

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. SIL-51

DIST. 13 REGION

W.P. No. 138-76-02

CONT. No. 88-233

W. O. No.

STR. SITE No. 44-19

HWY. No. 654

LOCATION Bear Creek Bridge  
~~88-233~~

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

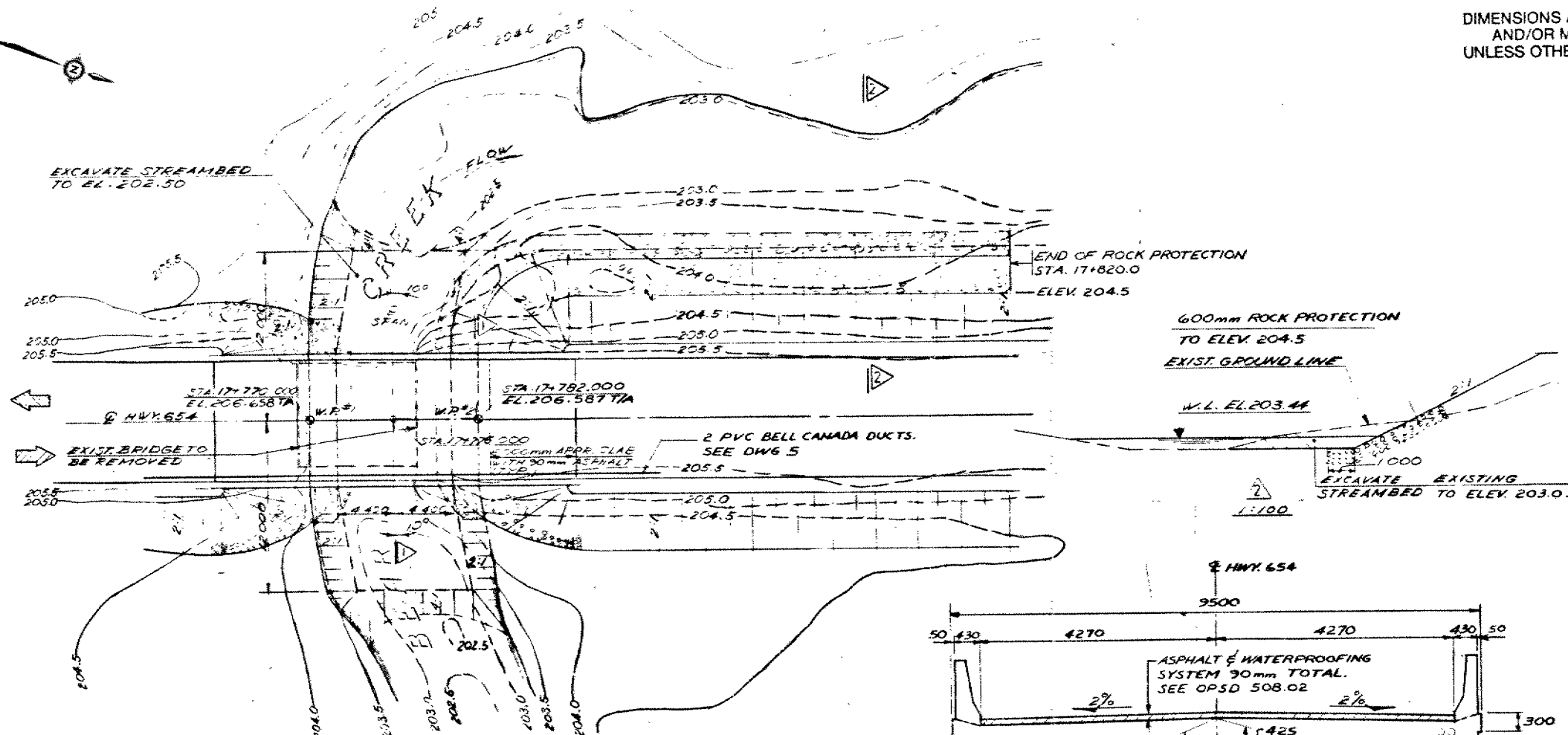
DIST. No. 13

CONT No

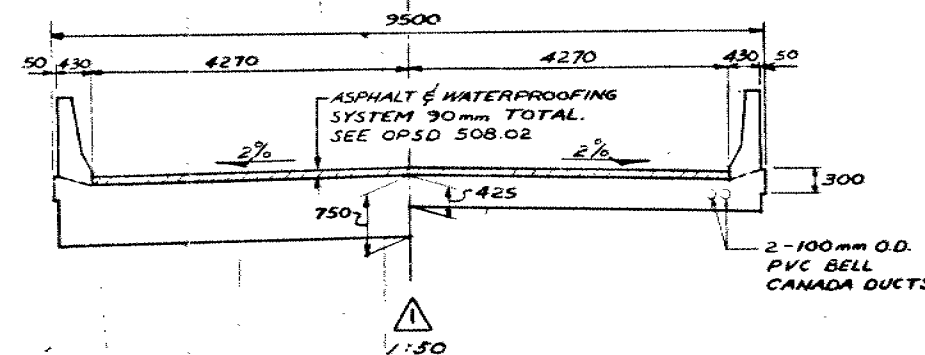
WP No 38-76-03

BEAR CREEK BRIDGE  
15.4 km WEST OF JUNCTION 444  
GENERAL ARRANGEMENT

SHEET



PLAN  
1:200

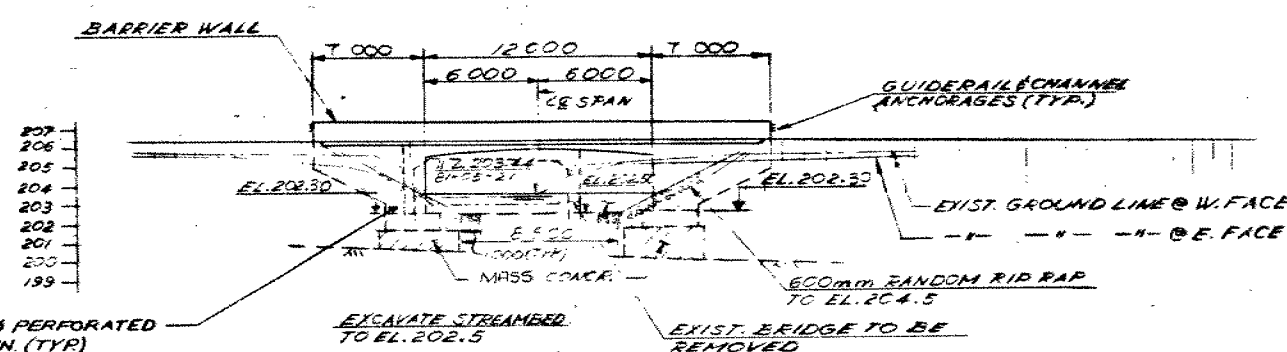


NOTES:

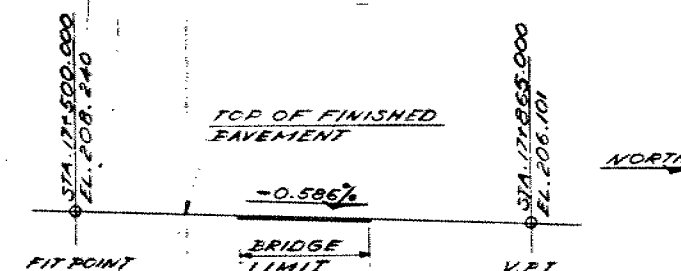
1. REINFORCING STEEL SHALL BE GRADE 400.
2. BARS MARKED WITH A SUFFIX 'C' SHALL BE COATED BARS.
3. CLASS OF CONCRETE  
MASS CONCRETE --- 20 MPa  
REMAINDER --- 30 MPa
4. CLEAR COVER TO REINFORCING STEEL SHALL BE  
FOOTINGS --- 100 ± 25 mm  
ABUT & WINGWALLS: FRONT FACE --- 80 ± 20 mm  
BACK FACE --- 70 ± 20 mm  
DECK: TOP --- 70 ± 20 mm  
BOTTOM --- 50 ± 10 mm  
REMAINDER, UNLESS OTHERWISE NOTED: 70 ± 20 mm

CONSTRUCTION NOTES:

1. FALSEWORK SUPPORTING WINGWALLS SHALL NOT BE REMOVED UNTIL CONCRETE IN THE DECK HAS ATTAINED A MINIMUM STRENGTH OF 20 MPa.
2. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHTS OF BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN THE ELEVATION BE GREATER THAN 600 mm.
3. THE ABUTMENTS SHALL BE BACKFILLED TO AT LEAST ELEVATION 205.0 PRIOR TO REMOVAL OF THE FALSEWORK SUPPORTING THE DECK.



