



FOUNDATION INVESTIGATION AND DESIGN REPORT

For

LIGHTING POLES AND SIGNS

WILLOW CREEK BRIDGE

HIGHWAY 400

GWP NO. 2360-10-00

BARRIE, ONTARIO

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PML Ref.: 12KF037A
Index No.: 103DIR and 104DDR
Geocres No.: 31D-629
November 5, 2015



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DRAFT
FOUNDATION INVESTIGATION REPORT
for

Lighting Poles and Signs
Willow Creek Bridge
Highway 400
GWP No. 2360-10-00
Barrie, Ontario

1. INTRODUCTION

This report summarizes the results of a foundation investigation carried out for the proposed relocation of the existing six (6) Lighting Poles and both the Overhead and the Structural Support Ground Mounted Signs along Highway 400 near Willow Creek Bridge. This investigation was carried out by Peto MacCallum Ltd. (PML) for MMM Group Limited on behalf of the Ministry of Transportation of Ontario (MTO).

2. SITE DESCRIPTION AND GEOLOGY

The site is located at the north end of the City of Barrie near Willow Creek Bridge, which is about 500 m south of the Highway 400/Highway 11 interchange.

The investigation area at these locations is grassed with trees and bushes extending beyond the pole and signs locations and the shoulders of Highway 400.

The site is located within the physiographic region known as the Simcoe Uplands, which includes pervious soil areas with shallow sand and gravel deposits. The overburden at the project site is primarily sand and silt deposits with occasional clayey soil zones.

3. INVESTIGATION PROCEDURES

Locations of the boreholes from previous and current investigations are shown on Drawing LS-1.

Previous subsurface investigations relevant to the site were carried out in 2012 by Golder Associates Ltd., for MTO project GWP2179-10-00 for a culvert replacement at Station 18+515, Highway 400 NBL. This investigation included three boreholes north of the existing Willow Creek Bridge (Borehole numbers 11-C1-01, 11-C1-02, and 11-C1-03). Refer to Appendix A.



Additional field work was carried out during the period of November 3 to 26, 2014 and consisted of two boreholes and cones (boreholes 14-7 and 14-8) drilled at the proposed new north abutment for the new Willow Creek Bridge, two boreholes (boreholes 14-9 and 14-10) drilled at the north approach to the bridge, one borehole (borehole 14-LS-1) drilled on the left shoulder of the Highway 400 SBL near Sta.18+420 and three new boreholes (boreholes 14-2, 14-C-1 and 14-C-2) drilled south of the bridge.

The locations of the new boreholes were established in the field by PML. The ground surface elevations at the borehole locations were surveyed by MMM Group Limited.

The boreholes were advanced using continuous flight solid stem augers, powered by a track-mounted CME-55 and truck-mounted CME-75 drill rigs, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of PML's engineering staff.

Representative samples of the soils were recovered, at typical 0.75 m and 1.5 m depth intervals with closer spacings at selected locations, using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

Groundwater conditions at the borehole locations were assessed during and immediately after drilling by visual examination of soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in open boreholes. The boreholes were backfilled with a bentonite/cement mixture where required and abandoned in accordance with the MTO guidelines and MOE Reg. 903.

The recovered samples were returned to the PML laboratory for detailed visual examination, classification and routine moisture content determination. Atterberg Limits tests and grain size distribution analyses were conducted on selected samples, with the results presented in the attached Figures. The laboratory test results are also shown on the Record of Borehole sheets. The laboratory tests were conducted according to ASTM and MTO Standards.



4. SUMMARISED SUBSURFACE CONDITIONS

All elevations in this report are geodetic and expressed in metres.

Reference is made to the Record of Borehole sheets for details of the subsurface conditions including soil classification, inferred stratigraphy, boundary elevations, standard and dynamic cone penetration test data, in situ vane shear strength values and groundwater observations. The results of laboratory Atterberg limits testing, grain size distribution analyses and moisture content determination are also shown on the Record of Borehole sheets. The borehole locations are shown on Drawing LS-1.

The boundaries between soil strata have been established at the borehole locations only. Between and beyond the boreholes, the boundaries are assumed and may vary.

The following sections include detailed description of the subsurface conditions encountered at the borehole locations.

4.1 Asphalt

Boreholes 14-7, 14-9, 14-10, 14-LS-1 and 14-C-1 were drilled through the paved areas of the north and south bridge approaches and shoulders of Highway 400. Approximately 100 to 140 mm thick layer of asphalt was encountered at these locations and was penetrated at elevation 231.1 to 232.0 m.

An approximate 100 mm thick layer of asphalt was encountered in borehole 11-C1-02, which was drilled through the paved shoulder of Highway 400 NBL.



4.2 Topsoil

A surficial 300 to 330 mm thick sandy topsoil layer was encountered in boreholes 14-2, 14-8 and 14-C-2 and was penetrated at elevation 230.3 to 231.3 m.

A 200 mm thick layer of topsoil was encountered in borehole 14-10 at a depth of 2.0 m below ground surface, (elevation 229.9 m) and extended to a depth of 2.2 m below ground surface, (elevation 229.7 m).

A 700 mm thick surficial layer of topsoil was encountered below the existing ground surface in boreholes 11-C1-01 and 11-C1-03 which was penetrated at elevations 230.9 to 231.0 m.

4.3 Fill

Pavement fill was encountered in boreholes 14-7, 14-9, 14-10, 14-LS1 and 14-C-1 underlying the asphalt layer and extended to a depth varied from 0.6 to 0.8 m (elevation 230.8 to 231.3 m). Underlying the pavement fill, gravelly sand / sand and gravel fill was encountered and extended to a depth varied from 1.8 to 3.7 m (elevation 228.3 to 230.2 m). Silty clay fill trace sand trace gravel was encountered in borehole 14-8 underlying the topsoil layer and extended to a depth of 0.9 m (elevation 229.4 m). The silty clay fill was soft to stiff (SPT-“N” values of 4 and 11).

The noncohesive component of the fill was very loose to compact (SPT-‘N’ values of 3 to 30) and moist to wet (moisture contents of 6 to 22%).

Loose to compact silty sand to sand and silt fill was encountered below the asphalt (elevation 233.7 m) in borehole 11-C1-02 and extended to a depth of 3.7 m below the ground surface (elevation 230.1 m).



4.4 Silty Clay / Clayey Silt

Deposit of cohesive silty clay / clayey silt was encountered in boreholes 14-2, 14-10, 14-C-1 and 14-C-2 at a depth of 0.3 to 4.0 m (elevation 227.9 to 231.0 m) and extended to a depth of 4.5 to 7.3 m (elevation 224.6 to 226.6 m). The silty clay contained some organics in borehole 14-C-2 which extended to a depth of 4.7 m (elevation 226.6 m) below the surficial topsoil.

The silty clay / clayey silt was very soft to stiff in consistency (from self-weight of drill rods to SPT-“N” values of 1 to 14) and was moist to wet (moisture contents of 21 to 110%).

The results of Atterberg limits testing and grain size distribution analysis performed on the sample of the deposit are presented in Figures LS-PC-1 and LS-GS-4 respectively.

4.5 Silty Sand

Underlying the fill material at 0.9 to 1.8 m (elevation 229.4 to 230.2 m) in boreholes 14-8, 14-9 and 14-LS1 was cohesionless deposit of low organic content silty sand material with an average organic content of 2.1%. This material extended to a depth varied from 2.8 to 3.7 m (elevation 227.3 to 229.2 m).

Underlying the above material in boreholes 14-8, 14-9 and 14-LS1, a cohesionless soil stratum of silty sand was encountered at a depth varied between 2.8 to 3.7 m (elevation 227.3 to 229.2 m). The silty sand contained occasional layers of silty clay / clayey silt at some borehole locations. This stratum extended to the termination depth of 9.8 and 6.7 m in boreholes 14-9 and 14-LS1 (elevation 222.1 and 225.3 m) respectively and to a depth of 15.8 m in borehole 14-8 (elevation 214.5 m) at the start of the dynamic cone penetration testing.

