REPORT

A world of capabilities delivered locally

October 2010

CELEBRATING 50 YEARS in 2010

REPORT ON

FOUNDATION INVESTIGATION AND DESIGN PROPOSED CULVERT REPLACEMENT TAYSIDE MUNICIPAL DRAIN CULVERT HIGHWAY 417 G.W.P. 4059-01-00

Submitted to:
D.M. Wills Associates Ltd.
452 Charlotte Street
Peterborough, Ontario
K9J 2W3

Report Number: 09-1121-1004-3000

Geocres Number: 31G-239

Distribution:

1 copy - D.M. Wills Associates Ltd.

5 copies - Ministry of Transportation, Ontario, Kingston, Ontario

1 copy - MTO Foundations Section, Downsview, Ontario

2 copies - Golder Associates Ltd., Ottawa, Ontario

Golder Associates

Table of Contents

TABLES

DRAWINGS

FIGURES

APPENDICES

PART A

FOUNDATION INVESTIGATION
PROPOSED CULVERT REPLACEMENT
TAYSIDE MUNICIPAL DRAIN CULVERT
HIGHWAY 417
G.W.P. 4059-01-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by D.M. Wills Associates Ltd. on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations for two existing structures along Highway 17 and Highway 417 in Ontario.

Foundation investigation services are required on this project for the following components:

- Petawawa River Bridge structural rehabilitation and widening; and,
- Tayside Municipal Drain Culvert replacement.

This report addresses the replacement of the Tayside Municipal Drain Culvert on Highway 417 under G.W.P. 4059-01-00 and W.P. 4009-08-01.

The terms of reference for the original scope of work are outlined in the MTO's Request for Proposal (RFP) dated August 2009 and in Section 6.8 (Foundations Engineering) of the *Technical Proposal* for this assignment as well as Addendums 1 & 2 dated October 2, 2009.

The work was carried out in accordance with Golder's Quality Control Plan dated March 2010.

2.0 SITE DESCRIPTION

The existing Tayside Municipal Drain Culvert is located on Highway 417 at about Station 14+810 within the eastbound lanes and about Station 14+880 within the westbound lanes, approximately 2 km east of Highway 138 on Lot 7, Concession 10 of the Township of Roxborough in the County of Prescott and Russell, Ontario. The culvert is aligned approximately northeast-southwest with a 45 degree skew and carries the Tayside Municipal Drain under the westbound and eastbound lanes of Highway 417. The existing culvert is a corrugated steel pipe arch approximately 4370 mm wide by 2870 mm high and about 96 m in length. The culvert inverts are at about Elevations 62.7 m and 62.5 m, at the south and north ends, respectively. The existing embankment slopes at the south and north ends of the culvert are generally 3H:1V, however the upper portion of the embankment slope at the north end of the culvert is sloped at about 2H:1V. There is no evidence of inlet/outlet protection at the culvert ends however the embankment slopes are well vegetated. The flow in the culvert is from south to north. The water level within the culvert at the time of the investigation was between about 0.2 and 0.3 metres in depth. The existing pavement grades of the eastbound and westbound lanes above the culvert are at about Elevation 66.3 m and 66.5 m, respectively.

There are no signs of pavement distress within the eastbound and westbound lanes above the culvert. However, D.M. Willis Associates Ltd. observed during their culvert inspection that there are indications of structural distress of the culvert in the form of localized deformations at the crown of the pipe arch as well as severe corrosion along the base of the culvert below the water line.

3.0 INVESTIGATION PROCEDURES

The subsurface investigation was carried out for the culvert replacement in April 2010, at which time three boreholes (number 10-1 to 10-3, inclusive) were advanced at the locations shown on Drawing 1.

The boreholes were advanced using 108 mm inside diameter continuous flight hollow stem augers on a track-mounted drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were advanced to depths of between about 12.0 and 14.3 m below the existing ground surface.

Soil samples were obtained at intervals ranging from 0.75 m to 1.5 m of depth, using a 50 mm outer diameter split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures. In-situ vane testing (using an N-size vane) was carried out within the cohesive deposits where possible. Six relatively undisturbed, 73 mm diameter thin-walled Shelby tube samples of the clay were retrieved using a fixed piston sampler.

A standpipe piezometer was installed in Borehole 10-1 to monitor the groundwater level at the site. The standpipe consists of a 50 mm diameter rigid PVC pipe with a 1.5 m long slotted screen section, installed within silica sand backfill and sealed by a 0.8 m long section of bentonite pellet backfill. The water level in the standpipe piezometer was measured on April 30 and May 11, 2010.

The boreholes were backfilled with bentonite pellets, mixed with native soils, and the site conditions restored following completion of work. The standpipe piezometer will be decommissioned following construction, unless instructed otherwise by the Ministry.

The field work was supervised throughout by a member of Golder's technical staff, who located the boreholes, supervised the drilling, sampling and in-situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's laboratories in Ottawa and Mississauga for further examination. Index and classification tests consisting of grain size distribution, water content, and Atterberg limit testing were carried out on selected soil samples at the Ottawa laboratory. An oedometer (consolidation) test was carried out on one sample of the silty clay from Borehole 10-1. This testing was carried out at the Mississauga laboratory. All of the laboratory tests were carried out to MTO and/or ASTM standards as appropriate.

The borehole elevations and locations were surveyed by Golder Associates Ltd. using a Trimble R8 GPS unit. The borehole 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 Drawing 1.

Borehole No.	Borehole Location	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
10-1	North end of the culvert	5022159.0	190502.8	66.1
10-2	Centre of the culvert in the median	5022136.5	190485.5	66.0
10-3	South end of the culvert	5022096.8	190439.8	66.1

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The study area for this assignment is within the *Winchester 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 Winchester Clay Plain lies between the Glengarry Till Plain and the sand plains of the United Counties of Prescott and Russell and composes an area of 580 square kilometres. It is a flat lying area located almost entirely within the drainage basin of the South Nation River.[1] The Winchester Clay Plain is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that overlie relatively thin, commonly reworked glacial till and glacial fluvial deposits that in turn overlie bedrock. This region is underlain by sedimentary rock, consisting of limestone interbedded with shale.

4.2 Site Stratigraphy

As part of the subsurface investigation at this site, three boreholes were advanced along the alignment of the existing Tayside Municipal Drain Culvert. The borehole locations, ground surface elevations and an interpreted stratigraphic profile are shown on Drawing 1.

The detailed subsurface soil, bedrock and groundwater conditions as encountered in the boreholes advanced during this investigation for the culvert, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets and on Figures 1 to 7.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the culvert consist of up to 4.1 metres of fill, underlain by a deposit of sensitive clay which extends to depths ranging from about 10.8 m to 11.9 m below the ground surface. The upper 1.6 m of the clay deposit in the median has locally been weathered to a grey brown crust. The clay beneath the fill material at the culvert ends and beneath the weathered portion in the median is unweathered and grey in colour and has a soft to stiff consistency. The silty clay deposit is underlain by silty sand and gravel till which was proven to depths of up to 14.3 m relative to the ground surface level (i.e., Elevation 51.8 m).

