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FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 118 CULVERT AT STATION 20+183
DRAPER TOWNSHIP, ONTARIO
ASSIGNMENT NO.: 5017-E-0003
GWP 5011-19-00

GEOCRES NO.: 31D14-002

Location: Lat: 44.997589°, Long: -79.179499°

Client Name: McIntosh Perry Consulting Engineers
Date: February 7, 2024
File: 20244

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PART 1. FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation conducted by McIntosh Perry Consulting Engineers (MPCE) for the replacement of the culvert that crosses Highway 118 near Sta. 20+183 in Draper Township within the Town of Bracebridge, Ontario. MPCE carried out the foundation investigation under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) carried out the preparation of the foundation investigation and design report on behalf of MPCE. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field information provided to aid in the preparation of this report.

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

In addition to the borehole records and laboratory test results, background information provided by MPCE included the DCP Contract Drawings of August 2023 and an email summarizing the existing and proposed culvert characteristics provided on October 27, 2023.

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. SITE DESCRIPTION

2.1 General

The culvert crosses Highway 118 approximately 10.9 km east of the junction between Highway 11 and Highway 118 or, alternatively, 650 m east of Uffington Road. For project purposes, Highway 118 is herein described as oriented east-west, and the culvert is described as oriented north-south.

In the area of the culvert, Highway 118 is a two-lane highway and has a posted speed limit of 80 km/h. The road surface near Sta. 20+183 is at an approximate elevation of 298.3 m. The embankment is a causeway with the north and south embankments sloping towards a pond and marshy area. The highway grade in the vicinity of the culvert slopes upwards to the east and west of the site. Galvanized W-beam guiderails on wooden posts are present along the eastbound and westbound shoulders of the highway. The shoulders are paved. Traffic volumes are understood to have been 4,300 AADT in 2019.

The existing culvert is reported in drawings provided by MPCE to be a 1,300 mm diameter, 31 m long, corrugated steel pipe (CSP US / SPCSP DS) culvert approximately perpendicular to the highway alignment. The culvert has a relatively flat gradient with the invert of the culvert near elevations 291.9 m and 291.8 m at the inlet and outlet, respectively. The cover above the existing culvert is approximately 5.1 m at the highway centreline. Water flows through the culvert from south to north towards the South Branch Muskoka River, which is approximately 360 m north of the highway alignment. Ponded water to the south of the highway was at approximate elevation 294.6 m at the time of the site visit and the water depth was recorded to be approximately 1.4 to 1.8 m at the location of the in-water boreholes.

The east- and westbound embankment side slopes are generally inclined at approximately 1.6H:1V. Cobbles and boulders are present on the slopes. MPCE examined the slopes in the field and did not observe any indications of slope instability. The site is in a rural setting and the area adjacent to the highway and ponded areas is undeveloped and densely vegetated with mixed forests of deciduous and some coniferous trees and shrubs. Overhead utility lines were present along the westbound embankment toe. A rock cut is present approximately 250 m east of the culvert site.

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

2.2 Site Geology

According to Crins et al. 2009[1] the project area is described as Ecoregion 5E (Georgian Bay Ecoregion) within the Ontario Shield Ecozone. According to Wester et al. 2018[2] the ecoregion is subdivided into Ecodistrict 5E-8 (Huntsville Ecodistrict). The area is characterized by shallow layers of morainal material and pockets of deeper glaciolacustrine sediment overlying Precambrian bedrock.

Bedrock Geology Map (MRD126)[3] indicates the site is underlain by derived gneisses or felsic igneous rocks such as tonalite, granodiorite, monzonite, and syenite.

2.3 Existing Information

A historical foundation investigation report was not available for this site within the online Geocres Library. Geocres Report 31E00-400 for a foundation investigation conducted 1.6 km southwest of the culvert was reviewed for regional information only but has not been used further in the report.

3. SITE INVESTIGATION AND FIELD TESTING

The foundation investigation and field-testing program was carried out between September 27, 2022, and July 26, 2023, and consisted of three on-road boreholes identified as CL47-1 MW, CL47-2, and CL47-3 MW and two off-road/in-water boreholes identified as CL47-4 and CL47-5. The on-road boreholes were advanced with a CME 75 truck mounted drill rig utilizing NW casing and coring techniques. The off-road boreholes were advanced with portable drilling equipment. MPCE has confirmed that utility clearances were acquired in the vicinity of the borehole locations prior to commencement of drilling.

It is noted that two originally planned boreholes near the culvert outlet were not drilled due to access issues and utility conflicts. Additional details are provided in a memorandum presented in Appendix G. This report is written based on the information provided by MPCE.

A summary of the borehole coordinates, elevations, and termination depths is provided within Table 3-1. The as-drilled borehole elevations were surveyed by MPCE with a Trimble R2 receiver with centimeter accuracy (vertical datum of CGVD28). Horizontal locations were measured by MPCE relative to existing site features with centimeter accuracy. The borehole coordinates and

[1] *https://files.ontario.ca/mnrf-ecosystemspart1-accessible-july2018-en-2020-01-16.pdf*
[2] *https://files.ontario.ca/ecosystems-ontario-part2-03262019.pdf*
[3] *http://www.geologyontario.mndm.gov.on.ca/mines/data/google/mrd126/doc.kml*

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 10.

Table 3-1 Borehole Summary

BOREHOLE NO.	DRILLED LOCATION	NORTHING (m)	EASTING (m)	GROUND SURFACE ELEVATION (m)	TERMINATION DEPTH (m)
CL47-1 MW	Eastbound Lane	4 984 220.1	330 059.6	298.1	15.9
CL47-2	Eastbound Lane	4 984 228.5	330 069.3	298.3	17.4
CL47-3 MW	Westbound Shoulder	4 984 239.0	330 072.0	298.5	15.9
CL47-4	South from the inlet	4 984 212.7	330 075.4	292.2	9.9
CL47-5	South from the inlet	4 984 210.4	330 079.8	291.7	9.5

The boreholes were advanced to depths ranging from 9.5 to 17.4 m below the existing ground surface (base elev. 282.3 to 280.9 m). 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. It is noted that an automatic hammer could not be used with the portable drill thus the SPT N-values from the portable drilling equipment are considered to be less reliable.

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

A 51 mm diameter well was installed in each of Boreholes CL47-1 MW and CL47-3 MW to allow for measurements of the groundwater level after drilling. The well details are illustrated on the respective Record of Borehole sheets provided in Appendix B.

MPCE has confirmed that following completion of the field investigation, the boreholes without a well were decommissioned in general in accordance with O.Reg. 903, as amended. Borehole CL47-2 was capped with cold patch asphalt to reinstate the pavement surface. The monitoring wells were left for further readings. MPCE has confirmed the wells have been tagged and are registered to the property owner, MTO; decommissioning will be at the discretion of MTO.

4. LABORATORY TESTING

Laboratory testing was selected in general accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. MPCE has confirmed that geotechnical laboratory testing included a visual identification of all retained soil samples. Select soil samples were tested for moisture content, grain size distribution and, where appropriate, Atterberg Limits testing in accordance with MTO and ASTM standards. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B.

MPCE selected one soil sample and submitted for analytical testing of corrosivity parameters.

All laboratory test results from the field investigation are provided 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 on 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 Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions will vary between and beyond borehole locations. Soil classification is in general accordance with ASTM D2487 with the description of secondary components as outlined in the MTO Guideline for Foundation Engineering Services Manual (April 2022). It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs.

In general, the encountered stratigraphy consists of granular fill overlying a native deposit of silt to silty sand over sand. Organics were encountered at the ground surface in the off-road boreholes.

5.1 Surficial Materials

5.1.1 Asphalt

Asphalt was encountered at the ground surface in the on-road boreholes. The asphalt was measured to have a thickness of approximately 110 to 125 mm.

5.2 Sandy Gravel to Gravelly Sand Fill to Rock Fill

A layer of sandy gravel to gravelly sand fill intermixed with rock fill was encountered below the asphalt in Boreholes CL47-1 MW, CL47-2, and CL47-3 MW. Varying amounts of silt, cobbles, and boulders were noted within the layer. Voids measuring up to 0.9 m vertically were noted in the layer in Borehole CL47-3 MW at depths of 0.7 m and 2.7 m below the asphalt surface. NQ coring techniques were required to penetrate past the cobbles and boulders. The fill was 5.8 to 7.4 m thick (base elev. 292.5 to 290.8 m). Full-depth SPT N-values ranging from 9 to 61 blows were recorded, indicating a typical compact to very dense relative density. Refusal N-values were routinely obtained and are attributed to the presence of cobbles and boulders.

MPCE Pavement report (GWP 5287-14-00, page 183, dated August 29, 2019) indicates NFP on rock fill at numerous stations located within the site of the current foundation investigation.

Moisture contents ranging from 6 to 15% were recorded. The results of gradation analyses completed on six samples of the layer are illustrated in Figures C1 to C6 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	20 – 65	
Sand	29 – 64	
Silt	5 – 15	12 - 16
Clay	1	

5.3 Organic Sediment and Organic Silt

A native deposit of organic sediments was encountered below the pond water in Boreholes CL47-4 and CL47-5. Varying amounts of gravel and silt were noted in the layer. The layer was 0.6 to 1.0 m thick (base elev. 291.2 to 291.1 m).

A silt layer containing organics was observed beneath the organic sediments in Borehole CL47-5 and beneath the fill in Boreholes CL47-2 and CL47-3 MW. The layer was 0.3 to 1.7 m thick (base elev. 290.8 to 290.5 m). The layer also contained variable amounts of sand and clay.

SPT N-values of Weight-of-Hammer (WOH) to 6 blows were recorded, indicating a very loose to loose relative density.

Moisture contents ranging from 49 to 64% were recorded. The results of gradation analyses completed on one sample of the layer are illustrated in Figure C7 of Appendix C. The results of the test are summarized in the table below and on the Record of Borehole sheet in Appendix B.

SOIL PARTICLE	PERCENTAGE (%)
Gravel	1
Sand	35
Silt	61
Clay	3

5.4 Silt to Sandy Silt

A deposit consisting predominantly of silt to sandy silt was encountered below the fill in Borehole CL47-1 MW and below the organics in all other boreholes. A sand pocket, which was 0.6 m thick (base elev. 289.7 m), was noted within the layer in Borehole CL47-4. Where fully penetrated, the layer was 5.9 to 6.1 m thick with an underside depth of 13.0 to 13.7 m (base elev. 285.1 to 284.6 m). Boreholes CL47-4 and CL47-5 were terminated in the layer at a depth of 9.9 m and 9.5 m below existing ground surface (base elev. 282.3 m), respectively. SPT N-values ranging from 2 to 59 blows were recorded, however, more typically the layer was compact in relative density. Two field vane tests were performed within the silt layer and reported undrained shear strengths of 19 and 57 kPa in Borehole CL47-5. Remolded vane tests recorded sensitives of 2 and 4, indicating a sensitivity class of medium sensitive (CFEM, 2006).

Moisture contents ranging from 14 to 31% were recorded. The results of gradation analyses completed on 12 samples of the layer are illustrated in Figures C8 to 19 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheets in Appendix B.

SOIL PARTICLE	PERCENTAGE (%)
Gravel	0 – 1
Sand	0 – 25
Silt	65 – 86
Clay	6 – 19

Results of Atterberg Limit testing carried out on seven samples yielded six tests with “Non-Plastic” results. The single plastic test result is illustrated in Figure C20 of Appendix C and summarized

below and on the Record of Borehole sheet. The laboratory results indicate that the silt exhibits non plastic to low plastic behavior (ML).

PARAMETER	VALUE
Liquid Limit	27
Plastic Limit	24
Plasticity Index	3

5.5 Sand to Silty Sand

A deposit of sand to silty sand was encountered below the silt in Boreholes CL47-1 MW, CL47-2, and CL47-3 MW. Those boreholes were terminated in this layer at a depth of 15.9 to 17.4 m (base elev. 282.6 to 280.9 m). SPT N-values typically ranging from 6 to 32 blows were recorded, indicating a typical compact to dense relative density.

The recovered samples were noted to be wet. The results of gradation analyses completed on three samples of the layer are illustrated in Figures C21 to C23 of Appendix C. The results of the tests are summarized in the table below and on the Record of Borehole sheets in Appendix B.

SOIL PARTICLE	PERCENTAGE (%)
Gravel	0 – 1
Sand	72 – 96
Silt	3 – 28
Clay	

Results of Atterberg Limit testing carried out on one sample yielded a “Non-Plastic” result.

5.6 Groundwater Level

The measured groundwater levels from within the wells are as summarized in Table 5-1.

Table 5-1 Measured Water Levels

Borehole	Bottom of Screen Depth /Elevation (m)	Soil in Zone of Screen	Groundwater Level		Date of Measurement
			Depth (mbgs)	Elevation (m)	
CL47-1 MW	284.2	Silt / Sand	4.8	293.3	2023-07-26
CL47-3 MW	284.7	Silt / Sand	5.2	293.3	2023-07-26

Water levels in the open boreholes would have been impacted by the water introduced as part of the drilling process for Boreholes CL47-1, CL 47-2 and CL47-3.

Ponded water was measured to be 1.4 m deep near Borehole CL47-4 and 1.8 m near Borehole CL47-5. The surface elevation of the ponded water north and south of the highway was measured to be 292.7 and 292.8 m in May 2018 as shown in the Centreline Culvert Inspection Summary provided by MPCE. The surface water elevation during drilling operations in July 2023 of the ponded water south of the highway was measured to range from 293.5 to 293.6 m.

It should be noted that the values shown above are considered short-term readings and may not reflect groundwater levels or surface water levels at the time of construction. Seasonal fluctuations of the water levels are to be expected. In particular, the level may be at a higher elevation after periods of significant and/or prolonged precipitation events. The water level should also be expected to change based on the steepness of the alignment of the highway and ditches which have the ability to convey water flow quickly.

In addition, it is noted that the water level in the South Branch Muskoka River is controlled by Ontario Power Generation (OPG) at Matthiasville Falls which is located approximately 2 km west of the site. Site observations indicate the water level was dropping during the July investigation. As per information provided by MPCE in an email dated February 6, 2024, the historical water levels at the Matthias Reservoir range from a low water zone of elev. 291.5 m to flood damage zone of elev. 293.7 m throughout the year. Daily water level statistics show that the water levels measure at approx. 292.8 m year round.

5.7 Analytical Testing

One soil sample was submitted for analytical testing. The analysis results are included in Appendix C and are summarized in Table 5-2.

Table 5-2 Analytical Test Results

BOREHOLE	CL47-3 MW
SAMPLE	SS4
DEPTH (ft/m)	14'6" – 16'6" 4.4 – 5.0
ELEVATION (m)	293.8
SOIL TYPE	Sandy Gravel Fill
pH	7.57
RESISTIVITY (Ohm-cm)	2,840
CHLORIDE (µg/g)	128
SULPHATE (µg/g)	14

6. MISCELLANEOUS

The as-drilled locations and ground surface elevation were measured by MPCE following completion of the field program. George Downing Estate Drilling Ltd. of Grenville, Quebec, and Ohlmann Geotechnical Services Inc. of Almonte, Ontario, supplied and operated the drill rigs used to drill, test, sample, and decommission the on-road and portable boreholes, respectively. Traffic control was performed in accordance with Ontario Book 7 and was provided by Robinson Haulage Incorporated of Kilworthy, Ontario. The field investigation was supervised on a full-time basis by J. Hutson, CET, and J. Patel, Field Technician of MPCE.

Analytical testing was completed by Paracel Laboratories Ltd. in Ottawa.

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

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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report provides an interpretation of the factual data from Part 1 of this report and presents foundation design recommendations to assist the project team in the design of the replacement of the culvert located on Highway 118 near Station 20+183 in the Township of Draper within the Town of Bracebridge, Ontario. McIntosh Perry Consulting Engineers (MPCE) carried out the field and laboratory investigations under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) prepared the foundation investigation and design report on behalf of MPCE. The discussion and recommendations presented in this report are based on information provided by MPCE and the factual data obtained during the field investigation. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field information provided to aid in the preparation of this report.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation Ontario and their designer, McIntosh Perry Consulting Engineers, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, and scheduling and the like.

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.

7.1 Background Information

In addition to the borehole records and laboratory test results, background information provided by MPCE included the DCP Contract Drawings of August 2023 and an email summarizing the existing and proposed culvert characteristics provided on October 27, 2023.

The culvert site is approximately 10.9 km east of the junction between Highway 11 and Highway 118. The road surface near the culvert is near elevation 298.3 m, and the invert of the culvert is near elevations 291.9 and 291.8 m at the inlet and outlet, respectively. The cover above the existing culvert is approximately 5.1 m at the highway centerline. Water flows through the culvert from south to north towards the South Branch Muskoka River, which is approximately 360 m north of the highway alignment. The existing culvert is reported in drawings provided by MPCE to be a 1,300 mm diameter, 31 m long corrugated steel pipe (CSP US / SPCSP DS) culvert. Ponded water is present on both sides of the highway. The ponded water to the south of the highway was measured to range from elevation 293.5 to 293.6 m at the time of the site visit and the water depth was recorded to be approximately 1.4 to 1.8 m at the location of the in-water boreholes.

In general, the encountered stratigraphy consists of granular/rock fill overlying a native deposit of silt to silty sand over sand. Cobble and boulder sized rock particles were observed in the fill. Voids were also noted in the embankment. Organics were encountered beneath the fill in two on-road boreholes and at the ground surface in the off-road boreholes. Groundwater was recorded at elev. 293.3 m during the field investigation. Surface water was measured at elev. 294.6 m during the field investigation.

As noted in Section 3 of this report, two originally planned boreholes near the culvert outlet were not drilled due to access issues and utility conflicts (see additional details provided in a memorandum presented in Appendix G). The investigation included 5 boreholes in total at this site: two boreholes were drilled in water to the south of the culvert to 11.3 m below the culvert invert and three boreholes were drilled from the roadway to depths ranging between 15 m and 17 m. It was observed that the soil profile is consistent in the five boreholes, thus it is our opinion that the observed conditions can be extrapolated to the culvert outlet (where boreholes were omitted).

7.2 Proposed Work

The proposed works for this culvert is indicated in the MPCE Foundation Engineering request dated October 05, 2023, with the approach recommended by MPCE to be culvert replacement with half and half staging and temporary grade lowering at approximately elevation 295.6 m above the culvert.

As per the Contract Drawings, the existing culvert will be abandoned and grouted in place. A new rigid frame bottom (RFB) box culvert measuring 2.5 m wide, 1.8 m high and approximately 32 m long will be constructed approximately 5 m west of the existing culvert alignment. The proposed invert of the culvert is at elevation 292.4 and 292.3 m at the inlet and outlet, respectively. The proposed cover above the existing culvert will be approximately 3.9 m at the highway centerline.

7.3 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed work, existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC), version CSA S6-19. The importance category and consequence classification are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation, Ontario (MTO).

It is understood that the culvert is to be designed to the “Major Route” importance category.

It is understood that the new culvert would have a consequence classification of *Typical Consequence*, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances. If this consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

As per Section 6.5.3.2 of the CHBDC, the degree of site prediction model understanding is considered to be *Typical* based on the current information.

The frost penetration depth and associated recommendations are provided in Section 10.4.

8. SEISMIC CONSIDERATIONS

8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC)[4]. The GSC seismic hazard calculation data sheet for this site for the *reference* ground condition (Site Class C) is presented in Appendix E. The site coefficients used to determine the design spectral acceleration values are a function of the Site Class, PGA, and Sa (0.2). The PGA value at this site provided by GSC for a *reference* Site

[4] *https://earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/calc-en.php*

Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.069g. This value is to be scaled by the F(PGA) based on the *site-specific* Site Class, as discussed in Section 8.3.

8.2 Liquefaction Potential

The susceptibility of the cohesionless soils at the site (including the low to non-plastic silt, sand to silty sand, and glacial till deposits) to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Section C6.14.8 of the Commentary to the CHBDC and Boulanger and Idriss (2014) [5]. The cohesionless soils at the site are not considered to be susceptible to liquefaction.

8.3 CHBDC Seismic Site Classification and Performance Category

In accordance with the CHBDC, the selection of the seismic site classification is based on the nature of the soil deposits within the upper 30 m of the stratigraphy. As per Table 4.1 within Section 4.4.3.2 of the CHBDC, the site has been classified as a Seismic Site Class E.

The F(PGA), as per Table 4.8 within Section 4.4.3.3 of the CHBDC, is equal to 1.81 for this site yielding a scaled *site-specific* Site Class C PGA of 0.125g.

As per Section 4.4.4 of the CHBDC, the Seismic Performance Category is assigned based on the fundamental period, the importance category and the spectral accelerations scaled to the site class. The F(0.2), as per Table 4.2 within Section 4.4.3.3 of the CHBDC, is equal to 1.64 for this site yielding a scaled site specific Sa(0.2) of 0.192. A Seismic Performance Category of 1 is applicable to this site based on Table 4.10 of the CHBDC. *As per Section 4.4.5.1 of the CHBDC, seismic loads are not required for bridges in Seismic Performance Category 1 indicating that no seismic analysis and recommendations would be required for the replacement bridge.* The seismic performance category should be confirmed by the structural engineer.

9. DESIGN OPTIONS

9.1 Culvert Type and Foundation Alternatives

Selection of the replacement culvert type must consider the proposed construction procedures, staging requirements, geotechnical resistance available in the foundation soils, depth to suitable

[5] *Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.*

bearing stratum, and post-construction settlement criteria. The replacement options that have been considered from a foundation perspective include:

- Circular Pipe (Concrete, HDPE, Steel)
  Pipe culverts are considered a feasible option from a foundation engineering perspective. The size of the pipe culvert would depend on the required hydraulic capacity. Open cut or trenchless installation methods are typically considered for pipe culverts.

- Closed Bottom Culvert (Box)
  A precast segmental box culvert is considered a feasible option from a foundation engineering perspective. Precast sections, rather than cast-in-place construction, can be installed expediently with less potential for disturbance of the founding soils during installation, require less excavation depth than open bottom culverts leading to more manageable dewatering conditions.

- Open Bottom Culvert (Box, Arch)
  An open bottom culvert would have greater construction concerns due to the high water table and requirement for a greater excavation depth to satisfy frost protection requirements, when compared to other culvert options. This leads to greater dewatering efforts to construct the culvert in the dry and would typically have greater differential settlement due to reduced footing widths. This option is not considered to be appropriate for the size of culvert required at this site and is not described further in this report.

A comparison of the alternatives, based on their respective advantages and disadvantages, is included in Appendix F. It is not considered to be economical or practical to support a culvert on deep foundations at this site and therefore this option is not presented in this report.

9.2 Construction Methodology Alternatives

For the proposed culvert replacement, construction methods that were considered are presented below. Common to all techniques discussed below are excavations through embankment fill and varying cohesionless native soils. It is understood that only a single lane of traffic is required to be maintained during replacement of the existing culvert. For an open cut, the side slopes of the open excavation for the culvert replacement should follow the recommendations outlined in Section 11.1, below. Alternatively, if space restrictions prohibit the use of slopes, a temporary protection system as per Section 11.2 should be used.

- Open Cut with Staged Temporary Widening Embankment
  Installation of a new culvert using an open cut staged replacement with a temporary embankment widening to accommodate passage of traffic during construction is considered feasible from a foundation perspective. However, the presence of peat and organic silt at the site and beneath the existing highway embankment limit the feasibility of any permanent embankment widening. Construction of temporary embankment widening is considered to be feasible provided that some settlement and periodic regrading of the widened portion is acceptable during the construction period.

- Open Cut with Staged Construction with Temporary Grade Lowering
  Installation of a new culvert using an open cut staged replacement with grade lowering to maintain movement of traffic within the existing embankment footprint is considered a feasible option from a foundation perspective. Voids were observed within the fill in Borehole CL47-3. The grade lowering approach provides an opportunity to remove the shallow voids. The prepared subgrade level should undergo proof rolling and additional voids exposed at the planned new pavement subgrade level or during proof rolling, can be backfilled. Given the presence of cobbles and boulders in the fill, over excavation will likely be required to allow construction of a suitable pavement structure. It is noted that grade lowering may generate excess soils if a suitable use on site isn't available.

- Open Cut with Full Road Closure and Temporary Detour
  Installation of a new culvert using open cut techniques and a full road closure would allow for an expedited construction schedule and could reduce costs associated with roadway protection or tunneling. However, it is anticipated that an acceptable detour route is not available and therefore this option is not carried forward.

- Open Cut with Staged Construction and Temporary Protection System
  Installation of a new culvert using an open cut staged replacement is considered feasible from a foundation perspective. The option would require roadway protection, as discussed further in Section 11.2, installed near the embankment centerline to maintain a single lane of traffic flow along the current highway embankment. The Contractor would need to consider the rockfill during the installation of roadway protection. To reduce lateral deflections, the TPS may need to include anchoring and/or bracing. The height of the TPS could be reduced if the road alignment constraints allowed for a temporary grade lowering to be included.

- Trenchless Techniques
  Installation of a new culvert using trenchless techniques would have the advantage of minimum disruption to traffic and would avoid a large excavation through the existing highway embankment. Based on the existing information, the culvert alignment will be near the base of granular/rock fill and through the native organics and/or silt layers, thus presenting mixed face conditions along the culvert alignment. High water levels were also present at the inlet and outlet. Moreover, moving construction equipment may be difficult in areas of organic deposits or excessively soft, loose/unstable and/or saturated subgrade. Based on the anticipated risks of encountering obstructions, mixed soil conditions, the dewatering challenges for the entry and exit pits, and the and associated costs, a trenchless installation is not recommended at this site.

