THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
ASSESSMENT OF REUSE OF EXISTING PILE FOUNDATIONS
GREENOCK CREEK BRIDGE REHABILITATION
HIGHWAY 9
BROCKTON, ONTARIO
ASSIGNMENT NUMBER: 3020-E-0004-04
G.W.P. 3075-14-00, SITE NO. 02X-0258/B0

LATITUDE: 44.096375º, LONGITUDE: -81.284513º

GEOCRES No.: 42A-252

Report

to

GHD

Date: August 15, 2022
File: 33249

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for reuse of the existing pile foundations for the Greenock Creek Bridge Rehabilitation, located on Highway 9 in Brockton, Ontario.

The purpose of this investigation was to drill a number of boreholes to collect soil and groundwater samples, and conduct analytical corrosivity testing to assess whether the soil and groundwater surrounding the existing piles are corrosive in nature and could result in corrosion and deterioration of the existing foundation. In addition, down-hole geophysical testing were carried out to estimate the length of the existing piles as no pile driving records were available. Based on this information, an assessment has been made of the carrying capacity of the existing piles.

Thurber carried out the investigation as a sub-consultant to GHD, under the Ministry of Transportation Ontario (MTO) Retainer Agreement Number 3020-E-0004, Work Order #4 and #9.

For preparation of this report, reference has been made to the following drawings:

- Contract Drawings for Greenock Creek Bridge – 5.8 Miles West of Walkerton West Limits, King's Highway No. 4 & 9, Township of Greenock, Site No. 2-258, W.P. No 7.66.01, dated January 1969. (Reference 1). Excerpts of the foundation drawings can be found in Appendix F. The drawings also show the borehole stratigraphy during the original construction of the bridge in 1971 (Contract No. 71-25).

2. SITE DESCRIPTION

Greenock Creek Bridge is located on Highway 9, which runs west to east between Highway 400 and the Town of Kincardine in the Municipality of Brockton, Ontario, and approximately 11 km west of the Highway 9 and Highway 4 junction at the Town of Walkerton.

This section of Highway 9 is a two-lane roadway and the existing bridge carries traffic over Greenock Creek. The height of the approach embankments are in the order of 3 to 4 m. The existing bridge, which was built in the 1971, is a single-span structure with a span of 17.7 m. Available drawings show the existing abutments are supported on battered BP12x53 piles (HP310x79) which were intended to be approximately 26 feet (7.9 m) long. The piles were driven into very dense silty sand with gravel till. Please refer to excerpts of archived historical contract drawings in Appendix F.

It is understood that the existing bridge is to be rehabilitated, which will involve superstructure replacement, and MTO is considering utilizing the existing foundations. It was not practical to expose the existing piles for visual examination. Therefore, this soil and groundwater assessment was conducted to assess whether there is a potential for the existing pile foundations to be corroded due to exposure to potentially corrosive soil and groundwater conditions. The geotechnical capacities of the existing piles were also assessed.

Greenock Creek and the surrounding area is environmentally protected, and the surrounding land zoned for agricultural use. The site topography is gently undulating. At the bridge location, the highway grade is at Elevation 283.7 to 283.9 m. The creek water surface elevation from Reference 1 is approximately 279.6 m.

Photographs in Appendix C show the general nature of the site and the existing bridge.

Archived historical contract drawings attached in Appendix F also show the old Greenock Creek bridge and alignment of the creek that was originally located just west of the current location. Remnants of the original bridge structure and creek bed may be present below the west abutment approach.

Based on the Physiography of Southern Ontario, the physiographic region of the Greenock Creek comprises horseshoe moraines, described as north-south trending moraines with variable and somewhat coarse material. Surficial geology mapping of the site indicates that the site primarily contains modern alluvial deposits from the existing Greenock Creek. North of the site, glaciofluvial

and glaciolacustrine deposits containing silt, clay, and minor sand and gravel are observed. Stone-poor clay till was mapped south of the site.

Based on the Ontario Geological Survey (OGS) Map MRD219 titled “Paleozoic Geology of Southern Ontario”, the bedrock at site is the Amhurstburg Formation. The Amhurstburg Formation primarily contains limestone and dolostone, the formation is described as bituminous, cherty, and locally biohermal.

3. INVESTIGATION PROCEDURES

The borehole investigation for this project was carried out between April 26th to May 12th, 2022. A total of six sampled boreholes, identified as 22-01 to 22-06, were advanced through the pavement/shoulder of Highway 9, and at the toes of the approach embankments of Greenock Creek Bridge. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Boreholes 22-01, 22-02, 22-05, and 22-06 were advanced through the pavement of Highway 9. Boreholes 22-05 and 22-06 were drilled through the existing bridge deck. Boreholes 22-03 and 22-04 were advanced adjacent to the toe of the approach embankment at the south corner of the west abutment and to the north corner of the east abutment, respectively. The boreholes were terminated at depths ranging from 10.4 m to 15.5 m (Elev. 270.8 to 268.2 m). Boreholes 22-03, 22-04, 22-05, and 22-06 were also strategically located as close as possible to the existing piles to facilitate the down-hole geophysical tests.

The borehole logs are included in Appendix A, and the approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The as-drilled borehole locations and elevations were surveyed using a Trimble Catalyst DA1 antenna with centimeter accuracy. The coordinate system MTM NAD 83, Zone 11 was used for the boreholes.

Details of the drilling program, including drilling depths, piezometer installation and completion details are summarized in Table 3.1 below. Groundwater levels were noted in the open boreholes. Piezometers were installed in Boreholes 22-01 and 22-02 and decommissioned in general accordance with O.Reg. 903 at the completion of the field program. The boreholes without monitoring wells (Boreholes 22-03 to 22-06) had a 50 mm diameter, Schedule 40 PVC pipe installed and the annulus around the pipe grouted in preparation for the geophysical investigation.

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Table 3.1 – Borehole Completion Details

Location	Boreholes	Borehole Depth/ Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
West Abutment	22-01	15.4 / 268.5	6.9 / 277.0	50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. Piezometer decommissioned and borehole backfilled with bentonite in general accordance with O.Reg. 903.
	22-03	10.4 / 270.8	None installed	50 mm diameter Schedule 40 PVC pipe installed and annulus grouted for geophysical testing
	22-05	15.5 / 268.4	None installed	50 mm diameter Schedule 40 PVC pipe installed and annulus grouted for geophysical testing. Hole through bridge deck was filled with quick-set grout.
East Abutment	22-02	15.5 / 268.2	15.2 /268.5	50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. Piezometer decommissioned and borehole backfilled with bentonite in general accordance with O.Reg. 903.
	22-04	12.5 / 268.6	None installed	50 mm diameter Schedule 40 PVC pipe installed and annulus grouted for geophysical testing
	22-06	15.5 / 268.3	None installed	50 mm diameter Schedule 40 PVC pipe installed and annulus grouted for geophysical testing. Hole through bridge deck was filled with quick-set grout.

Boreholes 22-01, 22-02, 22-05, and 22-06 were advanced using a truck-mounted Diedrich D90 drill rig, using hollow stem auger and/or wash boring techniques. Due to access constraints, Boreholes 22-03 and 22-04 were advanced using a portable Hilti drill equipment using wash boring techniques. In all boreholes with the truck-mounted drill rig, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT). For the portable Hilti drill equipment boreholes, soil samples were obtained at selected intervals with a 64 mm outside diameter split spoon sampler.

Traffic control services was employed during the drilling at the bridge approaches and while drilling through the bridge deck.

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 samples for transport to Thurber's laboratory for further examination and testing.

4. LABORATORY TESTING

4.1 Geotechnical Testing

All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to grain size distribution analysis (hydrometer and/or sieve analysis as appropriate). The results of these laboratory tests are summarized on the Record of Borehole Sheets included in Appendix A and are presented on the figures included in Appendix B.

4.2 Analytical Chemical Testing

A total of thirty-eight (38) of the recovered soil samples were submitted to an analytical laboratory for analysis of corrosivity parameters, including chloride, sulphate, pH, electrical conductivity (EC), resistivity, redox potential, and sodium adsorption ration (SAR). Samples taken at close intervals from the top of the existing piles to a depth of 8.2 m were subjected to the testing. The frequency of testing was reduced below this depth. Groundwater samples from Boreholes 22-01 and 22-02, as well as the Greenock Creek water sample were subsequently collected and were submitted to the laboratory to test for corrosivity parameters. The results of the analytical laboratory testing are shown on the Certificates of Analysis included in Appendix B.

5. GEOPHYSICAL INVESTIGATION

No as-built records were available to indicate the depth of existing piles and hence, down-hole geophysical tests were used to estimate the pile length. The tests were conducted by Geophysics GPR International Inc. at Boreholes 22-03 and 22-05 (referenced as BH-03 and BH-05, respectively) and at the west abutment, and Boreholes 22-04 and 22-06 (referenced as BH-04 and BH-06, respectively) at the east abutment for the purpose of determining the depth of the existing piles. The survey that was performed between May 17th to May 19, 2022, were comprised of the following tests in an attempt to determine the depth of the existing piles beneath the pile caps.

- Parallel Seismic Test - In accordance with ASTM D8381/D8381M-21
- Borehole Magnetometer Test – In accordance with ASTM D6726.01
- Electromagnetic Test - In accordance with ASTM D6726.01
- Natural Gamma Test - In accordance with ASTM D6274-18

6. 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. The boreholes drilled prior to the construction of the bridge (BH-1 and BH-3) are included in the Soil Strata Drawing. 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 general, the subsurface stratigraphy below the asphalt typically consists of a sand and gravel to silty sand fill, underlain by silty clay fill. Native materials underlying the fill include silty clay interbedded with organics, wood fibres or peat, which in turn was underlain by sand and gravel and silty sand till. More detailed descriptions of individual strata are presented below.

6.1 Pavement Structure

Asphalt with a thickness ranging from 140 mm to 200 mm was encountered at the road surface overlying 290 to 300 mm of approach slab concrete in Boreholes 22-01 and 22-02. Asphalt encountered at the road surface on the Greenock Creek Bridge ranged from 75 to 90 mm, followed by 150 to 215 mm of concrete in Boreholes 22-05 and 22-06 which were drilled through the concrete deck.

6.2 Granular Fill and Silty Clay Fill

Silty sand to sand and gravel fill was encountered below the pavement structure starting at depths of 0.4 to 0.5 m (Elev. 283.2 to 283.5 m) and extending to depths of 3.0 to 3.7 m (Elev. 280.2 to 280.7 m) in 22-02 and 22-01, respectively. The sand fill was encountered at surface and extended to depths of 2.2 m (Elev. 279.0 m) in Boreholes 22-03 and 22-04. In 22-05 and 22-06, the sand fill was encountered at the ground surface 3.0 m below the bridge deck and penetrated at 3.7 m below the bridge deck (Elev. 280.2 to 280.3 m).

The sand fill was brown in colour and contained trace to some gravel and trace to some silt. Occasional rootlets and organics were observed.

SPT N-Values in the sand to sand and gravel fill typically ranged from 2 to 54 blows per 0.3 m of penetration, indicating a very loose to very dense relative density. Recorded moisture contents in the fill ranged from 5 percent to 21 percent.

The results of grain size analyses conducted on two selected samples of sand and sand and gravel 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 (%)	
	Sand and Gravel Fill	Sand Fill
Gravel	53	6
Sand	39	50
Silt	8	40
Clay		4

Silty clay fill was observed locally in Borehole 22-02 below the sand fill from 3.0 to 4.5 m (Elev. 280.7 to 279.2 m) and in Borehole 22-06 at the ground surface, 3.0 to 3.7 m below the bridge deck (Elev. 280.9 to 280.2 m). The silty clay fill was described as brown, and containing trace sand, gravel, and occasional organics. The SPT N-Values in the clay fill ranged from 4 to 10 blows, indicating a firm to stiff relative density. The recorded moisture contents ranged from 18 percent to 22 percent.

6.3 Peat

A layer of peat was encountered in Borehole 22-06, between layers of silty clay fill and native clayey silt. The peat was described as brown and wet with occasional rootlets. The peat was encountered at a depth of 3.7 m below the bridge deck and was penetrated at a depth of 4.5 m (Elev. 280.2 to 279.4m).

The SPT N-Value taken in the peat was 2 blows per 0.3 m of penetration, indicating a very soft relative consistency. The recorded moisture content was 87 percent.

6.4 Silty Clay to Clayey Silt

A silty clay to clayey silt layer was encountered below the fill in all boreholes. This layer was brown in colour and contained trace organics, trace sand, trace gravel and occasional rootlets. Seams of organics were observed within the silty clay in Borehole 22-05 and a layer of peat was observed directly above the silty clay in Borehole 22-06.

The silty clay was encountered at depths ranging from 2.2 m to 3.7 m (Elev. 280.3 to 278.9 m) and was penetrated at depths from 3.0 m to 5.3 m (Elev. 279.5 to 278.1 m) in Boreholes 22-01, 22-04, and 22-05. The clayey silt was encountered at depths ranging from 2.2 m to 5.3 m (Elev. to 279.4 to 278.7 m) and was penetrated at depths from 3.0 m to 6.0 m (Elev. 278.2 to 277.7 m) in Boreholes 22-02, 22-03, 22-05, and 22-06.

The SPT N-Values taken in the silty clay to clayey silt ranged from 6 to 25 blows per 0.3 m of penetration, indicating a firm to very stiff relative consistencies. The recorded moisture contents ranged from 12 to 53 percent. The results of the grain size analysis completed on the one sample of the silty clay and three samples of the clayey silt deposit are provided on the Record of Borehole sheets in Appendix A, and plotted in Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
	Silty Clay / Clayey Silt
Gravel	0
Sand	2 to 3
Silt	77 to 82
Clay	16 to 21

The results the Atterberg limit tests completed on three samples of the clayey silt deposit indicate that the soil is considered a low to slight plasticity silt and clay (CL-ML). The results are provided on the Record of Borehole sheets in Appendix A, and plotted in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Liquid Limit	21 to 23
Plastic Limit	14 to 16
Plasticity Index	6 to 7

6.5 Sand and Gravel

A deposit of sand and gravel was encountered below the silty clay to clayey silt layer in all the boreholes. The sand and gravel was described as grey with trace silt, and was encountered at depths between 3.0 and 6.0 m (Elev. 279.5 to 277.7 m) and penetrated at depths from 6.8 to 10.2 m (Elev. 277.2 to 272.7 m). A boulder was encountered at the bottom of the sand and gravel deposit at a depth of 9.8 m (Elev. 274.1 m) in Borehole 22-02.

SPT N-Values in the sand and gravel generally ranged from 10 to 70 blows for 0.3 m of penetration, with N-values in 22-03, 22-05 and 22-06 locally exceeding 100 blows for less than 0.3 m of penetration, indicating a range from a loose to very dense relative density.

Moisture contents of 3 percent to 25 percent were recorded in the sand and gravel. The results of the grain size analysis conducted on samples of the sand and gravel deposit are provided on the Record of Borehole sheets in Appendix A, and plotted in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	27 to 81
Sand	15 to 63
Silt and Clay	3 to 21

It is noted that two grain size tests from Boreholes 22-01 and 22-02 were completed in gravelly layers.

6.6 Silty Sand Till

A silty sand till deposit was encountered below the sand and gravel layer in all the boreholes. It The silty sand till was brown to grey in colour, contained trace to some gravel, and trace clay.

The sand till was encountered at depths between 6.8 m and 10.2 m (277.2 to Elev. 272.7 m). All boreholes were terminated within the sand till at 10.4 to 15.5 m depths (270.8 to 268.2 m). The SPT N-Values in the silty sand till ranged from 43 blows per 0.3 m penetration to over 100 blows

for less than 0.3 m penetration, indicating a dense to very dense relative density. The high blow counts may represent the presence of cobbles and boulders in the till

The recorded moisture contents ranged from 6 percent to 11 percent. The results of grain size analysis conducted on five samples of the silty sand till are provided on the Record of Borehole sheets in Appendix A, and plotted in Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)	
Gravel	9 to 20	
Sand	39 to 43	
Silt	37 to 43	39
Clay	6 to 9	

Glacial tills inherently contain cobbles and boulders.

6.7 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Two (2) monitoring wells were installed in Boreholes 22-01 and 22-02 to permit longer term monitoring. The measured groundwater levels are summarized in the table below.

Table 6.1 - Depths and Elevations of Groundwater in Open Borehole

Borehole Number	Date	Groundwater Level		Comments
		Depth (m)	Elevation (m)	
22-01	May 11, 2022	3.7	280.1	Monitoring Well
	May 16, 2022	2.5	281.4	
22-02	May 11, 2022	3.7	280.0	Monitoring Well
	May 16, 2022	3.5	280.2	

It should also be noted that the groundwater level at the time of construction may vary and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation and spring snow melts.

It is noted that the creek surface water elevation from Reference 1 is approximately 279.6 m.

7. CORROSIVITY TEST RESULTS

A total of thirty-eight (38) samples tested. Nine (9) samples of the existing fill soils and twenty-nine (29) samples of the native soils were submitted for analytical corrosivity testing and SAR. One sample of surface water from Greenock Creek was also submitted for analytical testing of a corrosivity package. The results of the analytical laboratory tests are shown on the Certificates of Analysis included in Appendix B.

8. GEOPHYSICAL TEST RESULTS

The report of the geophysical tests conducted by Geophysics GPR International Inc.is attached in Appendix E.

9. MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The drilled borehole locations and ground surface elevations were determined using a Trimble R10 GNSS receiver.

