May 2016

REPORT ON

Foundation Investigation and Design
Retaining Wall Rehabilitation
March Road Underpass
Site No. 3-357
Highway 417
Ottawa, Ontario
W.P. 4104-13-01

Submitted to:
MMM Group Ltd.
1145 Hunt Club Road, Suite 300
Ottawa, Ontario
K1V 0Y3

REPORT

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Report Number: 1417217-1100

Geocres Number: 31F-192

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1 copy - Golder Associates Ltd.

Golder Associates

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PART A

FOUNDATION INVESTIGATION REPORT

RETAINING WALL REHABILITATION

MARCH ROAD UNDERPASS

SITE 3-357

HIGHWAY 417

OTTAWA, ONTARIO

W.P. 4104-13-01

May 2016
Report No. 1417217-1100

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 a foundation investigation for the rehabilitation of the retaining walls at the March Road underpass, Site No. 3-357 (W.P. 4104-13-01) located on Highway 417 approximately 8 km west of Highway 7 in Ottawa, Ontario as part of the MEGA 6 project.

As part of the current assignment, previously collected subsurface information pertinent to the site was reviewed and compiled. This existing subsurface information was contained in the following:

- Report prepared by Geocon Inc. for the MTO titled "*Subsurface Geotechnical Investigation, Proposed Highway 17 and 44, Underpass, Ottawa, Ontario, WP 34-81-02, Site 3-357"*, dated November 1990 (GEOCRES No. 31F-110).

The purpose of this current investigation was to assess the subsurface conditions at the site of the proposed retaining wall rehabilitation by borehole drilling and carrying out in-situ and laboratory testing on selected samples.

The terms of reference and scope of work for the foundation engineering services are outlined in MTO's Request for Proposal (RFP) for Assignment No. 4014-E-0015 dated October 2014 and in Golder's proposal for this project dated December 11, 2014.

2.0 SITE DESCRIPTION

The March Road underpass (structure Site No. 3-357) is located at about Station 18+507 on Highway 417 about 8 km west of Highway 7 in Ottawa, Ontario. Through this area, Highway 417 is a four lane divided highway with a rural cross-section. The existing structure is aligned approximately northeast-southwest and crosses the highway at a skew of approximately 55 degrees. However, for this report, the bridge alignment will be referred to as north-south. The bridge was constructed in about 1992 and consists of a two-span structure, approximately 90 m in length and 15.5 m in width (i.e., is two lanes wide). The abutments are perched within the embankments, and along with the pier, are supported on end bearing steel H-piles.

The existing approach embankments are about 8 to 9 m high relative to the surrounding ground surface and have approximately 2.5 horizontal to 1 vertical (i.e., 2.5H:1V) side slopes. No signs of embankment instability were observed. Retained Soil System (RSS) walls currently retain the embankment fill at the abutments and at the wing walls. The wing walls are aligned parallel to March Road and are about 9 m in length along the southeast and northwest sides of the embankments and about 16 m in length along the southwest and northeast sides of the embankments. There is evidence that the embankments have experienced settlement as there are visible gaps between the RSS wall panels at the face of the abutments and along the wing walls.

3.0 INVESTIGATION PROCEDURES

The subsurface investigation for the retaining wall rehabilitation was carried out between November 30 and December 8, 2015, at which time four boreholes (numbered 15-1 to 15-4, inclusive) and two test pits (numbered 15-101 and 15-103) were advanced at the locations shown on Drawings 1 and 2. The boreholes were advanced as follows:

- Boreholes 15-1, 15-3 and 15-4 were advanced near the toes of the existing north and south approach embankments, using 200 mm inside diameter continuous-flight hollow-stem augers on a track-mounted drill rig, supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths of about 11.8 to 12.2 m (Elevations 105.2 and 107.0 m) metres below the existing ground surface while carrying out soil sampling and in situ testing. Below these depths, the boreholes were advanced without sampling, using a dynamic cone penetration test (DCPT), to depths between about 21.8 and 25.1 m (Elevations 93.7 and 96.3 m) below the existing ground surface.
- Borehole 15-2 was advanced near the west toe of the existing south approach embankment using portable drilling equipment supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. The borehole was advanced using near-continuous sampling procedures to a depth of about 12.5 m below the existing ground surface, at about Elevation 105.9 m.
- Test pits 15-101 and 15-103 were advanced through the approach embankments, adjacent to one end of both the south and north abutments, respectively, using a backhoe supplied by Glenn Wright Excavating of Ottawa, Ontario. The test pits were advanced to depths of up to about 4 m below the existing ground surface. It should be noted that proposed test pits 15-102 and 15-104 could not be excavated due to limited site access at the proposed locations.

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 to depths between about 11.8 and 12.5 m (Elevations 105.2 and 107.0 m) in Boreholes 15-1, 15-3, and 15-4.

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 15-1, 15-3 and 15-4. In addition, six relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from these boreholes using a fixed piston sampler.

A standpipe piezometer was installed in Borehole 15-4 to monitor the groundwater level at the site. The standpipe consists of a 19 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 December 21, 2015.

Soil samples of embankment fill were obtained from the test pits and the groundwater seepage conditions in the test pits were observed during the short time they remained open.

The boreholes were backfilled with bentonite pellets, mixed with native soils in the overburden. The test pits were loosely backfilled upon completion of excavating and sampling. The site conditions were restored following completion of work.

The field work was supervised by members of Golder's technical staff, who located the boreholes and test pits, supervised the drilling/excavating, sampling and in situ testing operations, logged the boreholes and test pits, 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 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 at Golder's Mississauga and Ottawa laboratories. Consolidation testing was carried out on one sample obtained from Borehole 15-1 at Golder's Mississauga laboratory. All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

Prior to drilling, the borehole and test pit locations were staked and surveyed by Golder personnel using a Trimble R8 GPS unit. The borehole and test pit locations, including MTM NAD83 northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized in the following table and are shown on Drawings 1 and 2.

Test Hole Number	Type	Test Hole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
15-1	Borehole	South Embankment Toe (East)	5019276.6	339535.1	118.1
15-2	Borehole	South Embankment Toe (West)	5019307.6	339494.9	118.4
15-3	Borehole	North Embankment Toe (East)	5019341.3	339605.9	118.8
15-4	Borehole	North Embankment Toe (West)	5019375.9	339566.1	117.0
15-101	Test Pit	South Abutment (East)	5019288.3	339521.6	122.4
15-103	Test Pit	North Abutment (West)	5019356.9	339574.3	120.5

Notes: 1) Northing and Easting coordinates shown are relative to the MTM NAD83 (Zone 9) coordinate system.
2) Ground surface elevations shown are relative to Geodetic Datum.

Five boreholes had been advanced at the proposed abutment locations as part of the original investigation at this site in 1989/1990. The elevations of the ground surface at the borehole locations were surveyed relative to Geodetic datum at the time of the investigation. The borehole locations in plan were established by comparing the site plans prepared at the time of original design with the current site survey data received from MMM. As such, the MTM NAD83 northing and easting coordinates summarized in the following table and shown on Drawings 1 and 2 should be considered approximate only.

Borehole Number	Borehole Location	Northing (m)	Easting (m)	Former Ground Surface Elevation (m)
2	South Abutment	5019299.1	339510.7	116.6
3	South Abutment	5019295.1	339526.2	116.8
5	North Abutment	5019353.0	339573.5	117.5
6	North Abutment	5019348.4	339589.8	117.2
8	North Abutment	5019356.8	339577.8	117.2

Notes: 1) Northing and Easting coordinates shown are relative to the MTM NAD83 (Zone 9) coordinate system and are approximate only.
2) Ground surface elevations shown are relative to Geodetic Datum.

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*[1] 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.[2] 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 test pits put down as part of the current investigation and the results of related in situ and laboratory testing are given on the Record of Borehole and Test Pit sheets contained in Appendix A. The relevant borehole logs from the previous investigation, carried out in 1990 (prior to construction of the bridge), are included in Appendix B. The results of geotechnical laboratory testing carried out as part of the current investigation are also included in Appendix C. The results of consolidation test results from the previous 1990 investigation are included in Appendix D.

The interpreted stratigraphic conditions along the centreline of the south and north abutments are shown on Drawings 1 and 2. The stratigraphic boundaries shown on the Record of Borehole and Test Pit sheets and on the interpreted stratigraphic sections included on Drawings 1 and 2 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole and test pit locations.

In general, the subsurface conditions at the site consist of embankment fill overlying surficial silty sand and sandy silt, which is underlain by a thick deposit of sensitive silty clay to clayey silt followed by glacial till. A more detailed description of the subsurface conditions encountered in the boreholes and test pits is provided in the following sections, with a focus on the results from the current investigation, in addition to the consolidation test results from the 1990 investigation.

4.2.1 Embankment Fill

The embankment fill was proven to depths of about 4.0 and 3.2 m (Elevations 118.4 and 117.3 m) at Test Pits 15-101 and 15-103, respectively, and was fully penetrated at all of the current borehole locations to depths of between about 1.5 and 2.3 m (Elevations 115.3 and 116.6 m). Approximately 80 to 150 mm of topsoil fill was encountered at the ground surface at the Boreholes 15-1 to 15-4, inclusive. The underlying embankment fill generally consists of varying amounts of sand, gravel and silt. Organic matter, wood and cobbles were also encountered within the embankment fill at some locations.

[1] 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.

[2] 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.

Between about 1.2 and 2.1 m (i.e., Elevations 115.0 to 115.7 m) of surficial sand fill was encountered at ground surface at all of the previous borehole locations.

Standard Penetration Test (SPT) "N" values measured within the fill range from 5 to 37 blows per 0.3 m of penetration, indicating a loose to dense state of packing.

The results of grain size distribution testing carried out on samples of the embankment fill are provided on Figure C1 in Appendix C. The measured water content of selected samples of the embankment fill ranges from approximately 4 to 22 percent.

4.2.2 Silty Sand

About 1.1 to 2.3 m of silty sand were encountered below the embankment fill at the borehole locations with the exception of previous Boreholes 5, 6 and 8. The silty sand was fully penetrated to elevations of about 113.2 to 115.0 m.

The SPT "N" values measured within this material range from 4 to 38 blows per 0.3 m of penetration indicating a very loose to dense state of packing.

The results of grain size distribution testing carried out on samples of the silty sand are provided on Figure C2 in Appendix C. The results of Atterberg limits testing carried out on three samples of the silty sand indicate that the this material is non-plastic. The measured natural water content of selected samples of the silty sand ranges from about 18 to 22 percent.

4.2.3 Sandy Silt to Silt

An approximately 1.5 to 3.1 m thick layer of sandy silt to silt exists below the embankment fill at previous Boreholes 5, 6 and 8 and below the silty sand at Boreholes 15-1, 15-2 and 15-3. Where encountered, the material was fully penetrated to elevations of about 111.2 to 113.6 m.

The SPT "N" values measured within this material range from 1 to 20 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 samples of the sandy silt are provided on Figure C3 in Appendix C. The results of Atterberg limit testing carried out on samples of the sandy silt indicate plasticity index values between about 2 and 4 percent and liquid limit value between about 18 and 19 percent, as shown on Figure C4, indicating that the tested samples consist of silt of low plasticity. The measured natural water content of selected samples of the sandy silt ranges from about 20 to 29 percent.

4.2.4 Silty Clay to Clayey Silt

The silty sand and/or sandy silt are underlain by a deposit of grey silty clay to clayey silt. The silty clay to clayey silt was fully penetrated in the previous boreholes to elevations between about 96.4 to 103.4 m with thicknesses between 10.4 and 17.1 m. The deposit was proven to depths between about 11.8 and 12.5 m (Elevations 105.2 and 107.0 m) at the current borehole locations, then inferred to depths of between about 16.8 and 20.7 m (Elevations 96.3 and 101.4 m) from the results of the DCPT.

