



FINAL REPORT

FOUNDATION INVESTIGATION REPORT Unnamed Creek Culvert Rehabilitation - Hwy 634 (Site No. 39E-243/C, 49.519368N 81.502488W) Township of Adanac, District of Cochrane

**Agreement No. 5015-E-0007
Assignment No. 1
WO 2016-11014
Geocres No. 42H-63**

Prepared for:

Ontario Ministry of Transportation
Regional Director's Office -NE Region
447 McKeown Avenue, Suite 301
North Bay, ON P1B 9S9
Attn: J. P. Perron

Ontario Ministry of Transportation
Pavements and Foundations Section
Materials Engineering and Research Office
Room 223, 2/F
145 Sir William Hearst Avenue
Toronto, ON M3M 0B6
Attn: K. Ahmad

exp Services Inc.
August 29, 2016

Ontario Ministry of Transportation

Northeastern Region Geotechnical Section

Foundation Investigation Report

Agreement No. 5015-E-0007

Assignment No. 1

WO 2016-11014

MTO GEOCREs No. 42H-63

Type of Document:

FINAL

Project Name:

Unnamed Creek Culvert Rehabilitation - Hwy 634

Township of Adanac, District of Cochrane

Project Number:

ADM-00233185-A0

Prepared by:

Robert Bradford, P.Eng.

Silvana Micic, Ph.D., P.Eng.

Reviewed by:

Stan E. Gonsalves, M.Eng., P. Eng.

exp Services Inc.

56 Queen St, East, Suite 301

Brampton, ON L6V 4M8

Canada



Silvana Micic, Ph.D., P.Eng.
Senior Geotechnical Engineer



Stan E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact

Date Submitted:

29/08/2016

Table of Contents

PART I : FOUNDATION INVESTIGATION REPORT

1.1	Introduction	1
1.2	Site Description and Geological Setting	1
1.2.1	Site Description.....	1
1.2.2	Geological Setting.....	2
1.3	Investigation Procedures	2
1.3.1	Site Investigation and Field Testing.....	2
1.3.2	Laboratory Testing	3
1.3.3	Previous Investigation.....	4
1.4	Subsurface Conditions.....	4
1.4.1	Topsoil/ Organic/ Peat	4
1.4.2	Sandy Silt	5
1.4.3	Clayey Silt	5
1.4.4	Clayey Silt Till	5
1.5	Groundwater Conditions	7

PART II : CLOSURE

Appendices

APPENDIX A: PHOTOGRAPHS

APPENDIX B: DRAWING

APPENDIX C: BOREHOLE LOGS

APPENDIX D: LABORATORY DATA

1 Part I: FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This report presents the results of a geotechnical investigation completed by **exp** Services Inc. for temporary cofferdam design for the purpose of rehabilitation of the Unnamed Creek Culvert system on Highway 634, approximately 35.5 km north of Highway 11, in Adanac Township, District of Cochrane. The Unnamed Creek Culvert structure consists of two 2.4 m diameter SPCSP's each having a total length of approximately 24 m. The maximum depth of cover above the Unnamed Creek Culverts is approximately 1.4 m respectively.

The purpose of the investigation is to determine the existing soil conditions in the vicinity of the existing culverts for temporary cofferdams for the purpose of dewatering during the rehabilitation of the culverts.

The site specific geotechnical investigation consisted of a field investigation including visual inspections, drilling, soil sampling, and laboratory testing. Factual results of the investigation and laboratory testing are included in this report. The report has been prepared specifically and solely for the projects described in the report.

The work was undertaken under Agreement # 5015-E-0007, Assignment No. 1. The terms of reference (TOR) were as presented in MTO letter dated April 15, 2016.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Unnamed Creek Culverts are located along Hwy 634, approximately 35.5 km north of Hwy 11, in the Township of Adanac, at the approximate Station 20+280 (based on information provided in the TOR). Hwy 634 is a two lane, north/south roadway with approximately 1 m wide granular shoulders. The highway crosses above the Unnamed Creek Culverts with approximately 1.4 m of embankment fill, and 2H:1V slopes. Photographs of the site is included in Appendix A of this report. The culvert locations and cross sectional profiles are as shown on Drawings No. 1 to 3 in Appendix B.

During the site reconnaissance on May 30, 2016, the general site conditions were assessed. Unnamed Creek flow from the south-west to the north-east towards The Trappers River tributary, which itself flows north into the Abitibi River. Vegetation at the site consists primarily of large pine trees and wild bushes. The inlet and outlet of the culverts are surrounded by trees and shrubs. The terrain surrounding the inlet is swampy due to fluctuating water levels and surface runoff water.

In general, the slopes of highway embankments are partly covered with grass and/or light vegetation and granular material (portions of the embankment slopes, generally above and around the culverts, are covered with large boulders (up to 1.5 m in diameter). Bedrock outcrops were not

observed at the site. The surface of Hwy 634 at the culvert locations was in a fair shape with a number of localized cracks on the asphalt. No major transverse cracks were observed.

During the field investigation, the water level at Unnamed Creek was approximately at Elevation 97.8 m. The road surface elevation at the Unnamed Creek Culvert location is at about 100.54 m (it should be noted that these are the elevations which were provided in the TOR. These elevations will be referenced for the remainder of the report). It was observed that the culverts were experiencing significant creek flow through them.

All relevant photographs can be found in Appendix A.

1.2.2 Geological Setting

According the Ministry of Northern Development and Mines, Maps 2518 (Sacrificial Geology of Northern Ontario, 1987) and 2543 (Bedrock Geology of Ontario, East-Central Sheet, 1991), the site is located in the boundary between a clay-silt deposit and a till deposit underlain by Metasedimentary bedrock. The clay-silt deposit is mapped as glaciolacustrine deposit, while the till deposits is noted as unsorted mixture of boulders, sand, silt and clay sized particles. The Metasedimentary Rock Group comprises of argillite, slate, marble, chert, wacke, arkos, iron formation and minor metavolcanic rock intrusions.

