

**FOUNDATION INVESTIGATION REPORT
HWY 406 BEAVERDAMS ROAD UNDERPASS REHABILITATION
SITE 34-160, W.P. 2348-09-01, G.W.P. 2348-09-00
AND
HWY 58 RICHMOND STREET UNDERPASS REHABILITATION
SITE 34-280, W.P. 2377-09-01, G.W.P. 2365-09-00
CITY OF THOROLD, ONTARIO
P.O. 2010-E-0073**

GEOCRES No. 30M3-276

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation carried out at the locations of the proposed rehabilitation of the Beaverdams Road Underpass at Highway 406 and the Richmond Street Underpass at Highway 58 in the City of Thorold, Ontario. This investigation was carried out as part of a consolidated assignment to rehabilitate or replace six (6) bridge structures at five (5) site locations.

The purpose of this investigation was to explore the subsurface conditions at the two sites and, based on the data obtained, to provide borehole location plans and soil strata drawings with stratigraphic profiles, records of boreholes, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed for each of the sites based on the data obtained from the present and previous investigations.

Thurber carried out the investigation as a foundation sub-consultant to McCormick Rankin, a member of MMM Group (MRC) under MTO Purchase Order No. 2010-E-0073.

2 PROJECT AND SITE DESCRIPTION

The existing Beaverdams Road Bridge is comprised of four (4) spans. The bridge carries Regional Road 67 (Beaverdams Rd) over Highway 406 in the City of Thorold (Thorold), The Regional Municipality of Niagara (Niagara Region). The lands surrounding the bridge structure are primarily agricultural and are relatively flat.

The existing Richmond Street Bridge is comprised of two (2) spans. The bridge carries Richmond St. over Highway 58 in Thorold, Niagara Region. The lands surrounding the bridge structure are

relatively flat and consist primarily of light residential zoning at three quadrants except for the northwest quadrant where the land is used for agricultural purposes.

From published geological information, the bridge sites are situated within the physiographic region known as the Iroquois Plain in the vicinity of the Niagara Escarpment which extends from the Niagara River to the Bruce Peninsula. In this area, a deposit of glaciolacustrine silty clay overlies dolostone bedrock of the Lockport Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out during the period of April 9 to 18, 2012 and involved drilling and sampling four boreholes at the Beaverdams Road Bridge (identified as BR12-01 to BR12-04) and two boreholes at the Richmond Street Bridge (identified as RS12-01 and RS12-02). The borehole depths at Beaverdams Road ranged from 1.3 m to 14.3 m while the borehole depths at Richmond Street ranged from 19.1 m to 19.4 m.

In addition to the six boreholes drilled for the current investigation, three boreholes were previously drilled by MTO at each of the Beaverdams Road structure and Richmond Street structure. The borehole logs from the 1964 investigation at Beaverdams Rd are included in Appendix A and the borehole logs from the 1974 investigation at Richmond Street are included in Appendix B.

Solid stem augers and coring techniques were used to advance the boreholes through soil and bedrock. Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Boreholes BR12-01, BR12-04, RS12-01 and RS12-02, were advanced a minimum of 2.7 m into bedrock by NXL size diamond coring. The remaining boreholes were terminated upon auger and/or split spoon refusal on boulders or probable bedrock.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A piezometer, consisting of 19 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen surrounded with filter sand, was installed in each of Boreholes BR12-01, BR12-04, RS12-01 and RS12-02.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, processed the soil and rock core samples in labelled containers and wooden core boxes, respectively, for transport to Thurber's laboratory for further examination and testing.

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

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendices A and B. At least 25% of the recovered soil samples were subjected to grain size distribution analysis. Atterberg Limits tests were carried out on selected samples of silty clay to determine the plasticity characteristics. The results of these tests are presented on the figures included in Appendices A and B.

Point load testing was carried out on selected rock cores retrieved from Boreholes BR12-01, BR12-04, RS12-01 and RS12-02. These results are presented on the Record of Borehole sheets (as estimated UCS) included in Appendices A and B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference should be made to the Record of Borehole sheets included in Appendix A and Appendix B (from the current and previous investigations). Details of the encountered soil and rock stratigraphy are presented in these records and on the “Borehole Locations and Soil Strata” drawings included in Appendices A and B. The factual information at the borehole locations governs any interpretation of site conditions.

5.1 Highway 406 - Beaverdams Road Underpass

Three boreholes were previously drilled in the vicinity of the Beaverdams Road structure in 1964 (BH 1 to BH3) and four boreholes were drilled as part of the current investigation (BR12-01 to BR12-04). The borehole logs from 1964 indicate that the stratigraphy encountered in the boreholes consisted primarily of hard cohesive silt till with boulders at depth. Grey limestone bedrock was reported at 5.3 m depth (Elevation 174.5 m) in BH 3. The descriptions of the stratigraphy presented below are based on the current boreholes only.

In general, the subsurface at the site consists of pavement structure overlying fill which is underlain by a deposit of silty clay. The overburden is underlain by dolostone bedrock of the Lockport Formation.

5.1.1 Pavement Structure

A pavement structure consisting of asphalt overlying granular fill materials was encountered in the four boreholes drilled for the current investigation (BR12-01 to BR12-04). Asphalt was present at ground surface in boreholes drilled on the shoulder of Beaverdams Road (BR12-01 and BR12-04) and ramps to Highway 406 (BR12-02 and BR12-03). The thickness of the asphalt ranged from 75 to 275 mm. Concrete was

encountered below the asphalt in Boreholes BR12-02 and BR12-03. The thickness of the concrete ranged from 225 to 300 mm.

The granular fill encountered below the asphalt and/or concrete consisted of sand in Boreholes BR12-01 and BR12-04, and sand and gravel in Boreholes BR12-02 and BR12-03. The thickness of the granular fill ranged from 0.5 m to 1.2 m, with the lower boundary of the granular fill encountered at depths of 0.8 m to 1.4 m (Elevations 182.0 to 176.3 m).

SPT 'N' values recorded in the granular fill ranged from 17 to 32 blows per 0.3 m of penetration, indicating a compact to dense relative density. The moisture contents of samples of the granular fill ranged from 2 to 10 %.

It should be noted that the thickness of the pavement structure may vary between and beyond the borehole locations.

5.1.2 Fill

Fill was encountered below the pavement structure in all boreholes except for Borehole BR12-02. The fill generally consisted of silty clay, except in Borehole BR12-04 where a 0.8 m thick layer of sandy silt fill with trace clay was encountered between the pavement structure and the silty clay fill. The silty clay fill was brown and contained trace sand and asphalt fragments.

The thickness of the silty clay fill ranged between 0.5 and 2.6 m, with the lower boundary of the silty clay fill encountered at depths of 1.3 m to 4.0 m (Elevations 175.8 to 179.8 m).

SPT 'N' values recorded in the silty clay fill ranged from 6 to 24 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. A SPT 'N' value of 50 blows for 0.05 m was also recorded in the silty clay fill in Borehole BR12-04, indicating the presence of possible obstructions in the fill. The measured moisture contents of samples of the silty clay fill ranged between 18 and 24%.

Selected samples of the silty clay fill were subjected to grain size analysis, the results of which are summarized in the table below. These results are also presented on the Record of Borehole sheets included in Appendix A. Figure A1 in Appendix A illustrates the grain size distribution curves of these samples of the silty clay fill.

Soil Particles	Percentage (%)
Gravel	0
Sand	9
Silt	40 to 43
Clay	48 to 51

5.1.3 Silty Clay

A deposit of silty clay was encountered below the fill across the Beaverdams Road Bridge site, except in Borehole BR12-03 where the fill directly overlies bedrock. The silty clay contained trace to some sand and trace gravel.

The thickness of the silty clay layer ranged from 2.9 m to 4.4 m, with the lower boundary of the silty clay encountered at depths of 3.7 m to 8.4 m (Elevations 176.6 to 173.4 m).

SPT 'N' values recorded in the silty clay ranged from 31 blows for 0.3 m penetration to 100 blows for less than 0.3 m of penetration, indicating a hard consistency. In general, SPT 'N' values increased with depth. The measured moisture content of samples of the silty clay varied from about 12 to 19%.

Selected samples of the silty clay were subjected to gradation analysis and Atterberg Limits testing. The results of these tests are summarized in the tables below as well as on the Record of Borehole sheets included in Appendix A. Figure A2 presents the grain size distribution curves for these samples, and Figure A3 illustrates the results of the Atterberg Limits tests on plasticity charts.

Soil Particles	Percentage (%)
Gravel	0
Sand	2 to 5
Silt	54 to 70
Clay	28 to 41

Index Property	Percentage (%)
Liquid Limit	28 to 34
Plasticity Index	11 to 15

The results of the Atterberg Limits tests indicate that the silty clay is generally low plastic with a group symbol of CL.

5.1.4 Bedrock

The overburden soils described above are underlain by bedrock which was proven by coring in Boreholes BR12-01 and BR12-04. Boreholes BR12-02 and BR12-03 were terminated upon auger and/or split spoon refusal on probable bedrock or boulders. The following table summarizes the depths and elevations of bedrock or auger refusal encountered at the borehole locations. The depths and elevations of bedrock or auger refusal encountered at the 1974 borehole locations are also included for reference.

Foundation Element	Borehole Number	Depth to Bedrock or Auger Refusal (m)	Elevation of Top of Bedrock or Auger Refusal on Boulders or Probable Bedrock (m)
West Abutment	BR12-01*	8.4	174.4
	BH 1	6.0	173.5
Pier 1	BR12-02	3.7	173.3
Pier 2	BH 3*	5.3	174.5
Pier 3	BR12-03	1.3	175.8
East Abutment	BR12-04*	6.9	176.6
	BH 2	4.4	175.9

*Bedrock proven by coring

Based on the rock cores from the current investigation, the bedrock was described as thinly bedded, grey, dolostone. The bedrock was highly weathered near the silty clay – bedrock interface in Borehole BR12-01 and became moderately weathered to fresh with depth. Occasional joints were observed in the bedrock cores. MTO Borehole BH 3 indicates the presence of solution cavities in the upper part of the bedrock.

Total Core Recovery (TCR) of the bedrock typically ranged from 80 to 100%, except for Runs 1, 2, and 3 in Borehole BR 12-01 where a mixture of infilling sand and rock fragments was encountered with the TCR ranging from 0 to 20%. The Rock Quality Designation (RQD) values generally ranged from 62 to 91%, indicating a fair to excellent rock quality. RQD values of 0% were recorded for Runs 2 and 3 of Borehole BR12-01. The Fracture Index (FI) of the rock, expressed as fractures or joints per 0.3 m of core, was generally less than 5, except for the multiple fractures observed in Runs 1, 2 and 3 in Boreholes BR 12-01.

