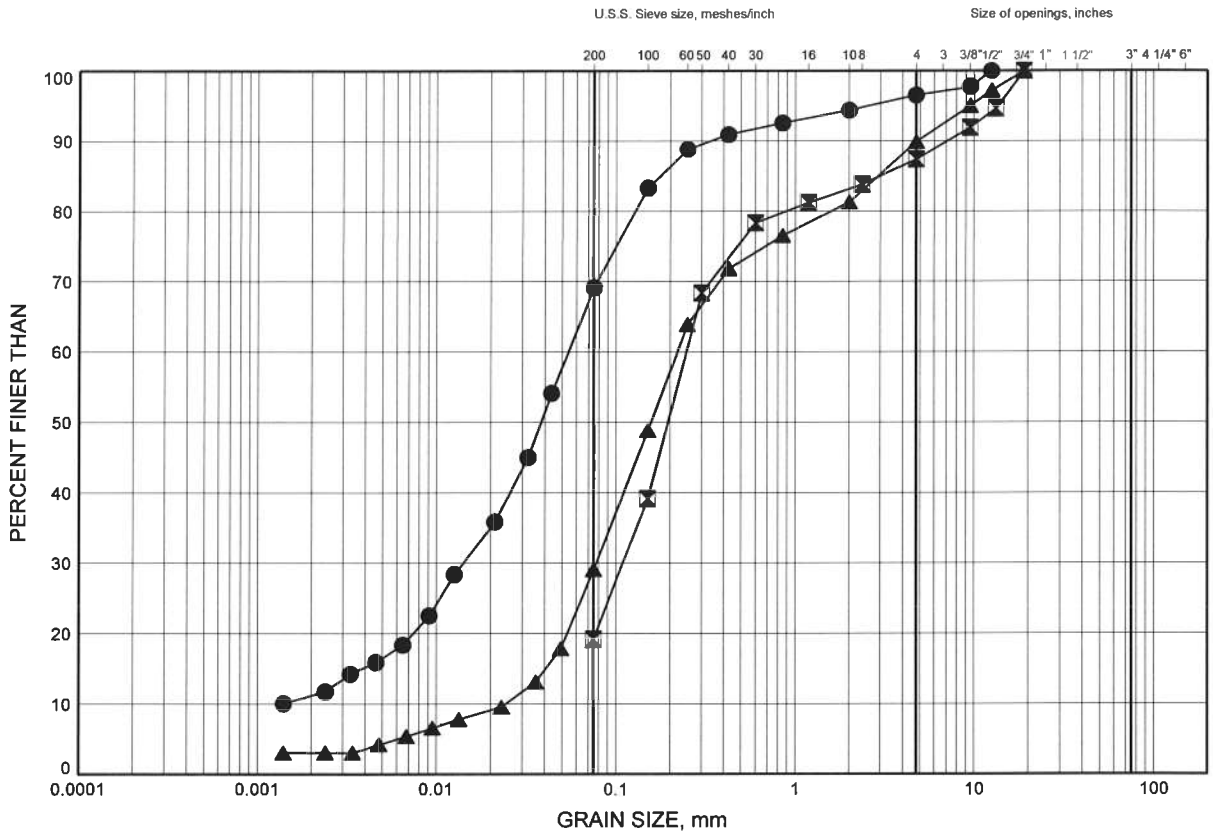
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B8

SANDY SILT to SILTY SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-06	10.97	176.27
⊠	SM2-08	12.50	174.29
▲	SM2-09	9.45	175.41

Date January 2013

WP# E2-2012

THURBER

Prep'd AN

Chkd. LRB

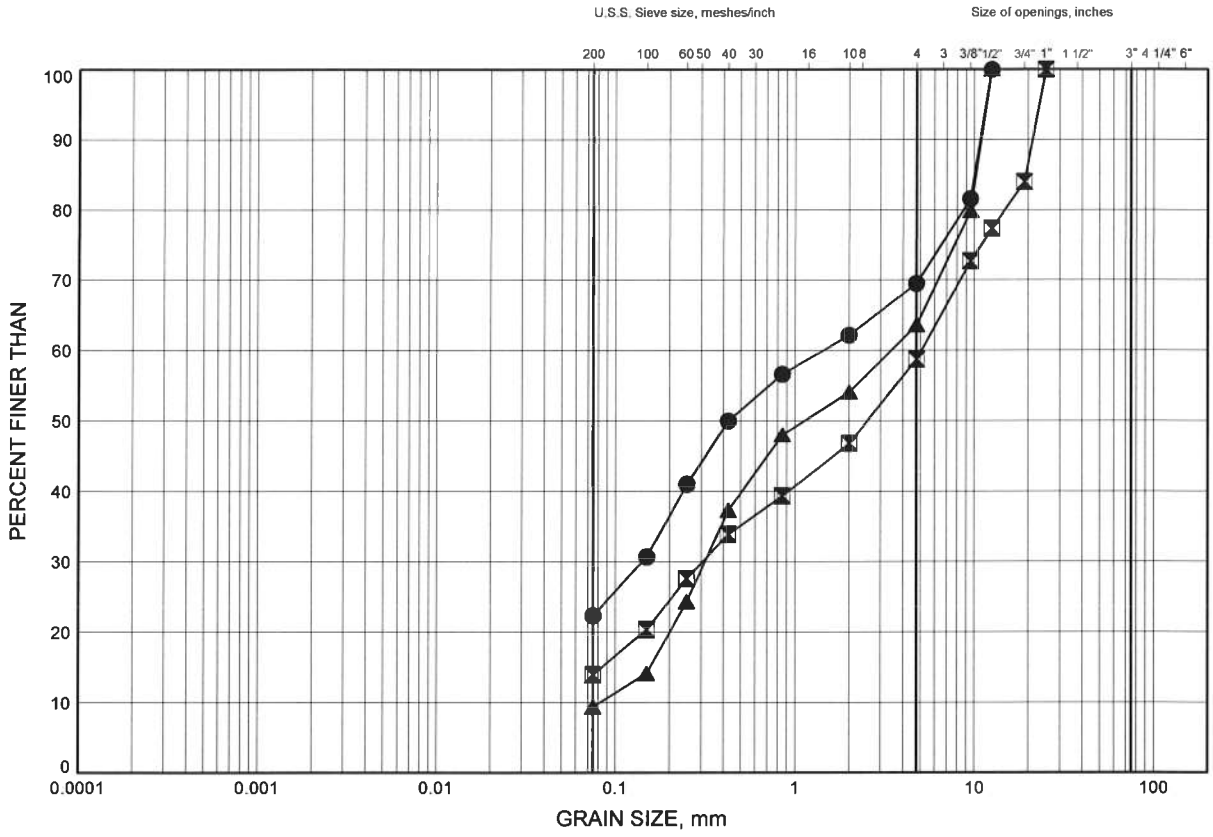
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B9

Lower SAND & GRAVEL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-11	9.45	174.57
⊠	SM2-12	10.97	175.07
▲	SM2-15	12.33	175.16