In situ vane testing carried out within the deposit measured undrained shear strengths ranging from 36 to 110 kPa, but more typically in the range of 42 to 60 kPa indicating a firm to stiff consistency.

The results of grain size distribution testing carried out on one sample of the silty clay to clayey silt are provided on Figure C5. The results of Atterberg limit testing carried out on several samples of the silty clay to clayey silt indicate plasticity index value between about 6 and 19 percent and liquid limit value between about 19 and 37 percent, as shown on Figure C6, indicating that the tested samples consist of silty clay to clayey silt of low to intermediate plasticity (but generally low). The measured natural water content of selected samples of the deposit ranges from 31 to 52 percent. These natural water contents are all above the measured liquid limits.

Oedometer consolidation testing was carried out on one relatively undisturbed sample of the grey silty clay to clayey silt deposit from Borehole 15-1, the results of which are provided on Figure C7. Consolidation testing was also carried out on two samples of the silty clay from Borehole 6 from the 1990 investigation the results of which are provided in Appendix D. The results of these consolidation tests are summarized in the table below.

Borehole/Sample Number	Sample Depth/Elevation (m)	Unit Weight (kN/m^3)	σ_P' (kP)	σ_{VO}' (kP)	$\sigma_P' - \sigma_{vo}'$ (kPa)	Cc	Cr	e_o	OCR
15-1 / 11	7.6 – 8.1 / 110.0 – 110.5	18.6	265	90	170	0.51	0.013	0.95	2.9
6 / 8	7.9 / 109.3	-	259	77	182	0.31	0.013	0.98	3.4
6 / 11	12.5 / 104.7	-	383	112	271	1.06	0.040	1.44	3.4

Notes: σ_P' - Apparent preconsolidation pressure; σ_{VO}' - Computed existing vertical effective stress; Cc - Compression index; Cr - Recompression index; e_o - Initial void ratio; OCR - Overconsolidation ratio

4.2.5 Till

Glacial till was encountered/inferred below the silty clay to clayey silt deposit. The till was fully penetrated at previous Boreholes 2 and 8 to about Elevations 97.3 and 93.8 m, respectively, and proven to about Elevations 102.6, 95.7 and 93.5 m at previous Boreholes 3, 5 and 6, respectively. The glacial till was interpreted from the results of the DCPT to elevations of about 96.3, 93.7 and 94.7 m at Boreholes 15-1, 15-3 and 15-4, respectively.

The glacial till is considered to generally consist of a heterogeneous mixture of gravel, cobbles and boulders in a matrix of sand and silt containing a trace to some clay.

The measured SPT “N” values within the till deposit range from 3 to 38 blows per 0.3 m of penetration, indicating a very loose to dense state of packing.

4.2.6 Refusal and Bedrock

Dynamic cone penetration refusal was encountered in Boreholes 15-1, 15-3 and 15-4; this refusal has been inferred to likely represent the bedrock surface. Bedrock was encountered beneath the till at previous Boreholes 2 and 8 where it was cored for depths of about 1.5 and 3.3 m, respectively.

The following table summarizes the bedrock surface depths and elevations encountered at the borehole locations during the current and previous investigations.

Borehole Number	Existing Ground Surface Elevation (m)	Depth to Bedrock (m)	Bedrock Surface Elevation (m)
15-1	118.1	21.8	96.3*
15-3	118.8	25.1	93.7*
15-4	117.0	22.3	94.7*
2	116.6	19.3	97.3
8	117.2	23.4	93.8

Note: * Depth and elevation to bedrock inferred from DCPT refusal.

The bedrock encountered in the cored boreholes of the previous investigation typically consists of fresh grey limestone bedrock. The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples typically ranged from about 54 to 80 percent, indicating fair to good quality rock.

4.2.7 Groundwater Conditions

The groundwater level measured in the standpipe piezometer in Borehole 15-4 is presented in the table below:

Borehole	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)	Date
15-4	117.0	0.5	116.5	December 21, 2015

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

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Susan Trickey, P.Eng., and reviewed by Mr. Mike Cunningham, P.Eng., a Principal and 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.

Susan Trickey, P.Eng.
Geotechnical Engineer

Mike Cunningham, P.Eng.
Principal, Geotechnical Engineer

Fin Heffernan, P.Eng.
Designated MTO Contact

SAT/MIC/FJH/ob

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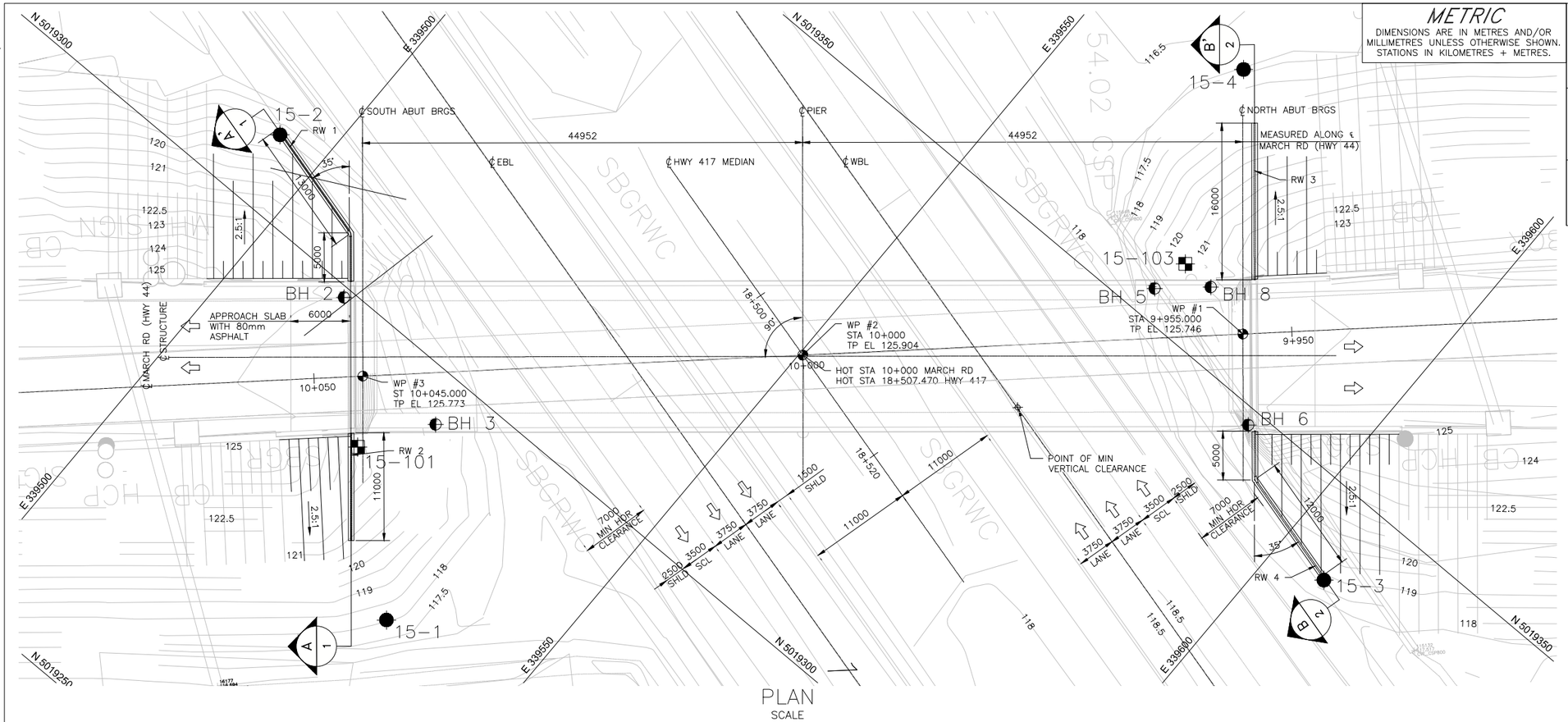
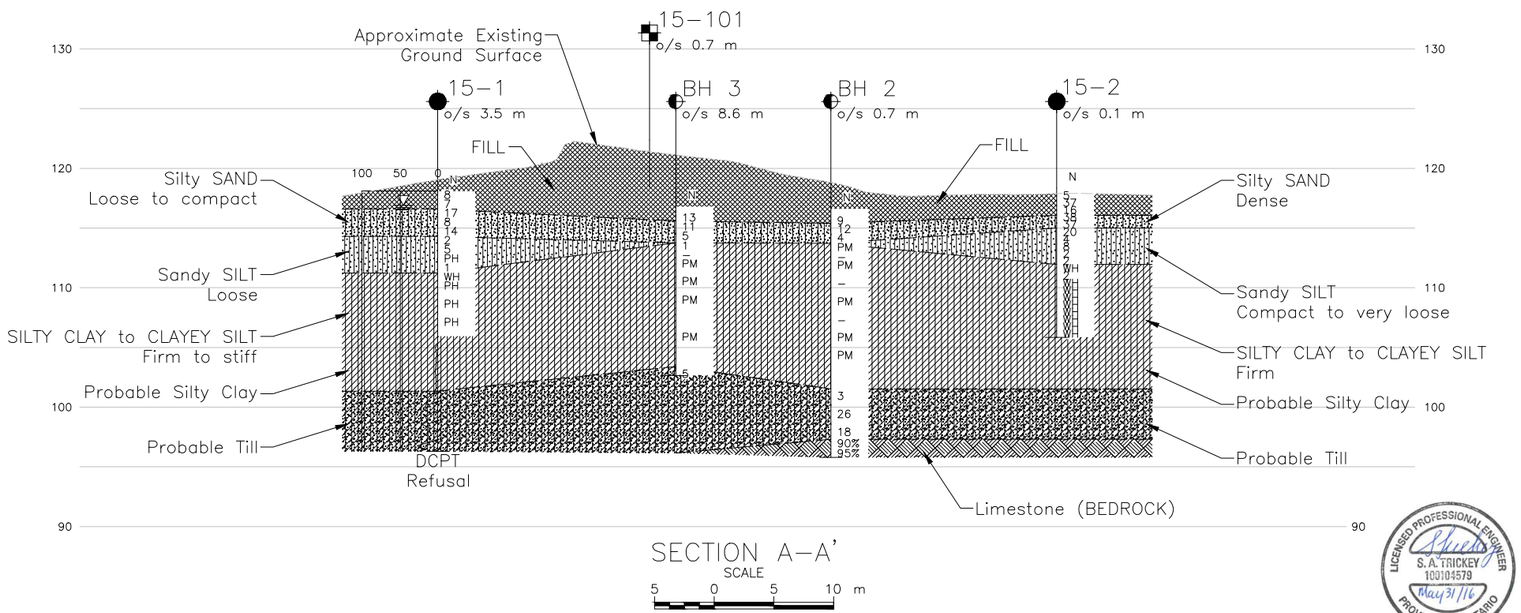
MINISTRY OF TRANSPORTATION, ONTARIO





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

CONT No. 2016-4032
WP No. 4104-13-01

RETAINING WALL REHABILITATION MARCH ROAD UNDERPASS HIGHWAY 417

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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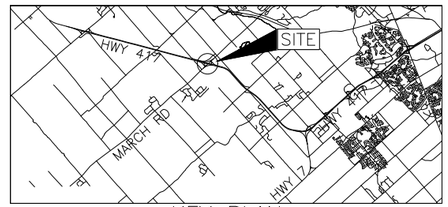

KEY PLAN
SCALE
4 0 4 6 km

LEGEND

- Borehole – Current Investigation
- Test Pit – Current Investigation
- Borehole – Previous Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Total Core Recovery (REC)
- WL in piezometer, measured on Dec. 21, 2015
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
15-1	118.1	5019276.6	339535.1
15-2	118.4	5019307.6	339494.9
15-3	118.8	5019341.3	339605.9
15-4	117.0	5019375.9	339566.1
15-101	122.4	5019288.3	339521.6
15-103	120.5	5019356.9	339574.3
BH 2	116.6	5019299.1	339510.7
BH 3	116.8	5019295.1	339526.2
BH 5	117.5	5019353.0	339573.5
BH 6	117.2	5019348.4	339589.8
BH 8	117.2	5019356.8	339577.8

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

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 is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MMM Group, drawing file no. March Road UP Plan.dwg, received Nov 6, 2015.

