



REPLACEMENT OF MOONBEAM CREEK CULVERT
SITE NO. 39W-0110/C0
HIGHWAY 11, SHACKLETON TOWNSHIP, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5159-13-00, WP 5215-13-01
FOUNDATION INVESTIGATION REPORT - REVISION 1

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1661607-R07

November 22, 2019

GEOCRES No.: 42H-079

Lat: 49.288199

Long: -80.879264



Distribution List

3 Copies + 1 PDF Copy: Ministry of Transportation, Ontario, North Bay, Ontario (Northeastern Region)

1 Copy + 1 PDF Copy: Ministry of Transportation, Ontario, Downsview, ON (Foundations Section)

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PART A

**FOUNDATION INVESTIGATION REPORT
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SITE NO. 39W-0110/C0
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Moonbeam Creek Culvert (Site No. 39W-0110/C0), located on Highway 11, 5.6 km East of Wellington Creek Bridge in Shackleton Township, Ontario. The Key Plan showing the general location of this section of Highway 11 and the location of the investigated area are shown on Drawing 1.

The purpose of this investigation is to establish the subsurface soil conditions at the existing culvert location by borehole drilling and laboratory testing on selected soil and bedrock core samples.

The Terms of Reference and Scope of Work for the Foundation Investigation are outlined in MTO's Request for Proposal dated April, 2016. Golder's proposal for foundation engineering services associated with replacement of Moonbeam Creek Culvert structure is contained in Section 17.8 of LEA's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundations engineering services for this project, dated January 11, 2017.

2.0 SITE DESCRIPTION

The existing Moonbeam Creek Culvert consists of a 35 m long concrete box with a span of 6 m and a height of 1.7 m. The approximate invert of the culvert is Elevation 228.0 m. In general, the topography at the culvert site is relatively flat, the ground surface being covered/vegetated with grass, shrubs and trees. At the culvert location, the highway grade is at Elevation 234 m with the embankment up to about 6 m high relative to the creek bottom which is approximately at Elevation 228 m. A railway embankment, about 4 m higher than the grade of the highway embankment, extends east-west along and parallel to the south side of the Highway 11 embankment.

General views at the culvert site are shown on Photographs 1 to 4, following the text of this report.

3.0 INVESTIGATION PROCEDURES

3.1.1 Boreholes

Field work was carried out between September 19 and September 24, 2017, during which time six boreholes (MB-1 to MB-6) were advanced at the locations shown on Drawing 1. The field investigation was carried out using the following drilling equipment:

- Borehole MB-1 was advanced using a portable tripod drill rig supplied and operated by Downing Drilling Inc. (Downing) of Grenville-sur-la-Rouge, Quebec.
- Boreholes MB-2 to MB-6 were advanced using a CME-55 track-mounted drill rig supplied and operated by Downing.

Boreholes were advanced using 108 mm inside diameter hollow-stem augers and/or NW casing with wash boring techniques. Where coring through cobbles or bedrock was required, an NQ-size core barrel was used. 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 on the CME-55 drill rig and a manual half-weight hammer on the portable drill rig, in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Split spoon samples were obtained with a half weight hammer in borehole MB-1 and the SPT-'N' values were adjusted

to the referred values that would be obtained using a standard weight hammer. An in-situ vane shear test using an N-size vane was carried out within the clayey silt fill in Borehole MB-2 in accordance with ASTM D2573 to determine the undrained shear strength of the cohesive layer of the fill. The groundwater level in the open boreholes was observed immediately following the drilling operations as described on the Record of Borehole sheets in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended); and a cold patch asphalt cap about 0.2 m thick was compacted at the top of the boreholes drilled on the highway.

Field work was supervised on a full-time basis by a member of Golder's staff, who located the boreholes in the field, arranged for the clearance of underground services, directed the drilling and sampling operations and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's Sudbury Laboratory for further examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Index and classification tests consisting of water content, Atterberg limits and grain size distribution were carried out on selected soil samples.

A soil sample was obtained on September 20, 2017, in Borehole MB-4, 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.

Classification of the rock mass quality of the bedrock core samples with respect to the Rock Quality Designation (RQD) and Uniaxial Compressive Strength (UCS) are described based on Table 3.10 and Table 3.5, respectively, of the *Canadian Foundation Engineering Manual* (CFEM, 2006¹). The degree of weathering of the bedrock samples (i.e., fresh to slightly weathered) and the strength classification of the intact rock mass based on field identification (i.e., strong to very strong) are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM²) standard classification system.

Borehole locations and elevations were measured in the field by Golder personnel, relative to existing site features and surveyed to point HCP-100. The borehole locations (referenced to the MTM NAD83 Zone 12 co-ordinate system), ground surface elevations (referenced to Geodetic datum) and borehole depths are presented on the borehole records in Appendix A and are summarized below.

Borehole	Location (MTM NAD 83, Zone12)		Location (World Geodetic System 84)		Ground Surface Elevation (m)	Borehole Depth/Rock Coring (m)
	Northing	Easting	Latitude	Longitude		
MB-1	5461523.5	240833.5	49.288366	-81.879377	229.6	3.8
MB-2	5461523.4	240848.4	49.288367	-81.879172	230.1	4.6*/3.0
MB-3	5461508.6	240828.2	49.288232	-81.879447	233.9	12.2*/1.5
MB-4	5461502.6	240846.6	49.288180	-81.879193	233.9	8.4*/3.4
MB-5	5461486.8	240834.9	49.288036	-81.879351	230.5	9.9*/3.4
MB-6	5461487.7	240850.6	49.288046	-81.879136	230.9	4.5*/3.1

*Includes bedrock coring.

¹ Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition.

² International Society for Rock Mechanics Commission on Test Methods, 1985. *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.* Vol 22, No. 2, pp. 51-60.

3.1.2 Existing Culvert Bottom

On October 10 and 30, 2019, Golder advanced hand probes along the culvert face at the inlet and outlet to assess the type of foundation (i.e., open footing versus box) of the existing culvert. Support for the initial investigation with respect to depth of water level was provided by Villeneuve Construction and support was received from MTO for removal of a beaver dam downstream of the culvert.

On October 10, 2019, at the south (inlet) end of the culvert, hand probes with a 300 mm long by 38 mm diameter auger at the tip of 19 mm diameter rods were advanced manually by Golder personnel standing at the top edge of the culvert at about 1 m spacing between probes. Refusal to further advancement of the hand probes along the south (inlet) end of the culvert was encountered constantly at a depth of about 2.0 m below the top of the culvert (at about Elevation 228.2 m).

On October 30, 2019, at the north (outlet) end of the culvert, hand probes were advanced manually by Golder from an aluminium boat, as the end of the culvert was not accessible for probing from the top of the culvert due to dense vegetation along the top edge of the culvert. The hand probes were advanced along the culvert end at about 1 m spacing. The hand probes along the north (outlet) end of the culvert penetrated a thickness of about 0.2 m to 0.3 m of sediment at the creek bed, and refusal to further advancement of the probes was encountered at depths between about 1.5 m to 1.6 m below the underside of the top of the culvert (at about Elevations 228.1 m and 228.0 m). Two additional hand probes were advanced about 1 m downstream of the culvert outlet to depths of 1.5 and 1.7 m below the water level (about 1.9 m and 2.1 m below the underside of the top of the culvert at Elevations 227.7 m and 227.5 m) without encountering refusal.

Based on the results of the hand probing investigation at the inlet and outlet ends of the culvert it is inferred that the existing culvert consists of a concrete box.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)³ mapping, the site is located within a ground moraine deposit consisting primarily of clayey till materials.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (MNDM)⁴, the site is underlain by bedrock from the metasedimentary paragneiss rocks and mafic and ultramafic intrusive rocks comprised of diabase dikes.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are presented on the borehole records in Appendix A and the laboratory test sheets Figures B1 to B7 in Appendix B. The results of the analytical testing are summarized in Table B1 included in Appendix B. The results of the in-situ field tests (i.e., SPT 'N'-values) as

³ Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41JNW

⁴ Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543

presented on the borehole records and in Section 4 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on Drawing 1 and on the cross-section on Drawing 2 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. A summary of the subsurface conditions as encountered in Boreholes MB-1 to MB-6 is presented below.

4.2.1 Subsoil Conditions

A description of the soil deposits encountered in the boreholes is provided below.