Date January 2013

WP# E2-2012

THURBER

Prep'd AN

Chkd. LRB

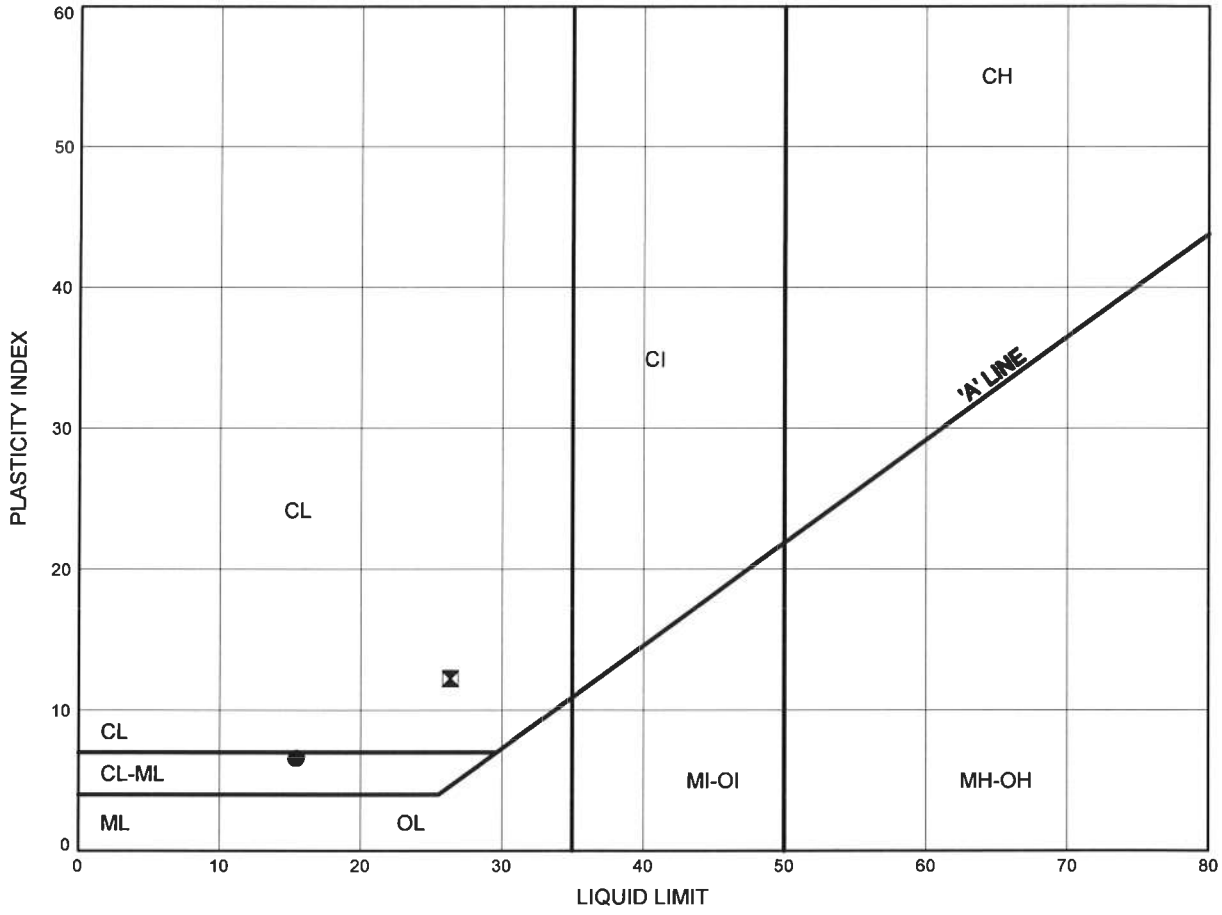
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 1/4/13

Hwy 407 Brock Road Connection - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

CLAYEY SILT & SAND TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM2-03	1.07	184.12
⊠	SM2-06	1.07	186.18

Date January 2013

WP# E2-2012

THURBER

Prep'd AN

Chkd. LRB

THURBALT 1130A.GPJ 1/4/13

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
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TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 13T677837

PROJECT NO: 19-5161-130A

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Lindsey Blaine

O. Reg. 153(511) - ORPs (Soil) pH

DATE RECEIVED: 2013-01-08 **DATE REPORTED: 2013-01-11**

		SAMPLE DESCRIPTION:		SM1-02 SS#4	SM1-04 SS#6	SM2-02 SS#4	SM2-08 SS#3	SM2-11 SS#2	SM2-17 SS#4	SM4-02 SS#1	SM4-04 SS#2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058631	4058632	4058634	4058636	4058638	4058640	4058642	4058644
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.90	7.91	7.98	7.92	7.44	7.89	7.83	7.90

		SAMPLE DESCRIPTION:		SM4-07 SS#4	SM8-03 SS#5	SM8-04 SS#6	SM9-02 SS#2	SM9-06A SS#3	SM9-08 SS#4	SM10-09 SS#2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058646	4058648	4058650	4058652	4058654	4058656	4058658
pH, 2:1 CaCl2 Extraction	pH Units		NA	8.02	8.06	7.94	7.92	7.91	7.86	7.39

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

4058631-4058658 pH was determined on the 0.01M CaCl2 extract obtained from 2:1 leaching procedure (2 parts extraction fluid :1 part wet soil).

Certified By: Elizabeth Rolakowska

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 13T677837

PROJECT NO: 19-5161-130A

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Lindsey Blaine

Sulphate (Soil)

DATE RECEIVED: 2013-01-08 **DATE REPORTED: 2013-01-11**

		SAMPLE DESCRIPTION:		SM1-02 SS#4	SM1-04 SS#6	SM2-02 SS#4	SM2-08 SS#3	SM2-11 SS#2	SM2-17 SS#4	SM4-02 SS#1	SM4-04 SS#2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058631	4058632	4058634	4058636	4058638	4058640	4058642	4058644
Sulphate (2:1)	µg/g		2.0	3.0	9.7	157	3.9	181	35.8	11.6	6.0

		SAMPLE DESCRIPTION:		SM4-07 SS#4	SM8-03 SS#5	SM8-04 SS#6	SM9-02 SS#2	SM9-06A SS#3	SM9-08 SS#4	SM10-09 SS#2
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013	1/7/2013
Parameter	Unit	G / S	RDL	4058646	4058648	4058650	4058652	4058654	4058656	4058658
Sulphate (2:1)	µg/g		2.0	8.9	9.4	23.3	5.8	15.3	10.3	544

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

4058631-4058658 The soluble Sulphate was determined on the DI water extract obtained from the 2:1 leaching procedure (2 part DI water: 1 part dry soil).