1.3 Investigation Procedures

1.3.1 Site Investigation and Field Testing

The field investigation was performed between June 1st and 2nd, 2016. The field program consisted of drilling four (4) sampled boreholes with a machine-powered drill rig (BH U1 to U4). These boreholes were located as close as possible to the locations instructed in the TOR: (i) BH-U1 was placed in the proximity of the northern outlet area; (ii) BH-U2 was placed in the proximity of the southern outlet area; (iii) BH-U3 was placed in the proximity of the northern inlet area; and (iv) BH-U4 was placed in the proximity of the southern inlet area. The summary of all four boreholes information is shown in Table 1.1 as follows:

Table 1.1. The summary of borehole investigation information

Borehole No.	Coordination (MTM)	Ground Surface Elevation (m)	Depth (m)
BH-U1	N5488213 E268225	98.3	10.5
BH-U2	N5488189 E268217	98.5	10.5
BH-U3	N5488013 E268196	98.0	10.5
BH-U4	N5487984 E268431	98.5	10.3

The boreholes were advanced using a track mounted CME-55 drill rig equipped with hollow stem auger and standard soil sampling equipment owned and operated by Landcore Drilling out of Sudbury, Ontario.

The drilled boreholes were advanced to a depth of approximately 10.5 m below ground surface. Drawing No. 1 to 3 in Appendix B show the locations of all eight boreholes and cross-sections of stratigraphy along the existing culvert alignment and the embankment.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by **exp** personnel following drilling. A temporary reference point (referred to as TBM) on the highway was selected because the other geodetic benchmarks could not be found in the vicinity. The elevation of the temporary TBM is estimated to be approximately 100.54 m at Unnamed Creek, based on the MTO drawings.

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D 1586), at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT "N" values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (Section 4.5.2) and used to provide an assessment of in-situ consistency or relative density of non-cohesive soils.

Following completion of boreholes, groundwater level measurements were carried out from the boreholes. However, due to the very fine grained, cohesive nature of the soils encountered throughout the entire depth of all boreholes, the stabilized ground water level could not be established by short term observation (the boreholes appeared open and dry). The drilled boreholes were decommissioned by bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by members of **exp**'s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO Soils Classification System for Foundation Investigation Report, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags, and returned to **exp**'s Brampton laboratory for additional visual, textual and olfactory examination. .

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content and particle size distribution for approximately 25% of the collected soil samples. Atterberg limits test were carried out for cohesive soils. All of the laboratory tests were carried out according to MTO and/or ASTM Standards as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses and plasticity chart are presented graphically in Appendix D.

1.3.3 Previous Investigation

No foundation reports are available in the MTO GEOCREST library for this site.

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. The “Explanation of Terms Used in Report” preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross section subsurface profiles are provided in Appendix B. It should be noted that the stratigraphic boundaries indicated on the borehole log and cross section stratigraphic profiles are inferred from semi-continuous sampling, observations of drilling progress and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the site was underlain by a native deposit of clayey silt till. Bedrock was not encountered at the locations of drilling. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 Topsoil/ Organic/ Peat

A layer of topsoil was encountered in all boreholes at the surface and had a thickness between 50 mm and 130 mm, extending to between Elev. 97.9 m to Elev. 98.4 m. The topsoil consists mainly of peat and organics (i.e., bits of decayed wood, bark, roots and rootlets) as well as some silt and clay, trace sand and trace gravel. It was dark brown in colour, and wet. The SPT “N” values within the topsoil layer are between 2 and 12 blows per 300 mm penetration, classifying this material as very loose to compact in relative density.

Laboratory testing performed on selected samples consists of three (3) moisture content tests. The test results are as follows:

Moisture content:

- 65% to 80%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

1.4.2 Sandy Silt

Underlying the topsoil in BH-U1 and BH-U4, a layer of native sandy silt was encountered. The layer is approximately 0.4 m thick in both boreholes, extending to Elev. 97.5 m (BH-U1) and Elev. 97.7 m (BH-U4).

The sandy silt contains some clay and gravel and trace rootlets and ice chunks in BH-U1. The layer was blackish brown in colour at BH-U1 and grey at BH-U4 and moist to wet. Two (2) standard penetration resistance "N" values were obtained ranging from 2 (BH-U4) to 12 (BH-U1) suggesting a very loose to compact relative density.

Laboratory testing performed on a selected sample consists of one (1) moisture content test. The test result is as follows:

Moisture Content:

- 28%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

1.4.3 Clayey Silt

A single occurrence of native clayey silt was encountered in BH-U3 below the topsoil. The layer is approximately 0.7 m thick, extending to Elev. 97.2 m.

The clayey silt contains some sand and trace gravel and organics. The layer was brown in colour and wet. One (1) Standard penetration resistance "N" value of 2 was obtained suggesting a very soft consistency.

Laboratory testing performed on selected samples consists of one (1) moisture content tests. The test result is as follows:

Moisture content:

- 42%

The result of the laboratory test is provided on the Record of Borehole sheets in Appendix C.

1.4.4 Clayey Silt Till

Native clayey silt till was encountered below the topsoil in BH-U2, below the sandy silt in BH-U1 and BH-U4, and below the clayey silt in BH-U3, and extended to the termination depth of all boreholes. The layer of clayey silt till extended to a depth of 10.3 m to 10.5 m below ground surface or to elevations ranging from 87.5 m to 88.2 m. The thickness of this layer ranges from 9.5 m to 10.4 m.

The clayey silt till contains trace to some sand and trace gravel. Borehole BH-U2 contains three separate seams of silt to sandy silt at approximate Elev. 97.3 m, Elev. 92.3 m and Elev. 89.2 m. Borehole BH-U3 contains a seam of sandy silt at Elev. 91.8 m and 0.8 m thick layer of silty sand, some gravel within the clayey silt till at Elev. 88.9 m. The one layer of sandy silt has an SPT "N" value of 21 blows indicating a compact relative density. The clayey silt till is brown to grey in colour and moist to wet. SPT "N" values within the till ranges from 2 to >100 blows per 300 mm penetration indicating a very soft to hard, but generally firm to very stiff consistency.

Laboratory testing performed on a selected samples of the clayey silt till consists of forty (40) moisture content, nine (9) grain size distribution and five (5) Atterberg Limits tests. The test results are as follows:

Moisture Content:

- 12% to 30%

Grain Size Distribution:

- 0% to 4% gravel
- 8% to 18% sand
- 59% to 62% silt, and
- 21% to 25% clay

Atterberg Limits:

- Liquid Limit: 21% to 22%
- Plastic Limit: 12% to 13%
- Plasticity Index: 8% to 9%

Laboratory testing performed on the sample of silty sand consists of one (1) moisture content and one (1) grain size distribution tests. The test results are as follows:

Moisture Content:

- 12%

Grain Size Distribution:

- 13% gravel
- 52% sand
- 35% fines

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheets in Appendix C. The results of the grain size distribution test are also provided on Figures 1 to 4 in Appendix D. The results of the Atterberg Limits tests are provided on Figure 3 in Appendix D.

