THURBER ENGINEERING LTD.

PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
LEMMON'S CREEK CULVERT, SITE NO. 16X-0239C
GWP 4024-20-00 / ASSIGNMENT NO.: 4019-E-0010.2

SITE NO. 16X-0239/C0

Geocres No.: 31B12-004

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.658180°
Longitude: -75.619668°

March 2024

Thurber File No.: 29381

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation Ontario (MTO) under Assignment No. 4019-E-0010, Work Item No. 2, to carry out Foundation Investigations to support the Preliminary Design and Environmental Assessment for the widening of Highway 401 from Highway 16 to Maitland Road. The overall scope of work comprises replacement or rehabilitation of 14 existing structures, including 10 bridges and four structural culverts.

This report addresses the Highway 401 culvert at Lemmon's Creek (Site 16X-0239/C0) located approximately 0.8 km east of Maitland Road in Augusta Township within Leeds and Grenville County, Ontario.

This section of the report presents the factual findings obtained from a preliminary foundation investigation completed at the site. A historical foundation investigation report was not available for this site within the online Geocres Library.

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

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2 BACKGROUND AND SITE DESCRIPTION

2.1 General

Highway 401 crosses Lemmon's Creek approximately 0.8 km east of Maitland Road, about 9 km east of Brockville, Ontario. The location of the structure is shown on the inset Key Plan on Drawing No. 1 in Appendix A. For project purposes, Highway 401 is herein described as oriented east-

west, and the creek and culvert are described as oriented north-south. Lemmon's Creek flows from north to south.

In the area of the culvert, Highway 401 is a four-lane divided freeway with a posted speed limit of 100 km/h and paved shoulders. The east and west bound lanes are separated by a median barrier. The median shoulders are paved and the outside shoulders are partially paved and granular. The surface of the highway is at approximate elevation 97.0 m. Within the vicinity of the culvert, the highway embankment side slopes are at inclinations ranging from about 5H:1V to 8H:1V. Traffic volume on Highway 401 is understood to have been approximately 35,800 to 36,500 AADT in 2016.

The lands adjacent to the site are forested to the south and northwest, and agricultural to the north. Concession Road 2 runs parallel to the north of the highway. The overall terrain is relatively flat apart from the nominal existing highway embankment and associated drainage ditches.

Based on the limited available original design drawings and OSIM report, the culvert consists of a reinforced, cast-in-place, open footing culvert. The culvert is approximately 52 m long, has a total internal span of 4.3 m, and an approximate internal height of about 1.7 m above the creek bed. The creek bed / invert of the culvert is at approximate Elevation 93.6 m. At the time of the current field investigation the creek water was about 0.6 m deep. The culvert structure includes a concrete headwall above the crown at each end and gabion baskets adjacent to the headwalls.

Photographs showing the existing conditions at the site at the time of the site visit are included in Appendix D.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies in the physiographic regions known as the Smith's Falls Limestone Plain. The Smith's Falls Limestone Plain is characterized by typically shallow bedrock but includes a few localized deep areas of highly variable soils consisting of clays, sands, and gravels. The area is known to be underlain by limestone and sandstone bedrock.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field-testing program was carried out on April 19, 2023, and consisted of two boreholes put down at the locations identified as 239-23-01 and 239-23-02 (see Drawing 1 in Appendix A).

The boreholes were advanced with a CME 55 track-mounted drill rig utilizing hollow stem augers (HSA), NW casing, and coring techniques. Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locates/clearances in the vicinity of the borehole locations. In addition, MTO was contacted to obtain the location of electrical and fibre optic utilities within the project limits.

The as-drilled borehole elevations were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The elevations were surveyed relative to available MTO benchmarks

and existing site features and are shown on the Borehole Location and Soil Strata Drawing in Appendix A and on the individual Record of Borehole sheets included in Appendix B. The borehole coordinates are referenced to MTM Zone 9. A summary of the borehole coordinates, elevations, and termination depths is provided in Table 3-1 below.

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. The boreholes were advanced to depths of about 6.1 m.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
239-23-01	Culvert Outlet (Hwy 401 EBL)	4 946 828.3 (44.658067º)	374 633.2 (-75.619451º)	96.5	6.1
239-23-02	Culvert Inlet (Hwy 401 WBL)	4 946 845.5 (44.658225º)	374 596.6 (-75.619911º)	96.6	6.1

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.

Following completion of the field investigation, the boreholes were decommissioned in general in accordance with MOE requirements (O.Reg. 903, as amended).

4 LABORATORY TESTING

Geotechnical laboratory testing carried out as part of the investigation included natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution and Atterberg Limits was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. One Unconfined Compressive Strength (UCS) Test was conducted on a recovered core sample from Borehole 239-23-01.

