



March 24, 2016

DRAFT DETAIL FOUNDATION INVESTIGATION AND DESIGN REPORT

PICKEREL CREEK CULVERT - SITE NO. 41-88/C
HIGHWAY 105, DISTRICT OF KENORA
UNSURVEYED TERRITORY
MINISTRY OF TRANSPORTATION, ONTARIO
G.W.P 6365-14-00, W.P. 6365-14-01

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REPORT





Table of Contents

PART A – DETAIL FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION.....	1
2.0 SITE DESCRIPTION.....	1
3.0 INVESTIGATION PROCEDURES	1
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	2
4.1 Regional Geology	2
4.2 Subsurface Conditions.....	3
5.0 CLOSURE.....	5

PART B – DETAIL FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS.....	7
6.1 General.....	7
6.2 Foundations	7
6.2.1 Foundation Options.....	7
6.2.1.1 Sheet-Pile Abutments Founding Conditions and Frost Protection	7
6.2.2 Geotechnical Resistances.....	8
6.2.3 Stability and Settlement	8
6.3 Lateral Earth Pressures	8
6.4 Construction Considerations.....	9
6.4.1 Temporary Roadway Protection.....	9
6.4.1.1 Backfill	10
6.4.2 Erosion Protection.....	10
6.4.3 Control of Groundwater and Surface Water	11
6.4.4 Obstructions.....	11
6.4.5 Analytical Testing for Construction Materials	11
7.0 CLOSURE.....	11

REFERENCES

TABLES

Table 1	Summary of Culvert Details
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DRAFT DETAIL FOUNDATION REPORT PICKEREL CREEK CULVERT - SITE NO. 41-88/C

DRAWING

Drawing 1 Borehole Locations and Soil Strata

PHOTOGRAPHS

APPENDIX A RECORD OF BOREHOLES

Lists of Abbreviations and Symbols
Record of Boreholes PK-1 to PK-6

APPENDIX B LABORATORY TEST RESULTS

Table B1	Summary of Analytical Testing of Pickerel Creek Water Sample
Figure B1	Grain Size Distribution – Sand (Fill)
Figure B2	Plasticity Chart – Organic Clay
Figure B3	Grain Size Distribution – Clayey Silt to Silty Clay
Figure B4	Plasticity Chart – Clayey Silt to Silty Clay
Figure B5	Grain Size Distribution – Silt to Silt and Sand
Figure B6	Grain Size Distribution – Silty Sand to Sand

APPENDIX C NON STANDARD SPECIAL PROVISIONS

NSSP Obstructions



PART A

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Hatch Mott MacDonald (HMM), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of the Pickerel Creek culvert (Site No. 41-88/C). The Pickerel Creek culvert is located in the District of Kenora on Highway 105 at STA 20+698, approximately 51.4 km north of the junction of Highway 17 and Highway 105. The key plan showing the general location of this section of Highway 105 and the location of the investigated area are shown on Drawing 1.

2.0 SITE DESCRIPTION

The Pickerel Creek culvert consists of a three-cell, timber box structure, the details of which (i.e., width, height, length, etc.) are summarized in Table 1 following the text of the report.

In general, the topography in this area is relatively flat with moderate to dense tree cover beyond the highway right-of-way. It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is typically reference to project north and therefore may differ from Magnetic North shown on the drawing. For the purposes of this report Highway 105 runs in a north-south direction with the culvert perpendicular in an east-west direction. At the culvert location, Pickerel Creek flows in an easterly direction. At the culvert location, the highway grade is at Elevation 365.4 m and the culvert invert is at approximately Elevation 362.2 m, at both the inlet (west) and outlet (east) ends. The creek water level measured by others on July 5, 2012, to be Elevations 362.6 m at the inlet (west) and outlet (east) ends and was measured by Golder on January 22, 2015, and February 11, 2016, at Elevation 362.5 m. Surface conditions in the culvert inlet (west) and outlet (east) are as are shown on Photographs 1 to 3, attached.

3.0 INVESTIGATION PROCEDURES

The initial field work for this subsurface investigation was carried out on January 21 and 22, and February 16 and 19, 2015, during which time four boreholes (Boreholes PK-1 to PK-4) were advanced at approximately the locations shown on Drawing 1. Two additional boreholes (Boreholes PK-5 and PK-6) and an accompanying Dynamic Cone Penetration Test (DCPT) were subsequently advanced between February 9 and 11, 2016. Boreholes PK-1, PK-4 and PK-6 were advanced at the toe of slope near the culvert inlet/outlet. Boreholes PK-2, PK-3 and PK-5 were advanced from the existing highway platform. Boreholes PK1 and PK-4 to PK-6 were advanced using 108 mm inside diameter hollow stem augers and Boreholes PK-2 and PK3 were advanced using NW casing and wash boring techniques. Boreholes PK-1 and PK-4 were advanced using a track mounted CME 55 drill rig and Boreholes PK-2 and PK3 were advanced using a truck-mounted CME 75 drill rig. Both drill rigs were supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec. Boreholes PK-5 and PK-6 were subsequently advanced using a track-mounted CME 850 drill rig supplied and operated by Cartwright Drilling of Thunder Bay, Ontario.

Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures (ASTM D1586). Samples of the cohesive soils were obtained using 76 mm O.D. thin walled Shelby Tubes (ASTM D1587) for relatively undisturbed samples. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane. The groundwater level in the open boreholes was observed during the drilling operations as described on the Record



DRAFT DETAIL FOUNDATION REPORT PICKEREL CREEK CULVERT - SITE NO. 41-88/C

of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The field work was supervised on a full-time basis by a member of Golder's technical staff who: located the boreholes in the field; arranged for the clearance of underground services; supervised the drilling and sampling operations; logged the boreholes; and examined and cared for the soil samples. The soil samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Sudbury for further examination and laboratory testing. Index and classification testing consisting of water content determinations, grain size distributions, and Atterberg limits were carried out on selected soil samples. The geotechnical laboratory testing was completed according to MTO LS standards.

A sample of the creek water was obtained during the field investigation (on January 26, 2015) using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of parameters, including pH, resistivity, conductivity, sulphates and chlorides. The results of the analytical testing are presented in Table B1 in Appendix B.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by member of our technical staff, referenced to the highway centerline and existing culvert and converted into Northing/Easting on the plan drawing. The ground surface elevation of the highway centerline was obtained from the profile drawing provided by MTO (BC5019311053.dwg). The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to geodetic datum and borehole depths at each borehole location are presented on the Record of Borehole sheets in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole / DCPT Depth (m)
PK-1	5566819.7	289210.6	362.8	11.3
PK-2	5566827.4	289205.6	365.3	11.3
PK-3	5566824.5	289192.7	365.4	11.3
PK-4	5566840.7	289197.4	363.1	11.3
PK-5	5566821.7	289195.7	365.4	18.9 / 21.3
PK-6	5566842.6	289198.2	362.9	17.4

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)¹ mapping, the subsoils in the vicinity of the Pickerel Creek culvert site generally consist of ground moraine deposits comprised of mainly sandy materials.

Based on geological mapping by the Ministry of Northern Development and Mines (Map 2542)², the site is underlain by bedrock of the Archean era, comprised of massive granodiorite to granite rocks.

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52KSW.

² Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.