1.5 Groundwater Conditions

The Information regarding groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion. However, due to the very fine grained, cohesive nature of the soils encountered throughout the entire depth of all boreholes, the stabilized ground water level could not be established by short term observation.

At the time of the investigation, the water level at Unnamed Creek were approximately at Elevation 97.8 m. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

2 Part II CLOSURE

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the works, should, in this light, decide on their own investigations as well as their own interpretations of the factual borehole results so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The borehole investigation program for this project was supervised by Robert Bradford, P.Eng. and Mo'oud Nasr, P.Eng. with **exp** Services Inc. This Foundation Investigation and Design Report has been prepared by Robert Bradford P.Eng. and Silvana Micic, Ph.D., P.Eng and reviewed by Stan Gonsalves, M.Eng., P.Eng., Designated MTO Foundation Contact.

We trust that these comments provide you with sufficient information to proceed with design. Should you have any questions, please do not hesitate to contact this office.

exp Services Inc.

Robert Bradford, P.Eng.
Geotechnical Engineer

Silvana Micic, Ph.D, P.Eng.
Senior Geotechnical Engineer

Stan E. Gonsalves, M.Eng., P.Eng.
Principal Engineer
Designated MTO Foundation Contact

Encl.



Appendix A – Photographs



Photo 1. BH-U3 at Unnamed Creek Culvert (facing west) on June 1, 2016



Photo 2. Outlet side of Unnamed Creek Culvert System (facing east) on June 1, 2016



Photo 3. BH-U2 at Unnamed Creek Culvert (facing north-east) on June 2, 2016

Appendix B – Drawings

METRIC
DIMENSIONS ARE IN METERS AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETERS +METERS

AGREEMENT NO. 5015-E-0007
ASSIGNMENT NO. 1
GEOCRES NO. 42H-63

UNNAMED CREEK CULVERT
(TOWNSHIP OF ADANAC)

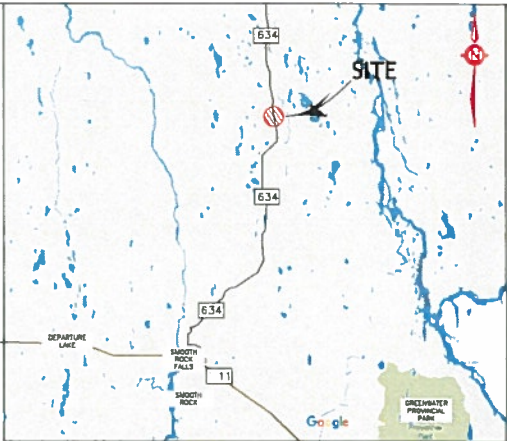
SHEET

1



exp Services Inc.

KEY PLAN



LEGEND

Approx. Current Investigated Borehole Locations

LEGEND

- | | |
|----------------------|-----------------|
| ASPHALT | PEAT/SANDY PEAT |
| FILL | SILTY SAND |
| COBBLES AND BOULDERS | SAND AND GRAVEL |
| BEDROCK | |

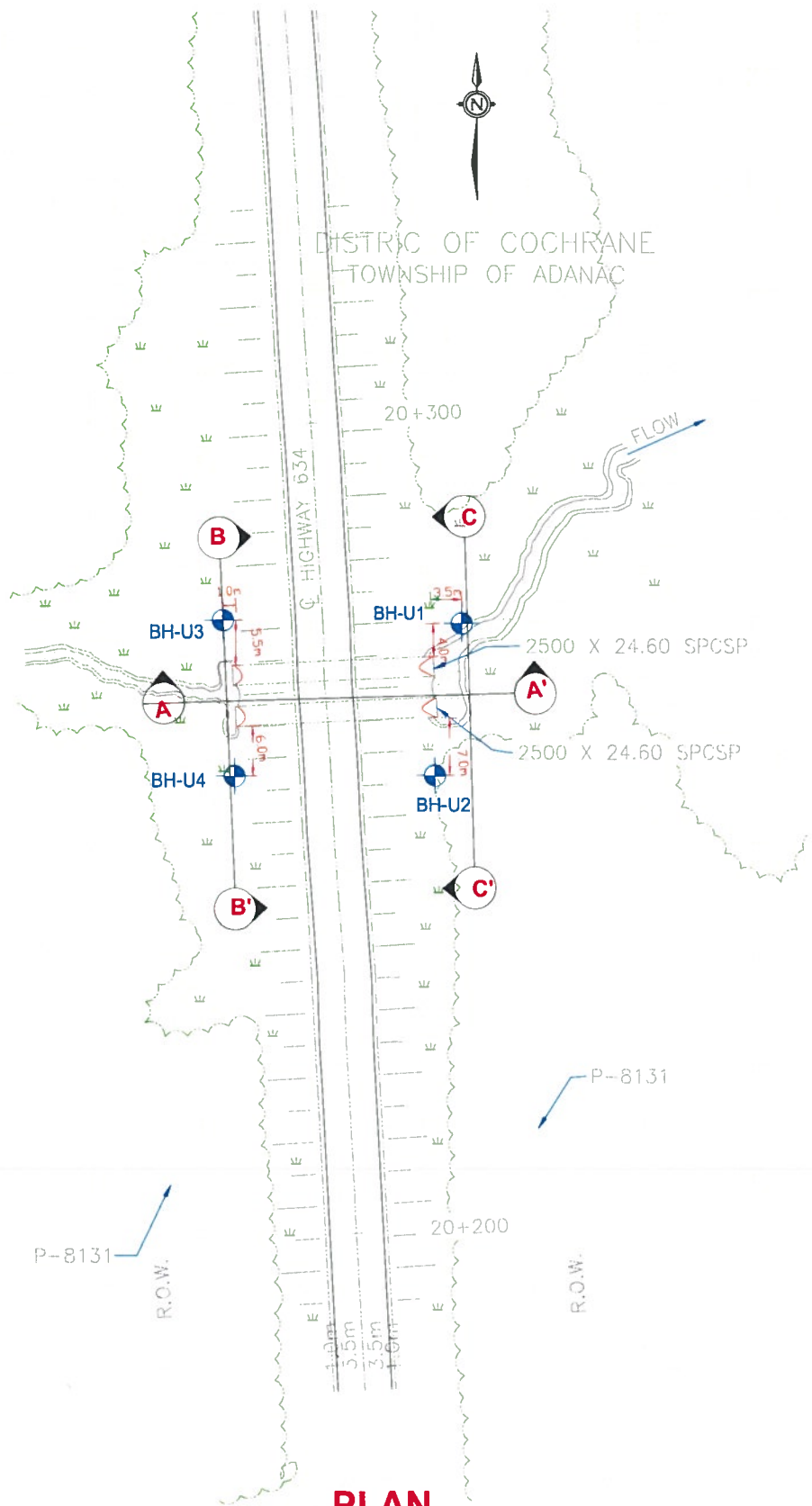
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U1	98.3	5488213	268225
BH-U2	98.5	5488189	268217
BH-U3	98.0	5488013	268196
BH-U4	98.5	5487984	268431

