



FINAL REPORT

**Foundation Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417
Ottawa, Ontario**

G.W.P. 4113-16-00

W.P. 4174-17-01

Submitted to:

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GEOCRES No. 31G-281

1899802-7000

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Longitude: -74.783229°

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Table of Contents

PART A – FOUNDATION INVESTIGATION

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
2.1 Site Description	1
2.2 Regional Geology.....	1
3.0 INVESTIGATION PROCEDURES	2
3.1 Current Investigation	2
4.0 DESCRIPTION OF SUBSURFACE CONDITIONS	3
4.1 General.....	3
4.2 Site Stratigraphy Overview.....	4
4.3 Highway 417 Embankment	4
4.3.1 Surface Cover / Surficial Materials.....	4
4.3.2 Pavement Structure and Embankment Fills	4
4.3.3 Clay	5
4.3.4 Glacial Till.....	5
4.4 Bedrock	5
4.5 Groundwater Conditions	6
4.6 Steel Corrosion and Sulphate Attack, Chemical Analysis	6
5.0 CLOSURE	7

TABLES

Table 1: Summary of Borehole Locations	3
Table 2: Summary of Bedrock Surface Depths and Elevations	6
Table 3: Steel Corrosion and Sulphate Attack, Chemical Analysis	6
Table 4: Site Class C Spectral Values for Subject Site	11
Table 5: Site Class E Spectral Values for Subject Site	12
Table 6: Unfactored Coefficients of Friction between Culvert Material and Founding Material	15

DRAWINGS

Drawings 1 and 2 – Structural Culvert 31X-0256/C1 Replacement Highway 417, Borehole Locations and Soil Strata

APPENDICES

APPENDIX A

Record of Boreholes

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes 19-7006A&B to 19-7010

Bedrock Core Photographs, Figures A1 to A10

APPENDIX B

Laboratory Test Results

Figure B1 – Grain Size Distribution Test Results – Sand and Gravel (Pavement Structure Fill)

Figure B2 – Grain Size Distribution Test Results – Sand and Gravel (Embankment Fill)

Figure B3 – Grain Size Distribution Test Results – Clay

Figure B4 – Plasticity Chart – Clay

Figure B5 – Grain Size Distribution Test Results – Silty Sandy Gravel to Silty Sand and Gravel (Till)

Figure B6 – Summary of Laboratory Compressive Strength Unconfined Compression Tests

APPENDIX C

Results of Chemical Analysis

Eurofins Environment Testing Report No. 1913683

APPENDIX D

Site Photographs

PART A

Foundation Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417
Ottawa, Ontario

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the detailed design of replacement of a structural culvert on Highway 417 and a non-structural culvert on Highway 416 under Assignment No. 7, of the Eastern Region Retainer Mega 10 (Assignment No. 4017-E-0019).

This report presents the results of the foundation investigation carried out for the replacement of Culvert Site 31X-0256/C1. The replacement of the structure is to be carried out in accordance with the current version of the Canadian Highway Bridge Design Code, S6-14 (CHBDC).

The scope of work for the foundation engineering services associated with the replacement was outlined in Golder's Change In Scope Memorandum dated May 8, 2019. The investigation program was developed to meet the requirements of Work Item Quote Form for Agreement No. 4016-E-0019, Assignment 7, as well as the structural requirements of Dillon to complete the design. The work has been carried out in accordance with Golder's Quality Control Plan for foundation engineering services for the project dated August 2019.

2.0 SITE DESCRIPTION AND GEOLOGY

2.1 Site Description

Site 31X-0256/C1 is located at Station 22+417 under the eastbound lanes of Highway 417, approximately 2 km west of Skye Road near Dunvegan, Ontario. The location of the culvert is shown on the Key Plan on Drawings 1 and 2. Site photographs showing the general conditions at the site are presented in Appendix D.

At this location, Highway 417 is a divided highway with two travel lanes in each direction separated by a wide, vegetated median ditch.

Information provided in the Work Order for this assignment indicates that the existing 38.7 m culvert is an ellipsoidal corrugated steel pipe culvert with a 3.33 m internal span and a height of 2.1 m. There are no headwalls at this location, however there is rip-rap placed around the both ends of the culvert. The elevation of the culvert invert ranges from 77.2 to 77.3 m and creek flow through the culvert is from south to north.

The base plan mapping provided by Dillon for this project and the ground surface elevations at the borehole locations surveyed during the field investigation indicate that the top of roadway elevation of Highway 417 in the vicinity of the culvert is 81.2 m and the top of culvert elevation is 79.3 m; corresponding to cover over the culvert from the shoulder to the top of the culvert of 1.9 m. Based on a visual observation at the time of the site investigation, no signs of foundation settlement were observed, and the existing slopes appear to be performing satisfactorily.

2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of Highway 417 lies within the minor physiographic region known as the Glengarry Till Plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

¹ Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.

The Glengarry Till Plain region is characterized as lowlands in which the surface is undulating to rolling, consisting of long morainic ridges and a few well-formed drumlins together with intervening clay flats. The deposit of sand and gravel till is very stony and contains large near surface boulders.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes that have recently occurred in the WQ zone are the 1935 Témiscaming event, which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event, which had a magnitude of 5.6.

3.0 INVESTIGATION PROCEDURES

3.1 Current Investigation

The field work for this investigation was carried out between July 12 and July 17, 2019 and included advancing six boreholes, numbered 19-7006A&B to 19-7010, with three located within the highway platform and one each at the culvert inlet and outlet. Borehole 19-7006B was advanced approximately 2.0 m north and east of 19-7006A as the drilling equipment became misaligned during drilling due to the proximity to the existing embankment slope.

Table 1 below further outlines the locations of the boreholes with respect to the existing culvert.

The boreholes were advanced using a combination of truck mounted (highway Boreholes 19-7008 to 19-7010) and track mounted (inlet/outlet Boreholes 19-7006A&B and 19-7007) drilling equipment. The drilling equipment was supplied and operated by George Downing Estate Drilling Limited of Hawkesbury, Ontario.

Traffic control required to close the driving lanes of Highway 417 while carrying out field operations was provided by Beacon Lite Ltd. of Ottawa, Ontario.

Soil samples in the boreholes were obtained at vertical sampling intervals of about 0.76 m, using a 50 mm outer diameter split-spoon sampler in general accordance with the procedure Standard Penetration Test (SPT) (ASTM D1586).

Bedrock core samples were obtained using NQ sized diamond drilling equipment in all boreholes except Borehole 19-7006A.

A monitoring well was installed in Borehole 19-7006B, to observe the stabilised groundwater level at the site. The monitoring well consists of a 32 mm outside diameter PVC tubing with a 1.5 m long slotted tip. The final groundwater level was measured in the well on September 3, 2019. The well was subsequently decommissioned according to Ontario MOE Regulation 903 (O.Reg 903) by a licenced well technician.

The boreholes were backfilled with bentonite within the bedrock and bentonite mixed with soil cuttings within the overburden. The boreholes were then capped with either asphaltic concrete cold patch or granular material, depending on the surrounding surface cover. The boreholes were backfilled in general accordance with the intent of O.Reg 903, as amended. The site conditions were restored following completion of the field work.

The field work was supervised on a full-time basis by members of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in-situ testing operations, logged the boreholes and examined and cared for the samples. The soil and bedrock samples were identified in the field, placed in labelled containers, and transported to Golder's laboratory in Ottawa for further examination and testing. Index and classification tests consisting of water content determinations, grain size distribution analyses, and Atterberg Limits testing were carried out on selected soil samples at Golder's Ottawa laboratory. Unconfined compressive strength testing was carried out on select samples of the limestone bedrock at Golder's Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

Two soil samples were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

The borehole locations and elevations were surveyed by Golder using a Trimble R8 GPS unit referenced to the NAD83 CSRS CBNv6-2010.0 MTM Zone 8 geodetic datum. The borehole locations, including northing and easting coordinates, ground surface elevations, and drilled depths are summarized in Table 1.

Table 1: Summary of Borehole Locations

Borehole	Location	NAD83 CSRS CBNv6-2010.0 MTM Zone 8		Ground Surface Elevation (m)	Drilled Depths (m)
		Northing (m)	Easting (m)		
19-7006A	Culvert Inlet	5028694.4	204328.3	80.5	6.1 ¹
19-7006B	Culvert Inlet	5028696.5	204329.0	80.5	8.8
19-7007	Culvert Outlet	5028712.3	204315.2	80.3	9.2
19-7008	Highway 417 EBL East of Culvert	5028722.4	204338.2	81.2	10.6
19-7009	Highway 417 EBL East of Culvert	5028701.2	204327.8	81.2	10.2
19-7010	Highway 417 EBL West of Culvert	5028688.6	204306.5	81.2	10.1

Notes: ¹Borehole terminated at auger refusal

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

The subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in-situ testing from the investigation are given on the Record of Borehole, and Drillhole sheets presented in Appendix A. The results of the laboratory testing carried out during the investigation are presented on the Record of Borehole sheets as well as on Figures B1 to B6 in Appendix B. The borehole locations and the interpreted stratigraphic profiles projected along the highway and along the alignment of the existing culvert are provided on Drawings 1 and 2, respectively.

Photographs of the core recovered from the underlying bedrock are shown on Figures A1 to A10, provided in Appendix A. The results of basic chemical analysis completed on select soil samples are provided in Appendix C.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic sections from Drawings 1 and 2, are inferred from observations of the drilling progress and noncontinuous 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.

4.2 Site Stratigraphy Overview

At the boreholes, the subsurface conditions generally consist of Portland Cement Concrete (PCC), asphaltic concrete pavement or topsoil, overlying fill materials, overlying native clay, which in turn overlies glacial till, all underlain by limestone bedrock.

The groundwater level was measured at the site at a depth of 2.9 m, corresponding to Elevations 77.6 m.

A more detailed description of the overburden soil deposits, and bedrock geology conditions encountered during the field investigation is provided in the following sections.

4.3 Highway 417 Embankment

4.3.1 Surface Cover / Surficial Materials

Boreholes 19-7008 to 19-7010 were advanced through the Highway 417 pavement structure. Both PCC surface (Boreholes 19-7008 and 19-7010) and asphaltic concrete (Borehole 19-7009) were encountered at the ground surface of the highway boreholes.

The thickness of the PCC pavement at Boreholes 19-7008 and 19-7010 was 300 mm. The thickness of the asphaltic concrete pavement at Borehole 19-7009 was 100 mm.

Topsoil with thicknesses of 0.2 and 0.6 m was encountered at surface at Boreholes 19-7006A&B and 19-7007, respectively.

4.3.2 Pavement Structure and Embankment Fills

Pavement structure fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the PCC concrete or asphaltic concrete pavement at the highway borehole locations. The top of this layer was encountered at elevations ranging from 80.9 to 81.1 m. The thickness of the pavement structure fill ranges from 1.4 to 2.0 m. The SPT N values ranged from 33 to 71 blows per 0.3 m of penetration, indicating a dense to very dense state of packing. The measured moisture content of one sample tested was 5 percent. The results of grain size analysis testing carried out on a single sample of this material are provided on Figure B1 in Appendix B.

