

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HURONTARIO STREET SOUTH TO HIGHWAY 401 EAST RAMP  
HWY 401 WIDENING, HWY 410 TO CREDIT RIVER  
MISSISSAUGA, ONTARIO  
G.W.P. 2107-05-00, WP 2107-05-02, SITE 24-757**

**Geocres Number: 30M12-266**

**Report to**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed grade separation structure to carry the proposed Hurontario Street South to Highway 401 East Ramp (ramp) over a new Hurontario Street South Access Road (access road) of the Highway 401-Hurontario Street interchange in Mississauga, Ontario. The proposed structure and associated RSS walls will be located on the south side of Highway 401 and the east side of Hurontario Street.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach embankments for the structure, as well as for the associated retaining walls.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 2005-A-000347.

**2 SITE DESCRIPTION**

The site is located at the southeast quadrant of Highway 401 and Hurontario Street interchange in Mississauga, Ontario.

The lands at the northwest quadrant of Highway 401 and Hurontario Street are generally vacant, undeveloped and/or agricultural. Vegetation is moderate consisting mainly of tall grass and shrubs. To the east of Hurontario Street and south of Highway 401, lands have been developed for commercial and industrial uses. The topography is typically flat.

The general site area is located within the physiographic region known as Peel Plain, characterized by a level to undulating cohesive glacial till plain underlain by reddish brown shale with limestone layers of the Queenston Formation.

### 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out from September 12 to 24, 2007 and consisted of drilling and sampling seventeen boreholes (numbered RSE-01 to RSE-17) at the site. Boreholes were drilled at locations of the structure abutments, approaches and retaining walls along the alignment of the proposed Hurontario Street South Access Road and Hurontario Street South- Highway 401 East Ramp (ramp).

Eleven boreholes were terminated upon auger refusal in shale bedrock at depths of 3.8 m to 7.7 m (elevations 187.6 m to 185.0 m). Six boreholes were further advanced into shale bedrock by coring to depths of 7.2 m to 10.8 m (elevations 183.5 m to 181.6m), with a minimum 3.0 m of rock cores recovered in each borehole.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix E. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

Solid stem augers were used to advance the boreholes in the overburden and into the shale. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ rock coring equipment was used to recover core samples of the underlying bedrock in selected boreholes.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Five standpipe piezometers consisting of 19 mm PVC pipes with slotted screens were installed in selected boreholes to permit monitoring of groundwater levels. Details of the piezometer installations and other borehole completion details are as shown in Table 3.1.

**Table 3.1 – Borehole Completion Details**

<b>Foundation Unit</b>	<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Completion Details</b>
<b>West Abutment</b>			
South	RSE-01	None installed	Bentonite grout to surface.
	RSE-02	7.2/183.5	Sand from 7.2 m to 5.2 m, bentonite grout to surface.
Centre	RSE-03	None installed	Bentonite grout to surface.
	RSE-04	None installed	Bentonite grout for full depth.
North	RSE-05	None installed	Bentonite grout to surface.
	RSE-06	6.4/186.0	Sand from 6.4 m to 4.6 m, bentonite grout to surface.
<b>East Abutment</b>			
South	RSE10	4.6/185.0	Sand from 4.6 m to 2.7, bentonite grout to surface.
	RSE11	None installed	Bentonite grout to surface.
Centre	RSE12	None installed	Bentonite grout to surface.
	RSE13	None installed	Bentonite grout to surface.
North	RSE14	10.8/181.6	Sand from 10.8 m to 8.8 m, bentonite grout to surface.
	RSE15	None installed	Bentonite grout to surface.
<b>West Approach</b>	RSE16	None installed	Bentonite grout to surface.
<b>East Approach</b>	RSE17	None installed	Bentonite grout to surface.
<b>Retaining Wall</b>			
Southeast	RSE-09	None installed	Bentonite grout to surface.
Northwest	RSE-07	None installed	Backfilled with bentonite grout to 0.3 m, cuttings to surface.
	RSE-08	7.7/185.0	Sand from 7.7 m to 5.8 m, bentonite grout to 0.3 m, sand and gravel to surface. Flushmount installed.

#### 4 LABORATORY TESTING

All recovered soil and rock samples were subjected to Visual Identification (VI) and geological logging. At least 25% of the recovered samples of soil were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. Moisture content determinations were carried out on all soil samples. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

Core samples of the shale bedrock were carefully protected to prevent drying during transport to the laboratory. Point load tests were carried out on selected samples of intact shale, siltstone and

limestone interbeds upon arrival at the laboratory to assist in evaluation of the compressive strength of the bedrock. Results of point load tests on the selected rock core samples are shown in Table 1 immediately following the text and on the Record of Borehole sheets in Appendix A.

## **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Records of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in this appendix and on the Borehole Locations and Soil Strata Drawing in Appendix E. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general terms, the soil stratigraphy encountered at this site consists of topsoil overlying fill which is underlain by native silty clay, silty clay/clayey silt till deposits and occasional sand layers. Weathered shale bedrock was contacted below the till deposits. More detailed descriptions of the individual strata are presented below.

### **5.1 Topsoil**

Topsoil was identified at ground surface in most of the boreholes, except in Boreholes RSE-07 to RSE-09 and RSE-13. The topsoil thickness generally ranged from 50 mm to 100 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

### **5.2 Fill**

Fill was encountered below the topsoil in all the boreholes. The fill generally consists of brown to grey silty clay and/or clayey silt with trace to some sand, trace of gravel and occasional rootlets. Sand and silt fill was revealed surficially along the proposed retaining walls (Boreholes RSE-07 to RSE-09). In Borehole RSE-14, located at the east abutment, a 600 mm-thick layer of reddish brown shale fill was contacted below the topsoil.

Based on recorded SPT N-values ranging from 8 to 86 blows for 0.3 m of penetration, the silty clay/clayey silt fill is described as stiff to hard. SPT N-values greater than 50 blows per 0.15 m penetration were observed within the clayey fill at 0.75 m depth in Borehole RSE-16. SPT values measured in the cohesionless fill were 18 and 39 blows per 0.3 m penetration indicating compact to dense conditions. The natural moisture content of the fill samples ranged from 3% to 18%.

The results of laboratory tests carried out on five samples were as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	24 to 40
Silt	38 to 50
Clay	19 to 29

Index Property	(%)
Liquid Limit	23 to 38
Plastic Limit	13 to 18
Plasticity Index	9 to 19

The above results show that the silty clay/clayey silt fill is of low to medium plasticity with a group symbol of CL to CI.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. Atterberg Limit test results are presented on Figure B7 of Appendix B.

The depth to the base of the clay fill layer ranged from 1.4 m to 4.6 m (from Elevations 191.3 to 187.9 m).

### 5.3 Silty Clay

Native brown to grey/dark grey silt clay trace to some sand, trace gravel and occasional rootlets and organic odour was encountered below the fill in Boreholes RSE-01, RSE-02, RSE-04, RSE-11, RSE-13, RSE-16 and RSE-17 located at the west and east abutments and approaches.

Based on SPT N-values ranging from 9 to 24 blows for 0.3 m of penetration, the silty clay is described as being stiff to very stiff. The natural moisture contents of the samples recovered from the silty clay layer ranged from 3 to 18%.

The results of laboratory tests carried out on one sample were as follows:

Soil Particles	(%)
Gravel	1
Sand	33
Silt	43
Clay	23

The grain size distribution curve for the sample tested is presented on the Record of Borehole sheet and on Figure B2 of Appendix B.



The base of the silty clay layer was ranging from 2.2 m to 3.0 m (elevation 187.8 to 189.4 m).

#### 5.4 Silty Clay to Clayey Silt Till

Deposits of brown to grey silty clay till and clayey silt till with sand, trace of gravel, occasional rootlets and red shale fragments were contacted below the fill and silty clay in all the boreholes, except in Borehole RSE-14 where the clayey silt till was present below a sand layer.

Based on SPT N-values ranging from 8 blows for 0.3 m of penetration to greater than 50 blows for 0.075 m of penetration, the silty clay till and clayey silt till are described as being stiff to hard. The natural moisture contents of the samples recovered from the silty clay till and clayey silt till layers ranged from 5 to 20%.

The results of laboratory tests carried out on several till samples were as follows:

Soil Particles	(%)
Gravel	0 to 9
Sand	22 to 46
Silt	37 to 62
Clay	14 to 28

Index Property	(%)
Liquid Limit	23 to 40
Plastic Limit	13 to 19
Plasticity Index	9 to 20

The above results show that the silty clay to clayey silt till is typically of low plasticity with a group symbol of CL. One tested sample is of medium plasticity with a group symbol of CI.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figures B3 to B5 of Appendix B. Atterberg Limit test results are presented on Figures B8 to B10 of Appendix B.

The depth to the base of the till deposit layers ranged from 3.4 m to 7.3 m (Elevations 187.6 m to 185.1 m).

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders at the lower part of the till may contain pieces and slabs of bedrock which may account for some high blow counts and resistance to augering.

### 5.5 Silty Sand and Sandy Silt Till

Silty sand and sandy silt till with trace of gravel were contacted below the cohesive till in Boreholes RSE-05 and RSE-08, respectively. A 1.5 m thick layer of silt till was encountered in Borehole RSE-15 at 4.6 m depth (elevation 187.9 m).

Based on recorded SPT N-values of 102 and 50 blows for 0.150 m of penetration, these cohesionless soils are described as very dense. The natural moisture content of the samples obtained from these deposits ranged from 10 to 18%.

The results of laboratory tests carried out on a sample of the silt till were as follows:

Soil Particles	(%)
Gravel	0
Sand	18
Silt	74
Clay	8

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure B6.

The depth to the base of these deposits ranged from 6.1 m to 7.3 m (Elevations 185.1 m to 186.4 m).

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders which may account for some high N-values and resistance to augering.

### 5.6 Sand

A 1.5 m-thick layer of brown sand with trace of silt and trace of gravel was contacted below the fill in Borehole RSE-14, located at the east abutment.

Based on a recorded SPT N-value of 50 blows for 0.15 m of penetration, the sand is described as very dense. The natural moisture content of the sample obtained from the sand layer was 17%.

The depth to the base of the sand was 6.1 m (Elevation 186.4 m).

### 5.7 Bedrock

The soils described above were found to be underlain by shale bedrock of the Queenston Formation. The shale encountered in the boreholes is described as fine grained, thinly bedded and contains numerous hard interbedded siltstone and limestone layers. The shale bedrock is highly to moderately weathered within the upper 2 m below which the degree of weathering decreases with depth. SPT N-values obtained in the upper part of the shale bedrock ranged from 54 to greater than 100 blows per 0.1 m penetration. Moisture contents

excellent rock quality. Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 10.

Results of the point load tests conducted on the rock core samples are presented in Table 1 immediately following the text. Average values are also shown on the Record of Borehole sheets. The typical ranges of inferred UCS for various types of rock cores are summarized in Table 5.2.

**Table 5.2 – Inferred Unconfined Compressive Strength**

<b>Rock Type</b>	<b>Inferred Unconfined Compressive Strength (MPa)</b>
Shale or shale/siltstone	3 to 10
Siltstone	16 to 125
Limestone	24 to 142

It must be noted, however, that point load tests were possible only on less weathered shale or higher strength limestone interbed samples as the more typical weathered shale cores tended to be not suitable for point load testing. Broken zones were observed within the cores at several depths.

The shale bedrock typically contains layers of siltstone and limestone that can be significantly harder than the shale itself. The distribution, thickness and strength of these layers vary from location to location, and these layers typically exhibit less pronounced weathering than the shale. The records of boreholes indicate that within the depths investigated, these hard interbeds range from 20 to 170 mm in thickness. Sampling and interpretation from small diameter boreholes may underestimate the frequency, thickness and strength of the strong layers and therefore geological expertise and past experience must be applied in any decision making process regarding the bedrock.

## **5.8 Water Levels**

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in five boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.3, along with the measurements in the boreholes upon completion of drilling.

**Table 5.3 – Measured Groundwater Levels**

Borehole	Date (2007)	Water Level (m)		Comment
		Depth	Elevation	
RSE-02	September 28	1.7	189.0	In piezometer
	October 5	1.6	189.1	
	October 18	1.5	189.2	
	November 1	1.5	189.2	
	November 15	1.3	189.4	
RSE-05	September 20	6.1	186.3	In open borehole
RSE-06	September 9	2.9	189.5	In piezometer
	September 19	2.8	189.6	
	September 28	2.9	189.5	
	October 5	3.1	189.3	
	October 18	2.7	189.7	
	November 1	2.6	189.8	
	November 15	2.7	189.7	
RSE-07	September 12	7.6	185.4	In open borehole
RSE-08	September 28	3.1	189.7	In piezometer
	October 5	3.1	189.6	
	November 1	2.8	190.0	
	November 15	2.9	189.9	
RSE-10	September 14	2.0	187.6	In piezometer
	September 19	1.9	187.7	
	September 28	2.1	187.5	
	October 5	1.9	187.7	
	October 18	1.7	187.9	
	November 1	1.6	188.0	
	November 15	1.4	188.2	
RSE-14	September 19	1.7	190.8	In piezometer
	September 28	1.8	190.7	
	October 5	1.8	190.7	
	October 18	1.8	190.7	
	November 1	1.6	190.9	
	November 15	1.7	190.8	

The piezometric readings indicate that the groundwater levels range from Elevations 187.5 m to 190.9 m.

The above values 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 the spring snowmelt or after periods of heavy rainfall. Further, perched water may be encountered at higher levels in pockets or zones of more permeable sands and silts within the heterogeneous tills, or within the fill.

## 6 MISCELLANEOUS

Borehole locations and ground surface elevations were supplied to Thurber by MMM Group Limited. The drilling and sampling equipment was supplied and operated by DBW Drilling of Ajax Ontario. The field work was supervised on a full time basis by Mr. George Azzopardi of Thurber Engineering Ltd.

Laboratory testing was carried out at Thurber's Laboratory in Oakville, Ontario.

Supervision of the field program, interpretation of the field data and preparation of the investigation report was conducted by Dr. Sydney Pang, P. Eng. and Ms. R. Palomeque Reyna, P.Eng.