Certified By: Elizabeth Rotakowska

AGAT Laboratories

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FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 13T677837

PROJECT NO: 19-5161-130A

ATTENTION TO: Lindsey Blaine

Soil Analysis

RPT Date: Jan 11, 2013			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Sulphate (Soil)															
Sulphate (2:1)	1	4058631	3.0	2.7	10.5%	< 2.0	95%	70%	130%	97%	70%	130%	96%	70%	130%
Sulphate (Soil)															
Sulphate (2:1)	1	4058650	23.3	24.0	3.0%	< 2.0		70%	130%		70%	130%		70%	130%
O. Reg. 153(511) - ORPs (Soil) pH															
pH, 2:1 CaCl2 Extraction	1	4058631	7.90	7.93	0.4%	NA	100%	90%	110%	NA			NA		

Certified By: Elizabeth Rolakowska

Appendix C

Borehole Logs
(Previous Investigation by others)

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 401

N 4 863 774
E 336 751

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
OUR PROJECT 98TF083D
BORING DATE November 20, 1998
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 186.89				
0.35	TOPSOIL : Dark brown sandy silt				
	SANDY SILT : Dense, light brown, trace of gravel, occasional cobble, wet	186	1	SS	9
2.50		185	2	SS	35
	SILTY SAND: Dense, grey, wet	184	3	SS	32
4.05	with gravelly layers	183			
		182	4	SS	48
5.55	becoming very dense, trace of gravel, occasional cobble	181			
6.30	BOREHOLE TERMINATED AT 6.30m	180	5	SS	108/100mm

SHEAR STRENGTH C_u (kPa) ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 1.50m.

Upon completion of augering, free water at 1.70m.

NOTES:

CHECKED BY: MRA

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 402

N 4 863 785
E 336 785

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
OUR PROJECT 98TF083D
BORING DATE November 19, 1998
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

GROUND ELEVATION 186.22

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
0		186	1	SS	5
0.35	TOPSOIL : Dark brown sandy silt				
	SILTY SAND: Dense, light brown, trace of gravel, moist	185			
1.5			2	SS	33
2.40	becoming grey silty sand and gravel, moist to wet	184			
3.0		183	3	SS	44
4.05	becoming very dense, silty sand, some gravel, wet	182			
4.5			4	SS	102
5.55	becoming moist	181			
6.0		180	5	SS	119
7.5		179			
8.60	BOREHOLE TERMINATED UPON REFUSAL TO AUGER AND SPLIT SPOON AT 8.60m. PROBABLE BOULDER.	178	6	SS	100/50mm*
9.0		177			
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲ (50, 100, 150, 200)
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST●
BLOWS/0.3M (20, 40, 60, 80)

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P — W — W_L
WATER CONTENT % (10, 20, 30)

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 1.20m.

Grain Size Distribution %

GR	SA	SI	CL
29	39	24	8

*No Recovery. Probable boulder

Upon completion of augering, free water at 1.00m.

NOTES:

CHECKED BY:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 403

N 4 863 779
E 336 769

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
OUR PROJECT 98TF083D
LOCATION Brougham Creek Structure
BORING DATE November 20, 1998 ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 186.26					
0.25	TOPSOIL : Dark brown sandy silt		186	1	SS	7
1.00	SANDY SILT: Compact, light brown, trace of gravel, wet		185			
1.5	becoming dense, grey, occasional cobbles with silty sand layers		184	2	SS	31
3.0	SAND AND GRAVEL : Compact, grey sand and gravel, trace of silt, saturated		183	3	SS	27
4.05	SILTY SAND: Very dense, grey, trace of gravel, moist		182			
4.5			181	4	SS	56
6.0			180	5	SS	77
6.55	BOREHOLE TERMINATED AT 6.55m		179			
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT — W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 1.70m.

Grain Size Distribution %

GR	SA	SI	CL
46	47	5	2

Upon completion of augering, free water at 1.00m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 404

N 4 883 805
E 336 800

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 20, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	GROUND ELEVATION 183.20					
0		183	1	SS	1	43%
0.35	TOPSOIL : Dark brown to black sandy silt					
	SILTY SAND : Dense, grey, trace of gravel, moist	182				Free water observed at 1.20m.
1.5			2	SS	44	
2.50	becoming very dense	181				
3.0		180	3	SS	141/275mm	9 49 34 8
3.95	becoming wet, with some gravel and cobbles	179				
4.5			4	SS	152	31 53 (16)
		178				
6.0		177	5	SS	100/150mm	
6.25	BOREHOLE TERMINATED AT 6.25m					Upon completion of augering, free water at 0.90m.
		176				
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲ — 50 100 150 200
DYNAMIC CONE PENETRATION ✕ STANDARD PENETRATION TEST ●
BLOWS/0.3M — 20 40 60 80
LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
WATER CONTENT % — 10 20 30
Grain Size Distribution % — GR SA SI CL

NOTES:

CHECKED BY:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 405

N 4 863 798
E 338 801

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 20, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

GROUND ELEVATION 183.04

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
0.35	TOPSOIL: Dark brown sandy silt				
	SANDY SILT: Very dense, grey, trace of gravel, moist	182			
2.50		181	1	SS	60
	SILTY SAND: Very dense, grey, trace of gravel, occasional cobble, moist	180	2	SS	94/275mm
		179			
4.70	becoming wet	178	3	SS	50/100mm
6.25	BOREHOLE TERMINATED AT 6.25m	177	4	SS	50/150mm
		176			

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Bentonite Seal
Native Backfill
19mm PVC Pipe
Bentonite Seal
Free water observed at 4.55m.
Filter Sand

Upon completion of augering, free water at 3.65m.

DATE	DEPTH TO WATER (m)
Dec. 1	0.25

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 406

N 4 883 811
E 336 813

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers

OUR PROJECT 98TF083D
BORING DATE November 23, 1998 ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

GROUND ELEVATION 182.76

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
0					
0.45	TOPSOIL : Dark brown sandy silt		1	SS	4
	SANDY SILT: Compact, grey, trace of clay and gravel, moist	182			
1.35			2	SS	11
1.5	becoming dense, grey				
1.85		181	3	SS	42
2.15	with trace of gravel				
	becoming very dense, with occasional cobbles, damp	180	4	SS	111
3.0			5	SS	79
		179			
4.5 4.60	becoming wet	178	6	SS	134/275mm
5.45		177			
6.0 6.25	SILTY SAND AND GRAVEL: Very dense grey silty sand and gravel, saturated		7	SS	100/150mm
	BOREHOLE TERMINATED AT 6.25m	176			
7.5					
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲ — 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M — 20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT % — 10 20 30

61%

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 3.20m.