Point load tests were carried out at regular intervals on selected rock cores. The estimated Unconfined Compressive Strength (UCS) of the bedrock as inferred from the point load tests ranged from 93 to 170 MPa, indicating a strong to very strong intact rock strength.

5.1.5 Water Levels

Standpipe piezometers were installed in selected boreholes to facilitate monitoring of the groundwater levels. The groundwater levels observed at the standpipe piezometers are summarized in the table below. The water levels observed in the open boreholes on completion of drilling have also been noted, and the water levels observed during the 1964 investigation are also included for reference.

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
BR12-01	July 16, 2012	10.0	172.8
BR12-04	July 16, 2012	6.6	176.9
BH 1	September 1964	4.1	175.4
BH 2	September 1964	3.1	177.2
BH 3	September 1964	2.3	177.6

All groundwater observations at this site are short term readings and the groundwater levels are expected to fluctuate seasonally and after severe climatic events.

5.2 Highway 58 - Richmond Street Underpass

Three boreholes were previously drilled in the vicinity of the Richmond Street structure in 1974 (BH 1 to BH3) and two boreholes were drilled as part of the current investigation (RS12-01 and RS12-02). The descriptions of the stratigraphy presented in the paragraphs below are based on the current boreholes and previous boreholes from 1974.

In general, the subsurface at the site consists of topsoil or pavement structure overlying cohesive fill which is underlain by a deposit of native silty clay. The overburden is underlain by dolostone bedrock of the Lockport Formation.

5.2.1 Topsoil

A thin layer of topsoil was encountered at the original ground surface in the three boreholes drilled during the 1974 investigation (BH 1 to BH3).

5.2.2 Pavement Structure

Pavement structure consisting of asphalt overlying granular fill was encountered in both boreholes from the current investigation (RS12-01 and RS12-02). The thickness of the asphalt ranged from 200 mm to 225 mm.

The granular fill encountered below the asphalt consisted of brown sand with some gravel and was found to be 1.2 m thick in both boreholes. The lower boundary of the granular fill was encountered at a depth of 1.4 m in both boreholes (Elevation 186.3 m). SPT 'N' values of 9 and 14 blows for 0.3 m penetration were recorded in the granular fill, indicating a loose to compact relative density. The moisture contents of samples of the granular fill ranged from 3 to 5%.

The thickness of the pavement structure may vary between and beyond the borehole locations.

5.2.3 Silty Clay Fill

Silty clay fill was encountered below the topsoil in Boreholes BH 1 to BH 3 and below the pavement structure in Boreholes RS12-01 and RS12-02. The silty clay fill contains trace to some sand and gravel and trace organics.

The thickness of the silty clay fill ranged from 0.9 m to 1.6 m in Boreholes BH 1 to 3, which were drilled near highway level and the silty clay fill was 5.9 m thick in Boreholes RS12-01 and RS12-02, which were drilled from the Richmond Street level. The lower boundary of the silty clay fill was encountered at depths of 0.9 m to 7.3 m (Elevations 178.9 to 180.5m).

SPT 'N' values recorded in the cohesive fill ranged from 5 to 21 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. The measured moisture contents of samples of the cohesive fill ranged between 18 and 25%.

Selected samples of the cohesive fill were subjected to gradation analysis and Atterberg Limits testing. The results of these tests are summarized in the tables below as well as on the Record of Borehole sheets included in Appendix B. Figure B1 presents the grain size distribution curves for these samples, and Figure B3 illustrates the results of the Atterberg Limits tests on plasticity charts. These figures show the results of testing from the current investigation only while the 1974 test results are included in the tables below.

Soil Particles	Percentage (%)
Gravel	0 to 2
Sand	5 to 13
Silt	43 to 50
Clay	42 to 47

Index Property	Percentage (%)
Liquid Limit	37 to 39
Plasticity Index	18 to 21

The results of the Atterberg Limits tests indicate that the fill is generally medium plastic with a group symbol of CI.

5.2.4 Silty Clay

A deposit of native brown silty clay was encountered below the cohesive fill in all five boreholes. The silty clay contains trace sand and occasional gravel.

The thickness of the silty clay deposit ranged from 7.5 m to 9.1 m, with the lower boundary of the silty clay encountered at depths of 8.4 m to 16.4 m (Elevations 171.4 to 171.7 m).

SPT 'N' values recorded in the silty clay ranged from 19 to 51 blows for 0.3 m of penetration, indicating a very stiff to hard consistency. The measured moisture content varied from about 13 to 24%.

Selected samples of the silty clay were subjected to gradation analysis and Atterberg Limits testing. The results of these tests (from both the 1974 investigation and current investigation) are summarized in the tables below as well as on the Record of Borehole sheets included in Appendix B. Figure B2 presents the grain size distribution curves for these samples, and Figure B4 illustrates the results of the Atterberg Limits tests on plasticity charts. These figures show the results of testing from the current investigation only.

Soil Particles	Percentage (%)
Gravel	0 to 4
Sand	2 to 13
Silt	38 to 66
Clay	18 to 55

Index Property	Percentage (%)
Liquid Limit	29 to 42
Plasticity Index	13 to 22

The results of the Atterberg Limits tests indicate that the silty clay has a low to intermediate plasticity with a group symbol of CL to CI.

5.2.5 Bedrock

The overburden soils described above are underlain by bedrock which was proven by coring in Boreholes BH-1, BH-2, RS12-01, and RS12-02. Bedrock was inferred by auger refusal at BH-3. The following table summarizes the depths and elevations at which bedrock was encountered at the borehole locations.

Foundation Element	Borehole Number	Depth to Bedrock or Auger Refusal (m)	Elevation of Top of Bedrock or Auger Refusal on Boulders or Probable Bedrock (m)
East Abutment	RS12-01*	16.4	171.4
	BH-2*	9.4	171.4
Pier	BH-3	8.4	171.4
West Abutment	RS12-02*	16.2	171.4
	BH-1*	9.2	171.7

*Bedrock proven by coring

The bedrock was described as thinly bedded, grey dolostone with occasional gypsum pockets and vugs. The dolostone was generally in a slightly weathered to fresh state. Occasional horizontal joints were observed in the bedrock cores.

Total Core Recovery (TCR) of the bedrock ranged from 97 to 100%. The Rock Quality Designation (RQD) values, where measured, ranged from 93 to 98%, indicating an excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures or joints per 0.3 m of core, ranged from 0 to 3.

Point load tests were carried out at regular intervals on selected rock cores. The estimated Unconfined Compressive Strength (UCS) of the rock as inferred from the point load tests ranged from 143 to 185 MPa, indicating a very strong intact rock strength.

5.3 Water Levels

Standpipe piezometers were installed in selected boreholes to facilitate monitoring of the groundwater levels. The groundwater levels observed at the standpipe piezometers are summarized in the table below. The water levels observed in the open boreholes on completion of drilling have also been noted.

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
RS12-01	July 16, 2012	9.8	178.0
RS12-02	July 16, 2012	10.5	177.2
BH 1	July 24, 1974	4.5	176.4
BH 2	July 26, 1974	2.0	178.8
BH 3	July 25, 1974	0.5	179.3

All groundwater observations at this site are short term readings and the groundwater levels are expected to fluctuate seasonally and after severe climatic events.

6 MISCELLANEOUS

Borehole locations were established in the field relative to the location of the existing structures. The ground surface elevations and coordinates at the borehole locations were surveyed by surveyors arranged by MRC upon completion of drilling.

Underground utility clearances were obtained for the borehole locations prior to drilling.

Elite Drilling Services of St. Catharines, Ontario supplied a truck-mounted CME-75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field investigation was supervised by Mr. Stephane Loranger and Mr. Dave Ametrano of Thurber.

Geotechnical laboratory testing was carried out in Thurber's Toronto Area laboratory.

Overall planning and supervision of the field program was conducted by Mr. Luke Gilarski, E.I.T. and Mr. Sydney Pang, P.Eng. Interpretation of the data and preparation of the report was carried out by Mr. Luke Gilarski, E.I.T. and Ms. Lindsey Blaine, E.I.T.

The report was reviewed by Messrs. Sydney Pang, P.Eng. and P.K. Chatterji, P.Eng., who is a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

L. Blaine
Jan. 29/13

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Appendix A
Highway 406 – Beaverdams Road Underpass

19-1351-221

RECORD OF BOREHOLE No BR12-01

1 OF 2

METRIC

W.P. 2365-09-00 LOCATION N 4 772 841.6 E 326 140.5 Beaverdams Rd. Underpass ORIGINATED BY SLL
HWY 406 BOREHOLE TYPE Solid Stem Augers/CME75/NXL Casing COMPILED BY AN
DATUM Geodetic DATE 2012.04.11 - 2012.04.12 CHECKED BY LPG

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
182.8 0.0	ASPHALT: (225mm)												
0.2	SAND, some gravel Compact Brown Moist (FILL)		1	GS			182						
			2	SS	17								
181.4 1.4	Silty CLAY, trace sand Firm to Very Stiff Brown (FILL)		3	SS	6		181						0 9 43 48
			4	SS	11		180						
	Asphalt fragments		5	SS	18								
178.8 4.0	Silty CLAY, trace sand, trace gravel Hard Brown						179						
			6	SS	34		178						
							177						
			7	SS	31								0 2 70 28
							176						
			8	SS	85/ 0-200		175						
	Auger refusal at 8.4m and start coring												
174.4 8.4	Highly weathered to 11.3m, thinly bedded, grey, strong to very strong: DOLOSTONE BEDROCK						174						RUN #1 TCR=83% SCR=57% RQD=57%
	Infilling sand mixed with limestone fragments from 9.2m to 11.3m		1	RUN									
							173						RUN #2

Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BR12-01

2 OF 2

METRIC

W.P. 2365-09-00 LOCATION N 4 772 841.6 E 326 140.5 Beaverdams Rd. Underpass ORIGINATED BY SLL
 HWY 406 BOREHOLE TYPE Solid Stem Augers/CME75/NXL Casing COMPILED BY AN
 DATUM Geodetic DATE 2012.04.11 - 2012.04.12 CHECKED BY LPG

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page												
			2	RUN			172					>10	TCR=20% SCR=0% RQD=0%
			3	RUN								>10	RUN #3 TCR=0% SCR=0% RQD=0%
	Becoming moderately weathered to fresh Sub-vertical joint from 11.8m to 12.1m		4	RUN			171					2	RUN #4 TCR=100% SCR=91% RQD=91% UCS=170MPa (Average)
	Rubble zone (100mm) at 12.3m											1	
	Horizontal joints at 12.9m, 13.0m, 13.2m		5	RUN			170					0	RUN #5 TCR=100% SCR=75% RQD=75% UCS=114MPa (Average)
												3	
			6	RUN			169					2	RUN #6 TCR=100% SCR=100% RQD=70% UCS=93MPa (Average)
												0	
168.5												0	
14.3	END OF BOREHOLE AT 14.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul.16/12 10.0 172.8												

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

RECORD OF BOREHOLE No BR12-02

1 OF 1

METRIC

W.P. 2365-09-00 LOCATION N 4 772 832.7 E 326 159.2 Beaverdams Rd. Underpass ORIGINATED BY DA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.04.18 - 2012.04.18 CHECKED BY LPG

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 ³	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							w _P w w _L		
							20 40 60 80 100				20 40 60						
177.0							177										
0.0	ASPHALT: (75mm)																
0.1																	
176.7	CONCRETE: (225mm)																
0.3																	
176.3	SAND and GRAVEL, trace silt, trace clay		1	AS													
0.8	Brown Moist (FILL)		1	SS	56		176										
	Silty CLAY, some sand, trace gravel																
	Hard Brown																
			2	SS	52		175										
			3	SS	57/ 0,100												
			4	SS	96		174										
173.4																	
3.7	END OF BOREHOLE AT 3.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.																

