

**FOUNDATION INVESTIGATION REPORT
SEWER PIPE INSTALLATION BY TRENCHLESS METHODS
HWY 401 WIDENING, HWY 410 TO WEST OF HURONTARIO STREET
MISSISSAUGA, ONTARIO
G.W.P. 2107-05-00**

Geocres Number: 30M12-280

Report to

MMM Group Limited

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a geotechnical investigation conducted at the location of two proposed sewer pipes to be installed by trenchless method at Highway 401 and Highway 410 interchange and Highway 401 and Hurontario Street interchange in Mississauga, Ontario. Installation of the sewer pipes is part of the Highway 401 widening from Highway 410 to west of Hurontario Street in Mississauga, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the proposed trenchless installation locations and, based on the data obtained, to provide a borehole location plan, records of boreholes, laboratory test results, stratigraphic profiles 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

Installation of two pipes by trenchless methods is proposed under Highway 401 mainline and 401E to 410N Ramp at the following locations:

- Approximately 245 m west of Hurontario Street and Highway 401 interchange
- Approximately 415 m west of Highway 410 and Highway 401 interchange

The lands west of the Highway 401 and Highway 410 interchange are generally vacant and undeveloped. Vegetation is moderate consisting mainly of tall grass and shrubs. In general the lands

to the west of Highway 401 and Hurontario Street interchange have been developed for commercial and industrial uses. The topography is typically flat, sloping gently towards Lake Ontario to the south.

Two photographs of the site are included in Appendix D and show the general nature of the surrounding land.

The general site area is located within the physiographic region known as the Peel Plain, characterized by a level to undulating cohesive glacial till typically less than 1 m to 7 m thick which is underlain by grey and reddish brown shale bedrock with hard limestone and siltstone interbeds.

3 SITE INVESTIGATION AND FIELD TESTING

Site investigation and field testing for the proposed trenchless installations consisted of drilling and sampling five boreholes at and near the proposed trenchless locations. Boreholes were drilled from March 25 to 30, 2009. A summary of the borehole designations is provided in Table 3.1.

Table 3.1 – Borehole Designations

Trenchless	Location	Borehole	Borehole Termination Depth (m)	Stratum at Termination Depth
1	Across Hwy 401 W- Hwy 410 N Ramp, 415 m west of Hwy 410	T-01	6.7	Shale bedrock
		T-02	5.3	Shale bedrock
2	Across Hwy 401 and across Hwy 401 W- Hurontario St. Ramp, 245 m west of Hurontario Street	T-03	7.0	Shale bedrock
		T-04	9.1	Shale bedrock
		T-05	7.3	Shale bedrock

No boreholes were drilled through the Highway 401 mainline or the ramps.

The approximate borehole locations are shown on the Borehole Location Drawing in Appendix E. The coordinates and elevations of the boreholes are given on this drawing 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 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ rock coring equipment was used to recover core samples of the bedrock in the 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. Two standpipe piezometers consisting of 19 mm PVC pipes with screens were installed in the boreholes to permit monitoring of groundwater levels. Details of the piezometer installations and other borehole completion details are as shown in Table 3.2.

Table 3.2 – Borehole Completion Details

Trenchless	Location	Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
1	Across Hwy 401 W- Hwy 410 N Ramp, 415 m west of Hwy 410	T-01	6.7/178.2	Piezometer with 1.5 m slotted screen installed with sand filter to 4.9 m, holeplug from 4.9 m to surface.
		T-02	No Installation	Holeplug to surface.
2	Across Hwy 401 and across Hwy 401 W- Hurontario St. Ramp, 245 m west of Hurontario Street	T-03	7.0/181.8	Piezometer with 1.5 m slotted screen installed with sand filter to 5.2 m, holeplug from 5.2 m to surface.
		T-04	No Installation	Holeplug to surface.
		T-05	No Installation	Holeplug to surface.

4 LABORATORY TESTING

All recovered soil and rock samples were subjected to Visual Identification (VI) and geological logging. Moisture content determinations were carried out on all soil samples. At total of 37% of the recovered soil 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 presented 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, limestone and siltstone upon arrival at the laboratory to assist evaluation of the compressive strength of the bedrock. The results of point load tests on the selected rock core samples are shown on the Record of Borehole sheets and in Table 1, immediately following the text.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

This section presents a generalized summary of the subsurface conditions encountered at the borehole locations drilled for the proposed trenchless alignments. Reference is made to the Records of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in the appendix. An overall description of the stratigraphy encountered in Boreholes T-01 to T-05 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 and fill underlain by native silty clay till deposit. Shale bedrock was contacted below the silty clay till deposit. More detailed descriptions of the individual stratum are presented below. It should be noted that since no boreholes were drilled through the Highway 401 mainline or ramps, information on any highway embankment fill (estimated to be 4.5 m high at Trenchless 1 and 2.0 m high at Trenchless 2) or the pavement structure along the pipe alignment are not available.

5.1 Topsoil

Topsoil was identified at ground surface in all the boreholes. The topsoil thickness ranged from 50 mm to 150 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 Boreholes T-01 and T-04.

The fill consists of brown to reddish brown silty clay containing trace to some sand and trace of gravel. Thickness of the fill was 750 mm.

The depth to the base of the fill was 0.8 m in both boreholes (Elevations 184.1 and 187.6).

Based on recorded SPT N-values of 7 blows for 0.3 m of penetration, the silty clay fill is described as firm.

The natural moisture contents of the fill samples obtained ranged approximately from 10% to 21%.

5.3 Silty Clay Till

Native brown to reddish brown and grey silty clay till containing trace sand to sandy and trace gravel was contacted below the fill in Boreholes T-01 and T-04 and below the topsoil in Boreholes T-02, T-03 and T-05. Thickness of the till deposits ranged from 0.75 m to 2.6 m.

The depth to the base of the silty clay till deposits ranged from 0.9 m to 3.4 m (Elevations 181.5 to 187.8).

Based on SPT N-values ranging from 5 to 77 blows for 0.3 m of penetration, the silty clay till is described as firm to hard, although typically the till is stiff to hard. An SPT N-value of 50 blows per 0.15 m of penetration was measured in Borehole T-01 near Elevation 181.7.

The natural moisture contents of the samples recovered from the silty clay till layer ranged from 10% to 25%.