9.3 Recommended Approach for Culvert Replacement

From a foundation engineering perspective, an open cut construction methodology with temporary grade lowering to allow a staged culvert construction is feasible. It is understood from Sheet 5 of the DCP drawings that a temporary grade lowering of 2.6 m at the culvert is proposed with the associated tie-ins to existing grade at 20+030 and 20+271.

10. OPEN CUT FOUNDATION DESIGN RECOMMENDATIONS

10.1 Foundation Bearing Resistances

It is understood that the replacement pipe or closed box culvert will have an invert elevation of 292.3 m at the outlet. Therefore, it is anticipated that the underside of the culvert will be within materials varying from granular/rock fill to silt to sandy silt.

The replacement culvert should be founded on a bedding layer (see Section 10.2). Subgrade preparation should follow the recommendation provided in Section 10.2.

Surface water diversion and dewatering will be required to place the bedding material and install the culvert in the dry (see Section 11.3).

10.1.1 Pipe Culvert

Bearing resistance values are not required for pipe culverts. However, a modulus of subgrade reaction of 20 MN/m^3 can be used for a pipe culvert at this site if required. The value should be divided by the pipe diameter when estimating the soil's spring constant.

If a concrete pipe is selected, resistance to lateral forces/sliding resistance between concrete and the underlying granular bedding layer should be evaluated following the recommendations presented in Section 10.1.2.

10.1.2 Closed Box Culvert

A closed box culvert would not need to be founded below the depth of frost (see Section 10.4). For a box culvert with a width of 2.5 m founded on a properly prepared granular bedding layer, the design can be based on factored geotechnical resistance values computed at the end of the culvert as follows:

- Factored Geotechnical Resistance at ULS of 250 kPa
- Factored Geotechnical Resistance at SLS of 125 kPa

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC, Table 6.1)
- Geotechnical resistance factors (as per CHBDC, Table 6.2)
    - ϕ_{gu} = 0.50 (static analysis; *typical* degree of understanding)
    - ϕ_{gs} = 0.80 (static analysis; *typical* degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted in accordance with CHBDC Clause 6.10.2. Foundation settlement, based on the supplied SLS resistance, is expected to be as much as 25 mm. The bearing resistances provided above are based on the assumption that subgrade is prepared as recommended in Section 10.2.

Resistance to lateral forces/sliding resistance between precast concrete and the underlying Granular bedding (see Section 10.2) should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of 0.45 for precast concrete. A geotechnical resistance factor of 0.8 (ϕ_{gu}), as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the sliding frictional capacity between concrete and Granular bedding.

10.2 Subgrade Preparation, Embedment, Bedding, Cover and Backfilling

“Granular A” and “Granular B Type II” in this section refer to OPSS Granular A or Granular B Type II meeting the specifications of OPSS.PROV 1010 and SP 110S06. Fills should be placed and compacted as per OPSS.PROV 501 and OPSS.PROV 206. The culvert should be constructed following OPSS.PROV 401 and either OPSS.PROV 421 (pipe culvert) or OPSS.PROV 422 (box culvert).

Subgrade preparation for the culvert replacement should include excavation and removal of the existing culvert if replaced along the same alignment. If the replacement culvert is placed on a new alignment, the existing culvert may be abandoned in place.

At the underside of the culvert bedding level, existing fill, soft/loose soils, disturbed soils, or otherwise deleterious materials encountered will need to be removed down to competent inorganic soils. Construction traffic should not travel on the exposed subgrade. As soon as practical, the excavation should be backfilled to the underside of the bedding elevation to protect the subgrade from disturbance from both construction traffic and weather. Granular A should be used in dewatered excavations to backfill any sub-excavations required for subgrade improvement, see further comments below for excavations in the wet.

Foundation preparation for a pipe culvert should be as per OPSS.PROV 421 and OPSD 802.010 (flexible pipe), OPSD 802.031 (rigid pipe), and OPSD 803.031 with bedding extending to 300 mm below the pipe in both cases. It is recommended that culvert cover, embedment and bedding materials consist of OPSS.PROV 1010 Granular A.

In order to provide a more uniform foundation subgrade condition for a closed box culvert, bedding and cover material conforming to OPSS.PROV 1010 Granular A requirements must be provided under the base of the culvert as per OPSS.PROV 422 and OPSD 803.010. The Granular bedding layer should be a minimum of 300 mm thick and covered with a 75 mm levelling course of Granular A.

It is noted that construction will extend below the observed water level. Dewatering will be required to place the granular bedding in the dry. Please review Section 11.3 for additional comments on groundwater and surface water control. Due to the anticipated difficulty in dewatering at this site, consideration may be given to preparing the subgrade in the wet during periods of significant precipitation and/or when the groundwater level is seasonally high and cannot be effectively lowered below the founding elevation by pumping. It may be prudent to carry forward subgrade preparation in the wet in the contract documents. Backfill below the bedding layer should consist of 19 mm clear stone meeting the requirements of OPSS.PROV 1004. The clear stone should be completely wrapped in a non-woven geotextile meeting OPSS.PROV 1860 Class II and have a FOS not greater than 212 μm to minimize migration of the fines into the clear stone. Clear stone placed above the water level must be compacted as per OPSS.PROV 206.07.05. Culvert bedding, as described above, placed on a clear stone layer at least 150 mm thick, should have a minimum thickness of 150 mm.

Backfill above the granular cover material for a closed box or rigid pipe culvert or above the embedment layer for a flexible pipe culvert should be in accordance with OPSS.PROV 902 and consist of materials meeting the requirements of OPSS Select Subgrade Material (SSM) or better.

Heavy compaction equipment, used adjacent to or directly above the culvert, must be restricted in accordance with OPSS.PROV 501 to protect the culvert from damage.

Voids were observed within the fill in Borehole CL47-3. The grade lowering approach provides an opportunity to remove the shallow voids. The prepared pavement subgrade level should undergo proof rolling and additional voids exposed at the new pavement subgrade level or during proof rolling, can be backfilled.

10.3 Lateral Earth Pressure

The equations for lateral earth pressure provided below are based on the assumption that the backfill is fully drained so that there are no unbalanced hydrostatic pressures. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design. A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC.

Lateral earth pressures acting on vertical walls should be computed in accordance with the Section 6.12 of the CHBDC but under fully drained conditions, the lateral pressures are generally given by the following expression:

$$\sigma_h = K * (\gamma\, d + q) \quad \text{[static]}$$

$$\sigma_{hAE} = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d) \quad \text{[combined static and seismic]}$$

where:

σ_h	=	static lateral earth pressure on the wall at depth d (kPa)
σ_{hAE}	=	combined static and seismic lateral earth pressure on wall at depth d (kPa)
K	=	static earth pressure coefficient (see table below) (K_A for yielding walls, K_o for non-yielding walls)
K_{AE}	=	combined static and seismic earth pressure coefficient
γ	=	unit weight of retained soil (kN/m^3), see table below adjusted to submerged unit weight below water level
d	=	depth below top of fill where pressure is computed (m)
H	=	total height of the wall (m)
q	=	value of any surcharge (kPa)

Static Lateral Earth Pressure

Typical lateral earth pressure parameters for use in the design for vertical walls for backfill material are shown in Table 10-1.

Table 10-1 Static Earth Pressure Coefficients

MATERIAL	UNIT WEIGHT (kN/m^3)	K_A (YIELDING WALL)	K_0 (NON-YIELDING WALL)	Kp (MOVEMENT TOWARD SOIL)	GROUND SURFACE BEHIND WALL
OPSS Granular A & Granular B Type II (Φ = 35°)	22.8	0.27	0.43	3.7	Horizontal
		0.39	0.43	10.8	2H:1V
OPSS Granular B Type I (Φ = 32°)	22.0	0.31	0.47	3.3	Horizontal
		0.47	0.47	8.6	2H:1V

As indicated in Section 8.3, the site is a Performance Category 1 and seismic loads are not required for bridges in seismic performance category 1 as per Section 4.4.5.1 of the CHBDC.

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. Figure C6.27 and Table C6.12 of the Commentary to the CHBDC indicates the relative movement required to fully mobilize the active earth pressure. Where ground surfaces are sloped at 2H:1V behind the walls, the corresponding coefficients provided in Table 10-1 should be used.

If lateral movement is not permissible and/or the wall is restrained, the at rest earth pressure coefficient should be used. If the wall design allows lateral movement, the active earth pressures should be used.

A geotechnical resistance factor of 0.5 (ϕ_{gu}) should be applied in static design to the passive earth pressures in accordance with Table 6.2 of the CHBDC (static analysis typical understanding). The soils within the depth of frost should be ignored from providing passive lateral resistance; however, the equivalent surcharge loading from the weight of the soils above the frost depth should be incorporated into the lower soil layers.

Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14 of the CHBDC, structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following

recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using Mononobe Okabe Method with:

- k_h = ½ * F(PGA) * PGA, for structures that allow 25 to 50 mm of movement, and
- k_h = F(PGA) * PGA, for non-yielding walls

The coefficients of horizontal earth pressure for seismic loading presented in Table 10-2 may be used for vertical walls. The provided earth pressure coefficients are based on a 1 in 2475yr seismic event and a Seismic Site Class E.

Table 10-2 Combined Static and Seismic Earth Pressure Coefficients

MATERIAL	UNIT WEIGHT (kN/m^3)	K_{AE} (YIELDING WALL)	K_{AE} (NON-YIELDING WALL)	GROUND SURFACE BEHIND WALL
OPSS Granular A & Granular B Type II (Φ = 35°)	22.8	0.31	0.34	Horizontal
		0.48	0.63	2H:1V
OPSS Granular B Type I (Φ = 32°)	21.2	0.34	0.38	Horizontal
		0.60	-	2H:1V

10.4 Frost Depth

The frost penetration depth at this site is 1.7 m as per OPSD 3090.101. It is not necessary to found a pipe or a closed box culvert below the depth of frost penetration.

Please refer to the pavement design report for frost taper recommendations for the pavement, if any.

10.5 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel used in buried infrastructure. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 μg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The sulphate content in the soils is 14 μg/g, see Section 5.7. The selection for class of concrete should include consideration of the effects of road de-icing salts.

The pH, resistivity, and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Section 5.7 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

10.6 Embankment Design and Reinstatement

10.6.1 Embankment Reinstatement

The existing highway embankment side slopes are generally sloped at approximately 1.6H:1V. MPCE has confirmed that the existing slopes did not show any visible signs of global instability at the time of the investigation; however, the embankment slopes above the culvert and the ditch alignment were both covered with rock protection.

It is understood that a temporary grade lowering is proposed along the Highway 118 alignment.

Embankment reinstatement after construction of the replacement culvert should be carried out in accordance with OPSS.PROV 206 with materials similar to the existing. If constructed using rock fill, the embankment could be reconstructed with side slopes of 1.5H:1V (or flatter). If constructed using Select Subgrade Material (SSM) or Granular B Type I, the embankment should be constructed with side slopes of 2H:1V (or flatter). The granular fill should be placed and compacted in accordance with OPSS.PROV 501.

Where newly placed embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, benching of the existing slope should be carried out in accordance with OPSD 208.010.

It is understood there is no grade raise proposed to the current embankment envelope. The settlement beneath the embankment is expected to be negligible.

The magnitude of the embankment self-compression constructed with granular fill is in the order of 0.5% of the newly reconstructed embankment height and is expected to occur predominately during fill placement.

If the existing culvert is to be abandoned and fully grouted or removed and backfilled, it is estimated that this would induce negligible settlement beneath the existing culvert alignment as the increased load imposed by the grout/fill is offset by the reduction in load due to grade lowering.

10.6.2 Temporary Grade Lowering

It is understood that a grade lowering of up to about 2.6 m would be required to create a working surface wide enough to maintain one lane of traffic within the existing embankment footprint without temporary protection systems. Sub-excavation of the embankment fill may be required to prepare a temporary pavement structure. Side slopes within the existing embankment fill should remain stable if the slopes are maintained at 1H:1V (or flatter). The temporary excavation slopes are the responsibility of the Contractor and should be constructed following the recommendations described in Section 11.1. Following culvert installation, the excavation should be reinstated as described in Section 10.2 and 10.6.1.

10.6.3 Temporary Widening or Detour Embankment

It is assumed that maintaining two lanes of traffic throughout construction will require the use of the shoulders which will require regrading. Minor temporary highway widenings could include placement of rock fill as steep as 1.25H:1V on the existing side slopes (after stripping where required). Design of a more substantial highway widening, where the existing toe of the embankment slope is pushed outward, would require further foundation investigation than was completed as part of the current assignment. A temporary culvert extension may also be required in the area of the embankment widening as well as a review of any drainage impacts. Additional field investigation may be required.

11. CONSTRUCTION CONSIDERATIONS

11.1 Excavation

All excavation must be conducted in accordance with the requirements of the Occupational Health & Safety Act & Regulations (OHSA) for Construction Projects. The existing embankment fill may be classified as Type 3 soil. The underlying silt, sandy silt, silty sand, and sand may be classified as Type 3 soils. Organics may be classified as Type 4 soils. *Where an excavation is within more than one soil type, the entire excavation must be completed in accordance with the more stringent requirement as per the requirements of the regulation*.

Excavation should occur in a dewatered environment (see Section 11.3). Excavations must be planned and carried out in a manner that does not impact on the stability of the existing roadway. The temporary cut slopes may have to be protected from precipitation and runoff to avoid surficial instabilities. The duration of temporary open excavations and cut slopes should be minimized to reduce the likelihood of causing instability concerns. Temporary embankment and cut slope stability is the responsibility of the Contractor.

Excavation for culvert replacement must be carried out in accordance with OPSS.PROV 401, OPSS.PROV 421 and OPSS.PROV 422 and will be carried out through existing embankment fill and into the underlying native soils. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor.

Material stockpiling is a temporary construction measure and the associated stability implications are the responsibility of the Contractor. The selection and placement of construction equipment (such as cranes) and construction of temporary construction access roads are also the Contractor's responsibility. Placement of the crane or temporary stockpiling must not destabilize the embankment slopes (existing, temporary, or new).

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 11.2.

11.2 Temporary Protection Systems

Temporary Protection Systems may be required during various stages of construction and must be implemented in accordance with OPSS.PROV 539 as amended by SP 105S09. Performance Level 2 (maximum 25 mm horizontal deflection) is considered appropriate where the protection supports the existing highway. More stringent performance levels may be required if the protection system is intended to support existing structures or utilities. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors must be considered when designing the shoring system.

The measured groundwater level observed during the investigation was approximately elevation 293.3 m. The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected highwater level defined in SP 517F01 and SP FOUN0003.

It will be difficult to drive sheet piles through the embankment at this site due to the presence of cobbles and boulders. A suggested contract provision concerning obstructions is provided in Appendix H. For conceptual design purposes, drilled-in soldier piles with lagging are recommended for TPS at this site. However, the selection and design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations. An anchoring and/or internal bracing system may need to be incorporated into the temporary protection design to resist lateral earth pressure loadings.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through new granular fill material consisting of Granular A or Granular B Type II are provided in Table 10-1 for static conditions. The lateral earth pressure coefficients for the existing fill and native soils are given below for a vertical wall and a horizontal backslope. Unit weights provided herein are to be adjusted for applications below the groundwater level. Unbalanced hydrostatic pressures should be considered in the design of the protection systems.

Table 11-1 Static Earth Pressure Coefficients for Existing Soils

MATERIAL	UNIT(*) WEIGHT (kN/m^3)	K_A (-)	K_p (-)	S_u (kPa)	GROUND SURFACE *BEHIND* WALL
Existing Granular Fill	20	0.32	3.1	-	Horizontal
Native Organic Soils	18	0.36	2.8	-	Horizontal
Native Silt to Sandy Silt	19	0.36	2.8	-	Horizontal
Native Sand to Silty Sand	20	0.33	3.0	-	Horizontal

Note: (*) to be adjusted when below water level

It is recommended that the protection systems in the vicinity of the culvert (within 3 m from the edge of the culvert) should be left in place and cut off in accordance with OPSS.PROV 539.

11.3 Surface and Groundwater Control

The measured groundwater level observed during the investigation was approximately elevation 293.3 m. The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected highwater level defined in SP 517F01 and SP FOUN0003. The proposed culvert invert at the outlet is elevation 292.3 m. Should a concrete box culvert be utilized, it is anticipated that the underside of the excavation will be at approximately 291.6 m to allow for the concrete base slab and levelling and bedding layers.

Excavations that extend below the groundwater level without prior dewatering are not recommended since the inflow of groundwater will make it difficult to maintain a dry, sound base on which to work. Disturbance of the subgrade soils is considered to be a risk without groundwater lowering. The presence of cohesionless subgrade soils and ponded water could result in increased seepage.

Typically, subgrade preparation, placement and compaction of granular bedding, and culvert construction, must be carried out in the dry. Based on the groundwater elevation at the time of the investigation, the site will require dewatering to lower the groundwater. Furthermore, surface runoff will tend to seep into and accumulate into the excavations. The Contractor must control groundwater, perched groundwater, and surface water flow at the site to permit construction in a dry and stable excavation. Typically, the groundwater level within the work zone should be lowered to a minimum of 0.5 m below the underside of the planned excavation base prior to each stage of excavation.

A properly designed dewatering system to control groundwater and ditch/surface water is required and may include cofferdams, ditch diversion, pumping etc. It is understood that the existing culvert will be used for flow diversion until the new culvert is completed. However, pumping may be required to enhance flow depending on the elevation of the surface water at the time of construction. The design of flow passage systems is the responsibility of the Contractor. Given the site conditions and anticipated works, the Designer Fill-In ***** in SP 517F01 Table A for flow passage systems should be “No; the design Engineer and design-checking Engineer do not need a minimum of 5 years of experience in designing similar flow passage systems.

The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then should be decommissioned and removed. The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS.PROV 902 and SP 517F01 which amends OPSS.PROV 517. Given the site conditions and anticipated works, the Designer Fill-In ***** in SP 517F01 Table A for dewatering systems should be “Yes”; the design Engineer and design-checking Engineer do need a minimum of 5 years of experience in designing similar dewatering systems. The possibility of basal heave due to unbalanced hydrostatic pressures must be considered in the dewatering design due to the presence of a fine grained silt deposit over a sand deposit. The dewatering plan must also be designed to support the temporary excavation slope assumptions. A preconstruction survey is not recommended, thus Designer Fill-In ** in this SP should be “N/A”.

For conceptual design purposes, watertight sheet piles are recommended for cofferdams. The lateral earth pressure coefficients and relevant design recommendations provided in Section 11.2 for Temporary Protection Systems are also applicable to Cofferdams. It is anticipated that sump pumps will likely be sufficient to extract water from an excavation carried out with watertight sheet pile coffer dams installed near the proposed inlet and outlet. Pumping should continue until control of inflow is achieved and the Granular bedding and culvert can be placed and backfilled in a dry, stable environment. More than one pump may be required.

Once flow has been directed to the new culvert, the existing culvert should be isolated by coffer dams at either end and dewatered prior to decommissioning it with grout.

Further assessment of dewatering requirements and the need for registration on the Environmental Activity and Sector Registry (EASR) or a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

11.4 Scour and Erosion Protection

The Contractor should provide silt fences and erosion control blankets as per OPSS.PROV 805 and OPSD 219.110 throughout the duration of construction to prevent transport of silt/sediment.

Particle size analysis on samples of the existing fill materials indicate that the soils have a low potential for soil erodibility (Wischmeier Nomograph factor, K). The native soils have a medium to high potential for soil erodibility.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes. A vegetation cover should be established on exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 803 and OPSS.PROV 804. Slope vegetation should be established as soon as possible after completion of construction in order to limit surficial erosion and water should be prevented from running down an unprotected slope.

Scour and erosion protection must be provided for the culvert inlet and outlet areas. Effective scour and erosion protection should be provided along the waterline and ditches. Design of the erosion protection measures must consider hydrologic and hydraulic factors and shall be carried out by specialists experienced in this field. Typically, rock protection should be provided over all earth surfaces subjected to flowing water in accordance with OPSS.PROV 511. Treatment at the outlet should be in accordance with OPSD 810.010.

Given the limited slope of the proposed culvert invert, a clay seal is not warranted for this site.

12. CONSTRUCTION CONCERNS

- Buried obstructions (i.e., cobbles and boulders) may be encountered during construction and interfere with excavations and installation of temporary protection/coffer dam systems. The Contractor must be prepared to dislodge or penetrate obstructions. Where obstructions are encountered near the surface, the Contractor may choose to remove such obstructions, provided it does not destabilize the existing embankment or temporary works.

- The thickness and presence of organic deposits were investigated at the borehole locations only. Organic deposits may extend to greater depths or be encountered at other locations between and beyond boreholes.
- Trafficability of construction equipment may be difficult in areas of organic deposits or excessively soft, loose/unstable and/or saturated subgrade. Disturbance of the subgrade by construction traffic must be minimized and the Contractor may have to adjust his operations in soft subgrade areas.
- It will be necessary to divert the flow around the excavation to place the bedding and construct the culvert in the dry. Excavations and placement of bedding material must be completed in the dry.

The successful performance of the project will depend largely upon good workmanship and quality control during construction. Subgrade examination and field density testing should be carried out by qualified personnel during construction to confirm that foundation recommendations are correctly implemented, and material specifications are met.

13. CLOSURE

As noted above, McIntosh Perry Consulting Engineers (MPCE) carried out the field and laboratory investigations under Agreement No. 5017-E-0003. Thurber Engineering Ltd. (Thurber) prepared the foundation investigation and design report on behalf of MPCE. The discussion and recommendations presented in this report are based on information provided by MPCE and the factual data obtained during the field investigation. It must be noted that MPCE is solely responsible for the accuracy of the subsurface information in their borehole logs and the field information provided to aid in the preparation of this report.

Engineering analysis and preparation of this report were carried out by A. de Oliveira and K. Walker, P.Eng. The report was reviewed by S. Peters, P.Eng. and F. Griffiths, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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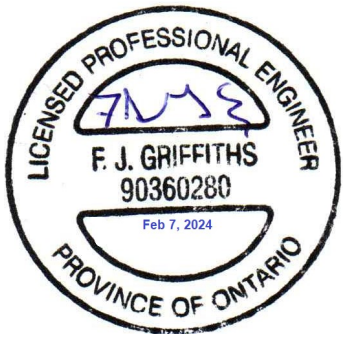

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LIMITATIONS OF REPORT

McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) carried out the geotechnical field investigation. This document is an integral part of the Foundation Investigation and Design report presented.

The conclusions and recommendations provided in this report are based on the information obtained at the borehole locations where the tests were conducted. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the specific locations where tests were conducted and conditions may become apparent during construction, which were not detected and could not be anticipated at the time of the site investigation. The benchmark level used and borehole elevations presented in this report are primarily to establish relative differenced in elevations between the borehole locations and should not be used for other purposes such as to establish elevations for grading, depth of excavations or for planning construction.

The recommendations presented in this report for design are applicable only to the intended structure and the project described in the scope of the work, and if constructed in accordance with the details outlined in the report. Unless otherwise noted, the information contained in this report does not reflect on any environmental aspects of either the site or the subsurface conditions.

The comments or recommendation provided in this report on potential construction problems and possible construction methods are intended only to guide the designer. The number of boreholes advanced at this site may not be sufficient or adequate to reveal all the subsurface information or factors that may affect the method and cost of construction. The contractors who are undertaking the construction shall make their own interpretation of the factual data presented in this report and make their conclusions, as to how the subsurface conditions of the site may affect their construction work.

The boundaries between soil strata presented in the report are based on information obtained at the borehole locations. The boundaries of the soil strata between borehole locations are assumed from geological evidences. If differing site conditions are encountered, or if the Client becomes aware of any additional information that differs from or is relevant to the McIntosh Perry findings, the Client agrees to immediately advise McIntosh Perry so that the conclusions presented in this report may be re-evaluated.

Under no circumstances shall the liability of McIntosh Perry for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify McIntosh Perry. Such errors and omissions policies are available for inspection by the Client at all times upon request, and if the Client desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, McIntosh Perry will co-operate with the Client to obtain such insurance.

McIntosh Perry prepared this report for the exclusive use of the Client. Any use which a third party makes of this report, or any reliance on or decision to be made based on it, are the responsibility of such third parties. McIntosh Perry accepts no responsibility and will not be liable for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

THURBER

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.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

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.

THURBER ENGINEERING LTD.

