



October 20, 2016

PRELIMINARY FOUNDATION INVESTIGATION REPORT

**ANNE STREET UNDERPASS, SITE NO. 30-347
HIGHWAY 400 WIDENING
FROM 1 KM SOUTH OF HIGHWAY 89 TO JUNCTION OF HIGHWAY 11
MINISTRY OF TRANSPORTATION, ONTARIO
W.O. 06-20016**

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GEOCRES NO: 31D-666

Report Number: 14-1111-0002-8

Distribution:

- 2 Copies – Ministry of Transportation, Ontario – Central Region
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REPORT





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PART A

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
ANNE STREET UNDERPASS – SITE NO. 30-347
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. (now AECOM) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the preliminary design for the replacement of the Anne Street Underpass in the City of Barrie. The proposed work is part of the preliminary and design-build ready design associated with the Highway 400 widening from 1 km south of Highway 89 to the junction of Highway 11 in Simcoe County, Ontario.

This report addresses the proposed replacement of the Anne Street Underpass (MTO Structure Site No. 30-347) and the associated approach embankments only.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated July 2013. Golder's scope of work for foundation engineering services associated with the Anne Street Underpass replacement is contained in Section 5.8 of AECOM's (previously URS Canada) Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for foundation engineering services for this project, dated January 20, 2014.

2.0 SITE DESCRIPTION

The Highway 400/Anne Street Underpass is located in the city of Barrie, Ontario and the existing bridge structure is a two-span concrete rigid frame supported on driven H-piles. The total length of the bridge is approximately 36 m measured along the centerline of Anne Street between abutments, and the total deck width is 17 m measured between fasciae.

The overall surface topography in the vicinity of the site is relatively flat and consists of both residential and commercial areas to the east and west of Highway 400. Anne Street has been constructed in fill with approach embankments up to about 7 m high at an existing grade between about Elevations 240.7 m and 242.5 m adjacent to the east and west abutments, respectively. The Highway 400 grade at Anne Street is at about Elevation 236 m, rising toward the north.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Borehole Investigation

A subsurface investigation was carried out at this site for the Department of Highways, Ontario (DHO) in June and July, 1957, by Universal Geotechnique Limited (GEOCREC No. 31D-182). At that time, a total of six boreholes were advanced in the vicinity of the abutments and pier for the then-proposed structure. Boreholes 1 and 2 were located in the vicinity of the east abutment, Boreholes 3 and 4 were drilled near the west abutment, and Boreholes 5 and 6 were advanced at the approximate location of the central pier. The boreholes were advanced to depths ranging between about 7.6 m and 18.7 m. All of the boreholes were advanced from approximately the Highway 400 grade and the locations are shown on Drawing 1.

Samples of the overburden were obtained at 0.75 m to 1.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. The groundwater conditions in the open borehole were observed during and following the drilling operations. There are no laboratory test results provided with the 1957 investigation report.



PRELIMINARY FOUNDATION REPORT - HIGHWAY 400 ANNE STREET UNDERPASS

The borehole locations in MTM NAD83 northing and easting coordinates have been estimated from the plotted locations on the Digital Terrain Model base plan, and, together with the ground surface elevations referenced to Geodetic datum and drilled depths are summarized below.

Borehole Number	Location (MTM NAD83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
1	4,916,194.1	288,232.1	235.3	7.6
2	4,916,212.5	288,238.4	235.5	18.7
3	4,916,225.7	288,212.6	235.8	15.2
4	4,916,241.8	288,219.9	236.0	7.8
5	4,916,209.2	288,222.6	235.1	7.6
6	4,916,226.7	288,229.7	235.5	7.8

3.2 Current Borehole Investigation

The field work at the site of the Anne Street Underpass was carried out on March 29 and April 20 and 21, 2016 during which time two boreholes were advanced to supplement the existing subsurface information. The Record of Borehole sheets are presented in Appendix A. The locations of these boreholes are shown in plan on Drawing 1 and in profile / cross section on Drawings 1 and 2.

The borehole investigation was carried out using a Diedrich D-90 truck-mounted drill rig supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The boreholes were advanced through the overburden using 210 mm outside diameter hollow stem augers. Soil samples were generally obtained at intervals of depth about 0.75 m and 1.5 m, using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure. The groundwater conditions and water level in the open boreholes were observed during and immediately following the completion of drilling operations. The boreholes were backfilled upon completion of drilling in accordance with Ontario Regulation 903 (as amended), and the pavement was reinstated using dry mix concrete and cold patch asphalt.

The field work was observed by members of Golder's engineering staff who located the boreholes, arranged for the clearance of underground services, observed 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 Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, grain size distribution and Atterberg limits) was carried out on selected soil samples. The results of the laboratory testing are included in Appendix B.

The as-drilled borehole locations were measured relative to the existing on-site features shown on the Digital Terrain Model (DTM) for the site, and the ground surface elevations were interpolated from the topographic data provided by AECOM. The borehole locations provided on the borehole records and shown in plan on Drawing 1 and in profile / cross section on Drawing 2 are given using MTM NAD83 northing and easting coordinates, and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.



PRELIMINARY FOUNDATION REPORT - HIGHWAY 400 ANNE STREET UNDERPASS

Borehole Number	Location (MTM NAD83)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (m)	Easting (m)		
AS1-1	4,916,217.8	288,209.9	236.0	18.8
AS1-2	4,916,185.3	288,241.7	240.5	18.1

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*¹, this section of Highway 400 from 6 km south of Highway 89 to the junction of Highway 11 traverses, generally in a south–north direction, the following physiographic regions: the Peterborough Drumlin Field; the Simcoe Lowlands; and the Simcoe Uplands. Along Highway 400, the Peterborough Drumlin Field is present from the southern limit of the project site to south of Line 13 of the Township of Bradford West Gwillimbury, as well as between about 1 km north of Highway 89 to about Essa Road. The Simcoe Lowlands covers the area from south of Line 13 to approximately 1 km north of Highway 89 and from about Essa Road to just north of Anne Street. The Simcoe Uplands extends from just north of Anne Street to beyond the northern limit of this project site.

The surficial soils in the Peterborough Drumlin Field, consist primarily of gravelly sand till or sand and gravel deposits. Deposits of silt, clay or peat may also be found in the low-lying areas between drumlins and eskers.

Along Highway 400, the Simcoe Lowlands include: the Holland River valley; the lowlands of the Lake Simcoe basin to the east; the lowlands of the Nottawasaga basin to the west, which includes Innisfil Creek and the Nottawasaga River to the south and west of the project limits, respectively. The Lake Simcoe and Nottawasaga basins are connected by a flat floored valley through Barrie which extends from the shores of Kempenfelt Bay west generally along Highway 90. The Simcoe Lowlands are generally characterized by deep deposits of deltaic or lacustrine silts, sands and clays associated with glacial Lake Algonquin.