NOTE

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.

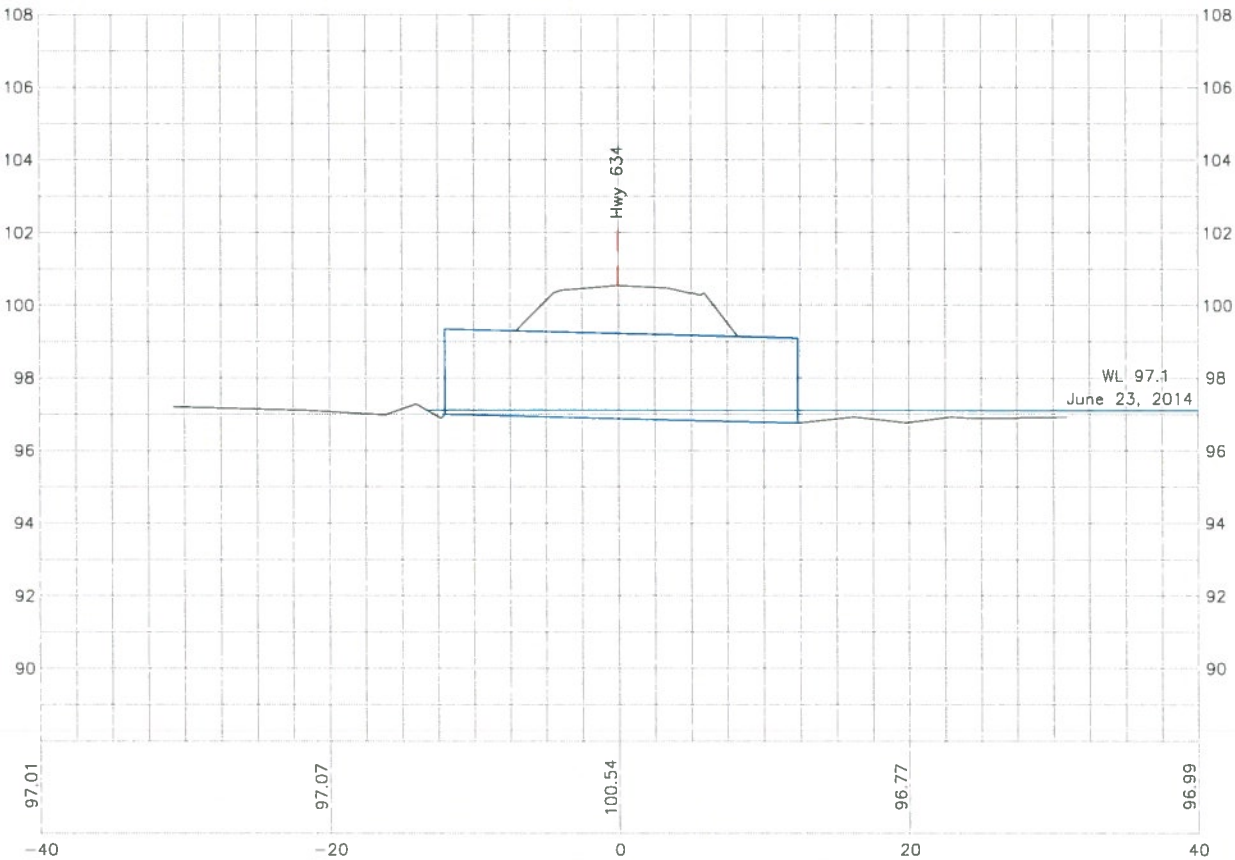
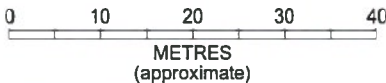
The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

AUG 2016	SM	FINAL SUBMISSION	
JULY 2016	TK	SUBMISSION FOR REVIEW	
DATE	BY	DESCRIPTION	
SCALE	SEE SCALE BAR	PROJECT NO.	ADM 00233185-A0
SUBMD SM	CHECKED SM	DATE AUG 2016	SITE No. 39E-243/C
DRAWN RB	CHECKED SM	APPROVED SG	DWG. 01



PLAN

UNNAMED CREEK CULVERT SITE 39E-243/C
(SCALE 1:800)
35.3 KM NORTH OF HIGHWAY 11



SECTION A-A'



METRIC
DIMENSIONS ARE IN METERS AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETERS +METERS

AGREEMENT NO. 5015-E-0007
ASSIGNMENT NO. 1
GEOCRES NO. 42H-63

UNNAMED CREEK CULVERT
(TOWNSHIP OF ADANAC)

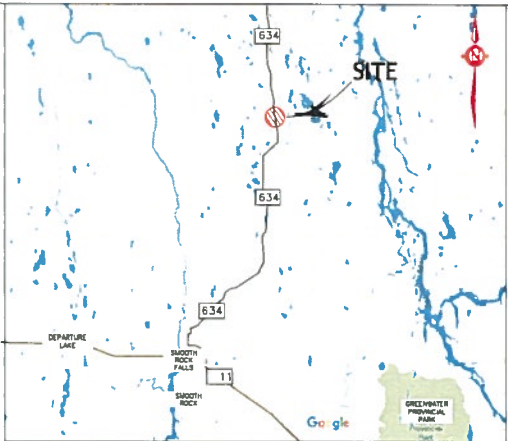
SHEET

1



exp Services Inc.