4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ tests (i.e., SPT 'N' values and undrained shear strengths from field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

Subsoil Conditions

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (for boreholes advanced through the embankment) underlain by organic deposits consisting of topsoil/peat, topsoil and organic clay. The organic deposits are underlain by a cohesive deposit of clayey silt to silty clay further underlain by deposits of silt to sand. A more detailed description of the soil deposits and groundwater conditions encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows) / Shear Strength	Laboratory Testing
				Consistency or Relative Density	
Asphalt	PK-2, PK-3 and PK5	0.09 – 0.10	365.4 – 365.3	n/a	n/a
(FILL) ¹ Sand, trace to some gravel, trace to some silt; brown; frozen to wet	PK-2, PK-3 and PK-5	3.3 – 3.6	365.3 – 365.2	N = 10 – 46 ²	w = 3% – 25% 2 - M (Fig. B1)
				Compact to Dense	
Peat/Topsoil , trace sand, trace wood, dark brown to black, frozen to wet	PK-1 to PK-6	0.0.08 – 1.5	363.1 – 361.7	5 ³	w = 71% - 172%
				Loose	
Organic Clay , dark brown, wet	PK-1	0.8	361.3	N = 2	w = 68% w _l = 86% w _p = 40% I _p = 46% OC = 9.4% 1 – AL (Fig. B2)
				Very Soft	
Clayey Silt to Silty Clay , trace sand, trace gravel, trace organics, silt laminated, brown to grey, frozen to wet	PK-1 to PK-6	3.0 – 5.5	362.8 – 360.5	N = 0 (weight of hammer) – 7 s _u = 24 – 81 ⁴ S = 1 - 3	w = 28% - 36% w _l = 24% - 38% w _p = 16% - 20% I _p = 6% - 18% 3 – MH (Fig. B3) 7 – AL (Fig. B4)
				Soft to Stiff	



DRAFT DETAIL FOUNDATION REPORT PICKEREL CREEK CULVERT - SITE NO. 41-88/C

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (blows) / Shear Strength	Laboratory Testing
				Consistency or Relative Density	
Silt to Silt and Sand , trace clay, grey, wet	PK-1 to PK-6	2.0 – 4.4	358.8 – 357.2	N = 0 (weight of hammer) – 7	w = 22% - 28% 6 – MH (Fig. B5) 3 – AL = NP
				Very Loose to Loose	
Silty Sand to Sand , trace to some silt, trace clay, grey, wet	PK-1 to PK-6	Boreholes terminated in this deposit	356.6 – 353.7	N = 4 – 52 ⁵	w = 16% – 24% 3 – MH and 3 – M (Fig. B6)
				Very Loose to Very Dense	

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
 s_u = Undrained Shear Strength (kPa)
 S = Sensitivity
 OC = Organic Content (%)
 w = Natural Moisture Content (%)
 w_p = Plastic Limit (%)
 w_l = Liquid Limit (%)
 I_p = Plasticity Index (%)
 M = Sieve analysis for particle size
 MH = Combined Sieve and Hydrometer analysis
 AL = Atterberg Limits Test
 NP = Non-Plastic test result

Notes:

¹ 75 mm diameter cobbles were encountered in Boreholes PK-2 and PK-3 at 0.9 m and 2.1 m depths, respectively.

² In the fill, the split spoon samples did not penetrate the entire SPT depth for two samples, inferred to be due to the frozen nature of the material. Additionally, 'N'-values of 41 blows, 44 blows and 81 blows for three samples also inferred to be due to the frozen nature of the material.

³ In the peat deposit one SPT 'N'-value of 10 blows was noted, however this is inferred to be due to the frozen nature of the material.

⁴ One undrained shear strength was measured at greater than 100 kPa, however this is inferred to be at the transition from the cohesive deposit to the underlying silt deposit and is not representative.

⁵ In the silty sand to sand deposit, one SPT 'N'-value of 0 blows (i.e. weight of hammer) was noted, however, this is inferred to be due to the heave inside the augers.



Groundwater Conditions

Unstabilized groundwater levels measured in the open boreholes upon completion of drilling are summarized below. The creek ice level was measured at Elevation 362.5 m on January 22, 2015 and February 11, 2016. Groundwater and creek water levels in the area are subject to seasonal fluctuations and variations due to precipitation events.

Borehole No.	Depth to Groundwater Level (m)	Groundwater Elevation (m)
PK-1	1.6	361.2
PK-2	1.5	363.8
PK-3	2.9	362.5
PK-4	1.5	361.6
PK-5	2.8	362.6
PK-6	0.5	362.4

Notes:

1. Boreholes PK-2 and PK-3 were advanced using NW casing and wash boring. As such, water levels may not be representative of in-situ groundwater conditions.

5.0 CLOSURE

The field drilling program was carried out under the supervision of Mr. Mathew Riopelle, under the overall direction of Mr. David Muldowney, P.Eng. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, P.Eng., and Mr. David Muldowney, P.Eng., provided a technical review of the report. Mr. Jorge M.A. Costa, P.Eng., the Designated MTO Foundations Contact and Principal, conducted an independent quality control review of this report.



Report Signature Page

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PART B

**DETAIL FOUNDATION DESIGN REPORT
PICKEREL CREEK – SITE NO. 41-88/C
HIGHWAY 105, DISTRICT OF KENORA
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides detail foundation design recommendations for the proposed replacement of the Pickerel Creek culvert. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during this subsurface investigation. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Foundations

6.2.1 Foundation Options

The existing Pickerel Creek culvert is located on Highway 105 at STA 20+698, 51.4 km north of the junction of Highway 17 and Highway 105 in the District of Kenora in Unsurveyed Territory. The highway embankment is constructed of granular fill material and is approximately 3.2 m high relative to the culvert invert with approximately 1.2 m of cover of the existing culvert. The existing culvert consists of a three cell timber box, the details of which (i.e., width, height, length, etc.) are summarized in Table 1.

As part of the preliminary design phase of the project, alternative types of culverts were considered for replacement of the existing structure, as reported in the "Preliminary Foundation Investigation and Design Report, Pickerel Creek Culvert – Site No. 41-88/C, Highway 105, District of Kenora, Unsurveyed Territory, G.W.P. 6365-14-00, GEOCRETS No. 52K-10, dated September 8, 2015", by Golder Associates Ltd.

Based on the General Arrangement (GA) drawing provided by HMM on December 15, 2015, the existing culvert is to be replaced with a pre-cast concrete slab supported on sheet-pile abutments, with the underside of the slab at about Elevation 364.1 m (about 1.3 m below the finished grade). We understand there is no proposed embankment grade raise at the proposed culvert location. We also understand that sheet-pile wing walls are being proposed at the culvert inlet/outlet and as such, there is no proposed widening at the culvert location.

6.2.1.1 Sheet-Pile Abutments Founding Conditions and Frost Protection

As the sheet piles will be advanced through the existing embankment fill, which consist of free-draining, non-frost susceptible sand extending below the estimated frost penetration depth estimated to be 2.5 m as per 3090.010 (Foundation, Frost Penetration Depth for Northern Ontario), frost induced heave is not anticipated. There is potential for adhesion and frost heaving near the ends of the culvert, where there is little to no embankment cover; however, as the native clayey silt to silty clay subgrade within the estimated frost penetration depth is generally of "low" to borderline "moderate" frost susceptibility, the risk for heave due to adhesion is also considered to be relatively low.



6.2.2 Geotechnical Resistances

Based on discussion with HMM, we understand that the sheet-piles for the culvert abutments and inlet/outlet wing walls will consist of SKZ-22 sections. We further understand that a factored unit geotechnical axial resistance of 380 kN/m at Ultimate Limit State (ULS) and a unit geotechnical axial resistance of 280 kN/m at Serviceability Limit State (SLS) per meter length of the sheeting is required to support the proposed pre-cast concrete slab.

As the sheet piles are continuous elements, it is difficult to test a single sheet pile to confirm that the required geotechnical resistance/reaction is achieved on site and therefore it is important to select a conservative sheet-pile embedment length. We recommend that the sheet-piles be driven into the compact portion of the silty sand to sand deposit at or below Elevation 349 m to provide 400 kN/m factored resistance at ULS and 300 kN/m reaction at SLS for 25 mm of settlement.

6.2.3 Stability and Settlement

Given that an embankment grade raise or widening is not proposed as part of the culvert replacement and highway embankment reconstruction, the existing native soils will not experience additional load, and therefore, settlement of the culvert after embankment reconstruction is estimated to be less than 25 mm.

For the subsurface conditions and the proposed embankments height up to about 3.5 m above the existing ground surface adjacent to the culvert, granular fill embankments at this site will be stable at side slopes inclined at 2 Horizontal to 1 Vertical (2H:1V) or flatter.

6.3 Lateral Earth Pressures

The lateral earth pressures acting on the sheet-pile abutments and wing walls will depend on the type and method of placement of backfill materials, the nature of soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the sheet-pile abutments and wing walls. It should be noted that these design recommendations and parameters are applicable to level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the requirements of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III should be used as backfill behind the walls, and on top of the concrete culvert slab for a minimum thickness of 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness. A perforated subdrain should be provided along both culvert walls at about the normal water level elevation to allow for positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (Compacting).
- The granular fill may be placed either in a zone with the width equal to at least 2.5 m behind the back of the walls for a restrained sheet-pile abutment wall (see Figure C6.20(a) of the Commentary to the CHBDC), or



DRAFT DETAIL FOUNDATION REPORT PICKEREL CREEK CULVERT - SITE NO. 41-88/C

within the wedge shaped zone defined by a line drawn at 1.5 H:1V extending up and back from the rear face of the base of the walls for an unrestrained wing wall (see Figure C6.20(b) of the Commentary to the CHBDC).