EAST ELEVATION  
1:200



PROFILE @ E HWY. 654  
N.T.S.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT.
2. BORE HOLE LOCATIONS AND SOIL STRATA.
3. FOOTING REINFORCING.
4. WINGWALL DETAILS.
5. RIGID FRAME DETAILS.
6. BARRIER WALL.
7. 6000 mm APPROACH SLAB.
8. BRIDGE DATE & SITE NUMBER DATA.
9. AS CONSTRUCTED ELEV. & DIMENSION.
10. QUANTITIES - STRUCTURE.

BM 203.382  
C.C. ON BED ROCK  
16.3 LT 17+813.85

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
1	03-10	CHD	LOADING CHD-CI-79
2	03-10	CHD	SITE NO 44-629-19
3	03-10	CHD	DWG 1

**METRIC**

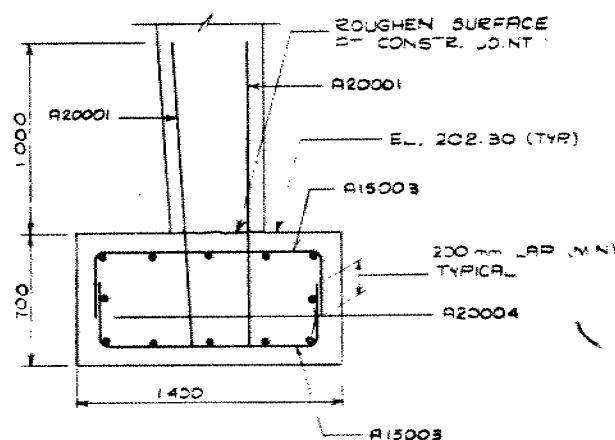
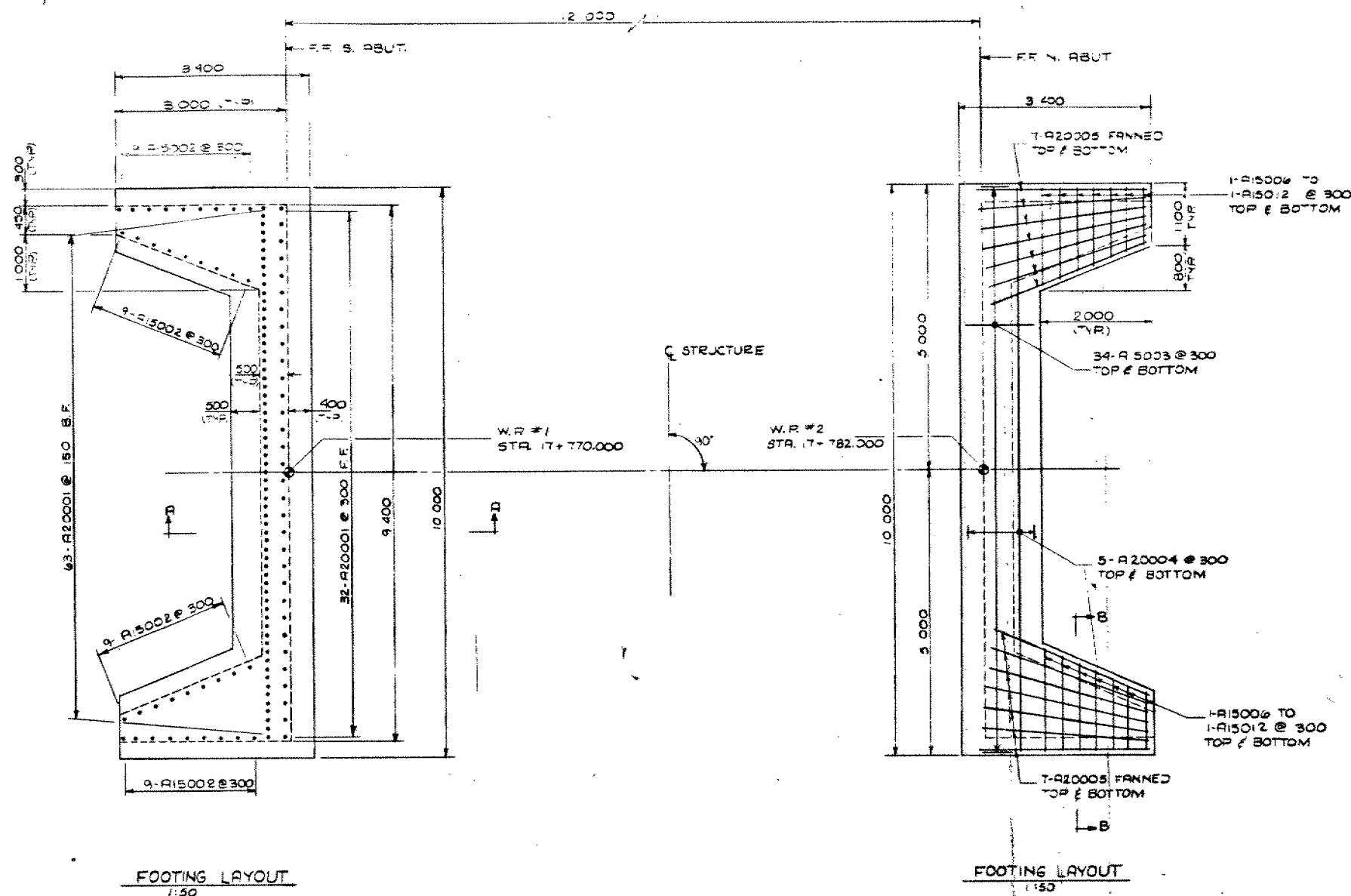
DIMENSIONS ARE IN MILLIMETRES  
UNLESS OTHERWISE SHOWN.  
ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES.

CONT No  
WP No 138-76-05

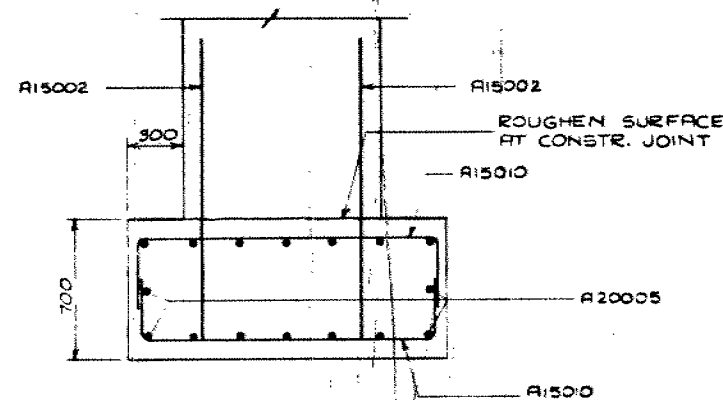
BEAR CREEK BRIDGE  
FOOTING REINFORCEMENT

SHEET

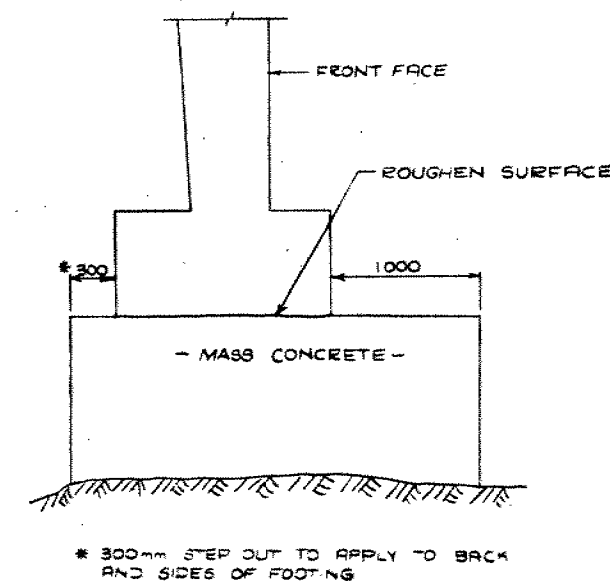
NOTES:  
REINFORCING AND LAYOUT SIMILAR  
FOR BOTH ABUTMENT FOOTINGS.