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

4.2.1 Embankment Fill

Embankment fill was encountered at ground surface at Boreholes 10-1, 10-2 and 10-3, with thicknesses of about 4.1 m (to Elevation 62.0 m), 1.5 m (to Elevation 64.5 m), and 3.4 m (to Elevation 62.7 m), respectively. The embankment fill consists of crushed stone overlying sand and gravel. The fill in the median consists of topsoil, overlying silty clay and sand and gravel.

[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.

Standard penetration test (SPT) "N" values in the granular fill typically ranged from 4 to 13 blows per 0.3 m of penetration, indicating a loose to compact state of packing. The results of grain size distribution testing on one sample of the sand and gravel fill are shown on Figure 1.

4.2.2 Sensitive Clay

The fill is underlain by a deposit of clay. The deposit was fully penetrated at depths ranging between about 10.8 m and 11.9 m below the ground/embankment surface level, at about Elevations 54.2 m to 55.2 m.

At Borehole 10-2 in the median, the upper 1.6 m of the clay has been weathered to a grey brown crust. Two measured SPT "N" values in this material were 6 and 4 blows per 0.3 m of penetration, indicating a very stiff to stiff consistency of the weathered crust.

The results of grain size distribution testing on one sample of the weathered clay are shown on Figure 2. The results of Atterberg limit testing on one sample of the weathered material indicate a plasticity index value of 35 percent and a liquid limit value of 62 percent, as shown on Figure 3, indicating a clay soil of high plasticity. Two measured natural water contents of the weathered material were 34 to 44 percent.

The clay below the depth of weathering at Borehole 10-2 and below the embankment fill at Boreholes 10-1 and 10-3 is grey in colour and about 8 metres in thickness.

The results of in situ vane testing carried out in this material indicate undrained shear strengths which range from 17 to 52 kPa indicating a soft to firm consistency.

The results of grain size distribution testing on one sample of the unweathered clay are shown on Figure 4. The results of Atterberg limit testing on samples of the unweathered clay indicate plasticity index values which range from 28 to 51 percent and liquid limit values that range from 53 to 80 percent, as shown on Figure 5, indicating a clay of high plasticity. The measured natural water content of the unweathered material ranges from 52 to 86 percent. These natural water contents are generally near or above the measured liquid limits.

Oedometer consolidation testing was carried out on one sample of the unweathered grey clay from Borehole 10-1 at Elevation 60.5 m. The results of that testing, which are provided on Figure 6 are summarized in the table below and indicate that this material is normally consolidated, with a preconsolidation pressure of 75 kPa and overconsolidation ratio of 1.0.

Borehole/ SAMPLE NUMBER	Sample Depth/Elev. (m)	Unit Weight (kN/m^3)	σ_P' (kP)	σ_{VO}' (kP)	$\sigma_P' - \sigma_{vo}'$ (kPa)	Cc	Cr	e_o	OCR
10-1 / 6	5.6 / 60.5	15.1	75	75	0	1.58	0.060	2.29	1.0

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

4.2.3 Silty Sand and Gravel Till

The clay is underlain by glacial till. The surface of the glacial till ranges from about Elevation 54.2 to 55.2 m. The glacial till was proven to depths of about 12.3 m, 12.0 m, and 14.3 m, at Boreholes 10-1, 10-2 and 10-3, respectively. The till is at least 0.4 to 3.0 m thick at these locations.

The glacial till is considered to be a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sand and silt with trace clay. However, those samples were retrieved using a 50 mm external diameter sampler and therefore the test results do not reflect the cobble and boulder portions of the deposit.

SPT "N" values of between 9 and 26 blows per 0.3 metres of penetration in the glacial till indicate a loose to compact state of packing.

The results of grain size distribution testing on samples of the glacial till are shown on Figure 7. The measured natural water content of the glacial till ranges from 7 to 9 percent.

4.2.4 Groundwater Conditions

The groundwater level in the piezometer in Borehole 10-1 was measured on April 30 and May 11, 2010. The groundwater levels in the piezometer are summarized in the table below:

Borehole	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)	Date
10-1	66.1	2.5	63.6	April 30, 2010
		2.6	63.5	May 11, 2010

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

5.0 CLOSURE

This report was prepared by Ms. Susan Trickey, P.Eng. and reviewed by Mr. Fintan Heffernan P.Eng., the designated MTO contact for this project.

Yours truly,

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
S. A. TRICKEY
100104579
PROVINCE OF ONTARIO

Susan Trickey, P.Eng.
Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
PROVINCE OF ONTARIO

Fintan Heffernan, P.Eng.
Designated MTO Contact

SAT/WC/FJH/am

n:\active\2009\1121 - geotechnical\09-1121-1004 dm wills petawawa bridge\foundations\tayside culvert\09-1121-1004-3000 rpt-001 october2010.docx

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	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample
DT	Dual Tube sample

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.)
DD- Diamond Drilling

Dynamic Penetration Resistance; N_d:
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, 60^0 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

Peizo-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 (PWP) 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

Consistency	C_u or S_u 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	plastic limited
w_l	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 (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 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
F	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 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 ($D_R= p_s/p_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is p. Unit weight symbol is γ where γ=pg(i.e. mass density x acceleration due to gravity)

(a) Index Properties (cont'd.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index=(w_l-w_p)
w_s	shrinkage limit
I_L	liquidity index=$(w-w_p)/I_p$
I_c	consistency index=$(w_l-w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index-$(e_{max}-e)/(e_{max}-e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio=σ'_p/σ'_{vo}

(d) Shear Strength

$\tau_p\tau_r$	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, S_u	undrained shear strength (ϕ=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. τ=c'σ' tan ϕ'
2. Shear strength=(Compressive strength)/2

Golder Associates

RECORD OF BOREHOLE No 10-1

 METRIC

PROJECT 09-1121-1004
G.W.P. 4059-01-00
DIST ____ HWY 417
DATUM Geodetic
LOCATION N 5022159.0 ;E 190502.8
BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem
DATE April 14, 2010
ORIGINATED BY HEC
COMPILED BY JM
CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	Water content / Atterberg	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.1	GROUND SURFACE					
0.0	Crushed stone (FILL) Grey					
65.3 0.8	Sand and gravel, some silt (FILL) Loose to compact Grey-brown to grey Moist	1	SS	4		
		2	SS	6		
		3	SS	12	o	42 46 12 0
		4	SS	12		
62.0 4.1	CLAY Soft to firm Grey Wet	5	SS	5	├──┤	
		6	TP	PH	├──┤ o	
		7	TP	PH		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O 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

Elevation scale: 66, 65, 64, 63, 62, 61, 60, 59, 58, 57

Continued Next Page

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

RECORD OF BOREHOLE No 10-1

 METRIC

PROJECT 09-1121-1004
G.W.P. 4059-01-00
LOCATION N 5022159.0 ;E 190502.8
ORIGINATED BY HEC
DIST ___ HWY 417
BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem
COMPILED BY JM
DATUM Geodetic
DATE April 14, 2010
CHECKED BY SAT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	-- CONTINUED FROM PREVIOUS PAGE --				
	CLAY Soft to firm Grey Wet	8	SS	WR	56
		9	SS	WH	55
54.2 11.9	Silty SAND and GRAVEL, trace clay (TILL) Compact Grey Wet	10	SS	26	54
53.8 12.3	End of Borehole Note: Water level in piezometer at 2.6 m depth (Elev. 63.5 m) on May 11, 2010.				

