



## **FINAL REPORT**

### **FOUNDATION INVESTIGATION REPORT**

**Hogg Creek Culvert Rehabilitation - Hwy 634  
(Site No. 39E-242/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-62**

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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-62

### Type of Document:

FINAL

### Project Name:

Hogg Creek Culvert Rehabilitation - Hwy 634

Township of Adanac, District of Cochrane

### Project Number:

ADM-00233185-A0

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### Date Submitted:

29/08/2016

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# 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 Hogg Creek Culvert system on Highway 634, approximately 34 km north of Highway 11, in Adanac Township, District of Cochrane. The Hogg Creek Culvert structure consists of three 3.4 m diameter SPCSP's each having a total length of approximately 24 m. The maximum depth of cover above the Hogg Creek Culvert is approximately 2.7 m.

The purpose of the investigation is to determine the existing soil conditions in the vicinity of the existing culvert system 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 Hogg Creek Culverts are located along Hwy 634, approximately 34 km north of Hwy 11, in the Township of Adanac, at the approximate Station of 9+970 (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 Hogg Creek Culverts with approximately 2.7 m of embankment fill, and 2H:1V slopes. Photographs of the site are included in Appendix A of this report. The culvert location 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. Hogg Creeks flows 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 embankment 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 location 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 Hogg Creek was approximately at Elevation 96.3 m. The road surface elevation at the Hogg Creek Culvert location is at about 100.79 m (it should be noted that these are the elevations 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 to 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 May 30th and 31st, 2016. The field program consisted of drilling four (4) sampled boreholes with a machine-powered drill rig (BH H1 to H4). These boreholes were located as close as possible to the locations instructed in the TOR: (i) BH-H1 was placed in the proximity of the northern inlet area; (ii) BH-H2 was placed in the proximity of the southern inlet area; (iii) BH-H3 was placed in the proximity of the northern outlet area; and (iv) BH-H4 was placed in the proximity of the southern outlet 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-H1	N5486990 E268397	98.0	10.5
BH-H2	N5486962 E268399	96.3	10.5
BH-H3	N5486984 E268430	96.5	10.5
BH-H4	N5486961 E268431	96.9	10.5

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. Drawings in Appendix B show the locations of all four 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 100.79 m at Hogg 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 GEOCREC 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 280 mm, extending to between Elev. 97.9 m to Elev. 96.2 m. The topsoil consisted 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 were between 2 and 5 blows per 300 mm penetration, classifying this material as very loose to loose in relative density.

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

Moisture content:

- 28% to 45%

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-H3 and BH-H4, a layer of native sandy silt was encountered. The layer was approximately 0.5 m (BH-H3) to 0.7 m (BH-H4) thick, extending to Elev. 95.8 m (BH-H3) and Elev. 96.1 m (BH-H4).

The sandy silt contained some clay and trace rootlets. The layer was brown in colour and moist. Standard penetration resistance “N” values ranged from 2 to 3 suggesting a very loose relative density.

Laboratory testing performed on a selected sample consisted of two (2) moisture content and one (1) grain size distribution tests. The test results are as follows:

Moisture Content:

- 12% to 21%

Grain Size Distribution:

- 1% gravel
- 21% sand
- 78% 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 2 in Appendix D.

### 1.4.3 Clayey Silt Till

Native clayey silt till was encountered below the topsoil in BH-H1 and BH-H2 and below the sandy silt in BH-H3 and BH-H4, and extended to the termination depth of all boreholes. The layer of clayey silt till extended to a depth of 10.5 m below ground surface or to elevations ranging from 85.8 m to 87.5 m. The thickness of this layer ranges from 9.7 m to 10.4 m.

The clayey silt till contained trace to some sand and gravel. Boreholes BH-H1, BH-H3 and BH-H4 also encountered small seams of native silt to sandy silt at Elev. 93.0 m, 90.8 m and 92.2 m, respectively. The layer was brown to grey in colour and moist to wet. SPT “N” values within this layer ranged from 2 to 79 blows per 300 mm penetration indicating a very soft to hard, but generally stiff consistency.

Laboratory testing performed on a selected sample consisted of forty-five (45) moisture content, nine (9) grain size distribution and six (6) Atterberg Limits tests. The test results are as follows:

Moisture Content:

- 12% to 21%

Grain Size Distribution:

- 0% to 2% gravel
- 5% to 22% sand
- 57 to 76% silt, and
- 5% to 30% clay

Atterberg Limits:

- Liquid Limit: 21% to 24%
- Plastic Limit: 13% to 14%
- Plasticity Index: 7% to 11%

It should be noted that SS8 in BH-H3 (silt seam) was identified as non-plastic following an Atterberg limit test. The results of the moisture content, grain size distribution and Atterberg limit 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 2 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 Hogg Creek was approximately at Elevation 96.3 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 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.