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

5 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 will vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Description of cohesive soils and secondary components are described as outlined in the MTO Guideline for Foundation Engineering Services Manual (April 2022).

In general, the encountered stratigraphy consists of gravelly sand embankment fill overlying a native deposit of glacial till which is, in turn, underlain by limestone bedrock.

5.1 Granular Fill

Granular embankment fill consisting of gravelly sand was encountered at the ground surface in Boreholes 239-23-01 and 239-23-02. Organics were observed in the fill in Borehole 239-23-02. The fill layer was 0.8 m to 1.0 m thick (base elev. 95.8 m to 95.5 m). SPT N-values in the fill layer ranged from 6 to 8 blows per 0.3 m of penetration, indicating a loose relative density.

The recorded moisture contents ranged from 8 to 15%. The results of a gradation analysis completed on one sample of the fill are illustrated in Figure C1 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	35
Sand	52
Silt	13
Clay	

5.2 Glacial Till

A deposit of glacial till consisting of sandy silt to silty sand with trace to some gravel and organics was encountered beneath the fill at both borehole locations. The glacial till was 1.9 m to 2.4 m thick (base elev. 93.6 m to 93.4 m). SPT N-values in the glacial till ranged from 4 to 8 blows per 0.3 m of penetration, indicating a loose relative density. The recorded moisture content ranged from 14 to 35%. The results of gradation analyses completed on two samples of the layer are illustrated in Figure C2 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheet in Appendix B

Soil Particle	Percentage (%)
Gravel	1 – 4
Sand	36 – 51
Silt	32 – 45
Clay	15 – 16

Atterberg Limit testing was carried out on the fines portion of two samples of the till deposit obtained from Borehole 239-23-02. The results are illustrated in Figure C3 of Appendix C and are

summarized below and on the Record of Borehole sheet in Appendix B. The laboratory results indicate that the fines portion of the glacial till were generally low plasticity (CL, CL-ML).

Parameter	Value
Liquid Limit	18 – 29
Plastic Limit	14 – 21
Plasticity Index	4 – 8

5.3 Bedrock

Bedrock was proven by coring in Boreholes 239-23-01 and 239-23-02. The depth to bedrock was 2.9 m to 3.2 m (elevation 93.6 to 93.4 m) in Boreholes 239-23-01 and 239-23-02, respectively.

The bedrock encountered consisted of fine grained, slightly weathered, grey, very strong limestone. Photographs of the bedrock cores are provided in Appendix C. The rock core quality is summarized in Table 5-1.

Table 5-1: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	96 – 100
Solid Core Recovery (SCR), %	86 – 100
Rock Quality Designation (RQD), %	0 – 100
Fracture Index (fractures per 0.3 m)(1)	0 – 6

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

Below the upper 0.5 m, the RQD values generally ranged from about 50% to 100% indicating a fair to excellent quality bedrock. (CFEM, 2006).

Unconfined compressive strength (UCS) testing was carried out on a sample of the limestone bedrock from Borehole 239-23-01. The results of this test indicated a UCS strength of 204 MPa indicating a very strong bedrock. The results of the UCS testing are included in Appendix C.

5.4 Groundwater

The water level in Lemmon’s creek was measured at the existing creek outlet to be at about Elevation 94.5 m on April 19, 2023. The structural drawings from the 2014 rehabilitation works indicates that the water level was measured at Elevation 94.3 m on August 8, 2012 and the design high water level was Elevation 95.1 m.

It should be noted that the elevations provided above are considered short-term and may not reflect creek or groundwater levels at the time of construction, and seasonal fluctuations of the are to be expected. In particular, the creek and groundwater levels may be at a higher elevation after periods of significant and/or prolonged precipitation.

6 MISCELLANEOUS

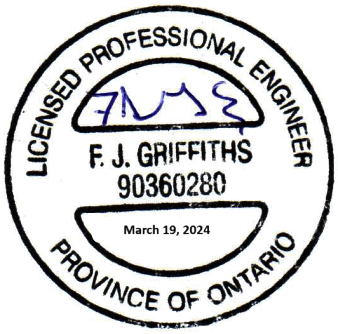
The borehole locations reflect existing site features and access constraints. The as-drilled locations and ground surface elevation were measured by Thurber following completion of the field program. The elevation survey of the boreholes was carried out with reference to geodetic elevation benchmarks provided by the MTO. Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, and borehole decommissioning. Traffic control was performed in accordance with Ontario Book 7 for short duration closures; all signs, barrels, cones, crash truck and water supply truck were provided by T.G Carrol Cartage of Carp, Ontario.

The field investigation was supervised on a full-time basis by Richard Howarth, C.Tech. Overall supervision of the field investigation program was provided by Katya Walker, P.Eng. Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Unconfined Compressive Strength of the bedrock was carried out by Stantec's laboratory in Ottawa, Ontario.

