THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
TEMPORARY PROTECTION SYSTEM FOR CULVERT REHABILITATION
HIGHWAY 8
CAMBRIDGE, ONTARIO
CR RETAINER 2016-E-0076
W.P. 2407-15-00, SITE NO. 36-286/C

LATITUDE: 43.3342º, LONGITUDE: -80.2347º

GEOCRES No.: 40P8-258

Report

to

McIntosh Perry

Date: September 13, 2018
File: 20000

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the culvert carrying Highway 8 over an unnamed watercourse, located in Cambridge, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to McIntosh Perry, under the Ministry of Transportation Ontario (MTO) Agreement Number 2016-E-0076, Assignment #2.

2. SITE DESCRIPTION

The culvert is located on Highway 8, approximately 160 m west of Studiman Road in the City of Cambridge, Ontario. The structure consists of a 23.5 m long single span open footing culvert with a width of 3.1 m and an approximate height of 1.5 m. The 23.5 m span consists of an original 17.2 m long reinforced cast-in-place concrete frame culvert and a 6.3 m long reinforced cast-in-place concrete rigid frame extension, that was added to the north of the original culvert under a road widening contract.

The creek flows from north to south. At the time of the investigation, the water depth in the creek was approximately 150 mm. The area immediately adjacent to culvert are treed and the wider area is developed mostly as farmland.

Photographs in Appendix C show the general nature of the site and Highway 8.

The site lies within the physiographical region known as the Flamborough Plain. Surficial geology at the site typically consists of a shallow layer of bouldery glacial till. Bedrock is found at shallow depths or exposed at surface and consist of dolostone of the Guelph Formation.

3. INVESTIGATION PROCEDURES

The site investigation and field testing for this project was carried out on July 9 and July 10, 2018. A total of three sampled boreholes, identified as 18-01 to 18-03, were advanced. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Boreholes 18-01 and 18-02 were drilled near the centreline of Highway 8, and Borehole 18-03 was drilled on the south side of the highway as close to possible to the south end of the Temporary Protection System (TPS). The boreholes were terminated at depths ranging from 5.1 m to 6.0 m, including bedrock coring in all three boreholes.

Details of the drilling program, including drilling depths, and completion details are summarized in Table 3.1 below.

Table 3.1 – Borehole Completion Details

Location	Boreholes	Borehole Depth/Bottom of Hole Elevation (m)	Completion Details
WBL of Highway 8	18-01	5.2 / 255.0	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface.
EBL of Highway 8	18-02	6.0 / 254.1	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface.
South shoulder of Hwy 8	18-03	5.1 / 255.0	Borehole backfilled with bentonite holeplug and cuttings to surface.

All boreholes were advanced using a CME55 track-mounted drill rig in combination with hollow stem augers and HW casing/coring methods. Samples of the encountered soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Core samples of the underlying bedrock were recovered from all boreholes using HQ rock coring equipment. Water for rock coring was brought to site in a tank by the drillers. All cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing. The ground surface elevations at the borehole locations were obtained from drawings provided by MTO.

Groundwater conditions were observed in the open boreholes during the drilling operations.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing, and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and are shown on the figures included in Appendix B.

Unconfined compressive strength (UCS) tests and point load tests (PLT) were performed on selected rock core samples from each borehole. Results of the UCS tests and the PLTs are provided in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the Borehole Locations and Soil Strata drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In summary, the subsurface stratigraphy below the fill typically consists of glacial till overlying dolostone bedrock. More detailed descriptions of individual strata are presented below.

5.1 Asphalt

Asphalt pavement was encountered in Boreholes 18-01 and 18-02. The thickness of the asphalt was measured to be 150 mm in both boreholes. No asphalt was encountered in Borehole 18-03. The asphalt thickness may vary between and beyond borehole locations.

5.2 Silty Sand Fill

Silty sand fill containing some gravel was encountered below the asphalt in Boreholes 18-01 and 18-02 and at the ground surface in Borehole 18-03. The fill thickness ranged between 0.6 m and 0.9 m and extended to depths of 0.8 m to 0.9 m (Elev. 259.4 m to 259.2 m).

One natural moisture content of 11% was measured in the silty sand fill.

5.3 Silty Clay Fill

A layer of brown to black silty clay fill was encountered below the silty sand fill in all three boreholes. The silty clay fill contained trace sand to sandy, trace gravel and trace organic material. The thickness of the silty clay fill ranged between 0.6 m and 1.5 m with the lower boundary encountered between 1.5 m and 2.3 m depth (Elev. 258.7 m to 257.8 m).

SPT-N values recorded in the silty clay fill ranged from 4 to 17 blows per 0.3 m of penetration, indicating a firm to very stiff consistency. Natural moisture contents of the silty clay fill ranged between 20% and 46%.

The results of one grain size analysis conducted on a sample of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	7
Sand	23
Silt	46
Clay	24

The results of one Atterberg limit test conducted on a sample of the fill are also shown on the Record of Borehole sheets in Appendix A and plotted in Figure B4 of Appendix B. Atterberg results indicate a low plasticity clay, CL. The results are summarized below.

Liquid Limit	29
Plastic Limit	17
Plastic Index	12

5.4 Sand and Silt Till

A deposit of brown sand and silt till was encountered below the silty clay fill in Borehole 18-01. The deposit contained some clay and some gravel. The thickness of the layer was 0.6 m with the lower boundary at 2.1 m depth (Elev. 258.1 m).

One SPT-N value of 16 blows per 0.3 m of penetration was recorded in the deposit, indicating a compact relative density. Natural moisture content of the cohesionless deposit was 10%.

The results of one grain size analysis conducted on a sample of the deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B2 of Appendix B. The results are summarized below.

Soil Particle	Percentage (%)
Gravel	11
Sand	40
Silt	38
Clay	11

Glacial till inherently contains cobbles and boulders and the lower part of the till may contain slabs of bedrock.

5.5 Silty Clay Till

A grey silty clay till deposit was encountered below the silty clay fill in Borehole 18-03. This deposit contained some sand. The thickness of the deposit was 0.6 m, with the lower boundary at 2.1 m depth (Elev. 258.0 m).

One SPT-N value of 24 blows per 0.3 m of penetration was recorded in the deposit, indicating a very stiff consistency. Natural moisture contents ranged from 17% to 19%.