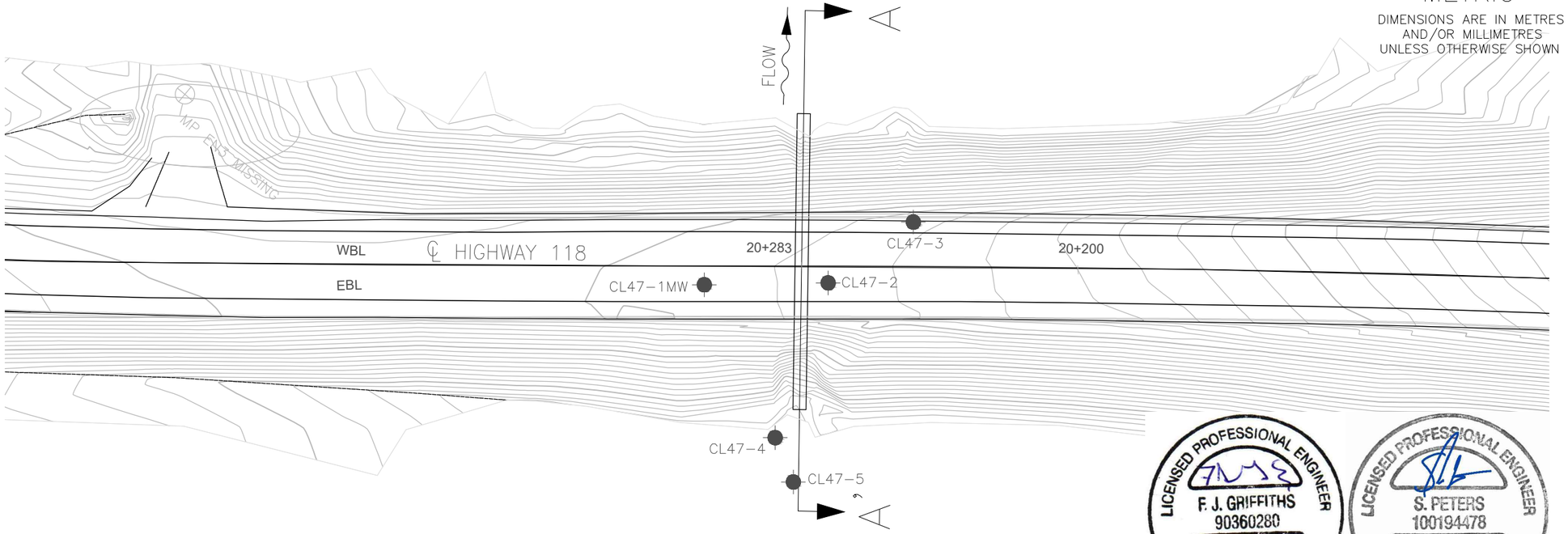
APPENDIX A

Borehole Locations and Strata Drawing

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



PLAN

10 0 10 20m

SCALE 1:500

SECTION A-A'

5 0 5 10m H 1:250

5 0 5 10m V 1:250

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
90360280
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. PETERS
100194478
Feb 7/24
PROVINCE OF ONTARIO

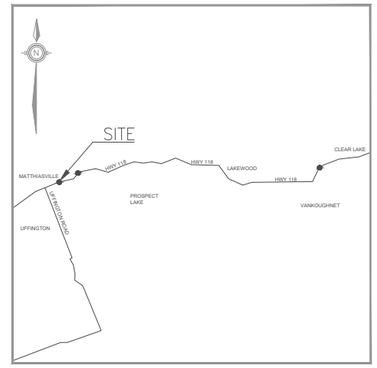
CONT No 2022-5007
GWP No 5011-19-00

SHEET

HIGHWAY 118
CULVERT at 20+183
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Current Borehole by MPCE
⊕	Previous Borehole by Others (Approx.)
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)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CL47-1MW	298.1	4 984 220.1	330 059.6
CL47-2	298.3	4 984 228.5	330 069.3
CL47-3MW	298.5	4 984 239.0	330 072.0
CL47-4	292.2	4 984 212.7	330 075.4
CL47-5	291.7	4 984 210.4	330 079.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 10.
4) Locations and elevations for boreholes are approximate.

GEOCRES No.

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	AO	CHK	KW	CODE	LOAD
DRAWN	JEM	CHK	KW		STRUCT

DATE NOV 2023
DWG 1

FILENAME: H:\Drafting\20000\20244\TED-20244-BHPP-CL47_49_68.dwg
PLOTDATE: 2/6/2024 9:48 PM

THURBER ENGINEERING LTD.

APPENDIX B

Symbols and Terms

Record of Boreholes Sheets (MPCE)

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ'	$^{-o}$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	$^{-o}$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L - W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_P)/ I_P$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L - W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	$e_{,max}$	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-1 MW 1 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330059.6 N4984220.1 / 44.997518 -79.179627 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-27 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.1	Asphalt									
298.0	**Asphalt 110 mm**						298			
297.8	**Fill :** gravelly sand, trace silt, dark brown, dry									
0.3	**Fill :** sandy gravel, some silt, frequent cobbles, some boulders, brown to dark brown, compact to dense, moist to wet		1	SS	50/ 75mm					24 64 (12)
			1	NQ						- cored through cobbles
			2	SS	50/ 75mm		297			
			2	NQ						- cored through cobbles
			3	SS	9					
							296			
			3	NQ						- cored through cobbles
			4	SS	13					
			4	NQ			295			- cored through cobbles
			5	SS	50/ 100mm					
			5	NQ		▼ El. 293.338 m on July 26, 2023	294			- 380 mm boulder
						▽ El. 292.908 m on Sept 28, 2022	293			
			6	SS	38			○		65 29 5 1
			6	NQ			292			- cored through cobbles
291.2			7	SS	50/ 0mm					
290.9	**Fill :** silt with gravel, dark grey, compact, wet									
7.0	**Sandy Silt**, trace clay, grey, compact, wet		8	SS	27		291			
			9	SS	31			○		0 25 65 10
289.7							290			
8.4	**Silt**, trace sand, grey, compact to dense, wet		10	SS	26			○		Non-Plastic 0 2 79 19
			1	ST			289			- Shelby tube sample taken
			11	SS	30					

Continued Next Page

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-1 MW 2 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330059.6 N4984220.1 / 44.997518 -79.179627 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-27 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silt, trace sand, grey, compact to dense, wet *(continued)*		12	SS	35		288		○	Non-Plastic
			13	SS	30		287			
			14	SS	22		286			
			15	SS	31					
285.1										
13.0	**Sand**, trace silt, grey, compact, wet		16	SS	32		285			
			17	SS	15		284			
			18	SS	25		283			
282.8										
15.2	**Sand**, trace silt, poorly graded, grey, compact, wet		19	SS	14					1 96 (3)
282.2										
15.9	**End of borehole**									

Monitor well installed. Well Details (51mm dia):

0.0 - 7.3m = Bentonite seal
7.3 - 7.9m = Filter sand above slotted screen
7.9 - 14.0m = Sloted screen in filter sand
14.0 - 13.9m = Pipe cap
14.0 - 15.9m = Filter sand at bottom of borehole

▮ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontaio

SPL 750-1001

RECORD OF BOREHOLE No CL47-2 1 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330069.3 N4984228.5 / 44.997589 -79.179499 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-28 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.3	Asphalt										
298.2 / 0.1	**Asphalt 125 mm**						298				
298.0 / 0.3	**Fill :** garvelly sand, some fines, dark brown, compact, dry		1	SS	50/ 75mm						23 63 (14)
297.6 / 0.7	**Fill :** gravelly sand, trace silt, brown, compact, dry										
	Fill : sandy gravel, some silt, frequent cobbles, some boulders, brown to dark brown, compact to dense, moist to wet		1	NQ			297				- cored through cobbles
			2	SS	50/ 25mm						
			2	NQ			296				- cored through cobbles and a 420 mm boulder
			3	SS							
			3	NQ			295				- cored through cobbles
			4	SS	61						
			4	NQ			294				- cored through cobbles
			5	SS	12	▽ El. 292.513 m on Sept 29, 2022	293				
			5	NQ							- cored through cobbles
			6	SS	25		292		○		20 64 15 1
			7	SS	11						
290.8 / 7.5	**Silt**, trace sand, some organics, dark brown, compact, wet	×					291				
290.5 / 7.8	**Sandy Silt**, grey, compact, wet		8	SS	32				○		0 17 77 6
289.9 / 8.4	**Silt**, some sand, grey, compact to dense, wet		9	SS	32		290		○		Non-Plastic
			10	SS	35		289				

Continued Next Page

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-2 2 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330069.3 N4984228.5 / 44.997589 -79.179499 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-28 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silt, some sand, grey, compact to dense, wet *(continued)*		11	SS	26		288			
			12	SS	25		287			
			13	SS	23			○		Non-Plastic 0 0 83 17
			14	SS	29		286			
			15	SS	30		285			
284.6										
13.7	**Silty Sand**, grey, compact to loose, wet		16	SS	12		284			Non-Plastic 0 75 (25)
			17	SS	19					
			18	SS	12		283			
			19	SS	30		282			
			20	SS	6					
280.9							281			
17.4	**End of borehole**									

▮ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-3 MW 1 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330072.0 N4984239.0 / 44.997690 -79.179463 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-29 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.5	Asphalt										
298.3 / 0.2	**Asphalt 125 mm**										
298.2 / 0.3	**Fill :** gravelly sand, some silt/clay, dark brown, dense, dry		1	SS	43		298				23 61 (16)
298.0 / 0.5	**Fill :** gravelly sand, trace silt, brown, dense, moist										
297.7 / 0.7	**Fill :** silt, some sand and gravel, brown, dense, moist **Void in fill**										
296.9 / 1.6	**Fill :** cobbles and boulders		1	NQ			297				- cored through cobbles
			2	SS	19						
295.8 / 2.7	**Void in fill**						296				
294.9 / 3.6	**Fill :** sandy gravel, brown, compact, moist		3	SS	14						
294.3 / 4.1	**Fill :** cobbles		2	NQ			295				- cored through cobbles
294.0 / 4.4	**Fill :** sandy gravel, trace silt, brown, dense, moist		4	SS	48				○		53 37 9 1
293.4 / 5.0	**Fill :** cobbles		3	NQ		▼ El. 293.337 m on July 26, 2023	294				- cored through cobbles
293.3 / 5.2	**Fill :** gravelly sand, some silt, brown, compact, moist		5	SS	10	▽ El. 299.077 m on Sept 30, 2022	293				
292.5 / 5.9	**Sandy Silt**, brown to dark brown to black silt with organics, loose, wet		6	SS	4						
			7	SS	6		292			64 Φ	1 35 61 3
290.8 / 7.6	**Silt**, some sand, grey, compact, wet		8	SS	34		291		○		0 11 78 11
290.2 / 8.2	**Silt**, some sand, grey, compact to dense, wet		9	SS	59		290				
			10	SS	36		289				

Continued Next Page

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-3 MW 2 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330072.0 N4984239.0 / 44.997690 -79.179463 ORIGINATED BY JH-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Wash boring - CME 75 Truck Mounted Drill COMPILED BY JF-MPCE

DATUM Geodetic(Trimble R2) DATE 2022-09-29 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silt, some sand, grey, compact to dense, wet *(continued)*		11	SS	32		288				0 1 86 13
			12	SS	23						
			13	SS	15		287		○		Non-Plastic
			14	SS	32		286				
			15	SS	37		285				
284.7											
13.7	**Silty Sand**, brown to grey, compact, wet		16	SS	24						0 72 (28)
			17	SS	25		284				
			1	SS	15		283				
282.6											
15.9	**End of borehole**										
	Monitor well installed. Well Details (51mm dia): 0-7.01m = Bentonite seal 7.01-7.62m = Filter sand above slotted screen 7.62-13.72m = Sloted screen in filter sand 13.72-13.82m = Pipe cap 13.72-15.85m = Filter sand at bottom of borehole										

▮ ^{3}, × ^{3}: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-4 1 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330075.4 N4984212.7 / 44.997454 -79.179424 ORIGINATED BY JP-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT(Full weight) COMPILED BY JP-MPCE

DATUM Geodetic(Trimble R2) DATE 2023-07-18 - 2023-07-25 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
293.6	Water									
0.0	**Water: 1.4 m**						293			
292.2										
1.4	**Organic Sediments** with trace gravel						292			
291.2										
2.4	**Sandy Silt/Silty Sand**, trace clay, brown, compact, wet		1	SS	11		291			
			2	SS	11					
			3	SS	16		290			
289.3										
4.3	**Sand**, brown, compact, wet		4	SS	21		289			
288.7										
4.9	**Silt**, some clay and sand, grey, compact, moist to wet		5	SS	31					
288.1							288			
5.5	**Silt**, trace sand, grey, compact to dense, moist		6	SS	28					0 1 84 15
							287			
			7	SS	33		286			0 3 82 15
284.5							285			
9.1	**Silt**, some sand, grey, very loose, wet		8	SS	2		284			

Continued Next Page

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-4 2 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330075.4 N4984212.7 / 44.997454 -79.179424 ORIGINATED BY JP-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT(Full weight) COMPILED BY JP-MPCE

DATUM Geodetic(Trimble R2) DATE 2023-07-18 - 2023-07-25 CHECKED BY MA-MPCE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Silt, some sand, grey, very loose, wet *(continued)*										
282.9 / 10.7	**Sandy Silt**, grey, loose , wet		9	SS	9		283		○		
282.3 / 11.3	End of Borehole										

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontaio

SPL 750-1001

RECORD OF BOREHOLE No CL47-5 1 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330079.8 N4984210.4 / 44.997427 -79.179373 ORIGINATED BY JP-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT(Full weight) COMPILED BY JP-MPCE

DATUM Geodetic(Trimble R2) DATE 2023-07-25 - 2023-07-26 CHECKED BY MA-MPCE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
293.5	Water										
0.0	**Water: 1.8 m**						293				
291.7							292				
1.8	**Organic Sediments**, brown, very loose, wet		1	SS	WOH				62		
291.1							291				
2.4	**Organic**, silt sediments, grey, loose to stiff, wet		2	SS	4				49		
290.5											
3.1	**Silt**, trace sand, grey, loose, wet		3	SS	8		290				0 8 86 6
			4	SS	17						
			5	SS	39		289				1 6 81 12
			6	SS	18						
				VANE			288	4			
				VANE				2			
							287				
							286				Non-Plastic
			7	SS	18						0 1 84 15
							285				
284.4											
9.1	**Silt**, trace sand, grey, compact, moist to wet		8	SS	15		284				0 0 85 15

Continued Next Page

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

Ministry of Transportation Ontario

SPL 750-1001

RECORD OF BOREHOLE No CL47-5 2 OF 2 METRIC

W.P. 5011-19-00 / MP: OKM-17-7060-11 LOCATION E330079.8 N4984210.4 / 44.997427 -79.179373 ORIGINATED BY JP-MPCE

DIST NER HWY Hwy 118 BOREHOLE TYPE Portable SPT(Full weight) COMPILED BY JP-MPCE

DATUM Geodetic(Trimble R2) DATE 2023-07-25 - 2023-07-26 CHECKED BY MA-MPCE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL ▮ FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Silt, trace sand, grey, compact, moist to wet *(continued)*						283				
282.3			9	SS	19				○		
11.3	End of borehole										

▮ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MP MTO GINT HWY118_CL47 AND 49 BRACEBRIDGE.GPJ MP_OTTAWA_FOUNDATIONS.GDT 23-12-14

THURBER ENGINEERING LTD.

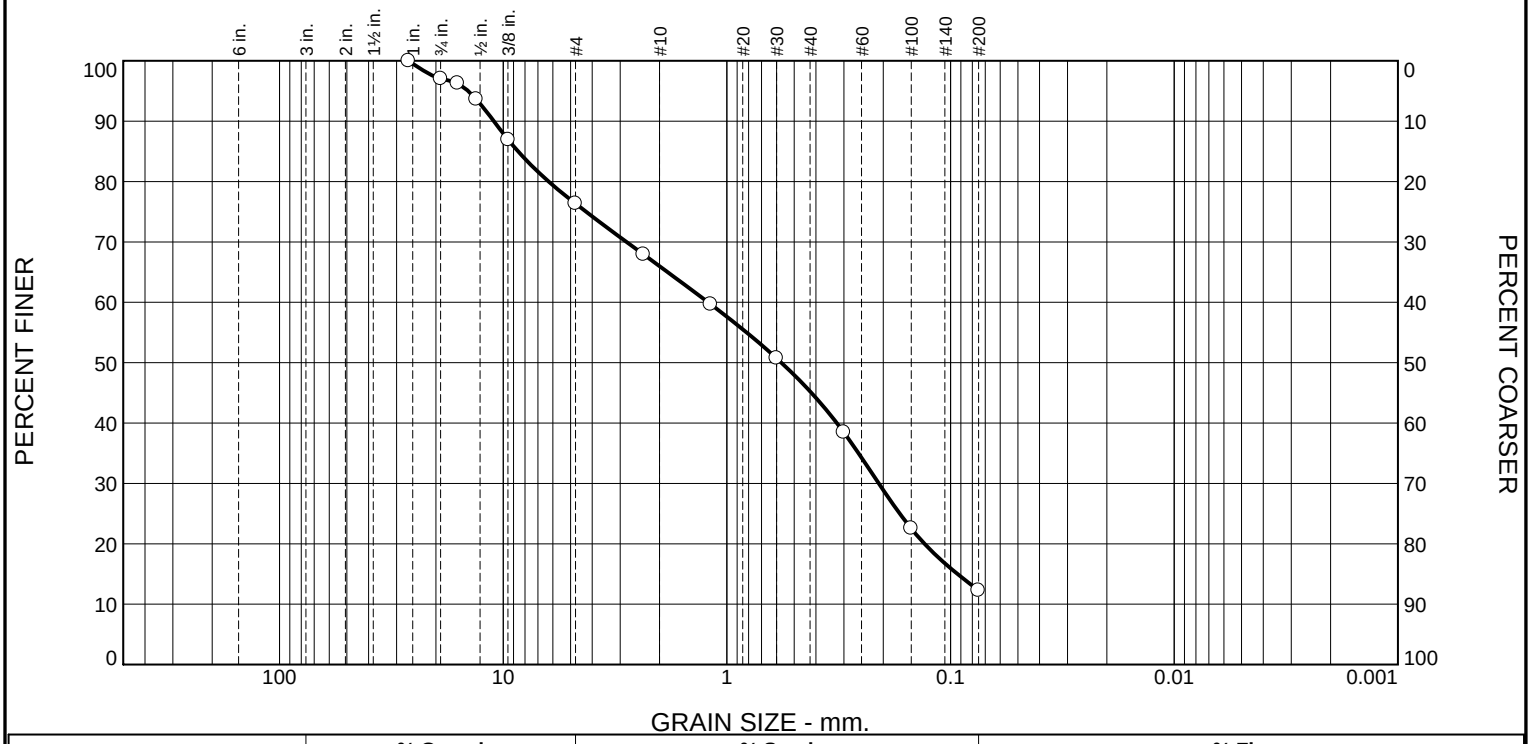
APPENDIX C

Particle Size Analysis Figures

Atterberg Limits Figures

Analytical Testing Results

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.9	20.7	10.4	20.7	33.0	12.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
26.5mm	100.0		
19.0mm	97.0		
16.0mm	96.3		
13.2mm	93.6		
9.5mm	86.9		
4.75mm	76.4		
2.36mm	67.9		
1.18mm	59.7		
0.600mm	50.7		
0.300mm	38.5		
0.150mm	22.5		
0.075mm	12.3		

* (no specification provided)

Material Description

Sand with Gravel some Silt/Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 11.0145 D_{85}= 8.5811 D_{60}= 1.2132
D_{50}= 0.5708 D_{30}= 0.2094 D_{15}= 0.0932
D_{10}= C_u= C_c=

Remarks

F.M.=3.00

Date Received: Nov 3,2022 **Date Tested:** Nov 4,2022

Tested By:

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-1 SS-1
Sample Number: SS-1 **Depth:** 5"-20"

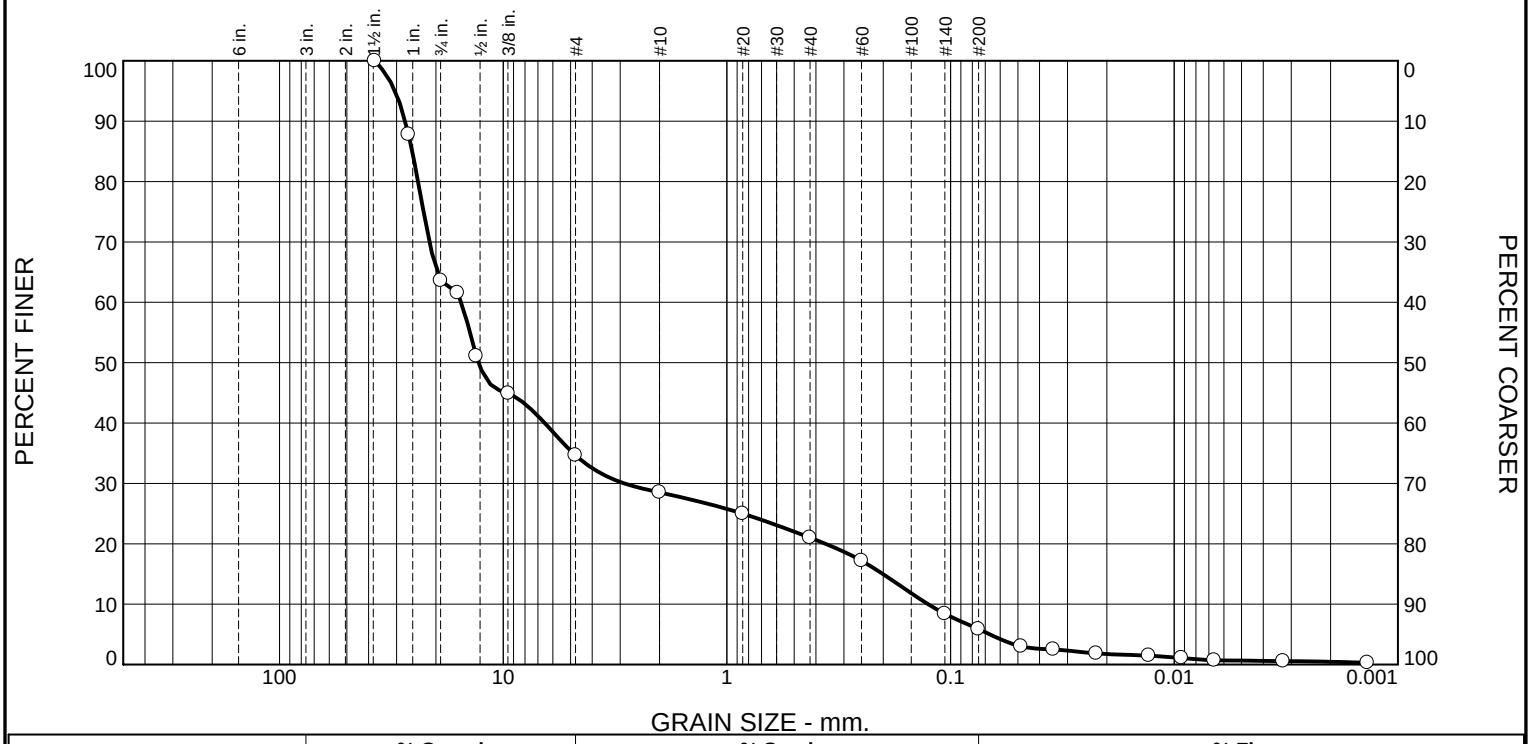
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C1**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	36.3	29.0	6.2	7.5	15.1	5.2	0.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
37.5mm	100.0		
26.5mm	87.8		
19.0mm	63.6		
16.0mm	61.5		
13.2mm	51.1		
9.5mm	44.9		
4.75mm	34.7		
2.00mm	28.5		
0.850mm	25.0		
0.425mm	21.0		
0.250mm	17.2		
0.106mm	8.4		
0.075mm	5.9		
0.0484 mm.	3.0		
0.0347 mm.	2.5		
0.0223 mm.	1.8		
0.0130 mm.	1.5		
0.0093 mm.	1.1		
0.0066 mm.	0.7		
0.0033 mm.	0.6		
0.0014 mm.	0.3		

* (no specification provided)

Material Description

Gravel with Sand trace Silt trace Clay

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 27.4066 D_{85}= 25.5303 D_{60}= 15.3711
D_{50}= 12.9105 D_{30}= 2.8756 D_{15}= 0.2007
D_{10}= 0.1262 C_u= 121.83 C_c= 4.26

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=5.48

Date Received: Nov 3,2022 **Date Tested:** Nov8,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-1 SS-6
Sample Number: SS-6 **Depth:** 17'0"-19'0"

