



**April 2016**

## **REPORT ON**

**Foundation Investigation  
Un-Named Creek Culvert Replacement  
Site No. 3-728c  
Highway 417, 130 m West of March Road  
Ottawa, Ontario  
W.P. 4168-11-01**

**Submitted to:**  
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**REPORT**



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# PART A

FOUNDATION INVESTIGATION REPORT  
UN-NAMED CREEK CULVERT REPLACEMENT  
SITE 3-728C  
HIGHWAY 417, 130 M WEST OF MARCH ROAD  
OTTAWA, ONTARIO  
W.P. 4168-11-01



## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by MMM Group Ltd. (MMM) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with the design of bridge and culvert replacements at various locations in the Eastern Region of Ontario as part of the 22 Structures MEGA 2 project.

This report presents the results of the foundation investigation conducted for the replacement of the Un-Named Creek culvert (MTO Structure Site No. 3-728c under W.P. 4168-11-01), located on Highway 417 about 130 m west of March Road in Ottawa, Ontario.

Initially, the culvert replacement at this site was planned to be undertaken as a Design-Build project. It is now understood that MMM will be completing the detailed design of the culvert replacement. The purpose of the foundation investigation was to assess the subsurface conditions for the proposed culvert replacement by drilling boreholes and carrying out in-situ testing and laboratory testing on selected soil samples.

The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated April 2012. In addition, Golder's letter dated March 11, 2015 described the work plan for additional foundation engineering services for detail design.

The work was carried out in accordance with Golder's Quality Control Plan dated August 2012.



## **2.0 SITE DESCRIPTION**

The Un-Named Creek culvert is located on Highway 417 about 130 m west of March Road in Ottawa, Ontario. The existing culvert (Structure Site No. 3-728c) is located at about Station 18+380 m.

The existing culvert consists of a sectional plate, corrugated steel pipe arch measuring about 3.1 m wide by 2.0 m high. The north portion of the culvert that extends beneath the westbound lanes of Highway 417 was constructed in the 1960s. The culvert was extended to the south beneath the eastbound lanes of Highway 417 in 1993 and has an overall length of about 86 m. It is understood that the culvert has corroded and is perforated at many locations along the spring line with some loss of backfill into the culvert near the mid span. The existing culvert inverts are at about Elevations 111.9 and 112.6 m at the north and south ends, respectively, with flow in the culvert from south to north. The depth of water within the culvert was less than about 200 mm at the time of the field investigation in July, 2014. The width of the water course was estimated to be about 1.0 to 1.5 m.

The existing pavement grade at the culvert location is at about Elevation 118.4 m. In this area, Highway 417 is typically two lanes wide in each direction (i.e., a separated four-lane highway). At the existing culvert crossing, the overall lane configuration also includes two acceleration lanes: one north of the highway, connecting March Road north to Highway 417 west, and one south of the highway (part of the off-ramp), connecting March Road south to Highway 417 east. The existing embankment slopes at the culvert locations are about 4 to 5 m in height and are oriented between about 2 horizontal to 1 vertical and 3 horizontal to 1 vertical (i.e., 2H:1V and 3H:1V). Based on visual observation at the time of the site investigation, the existing embankment slopes appear to be performing satisfactorily.



### **3.0 INVESTIGATION PROCEDURES**

The subsurface investigation for the culvert replacement was carried out in two stages. During the first stage, a preliminary investigation was carried out between July 14 and 16, 2014 for a design build project. A second stage of investigation for a detail design was carried out on December 8, 2015. Overall, five boreholes (numbered 14-321 to 14-324, inclusive, and 15-325) were advanced at the locations shown on Drawing 1. The boreholes were advanced as follows:

- Boreholes 14-321 and 14-324 were advanced near the culvert ends at the toes of the Highway 417 embankments using portable drilling equipment supplied and operated by OGS Inc. of Almonte, Ontario. The boreholes were advanced using near-continuous sampling procedures to depths of up to about 12.2 m below the existing ground surface, to about Elevation 101 m and 10 m below the culvert invert level.
- Boreholes 14-322 and 14-323 were advanced through the existing Highway 417 westbound and eastbound embankments, respectively, using 108 mm inside diameter continuous-flight hollow-stem augers on a truck-mounted drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths of up to about 18.9 m (Elevation 99 m) below the existing ground surface.
- Borehole 15-325 was advanced within the median of Highway 417 using 108 mm inside diameter continuous-flight hollow-stem augers on a track-mounted drill rig, supplied and operated by CCC Drilling of Ottawa, Ontario. The borehole was advanced to a depth of 11.7 m (Elevation 105.4 m) below the existing ground surface.

Soil samples in the boreholes were obtained at vertical intervals of about 0.60 to 1.52 m, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures.

Where appropriate, the SPT sampling was supplemented with in-situ shear vane testing. An MTO “N”-size vane was used to measure the undrained shear strength of the cohesive soils encountered at Boreholes 14-322, 14-323, and 15-325. To carry out in-situ shear vane testing at Boreholes 14-321 and 14-324, a ‘B’ sized vane was used to accommodate the narrower casing size used with the portable drill rig.

A standpipe piezometer was installed in Borehole 14-321 to monitor the groundwater level at the site. The standpipe consists of a 32 mm diameter rigid PVC pipe with a 1.5 m long slotted screen section, installed within silica sand backfill and sealed by a section of bentonite pellet backfill. The water level in the standpipe piezometer was measured on August 13, 2014 and on December 8, 2015.

The boreholes were backfilled with bentonite pellets, mixed with native soils in the overburden and bentonite pellets in the bedrock. The site conditions were restored following completion of work.

The field work was supervised by members of Golder’s technical and engineering staff, who located the boreholes, supervised the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder’s laboratories in Ottawa and Mississauga for further examination. Index and classification tests consisting of grain size distribution, Atterberg limits, and water content testing were carried out on selected soil samples. Consolidation testing was carried out on one sample obtained from Borehole 14-322 at about Elevation 106.2 m. All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.



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Prior to drilling, the boring locations were staked and surveyed by Golder personnel using a Trimble R8 GPS unit. The boreholes and locations, including MTM NAD83 (Zone 9) northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized in the following table and are shown on Drawing 1.

<b>Borehole Number</b>	<b>Borehole Location</b>	<b>MTM NAD83 Northing (m)</b>	<b>MTM NAD83 Easting (m)</b>	<b>Ground Surface Elevation (m)</b>
14-321	North end of culvert	5019397.0	339451.6	113.2
14-322	Highway 417 westbound lane shoulder on the east side of the culvert	5019378.6	339445.1	118.1
14-323	Highway 417 eastbound S-E off-ramp on the east side of the culvert	5019328.9	339427.4	118.0
14-324	South end of culvert	5019312.8	339422.6	113.7
15-325	Median of HWY 417	5019353.0	339435.4	117.1



## 4.0 SITE GEOLOGY AND STRATIGRAPHY

### 4.1 Regional Geological Conditions

The study area for this assignment lies within the minor physiographic region known as the Ottawa Valley Clay Plain, as delineated in *The Physiography of Southern Ontario*<sup>1</sup> that lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie bedrock.<sup>2</sup> This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain by igneous and metamorphic bedrock of the Precambrian Shield.

### 4.2 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B8 contained in Appendix B.

A soil stratigraphy section projected along the centreline of the existing culvert area is shown on Drawing 1. The stratigraphic boundaries shown on the Record of Borehole sheets and on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the location of the existing culvert consist of sand and gravel embankment fill overlying sand to silty sand, which is underlain by a deposit of sensitive clayey silt to silty clay followed by glacial till. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

#### 4.2.1 Topsoil

About 100 mm of topsoil was encountered at Boreholes 14-321 and 14-324, which were advanced near the culvert ends at the toes of the Highway 417 embankments.

#### 4.2.2 Pavement Structure and Embankment Fill

The pavement structure within Highway 417 was penetrated within the westbound lane shoulder at Borehole 14-322 and the eastbound S-E on-ramp at Borehole 13-323. At Borehole 14-323, the pavement structure for Highway 417 consists of about 190 mm of asphaltic concrete overlying about 200 mm of gravelly sand base course. At Borehole 14-322, at the S-E ramp, the 760 mm gravelly base course is directly at the ground surface. The granular base is underlain by about 3.0 to 4.2 m of subbase/embankment fill. At these locations, the subbase/embankment fill generally consists of varying compositions of sand and gravel, containing some silt. The lower portion of the embankment fill contains limestone fragments (i.e., rockfill).

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

<sup>2</sup> Belanger, J.R. "Urban Geology of Canada's National Capital Area", in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.





Embankment fill was encountered at surface in the median area, at the location of Borehole 15-325, and generally consists of sand with some silt and pockets of silty clay.

The embankment fill was fully penetrated to depths of about 3.8 to 4.6 m (Elevations 112.5 to 113.5 m) at Boreholes 14-322, 14-323, and 15-325.

Standard Penetration Test (SPT) "N" values measured within the embankment fill range from 8 to 52 blows per 0.3 m of penetration, indicating a loose to very dense state of packing.