RECORD OF BOREHOLE No BR12-03

1 OF 1

METRIC

W.P. 2365-09-00 LOCATION N 4 772 862.2 E 326 211.2 Beaverdams Rd. Underpass ORIGINATED BY DA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.04.18 - 2012.04.18 CHECKED BY LPG

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 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 × LAB VANE		WATER CONTENT (%) w _p w w _L				
177.1							20	40	60	80	100			
0.0	ASPHALT: (100mm)						177							
0.1														
176.8	CONCRETE: (300mm)													
0.3	SAND and GRAVEL, trace silt, trace clay		1	AS										
176.3	Brown Moist (FILL)		1	SS	24									
0.8							176							
175.8	Silty CLAY, some sand, some gravel													
1.3	Very Stiff Brown (FILL)													
END OF BOREHOLE AT 1.3m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.3m, CONCRETE TO 0.1m, THEN ASPHALT TO SURFACE.														

RECORD OF BOREHOLE No BR12-04

1 OF 2

METRIC

W.P. 2365-09-00 LOCATION N 4 772 882.5 E 326 232.4 Beaverdams Rd. Underpass ORIGINATED BY SLL
 HWY 406 BOREHOLE TYPE Solid Stem Augers/CME55/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012 04 12 - 2012 04 13 CHECKED BY LPG

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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
183.5												
0.0	ASPHALT: (275mm)											
183.2												
0.3	SAND, some gravel Dense Brown Moist (FILL)		1	GS			183					
			2	SS	32							
182.0							182					
1.4	Sandy SILT, trace clay Compact Brown Moist (FILL)		3	SS	19							
181.3							181					
2.2	Silty CLAY, trace sand Very Stiff Brown (FILL)		4	SS	18							0 9 40 51
			5	SS	50/ 0.050							
	Asphalt fragments						180					
179.8							179					0 5 54 41
3.7	Silty CLAY, trace sand Hard Brown		6	SS	60							
							178					
			7	SS	100/ 0.200		177					
176.6							176					
6.9	Moderately weathered to fresh, thinly bedded, grey, strong to very strong: DOLOSTONE BEDROCK Horizontal joints at 6.9m, 7.0m, 7.3m, 7.5m, 7.6m, 7.7m		1	RUN								RUN #1 TCR=87% SCR=87% RQD=68% UCS=116MPa (Average)
	Horizontal joints at 8.2m, 8.3m, 8.4m, 8.6m, 8.9m, 9.3m, 9.6m		2	RUN								RUN #2 TCR=82% SCR=82% RQD=62% UCS=112MPa (Average)
	Vertical joint (50mm) at 8.6m		3	RUN			175					RUN #3 TCR=100% SCR=100% RQD=83% UCS=108MPa (Average)
	Horizontal joints at 9.9m, 10.0m, 10.1m, 10.2m						174					RUN #4 TCR=100% SCR=100%

Continued Next Page

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

RECORD OF BOREHOLE No BR12-04

2 OF 2

METRIC

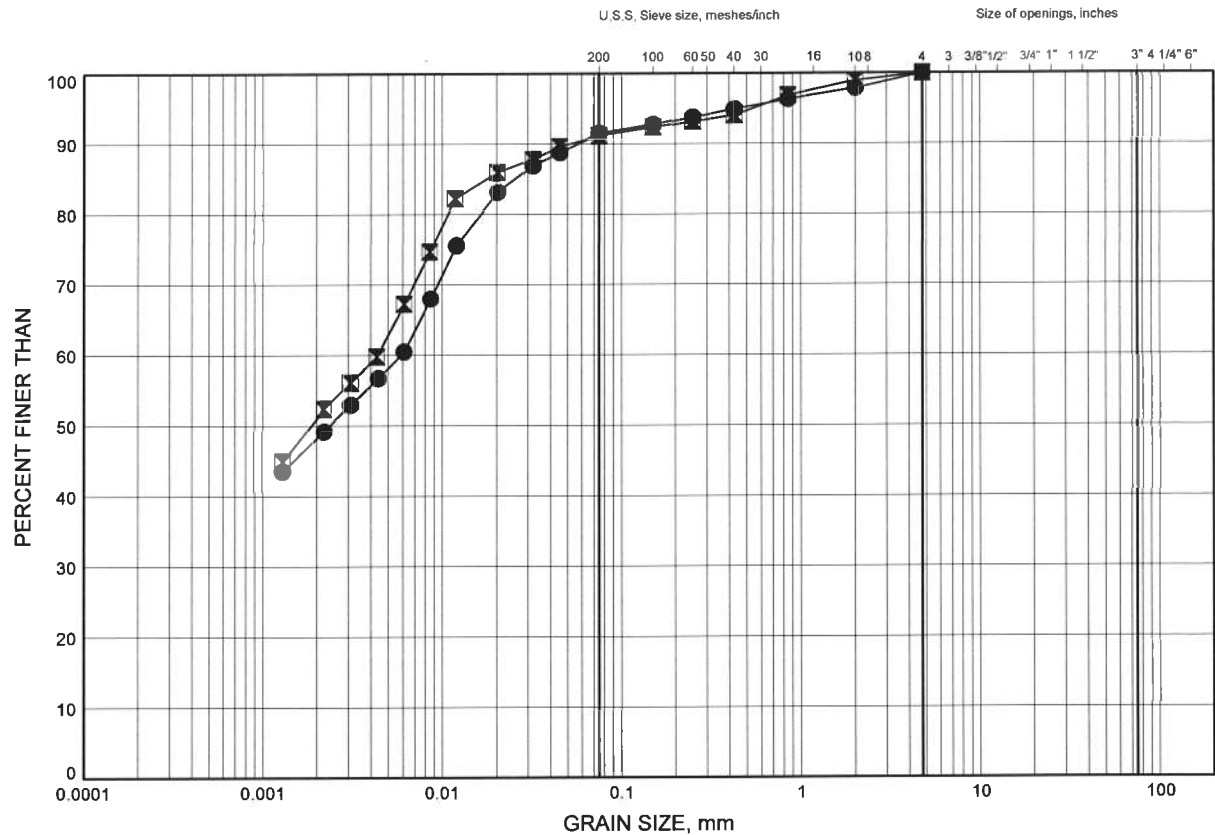
W.P. 2365-09-00 LOCATION N 4 772 882 5 E 326 232 4 Beaverdams Rd. Underpass ORIGINATED BY SLL
 HWY 406 BOREHOLE TYPE Solid Stem Augers/CME55/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.12 - 2012.04.13 CHECKED BY LPG

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
	Continued From Previous Page		4	RUN				20 40 60 80 100		20 40 60				
173.2														
10.3	END OF BOREHOLE AT 10.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul 16/12 6.6 176.9												GR SA SI CL RQD=81% UCS=111MPa (Average)	

5 Bridges, Welland and St. Catharines
GRAIN SIZE DISTRIBUTION

FIGURE A1

SILTY CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR12-01	1.83	180.96
⊠	BR12-04	2.59	180.90

Date December 2012
W.P.# 2365-09-00

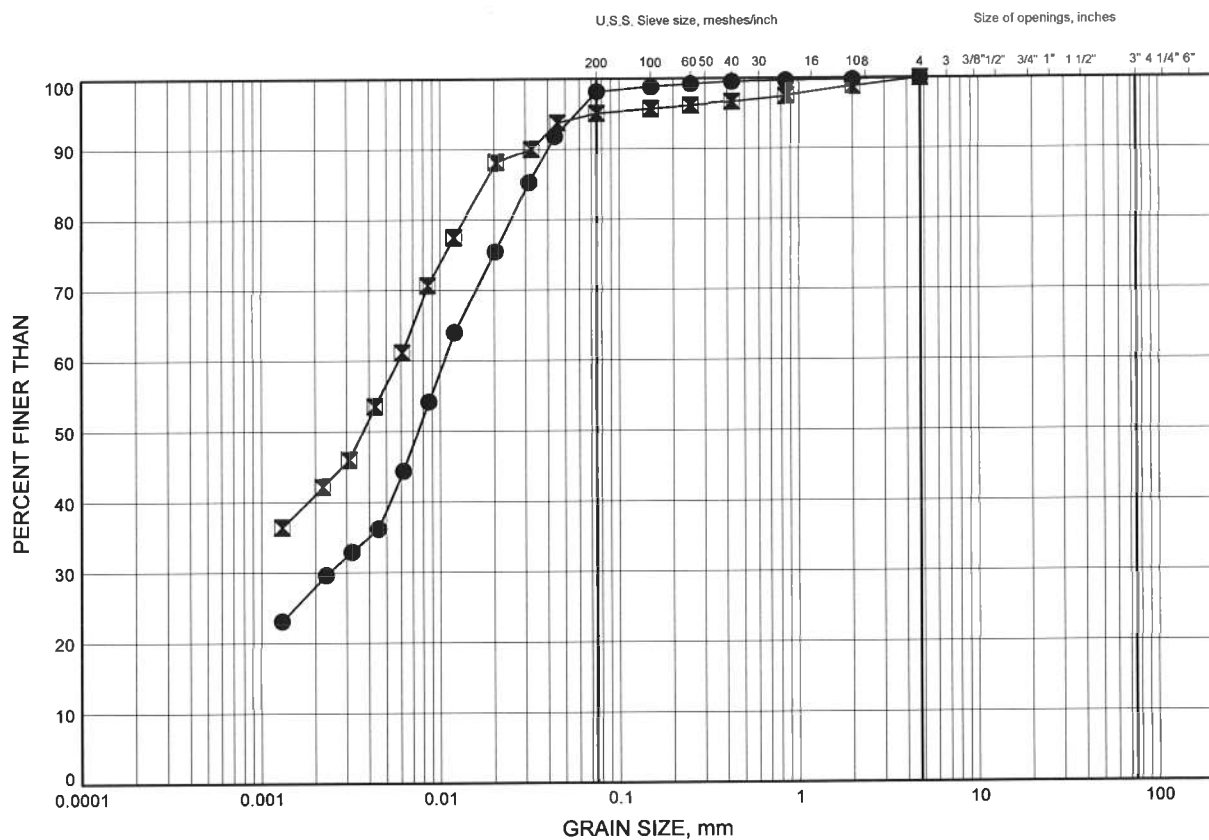


Prep'd AN
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5 Bridges, Welland and St. Catharines
GRAIN SIZE DISTRIBUTION

