THURBER ENGINEERING LTD.

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
CULVERT 105
DUGALD ROAD, STA. 9+890, HORTON TOWNSHIP
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009

Geocres No.: 31F07-003

Report to:

Ministry of Transportation Ontario

Latitude: 45.499359°
Longitude: -76.665894°

December 2024
Thurber File No.: 24726

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street within the County of Renfrew, Ontario. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018-E-0009.

This report addresses the proposed structural culvert at about Sta. 9+890 on the realignment of Dugald Road in Horton Township, north of the new Bruce Street Interchange.

This section of the report presents the factual findings obtained from the foundation investigation conducted by Thurber as part of the current study. Thurber carried out the investigation under Ministry of Transportation (MTO) Assignment No. 4018 E 0009.

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

Under the same MTO Assignment a foundation investigation was conducted by Thurber for the new Bruce Street Interchange, which is located approximately 440 m west of the site. The available information was reviewed prior to this investigation and can be found in the Geocres Library under Geocres Number 31F-234.

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.

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2 SITE DESCRIPTION

2.1 General

Dugald Road is to be re-aligned as part of the construction of the Bruce Street (County Road 20) Interchange. The realignment will shift the County Road 20 intersection with Dugald Road 315 m to the north. For project purposes, the proposed realignment of Dugald Road is herein described as oriented north-south. A new culvert will be required to convey a creek beneath the newly aligned Dugald Road at approximate Sta. 9+890 with creek flow from west to east.

The land adjacent to the site generally consists of undeveloped agricultural fields. The terrain is relatively flat in the vicinity of the proposed culvert site and generally more rugged along the creek. The area directly adjacent to the proposed culvert is a low-lying marsh dominated with grasses and transitions to mostly farmland with some deciduous trees and shrubs found along the creek line. A driveway crossing an 1,800 mm diameter culvert is currently located approximately 20 m northeast of the site. Overhead utility lines parallel that driveway.

Upstream of the site, a creek crosses beneath County Road 20 through an existing 3600 mm diameter CSP culvert. It is understood that the CSP culvert has an invert elevation at the outlet of 142.6 m.

The water depth in the creek at the proposed location of the culvert was measured to be approximately 600 mm at the time of the field investigation. The elevation of the creek bed near the proposed culvert location was surveyed as 142.3 m on July 26, 2024.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix D for reference.

2.2 Site Geology

According to Crins et al. 2009[1] the project area is described as Ecoregion 6E (Lake Simcoe-Rideau Ecoregion) within the Mixedwood Plains Ecozone. According to Wester et al. 2018[2] the ecoregion is subdivided into Ecodistrict 6E-16 (Pembroke Ecodistrict). The area is characterized by glaciolacustrine dominated landscape overlying a mix of Paleozoic to Precambrian bedrock.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.

[1] *https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf*
[2] *https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf*

Ontario Geological Survey Map P.3784[3] for Precambrian Geology for the Horton Area suggests the bedrock is dolomitic and calcitic carbonate metasedimentary bedrock including grey to white calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out on February 27 and 28, 2024, and consisted of two off-road boreholes identified as SC105-1 and SC105-2. The boreholes were advanced with a CME 55 track mounted drill rig utilizing hollow stem augers, and NW casing and coring techniques. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

A summary of the borehole coordinates, elevations, and termination depths is provided in Table 3-1. The locations and elevations of the boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy and were measured relative to BM HCP 102 (Elevation 129.023 m). Horizontal locations were measured by Thurber relative to existing site features. The elevations and borehole coordinates were reviewed and referenced to the survey data provided by the MTO. The borehole coordinates and elevations are shown on the Borehole Location and Soil Strata drawing included in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 9.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
SC105-1	Near Inlet	5 039 944.1 (45.499299)	291 820.4 (-76.666084)	143.2	14.1
SC105-2	Near Outlet	5 039 955.1 (45.499398)	291 854.0 (-76.665654)	143.2	7.5

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D 1586. In-situ shear vane testing was carried out within the cohesive layers, where possible, using an MTO 'N' sized vane in general accordance with ASTM D 2573. A Thin-Walled (Shelby) Tube samples were pushed and retrieved in Borehole SC105-1 to obtain a relatively undisturbed cohesive soil sample for further laboratory testing.

A 50 mm diameter well was installed in each of the boreholes to allow for measurements of the groundwater level after drilling. The details for the wells are illustrated on the respective Record of Borehole sheets provided in Appendix B. The monitoring wells installed as part of the current

[3] *http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml*

investigation will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's Ottawa laboratory for further examination and testing.

4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to testing for grain size distribution analysis and, where appropriate, Atterberg Limits in accordance with MTO and ASTM standards. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on a sample of the soil.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487 with the description of secondary components as outlined in the MTO Guideline for Foundation Engineering Services (GFES) Manual (April 2022) and the 4th Edition of the Canadian Foundation Engineering Manual.

In general, the encountered stratigraphy consists of organic silt over a native deposit of clayey silt followed by silty sand glacial till over bedrock.

5.1 Organic Silt (OI)

A deposit of organic silt containing root material, peat, and various amounts of sand was encountered below the ground surface in the boreholes. The thickness of the layer was 0.6 m (base elev. 142.6 m). The organic silt is described as very loose based on tactile evaluations of strength.

The moisture content of two samples tested were 67 and 153%. The results of a grain size analysis test conducted on a sample of this material are summarized in the table below and are

illustrated on Figure C1 in Appendix C. It is noted that hydrometer testing is less accurate for soils containing organic material.

Summary of Grain Size Distribution Testing – Organic Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	20
Silt	59
Clay	21

The results of Atterberg Limits testing carried out on a sample of this material are summarized below and are illustrated on Figure C2 in Appendix C. The laboratory results indicate that the organic silt is of intermediate plasticity (OI).

Summary of Atterberg Limit Testing – Organic Silt

Parameter	Value
Liquid Limit	43
Plastic Limit	28
Plasticity Index	15

5.2 Clayey Silt (CL)

A glaciomarine native deposit of clayey silt was encountered below the organic silt in the boreholes. Varying amounts of sand were noted within the layer. The thickness of the layer ranged from 2.4 to 6.3 m (base elev. 140.2 to 136.3 m).

Where SPT was conducted within the layer, the N-values typically ranged from weight-of-hammer (WH) to 8 blows. Field vane tests were performed within this layer where possible. All undrained shear strengths obtained were greater than 100 kPa. Remolded vane tests recorded sensitives typically ranging from less than 5 to 24, indicating that the clayey silt sensitivity varies from sensitive to quick clay (CFEM, 2006). The layer is described as stiff to very stiff in consistency based on N-values, undrained shear strength measurements, and tactile evaluations of strength.