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Senior Geotechnical Engineer

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

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## **Appendix A – Photographs**



Photo 1. Inlet side of Hogg Creek Culvert System (facing west) on May 30, 2016



Photo 2. Outlet side of Hogg Creek Culvert System (facing east) on May 30, 2016



Photo 3. Inlet side of Hogg Creek at BH-H2 (facing north-east) on May 31, 2016



Photo 4. Outlet side of Hogg Creek at BH-H3 (facing south-west) on May 30, 2016

## **Appendix B – Drawings**

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

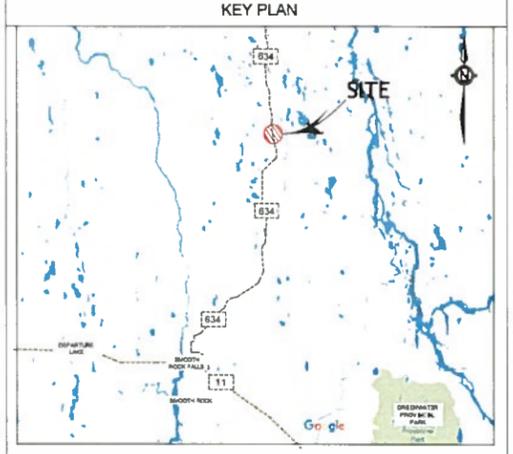
AGREEMENT NO. 5015-E-0007  
 ASSIGNMENT NO. 1  
 GEOCRETS NO. 42H-62

HOGG CREEK CULVERT  
 (TOWNSHIP OF ADANAC)