Overall project management and direction of the field investigation was provided by Matt Kennedy, P.Eng. Interpretation of the factual data and preparation of this report was completed by Ibrahim Khan, EIT. The report was reviewed by Matt Kennedy, P.Eng., and Fred Griffiths, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

Ibrahim Khan, EIT
Engineering Intern

Matt Kennedy, M.Sc.(Eng.), P.Eng.
Senior Geotechnical Engineer



Fred Griffiths, Ph.D., P.Eng.
Designated Principal Contact
Senior Geotechnical Engineer

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STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

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5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

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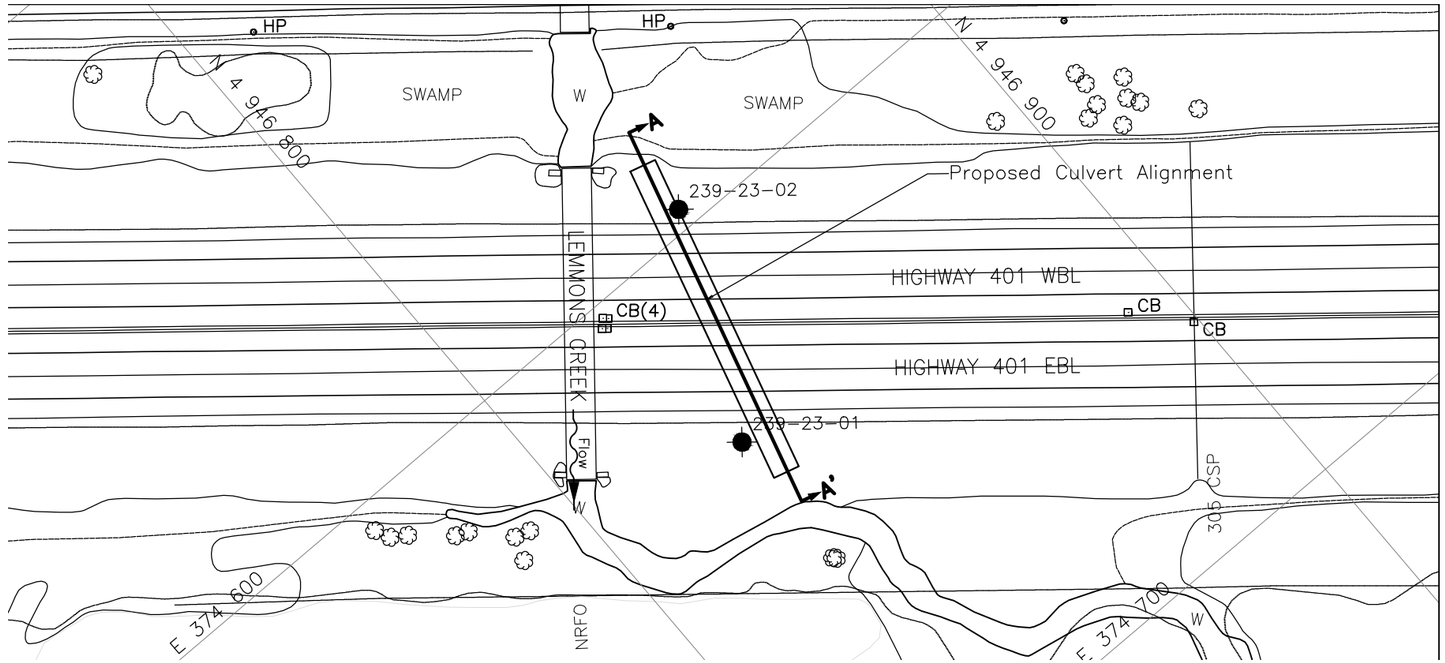
Appendix A.

