THURBER ENGINEERING LTD.

PRELIMINARY GEOTECHNICAL INVESTIGATION
CLASS ENVIRONMENTAL ASSESSMENT STUDY
BRITANNIA ROAD (REGIONAL ROAD 6)
FROM TREMAINE ROAD TO HIGHWAY 407
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

Report Submitted

To

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THURBER

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1.0 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation carried out by Thurber Engineering Ltd. in support of the Class Environmental Assessment Study underway for the proposed widening and improvements to Britannia Road in the Town of Milton, Ontario. The project corridor is approximately 12.5 km in length and extends from Tremaine Road (at the west extent) to Highway 407 (at the east extent).

The purpose of this investigation is to obtain subsurface information along the roadway corridor and based on the findings, to provide preliminary geotechnical recommendations regarding roadway reconstruction, pavement design, replacement of bridge and culvert structures, and construction of a new CN Rail grade separation structure.

The geotechnical investigation was carried out in general accordance with Thurber's proposal letter No. 110-3285 dated May 11, 2010.

The contents of this report are subject to the Statement of Limitations and Conditions attached at the end of the text. The reader's attention is specifically drawn to these conditions as it is essential that they be followed for the proper use and interpretation of this report.

2.0 PROJECT AND SITE DESCRIPTION

Britannia Road is functionally designated as a Major Arterial Roadway and is under the jurisdiction of Halton Region. The roadway presently has a two-lane rural cross-section with gravel shoulders and side ditches. The shoulder width varies, but is typically between 0.5 to 2.0 m wide.

The anticipated road improvements include widening of the roadway from a two to an ultimate six lane cross-section, intersection improvements, and possible vertical and horizontal grade adjustments. The project will also include the following:

- Construction of a railway grade separation structure at the CN Rail crossing between Tremaine Road and First Line;
- Replacement of the Sixteen Mile Creek bridge (west branch) between Regional Road 25 and Third Line;

- Replacement of the Sixteen Mile Creek bridge (east branch) west of Trafalgar Road; and
- Replacement of culverts at all watercourse crossings, including approximately seven structural culverts.

A grade separation is not planned for the CP Rail spur line crossing immediately west of Highway 407.

At present, the existing pavement surface on Britannia Road between Tremaine Road and Trafalgar Road is currently in good to excellent condition with a very smooth ride, slight distortion and wheel track rutting, and intermittent slight to moderate centreline/joint cracking. East of Trafalgar Road, the pavement surface is in fair condition with extensive moderate map cracking, intermittent moderate transverse and longitudinal cracks, as well as moderate ravelling and wheel track rutting.

The surrounding lands are rural and relatively flat with the exception of the Sixteen Mile Creek valleys.

Photographs of the roadway pavement, bridge sites and CN Rail crossing are provided in Appendix D.

The study area is located within the Peel Plain physiographic region, a till plain consisting of clayey silt to silty clay which has been modified by a veneer of clay. Approximately 1 km both east and west of Trafalgar Road, the roadway crosses a localized tract of sandy soil overlying the till. Alluvial deposits are present within the low-lying floodplains of the Sixteen Mile Creek west and east branches.

The area is underlain by red shale bedrock of the Queenston Formation. The bedrock typically lies at depths of 10 to 15 m below the ground surface, and locally at shallower depths within the major creek valleys.

3.0 INVESTIGATION PROCEDURES

3.1 Field Investigation

The field investigation was carried out during the period of March 2 to 7, 2012 and comprised of 18 boreholes drilled through the pavement along the existing Britannia Road and one borehole drilled along Fourth Line. The locations and depths of the boreholes

are summarized in Table 3.1. Two programmed boreholes adjacent to the CN railway crossing could not be drilled.

Table 3.1 – Borehole Locations and Depths

Component	Borehole Numbers	Borehole Depths (m)	Comment
Sixteen Mile Creek bridge (west crossing)	12-07, 12-08	6.2	terminated in shale
Sixteen Mile Creek bridge (east crossing)	12-17, 12-18	8.6, 12.3	BH12-18 terminated in shale
Culverts	12-01, 12-04, 12-05, 12-06, 12-09, 12-15	4.7 - 6.7	BH12-15 terminated in shale
Pavement	12-10, 12-12, 12-13, 12-14, 12-16, 12-19, 12-20, 12-21	5.2 – 9.3	BH12-21 terminated in shale
Fourth Line (realignment)	12-11	6.7	-
CN Rail Crossing	12-02, 12-03	-	*not drilled*

The approximate borehole locations are shown on Drawing 17-454-112-1, Appendix A. The borehole locations were established in the field by Thurber relative to existing site features. The locations were subsequently tied in using a GPS survey unit with an accuracy of approximately 0.3 m horizontally and 0.5 m vertically.

All borehole locations were cleared of utilities and road occupancy permits were obtained prior to commencement of drilling. The boreholes were repositioned as necessary in consideration of the utility locations and surface features if required. Traffic control was provided on a full time basis by On Track Safety Limited (OTS) during drilling of all boreholes.

The boreholes were advanced using a truck-mounted CME-55 drill rig supplied and operated by DBW Drilling Limited. Solid stem augers were employed to advance the boreholes, and soil samples were obtained in conjunction with the Standard Penetration Test (SPT).

The field investigation was carried out under the full-time supervision of Thurber's technical staff. All boreholes were logged in the field. Soil samples were identified and transported back to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed during drilling. Standpipe piezometers were installed in selected boreholes to measure groundwater levels. The piezometers were decommissioned in general accordance with MOE Regulation 903.

Upon completion, all boreholes without piezometers were backfilled with bentonite holeplug and auger cuttings in general accordance with MOE Regulation 903. Cold patch asphalt was placed at the surface to restore the roadway pavement.

Results of the field drilling, sampling and testing are presented on the Record of Borehole sheets in Appendix B.

3.2 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determinations, visual classification and description of all soil samples. Grain size distribution analyses were carried out on selected samples of the pavement granular materials and subgrade soils. Atterberg limits were conducted on selected samples.

Results of the geotechnical laboratory testing are presented on the Record of Borehole sheets, Appendix B, and in Appendix C.

4.0 SUMMARY OF SUBSURFACE CONDITIONS

A generalized description of the subsurface conditions encountered in the boreholes drilled at the site is given below. The Record of Borehole sheets in Appendix B provide detailed descriptions of the soil conditions at specific locations drilled, and must be used in preference to these generalized descriptions. It should be recognized that soil conditions may vary between and beyond borehole locations.

The subsurface stratigraphy encountered in the boreholes generally comprises a surficial pavement structure overlying a silty clay layer underlain by silty clay till. Fill was encountered below the pavement structure locally, and sand/silt deposits were encountered in two boreholes. Shale bedrock was contacted in five boreholes.

4.1 Pavement Structure

A flexible pavement structure was encountered in all boreholes drilled on Britannia Road. The thickness of the pavement structure components revealed in the boreholes, as well as the estimated Granular Base Equivalency (GBE), is summarized in Table 4.1.

Table 4.1 – Existing Pavement Thickness

Component	Pavement	
	Range (mm)	Average (mm)
Asphalt	50 – 190	135
Sand & Gravel Base	345 - 1330	690
Total Thickness	460 - 1470	825
Estimated GBE	350 – 925	560

The results of grain size distribution analyses conducted on five samples of the sand and gravel fill are presented on Figure C1 of Appendix C. The results are summarized as follows:

Gravel	25 – 48%
Sand	43 – 65%
Fines	2 – 15%

The gradation of the samples generally meets the OPSS Granular B Type I gradation specification with the exception of the fines content. The percentage of fines (% passing the 75 μm sieve) measured in the samples ranged from 2 to 15%, with two out of the five samples exceeding the OPS specification of 10%. The fines content may reflect the effects of the auger sampling procedures, infiltration of fines with road runoff, or deterioration of the granular material over time.

Standard Penetration Test (SPT) N-values of 7 and 16 blows/0.3 m of penetration were recorded in the pavement base materials, indicating a loose to compact condition. Moisture contents ranged from 3 to 14%.

4.2 Silty Clay Fill and Sand Fill

Fill was encountered below the pavement materials in Boreholes 12-07, 08, 15, 16, 17 and 18. The fill typically consisted of silty clay, locally sand in Borehole 12-16. At the Sixteen Mile Creek bridge approaches (Boreholes 12-07, 08, 17 and 18), the fill thickness ranged from 2.4 to 4.8 m, and the lower boundary was at depths of 3.0 to 5.5 m (Elev. 173.8 to 177.9). In Boreholes 12-15 and 12-16, the fill was 0.7 and 0.8 m thick with a lower boundary at 1.3 and 1.5 m depth (Elev. 189.3 and 188.8).

The results of a grain size distribution analysis conducted on a single sample of the silty clay fill are presented on Figure C2 of Appendix C. The results are summarized as follows:

Gravel	0%
Sand	24%
Silt	49%
Clay	26%

Atterberg Limit tests (Figure C6 of Appendix C) indicate that the clay fill has a low plasticity and is classified as CL according to the Modified Unified Soil Classification System.

SPT N-values obtained in the clay fill generally varied from 4 to 18 blows/0.3 m of penetration, indicating a firm to very stiff consistency. An N-value of 6 blows/0.3 m was obtained in the sand fill, indicating a loose condition. Moisture contents ranged from 10 to 28%, typically 10 to 18%.

4.3 Gravel

A gravel layer was encountered below the fill in Borehole 12-17 drilled at the Sixteen Mile Creek (east branch). The gravel layer was 1.1 m thick with a lower boundary at 6.6 m depth (Elev. 175.4).

The results of a grain size distribution analysis conducted on a sample of the gravel are presented on Figure C3 of Appendix C. The results are summarized as follows:

Gravel	67%
Sand	23%
Fines	10%

An SPT N-value of 50 blows/0.125 m was recorded in the gravel, indicating a very dense condition. A moisture content of 19% was measured.

4.4 Silty Sand to Sandy Silt

A layer of silty sand was encountered below the fill in Borehole 12-16 and below the pavement structure in Borehole 12-20. The sand/silt layer was 0.8 and 2.1 m thick with a lower boundary at 2.3 and 2.8 m depth (Elev. 188.0 and 187.6) in Boreholes 12-16 and 12-20, respectively.

SPT N-Values recorded in the sand/silt layer varied from 6 to 11 blows/0.3 m of penetration, indicating a loose to compact condition. Moisture contents of 20 to 24% were determined within this layer.

4.5 Silty Clay

A stratum of silty clay was encountered below the pavement structure, fill or sand in all boreholes except Boreholes 12-17 and 12-19. This unit varied from 0.7 to 3.5 m in thickness with a lower boundary ranging between 1.4 and 5.5 m below ground surface (Elev. 173.1 to 193.4). Borehole 12-20 was terminated in the silty clay at 6.7 m depth (Elev. 183.7).

The results of grain size distribution analyses conducted on three samples of the silty clay are presented on Figure C4 of Appendix C. The results are summarized as follows:

Gravel	0 - 1%
Sand	8 - 19%
Silt	41 - 59%
Clay	22 - 46%

Atterberg Limit tests (Figure C7 of Appendix C) indicate that the silty clay has a low plasticity and is classified as CL according to the Modified Unified Soil Classification System.

SPT N-values were recorded between 4 to 18 blows/0.3 m of penetration, indicating a firm to very stiff consistency. Moisture contents of 13 to 31% were recorded.