**BOREHOLE LOCATIONS AND SECTION A-A'**

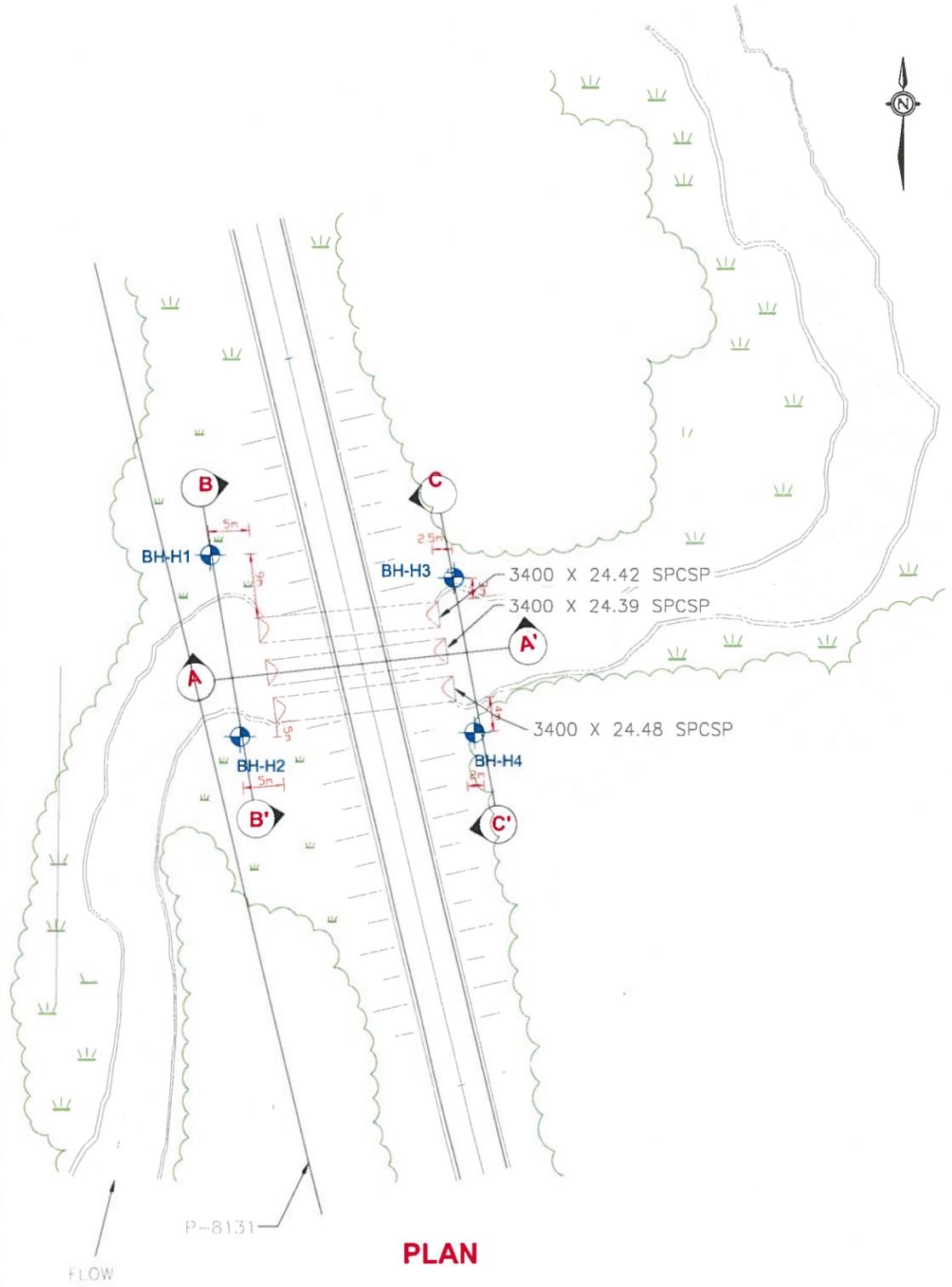
SHEET 1

**exp** **exp Services Inc.**



LEGEND

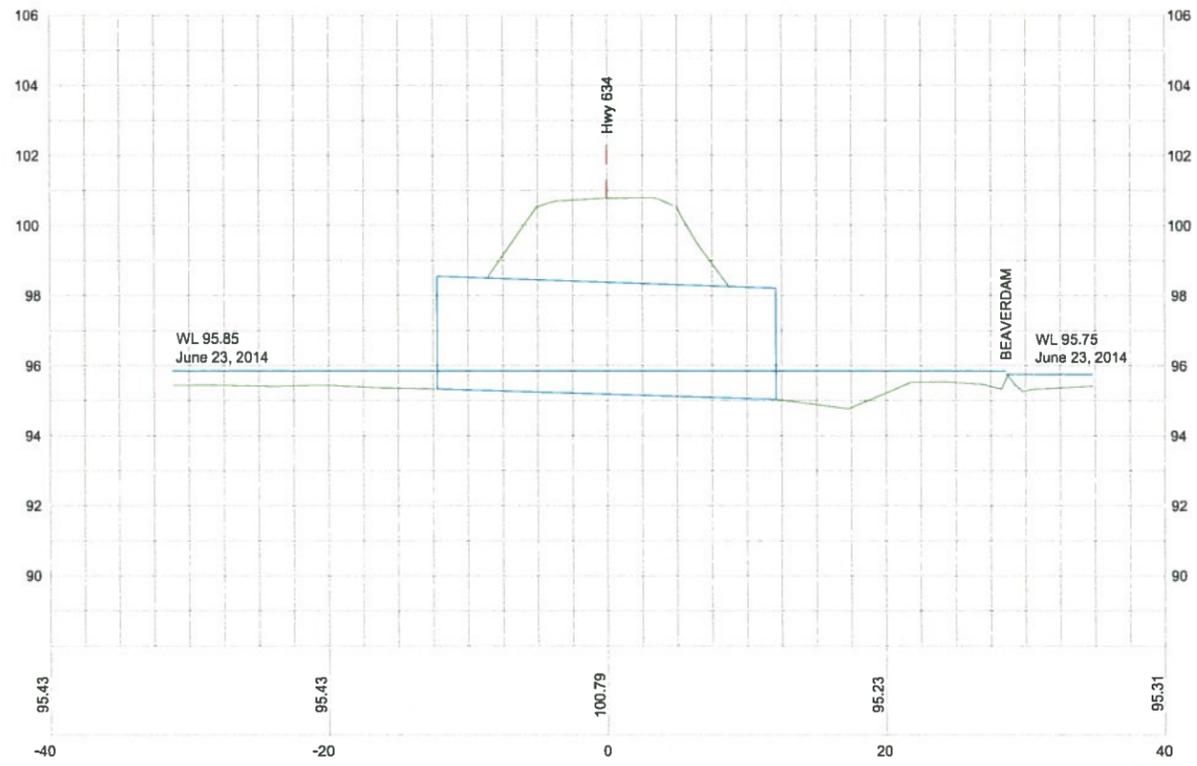
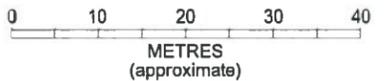
Approx. Current Investigated Borehole Locations



**PLAN**

HOGG CREEK CULVERT SITE 39E-242/C  
 (SCALE 1:800)

34.0 KM NORTH OF HIGHWAY 11



**SECTION A-A'**



BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
1	98.0	5 486 990	268 397
2	96.3	5 486 962	268 399
3	96.5	5 486 984	268 430
4	96.9	5 486 961	268 431

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 Contract 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.

DATE	BY	DESCRIPTION
AUGUST 2016	SM	FINAL SUBMISSION
JULY 2016	TK	SUBMISSION FOR REVIEW
SCALE	SEE SCALE BAR	PROJECT NO. ADM 00233185-A0
SUBMD	SM	CHECKED SM
DATE	AUG 2016	SITE NO. 39E-242/C
DRAWN	RB	CHECKED SM
APPROVED	SG	DWG. 01

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

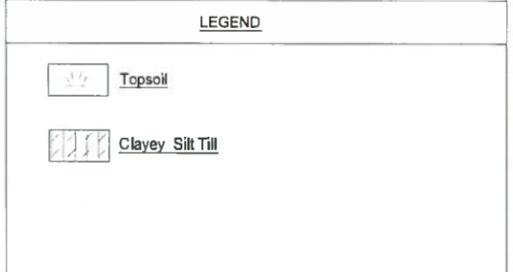
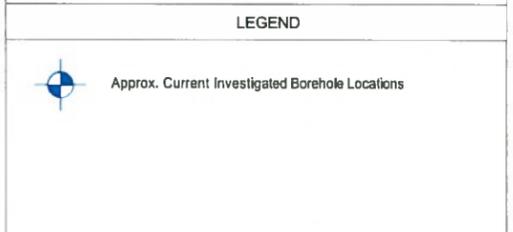
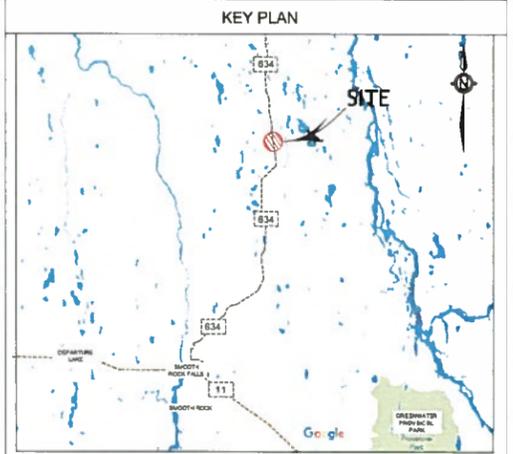
AGREEMENT NO. 5015-E-0007  
 ASSIGNMENT NO. 1  
 GEOCRETS NO. 42H-62