Clayey silt fill was encountered underlying the surficial topsoil at the boreholes advanced at the culvert ends and below the pavement structure fill at Borehole 19-7010. The top of this layer was encountered at elevations ranging from 79.5 to 80.3 m. The thickness of the clayey silt fill ranges from 0.7 to 2.0 m. The SPT N values ranged from 4 to 33 blows per 0.3 metres of penetration, but were more typically 5 to 13, indicating a stiff to very stiff consistency.

Fill consisting predominantly of sand and gravel with varying amounts of silt was encountered below the clayey silt fill at the inlet/outlet boreholes and below the pavement structure fill at Borehole 19-7009. The top of this layer was encountered at elevations ranging from 78.4 to 79.7 m. The thickness of the fill ranges from 0.8 to 1.6 m. The SPT N values ranged from 4 to 20 blows per 0.3 m of penetration, but were more typically 7 to 15, indicating a loose to compact state of packing. The measured moisture contents of the two samples tested were 3 and 4 percent. The results of grain size analysis testing carried out on two samples of this material are provided on Figure B2 in Appendix B.

4.3.3 Clay

A clay deposit was encountered beneath the fill at all the boreholes.

The upper portion of the deposit at Boreholes 19-7007 to 19-7010 has been weathered to a stiff crust. The top of the crust was encountered at elevations ranging from 78.2 to 78.9 m. The thickness of the crust ranges from 0.8 to 1.7 m and the SPT N values ranged from 4 to 10 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency.

The moisture content of the samples of the clay crust tested ranged from 44 to 72 percent. The results of grain size analysis testing carried out on two samples of this material are illustrated on Figure B3 in Appendix B. The results of Atterberg Limits testing completed on three samples of the weathered crust indicate liquid limits ranging from 76 to 100, plastic limits ranging from 21 to 29 and plasticity indices ranging from 47 to 56. The Atterberg Limits analysis results are illustrated on Figure B4 in Appendix B and indicate a clay with high plasticity (CH).

The clay below the depth of weathering at Boreholes 19-7007 to 19-7010 and below the fill material at Boreholes 19-7006A&B is grey. The top of the grey clay was encountered at elevations ranging from 76.8 to 77.6 m. The thickness of the grey clay ranges from 1.2 to 3.0 m. The SPT N values ranged from weight of hammer (WH) to 3 blows per 0.3 m of penetration. In-situ shear vane test results indicate the undrained shear strength of the grey unweathered clay ranges from 20 to 58 kPa, but more typically 23 to 38 kPa, indicating a soft to firm consistency. Based on the ratio of the measured in-situ natural shear strength to the remolded shear strength ranging from 4 to 6, the clay is classified as medium sensitive to sensitive.

The moisture content of the samples tested ranged from 51 to 97 percent. The results of grain size analysis testing conducted on four samples of the grey clay are illustrated on Figure B3 in Appendix B. The results of Atterberg Limits testing completed on five samples of the grey clay indicate liquid limits ranging from 57 to 99, plastic limits ranging from 16 to 24 and plasticity indices ranging from 50 to 75. The Atterberg Limits analysis results are illustrated on Figure B4 in Appendix B and indicate a clay with high plasticity (CH).

4.3.4 Glacial Till

Glacial till was encountered below the clay in all boreholes at elevations ranging from 74.2 to 75.9 m. The glacial till generally consists of a heterogeneous mixture of cobbles and boulders within a soil matrix of sand, gravel and silt with trace amounts of clay. The thickness of the till layer at the borehole locations ranges from 0.4 to 1.2 m.

The SPT N values ranged from 14 to greater than 100 blows per 0.3 m of penetration, but more typically 14 to 31, indicating a compact to dense state of packing. The higher blow count (i.e., greater than 100) noted on the Record of Boreholes for the till may have been influenced by the presence of cobbles or boulders within the till or the presence of bedrock, rather than the state of packing of the soil matrix.

The measured moisture content of the three samples tested ranged from 9 to 20 percent. The results of grain size analysis testing carried out on three samples of this material are provided on Figure B5 in Appendix B.

4.4 Bedrock

The overburden materials are underlain by limestone bedrock with shale partings and interbeds.

Bedrock core samples were obtained using NQ sized diamond drilling equipment in all boreholes, except Borehole 19-7006A.

Table 2 summarizes the depths and the elevations of the bedrock surface as encountered at the borehole locations.

Table 2: Summary of Bedrock Surface Depths and Elevations

Borehole	Location	Existing Ground Surface Elevation (m)	Depth to Bedrock Surface (m)	Bedrock Surface Elevation (m)
19-7006B	Culvert Inlet	80.5	6.0	74.5
19-7007	Culvert Outlet	80.3	5.1	75.2
19-7008	Highway 417 EBL East of Culvert	81.2	7.4	73.8
19-7009	Highway 417 EBL East of Culvert	81.2	7.1	74.1
19-7010	Highway 417 EBL West of Culvert	81.2	6.5	74.7

In general, the bedrock encountered was slightly weathered to fresh and medium bedded. A thin layer of weathered bedrock was encountered at Borehole 19-7009. Thin shale interbeds were present in the bedrock core. Rock Quality Designation (RQD) values measured on recovered bedrock core samples ranged from about 23 to 100 percent, but were more typically 52 to 93 percent, indicating a fair to excellent rock quality.

Results of unconfined compressive strength (UCS) testing carried out on three bedrock core samples are presented on Figure B6 provided in Appendix B. The samples tested had UCS values ranging from 55 to 128 MPa, indicating a strong to very strong bedrock.

4.5 Groundwater Conditions

A monitoring well was installed in Borehole 19-7006B, to observe the stabilized groundwater level at the site. The final groundwater level was measured on September 3, 2019 at a depth of 2.9 m, corresponding to Elevation 77.6 m.

The groundwater level in the area of the culvert is expected to reflect the creek water level.

It is expected that the groundwater levels will be subject to fluctuations both seasonally and as a result of precipitation events.

4.6 Steel Corrosion and Sulphate Attack, Chemical Analysis

Two soil samples were submitted to Eurofins Environment Testing for chemical analysis related to the potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The test results are provided in Appendix C and are summarized in Table 3.

Table 3: Steel Corrosion and Sulphate Attack, Chemical Analysis

Borehole	Sample	Sample Depth (m)	Sample Type	Chloride (%)	Sulphate (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
19-7006B	SS5	3.5	Clay	0.067	<0.01	0.64	8.1	1,570
19-7009	SS3	1.9	Fill	0.006	<0.01	0.16	8.6	6,130

5.0 CLOSURE

This report was prepared by Mr. Kenton Power, P.Eng. It was reviewed by Mr. Bill Cavers, P.Eng., a Senior Geotechnical Engineer and Associate with Golder. Mr. Fintan Heffernan, P.Eng. a Senior Consultant with Golder and the Designated MTO Foundations Contact for this project, carried out an independent quality control review of this report.

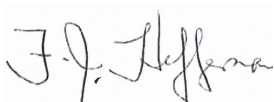
Golder Associates Ltd.



Kenton C. Power, P.Eng.
Geotechnical Engineer



William Cavers, P.Eng
Associate, Senior Geotechnical Engineer



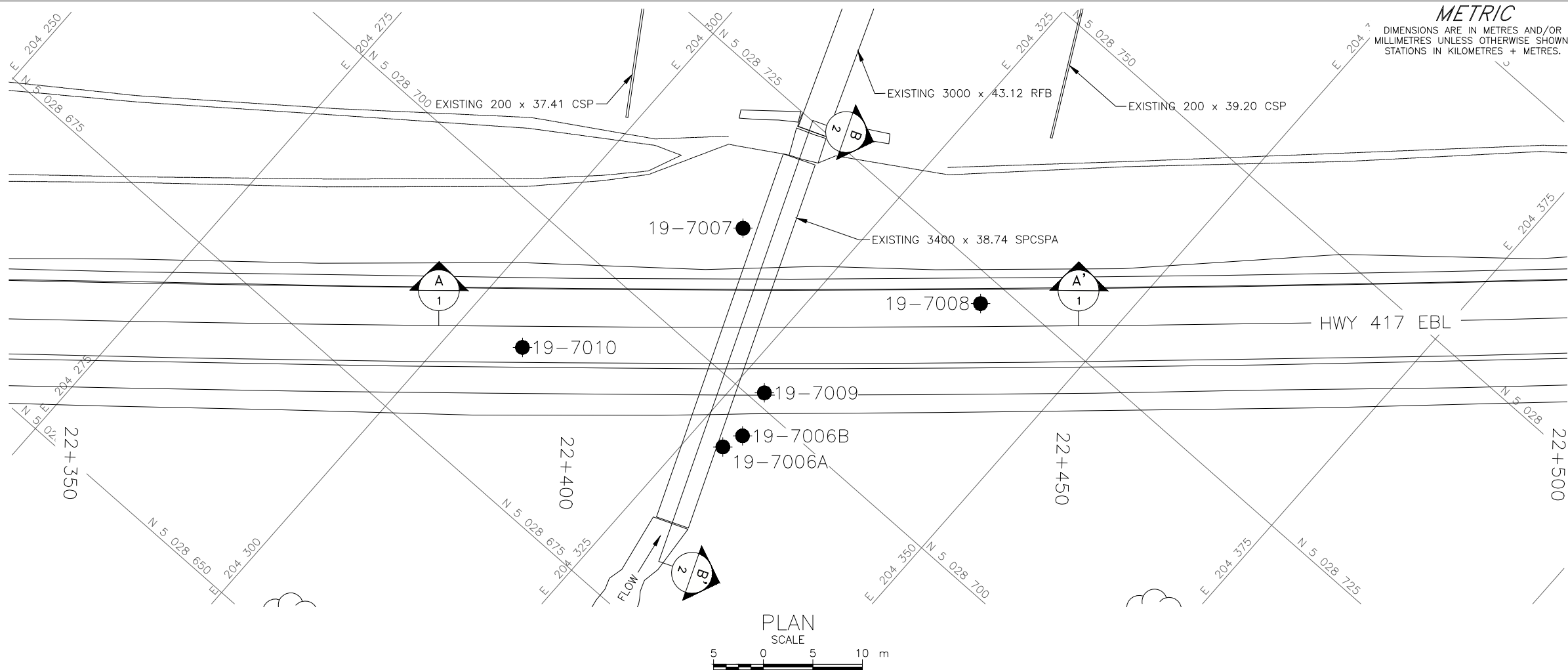
Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact



KCP/WC/FJH/hdw

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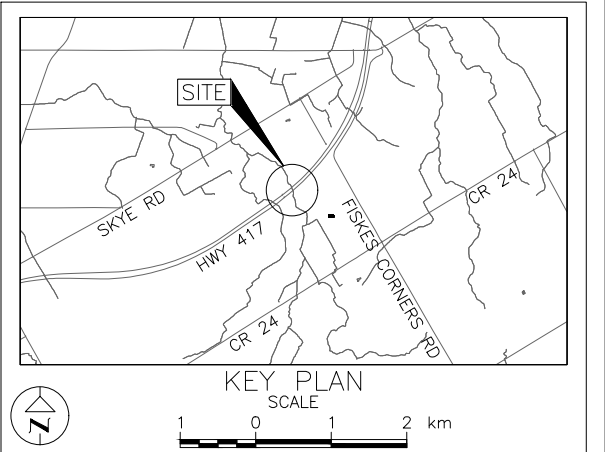


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.4174-17-01

REPLACEMENT OF CULVERT
31X-0256/C1
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.391088 LONG. -74.783229

SHEET



LEGEND

N

16

100%

Borehole - Current Investigation

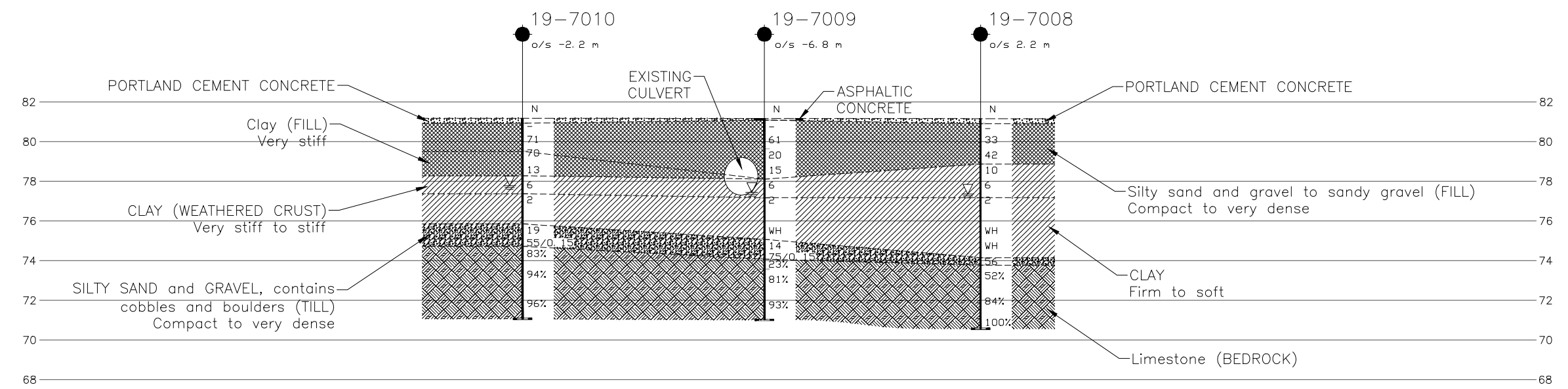
Standard Penetration Test Value

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

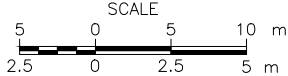
Rock Quality Designation (RQD)

WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 8			
No.	ELEVATION	NORTHING	EASTING
19-7006A	80.5	5028694.4	204328.3
19-7006B	80.5	5028696.5	204329.0
19-7007	80.3	5028712.3	204315.2
19-7008	81.2	5028722.4	204338.2
19-7009	81.2	5028701.2	204327.8
19-7010	81.2	5028688.6	204306.5



PROFILE A-A' ALONG HWY 417 EBL



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.

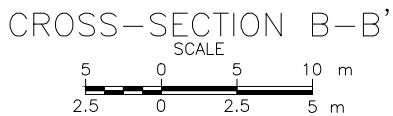
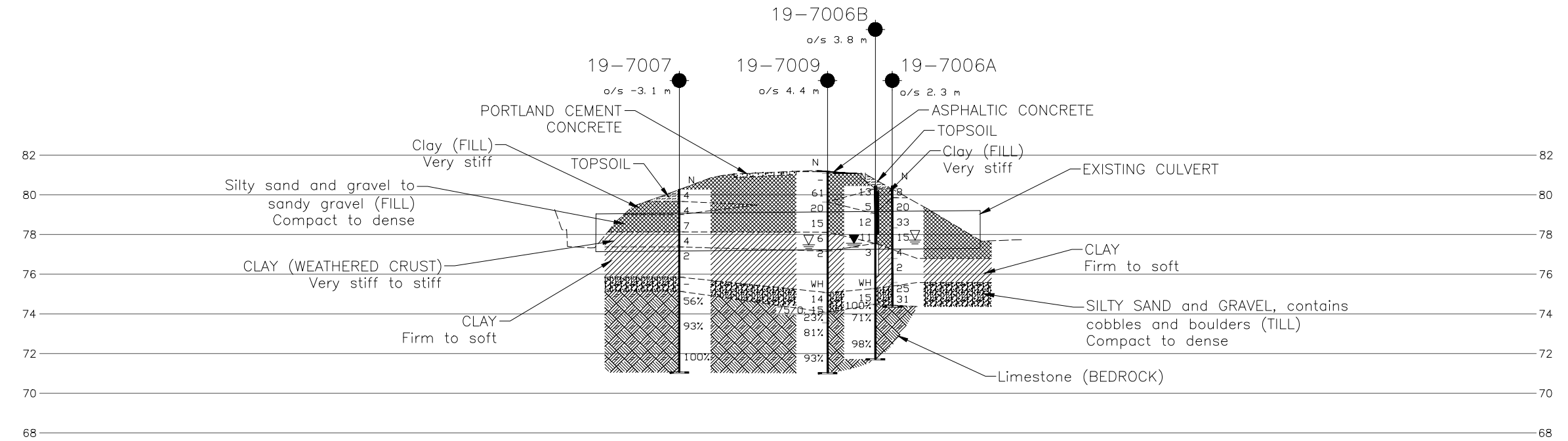
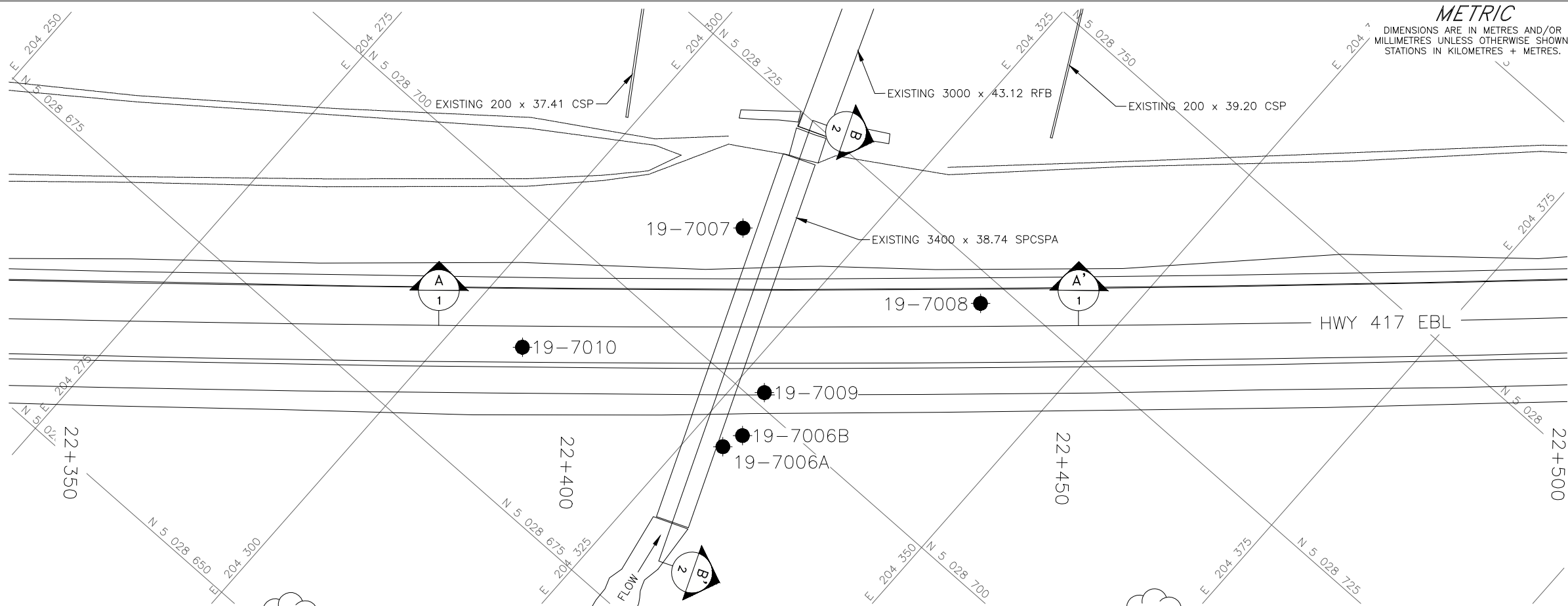
Although not shown it is anticipated that backfill material exists around the culvert.

REFERENCE

Base plans provided in digital format by Dillon Consulting Limited, drawing file no. ACAD-388-417-18-1.dwg, received JULY 22, 2019.

NO.	DATE	BY	REVISION
Geocres No. 31G-281			
HWY. 417		PROJECT NO. 1899802-7000	
SUBM'D. KCP		CHKD. KCP	DATE: 3/30/2020
DRAWN: JM		CHKD. FJH	APPD. FJH
DIST. EASTERN		SITE: 31X-0256/C1	
DWG. 1			

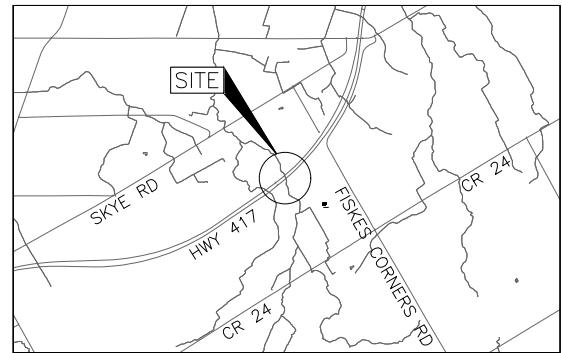




METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No.4174-17-01

REPLACEMENT OF CULVERT
31X-0256/C1
HIGHWAY 417
BOREHOLE LOCATIONS AND SOIL STRATA
LAT. 45.391088 LONG. -74.783229



KEY PLAN
SCALE



LEGEND

- Borehole - Current Investigation
- ⬮ Seal
- ⬮ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ≡ WL in piezometer, measured on 09 03, 2019
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES NAD 83 (CSRS)/MTM ZONE 8			
No.	ELEVATION	NORTHING	EASTING
19-7006A	80.5	5028694.4	204328.3
19-7006B	80.5	5028696.5	204329.0
19-7007	80.3	5028712.3	204315.2
19-7008	81.2	5028722.4	204338.2
19-7009	81.2	5028701.2	204327.8
19-7010	81.2	5028688.6	204306.5

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.

Although not shown it is anticipated that backfill material exists around the culvert.