The Simcoe Uplands consist of till plains and ancient shorelines. The till deposits range from clayey to silty and generally become more sandy and containing more boulders in the north. The low-lying areas of this region may also contain shallow deposits of sand and gravel associated with former glacial lake shorelines.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation, together with the results of in situ and laboratory testing, are presented on the Record of Borehole sheets and laboratory test summary figures provided in Appendices A and B, respectively. The Record of Borehole sheets from the previous investigation are presented in Appendix C. The interpreted stratigraphic profile and cross-sections are shown on Drawings 1 and 2.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile and cross-sections are inferred from observations of drilling progress and non-continuous sampling and, therefore,

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



PRELIMINARY FOUNDATION REPORT - HIGHWAY 400 ANNE STREET UNDERPASS

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 site consist of a layer of asphalt (at boreholes drilled from the road platform) and non-cohesive fill material associated with the existing Highway 400 approach embankments, underlain by a deposit of sand, in places interlayered by silt, silty clay and sand and gravel layers / pockets.

A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt

An approximately 200 mm thick layer of asphalt was encountered at ground surface in Boreholes AS1-2.

4.2.2 Gravelly Sand to Sand and Gravel Fill

A 1.9 m and 3.9 m thick deposit of fill comprised of gravelly sand, trace to some clay containing wood fragment, to sand and gravel was encountered at ground surface at about Elevation 236.0 in Borehole AS1-1 and below the asphalt in Borehole AS1-2 at about Elevation 240.3 m.

The measured Standard Penetration Test (SPT) 'N'-values measured within the fill deposit range from 4 blows to 31 blows per 0.3 m of penetration, indicating a loose to dense relative density.

The natural water content measured on two samples of the fill measured about 3 per cent and 8 per cent.

The grain size distributions of a sample of the gravelly sand portion of the fill material is shown on Figure B1 in Appendix B.

4.2.3 Silty Sand to Sand Fill

A 4.2 m thick deposit of fill comprised of silty sand, trace to some gravel, trace clay, to sand, some silt, trace gravel and containing organic silt layers was encountered below the sand and gravel fill in Borehole AS1-2 at about Elevation 236.4 m. The 1957 boreholes encountered between 2 m and 2.5 m of fill at ground surface comprised of sand containing gravel, clay, organics and wood fragments.

The SPT 'N'-values measured within the fill deposit from the current investigation range from 12 blows to 29 blows per 0.3 m of penetration, indicating a compact relative density. The SPT 'N'-values in the previous investigation range from 9 blows to 29 blows per 0.3 m of penetration, indicating that the fill has a loose to compact relative density.

The natural water content measured on a sample of the fill measured about 14 per cent and a moisture content measured on a sample of the organic silt measured about 77 per cent.



4.2.4 Silt to Sandy Silt to Sand

A non-cohesive deposit comprised primarily of sand silt to sand containing trace to some gravel, trace clay was encountered below the fill at all borehole locations between about Elevation 232.2 m and 236.0 m.. Pockets of silt clay were encountered within the sand deposit in Borehole AS1-1 as well as in Borehole 2 and 3. In addition, pockets or interlayers of silt as well as of sand and gravel were encountered within the sand deposit in Borehole 2 and 4.

The SPT 'N'-values measured within the non-cohesive deposit generally range from 11 blows to 130 blows per 0.3 m of penetration, indicating a compact to very dense relative density. It should be noted that one SPT 'N'-value measured 1 blow per 0.3 m of penetration measured in the sand deposit in Borehole AS1-1 and was likely caused by disturbed material as a result of the drilling operation near the groundwater level and is not considered a representative SPT 'N'-value of the deposit.

The natural water content measured on samples of this deposit taken during the current investigation ranges from about 14 per cent to 23 per cent and a natural water content measured on the silty clay layer measured about 25 per cent.

The grain size distributions of samples of the sand deposit and the silt to sandy silt interlayers from the current investigation are shown on Figures B2-1 and B2-2, respectively in Appendix B.

An Atterberg limits test carried out on a sample of the silty clay pocket measured a liquid limit of about 40 per cent, a plastic limit of about 15 per cent and a corresponding plastic index of about 25 per cent. The result of the Atterberg limits test, presented on Figure B3, indicates that the material is classified as a silty clay of intermediate plasticity.

4.3 Groundwater Conditions

The water level encountered during drilling and observed in Borehole AS1-2 upon completion of drilling for the current investigation is at about Elevation 231.9 m. The water levels observed in the open boreholes following completion of the 1957 investigation were measured at between Elevation 233.5 m and 234.5 m.

It should be noted that the water level observed in the open boreholes during and/or on completion of drilling may not represent the longer-term, stabilized groundwater level at the site. In addition, the water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.



PRELIMINARY FOUNDATION REPORT - HIGHWAY 400 ANNE STREET UNDERPASS

5.0 CLOSURE

This report was prepared by Mr. Billy Murphy, B.Eng., a member of the geotechnical engineering group, and was reviewed by Mr. Christopher Ng, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge M. A. Costa, P.Eng., a Senior Consultant with Golder and Designated MTO Foundations Contact, conducted an independent quality control review of this report.

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PRELIMINARY FOUNDATION REPORT - HIGHWAY 400 ANNE STREET UNDERPASS

REFERENCES

Chapman, L. J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Department of Highways, Ontario, 1957. *Report on Subsurface Exploration for Proposed Overpass at Anne Street and Highway 400, Barrie, Ontario*, GEOCREs No. 31D-182.

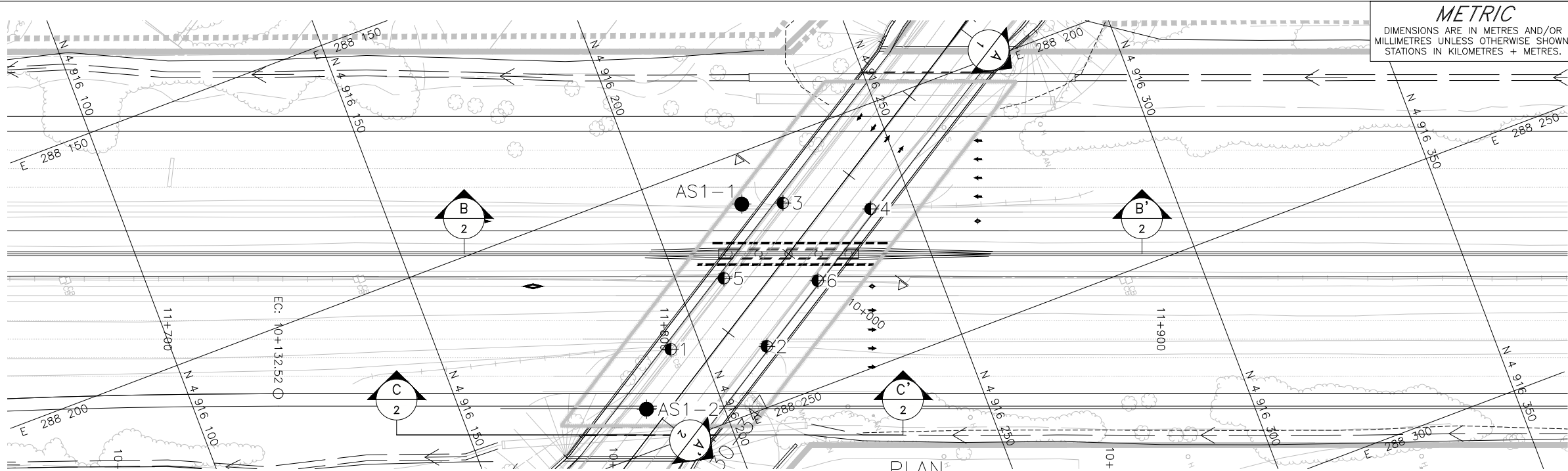
Ministry of Transportation, Ontario, 2002. *Preliminary Foundation Investigation and Design Report Anne Street Underpass, Structure Site 30-347; Highway 400 Widening from 1 km South of Highway 89 to Highway 11, G.W.P. 30-95-00*, prepared by Golder Associates Ltd.

