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FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-91



Ontario

Ministry of
Transportation and
Communications

1

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3-27	Foundation Investigation Report for Cedar Creek Bridge Replacement W.P. 50-85-01, Site 6-182 Hwy. 18, Dist. 1, Chatham

Note: For purposes of the contract, this report supercedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

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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.

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 (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_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

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

For

Cedar Creek Bridge Replacement

W.P. 50-85-01; Str. Site 6-182

Hwy. 18, District 1, Chatham

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed detours and replacement of the existing structure on Hwy. 18 crossing Cedar Creek, during the period from 87-03-02 to 87-03-17. The fieldwork consisted of 10 sampled boreholes and 11 dynamic cone penetration tests. The borings were advanced by hollow stem auger (82 mm I.D.) and BX casing (60 mm I.D.) using a machine mounted on a muskeg vehicle. Sampling was performed to a maximum depth of 19.4 m to an approximate elevation of 156.5 m and the cone tests to a maximum depth of 8.5 m to elevation 169.4 m.

SITE DESCRIPTION

The site is located 6.5 km west of Kingsville's west limit on Hwy. 18 over Cedar Creek, in the Township of Colchester South. The terrain in the immediate vicinity is flat, with Cedar Creek in a depressed wet hollow, vegetated by trees, grass, bullrushes, etc., with a swamp to the immediate northwest. The physiographic region is a Bevelled Till Plain.

The existing approaches are 8.5 m above the bottom of the creek. The existing structure was built in 1932 and is a 2 span reinforced concrete bridge with concrete "T" beams.

SUBSURFACE CONDITIONS

General

The subsoil was found to consist of 3 to 5 m of soft to stiff silty clay to clay, some sand, trace of gravel with varying amounts of organics and a layer of peat encountered within the cohesive deposits in the Boreholes 1

and 13. The cohesive material is underlain by deposits of loose to very dense silty sand, traces of gravel with layers of sandy silt extending to dolostone bedrock 19.4 m below the ground level at approximate elevation 159.5 m. The fill material found in the existing approach fills consisted of a hard silty clay, some sand, some gravel with varying amounts of organic.

A brief description of the different soil types is given below.

Silty Clay to Clay (Fill Material)

Fill material consisting of silt clay of low to medium plasticity to a clay of high plasticity, some sand, traces of gravel with varying amounts of organics was found at the surface or just below the shoulder granular at all but the boreholes north of the highway. The material ranged in depth from 1.0 to 5.1 m. The organic content varied from none in borehole 3 to 15% in borehole 2. The record of borehole sheets in the appendix should be consulted regarding plasticity and organic content, however boreholes 1 and 2 were generally clay, some sand with varying amount of organics, trace of gravel and the other boreholes were generally silty clay, some sand, with varying amounts of organics with a 1.7 layer of clay (some sand, varying amounts of organics, trace of gravel) under the silty clay on the southwest quadrant.

The physical properties of the silty clay and the clay fill as determined by field and laboratory tests are summarized below.

1. Silty Clay

		<u>Range</u>
Natural Moisture Content (w) %		11.5-28.5
Liquid Limit	(w _L) %	24.5 - 50
Plastic Limit	(w _p) %	12.5 - 22
Unit Weight (t/m ³)	(γ)	1.94-2.08

Figure 1 indicates that the material plots as a CL-CI on the plasticity chart.

2. Clay

		<u>Range</u>
Natural Moisture Content (w) %		24-97.5
Liquid Limit (w _L) %		55-70.5
Plastic Limit (w _p) %		23-35
Unit Weight (t/m ³)	(Y)	(1.41)

Figure 2 indicates that the material plots as a CH on the plasticity chart.

The grain size distribution for the silty clay to clay fill is shown in Figure 3 in the Appendix in envelope form. The consistency of the cohesive deposit ranged from very soft to stiff to hard.

Peat

At boreholes 1 and 13 a very soft to firm deposit of fine to medium fibrous peat was encountered under the cohesive fill described above. The peat was approximately 1 m in thickness, with a natural moisture content of 22%.

Silty Clay, with Sand, Trace of Gravel

This 1 to 3 m± deposit was found below the surface, north of the structure by the swamp, beneath the creek bed and under the clay deposit on the south side (Borehole 1). It consisted of silty clay, with sand, trace of gravel, with varying amounts of organics.

The natural moisture content (w) ranged from 25 to 50%, liquid limit (w_L) from 29 to 41%, plastic limit (w_p) from 14 to 22%. Figure 4 indicates that the deposit plots as a silty clay of low to intermediate plasticity. The organic content ranged from 1.7 to 60% by weight.

The grain size distribution tests showed 1 to 4% gravel, 31 to 39% sand and 58 to 67% silt and clay. The N-blows from the standard penetration tests averaged at 3, ranging from 2 to 6, tending to become harder with depth. The consistency of the material ranged from soft to firm.

Clay

In borehole 1 beneath the peat and under the silty clay described above on the northeast side of the structure (Borehole 7), 2.3 m± below ground level was a 0.7 to 2.4 m thick deposit of very soft to firm clay of high plasticity (CH). The lab tests indicated that the natural moisture content (w) was 27 to 49%, liquid limit (w_L) 58% and the plastic limit (w_p) 22%.

Silty Sand, trace of Gravel

Below all the cohesive deposits mentioned above is a deposit of silty sand, trace of gravel with layers of sandy silt extending to bedrock.

The natural moisture content ranged from 10.5% to 22.5% with a mean of 18%. The denseness of the overall material ranged from compact to very dense increasing with depth. Figure 5 shows the results of the grain size distribution for this material in envelope form. The layers of sandy silt are discussed below.

Sandy Silt Layers, occ. traces of Gravel

Within the silty sand, trace of gravel deposit there are two layers of sandy silt, occ. traces of gravel. These two layers range in thickness from 0.6 to 1.1 m. The top layer is between elevation 170 and 175 m and the lower between elevation 166 and 168 m.

The natural moisture content ranged from 13.5 to 21% with a mean of 18.5%. The denseness ranged from loose to very dense. Figure 6 shows the results of the grain size distribution for the layers in envelope form.

BEDROCK

Bedrock was encountered below the overburden material at the following estimated elevations:

	<u>Bedrock (m)</u>	<u>Unweathered Bedrock (m)</u>
BH #1	160.1	159.7
BH #4	159.5	159.5
BH #6	159.3	159.1

Bedrock is a sandy dolostone and dolostone of the Detroit River Group. The rock core samples were examined by S. A. Senior, Geological Engineer, and his description is included in Figure 7 of the Appendix of this report.

GROUNDWATER CONDITIONS

The following groundwater conditions were observed during the field investigation:

<u>Borehole</u>	<u>Elevation (m)</u>
1	Artesian conditions encountered at: elev. 170.9 m, head not recorded elev. 164.9 m, head to 176.1 m elev. 161.4 m, head to 178.2 m.
2	Artesian conditions encountered at: elev. 172.6 m, head not recorded elev. 168.0 m, head to 176.5 m.

cont'd

BoreholeElevation (m)

3	Artesian conditions encountered at: elev. 173.8 m, head not recorded
4	Artesian conditions encountered at: elev. 172.9 m, head not recorded
5	NOT RECORDED
6	Artesian conditions encountered at: elev. 174.2 m, head not recorded elev. 161.0 m, head to 178.6 m
7	NOT RECORDED
11	Artesian conditions encountered at: elev. 172.4 m, head to 178.3 m
13	NOT RECORDED

The boreholes indicate artesian water was encountered at elevation 174.2 to 170.9 m just below the cohesive material with a maximum head found to 178.6 m, 3.1 m above the ground level.



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APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 50-85-01 LOCATION Sta: 24 + 266, Offset 16 m Rt. C
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.) / BX Casing
DATUM Geodetic DATE 87 03 03 to 87 03 06
ORIGINATED BY PM
COMPILED BY PM
CHECKED BY CT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALES	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			20 40 60 80 100	20 40 60 80 100					
175.1	Ground Level						175.2							
0.0	Clay Some Sand Trace of Organics Very Soft (Fill)						174.1							
174.1	Peat		1	SS	1		174							
1.0	Fine to Medium Fibre Very Soft		2	SS	2									
172.6	Clay		3	SS	1									
171.9	Very Soft		4	TW	PM		172							
3.3	Silty Clay		5	SS	2		170.9							
171.0	Soft to Firm		6	SS	24		170							
4.1	Silty Sand, Layer of Sandy Silt		7	SS	44		168							4 91 5
			8	SS	122		170							6 49 45
	Trace of Gravel		9	SS	63		166							1 93 6
	Layer of Sandy Silt		10	SS	48		164.9							4 42 54
	Compact to Very Dense		11	SS	96		164							1 97 2 22 77 1 2 84 14
			12	SS	29		162							10 89 1
160.1			13	SS	100/	5cm	161.4							
15.0	Weathered Dolostone Sound Bedrock		14	RC	REC 78		160							
157.0			15	RC	REC 100		158							
18.1	End of Borehole * Artesian Conditions Encountered at Elev. 170.9 m (Head not Recorded) at Elev. 164.9 m Artesian Head to Elev. 176.1 m and at Elev. 161.4 m Artesian Head to Elev. 178.2													

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2										METRIC				
W P 50-85-01		LOCATION Station: 24 + 272.6; Offset 16.2 m Rt. of C				ORIGINATED BY PM								
DIST 1 HWY 18		BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing				COMPILED BY PM								
DATUM Geodetic		DATE 87 03 06 to 87 03 09				CHECKED BY ST								
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			20	40					
175.3	Ground Level													
0.0	Clay Some Sand Trace of Gravel With Varying Amounts of Organics Very Soft to		2	SS	1									
			3	TW	PM									
172.6	Soft (Fill)													
2.7	Layer of Sandy Silt		4	SS	24									
			5	SS	41									
	Silty Sand		6	SS	76									
			7	SS	71									
			8	SS	73									
	Compact to Very Dense		9	SS	120/									
165.7	Layer of Sandy Silt		10	SS	129									
9.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3										METRIC				
W P 50-85-01		LOCATION Station: 24 + 310; Offset 12 m Rt. of C				ORIGINATED BY PH								
DIST 1 HWY 18		BOREHOLE TYPE Cont. Flight Auger (H.S.)				COMPILED BY PH								
DATUM Geodetic		DATE 87 03 06 to 87 03 09				CHECKED BY DT								
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	20						40
177.5	Ground Level													
0.0	Silty Clay, Some Sand, Some Gravel (Fill)	X	1	TW	PH									
			2	SS	37									
			3	SS	50									
174.1	Hard		4	SS	43								15 20 65	
3.4	Silty Sand		5	SS	30								0 91 9	
172.9	Dense													
4.6	End of Borehole													
	* Artesian Conditions encountered at Elev. 173.8 m (Head not recorded)													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 50-85-01 LOCATION Station: 24 + 202.1; Offset 15.2 m Rt. of C ORIGINATED BY MJ
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.) ; BX Casing COMPILED BY PM
 DATUM Geodetic DATE 87 03 10 to 87 03 11 CHECKED BY

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 t/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
175.9	Ground Level															
0.0	Silty Clay Some Sand Trace of Gravel Trace of Organics (Fill)		1	TW	PH										2.03	0 9 91 * 1.35
			2	SS	16											
172.9	Stiff		3	SS	14											2 22 76
3.0	Silty Sand Trace of Gravel Compact to Dense		4	SS	19											
			5	SS	45											14 61 25
			6	SS	54											
	Layer of Sandy Silt		7	SS	110/	20 cm										
	to		8	SS	68											0 22 78
	Very Dense		9	SS	135											
	Layer of Sandy Silt		10	SS	145											0 20 80
			11	SS	153											
			12	SS	220											
			13	SS	74											2 88 10
			14	SS	129											
159.5																
16.4	Dolostone Sound Bedrock		1	RC	REC 100											
156.5			2	RC	REC 97											
19.4	End of Borehole															
	* Organic Content % by Weight															
	** Artesian Conditions encountered at Elev. 172.9 m (Head not recorded)															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 50-85-01 LOCATION Station: 24 + 212.1; Offset 8 m Rt. of C ORIGINATED BY MJ
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 87 03 12 CHECKED BY PF

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	20					
178.6	Ground Level												
0.0	Silty Clay With Sand Trace of Gravel Trace of Organics		1	SS	5							Org. % 0.82	9 27 64
			2	SS	4								
			3	TW	PH								
	to		4	SS	6								
	Clay Some Sand (Occ. Wood) (Fill)		5	SS	7								
174.0	Firm to Hard		6	SS	44								1 16 83
4.6	Layer of Sandy Silt Loose		7	SS	5								
			8	SS	36								
	Silty Sand Occ. Trace of Gravel Dense to Very Dense		9	SS	43								3 32 65
170.4			10	SS	93								0 57 43
8.2	End of Borehole												
	* WL not recorded												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 50-85-01 LOCATION Station: 24 + 203.1; Offset 18.4 m Lt. of E ORIGINATED BY MJ
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing COMPILED BY PM
DATUM Geodetic DATE 87 03 12 to 87 03 13 CHECKED BY ET

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION-SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ t/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
176.4	Ground Level						178							
0.0	Silty Clay With Sand Trace of Gravel With Varying Amounts of Organics Firm		1	TW	PH		176						1.99*	4 37 36 23
			2	TW	PH		174.2						Org. 6.01%	1 36 37 26
173.5			3	CS	6		174							
2.9	Layer of Sandy Silt		4	CS	36									
			5	SS	31									
	Silty Sand Dense to Very Dense		6	CS	49		172							0 14 86
			7	SS	56									0 60 40
			8	SS	64		170							
			9	CS	72									
			10	SS	72		168							
			11	SS	40		166							0 83 17
	Occ. Traces of Gravel		12	SS	59		164							
			13	SS	106		162							
			14	SS	91		160							0 83 17
159.3							161.0 m							
17.1	Weathered		1	RC	REC 60									
	Dolostone Sound Bedrock		2	RC	REC 95		158							
157.2														
19.2	End of Borehole													
	* Organic Content 2.77%													
	** Artesian Conditions encountered at 174.2 m (Head not recorded)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 50-85-01 LOCATION Station: 24 + 288.1; Offset 21 m Lt. of E ORIGINATED BY MJ
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing COMPILED BY PH
 DATUM Geodetic DATE 87 03 13 to 87 03 14 CHECKED BY ST

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							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
175.4	Ground Level							20 40 60 80 100						GR SA SI CL	
0.0	Silty Clay With Sand Trace of Gravel, With Varying Amounts of Organics. Occ Buried Logs Soft to Firm		1	SS	2	*	174						Org. %	2 31 67	
173.2			2	SS	2								5.9		
2.2	Clay With Sand, Trace of Gravel, With Varying Amounts of Organics		3	SS	100/		172						Org. %	6 28 66	
170.8	Soft to Firm		4	SS	2										
4.6			5	SS	2										
			6	SS	5										
	Silty Sand Very Loose to Very Dense		7	SS	0		170								
			8	SS	21										
			9	SS	42									0 84 16	
			10	SS	120/	23 cm	168								
165.8	Layer of Sandy Silt		11	SS	83		166								
9.6	End of Borehole														
	* WL not recorded														

OFFICE REPORT ON SOIL EXPLORATION

*³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8										METRIC	
W P 50-85-01		LOCATION Station: 24 + 178; Offset 15 m Rt. of C				ORIGINATED BY MJ					
DIST 1 HWY 18		BOREHOLE TYPE Cone Test				COMPILED BY PM					
DATUM Geodetic		DATE 87 03 12				CHECKED BY					
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
	Ground Level										
3.9	End of Cone										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 50-85-01 LOCATION Station: 24 + 346; Offset 9 m Lt. of C ORIGINATED BY PM
 DIST 1 HWY 18 BOREHOLE TYPE Cone Test COMPILED BY PM
 DATUM Geodetic DATE 87 03 16 CHECKED BY ST

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
0.0	Ground Level							20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100					
3.3	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 11

METRIC

W P 50-85-01 LOCATION Station: 24 + 292; Offset 5.2 m Lt. of C ORIGINATED BY PM
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.), BX Casing COMPILED BY PM
 DATUM Geodetic DATE 87 03 16 CHECKED BY DT

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y t/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
178.9	Ground Level													
0.0	Shoulder Granular						178.3							
178.3			1	SS	10		178							
0.6			2A	SS	2									
			2B	SS	3									
	Silty Clay Some Sand Trace of Gravel Trace of Organics (Fill)		3	SS	3		176						2.04	1 10 89 4 24 72
			4	SS	4									
			5	TW	PH		174						2.08 Org. % 1.12	3 18 39 40
173.2	Stiff						172.4							
5.7	Silty Clay Layer		6	SS	27		172							
	Layer of Sandy Silt		7	SS	13									1 .6 93
	Silty Sand		8	SS	47		170							
	Trace of Gravel		9	SS	38		168							5 67 28
			10	SS	73									
			11	SS	36		166							
			12	SS	60		164							
	Compact to Very Dense		13	SS	115		162							0 75 25
161.7														
17.2	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