The results of grain size distribution testing carried out on three samples of the embankment fill are provided on Figure B1 in Appendix B. The measured water content of selected samples of the embankment fill ranges from approximately 7 to 12 percent.

#### **4.2.3 Sand and Silty Sand**

About 1.7 to 3.8 m of sand and silty sand was encountered below the embankment fill or surficial topsoil, where encountered, at the borehole locations. The sand and silty sand was fully penetrated to elevations of about 109.4 to 111.9 m.

The SPT "N" values measured within this material range from 1 to 13 blows per 0.3 m of penetration indicating a very loose to compact state of packing.

The results of grain size distribution testing carried out on seven samples of the sand are provided on Figure B2 in Appendix B. The measured natural water content of selected samples of the sand and silty sand ranges from about 18 to 42 percent.

#### **4.2.4 Clayey Silt to Silty Clay**

The sandy soils are underlain by a deposit of grey clayey silt to silty clay. The clayey silt to silty clay was fully penetrated in Boreholes 14-322 to 14-324 to elevations between about 99.7 to 102.9 m with thicknesses between 9 and 10 m. The clayey silt to silty clay was not fully penetrated in Boreholes 14-321 and 15-325 but proven to an elevation of 101.0 m and 105.4 m, respectively.

The measured SPT "N" values within the clayey silt to silty clay deposit range from "weight of rods" to 5 blows per 0.3 m of penetration. In situ vane testing carried out within the deposit measured undrained shear strengths ranging from about 40 near the surface of the clay to 102 kPa at depth. The results of the in-situ testing indicate a firm to very stiff consistency. In situ vane testing carried out on remoulded grey clayey silt to silty clay measured undrained shear strengths generally ranging from 3 to 17 kilopascals, indicating a sensitivity generally ranging from about 3 to 19.

The results of grain size distribution testing carried out on three samples of the clayey silt and seven samples of the silty clay are provided on Figure B3 and B4, respectively. The results of Atterberg limit testing carried out on ten samples of the clayey silt to silty clay indicate plasticity index value between 10 and 24 percent and liquid limit value between 29 and 48, as shown on Figure B5, indicating that the tested samples consist of clayey silt to silty clay of low to intermediate plasticity. The measured natural water content of selected samples of the deposit ranges from 23 to 57 percent. These natural water contents are generally near or above the measured liquid limits.



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Oedometer consolidation testing was carried out on one relatively undisturbed sample of the grey clayey silt to silty clay deposit from Borehole 14-322. The results of that testing, which are provided on Figure B6 and are summarized in the table below, indicate that this material (i.e., at the depth and location of the sample) is slightly preconsolidated, with a preconsolidation pressure of about 290 kPa and an overconsolidation ratio of 1.9.

Borehole/Sample Number	Sample Depth/Elevation (m)	Unit Weight (kN/m <sup>3</sup> )	$\sigma_P'$ (kP)	$\sigma_{vo}'$ (kP)	$\sigma_P' - \sigma_{vo}'$ (kPa)	Cc	Cr	e <sub>o</sub>	OCR
14-322 / 14	11.9 / 106.2	16.6	295	155	140	1.47	0.010	1.58	1.9

**Notes:**

$\sigma_P'$	-	Apparent preconsolidation pressure	Cr	-	Recompression index
$\sigma_{vo}'$	-	Computed existing vertical effective stress	e <sub>o</sub>	-	Initial void ratio
Cc	-	Compression index	OCR	-	Overconsolidation ratio

### 4.2.5 Gravelly Silty Sand

A layer of gravelly silty sand with some clay was encountered within the silty clay deposit in Borehole 14-323 at a depth of 15.4 m below the existing ground surface, having a thickness of about 0.5 m.

The result of one standard penetration test measured an “N” value of 2 blows per 0.3 m of penetration, indicating a very loose state of packing.

The results of grain size distribution testing carried out on one sample of the deposit are provided on Figure B7. The measured natural water content of one sample of gravelly silty sand was about 14 percent.

### 4.2.6 Till

Glacial till was encountered below the clayey silt to silty clay deposit in Boreholes 14-322, 14-323 and 14-324, at elevations of 99.7, 101.4, and 102.9, respectively. Refusal to augering or to sampling was encountered at Elevation 101.1 m and 101.5 m in Boreholes 14-323 and 14-324, respectively.

In the area of the site, the glacial till is generally a heterogeneous mixture of gravel and cobbles in a matrix of sand and silt containing a trace to some clay.

The measured SPT “N” values within the till deposit range from “pushed manually” to over 50 blows per 0.3 m of penetration, indicating a very loose to very dense state of packing, although the higher ‘N’ values could reflect the presence of cobbles, rather than the state of packing of the soil matrix.

The results of grain size distribution testing carried out on two samples of the till are provided in Figure B8 in Appendix B. The results do not reflect the cobble or full gravel contents of the material, since the samples were retrieved using a 50 mm outside diameter split-spoon sampler. The measured natural water content of two samples of the till were 11 and 13 percent.

### 4.2.7 Refusal and Possible Bedrock

Refusal to advancement of the auger and sampler was encountered in/below the till deposit in Boreholes 14-323 and 14-324, respectively. About 50 mm of possible weathered bedrock was encountered within the sampler in portable Borehole 14-324 below the till. The following table summarizes the refusal surface depths and elevations as encountered at the two borehole locations.



## FOUNDATION REPORT UN-NAMED CREEK CULVERT REPLACEMENT - HIGHWAY 417

Borehole Number	Existing Ground Surface Elevation (m)	Depth to Refusal (m)	Possible Bedrock Surface Elevation (m)
14-323	118.0	16.9	101.1
14-324	113.7	12.2	101.5

### 4.2.8 Groundwater Conditions

The groundwater level measured in the standpipe piezometer in Borehole 14-321 is presented in the table below:

Borehole	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)	Date
14-321	113.24	0.02	113.2	August 13, 2014
		0.13	113.1	December 8, 2015

The groundwater level in the creek was given as Elevation 112.7 m on March 17, 2014.

It should be noted that groundwater levels in the area are subject to fluctuations both seasonally and with precipitation events.

### 4.2.9 Groundwater Corrosion Testing

One sample of surface water from the Unnamed Creek culvert site was submitted to Exova (Ottawa) for chemical analysis related to potential corrosion of steel elements and potential sulphate attack on concrete elements. The results of this testing are summarized below.

Sample Number	Sample Date	Chloride (mg/L)	SO <sub>4</sub> (mg/L)	pH	Resistivity (ohm-cm)
1123431	July 29, 2014	10	14	8.14	1908



## 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Kim Lesage, P.Eng., a geotechnical engineer with Golder. Mr. Fin Heffernan, P.Eng., Golder's Designated MTO Foundations Contact for this project, conducted an independent quality review of the report.