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NO.	DATE	BY	REVISION
Geocres No. 31G-281			
HWY. 417		PROJECT NO. 1899802-7000	
SUBM'D. KCP		DATE: 3/30/2020	
DRAWN: JM		APPD. FJH	
CHKD. KCP		SITE: 31X-0256/C1	
CHKD. FJH		DWG. 2	



APPENDIX A

Record of Boreholes

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes 19-7001 to 19-7005 and 19-7015

Bedrock Core Photographs, Figures A1 to A10

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (<i>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , trace fines)

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An 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 (u) and sleeve friction (f_s) are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL, w_p	plastic limit
LL, 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
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
Y	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

Term	SPT 'N' (blows/0.3m) ²
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

3. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

4. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N' ^{1,2} (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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

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

(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 $= (w_l - w_p)$
NP	non-plastic
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 $= \sigma'_p / \sigma'_{vo}$

(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

Notes: 1
2

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

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		RECORD OF BOREHOLE				No 19-7006A		SHEET 1 OF 1		METRIC							
G.W.P. 1899802-7000		LOCATION		N 5028694.4; E 204328.3 NAD 83 MTM ZONE 8 (LAT. 45.391009; LONG. -74.783152)				ORIGINATED BY AP/DG									
DIST Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)				COMPILED BY ZS									
DATUM Geodetic		DATE		July 15, 2019				CHECKED BY KCP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
80.5	GROUND SURFACE																
0.0	(SM) Silty sand, contains rootlets (TOPSOIL)																
0.2	Brown Moist		1	SS	8												
79.9	(CL) Clayey silt, some gravel, contains rootlets (FILL)																
0.6	Firm Brown Moist		2	SS	20												
	(CI) SILTY CLAY, trace sand, slightly fissured (FILL)																
	Very stiff Grey-brown		3	SS	33												
78.4																	
2.1	(SM/GM) Sand and gravel, trace silt (FILL)																
	Compact to loose Brown Moist to wet		4	SS	15												
			5	SS	4												
76.8																	
3.7	(CH) CLAY Firm Grey with black mottling		6	SS	2												
75.6																	
4.9	(SM/GM) SILTY SAND and GRAVEL, trace clay, contains cobbles (TILL)		7	SS	25												
	Compact to dense Grey Wet		8	SS	31												
74.4																	
6.1	END OF BOREHOLE																
NOTES:																	
1. Water level in open borehole at a depth of 2.4 m below ground surface (Elev. 77.8 m), upon completion of drilling																	

PROJECT		1899802-7000		RECORD OF BOREHOLE No 19-7006B		SHEET 1 OF 2		METRIC								
G.W.P.		4174-17-01		LOCATION		N 5028696.5; E 204329.0 NAD 83 MTM ZONE 8 (LAT. 45.390990; LONG. -74.783143)		ORIGINATED BY								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core		COMPILED BY								
DATUM		Geodetic		DATE		July 15, 2019		CHECKED BY								
								KCP								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
80.5	GROUND SURFACE															
0.0	(SM) Silty sand, contains rootlets (TOPSOIL)															
0.2	(CL) Clayey silt (FILL) Very stiff to stiff Brown Moist		1	SS	13											
			2	SS	5											
79.1																
1.4	(SM/GM) Sand and gravel, trace silt (FILL) Compact Brown Moist		3	SS	12											46 46 (8)
			4	SS	11											
77.6																
2.9	(CH) CLAY, contains silt seams Firm to soft Grey-brown to grey, with black mottling		5	SS	3											
			6	SS	WH											0 4 14 82
75.3																
5.2	(SM/GM) SILTY SAND and GRAVEL, contains bedrock pieces (TILL) Compact Grey-brown Wet		7	SS	15											
74.5																
6.0	Limestone (BEDROCK)		1	RC	REC 100%											RQD = 100%
	Bedrock cored from depths 6.0 m to 8.8 m		2	RC	REC 100%											RQD = 71%
	For bedrock coring detail refer to Record of Drillhole 19-7006B															
			3	RC	REC 100%											RQD = 98%
71.8																
8.8	END OF BOREHOLE															
	NOTES: 1. Water level in well screen at a depth of 2.9 m below ground surface (Elev. 77.6 m), measured on September 3, 2019															

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PROJECT: 1899802-7000

RECORD OF DRILLHOLE: 19-7006B

SHEET 2 OF 2

LOCATION: N 5028696.5 ;E 204329.0

DRILLING DATE: July 15, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: LMC Track Mount

DRILLING CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																		FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT INDEX PER	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec			WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
							TOTAL CORE %	SOLID CORE %			DIP W/L CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	C 10 0	C 10 0	C 10 0	W1	W2	W3	W4		W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
6	Rotary Drill NQ Core	Continued from Record of Borehole 19-7006B		74.48																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

DEPTH SCALE

1 : 50



GOLDER

LOGGED: AP/DG

CHECKED: KCP

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PROJECT		1899802-7000		RECORD OF BOREHOLE No 19-7007		SHEET 1 OF 2		METRIC								
G.W.P.		4174-17-01		LOCATION		N 5028712.3; E 204315.2 NAD 83 MTM ZONE 8 (LAT. 45.391149; LONG. -74.783322)		ORIGINATED BY								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core		COMPILED BY								
DATUM		Geodetic		DATE		July 12, 2019		CHECKED BY								
								KCP								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
80.3	GROUND SURFACE						20	40	60	80	100	W _p	W	W _L		
0.0	(CL) Clayey silt, trace gravel, contains rootlets (TOPSOIL) Dark brown		1	SS	4											
79.7																
0.6	(CL) Clayey silt, trace sand and gravel, contains rootlets (FILL) Grey-brown		2	SS	4											
79.0																
1.3	(GM/SM) Gravel and sand, some silt (FILL) Loose Brown Moist		3	SS	7											51 39 (10)
78.2																
2.1	(CH) CLAY, contains sand seams (WEATHERED CRUST) Stiff Grey-brown mottling		4	SS	4											0 1 30 69
77.4																
2.9	(CH) CLAY Stiff to firm Grey		5	SS	2											0 17 19 64
75.9																
4.4	(GM/SM) Silty GRAVEL and SAND, contains cobbles and boulders (TILL) Grey		6	RC	-											
75.2																
5.1	Limestone (BEDROCK)															
	Bedrock cored from depths 5.1 m to 9.2 m		1	RC	REC 100%											RQD = 56%
	For bedrock coring detail refer to Record of Drillhole 19-7007															
			2	RC	REC 100%											RQD = 93%
			3	RC	REC 100%											RQD = 100%
71.1																
9.2	END OF BOREHOLE															

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SHEET 2 OF 2

DATUM: Geodetic

DRILLING CONTRACTOR: Downing Drilling

[illegible]

DEPTH SCALE

1 : 50




GOLDER

LOGGED: AP/DG

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IM\MTOWHWY417BRIDGES\02_DATA\GIN\T1899802\1899802.GPJ GAL-MISS.GDT 20-3-19 ZS

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

PROJECT		RECORD OF BOREHOLE No 19-7008				SHEET 2 OF 3		METRIC									
G.W.P. 4174-17-01		LOCATION N 5028722.4; E 204338.2 NAD 83 MTM ZONE 8 (LAT. 45.391243; LONG. -74.783031)				ORIGINATED BY DG											
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core				COMPILED BY ZS											
DATUM Geodetic		DATE July 17, 2019				CHECKED BY KCP											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
	Limestone (BEDROCK)		-	RC			71										GR SA SI CL
70.6			-	RC	REC 100%												RQD = 100%
10.6	END OF BOREHOLE																RQD = 100%
	NOTES: 1. Water level in open borehole at 3.8 m depth below ground surface (Elev. 77.4 m), upon completion of drilling.																

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTOWHY417BRIDGES\02_DATA\GINTV1899802\1899802.GPJ GAL-GTA.GDT 20-3-19 ZS

PROJECT: 1899802-7000

RECORD OF DRILLHOLE: 19-7008

SHEET 3 OF 3

LOCATION: N 5028722.4 ;E 204338.2

DRILLING DATE: July 17, 2019

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																		FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							TOTAL CORE %	SOLID CORE %			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 ⁻⁹	10 ⁻⁸	10 ⁻⁷	10 ⁻⁶	W1	W2	W3		W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
		Continued from Record of Borehole 19-7008		73.77																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: DG

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417\BRIDGES\02_DATA\GINT\1899802\1899802.GPJ GAL-MISS.GDT 20-3-19 ZS

GTA-MTO 001 N:\ACTIVE\SPATIAL IM\TOIHWY417BRIDGES\02 DATA\GINT\1899802\1899802.GPJ GAL-GTA.GDT 20-3-19 ZS

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

PROJECT		RECORD OF BOREHOLE				No 19-7009		SHEET 2 OF 3		METRIC						
G.W.P. 1899802-7000		LOCATION		N 5028701.2; E 204327.8 NAD 83 MTM ZONE 8 (LAT. 45.391051; LONG. -74.783159)				ORIGINATED BY AP/DG								
DIST Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core				COMPILED BY ZS								
DATUM Geodetic		DATE		July 16, 2019				CHECKED BY KCP								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
71.1			3	RC												GR SA SI CL
10.2	END OF BOREHOLE															RQD = 93%
	NOTES: 1. Water level in open borehole at 3.7 m depth below ground surface (Elev. 77.5 m), upon completion of drilling.															

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMTO\HWY417BRIDGES\02_DATA\GINTV1899802\1899802.GPJ GAL-GTA.GDT 20-3-19 ZS

SHEET 3 OF 3

DATUM: Geodetic

DRILLING CONTRACTOR: Downing Drilling

[illegible]

DEPTH SCALE

1 : 50



GOLDER

LOGGED: AP/DG

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL_IMMTO\HWY417BRIDGES\02_DATA\GINT\1899802\1899802.GPJ GAL-MISS.GDT 20-3-19 ZS

PROJECT		1899802-7000		RECORD OF BOREHOLE No 19-7010		SHEET 1 OF 3		METRIC									
G.W.P.		4174-17-01		LOCATION		N 5028688.6; E 204306.5 NAD 83 MTM ZONE 8 (LAT. 45.390934; LONG. -74.783429)		ORIGINATED BY		AP/DG							
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core		COMPILED BY		ZS							
DATUM		Geodetic		DATE		July 16, 2019		CHECKED BY		KCP							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
81.2	GROUND SURFACE							20	40	60	80	100					
0.0	PORTLAND CEMENT CONCRETE						81										
0.3	(SM/GM) Silty sand and gravel, contains cobbles (FILL) Very dense Grey		1	GS	-		80										
			2	SS	71												
79.5	(CH) Clay, some gravel (FILL) Very stiff Brown Moist		3	SS	70		79										
			4	SS	13												
78.3	(CH) CLAY, trace sand, slightly fissured (WEATHERED CRUST) Very stiff Grey-brown, with black mottling		5	SS	6		78										
77.4	(CH) CLAY Firm to soft Grey-brown, with black mottling		6	SS	2		77										
								X	+								
								X		+							
75.9	(GM/SM) SILTY SAND and GRAVEL (TILL) Compact Grey Wet		7	SS	19		76										
			8	SS	55/0.15		75										36 39 (25)
74.7	Limestone (BEDROCK) Bedrock cored from depths 6.5 m to 10.1 m For bedrock coring detail refer to Record of Drillhole 19-7010		1	RC	REC 100%		74										RQD = 83%
			2	RC	REC 100%		73										RQD = 94%
			3	RC	REC 100%		72										RQD = 96%

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IM\MTD\HWY417BRIDGES\02_DATA\GINTV1899802\1899802.GPJ GAL-GTA.GDT 20-3-19 ZS

PROJECT		RECORD OF BOREHOLE				No 19-7010		SHEET 2 OF 3		METRIC						
G.W.P. 1899802-7000		LOCATION		N 5028688.6; E 204306.5 NAD 83 MTM ZONE 8 (LAT. 45.390934; LONG. -74.783429)				ORIGINATED BY AP/DG								
DIST Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Rotary Drill, NQ Core				COMPILED BY ZS								
DATUM Geodetic		DATE		July 16, 2019				CHECKED BY KCP								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
71.1 10.1	END OF BOREHOLE	X	3	RC												GR SA SI CL ROD = 96%
	NOTES: 1. Water level in open borehole at 3.4 m depth below ground surface (Elev. 77.8 m), upon completion of drilling.															