SECTION A-A  
1:20



SECTION B-B  
1:20



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN			LOADING AND CONSTRUCTION DATE 6-4-79
DRAWING			SITE No 44-629-19 DWG 3

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 88-233



Ministry of  
Transportation and  
Communications

## I N D E X

<u>Page</u>	<u>Contents</u>
1	Index
2	Symbols & Abbreviaions
3 - 16	Foundation Investigation Report For Bear Creek Structure W.P. 138-76-02; Site 44-629-19 Hwy. 654, District 13, North Bay

NOTE: For the purposes of this Contract, this report supersedes all other reports prepared by or for the Ministry in connection with the above-noted project.

## 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 (SIGNATION (R Q D)), 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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT  
For  
Bear Creek Structure, Hwy. 654  
W.P. 138-76-02, Site 44-629-19  
District 13, North Bay

INTRODUCTION:

This report summarizes the factual information obtained from a foundation investigation carried out on 83 05 10 and 83 05 11 at the above mentioned structure site.

The fieldwork consisted of 6 sampled boreholes advanced by means of solid stem augers, with 2 of the boreholes being cored using a BX core barrel. The borings ranged in depth from 2.1 m to 5.0 m.

SITE DESCRIPTION

The site is located at the crossing of Highway 654 over Bear Creek, in the Township of Nipissing, District of Parry Sound. Bear Creek generally flows in a northwesterly direction and 4 km downstream of the site empties into Lake Nipissing on the south shore.

The depth of the stream varies from 0.4 m downstream of the structure to 1.5 m just upstream of the bridge, with an average width of 7.0 m. The water level can change dramatically over a short period of time, as this was the situation observed during the field investigation.

The stream bed consists of a silty clay sediment upstream of the structure and exposed bedrock 10.0 m downstream.

The existing topography around the site is relatively flat and level with occasional knobs caused by bedrock outcrops. The existing structure is a single 7 m span bridge and crosses Bear Creek at a point where it is flowing from east to west. Available information indicates the existing structure is founded on 0.76 m (30") diameter caissons which vary in length from 1.7 m to 2.3 m and are founded on bedrock.

The existing approach fills are up to 3.5 m above the stream bed level and are composed of rock fill.

## SUBSURFACE CONDITIONS

### General

The subsurface soil conditions are quite variable. The predominant soil stratum is a silty clay which varies in thickness from 0.8 m to 3.1 m. This silty clay is the surficial deposit on the west side of the structure whereas on the east side of the structure this soil is overlain by sands varying in thickness from 1.4 m to 1.9 m.

The silty clay is underlain by a 0.9 m to 1.0 m sand and gravel to sand deposit south of the structure.

Underlying the soil deposits is a granite gneiss bedrock which predominantly slopes from west to east.

The boundaries between the various soil types, insitu and laboratory test results, and stabilized ground water levels, are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with a profile showing an estimated stratigraphical section based on borehole data, are shown on Drawing 2 of the Contract Drawings.

The various soil types encountered are briefly described in the following paragraphs.

### Silty Clay

The silty clay is the dominant soil layer and is present in all borehole locations. The deposit varies in thickness from 1.4 m to 2.1 m on the west side of the structure and from 2.0 to 3.1 m on the east side.

In the upper portion of the deposit a 0.8 m to 1.0 m thick zone of very soft to firm clay was encountered east of the existing structure.

Atterberg limit and natural moisture content tests were conducted on samples obtained from this silty clay deposit and results are plotted on Figure 2. These results indicate that the deposit is a silty clay of low plasticity (CL) with a zone of clay of high plasticity (CH).

Based on interpretation of 'N' values ranging from 1 to 10 blows per 0.3 m and augering operations, the consistency of the deposit is assessed as being very soft to firm.



#### Sand with Silt some Clay

Overlying the silty clay the surficial material in the northeastern quadrant is a sand with silt some clay and a trace of gravel extending to a depth of 1.9 m. The results of a grain size distribution test for a sample of material for this strata is shown on Figure 1.

The 'N' values obtained from sampling ranging from 3 to 6 blows per 0.3 m indicate that this material is loose to very loose.

#### Silty Sand trace Clay

This surficial deposit of silty fine sand with traces of clay overlies the silty clay southeast of the structure and extend to a depth of 1.4 m. The results of a grain size distribution test on a sample from this deposit is also indicated on Figure 1. This material has a higher silt and fine sand content than the surficial deposit to the north.

The 'N' value of 2 blows per 0.3 m indicate this material to be very loose.

#### Sand trace of Silt trace of Clay

This deposit of fine sand containing traces of silt and clay is sandwiched between the upper silty clay deposit and the underlying bedrock in the southwest area of the structure. This layer is 1.0 m thick. A grain size distribution test performed on a sample obtained from this deposit is shown on Figure 1.

The denseness of this material is loose as indicated by an 'N' value of 9 blows per 0.3 m.

#### Sand and Gravel

A sand and gravel layer 0.9 metres thick, is sandwiched between the upper silty clay deposit and the bedrock southeast of the structure. The 'N' value of 28 indicate that this soil stratum is compact.

### Bedrock

The bedrock is a Precambrian granite gneiss bedrock of the Grenville Structural Province. This bedrock was cored to maximum depth of 0.8 m. The coring of bedrock and augering to refusal on bedrock indicate that it slopes in an easterly direction with rock being encountered at elevations 202.4 and 202.7 in the west and elevations of 199.3 and 199.6 in the east.

The bedrock also slopes gently from south to north as is indicated by a bedrock elevation of 202.7 southwest of the structure which gradually slopes down to an elevation of 201.4 m some 35 m north of the existing structure.

The bedrock is generally sound except for a 0.3 m zone of fractured possibly weathered rock encountered to the southeast of the structure.

### Groundwater Conditions

Overnight and same day stabilized water level readings taken in open boreholes indicated the general groundwater table to vary between elevation 203.2 to 203.8 which closely corresponds to the water level of approximately 203.4 in the stream.

Borehole 2 was the only exception with a water level at elevation 204.8. This may have been caused by cave in the lower part of the hole. The approximate groundwater elevation of 203.5 will fluctuate with the normal seasonal variations in the stream level.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. H. J. Sturm, Project Foundations Engineer, using equipment owned and operated by Atcost Soil Investigation, Toronto. The report was written by Mr. H. J. Sturm and reviewed by Mr. M Devata, Senior Foundations Engineer.



*D. H. Dundas*

D. H. Dundas, P. Eng.  
Sr. Foundations Engineer

*M. Devata*

M. Devata, P. Eng.  
Chief Foundations Engineer  
(East)

## A P P E N D I X

# RECORD OF BOREHOLE No 1

METRIC

W P 138-76-02 LOCATION Sta. 17 + 790.0; o/s 9.5 m LT & Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 10 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	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
204.5	Ground Surface																
0.0	Silty clay Trace of sand Trace of fibrous organics Soft	Brown Grey	1	SS	3												
202.4	End of Borehole Refusal to augering Probable bedrock		2	SS	3												
2.1																	

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2										METRIC					
W P 138-76-02		LOCATION Sta. 17 + 766.0; o/s 14.5 m LT & Hwy. 654				ORIGINATED BY JIS									
DIST 13 HWY 654		BOREHOLE TYPE Solid Stem Auger, BX Rock Core				COMPILED BY HS									
DATUM Geodetic		DATE 1983 05 10				CHECKED BY CR									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
205.1	Ground Surface														
0.0	Silty Clay Trace of fibrous Organics Firm Grey		1	SS	10		205								
203.7							204								
1.4	Sand Trace of Silt Trace of Clay Loose Brown		2	SS	9		203								0 84 8 8
202.7															
2.4	Granite Gneiss Bedrock Sound		4	BX RC	96Z REC		202								
201.9															
3.2	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3

METRIC

W P 138-76-02 LOCATION Sta. 17 + 769.4; o/s 13.4 m RT Q Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger, BX Rock Core COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 10 CHECKED BY EP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
203.9	Ground Surface												
0.0													
	Silty Sand Trace of Clay Very loose		1	SS	2								0 47 45 8
202.5													
1.4	Silty Clay Firm		2	SS	6								
	Clay Very soft		3	SS	2								
200.5			4	SS	11								
3.4	Sand and Gravel Compact												
199.6			5	SS	28								
4.3	Granite Weathered		6	BX	55% REC								
199.0	Gneiss Bedrock Sound												
4.9	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4