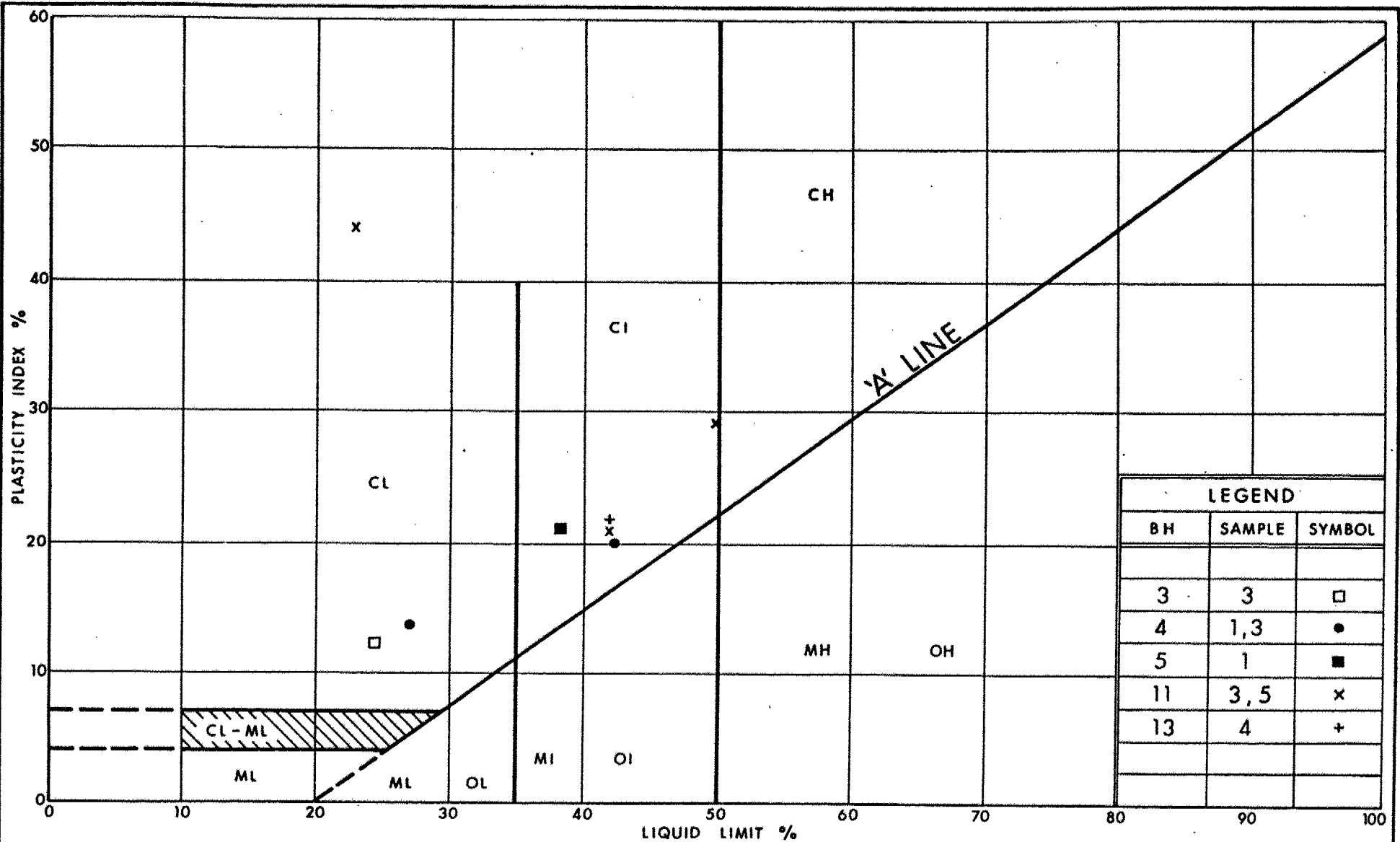
RECORD OF BOREHOLE No 13

METRIC

W P 50-85-01 LOCATION Station: 24 + 223; Offset 4.9 m Lt. of C ORIGINATED BY PM
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing COMPILED BY PM
 DATUM Geodetic DATE 87 03 17 CHECKED BY PM

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
178.5	Ground Level														GR SA SI CL
0.0															
177.1	Shoulder Granular					*	178								
1.4			1	SS	7										
			2	TW	PH		176								
	Silty Clay Trace of Sand Trace of Gravel With Varying Amounts of Organics (Fill)		3	SS	7										
			4	TW	PH		174								
	Firm to Stiff													1.94	0 9 91
172.2			5	SS	3		172								
6.3	Peat, Fine to Medium Fibre, Firm														
171.5															
7.0			6	SS	5		170								
	Layer of Organic Silty Sand													Org. % 7.72	0 47 41 12
			7	SS	11										
	Silty Sand														
	Loose						168								
	to		8	SS	65										
	Very Dense														
	Layer of		9	SS	120/	24 cm	166								
	Sandy Silt														
	Trace of														
	Gravel						164								
162.8			10	SS	120/	25 cm									1 82 17
15.7	End of Borehole														
	* Water Level not recorded														

OFFICE REPORT ON SOIL EXPLORATION

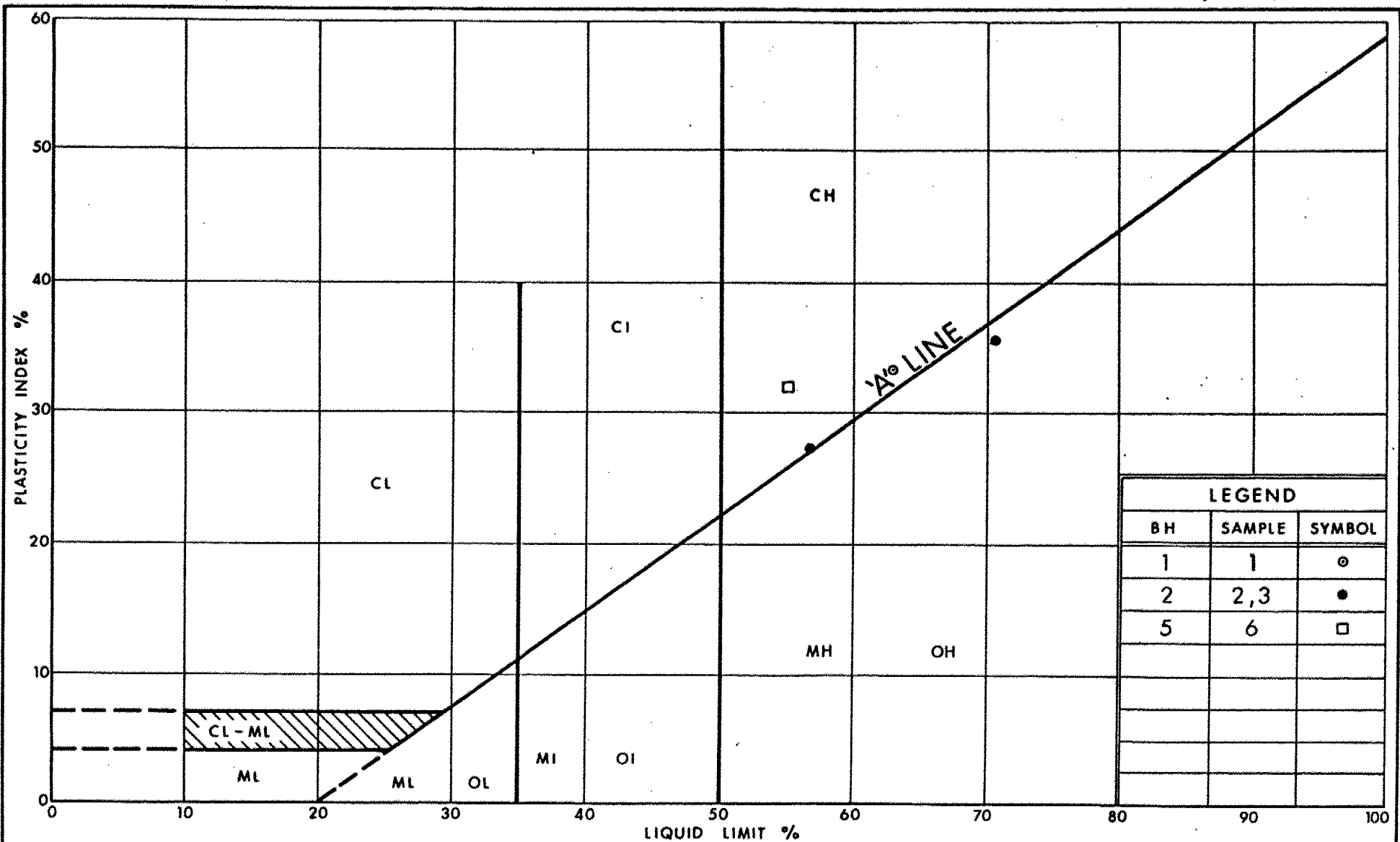


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PLASTICITY CHART
SILTY CLAY (Fill) (CL, CI) SOME SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORG'S

FIG No 1

W P 50 - 85 - 01



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PLASTICITY CHART
CLAY (fill) (CH) SOME SAND
WITH VARYING AMOUNTS OF ORG'S, TR OF GRAVEL

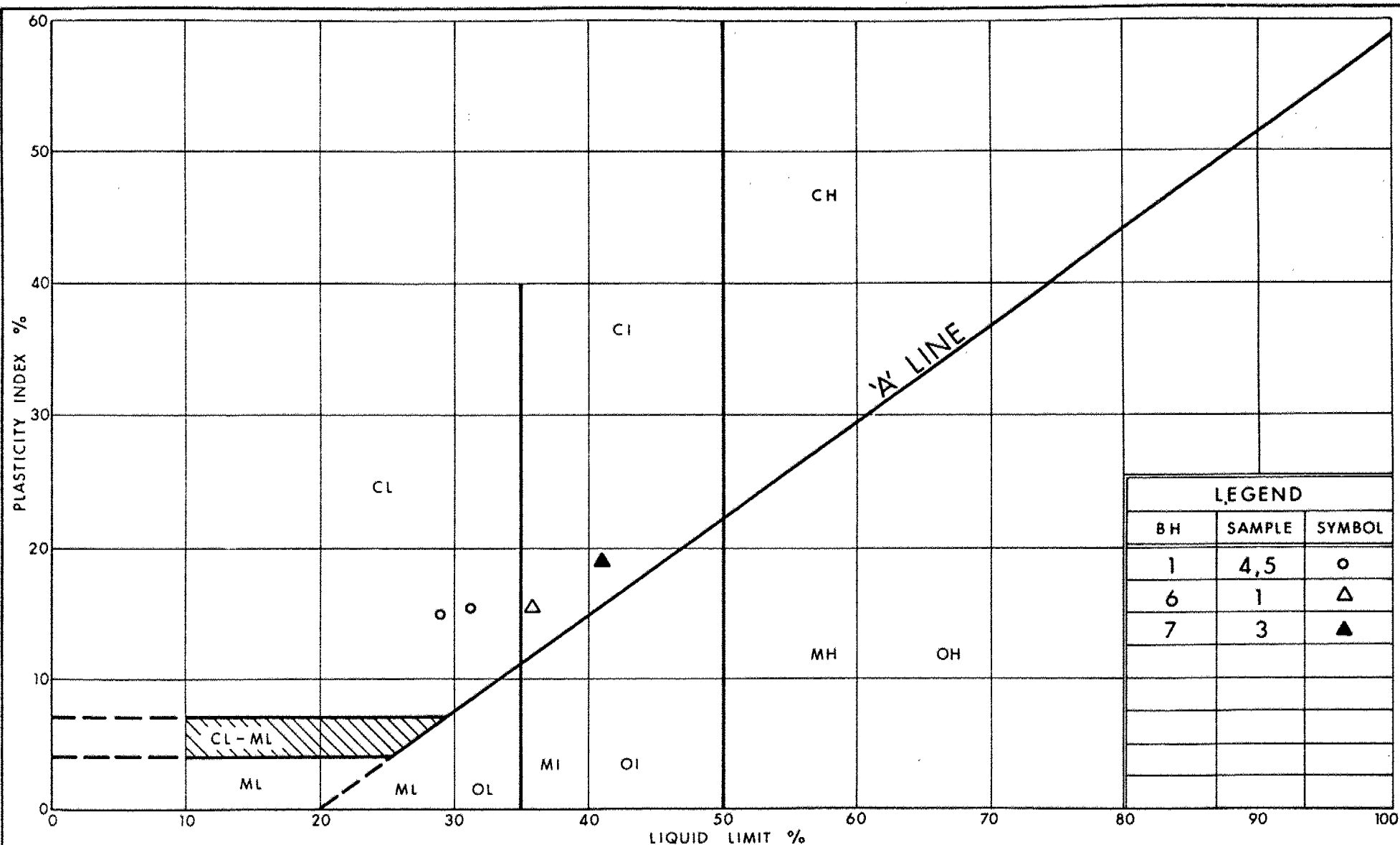
FIG No 2

W P 50 - 85 - 01



GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY SOME SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORG'S

W P 50 - 85 - 01



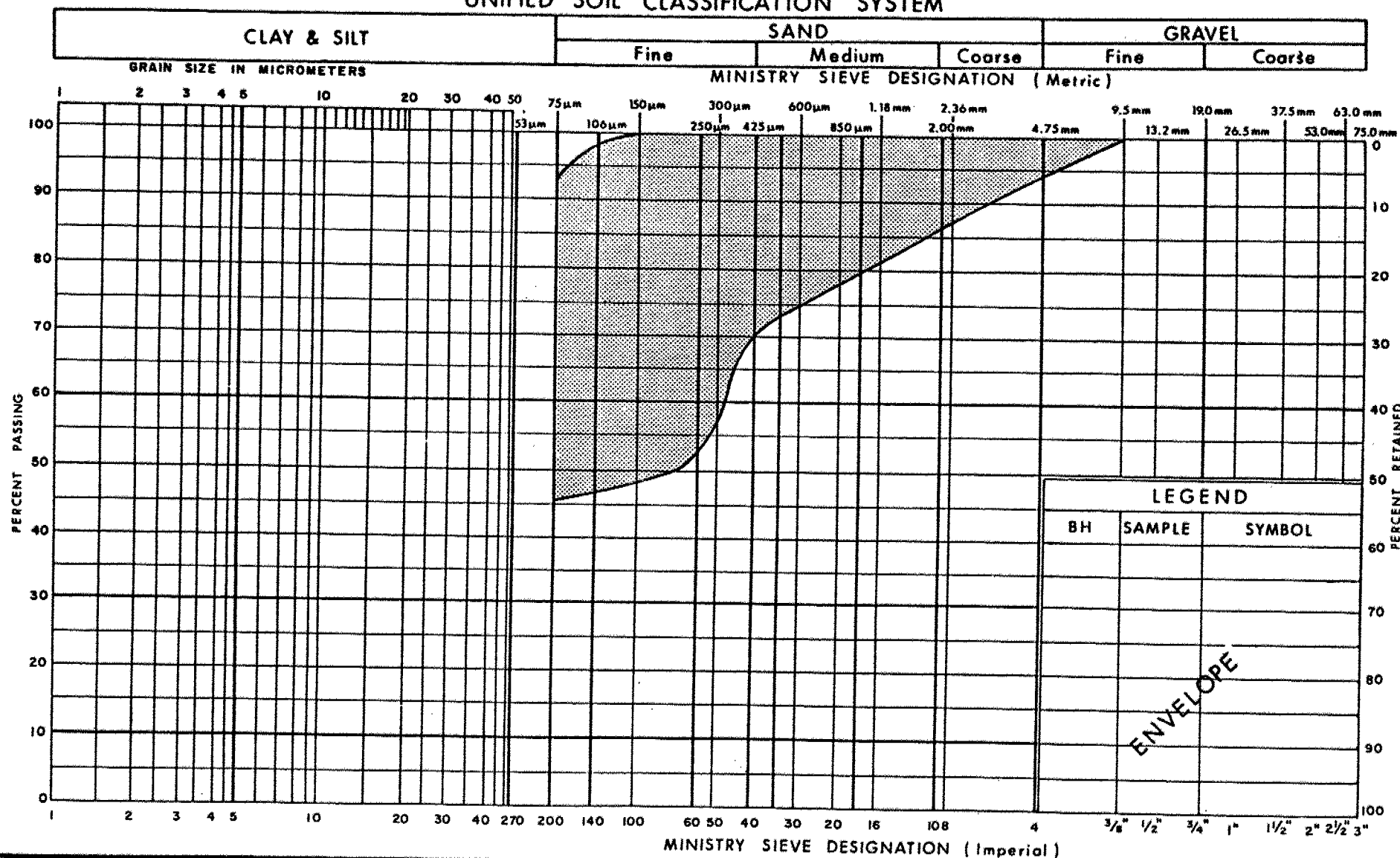
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PLASTICITY CHART
SILTY CLAY (CL, CI) WITH SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORGANICS

FIG No 4

W P 50-85-01



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GRAIN SIZE DISTRIBUTION
SANDY SILT LAYERS, OCC TRACE OF GRAVEL

FIG No 6

W P 50 - 85 - 01

DESCRIPTION OF ROCK CORE - W.P.

50-85-01

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR *	% RQD *	DEPTH (m)	DESCRIPTION
1	15.00-16.52	78	57	15.00-16.22	SANDY DOLOSTONE, medium brown, medium grained, porous (vugs to 2 cmØ), thickly bedded, slightly weathered, closely to very closely fractured
	16.52-18.05	100	73	16.22-17.49	DOLOSTONE, medium grey to brown, fine grained, slightly vuggy, very thinly laminated, (stylolitic), unweathered, moderately to closely spaced fractures
				17.49-18.05	DOLOSTONE, medium brown to grey, fine grained, slightly vuggy, very thickly bedded, unweathered, widely spaced fractures
4	16.39-17.92	100	70	16.39-17.00	SANDY DOLOSTONE, Medium brown, medium grained, porous, thickly bedded, slightly weathered, moderately fractured, fractures inclined @ 75°, rough
	17.92-19.44	97	90	17.00-18.07	DOLOSTONE, medium grey to brown, fine grained, thinly laminated, moderately weathered to unweathered; infilled zones of cemented sand/clay at 17.13 and 17.66
				18.07-19.44	DOLOSTONE, medium brown to grey, fine to medium grained, slightly vuggy, thickly bedded, unweathered, widely spaced fractures
6	17.08-17.72	68	0	17.08-17.74	SANDY DOLOSTONE, medium brown, medium grained, slightly porous, thickly bedded, slightly weathered, moderately fractured, high angle (75°) through this section of core
	17.72-19.24	95	85	17.74-19.09	DOLOSTONE, medium grey to brown, fine grained, thinly laminated, slightly weathered, organic rich, cemented sands/clay at 18.58
				19.09-19.24	DOLOSTONE, medium brown to grey, fine grained, thickly bedded, unweathered

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 50-85-01 DIST 1
HWY 18 STR SITE 6-182

Cedar Creek Bridge Replacement

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FOUNDATION INVESTIGATION REPORT
For
Cedar Creek Bridge Replacement
W.P. 50-85-01; Str. Site 6-182
Hwy. 18, District 1, Chatham

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed detours and replacement of the existing structure on Hwy. 18 crossing Cedar Creek, during the period from 87-03-02 to 87-03-17. The fieldwork consisted of 10 sampled boreholes and 11 dynamic cone penetration tests. The borings were advanced by hollow stem auger (82 mm I.D.) and BX casing (60 mm I.D.) using a machine mounted on a muskeg vehicle. Sampling was performed to a maximum depth of 19.4 m to an approximate elevation of 156.5 m and the cone tests to a maximum depth of 8.5 m to elevation 169.4 m.