Borehole Location Plan and Stratigraphic Drawing

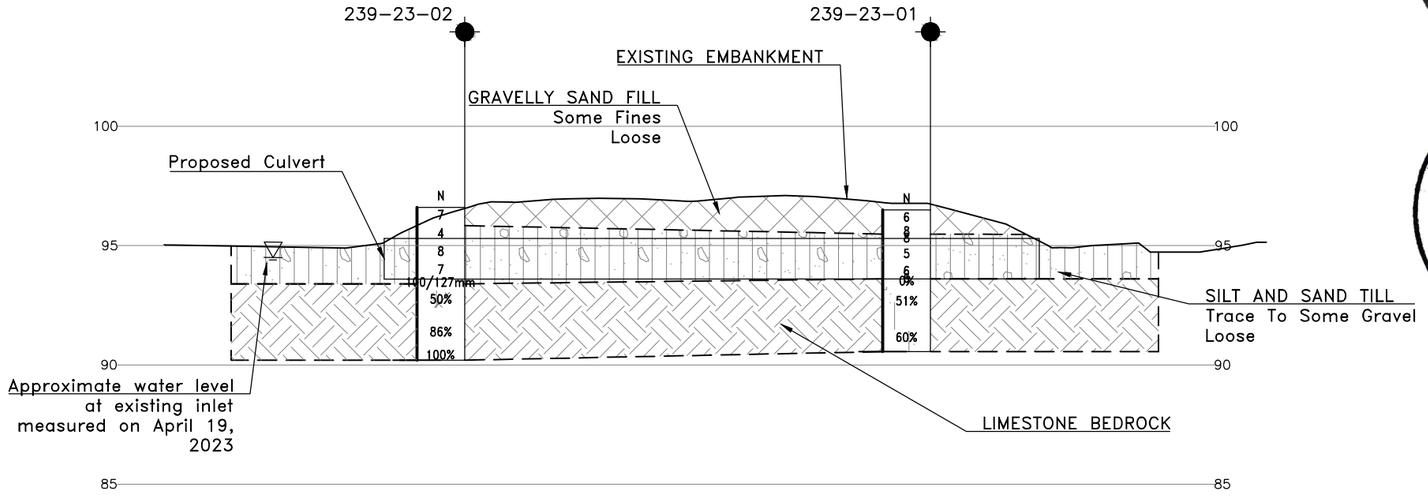
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

20 0 20 40m

SCALE 1:1000



PROFILE ALONG ℄ OF LEMMONS CREEK (A–A)

10 0 10 20m H 1:500

5 5 10m V 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

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F. J. GRIFFITHS
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March 19, 2024
PROVINCE OF ONTARIO

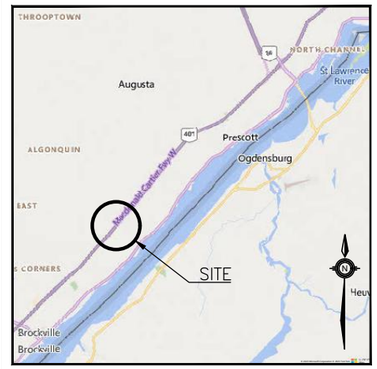
CONT No
GWP No 4024-20-00

SHEET

HIGHWAY 401
LEMMONS CREEK CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

	LEGEND
●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
×	Exposed Bedrock Surface Point Elevation

NO	ELEVATION	NORTHING	EASTING
239-23-01	96.5	4 946 828.3	374 633.2
239-23-02	96.6	4 946 845.5	374 596.6

-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. 31B12-004

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN AO	CHK IK	CODE	LOAD	DATE MARCH 2024	
DRAWN JW	CHK MJK	SITE 16X-239/C	STRUCT	DWG 1	

FILENAME: H:\Drafting\29000\29381\TED-29381-BHPP(239).dwg
PLOTDATE: 3/26/2024 2:14 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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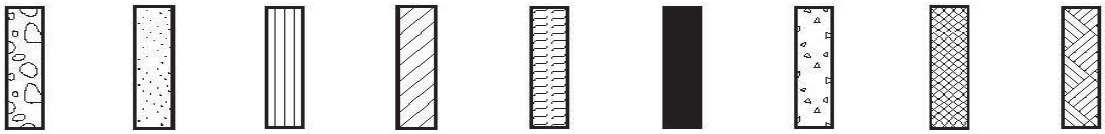
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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 239-23-01 1 OF 1 METRIC

GWP# 4024-20-00 LOCATION Lat: 44.658067°, Long: -75.619451° HWY 401 & Lemons Creek - MTM z9 N 4 946 828.3 E 374 633.2 ORIGINATED BY RH

HWY 401 BOREHOLE TYPE CME 55 Track HSA / NW Casing / NQ Coring COMPILED BY RH

DATUM Geodetic DATE 2023.04.19 - 2023.04.19 CHECKED BY KW

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
96.5	**Ground Surface**										
0.0	**GRAVELLY SAND**, some fines loose brown **FILL**		1	SS	6		96	○	○		35 52 13 (SI+CL)
95.5			2A/B	SS	8				○ ○		
1.0	Sandy **SILT** trace gravel contains organics loose grey-black **GLACIAL TILL**		3	SS	5		95		○		
94.2											
2.3	**SILTY SAND** some gravel loose grey		4A/B	SS	6		94		○	FI	
93.6	**GLACIAL TILL**		1	RUN						6	RUN #1 TCR=100% SCR=98% RQD=0%
2.9	**LIMESTONE BEDROCK** grey slightly weathered thinly bedded		2	RUN			93			5 6 3 5	RUN #2 TCR=100% SCR=100% RQD=51%
			3	RUN			92			5 6 2	RUN #3 TCR=100% SCR=98% RQD=60% UCS=204MPa
90.4							91			6 4 4	
6.1	End of Borehole Note: A representative open-hole groundwater level measurement was not obtained due to the introduction of water during drilling.										