ASTM International:

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils



DRAWINGS



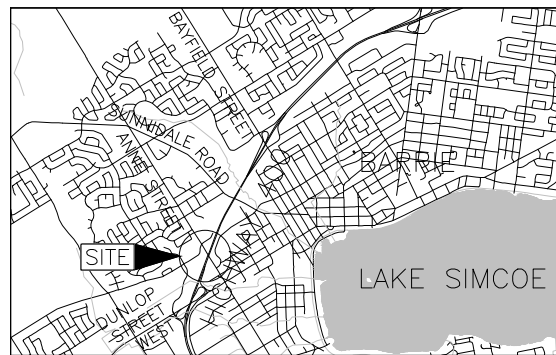
METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No.06-20016

ANNE STREET UNDERPASS
HIGHWAY 400 WIDENING
BOREHOLE LOCATIONS
AND SOIL STRATA



SHEET



KEY PLAN

SCALE
1 0 1 2 km

LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31D-182)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
1	235.3	4916194.1	288232.1
2	235.5	4916212.5	288238.4
3	235.8	4916225.7	288212.6
4	236.0	4916241.8	288219.9
5	235.1	4916209.2	288222.6
6	235.5	4916226.7	288229.7
AS1-1	236.0	4916217.8	288209.9
AS1-2	240.5	4916185.3	288241.7

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.

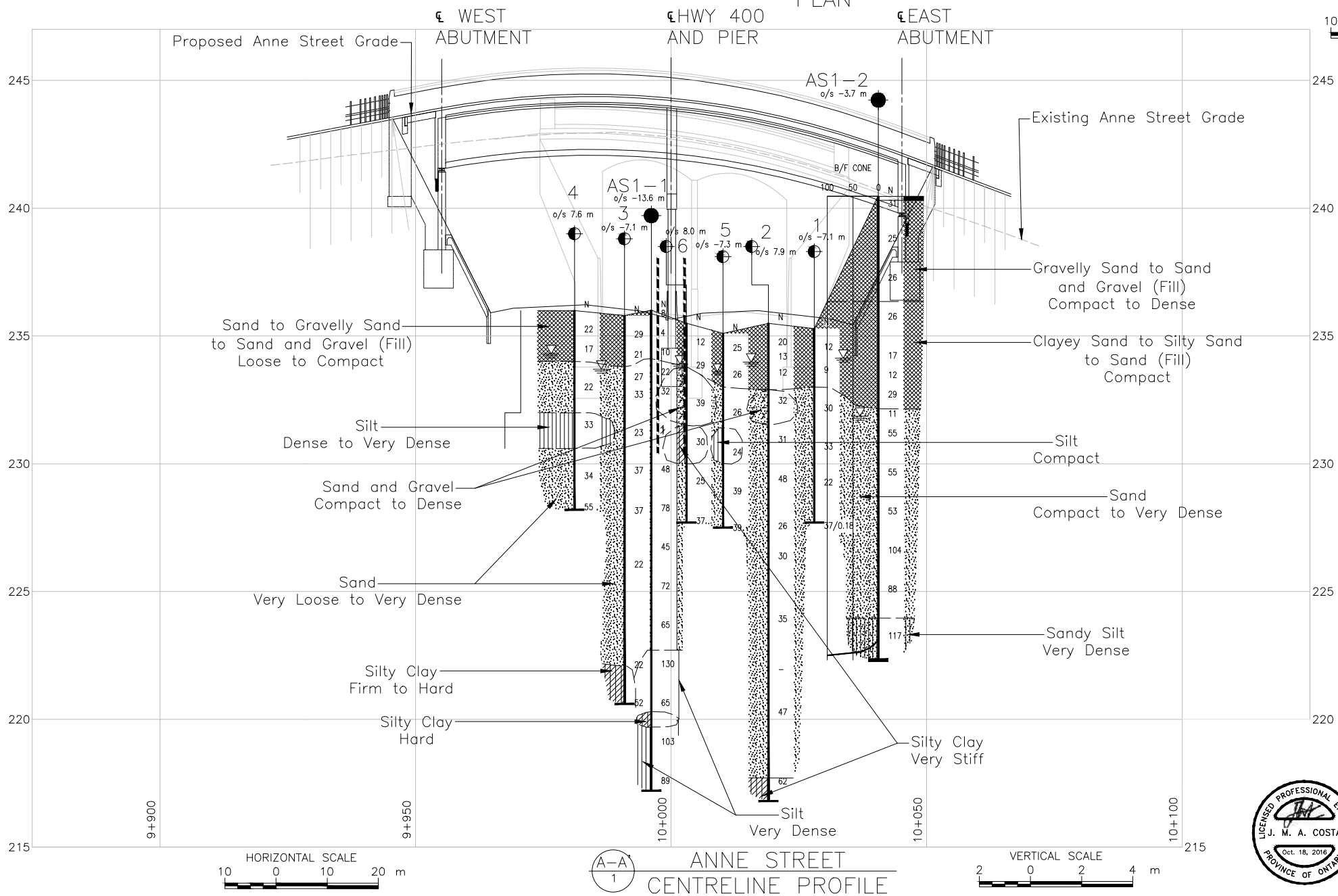
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

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

General arrangement, designs, base plans, profile and surface data provided in digital format by AECOM, drawing file nos. "01_Anne Street_GA(2).dwg", received June 23, 2016, "X-Base_All.dwg", received January 27, 2016, "X-Design_4th Line_Interim.dwg", received June 22, 2015, and "X-Surfaces.dwg", received April 14, 2015.

