



**FOUNDATION INVESTIGATION REPORT
for
REPLACEMENT OF SHALLOW LAKE BRIDGE
OVER STONEY CREEK, HIGHWAY 6
SITE NO. 8-9
SHALLOW LAKE, ONTARIO
G.W.P. 43-00-00**

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FOUNDATION INVESTIGATION REPORT

For
Replacement of Shallow Lake Bridge over Stoney Creek
Site No. 8-9
Highway 6, G.W.P. 43-00-00
Shallow Lake, Ontario

1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed replacement of Shallow Lake Bridge on Highway 6 in Shallow Lake. The investigation was conducted for McCormick Rankin (MRC), a member of MMM Group Ltd. on behalf of the Ministry of Transportation of Ontario (MTO).

The existing bridge over the Stoney Creek includes an approximately 10.0 m long, single span concrete structure. The bridge deck is at approximate elevation 223.8. The approach embankments are level with the bridge deck.

This report provides subsurface information pertaining to the foundation of the proposed new bridge and approach embankments within about 20 m of the abutments.

All elevations in this report are expressed in meters.

2. SITE DESCRIPTION AND GEOLOGY

The site is located on Highway 6 (Princess Street), about 170 m west of the intersection of Highway 170 and Highway 6 in Shallow Lake. The topography in the general area of the bridge is relatively level. The surrounding vegetation consists of landscaped areas and scattered mature trees. The surrounding area has commercial/residential land uses. Site photographs are shown in the Appendix A.

Physiographically, the site is located in the region referred to as the Bruce Peninsula. This region has a thin overburden scattered over grey dolomite bedrock.



3. INVESTIGATION PROCEDURES

The field work for the bridges was carried out on January 4, 5 and 10, 2012. The subsurface investigation comprised six (6) boreholes S1 to S6, that were advanced through the soil cover to bedrock depths of 2.6 to 4.1 m, elevations 219.6 to 221.1, at the locations shown on the appended Drawing SL-1. Boreholes S3 and S4 were cored 3.8 and 4.1 m into the bedrock to depths of 6.7 and 6.6 m, elevations 217.0 and 217.3, respectively.

Borehole locations were laid out in the field by PML by measuring distances from the existing bridge abutments and surveyed by MRC.

The boreholes were advanced using continuous flight hollow augers powered by a truck-mounted CME-45, equipped for rotary core (NQ size) drilling, supplied and operated by a specialist drilling contractor. The drilling crews worked under the full-time supervision of a member of our engineering staff. The rock core photographs are shown in Appendix B.

In order to determine foundation support conditions for the existing bridge abutments and wing walls, a geotechnical investigation program consisting of a series of auger probes was requested by MRC. Results of auger probe findings are included in Appendix C.

Representative samples of the soils encountered in the boreholes were recovered at 0.75 m intervals. Soil samples were obtained using a split spoon sampler in conjunction with standard penetration tests. Where standard penetration tests were not carried out the consistency/relative density of the encountered soils was estimated from manual examination or the rate (ease) of advance of the augers.

The boreholes were backfilled in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures using a bentonite/cement mixture grout.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and, when appropriate, by measurement of the water level in the open boreholes.



Soils were identified in the field in accordance with the MTO Soil Classification procedures. Recovered soil samples were returned to our laboratory for detailed visual examination and soil classification. The laboratory test program comprised the following tests:

- Natural moisture content determinations (16)
- Grain size analyses (6)
- Atterberg limits tests (2)

The results of the laboratory tests are shown on the Record of Borehole sheets. The grain size distribution charts are presented in Figures SL-GS-1 to SL-GS-6 and the plasticity charts are presented in Figures SL-PC-1 and SL-PC-2.

4. SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including moisture conditions, soil classifications, bedrock descriptions, inferred stratigraphy, boundary elevations and groundwater observations.

The borehole locations, stratigraphic profile and cross-sections prepared from the borehole data are presented on the foundation Drawing SL-1.

The subsurface stratigraphy consisted of a pavement structure overlying fill and silty sand mantling dolostone bedrock. Localized silty clay, clayey silt and gravelly sand layers were contacted in some boreholes.

4.1 Pavement Structure

A pavement structure generally comprising 100 and 125 mm of asphalt underlain by 470 to 925 mm of sand and gravel base course was contacted in all the boreholes.



4.2 Fill

Below the pavement structure, a 0.4 to 1.4 m thick, mixed fill was contacted to 1.1 to 2.3 m depth, elevation 221.5 to 222.3 in all boreholes except borehole S6. The fill consisted of very soft to firm, clayey silt, loose to compact sandy silt and loose sand with some silt. SPT N values in the fill ranged from 2 to 27.

A grain size distribution chart of the recovered sand fill sample is presented in Figure SL-GS-1. The sample comprised 74% sand, 13% silt, 9% gravel and 4% clay size materials.

4.3 Silty Clay / Clayey Silt

Below the fill in borehole S-1, a localized 1.1 m thick, firm silty clay stratum was contacted to 2.2 m depth, elevation 221.2. Below the pavement structure in borehole S-6, a localized 1.5 m thick firm clayey silt stratum was contacted to 2.2 m depth, elevation 221.7. These deposits contained variable amounts of cobbles and boulders detected during the augering of the boreholes.

A grain size distribution chart of the recovered silty clay sample is presented in Figure SL-GS-2. The sample comprised 50% clay, 47% silt, and 3% sand size particles. A plasticity chart of the silty clay sample is presented in Figure SL-PC-1. The Atterberg liquid and plastic limit were 44 and 21 respectively, with a plasticity index of 23. The natural moisture content of the silty clay sample was 30%.

A grain size distribution chart of the recovered clayey silt sample is presented in Figure SL-GS-3. The sample comprised 68% silt, 27% clay and 5% sand size particles. A plasticity chart of the clayey silt sample is presented in Figure SL-PC-2. The Atterberg liquid and plastic limit were 27 and 17 respectively, with a plasticity index of 10. The natural moisture content of the clayey silt sample was 22%.



4.4 Silt

Below the fill in borehole S2, a localized 2.3 m thick, loose to compact silt stratum was contacted to 4.1 m depth, elevation 219.6.

A grain size distribution chart of the recovered silt sample is presented in Figure SL-GS-4. The sample comprised 83% silt, 13% clay and 4% sand size particles. The natural water content of the silt sample was 21%.

4.5 Silty Sand/ Sandy Silt

Silty sand was contacted in borehole S1, underlying the silty clay and underlying the pavement structure in boreholes S3, S4 and S5 at 1.4 to 2.3 m depth, elevation 221.5 to 223.3 and extended to termination on probable bedrock at 2.6 to 3.8 m depth, elevation 219.6 to 222.1. SPT N values in the 1.0 to 1.6 m thick silty sand layer ranged from 3 to 13 indicating a loose to compact relative density. Boulders and cobbles were encountered in the silty sand as evidenced by SPT N values of 50 blows over 100 mm in Borehole S3.

Sandy silt was contacted below the clayey silt at 2.2 m depth, elevation 221.7, in borehole S6. SPT N values in the sandy silt were 6 and 12. The natural moisture content of the sandy silt samples were 19 and 21%.

A grain size distribution chart of the recovered sandy silt sample is presented in Figure SL-GS-5. The sample comprised 56% silt, 34% sand, 5% clay and 5% gravel.



4.6 Sand with gravel

Below the silty sand in borehole S-4, a localized 0.5 m thick stratum of very dense sand with gravel was contacted from 2.3 to 2.8 m depth, elevation 221.6 to 221.1.

A grain size distribution chart of the recovered silty sand sample is presented in Figure SL-GS-6. The sample comprised 53% sand, 23% gravel, 20% silt and 4% clay. A moisture content determination obtained 10%.

4.7 Bedrock

Auger refusal on bedrock/probable bedrock was contacted in all boreholes at 2.6 to 4.1 m depth, elevation 219.6 to 221.1. Dolomite bedrock was cored for 4.1 and 3.8 m in boreholes S3 and S4, respectively.

A detailed description of the rock cores retrieved from the boreholes is provided in the attached Table 1 and included on the Record of Borehole logs.

The bedrock comprised light grey to blue grey dolomite of low to medium strength in slightly weathered to unweathered condition, and is described in further detail in the following sections.

4.7.1 South East Corner of Existing Bridge

Borehole S3 was advanced at the southeast corner of the existing bridge. The bedrock surface was encountered at 2.6 m depth, elevation 221.1 and cored 4.1m to elevation 217.0.

The measured core recovery varied from 90 to 98%. The Rock Quality Designation (RQD) for the recovered cores ranged from 45 to 98%, increasing with depth indicating poor to excellent rock quality.



4.7.2 North West Corner of Existing Bridge

Borehole S4 was advanced at the northwest corner of the existing bridge. The bedrock surface was encountered at 2.8 m depth, elevation 221.1 and cored 3.8 m to 217.3.

The measured core recovery varied from 67 to 90%. The RQD for the recovered cores ranged from 15 to 78%, indicating very poor to good rock quality.

Photographs of the rock cores taken from the current boreholes are included in Appendix B.