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

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

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 3-19-24

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No 239-23-02 1 OF 1 METRIC

GWP# 4024-20-00 LOCATION Lat: 44.658225°, Long: -75.619911° HWY 401 & Lemons Creek - MTM z9 N 4 946 845.5 E 374 596.6 ORIGINATED BY RH

HWY 401 BOREHOLE TYPE CME 55 Track HSA / NW Casing / NQ Coring COMPILED BY RH

DATUM Geodetic DATE 2023.04.19 - 2023.04.19 CHECKED BY KW

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
96.6	Ground Surface										
0.0	**GRAVELLY SAND** contains organics loose brown moist		1	SS	7				○		
95.8	**FILL**						96				
0.8	**SILT** and **SAND** and low-plastic fines contains organics loose grey **GLACIAL TILL**		2	SS	4				○		
			3	SS	8		95		⊕		4 36 45 15
94.3											
2.3	**SILTY SAND**, contains low-plastic fines loose grey **GLACIAL TILL**		4	SS	7		94		⊕○		1 51 32 16
93.4			5	SS	100/127mm				○	FI	
3.2	**LIMESTONE BEDROCK** grey slightly weathered thinly bedded		1	RUN			93			4 3 4 4	RUN #1 TCR=100% SCR=90% RQD=50%
			2	RUN			92			6 4 3 4	RUN #2 TCR=96% SCR=86% RQD=86% RUN #3 TCR=100% SCR=100% RQD=100%
90.5			3	RUN			91			4 4	
6.1	End of Borehole Note: A representative open-hole groundwater level measurement was not obtained due to the introduction of water during drilling.										

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

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

DOUBLE LINE 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 2012TEMPLATE(MTO).GDT 3-19-24

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Appendix C.

Laboratory Testing

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Appendix C.1

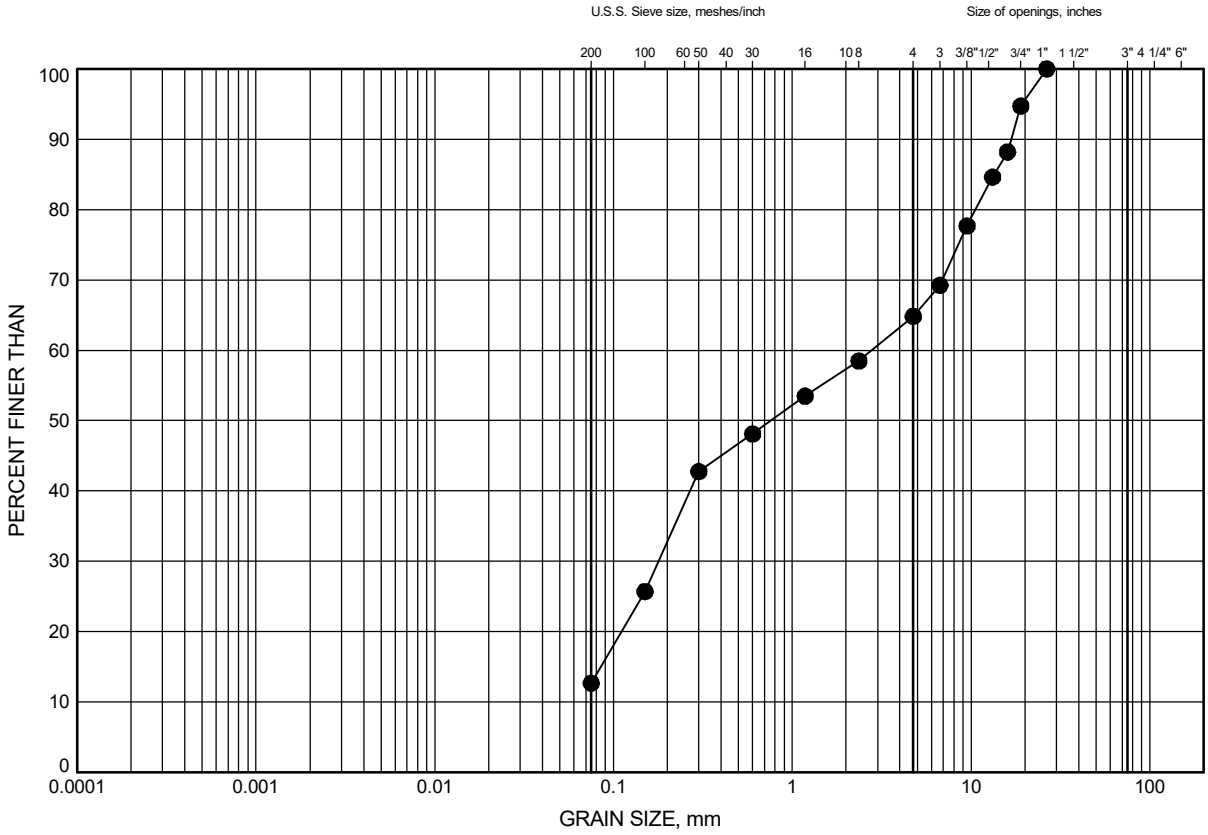
Particle Size Analysis Figures
Atterberg Limit Test Results