Chart headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O 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

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

Golder Associates

RECORD OF BOREHOLE No 10-2

 METRIC

PROJECT 09-1121-1004
G.W.P. 4059-01-00 LOCATION N 5022136.5 ;E 190485.5 ORIGINATED BY HEC
DIST HWY 417 BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem COMPILED BY JM
DATUM Geodetic DATE April 13, 2010 CHECKED BY SAT

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
66.0	GROUND SURFACE					
0.0 / 65.8	Topsoil (FILL)					
0.2	Silty clay, some sand and gravel, trace organic matter (FILL) Grey-brown					
65.2 / 0.8	Sand and gravel (FILL) Compact Brown Moist	1	SS	13		
64.5 / 1.5	CLAY (Weathered Crust) Very stiff to stiff Grey-brown Moist	2	SS	6		0 1 29 70
		3	SS	4		
62.9 / 3.1	CLAY Soft to firm Grey Moist to wet	4	SS	WH		0 0 28 72
					∇	
		5	TP	PH		
		6	SS	WH		
		7	TP	PH		
		8	SS	WH		

ELEVATION SCALE: 65, 64, 63, 62, 61, 60, 59, 58, 57

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O 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 (%)

Continued Next Page

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

RECORD OF BOREHOLE No 10-2

 METRIC

PROJECT 09-1121-1004
G.W.P. 4059-01-00
DIST ___ HWY 417
DATUM Geodetic

LOCATION N 5022136.5 ;E 190485.5
BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem
DATE April 13, 2010

ORIGINATED BY HEC
COMPILED BY JM
CHECKED BY SAT

-- CONTINUED FROM PREVIOUS PAGE --

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY Soft to firm Grey Moist to wet						
55.2 10.8	Silty SAND and GRAVEL, trace clay (TILL) Compact Grey Wet	9	SS	20		55	53 36 9 2
		10	SS	24			
54.0 12.0	End of Borehole Note: Water level in open borehole at 3.8 m depth below ground surface upon completion of drilling					54	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O 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

+3, ×3: Numbers refer to Sensitivity

O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 10-3

 METRIC

PROJECT 09-1121-1004
G.W.P. 4059-01-00
LOCATION N 5022096.8 ;E 190439.8
ORIGINATED BY HEC
DIST ___ HWY 417
BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem
COMPILED BY JM
DATUM Geodetic
DATE April 12, 2010
CHECKED BY SAT

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
66.1	GROUND SURFACE				
0.0	Crushed stone (FILL) Grey				
65.5 / 0.6	Sand, some gravel and silty clay, trace organic matter (FILL) Loose Brown Moist	1	SS	6	
		2	SS	6	
63.8 / 2.3	Sand and gravel (FILL) Compact Brown Moist	3	SS	12	∇ (approx. El. 63)
62.7 / 3.4	CLAY Soft to stiff Grey Wet	4	SS	3	
		5	SS	WR	
		6	TO	PH	
		7	SS	WR	
		8	TO	PH	
		9	SS	WR	

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; ELEVATION SCALE (66 to 57); 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 Next Page

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

RECORD OF BOREHOLE No 10-3

 METRIC

PROJECT 09-1121-1004			
G.W.P. 4059-01-00	LOCATION N 5022096.8 ;E 190439.8		ORIGINATED BY HEC
DIST	HWY 417	BOREHOLE TYPE Power Auger, 200mm Diam. Hollow Stem	COMPILED BY JM
DATUM Geodetic	DATE April 12, 2010		CHECKED BY SAT

— CONTINUED FROM PREVIOUS PAGE —

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY Soft to stiff Grey Wet				56	
		10	SS	WR	55	
54.8 11.3	Silty SAND and GRAVEL, trace clay (TILL) Loose to compact Grey Wet	11	SS	9	54	
		12	SS	18		47 33 18 2
		13	SS	24	53	
		14	SS	24	52	26 32 36 6
51.8 14.3	End of Borehole Note: Water level in open borehole at 3.1 m depth below ground surface upon completion of drilling					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "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

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

MINISTRY OF TRANSPORTATION, ONTARIO

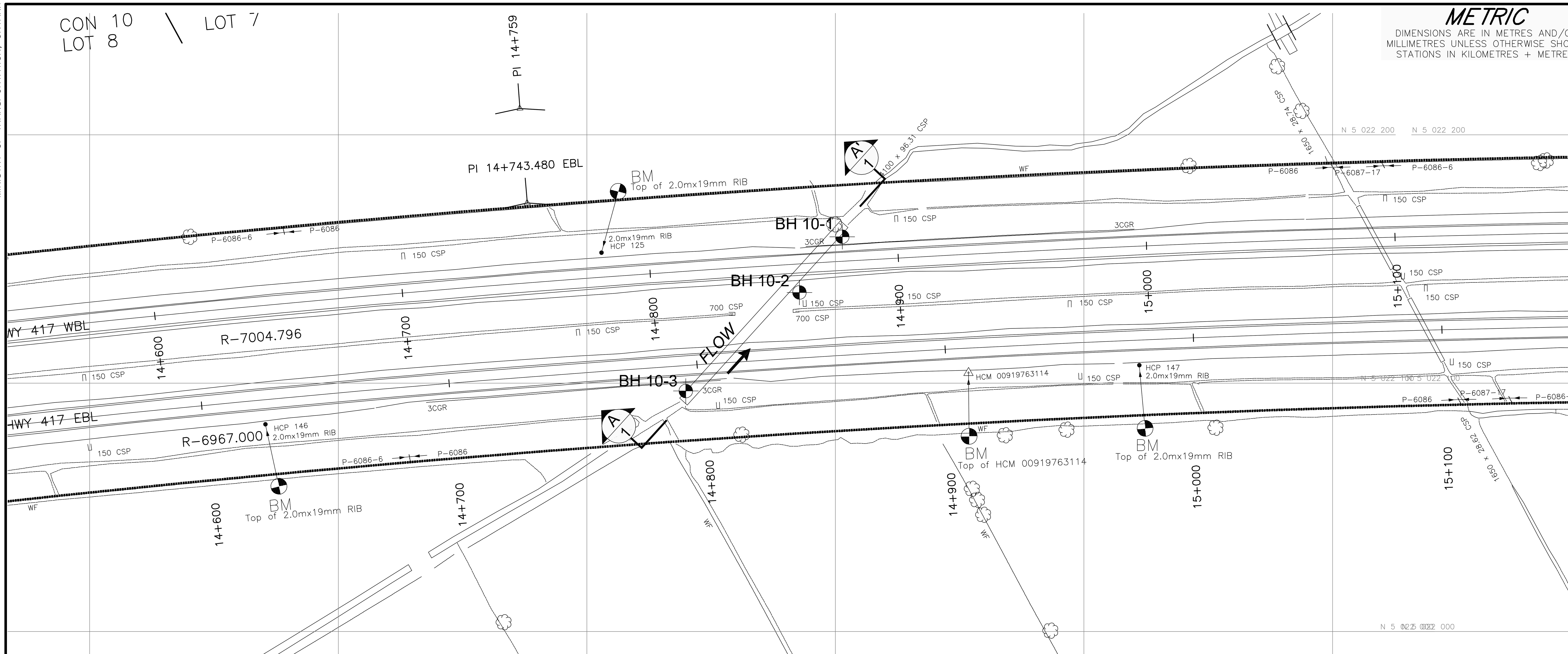
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 4059-01-00