The results of a grain size analysis conducted on one sample of this deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B3 of Appendix B. The results are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	17
Silt	45
Clay	38

The results of one Atterberg Limits tests conducted on a sample of this deposit are also provided on the Record of Borehole sheets in Appendix A and plotted in Figure B5 of Appendix B. Results indicate a low plasticity clay, CL. The results are summarized below.

Liquid Limit	34
Plastic Limit	17
Plastic Index	17

Glacial till inherently contains cobbles and boulders and the lower part of the till may contain slabs of bedrock.

5.6 Bedrock

Dolostone bedrock was encountered in Borehole 18-01 below the sand and silt till layer, underlying the silty clay fill in Borehole 18-02, and underlying the silty clay till in Borehole 18-03. The presence of bedrock was proven by coring in all boreholes. Table 5.1 summarizes the depth to bedrock and the bedrock surface elevations determined in the boreholes.

Table 5.1 – Depth to Bedrock at Borehole Locations

Borehole	Depth to Bedrock (mbgs)	Top of Bedrock Elevation (m)
18-1	2.1	258.1
18-2	2.3	257.8
18-3	2.1	258.0

The bedrock is generally described as moderately to slightly weathered, grey dolostone. A clay seam was encountered in Borehole 18-01. Total Core Recovery (TCR) in the bedrock ranged from 95% to 100%. The Rock Quality Designation (RQD) determined from the recovered cores ranged from 28 to 77%, indicating poor to good rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to greater than 10.

The results of three UCS tests ranged from ranged between 43 MPa and 113 MPa. The UCS strength of the rock, estimated from the results of point load tests, ranged from 10 MPa to 135 MPa, typically from 40 MPa to 115 MPa. This would indicate that the bedrock is medium strong to very strong rock.

Photographs of the rock cores are included in Appendix E.

5.7 Groundwater Conditions

Water levels were monitored in the open boreholes during drilling operations. All boreholes, from 18-01 to 18-03, were observed to be dry upon completion of augering. Creek water levels were observed to be at approximately Elev. 258.2 during drilling operations. Seasonal fluctuations of the groundwater and creek levels are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6. MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The coordinates and elevations of the boreholes were established based on topographic survey information provided by MTO.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Geo-Environmental Drilling of Halton Hills, Ontario supplied a track-mounted CME-55 drill rig, and conducted the drilling, sampling and in-situ testing operations for the boreholes.

Temporary traffic control during the field investigation was provided by Direct Traffic Management Inc. of Hamilton, Ontario.

The drilling operations were supervised by Mr. Jilesh Patel, EIT of Thurber. Overall supervision of the field program and interpretation of the data were carried out by Mr. Matthew Boucher, P.Eng.

The report was prepared by Ms Judy Mei, EIT, and reviewed by Mr. Matthew Boucher, P.Eng., and Dr. P.K. Chatterji , P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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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

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

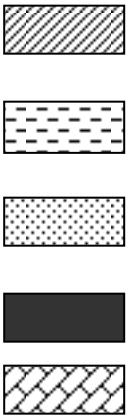
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

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.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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RECORD OF BOREHOLE No 18-01 1 OF 1 METRIC

W.P. 2407-15-00 LOCATION MTM NAD 83 Zone10: N 4 799 633.5 E 245 226.4 ORIGINATED BY JP

HWY 8 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY AN

DATUM Geodetic DATE 2018.07.09 - 2018.07.10 LATITUDE 43.334228 LONGITUDE -80.234664 CHECKED BY MTB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	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 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.2	GROUND SURFACE						260				
0.0	**ASPHALT:** (150mm)										
0.2	Silty **SAND**, some gravel Brown Moist (FILL)										
259.4											
0.8	Silty **CLAY**, trace sand, trace gravel, trace organics, pieces of cobbles Firm Brown Moist (FILL)		1	SS	4		259		○		
258.7											
1.5	**SAND** and **SILT**, some clay, some gravel Compact Brown Moist (TILL)		2	SS	16				○		11 40 38 11
258.1							258			FI	
2.1	**DOLOSTONE** moderately to slightly weathered, medium to very strong, grey: (Guelph Formation) vertical fracture (500mm) at 2.1m vertical fracture (300mm) at 3.5m clay seam at 3.5m		1	RUN			257			3 3 1 1 3 >10 5 3 4 2	RUN #1 TCR=95% SCR=53% RQD=46% RUN #2 TCR=100% SCR=89% RQD=44%
255.0			2	RUN			256				
5.2	END OF BOREHOLE AT 5.2m. BOREHOLE DRY UPON COMPLETION OF AUGERING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.						255				

$+^3$, $\times^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 18-02 1 OF 1 METRIC

W.P. 2407-15-00 LOCATION MTM NAD 83 Zone10: N 4 799 635.1 E 245 216.3 ORIGINATED BY JP

HWY 8 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.07.09 - 2018.07.09 LATITUDE 43.334242 LONGITUDE -80.234788 CHECKED BY MTB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	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 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.1	GROUND SURFACE						260				
0.0	**ASPHALT**: (150mm)										
0.2	Silty **SAND**, some gravel Brown Moist (FILL)										
259.3							259				
0.8	Silty **CLAY**, sandy, trace gravel, trace organics, trace rootlets Stiff to Very Stiff Grey to Black Moist (FILL)		1	SS	9						7 23 46 24
			2	SS	17						
257.8			3	SS	100/ 0.025		258			FI	
2.3	**DOLOSTONE**, moderately to slightly weathered, medium strong to very strong, grey: (Guelph Formation) sub vertical fracture at (175mm) at 2.3m, (100mm) at 2.6m, (75mm) at 3.2m		1	RUN						5 4 4	RUN #1 TCR=100% SCR=65% RQD=28%
							257			2	
	vertical fracture (25mm) at 3.6m and 4.1m Note: No return of coring fluid below 4.0m		2	RUN						5 5 4	RUN #2 TCR=100% SCR=67% RQD=31%
							256			4	
			3	RUN						5 4 3	RUN #3 TCR=100% SCR=71% RQD=34%
							255			2	
254.1	vertcial fracture (275mm) at 5.7m									2	
6.0	END OF BOREHOLE AT 6.0m. BOREHOLE DRY UPON COMPLETION OF AUGERING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

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Ontario

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RECORD OF BOREHOLE No 18-03 1 OF 1 METRIC