METRIC

W P 138-76-02 LOCATION Sta. 17 + 783.8; o/s 8.2 m RT Q Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY CP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			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	Wp	W	W <sub>L</sub>		
204.3	Ground Surface												
0.0	Sand with Silt Some Clay  Very loose		1	SS	3								
202.4			2	SS	6								
1.9	Clay		3	SS	7								
	Silty Clay Very soft to firm		4	SS	3								
			5	SS	1								
199.3			6	SS	8								
5.0	End of Borehole Refusal to augering Probable bedrock												

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 5

METRIC

W P 138-76-02 LOCATION Sta. 12 + 803.0; w/p 9.5 m LT 4 Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY ef

SOIL PROFILE		STRAT PLOT	SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W		
204.0	Ground Surface															
0.0	Silty Clay Trace of Sand Trace of fibrous Organics		1	SS	2											
201.8	Soft to Firm		2	SS	6											
2.2	End of Borehole Refusal to auger Probable bedrock															

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 6

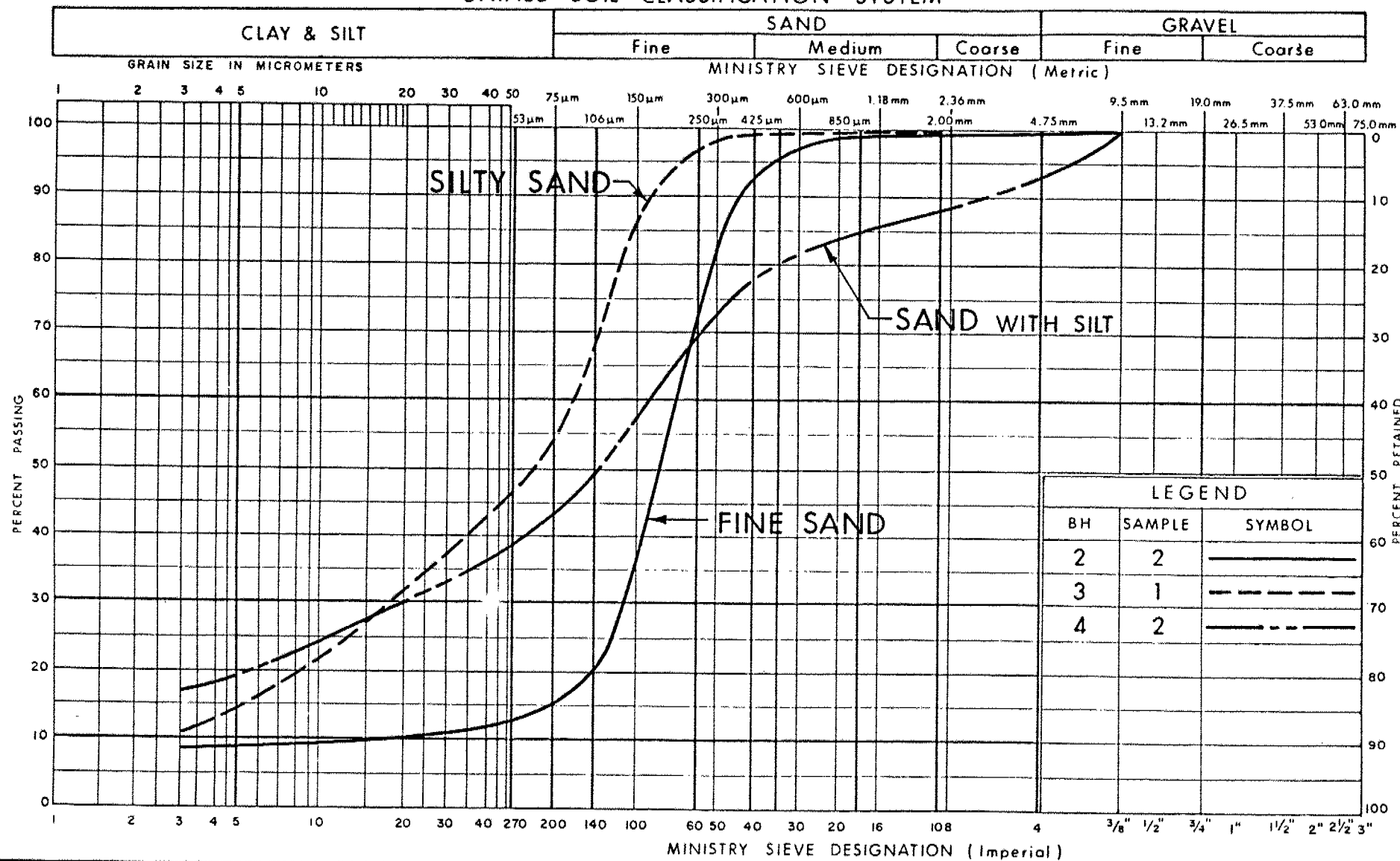
METRIC

W P 138-76-02 LOCATION Sta. 17 + 812.0; o/s 10.0 m LT 6 Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY CF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
204.0	Ground Surface													
0.0	Silty Sand Trace of Clay													
	Loose		1	SS	6		203							
202.2	Sand		2	SS	7									
1.8	Silty Clay						202							
201.4	Firm													
2.6	End of Borehole													
	Refusal to augering													
	Probable bedrock													

OFFICE REPORT ON SOIL EXPLORATION

## UNIFIED SOIL CLASSIFICATION SYSTEM



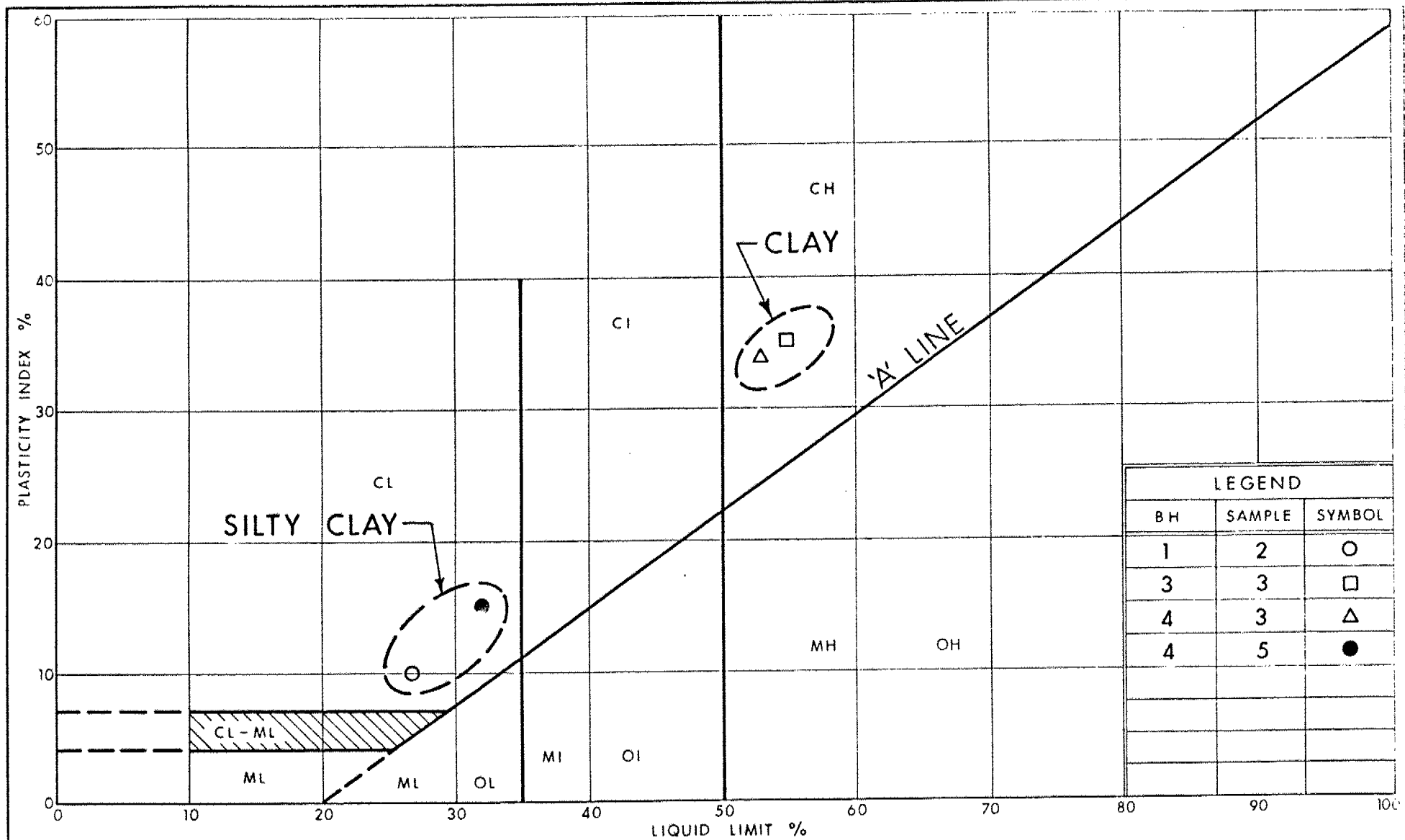
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## GRAIN SIZE DISTRIBUTION