4.6 Silty Clay Till

A silty clay till deposit was encountered in all boreholes except Boreholes 12-07, 08 and 20. Where the lower boundary of the clay till was penetrated, the thickness of this deposit ranged from 2.1 to 3.5 m and the lower boundary was at depths of 4.3 to 9.0 m (Elev. 172.9 to 186.3). The till graded to sandy silt below 5.4 m depth in Borehole 12-05 and to clayey sandy silt below 4.3 m depth in Borehole 12-15. All boreholes except Boreholes 12-07, 08, 15, 18, 20 and 21 were terminated in the till at the maximum depths of investigation of 4.7 to 8.6 m (Elev. 173.4 to 189.7 m).

The results of grain size distribution analyses conducted on four samples of the till are presented on Figure C5 of Appendix C. The results are summarized as follows:

Gravel	0 – 2%
Sand	19 – 30%
Silt	47 – 51%
Clay	18 – 33%

Till soils frequently contain cobbles and boulders, and these should be anticipated when excavating during construction.

Atterberg Limit tests (Figure C8 of Appendix C) indicate that the till has a low plasticity and is classified as CL according to the Modified Unified Soil Classification System.

SPT N-values recorded in the till varied widely from 6 blows/0.3 m to 50 blows/0.05 m of penetration, indicating a firm to hard consistency. Moisture contents generally ranged from 6 to 23%, typically 10 to 15%.

4.7 Shale

Shale, of the Queenston Formation, was encountered below the silty clay and till deposits in Boreholes 12-07, 08, 15, 18 and 21. The depths to the shale encountered in the boreholes are summarized in Table 4.2.

Table 4.2 – Depth / Elevation of Shale Bedrock

Borehole	Depth to Shale (m)	Bedrock Elevation (m)
12-07	4.4	173.1
12-08	4.5	173.5
12-15	5.5	185.1
12-18	9.0	172.9
12-21	7.5	182.6

The above boreholes were terminated in the shale at depths of 6.2 to 12.3 m (Elev. 169.6 to 184.2 m) after advancing 0.9 to 3.3 m below the shale surface by augering.

SPT N-values of 50 blows for 0.08 to 0.15 m of penetration were recorded in the shale. One value of 21 blows/0.3 m was measured in the highly weathered upper part of the shale in Borehole 12-08. Moisture contents generally ranged from 5 to 16%.

4.8 Groundwater Levels

Water was observed in Boreholes 12-08, 16, 17 and 20 at depths of 2.5 to 5.3 m upon completion of drilling. Water was not observed in the remaining boreholes during or at completion of drilling. Standpipe piezometers were installed in Boreholes 12-01, 05, 07, 09, 11, 13, 15, 18, 19 and 21 upon completion of drilling. The depths and elevations of water levels measured in the boreholes upon completion of drilling and in the installed piezometers are summarized in Table 4.3.

Table 4.3 – Measured Groundwater Levels

Borehole No.	Date	Measured Water Levels		Comment
		Depth (m)	Elevation (m)	
12-01	Mar. 29, 2012 Apr. 02, 2013	1.0 0.8	183.8 184.0	In piezometer
12-05	Mar. 29, 2012 Apr. 02, 2013	1.3 1.4	184.9 184.8	In piezometer
12-07	Mar. 29, 2012 Apr. 02, 2013	4.0 3.9	173.5 173.6	In piezometer
12-08	Mar. 06, 2012	5.3	172.7	Upon completion of drilling borehole
12-09	Mar. 29, 2012 Apr. 02, 2013	1.1 0.9	188.6 188.8	In piezometer
12-11	Mar. 29, 2012 Apr. 02, 2013	1.2 0.9	191.7 192.0	In piezometer
12-13	Mar. 29, 2012 Apr. 02, 2013	1.9 1.8	192.4 192.5	In piezometer
12-15	Mar. 29, 2012 Apr. 02, 2013	1.2 1.0	189.4 189.6	In piezometer
12-16	Mar. 07, 2012	5.3	185.0	Upon completion of drilling borehole
12-17	Mar. 05, 2012	4.6	177.4	Upon completion of drilling borehole
12-18	Mar. 29, 2012 Apr. 02, 2013	4.0 4.4	177.9 177.5	In piezometer
12-19	Mar. 29, 2012 Apr. 02, 2013	0.8 0.6	187.9 188.1	In piezometer
12-20	Mar. 02, 2012	2.5	187.9	Upon completion of drilling borehole
12-21	Mar. 29, 2012 Apr. 02, 2013	1.1 1.0	188.9 189.0	In piezometer

The recorded levels are short-term readings and seasonal fluctuations are to be expected. The groundwater level may be at a higher elevation after the spring snowmelt or after periods of significant precipitation.

5.0 GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

This section provides preliminary geotechnical recommendations regarding pavement design, subgrade preparation, and foundation design for bridge, culvert and grade separation structures.

The preliminary recommendations are based on the subsurface soil and groundwater conditions encountered during the investigation, and are for planning and preliminary design purposes only. A detailed geotechnical investigation is required to further define the subsurface conditions and confirm the preliminary recommendations when details of the design are established.

5.1 Pavement Reconstruction

5.1.1 Pavement Design

Britannia Road is functionally designated as a Major Arterial Roadway. The roadway presently has a two lane rural cross-section with gravel shoulders and side ditches. Reconstruction and widening of the roadway to an ultimate six lane cross-section is proposed.

Traffic volumes on Britannia Road currently range from 3,000 to 16,000 AADT (in 2008) and are projected to increase to 13,000 to 27,000 AADT in 2031. Truck volumes represent about 2 to 3% of the total traffic.

The pavement subgrade is expected to consist primarily of firm to very stiff silty clay or silty clay fill, locally loose sand/silt. Based on the anticipated subgrade, the projected traffic volumes, and assuming adequate subgrade drainage, the following pavement design is recommended for complete reconstruction and widening of Britannia Road:

Hot Mix HL-1 (or Superpave 12.5FC 1)	40 mm
Hot Mix HDBC (or Superpave 19.0)	100 mm
19 mm Crusher Run Limestone Base (OPSS Granular A)	150 mm
50 mm Crusher Run Limestone Subbase (OPSS Granular B Type II)	450 mm
Granular Base Equivalency	730 mm

Locally in Boreholes 12-16 and 12-20, highly frost susceptible sandy silt to silty sand was encountered at the pavement subgrade level. An increased subbase thickness of 600 mm is recommended in these localized areas. The extent of the frost susceptible soils should be determined during the detailed investigation.

Considering the highly variable thickness of the existing pavement structure encountered in the boreholes, the variable condition of the pavement subgrade, the narrow existing shoulders along most of the alignment, and the results of the laboratory testing conducted on samples of the existing granular road base, complete reconstruction of the roadway is recommended.

Rehabilitation and incorporation of the existing pavement structure into portions of the widened roadway could be considered subject to final road grades, alignment, detailed investigation and further assessment. Reuse of the existing granular materials in the lower part of the subbase of the new pavement is considered feasible.

Acceptance, placement and compaction of the pavement materials should be carried out in accordance with the applicable Halton Region or OPS specifications. The pavement granular material should be compacted to 100% of SPMDD.

5.1.2 Pavement Subgrade Preparation

Subgrade preparation for new pavement construction should include stripping of all existing pavement materials, topsoil, organic or compressible material and any excessively soft/loose soils. The exposed subgrade should be compacted and proofrolled with a heavy roller and examined to identify any areas of unstable subgrade. Any soft/wet areas identified should be subexcavated and replaced with approved material within 2% of optimum moisture content and compacted to at least 98% of SPMDD. Wet soils should be anticipated in the area of existing creeks, culverts and ditches.

The subgrade soils are susceptible to softening when exposed to excess moisture or disturbance. Accordingly, appropriate drainage should be provided to maintain a reasonably dry subgrade and construction traffic should not be allowed on any wet areas. Construction traffic on the approved subgrade should also be avoided without adequate granular cover.

Depending upon prevailing weather conditions, the upper 300 to 600 mm of clay may be wet and softer than the underlying material. A contingency should be made in the

construction contract for additional subexcavation or alternatively scarifying, moisture conditioning and recompaction of any upper wet zones of clay.

The top of the compacted subgrade should be graded smooth with a minimum crossfall of 3% towards side ditches or subdrains. The pavement granular layers should daylight into ditches or alternatively subdrains should be included at each edge of the pavement. The subdrains should be installed below or just behind the curb line and consist of 150 mm diameter perforated pipe placed in a clear stone trench wrapped with geotextile, as per OPSD 216.021.

5.2 Structure Foundations

5.2.1 CN Rail Crossing (Boreholes 12-02 and 12-03)

Based on the subsurface information from the boreholes nearest to the CN Rail crossing (Boreholes 12-01 and 12-04; programmed Boreholes 12-02 and 12-03 could not be drilled), the stratigraphy at the CN crossing is expected to consist of firm to stiff silty clay and clay till overlying bedrock. The bedrock surface has not been established but is expected to be near 10 to 15 m depth based on geologic data.

The geotechnical resistance available for design of spread footings founded in the firm to stiff native silty clay and silty clay till, within the depth of investigation, is not considered adequate for support of the structure loads. It is anticipated that a deep foundation system comprising either steel piles driven to bedrock or augered caissons socketed into shale bedrock will be required to support the grade separation structure.

For HP 310X110 steel piles driven to refusal in the shale bedrock, a factored geotechnical resistance (axial) of 1,600 kN per pile is recommended for preliminary design purposes. The SLS condition will not govern for piles founded on the bedrock.

Augered caissons, if employed, should be socketed a minimum 3 m into the shale bedrock. For preliminary planning purposes, a factored geotechnical resistance of 4,000 kN per caisson is recommended for a 1.2 m diameter caisson socketed at least 3 m below the shale surface. Additional investigation including rock coring will be required to confirm the resistance values. The SLS condition will not govern for caissons socketed into bedrock.

5.2.2 Sixteen Mile Creek Bridge - West Branch (Boreholes 12-07 and 12-08)

The stratigraphy encountered below the pavement structure in Boreholes 12-07 and 12-08 drilled at the west branch of the Sixteen Mile Creek consisted of firm to stiff silty clay fill and silty clay overlying shale bedrock at depths of 4.4 and 4.5 m (Elev. 173.1 and 173.5).

The fill and native silty clay are considered unsuitable strata for support of bridge foundation loads. It is recommended that the bridge be supported on spread footings bearing on sound shale below the level of all fill, silty clay and highly weathered shale. For preliminary purposes, a factored geotechnical resistance of 1,000 kPa is recommended for design of spread footings founded at least 0.6 m below the shale surface.

The use of augered caissons is also considered feasible. For preliminary planning purposes, a factored geotechnical resistance of 4,000 kN per caisson is recommended for a 1.2 m diameter caisson socketed at least 3 m below the shale surface. Additional investigation including rock coring will be required to confirm the resistance values. The SLS condition will not govern for caissons socketed into bedrock.

Driven steel piles are unlikely to be the preferred foundation system due to the relatively shallow depth to bedrock.

5.2.3 Sixteen Mile Creek Bridge – East Branch (Boreholes 12-17 and 12-18)

The stratigraphy encountered below the pavement structure in Boreholes 12-17 and 12-18 drilled at the east branch of the Sixteen Mile Creek consisted of firm to stiff silty clay fill overlying firm silty clay or very dense gravel, underlain by hard silty clay till at depths of 6.6 and 5.5 m (Elev. 175.4 and 176.4). Shale bedrock was encountered below the till at 9.0 m depth (Elev. 172.9) in one borehole.

The fill, native silty clay and gravel deposits are considered unsuitable strata for support of bridge foundation loads. At this site, consideration may be given to supporting the bridge on spread footings bearing on the hard clay till or on a deep foundation system comprising either steel piles driven to bedrock or augered caissons socketed into shale bedrock.