- The following parameters (unfactored) may be used to calculate the lateral earth pressures acting on the sheet-piles:

	Internal Angle of Friction (ϕ)	Unit Weight (kN/m^3)	Coefficients of Static Lateral Earth Pressure		
			At-Rest, K_o	Active, K_a	Passive, K_p
Granular 'A'	35°	22	0.43	0.27	3.69
Granular 'B' Type II	35°	21	0.43	0.27	3.69
Granular 'B' Type I or III	32°	21	0.47	0.30	3.26
Native Clayey Silt o Silty Clay	27°	17	0.55	0.37	2.66
Native Silt to Silt and Sand	27°	19	0.55	0.37	2.66
Native Silty Sand to Sand	28°	20	0.53	0.36	2.77

If the structure allows for lateral yielding, active earth pressures may be used in the design of the structure(s). If the structure does not allow for lateral yielding, at-rest earth pressures should be assumed for design. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as presented in Table C6.6 of the Commentary to the CHBDC.

6.4 Construction Considerations

6.4.1 Temporary Roadway Protection

The temporary excavation for the culvert replacement will be made through the existing embankment granular fill, comprised of compact to very dense sand to approximately Elevation 363.5 m. All excavations must be carried out in accordance with Ontario Regulation 213, Ontario Occupational Health and Safety Act for Construction Projects (as amended). For excavations above the groundwater level, which appears to be the case to about elevation 363.7 m the granular fill is considered to be Type 3 soil. Temporary open-cut excavations in Type 3 soils should remain stable if side slopes are formed no steeper than 1H:1V. Where excavations extend below the groundwater, the granular fill is considered to be Type 4 soils and temporary side slope no steeper than 3H:1V will be required.

Based on the GA drawing provided by HMM, a temporary protection support system is being proposed along the highway centerline to facilitate construction staging and maintain traffic during culvert replacement work. At this site, the installation of the sheet piles for the replacement culvert and/or temporary shoring may be impeded by the presence of cobbles within the embankment fill, such as encountered in Boreholes PK-2 and PK-3. It is recommended that an NSSP be included in the Contract to alert the Contractor to the presence of potential obstructions within the embankment fill at this culvert site; a sample NSSP is included in Appendix C.



As an alternative to sheet-piling, the temporary support systems could consist of soldier piles and lagging, where H-piles are driven to a suitable depth and horizontal lagging is installed as the excavation proceeds. Support to the system could be in the form of struts and walers and rakers or anchors. Where required, temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways.

The installation of the sheet-piles for culvert construction and/or temporary shoring may be impeded by the presence of cobbles (up to 75 mm in size) within the fill material. It may be necessary to excavate and replace the existing fill material in the areas of sheet-pile installation in a series of limited length and narrow trenches. In general, the narrowest suitable excavator bucket should be used. The replacement fill could consist of excavated fill material or imported granular material. Sieving, sorting or picking of large particles from the excavated spoil pile may be required if the excavated material is re-used. Alternatively, imported Granular 'A' or Granular 'B' Type I, II or III may be used as backfill for the excavated trench. Excavation and replacement should be carried out on the same day to avoid leaving any trench open overnight. Consideration should be given to include an NSSP in the contract to address obstructions. A sample NSSP can be provided at the detail design stage, if required depending on final culvert design and construction staging.

6.4.1.1 Backfill

Backfill behind the sheet pile abutments and wing walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type I, II or III. The backfill should be placed in maximum 200 mm thick loose lifts and be compacted to at least 98 per cent of the SPMDD of the materials in accordance with OPSS.PROV 501 (Compacting). The fill should be placed concurrently on both sides of the culvert, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm.

Backfill placement for reconstruction of the roadway embankments over the culvert should be carried out as per OPSD 208.010 (Benching of Earth Slopes) to integrate the existing embankment fill and new fill along the cut faces. Given that the existing embankment fill at this site consist of generally non-frost susceptible sand fill, a frost taper is not required.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

6.4.2 Erosion Protection

Based on the GA drawing provided by HMM, we understand that sheet-pile wings walls, which will provide erosion protection for the culvert embankment, will be constructed at the culvert inlet/outlet extending approximately 6 m outward perpendicular to the sheet-pile abutments. We also understand that rip rap treatment will be provided along the creek side slopes and along the face of the sheet-pile wing walls. Therefore, additional provisions for a clay seal or cut-off wall are not required.



The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (Rip Rap Treatment) and extend onto the creek banks to the ends of the sheet-pile wing walls. Erosion protection for the inlet of the culvert should also follow the standard presented in OPSD 810.010 (Rip Rap Treatment) similar to the outlet but with the rip rap placed up to the toe of slope level to the ends of the sheet-pile wing walls.

6.4.3 Control of Groundwater and Surface Water

Based on the GA drawing provided by HMM, excavation of the existing embankment fill along the culvert alignment will be required to allow installation of the concrete slab and subdrains. Excavations are anticipated to be above the groundwater level. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the existing embankment fill.

Based on the GA drawing provided by HMM, we understand that the creek flow will continue to pass through the existing 3-cell timber culvert during construction. Dewatering of all excavations (if required) should be carried out in accordance with OPSS 517 (Dewatering).

6.4.4 Obstructions

The contractor should be alerted to the presence of cobbles within the embankment fill material as encountered in Boreholes PK-2 and PK-3. An NSSP should be developed at the detail design stage for inclusion into the Contract Documents to alert the contractor to the potential presence of such obstructions.

6.4.5 Analytical Testing for Construction Materials

The results of an analytical test on a sample of creek water taken at the culvert site are presented in Table B1 in Appendix B. The suite of parameters tested is intended to allow the design engineer to assess the requirements for the appropriate type of cement to be used in construction and the need for corrosion protection of steel reinforcing elements.

7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, P.Eng., and the technical aspects were reviewed by Mr. David Muldowney, P.Eng. Mr. Jorge M. A. Costa, P.Eng., Designated MTO Foundations Contact and Principal, conducted an independent quality control review of this report.



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Designated MTO Foundations Contact, Principal

AC/DAM/JMAC/kp

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\\sud1-s-fs01.golder.gds\data\data\active\2014\1190 sudbury\1191\1411523 - hmm 26 culverts thunder bay\reporting\detail design\d9 - pickerel creek\draft\1411523 dft rpt d09 16mar24
pickerel creek fdr.docx



REFERENCES

Canadian Standards Association (CSA), 2006. Canadian Highway Bridge Design Code and Commentary on CAN/CSA S6 06. CSA Special Publication, S6.1 06.

Occupational Health and Safety Act and Regulation for Construction Projects (as amended).

Ministry of Northern Development of Mines. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey – Map 2542.

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52KSW.

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils
ASTM D1587	Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D2573	Standard Test Method for Field Vane Shear Test in Cohesive Soil

Ontario Provincial Standard Specifications (OPSS)

OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
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Ontario Provincial Standard Specifications (OPSS) – Provincial Oriented

OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

OPSD 208.010	Benching of Earth Slopes
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

Ontario Water Resource Act:

Regulation 903	Wells (as amended)
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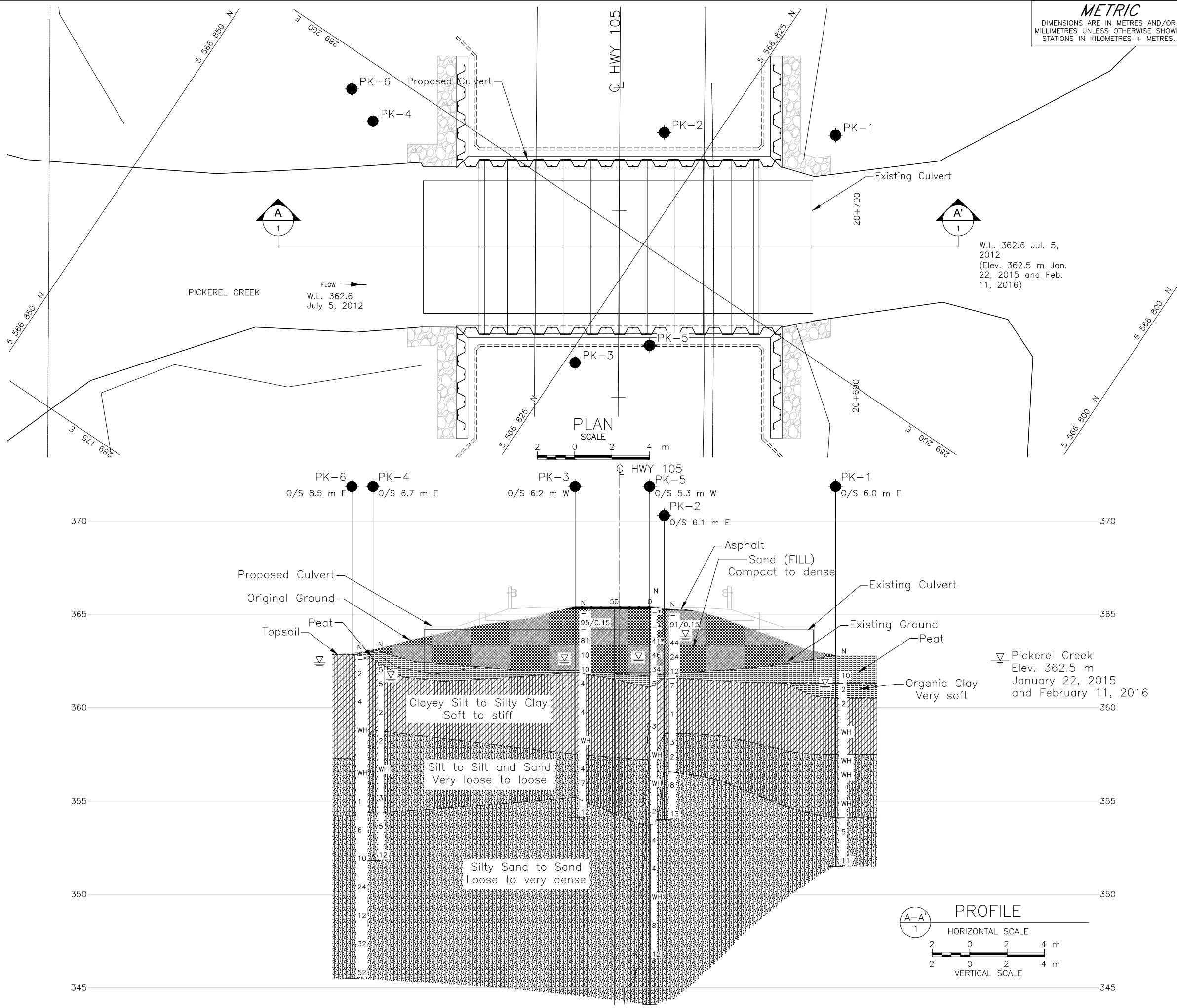
**DRAFT DETAIL FOUNDATION REPORT
PICKEREL CREEK CULVERT - SITE NO. 41-88/C**

Table 1: Summary of Culvert Details

Culvert Location	Site #	Approximate Height of Embankment ¹ (m)	Existing Culvert			Approximate Invert Elevation ²	
			Type	Approximate Dimension ²	Approximate Length (m)	West End of Culvert (m)	East End of Culvert (m)
Hwy 105 STA 20+698	41-88/C	3.3	Three Cell Timber Box	2.1 m x 2.0 m each of 3 cells	21	362.2	362.2

Notes: 1. Embankment height is relative to existing ground surface at the centreline of the roadway and the invert elevation of the existing culvert.
2. Culvert dimensions and invert elevations are based on the plan and profile drawings provided by MTO (Drawing BC5019311053.dwg).

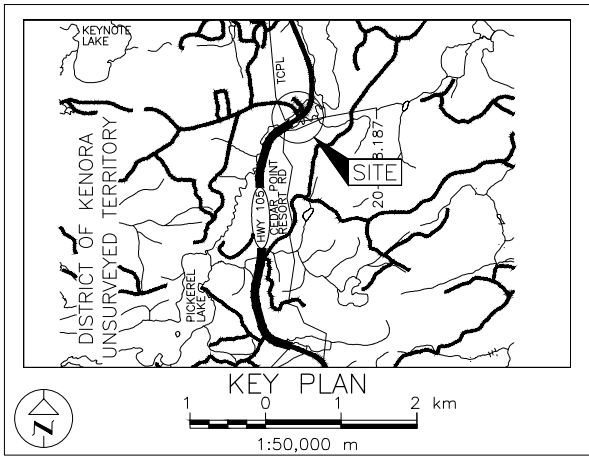
Prepared by: AC
Checked by: SEMP
Reviewed by: JMAC



METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 6365-14-01

HIGHWAY 105
PICKEREL CREEK CULVERT STA 20+698
BOREHOLE LOCATIONS AND SOIL
STRATA



LEGEND

N

16

Borehole – Current Investigation

Standard Penetration Test Value

Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)

WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
PK-1	362.8	5566819.7	289210.6
PK-2	365.3	5566827.4	289205.6
PK-3	365.4	5566824.5	289192.7
PK-4	363.1	5566840.7	289197.4
PK-5	365.4	5566821.7	289195.7
PK-6	362.9	5566842.6	289198.2

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC5019311053, received FEB 20, 2015. General arrangement plan drawing file no. ST-343032-PICKEREL CREEK TIMBER CULVERT-01-GENERAL ARRANGEMENT.dwg, received MAR 9, 2016.

DRAFT

NO.	DATE	BY	REVISION	
Geocres No. .				
HWY. 105		PROJECT NO. 1411523		DIST. .
SUBM'D. AC	CHKD. .	DATE: 3/09/2016	SITE: 41-88/C	
DRAWN: JJL	CHKD. DAM	APPD. JMAC	DWG. 1	



PHOTOGRAPHS

**Photograph 1: Pickerel Creek Culvert
West Side - Inlet (Taken from MTO, OSIM 18-Sep-13)**



**Photograph 2: Pickerel Creek Culvert
East Side - Outlet (Taken from MTO, OSIM 18-Sep-13)**





PHOTOGRAPHS

**Photograph 3: Pickerel Creek Culvert
Looking North at Culvert (Golder – January 21, 2015)**





APPENDIX A

Record of Boreholes



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	c_u, s_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT 1411523		RECORD OF BOREHOLE No PK-1				1 OF 1 METRIC													
G.W.P. 6365-14-00		LOCATION N 5566819.7; E 289210.6				ORIGINATED BY MR													
DIST HWY 105		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY AC													
DATUM GEODETIC		DATE February 19, 2015				CHECKED BY SEMP													
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20	40
362.8	GROUND SURFACE																		
0.0	PEAT (Amorphous) Black to dark brown Frozen*																		
361.3	ORGANIC CLAY Very soft Dark brown Wet		1	SS	10*														
1.5																			
360.5	CLAYEY SILT, trace clay Soft to firm Grey Wet		2	SS	2														
2.3																			
357.5			3	SS	2														
5.3	SANDY SILT, trace clay Very loose Grey Wet		4	SS	WH														
5.3																			
354.1			5	SS	WH														
8.7	SAND, some silt, trace clay Loose to compact Grey Wet		6	SS	WH														
8.7																			
351.5			7	SS	WH														
11.3	END OF BOREHOLE		8	SS	5														
11.3																			
351.5			9	SS	11														
11.3																			
11.3	Notes: 1. Water level at a depth of 1.6 m below ground surface (Elev. 361.2 m) upon completion of drilling. 2. Moved 1 m north of borehole and retrieved a Shelby Tube sample at 2.3 m depth below existing grade. Additionally field vanes were obtained between 3.4 m and 3.7 m depth (Italics).																		

