

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
CULVERT EXTENSIONS  
HWY 401 WIDENING, HWY 410 TO CREDIT RIVER  
MISSISSAUGA, ONTARIO  
G.W.P. 2107-05-00**

**Geocres Number: 30M12-276**

**Report to**

**MMM Group Limited**

Thurber Engineering Ltd.  
2010 Winston Park Drive, Suite 103  
Oakville, Ontario  
L6H 5R7  
Phone: (905) 829 8666  
Fax: (905) 829 1166

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detail design of four proposed culvert extensions for widening of Highway 401 from the Hurontario Street and Highway 401 interchange to approximately 900 m west of Hurontario Street.

The purpose of the investigation was to explore the subsurface conditions at the culvert locations and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile and a written description of the subsurface conditions.

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**

In general, the lands at the northwest quadrant of Highway 401 and Hurontario Street are vacant and undeveloped. 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 the Peel Plain, characterized by a level to undulating cohesive glacial till which is underlain by reddish brown shale with hard limestone interbeds of the Queenston Formation.

The designations and approximate locations of the culvert extensions are as follows:

<b>Culvert</b>	<b>Location</b>
1	Highway 401, Station 18+235, approx. 900 m west of Hurontario St.
2	Highway 401, Station 18+585, approx. 500 m west of Hurontario St.
3	Highway 401 East to Hurontario Street South Ramp, Station 18+831, approx. 300 m west of Hurontario St.
4	Highway 401, Station 19+200, approx. 100 m east of Hurontario St.

### 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at the locations of the proposed culverts extensions were carried out on September 13, October 4, 5 and 12, and November 13, 2007. A total of 14 sampled boreholes were drilled for the proposed culvert extensions. A summary of the borehole designations employed at each culvert is provided in Table 3.1. The respective appendices of the borehole logs, laboratory results, Borehole Locations and Soil Strata drawings are also provided in Table 3.1. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets.

**Table 3.1 – Borehole Designations**

<b>Culvert</b>	<b>Borehole</b>	<b>Location Relative to Culvert</b>	<b>Borehole Termination Depth (m)</b>	<b>Borehole Termination Elevation (m)</b>	<b>Stratum at Termination Depth</b>	<b>Appendix</b>
1	C1-1	Highway 401, WBL	5.8	182.9	Shale bedrock	B
	C1-2	Highway 401, WBL	4.9	183.5	Silty Clay till	
	C1-3	Highway 401, EBL	4.9	182.8	Silty Clay till	
	C1-4	Highway 401, EBL	4.9	181.5	Silty Clay till	
2	C2-1	Highway 401, WBL	2.3	185.3	Silty Clay till	C
	C2-2	Highway 401, WBL	4.6	182.7	Shale bedrock	
	C2-3	Highway 401, EBL	4.7	182.1	Shale bedrock	
	C2-4	Highway 401, EBL	4.7	181.1	Shale bedrock	
3	C3-1	Highway 401 E to Hurontario St. S Ramp, North side	3.2	183.0	Shale bedrock	D
	C2-2	Highway 401 E to Hurontario St. S Ramp, South side	3.1	181.8	Shale bedrock	
4	C4-1	Highway 401, WBL	4.9	186.2	Silty Clay till	E
	C4-2	Highway 401, WBL	4.7	187.2	Sand and Silt Till	
	C4-3	Highway 401, EBL	6.1	185.7	Shale bedrock	
	C4-4	Highway 401, EBL	6.2	184.4	Shale bedrock	

The approximate locations of all the boreholes are shown on the Borehole Location Drawing 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 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

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.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A total of seven standpipe piezometers consisting of 19 mm PVC pipes with screens were installed in selected boreholes to permit monitoring of groundwater levels. Details of the piezometer installations and other borehole completion details are shown in Table 3.2.

**Table 3.2 – Borehole Completion Details**

<b>Culvert</b>	<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Completion Details</b>
1	C1-1	None installed	Bentonite holeplug to surface.
	C1-2	3.7/184.7	Sand from 3.7 m to 1.8 m, bentonite grout to surface.
	C1-3	None installed	Bentonite holeplug to surface.
	C1-4	4.9/181.5	Sand from 4.9 m to 3.0 m, bentonite grout to surface.
2	C2-1	2.0/185.6	Sand from 2.0 m to 0.3 m, bentonite grout to surface.
	C2-2	None installed	Bentonite holeplug to surface.
	C2-3	None installed	Bentonite holeplug to surface.
	C2-4	4.0/181.8	Sand from 4.0 m to 2.1 m, bentonite grout to surface.
3	C3-1	None installed	Bentonite holeplug to surface.
	C3-2	3.0/181.9	Sand from 3.0 m to 1.2 m, bentonite grout to surface.
4	C4-1	None installed	Bentonite holeplug to surface.
	C4-2	4.7/187.2	Sand from 4.7 m to 2.7 m, bentonite grout to surface.
	C4-3	None installed	Bentonite holeplug to surface.
	C4-4	6.2/184.4	Sand from 6.2 m to 4.3 m, bentonite grout to surface.

#### 4 LABORATORY TESTING

All recovered samples were subjected to Visual Identification (VI) and moisture content determination. At least 25% of the recovered samples were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets and figures contained in Appendices B to E.

#### 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices B to E for details of the encountered soil and rock stratigraphy. Stratigraphic profiles are presented on the Borehole Locations and Soil Strata Drawings in the appendices, for illustrative purposes. Overall descriptions of the stratigraphy are given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.



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

## **5.1 Culvert 1 - Highway 401, Station 18+235 (Boreholes C1-1 to C1-4)**

### **5.1.1 Topsoil**

Topsoil was identified at ground surface in Boreholes C1-1 to C1-4. The topsoil thickness generally ranged from 50 mm to 125 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

### **5.1.2 Fill**

Fill was encountered below the topsoil in Boreholes C1-3 and C1-4 located on the south side of Highway 401 EBL. The fill generally consists of brown to reddish brown silty clay containing trace to some sand, trace of gravel and occasional red shale fragments and rootlets. An 800-mm thick layer of reddish brown shale fill was contacted just below the topsoil in Borehole C1-4.

Based on recorded SPT values ranging from 11 blows for 0.3 m of penetration to greater than 50 blows per 0.05 m penetration, the silty clay fill and shale fill are described as being stiff to hard in consistency.

The natural moisture content of the samples obtained from the fill layer ranged from 8% to 18%.

The depth to the base of the fill layer was 0.8 m and 2.0 m (elevations 187.0 m and 184.4 m) in Boreholes C1-3 and C1-4, respectively.

### **5.1.3 Silty Clay Till**

Native brown to grey silty clay till with sand, trace of gravel and occasional rootlets was contacted below the topsoil and fill in all the boreholes.

Based on SPT values ranging from 9 blows for 0.3 m of penetration to greater than 70 blows for 0.15 m of penetration, the silty clay till is described as being stiff to hard.

The natural moisture contents of the samples recovered from the silty clay till layer ranged from 9 to 22%.

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 B2 of Appendix B. The results of laboratory tests carried out on six samples were as follows:

Soil Particles	(%)
Gravel	2 to 4
Sand	27 to 33
Silt	41 to 48
Clay	19 to 29

Index Property	(%)
Liquid Limit	27 to 28
Plastic Limit	13 to 18
Plasticity Index	12 to 15

The above results show that the silty clay till is of low plasticity with a group symbol of CL.

The depth to the base of the clay till deposit layer was 5.2 m (elevation 183.5 m) in Borehole C1-1. Boreholes C1-2 to C1-4 did not fully penetrate the silty clay till.

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders, and 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.

#### 5.1.4 Bedrock

Shale bedrock of the Queenston Formation was contacted below the silty clay till at 5.2 m depth (elevation 183.5 m) in Borehole C1-1. Queenston shale typically contains numerous interbedded siltstone and limestone layers that can be significantly harder than the shale itself. The shale is described as reddish brown, highly weathered and thinly bedded.

#### 5.1.5 Water Levels

Water level was observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in two boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.1, along with the measurements in the boreholes upon completion of drilling.

**Table 5.1 – Measured Groundwater Levels**

Culvert	Borehole	Date (2007)	Water Level (m)		Comment
			Depth	Elevation	
I	C1-1	October 10	Dry	-	In open borehole
	C1-2	October 5	Dry	-	In piezometer
		October 18	1.7	186.7	
		November 1	1.5	186.9	
		November 15	1.7	186.7	
	C1-3	October 10	Dry	-	In open borehole
	C1-4	October 18	1.7	184.7	In piezometer
		November 1	1.5	184.9	
		November 15	1.7	184.7	

The piezometric readings indicate that the groundwater levels ranges from north to south from Elevations 186.9 m to 184.7 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.

## **5.2 Culvert 2 - Highway 401, Station 18+585 (Boreholes C2-1 to C2-4)**

### **5.2.1 Topsoil**

Topsoil was identified at ground surface in Boreholes C2-1 to C2-4. The topsoil thickness generally ranged from 50 mm to 250 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

### **5.2.2 Fill**

Fill was encountered below the topsoil. The fill generally consists of brown to reddish brown silty clay with trace to some sand, trace of gravel and occasional asphalt fragments and rootlets. Fill thickness ranged from 0.5 m to 1.5 m.

Based on recorded SPT values ranging from 12 blows for 0.3 m of penetration to greater than 50 blows per 0.15 m penetration, the silty clay fill is described as being stiff to hard in consistency.

The natural moisture content of the samples obtained from the fill layer ranged from 9 to 18%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure C1 of Appendix C. Atterberg Limit test results are presented on Figure C3 of Appendix C. The results of laboratory tests carried out on one sample were as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0
Sand	11
Silt	68
Clay	21

Index Property	(%)
Liquid Limit	42
Plastic Limit	23
Plasticity Index	19

The above results show that the silty clay fill is of medium plasticity with a group symbol of CL.

The depth to the base of the fill ranged from 0.8 m to 1.5 m (elevations 184.3 m to 186.9 m).

### 5.2.3 Silty Clay Till

Native brown to grey silty clay till with sand, trace of gravel and occasional rootlets was contacted below the fill in all the boreholes.

Based on SPT values ranging from 7 blows for 0.3 m of penetration to greater than 70 blows for 0.15 m of penetration, the silty clay till is described as being firm to hard.

The natural moisture contents of the samples recovered from the silty clay till layer ranged from 8 to 20%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure C2 of Appendix C. Atterberg Limit test results are presented on Figure C4 of Appendix C. The results of laboratory tests carried out on four samples were as follows:

Soil Particles	(%)
Gravel	0 to 5
Sand	22 to 27
Silt	40 to 53
Clay	23 to 33

Index Property	(%)
Liquid Limit	30 to 34
Plastic Limit	16 to 18
Plasticity Index	14 to 15

The above results show that the silty clay till is of low plasticity with a group symbol of CL.

The depth to the base of the native till deposit layer ranged from 2.3 m to 3.8 m (elevations 182.1 to 185.3 m).

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders and 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.

#### 5.2.4 Bedrock

The soils described above were found to be underlain by shale bedrock of the Queenston Formation. Queenston shale typically contains numerous interbedded siltstone and limestone layers that can be significantly harder than the shale itself. The shale is described as reddish brown, highly weathered and thinly bedded.

SPT N-values obtained in the shale bedrock were greater than 100 blows per 0.125 m penetration. Moisture contents ranged from 2% to 5%. Elevations of the top of weathered bedrock are shown in Table 5.2.

**Table 5.2 – Elevation of Top of Weathered Bedrock**

Culvert	Borehole	Depth to Weathered Bedrock (m)	Top of Weathered Bedrock Elevation (m)
2	C2-1	-	-
	C2-2	2.4	184.8
	C2-3	3.8	183.0
	C2-4	3.7	182.1

#### 5.2.5 Water Levels

Water level was observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in two 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**

Culvert	Borehole	Date (2007)	Water Level (m)		Comment
			Depth	Elevation	
2	C2-1	October 5	Dry	-	In piezometer
		October 18			
		November 1			
		November 15			
	C2-2	October 4	Dry	-	In open borehole
	C2-3	October 12	Dry	-	In open borehole
	C2-4	October 18	Dry	-	In piezometer
		November 1	2.9	182.9	
		November 15	2.2	183.6	

The piezometric readings indicate that the groundwater levels range from elevations 182.9 m to 183.6 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.

### **5.3 Culvert 3 - Highway 401 East to Hurontario Street South Ramp, Station 18+831 (Boreholes C3-1 and C3-2)**

#### **5.3.1 Topsoil**

A 100-mm thick layer of topsoil was identified at ground surface in Borehole C3-2. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

#### **5.3.2 Silty Clay Till**

Native brown to grey silty clay till with sand, trace of gravel and occasional rootlets was contacted surficially in Borehole C3-1 and below the topsoil in Borehole C3-2.

Based on SPT values of 8 and 14 blows for 0.3 m of penetration, the silty clay till is described as being stiff.

The natural moisture contents of the samples recovered from the silty clay till were 9% and 21%.

The depth to the base of the till deposit layer was 0.6 m, elevations 185.6 m and 184.4 m in Boreholes C3-1 and C3-2, respectively.

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders and 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.

#### **5.3.3 Bedrock**

The soils described above were found to be underlain by shale bedrock of the Queenston Formation. Queenston shale typically contains numerous interbedded siltstone and limestone layers that can be significantly harder than the shale itself. The shale is described as reddish brown, highly weathered and thinly bedded.

SPT N-values obtained in the shale bedrock were greater than 100 blows per 0.1 m penetration. Moisture contents ranged from 5 to 8%. Elevations of the top of weathered bedrock are shown in Table 5.4.

**Table 5.4 – Elevation of Top of Weathered Bedrock**

Culvert	Borehole	Depth to Weathered Bedrock (m)	Top of Weathered Bedrock Elevation (m)
3	C3-1	0.6	185.6
	C3-2	0.6	184.4

### 5.3.4 Water Levels

Water level was observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in one borehole (Borehole C3-2) to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.5, along with the measurements in the boreholes upon completion of drilling.

**Table 5.5 – Measured Groundwater Levels**

Culvert	Borehole	Date (2007)	Water Level (m)		Comment
			Depth	Elevation	
3	C3-1	October 12	Dry	-	In open borehole
	C3-2	October 18 November 1 November 15	Dry	-	In piezometer

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.

## 5.4 Culvert 4 - Highway 401, Station 19+200 (Boreholes C4-1 to C4-4)

### 5.4.1 Topsoil

Topsoil was identified at ground surface in Boreholes C4-1 to C4-4. The topsoil thickness generally ranged from 80 mm to 125 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

### 5.4.2 Fill

Fill was encountered below the topsoil in all the boreholes. The fill generally consists of brown silty clay containing trace to some sand, trace of gravel and occasional rootlets. Fill thickness ranged from 1.3 m to 1.4 m.

Based on recorded SPT values ranging from 10 to 25 blows for 0.3 m of penetration, the silty clay fill is described as being stiff to very stiff in consistency.

The natural moisture content of the samples obtained from the fill layer ranged from 10% to 19%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure E1 of Appendix E. Atterberg Limit test results are presented on Figure E4 of Appendix E. The results of laboratory tests carried out on one sample were as follows:

Soil Particles	(%)
Gravel	0
Sand	28
Silt	52
Clay	20

Index Property	(%)
Liquid Limit	34
Plastic Limit	18
Plasticity Index	16

The above results show that the silty clay fill is of low plasticity with a group symbol of CL.

The depth to the base of the fill ranged from 1.4 m to 1.5 m (elevations 189.3 m to 190.4 m).

#### 5.4.3 Silty Clay Till

Native brown to grey silty clay till with sand, trace of gravel and occasional shale fragments was contacted below the fill in all the boreholes.