W.P. 2407-15-00 LOCATION MTM NAD 83 Zone10: N 4 799 624.9 E 245 223.7 ORIGINATED BY JP

HWY 8 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.07.09 - 2018.07.09 LATITUDE 43.334151 LONGITUDE -80.234696 CHECKED BY MTB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.1	GROUND SURFACE						260			
0.0	Silty **SAND**, some gravel Brown Dry to Moist (FILL)									
259.2			1	SS	9		259			
0.9	Silty **CLAY**, trace sand, trace gravel Stiff Grey Moist (FILL)									
258.6			2	SS	24		258			0 17 45 38
1.5	Silty **CLAY**, some sand Very Stiff Grey Moist (TILL)									
258.0	**DOLOSTONE** moderately to slightly weathered, strong to very strong, grey: (Guelph Formation) vertical fracture (250mm) at 2.3m and (50mm) at 2.6m Note: No return of coring fluid below 3.6m		1	RUN			257			FI 2 2 3 0 0 >10 3 4 3 1
2.1			2	RUN			256			RUN #1 TCR=100% SCR=81% RQD=77% RUN #2 TCR=100% SCR=97% RQD=68%
255.0										
5.1	END OF BOREHOLE AT 5.1m. BOREHOLE OPEN AND DRY UPON COMPLETION OF AUGERING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.									

$+^3$, $\times^3$: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S2 MTO-20000.GPJ 2017TEMPLATE(MTO).GDT 8/29/18

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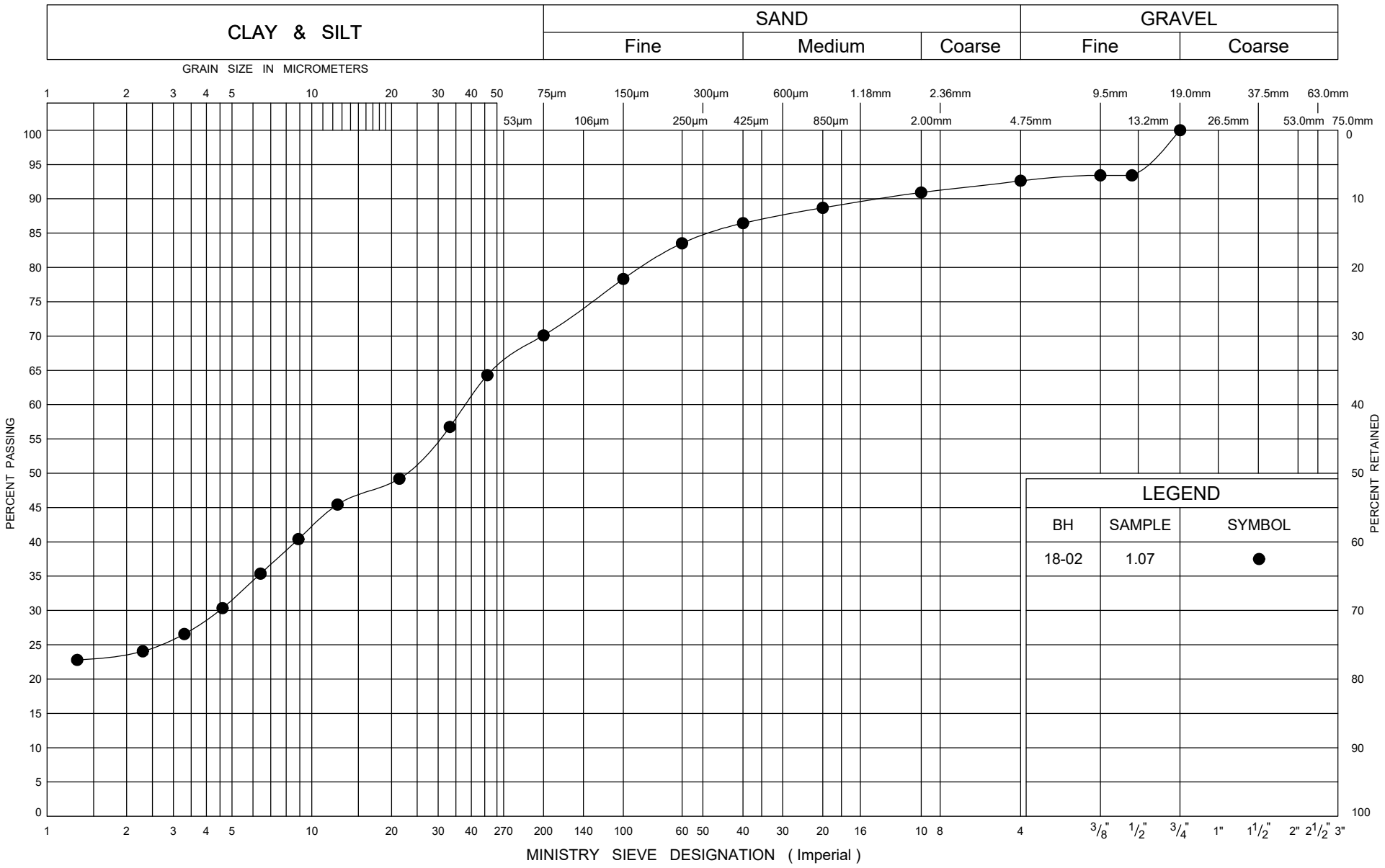
Appendix B