FIG No 1

W P 138-76-02



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## PLASTICITY CHART

FIG No 2

W P 138-76-02

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 138-76-02 DIST 13  
HWY 654 STR SITE 44-19

Bear Creek Structure

DISTRIBUTION

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## FOUNDATION INVESTIGATION REPORT

For

Bear Creek Structure, Hwy. 654

W.P. 138-76-02, Site 44-19

District 13, North Bay

### INTRODUCTION:

This report summarizes the factual information obtained from a foundation investigation carried out on 83 05 10 and 83 05 11 at the above mentioned structure site. Detailed recommendations pertaining to the structure foundations and related earthworks are presented in this report.

The fieldwork consisted of 6 sampled boreholes advanced by means of solid stem augers, with 2 of the boreholes being cored using a BX core barrel. The borings ranged in depth from 2.1 m to 5.0 m.

### SITE DESCRIPTION

The site is located at the crossing of Highway 654 over Bear Creek, in the Township of Nipissing, District of Parry Sound. Bear Creek generally flows in a northwesterly direction and 4 km downstream of the site empties into Lake Nipissing on the south shore.

The depth of the stream varies from 0.4 m downstream of the structure to 1.5 m just upstream of the bridge, with an average width of 7.0 m. The water level can change dramatically over a short period of time, as this was the situation observed during the field investigation.

The stream bed consists of a silty clay sediment upstream of the structure and exposed bedrock 10.0 m downstream.

The existing topography around the site is relatively flat and level with occasional knobs caused by bedrock outcrops. The existing structure is a single 7 m span bridge and crosses Bear Creek at a point where it is flowing from east to west. Available information indicates the existing structure is founded on 0.76 m (30") diameter caissons which vary in length from 1.7 m to 2.3 m and are founded on bedrock.

The existing approach fills are up to 3.5 m above the stream bed level and are composed of rock fill.

## SUBSURFACE CONDITIONS

### General

The subsurface soil conditions are quite variable. The predominant soil stratum is a silty clay which varies in thickness from 0.8 m to 3.1 m. This silty clay is the surficial deposit on the west side of the structure whereas on the east side of the structure this soil is overlain by sands varying in thickness from 1.4 m to 1.9 m.

The silty clay is underlain by a 0.9 m to 1.0 m sand and gravel to sand deposit south of the structure.

Underlying the soil deposits is a granite gneiss bedrock which predominantly slopes from west to east.

The boundaries between the various soil types, insitu and laboratory test results, and stabilized ground water levels, are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with a profile showing an estimated stratigraphical section based on borehole data, are shown on Drawing #1387602-A.

The various soil types encountered are briefly described in the following paragraphs.

### Silty Clay

The silty clay is the dominant soil layer and is present in all borehole locations. The deposit varies in thickness from 1.4 m to 2.1 m on the west side of the structure and from 2.0 to 3.1 m on the east side.

In the upper portion of the deposit a 0.8 m to 1.0 m thick zone of very soft to firm clay was encountered east of the existing structure.

Atterberg limit and natural moisture content tests were conducted on samples obtained from this silty clay deposit and results are plotted on Figure 2. These results indicate that the deposit is a silty clay of low plasticity (CL) with a zone of clay of high plasticity (CH).

Based on interpretation of 'N' values ranging from 1 to 10 blows per 0.3 m and augering operations, the consistency of the deposit is assessed as being very soft to firm.

#### Sand with Silt some Clay

Overlying the silty clay the surficial material in the northeastern quadrant is a sand with silt some clay and a trace of gravel extending to a depth of 1.9 m. The results of a grain size distribution test for a sample of material for this strata is shown on Figure 1.

The 'N' values obtained from sampling ranging from 3 to 6 blows per 0.3 m indicate that this material is loose to very loose.

#### Silty Sand trace Clay

This surficial deposit of silty fine sand with traces of clay overlies the silty clay southeast of the structure and extend to a depth of 1.4 m. The results of a grain size distribution test on a sample from this deposit is also indicated on Figure 1. This material has a higher silt and fine sand content than the surficial deposit to the north.

The 'N' value of 2 blows per 0.3 m indicate this material to be very loose.

#### Sand trace of Silt trace of Clay

This deposit of fine sand containing traces of silt and clay is sandwiched between the upper silty clay deposit and the underlying bedrock in the southwest area of the structure. This layer is 1.0 m thick. A grain size distribution test performed on a sample obtained from this deposit is shown on Figure 1.

The denseness of this material is loose as indicated by an 'N' value of 9 blows per 0.3 m.

#### Sand and Gravel

A sand and gravel layer 0.9 metres thick, is sandwiched between the upper silty clay deposit and the bedrock southeast of the structure. The 'N' value of 28 indicate that this soil stratum is compact.



### Bedrock

The bedrock is a Precambrian granite gneiss bedrock of the Grenville Structural Province. This bedrock was cored to maximum depth of 0.8 m. The coring of bedrock and augering to refusal on bedrock indicate that it slopes in an easterly direction with rock being encountered at elevations = 202.4 and 202.7 in the west and elevations of 199.3 and 199.6 in the east.

The bedrock also slopes gently from south to north as is indicated by a bedrock elevation of 202.7 southwest of the structure which gradually slopes down to an elevation of 201.4 m some 35 m north of the existing structure.

The bedrock is generally sound except for a 0.3 m zone of fractured possibly weathered rock encountered to the southeast of the structure.

### Groundwater Conditions

Overnight and same day stabilized water level readings taken in open boreholes indicated the general groundwater table to vary between elevation 203.2 to 203.8 which closely corresponds to the water level of approximately 203.4 in the stream.

Borehole 2 was the only exception with a water level at elevation 204.8. This may have been caused by cave in the lower part of the hole. The approximate groundwater elevation of 203.5 will fluctuate with the normal seasonal variations in the stream level.

## DISCUSSION AND RECOMMENDATIONS

The reconstruction of Highway 654 will require the replacement of the existing structure over Bear Creek, since the new road will be wider. The span of the proposed structure will be increased to 12 m from the existing 7 m. No changes in the highway alignment are proposed, however, plans call for raising the grade by an additional 0.5 m. In addition some minor realignment and widening of the stream bed are contemplated.

The field investigation revealed the presence of a very soft to firm silty clay deposit extending across the site which is overlain in some areas by sands and silty sands. The silty clay is underlain by granite bedrock north of the existing structure, whereas to the south deposits of sand and gravel are present between the silty clay and bedrock.

In the following paragraphs the recommendations pertaining to the foundations of the new structure and related earthworks are detailed.

### Structure Foundations

The structure can be founded by means of spread footings located on the sound bedrock surface. Due to the sloping nature of the bedrock surface it will be necessary to step the abutment footing down from approximate elevation 202.4 on the west side to approximate elevation 199.3 on the east side. In view of the possibility of rock knobs and depressions it may be necessary to incorporate mass concrete and rock excavation techniques.

For spread footings founded on sound bedrock a factored capacity at the U.L.S. of 10,000 kPa may be used for design purposes. The capacity at the S.L.S. Type II will not govern since settlement will not occur at loadings less than the U.L.S.