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

Walker Drilling LTD. Of Barrie, Ontario supplied a truck-mounted Diedrich D-90 dill rig, and a Forage Fusion Drilling of Hawkesbury, Ontario suppled a portable Hilti drilling machine. Both drills conducted the drilling, sampling, and in-situ testing operations for the boreholes. The geophysical investigation was completed by Geophysics GPR International Inc. of Mississauga, Ontario.

The field investigation was supervised on a full-time basis by Mr. George Azzopardi, C.Tech. and Manjul Acharya, P.Eng., of Thurber. Overall supervision of the field program was provided by Mr. Rod de Castro, P.Eng.

The report was prepared by Ms. Rachel Bourassa, E.I.T, and reviewed by Mr. Rod de Castro, 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.

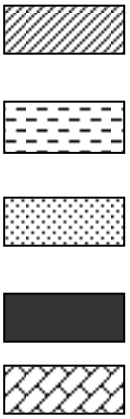
(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of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

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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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			

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No 22-01 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 597.7 E 161 904.7 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.09.05 - 2022.10.05 LATITUDE 44.096432 LONGITUDE -81.284661 CHECKED BY RdC

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 ● QUICK TRIAXIAL + FIELD VANE × 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.9	GROUND SURFACE										
0.0	**ASPHALT:** (140mm)										
0.1 / 283.5	**CONCRETE:** (290mm)										
0.4	**SAND** and **GRAVEL**, trace to occasional silt Dense to Very Dense Brown Moist (FILL)		1	SS	54				○		
			2	SS	31		283		○		53 39 8 (SI+CL)
282.4											
1.4	**SAND**, trace to some gravel, trace silt Compact Brown Moist to Wet (FILL)		3	SS	23		282		○		
			4	SS	17	▼			○		
			5	SS	10		281		○		
280.2											
3.7	Silty **CLAY**, occasional rootlets and wood fibres Firm to Stiff Brown Wet		6	SS	6		280		○		
			7	SS	10		279		○		
278.6											
5.3	**SAND** and **GRAVEL** Compact to Dense Grey Wet		8	SS	10		278		○		
			9	SS	30				○		
	Gravelly zone at 7.0m		10	SS	25		277		○		81 15 4 (SI+CL)
276.4											
7.5	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)		11	SS	43		276		○		13 43 37 7
							275				
			12	SS	115				○		
							274				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 22-01 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 597.7 E 161 904.7 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.09.05 - 2022.10.05 LATITUDE 44.096432 LONGITUDE -81.284661 CHECKED BY RdC

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)										
			13	SS	112		273		○		
							272				
			14	SS	112				○		
							271				
			15	SS	163		270		○		
							269				
268.5			16	SS	106/				○		
15.4	END OF BOREHOLE AT 15.4m Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2022.05.11 3.7 280.1 2022.05.16 2.5 281.4				0.150						

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

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No 22-02 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 593.5 E 161 929.8 ORIGINATED BY MA

DIST HWY 9 BOREHOLE TYPE Wash Boring COMPILED BY AA

DATUM Geodetic DATE 2022.03.05 - 2022.04.05 LATITUDE 44.096400 LONGITUDE -81.284347 CHECKED BY RdC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"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
283.7	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2 / 283.2	**CONCRETE:** (300mm)										
0.5	**SAND**, some gravel, trace silt Very Loose Brown Wet (FILL)		1	SS	2		283		○		6 50 40 4
			2	SS	3		282				
280.7							281				
3.0	Silty **CLAY**, trace gravel and sand, some organics Stiff to Firm Brown Wet (FILL)		3	SS	10		280		○		
			4	SS	4						
279.2							279		⊢○		0 2 79 19
4.5	Clayey **SILT**, trace gravel and sand, trace organics Firm to Very Stiff Grey Wet		5	SS	6				○		
			6	SS	25		278		○		
277.7											
6.0	**SAND** and **GRAVEL** Compact to Dense Grey Wet		7	SS	30		277		○		
			8	SS	17				○		
			9	SS	37		276		○		81 16 3 (SI+CL)
	Gravelly zone at 8.0m						275				
			10	SS	29				○		
	Boulder encountered at 9.8 m -						274				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 22-02 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 593.5 E 161 929.8 ORIGINATED BY MA

DIST HWY 9 BOREHOLE TYPE Wash Boring COMPILED BY AA

DATUM Geodetic DATE 2022.03.05 - 2022.04.05 LATITUDE 44.096400 LONGITUDE -81.284347 CHECKED BY RdC

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
	Continued From Previous Page										
273.5	Advanced with HQ Coring										
10.2	Silty **SAND**, some gravel Very Dense Grey Wet (TILL)		11	SS	58		273		○		
			12	SS	92		272		○		20 41 39 (SI+CL)
			13	SS	59		271		○		
							270				
268.2			14	SS	104		269		○		
15.5	END OF BOREHOLE AT 15.5m Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2022.05.11	3.7	280.0
2022.05.16	3.4	280.2

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No 22-03 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 587.1 E 161 909.5 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Drill COMPILED BY AA

DATUM Geodetic DATE 2022.04.26 - 2022.03.05 LATITUDE 44.096338 LONGITUDE -81.284598 CHECKED BY RdC

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 ● QUICK TRIAXIAL + FIELD VANE × 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
281.2	GROUND SURFACE														
0.0	**SAND**, trace silt, trace rootlets, occasional gravel Loose Brown Dry		1	SS	8		281								
280.5															
0.7	(FILL)														
	Silty **SAND**, with clay, trace gravel Dense Brown Damp (FILL)		2	SS	32		280								
			3	SS	14										
279.0							279								
2.2	Clayey **SILT**, occasional sand Very Stiff Grey Wet		4	SS	16										
278.2							278								
3.0	**SAND** and **GRAVEL**, some silt Dense to Very Dense Grey Wet		5	SS	22										
			6	SS	24		277								
			7	SS	42										
	Gravelly zone between 6.1m and 8.1m		8	SS	70		276								
			9	SS	51/ 0.150		275								42 37 21 (SI+CL) (SS8 and SS9 Combined)
272.7							274								
8.5	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)		10	SS	66		273								
							272								

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 22-03 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 587.1 E 161 909.5 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Drill COMPILED BY AA

DATUM Geodetic DATE 2022.04.26 - 2022.03.05 LATITUDE 44.096338 LONGITUDE -81.284598 CHECKED BY RdC

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 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
270.8	Silty **SAND**, some gravel, trace clay Dense to Very Dense Grey Wet (TILL)						271				
10.4	END OF BOREHOLE AT 10.4m Pipe installation consists of 50mm diameter Schedule 40 PVC pipe										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

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RECORD OF BOREHOLE No 22-04 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 602.4 E 161 922.6 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Drill COMPILED BY AA

DATUM Geodetic DATE 2022.03.05 - 2022.06.05 LATITUDE 44.096478 LONGITUDE -81.284439 CHECKED BY RdC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.1	GROUND SURFACE										
0.0	**SAND**, trace silt, occasional gravel Dense to Loose Brown Moist (FILL)		1	SS	39		281				
			2	SS	10		280				
			3	SS	2						
278.9							279				
2.2	Silty **CLAY**, trace sand and gravel Very Stiff Grey Wet		4	SS	21						0 3 79 18
278.1							278				
3.0	**SAND** and **GRAVEL**, trace silt Very Dense Grey Wet		5	SS	51						
			6	SS	52/ 0.125		277				
			7	SS	65/ 0.150						
							276				
			8	SS	52/ 0.150		275				
274.2											
6.9	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)		9	SS	55/ 0.150		274				
							273				
			10	SS	81		272				13 43 38 6

Continued Next Page

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 22-04 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 602.4 E 161 922.6 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Wash Boring / Coring Portable Drill COMPILED BY AA

DATUM Geodetic DATE 2022.03.05 - 2022.06.05 LATITUDE 44.096478 LONGITUDE -81.284439 CHECKED BY RdC

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 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)						271				
			11	SS	66/ 0.150		270		○		
							269				
268.6			12	SS	81				○		
12.5	END OF BOREHOLE AT 12.5m Pipe installation consists of 50mm diameter Schedule 40 PVC pipe										

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

$\overset{20}{15\oplus 5}$ (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No 22-05 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 589.9 E 161 909.3 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.11.05 - 2022.12.05 LATITUDE 44.096363 LONGITUDE -81.284601 CHECKED BY RdC

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.0	GROUND SURFACE										
0.0	**ASPHALT:** (90mm)										
0.1 / 283.7	**CONCRETE:** (215mm)										
0.3	Open Space Below Bridge Deck										
281.0							283				
							282				
3.0	**SAND**, trace silt, occasional rootlets Loose Brown Moist		1	SS	6		281		○		Removed Rip-rap below bridge deck to drill borehole
280.3	(FILL)										
3.7	Silty **CLAY**, occasional peat seams and organics Firm Dark Brown and Grey		2	SS	8		280		○		
279.5	Moist										
4.5	**SAND** and **GRAVEL**, trace silt, Compact Grey Wet		3	SS	12		279		○		
278.7											
5.3	Clayey **SILT**, trace sand Stiff Grey Wet		4	SS	9		278		⊢○		0 2 77 21
278.0											
6.0	**SAND** and **GRAVEL**, trace silt Dense Grey Wet		5	SS	43				○		62 23 15 (SI+CL)
277.2							277				
6.8	Silty **SAND**, some gravel, trace clay Very Dense Brown Wet (TILL)		6	SS	84				○		
			7	SS	71		276		○		
							275				
			8	SS	103				○‖		9 39 43 9
							274				

Continued Next Page

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 22-05 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 589.9 E 161 909.3 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.11.05 - 2022.12.05 LATITUDE 44.096363 LONGITUDE -81.284601 CHECKED BY RdC

SOIL PROFILE			SAMPLES			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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some gravel, trace clay Very Dense Brown Wet (TILL)										
			9	SS	69		273		○		
							272				
			10	SS	104				○		
							271				
			11	SS	136				○		
							270				
							269				
268.5			12	SS	146				○		
15.5	END OF BOREHOLE AT 15.5m Pipe installation consists of 50mm diameter Schedule 40 PVC pipe										

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

$\overset{20}{\underset{10}{15\oplus 5}}$ (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 22-06 1 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 599.9 E 161 922.7 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.10.05 - 2022.11.05 LATITUDE 44.096455 LONGITUDE -81.284437 CHECKED BY RdC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.9	GROUND SURFACE								
0.0	**ASPHALT:** (75mm)								
0.1	**CONCRETE:** (150mm)								
0.2	Open Space Below Bridge Deck								
280.9									
3.0	Silty **CLAY**, trace sand, occasional gravel Firm Brown Wet		1	SS	7				Removed Rip-rap below bridge deck to drill borehole
280.2	(FILL)								
3.7	**PEAT**, organic soil, occasional rootlets Very Soft Brown		2	SS	2				
279.4	Wet								
4.5	Clayey **SILT**, some sand, trace rootlets Firm to Stiff Grey Wet		3	SS	6				
			4	SS	11				0 2 82 16
277.9									
6.0	**SAND** and **GRAVEL** Compact to Very Dense Grey Wet		5	SS	23				
			6	SS	35				27 63 10 (SI+CL)
			7	SS	100/ 0.150				
275.2									
8.7	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)		8	SS	50				

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

ELEVATION SCALE: 283, 282, 281, 280, 279, 278, 277, 276, 275, 274

Continued Next Page

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No 22-06 2 OF 2 METRIC

GWP# 3075-14-00 LOCATION Greenock Creek Bridge; MTM NAD83-10: N 4 885 599.9 E 161 922.7 ORIGINATED BY GA

DIST HWY 9 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AA

DATUM Geodetic DATE 2022.10.05 - 2022.11.05 LATITUDE 44.096455 LONGITUDE -81.284437 CHECKED BY RdC

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **SAND**, some gravel, trace clay Very Dense Grey Wet (TILL)										
			9	SS	100		273				
							272				
			10	SS	60						13 41 38 8
							271				
			11	SS	116		270				
							269				
268.4			12	SS	119						
15.5	END OF BOREHOLE AT 15.54m Pipe installation consists of 50mm diameter Schedule 40 PVC pipe										

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

$\overset{20}{15\leftarrow\oplus\rightarrow 5}$ $\overset{}{10}$ (%) STRAIN AT FAILURE

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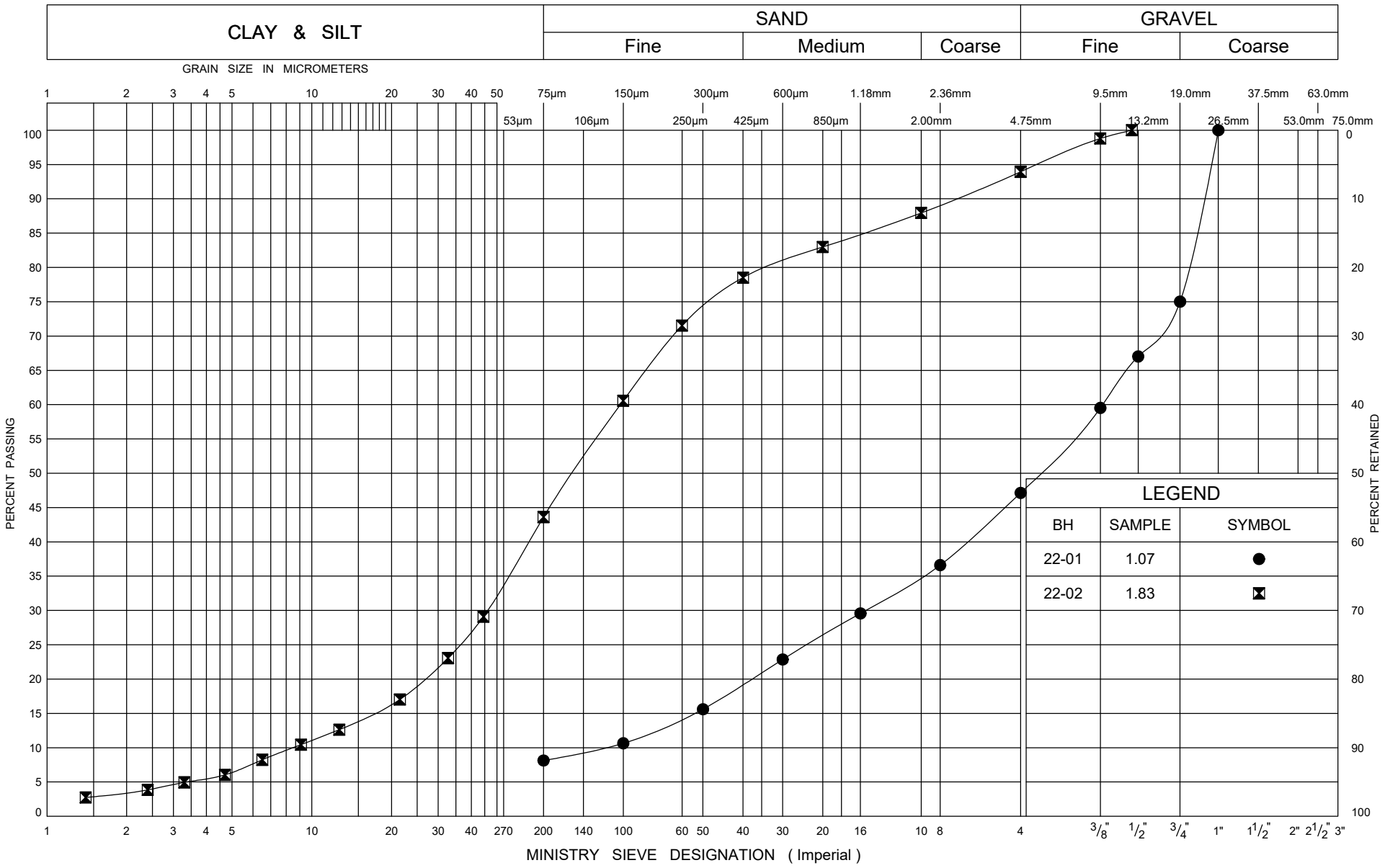
Appendix B

