

**PRELIMINARY
FOUNDATION INVESTIGATION REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
CULVERTS 20 AND 20N
STA. 24+936, HORTON TOWNSHIP
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009**

Geocres No.: 31F07-006

Report to:

Ministry of Transportation Ontario

Latitude: 45.459436°
Longitude: -76.612878°

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 Highway 17 culvert crossing located near Station 24+936 in Horton Township within the Renfrew County, Ontario. The existing Highway 17 alignment at this site will become the future Highway 17 eastbound lanes and new westbound lanes will be constructed to the north of the existing alignment at this location. The existing culvert (Culvert 20) will be replaced, and a new culvert (Culvert 20N) is required to convey an unnamed tributary of Deil's Creek below the embankment supporting the proposed Highway 17 westbound lanes.

This section of the report presents the factual findings obtained from the foundation investigation conducted by Thurber as part of the current study.

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.

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.

2 SITE DESCRIPTION

2.1 General

For project purposes, Highway 17 is herein described as oriented east west, and the existing culvert is described as oriented north south. The culvert crosses Highway 17 at Sta. 24+936

Horton which is approximately 370 m west of the Millenium Trail overpass in Horton Township or, alternatively, 1.3 km east of Lochwinnock Road.

In the area of the culvert, the existing Highway 17 is a two-lane highway and has a posted speed limit of 90 km/h. The road surface near the culvert is at approximate elevation 148.6 m. The shoulders have a total width of approximately 2.7 m in the east- and westbound directions with approximately 0.3 m being paved. Steel cable guide rails on wooden posts are present along both shoulders. The traffic volume for this section of Highway 17 is understood to have been 13,900 AADT in 2016.

The existing culverts under the existing Highway 17 embankment are twin 1,220 mm diameter, 49.7 m long, corrugated steel pipe (CSP) culverts with an approximate skew of 55° to the highway alignment. The culvert has an approximate gradient of approximately 0.6% with the invert of the culvert being near elevations 142.5 and 142.2 m at the inlet and outlet, respectively. The cover above the existing culvert is approximately 5.0 m at the highway centerline. The creek flows through the culvert under the highway embankment from north to south. It is understood that the general drainage is near parallel to the south side of the highway alignment to the west of the culvert. The depth of standing water near the inlet and outlet was measured as 1,130 mm and 730 mm, respectively, on July 26, 2024.

Embankment side slopes, in the vicinity of the culvert, are inclined at approximately 2.4H:1V on the north side and 1.9H:1V on the south side. The existing embankment side slopes at the culvert site did not show any visible signs of global instability at the time of the investigation.

The site is in a rural setting, and the terrain along the ditch line is relatively flat. The area near the culvert is mostly farmland with some deciduous trees and shrubs. Temporary silt fences on wooden posts were located immediately near the culvert inlet. A natural gas pipeline crossing under the Highway 17 is located approximate 100 meters west of the culvert site. Overhead utility lines were not present.

Photographs of the project area are included in Appendix D. These photographs show the existing condition of the highway embankment and the culvert at the time of the field investigation.

2.2 Site Geology

Under the same MTO Assignment a Foundation investigation was conducted by Thurber at several high fill locations within the Highway 17 twinning project boundaries. The available information was reviewed prior to this investigation and can be found in the Geocres Library under Geocres Number 31F-235. Borehole NS21-09 from that investigation is relevant to the present report and has been included in Appendix B.

According to Crins et al. 2009¹ the project area is described as Ecoregion 6E (Lake Simcoe-Rideau Ecoregion) within the Mixedwood Plains Ecozone. According to Wester et al. 2018² the

¹ <https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf>

² <https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf>

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.

Ontario Geological Survey Map P.3784³ for Precambrian Geology for the Horton Area suggests that the site is underlain by grey to white calcite, fine to medium grained, impure calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

Borehole NS21-09 was drilled off-road on November 19, 2021, using a Diedrich 50 track mounted drill equipped with hollow stem augers.

The foundation investigation and field-testing program was augmented between March 26 and April 02, 2024, and consisted of one on-road borehole identified as NSC20-3 and two off-road boreholes identified as NSC20-1 and NSC20-2. The on-road borehole was advanced with a CME 75 truck mounted drill rig utilizing hollow stem augers, NW casing, and coring techniques in bedrock. The off-road boreholes were advanced with a CME 75 track mounted drill rig utilizing hollow stem augers, NW casing, and coring techniques in bedrock.

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)
NSC20-1	Proposed WB Culvert Inlet	5 035 503.6 (45.459407°)	296 054.7 (-76.611823°)	143.6	11.3
NSC20-2	Proposed WB embankment	5 035 504.8 (45.459417°)	296 032.8 (-76.612104°)	143.3	15.3

³ <http://www.geologyontario.mndm.gov.on.ca/index.html>

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
NSC20-3	Existing Eastbound Shoulder	5 035 481.0 (45.459436°)	295 972.3 (-76.612878°)	148.6	16.6
NS21-09	Existing Inlet	5 035 507.8 (45.459444°)	296 012.5 (-76.612363°)	143.1	6.7

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. Thin-Walled (Shelby) Tube samples were pushed and retrieved in Borehole NSC20-2 to obtain relatively undisturbed cohesive soil samples for further laboratory testing.

A 50 mm diameter monitoring well was installed in each of Boreholes NSC20-1 and NS21-09 to allow for measurements of the groundwater level after drilling. The details of the well installations are illustrated on the respective Record of Borehole sheets provided in Appendix B. The monitoring wells installed as part of the current investigation will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

Boreholes NSC20-2 and NSC20-3 were backfilled in accordance with MOE requirements (O.Reg 903, as amended).

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.

One-dimensional consolidation testing (ASTM D 2435) was carried out on one relatively undisturbed cohesive sample from Borehole NSC20-2.

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 descriptions is in accordance with 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 topsoil and organic silt over a native deposit of silty clay to clayey silt underlain by silty sand with gravel over bedrock. Sand to silty sand fill was encountered at ground surface in the on-road borehole.

5.1 Embankment Fill

5.1.1 Sand to Silty Sand Fill

A fill layer consisting of sand to silty sand with varying amounts of gravel was encountered at the ground surface in Borehole NSC20-3. The thickness of the layer was 6.1 m (base elev. at 142.5 m). The SPT N values ranged from 11 to 60 blows, indicating a compact to very dense relative density.

The moisture content of the samples tested ranged from 3 to 12%. The results of grain size analyses conducted on two samples of this fill material are summarized in the table below and are illustrated on Figure C1 in Appendix C.

Summary of Grain Size Distribution Testing – Sand to Sandy Silt Fill

Soil Particle	Percentage (%)
Gravel	14 – 17
Sand	62 – 75
Silt & Clay	11 – 21

5.2 Topsoil

A 75 mm thick layer of topsoil was encountered at the ground surface in Borehole NS21-09.

5.3 Organic Silt (MI-OI)

A native deposit of organic silt was encountered at the ground surface in Boreholes NSC20-1 and NSC20-2. Varying amounts of sand and peat inclusions were noted within the layer. The thickness of the layer ranged from 0.4 to 1.0 m (base elev. 143.2 to 142.3 m). The SPT N-values recorded were 1 and 2 blows, indicating a very loose relative density.

The moisture content of the samples tested ranged from 37 to 50%. The results of grain size analysis conducted on one sample of this layer are summarized in the table below and are illustrated on Figure C2 in Appendix C.

Summary of Grain Size Distribution Testing – Organic Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	35
Silt	46
Clay	19

The results of Atterberg Limits testing carried out on one sample of this material are summarized below and are illustrated on Figure C3 in Appendix C. The laboratory results indicate that the organic silt is of intermediate plasticity (MI-OI).

Summary of Atterberg Limit Testing – Organic Silt

Parameter	Value
Liquid Limit	40
Plastic Limit	27
Plasticity Index	13

5.4 Silty Clay (CI) to Clayey Silt (CL)

A native deposit of silty clay to clayey silt was encountered below the organic silt in Boreholes NSC20-1 and NSC20-2, below the sand to silty sand fill in Borehole NSC20-3, and below the topsoil in Borehole NS21-09. Sand partings and seams were encountered throughout the layer. Where fully penetrated, the thickness of the layer ranged from 2.8 to 6.3 m (base elev. 140.4 to 136.0 m). The layer was not fully penetrated in Borehole NS21-09 but was proven to extend to a depth of 6.7 m (elev. 136.4 m).

Where SPT was conducted within the layer, the N-values typically ranged from 4 to 12 blows. Field vane tests were performed within this layer where possible. Undrained shear strengths were obtained and ranged from 75 to greater than 100 kPa. Remolded vane tests recorded sensitivities typically ranging from 5 to 7, indicating a sensitive material (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 20 to 43% but were typically greater than 30%. The results of grain size analysis tests conducted on eight samples of this material are summarized in the table below and are illustrated on Figures C4 and C5 in Appendix C.

Summary of Grain Size Distribution Testing – Silty Clay to Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	1 – 21
Silt	53 – 67
Clay	26 – 38

The results of Atterberg Limits testing carried out on eight samples of this material are summarized below and are illustrated on Figure C6 and C7 in Appendix C. The laboratory results indicate that the silty clay to clayey silt is of intermediate to low plasticity (CI to CL).

Summary of Atterberg Limit Testing – Silty Clay to Clayey Silt

Parameter	Value
Liquid Limit	30 – 39
Plastic Limit	18 – 25
Plasticity Index	10 – 17

One-dimensional consolidation testing (ASTM D 2435) was carried out on one relatively undisturbed cohesive sample from Borehole NSC20-2. Load increments were maintained for 24 hours. Photographs of the extruded sample are provided in Appendix C. The testing results are presented in Appendix C and are summarized in Table 3-1. The preconsolidation stress summarized in the table was obtained from the end-of-increment void ratios. It should be expected that compressibility characteristics will vary with depth in accordance with the soil index parameters and stress history.

Table 5-1: Advanced Laboratory Test Results

Borehole	NSC20-2
Sample	TW7
Sample Depth (m)	4.6 – 5.2
Sample Elevation (m)	138.4
Soil Layer	Clayey Silt (CL)
Load Increment Duration (hrs.)	24
Moisture Content (%)	34
Liquidity Index (-)	1
Initial Void Ratio, e_0 (-)	0.96
Moist Unit Weight (kN/m^3)	18.6
In-situ Vertical Effective Stress (kPa)	50
Preconsolidation Stress, P'_c (kPa)	246
Overconsolidation Ratio (-)	5
Recompression Index, C_r (-)	0.03
Compression Index, C_c (-)	0.46
Coefficient of Reconsolidation, C_{vr} (cm^2/sec)	0.007
Coefficient of Consolidation, C_v (cm^2/sec)	0.002

5.5 Silty Sand (SM)

A deposit of silty sand with gravel was encountered beneath the silty clay to clayey silt in Boreholes NSC20-1 through NSC20-3. The thickness of the layer ranged from 0.5 to 2.0 m (base elev. 138.8 to 135.5 m). The SPT N-values ranged from 11 to 65 blows, indicating a compact to very dense relative density. A refusal blow count was encountered at the base of the layer in Borehole NSC20-2 but is attributed to the bedrock surface.

The moisture content of the samples tested ranged from 6 to 16%. The results of gradation analyses completed on two samples of the layer are illustrated in Figure C8 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	36 – 39
Sand	43 – 47
Silt & Clay	17 – 18

5.6 Bedrock

Bedrock was proven by coring in Boreholes NSC20-1, NSC20-2, and NSC20-3. The bedrock surface sloped downwards from north to south with depths ranging from 4.8 to 12.7 m (elevation 138.8 to 135.5 m).

