FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 407/BROCK ROAD INTERCHANGE CONNECTION
STRUCTURE M-8
REALIGNED BROCK ROAD OVER HIGHWAY 407
Contract No.: E2-2012

Report to

MMM Group Limited

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation, completed at the location of a proposed underpass, for the realigned Brock Road to be carried over Hwy 407 East Extension near Brougham, Ontario. The new alignment of Brock Road is to be located east of its current alignment, adjacent to the west side of the current Sideline 16 alignment.

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, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited.

2 SITE DESCRIPTION

The realigned Brock Road underpass, as shown on the General Arrangement (GA) drawing dated July 2012, is to be located approximately 800 m east of the existing alignment crossing Hwy 7, adjacent to the west side of the existing Sideline 16 at-grade crossing. The land surrounding the site is gently rolling farm land and includes vegetation consisting of grasses, shrubs and trees.

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, underlying or overlying glacial till sheets. Lacustrine clay deposited by Lake Iroquois, is often encountered between or overlying the till sheets. ‘Surficial Geology of Southern Ontario’ as produced by The Ontario Geological Survey shows that the site is located in an area covered by sandy silt to silty sand till on Paleozoic terrain.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between August 31st and September 7th, 2012 and consisted of drilling and sampling a total of eight boreholes (identified as SM8-01 to 08). A single borehole was drilled at each approach embankment and a pair of boreholes was drilled at both bridge abutments and at the pier location. Boreholes were extended to depths ranging from 6.1 to 13.8 m below the existing ground surface. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix F.

Drilling was carried out using a truck mounted CME 75 drill rig and solid stem augers to advance boreholes SM8-04 and 05 which were located on the current alignment of Hwy 7. The remaining boreholes, located adjacent to the Hwy 7 alignment, were drilled using a track mounted B57 drill rig with solid stem augers. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Utility clearances were obtained prior to drilling.

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

Groundwater conditions were observed in the open boreholes during and upon completion of the drilling operations. Two standpipe piezometers, consisting of 19 mm PVC pipe with a 1.5 m long slotted screen, were installed at alternate corners of the structure within boreholes SM8-02 and SM8-07. The piezometers screens were enclosed in filter sand to permit groundwater level monitoring. The boreholes were backfilled in genral accordance with O.Reg. 903 upon completion and the details are shown in Table 3-1.

Table 3-1. Borehole Installation and Backfilling Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Borehole Backfilling Details
SM8-01	N/A	Backfilled with bentonite holeplug to 1.6 m and cuttings to surface.
SM8-02	11.5 / 173.1	Piezometer with 1.5 m slotted screen installed with sand filter to 9.1 m, bentonite to 1.4 m and cuttings to surface.
SM8-03	N/A	Backfilled with bentonite holeplug to 1.7 m and cuttings to surface
SM8-04	N/A	Backfilled with bentonite holeplug to 1.0 m, cuttings to 0.8 m, concrete to 0.15 m and asphalt patch to surface.
SM8-05	N/A	Backfilled with bentonite holeplug to 0.8 m, cuttings to 0.6 m, concrete to 0.15 m and asphalt patch to surface.
SM8-06	N/A	Backfilled with bentonite holeplug to 1.5 m and cuttings to surface.
SM8-07	9.1 / 174.2	Piezometer with 1.5 m slotted screen installed with sand filter to 6.7 m, bentonite to 1.8 m and cuttings to surface.
SM8-08	N/A	Backfilled with bentonite holeplug to 1.8 m and cuttings 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 and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A and on the "Borehole Locations and Soil Strata" drawing included in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets governs any interpretation of the site conditions.

In general terms, the two boreholes drilled within the current alignment of Hwy 7 encountered a pavement structure of asphalt and sand fill underlain by silt and sand till. The three boreholes drilled north of the Hwy 7 alignment generally encountered organics at the surface followed by an underlying layer of sand and silt till. The remaining three boreholes, drilled south of the Hwy 7 alignment generally encountered a clayey silt fill with an underlying layer of native clayey silt, which was then underlain by a sand and silt till. Boreholes were terminated upon three or more consecutive SPT refusals (100 blows per 0.3 m or less of penetration) occurring within the sand and silt till layer. More detailed descriptions of the individual strata are presented below.

5.1 Pavement Structure

Boreholes SM8-04 and 05 drilled through the existing Hwy 7 encountered a pavement structure consisting of approximately 125 to 140 mm of asphalt overlying granular road base.

The granular fill was predominantly sand with some gravel and trace silt with an underside depth of 1.4 and 0.8 m below ground surface (elev. 180.6 and 181.5 m) in boreholes SM8-04 and 05, respectively. Borehole SM8-05 was further underlain by a layer of fill consisting of sandy silt with trace gravel to underside depth of 1.4 m below ground surface (elev. 181.0 m).

SPT tests performed in the road base fill layers gave N-Values between 24 and 61 blows per 0.3 m of penetration, indicating a relative density of compact to very dense.

Moisture contents within the road base fill varied from 2 to 42%.

5.2 Organics

A layer of organics was encountered at the ground surface in the remaining boreholes (SM8-01 to 03 and 06 to 08). The thickness of the organic layer varied between 150 to 250 mm.

5.3 Clayey Silt Fill

Clayey silt fill, containing trace gravel, was encountered below the organics in boreholes SM8-07 and 08. The thickness of the clayey silt fill, within these boreholes, varied between 1.0 to 1.3 m (elev. 182.1 to 181.7 m).

SPT tests performed in the clayey silt fill layer gave N-Values between 28 and 29 blows per 0.3 m of penetration, indicating very stiff consistency.

Moisture contents within the clayey silt fill varied from 11 to 15%.

5.4 Silty Clay to Clayey Silt

A layer of native silty clay to clayey silt with topsoil staining was encountered below the organics in borehole SM8-06 and below the clayey silt fill in boreholes SM8-07 and 08. The thickness of this layer ranged from 0.3 to 1.5 m. The layer had an underside depth between 1.4 to 3.0 m below the ground surface and the underside elevation ranged from 180.2 to 181.8 m.

SPT tests performed in this layer gave N-Values between 21 to 41 blows per 0.3 m of penetration, indicating very stiff to hard consistency.

Moisture contents within the silty clay varied from 8 to 19%.

5.5 Sand and Gravel

A layer of sand and gravel with some fines was encountered in borehole SM8-02 at 5.3 m (elev. 179.3 m) below the ground surface and was 2.6 m thick with an underside depth of 7.9 m (elev. 176.7 m). The sand and gravel layer was interlayered within the sand and silt till.

SPT tests performed in the sand and gravel layer gave an N-Value of 100 blows per 0.3 m of penetration, indicating a very dense relative density.

The two moisture contents within the sand and gravel layer were 8%.

A gradation analysis was completed on a sample of the sand and gravel. The results are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curve for this sample is included in Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	49
Sand	39
Silt and Clay	12

5.6 Gravelly Sand Till

A gravelly sand till with some fines was encountered directly below the organics in borehole SM8-03. The thickness of this layer was 3.5 m with an underside depth of 3.7 m below the ground surface (elev. 180.9 m).

SPT tests performed in this layer gave N-Values of 100 blows per 0.15 m of penetration to 100 blows per 0.25 m of penetration, indicating a very dense relative density.

The moisture content of the gravelly sand till layer was 3%.

A gradation analysis was completed on a sample of the gravelly sand till. The results are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curve for this sample is included in Figure B2 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	26
Sand	52
Silt and Clay	21

5.7 Silt to Sand and Silt to Silty Sand Till

Underlying the above deposits was a till layer varying from silt to sand and silt to silty sand with trace to some clay and trace gravel in all boreholes. Occasional cobbles were also encountered within this till layer. This till layer was encountered at depths ranging from 0.2 to 3.7 m (elev. 180.2 to 184.9 m) and the boreholes were terminated in this layer at depths of 6.1 to 13.8 m (elev. 168.2 to 178.8 m).

SPT tests performed in the till layers gave N-Values between of 21 blows per 0.30 m of penetration to 100 blows per 0.05 m of penetration, indicating compact to very dense consistency. The SPT N-values were typically in the order of 100 blows.

The moisture content of the till layers ranged between 4% and 18%.

Gradation analyses were completed on selected samples of the till. The results are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curves for these samples are included in Figure B3 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Percentage (%)
Gravel	0 to 14
Sand	14 to 55
Silt	25 to 65
Clay	4 to 21

Atterberg Limit analyses were also completed on selected samples of the till. The results are summarized on the Record of Borehole sheets in Appendix A and the Atterberg Limit graphs for these samples are included in Figure B4 of Appendix B. The results of the laboratory tests indicate the till is low plasticity and is summarized as follows:

Parameter	Value (%)
Plastic Limit	10 to 12
Liquid Limit	17 to 23
Plasticity Index	7 to 11

Glacial tills inherently contain cobbles and boulders.

5.8 Groundwater Levels

Where present, water levels were observed in the open boreholes upon completion of the drilling. As outlined in Table 3-1, two standpipe piezometers were installed in boreholes SM08-02 and 07 to monitor groundwater levels. The measured groundwater levels are summarized in Table 5-1.

The values shown are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation events.

Table 5-1. Measured Groundwater Levels

Borehole	Date	Groundwater Level		Comment
		Depth (m)	Elevation (m)	
SM8-01	Sept. 06, 2012	dry	-	Open borehole
SM8-02	Oct. 16, 2012	5.0	179.6	Piezometer
	Jan. 3, 2013	4.8	179.8	Piezometer
SM8-03	Sept. 06, 2012	dry	-	Open borehole
SM8-04	Aug. 31, 2012	4.1	177.9	Open borehole
SM8-05	Aug. 31, 2012	4.9	177.4	Open borehole
SM8-06	Sept. 05, 2012	2.6	179.4	Open borehole
SM8-07	Oct. 16, 2012	3.5	179.8	Piezometer
	Jan. 3, 2013	2.7	180.6	Piezometer
SM8-08	Sept. 06, 2012	dry	-	Open borehole

5.9 Results of Analytical Testing

Two samples of the soils recovered from the boreholes at this site were submitted to AGAT Laboratories Limited for pH and soluble sulphate testing. The samples that were submitted are summarized below and the results are presented on the Certificate of Analysis included in Appendix B:

Location	Borehole	Sample	Depth (m)	Material
North Abutment	SM8-03	SS 5	4.6 – 5.2	Sand and Silt Till
Centre Pier	SM8-04	SS 6	4.6 – 4.9	Silty Sand Till

6 MISCELLANEOUS

Borehole locations were selected and marked in the field by an experienced Thurber staff member and were established with a Trimble Pathfinder ProXRT differential GPS unit. The co-ordinates and ground surface elevations at the boreholes were surveyed by MMM Group Limited upon completion of drilling.