Upon completion of augering, free water at 2.00m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 407

N 4 883 744
E 336 767

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 20, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

GROUND ELEVATION 186.53

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
0					
0.37	**TOPSOIL**: Dark brown sandy silt	186	1	SS	6
	SILTY SAND: Compact, brown, moist, with layers of dark grey sand		2	SS	13
1.35	becoming wet	185	3	SS	26
1.5					
2.50	becoming very dense, grey, some gravel, occ. cobbles	184			
3.0			4	SS	56
		183			
4.5		182	5	SS	80
		181			
6.0			6	SS	119
6.40	**BOREHOLE TERMINATED AT 6.40m**	180			
7.5					
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲ — 50, 100, 150, 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M — 20, 40, 60, 80
LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT % — 10, 20, 30

GROUNDWATER OBSERVATIONS AND REMARKS

Grain Size Distribution %

GR	SA	SI	CL
			Organic Content=4.5%
8	53	29	10
			Free water observed at 1.85m.
17	43	32	8
			Upon completion of augering, free water at 1.40m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 408

N 4 863 757
E 336 784

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
OUR PROJECT 98TF083D
BORING DATE November 20, 1998
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 186.05				
0	CLAYEY SILT: Firm, brown, trace of sand, slightly plastic, A.P.L., with organic inclusions (plowed field)	185	1	SS	7
1.00					
1.5	SILTY SAND: Dense, light brown, trace of gravel, moist	184	2	SS	40
2.50	becoming very dense, light grey, with some gravel and cobbles	183	3	SS	50
3.0		182			
4.5	4.80 becoming grey, wet, trace of gravel	181			
6.0		180	4	SS	53
6.55	BOREHOLE TERMINATED AT 6.55m	179			
7.5					
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Bentonite Seal
Native Backfill
19mm PVC Pipe
Bentonite Seal
Filter Sand
Free water observed at 5.80m.

Upon completion of augering, free water at 5.65m.

DATE	DEPTH TO WATER (m)
Dec. 1	3.20

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 409

N 4 863 751
E 336 789

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 19, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

SOIL PROFILE | SAMPLES | SHEAR STRENGTH C_u (kPa) 50 100 150 200 | LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W | GROUNDWATER OBSERVATIONS AND REMARKS

DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80

WATER CONTENT % 10 20 30

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 186.02					
0						
0.36	TOPSOIL : Dark brown sandy silt			1	SS	11
	SANDY SILT : Compact, light brown, moist to damp		185			
1.5				2	SS	27
			184			
2.50	becoming dense, trace of gravel					
3.0			183	3	SS	37
4.05	becoming very dense, grey					
4.5			182	4	SS	120*
			181			
6.0						
6.10	becoming wet		180	5	SS	139
			179			
7.5				6	SS	100/140mm*
			178			
9.0			177			
				7	SS	125
			176			
10.5						
10.85	SANDY SILTY CLAY : Hard, grey, trace of gravel, low plastic, W.T.P.L		175			
12.0			174			
				8	SS	42
			173			
13.5						
			172			
15.0						
15.00	continued on next page		171			
				9	SS	63
16.5						

GROUNDWATER OBSERVATIONS AND REMARKS

Grain Size Distribution %

	GR	SA	SI	CL
* Possibly driving on cobble				
	9	38	43	10
Free water observed at 6.40m.				
* No Recovery				
	1	31	39	29

NOTES:

CHECKED BY: MMR

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 409 (cont'd)

N 4 863 751
E 336 789

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
OUR PROJECT 98TF083D
BORING DATE November 19, 1998
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION					
15.0	**SANDY SILTY CLAY** (continued): Hard, grey, trace of gravel, low plastic, W.T.P.L.		170	9	SS	63
16.5	17.00		169			
	becoming very stiff		168			
18.0				10	SS	25
			167			
19.5	20.00		166			
	becoming hard, A.P.L.		165			
21.0				11	SS	53
	21.80		164			
	BOREHOLE TERMINATED AT 21.80m					
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS
Grain Size Distribution %
GR SA SI CL

Upon completion of augering, free water at 5.80m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 410

N 4 863 779
E 338 814

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 23, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demorchi

GROUND ELEVATION 182.30

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m VALUES N	GROUNDWATER OBSERVATIONS AND REMARKS
0		182	1	SS	5	
0.35	TOPSOIL : Dark brown sandy silt					
1.00	SANDY SILT: Loose, light brown, wet	181				
1.5	layer of very dense, grey gravelly sand with silt, moist to wet		2	SS	55	Grain Size Distribution %: GR 32, SA 39, SI 25, CL 4
1.80	becoming very dense, wet, occasional cobbles	180				
3.0		179	3	SS	141	Free water observed at 3.00m.
4.00	with occasional dark grey silty sand inclusions	178				
4.5			4	SS	106/150mm	
		177				
6.0		176	5	SS	100/100mm	Upon completion of augering, free water at 1.50m.
6.20	BOREHOLE TERMINATED AT 6.20m					
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %
10 20 30

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 411

N 4 883 766
E 336 810

PROJECT HIGHWAY 407 EAST, W.P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 20, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 182.84					
0						
0.35	TOPSOIL : Dark brown sandy silt			1	SS	7
	SILTY SAND: Compact, brownish grey, trace of gravel, moist		182			
1.5			181	2	SS	24
2.50	becoming very dense, grey		180			
3.0				3	SS	148/275mm
			179			
4.50	becoming wet					
4.5			178	4	SS	155/250mm
			177			
6.0 6.20	BOREHOLE TERMINATED AT 6.20m			5	SS	100/100mm
			176			
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲ — 50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M — 20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P — W — W_L
WATER CONTENT % — 10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Organic Content=7.9%

Free water observed at 2.45m.

Grain Size Distribution %

GR	SA	SI	CL
5	53	37	5

Upon completion of augering, free water at 3.05m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 412

N 4 863 785
E 336 826

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE November 23, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN C. Demarchi

GROUND ELEVATION 181.74

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
0					
0.35	**TOPSOIL** : Dark brown sandy silt	181			
	SILTY SAND : Dense, grey, trace of gravel, moist		1	SS	36
1.35					
1.5	layer of very dense sandy silt, some gravel, occasional cobbles, damp	180	2	SS	67
2.50		179			
3.0	becoming silty sand, wet		3	SS	122
		178			
4.5	4.60	177	4	SS	130
	SILTY CLAY: Hard, grey, trace of sand and gravel, low plastic, A.P.L., with layers of clayey silt, trace of gravel	176			
6.0	6.20		5	SS	100/125mm
	BOREHOLE TERMINATED AT 6.20m	175			
7.5					
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT — W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 3.20m.

Upon completion of augering, free water at 1.60m.

Grain Size Distribution %

GR	SA	SI	CL
4	7	42	47

NOTES:

CHECKED BY: MRM

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 413

N 4 883 823
E 336 830

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 30, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 182.04					
0	**TOPSOIL** : Dark brown sandy silt		181			
1.20						
1.5	**SAND** : Dense, grey, fine to medium sand, some gravel, wet		180	1	SS	30
2.50						
3.0	**SILTY SAND** : Very dense, grey, some gravel, wet; occasional cobbles		179	2	SS	112
4.10	becoming fine sand, some silt		178			
4.5				3	SS	117
5.05	BOREHOLE TERMINATED AT 5.05m		177			
6.0						
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲ — 50 100 150 200
DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ●
BLOWS/0.3M — 20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT % — 10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 0.90m.

Upon completion of augering, free water at 1.20m, cave at 4.25m.