Laboratory Test Results



Ministry of Transportation
Ontario

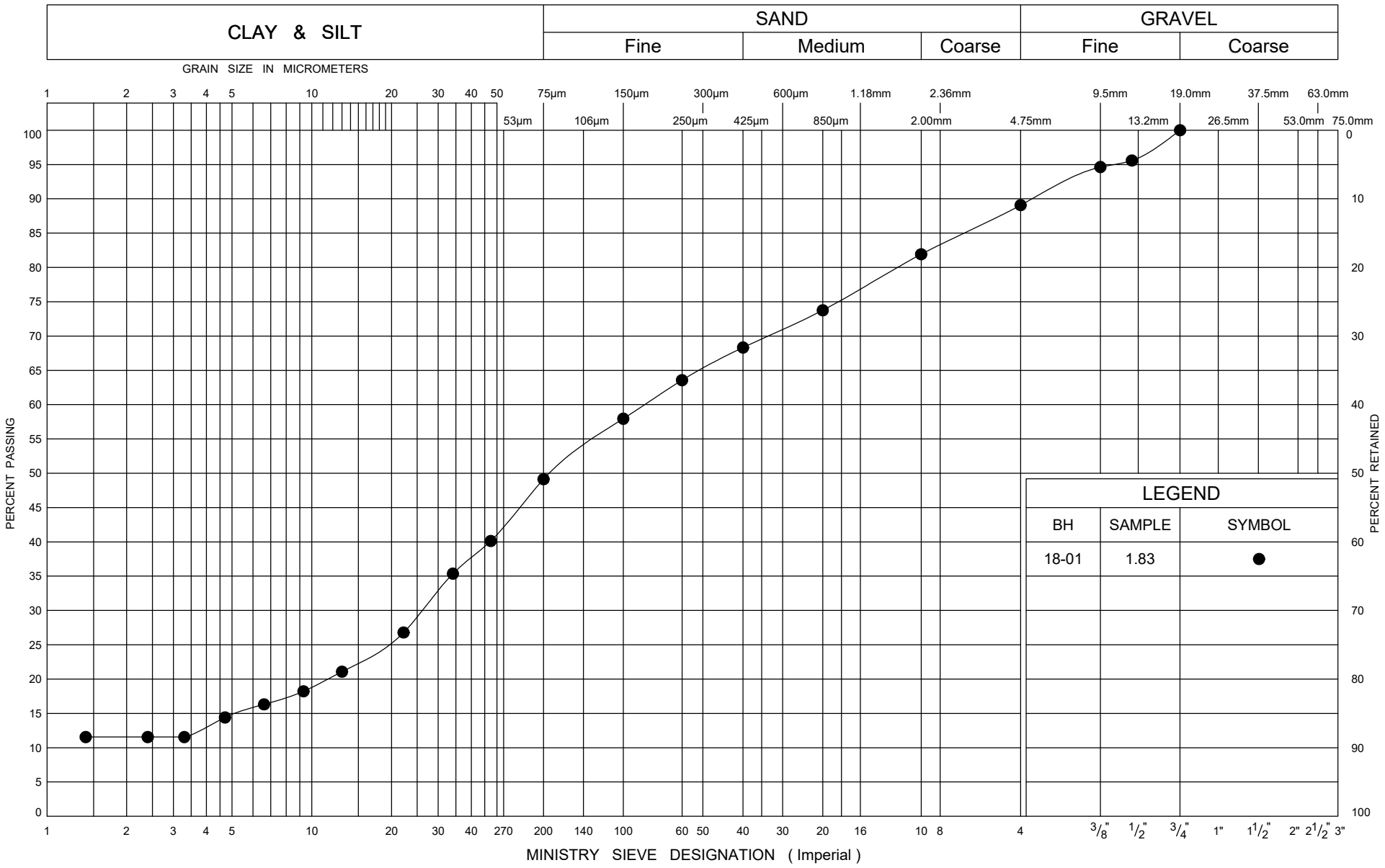
GRAIN SIZE DISTRIBUTION

Silty CLAY FILL

FIG No B1

W P 2407-15-00

ONTARIO MOT GRAIN SIZE 2 MTO-20000.GPJ ONTARIO MOT.GDT 8/29/18



ONTARIO MOT GRAIN SIZE 2 MTO-20000.GPJ ONTARIO MOT.GDT 8/29/18

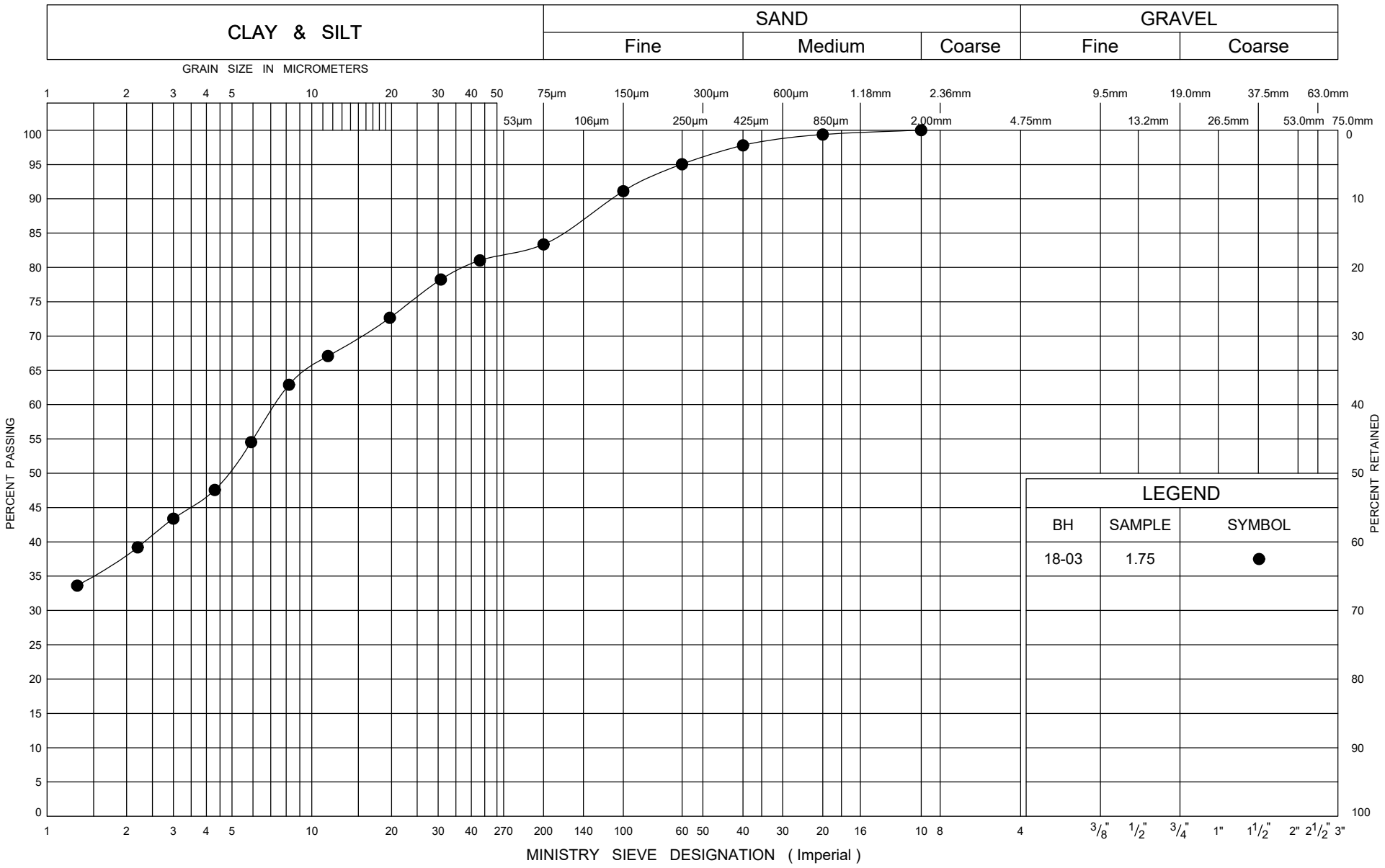
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