Based on SPT values ranging from 8 blows for 0.3 m of penetration to greater than 50 blows for 0.15 m of penetration, the silty clay till is described as being firm to hard.

The natural moisture contents of the samples recovered from the silty clay till ranged from 8 to 28%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure E2 of Appendix E. Atterberg Limit test results are presented on Figure E5 of Appendix E. The results of laboratory tests carried out on seven samples were as follows:

Soil Particles	(%)
Gravel	0 to 5
Sand	27 to 35
Silt	46 to 50
Clay	15 to 23



<b>Index Property</b>	<b>(%)</b>
Liquid Limit	20 to 29
Plastic Limit	12 to 15
Plasticity Index	8 to 14

The above results show that the silty clay till is of low plasticity with a group symbol of CL.

The depth to the base of the till deposit layer ranged from 4.3 m to 4.6 m (elevations 186.1 m to 187.7 m), except in Borehole C4-1 where the silty clay till layer was not fully penetrated.

Although not encountered in the boreholes, glacial tills inherently contain cobbles and boulders and 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.

#### **5.4.4 Sand and Silt Till**

Sand and silt till with some clay and trace of gravel were contacted below the cohesive silty clay till in Boreholes C4-2 to C4-4. Thickness of the cohesionless layer was 0.6 m and 0.9 m in Boreholes C4-3 and C4-4, respectively.

SPT N-values were 103 and 50 blows per 0.15 m penetration, indicating a very dense relative density. The natural moisture contents of the samples recovered from the sand and silt layer were from 7 and 11%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure E3 of Appendix E. The results of laboratory tests carried out on two samples of the sand and silt were as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	2 to 6
Sand	42 to 44
Silt	38 to 44
Clay	10 to 14

#### **5.4.5 Bedrock**

Shale bedrock of the Queenston Formation was contacted below the silty clay till and sand and silt till in Boreholes C4-3 and C4-4. Queenston shale typically contains numerous interbedded siltstone and limestone layers that can be significantly harder than the shale itself. The shale is described as reddish brown, highly weathered and thinly bedded.

SPT N-value obtained in the shale bedrock was 100 blows per 0.15 m penetration, indicating a hard consistency. Moisture contents ranged from 5 to 7%. Elevations of the top of weathered bedrock are shown in Table 5.6.

**Table 5.6 – Elevation of Top of Weathered Bedrock**

Culvert	Borehole	Depth to Weathered Bedrock (m)	Top of Weathered Bedrock Elevation (m)
4	C4-1	-	-
	C4-2	-	-
	C4-3	5.2	186.6
	C4-4	5.5	185.2

**5.4.6 Water Levels**

Water level was observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in two boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.7, along with the measurements in the boreholes upon completion of drilling.

**Table 5.7 – Measured Groundwater Levels**

Culvert	Borehole	Date (2007)	Water Level (m)		Comment
			Depth	Elevation	
4	C4-1	October 5	Dry	-	In open borehole
	C4-2	October 18	1.2	190.7	In piezometer
		November 1	1.1	190.8	
			1.1	190.8	
	C4-3	September 13	Dry	-	In open borehole
	C4-4	September 14	0.9	189.8	In piezometer
		September 19	0.8	189.9	
		September 28	1.0	189.7	
		October 5	0.8	189.9	
		October 18	0.8	189.9	
		November 1	0.8	189.9	
		November 15	0.7	190.0	

The piezometric readings indicate that the groundwater levels range from elevations 190.0 m to 190.8 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.

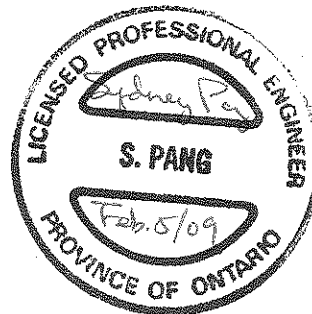
Supervision of the field program, interpretation of the field data and preparation of the investigation report was conducted by Mr. Sydney Pang, P. Eng. and Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd.  
Rocío Palomeque Reyna, P.Eng.  
Geotechnical Engineer



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



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT**  
**CULVERT EXTENSIONS**  
**HWY 401 WIDENING, HWY 410 TO CREDIT RIVER**  
**MISSISSAUGA, ONTARIO**  
**G.W.P. 2107-05-00**

**Geocres Number: 30M12-276**

**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 INTRODUCTION**

This report presents interpretation of the geotechnical data in the factual report and presents foundation design recommendations to assist the design team to carry out design of suitable foundation systems for the culvert extensions.

The project involves extension of four existing culverts under Highway 401 from the Highway 401 and Hurontario Street interchange to approximately 900 m west of Hurontario Street. The culverts will be lengthened to the north and south sides.

A description of the proposed culvert extensions is presented in Table 7.1.

**Table 7.1 – Proposed Culvert Extensions**

Culvert	Station	Type	Culvert Size (m)	Proposed Extension (length) (m)	
				North	South
1	18+235	Rigid frame box	1.24 x 1.24	42	24
2	18+585	Rigid frame open	1.22 x 1.15	33	15
3	18+831	CSP	1.0 diameter	-	24
4	19+200	Rigid frame open	1.84 x 1.25	28	26

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. The plans used for preparation of this report were provided by MMM in 2007.

## 8 CULVERT FOUNDATIONS

### 8.1 General

Details regarding the invert levels and the type of proposed culvert extensions were not available to Thurber at the time of report preparation.

The subsurface stratigraphy revealed in the boreholes drilled at the culvert extension locations consists of surficial topsoil layer, overlying silty clay fill underlain by native stiff to hard silty clay till and very dense sand and silt till. Highly weathered shale bedrock was contacted in 8 of the 14 boreholes drilled at the culvert locations. Readings in the piezometer installed at selected boreholes indicate that the groundwater level at each culvert location is as shown in Table 8.1.

**Table 8.1 – Measured Groundwater Elevations**

<b>Culvert</b>	<b>Measured Groundwater Elevation (m)</b>
1	184.7 to 186.9
2	182.9 to 183.6
3	Dry
4	190.0 to 190.8

### 8.2 Foundation Alternatives

The following types of culvert extension have been considered in this report:

- Concrete open frame culvert with spread footings on native soil
- Concrete closed box culvert supported on native soil
- CSP

It is preferable to use precast concrete sections rather than cast-in-place construction for the main body of the culvert extension, since the former type can be installed more expediently with less potential for disturbance of the founding soils. Any wingwall or headwall may use the cast-in-place method of construction.

### 8.3 Foundation Design

Foundation design issues for the culvert extensions are subgrade conditions, bearing resistances, settlement of foundation soils and stability of the widening embankments adjacent to the culverts.

The culvert extensions should be founded at the same level as the existing base of culverts, to avoid undermining of the existing structures and disturbing the founding soils.

The native undisturbed stiff to very stiff silty clay till is considered suitable for supporting the shallow foundations for open frame culverts, the base of precast box culverts or CSP culverts. Based on the borehole data, it is anticipated that stiff/very stiff silty clay till will be present at depths and elevations shown in Table 8.2.

**Table 8.2 – Culvert Base or Founding Levels**

Culvert	North Extension		South Extension	
	Depth to native stiff/very stiff silty clay till (m)	Elevation native stiff/very stiff silty clay till (m)	Depth to native stiff/very stiff silty clay till (m)	Elevation native stiff/very stiff silty clay till (m)
1	0.1 to 0.4	188.3	1.7 to 2.0	184.4 to 186.0
2	0.7 to 0.8	186.5 – 186.9	1.5 to 2.5	184.3
3	-	-	0.6	184.4* to 185.6 *
4	1.5	189.5 – 190.4	1.4 – 2.2	188.5 to 190.3

\* Top of bedrock

The culvert extensions should be designed to resist frost forces, lateral earth pressures, weight of embankment fill, traffic loading and surcharge due to construction equipment.

### 8.3.1 Open Frame Concrete Culvert Extension

For a concrete open frame culvert extension on spread footings, the culverts and adjacent wingwall/headwall footings should be founded on the hard silty clay till, at or below the elevations indicated in Table 8.2.

The following geotechnical resistances are recommended for design of spread footings founded on the native very stiff to hard silty clay till, assuming a minimum 1.5 m wide footing subjected to vertical concentric loading:

- Factored geotechnical resistance of 300 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 200 kPa at Serviceability Limit States (SLS)

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

The geotechnical resistance at SLS was computed on the basis of limiting the settlement of an individual culvert footing to 25 mm under the applied load. Comments in this regard are presented in Section 8.4. of this report.

The sliding resistance of mass concrete poured on the native silty clay 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.

Following excavation to the design founding level, any remaining fill, topsoil, streambed deposits or soft soils on the bearing surface should be subexcavated and replaced with mass concrete or compacted Granular A or Granular B Type II material. All foundation excavation should be carried out in accordance with SP 902S01. A 100 mm thick mat of concrete should be placed over the approved founding surfaces within 24 hours of excavation, inspection and approval to protect the surface from disturbance during construction. The mat concrete should be of the same class as the footing concrete.

The subgrade for the footings of an open frame culvert should be inspected by qualified geotechnical personnel to confirm that the exposed surface conforms to the design requirements and has been adequately prepared to receive concrete.

For frost protection purposes, the culvert design should incorporate 1.2 m of earth cover, or its thermal equivalent, to the founding base.

### **8.3.2 Concrete Box (Closed) Culvert Extension**

Following excavation to the design base level of the culvert, any remaining fill, topsoil, streambed deposits or soft soils within the culvert footprint should be subexcavated to the undisturbed stiff to very stiff silty clay till at or below elevations shown in Table 8.2. The exposed surface must be inspected to confirm that the subgrade is suitable and uniformly competent. Any soft areas should be subexcavated and replaced with well compacted granular fill. Any fill placed below the culvert to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried in accordance with SP 902S01.

In order to provide a more uniform foundation subgrade condition, a 150 mm thick layer of bedding material conforming to OPSS Granular A requirements should be provided under the base of box culverts as per OPSD 803.010. The bedding material should be placed as soon as practicable following inspection and approval of the final subgrade as protection from disturbance during construction.

Culverts founded on the native, undisturbed, stiff to very stiff silty clay till at the anticipated levels should be designed using a concentric, vertical geotechnical resistance of 300 kPa Ultimate Limit State (ULS).

Settlement of the culvert will be governed by compression of the foundation soils under the weight of the road embankment fill. Therefore, the SLS resistance does not apply to the design of the box culvert. Comments in this regard are presented in Section 8.4 of this report.

Resistance to lateral forces / sliding resistance between the concrete slab and the underlying Granular A should be calculated assuming an ultimate coefficient of friction of 0.6.

### 8.3.3 Corrugated Steel Pipe (CSP)

CSPs may be used as further extensions at locations where this type of culvert is already in place. Subgrade preparation procedures are similar to those described above for box culvert. Reference should be made to OPSD 800.011 for detailed requirements.

## 8.4 Settlement

The actual settlement of the culvert is expected to be controlled primarily by the settlement of the subgrade under the weight of the road embankment fill. The native foundation till soils are stiff to very stiff at the culvert sites and negligible settlements are expected in the native soils under the weight of the widened embankment fill. Any settlement should be immediate in nature and should be essentially completed by the end of construction.

## 9 CULVERT BEDDING, BACKFILL AND LATERAL EARTH PRESSURES

Culvert backfill should consist of free-draining granular material conforming to OPSS Granular A or Granular B Type II specifications. The granular material should be placed to the extents shown in OPSD 803.010.

Backfill should be placed and compacted in simultaneous equal lifts on both sides of the culvert, and the top of backfill elevation should be within 400 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and roof of the culvert. Compaction should be carried out in accordance with SP 105S10.

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

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

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

Earth pressure coefficients for backfill to the culvert are dependent on the material used as backfill. Recommended unfactored values are shown in Table 9.1. The at-rest coefficients should be employed for closed box culvert walls. Active pressures shall be used for any wingwalls or unrestrained walls.



**Table 9.1 – Earth Pressure Coefficients (K)**

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or 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 Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.43*
At rest (Restrained Wall)	0.43	-	0.47	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

\* For wing walls, if employed.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.9.1 (a) of the Commentary to the CHBDC.

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.

The design of the culvert must incorporate measures such as weepholes or subdrains to permit drainage of the culvert backfill, or alternatively the culvert walls should be designed to withstand the potential build-up of hydrostatic pressures behind the walls.

## 10 EMBANKMENT DESIGN AND CONSTRUCTION

It is understood that new fill is required to be placed adjacent to and over the culvert extensions in order to widen the existing highway embankment. The embankment heights at the culvert extensions were not available at the time of preparation of this report.

Embankment construction using either Select Subgrade Material (SSM) or earth fill is feasible on the foundation soils encountered at these sites. Shale bedrock should not be used as embankment fill.

Embankment construction should be carried out in accordance with Special Provision No. 206S03 “Amendment to OPSS 206, December 1993” dated November 2006. The embankment material should consist of earth fill or Select Subgrade Material (SSM) in compliance with Special Provision No. 110F13, “Amendment to OPSS 1010, November 2003” March 2004.

Provided that the earth fill or SSM is placed as recommended, it is anticipated that a slope inclination of 2H : 1V or flatter should remain stable.

In general, surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the culvert extension area and embankment footprint. Inspection and approval of the foundation surfaces by qualified geotechnical personnel is recommended.

## **11 EROSION CONTROL**

Erosion protection should be provided at the culvert inlet area where the extension is to be located. Design of the erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field.

Typically, rip-rap should be provided over all surfaces with which stream flow is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with SP 572S01.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS 1205.

## **12 EXCAVATION AND GROUNDWATER CONTROL**

In general, surface vegetation, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the culvert area and embankment footprint prior to culvert installation/extension.

Excavation is expected to be carried out through existing fills, soft creek bed soils/organics or native silty clay till.

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). Excavation and backfilling for foundation construction must be carried out in accordance with Special Provision 902S01. For the purposes of the OHSA, the soils within the likely depth of excavation at this site may be classed as Type 3 soils for fills and Type 2 for native stiff to hard silty clay till; sands and silts below the groundwater level may be classed as Type 3. The upper 2 m of the shale (weathered zone) may be classed as a Type 2 material.

Temporary shoring may be required at locations where unsupported open cutting cannot be carried out. Roadway protection (shoring) systems should be designed and implemented in accordance with SP 105S19. Any shoring system should be designed licensed Professional Engineers experienced in such designs, taking account of the need to maintain the integrity of the existing culvert foundations.

In general, surface water must be diverted away from any excavation at all times. It is anticipated that pumping from properly filtered sumps may be suitable to handle the groundwater on this project. Temporary water course diversion may be required during wet seasons.

## **13 SEISMIC CONSIDERATIONS**

### **13.1 Seismic Design Parameters**

The following seismic parameters should be used for design:

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

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.

### **13.2 Liquefaction Potential**

The new fill for embankment widening is expected to consist of earth fill or SSM. The existing embankment fill comprises silty clays that are unlikely to liquefy. The groundwater levels are below the base level of the embankments. As such, it is considered that there is negligible potential for liquefaction of the embankments.

## **14 CONSTRUCTION CONCERNS**

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

- Dewatering is essential to maintaining a reasonably dry excavation.
- 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.
- Even though organic soils were not observed during the drilling operations, soft organic, or alluvial material may be present in the stream channels which require sub-excavation.
- Care must be taken during footing excavation or any other excavation to avoid disturbing and undermining the nearby existing travelled lanes of the Highway 401. Suggested wording for an NSSP addressing the above issues is included in Appendix F.