DBW Drilling from Ajax, Ontario supplied both the truck mounted CME75 and a track mounted B57 drill rigs and conducted the drilling, sampling and in-situ testing operations.

The field investigation was supervised on a full time basis by Mr. Stephane Loranger. C.E.T. of Thurber. Overall supervision of the investigation program was conducted by Ms. Lindsey Blaine, E.I.T.

Routine laboratory testing was carried out by Thurber's geotechnical laboratory in Oakville, Ontario. Interpretation of the data and preparation of this report were carried out by Mr Stephen Peters, P.Eng(MB) and Mr Alastair Gorman, P.Eng.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This section of the report provides an interpretation of the factual data and also presents geotechnical recommendations for design of the realigned Brock Road underpass. The plans and profiles used for preparation of this report were provided by MMM Group Limited.

The proposed underpass structure, as shown on the General Arrangement (GA) drawing dated July 2012, is a two span structure with a total span length of 80.0 m and deck width of 32.7 m to carry six lanes of traffic. The abutments are proposed to be supported on H-Piles. To elevate the structure over Hwy 407 East Extension, the height of the approach embankments will be approximately 5.8 to 8.5 m above the existing ground surface at the north and south approaches, respectively. Additionally, the undersides of the abutments are proposed at elevation 186.66 and 187.22 m for the north and south abutment, respectively. A false integral abutment structure is proposed.

8 STRUCTURE FOUNDATIONS

In general terms, the site was found to be underlain by very dense glacial till comprised of predominantly sand and silt with some clay, trace gravel and occasional cobbles. The till was covered by either: a surficial layer of organics north of Hwy 7 alignment, asphalt and granular fill within Hwy 7 alignment or organics followed by clayey silt fill and native clayey silt, south of Hwy 7 alignment.

The groundwater level at the site was measured at 2.6 to 4.9 m (elevation 177.4 to 179.4) below the ground surface at completion of drilling.

Consideration was given to the following foundation types:

- Spread footings:
  - bearing on native soil
  - bearing on engineered fill
- Augered caissons (drilled shafts)
- Driven steel H-piles

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

8.1 Spread Footings Bearing on Native Soil

The existing fill and the native silty clay to clayey silt soils are not considered to be suitable for the support of spread footings and the footings must be placed on the underlying dense to very dense sand and silt till. The design of spread footings bearing on undisturbed native dense to very dense sand and silt till must be in accordance with the elevations and geotechnical resistance at factored Ultimate Limit States (ULS_f) and geotechnical resistance at Serviceability Limit States (SLS) as provided in Table 8-1 for an assumed minimum footing width of 3 m.

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

Locations	Highest Founding Elevation (m)	Factored ULS_f Resistance (kPa)	SLS Resistance (kPa)
North Abutment (SM8-02 & 03)	182.5	600	400
Pier (SM8-04 & 05)	177.5	600	400
South Abutment (SM8-06 & 07)	178.5	600	400

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 reduced in accordance with 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 15 mm across the width of the structure or the span from pier to abutment.

Founding elevations presented in Table 8-1 are near 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. Excavations and backfilling of the foundation should be carried out in accordance with OPSS 902.

The horizontal resistance against sliding between cast-in-place concrete founded on undisturbed sand and silt till can be computed using an ultimate friction factor of 0.55.

8.2 Spread Footings Bearing on Engineered Fill

If higher founding elevations are required, than those shown in Table 8-1, spread footings could be constructed on engineered fill pad consisting of Granular "A" material. This option would be suitable for abutment footings which may be perched within the approach embankment and above the existing ground surface elevation.

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. The engineered fill must bear on native dense to very dense sand and silt till and the highest permitted base elevation, 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	Highest Founding Elevation (m)	Factored ULS_f Resistance (kPa)	SLS Resistance (kPa)
North Abutment (SM8-02 & 03)	183.5	700	350
Pier (SM8-04 & 05)	180.0		
South Abutment (SM8-06 & 07)	180.0		

The geotechnical resistances shown in Table 8-2 are based on footings founded on a minimum 2.0 m thick layer of engineered granular fill and an assumed minimum footing width of 3 m. Additionally, the resistance values shown are for concentric, vertical loads only. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with 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 15 mm across the width of the structure or the span from pier to abutment.

The Granular "A" pad must be placed in 150 mm lifts and compacted to 100% Standard proctor maximum dry density (SPMDD) at optimum moisture content ±2%. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

The horizontal resistance against sliding between cast-in-place concrete founded on engineered fill can be computed using an ultimate friction factor of 0.60.

8.3 Caissons

Augered caissons, 1.2 m in diameter, founded at a minimum of 3 m into the “100-blow” sand and silt till, at or below elevation shown in Table 8-3, are considered a feasible foundation alternative for the abutments and pier. The base of the caissons will be below the groundwater level, which may result in some difficulties in dewatering, base cleaning and base inspection. Construction of the caissons will require the use of a sealed liner and/or slurry methods to control groundwater and to support the sidewalls of the shaft. The presence of cobbles and boulders within the till may cause difficulty for drilling operations. For these reasons, caissons are not recommended in these soil conditions.

Table 8-3. Founding Elevation and Axial Resistance for Caissons

<table>
<tr><th>Locations</th><th>Highest Caisson Founding Elevation (m)</th><th>Factored ULS$_f$ Resistance (kN)</th><th>SLS Resistance (kN)</th></tr>
<tr><td>North Abutment
(SM8-02 & 03)</td><td>180.0</td><td rowspan="3">4000</td><td rowspan="3">3200</td></tr>
<tr><td>Pier
(SM8-04 & 05)</td><td>175.5</td></tr>
<tr><td>South Abutment
(SM8-06 & 07)</td><td>176.0</td></tr>
</table>

8.4 Steel H-Pile Foundations

The soil stratigraphy encountered at this site is also considered to be suitable for the support of foundations on driven steel piles. Steel H-piles (HP 310x110) driven to refusal within the “100-blow” sand and silt till, may be designed for the geotechnical resistances presented in Table 8-4 based on the tip elevations shown.

Table 8-4. Recommended Axial Resistance for Steel H-Piles

<table>
<tr><th>Locations</th><th>Approximate Pile Tip Elevation (m)</th><th>Factored ULS Resistance (kN)</th><th>SLS Resistance (kN)</th></tr>
<tr><td>North Abutment
(SM8-02 & 03)</td><td>At or Below
179.0</td><td rowspan="3">1800</td><td rowspan="3">1600</td></tr>
<tr><td>Pier
(SM8-04 & 05)</td><td>At or Below
174.0</td></tr>
<tr><td>South Abutment
(SM8-06 & 07)</td><td>At or Below
179.0</td></tr>
</table>

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 possible presence of cobble and boulders, the tips of all driven piles must be reinforced. This can be achieved by fitting the piles with steel H-pile 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 design load at ULS.

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

8.4.3 Downdrag

Downdrag on the piles is not considered to be an issue at this site, since the till is dense to very dense in consistency 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.

If an integral abutment design is adopted, the piles must be placed in concentric CSPs as described in the requirements for an MTO integral abutment design.

8.4.5 Pile Lateral Resistance

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

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

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

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 till)
γ = 10 kN/m^3 (unit weight)

γ_w = 10 kN/m^3 (submerged unit weight below water table)
K_p = passive earth pressure coefficient
= 3.9 (for dense to very dense till)

The above equations and recommended parameters may be used to analyze 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, $K_s = k_s$ x L x D (kN/m), where L is the length (m) of the pile segment or element used in the analysis and remaining variables are as defined earlier. The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}$ x L x 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 ULS_f and 50 kN at SLS.

The modulus of subgrade reaction may have to be reduced due to pile interaction, based on the center-to-center 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 8-5. Reduction of Subgrade Reaction Factors based on Pile Spacing

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 width of pile

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 very dense sand and silt till. The recommended pier foundation is a spread footing founded at elev. 177.5 m.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the boreholes drilled within the approach areas (SM8-01 & 08), the embankments will be constructed on very stiff clayey silt (fill and native) and very dense sand and silt till. The 5.8 to 8.5 m high embankments should be stable at side slopes of 2H:1V (or flatter) if constructed using SSM or granular fill. Provided proper construction methods are used, no long term settlement or global stability issues are anticipated for approach embankments built at this site.

10 EXCAVATION AND GROUNDWATER CONTROL

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the sand fill forming the existing Hwy 7 embankment may be classified as Type 3 soils. The native soils above the till may also be classed as Type 3 soils. The underlying till is a Type 2 soil.

The sides of temporary excavations must be sloped in accordance with the requirements of the OHSA. Where space does not permit the sides to be sloped, roadway protection must be used.

Based on the preliminary GA, minor excavation below the groundwater level to construct the pier footing may be required. Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

The design of the dewatering system, that may be 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 must be done in the dry. Unwatering 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 backfill to the abutment walls must be Granular A or 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 1
- 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 foundations soils was assessed using the Seed and Idriss (1971) method1. Using this method, it is estimated that under the existing conditions the foundation soils are not prone to liquefaction.

[1] Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 101, No. SM9, September, pp. 1249-1273.

The existing 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

If roadway protection is required, it 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 unit weight)
γ_w	=	10 kN/m^3	(submerged unit weight under groundwater table)
K_a	=	0.33	(Active pressure coefficient for road embankment fill)
	=	0.26	(Active pressure coefficient for till)
K_p	=	3.0	(Passive pressure coefficient for road embankment fill)
	=	3.9	(Passive pressure coefficient for till)
h_w	=	179.4 m	(elevation for hydrostatic pressure build-up behind temporary shoring)

The design of roadway protection is 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 must be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

Temporary groundwater and surface water control measures will be required during construction.