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 08/03/16 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No PK-2			1 OF 1 METRIC															
G.W.P. 6365-14-00			LOCATION N 5566827.4; E 289205.6			ORIGINATED BY MR															
DIST _____ HWY 105			BOREHOLE TYPE NW Casing and Wash Boring			COMPILED BY AC															
DATUM GEODETIC			DATE January 22, 2015			CHECKED BY SEMP															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ					
								20 40 60 80 100	20 40 60 80 100	20 40 60	W _p	W	W _L								
365.3	GROUND SURFACE																				
0.0	ASPHALT (90 mm)		1	WS	-		365														
	Sand, trace to some silt, trace to some gravel (FILL)		2	SS	91/0 15																
	Compact Brown Frozen* to wet																				
	A 75 mm cobble encountered at 0.9 m depth.																				
			3	SS	44*		364														
			4	SS	24		363														
			5A	SS	12		362														
361.8	PEAT, trace wood Dark brown Wet		5B																		
3.7	SILTY CLAY, trace gravel, trace silt laminated Firm to stiff Grey Wet		6	SS	7		361														
							360														
			7	SS	1		359														
358.6	Sandy SILT, trace clay Very loose Grey Wet		8	SS	3																
6.7			9	SS	2		358														
							357														
356.6	SAND, some silt Loose to compact Grey Wet		10	SS	8		356														
8.7							355														
			11	SS	13																
354.0	END OF BOREHOLE						354														
11.3	Note: 1. Water level at a depth of 1.5 m below ground surface (Elev. 363.8 m) upon completion of drilling.																				

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 08/03/16 DATA INPUT:

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

PROJECT 1411523			RECORD OF BOREHOLE No PK-3			1 OF 1 METRIC																	
G.W.P. 6365-14-00			LOCATION N 5566824.5; E 289192.7			ORIGINATED BY MR																	
DIST _____ HWY 105			BOREHOLE TYPE NW Casing and Wash Boring			COMPILED BY AC																	
DATUM GEODETIC			DATE January 21, 2015			CHECKED BY SEMP																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60	20 40 60 80 100	20 40 60	γ	GR SA SI CL						
365.4	GROUND SURFACE																						
0.0	ASPHALT (100 mm)		1	WS	-		365																
0.1	Sand, trace to some silt, trace to some gravel (FILL) Compact Brown Frozen* to wet		2	SS	95/0 15																		
			3	WS	-		364										0 95 (5)						
			4	SS	81*																		
	A 75 mm cobble encountered at 2.1 m depth.		5	SS	10		363																
362.0	PEAT, trace sand Dark brown Wet		6A 6B 6C	SS	10		362																
3.5	CLAYEY SILT, trace sand, trace silt laminated Firm Grey Wet		7	SS	4		361																
			8	SS	4		360																
			9	SS	WH		359																
357.5	SILT, some sand, trace clay Loose Grey Wet		10	SS	4		357										0 16 80 4						
7.9			11	SS	7		356																
355.2	SAND, some silt Compact Grey Wet		12	SS	12		355																
10.2																							
354.1	END OF BOREHOLE																						
11.3	Note: 1. Water level at a depth of 2.9 m below ground surface (Elev. 362.5 m) upon completion of drilling.																						

PROJECT 1411523			RECORD OF BOREHOLE No PK-4			1 OF 1 METRIC														
G.W.P. 6365-14-00			LOCATION N 5566840.7; E 289197.4			ORIGINATED BY MR														
DIST _____ HWY 105			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC														
DATUM GEODETIC			DATE February 16, 2015			CHECKED BY SEMP														
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	SHEAR STRENGTH kPa					W _p W W _L			γ	GR SA SI CL			
363.1	GROUND SURFACE							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)							
0.0	TOPSOIL (80 mm)						363													
362.6	PEAT Dark brown Frozen						362													
0.5	SILTY CLAY, laminated Firm Brown to grey Wet Trace organics in Sample 1.		1	SS	5		362													
			2	SS	5		361													
							360													
			3	SS	2		359													
358.8	Sandy SILT, trace clay Very loose Grey Wet		4	SS	2		358									NP	0 22 74 4			
4.3							357													
			5	SS	WH		356													
			6	SS	3		355													
354.4	Silty SAND Loose to compact Grey Wet		7	SS	5		354													
8.7							353													
			8	SS	12		352										0 74 (26)			
351.8	END OF BOREHOLE																			
11.3	Notes: 1. Water level at a depth of 1.5 m below ground surface (Elev. 361.6 m) upon completion of drilling. 2. Moved 1 m east of borehole and retrieved a Shelby Tube sample at 3.0 m depth below existing grade. Additionally, field vanes were obtained between 2.4 m and 4.3 m depth (Italics).																			

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 08/03/16 DATA INPUT:

PROJECT 1411523		RECORD OF BOREHOLE No PK-5		1 OF 2 METRIC										
G.W.P. 6365-14-00		LOCATION N 5566821.7; E 289195.7		ORIGINATED BY MR										
DIST HWY 105		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers		COMPILED BY AC										
DATUM GEODETIC		DATE February 9, 2016		CHECKED BY DAM										
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL	
365.4	GROUND SURFACE													
0.0	ASPHALT (90 mm)		1	AS	-*		365							
0.1	Sand, some gravel, trace to some silt (FILL) Dense Brown Frozen* to wet		2	AS	-*		364							
			3	SS	41*		363						13 77 (10)	
	Coarse gravel below 2.3 m depth.		4	SS	46		362							
361.7			5	SS	34		361							
3.7	Peat Loose Dark brown Wet		6	SS	5		360							
361.1							359						0 1 71 28	
4.3	CLAYEY SILT, trace sand Soft to stiff Grey Wet		7	SS	3		358							
	Silt laminations below 7.6 m depth.		8	SS	WH		357							
357.2							356							
8.2	SILT and SAND, trace clay Very loose Grey Wet		9	SS	WH		355						0 48 50 2	
	Approximately 0.7 m and 1.1 of heave inside augers at 9.1 m and 10.7 m depth, respectively.		10	SS	2		354							
353.7							353							
11.7	SAND, some silt, trace clay Very loose to compact Grey Wet		11	SS	4		352							
	Approximately 0.8 m to 1.9 m of heave inside augers above 15.2 m depth.		12	SS	4		351							

PROJECT 1411523			RECORD OF BOREHOLE No PK-5			2 OF 2 METRIC													
G.W.P. 6365-14-00			LOCATION N 5566821.7; E 289195.7			ORIGINATED BY MR													
DIST _____ HWY 105			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC													
DATUM GEODETIC			DATE February 9, 2016			CHECKED BY DAM													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL		
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	20 40 60	kN/m ³					
346.5	SAND, some silt, trace clay Very loose to compact Grey Wet		13	SS	WH		350										0 79 19 2		
18.9	END OF BOREHOLE						349												
	Note: 1. Water level at a depth of 2.8 m below ground surface (Elev. 362.6 m) upon completion of drilling. 2. Advanced DCPT 0.4 m east and 1.5 m south of Borehole PK-5.						348												
	Trace gravel below 18.3 m depth.		14	SS	8		347												
344.1	END OF DYNAMIC CONE PENETRATION TEST		15	SS	12		346												
21.3							345												

PROJECT 1411523			RECORD OF BOREHOLE No PK-6			1 OF 2 METRIC											
G.W.P. 6365-14-00			LOCATION N 5566842.6; E 289198.2			ORIGINATED BY MR											
DIST _____ HWY 105			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC											
DATUM GEODETIC			DATE February 10 and 11, 2016			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL					
362.9	GROUND SURFACE																
0.9	TOPSOIL (80 mm)		1	AS	-		362										
	CLAYEY SILT to SILTY CLAY		2	SS	2		361										
	Soft to stiff																
	Brown to grey																
	Frozen* to wet																
	Trace organics in Samples 1 and 2.																
			3	SS	4		360										
	Silt laminations below 3.0 m depth.																
			4	SS	WH		359										
							358										
357.3							357										
5.6	SILT and SAND, trace clay		5	SS	WH		356										
	Very loose																
	Grey																
	Wet																
			6	SS	1		355										
354.2							354										
8.7	SAND, trace to some silt, trace gravel, trace clay		7	SS	6		353										
	Loose to very dense																
	Grey																
	Wet																
	Approximately 0.4 m to 1.6 m of heave inside augers throughout.																
			8	SS	10		352										
			9	SS	24		351										
							350										
			10	SS	12		349										
							348										

Continued Next Page

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

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 08/03/16 DATA INPUT:

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

CSUD-MTO 001 1411523.GPJ GAL-MISS.GDT 08/03/16 DATA INPUT:



APPENDIX B

Laboratory Test Results



DRAFT DETAIL FOUNDATION REPORT PICKEREL CREEK CULVERT - SITE NO. 41-88/C

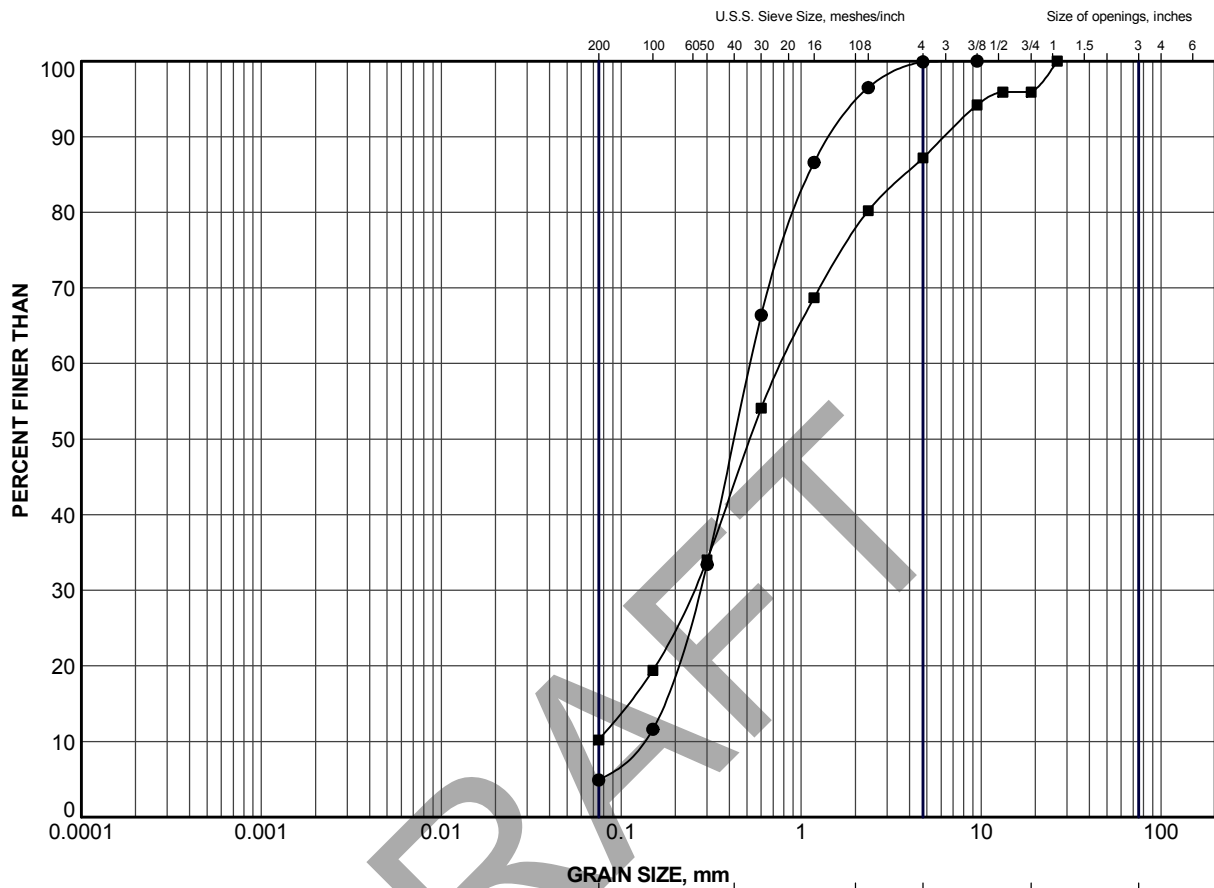
Table B1: Summary of Analytical Testing of Pickerel Creek Water Sample

Parameter	Units	Result
Chloride (CL)	mg/L	4.02
Sulphate (SO4)	mg/L	1.53
Conductivity (EC)	µS/cm	112
Resistivity	µohm-cm	8,929
pH	n/a	7.14

Notes:

1. Sample obtained on January 26, 2015.
2. Analytical testing carried out by ALS Canada Ltd.


Prepared by: AC
Checked by: DAM
Reviewed by: JMAC



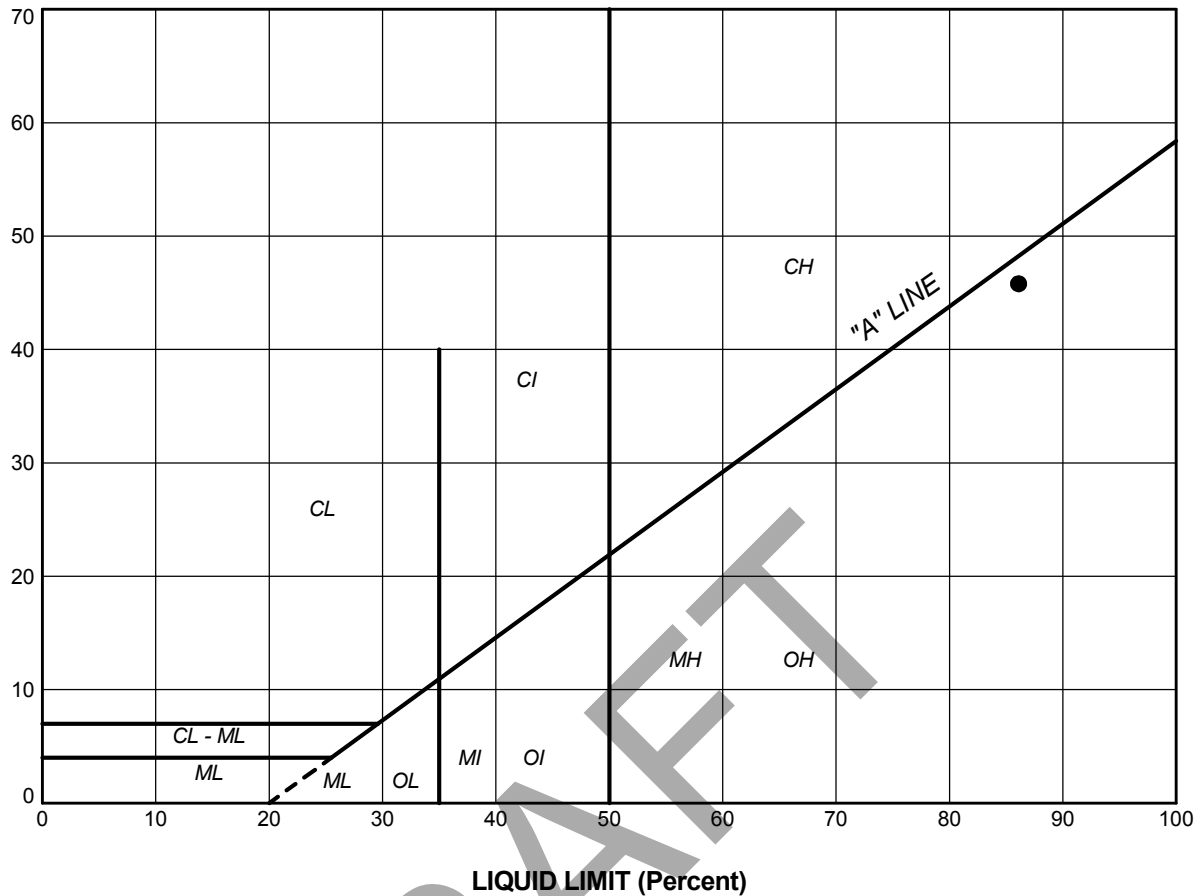
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PK-3	3	364.2
■	PK-5	3	363.6

PROJECT					
HIGHWAY 105 PICKEREL CREEK CULVERT STA 20+698					
TITLE					
GRAIN SIZE DISTRIBUTION SAND (FILL)					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016			
APPR	JMAC	Mar 2016			
 Golder Associates SUDBURY, ONTARIO			FIGURE B1		

PLASTICITY INDEX (Percent)




LIQUID LIMIT (Percent)