4.8 Groundwater

Groundwater was observed during augering in boreholes S1, S2, S5 and S6 at 2.1 to 2.3 m depth, elevation 221.1 to 221.6. Upon completion of augering, groundwater was established at 1.9 to 2.2 m depths, elevations 221.2 to 221.8, in boreholes S1, S2, S5 and S6.

Boreholes S3 and S4 were charged with water due to coring operations hence groundwater measurements were not taken in these boreholes.

The groundwater level in the Stoney Creek was indicated to be at approximately elevation 222.0 on the MRC preliminary drawing.

The groundwater is subject to fluctuations at the site due to seasonal conditions and rainfall patterns.



5. CLOSURE

The field work was carried out under the supervision of Mr. A. Lo, Senior Technician, and direction of Ms. N. Balakumaran, P.Eng and Mr. C. M. P. Nascimento, P.Eng., Project Manager and MTO Designated Principal Contact. Aardvark Drilling supplied the soil and rock drilling equipment.

This report was prepared by Mr. H. Gharegrat, P.Eng., and reviewed by Mr. B.R. Gray, MEng, P.Eng., Principal Consultant. Mr. C.M.P. Nascimento, P.Eng. carried out an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.



Harry Gharegrat, MS, P.Eng.
Senior Engineer



Brian R. Gray, MEng, P.Eng.
Principal Consultant



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

HG/CN/BRG/hg-nk

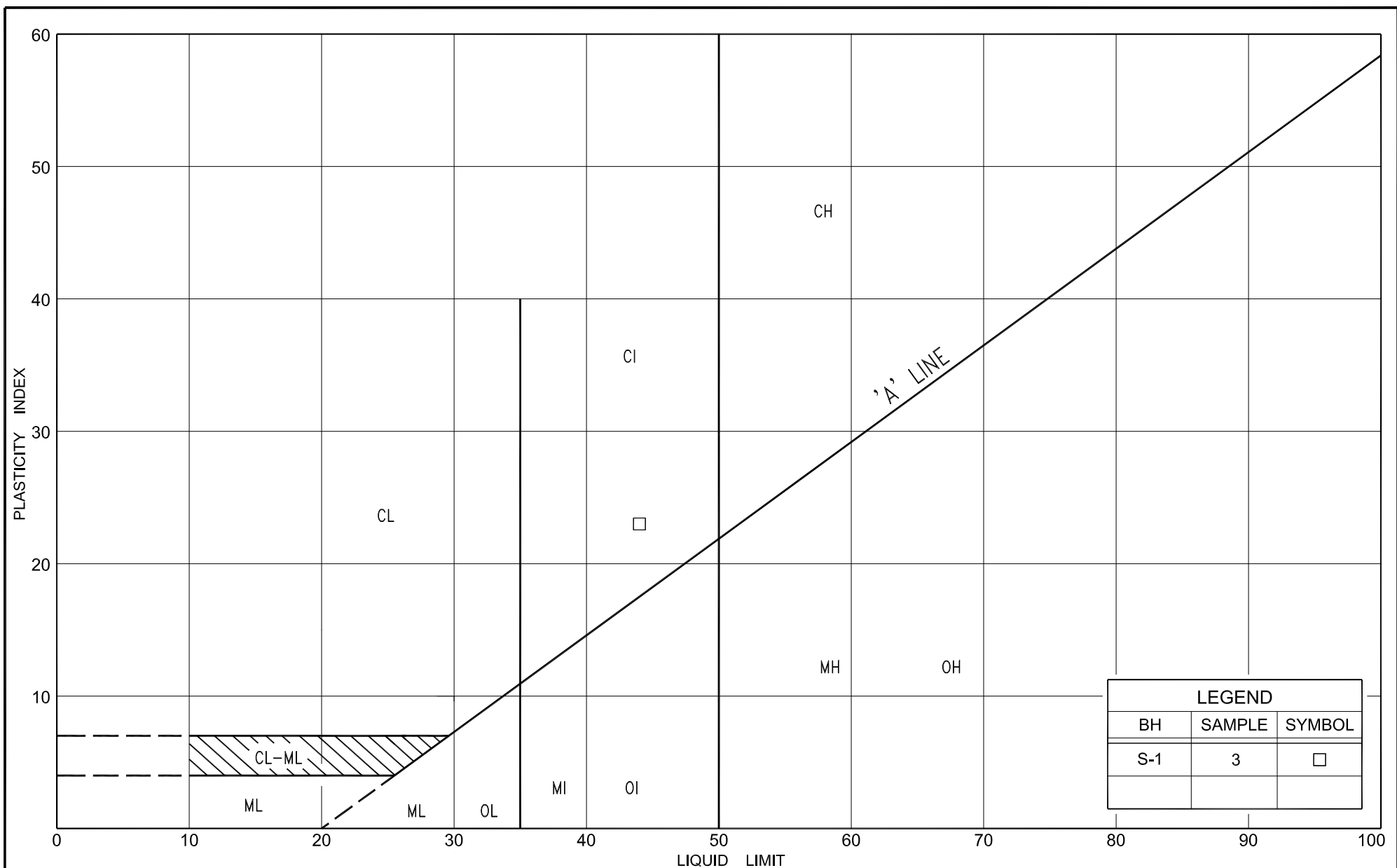


TABLE 1
ROCK CORE DESCRIPTIONS

CORE RECOVERY					CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
S3	5	2.6 – 3.7	93	45	2.6 – 3.7	DOLOMITE: Light grey, fine crystalline, highly porous, fossiliferous, low to medium strength, slightly weathered, close spaced flat discontinuities, tight, poor quality.
	6	3.7 – 5.2	90	69		
	7	5.2 – 6.7	98	98	3.7 – 6.7	DOLOMITE: Blue grey to buff with dark bituminous or argillaceous laminations, aphanitic, with occasional vugs, 5 to 25 mm in diameter with calcite crystals, medium strength, slightly weathered, close to moderately spaced flat bedding layers, rough planar, tight to slightly altered with oxidation stains on partings, fair to excellent quality.
S4	5	2.8 – 3.6	80	37	2.8 – 6.6	DOLOMITE: Blue grey to buff with dark bituminous or argillaceous laminations, aphanitic, with occasional vugs to 50 mm diameter, with calcite crystals, medium strength, slightly weathered to unweathered with possible highly weathered zone, close to moderately spaced flat bedding layers, smooth to rough planar, tight to slightly altered, very poor to good quality. <u>Note:</u> Low core recovery in run 6 may reflect highly weathered material.
	6	3.6 – 5.1	67	15		
	7	5.1 – 6.6	90	78		