For preliminary purposes, spread footings bearing on hard native clay till encountered at depths of 6.6 and 5.5 m may be designed using geotechnical resistances of 600 kPa at factored ULS and 400 kPa at SLS. Excavation shoring and dewatering will be required for construction of footings extended to the clay till.

Augered caissons, if employed, should be socketed a minimum 3 m into the shale bedrock. For preliminary planning purposes, a factored geotechnical resistance of 4,000 kN per caisson is recommended for a 1.2 m diameter caisson socketed at least 3 m below the shale surface. Additional investigation including rock coring will be required to confirm the resistance values and the depth to bedrock at each foundation unit. The SLS condition will not govern for caissons socketed into bedrock.

For HP310X110 steel piles driven to refusal in the shale bedrock, a factored geotechnical resistance (axial) of 1,600 kN per pile is recommended for preliminary design purposes. The SLS condition will not govern for piles founded on the bedrock.

5.2.4 Foundations - General

The depth of earth cover required to provide frost protection for footings and pile caps on this project is 1.2 m. It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation.

The bearing resistance values for spread footings are provided for vertical concentric loads only. Effects of load inclination and eccentricity need to be taken into account as per the CHBDC.

For footings designed on the basis of the SLS resistance values given above, total settlement under a footing is not expected to exceed 25 mm.

The horizontal resistance against sliding between cast-in-place concrete and the undisturbed founding surface can be computed using ultimate friction factors of 0.4 for firm to stiff silty clay, 0.45 for stiff to hard silty clay till, and 0.5 for shale.

The tips of driven piles, if employed, should be fitted with cast steel, H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

Use of a temporary steel liner may be required to support the sidewalls of caisson excavations where cohesionless soils are encountered below the groundwater level. The liners must be sealed into the bedrock to minimize sidewall instability and inflow of water above the bedrock surface.

It is possible that cobbles and boulders will be encountered in the till during footing excavation, caisson installation and pile driving. Equipment employed during foundation construction should be capable of dislodging, handling and/or removing cobbles and boulders.

5.3 Replacement of Culverts

Boreholes were drilled at the locations of six selected structural culverts along Britannia Road. The subsurface stratigraphy encountered in the boreholes generally consisted of firm to stiff silty clay overlying stiff to hard silty clay till.

Based on the borehole data, supporting the culverts on spread footings is considered feasible. Culvert footings founded on the firm to stiff native silty clay or extended down to the stiff to hard silty clay till may be designed using the following geotechnical resistances:

	Silty Clay	Silty Clay Till
Factored Resistance at ULS	150 kPa	300 kPa
Resistance at SLS	100 kPa	200 kPa

The above geotechnical resistances are provided for footings founded at the following depths:

Table 5.1 – Founding Levels for Culvert Footings

Borehole	Founding Level (Depth below Existing Road Grade at Borehole, m)	
	Firm to Stiff Silty Clay	Stiff to Hard Silty Clay Till
12-01	1.2	2.2
12-04	1.2	1.4
12-05	1.5	3.0
12-06	1.2	1.5
12-09	-	2.2
12-15	1.3	3.0

All existing fill, topsoil, organic/streambed deposits and soft/loose soils must be removed from the founding surface prior to placement of the footing concrete.

Erosion protection must be provided at the new culvert inlet and outlet areas. Vegetation cover, riprap or other protective measures should be established on the creek banks to protect against surficial erosion and seepage-induced material loss.

A concrete cut-off wall or clay seal should be installed at the culvert inlet to minimize the potential for seepage through the granular bedding and backfill material and avoid consequent erosion of these materials.

5.4 Earth Pressure Parameters

Backfill to abutment walls, culverts, headwalls and any retaining walls should consist of non-frost susceptible granular materials conforming to OPS Granular A or Granular B Type II requirements. Reference should be made to the backfill arrangements stipulated in OPSD 803.010, 3101.150 and 3121.150, as appropriate.

The lateral earth pressures acting on the wall/culvert, assuming full drainage from behind the walls, may be computed using the following pressure distribution:

$$p = K(\gamma H + q)$$

where p = lateral earth pressure acting at depth H, kPa

K = earth pressure coefficient (see Table below)

γ = unit weight of retained soil or backfill, kN/m^3 (see Table below)

H = depth below ground surface where pressure is computed, m

q = surcharge pressure including traffic loads, kPa

Table 5.2 lists the unfactored parameters recommended for design, assuming an essentially level ground surface behind and in front of the culvert and walls:

Table 5.2 – Earth Pressure Parameters

Parameter	Retained Material	
	OPSS Granular A or Granular B Type II	OPSS Granular B Type I
Unit Weight, kN/m^3	22.8	21.2
Friction Angle, degrees	35	32
Active Pressure Coefficient, K_a	0.27	0.31
At-Rest Pressure Coefficient, K_0	0.43	0.47
Passive Pressure Coefficient, K_p	3.7	3.3

If lateral movement is not permissible and/or the wall is restrained from lateral yielding, the at-rest pressure coefficient, K_o, should be used. If the wall design allows lateral yielding (non-rigid structure), the active earth pressure coefficient, K_a, may be used.

If the design includes a sloping ground surface behind or in front of the wall, the earth pressure parameters will require modification. Thurber should be contacted to provide appropriate earth pressure coefficients for a sloping ground situation.

The earth pressure coefficients in the table above do not include potential compaction effects that must be included in the design. Compaction effects should be considered as per the CHBDC.

5.5 Excavation and Groundwater Control

Excavation for foundation construction, grade separation, culvert installation and any municipal services will primarily extend through the existing roadway pavement structure and embankment fill, and into native silty clay and silty clay till deposits. Use of a hydraulic excavator should be suitable for excavation within these materials. Provision should be made for handling and removal of possible obstructions in the fill and cobbles and boulders in the till soils.

All temporary excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and local regulations. In general, the fill and native soils are classified as Type 3 soils above the groundwater level, and Type 4 soils if excavation extends into cohesionless soils below the water level without prior dewatering.

Where space restrictions preclude excavation of inclined slopes, service installation may be carried out using a trench box or temporary shoring. Where the trench depth exceeds 6 m, the support system must be designed specifically for this project.

Excavation of the upper 2 to 3 m of weathered shale, if required, should be possible using heavy excavation equipment and rippers, supplemented by pneumatic rock breakers where thick layers of hard material such as limestone are encountered. The shale typically becomes stronger and less weathered with depth, and intensive use of pneumatic/hydraulic breakers, line drilling or other methods of loosening the bedrock will be required with increasing depth. Near vertical sidewalls may be employed for temporary excavation in shale bedrock.

Water was measured at depths of 0.6 to 4.4 m in the piezometers installed in the boreholes. Considering the observations during drilling and the consistency of the soils on site, dewatering of any seepage into shallow excavations should generally be feasible using sumps and pumps. However, dewatering to lower the groundwater level below the base of the trench prior to excavation may be required to provide a stable trench base and walls in areas where cohesionless sand/silt layers are encountered below the groundwater level (Boreholes 12-16 and 12-20). Further, localized zones of perched water may be encountered in the fill, and seepage should be anticipated in the Sixteen Mile Creek floodplains.

Further assessment of dewatering requirements and the need for a Permit to Take Water (PTTW), as well as confirmation of groundwater levels and permanent dewatering measures at the grade separation location, will be required during detailed design.

5.6 Detailed Geotechnical Investigation

The information presented in this report is provided for preliminary design and planning purposes only. Detailed geotechnical investigation will be required to confirm the subsurface conditions and recommendations. This work should include:

- additional boreholes within the existing roadway pavement to confirm the preliminary pavement design recommendations, particularly if portions of the existing pavement structure will be incorporated into the widened roadway;
- additional boreholes in the vicinity of Boreholes 12-16 and 12-20 to determine the limits of frost susceptible silt soils;
- additional boreholes along proposed underground utility alignments, if applicable, when further details regarding the alignment and depth of these services are established;
- additional boreholes and rock coring at the locations of the bridges, grade separation and culverts to confirm the preliminary recommendations for foundation design and construction;
- investigation at any additional structures defined during detailed design;
- further assessment of dewatering requirements and the need for a Permit to Take Water (PTTW); and
- chemical testing to evaluate excess material disposal.

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering or environmental consulting practices in this area. No other warranty, expressed or implied, is made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document, subject to the limitations provided herein, are only valid to the extent that this Report expressly addresses proposed development, design objectives and purposes, and then only to the extent there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation or to consider such representations, information and instructions.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS WE MAY EXPRESSLY APPROVE. The contents of the Report remain our copyright property. The Client may not give, lend or, sell the Report, or otherwise make the Report, or any portion thereof, available to any person without our prior written permission. Any use which a third party makes of the Report, are the sole responsibility of such third parties. Unless expressly permitted by us, no person other than the Client is entitled to rely on this Report. We accept no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without our express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and this report is delivered on the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by us. We are entitled to rely on such representations, information and instructions and are not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

(see over ...)

INTERPRETATION OF THE REPORT *(continued...)*

c) Design Services: The Report may form part of the design and construction documents for information purposes even though it may have been issued prior to the final design being completed. We should be retained to review the final design, project plans and documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the report recommendations and the final design detailed in the contract documents should be reported to us immediately so that we can address potential conflicts.

d) Construction Services: During construction we must be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RISK LIMITATION

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause an accidental release of those substances. In consideration of the provision of the services by us, which are for the Client's benefit, the Client agrees to hold harmless and to indemnify and defend us and our directors, officers, servants, agents, employees, workmen and contractors (hereinafter referred to as the "Company") from and against any and all claims, losses, damages, demands, disputes, liability and legal investigative costs of defence, whether for personal injury including death, or any other loss whatsoever, regardless of any action or omission on the part of the Company, that result from an accidental release of pollutants or hazardous substances occurring as a result of carrying out this Project. This indemnification shall extend to all Claims brought or threatened against the Company under any federal or provincial statute as a result of conducting work on this Project. In addition to the above indemnification, the Client further agrees not to bring any claims against the Company in connection with any of the aforementioned causes.

7. SERVICES OF SUBCONSULTANTS AND CONTRACTORS

The conduct of engineering and environmental studies frequently requires hiring the services of individuals and companies with special expertise and/or services which we do not provide. We may arrange the hiring of these services as a convenience to our Clients. As these services are for the Client's benefit, the Client agrees to hold the Company harmless and to indemnify and defend us from and against all claims arising through such hirings to the extent that the Client would incur had he hired those services directly. This includes responsibility for payment for services rendered and pursuit of damages for errors, omissions or negligence by those parties in carrying out their work. In particular, these conditions apply to the use of drilling, excavation and laboratory testing services.

8. CONTROL OF WORK AND JOBSITE SAFETY

We are responsible only for the activities of our employees on the jobsite. The presence of our personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that we never occupy a position of control of the site. The Client undertakes to inform us of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions or materials and that such a discovery may result in the necessity to undertake emergency procedures to protect our employees as well as the public at large and the environment in general. These procedures may well involve additional costs outside of any budgets previously agreed to. The Client agrees to pay us for any expenses incurred as the result of such discoveries and to compensate us through payment of additional fees and expenses for time spent by us to deal with the consequences of such discoveries. The Client also acknowledges that in some cases the discovery of hazardous conditions and materials will require that certain regulatory bodies be informed and the Client agrees that notification to such bodies by us will not be a cause of action or dispute.

9. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on our interpretation of conditions revealed through limited investigation conducted within a defined scope of services. We cannot accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

APPENDIX A

BOREHOLE LOCATION PLANS

TREMAINE ROAD

12-01

WEST TRIBUTARY OF INDIAN CREEK

12-02 (NOT DRILLED)

CN RAILWAY

12-03 (NOT DRILLED)

EAST TRIBUTARY OF INDIAN CREEK

12-04

EAST TRIBUTARY OF INDIAN CREEK

FIRST LINE

WEST TRIBUTARY OF SIXTEEN MILE CREEK

12-05

WEST TRIBUTARY OF SIXTEEN MILE CREEK

12-06

REGIONAL ROAD 25

BOYNE SOCCER FIELD

12-07

12-08

SIXTEEN MILE CREEK (WEST BRANCH)

OMAGH PRESBYTERIAN CHURCH

EAST TRIBUTARY OF SIXTEEN MILE CREEK

THOMPSON ROAD

12-09

12-10

OMAGH CHURCH OF CHRIST

OMAGH BALL PARK

FOURTH LINE

12-11

12-12

LEGEND:

APPROXIMATE BOREHOLE LOCATION

DELCAN CORPORATION

BRITANNIA ROAD
TREMAINE ROAD TO
HIGHWAY 407

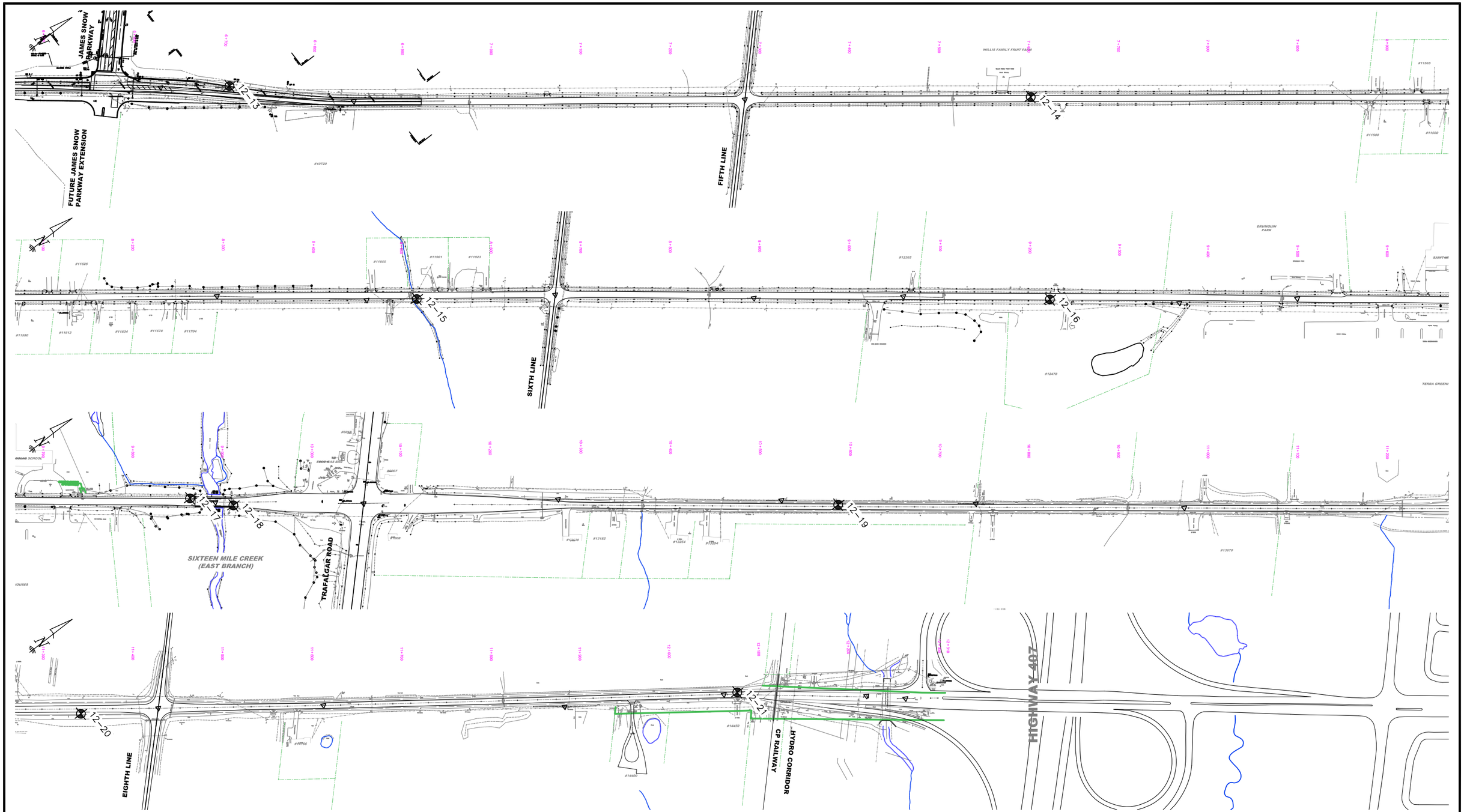
BOREHOLE LOCATION PLAN

JOB# 17-454-112

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
SBP	MFA	MRA
DATE :	SCALE :	DRAWING No.
APRIL 2013	1:4000	17-454-112-1

FILENAME: H:\Drafting\17\454\112\ted4112-BoreholePlan4.dwg
PLOTDATE: Apr 9, 2013 - 2:59 PM



LEGEND:

⌖ APPROXIMATE BOREHOLE LOCATION

DELCAN CORPORATION

BRITANNIA ROAD
TREMAINE ROAD TO
HIGHWAY 407

BOREHOLE LOCATION PLAN

JOB# 17-454-112

THURBER ENGINEERING LTD.

ENGINEER :	DRAWN :	APPROVED :
SBP	MFA	MRA
DATE :	SCALE :	DRAWING No.
APRIL 2013	1:4000	17-454-112-2

FILENAME: H:\Drafting\17\454\112\ted4112-BoreholePlan4.dwg
PLOTDATE: Apr 9, 2013 - 3:00 PM

APPENDIX B

RECORD OF BOREHOLE SHEETS

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

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

▼ 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			

RECORD OF BOREHOLE 12-01

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 7 March 2012
COMPLETED : 7 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 813 657.8 E 592 778.7
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		184.80			
		ASPHALT (150 mm)		184.65			
		SAND and GRAVEL, compact, brown, moist (FILL)		0.15	1	GS	
				184.11			
1		**CLAY**, silty, topsoil stained, firm to stiff, dark brown, moist		0.69	2	SS	7
2					3	SS	11
				182.59			
		CLAY, silty, some sand, very stiff to hard, brown, moist (TILL)		2.21	4	SS	28
3					5	SS	33
4							
		brown to grey, stiff			6	SS	13
5							
6		trace limestone fragments, grey, firm			7	SS	7
				178.09			
7		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		6.71			
8							
9		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 1.0 183.8 Apr. 02/12 0.8 184.0					
10							
11							
12							
13							
14							

COMMENTS
DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

Grain Size Analysis:
Gr 0%/ Sa 19%/ Si 47%/ Cl 33%

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-04

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 814 360.3 E 593 329.3
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	COMMENTS DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		186.60							
		ASPHALT (150 mm)		186.45 0.00							
		SAND and GRAVEL, brown, frozen (FILL)		0.15	1	GS			○		
				185.89							
1		**CLAY**, silty, trace gravel, occasional cobbles, firm, brown, moist		0.71	2	SS	6				
				185.20							
		CLAY, silty, some sand, trace gravel, limestone fragments, very stiff, brown, moist (TILL)		1.40	3	SS	20		○ ▲		
2											
					4	SS	17		○ ▲		
3											
					5	SS	16		○ ▲		
4											
		stiff, brown to grey			6	SS	10		○ ▲		
5											
6		grey			7	SS	11		▲		
				179.89							
7		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Borehole backfilled with bentonite holeplug from base to 1.1 m, cuttings to 0.15 m and asphalt to surface		6.71							
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-05

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 7 March 2012
COMPLETED : 7 March 2012
N 4 814 983.0 E 593 794.0

Project No. 17-454-112
SHEET 1 OF 1
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		186.20				20 40 60 80 100			
		ASPHALT (140 mm)		186.06							
		SAND and GRAVEL, compact to loose, brown, moist (FILL)		0.14	1	GS			○		
1					2	SS	7		○		▼
		CLAY, silty, trace sand, rootlets, topsoil stained, firm, dark brown, moist		184.73 1.47	3	SS	7	Grain Size Analysis: Gr 0%/ Sa 8%/ Si 46%/ Cl 46%	▲ ○		
2		**CLAY**, silty, some sand, trace gravel, occasional limestone fragments, stiff, brown to grey, moist (TILL)		183.99 2.21	4	SS	9		◑ ▲		
3		shale fragments, very stiff to hard			5	SS	24		○ ▲		
4											
5					6	SS	32		○		
		SILT, sandy, trace gravel, very dense, grey, moist (TILL)		180.79 5.41							
6				179.98	7	SS	50/.125		○		
		END OF BOREHOLE AT 6.2 m BELOW GROUND SURFACE 1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		6.22							
7											
8		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 1.3 184.9 Apr. 02/12 1.4 184.8									
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-06

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 815 469.0 E 594 179.9
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		183.43				
		ASPHALT (150 mm)		183.28				Grain Size Analysis:
		SAND and GRAVEL, dark brown, frozen (FILL)		0.15	1	GS		Gr 33%/Sa 65%/ Si & Cl 2%
				182.74				
1		**CLAY**, silty, trace gravel, stiff, brown, moist		0.69	2	SS	10	
				181.96				
		CLAY, silty, some sand, trace gravel, very stiff to hard, brown, moist (TILL)		1.47	3	SS	16	
2		limestone fragments			4	SS	57	
3					5	SS	25	
4								
5					6	SS	26	
6					7	SS	38	
				176.72				
7		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Borehole backfilled with bentonite holeplug from base to 0.8 m, cuttings to 0.15 m and asphalt to surface		6.71				
8								
9								
10								
11								
12								
13								
14								

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

SHEAR STRENGTH: Cu, KPa (nat V - ✚ Q - ✖ rem V - ● Cpen ▲) (40 80 120 160)

WATER CONTENT, PERCENT (wp w wl) (10 20 30 40)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-07

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 816 010.2 E 594 593.9
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) / WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		177.49							
		ASPHALT (130 mm)		177.36							
		SAND and GRAVEL, brown, frozen (FILL)		0.13	1	GS					
				176.88							
		CLAY, silty, trace gravel, shale fragments, firm to stiff, brown, moist (FILL)		0.61	2	SS	7				
1											
		limestone fragments, brown to grey			3	SS	11				
2											
					4	SS	8				
3											
					5	SS	7				
				173.83							
		CLAY, silty, some sand, trace gravel, rootlets, limestone fragments, firm, brown, moist		3.66							
4				173.13							
		SHALE, highly weathered, reddish-brown, moist (Queenston Formation)		4.36	6	SS	50/.150				
5											
6				171.29	7	SS	50/.100				
		END OF BOREHOLE AT 6.2 m BELOW GROUND SURFACE		6.20							
		1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen									
7											
		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 4.0 173.5 Apr. 02/12 3.9 173.6									
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-08