The moisture content of the samples tested ranged from 25 to 34%. The results of three grain size analysis tests conducted on samples of this material are summarized in the table below and are illustrated on Figure C3 in Appendix C.

Summary of Grain Size Distribution Testing – Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	6 – 11
Silt	57 – 59
Clay	32 – 35

The results of Atterberg Limits testing carried out on three samples of this material are summarized below and are illustrated on Figure C4 in Appendix C. The laboratory results indicate that the clayey silt is of low plasticity (CL). Summary of Atterberg Limit Testing – Clayey Silt

Summary of Atterberg Limit Testing – Clayey Silt

Parameter	Value
Liquid Limit	25 – 27
Plastic Limit	15 – 17
Plasticity Index	9 – 12

5.3 Silty Sand (Glacial Till)

A layer of silty sand till was encountered below the clayey silt deposit in the boreholes. Varying amounts of gravel were encountered throughout the layer. The layer thickness was observed to range from 1.4 to 4.2 m (base elev. 138.8 to 132.1 m). SPT N-values ranged from 11 to 93 blows, indicating a compact to very dense relative density. A refusal blow counted encountered at the base of the layer is attributed to the bedrock surface. Although not observed in the boreholes, it should be anticipated that cobbles and boulders are also present in the glacial till deposit.

The moisture content of the samples tested ranged from 12 to 17%. The results of gradation analyses completed on two samples of the layer are illustrated in Figure C5 of Appendix C. The results of the tests are summarized below and on the Record of Borehole sheets in Appendix B.

Summary of Grain Size Distribution Testing – Silty Sand

Soil Particle	Percentage (%)
Gravel	1 – 13
Sand	61 – 65
Silt	18 – 27
Clay	4 – 11

The results of Atterberg Limit testing conducted on the fines portion of two samples of the deposit indicate a non-plastic material.

5.4 Bedrock

Bedrock was proven by coring in the boreholes. The bedrock surface was sloping with the depth to bedrock observed to be 4.4 and 11.1 m (elevation 138.8 and 132.1 m) in Boreholes SC105-2 and SC105-1 respectively.

The bedrock encountered consisted of fine to medium grained, grey to greyish white, strong marble. Sand seams were encountered within the weathered joints. Photographs of the bedrock cores are provided in Appendix C. The rock core quality measurements are summarized in Table 5-1.

Table 5-1: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	78 – 100
Solid Core Recovery (SCR), %	53 – 96
Rock Quality Designation (RQD), %	30 – 96
Fracture Index (fractures per 0.3 m)(1)	0 – >10
Unconfined Compressive Strength (MPa)	67 – 71

Note: (1) Indicated as “FI” on Borehole Logs

The RQD values ranged from 30% to 96%, indicating a bedrock of poor to excellent quality (CFEM, 2023). The results of unconfined compressive strength tests (UCS) were 67 and 71 MPa, indicating that the tested samples of the bedrock are strong (CFEM, 2023). The UCS test results are included in Appendix C.

5.5 Groundwater

Monitoring wells with diameters of 50 mm were installed in Boreholes SC105-1 and SC105-2. Groundwater levels recorded in the wells are presented in Table 5-2.

Table 5-2: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Groundwater Depth[(a)] (m)	Groundwater Elevation (m)	Date of Measurement
SC105-1	132.2	-0.4	143.6	March 07, 2024
		-0.1	143.3	March 22, 2024
		-0.1	143.3	April 10, 2024
		-0.2	143.4	April 24, 2024
		0.1	143.1	June 04, 2024
		-0.2	143.4	June 26, 2024
		0.1	143.1	August 30, 2024
SC105-2	138.8	-0.1	143.3	March 07, 2024
		0.0	143.2	March 22, 2024
		0.0	143.2	April 10, 2024
		-0.1	143.3	April 24, 2024
		0.0	143.2	June 04, 2024
		-0.2	143.4	June 25, 2024
		-0.1	143.3	July 15, 2024
		0.0	143.2	August 30, 2024

Notes: (a) negative ground water depths indicate artesian conditions

The water depth in the creek was measured to be approximately 600 mm and the elevation of the creek bed near the proposed culvert location was surveyed as 142.3 m on July 26, 2024.

These observations are considered short term as they were recorded at discrete times, and it should be noted that the groundwater level at the time of construction may be different. Seasonal fluctuations of the groundwater level are to be expected. Furthermore, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.6 Analytical Testing

One sample of the native clayey silt was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity, and conductivity. The analysis results are summarized in Table 5-3. Copies of the test results are provided in Appendix C.

Table 5-3: Results of Chemical Analysis

Borehole	Sample	Depth (m)	Chloride (µg/g)	Sulphate (µg/g)	Sulphide (%)	pH (-)	Resistivity (Ohm-cm)
SC105-2	SS2	0.8 – 1.4	< 10	< 10	< 0.01	7.24	11,100

6 MISCELLANEOUS

The borehole locations reflect existing site features and access constraints. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program. George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated the drill rig used to drill, test, and sample. The field investigation was supervised on a full-time basis by Mr. R. Howarth, Geotechnical Technician. Overall supervision of the field investigation program was provided by Mr. J. Gray, P.Eng.

Routine geotechnical laboratory testing were completed by Thurber's laboratory in Ottawa. UCS testing were completed by Thurber's laboratory in Oakville. Analytical testing was completed by Paracel Laboratories Ltd. in Ottawa.

