

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40P2-40  
40P2-31

DIST. 4 REGION                     

W.P. No. 166-60-01

CONT. No. 87-20

W. O. No.                     

STR. SITE No. 23-89-311

HWY. No. 403/401

LOCATION 403 W.B.L. HWY 401

INTERCHANGE

No of PAGES -                     

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 87-20



Ministry of  
Transportation and  
Communications

I N D E X

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Note: For purposes of the contract this report supersedes all other foundation reports prepared by or for the ministry in connection with the above-mentioned project.

## 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

### 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						

## FOUNDATION INVESTIGATION REPORT

For

W.P. 166-60-01, Site 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

Hwy. 403, District 2, LondonINTRODUCTION:

This report summarizes the results of the foundation investigation required for the proposed structure and approach embankments at this site.

The fieldwork was conducted during the period from 82 07 21 - 27 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers.

This work consisted of 5 sampled boreholes/dynamic cone penetration tests.

SITE DESCRIPTION

The site is located east of Co. Rd. 15 along Hwy. 401 at Woodstock (Lot 13, Con. II, Twp. Norwich, Geog. Twp. (East) Oxford, County of Oxford).

Physiographically, the site is located in the Oxford Till Plain.

SUBSURFACE CONDITIONSGeneral

The Record of Borehole Sheets (Appendix) illustrate the conditions at the borehole locations. The location and elevations of the boreholes, and a stratigraphical profile based on the borehole data are shown on Drawing No. 2 of the contract DWG's.

The overburden at this site is composed of till. A predominantly cohesive silty clay till overlies a predominantly non-cohesive sandy silt to silty sand till. The boundary between these two general soil types dips gradually towards the south (from elev. 290.1 m at BH #1 to elev. 284.7 m at BH #5).

Silty Clay (CL), Some Sand, Trace Gravel

This firm to hard till material extends from the surface for depths ranging from 10.1 m at BH #1 to 21.3 m at BH #5. The deposit is generally silty clay of low plasticity containing some sand and traces of gravel. The sand content generally increases with depth especially at BH #1, #2 and #3. Occasional layers of dense silty sand were encountered within this deposit at BH #1 and BH #4, generally between Elev. 300 and elev. 298.

Physical properties of the cohesive portion of this material, as determined from field and laboratory tests, are summarized below:

	<u>Range</u>	<u>Average</u>
Natural Water Content (w)	8.0-14.5%	11.3%
Liquid Limit (W <sub>L</sub> )	14.0-26.0%	20.0%
Plastic Limit (W <sub>p</sub> )	11.0-15.0%	13.0%

Generally the material did not fail during field vane shear testing, indicating undisturbed shear strengths in excess of 107 kPa. A field vane shear strength value of 34.5 kPa, obtained near elev. 298 m at BH #3, was considered to be non-representative of the general deposit. Shear strength values from unconfined compression tests of similar material in the immediate vicinity of this site led to the selection of 150 kPa as the average shear strength for the silty clay till deposit.

Figure 1 illustrates a typical grain size distribution for the cohesive portion of this deposit.

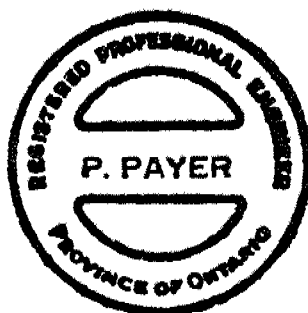
#### Sandy Silt to Silty Sand, Some Gravel, Trace Clay

This very dense till deposit underlies the silty clay till across the entire site. As indicated in Drawing No. 2, occasional layers of cohesive silty clay were encountered between elev. 286 m and elev. 282 m at BH #1 and BH #3. Occasional boulders were encountered while augering within this deposit. The natural water content of the non-cohesive portion of this deposit ranged from 6.0 - 10.5%.

Figure 2 illustrates a typical grain size distribution for the noncohesive portion of this deposit.

#### Groundwater

The groundwater elevation was estimated at 298 m. This estimate was based on field observations, data from previous foundation investigations in the immediate vicinity, and well records.



*P. Payer*  
 P. Payer, P. Eng.  
 Senior Foundations Engineer

*K. G. Selby*  
 K. G. Selby, P. Eng.  
 Chief Foundations Engineer

APPENDIX

# RECORD OF BOREHOLE No 1

METRIC

W P 166-60-01 LOCATION Sta. 11 + 257 E.W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 22 CHECKED BY DD

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					
300.2	Ground Surface																
0.0																	
	occ. layers of Silty Sand, Compact		1	SS	16	**											5 42 43 10
			2	SS	17												9 40 37 14
	Silty Clay (CL)		3	SS	29												
	Some Sand		4	SS	24												
	Trace Gravel		5	SS	11												
	Stiff to Very Stiff (Till)		6	SS	10												
	with Sand		7	SS	20												
			8	SS	18												
290.1																	5 43 38 14
10.1	Sandy Silt to Silty Sand		9	SS	100/	24 cm											19 37 37 7
	Some Gravel																
	Trace Clay		10	SS	100/	22 cm											15 37 42 6
	Very Dense (Till)		11	SS	100/	22 cm											
	occ. layers of Silty Clay (CL) Hard		12	SS	100/	18 cm											
			13	SS	100/	24 cm											
281.9			14	SS	100/	19 cm											
18.3	End of Borehole																*C <sub>u</sub> > 107kPa
	** Stabilized ground water level estimated from well records																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10