**15 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 P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

**THURBER ENGINEERING LTD.**

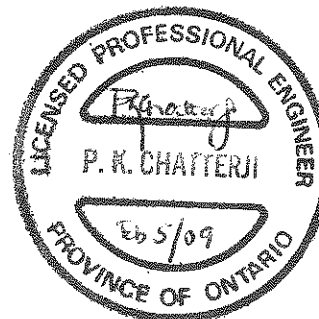
Rocio Palomeque Reyna, P.Eng.  
Geotechnical Engineer



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

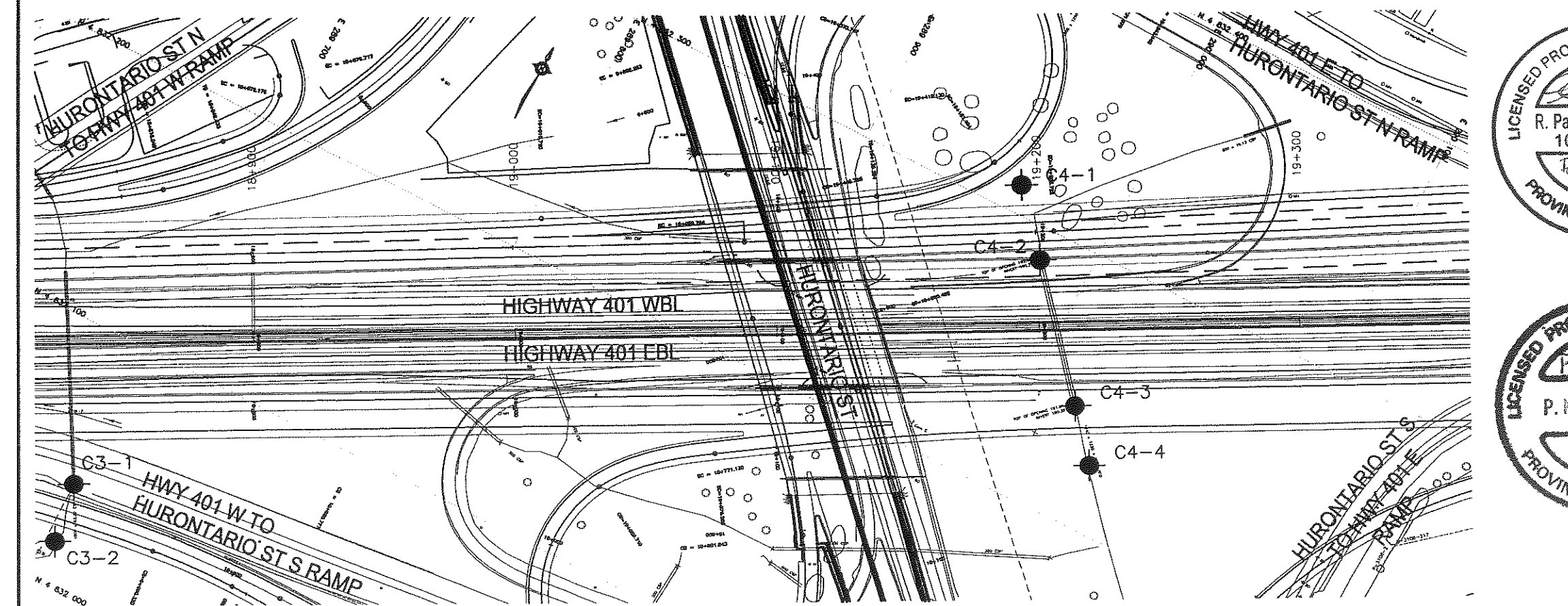
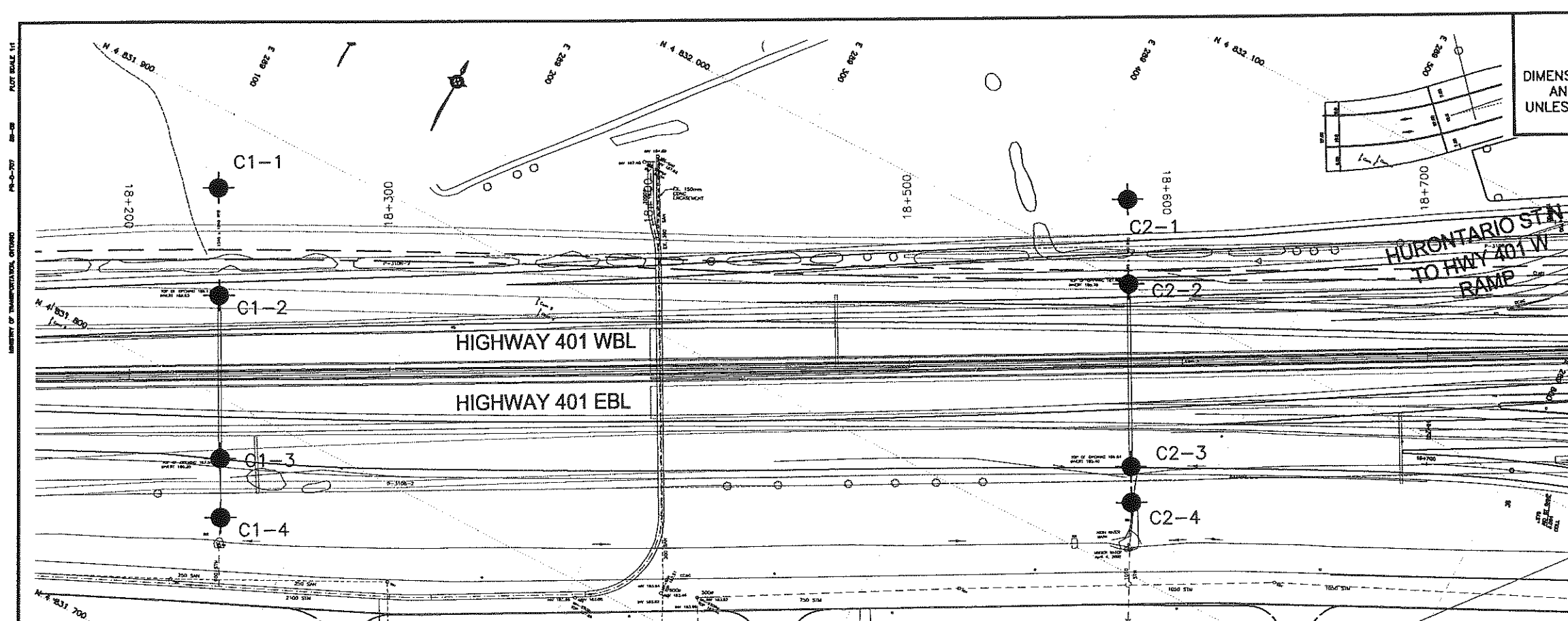


P.K. Chatterji, P.Eng.  
Review Principal



**Appendix A**

**Borehole Location Drawing**



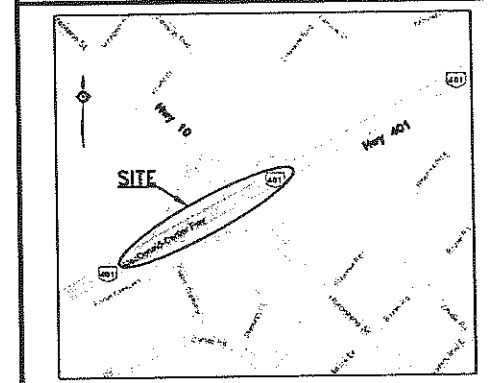
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

HWY 401  
SITE No  
GWP No 2107-05-00

HIGHWAY 401  
CULVERT EXTENSIONS AT STATIONS  
18+235, 18+585, 18+831, & 19+200  
BOREHOLE LOCATIONS PLAN

MMM GROUP

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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
C1-1	188.7	4 831 871.9	289 108.1
C1-2	188.4	4 831 834.9	289 128.0
C1-3	187.7	4 831 779.0	289 158.1
C1-4	186.4	4 831 758.7	289 169.0
C2-1	187.6	4 832 029.5	289 420.8
C2-2	187.2	4 832 000.4	289 436.4
C2-3	186.8	4 831 937.6	289 470.0
C2-4	185.8	4 831 925.3	289 476.6
C3-1	186.2	4 832 040.5	289 694.4
C3-2	185.0	4 832 017.2	289 698.4
C4-1	191.0	4 832 310.8	289 961.5
C4-2	191.9	4 832 288.0	289 981.0
C4-3	191.8	4 832 243.6	290 019.1
C4-4	190.7	4 832 225.3	290 034.7

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. 30M12-276



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FILENAME: H:\Drawing\151423111 Hwy 401\151423111-Culverts.dwg  
PLOTDATE: Feb 04, 2009 8:38am

**Appendix B**

**Culvert 1**

**Highway 401, Station 18+235**

**Record of Borehole Sheets, Figures and Drawings**

## 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			

# RECORD OF BOREHOLE No C1-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+235 N 4 831 871.899 E 289 108.067 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 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										
188.7						20	40	60	80	100	20	40	60					
0.0	TOPSOIL: (80mm)		1	SS	33													
0.1	Silty CLAY with sand, trace gravel, occasional oxidized stains, occasional rootlets Hard Brown (TILL)		2	SS	50/ .150													
			3	SS	50/ .150												4 32 41 23	
			4	SS	60/ .150													
			5	SS	50/ .150													
			6	SS	70/ .150												2 27 42 29	
183.5	SHALE, highly weathered, thinly bedded, reddish brown																	
5.2																		
182.9	END OF BOREHOLE AT 5.79m. AUGER REFUSAL ON POSSIBLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																	
5.8																		

+<sup>3</sup> . X<sup>3</sup> : Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C1-2

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+235 N 4 831 834.920 E 289 127.969 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 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								
188.4							20	40	60	80	100					
0.0	TOPSOIL: (125mm)						20	40	60	80	100					
0.1	Silty CLAY with sand, trace gravel, occasional rootlets Very Stiff to Hard Brown (TILL) Brown to Mottled Brown-Grey		1	SS	26								○			
			2	SS	80								○			
			3	SS	50/ .150								○			
			4	SS	64/ .150								○			4 33 42 21
			5	SS	50/ .150								○			
	Grey															
183.5			6	SS	70/ .150								○			
4.9	END OF BOREHOLE AT 4.88m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE      DEPTH(m)    ELEV.(m) Oct 05/07    Dry Oct 18/07    1.7      186.7 Nov 01/07    1.5      186.9 Nov 15/07    1.7      186.7															

# RECORD OF BOREHOLE No C1-3

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+235 N 4 831 778.955 E 289 158.096 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 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						
187.7								20 40 60 80 100						
0.0 0.1	TOPSOIL: (50mm)							20 40 60 80 100						
	Silty CLAY, trace to some sand, trace gravel, occasional rootlets		1	SS	11									
	Stiff													
187.0	Brown (FILL)													
0.8	Silty CLAY with sand, trace gravel, occasional rootlets		2	SS	9		187							
	Stiff to Hard													
	Mottled Brown/Black-Grey (TILL)													
	oxidized stains		3	SS	31		186							
			4	SS	50/ .150		185							3 29 47 21
			5	SS	51/ .150									
							184							
182.8	Grey		6	SS	44/ .150		183							4 29 48 19
4.9	END OF BOREHOLE AT 4.88m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

+ 3, X 3: Numbers refer to Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C1-4

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+235 N 4 831 758.703 E 289 168.995 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 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		
186.4	TOPSOIL: (80mm)		1	SS	63		186							
0.0 0.1	SHAILE, very dense, reddish brown (FILL)													
185.6	Silty CLAY, trace to some sand, trace gravel, occasional shale fragments Hard Reddish Brown (FILL)		2	SS	58		185							
0.8			3	SS	507 .050									
184.4	Silty CLAY with sand, trace gravel Hard Mottled Brown-Grey (TILL)		4	SS	41		184							
2.0	oxidized stains Brown to Greenish Brown		5	SS	75		183							3 29 47 21
							182							
181.5			6	SS	114									
4.9	END OF BOREHOLE AT 4.88m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Oct 18/07 1.7 184.7 Nov 01/07 1.5 184.9 Nov 15/07 1.7 184.7													

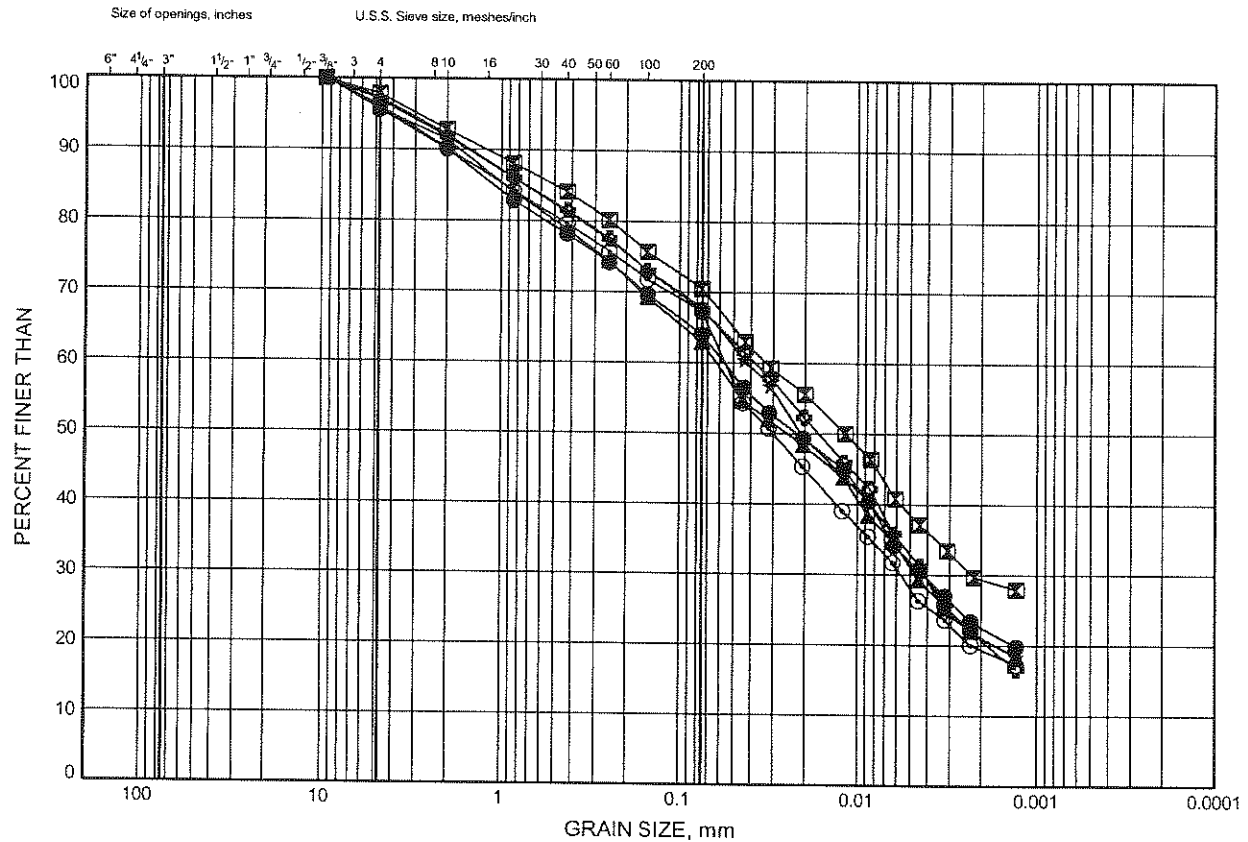
+ 3. x 3. Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

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

FIGURE B1

**Silty Clay with Sand (TILL)**



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C1-1	1.68	187.05
■	C1-1	4.72	184.00
▲	C1-2	2.44	185.93
★	C1-3	2.44	185.28
⊙	C1-3	4.72	182.99
⊗	C1-4	3.35	183.03