Geotechnical and Analytical Laboratory Test Results



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GRAIN SIZE DISTRIBUTION

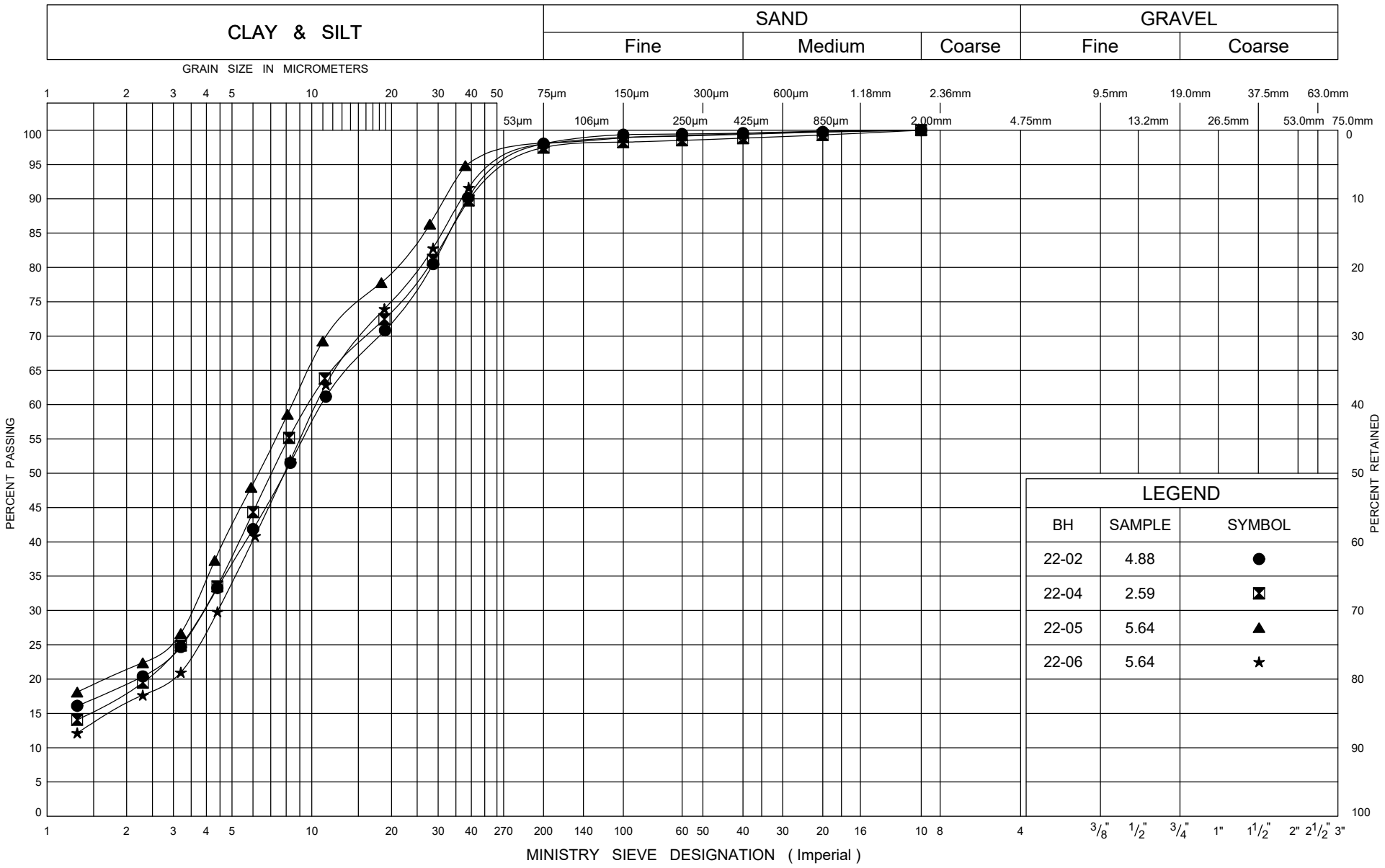
SAND FILL & SAND and GRAVEL FILL

FIG No B-1

W P 3075-14-00

Greenock Creek Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-33249.GPJ ONTARIO MOT.GDT 6/30/22



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GRAIN SIZE DISTRIBUTION

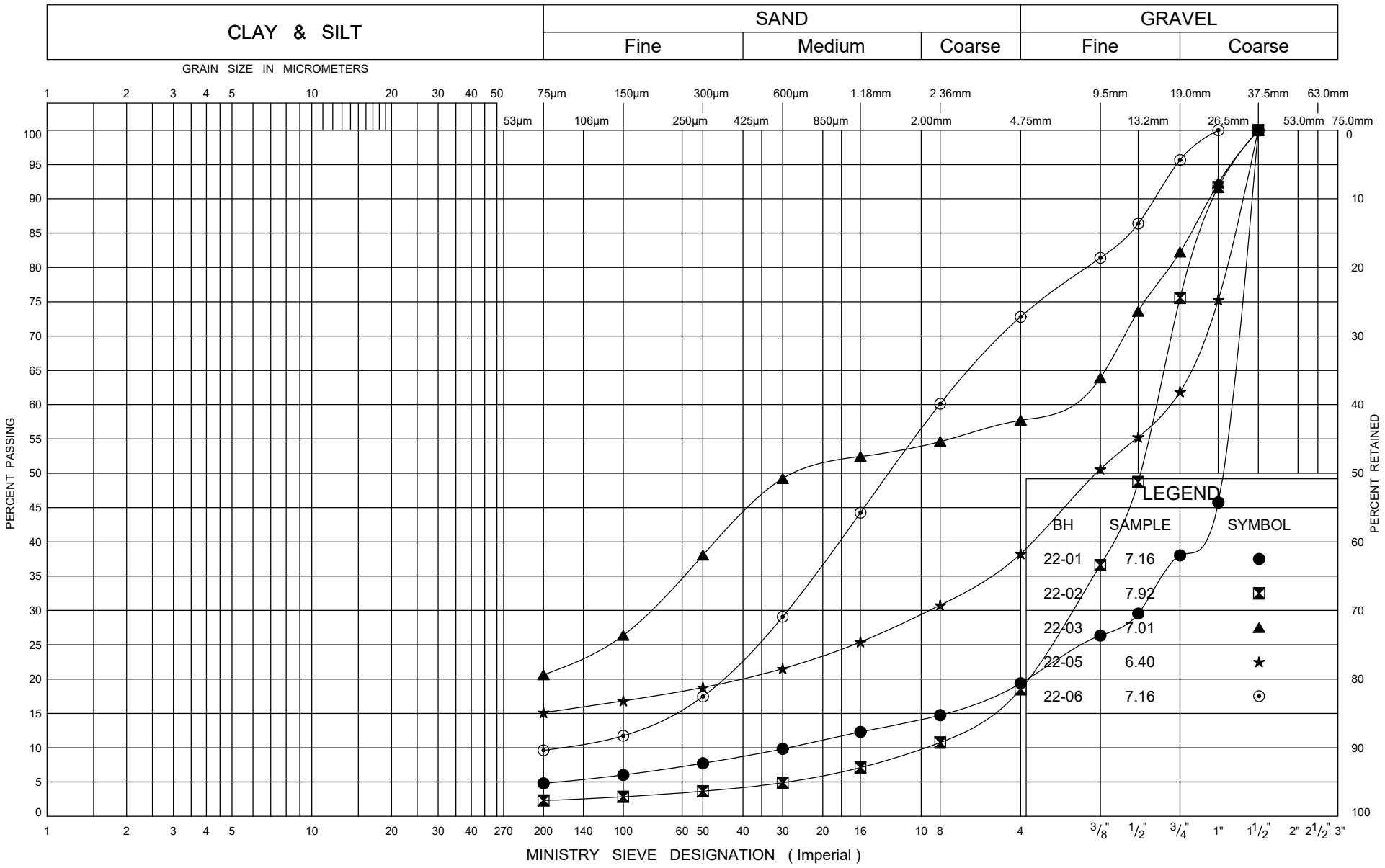
Silty CLAY / Clayey SILT

FIG No B-2

W P 3075-14-00

Greenock Creek Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-33249.GPJ ONTARIO MOT.GDT 6/30/22



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

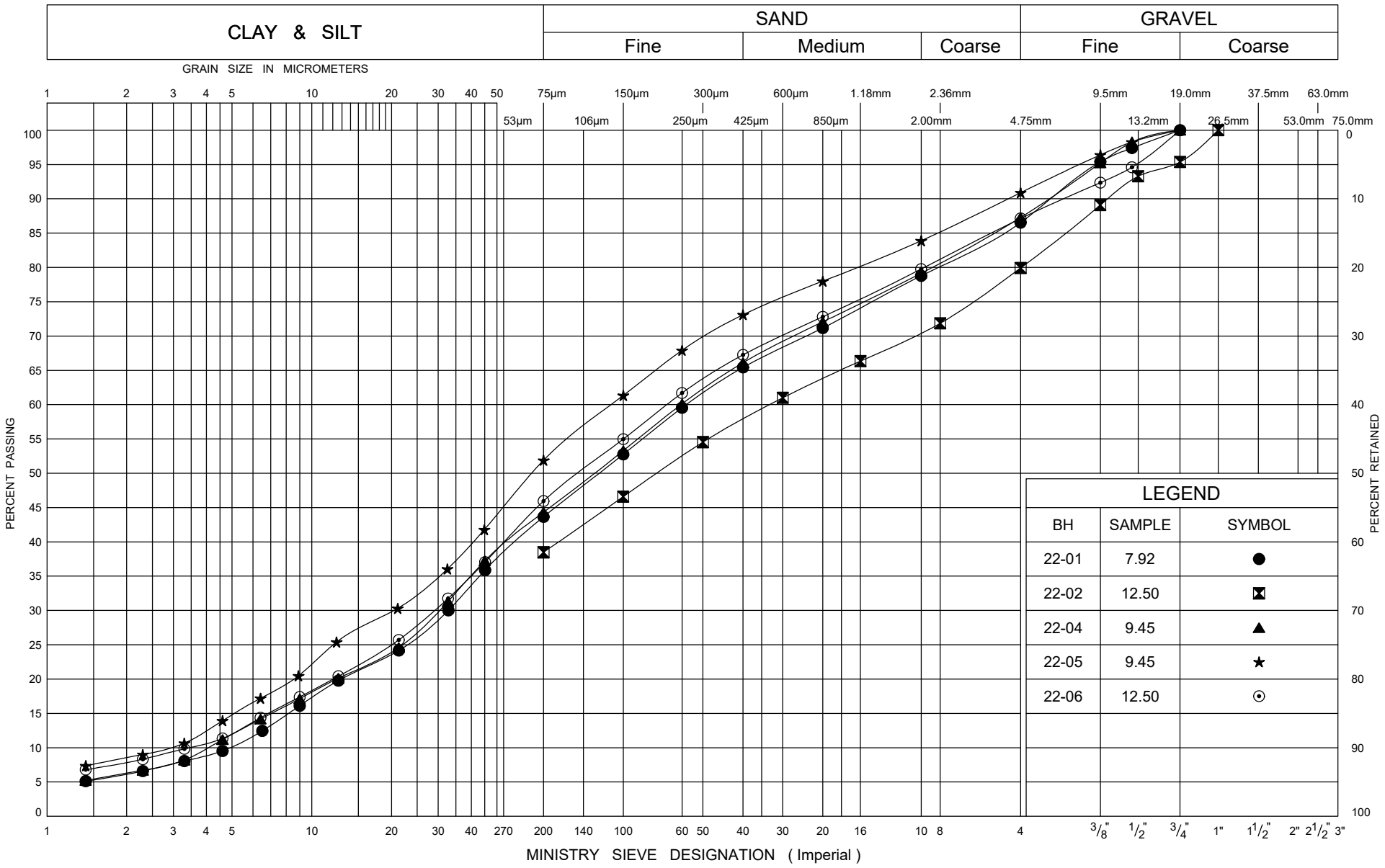
SAND and GRAVEL

FIG No B-3

W P 3075-14-00

Greenock Creek Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-33249.GPJ ONTARIO MOT.GDT 6/30/22



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty SAND TILL

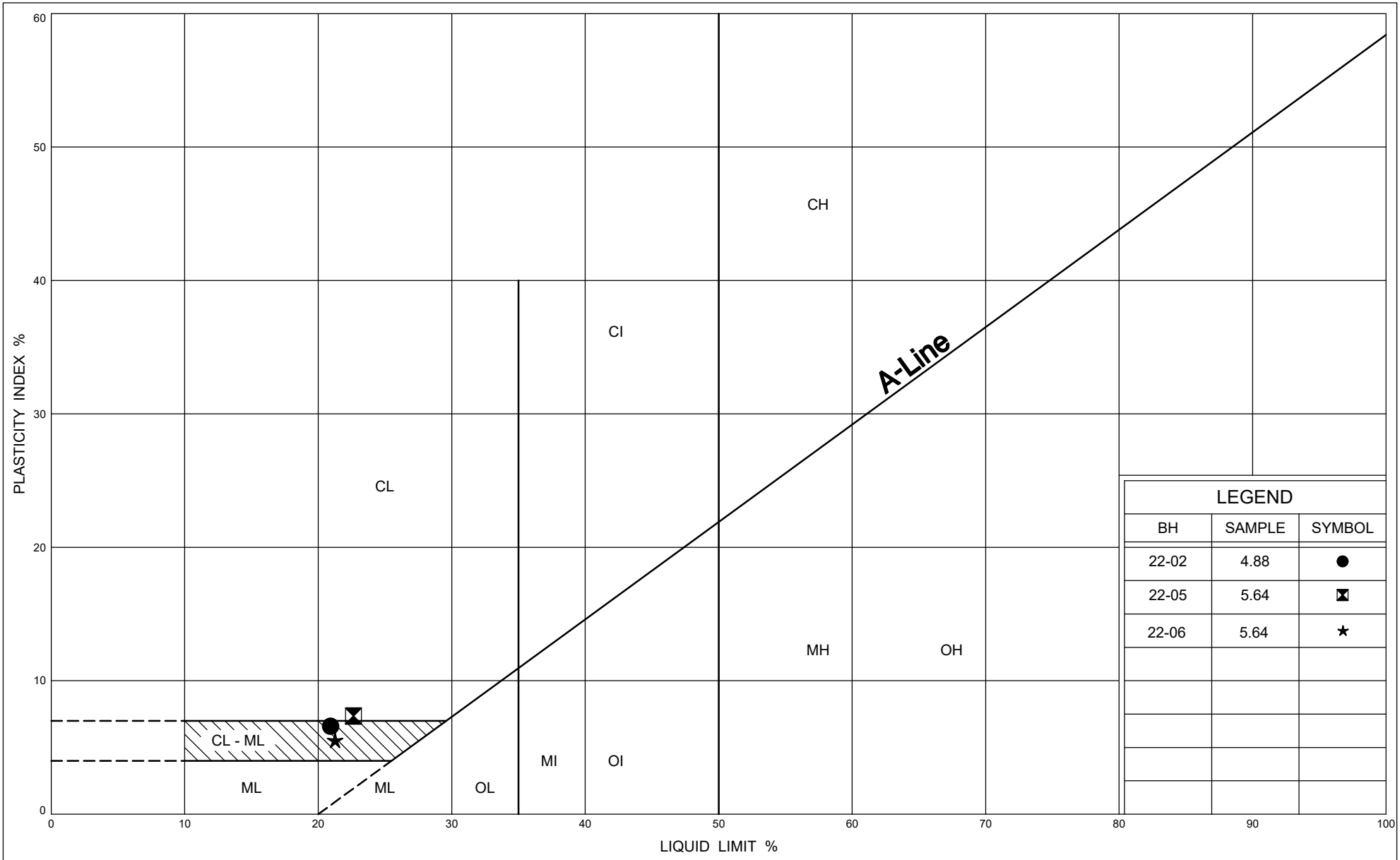
FIG No B-4

W P 3075-14-00

Greenock Creek Bridge

ONTARIO MOT GRAIN SIZE 2 MTO-33249.GPJ ONTARIO MOT.GDT 6/30/22

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART MTO-33249.GPJ ONTARIO MOT.GDT 6/30/22

Ministry of Transportation
Ontario

PLASTICITY CHART
Silty Clay / Clayey Silt

FIG No B-5

W P 3075-14-00

Greenock Creek Bridge

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666
ATTENTION TO: Rod de Castro
PROJECT: NWR 3020-E-0004
AGAT WORK ORDER: 22T891310
SOIL ANALYSIS REVIEWED BY: Jacky Zhu, Spectroscopy Technician
DATE REPORTED: May 10, 2022
PAGES (INCLUDING COVER): 6
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
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Certificate of Analysis

AGAT WORK ORDER: 22T891310

PROJECT: NWR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton, ON

SAMPLED BY:GA/MA

Corrosivity Package

DATE RECEIVED: 2022-05-04

DATE REPORTED: 2022-05-10

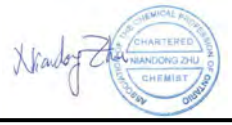
		SAMPLE DESCRIPTION:		22-03 SS1	22-03 SS3	22-03 SS5	22-03 SS7
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-04-26	2022-04-26	2022-04-26	2022-04-26
Parameter	Unit	G / S	RDL	3815560	3815574	3815575	3815576
Chloride (2:1)	µg/g		2	73	321	148	37
Sulphate (2:1)	µg/g		2	124	88	42	58
pH (2:1)	pH Units		NA	8.46	8.41	8.60	8.49
Electrical Conductivity (2:1)	mS/cm		0.005	0.551	0.821	0.431	0.237
Resistivity (2:1) (Calculated)	ohm.cm		1	1810	1220	2320	4220
Redox Potential 1	mV		NA	400	324	364	330
Redox Potential 2	mV		NA	401	324	363	331
Redox Potential 3	mV		NA	402	324	363	331

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3815560-3815576 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



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Certificate of Analysis

AGAT WORK ORDER: 22T891310

PROJECT: NWR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton, ON

SAMPLED BY:GA/MA

SAR (Soil)

DATE RECEIVED: 2022-05-04

DATE REPORTED: 2022-05-10

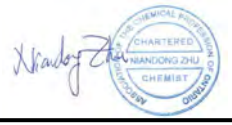
		SAMPLE DESCRIPTION:		22-03 SS1	22-03 SS3	22-03 SS5	22-03 SS7
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-04-26	2022-04-26	2022-04-26	2022-04-26
Parameter	Unit	G / S	RDL	3815560	3815574	3815575	3815576
Sodium Adsorption Ratio	NA		NA	6.95	5.42	1.04	0.155

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3815560-3815576 SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



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Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 22T891310