HOGG CREEK CULVERT  
 (TOWNSHIP OF ADANAC)

**SOIL STRATA - SECTION B-B'**

SHEET  
 1

**exp** exp Services Inc.



BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-H1	98.0	5 486 990	268 397
BH-H2	96.3	5 486 962	268 399

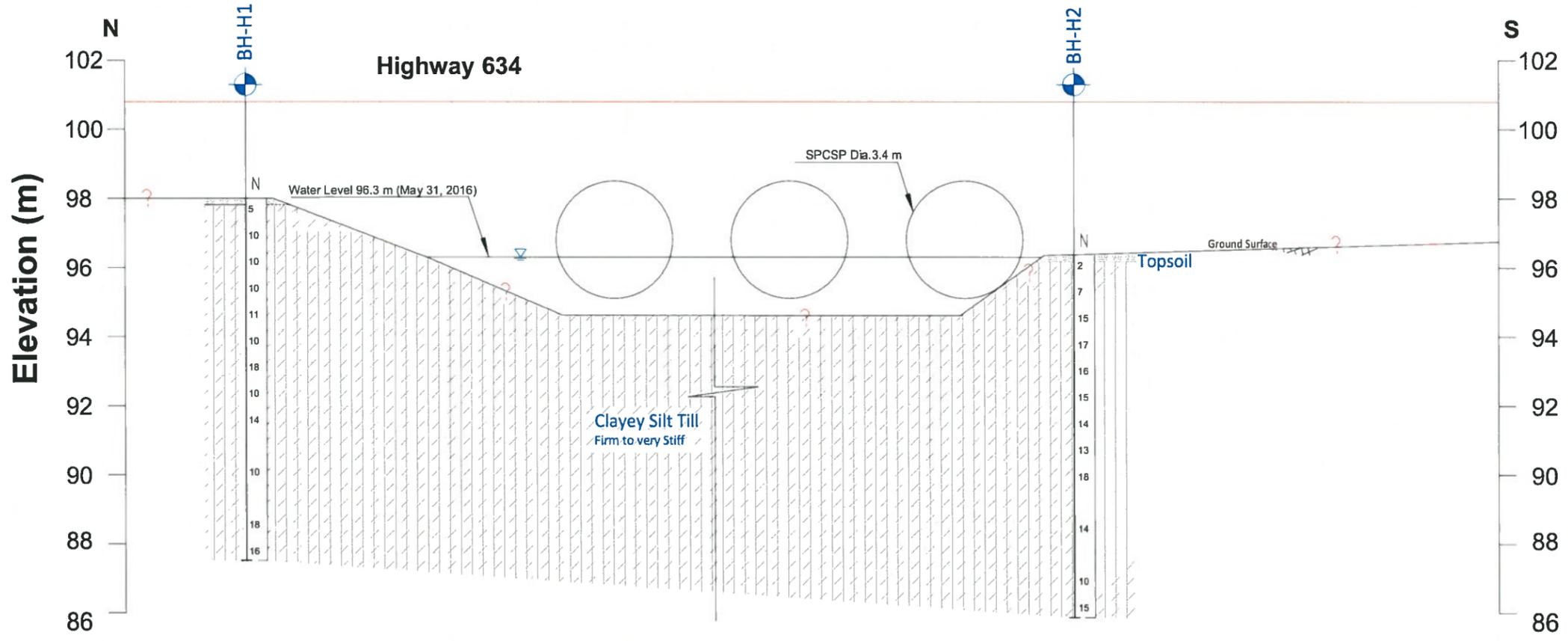
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SCALE	SEE SCALE BAR	PROJECT NO. ADM 00233185-A0
SUBM'D	SM	CHECKED SM
DATE	AUG 2016	SITE NO. 39E-242/C
DRAWN	RB	CHECKED SM
APPROVED	SG	DWG. 02

### Hogg 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

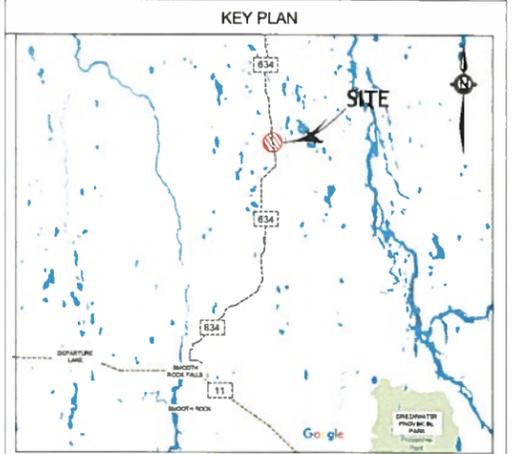
AGREEMENT NO. 5015-E-0007  
 ASSIGNMENT NO. 1  
 GEOCRETS NO. 42H-62

HOGG CREEK CULVERT  
 (TOWNSHIP OF ADANAC)