### GOLDER ASSOCIATES LTD.

Geotechnical Engineer

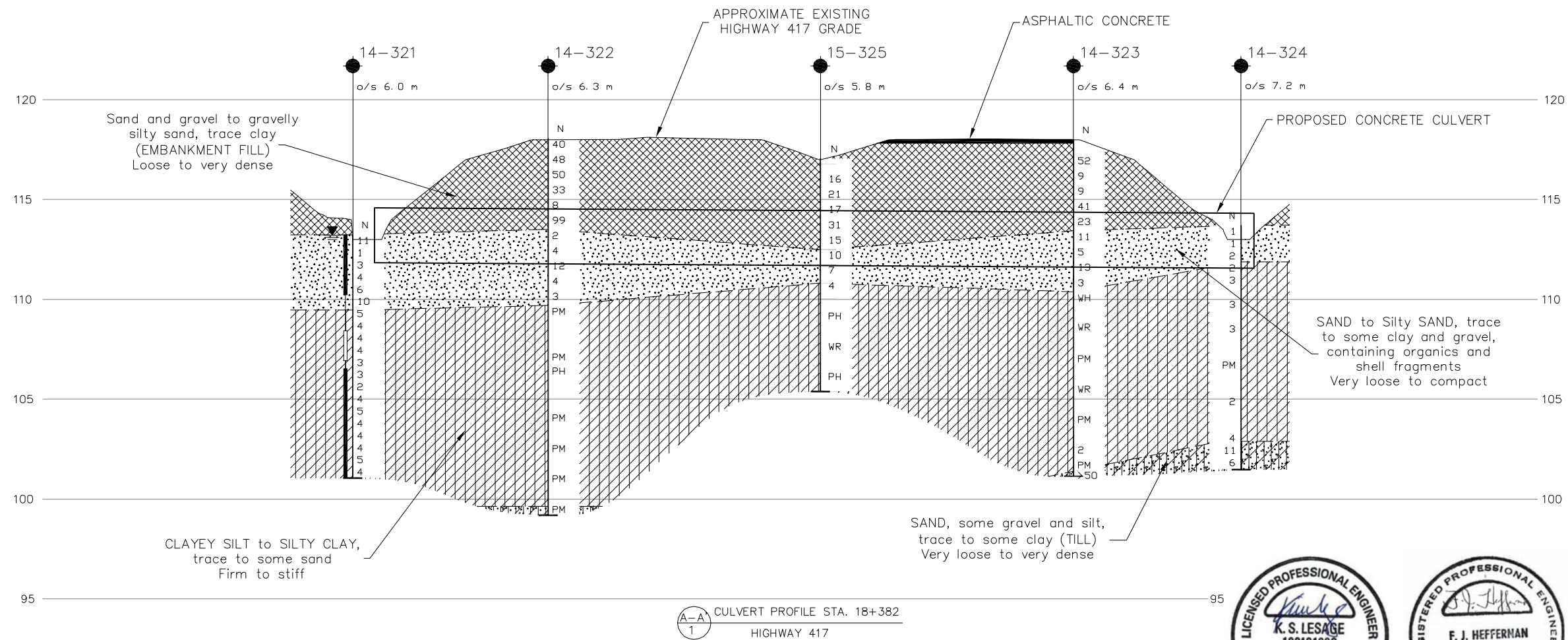
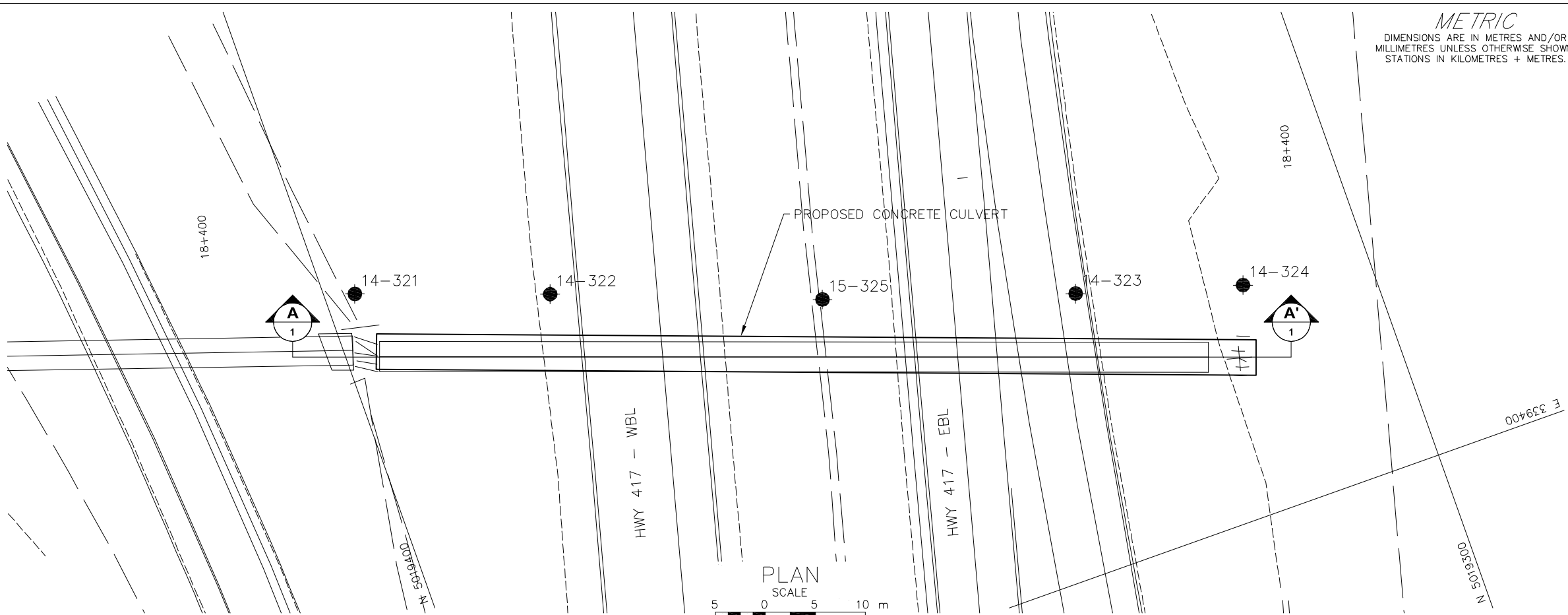


Fin Heffernan, P.Eng.  
Designated MTO Contact

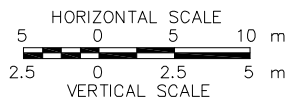


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CULVERT PROFILE STA. 18+382  
HIGHWAY 417



CONT No. 2016-4032  
WP No. 4168-11-01

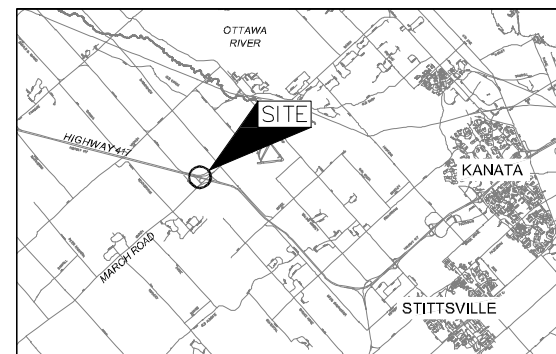


HIGHWAY 417  
CULVERT AT STA. 18+382  
BOREHOLE LOCATIONS AND  
SOIL STRATA

SHEET  
44



**Golder Associates Ltd.**  
SUDBURY, ONTARIO, CANADA



KEY PLAN



#### LEGEND

- Borehole - Current Investigation
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated  
(Std. Pen. Test, 475 j/blow)
- PH Sampler advanced by hydraulic pressure
- PM Sampler advanced by manual pressure
- WR Sampler advanced by static weight of hammer
- ≡ WL in piezometer, measured on Aug. 13, 2014

#### BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
14-321	113.2	5019397.0	339451.6
14-322	118.1	5019378.6	339445.1
14-323	118.0	5019328.9	339427.4
14-324	113.7	5019312.8	339422.6
15-325	117.1	5019353.0	339435.4

#### 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 Preliminary Design Report.

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

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

#### REFERENCE

Base plans provided in digital format by MMM Group Limited, drawing file nos. Plan-3-728.dwg, received August 7, 2014.

NO.	DATE	BY	REVISION
Geocres No. 31F-191			
HWY. 417	PROJECT NO. 12-1121-0099		DIST. EASTERN
SUBM'D. MJK	CHKD. MJK	DATE: FEB. 2016	SITE: 3-728c
DRAWN: JJJ/JM	CHKD. FJH	APPD. FJH	DWG. 1



# **APPENDIX A**

**List of Abbreviations and Symbols**  
**Lithological and Geotechnical Rock Description Terminology**  
**Borehole and Drillhole Records**

## LIST OF ABBREVIATIONS

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

<b>I. SAMPLE TYPE</b>		<b>III. SOIL DESCRIPTION</b>		
AS	Auger sample	<b>(a) Cohesionless Soils</b>		
BS	Block sample	<b>Density Index (Relative Density)</b>		<b>N</b>
CS	Chunk sample			<u>Blows/300 mm</u>
DO or DP	Seamless open-ended, driven or pushed tube samplers			<u>Or Blows/ft.</u>
DS	Denison type sample		Very loose	0 to 4
FS	Foil sample		Loose	4 to 10
RC	Rock core		Compact	10 to 30
SC	Soil core		Dense	30 to 50
SS	Split spoon sampler		Very dense	over 50
ST	Slotted tube	<b>(b) Cohesive Soils</b>		
TO	Thin-walled, open	<b>Consistency</b>		<b>C<sub>u</sub> or S<sub>u</sub></b>
TP	Thin-walled, piston			
WS	Wash sample		<u>kPa</u>	<u>Psf</u>
DT	Dual tube sample		Very soft	0 to 12
DD	Diamond drilling		Soft	12 to 25
			Firm	25 to 50
			Stiff	50 to 100
			Very stiff	100 to 200
			Hard	Over 200
				Over 4,000
<b>II. PENETRATION RESISTANCE</b>		<b>IV. SOIL TESTS</b>		
<b>Standard Penetration Resistance (SPT), N:</b>		w	Water content	
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.).		w <sub>p</sub> or PL	Plastic limited	
<b>Dynamic Cone Penetration Resistance (DCPT); N<sub>d</sub>:</b>		w <sub>l</sub> or LL	Liquid limit	
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive an uncased 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).		C	Consolidation (oedometer) test	
<b>PH:</b> Sampler advanced by hydraulic pressure		CHEM	Chemical analysis (refer to text)	
<b>PM:</b> Sampler advanced by manual pressure		CID	Consolidated isotropically drained triaxial test <sup>1</sup>	
<b>WH:</b> Sampler advanced by static weight of hammer		CIU	Consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>	
<b>WR:</b> Sampler advanced by weight of sampler and rod		D <sub>R</sub>	Relative density	
<b>Cone Penetration Test (CPT):</b>		DS	Direct shear test	
An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm <sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q <sub>t</sub> ), porewater pressure (u) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.		G <sub>s</sub>	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 <sub>4</sub>	Concentration of water-soluble sulphates	
		UC	Unconfined compression test	
		UU	Unconsolidated undrained triaxial test	
		V	Field vane test (LV-laboratory vane test)	
		γ	Unit weight	

Note: <sup>1</sup> Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.

## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	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
V	volume
W	weight

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma'$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial vertical effective overburden stress
$\sigma_1 \sigma_2 \sigma_3$	principal stresses (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3) / 3$
$\tau$	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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) formerly ( $G_s$ )
$e$	void ratio
$n$	porosity
$S$	degree of saturation
*	Density symbol is $\rho$ . Unit weight symbol is $\gamma$ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

#### (a) Index Properties (continued)

$w$	water content
$w_L$ or $LL$	liquid limit
$w_p$ or $PL$	plastic limit
$I_p$ or $PI$	plasticity Index $= (w_L - w_p)$
$w_s$	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 (overconsolidated range)
$C_s$	swelling index
$C_\alpha$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation (vertical direction)
$T_v$	time factor (vertical direction)
$U$	degree of consolidation
$\sigma'_p$	pre-consolidation stress
OCR	overconsolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

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

Notes:

$$^1 \tau = c' + \sigma' \tan \phi'$$

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



# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

**Fresh:** no visible sign of rock material 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 texture and structure are preserved.

## BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing</u>
Very Thickly Bedded	> 2 m
Thickly Bedded	0.6 m to 2m
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	< 6 mm

## JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very Wide	> 3 m
Wide	1 – 3 m
Moderately Close	0.3 – 1 m
Close	50 – 300 mm
Very Close	< 50 mm

## GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

Note: \*Grains > 60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery

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 varies from 0% for completely broken core 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including naturally occurring fractures but not including mechanically induced breaks caused by drilling.

### Dip with Respect to (W.R.T.) 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 abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature information concerning the nature of fracture surfaces and infillings are also noted.

### Abbreviations

BD -	Bedding	PY -	Pyrite
FO -	Foliation/Schistosity	Ca -	Calcite
CL -	Clean	PO -	Polished
SH -	Shear Plane/Zone	K -	Slickensided
VN -	Vein	SM -	Smooth
FLT -	Fault	RO -	Ridged/Rough
CO -	Contact	ST -	Stepped
JN -	Joint	PL -	Planar
FR -	Fracture	IR -	Irregular
MB -	Mechanical Break	UN -	Undulating
BR -	Broken Rock	CU -	Curved
BL -	Blast Induced	TCA -	To Core Axis
II -	Parallel To	STR -	Stress Induced
OR -	Orthogonal		

PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 14-321</b>		SHEET 1 OF 2		<b>METRIC</b>							
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019397.0; E 339451.6</u>		ORIGINATED BY <u>NJ</u>									
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill, NW/BW Casing</u>		COMPILED BY <u>JL</u>									
DATUM <u>Geodetic</u>		DATE <u>July 14, 2014</u>		CHECKED BY <u>MJK</u>									
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID UNIT REMARKS				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	γ	GR SA SI CL
113.2	GROUND SURFACE												
0.0	TOPSOIL, with sand, with organics Brown		1	SS	11		113						
0.1	SAND, some silt to silty, trace gravel Very loose to loose Brown to grey Wet		2	SS	1								
			3	SS	3		112						2 81 14 3
			4	SS	4								
			5	SS	6		111						
110.2	SAND, some silt Compact Grey Wet		6	SS	10		110						1 86 12 2
3.0													
109.4	CLAYEY SILT to SILTY CLAY, some sand, some gravel, with organics Firm to very stiff Grey Wet		7	SS	5		109						
3.8			8	SS	4								
			9	SS	4		108						
			10	SS	4								
			11	SS	3		107						
			12	SS	3		106						12 13 35 40
			13	SS	2								
			14	SS	4		105						
			15	SS	5								
			16	SS	4		104						

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

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PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 14-321</b>				SHEET 2 OF 2		<b>METRIC</b>											
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019397.0 ; E 339451.6</u>				ORIGINATED BY <u>NJ</u>													
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill, NW/BW Casing</u>				COMPILED BY <u>JL</u>													
DATUM <u>Geodetic</u>		DATE <u>July 14, 2014</u>				CHECKED BY <u>MJK</u>													
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  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)		
	--- CONTINUED FROM PREVIOUS PAGE ---																		
101.6	CLAYEY SILT to SILTY CLAY, some sand, some gravel, with organics Firm to very stiff Grey Wet		17	SS	4		103												
			18	SS	4														
			19	SS	5														
101.6 11.6	SILTY CLAY Stiff Grey Wet		20	SS	4		102											0 1 45 54	
101.0 12.2	END OF BOREHOLE																		
	NOTES:  1. Water level in well at 0.0 m depth below ground surface (Elev. 113.2 m), measured on August 13, 2014.																		

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PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 14-322</b>		SHEET 1 OF 2		<b>METRIC</b>	
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019378.6 ;E 339445.1</u>		ORIGINATED BY <u>DWM</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JL</u>			
DATUM <u>Geodetic</u>		DATE <u>July 14, 2014</u>		CHECKED BY <u>MJK</u>			

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

PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 14-322</b>		SHEET 2 OF 2		<b>METRIC</b>	
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019378.6; E 339445.1</u>		ORIGINATED BY <u>DWM</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JL</u>			
DATUM <u>Geodetic</u>		DATE <u>July 14, 2014</u>		CHECKED BY <u>MJK</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	WATER CONTENT (%)					
							20	40	60	80	100						
	--- CONTINUED FROM PREVIOUS PAGE ---						108	×		+							
			13	SS	PM			×		+							
			14	TP	PH												
							106										
								×		+							
								×			+						
			15	SS	PM			×			+						
								×									
								×			+						
			16	SS	PM												
								×			+						
								×									
			17	SS	PM						+						
								×									
								×			+						
								×									
								×			+						
99.7							100										
18.4	SAND, some gravel, silt and clay (TILL) Very loose Grey Wet		18	SS	PM												18 49 21 12
99.2																	
18.9	END OF BOREHOLE																

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PROJECT 12-1121-0099-1320		RECORD OF BOREHOLE No 14-323		SHEET 1 OF 2		METRIC															
G.W.P. 4168-11-01		LOCATION N 5019328.9; E 339427.4		ORIGINATED BY DWM																	
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem)		COMPILED BY JL																	
DATUM Geodetic		DATE July 16, 2014		CHECKED BY MJK																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ					
								20 40 60 80 100	○ UNCONFINED + FIELD VANE	○	25 50 75	○	GR SA SI CL								
118.0	GROUND SURFACE																				
117.8	ASPHALT (190 mm)																				
117.6	Gravelly sand (FILL)																				
0.4	Grey Sand and gravel, some silt (FILL)																				
	Loose to dense																				
	Brown Dry																				
			1	SS	52		117														
			2	SS	9		116										31 55 10 4				
			3	SS	9																
115.0	Silty sand, some gravel, containing limestone fragments (ROCK FILL)						115														
3.1	Dense Brown to grey Moist																				
			4	SS	41																
114.2	Sand, some silt (FILL)																				
3.8	Compact Brown Moist						114														
			5	SS	23																
113.4	SAND, some silt, trace gravel																				
4.6	Loose to compact Brown Wet						113										7 79 13 1				
			6	SS	11																
			7	SS	5		112														
			8	SS	13																
111.1	Silty SAND to CLAYEY SILT, containing shells						111														
6.9	Very loose Grey Wet																				
			9	SS	3																
110.4	CLAYEY SILT to SILTY CLAY																				
7.6	Firm Grey Wet						110														
			10	SS	WH																
							109														
			11	TP	WR																

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

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PROJECT		12-1121-0099-1320		RECORD OF BOREHOLE No 14-323		SHEET 2 OF 2		METRIC						
G.W.P.		4168-11-01		LOCATION		N 5019328.9 ; E 339427.4		ORIGINATED BY		DWM				
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger 200 mm Diam. (Hollow Stem)		COMPILED BY		JL				
DATUM		Geodetic		DATE		July 16, 2014		CHECKED BY		MJK				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100						
	CLAYEY SILT to SILTY CLAY Firm Grey Wet							20 40 60 80 100						
			12	SS	PM									0 0 43 57
			13	SS	WR									
	- Becomes stiff at 13.1 m depth													
			14	SS	PM									
102.6	Gravelly Silty SAND, some clay Very loose Grey Wet		15	SS	2									22 35 27 16
102.2	SILTY CLAY, trace sand Very loose Grey Wet													
15.9			16	SS	PM									0 5 45 50
101.4														
101.1	SAND (TILL) Very dense Grey Wet		17	SS	50/10 T									
16.9	END OF BOREHOLE AUGER REFUSAL on Possible Bedrock													

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METRIC

CHECKED BY MJK


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa							WATER CONTENT (%)		
							<div><div>○ UNCONFINED    + FIELD VANE</div><div>● QUICK TRIAXIAL    × REMOULDED</div></div>							<div><div>W<sub>p</sub>                  W                  W<sub>L</sub></div><div>PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT</div></div>		
							<div><div>20   40   60   80   100</div><div>20   40   60   80   100</div></div>							<div><div>25   50   75</div></div>		
113.7	GROUND SURFACE															
0.0	TOPSOIL															
0.1	Brown															
	SAND, some silt, trace clay, trace roots		1	SS	1								○			
	Very loose															
	Brown															
	Moist to wet															
			2	SS	1											
			3	SS	2								○		0 71 22 7	
111.9																
1.8	CLAYEY SILT to SILTY CLAY, trace sand seams		4	SS	2											
	Firm to stiff															
	Grey															
	Wet															
			5	SS	3										0 9 55 36	
			6	SS	3		×		+							
							×		+							
							×		+							
							×		+							
			7	SS	3								○			
							×		+							
							×		+							
							×		+							
							×		+							
			8	SS	PM											
	- Becomes stiff at 8.2 m depth															
			9	SS	2										0 0 44 56	
							×		+							
103.7								×			+					