# RECORD OF BOREHOLE No 2

METRIC

W P 166-60-01 LOCATION Sta. 11 + 278 f W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 23 CHECKED BY DD

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	20 40 60 80 100					
300.7	Ground Surface													
0.0	Silty Clay (CL)													
	Some Sand		1	SS	13									
	Trace Gravel		2	SS	18									
	Stiff to Hard		3	SS	33									
	(Till)		4	SS	34									
			5	SS	29									
			6	SS	10									
			7	SS	20									
	with Sand		8	SS	15									
			9	SS	16									
289.1														
11.6	Sandy Silt to Silty Sand, Some Gravel		10	SS	100/	18 cm								
	Trace Clay													
	Very Dense													
	(Till)													
286.7			11	SS	100/	17 cm								
14.0	End of Borehole													
	** Stabilized ground water level estimated from well records													*Cu > 107kPa

# RECORD OF BOREHOLE No 3

METRIC

W P 166-60-01 LOCATION Sta. 11 + 320 E W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 21 CHECKED BY DD

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			20 40 60 80 100	20 40 60 80 100					
302.1	Ground Surface												GR SA SI CL
0.0	Silty Clay (CL)												
	Some Sand		1	SS	16								
	Trace Gravel		2	SS	18								
	Firm to Hard		3	SS	15								
	(Till)		4	SS	5	**							
			5	SS	22								
			6	SS	24								
			7	SS	17								
			8	SS	20								
			9	SS	21								
	with Sand		10	SS	12								
289.0													
13.1	Sandy Silt to Silty Sand		11	SS	100/	15 cm							
	Some Gravel												
	Trace Clay		12	SS	100								
	Very Dense												
	(Till)												
	occ. layers of Silty Clay (CL) Hard		13	SS	100								
280.3			14	SS	100								
21.8	End of Borehole												*Cu > 107kPa
	** Stabilized ground water level estimated from well records												

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



# RECORD OF BOREHOLE No 4

METRIC

W P 166-60-01 LOCATION Sta. 11 + 354 @ W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
301.9	Ground Surface										
0.0			1	SS	31						
			2	SS	29						
	occ. layers of Silty Sand, Compact		3	SS	19						
			4	SS	15						
	Silty Clay (CL)										
	Some Sand		5	SS	21						
	Trace Gravel										
	Stiff to Hard		6	SS	26						
	(Till)										
			7	SS	29						
			8	SS	36						
			9	SS	47						
			10	SS	32						
288.0			11	SS	57						
13.9	Sandy Silt to Silty Sand Some Gravel Trace Clay Very Dense		12	SS	100						4 30 56 10
284.7	(Till)		13	SS	100						9 43 42 6
17.2	End of Borehole										*C <sub>u</sub> > 107kPa
	** Stabilized ground water level estimated from well records										

# RECORD OF BOREHOLE No 5

METRIC

W P 166-60-01 LOCATION Sta. 11 + 375, 5.0 m Rt. of W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 23-26 CHECKED BY DD