SITE DESCRIPTION

The site is located 6.5 km west of Kingsville's west limit on Hwy. 18 over Cedar Creek, in the Township of Colchester. The terrain in the immediate vicinity is flat, with Cedar Creek in a depressed wet hollow, vegetated by trees, grass, bullrushes, etc., with a swamp to the immediate northwest. The physiographic region is a Bevelled Till Plain.

The existing approaches are 8.5 m above the bottom of the creek. The existing structure was built in 1932 and is a 2 span reinforced concrete bridge with concrete "T" beams, and it is reported to be supported on spread footing type foundations.

SUBSURFACE CONDITIONS

General

The subsoil was found to consist of 3 to 5 m of soft to stiff silty clay to clay, some sand, trace of gravel with varying amounts of organics and a layer of peat encountered within the cohesive deposits in the Boreholes 1

and 13. The cohesive material is underlain by deposits of loose to very dense silty sand, traces of gravel with layers of sandy silt extending to dolostone bedrock 19.4 m below the ground level at approximate elevation 159.5 m. The fill material found in the existing approach fills consisted of a hard silty clay, some sand, some gravel with varying amounts of organic.

A brief description of the different soil types is given below.

Silty Clay to Clay (Fill Material)

Fill material consisting of silt clay of low to medium plasticity to a clay of high plasticity, some sand, traces of gravel with varying amounts of organics was found at the surface or just below the shoulder granular at all but the boreholes north of the highway. The material ranged in depth from 1.0 to 5.1 m. The organic content varied from none in borehole 3 to 15% in borehole 2. The record of borehole sheets in the appendix should be consulted regarding plasticity and organic content however boreholes 1 and 2 were generally clay, some sand with varying amount of organics, trace of gravel and the other boreholes were generally silty clay, some sand, with varying amounts of organics with a 1.7 layer of clay (some sand, varying amounts of organics, trace of gravel) under the silty clay on the southwest quadrant.

The physical properties of the silty clay and the clay fill as determined by field and laboratory tests are summarized below.

1. Silty Clay

		<u>Range</u>
Natural Moisture Content (w) %		11.5-28.5
Liquid Limit	(w _L) %	24.5 - 50
Plastic Limit	(w _p) %	12.5 - 22
Density (t/m ³)	γ	1.94-2.08

Figure 1 indicates that the material plots as a CL-CI on the plasticity chart.

2. Clay

		<u>Range</u>
Natural Moisture Content (w) %		24-97.5
Liquid Limit (w _L) %		55-70.5
Plastic Limit (w _p) %		23-35
Density (t/m ³)	γ	(1.41)

Figure 2 indicates that the material plots as a CH on the plasticity chart.

The grain size distribution for the silty clay to clay fill is shown in Figure 3 in the Appendix in envelope form. The consistency of the cohesive deposit ranged from very soft to stiff to hard.

Peat

At boreholes 1 and 13 a very soft to firm deposit of fine to medium fibrous peat was encountered under the cohesive fill described above. The peat was approximately 1 m in thickness, with a natural moisture content of 22%.

Silty Clay, with Sand

This 1 to 3 m± deposit was found below the surface, north of the structure by the swamp, beneath the creek bed and under the clay deposit on the south side (Borehole 1). It consisted of silty clay, with sand, trace of gravel, with varying amounts of organics.

The natural moisture content (w) ranged from 25 to 50%, liquid limit (w_L) from 29 to 41%, plastic limit (w_p) from 14 to 22%. Figure 4 indicates that the deposit plots as a silty clay of low to intermediate plasticity. The organic content ranged from 1.7 to 60% by weight.

The grain size distribution tests showed 1 to 4% gravel, 31 to 39% sand and 58 to 67% silt and clay. The N-blows from the standard penetration tests averaged at 3, ranging from 2 to 6, tending to become harder with depth. Based on these values the consistency of the material ranged from soft to firm.

Clay

In borehole 1 beneath the peat and under the silty clay described above on the northeast side of the structure (Borehole 7), 2.3 m± below ground level was a 0.7 to 2.4 m thick deposit of very soft to firm clay of high plasticity (CH). The lab tests indicated that the natural moisture content (w) was 27 to 49%, liquid limit (w_L) 58% and the plastic limit (w_p) 22%. The grain size distribution test showed 6% gravel, 28% sand and 66% silt and clay.

Silty Sand, trace of Gravel

Below all the cohesive deposits mentioned above is a deposit of silty sand, trace of gravel with layers of sandy silt extending to bedrock.

The natural moisture content ranged from 10.5% to 22.5% with a mean of 18%. The denseness of the overall material ranged from compact to very dense increasing with depth. Figure 5 shows the results of the grain size distribution for this material in envelope form. The layers of sandy silt are discussed below.

Sandy Silt Layers, occ. traces of Gravel

Within the silty sand, trace of gravel deposit there are two layers of sandy silt, occ. traces of gravel. These two layers range in thickness from 0.6 to 1.1 m. The top layer is between elevation 170 and 175 m and the lower between elevation 166 and 168 m.

The natural moisture content ranged from 13.5 to 21% with a mean of 18.5%. The denseness ranged from loose to very dense. Figure 6 shows the results of the grain size distribution for the layers in envelope form.

Organic Silty Sand

In borehole 13, 8 m below the ground level a 0.6 m thick layer of organic silty sand was found within the silty sand. This deposit's natural moisture content (w) was 40%, the liquid limit (w_L) 34.5% and plastic limit (w_p) 23.5%. The percentage of organic material was 7.72. The grain size distribution test showed sand 48%, silt 41% and clay 11%. The denseness of the deposit was compact.

BEDROCK

Bedrock was encountered below the overburden material at the following estimated elevations:

	<u>Bedrock (m)</u>	<u>Unweathered Bedrock (m)</u>
BH #1	160.1	159.7
BH #4	159.5	159.5
BH #6	159.3	159.1

Bedrock is a sandy dolostone and dolostone of the Detroit River Group. The rock core samples were examined by S. A. Senior, Geological Engineer, and his description is included in Figure 7 of the Appendix of this report.

GROUNDWATER CONDITIONS

The following groundwater conditions were observed during the field investigation:

<u>Borehole</u>	<u>Elevation (m)</u>
1	Artesian conditions encountered at: elev. 170.9 m, head not recorded elev. 164.9 m, head to 176.1 m elev. 161.4 m, head to 178.2 m.
2	Artesian conditions encountered at: elev. 172.6 m, head not recorded elev. 168.0 m, head to 176.5 m.
3	Artesian conditions encountered at: elev. 173.8 m, head not recorded
4	Artesian conditions encountered at: elev. 172.9 m, head not recorded
5	NOT RECORDED
6	Artesian conditions encountered at: elev. 174.2 m, head not recorded elev. 161.0 m, head to 178.6 m
7	NOT RECORDED
11	Artesian conditions encountered at: elev. 172.4 m, head to 178.3 m
13	NOT RECORDED

The boreholes indicate artesian water was encountered at elevation 174.2 to 170.9 m just below the cohesive material with a maximum head found to 178.6 m, 3.1 m above the ground level.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing two-span concrete T-beam structure at the same location. The proposed new structure is to be a single span beam type structure of 27.5 to 17 m± span length.

A bailey bridge is to be used for the detour of highway traffic during the construction. The location of the proposed bailey bridge detour is approximately 23 m south (or north) of the centreline of the existing structure.

Structure Foundations

In view of the encountered subsurface conditions, the following foundation recommendations are being made:

1. The new replacement and detour structures should be founded on steel 'H' piles driven to bedrock. This is likely to be difficult due to the very dense sand, therefore the hammer used should have a minimum energy of 90,000 joules/blow. The estimated bedrock elevations for the piles are given below:

	<u>West(m)</u>	<u>East(m)</u>		
Replacement Structure				
and 1 span south (and north detour)	159.7	159.9		
	<u>West Abut.</u>	<u>W. Pier</u>	<u>E. Pier</u>	<u>East Abut.</u>
South (and north) detour	159.5	159.7	159.8	160.0

For HP 310x110 steel 'H' piles, a design load of 1150 kN is recommended. For the purpose of the O.H.B.D.C., the following values are recommended:

Factored Capacity at U.L.S.	1600 kN
Capacity at S.L.S. Type II	1150 kN

All piles should be reinforced with pile tips. The pile caps should have a minimum of 1.2 m of earth cover for frost protection.

2. The abutments for the 3 span detour structure can be supported on cribs placed on a granular pad. Subexcavate 3 to 4 m below the existing ground level to remove all unsuitable material and 1 m larger all round in the plan area than the crib. Backfill with Granular 'B', to the required level. The recommended design load for the crib is 150 kPa, and for the purposes of the O.H.B.D.C. the following design values are recommended:

Factored Capacity at U.L.S. 450 kPa

Capacity at S.L.S. Type II 150 kPa

Earth pressure should be computed as per Subsection 6.6.1.2.2 of the Code. A yielding foundation condition may be assumed. Backfill to the structure should consist of Granular 'A' or Granular 'B' for which the following properties may be assumed:

Granular 'A' $\gamma = 22.8 \text{ kN/m}^2$, $\phi = 35^\circ$, $K_a = 0.271$

Granular 'B' $\gamma = 21.3 \text{ kN/m}^2$, $\phi = 30^\circ$, $K_a = 0.333$

Approaches

Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches at locations through which piles have to be driven, and it is recommended that this portion of the fill contain no larger grain sizes than 75 mm.

Embankments should be constructed with forward and side slopes not steeper than 2 horizontal to 1 vertical.

Settlements will occur due to consolidation of the cohesive soil, organics and peat in the original ground due to the weight of the new approach embankments.

To insure an acceptable amount of settlement of the approaches to the replacement structure, the peat and soft material deposits should be removed. Figure 8 in the Appendix indicates the geometry for the subexcavation under the proposed approaches. The peat, soft cohesive and organic material is to be subexcavated down to elevation 170 m. It is to be filled with granular material to a level 0.5 m above the prevailing ground water level. The upper 1 m of this material should be Granular 'A' and the remainder Granular 'B'. The remainder of the abutments may consist of any suitable material. The subexcavation is to extend from the toe of the slope at the creek back 20 m from the abutments centreline of bearing.

Dewatering

Concrete should be placed in the 'dry'. A dewatering scheme will be required for excavations below the prevailing groundwater level (creek level). In addition, if working below the cohesive deposits, artesian water conditions will most likely exist.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mrs. P. Marks, Project Foundation Engineer. The equipment was owned and operated by Atcost Soil Drilling Inc. This report was prepared by Mrs. P. Marks and reviewed by Mr. K. G. Selby.



A handwritten signature in cursive script, appearing to read "P. Marks".

P. Marks, P. Eng.
Project Foundation Engineer

A handwritten signature in cursive script, appearing to read "M. Devata".

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

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.

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

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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

METRIC

W P 50-85-01 LOCATION Sta: 24 + 266. Offset 16 m Rt. 4
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.)/ BX Casing
DATUM Geodetic DATE 87 03 03 to 87 03 06
ORIGINATED BY
COMPILED BY PM
CHECKED BY DT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALES	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			20 40 60 80 100	20 40 60 80 100					
175.1	Ground Level						178.2							
0.0	Clay Some Sand Trace of Organics Very Soft (Fill)						178.1							
174.1	1.0 Peat		1	SS	1									
	2.5 Fine to Medium Fibre Very Soft		2	SS	2									
172.6	3.2 Clay		3	SS	1									
171.9	4.1 Very Soft		4	TW	PM									
	5.2 Silty Clay		5	SS	2									
171.0	Soft to Firm													
4.1	Silty Sand, Layer of Sandy Silt		6	SS	24									
	7		7	SS	44									4 91 5
	8		8	SS	122									6 49 45
	Trace of Gravel		9	SS	63									1 93 6
	Layer of Sandy Silt		10	SS	48									4 42 54
	Compact to Very Dense		11	SS	96									1 97 2 22 77 1 2 84 14
			12	SS	29									10 89
160.1	13		13	SS	100/	5 cm								
15.0	14		14	RC	REC 78									
	Dolostone Sound Bedrock		15	RC	REC 100									
157.0	15													
18.1	End of Borehole													
	* Artesian Conditions Encountered at Elev. 170.9 m (Head not Recorded) at Elev. 164.9 m Artesian Head to Elev. 176.1 m and at Elev. 161.4 m Artesian Head to Elev. 178.2													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 50-85-01 LOCATION Station: 24 + 272.6; Offset 16.2 m Rt. of C ORIGINATED BY PM
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing COMPILED BY PM
 DATUM Geodetic DATE 87 03 06 to 87 03 09 CHECKED BY ET

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			20	40	60	80	100				
175.3	Ground Level															
0.0	Clay Some Sand Trace of Gravel With Varying Amounts of Organics Very Soft to Soft (Fill)		2	SS	1		174								Org. % 5.54	1 13 86
172.6	Layer of Sandy Silt		3	TW	PM		172.6								1.42	0 18 82
2.7	Silty Sand		4	SS	24		172								Org. % 15.6	2 48
			5	SS	41		170									10 70 20
			6	SS	76											
			7	SS	71											
			8	SS	73											0 91 9
	Compact to Very Dense		9	SS	120/		168									
165.7	Layer of Sandy Silt		10	SS	129		166									0 35 65
9.6	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 50-85-01 LOCATION Station: 24 + 310; Offset 12 m Rt. of C
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.)
DATUM Geodetic DATE 87 03 06 to 87 03 09
ORIGINATED BY PM
COMPILED BY PM
CHECKED BY DT

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
177.5	Ground Level													
0.0	Silty Clay, Some Sand, Some Gravel (Fill)		1	TW	PH	*								
			2	SS	37									
			3	SS	50									
174.1	Hard		4	SS	43									
3.4	Silty Sand		5	SS	30									
172.9	Dense													
4.6	End of Borehole													
	* Artesian Conditions encountered at Elev. 173.8 m (Head not recorded)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 50-85-01 LOCATION Station: 24 + 202.1; Offset 15.2 m Rt. of C ORIGINATED BY MJ
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.) ; BX Casing COMPILED BY PM
 DATUM Geodetic DATE 87 03 10 to 87 03 11 CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
175.9	Ground Level																
0.0	Silty Clay Some Sand Trace of Gravel Trace of Organics (Fill)		1	TW	PH											2.03	0 9 91 * 1.35
172.9	Stiff		2	SS	16												2 22 76
3.0	Silty Sand Trace of Gravel Compact to Dense		3	SS	14												14 61 25
			4	SS	19												
			5	SS	45												
			6	SS	54												
	Layer of Sandy Silt		7	SS	110/	20 cm											
	to		8	SS	68												0 22 76
	Very Dense		9	SS	135												
	Layer of Sandy Silt		10	SS	145												0 20 80
			11	SS	153												
			12	SS	220												
			13	SS	74												2 88 10
			14	SS	129												
159.5																	
16.4	Dolostone Sound Bedrock		1	RC	REC 100												
156.5			2	RC	REC 97												
19.4	End of Borehole																
	* Organic Content % by Weight																
	** Artesian Conditions encountered at Elev. 172.9 m (Head not recorded)																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 50-85-01 LOCATION Station: 24 + 212.1; Offset 8 m Rt. of C ORIGINATED BY MJ
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.) COMPILED BY BY
 DATUM Geodetic DATE 87 03 12 CHECKED BY

SOIL PROFILE		STRAT. PLOT	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		NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
178.6	Ground Level													
0.0	Silty Clay With Sand Trace of Gravel Trace of Organics		1	SS	5	*	178						Org. % 0.82	9 27 64
			2	SS	4									
			3	TW	PH									
			4	SS	6		176							
	to Clay Some Sand (Occ. Wood) (Fill)		5	SS	7									
174.0	Firm to Hard		6	SS	44		174							1 16 83
4.6	Layer of Sandy Silt Loose		7	SS	5									
			8	SS	36									
	Silty Sand Occ. Trace of Gravel Dense to Very Dense		9	SS	43		172							3 32 65
170.4			10	SS	93									0 57 43
8.2	End of Borehole													
	* WL not recorded													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 50-85-01 LOCATION Station: 24 + 203.1; Offset 18.4 m Lt. of C
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing
DATUM Geodetic DATE 87 03 12 to 87 03 13
ORIGINATED BY
COMPILED BY
CHECKED BY

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			20 40 60 80 100	20 40 60 80 100	25 50 75					
176.4	Ground Level														
0.0	Silty Clay With Sand Trace of Gravel With Varying Amounts of Organics Firm		1	TW	PH		176						1.99*	4 37 36 23	
			2	TW	PH								Org. 6.01%	1 36 37 23	
173.5			3	CS	6		174.2								
2.9	Layer of Sandy Silt Silty Sand Dense to Very Dense Occ. Traces of Gravel		4	SS	36		174								
			5	SS	31									0 14	
			6	SS	49										
			7	SS	56									0 60 40	
			8	SS	64										
			9	SS	72										
			10	SS	72										
			11	SS	40									0 83 17	
			12	SS	59										
			13	SS	106										
			14	SS	91		161.0 m							0 83 17	
159.3		Weathered Dolostone Sound Bedrock		1	RC	REC 60									
17.1				2	RC	REC 95		158							
157.2		Bedrock													
19.2	End of Borehole														
	* Organic Content 2.77%														
	** Artesian Conditions encountered at 174.2 m (Head not recorded)														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 50-85-01 LOCATION Station: 24 + 288.1; Offset 21 m Lt. of C ORIGINATED BY M
 DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing COMPILED BY 1
 DATUM Geodetic DATE 87 03 13 to 87 03 14 CHECKED BY DT