Interpretation of the factual data and preparation of this report was completed by A. de Oliveira, P.Eng. The report was reviewed by Dr. F. Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
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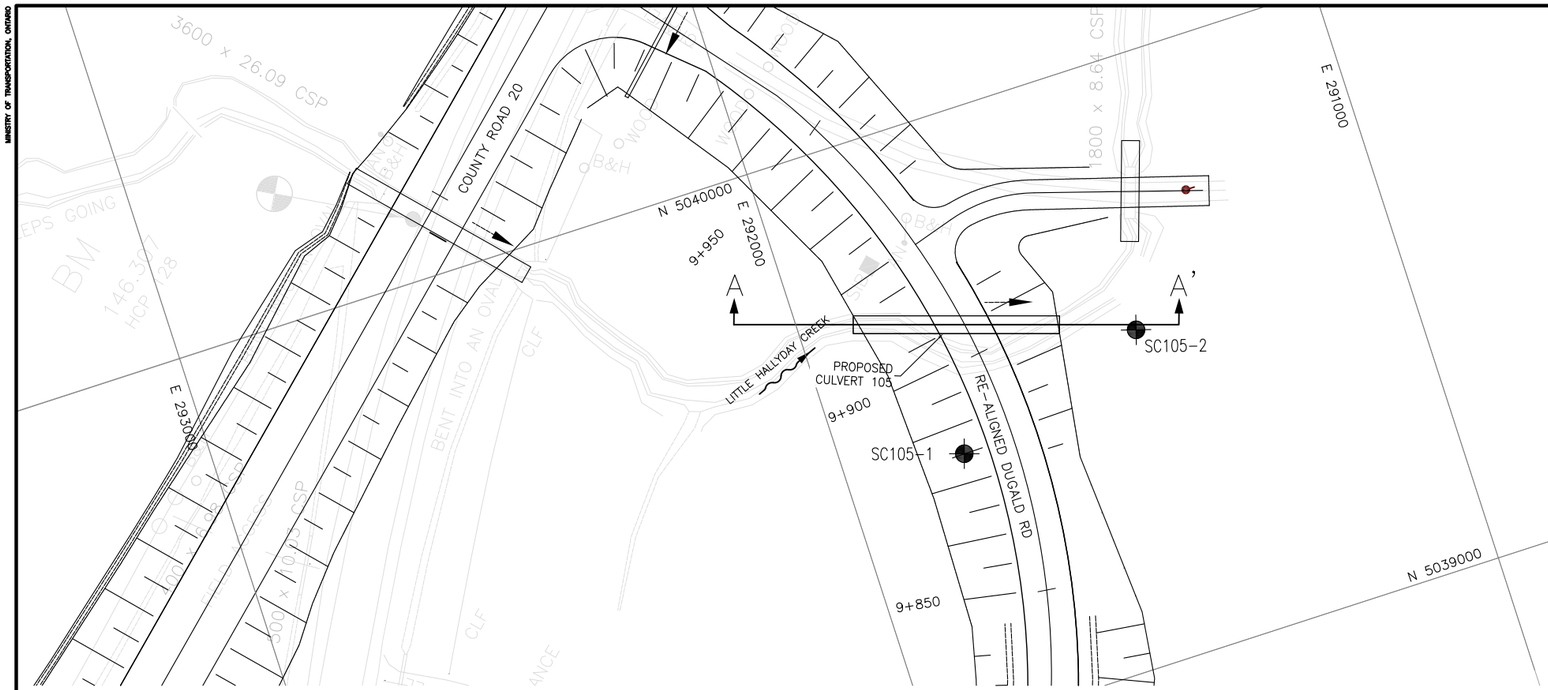
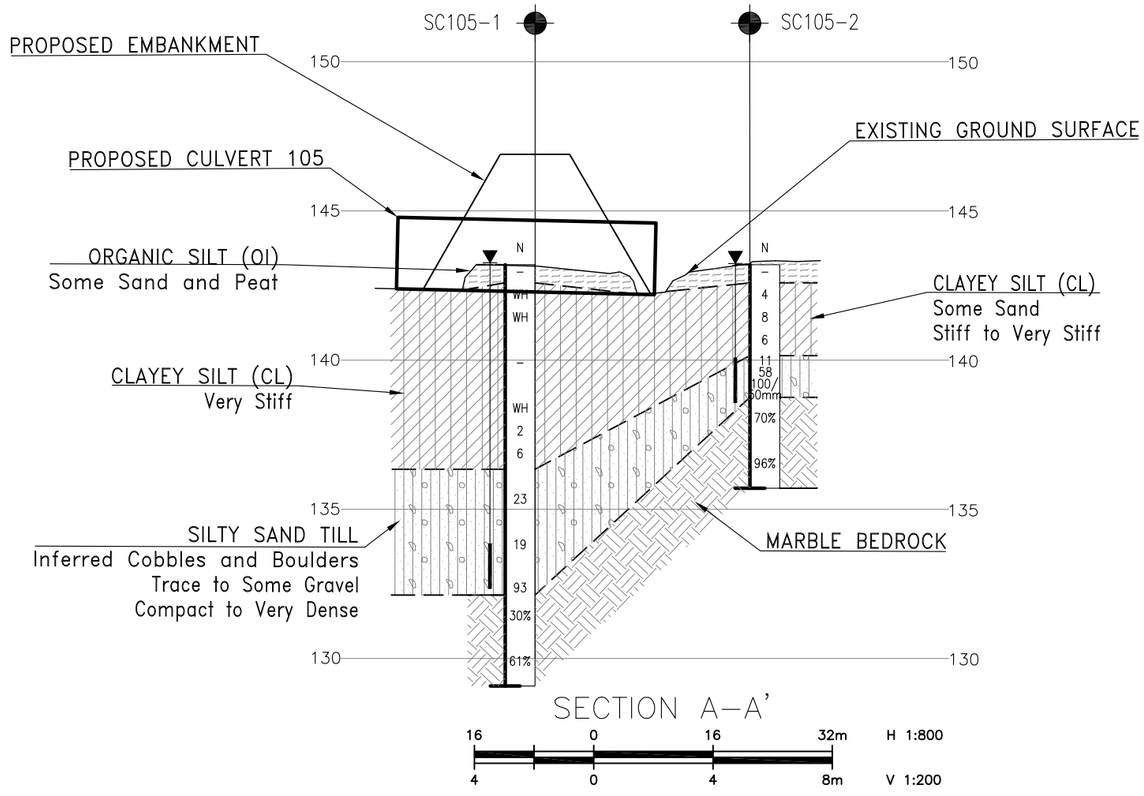
Appendix A.

Borehole Location Plan and Stratigraphic Drawings





METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

GWP No 4068-09-00

HIGHWAY 17 TWINNING
RE-ALIGNED DUGALD RD
STA. 9+890, CULVERT 105
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET 1

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KEYPLAN

LEGEND

⊕	Borehole
⊕	Historic Borehole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level Upon Completion of Drilling
▼	Water Level in Mointoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SC105-1	143.2	5 039 944.1	291 820.4
SC105-2	143.2	5 039 955.1	291 854.0

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F07-003

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
90360280
Dec 19, 2024
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Dec 19, 2024
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	AO	CHK –	CODE	LOAD	DATE NOV 2024
DRAWN	RH	CHK FG	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\24000\24728\Culvert 105\TED-24728-BHPP-Culvert 105.dwg
PLOTDATE: 12/16/2024 4:55 PM

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Appendix B.