Grain size distribution curves for silty clay till 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 B3 of Appendix B.

The results of laboratory gradation and Atterberg Limits tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 8
Sand	15 to 34
Silt	41 to 53
Clay	17 to 34

Index Property	(%)
Liquid Limit	29 to 35
Plastic Limit	17 to 18

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

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, particularly slabs of hard limestone or siltstone.

5.4 Bedrock

The soils described above were found to be underlain by grey to reddish brown shale bedrock. The shale encountered in the boreholes is described as thinly bedded and contains numerous hard interbedded siltstone and limestone layers. The shale bedrock is typically highly weathered within the upper 1.0 m to 2.0 m with the degree of weathering decreasing with depth. SPT N-values obtained in the upper part of the shale bedrock ranged from 20 blows per 0.3 m of penetration to higher than 50 blows per less than 0.15 m penetration. Moisture contents of disturbed shale samples ranged from 8% to 16%. Elevations of the top of bedrock are shown in Table 5.1.

Table 5.1 – Elevation of Top of Weathered Bedrock

Trenchless	Location	Borehole	Depth to Weathered Bedrock (m)	Top of Weathered Bedrock Elevation (m)
1	Across Hwy 401 W- Hwy 410 N Ramp, 415 m west of Hwy 410	T-01*	3.4	181.5
		T-02*	2.1	182.1
2	Across Hwy 401 and Hwy 401 W- Hurontario St. Ramp, 245 m west of Hurontario Street	T-03*	1.1	187.8
		T-04*	2.6	185.8
		T-05*	0.9	185.2

* Proved by coring below augered depth

Bedrock cores were collected using NQ sized coring equipment. Total Core Recovery (TCR) in the bedrock ranged from 70% to 100% in all the core runs.

The RQD values recorded for most of the core runs ranged from 48% to 100% indicating poor to excellent rock quality. RQD values of 21% and 30% were measured in Borehole T-04 Run 1 and Borehole T-05 Run 1, respectively. Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 5.

The results of Point Load tests conducted on shale samples and hard interbeds of siltstone and limestone core samples were as follows:

Rock Type	Inferred Unconfined Compressive Strength (UCS) (MPa)
Shale	3 to 9
Siltstone	3 to 32
Limestone	3 to 169

Typically the inferred UCS of siltstone interbeds is approximately 30 MPa and the inferred UCS of limestone interbeds ranges from 16 to 169 MPa.

It must be noted, however, that point load tests were possible only on less weathered shale or higher strength limestone and siltstone interbed samples as the more typically weathered shale cores tended to be too weak for point load testing. Broken zones were observed within the cores at various depths as indicated in the logs.

The strength of the shale bedrock increases with depth. Furthermore, the shale bedrock typically contains frequent 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 borehole logs indicated that these hard interbeds range approximately from 10 to 400 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.

5.5 Water Levels

Water level was observed in the boreholes during and upon completion of drilling. Two standpipe piezometers were installed to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.2.

Table 5.2 – Measured Groundwater Levels

Trenchless	Location	Borehole	Date (2009)	Water Level (m)		Comment
				Depth	Elevation	
1	Across Hwy 401 W- Hwy 410 N Ramp, 415 m west of Hwy 410	T-01	April 7	1.9	183.0	In piezometer
		T-02	March 30	0.3	184.0	In open borehole*
2	Across Hwy 401 and Hwy 401 W- Hurontario St. Ramp, 245 m west of Hurontario Street	T-03	April 7	4.5	184.3	In piezometer
		T-04	March 25	2.1	186.3	In open borehole*
		T-05	March 30	0.0	186.1	In open borehole*

*Affected by coring water

The above table indicates that the groundwater levels range from Elevations 183.0 to 184.3 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.

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 and Walker Drilling Ltd. of Utopia, 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 was conducted by Mr. David E. Elwood, P.Eng. and Ms. R. Palomeque Reyna, P.Eng. Interpretation of the field data and preparation of the investigation report was conducted by Ms. Rocío Palomeque Reyna, P.Eng. and Mr. A. Gorman, P. Eng.

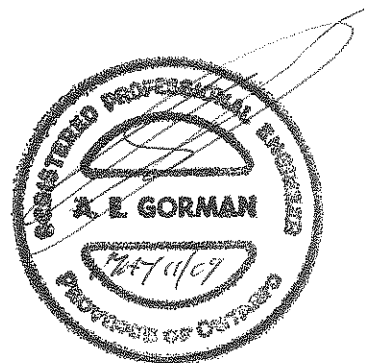
Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

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**TABLE 1 -Point Load a Test Results
Highway 401 Widening – TRENCHLESS**

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**TABLE 1 -Point Load a Test Results
Highway 401 Widening – TRENCHLESS**

[illegible][illegible]

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 ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

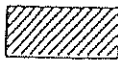
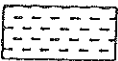
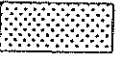


 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Medium bedded	0.2 to 0.6m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Thinly bedded	60mm to 0.2m	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Very thinly bedded	20 to 60mm	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Laminated	6 to 20mm	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Thinly Laminated	Less than 6mm	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 T-01

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION N 4 833 013.9 E 291 488.9 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ2 Coring Equipment COMPILED BY AN
 DATUM Geodetic DATE 2009.03.25 - 2009.03.26 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								WATER CONTENT (%)				
184.9	Geodetic											
0.0	TOPSOIL: (50mm)		1	SS	7							
184.1	Silty CLAY, trace to some sand, trace gravel Firm Brown (FILL)		2	SS	16							
0.8	Silty CLAY, trace to some sand, trace gravel, occasional oxidized staining Very Stiff to Hard Brown (TILL)		3	SS	26							
			4	SS	77							
181.5			5	SS	50/							
3.4	SHALE, highly weathered Grey Coring started at 3.6m. Slightly weathered to fresh, strong Horizontal joints at 3.9m and 4.5m. Shale interbeds from 4.9m to 5.0m. Slightly weathered to fresh, strong to weak Horizontal joints from 5.7m to 5.9m. Limestone interbeds at 5.3m to 5.7m, 5.8m, 5.9m, 6.0m, 6.1m, 6.2m, 6.3m and 6.4m and 6.6m. Highly broken zone at 5.7m and 5.8m.		1	RUN	0.150							
			2	RUN								
178.2												
6.7	END OF BOREHOLE AT 6.7m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.04.07 1.9 183.0 2009.04.15 1.8 183.1											