PROJECT: NWR 3020-E-0004

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton, ON

SAMPLED BY:GA/MA

Soil Analysis

RPT Date: May 10, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	3803427		3	2	NA	< 2	97%	70%	130%	107%	80%	120%	98%	70%	130%
Sulphate (2:1)	3803427		21	21	0.0%	< 2	102%	70%	130%	106%	80%	120%	101%	70%	130%
pH (2:1)	3815969		8.00	7.94	0.8%		99%	80%	120%						
Electrical Conductivity (2:1)	3822249		0.589	0.568	3.6%	< 0.005	97%	80%	120%						
Redox Potential 1							100%	90%	110%						
SAR (Soil)															
Sodium Adsorption Ratio	3822249		18.6	17.1	8.4%	NA									

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

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FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 22T891310

PROJECT: NWR 3020-E-0004

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton, ON

SAMPLED BY:GA/MA

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories
5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: Thurber Engineering Ltd
Contact: Rod de Castro
Address: 2010 Winston Park Drive Unit 103
Oakville ON L6H 5R7
Phone: _____ Fax: _____
Reports to be sent to:
1. Email: rdecastro@thurber.ca
2. Email: _____

Project Information:

Project: ~~Hwy~~ 9 NWR 3020-E-0004
Site Location: Highway 9, Brockton, ON
Sampled By: GA/MA
AGAT ID #: _____ PO: _____
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐
Company: _____
Contact: _____
Address: _____
Email: _____

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table _____ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table _____ *Indicate One*
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
_____ *Region*
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
_____ *Indicate One*

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Laboratory Use Only

Work Order #: 22T891316
Cooler Quantity: 1 Blk. Cooler (Ice).
Arrival Temperatures: 6.5 | 6.2 | 5.9
Custody Seal Intact: ☐ Yes ☐ No ☐ N/A
Notes: ABS ICE & COOLER

Turnaround Time (TAT) Required:

Regular TAT (Most Analysis) ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply): _____

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y/N	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153: BTEX, F1-F4 PHCs	O. Reg 153: Analyze F4G if required ☐ Yes ☐ No	O. Reg 153: PAHs	O. Reg 153: Total PCBs ☐ Aroclor	O. Reg 153: VOC	O. Reg 558: Landfill Disposal Characterization TCLP: ☐ M&I ☐ vOCs ☐ ABNs ☐ 3&4P ☐ PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach SPLP: ☐ Metals ☐ vOCs ☐ sVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Corrosivity Package (LND SOIL PH Only)	Potentially Hazardous or High Concentration (Y/N)
22-03 SS1	4/26/22	AM/PM	1	S			✓										✓	✓	
22-03 SS3	↓	AM/PM	1	S			✓										✓	✓	
22-03 SS5		AM/PM	1	S			✓										✓	✓	
22-03 SS7		AM/PM	1	S			✓										✓	✓	
		AM/PM																	
		AM/PM																	
		AM/PM																	
		AM/PM																	
		AM/PM																	
		AM/PM																	
		AM/PM																	

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Rod de Castro	May 4/22	10:00	Neil Normandin	Aug 4/22	11:50AM

Page ____ of ____
Nº: T 123750

Document ID: DW-78-1511-020

Pink Copy - Client | Yellow Copy - AGAT | White Copy- AGAT

AGAT Laboratories

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CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666
ATTENTION TO: Rod de Castro
PROJECT: WR 3020-E-0004
AGAT WORK ORDER: 22T894067
SOIL ANALYSIS REVIEWED BY: Jacky Zhu, Spectroscopy Technician
DATE REPORTED: May 20, 2022
PAGES (INCLUDING COVER): 7
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

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TEL (905)712-5100
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Certificate of Analysis

AGAT WORK ORDER: 22T894067

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton ON

SAMPLED BY:GA, MA

Corrosivity Package

DATE RECEIVED: 2022-05-11

DATE REPORTED: 2022-05-20

				22-02, SS2 -	22-02, SS4 -	22-02, SS6 -	22-02, SS8 -	22-02, SS10 -	22-02, SS12 -	22-02, SS14	22-03 SS9
		SAMPLE DESCRIPTION:		7.5'-9.5'	12.5'-14.5'	17.5'-19.5'	22.5'-24.5'	30'-32'	40'-42'	50'-52'	25'5"-27'6"
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-03	2022-05-03	2022-05-03	2022-05-03	2022-05-03	2022-05-04	2022-05-04	2022-05-02
Parameter	Unit	G / S	RDL	3846039	3846042	3846043	3846044	3846045	3846046	3846047	3846048
Chloride (2:1)	µg/g		2	507	1450	365	58	59	65	86	114
Sulphate (2:1)	µg/g		2	17	425	76	9	158	94	60	49
pH (2:1)	pH Units		NA	9.47	7.87	8.57	9.00	8.37	8.61	8.76	8.35
Electrical Conductivity (2:1)	mS/cm		0.005	1.03	3.13	0.845	0.181	0.324	0.282	0.263	0.319
Resistivity (2:1) (Calculated)	ohm.cm		1	971	319	1180	5520	3090	3550	3800	3130
Redox Potential 1	mV		NA	459	424	398	393	378	348	366	227
Redox Potential 2	mV		NA	460	426	401	395	380	344	367	228
Redox Potential 3	mV		NA	461	427	401	395	381	350	368	228

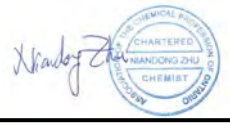
				22-04 SS2 2.	22-04 SS4 7.	22-04 SS6 12.	22-04 SS8	22-04 SS10	22-04 SS12
		SAMPLE DESCRIPTION:		56-4.5'	5'-9.5'	5'-14.5'	20'-22'	30'-32'	40'-42'
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-04	2022-05-04	2022-05-04	2022-05-05	2022-05-05	2022-05-06
Parameter	Unit	G / S	RDL	3846049	3846050	3846051	3846052	3846053	3846054
Chloride (2:1)	µg/g		2	480	795	173	416	43	35
Sulphate (2:1)	µg/g		2	126	84	26	30	129	129
pH (2:1)	pH Units		NA	8.47	8.59	9.32	9.26	8.32	8.28
Electrical Conductivity (2:1)	mS/cm		0.005	1.14	1.64	0.375	0.795	0.290	0.263
Resistivity (2:1) (Calculated)	ohm.cm		1	877	610	2670	1260	3450	3800
Redox Potential 1	mV		NA	258	243	262	310	199	198
Redox Potential 2	mV		NA	252	243	256	309	199	199
Redox Potential 3	mV		NA	259	242	256	308	209	200

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3846039-3846054 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



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AGAT Laboratories

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TEL (905)712-5100
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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T894067

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton ON

SAMPLED BY:GA, MA

O. Reg. 153(511) - SAR

DATE RECEIVED: 2022-05-11

DATE REPORTED: 2022-05-20

Parameter	Unit	G / S	RDL	22-02, SS2 - 7.5'-9.5' Soil 2022-05-03 3846039	22-02, SS4 - 12.5'-14.5' Soil 2022-05-03 3846042	22-02, SS6 - 17.5'-19.5' Soil 2022-05-03 3846043	22-02, SS8 - 22.5'-24.5' Soil 2022-05-03 3846044	22-02, SS10 - 30'-32' Soil 2022-05-03 3846045	22-02, SS12 - 40'-42' Soil 2022-05-04 3846046	22-02, SS14 50'-52' Soil 2022-05-04 3846047	22-03 SS9 25'5"-27'6" Soil 2022-05-02 3846048
Sodium Adsorption Ratio	NA		NA	20.1	16.8	10.4	1.31	0.125	0.149	0.338	0.164

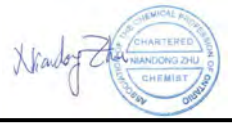
Parameter	Unit	G / S	RDL	22-04 SS2 2. 56-4.5' Soil 2022-05-04 3846049	22-04 SS4 7. 5'-9.5' Soil 2022-05-04 3846050	22-04 SS6 12. 5'-14.5' Soil 2022-05-04 3846051	22-04 SS8 20'-22' Soil 2022-05-05 3846052	22-04 SS10 30'-32' Soil 2022-05-05 3846053	22-04 SS12 40'-42' Soil 2022-05-06 3846054
Sodium Adsorption Ratio	NA		NA	6.87	24.1	0.872	0.981	0.094	0.101

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3846039-3846054 SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories
5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 22T894067
PROJECT: WR 3020-E-0004
ATTENTION TO: Rod de Castro
SAMPLING SITE:Highway 9, Brockton ON
SAMPLED BY:GA, MA

Soil Analysis

RPT Date: May 20, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	3852523		53	54	1.9%	< 2	99%	70%	130%	108%	80%	120%	111%	70%	130%
Sulphate (2:1)	3852523		10	10	0.0%	< 2	104%	70%	130%	104%	80%	120%	111%	70%	130%
pH (2:1)	3852523		9.29	8.00	14.9%	NA	98%	80%	120%						
Electrical Conductivity (2:1)	3862752		0.232	0.238	2.6%	< 0.005	95%	80%	120%						
Redox Potential 1							100%	90%	110%						
O. Reg. 153(511) - SAR															
Sodium Adsorption Ratio	3862752		0.383	0.377	1.6%	NA									

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

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Results relate only to the items tested. Results apply to samples as received.

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CANADA L4Z 1Y2
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FAX (905)712-5122
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Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 22T894067

PROJECT: WR 3020-E-0004

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton ON

SAMPLED BY:GA, MA

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES

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AGAT Laboratories

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Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 22T894067

Cooler Quantity: 1 Lg

Arrival Temperatures: 11.3 | 12.1 | 11.7

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes: Ice Packs

Report Information:

Company: Thurber Engineering Ltd
Contact: Rod de Castro
Address: 2010 Winston Park Drive, Unit 103
Oakville ON L6H 5R7
Phone: 905.829.8647 Fax: 905.829.3710
Reports to be sent to:
1. Email: rdecastro@thurber.ca
2. Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table _____ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table _____ *Indicate One*
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
_____ *Region*
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
_____ *Indicate One*

Is this submission for a **Record of Site Condition**? ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT (Most Analysis) ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply): _____

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: WR 3020-E-0004
Site Location: ~~Hwy~~ Highway 9, Brockton, ON
Sampled By: GA/MA
AGAT ID #: _____ PO: _____
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y/N	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐CrVI, ☐Hg, ☐HWSB	O. Reg 153: BTEX, F1-F4 PHCs	O. Reg 153: Analyze F4G if required ☐Yes ☐No	O. Reg 153: PAHs	O. Reg 153: Total PCBs ☐Aroclor	O. Reg 153: VOC	O. Reg 558: Landfill Disposal Characterization TCLP: ☐M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach SPLP: ☐Metals ☐VOCs ☐SVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Potentially Hazardous or High Concentration (Y/N)
22-02, SS2 - 7½-9½'	May 3/22	AM PM	1	S													✓	
22-02, SS4 - 12½-14½'	May 3/22	AM PM	1	S													✓	
22-02, SS6 - 17½-19½'	May 3/22	AM PM	1	S													✓	
22-02, SS8 22½-24½'	May 3/22	AM PM	1	S													✓	
22-02, SS10 30-32'	May 3/22	AM PM	1	S													✓	
22-02, SS12 40-42'	May 4/22	AM PM	1	S													✓	
22-02, SS14 50-52'	May 4/22	AM PM	1	S													✓	
		AM PM																
		AM PM																
		AM PM																
		AM PM																

Samples Relinquished By (Print Name and Sign):	Date: May 4/22	Time: 10:45	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign): Armando Cicco	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

22 MAY 11 11:35

Page 1 of 2

N°: T 123752

AGAT Laboratories
5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: [illegible]
Contact:
Address:
Phone: Fax:
Reports to be sent to:
1. Email:
2. Email:

Project Information:

Project:
Site Location:
Sampled By:
AGAT ID #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☐ No ☐
Company:
Contact:
Address:
Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table ___ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table ___ *Indicate One*
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
___ *Region*
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
___ *Indicate One*

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Laboratory Use Only

Work Order #:
Cooler Quantity:
Arrival Temperatures: See | 1ST | Page
Custody Seal Intact: ☐Yes ☐No ☐N/A
Notes:

Turnaround Time (TAT) Required:

Regular TAT (Most Analysis) ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y/N	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153: BTEX, F1-F4 PHCs Analyze F4G if required ☐ Yes ☐ No	O. Reg 153: PAHs	O. Reg 153: Total PCBs ☐ Aroclor	O. Reg 153: VOC	O. Reg 558: Landfill Disposal Characterization TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach ☐ Metals ☐ VOCs ☐ SVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Corrosivity (resistivity, pH)	Potentially Hazardous or High Concentration (Y/N)
22-03 SS9 25'6"-27'4"	May 3/22	AM PM	1	S												✓	✓	
22-04 SS2 2½-4½'	May 4/22	AM PM	1	S												✓	✓	
22-04 SS4 7½-9½'	May 4/22	AM PM	1	S												✓	✓	
22-04 SS6 12½-14½'	May 4/22	AM PM	1	S	- contact re conclusion - OS	QM-17										✓	✓	
22-04 SS8 20-22'	May 5/22	AM PM	1	S	"											✓	✓	
22-04 SS10 30-32'	May 5/22	AM PM	1	S	"											✓	✓	
22-04 SS12 40-42'	May 6/22	AM PM	1	S												✓	✓	
		AM PM																
		AM PM																
		AM PM																
		AM PM																

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
[illegible]	May 11/22	1045	[illegible]		
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

22 MAY 11 11:35AM

Page 2 of 2

N°: T 123751

AGAT Laboratories

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TEL (905)712-5100
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http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666
ATTENTION TO: Rod de Castro
PROJECT: WR 3020-E-0004
AGAT WORK ORDER: 22T895781
SOIL ANALYSIS REVIEWED BY: Jacky Zhu, Spectroscopy Technician
DATE REPORTED: May 25, 2022
PAGES (INCLUDING COVER): 8
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
- The test results reported herewith relate only to the samples as received by the laboratory.
- Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.
- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.

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Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T895781

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brokton ON

SAMPLED BY:GA

Corrosivity Package

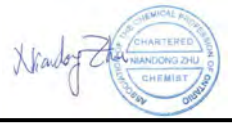
DATE RECEIVED: 2022-05-16

DATE REPORTED: 2022-05-25

				22-05 SS2 12.	22-05 SS4 17.	22-05 SS6 22.	22-05 SS8	22-05 SS10	22-06 SS1	22-06 SS3	22-06 SS5
		SAMPLE DESCRIPTION:		5-14.5'	5-19.5'	5-24.5'	30-32'	40-42'	10-12'	15-17'	20-22'
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-12	2022-05-12	2022-05-12	2022-05-12	2022-05-12	2022-05-10	2022-05-10	2022-05-10
Parameter	Unit	G / S	RDL	3862873	3862874	3862875	3862876	3862877	3862878	3862879	3862880
Chloride (2:1)	µg/g		2	984	203	130	52	26	935	761	115
Sulphate (2:1)	µg/g		2	67	212	111	88	56	306	228	29
pH (2:1)	pH Units		NA	7.94	8.03	8.58	8.54	8.54	8.56	8.44	7.25
Electrical Conductivity (2:1)	mS/cm		0.005	2.08	0.670	0.381	0.240	0.165	2.22	1.80	0.317
Resistivity (2:1) (Calculated)	ohm.cm		1	481	1490	2620	4170	6060	450	556	3150
Redox Potential 1	mV		NA	350	368	363	299	294	136	197	222
Redox Potential 2	mV		NA	351	369	370	301	294	178	197	225
Redox Potential 3	mV		NA	352	369	370	300	298	166	197	232

				22-06 SS7	22-06 SS9	22-06 SS11	22-01 SS1 1.		22-01 SS5	22-01 SS7	22-01 SS9
		SAMPLE DESCRIPTION:		25-27'	35-37'	45-47'	5-2.5'	22-01 SS3 5-7'	10-12'	15-17'	20-22'
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-10	2022-05-10	2022-05-10	2022-05-09	2022-05-09	2022-05-09	2022-05-09	2022-05-09
Parameter	Unit	G / S	RDL	3862881	3862882	3862883	3862884	3862885	3862886	3862887	3862888
Chloride (2:1)	µg/g		2	34	16	21	414	454	238	1390	196
Sulphate (2:1)	µg/g		2	14	79	127	276	305	18	131	17
pH (2:1)	pH Units		NA	8.61	8.48	8.35	11.4	10.5	9.62	8.19	8.57
Electrical Conductivity (2:1)	mS/cm		0.005	0.144	0.185	0.239	2.04	1.29	0.687	2.55	0.457
Resistivity (2:1) (Calculated)	ohm.cm		1	6940	5410	4180	490	775	1460	392	2190
Redox Potential 1	mV		NA	259	218	209	20.4	32.7	201	183	168
Redox Potential 2	mV		NA	260	218	211	23.4	38.4	201	181	168
Redox Potential 3	mV		NA	262	218	212	22.3	33.5	203	180	167

Certified By:



Results relate only to the items tested. Results apply to samples as received.