**SOIL STRATA - SECTION C-C'**

SHEET  
 1

**exp** exp Services Inc.



LEGEND

Approx. Current Investigated Borehole Locations

LEGEND

Topsoil

Sandy Silt

Clayey Silt Till

BH No.	APPROX. ELEV.	MTM CO-ORDINATES	
		NORTH	EAST
BH-H3	96.5	5 486 984	268 430
BH-H4	96.9	5 486 961	268 431

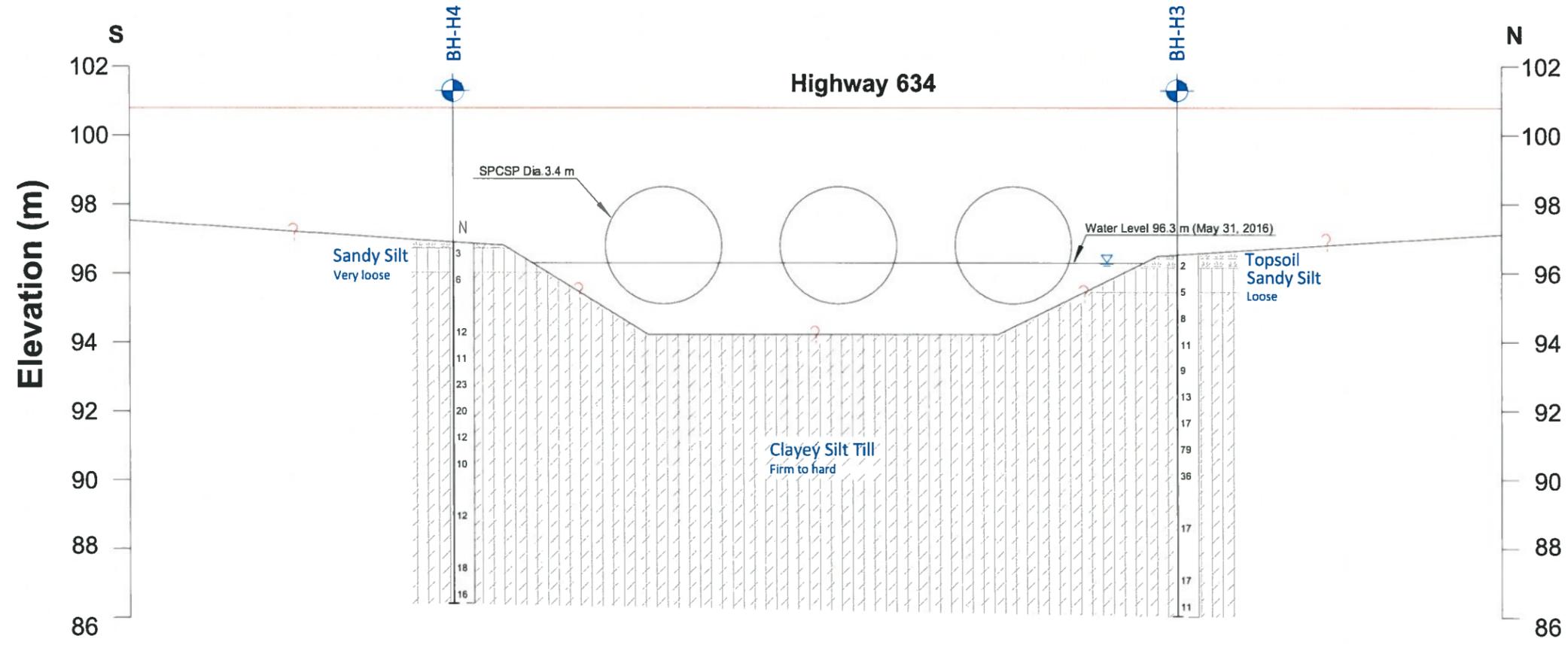
NOTE

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 Contract 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.

DATE	BY	DESCRIPTION
AUGUST 2016	SM	FINAL SUBMISSION
JULY 2016	TK	SUBMISSION FOR REVIEW
SCALE	SEE SCALE BAR	PROJECT NO. ADM 00233185-A0
SUBM'D	SM	CHECKED SM
DATE	AUG 2016	SITE NO. 39E-242/C
DRAWN	RB	CHECKED SM
APPROVED	SG	DWG. 03

## Hogg 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.

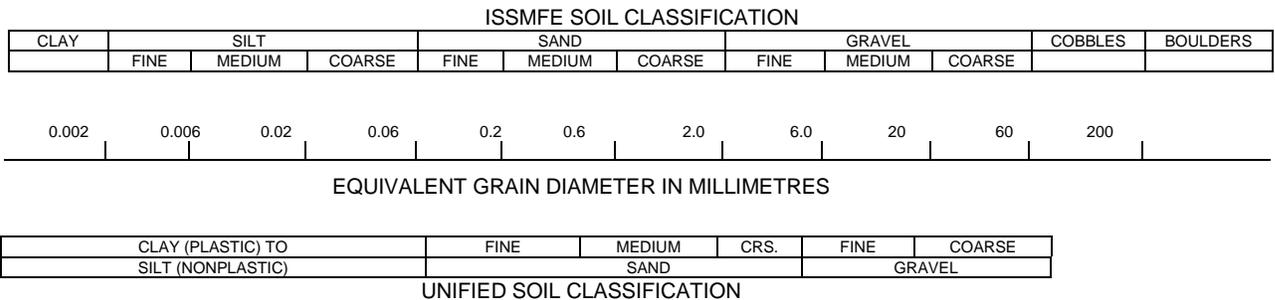
*Seam:* a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

*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.