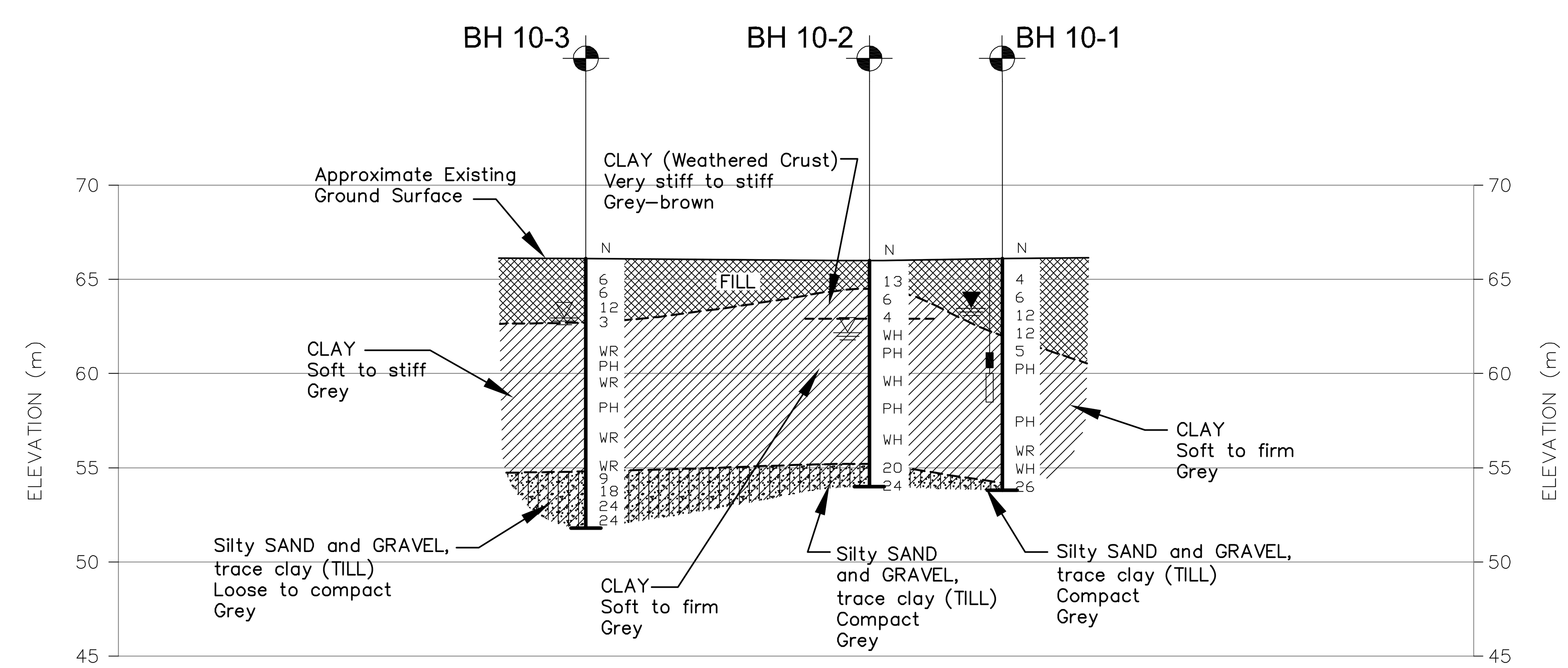
SHEET

HIGHWAY 417
TAYSIDE MUNICIPAL DRAIN CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

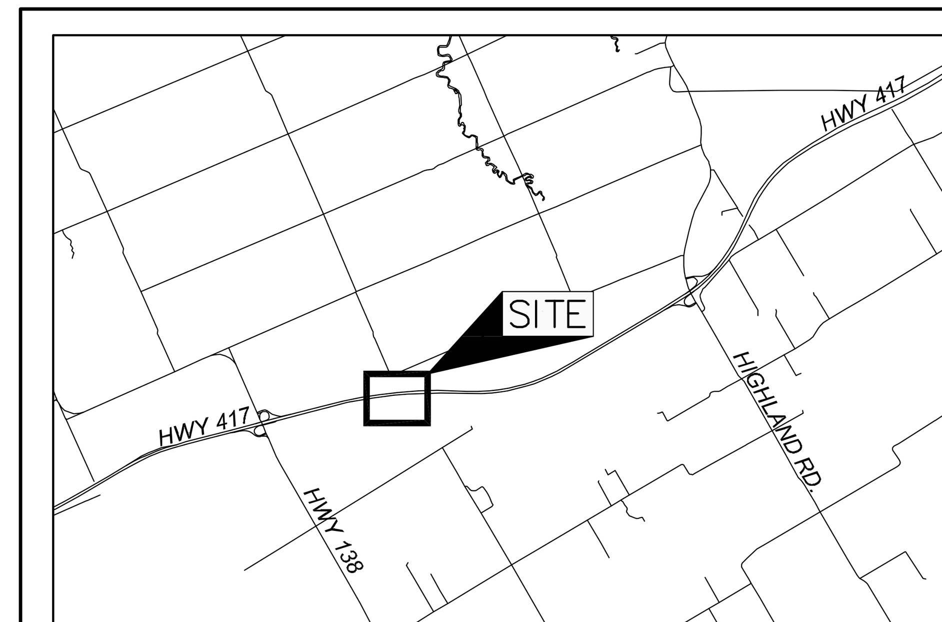
Golder Associates Ltd.
OTTAWA, ONTARIO, CANADA



PLAN
SCALE
20 0 20 40 m



SECTION A-A'
HORIZONTAL SCALE
20 0 20 40 m
5 0 5 10 m
VERTICAL SCALE



KEY PLAN
SCALE
2 0 2 4 km

LEGEND

- Borehole – Current Investigation
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, May 11, 2010
- WL upon completion of drilling
- Seal
- Piezometer

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
10-1	66.1	5022159.0	190502.8
10-2	66.0	5022136.5	190485.5
10-3	66.1	5022096.8	190439.8

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 Preliminary Design Report.

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

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

REFERENCE

Base plan provided in digital format by D.W. Wills Associates Ltd. (Drawing File No. "b-389-417-1.dwg", received May 11, 2010.