LICENSED PROFESSIONAL ENGINEER S. A. TRICKEY 100104579 May 31/16 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER F. J. HEFFERNAN May 31, 2016 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION
.	.	.	.

Geocres No. 31F-192

HWY. 417	PROJECT NO. 1417217		DIST. EASTERN
SUBM'D. SAT	CHKD. SAT	DATE: 03/24/2016	SITE: 3-357
DRAWN: JM	CHKD. MIC	APPD. FJH	DWG. 1

PLOT DATE: June 2, 2016
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METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No. 2016-4032
WP No. 4104-13-01

RETAINING WALL REHABILITATION MARCH ROAD UNDERPASS HIGHWAY 417

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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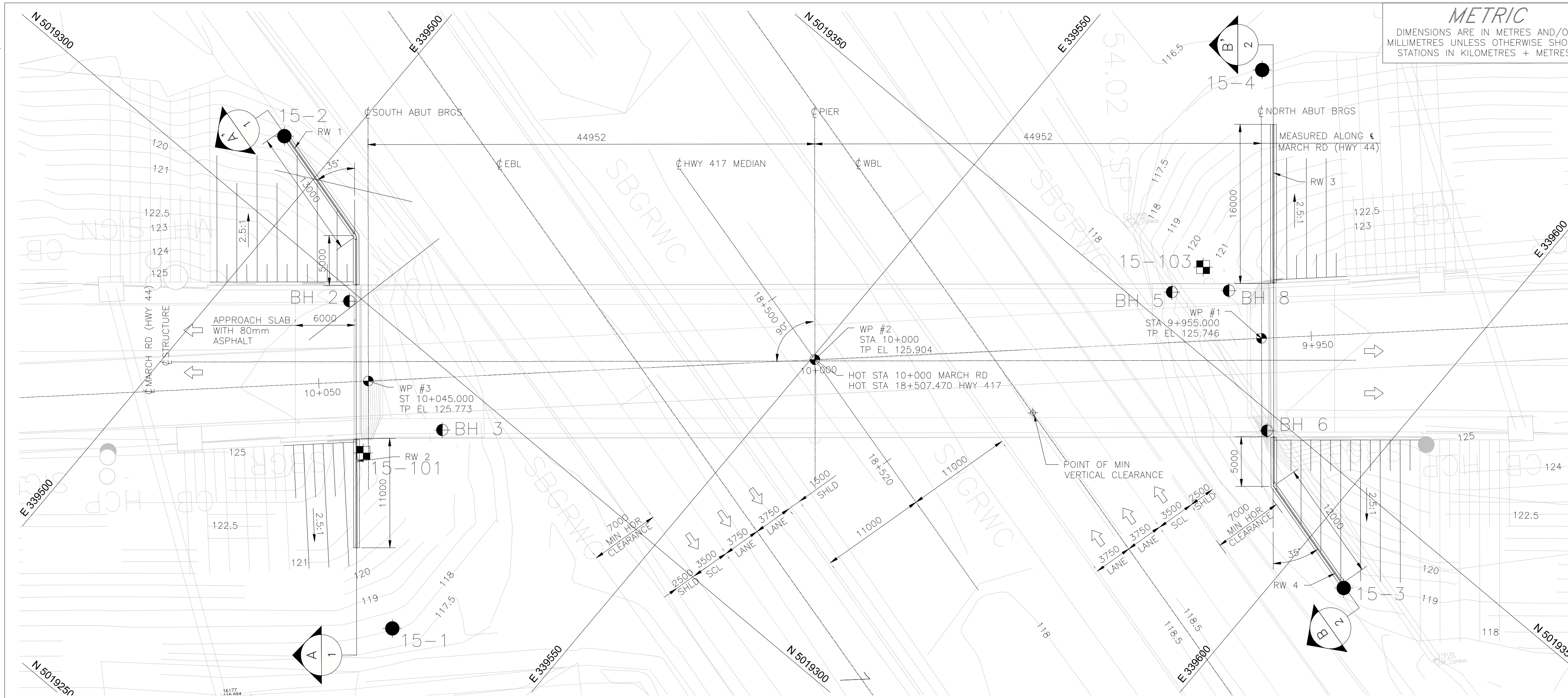

PLAN

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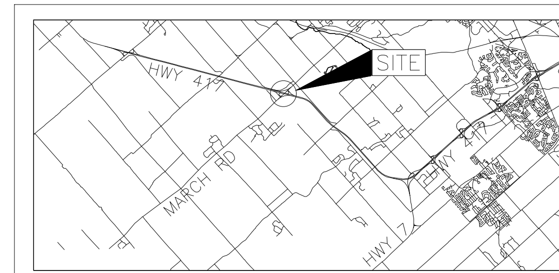

KEY PLAN

SCALE 4 0 4 6 km

LEGEND

●	Borehole – Current Investigation
▣	Test Pit – Current Investigation
◐	Borehole – Previous Investigation
	Seal
	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Total Core Recovery (REC)
	WL in piezometer, measured on Dec. 21, 2015
	WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
15-1	118.1	5019276.6	339535.1
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15-101	122.4	5019288.3	339521.6
15-103	120.5	5019356.9	339574.3
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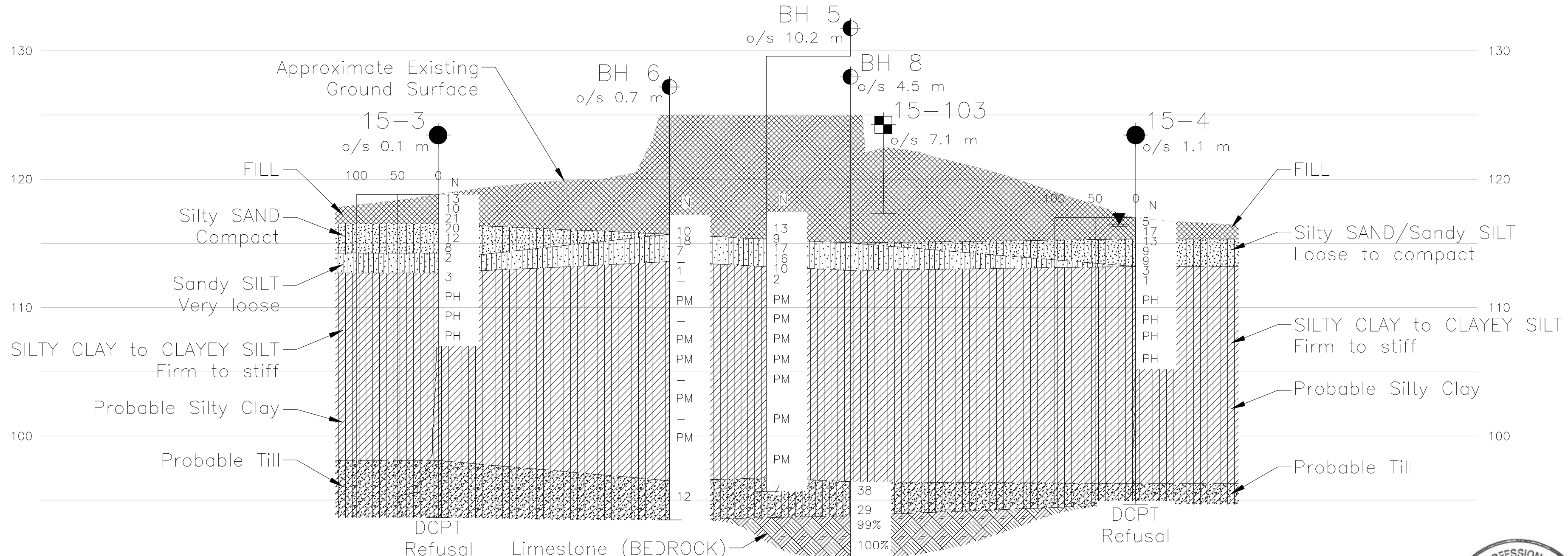
BH 3	116.8	5019295.1	339526.2
BH 5	117.5	5019353.0	339573.5
BH 6	117.2	5019348.4	339589.8
BH 8	117.2	5019356.8	339577.8



SECTION B–B'

SCALE 5 0 5 10 m

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NO.	DATE	BY	REVISION

Geocres No. 31F-192

HWY. 417	PROJECT NO. 1417217		DIST. EASTERN
SUBM'D. SAT	CHKD. SAT	DATE: 03/24/2016	SITE: 3-357
DRAWN: JM	CHKD. MIC	APPD. FJH	DWG. 2

APPENDIX A

List of Abbreviations and Symbols
Borehole Records

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open-ended, driven or pushed tube samplers
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample
DT	Dual tube sample
DD	Diamond drilling

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.).

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive an uncased 50 mm (2 in.) diameter, 60^0 cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60^0 conical tip and a projected end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	**N** Blows/300 mm Or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

C_u or S_u

Consistency	kPa	Psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	Over 200	Over 4,000

IV. SOIL TESTS

w	Water content
w_p or PL	Plastic limited
w_1 or LL	Liquid limit
C	Consolidaiton (oedometer) test
CHEM	Chemical analysis (refer to text)
CID	Consolidated isotropically drained triaxial test[1]
CIU	Consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	Relative density
DS	Direct shear test
Gs	Specific gravity
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	Organic content test
SO_4	Concentration of water-soluble sulphates
UC	Unconfined compression test
UU	Unconsolidated undrained triaxial test
V	Field vane test (LV-laboratory vane test)
γ	Unit weight

Note: [1] 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

π	3.1416
ln x	natural logarithm of x
$\log_{10}$ x or log x	logarithm of x to base 10
g	acceleration due to gravity
t	time
FOS	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma'$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial vertical effective overburden stress
$\sigma_1\sigma_2\sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3) / 3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation

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

(a) Index Properties (continued)

w	water content
w_1 or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity Index = $(w_1 - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_c	consistency index = $(w_1 - w) / I_p$
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_α	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
σ'_p	pre-consolidation stress
OCR	overconsolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p or τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
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] shear strength = (compressive strength) / 2

Golder Associates

RECORD OF BOREHOLE No 15-1

SHEET 1 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019276.6 ;E 339535.1 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 3-4, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.1	GROUND SURFACE										
0.0	Sandy silt (TOPSOIL/FILL)										
0.2	Dark brown Moist Silty sand, trace gravel, clay and organic matter, contains cobbles (FILL)		1	SS	8						
117.3	Loose										
0.8	Grey-brown		2	SS	7	▽			○		
117.0	Moist										
1.1	Wood, organic matter and silty sand (FILL) Loose										
116.6	Dark brown										
1.5	Wet Silty sand, trace organic matter (FILL) Loose Black to grey		3	SS	17						
115.8	Wet										
2.3	Silty SAND Compact Brown Wet Silty SAND, contains non-plastic fines and shells Loose to compact Grey Wet		4	SS	8				○		0 50 41 9
			5	SS	14						
114.3											
3.8	Sandy SILT, contains shells and sand seams Very loose to loose Grey Wet		6	SS	2				‖ ○		
			7	SS	5				○		0 23 69 8
			8	SS	PH						
			9	SS	1				‖ ○		
111.2											
6.9	SILTY CLAY to CLAYEY SILT Firm to stiff Grey Wet		10	SS	WH						
			11	TP	PH				H ○		18.6
								× + × +			
			12	SS	PH				○		