A cohesionless soil stratum of silty sand was present in boreholes 14-2, 14-7, 14-10, 14-C-1 and 14-C-2 at depths of 0.9 to 7.0 m (elevation 225.0 to 230.2 m) interbedded with silty clay / clayey silt layers in boreholes 14-2 and 14-10. This stratum extended to the termination depth of 9.8 m in boreholes 14-7 and 14-10 (elevation 221.8 and 222.1 m) respectively and to the termination depth of 8.1 to 10.5 m (elevation 221.5 to 223.2 m) in boreholes 14-2, 14-C-1 and 14-C-2.



The noncohesive portion of the layer was very loose to compact (SPT-‘N’ values of 1 blow to 25) and was moist to wet (moisture contents of 17 to 54%).

The results of grain size distribution analyses performed on selected cohesionless samples of the stratum are presented in respective Figures LS-GS-1, LS-GS-2 and LS-GS-3.

Very loose to compact sand and silt to silt deposit was encountered in boreholes 11-C1-01, 11-C1-02, and 11-C1-03. This deposit was ranging in thickness between 3.0 to 3.8 m and extended to depths ranging from 4.2 to 7.5 m below the ground surface (elevations 226.8 to 226.3 m).

A 700 mm thick layer of loose sand was encountered below the topsoil in borehole 11-C1-03 and extended to a depth of 1.4 m (elevation 229.5 m). Very loose to very dense deposit of sand to silty sand was also encountered in boreholes 11-C1-01, 11-C1-02, and 11-C1-03 at depths of 3.7 to 4.4 m (elevation 226.3 to 226.8 m). This deposit ranged in thickness from 6.7 to 8.4 m and extended to the termination depth ranging from 11.1 to 14.2 m below the ground surface (elevations 218.4 to 219.8 m).

4.6 Groundwater

Water levels first observed in the boreholes during drilling and upon completion of drilling are summarized in the table 4.6(a) below.

Table 4.6(a) – Water Levels in Identified Boreholes

Borehole No.	Drilling Date	Groundwater Level (m)	
		Depth During Drilling / Elevation (m)	Depth upon Completion of Drilling / Elevation (m)
14-LS-1	November 3 and 4, 2014	0.9 / 231.1	2.7 / 229.3
14-7	November 6 and 7, 2014	2.6 / 229.0	231.6
14-8	November 24, 2014	0.9 / 229.4	–
14-9	November 3 and 4, 2014	1.4 / 230.5	3.1 / 228.8
14-10	November 4 and 5, 2014	0.8 / 231.1	2.1 / 229.8



Borehole No.	Drilling Date	Groundwater Level (m)	
		Depth During Drilling / Elevation (m)	Depth upon Completion of Drilling / Elevation (m)
14-2	November 26, 2014	2.3 / 228.8	2.1 / 229.0
14-C-1	November 12, 2014	2.1 / 229.9	2.1 / 229.9
14-C-2	November 26, 2014	4.7 / 226.6	4.6 / 226.7

The ground water levels recorded in borehole 11-C1-01, 11-C1-02, and 11-C1-03 are summarized in the table 4.6.b below.

Table 4.6(b) – Water Levels in Identified Additional Boreholes

Borehole No.	Drilling Date	Ground Water Level
		Depth / Elevation (m)
11-C1-01	December 21, 2011	4.6 / 226.4 ⁽¹⁾
11-C1-02	December 21, 2011	3.7 / 230.1 ⁽¹⁾
11-C1-03	December 21, 2011	3.0 / 227.9 ⁽¹⁾

Note: ⁽¹⁾ Recorded unstabilized water level

It is anticipated that the groundwater levels at the site are subject to seasonal fluctuations and rainfall patterns and is controlled by the creek level.



5. CLOSURE

The field work was carried out under the supervision of Mr. F. Portela and direction of Mr. K. Daly, B.Eng Project Supervisor, Geotechnical Services. The equipment was supplied by Canadian Soils Drilling.

This report was prepared by Ms. Souzan Dabbagh, MEng, P.Eng., Project Engineer, Geotechnical Services, and reviewed by Mr. David Dundas, P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

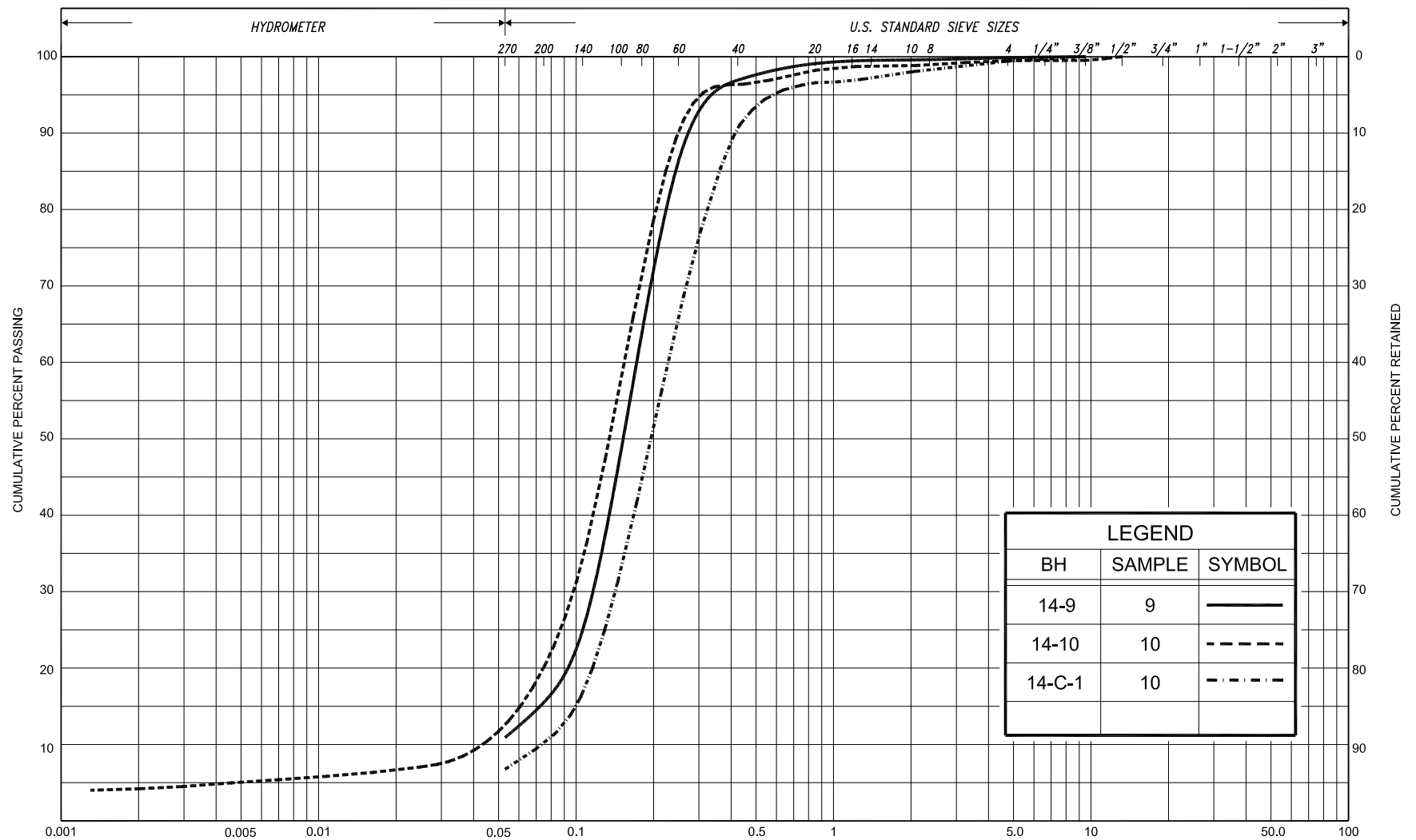


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Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng.
Project Manager and
MTO Designated Principal Contact