The bedrock encountered consisted of completely to slightly weathered, coarse grained, white to light grey, medium strong to strong marble. Photographs of the bedrock cores are provided in Appendix C. The rock core quality measurements are summarized in Table 5-2.

Table 5-2: Bedrock Details

Parameter	Range
Total Core Recovery (TCR), %	15 – 100
Solid Core Recovery (SCR), %	5 – 100
Rock Quality Designation (RQD), %	0 – 100
Fracture Index (fractures per 0.3 m) ⁽¹⁾	0 – >10
Unconfined Compressive Strength (MPa)	54 – 65

Notes: (1) Indicated as "FI" on Borehole Logs

The RQD values ranged from 0 to 100% but were typically less than 37%, indicating a bedrock of very poor to poor quality (CFEM, 2023). The fracture index was typically greater than 10 fractures per 0.3 m. The results of unconfined compressive strength tests (UCS) were 54 to 65 MPa, indicating that the tested samples of the bedrock are strong (CFEM, 2023). The UCS test results are included in Appendix C.

5.7 Groundwater

Monitoring wells with a diameter of 50 mm were installed in Boreholes NSC20-1 and NS21-09. The recorded groundwater levels are presented in Table 5-3.

Table 5-3: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
NSC20-1	139.6	0.3	143.3	April 09, 2024
		0.4	143.2	May 01, 2024
		0.5	143.1	June 07, 2024
		0.5	143.1	June 28, 2024
		0.5	143.1	July 12, 2024
		0.5	143.1	August 29, 2024
NS21-09	137.0	0.3	142.8	November 29, 2021
		0.5	142.6	December 02, 2021
		0.5	142.6	December 13, 2021
		0.5	142.6	January 21, 2022
		0.4 ^(a)	142.7	May 02, 2024
		0.5 ^(a)	142.6	August 29, 2024

Notes: (a) water level taken after borehole log was finalized

The elevation of the ponded water surface in the creek was at approximately 143.6 m and 142.9 m near the culvert inlet and outlet, respectively on July 26, 2024; water depths ranged from 0.7 to 1.1 m.

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 and seasonal fluctuations of the groundwater level are to be expected. In particular, the creek water and groundwater levels may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.8 Analytical Testing

One sample of the native organic 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 5-4. Copies of the test results are provided in Appendix C.

Table 5-4: Results of Chemical Analysis

Borehole	Sample	Depth (m)	Chloride (µg/g)	Sulphate (µg/g)	Sulphide (%)	pH (-)	Resistivity (Ohm-cm)
NSC20-2	SS2A	0.8 – 1.0	37	21	< 0.01	6.65	4,920

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 rigs used to drill, test, sample, and decommission the boreholes. Traffic control was performed in accordance with Ontario Book 7 and was provided by C&C Services of Renfrew, Ontario. The field investigation was supervised on a full-time basis by Mr. B. Coote, EIT, and Mr. D. Amorim Pereira, 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 D. Amorim Pereira, Geotechnical Technician, and A. de Oliveira, P.Eng. The report was reviewed by Dr. F. Griffiths, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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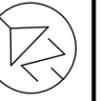
Dr. P.K. Chatterji, P.Eng.
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Appendix A.

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
STA. 24+936, HORTON TWP
CULVERT 20/20N
BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET
1



KEYPLAN

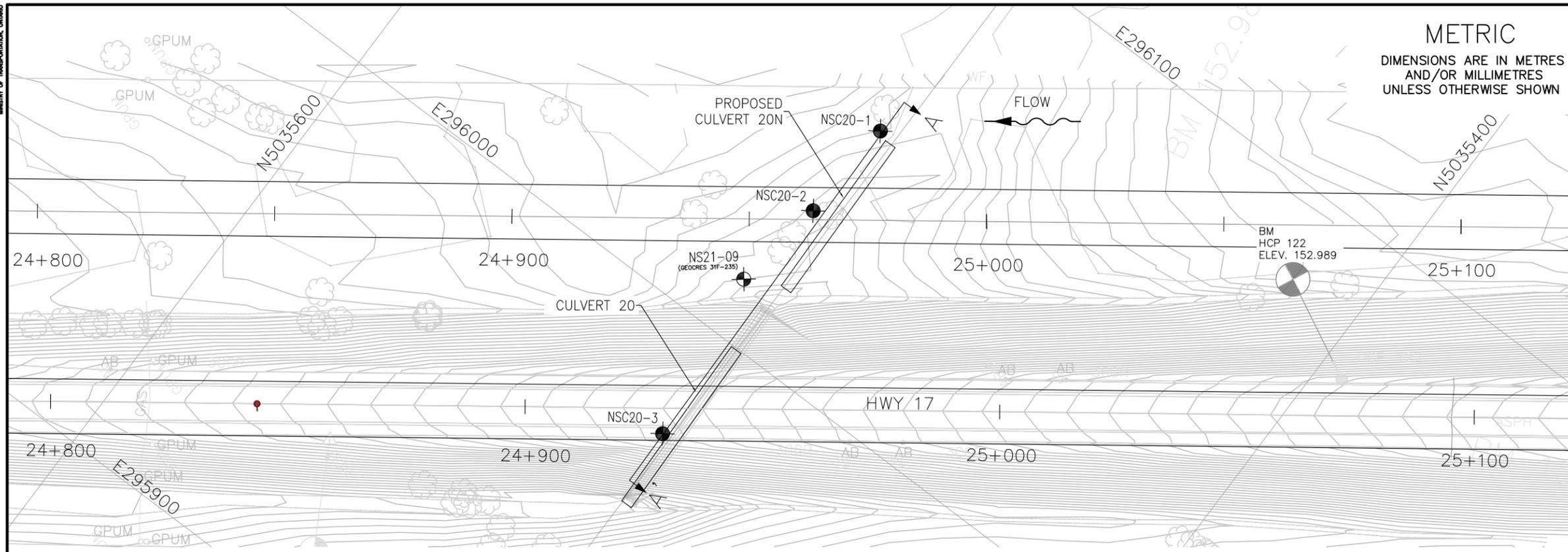
LEGEND

- 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 Monitoring Well/Piezometer
- ⊥ Monitoring Well/Piezometer Screen
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

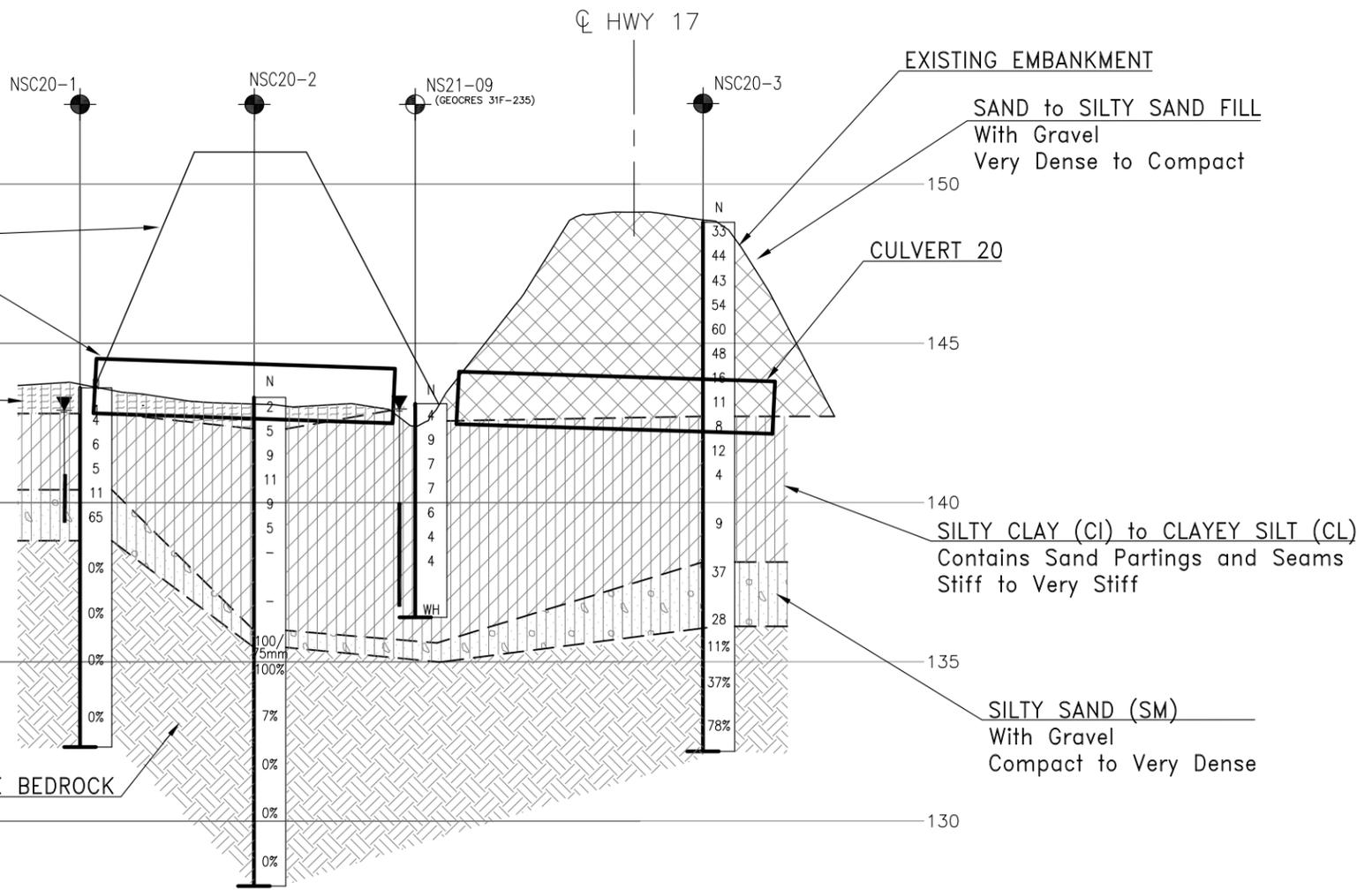
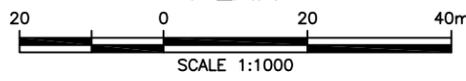
NO	ELEVATION	NORTHING	EASTING
NCS20-1	143.6	5 035 503.6	296 054.7
NCS20-2	143.3	5 035 504.8	296 032.8
NCS20-3	148.6	5 035 481.0	295 972.3
NS21-09	143.1	5 035 507.8	296 012.5

-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.			

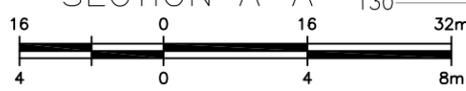
GEOCRES No. 31F07-006



PLAN



SECTION A-A'



REVISIONS	DATE	BY	DESCRIPTION

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

Appendix B.
Record of Borehole Sheets



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).

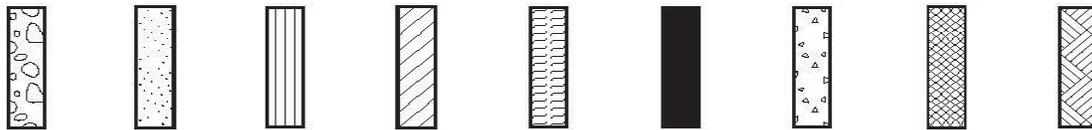
DYNAMIC CONE PENETRATION TEST (DCPT):

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.