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 15-1

SHEET 2 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019276.6 ;E 339535.1 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 3-4, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY CLAY to CLAYEY SILT Firm to stiff Grey Wet						108				
			13	TP	PH		107				
							106				
105.9 12.2	Probable Silty Clay						105				
							104				
							103				
							102				
101.3 16.8	Probable Till						101				
							100				
							99				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

WATER CONTENT (%): 25 50 75

Continued Next Page

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

Golder Associates

PROJECT 1417217

RECORD OF BOREHOLE No 15-1

SHEET 3 OF 3

METRIC

G.W.P. 4104-13-01 LOCATION N 5019276.6 ;E 339535.1 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 3-4, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Probable Till						98				
							97				
96.3											
21.8	END OF BOREHOLE DCPT REFUSAL										
	NOTES: 1. Water level in open borehole at a depth of 1.2 m below ground surface (Elev. 116.9 m), measured during drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 15-2

SHEET 1 OF 2 **METRIC**

PROJECT 1417217
G.W.P. 4104-13-01
DIST Eastern HWY 417
DATUM Geodetic

LOCATION N 5019307.6 ;E 339494.9
BOREHOLE TYPE Portable
DATE December 1-2, 2015

ORIGINATED BY DWM
COMPILED BY JM
CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.4	GROUND SURFACE										
0.0 / 118.2	Sandy silt to silty sand (TOPSOIL/FILL)										
0.2 / 117.5	Brown Silty sand, trace gravel, clay and organic matter, occasional cobble (FILL) Loose Dark brown to black		1	SS	5		118				
0.9 / 116.9	Moist Silty sand, some gravel (FILL) Dense Grey-brown		2	SS	37		117				
1.5 / 116.1	Moist Sand and gravel, trace silt (FILL) Compact Grey-brown Wet		3	SS	16						
2.3 / 115.1	Silty SAND, some gravel, contains non-plastic fines Dense Grey-brown Wet		4	SS	38		116		○		1 74 18 7
			5	SS	37						
3.4 / 112.0	Sandy SILT Compact to very loose Grey Wet		6	SS	20		115				
			7	SS	4		114				
			8	SS	8				○		0 15 71 14
			9	SS	2		113		H ○		
			10	SS	2		112				
6.4	SILTY CLAY to CLAYEY SILT, contains sandy silt seams Firm Grey Wet		11	SS	WH				H ○		
			12	SS	2		111				
			13	SS	WH						
			14	SS	WH		110				
			15	SS	WH						
			16	SS	WH		109				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 15-2

SHEET 2 OF 2

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019307.6 ;E 339494.9 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Portable COMPILED BY JM

DATUM Geodetic DATE December 1-2, 2015 CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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			SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	WATER CONTENT (%)	γ kN/m^3	GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	25 50 75		
	SILTY CLAY to CLAYEY SILT, contains sandy silt seams Firm Grey Wet		17	SS	WH		108				
			18	SS	WH						
			19	SS	WH		107				
			20	SS	WH						
105.9							106				
12.5	END OF BOREHOLE										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 15-3

SHEET 1 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019341.3 ;E 339605.9 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 4-7, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.8	GROUND SURFACE										
0.0	TOPSOIL/FILL										
0.1	Silty sand, trace gravel and organic matter (FILL) Compact Grey-brown Moist		1	SS	13						
118.0							118				
0.8	Sand, some silt, trace gravel and clay Compact Brown Wet		2	SS	10				○		8 76 12 4
			3	SS	21		117				
116.5											
2.3	Silty SAND, contains non-plastic fines Compact to loose Grey Wet		4	SS	20		116				
			5	SS	12				○		0 52 40 8
			6	SS	8		115		○		0 48 44 8
114.2											
4.6	Sandy SILT Very loose Grey Wet		7	SS	2		114		○		0 17 71 12
112.7							113				
6.1	SILTY CLAY to CLAYEY SILT, contains sand seams Firm to stiff Grey Wet		8	SS	3		112	× + × +			
			9	TP	PH		111				
			10	TP	PH		110	× +			
							109				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 15-3

SHEET 2 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019341.3 ;E 339605.9 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 4-7, 2015 CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY CLAY to CLAYEY SILT, contains sand seams Firm to stiff Grey Wet										
			11	SS	PH		108				
107.0 11.8	Probable Silty Clay						107				
							106				
							105				
							104				
							103				
							102				
							101				
							100				
							99				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 15-3

SHEET 3 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019341.3 ;E 339605.9 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 4-7, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Probable Silty Clay										
98.1											
20.7	Probable Till						98				
							97				
							96				
							95				
							94				
93.7											
25.1	END OF BOREHOLE DCPT REFUSAL										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL_IMMMM_GROUP\MEGA6_VARIOUSSTRUCTURES\02_DATA\GINT\1417217.GPJ GAL-GTA.GDT 05/31/16 JM

Golder Associates

RECORD OF BOREHOLE No 15-4

SHEET 1 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019375.9 ;E 339566.1 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 7-8, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
117.0	GROUND SURFACE										
0.0	TOPSOIL/FILL										
0.2	Silty sand, trace organic matter (FILL) Loose Grey-brown Wet		1	SS	5	▼					
116.2							116				
0.8	Silty sand (FILL) Compact Brown Wet		2	SS	17						
115.3											
1.7	Silty SAND/Sandy SILT, contains non-plastic fines and shells Loose to compact Grey Wet		3	SS	13		115		○		0 55 34 11
			4	SS	9						
			5	SS	9		114		○		0 37 55 8
113.2											
3.8	SILTY CLAY to CLAYEY SILT, contains sand seams and shells Firm to stiff Grey Wet		6	SS	3		113				
			7	SS	1		112	× + × +	H ○		
			8	TP	PH		111				
							110	× + × +			
			9	SS	PH		109		H ○		
								× + × +			
			10	TP	PH		108				
								× +			

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 15-4

SHEET 2 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019375.9 ;E 339566.1 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT COMPILED BY JM

DATUM Geodetic DATE December 7-8, 2015 CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SILTY CLAY to CLAYEY SILT, contains sand seams and shells Firm to stiff Grey Wet										
			11	SS	PH		106				
105.2 11.8	Probable Silty Clay						105				
							104				
							103				
							102				
							101				
							100				
							99				
							98				

Continued Next Page

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

Golder Associates

RECORD OF BOREHOLE No 15-4

SHEET 3 OF 3

METRIC

PROJECT 1417217

G.W.P. 4104-13-01

LOCATION N 5019375.9 ;E 339566.1

ORIGINATED BY DWM

DIST Eastern HWY 417

BOREHOLE TYPE Power Auger 200 mm Diam. (Hollow Stem), DCPT

COMPILED BY JM

DATUM Geodetic

DATE December 7-8, 2015

CHECKED BY SAT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
96.3	Probable Silty Clay										
20.7	Probable Till						96				
							95				
94.7											
22.3	END OF BOREHOLE DCPT REFUSAL										

NOTES:

1. Water level in piezometer at a depth of 0.5 m below ground surface (Elev. 116.5 m), measured Dec. 21, 2015.

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF TEST PIT No 15-101

SHEET 1 OF 1

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019288.3 ;E 339521.6 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Excavator COMPILED BY JM

DATUM Geodetic DATE November 30, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
122.4	GROUND SURFACE										
0.0	Silty sand (TOPSOIL/FILL) Brown										
0.1	Sandy gravel/gravelly sand, some silt, trace clay (FILL) Grey-brown Moist		1	GRAB	-		122		○		50 35 11 4
			2	GRAB	-						
			3	GRAB	-		121		○		27 43 21 9
119.4							120				
3.0	Sandy silt, trace gravel and rootlets (FILL) Dark brown Moist		4	GRAB	-						
119.0							119				
3.4	Silty sand (FILL) Grey-brown Moist		5	GRAB	-						
			6	GRAB	-						
118.4											
4.0	END OF TEST PIT										

NOTES:

1. Test pit dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF TEST PIT No 15-103

SHEET 1 OF 1

METRIC

PROJECT 1417217

G.W.P. 4104-13-01 LOCATION N 5019356.9 ;E 339574.3 ORIGINATED BY DWM

DIST Eastern HWY 417 BOREHOLE TYPE Excavator COMPILED BY JM

DATUM Geodetic DATE November 30, 2015 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
120.5	GROUND SURFACE										
0.0	Sandy silt to silty sand (TOPSOIL/FILL) Brown		1	GRAB	-		120				
0.1	Sandy gravel/gravelly sand, some silt, trace clay (FILL) Grey-brown Moist		2	GRAB	-						
			3	GRAB	-				○		35 40 19 6
			4	GRAB	-		119		○		
							118				
117.6											
2.9	Sand, some silt to silty sand (FILL) Brown		5	GRAB	-						
117.3			6	GRAB	-						
3.2	END OF TEST PIT										

NOTES:

1. Test pit dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

APPENDIX B

Borehole Records, Previous Investigation (1990)

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 34-81-02 LOCATION CH 10 + 045.9 - 8.7 RT (Hwy. 44) ORIGINATED BY R.K.

DIST 9 HWY 44 BOREHOLE TYPE Hollow Stem Auger, Rotary Coring (BQ) @ 15.09 m. COMPILED BY I.C.

DATUM Geodetic DATE December 11, 1989 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_l	UNIT WEIGHT γ	REMARKS & GRAIN SIZ DISTRIBUTIC (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)		GR SA SI C
116.62	Ground Level							SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 25 50 75 100 125	25 50 75		
0.00 / 115.40	Loose, brown sand. Some silt. Fill		1	SS	9		116				
1.22 / 113.72	Compact to loose silty fine sand. Tr clay. Silt and clay. Contents increase with depth.		2	SS	12						0, 40, 53, 7
2.90			3	SS	4		114	+114			
			4	SS	PM*						
	Stiff, grey silty clay with 3 mm thick clayey silt varves at 25-30 mm spacings.		5	ST	-		112	+9 +9 +9 +12			
			6	SS	PM*						
			7	ST	-		110	+9 +16			
			8	SS	PM	Seal		+24 +31			
101.53			9	ST	-		108	+6 +7			
15.09	Loose to compact, grey silty sand. Tr clay, some gravel. Occ boulder. Till		10	SS	PM		106	+20 +13			
			11	SS	PM		104				
			12	SS	3			+9 +10			
			13	SS	26		102				12, 44, 20,
	Fresh, grey, medium grained limestone bedrock with dark grey, closely spaced, dark grey partings (below 10mm) of shale 50mm fractured zone at 20.2 m.		14	SS	18		100				
97.31 / 19.31			15	BQ				Rec % 90 / RQD % 65 / Water Return 100		98	
95.79			16	BQ				Rec % 95 / RQD % 80 / Water Return 100		96	
20.83	End of Borehole										

Notes

Water level in standpipe Piezometer at elevation 115.78 m on 22/12/89.

PM* - Sample taken from disturbed ground.

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 3

METRIC

W P 34-81-02 LOCATION CH 10 + 037.2 - 5.2 LT (Hwy. 44) ORIGINATED BY R.K.

DIST 9 HWY 44 BOREHOLE TYPE Hollow Stem Auger & Penetration Test COMPILED BY I.C.