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (Blows)	Laboratory Testing
				Field Vane Results (kPa)	
				Consistency or Relative Density	
Asphalt Pavement¹	MB-3, MB-4	0.1 to 0.2	233.9	n/a	n/a
(FILL) Sand, Gravelly Sand, Silty Sand, Organic Silty Sand, Clayey Sand, Silty Clay^{1,2}	MB2 to MB-6	0.6-6.0	233.7 – 230.1	N = WH – 43 and 6 blows/0.15 m	w = 4% – 19% 2 – MH (Fig. B1) 2 – M (Fig. B1) 2 – NP 1 – AL (Fig. B2) w _i = 23% w _p = 13% I _p = 10%
				S _u = 62 S = 2	
				Very loose to dense; firm to stiff	
Peat (Amorphous)	MB-1, MB-3, MB-5, MB-6	0.8 – 2.1	230.3 – 227.7	N = 2 – 7	w = 36% – 91%
				n/a	
				Very soft to firm	
Clayey Silt to Silty Clay	MB-1, MB-2, MB-5	0.5 – 0.8	229.3 – 227.5	N = 3 – 7	w = 23% – 33% 3 – AL (Fig. B3) w _i = 23% – 35% w _p = 16% – 22% I _p = 8% – 18% 1 – MH (Fig. B4)
				n/a	
				Soft	
Silt and Sand	MB-5	0.9	226.7	N = 17	w = 19% 1 – MH (Fig. B5)
				n/a	
				Compact	

Deposit/Layer Description	Boreholes	Deposit Thickness (m)	Deposit Surface Elevation (m)	N Values (Blows)	Laboratory Testing
				Field Vane Results (kPa)	
				Consistency or Relative Density	
Sand and Gravel (TILL)	MB-1, MB-3	1.2 – 3.7	227.0 – 226.9	N = 41 – 96	w = 7% – 11% 1 – M (Fig. B6) 1 – MH (Fig. B6)
				n/a	
				Dense to very dense	
Cobbles	MB-5	1.8	225.8	n/a	n/a

Where:

N = SPT 'N'-value; number of blows for 0.3 m of penetration
 s_u = undrained shear strength from in situ field 'N'-vane (kPa)
S = calculated sensitivity
w = natural moisture content (%)
M = sieve analysis for particle size
MH = combined sieve and hydrometer analysis
AL = Atterberg limits test
 w_p = plastic limit (%)
 w_l = liquid limit (%)
 I_p = plasticity index (%)
NP = non-plastic Atterberg limits test result

Notes:

¹ Asphalt pavement layers (0.1 m and 0.2 m thick) were encountered within the fill in Borehole MB-3 at depths of 0.5 m and 2.1 m, respectively, and 0.1 m thick in Borehole MB-4 at a depth of 0.3 m.

² A 0.1 m thick piece of wood was encountered within the fill in Borehole MB-3 at a depth of 3.8 m below ground surface; and cobbles were encountered within the fill in Borehole MB-4 between 4.7 m and 5.0 m depth.

4.2.2 Bedrock/Refusal

Borehole MB-1 was terminated on “refusal” conditions to further casing and split-spoon advancement and bedrock was cored in Boreholes MB-2 to MB-6. The depth/elevation of the actual/inferred bedrock surface is presented below.

Borehole No.	Depth to Bedrock/Refusal (below ground surface) (m)	Bedrock Surface/DCPT Refusal Elevation (m)	Refusal Condition (m)
MB-1	3.8	225.8	Split-spoon and casing refusal
MB-2	1.6	228.5	3.0 m bedrock core length
MB-3	10.7	223.2	1.5 m bedrock core length
MB-4	5.0	228.9	3.4 m bedrock core length

Borehole No.	Depth to Bedrock/Refusal (below ground surface) (m)	Bedrock Surface/DCPT Refusal Elevation (m)	Refusal Condition (m)
MB-5	6.5	224.0	3.4 m bedrock core length
MB-6	1.4	229.5	3.1 m bedrock core length

The retrieved bedrock core samples from the boreholes are described as slightly weathered to fresh, fine to medium grained, dark grey diabase dike or metasedimentary conglomerate. More detailed descriptions of the bedrock cores are presented on the drillhole in Appendix A, including data regarding the discontinuity frequency and type. Photographs of the bedrock core samples are shown on Figure B7 in Appendix B. The bedrock properties, as encountered in the cored boreholes, are summarized below.

Borehole No.	Total Core Recovery (TCR)	Rock Quality Designation (RQD)	Quality Classification (Table 3.10 of CFEM 2006 ³)	UCS (MPa)	Strength Classification (Table 3.5 of CFEM 2006 ³)
MB-2	100%	61% - 93%	Fair to Excellent	90	(R4) Strong
MB-3	100%	100%	Excellent	-	-
MB-4	100%	62% - 91%	Fair to Excellent	202	(R5) Very Strong
MB-5	100%	86% - 100%	Good to Excellent	-	-
MB-6	100%	76% - 97%	Good to Excellent	70	(R4) Strong

4.3 Groundwater Conditions

The depths to/elevations of unstabilized groundwater levels measured in the open boreholes upon completion of NW casing and wash boring techniques, prior to and after NQ coring are presented below. It should be noted that the introduction of drilling water to advance NW casing in the boreholes may have impacted the measured groundwater levels. Water levels should be expected to vary depending on the time of year and precipitation events.

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
MB-1	At ground surface	229.6
MB-2	0.2	229.9

Borehole No.	Depth to Unstabilized Groundwater Level (m)	Approximate Groundwater Elevation (m)
MB-3	2.8	231.1
MB-4	3.2	230.7
MB-5	0.3	230.2
MB-6	0.3	230.6

The creek water level was measured by Golder at Elevation 229.6 m on September 24, 2017.

5.0 CLOSURE

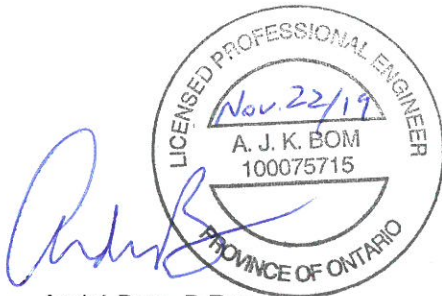
The field drilling program was supervised by Mr. Mathew Riopelle. This Foundation Investigation Report was prepared by Mr. Tibor Berecz and the technical aspects were reviewed by Mr. André Bom, P.Eng., a geotechnical engineer and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., an MTO Foundations Designated Contact and Senior Consultant of Golder, conducted an independent quality control review and technical audit of this report.

Signature Page

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MTO Foundations Designated Contact, Senior Consultant

TB/AB/JMAC/kp/sb/ca

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Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.

Ministry of Transportation, *MTO Gravity Pipe Design Guidelines*, MTO Drainage and Hydrology Design and Contract Standards Office, May 2014

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society.

Transportation Research Board, National Research Council, 1998. *Service Life Drainage Pipe*, National Cooperative Highway Research Program (NCHRP) Synthesis 254.

ASTM International

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils
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Ontario Provincial Standard Drawings (OPSD)

OPSD 203.020	Embankments Over Swamp, Existing Slope Excavated, Widening
OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans less than or Equal to 3 m
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.100	Foundation Frost Penetration Depths for Northern Ontario

Ontario Provincial Standard Specifications (OPSS)