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T895781

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brokton ON

SAMPLED BY:GA

Corrosivity Package

DATE RECEIVED: 2022-05-16

DATE REPORTED: 2022-05-25

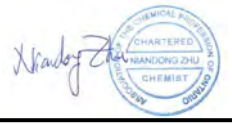
				22-01 SS11	22-01 SS13	22-01 SS15	22-05 SS12
		SAMPLE DESCRIPTION:		25-22'	35-37'	45-47'	50-52.3'
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-09	2022-05-09	2022-05-09	2022-05-12
Parameter	Unit	G / S	RDL	3862889	3862890	3862891	3862892
Chloride (2:1)	µg/g		2	64	34	14	65
Sulphate (2:1)	µg/g		2	123	97	43	48
pH (2:1)	pH Units		NA	8.41	8.26	8.35	8.46
Electrical Conductivity (2:1)	mS/cm		0.005	0.293	0.237	0.156	0.244
Resistivity (2:1) (Calculated)	ohm.cm		1	3410	4220	6410	4100
Redox Potential 1	mV		NA	184	163	194	170
Redox Potential 2	mV		NA	184	159	194	169
Redox Potential 3	mV		NA	176	158	194	169

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3862873-3862892 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

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MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T895781

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brokton ON

SAMPLED BY:GA

O. Reg. 153(511) - SAR

DATE RECEIVED: 2022-05-16

DATE REPORTED: 2022-05-25

Parameter	Unit	G / S	RDL	22-05 SS2 12. 5-14.5' Soil 2022-05-12 3862873	22-05 SS4 17. 5-19.5' Soil 2022-05-12 3862874	22-05 SS6 22. 5-24.5' Soil 2022-05-12 3862875	22-05 SS8 30-32' Soil 2022-05-12 3862876	22-05 SS10 40-42' Soil 2022-05-12 3862877	22-06 SS1 10-12' Soil 2022-05-10 3862878	22-06 SS3 15-17' Soil 2022-05-10 3862879	22-06 SS5 20-22' Soil 2022-05-10 3862880
Sodium Adsorption Ratio	NA		NA	14.6	4.03	1.88	0.555	0.282	22.3	19.6	2.67

Parameter	Unit	G / S	RDL	22-06 SS7 25-27' Soil 2022-05-10 3862881	22-06 SS9 35-37' Soil 2022-05-10 3862882	22-06 SS11 45-47' Soil 2022-05-10 3862883	22-01 SS1 1. 5-2.5' Soil 2022-05-09 3862884	22-01 SS3 5-7' Soil 2022-05-09 3862885	22-01 SS5 10-12' Soil 2022-05-09 3862886	22-01 SS7 15-17' Soil 2022-05-09 3862887	22-01 SS9 20-22' Soil 2022-05-09 3862888
Sodium Adsorption Ratio	NA		NA	0.592	0.233	0.271	23.9	7.92	11.5	20.3	3.99

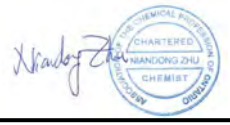
Parameter	Unit	G / S	RDL	22-01 SS11 25-22' Soil 2022-05-09 3862889	22-01 SS13 35-37' Soil 2022-05-09 3862890	22-01 SS15 45-47' Soil 2022-05-09 3862891	22-05 SS12 50-52.3' Soil 2022-05-12 3862892
Sodium Adsorption Ratio	NA		NA	1.06	0.450	0.217	0.846

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3862873-3862892 SAR is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories
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CANADA L4Z 1Y2
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FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD
AGAT WORK ORDER: 22T895781
PROJECT: WR 3020-E-0004
ATTENTION TO: Rod de Castro
SAMPLING SITE:Highway 9, Brokton ON
SAMPLED BY:GA

Soil Analysis

RPT Date: May 25, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	3862873	3862873	984	985	0.1%	< 2	95%	70%	130%	103%	80%	120%	102%	70%	130%
Sulphate (2:1)	3862873	3862873	67	68	1.5%	< 2	93%	70%	130%	101%	80%	120%	97%	70%	130%
pH (2:1)	3865809		8.19	8.18	0.1%	NA	96%	80%	120%						
Electrical Conductivity (2:1)	3865809		0.174	0.174	0.0%	< 0.005	96%	80%	120%						
Redox Potential 1							100%	90%	110%						
O. Reg. 153(511) - SAR															
Sodium Adsorption Ratio	3862880	3862880	2.67	2.63	1.5%	NA									
Corrosivity Package															
pH (2:1)	3862880	3862880	7.25	7.24	0.1%	NA	98%	80%	120%						
Electrical Conductivity (2:1)	3862880	3862880	0.317	0.310	2.2%	< 0.005	97%	80%	120%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

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Results relate only to the items tested. Results apply to samples as received.

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Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 22T895781

PROJECT: WR 3020-E-0004

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brokton ON

SAMPLED BY:GA

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Sodium Adsorption Ratio	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010C	ICP/OES

Results relate only to the items tested. Results apply to samples as received.

AGAT Laboratories

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Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 22T895781

Cooler Quantity: 1 large blue

Arrival Temperatures: 9.3 | 8.8 | 9.1

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes: ICE pack

Report Information:

Company: Thurber Engineering Ltd

Contact: Raul de Castro

Address: 2010 Winston Park Drive Unit 103
Oakville ON L6H 5R7

Phone: ~~905-8~~ 647.525.3710 Fax:

Reports to be sent to:

1. Email: rdecastro@thurber.ca

2. Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table ____ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table ____ *Indicate One*

☐ Regulation 558

☐ CCME

☐ Sewer Use
☐ Sanitary ☐ Storm
____ *Region*

☐ Prov. Water Quality Objectives (PWQO)

☐ Other
____ *Indicate One*

Is this submission for a Record of Site Condition? ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT (Most Analysis) ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: WR 3020-E-00004

Site Location: Highway 9, Brockton, ON

Sampled By: GA

AGAT ID #: PO:

Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:

Contact:

Address:

Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y/N	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153: BTEX, F1-F4 PHCs, Analyze F4G if required ☐ Yes ☐ No	O. Reg 153: PAHs	O. Reg 153: Total PCBs ☐ Arocior	O. Reg 153: VOC	O. Reg 558: Landfill Disposal Characterization TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach SPLP: ☐ Metals ☐ VOCs ☐ SVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Corrosivity (except Sulphide)						Potentially Hazardous or High Concentration (Y/N)
22-05 SS2 12.5-14.5'	May 12/22	AM PM	1	S													✓							
22-05 SS4 17.5-19.5'	May 12/22	AM PM	1	S													✓							
22-05 SS6 22.5-24.5	May 12/22	AM PM	1	S													✓							
22-05 SS8 30-32'	May 12/22	AM PM	1	S													✓							
22-05 SS10 40-42'	May 12/22	AM PM	1	S													✓							
22-06 SS1 10-12'	May 10/22	AM PM	1	S													✓							
22-06 SS3 15-17'	May 10/22	AM PM	1	S													✓							
22-06 SS5 20-22'	May 10/22	AM PM	1	S													✓							
22-06 SS7 25-27'	May 10/22	AM PM	1	S													✓							
22-06 SS9 35-37'	May 10/22	AM PM	1	S													✓							
22-06 SS11 45-47'	May 10/22	AM PM	1	S													✓							

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
			Amber D.		
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

'22 MAY 16 11:19AM

Page 1 of 2

Nº: T 123753

AGAT Laboratories
5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company:
Contact:
Address:
Phone: Fax:
Reports to be sent to:
1. Email:
2. Email:

Project Information:

Project:
Site Location:
Sampled By:
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis

Invoice Information:

Bill To Same: Yes ☐ No ☐

Company:
Contact:
Address:
Email:

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Excess Soils R406
Table *Indicate One*
☐ Regulation 558
☐ CCME

☐ Sewer Use ☐ Sanitary ☐ Storm
Region
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
Indicate One

Is this submission for a Record of Site Condition? ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Laboratory Use Only

Work Order #:
Cooler Quantity:
Arrival Temperatures: Sat 1st
Custody Seal Intact: ☐Yes ☐No ☐N/A
Notes:

Turnaround Time (TAT) Required:

Regular TAT ☐ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

	Sample Identification		Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y/N	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153: BTEX, F1-F4 PHCs Analyze F4G if required ☐ Yes ☐ No	O. Reg 153: PAHs	O. Reg 153: PCBs	O. Reg 153: VOC	O. Reg 558: Landfill Disposal Characterization TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	O. Reg 406: Excess Soils SPLP Rainwater Leach ☐ Metals ☐ VOCs ☐ SVOCs	O. Reg 406: Excess Soils Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Salt - EC/SAR	Co-ordinate Surface							Potentially Hazardous or High Concentration (Y/N)
22-01	SS 1	1.5-2.5'	May 9/22	AM PM	1	S												/	/							
22-01	SS 3	5-7'	May 9/22	AM PM	1	S												/	-							
22-01	SS 5	10-12'	May 9/22	AM PM	1	S												/	/							
22-01	SS 7	15-17'	May 9/22	AM PM	1	S												/	/							
22-01	SS 9	20-22'	May 9/22	AM PM	1	S												/	/							
22-01	SS 11	25-27'	May 9/22	AM PM	1	S												/	/							
22-01	SS 13	35-37'	May 9/22	AM PM	1	S												/	/							
22-01	SS 15	45-47'	May 9/22	AM PM	1	S												/	/							
				AM PM																						
				AM PM																						
				AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time

Page 2 of 2

N°: T 132490

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TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666
ATTENTION TO: Rod de Castro
PROJECT: WR 3020-E-0004
AGAT WORK ORDER: 22T896882
SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganics Report Writer
WATER ANALYSIS REVIEWED BY: Yris Verastegui, Report Reviewer
DATE REPORTED: May 27, 2022
PAGES (INCLUDING COVER): 21
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.
- AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.
- This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
- The test results reported herewith relate only to the samples as received by the laboratory.
- Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.
- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.

Member of: Association of Professional Engineers and Geoscientists of Alberta (APEGA)
Western Enviro-Agricultural Laboratory Association (WEALA)
Environmental Services Association of Alberta (ESAA)

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AGAT Laboratories

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FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T896882

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton ON

SAMPLED BY:GA

Corrosivity Package

DATE RECEIVED: 2022-05-18

DATE REPORTED: 2022-05-27

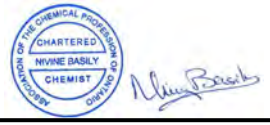
				C6-01 SS7	C6-01 SS10 22.	C8-01 SS9	C8-01 SS11
		SAMPLE DESCRIPTION:		15-17'	5-24.3'	20-22'	25-27'
		SAMPLE TYPE:		Soil	Soil	Soil	Soil
		DATE SAMPLED:		2022-05-16	2022-05-16	2022-05-17	2022-05-17
Parameter	Unit	G / S	RDL	3874389	3874395	3874396	3874397
Chloride (2:1)	µg/g		2	279	186	442	37
Sulphate (2:1)	µg/g		2	9	22	6	5
pH (2:1)	pH Units		NA	7.85	8.70	8.18	8.32
Electrical Conductivity (2:1)	mS/cm		0.005	0.605	0.531	0.887	0.173
Resistivity (2:1) (Calculated)	ohm.cm		1	1650	1880	1130	5780
Redox Potential 1	mV		NA	163	191	204	215
Redox Potential 2	mV		NA	163	190	201	201
Redox Potential 3	mV		NA	164	190	199	199

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3874389-3874397 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:



Results relate only to the items tested. Results apply to samples as received.

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FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 22T896882

PROJECT: WR 3020-E-0004

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Rod de Castro

SAMPLING SITE:Highway 9, Brockton ON

SAMPLED BY:GA

(Water) Inorganic Chemistry

DATE RECEIVED: 2022-05-18

DATE REPORTED: 2022-05-27

				SAMPLE DESCRIPTION:		22-01		22-02		C6-02		C8-03
				SAMPLE TYPE:		Water		Water		Water		Water
				DATE SAMPLED:		2022-05-16 16:45		2022-05-16 17:00		2022-05-17 18:15		2022-05-17 14:00
Parameter	Unit	G / S	RDL	3874272	RDL	3874309	RDL	3874310	RDL	3874314		
pH	pH Units		NA	7.77	NA	7.72	NA	7.77	NA	7.72		
Electrical Conductivity	µS/cm		2	1670	2	719	2	1760	2	1170		
Resistivity	ohms.cm			599		1390		568		855		
Chloride	mg/L		0.12	354	0.10	18.6	0.24	399	0.12	148		
Sulphate	µg/L		100	60700	100	144000	190	23400	100	26600		

			SAMPLE DESCRIPTION:	Greenock Creek
			SAMPLE TYPE:	Water
			DATE SAMPLED:	2022-05-16 17:30
Parameter	Unit	G / S	RDL	3874388
pH	pH Units		NA	7.90
Electrical Conductivity	µS/cm		2	542
Resistivity	ohms.cm			1850
Chloride	mg/L		0.10	18.9
Sulphate	µg/L		100	10300

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

3874272-3874388 Dilution required, RDL has been increased accordingly.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By: Iris Verástegui

Results relate only to the items tested. Results apply to samples as received.

THURBER

Appendix C

Site Photographs

THURBER

Photo 1 (left) : Looking south – Borehole drilling at 22-06 through bridge deck

Photo 2 (right) : Bridge deck remediation with wooden plank filled with grout after drilling

Photo 3: Looking west – Borehole drilling at 22-06 with truck-mount drill rig

Photo 4: Looking west – Borehole drilling at 22-03 with portable Hilti drilling machine

Photo 5: Looking south - Parallel Seismic Testing at Borehole 22-03 at west abutment

Photo 6: Looking South – Borehole Magnetometer Testing at Borehole 22-03

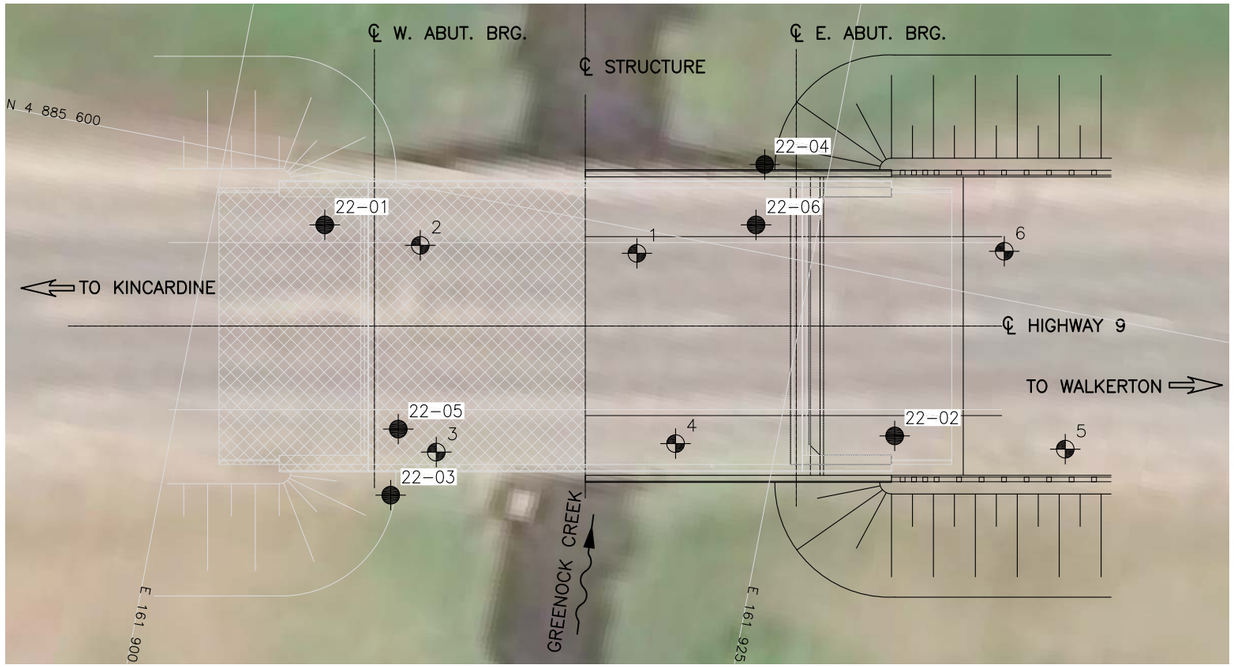
Photo 7: Looking northeast – Natural Gamma testing at Borehole 22-04

THURBER

Appendix D

Borehole Locations and Soil Strata Drawing

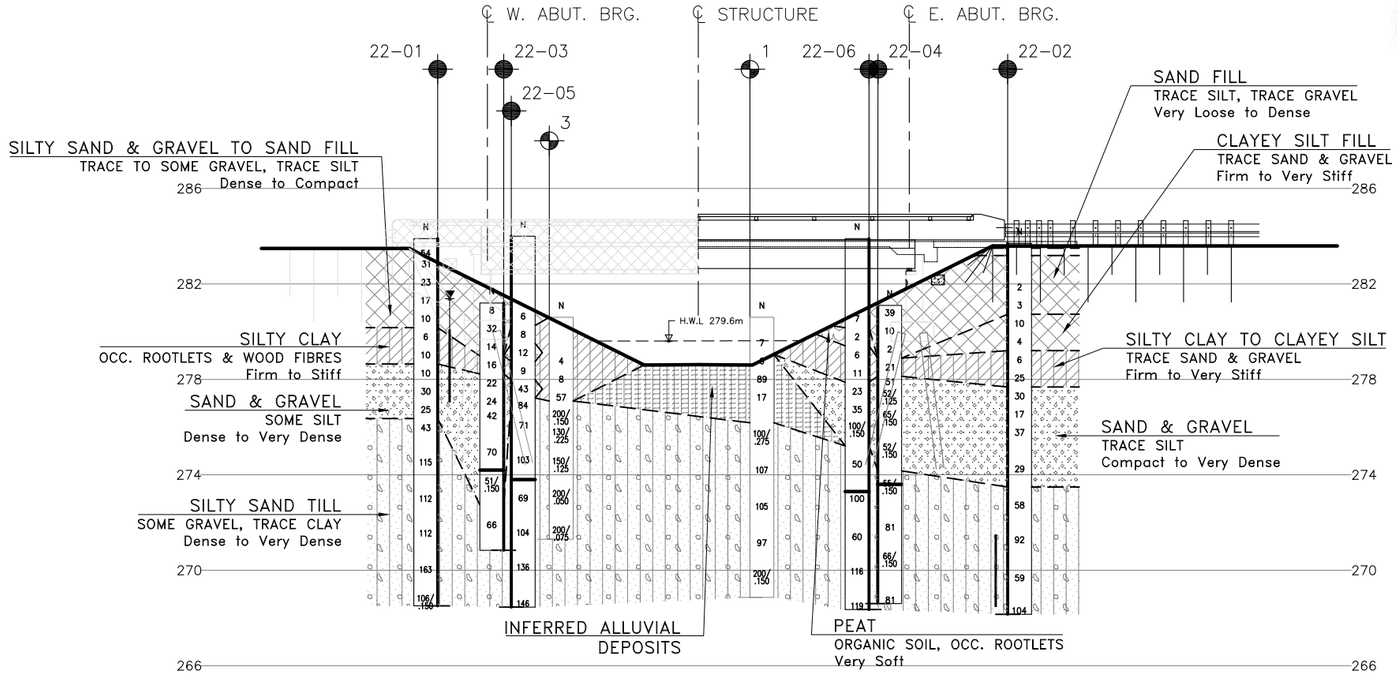
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

5 0 5 10m

SCALE 1:250



SOIL PROFILE ALONG ℄ HIGHWAY 9

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No

HIGHWAY 9
GREENOCK CREEK BRIDGE REHABILITATED
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.