DATUM Geodetic DATE December 13-14, 1989 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS
116.81	Ground Level					
0.00 / 115.59	Compact, brown sand Fill		1	SS	13	
1.22 / 113.76	Compact to loose sandy Silt. Tr Clay. Silt and clay contents increase with depth.		2	SS	11	
			3	SS	5	
3.05	Stiff grey silty clay with 3 mm thick clayey silt varves at 25-30 mm spacings.		4	SS	1/50cm	▽
			5	ST	-	
			6	SS	PM	
			7	SS	PM	
			8	SS	PM	
			9	SS	PM	
103.40						
13.41 / 102.64	Loose, grey silty sand some gravel, Till.		10	SS	5	
14.17	End of Borehole					
96.16						
20.63	End of penetration test					

Notes

Water level in standpipe at elevation 113.81 m on 24/01/90

ELEVATION SCALE: 116, 114, 112, 110, 108, 106, Seal, 104, 102, 100, 98

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPo
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
25 50 75 100 125

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 25 50 75

UNIT WEIGHT γ

REMARKS & GRAIN SIZ DISTRIBUTIO (%) GR SA SI C

Redrive values after pulling back 0.9 m

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \; 10} \; 5$ (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 5

METRIC

W P 34-81-02 LOCATION CH 9 + 962.8 - 5.0 RT (Hwy. 44) ORIGINATED BY R.K.

DIST 9 HWY 44 BOREHOLE TYPE Hollow Stem Auger COMPILED BY I.C.

DATUM Geodetic DATE December 4, 1989 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (25 50 75 100 125)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (25 50 75)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI C
117.46	Ground Level										
0.00	Compact to loose brown sand. Occ organics. Fill.		1	SS	13						
115.33			2	SS	9		116				
2.13	Compact, grey silt. Tr. sand and clay. Occ. shells		3	SS	17						
			4	SS	16		Seal 114				
113.19			5	SS	10						
4.27	Stiff to firm, grey silty clay with 3 mm thick clayey silt varves at 25-30 mm spacings.		6	SS	2						
			7	SS	PM*		112				
			8	SS	PM		110				
			9	SS	PM		108				
			10	SS	PM		106				
			11	SS	PM		104				
			12	SS	PM		102				
			13	SS	PM		100				
96.74							98				
20.72	Loose, grey silty sand										
95.67	Some gravel. Till		14	SS	7						
21.79	End of Borehole										

Note

Piezometer installed a short distance away from Borehole 5.

Water level in standpipe at elevation 116.06 m on 22/12/89.

PM* - Sample taken from disturbed ground.

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 6

METRIC

W P 34-81-02 LOCATION CH 9 + 954.1 - 9.0 LT (Hwy. 44) ORIGINATED BY R.K.

DIST 9 HWY 44 BOREHOLE TYPE Hollow Stem Auger COMPILED BY I.C.

DATUM Geodetic DATE December 5, 6, 1989 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 25 50 75 100 125	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 25 50 75	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZ DISTRIBUTIC (%) GR SA SI C
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
117.23	Ground Level										
0.00 / 115.71	Loose, brown sand. Tr Silt Fill		1	SS	10		116				
1.52 / 113.57	Compact to loose, grey sandy silt. Tr. clay. Occ. shells		2	SS	18						
			3	SS	7						
			4	ST	–		114			21.1	0, 54, 45,
3.66	Stiff, grey silty clay with 3 mm thick clayey silt varves at 25-30mm spacings.		5	SS	1/50 cm						
			6	SS			112				
			7	SS	PM						
			8	ST	–		110			18.4	
			9	SS	PM		108				
			10	SS	PM		106				
			11	ST	–					16.8	0, 2, 52, 4
			12	SS	PM		104				
			13	ST	–		102				
			14	SS	PM		100				
96.51							98				
20.72	Compact, grey silty sand and gravel. Tr clay. Occ boulder.		15	SS	12		96				
93.46	Till.						94				
23.77	End of Borehole Auger refusal										

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 8

METRIC

W P 34-81-02 LOCATION CH 9 + 957 - 5.0 Rt (Hwy 44) ORIGINATED BY MK
DIST 9 HWY 44 BOREHOLE TYPE Hollow Stem Auger, Rotary Coring (BQ) @ 23.37 m COMPILED BY IC
DATUM Geodetic DATE January 22, 23 and 24, 1990 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SI DISTRIBUTI (%) GR SA SI
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
117.16 / 0.00	Ground Level										
	Overburden not sampled to 21.33 m. For stratigraphy see Borehole 5.						116				
							114				
							112				
							110				
							108				
							106				
							104				
							102				
							100				
							98				
95.83							96				
21.33	Compact to dense, grey silty sand. Some gravel, occ. boulders. Till		1	SS	38						
93.79			2	SS	29						94
23.37	Fresh, sound dark grey limestone bedrock with very closely spaced thin (<1 mm) shale partings. Core splits readily on shale partings. Parted surfaces generally very irregular		3	BQ				Recovery % 99; RQD % 54; Water Return % 100			
			4	BQ				Recovery % 100; RQD % 59; Water Return % 100			92
90.49											
26.67	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

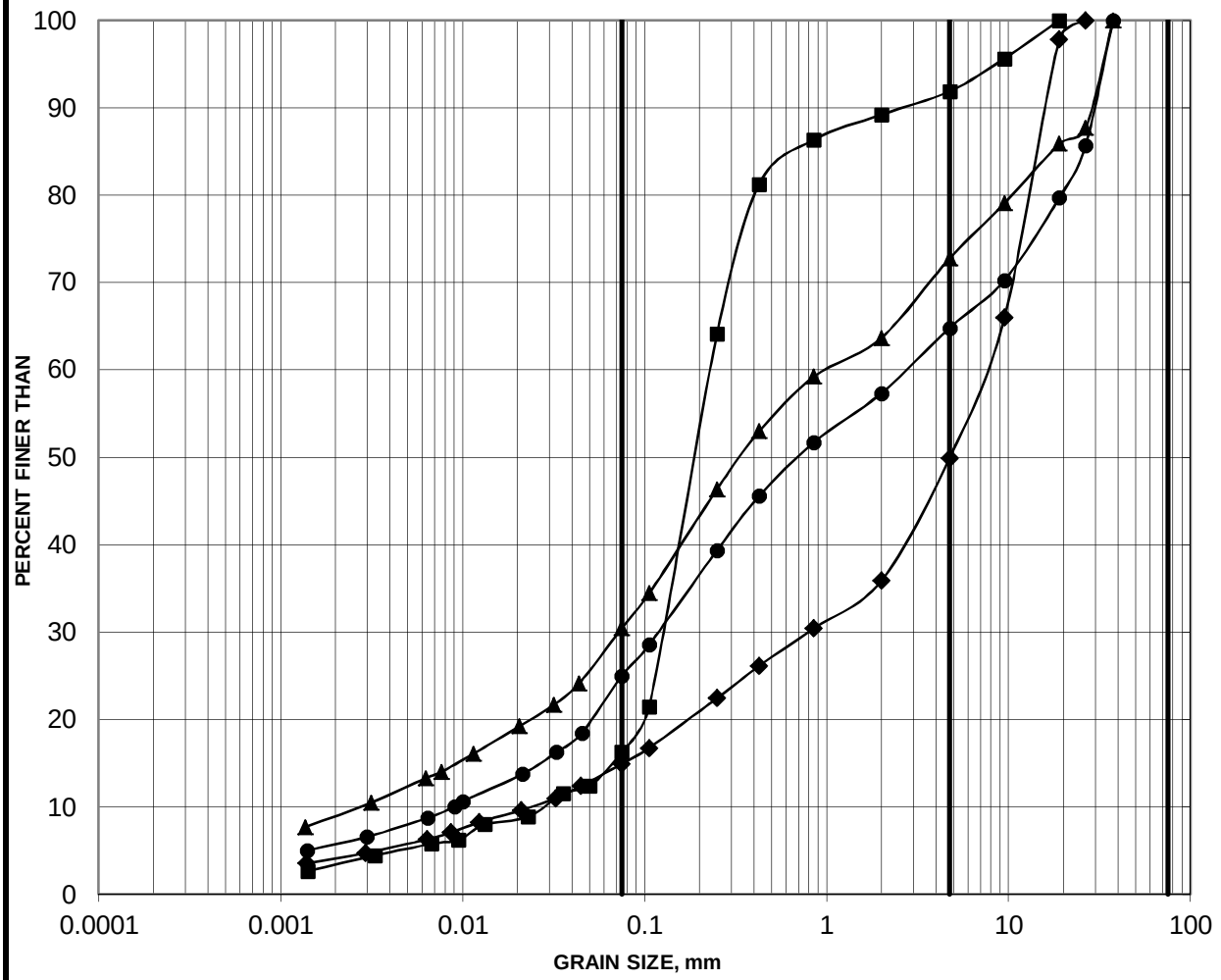
20 / 15 / 10 (%) STRAIN AT FAILURE

APPENDIX C

Laboratory Test Results, Current Investigation

GRAIN SIZE DISTRIBUTION	FIGURE C1

Embankment Fill



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

Borehole	Sample	Depth (m)
15-3	2	0.76-1.37
15-101	1	0.13-0.90
15-101	3	1.20-1.60
15-103	4	1.40-1.70

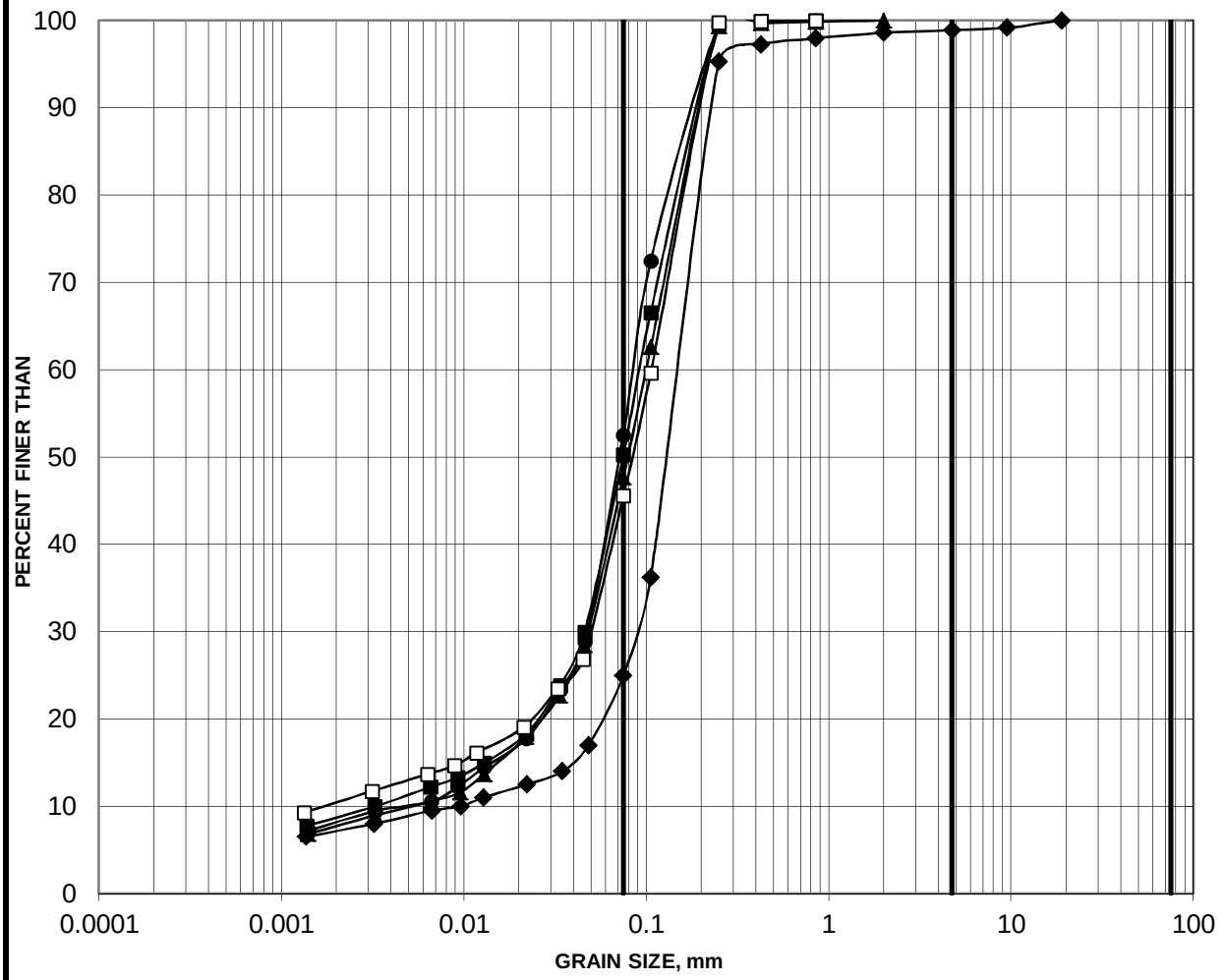
Project: 1417217-1100

Golder Associates

Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION	FIGURE C2

Silty SAND



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

Borehole	Sample	Depth (m)
15-1	4	2.28-2.89
15-2	4	2.13-2.74
15-3	5	3.05-3.66
15-3	6	3.81-4.42
15-4	3	1.52-2.13