FIGURE A2

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR12-01	6.32	176.46
■	BR12-04	4.80	178.69

GRAIN SIZE DISTRIBUTION - THURBER 1221 GPJ 12/3/12

Date December 2012
W.P.# 2365-09-00

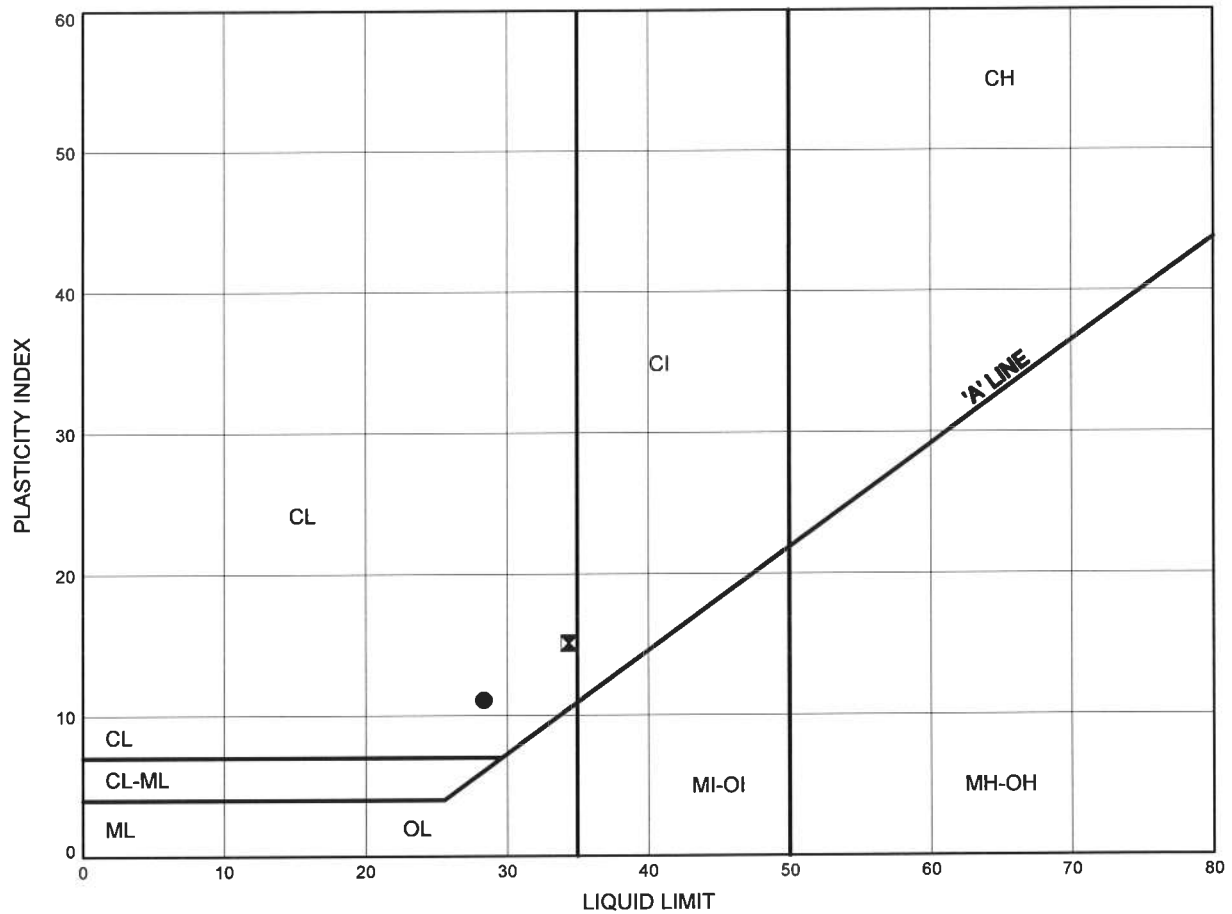


Prep'd AN
Chkd. SKP

5 Bridges, Welland and St. Catharines
ATTERBERG LIMITS TEST RESULTS

FIGURE A3

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BR12-01	6.32	176.46
⊠	BR12-04	4.80	178.69

RECORD OF BOREHOLE No BR64-01

1 OF 1

METRIC

W.P. 93-63 LOCATION Beaverdams Rd. Underpass ORIGINATED BY WAT (DHO)
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY WAT (DHO)
 DATUM Geodetic DATE 1964.09.01 - 1964.09.23 CHECKED BY WAT (DHO)

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
179.5	Clayey SILT, crushed stone, roots (FILL)												
179.0	Silty CLAY Hard Brown (TILL)		1	SS	12		179					20.7	
178.0	Silty CLAY, occasional gravel Hard Brown Moist (TILL)		2	SS	32*		178						
177.5			3	TW	42*		177					20.6	*50mm Shelby Tube was reportedly driven
177.0			4	TW	66*		176						
176.5							175						
176.0	Inferred cobbles and boulders		5	SS	50/ 0.100		174						
173.5			6	SS	50/ 0.050								
173.0	END OF BOREHOLE AT 6.0m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY AT 5.8m ONE AND A HALF HOURS AFTER COMPLETION, WATER LEVEL AT 4.1m AFTER 3 DAYS.												

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BR64-02

1 OF 1

METRIC

W.P. 93-63 LOCATION Beaverdams Rd. Underpass ORIGINATED BY WAT (DHO)
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY WAT (DHO)
 DATUM Geodetic DATE 1964.09.01 - 1964.09.23 CHECKED BY WAT (DHO)

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			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		
180.3														
0.0	Clayey SILT, crushed stone (FILL)						180							
179.7														
0.6	Silty CLAY Hard Brown (TILL)		1	SS	12		179							
			2	TW	38*		178							
			3	SS	66*		177							
			4	SS	60/ 0.100		176							
175.9														
4.4	END OF BOREHOLE AT 4.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY ON COMPLETION, WATER LEVEL AT 3.1m AFTER 3 DAYS.													

RECORD OF BOREHOLE No BR64-03

1 OF 1

METRIC

W.P. 93-63 LOCATION Beaverdams Rd. Underpass ORIGINATED BY WAT (DHO)
 HWY 406 BOREHOLE TYPE Solid Stem Augers/AX Core COMPILED BY WAT (DHO)
 DATUM Geodetic DATE 1964.09.01 - 1964.09.23 CHECKED BY WAT (DHO)

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
179.8	CRUSHED STONE, silt, brown (FILL)										20.9	GR SA SI CL			
0.0								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
179.2	Silty CLAY Hard Brown (TILL)		1	SS	22		179								
0.6			2	TW	35*		178								
			3	SS	42		177								
			4	TW	66*		176								
			5	SS	80		175								
174.5	BEDROCK, grey limestone, solution cavities		1	RUN			174								RUN #1 TCR=80%
5.3															
173.1	END OF BOREHOLE AT 6.7m. BOREHOLE DRY ON COMPLETION, WATER LEVEL AT 2.2m AFTER 3 DAYS.														
6.7															

+ 3, × 3: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RS12-01

1 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 243.3 E 327 471.8 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.10 - 2012.04.11 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
187.8												
0.0	ASPHALT: (225mm)											
0.2	SAND, some gravel Compact Brown Moist (FILL)		1	GS			187					
			2	SS	14							
186.3												
1.4	Silty CLAY, trace sand, trace rootlets Stiff to Very Stiff Brown (FILL)		3	SS	17		186					0 5 50 45
			4	SS	17							
			5	SS	9							
			6	SS	17							
	Wood fragments											
			7	SS	17							0 8 45 47
180.5												
7.3	Silty CLAY, trace sand Very Stiff to Hard Brown		8	SS	24		180					
			9	SS	42							
							178					

Continued Next Page

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

RECORD OF BOREHOLE No RS12-01

2 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 243.3 E 327 471.8 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.10 - 2012.04.11 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
			10	SS	33		177				
							176				
			11	SS	23						0 8 38 54
							175				
			12	SS	25		174				
							173				
			13	SS	38		172				
171.4											
16.4	Slightly weathered to fresh, thinly bedded, grey, very strong, with gypsum pockets: DOLOSTONE BEDROCK Horizontal joints at 16.9m, 17.1m, 17.2m, 17.3m Horizontal joints at 17.6m, 17.8m, 17.9m, 18.6m		1	RUN			171				RUN #1 TCR=100% SCR=100% RQD=93% UCS=143MPa (Average)
							170				RUN #2 TCR=100% SCR=100% RQD=98% UCS=159MPa (Average)
168.7							169				
19.1	END OF BOREHOLE AT 19.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

Continued Next Page

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

ONTMT4S 1221.GPJ 12/3/12

RECORD OF BOREHOLE No RS12-01

3 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 243.3 E 327 471.8 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.10 - 2012.04.11 CHECKED BY LPG

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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40					
	Continued From Previous Page													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul.16/12 9.8 178.0													