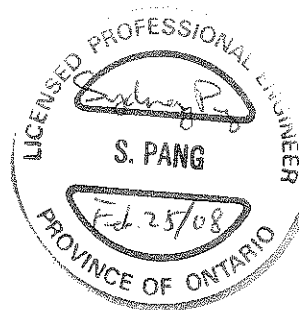
Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

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**PART 2: ENGINEERING DISCUSSIONS AND RECOMMENDATIONS**

**7 INTRODUCTION**

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach fills for the proposed structure and associated RSS walls.

It is understood that the proposed overpass is to carry the new Hurontario Street south to Highway 401 East Ramp (ramp) over a new Hurontario Street South Access Road (access road). The new road under the ramp will be formed in a cut varying in depth from approximately 0.5 m to 3.0 m (from south to north sides of the structure).

The preliminary General Arrangement (GA) drawing indicates that the proposed structure is a single-span, concrete, rigid frame with a clear span of 11.5 m (perpendicular to the access road alignment) and an approximate length of 25 m (parallel to the access road alignment). The ramp will lie at approximate Elevation 196.2 m and the access road lanes will lie at approximate Elevation 189.6 m. Two RSS walls are also included in the design. These walls will extend parallel to the access road, adjacent to the northwest and southeast corners of the rigid frame structure. The proposed elevations of the underside of the rigid frame footings vary from approximate elevations 188.2 m to 188.5 m.

At the west approach, the original ground lies between Elevations 190.7 m to 192.4 m, resulting in an approach fill of approximately 3.8 m to 5.5 m high. At the east approach, the original ground lies between Elevations 189.6 m to 192.5 m, resulting in an approach fill of approximately 3.7 m to 6.6 m high.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained during the course of the investigation.

## 8 FOUNDATION DESIGN

In general terms, the stratigraphy at the site consists of topsoil and fill overlying native silty clay, silty clay/clayey silt till deposits, which is underlain by shale bedrock contacted at depths ranging from 3.4 to 7.3 m (Elevations 187.5 m to 185.1 m). Piezometers installed in the boreholes revealed that the groundwater level is anticipated to range from 1.3 m to 3.1 m depth (Elevations 187.5 m to 190.9 m) although perched water may be encountered at higher levels within the till and overlying fill.

The GA drawing indicates that the foundation system for the proposed rigid frame structure consists of spread footings founded below the final grade of the access road.

Initial consideration was given to the following foundation types:

- Spread footings on native soil
- Spread footings on shale bedrock
- Augered Caissons (drilled shafts)
- Driven steel H-piles

A comparison of the foundation alternatives based on the advantages and disadvantages of each is included in Appendix C.

From a geotechnical perspective and based on the subsurface conditions, spread footings founded on the native hard till immediately overlying bedrock is considered the most cost effective foundation option for supporting the rigid frame structure at this site. If a higher bearing capacity is required, spread footings founded on shale bedrock may be considered although this will extend the footing excavation up to 4 m to 5 m below the proposed access road grade for foundation construction.

Use of deep foundations such as piles and caissons are not considered cost effective at this site due to the presence of competent tills overlying relatively shallow bedrock at this site. If these are to be used, both the piles and caissons would need to be socketted into the shale bedrock. Pre-augering will likely be required to achieve adequate pile embedment into the shale.

### 8.1 Spread Footings on Native Soil

Spread footings can be founded on the hard native undisturbed silty clay to clayey silt till and or very dense sand/silt. The highest permitted founding elevations for spread footings are given in Table 8.1.

Provided a minimum footing width of 2 m is maintained, footings founded on the above recommended strata may be designed for the following values:

- Factored geotechnical resistance of 600 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 400 kPa at Serviceability Limit States (SLS)

The geotechnical resistances quoted above are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC 2006 Clause 6.7.3 and Clause 6.7.4.

**Table 8.1 – Highest Permitted Founding Elevations**

Foundation Unit	Borehole	Depth to Hard/Dense Native Till (m)	Native Hard/Dense Till Elevation (m)	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
<b>West Abutment</b>					
South	RSE-01	2.2	188.5	4.0	186.7
	RSE-02	2.2	188.4	3.8	186.9
Centre	RSE-03	3.0	188.4	-	-
	RSE-04	3.0	188.8	4.3	187.5
North	RSE-05	4.6	187.8	7.3	185.1
	RSE-06	4.6	187.8	6.1	186.3
<b>East Abutment</b>					
South	RSE10	2.2	187.4	3.7	185.9
	RSE11	2.2	187.8	3.4	186.7
Centre	RSE12	2.2	188.9	3.8	187.3
	RSE13	3.0	188.7	4.6	187.2
North	RSE14*	4.6	187.9	7.3	185.1
	RSE15*	4.6	187.9	6.1	186.4
<b>West Approach</b>	RSE16	4.6	187.8	5.8	186.6
<b>East Approach</b>	RSE17	3.0	188.3	4.0	187.3

\* Native very dense sand and silt

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure. Footings must not be placed on fill. Sub-excavation will be required to expose the underlying undisturbed hard native till in areas where the existing fill extends below the desired footing founding elevations.

The sliding resistance of mass concrete poured on the native till may be computed on the basis of an ultimate coefficient of friction of 0.5. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

The bases of the foundation excavations should be inspected by geotechnical personnel to confirm that the exposed surface conforms to the design requirements and has been



adequately prepared to receive concrete. Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using engineered fill or concrete of the same class as the footing. The engineered fill must consist of OPSS Granular “A” placed in 150 mm lifts, compacted to 100% of its SPMDD at  $\pm 2\%$  of optimum moisture content.

## 8.2 Spread Footings on Shale Bedrock

Based on the subsurface stratigraphy encountered and the proposed ramp grade, the depth of bedrock below the proposed road grade varies from 2.1 m to 4.5 m, except in Borehole RSE-3 where shale bedrock was not confirmed. Spread footings bearing on undisturbed weathered shale bedrock may be designed for the following geotechnical resistance:

- Factored geotechnical resistance of 750 kPa at Ultimate Limit States (ULS)

The SLS condition will not govern design for footings founded on shale bedrock.

The highest permissible bearing elevations for spread footings on bedrock are given in Table 8.1.

These resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC 2006 Clause 6.7.3 and Clause 6.7.4.

The lateral resistance of the footings founded on shale may be computed using an unfactored friction coefficient of 0.55. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

The bearing surface should be prepared by removing all loose/disturbed material and shattered rock, and protecting the shale from deterioration by placing a working mat of concrete of the same class as the footing within 4 hours of completing excavation. Areas requiring subexcavation beneath the underside of footing should be backfilled with the same class of concrete as used in the footing. A mud slab should have a minimum thickness of 100 mm. Also, if the bedrock surface lies below the required footing base, any difference between the underside of the footing and the top of bedrock may be made up using the same class of concrete as used in the footing. In this case, the geotechnical resistance of 750 kPa may still be used for footing design.

The mass concrete fill must extend beyond the footing perimeter by a sufficient distance to distribute the shear stresses from the footing and prevent stress concentrations under the edge of the footing. This condition must be checked structurally but extension of the mass concrete to 200 mm beyond the edge of the footing should be considered. Similarly, the maximum depth of mass concrete that may be permitted below the footing is a function of the structural behaviour of the concrete and is not an issue of geotechnical resistance. Where the bedrock slopes within the foundation footprint, the foundation shall be prepared by

excavation of a horizontal surface in bedrock, though stepping of the footing base is permissible.

### **8.3 Frost Protection**

The design depth of frost penetration at this site through earth or granular materials is 1.2 m.

Although the shale is geologically defined as bedrock, it is susceptible to frost action. Therefore, all footings must be provided with a minimum of 1.2 m of earth cover as frost protection. It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation and typically 25 mm of Styrofoam is equivalent to 600 mm of earth cover. Synthetic insulation must be covered to provide protection where it is used.

## **9 PERMANENT CUT**

Permanent earth cuts are required to construct the access road at this site. The cut will be formed predominantly through about 0.5 m to 3.0 m (from south to north) of the existing clayey silt to silty clay fill overlying native silty clay till. Based on this stratigraphy, cuts through the cohesive fills and native soils are expected to be stable at inclinations not steeper than 2H : 1V. It is anticipated that the base of the cut will generally consist of stiff silty clay to clayey silt till.

The ground water level is between about 1.5 m above the base of the cut to just below the base of the cut. The cohesive fills and native soils that will be exposed within the cut are considered to be of generally low permeability and consequently seepage from the sides of the cut is expected to be of low volume. Much of the water is anticipated to originate from surface runoff and perched water within the fill. It is recommended that water in the cut be drained by means of subdrains behind the abutments of the structure and subdrains installed along the sides of the access road. The subdrains must be kept frost free and be connected to a positive outlet outside the cut.

Vegetative cover should be established on all exposed earth slopes to protect against surficial erosion. Reference may be made to special provision SP572S01 for more detailed requirements, where applicable.

## **10 EXCAVATION**

### **10.1 General**

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the likely depth of excavation at this site may be classed as Type 3 for cohesive fills and Type 2 for native hard cohesive till soils; silts below the groundwater level may be classed as Type 3.

## **10.2 Foundations**

The excavation and backfilling for foundations must be carried out in accordance with SP 902S01.

## **10.3 Earth Excavation**

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions.

Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

A NSSP should be included in the contract alerting the Contractor to the possible presence of cobbles, boulders and bedrock fragments in the overburden, particularly in the hard silty clay till layer above the bedrock.

## **10.4 Bedrock**

Any rock excavation should be carried out in accordance with the Special Provision, Amendment to OPSS 120, 1994.

The selection of the method of excavating and removing the bedrock is the responsibility of the contractor and the contractor is solely responsible for assessing the type, size and power rating of the required equipment.

If rock excavation is required at this site, bidders must be alerted to the fact that the shale bedrock gets stronger with depth and contains frequent very strong interbeds, and rock-breaking equipment must be provided for rock excavation. Excavation of the bedrock will become more arduous with increasing depth into the deposit and the contractor may have to employ specialized methods such as ripping, and pneumatic breaking to dislodge the rock.

## **10.5 Roadway Protection**

It is anticipated that roadway protection will be required during construction. An item titled “Protection System” as per SP 105S19 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.02.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall. It is anticipated that the soldier piles will need to be socketted into the very stiff to hard silty clay to clayey silt till to develop the required toe resistance. It is anticipated that the shoring system may be stiffened by cross bracings, where applicable.

A temporary braced soldier pile and lagging wall may be designed using the parameters given below:

$\gamma$	=	20 kN/m <sup>3</sup>
$\gamma_w$	=	10 kN/m <sup>3</sup>
$K_a$	=	0.35 (existing fill)
	=	0.33 (silty clay to clayey silt tills)
$h_w$	=	0 (assuming no hydrostatic pressure build-up behind a presumably permeable wall)
$H$	=	depth to base of excavation (m)

For pile sockets formed within the very stiff to hard till, the ultimate passive force that can be mobilized by the embedded portion of a socket is given by :

$$P_p = 6 \cdot c \cdot D \cdot L$$

where  $c$  = 150 kPa

$D$  = diameter of socket, m

$L$  = depth of socket in till, m

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall. These factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

## 11 UNWATERING

Piezometers installed in boreholes revealed that groundwater level ranges from about 1.5 m to 3.1 m depth (elevations 187.5 m to 190.9 m) although perched water may be encountered at higher levels within the overlying fill.

During the formation of the cut, seepage of perched water into the excavation and ponding of surface runoff and precipitation could occur. Unwatering measures such as the use of sumps and pumps are considered feasible at this site.

Temporary excavations for construction of footings founded on native hard till are anticipated to extend to the order of 0.1 m to 3.5 m below the groundwater level. If footings are founded on bedrock, temporary excavations for construction are anticipated to extend to the order of 0.2 to 5.8 m below the groundwater level. Considering the consistency and low permeability of the clayey soils, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove any accumulation of water from the footing base prior to placing concrete.

If footings are founded on shale bedrock, they must be constructed in the dry as shale is prone to rapid deterioration upon exposure to water and air. Unwatering must remain operational and effective until the footing is constructed and backfilled.

The design of the unwatering systems is the responsibility of the Contractor.

## **12 APPROACH EMBANKMENTS**

The foundation soils governing stability of the approach embankments consist of existing stiff to hard fill, overlying native stiff to hard silty clay and silt/clay till deposits, underlain by shale bedrock. The proposed embankment heights are approximately 3.8 m to 5.5 m at the west approach and 3.7 m to 6.6 m high at the east approach.

The embankment foundation soils are considered to provide satisfactory resistance to instability under the loading imposed by embankments of up to 5 m to 8 m in height. Earth fill slopes inclined at 2H : 1V or flatter are considered stable.

Considering the embankment height and consistency of the foundation soils, post construction settlement induced by embankment loading will be negligible. Completing embankment construction three months in advance of road paving is recommended as a good construction practice to minimize any time-dependent settlement due to consolidation or particle re-organization in the embankment fill itself.

All topsoil and organic soils should be stripped from the footprint of the approach fills. Particular attention should be paid to removing all softened material from existing ditches that fall within the footprint of the new embankment.

Embankment construction should be in accordance with OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2002. Any existing slopes must be benched in accordance with OPSD 208.010 prior to placing new fill.

Earth fill embankment slopes must be provided with erosion protection in accordance with SP572S01.

## **13 BACKFILL TO ABUTMENTS**

Backfill to the abutments should consist of Granular A or Granular B material. The backfill must be in accordance with OPSS 902 as amended by Special Provision 902S01, and placed to the extents shown in OPSD 3101.150. All granular materials should meet the specifications of SP 110F13 “Amendment to OPSS 1010, March 1993”.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with SP105S01.

The design of the abutment must include a subdrain as shown in OPSD 3102.100.

## 14 STATIC 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 expression:

$$P_h = K (\gamma h + q)$$

where:  $P_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient (see Table 14.1)

$\gamma$  = unit weight of retained soil (see Table 14.1)

$h$  = depth below top of fill where pressure is computed (m)

$q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

**Table 14.1 – Earth Pressure Coefficients (K)**

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.27	0.40*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.43	-	0.47	-
Passive	3.7	-	3.7	-	3.3	-

\* For wing walls.