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



PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 14-324</b>		SHEET 2 OF 2		<b>METRIC</b>	
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019312.8 ; E 339422.6</u>		ORIGINATED BY <u>NJ</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Portable Drill, NW/BW Casing</u>		COMPILED BY <u>JL</u>			
DATUM <u>Geodetic</u>		DATE <u>July 16, 2014</u>		CHECKED BY <u>MJK</u>			

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>	
10.0	SILTY CLAY Very stiff Grey Wet		10	SS	4	103												
102.9	SAND, some gravel and silt, trace clay (TILL) Loose to compact Grey Wet		11	SS	11		102											
10.8			12	SS	6													
101.6	Possible Weathered Bedrock		13	SS	50/0.1												14 50 27 9	
12.2	END OF BOREHOLE SAMPLER REFUSAL on Possible Bedrock																	

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PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 15-325</b>		SHEET 1 OF 2		<b>METRIC</b>	
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019353.0 ; E 339435.4</u>		ORIGINATED BY <u>DWM</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>		DATE <u>December 8, 2015</u>		CHECKED BY _____			

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SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
							20	40	60	80	100						
117.1	GROUND SURFACE																
0.0	Sand, some gravel and silt (FILL)																
116.8	Brown Moist																
0.3	Sand, some silt, trace gravel, contains pockets of silty clay (FILL)																
	Compact to dense Brown Moist to wet		1	SS	16												
			2	SS	21												
			3	SS	17												
			4	SS	31												
			5	SS	15												
112.5	SAND to Silty SAND, contains organic matter and decomposed wood		6	SS	10												
4.6	Loose to compact Black to grey Wet		7	SS	7												
111.8	SAND to Silty SAND, contains organic matter		8	SS	4												
5.3	Loose Dark grey Wet		9	SS	PH												
110.9	CLAYEY SILT		10	SS	WR												
6.3	Stiff Grey Moist																
110.1	CLAYEY SILT to SILTY CLAY, contains shells																
7.0	Firm Grey Wet																

Continued Next Page

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PROJECT <u>12-1121-0099-1320</u>		<b>RECORD OF BOREHOLE No 15-325</b>		SHEET 2 OF 2		<b>METRIC</b>	
G.W.P. <u>4168-11-01</u>		LOCATION <u>N 5019353.0 ; E 339435.4</u>		ORIGINATED BY <u>DWM</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>JM</u>			
DATUM <u>Geodetic</u>		DATE <u>December 8, 2015</u>		CHECKED BY _____			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		GR	SA	SI	CL
-- CONTINUED FROM PREVIOUS PAGE --								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × REMOULDED					WATER CONTENT (%)							
								20	40	60	80	100								
							107	×		+										
								×		+										
			11	SS	PH		106								○					
105.4								×		+										
11.7	END OF BOREHOLE																			