Grain Size Distribution %

GR	SA	SI	CL
33	55		(12)

NOTES:

CHECKED BY:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 414

N 4 863 816
E 336 834

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 30, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 181.96					
0	TOPSOIL : Dark brown sandy silt		181	1	SS	2
-1.05	SILTY SAND: Dense, grey, trace of gravel, occasional cobbles, moist			2	SS	13
1.5			180	3	SS	49
-2.15	becoming very dense					
			179	4	SS	101
3.0				5	SS	89
-4.00	layer of medium to coarse sand, trace of gravel and silt, wet		178			
4.5			177	6	SS	87/225mm
-5.50						
6.0 -6.20	BOREHOLE TERMINATED AT 6.20m		176	7	SS	90/100mm
			175			
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST •
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

40%
57%

GROUNDWATER OBSERVATIONS AND REMARKS

Free water observed at 1.85m.

Grain Size Distribution %

GR	SA	SI	CL
16	47	28	7

Upon completion of augering, free water at 1.50m, cave at 3.00m.

NOTES:

CHECKED BY:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 415

N 4 883 829
E 336 845

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 30, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 185.15				
0	TOPSOIL : Dark brown sandy silt	185	1	SS	6
0.70	SANDY SILT: Compact, brown, trace of gravel, moist	184	2	SS	13
1.35	becoming dense		3	SS	34
1.5		183	4	SS	42
3.0		182	5	SS	43
4.05	becoming grey	181	6	SS	42
4.5		180			
5.55	becoming wet	179	7	SS	55/150mm
6.0 6.25	BOREHOLE TERMINATED AT 6.25m	178			
7.5					
9.0					
10.5					
12.0					
13.5					
15.0					
16.5					

SHEAR STRENGTH C_u (kPa) ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST •
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %
10 20 30

48%

GROUNDWATER OBSERVATIONS AND REMARKS

Grain Size Distribution %

GR	SA	SI	CL
7	34	44	15
10	41	41	18

Bentonite Seal
Native Backfill
19mm PVC Pipe
Bentonite Seal
Filter Sand
Free water observed at 5.95m.

DATE	DEPTH TO WATER (m)
Dec 30	5.45

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 416

N 4 883 794
E 336 848

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 30, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m VALUES N	GROUNDWATER OBSERVATIONS AND REMARKS
	GROUND ELEVATION 181.95						
0	TOPSOIL: Dark brown sandy silt			1	SS	3	
0.70			181				
	SAND: Compact, brown, fine to medium sand, some gravel, wet			2	SS	15	38 45 (17) Free water observed at 1.20m.
1.35							
1.5	SILTY SAND: Very dense, grey, trace of gravel, numerous cobbles, moist		180	3	SS	65	
			179	4	SS	61	
3.0				5	SS	50/150mm	
			178				
4.55							Upon completion of augering, free water at 1.05m, cave at 2.15m.
4.5	BOREHOLE TERMINATED UPON REFUSAL TO AUGER AND SPLIT SPOON AT 4.55m. PROBABLE BOULDER.		177				
6.0							
7.5							
9.0							
10.5							
12.0							
13.5							
15.0							
16.5							

SHEAR STRENGTH C_u (kPa) ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
WATER CONTENT %
10 20 30

Grain Size Distribution %
GR SA SI CL

NOTES:

CHECKED BY:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 417

N 4 863 788
E 336 852

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 29, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES	GROUNDWATER OBSERVATIONS AND REMARKS
	GROUND ELEVATION 181.89						
0	**TOPSOIL** : Dark brown sandy silt		181				
0.75	**SILTY SAND**: Very dense, grey, some gravel, moist; occasional cobbles						
1.5			180	1	SS	69	Free water observed at 1.85m.
			179				21 46 27 6
3.0				2	SS	121	
4.00			178				
4.5	**SAND** : Very dense, grey, medium to coarse sand, some gravel, wet		177	3	SS	102	32 61 (7)
5.50							
6.0	**SILT** : Very dense, grey, trace of sand, clay and gravel, moist; with clayey silt lenses		176				
6.30				4	SS	117/225mm	Upon completion of augering, free water at 1.20m, cave at 3.65m.
	BOREHOLE TERMINATED AT 6.30m.		175				
7.5							
9.0							
10.5							
12.0							
13.5							
15.0							
16.5							

SHEAR STRENGTH C_u (kPa) 50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M 20 40 60 80
LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT % 10 20 30

Grain Size Distribution %
GR SA SI CL

NOTES:

CHECKED BY: SMA

PetoMacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 418

N 4 863 806
E 336 875

PROJECT HIGHWAY 407 EAST, W. P. 282-86-01
LOCATION Brougham Creek Structure
BORING METHOD Continuous Flight Solid Stem Augers
BORING DATE December 30, 1998
OUR PROJECT 98TF083D
ENGINEER M. R. Anderson
TECHNICIAN F. Portella

DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 185.67					
0	SANDY SILT FILL: Brown sandy silt with topsoil inclusions		185	1	SS	7
1.35				2	SS	15
1.5	SANDY SILT: Dense, brown, trace of gravel, damp to moist		184	3	SS	40
			183	4	SS	35
3.0				5	SS	39
			182			
4.05	becoming very dense					
4.5			181	6	SS	60
5.55	becoming grey, wet		180			
6.0				7	SS	73
6.55	BOREHOLE TERMINATED AT 6.55m		179			
7.5						
9.0						
10.5						
12.0						
13.5						
15.0						
16.5						

SHEAR STRENGTH C_u (kPa) ▲
50 100 150 200
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %
10 20 30

GROUNDWATER OBSERVATIONS AND REMARKS

Grain Size Distribution %

GR	SA	SI	CL
16	39	34	11

Free water observed at 5.80m.

Upon completion of augering, free water at 5.50m.

NOTES:

CHECKED BY:

Golder Associates

RECORD OF BOREHOLE No WM1-1

1 OF 2 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic
LOCATION N 4864055.5 ;E 336810.0
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
DATE January 25, 2008
ORIGINATED BY GD
COMPILED BY DD
CHECKED BY VO/HJ

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, ● QUICK TRIAXIAL, + FIELD VANE, × 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
185.4	GROUND SURFACE						185				
0.0	Topsoil (FILL)										
0.2	Sandy silt to silty sand, some clay, some gravel, containing cobbles, rootlets and wood fragments (FILL) Very loose to compact Brown Moist		1	SS	3						
			2	SS	13						
			3	SS	6		184				
183.2											
2.2	SAND and SILT, some gravel, trace to some clay, containing cobbles/boulders (TILL) Compact Brown Moist to wet		4	SS	21	▽	183				19 40 34 7
182.4											
3.0	SAND and GRAVEL, trace silt, containing cobbles/boulders Dense Brown Wet		5	SS	38		182				
181.3											
4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Very dense Grey Moist to wet		6	SS	50/0.13		181				10 45 35 8
			7	SS	50/0.08		180				
178.4							179				
7.0	SAND and GRAVEL, some silt, containing cobbles/boulders Very dense Grey Wet		8	SS	51		178				45 43 11 1
			9	SS	50/0.08		177				
			10	SS	50/0.08		176				
173.7							175				
11.7	SAND and SILT, trace to some gravel and clay, containing cobbles (TILL) Very dense Grey Wet		11	SS	50/0.08		174				
172.0							173				
13.4	SAND, trace to some silt Very dense Grey Wet		12	SS	50/0.15		172				
171.4											
14.0	END OF BOREHOLE										

Continued Next Page

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

Golder Associates

PROJECT 07-1111-0053

RECORD OF BOREHOLE No WM1-1

2 OF 2 **METRIC**

W.O. 07-20015 LOCATION N 4864055.5 ;E 336810.0 ORIGINATED BY GD

DIST Central HWY 407 BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers COMPILED BY DD

DATUM Geodetic DATE January 25, 2008 CHECKED BY VO/HJ

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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	— CONTINUED FROM PREVIOUS PAGE —										
	NOTE: 1. Water level measured in open borehole upon completion of drilling at a depth of 2.9 m below ground surface (Elevation 182.5 m).										