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 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.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 14.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC 2006.

## 15 RETAINED SOIL SYSTEMS

It is understood that Retained Soil System (RSS) walls are proposed to support the west and east approaches. RSS walls located on the northeast and southwest sides of the proposed structure are approximately 24.2 m and 13.5 m long, respectively. The borehole information indicates that the foundation conditions at the wall locations are comprised of approximately 1.4 m to 2.2 m of stiff to very stiff silty clay fill or compact sand fill overlying very stiff to hard silty clay till and weathered shale bedrock.

The soil conditions encountered on site are generally suitable for the support of RSS walls. The RSS should be specified as “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

The performance of a RSS is dependent on, among other factors, the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. It is critical that the RSS walls are not subject to settlement due to compression of the foundation soils and embankment fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass must be founded on the native undisturbed very stiff to hard clayey tills, dense sand/silt or shale bedrock below the proposed access road grade. The highest base levels for the underside of the wall are indicated in Table 12.1.

**Table 12.1 – Maximum Elevation at Underside of Wall Base or Granular A Fill**

Foundation Unit	Borehole	Depth to Native Very Stiff/Dense Till (m)	Native Very Stiff/Dense Till Elevation (m)	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
<b>Retaining Wall</b>					
Southwest	RSE-09	2.2	189.3	4.0	187.5
	RSE10	2.2	187.4	3.7	185.9
Northeast	RSE-06	4.4	188.0	6.1	186.3
	RSE-07	3.0	190.0	6.4	186.6
	RSE-08	3.0	189.8	6.7	186.0

A wall founded on native very stiff to hard silty clay till at or below elevations shown in Table 12.1 should be designed for a factored bearing resistance of 500 kPa at ULS and a bearing resistance of 250 kPa at SLS.

For RSS wall founded on shale bedrock, detailed design recommendations on vertical and horizontal geotechnical resistances and stepped footings are similar to those for the rigid frame structure footings (see previous Section 8.2, Spread Footings on Shale Bedrock).

Alternatively, the RSS may be founded on engineered fill founded on the native very stiff to hard silty clay till contacted at the above elevations. Engineered fill placed under the RSS mass to achieve the design founding level must consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered pad must be at least 500 mm beyond the limits of the RSS mass and levelling strip.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7.

The entire block of reinforced earth must be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on engineered granular fill may be estimated using an ultimate friction coefficient of 0.55 and an ultimate friction coefficient of 0.45 for native clayey silt/silty clay till.

Topsoil, loose fill, and any soft/wet native material should be stripped from the footprint of the RSS. The native soil under the RSS foundation should be proofrolled to detect and replace any soft areas.

The proprietary RSS system must meet the Ministry’s specifications for performance and appearance. The RSS supplier/designer may specify more stringent criteria or other requirements related to the particular design. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

If a RSS wall system is selected, the global stability must be analyzed after the location of the wall is known. The global stability of the RSS wall is dependent on the characteristics of the embankment fill and the foundation soils, the geometry of the embankment and location of the RSS within the embankment. Typically, global stability should not be a major concern for a 7 to 8 m-high RSS wall founded on the very stiff to hard till at this site. Furthermore, the minimum length of reinforcement is usually equal to 70% of the wall height. A global stability analysis of the RSS wall will be conducted once the wall design details are available.



## 16 SEISMIC CONSIDERATIONS

### 16.1 Seismic Design Parameters

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.04

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

### 16.2 Liquefaction Potential

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method<sup>1</sup>.

Using this method, the foundation soils at the site are assessed as not being prone to liquefaction.

### 16.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC 2006, retaining structures should be designed using active ( $K_{AE}$ ) and passive ( $K_{PE}$ ) earth pressure coefficients that incorporate the effects of earthquake loading.

In calculating the active, passive and at rest earth pressure coefficients the angle of friction between the wall and backfill material is assumed to be  $0.5 \phi$ . For the design of retaining walls, the coefficients of horizontal earth pressure in Table 16.1 may be used:

<sup>1</sup> 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.

**Table 16.1 – Earth Pressure Coefficient for Earthquake Loading**

<b>Earth Pressure Coefficient (K) for Earthquake Loading</b>				
<b>Wall Condition</b>	<b>Granular A or Granular B Type II</b> $\phi = 35^\circ; \delta = 17.5^\circ$ $\gamma = 22.8 \text{ kN/m}^3$		<b>OPSS Granular B Type I</b> $\phi = 32^\circ; \delta = 16^\circ$ $\gamma = 21.2 \text{ kN/m}^3$	
	<b>Horizontal Surface Behind Wall</b>	<b>Sloping Surface Behind Wall (2H:1V)</b>	<b>Horizontal Surface Behind Wall</b>	<b>Sloping Surface Behind Wall (2H:1V)</b>
Active ( $K_{AE}$ )*	0.3	0.45	0.33	0.54
Passive ( $K_{PE}$ )	6.3	6.3	5.4	5.4
At Rest ( $K_{OE}$ )**	0.59		0.63	

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

\*\* After Woods

## 17 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not limited to:

### 1. Excavations

Care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade soils should be expeditiously inspected, approved and protected from disturbance.

### 2. Perched groundwater

Perched water may be encountered within the existing fills and associated with sand and silt interlayers within the underlying native tills. The impact of this perched groundwater is not expected to be significant. However, the Contractor's unwatering plan must be available for rapid implementation should the need arise.

## 18 CLOSURE

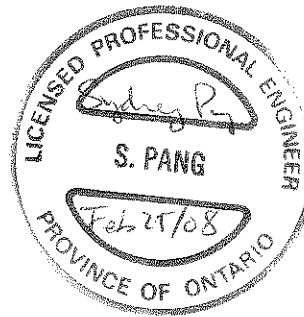
Engineering analysis and preparation of the foundation design report was conducted by and Dr. Sydney Pang, P.Eng. and Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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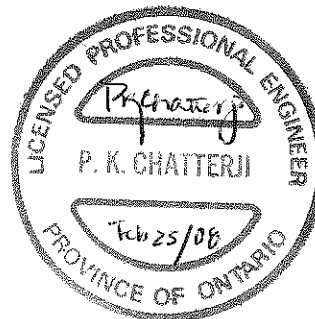
Rocío Palomeque Reyna, P.Eng.  
Geotechnical Engineer



Sydney Pang, P.Eng.,  
Associate, Senior Project Engineer



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



**TABLE 1 -Point Load and Unconfined Compression Test Results**  
 Highway 401 Widening – Hurontario Street South to Highway 401 East Ramp

RSE-2	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS (MPa)	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #1	14	4	4.37	0.000	0.000	3.00	limestone	RUN #1:	AVERAGE	MAX	MIN
	18	3	5.56	5.849	5.231	125.55	siltstone				
								Shale			
								Siltstone	125.55	125.55	125.55
								Shale/Siltstone			
								Limestone	3.00	3.00	3.00
RUN #2	19	6	5.94	0.000	0.000	3.00	shale	RUN #2:	AVERAGE	MAX	MIN
	20	7	6.27	0.000	0.000	3.00	shale				
	21	6	6.55	0.000	0.000	3.00	shale	Shale	3.00	3.00	3.00
	22	4	6.81	0.000	0.000	3.00	shale	Siltstone			
	23	6	7.16	0.000	0.000	3.00	shale, siltstone	Shale/Siltstone	3.00	3.00	3.00
								Limestone			
								SUMMARY	AVERAGE	MAX	MIN
								Shale	3.00	3.00	3.00
								Siltstone	125.55	125.55	125.55
								Shale/Siltstone	3.00	3.00	3.00
								Limestone	3.00*	3.00*	3.00*

\* Untypically low value

RSE-4	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #1	21	7	6.58	0.000	0.000	3.00	shale	RUN #1:	AVERAGE	MAX	MIN
	23	7	7.19	3.116	3.384	81.22	siltstone				
	24	6	7.47	0.000	0.000	3.00	shale, siltstone	Shale	3.00	3.00	3.00
								Siltstone	81.22	81.22	81.22
								Shale/Siltstone	3.00	3.00	3.00
								Limestone			
RUN #2	24	11	7.59	0.000	0.000	3.00	shale, siltstone	RUN #2:	AVERAGE	MAX	MIN
	26	1	7.95	0.000	0.000	3.00	shale				
	28	5	8.66	0.000	0.000	3.00	shale	Shale	3.00	3.00	3.00
	29	6	8.99	2.172	2.172	52.14	siltstone	Siltstone	52.14	52.14	52.14
								Shale/Siltstone	3.00	3.00	3.00
								Limestone			
								SUMMARY	AVERAGE	MAX	MIN
								Shale	3.00	3.00	3.00
								Siltstone	66.68	81.22	52.14
								Shale/Siltstone	3.00	3.00	3.00
								Limestone			

**TABLE 1 -Point Load and Unconfined Compression Test Results**  
 Highway 401 Widening – Hurontario Street South to Highway 401 East Ramp

RSE-5	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #1	26	5	8.05	3.760	4.119	98.85	siltstone	RUN #1:			
	27	8	8.43	0.000	0.000	3.00	shale		AVERAGE	MAX	MIN
	28	7	8.71	0.374	0.433	10.39	shale	Shale	5.46	10.39	3.00
	29	5	8.97	0.000	0.000	3.00	shale	Siltstone	98.85	98.85	98.85
	30	4	9.25	0.307	0.320	7.68	shale, siltstone	Shale/Siltstone	7.68	7.68	7.68
								Limestone			
RUN #2	30	8	9.35	0.000	0.000	3.00	shale, siltstone	RUN #2:			
	32	1	9.78	3.702	4.105	98.52	limestone	Shale			
	32	10	10.01	0.666	1.173	28.14	siltstone	Siltstone	28.14	28.14	28.14
	33	7	10.24	0.000	0.000	3.00	shale, siltstone	Shale/Siltstone	4.30	6.90	3.00
	25	2	7.67	0.248	0.288	6.90	shale, siltstone	Limestone	98.52	98.52	98.52
								SUMMARY	AVERAGE	MAX	MIN
								Shale	5.46	10.39	3.00
								Siltstone	63.50	98.85	28.14
								Shale/Siltstone	5.15	7.68	3.00
								Limestone	98.52	98.52	98.52

RSE-11	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #1	17	11	5.46	0.393	0.363	8.70	shale, siltstone	RUN #1:			
	19	9	6.02	2.930	3.315	79.55	siltstone		AVERAGE	MAX	MIN
								Shale			
								Siltstone	79.55	79.55	79.55
								Shale/Siltstone	8.70	8.70	8.70
								Limestone			
RUN #2	19	9	6.02	0.000	0.000	3.00	shale, siltstone	RUN #2:			
	21	1	6.43	0.000	0.000	3.00	shale, siltstone	Shale	8.06	8.06	8.06
	22	6	6.86	0.338	0.336	8.06	shale	Siltstone	63.94	63.94	63.94
	23	6	7.16	0.000	0.000	3.00	shale, siltstone	Shale/Siltstone	3.00	3.00	3.00
	24	3	7.39	2.506	2.664	63.94	siltstone	Limestone			
								SUMMARY	AVERAGE	MAX	MIN
								Shale	8.06	8.06	8.06
								Siltstone	71.74	79.55	63.94
								Shale/Siltstone	4.43	8.70	3.00
								Limestone			

**TABLE 1 -Point Load and Unconfined Compression Test Results**  
 Highway 401 Widening – Hurontario Street South to Highway 401 East Ramp

RSE-12	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #2	20	7	6.27	5.401	5.374	128.98	limestone	RUN #1:			
	22	0	6.71	0.334	0.334	8.02	shale, siltstone		AVERAGE	MAX	MIN
	23	3	7.09	0.000	0.000	3.00	shale	Shale	3.00	3.00	3.00
								Siltstone			
								Shale/Siltstone	8.02	8.02	8.02
								Limestone	128.98	128.98	128.98
RUN #3	24	3	7.39	0.000	0.000	3.00	shale	RUN #2:			
	24	11	7.59	0.000	0.000	3.00	siltstone	Shale	3.00	3.00	3.00
	25	11	7.90	0.000	0.000	3.00	shale, siltstone	Siltstone	9.52	16.04	3.00
	26	9	8.15	0.668	0.668	16.04	siltstone	Shale/Siltstone	3.00	3.00	3.00
	28	1	8.56	0.578	1.001	24.02	limestone	Limestone			
RUN #4	26	6	8.08	0.000	0.000	3.00	shale, siltstone	RUN #3:			
								Shale			
								Siltstone			
								Shale/Siltstone	3.00	3.00	3.00
								Limestone			
								SUMMARY	AVERAGE	MAX	MIN
								Shale	3.00	3.00	3.00
								Siltstone	9.52	16.04	3.00
								Shale/Siltstone	4.67	8.02	3.00
								Limestone	76.50	128.98	24.02

RSE-14	DEPTH			Is (MPa)	Is50 (MPa)	Inferred UCS	Rock Type	Inferred UC Test Average			
	FT.	IN.	(m)								
RUN #1	26	8	8.13	1.083	1.126	27.01	Siltstone	RUN #1:			
	27	10	8.48	0.000	0.000	3.00	shale		AVERAGE	MAX	MIN
	29	1	8.86	0.000	0.000	3.00	shale	Shale	3.00	3.00	3.00
								Siltstone	27.01	27.01	27.01
								Shale/Siltstone			
								Limestone			
RUN #2	31	3	9.53	0.328	0.331	7.94	shale, siltstone	RUN #2:			
	31	11	9.73	5.784	5.899	141.58	limestone	Shale	3.00	3.00	3.00
	32	9	9.98	4.178	4.576	109.83	limestone	Siltstone			
	33	8	10.26	0.000	0.000	3.00	shale, siltstone	Shale/Siltstone	5.47	7.94	3.00
	34	9	10.59	0.000	0.000	3.00	shale	Limestone	125.70	141.58	109.83
								SUMMARY	AVERAGE	MAX	MIN
								Shale	3.00	3.00	3.00
								Siltstone	27.01	27.01	27.01
								Shale/Siltstone	5.47	7.94	3.00
								Limestone	125.70	141.58	109.83

## **Appendix A**

### **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 <sup>(1)</sup> '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<sub>pen</sub>

Shear Strength Determination by Pocket Penetrometer






- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.