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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
175.4	Ground Level												
0.0	Silty Clay With Sand Trace of Gravel, With Varying Amounts of Organics, Occ Buried Logs Soft to Firm		1	SS	2							Org.%	
			2	SS	2							5.9	2 31 67
173.2			3	SS	100/								
2.2	Clay With Sand, Trace of Gravel, With Varying Amounts of Organics		4	SS	2							Org.%	
			5	SS	2							3.52	6 28 66
170.8	Soft to Firm		6	SS	5								
4.6	Silty Sand Very Loose to Very Dense		7	SS	0								
			8	SS	21								
			9	SS	42								
			10	SS	120/								
165.8	Layer of Sandy Silt		11	SS	83								
9.6	End of Borehole												
	* WL not recorded												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 50-85-01 LOCATION Station: 24 + 178; Offset 15 m Rt. of C ORIGINATED BY
 DIST 1 HWY 18 BOREHOLE TYPE Cone Test COMPILED BY
 DATUM Geodetic DATE 87 03 12 CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
	Ground Level													
3.9	End of Cone													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 50-85-01 LOCATION Station: 24 + 346; Offset 9 m Lt. of C ORIGINATED BY PM
 DIST I HWY 18 BOREHOLE TYPE Cone Test COMPILED BY PM
 DATUM Geodetic DATE 87 03 16 CHECKED BY BT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
0.0	Ground Level												
3.3	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11

METRIC

W P 50-85-01 LOCATION Station: 24 + 292; Offset 5.2 m Lt. of C
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.), BX Casing ORIGINATED BY BY
DATUM Geodetic DATE 87 03 16 COMPILED BY R
CHECKED BY DT

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
178.9	Ground Level																
0.0	Shoulder Granular																
178.3																	
0.6			1	SS	10		178.3										
			2A	SS	2		178										
	Silty Clay Some Sand		2B	SS	3												
	Trace of Gravel		3	SS	3		176										1 10 89
	Trace of Organics		4	SS	4												4 24 72
	(Fill)		5	TW	PH		174										
173.2	Stiff		6	SS	27		172.4										
5.7	Silty Clay Layer		7	SS	13		172										
	Layer of Sandy Silt		8	SS	47		170										
	Silty Sand		9	SS	38		168										
	Trace of Gravel		10	SS	73		166										
			11	SS	36		164										
			12	SS	60		162										
161.7	Compact to Very Dense		13	SS	115												
17.2	End of Borehole																0 75 25

OFFICE REPORT ON SOIL EXPLORATION

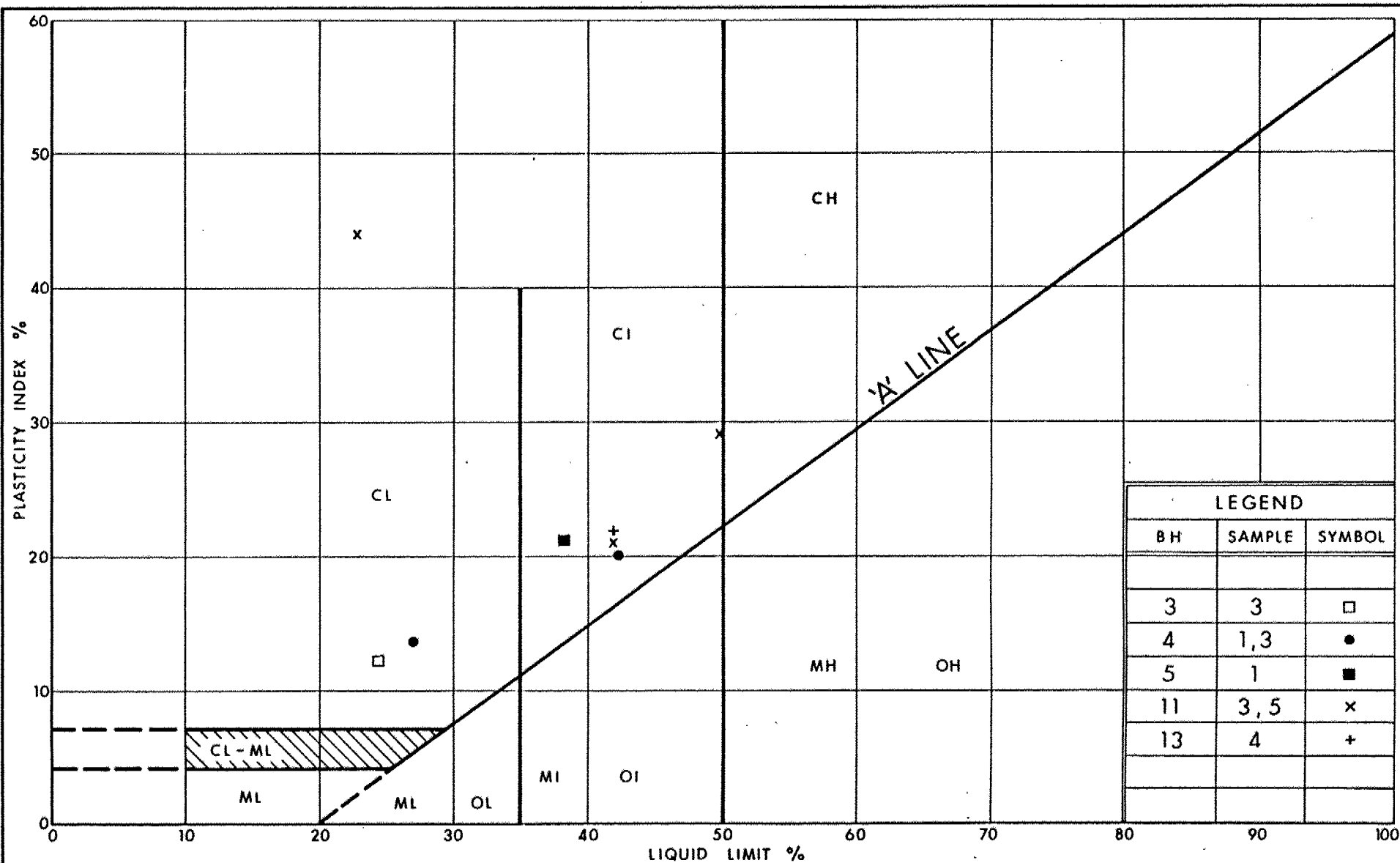
RECORD OF BOREHOLE No 13

METRIC

W P 50-85-01 LOCATION Station: 24 + 223; Offset 4.9 m Lt. of 4
DIST 1 HWY 18 BOREHOLE TYPE Cont. Flight Auger (H.S.); BX Casing
DATUM Geodetic DATE 87 03 17
ORIGINATED BY
COMPILED BY
CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
178.5	Ground Level													GR SA SI CL
0.0	Shoulder Granular					*	178							
177.1														
1.4			1	SS	7									
	Silty Clay Trace of Sand Trace of Gravel With Varying Amounts of Organics (Fill)		2	TW	PH		176							
			3	SS	7									
	Firm to Stiff		4	TW	PH		174							
172.2			5	SS	3		172						1.94	0 9 91
6.3	Peat, Fine to Medium Fibre, Firm													
171.5			6	SS	5		170						Org. 2 7.72	0 47 41 12
7.0	Layer of Organic Silty Sand		7	SS	11									
	Silty Sand Loose to Very Dense		8	SS	65		168							
	Layer of Sandy Silt		9	SS	120/	24 cm	166							
	Trace of Gravel						164							
162.8			10	SS	120/	25 cm								1 82 17
13.7	End of Borehole													
	* Water Level not recorded													

OFFICE REPORT ON SOIL EXPLORATION

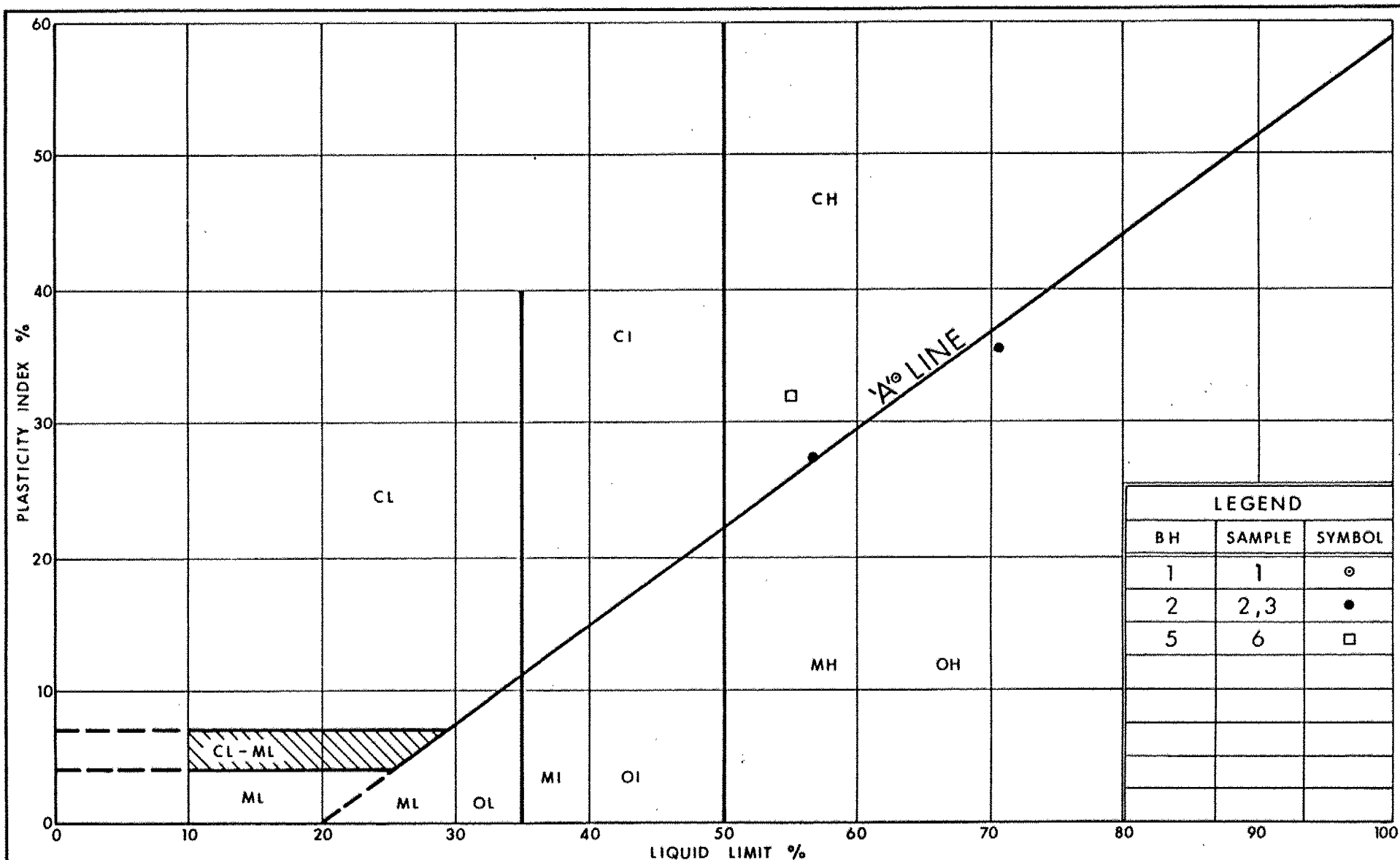


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PLASTICITY CHART
SILTY CLAY (Fill) (CL, CI) SOME SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORG'S

FIG No 1

W P 50-85-01



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PLASTICITY CHART
CLAY (Fill) (CH) SOME SAND
WITH VARYING AMOUNTS OF ORG'S, TR OF GRAVEL

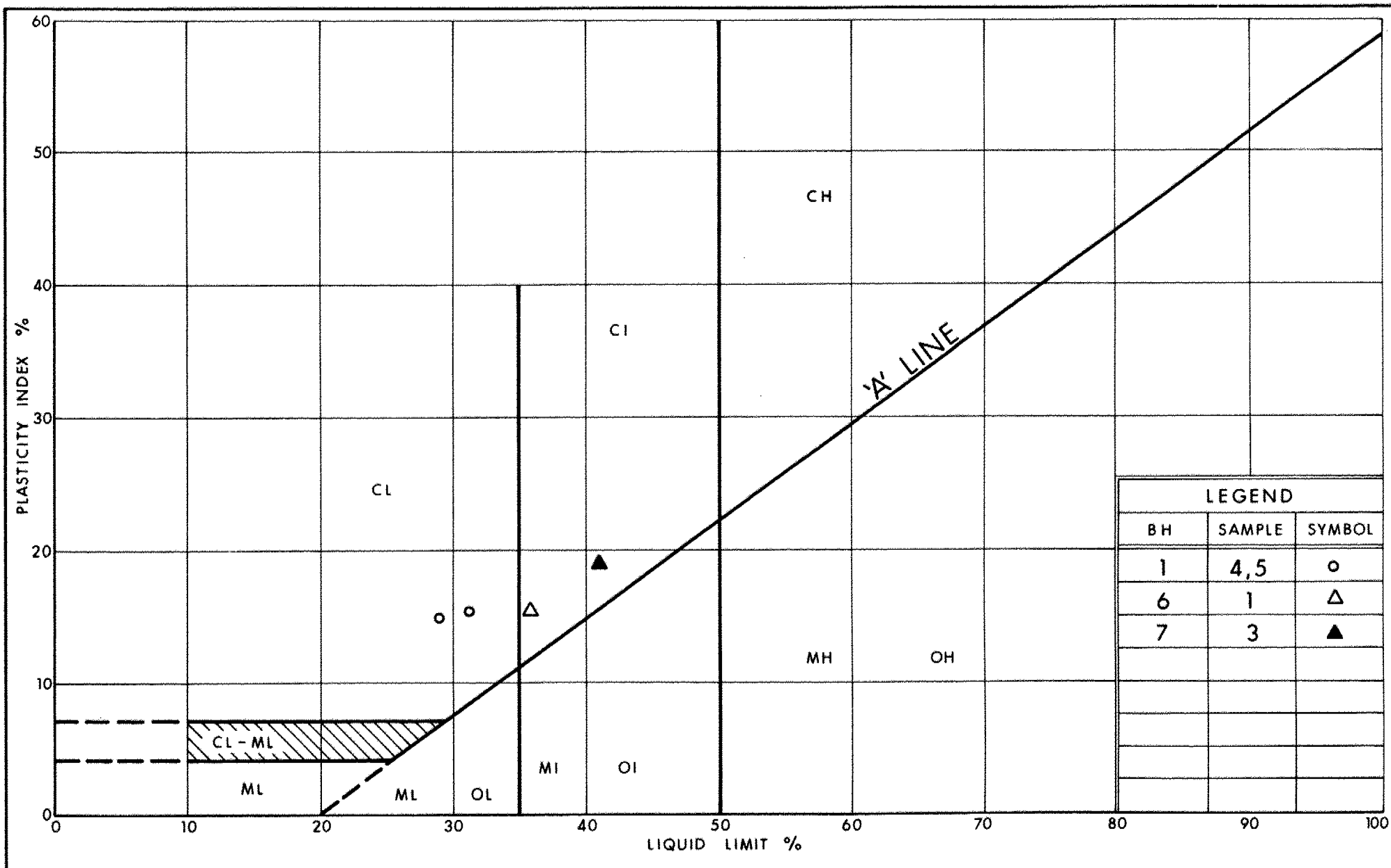
FIG No 2

W P 50 - 85 - 01



GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAY SOME SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORG'S

W P 50-85-01



Ministry of
Transportation

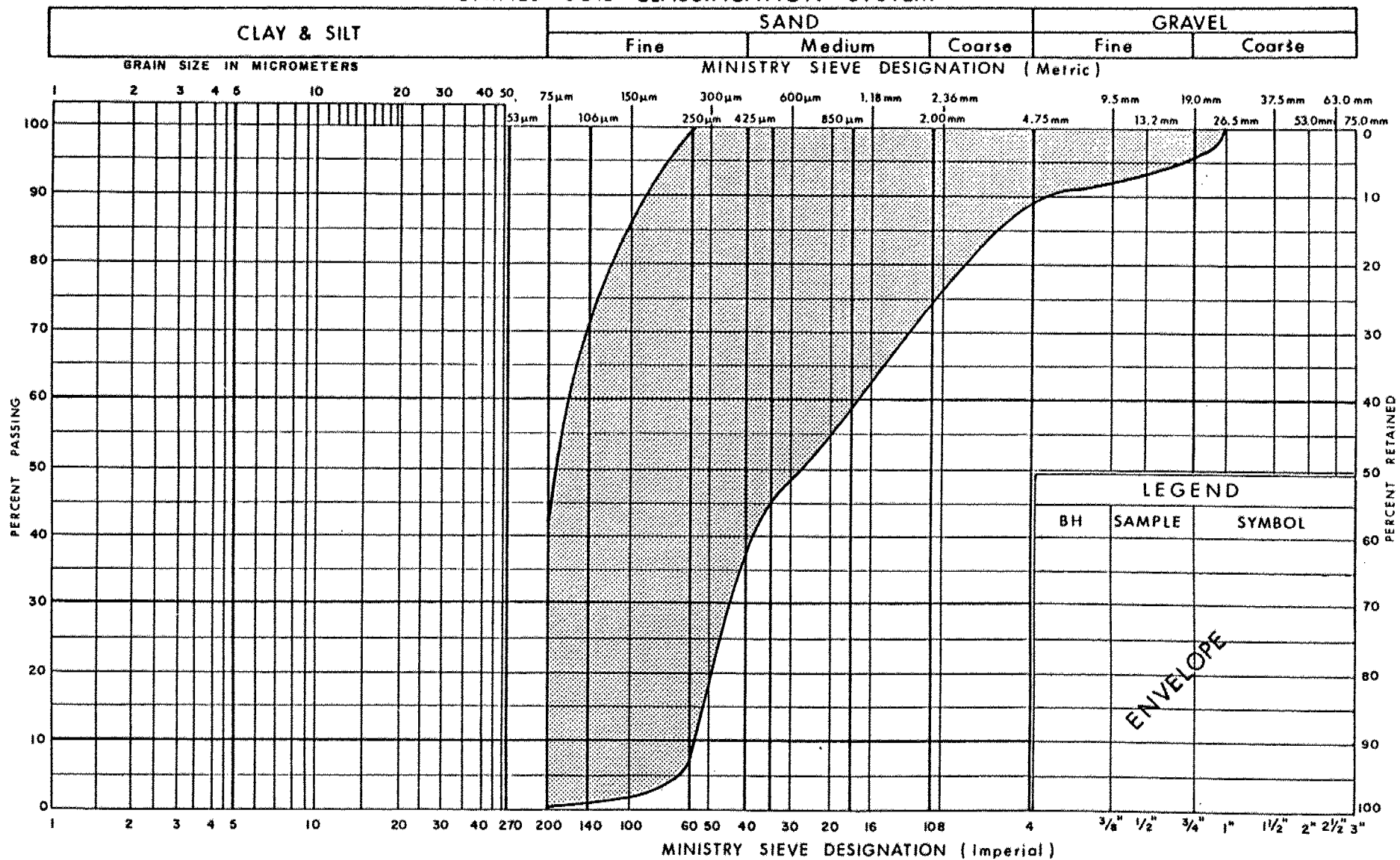
Ontario

PLASTICITY CHART
SILTY CLAY (CL, CI) WITH SAND
TR OF GRAVEL, WITH VARYING AMOUNTS OF ORGANICS

FIG No 4

W P 50-85-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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Communications