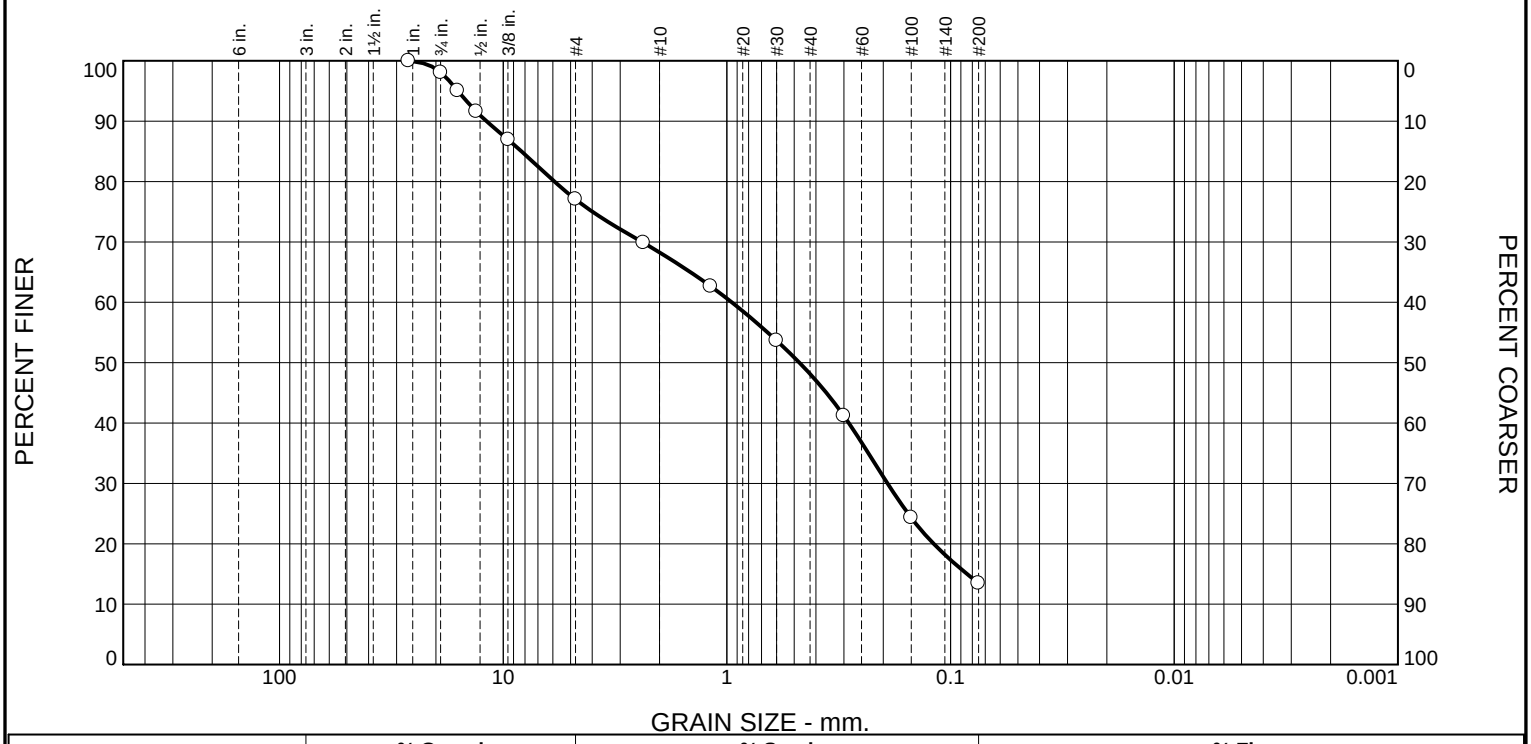
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C2**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.9	21.0	8.8	20.2	34.6	13.5	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
26.5mm	100.0		
19.0mm	98.1		
16.0mm	95.0		
13.2mm	91.6		
9.5mm	86.9		
4.75mm	77.1		
2.36mm	69.9		
1.18mm	62.6		
0.600mm	53.7		
0.300mm	41.2		
0.150mm	24.3		
0.075mm	13.5		

* (no specification provided)

Material Description

Sand with Gravel some Silt/Clay

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 11.8812 D_{85}= 8.2897 D_{60}= 0.9505
D_{50}= 0.4741 D_{30}= 0.1914 D_{15}= 0.0844
D_{10}= C_u= C_c=

Remarks

F.M.=2.86

Date Received: Nov 3,2022 **Date Tested:** Nov 4,2022

Tested By:

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-2 SS-1B
Sample Number: SS-1B **Depth:** 0'6"-2'6"

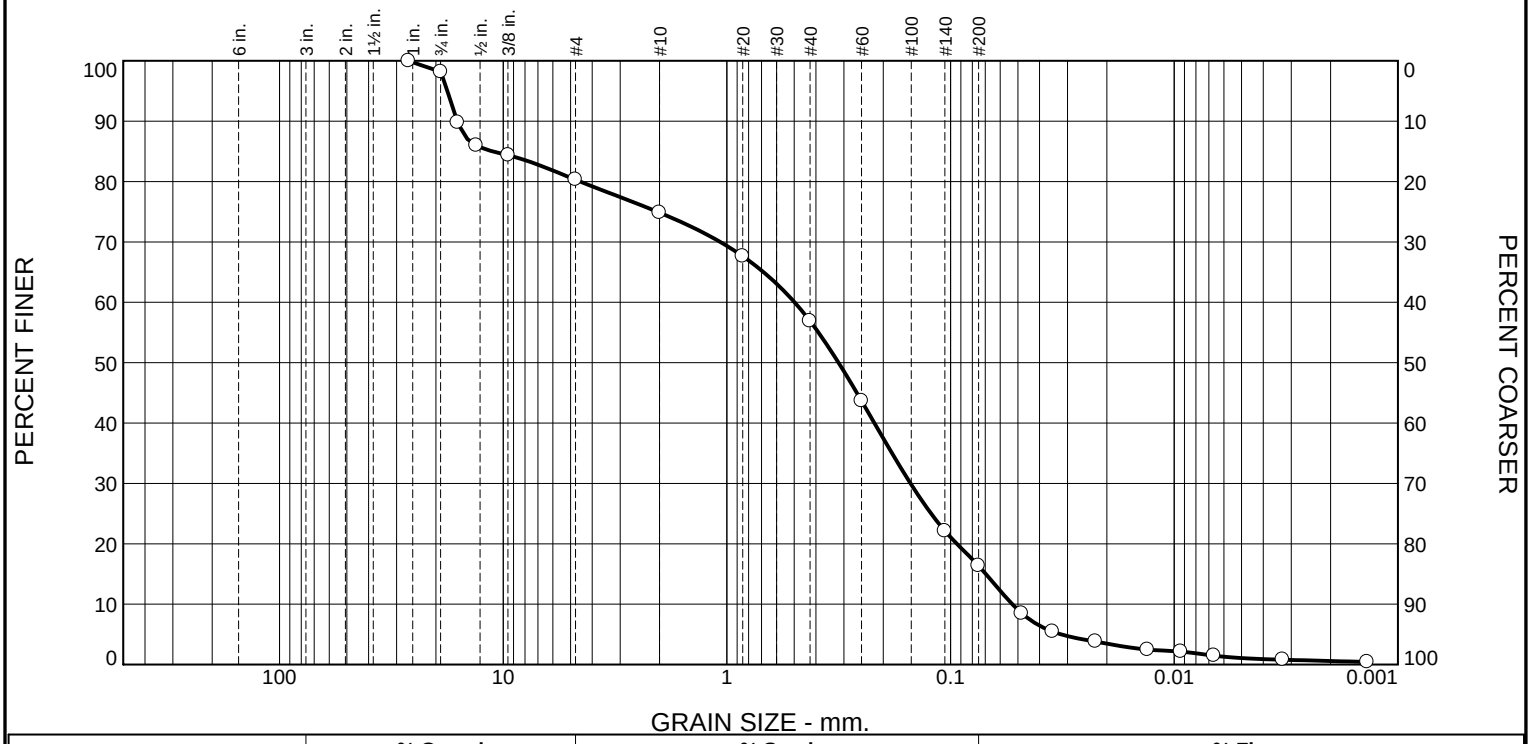
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C3**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	1.8	17.9	5.5	17.9	40.5	15.3	1.1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
26.5mm	100.0		
19.0mm	98.2		
16.0mm	89.8		
13.2mm	86.0		
9.5mm	84.4		
4.75mm	80.3		
2.00mm	74.8		
0.850mm	67.6		
0.425mm	56.9		
0.250mm	43.7		
0.106mm	22.1		
0.075mm	16.4		
0.0481 mm.	8.5		
0.0350 mm.	5.5		
0.0225 mm.	3.8		
0.0132 mm.	2.5		
0.0093 mm.	2.1		
0.0066 mm.	1.5		
0.0033 mm.	0.8		
0.0014 mm.	0.4		

* (no specification provided)

Material Description

Sand some Gravel some Silt trace Clay

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 16.0815 D_{85}= 11.1548 D_{60}= 0.4981
D_{50}= 0.3170 D_{30}= 0.1511 D_{15}= 0.0696
D_{10}= 0.0530 C_u= 9.40 C_c= 0.86

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=2.49

Date Received: Nov 3,2022 **Date Tested:** Nov 8,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-2 SS-6
Sample Number: SS-6 **Depth:** 20'4"-22'4"

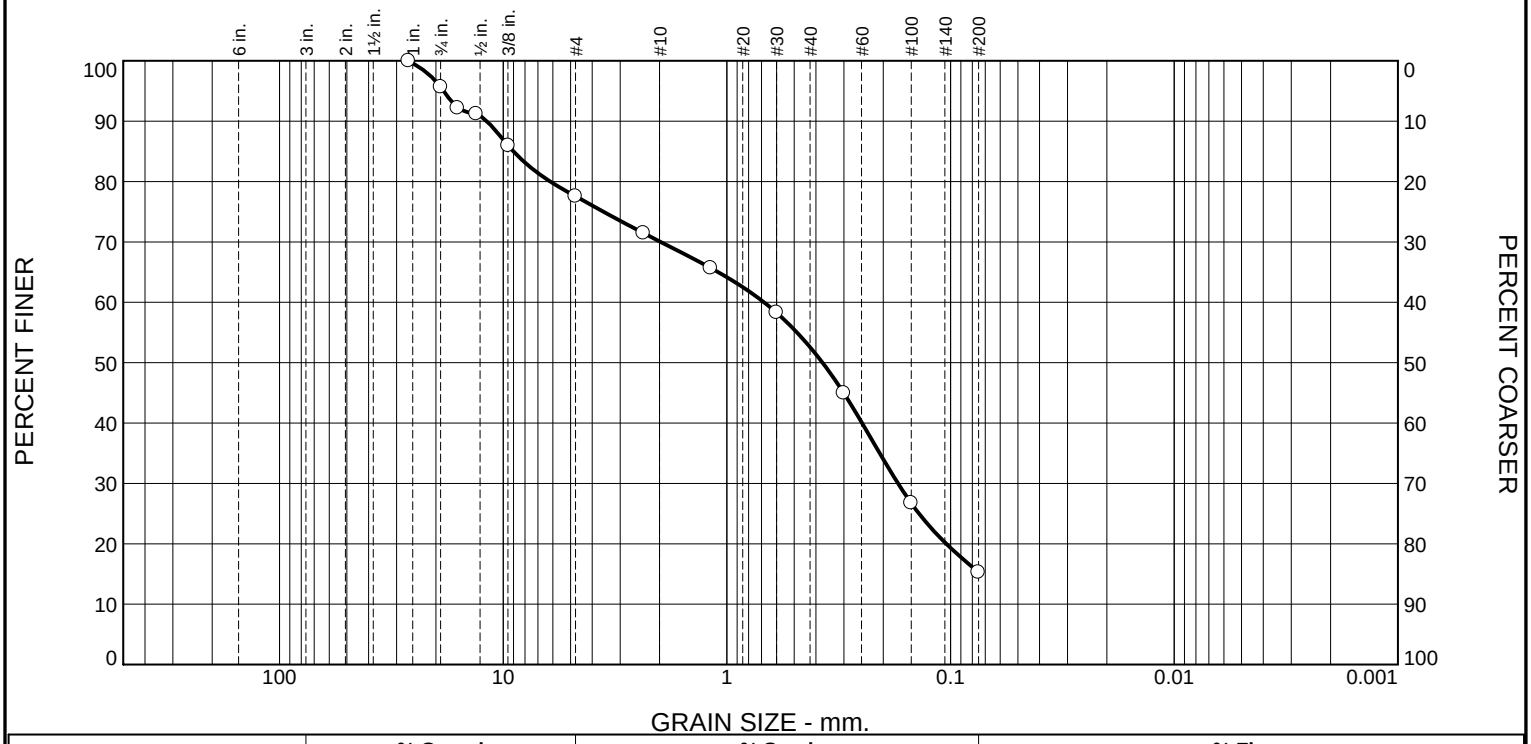
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C4**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	4.3	18.1	7.5	17.5	37.3	15.3	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
26.5mm	100.0		
19.0mm	95.6		
16.0mm	92.2		
13.2mm	91.2		
9.5mm	86.0		
4.75mm	77.6		
2.36mm	71.5		
1.18mm	65.7		
0.600mm	58.3		
0.300mm	44.9		
0.150mm	26.7		
0.075mm	15.3		

* (no specification provided)

Material Description

Sand with Gravel some Silt/Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 11.8383 D_{85}= 9.0014 D_{60}= 0.6823
D_{50}= 0.3737 D_{30}= 0.1719 D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=2.74

Date Received: Nov 3,2022 **Date Tested:** Nov 4,2022

Tested By:

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-3 SS-1
Sample Number: SS-1 **Depth:** 0'5"-2'-6"

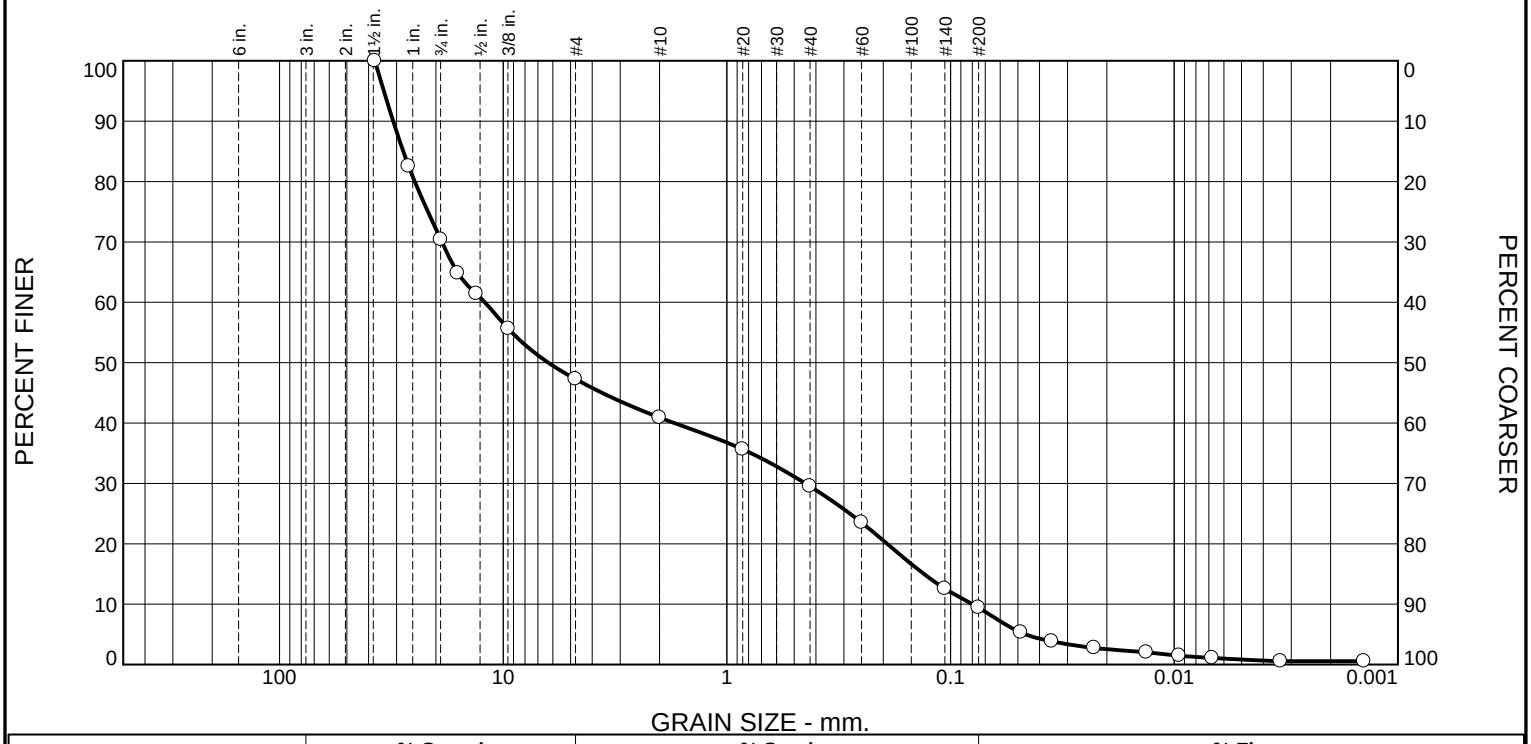
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C5**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	29.5	23.2	6.4	11.4	20.1	8.6	0.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
37.5mm	100.0		
26.5mm	82.6		
19.0mm	70.4		
16.0mm	64.8		
13.2mm	61.4		
9.5mm	55.6		
4.75mm	47.3		
2.00mm	40.9		
0.850mm	35.6		
0.425mm	29.5		
0.250mm	23.5		
0.106mm	12.6		
0.075mm	9.4		
0.0485 mm.	5.3		
0.0353 mm.	3.8		
0.0228 mm.	2.7		
0.0133 mm.	2.0		
0.0095 mm.	1.5		
0.0068 mm.	1.1		
0.0033 mm.	0.5		
0.0014 mm.	0.5		

* (no specification provided)

Material Description

Sandy Gravel trace Silt trace Clay

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 31.0458 D_{85}= 28.0047 D_{60}= 12.0934
D_{50}= 6.2898 D_{30}= 0.4461 D_{15}= 0.1316
D_{10}= 0.0799 C_u= 151.40 C_c= 0.21

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=4.72

Date Received: Nov 3,2022 **Date Tested:** Nov 14,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-3 SS-4
Sample Number: SS-4 **Depth:** 14'6"-16'6"

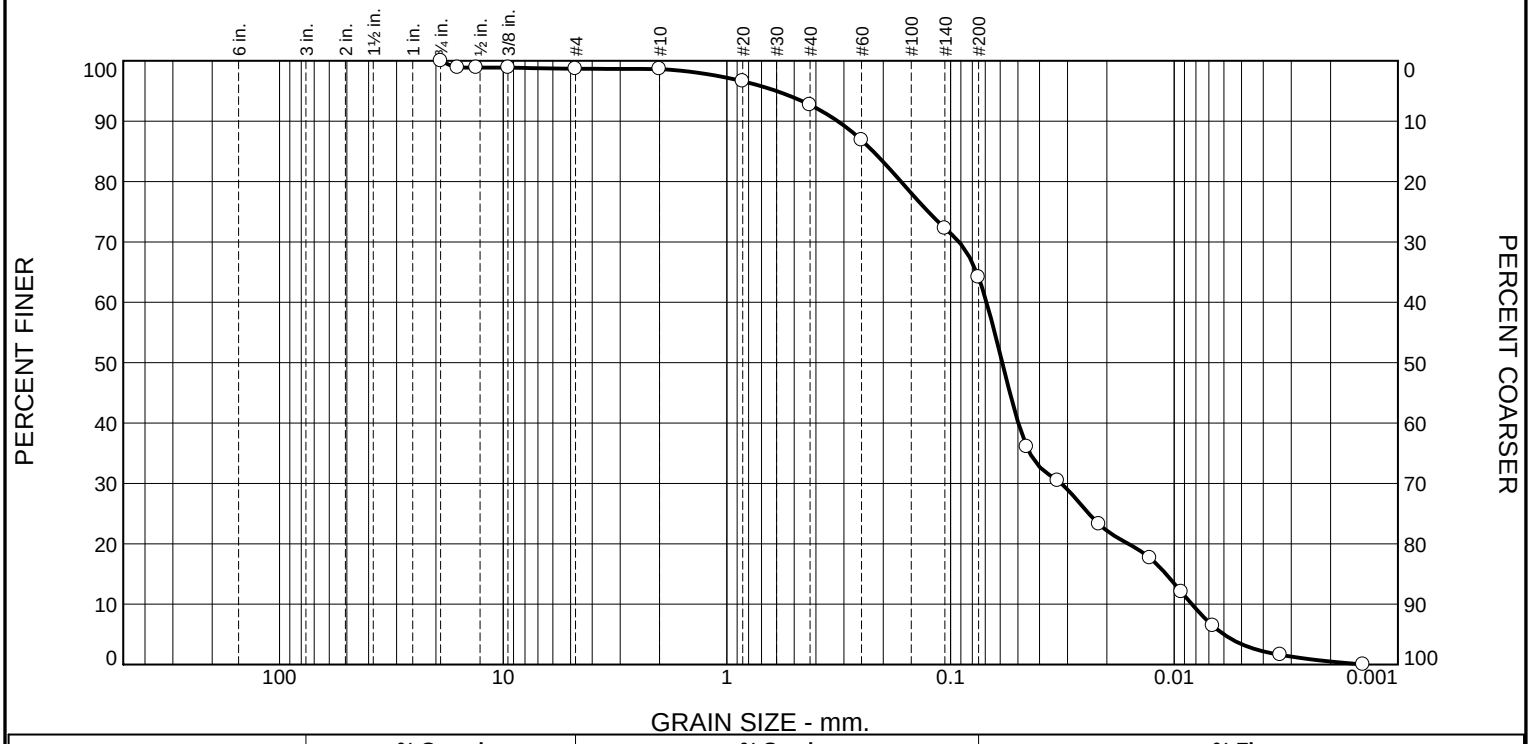
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C6**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.3	0.1	5.9	28.5	60.8	3.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
19.0mm	100.0		
16.0mm	98.9		
13.2mm	98.9		
9.5mm	98.9		
4.75mm	98.7		
2.00mm	98.6		
0.850mm	96.6		
0.425mm	92.7		
0.250mm	86.9		
0.106mm	72.3		
0.075mm	64.2		
0.0456 mm.	36.1		
0.0332 mm.	30.5		
0.0217 mm.	23.3		
0.0128 mm.	17.6		
0.0093 mm.	12.0		
0.0067 mm.	6.4		
0.0034 mm.	1.6		
0.0014 mm.	0.0		

* (no specification provided)

Material Description

Sandy Silt trace Clay trace Gravel

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.3196 D_{85}= 0.2217 D_{60}= 0.0690
D_{50}= 0.0588 D_{30}= 0.0320 D_{15}= 0.0109
D_{10}= 0.0084 C_u= 8.27 C_c= 1.78

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=0.44

Date Received: Nov 3,2022 **Date Tested:** Nov 14,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-3 SS-7
Sample Number: SS-7 **Depth:** 5'0"-7'0"

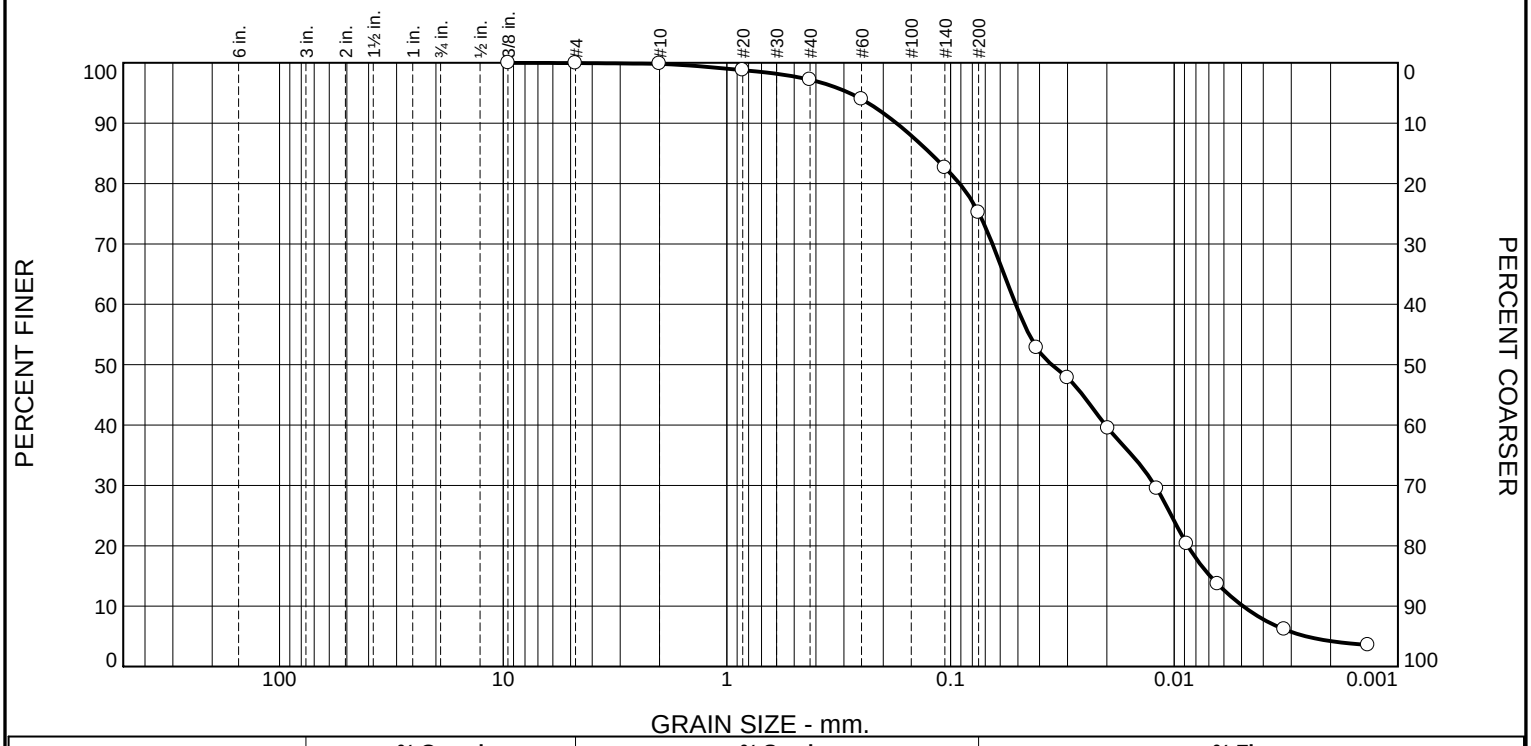
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C7**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	2.6	22.0	65.0	10.2