# UNIFIED SOILS CLASSIFICATION

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

## EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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

# RECORD OF BOREHOLE No RSE-01

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 165.3 E 290 098.5 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-12 - 2007-09-12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)
								20	40	60			
190.7													
0.0 0.1	TOPSOIL: (75mm)  Silty CLAY, trace to some sand, trace gravel, occasional rootlets Hard to Stiff Brown to Mottled Brown Grey (FILL)		1	SS	40								
			2	SS	14								
189.2													
1.5	Silty CLAY, trace sand, occasional rootlets Stiff Dark Grey		3	SS	9								
188.5													
2.2	Clayey SILT with sand, trace gavel Hard Brown to Mottled Brown (TILL)  occasional reddish brown to brown shale fragments		4	SS	52								
			5	SS	50/ .150								
186.7													
4.0	SHALE, highly weathered, thinly bedded, reddish brown												
185.8			6	SS	118								
4.9	END OF BOREHOLE AND AUGER REFUSAL AT 4.9m. BOREHOLE OPEN AND DRY TO 4.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

# RECORD OF BOREHOLE No RSE-02

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 161.2 E 290 099.6 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-17 - 2007-09-19 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								20	40	60	80						
190.7																	
0.0																	
0.1	TOPSOIL: (100mm)																
	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff to Hard Brown (FILL)		1	SS	26												
			2	SS	86												
189.3																	
1.4	Silty CLAY, trace sand, occasional rootlets Stiff Dark Grey to Mottled Dark Grey/Grey		3	SS	14												
188.5																	
2.2	Clayey SILT with sand, trace gravel, occasional oxide lenses Hard Mottled Brown/Grey (TILL)		4	SS	44												
			5	SS	87												
186.9																	
3.8	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown, with occasional green siltstone interbeds Coring started at 4.26m Highly broken zones at 4.24 to 4.37, 4.57 to 4.62, 4.88 to 5.08, and 5.23 to 5.39m Green siltstone interbed at 4.27 to 4.37m Limestone interbeds at 4.37 to 4.42 and 5.69 to 5.79m  Slightly weathered to fresh Green siltstone interbeds at 5.79 to 5.92, 6.10 to 6.15, 6.96 to 7.03, and 7.19m		1	RUN													
			2	RUN													
183.5																	
7.2	END OF BOREHOLE AND AUGER REFUSAL AT 7.2m. BOREHOLE OPEN AND DRY TO 7.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Sep28/07 1.7 189.0 Oct05/07 1.6 189.1 Oct18/07 1.5 189.2 Nov01/07 1.5 189.2 Nov15/07 1.3 189.4																

# RECORD OF BOREHOLE No RSE-03

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 171.8 E 290 104.9 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-12 - 2007-09-12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  Y  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)
								20	40	60			
191.4													
0.0 0.1	TOPSOIL: (75mm)												
190.7	Clayey SILT, trace to some sand, trace gravel Hard Brown (FILL)		1	SS	47		191						
0.7													
189.9	SILT, clayey, some sand, trace gravel Very Stiff Brown (FILL)		2	SS	18		190						
1.4													
	Clayey SILT with sand, trace gravel Very Stiff to Hard Mottled Brown/Grey (TILL)		3	SS	19		189						
	Mottled Reddish Brown to Brown		4	SS	18		188						
			5	SS	85								
187.6													
3.8	END OF BOREHOLE AND AUGER REFUSAL AT 3.8m, PROBABLE BEDROCK. BOREHOLE OPEN AND DRY TO 3.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

# RECORD OF BOREHOLE No RSE-04

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 172.4 E 290 110.7 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-19 - 2007-09-20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
191.8							20	40	60	80	100		
0.0	TOPSOIL: (75mm)						20	40	60	80	100		
0.1	Clayey SILT with sand, trace gravel, occasional rootlets Stiff to Hard Brown (FILL)		1	SS	30								
			2	SS	18								1 36 44 19
			3	SS	12								
189.6													
2.2	Silty CLAY, some sand, trace gravel, occasional rootlets Very Stiff Dark Grey		4	SS	15								1 33 43 23
188.8													
3.0	Silty CLAY, some sand, trace gravel Hard Mottled Brown (TILL)		5	SS	49								2 32 44 22
187.5													
4.3	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown, with frequent green siltstone interbeds, occasional limestone interbeds, and clay seams		6	SS	54								
	Coring started at 6.09m Clay seams at 6.30 to 6.48, 6.73, 6.81, 6.96, 7.21, and 7.29m Limestone interbeds at 6.91 to 6.96 and 7.14 to 7.19m Siltstone interbeds at 6.50, 6.78 to 6.81, 6.83, 7.06 to 7.11, 7.19 to 7.24, and 7.39m Highly broken zone at 6.10 to 6.27m		1	RUN									RUN 1# TCR=100%, SCR=66%, RQD=39%, UCS=29MPa
	Moderately weathered to fresh Green siltstone interbeds at 7.52 to 7.57, 8.51 to 8.53, 8.63 to 8.66, 8.74 to 8.76, and 8.92 to 9.04m Clay seams at 8.63 and 8.92m		2	RUN									RUN 2# TCR=100%, SCR=95%, RQD=95%, UCS=15MPa
182.8													
9.0	END OF BOREHOLE AT 9.0m. BOREHOLE OPEN AND DRY TO 9.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE												

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-05

1 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 183.5 E 290 116.5  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring  
 DATUM Geodetic DATE 2007-09-14 - 2007-09-20  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								20 40 60 80 100						
							WATER CONTENT (%)							
							20 40 60							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
							w <sub>p</sub> w w <sub>L</sub>							
							○ UNCONFINED + FIELD VANE							
							● QUICK TRIAXIAL x LAB VANE							
							20 40 60 80 100							
							20 40 60							
192.4														
0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY, some sand, trace gravel, occasional rootlets Hard Brown (FILL)		1	SS	32		192							
			2	SS	41									
	Stiff Mottled Brown to Greenish Grey/Grey		3	SS	11		191							
190.2														
2.2	Clayey SILT with sand, occasional rootlets Stiff Mottled Brown to Greenish Grey/Grey (TILL)		4	SS	8		190							
			5	SS	14									
							189							
187.8														
4.6	Silty CLAY, some sand, trace gravel Hard Brown (TILL)		6	SS	50/ .150		188							
							187							
186.3														
6.1	Silty SAND, trace gravel Very Dense Grey to Reddish Brown (TILL)		7	SS	102		186							
185.1							185							
7.3	SHALE, highly weathered, fine grained, thinly bedded, reddish brown, with occasional green siltstone and limestone interbeds Coring Started at 7.94m Slightly weathered to fresh Green siltstone interbeds at 7.95 to 8.05, 8.31 to 8.33, 9.12 to 9.17, 9.17 to 9.22, and 9.30 to 9.35m Highly broken zone at 7.95 to 8.05m Limestone interbeds at 8.05 to 8.13 and 8.21 to 8.25m		8	SS	100/ .150									
							184							
			1	RUN										
							183							
	Slightly weathered to fresh Limestone interbed at 9.75 to 9.81m Green siltstone interbeds at 9.45 to 9.50, 9.55, 9.68 to 9.78, 9.85 to 9.96,													

Continued Next Page

+<sup>3</sup> ×<sup>3</sup> Numbers refer to  
Sensitivity

20  
15  
10


(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RSE-05

2 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 183.5 E 290 116.5  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring  
 DATUM Geodetic DATE 2007-09-14 - 2007-09-20  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
Continued From Previous Page						20 40 60 80 100					20 40 60									
181.6	10.01 to 10.16, 10.34 to 10.42, 10.44 to 10.54, 10.62 to 10.67, and 10.74 to 10.77m Highly broken zone at 9.83 to 9.96m		2	RUN			182									0				
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE OPEN TO 10.8m AND WATER LEVEL AT 6.1m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.															0				

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No RSE-06

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 178.8 E 290 118.0  
 HWY 401 BOREHOLE TYPE Solid Stem Augers  
 DATUM Geodetic DATE 2007-09-13 - 2007-09-13  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  Y  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
192.4								20 40 60 80 100					
0.0	TOPSOIL: (75mm)							20 40 60 80 100					
0.1	Silty CLAY, trace to some sand, trace gravel Hard to Stiff Brown (FILL)		1	SS	38		192						
			2	SS	19								
			3	SS	16		191						
	occasional rootlets and wood fibres Mottled Grey to Greenish Grey		4	SS	14		190						0 24 47 29
189.4													
3.0	Silty CLAY, some sand, trace gravel Stiff Greenish Brown (TILL)		5	SS	14		189						
			6	SS	50/ .150		188						4 28 46 22
							187						
186.3													
6.1	SHALE, highly weathered, thinly bedded, reddish brown		7	SS	105								
186.0													
6.4	END OF BOREHOLE AND AUGER REFUSAL AT 6.4m. BOREHOLE OPEN AND DRY TO 6.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Sep09/07 2.9 189.5 Sep19/07 2.8 189.6 Sep28/07 2.9 189.5 Oct05/07 3.1 189.3 Oct18/07 2.7 189.7 Nov01/07 2.6 189.8 Nov15/07 2.7 189.7												

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-07

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 188.4 E 290 126.1  
 HWY 401 BOREHOLE TYPE Solid Stem Augers  
 DATUM Geodetic DATE 2007-09-12 - 2007-09-12  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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+<sup>3</sup> X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-08

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 196.9 E 290 134.6 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-24 - 2007-09-24 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
192.8								20	40	60	80	100				
0.0	SAND, trace silt, trace gravel Compact Brown (FILL)		1	SS	29											
192.1																
0.7	Silty CLAY, trace to some sand, trace gravel Very Stiff Brown (FILL)		2	SS	16											
191.3																
1.4	Silty CLAY with sand, trace gravel, occasional rootlets Stiff to Hard Grey to Greenish Grey (TILL)  Greenish Grey to Brown		3	SS	11											
			4	SS	20											
			5	SS	53											
	occasional iron oxide staining		6	SS	92											
186.7																
6.1	Sandy SILT, trace gravel Very Dense Grey (TILL)		7	SS	50/ .150											
186.0																
6.7	SHALE, highly weathered, thinly bedded, reddish brown															
185.0			8	SS	100/ .125											
7.7	END OF BOREHOLE AT 7.7m. BOREHOLE OPEN TO 7.7m AND WATER LEVEL AT 7.7m UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Sep28/07 3.1 189.7 Oct05/07 3.1 189.7 Nov01/07 2.8 190.0 Nov15/07 2.9 189.9															

+ 3 x 3 Numbers refer to  
Sensitivity 20  
15 10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-09

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 138.6 E 290 093.9 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-13 - 2007-09-13 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
191.5																				
0.0	Sandy SILT, some clay, trace to some sand, trace gravel Compact Brown (FILL)		1	SS	18															
190.8																				
0.7	Clayey SILT to silty CLAY, trace to some sand, trace gravel Hard Brown (FILL) occasional wood fibres and rootlets, organic odour Dark Grey		2	SS	34															
			3	SS	32															
189.3																				
2.2	Clayey SILT with sand, trace gravel Hard Brown to Mottled Brown/Grey (TILL)  occasional shale fragments		4	SS	64															
			5	SS	50/ .150															
187.5																				
4.0	SHALE, highly weathered, thinly bedded, reddish brown																			
186.9																				
4.6	END OF BOREHOLE AND AUGER REFUSAL AT 4.6m. BOREHOLE OPEN AND DRY TO 4.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																			

# RECORD OF BOREHOLE No RSE-10

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 148.6 E 290 103.3 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-13 - 2007-09-13 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)
								20 40 60 80 100										
189.6																		
0.0																		
0.1	TOPSOIL: (100mm)																	
	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff to Hard Brown (FILL)		1	SS	21													
			2	SS	39													
188.1																		
1.4	Clayey SILT with sand, trace gravel, occasional iron oxide staining Very Stiff to Hard Mottled Brown/Grey (TILL)		3	SS	16													
			4	SS	54													
			5	SS	50/ .150													
185.9																		
3.7	SHALE, highly weathered, thinly bedded, reddish brown																	
185.0																		
4.6	END OF BOREHOLE AND AUGER REFUSAL AT 4.6m. BOREHOLE OPEN AND DRY TO 4.6m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH(m)    ELEV.(m) Sep14/07    2.0        187.6 Sep19/07    1.9        187.7 Sep28/07    2.1        187.5 Oct05/07    1.9        187.7 Oct18/07    1.7        187.9 Nov01/07    1.6        188.0 Nov15/07    1.4        188.2																	

# RECORD OF BOREHOLE No RSE-11

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 144.5 E 290 104.5  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring  
 DATUM Geodetic DATE 2007-09-17 - 2007-09-24  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
190.0													
0.0 0.1	TOPSOIL: (75mm)												
	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff to Hard Brown (FILL)		1	SS	26								
			2	SS	33								
188.6													
1.4	Silty CLAY, trace sand, trace gravel, occasional rootlets Very Stiff Mottled Dark Grey/Grey		3	SS	24								
187.8													
2.2	Silty CLAY, some sand, occasional shale fragments Hard Brown to Reddish Brown Moist (TILL)		4	SS	58								
186.7													
3.4	SHALE, highly to slightly weathered, fine grained, thinly bedded, reddish brown, with occasional green siltstone interbeds		5	SS	107								
	Coring started at 4.50m Highly broken zone at 4.57 to 5.41m Green siltstone interbeds at 5.49, 5.61 to 5.69, and 5.77 to 5.94m		1	RUN									
	Slightly weathered to fresh Limestone interbed at 7.47 to 7.54m Green siltstone interbeds at 6.15 to 6.20, 6.55, 6.91 to 6.93, 7.01, 7.11, 7.21 to 7.26, 7.29, 7.34, and 7.39 to 7.47m		2	RUN									
182.5													
7.5	END OF BOREHOLE AT 7.5m. BOREHOLE OPEN AND DRY TO 7.5m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