DD/CN:dd-mi-jk



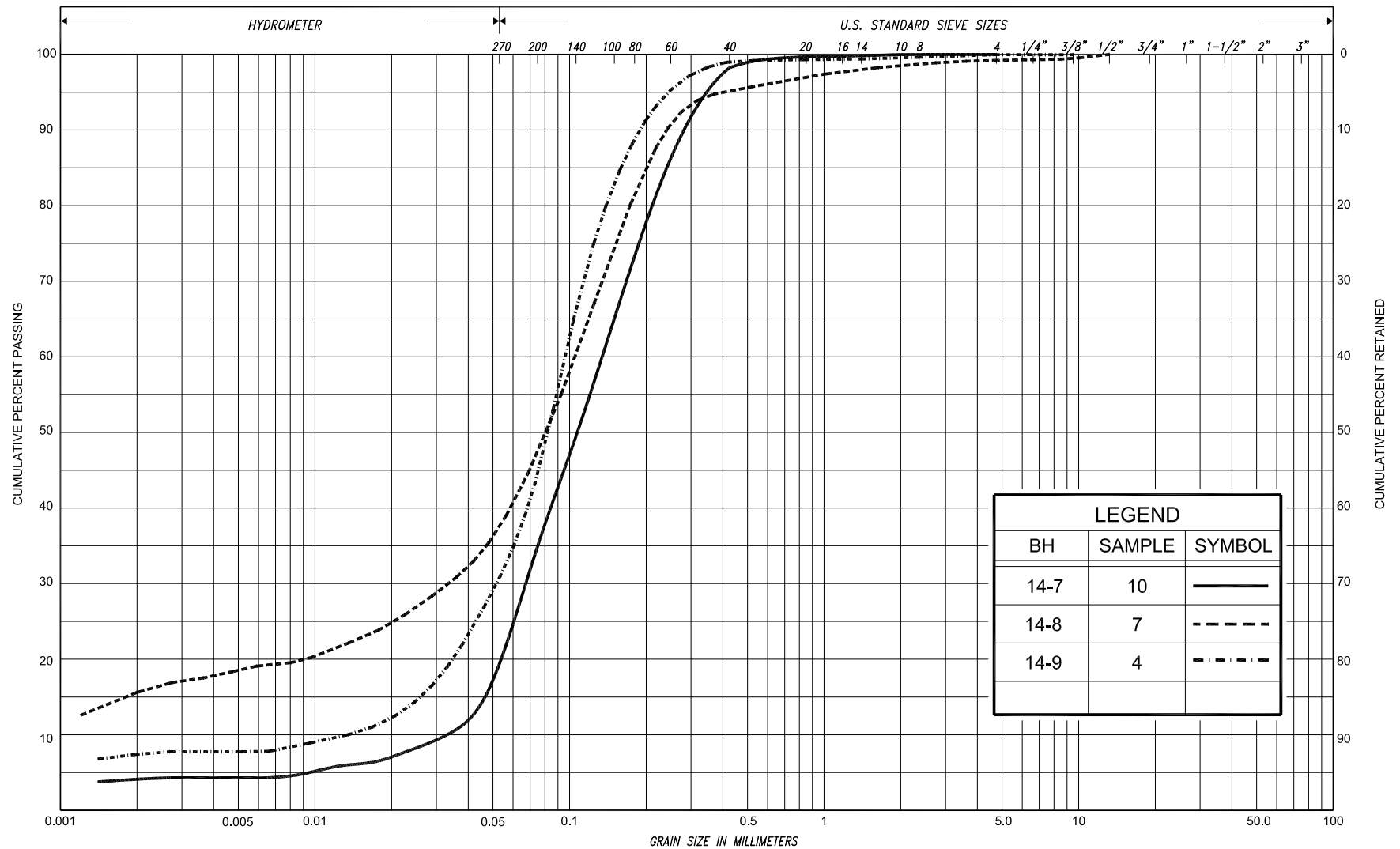
SILT & CLAY				FINE			MEDIUM		COARSE	GRAVEL		COBBLES	UNIFIED
							SAND						
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE				GRAVEL		COBBLES	M.I.T.
							SILT						
CLAY		SILT		V. FINE	FINE	MED.	COARSE			GRAVEL			U.S. BUREAU
				SAND									

GRAIN SIZE DISTRIBUTION

SAND, trace to some silt, trace clay, trace gravel

FIG No.	LS-GS-1
HWY:	400 / 11
G.W.P. No.	2360-10-00





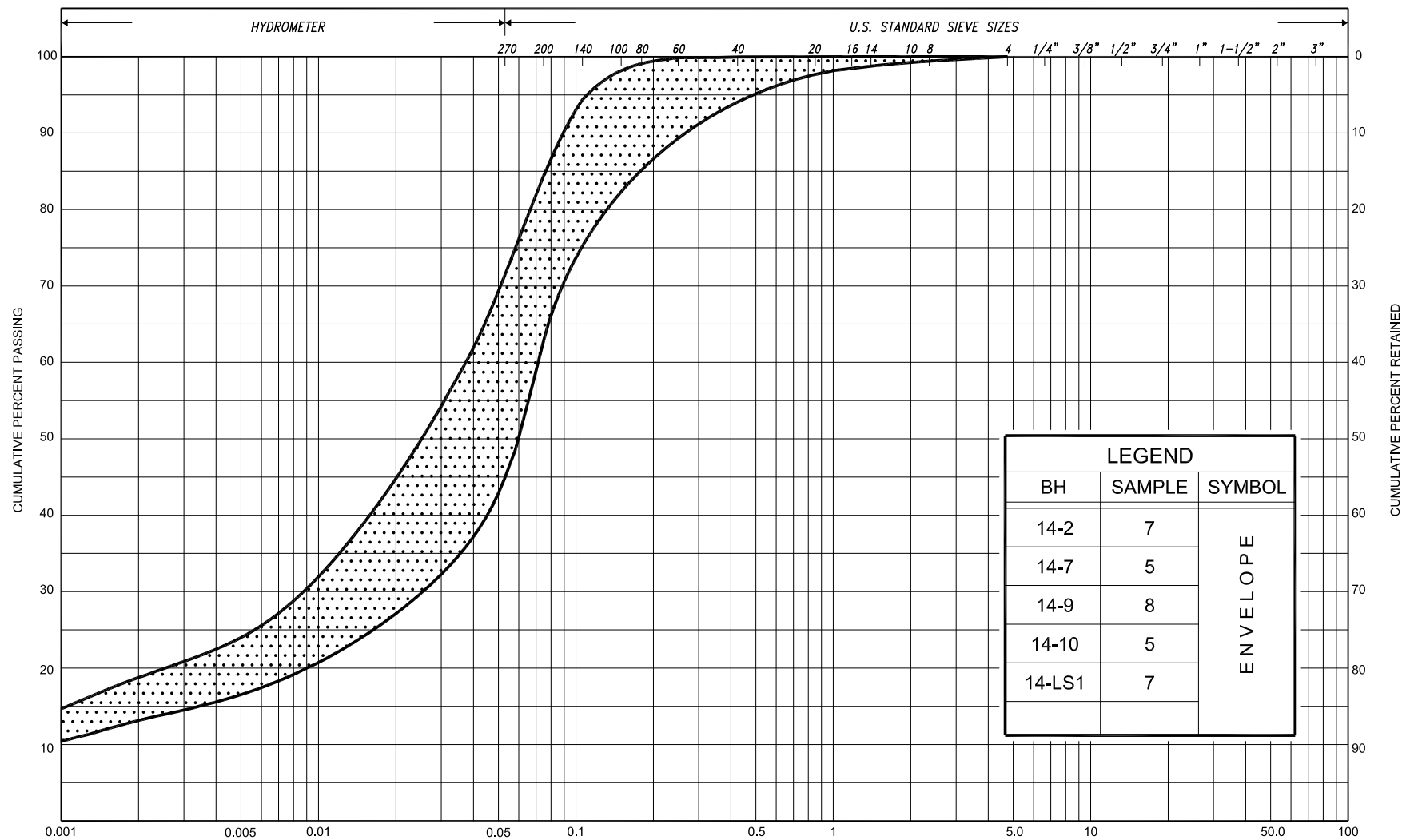
SILT & CLAY				FINE			MEDIUM		COARSE	GRAVEL		COB BLES	UNIFIED
							SAND						
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	SAND			GRAVEL		COBBLES	M.I.T.
CLAY		SILT		V. FINE	FINE	MED.	COARSE	SAND		GRAVEL			U.S. BUREAU

GRAIN SIZE DISTRIBUTION

SILTY SAND, trace to some clay, trace gravel

FIG No.	LS-GS-2
HWY:	400 / 11
G.W.P. No.	2360-10-00





SILT & CLAY				FINE SAND			COARSE SAND	GRAVEL	COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL			M.I.T.
	SILT			V. FINE	FINE	MED.	COARSE	GRAVEL		
CLAY		SILT		SAND				GRAVEL		