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMITOHWY417BRIDGES\02_DATA\GINTV1899802\1899802.GPJ GAL-GTA.GDT 20-3-19 ZS

SHEET 3 OF 3

DATUM: Geodetic

DRILLING CONTRACTOR: Downing Drilling

[illegible]

DEPTH SCALE

1 : 50



GOLDER

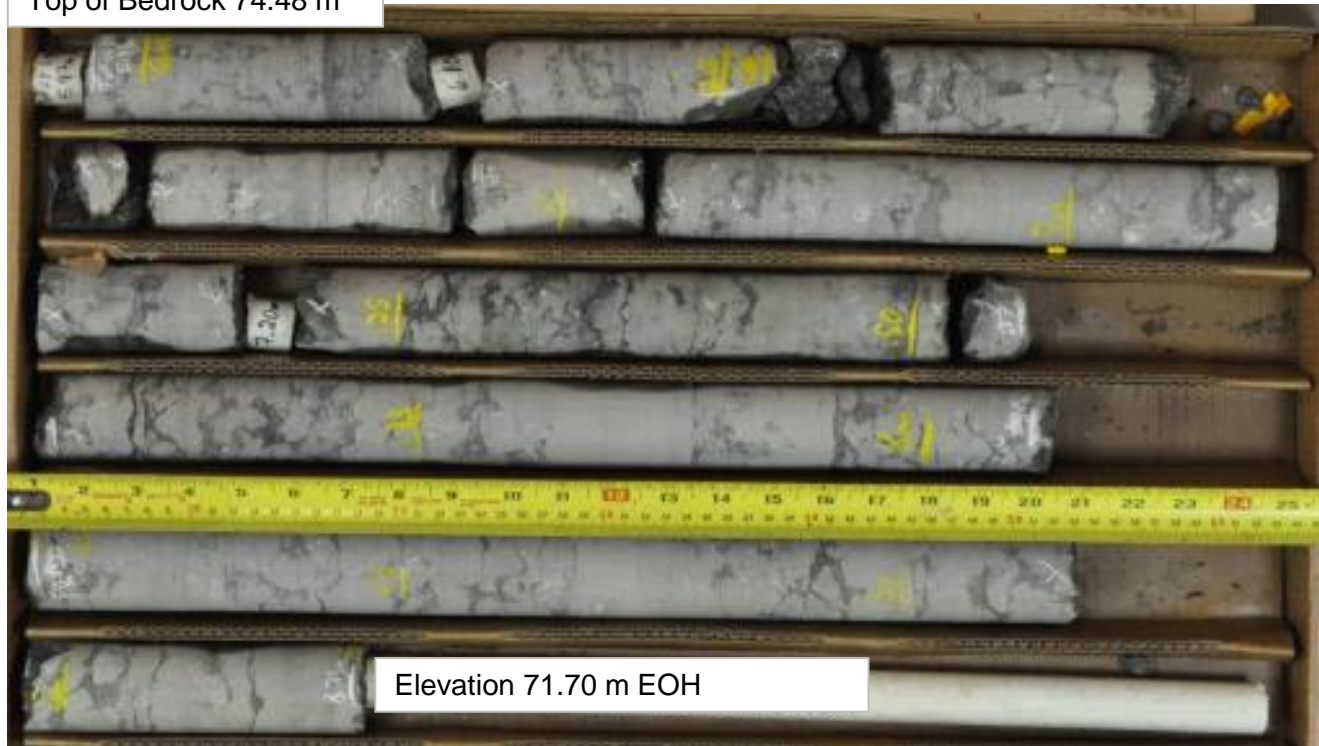
LOGGED: AP/DG

CHECKED: KCP

GTA-RCK 031 N:\ACTIVE\SPATIAL IMMTO\HWY417BRIDGES\02 DATA\GINT\1899802\1899802.GPJ GAL-MISS.GDT 20-3-19 ZS

BH 19-7006B (Dry)
Core Box 1 and 2 of 2

Top of Bedrock 74.48 m



Elevation 71.70 m EOH



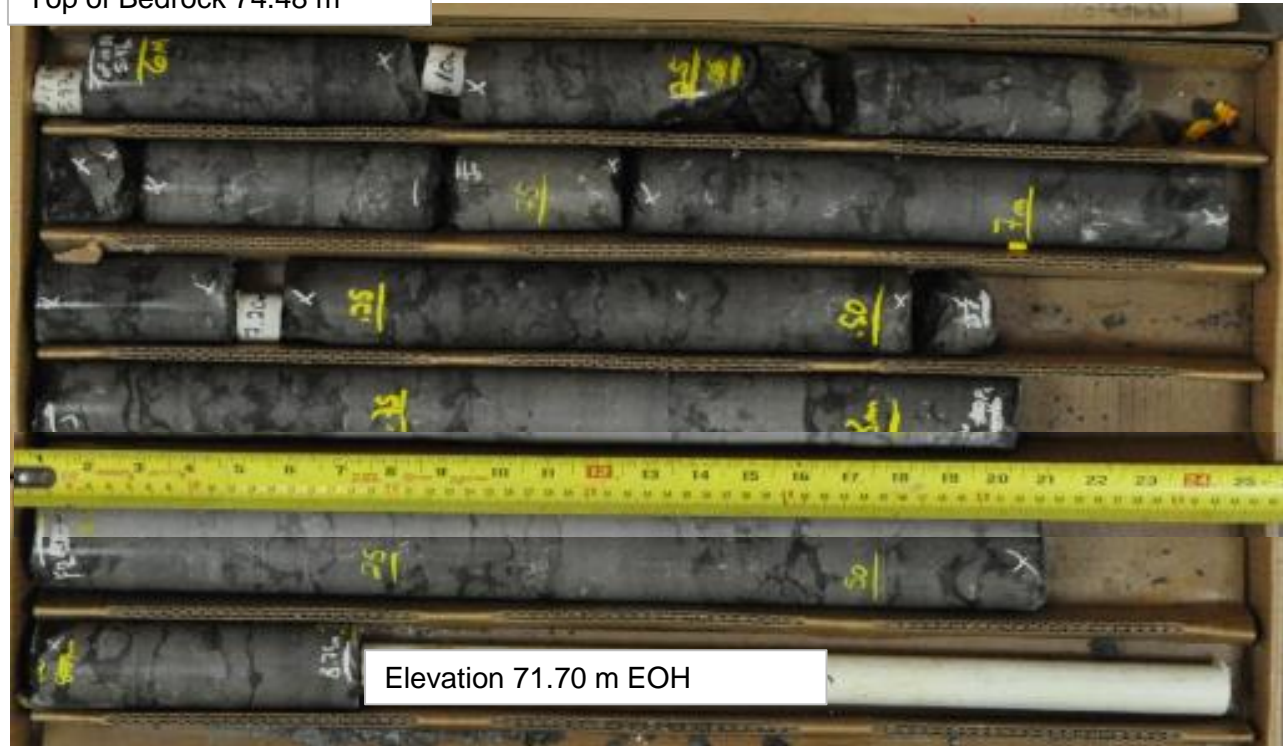
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A1

BH 19-7006B (Wet)
Core Box 1 and 2 of 2

Top of Bedrock 74.48 m



Elevation 71.70 m EOH



Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
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Figure A2

BH 19-7007 (Dry)
Core Box 1 and 2 of 2



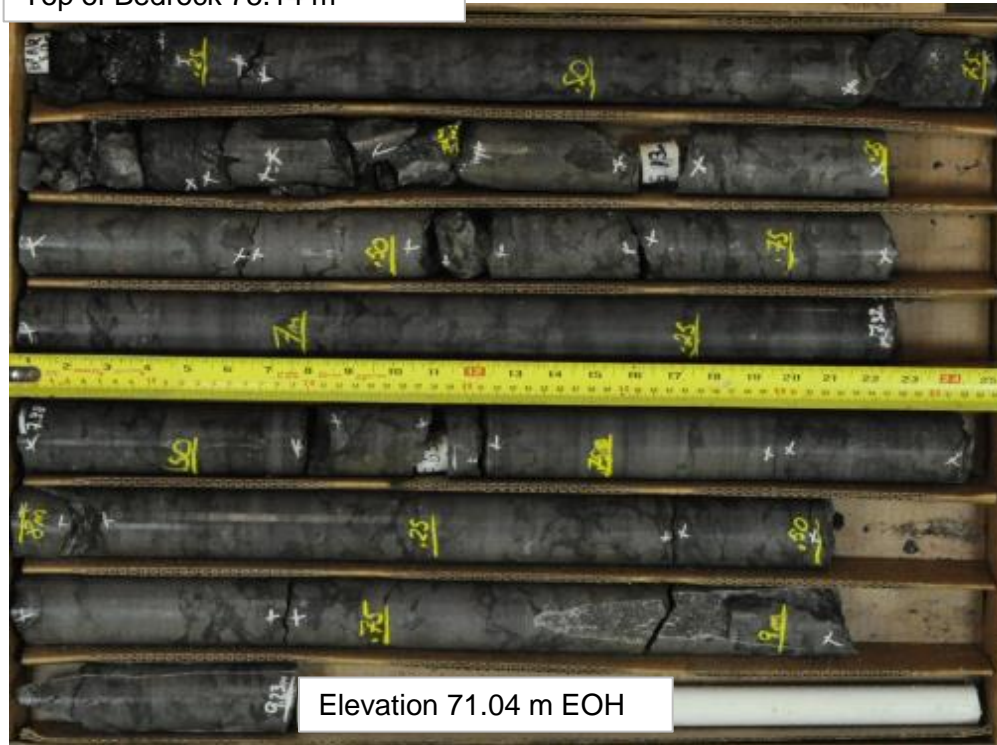
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A3