+ 3, × 3 Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No T-02

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION N 4 832 983.0 E 291 518.8 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ2 Coring Equipment COMPILED BY AN
 DATUM Geodetic DATE 2009.03.30 - 2009.03.30 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	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							
184.3	Geodetic						20	40	60	80	100				
0.0	TOPSOIL (100mm)						40	80	120	160	200				
0.1	Silty CLAY, some sand to sandy, trace gravel Stiff to Very Stiff Brown Dry (TILL)		1	SS	8	▽									5 31 46 18
			2	SS	29										
			3	SS	26										
182.1	SHALE, slightly weathered to fresh Grey Coring started at 2.3m.														
2.1	Horizontal joints at 2.8m, 3.4m, 3.5m and 3.7m.		1	RUN											RUN 1# TCR=100%, SCR=100%, ROD=100%, Average UCS=77MPa (Limestone)
	Horizontal joints at 3.8m, 3.9m, 4.4m, 4.5m, 4.6m and 5.2m. Shale interbeds at 3.9m, 4.0m, 4.4m, 4.6m, 4.9m, 5.1m and 5.2m.		2	RUN											RUN 2# TCR=100%, SCR=100%, ROD=100%, Average UCS=70MPa (Limestone)
178.9	END OF BOREHOLE AT 5.3m. BOREHOLE OPEN AND WATER LEVEL AT 0.3m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.														
5.3															

RECORD OF BOREHOLE No T-03

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION N 4 832 124.3 E 289673.4 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NQ2 Coring Equipment COMPILED BY AN
 DATUM Geodetic DATE 2009.03.25 - 2009.03.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
							WATER CONTENT (%)						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT						
							w _p w w _L						
							20 40 60 80 100						
							40 80 120 160 200						
							20 40 60						
188.8	Geodetic												
0.0	TOPSOIL (50mm)												
	Silty CLAY, some sand to sandy, trace gravel Very Stiff Grey to Reddish Brown (TILL)		1	SS	16								8 34 41 17
187.8			2	SS	20								
1.1	SHALE, highly weathered, thinly bedded Reddish Brown		3	SS	74								8 26 54 12
			4	SS	89								
			5	SS	50/ 0.150								
	Coring started at 3.9m. Slightly weathered Highly broken zone from 3.9 to 4.0m and 5.4 to 5.5m. Horizontal joints at 4.1, 4.2, 4.3, 4.8 and 5.1m. Limestone interbeds at 4.2, 4.3 and 5.3m. Siltstone interbeds at 4.1, 4.5, 5.1, 5.3 and 5.5m.		1	SS									RUN 1# TCR=100%, SCR=83%, RQD=48%, UCS=3MPa
	Slightly weathered Limestone interbeds at 5.7 and 6.1m. Siltstone interbeds at 5.5, 5.6, 5.7, 5.9, 6.2, 6.3, 6.4, 6.6 and 6.7m. Highly broken zone at 5.6, 5.7 and 5.8m. Horizontal joints at 5.5, 5.6 and 5.8m.		2	SS									(Shale) UCS= 8MPa (Silt Stone)
181.8	END OF BOREHOLE AT 7.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.												RUN 2# TCR=100%, SCR=100%, RQD=93%, UCS=3MPa
7.0													(Shale)
WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.04.07 4.5 184.3 2009.04.15 3.2 185.6													

+ 3 x 5 : Numbers refer to
Sensitivity
20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No T-04

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION N 4 832 075.6 E 289 699.9 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NO2 Coring Equipment COMPILED BY AN
 DATUM Geodetic DATE 2009.03.25 - 2009.03.25 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	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					w _p w w _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
188.4	Geodetic																
0.0	TOPSOIL (50mm)		1	SS	7		188										
187.6	Silty CLAY, some sand to sandy, trace gravel Firm Reddish Brown (FILL)		2	SS	12		187						0 27 53 20				
0.8	Silty CLAY, trace to some sand, trace gravel Stiff to Hard Reddish Brown (TILL)		3	SS	12												
185.8			4	SS	66		186						2 26 52 20				
2.6	SHALE, highly to moderately weathered, thinly bedded Very Stiff Grey to Reddish Brown		5	SS	66/ 0.300		185										
	Coring started at 3.9m. Highly broken zone at 3.9m, 4.2m, 4.4m to 4.5m, 5.1m to 5.2m and 5.2m to 5.3m. Core washed away from 4.5 to 5.0m.		1	RUN			184						RUN 1# TCR=71%, SCR=90%, RQD=21%, Average UCS=3MPa (Shale) UCS=147MPa (Limestone)				
	Limestone interbeds at 5.3m. Silt stone interbeds at 5.5m, 5.7m, 5.8m, 6.3m, 6.4m, 6.5m, 6.6m, 6.7m and 7.0m. Horizontal joints at 5.6m, 6.0m and 6.4m.		2	RUN			183						RUN 2# TCR=100%, SCR=96%, RQD=85%, Average UCS=3MPa (Shale) UCS=30MPa (Silt Stone) UCS=52MPa (Limestone)				
	Limestone interbeds at 6.7m, 7.1m, 7.2m and 8.3m.		3	RUN			181						RUN 3# TCR=70%, SCR=70%, RQD=70%, Average UCS=3MPa (Shale) UCS=3MPa (Silt Stone) UCS=36MPa (Limestone)				
	Silt stone interbeds at 7.3m, 7.4m, 7.5m and 7.7m.		4	RUN			180						RUN 4# TCR=100%, SCR=91%, RQD=91%, Average UCS=67MPa (Limestone)				
179.2	END OF BOREHOLE AT 9.1m. BOREHOLE OPEN AND WATER LEVEL AT 2.1m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																
9.1																	