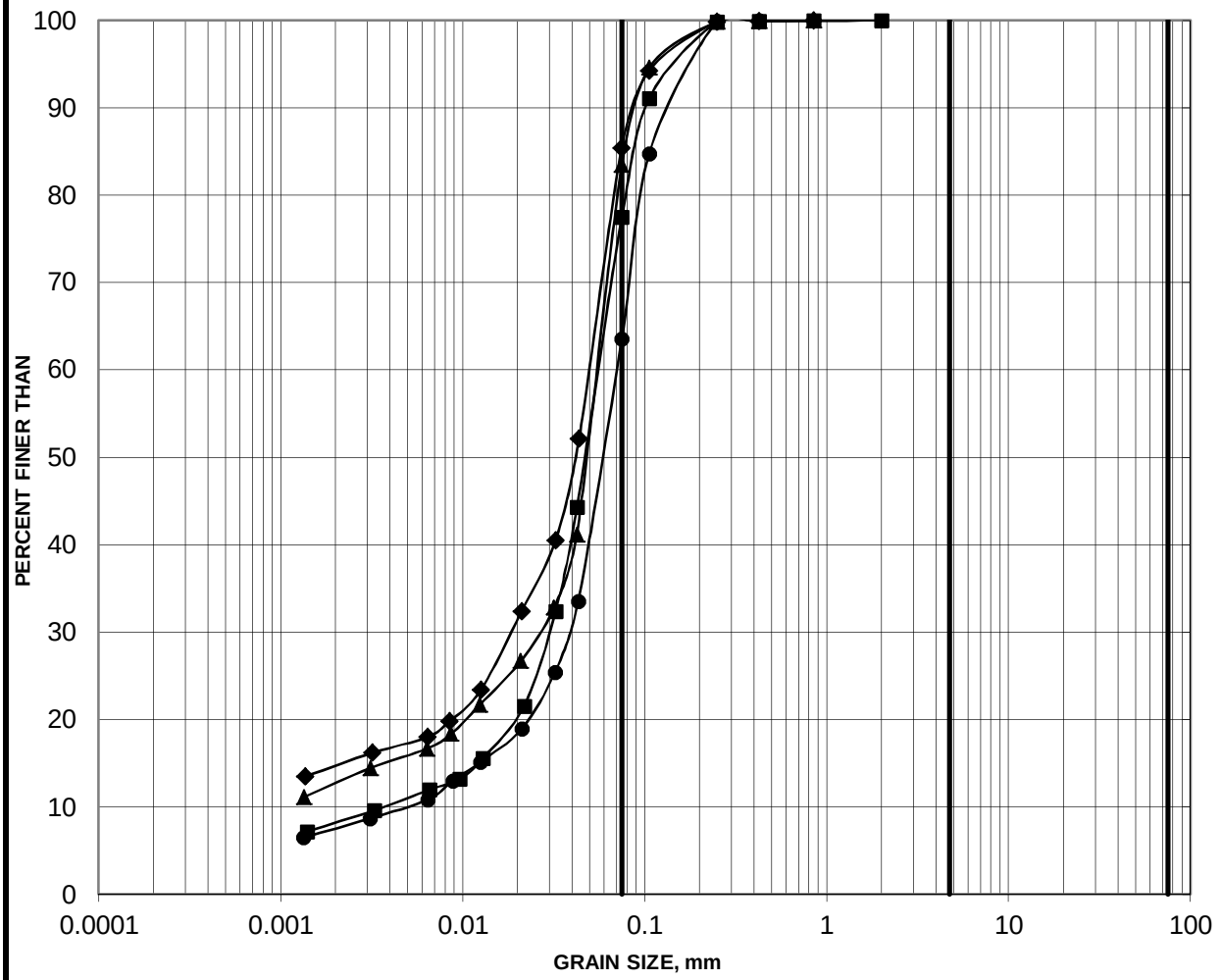
Project: 1417217-1100

Golder Associates

Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION	FIGURE C3

Sandy SILT



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

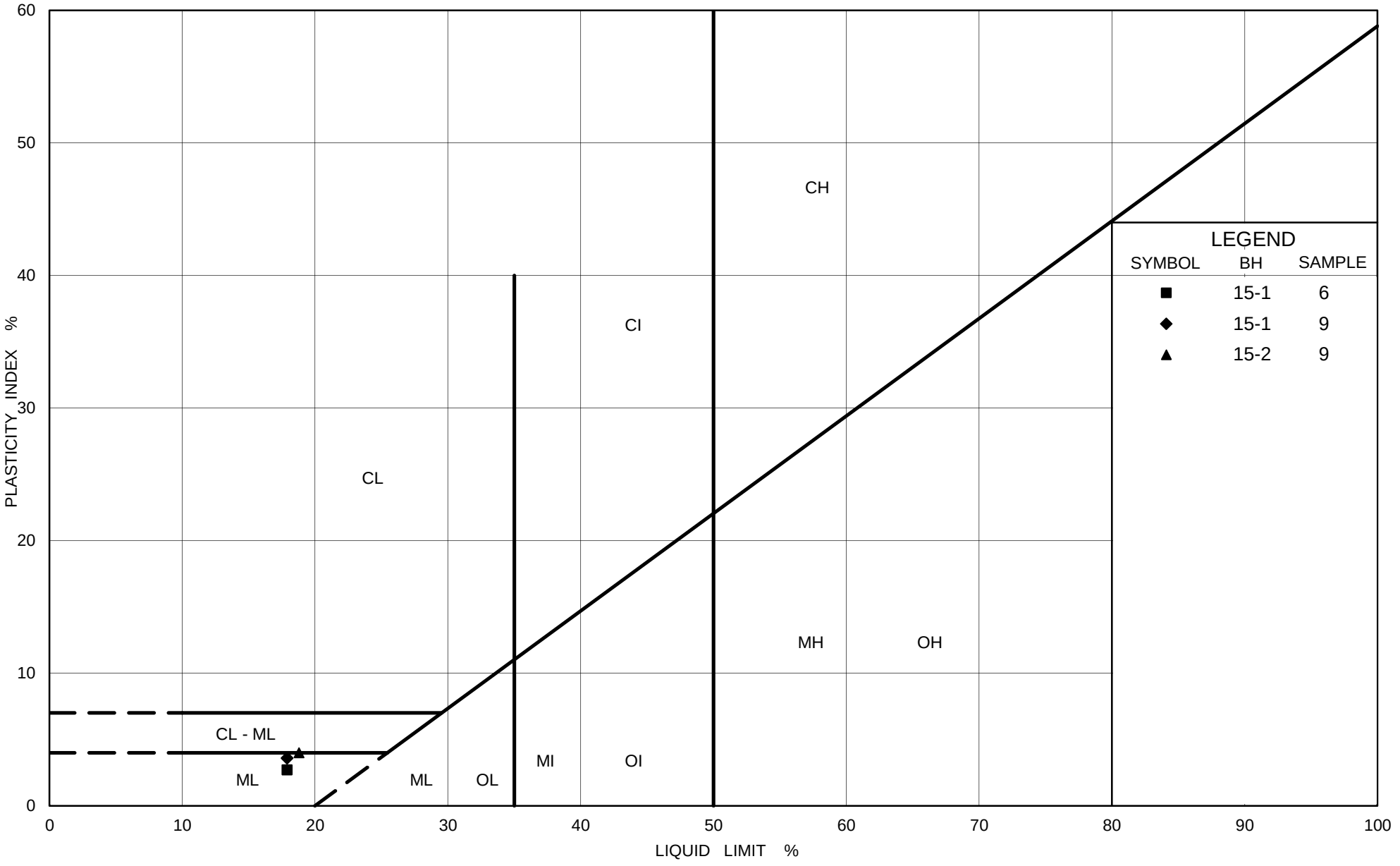
Borehole	Sample	Depth (m)
15-1	7	4.57-5.18
15-2	8	4.57-5.18
15-3	7	4.57-5.18
15-4	5	3.05-3.66