U.S. BUREAU



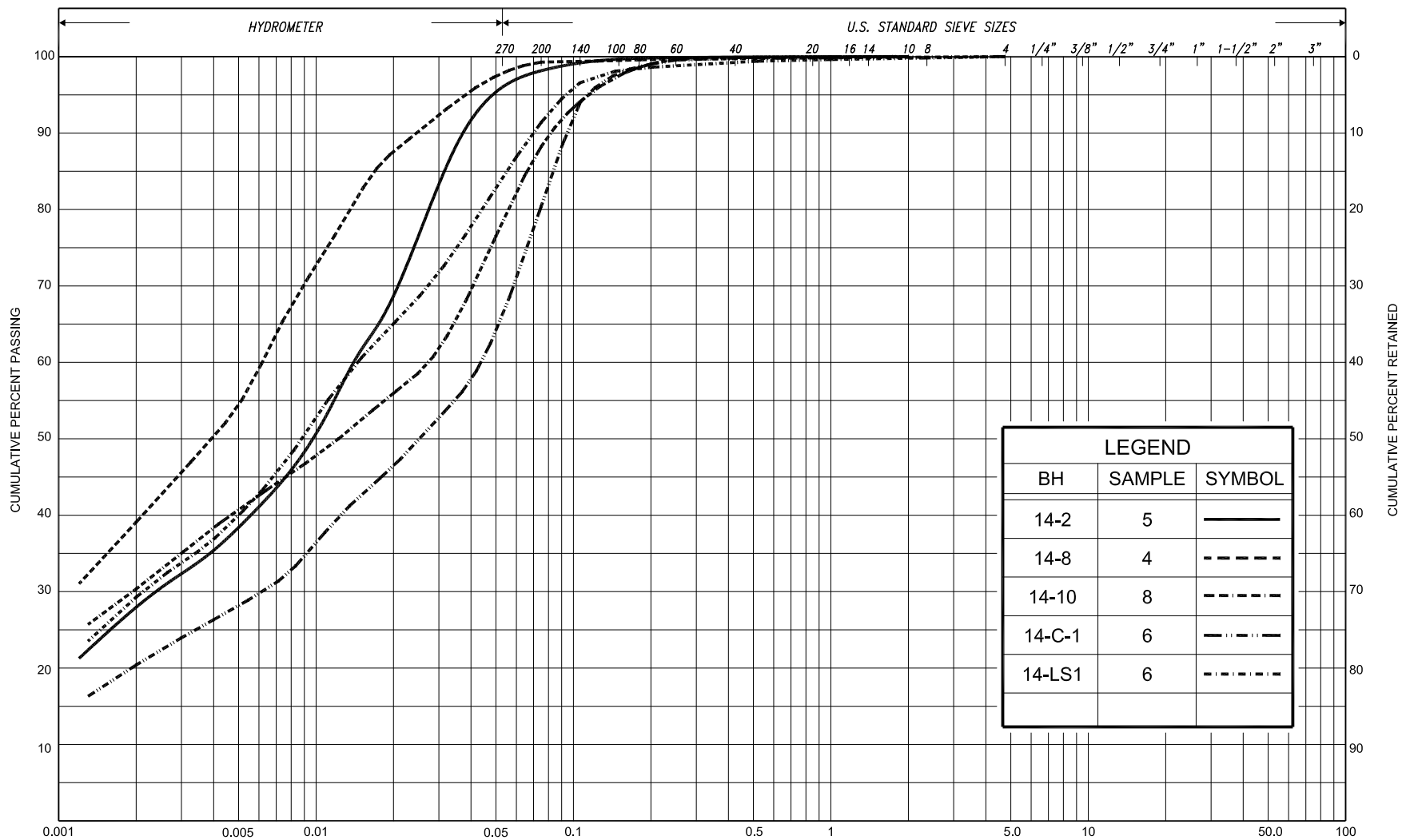
GRAIN SIZE DISTRIBUTION

SILT, some sand to SANDY, some clay

FIG No. LS-GS-3

HWY: 400 / 11

G.W.P. No. 2360-10-00



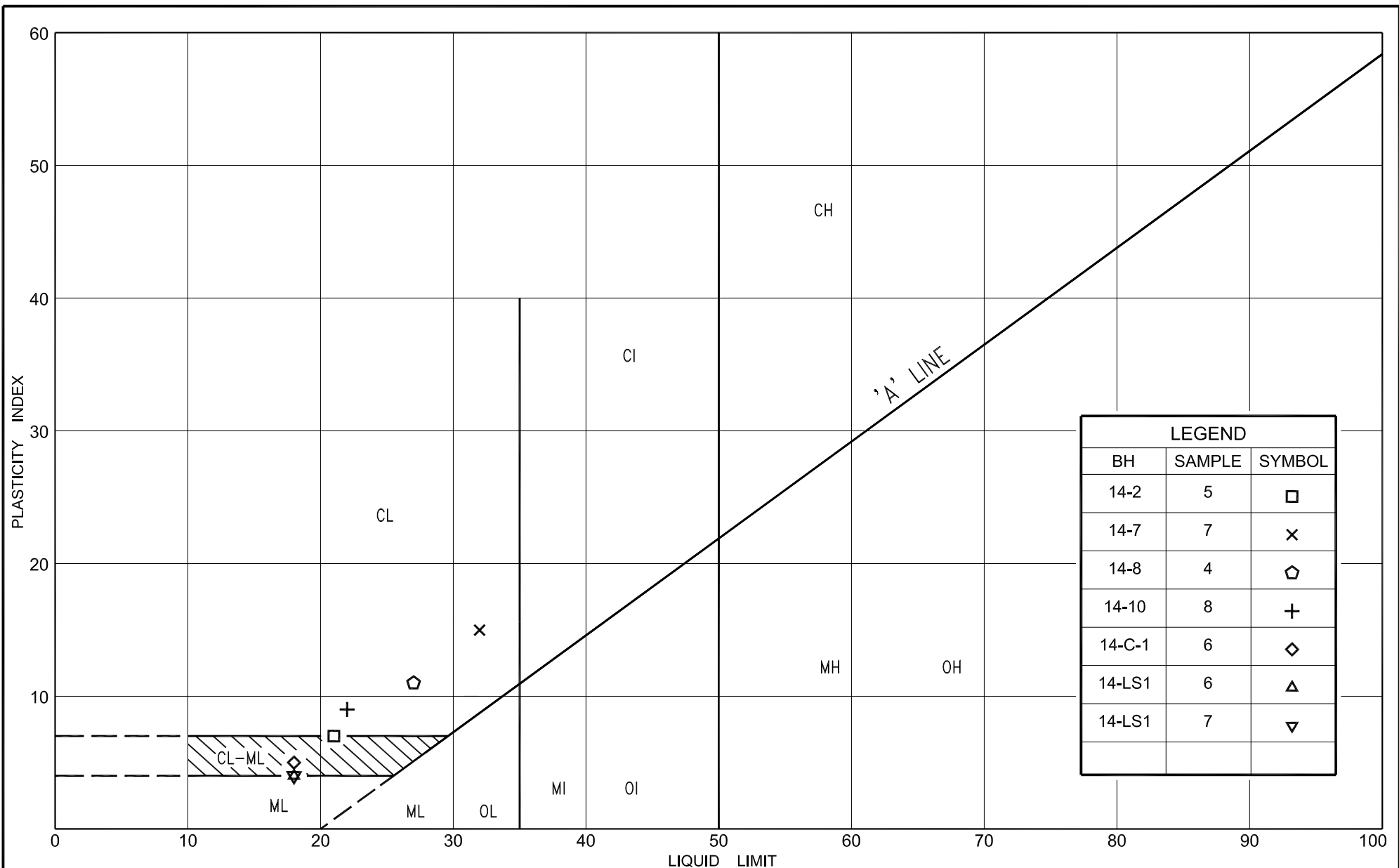
SILT & CLAY				FINE		MEDIUM		COARSE		GRAVEL				COBBLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE		SAND				GRAVEL				COBBLES	M.I.T.
							FINE		MEDIUM							
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL					U.S. BUREAU
						SAND										

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, trace sand (CL / CL-ML)

FIG No. LS-GS-4
 HWY: 400 / 11
 G.W.P. No. 2360-10-00





PLASTICITY CHART CLAYEY SILT, trace sand (CL / CL-ML)

FIG No.	LS-PC-1
HWY:	400 / 11
G.W.P. No.	2360-10-00

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE
F V FIELD VANE	

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No 14-LS1

1 of 1

METRIC

G.W.P. 2360-10-00 LOCATION Coords: 4 920 646.7 N; 292 666.6 E ORIGINATED BY F.P.
DIST Central HWY 400 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY S.D.
DATUM Geodetic DATE November 03 & 04, 2014 CHECKED BY D.D.