Record of Borehole Sheets

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SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

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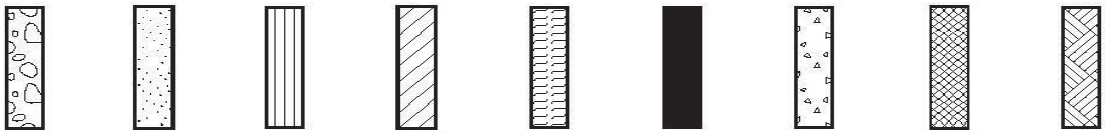
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel

Sand

Silt

Clay

Organics

Asphalt

Concrete

Fill

Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

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MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

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EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SC105-1 1 OF 2 METRIC

WP# 4068-09-00 LOCATION Lat: 45.499299°, Long: -76.666084° Culvert 105; Horton Township; MTM z9: N 5 039 944.1 E 291 820.4 ORIGINATED BY RH

HWY 17 BOREHOLE TYPE CME 55 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO

DATUM Geodetic DATE 2024.02.27 - 2024.02.27 CHECKED BY CM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
143.2	**Ground Surface**							20 40 60 80 100	20 40 60		
0.0	**ORGANIC SILT (OI)**, some sand contains root material and peat very loose brownish black		1	GS	-		143				0 20 59 21
142.6											
0.6	**CLAYEY SILT (CL)** very stiff grey		2	SS	WH		142				
			3	SS	WH						0 6 59 35
							141	24.0 + > 115 kPa			
			4	TW	-		140				
								4.8 + 8.0 +			
			5	SS	WH		139				
							138				
	- unable to push vane		6	SS	2						
			7	SS	6		137				0 7 59 34
136.3	- unable to push vane										
6.9	**SILTY SAND (SM)**, trace gravel inferred cobbles and boulders compact to very dense grey **GLACIAL TILL**						136				
			8	SS	23		135				
			9	SS	19		134				1 61 27 11 Non-plastic

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

DOUBLE LINE 24726 CULVERT 105.GPJ 2012TEMPLATE(MTO).GDT 12-16-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SC105-1 2 OF 2 METRIC

WP# 4068-09-00 LOCATION Lat: 45.499299°, Long: -76.666084° Culvert 105; Horton Township; MTM z9: N 5 039 944.1 E 291 820.4 ORIGINATED BY RH

HWY 17 BOREHOLE TYPE CME 55 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO

DATUM Geodetic DATE 2024.02.27 - 2024.02.27 CHECKED BY CM

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
132.1	**SILTY SAND**, trace gravel inferred cobbles and boulders compact to very dense grey **GLACIAL TILL**		10	SS	93		133		○	FI	
11.1	**MARBLE BEDROCK** slightly weathered to fresh jointed grey fine to medium grained strong - sand seam from a depth of 11.9 to 12.3 m		1	RUN	-		132 131			4 6 10 >10 3	RUN #1 TCR=78% SCR=53% RQD=30% UCS=71MPa
129.1			2	RUN	-		130			1 3 5 >10 3	RUN #2 TCR=93% SCR=68% RQD=61%
14.1	**End of Borehole** **Monitoring Well installed:** Schedule 40 PVC standpipe with 50-mm diameter and 3.0-m slotted screen. Stick-up cover installed at ground surface. **Water Level Readings:** **DATE — DEPTH (m) — ELEV. (m)** 2024/03/07 -0.4 143.6 2024/03/22 -0.1 143.3 2024/04/10 -0.1 143.3 2024/04/24 -0.2 143.4 2024/06/04 0.1 143.1 2024/06/26 -0.2 143.4 2024/08/30 0.1 143.1										

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

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

DOUBLE LINE 24726 CULVERT 105.GPJ 2012TEMPLATE(MTO).GDT 12-16-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No SC105-2 1 OF 1 METRIC

WP# 4068-09-00 LOCATION Lat: 45.499398°, Long: -76.665654° Culvert 105; Horton Township; MTM z9: N 5 039 955.1 E 291 854.0 ORIGINATED BY RH

HWY 17 BOREHOLE TYPE CME 55 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO

DATUM Geodetic DATE 2024.02.28 - 2024.02.28 CHECKED BY CM

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
143.2	**Ground Surface**										
0.0 / 142.6	**ORGANIC SILT (OI)** contains root material and peat very loose brownish black		1	GS	-		143				
0.6 / 140.2	**CLAYEY SILT (CL)**, some sand stiff to very stiff grey		2	SS	4		142				
			3	SS	8		141				0 11 57 32
			4	SS	6						
3.0 / 138.8	**SILTY SAND (SM)**, some gravel inferred cobbles and boulders compact to very dense grey **GLACIAL TILL**		5	SS	11		140				13 65 18 4 Non-plastic
			6	SS	58		139				
			7	SS	100/ 0mm					FI	
4.4 / 135.7	**MARBLE BEDROCK** slightly weathered to fresh jointed greyish white fine to medium grained strong		1	RUN	-		138			4 3 1 0 0	RUN #1 TCR=90% SCR=83% RQD=70%
			1	RUN	-		137			1 2 0 1 0	RUN #1 TCR=100% SCR=96% RQD=96% UCS=67MPa
7.5	**End of Borehole**						136				

Monitoring Well installed:
Schedule 40 PVC standpipe with 50-mm diameter and 3.0-m slotted screen. Stick-up cover installed at ground surface.

Water Level Readings:

DATE	DEPTH (m)	ELEV. (m)
2024/03/07	-0.1	143.3
2024/03/22	0.0	143.2
2024/04/10	0.0	143.2
2024/04/24	-0.1	143.3
2024/06/04	0.0	143.2
2024/06/25	-0.2	143.4
2024/07/15	-0.1	143.3
2024/08/30	0.0	143.2

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

(%) STRAIN AT FAILURE

DOUBLE LINE 24726 CULVERT 105.GPJ 2012TEMPLATE(MTO).GDT 12-16-24

Appendix C.