NOTE: RQD = Rock Quality Designation

Originated: JFW
 Compiled: FP
 Checked: NB / CN

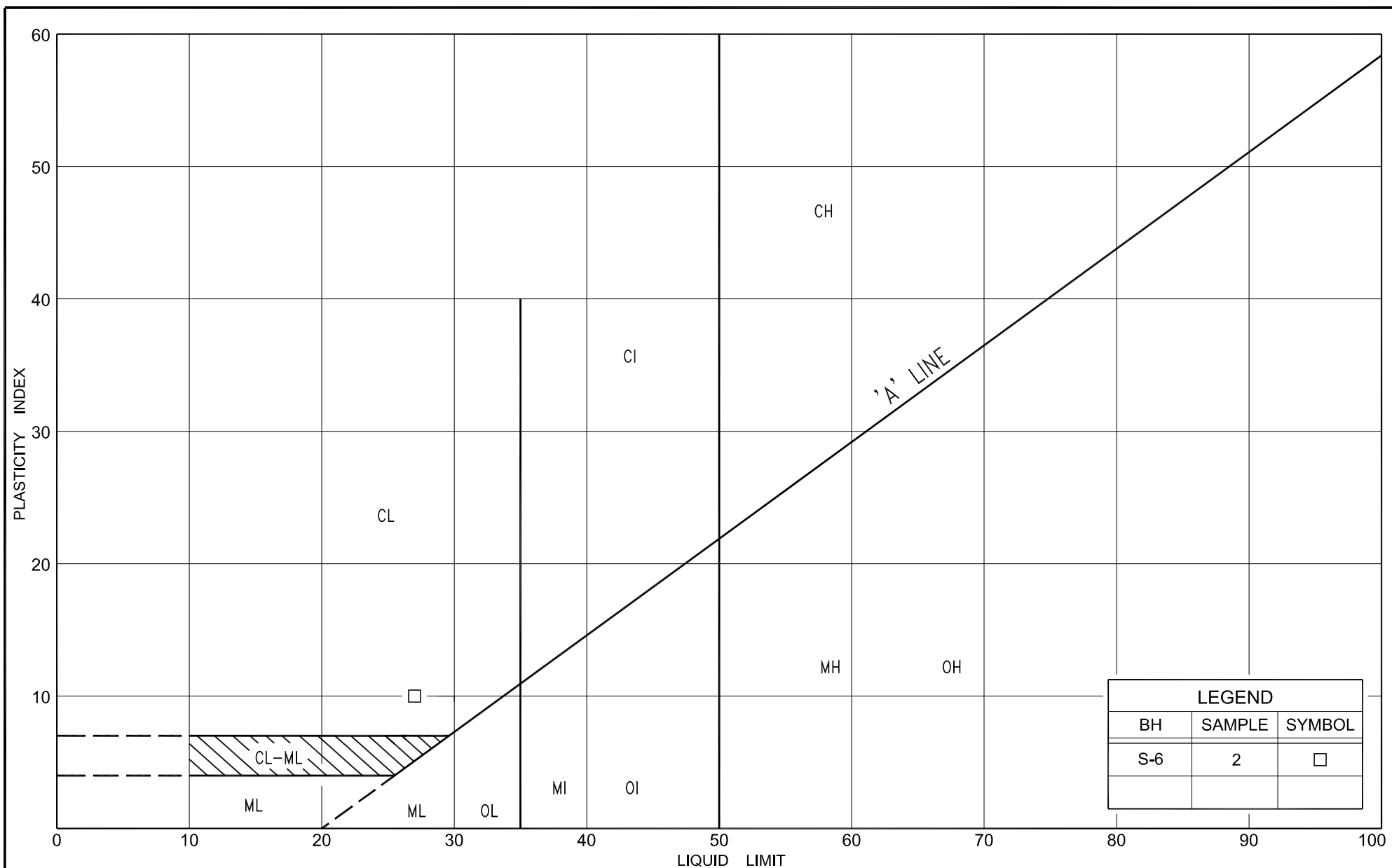


LEGEND		
BH	SAMPLE	SYMBOL
S-1	3	□



PLASTICITY CHART
 SILTY CLAY, trace sand (CI)

FIG No. SL-PC-1
 HWY: 6
 G.W.P. No. 43-00-00

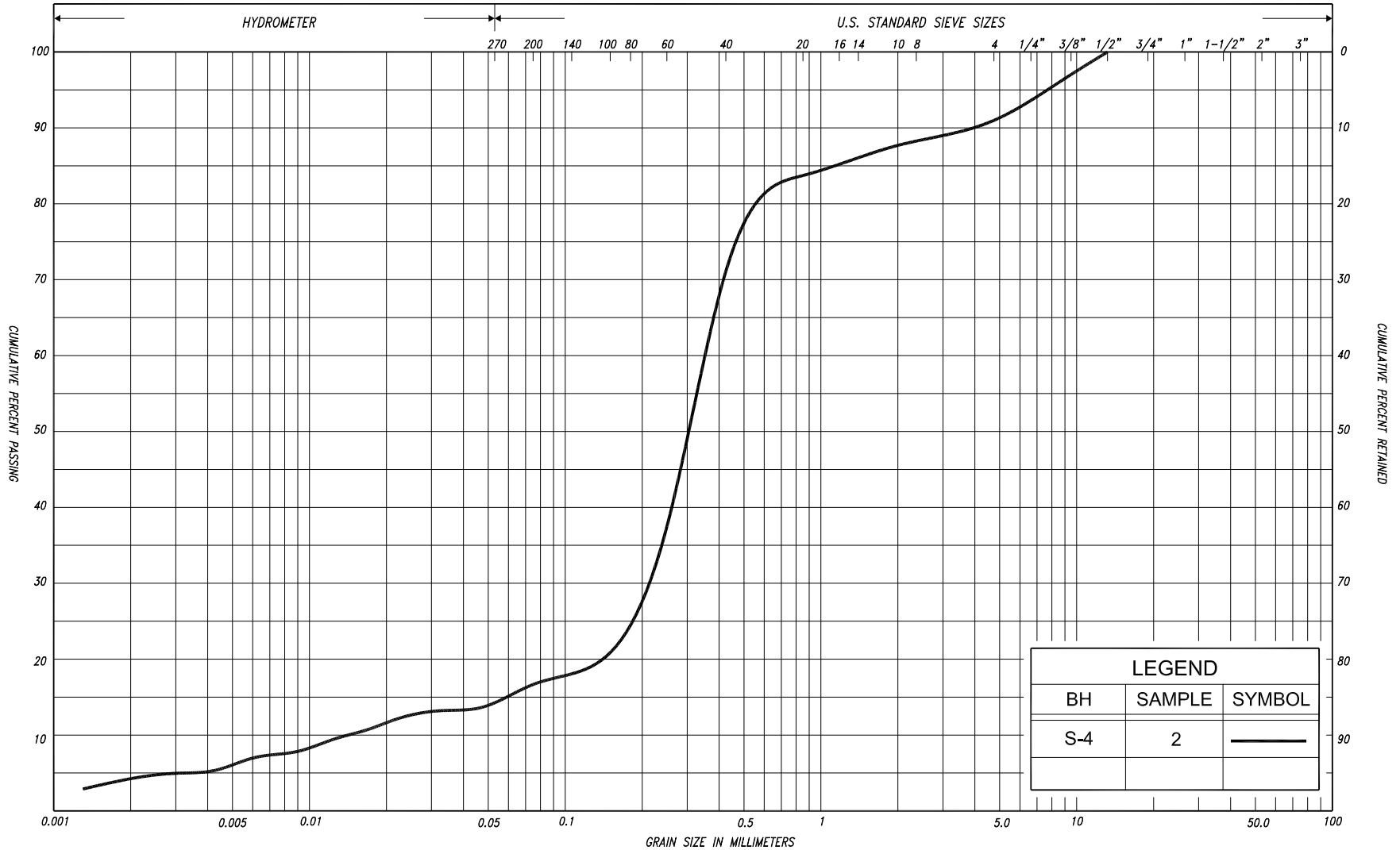


PLASTICITY CHART CLAYEY SILT, trace sand (CL)

FIG No. SL-PC-2

HWY: 6

G.W.P. No. 43-00-00



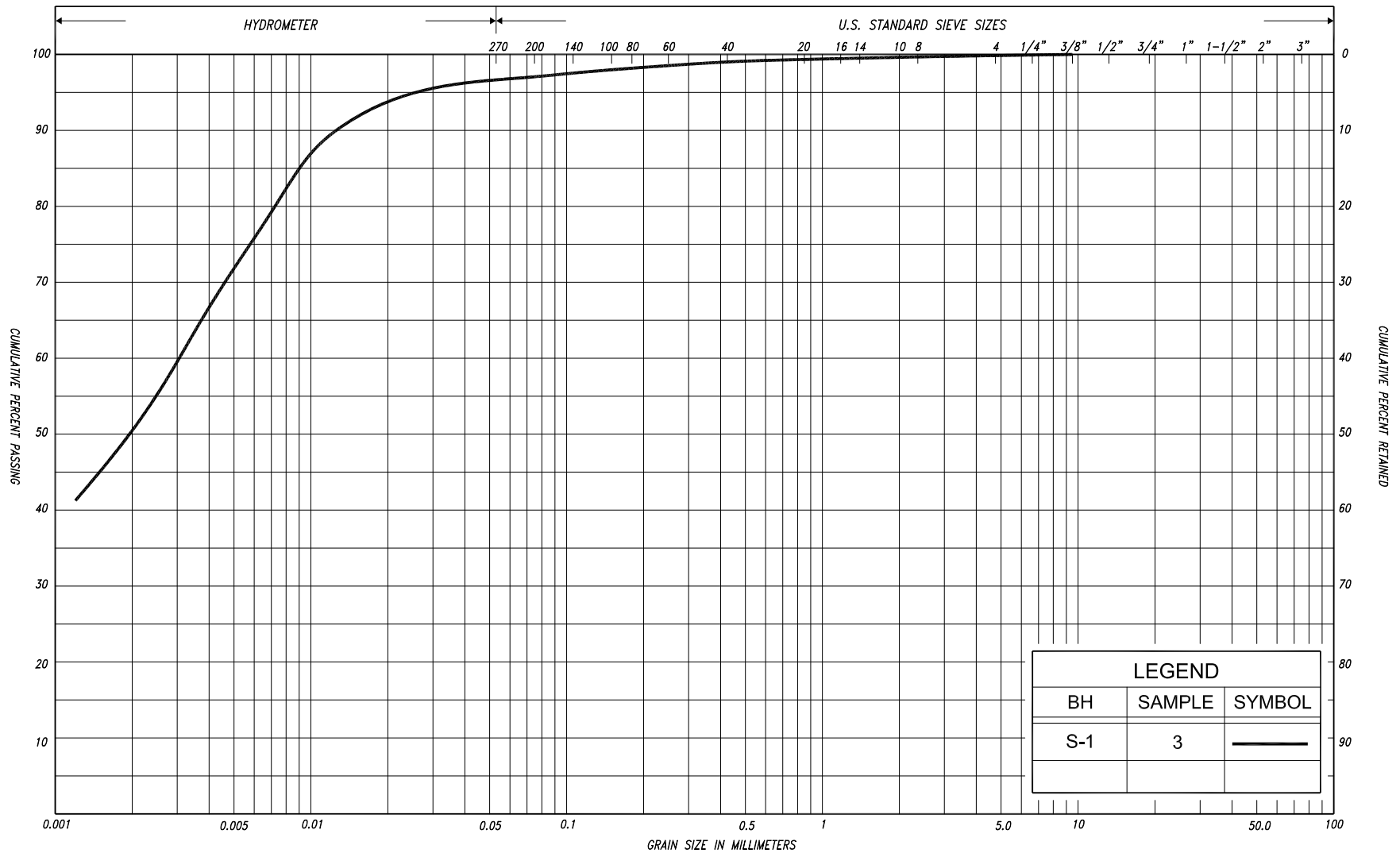
SILT & CLAY			FINE			MEDIUM			COARSE			GRAVEL			COB BLES	UNIFIED
						SAND										M.I.T.
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	GRAVEL			COBBLES						U.S. BUREAU
CLAY			SILT			V. FINE	FINE	MED.	COARSE	GRAVEL						
						SAND										