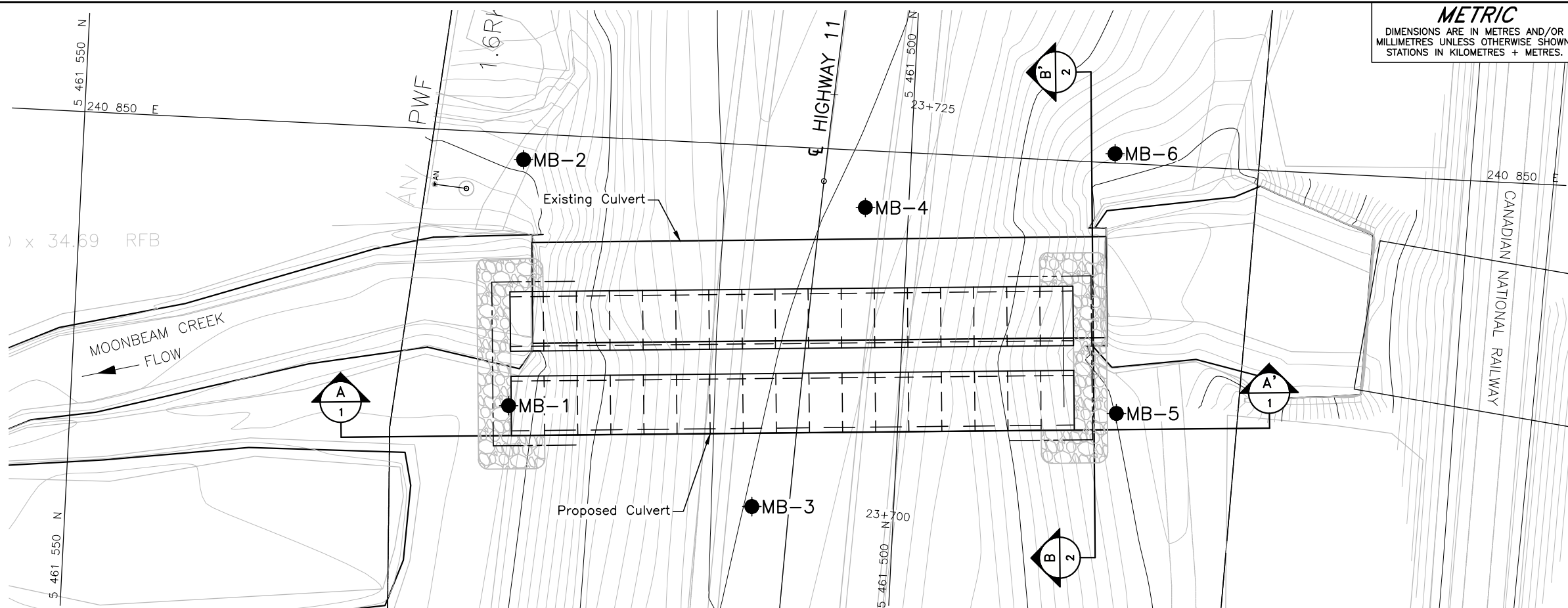
OPSS.PROV 120	Explosives
OPSS.PROV 202	Rock Removal - Manual or Blasting
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS.PROV 209	Construction Specification for Embankments over Swamps and Compressible Soils
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1004	Aggregates Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal

Ontario Water Resource Act

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects (as amended)

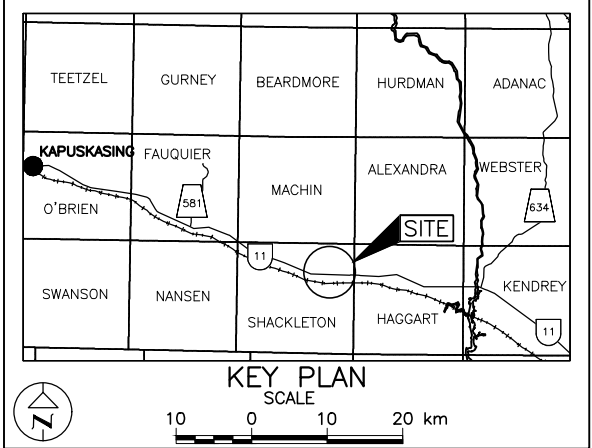


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No. WP No. 5215-13-01

MOONBEAM CREEK CULVERT

BOREHOLE LOCATIONS AND SOIL STRATA



- LEGEND**
- Borehole
 - N Standard Penetration Test Value
 - 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
 - R Refusal
 - 100% Rock Quality Designation (RQD)
 - WL upon completion of drilling

BOREHOLE CO-ORDINATES (NAD 83 MTM ZONE 12)			
No.	ELEVATION	NORTHING	EASTING
MB-1	229.6	5461523.5	240833.5
MB-2	230.1	5461523.4	240848.4
MB-3	233.9	5461508.6	240828.2
MB-4	233.9	5461502.6	240846.6
MB-5	230.5	5461486.8	240834.9
MB-6	230.9	5461487.7	240850.6

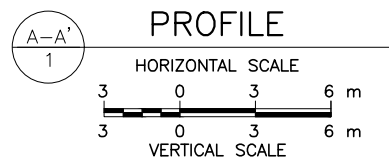
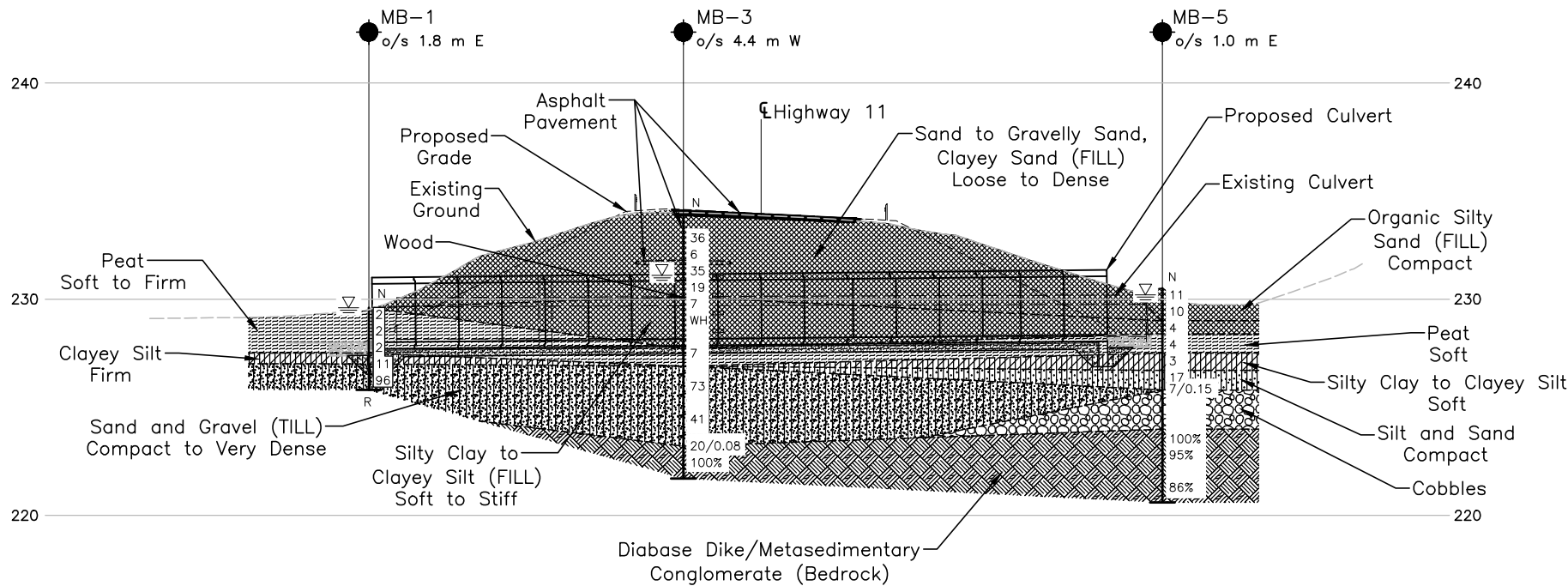
NOTES

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.

REFERENCE

Base plans provided in digital format by LEA, drawing file no. x17197 Moon base.dwg, received JAN 19, 2018. General arrangement plan file no. 17197-Moonbeam Culvert-S01-General Arrangement.dwg, received MAY 22, 2019.



NO.	DATE	BY	REVISION
1	11/11/19	TB	PROFILE UPDATE SHOWING BHS MB-1, MB-3, MB-5
Geocres No. 42H-079			
HWY. 11	PROJECT NO. 1661607		DIST. .
SUBM'D.	CHKD.	DATE: 11/12/2019	SITE: 39W-0110/C0
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 1

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

CONT No. 5215-13-01
WP No. 5215-13-01
MOONBEAM CREEK CULVERT
SOIL STRATA

SHEET



LEGEND

- Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling

BOREHOLE CO-ORDINATES (NAD83 MTM ZONE 12)