# RECORD OF BOREHOLE No RSE-12

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 154.3 E 290 108.9  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring  
 DATUM Geodetic DATE 2007-09-17 - 2007-09-19  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT								
							W <sub>P</sub> W W <sub>L</sub>								
							20 40 60								
191.1							191								
0.0	TOPSOIL: 75mm)		1	SS	34										
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Hard to Very Stiff Brown (FILL)		2	SS	20		190								
189.2			3	SS	15										
2.0	Silty CLAY, some sand, trace gravel Hard Mottled Brown/Grey (TILL)  occasional oxide lenses		4	SS	46		189								
187.3			5	SS	50/ .200		188								
3.8	SHALE, highly to moderately weathered, fine grained, thinly bedded, reddish brown, with limestone and green siltstone interbeds  Coring started at 4.50m Highly broken zone at 4.57 to 5.28m						187								
			1	RUN			186						RUN 1# TCR=47%, SCR=7%, RQD=7%, UCS=46MPa		
	Clay seam at 7.16 to 7.21m Highly broken zones at 6.10 to 6.15 and 6.40 to 6.45m Green siltstone interbeds at 6.17 to 6.27, and 6.73m Limestone interbed at 6.27 to 6.35m		2	RUN			185						RUN 2# TCR=100%, SCR=81%, RQD=66%, UCS=9MPa		
	Limestone interbed at 8.59 to 8.71m weak to strong Siltstone interbeds at 7.60, 7.62, 7.90 to 7.95, 7.98, 8.03, 8.15 to 8.23, 8.36, and 8.74m Clay seam at 7.77 to 7.80m		3	RUN			184						RUN 3# TCR=100%, SCR=100%, RQD=92%, UCS=3MPa		
182.0	Siltstone interbed at 8.76 to 8.86m		4	RUN			183						RUN 4# TCR=100%, SCR=100%, RQD=100%, UCS=3MPa		
9.1	END OF BOREHOLE AT 9.1m. BOREHOLE OPEN AND DRY TO 9.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.														

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-13

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 156.4 E 290 116.2 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-12 - 2007-09-12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								20 40 60 80 100							
191.8															
0.0	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Hard to Stiff Brown (FILL)		1	SS	35										
			2	SS	23										
			3	SS	9										
189.5															
2.3	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff Mottled Brown/Grey to Grey		4	SS	16										
188.7															
3.0	Clayey SILT with sand, trace gravel Hard Brown (TILL)		5	SS	45										
187.2															
187.2	SHALE, highly weathered, thinly bedded, reddish brown		6	SS	100/										
4.7	END OF BOREHOLE AT 4.7m. BOREHOLE OPEN AND DRY TO 4.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				.125										



# RECORD OF BOREHOLE No RSE-14

1 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 166.8 E 290 121.3  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring  
 DATUM Geodetic DATE 2007-09-17 - 2007-09-18  
 ORIGINATED BY GA  
 COMPILED BY MFA  
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
192.5	TOPSOIL: (75mm)													
0.1	SHALE; highly weathered, reddish brown: (FILL)		1	SS	32		192							
191.8	Silty CLAY, some sand, trace gravel Stiff to Very Stiff Reddish Brown to Brown (FILL)		2	SS	19		191							
0.7	occasional rootlets Dark Grey to Grey		3	SS	13		190							
			4	SS	14		189							
			5	SS	10		188							
187.9	SAND, trace silt, trace gravel Very Dense Brown Moist to Wet		6	SS	50/ .150		187							
186.4	Clayey SILT with sand, trace gravel, occasional to trace shale fragments Hard Brown (TILL)		7	SS	111		186							
185.1	SHALE, moderately to highly weathered, fine grained, thinly bedded, reddish brown, with green siltstone interbeds Coring started at 7.77m Highly broken zone at 7.77 to 7.92m Green siltstone interbeds at 7.77 to 7.85, 8.13 to 8.18, and 9.09 to 9.14m		8	SS	100/ .150		185							
	Green siltstone interbeds at 9.37 to 9.40, 9.45 to 9.47, 9.83 to 9.91, 9.98, 10.54, and 10.72m Limestone interbeds at 9.60 to 9.75		1	RUN			184							
							183							

Continued Next Page

+ 3, X 3: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-14

2 OF 2

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 166.8 E 290 121.3 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-17 - 2007-09-18 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE									
	Continued From Previous Page						20 40 60 80 100										
	and 10.01 to 10.26m		2	RUN												2	
181.6							182									0	
10.8	END OF BOREHOLE AT 10.8m. BOREHOLE OPEN AND DRY TO 10.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Sep19/07 1.7 190.8 Sep28/07 1.8 190.7 Oct05/07 1.8 190.7 Oct18/07 1.8 190.7 Nov01/07 1.6 190.9 Nov15/07 1.7 190.8																

# RECORD OF BOREHOLE No RSE-15

1 OF 1

METRIC

G.W.P. 2107-05-00

LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 162.7 E 290 122.5

ORIGINATED BY GA

HWY 401

BOREHOLE TYPE Solid Stem Augers

COMPILED BY MFA

DATUM Geodetic

DATE 2007-09-12 - 2007-09-12

CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
192.5	<b>TOPSOIL: (50mm)</b> Clayey SILT with sand, occasional shale fragments Stiff to Hard Reddish Brown (FILL)		1	SS	30		192							
			2	SS	16									
	occasional rootlets Mottled Brown/Grey		3	SS	11		191							
	Grey to Dark Grey		4	SS	8		190							
			5	SS	17		189							
187.9														
4.6	<b>SILT</b> , some sand, trace clay, occasional iron oxide staining Very Dense Brown (TILL)		6	SS	50/ .075		188							
							187							
186.4														
6.1	<b>SHALE</b> , highly weathered, thinly bedded, reddish brown		7	SS	50/ .150		186							
185.7														
6.7	END OF BOREHOLE AND AUGER REFUSAL AT 6.7m. BOREHOLE OPEN AND DRY TO 6.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN CUTTINGS TO SURFACE.													

+ <sup>3</sup> x <sup>3</sup> Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-16

1 OF 1

METRIC

G.W.P.: 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 192.2 E 290 114.6 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-13 - 2007-09-13 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								20 40 60 80 100						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT							
							WATER CONTENT (%)							
							20 40 60							
							20 40 60 80 100							
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+ <sup>3</sup> × <sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No RSE-17

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Hurontario St. South to HWY 401 East Ramp N 4 832 134.2 E 290 109.1 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-09-13 - 2007-09-13 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						WATER CONTENT (%) w <sub>p</sub> w      w <sub>L</sub>			
191.3							20	40	60	80	100						
0.0 0.1	TOPSOIL: (75mm)																
	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff to Hard Brown (FILL)		1	SS	17												
			2	SS	36												
189.9																	
1.4	Silty CLAY, trace sand, occasional rootlets, organic odour Very Stiff Grey		3	SS	16												
189.1																	
2.2	Silty CLAY, some sand, trace gravel Very Stiff to Hard Mottled Brown/Grey (TILL)		4	SS	21												
			5	SS	68												
187.3																	
4.0	SHALE, highly weathered, thinly bedded, reddish brown																
186.7																	
4.6	END OF BOREHOLE AND AUGER REFUSAL AT 4.6m. BOREHOLE OPEN AND DRY TO 4.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.		6	SS	50/ .000												

+<sup>3</sup> ×<sup>3</sup> Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

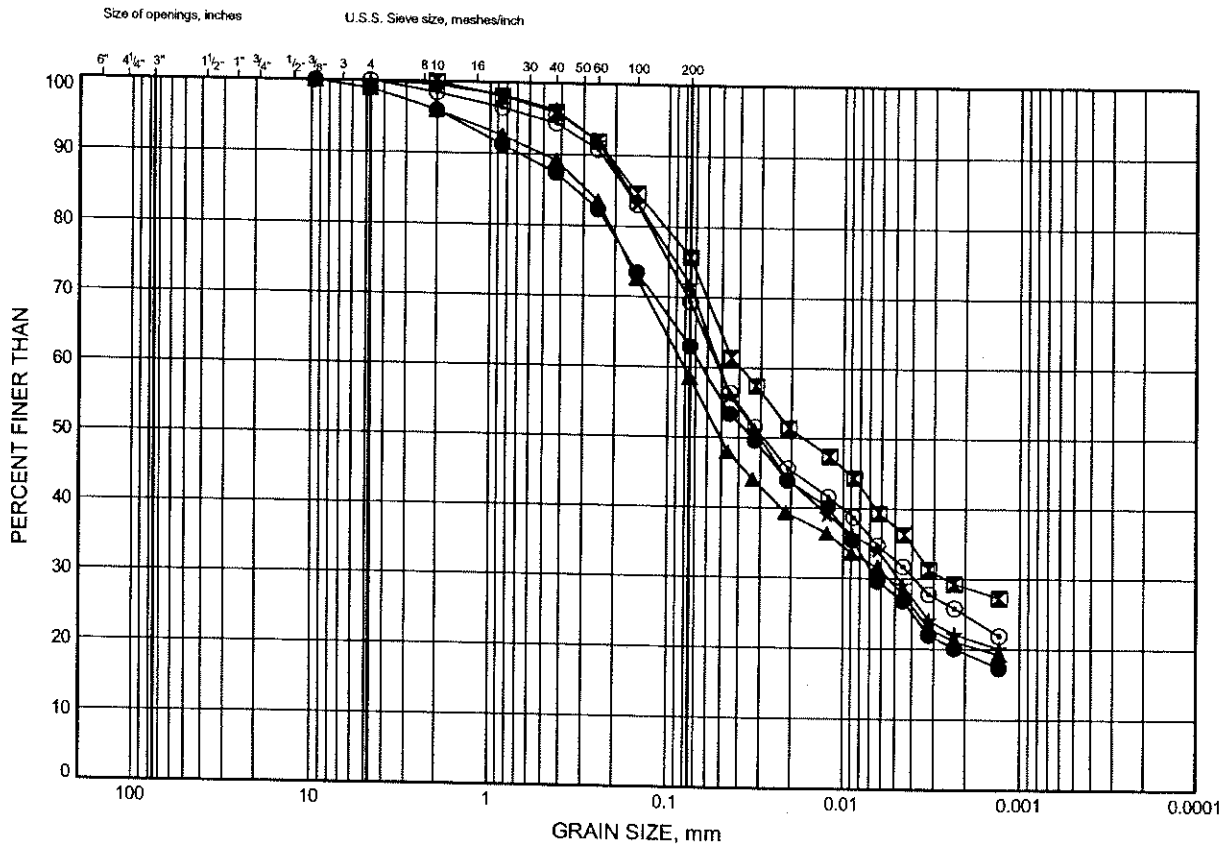
## **Appendix B**

### **Laboratory Test Results**

# Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE B1

## SILTY CLAY / CLAYEY SILT FILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-04	1.07	190.75
⊠	RSE-06	2.59	189.83
▲	RSE-14	3.35	189.11
★	RSE-15	3.35	189.10
⊙	RSE-16	1.83	190.58

