



**FOUNDATION INVESTIGATION REPORT
for
REPLACEMENT OF UNIVERSITY AVENUE EAST N-E/W RAMP
OVERHEAD CANTILEVER SIGN, SITE NO. 33-816-S-S
REHABILITATION / RESURFACING OF HIGHWAY 85
G.W.P. 168-89-00
CITY OF WATERLOO, ONTARIO**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

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FOUNDATION INVESTIGATION REPORT

for

Replacement of University Avenue East N-E/W Ramp Overhead Cantilever Sign

Rehabilitation / Resurfacing of Highway 85

GWP 168-89-00

City of Waterloo, Ontario

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the replacement of the University Avenue East N-E/W Ramp overhead cantilever sign. The investigation was carried out by Peto MacCallum Ltd. (PML) for McCormick Rankin Corporation (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

As per the terms of reference, this report provides only a summary of the factual information obtained during the field investigation.

2. SITE DESCRIPTION AND GEOLOGY

The contemplated replacement structure is located about 350 m north of the University Avenue East underpass between the N-E/W ramp and the Highway 85 SBL. The site is about 4.5 km north of the Highway 7 (Victoria Street) Interchange in the City of Waterloo.

Land use in the vicinity of the site includes the existing Highway 85 transportation corridor amidst residential areas. The local topography of the site is generally flat at the sign structure location and Highway 85 and the terrain rises away from highway corridor. The ground cover adjacent to the pavements at the sign location includes a grassy area and traffic crash protection.

The project site is situated within in the physiographic region known as the Waterloo Hills characterised by sandy hills, sandy till ridges, kames and kames moraines with outwash sandy soils occupying the intervening hollows. The principal surficial soil along the study corridor is fine sand at the hilly region to more uniform sandy and gravelly materials at the alluvial terraces of the Grand River spillway. Typically, the surficial soils overlay clay tills.

The bedrock in this project site belongs to the Salina Formation comprising dolostone, shale, gypsum and salt. The soil/bedrock interface is generally deep greater than 20 m.



3. INVESTIGATION PROCEDURES

The subsurface investigation comprised one borehole that was carried out on May 11, 2011. The borehole was drilled to 6.4 m at the location shown on Drawing CS-1, appended.

The borehole was advanced by using continuous flight solid stem augers through the soil cover with a track-mounted D-50 drill rig, supplied and operated by a specialist drilling contractor working under the full-time supervision of a PML field supervisor.

Soil samples were recovered from the boreholes at regular 0.75 and 1.5 m intervals of depth using the standard penetration test method. Soils were identified in accordance with the MTO soil classification manual procedures. The groundwater conditions in the boreholes were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, where encountered, by measuring the groundwater level in the open holes.

The borehole was backfilled with a bentonite/cement mixture where required in accordance with the MTO guideline and MOE Reg. 903 for borehole abandonment.

The location of the test hole was laid out and surveyed by MMM Group Limited. All elevations in this report are reported in metres.

The recovered soil samples were returned to our laboratory in Toronto for detailed visual examination, laboratory testing and classification. The laboratory testing program included the following tests:

- Natural moisture content determinations (9)
- Grain size distribution analyses (2)
- Atterberg limits test (1)

The laboratory grain size distribution charts are presented in Figures CS-GS-1 and CS-GS-2. The Atterberg plasticity test results are shown on Figure CS-PC-1. All of the test results are summarized on the Record of Borehole Sheet.



4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole Sheet for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test results as well as groundwater observations. The results of laboratory particle size distributions, Atterberg limits and moisture content determinations are also shown on the Record of Borehole Sheet.

The general stratigraphy revealed in borehole comprised of fill over silty clay underlain by cohesionless silt with sand followed by silty clay till. Bedrock was not encountered in the borehole which was terminated within the silty clay till at 6.4 m depth. Groundwater was observed at 1.2 m during drilling and measured at 2.6 m upon completion of drilling.

A summary of the findings is given below.

4.1.1 Fill

A 600 mm thick fill layer was present surficially extending to 0.6 m depth (elevation 318.0). The fill contains about 100 mm topsoil over sand and gravel. An N value of 12 was obtained indicating a compact condition. One moisture content result was about 4%.