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:

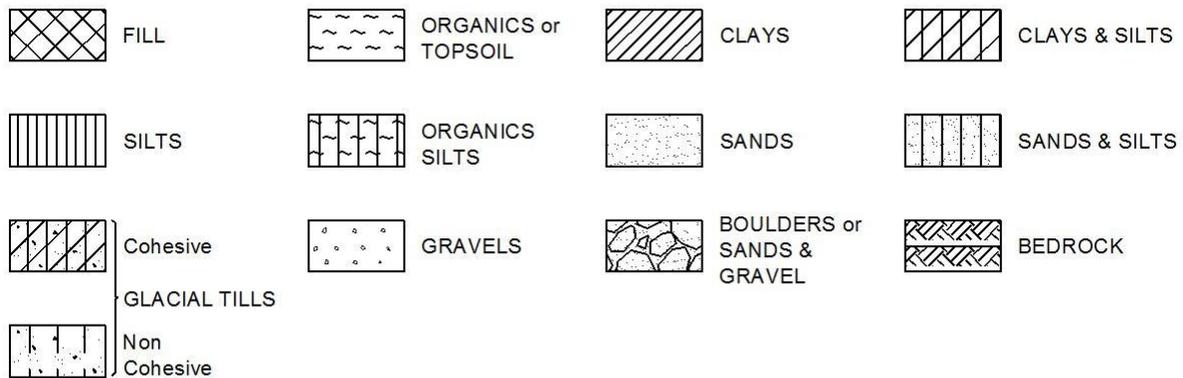
Table c: Consistency of Cohesive Soil

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
$\sigma$	kPa	Total normal stress
$\sigma'$	kPa	Effective normal stress
$\tau$	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
$\varepsilon$	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
$\mu$	1	Coefficient of friction

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	Coefficient of volume change
$c_c$	1	Compression index
$c_s$	1	Swelling index
$c_r$	1	Recompression index
$c_v$	$\text{m}^2/\text{s}$	Coefficient of consolidation
H	m	Drainage path
$T_v$	1	Time factor
U	%	Degree of consolidation
$\sigma'_{v0}$	kPa	Effective overburden pressure
$\sigma'_p$	kPa	Preconsolidation pressure
$\tau_f$	kPa	Shear strength
$c'$	kPa	Effective cohesion intercept
$\phi'$	$-\circ$	Effective angle of internal friction
$c_u$	kPa	Apparent cohesion intercept
$\phi_u$	$-\circ$	Apparent angle of internal friction
$\tau_R$	kPa	Residual shear strength
$\tau_r$	kPa	Remoulded shear strength
$S_t$	1	Sensitivity = $c_u/\tau_r$

### PHYSICAL PROPERTIES OF SOIL

$P_s$	$\text{kg}/\text{m}^3$	Density of solid particles
$\gamma_s$	$\text{kN}/\text{m}^3$	Unit weight of solid particles
$\rho_w$	$\text{kg}/\text{m}^3$	Density of water
$\gamma_w$	$\text{kN}/\text{m}^3$	Unit weight of water
$\rho$	$\text{kg}/\text{m}^3$	Density of soil
$\gamma$	$\text{kN}/\text{m}^3$	Unit weight of soil
$\rho_d$	$\text{kg}/\text{m}^3$	Density of dry soil
$\gamma_d$	$\text{kN}/\text{m}^3$	Unit weight of dry soil
$\rho_{sat}$	$\text{kg}/\text{m}^3$	Density of saturated soil
$\gamma_{sat}$	$\text{kN}/\text{m}^3$	Unit weight of saturated soil
$\rho'$	$\text{kg}/\text{m}^3$	Density of submerged soil
$\gamma'$	$\text{kN}/\text{m}^3$	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	$\text{m}^3/\text{s}$	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	$\text{kN}/\text{m}^3$	Seepage force

Brampton, Ontario

**RECORD OF BOREHOLE No H1**

1 OF 1

**METRIC**

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5486990 E268397 ORIGINATED BY R.B.  
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.  
 DATUM Geodetic DATE 2016/05/30 - 2016/05/30 CHECKED BY S.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60	80	100	10	20
98.0	Ground Surface																						
97.9	<p><b>TOPSOIL:</b> (~130 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.</p> <p><b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown to grey, wet to moist, firm to very stiff.</p> <p>- becoming grey</p> <p>- sandy silt seam (~75 mm)</p>	1	SS	5																			
0.1		2	SS	10																			
		3	SS	10																			1 11 67 21
		4	SS	10																			
		5	SS	11																			
		6	SS	10																			
		7	SS	18																			1 22 (77)
		8	SS	10																			
		9	SS	14																			
		10	SS	10																			
			VANE																				
			11	SS	18																		1 5 71 23
		12	SS	16																			
87.5	<b>END OF BOREHOLE</b>																						
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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

Brampton, Ontario

**RECORD OF BOREHOLE No H2**

1 OF 1

**METRIC**

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5486962 E268399 ORIGINATED BY R.B.  
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.  
 DATUM Geodetic DATE 2016/05/31 - 2016/05/31 CHECKED BY S.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60	80	100	10
96.3	Ground Surface																					
96.2 0.1	<p><b>TOPSOIL:</b> (~130 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.</p> <p><b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, brown to grey, wet to moist, very soft to very stiff.</p> <p>- becoming grey</p>	1	SS	2																		
		2	SS	7																		
		3	SS	15																		
		4	SS	17																		
		5	SS	16																		
		6	SS	15																		
		7	SS	14																		1 7 65 27
		8	SS	13																		
		9	SS	18																		
		10	SS	14																		1 7 (92)
		11	SS	10																		
		12	SS	15																		
85.8 10.5	<b>END OF BOREHOLE</b>																					
	Notes:																					
	<p>1. Borehole open and dry upon completion</p> <p>2. This drawing is to be read with the subject report and project numbers as presented above.</p> <p>3. Interpretation assistance by exp is required before use by others.</p>																					