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 816 042.3 E 594 624.1
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	COMMENTS
		GROUND SURFACE		178.03				
		ASPHALT (190 mm)		177.84				Grain Size Analysis:
		SAND and GRAVEL, trace silt, brown, frozen (FILL)		0.19	1	GS		Gr 25%/Sa 61%/Si & Cl 14%
				177.32				
1		**CLAY**, silty, trace gravel, limestone fragments, stiff to firm, brown, moist (FILL)		0.71	2	SS	9	
2					3	SS	4	
3					4	SS	5	
		CLAY, silty, some sand, trace gravel, shale fragments, firm, brown, moist		174.68 3.35	5	SS	4	
4				173.51				
		SHALE, highly weathered, grey limestone layers, reddish-brown, moist to wet (Queenston Formation)		4.52	6	SS	21	
5								
6				171.86	7	SS	50/.075	
		END OF BOREHOLE AT 6.2 m BELOW GROUND SURFACE 1) Borehole open upon completion of drilling 2) Water level at 5.3 m below ground surface upon completion of drilling 3) Borehole backfilled with bentonite holeplug from base to 1.1 m, cuttings to 0.15 m and asphalt to surface		6.17				
7								
8								
9								
10								
11								
12								
13								
14								

COMMENTS
DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 6 March 2012

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-09

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 5 March 2012
COMPLETED : 5 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 816 716.4 E 595 130.0
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		189.71				20 40 60 80 100			
		ASPHALT (140 mm)		189.57							
		SAND and GRAVEL, brown, frozen (FILL)		0.14	1	GS			○		
1					2	SS	16		○		▼
		CLAY, silty, topsoil stained, firm, brown, moist		188.39 1.32							
2					3	SS	5		▲ ○		
		CLAY, silty, some sand, trace gravel, limestone fragments, very stiff to hard, brown, moist (TILL)		187.50 2.21							
3					4	SS	22		○ ⊢ ▲		
					5	SS	37		○	▲	
4											
				184.98	6	SS	50/.150		○		
5		END OF BOREHOLE AT 4.7 m BELOW GROUND SURFACE 1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		4.72							
6		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 1.1 188.6 Apr. 02/12 0.9 188.8									
7											
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-10

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 5 March 2012
COMPLETED : 5 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 817 202.6 E 595 515.3
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		194.61				
		ASPHALT (140 mm)		194.47 0.14				
		SAND and GRAVEL, brown, frozen (FILL)		194.01 0.61	1	GS		
1		**CLAY**, silty, trace gravel, stiff, brown, moist			2	SS	12	
				193.17 1.45				
2		**CLAY**, silty, some sand, trace gravel, shale fragments, very stiff to hard, brown, moist (TILL)			3	SS	21	
					4	SS	50/.075	
3		brown to grey			5	SS	30	Grain Size Analysis: Gr 1%/ Sa 22%/ Si 51%/ Cl 26%
4								
5					6	SS	28	
				189.43 5.18				
6		END OF BOREHOLE AT 5.2 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Borehole backfilled with bentonite holeplug from base to 0.7 m, cuttings to 0.15 m and asphalt to surface						
7								
8								
9								
10								
11								
12								
13								
14								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-11

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 5 March 2012
COMPLETED : 5 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 817 661.4 E 595 986.9
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE		192.85			
		ASPHALT (115 mm)		192.74			
		SAND and GRAVEL, brown, moist (FILL)		192.39	1	GS	
		CLAY, silty, trace gravel, very stiff, brown, moist		0.46	2	SS	16
		CLAY, silty, some sand, trace gravel, very stiff to hard, brown, moist (TILL)		191.40 1.45	3	SS	27
		limestone fragments, brown to grey			4	SS	30
					5	SS	30
		grey			6	SS	19
					7	SS	28
		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		186.14 6.71			

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Mar. 29/12	1.2	191.7
Apr. 02/12	0.9	192.0

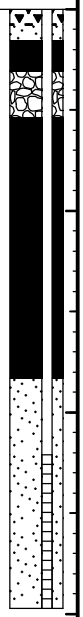
COMMENTS
DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-12

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 817 988.6 E 596 120.7
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) (40 80 120 160) / WATER CONTENT, PERCENT (wp, w, wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		193.33							
		ASPHALT (140 mm)		193.20							
		SAND and GRAVEL, brown, frozen (FILL)		193.00 0.14	1	GS		Grain Size Analysis: Gr 32%/Sa 64%/ Si & Cl 4%	○		
				192.62							
1		**CLAY**, silty, trace gravel, stiff, moist		0.71	2	SS	13		○ ▲		
				191.91							
		CLAY, silty, some sand, trace gravel, shale fragments, very stiff to hard, brown, moist (TILL)		1.42	3	SS	15		○ ▲		
2											
					4	SS	21		○ ▲		
3											
					5	SS	32		○		
4											
		limestone fragments, brown to grey			6	SS	16		○ ▲		
5				188.15							
		END OF BOREHOLE AT 5.2 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Borehole backfilled with bentonite holeplug from base to 0.9 m, cuttings to 0.15 m and asphalt to surface		5.18							
6											
7											
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-13

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 6 March 2012
COMPLETED : 6 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 818 372.5 E 596 418.9
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) / WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		194.25							
		ASPHALT (90 mm)		194.16 0.09							
		SAND and GRAVEL, brown, frozen (FILL)			1	GS					
				193.51							
1		**CLAY**, silty, trace gravel, firm, brown, moist		0.74	2	SS	7				
				192.80							
		CLAY, silty, some sand, trace gravel, stiff to hard, brown, moist (TILL)		1.45	3	SS	13				
2		shale fragments			4	SS	20				
3		reddish-brown			5	SS	26				
4											
5					6	SS	33				
				189.07							
		END OF BOREHOLE AT 5.2 m BELOW GROUND SURFACE 1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		5.18							
6											
7		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 1.9 192.4 Apr. 02/12 1.8 192.5									
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-14

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 2 March 2012
COMPLETED : 2 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 819 072.2 E 596 975.9
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	COMMENTS
		GROUND SURFACE		194.89				
		ASPHALT (90 mm)		194.75				
		SAND and GRAVEL, brown, frozen (FILL)		0.14	1	GS		
				194.20				
1		**CLAY**, silty, some sand, trace gravel, stiff, brown, moist		0.69	2	SS	10	Grain Size Analysis: Gr 1%/ Sa 16%/ Si 41%/ Cl 43%
				193.37				
2		**CLAY**, silty, some sand, trace gravel, very stiff, brown, moist (TILL)		1.52	3	SS	22	
		shale fragments			4	SS	19	
3		reddish-brown			5	SS	26	
4								
5					6	SS	25	
				189.71				
		END OF BOREHOLE AT 5.2 m BELOW GROUND SURFACE 1) Borehole open and dry upon completion of drilling 2) Borehole backfilled with bentonite holeplug from base to 1.9 m, cuttings to 0.15 m and asphalt to surface		5.18				
6								
7								
8								
9								
10								
11								
12								
13								
14								

COMMENTS
DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-15

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 2 March 2012
COMPLETED : 2 March 2012
N 4 819 794.6 E 597 537.1

Project No. 17-454-112
SHEET 1 OF 1
DATUM

DEPTH SCALE (metres)	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
	GROUND SURFACE		190.56				
	ASPHALT (140 mm)		190.41 0.00				
	SAND and GRAVEL, dark brown, moist (FILL)		0.15	1	GS		
	CLAY, silty, trace gravel, firm, dark brown, moist (FILL)		189.95 0.61	2	SS	6	
	CLAY, silty, trace gravel, rootlets, stiff, mottled, brown, moist		189.27 1.30	3	SS	8	
	CLAY, silty, some sand, trace gravel, shale fragments, very stiff, brown, moist (TILL)		188.35 2.21	4	SS	13	
				5	SS	27	
	SILT, clayey, sandy, trace gravel, limestone fragments, hard, grey, moist (TILL)		186.29 4.27	6	SS	50/.150	Grain Size Analysis: Gr 2%/ Sa 30%/Si 50%/ Cl 18%
	SHALE, highly weathered, limestone layers, reddish-brown, moist (Queenston Formation)		185.07 5.49	7	SS	50/.125	
	END OF BOREHOLE AT 6.4 m BELOW GROUND SURFACE		184.19 6.38				

1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
Mar. 29/12	1.2	189.4
Apr. 02/12	1.0	189.6

SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160
WATER CONTENT, PERCENT wp w wl 10 20 30 40
DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
ADDITIONAL LAB. TESTING
PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-16

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 7 March 2012
COMPLETED : 7 March 2012
N 4 820 353.1 E 597 969.9

Project No. 17-454-112
SHEET 1 OF 1
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	COMMENTS DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		190.29							
		ASPHALT (150 mm)		190.14 0.00							
		SAND and GRAVEL, compact, brown, moist (FILL)		0.15	1	GS			○		
		SAND, some silt, loose, brown, moist to wet (FILL)		189.68 0.61	2	SS	6		○		
		SAND, silty, compact, brown, moist to wet		188.84 1.45	3	SS	10		○		
		CLAY, silty, some sand seams, stiff, brown, moist		188.00 2.29	4	SS	12		▲ ○		
		CLAY, silty, some sand, trace gravel, very stiff, brown, moist (TILL)		187.29 3.00	5	SS	19		○ ▲		
		grey			6	SS	16		○		▽
					7	SS	15		○ ▲		
		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Borehole open upon completion of drilling 2) Water level at 5.3 below ground surface upon completion of drilling 3) Borehole backfilled with bentonite holeplug from base to 0.6 m, cuttings to 0.15 m and asphalt to surface		183.58 6.71							

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 7 March 2012

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-17

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 5 March 2012
COMPLETED : 5 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 820 860.7 E 598 360.4
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		182.00							
		ASPHALT (150 mm)		181.84 0.00							
		SAND and GRAVEL, brown, frozen (FILL)		0.15	1	GS			○		
		CLAY, silty, trace gravel, firm to stiff, brown, moist (FILL)		181.34 0.66							
1					2	SS	9		○ ▲		
		limestone fragments									
2					3	SS	18		○ ▲		
		firm									
					4	SS	5		▲ ○		
3											
					5	SS	4	Grain Size Analysis: Gr 0%/ Sa 24%/Si 49%/ Cl 26%	▲ ○		
4											
					6	SS	50/.100		○		▽
5											
		GRAVEL, some sand, trace silt, very dense, dark grey, wet		176.51 5.49							
6					7	SS	50/.125	Grain Size Analysis: Gr 67%/Sa 23%/Si & Cl 10%	○		
		CLAY, silty, some sand, trace gravel, shale fragments, limestone fragments, hard, reddish-brown, moist (TILL)		175.44 6.55							
7											
					8	SS	57		○		
8											
				173.41 8.59	9	SS	50/.050				
		END OF BOREHOLE AT 8.6 m BELOW GROUND SURFACE 1) Borehole open to 6.2 m below ground surface upon completion of drilling 2) Water level at 4.6 m below ground surface upon completion of drilling 3) Borehole backfilled with bentonite holeplug from base to 1.1 m, cuttings to 0.15 m and asphalt to surface									
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 5 March 2012

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-18

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 2 March 2012
COMPLETED : 2 March 2012
N 4 820 894.2 E 598 396.2

Project No. 17-454-112
SHEET 1 OF 1
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		181.87				20 40 60 80 100			
		ASPHALT (165 mm)		181.70 0.00				Grain Size Analysis:			
		SAND and GRAVEL, trace silt, brown, moist (FILL)		0.17	1	GS		Gr 48%/Sa 43%/ Si & Cl 9%	○		
				181.11							
1		**CLAY**, silty, trace gravel, firm to stiff, brown, moist (FILL)		0.76	2	SS	6		○		
2					3	SS	4		○		
		limestone fragments			4	SS	15		○		
3					5	SS	9		○		
4		**CLAY**, silty, trace sand seams, firm, brown, moist		177.91 3.96							▼
5					6	SS	5		▲ ○		
		CLAY, silty, some sand, trace gravel, shale fragments, hard, reddish-brown, moist (TILL)		176.39 5.49							
6					7	SS	50/.150		○		
7											
		grey			8	SS	57		○		
8											
9		**SHALE**, highly weathered, grey limestone layers, reddish-brown, moist (Queenston Formation)		172.88 8.99	9	SS	50/.150		○		
10											
11					10	SS	50/.075		○		
12											
		END OF BOREHOLE AT 12.3 m BELOW GROUND SURFACE		169.58 12.29	11	SS	50/.100		○		
13		1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen									
14		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 4.0 177.9 Apr. 02/12 4.4 177.5									