GRAIN SIZE DISTRIBUTION
SILTY SAND, TRACE OF GRAVEL

FIG No 5

W P 50-85-01



GRAIN SIZE DISTRIBUTION
SANDY SILT LOAMS, OCC TRACE OF GRAVEL

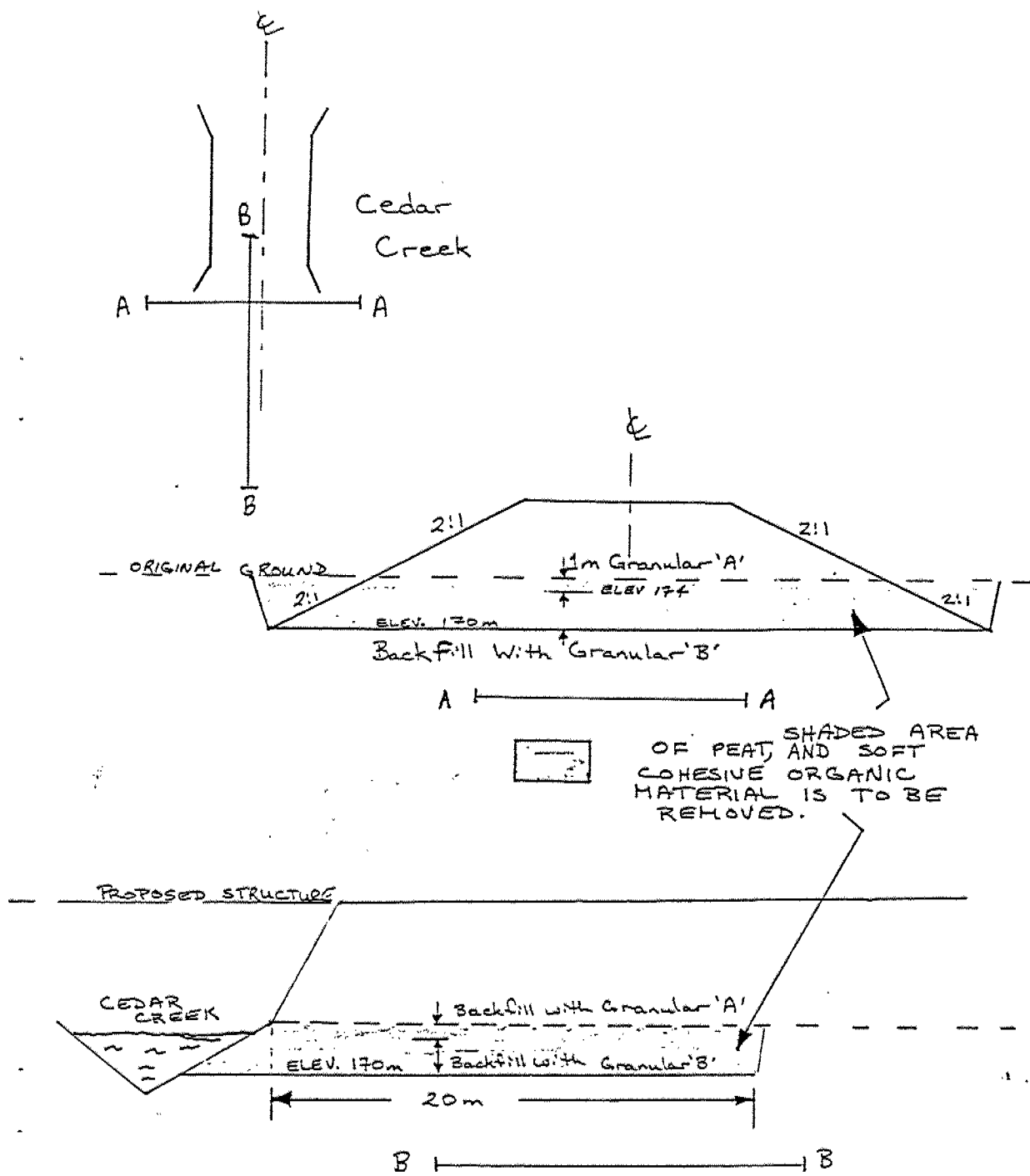
W P 50 - 85 - 01

DESCRIPTION OF ROCK CORE - W.P.

50-85-01

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR *	% RQD *	DEPTH (m)	DESCRIPTION
1	15.00-16.52	78	57	15.00-16.22	SANDY DOLOSTONE, medium brown, medium grained, porous (vugs to 2 cmØ), thickly bedded, slightly weathered, closely to very closely fractured
	16.52-18.05	100	73	16.22-17.49	DOLOSTONE, medium grey to brown, fine grained, slightly vuggy, very thinly laminated, (stylolitic), unweathered, moderately to closely spaced fractures
				17.49-18.05	DOLOSTONE, medium brown to grey, fine grained, slightly vuggy, very thickly bedded, unweathered, widely spaced fractures
4	16.39-17.92	100	70	16.39-17.00	SANDY DOLOSTONE, Medium brown, medium grained, porous, thickly bedded, slightly weathered, moderately fractured, fractures inclined @ 75°, rough
	17.92-19.44	97	90	17.00-18.07	DOLOSTONE, medium grey to brown, fine grained, thinly laminated, moderately weathered to unweathered; infilled zones of cemented sand/clay at 17.13 and 17.66
				18.07-19.44	DOLOSTONE, medium brown to grey, fine to medium grained, slightly vuggy, thickly bedded, unweathered, widely spaced fractures
6	17.08-17.72	68	0	17.08-17.74	SANDY DOLOSTONE, medium brown, medium grained, slightly porous, thickly bedded, slightly weathered, moderately fractured, high angle (75°) through this section of core
	17.72-19.24	95	85	17.74-19.09	DOLOSTONE, medium grey to brown, fine grained, thinly laminated, slightly weathered, organic rich, cemented sands/clay at 18.58
				19.09-19.24	DOLOSTONE, medium brown to grey, fine grained, thickly bedded, unweathered

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



NOTE: DRAWINGS NOT TO SCALE

FIGURE 8.: SUBEXCAVATION UNDER
REPLACEMENT STRUCTURES
APPROACHES

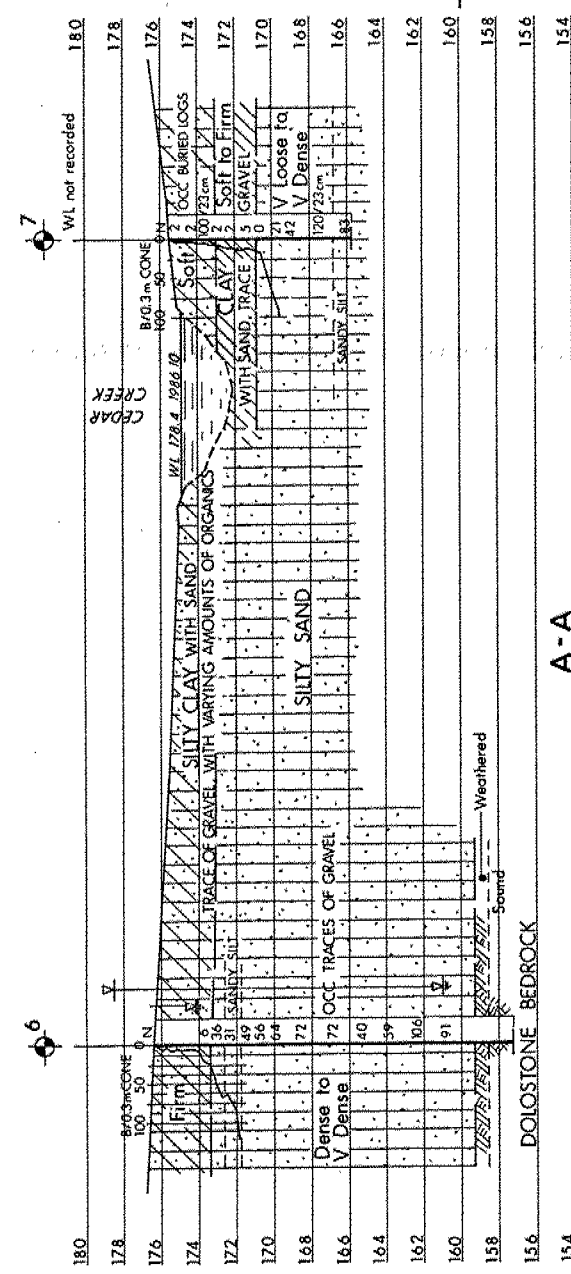
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES - METRES.

CONT No
WP No 50-85-01

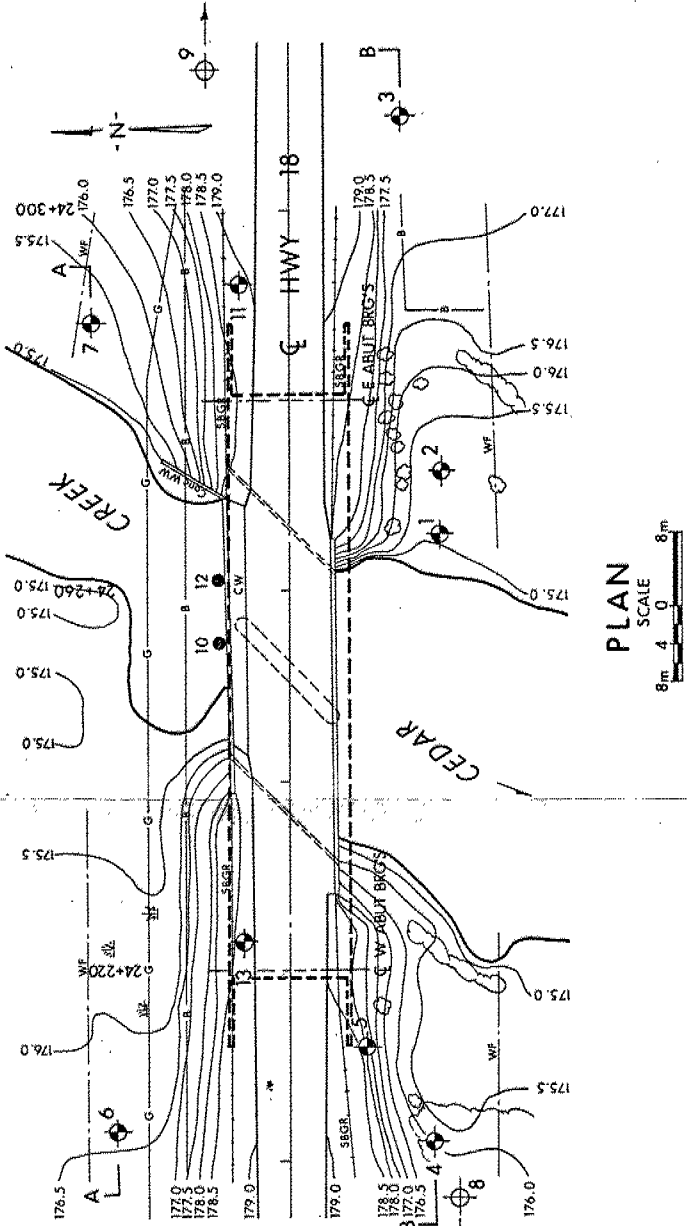
CEDAR CREEK

SHEET

BORE HOLE LOCATIONS & SOIL STRATA



A-A



PLAN
SCALE
8m 4 0 8m
4m 2 0 4m

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 1987 03
- Probe Hole
- Head
- ARTESIAN CONDITIONS

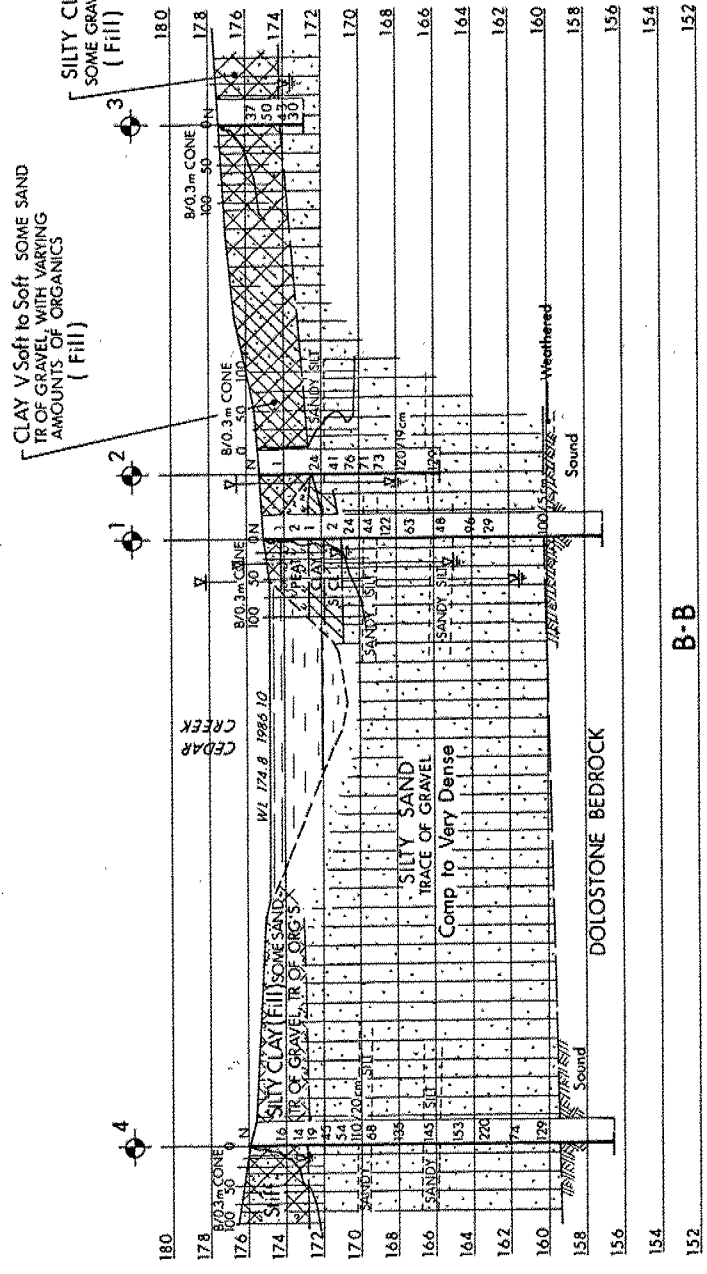
No	ELEVATION	STATION	OFFSET
1	175.1	24+266.0	16.0 m RT
2	175.3	24+272.6	16.2 m RT
3	177.5	24+310.0	12.0 m RT
4	175.9	24+202.1	15.2 m RT
5	178.6	24+212.1	8.0 m RT
6	176.4	24+203.1	18.4 m LT
7	175.4	24+288.1	21.0 m LT
8	-	24+178.0	15.0 m RT
9	-	24+346.0	9.0 m LT
11	178.9	24+292.0	5.2 m LT
13	178.5	24+223.0	4.9 m LT
10	-	24+254.6	7.0 m LT
12	-	24+261.0	7.0 m LT

SECTIONS

SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert

PROFILE HWY 18

SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert



B-B

PROFILE HWY 18

SCALE
8m 4 0 8m Hor
4m 2 0 4m Vert

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

NOTE: The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

DATE	BY	DESCRIPTION
1987 07 16	1	1
1987 07 16	2	2

Geotitles No 4012-38

HWY No. 18	DATE 1987 07 16	SITE 6-182
SUBMIT PM CHECKED	DATE 1987 07 16	DWG 2
DRAWN SO CHECKED	DATE 1987 07 16	DWG 2

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40#P2-38

DIST. _____ REGION _____

W.P. No. 151-73-05

CONT. No. 82-02

W. O. No. _____

STR. SITE No. 23-345

HWY. No. 7169 (Co. Rd. 6)

LOCATION C.W.R. Approach Fill
Over Backfilled Quarry Site

No of PAGES -

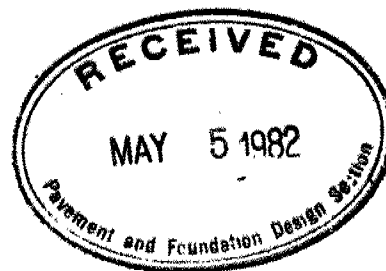
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82-02



Ministry of
Transportation and
Communications

Index

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2	Abbreviations & Symbols
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NOTE: For purposes of the contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above-mentioned projects.

EXPLANATION OF TERMS USED IN REPORT

2

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.