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



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 or 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



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

RECORD OF BOREHOLE No NSC20-1

1 OF 2

METRIC

WP# 4068-09-00 LOCATION Culvert 20/20N; Horton Township; MTM z9: N 5 035 503.6 E 296 054.7 ORIGINATED BY BC
 HWY 17 BOREHOLE TYPE CME 75 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2024.04.01 - 2024.04.01 CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
143.6	Ground Surface															
0.0	Sandy ORGANIC SILT (MI-OI) contains peat inclusions very loose brown to black SILTY CLAY (CI) contains sand partings and seams very stiff greyish brown to brown		1	SS	1											
143.2															0 5 59 36	
0.4																
					2	SS	4									
			3	SS	6											
			4	SS	5									0 4 61 35		
140.4	SILTY SAND (SM) with gravel compact to very dense grey to brown		5	SS	11											
3.2																
			6	SS	65									39 43 18 (SI+CL)		
138.8	MARBLE BEDROCK completely to slightly weathered light grey coarse grained medium strong to strong		1	RUN	-								FI			
4.8														>10	RUN #1 TCR=23% SCR=5% RQD=0%	
														>10		
														>10		
					2	RUN	-								>10	RUN #2 TCR=15% SCR=5% RQD=0%
															>10	
													>10			
													>10			
			3	RUN	-								>10	RUN #3 TCR=51% SCR=7% RQD=0%		
													>10			
													>10			
													>10			
													>10			
													>10			
													>10			
													>10			
													>10			

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 12-17-24

Continued Next Page

+³, x³: Numbers refer to Sensitivity
 20
 15 10 5 0
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No NSC20-1

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.459407°, Long: -76.611823°
Culvert 20/20N; Horton Township; MTM z9: N 5 035 503.6 E 296 054.7 ORIGINATED BY BC
 HWY 17 BOREHOLE TYPE CME 75 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2024.04.01 - 2024.04.01 CHECKED BY JG

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)																										
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P W W L 20 40 60																										
132.3	MARBLE BEDROCK completely to slightly weathered light grey coarse grained medium strong to strong		4	RUN	-		133									>10	RUN #4 TCR=46% SCR=5% RQD=0%																				
11.3	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: <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH (m)</th> <th>ELEV. (m)</th> </tr> </thead> <tbody> <tr><td>2024/04/09</td><td>0.3</td><td>143.3</td></tr> <tr><td>2024/05/01</td><td>0.4</td><td>143.2</td></tr> <tr><td>2024/06/07</td><td>0.5</td><td>143.1</td></tr> <tr><td>2024/06/28</td><td>0.5</td><td>143.1</td></tr> <tr><td>2024/07/12</td><td>0.5</td><td>143.1</td></tr> <tr><td>2024/08/29</td><td>0.5</td><td>143.1</td></tr> </tbody> </table>	DATE	DEPTH (m)	ELEV. (m)	2024/04/09	0.3	143.3	2024/05/01	0.4	143.2	2024/06/07	0.5	143.1	2024/06/28	0.5	143.1	2024/07/12	0.5	143.1	2024/08/29	0.5	143.1															
DATE	DEPTH (m)	ELEV. (m)																																			
2024/04/09	0.3	143.3																																			
2024/05/01	0.4	143.2																																			
2024/06/07	0.5	143.1																																			
2024/06/28	0.5	143.1																																			
2024/07/12	0.5	143.1																																			
2024/08/29	0.5	143.1																																			

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 12-17-24

RECORD OF BOREHOLE No NSC20-2 1 OF 2 METRIC

WP# 4068-09-00 LOCATION Lat: 45.459417°, Long: -76.612104° ORIGINATED BY BC
 HWY 17 BOREHOLE TYPE CME 75 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2024.04.02 - 2024.04.02 CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
							20	40	60	80	100						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
143.3	Ground Surface																
0.0	Sandy ORGANIC SILT (MI-OI) very loose brown		1	SS	2											0 35 46 19	
142.3	CLAYEY SILT (CL) contains sand partings and seams very stiff to stiff brown - becomes grey at a depth of 3.8 m (elev. 139.5 m) - unable to push vane		2	SS	5												
1.0			3	SS	9												
			4	SS	11												0 3 62 35
			5	SS	9												
			6	SS	5												
			7	TW	-												0 1 63 36
			8	TW	-												OED: e _s = 0.96 C _c = 0.46 C _u = 0.03 P _c = 246 kPa
136.0	SILTY SAND (SM) with gravel very dense grey		9	SS	100/ 75mm											FI	
7.3	MARBLE BEDROCK completely to highly weathered white to light grey coarse grained medium strong to strong		1	RUN	-											0	
135.5																0	
7.8																0	
																0	
																>10	
																>10	
																>10	

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 12-17-24

Continued Next Page

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

RECORD OF BOREHOLE No NSC20-2 2 OF 2 METRIC

WP# 4068-09-00 LOCATION Lat: 45.459417°, Long: -76.612104°
Culvert 20/20N; Horton Township; MTM z9: N 5 035 504.8 E 296 032.8 ORIGINATED BY BC
 HWY 17 BOREHOLE TYPE CME 75 Trackmount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2024.04.02 - 2024.04.02 CHECKED BY JG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)			
	Continued From Previous Page						20	40	60	80	100	W P	W	W L						
							○ UNCONFINED	+	FIELD VANE											
							● QUICK TRIAXIAL	×	LAB VANE											
	MARBLE BEDROCK completely to highly weathered white to light grey coarse grained medium strong to strong		2	RUN	-												>10			
																		>10		
																			>10	RUN #3 TCR=25% SCR=5% RQD=0%
																			>10	RUN #4 TCR=97% SCR=13% RQD=0%
																			>10	RUN #5 TCR=97% SCR=15% RQD=0%
128.0																				
15.3	End of Borehole																			

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 12-17-24

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

RECORD OF BOREHOLE No NSC20-3

2 OF 2

METRIC

WP# 4068-09-00 LOCATION Lat: 45.459436°, Long: -76.612878°
Culvert 20/20N; Horton Township; MTM z9: N 5 035 481.0 E 295 972.3 ORIGINATED BY DAP
 HWY 17 BOREHOLE TYPE CME 75 Truckmount / HSA / NW Casing / NQ Coring COMPILED BY AO
 DATUM Geodetic DATE 2024.03.26 - 2024.03.26 CHECKED BY JG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
137.9	SILTY CLAY (CI) contains sand partings and seams very stiff grey to light brown						138										
10.7	SILTY SAND (SM) with gravel dense to compact light brown		13	SS	37		137										
135.9			14	SS	28		136									36 47 17 (SI+CL)	
12.7	MARBLE BEDROCK completely to highly weathered light grey coarse grained medium strong to strong		1	RUN	-		135									RUN #1 TCR=45% SCR=11% RQD=11%	
			2	RUN	-		134									RUN #2 TCR=100% SCR=34% RQD=37%	
			3	RUN	-		133									RUN #3 TCR=100% SCR=70% RQD=78% UCS=65MPa	
132.0							132										
16.6	End of Borehole																

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 12-17-24

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

RECORD OF BOREHOLE No NS21-09

1 OF 1

METRIC

WP# 4068-09-00 LOCATION Lat: 45.459444° Long: -76.612363° Culvert 24+950 Horton N 5 035 507.8 E 296 012.5 ORIGINATED BY NW
 HWY 17 BOREHOLE TYPE Diedrich 50 (D-50) Trackmount / HSA COMPILED BY AO
 DATUM Geodetic DATE 2021.11.19 - 2021.11.19 CHECKED BY JG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80					
143.1	Ground Surface														
0.0	TOPSOIL (75 mm)														
0.1	SILTY CLAY (CI) very stiff brown WEATHERED CRUST	1	SS	4											
		2	SS	9											
		3	SS	7										0 5 67 28	
		4	SS	7											
		5	SS	6											
139.4	CLAYEY SILT (CL) very stiff to stiff brown	6	SS	4											
3.7		7	SS	4											
	- becomes grey														
		8	SS	WH										0 1 62 37	
136.4	End of Borehole														
6.7	Monitoring well consists of 50 mm diameter Schedule 40 PVC pipe with a 3.0 m slotted screen														
	Water Level Readings: DATE DEPTH (m) ELEV. (m) 2021/11/29 0.3 142.8 2021/12/02 0.5 142.6 2021/12/13 0.5 142.6 2022/01/21 0.5 142.6														

DOUBLE LINE CULVERT 20 GINT LOGS.GPJ 2012TEMPLATE(MTO).GDT 11-20-24

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

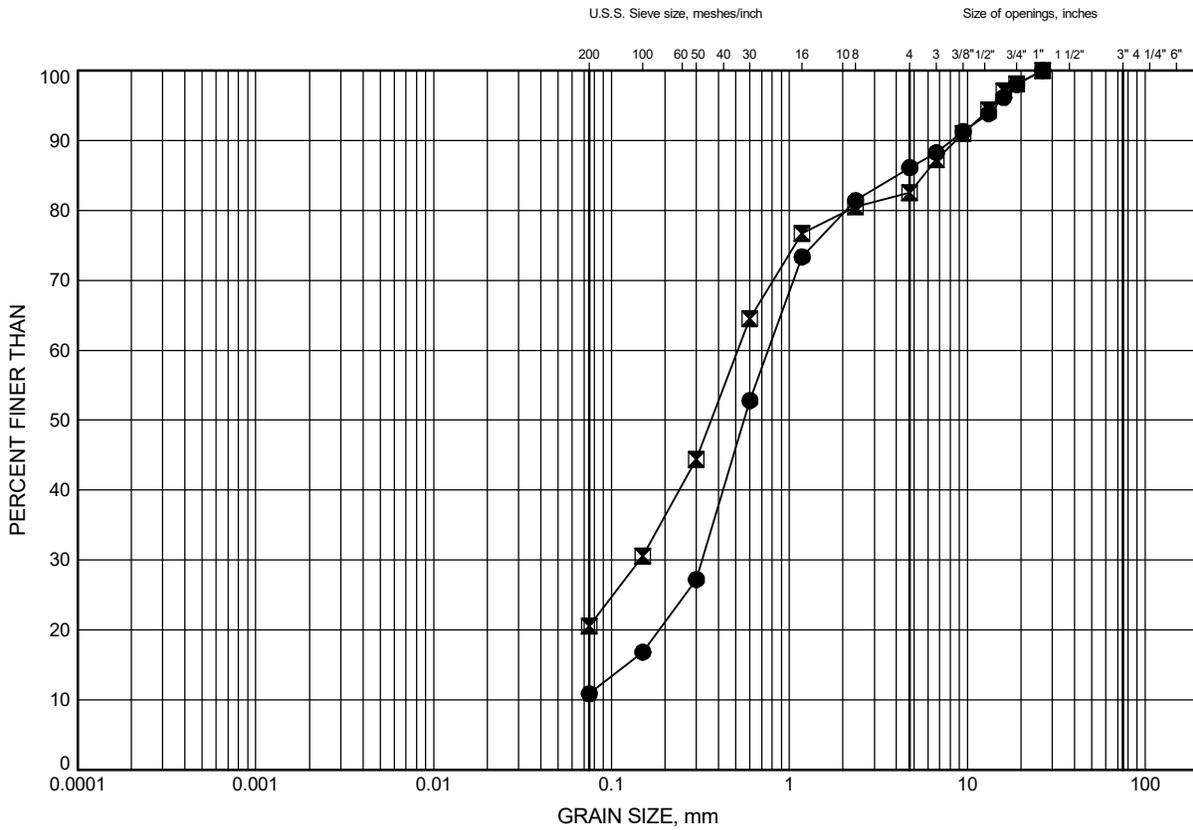
Appendix C.
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures
Atterberg Limit Test Results
Consolidation Testing Results
Unconfined Compressive Strength Testing Results
Rock Core Photos

Highway 17 Twinning, Sta. 24+936, Culvert 20
GRAIN SIZE DISTRIBUTION

FIGURE C1

FILL: Sand to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-3	2.6	146.0
☒	NSC20-3	4.9	143.7

GRAIN SIZE DISTRIBUTION - THURBER CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