Laboratory Testing

THURBER

Appendix C.1

Particle Size Analysis Figures

Atterberg Limit Test Results

Unconfined Compressive Strength Testing Results

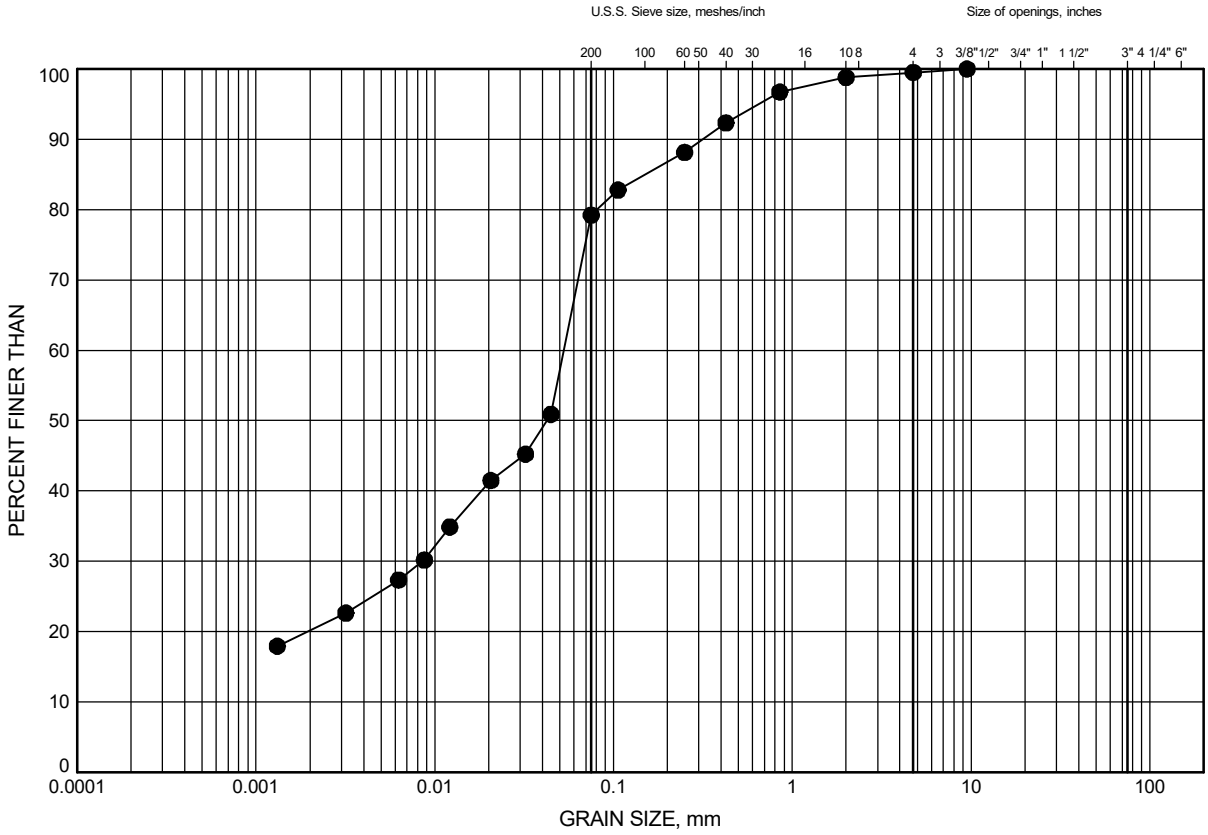
Rock Core Photos

Highway 17 Twinning, Culvert 105 (Dugald Road)

GRAIN SIZE DISTRIBUTION

FIGURE C1

Organic Silt (OI)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC105-1	0.3	142.9

Date July 2024

WP# 4068-09-00

THURBER

Prep'd RH

Chkd. MJK

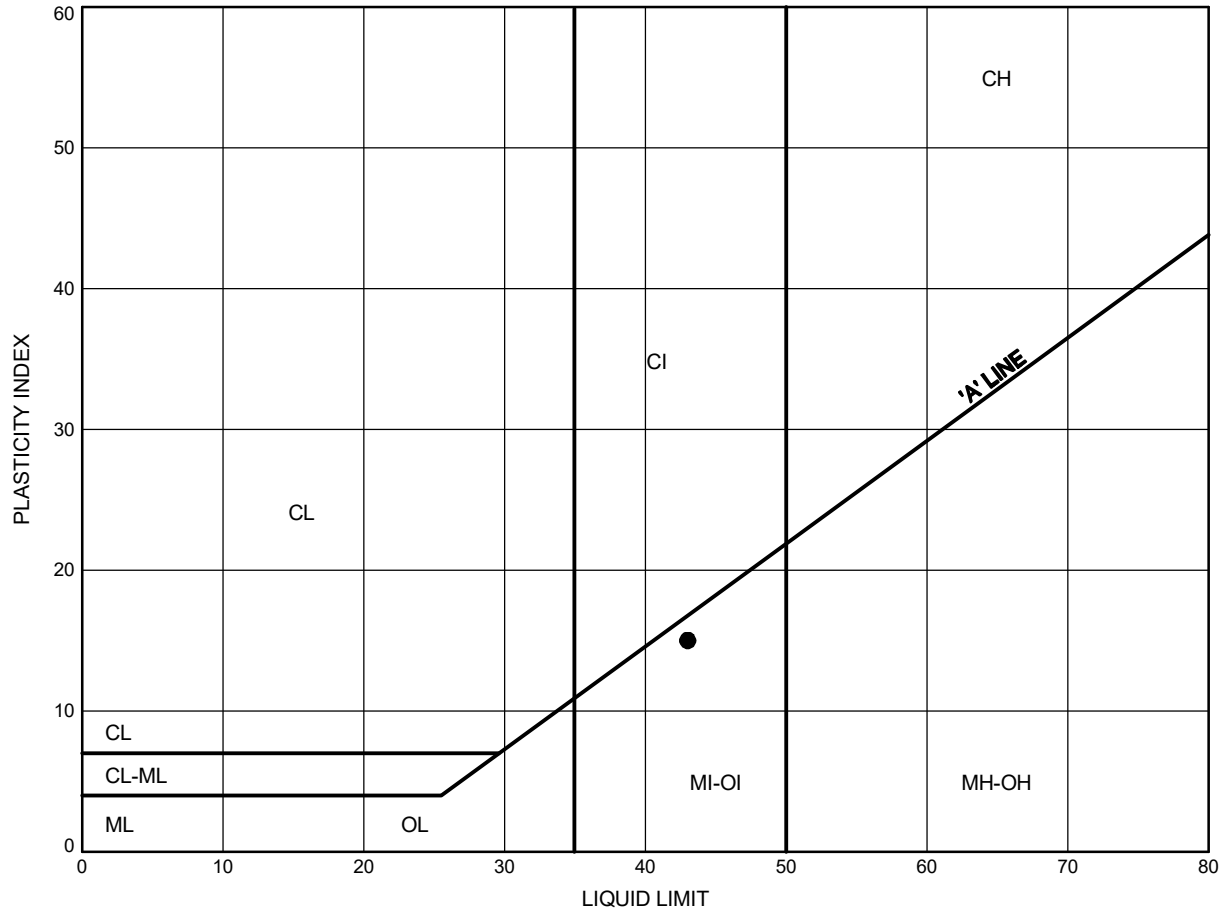
GRAIN SIZE DISTRIBUTION - THURBER 24726 CULVERT 105.GPJ 7-11-24

Highway 17 Twinning, Culvert 105 (Dugald Road)

ATTERBERG LIMITS TEST RESULTS

FIGURE C2

Organic Silt (OI)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC105-1	0.3	142.9