+ 3 x 3 Numbers refer to 20 15 10 5 (%) STRAIN AT FAILURE
 Sensitivity

RECORD OF BOREHOLE No T-05

1 OF 1

METRIC

G.W.P. 2107-05-00 LOCATION N 4 832 038.7 E 289 701.6
 HWY 401 BOREHOLE TYPE Solid Stem Augers/NO2 Coring Equipment
 DATUM Geodetic DATE 2009.03.30 - 2009.03.30
 ORIGINATED BY GA
 COMPILED BY AN
 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
186.1	Geodetic							20 40 60 80 100							
0.0	TOPSOIL (150mm)							40 80 120 160 200							
0.2	Silty CLAY, trace to some sand, trace gravel Firm to Hard Brown to Reddish Brown (TILL)		1	SS	5		186								GR SA SI CL
185.2	SHALE, highly weathered, thinly bedded Hard Reddish Brown to Grey		2	SS	67/ 0.300		185								0 22 53 25
0.9	Occasional limestone layers		3	SS	50/ 0.0		184								
	Coring started at 2.7m. Highly broken zone from 2.9m to 3.0m, 3.1m, 3.5m to 3.6m, 3.7m and 4.0m. Silt stone interbeds at 2.9m, 3.3m, 3.6m and 3.7m. Horizontal joints at 2.9m, 3.0m, 3.2m, 3.4m, 3.7m, 3.8m and 4.0m. Limestone interbeds at 3.0m and 3.2m.		1	RUN			183								RUN 1# TCR=88%, SCR=63%, RQD=30%, Average UCS=20MPa (Limestone)
	Silt stone interbeds at 4.3m, 4.4m, 4.6m, 4.7m, 4.8m, 5.0m, 5.1m, 5.5m and 5.6m.		2	RUN			182								RUN 2# TCR=100%, SCR=96%, RQD=75%, Average UCS=22MPa (Silt Stone) UCS=36MPa (Limestone)
	Limestone interbeds at 5.0m and 5.1m to 5.3m. Highly broken zone at 4.8m and 4.9m. Horizontal joints at 4.4m, 4.6m, 4.7m, 4.8m, 5.1m and 5.5m.		3	RUN			181								RUN 3# TCR=100%, SCR=100%, RQD=100%, Average UCS=3MPa (Shale) UCS=54MPa (Limestone)
	Silt stone interbeds at 5.7m, 5.8m, 5.9m, 6.0m, 6.2m, 6.4m, 6.6m and 6.8m.						180								
	Limestone interbeds at 6.5m, 6.6m, 6.7m, 6.9m and 7.1m.						179								
178.8	END OF BOREHOLE AT 7.3m. BOREHOLE OPEN AND WATER LEVEL AT SURFACE. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.														
7.3															

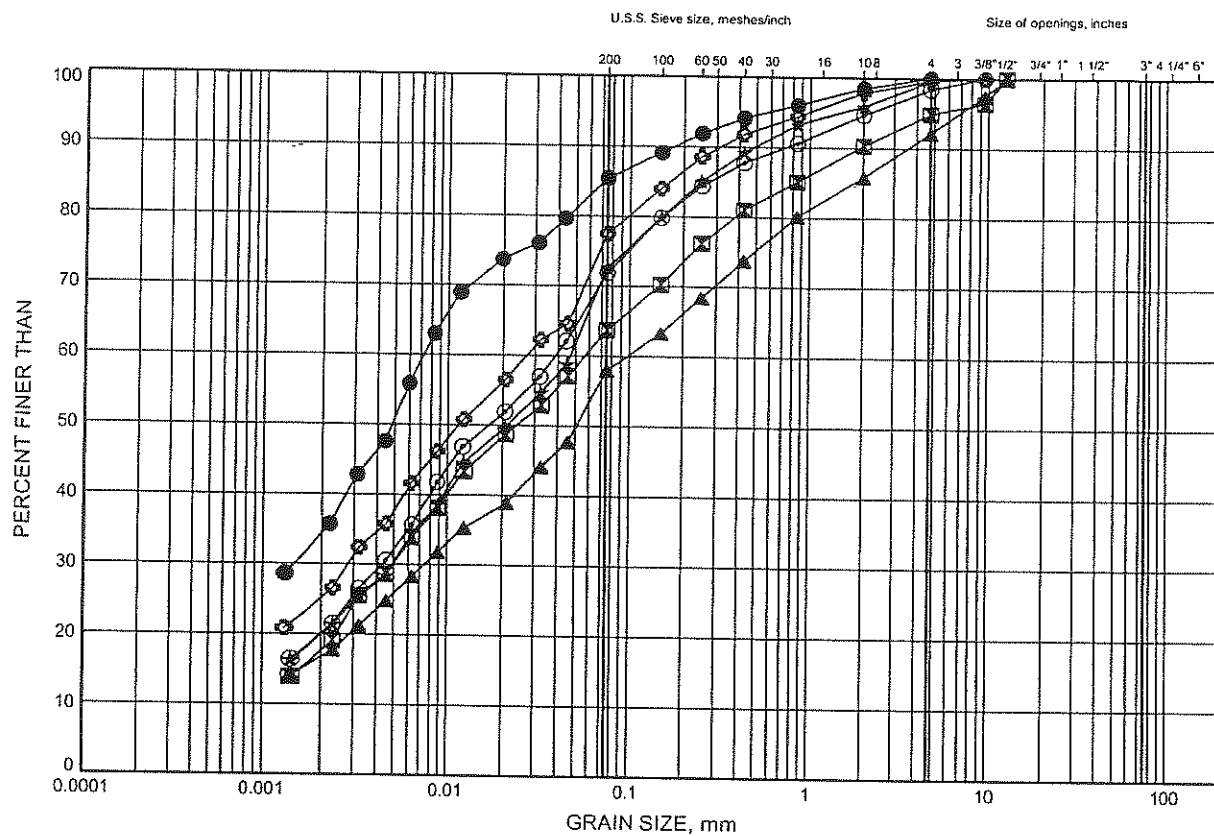
Appendix B

Laboratory Test Results

Hwy 401 Widening GRAIN SIZE DISTRIBUTION

FIGURE B1

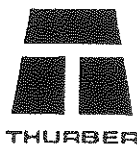
Silty Clay TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	T-01	1.83	183.07
⊠	T-02	1.07	183.19
▲	T-03	0.30	188.52
★	T-04	1.07	187.29
⊙	T-04	2.59	185.77
⊕	T-05	0.30	185.79