SAND & SILT TILL

FIG No B2

W P 2407-15-00



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GRAIN SIZE DISTRIBUTION

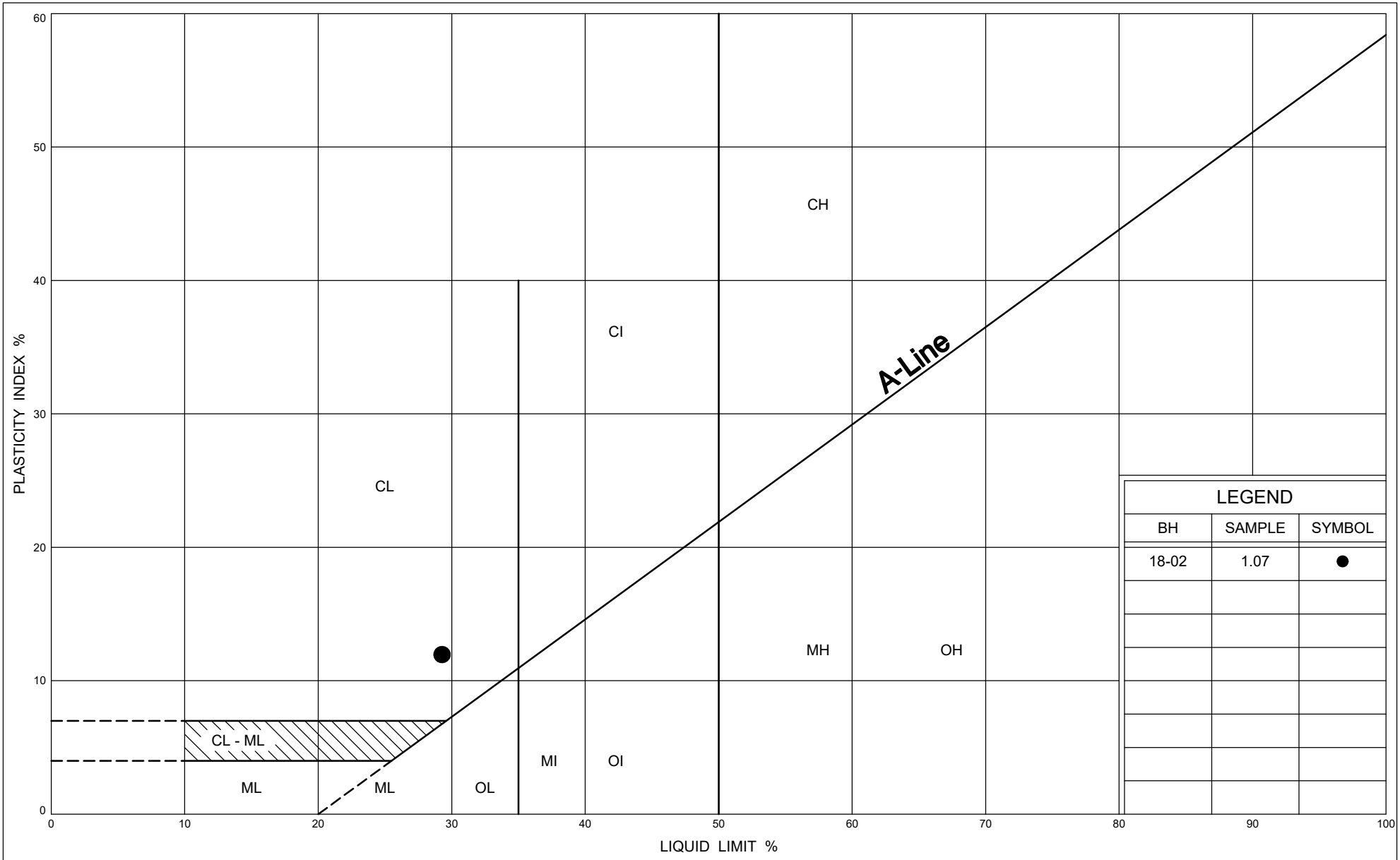
Silty CLAY TILL

FIG No B3

W P 2407-15-00

ONTARIO MOT GRAIN SIZE 2 MTO-20000.GPJ ONTARIO MOT.GDT 8/29/18

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-20000.GPJ ONTARIO MOT.GDT 8/29/18