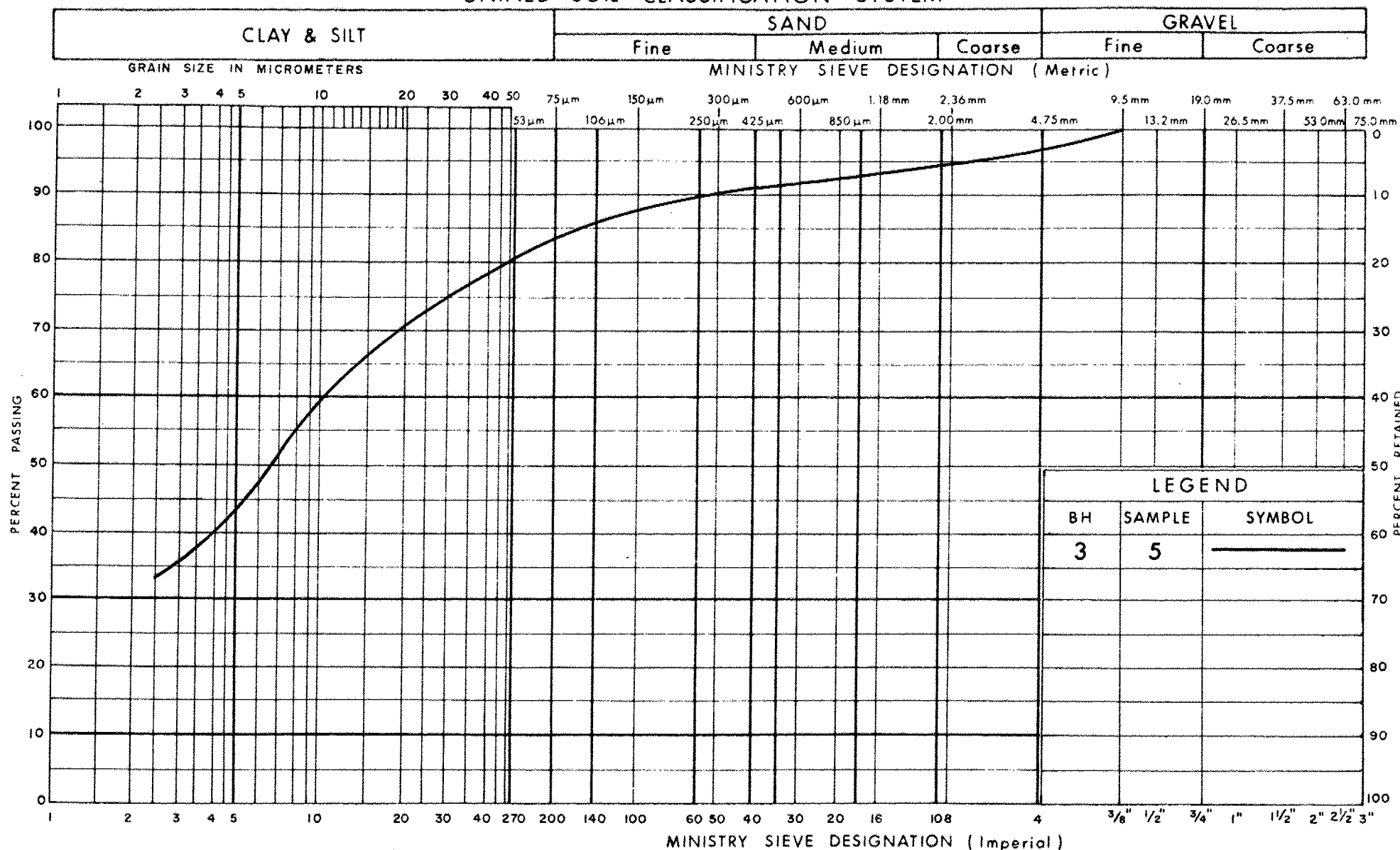
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
306.0	Ground Surface																
0.0	Silty Clay (CL) Some Sand Trace Gravel Stiff to Hard  (Till)		1	SS	29												
			2	SS	37												
			3	SS	29												
			4	SS	15												
			5	SS	19												
			6	SS	17												
			7	SS	17												
			8	SS	27												
			9	SS	19												
			10	SS	25												
			11	SS	27												
			12	SS	29												
			13	SS	31												
284.7			14	SS	100	20 cm											
21.3	Sandy Silt to Silty Sand Some Gravel, Trace Clay Very Dense (Till)		15	SS	100	28 cm											
282.5	Probable Boulder Refusal to Auger End of Borehole  ** Stabilized ground water level estimated from well records															*C <sub>u</sub> > 107kPa	