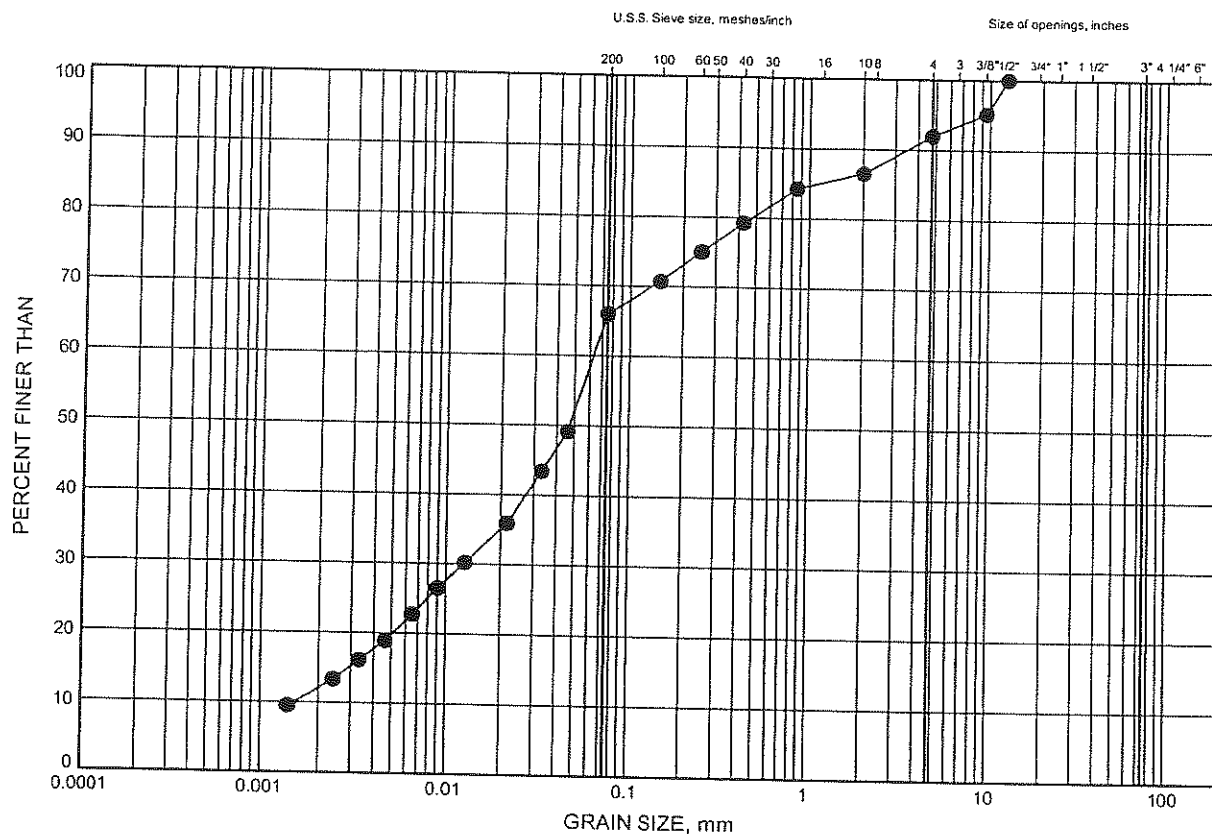


W.P.# 2107-05-00
Prepared By AN
Checked By RPR

Hwy 401 Widening GRAIN SIZE DISTRIBUTION

FIGURE B2

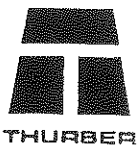
Shale



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	T-03	1.83	187.00



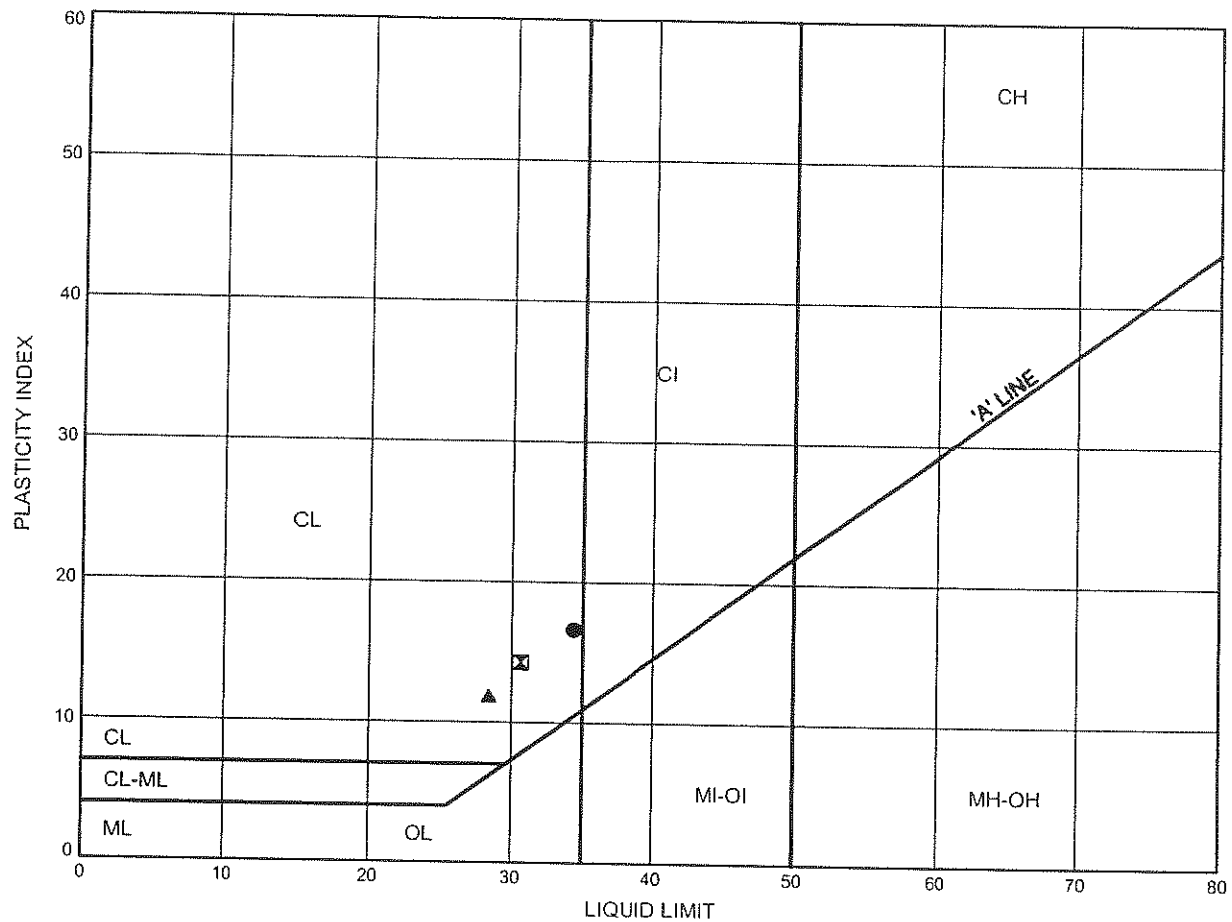
THURBER

W.P.# 2107-05-00
Prepared By AN
Checked By RPR

Hwy 401 Widening ATTERBERG LIMITS TEST RESULTS

FIGURE B3

Silty Clay TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	T-01	1.83	183.07
⊠	T-02	1.07	183.19
▲	T-04	1.07	187.29