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

Golder Associates

RECORD OF BOREHOLE No WM2-1

1 OF 1 **METRIC**

PROJECT 07-1111-0053
W.O. 07-20015
DIST Central HWY 407
DATUM Geodetic

LOCATION N 4864046.9 ;E 336863.6
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers
DATE January 24, 2008

ORIGINATED BY GD
COMPILED BY DD
CHECKED BY VO/HJ

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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
187.6	GROUND SURFACE										
0.0	Topsoil (FILL)										
0.3	Sandy silt to silty sand, trace clay, trace to some gravel, containing rootlets and organic matter (FILL) Very loose to compact Brown Moist		1	SS	2		187				
			2	SS	14						
185.4			3	SS	10		186		o		
2.2	Silty sand, some gravel, trace to some clay, trace organic matter and wood fragments, containing clayey silt interlayers (FILL) Loose Brown Moist		4	SS	4		185		d — I		23 38 26 11
183.5			5	SS	4		184				
4.1	SAND and SILT, trace to some clay and gravel, containing cobbles/boulders (TILL) Compact to very dense Brown to grey Moist		6	SS	26		183				
			7	SS	50/0.28		182		o		11 39 37 13
180.4							181				
7.2	Silty SAND and GRAVEL, containing silty sand layer and cobbles/boulders Very dense Grey Wet		8	SS	50/0.25		180		o		
			9	SS	50/0.25		179		o		41 32 24 3
176.8			10	SS	50/0.10		178		o		
10.8	END OF BOREHOLE						177				

NOTES:

1. Water level measured in piezometer at depth of 8.7m below ground surface (Elevation 177.9 m) upon completion of installation.

2. Water level measured in piezometer at depth of 5.0 m below ground surface (Elevation 182.6 m) on February 28, 2008.

3. Water level measured in piezometer at depth of 4.5 m below ground surface (Elevation 183.1 m) on April 4, 2008.

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

MIS-MTO 001 07-1111-0053.GPJ GAL-MISS.GDT 5/19/10 DD/SAC

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Footings on Native Soil	Spread Footings on Engineered Fill	Caissons	Driven H-Piles
Advantages: i. Generally less costly construction than deep foundation elements.	***Advantages:*** i. Generally less costly construction than deep foundation elements.	***Advantages:*** i. Construction of caissons could continue in freezing weather.	***Advantages:*** i. Higher geotechnical resistances can be achieved if piles are driven to refusal. ii. Installation of piles could continue in freezing weather iii. Foundation construction may require less volume of excavation than footings.
Disadvantages: i. Lower available geotechnical resistance in till deposit. ii. Excavation to base of foundation is required for footing construction. iii. Dewatering will be required.	***Disadvantages:*** i. Better geotechnical resistance than spread footings on native, but still influenced by the compact soils at the surface. ii. Dewatering may be required, depending on depth of excavation.	***Disadvantages:*** i. Higher cost than spread footings ii. Specialized installation measures such as temporary liners and drilling mud will be required to install caissons in cohesionless soils under the water table. iii. Potential difficulty in cleaning and inspecting bases.	***Disadvantages:*** i. Higher unit costs than footings. ii. Pile lengths required to achieve design resistance may vary.
NOT RECOMMENDED	**NOT RECOMMENDED**	**NOT RECOMMENDED**	**RECOMMENDED**

Appendix E

List of SPs and OPSS and Suggested Text for NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 903, November 2009
- OPSD 3000.100
- OPSS 804, November 2010
- OPSS 902, November 2010
- OPSS 501 dated November 2010
- OPSD 3101.150
- Special Provisions 110S13 "Amendment to OPSS 1010, April 2004"
- OPSS 539

2. Suggested text for a NSSP on Pile Installation

If a pile meets refusal at a depth less than the anticipated depth, the QVE must terminate driving before the pile is damaged due to over-driving

Appendix F

Selected Photographs

Photo 1: Looking west across Brougham Creek, just north of the existing Highway 407.

Photo 2: Looking northeast from the existing Highway 407 towards the area of the east abutments and approaches.

Photo 3: Looking northwest from the existing Highway 407 towards the area of the west abutments and approaches.

Photo 4: Brougham Creek flood plain near the proposed east abutment of the NW ramp, looking south towards existing Highway 407.