Project: 1417217-1100

Golder Associates

Created by: MI
Checked by: CNM

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Sandy SILT

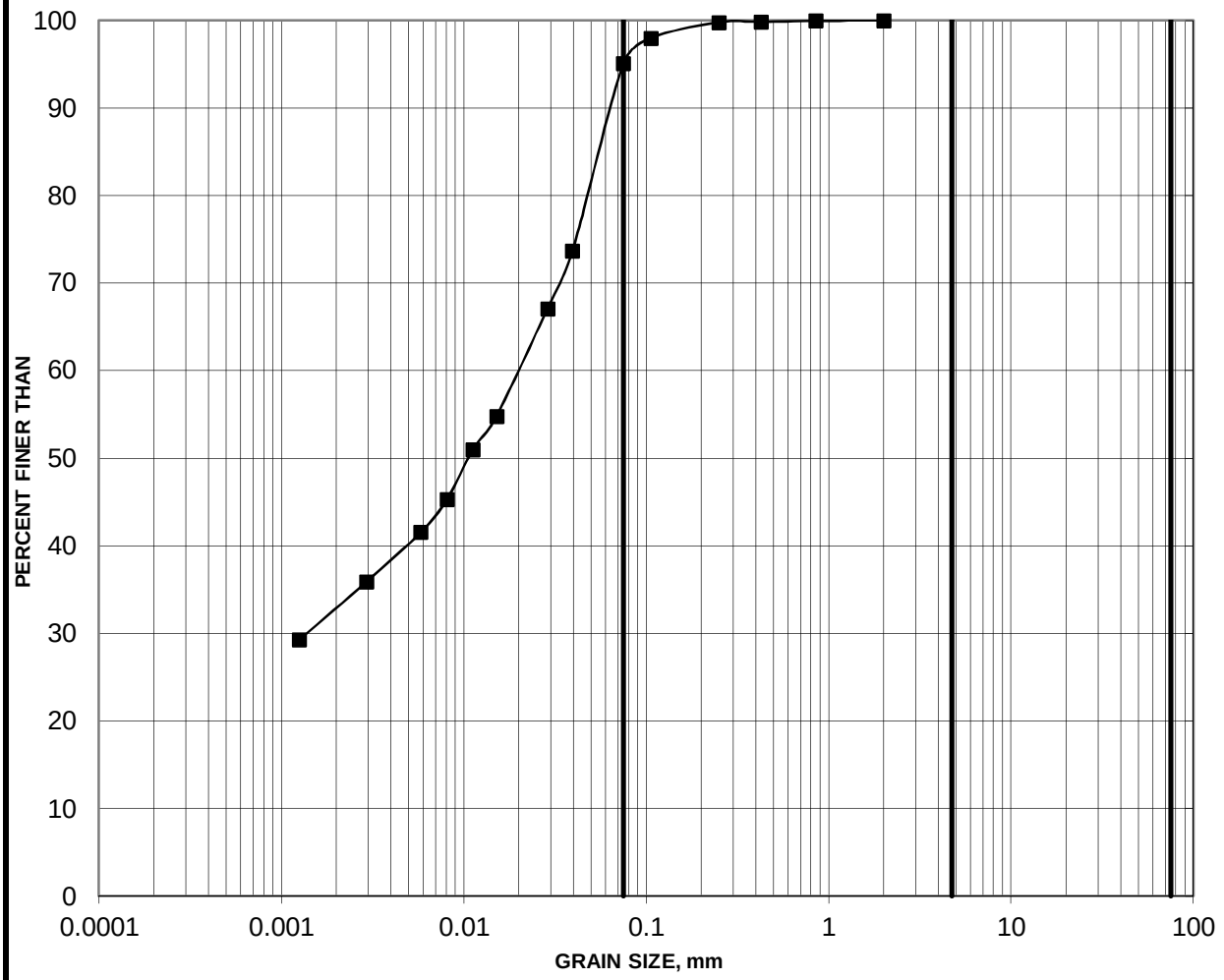
FIG No. C4

Project No. 1417217

Compiled By : MI Checked By : CNM

GRAIN SIZE DISTRIBUTION	FIGURE C5

SILTY CLAY TO CLAYEY SILT



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

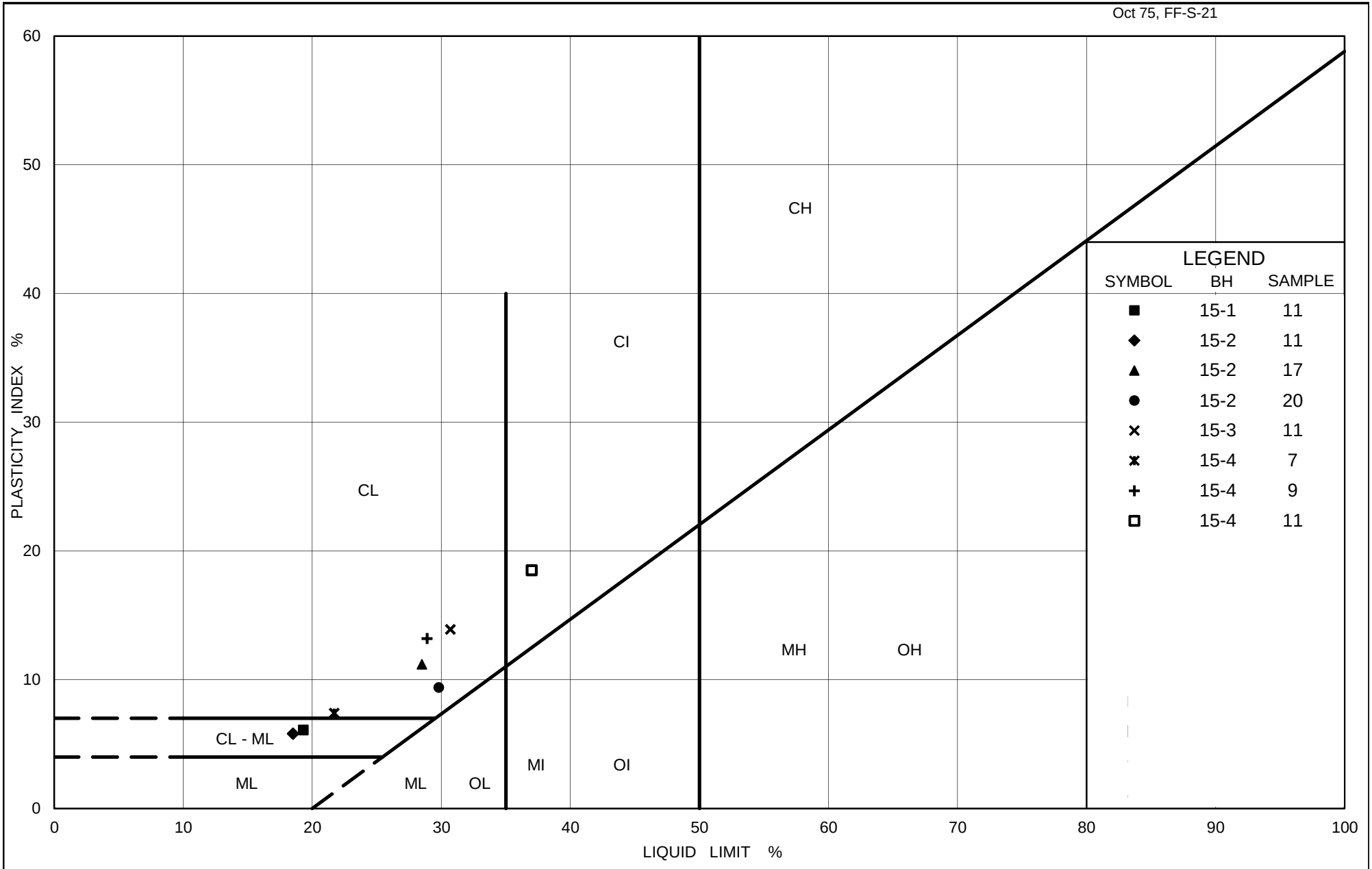
Borehole	Sample	Depth (m)
15-2	14	8.23-8.84

Project: 1417217-1100

Golder Associates

Created by: MI
Checked by: CNM

Oct 75, FF-S-21



Ministry of Transportation

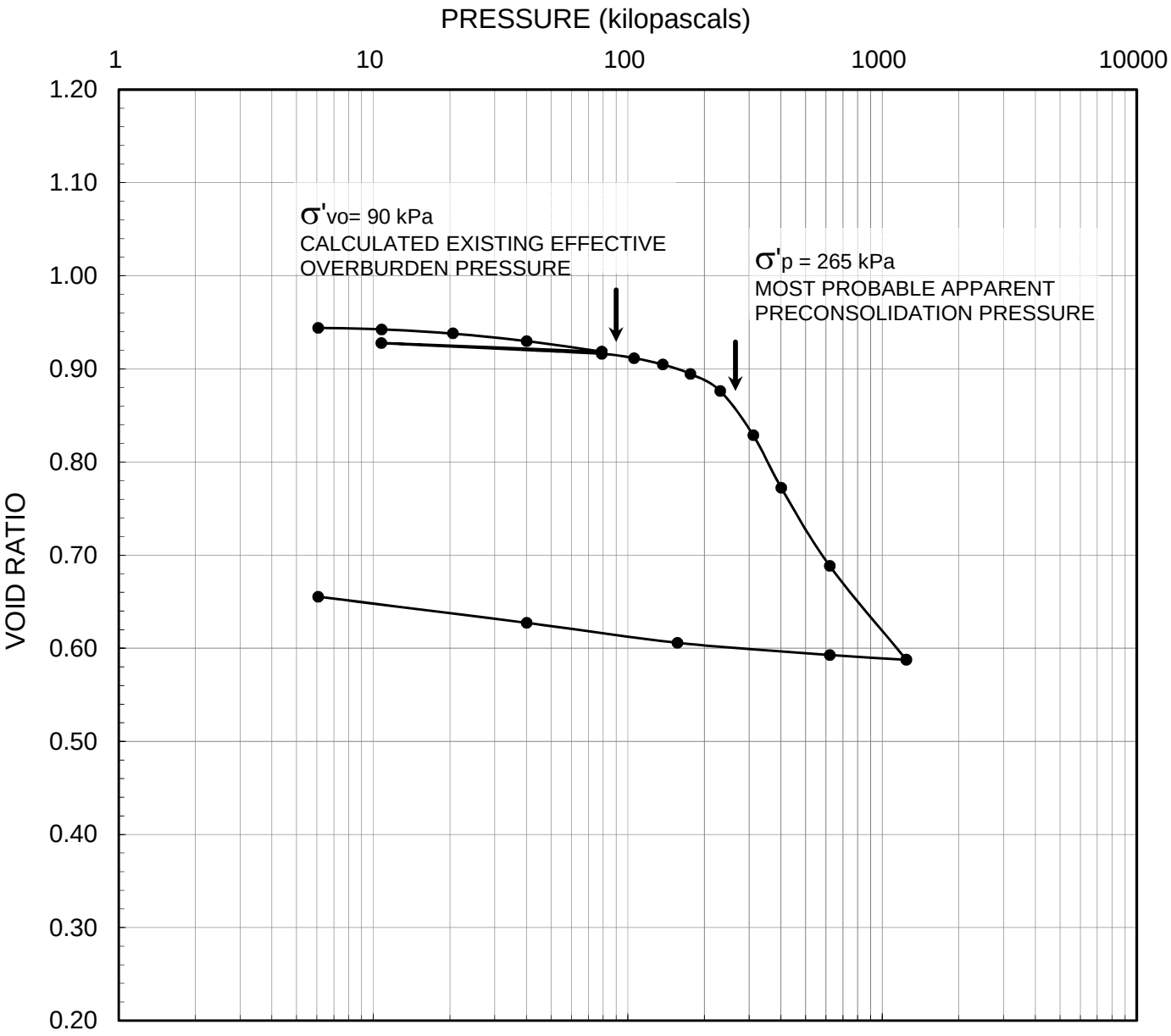
Ontario

PLASTICITY CHART
SILTY CLAY TO CLAYEY SILT

FIG No. C6

Project No. 1417217

Compiled By : MI Checked By : CNM



LEGEND

Borehole:	15-1	w_i = 34%	S_o = 98%	γ = 18.6 kN/m³
Sample:	11	w_f = 24%	e_o = 0.95	G_s = 2.77
Depth (m):	7.6-8.1	w_l = 19%	C_c = 0.51	
Elevation (m):	110.5-110.0	w_p = 13%	C_r = 0.013	