Appendix C

Site Photographs

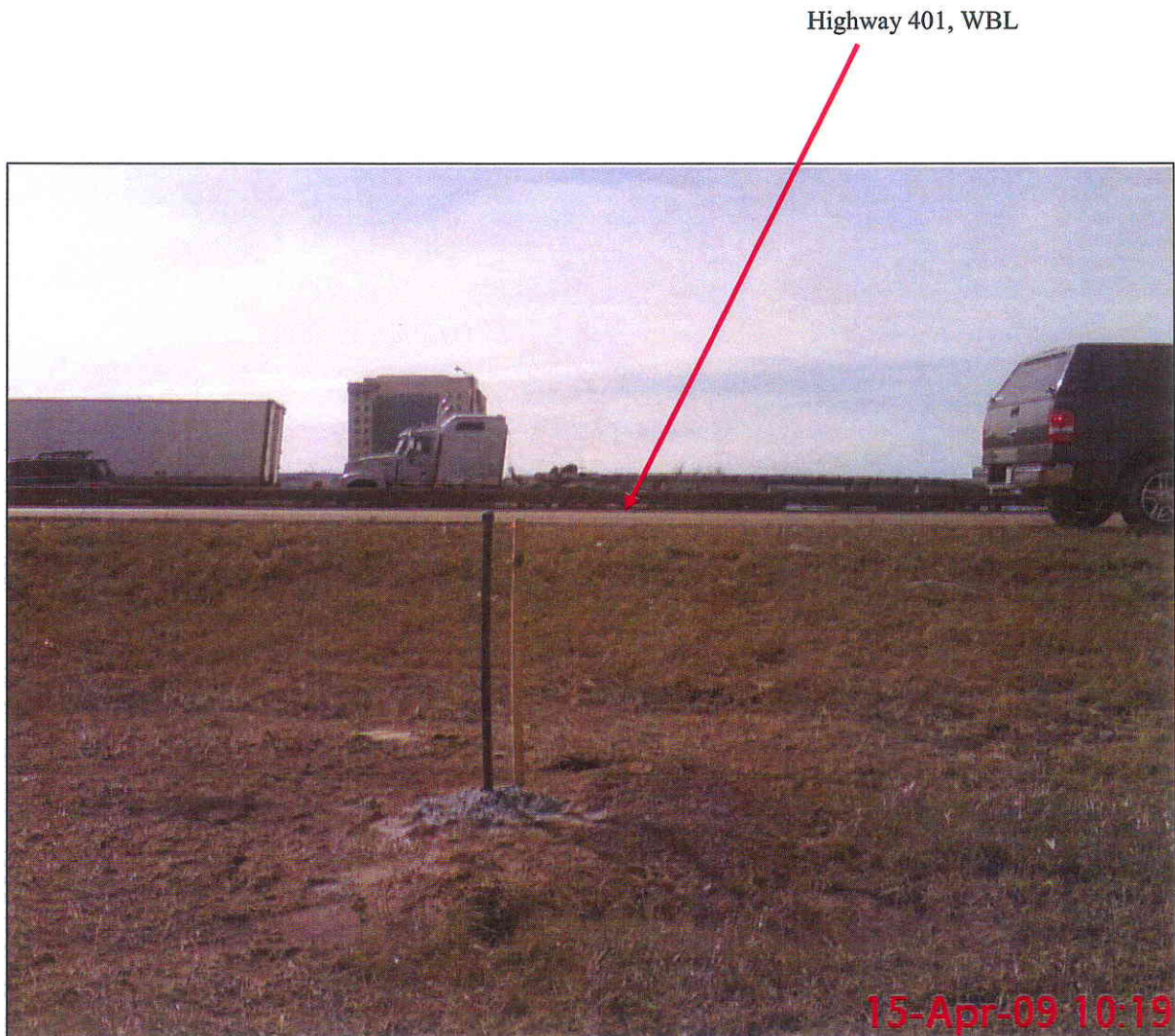


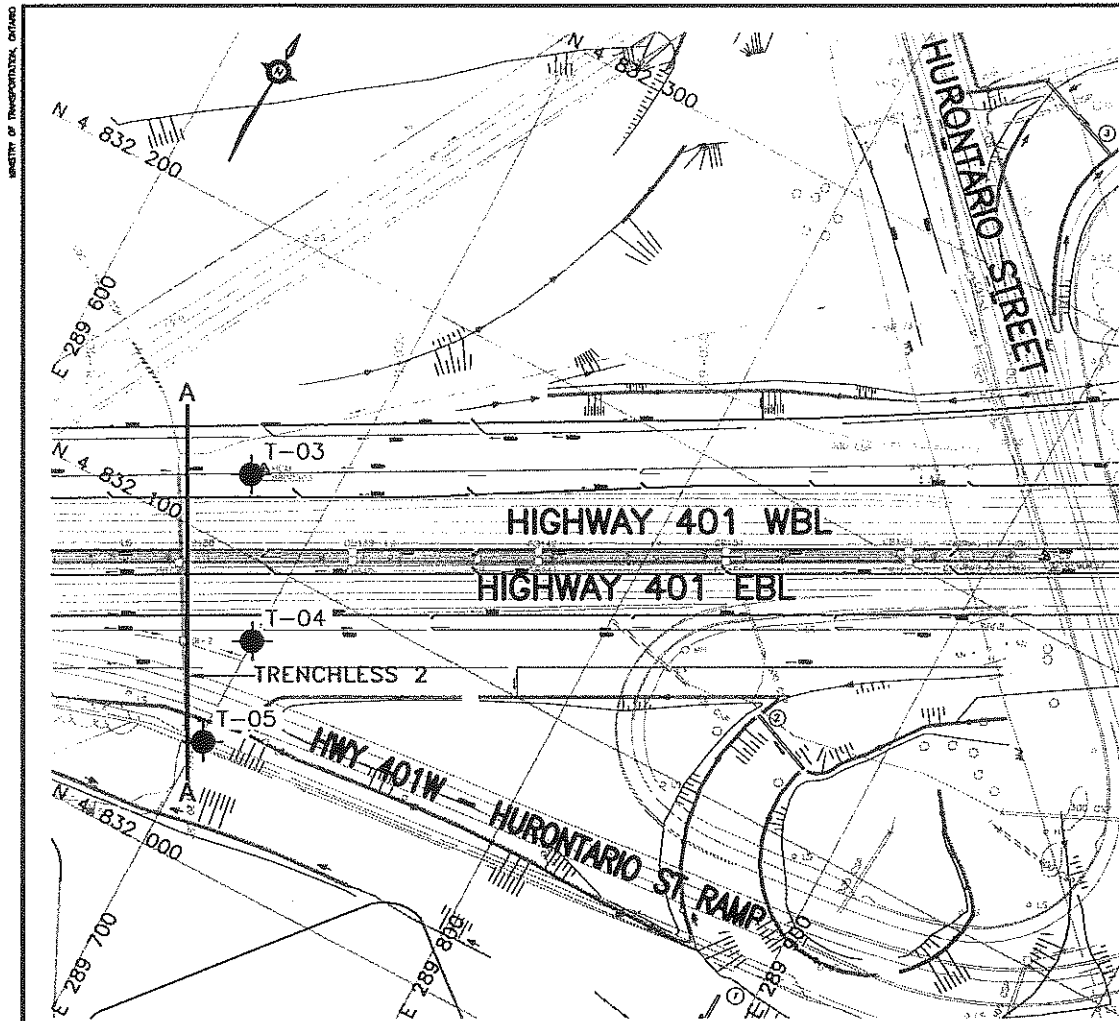
Photo 1 - Looking south of Borehole T-3