NO.	DATE	BY	REVISION

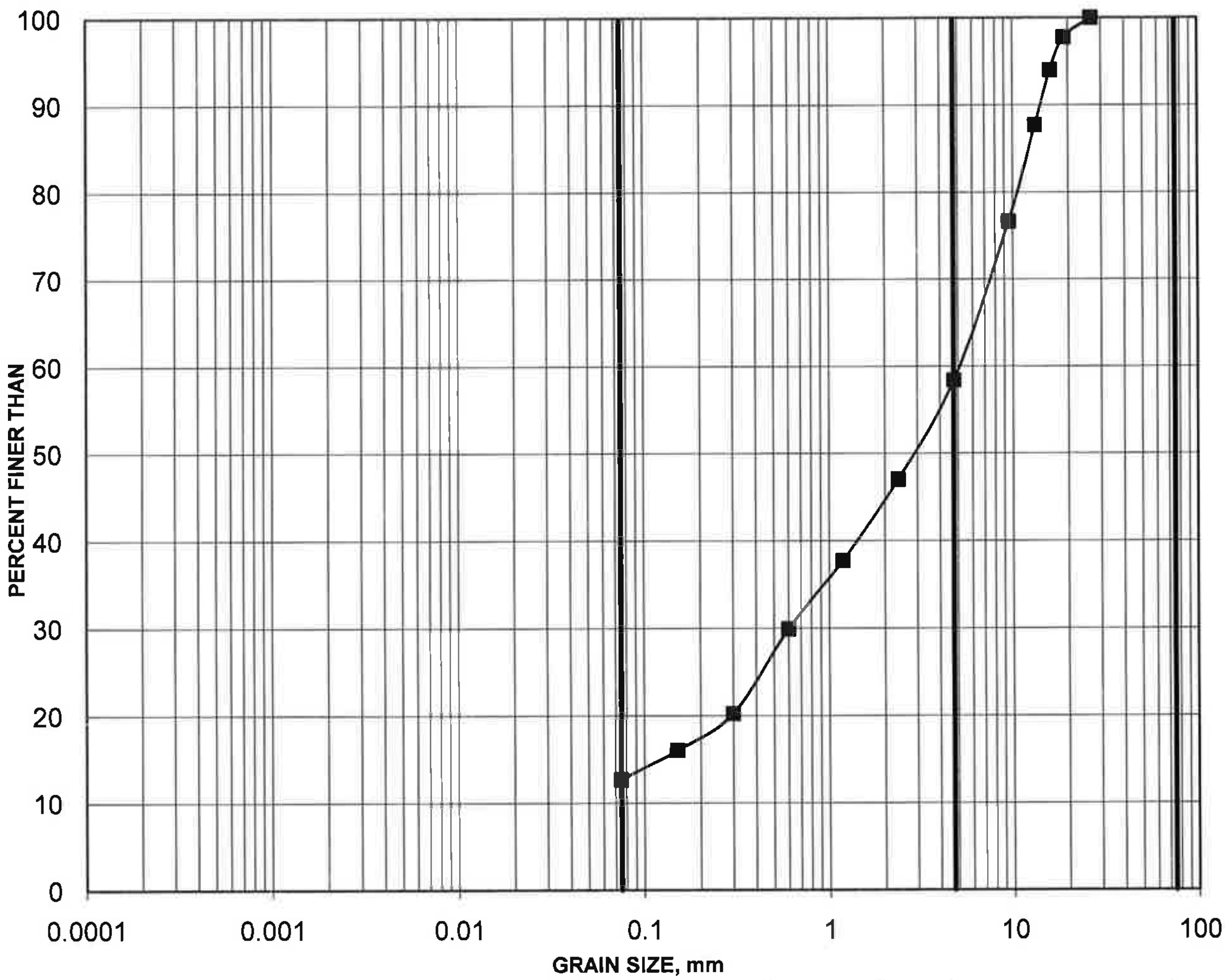
Geocres No. 31G-239

HWY. 417		PROJECT NO. 09-1121-1004	DIST.
SUBM'D. SAT	CHKD. SAT	DATE: 5/15/2010	SITE:
DRAWN: JM	CHKD. WC	APPD. FJH	DWG. 1

GRAIN SIZE DISTRIBUTION

FIGURE 1

FILL (SAND AND GRAVEL)



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

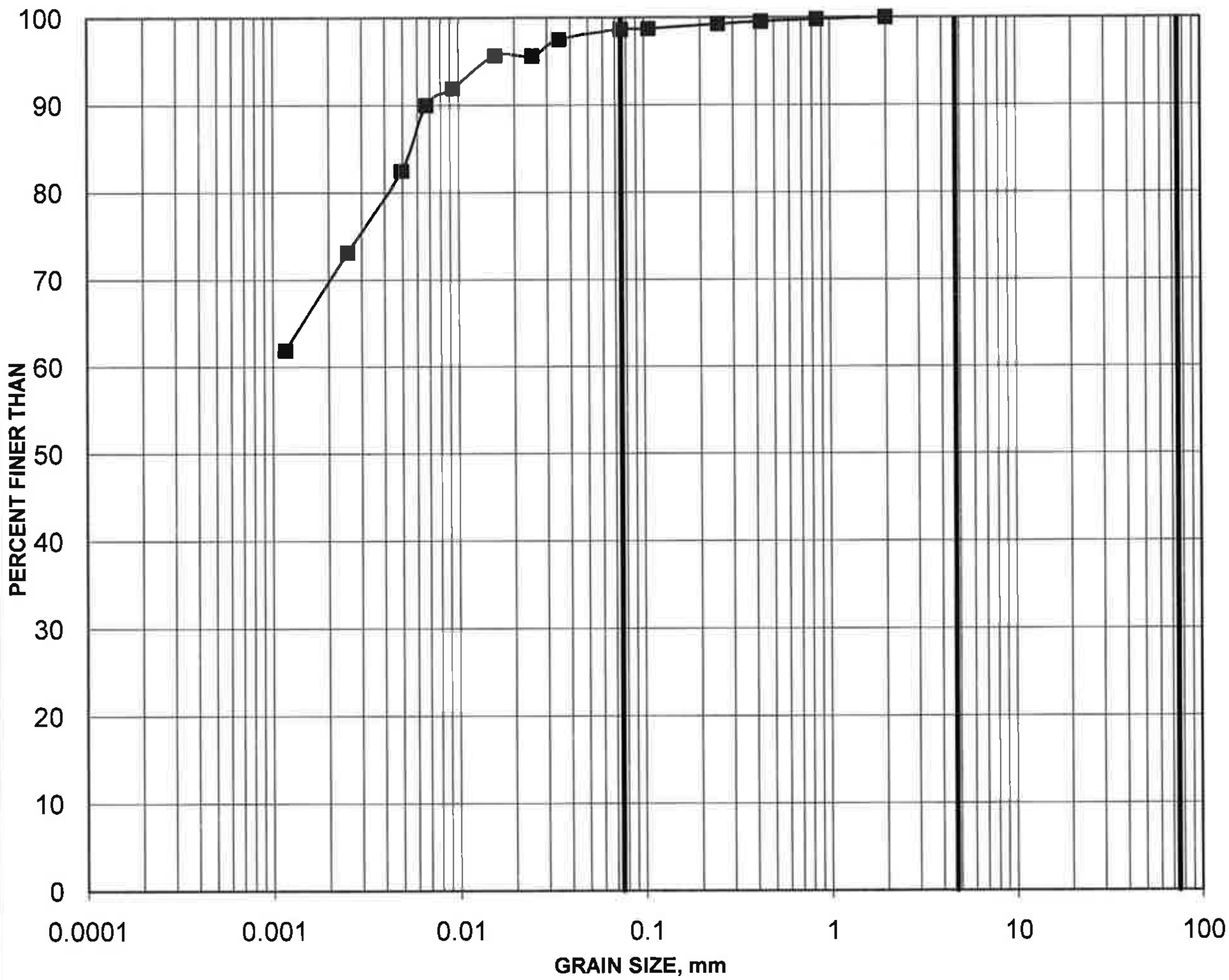
Borehole	Sample	Depth (m)
—■— 10-1	3	2.29-2.90