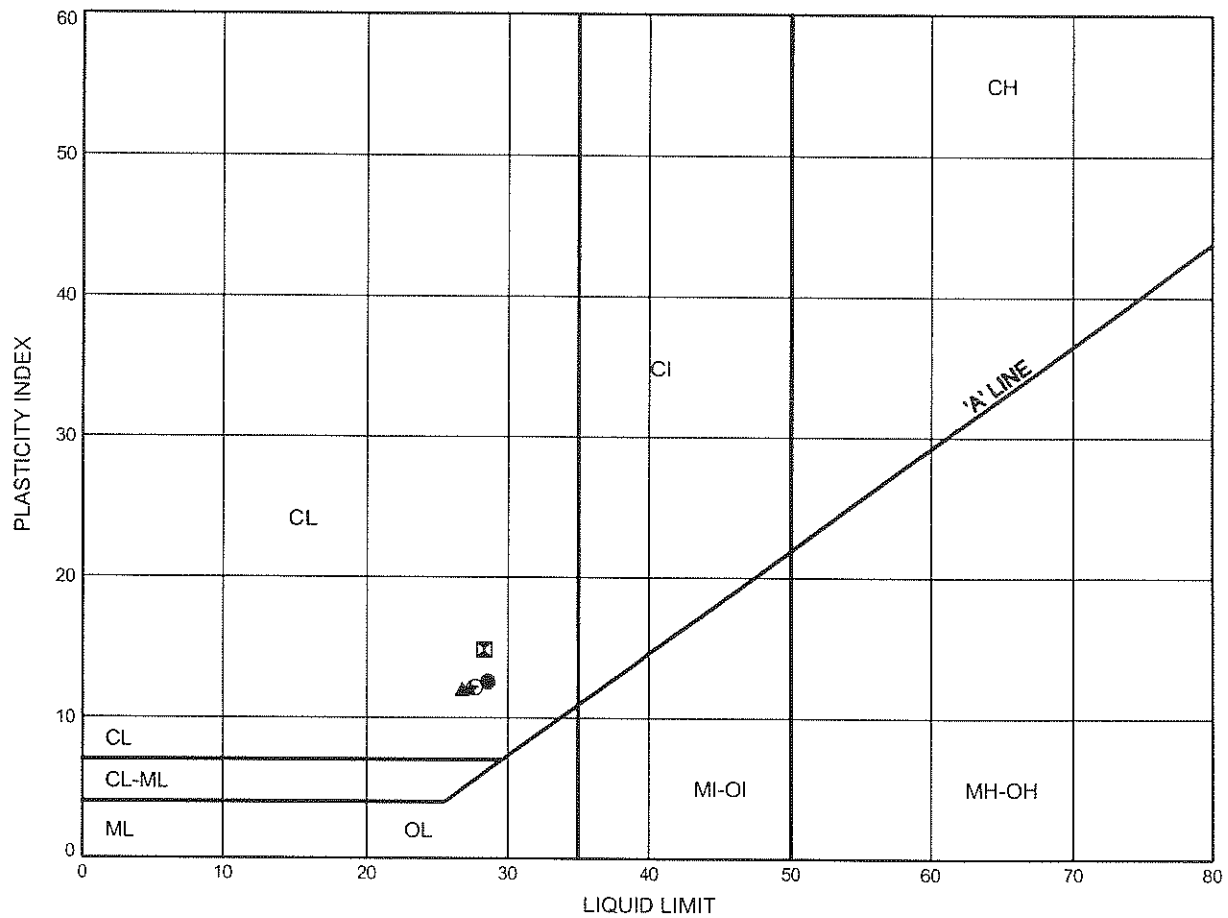
Date February 2008  
 Project 2107-05-00

Prep'd MFA  
 Chkd. RPR

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

FIGURE B2

Silty Clay with Sand (TILL)

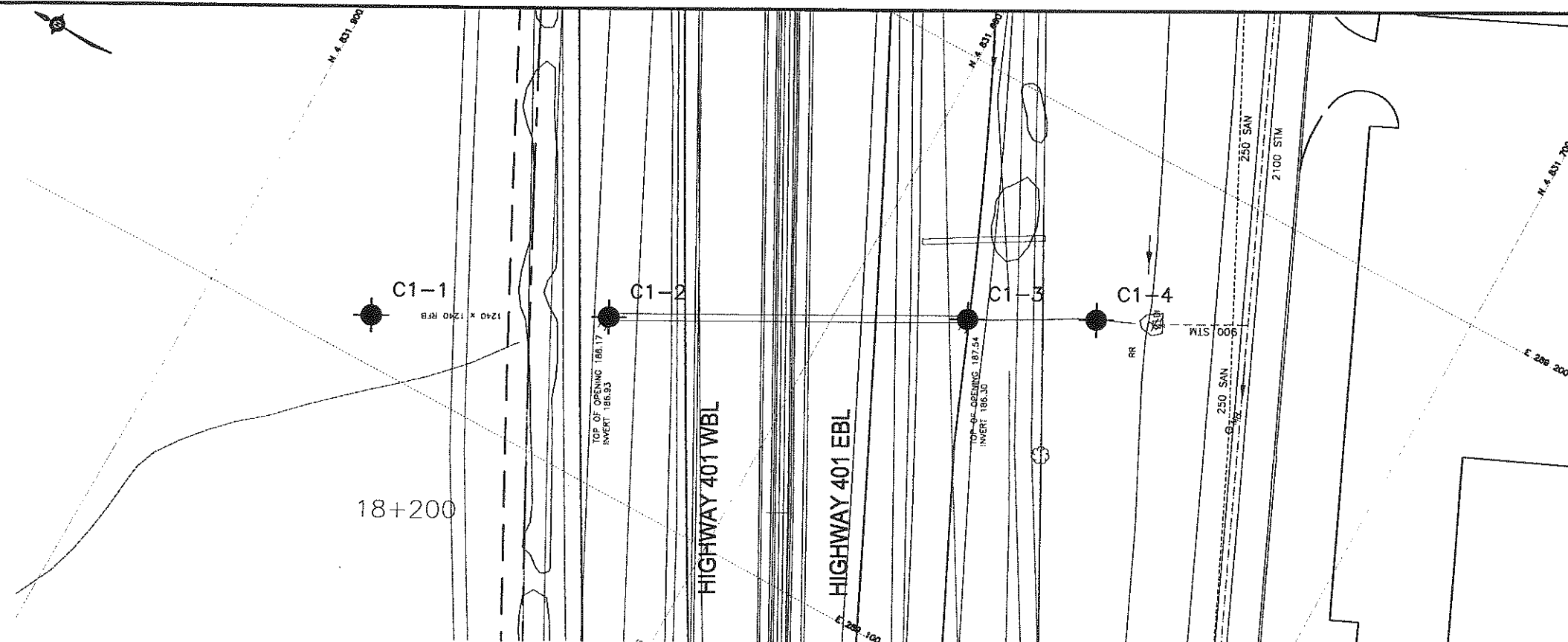


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C1-1	1.68	187.05
⊠	C1-1	4.72	184.00
▲	C1-2	2.44	185.93
★	C1-3	2.44	185.28
⊙	C1-4	3.35	183.03

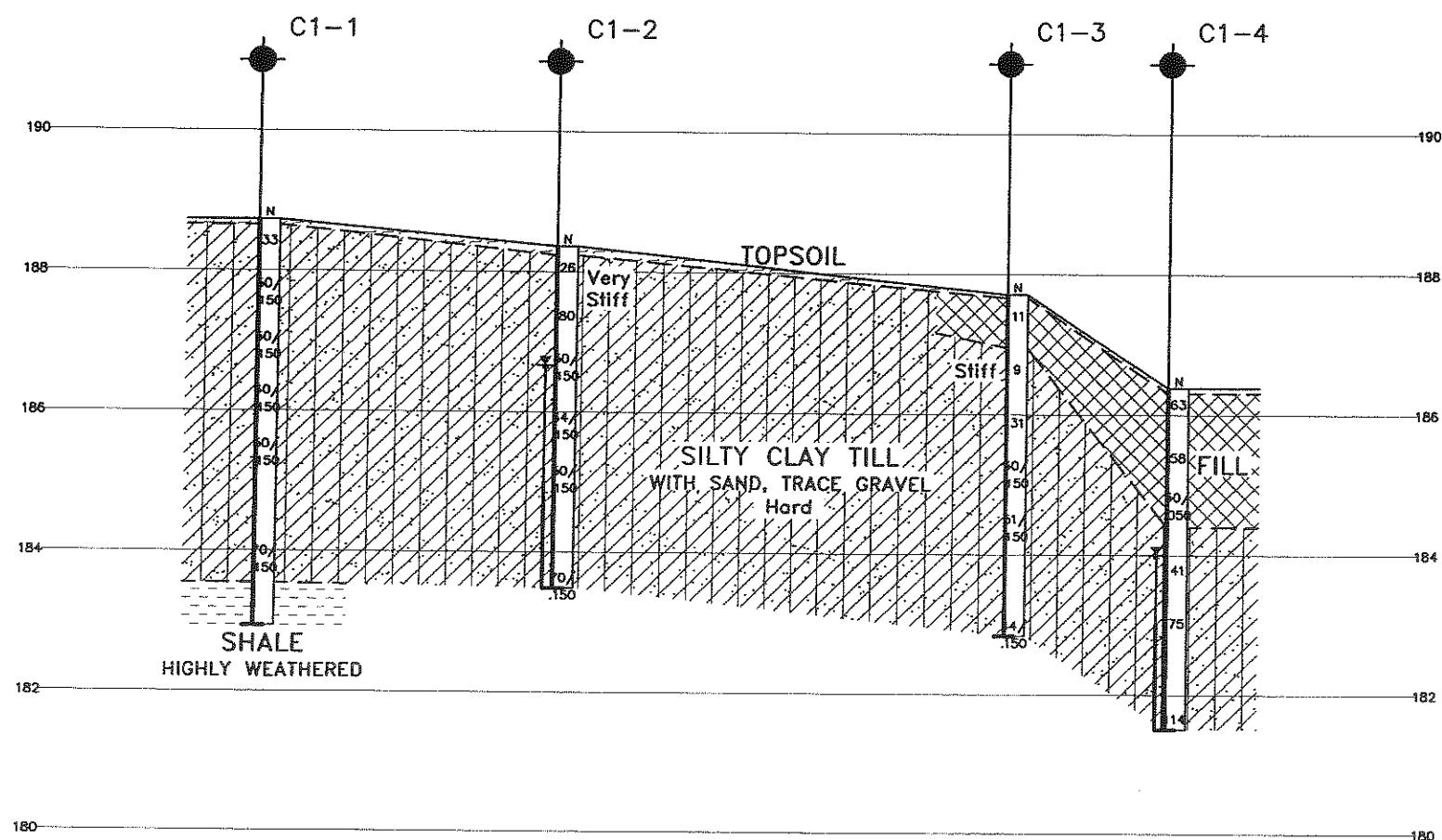
Date February 2008  
 Project 2107-05-00



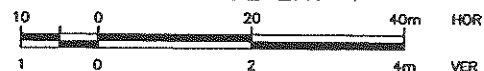
Prep'd MFA  
 Chkd. RPR



PLAN CULVERT 1



SECTION CULVERT 1



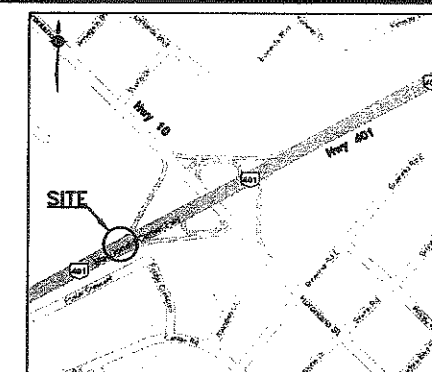
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

HWY 401  
SITE No  
GWP No 2107-05-00








SHEET

HIGHWAY 401  
CULVERT AT STATION 18+235  
BOREHOLE LOCATIONS AND SOIL STRATA

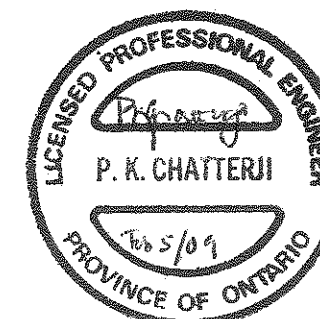


## KEYPLAN

## 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
C1-1	188.7	4 831 871.9	289 108.1
C1-2	188.4	4 831 834.9	289 128.0
C1-3	187.7	4 831 779.0	289 158.1
C1-4	186.4	4 831 758.7	289 169.0



**-NOTES-**

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

**GEOCREs No. 30M12-276**

REV						
	DATE	BY				DESCRIPTION
DESIGN	RPR	CHK	SKP	CODE	[LOAD]	DATE FEB. 2009
DRAWN	MFA	CHK	PKC	SITE	[STRUCT.] [SCHEME]	DWG 2



**Appendix C**

**Culvert 2**

**Highway 401, Station 18+585**

**Record of Borehole Sheets, Figures and Drawings**

# RECORD OF BOREHOLE No C2-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+585 N 4 832 029.499 E 289 420.771 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
187.6								20	40	60	80	100					
0.0 187.4	TOPSOIL: (250mm)																
0.3	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff Brown		1	SS	29												
186.9	(FILL)		2	SS	50/												
0.8	Silty CLAY with sand, trace gravel Hard Brown to Mottled Brown-Grey (TILL)				.075												
			3	SS	50/												3 22 43 32
					.150												
185.3			4	SS	50/												
2.3	END OF BOREHOLE AT 2.29m. AUGER REFUSAL ON POSSIBLE LIMESTONE LAYER. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE      DEPTH(m)    ELEV.(m) Oct 05/07    Dry            - Oct 18/07    Dry            - Nov 01/07    Dry            - Nov 15/07    Dry            -				.000												

# RECORD OF BOREHOLE No C2-2

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+585 N 4 832 000.390 E 289 436.355 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-04 - 2007-10-04 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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
187.2 0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY, some sand, trace gravel, trace rootlets Very Stiff		1	SS	17		187							
186.5 0.7	Brown (FILL)		2	SS	50/ .150									
	Silty CLAY with sand, trace gravel Hard Mottled Brown-Grey (TILL)		3	SS	50/ .150		186							
184.8 2.4	SHALE, highly weathered, thinly bedded, reddish brown		4	SS	50/ .150		185							5 22 40 33
			5	SS	60/ .150		184							
182.7 4.6	Limestone layer at 4.57m.  END OF BOREHOLE AT 4.57m UPON AUGER REFUSAL. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.						183							

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

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C2-3

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+585 N 4 831 937.635 E 289 470.009 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 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		
186.8	TOPSOIL: (80mm)		1	SS	13									
0.0 0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Stiff to Hard Brown to Reddish Brown (FILL)		2	SS	50/									
185.8	occasional asphalt fragments				.150									
1.1	Silty CLAY with sand, trace gravel, occasional rootlets Firm Reddish Brown (TILL)		3	SS	7									
	occasional oxidized stains Hard Brown to Mottled Brown-Grey		4	SS	33									
			5	SS	70/									
					.150									
183.0	SHALE, highly weathered, thinly bedded, reddish brown													
3.8			6	SS	100/									
182.1	END OF BOREHOLE AT 4.70m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				.125									
4.7														

+ 3, x 3: Numbers refer to Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C2-4

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+585 N 4 831.925 285 E 289 476.603 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 CHECKED BY RPR