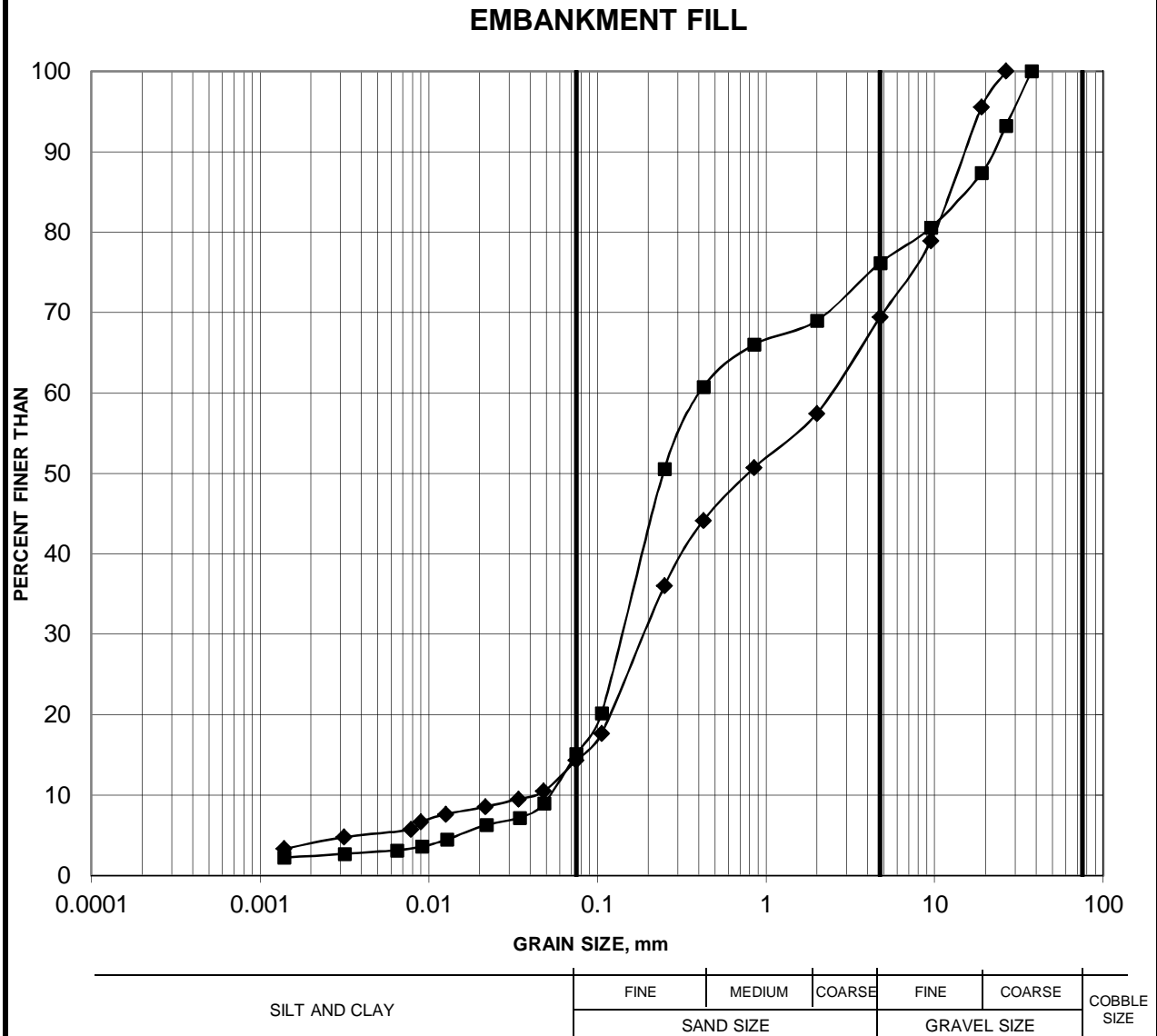


# APPENDIX B

## Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

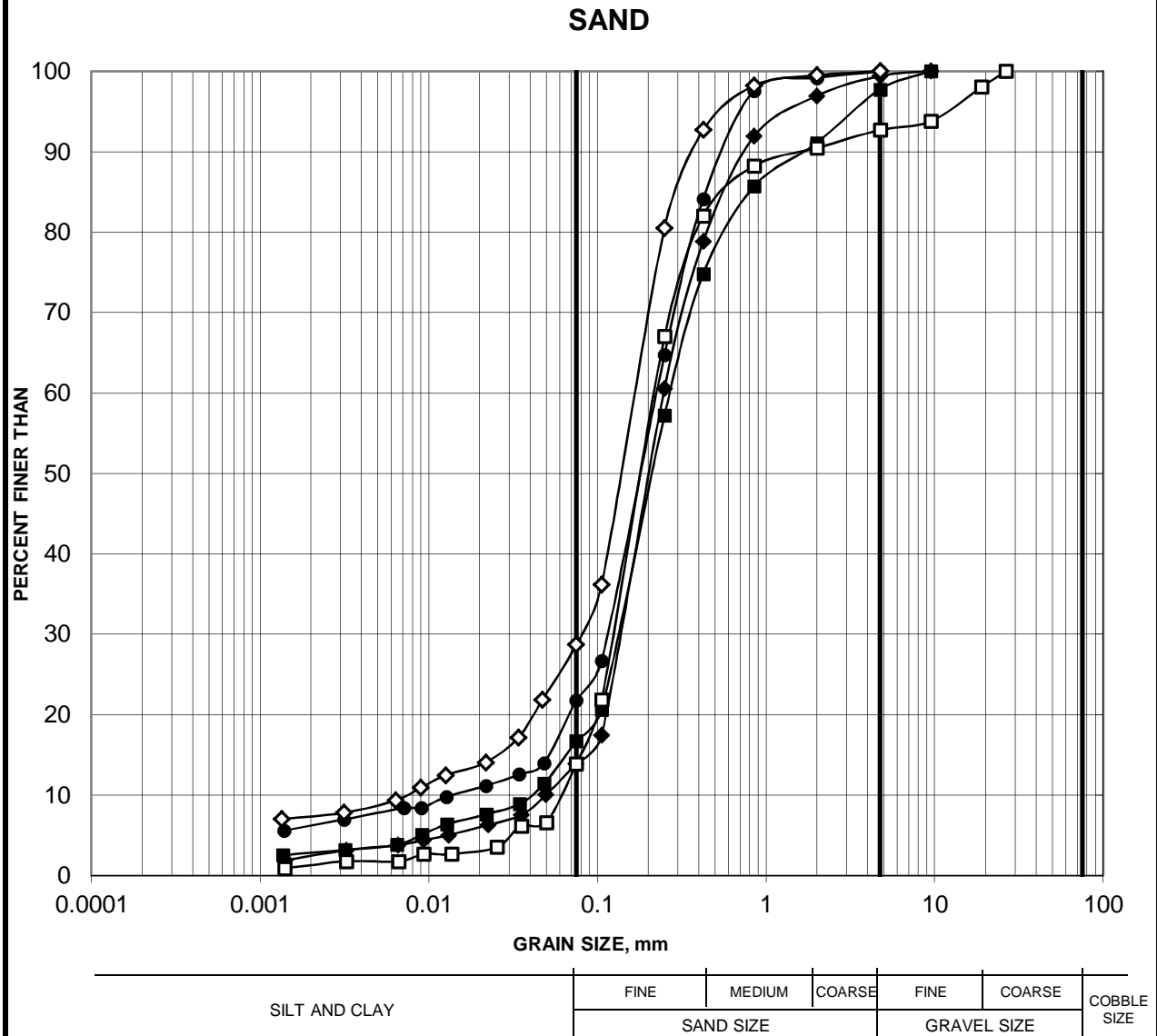
FIGURE B1



Borehole	Sample	Depth (m)
■ 14-322	2	1.52-2.13
◆ 14-323	4	2.29-2.90

# GRAIN SIZE DISTRIBUTION

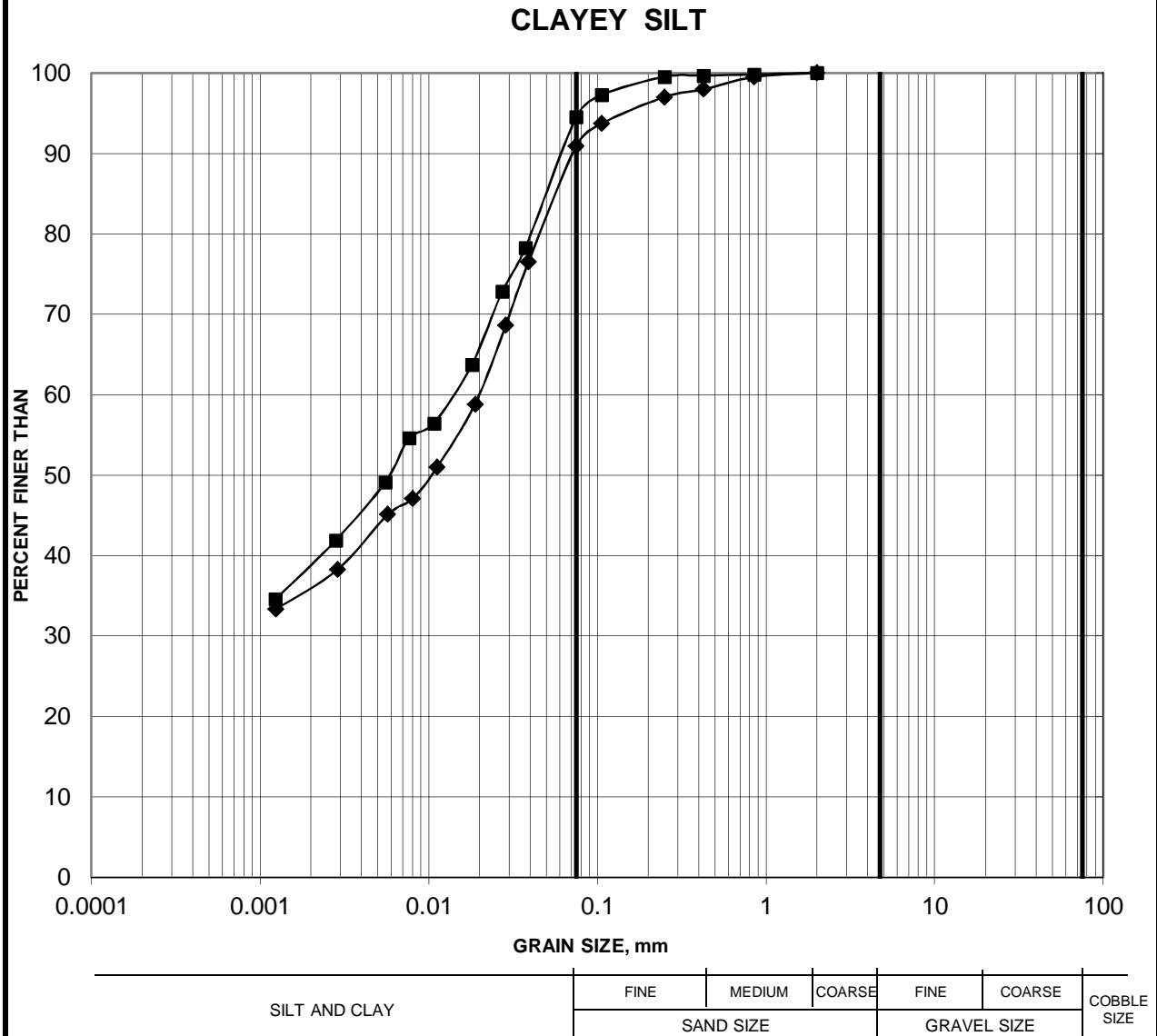
FIGURE B2



Borehole	Sample	Depth (m)
■ 14-321	3	1.22-1.83
◆ 14-321	6	3.05-3.66
● 14-322	10	6.86-7.47
□ 14-323	6	4.57-5.18
◇ 14-324	3	1.22-1.83