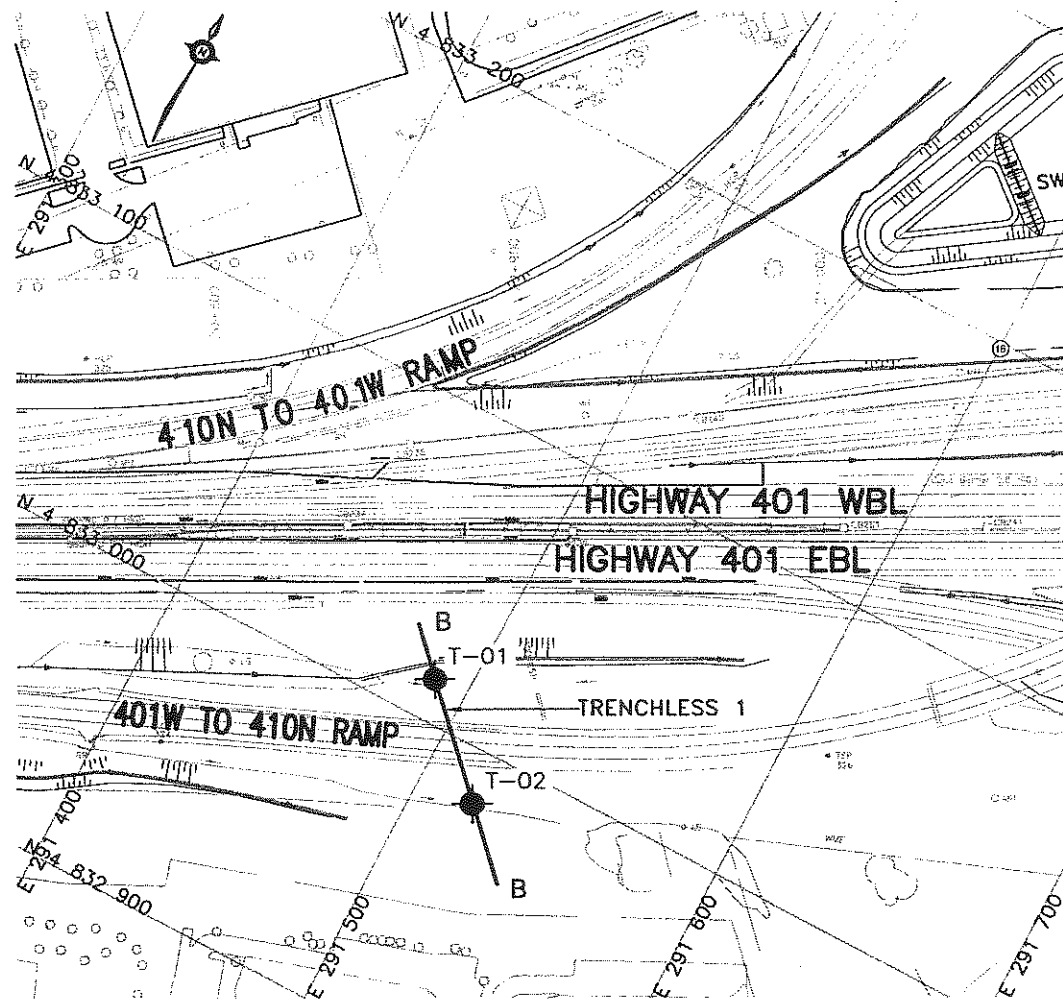
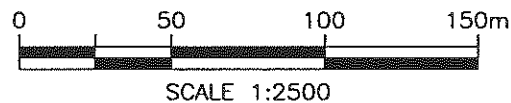
Photo 2 - Looking north of Borehole T-5