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 (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL						× LAB VANE		
232.0	Ground Surface						20	40	60	80	100									
0.0	140mm asphalt over sand and gravel		1	SS	30	▽*														
	(PAVEMENT FILL)																			
231.2	Sand, trace gravel		2	SS	16															
0.8	Compact to Brown Moist loose					▽*														
	(FILL)		3	SS	9															
230.2	Silty sand, some clay organics																			
1.8	Loose to Dark Moist very loose grey		4	SS	4	▽*														
	(ALLUVIUM)																			
229.2	Silty sand		5	SS	12															
2.8	Compact to Grey Wet very loose					▽*														
	clayey silt layers		6	SS	2															
			7	SS	9	▽*														
	silt layer some sand, some clay																			
	Loose to compact																			
225.3			8	SS	25	▽*														
6.7	End of borehole																			

* 2014 11 03 & 04

▽ Water level observed during drilling

▼ Water level measured after drilling

RECORD OF BOREHOLE No. 14-C-1

1 of 2

METRIC

G.W.P.	2360-10-00	LOCATION	Coords: 4 920 445.8 N; 292 601.6 E	ORIGINATED BY	F.P.
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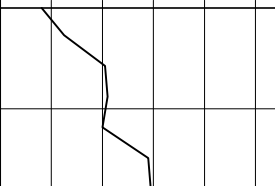


DIST Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.

DATUM Geodetic **DATE** November 05 & 06, 2014 **CHECKED BY** D.D.

[illegible]

RECORD OF BOREHOLE No. 14-C-1
2 of 2
METRIC

G.W.P. 2360-10-00 **LOCATION** Coords: 4 920 445.8 N; 292 601.6 E **ORIGINATED BY** F.P.
DIST Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.
DATUM Geodetic **DATE** November 05 & 06, 2014 **CHECKED BY** D.D.

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										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
217.0								20	40	60	80	100								
15.0	Dynamic cone penetration test (Cont'd.)						216													
215.2																				
16.8	End of dynamic cone penetration test																			
	<div>* 2014 11 05 & 06</div> <div> Water level observed during drilling</div> <div> Water level measured after drilling</div> <div>WH** denotes penetration due to weight of rods and hammer</div>																			

RECORD OF BOREHOLE No. 14-C-2

1 of 1

METRIC

G.W.P. 2360-10-00 **LOCATION** Coords: 4 920 368.7 N; 292 596.1 E **ORIGINATED BY** F.P.
DIST Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** S.D.
DATUM Geodetic **DATE** November 26, 2014 **CHECKED BY** D.D.

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										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
231.3	Ground Surface																			
0.0 231.0	Topsoil																			
0.3	Silty clay, organincs		1	SS	3		231													
	Firm to Dark Wet very soft brown																			
	(ALLUVIUM)		2	SS	4		230							110						
			3	SS	2		229							89						
228.5	Silty clay		4	SS	3															
2.8	organic sand layers																			
	Very soft Grey Wet to firm		5	SS	WH**		228													
				FV				2												
			6	SS	WH															
				FV			227													
226.6	Silty sand, trace clay		7	SS	6				2											
4.7	Loose to Grey Wet very loose						226													
	silty clay seams		8	SS	2															
	trace gravel						225													
	Compact Grey Wet		9	SS	16															
							224													
			10	SS	20															
223.2	End of borehole																			
8.1																				

* 2014 11 26
 ▽ Water level observed during drilling
 ▼ Water level measured after drilling
 WH** denotes penetration due to weight of rods and hammer

RECORD OF BOREHOLE No. 14-2

1 of 1

METRIC

G.W.P. 2360-10-00 **LOCATION** Coords: 4 920 466.6 N; 292 641.9 E **ORIGINATED BY** F.P.
DIST Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** S.D.
DATUM Geodetic **DATE** November 26, 2014 **CHECKED BY** D.D.

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									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
231.1	Ground Surface						20	40	60	80	100						
0.0 230.8	Topsoil		1	SS	3												
0.3	Sand, trace silt layers																
230.2	Loose Dark Moist Grey (FILL)		2	SS	6												
0.9	Silty sand topsoil inclusions																
	Very loose Grey Wet		3	SS	3												
			4	SS	2												
228.1	Clayey silt, trace sand		5	SS	1												
3.0	Very soft Grey Wet to firm		6	SS	5												
			7	SS	1												
226.6	Silty sand, some clay occasional silt layers																
4.5	Very loose Grey Wet to compact		8	SS	6												
			9	SS	6												
	some gravel																
			10	SS	13												
222.9	End of borehole																
8.2																	
	* 2014 11 26																
	▽ Water level observed during drilling																
	▾ Water level measured after drilling																

* 2014 11 26
 ▽ Water level observed during drilling
 ▼ Water level measured after drilling

RECORD OF BOREHOLE No 14-7

1 of 3

METRIC

G.W.P. 2360-10-00 LOCATION Coords: 4 920 556.3 N; 292 622.5 E ORIGINATED BY F.P.
DIST Central HWY 400 BOREHOLE TYPE C.F.S.S.A. and Mud Rotary + Dynamic Cone Penetration test COMPILED BY S.D.
DATUM Geodetic DATE November 06 & 07, 2014 CHECKED BY D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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									
							○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
231.6	Ground Surface						20	40	60	80	100					
0.0	140mm asphalt over sand and gravel		1	SS	19											
	(PAVEMENT FILL)															
230.8	Sand and gravel trace silt		2	SS	8											
0.8	Loose Brown Moist															
	(FILL)		3	SS	4											
229.0	Silty sand, some clay		4	SS	3											
2.6	Very loose Grey Wet to compact															
	occasional silt layer		5	SS	5											
			6	SS	4											
	silty clay layers		7	SS	11											
	Loose to very loose		8	SS	7											
			9	SS	3											
	trace clay															
			10	SS	7											
221.8	Switched to dynamic cone penetration test															
9.8																

RECORD OF BOREHOLE No 14-7

2 of 3

METRIC

G.W.P.	2360-10-00	LOCATION	Coords: 4 920 556.3 N; 292 622.5 E	ORIGINATED BY	F.P.
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DIST Central HWY 400 BOREHOLE TYPE C.F.S.S.A.and Mud Rotary + Dynamic Cone Penetration test COMPILED BY S.D.

DATUM Geodetic DATE November 06 & 07, 2014 CHECKED BY D.D.

[illegible]

RECORD OF BOREHOLE No 14-7

3 of 3

METRIC

G.W.P. 2360-10-00 LOCATION Coords: 4 920 556.3 N; 292 622.5 E ORIGINATED BY F.P.
DIST Central HWY 400 BOREHOLE TYPE C.F.S.S.A. and Mud Rotary + Dynamic Cone Penetration test COMPILED BY S.D.
DATUM Geodetic DATE November 06 & 07, 2014 CHECKED BY D.D.

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 (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE						LAB VANE		
201.6								20	40	60	80	100								
30.0	Dynamic cone penetration test (Cont'd.)							20	40	60	80	100								
							201													
							200													
							199													
198.3	End of dynamic cone penetration test																			
33.3																				

RECORD OF BOREHOLE No. 14-8
1 of 3
METRIC

G.W.P. 2360-10-00 **LOCATION** Coords: 4 920 529.1 N; 292 680.3 E **ORIGINATED BY** F.P.
DIST Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.
DATUM Geodetic **DATE** November 24, 2014 **CHECKED BY** D.D.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m³	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 40 60		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
230.3	Ground Surface																		
0.0	Topsoil		1	SS	4	V*	230												
	Silty clay trace sand, trace gravel																		
229.4	Soft to Brown Moist firm (FILL)		2	SS	11		229												
	Silty sand, orgaincs																		
	Loose to Black Wet very loose (ALLUVIUM)		3	SS	8														
			4	SS	2		228												
	clayey silt layer																		
227.3				FV															
3.0	Silty sand, trace gravel silty clay seams to 5.0m depth		5	SS	9		227												
	Very loose Grey Wet to compact		6	SS	1														
				FV			226												
			7	SS	9														
			8	SS	6		225												
			9	SS	11	224													
						223													
						222													
						221													
						220													
						219													
						218													
						217													
						216													
215.3																			

RECORD OF BOREHOLE No. 14-8

2 of 3

METRIC

G.W.P.	2360-10-00	LOCATION	Coords: 4 920 529.1 N; 292 680.3 E	ORIGINATED BY	F.P.
---------------	------------	-----------------	------------------------------------	----------------------	------

DIST Central **HWY** 400 **BOREHOLE TYPE** C.F.S.S.A. and Dynamic Cone Penetration Test **COMPILED BY** S.D.