No.	ELEVATION	NORTHING	EASTING
MB-3	233.9	5461508.6	240828.2
MB-5	230.5	5461486.8	240834.9
MB-6	230.9	5461487.7	240850.6

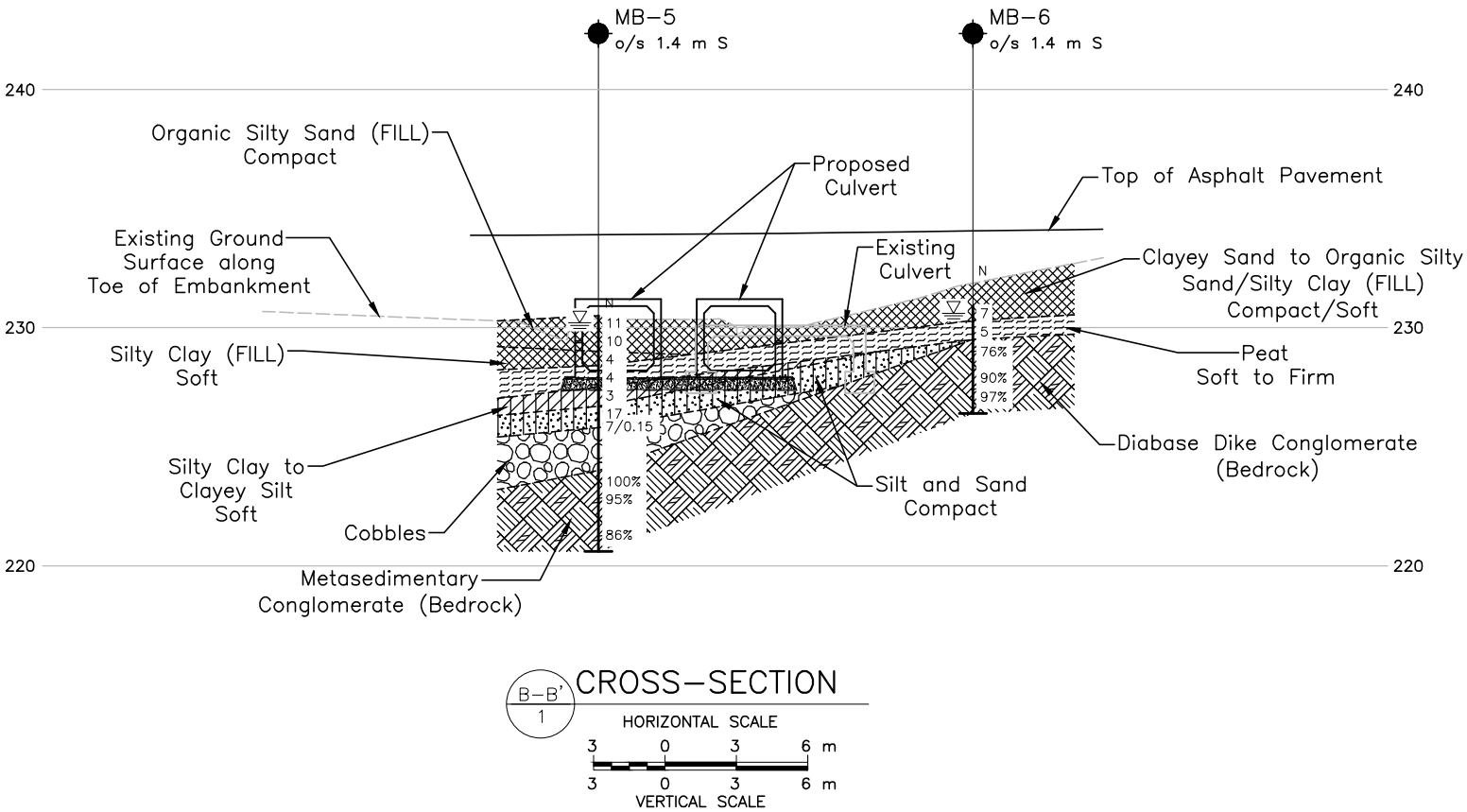
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1	11/11/19	TB	BH-3 REMOVED FROM CROSS-SECTION
NO.	DATE	BY	REVISION
Geocres No. 42H-079			
HWY. 11	PROJECT NO. 1661607		DIST. .
SUBM'D.	CHKD.	DATE: 11/13/2019	SITE: 39W-0110/CO
DRAWN: TB	CHKD. AB	APPD. JMAC	DWG. 2

**Photograph 1: Moonbeam Creek Culvert
West approach looking east (September 2017)**



**Photograph 2: Moonbeam Creek Culvert
Culvert Inlet looking west (September 2017)**



**Photograph 3: Moonbeam Creek Culvert
Culvert outlet looking east (September 2017)**



**Photograph 4: Moonbeam Creek Culvert
North embankment side slope looking east (September 2017)**



APPENDIX A

Record of Boreholes

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	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
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

(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

* 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

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

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

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

<u>Description</u>	<u>Bedding Plane Spacing</u>
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

<u>Description</u>	<u>Spacing</u>
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

<u>Term</u>	<u>Size*</u>
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, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

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 1661607		RECORD OF BOREHOLE No MB-1		1 OF 1 METRIC	
W.P. 5215-13-01		LOCATION N 5461523.5; E 240833.5 NAD83 MTM ZONE 12 (LAT. 49.288366; LONG. -81.879377)		ORIGINATED BY MR	
DIST _____ HWY 11		BOREHOLE TYPE Portable Drill, NW Casing and Wash Boring		COMPILED BY AD	
DATUM GEODETIC		DATE September 24, 2017		CHECKED BY AB	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _P	W	W _L
229.6	GROUND SURFACE																
0.0	PEAT (Amorphous) Very soft Dark brown Wet		1	SS	2												
			2	SS	2												
			3	SS	2												
227.5																	
2.1	CLAYEY SILT, trace to some gravel Firm Grey Wet		4A														
227.0																	
2.6	SAND and GRAVEL, some silt, trace clay (TILL) Compact to very dense Grey Wet		4B	SS	11												
			5	SS	96												
225.8																	
3.8	END OF BOREHOLE SPLIT-SPOON AND CASING REFUSAL		6	SS													
	Note: 1. Water level at ground surface (Elev. 229.6 m) upon completion of drilling. 2. Split spoon sample obtained by driving with a half weight hammer. SPT 'N' value has been adjusted to the inferred values that would be obtained using a standard weight hammer.																

PROJECT <u>1661607</u>		RECORD OF BOREHOLE No MB-2				1 OF 1 METRIC											
W.P. <u>5215-13-01</u>		LOCATION <u>N 5461523.4; E 240848.4 NAD83 MTM ZONE 12 (LAT. 49.288367; LONG. -81.879172)</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AD</u>											
DATUM <u>GEODETIC</u>		DATE <u>September 22, 2017</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
230.1	GROUND SURFACE																
0.0	Organic silty sand (FILL) Loose Dark brown Wet		1	SS	4		230										
229.3							229										
0.8	CLAYEY SILT with SAND, trace gravel, some clay Firm Grey to brown Wet		2	SS	7		229										2 47 36 15
228.5																	
1.6	DIABASE DIKE (BEDROCK) Bedrock cored from 1.6 m depth to 4.6 m depth For coring details see Record of Drillhole MB-2		1	RC	REC 100%		228										RQD = 90%
			2	RC	REC 100%		227										RQD = 61%
			3	RC	REC 100%		226										RQD = 93%
225.5	END OF BOREHOLE																
4.6	Note: 1. Water level at a depth of 0.2 m below ground surface (Elev. 229.9 m) upon completion of drilling.																

SUD-MTO 001 MTM ZNI INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049_NE REGION\02_DATA\GINT\1661607.GPJ GAL-MISS.GDT 4/6/18 TBJJL

INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DATUM: GEODETIC

1 : 60




CHECKED: AB

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

PROJECT <u>1661607</u>		RECORD OF BOREHOLE No MB-3				2 OF 2 METRIC															
W.P. <u>5215-13-01</u>		LOCATION <u>N 5461508.6; E 240828.2 NAD83 MTM ZONE 12 (LAT. 49.288232; LONG. -81.879447)</u>				ORIGINATED BY <u>MR</u>															
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AD</u>															
DATUM <u>GEODETIC</u>		DATE <u>September 19, 2017</u>				CHECKED BY <u>AB</u>															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa													
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 20 40 60 </div>									
221.7	END OF BOREHOLE		1	RC																	
12.2	Note: 1. Water level at a depth of 2.8 m below ground surface (Elev. 231.1 m) upon completion of drilling.																				