OFFICE REPORT ON SOIL EXPLORATION

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

## UNIFIED SOIL CLASSIFICATION SYSTEM



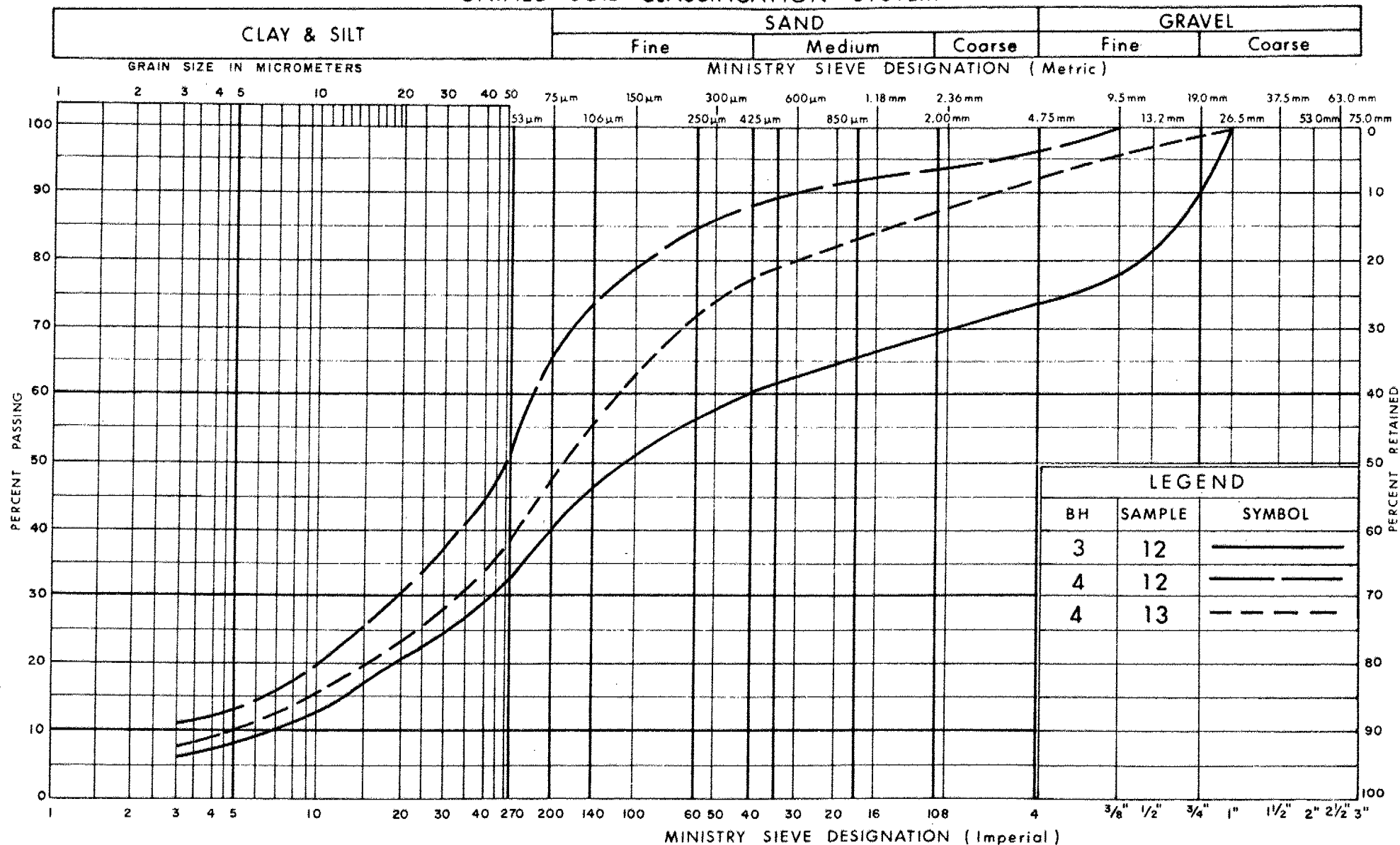
Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**SILTY CLAY (Till)**  
**SOME SAND TRACE GRAVEL**

FIG No 1

W P 166-60-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SANDY SILT TO SILTY SAND  
SOME GRAVEL TRACE CLAY

FIG No 2

W P 166-60-01

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MEMORANDUM

TO: Mr. A. P. Watt, (2)  
Reg. Structural Planning Eng.,  
Southwestern Region,  
London, Ont.

FROM: Foundations Office,  
Design Services Branch,  
West Bldg., Downsview.

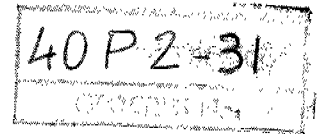
ATTENTION:

DATE: August 10, 1972

OUR FILE REF.

IN REPLY TO **AUG 24 1972**

SUBJECT:



FOUNDATION INVESTIGATION REPORT  
For

The Hwy. #401 Overpass of Proposed  
Hwy. #403; 20.6 Mi. West of Brantford  
West Limits District #4 Hamilton  
W.O. 72-11048 - W.P. 166-60-01

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac,  
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ht  
Attch.

c.c. D. W. Farren  
B. R. Davis  
A. Rutka  
A. McConnell  
C. R. Robertson  
B. J. Giroux  
J. R. Roy  
G. A. Wrong  
B. A. Singh

Foundations Files  
Documents

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## FOUNDATION INVESTIGATION REPORT

For

The Hwy. #401 Overpass of Proposed  
Hwy. #403; 20.6 Mi. West of Brantford  
West Limits ~~District #4~~ Hamilton  
W.O. 72-11048 -- W.P. 166-60-01

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### 1. INTRODUCTION:

The Foundations Office was requested to carry out an investigation at the site of the Hwy. #401 overpass of proposed Hwy. #403, Line 'E', W.B.L., some 20.6 miles west of Brantford west limits. The request was contained in a memo, dated March 21, 1972 by Mr. S. Jants, Bridge Planning Technician, Southwestern Region.

The subsequent fieldwork, as well as the laboratory testing programme were supervised by this Office, while the boreholes were located and related to geodetic benchmark by personnel of the Engineering Survey Office, Southwestern Region. Presented in this report are the results of the investigations, together with recommendations concerning structure foundations.

### 2. DESCRIPTION OF THE SITE AND GEOLOGY:

The proposed bridge site is situated within the right of way of existing Hwy. #401. The top of pavement of the highway at this location is around general groundlevel. The area within the right of way is conventionally landscaped. The fields in the vicinity are occupied by farms, usually growing crops. The terrain has a gentle gradient, sloping from east to west. Geologically, the proposed crossing site belongs to what is known to be the "Oxford Till Plain" physiographic region. The surface of this region is drumlinized, with good drumlines appearing south of Woodstock, where the glacial deposit apparently overrode an older moraine and faint drumlines and flutings further north. The till is a pale brown calcareous boulder loam, in which Onondaga limestone is the dominant material.