Excavations for the structure footings will require dewatering measures. This can be accomplished by driving sheeting to the bedrock surface. Water inflow from the granular layers above the bedrock or from the fractures in the upper bedrock surface can be expected beneath the sheeting. In view of this tremie concrete methods may be required.

Earth pressures against the abutment wall should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. Manual.

#### Stability of Embankment

The existing fill heights at the Bear Creek crossing are up to 3.5 m above the creek bed elevation with side slopes of approximately 1.5:1 and no signs of distress. Present proposals call for raising the grade by up to 0.5 m.

The surficial organics should be removed within the plan limits of the widening.

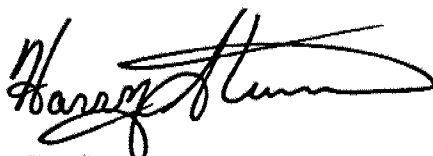
No stability problems are anticipated with fill heights up to 4.0 m above the stream bed level using standard 2:1 earth side slopes.

#### Settlement

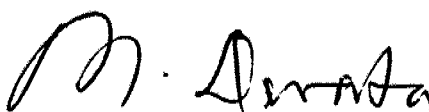
The widening of the existing embankments will create differential settlements between the existing and newly placed fills. This differential settlement can be minimized by placing the fills 6 months to 1 year in advance of the final paving operations.

#### MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. H. J. Sturm, Project Foundations Engineer, using equipment owned and operated by Atcost Soil Investigation, Toronto. The report was written by Mr. H. J. Sturm and reviewed by Mr. M Devata, Senior Foundations Engineer.



H. J. Sturm  
Project Foundations Engineer



M. Devata, P. Eng.  
Senior Foundations Engineer

A P P E N D I X



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# RECORD OF BOREHOLE No 1

METRIC

W P 138-76-02 LOCATION Sta. 17 + 790.0; o/s 9.5 m LT & Hwy. 654 ORIGINATED BY HS  
DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
DATUM Geodetic DATE 1983 05 10 CHECKED BY *HS*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
204.5	Ground Surface												
0.0	Silty clay						204						
	Trace of sand		1	SS	3								
	Trace of fibrous organics												
	Brown												
	Grey		2	SS	3		203						
202.4	Soft												
2.1	End of Borehole												
	Refusal to augering												
	Probable bedrock												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 2

METRIC

W P 138-76-02 LOCATION Sta. 17 + 766.0; o/s 14.5 m LT & Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger, BX Rock Core COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 10 CHECKED BY GR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
205.1	Ground Surface																GR SA SI CL
0.0	Silty Clay Trace of fibrous Organics Firm Grey		1	SS	10		205										
203.7	Sand Trace of Silt Trace of Clay Loose Brown		2	SS	9		204										0 84 8 8
202.7	Granite Gneiss Bedrock Sound		4	BX RC	96% REC		203										
201.9							202										
3.2	End of Borehole																

\*3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



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# RECORD OF BOREHOLE No 3

METRIC

W P 138-76-02 LOCATION Sta. 17 + 769.4; o/s 13.4 m RT Q Hwy. 654 ORIGINATED BY HS  
DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger, BX Rock Core COMPILED BY HS  
DATUM Geodetic DATE 1983 05 10 CHECKED BY EP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
203.9	Ground Surface																
0.0																	
	Silty Sand Trace of Clay Very loose		1	SS	2		203							o			0 47 45 8
202.5																	
1.4	Silty Clay Firm		2	SS	6		202										
	Clay Very soft		3	SS	2		201								o		
200.5			4	SS	11		200										
3.4	Sand and Gravel Compact		5	SS	28												
199.6			6	BX RC	55% REC												
4.3	Granite Weathered																
199.0	Gneiss Bedrock Sound																
4.9	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 4

METRIC

W P 138-76-02 LOCATION Sta. 17 + 783.8; o/s B.2 m RT Q Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
204.3	Ground Surface																
0.0	Sand with Silt Some Clay  Very loose		1	SS	3		204										
202.4			2	SS	6		203										
1.9	Clay Firm		3	SS	7		202										
	Silty Clay Very soft to firm		4	SS	3		201										
			5	SS	1		200										
199.3			6	SS	8												
5.0	End of Borehole Refusal to augering Probable bedrock																

+3, x5: Numbers refer to  
Sensitivity

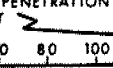


20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 5

METRIC

W P 138-76-02 LOCATION Sta. 17 + 803.0: o/s 9.5 m LT & Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
204.0	Ground Surface																
0.0																	
	Silty Clay Trace of Sand Trace of fibrous Organics		1	SS	2		203										
	Soft to Firm																
201.8			2	SS	6		202										
2.2	End of Borehole Refusal to augering Probable bedrock																

+3, x5: Numbers refer to 20  
Sensitivity 15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 6

METRIC

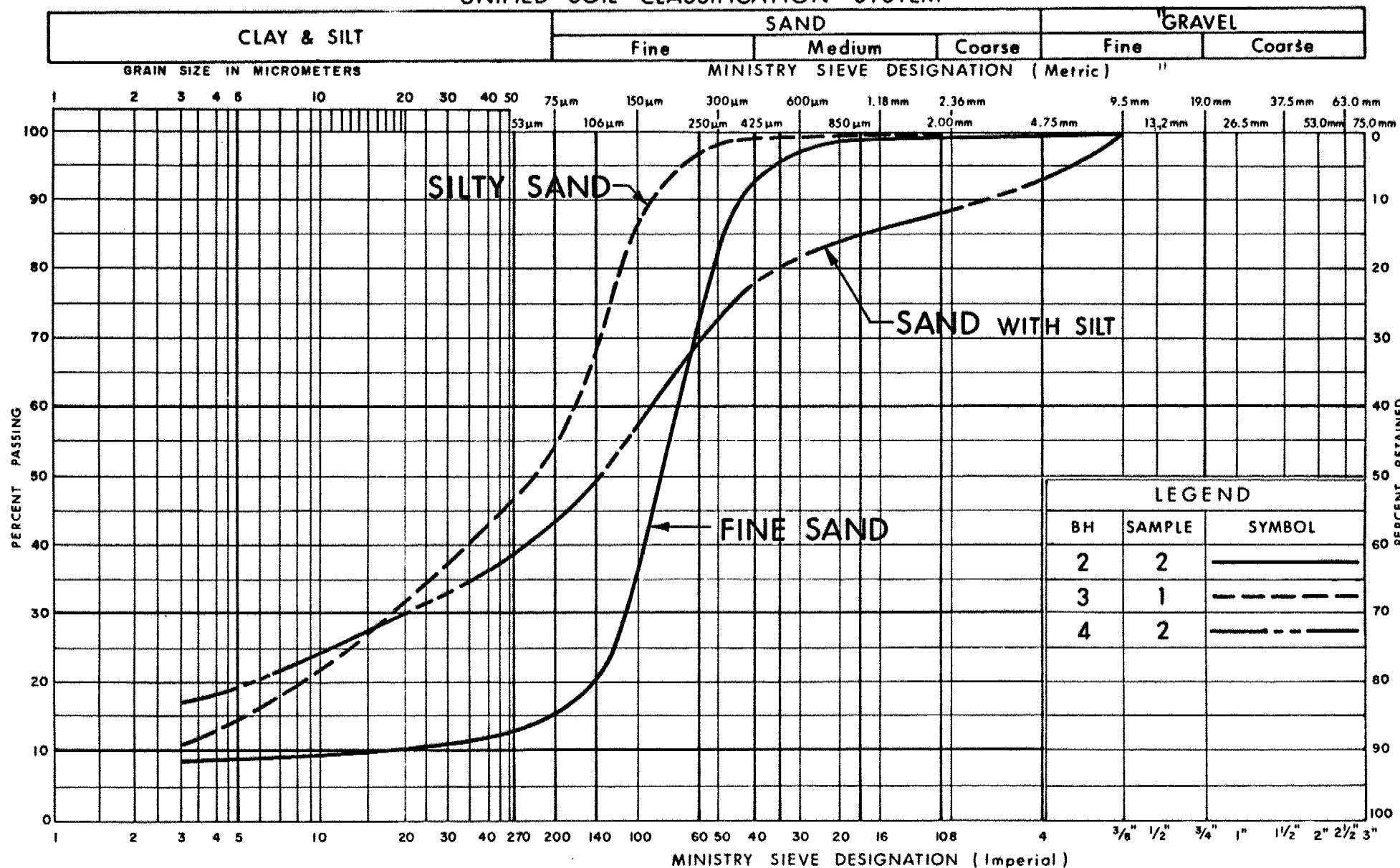
W P 138-76-02 LOCATION Sta. 17 + 812.0; o/s 10.0 m LT & Hwy. 654 ORIGINATED BY HS  
 DIST 13 HWY 654 BOREHOLE TYPE Solid Stem Auger COMPILED BY HS  
 DATUM Geodetic DATE 1983 05 11 CHECKED BY JP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
204.0	Ground Surface																
0.0	Silty Sand Trace of Clay																
	Loose		1	SS	6												
202.2	Sand		2	SS	7												
1.8	Silty Clay Firm																
201.4																	
2.6	End of Borehole Refusal to augering Probable bedrock																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