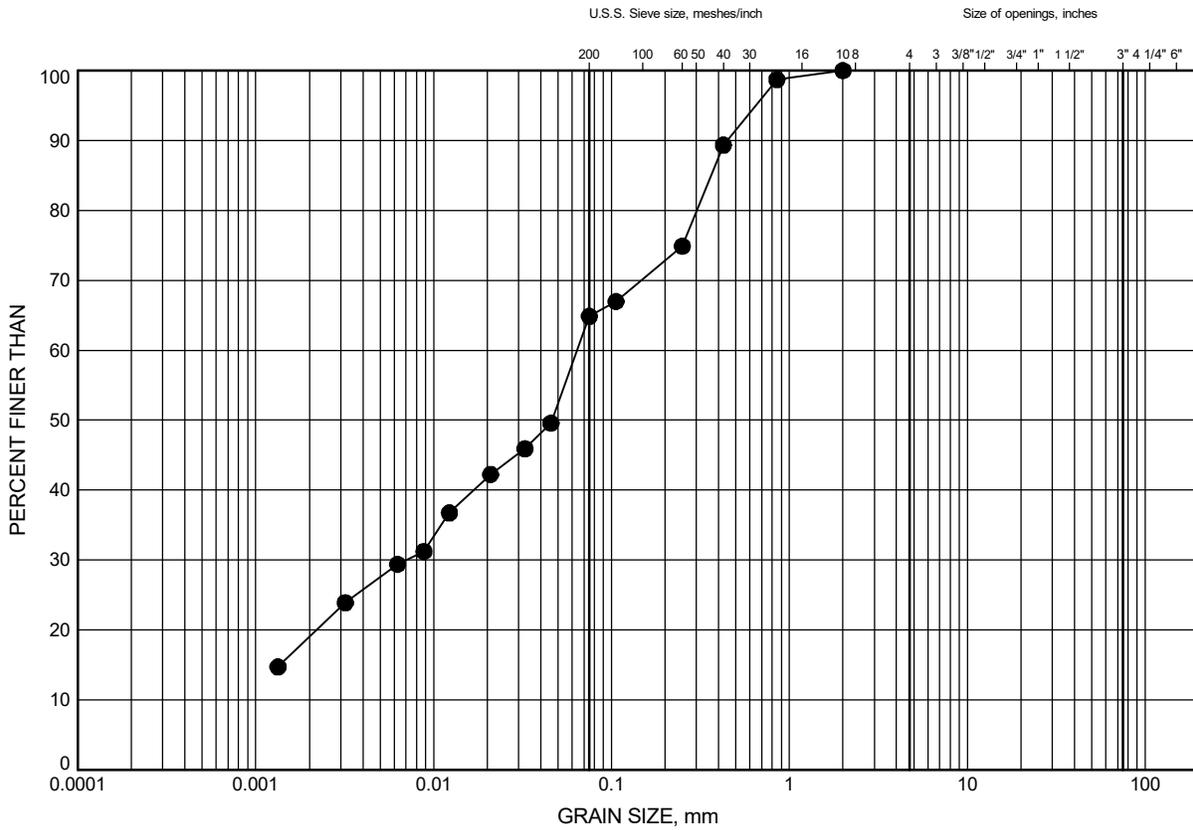


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
GRAIN SIZE DISTRIBUTION

FIGURE C2

Organic Silt (MI-OI)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-2	0.3	143.0

GRAIN SIZE DISTRIBUTION - THURBER CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

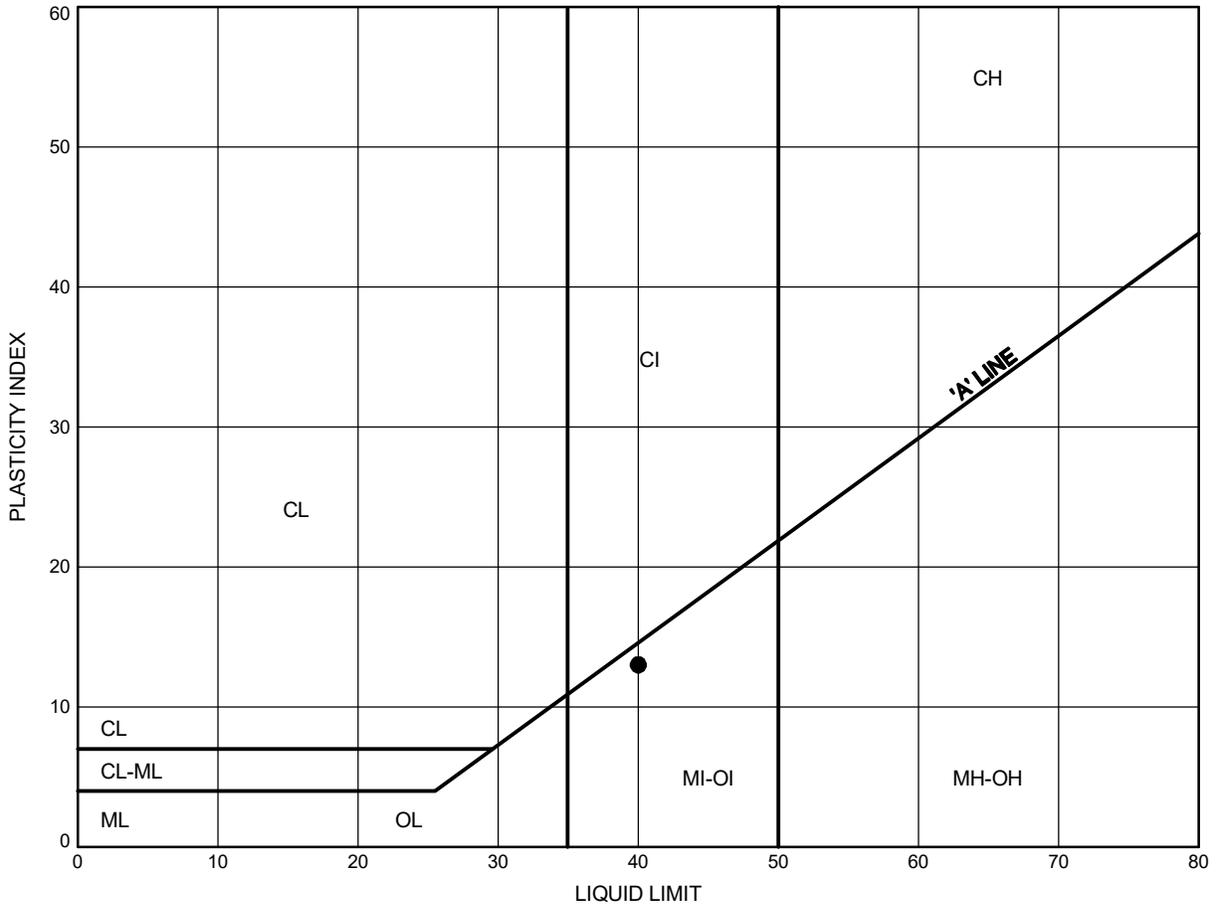


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
ATTERBERG LIMITS TEST RESULTS

FIGURE C3

Organic Silt (MI-OI)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-2	0.3	143.0

THURBALT CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

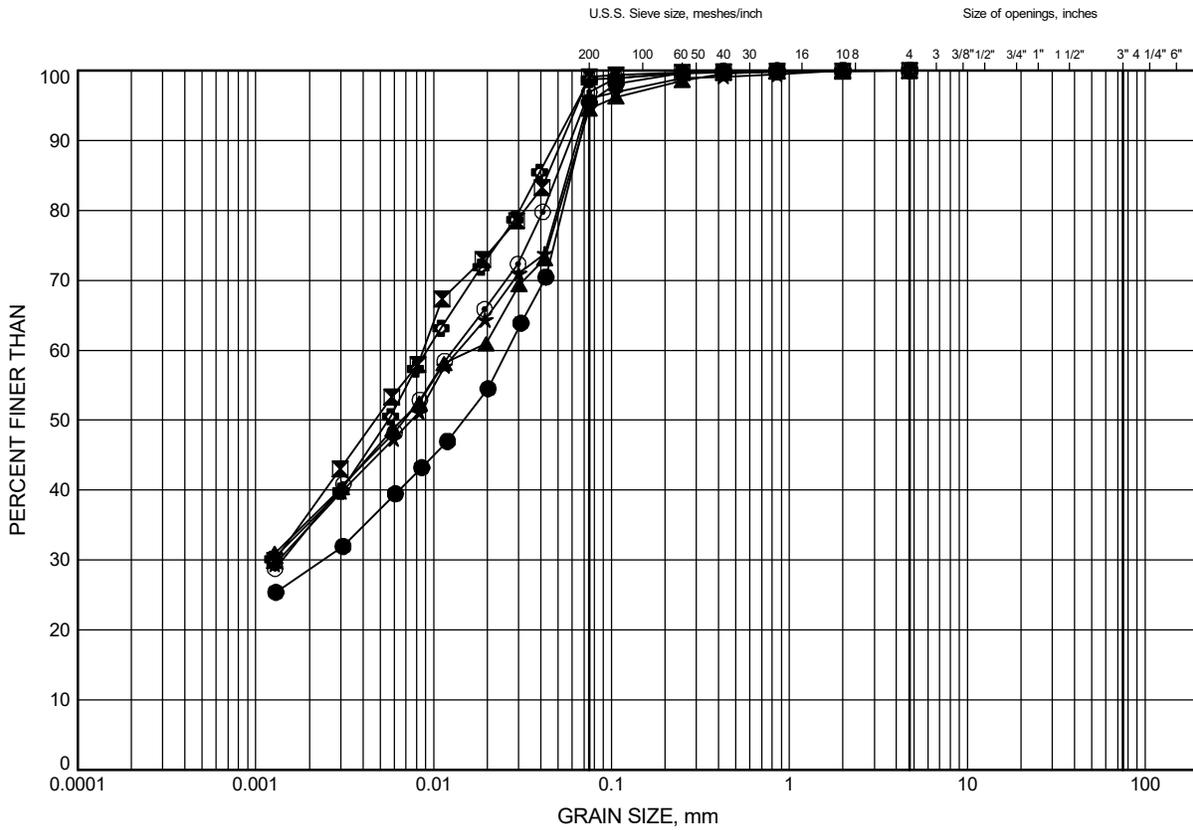


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
GRAIN SIZE DISTRIBUTION

FIGURE C4

Silty Clay (CI) to Clayey Silt (CL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NS21-09	1.8	141.3
⊠	NS21-09	6.4	136.7
▲	NSC20-1	1.1	142.5
★	NSC20-1	2.6	141.0
⊙	NSC20-2	2.6	140.7
⊕	NSC20-2	4.9	138.4

GRAIN SIZE DISTRIBUTION - THURBER CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