15 CONSTRUCTION CONCERNS

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

- Potential variability of pile lengths due to the presence of probable cobbles/boulders and very dense till. It is possible that piles will achieve refusal at limited depths. If design requires longer piles, pre-augering will be required.
- Excavation below the water level, if required, will involve lowering of the groundwater level below the excavation base to maintain a reasonably dry excavation and stable side slopes.

- Roadway protection must be provided to maintain traffic during construction. Temporary shoring systems should be properly designed by a Professional Engineer experienced in such designs.
- The side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, erosion control measures must be implemented.

The successful performance of the underpass will depend largely upon good workmanship and quality control during construction. Pile driving supervision, subgrade examination and field density testing should be carried out by qualified geotechnical personnel during construction to confirm that foundation recommendations are correctly implemented and material specifications are met.

16 CLOSURE

Engineering analysis and preparation of the report was carried out by Mr Stephen Peters P.Eng(MB) and 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.

Stephen Peters, P.Eng(MB)
Geotechnical Engineer

Alastair Gorman, P.Eng.
Senior Foundation Engineer

P. K. Chatterji, P.Eng.
Review Principal

Appendix A

Record of Borehole Sheets

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM8-01

METRIC

WP#	E2-2012	LOCATION	N 4 864 382.7 E 337 059.3	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.06 - 2012.09.06	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
185.1									
0.0	**ORGANICS**, with rotos and rootlets: (175mm)								
0.2	Silty **SAND**, some gravel, trace clay, occasional cobbles Very Dense Brown Moist (TILL)								
		1	SS	100/ 0.100	○				
		2	SS	100/ 0.250	○				
		3	SS	100	○	14	52	25	8
		4	SS	100/ 0.150	○				
		5	SS	15/ 0.150	○				
		6	SS	100/ 0.250	○				
178.8 / 6.3	END OF BOREHOLE AT 6.3m. BOREHOLE OPEN AND NO WATER AFTER COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.6m, THEN CUTTINGS TO SURFACE.								

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (185, 184, 183, 182, 181, 180, 179); 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

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-02

METRIC

WP#	E2-2012	LOCATION	N 4 864 380.0 E 337 077.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.07 - 2012.09.07	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
184.6									
0.0	**ORGANICS**, with roots and rootlets: (175mm)								
0.2	**SAND and SILT**, trace gravel, trace clay, occasional cobbles Dense to Very Dense Brown Moist (TILL)	1	SS	38	○				
		2	SS	100/ 0.225	○				
		3	SS	100/ 0.175	○	6	55	35	4
		4	SS	100/ 0.150	○				
		5	SS	100/ 0.075	○				
179.3 / 5.3	**SAND and GRAVEL**, some fines, occasional cobbles Very Dense Grey Wet	6	SS	100	○	49	39	12 (SI+CL)	
176.7 / 7.9	Sandy **SILT**, some clay, trace gravel Very Dense Grey Moist (TILL)	7	SS	76	○ ○				
		8	SS	100/ 0.250	○				

Elevation scale: 184, 183, 182, 181, 180 (groundwater level ▼ at approx. 180), 179, 178, 177, 176, 175

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

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SM8-02

METRIC

WP#	E2-2012	LOCATION	N 4 864 380.0 E 337 077.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.07 - 2012.09.07	CHECKED BY	LRB

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page									
					174					
		9	SS	100/ 0.250			0	31	52	18
					173					
172.2		10	SS	100/ 0.075						
12.4	END OF BOREHOLE AT 12.4m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.									

Column headings: SOIL PROFILE; STRAT PLOT; 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

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Sep. 24/12	Dry	
Oct. 16/12	5.0	179.6
Jan. 03/13	4.8	179.8

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-03

METRIC

WP# E2-2012 | LOCATION N 4 864 359.2 E 337 065.1 | ORIGINATED BY SLL

HWY 407 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2012.09.06 - 2012.09.06 | CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
184.6							
0.0	**ORGANICS**, with roots and rootlets: (150mm)						
0.2	Gravelly **SAND**, some fines, occasional cobbles, Very Dense, Brown, Moist (TILL)				184		
		1	SS	100/0.200		○	26 52 21 (SI+CL)
		2	SS	100/0.250	183	○	
		3	SS	100/0.150	182	○	
		4	SS	100/0.150		○	
	Gravel, sandy seam				181		
180.9 / 3.7	**SAND and SILT**, some clay, trace gravel, occasional cobbles, Very Dense, Brown to Grey, Moist (TILL)				180		
		5	SS	100/0.150	179	○	
		6	SS	100/0.175	178	○ ⊢⊣	0 44 37 20
		7	SS	100/0.150	177	○	
		8	SS	100/0.200	176, 175	○	

Chart headings: 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; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM8-03

METRIC

WP#	E2-2012	LOCATION	N 4 864 359.2 E 337 065.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.06 - 2012.09.06	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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
							174				
173.6			9	SS	100/ 0.150				○		
11.0	END OF BOREHOLE AT 11.0m.										

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-04

METRIC

WP# E2-2012 LOCATION N 4 864 352.5 E 337 103.7 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.08.31 - 2012.08.21 CHECKED BY LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
182.0						182						
0.0	**ASPHALT:** (140mm)											
0.1	**SAND**, some gravel, trace silt Compact to Very Dense Brown Moist (FILL)	1	SS	24			~42					
		2	SS	61		181	~7					
180.6 1.4	Silty **SAND**, some clay, trace gravel, occasional cobbles Compact to Very Dense Brown Moist (TILL)	3	SS	37		180	~4		3	51	32	14
		4	SS	52			~7					
		5	SS	42		179	~8					
					∇ (178.0)	178						
	Grey	6	SS	100/ 0.200		177	~7					
		7	SS	66		176	~8					
		8	SS	21		175 / 174	~9 (wP–wL plotted)		7	43	30	20
		9	SS	58		173	~12					

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 wP — NATURAL MOISTURE CONTENT w — LIQUID LIMIT wL; WATER CONTENT (%) 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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 SM8-04

METRIC

WP#	E2-2012	LOCATION	N 4 864 352.5 E 337 103.7	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.31 - 2012.08.21	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 (%)

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT	GR	SA	SI	CL
	Continued From Previous Page												
172.0 10.1	**SILT**, some sand, some clay, trace gravel Very Dense Grey Moist (TILL)						172						
			10	SS	100/ 0.250			○					
							171						
							170						
			11	SS	100/ 0.150			○		0	14	65	21
							169						
168.2 13.8	END OF BOREHOLE AT 13.8m. BOREHOLE OPEN TO 8.0m AND WATER LEVEL AT 4.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.0m, THEN CUTTINGS TO 0.8m, THEN CONCRETE TO 0.15m, THEN ASPHALT TO SURFACE.		12	SS	100/ 0.100			○					

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+ ³, × ³: Numbers refer to Sensitivity

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Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-05

METRIC

WP#	E2-2012	LOCATION	N 4 864 327.2 E 337 086.1	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.08.31 - 2012.08.31	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
182.3											
0.0	**ASPHALT:** (125mm)										
0.1	**SAND**, some gravel, Dense, Brown, Moist, (FILL)	1	SS	40		182	~1				
181.5 / 0.8	Sandy **SILT**, trace gravel, Dense, Brown, Moist, (FILL)	2	SS	32			~4				
181.0 / 1.4	Silty **SAND**, some clay, trace gravel, occasional cobbles, Very Dense, Brown, Moist, (TILL)	3	SS	42		181	~4 (with plastic/liquid limit bar)	4	43	37	17
		4	SS	45		180	~5				
		5	SS	100/ 0.225		179	~4				
	Grey	6	SS	100/ 0.150	▽	178	~4				
		7	SS	130/ 0.275		177, 176	~11	1	45	34	20
		8	SS	100/ 0.150		175	~7				
173.0		9	SS	100/ 0.150		174	~9				
9.3	END OF BOREHOLE AT 9.3m. BOREHOLE OPEN TO 8.6m AND WATER LEVEL AT 4.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH										

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × 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

Continued Next Page

+³, ×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 SM8-05

METRIC

WP# E2-2012 LOCATION N 4 864 327.2 E 337 086.1 ORIGINATED BY SLL

HWY 407 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2012.08.31 - 2012.08.31 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										
	BENTONITE HOLEPLUG TO 0.8m, THEN CUTTINGS TO 0.6m, THEN CONCRETE TO 0.15m, THEN ASPHALT TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-06

METRIC

WP#	E2-2012	LOCATION	N 4 864 322.2 E 337 130.7	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.05 - 2012.09.05	CHECKED BY	LRB

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
182.1 / 0.0	**ORGANICS**, with roots and rootlets, Black (250mm)									
181.8 / 0.3	Silty **CLAY**, topsoil stained, Hard, Dark Brown, Moist	1	SS	41						
180.7 / 1.4	**SAND and SILT**, some clay, trace gravel, Very Dense, Brown, Moist (TILL)	2	SS	80			2	43	36	19
		3	SS	86	▽					
		4	SS	100/ 0.200						
	Grey	5	SS	100/ 0.150						
		6	SS	100/ 0.075						
	Moist to Wet, Occasional cobbles	7	SS	100/ 0.100						
		8	SS	100/ 0.275			3	46	37	14

Elevation scale: 182, 181, 180, 179, 178, 177, 176, 175, 174, 173

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 (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM8-06

METRIC

WP#	E2-2012	LOCATION	N 4 864 322.2 E 337 130.7	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.05 - 2012.09.05	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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						172				
171.3			9	SS	100/ 0.150				○		
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE OPEN TO 7.4m AND WATER LEVEL AT 2.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.5m AND CUTTINGS TO SURFACE.										

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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No SM8-07

METRIC

WP#	E2-2012	LOCATION	N 4 864 298.0 E 337 111.7	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.05 - 2012.09.05	CHECKED BY	LRB

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
183.3	
0.0	**ORGANICS**, with roots and rootlets
0.2	Clayey **SILT**, trace gravel Very Stiff Brown Moist (FILL)
182.1 / 1.2	Clayey **SILT**, topsoil stained, trace rootlets Dark Brown Moist
181.8 / 1.5	Silty **SAND**, some clay, trace gravel, occasional rootlets Very Dense Brown Moist (TILL) Grey
174.0 / 9.3	END OF BOREHOLE AT 9.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.