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	100.0		
2.00mm	99.8		
0.850mm	98.8		
0.425mm	97.2		
0.250mm	94.0		
0.106mm	82.6		
0.075mm	75.2		
0.0412 mm.	52.8		
0.0300 mm.	47.8		
0.0198 mm.	39.5		
0.0120 mm.	29.5		
0.0088 mm.	20.3		
0.0064 mm.	13.7		
0.0032 mm.	6.2		
0.0014 mm.	3.6		

* (no specification provided)

Material Description

Silt with Sand some Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.1743 D_{85}= 0.1230 D_{60}= 0.0511
D_{50}= 0.0353 D_{30}= 0.0122 D_{15}= 0.0069
D_{10}= 0.0049 C_u= 10.37 C_c= 0.59

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=0.19

Date Received: Nov 3,2022 **Date Tested:** Nov 8,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-1 SS-9
Sample Number: SS-9 **Depth:** 25'0"-27'0"

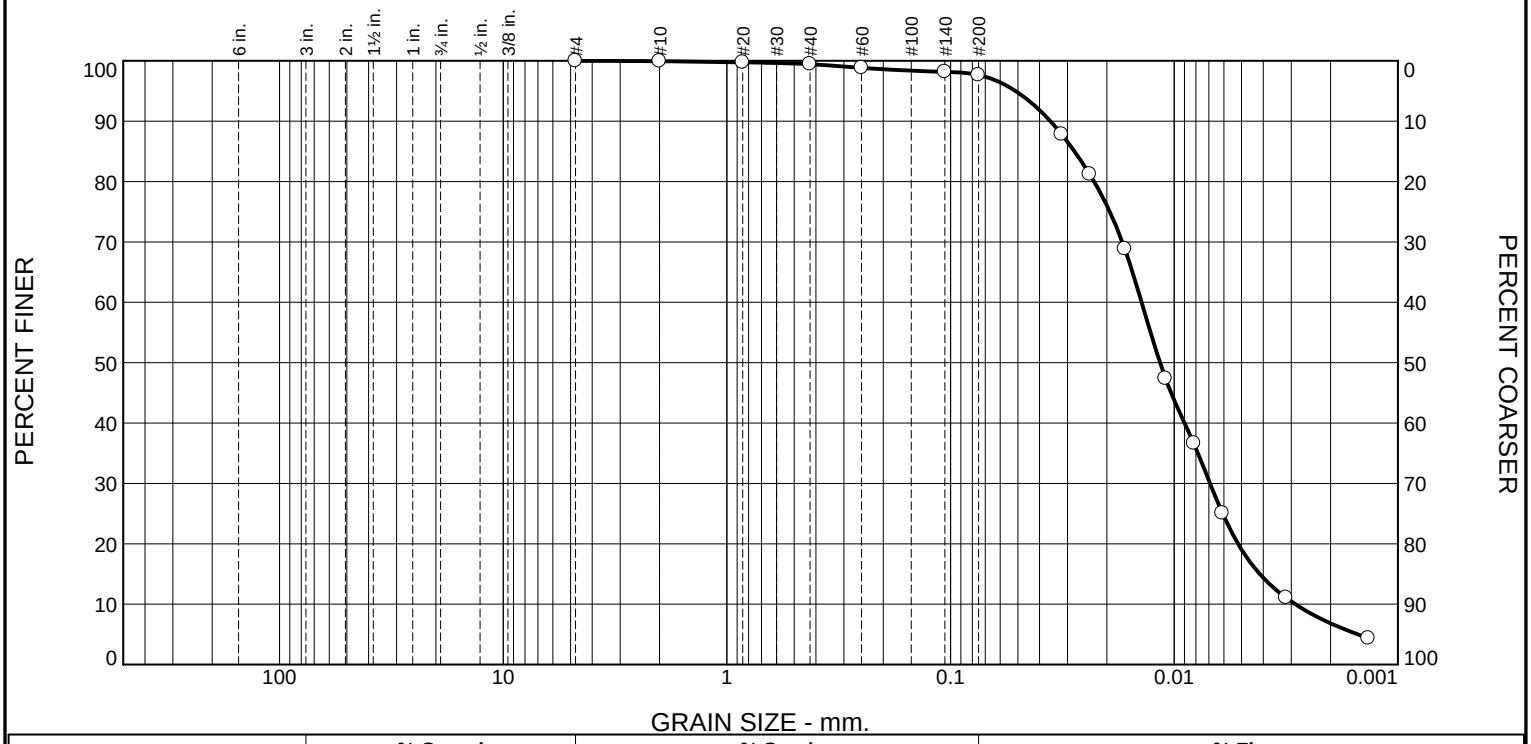
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C8**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.5	1.7	78.7	19.0

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	99.9		
0.850mm	99.7		
0.425mm	99.4		
0.250mm	98.8		
0.106mm	98.2		
0.075mm	97.7		
0.0318 mm.	87.8		
0.0239 mm.	81.2		
0.0166 mm.	68.8		
0.0109 mm.	47.4		
0.0082 mm.	36.6		
0.0061 mm.	25.1		
0.0032 mm.	11.1		
0.0014 mm.	4.3		

* (no specification provided)

Material Description

Silt some Clay trace fine Sand

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0358 D_{85}= 0.0279 D_{60}= 0.0140
D_{50}= 0.0116 D_{30}= 0.0069 D_{15}= 0.0041
D_{10}= 0.0029 C_u= 4.86 C_c= 1.19

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=0.03

Date Received: Nov 3,2022 **Date Tested:** Nov8,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-1 SS-10
Sample Number: SS-10 **Depth:** 27'6"-29'6"

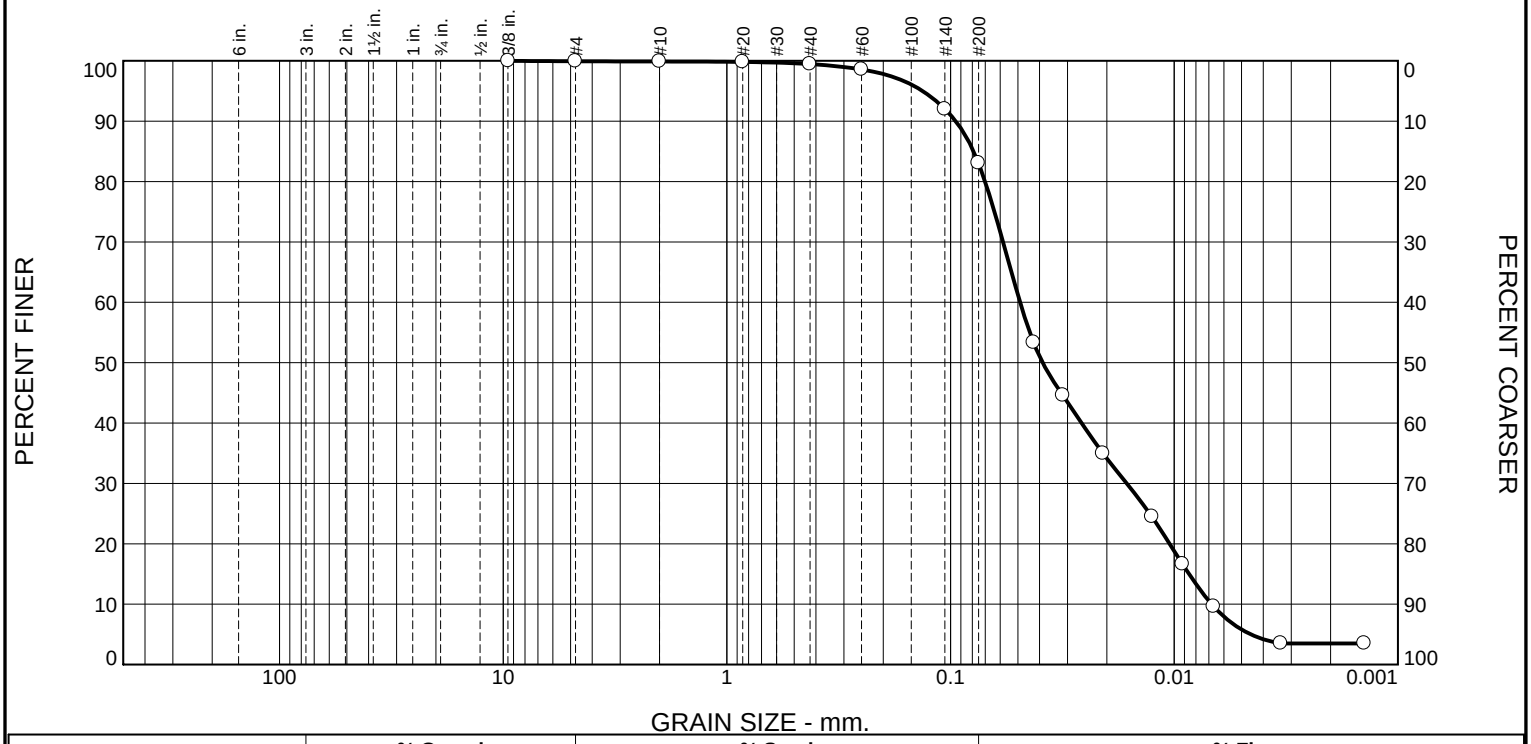
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C9**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.0	0.4	16.4	77.3	5.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	99.9		
2.00mm	99.9		
0.850mm	99.8		
0.425mm	99.5		
0.250mm	98.6		
0.106mm	92.0		
0.075mm	83.1		
0.0426 mm.	53.3		
0.0315 mm.	44.6		
0.0208 mm.	35.0		
0.0126 mm.	24.5		
0.0092 mm.	16.6		
0.0067 mm.	9.6		
0.0033 mm.	3.5		
0.0014 mm.	3.5		

* (no specification provided)

Material Description

Silt some fine Sand trace Clay

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0948 D_{85}= 0.0789 D_{60}= 0.0489
D_{50}= 0.0388 D_{30}= 0.0163 D_{15}= 0.0086
D_{10}= 0.0068 C_u= 7.19 C_c= 0.80

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=0.06

Date Received: Nov 4,2022 **Date Tested:** Nov 16,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-2 SS-8
Sample Number: SS-8 **Depth:** 25'0"-27'0"

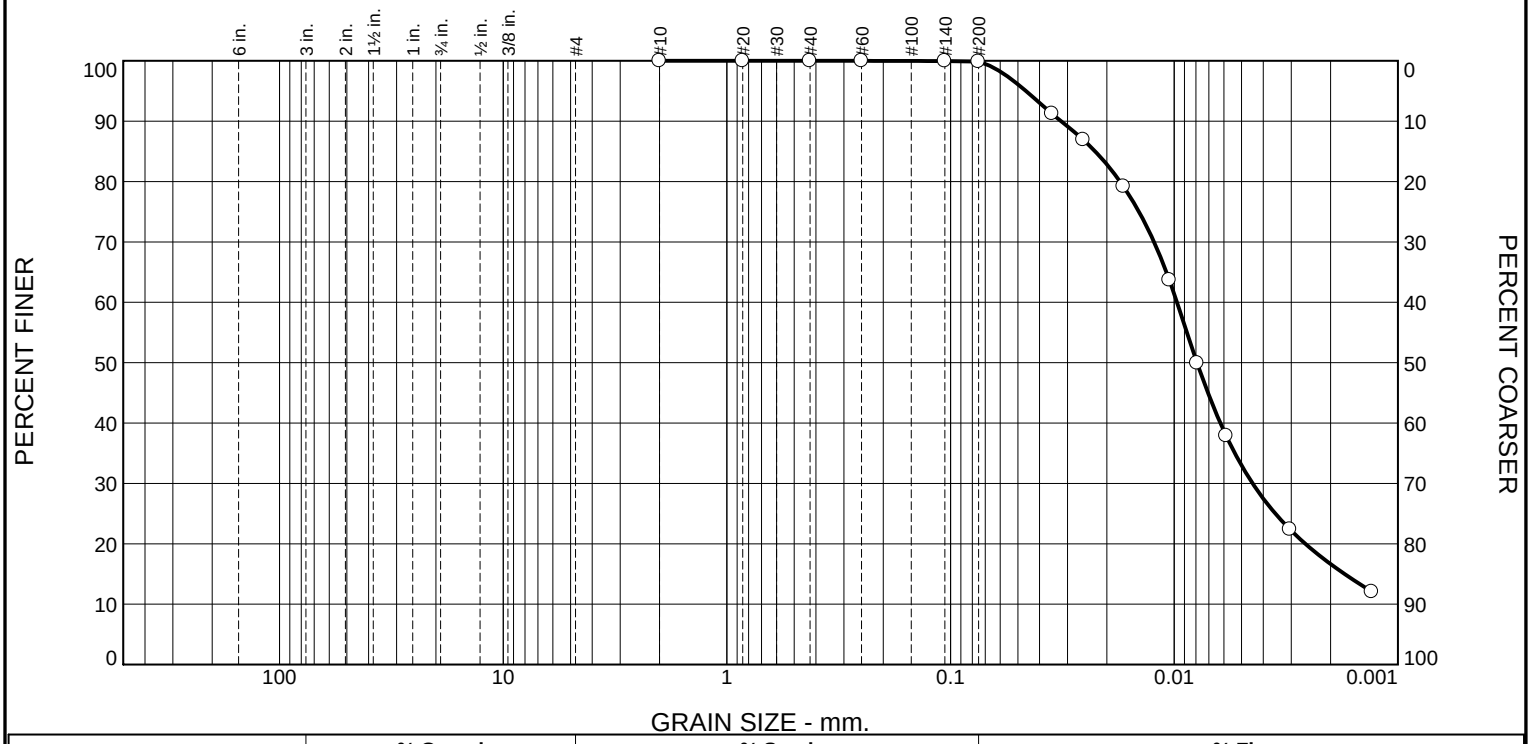
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C10**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.1	83.3	16.6

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	100.0		
0.425mm	100.0		
0.250mm	100.0		
0.106mm	100.0		
0.075mm	99.9		
0.0352 mm.	91.2		
0.0255 mm.	86.9		
0.0169 mm.	79.2		
0.0105 mm.	63.7		
0.0079 mm.	49.9		
0.0059 mm.	37.9		
0.0030 mm.	22.4		
0.0013 mm.	12.0		

* (no specification provided)

Material Description

Silt some Clay

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NP **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 0.0320 D_{85}= 0.0226 D_{60}= 0.0097
D_{50}= 0.0079 D_{30}= 0.0045 D_{15}= 0.0017
D_{10}= C_u= C_c=

Remarks

Note: Specific gravity of soil assumed.
F.M.=0.00

Date Received: Nov 23,2023 **Date Tested:** Nov 27,2023

Tested By: R.C

Checked By: J.H-J

Title: Lab Manager

Location: Culvert 47-2
Sample Number: SS-13 **Depth:** 37.5-39.5

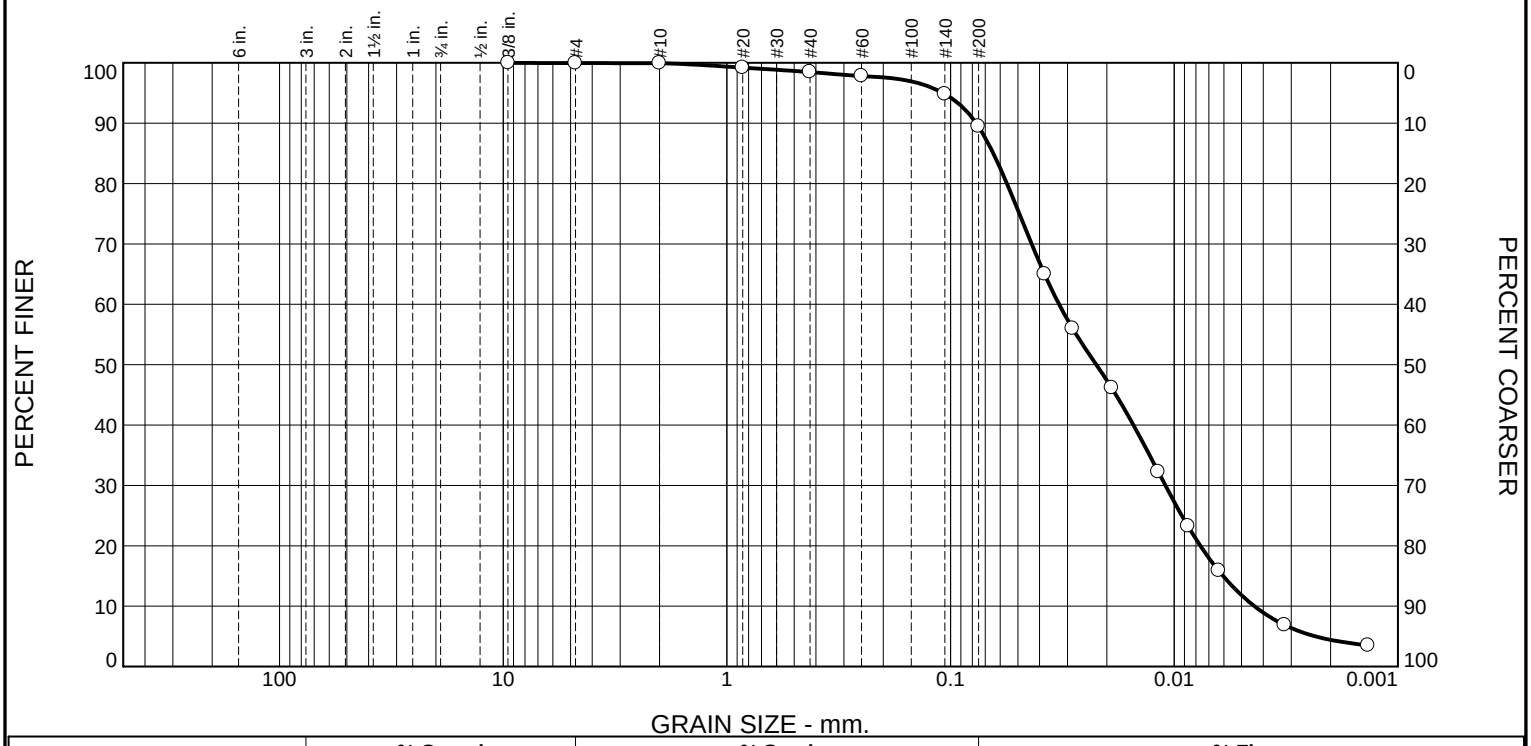
Date Sampled: July 26,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO177060

Figure C11

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.5	9.0	77.7	11.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	100.0		
2.00mm	100.0		
0.850mm	99.2		
0.425mm	98.5		
0.250mm	97.8		
0.106mm	94.8		
0.075mm	89.5		
0.0380 mm.	65.0		
0.0285 mm.	56.0		
0.0190 mm.	46.2		
0.0118 mm.	32.2		
0.0087 mm.	23.2		
0.0063 mm.	15.9		
0.0032 mm.	6.9		
0.0014 mm.	3.5		

* (no specification provided)

Material Description

Silt some Clay some Sand

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0767 D_{85}= 0.0644 D_{60}= 0.0327
D_{50}= 0.0223 D_{30}= 0.0110 D_{15}= 0.0061
D_{10}= 0.0044 C_u= 7.46 C_c= 0.84

Remarks

Note: Specific Gravity of Soils is assumed.
F.M.=0.07

Date Received: Nov 3,2022 **Date Tested:** Nov 9,2022

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: CL47-3 SS-8
Sample Number: SS-8 **Depth:** 25'0"-27'0"

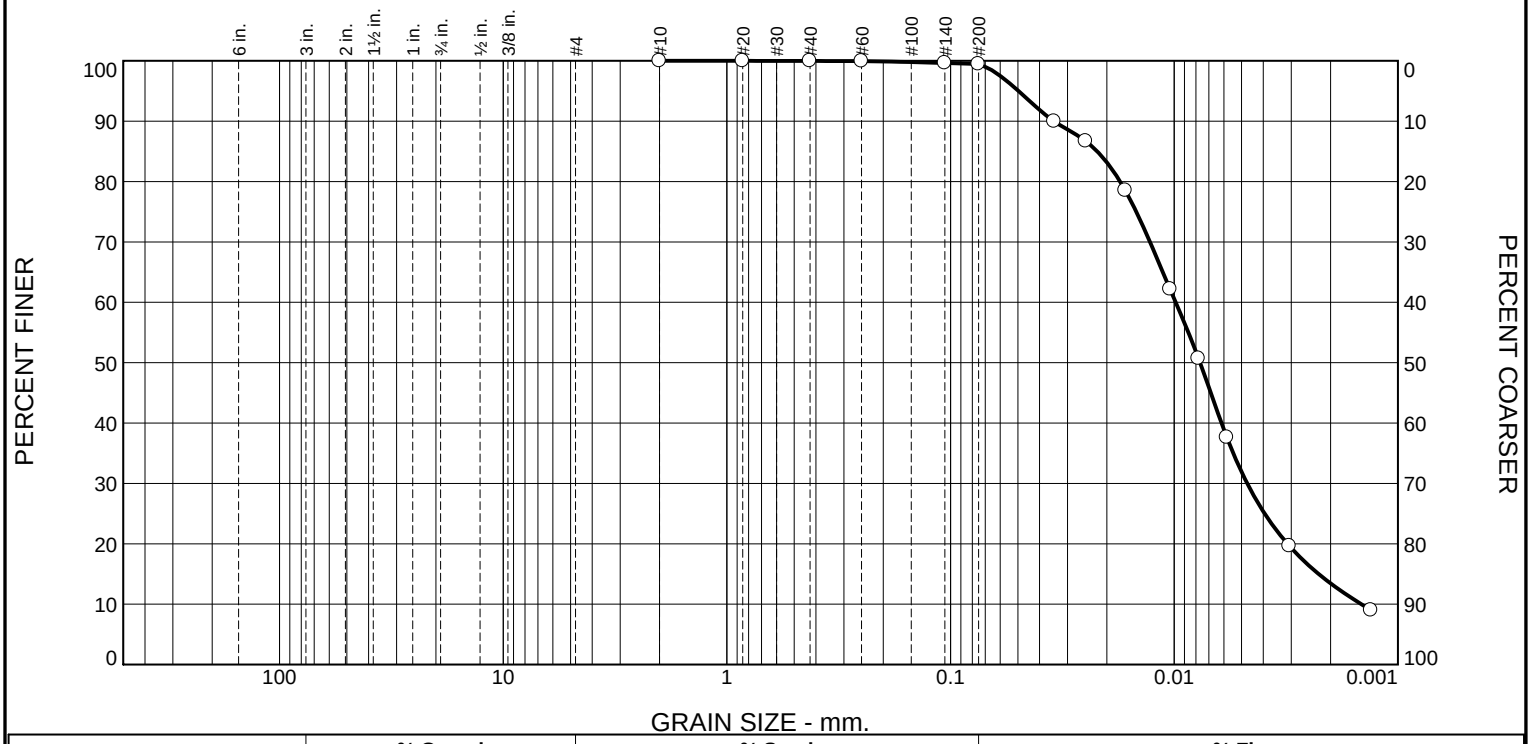
Date Sampled: Sept 27,2022

McINTOSH PERRY

Client: MTO Northeastern Region
Project: HWY 118

Project No: CCO-177060-11 **Figure C12**

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	0.5	86.1	13.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	100.0		
0.425mm	100.0		
0.250mm	99.9		
0.106mm	99.6		
0.075mm	99.5		
0.0344 mm.	90.0		
0.0249 mm.	86.7		
0.0165 mm.	78.5		
0.0104 mm.	62.2		
0.0078 mm.	50.7		
0.0058 mm.	37.6		
0.0031 mm.	19.6		
0.0013 mm.	9.0		

* (no specification provided)

Material Description

Silt some Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0345 D_{85}= 0.0221 D_{60}= 0.0099
D_{50}= 0.0077 D_{30}= 0.0047 D_{15}= 0.0023
D_{10}= 0.0015 C_u= 6.76 C_c= 1.55