KEY PLAN



LEGEND



LEGEND



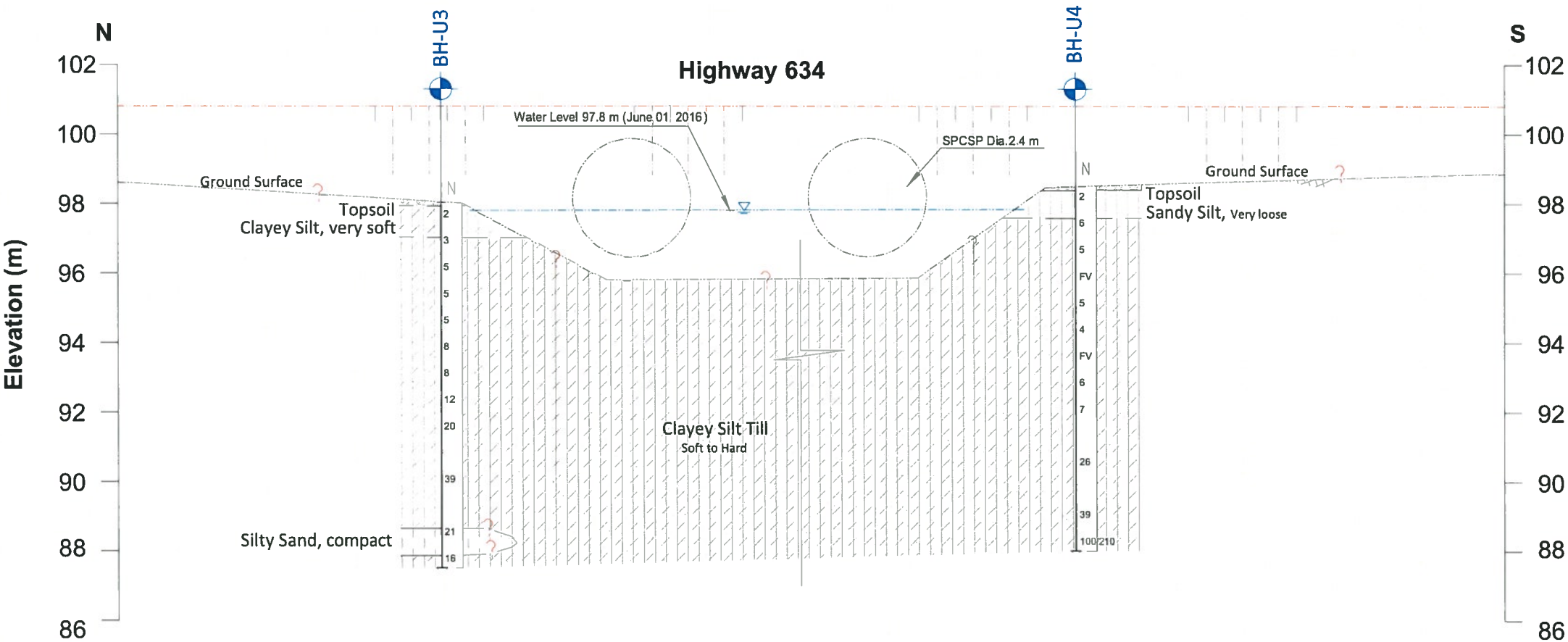
BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U3	98.0	5488013	268196
BH-U4	98.5	5487984	268431

NOTE

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 complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

AUG 2016	SM	FINAL SUBMISSION	
JULY 2016	TK	SUBMISSION FOR REVIEW	
DATE	BY	DESCRIPTION	
SCALE	SEE SCALE BAR	PROJECT NO.	ADM 00233185-A0
SUBM'D	SM	CHECKED	SM
DATE	AUG 2016	SITE No.	39E-243/C
DRAWN	RB	CHECKED	SM
APPROVED	SG	DWG. 02	

Unnamed Creek Culvert Inlet



SECTION B-B'



Note:
The geometry of the existing ground surface is assumed based on the investigated elevations of boreholes and the bottom of the creek.

METRIC
DIMENSIONS ARE IN METERS AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETERS + METERS

AGREEMENT NO. 5015-E-0007
ASSIGNMENT NO. 1
GEOCRES NO. 42H-63

UNNAMED CREEK CULVERT
(TOWNSHIP OF ADANAC)

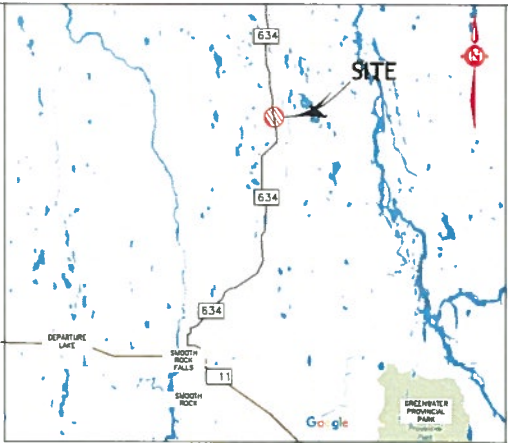
SHEET

1



exp Services Inc.

KEY PLAN



LEGEND



Approx. Current Investigated Borehole Locations

LEGEND



TOPSOIL



SANDY SILT



CLAYEY SILT TILL

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-U1	98.3	5488213	268225
BH-U2	98.5	5488189	268217