4.1.2 Silty Clay

A 0.5 m thick silty clay stratum was encountered at 0.6 m (elevation 318.0) extending to 1.1 m (elevation 317.5). A composite N value of 18 was obtained indicating very stiff consistency. One moisture content result was 16%.

4.1.3 Silt

A cohesionless silt deposit was encountered below the silty clay at 1.1 m (elevation 317.5) in borehole S-1. The unit was 2.6 m thick extending to 3.7 m (elevation 314.9). N values ranged from 29 to 56 indicating compact to very dense relative density.



A grain size distribution chart for a silt with sand sample is presented in Figure CS-GS-1. The moisture content results varied from 14 to 20%.

4.1.4 Silty Clay Till

A cohesive silty clay till layer was encountered below the silt at 3.7 m (elevation 314.9) in borehole S-1. The stratum was at least 3.7 m thick containing silty sand layers and cobbles. The silty clay till extended to the borehole termination depth of 6.4 m (elevation 312.2). N values ranged from 41 to 50 for 8 cm sampler penetration indicating hard consistency.

The results of grain size distribution analysis for a silty clay till sample are included in Figure CS-GS-2. The plasticity chart is presented in Figure CS-PC-1. The liquid limit and plastic limit determinations on the silty clay till sample tested were 41 and 19, respectively with corresponding plasticity index value of 22. The moisture content determinations varied from 16 to 19%.

4.1.5 Bedrock

No bedrock was encountered in the borehole terminated within the silty clay till at 6.4 m (elevation 312.2).

4.1.6 Groundwater

Groundwater was encountered during and upon completion of drilling at 1.2 and 2.6 m (elevation 317.4 and 316.0), respectively. Cave-in was observed at 2.6 m (elevation 316.0) upon completion. Groundwater levels are subject to seasonal fluctuation and rainfall patterns.



5. CLOSURE

Mr. F. Portela carried out the field investigation for this study under the supervision of Mrs. N.S. Balakumaran, P. Eng., Project Engineer and Mr. C. M. P. Nascimento, P. Eng., Project Manager. London Soils Ltd. supplied the drill rig utilized for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Mrs. N. S. Balakumaran, P.Eng., Project Engineer and reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact. Mr. C. M. P. Nascimento, P. Eng., Project Manager conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.