NO.	DATE	BY	REVISION
Geocres No. 31D-666			
HWY. 400		PROJECT NO. 14-1111-0002	DIST. .
SUBM'D. BM	CHKD. CN	DATE: 7/22/2016	SITE: 30-347
DRAWN: MR	CHKD. BM	APPD. JMAC	DWG. 1



HORIZONTAL SCALE
10 0 10 20 m

A-A
1

ANNE STREET
CENTRELINE PROFILE

VERTICAL SCALE
2 0 2 4 m

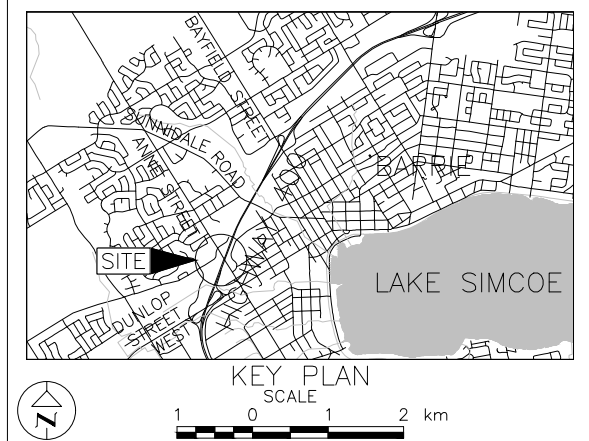


METRIC
DIMENSIONS ARE IN METRES AND/OR
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CONT No.
GWP No. 06-20016

ANNE STREET UNDERPASS
HIGHWAY 400 WIDENING
SOIL STRATA

SHEET



LEGEND

- | | |
|---|--|
|  | Borehole – Current Investigation |
|  | Borehole – Previous Investigation
(Geocres No. 31D-182) |
| N | Standard Penetration Test Value |
| 16 | Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow) |
|  | WL upon completion of drilling |

BOREHOLE CO-ORDINATES			
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NOTES

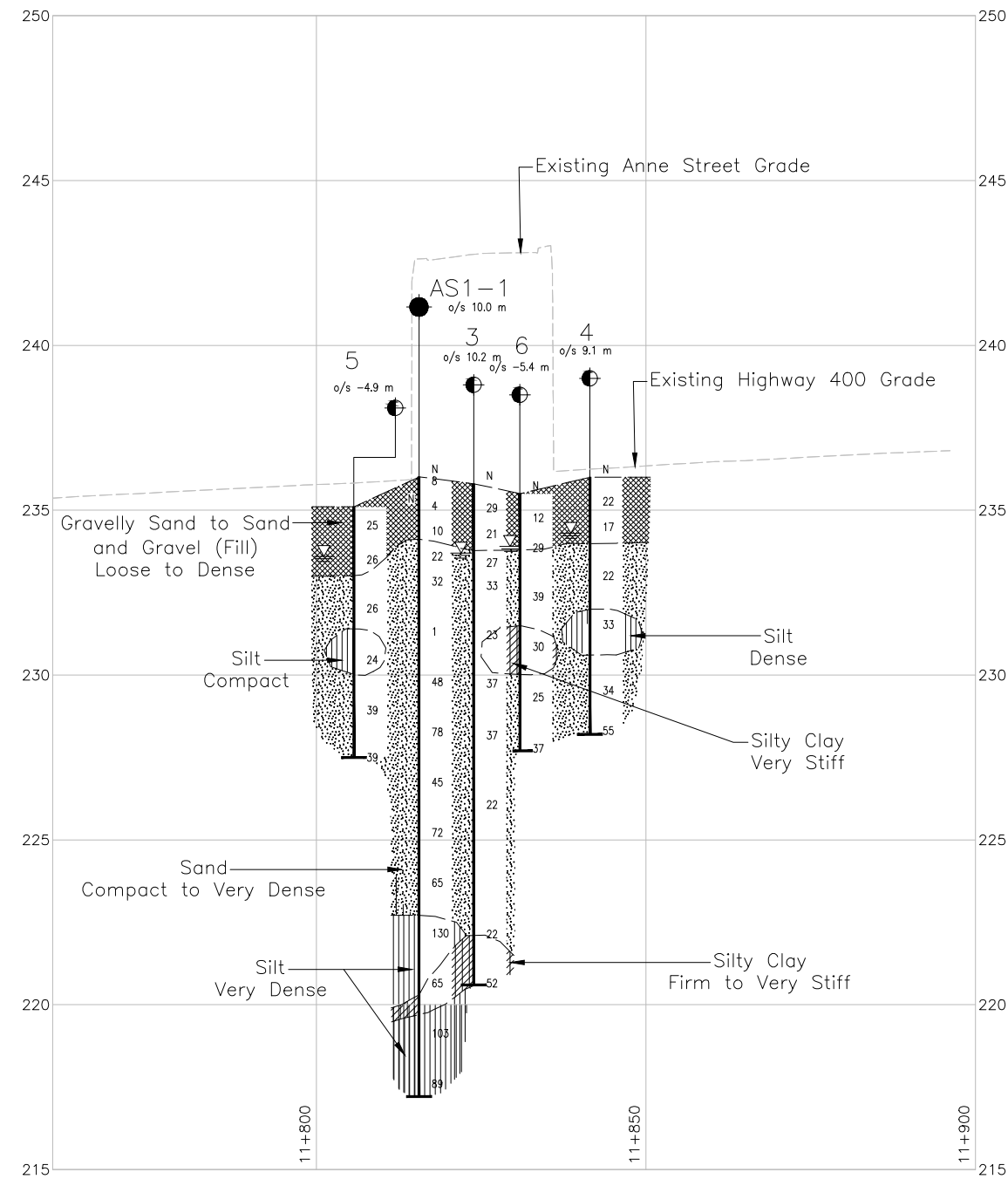
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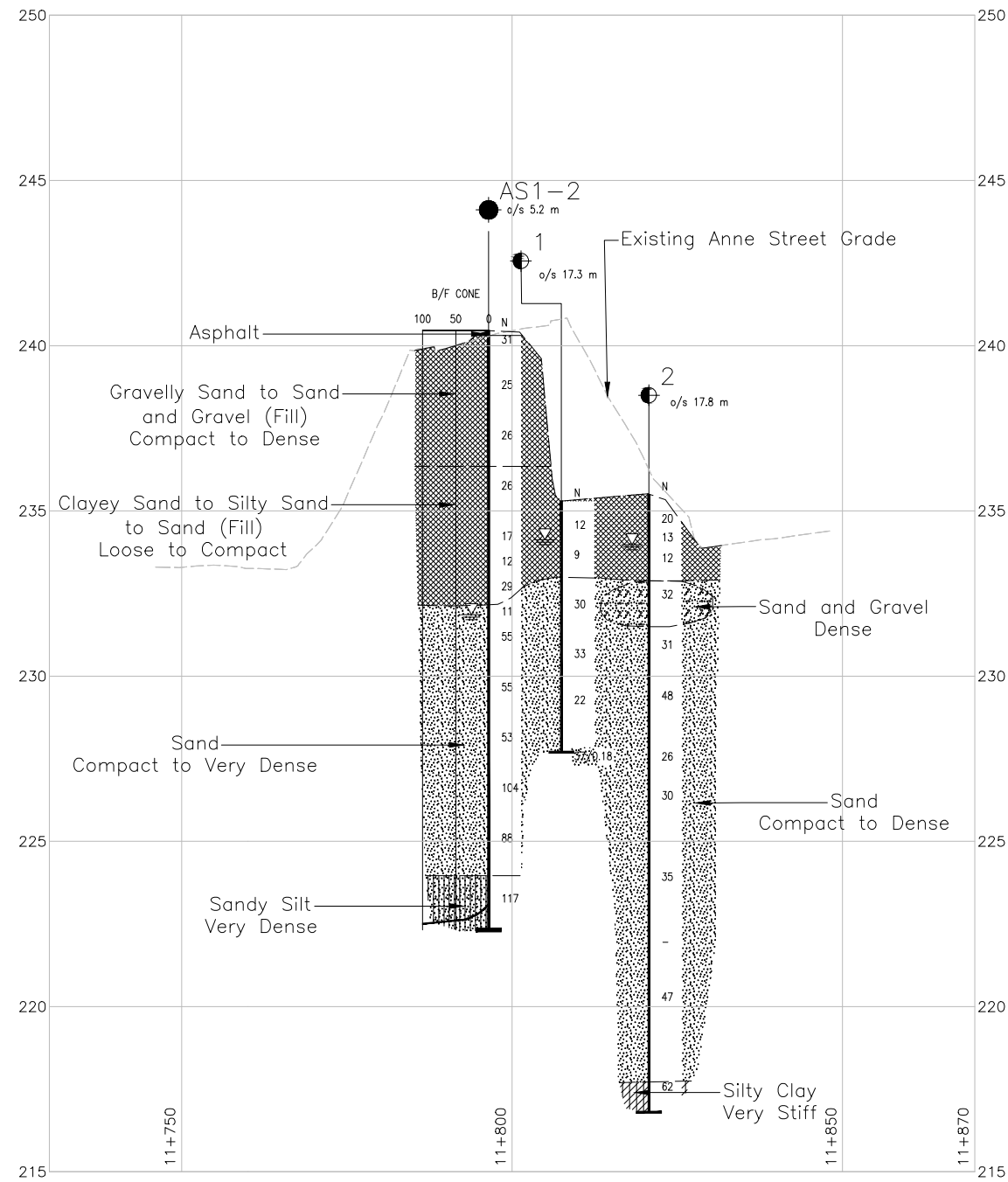
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