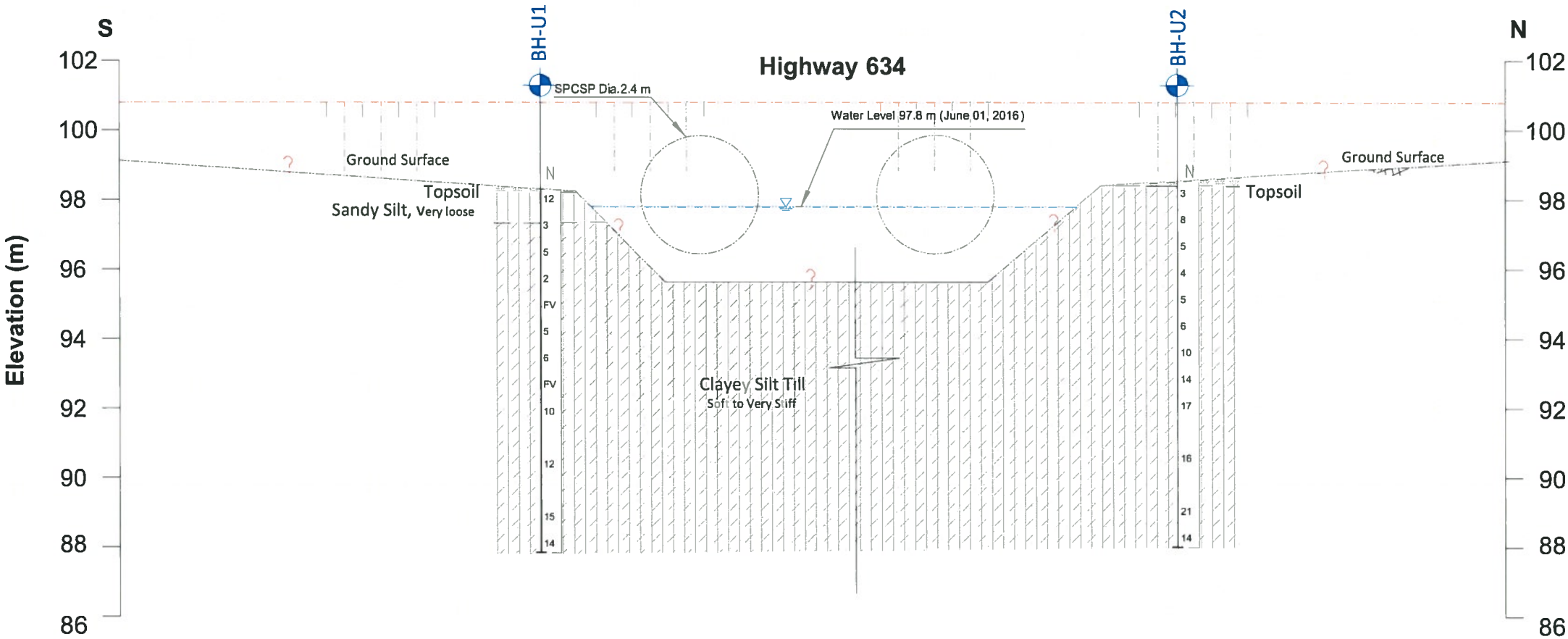
NOTE

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 complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

AUG 2016	SM	FINAL SUBMISSION
JULY 2016	TK	SUBMISSION FOR REVIEW
DATE	BY	DESCRIPTION
SCALE	SEE SCALE BAR	PROJECT NO. ADM 00233185-A0
SUBM'D SM	CHECKED SM	DATE AUG 2016 SITE No. 39E-243/C
DRAWN RB	CHECKED SM	APPROVED SG DWG. 03

Unnamed Creek Culvert Outlet



SECTION C-C'



Note:
The geometry of the existing ground surface is assumed based on the investigated elevations of boreholes and the bottom of the creek.

Appendix C – Borehole Logs

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.		FINE COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED SOIL CLASSIFICATION											

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

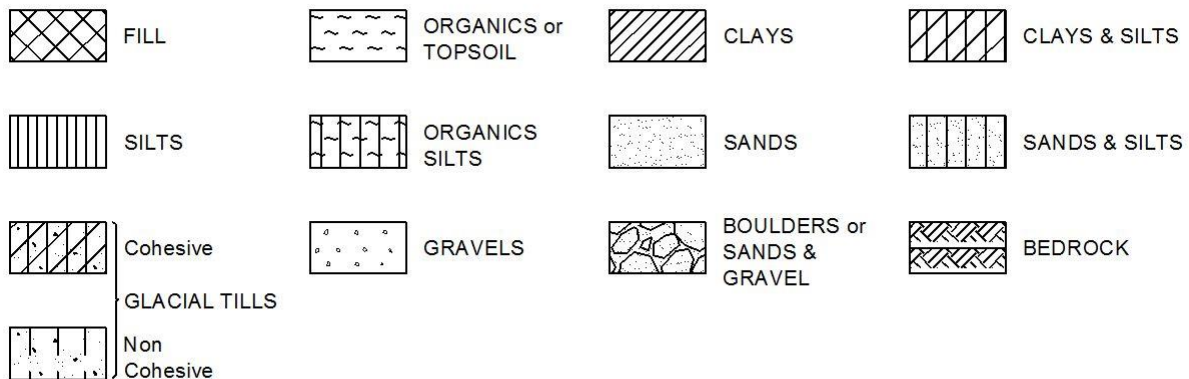
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



Open Borehole or Test Pit



Monitoring Well, Piezometer or Standpipe

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

STRESS AND STRAIN

u_w	kPa	Pore water pressure
r_u	1	Pore pressure ratio
σ	kPa	Total normal stress
σ'	kPa	Effective normal stress
τ	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
ε	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m ² /s	Coefficient of consolidation
H	m	Drainage path
T_v	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_p	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	—°	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	—°	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m ³	Density of solid particles
γ_s	kN/m ³	Unit weight of solid particles
ρ_w	kg/m ³	Density of water
γ_w	kN/m ³	Unit weight of water
ρ	kg/m ³	Density of soil
γ	kN/m ³	Unit weight of soil
ρ_d	kg/m ³	Density of dry soil
γ_d	kN/m ³	Unit weight of dry soil
ρ_{sat}	kg/m ³	Density of saturated soil
γ_{sat}	kN/m ³	Unit weight of saturated soil
ρ'	kg/m ³	Density of submerged soil
γ'	kN/m ³	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_p	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_p$
I_C	%	Consistency index = $(W_L - W)/I_p$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m ³ /s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m ³	Seepage force

Brampton, Ontario

RECORD OF BOREHOLE No U1

1 OF 1

METRIC

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5488213 E268225 ORIGINATED BY R.B.
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.
 DATUM Geodetic DATE 2016/06/01 - 2016/06/01 CHECKED BY S.M.