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PROJECT: 1661607

RECORD OF DRILLHOLE: MB-3

SHEET 1 OF 1

LOCATION: N 5461508.6; E 240828.2

DRILLING DATE: September 19, 2017

DATUM: GEODETIC

NAD83 MTM ZONE 12 (LAT. 49.288232; LONG. -81.879447)

DRILL RIG: CME 55

INCLINATION: -90° AZIMUTH: —

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.		RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA					HYDRAULIC CONDUCTIVITY			Diametral Point Load Index (MPa)	RMC -Q AVG.
	CME 55	NW NQ Coring			DEPTH (m)	TOTAL CORE %				SOLID CORE %	B Angle			DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s				
REFER TO PREVIOUS PAGE		223.2																					
11		METASEDIMENTARY CONGLOMERATE Fresh Fine grained Strongly foliated with rock fragments Dark grey		10.7	1	Grey 100																	
12																							
END OF DRILLHOLE		221.7																					
13																							
14																							
15																							
16																							
17																							
18																							
19																							
20																							
21																							
22																							

DEPTH SCALE

1 : 60

**GOLDER**

LOGGED: MR

CHECKED: AB

SUD-ROCK MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049 NE REGION02_DATA\GINT\1661607 GPJ GAL-MISS.GDT 4/6/18 TB/JLL

PROJECT <u>1661607</u>		RECORD OF BOREHOLE No MB-4				1 OF 1 METRIC											
W.P. <u>5215-13-01</u>		LOCATION <u>N 5461502.6; E 240846.6 NAD83 MTM ZONE 12 (LAT. 49.28818; LONG. -81.879193)</u>				ORIGINATED BY <u>MR</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>				COMPILED BY <u>AD</u>											
DATUM <u>GEODETIC</u>		DATE <u>September 20, 2017</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
233.9	GROUND SURFACE																
0.0	ASPHALT Pavement (200 mm)																
	Gravelly sand (FILL)																
	ASPHALT Pavement (100 mm)																
	Gravelly sand (FILL)																
0.6	Sand, trace to some gravel, some silt (FILL) Compact to dense Brown Moist		1	SS	24		233										
			2	SS	43		232										9 79 (12)
			3	SS	25		231										
	Clay pockets encountered in Sample 4.		4	SS	23												
230.1	Silt and sand, some clay, trace to some gravel (FILL) Very loose Grey Wet		5	SS	3		230									NP	3 39 40 18
	Cobbles encountered between 4.7 m and 5.0 m depth.		6	SS	6/0.15											NP	12 54 29 5
228.9	DIABASE DIKE (BEDROCK)						229										
5.0	Bedrock cored from 5.0 m depth to 8.4 m depth For coring details see Record of Drillhole MB-4		1	RC	REC 100%		228										RQD = 62%
			2	RC	REC 100%		227										RQD = 90%
			3	RC	REC 100%		226										RQD = 91%
225.5	END OF BOREHOLE																
8.4	Note: 1. Water level at a depth of 3.2 m below ground surface (Elev. 230.7 m) upon completion of drilling.																

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PROJECT: 1661607

LOCATION: N 5461502.6; E 240846.6

NAD83 MTM ZONE 12 (LAT. 49.28818; LONG. -81.879193)

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: MB-4







SHEET 1 OF 1

DRILLING DATE: September 20, 2017

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	RECOVERY										DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY		Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
								FLUSH	TOTAL CORE %		SOLID CORE %	R.Q.D. %	FRACT INDEX METRES	B Angle	DIP w.r.t CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	k, cm/s																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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5	NW	REFER TO PREVIOUS PAGE		228.9	1	Grey 100						JNIRRo JNIRRo JNPLSM SHRSTRo JNCURo JNCURo JNIRRo JNIRRo																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

DEPTH SCALE









1 : 60


GOLDER

LOGGED: MR

CHECKED: AB

SUD-RCK MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049 NE REGION02 DATA\GINT\1661607 GPJ GAL-MISS GDT 4/6/18 TB\JLL

PROJECT 1661607		RECORD OF BOREHOLE No MB-5				1 OF 1 METRIC											
W.P. 5215-13-01		LOCATION N 5461486.8; E 240834.9 NAD83 MTM ZONE 12 (LAT. 49.288036; LONG. -81.879351)				ORIGINATED BY MR											
DIST _____ HWY 11		BOREHOLE TYPE NW Casing and NQ Coring				COMPILED BY AD											
DATUM GEODETIC		DATE September 22, 2017				CHECKED BY AB											
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									
230.5	GROUND SURFACE							20	40	60	80	100					
0.0	Organic silty sand, trace gravel (FILL) Compact Brown Moist		1	SS	11		230										
			2	SS	10		229										
229.0							229										
1.5	Silty clay, trace wood (FILL) Soft Grey Wet		3	SS	4		228										
228.4							228										
2.1	PEAT (Amorphous) Soft Dark brown Wet		4	SS	4		227										
227.5							227										
3.0	CLAYEY SILT to SILTY CLAY Soft Grey Wet		5	SS	3	226											
226.7						226											
3.8	SILT and SAND, trace clay Compact Grey Wet		6	SS	17	225											
225.8						225											
4.7	COBBLES, some gravel		7	SS	7/0.15	224											
						224											
224.0						223											
6.5	METASEDIMENTARY CONGLOMERATE (BEDROCK) Bedrock cored from 6.5 m depth to 9.9 m depth For coring details see Record of Drillhole MB-5		1	RC	REC 100%	222											
			2	RC	REC 100%	221											
			3	RC	REC 100%												
220.6	END OF BOREHOLE																
9.9	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 230.2 m) upon completion of drilling.																

SUD-MTO 001 MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049_NE REGION\02_DATAGINT\1661607 GPJ GAL-MISS GDT 4/6/18 TBJJL

PROJECT: 1661607

LOCATION: N 5461486.8; E 240834.9

NAD83 MTM ZONE 12 (LAT. 49.288036; LONG. -81.879351)

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: MB-5

SHEET 1 OF 1

DRILLING DATE: September 22, 2017

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	FLUSH	RECOVERY		R.Q.D. %	FRACT. INDEX METRES	DISCONTINUITY DATA										HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q AVG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
								TOTAL CORE %	SOLID CORE %			B Angle		DIP w.r.t CORE AXIS		TYPE AND SURFACE DESCRIPTION		Jr	Ja	Jun																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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7	CME 55 NW NQ Coring	REFER TO PREVIOUS PAGE		224.0 6.5	1	Grey 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

DEPTH SCALE

1 : 60

**GOLDER**

LOGGED: MR

CHECKED: AB

SUD-PCCK MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049 NE REGION\02_DATA\GINT\1661607.GPJ GAL-MISS.GDT 4/6/18 TB/JLL

PROJECT <u>1661607</u>		RECORD OF BOREHOLE No MB-6		1 OF 1 METRIC												
W.P. <u>5215-13-01</u>		LOCATION <u>N 5461487.7; E 240850.6 NAD83 MTM ZONE 12 (LAT. 49.288046; LONG. -81.879136)</u>		ORIGINATED BY <u>MR</u>												
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. Hollow Stem Augers, NW Casing and NQ Coring</u>		COMPILED BY <u>AD</u>												
DATUM <u>GEODETIC</u>		DATE <u>September 20, 2017</u>		CHECKED BY <u>AB</u>												
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
230.9	GROUND SURFACE						20	40	60	80	100					
0.0	Organic silty sand (FILL) Dark brown		1	SS	7	▽										
0.2	Clayey sand, trace to some gravel (FILL)															
230.3	Loose Brown Moist		2	SS	5											
0.6	PEAT (Amorphous) Firm Black Wet															
229.5	DIABASE DIKE (BEDROCK)		1	RC	REC 100%											
1.4	Bedrock cored from 1.4 m depth to 4.5 m depth															
	For coring details see Record of Drillhole MB-6		2	RC	REC 100%											
			3	RC	REC 100%											
226.4	END OF BOREHOLE															
4.5	Note: 1. Water level at a depth of 0.3 m below ground surface (Elev. 230.6 m) upon completion of drilling.															

SUD-MTO 001 MTM ZNI INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049_NE REGION\02_DATA\GINT\1661607.GPJ GAL-MISS.GDT 4/6/18 TB/JUL

PROJECT: 1661607

LOCATION: N 5461487.7; E 240850.6

NAD83 MTM ZONE 12 (LAT. 49.288046; LONG. -81.879136)

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: MB-6

SHEET 1 OF 1

DRILLING DATE: September 20, 2017

DATUM: GEODETIC

DRILL RIG: CME 55

DRILLING CONTRACTOR: George Downing Estate Drilling Ltd

DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN	JN - Joint		BD - Bedding		PL - Planar		PO - Polished		BR - Broken Rock																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
								FLT - Fault	SHR - Shear	FO - Foliation	CU - Curved	K - Slickensided	SM - Smooth	Ro - Rough	MB - Mechanical Break																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
	VN - Vein	CJ - Conjugate						CO - Contact	UN - Undulating	ST - Stepped	IR - Irregular	NOTE: For additional abbreviations refer to list of abbreviations & symbols.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
	FLUSH	TOTAL CORE %						SOLID CORE %	R.Q.D. %	FRACT. INDEX METRES	B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jn	HYDRAULIC CONDUCTIVITY k, cm/s	Diametral Point Load Index (MPa)	RMC -Q AVG.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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UCS = 69.9 MPa

DEPTH SCALE

1 : 60

**GOLDER**

LOGGED: MR

CHECKED: AB

SUD-PCCK MTM ZN INC LAT/LONG S:\CLIENTS\MTM\1661607 LEA_5015-E-0049 NE REGION\02_DATA\GINT\1661607.GPJ GAL-MISS.GDT 4/6/18 TB/JLL