DATUM Geodetic **DATE** November 24, 2014 **CHECKED BY** D.D.

[illegible]

RECORD OF BOREHOLE No. 14-8

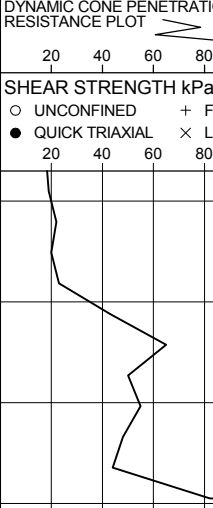
3 of 3

METRIC

G.W.P.	2360-10-00	LOCATION	Coords: 4 920 529.1 N; 292 680.3 E	ORIGINATED BY	F.P.
---------------	------------	-----------------	------------------------------------	----------------------	------

DIST	Central	HWY	400	BOREHOLE TYPE	C.F.S.S.A. and Dynamic Cone Penetration Test	COMPILED BY	S.D.
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DATUM	Geodetic	DATE	November 24, 2014	CHECKED BY	D.D.
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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					WATER CONTENT (%)									
						○ UNCONFINED	● QUICK TRIAXIAL			+	×	FIELD VANE	LAB VANE							
200.3	Dynamic cone penetration test (Cont'd.)						200		20	40	60	80	100	20	40	60				
30.0																				
196.8																				
33.5																				
197																				
304	120/2cm																			
* 2014 11 24																				
▽ Water level observed during drilling																				

RECORD OF BOREHOLE No 14-9

1 of 1

METRIC

G.W.P. 2360-10-00 LOCATION Coords: 4 920 570.7 N; 292 638.8 E ORIGINATED BY F.P.
DIST Central HWY 400 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY S.D.
DATUM Geodetic DATE November 03 & 04, 2014 CHECKED BY D.D.

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED + FIELD VANE													
								● QUICK TRIAXIAL × LAB VANE													
							WATER CONTENT (%)														
							20 40 60 80 100					20 40 60									
231.9	Ground Surface																				
0.0	140mm asphalt over sand and gravel		1	SS	23																
	(PAVEMENT FILL)																				
231.1	Sand and gravel organic seams		2	SS	17		231														
0.8	Compact Brown Wet																				
230.1	Sandy silt		3	SS	14		230														
1.8	Compact Grey Wet																				
	(FILL)																				
	Silty sand, some clay orgaincs		4	SS	6																
	Loose to Dark Moist						229										0 56 36 8				
	very loose brown																				
	(ALLUVIUM)		5	SS	3																
228.2	Silty sand						228														
3.7	Loose to Grey Wet		6	SS	4																
	compact																				
	silty clay layers		7	SS	20		227														
							226														
	sandy silt, some clay		8	SS	4												0 37 47 16				
	Loose Grey Wet			FV			225														
							224										0 84 (16)				
	sand layer		9	SS	3																
	some silt, trace clay																				
	Very loose Grey Wet						223														
	to compact		10	SS	23																
222.1	End of borehole																				
9.8																					

* 2014 11 03 & 04

▽ Water level observed during drilling

▼ Water level measured after drilling

RECORD OF BOREHOLE No 14-10

1 of 1

METRIC

G.W.P. 2360-10-00 **LOCATION** Coords: 4 920 546.9 N; 292 677.4 E **ORIGINATED BY** F.P.
DIST Central **HWY** 400 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** S.D.
DATUM Geodetic **DATE** November 04 & 05, 2014 **CHECKED BY** D.D.

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									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
231.9	Ground Surface						20	40	60	80	100						
0.0	140mm asphalt over sand and gravel		1	SS	19	▽*											
231.3	----- (PAVEMENT FILL) -----		2	SS	14												
0.6	Sand and gravel		3	SS	20												
	Compact Brown Wet																
	(FILL)																
229.9	Topsoil					▼											
2.0																	
229.7	Silty sand silt seams		4	SS	24												
2.2	Compact Grey Wet																
	seams of silt with sand, some clay		5	SS	8												
	Loose Grey Wet																
227.9	Clayey silt, trace sand		6	SS	WH**												
4.0	Very soft Grey Wet to stiff			FV													
			7	SS	14												
			8	SS	1												
				FV													
224.6	Silty sand trace clay, trace gravel																
7.3	Loose to Grey Wet compact		9	SS	9												
	sand layer, some silt																
			10	SS	13												
222.1	End of borehole																
9.8																	
* 2014 11 04 & 05																	
▽ Water level observed during drilling																	
▼ Water level measured after drilling																	
WH** denotes penetration due to weight of rods and hammer																	