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	×	QUICK TRIAXIAL	LAB VANE											
98.3	Ground Surface							20	40	60	80	100											
98.4	TOPSOIL: (~51 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose. SANDY SILT: some clay, trace gravel, trace rootlets, frozen ground, black and brown, moist, very loose. CLAYEY SILT TILL: trace to some sand, trace gravel, brown to grey, wet to moist, soft to very stiff. - becoming grey		1	SS	12		98																
97.5			2	SS	3		97													2 18 (80)			
0.8			3	SS	5		96																
			4	SS	2		95																
				VANE			94														2 14 61 23		
			5	SS	5		93																
			6	SS	6		92																
				VANE			91																
			7	SS	10		90																
			8	SS	12		89														1 13 62 24		
	9	SS	15		88																		
	10	SS	14																				
87.7	END OF BOREHOLE																						
10.5	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																						

EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 8/19/16

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

Brampton, Ontario

RECORD OF BOREHOLE No U2

1 OF 1

METRIC

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5488189 E268217 ORIGINATED BY R.B.
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.
 DATUM Geodetic DATE 2016/06/02 - 2016/06/02 CHECKED BY S.M.

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	×	QUICK TRIAXIAL	LAB VANE											
98.5	Ground Surface							20	40	60	80	100											
98.4	TOPSOIL: (~50 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose. CLAYEY SILT TILL : trace to some sand, trace gravel, brown to grey, wet to moist, soft to very stiff. - sandy silt seam (~75 mm) - brown with orange stains		1	SS	3		98											1	27	(72)			
			2	SS	8		97																
			3	SS	5																		
	- becoming grey		4	SS	4		96																
			5	SS	5		95																
			6	SS	6		94																
			7	SS	10		93											3	13	63 21			
			8	SS	14																		
	- sandy silt seam, some gravel (~300 mm)		9	SS	17		92																
							91																
			10	SS	16		90																
	- silt seam, becoming dry		11	SS	21		89											1	8	(91)			
			12	SS	14																		
87.9	END OF BOREHOLE						88																
10.5	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																						

EXP RECORD OF BOREHOLE: MTO BH LOGS.GPJ ONTARIO MOT.GDT 8/19/16

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

Brampton, Ontario

RECORD OF BOREHOLE No U3

1 OF 1

METRIC

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5488013 E268196 ORIGINATED BY R.B.
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.
 DATUM Geodetic DATE 2016/06/01 - 2016/06/01 CHECKED BY S.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
98.0	Ground Surface																
97.9 0.1	TOPSOIL: (~130 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.		1	SS	2											80.4 41.6	
97.2 0.8	CLAYEY SILT: some sand, trace gravel, trace organics, brown, wet, very soft. CLAYEY SILT TILL: trace to some sand, trace gravel, brown to grey, wet to moist, soft to hard. - becoming grey		2	SS	3		97							○			
			3	SS	5		96							○			
			4	SS	5		95							○			
			5	SS	5		94							○			
			6	SS	8		93							○			
			7	SS	8		92							○			
			8	SS	12		91							○			
	- sandy silt seam, trace clay (~150 mm)		9	SS	20		90							○			
			10	SS	39		89							○			
88.9 9.1	SILTY SAND: some gravel and clay, grey, wet, compact.		11	SS	21		88							○			2 13 61 24
88.1 9.9	CLAYEY SILT TILL: trace to some sand, trace gravel, grey, moist, very stiff.		12	SS	16									○			
87.5 10.5	END OF BOREHOLE Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																13 52 (35)

EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 8/19/16

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

Brampton, Ontario

RECORD OF BOREHOLE No U4

1 OF 1

METRIC

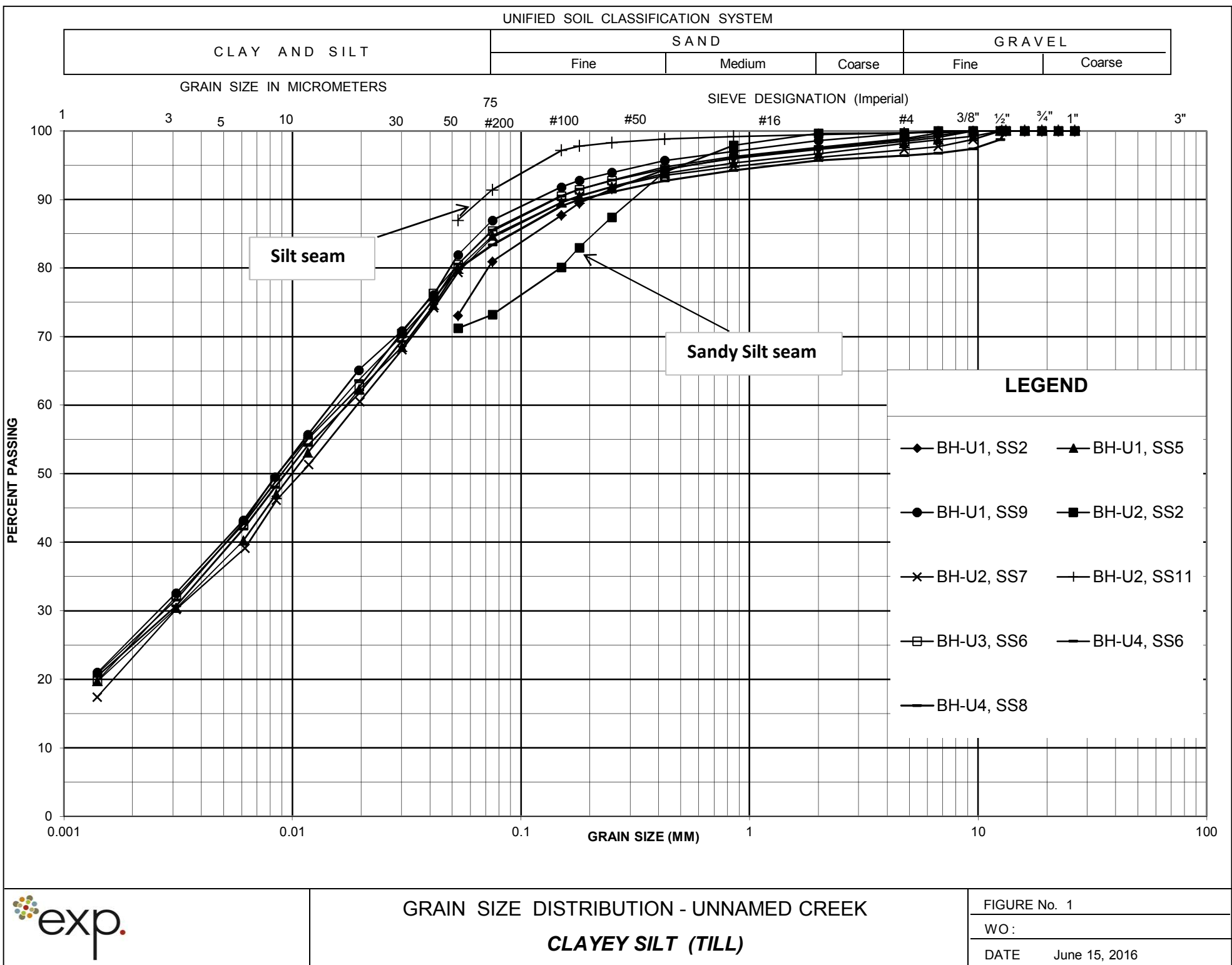
W. P. ADM-00233185-A0 LOCATION MTM Z10 5486984 E268431 ORIGINATED BY R.B.
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.
 DATUM Geodetic DATE 2016/06/01 - 2016/06/01 CHECKED BY S.M.