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-19

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 7 March 2012
COMPLETED : 7 March 2012
N 4 821 428.4 E 598 808.8

Project No. 17-454-112
SHEET 1 OF 1
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		188.67				
		ASPHALT (140 mm)		188.52				
		SAND and GRAVEL, brown, frozen (FILL)		0.15	1	GS		
1					2	SS	8	
				187.22				
		CLAY, silty, some sand, trace gravel, stiff to very stiff, brown, moist (TILL)		1.45	3	SS	14	
2		shale/limestone fragments						
					4	SS	22	Grain Size Analysis: Gr 0%/ Sa 24%/ Si 51%/ Cl 25%
3					5	SS	22	
4								
		grey, stiff to firm			6	SS	8	
5								
6					7	SS	6	
				181.97				
7		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen		6.71				
8								
9		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 0.8 187.9 Apr. 02/12 0.6 188.1						
10								
11								
12								
13								
14								

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-20

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 2 March 2012
COMPLETED : 2 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 822 019.6 E 599 278.2
DATUM

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		190.44							
		ASPHALT (50 mm)		190.39 0.05				Grain Size Analysis: Gr 40%/Sa 45%/Si & Cl 15%			
		SAND and GRAVEL, some gravel, trace silt, brown, moist (FILL)			1	GS					
				189.75 0.69							
1		**SILT**, sandy, loose, brown, moist to wet			2	SS	6				
2					3	SS	7				
					4	SS	11				▽
				187.64 2.79							
3		**CLAY**, silty, firm to stiff, brown to grey, moist			5	SS	7				
4											
5					6	SS	6				
6											
					7	SS	9				
				183.73 6.71							
7		END OF BOREHOLE AT 6.7 m BELOW GROUND SURFACE 1) Borehole open to 3.2 m below ground surface upon completion of drilling 2) Water level at 2.5 m below ground surface upon completion of drilling 3) Borehole backfilled with bentonite holeplug from base to 0.9 m, cuttings to 0.15 m and asphalt to surface									
8											
9											
10											
11											
12											
13											
14											

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 2 March 2012

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date)

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

RECORD OF BOREHOLE 12-21

PROJECT : Britannia Road EA
LOCATION : Britannia Road (Tremaine Road to HWY 407)
STARTED : 7 March 2012
COMPLETED : 7 March 2012

Project No. 17-454-112
SHEET 1 OF 1
N 4 822 613.5 E 599 707.7
DATUM

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		190.03				
		ASPHALT (150 mm)		189.88				
		SAND and GRAVEL, brown, frozen (FILL)		0.15	1	GS		
				189.40				
		CLAY, silty, trace sand seams, firm, brown, moist		0.63	2	SS	5	Grain Size Analysis: Gr 0%/ Sa 19%/ Si 59%/ Cl 22%
1								
					3	SS	8	
2								
					4	SS	18	
3								
					5	SS	5	
4				185.92				
		CLAY, silty, some sand, trace gravel, limestone fragments, hard to very stiff, grey, moist (TILL)		4.11				
					6	SS	37	
5								
6								
					7	SS	18	
7				182.57				
		SHALE, highly weathered, limestone layers, reddish-brown, moist (Queenston Formation)		7.47				
					8	SS	50/.150	
8								
9				180.74	9	SS	50/.125	
		END OF BOREHOLE AT 9.3 m BELOW GROUND SURFACE		9.30				
10		1) Piezometer installation consists of 19 mm diameter PVC pipe with a 1.52 m slotted screen						
11		WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Mar. 29/12 1.1 188.9 Apr. 02/12 1.0 189.0						
12								
13								
14								

SHEAR STRENGTH: Cu, KPa
nat V - ✚ Q - ✖
rem V - ● Cpen ▲
40 80 120 160

WATER CONTENT, PERCENT
wp w wl
10 20 30 40

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 29 March 2012

LOGGED : SSL
CHECKED : SBP

THURBER

THURBER2S 4112.GPJ 2/4/13

APPENDIX C

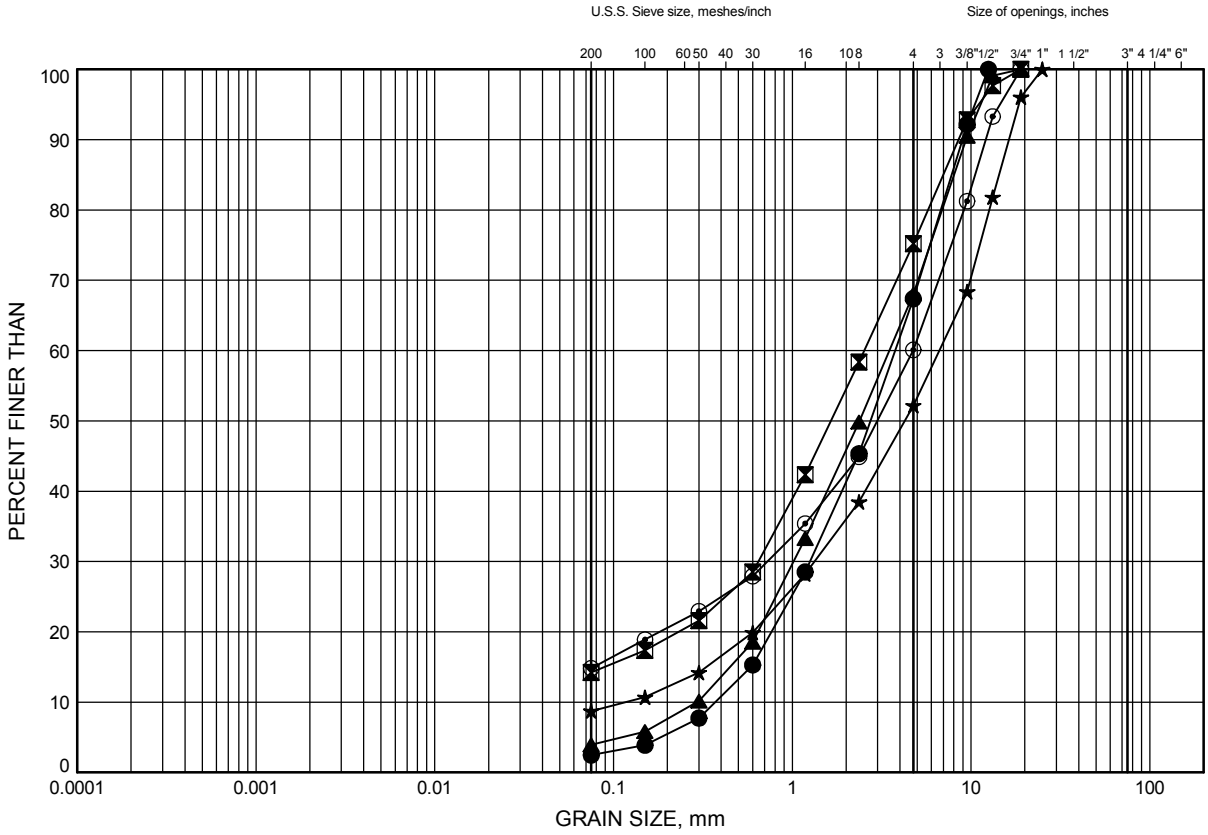
GEOTECHNICAL LABORATORY TEST RESULTS

Britannia Road EA

GRAIN SIZE DISTRIBUTION

FIGURE 1

SAND and GRAVEL (Fill)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	12-06	0.30	183.12
⊠	12-08	0.30	177.73
▲	12-12	0.30	193.03
★	12-18	0.27	181.61
⊙	12-20	0.30	190.13

W.P.# 17-454-112
Prepared By MFA
Checked By SBP

THURBER

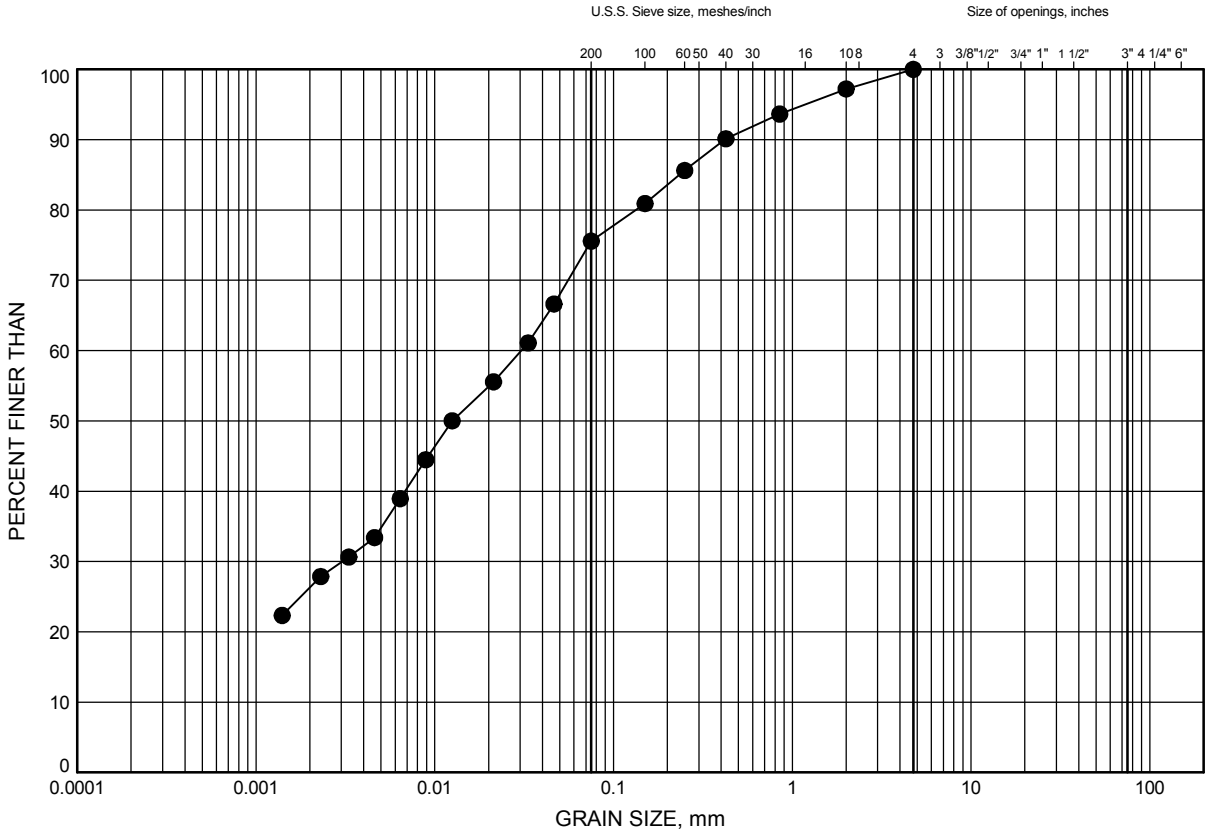
GRAIN SIZE DISTRIBUTION - THURBER 4112.GPJ 2/4/12

Britannia Road EA

GRAIN SIZE DISTRIBUTION

FIGURE 2

Silty CLAY (Fill)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	12-17	3.35	178.64