GRAIN SIZE DISTRIBUTION

SAND, some silt, trace clay, trace gravel
(FILL)

FIG No. SL-GS-1
HWY: 6
G.W.P. No. 43-00-00



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												



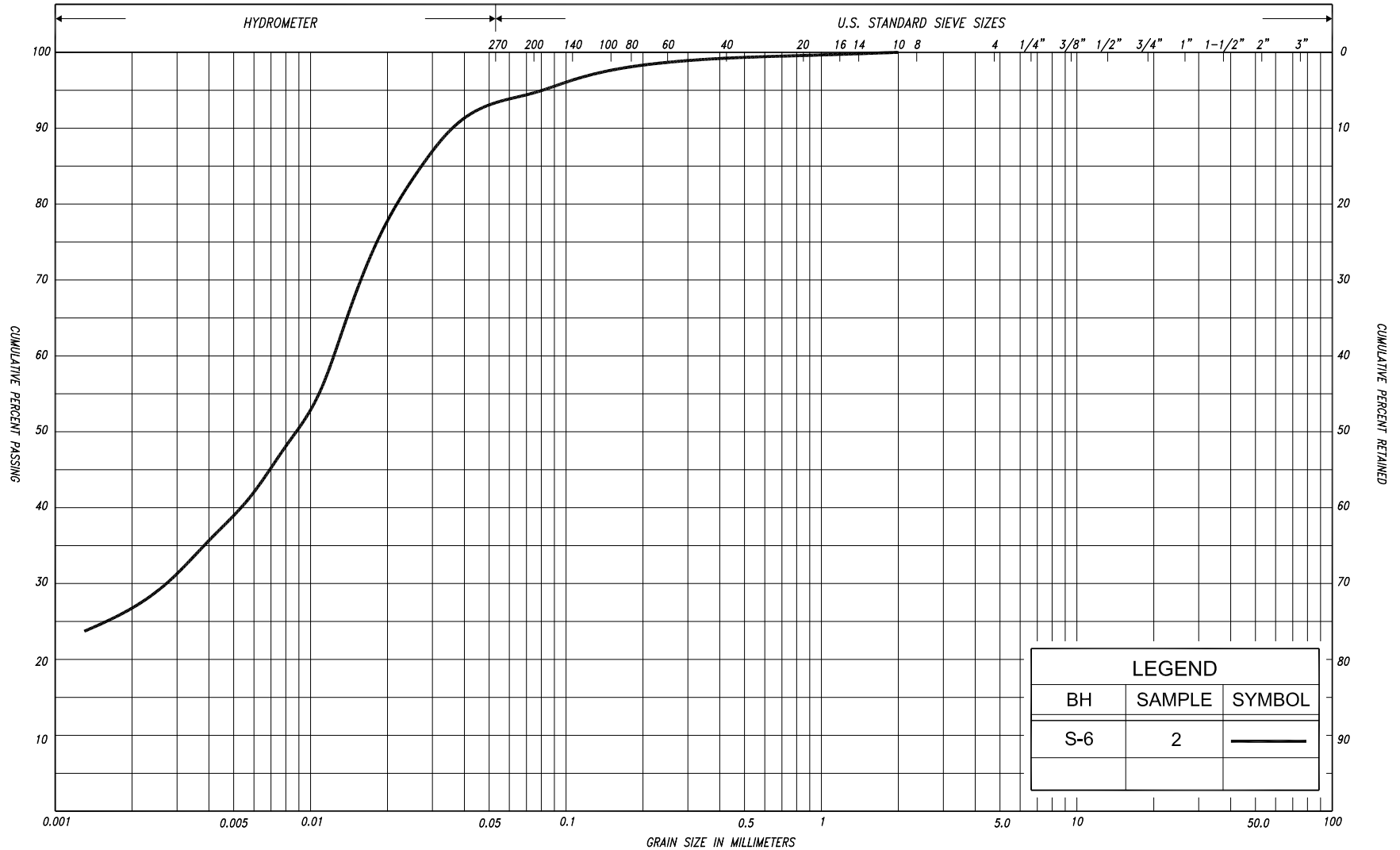
GRAIN SIZE DISTRIBUTION

SILTY CLAY, trace sand (CI)

FIG No. SL-GS-2

HWY: 6

G.W.P. No. 43-00-00



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										

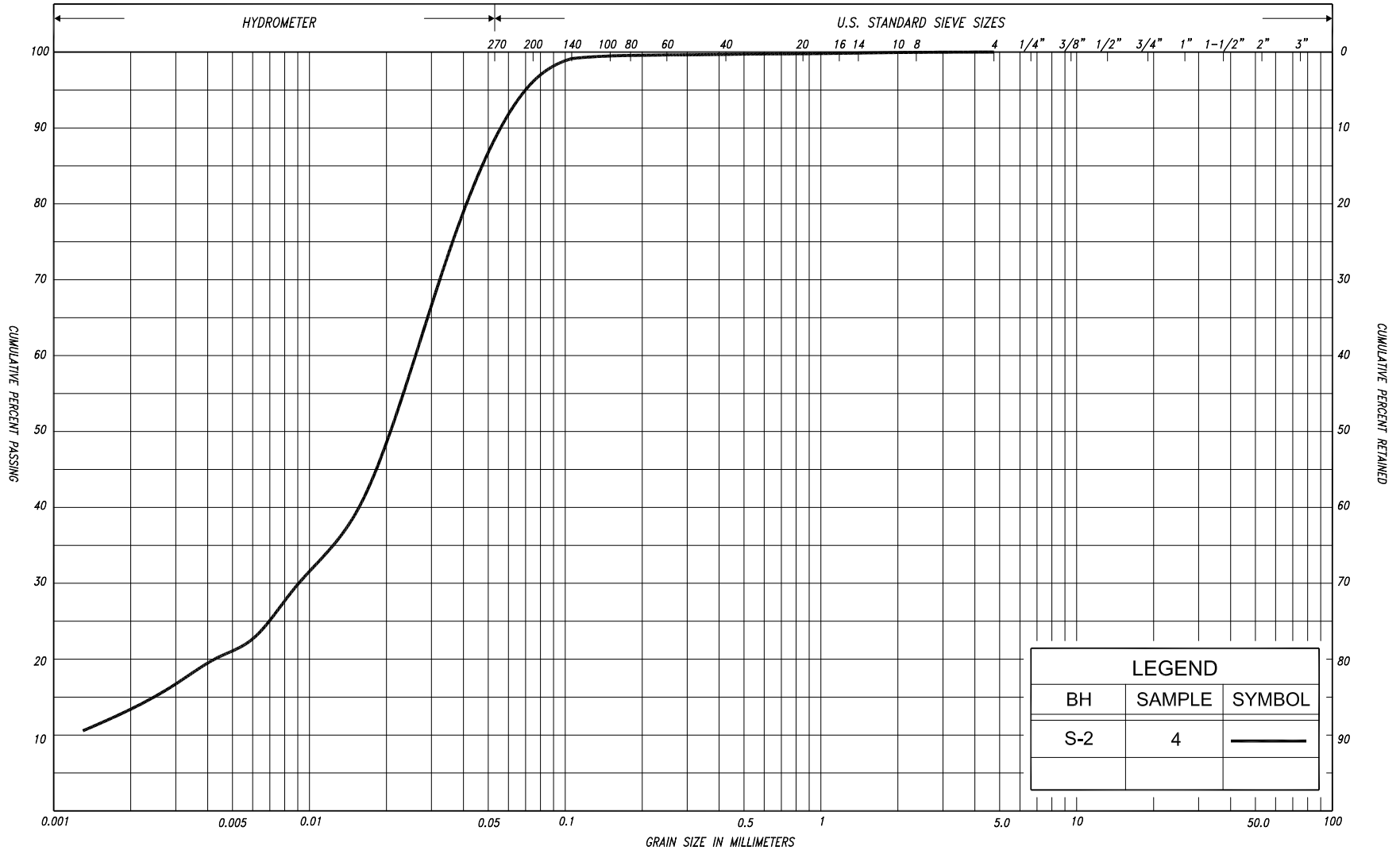


GRAIN SIZE DISTRIBUTION CLAYEY SILT, trace sand (CL)