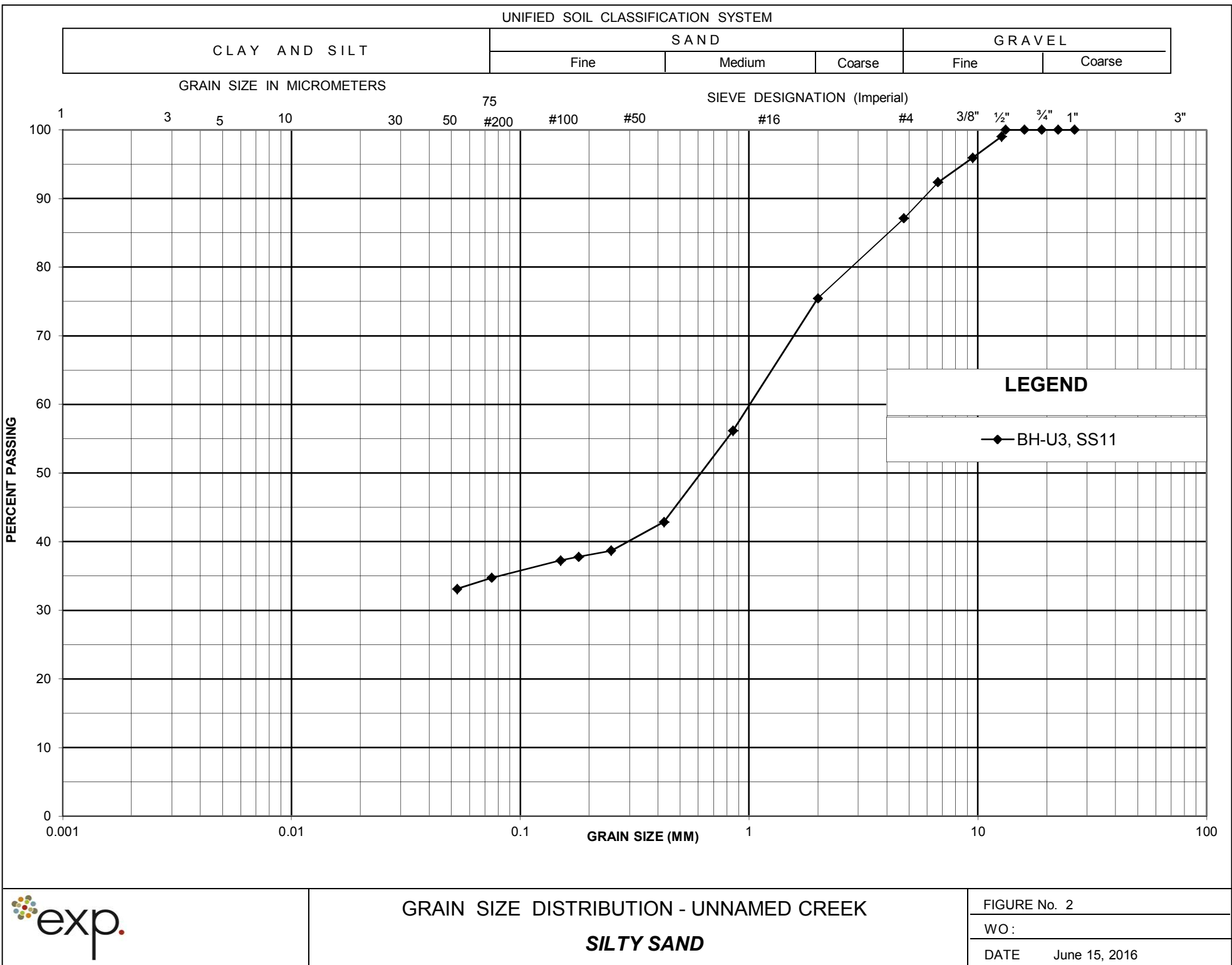
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa ○ UNCONFINED + FIELD VANE × QUICK TRIAXIAL LAB VANE									
98.5	Ground Surface							20	40	60	80	100					
98.4	TOPSOIL: (~51 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.		1	SS	2		98								○		
97.7	SANDY SILT: trace rootlets, grey, wet, very loose.																
0.8	CLAYEY SILT TILL: trace to some sand, trace gravel, brown grey, moist to dry, firm to hard.		2	SS	6		97								○		
			3	SS	5		96								○		
				VANE													
	- becoming grey		4	SS	5		95								○		1 13 61 25
			5	SS	4		94								○		
				VANE													
			6	SS	6		93								○		
			7	SS	7		92								○		
							91										
			8	SS	26		90								○		4 13 59 24
	-becoming dry		9	SS	39		89								○		
88.2			10	SS	100/ 210 mm										○		
10.3	END OF BOREHOLE																
	Notes: 1. Borehole open and dry upon completion 2. This drawing is to be read with the subject report and project numbers as presented above. 3. Interpretation assistance by exp is required before use by others.																

EXP RECORD OF BOREHOLE MTO BH LOGS.GPJ ONTARIO MOT.GDT 8/19/16

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

Appendix D – Laboratory Data





UNNAMED CREEK