SAMPLES

NUMBER	TYPE	"N" VALUES	Water content (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	29		
2	SS	43		
3	SS	72		3 46 33 18
4	SS	63		
5	SS	100/ 0.275		
6	SS	100/ 0.025		
7	SS	100/ 0.150		4 42 34 20
8	SS	100/ 0.150		

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (183, 182, 181, 180, 179, 178, 177, 176, 175); 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.

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SM8-07

METRIC

WP#	E2-2012	LOCATION	N 4 864 298.0 E 337 111.7	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.05 - 2012.09.05	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)
Oct. 16/12	3.4	179.9
Oct. 26/12	2.8	180.5
Nov. 26/12	2.7	180.6
Dec. 19/12	2.5	180.8
Jan. 03/13	2.7	180.6

ONTMT4S 1130A.GPJ 1/17/13

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No SM8-08

METRIC

WP#	E2-2012	LOCATION	N 4 864 301.0 E 337 130.4	ORIGINATED BY	SLL
HWY	407	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2012.09.06 - 2012.09.06	CHECKED BY	LRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
183.2									
0.0 / 0.2	**ORGANICS**, with roots and rootlets: (150mm)								
	Clayey **SILT**, trace gravel, topsoil stained, Very Stiff, Brown, Moist (FILL)	1	SS	28					
181.7 / 1.5	Clayey **SILT**, trace gravel, with rootlets, topsoil stained, Very Stiff, Dark Brown, Moist	2	SS	21					
		3	SS	25					
180.2 / 3.0	**SAND and SILT**, some clay, trace gravel, Very Dense, Brown, Moist (TILL)	4	SS	100/0.250		3	45	36	16
		5	SS	100/0.200					
177.1 / 6.1		6	SS	100/0.050					

END OF BOREHOLE AT 6.1m.
BOREHOLE OPEN AND DRY ON COMPLETION.
BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, THEN CUTTINGS TO SURFACE.

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (183, 182, 181, 180, 179, 178); 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

Appendix B

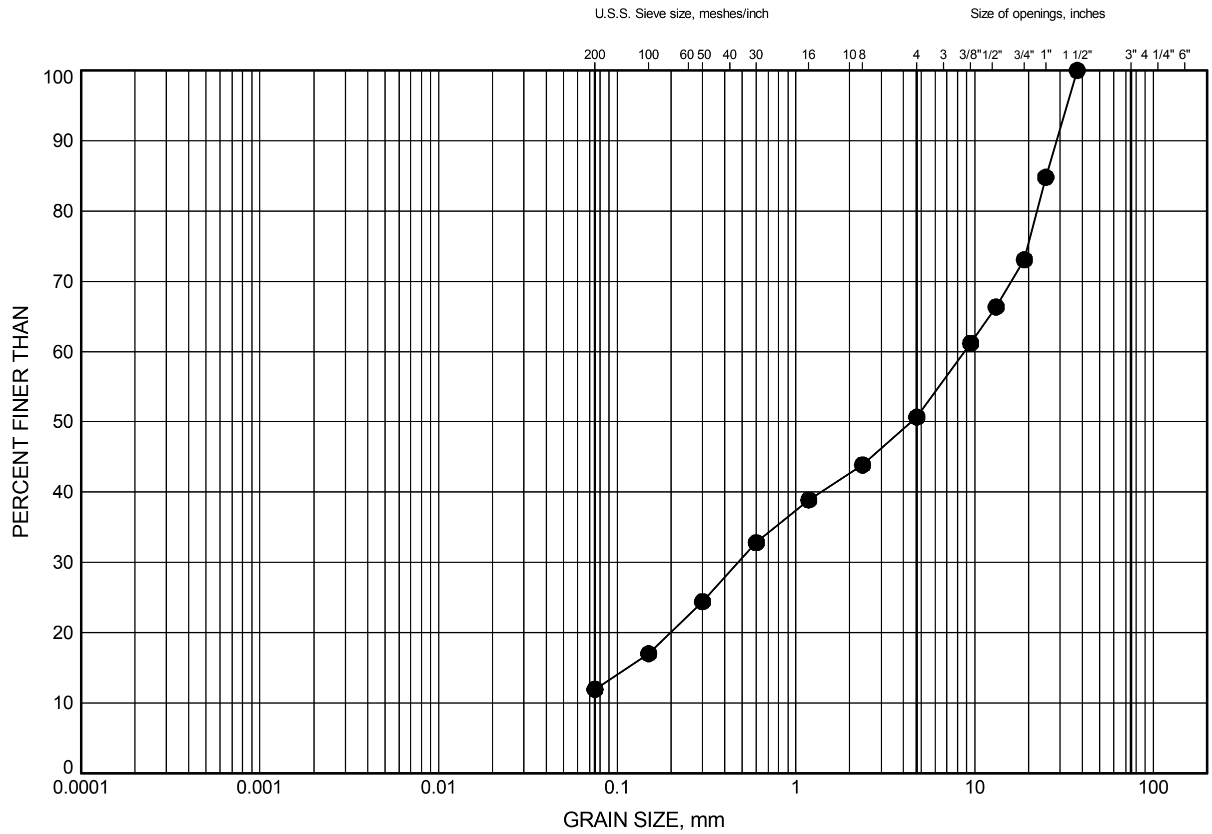
Laboratory Test Results

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B1-1

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM8-02	6.32	178.28

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 28/11/12

Date November 2012

W.P.# E2-0212

THURBER

Prep'd SBP

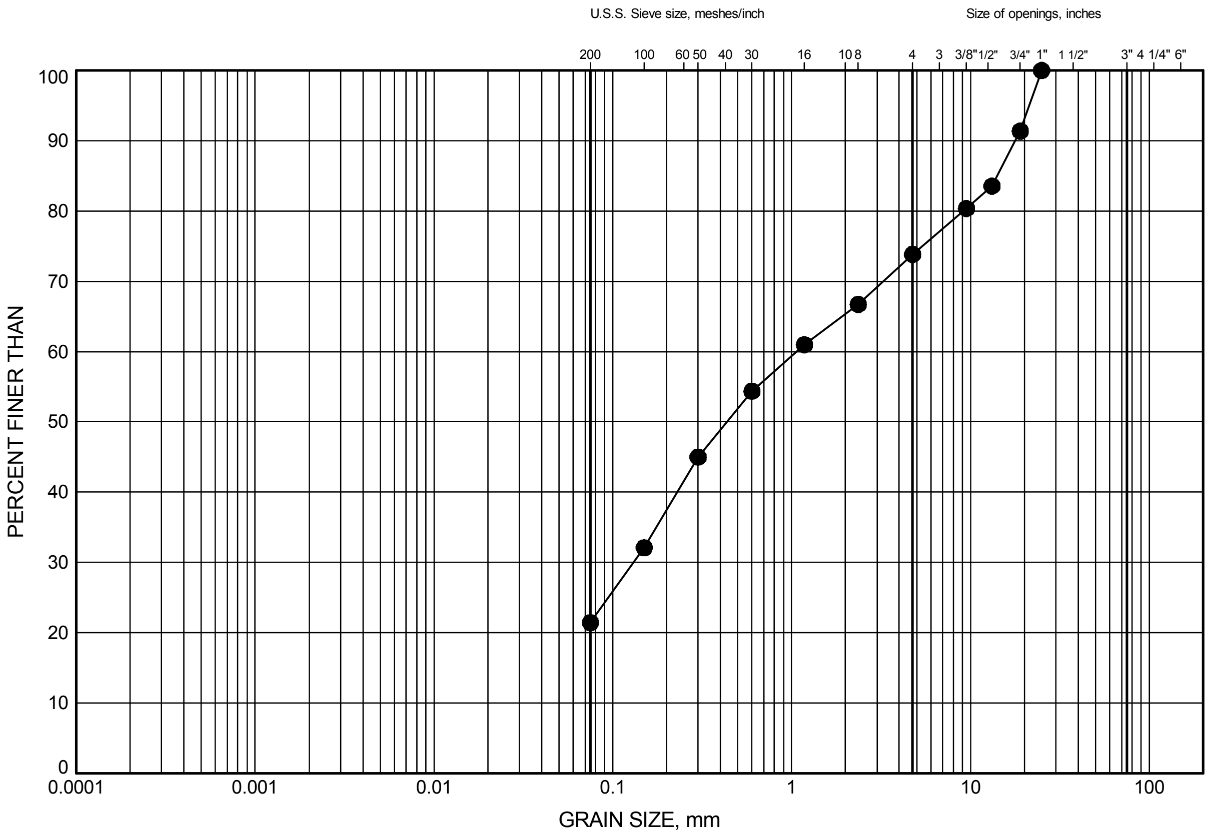
Chkd.