RECORD OF BOREHOLE No RS12-02

1 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 199.3 E 327 393.1 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.09 - 2012.04.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT Y kN/m ³	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		
187.7 0.0	ASPHALT: (200mm)											
0.2	SAND, some gravel Loose Brown Moist (FILL)		1	GS			187					
			2	SS	9							
186.3 1.4	Silty CLAY, trace to some sand, trace gravel Firm to Very Stiff Brown (FILL)		3	SS	6		186					
			4	SS	11		185					2 13 43 42
			5	SS	8		184					
			6	SS	13		183					
			7	SS	21		182					
							181					
180.3 7.3	Silty CLAY, trace to some sand, trace rootlets, topsoil stained Very Stiff to Hard Grey		8	SS	19		180					0 6 52 42
			9	SS	41		179					
							178					

Continued Next Page

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

RECORD OF BOREHOLE No RS12-02

2 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 199.3 E 327 393.1 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.09 - 2012.04.09 CHECKED BY LPG

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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
	Becoming reddish brown		10	SS	45		177					
							176					
			11	SS	31		175					
							174					
			12	SS	24		173					0 13 49 38
							172					
171.4	Auger refusal on bedrock, start NW Casing at 16.2m		13	SS	22		171					
16.2	Fresh, thinly bedded, grey, very strong: DOLOSTONE BEDROCK						170					
	Gypsum pockets at 16.4m, 16.6m, 16.9m		1	RUN			169					RUN #1 TCR=100% SCR=100% RQD=95% UCS=175MPa (Average)
	Horizontal joints at 16.8m, 17.1m, 17.7m											
	Horizontal joints at 18.3m, 19.0m, 19.1m, 19.2m		2	RUN								RUN #2 TCR=98% SCR=98% RQD=95% UCS=185MPa (Average)
	Gypsum pocket (50mm thick) at 18.6m											
168.2	END OF BOREHOLE AT 19.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.											
19.4												

Continued Next Page

+ 3 × 3 : Numbers refer to 20 15 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RS12-02

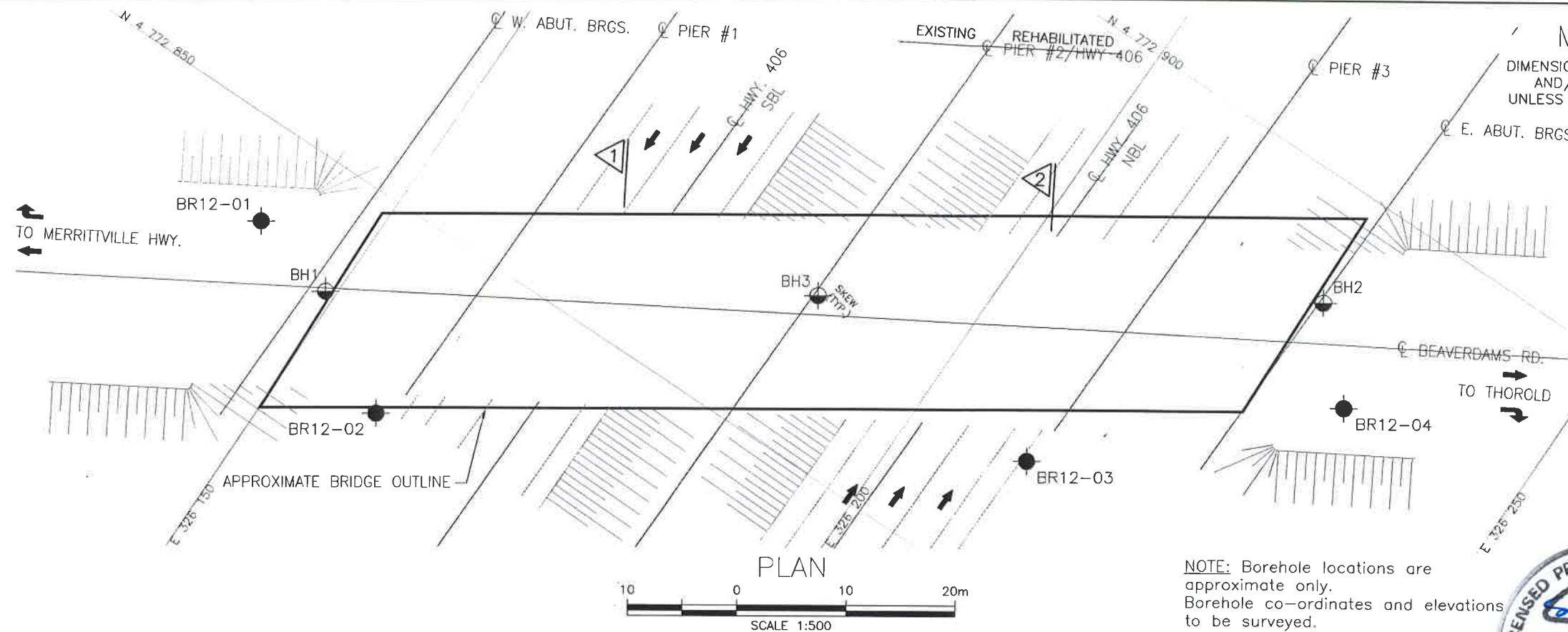
3 OF 3

METRIC

W.P. 2365-09-00 LOCATION N 4 775 199 3 E 327 393 1 Richmond St. Underpass ORIGINATED BY SLL
 HWY 58 BOREHOLE TYPE Solid Stem Augers/NXL Coring COMPILED BY AN
 DATUM Geodetic DATE 2012.04.09 - 2012.04.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	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 _p W W _L				
	Continued From Previous Page													
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul.16/12 10.5 177.2													

ONTMT4S 1221.GPJ 12/3/12








NOTE: Borehole locations are approximate only.
Borehole co-ordinates and elevations to be surveyed.



KEYPLAN

LEGEND

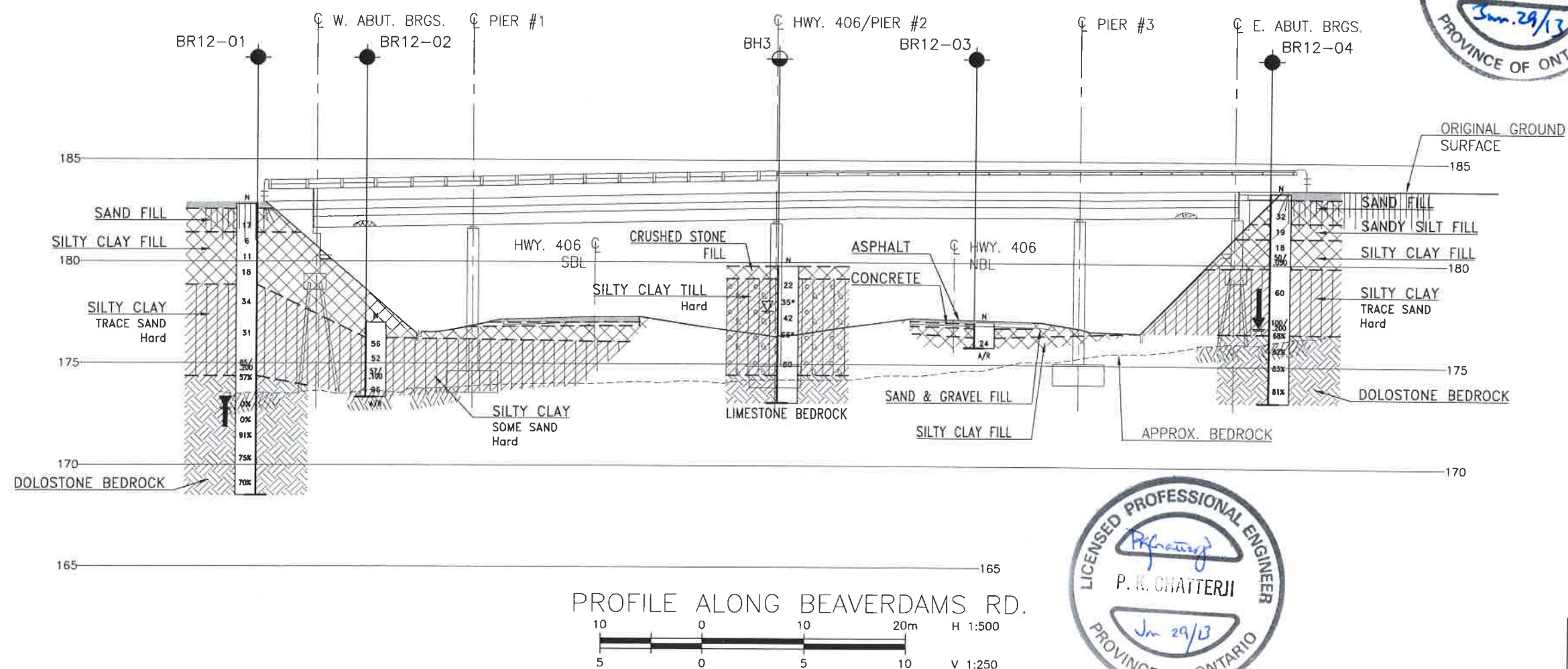
	Borehole (Current Investigation)
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