Golder Associates

SCALE	AS SHOWN
DATE	03/23/16
CADD	LH
ENTERED	MI
CHECK	CNM
REVIEW	SAT

TITLE

CONSOLIDATION TEST RESULTS

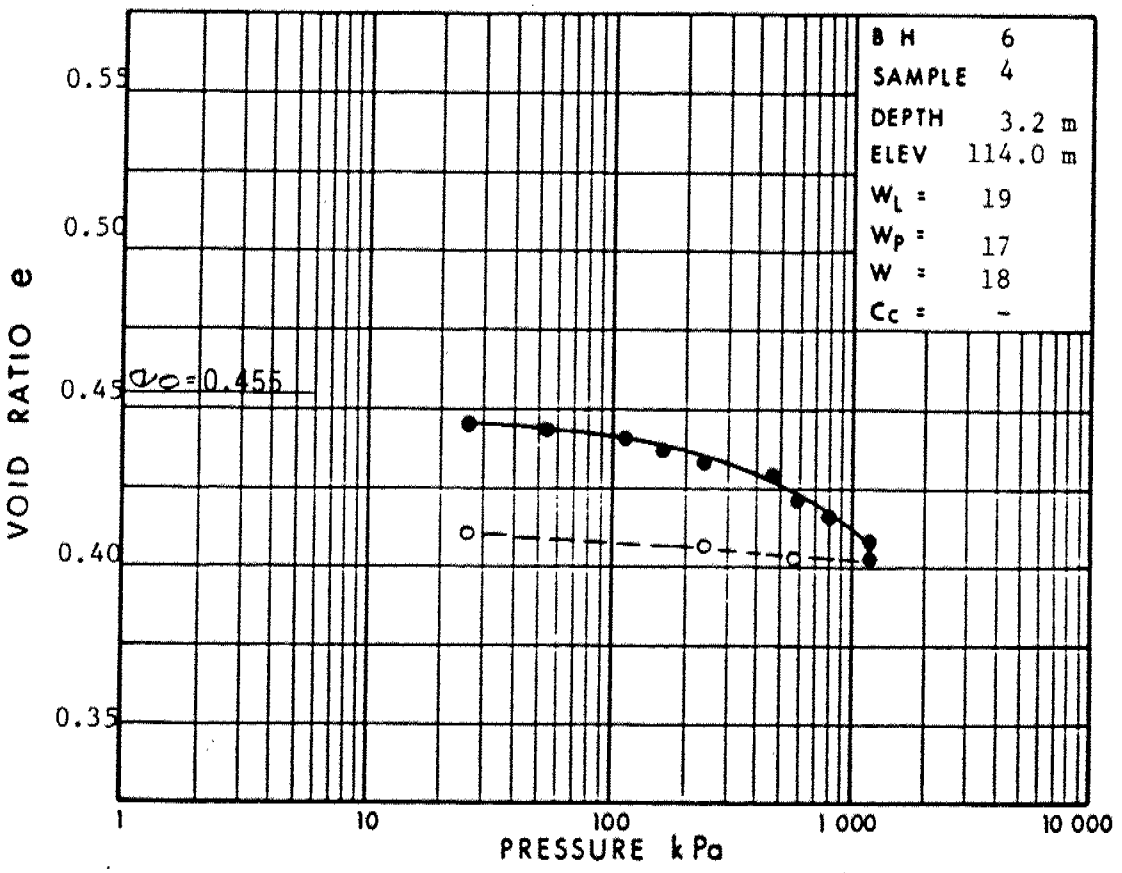
FILE No.	Consolidation summary		
PROJECT No.	1417217 /1100	REV.	3

FIGURE **C7**

APPENDIX D

Consolidation Test Results, Previous Investigation (1990)

VOID RATIO - PRESSURE CURVES



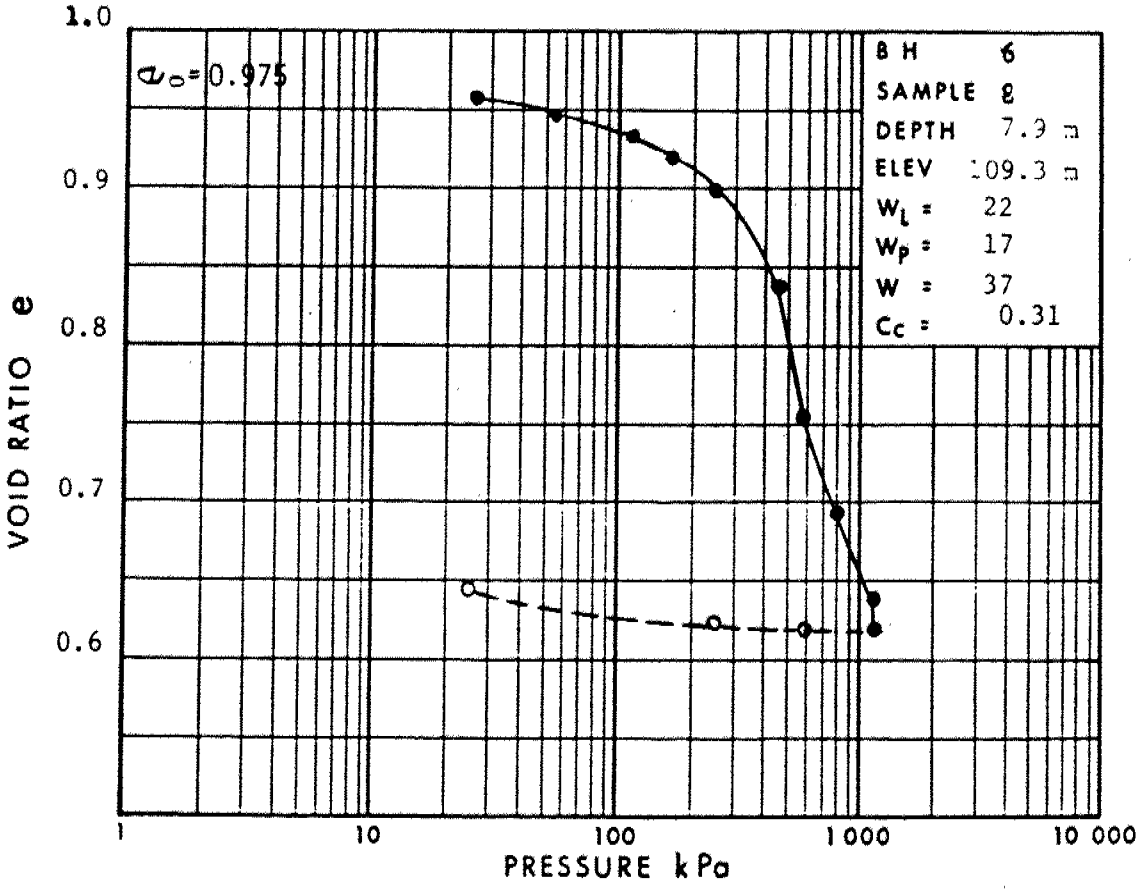
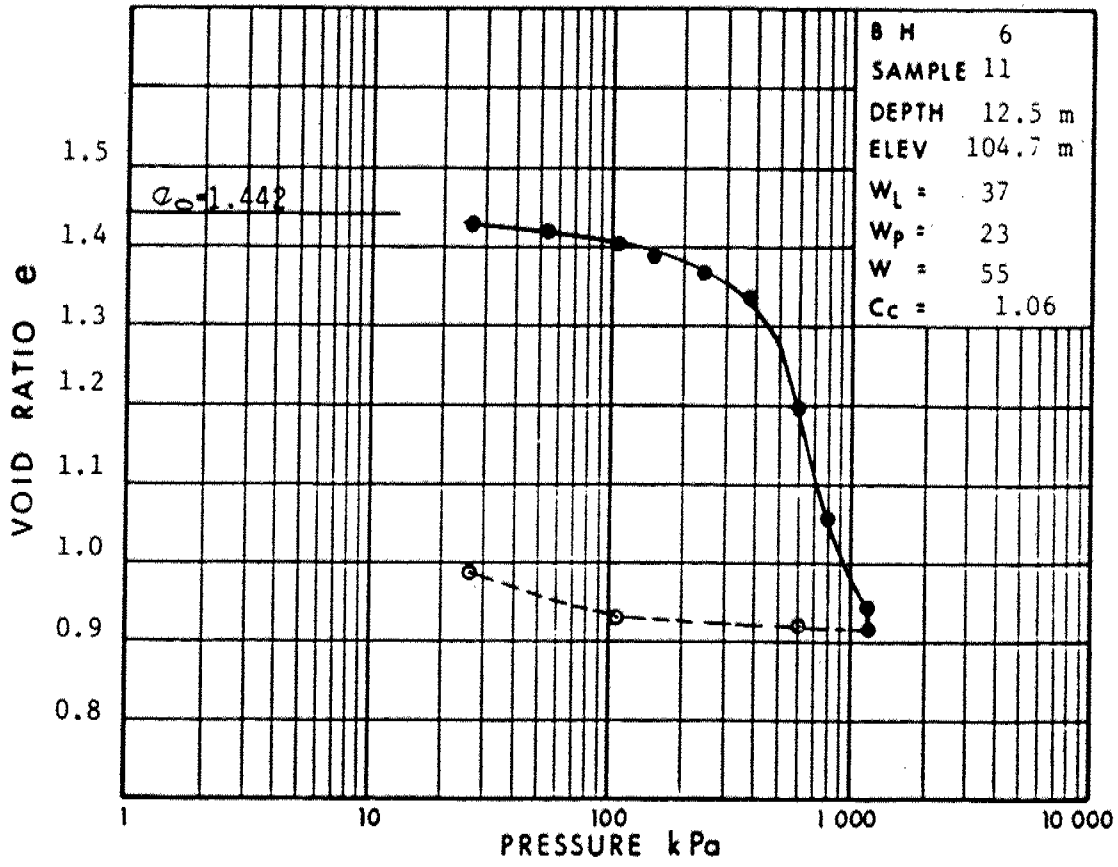


Fig No 4 WP 34-81-02

VOID RATIO - PRESSURE CURVES



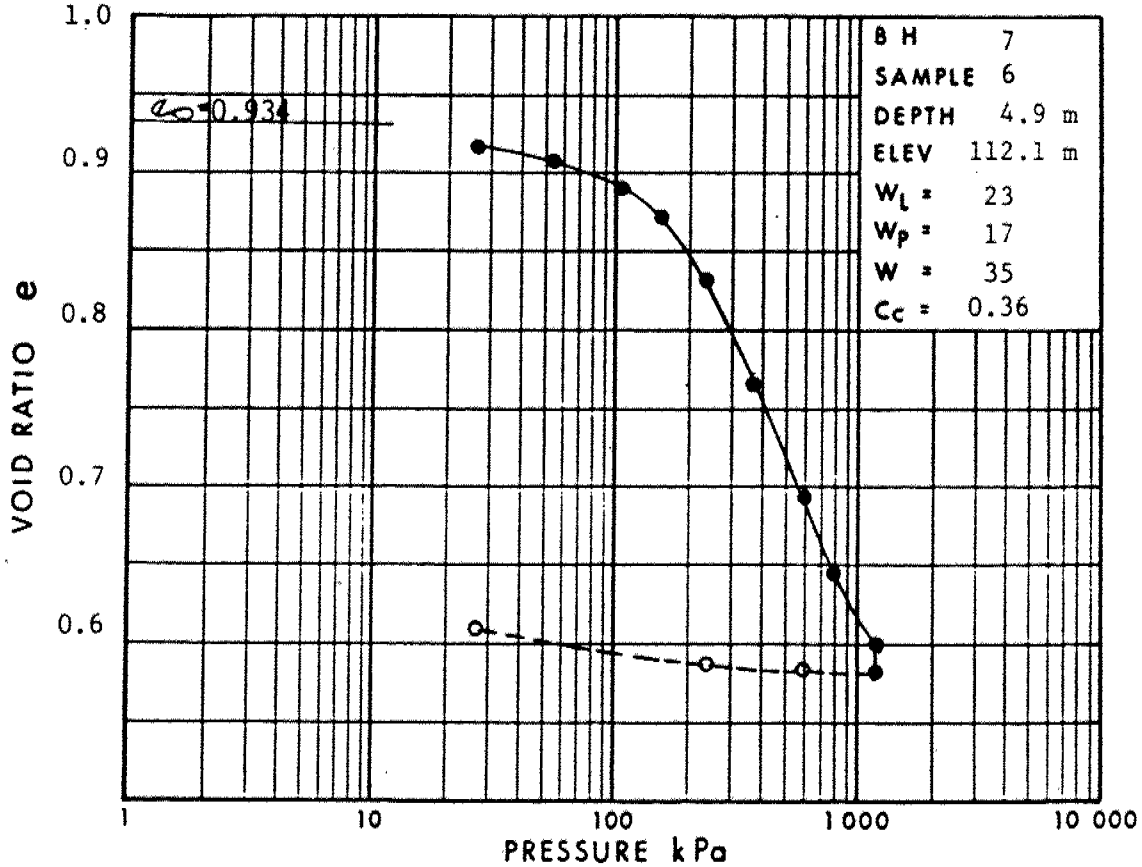


Fig No 5 WP 34-81-02

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario, K2H 5B7
Canada
T: +1 (613) 592 9600

Golder Associates