APPENDIX B

Laboratory Testing

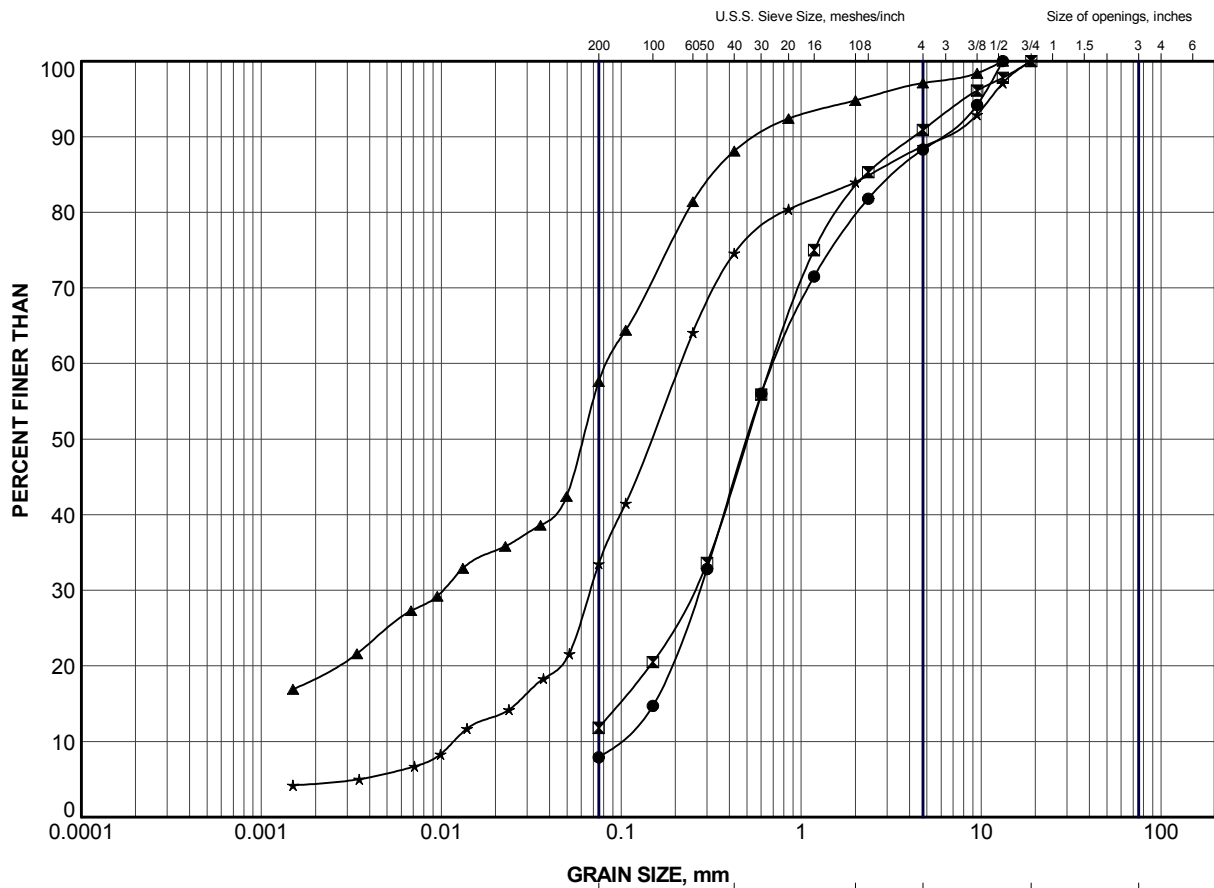
Table B1 - Summary of Analytical Testing of Soil Sample

Parameter	Units	Borehole MB-4
Resistivity	ohm-cm	6,000
Conductivity	µmho/cm	168
pH	pH	7.98
Sulphate	µg/g	24
Chloride	µg/g	37

Notes:

1. Sample obtained September 20, 2017
2. Analytical testing carried out by Maxxam Analytics Inc.

Prepared by: AD
Reviewed by: AB

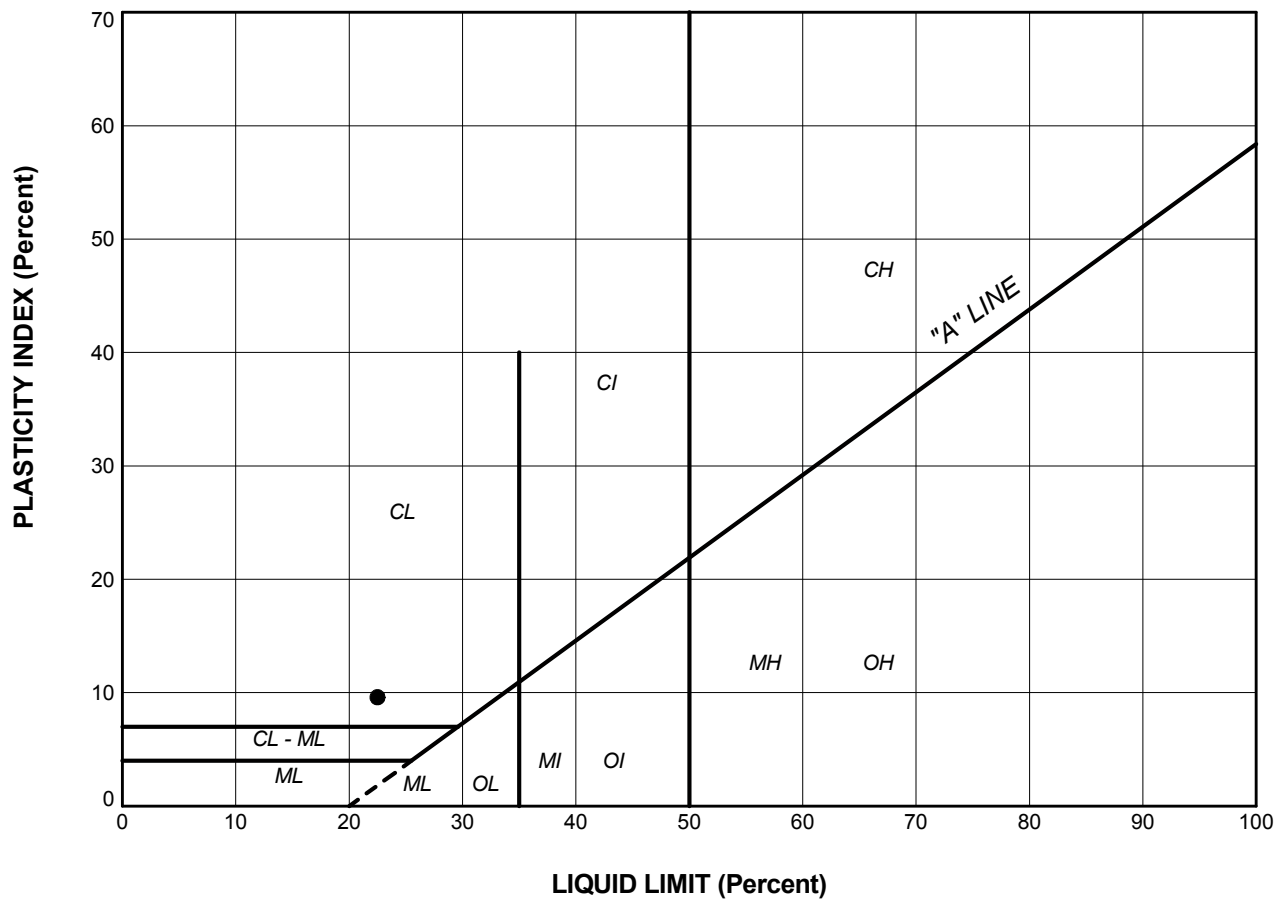


CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MB-3	4	230.5
⊠	MB-4	2	232.1
▲	MB-4	5	229.8
★	MB-4	6	229.3