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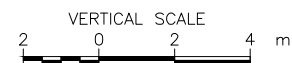
General arrangement, designs, base plans, profile and surface data provided in digital format by AECOM, drawing file nos. "01_Anne Street_GA(2).dwg", received June 23, 2016, "X-Base_All.dwg", received January 27, 2016, "X-Design_4th Line_Interim.dwg", received June 22, 2015, and "X-Surfaces.dwg", received April 14, 2015.



ANNE STREET CENTRE
PIER CROSS-SECTION



ANNE STREET
EAST ABUTMENT AREA CROSS-SECTION

[illegible]



APPENDIX A

Record of Boreholes – Golder 2016 Investigation



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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

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

* 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_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 (over-consolidated range)
C_s	swelling index
C_{α}	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

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

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2



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
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Non-Cohesive Soils

Density Index	N
Relative Density	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

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.) drive open sampler for a distance of 300 mm (12 in.)

(b) Cohesive Soils

Consistency	Cu, Su	psf
Very soft	0 to 12 kPa	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

Dynamic Cone Penetration Resistance; Nd:

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Qt), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w _p	plastic limit
w _l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
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 (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT <u>14-1111-0002</u>		RECORD OF BOREHOLE No AS1-1		SHEET 1 OF 2		METRIC	
G.W.P. <u>06-20016</u>		LOCATION <u>N 4916217.8 ; E 288209.9</u>		ORIGINATED BY <u>ML</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Truck - Mounted D-50 108 mm I.D., 194 mm O.D. Hollow Stem Auger</u>		COMPILED BY <u>MCK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 29, 2016</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			W _p	W	W _L
236.0	GROUND SURFACE																
0.0	Gravelly sand, trace to some clay, containing wood fragments (FILL) Loose to compact Brown to grey Moist		1	SS	8												
			2	SS	4												
			3A														
234.1			3B	SS	10												
1.9	SAND, trace to some gravel, trace to some silt Very loose to very dense Brown to grey Wet		4	SS	22											16 74 8 2	
			5	SS	32												
			6	SS	1												
			7	SS	48											4 75 19 2	
			8	SS	78												
			9	SS	45												
			10	SS	72												
			11	SS	65												
222.7																	
13.3	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		12	SS	130											0 6 90 4	

Continued Next Page

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

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PROJECT 14-1111-0002			RECORD OF BOREHOLE No AS1-1			SHEET 2 OF 2			METRIC								
G.W.P. 06-20016			LOCATION N 4916217.8 ; E 288209.9			ORIGINATED BY ML											
DIST Central HWY 400			BOREHOLE TYPE Truck - Mounted D-50 108 mm I.D., 194 mm O.D. Hollow Stem Auger			COMPILED BY MCK											
DATUM Geodetic			DATE March 29, 2016			CHECKED BY CN											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
220.3	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		13A	SS	65												
15.7			13B														
219.7	SILTY CLAY Hard Grey Wet																
16.3																	
	SILT, trace to some sand, trace clay Very dense Brown to grey Wet		14	SS	103												0 5 87 8
217.2	END OF BOREHOLE		15	SS	89												
18.8	NOTE: 1. Borehole caved to a depth of 1.2 m.																

PROJECT <u>14-1111-0002</u>		RECORD OF BOREHOLE No AS1-2		SHEET 1 OF 2		METRIC	
G.W.P. <u>06-20016</u>		LOCATION <u>N 4916185.3; E 288241.7</u>		ORIGINATED BY <u>ML</u>			
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>Truck - Mounted D-90, 108 mm I.D. 194 mm O.D. Hollow Stem Auger</u>		COMPILED BY <u>MK</u>			
DATUM <u>Geodetic</u>		DATE <u>April 20 and 21, 2016</u>		CHECKED BY <u>CN</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				
								20	40	60	80	100	20		
240.5	GROUND SURFACE														
0.0	ASPHALT														
0.2	Gravelly sand to sand and gravel, trace silt (FILL) Compact to dense Brown Moist		1	SS	31										
			2	SS	25										
			3	SS	26										
236.4															
4.1	Silty sand, trace to some gravel, trace clay, containing black organic silt pockets (FILL) Compact Grey Moist		4A	SS	26										
235.6			4B												
4.9	Sand, some silt, trace gravel to gravelly, trace organics (FILL) Compact Grey to brown Moist to wet														
			5	SS	17										
			6A												
			6B	SS	12										
	- 130 mm organic silt pocket encountered at a depth of about 7.1 m - 80 mm clayey silt pocket encountered at a depth of about 7.3 m														
			7	SS	29										
232.2															
8.3	SAND, trace gravel, trace to some silt Compact to very dense Brown Wet		8	SS	11										
			9	SS	55										
			10	SS	55										
			11	SS	53										
			12	SS	104										

Continued Next Page

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

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PROJECT		14-1111-0002		RECORD OF BOREHOLE No AS1-2		SHEET 2 OF 2		METRIC									
G.W.P.		06-20016		LOCATION		N 4916185.3 ; E 288241.7		ORIGINATED BY ML									
DIST		Central HWY 400		BOREHOLE TYPE		Truck - Mounted D-90, 108 mm I.D., 194 mm O.D. Hollow Stem Auger		COMPILED BY MK									
DATUM		Geodetic		DATE		April 20 and 21, 2016		CHECKED BY CN									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
224.0	SAND, trace gravel, trace to some silt Compact to very dense Brown Wet		13	SS	88												
16.5	Sandy SILT Very dense Brown Wet																
223.0			14	SS	117												
17.5	Start of Dynamic Cone Penetration Test (DCPT)																
222.4																	
18.1	END OF BOREHOLE																
	NOTES: 1. Water level at a depth of about 8.6 m below ground surface (Elev. 231.9 m) upon completion of drilling. 2. Borehole caved to a depth of about 4.0 m.																