### 3. FIELD AND LABORATORY INVESTIGATIONS:

One sampled borehole and two dynamic cone penetration tests were carried out at each proposed footing location, as shown on the accompanying Drawing #72-11048A. The borings were implemented by means of a Bombardier mounted hollow stem auger (CME - 55), taking samples at regular intervals. Undisturbed samples were recovered by Shelby Tubes, which were pushed 18 inches into the soils, using the hydraulic head of the auger. Split spoon samplers were advanced by performing Standard Penetration Tests. Penetration resistances expressed as the number of hammer blows of a 140 lbs. hammer falling 30 inches for 1 ft. penetration, are recorded on the borelog sheets.

Samples were identified in the field, and again upon arrival in the laboratory. Laboratory testings were carried out on representative samples in order to determine natural moisture contents, Atterberg limits and grain-size distributions of the various deposits. The undrained shear strengths of the undisturbed samples were determined by laboratory unconfined compression tests. Laboratory test results are compiled in the borelogs attached to this report.

### 4. SOIL CONDITIONS:

#### 4.1) General:

Heterogeneous glacial deposits, consisting of clayey silts and sandy silts with some gravel were found in the boreholes. Due to the very stiff to hard consistency of the clayey silts all the dynamic cone penetration tests reached resistances of 100 blows/ft. or over, around elevation 971-981 ft., some 9 - 18 ft. below groundlevel.

Detailed descriptions of the deposits are as follows:

#### 4.2) Clayey Silts with some Sand and Traces of Gravel:

This is the uppermost deposit, found in the borings, except in B.H. #1, where the clayey silts are overlain by a 13 ft. thick fine sandy silt stratum. The depth of the clayey silts varies between 27 ft. and 42 ft., extending to geodetic elevations of 944 ft. - 957 ft. Penetration resistances ranging from 15 blows/ft. to 63 blows/ft. were noted within this soil, indicating very stiff to hard consistencies. The minimum value of laboratory

undrained shear strength was 1,500 PSF, the corresponding field strength being 2,000 PSF, estimated by the obtained 'N' values. The material exhibited slight plasticity; Atterberg limit tests resulted in plastic limits of 13% - 20% and liquid limits of 22% - 34%, with natural moisture contents of 10% - 19%.

Several grain-size analyses were carried out, the range of constituent particles being computed to be as follows: gravel - 1-6%, sand - 9-25%, silt - 50-61% and clay - 13-40%.

#### 4.3) Sandy Silt with some Clay and Gravel:

Below the clayey silts, sandy silts to silty sands with some clay and gravel were encountered, extending to the bottom of the holes at el. 929 Ft. - 940 Ft. High penetration resistances were observed within this stratum, 'N' values being between 24 blows/ft. and much above 100 blows/ft. Based on these values, the relative density of the deposit was classified to be compact to very dense. The heterogeneous and unsorted nature of the soils was confirmed by particle size analyses. The gravel size particles range from 8% to 24%, the sands from 22% to 37%, silts from 29% to 49% and the clays from 9% to 20%.

Occasionally, samples had some slight plasticity, with approximately 12% plastic limit and 19% liquid limit. The majority of the samples, however, were found to be nonplastic. All the samples were terminated within the very dense portion of the sandy silts.

#### 4.4) Groundwater Conditions:

Groundwater levels were observed in the borings, which were kept open until equilibrium watertable was reached. Such levels were established some 3 - 7 ft. below general groundsurface, corresponding to elevations of 978 ft. - 988 ft.

### 5. DISCUSSION AND RECOMMENDATIONS:

#### 5.1) General:

The overpass structure at the crossing of Hwy. #401 and proposed Hwy. #403, Line "E" W.B.L. is planned to be a 4-span bridge with approach fills of some 32 ft. height at the west approach and some 24 - 26 ft. height at the east. The grade of Hwy. #403 at the crossing is proposed to be at

elevation 1,013.5 ft. It is assumed that the abutments will be of the spill through type.

Subsoil at the footing locations was observed to be clayey silt with some sand and traces of gravel of very stiff to hard consistency, underlain by sandy silt with some clay and gravel of compact to very dense relative density.

#### 5.2) Structure Foundation:

On account of the very stiff to hard consistency of the surficial deposit, the use of spread footings appear to be feasible and the most economical. Footings may be designed at four feet below existing groundlevel or anywhere below this depth. Based on the minimum average 'N' value, safe design loads of 3.0 TSF are recommended to be used for design purposes on the footing bases. Four ft. cover should be maintained over the bottom of the footings for frost protection.

Perched abutments may also be supported on piles, driven through the approach fills, which should be devoid of bouldery material at the locations of the piles. It is believed that steel tubular piles will be the most practical in these soils, piles being driven to 70 Ton/pile capacity, according to Standard BD - 82 - 7. In estimating pile lengths, it is assumed that on 12 3/4 inch diameter steel tubes 70 Ton/pile design loads will be reached by driving the piles to approximate elevation 935 ft - 940 ft.