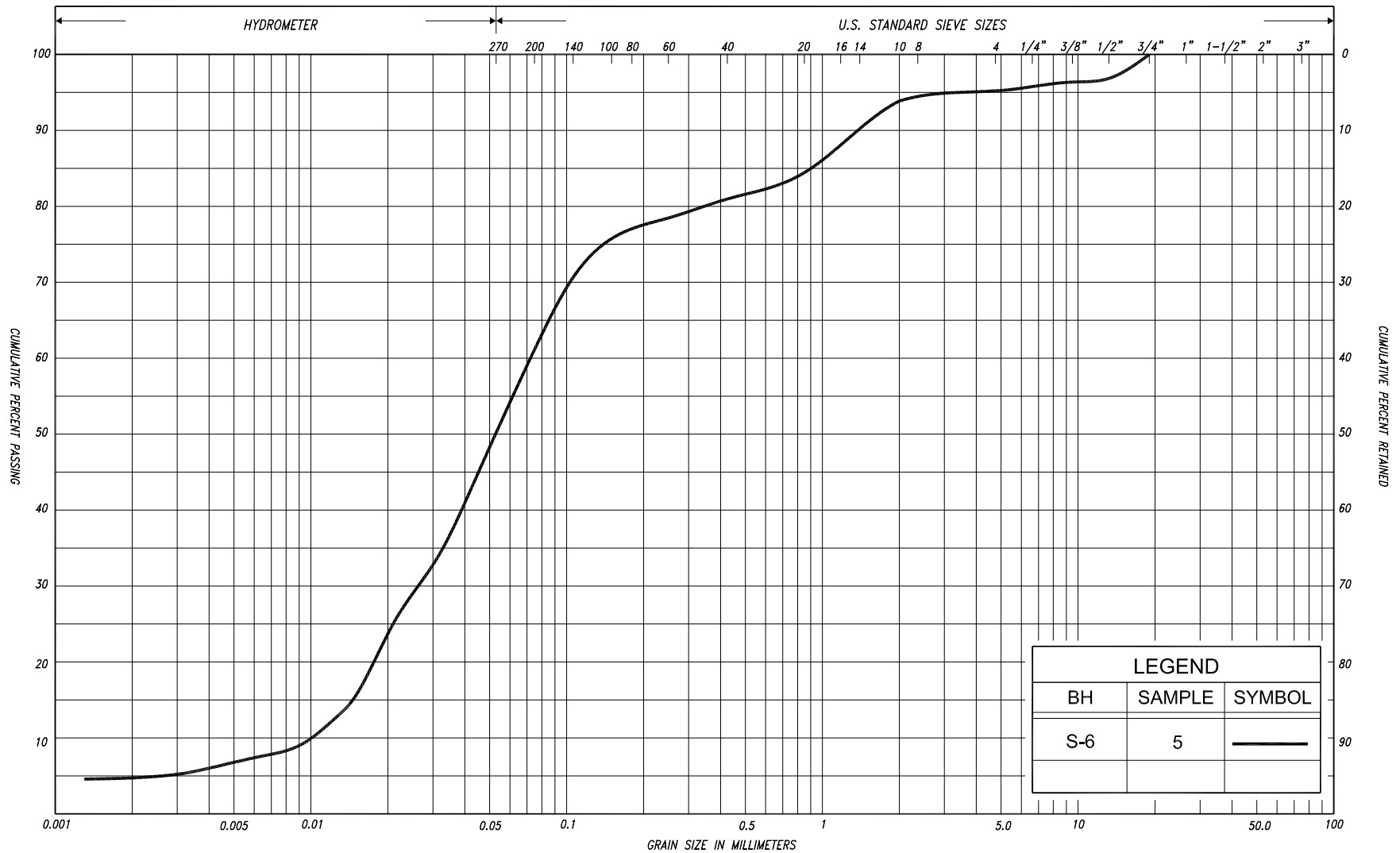
FIG No. SL-GS-3

HWY: 6

G.W.P. No. 43-00-00



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												



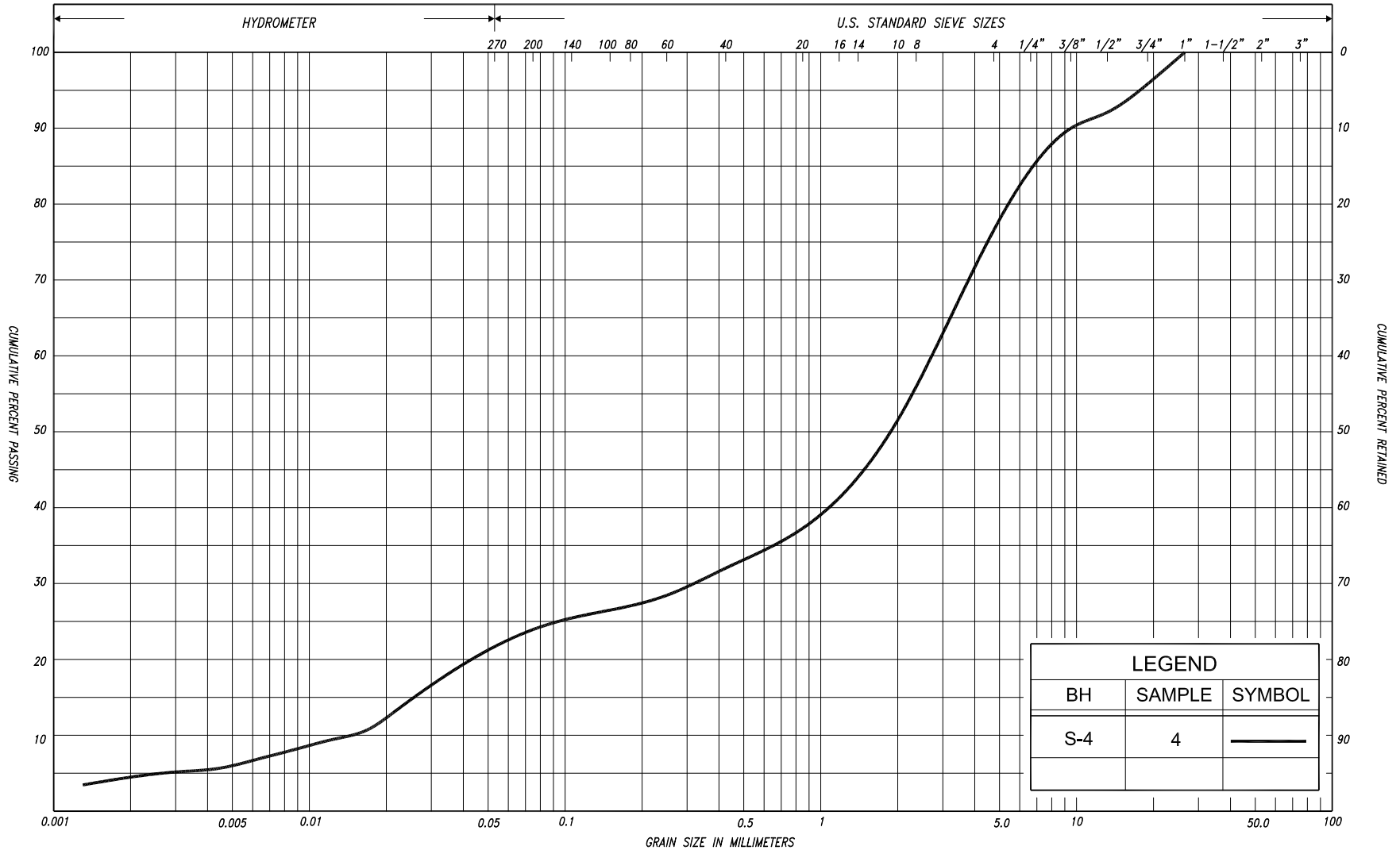
LEGEND		
BH	SAMPLE	SYMBOL
S-6	5	—

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



GRAIN SIZE DISTRIBUTION
SANDY SILT, trace clay, trace gravel

FIG No. SL-GS-5
HWY: 6
G.W.P. No. 43-00-00



LEGEND		
BH	SAMPLE	SYMBOL
S-4	4	—

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

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 S1

1 of 1

METRIC

G.W.P. 43-00-00 **LOCATION** Co-ords: 4 942 658.6 N ; 416 957.4 E
Hwy 6, Sta. 20+397, o/s 4.5m Lt. **ORIGINATED BY** A.L.
DIST London **HWY** 6 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** H.G.
DATUM Geodetic **DATE** January 10, 2012 **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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE									
								● QUICK TRIAXIAL × LAB VANE									
					WATER CONTENT (%)												
223.4	Ground Surface						20	40	60	80	100	20	40	60		GR SA SI CL	
0.0	130mm asphalt over 600mm sand and gravel		1	SS	14	▽* ▼*										0 3 47 50	
	Compact Brown																
222.3	Clayey silt, trace sand trace gravel, rootlets topsoil inclusions		2	SS	4												
1.1	Firm Brown Moist (FILL)		3	SS	4												
	Silty clay, trace sand																
221.2	Firm Greyish Moist brown																
2.2	Silty sand, trace clay cobbles and boulders		4	SS	3												
	Loose to Greyish Wet compact brown		5	SS	10												
219.6	layer of gravel																
3.8	End of borehole Refusal on probable bedrock																
* 2012 01 10																	
▽ Water level observed during drilling																	
▼ Water level measured after drilling																	

RECORD OF BOREHOLE No S2

1 of 1

METRIC

G.W.P. 43-00-00

LOCATION

Co-ords: 4 942 669.4 N ; 416 938.2 E
Hwy 6, Sta. 20+419, o/s 5.0m Lt.