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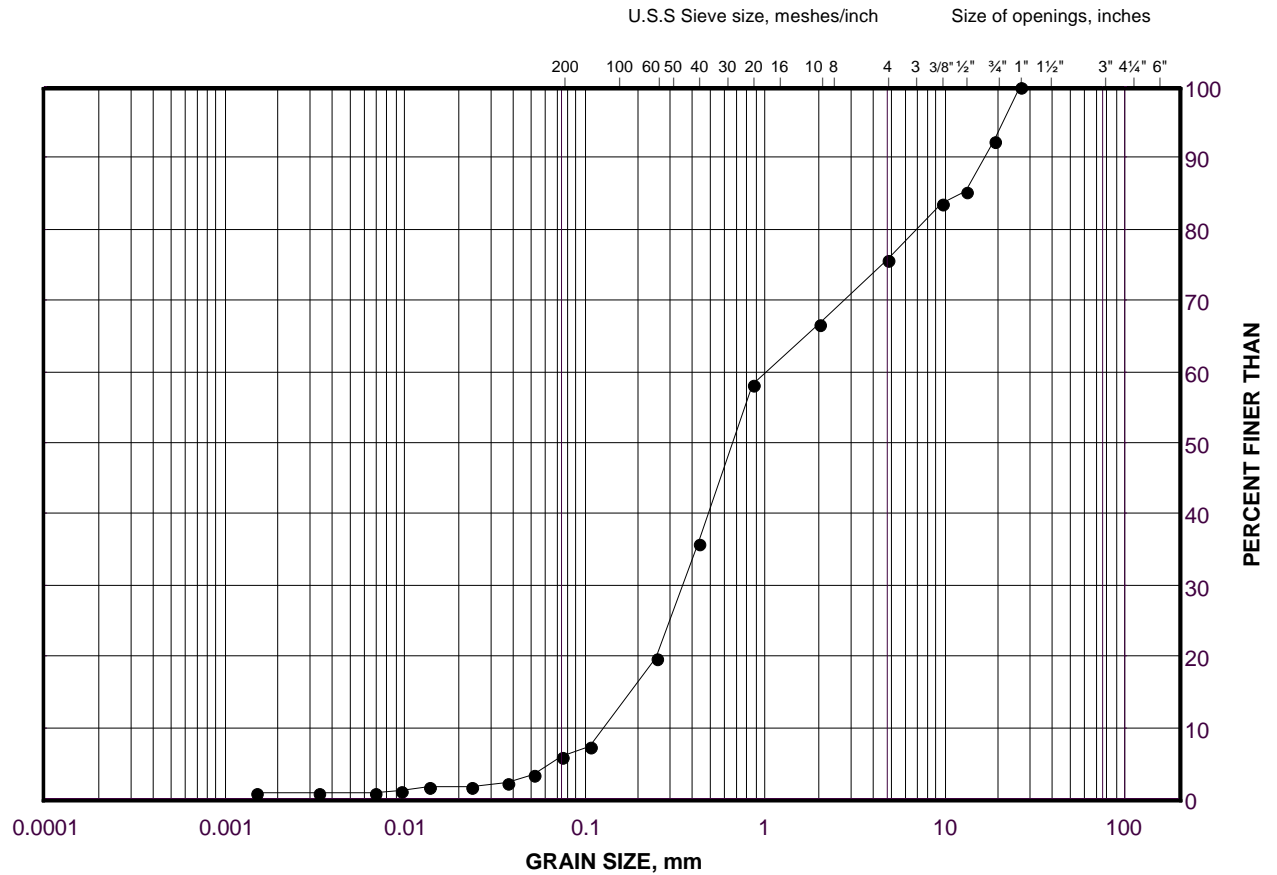
APPENDIX B

Laboratory Test Results – Golder 2016 Investigation

GRAIN SIZE DISTRIBUTION

Gravelly Sand (Fill)

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
•	AS1-2	2	238.7

Project Number: 14-1111-0002

Checked By: CN

Golder Associates

Date: 21-Jul-16

Sand

U.S.S. Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer (%) - Circles	Percent Finer (%) - Diamonds	Percent Finer (%) - Squares
0.075	20	10	5
0.15	90	85	40
0.3	95	90	65
0.6	98	92	75
1.2	99	93	80
2.5	100	94	82
5.0	100	95	85
10.0	100	96	88
20.0	100	97	90
40.0	100	98	92
60.0	100	99	94
100.0	100	100	96

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

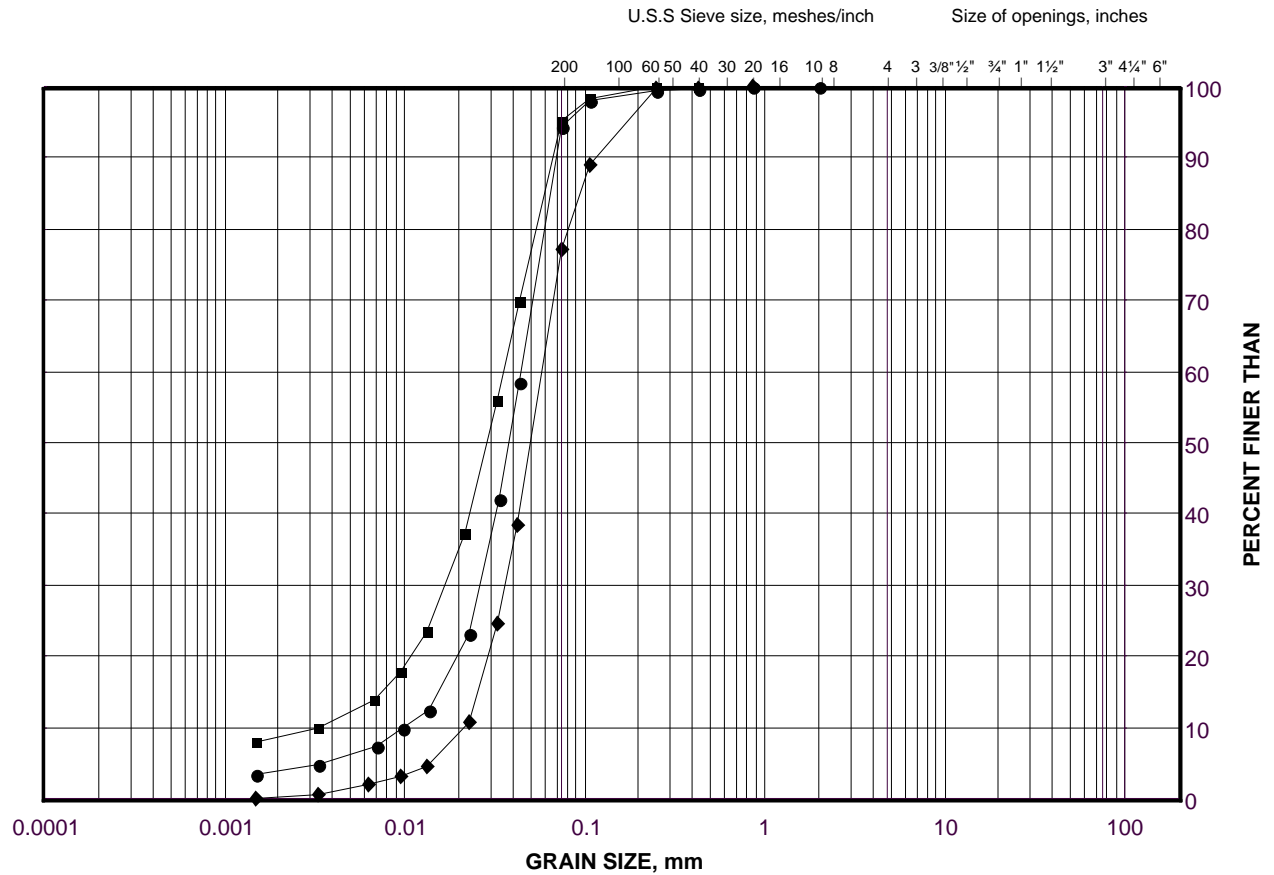
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	AS1-2	11	228
■	AS1-1	4	233.4
◆	AS1-1	7	229.7