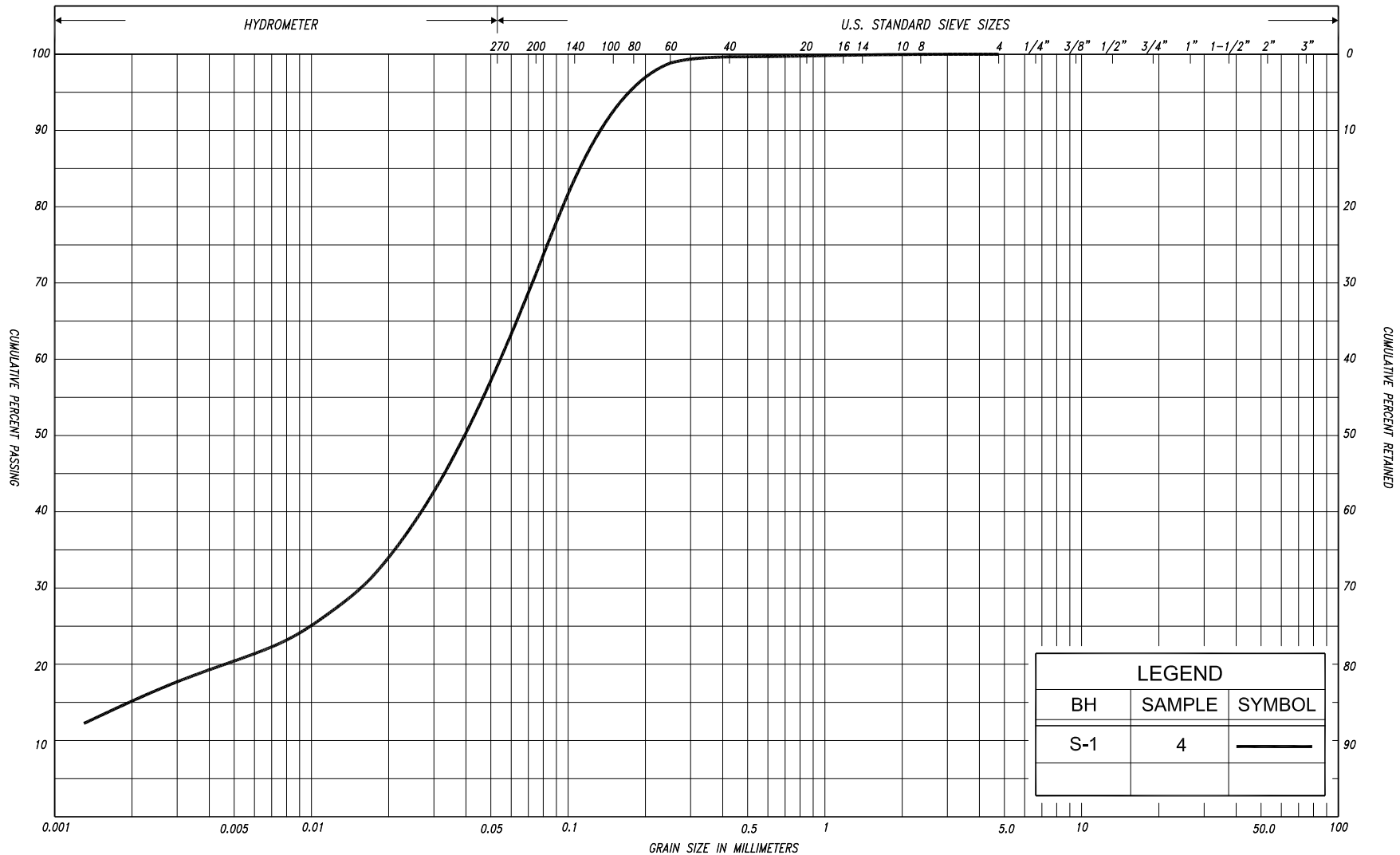


Carlos M.P. Nascimento, P.Eng.
Project Manager



Brian R. Gray, MEng, P.Eng.
MTO Designated Principal Contact

CN/BRG:mi-nk



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



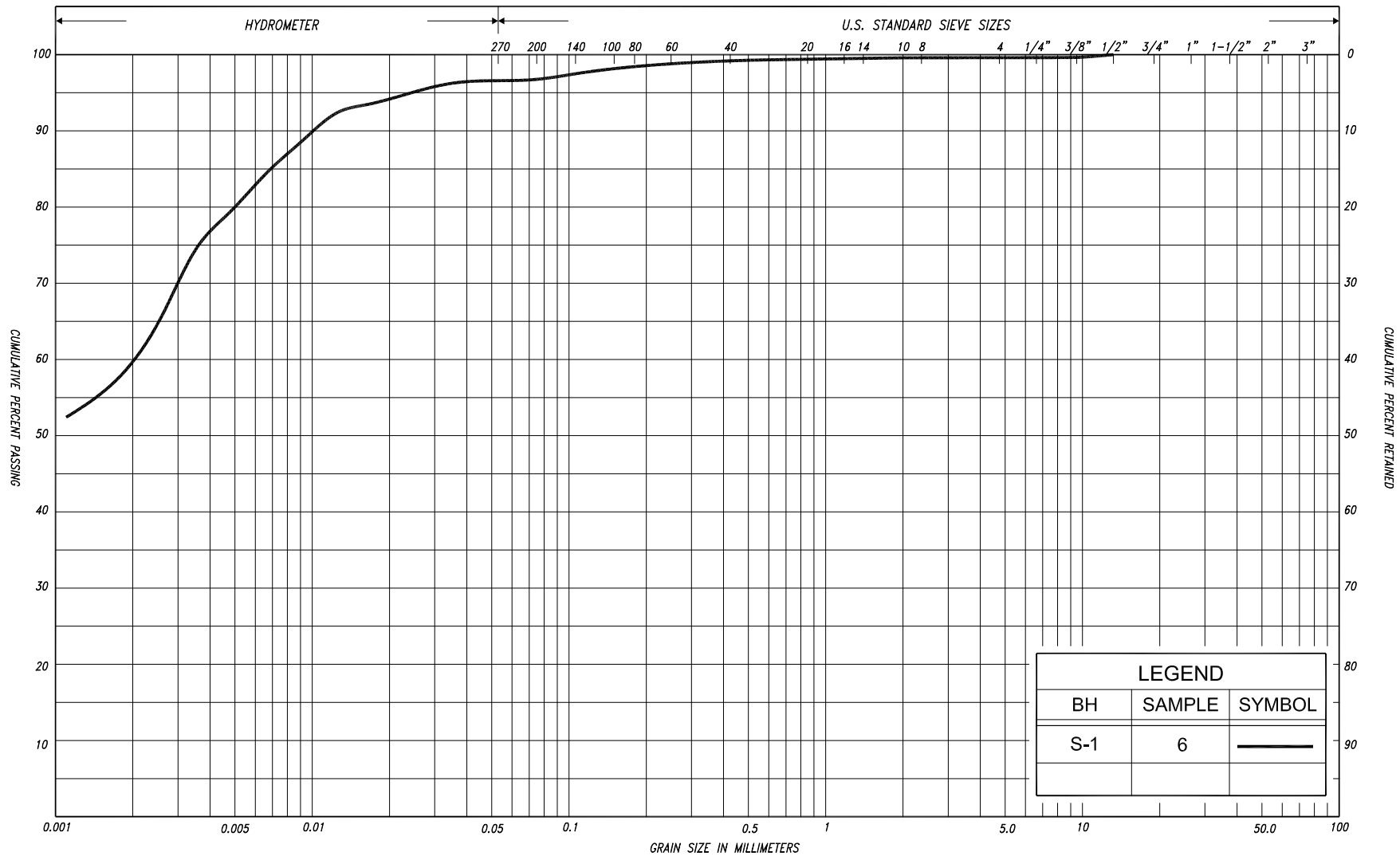
GRAIN SIZE DISTRIBUTION

SILT, with sand, some clay

FIG No. CS-GS-1

HWY: 85

G.W.P. No. 168-89-00



LEGEND		
BH	SAMPLE	SYMBOL
S-1	6	—

SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COB BLES	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												