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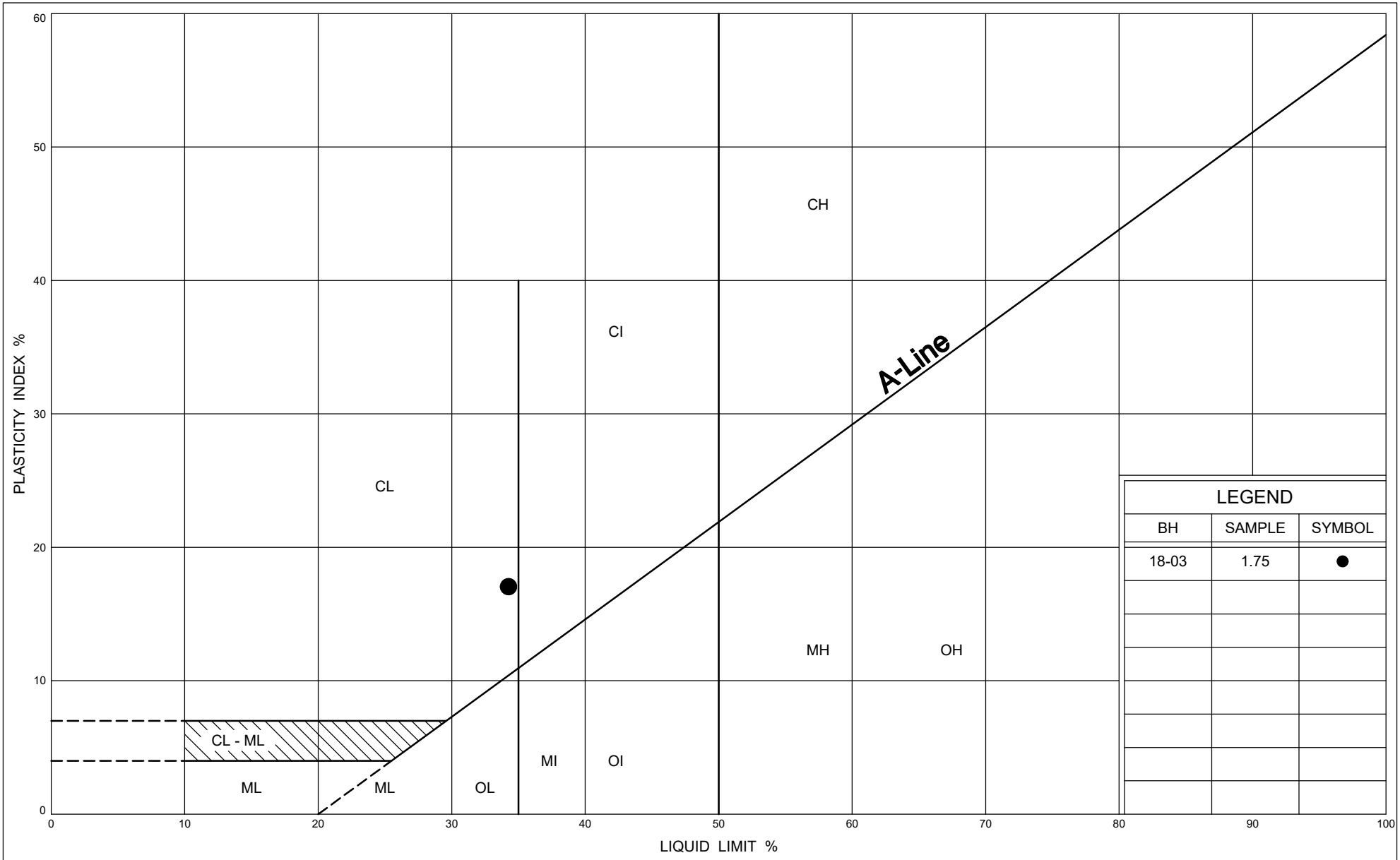
PLASTICITY CHART

Silty CLAY FILL

FIG No B4

W P 2407-15-00

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-20000.GPJ ONTARIO MOT.GDT 8/29/18

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Ontario

PLASTICITY CHART

Silty CLAY TILL

FIG No B5

W P 2407-15-00

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UNCONFINED COMPRESSION TEST REPORT

ASTM D 2938 - 95

CLIENT:	McIntosh Perry	FILE NUMBER:	20000
PROJECT NAME:	CR RETAINER 2016-E-0076	REPORT DATE:	17-Aug-18
BOREHOLE No.:	18-01	TEST DATE:	3-Aug-18
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	9'10" - 10'3"		
DESCRIPTION:	DOLOSTONE		

Avg. Height (cm):	12.75	Weight (g):	1096.8
Avg. Diameter (cm):	6.34	Wet Density (kg/m^3):	2,725
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,721
Cross Sectional Area (cm^2):	31.57	Moisture Content* (%):	0.1
Sample Volume (cm^3):	402.51		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

MAXIMUM COMPRESSIVE LOAD:	210.0	kN
UNCONFINED COMPRESSIVE STRENGTH:	66.5	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: EA
REVIEWED BY: WM

UCS Test Results

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

ASTM D 2938 - 95

CLIENT:	McIntosh Perry	FILE NUMBER:	20000
PROJECT NAME:	CR RETAINER 2016-E-0076	REPORT DATE:	17-Aug-18
BOREHOLE No.:	18-02	TEST DATE:	3-Aug-18
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	9'4" - 9'9"		
DESCRIPTION:	DOLOSTONE		

Avg. Height (cm):	12.18	Weight (g):	1030.2
Avg. Diameter (cm):	6.33	Wet Density (kg/m^3):	2,688
H. to Dia. Ratio**:	1.9:1	Dry Density (kg/m^3):	2,684
Cross Sectional Area (cm^2):	31.47	Moisture Content* (%):	0.2
Sample Volume (cm^3):	383.31		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

MAXIMUM COMPRESSIVE LOAD:	135.0	kN
UNCONFINED COMPRESSIVE STRENGTH:	42.9	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: EA
REVIEWED BY: WM

UCS Test Results

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

ASTM D 2938 - 95

CLIENT:	McIntosh Perry	FILE NUMBER:	20000
PROJECT NAME:	CR RETAINER 2016-E-0076	REPORT DATE:	17-Aug-18
BOREHOLE No.:	18-03	TEST DATE:	3-Aug-18
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	9'6" - 9'11"		
DESCRIPTION:	DOLOSTONE		

Avg. Height (cm):	12.90	Weight (g):	1100.4
Avg. Diameter (cm):	6.33	Wet Density (kg/m^3):	2,711
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,706
Cross Sectional Area (cm^2):	31.47	Moisture Content* (%):	0.2
Sample Volume (cm^3):	405.96		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

MAXIMUM COMPRESSIVE LOAD:	355.0	kN
UNCONFINED COMPRESSIVE STRENGTH:	112.8	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: EA
REVIEWED BY: WM

UCS Test Results

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	20000	**Date Drilled:**	10 July, 2018
Client:	McIntosh Perry	**Date Tested:**	11 July, 2018
Project Name:	CR Retainer 2016-E-0076	**Tester:**	BS
Core Size:	HQ **BH No :** 18-01	**Reviewed by:**	MTB