# GRAIN SIZE DISTRIBUTION

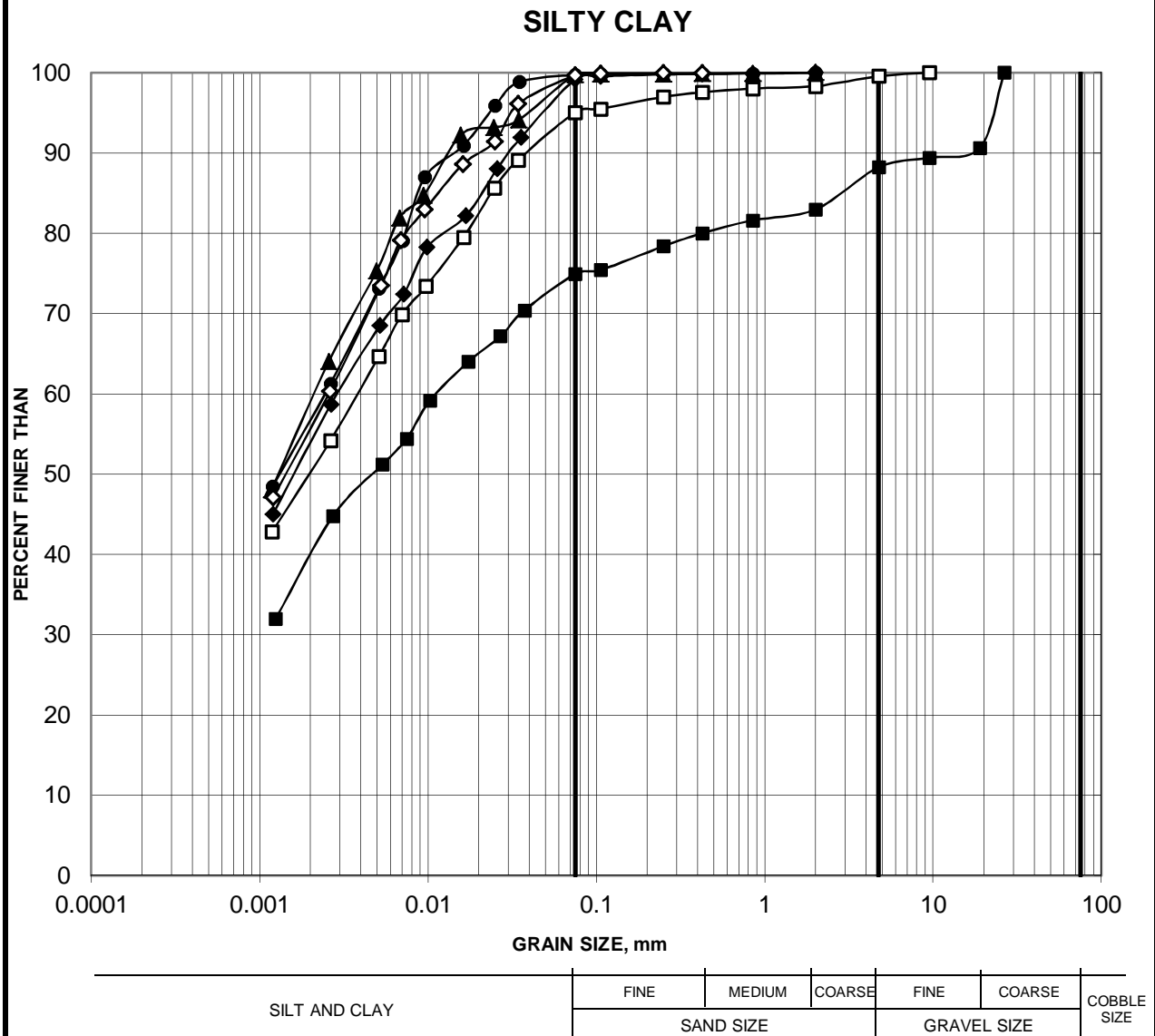
FIGURE B3



Borehole	Sample	Depth (m)
■ 14-322	12	8.38-8.99
◆ 14-324	5	2.44-3.05

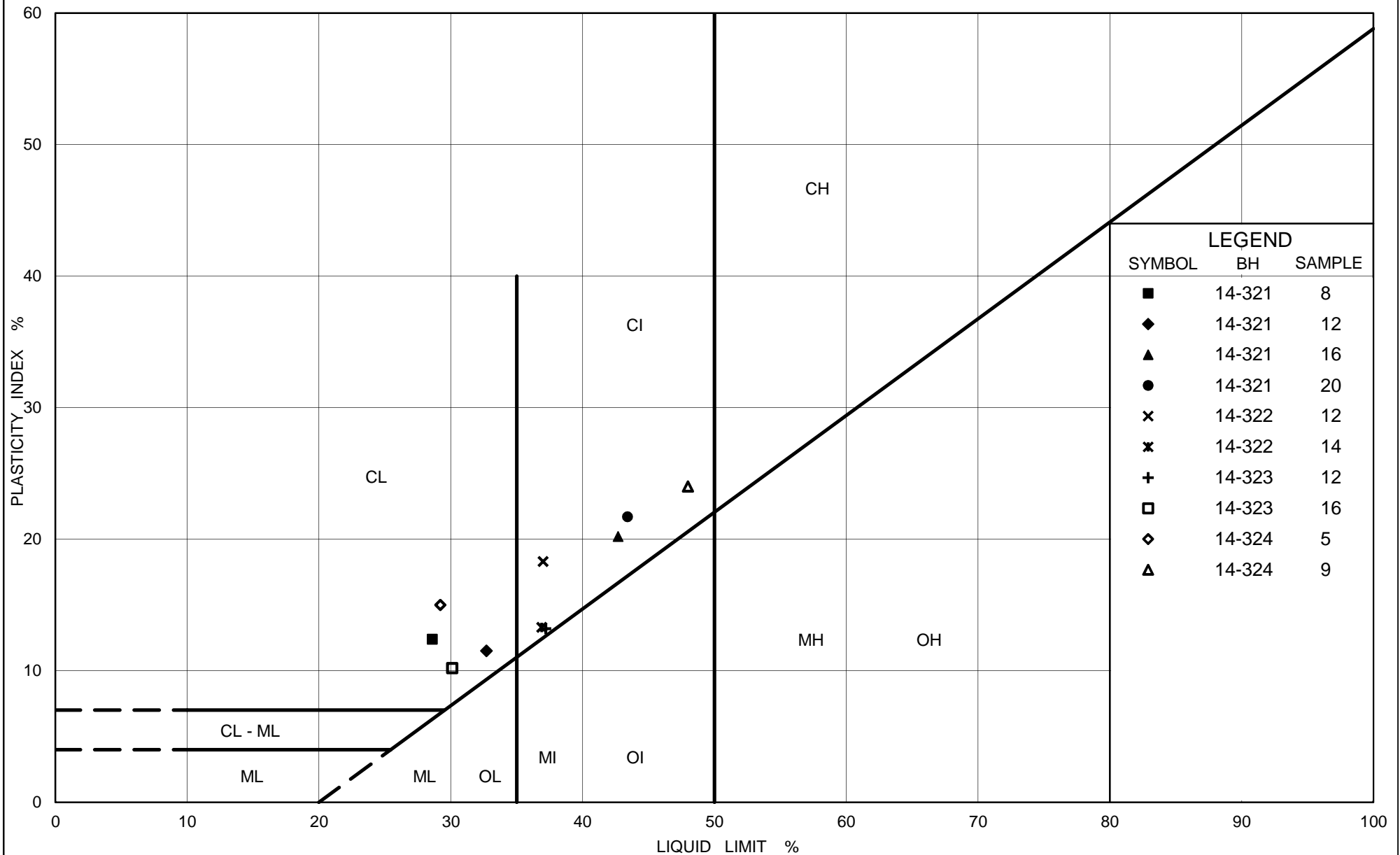
# GRAIN SIZE DISTRIBUTION

FIGURE B4



Borehole	Sample	Depth (m)
■ 14-321	12	6.71-7.32
◆ 14-321	20	11.59-12.20
▲ 14-322	14	11.43-12.04
● 14-323	12	10.67-11.28
□ 14-323	16	16.01-16.62
◇ 14-324	9	8.54-9.15





Ministry of Transportation

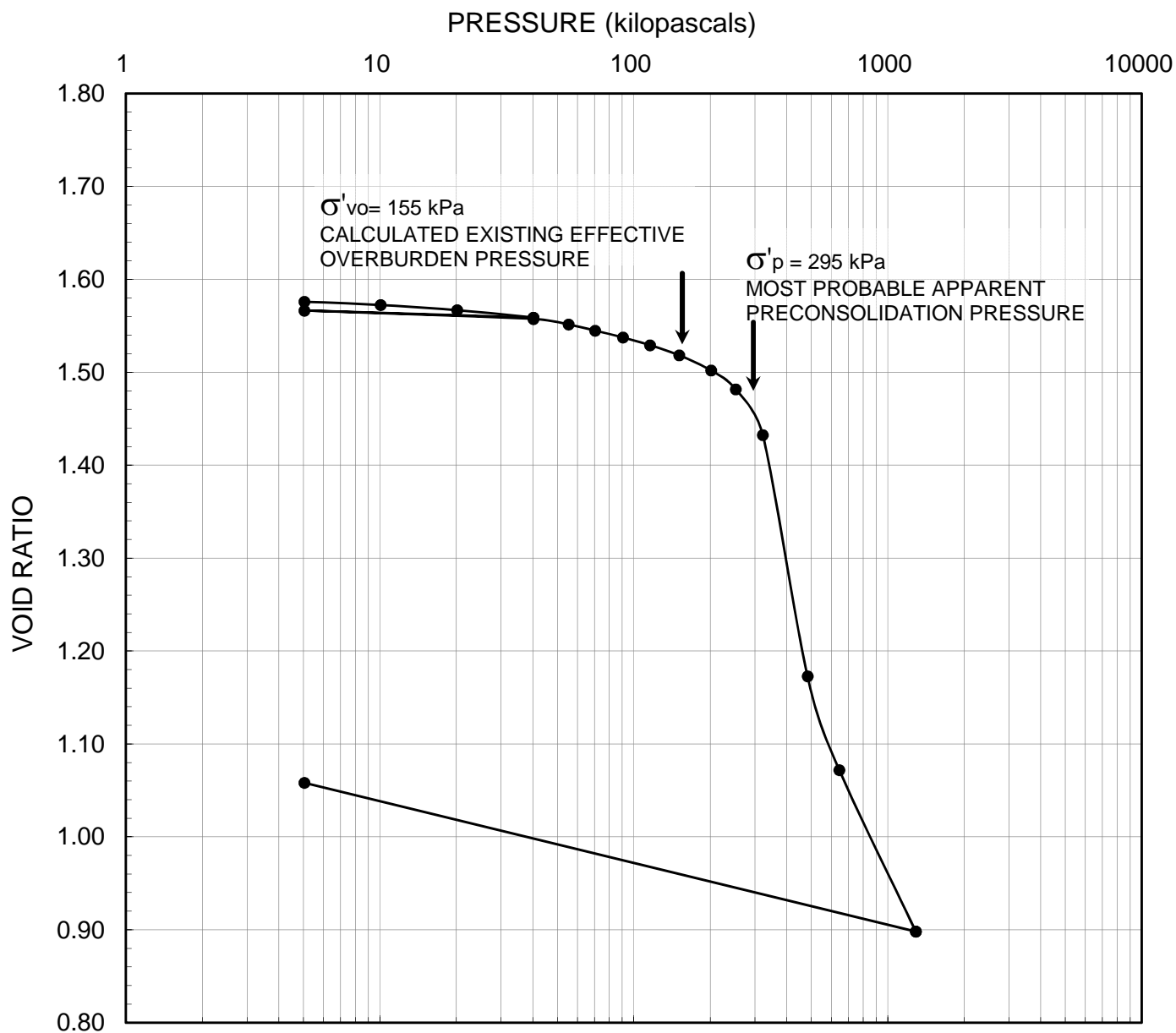
Ontario

# PLASTICITY CHART CLAYEY SILT to SILTY CLAY

FIG No. B5

Project No. 12-1121-0099/1320

Compiled By : MI      Checked By : CNM



#### LEGEND

Borehole:	14-322	$w_i = 57\%$	$S_o = 100\%$	$\gamma = 16.6 \text{ kN/m}^3$
Sample:	14	$w_f = 38\%$	$e_o = 1.58$	$G_s = 2.78$
Depth (m):	11.9	$w_l = 37\%$	$C_c = 1.47$	
Elevation (m):	106.2	$w_p = 24\%$	$C_r = 0.010$	