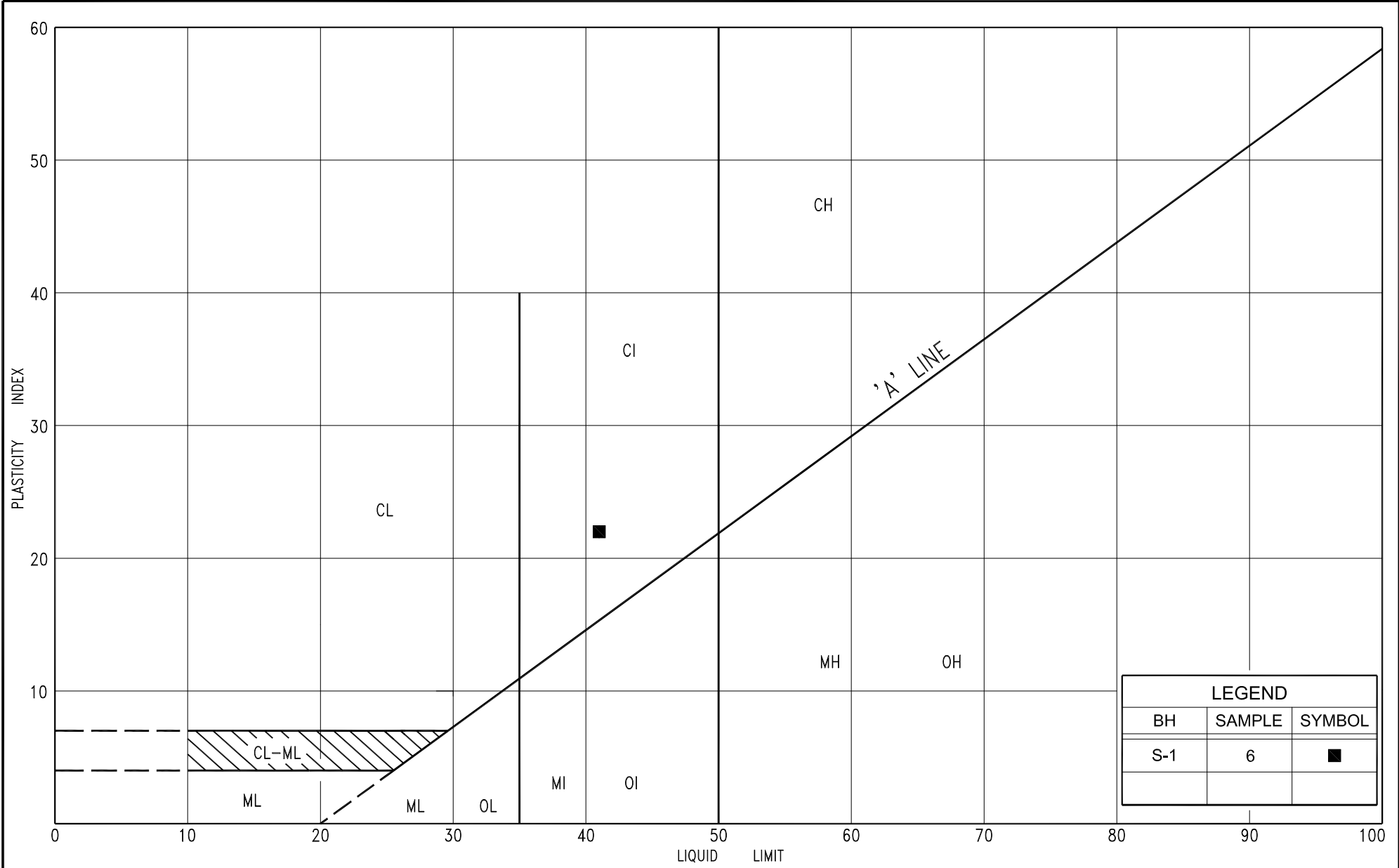


GRAIN SIZE DISTRIBUTION SILTY CLAY, trace sand, trace gravel (CI) (TILL)

FIG No. CS-GS-2

HWY: 85

G.W.P. No. 168-89-00



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'_{v0}	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				i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO	WTPL		WETTER THAN PLASTIC LIMIT			