N/A: Not Available

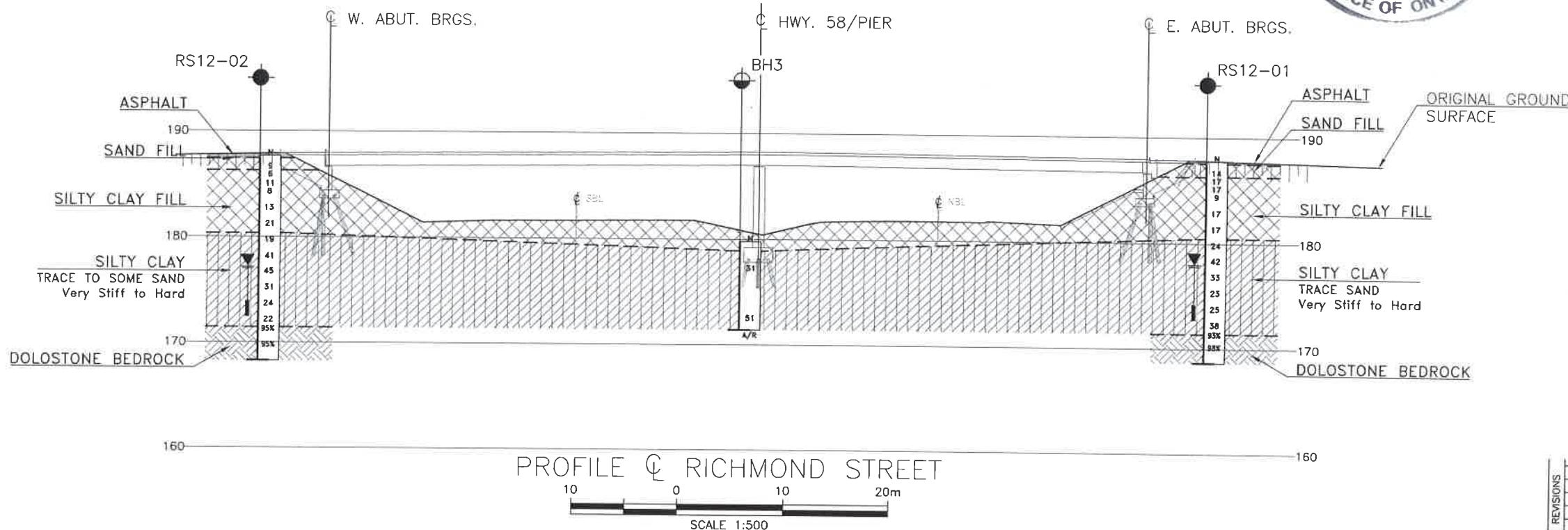
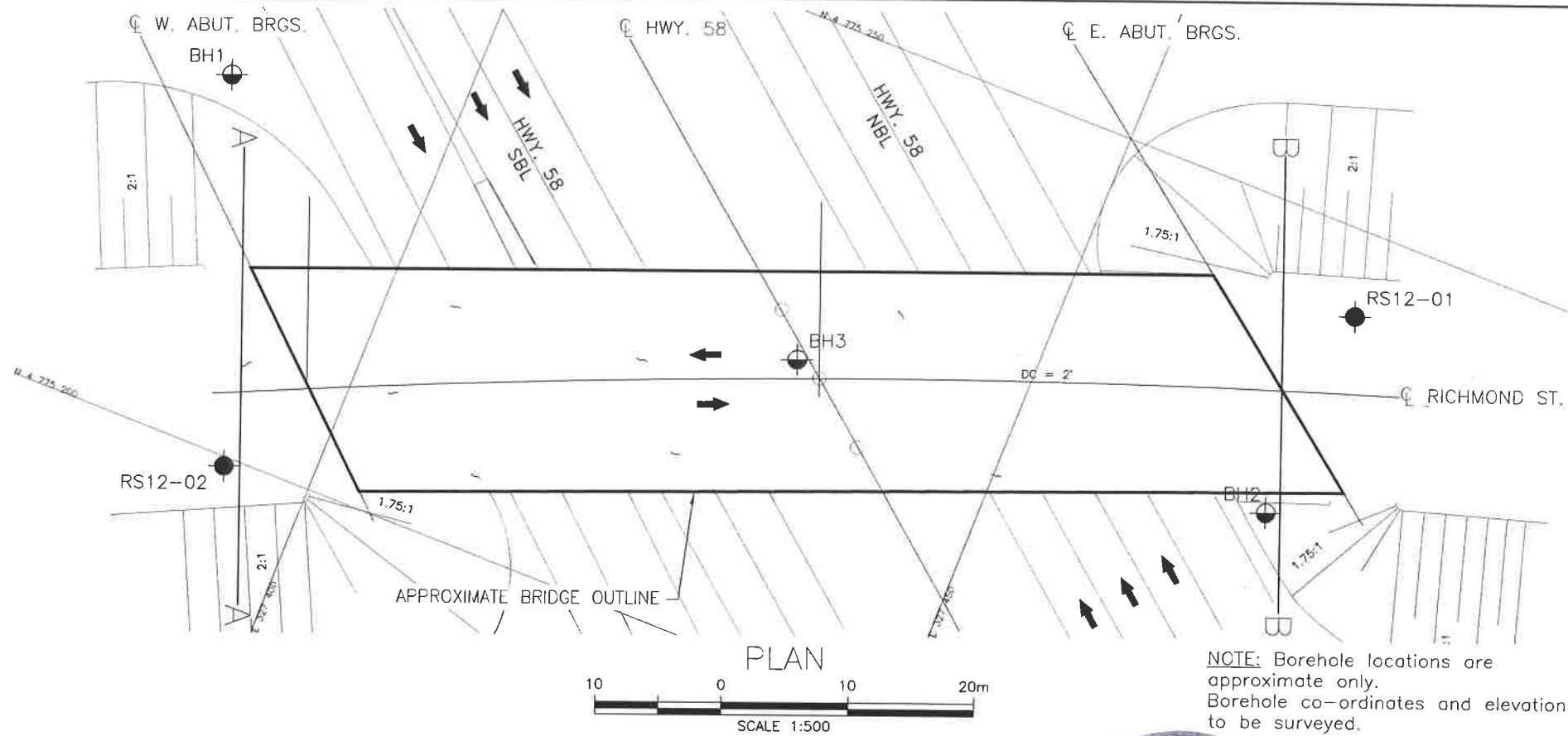
-NOTES-

- 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.



REVISIONS												
	DATE	BY										
DESIGN	LRB	CHK	LRB	CODE				DESCRIPTION				
DRAWN	MFA	CHK	SKP	SITE	34-160	STRUCT	IDWC	1	DATE	DEC.	2012	



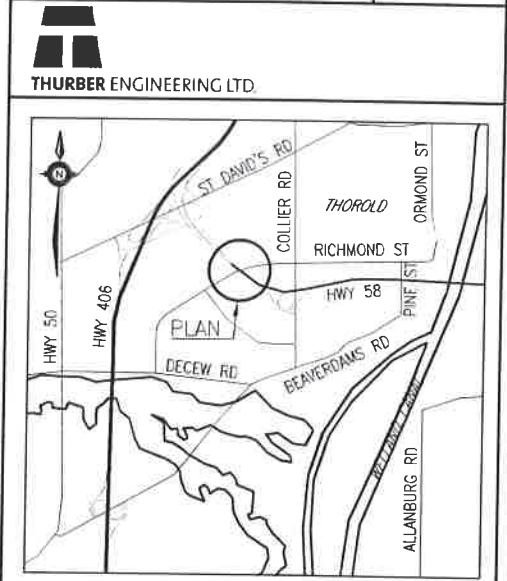
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2365-09-00
WP No 2377-09-01

HIGHWAY 58
RICHMOND STREET UNDERPASS
BRIDGE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
56

MRC
McCormick Rankin
A member of MMA GROUP



LEGEND

	Borehole (Current Investigation)
	Borehole (Previous Investigation)
	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
RS12-01	187.8	4 775 243.3	327 471.8
RS12-02	187.7	4 775 199.3	327 393.1
BH1	180.9	N/A	N/A
BH2	180.8	N/A	N/A
BH3	179.8	N/A	N/A

N/A: Not Available

- 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.

REVISIONS

DATE	BY	DESCRIPTION
DESIGN	LRB	CHK LRB CODE
DRAWN	MFA	CHK SKP SITE 34-280
		STRUCT
		DWG 2

DATE JAN. 2013

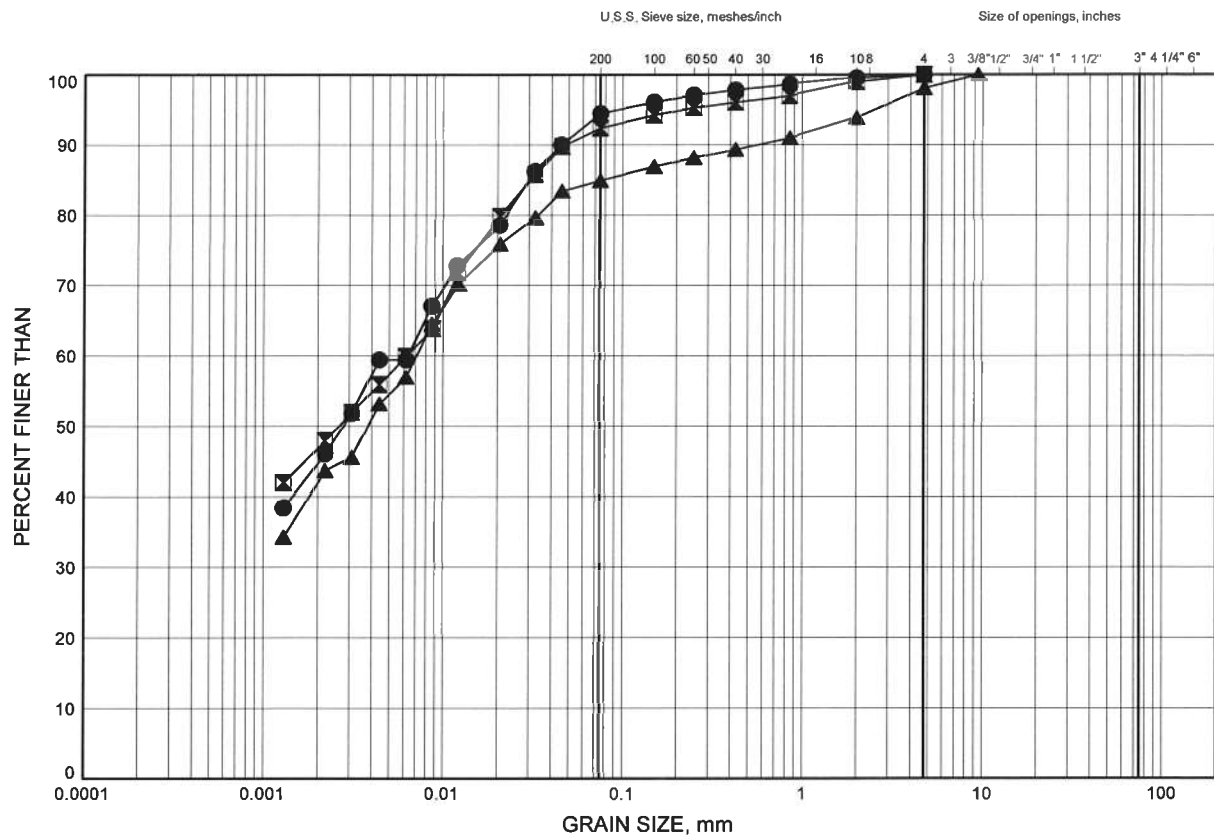
Appendix B
Highway 58 – Richmond Street Underpass

19-1351-221

5 Bridges, Welland and St. Catharines
GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RS12-01	1.83	185.96
■	RS12-01	6.40	181.38
▲	RS12-02	2.59	185.06