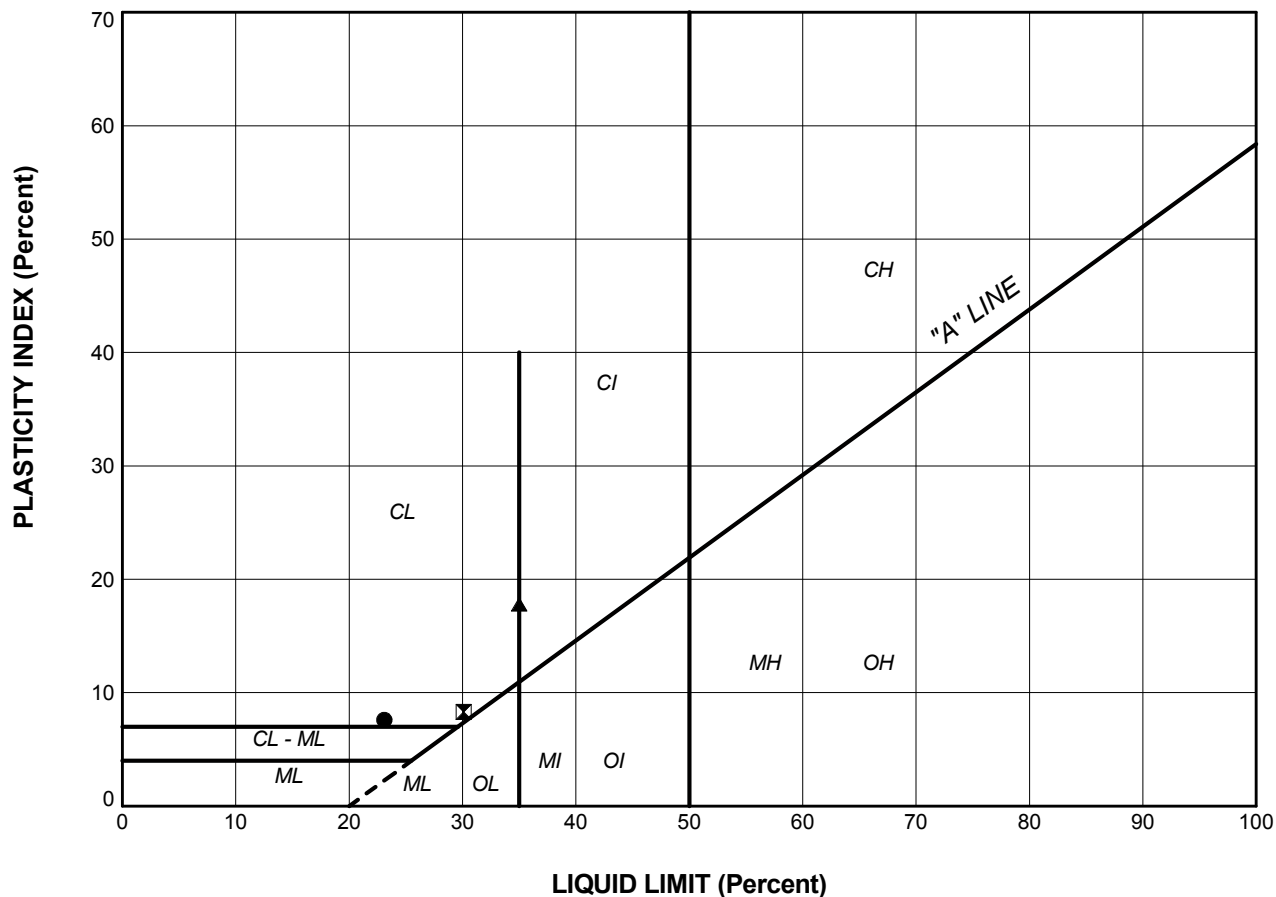
PROJECT					
HIGHWAY 11 MOONBEAM CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SILT and SAND to SAND (FILL)					
PROJECT No.		1661607		FILE No. 1661607.GPJ	
DRAWN	TB	Apr 2018	SCALE	N/A	REV.
CHECK	AB	Apr 2018	FIGURE B1		
APPR	JMAC	Apr 2018			
SUDBURY, ONTARIO					



LEGEND


SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MB-3	5	22.5	12.9	9.6

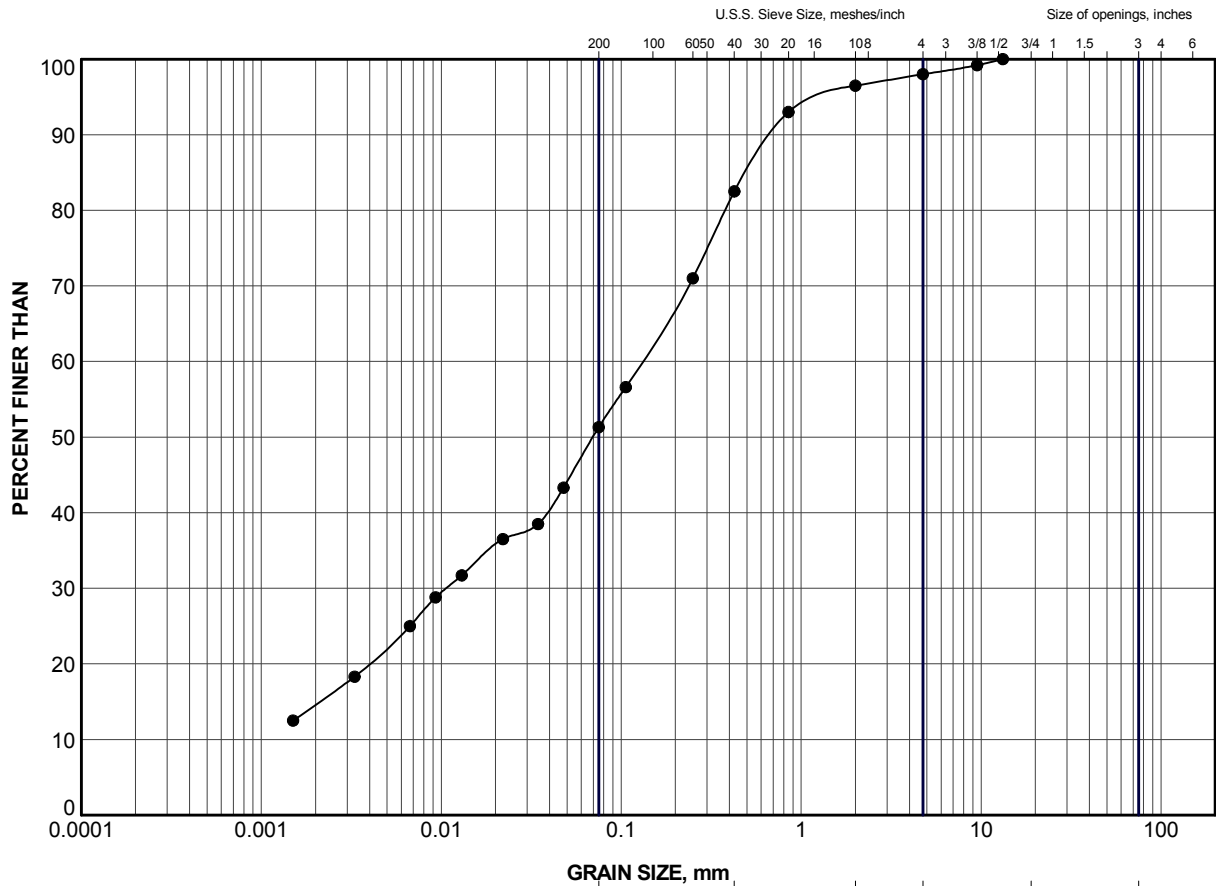
PROJECT						
HIGHWAY 11 MOONBEAM CREEK CULVERT						
TITLE						
PLASTICITY CHART CLAYEY SILT (FILL)						
 GOLDER SUDBURY, ONTARIO		PROJECT No.			1661607	
		DRAWN			TB	Apr 2018
		CHECK			AB	Apr 2018
		APPR			JMAC	Apr 2018
		FILE No.			1661607.GPJ	
		SCALE			N/A	REV.
					FIGURE B2	



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	MB-1	4A	23.1	15.5	7.6
⊠	MB-2	2	30.1	21.8	8.3
▲	MB-5	5	35.0	17.2	17.8

PROJECT						HIGHWAY 11 MOONBEAM CREEK CULVERT					
TITLE						PLASTICITY CHART CLAYEY SILT to SILTY CLAY					
PROJECT No.			1661607			FILE No.			1661607.GPJ		
DRAWN		TB		Apr 2018		SCALE		N/A		REV.	
CHECK		AB		Apr 2018							
APPR		JMAC		Apr 2018							
 GOLDER SUDBURY, ONTARIO						FIGURE B3					