Remarks

Note: Specific gravity of soil assumed.
F.M.=0.00

Date Received: Nov 23,2023 **Date Tested:** Nov 27,2023

Tested By: R.C

Checked By: J.H-Jones

Title: Lab Manager

Location: Culvert 47-3
Sample Number: SS-11 **Depth:** 32.5-34.5

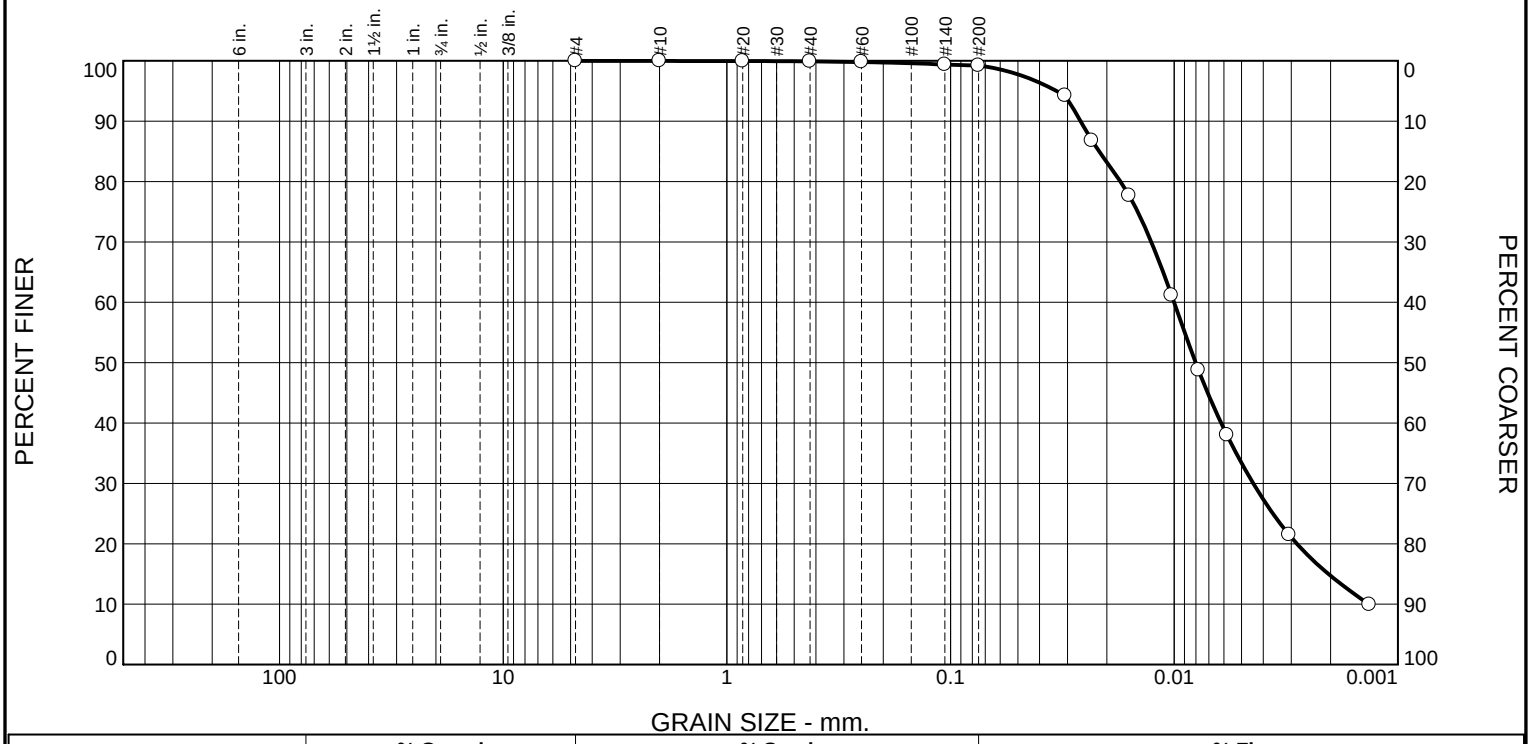
Date Sampled: July 24,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO177060

Figure C13

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	0.7	84.5	14.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	100.0		
0.850mm	100.0		
0.425mm	99.9		
0.250mm	99.8		
0.106mm	99.4		
0.075mm	99.2		
0.0308 mm.	94.2		
0.0233 mm.	86.8		
0.0159 mm.	77.7		
0.0103 mm.	61.2		
0.0078 mm.	48.8		
0.0058 mm.	38.0		
0.0031 mm.	21.5		
0.0013 mm.	9.9		

* (no specification provided)

Material Description

Silt some Clay trace sand

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0262 D_{85}= 0.0217 D_{60}= 0.0100
D_{50}= 0.0080 D_{30}= 0.0044 D_{15}= 0.0020
D_{10}= 0.0014 C_u= 7.41 C_c= 1.45

Remarks

Specific gravity of soil is assumed.
F.M.=0.01

Date Received: August 2,2023 **Date Tested:** August 8,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-4 SS-6
Sample Number: SS-6

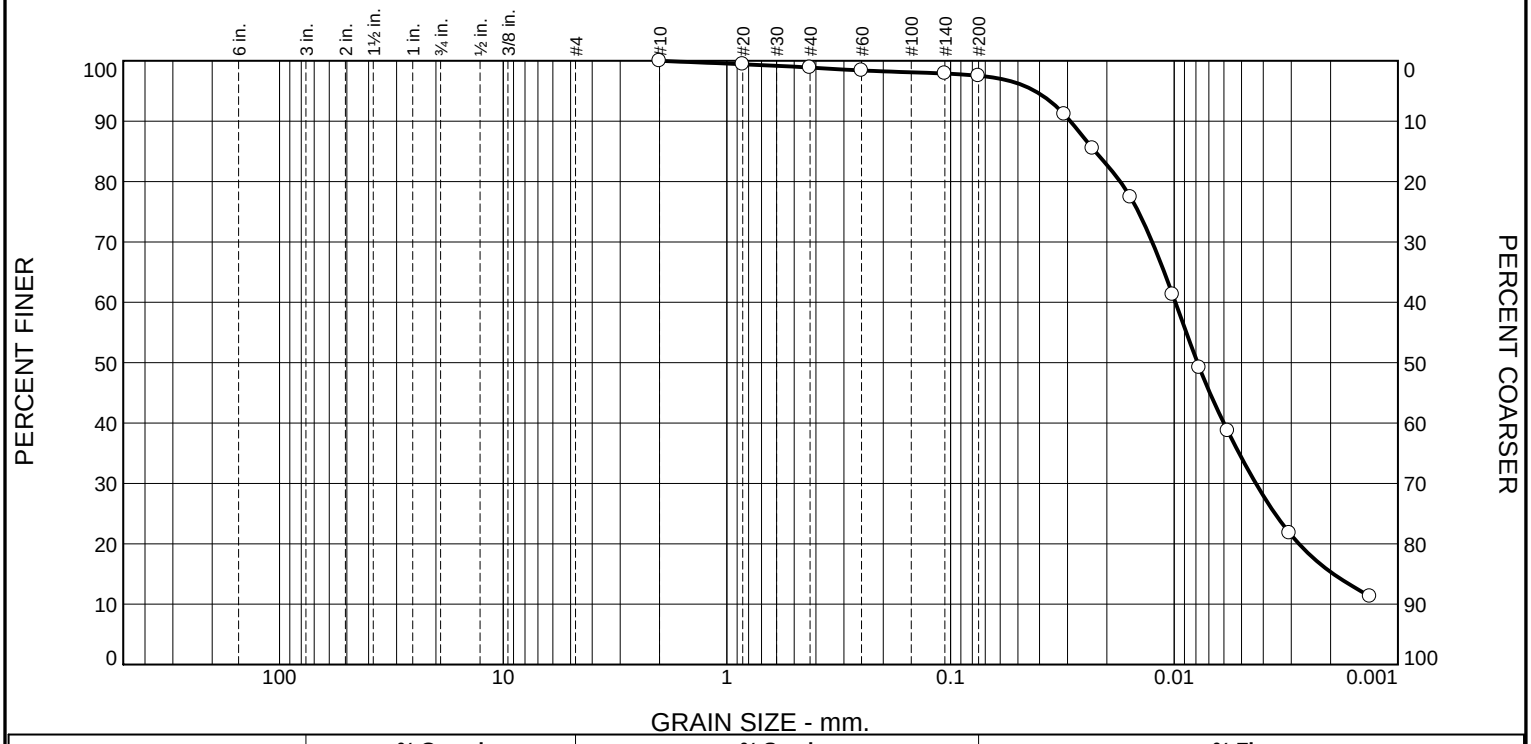
Date Sampled: July 28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C14

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.1	1.4	82.2	15.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	99.4		
0.425mm	98.9		
0.250mm	98.4		
0.106mm	97.9		
0.075mm	97.5		
0.0310 mm.	91.1		
0.0232 mm.	85.5		
0.0157 mm.	77.4		
0.0102 mm.	61.3		
0.0077 mm.	49.2		
0.0058 mm.	38.7		
0.0031 mm.	21.8		
0.0013 mm.	11.3		

* (no specification provided)

Material Description

Silt some Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0291 D_{85}= 0.0226 D_{60}= 0.0099
D_{50}= 0.0079 D_{30}= 0.0043 D_{15}= 0.0019
D_{10}= C_u= C_c=

Remarks

Specific gravity of soil is assumed.
F.M.=0.04

Date Received: August 2,2023 **Date Tested:** Aug 8,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-4 SS-7
Sample Number: SS-7 **Depth:** 25'-27'

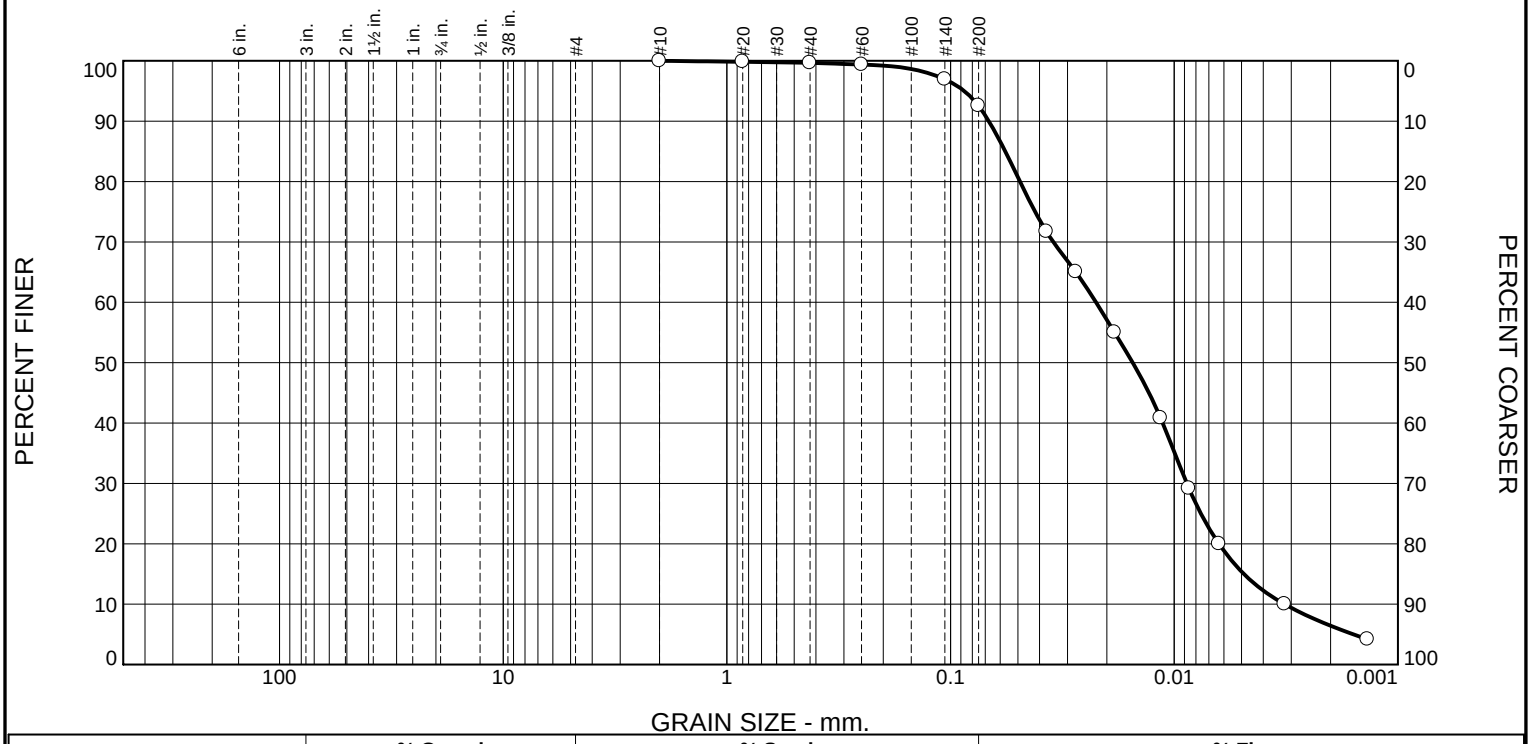
Date Sampled: July 28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C15

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.3	7.2	86.1	6.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	99.8		
0.425mm	99.7		
0.250mm	99.4		
0.106mm	96.9		
0.075mm	92.5		
0.0373 mm.	71.7		
0.0275 mm.	65.0		
0.0185 mm.	55.0		
0.0115 mm.	40.9		
0.0086 mm.	29.2		
0.0063 mm.	20.0		
0.0032 mm.	10.0		
0.0014 mm.	4.2		

* (no specification provided)

Material Description

Silt trace Clay trace fine Sand

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0674 D_{85}= 0.0570 D_{60}= 0.0224
D_{50}= 0.0153 D_{30}= 0.0088 D_{15}= 0.0049
D_{10}= 0.0032 C_u= 6.97 C_c= 1.07

Remarks

Specific gravity of soil is assumed.
F.M.=0.02

Date Received: August 2,2023 **Date Tested:** August 9,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-5 SS-3
Sample Number: SS-3 **Depth:** 10'-12'

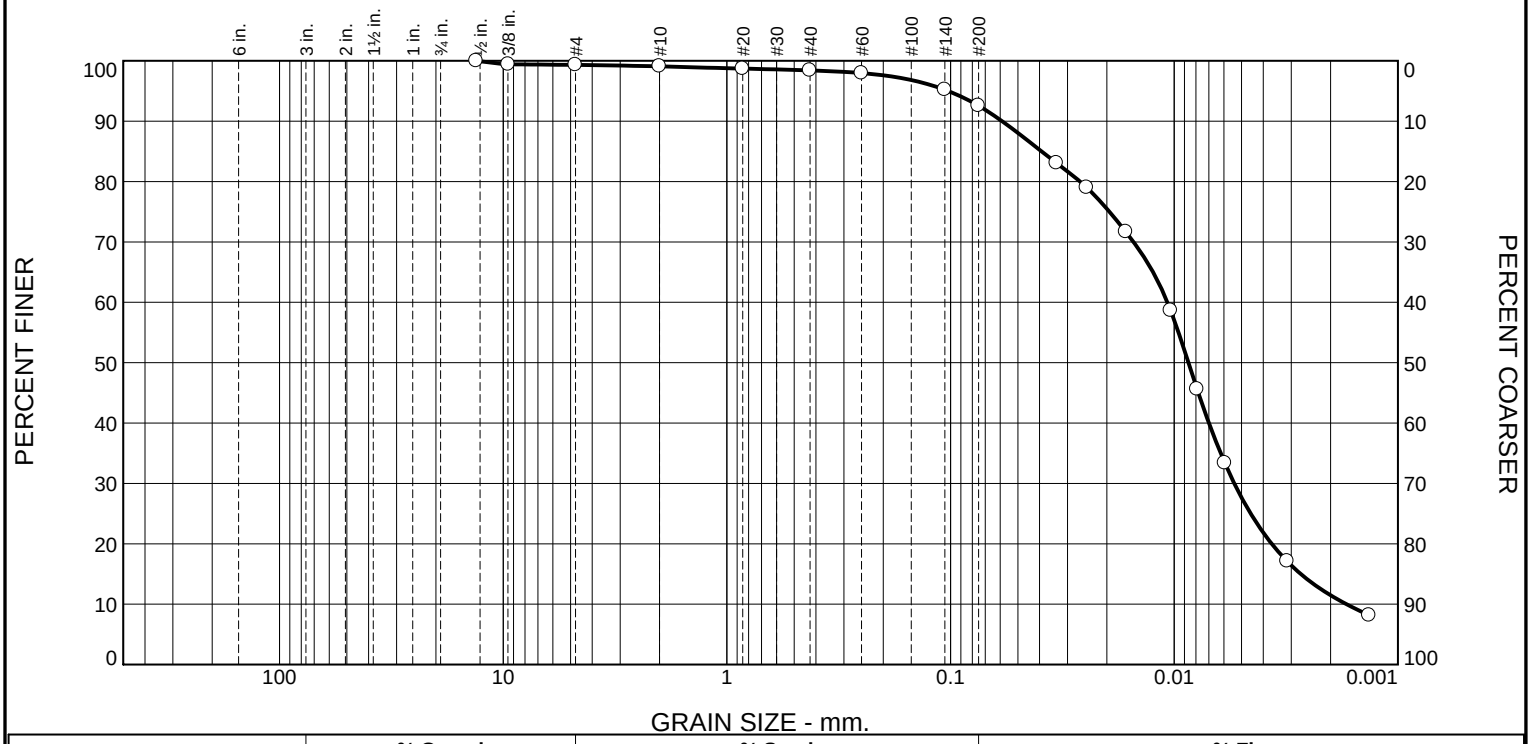
Date Sampled: July 28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C16

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.7	0.2	0.7	5.8	81.1	11.5

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
13.2mm	100.0		
9.5mm	99.4		
4.75mm	99.3		
2.00mm	99.1		
0.850mm	98.7		
0.425mm	98.4		
0.250mm	98.0		
0.106mm	95.2		
0.075mm	92.6		
0.0336 mm.	83.1		
0.0246 mm.	79.0		
0.0165 mm.	71.7		
0.0104 mm.	58.6		
0.0079 mm.	45.6		
0.0059 mm.	33.4		
0.0031 mm.	17.1		
0.0013 mm.	8.1		

* (no specification provided)

Material Description

Silt some Clay trace Sand trace fine Gravel

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0588 D_{85}= 0.0392 D_{60}= 0.0107
D_{50}= 0.0086 D_{30}= 0.0054 D_{15}= 0.0027
D_{10}= 0.0017 C_u= 6.32 C_c= 1.59

Remarks

Specific gravity of soil is assumed.
F.M.=0.10

Date Received: August 2,2023 **Date Tested:** August 9,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-5 SS-5
Sample Number: SS-5 **Depth:** 14'-16'

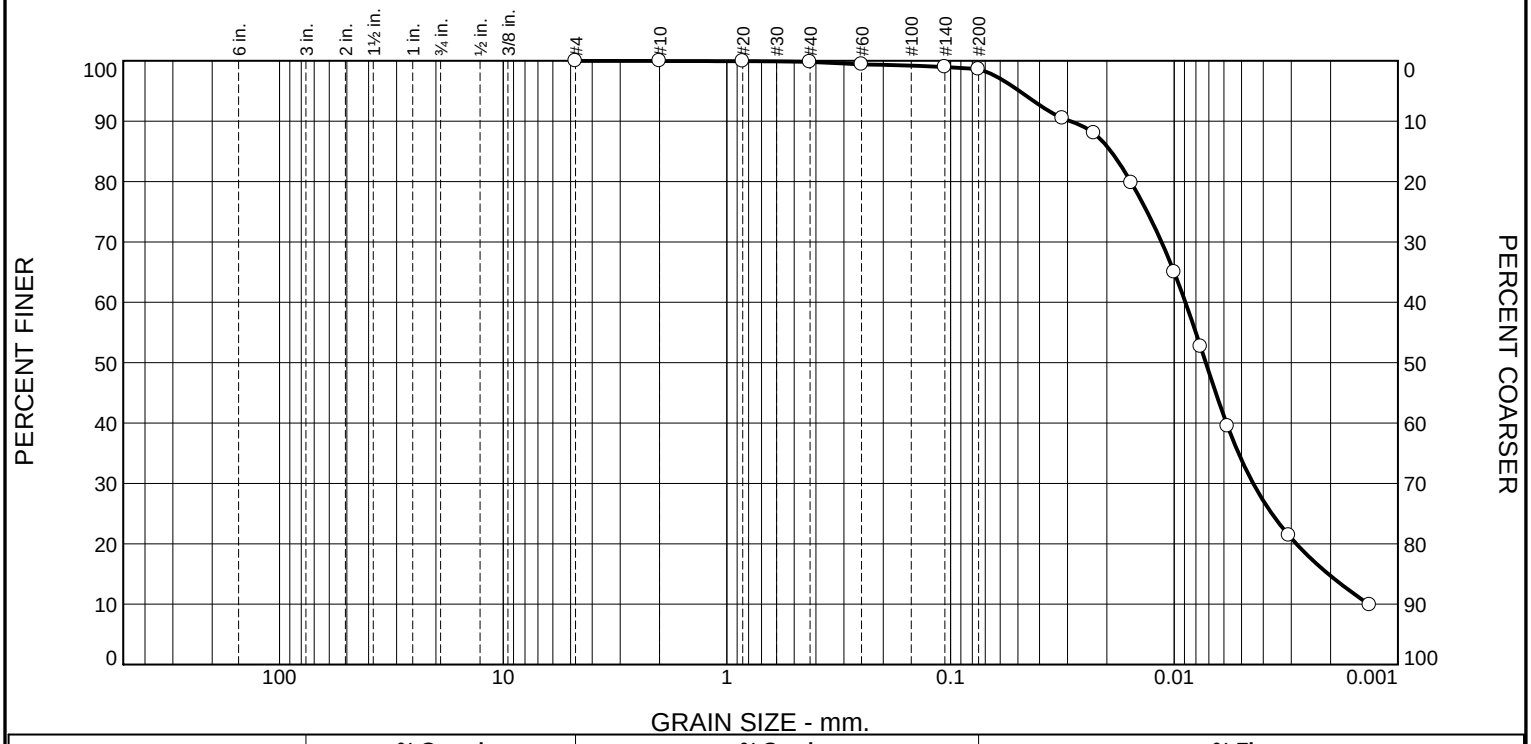
Date Sampled: July 28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C17

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	1.2	83.9	14.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.00mm	100.0		
0.850mm	99.9		
0.425mm	99.8		
0.250mm	99.4		
0.106mm	99.0		
0.075mm	98.6		
0.0316 mm.	90.5		
0.0229 mm.	88.0		
0.0156 mm.	79.8		
0.0100 mm.	65.0		
0.0076 mm.	52.7		
0.0058 mm.	39.5		
0.0031 mm.	21.4		
0.0013 mm.	9.9		

* (no specification provided)

Material Description

Silt some Clay trace Sand

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0292 D_{85}= 0.0192 D_{60}= 0.0089
D_{50}= 0.0072 D_{30}= 0.0044 D_{15}= 0.0020
D_{10}= 0.0014 C_u= 6.59 C_c= 1.63

Remarks

Specific gravity of soil is assumed.
F.M.=0.01

Date Received: August 2,2023 **Date Tested:** August 9,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-5 SS-7
Sample Number: SS-7 **Depth:** 25'-27'

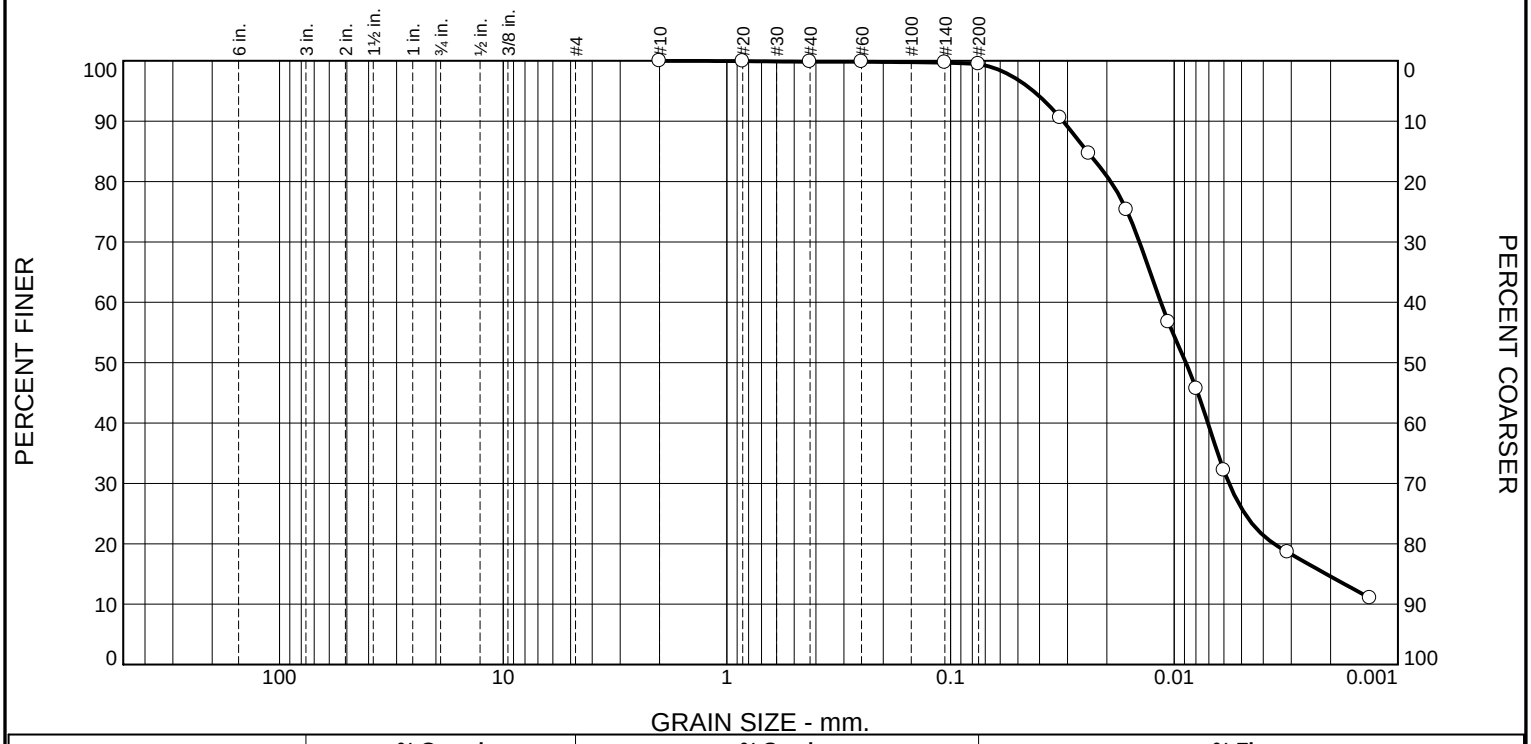
Date Sampled: July28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C18