BH 19-7007 (Wet)
Core Box 1 and 2 of 2

Top of Bedrock 75.14 m



Elevation 71.04 m EOH

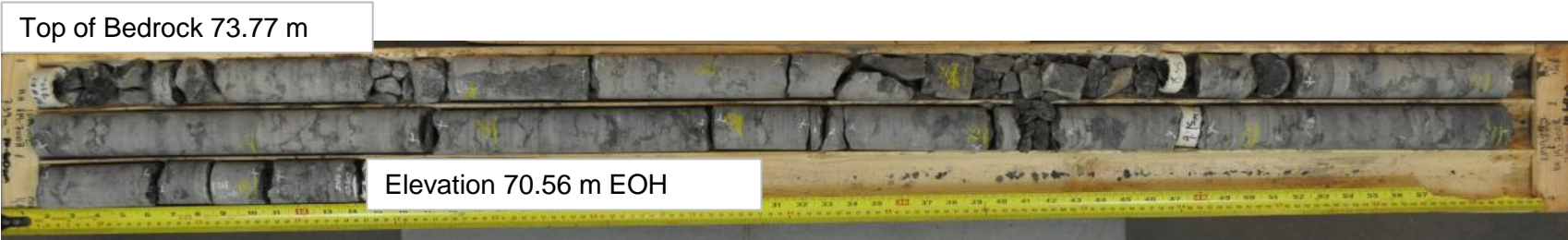


Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A4

BH 19-7008 (Dry)
Core Box 1 of 1



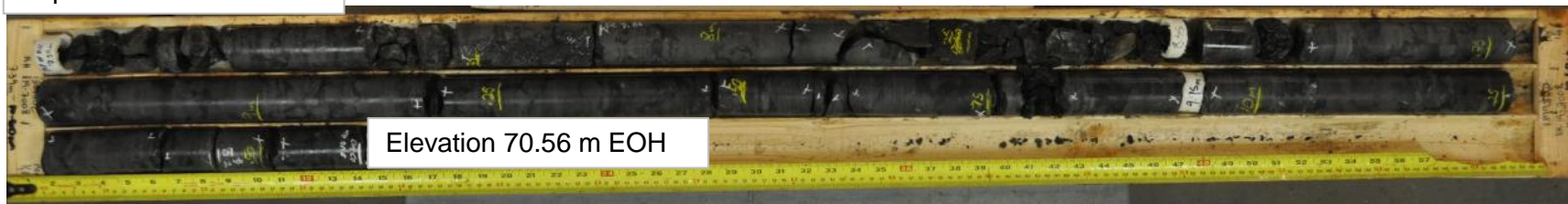
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A5

BH 19-7008 (Wet)
Core Box 1 of 1

Top of Bedrock 73.77 m



Elevation 70.56 m EOH



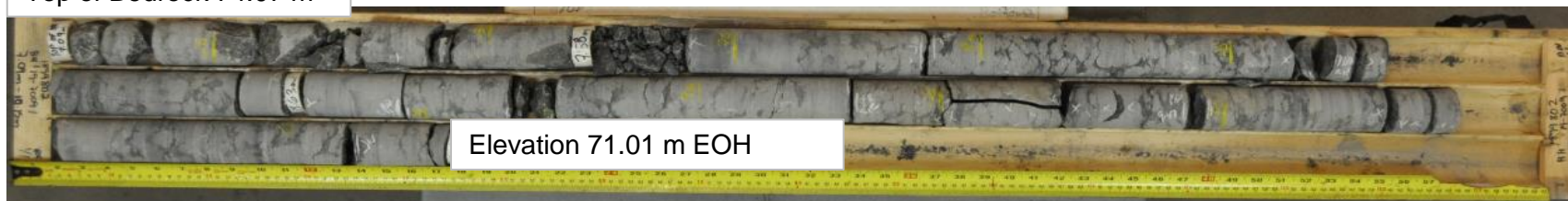
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A6

BH 19-7009 (Dry)
Core Box 1 of 1

Top of Bedrock 74.07 m



Elevation 71.01 m EOH



Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A7

BH 19-7009 (Wet)
Core Box 1 of 1

Top of Bedrock 74.07 m



Elevation 71.01 m EOH



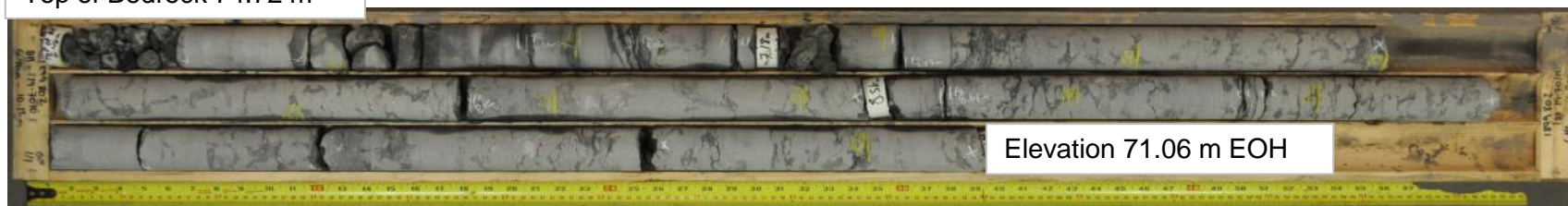
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A8

BH 19-7010 (Dry)
Core Box 1 of 1

Top of Bedrock 74.72 m



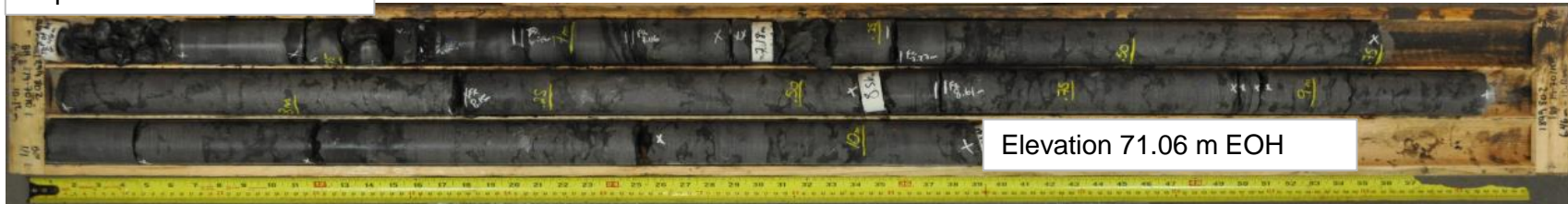
Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A9

BH 19-7010 (Wet)
Core Box 1 of 1

Top of Bedrock 74.72 m



Geotechnical Investigation
Replacement of Structural Culvert 31X-0256/C1
Highway 417 Ottawa, Ontario

Project No.	1899802 / 7000
Drawn:	MS
Date:	2019-07-23
Checked:	KCP
Review:	FJH

Figure A10

APPENDIX B

Laboratory Test Results

Figure B1 – Grain Size Distribution Test Results – Sand and Gravel
(Pavement Structure Fill)

Figure B2 – Grain Size Distribution Test Results – Sand and Gravel
(Embankment Fill)

Figure B3 – Grain Size Distribution Test Results – Clay

Figure B4 – Plasticity Chart – Clay

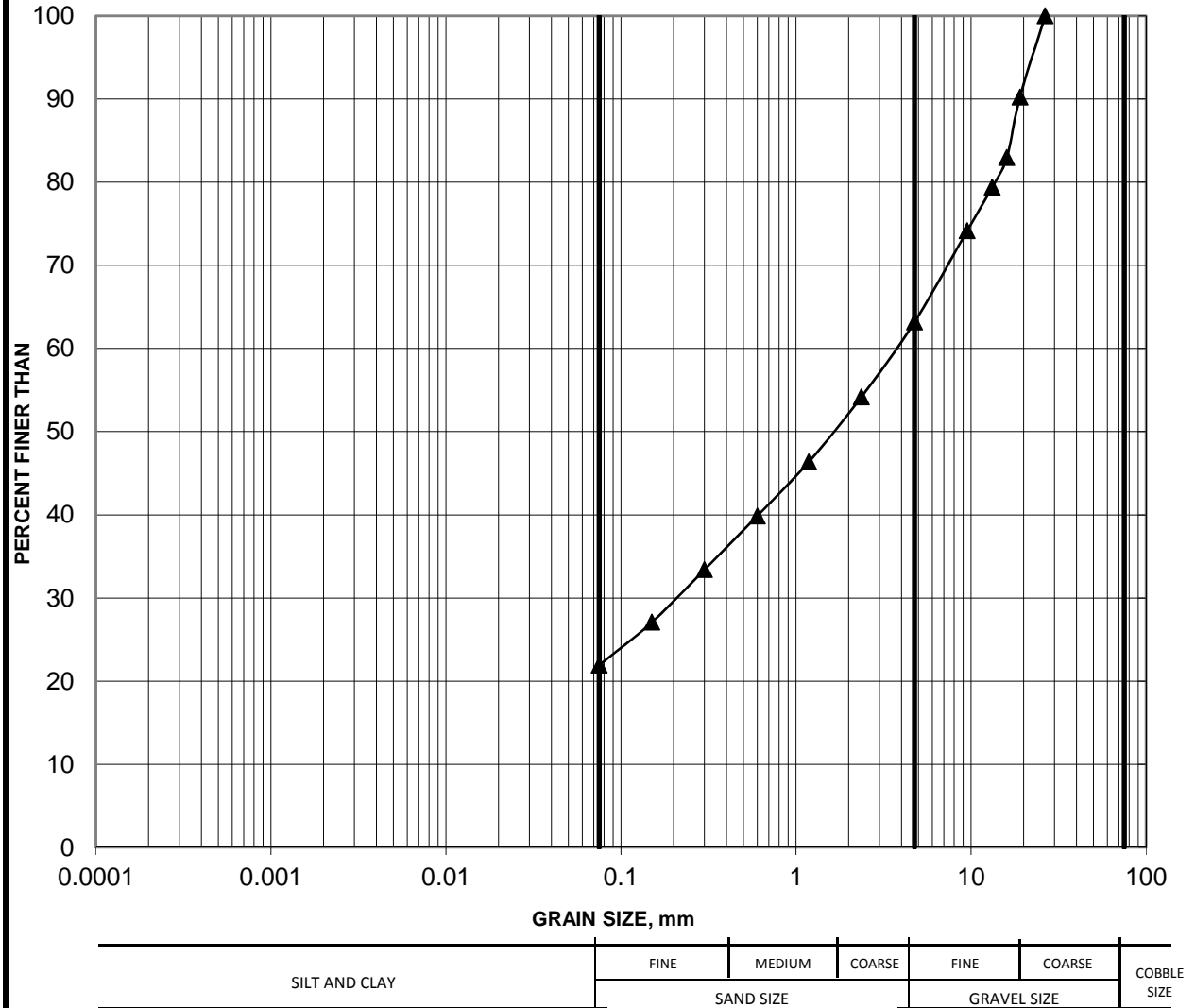
Figure B5 – Grain Size Distribution Test Results – Silty Sandy Gravel to Silty
Sand and Gravel (Till)