ORIGINATED BY A.L.

DIST London

HWY 6

BOREHOLE TYPE

Continuous Flight Hollow Stem Augers

COMPILED BY H.G.

DATUM Geodetic

DATE

January 05 and 10, 2012

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 (%)								
								20 40 60 80 100										20 40 60								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																		
223.7	Ground Surface					▽*	▽	223																		
0.0	130mm asphalt over 680mm sand and gravel		1	SS	29																					
	Compact Brown																									
	Sandy silt trace clay, trace gravel rootlets, topsoil inclusions limestone fragments cobbles and boulders		2	SS	27																					
221.9	Compact Brown Moist (FILL)		3	SS	10			222																		
1.8	Silt some clay, trace sand cobbles and boulders		4	SS	3			221								0 4 83 13										
	Loose to Greyish Wet compact brown		5	SS	25			220																		
219.6	layer of gravel																									
4.1	End of borehole Refusal on probable bedrock																									

RECORD OF BOREHOLE No S3

1 of 1

METRIC

G.W.P. 43-00-00 **LOCATION** Co-ords: 4 942 677.0 N ; 416 945.1 E
 Hwy 6, Sta. 20+417, o/s 5.0m Rt. **ORIGINATED BY** A.L.
DIST London **HWY** 6 **BOREHOLE TYPE** C.F.H.S.A. and NQ Diamond Coring **COMPILED BY** H.G.
DATUM Geodetic **DATE** January 10, 2012 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					w _p	w	w _L					
								SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
223.7	Ground Surface																			
0.0	130mm asphalt over 470mm sand and gravel						223													
	Compact Brown Sandy silt, trace clay trace gravel, rootlets topsoil inclusions		1	SS	17															
			2	SS	5															
222.3	Loose Dark Moist brown (FILL)						222													
1.4			3	SS	50/10cm															
	Silty sand trace clay, trace gravel cobbles and boulders																			
221.1	Dense Brown Moist		4	SS	50/0cm		221													
2.6	Dolomite bedrock																			
	Slightly weathered		5	RC NQ	REC 93%												RQD 45%			
	Low to medium strength																			
	Poor to excellent quality occasional vugs 5 to 25mm diameter		6	RC NQ	REC 90%		220									RQD 69%				
							219													
			7	RC NQ	REC 98%		218									RQD 98%				
217.0	End of borehole						217													
6.7																				
	* Borehole charged with drilling water																			

RECORD OF BOREHOLE No S4

1 of 1

METRIC

G.W.P. 43-00-00

LOCATION

Co-ords: 4 942 682.8 N ; 416 915.9 E
Hwy 6, Sta. 20+445, o/s 5.0m Lt.

ORIGINATED BY A.L.

DIST London

HWY 6

BOREHOLE TYPE C.F.H.S.A. and NQ Diamond Coring

COMPILED BY H.G.

DATUM Geodetic

DATE _____

January 04 and 05, 2012

CHECKED BY B.R.G.

[illegible]

RECORD OF BOREHOLE No S5

1 of 1

METRIC

G.W.P. 43-00-00

LOCATION

Co-ords: 4 942 692.0 N ; 416 919.1 E
Hwy 6, Sta. 20+447, o/s 4.5m Rt.

ORIGINATED BY A.L.

DIST London

HWY 6

BOREHOLE TYPE

Continuous Flight Hollow Stem Augers

COMPILED BY H.G.

DATUM Geodetic

DATE _____

January 05, 2012

CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p	w	w _L		GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
223.8	Ground Surface																				
0.0	130mm asphalt over 925mm sand and gravel		1	SS	20		223														
	Compact Brown to loose		2	SS	7																
	Clayey silt, trace sand rootlets, organics and topsoil inclusions																				
	Firm to Brown Moist very soft		3	SS	2		222						○								
221.5	(FILL)					▽*															
2.3	Silty sand		4	SS	12		221						○								
	Compact Brown Wet																				
	cobbles		5	SS	13								○								
220.2	End of borehole																				
3.6	Refusal on probable bedrock																				
<div>* 2012 01 05</div> <div>▽ Water level observed during drilling</div> <div>▼ Water level measured after drilling</div>																					

RECORD OF BOREHOLE No S6

1 of 1

METRIC

G.W.P. 43-00-00 **LOCATION** Co-ords: 4 942 702.3 N ; 416 902.0 E
 Hwy 6, Sta. 20+467, o/s 4.5m Rt. **ORIGINATED BY** A.L.
DIST London **HWY** 6 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** H.G.
DATUM Geodetic **DATE** January 05, 2012 **CHECKED BY** B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					w _p	w	w _L					
								SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
223.9	Ground Surface																			
0.0	130mm asphalt over 550mm sand and gravel		1	SS	20															
223.2	Compact Brown																			
0.7	Clayey silt, trace sand		2	SS	5															
	Firm Brown Moist																			
	cobbles and boulders		3	SS	50/5cm															
	Greyish brown																			
221.7	Sandy silt																			
2.2	trace clay, trace gravel		4	SS	6															
	Loose to Brown Wet compact																			
			5	SS	12															
220.4	seams/layer of sand and gravel																			
3.5	End of borehole																			
	Refusal on probable bedrock																			

* 2012 01 05

▽ Water level observed
during drilling

▼ Water level measured
after drilling



KEY PLAN
NOT TO SCALE

LEGEND

- Borehole
- Auger Probe
- 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. and Dec. 2011
- * Water level not established
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
S1	223.4	4 942 658.6	416 957.4
S2	223.7	4 942 669.4	416 938.2
S3	223.7	4 942 677.0	416 945.1
S4	223.9	4 942 682.8	416 915.9
S5	223.8	4 942 692.0	416 919.1
S6	223.9	4 942 702.3	416 902.0

NOTE

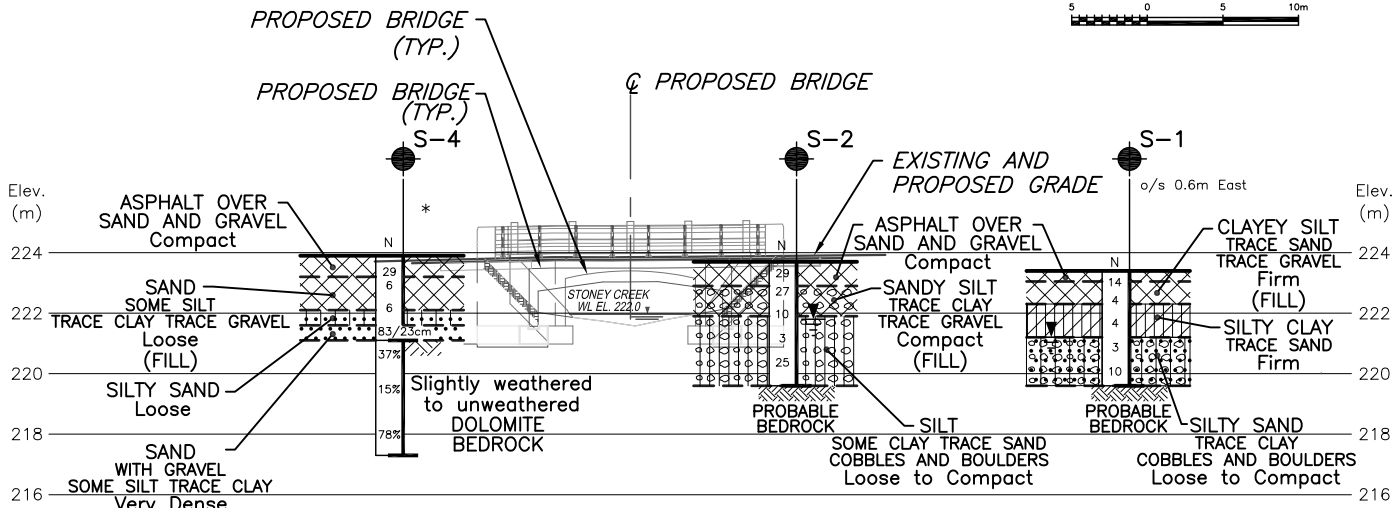
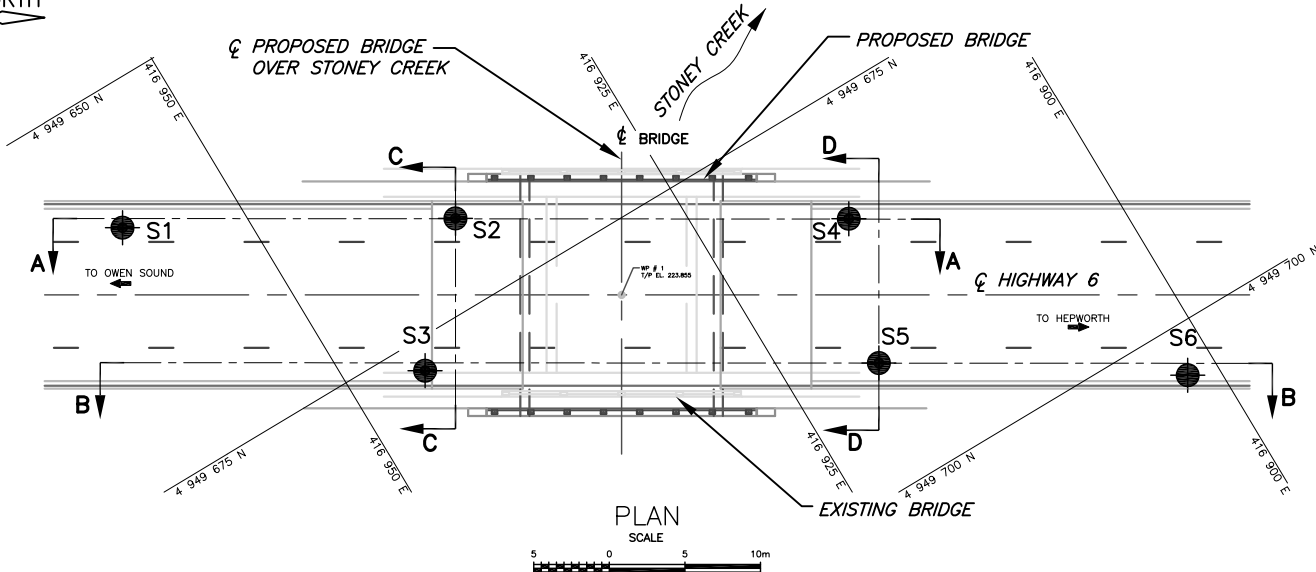
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