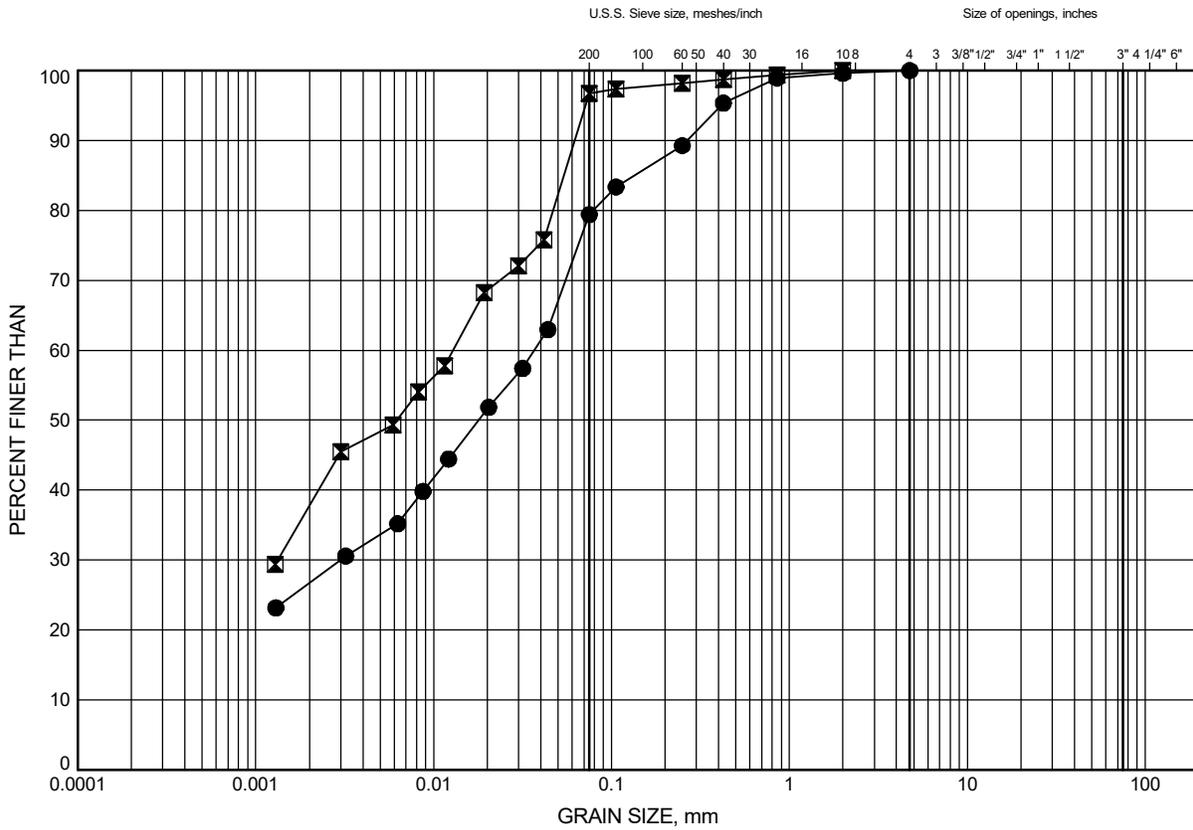


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
GRAIN SIZE DISTRIBUTION

FIGURE C5

Silty Clay (CI) to Clayey Silt (CL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-3	7.2	141.4
⊠	NSC20-3	9.4	139.2

GRAIN SIZE DISTRIBUTION - THURBER CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

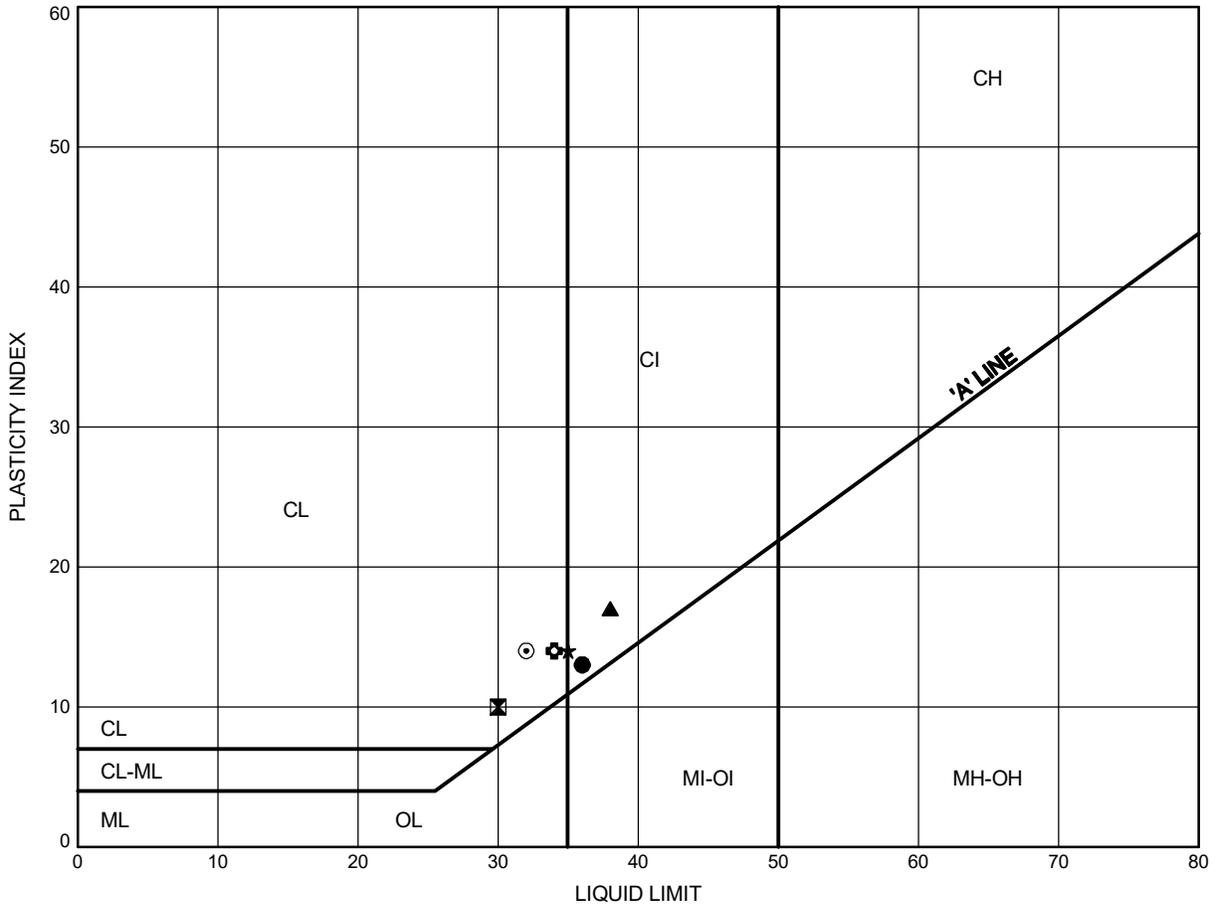


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
ATTERBERG LIMITS TEST RESULTS

FIGURE C6

Silty Clay (CI) to Clayey Silt (CL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NS21-09	1.8	141.3
⊠	NS21-09	6.4	136.7
▲	NSC20-1	1.1	142.5
★	NSC20-1	2.6	141.0
⊙	NSC20-2	2.6	140.7
⊕	NSC20-2	4.9	138.4

Date July 2024
 GWP# 4018-E-0009

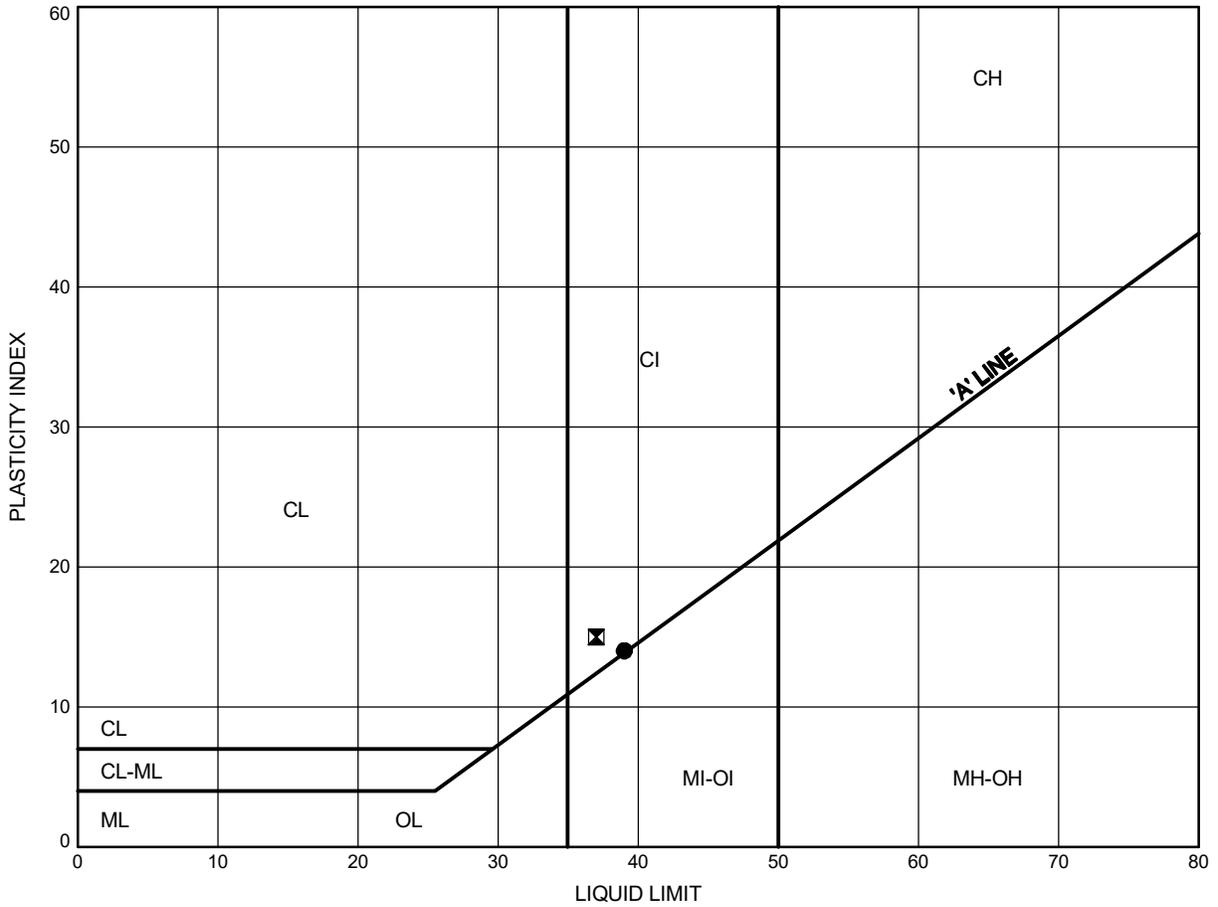


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
ATTERBERG LIMITS TEST RESULTS

FIGURE C7

Silty Clay (CI) to Clayey Silt (CL)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-3	7.2	141.4
⊠	NSC20-3	9.4	139.2