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	2.7	Diametral	7.7	62.6	65.7	1.6	39.5	Dolostone	Medium Strong
2	1	3.1	Diametral	17.5	62.7	66.5	3.7	89.1	Dolostone	Strong
3	2	4.0	Diametral	2.0	62.8	64.1	0.4	10.2	Dolostone	Weak
4	2	4.2	Diametral	14.9	62.7	64.9	3.2	77.2	Dolostone	Strong
5	2	4.6	Diametral	25.3	62.5	63.0	5.6	134.4	Dolostone	Very Strong
6	2	4.9	Diametral	19.7	62.6	62.1	4.4	105.8	Dolostone	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	20000	**Date Drilled:**	9 July, 2018
Client:	McIntosh Perry	**Date Tested:**	11 July, 2018
Project Name:	CR Retainer 2016-E-0076	**Tester:**	BS
Core Size:	HQ **BH No :** 18-02	**Reviewed by:**	MTB

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	2.9	Diametral	3.2	62.7	68.9	0.7	16.0	Dolostone	Weak
2	1	3.1	Diametral	17.5	62.9	65.5	3.7	89.6	Dolostone	Strong
3	2	3.5	Diametral	7.8	62.6	61.9	1.7	41.8	Dolostone	Medium Strong
4	2	4.0	Diametral	14.4	62.8	67.4	3.0	72.1	Dolostone	Strong
5	2	4.5	Diametral	23.3	62.8	67.6	4.9	116.6	Dolostone	Very Strong
6	3	5.3	Diametral	19.7	62.5	64.5	4.3	102.9	Dolostone	Very Strong
7	3	5.6	Diametral	25.5	62.9	62.9	5.6	134.9	Dolostone	Very Strong
8										
9										
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
  Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	20000	**Date Drilled:**	9 July, 2018
Client:	McIntosh Perry	**Date Tested:**	11 July, 2018
Project Name:	CR Retainer 2016-E-0076	**Tester:**	BS
Core Size:	HQ **BH No :** 18-03	**Reviewed by:**	MTB

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	2.3	Diametral	3.9	62.8	68.3	0.8	19.3	Dolostone	Weak
2	1	2.7	Diametral	23.4	62.7	66.7	4.9	118.6	Dolostone	Very Strong
3	1	3.1	Diametral	19.1	62.7	67.1	4.0	96.1	Dolostone	Strong
4	1	3.4	Diametral	4.8	62.6	69.0	1.0	23.6	Dolostone	Weak
5	2	3.9	Diametral	17.5	62.6	68.1	3.6	87.1	Dolostone	Strong
6	2	4.4	Diametral	20.6	62.8	65.2	4.4	106.2	Dolostone	Very Strong
7	2	4.9	Diametral	21.4	62.8	64.0	4.6	111.6	Dolostone	Very Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
  Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