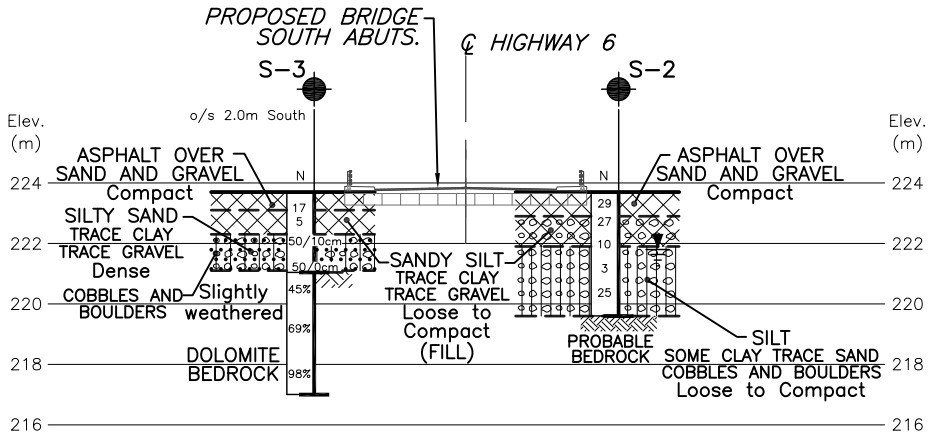
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HWY No	6	CHECKED	HG	DATE	OCT. 12, 2012	DIST	London
SUBM'D	NA	CHECKED	BRG	APPROVED	CN	SITE	8-9
DRAWN	NA	CHECKED	BRG	APPROVED	CN	DWG	SL-1

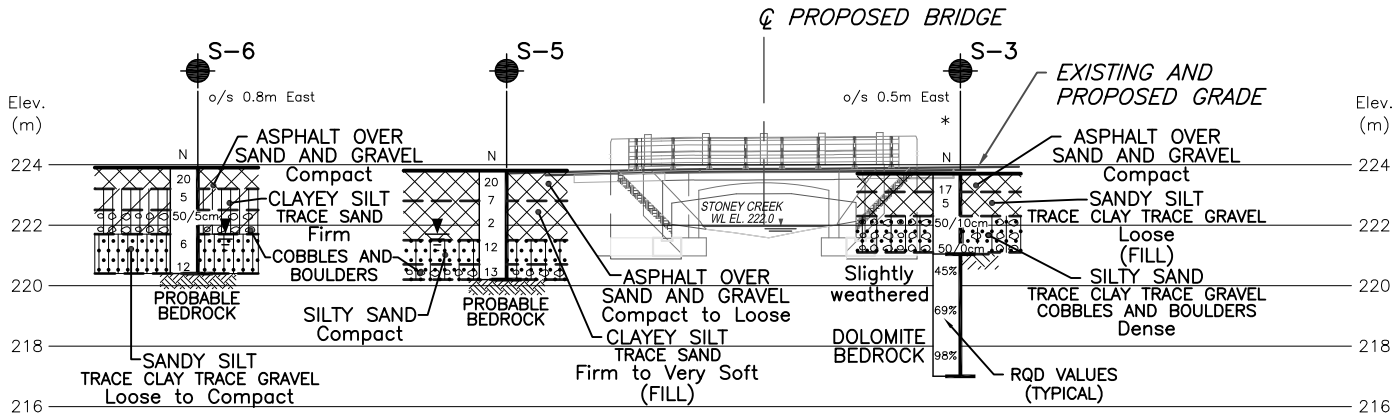
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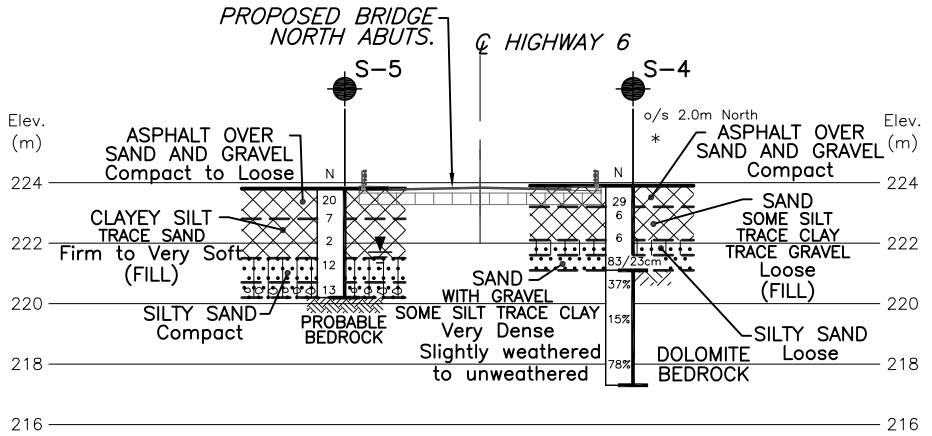
PROFILE A-A



SECTION C-C

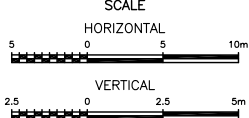


PROFILE B-B



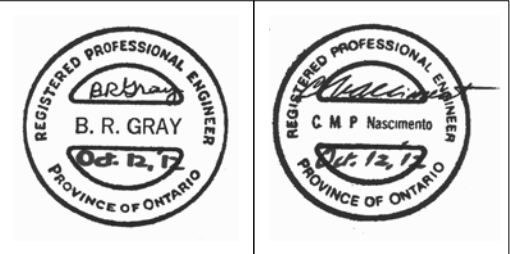
SECTION D-D

PROFILES AND SECTIONS



NOTES:

- THIS DRAWING SL-1 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.



REF MRC Drawing:
3811011-310-001GA_D.dwg dated March 2012



APPENDIX A

Site Photographs



Photograph 1: Looking north from the east side of Highway 6 towards the bridge. (January 10, 2012)



Photograph 2: Looking north from the west side of Highway 6. (January 10, 2012)

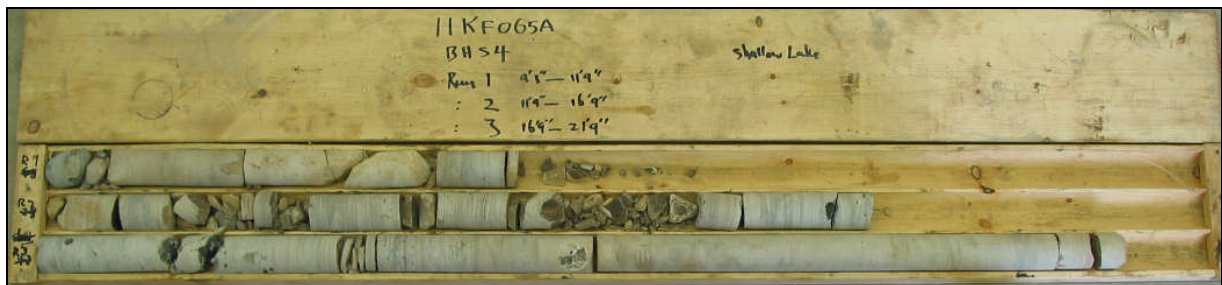


APPENDIX B

Rock Core Photographs



Photograph 1: Cores retrieved from borehole S3. Cores 5 to 7 from 2.6 to 6.7 m depth. RQD values ranged from 45 to 98%, indicating poor, fair to excellent rock quality.



Photograph 2: Cores retrieved from borehole S4. Cores 5 to 7 from 2.8 to 6.6 m depth. RQD values ranged from 15 to 78%, indicating very poor to good rock quality.