Date: 22-Jul-16

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE B2-2



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

LEGEND

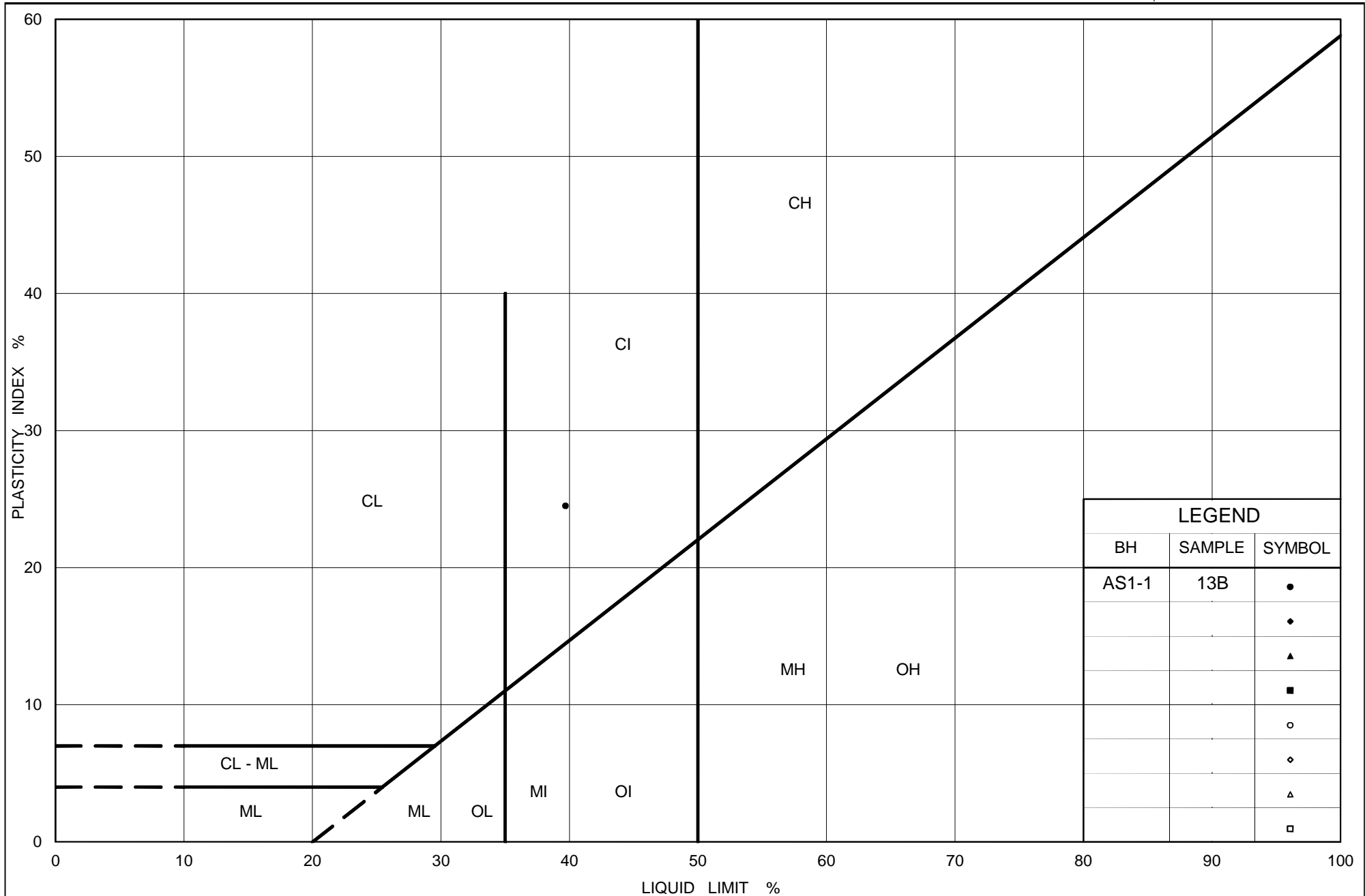
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	AS1-1	12	222
■	AS1-1	14	219
◆	AS1-2	14	223.2

Project Number: 14-1111-0002

Checked By: _____ CN _____

Golder Associates

Date: 22-Jul-16



Ministry of Transportation

Ontario

PLASTICITY CHART Silty Clay

Figure No. B3

Project No. 14-1111-0002

Checked By: CN



APPENDIX C

Record of Boreholes – Previous Investigation (GEOCRES No. 31D-182)

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PRO Anne Street Overpass, Barrie, Ontario. ORDER NO. I.277/57
 CLIENT Department of Highways, Ontario.
 BOREHOLE NO. BH.1 DIAMETER 2-1/2" CASING 2-1/2"
 BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1A (Rev. 6-64)
(With Stamp)

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm brown to gray clayey sand with some organic matter and fine to medium gravel. Probably FILL.	771.82 235.3m		• 1	Zero	0.0m	12	Moist Low to medium dry strength.
Loose brown to gray sand with fine to medium gravel and some organic matter. Probably FILL.			• 2	Free Water ▽		9	Moist Low dry strength.
Dense brown to gray fine to coarse SAND with generally subrounded fine to medium gravel.			• 3			30	do
Dense brown gray generally fine calcareous SAND with fine to medium subrounded gravel.			• 4			33	do
Firm do			• 5			22	do
Dense brown gray fine to medium calcareous SAND with fine to medium subrounded gravel.	227.7m		• 6	25'-1" = 7.6m End of Borehole		37 (7")	do

SCALE: 1" = 5'-0"

• DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario.