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	0.4	84.9	14.6

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.00mm	100.0		
0.850mm	99.9		
0.425mm	99.9		
0.250mm	99.8		
0.106mm	99.7		
0.075mm	99.5		
0.0324 mm.	90.6		
0.0241 mm.	84.7		
0.0164 mm.	75.3		
0.0106 mm.	56.7		
0.0080 mm.	45.7		
0.0060 mm.	32.2		
0.0031 mm.	18.6		
0.0013 mm.	11.0		

* (no specification provided)

Material Description

Silt some Clay trace fine Sand

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.0314 D_{85}= 0.0245 D_{60}= 0.0115
D_{50}= 0.0089 D_{30}= 0.0057 D_{15}= 0.0021
D_{10}= C_u= C_c=

Remarks

Specific gravity of soil is assumed.
F.M.=0.00

Date Received: August 2,2023 **Date Tested:** August 9,2023

Tested By: R.C

Checked By: J.Hopwood-Jones

Title: Lab Manager

Location: Culvert 47-5 SS-8
Sample Number: SS-8 **Depth:** 30'-32'

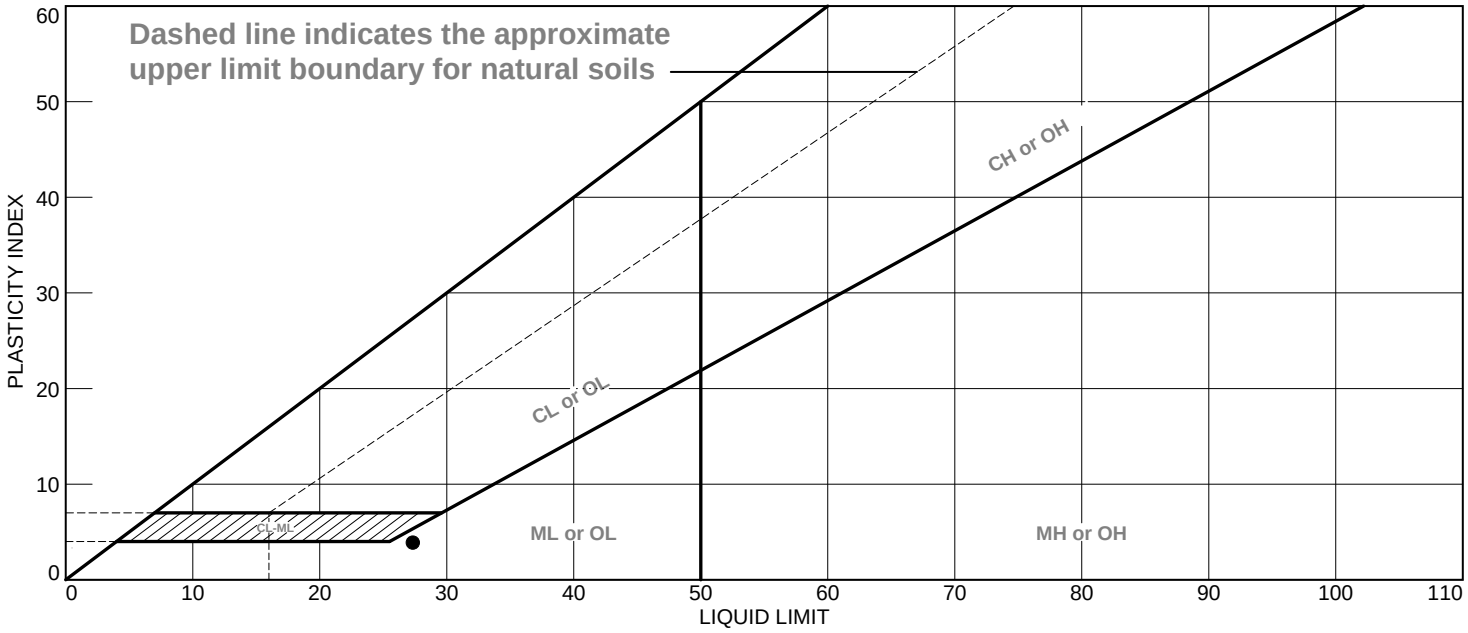
Date Sampled: July 28,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO-177060-11

Figure C19

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		27.4	23.6	3.8			

Project No. CCO177060 **Client:** MTO Northeastern

Project: MTO NER-CO#11-Additional Drilling

Hwy 118 Culverts

Location: Culvert 47-4

Sample Number: SS-7 **Depth:** 25-27

McINTOSH PERRY

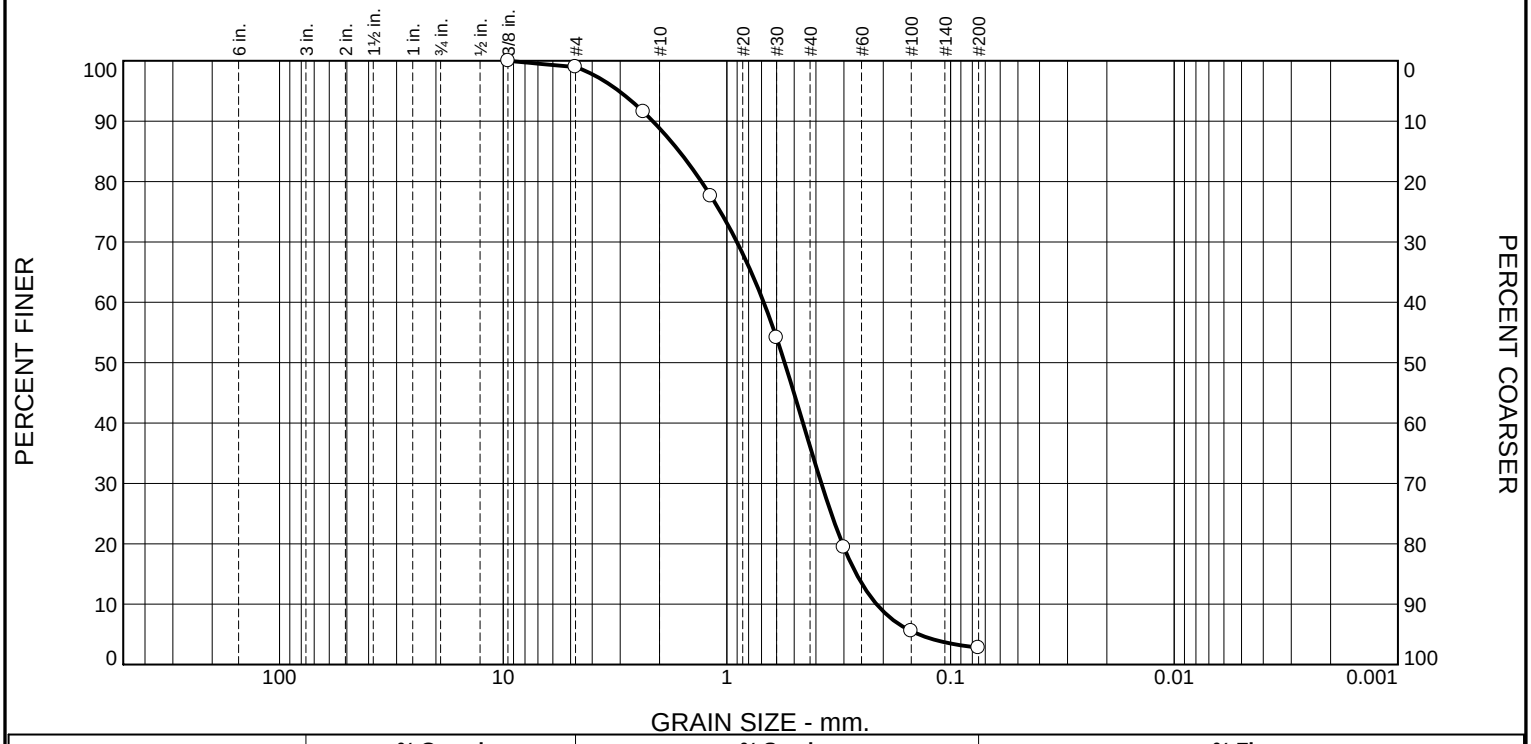
Remarks:

●Soils very Silty

Figure C20

Tested By: J.H-J **Checked By:** J.H-J

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.0	10.2	52.7	33.3	2.8	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	99.0		
2.36mm	91.5		
1.18mm	77.6		
0.600mm	54.1		
0.300mm	19.4		
0.150mm	5.6		
0.075mm	2.8		

* (no specification provided)

Material Description

Sand trace Silt/Clay trace fine Gravel

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= SP AASHTO (M 145)=

Coefficients

D_{90}= 2.1436 D_{85}= 1.6322 D_{60}= 0.6848
D_{50}= 0.5518 D_{30}= 0.3783 D_{15}= 0.2637
D_{10}= 0.2144 C_u= 3.19 C_c= 0.97

Remarks

F.M.=2.53

Date Received: Nov 23,2023 **Date Tested:** Nov 27,2023

Tested By: R.C

Checked By: J.H-J

Title:

Location: Culvert 47-1
Sample Number: SS-19 **Depth:** 50-52

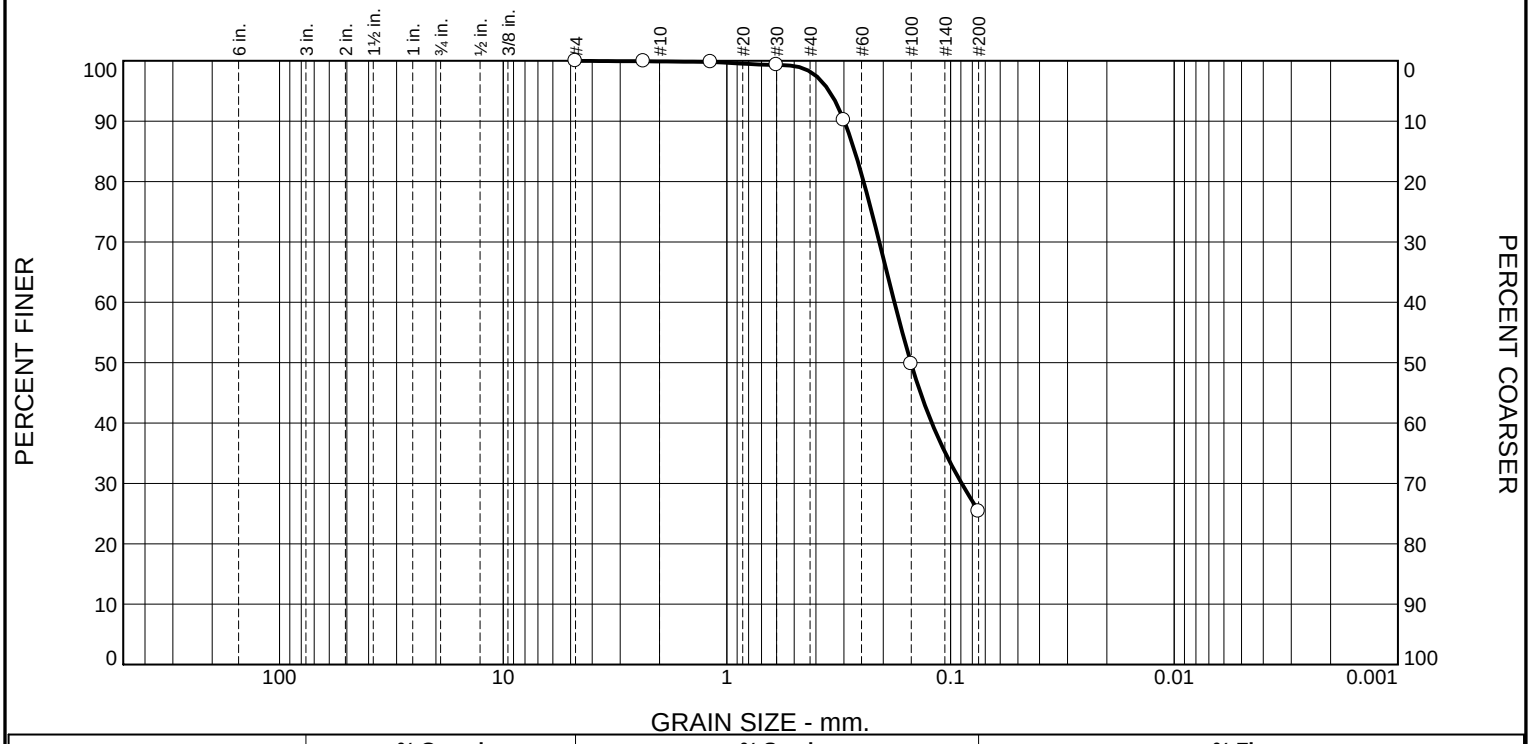
Date Sampled: July 26,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO177060

Figure C21

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	1.7	72.8	25.4	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
4.75mm	100.0		
2.36mm	99.9		
1.18mm	99.8		
0.600mm	99.3		
0.300mm	90.2		
0.150mm	49.8		
0.075mm	25.4		

* (no specification provided)

Material Description

Sand with Silt/Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.2985 D_{85}= 0.2680 D_{60}= 0.1783
D_{50}= 0.1506 D_{30}= 0.0892 D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.61

Date Received: Nov 23,2023 **Date Tested:** Nov 27,2023

Tested By: R.C

Checked By: J.H-Jones

Title: Lab Manager

Location: Culvert 47-2
Sample Number: SS-16 **Depth:** 45-47

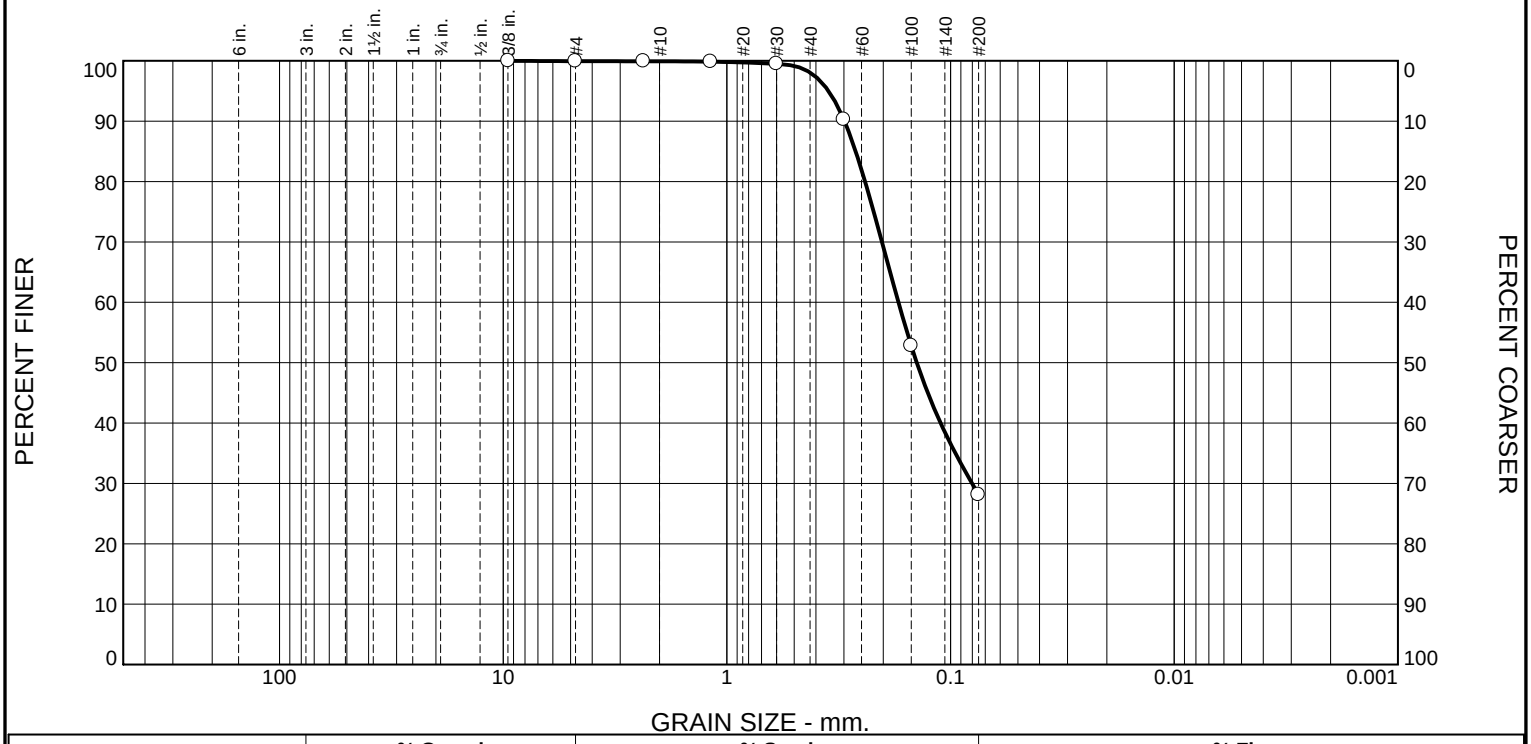
Date Sampled: July 23,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO177060

Figure C22

Particle Size Distribution Report



% +75mm	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.0	1.8	70.0	28.1	

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
9.5mm	100.0		
4.75mm	99.9		
2.36mm	99.9		
1.18mm	99.9		
0.600mm	99.5		
0.300mm	90.3		
0.150mm	52.8		
0.075mm	28.1		

* (no specification provided)

Material Description

Sand with Silt/Clay

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.2978 D_{85}= 0.2656 D_{60}= 0.1712
D_{50}= 0.1417 D_{30}= 0.0802 D_{15}=
D_{10}= C_u= C_c=

Remarks

F.M.=0.58

Date Received: Nov 27,2023 **Date Tested:** Nov 27,2023

Tested By: R.C

Checked By: J.H-J

Title: Lab Manager

Location: Culvert 47-3
Sample Number: SS-16 **Depth:** 45-47

Date Sampled: July 26,2023

McINTOSH PERRY

Client: MTO Northeastern
Project: MTO NER-CO#11-Additional Drilling
Hwy 118 Culverts
Project No: CCO177060

Figure C23

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Certificate of Analysis

McIntosh Perry Consulting Eng. (Nepean)
215 Menten Place, Unit 104
Nepean, ON K2H 9C1
Attn: Jason Hopwood-Jones

Client PO: Hwy 118
Project: 0KM-17-7060
Custody: 69125

Report Date: 17-Nov-2022
Order Date: 9-Nov-2022

Order #: 2246317

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
2246317-01	CL47-3 SS4

Approved By:

Milan Ralitsch, PhD
Senior Technical Manager

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	14-Nov-22	14-Nov-22
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	11-Nov-22	12-Nov-22
Resistivity	EPA 120.1 - probe, water extraction	14-Nov-22	14-Nov-22
Solids, %	CWS Tier 1 - Gravimetric	11-Nov-22	11-Nov-22

Summary of Criteria Exceedances

(If this page is blank then there are no exceedances)

Only those criteria that a sample exceeds will be highlighted in red

Regulatory Comparison:

Paracel Laboratories has provided regulatory guidelines on this report for informational purposes only and makes no representations or warranties that the data is accurate or reflects the current regulatory values. The user is advised to consult with the appropriate official regulations to evaluate compliance. Sample results that are highlighted have exceeded the selected regulatory limit. Calculated uncertainty estimations have not been applied for determining regulatory exceedances.

Sample	Analyte	MDL / Units	Result	-	-

	Client ID:	CL47-3 SS4	-	-	-		
	Sample Date:	29-Sep-22 10:30	-	-	-	-	-
	Sample ID:	2246317-01	-	-	-		
	Matrix:	Soil	-	-	-		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	90.6	-	-	-	-	-
General Inorganics							
pH	0.05 pH Units	7.57	-	-	-	-	-
Resistivity	0.1 Ohm.m	28.4	-	-	-	-	-
Anions							
Chloride	5 ug/g	128	-	-	-	-	-
Sulphate	5 ug/g	14	-	-	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions								
Chloride	ND	5	ug/g					
Sulphate	ND	5	ug/g					
General Inorganics								
Resistivity	ND	0.10	Ohm.m					

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	54.5	5	ug/g	56.4			3.3	20	
Sulphate	71.9	5	ug/g	74.1			3.0	20	
General Inorganics									
pH	12.34	0.05	pH Units	12.33			0.1	10	
Resistivity	32.1	0.10	Ohm.m	32.3			0.5	20	
Physical Characteristics									
% Solids	94.3	0.1	% by Wt.	93.4			0.9	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	161	5	ug/g	56.4	105	82-118			
Sulphate	186	5	ug/g	74.1	112	80-120			

Qualifier Notes:

Login Qualifiers :

Sample - One or more parameter received past hold time - Chloride, pH, sulphate

Applies to Samples: CL47-3 SS4

Sample Data Revisions:

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

NC: Not Calculated

Soil results are reported on a dry weight basis unlesss otherwise noted.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

PARACE LABORATORIES I

Paracel ID: 2246317

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n

Paracel Order Number (Lab Use Only)	Chain Of Custody (Lab Use Only)
2246317	№ 69125

Client Name: McIntosh Perry
Contact Name: Jason Hopwood-Jones
Address: 215 Morton Place
Nepean ON
K2H 9C1
Telephone:

Project Ref: OKH-17-7060
Quote #: Hwy 118
PO #:
E-mail: j.hopwood-jones@McIntoshperry.com

Page 1 of 1

Turnaround Time
☐ 1 day ☐ 3 day
☐ 2 day ☒ Regu
Date Required:

☐ REG 153/04 ☐ REG 406/19

☐ Table 1 ☐ Res/Park ☐ Med/Fine
☐ Table 2 ☐ Ind/Comm ☐ Coarse
☐ Table 3 ☐ Agri/Other
☐ Table ___
For RSC: ☐ Yes ☐ No

Other Regulation
☐ REG 558 ☐ PWQO
☐ CCME ☐ MISA
☐ SU - Sani ☐ SU - Storm
Mun:
☐ Other:

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken Date	Sample Taken Time	Required Analysis: ☒ Corrosivity Package
1	CL47-3 SS4	S					☒
2							
3							
4							
5							
6							
7							
8							
9							
10							

Comments:

Method of Delivery: Walk In

Relinquished By (Sign): Ricky Collette	Received By Driver/Depot:	Received at Lab: Aimee Dorn	Verified By: Rhman
Relinquished By (Print): Ricky Collette	Date/Time: NOV 9 22 9:30 AM	Date/Time: NOV 09 2022 12:37	Date/Time:
Date/Time: 11/04/22	Temperature: 15.4 °C	Temperature: 6.9 °C	pH Verified: ☐ By:

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APPENDIX D

Site Photographs

Photo 1: Culvert inlet *(taken by MPCE) [Summer 2023]*

Photo 2: Culvert outlet *(taken by MPCE) [Summer 2023]*

Photo 3: Looking south from the culvert inlet *(taken by MPCE) [Summer 2023]*

Photo 4: Looking north from the culvert outlet *(taken by MPCE) [Summer 2023]*

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APPENDIX E

GSC Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 44.998N 79.179W **User File Reference:** Hwy 118, Sta 20+183 Draper 2023-10-31 18:30 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.084	0.054	0.036	0.013
Sa (0.1)	0.118	0.078	0.053	0.020
Sa (0.2)	0.117	0.079	0.055	0.021
Sa (0.3)	0.102	0.070	0.048	0.019
Sa (0.5)	0.085	0.057	0.040	0.015
Sa (1.0)	0.052	0.034	0.023	0.007
Sa (2.0)	0.027	0.017	0.011	0.003
Sa (5.0)	0.007	0.004	0.003	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.069	0.045	0.030	0.011
PGV (m/s)	0.071	0.045	0.029	0.009

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

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APPENDIX F

Foundation Comparisons

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CIRCULAR PIPE	OPEN BOTTOM CULVERT	CLOSED BOTTOM CULVERT	TRENCHLESS
Advantages			
- Flexible pipe can tolerate larger magnitude of settlement than rigid culverts - Readily available materials and simple installation methods	- Relatively expedient installation if precast units are used - Possibility to maintain work zone to span the existing culvert; however, the replacement would need to be significantly wider than existing to allow for foundation excavation without conflict with existing pipe.	- Relatively expedient installation if precast units are used - Smaller magnitude of settlement than open bottom culvert	- Avoids open cut and reduces need for roadway protection systems - Allows for two directions of traffic to be maintained throughout construction without grade lowering.
Disadvantages			
- Requires moderate excavation - Protection system will require bracing, anchors and/or rakers - May require temporary flow passage system	- Requires largest and deepest excavation - Protection system is higher so will require additional bracing, anchors and/or rakers - Dewatering to greater depth - May require temporary flow passage system - Founding subgrade will provide lower geotechnical resistances - Potential for post construction differential settlement	- Requires moderate excavation - Protection system will require bracing, anchors and/or rakers - May require temporary flow passage system	- Requires specialized construction equipment and Contractor - Requires construction of entry and exit pits and access to the toes of the slope - Entry and exit pits would be constructed in ponded water - Slow progress in gravel and cobbles
Risks			
- Cohesionless soils may increase seepage rates requiring more robust sump pumps. Complete subgrade preparation in the wet. - Potential for base disturbance	- Cohesionless soils may increase seepage rates requiring more robust sump pumps. Complete subgrade preparation in the wet. - Increased risk of basal instability of footings due to depth of excavation below water table	- Cohesionless soils may increase seepage rates requiring more robust sump pumps. Complete subgrade preparation in the wet. - Potential for base disturbance	- Entry and exit pits could require sheet pile enclosure excavation - Poor soil conditions anticipated in entry and exit pits - A mixed face is anticipated. - Difficult advancing through rockfill
Recommendation			
Recommended	Not Recommended	Recommended	Not feasible

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APPENDIX G

Memorandum prepared by MPCE - Access Issues and Utility Conflicts

McINTOSH PERRY

MEMORANDUM

To:	MTO
From:	McIntosh Perry Consulting Engineers Ltd (McIntosh Perry)
Date:	19-Dec-2023
Re:	Culvert 47 (Stn 20+183) Draper Township **Accessibility Issues for Drilling on North Side of Hwy 118**

The purpose of this memo is to summarise access issues encountered by Mcintosh Perry and their drilling subcontractor, Ohlman Geotechnical Services (OGS) out of Almonte, Ontario, during in water drilling operations for proposed boreholes north of Highway 118 at the culvert 47 location.