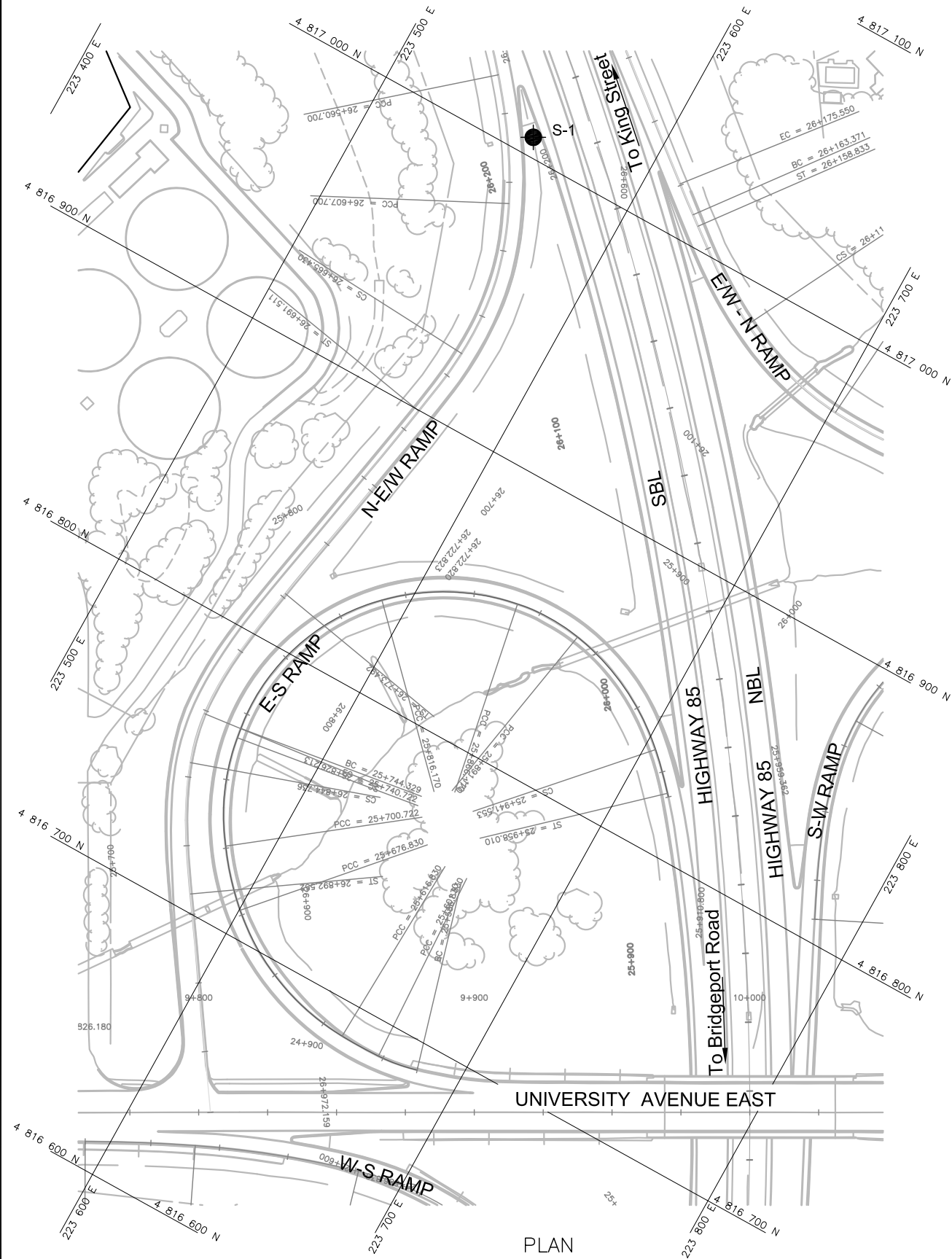
RECORD OF BOREHOLE No. S-1

1 of 1

METRIC

G.W.P. 168-89-00 **LOCATION** Coords: 4 817 006.8 N; 223 557.3 E **ORIGINATED BY** F.P.
DIST London **HWY** 85 **BOREHOLE TYPE** Continuous Flight Solid Stem Augers **COMPILED BY** N.S.B.
DATUM Geodetic **DATE** May 11, 2011 **CHECKED BY** B.R.G.

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												
318.6	Ground Surface						20	40	60	80	100									
0.0	Topsoil		1	SS	12	▽*							○							
318.0	Sand and gravel						318													
0.6	Compact Brown Moist (FILL)																			
317.5	Silty clay trace sand, trace gravel		2	SS	18									○						
1.1	Very stiff Brown Moist						317							○						
	Silt with sand, some clay		3	SS	56	▼*								○		0 28 57 15				
	Compact to Brown Wet very dense						316							○						
	clayey silt layers		4	SS	48															
														○						
			5	SS	29		315													
314.9	Silty clay, trace sand trace gravel, cobbles		6	SS	41								○			1 2 37 60				
	Hard Brown/ Moist grey						314							○						
	silty sand layers		7	SS	96/25cm									○						
	(TILL)		8	SS	53		313							○						
312.2			9	SS	50/8cm								○							
6.4	End of borehole																			
	Samples 7 and 9: Sampler bouncing																			
	* 2011 05 11																			
	▽ Water level observed during drilling																			
	▼ Water level measured after drilling																			
	Note: Borehole cave-in at 2.6m after drilling																			



NOTES:

- DRAWING CS-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLE.
- 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.