Highway 401 Lemmon's Creek Culvert (Site No. 16X-0239/C0

GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL: Silty Sand with Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	239-23-01	0.3	96.2

Date October 2023

GWP# 4024-20-00

THURBER

Prep'd RH

Chkd. MJK

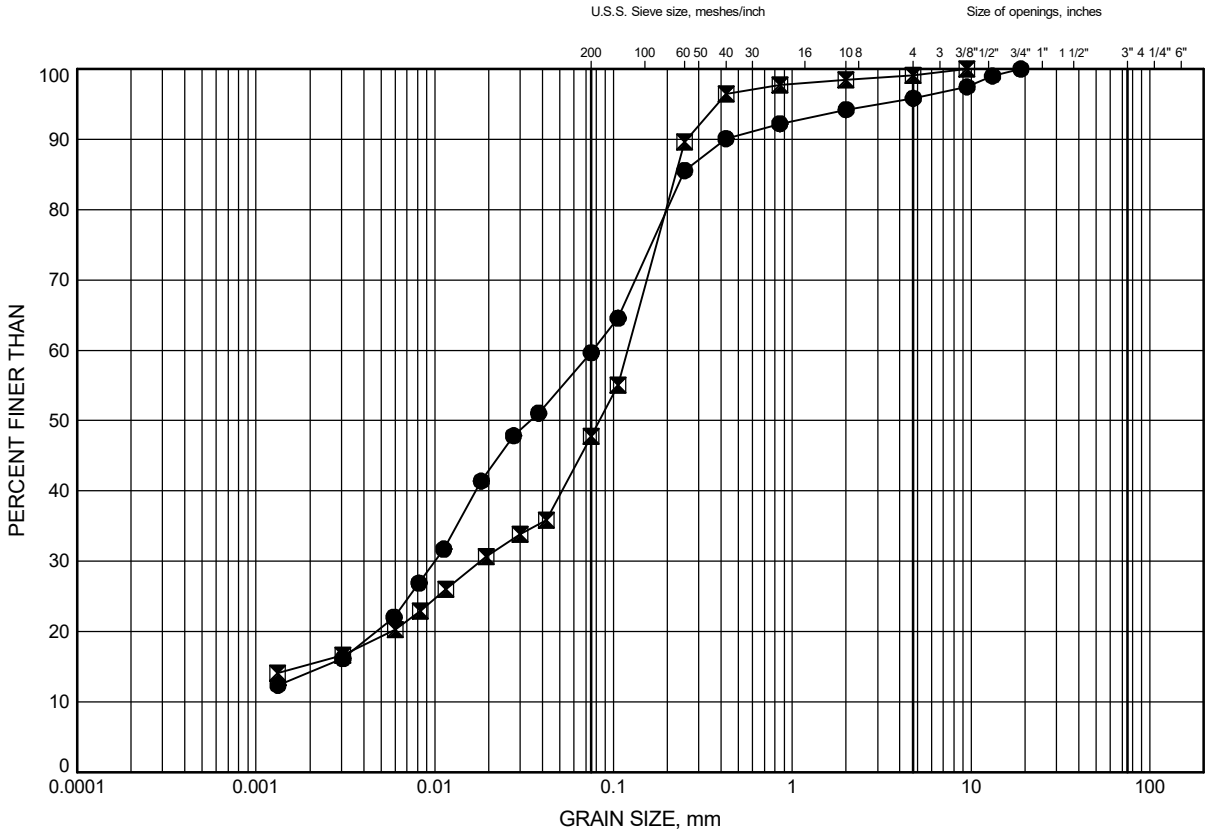
GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 10-3-23

Highway 401 Lemmon's Creek Culvert (Site No. 16X-0239/C0

GRAIN SIZE DISTRIBUTION

FIGURE C2

Native : Glacial Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	239-23-02	1.8	94.8
⊠	239-23-02	2.6	94.0