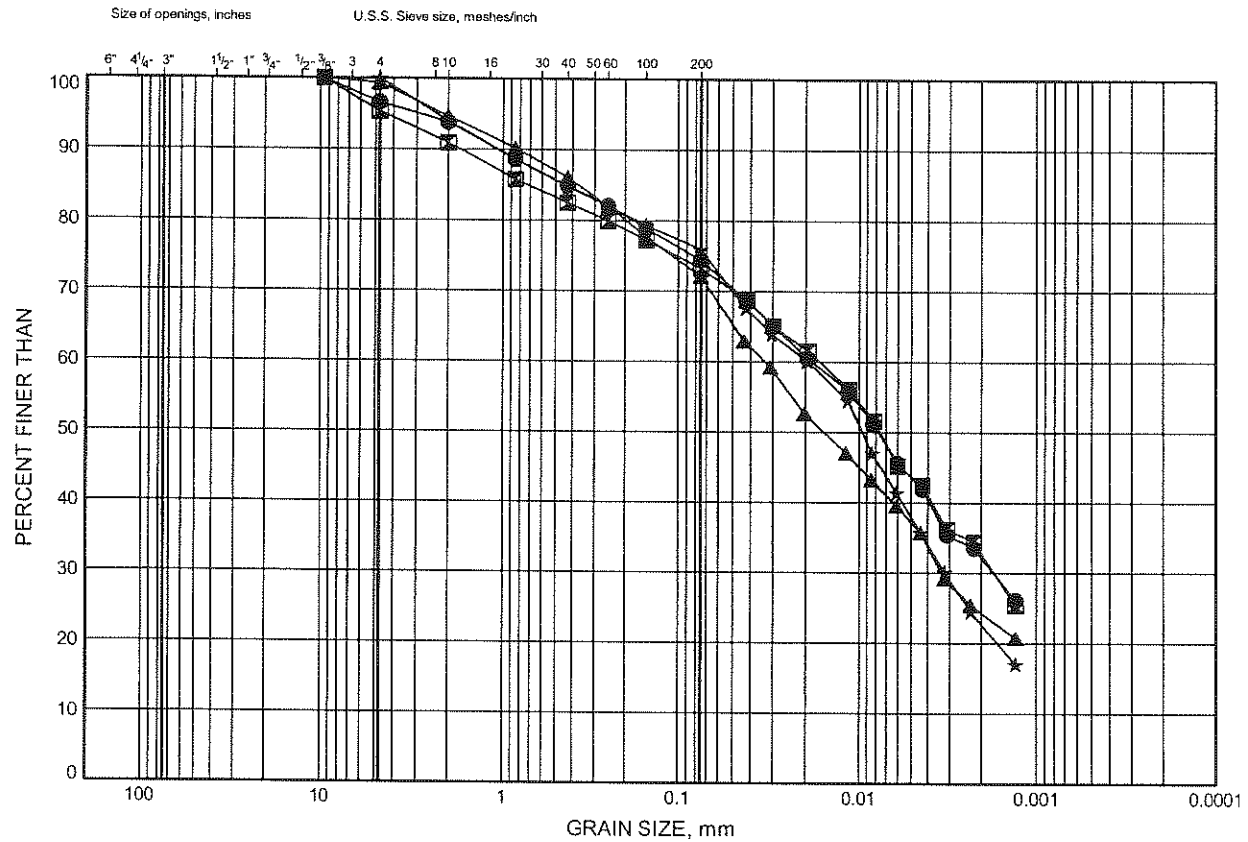
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
185.8								20	40	60	80	100			
0.0 0.1	TOPSOIL: (50mm)		1	SS	18										
	Silty CLAY, some sand, occasional rootlets Stiff to Very Stiff Brown (FILL)		2	SS	12										0 11 68 21
184.3															
1.5	Silty CLAY, with sand, trace gravel, occasional oxide stains Very Stiff to Hard Mottled Brown to Grey (TILL) Brown		3	SS	21										
			4	SS	50										
			5	SS	133										0 24 53 23
182.1															
3.7	SHALE, highly weathered, thinly bedded, reddish brown														
181.1			6	SS	100/										
4.7	END OF BOREHOLE AT 4.72m. BOREHOLE DRY AND OPEN TO 3.96m UPON COMPLETION. Piezometer installation consists of 19mm schedule PVC pipe. WATER LEVEL READINGS: DATE      DEPTH(m)    ELEV.(m) Oct 18/07    Dry Nov 01/07    2.9      182.9 Nov 18/07    2.2      183.6				.150										

FIGURE C1

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

FIGURE C2

**Silty Clay with Sand (TILL)**



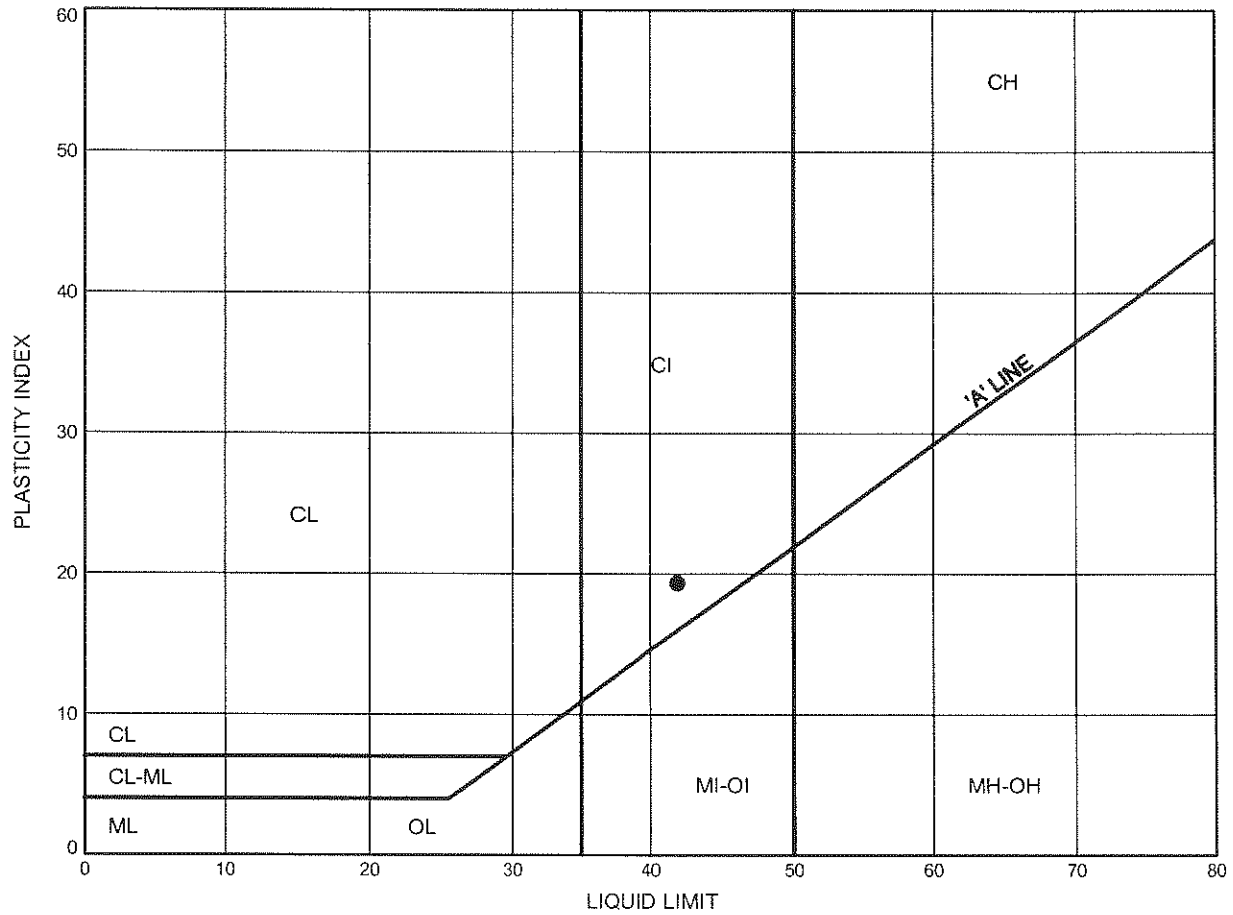
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C2-1	1.68	185.95
⊠	C2-2	1.68	185.56
▲	C2-3	2.59	184.23
★	C2-4	3.20	182.61

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

FIGURE C3

Silty Clay with Sand (FILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C2-4	1.07	184.74

Date February 2008

Project 2107-05-00



Prep'd MFA

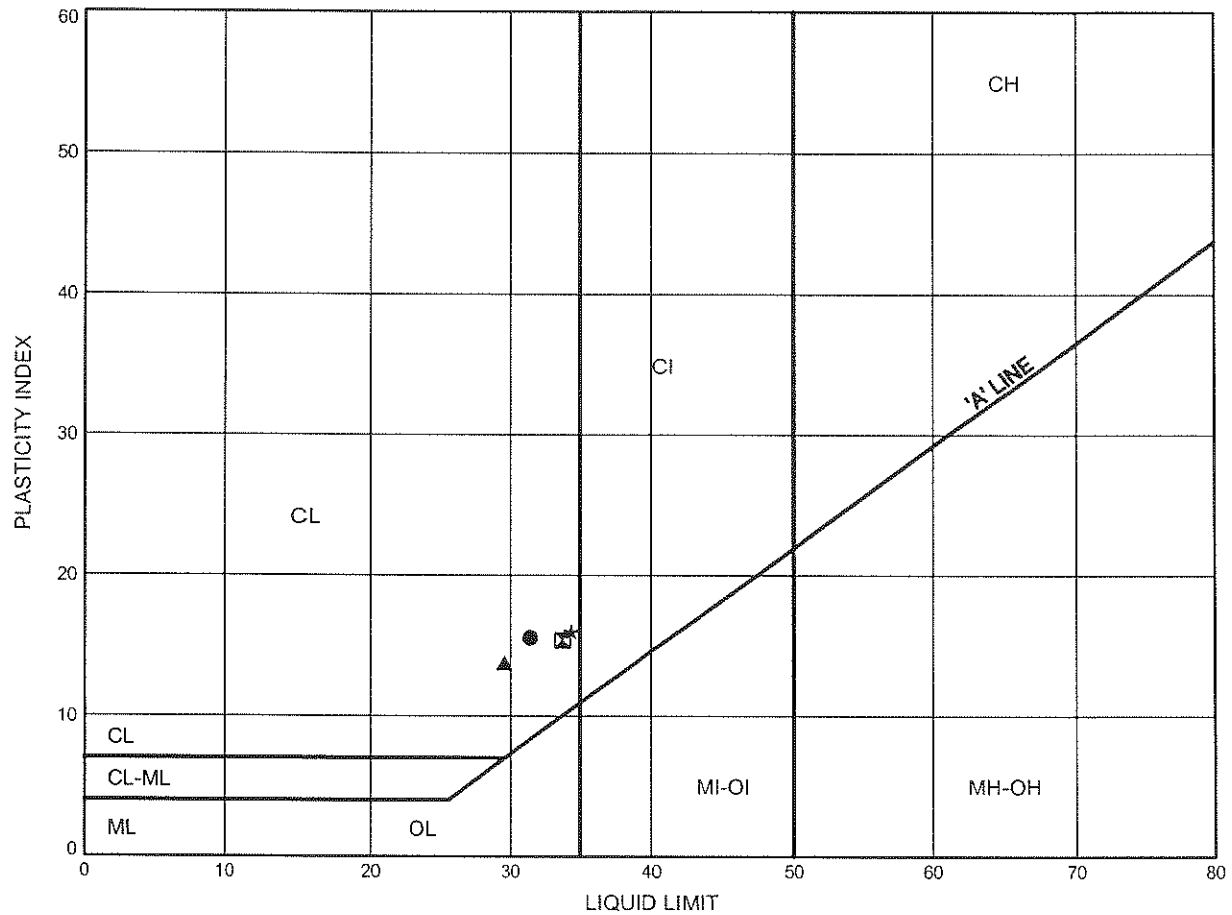
Chkd. RPR



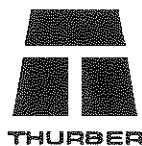
Hwy 401/410 to Credit River  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE C4

Silty Clay with Sand (TILL)

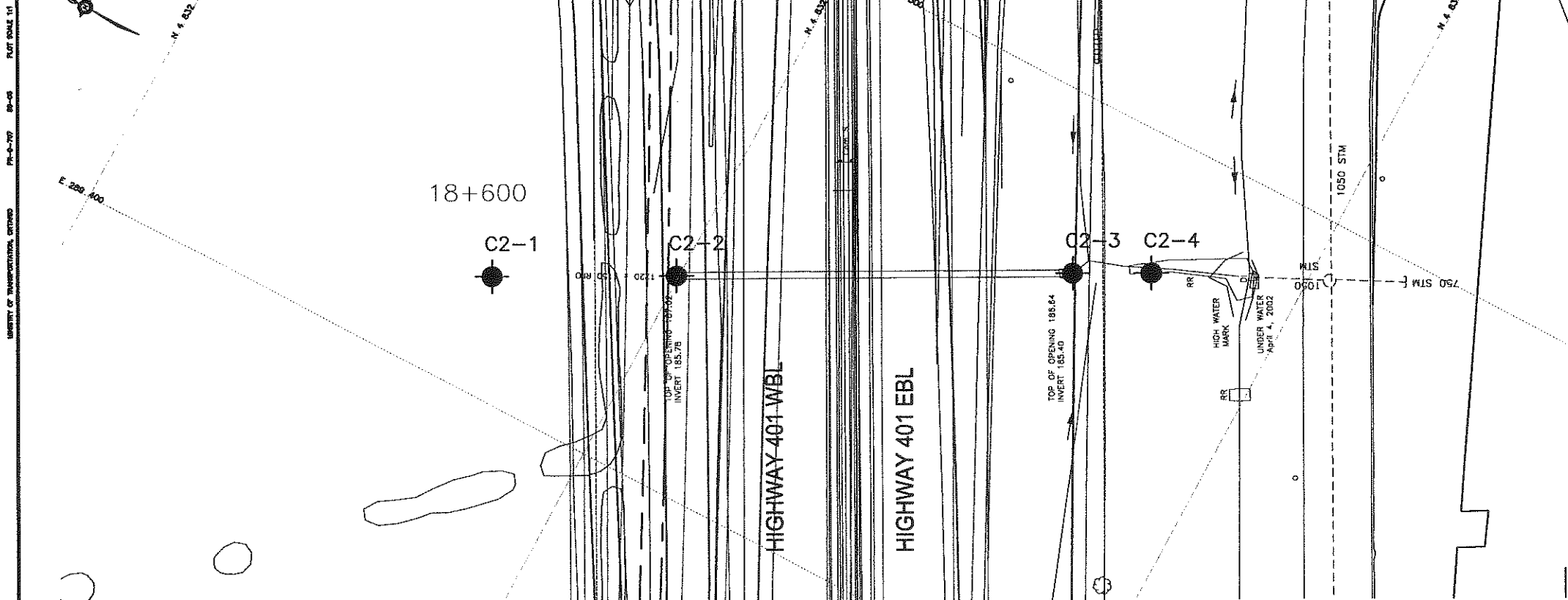


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C2-1	1.68	185.95
⊠	C2-2	1.68	185.56
▲	C2-3	2.59	184.23
★	C2-4	3.20	182.61