LICENSED PROFESSIONAL ENGINEER
R. S. DE CASTRO JR.
100121096
Aug.15, 2022
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Aug.15, 2022
PROVINCE OF ONTARIO

KEYPLAN

LEGEND

●	Borehole (By Thurber)
⊕	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
–	Estimated Tip Of Pile (Geophysics Testing)

NO	ELEVATION	NORTHING	EASTING
1	280.6	4 885 599.0	161 917.7
2	280.7	4 885 597.6	161 908.8
3	280.6	4 885 589.2	161 911.1
4	280.6	4 885 591.5	161 920.8
5	280.5	4 885 594.3	161 936.9
6	280.5	4 885 602.0	161 932.8
22–01	283.9	4 885 597.7	161 904.7
22–02	283.7	4 885 593.5	161 929.8
22–03	281.2	4 885 587.1	161 909.5
22–04	281.1	4 885 603.7	161 922.3
22–05	284.0	4 885 589.9	161 909.3
22–06	283.9	4 885 601.1	161 922.4

-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. 41A-252

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	Rdc	CHK	PKC	CODE	LOAD
DRAWN	AN	CHK	Rdc	SITE	STRUCT

DATE JUL 22
DWG 1

FILENAME: H:\Drafting\33000\33249\TED-33249-PLPR-GB.dwg
PLOTDATE: 8/9/2022 9:58 AM

THURBER

Appendix E

Geophysical Testing to Determine Length of Existing Piles

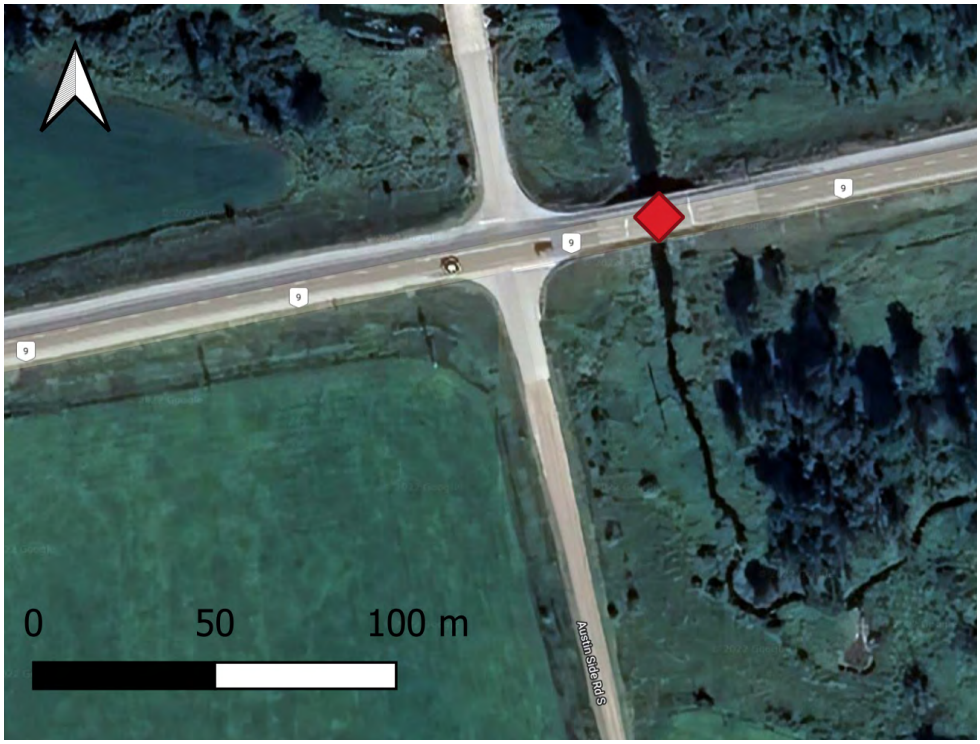
GEOPHYSICS GPR
INTERNATIONAL INC.

GEOPHYSICAL DOWN-HOLE PILE DEPTH INVESTIGATION, ONTARIO HWY 9 & AUSTIN SIDE RD, GREENOCK, ONTARIO

Presented to :

THURBER ENGINEERING LTD.

Thurber Engineering Ltd.
Suite 103, 2010 Winston Park Drive
Oakville, Ontario
L6H 5R7



Geophysics GPR International Inc.
6741 Columbus Road, Unit 14
Mississauga (Ontario) L5T 2G9
Tel. : +1 905.696.0656
info@geophysicsgpr.com
June 2022 GPR-22-3856

TABLE OF CONTENT

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INTRODUCTION

Geophysics GPR International, Inc. has been requested by Thurber Engineering Ltd. to carry out a geophysical down-hole survey for the purpose of determining the depth of steel piles beneath a bridge spanning Greenock Creek on Ontario Highway 9 east of Austin Sideroad.

The survey was performed on May 17th to 19th, 2022.

The investigations involved a combination of seismic, magnetic, electromagnetic and passive gamma ray measurements within four boreholes to attempt to determine the depth extent of the piles beneath the bridge.

The boreholes were drilled and prepared under the supervision of the client.

The following paragraphs describe the survey design, the principles of the test method, the methodology for interpreting the data, and provide a culmination of the results in chart format.

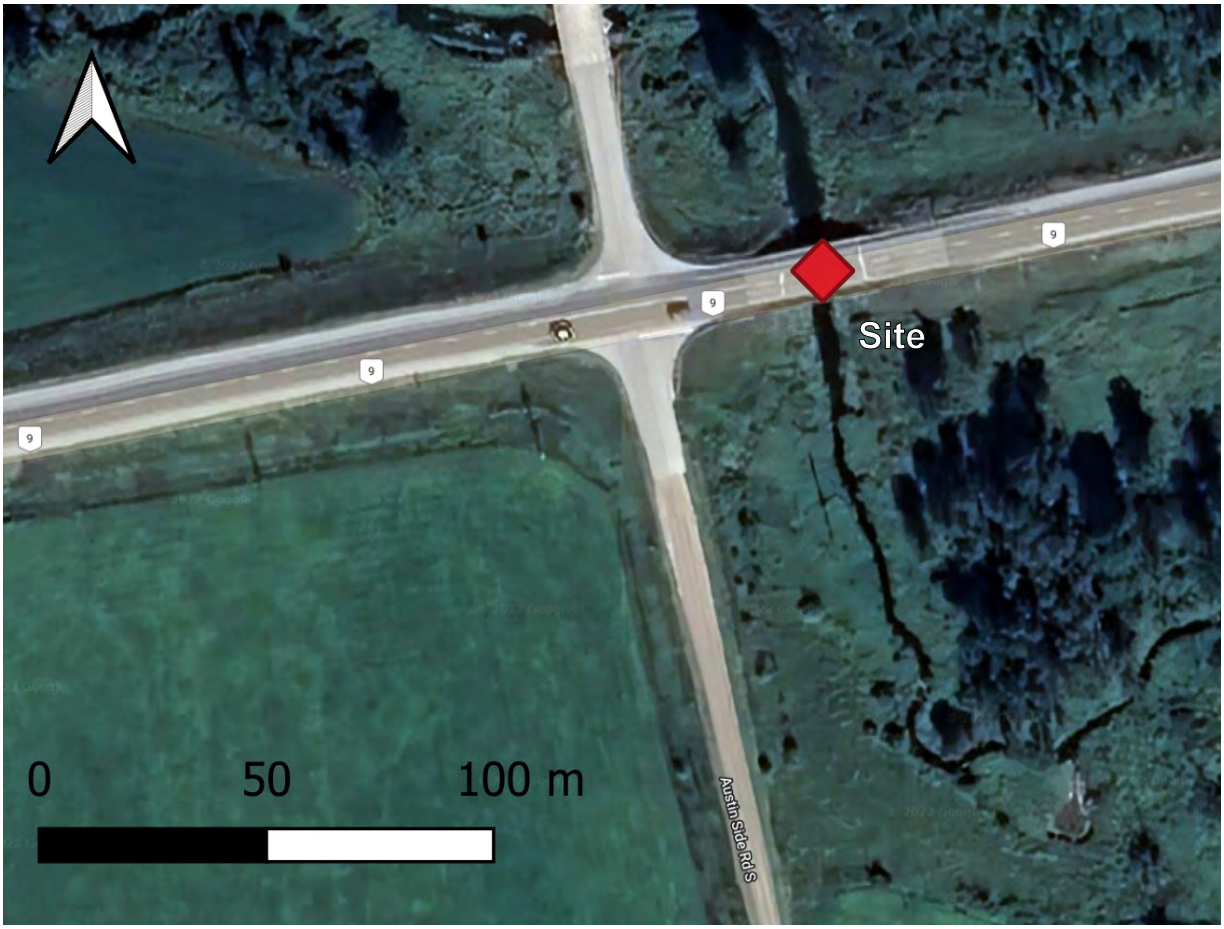


Figure 1: Location of survey site beneath bridge, east of intersection between Austin Sideroad and Ontario Highway 9

METHODOLOGY

Borehole Magnetometer

The total magnetic field is a sum of all magnetic fields generated by all magnetically susceptible objects, including the Earth itself. A target will generate a magnetic field that will alter the Earth's field in a localized area. Typically the largest influence is from ferromagnetic materials. By recording the magnetic field data, the perturbations in the Earth's field can be quantified.

The range of influence for a magnetometer is anomaly dependent. This means that a larger metallic object can be detected at a greater distance than a smaller object.

Borehole magnetometer data were collected with a Sensys FGM3D three-axis Fluxgate magnetometer. The magnetic field readings were time sampled (10Hz) and referenced to cable timed cable markers at 0.5m intervals. The data were subsequently filtered to low pass filtered to remove high frequency noise.

Additional data were collected in boreholes with a LIM BHTV42 acoustic televiewer with magnetometer. The BHTV magnetometer was used to record the magnetic field data. The magnetic data along with the borehole tool depth were recorded at 2cm depth intervals.

Electromagnetic Measurements

The electromagnetic (EM) conductivity meter provides a measurement of the electrical conductivity/resistivity of the soil surrounding a borehole using the inductive electromagnetic technique. It also provides an estimate of the magnetic susceptibility (higher for more ferromagnetic materials).

Data were collected with an ALT Matrix Logger acquisition system, a Mount Sopris Mini Winch and a Geonics EM39 tool. The EM39 tool is equipped with two coaxial coils with an intercoil spacing of 50cm which provides an effective radius of exploration of approximately 1 m into the formation. The borehole logs were collected down and up the hole at a speed of 1.5 to 2 m/min. In this manner 2 logs were collected in each borehole in order to compare them to each other for accuracy of results. Conductivity readings were collected at 0.05 m intervals.

The EM-39 borehole tool was zeroed prior to the first measurement by recording the measured conductivity at a height of 3 m in the air at least 10 m horizontally removed from any large metallic objects.

Natural Gamma Ray Logging

The relative prevalence of higher-conductivity clays in the soil can be estimated using natural gamma ray logs. This method records the rate of occurrence (expressed as counts per second) of gamma rays passively detected by the sensor. Soils with greater clay mineral content (and therefore electrical conductivity) are expected to produce higher gamma ray counts relative to other soils adjacent to the borehole due to their higher concentration of potassium, and therefore also radioactive potassium-40.

This method can be used in conjunction with EM methods to distinguish metallic conductors (high conductivity, low gamma) from conductive clay layers in the soil (high conductivity, high gamma).

Data were collected using a Mount Sopris 2PGA natural gamma ray probe.

Seismic Down-hole

The seismic down-hole method relies on the accurate measurement of the transit time for a generated wave to travel from a shot-point on the surface to a receiver (geophone) at sequential depths within a borehole. The velocities at which the waves propagate are then determined from the arrival times of the impulse signals. The seismic "P" wave velocity depends mainly on volumetric elastic ratio of the constituent soil particles and pore water.

A tri-axial geophone, containing two orthogonal horizontal geophones, for detecting the shear (S) wave arrivals, and a vertical geophone for detecting the compressional (P) wave arrivals, was used as the receiver. The geophone was held firm to the borehole casing by a motorized wall-lock.

Data were recorded with an ABEM Terraloc Mark 6 seismograph. The sampling interval was set to 25 μs with 8192 samples for a total record length of 200 ms with a pre-trigger delay of 10 ms.

The seismic source was a sledge hammer. For boreholes BH-03, BH-05 and BH-06, a steel bar placed adjacent to the bridge was struck, while for hole BH-04, the concrete of the bridge was struck directly (due to the apparent increase in fill material at the toe of the abutment in this area). In both cases, two recordings were made at each depth in each hole, one for when the hammer strike was directed vertically (downwards) and one for when the strike was directed horizontally (perpendicular to and away from the creek).

Interpretation of the down-hole seismic data involves identifying the first arrival times of the P-waves and/or S-waves from the shot records at each depth interval.

The preferred method for analyzing down-hole data is to produce time-distance plots and calculate the velocities from the slope of the best-fit lines. The selection of the best-fit lines can be visually interpreted by the analyst or can be computer aided. Additionally, the pile can be expected to act as a waveguide, and so assuming that the energy in each shot is the same, then the relative absolute amplitude of seismic waves will be greater when the geophone is above the bottom of the pile than when it is below it.

RESULTS

The testing was completed in four boreholes beneath or immediately adjacent to the bridge deck. Table 1 below outlines the borehole information provided by the client. The reader is referred to the geotechnical report for borehole log details.

Attached at the end of this report are site photos of the field operations.

Table 1: Borehole parameters

Borehole ID	Depth Drilled (m)
BH-03	10.5
BH-04	11.7
BH-05	12.2
BH-06	12.6

The magnetometry survey is used to locate metal content (e.g. steel casing or reinforcing) at depth. The expected background total magnetic field strength for this site was 53 769 nT based on information provided from the US National Oceanic and Atmospheric Administration Magnetic Field Calculator. Figure 2 (a, b, c & d) plots the magnitudes of the horizontal component (the vector sum of the longitudinal and transverse components) and the first (vertical) derivative of the vertical component of the magnetic field versus depth for the four boreholes.

The base of the steel is generally interpreted to correspond with the midway point along the linear slope between the background vertical magnetic field (observed at depth) and the vertical magnetic field measurements influenced by the presence of the piles. This sloped area can be better represented as the peak of the first derivative (gradient) of the vertical magnetic field. The base of the pile can also be interpreted to correspond with the peak of the horizontal magnetic field.

The quality of borehole data at this particular site was generally good, with strong peaks in the derivative of the vertical component over a relatively narrow depth range and broader peaks in the horizontal component giving pile depths with an agreement of 0.5 m or better within the same hole. This agreement is particularly good for borehole BH-03. All boreholes show a strong peak in both plotted signals at approximately 1.5 m depth, however this is likely a spurious peak from near-surface infrastructure and not indicative of pile depth.

Borehole BH-03 (Figure 2a) shows relatively broad peaks in both the vertical derivative and horizontal component. However, the centre of the region where the magnetic field is above background levels occurs at the same depth of 6.8 m for both channels, increasing confidence in the results. Similarly, the signals from borehole BH-04 (Figure 2d) lack clear peaks, but the vertical derivative is above background levels from 4.6 m to 9.5 m depth, and the horizontal component from 4.1 m to 9.8 m, giving closely agreeing estimates of pile extent of 7.05 m and 6.95 m, respectively. The less sharply

defined peaks in the data for these holes may be a result of the holes being relatively far from their respective piles compared to the other holes. This increased distance would be expected to reduce the influence that the magnetic fields induced in the piles would have on the readings, making the resulting deviation from background field levels less distinct.

Borehole BH-06 (Figure 2c) has the same broad peak in the horizontal component as the preceding holes, but with a much stronger peak in the derivative of the vertical component at 7.6 m. Additionally, the midpoint of the anomaly in the horizontal component also occurs at 7.6 m, suggesting that this is a good estimate of pile depth.