## UNIFIED SOIL CLASSIFICATION SYSTEM

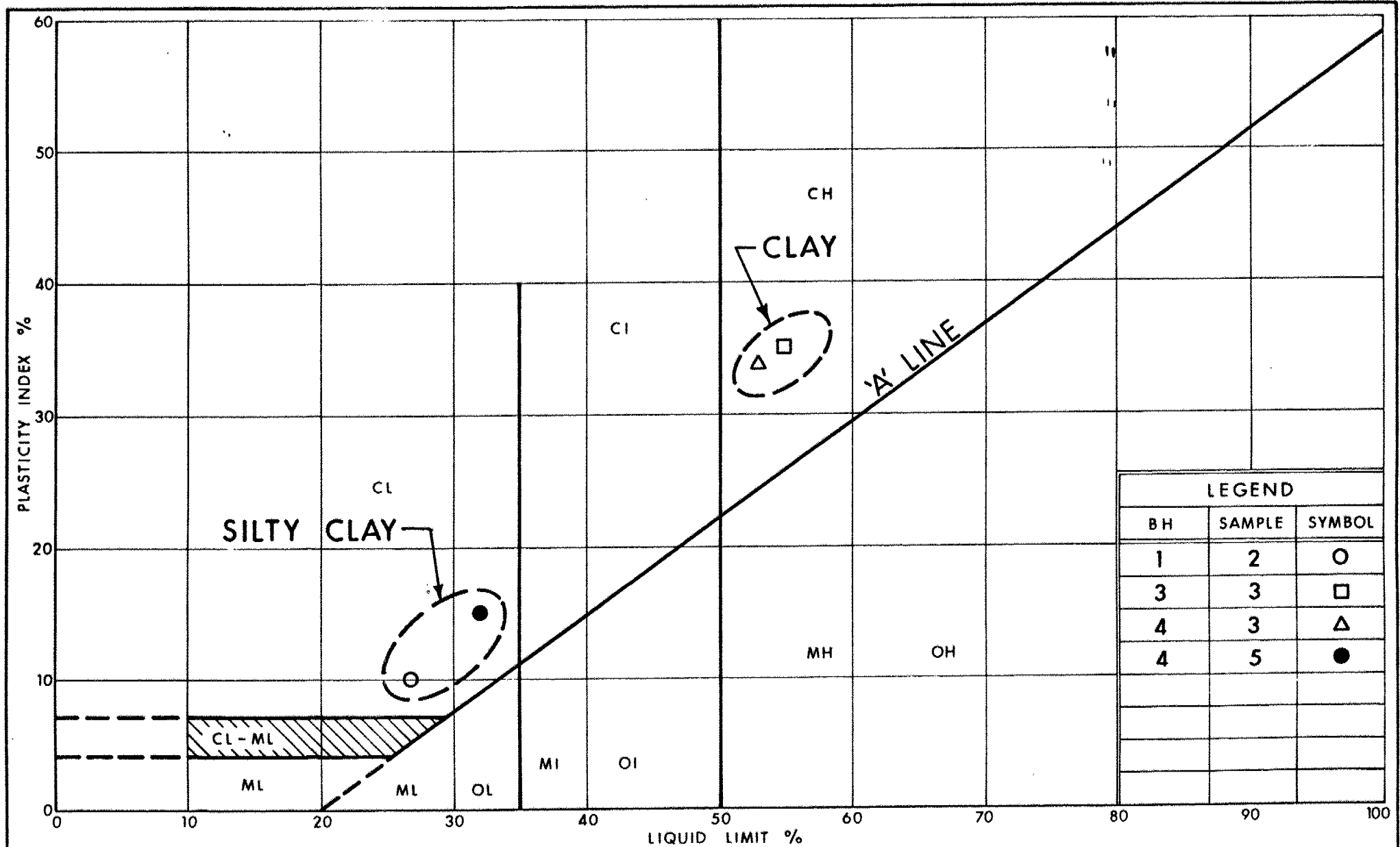


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## GRAIN SIZE DISTRIBUTION

FIG No 1

W P 138-76-02



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## PLASTICITY CHART

FIG No 2

W P 138-76-02

## 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:

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

### MECHANICAL PROPERTIES OF SOIL

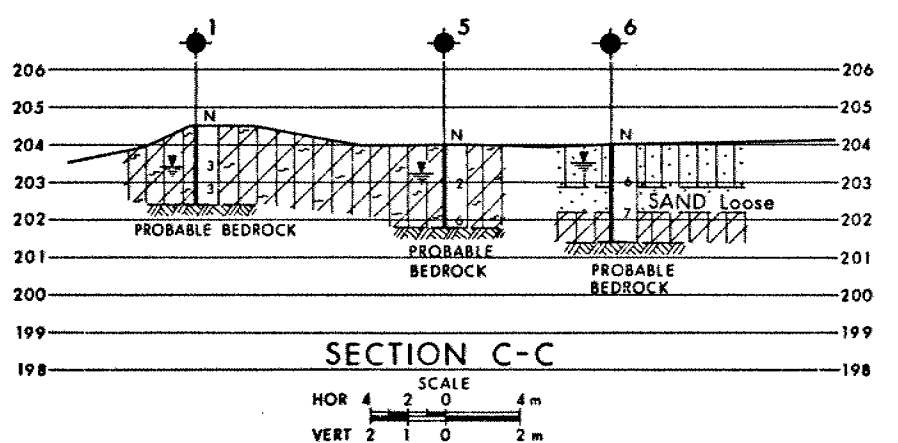
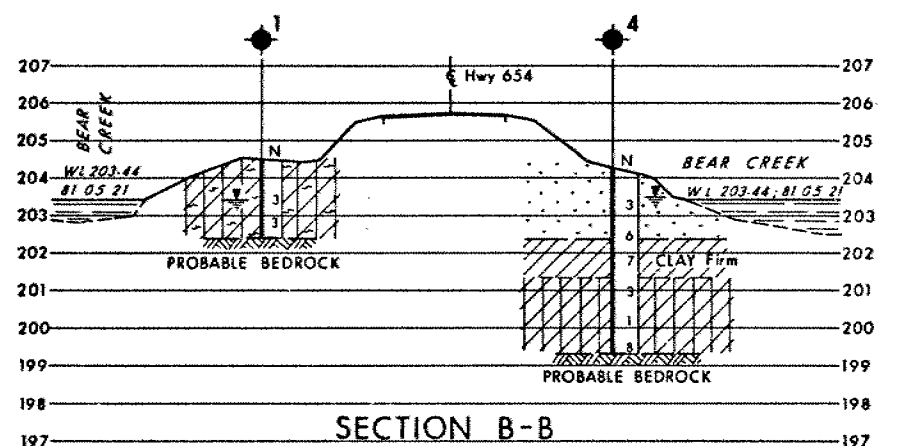
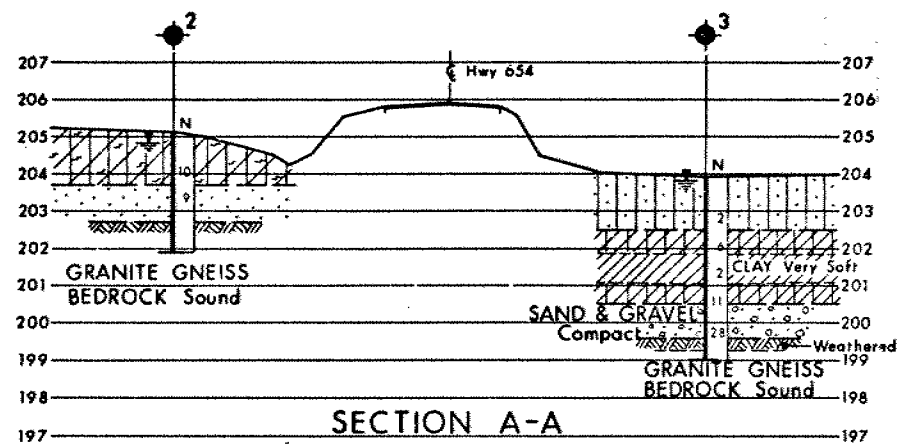
$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