Due to the cohesive strength of the clayey silts no dewatering problems are foreseen in the footing excavations. Any seepage which may occur, could be handled by conventional pumping from shallow sumps around the perimeter of the oversized excavations. If the excavations are kept open for some time a lean concrete working slab should be poured at the base to prevent it from softening.

No stability problems will be encountered for the approach fills, provided that they are built with 2 horizontal to 1 vertical slopes.

#### 6. MISCELLANEOUS:

The fieldwork was carried out during the period of May 19 - 26, 1972, under supervision of Mr. L.J. Hodge, Engineering Student.

Equipment used was owned and operated by P.V.K. Drilling Company, Burford, Ontario.

This report was written by Mr. A.K. Barsvary, Senior Foundations Engineer, and reviewed by Mr. K.G. Selby, Supervising Foundations Engineer.



A.K. Barsvary, P. Eng.

*K. G. Selby*

K.G. Selby, P. Eng.

AKB/ht

August 2, 1972

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

 JOB 72-11048 LOCATION Sta. 111 + 19 80' Lt. Ø Hwy. 401  
 W.P. 166-60-0 BORING DATE May 24 & 26, 1972  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger

 ORIGINATED BY LJH  
 COMPILED BY LJH  
 CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %		
							20	40	60	80	100	+ FIELD VANE x LAB. VANE					$w_p$	$w$	$w_L$
990.6	Ground Level																		
0.0	Fine sandy silt, traces of clay and gravel.  Very Stiff		1	SS	26	990											▽  9 15 66 10  0 39 54 7   		

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 112 + 02 85' Lt. Ø Hwy. 407

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 24, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WATER CONTENT % $w_p$ — $w$ — $w_L$				
988.2	Ground Level															
0.0																
						980										
974.3																
13.9	End of Cone Test					970										



20  
15-5 % STRAIN AT FAILURE

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 112 + 38 53' Lt. Ø Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 23, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w <sub>L</sub> PLASTIC LIMIT ——— w <sub>p</sub> WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					SHEAR STRENGTH P.S.F.				
							20	40	60	80	100	+ FIELD VANE × LAB. VANE				
989.3	Ground Level															
0.0	Clayey silt with some sand & traces of gravel.  Very Stiff to Hard.  Grey		1	SS	23	980										3 17 55 25
			2	SS	24											1 11 58 30
			3	SS	43											No water observed
			4	SS	56											
			5	SS	63											
			6	SS	26											
			7	SS	18											
			8	SS	23	960									135	
			9	TW	PH											
			10	SS	48											1 9 50 40
			11	SS	56											
952.8	36.5 Sandy silt to silty sand, some clay and gravel. Hard and Dense to Very Dense		12	SS	27	950										24 37 29 10
			13	SS	115											
940.3			14	SS	100											8 28 45 19
49.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 72-11048      LOCATION Sta. 112 + 08 2' Lt. Ø Hwy. 401      ORIGINATED BY LJH

W.P. 166-60-0      BORING DATE May 25, 1972      COMPILED BY LJH

DATUM Geodetic      BOREHOLE TYPE Hollow Stem Auger & Cone Test      CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— w <sub>L</sub> PLASTIC LIMIT ——— w <sub>P</sub> WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT									
							SHEAR STRENGTH P.S.F.				w <sub>P</sub> ——— w ——— w <sub>L</sub>					
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				WATER CONTENT %					
							1000 2000				10 20 30					
989.0	Ground Level															
0.0	Clayey silt with traces of sand and gravel.  Very Stiff to Hard.  Grey		1	SS	26	980						○		142		
			2	SS	27								○			
			3	SS	27								○			
			4	SS	63								○			
			5	SS	52	970							○		137	1 14 60 25
			6	SS	23								○			
			7	SS	19								○			
			8	TW	PH								○			
			9	SS	31	960							○		6 40 40 14	9 34 43 14
			10	TW	PH								○			
957.0	Sandy silt with seam of clayey silt  some clay, traces of gravel.  Very Stiff to Hard.  Grey		11	SS	31	950						○				
32.0			12	SS	24								○			
			13	SS	104 1/6"								○			
			14	SS	100 1/3"		940						○			
935.0			15	SS	100 1/2"											
54.0	End of Borehole															

FOUNDATION SECTION

ORIGINATED BY LJH

COMPILED BY L J H

CHECKED BY

20  
15- $\phi$ -5 % STRAIN AT FAILURE  
10

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 72-11048 LOCATION Sta. 112 +73 58' Rt. 0 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WATER CONTENT % $w_p$ — $w$ — $w_L$				
988.4	Ground Level															
0.0																
977.7						980										
10.7	End of Cone Test					970										

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 72-11048 LOCATION Sta. 113 + 66 57' Rt. 6 Hwy. 401  
 W.P. 166-60-0 BORING DATE May 19 & 23 - 24, 1972  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger and Cone Test