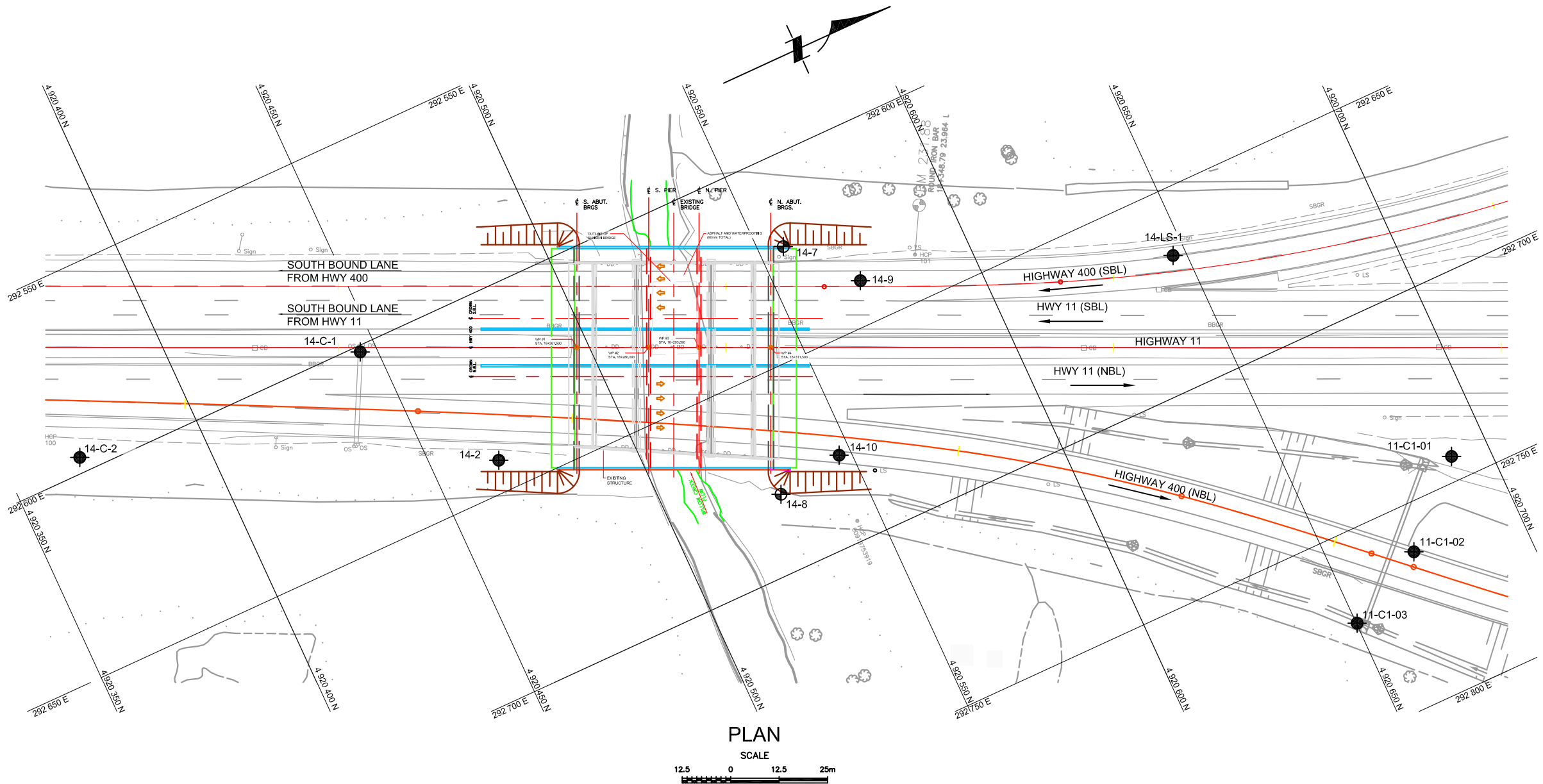
CONT No
GWP No 2360-10-00



LIGHTING POLES AND SIGNS
HIGHWAY 400/11
BOREHOLE LOCATIONS

SHEET

PML Peto MacCallum Ltd.
CONSULTING ENGINEERS



LEGEND			
	Borehole		
	Borehole and Cone		
	Geocres Borehole (31D-548)		
N	Blows/0.3m (Std. Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60' Cone, 475 J/blow)		
	WL at time of investigation Nov. 2014		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		

BH No	ELEVATION	NORTHINGS	EASTINGS
14-2	231.1	4 920 466.6	292 641.9
14-7	231.6	4 920 556.3	292 622.5
14-8	230.3	4 920 529.1	292 680.3
14-9	231.9	4 920 570.7	292 638.8
14-10	231.9	4 920 546.9	292 677.4
14-C-1	232.0	4 920 445.8	292 601.6
14-C-2	231.3	4 920 368.7	292 596.1
14-LS-1	232.0	4 920 646.7	292 666.6
11-C1-01	231.0	4 920 690.3	292 743.7
11-C1-02	233.8	4 920 671.2	292 762.0
11-C1-03	230.9	4 920 650.2	292 772.6

NOTE
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.



REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31D-629			
HWY No	400 / 11	DATE	NOV. 05, 2015
SUBM'D	NA	CHECKED	DS
DRAWN	NA	CHECKED	NR
		APPROVED	CN
			DWG LS-1

Ref. Drawing: S3212095-309-011GA-Replacement dated December 2014

- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
 - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
 - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



APPENDIX A

Record of Previous Borehole Sheets – Boreholes 11-C1-01 to 11-C1-03

PROJECT		RECORD OF BOREHOLE		No 11-C1-01		SHEET 1 OF 2		METRIC					
G.W.P.		LOCATION		ORIGINATED BY									
DIST		BOREHOLE TYPE		COMPILED BY									
DATUM		DATE		CHECKED BY									
09-1111-0022		N 4920690.3 ; E 292743.7		DD									
2079-10-00		D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger		NLP									
Central HWY 400		December 21, 2011		TVA/RA									
Geodetic													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	GR SA SI CL
231.0	GROUND SURFACE												
0.0	TOPSOIL Brown		1	SS	11								
230.3													
0.7	SAND and SILT to Sandy SILT, trace to some clay, trace gravel Loose to compact Grey Wet		2	SS	12		230						
			3	SS	5		229						4 45 41 10
			4	SS	22		228						
			5	SS	5								0 27 63 10
226.8			6	SS	18		227						
4.2	SAND, trace to some silt, trace clay Loose Brown to grey Wet		7	SS	9		226						
			8	SS	7		225						0 86 9 5
			9	SS	7		224						
			10	SS	7		223						
			11	SS	14		222						
			12	SS	4		221						
218.4							220						
12.6	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						219						
							218						
							217						

Continued Next Page

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

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 6/19/12 DD/SAC

PROJECT <u>09-1111-0022</u>		RECORD OF BOREHOLE No 11-C1-01		SHEET 2 OF 2		METRIC											
G.W.P. <u>2079-10-00</u>		LOCATION <u>N 4920690.3 ; E 292743.7</u>		ORIGINATED BY <u>DD</u>													
DIST <u>Central</u> HWY <u>400</u>		BOREHOLE TYPE <u>D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger</u>		COMPILED BY <u>NLP</u>													
DATUM <u>Geodetic</u>		DATE <u>December 21, 2011</u>		CHECKED BY <u>TVA/RA</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					W _p	W			W _L
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
215.2	END OF DCPT																
15.8	NOTES: 1. Unstabilized water level measured at a depth of 4.6 m (Elev. 226.4 m) below ground surface upon completion of drilling.																

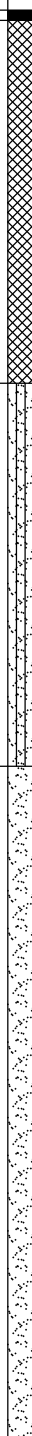



PROJECT 09-1111-0022

G.W.P. 2079-10-00 LOCATION N 4920671.2 ;E 292762.0 ORIGINATED BY DD

DIST Central HWY 400 BOREHOLE TYPE D-50 Track-Mount, 108 mm Diameter Hollow Stem Auger COMPILED BY NLP

DATUM Geodetic DATE December 20, 2011 CHECKED BY TVA/RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED											
233.8 0.9 0.1	GROUND SURFACE ASPHALT (100 mm) Silty sand to sand and silt, trace to some clay, trace to some gravel, occasional cobbles (FILL) Loose to compact Brown Moist to wet		1	SS	15	▽													
			2	SS	29														
230.1 3.7	SAND and SILT to SILT, trace to some clay Very loose to compact Grey Wet		4	SS	3														
			5	SS	8														
			6	SS	3														
			7	SS	13														
			8	SS	2														
226.3 7.5	SAND, trace silt, trace to some gravel Compact to very dense Brown Wet		9	SS	13														

Continued Next Page

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



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

GTA-MTO 001 09-1111-0022.GPJ GAL-MISS.GDT 6/19/12 DD/SAC



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



FOUNDATION DESIGN REPORT

For

**LIGHTING POLES AND SIGNS
WILLOW CREEK BRIDGE
HIGHWAY 400
GWP NO. 2360-10-00
BARRIE, ONTARIO**

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FOUNDATION DESIGN REPORT

for

Lighting Poles and Signs
Willow Creek Bridge
Highway 400
GWP No. 2360-10-00
Barrie, Ontario

1. INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of the foundations for the proposed six (6) Lighting Poles foundations, the Overhead and the Structural Support Ground Mounted Signs along Highway 400 in the vicinity of the existing Willow Creek Bridge.

Willow Creek Bridge is located about 500 m south of the existing overpass structure at the Highway 400/Highway 11 interchange at the north end of the City of Barrie.

Three (3) lighting poles are located along the Northbound Lane (NBL) and ramp shoulders and three (3) lighting poles are located along the Southbound Lane (SBL) and ramp shoulders. Refer to the Contract Documents for lighting poles locations.

The sign locations are on the NBL's south of Willow Creek Bridge. Refer to the Contract Documents for sign locations. The proposed location of the Overhead Sign is Station 18+237 with one footing at approximately 1.5 m left (west) of the existing Highway 400 NBL shoulder with one footing at approximately 7.5 m right (east) of the existing Highway 400 NBL shoulder. The proposed location of the Structural Support Ground Mounted Sign is Station 18+137. The edge of this sign is at approximately 8.5 m right (east) of the existing Highway 400 NBL shoulder.

2. FOUNDATION DESIGN

2.1 Lighting Poles Foundations

Lighting pole foundations can be designed in conformance with the MTO report titled 'Guidelines for the Design of High Mast Pole Foundations', Fourth Edition, dated May 2004. Geotechnical parameters at the borehole locations are summarized in Table 2.1(a) below. Parameters from the borehole in closest proximity to the lighting poles or sign foundation should be used for design. The groundwater table should be assumed to be at elevation 230.0 m. Resistance within the frost zone should be discounted in the design.



Where a caisson is installed in proximity of a slope, the passive resistance within portions of the caisson closer than 3 m in plan to surface of the slope, should be neglected.