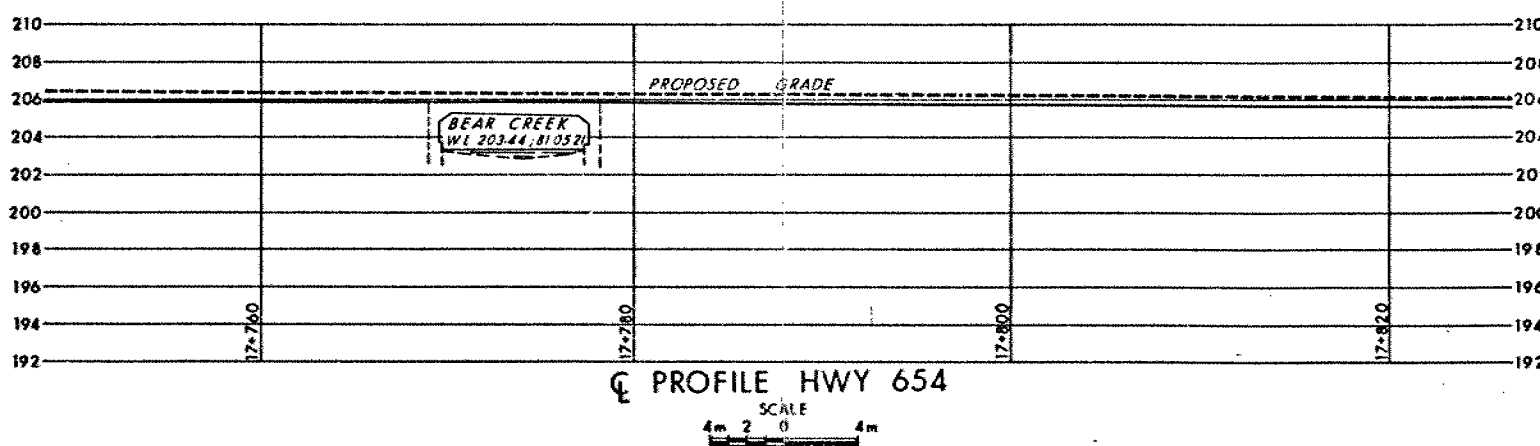
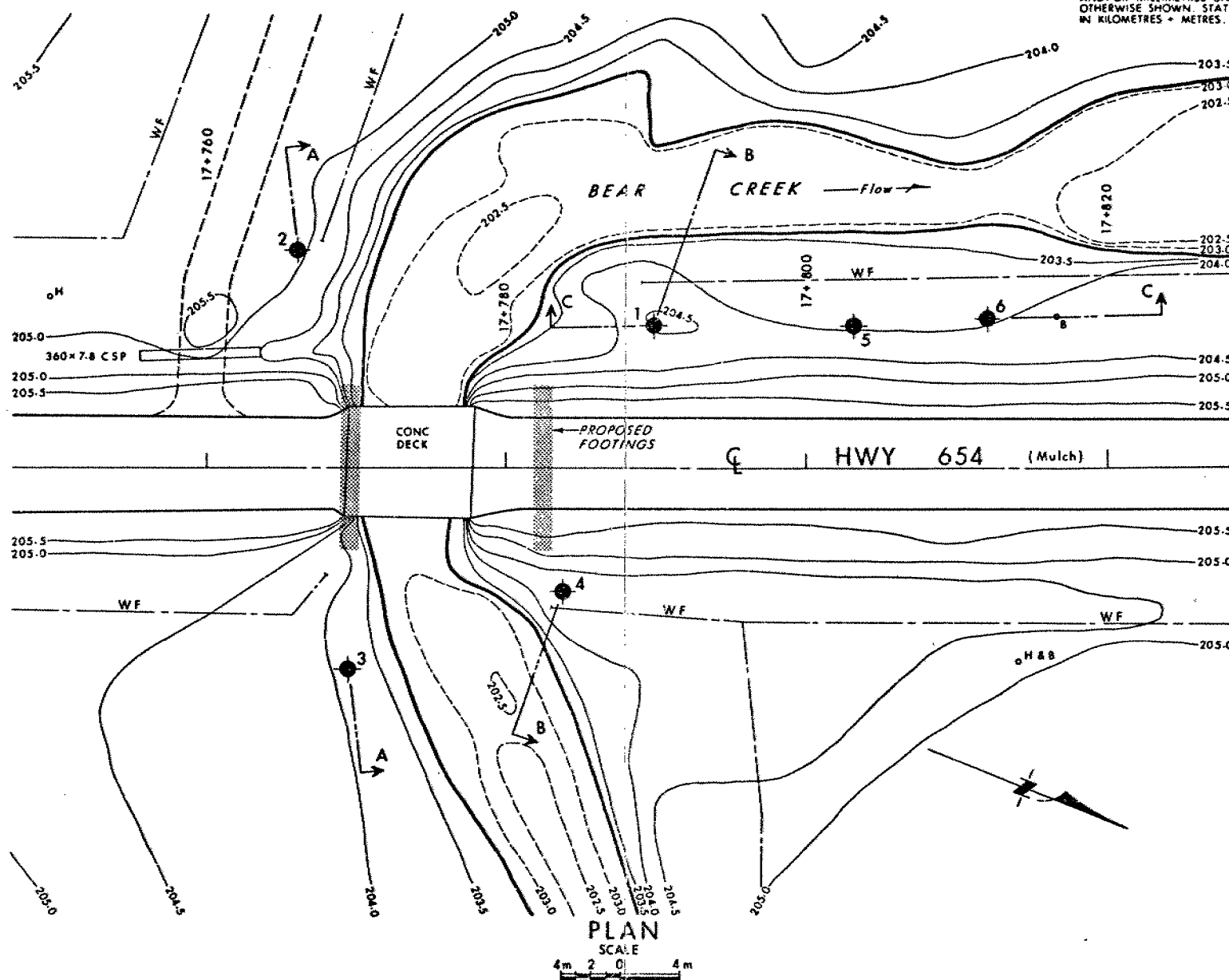
### PHYSICAL PROPERTIES OF SOIL

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



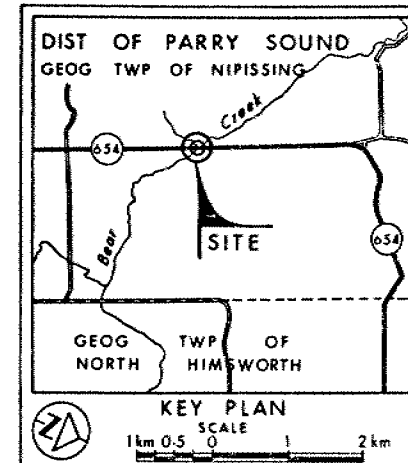
# SOIL STRATIGRAPHY LEGEND

- SILTY CLAY  
TRACE OF SAND & FIBROUS ORGANICS  
Soft to Firm
- SILTY SAND, TRACE OF CLAY  
Very Loose to Loose
- SAND WITH SILT  
TRACE TO SOME CLAY  
Very Loose to Loose
- SILTY CLAY  
Very Soft to Firm



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

CONT No  
WP No 138-76-02  
BEAR CREEK  
BORE HOLE LOCATIONS & SOIL STRATA



# LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (5rd Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation  
1983 05 10 and 11

No	ELEVATION	STATION	OFFSET
1	204.5	17+790.0	9.5m Lt
2	205.1	17+766.0	14.5m Lt
3	203.9	17+769.4	13.4m Rt
4	204.3	17+783.8	8.2m Rt
5	204.0	17+803.0	9.5m Lt
6	204.0	17+812.0	10.0m Lt

# NOTE

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

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.

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