Date July 2024

WP# 4068-09-00

THURBER

Prep'd RH

Chkd. MJK

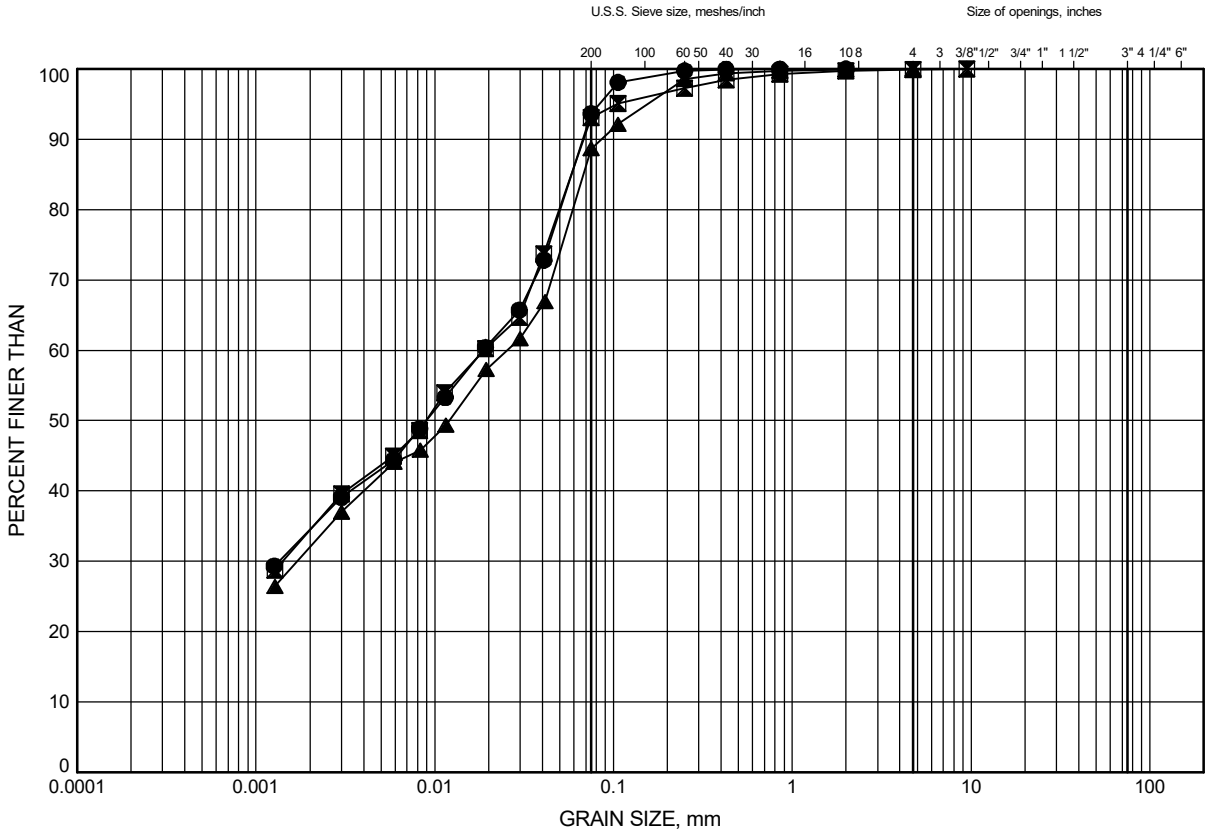
THURBALT 24726 CULVERT 105.GPJ 7-11-24

Highway 17 Twinning, Culvert 105 (Dugald Road)

GRAIN SIZE DISTRIBUTION

FIGURE C3

Clayey Silt (CL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC105-1	1.8	141.4
⊠	SC105-1	6.4	136.8
▲	SC105-2	1.8	141.4

Date July 2024

WP# 4068-09-00

THURBER

Prep'd RH

Chkd. MJK

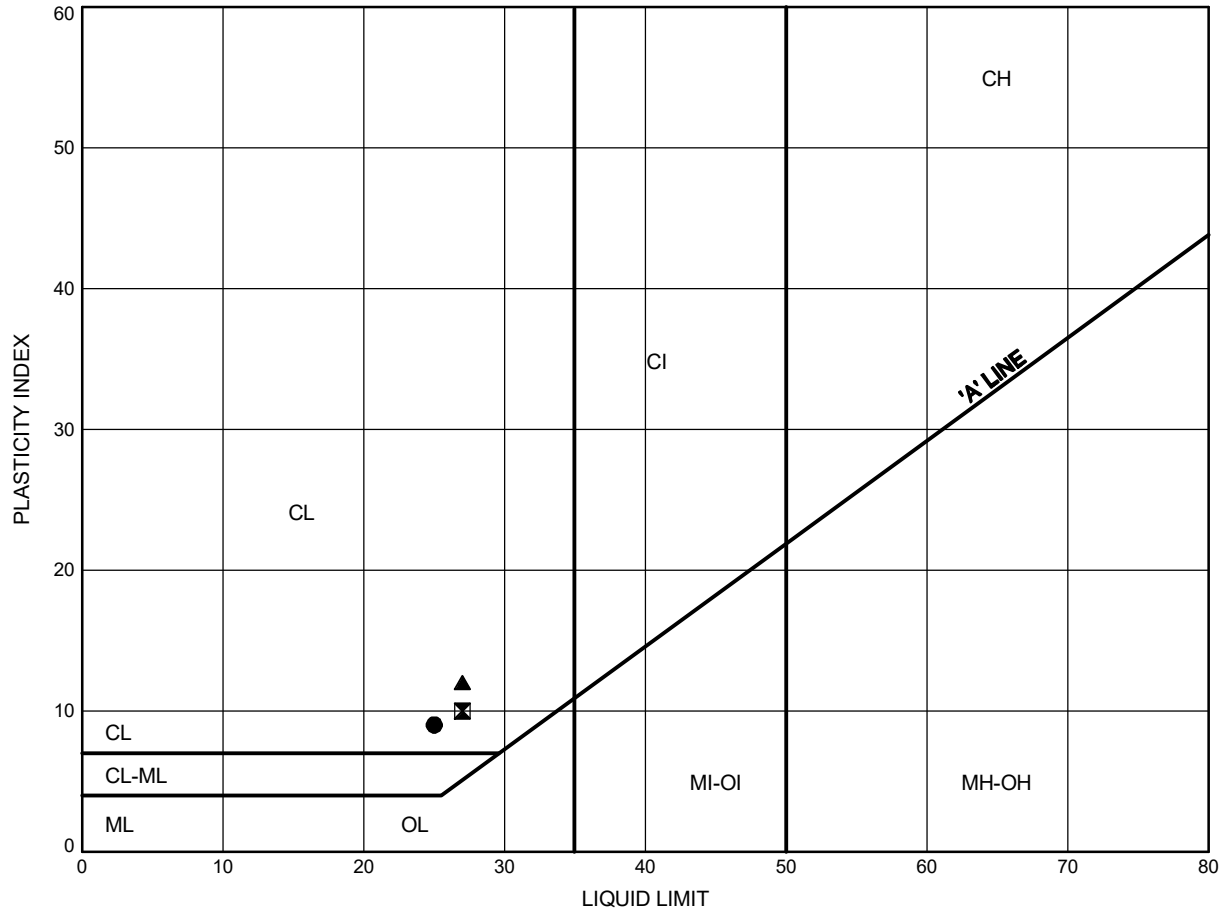
GRAIN SIZE DISTRIBUTION - THURBER 24726 CULVERT 105.GPJ 7-11-24