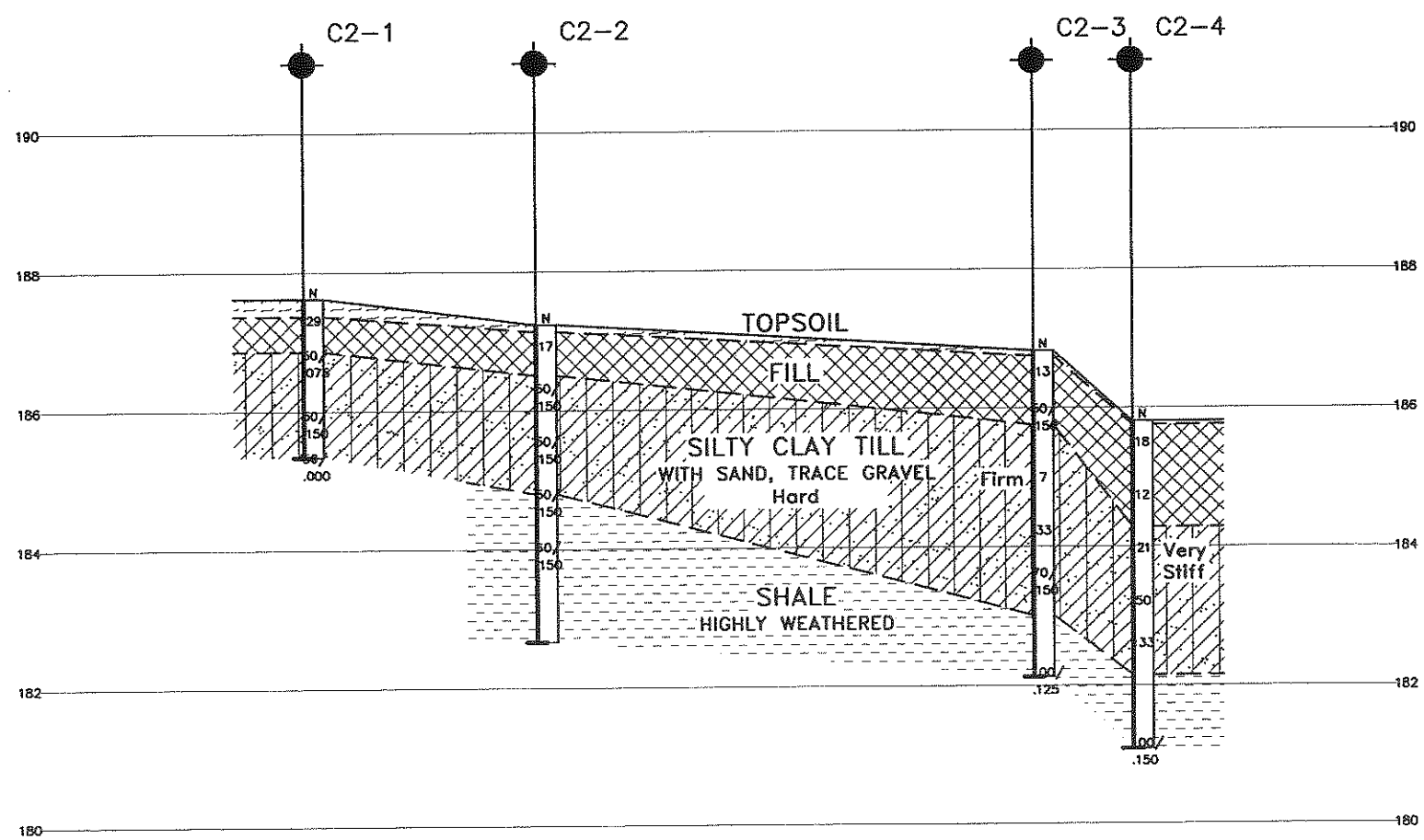


Date February 2008  
 Project 2107-05-00

Prep'd MFA  
 Chkd. RPR



PLAN CULVERT 2  
 10 0 20 40m



SECTION CULVERT 2  
 10 0 20 40m HOR  
 1 0 2 4m VER

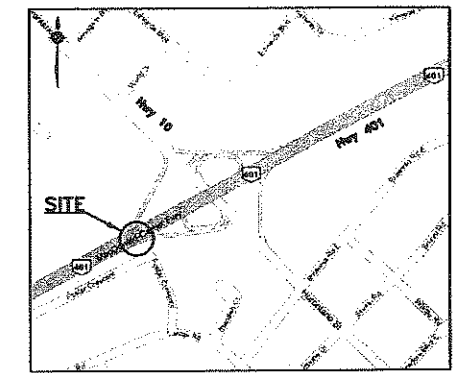
METRIC  
 DIMENSIONS ARE IN METRES  
 AND/OR MILLIMETRES  
 UNLESS OTHERWISE SHOWN

HWY 401  
 SITE No  
 GWP No 2107-05-00

HIGHWAY 401  
 CULVERT AT STATION 18+585  
 BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

THURBER ENGINEERING LTD.  
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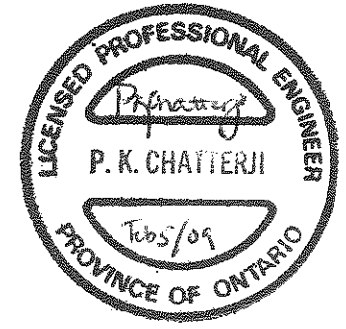


KEYPLAN

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
C2-1	187.6	4 832 029.5	289 420.8
C2-2	187.2	4 832 000.4	289 436.4
C2-3	186.8	4 831 937.6	289 470.0
C2-4	185.8	4 831 925.3	289 476.6



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. 30M12-276

REVISIONS	DATE	BY	DESCRIPTION
DESIGN RPR	CHK SKP	CODE	LOAD
DRAWN MFA	CHK PKC	SITE	STRUCT
			SCHEME
			DWG 3

**Appendix D**

**Culvert 3**

**Highway 401, Station 18+831**

**Record of Borehole Sheets, and Drawings**

# RECORD OF BOREHOLE No C3-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+831 N 4 832 040.459 E 289 694.397 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 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		
186.2 0.0	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Stiff		1	SS	8		186							
185.6 0.6	Brown (TILL)		2	SS	50/ .100		185							
	SHALE, highly weathered, thinly bedded, reddish brown		3	SS	100/ .125		184							
	Grinding at 2.44m to 2.74m		4	SS	100/ .100									
183.0 3.2	END OF BOREHOLE AT 3.18m. BOREHOLE DRY AND OPEN UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.		5	SS	100/ .125									

# RECORD OF BOREHOLE No C3-2

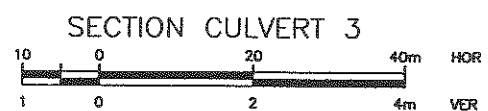
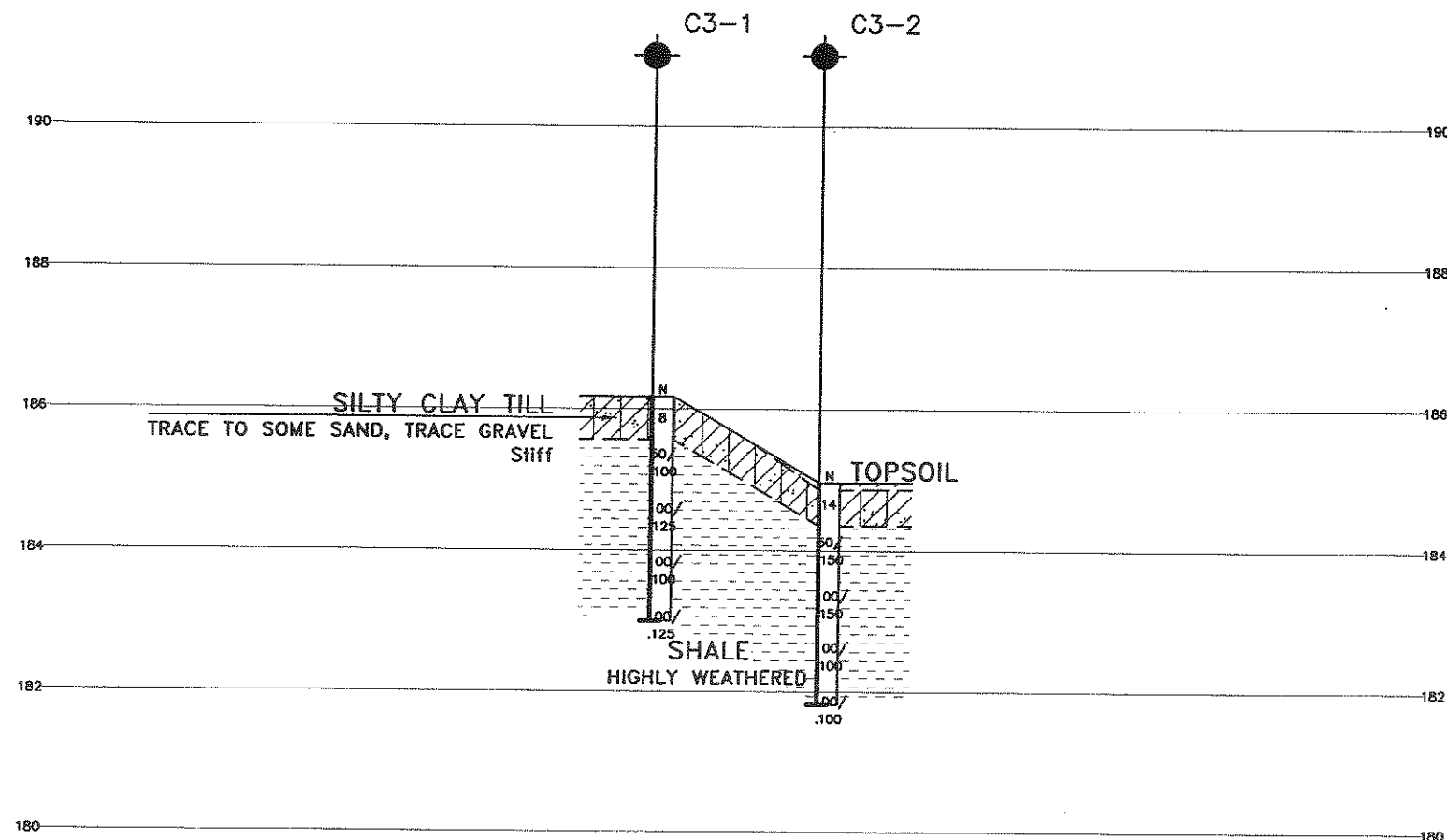
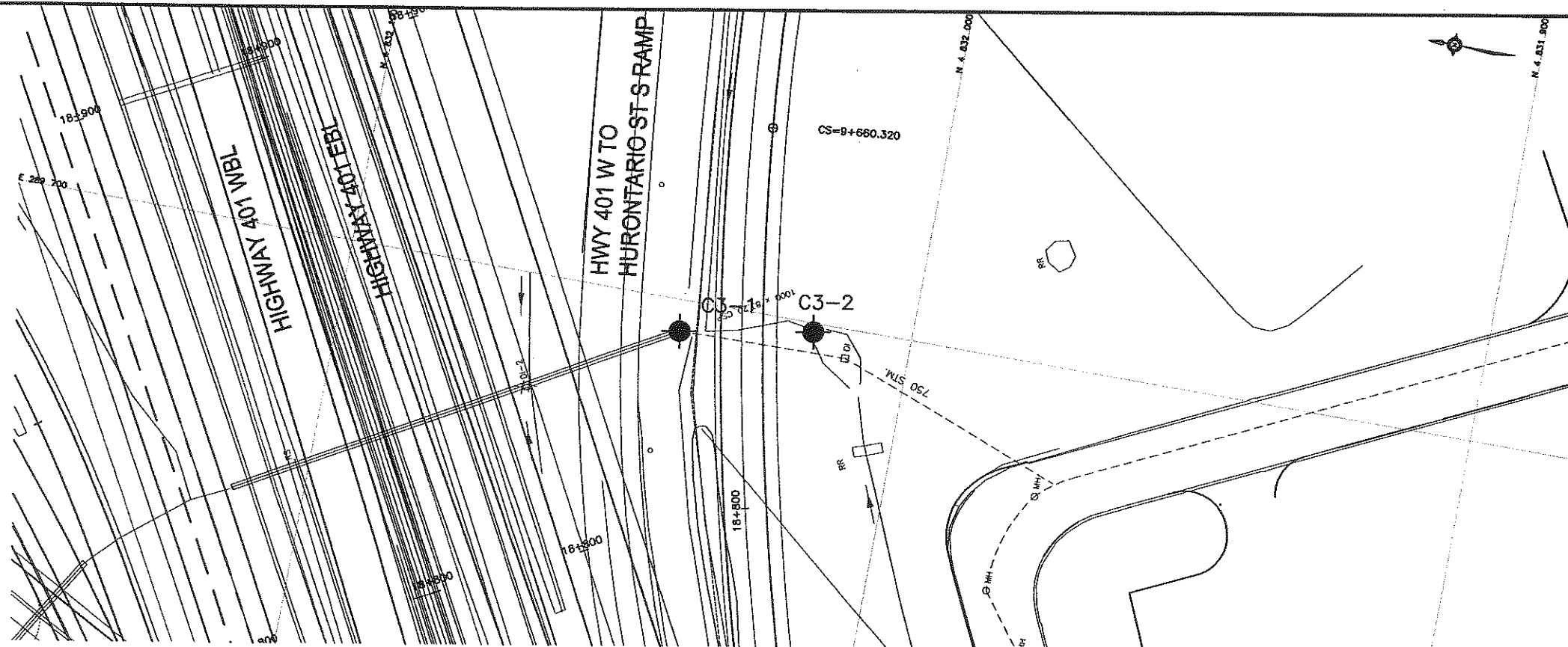
1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 18+831 N 4 832 017.210 E 289 698.431 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-12 - 2007-10-12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)			
185.0	TOPSOIL: (100mm)		1	SS	14									
0.0 0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets, Stiff Brown (TILL)		2	SS	50/									
184.4 0.6	SHALE, highly weathered, thinly bedded, reddish brown		3	SS	100/									
			4	SS	100/									
181.8	END OF BOREHOLE AT 3.15m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter schedule PVC pipe. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) Oct 18/07 Dry - Nov 01/07 Dry - Nov 15/07 Dry -		5	SS	100/									

MINISTRY OF TRANSPORTATION, ONTARIO  
PROJECT NO. 2107-05-00  
SHEET 11



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

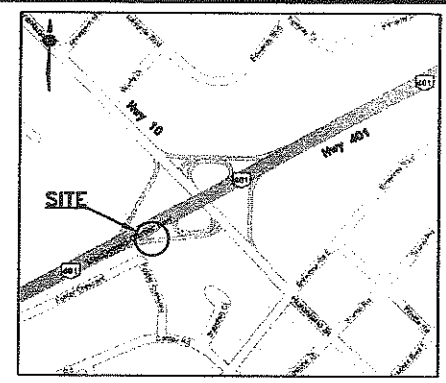
HWY 401  
SITE No  
GWP No 2107-05-00

HIGHWAY 401  
CULVERT AT STATION 18+831  
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

THURBER ENGINEERING LTD.  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

SHEET



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
C3-1	186.2	4 832 040.5	289 694.4
C3-2	185.0	4 832 017.2	289 698.4

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. 30M12-276



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FILENAME: H:\Drafting\18\1423\11 Hwy 401\182311-Culverta.dwg  
PLOTDATE: Feb 05, 2009 1:48pm

**Appendix E**

**Culvert 4**

**Highway 401, Station 19+200**

**Record of Borehole Sheets, Figures and Drawings**

# RECORD OF BOREHOLE No C4-1

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 19+200 N 4 832 310.809 E 289 961.458 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-05 - 2007-10-05 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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
191.0														
0.0	TOPSOIL: (80mm)													
0.1	Silty CLAY with sand, occasional rootlets Very Stiff Brown to Dark Brown (FILL)		1	SS	15		191							
			2	SS	15		190							0 28 52 20
189.5														
1.5	Silty CLAY with sand, trace gravel, occasional oxide staining Hard Mottled Brown-Grey to Brown (TILL)		3	SS	41		189							
			4	SS	50/ .150									
			5	SS	128		188							
							187							
186.2	Grey		6	SS	107									5 27 47 21
4.9	END OF BOREHOLE AT 4.88m. BOREHOLE DRY AND OPEN UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													



# RECORD OF BOREHOLE No C4-2

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 19+200 N 4 832 288.024 E 289 980.973 ORIGINATED BY GA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY ES  
 DATUM Geodetic DATE 2007-10-05 - 2007-10-05 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 ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE					
191.9						20	40	60	80	100				
0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Very Stiff Brown to Mottled Brown-Grey (FILL)		1	SS	25									
			2	SS	21									
190.4														
1.5	Silty CLAY with sand, trace gravel Very Stiff to Hard Mottled Brown-Grey to Brown (TILL)		3	SS	15									0 31 46 23
			4	SS	50/ .150									
			5	SS	71/ .150									1 35 46 18
187.7														
4.3	SAND and SILT, some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	100/ .125									
187.2														
4.7														
BOREHOLE ENDED AT 4.70m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe. WATER LEVEL READINGS: DATE    DEPTH(m)    ELEV.(m) Oct 18/07    1.2    190.7 Nov 01/07    1.1    190.8 Nov 15/07    1.1    190.8														

+ 3, x 3: Numbers refer to Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No C4-3

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 19+200 N 4 832 243.563 E 290 019.052 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			20	40	60	80	100		
191.8 0.0	TOPSOIL: (100mm)													
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Stiff to Very Stiff Brown to Greenish Grey (FILL)		1	SS	12									
			2	SS	20									
190.3														
1.4	Silty CLAY with sand, trace gravel Stiff to Hard Brown to Mottled Brown/Grey (TILL)		3	SS	13									
	occasional oxidized stains		4	SS	38									
	occasional shale fragments		5	SS	50/ .150									
187.2														
4.6	SAND and SILT, some clay, trace gravel, occasional shale fragments Very Dense Reddish Brown (TILL)		6	SS	103									
186.6														
5.2	SHALE, highly weathered, thinly bedded, reddish brown													
185.7														
6.1	END OF BOREHOLE AT 6.1m UPON AUGER REFUSAL. BOREHOLE OPEN AND DRY TO 6.1m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.													