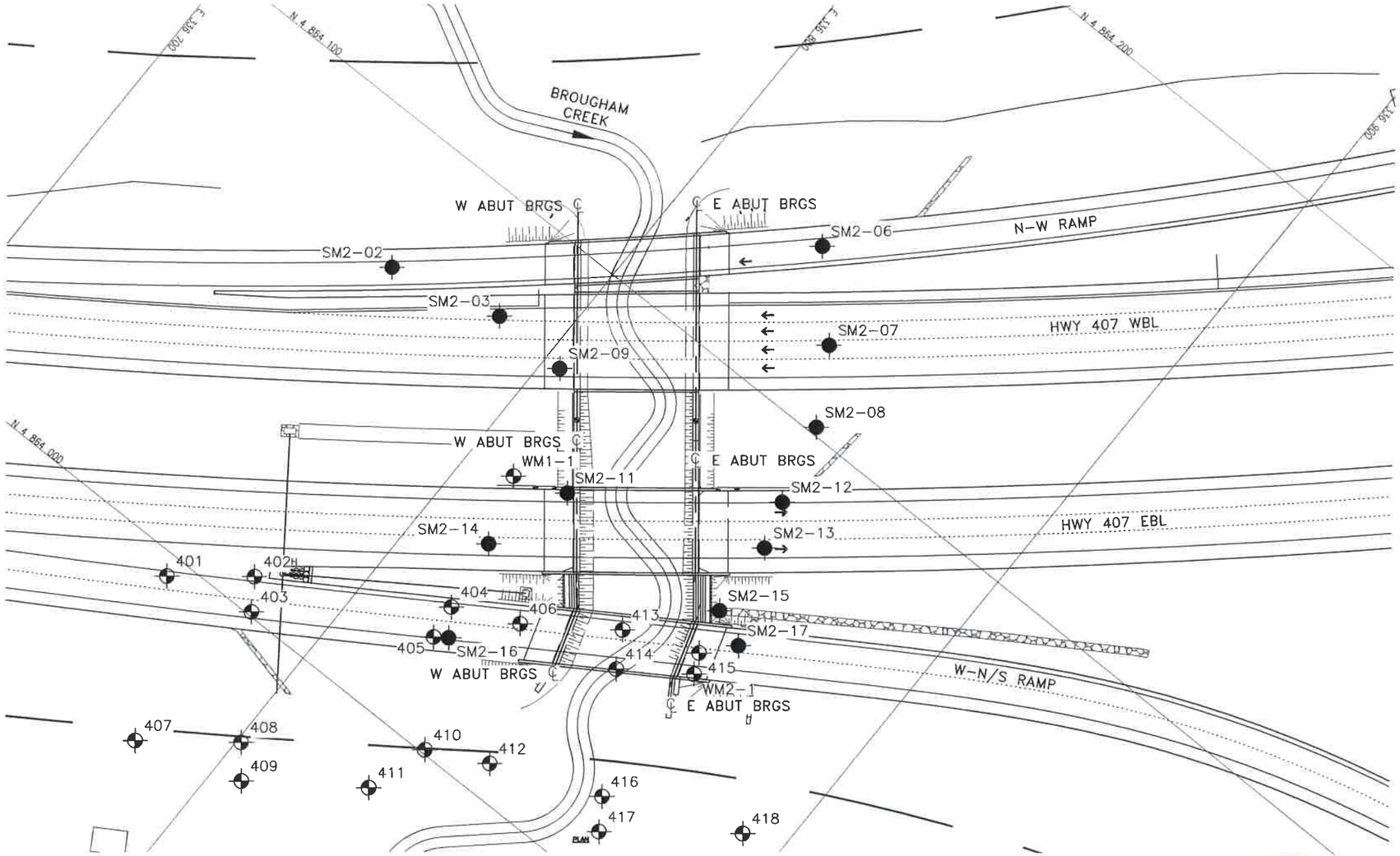
Appendix G

Borehole Locations and Soil Strata Drawings

NO.	DATE	REVISIONS	BY	CHK	LEAD DISC	PROJ MAN

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

20 0 20 40m

SCALE 1:1000

REGISTERED PROFESSIONAL ENGINEER A. E. GORMAN JAN25/13 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Jan 25/13 PROVINCE OF ONTARIO

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CREATED: January 2, 2013 MODIFIED: January 24, 2013

CONTRACT No. E2-2012

HWY 407/BROCK ROAD INTERCHANGE

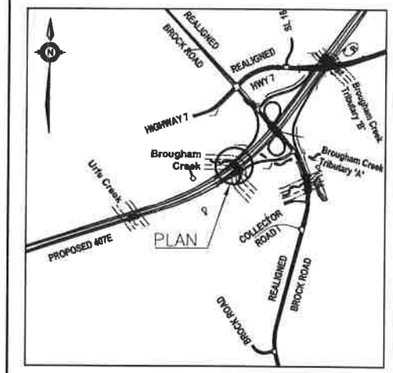
STRUCTURE M-2 (SITE 3) HIGHWAY 407 OVER BROUGHAM CREEK
BOREHOLE LOCATIONS PLAN

SHEET

407 ETR Express Toll Route

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

⊕	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▽	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SM2-02	185.9	4 864 073.3	336 764.2
SM2-03	185.2	4 864 079.1	336 787.4
SM2-06	187.2	4 864 131.0	336 829.3
SM2-07	187.0	4 864 116.2	336 843.1
SM2-08	186.8	4 864 101.5	336 851.6
SM2-09	184.9	4 864 078.5	336 803.7
SM2-11	184.0	4 864 059.6	336 820.7
SM2-12	186.0	4 864 085.4	336 855.8
SM2-13	186.7	4 864 075.8	336 858.8
SM2-14	187.6	4 864 041.6	336 814.7
SM2-15	187.5	4 864 060.2	336 859.8
SM2-16	188.7	4 864 021.7	336 820.4
SM2-17	187.7	4 864 057.0	336 867.2

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

DESIGN	LRB	CHK	LRB	CODE		LOAD	DATE JAN 2013
DRAWN	AN	CHK		SITE 3	STRUCT M-2	DWG 1	

NO.	DATE	REVISIONS	BY	CHK	LEAD DISC.	PROJ MAN.

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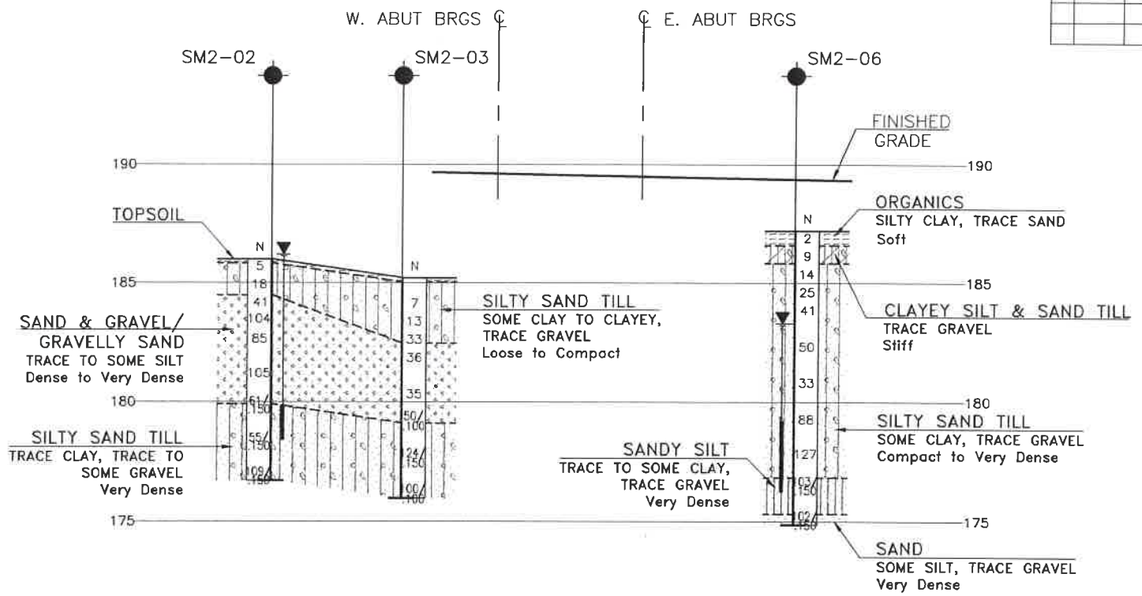