Borehole BH-05 (Figure 2b) shows a similar response to borehole BH-06, with a strong peak in the derivative of the vertical component and a broad anomaly in the horizontal component. Unlike in BH-06 though, these two signals give pile extent estimates that differ by about 1.1 m. However, given the narrower, clear peak in the derivative of the vertical component, it is likely more indicative of the true depth extent of the pile than is the horizontal component.

Pile depth extent estimates determined through magnetometry for all boreholes are tabulated in Table 2.

Table 2: Pile extent estimates from magnetometry

Borehole ID	Pile extent estimate, horizontal comp. (m)	Pile extent estimate, vertical comp. derivative (m)
BH-03	6.8	6.8
BH-05	6.1	7.2
BH-06	7.6	7.6
BH-04	7.0	7.2

The EM data provide a measurement of the bulk conductivity of the material in the vicinity of the borehole. The presence of metal within that zone of influence (typically assumed to be equal to the coil spacing of 60cm) will increase the bulk conductivity. The EM conductivity data are plotted on the right-hand side of Figure 2. At this particular site, EM data were collected as a tertiary method due to the physical limitations in how close the boreholes could be drilled to the walls and columns.

The EM data will be strongly influenced by the geology, in particular the clay and moisture content, in the immediate vicinity of the borehole. It is difficult to remove the influence of the geology from the influence of any adjacent steel given the horizontal offset, although this can be accomplished to some extent if interpreted in conjunction with natural gamma datasets.

All boreholes show moderately elevated conductivity in roughly the upper 3 m of the ground. The depth of this conductivity anomaly and the concurrent elevated gamma ray counts suggest that it is the result of bentonite used to grout the borehole in preparation for seismic surveys. Due to its high capacity to exchange cations with soil moisture, the presence of bentonite can significantly increase the apparent conductivity of soils.

BH-06 shows the most compelling evidence of having detected the pile due to the strong negative conductivity anomaly between about 4.7 m and 8.6 m depth. Displayed negative conductivity values are characteristic of metallic conductors, as the assumptions that the sensor uses to convert measured electric potential to conductivity break down for metallic materials, leading to seemingly impossible values. Additionally, there is no associated increase in gamma counts in this interval, and the point where conductivity values begin to drop to background levels is within a metre of the peak in the first vertical derivative of the magnetic field. Finally, the magnetic susceptibility in this hole is elevated (indicating the presence of ferromagnetic materials) over approximately the same depth range as where the negative conductivity values occur.

The seismic surveys were used to measure the arrival time of a wave transmitted from the surface to a vibration sensor at increasing depths. The arrival times of the waves allow a velocity of wave propagation to be measured. Different materials will exhibit different velocities. Shot records with preferential compressional (P) waves and shear (S) waves were recorded by impacting an area close to, or directly on, the bridge. The vector norms of the three-component seismic data over time are presented concurrently with magnetometry data from the corresponding hole in Figure 2.

In all of the boreholes, the change in slope of the line connecting first arrivals in the time-distance plot (indicative of the end of the higher-velocity pile) is relatively subtle, possibly owing to the inclination of the piles relative to the boreholes. Interpreted pile extents determined through this method are presented in Table 3.

Table 3: Estimated pile depths determined by seismic survey

Borehole ID	Pile depth extent estimate (m)
BH-03	7.5
BH-05	7.3
BH-06	7.7
BH-04	7.5

Boreholes BH-06 and to a much lesser extent, BH-04, show a pattern of arrival times known as a “reversal”, where waves take less time to travel to a further point than to a closer point. This is typical of environments where there is a very strong contrast in velocity between materials, as would be the

case in BH-06 where the pile would be expected to have a much higher seismic velocity than the relatively loose grout surrounding the upper portions of the borehole. The occurrence of this reversal in BH-06 is also likely related to the particularly close proximity of this hole to the corresponding pile, and good coupling between the concrete of the bridge and the seismic source.

Seismic records from all boreholes except BH-04 show a decrease in the amplitude of the seismic waves further down in the borehole at a depth roughly corresponding with that of the change of slope in the travel-time curve of first arrivals. Assuming that each shot produces waves with equivalent initial amplitude, then this decrease in amplitude would be expected as the geophone passes the end of the pile and the waves must travel further through less competent material to reach the geophone. While this transition is not distinct enough to determine a precise pile extent on its own, it supports the interpretation of the refraction data.

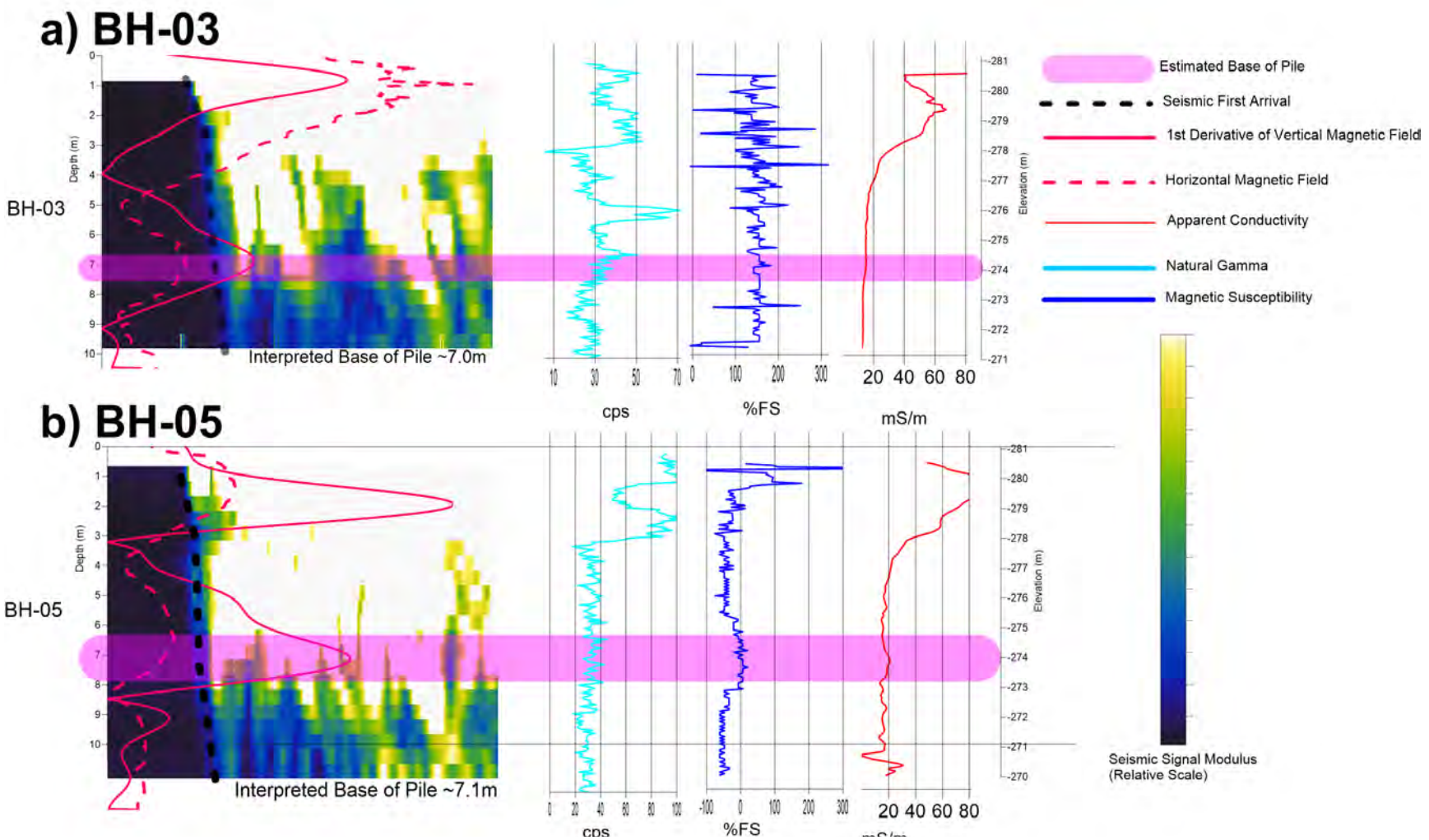


Figure 2: Plots of borehole geophysical data logs showing estimated depth extents of bridge piles

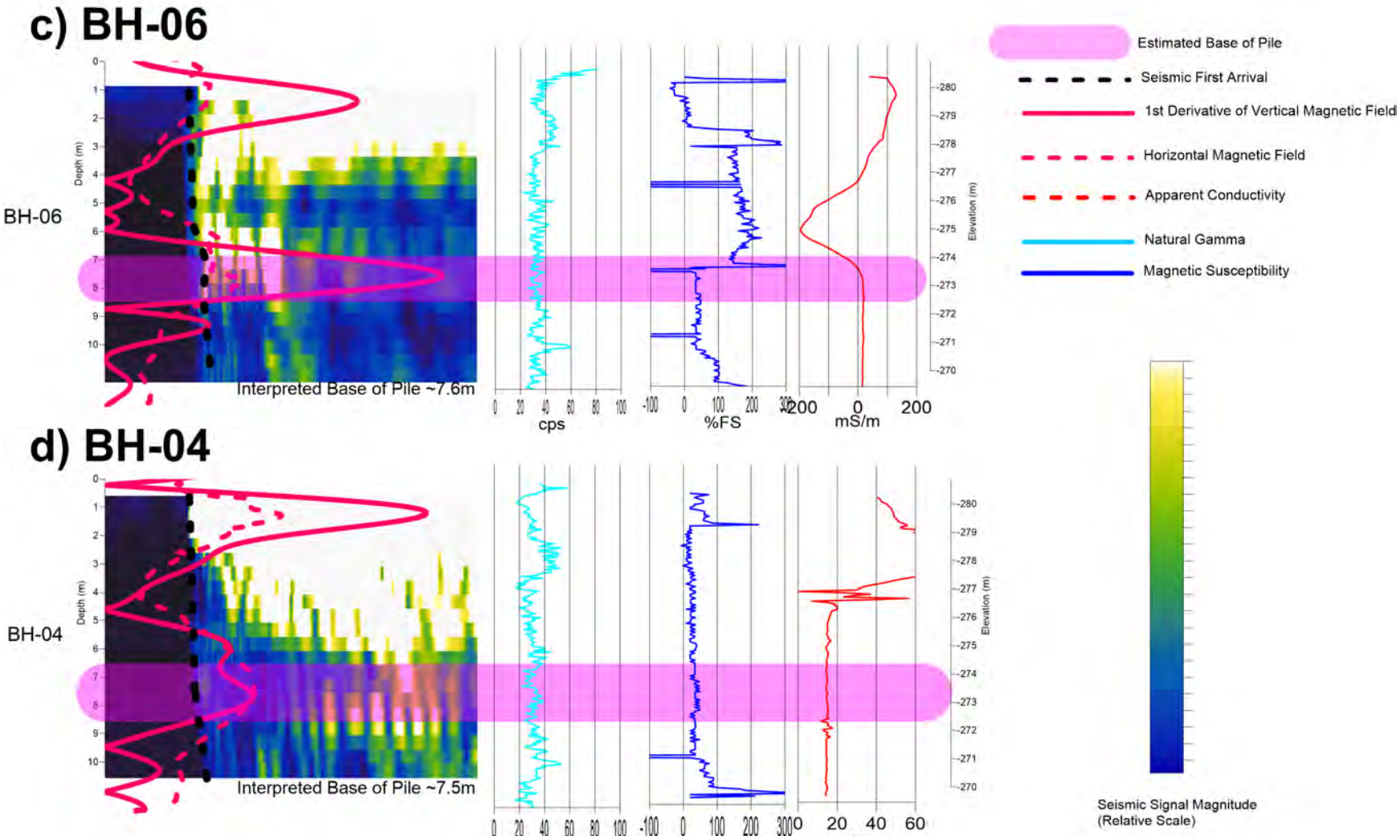


Figure 2 (cont.): Plots of borehole geophysical data logs showing estimated depth extents of bridge piles

CONCLUSIONS

Four different borehole geophysical methodologies were employed to attempt to measure the depth extent of battered steel piles beneath the bridge over Greenock Creek on Ontario Highway 9.

Four boreholes were investigated, BH-03 (SW), BH-05 (West central), BH-06 (East central) and BH-04 (NE). The boreholes were drilled under the supervision of Thurber Engineering.

The results of the investigation are presented in chart format in Figure 2 and summarized in Table 4.

Table 4: Estimated depth below ground surface (BGS) to base of piles and shear-walls based on geophysical measurements

Borehole ID	**Estimated Depth Below Ground Surface (BGS) to Base of Pile (m)**	**Estimated Base of Pile Elevation (m)**	Depth BGS to peak zone of influence (m)	Depth BGS to No influence (m)	Estimated Depth BGS to Base of Pile based on zone of influence (m)	Estimated Depth BGS to Base of Pile based on calculated peak in gradient (m)	Estimated Depth BGS to base of pile based on Seismic Data (m)
BH-03	**7.0**	274.2	3.9	9.1	6.5	6.8	7.5
BH-05	**7.1**	274.0	3.2	10.2	6.7	7.2	7.3
BH-06	**7.6**	273.3	5.9	10.4	8.2	7.6	7.7
BH-04	**7.5**	273.4	4.5	9.5	7	7.7	7.5

The magnetic field values (both horizontal component and the gradient of the vertical component) for all boreholes show two anomalous zones, one extending from the surface to about 3 m depth, and another centred about 7 m depth. The lower of these two anomalies likely represents the approximate base of the bridge piles. In all of the holes, the gradient of the vertical component showed much clearer peaks than did the horizontal component, suggesting that the vertical derivative may be able to delineate the pile extent with greater precision.

In the EM-39 borehole conductivity data, only borehole BH-06 shows a conductivity anomaly that is not correlated with an elevated gamma ray anomaly (and therefore increased clay content). The readings from this hole have a strong peak in conductivity with negative values, indicative of a metallic conductor, at about 6.5 m depth. Given the instrument's coil spacing of 0.6 m, this likely represents the point where the pile is closest to the borehole, and indicates that the other boreholes are potentially too far from their respective piles for those piles to be detected.

Interpretation of the seismic data suggests that the piles in all holes extend to approximately 7.5 m below grade. The ends of the piles can primarily be detected through detected through refraction methods,

producing results that align well with the magnetic gradient, but also through an observed reduction in wave amplitude below the assumed base of the pile.

Out of all of the methods, the gradient of the vertical magnetic field and seismic refraction appear to give the clearest indications of pile extent, and there is good agreement between their results. The combination of the methods increases the confidence level. The results of the geophysical surveys suggest that the piles extend to between 7.0 and 7.6 m depth below the surface. Confidence is greater for boreholes BH-03 and BH-06, due to good agreement between the methods employed, and possibly owing to the closer proximity of these holes to their respective piles.

The battered piles present some unique challenges both in the drilling and interpretation of the seismic results. In terms of the drilling, having the borehole located as close to the projected tip/base of pile will provide the most accurate results. With regards to the interpretation, the seismic arrival times and velocities will be influenced by variations in the surrounding soils and borehole pile offsets to a greater extent than for vertical piles and the magnetometer data will have less well defined peaks.

The assistance of Thurber Engineering is greatly appreciated in the completion of this project.

This report has been prepared by Nathan Stoikopoulos, M.Sc. and Ben McClement, P.Eng.

Ben McClement, P.Eng.