ORIGINATED BY LJH  
 COMPILED BY LJH  
 CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$		BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT %			
986.7	Ground Level											
0.0	Clayey silt topsoil some black organics.	~ ~ ~	1	SS	20							
980.2		~ ~ ~	2	SS	17							
6.5	Clayey silt with traces of sand and gravel.		3	SS	36							
			4	SS	45							
			5	SS	53							
			6	SS	29							
	Very Stiff to Hard		7	SS	15							
			8	SS	27							
	Brown becoming Grey		9	SS	30							
			10	SS	19							
			11		29							
			12	TW	PH							
944.7												
42.0	Sandy silt with traces of clay & gravel.		13	SS	100/4"							
937.7	Very Dense and Hard		14	SS	134							
49.0	End of Borehole											

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 72-11048 LOCATION Sta. 113 + 13 92' Rt. 0 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19 &amp; 23, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					WATER CONTENT %				
							20	40	60	80	100	$w_p$	$w$	$w_L$		
SHEAR STRENGTH P.S.F.							UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
983.0	Ground Level															
0.0	Clayey silt with some sand and traces of gravel.		1	SS	36	980										
			2	SS	41											
			3	SS	30											
			4	SS	19											
	Hard to Very Stiff		5	SS	18	970										
			6	SS	18											
	Brown becoming Grey		7	SS	21											
			8	SS	25	960										
955.5			9	SS	27											
27.5	Sandy silt with some clay and gravel.		10	SS	31	950										
			11	SS	100/5"											
	Compact to Very Dense		12	SS	100/5"	940										
			13	SS	101/3"											
	Grey															
929.0			14	SS	100/4"	930										
54.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 114 + 04 89' Rt. 0 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT 20 40 60 80 100					SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				
982.1	Ground Level					980										
0.0																
971.5																
10.6	End of Cone Test					970										



## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_c$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma'}$
$c_v$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma'}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