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

For

C.N.R. Overhead, 1 km North of Oxford County Road 9
W.P. 151-73-05, Site 23-345
Hwy. 7169, District 2, London

INTRODUCTION

This report contains the results of a foundation investigation for the above listed project. Fieldwork consisted of 3 boreholes advanced by means of a CME 750 auger mounted on a rubber tired all-terrain vehicle. Hollow stem augers were employed to advance the boreholes to bedrock after which BX rock core was recovered from 2 of them to prove bedrock. This work was carried out November 19th and 20th, 1979.

SITE DESCRIPTION

The site is located 3 kilometres east of Ingersol where existing Oxford County Road 6 crosses the C.N.R. tracks. At the crossing there are 2 main lines plus 2 spur lines serving the limestone quarry and lime plants located about 200 metres west of the crossing. Early plans of the area show the Thames River flowing next to the tracks with a bridge in the area of the proposed south abutment. The Thames River has been diverted 0.5 kilometres to the south and bedrock in the area has been quarried except immediately under the road allowance and railroad right-of-way. This portion of the quarry has been backfilled with overburden creating a level area south of the tracks. To the north the land gradually rises to about 25 metres above the level of the crossing.

SUBSURFACE CONDITIONS

General

The following description of the subsurface conditions must be read in conjunction with the record of borehole sheets contained in the report Appendix and with Drawing No. 2 of the contract drawings. The record of borehole sheets shows the different soil and rock types encountered and the summarized results of all field and laboratory tests performed. Drawing No. 2 shows the locations and elevations of all borings and the inferred soil and rock stratigraphy.

Subsoil

Subsoil consists of from 5 to 7 metres of sand and gravel with occasional silty layers. Relative density ranges from loose to dense as indicated by Standard Penetration 'N' values which range from 5 to 40 blows per 0.3 metres. In general, the higher densities were found in the upper half of the deposit. This is partly the result of organic contamination found at depths between 3.5 and 5.5. metres in the area of the north abutment. Typical grain-size distribution curves for the deposit are shown as Figure 1 in the Appendix.

Bedrock

Limestone bedrock underlies the site varying in elevation from 265.7 at the south abutment to 267.7 at the north abutment. Frequent horizontal joints are present in the rock, however, no large solution cavities were encountered in the 2 rock cores recovered.

Groundwater

No groundwater was encountered in the subsoil overlying the bedrock. This is probably the result of water draining through fissures in the bedrock into the large drained quarries to the south.

P. Payer
P. Payer, P. Eng.
Foundations Engineer



K.G. Selby
K.G. Selby, P. Eng.
Senior Foundations Engineer

April, 1982

APPENDIX



Ministry of
Transportation and
Communications
Ontario

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

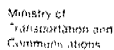
METRIC 7

W P 151-73-05 LOCATION Co-ords. N 4 770 915.6, E 194 457.9 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979 11 19 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
273.2	Ground Level												
0.0	Sand and gravel Some silt Compact to dense		1	SS	18		272						49 39 11 3
			2	SS	16								
269.5			3	SS	41		270						
3.7	Silt and sand Organic Contamination		4	SS	8								
267.7	Loose to compact		5	SS	14		268						
5.5	Limestone bedrock		6	BX RX	88% REC			Refusal to augering at 5.5 m					RQD 40%
265.7							266						
7.5	End of Borehole Note: Water level not established												

*3, *5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

METRIC 8

W P	151-73-05	LOCATION	Co-ords. N 4 770 883.4, E 194 485.6	ORIGINATED BY	PJS
DIST	2 HWY 7169	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	PJS
DATUM	Geodetic	DATE	1979 11 20	CHECKED BY	

[illegible]

+ 3, x⁵: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

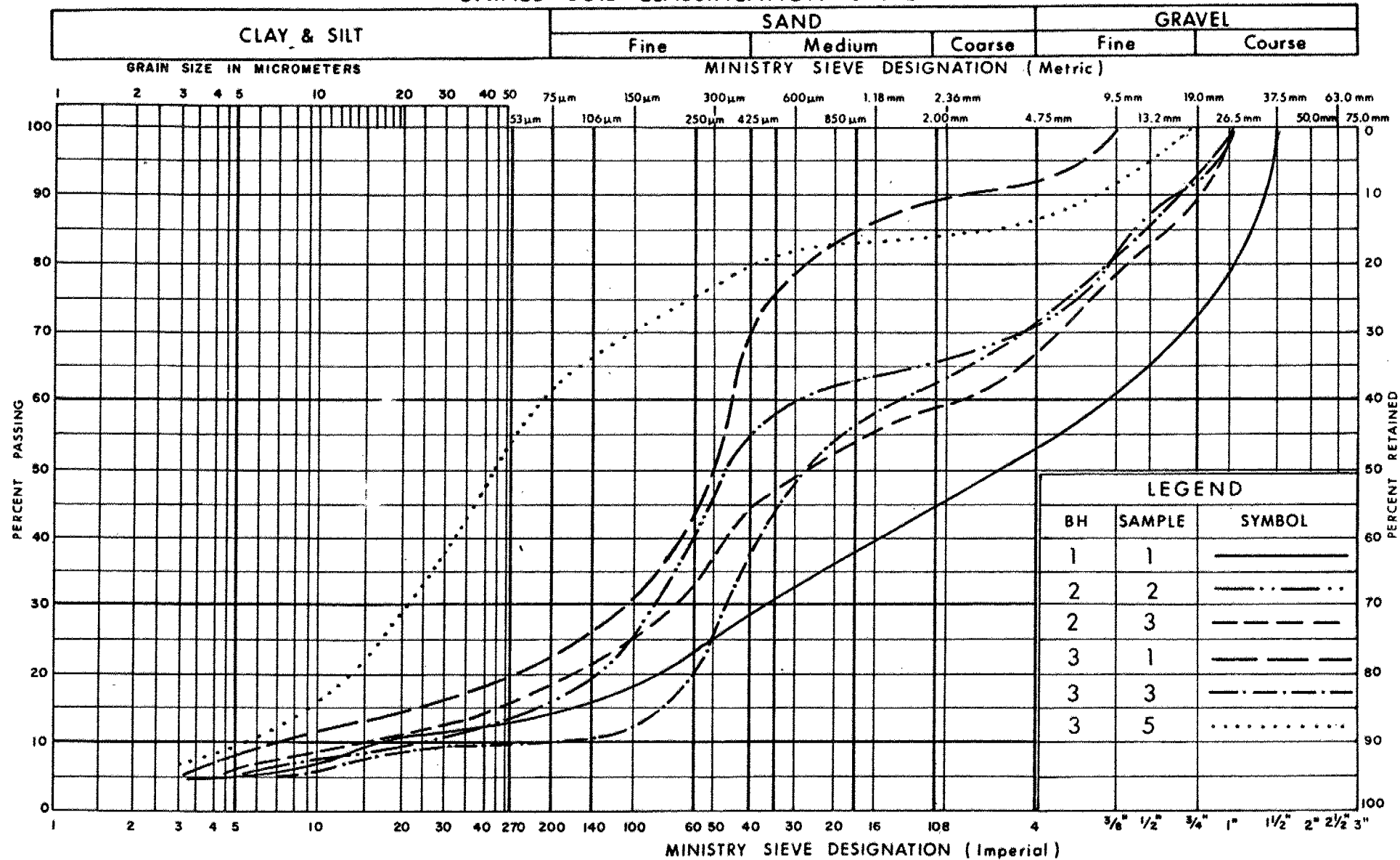
METRIC 9

W P 151-73-05 LOCATION Co-ords. N 4 770 875.8, E 194 504.4 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979 11 20 CHECKED BY

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			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)				
272.4	Ground Level													GR SA SI CL
0.0	Sand and gravel with silty layers Compact to loose		1	SS	25		272							8 70 20 2
			2	SS	8		270							28 61 7 4
			3	SS	11		268							14 23 58 5
			4	SS	19									
			5	SS	9									
265.7			6	SS	17		266							
6.7	Limestone bedrock		7	BX RC	73% REC		264							
264.1														
8.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

 GRAIN SIZE DISTRIBUTION
SAND & GRAVEL
SOME SILT

FIG No 1

W P 151-73-05

FOUNDATION INVESTIGATION REPORT

For

Thames River Bridge
W.P. 151-73-06, Site 23-147
Hwy. 7169, District 2, London

INTRODUCTION

This report contains the results of a foundation investigation for the above listed project. Fieldwork consisted of 5 sampled boreholes of which 3 were advanced on the river banks with a skid mounted diamond drill and B size casing. A CME 750 equipped with hollow stem augers was employed for the other 2 boreholes. This work was carried out in the period November 7th to 20th, 1979.

SITE DESCRIPTION

The site is located 3 kilometres east of Ingersol where proposed Hwy. 7169 crosses the Thames River. In this area the Thames River has been realigned to flow parallel to and 50 metres to the north of the C.P.R. track which in turn parallels County Road 9. County Road 6 crosses the Thames on a 3 span steel beam structure some 25 metres east of the new alignment.

The Thames River was realigned and dyked to allow development of 3 large limestone quarries on its flood plain in this area. A private road referred to locally as the dyke road runs along this dyke on the north side of the Thames. Behind it are the limestone quarries which in the immediate vicinity of the crossing have been backfilled with overburden stripped from new areas to be mined. This has created a relatively flat area sloping gently to the north. The Thames channel has a bottom width of about 20 metres with slopes 8 to 10 metres in height. These slopes were designed to be 1.5 horizontal to 1 vertical but have been locally altered by erosion. Repairs have been made with waste rock from the quarry.

SUBSURFACE CONDITIONS

General

The following description of the subsurface conditions must be read in conjunction with the record of borehole sheets contained in the report Appendix and with Drawing No. 2 of the contract drawings. The record of borehole sheets shows the different soil and rock types encountered and the summarized results of all field and laboratory tests performed. Drawings No. 2 shows the locations and elevations of all borings and the inferred soil and rock stratigraphy.

Subsoil

Two subsoil types are found in the area of the structure. At the north abutment there is about 7.7 metres of compact to very dense sand containing silty and gravelly layers. Typical grain-size curves are shown in Figure 1 of the Appendix. This is a water laid deposit produced by the Thames River and its post glacial ancestor when the valley acted as a spillway for glacial meltwater. Standard Penetration 'N' values range from 12 to 59 with the low values found in the upper 3 metres which was repositioned during the realignment of the Thames Channel. The shallow depth of soil in the area of the piers and the 12.5 metres of material at the south abutment consists of compact to very dense silty sand with gravel and is of glacial origin. Standard Penetration 'N' values ranged from 10 to 20 for the upper 3 to 4 metres and then increase to greater than 100 blows per 0.3 metres. Grain-size distribution for this deposit is shown as an envelope in Figure 2.

Bedrock

Limestone bedrock underlies the site varying in elevation from 266 at the south abutment to 268 at the north abutment.

Frequent horizontal joints are present and in some cases are open or sand filled. This resulted in frequent jamming during coring operations and the complete loss of water in one borehole. However, no large voids were encountered in the 4 boreholes from which rockcore was recovered.

Groundwater

In the area south of the Thames, groundwater was encountered at about elevation 270 some 3 metres above the bedrock surface. In contrast, no groundwater was encountered above the bedrock surface in the area north of the river even though the bedrock is below the river level. This may be explained by downward drainage through fissures in the bedrock toward the large drained quarry located north of the river.

P. Payer

P. Payer, P. Eng.
Foundations Engineer



K.G. Selby

K.G. Selby, P. Eng.
Senior Foundations Engineer

April, 1982

APPENDIX



Ministry of
Transportation and
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Ontario

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

METRIC 15

W P 151-73-06 LOCATION Co-ords. N 4 770 635.0; E 194 855.5 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979 11 07 CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
276.0	Ground Level													
0.0	Sand, Some gravel, Occasional silty layers Compact to very dense		1	SS	12		274							3 23 68 6
			2	SS	12									
			3	SS	28		272							21 71 (8)
			4	SS	37									25 69 (6)
			5	SS	30		270							7 87 (6)
			6	SS	44									
			7	SS	59									
268.3	Boulder		8	BXT	40%									
7.7	Limestone bedrock		9	BXT	100%		268							
267.3			10	BXT	RC									
8.7	End of Borehole Note: Borehole dry to rock surface													

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC 16

W P 151-73-06 LOCATION Co-ords. N 4 770 623.6; E 194 868.8 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE B Casing COMPILED BY PJS
DATUM Geodetic DATE 1979 11 13 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
269.6	Ground Level															
0.0	Silty sand, with gravel, Trace of clay, Very dense (Glacial till)	1	SS	10												
		2	SS	100/	254 mm										33 39 24 4	
267.3	(Glacial till)	3	SS	100/	279 mm											
2.3	Limestone bedrock	4	BXL	83% REC												
		5	BXL	90% REC											RQD 55%	
265.6		6	BXL	95% REC	266											
4.0	End of Borehole															
	Note: Water level not established															

+3, x5: Numbers refer to
Sensitivity

20
5-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 3

METRIC 17

W P 151-73-06 LOCATION Co-ords. N 4 770 635.4; E 194 874.0 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE B Casing COMPILED BY PJS
DATUM Geodetic DATE 1979 11 14 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
269.8	Ground Level																
0.0	Silty sand with gravel Trace of clay Very dense (Glacial till)		1	SS	15		268										25 42 29 4
267.1			2	SS	56												
			3	SS	100	305 mm											
2.7	Limestone bedrock		4	BXL	70%												
			5	BXL	80%												
265.5			6	BXL	85%		266										
4.3	End of Borehole			RC	REC												

*3, x5: Numbers refer to
Sensitivity

20
5-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC 18

W P 151-73-06 LOCATION Co-ords. N 4 770 618.0; E 194 892.5 ORIGINATED BY PJS
 DIST 2 HWY 7169 BOREHOLE TYPE B Casing COMPILED BY PJS
 DATUM Geodetic DATE 1979 11 16 CHECKED BY

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
269.4	Ground Level															
0.0	Silty sand with gravel Trace of clay Compact to dense (Glacial till)		1	SS	11											
			2	SS	8											20 42 36 2
266.5			3	SS	42											35 44 17 4
2.9	Limestone bedrock		4	BXL RC	100% REC	266										RQD 60%
265.1																
4.3	End of Borehole															
	Note: Water level not established															

⁺³, ^{x5}: Numbers refer to Sensitivity
 20
 15 ϕ 5 (%) STRAIN AT FAILURE
 10



RECORD OF BOREHOLE No 5

METRIC 19

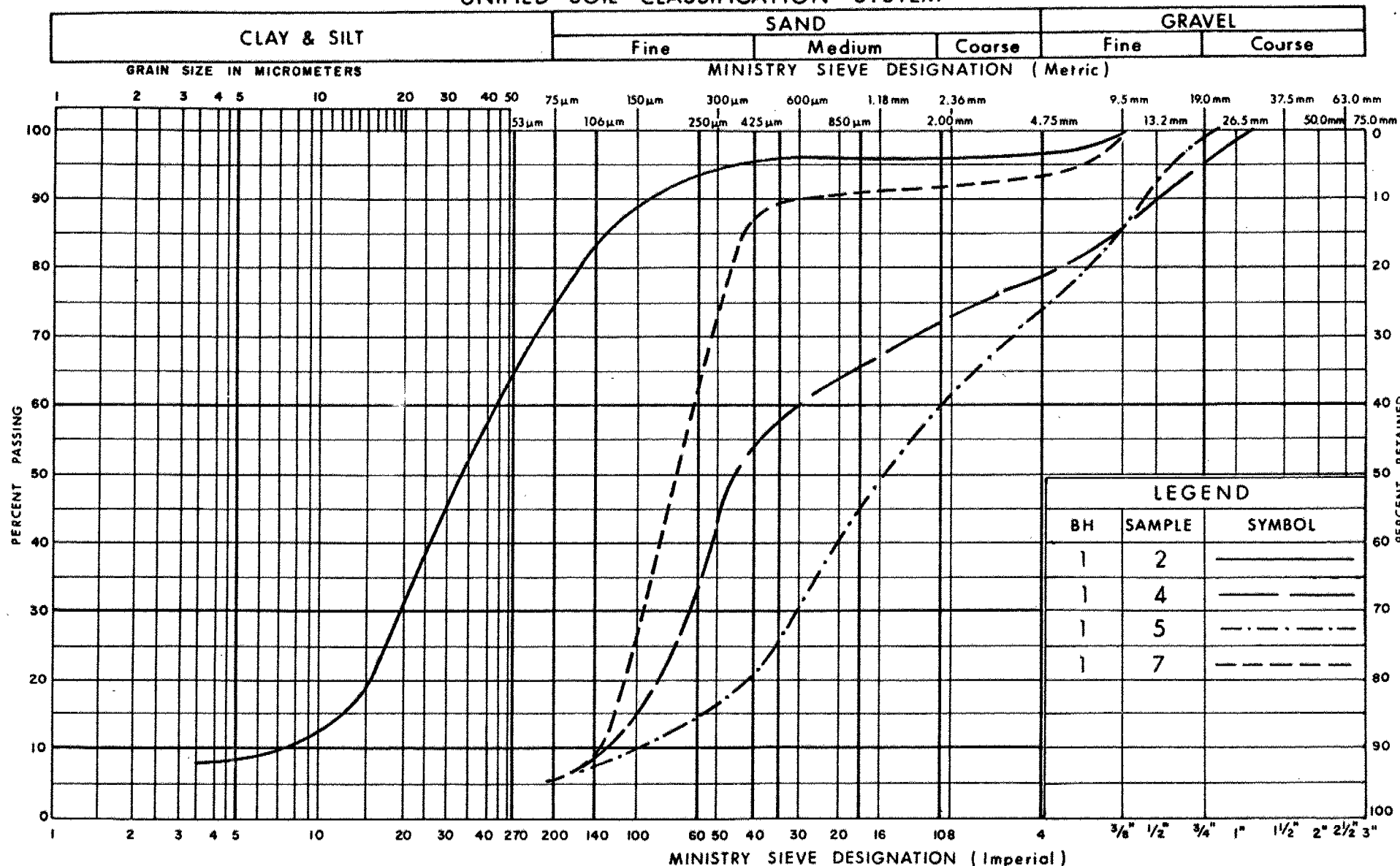
W P 151-73-06 LOCATION Co-ords. N 4 770 604.8; E 194 910.6 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979 11 19 CHECKED BY