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B2-1

Gravelly Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM8-03	0.94	183.66

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 28/11/12

Date November 2012

W.P.# E2-0212

THURBER

Prep'd SBP

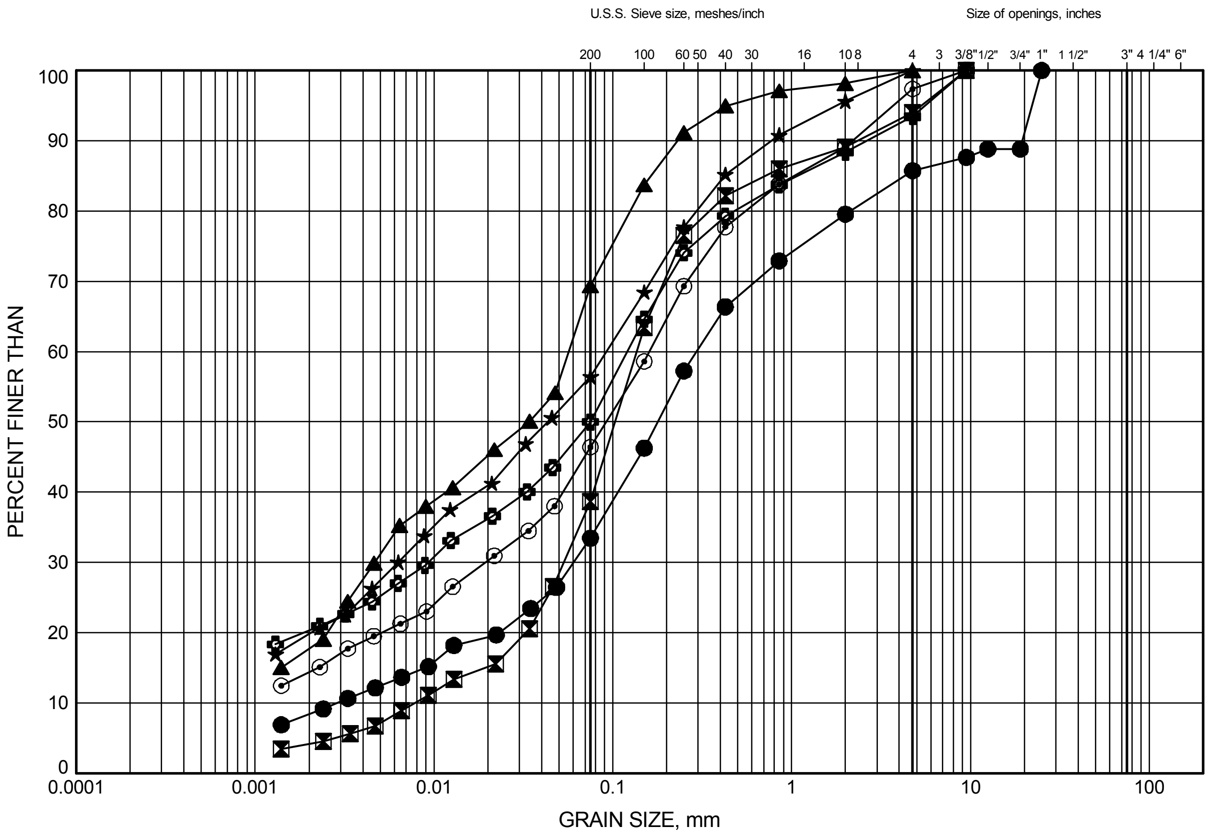
Chkd.

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3-1

Silt to Sand and Silt 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)
●	SM8-01	2.44	182.66
⧗	SM8-02	2.45	182.15
▲	SM8-02	10.87	173.73
★	SM8-03	6.26	178.34
⊙	SM8-04	1.83	180.20
✿	SM8-04	7.92	174.10

GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 28/11/12

Date November 2012

W.P.# E2-0212

THURBER

Prep'd SBP

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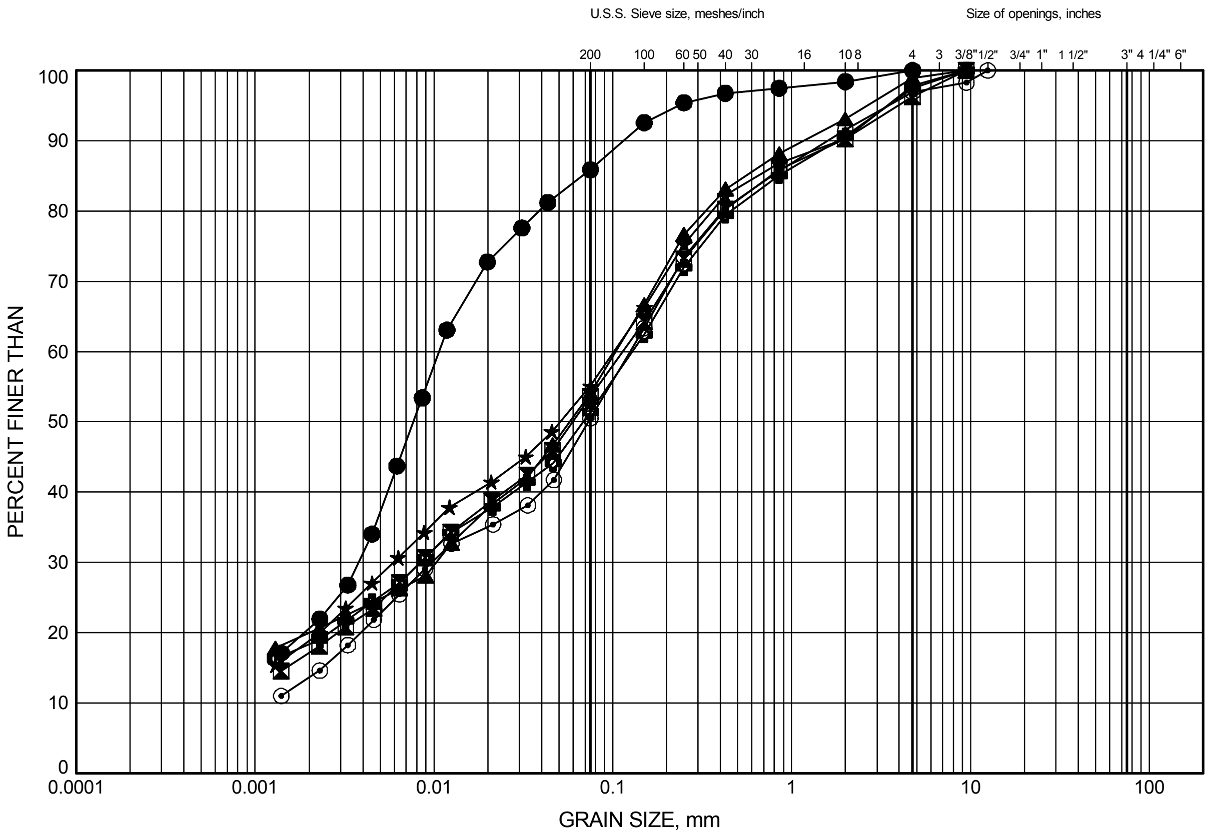
Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3-2

Silt to Sand and Silt 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)
●	SM8-04	12.27	169.76
⧗	SM8-05	1.83	180.51
▲	SM8-05	6.30	176.03
★	SM8-06	1.78	180.32
⊙	SM8-06	9.36	172.74
✿	SM8-07	2.59	180.71

Date November 2012

W.P.# E2-0212

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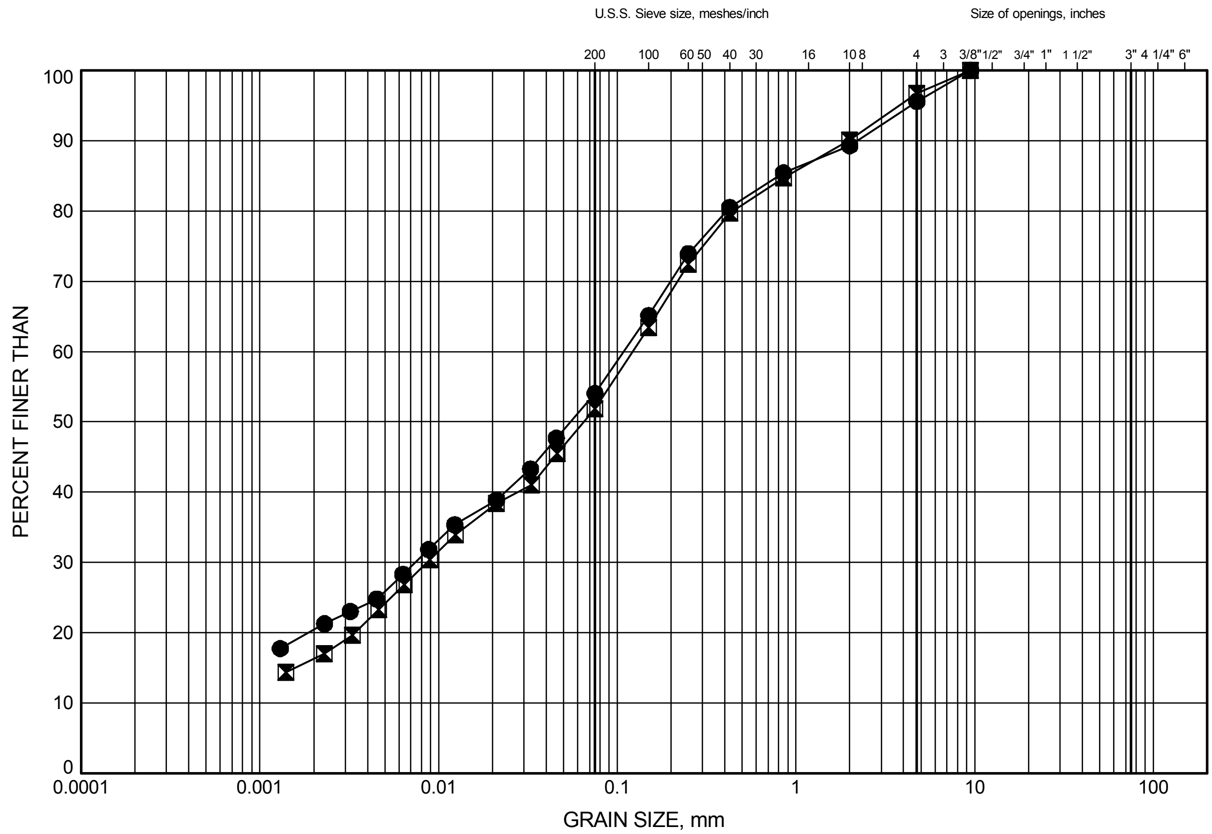
GRAIN SIZE DISTRIBUTION - THURBER 1130A.GPJ 28/11/12

Hwy 407 Brock Road Connection - Foundations

GRAIN SIZE DISTRIBUTION

FIGURE B3-3

Silt to Sand and Silt 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)
●	SM8-07	7.77	175.53
⧗	SM8-08	3.25	179.95