Created by:	MI
Checked by:	CNM

Project: 09-1121-1004/3000 **Golder Associates**

GRAIN SIZE DISTRIBUTION	FIGURE 2

WEATHERED CLAY



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

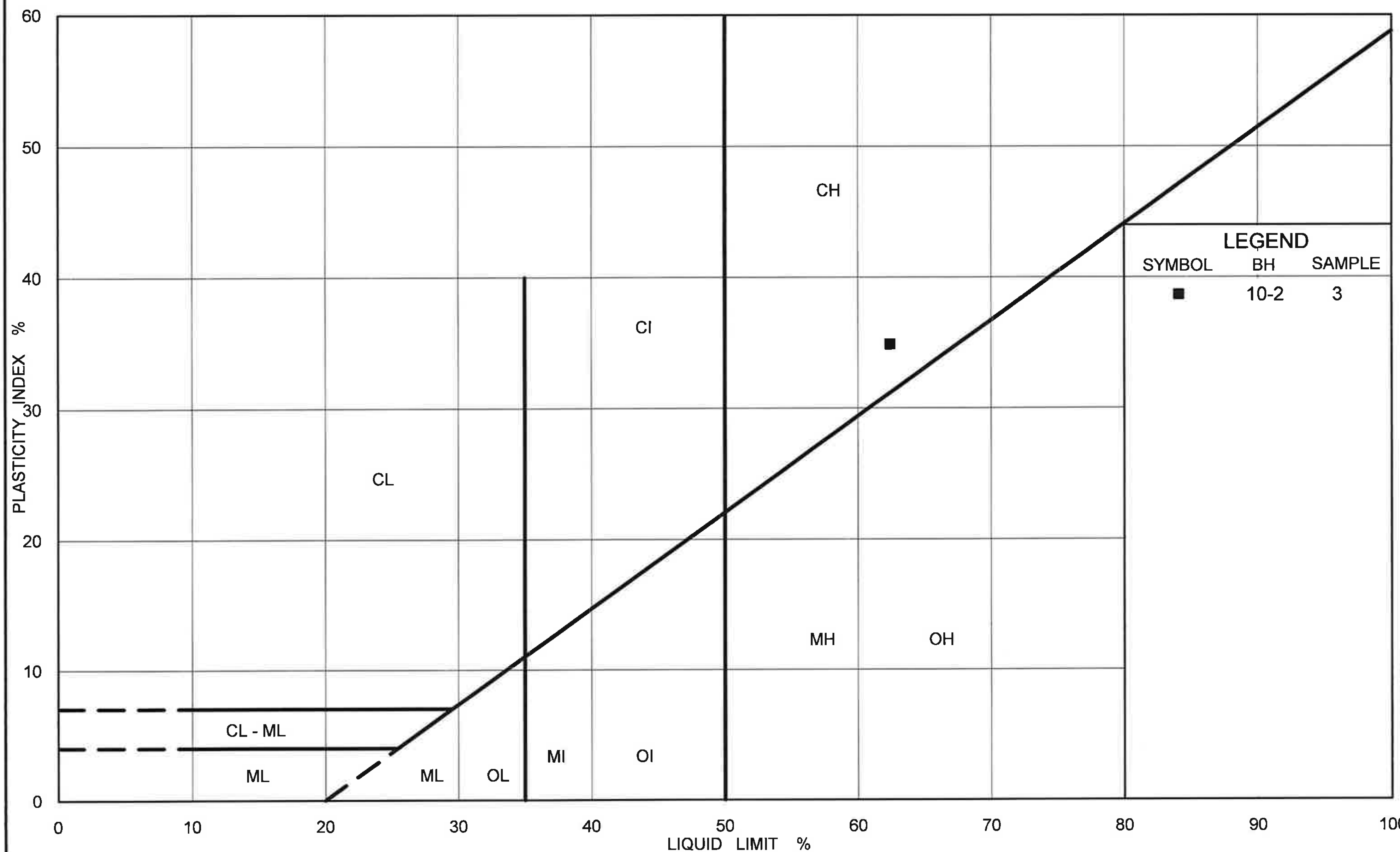
Borehole	Sample	Depth (m)
10-2	2	1.52-2.13