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH						WATER CONTENT (%)
279.0	Ground Level							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	10 20 30					
0.0	Silty sand, some gravel, Trace of clay Compact to very dense (Glacial till)						278							18 51 27 4 13 38 38 11 15 37 36 12 32 51 12 5	
			1	SS	21										
			2	SS	13										
			3	SS	21				276						
			4	SS	73										
			5	SS	82										
			6	SS	100/229 mm				274						
			7	SS	100/254 mm										
			8	SS	100/152 mm				272						
			9	SS	100/297 mm				270						
			10	SS	50/76 mm				268	Spoon Bouncing					
266.5			11	SS	70/229 mm		Refusal to auger								
12.5	Probable bedrock End of Borehole														

+³, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM

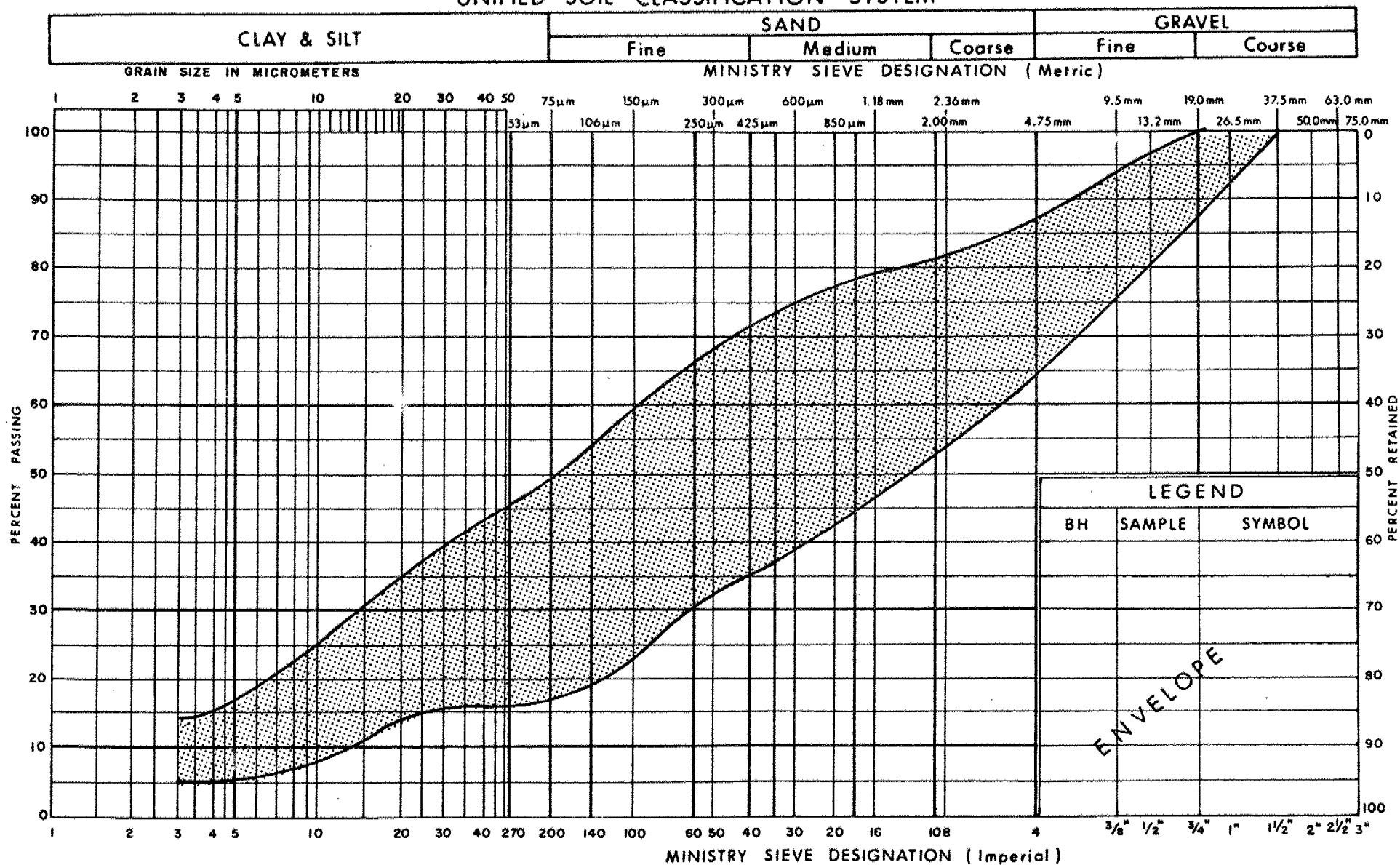


Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SAND
SOME GRAVEL OCCASIONAL SILTY LAYERS

FIG No 1

W P 151-73-06



**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION SILTY SAND

SOME GRAVEL TRACE OF CLAY (GLACIAL TILL)

FIG No 2

W P 151-73-06

SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	80-01-23	1488
TUBES	80-01-23	1488
ROCK CORES	After Award	1488

CONT # 82-02

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 151-73-05 DIST 2
HWY 7169 STR SITE 23-345
C.N.R. Overhead
1 km North of Oxford County Road 9

DISTRIBUTION

A. P. Watt (2)
J. R. Roy
A. Wittenberg
J. H. Blevins (2)

A. E. McKim
B. J. Giroux

R. Hore

A. Crowley)
J. Anderson) Cover only
T. J. Kovich)

Files

0.45

COEFFICIENT OF FRICTION
SAFE SOIL PRESSURE
BEARING CAPACITY AT PL 270
(1TSE)

ϕ FOR GRANULAR B: 30°

811 (385-3234)

GIVEN TO J. LOW
CD PARKER

ON APR, 10 11/85

~~151-73-05~~

W.P. 151-73-05

$n_s = 21 \text{ t/ft}^2$ FOR A PILE
1 FT. WIDE

PARKER CONSULTANTS

C.C. Parker Consultants Limited
Consulting Professional Engineers
1400 Rymal Road East, Hamilton,
Ontario L0R 1P0 (416) 385-3234

April 30, 1986

Ministry of Transportation
and Communications
Foundation Design Section
Central Building, 3rd Floor
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Attention: Mr. Paul Payer, P. Eng.

Gentlemen:

RE: CNR Overhead, 1 km North of Oxford County Road 9
Highway 7169, District 2, London
W.P. 151-73-05, Site 23-345

With regard to our telephone conversations of April 10, 11 and 22, 1986, I am herewith verifying the following values that you verbally gave me:

1. At founding elevation 271.50 m (approx.) - allowable bearing capacity at SLSII = 2000 psf (this will restrict settlement to 25 mm).
2. Coefficient of friction for granular 'B' backfill $\phi = 30^\circ$.
3. Coefficient of friction against sliding = 0.45.
4. Coefficient of horizontal subgrade reaction for a 1'-0" wide pile $n_h = 21.0$ pcf.

Thank you for sending a copy of the Foundation Investigation and Design Report for the above noted structure, it was greatly appreciated.

Yours truly

C.C. PARKER CONSULTANTS LIMITED



John C. Low
John C. Low, P. Eng.
for
D.C. Cramm, P. Eng.

JCL:n



Hamilton

London

Ottawa

FOUNDATION INVESTIGATION REPORT

For

C.N.R. Overhead, 1 km North of Oxford County Road 9

W.P. 151-73-05, Site 23-345

Hwy. 7169, District 2, London

INTRODUCTION

This report contains the results of a foundation investigation for the above listed project. Fieldwork consisted of 3 boreholes advanced by means of a CME 750 auger mounted on a rubber tired all-terrain vehicle. Hollow stem augers were employed to advance the boreholes to bedrock after which B size rock core was recovered from 2 of them to prove bedrock. This work was carried out November 19th and 20th, 1979.

SITE DESCRIPTION

The site is located 3 kilometres east of Ingersol where existing Oxford County Road 6 crosses the C.N.R. tracks. At the crossing there are 2 main lines plus 2 spur lines serving the limestone quarry and lime plant located about 200 metres west of the crossing. Early plans of the area show the Thames River flowing next to the tracks with a bridge in the area of the proposed south abutment. The Thames River has been diverted 0.5 kilometres to the south and bedrock in the area has been quarried except immediately under the road allowance and railroad right-of-way. This portion of the quarry has been backfilled with overburden creating a level area south of the tracks. To the north the land gradually rises to about 25 metres above the level of the crossing.

SUBSURFACE CONDITIONS

Subsoil

Subsoil consists of from 5 to 7 metres of sand and gravel with

occasional silty layers. Relative density ranges from loose to dense as indicated by Standard Penetration 'N' values which range from 5 to 40 blows per 0.3 metres. In general, the higher densities were found in the upper half of the deposit. This is partly the result of organic contamination found at depths between 3.5 and 5.5 metres in the area of the north abutment. Typical grain-size distribution curves for the deposit are shown as Figure 1 in the Appendix.

Reference should be made to the Record of Borehole Sheets which are also contained in the Report Appendix. They show the different soil types, as well as a summary of all field and laboratory tests performed. Reference should also be made to Drawing No. 1517305-A which shows the location and elevation of all borings together with a profile showing inferred subsoil stratigraphy.

Bedrock

Limestone bedrock underlies the site varying in elevation from 265.7 at the south abutment to 267.7 at the north abutment. Frequent horizontal joints are present in the rock, however, no large solution cavities were encountered in the 2 rock cores recovered.

Groundwater

No groundwater was encountered in the subsoil overlying the bedrock. This is probably the result of water draining through fissures in the bedrock into the large drained quarries to the south.

RECOMMENDATIONS

H-Piles

It is recommended that the proposed structure be supported on H-piles driven to bedrock at approximate elevation 265 for the south abutment and elevation 267 for the piers and north abutment. Loads equal to the allowable structural capacity of the section chosen may be employed. Typically the load on a 310 x 110 section may be up to 1070 kN. The pile tips should be reinforced with standard flange plates to prevent damage from boulders and to increase the contact area with the bedrock.

Spread Footings

As an alternative to be considered on economic grounds, the piers may be supported on spread footings on the limestone bedrock at elevation 267.5 with a design loading of up to 2 MPa. Resistance to sliding should be calculated employing a coefficient of friction of 0.5. In this scheme the excavations to bedrock for the pier footings should take place within interlocking steel sheeting in order to protect the railway tracks from possible soil movement.

Dewatering

No dewatering problems are anticipated as no groundwater was encountered above the bedrock surface.

Frost Protection

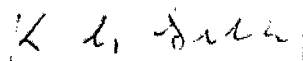
The base of all spread footings or pile caps should be protected from frost action by a minimum of 1.2 metres of cover.

Approach Embankments

No stability problems will result if the approach fills are constructed with 2 horizontal to 1 vertical slopes.



P. J. Stuart, P. Eng.
Foundations Engineer.

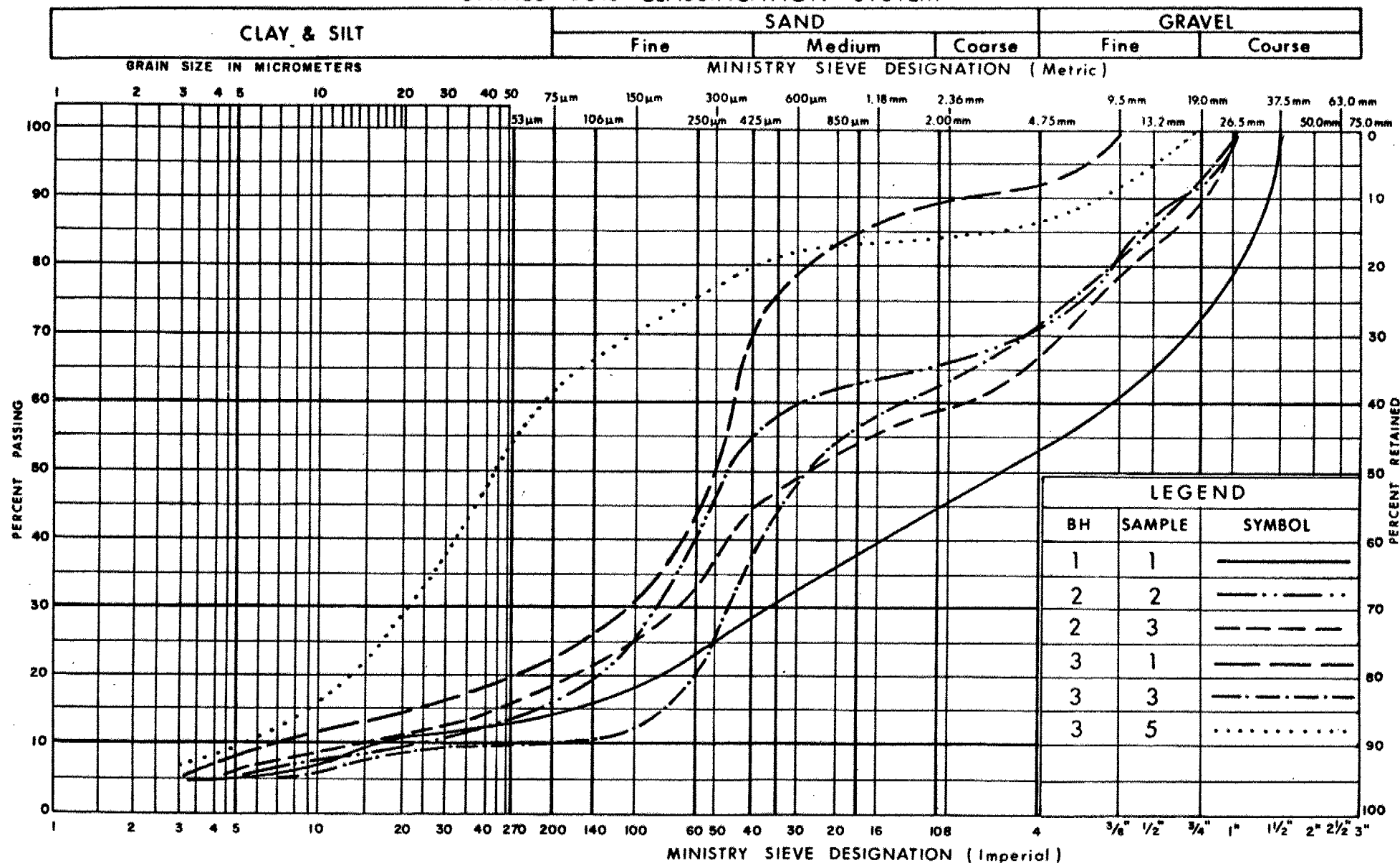


K. G. Selby, P. Eng.
Senior Foundations Engineer.

January, 1980.

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
SAND & GRAVEL
 SOME SILT

FIG No 1

W P 151-73-05



Ministry of
Transportation and
Communications

RECORD OF BOREHOLE No. 1

METRIC

W P 151-73-05 LOCATION Co-ords. N 4 770 915.6, E 194 457.9 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979 11 19 CHECKED BY

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			20	40	60	80	100					
273.2	Ground Level																GR SA SI CL
0.0	Sand and gravel Some silt Compact to dense		1	SS	18		272										49 39 11 3
			2	SS	16												
269.5			3	SS	41		270										
3.7	Silt and sand Organic Contamination Loose to compact		4	SS	8												
267.7			5	SS	14		268										
5.5	Limestone bedrock							Refusal to augering at 5.5 m									RQD 40%
265.7			6	BX RX	88% REC		266										
7.5	End of Borehole Note: Water level not established																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

METRIC

W P 151-73-05 LOCATION Co-ords. N 4 770 883.4, E 194 485.6 ORIGINATED BY PJS
DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
DATUM Geodetic DATE 1979-11-20 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
272.5	Ground Level																
0.0	Sand and gravel Some silt Compact to loose		1	SS	13		272										
			2	SS	15		270						o				29 55 14 2
			3	SS	5								o				33 48 18 1
			4	SS	6		268						o				
267.5			5	SS	10	100											
								Spoon bouncing					Refusal to augering				
5.0	Probable bedrock End of Borehole Note: Borehole dry																

3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

METRIC

W P 151-73-05 LOCATION Co-ords. N 4 770 875.8, E 194 504.4 ORIGINATED BY PJS
 DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY PJS
 DATUM Geodetic DATE 1979 11 20 CHECKED BY _____

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
272.4	Ground Level																
0.0	Sand and gravel with silty layers Compact to loose		1	SS	25											8 70 20 2	
			2	SS	8												
			3	SS	11											28 61 7 4	
			4	SS	19												
			5	SS	9											14 23 58 5	
265.7			6	SS	17												
6.7	Limestone bedrock		7	BX RC	73% REC												
264.1																	
8.3	End of Borehole																

+3, x5 : Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

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.