Site Photos

Photo 1: Seismic Survey at BH-05

Photo 2: Seismic Survey at BH-06

Photo 3: EM/Gamma survey in BH-03

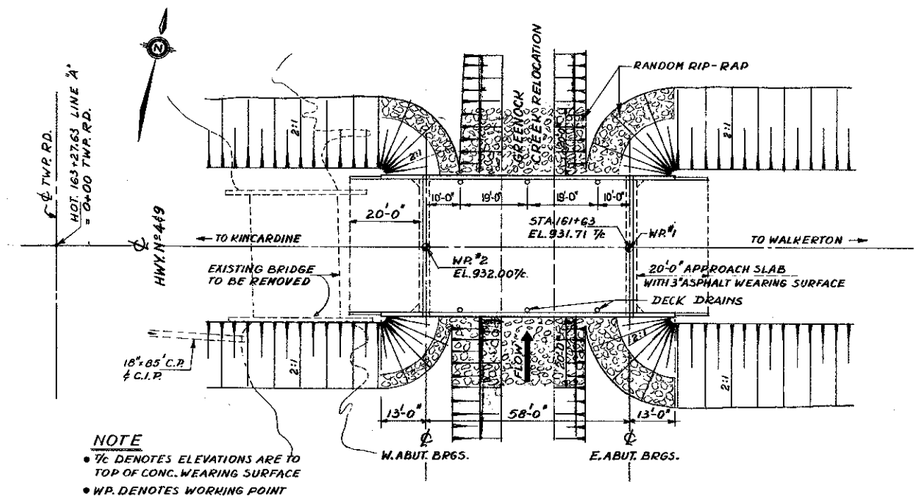
Photo 4: Magnetometer Survey in BH-05

Photo 5: Survey Setup at BH-06

Photo 6: EM/Gamma Survey in BH-04

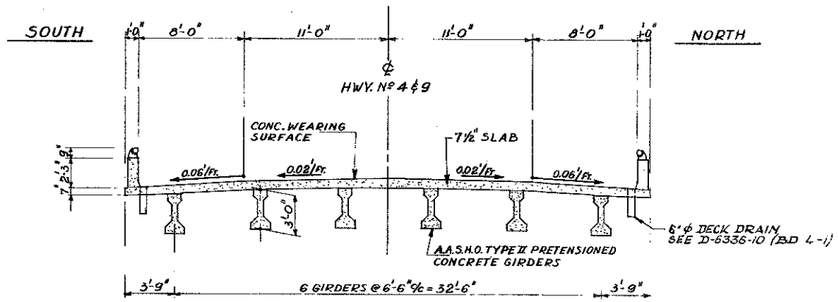
THURBER

Appendix F
Excerpts from Archived Historical Contract Drawings for Greenock Creek Brdige



NOTE
- ℄ DENOTES ELEVATIONS ARE TO TOP OF CONC. WEARING SURFACE
- WP. DENOTES WORKING POINT

PLAN
SCALE :- 1"=20'-0"



TYPICAL DECK SECTION
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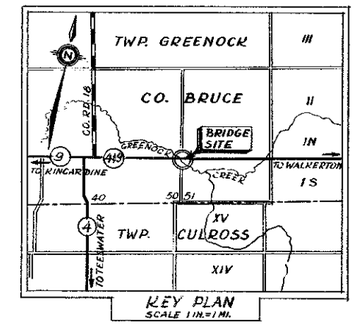
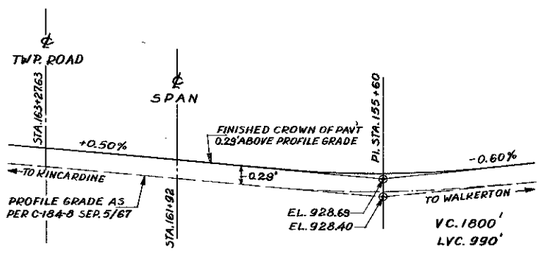
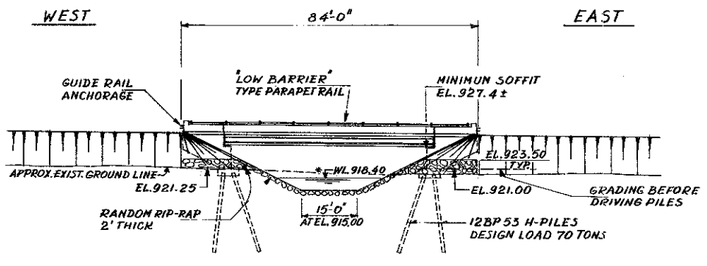




PROFILE OF HWY. Nº 4 & 9
NOT TO SCALE



* W.L. MAY. 1967 AS PER E-4806-1

ELEVATION
SCALE :- 1"=20'-0"

LIST OF DRAWINGS

NOTES

CLASS OF CONCRETE

DECK, PARAPET WALLS	4000 PSI.
REMAINDER	3000 PSI. OR AS NOTED

CLEAR COVER ON REINFORCING STEEL

FOOTINGS	ABUTMENTS	DECK TOP	DECK BOTTOM
3"	3"	1½"	1"

DIAPHRAGMS	PARAPET WALLS	APPROACH SLABS
1½"	1½"	2"

CONSTRUCTION NOTES
THE CONTRACTOR SHALL BE RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8". NO CONCRETE SHALL BE PLACED ABOVE THE BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

D.H.O. PRECISE B.M. Nº 65-292 ELEV. 397.202
TWO STORY STONE HOUSE (RESIDENCE OF P. WALLACE) ON THE NORTH SIDE OF HWY Nº 4 AND 9. BEING 0.95 MILES WEST OF THE JUNCTION OF HWYS. Nº 4 AND Nº 9 AND GREENOCK RD. Nº 15 IN THE HAMLET OF GREENOCK 0.35 MILES EAST OF TOWN-SHIP ROAD Nº 13 BETWEEN LOTS 50 AND 51, AND 120 FEET NORTH OF CENTRELINE OF PAVEMENT. TABLET IS SET HORIZONTALLY IN THE EAST FACE OF STONE WALL, BEING 2.7 FEET NORTH OF THE SOUTH-EAST CORNER, AND 1.6 FEET ABOVE GROUND

REVISIONS			
	DATE	BY	DESCRIPTION

REGISTERED PROFESSIONAL ENGINEERS PROVINCE OF ONTARIO
CIVIL
B. RUTTNER

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

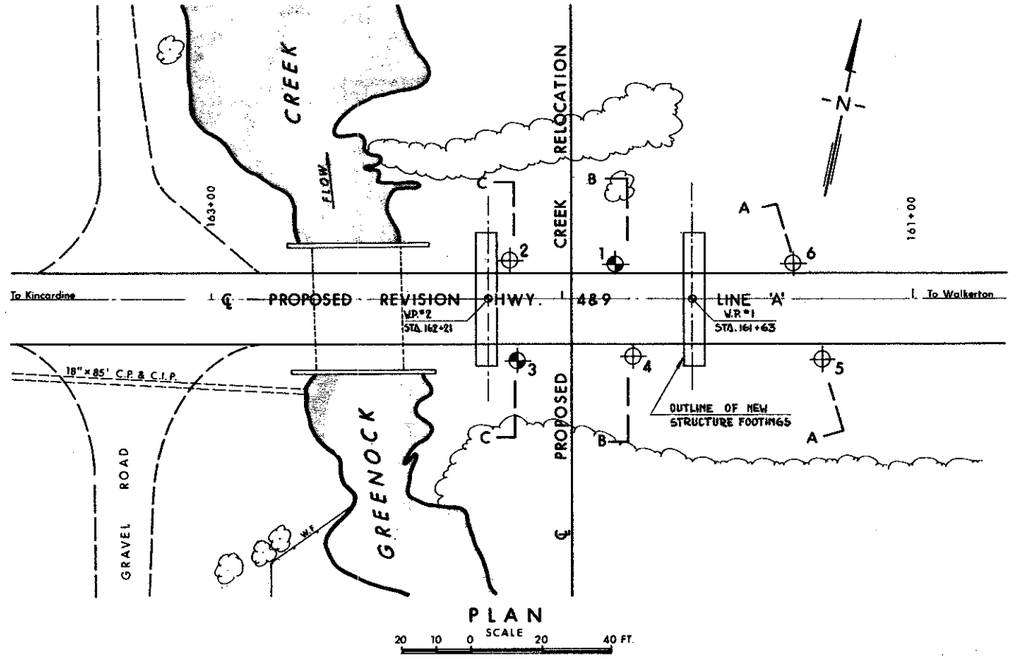
GREENOCK CREEK BRIDGE
6.8 MILES WEST OF WALKERTON WEST LIMITS

KING'S HIGHWAY No. 4 & 9 — DIST. No. 5
CO. BRUCE
TWP. GREENOCK — LOT 51 — CON. LINES OF DURHAM RD.

GENERAL LAYOUT

APPROVED ____ BRIDGE ENGINEER

DESIGN	B.R.	CHECK	W.T.H.	SITE No. 2-258	W.P. No. 7-66-01
DRAWING	J.S.	CHECK	J.L.K.	CONTRACT Nos.	71-25
DATE	JAN.69	LOADING	HS20-44	DRAWING No.	D-6336-1



PLAN

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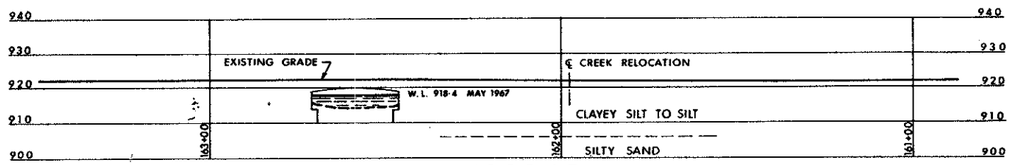
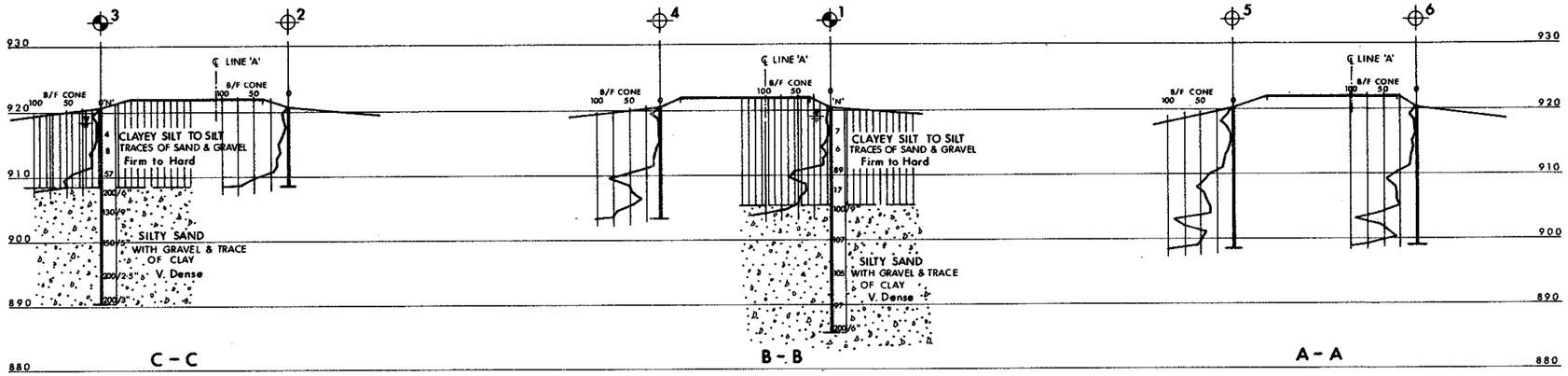


℄ PROFILE

SCALE 20 10 0 20 40 FT.



SECTIONS

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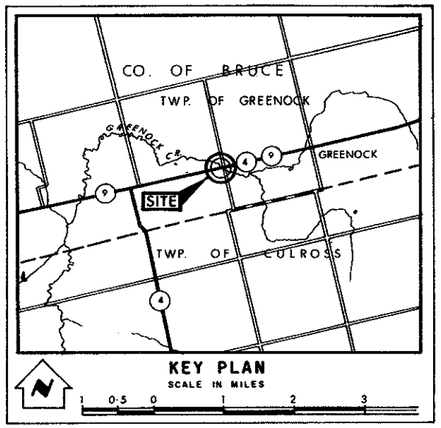


LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. JULY 1967

NO.	ELEVATION	STATION	OFFSET
1	920·6	161+85	10' RT.
2	920·8	162+15	11' RT.
3	920·7	162+13	17·5' LT.
4	920·6	161+80	16' LT.
5	920·2	161+26	17' LT.
6	920·3	161+34	10' RT.

-NOTE-

The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Owen Sound District Office.

- NOTE -

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION - FOUNDATION SECTION

GREENOCK CREEK RELOCATION

KING'S HIGHWAY NO. 4 & 9 LINE 'A' DIST. NO. 5

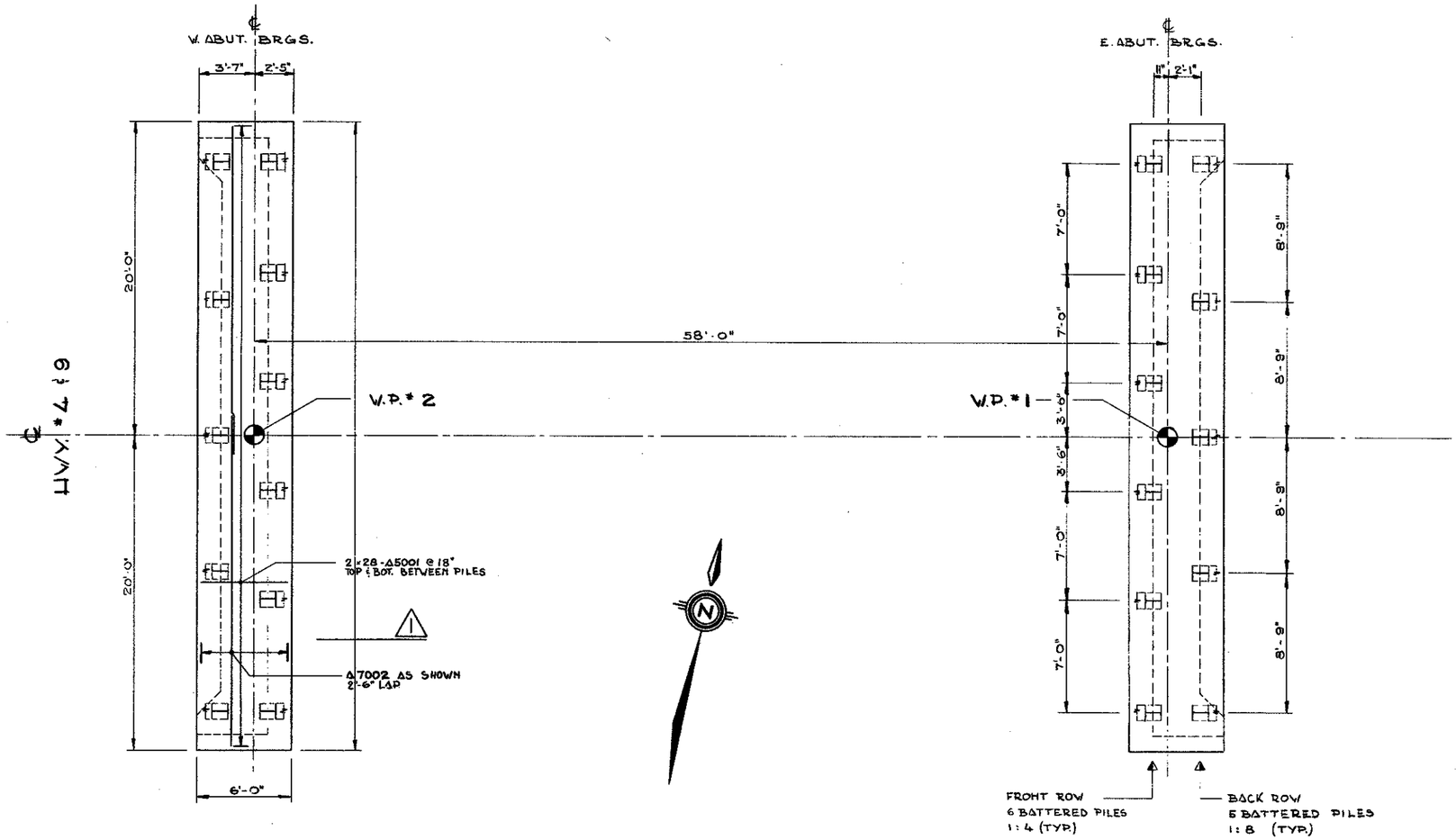
CO. BRUCE

TWP. GREENOCK LOT 51 CON. I N & S D R.

BORE HOLE LOCATIONS & SOIL STRATA

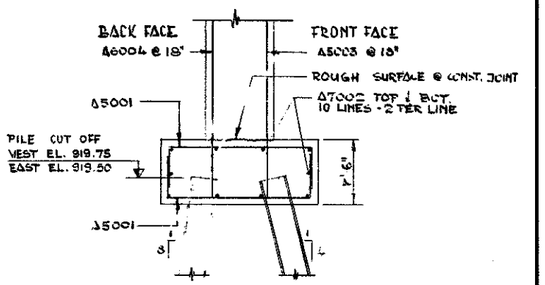
SUBM'D. A.S.	CHECKED	W.P. NO. 7-66-01	M.&T. DRAWING NO. 67-F-61A
DRAWN S.O.	CHECKED	JOB NO. 67-F-61	
DATE 5 SEPT. 1967		SITE NO. 2-258	BRIDGE DRAWING NO. D-6336-2
APPROVED A. A. Thomas PRINCIPAL FOUNDATION ENGINEER		CONT. NO. 71-25	

REF. NO. E-4806-1



FOUNDATION LAYOUT

SCALE : 1/4" = 1'-0"



SCALE : 3/8" = 1'-0"

NOTES:

FOOTING DIMENSIONS AND PILE LAYOUTS FOR BOTH ABUTMENTS ARE SIMILAR.

SPACING OF PILES TO BE MEASURED AT UNDERSIDE OF FOOTINGS.

PILES SHALL BE DRIVEN IN ACCORDANCE WITH 3.D.82-7. SEE D-6336-5

PILES SUPPLIED			
LOCATION	NO.	LENGTH	TYPE
WEST ABUT.	11	26'-0"	12BP53 H-PILES
EAST ABUT.	11	26'-0"	12BP53 H-PILES
DESIGN LOAD PER PILE = 70 TONS			

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

GREENOCK CREEK BRIDGE

6.8 MILES WEST OF WALKERTON WEST LIMITS.

KING'S HIGHWAY No. 4 & 9 — DIST. No. 5

CO. BRUCE

TWP. GREENOCK — LOT 51 — CON. I.H. & S. OF NORTHERN RD.

FOOTINGS

REGISTERED PROFESSIONAL ENGINEER — CIVIL — B. RUTTNER — PROVINCE OF ONTARIO

APPROVED _____ BRIDGE ENGINEER

DESIGN	B.R.	CHECK	W.T.H.
DRAWING	J.P.M.	CHECK	B.R.
DATE	JAN. 69	LOADING	H520-44

SITE No. 2-258 — W.P. No. 7-66-01

CONTRACT Nos. — 71 27

DRAWING No. D-6336-3