Date November 2012

W.P.# E2-0212

THURBER

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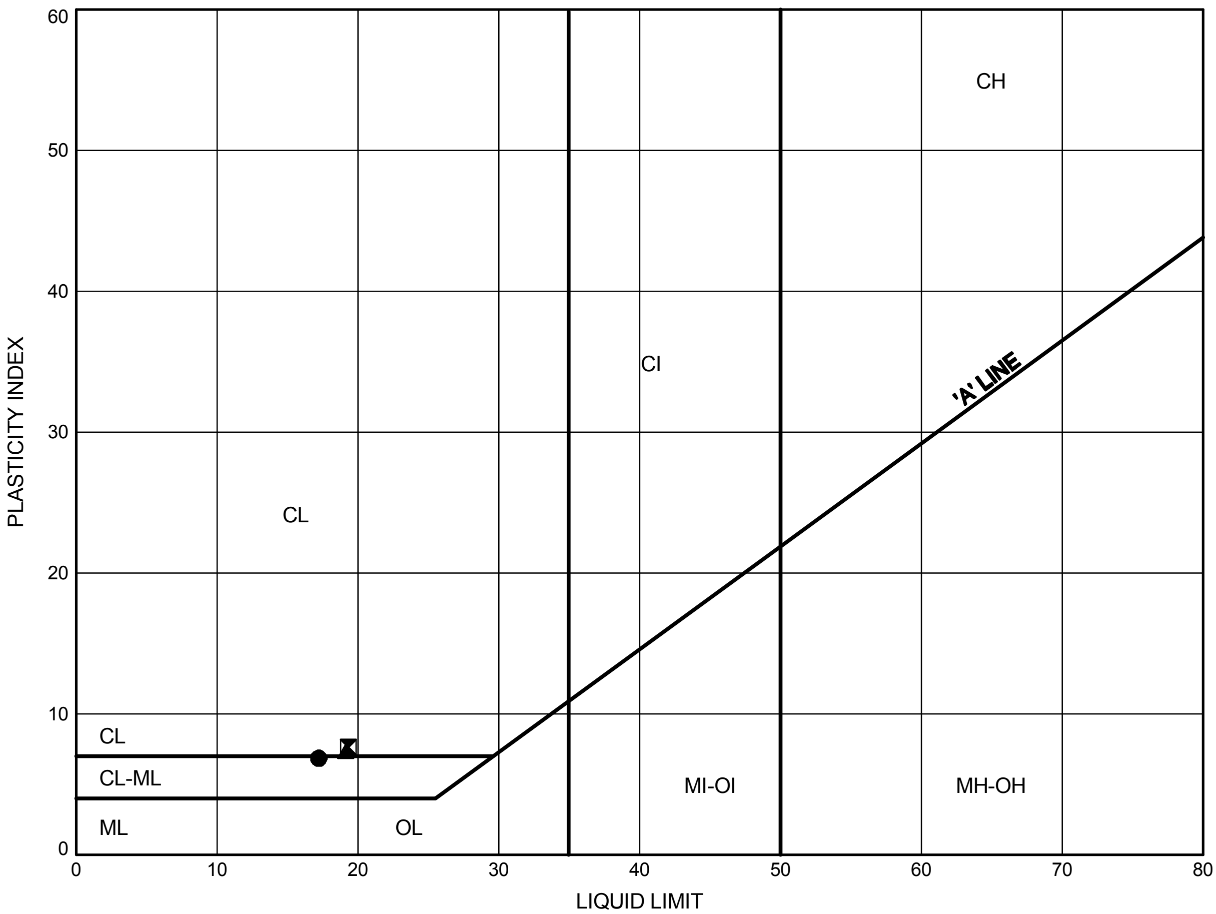
Hwy 407 Brock Road Connection - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-1

Silt to Sand and Silt to Silty Sand Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM8-06	9.36	172.74
⧗	SM8-07	2.59	180.71
▲	SM8-08	3.25	179.95

Date November 2012

W.P.# E2-0212

THURBER

Prep'd SBP

Chkd.

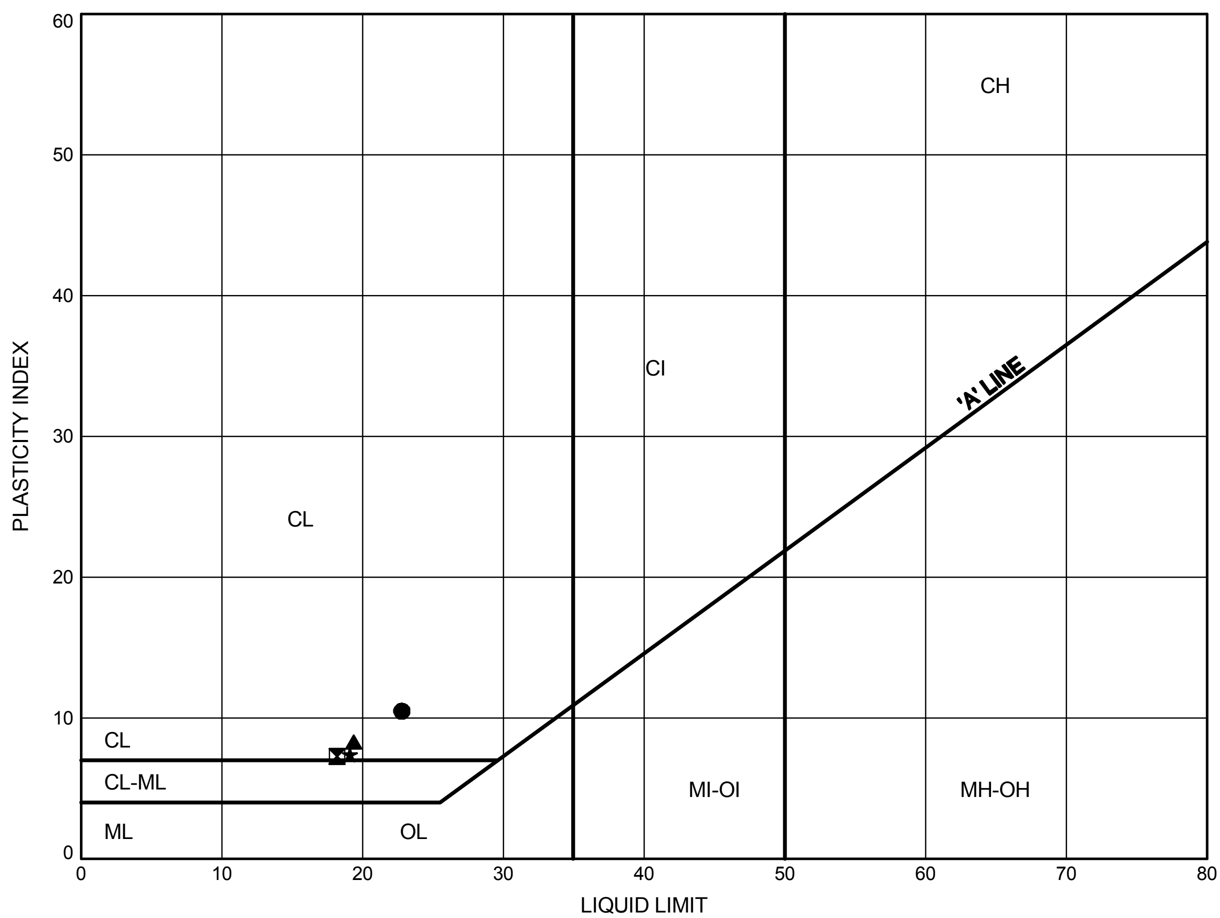
THURBALT 1130A.GPJ 28/11/12

Hwy 407 Brock Road Connection - Foundations

ATTERBERG LIMITS TEST RESULTS

FIGURE B4-1

Silt to Sand and Silt to Silty Sand Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SM8-02	10.87	173.73
⧗	SM8-03	6.26	178.34
▲	SM8-04	7.92	174.10
★	SM8-05	1.83	180.51

Date November 2012

W.P.# E2-0212

THURBER

Prep'd SBP

Chkd.

THURBALT 1130A.GPJ 28/11/12

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666

ATTENTION TO: Lindsey Blaine

PROJECT NO: 19-5161-130A

AGAT WORK ORDER: 13T677837

SOIL ANALYSIS REVIEWED BY: Elizabeth Polakowska, MSc (Animal Sci), PhD (Agri Sci), Inorganic Lab Supervisor

TRACE ORGANICS REVIEWED BY: Oksana Gushyla, Analyst

DATE REPORTED: Jan 11, 2013

PAGES (INCLUDING COVER): 6

VERSION*: 3

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES
VERSION 3:
Revised Report - pH added to analysis (January 17th 2013)
Reporting only Sulphate and pH (January 18th 2013)

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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AGAT Laboratories

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 Rolakowska

AGAT Laboratories

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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 Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits 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:

AGAT Laboratories
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Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD — AGAT WORK ORDER: 13T677837

PROJECT NO: 19-5161-130A — ATTENTION TO: Lindsey Blaine

Trace Organics Analysis

RPT Date: Jan 11, 2013			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
O. Reg. 153(511) - PAHs (Soil)															
Naphthalene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	98%	50%	140%	96%	50%	140%	97%	50%	140%
Acenaphthylene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	104%	50%	140%	97%	50%	140%	93%	50%	140%
Acenaphthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	99%	50%	140%	96%	50%	140%	91%	50%	140%
Fluorene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	102%	50%	140%	99%	50%	140%	92%	50%	140%
Phenanthrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	94%	50%	140%	94%	50%	140%	93%	50%	140%
Anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	96%	50%	140%	92%	50%	140%	93%	50%	140%
Fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	87%	50%	140%	93%	50%	140%	98%	50%	140%
Pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	90%	50%	140%	97%	50%	140%	92%	50%	140%
Benz(a)anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	85%	50%	140%	84%	50%	140%	81%	50%	140%
Chrysene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	91%	50%	140%	98%	50%	140%	83%	50%	140%
Benzo(b)fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	104%	50%	140%	85%	50%	140%	84%	50%	140%
Benzo(k)fluoranthene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	109%	50%	140%	99%	50%	140%	83%	50%	140%
Benzo(a)pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	106%	50%	140%	82%	50%	140%	91%	50%	140%
Indeno(1,2,3-cd)pyrene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	93%	50%	140%	81%	50%	140%	80%	50%	140%
Dibenz(a,h)anthracene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	90%	50%	140%	79%	50%	140%	78%	50%	140%
Benzo(g,h,i)perylene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	93%	50%	140%	86%	50%	140%	91%	50%	140%
2-and 1-methyl Naphthalene	1	4058640	< 0.05	< 0.05	0.0%	< 0.05	105%	50%	140%	98%	50%	140%	95%	50%	140%

Certified By:

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Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 13T677837