THURBALT CULVERT 20 GINT LOGS.GPJ 7-30-24

Date July 2024
 GWP# 4018-E-0009

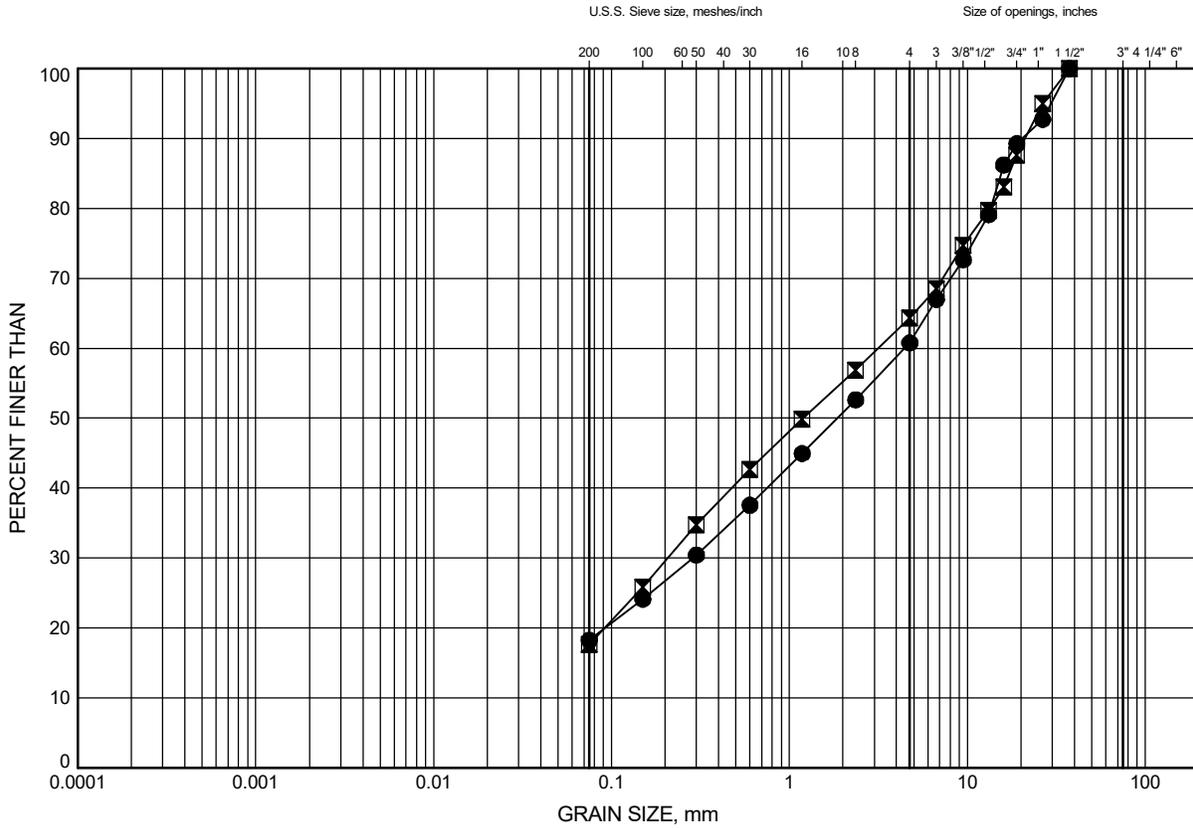


Prep'd RH
 Chkd. AO

Highway 17 Twinning, Sta. 24+936, Culvert 20
GRAIN SIZE DISTRIBUTION

FIGURE C8

Silt Sand (SM)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	NSC20-1	4.2	139.4
⊠	NSC20-3	12.5	136.1

GRAIN SIZE DISTRIBUTION - THURBER CULVERT 20 GINT LOGS.GPJ 7-30-24

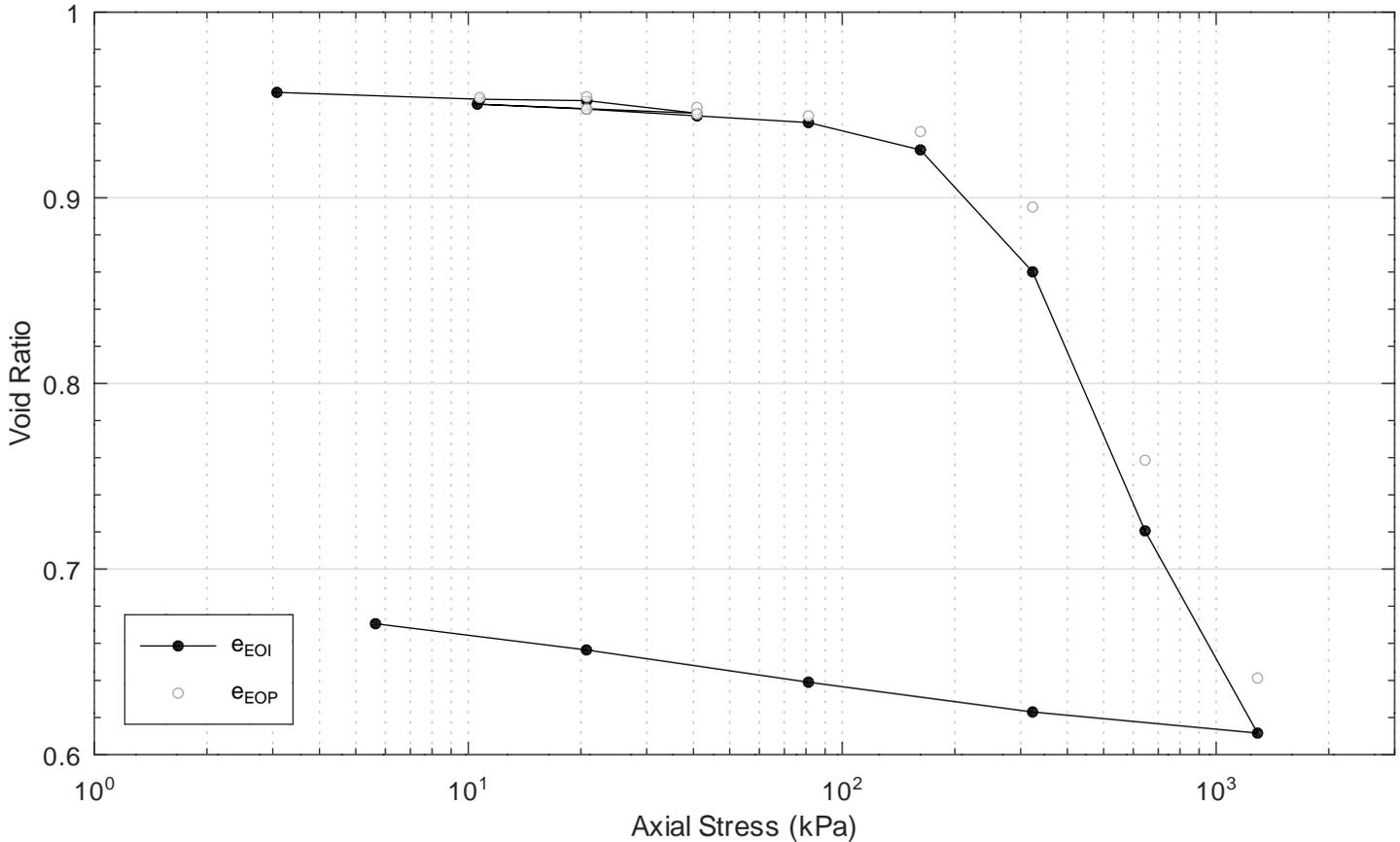
Date July 2024
 GWP# 4018-E-0009



Prep'd RH
 Chkd. AO



Project: 24726
 Hwy 17 Twinning
 Borehole: NSC20-2
 Sample: TW7
 Depth: 4.6m
 Client: MTO



Start of Test		2024-06-07	
Diameter of Sample	cm	D	6.327
Height of Sample	cm	H _o	2.540
Height of Solids	cm	H _s	1.298
Water Content	%	w _o	33.75
Dry Density	g/cm ³	ρ _d	1.42
Moist Unit Weight	kN/m ³	γ	18.6
Void Ratio	-	e _o	0.956
Degree of Saturation	-	S _{ro}	0.98
Specific Gravity	-	G _s	2.771
End of Test		2024-06-24	
Height of Sample	cm	H _f	2.169
Water Content	%	w _f	24.71
Void Ratio	-	e _f	0.671

TRIMMING: the specimen was manually trimmed to the size of the consolidation ring, then mounted in a fixed ring consolidometer

LOADING: the consolidometer was flooded with water with the seating load adjusted to limit swelling

CALCULATIONS: coefficients of consolidation were calculated by the square root time method, secondary consolidation was calculated based on the available duration of the time step

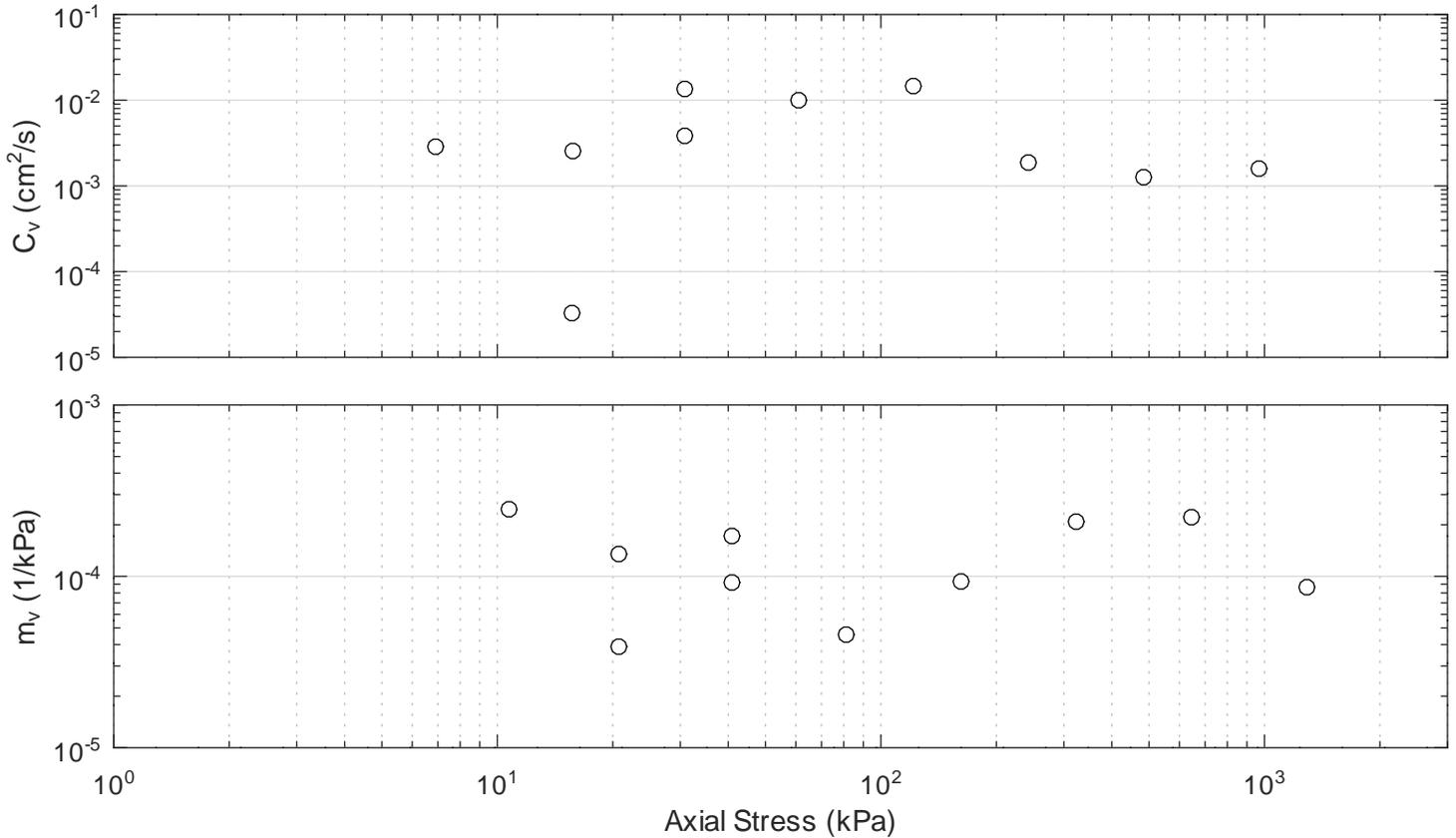
Interpreted Results

Recompression Index (reloading)	-	C _r	0.031
Compression Index	-	C _c	0.464
Recompression Index (unloading)	-	C _r	0.027
Probable Preconsolidation Pressure	kPa	p' _c	246

Check: AO/SP Review: KS/PK



Project: 24726
 Hwy 17 Twinning
 Borehole: NSC20-2
 Sample: TW7
 Depth: 4.6m
 Client: MTO