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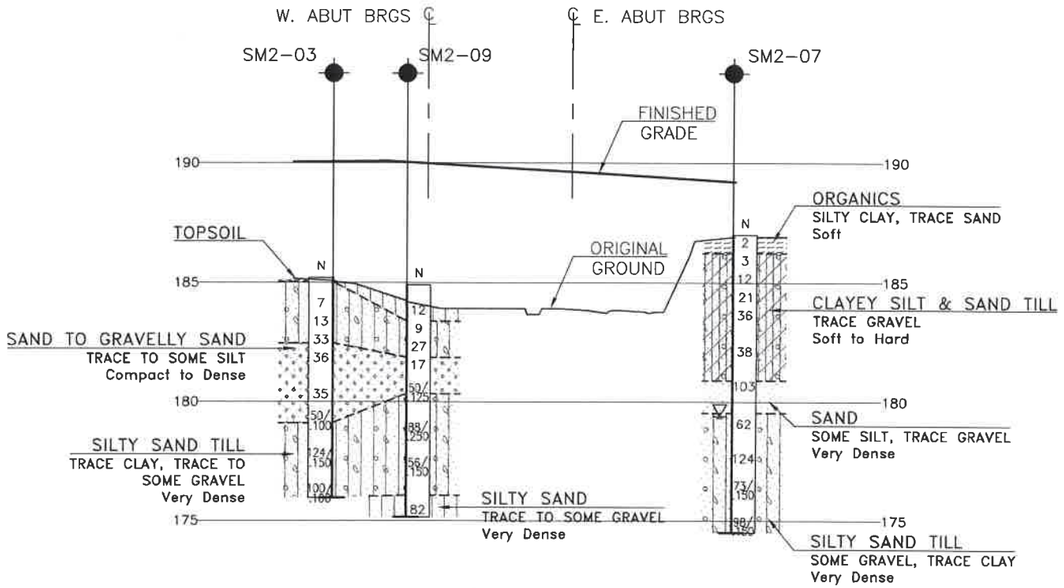

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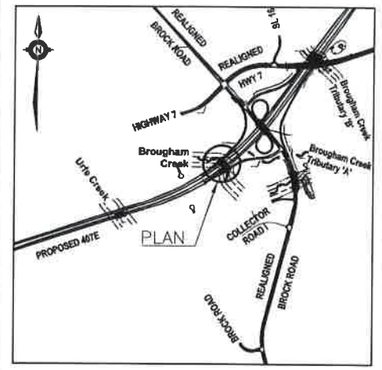

KEYPLAN

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LICENSED PROFESSIONAL ENGINEER P. K. CHATTERJI Jan 25/13 PROVINCE OF ONTARIO

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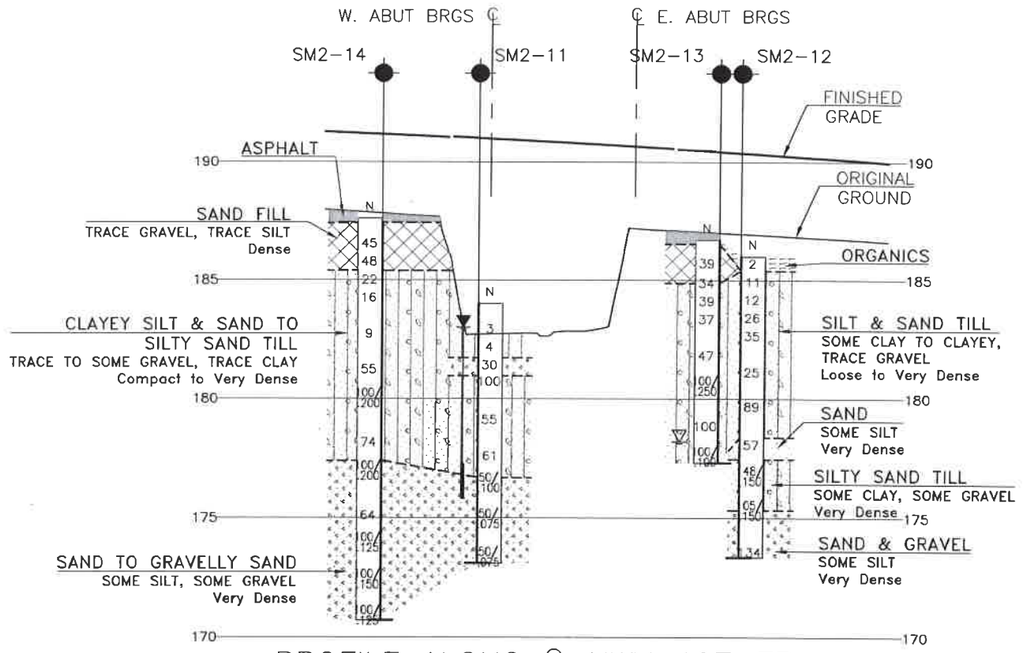

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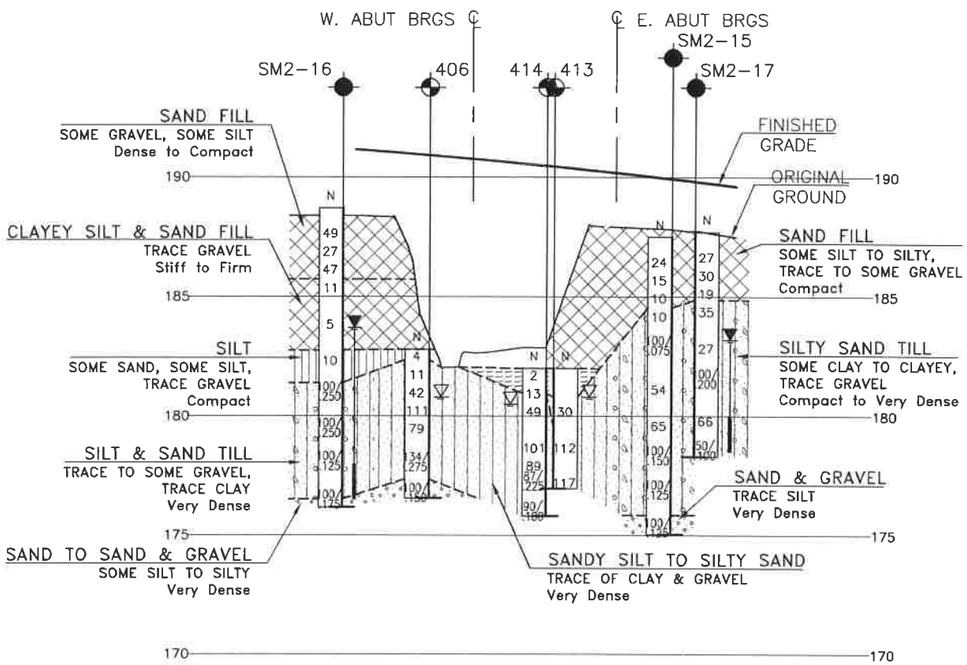

PROFILE ALONG ℄ W-N/S RAMP

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5 0 5 10m VER 1:250

NO.	DATE	REVISIONS	BY	CHK	LEAD DES.	PROJ. MAN.

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BOREHOLE LOCATIONS AND SOIL STRATA

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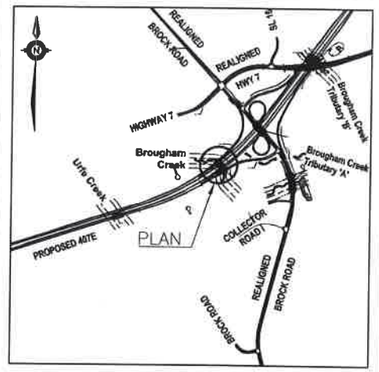

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