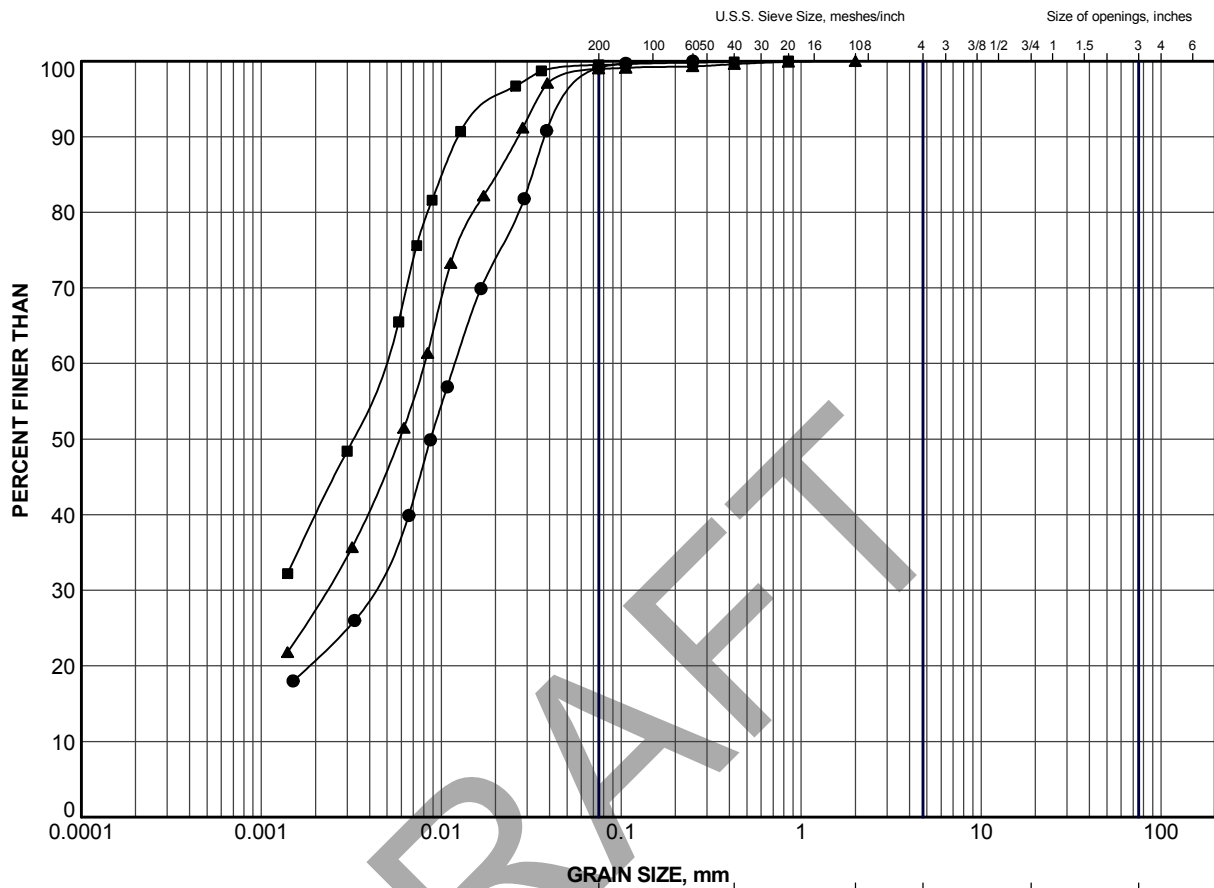
SOIL TYPE
C = Clay
M = Silt
O = Organic

PLASTICITY
L = Low
I = Intermediate
H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	PK-1	2	86.1	40.3	45.8

PROJECT					
HIGHWAY 105 PICKEREL CREEK CULVERT STA 20+698					
TITLE					
PLASTICITY CHART ORGANIC CLAY					
PROJECT No.		1411523		FILE No.	
DRAWN		J.J.L.		Mar 2016	
CHECK		DAM		Mar 2016	
APPR		JMAC		Mar 2016	
PROJECT No.		1411523		FILE No.	
DRAWN		J.J.L.		Mar 2016	
CHECK		DAM		Mar 2016	
APPR		JMAC		Mar 2016	
 Golder Associates SUDBURY, ONTARIO				FIGURE B2	



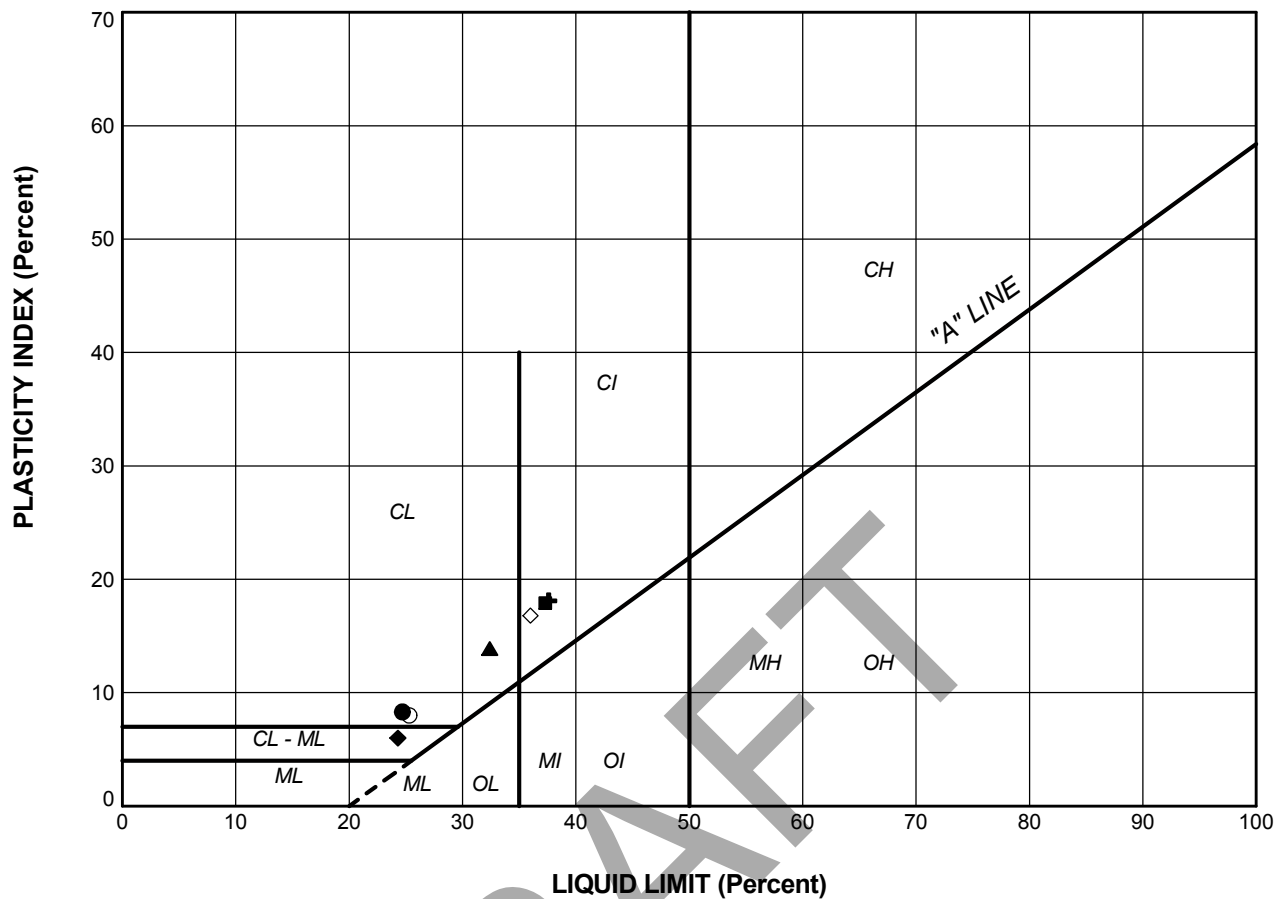
CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PK-1	4	358.7
■	PK-4	2	361.3
▲	PK-5	7	359.0


PROJECT					
HIGHWAY 105 PICKEREL CREEK CULVERT STA 20+698					
TITLE					
GRAIN SIZE DISTRIBUTION CLAYEY SILT to SILTY CLAY					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016			
APPR	JMAC	Mar 2016			
			FIGURE B3		