Where an undrained shear strength, c_u , is provided in Table 2.1(a), the undrained capacity of the caisson should be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within cohesive soil should be calculated assuming an internal angle of friction, $\phi' = 0$ degrees and an unfactored passive lateral pressure distribution equivalent to nine times the undrained shear strength acting over the actual width of the caisson.

Table 2.1(a) – Soil Parameters for Lighting Pole Foundation Design

Borehole No. / Lighting Poles	Borehole Ground Surface Elevation (m)	Soil Strata	Strata Elevation (m)	c_u (kPa)	Φ' (Deg)	γ_{bulk} (kN/m ³)
14-LS-1 / (LS-E & LS-F)	232.0	Non-cohesive Fill	~ 232.0 – 230.2	–	28	20
		Silty Sand (Alluvium)	230.2 – 229.2	–	27	17
		Silty Sand (v. loose to compact)	229.2 – 225.3	–	28	19
14-7 / (LS-A)	231.6	Non-cohesive Fill	~ 231.6 – 229.0	–	28	20
		Silty Sand (v. loose to compact)	229.0 – 218.0	–	28	19
		A layer penetrated by DCPT (blows generally greater than 20).	218.0 – 198.3	–	30	20
14-8 / (LS-B)	230.3	Silty Clay Fill	~ 230.0 – 229.4	15	27	16
		Silty Sand (Alluvium)	229.4 – 227.3	–	27	17
		Silty Sand (DCPT below Elev. 214.5 m) (v. loose to compact)	227.3 – 200.0	–	28	19
		A layer penetrated by DCPT (blows generally greater than 20).	200.0 – 196.8	–	30	20
14-9 / (LS-A)	231.9	Non-cohesive Fill	~ 231.9 – 230.1	–	28	20
		Silty Sand (Alluvium)	230.1 – 228.2	–	27	17
		Silty Sand (v. loose to compact)	228.2 – 222.1	–	28	19
14-10 / (LS-B)	231.9	Non-cohesive Fill	~ 231.9 – 229.7	–	28	20
		Silty Sand (loose to compact)	229.7 – 227.9	–	28	19
		Clayey Silt (v. soft to stiff)	227.9 – 224.6	15	27	16
		Silty Sand (loose to compact)	224.6 – 222.1	–	28	19
14-2 / (Signs)	231.1	Non-cohesive Fill	~ 231.1 – 230.2	–	28	20
		Silty Sand (v. loose)	230.2 – 228.1	–	27	17
		Clayey Silt (v. soft to firm)	228.1 – 226.6	15	27	16
		Silty Sand (v. loose to compact)	226.6 – 222.9	–	28	19



Borehole No. / Lighting Poles	Borehole Ground Surface Elevation (m)	Soil Strata	Strata Elevation (m)	c_u (kPa)	Φ' (Deg)	γ_{bulk} (kN/m ³)
14-C-1 / (Signs)	232.0	Non-cohesive Fill	~ 232.0 – 228.3	–	28	20
		Clayey Silt (Soft to Stiff)	228.3 – 225.0	40	28	18
		Silty Sand (v. loose to compact)	225.0 – 221.5	–	28	19
14-C-2 / (Signs)	231.3	Silty Clay (Alluvium)	231.0 – 228.5	10	25	16
		Silty Clay (v. soft to firm)	228.5 – 226.6	20	26	16
		Silty Sand (v. loose to compact)	226.6 – 223.2	–	28	19
11-C1-01 / (LS-C & LS-D)	231.0	Sand and Silt to Sandy Silt (loose to compact)	230.3 – 226.8	–	29	20
		Sand (loose to compact)	226.8 – 215.2	–	29	20
11-C1-02 / (LS-C & LS-D)	233.8	Non-cohesive Fill	233.7 – 230.1	–	28	20
		Sand and Silt to Silt (v. loose to compact)	230.1 – 226.3	–	28	19
		Sand (compact to very dense)	226.3- 219.6	–	31	20
11-C1-03 / (LS-C & LS-D)	230.9	Sand (loose)	230.2 – 229.5	–	28	20
		Sand and silt (loose to compact)	229.5 – 226.5	–	28	20
		Silty Sand (v. loose to compact)	226.5 – 219.8	–	28	19

Legend:

c_u = Unconfined shear strength of cohesive soils (kPa)

Φ = Angle of internal friction of cohesionless soils (Degrees)

γ_{bulk} = Estimated in-situ unit weight (kN/m³)

Notes:

(1) For soils below the groundwater level, submerged unit weight, i.e., $\gamma_{submerged} = \gamma_{bulk} - \gamma_{water}$ should be used.

(2) Although the passive resistance in the upper 1.4 m is neglected to account for frost action, geotechnical design parameters are provided, in the event that the ground surface varies significantly between the typical stratigraphy profile and the final structure location.



The coefficient of horizontal subgrade reaction K_h for cohesive soils should be computed using the following formula:

$$K_h = \frac{n_1 n_2 80 q_u}{D}$$

where D = Diameter of caisson (m)
 q_u = Unconfined compressive strength (kPa)
 n_1 = Coefficient as defined below:

Unconfined Compressive Strength q_u (kPa)	n_1
< 50	0.32
50 to 200	0.36
> 200	0.40

n_2 = Coefficient based on pile material. Use 1.15 for concrete

For cohesionless soils, the coefficient of horizontal subgrade reaction K_h should be computed using the following formula:

$$K_h = \frac{n_h Z}{D}$$

where D = Diameter of caisson (m)
 Z = Depth below ground surface (m)
 n_h = Coefficient (kN/m³) evaluated as follows:

Relative Density	n_h (x 1000) (kN/m ³)	
	Above Groundwater	Below Groundwater
Loose	2.5	1.2
Compact	6.5	4.5
Dense	17.5	10.5

For installation of lighting poles and signs, the groundwater levels at this site are to be considered within 1.0 m of the ground surface.

Where required to raise the grade at the pole locations, 50% of the calculated horizontal resistance from the fill material should be assumed.

The frost protection depth is 1.5 m. The lateral resistance of the material within the frost depth should be ignored.



2.2 Sign Foundations

Sign foundations may be designed in accordance with the MTO Sign Support Manual (dated April 2015).

3. FOUNDATION CONSTRUCTION

Caissons should be installed in accordance with the requirements of OPSS 903. Pile caps, if any, should be provided with at least 1.5 m of earth cover or equivalent thermal insulation as protection against frost action.

In case that the lighting poles and signs will be founded on cast-in-place concrete drilled caissons, difficulties and delays in drilling may be encountered due to the presence of cohesionless material and the high ground water levels which will require mud drilling and tremie concreting methods for installation. The NSSP in Appendix 1 should be included in Contract Documentation.

It is anticipated that the existing ground surface at the pole and signs locations will not be altered significantly. If excavations into the fill embankments are required during construction, the existing fill should be considered Type 3 soil according to the Occupational Health and Safety Act (OHSA) 1990 and Regulation 213/1991 for Construction Projects.



4. CLOSURE

This report was prepared by Ms. Souzan Dabbagh, MEng, P.Eng., Project Engineer, Geotechnical Services, and reviewed by Mr. David H. Dundas, P. Eng., Senior Engineer, Geotechnical Services. Mr. C.M.P. Nascimento, P.Eng., Project Manager, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



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DD/CN:dd-mi-jk



APPENDIX A

OPSS's and NSSP



OPSS's Relevant to Report

DOCUMENT	TITLE
OPSS 903	Construction Specification for Deep Foundations
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

NSSP for Preventing Caisson Disturbance

OPSS 903 is amended with the following addition:

The Contractor shall be advised that the subsurface conditions at the site consist of noncohesive deposits and a high groundwater table. The ground is susceptible to disturbance under conditions of unbalanced hydrostatic head. The Contractor shall be responsible for installing caissons for lighting poles and sign foundations without disturbing the sides and bases of caisson excavations. Although the Contractor shall remain responsible for using equipment and procedures to accomplish caisson installation without disturbance of the foundation soils, the Contractor is advised that open hole techniques will not be effective and that consideration should be given to using temporary liners and mud drilling and tremie concreting techniques.

NSSP for Relevant Subsurface Conditions

OPSS 903 is amended with the following addition:

The Contractor shall assume that the closest borehole to a caisson foundation represents the subsurface conditions at that caisson location.