**Golder  
Associates**

SCALE	AS SHOWN
DATE	11/14/14
CADD	N/A
ENTERED	MI
CHECK	CNM
REVIEW	KSL

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

PROJECT No. 12-1121-0099/1320 REV. 0

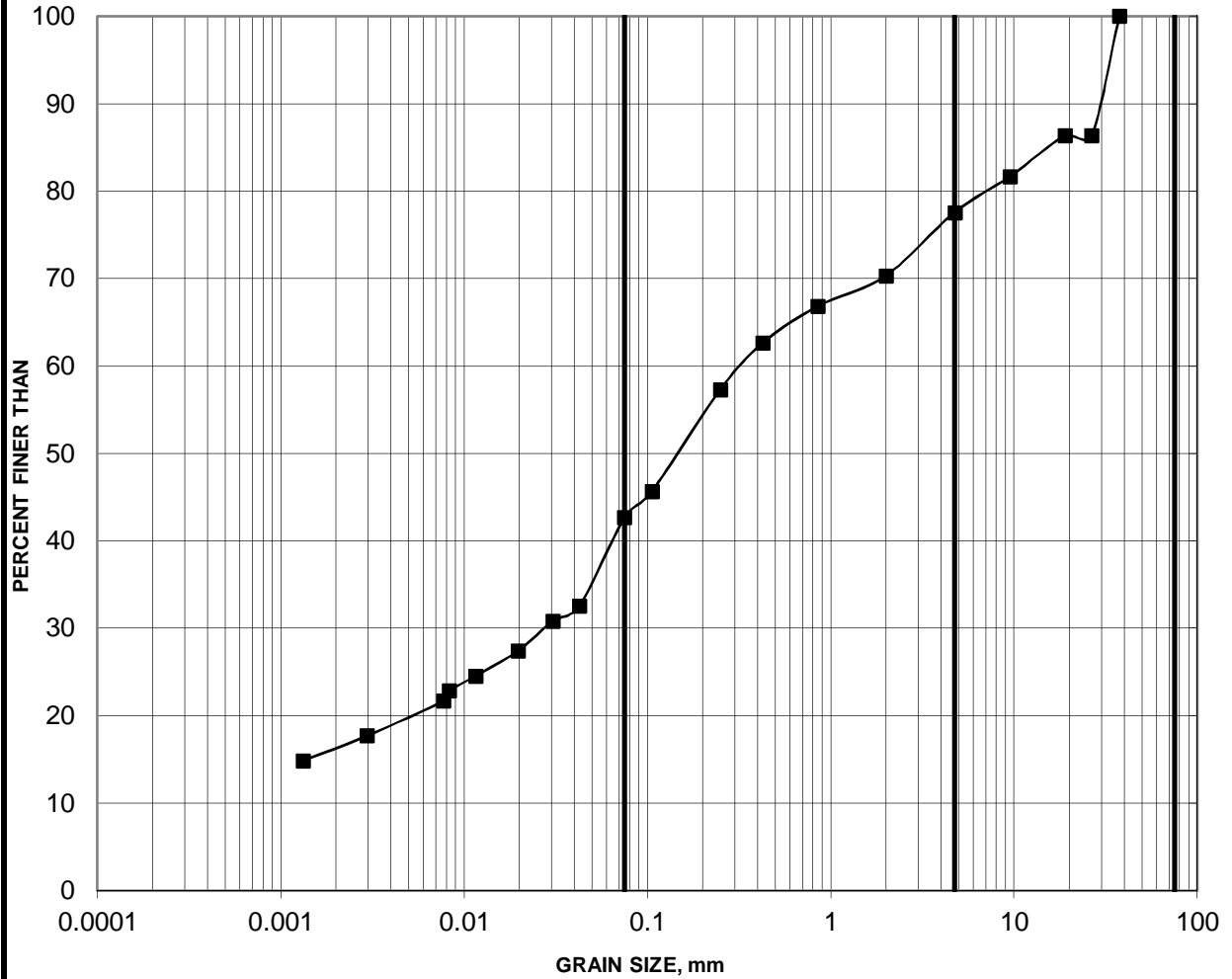
FIGURE

**B6**

# GRAIN SIZE DISTRIBUTION

FIGURE B7

## Gravelly Silty SAND

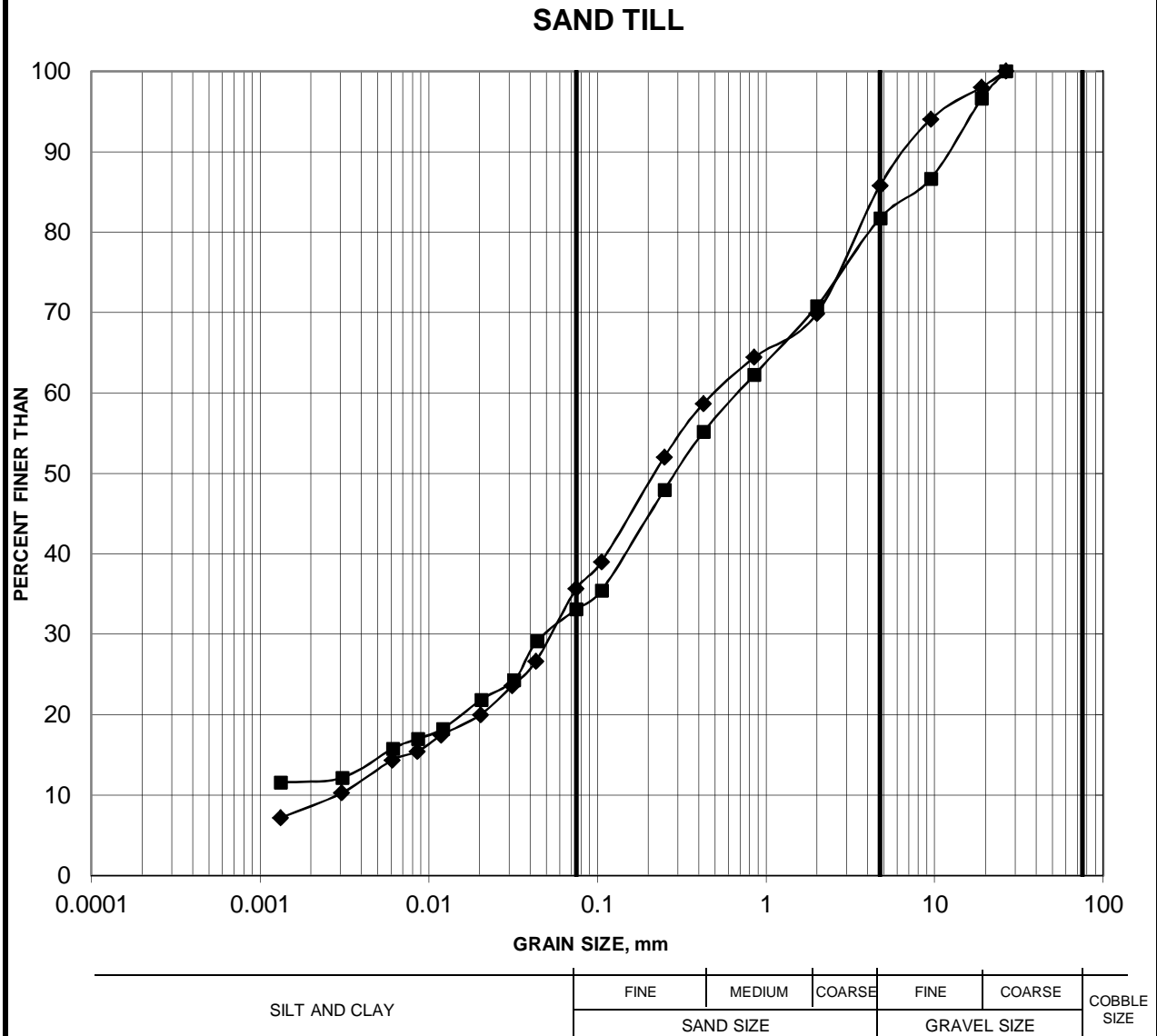


SILT AND CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
	SAND SIZE			GRAVEL SIZE		

Borehole	Sample	Depth (m)
—■ 14-323	15	15.24-15.85

# GRAIN SIZE DISTRIBUTION

FIGURE B8



Borehole	Sample	Depth (m)
14-322	18	18.29-18.90
14-324	12	11.59-12.20

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