OGS was retained by McIntosh Perry to drill off a barge in the water north of the north culvert end at the end of the culvert, and 10 metres north of the culvert. At the time of the planned drilling operations, OGS contacted McIntosh Perry with concerns of shallow water levels at the north end of culvert 47 not allowing access from the north channel accessed from a public boat launch located northwest of the site.

According to a local utility worker who has knowledge of the area, Ontario Power Generation had completed their seasonal water drop within proximity to the culvert. Given the significant water drop in a very short period of time, OGS was reluctant to move their barge and equipment into place in an attempt to drill the boreholes at the culvert for fear of the barge becoming trapped on shallow soil and rock. Alternative options to complete the drilling were explored at the time of investigation by OGS and McIntosh Perry Staff which did not conclude to a viable and safe drilling option. Due to low hanging high voltage power lines and steep rocky side slopes at the culvert outlet, it was not possible to safely access the site from the road. OGS drillers refused to proceed, and operations were terminated. The concerns brought forward by OGS are outlined in a letter from their office manager included in this memo. Additional photos are included with this letter to provide more information with respect to site accessibility issue.

As a result of the concerns outlined by OGS with their refusal to drill north of Highway 118, McIntosh Perry re-evaluated the need to drill the two boreholes north of the culvert and approached MTO's representative (Mr. N'eem Tavakkoli) to discuss the issue. An email dated September 20, 2023 was prepared and presented to MTO to address the issue followed by a phone call meeting with McIntosh Perry's representative Mr Jeff Forrester. A following up email from Mr. N'eem Tavakkoli on behalf of MTO was received on September 22, 2023 to acknowledge the issue and approve the in-water drilling termination at the north end of the culvert, given that:

- Additional information was available from three boreholes drilled on the existing road surface, and two in water boreholes located south of the existing culvert.
- The medium complexity foundation subconsultant review and accept the available information to provide FIDR for the project.

A pdf copy of the aforementioned correspondence is enclosed.

Jeff Forrester, CET

McIntosh Perry

Attachments :

- Letter from Olhman Geotechnical Services
- Email Correspondences with MTO dated September 20, 2023 and September 22, 2023.

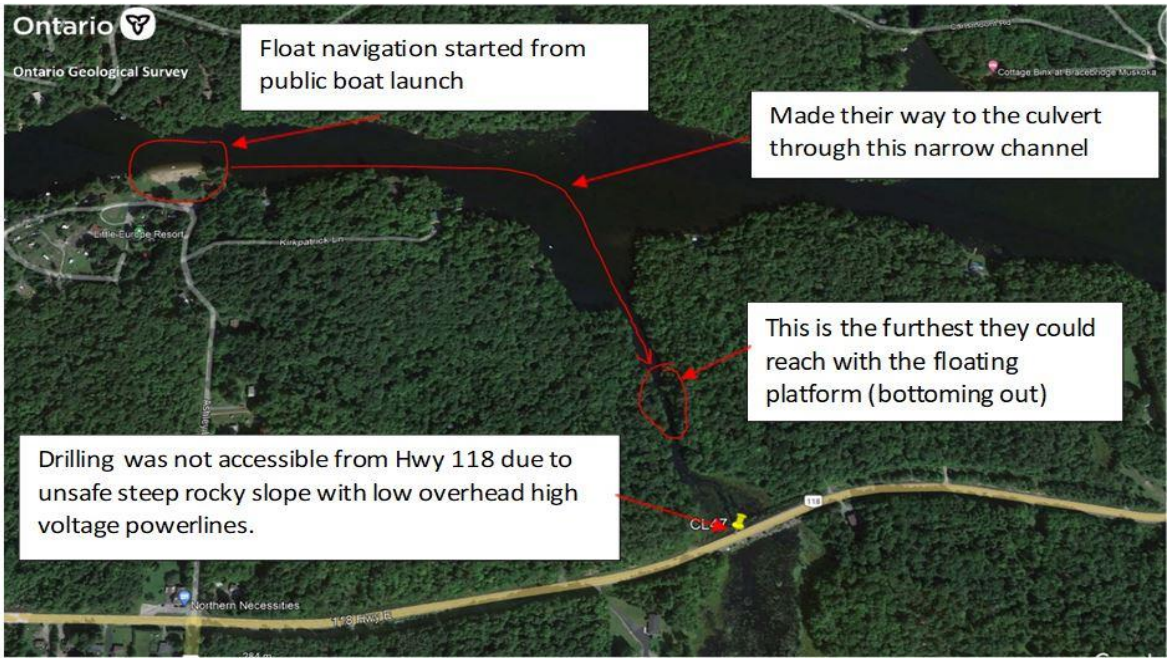

Photo 1 – Overview Map and Notes on Access Restrictions

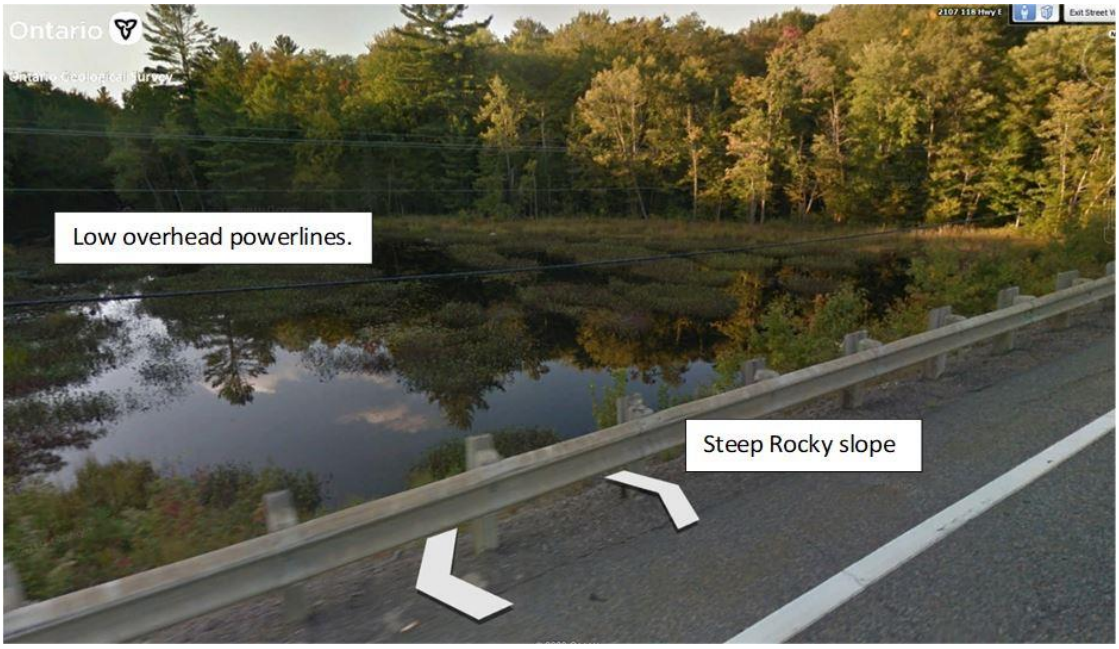

Photo 2 – Low Overhead Utilities

Photo 3 – Steep Rock Embankment Slope

To whom it may concern,

This report is created to explain the access issues on site during a drilling project on Hwy #118 in Bracebridge Ontario. OGS Inc. was hired by McIntosh Perry for drilling boreholes for culverts on Hwy #118, many of which were completed successfully.

On Thursday August 31st 2023 access to the culvert in question was scouted by 2 OGS Inc. drillers and field Technician from McIntosh Perry by boat. Prior to this it was determined that the only possible access to the drilling location had to be by pulling the assembled platform downstream. While scouting the water access it was determined that the water levels were adequate for floating the 12' x 12' drilling platform into position.

When OGS Inc. and the McIntosh Perry Technician returned on Tuesday September 5th 2023 (just after labour day weekend), the platform was assembled and was being floated into the drilling area. As the drillers approached the drilling area with the platform it became abundantly clear that the water level had decreased since Thursday August 31st 2023. Due to the drop in water level the floating platform was bottoming out and not able to reach the drilling location. The closest the platform could get to the drilling location was approximately 200 feet away which would not gather relative soil information for the culvert.

It was decided that the platform had to be removed from the waterway before the possibility of it becoming stranded with no way of getting it removed before the following spring. It is our understanding that the waterway at this culvert is affected by a seasonal water control by local dam systems and would continue to drop for the year.

All possible alternative options were evaluated by the OGS Inc. staff on site and the McIntosh Perry on site technician. None of the options were a possibility due to safety and ground conditions.

The direct access straight down to the location was not possible due to the shear vertical drop to the water and large blast rock on the slope making impossible and unsafe to put together the platform or even build an alternate platform in the drilling location as shown below in the following photo. *Please note Fig. 1 on the following page.*

OGS INC. 5518 APPLETON SIDE ROAD, ALMONTE, ON K0A 1A0
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ogsinc@bellnet.ca • www.ogsdrilling.ca

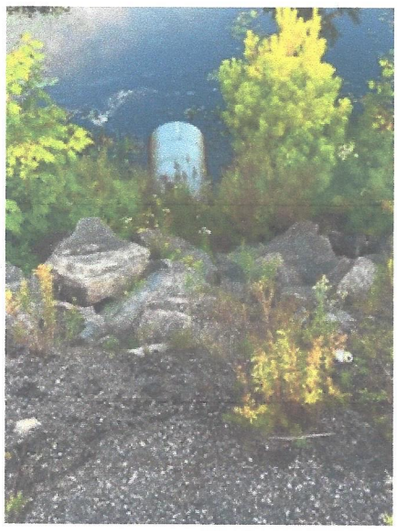


Fig. 1 – Direct Vertical access

It was also confirmed that the access to enter from the side of the culvert was also not possible due the soft marsh soil and cattails. This access was not possible to walk through with the equipment and platform to the water's edge for assembly. *Please note Fig. 2 below.*

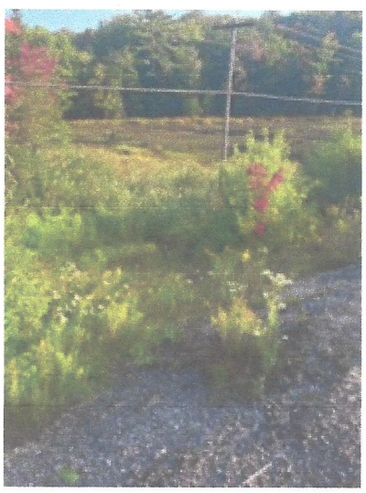


Fig. 2 – Side access

One alternative possibility in these situations is to have a boom truck sling our platform and equipment into place after assembling the platform on the roadway. This was deemed not possible due to the existing power lines on the culvert side of the road. *Please note Fig. 3 below.*

Fig. 3 – Hydro Lines

Due to all of the issues stated above, OGS Inc. did not have any possible option to access the drilling location for the 2 holes beside the culvert. The main cause for not accessing the location would be the rapid decrease in water level.

Possible Alternative Options

The only other suggestions for accessing the drilling locations if still required would be as follows:

Option 1 – Wait for the yearly water levels to rise and complete it in the spring / early summer of 2024.

Option 2 – Drill the locations in the winter from the ice. This is possible with our equipment with stipulations. There must be enough ice to safely conduct the drilling (assume 6"-8" around the drilling area) and the access from the left side must also be frozen enough to walk the equipment out to the drilling area. The concern about the access is that the marsh area tends to be quite temperamental to freezing. This area would also have to be deemed safe to access the location.

For any questions of concerns please contact:

OGS Inc. – Office Manager – Geoffrey Coombs – 613-256-7666 / ogsinc@bellnet.ca

Jeffrey Forrester

From: Tavakkoli, N'eem (MTO) <N'eem.Tavakkoli@ontario.ca>
Sent: September 22, 2023 11:45 AM
To: Christine Shillinglaw
Cc: Libita, Beauty (MTO); Bucci, Jim (MTO); Jeffrey Forrester; Mohammed Al-Khazaali; Mathew Koprash; Philip Almond
Subject: RE: GWP 5011-19-00 Hwy 118 - SC#11 Drilling Operations

Christine,

Just spoke with Jeff. I'm okay with no boreholes at the north side, but only if your medium complexity foundation sub is okay with it. There should be a few words included in the report on why the north borehole wasn't drilled. Ultimately, it is expected to see an option analysis or a discussion on the coffer dam design/installation for both the south and the north sides. As long as that can be provided, then we are good.

Thanks,

N'eem

From: Tavakkoli, N'eem (MTO)
Sent: Thursday, September 21, 2023 4:07 PM
To: Christine Shillinglaw <c.shillinglaw@mcintoshperry.com>
Cc: Libita, Beauty (MTO) <Beauty.Libita@ontario.ca>; Bucci, Jim (MTO) <Jim.Bucci@ontario.ca>; Jeffrey Forrester <j.forrester@mcintoshperry.com>; Mohammed Al-Khazaali <m.al-khazaali@mcintoshperry.com>; Mathew Koprash <m.koprash@mcintoshperry.com>; Philip Almond <p.almond@mcintoshperry.com>
Subject: RE: GWP 5011-19-00 Hwy 118 - SC#11 Drilling Operations

Hi Christine,

I'll call Jeff tomorrow if he is available and will get back to you shortly.

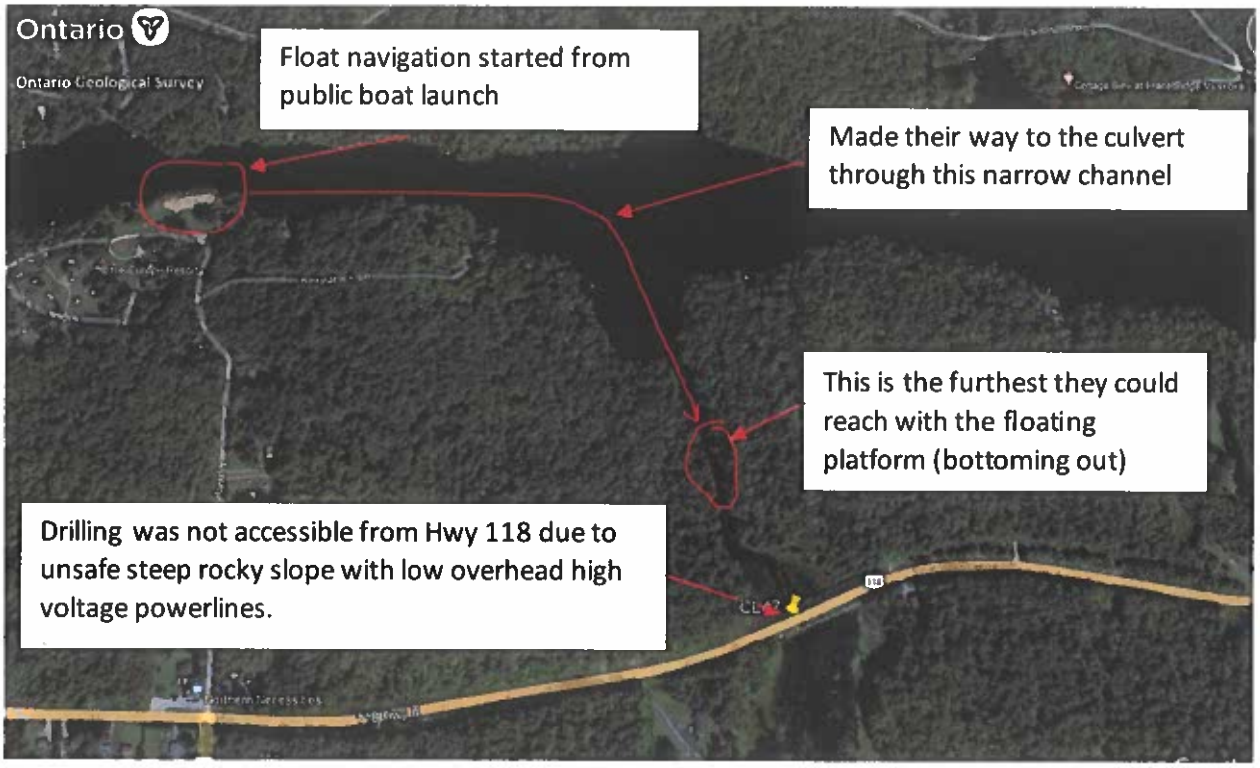
Thanks,

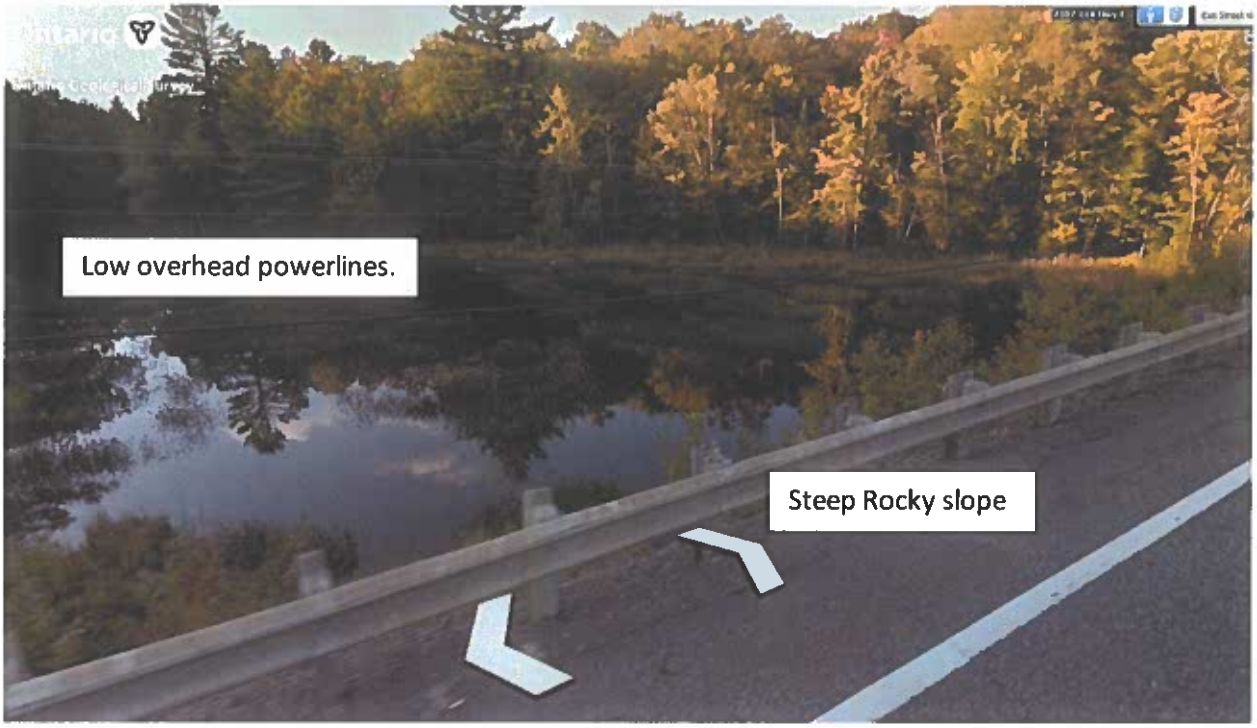
From: Christine Shillinglaw <c.shillinglaw@mcintoshperry.com>
Sent: Wednesday, September 20, 2023 3:21 PM
To: Tavakkoli, N'eem (MTO) <N'eem.Tavakkoli@ontario.ca>
Cc: Libita, Beauty (MTO) <Beauty.Libita@ontario.ca>; Bucci, Jim (MTO) <Jim.Bucci@ontario.ca>; Jeffrey Forrester <j.forrester@mcintoshperry.com>; Mohammed Al-Khazaali <m.al-khazaali@mcintoshperry.com>; Mathew Koprash <m.koprash@mcintoshperry.com>; Philip Almond <p.almond@mcintoshperry.com>
Subject: GWP 5011-19-00 Hwy 118 - SC#11 Drilling Operations

Hi N'eem,

I understand you have taken over the Hwy 118 project for Brady Lin. We wanted to touch base on the scope of work for SC#11. The scope change is attached for your reference. The purpose of the drilling work was to provide data for the awarded Contractor to facilitate dewatering designs. MP has completed their field work but ran into some challenges on CL 47 that we wanted to bring to MTO's attention.

The scope change was approved on July 11, 2022 and due to in water timing windows and driller availability we had to finish up drilling this summer/fall. While completing drilling this month we were faced with unexpected challenges at CL47. Ontario Power Generation had completed their seasonal water drop within proximity to the culvert. The receded water levels did not allow for the drillers to navigate their floating platform to the drilling location through the narrow channel (highlighted in the snapshot below). Also, due to low hanging high voltage power lines and steep rocky side slopes at the culvert outlet, it was not possible to safely access the site from the road. Our drillers refused to proceed and operations were terminated.





Our team has drilled 5 boreholes in total at CL 47. Two boreholes were drilled in water to the south of the culvert to depths below the invert of 11.3 m. Three boreholes were drilled on the roadway to depths ranging between 15 m and 17 m. It was observed that the soil profile is consistent in all boreholes. We encountered silty sand to sandy silt sand at elevations ranging approximately between 293.2 m and 291.5 m in all five boreholes. We feel the soil profile would be consistent to the north of the culvert based on the data obtained. Can MTO please advise if they are ok with this approach? I am also happy to set up a call to further to discuss.

Thanks,
Christine

Christine Shillinglaw, P.Eng.
Assistant Vice President, Transportation Structures
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c.shillinglaw@mcintoshperry.com | www.mcintoshperry.com

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APPENDIX H

List of Referenced Specifications and Contract Provisions

1. The following Special Provisions and OPSS Documents referenced in this report:

- OPSS.PROV 206
- OPSS.PROV 401
- OPSS.PROV 421
- OPSS.PROV 422
- OPSS.PROV 501
- OPSS.PROV 511
- OPSS.PROV 517
- OPSS.PROV 539
- OPSS.PROV 803
- OPSS.PROV 804
- OPSS.PROV 805
- OPSS.PROV 902
- OPSS.PROV 1004
- OPSS.PROV 1010
- OPSS.PROV 1860
- SP 105S09
- SP 110S06
- SP 517F01
- SP FOUN0003
- OPSD 208.010
- OPSD 219.110
- OPSD 802.010
- OPSD 802.031
- OPSD 803.010
- OPSD 803.031
- OPSD 810.010
- OPSD 3090.101

2. Contract Provision – Obstructions

Installation of roadway protection systems and coffer dams will encounter obstructions such as cobbles and boulders. Such obstructions may impede the work from reaching the design depth of installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the work to the design depths. The work must not destabilize the culvert(s) or embankment.

3. Notice to Contractor – Protection of Sensitive Foundation Soils

The Contractor is advised that the thickness and presence of organic deposits may extend to greater depths or be encountered at other locations between and beyond boreholes. The Trafficability of construction equipment may be difficult in areas of organic deposits or excessively soft, loose/unstable and/or saturated subgrade. Disturbance of the subgrade by construction traffic must be minimized and the Contractor may have to adjust his operations in soft subgrade areas. Construction equipment should not be permitted to travel on the exposed subgrade.

4. Contract Provision – Dewatering and Temporary Flow Passage

It will be necessary to divert the ditch flow around the excavation to place the bedding and construct the culvert in the dry. Excavations and placement of bedding material must be completed in the dry. The presence of cohesionless native soils may increase seepage rates. A suitable diversion and dewatering / unwatering system must be employed to enable control of groundwater seepage and inflow. The dewatering scheme will be critical for culvert construction at this site. The Contractor should be prepared to take appropriate measures to construct the bedding layer and place the culvert in a dry and stable environment.