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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

Brampton, Ontario

**RECORD OF BOREHOLE No H3**

1 OF 1

**METRIC**

W. P. ADM-00233185-A0 LOCATION MTM Z10 N5486984 E268430 ORIGINATED BY R.B.  
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.  
 DATUM Geodetic DATE 2016/05/30 - 2016/05/30 CHECKED BY S.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60	80	100	10
96.5	Ground Surface																					
96.2 0.3	<b>TOPSOIL:</b> (~280 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.	1	SS	2																		1 21 (78)
95.8 0.8	<b>SANDY SILT:</b> some clay, trace rootlets, brown, moist, very loose. <b>CLAYEY SILT TILL:</b> trace to some sand, trace gravel, grey, wet to moist, firm to hard.	2	SS	5																		
		3	SS	8																		
		4	SS	11																		
		5	SS	9																		1 12 61 26
		6	SS	13																		
		7	SS	17																		
	- silt to sandy silt seam, trace clay (~150 mm)	8	SS	79																		0 19 76 5 non-plastic
		9	SS	36																		
		10	SS	17																		
		11	SS	17																		
		12	SS	11																		
86.0 10.5	<b>END OF BOREHOLE</b>																					
	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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

**RECORD OF BOREHOLE No H4**

1 OF 1

**METRIC**

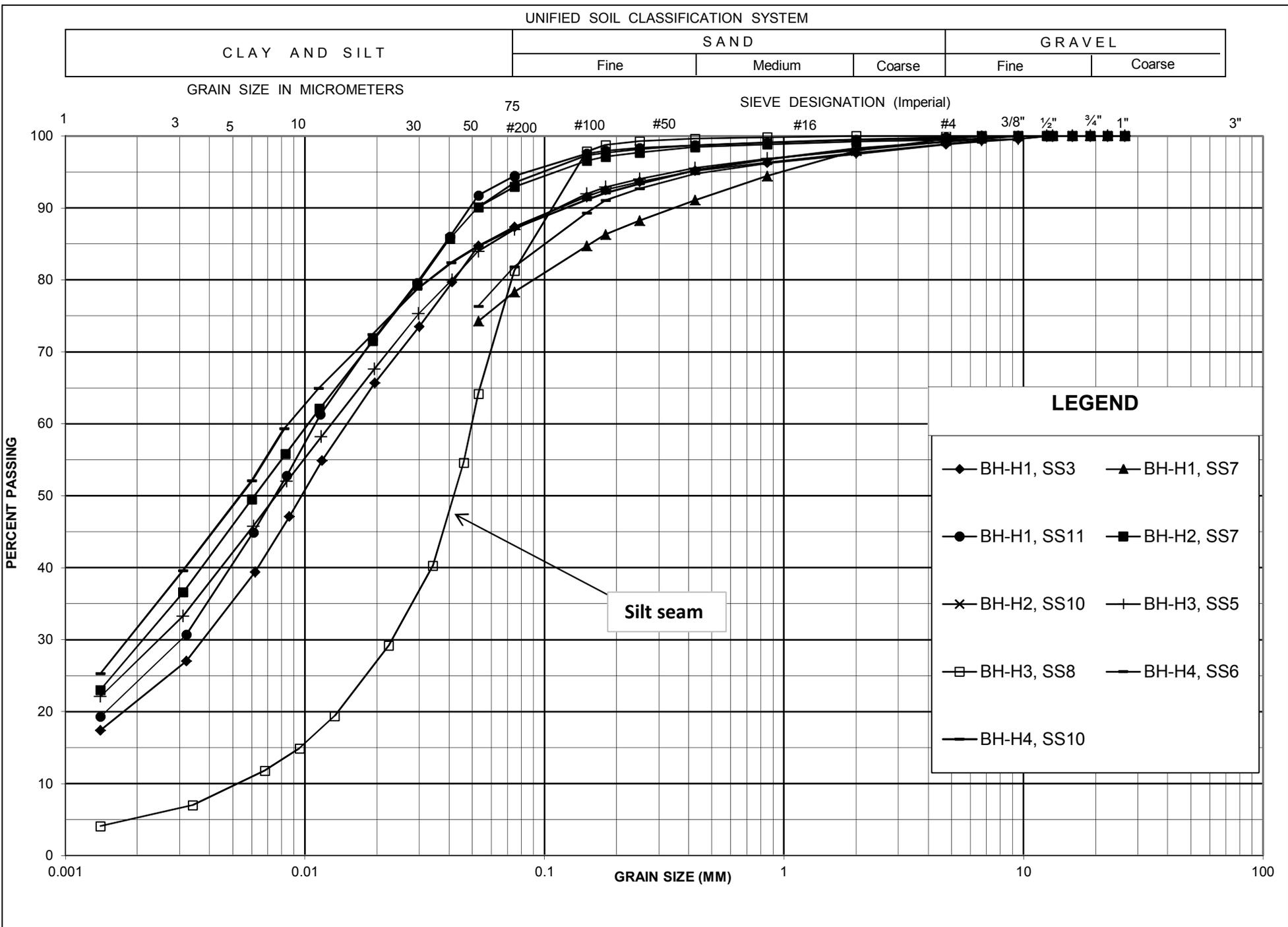
W. P. ADM-00233185-A0 LOCATION MTM Z10 N5486961 E268431 ORIGINATED BY R.B.  
 DIST 634 BOREHOLE TYPE CME 55 Track COMPILED BY M.N.  
 DATUM Geodetic DATE 2016/05/31 - 2016/05/31 CHECKED BY S.M.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						20	40	60	80	100	10	20
96.9	Ground Surface																						
96.7 0.1	<b>TOPSOIL:</b> (~130 mm) some roots and rootlets, some silt and clay, trace sand and gravel, dark brown, wet, very loose to loose.	1	SS	3																			
96.1 0.8	<b>SANDY SILT:</b> some clay, trace rootlets, brown, moist, very loose. <b>CLAYEY SILT TILL:</b> trace to some sand, trace to some gravel, brown grey, wet to moist, firm to very stiff.	2	SS	6																			
			VANE																				
		3	SS	12																			
	- becoming grey	4	SS	11																			
		5	SS	23																			
	- silt to sandy silt seam, trace gravel and clay (~150 mm)	6	SS	20																			2 17 (81)
		7	SS	12																			
		8	SS	10																			
		9	SS	12																			
		10	SS	11																			1 12 57 30
		11	SS	10																			
86.4 10.5	<b>END OF BOREHOLE</b>																						
	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