Project: 09-1121-1004/3000

Golder Associates

Created by: MI
Checked by: CNM

Oct 75, FF-S-21



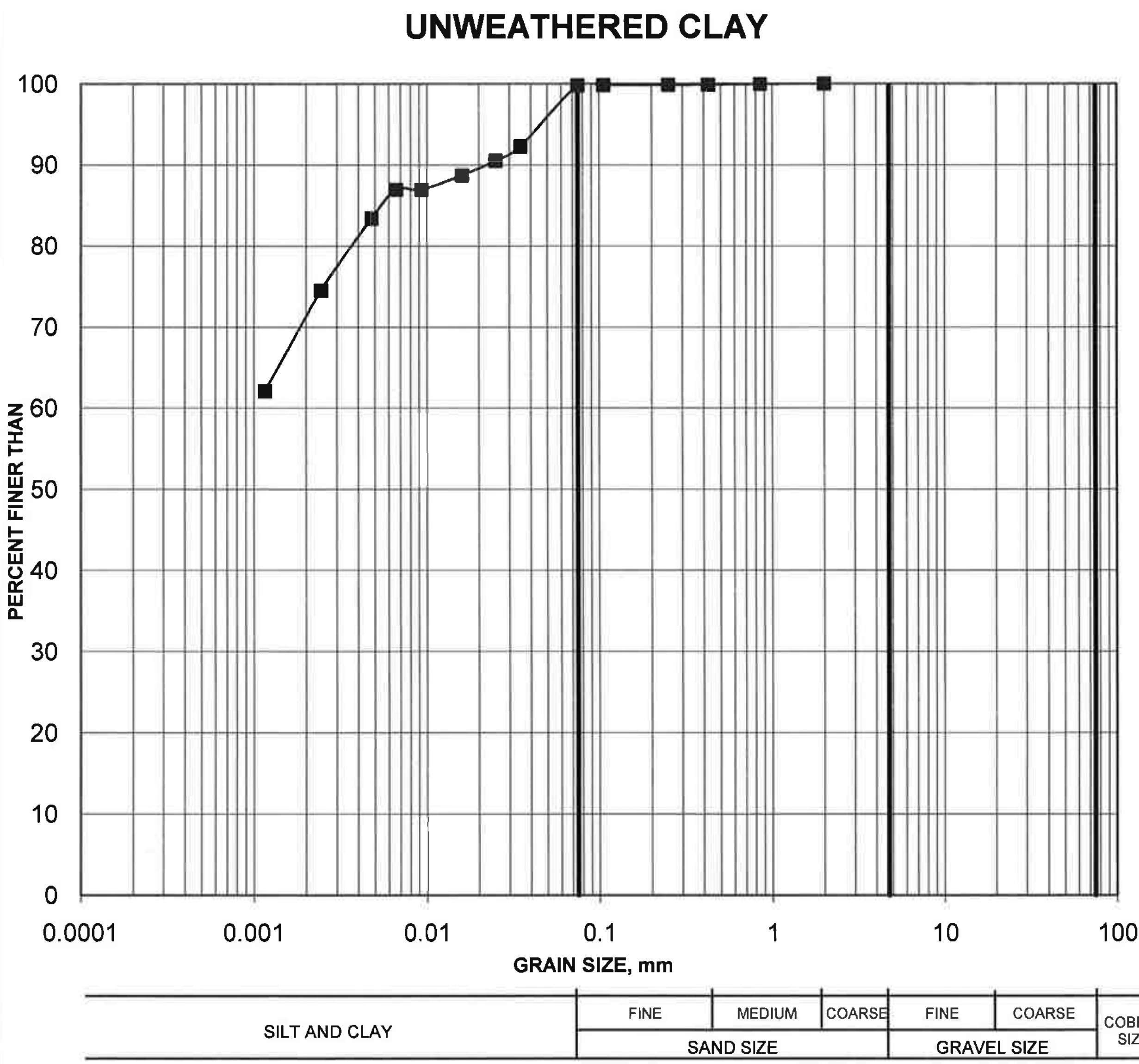
Ministry of Transportation
Ontario

PLASTICITY CHART
Weathered Clay

FIG No. 3

Project No. 09-1121-1004/3000

GRAIN SIZE DISTRIBUTION	FIGURE 4

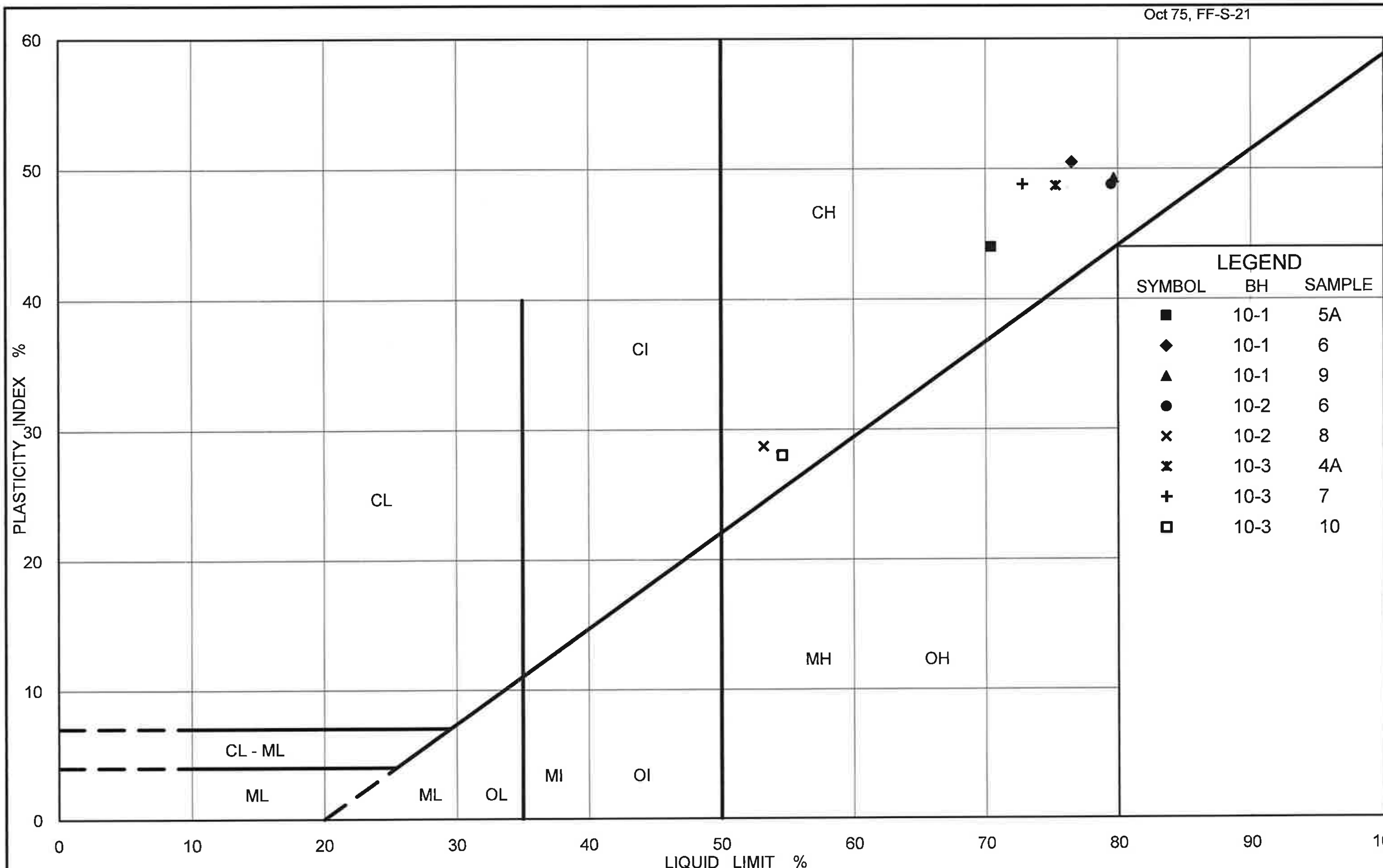


Borehole	Sample	Depth (m)
10-2	4	3.05-3.66

Project: 09-1121-1004/3000

Golder Associates

Created by: MI
Checked by: CNM



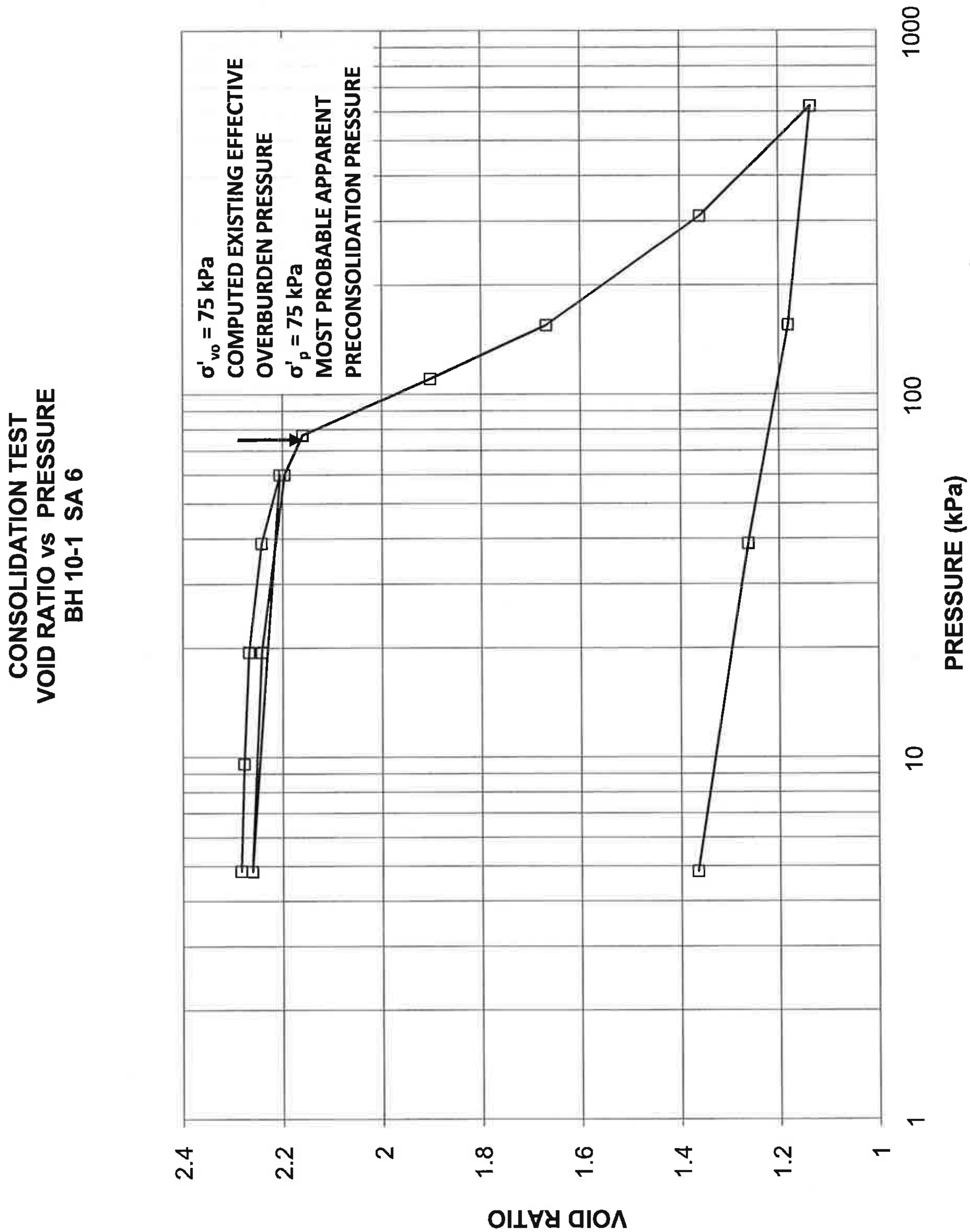
Ministry of Transportation