Highway 17 Twinning, Culvert 105 (Dugald Road)

ATTERBERG LIMITS TEST RESULTS

FIGURE C4

Clayey Silt (CL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC105-1	1.8	141.4
⊠	SC105-1	6.4	136.8
▲	SC105-2	1.8	141.4

Date July 2024

WP# 4068-09-00

THURBER

Prep'd RH

Chkd. MJK

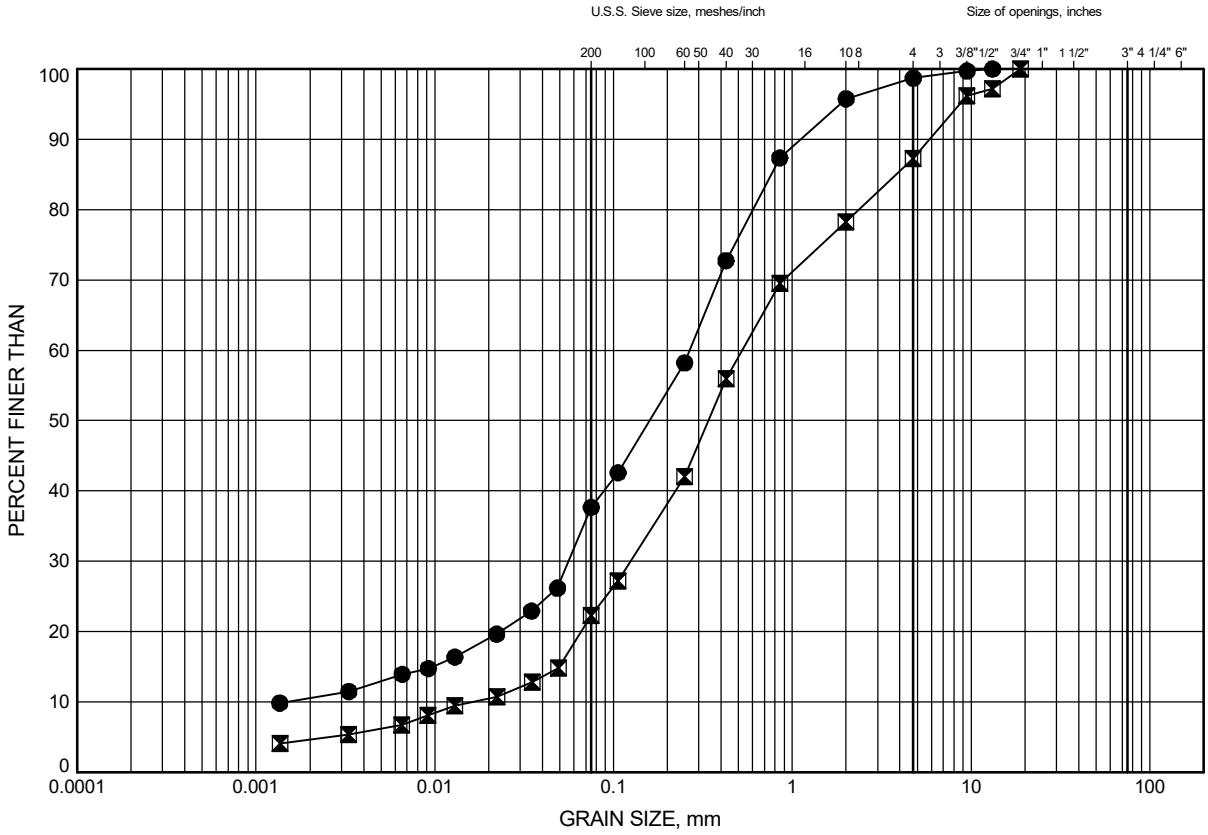
THURBALT 24726 CULVERT 105.GPJ 7-11-24

Highway 17 Twinning, Culvert 105 (Dugald Road)

GRAIN SIZE DISTRIBUTION

FIGURE C5

Silty Sand (Glacial Till)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC105-1	9.4	133.8
⊠	SC105-2	3.4	139.8

Date July 2024

WP# 4068-09-00

THURBER

Prep'd RH

Chkd. MJK

GRAIN SIZE DISTRIBUTION - THURBER 24726 CULVERT 105.GPJ 7-11-24

THURBER ENGINEERING LTD.

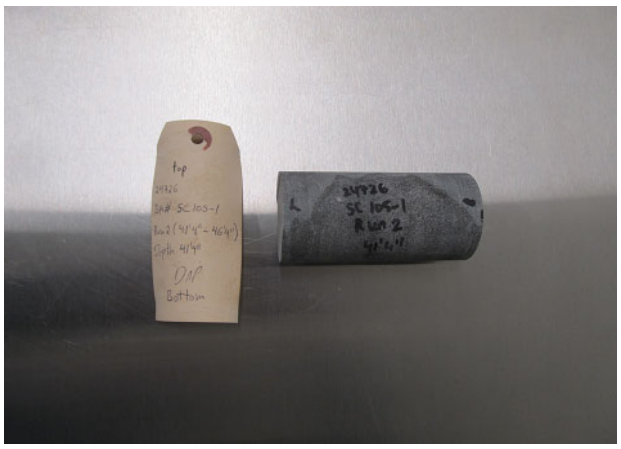
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

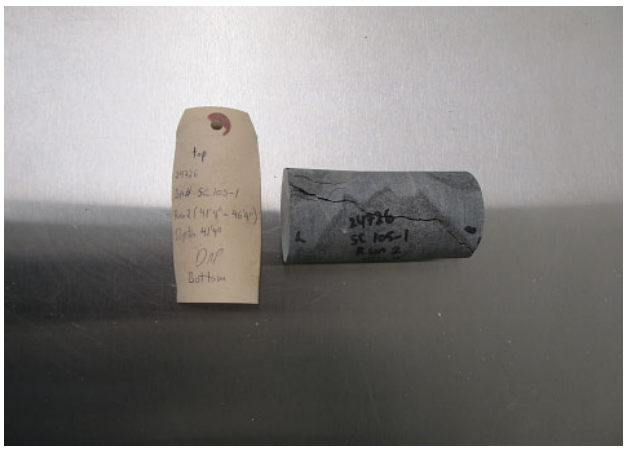
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	11-Jul-24
BOREHOLE No.:	SC105-1	TEST DATE:	9-May-24
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	12.6 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.6	Weight (g):	457.4
Avg. Diameter (cm):	4.7	Wet Density (kg/m^3):	2,746
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,746
Cross Sectional Area (cm^2):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm^3):	166.55		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250	MPa/s
MAXIMUM COMPRESSIVE LOAD:	123.6	kN
UNCONFINED COMPRESSIVE STRENGTH:	71.2	MPa

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

TEST DONE BY: GF
REVIEWED BY: WM

THURBER ENGINEERING LTD.