Date December 2012
W.P.# 2365-09-00

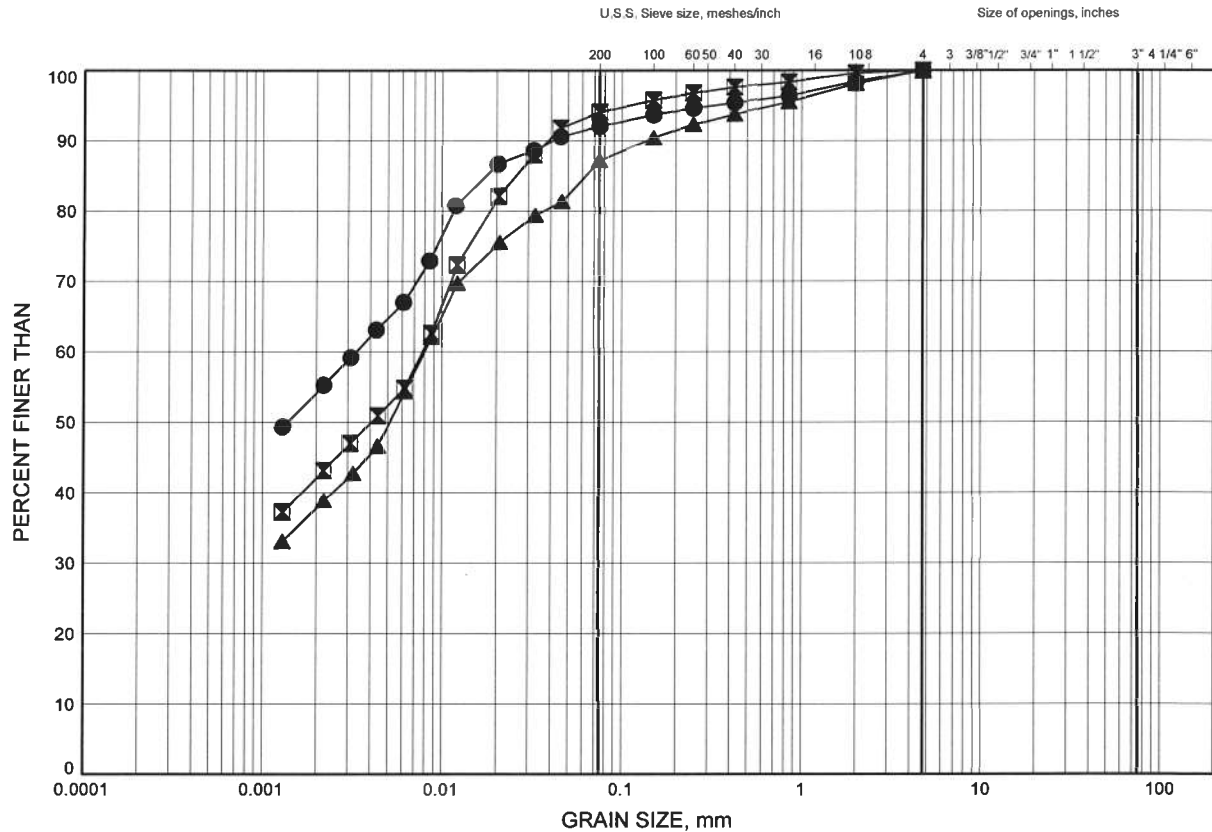


Prep'd AN
Chkd. SKP

5 Bridges, Welland and St. Catharines
GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RS12-01	12.42	175.36
■	RS12-02	7.92	179.73
▲	RS12-02	13.94	173.71

Date December 2012
W.P.# 2365-09-00

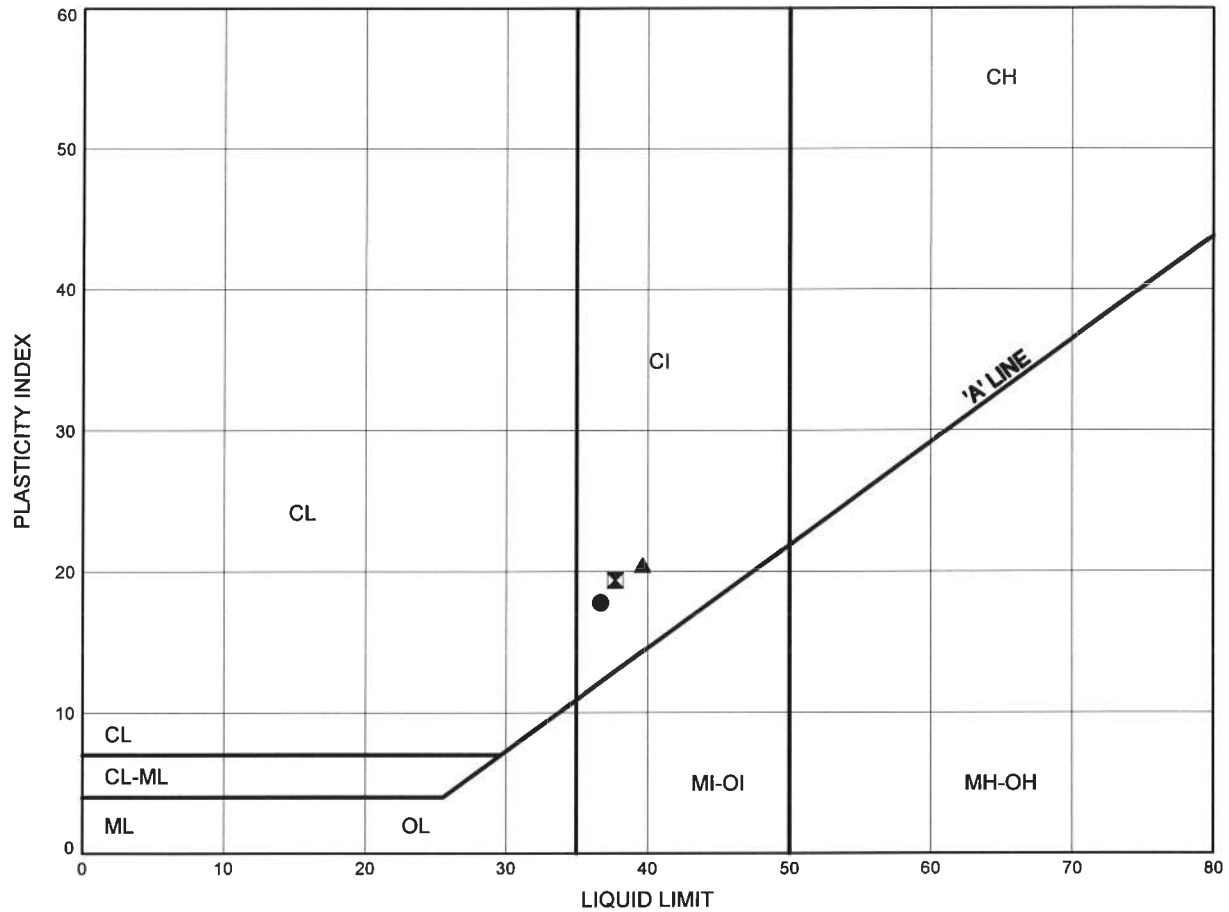


Prep'd AN
Chkd. SKP

5 Bridges, Welland and St. Catharines
ATTERBERG LIMITS TEST RESULTS

FIGURE B3

SILTY CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RS12-01	1.83	185.96
⊠	RS12-01	6.40	181.38
▲	RS12-02	2.59	185.06

Date December 2012
W.P.# 2365-09-00



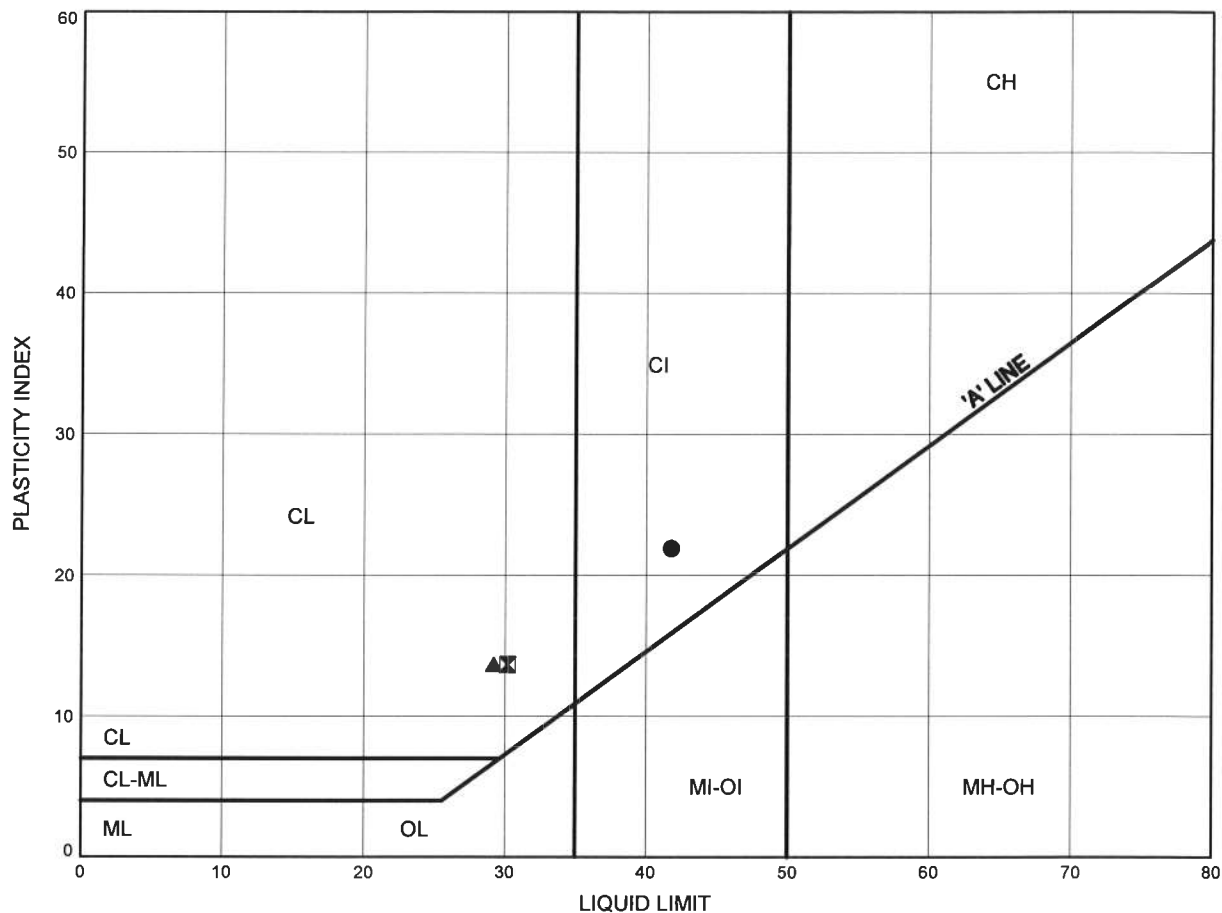
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5 Bridges, Welland and St. Catharines