Figure B6 – Summary of Laboratory Compressive Strength Unconfined
Compression Tests

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND AND GRAVEL (PAVEMENT STRUCTURE FILL)

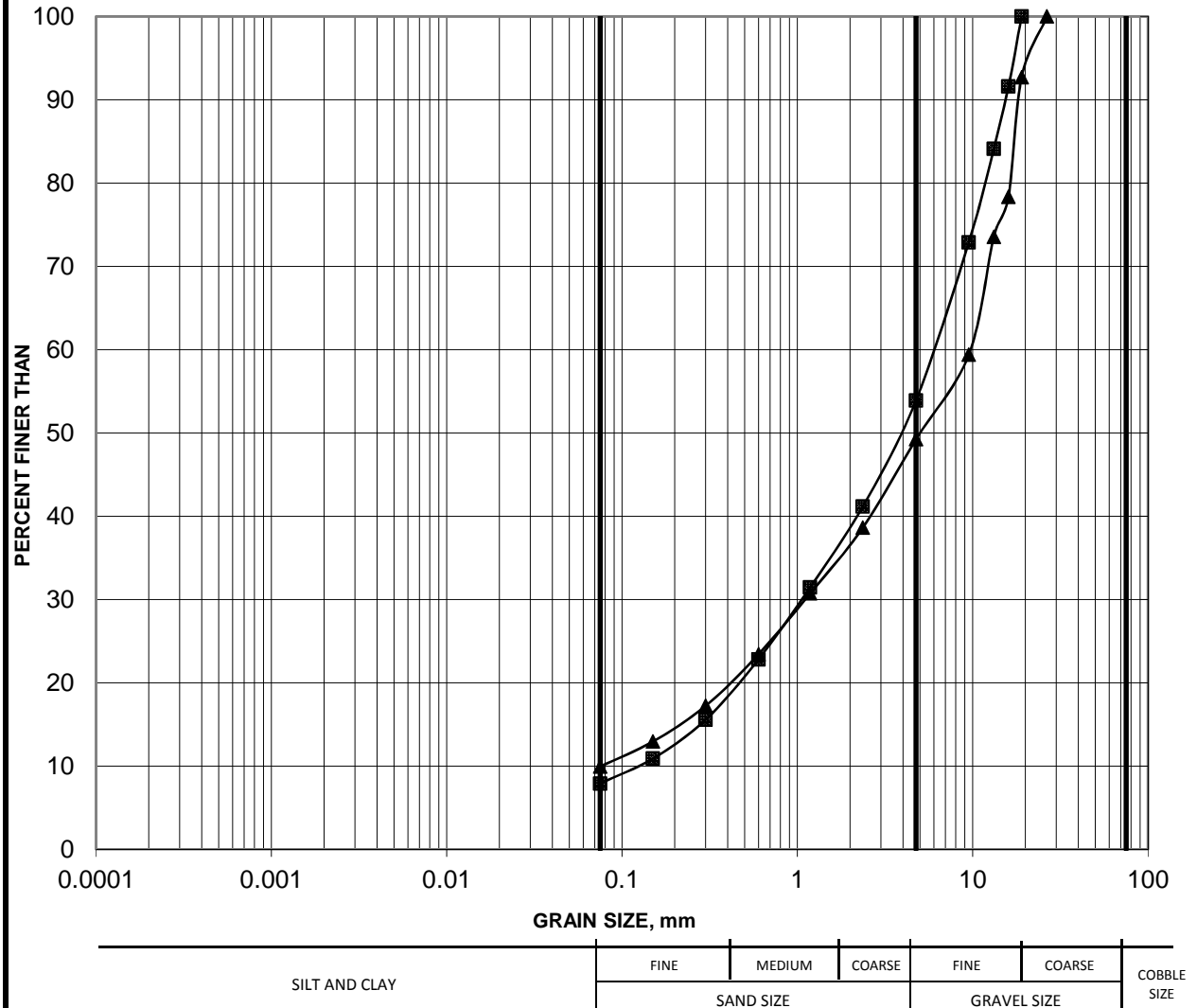


Borehole	Sample	Depth (m)
—▲ 19-7008	3	1.52-2.13

GRAIN SIZE DISTRIBUTION

FIGURE B2

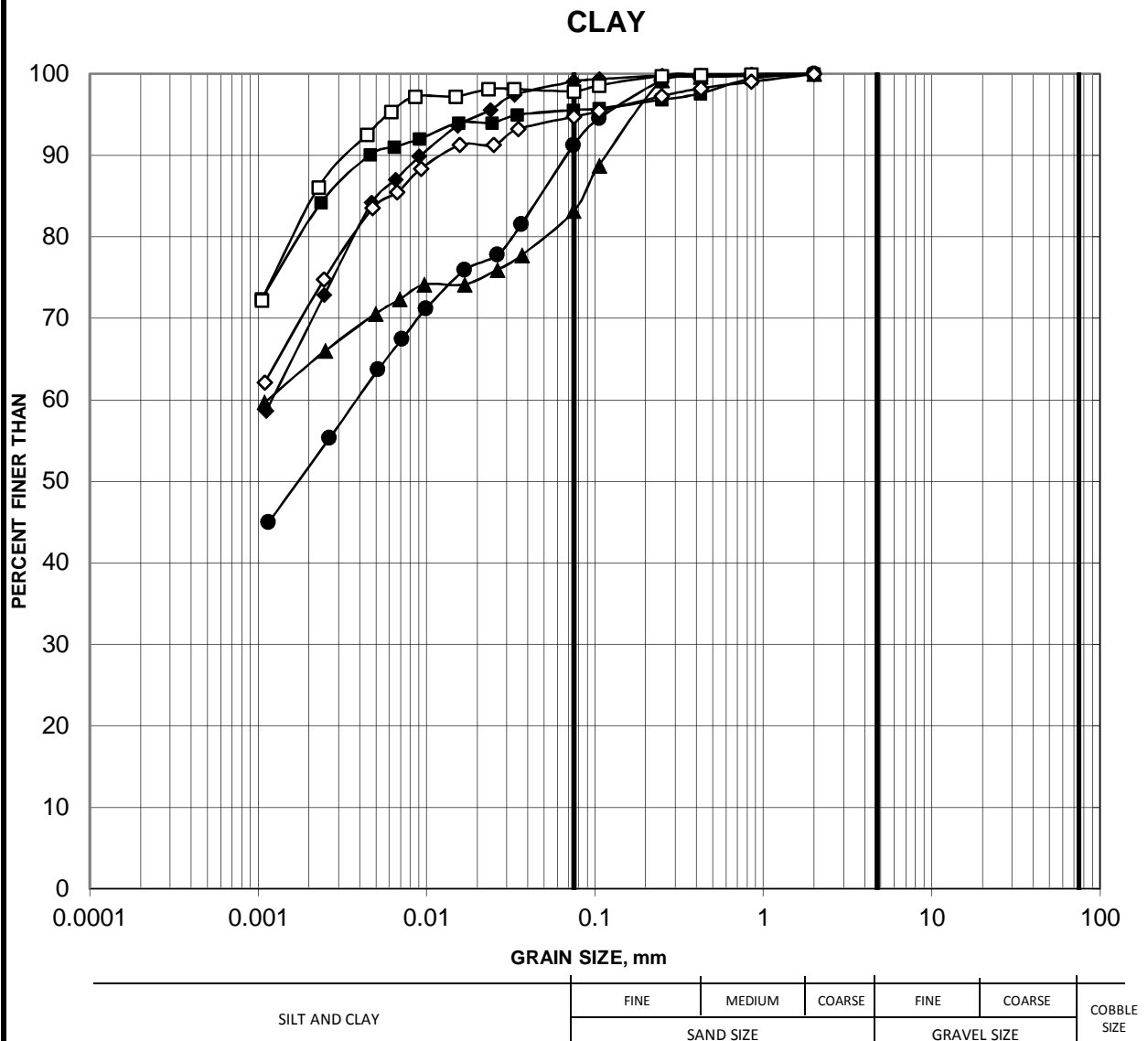
SAND AND GRAVEL (EMBANKMENT FILL)



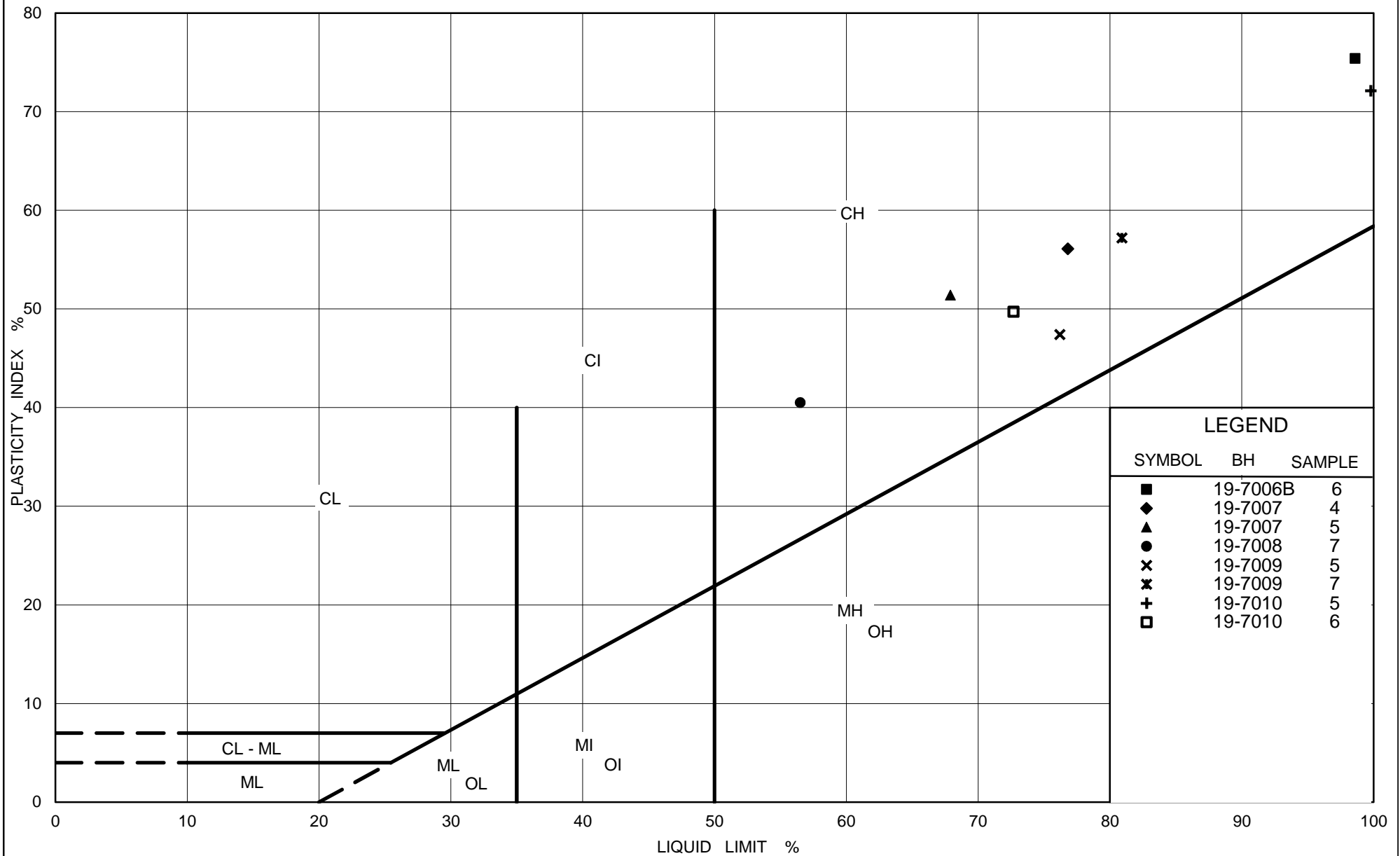
Borehole	Sample	Depth (m)
19-7006B	3	1.52-2.13
19-7007	3	1.52-2.13