# RECORD OF BOREHOLE No C4-4

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION Highway 401 Station 19+200 N 4 832 225.335 E 290 034.664 ORIGINATED BY CA  
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY MFA  
 DATUM Geodetic DATE 2007-11-13 - 2007-11-13 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			20	40	60	80	100		
190.7														
0.0	TOPSOIL: (125mm)													
0.1	Silty CLAY, trace to some sand, trace gravel, occasional rootlets Stiff Brown (FILL)		1	SS	13		190							
			2	SS	10									
189.2														
1.4	Silty CLAY with sand, trace gravel, occasional oxide stains Firm to Hard Mottled Brown-Grey to Brown (TILL)		3	SS	8		189							
			4	SS	49		188							
			5	SS	50/ .150		187							2 34 46 18
186.1														
4.6	SAND and SILT, some clay, trace gravel Very Dense Grey Damp to Moist (TILL)		6	SS	50/ .150		186							2 44 44 10
185.2														
5.5	SHALE, highly weathered, thinly bedded, reddish brown						185							
184.4			7	SS	100/ .150									
6.2	END OF BOREHOLE AT 6.2m UPON AUGER REFUSAL. BOREHOLE OPEN TO 6.2m AND WATER LEVEL AT 1.5m 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) Sep 14/07 0.9 189.8 Sep 19/07 0.8 189.9 Sep 28/07 1.0 189.7 Oct 05/07 0.8 189.9 Oct 18/07 0.8 189.9 Nov 01/07 0.8 189.9 Nov 15/07 0.7 190.0													

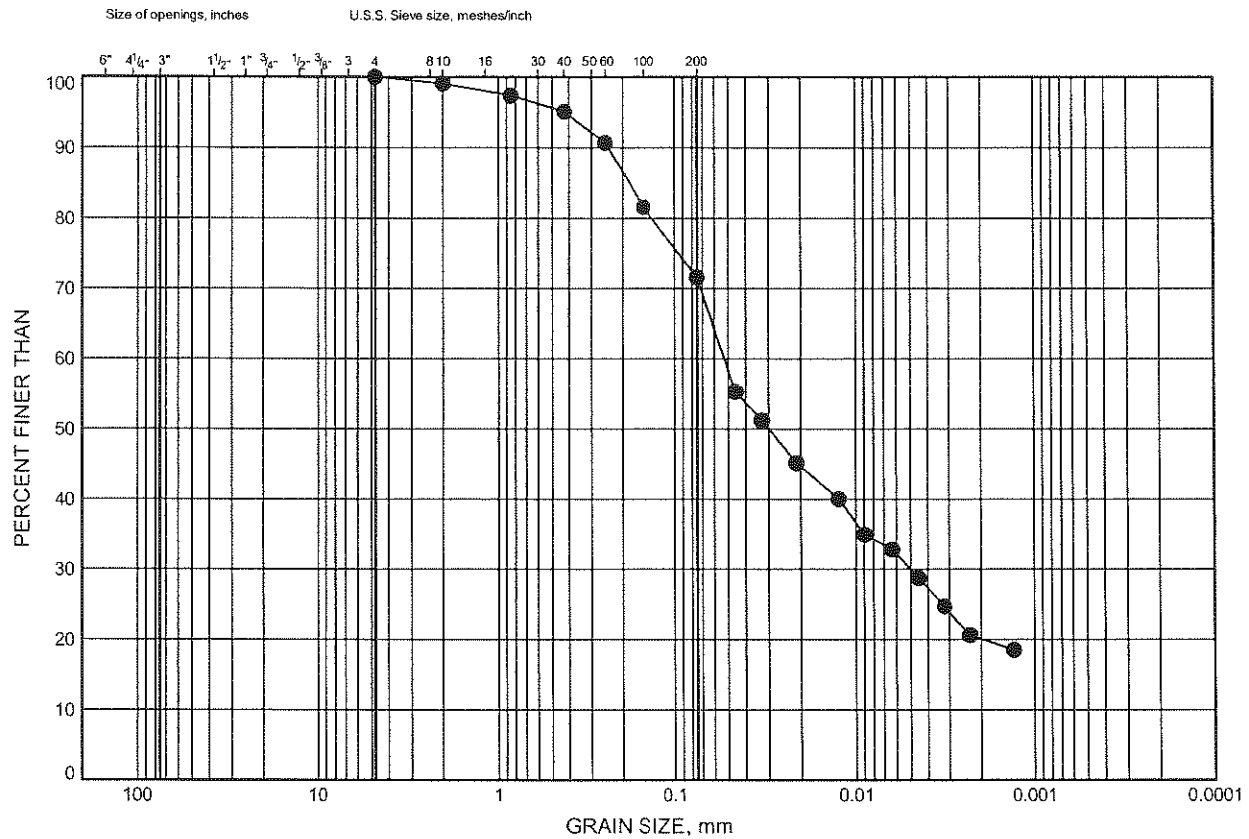
+ 3 . X 3 : Numbers refer to Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# Hwy 401/410 to Credit River GRAIN SIZE DISTRIBUTION

FIGURE E1

## Silty Clay with Sand (FILL)

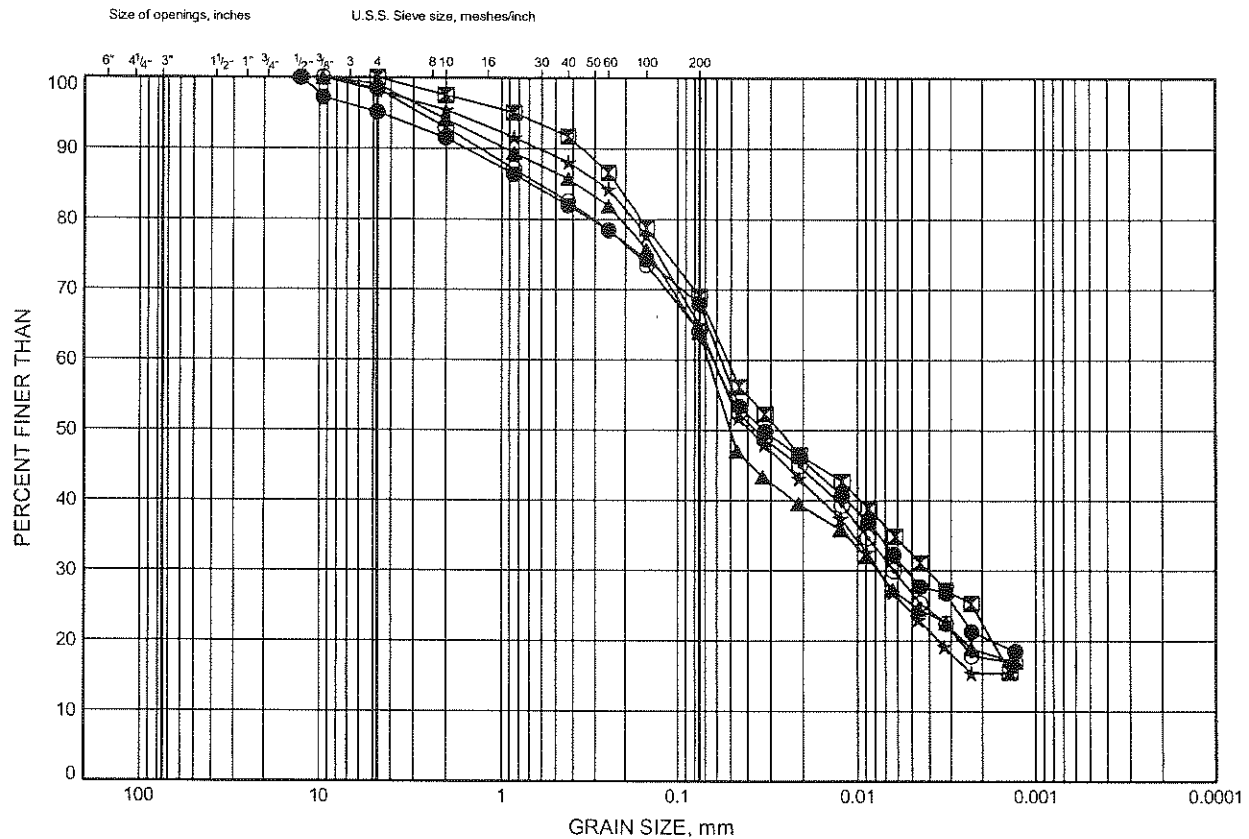


# Hwy 401/410 to Credit River

## GRAIN SIZE DISTRIBUTION

FIGURE E2

### Silty Clay with Sand (TILL)



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

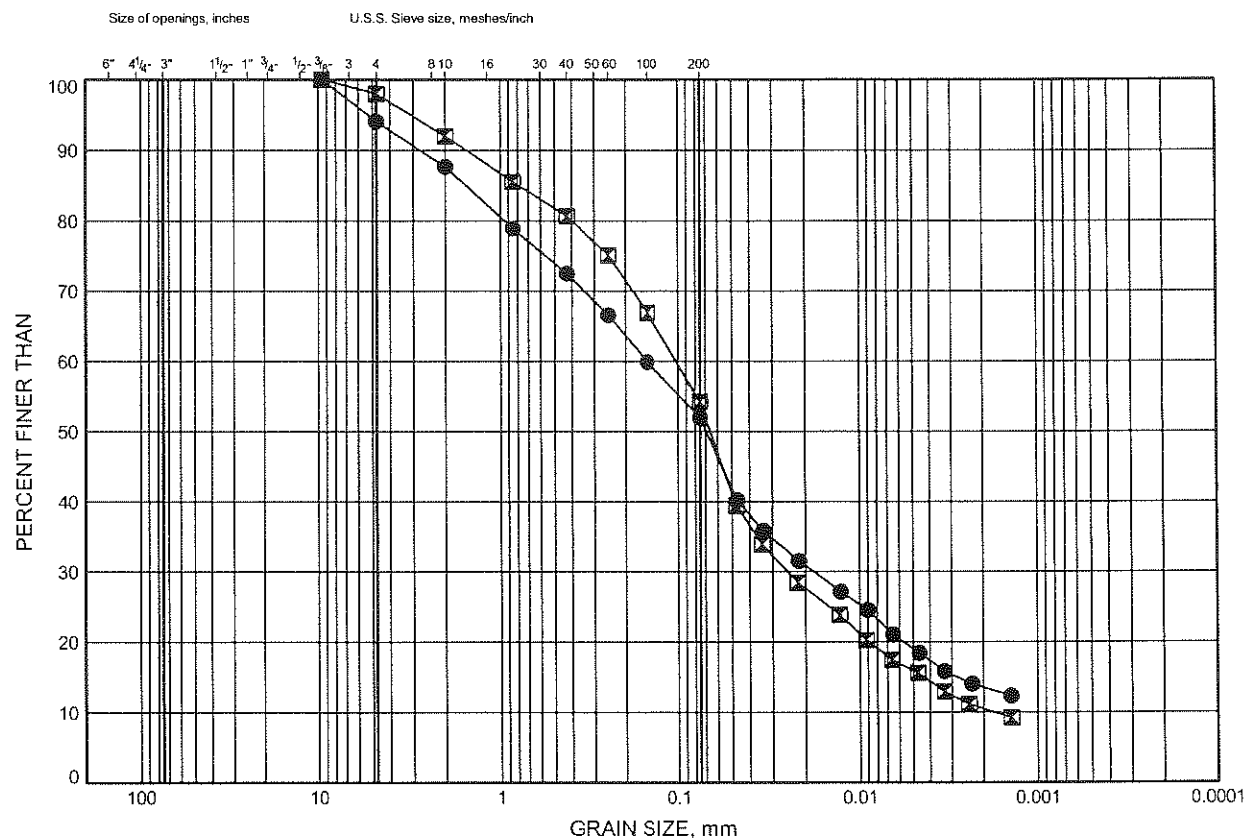
SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C4-1	4.72	186.32
⊠	C4-2	1.83	190.11
▲	C4-2	3.20	188.74
★	C4-3	2.59	189.19
⊙	C4-4	3.35	187.34