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 (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

METRIC

NOTE:
DIMENSIONS ARE IN METERS
AND/OR MILLIMETERS UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETERS + METERS

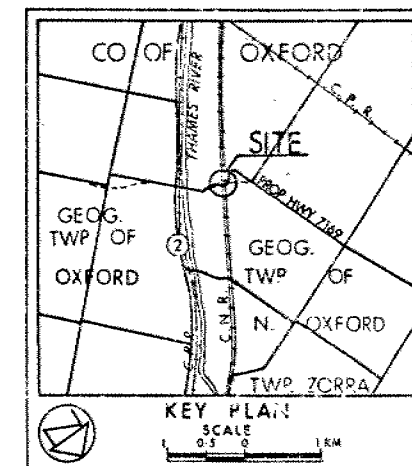
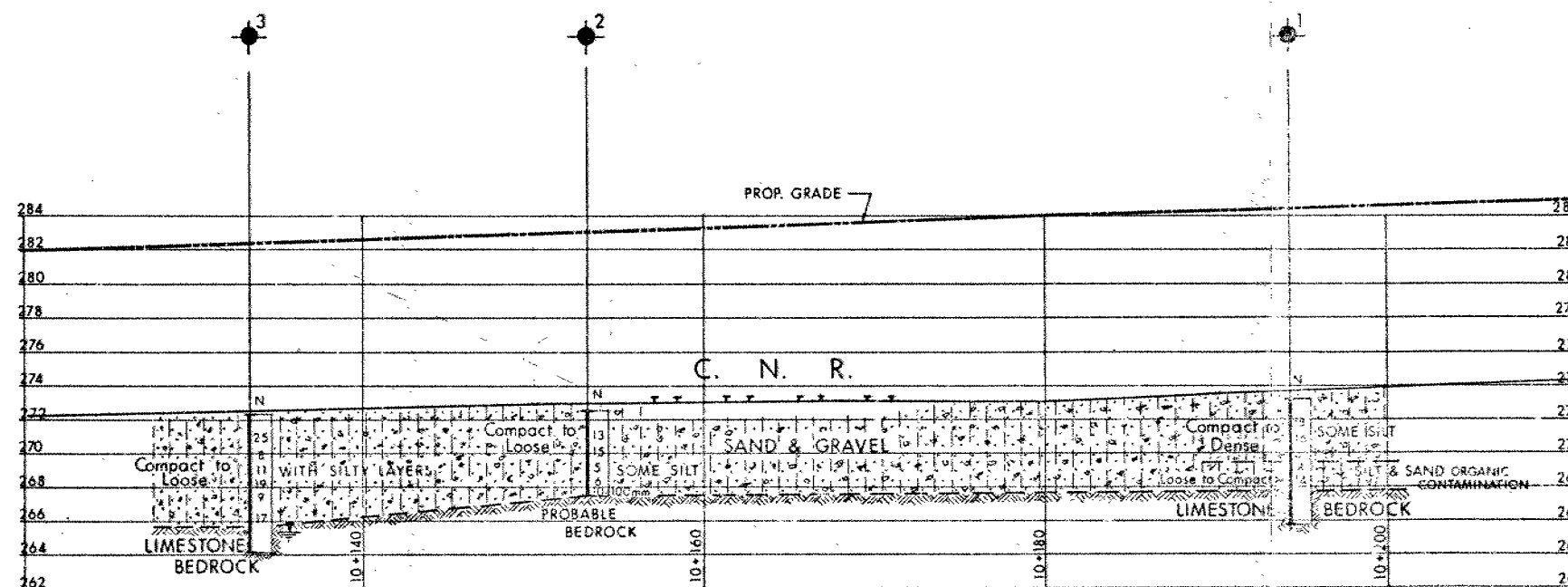
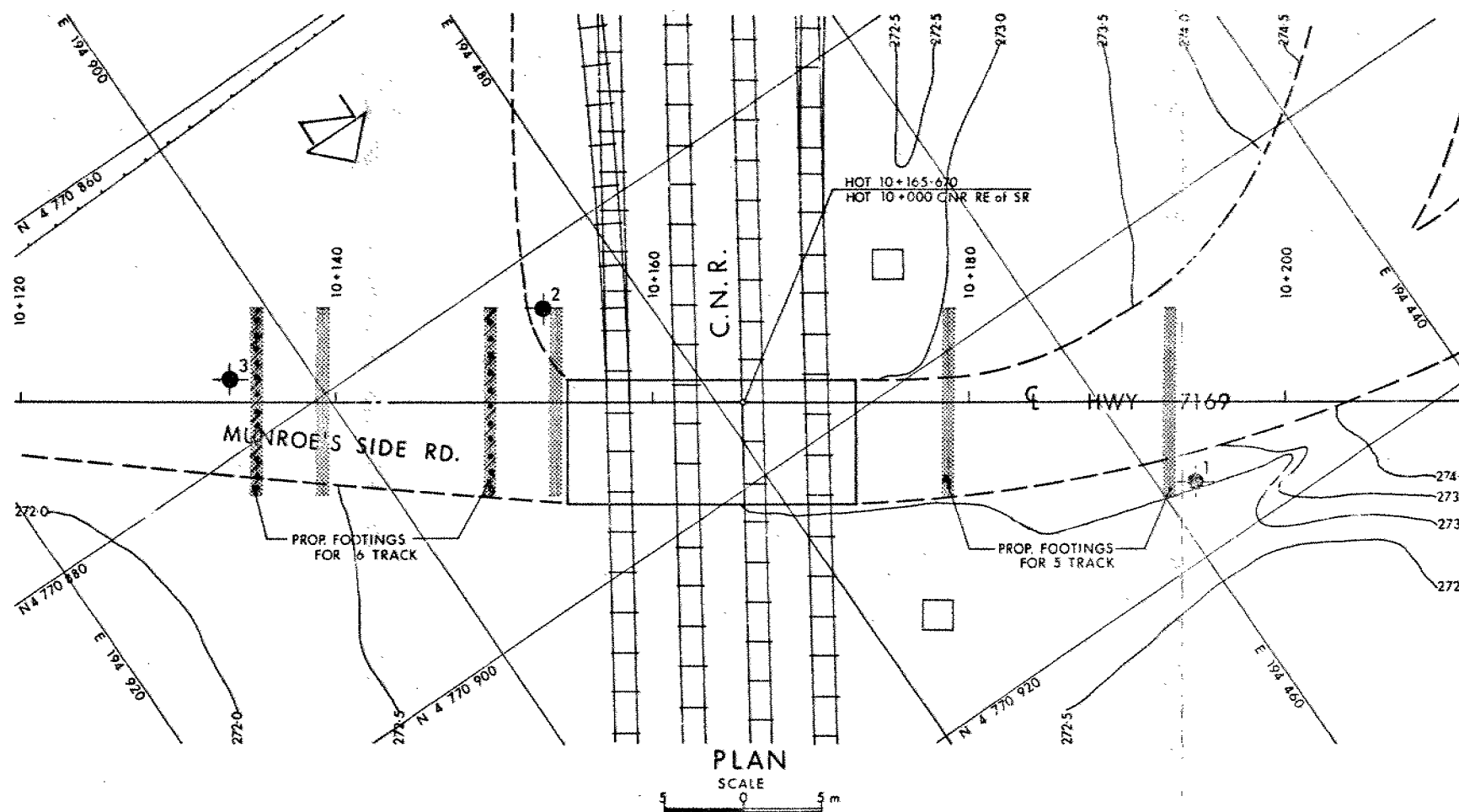
CONT No
WP No 151-73-05

HWY 7169 & C.N.R. OVERHEAD

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 79 09 20
- W.L. NOT Established in BH No 1
- BH No 2 Dry

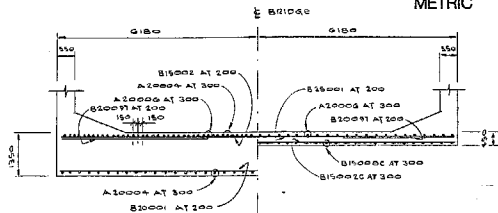
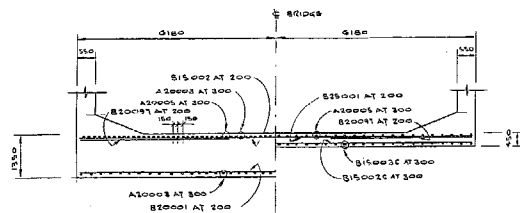
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	273.2	4 770 915.6	194 457.9
2	272.5	4 770 883.4	194 485.6
3	272.4	4 770 875.8	194 504.4

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 40P2-38

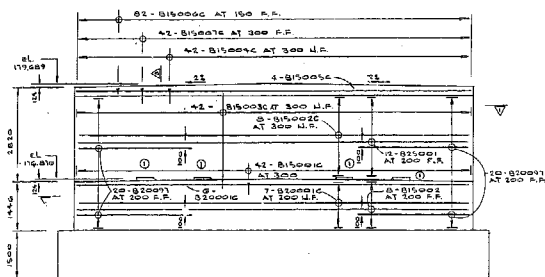


BEARING SEAT ELEVATIONS

① 176.935 ② 177.465

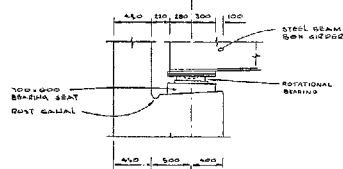
-LEGEND

- U.S. WEAR PACE
R.R. PAID PAID



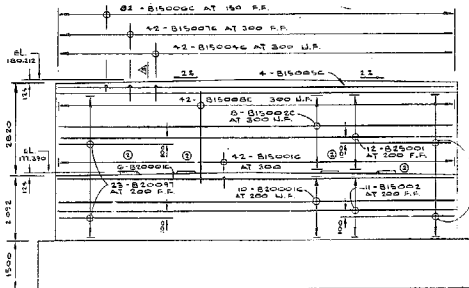
WEST ABUTMENT

SCALE=11.09



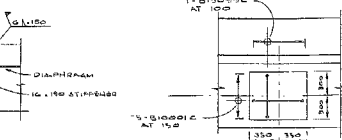
ELEVATION

SCALE = 1 : 20



EAST ABUTMENT

SCALE-1: 05

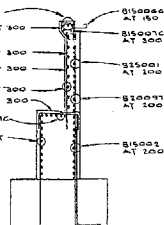


PLAN OF BEARINGS

SCALE = 1 : 20

PLAN OF BEARING SEAT

RING REINF

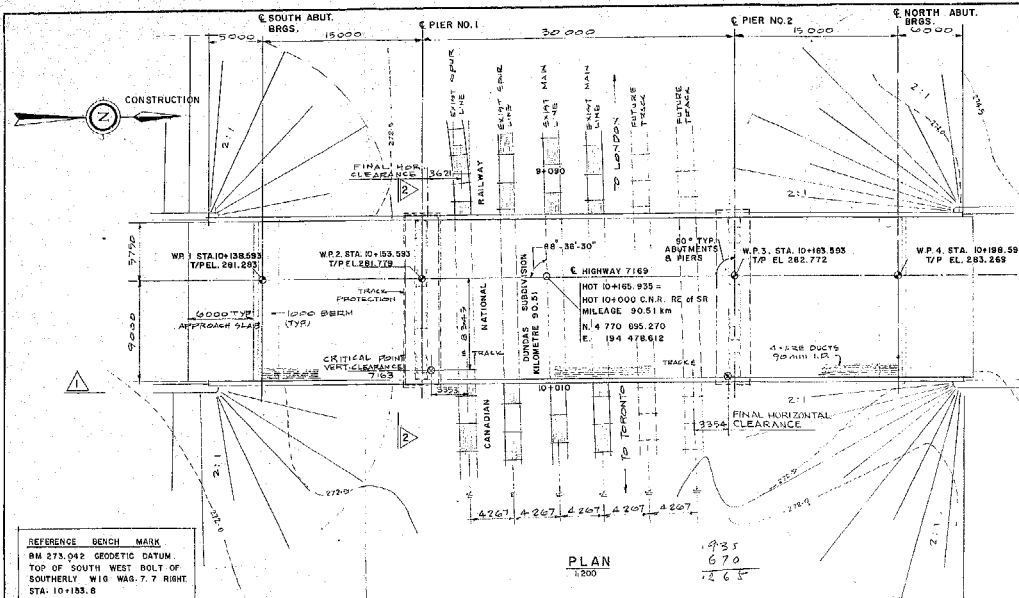
 Springer

SCALE-1.

- NOTES FOR ADDITIONAL BEARINGS**
1. Heights of bearings including 10 mm bedding grout assumed in establishing bearing seat elevations are as follows. The contractor shall adjust bearing seat elevations and reinforcing steel to suit actual heights of bearings.

Abutments 147 mm
 2. Nonrotational bearings shall be class/Classes listed in DMR List 9-15.10 under the heading "Bearings, Bridge (Structural)".
 3. The TRB Basin at the sliding surfaces shall be filled about.
 4. West abutment bearing to be fixed. Longitudinal translations are zero.
 5. Slope about horizontal axis does not include the slope of the bridge from west to west abutment of -

ROTATIONAL BEARING DESIGN DATA



DISTRICT 2 LONDON
CONT No
WP No 151-73-05

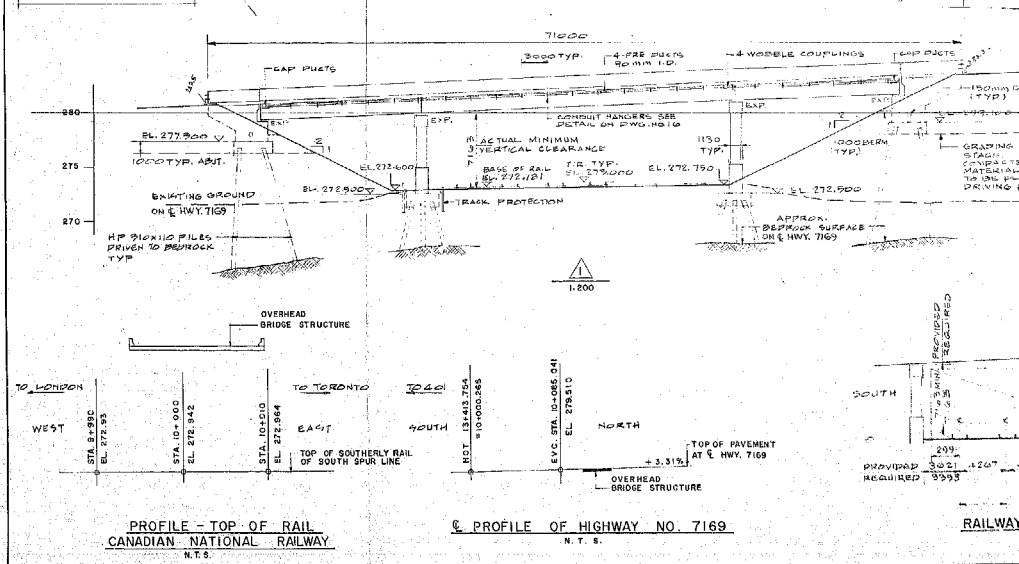
CNR OVERHEAD
1 km NORTH OF OXFORD COUNTY
GENERAL ARRANGEMENT

DelCan CONSULTING ENGINEERS AND PLANNERS

METRIC
DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.

NOTES:
1. W.P. DENOTES WORKING POINT.
2. T/P. DENOTES TOP OF PAVEMENT.

WEST **EAST**



LIST OF DRAWINGS:

- GENERAL ARRANGEMENT
- SOIL STRATA AND BOREHOLE LOCATIONS
- FOUNDATION LAYOUT & DETAILS
- SOUTH ABUTMENT LAYOUT
- SOUTH ABUTMENT REINFORCEMENT
- NORTH ABUTMENT LAYOUT
- NORTH ABUTMENT REINFORCEMENT
- PIER NO.1 LAYOUT AND REINFORCEMENT
- PIER NO.2 LAYOUT AND REINFORCEMENT
- PRESTRESSED GIRDERS AND BEARINGS I
- PRESTRESSED GIRDERS AND BEARINGS II
- DECK LAYOUT
- DECK REINFORCEMENT
- APPROACH SLABS
- BARRIER WALLS
- STANDARD DETAILS
- TRACK PROTECTION
- BRIDGE DATA & SITE NUMBER DATA
- AS CONSTRUCTED ELEVATIONS & DIMENSIONS

NOTES:
CLASS OF CONCRETE
DECK 30MPa
PIER AND BARRIER WALL 30MPa
REINFORCEMENT OR AS NOTED ON DWG. 20MPa

CLEAR COVER TO REINFORCING STEEL
DECK: TOP 50 mm
BOTTOM 40 mm
ABUTMENTS 75 mm
PIERS 50 mm
FOOTINGS 75 mm
BARRIER WALLS 80 mm
APPROACH SLABS 50 mm
OR AS NOTED ON DRAWINGS.

TO ACHIEVE THE MINIMUM CLEAR COVER OF 50 mm SPECIFIED AT THE TOP OF THE DECK, THE TOP LAYER OF REINFORCEMENT SHALL BE PLACED PRIOR TO CONCRETING, WITH A CLEAR COVER OF 60 ± 10 mm TOLERANCE.

REINFORCING STEEL GRADE
REINFORCING STEEL SHALL BE IN ACCORDANCE WITH CSA - 630-12-M 1977. GRADE 400. REINFORCING BARS WITH DESIGNATION 'C' AT END OF BAR MARK SHALL BE EPOXY COATED BARS.

CONSTRUCTION NOTES:
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 3 mm.
NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

CONCRETE QUANTITIES
CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS.

ITEM	QUANTITY	UNIT
1. CONCRETE IN PIERS	162	m ³
2. CONCRETE IN ABUTMENTS & WINDOW WALL	150	m ³
3. CONCRETE IN DECK AND DIAPHRAGMS	232	m ³
4. CONCRETE IN BARRIER WALLS	37	m ³
5. CONCRETE IN APPROACH SLABS	45	m ³

RAILWAY CLEARANCE DIAGRAM
1:200

DATE BY DESCRIPTION
DESIGN: M.P. CHECK: M.A. LEADING: M.P. DATE: 01-03
DRAWING: J.L. CHECK: M.A. SITE: 23-340 DWG: 1

WARNING: DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



RECORD OF BOREHOLE No. 1

W.P. 151-77-04/05 LOCATION Sta. 10 376, Along E. Hwy. 7169 ORIGINATED BY R.M.
 DIST 2 HWY 7169 BOREHOLE TYPE Hollow Stem Auger COMPILED BY R.M.
 DATUM Gageville DATE 80-12-15 CHECKED BY T.J.K.

SOIL PROFILE					GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER TYPE	"N" VALUES			20 40 60 80 100	W _p	W					
290.7	Ground Surface													GR SA 51 CL
0.0														
	Grey - Brown Silty Clay to Clayey Silt (CL-ML) With Sand and Gravel (Till Backfill)		1 SS 14			290								9 32 44 15
			2 SS 28			288								
			3 SS 16			286								37 25 30 8
			4 SS 83			284								
	- Occasional Cobbles and Boulders Throughout		5 SS 23			282								26 33 33 8
	Very Stiff		6 SS 23			280								
			7 SS 24			278								
			8 SS 24			276								
			9 SS 18			274								
			10 SS 19			272								26 16 49 9
			11 SS 20			270								
			12 SS 20			268								
						266								
						264								
259.01														

31.70 End of Borehole

Note: Borehole
dry at end of investigation.

*³, *⁵: Numbers refer to
Sensitivity

20
15-20 (%) STRAIN AT FAILURE
10