Date October 2023

GWP# 4024-20-00

THURBER

Prep'd RH

Chkd. MJK

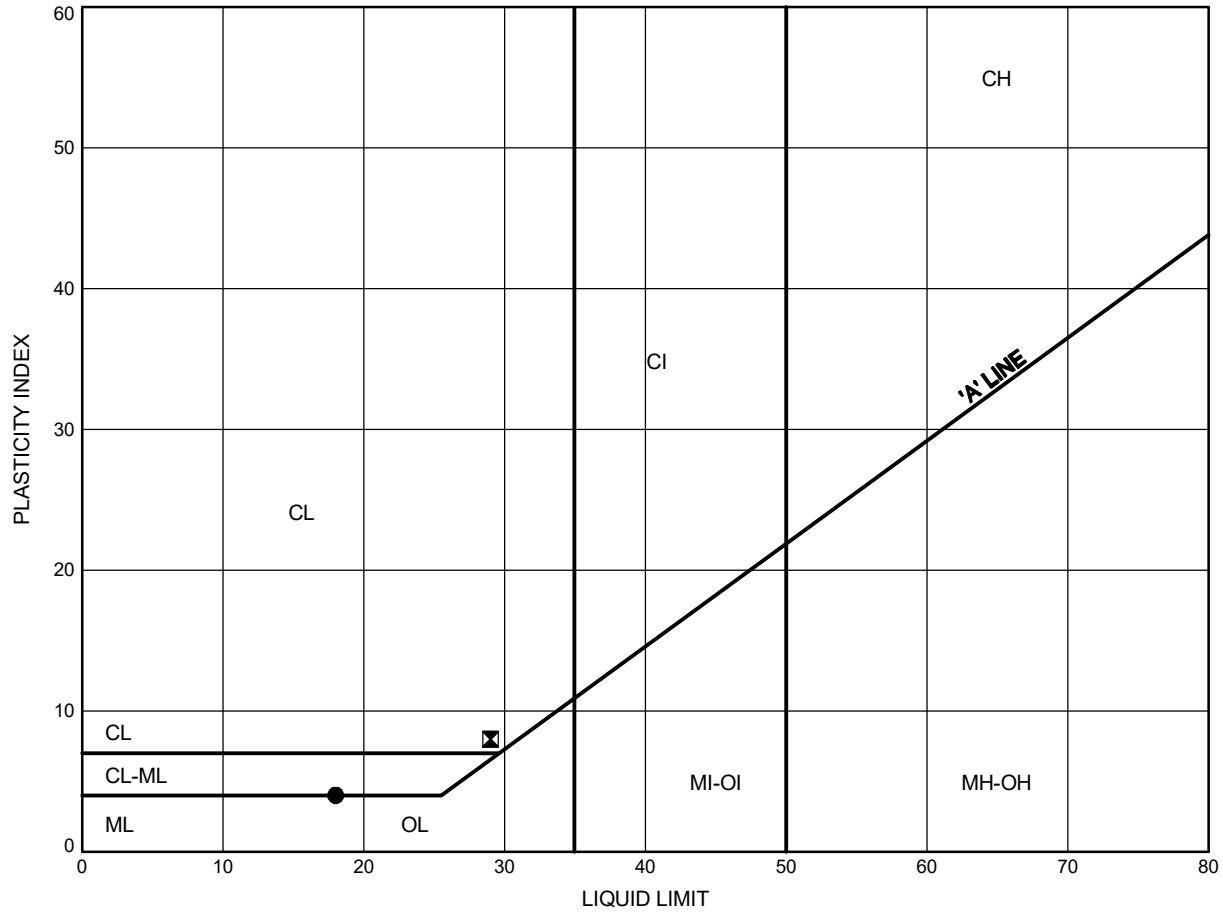
GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 10-3-23

Highway 401 Lemmon's Creek Culvert (Site No. 16X-0239/C0

ATTERBERG LIMITS TEST RESULTS

FIGURE C3

Native : Glacial Till



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	239-23-02	1.8	94.8
⊠	239-23-02	2.6	94.0

Date October 2023

GWP# 4024-20-00

THURBER

Prep'd RH

Chkd. MJK

THURBALT 29381 BOREHOLE LOGS REPLACEMENT SITES.GPJ 10-3-23

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Appendix C.2

UCS Test Results

Stantec Consulting Ltd.
2781 Lancaster Rd, Suite 100 A&B, Ottawa ON K1B 1A7

May 3, 2023
File: 122410864

Client: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core
Hwy 401

The following table summarizes unconfined compressive strength results for three intact rock cores.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
239-23-01 Run-3	15'11'-16'6''	*203.8*	Vertical crack no cone
26-23-01 Run-2	15'2''-16'1''	*148.7*	Cones on both ends
165-23-02 Run-2	19'2''-20'2''	*154.2*	Cones on both ends

Sincerely,

Stantec Consulting Ltd.