APPENDIX C

Auger Probe Findings

April 4, 2012

PML Ref.: 11KF065A
Index No.: 049LET

Mr. Scott Leitch, M.E.Sc., P.Eng.
Project Manager – Associate
Bridge Engineering
McCormick Rankin Corporation
72 Victoria Street South, Suite 100
Kitchener, Ontario
N2G 4Y9

Dear Mr. Leitch

Auger Probe Findings
Existing Shallow Lake Bridge Over Stoney Creek
Highway 6
Site No. 8-9, W.P. 43-00-00
Shallow Lake, Ontario

Peto MacCallum Ltd. (PML) is pleased to present our findings for the subsurface investigation conducted at the above-referenced site. Authorization to proceed with this assignment was provided by Mr. Leitch via email dated March 1, 2012.

Project Background

A geotechnical investigation report is currently being prepared for a bridge which will replace the existing Shallow Lake Bridge over Stoney Creek on Highway 6 in Shallow Lake, Ontario. In order to determine foundation support conditions for the existing bridge abutments and wing walls, a subsurface investigation program was requested by McCormick Rankin Corporation (MRC).

Investigation Procedures

The investigation program recommended by McCormick Rankin consisted of a series of auger probes at the southwest and northeast corners of the bridge, near the abutments and wing walls to determine the extent and thickness of the shallow spread footings used for bridge support.

Due to an existing overhead electrical utility which traverses the bridge at the southwest and northeast corners the probes were advanced at the southeast and northwest corners. The boreholes were advanced without sampling to auger refusal and the refusal materials sampled by coring methods in four probes.

The field work was carried out on March 20 and 21, 2012. The subsurface investigation comprised seven auger probes, three at the northwest corner (Probes 1S, 2S, 3S) and four at the southeast corner (Probes 1N to 4N).

Probes locations were laid out by PML based on distances from the existing bridge abutment specified by MRC.

The probes were advanced using continuous flight solid stem augers powered by a truck-mounted D-25, equipped for rotary core (NQ size) drilling, supplied and operated by a specialist drilling contractor. The drilling crews worked under the full-time supervision of a member of our engineering staff.



The refusal materials were cored in four auger probes locations. After completion of augering and coring, the holes were backfilled in accordance with the MTO guidelines and MOE Regulation 903 for borehole abandonment procedures using a bentonite/cement mixture grout.

Encountered Conditions

A summary of findings is provided in the Table below:

Borehole No.	Location	Depth to Auger Refusal (m)	Core Length (m)	Material Recovered in Core
1S (NW corner)	0.5 m north of north abutment, at approximate centreline of southbound shoulder lane	4.6	0.075 m	Bedrock
2S (NW corner)	2.85 m north of north abutment, 0.55 m east of wing wall pedestrian rail Probes drilled on a slight angle towards the wing wall. Due to this, the footing projection may be about 0.12 m less than indicated.	3.2	0.46	Concrete with 0.15 m of loose aggregate in middle of core
3S (NW Corner)	2.85 m north of north abutment, 1.1 east of wing wall pedestrian rail	3.05	1.07	Granular and cobble fragments
1N (SE corner)	0.5 m south of south abutment, 1.2 m west of wing wall pedestrian rail	3.66	---	---
2N (SE corner)	1.5 m south of south abutment, 1.2 m west of wing wall pedestrian rail	3.66	----	----
3 N (SE corner)	2.5 m south of south abutment, 1.2 m west of wing wall pedestrian rail	3.66	----	----
4 N (SE corner)	2.4 south of south abutment, 0.4 m west of wing wall pedestrian rail	1.5	2.6	1.67 m of cobbles underlain by 0.93 m of concrete. Top 0.12 m of concrete flat sided.



The auger probe findings indicate that a concrete footing was not encountered beyond 0.5 m of the abutment at the southeast and northwest corners of the bridge. The probe drilled at the wing wall at the northwest corner of the bridge contacted concrete 0.55 m east of the wing wall. This dimension is approximately 0.12 m smaller due to a small angle of drilling towards the wall that was required to set-up the drill rig. The borehole drilled at the southeast corner of the bridge contacted concrete 0.4 m west of the wing wall.

We trust the information presented in this report is sufficient for your present purposes. If you have any questions, please do not hesitate to contact our office.

Sincerely

Peto MacCallum Ltd.



Harry Gharegrat, MS, P.Eng.
Senior Engineer



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

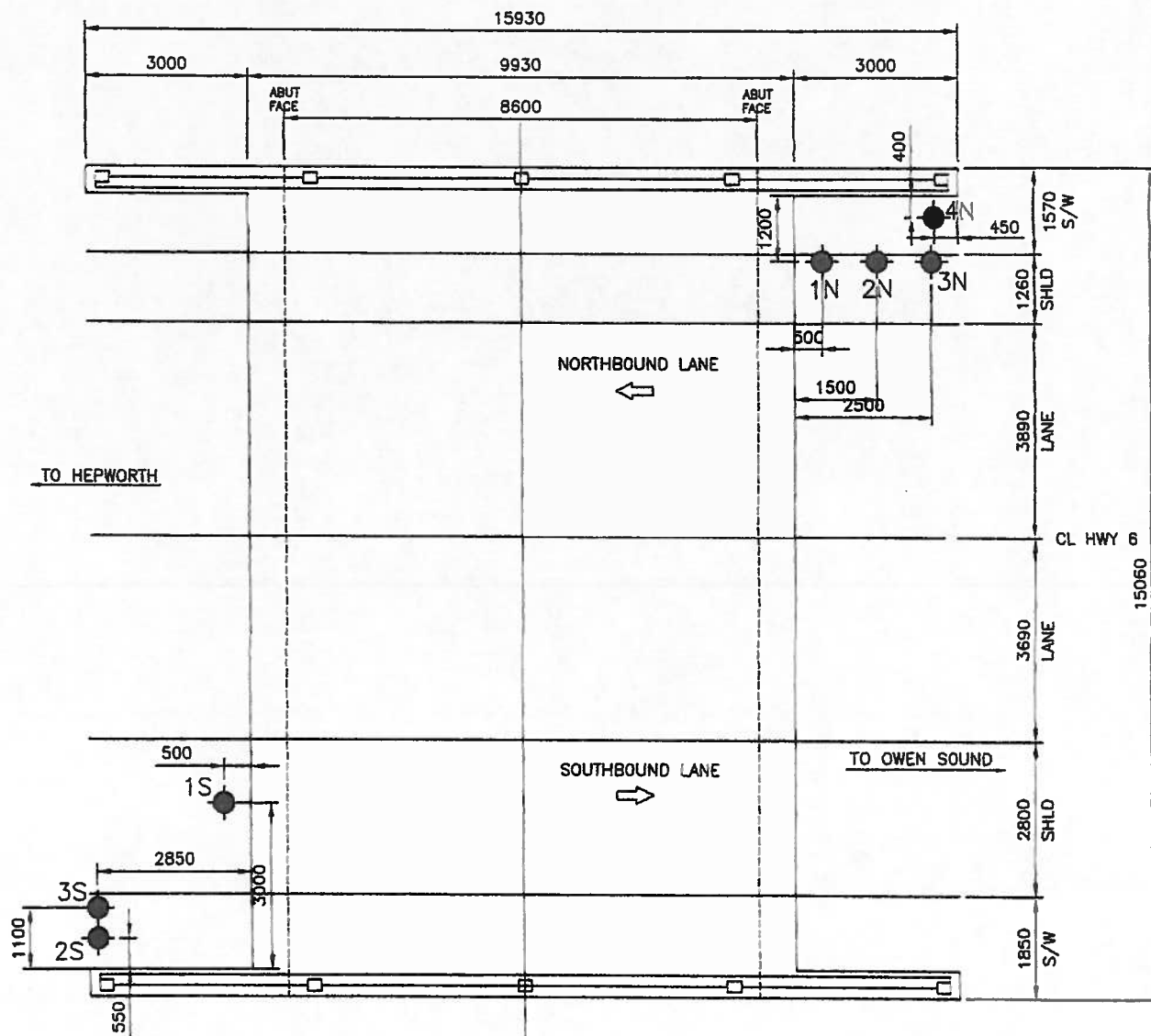
HG/CN:mm

Enclosure(s):

Sketch 1 – Auger Probe Location Plan

Distribution:


- 1 cc: Mr. Scott Leitch, McCormick Rankin Corporation
- 1 cc: Mr. Dan Green, McCormick Rankin Corporation
- 1 cc: PML Toronto
- 1 cc: PML Kitchener



HIGHWAY 6

REFERENCE:

This sketch was prepared from MRC drawing, 'shallow lake skect_SL jan 27 2012' named GA Shallow Lake Bridge - Structure Rehabilitation, received via email dated March 29, 2012.

SHALLOW LAKE BRIDGE		 Peto MacCallum Ltd. <i>C O N S U L T I N G E N G I N E E R S</i>				
SITE 8 - 9, W.P. 43-00-00						
HIGHWAY 6		DRAWN: N.A.	DATE	SCALE	JOB NO.	SKETCH NO.
AUGER PROBE LOCATION PLAN		CHECKED: H.G.	APRIL 2012	1 : 125	11KF065A	1
		APPROVED: C.N.				