ORDER NO. 1,227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.2

DIAMETER 2-1/2"

CASING 2-1/2"

BOREHOLE LOCATION See Plan

INCLINATION Vertical

BEARING

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm brown grey sand, clayey concentrations. Black organic matter. Probably FILL.	772.65		• 1	Zero	0.0m	20	Moist
Firm do	235.5m		• 2	Free Water		15	do
do			• 3			12	do
Iron staining							
Dense grey brown fine to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.	232.9m		• 4	8'-6"	2.6m	32	Moist Low dry strength.
Dense brown sandy SILT with lenses of fine to medium SAND. Traces of bedding.	231.5m		• 5	13'-0"	4.0m	31	Moist, Low to medium dry strength.
do			• 6			48	do
Some iron staining							
Firm brown grey fine to medium calcareous SAND. Lenses of fine subrounded to rounded gravel embedded in clay.	228.5m		• 7	23'-0"	7.0m	26	Moist Low dry strength.
Dense brown grey fine to medium calcareous SAND with fine to medium gravel, generally subrounded.			• 8			30	do
do			• 9			35	do
do			• 10			-	Wash Sample
Dense grey generally fine calcareous SAND.	221.2m		• 11	47'-0"	14.3m	47	Moist Low dry strength.

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

FORM 8-1A 800-5-84
(UNITED STATES OF AMERICA)

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG




PROJECT Anne Street Overpass, Barrie, Ontario, ORDER NO. T.227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.2 DIAMETER 2-1/2" CASING 2-1/2"

BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1-A BOREHOLE LOG

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Dense gray generally fine calcareous SAND.	226.3m			50'-0"	15.2m		
Very stiff gray calcareous silty CLAY.	217.7m		• 12	58'-6"	17.8m	62	Molst. Sand: Low dry strength. Clay: High dry strength.
	216.8m			61'-6"	18.7m		
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL

GEOTECHNIQUE

LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. I.227/57CLIENT Department of Highways, Ontario.BOREHOLE NO. BH.3 DIAMETER 2-1/2" CASING 2-1/2"BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING ---FORM G-1A 800-e-84
(UNIVERSITY/84)

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
	773.58			Zero	0.0m		
Firm brown sand, gravel, little clay and bits of wood. FILL.	235.8m		• 1			29	Moist
Firm brown sand and black organic matter. Probably FILL.			• 2			21	do
Firm grey to iron-stained yellow fine to medium SAND with fine to medium generally subrounded gravel.	233.8m		• 3	6'-7"	Free Water	27	Wet Low dry strength.
do			• 4		2.0m	33	Moist Low dry strength.
do			• 5			23	do
Dense grey generally fine calcareous silty SAND.	230.2m		• 6	18'-6"	5.6m	37	do
do			• 7			37	do
Slight iron staining.			• 8			22	Wet Low dry strength.
do			• 9				
No iron staining.	225.4m		• 10	34'-0"	10.4m		
Brown grey fine to medium calcareous SAND.			• 11			22	Moist Low dry strength.
Grey generally fine calcareous SAND.			• 12	45'-0"	13.7m		
do	222.1m						
Firm grey silty CLAY.							
Hard do	220.6m			50'-0"	15.2m	52	Last sample

SCALE: 1" = 5'-0" • DISTURBED SAMPLE End of Borehole ■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG




PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. T.227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH.4 DIAMETER 2-1/2" CASING 2-1/2"

BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1A 500-5-54
L. M. STANLEY CO.

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	IN	REMARKS
Firm grey brown fine to medium somewhat clayey sand with gravel. Probably FILL.	774.26		• 1	Zero	0.0m	22	Moist
do With traces of organic matter. Probably FILL.	236.0m		• 2	Free Water		17	Wet
Firm grey brown fine to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.			• 3			22	Wet No dry strength.
	232.0m		• 4	13'-0"	4.0m	33	Damp Low to medium dry strength.
Dense brown sandy SILT with thin lenses of clay. Exhibits bedding.			• 5			34	Wash sample
Dense grey generally fine calcareous SAND.			• 6	25'-6"	7.8m	55	Moist. Low to medium dry strength.
Dense grey brown generally fine calcareous SAND with occasional fine gravel. Exhibits faint bedding and some iron staining.	228.2m			End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE ■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED

SOIL MECHANICS LABORATORY

BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario.

ORDER NO. L227/57

CLIENT Department of Highways, Ontario.

BOREHOLE NO. BH-5

DIAMETER 2-1/2"







CASING 2-1/2"

BOREHOLE LOCATION See Plan

INCLINATION Vertical

BEARING

FORM G-11A 900-6-84
LIMITED LIABILITY

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
Firm grey brown sand, gravel and little clay. Probably FILL.	771.38 235.1m		• 1	Zero	0.0m	25	Moist
do With some organic matter.			• 2	Free Water		26	Moist
	233.0m			7'-0"	2.1m		
Firm grey brown fine to coarse SAND with fine to medium generally subrounded GRAVEL.			• 3			26	Wet No dry strength.
	231.4m			12'-0"	3.7m		
Firm brown sandy SILT with some gravel and clay bands.			• 4			24	Moist Low to medium dry strength.
			• 5			39	Moist Low dry strength.
Dense grey brown fine to medium calcareous SAND.							
do	227.5m		• 6	25'-1"	7.6m	39 (7")	Wet Low dry strength.
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

UNIVERSAL GEOTECHNIQUE LIMITED
SOIL MECHANICS LABORATORY
BOREHOLE LOG

PROJECT Anne Street Overpass, Barrie, Ontario. ORDER NO. L227/57
 CLIENT Department of Highways, Ontario.
 BOREHOLE NO. BH.6 DIAMETER 2-1/2" CASING 2-1/2"
 BOREHOLE LOCATION See Plan INCLINATION Vertical BEARING

FORM G-1A 800-6-84
UNIVERSAL GEOTECHNIQUE

DESCRIPTION OF STRATA	ELEVATION	LEGEND	SAMPLE	DEPTH	THICKNESS	N	REMARKS
	772.48			Zero	0.0m		
Firm grey sand and black organic matter. Probably FILL.	235.5m		• 1			12	Moist
Firm grey and iron-stained yellow sand, little clay, Probably FILL.			• 2	Free Water		29	Moist
Dense medium to coarse calcareous SAND and fine to medium generally subrounded GRAVEL.			• 3			39	Wet No dry strength.
	231.5m			13'-0"	4.0m		
Very stiff brown sandy silty calcareous CLAY with fine to medium subangular to subrounded gravel.			• 4			30	Moist High dry strength.
Firm grey brown fine to coarse SAND and fine to medium subangular to subrounded GRAVEL.			• 5			25	Wet No dry strength.
Dense grey brown fine to medium calcareous SAND with gene. silty subrounded gravel.	227.7m		• 6	25'-6"	7.8m	37	Moist Low dry strength.
				End of Borehole			

SCALE: 1" = 5'-0" • DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. 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 who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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