Ontario

PLASTICITY CHART
Unweathered Clay

FIG No. 5

Project No. 09-1121-1004/3000

CONSOLIDATION TEST VOID RATIO VS LOG PRESSURE	FIGURE 6



Project No. 09-1121-1004

Prepared By: LFG

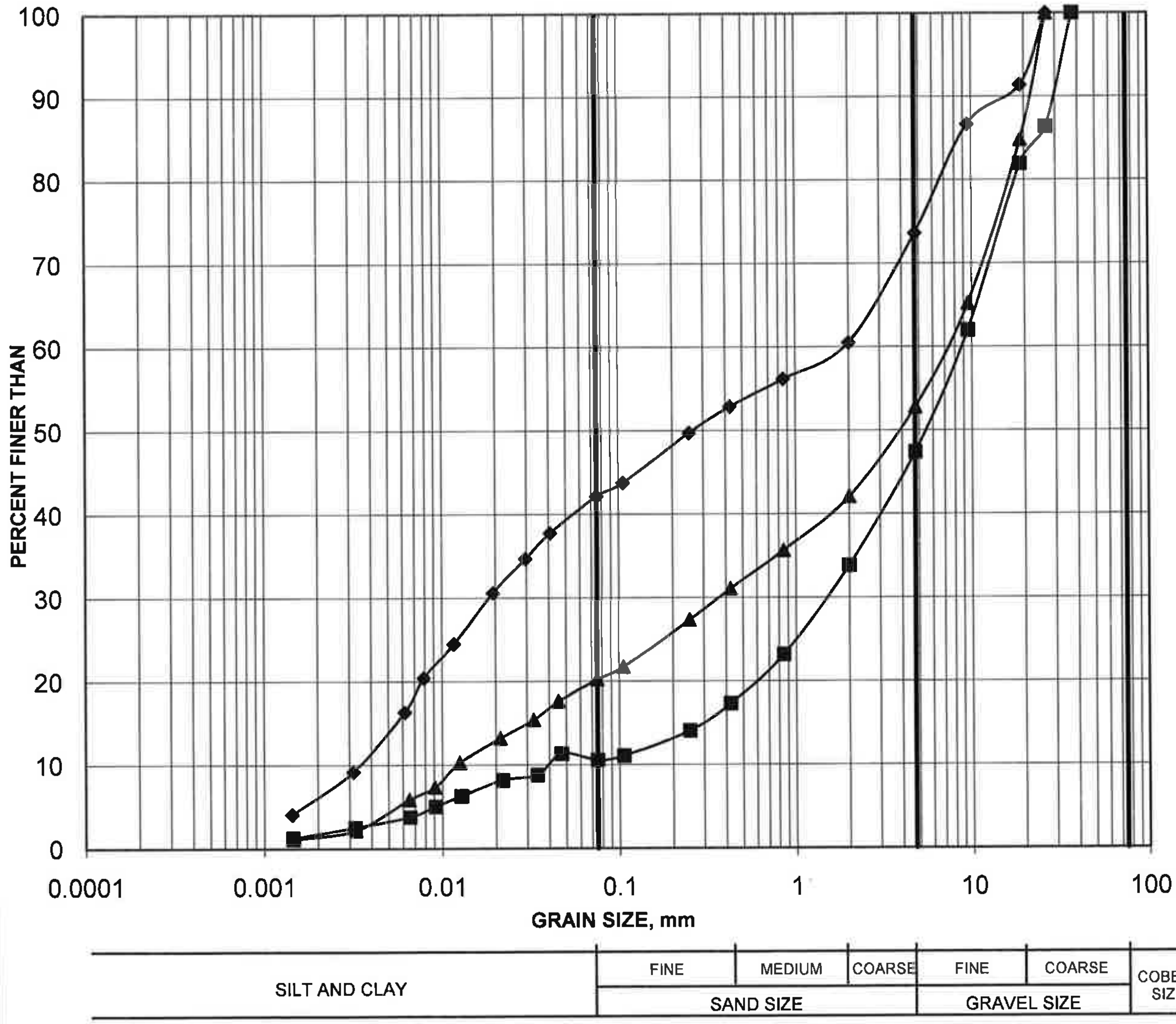
Golder Associates

Checked By: RO

GRAIN SIZE DISTRIBUTION

FIGURE 7

SILTY SAND AND GRAVEL (TILL)



Borehole	Sample	Depth (m)
■ 10-2	9A	11.13-11.28
▲ 10-3	12	12.20-12.80
◆ 10-3	14	13.72-14.33

Project: 09-1121-1004/3000 **Golder Associates**

Created by: MI
Checked by: CNM