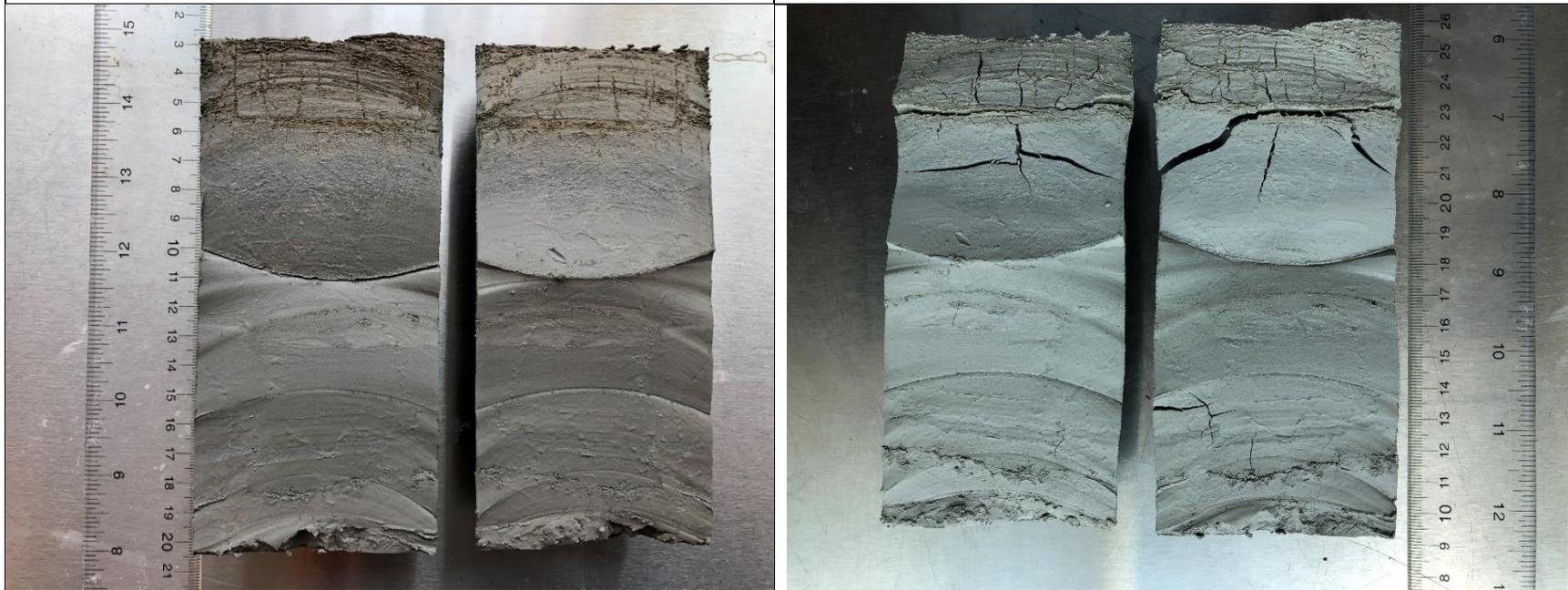
Load No.	Axial Stress kPa	Load Duration min	System Deflec. mm	Dial mm	Sample Height cm	Axial Strain %	Void Ratio (EOI)	Void Ratio (EOP)	Time U(0.99) min	C _v cm ² /s	k _v cm/s	C _{ae} -
0				10.000	2.540	0.00	0.956					
1	3.1	1440.1	0.008	10.002	2.541	-0.04	0.957					
2	10.7	1440.1	0.041	9.920	2.536	0.15	0.953	0.954	16.5	2.87e-03	6.93e-08	0.0002
3	20.7	1440.4	0.102	9.849	2.535	0.19	0.952	0.954	18.6	2.56e-03	9.75e-09	0.0007
4	40.9	1440.5	0.141	9.722	2.526	0.53	0.946	0.949	3.5	1.35e-02	2.28e-07	0.0006
5	10.6	1440.5	0.115	9.811	2.532	0.28	0.950					
6	20.7	1440.2	0.122	9.770	2.529	0.42	0.948	0.948	1440.1	3.28e-05	4.35e-10	0.0046
7	40.9	1440.3	0.141	9.704	2.524	0.61	0.944	0.945	12.3	3.84e-03	3.47e-08	0.0004
8	81.2	1440.0	0.213	9.585	2.520	0.79	0.941	0.944	4.7	9.98e-03	4.48e-08	0.0008
9	161.8	1440.2	0.295	9.312	2.500	1.54	0.926	0.936	3.1	1.46e-02	1.34e-07	0.0020
10	322.9	1440.3	0.382	8.372	2.415	4.90	0.860	0.895	21.2	1.87e-03	3.83e-08	0.0103
11	645.2	1440.3	0.484	6.459	2.234	12.04	0.721	0.759	17.8	1.26e-03	2.74e-08	0.0109
12	1290.0	1440.5	0.601	4.927	2.093	17.61	0.612	0.641	13.6	1.59e-03	1.35e-08	0.0086
13	322.9	1440.4	0.466	5.210	2.107	17.03	0.623					
14	81.2	1440.2	0.347	5.538	2.128	16.21	0.639					
15	20.7	1440.4	0.280	5.831	2.151	15.32	0.656					
16	5.6	2760.1	0.223	6.072	2.169	14.59	0.671					

Borehole NSC20-2, Sample TW7, Depth 4.9 m

(sample width approximately equal to diameter of Thin-Walled sample tube, ~70 mm)

“Wet”

“Dry”





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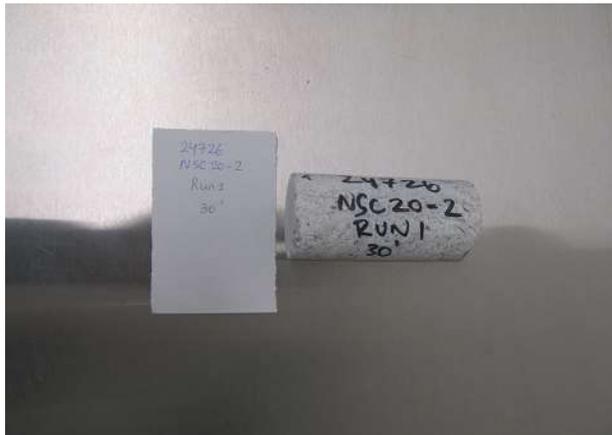
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

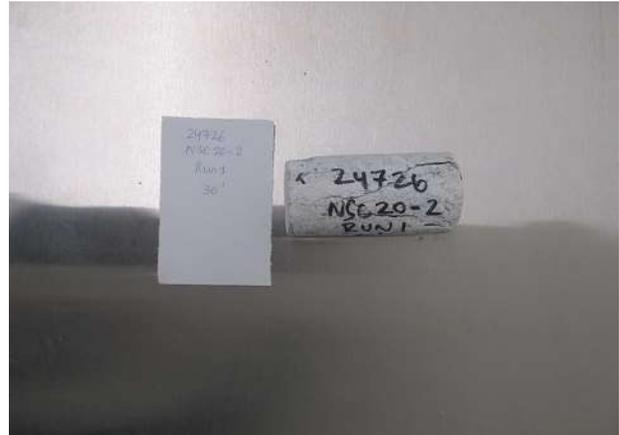
CLIENT: Thurber Engineering (Ottawa) FILE NUMBER: 24726
PROJECT NAME: Highway 17 Twinning - Renfrew REPORT DATE: 18-Jul-24
BOREHOLE No.: NSC20-2 TEST DATE: 9-May-24
SAMPLE No.: Run 1
SAMPLE DEPTH: 9.14 m
DESCRIPTION: Marble

Avg. Height (cm):	9.7	Weight (g):	462.3
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,747
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m ³):	2,747
Cross Sectional Area (cm ²):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm ³):	168.29		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE: 0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD: 94.3 kN
UNCONFINED COMPRESSIVE STRENGTH: 54.4 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

UCS NSC20-2 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	18-Jul-24
BOREHOLE No.:	NSC20-3	TEST DATE:	9-May-24
SAMPLE No.:	Run 3		
SAMPLE DEPTH:	15.42 m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.5	Weight (g):	470.3
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,853
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,853
Cross Sectional Area (cm ²):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm ³):	164.82		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.250 MPa/s
MAXIMUM COMPRESSIVE LOAD:	113.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	65.4 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

UCS NSC20-3 Run 3

Borehole NSC20-1
Run 1, 2, 3 and 4
Depth 4.8 to 11.3 m
Elevation 138.8 to 132.3 m
Dry Sample

Run 1 Start
elev. 138.8 m

Run 1 End
elev. 137.3 m

Run 2 Start
elev. 137.3 m

Run 2 End
elev. 135.9 m



Run 3 Start
elev. 135.9 m

Run 3 End
elev. 134.3 m



Run 4 End
elev. 132.3 m

Run 4 Start
elev. 134.3 m



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 20.20N (Hwy 17, Sta. 24+900)
Renfrew, Ontario

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

Borehole NSC20-1
Run 1, 2, 3 and 4
Depth 4.8 to 11.3 m
Elevation 138.8 to 132.3 m
Wet Sample

Run 1 Start
elev. 138.8 m

Run 1 End
elev. 137.3 m

Run 2 Start
elev. 137.3 m

Run 2 End
elev. 135.9 m



Run 3 Start
elev. 135.9 m

Run 3 End
elev. 134.3 m



Run 4 End
elev. 132.3 m

Run 4 Start
elev. 134.3 m

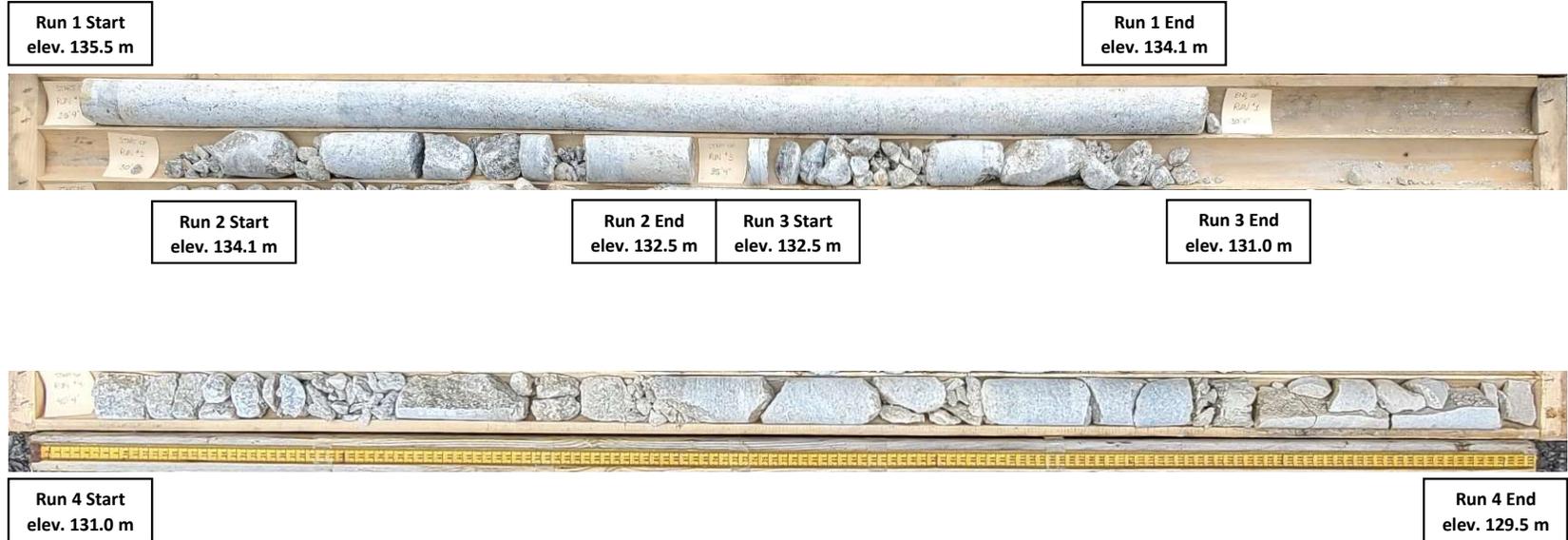


THURBER ENGINEERING LTD.