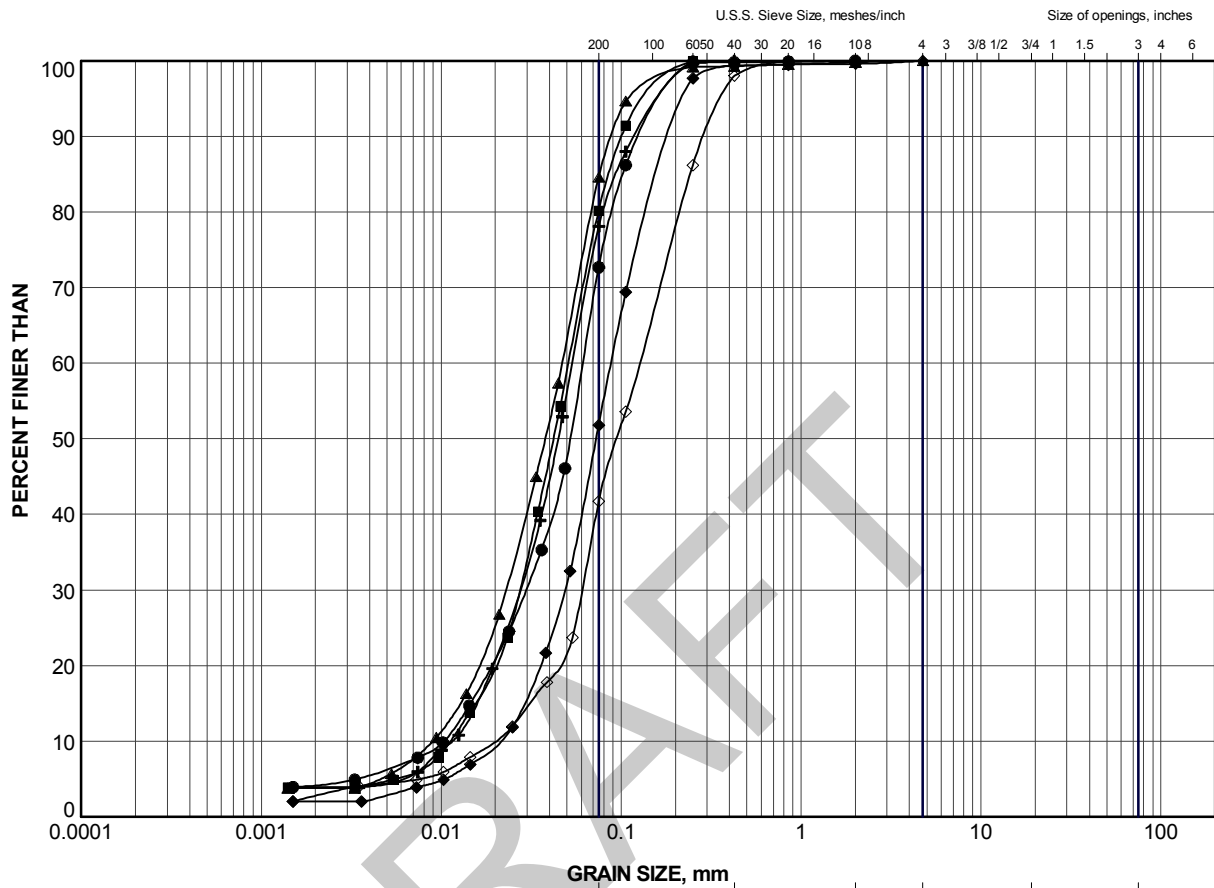




LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	PK-1	4	24.7	16.4	8.3
■	PK-2	6	37.3	19.4	17.9
▲	PK-3	8	32.4	18.5	13.9
+	PK-4	2	37.6	19.5	18.1
◆	PK-5	7	24.3	18.3	6.0
◇	PK-6	2	36.0	19.2	16.8
○	PK-6	3	25.3	17.3	8.0

PROJECT					
HIGHWAY 105 PICKEREL CREEK CULVERT STA 20+698					
TITLE					
PLASTICITY CHART CLAYEY SILT to SILTY CLAY					
PROJECT No.		1411523		FILE No.	
DRAWN		J.J.L.		Mar 2016	
CHECK		DAM		Mar 2016	
APPR		JMAC		Mar 2016	
 Golder Associates SUDBURY, ONTARIO				SCALE N/A REV.	
				FIGURE B4	



CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PK-1	5	357.2
■	PK-2	9	357.4
▲	PK-3	10	356.7
+	PK-4	4	358.2
◆	PK-5	10	354.4
◇	PK-6	6	355.0

PROJECT

HIGHWAY 105
PICKEREL CREEK CULVERT STA 20+698

TITLE

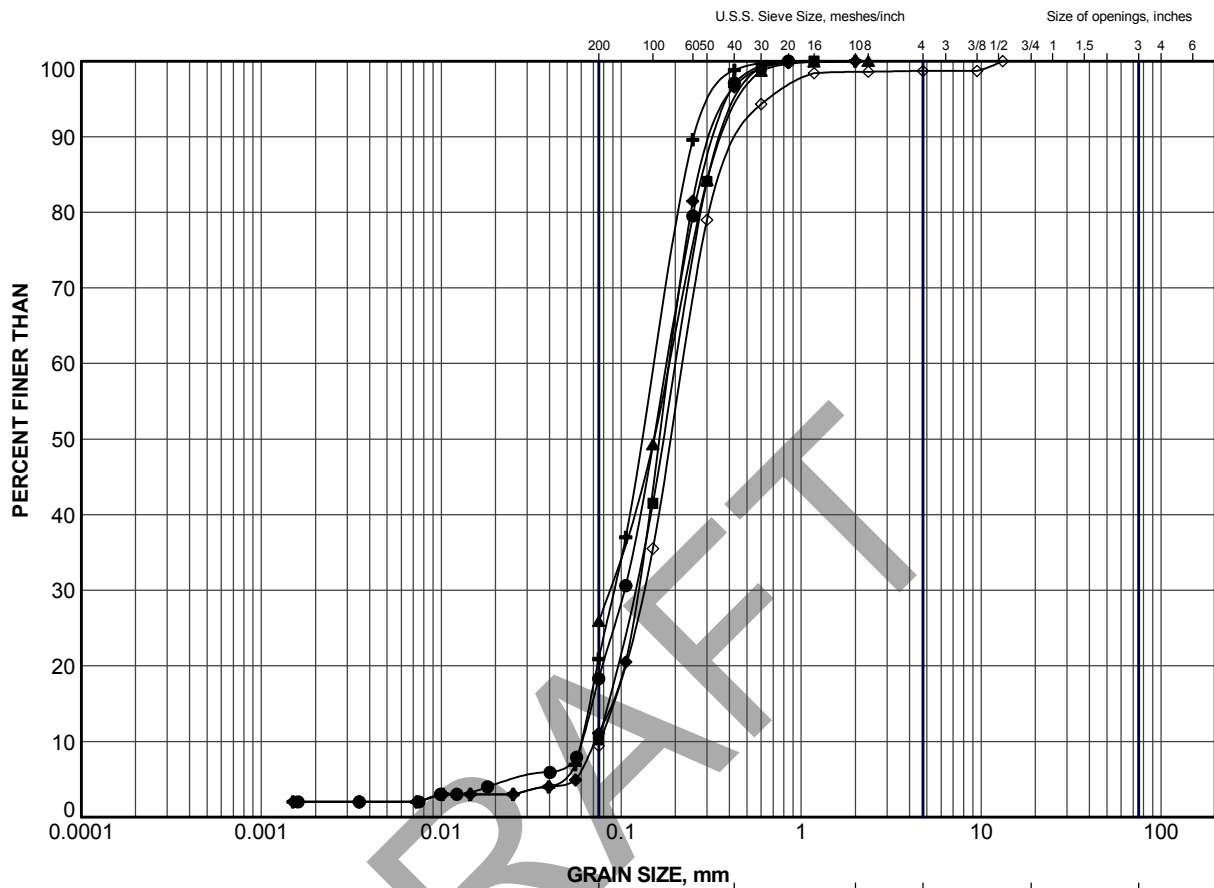
GRAIN SIZE DISTRIBUTION

SILT to SILT and SAND



Golder Associates
SUDBURY, ONTARIO

PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016	FIGURE B5		
APPR	JMAC	Mar 2016			



CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	PK-1	8	353.4
■	PK-2	11	354.3
▲	PK-4	8	352.1
+	PK-5	13	349.9
◆	PK-6	9	350.4
◇	PK-6	11	347.4

PROJECT					
HIGHWAY 105 PICKEREL CREEK CULVERT STA 20+698					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	JJL	Mar 2016	SCALE	N/A	REV.
CHECK	DAM	Mar 2016	FIGURE B6		
APPR	JMAC	Mar 2016			





APPENDIX C

Non Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

The Contactor shall be alerted to the presence of cobbles within the embankment fill material as encountered during borehole advancement. Considerations of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for sub-excavation and installation of the temporary roadway protection system and sheet-pile abutments.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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