W.P.# 17-454-112
Prepared By MFA
Checked By SBP

THURBER

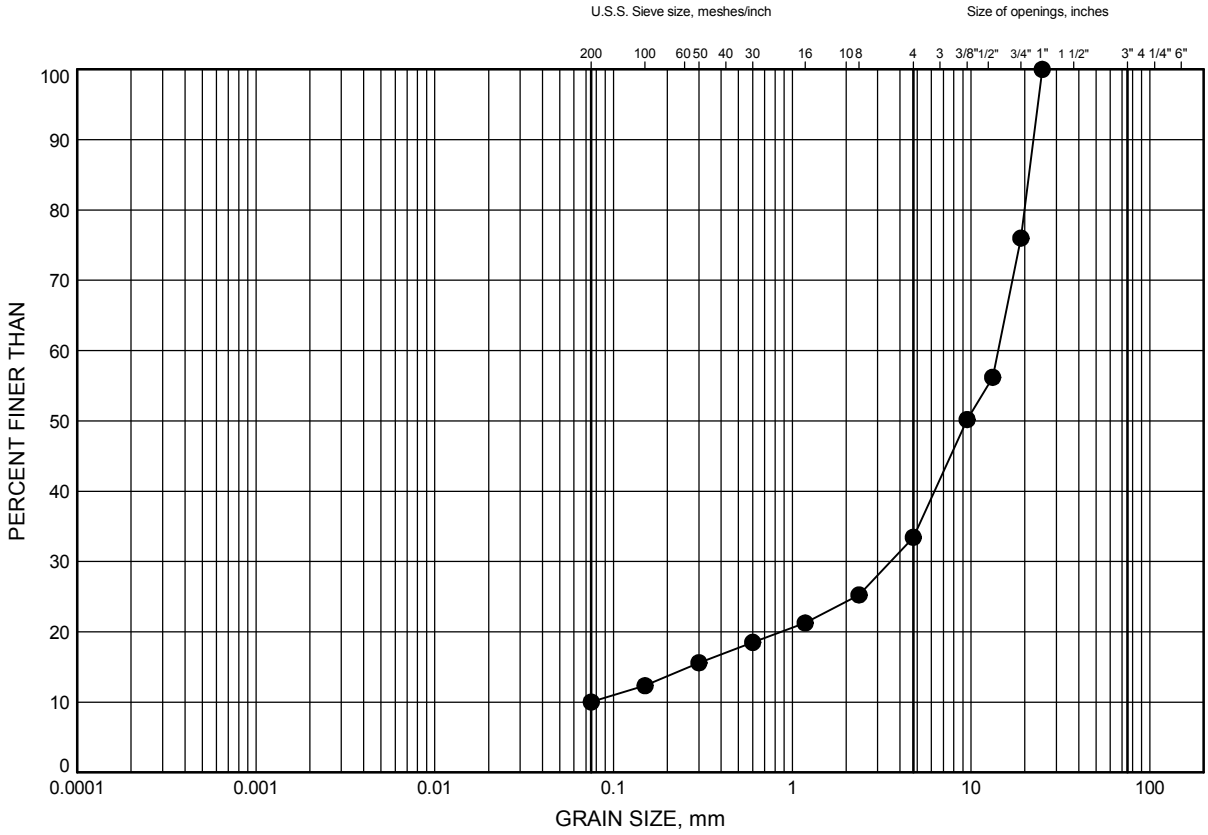
GRAIN SIZE DISTRIBUTION - THURBER 4112.GPJ 2/4/12

Britannia Road EA

GRAIN SIZE DISTRIBUTION

FIGURE 3

GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	12-17	6.40	175.60

W.P.# 17-454-112
Prepared By MFA
Checked By SBP

THURBER

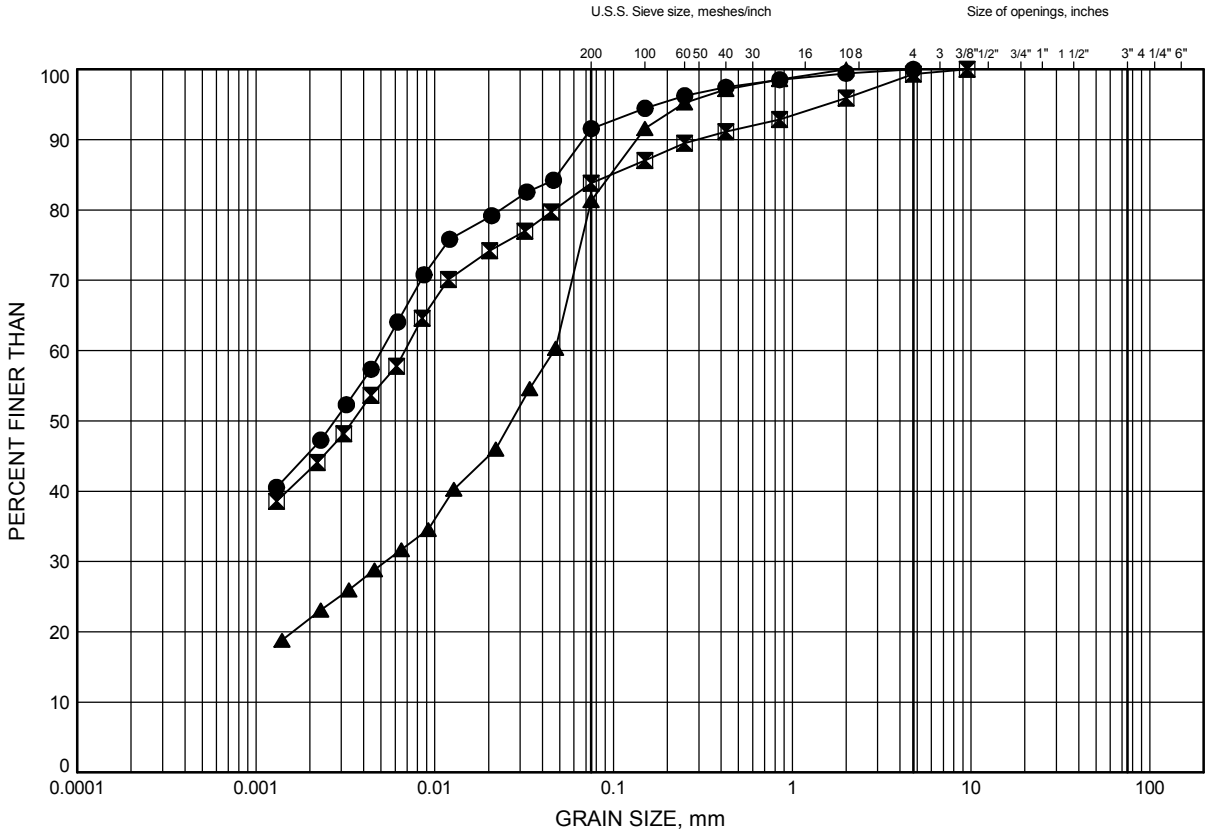
GRAIN SIZE DISTRIBUTION - THURBER 4112.GPJ 2/4/12

Britannia Road EA

GRAIN SIZE DISTRIBUTION

FIGURE 4

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	12-05	1.83	184.37
⊠	12-14	1.07	193.82
▲	12-21	1.07	188.97

W.P.# 17-454-112
Prepared By MFA
Checked By SBP

THURBER

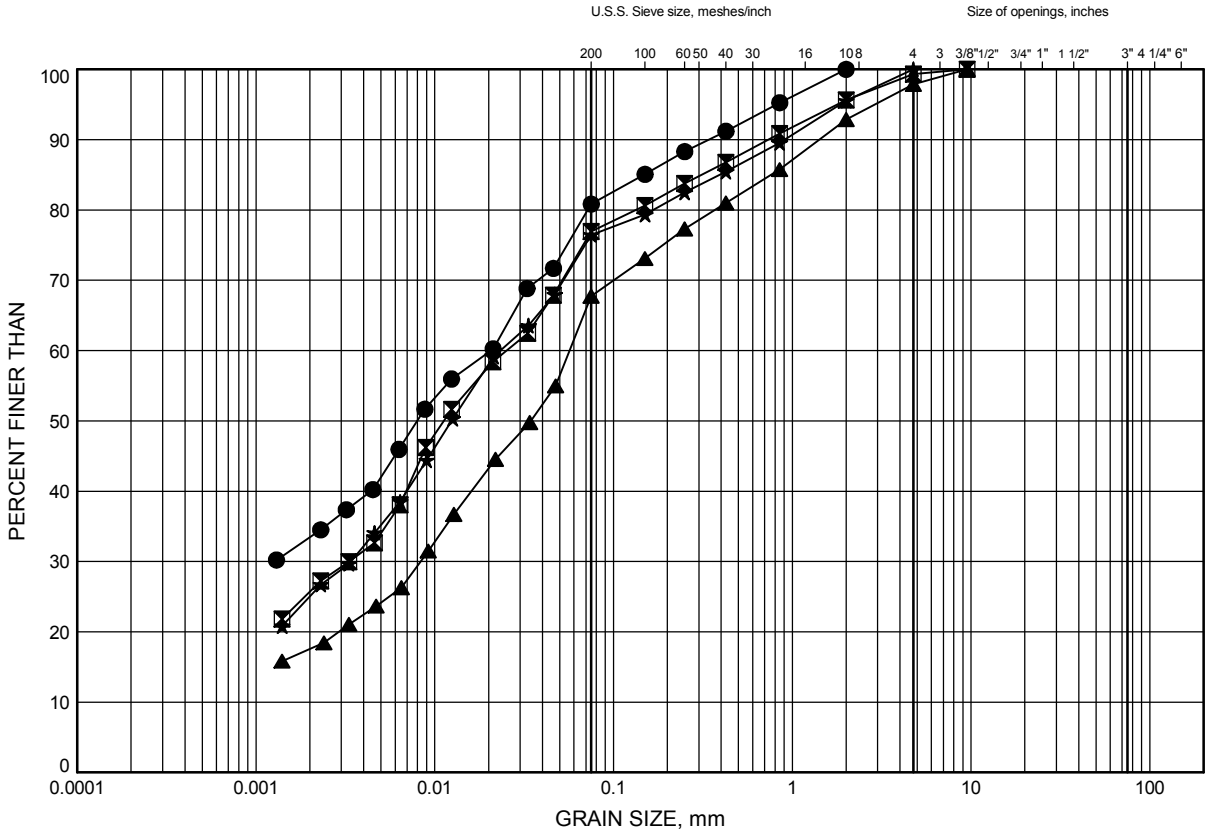
GRAIN SIZE DISTRIBUTION - THURBER 4112.GPJ 2/4/12

Britannia Road EA

GRAIN SIZE DISTRIBUTION

FIGURE 5

Silty CLAY (Till)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	12-01	3.35	181.45
⊠	12-10	3.35	191.26
▲	12-15	4.80	185.76
★	12-19	2.59	186.08