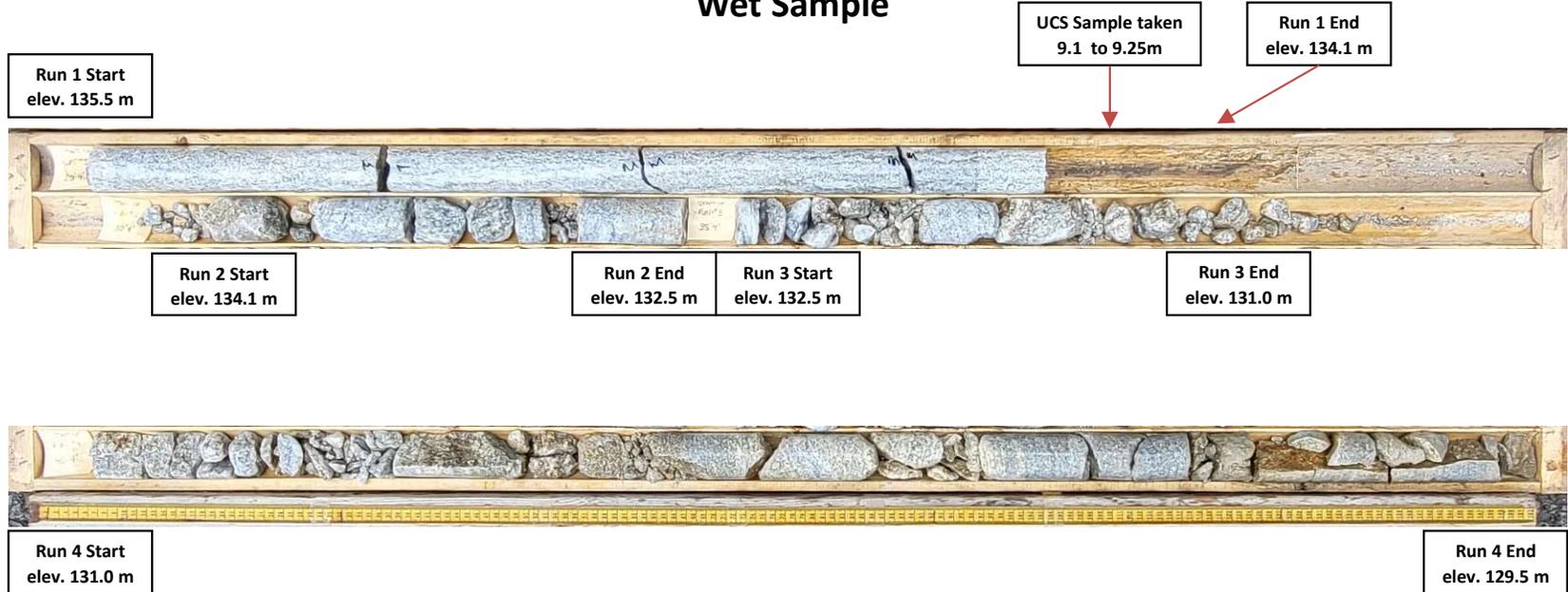
Foundation Investigation
Culvert 20.20N (Hwy 17, Sta. 24+900)
Renfrew, Ontario

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

Borehole NSC20-2
Run 1, 2, 3 and 4
Depth 7.8 to 13.8 m
Elevation 135.5 to 129.5 m
Dry Sample



Borehole NSC20-2
Run 1, 2, 3 and 4
Depth 7.8 to 13.8 m
Elevation 135.5 to 129.5 m
Wet Sample



Borehole NSC20-2
Run 5
Depth 13.8 to 15.3 m
Elevation 129.5 to 128.0 m
Dry Sample

Run 5 Start
elev. 129.5 m

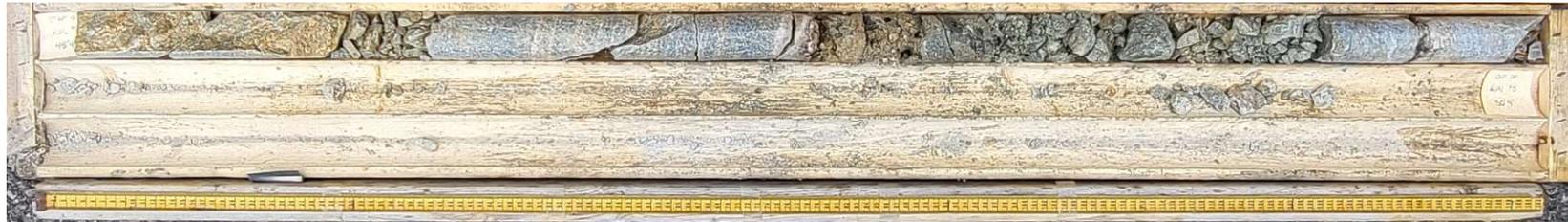
Run 5 End
elev. 128.0 m



Borehole NSC20-2
Run 5
Depth 13.8 to 15.3 m
Elevation 129.5 to 128.0 m
Wet Sample

Run 5 Start
elev. 129.5 m

Run 5 End
elev. 128.0 m



Borehole NSC20-3
Run 1, 2 and 3
Depth 12.7 to 16.6 m
Elevation 135.9 to 132.0 m
Dry Sample

Run 1 Start
elev. 135.9 m

Run 1 End
elev. 134.7 m

Run 2 Start
elev. 134.7 m



Run 2 End
elev. 136.6 m

Run 3 Start
elev. 136.6 m



Run 3 End
elev. 132.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 20.20N (Hwy 17, Sta. 24+900)
Renfrew, Ontario

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

Borehole NSC20-3
Run 1, 2 and 3
Depth 12.7 to 16.6 m
Elevation 135.9 to 132.0 m
Wet Sample

Run 1 Start
elev. 135.9 m

Run 1 End
elev. 134.7 m

Run 2 Start
elev. 134.7 m



Run 2 End
elev. 136.6 m

Run 3 Start
elev. 136.6 m



Run 3 End
elev. 132.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
Culvert 20.20N (Hwy 17, Sta. 24+900)
Renfrew, Ontario

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

Appendix C.2
Analytical Testing Results

Certificate of Analysis

Report Date: 18-Apr-2024

Client: Thurber Engineering Ltd.

Order Date: 12-Apr-2024

Client PO: Highway 17 Renfrew, Various Sites

Project Description: 24726 task 700.706a

Client ID:	BON24-2 SS4 10'-12'	NSC20-2 SS2A 2'6"-3'3"	SC10-1 SS2B 3'-4'	SC10-4 SS2 2'6"-4'6"	-	-
Sample Date:	09-Apr-24 09:00	02-Apr-24 09:00	21-Mar-24 09:00	04-Apr-24 09:00	-	-
Sample ID:	2415421-05	2415421-06	2415421-07	2415421-08	-	-
Matrix:	Soil	Soil	Soil	Soil	-	-
MDL/Units						

Physical Characteristics

% Solids	0.1 % by Wt.	77.6	69.1	73.2	77.5	-	-
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General Inorganics

Conductivity	5 uS/cm	286	203	316	247	-	-
pH	0.05 pH Units	6.79	6.65	6.95	6.84	-	-
Resistivity	0.1 Ohm.m	35.0	49.2	31.6	40.5	-	-

Anions

Chloride	10 ug/g	12	37	97	27	-	-
Sulphate	10 ug/g	24	21	44	<10	-	-



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

19-April-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. : 16 April 2024
LR Report: CA12714-APR24
Reference: Project#: 2415421

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide (Na2CO3) %
1: Analysis Start Date		19-Apr-24
2: Analysis Start Time		13:06
3: Analysis Completed Date		19-Apr-24
4: Analysis Completed Time		13:12
5: RL		0.01
6: SC18-3 SS3A 5' 0"	11 Mar 24	< 0.01
7: SC23-2 SS5 10' 12"	13 Mar 24	0.83
8: DOC23-1 SS7, 15' 17"	11 Mar 24	0.01
9: OBR23-1 SS16 48' 50"	27 Mar 24	< 0.01
10: DON24-2 SS4 10' 12"	09 Apr 24	< 0.01
11: NSC20-2 SS2A 2'6"-3'3"	02-Apr-24	< 0.01
12: SC10-1 SS2B 3' 4"	21 Mar 24	< 0.01
13: SC10-4 SS2 2'6"-4'0"	04 Apr 24	< 0.01

RL - SGS Reporting Limit

Note: Samples taken March 11 and 13th were past the 28 day holding time for Sulphide analysis when received; result may be unreliable. Processed past holding time as per client's instructions.

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

Appendix D.
Site Photographs



Photo 1. Looking north along fence line and trees (March 12, 2024)



Photo 2. Looking south at culvert inlet (March 12, 2024)



Photo 3. Gas line sign at approx. 100 m northwest of the site (July 26, 2024)



Photo 4. Looking south at the well protection for Borehole NSC20-1 (April 02, 2024)



Photo 5. Looking southwest along silt fence near to the culvert site (March 12, 2024)

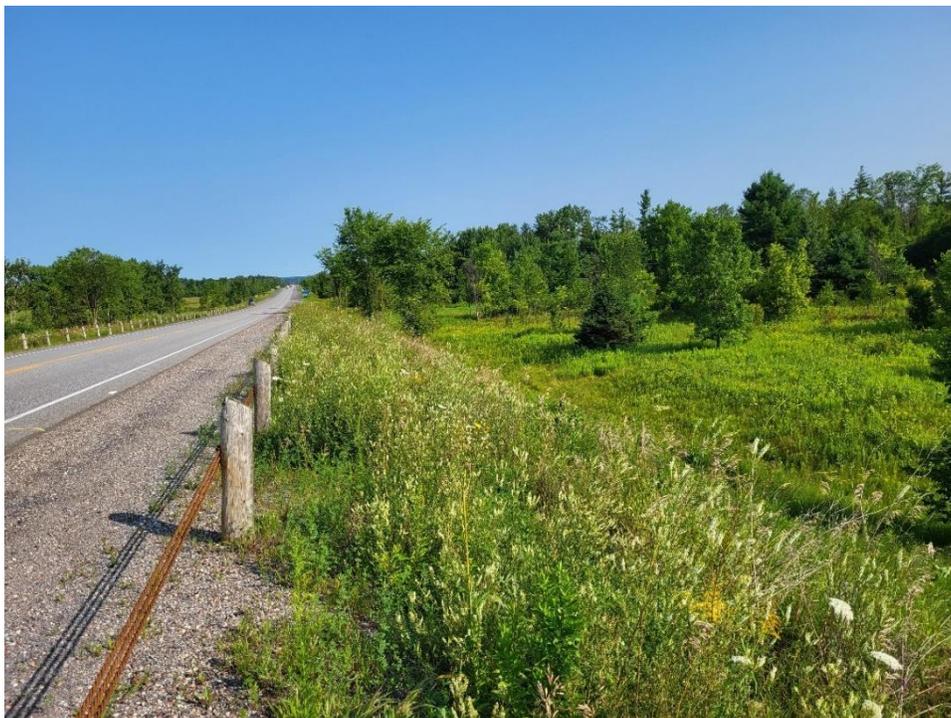


Photo 6. Looking northwest along Highway 17 westbound embankment (July 26, 2024)