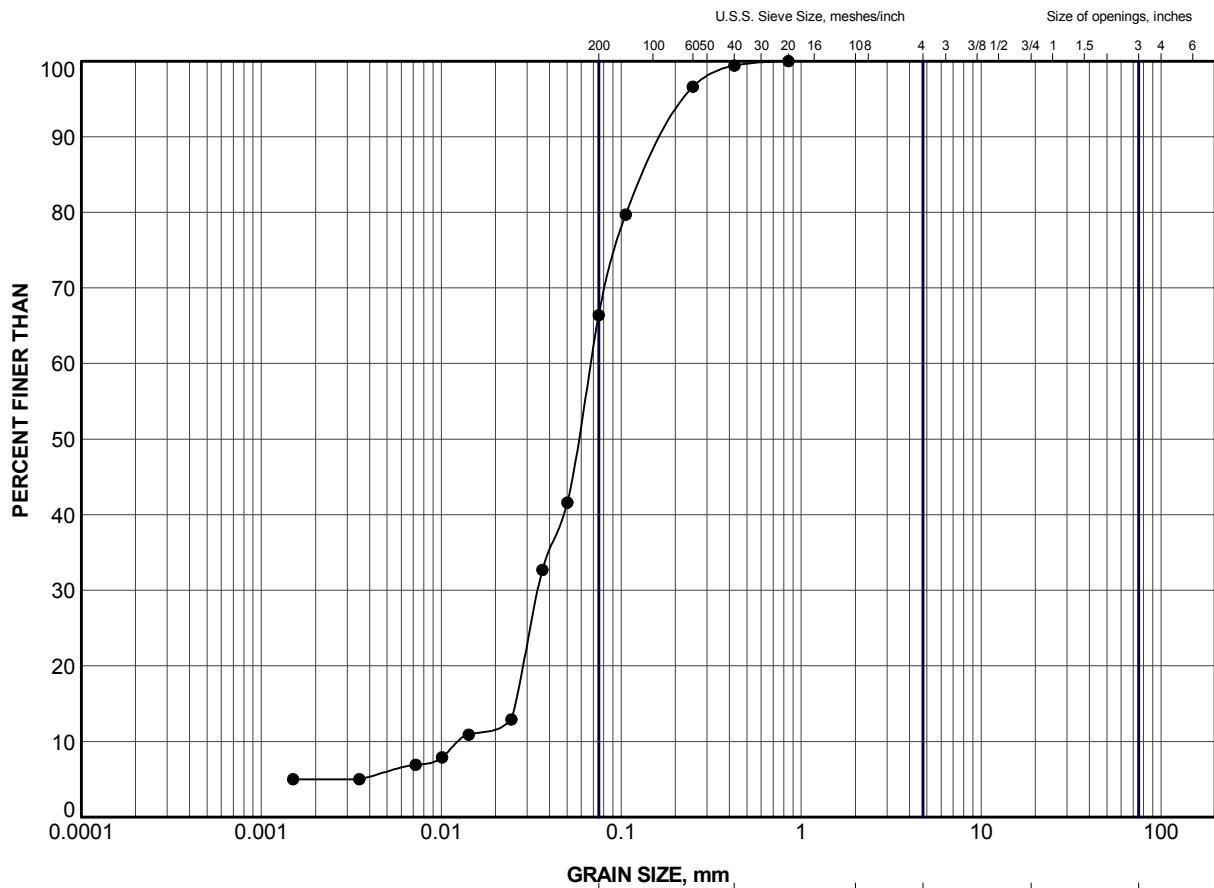


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MB-2	2	229.0

PROJECT						HIGHWAY 11 MOONBEAM CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION CLAYEY SILT with SAND					
PROJECT No.			1661607			FILE No.			1661607.GPJ		
DRAWN	TB	Apr 2018	SCALE	N/A	REV.						
CHECK	AB	Apr 2018									
APPR	JMAC	Apr 2018				FIGURE B4					
GOLDER											
SUDBURY, ONTARIO											

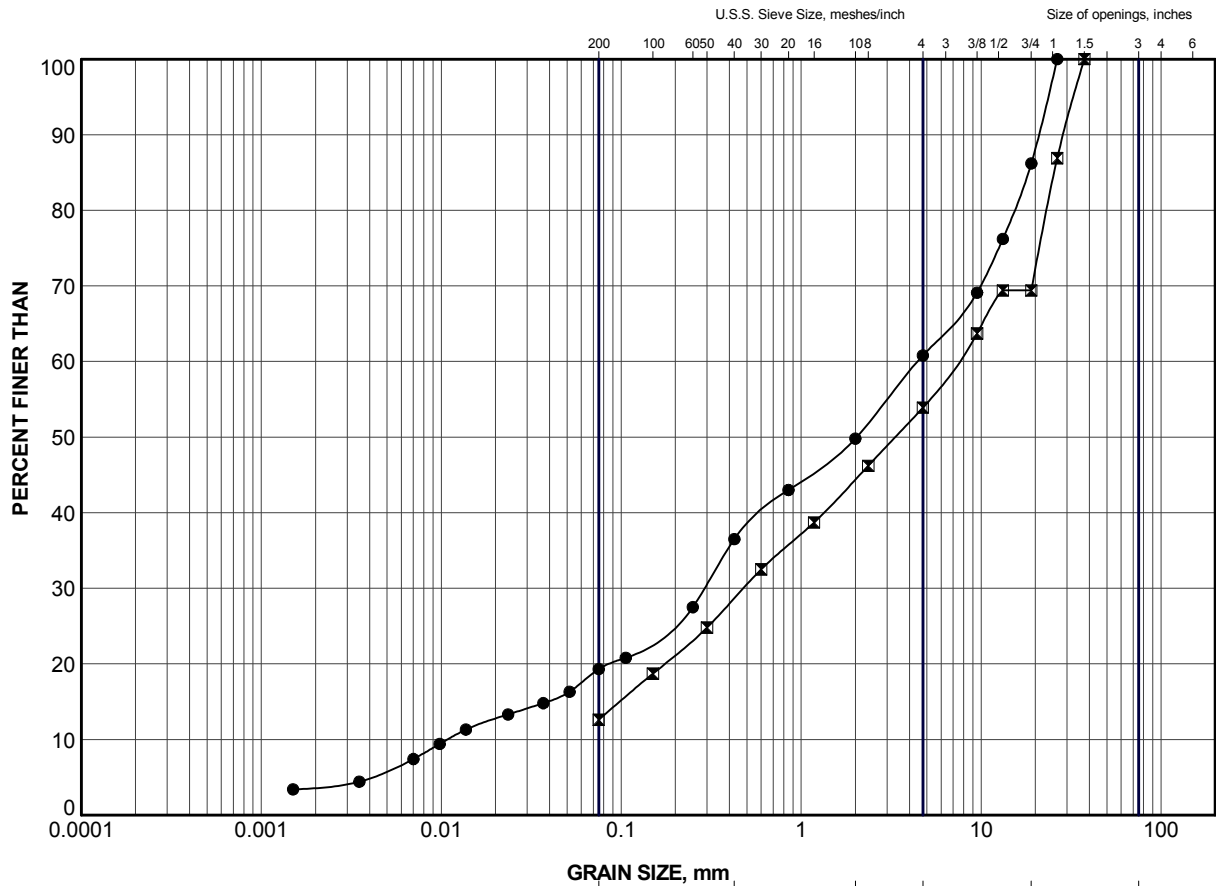


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MB-5	6	226.4


PROJECT					
HIGHWAY 11 MOONBEAM CREEK CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION SILT and SAND					
PROJECT No.		1661607		FILE No.	
DRAWN		TB		Apr 2018	
CHECK		AB		Apr 2018	
APPR		JMAC		Apr 2018	
SCALE		N/A		REV.	
GOLDER		SUDBURY, ONTARIO		FIGURE B5	



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	MB-1	5	226.2
×	MB-3	9	224.5

PROJECT						HIGHWAY 11 MOONBEAM CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SAND and GRAVEL (TILL)					
PROJECT No.				1661607		FILE No.				1661607.GPJ	
DRAWN		TB		Apr 2018		SCALE		N/A		REV.	
CHECK		AB		Apr 2018							
APPR		JMAC		Apr 2018							
 GOLDER SUDBURY, ONTARIO						FIGURE B6					

Borehole MB-2



Box 1: 1.6 m – 4.5 m

Borehole MB-3



Box 1: 10.7 m – 12.2 m

Borehole MB-4



Box 1: 5.0 m – 8.4 m

Borehole MB-5




Box 1: 6.5 m – 9.9 m

Borehole MB-6



Box 1: 1.4 m – 5.4 m

REVISION DATE: July, 2017 BY: AB Project: 1661607

PROJECT		Highway 11 Moonbeam Creek Culvert			
TITLE		Bedrock Core Photographs			
 GOLDER	PROJECT No. 1661607		FILE No. ----		
	DESIGN	AD	DEC	SCALE	NTS
	CADD	--		FIGURE B7	
	CHECK	AB	DEC		
REVIEW					



golder.com