Appendix D

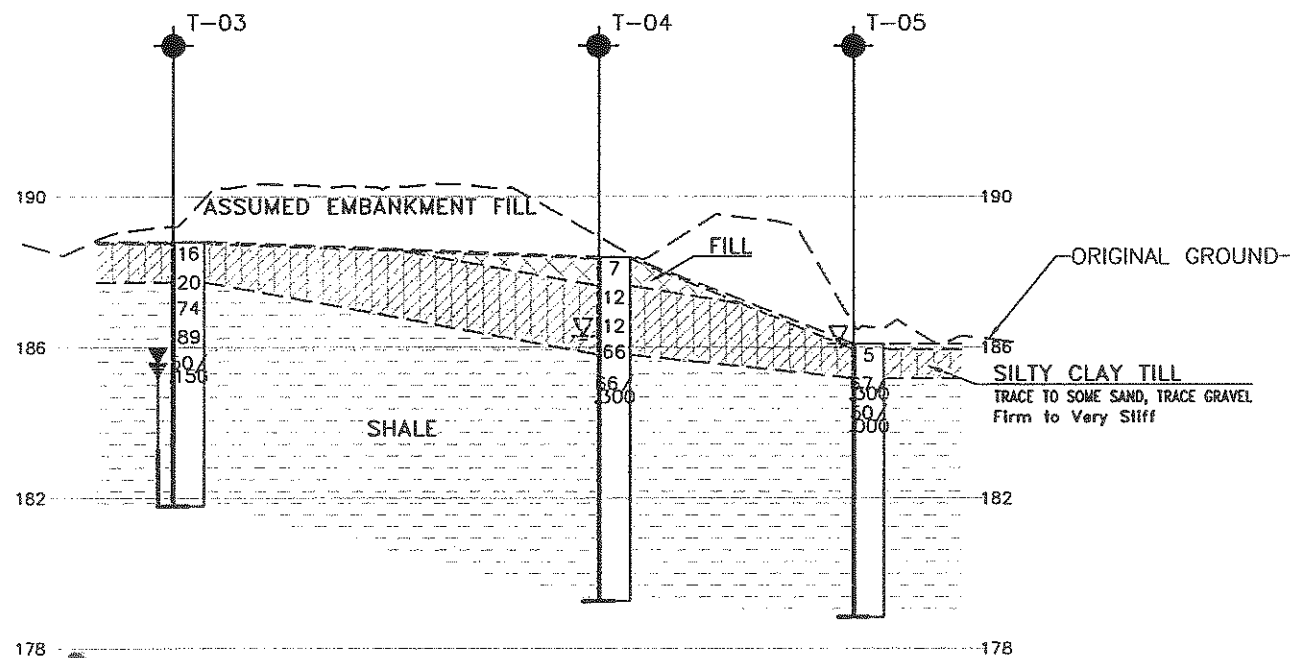
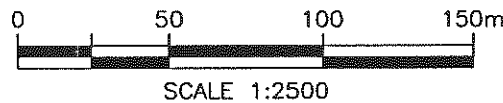
Borehole Location Drawing



PLAN



PLAN

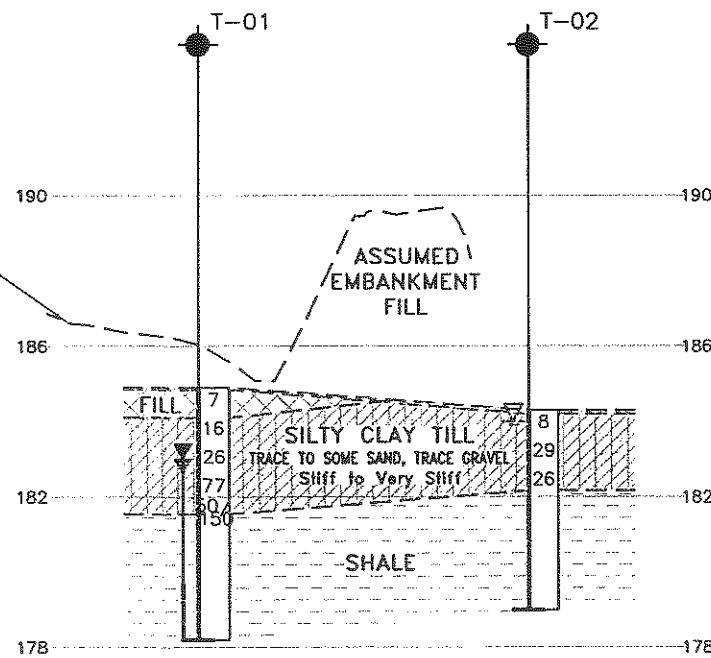


SECTION A-A



HOR 1:1000

VER 1:200



SECTION B-B



HOR 1:1000

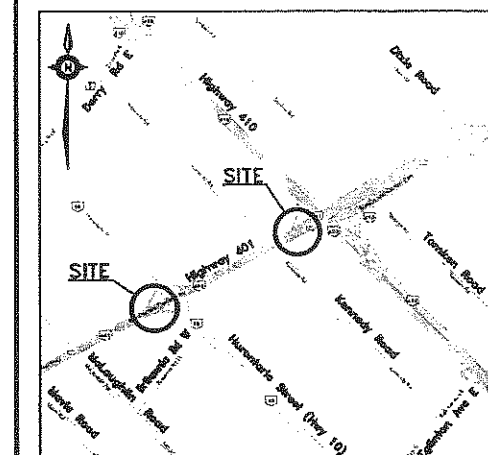
VER 1:200

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



CONT No
GWP No

HIGHWAY 401
AT HIGHWAY 410 & HURONTARIO ST
TRENCHLESS
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Blows /0.3m (Std Pen Test, 475J/blow)
	Blows /0.3m (60' Cone, 475J/blow)
	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
	Rock Quality Designation (RQD)
	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
T-01	184.9	4 833 013.9	291 488.9
T-02	184.3	4 832 983.0	291 518.8
T-03	188.8	4 832 124.3	289 673.4
T-04	188.4	4 832 075.6	289 699.9
T-05	186.1	4 832 038.7	289 701.6

-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.

DATE	BY	DESCRIPTION	DATE
DESIGN	RPR	CHK PKC	CODE
DRAWN	MFA	CHK AEG	SITE
			ISTRUCT
			DWG 1

FILENAME: c:\pdring\101\1023\11 Hwy 401 Trenchless.dwg
PLOTDATE: Apr 22, 2009 - 5:15pm