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Appendix C

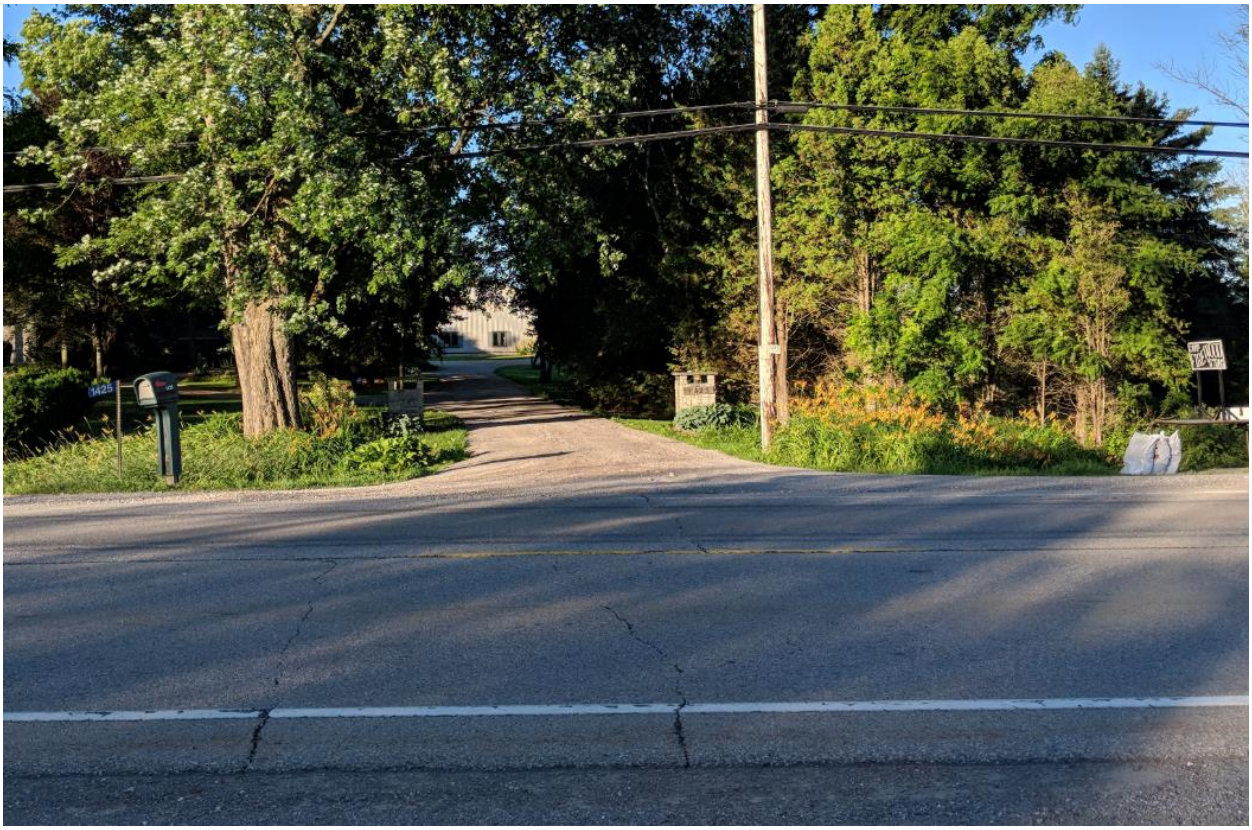
Site Photographs

Photograph 1 – Stream North of Culvert

Photograph 2 – Stream South of Culvert

Photograph 3 – Highway 8, Facing West

Photograph 4 – Highway 8, Facing East



Photograph 5 – Highway 8, Facing South

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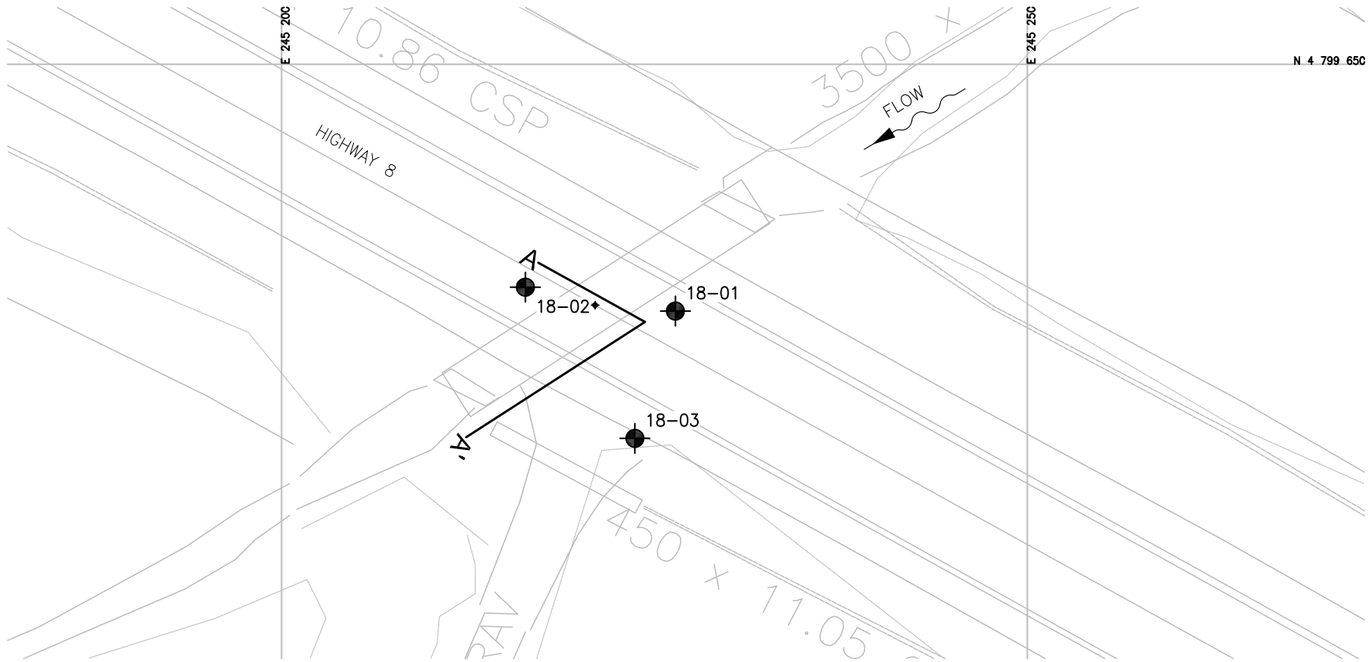
Appendix D

Borehole Locations and Soil Strata Drawing

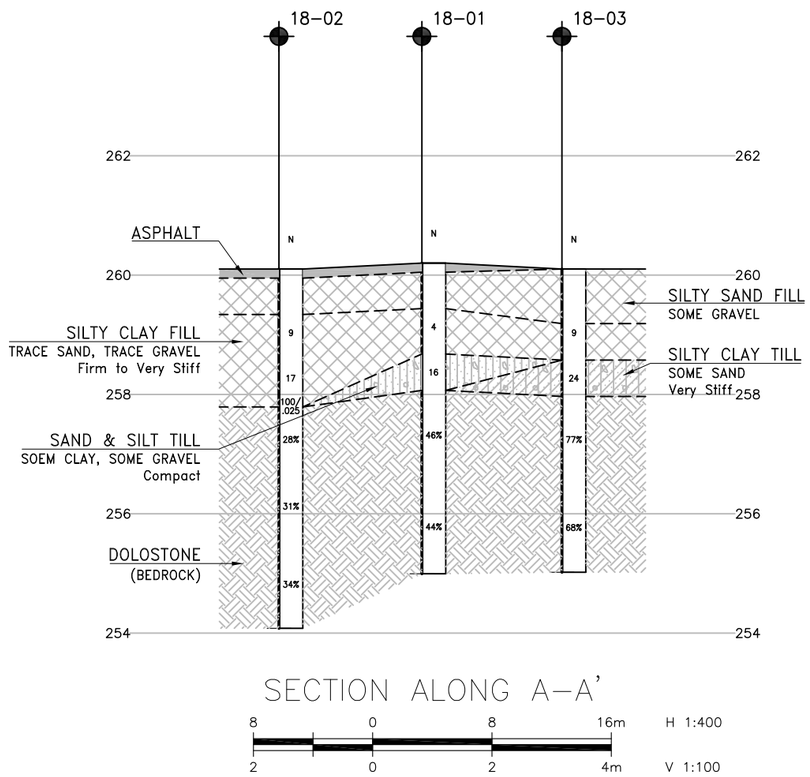
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

8 0 8 16m

SCALE 1:400



SECTION ALONG A–A'

8 0 8 16m H 1:400

2 0 2 4m V 1:100

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 2407-15-00

SHEET

HIGHWAY 8
CULVERT REHABILITATION
TEMPORARY PROTECTION SYSTEM
BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
18-01	260.2	4 799 633.5	245 226.4
18-02	260.1	4 799 635.1	245 216.3
18-03	260.0	4 799 624.9	245 223.7

-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.
3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 40P08-258

LICENSED PROFESSIONAL ENGINEER
M. T. BOUCHER
100181961
Sept. 13/18
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Sep 13/18
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	MTB	CHK	CODE	LOAD	DATE AUG 2018
DRAWN	AN	CHK MTB	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\20000\20000\TED-20000-PLPR.dwg
PLOTDATE: 8/29/2018 5:06 PM

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Appendix E

Photos of Rock Core Samples

Rock Core Photos for Borehole 18-01: Run #1 (2.1 m – 3.6 m) and Run #2 (3.6 m – 5.2 m)

Rock Core Photos for Borehole 18-02: Run #1 (2.3 m – 3.4 m), Run #2 (3.4 m – 4.5 m) and Run #3 (4.5 m – 6.0 m)

Rock Core Photos for Borehole 18-03: Run #1 (2.1 m – 3.6 m) and Run #2 (3.6 m – 5.1 m)