ATTERBERG LIMITS TEST RESULTS

FIGURE B4

SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RS12-01	12.42	175.36
⊠	RS12-02	7.92	179.73
▲	RS12-02	13.94	173.71

Date December 2012
W.P.# 2365-09-00



Prep'd AN
Chkd. SKP

RECORD OF BOREHOLE No RS74-01

1 OF 2

METRIC

W.P. 80-73-03 LOCATION Richmond St. Underpass ORIGINATED BY HS (DHO)
HWY 58 BOREHOLE TYPE Solid Stem Augers/BXL Coring COMPILED BY NT (DHO)
DATUM Geodetic DATE 1974.07.24 - 1974.07.24 CHECKED BY

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			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
180.9 0.0	Silty CLAY with gravel, trace organics Firm to Stiff (FILL)		1	SS	9							
			2	SS	5		180					
179.5 1.4	Silty CLAY , trace of sand and gravel Very Stiff to Hard		3	TW	PH		179				19.3	
			4	TW	PH		178				20.4	
			5	SS	46							
			6	SS	33		177					6 8 51 35
			7	SS	33		176					
			8	SS	37		175					
			9	SS	25		173					
171.7 9.2	Sandy silt layer						172					
	DOLOMITE BEDROCK		1	RUN			171					RUN #1 TCR=97%

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RS74-01

2 OF 2

METRIC

W.P. 80-73-03 LOCATION Richmond St. Underpass ORIGINATED BY HS (DHO)
 HWY 58 BOREHOLE TYPE Solid Stem Augers/BXL Coring COMPILED BY NT (DHO)
 DATUM Geodetic DATE 1974.07.24 - 1974.07.24 CHECKED BY

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						
	Continued From Previous Page							20 40 60 80 100						
170.0														
10.9	END OF BOREHOLE AT 10.9m.													

RECORD OF BOREHOLE No RS74-02

1 OF 2

METRIC

W.P. 80-73-03 LOCATION Richmond St. Underpass ORIGINATED BY HS (DHO)
HWY 58 BOREHOLE TYPE Solid Stem Augers (BXL Coring) COMPILED BY NT (DHO)
DATUM Geodetic DATE 1974.07.26 - 1974.07.26 CHECKED BY

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							WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE								
								● QUICK TRIAXIAL	× LAB VANE								
180.8 0.0	Silty CLAY , with some sand, trace gravel, trace organics Firm to Stiff (FILL)																
			1	TW	PH								19.9				
179.2 1.6			Silty CLAY , trace sand and gravel Very Stiff to Hard		2	TW	PH		179						19.6		
	3	SS			45	178								0 3 62 35			
	4	SS			37	177											
	5	SS			35	176								0 2 43 55			
	6	SS			20	175											
	7	TW			PH	174								20.7			
	8	SS			33	173											
							172										
171.4 9.4	DOLOMITE BEDROCK									171							RUN #1 TCR=100%

Continued Next Page

+ 3, × 3

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RS74-02

2 OF 2

METRIC

W.P. 80-73-03 LOCATION Richmond St. Underpass ORIGINATED BY HS (DHO)
 HWY 58 BOREHOLE TYPE Solid Stem Augers (BXL Coring) COMPILED BY NT (DHO)
 DATUM Geodetic DATE 1974.07.26 - 1974.07.26 CHECKED BY

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						
	Continued From Previous Page		1	RUN										
169.7							170							
11.1	END OF BOREHOLE AT 11.1m													

+ 3, x 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RS74-03

1 OF 1

METRIC

W.P. 80-73-03 LOCATION Richmond St. Underpass ORIGINATED BY HS (DHO)
HWY 58 BOREHOLE TYPE Solid Stem Augers COMPILED BY NT (DHO)
DATUM Geodetic DATE 1974.07.25 - 1974.07.25 CHECKED BY

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							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
179.8 0.0	Silty CLAY , trace gravel (FILL)		1	SS												
178.9 0.9	Silty CLAY , trace sand and gravel Stiff to Hard		2	SS												
			3	SS												
			4	SS	31											
			5	SS												
			6	SS												
			7	SS												
			8	SS												
			9	SS	51											
171.4 8.4	END OF BOREHOLE AT 8.4m UPON AUGER REFUSAL ON PROBABLE BEDROCK.															

ONTMT4S 1221.GPJ 12/4/12

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

CONT No
GWP No 2365-09-00
WP No 2377-09-01






HIGHWAY 58
RICHMOND STREET UNDERPASS
BRIDGE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
57



KEYPLAN

LEGEND

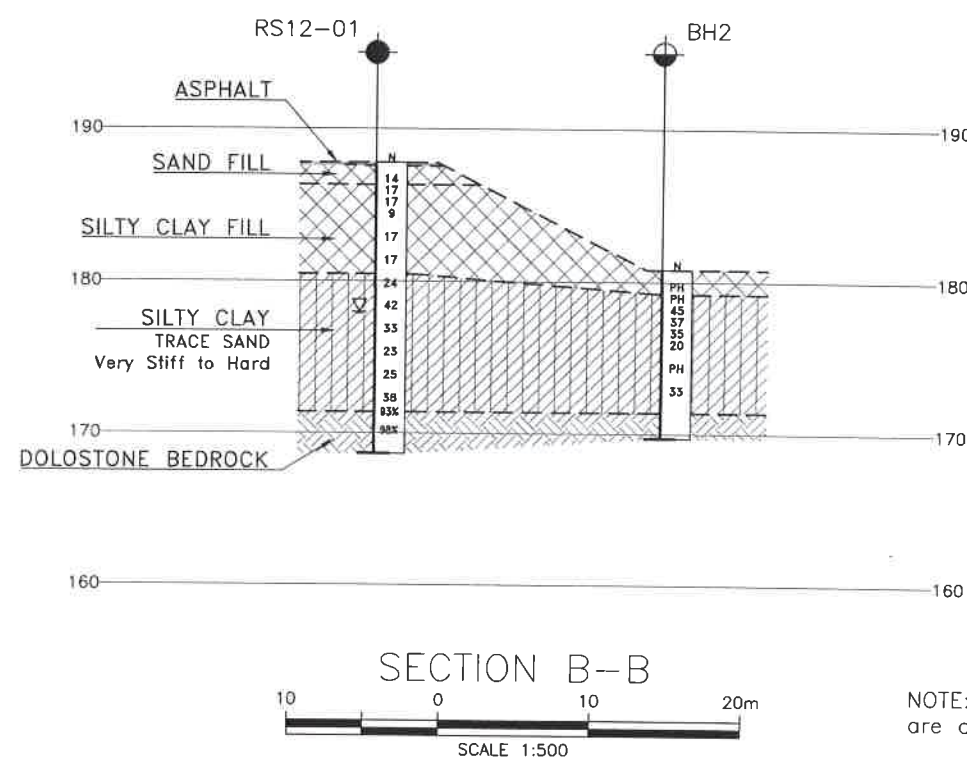
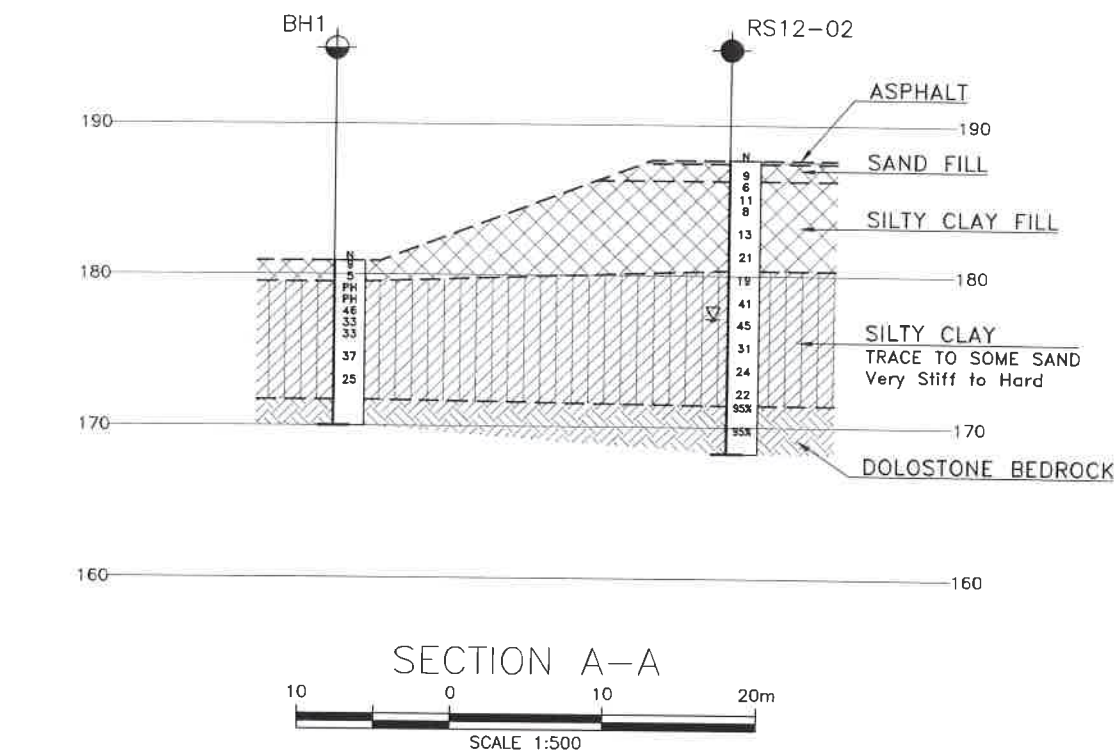
- | | |
|---|---------------------------------------|
|  | Borehole (Current Investigation) |
|  | Borehole (Previous Investigation) |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |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

NO	ELEVATION	NORTHING	EASTING
RS12-01	187.8	4 775 243.3	327 471.8
RS12-02	187.7	4 775 199.3	327 393.1
BH1	180.9	N/A	N/A
BH2	180.8	N/A	N/A
BH3	179.8	N/A	N/A
		N/A: Not Available	

-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.



NOTE: The locations of Boreholes BH1 to 3 are approximate only.

[illegible]