# Hwy 401/410 to Credit River

## GRAIN SIZE DISTRIBUTION

FIGURE E3

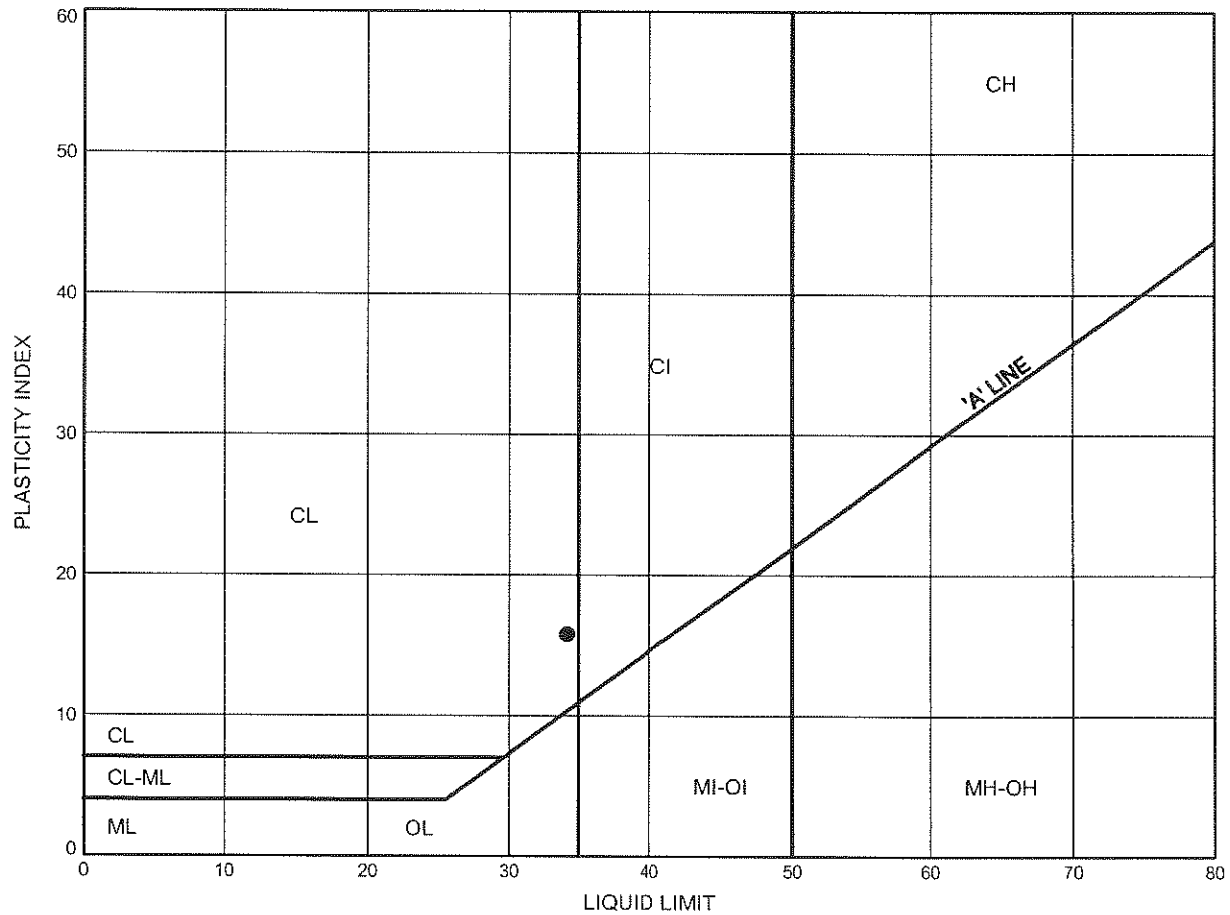
### Sand and Silt (TILL)



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

FIGURE E4

Silty Clay with Sand (FILL)

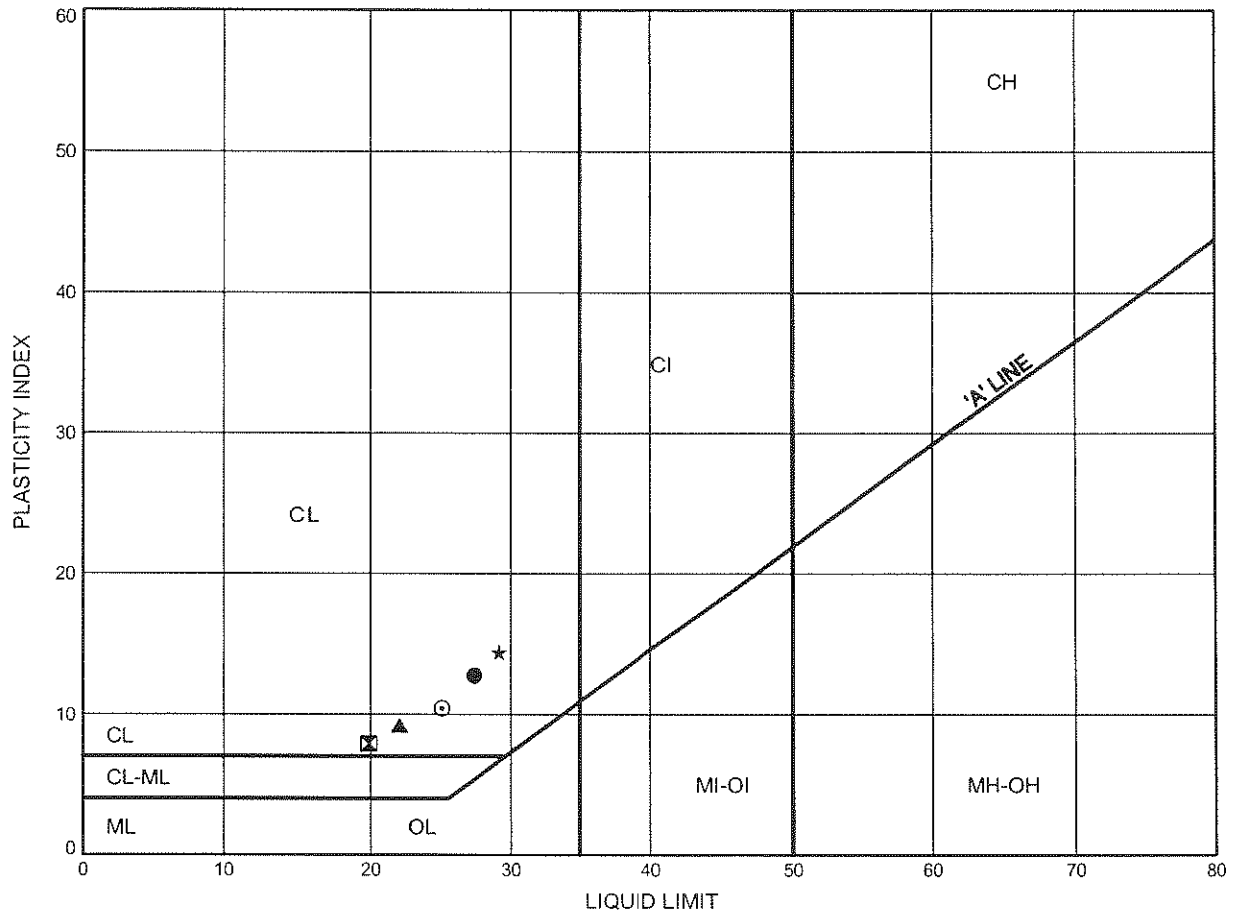


SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C4-1	1.07	189.98

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

FIGURE E5

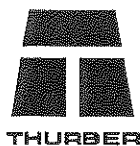
Silty Clay with Sand (TILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	C4-2	1.83	190.11
⊠	C4-2	3.20	188.74
▲	C4-3	2.59	189.19
★	C4-4	1.83	188.87
⊙	C4-4	3.35	187.34

Date February 2008

Project 2107-05-00

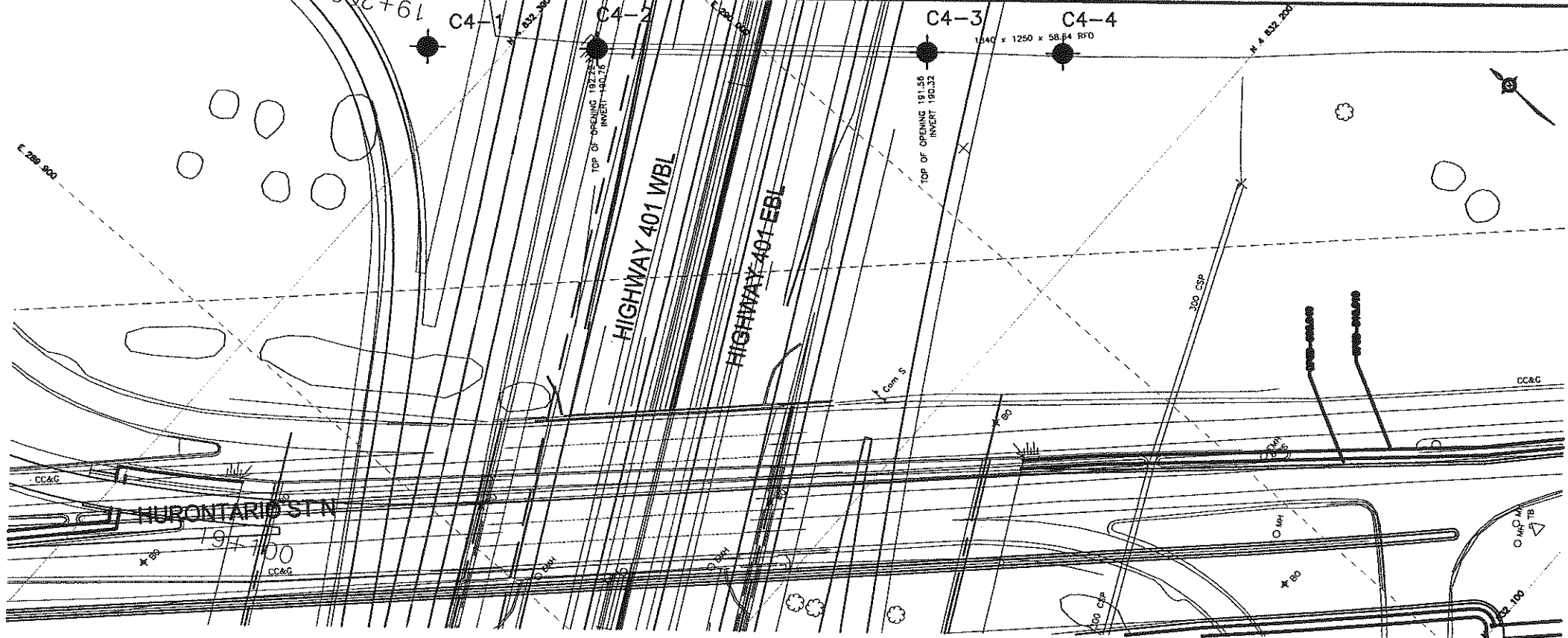


Prep'd MFA

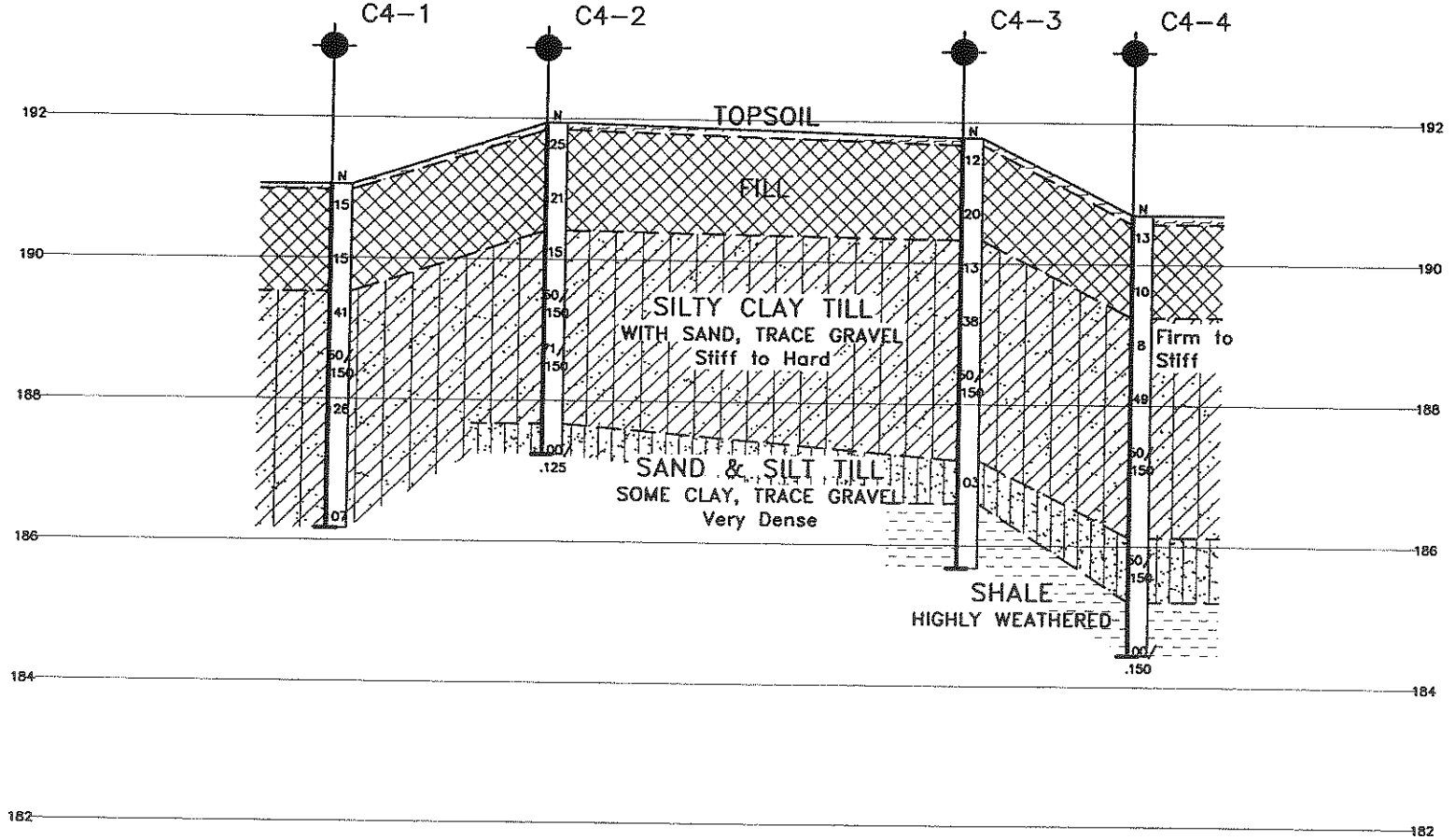
Chkd. RPR



MINISTRY OF TRANSPORTATION, ONTARIO  
PS-0-107 08-08  
PLAN SCALE 1:1



PLAN CULVERT 4



SECTION CULVERT 4

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

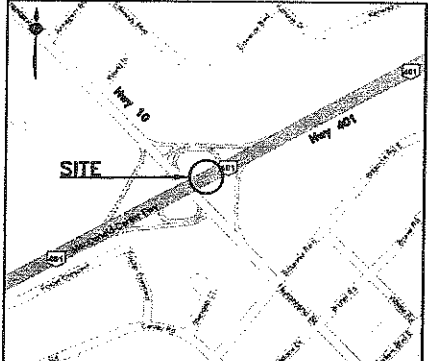
HWY 401  
SITE No  
GWP No 2107-05-00

HIGHWAY 401  
CULVERT AT STATION 19+200  
BOREHOLE LOCATIONS AND SOIL STRATA

MMM GROUP

SHEET

THURBER ENGINEERING LTD.  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

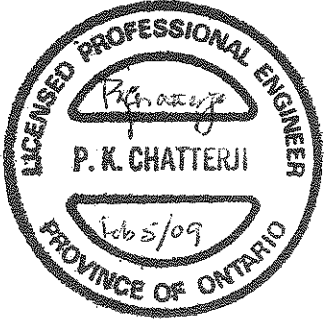
LEGEND	
	Borehole (Present Investigation, 2007)
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C4-1	191.0	4 832 310.8	289 961.5
C4-2	191.9	4 832 288.0	289 981.0
C4-3	191.8	4 832 243.6	290 019.1
C4-4	190.7	4 832 225.3	290 034.7

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. 30M12-276



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## **Appendix F**

### **List of SPs and OPSS, and Suggested Text for Selected NSSP**

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

- SP 902 S01
- SP 105S10
- SP 572S01
- SP 105S19
- OPSD 803.010
- OPSD 800.011
- OPSD 810.010
- OPSS 1205

OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2006.

Special Provision No. 105S10 “Amendment to OPSS 501, February 1996” dated November 2004.

**1. Suggested Text for NSSP on “Impact on Adjacent Structure”**

- It is critical that Contractor’s excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the travelled lanes of the Highway 401.