PROJECT NO: 19-5161-130A

ATTENTION TO: Lindsey Blaine

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	pH METER
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Trace Organics Analysis			
Naphthalene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Acenaphthylene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Acenaphthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Fluorene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Phenanthrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benz(a)anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Chrysene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(b)fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(k)fluoranthene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(a)pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Indeno(1,2,3-cd)pyrene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Dibenz(a,h)anthracene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Benzo(g,h,i)perylene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
2-and 1-methyl Naphthalene	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS
Moisture Content	Org 5506	EPA SW-846 3540 & 8270	BALANCE
Chrysene-d12	ORG-91-5106	EPA SW846 3541 & 8270	GC/MS

Appendix C

Foundation Comparison

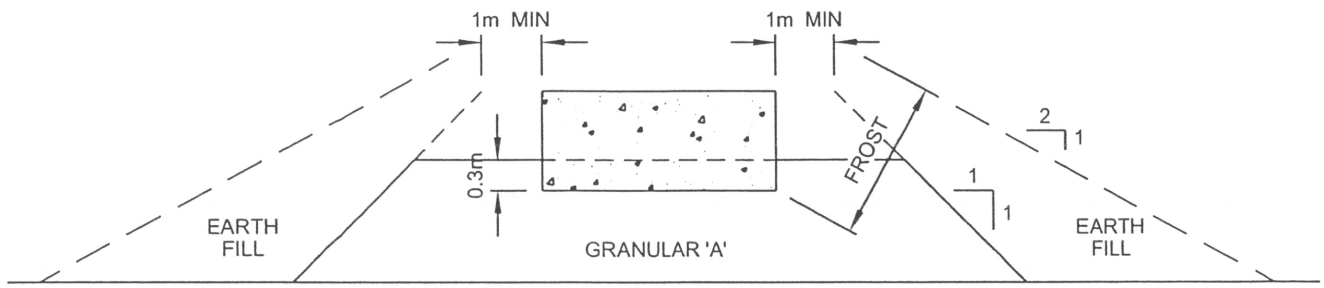
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

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. ii. Lesser depth of excavation is required compared to footings on native fill	***Advantages:*** i. Construction of caissons could continue in freezing weather.	***Advantages:*** i. Higher geotechnical resistances can be achieved if piles are driven into the dense glacial till ii. Installation of piles could continue in freezing weather iii. Foundation construction may require less volume of excavation than footings. iv. Required for integral abutment
Disadvantages: i. Excavation to base of foundation is required for footing construction. ii. Dewatering will be required.	***Disadvantages:*** i. 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.
RECOMMENDED FOR PIER	**FEASIBLE AT THE ABUTMENTS**	**NOT RECOMMENDED**	**RECOMMENDED AT THE ABUTMENTS**

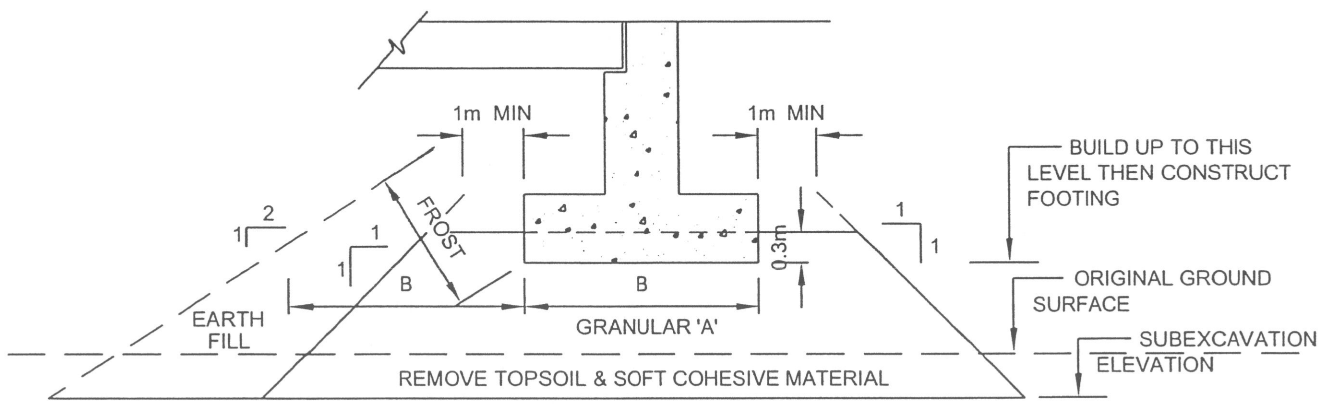
Appendix D

Figure 1, Abutment on Compacted Fill

March , 2004



CROSS-SECTION



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ENGINEER AEG	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE	THURBER
DRAWN SS		
DATE April , 2004		
APPROVED PKC		
SCALE NTS		DWG. NO. FIGURE 1

TED35146.DWG

Appendix E

List of SPs and OPSS, and Suggested Text for NSSP

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

- Special Provision 110S13
- OPSS 501
- OPSS 539
- OPSS 902
- OPSS 903
- OPSS 1010
- OPSD 3000.100
- OPSD 3101.150

2. Suggested text for a NSSP on Pile Installation

The presence of cobbles and boulders in the dense glacial till may potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- The cobbles and boulders may impede the driving of the piles resulting in more arduous driving in the very dense soils
- Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving
- As a result of the presence of boulders, piles may meet refusal at varying depths
- Pile driving must be controlled according to the criteria specified for the site

Appendix F

Borehole Locations and Soil Strata Drawings

CONTRACT No. E2-2012

HWY 407/BROCK ROAD INTERCHANGE

STRUCTURE M-8
REALIGNED BROCK ROAD
OVER HIGHWAY 407
BOREHOLE LOCATIONS AND SOIL STRATA

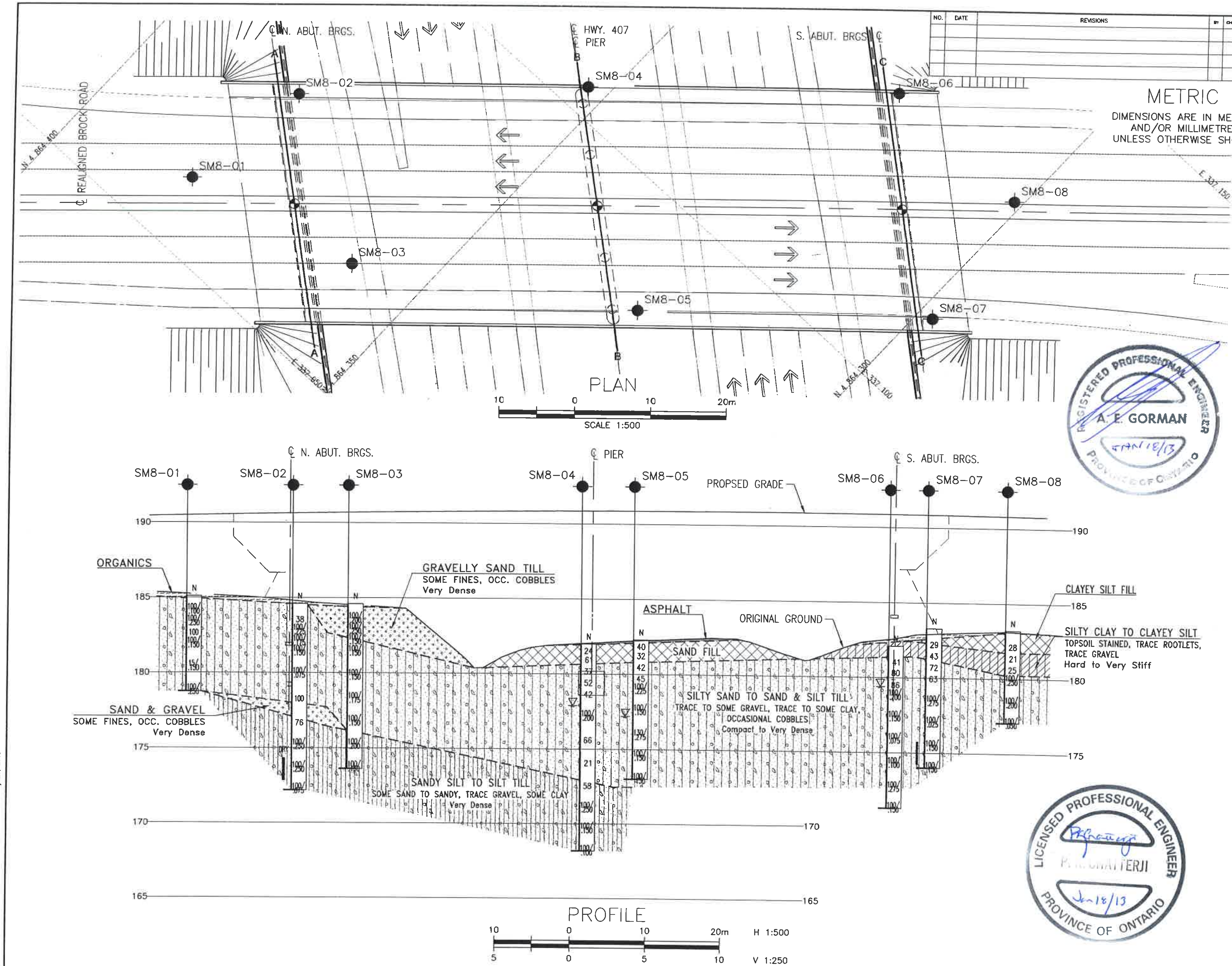
SHEET

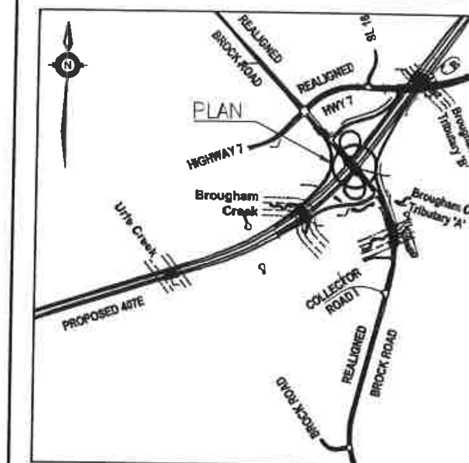
407 ETR Express Toll Route

MMM GROUP

THURBER ENGINEERING LTD.