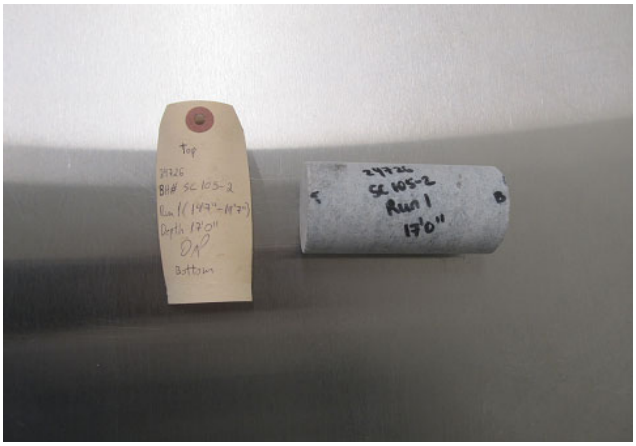
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

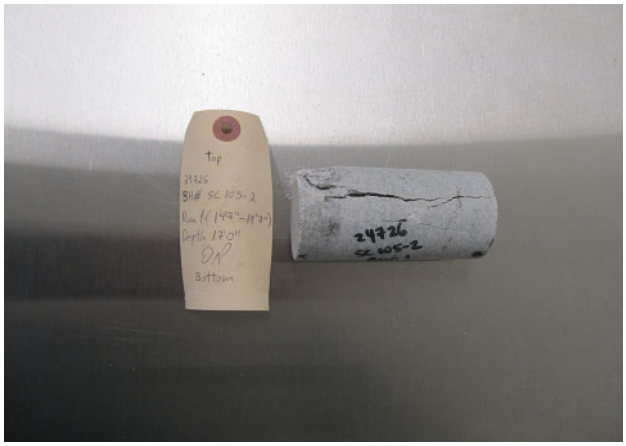
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	11-Jul-24
BOREHOLE No.:	SC105-2	TEST DATE:	9-May-24
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	5.18 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.6	Weight (g):	454.8
Avg. Diameter (cm):	4.7	Wet Density (kg/m^3):	2,731
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,731
Cross Sectional Area (cm^2):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm^3):	166.55		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250	MPa/s
MAXIMUM COMPRESSIVE LOAD:	116.4	kN
UNCONFINED COMPRESSIVE STRENGTH:	67.1	MPa

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

TEST DONE BY: GF
REVIEWED BY: WM

Borehole SC105-1

Runs 1 and 2
Depth 11.1 to 14.1 m
Elevation 132.1 to 129.1 m
Dry Sample

Run 1 Start
elev. 132.1 m

Sand Seam from 39'2" to 40'3"

Run 1 End
elev. 130.6 m

Run 2 Start
elev. 130.6 m

Run 2 End
elev. 129.1 m

THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 105 (Dugald Road, Sta. 9+890)
Horton Township, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC105-1

Runs 1 and 2
Depth 11.1 to 14.1 m
Elevation 132.1 to 129.1 m
Wet Sample

Run 1 Start
elev. 132.1 m

Sand Seam from 39'2" to 40'3"

Run 1 End
elev. 130.6 m

Run 2 Start
elev. 130.6 m

Run 2 End
elev. 129.1 m

THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 105 (Dugald Road, Sta. 9+890)
Horton Township, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC105-2

Runs 1 and 2
Depth 4.4 to 7.5 m
Elevation 138.8 to 135.7 m
Dry Sample

Run 1 Start
elev. 138.8 m

Run 1 End
elev. 137.2 m

Run 2 Start
elev. 137.2 m

Run 2 End
elev. 135.7 m

THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 105 (Dugald Road, Sta. 9+890)
Horton Township, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole SC105-2

Runs 1 and 2
Depth 4.4 to 7.5 m
Elevation 138.8 to 135.7 m
Wet Sample

Run 1 Start
elev. 138.8 m

Run 1 End
elev. 137.2 m

Run 2 Start
elev. 137.2 m

Run 2 End
elev. 135.7 m

THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 105 (Dugald Road, Sta. 9+890)
Horton Township, Ontario

W.P. 4068-09-00
Project No.: 24726

THURBER

Appendix C.2

Analytical Testing Results

PARACEL LABORATORIES LTD.

Order #: 2410180

Certificate of Analysis

Report Date: 11-Mar-2024

Client: **Thurber Engineering Ltd.**

Order Date: 5-Mar-2024

Client PO: **Culvert 105 and Culvert 7**

Project Description: 24726 task 700.706a

	Client ID:	SC105-2 SS#2 2'6"-4'6"	SC7-1 SS#3A 5'-6'	-	-		
	Sample Date:	28-Feb-24 09:00	26-Feb-24 15:00	-	-	-	-
	Sample ID:	2410180-01	2410180-02	-	-		
	Matrix:	Soil	Soil	-	-		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	81.5	76.1	-	-	-	-
General Inorganics							
Conductivity	5 uS/cm	90	679	-	-	-	-
pH	0.05 pH Units	7.24	7.11	-	-	-	-
Resistivity	0.1 Ohm.m	111	14.7	-	-	-	-
Anions							
Chloride	10 ug/g	<10	194	-	-	-	-
Sulphate	10 ug/g	<10	215	-	-	-	-

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

12-March-2024

Paracel Laboratories
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

Date Rec. : 07 March 2024
LR Report: **CA13227-MAR24**
Reference: Project#: 2410180

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Sample ID	Sample Date & Time	Sulphide (Na2CO3) %
1: Analysis Start Date		12-Mar-24
2: Analysis Start Time		07:24
3: Analysis Completed Date		12-Mar-24
4: Analysis Completed Time		09:03
5: RL		0.01
6: SC105-2 SS#2 2'6"-4'6"	28-Feb-24 09:00	< 0.01
~~7: SC7-1 SS#3A 5'-6'~~	~~26-Feb-24 15:00~~	~~0.60~~

RL - SGS Reporting Limit

Method Descriptions

Parameter	Description	SGS Method Code
Sulphide (Na2CO3)	Sulphide by ECS	ME-CA-[ENV]ARD-LAK-AN-020

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0003645361

Appendix D.

Site Photographs

Photo 1. Looking northeast near Station 9+890 (March 22, 2024)
Note: private driveway and CSP to northeast of the site.

Photo 2. Looking northwest near Station 9+890 (March 22, 2024)