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

## Appendix D – Laboratory Data

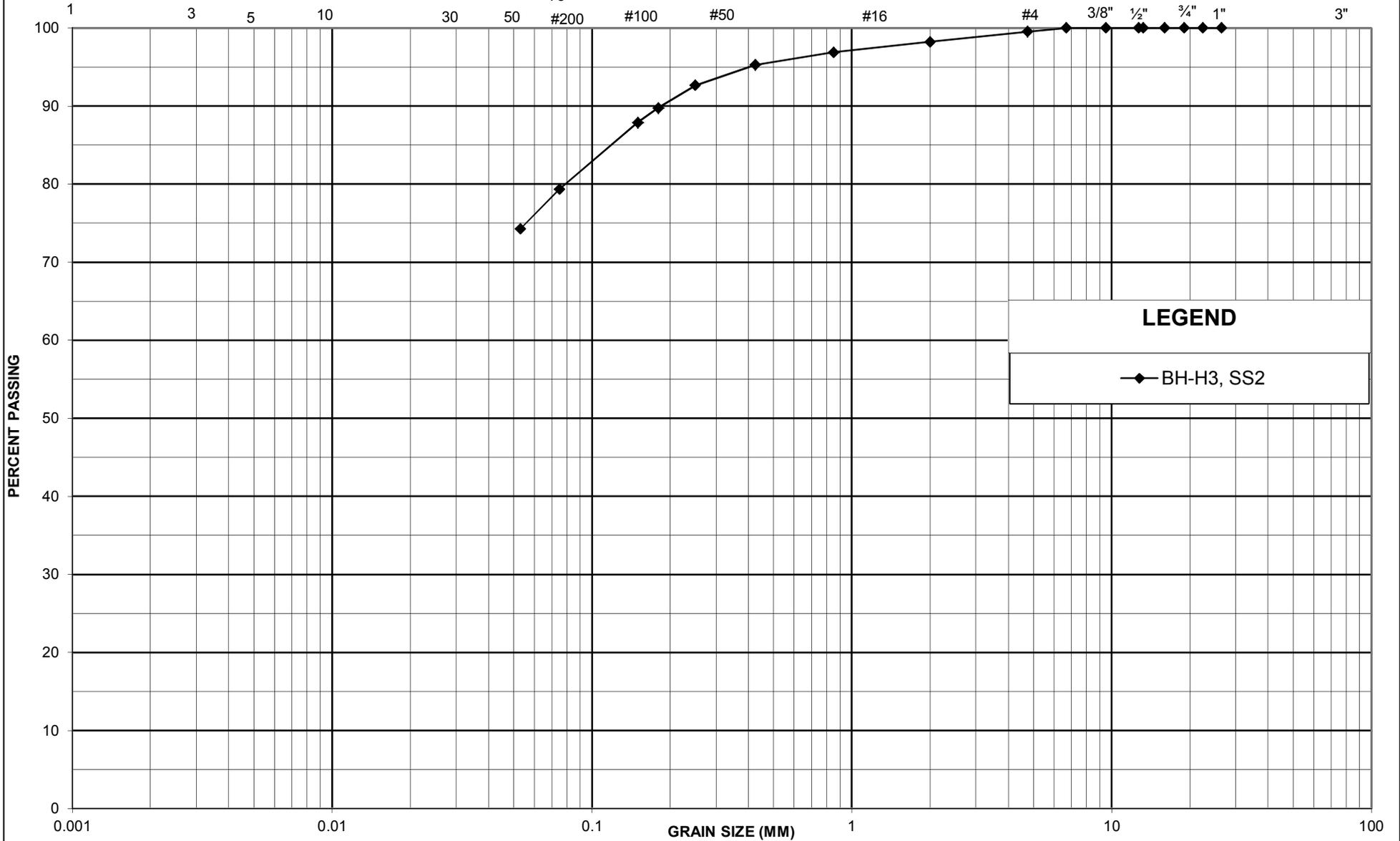


UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Imperial)



LEGEND

—◆— BH-H3, SS2



GRAIN SIZE DISTRIBUTION - HOGG CREEK  
**SANDY SILT**

FIGURE No. 2

WO:

DATE June 15, 2016

# HOGG CREEK