Date November 2007  
Project 2107-05-00

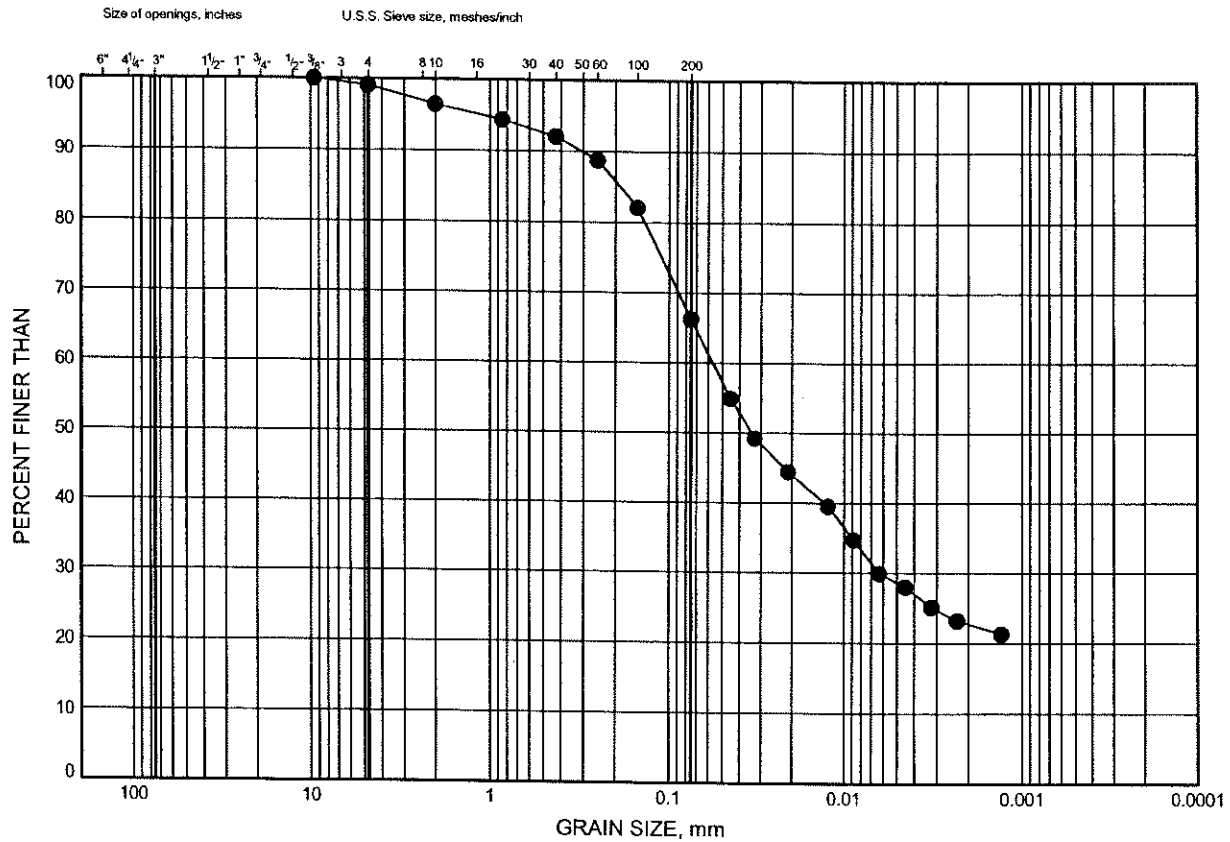


Prep'd MFA  
Chkd. RPR

Hwy 401/410 to Credit River  
**GRAIN SIZE DISTRIBUTION**

FIGURE B2

**SILTY CLAY**



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-04	2.59	189.23

Date November 2007  
 Project 2107-05-00



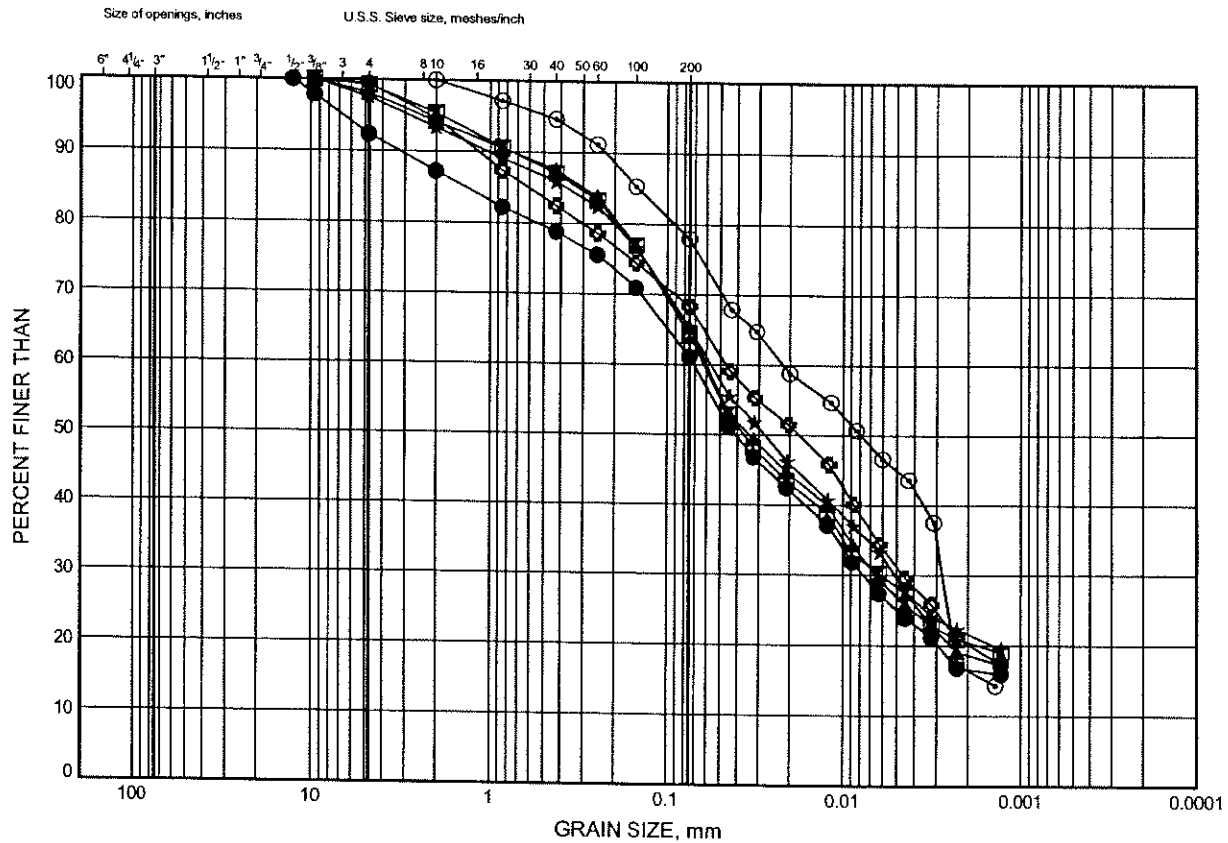
Prep'd MFA  
 Chkd. RPR



Hwy 401/410 to Credit River  
GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY / CLAYEY SILT TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-01	2.59	188.09
⊠	RSE-02	2.59	188.06
▲	RSE-03	1.83	189.53
★	RSE-04	3.35	188.46
⊙	RSE-05	2.59	189.81
⊕	RSE-05	4.88	187.52

Date November 2007

Project 2107-05-00



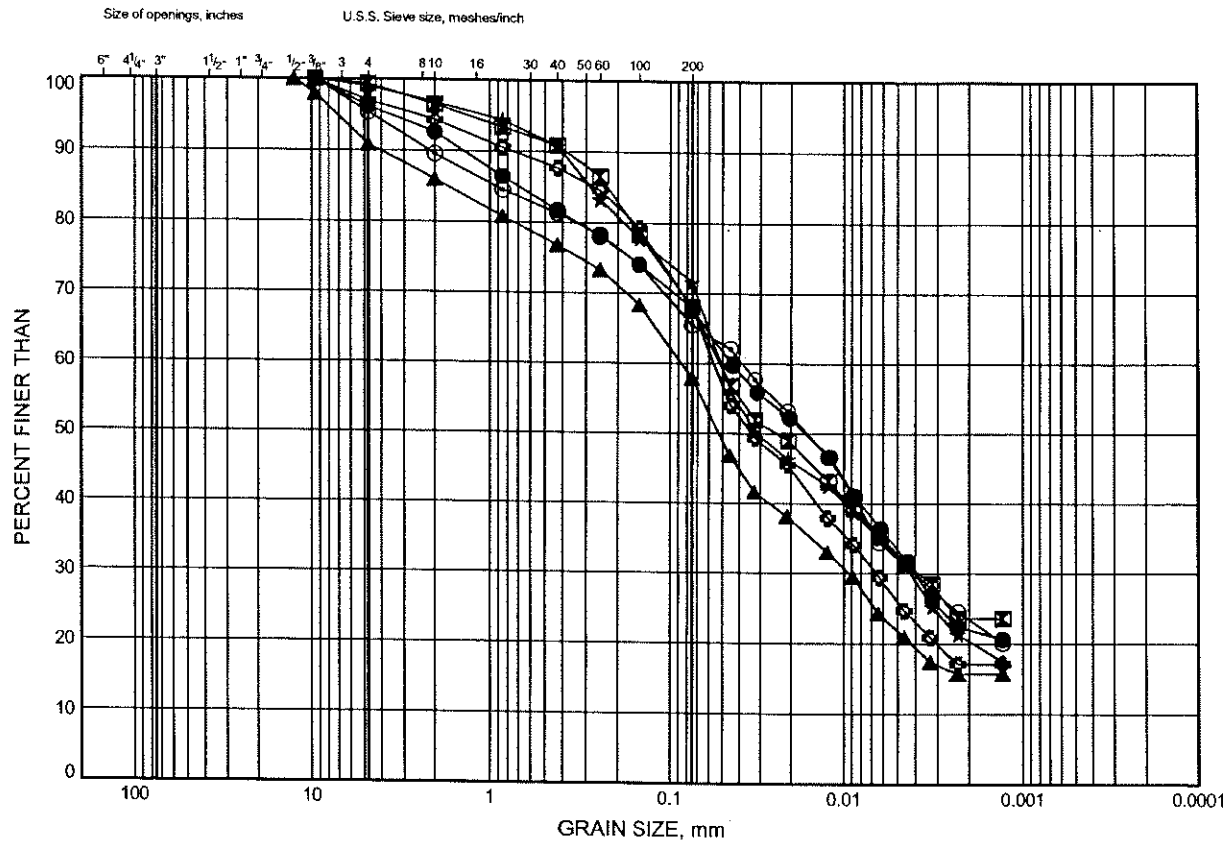
Prep'd MFA

Chkd. RPR

Hwy 401/410 to Credit River  
**GRAIN SIZE DISTRIBUTION**

FIGURE B4

**SILTY CLAY / CLAYEY SILT TILL**



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-06	4.88	187.54
⊠	RSE-07	2.59	190.40
▲	RSE-07	4.88	188.11
★	RSE-08	2.59	190.16
⊙	RSE-08	4.88	187.88
⊗	RSE-09	2.59	188.91

Date November 2007

Project 2107-05-00



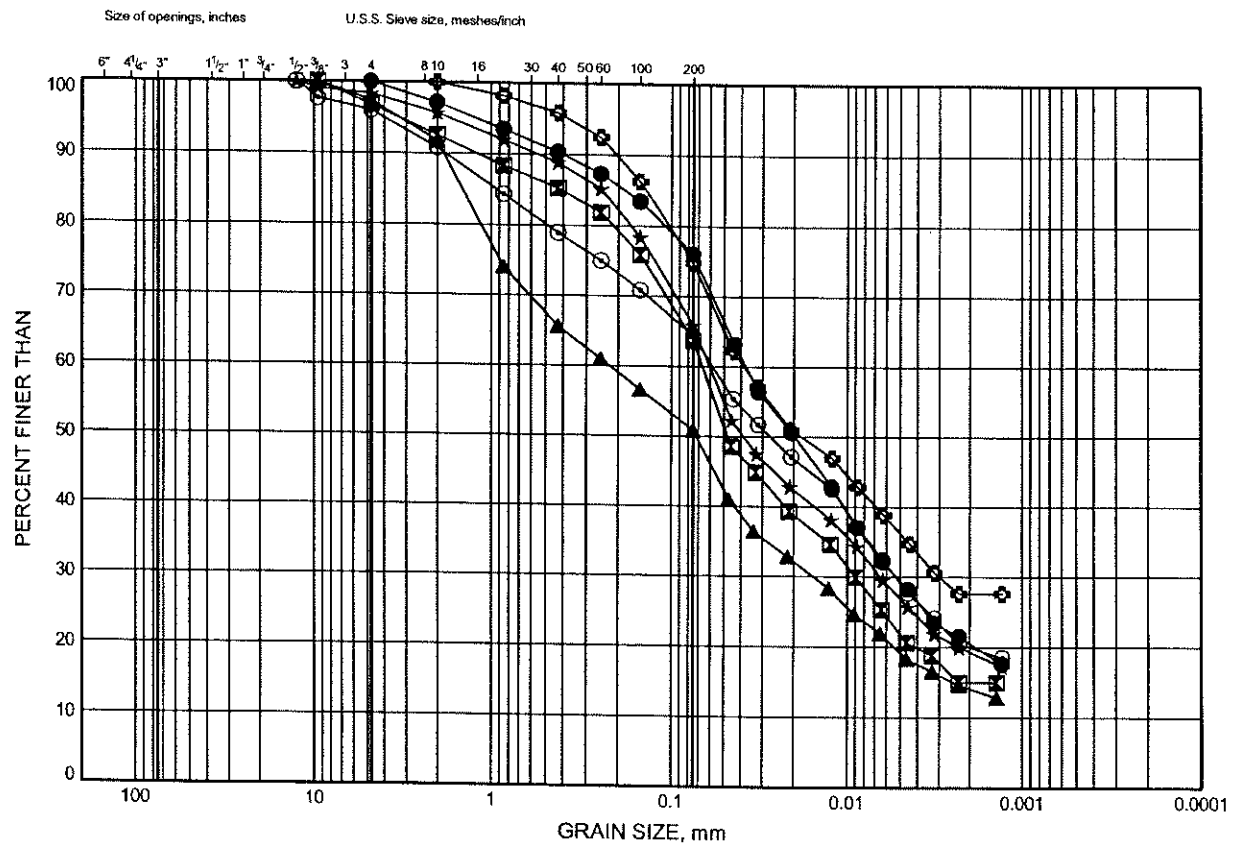
Prep'd MFA

Chkd. RPR

Hwy 401/410 to Credit River  
GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY / CLAYEY SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-11	3.35	186.69
⊠	RSE-13	3.35	188.42
▲	RSE-14	6.40	186.06
★	RSE-16	3.35	189.05
⊙	RSE-16	4.88	187.53
⊛	RSE-17	2.59	188.72

Date November 2007  
Project 2107-05-00



Prep'd MFA  
Chkd RPR

## FIGURE B6

Size of openings, inches

U.S.S. Sieve size, meshes/inch

6" 4 1/4" 3" 1 1/2" 1" 3/4" 1/2" 3/8" 3/16" 3 4 8 10 16 30 40 50 60 100 200

PERCENT FINER THAN

100 90 80 70 60 50 40 30 20 10 0

GRAIN SIZE, mm

100 10 1 0.1 0.01 0.001 0.0001

Grain Size (mm)	Percent Finer (%)
100	100
4.75	100
2.0	100
0.85	99
0.425	98
0.25	97
0.15	95
0.075	90
0.0475	82
0.025	60
0.015	49
0.0075	36
0.00475	26
0.0025	20
0.0015	15
0.00075	12
0.000475	9
0.00025	8
0.00015	6

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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-15	4.88	187.58