GRAIN SIZE DISTRIBUTION

FIGURE B3



Borehole	Sample	Depth (m)
19-7006B	6	4.57-5.18
19-7007	4	2.29-2.90
19-7007	5	3.05-3.66
19-7008	7	5.33-5.94
19-7009	5	3.05-3.66
19-7009	7	5.33-5.94



Ministry of Transportation

Ontario

PLASTICITY CHART CLAY

FIG No. B4

Project No. 1899802/7000

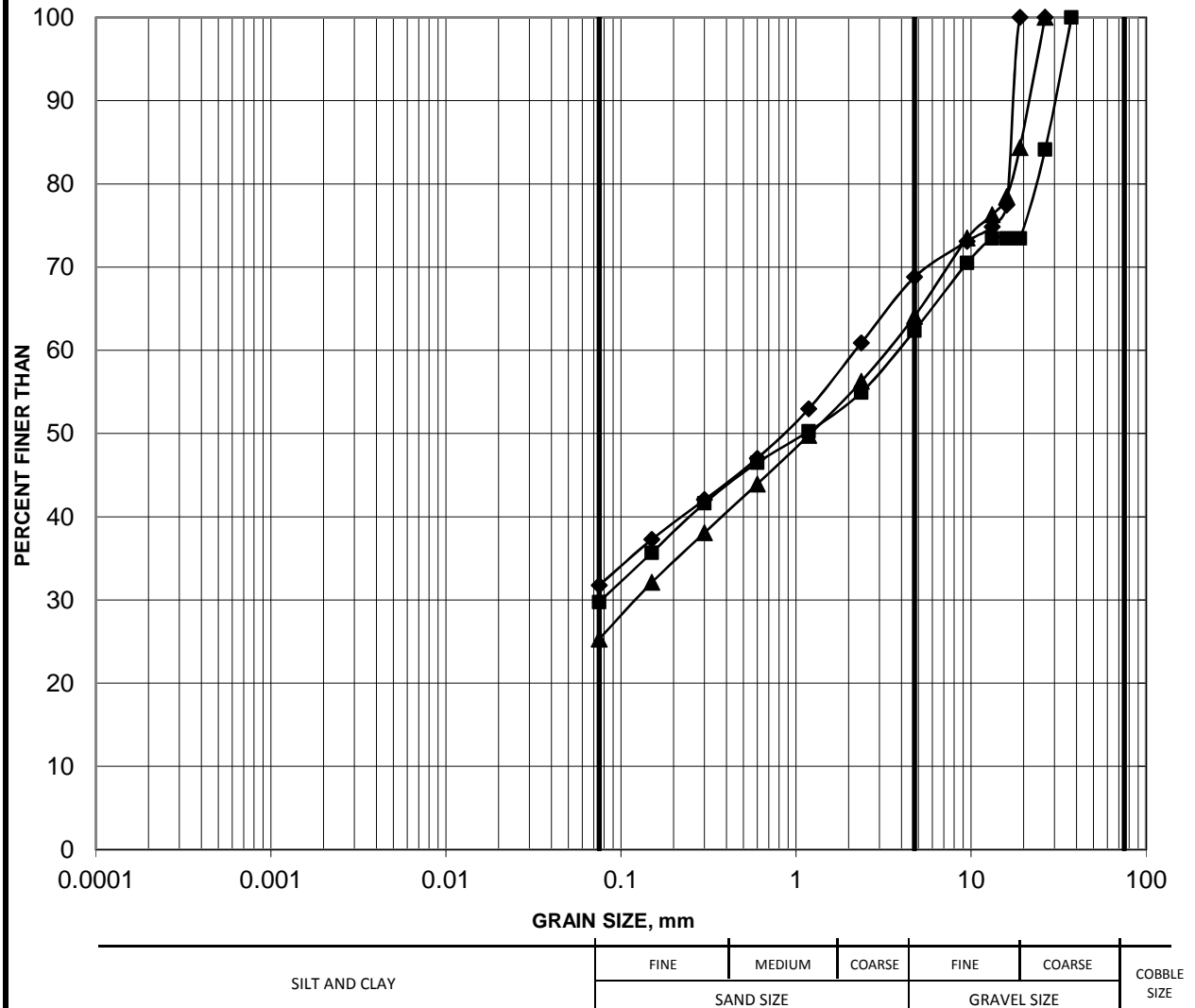
Compiled By : MI

Checked By : CW

GRAIN SIZE DISTRIBUTION

FIGURE B5

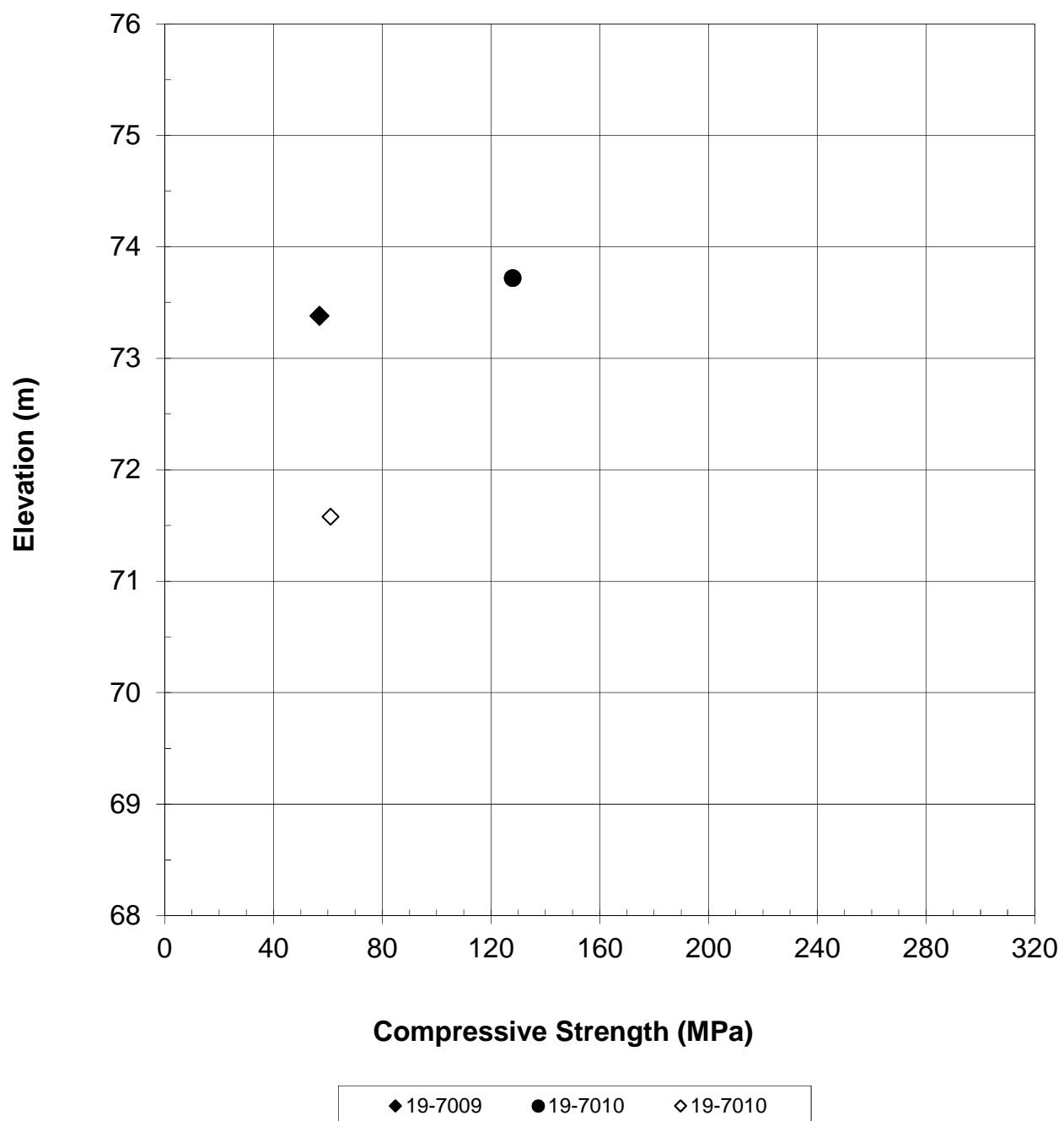
SILTY SANDY GRAVEL TO SILTY GRAVEL AND SAND (TILL)



Borehole	Sample	Depth (m)
19-7008	9	7.01-7.41
19-7009	9	6.86-7.10
19-7010	8	6.10-6.46

SUMMARY OF LABORATORY COMPRESSIVE STRENGTH UNCONFINED COMPRESSION TESTS

FIGURE B6



APPENDIX C

Results of Chemical Analysis

Eurofins Environment Testing Report No. 1913683



Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario

Attention: Kenton Power

PO#:

Invoice to: Golder Associates Ltd

Report Number: 1913683
Date Submitted: 2019-07-31
Date Reported: 2019-08-08
Project: 1899802/7000
COC #: 847133

					Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.		
					1444568 Soil 2019-07-11 19-7004 sa5	1444569 Soil 2019-07-15 19-7006B sa5	1444570 Soil 2019-07-16 19-7009 sa3
Group	Analyte	MRL	Units	Guideline			
Anions	Cl	0.002	%		0.006	0.067	0.006
	SO4	0.01	%		<0.01	<0.01	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.12	0.64	0.16
	pH	2.00			8.66	8.06	8.56
	Resistivity	1	ohm-cm		8700	1570	6130

Guideline =

* = Guideline Exceedence

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX D

Site Photographs



Photograph 1: Highway 417 platform looking northeast at culvert crossing; 2019-06-26



Photograph 2: Looking north downstream from culvert inlet towards Highway 417 westbound; 2019-07-12



Photograph 3: Looking south upstream from culvert outlet; 2019-07-15



Photograph 4: Looking west along south embankment / ditchline; 2019-06-26



Photograph 5: Looking east along north embankment / ditchline; 2019-06-26



Photograph 6: Proximity of Highway 417 westbound culvert to outlet of Culvert 31X-0256/C1