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN





KEYPLAN

LEGEND

⯁	Borehole
⯁	Borehole and Cone
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
SM8-01	185.1	4 864 382.7	337 059.3
SM8-02	184.6	4 864 380.0	337 077.1
SM8-03	184.6	4 864 359.2	337 065.1
SM8-04	182.0	4 864 352.5	337 103.7
SM8-05	182.3	4 864 327.2	337 086.1
SM8-06	182.1	4 864 322.2	337 130.7
SM8-07	183.3	4 864 298.0	337 111.7
SM8-08	183.2	4 864 301.0	337 130.4

-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 SBP	CHK AEG	CODE	LOAD		DATE JAN. 2013
DRAWN MFA	CHK SBP	SITE	STRUCT M-8	DWG 1	

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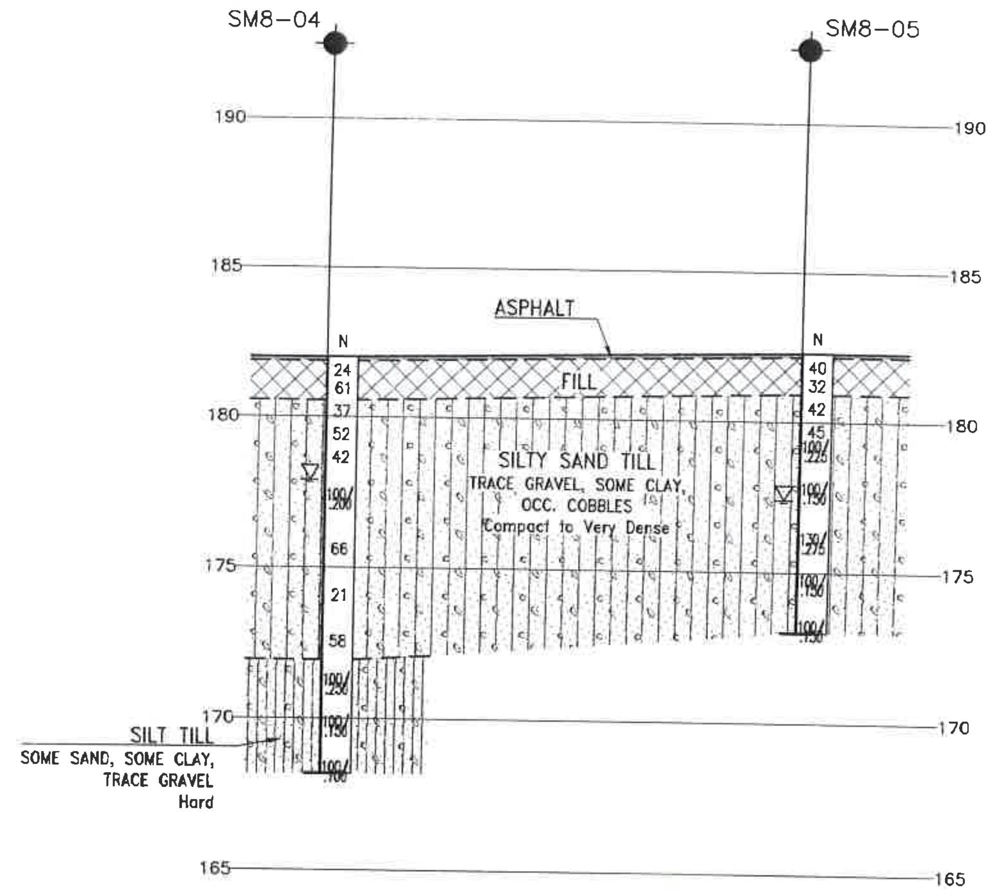
CREATED: August 14, 2012 MODIFIED: January 23, 2013

NO.	DATE	REVISIONS				

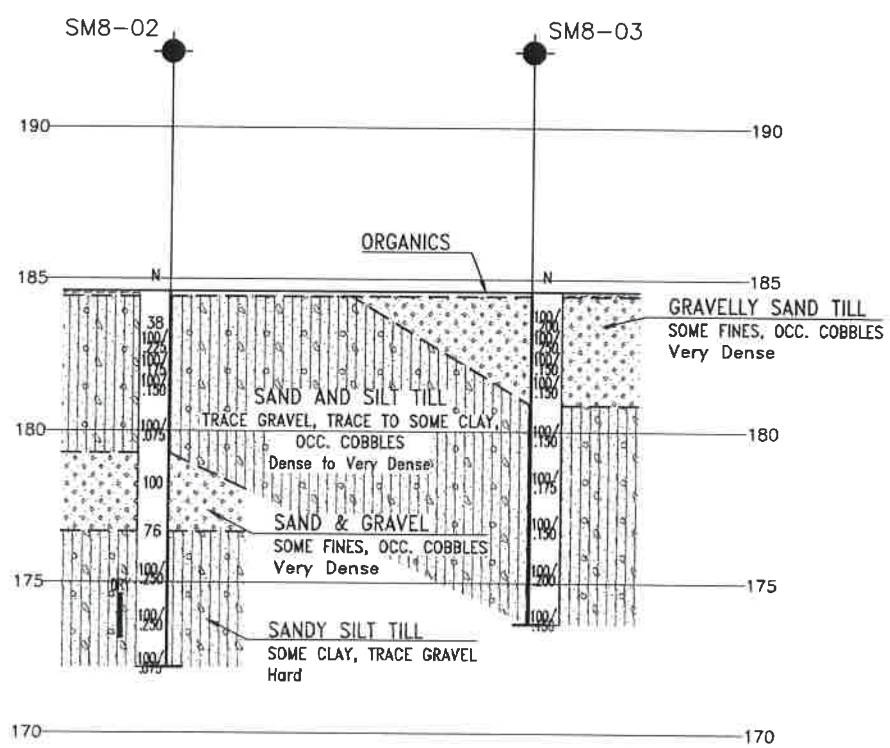


SECTION B-B

H 1:500
V 1:250

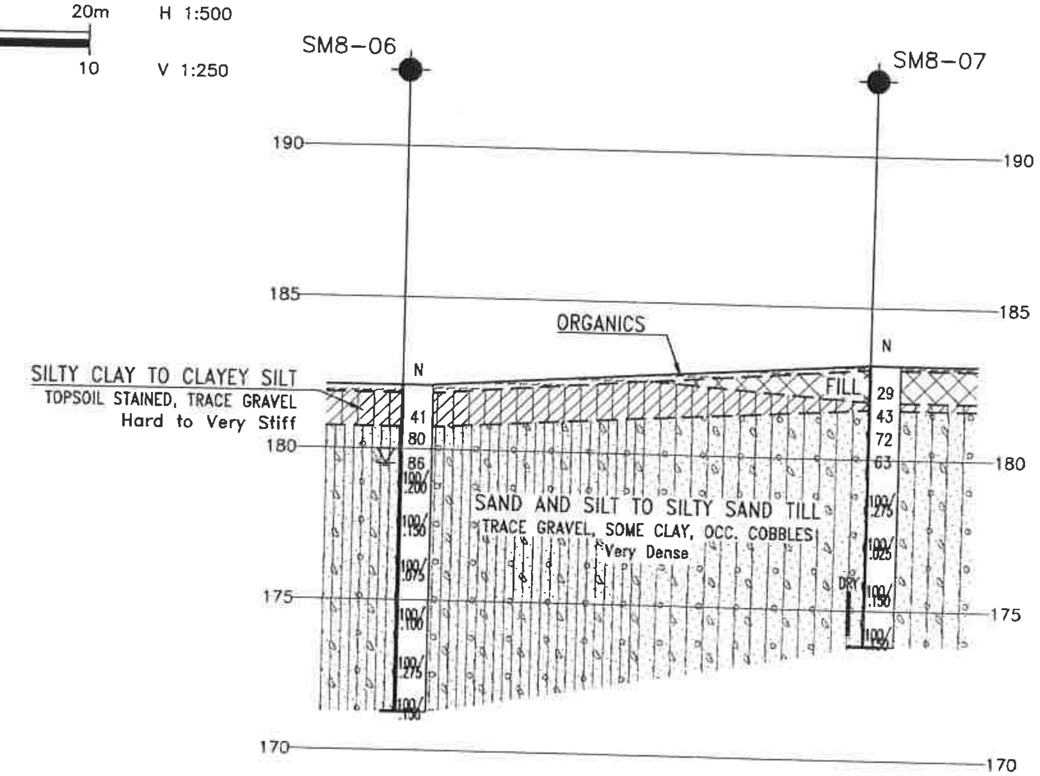
METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



SECTION A-A

H 1:500
V 1:250



SECTION C-C

H 1:500
V 1:250

CONTRACT No. E2-2012
HWY 407/BROCK ROAD INTERCHANGE

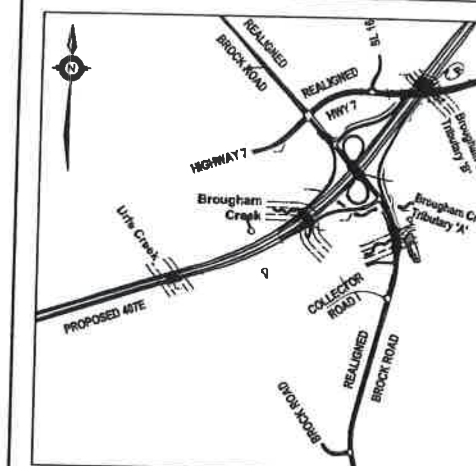
STRUCTURE M-8
REALIGNED BROCK ROAD OVER HIGHWAY 407
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

407 ETR Express Toll Route

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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(symbol)	Borehole and Cone
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(symbol)	Water Level
(symbol)	Head Artesian Water
(symbol)	Piezometer
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DESIGN SBP	CHK AEG	CODE	LOAD	DATE JAN. 2013
DRAWN MFA	CHK SBP	SITE	STRUCT M-8	DWG 2

DRAWING NAME: H:\Drafting\19\5161\130\ted1130A-BrockRoadUnderpass.dwg
CREATED: August 14, 2012 MODIFIED: January 23, 2013