Date November 2007  
Project 2107-05-00

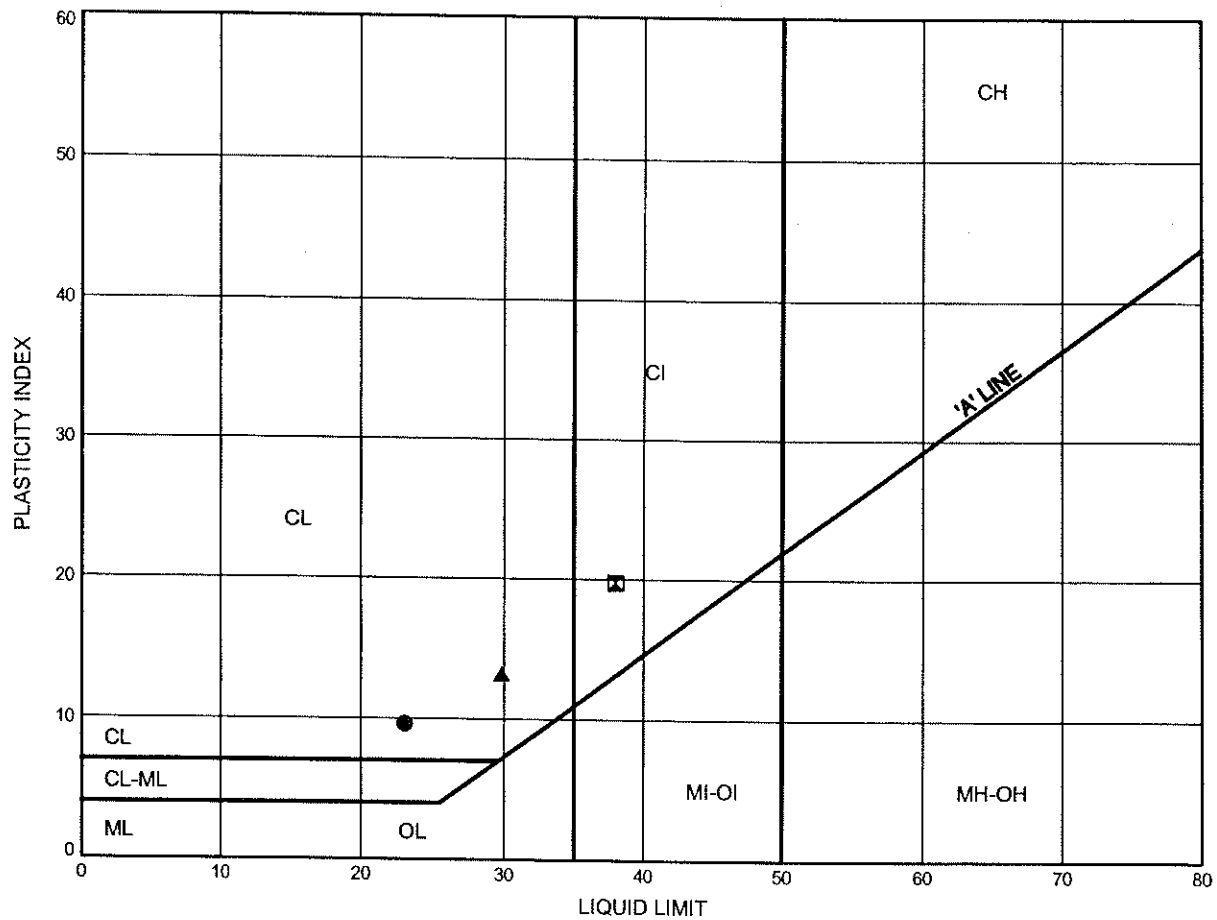


Prep'd MFA  
Chkd. RPR

Hwy 401/410 to Credit River  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B7

**SILTY CLAY / CLAYEY SILT FILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-04	1.07	190.75
⊠	RSE-06	2.59	189.83
▲	RSE-14	3.35	189.11

Date November 2007  
 Project 2107-05-00

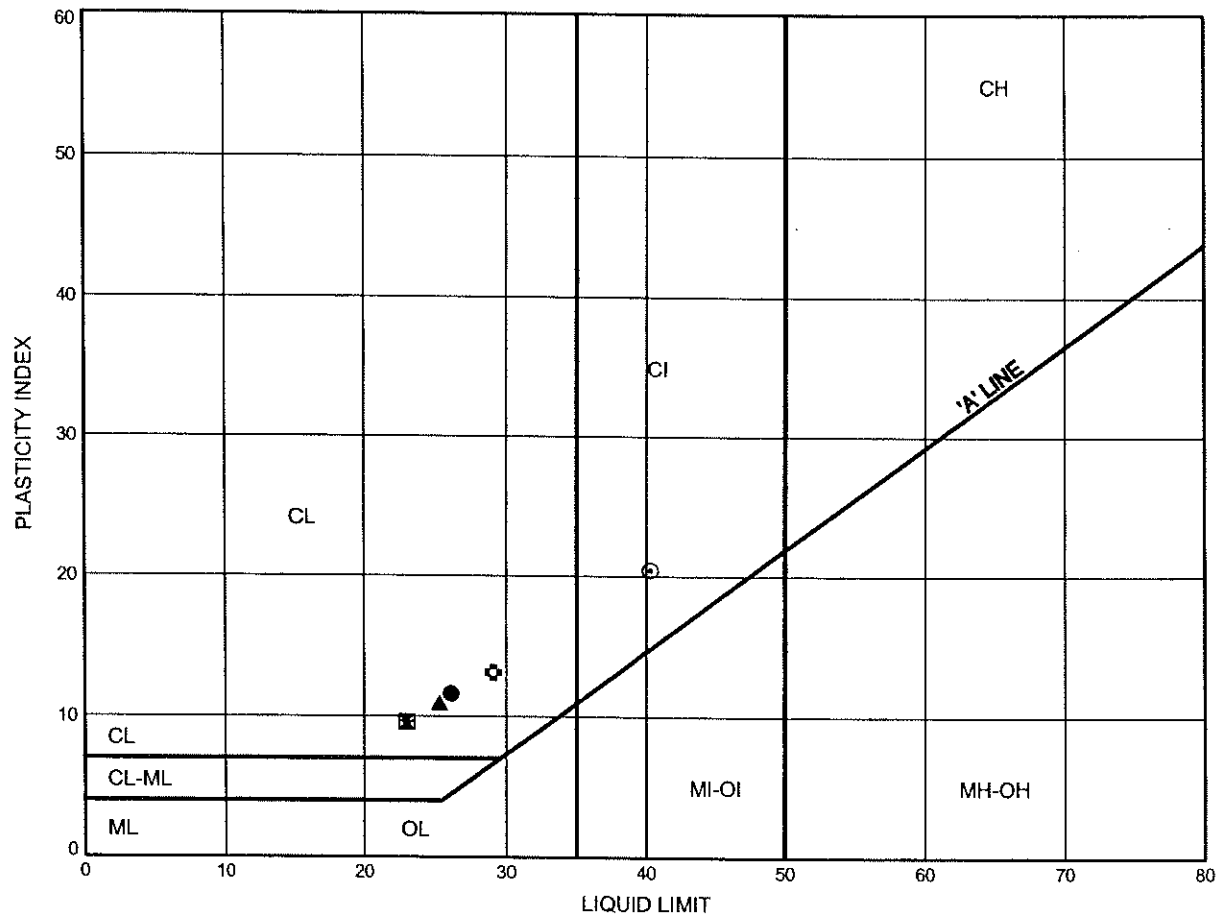


Prep'd MFA  
 Chkd. RPR

Hwy 401/410 to Credit River  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B8

**SILTY CLAY / CLAYEY SILT TILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-01	2.59	188.09
⊠	RSE-02	2.59	188.06
▲	RSE-03	1.83	189.53
★	RSE-04	3.35	188.46
⊙	RSE-05	2.59	189.81
⊕	RSE-06	4.88	187.54

Date November 2007  
 Project 2107-05-00

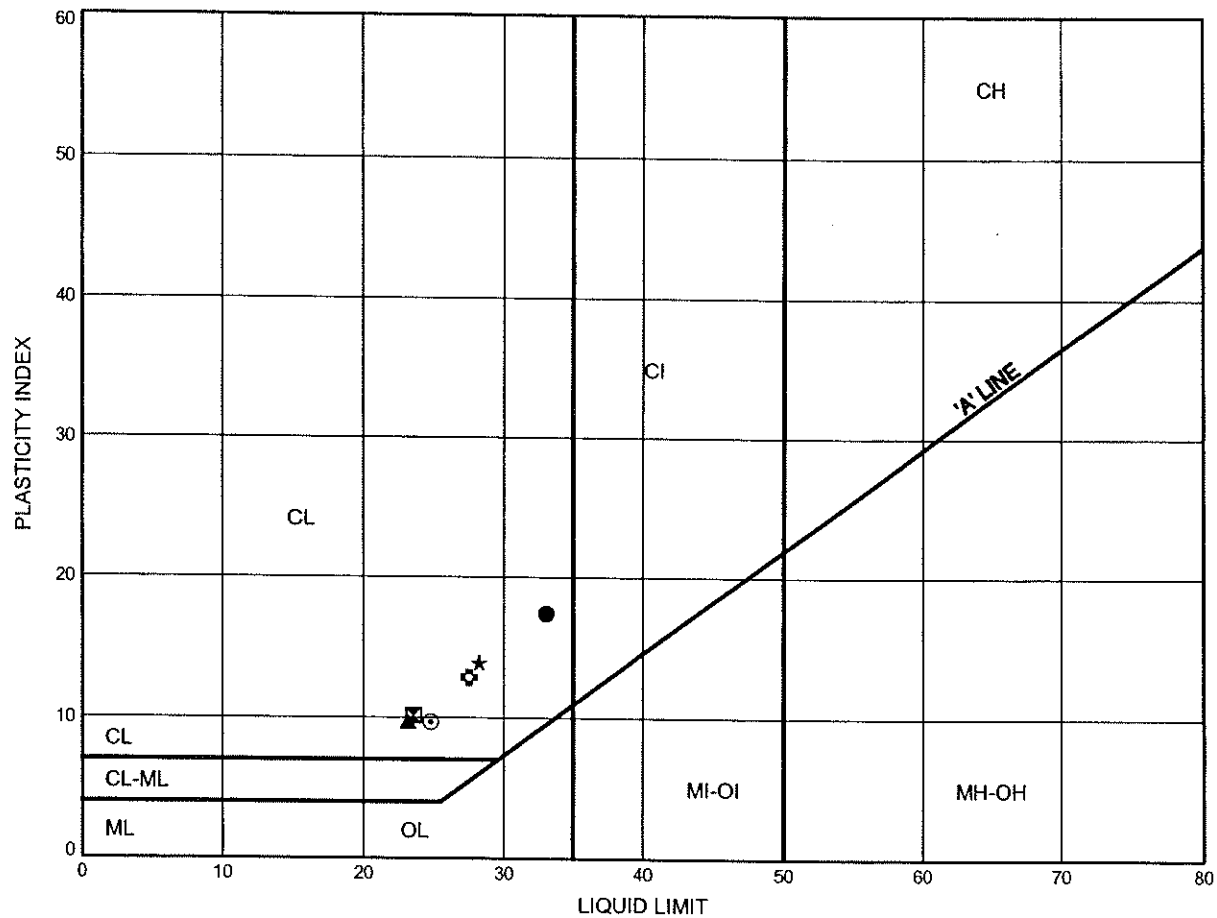


Prep'd MFA  
 Chkd. RPR

Hwy 401/410 to Credit River  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B9

**SILTY CLAY / CLAYEY SILT TILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-07	2.59	190.40
⊠	RSE-07	4.88	188.11
▲	RSE-09	2.59	188.91
★	RSE-10	1.83	187.76
⊙	RSE-11	3.35	186.69
⊛	RSE-12	2.59	188.56

Date November 2007  
 Project 2107-05-00

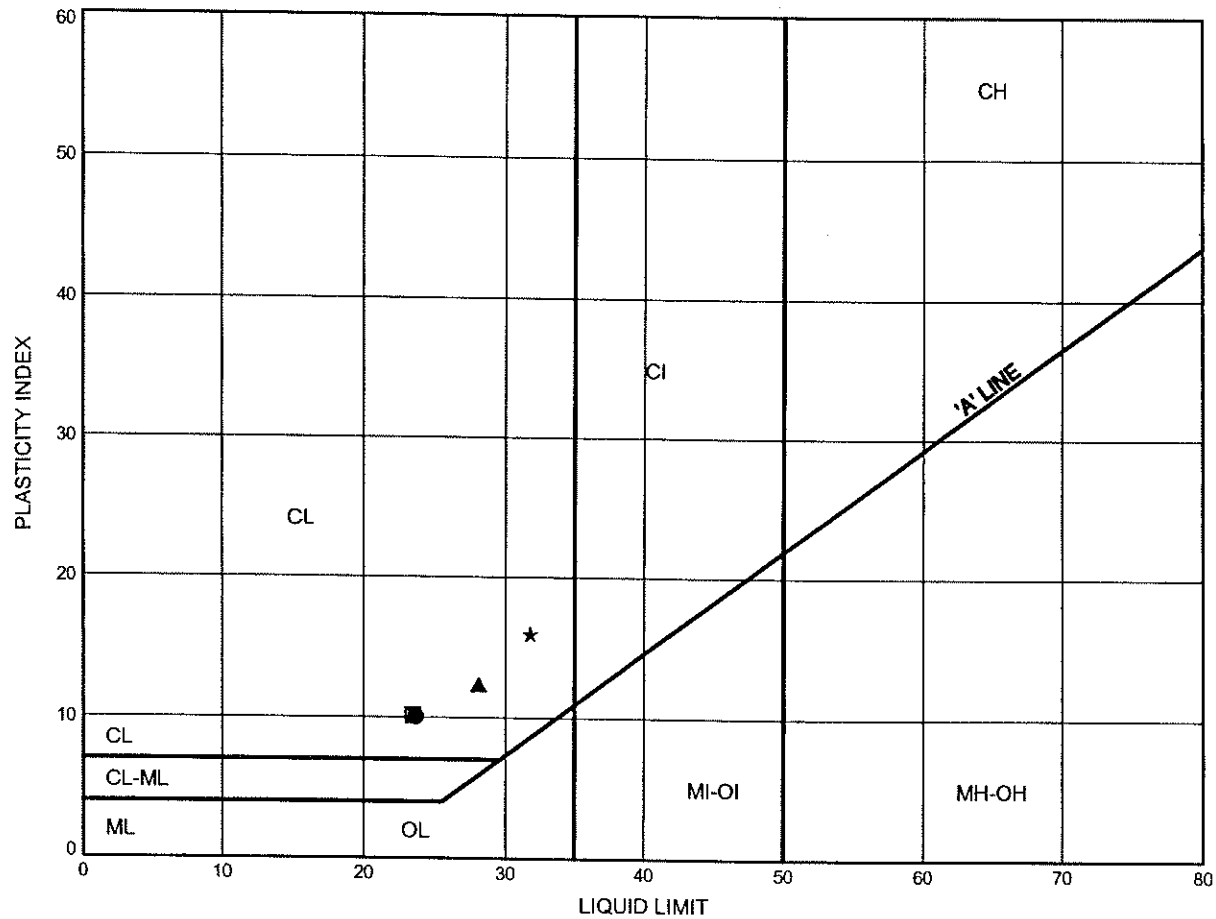


Prep'd MFA  
 Chkd. RPR

Hwy 401/410 to Credit River  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B10