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-722-2799
brian.prevost@stantec.com

v:\01216\active\laboratory_standing_offers\2023-laboratory standing offers\122410864 thurber engineering ltd\rock core\april 26, three rock cores, thurber# 29381\rock_core_summary_letter.docx

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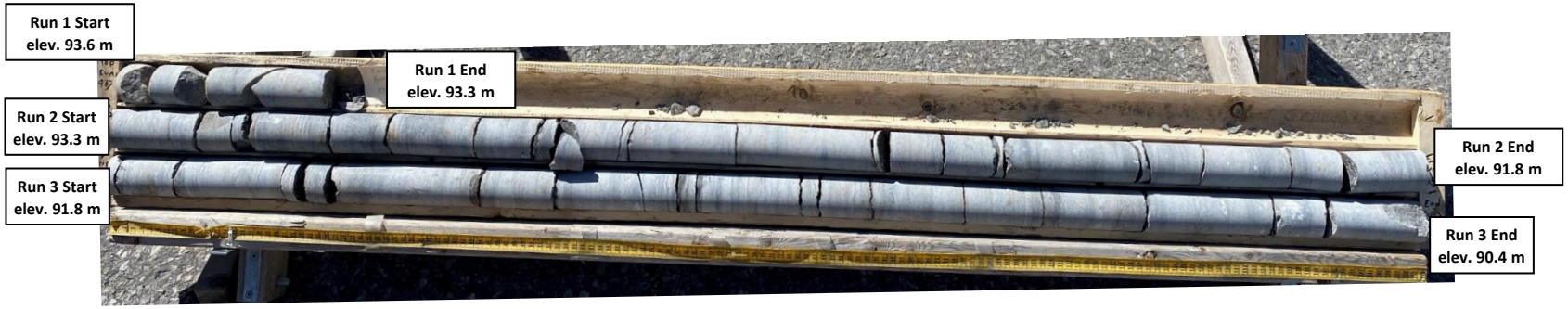
Appendix C.3

Bedrock Core Photographs

Borehole 239-23-01

Runs 1 to 3
Depth 2.8 m to 6.0 m
Elevation 93.6 m to 90.4 m
Dry Sample



THURBER ENGINEERING LTD.

Highway 401 Lemmon's Creek Culvert
(Site No. 16X-0239/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 239-23-01
Project No.: 29381

Borehole 239-23-01

Runs 1 to 3
Depth 2.8 m to 6.0 m
Elevation 93.6 m to 90.4 m
Wet Sample

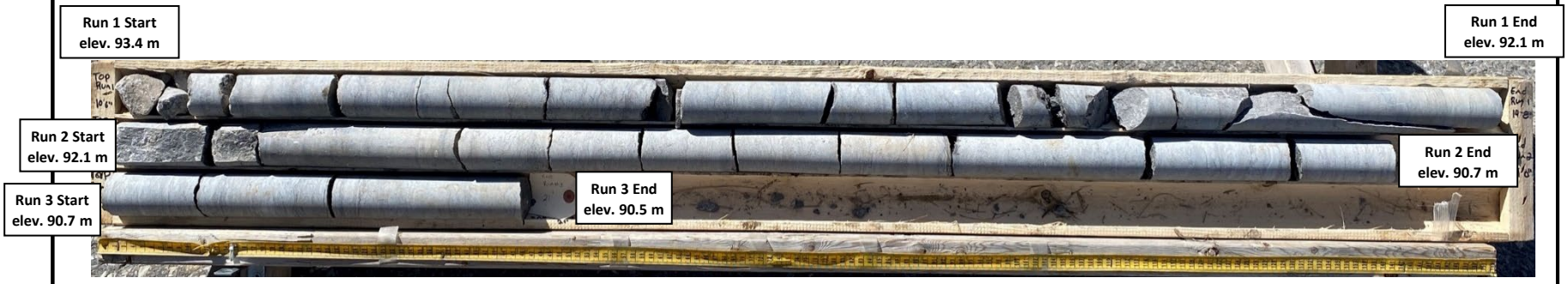
THURBER ENGINEERING LTD.

Highway 401 Lemmon's Creek Culvert
(Site No. 16X-0239/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 239-23-01
Project No.: 29381

Borehole 239-23-02

Runs 1 to 3
Depth 3.2 m to 6.4 m
Elevation 93.4 m to 90.5 m
Dry Sample



THURBER ENGINEERING LTD.

Highway 401 Lemmon's Creek Culvert
(Site No. 16X-0239/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 239-23-02
Project No.: 29381

Borehole 239-23-02

Runs 1 to 3
Depth 3.2 m to 6.4 m
Elevation 93.4 m to 90.5 m
Wet Sample

THURBER ENGINEERING LTD.

Highway 401 Lemmon's Creek Culvert
(Site No. 16X-0239/C0)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 239-23-02
Project No.: 29381

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Appendix D.

Selected Site Photographs

Photograph 1: Culvert Outlet – Eastbound Highway 401 *[taken April 2023]*

Photograph 2: Eastbound Highway 401 *[taken April 2023]*

Photograph 3: Eastbound Embankment Highway 401 *[taken April 2023]*

Photograph 4: Culvert Inlet Highway 401 *[taken April 2023]*