W.P.# 17-454-112
Prepared By MFA
Checked By SBP

THURBER

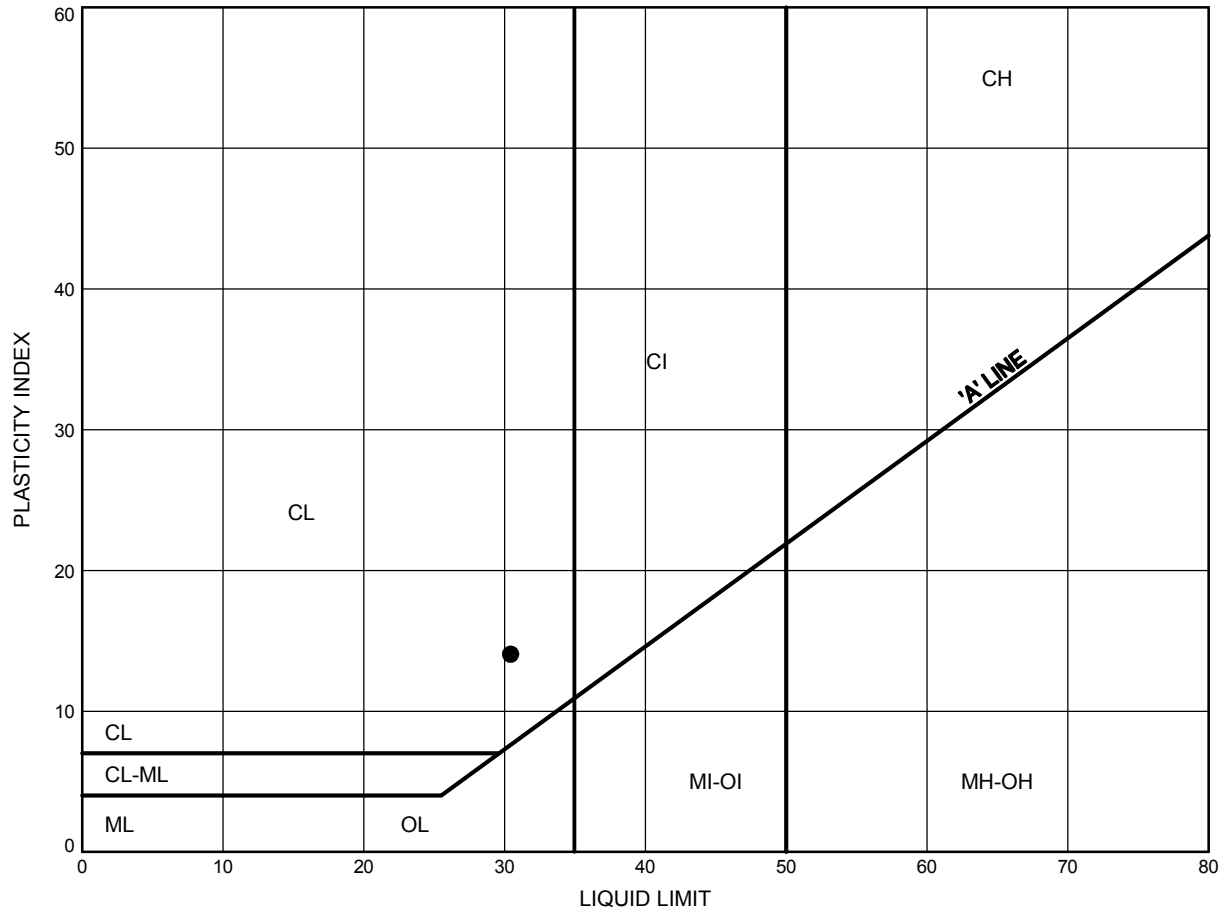
GRAIN SIZE DISTRIBUTION - THURBER 4112.GPJ 2/4/12

Britannia Road EA

ATTERBERG LIMITS TEST RESULTS

FIGURE 6

Silty CLAY (Fill)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	12-07	1.07	176.42

Date April 2012

Project 17-454-112

THURBER

Prep'd MFA

Chkd. SBP

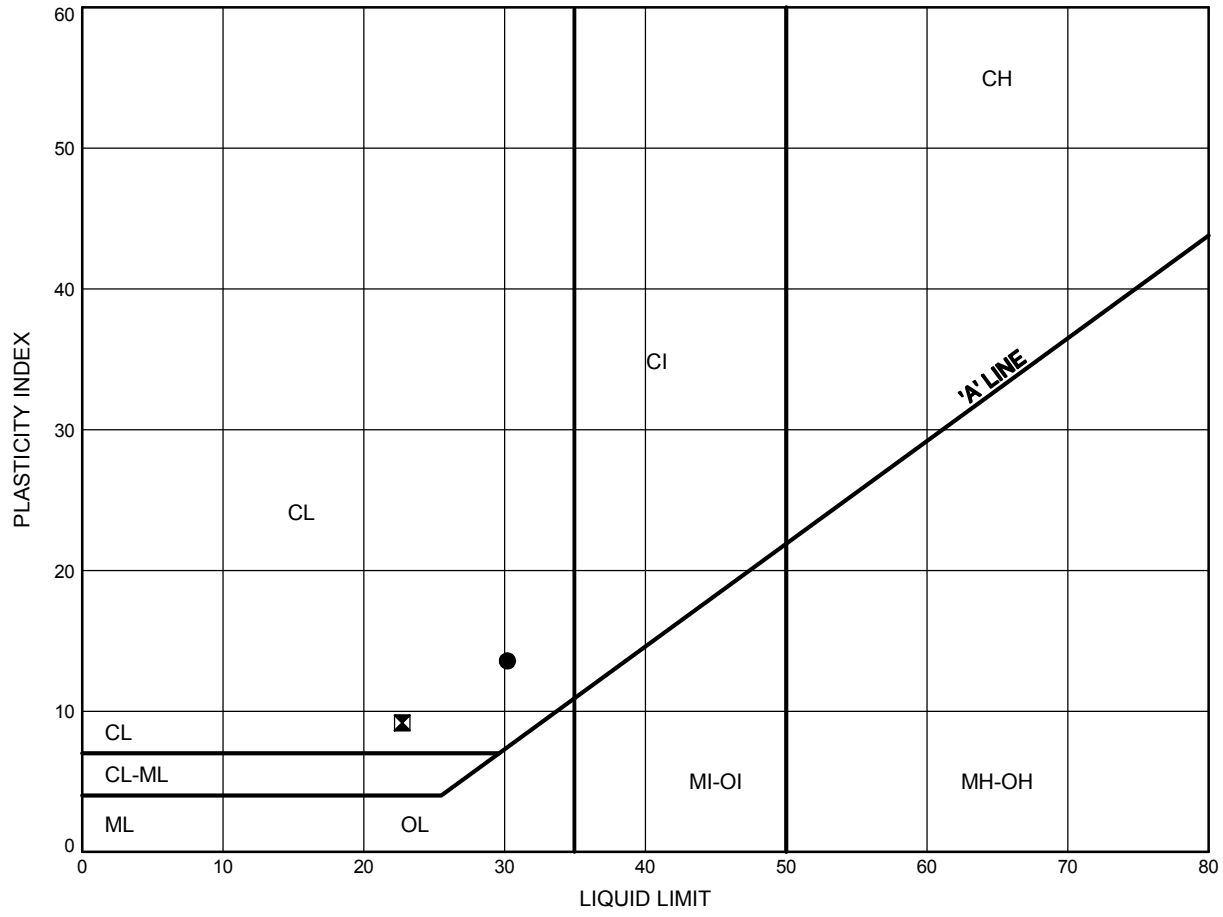
THURBALT 4112.GPJ 2/4/12

Britannia Road EA

ATTERBERG LIMITS TEST RESULTS

FIGURE 7

Silty CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	12-11	1.07	191.78
⊠	12-21	6.40	183.63

Date April 2012

Project 17-454-112

THURBER

Prep'd MFA

Chkd. SBP

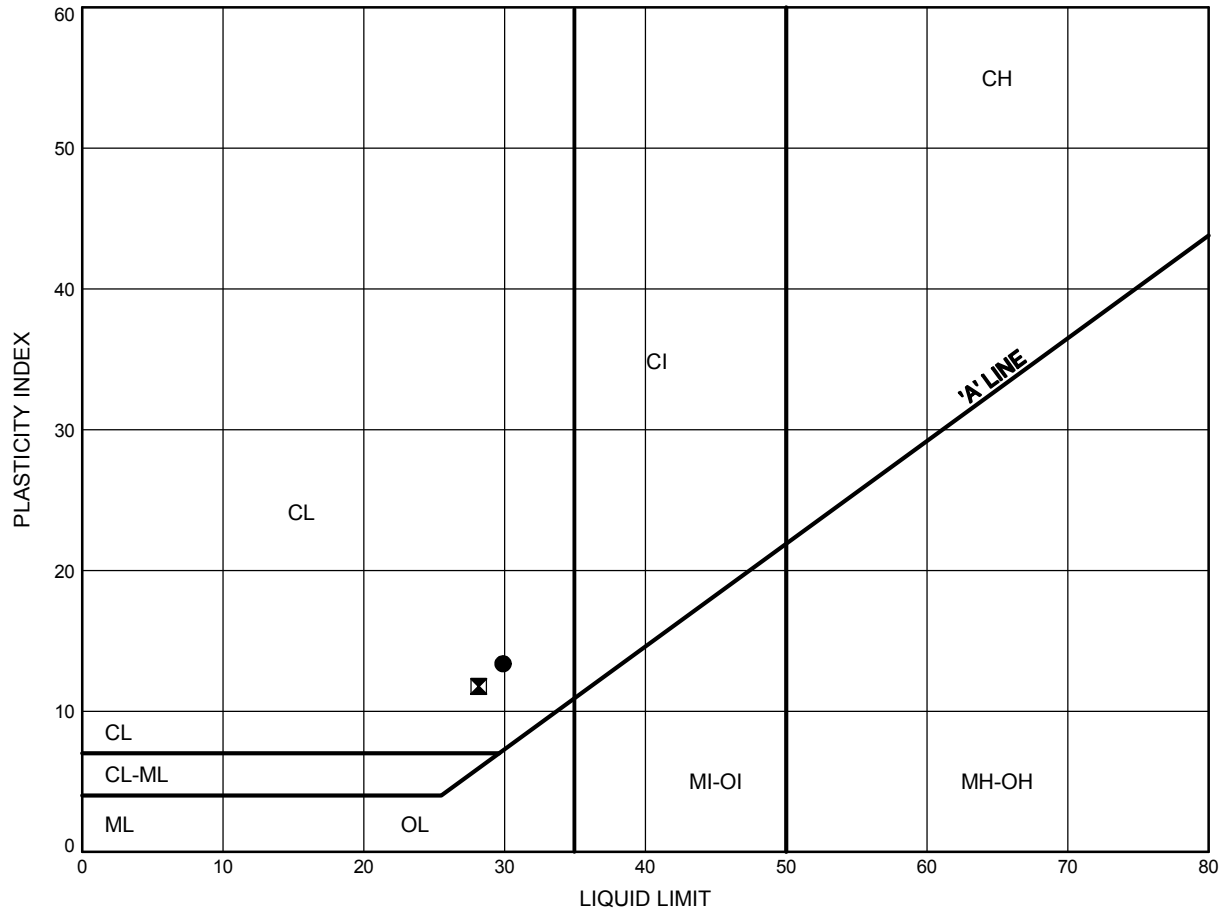
THURBALT 4112.GPJ 2/4/12

Britannia Road EA

ATTERBERG LIMITS TEST RESULTS

FIGURE 8

Silty CLAY (Till)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	12-09	2.59	187.12
⊠	12-13	1.83	192.42

Date April 2012

Project 17-454-112

THURBER

Prep'd MFA

Chkd. SBP

THURBALT 4112.GPJ 2/4/12

APPENDIX D

PHOTOGRAPHS

Photo 1: CN Railway, looking East [Borehole 12-02 and 12-03, to be drilled]

Photo 2: West tributary of Sixteen Mile Creek, looking East [Borehole 12-05]

Photo 3: Sixteen Mile Creek (West Branch), looking East. [Borehole 12-07 and 12-08]

Photo 4: East of Fifth Line, looking East. [Borehole 12-14]

Photo 5: Sixteen Mile Creek (East Branch), looking East. [Borehole 12-17 and 12-18]


Photo 6: CP Railway, looking East. [Borehole 12-21]