**SILTY CLAY / CLAYEY SILT TILL**



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	RSE-13	3.35	188.42
⊠	RSE-16	3.35	189.05
▲	RSE-16	5.18	187.22
★	RSE-17	2.59	188.72

Date November 2007

Project 2107-05-00



Prep'd MFA

Chkd. RPR



## **Appendix C**

### **Foundation Comparison**

Highway 401 Widening – Hurontario Street South to Highway 401 East Ramp

**COMPARISON OF FOUNDATION ALTERNATIVES**

Footings on Native Soil	Footings on Shale	Driven Piles
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Ease of construction.</li> <li>ii. Good geotechnical resistance is available on the till deposits.</li> <li>iii. Lower cost than deep foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Subexcavation might be required to penetrate fill.</li> <li>ii. Lower geotechnical resistance in soil than in bedrock</li> </ul> <p><b>RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High values of geotechnical resistance are available on the bedrock.</li> <li>ii. Relatively simple construction method</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Mass concrete fill may be required to raise the founding subgrade level.</li> <li>ii. Stepped footing may be required to compensate undulation of bedrock.</li> <li>iii. Higher cost of excavation to bedrock.</li> </ul> <p><b>RECOMMENDED</b></p>	<p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Not practical to drive piles into shale bedrock.</li> <li>ii. Higher unit cost than footings.</li> </ul> <p><b>NOT RECOMMENDED AT THIS SITE</b></p>

## **Appendix D**

### **List of SPs and OPSS**

#### **Suggested Text for Selected NSSP**

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

- SP 902 S01
- OPSD 3501.150.
- OPSD 3102.100.
- OPSS 902
- SP 105S19
- SP 105S01
- SP 572 S01

OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2002.

All granular material should meet the specifications of Special Provision 110F13 “Amendment to OPSS 1010, March 1993”.

**2. Suggested Text for NSSP on “Native Hard Till” and “Rock Excavation”**

Cobbles and boulders should be expected within the silty clay till layer. The silty clay till grades into weathered bedrock, accordingly, excavation of the lower zones of the till may be difficult.

The strength of the shale bedrock increases with depth and there is presence of very hard limestone and/or siltstone interbeds within the shale bedrock. Bulk excavation through the sound shale and the hard interbeds may be difficult. As such, rock coring equipment, pneumatic rock splitting/breaking equipment and ripping machinery should be available on site to assist in excavation and drilling.

Although shale bedrock is intrinsically of low permeability, the possibility exists that concentrated seepage may be experienced from localized seams or fractures in the rock. Means to handle this seepage, such as additional pumps, should be made available.

## **Appendix E**

### **Borehole Locations and Soil Strata Drawing**

PLATE SCALE 1:1  
PL-A-757  
MINISTRY OF TRANSPORTATION, ONTARIO  
DRAWING NAME:  
CREATED:

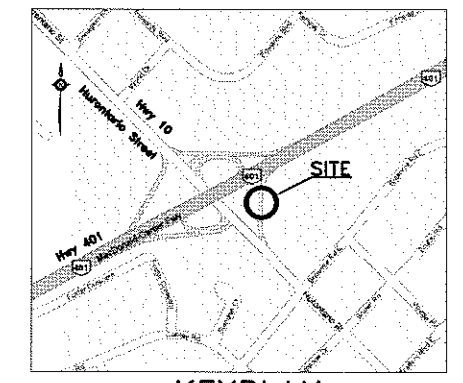
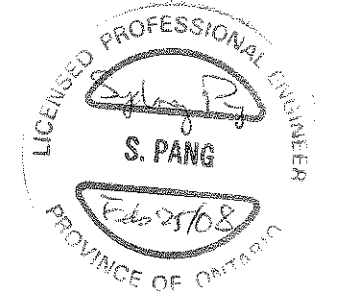
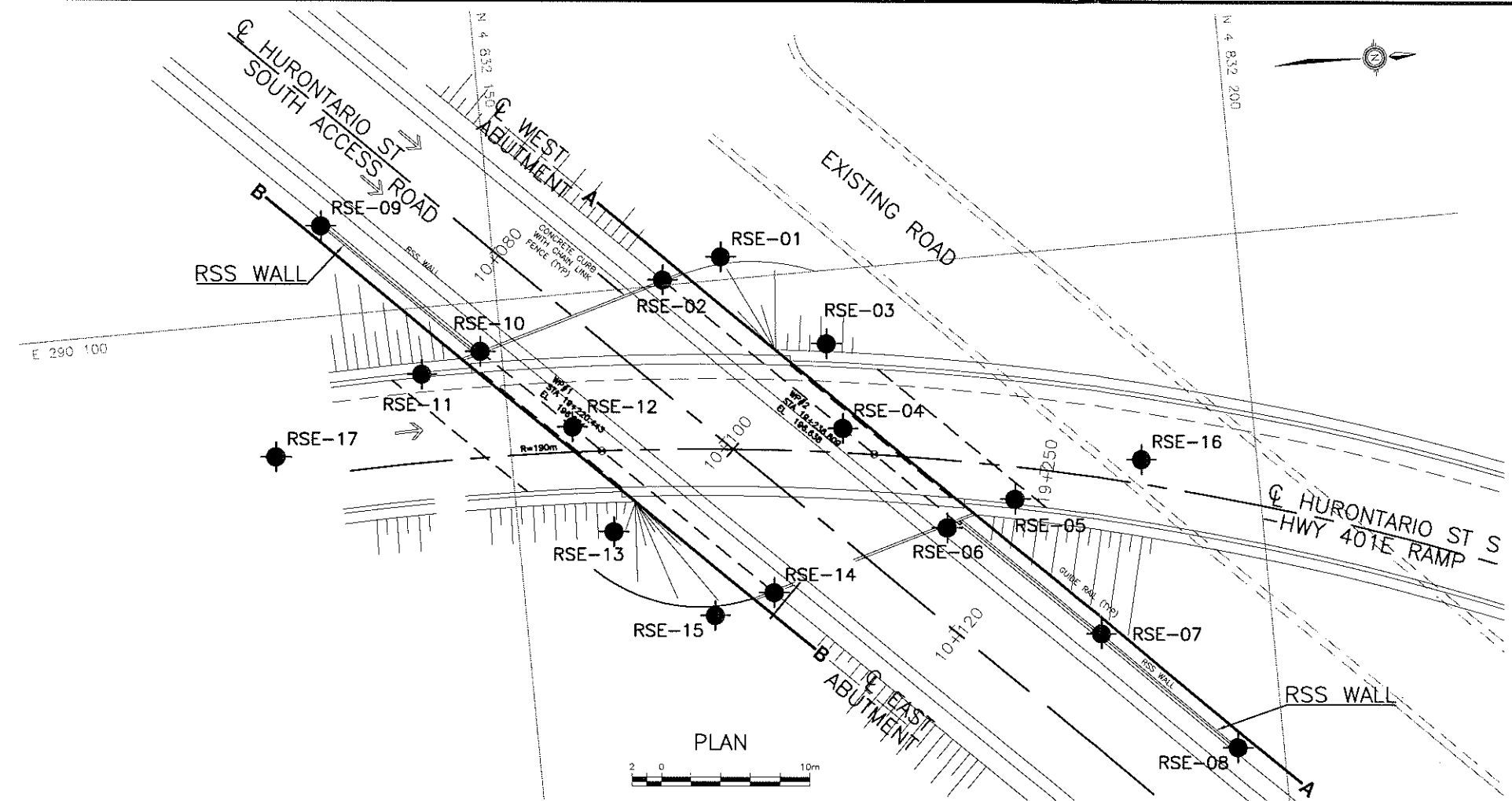
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

HIGHWAY 401  
SITE No 24-757  
GWP No 2107-05-00

HURONTARIO ST. SOUTH TO  
HWY 401 EAST RAMP  
BOREHOLE LOCATIONS AND SOIL STRATA

**Marshall  
Macklin  
Monaghan**  
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS

**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

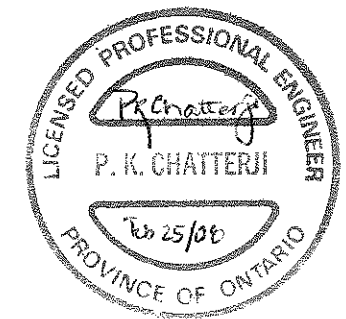
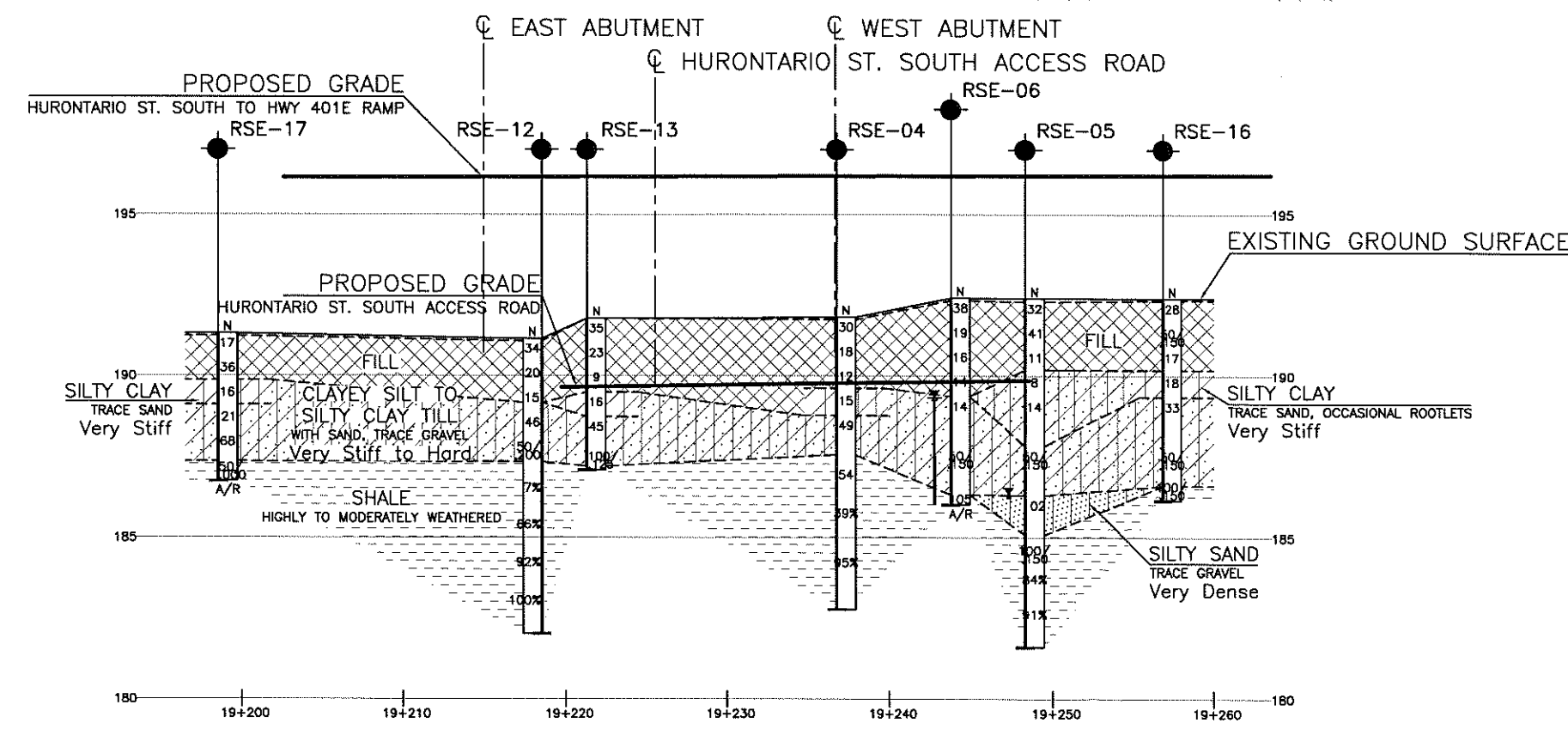
- Borehole (Present Investigation, 2007)
- Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RSE-01	190.7	4 832 165.3	290 098.5
RSE-02	190.7	4 832 161.2	290 099.6
RSE-03	191.4	4 832 171.8	290 104.9
RSE-04	191.8	4 832 172.4	290 110.7
RSE-05	192.4	4 832 183.5	290 116.5
RSE-06	192.4	4 832 178.8	290 118.0
RSE-07	193.0	4 832 188.4	290 126.1
RSE-08	192.8	4 832 196.9	290 134.6
RSE-09	191.5	4 832 138.6	290 093.9
RSE-10	189.6	4 832 148.6	290 103.3
RSE-11	190.0	4 832 144.5	290 104.5
RSE-12	191.1	4 832 154.3	290 108.9
RSE-13	191.8	4 832 156.4	290 116.2
RSE-14	192.5	4 832 166.8	290 121.3
RSE-15	192.5	4 832 162.7	290 122.5
RSE-16	192.4	4 832 192.2	290 114.6
RSE-17	191.3	4 832 134.2	290 109.1

NOTES

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

GEOCRES No. 30M12-266



REVISIONS	DATE	BY	DESCRIPTION
DESIGN AEG	CHK	SKP	CODE
DRAWN MFA	CHK	PKC	SITE
STRUCT	IS	SCHEME	DWG 1

Refer to DWG 2 for Sections A-A and B-B.

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

FILENAME: C:\V08 FILES\19\1423\11 Hwy 401\242311-RSE.dwg  
PLOTDATE: Feb 28, 2008 - 10:26am