### GENERAL

$\pi$	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

### STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

### SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

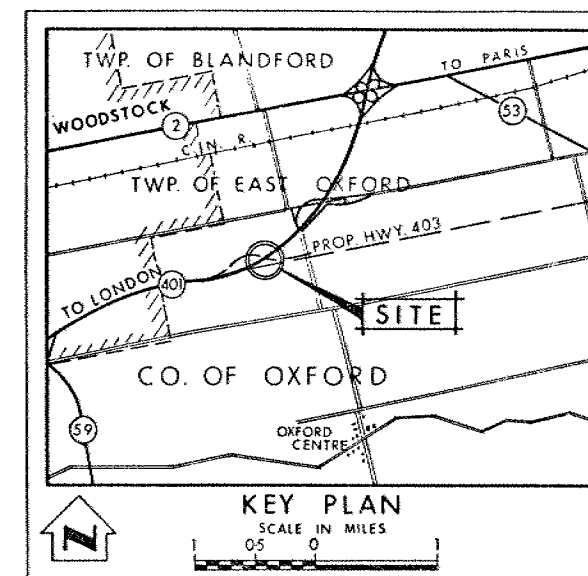
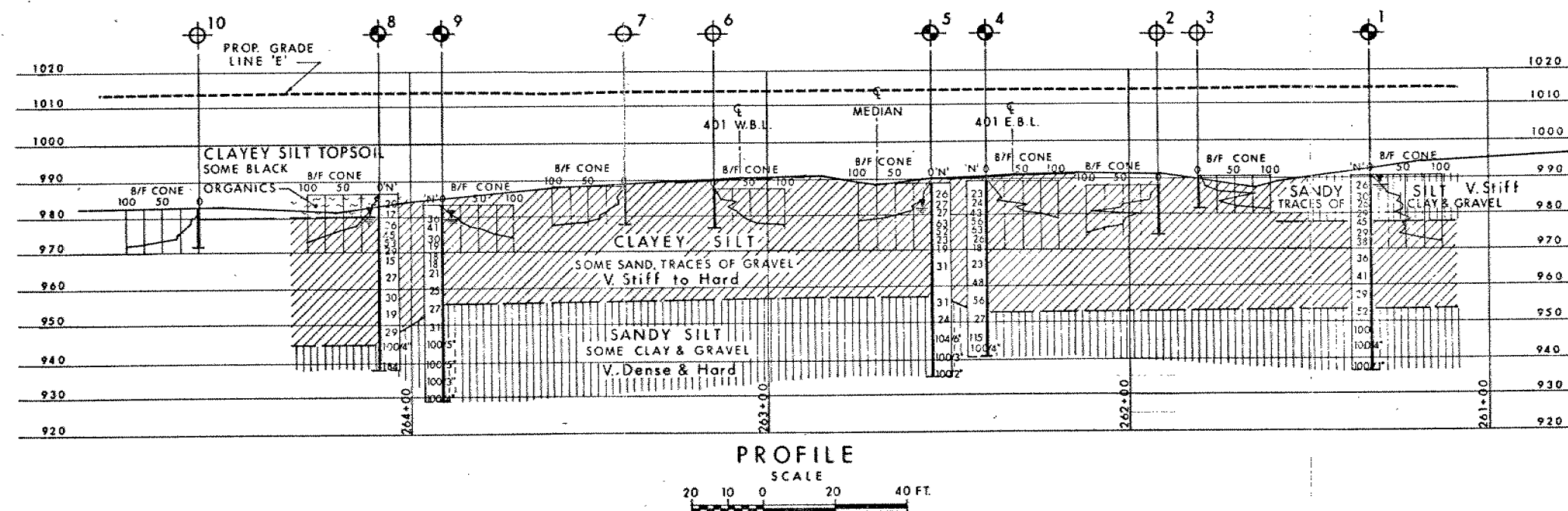
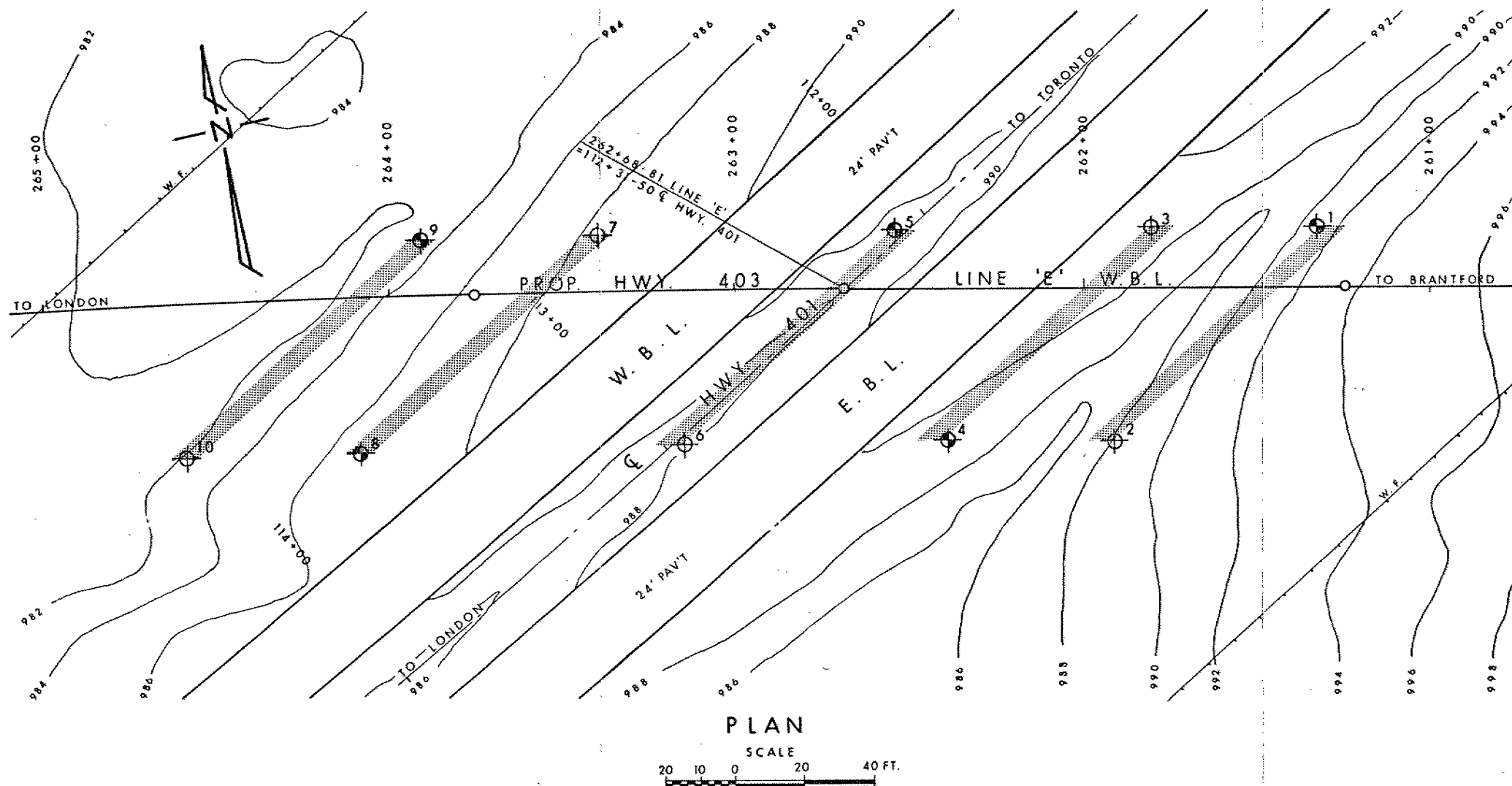
<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, MAY 1972		
	Water Level not established in Borehole No. 4		
NO.	ELEVATION	STATION	OFFSET
1	990.6	111+19	80' LT.
2	988.2	112+02	85' LT.
3	990.4	111+54	47' LT.
4	989.3	112+38	53' LT.
5	989.0	112+08	2' LT.
6	987.5	112+94	2' LT.
7	988.4	112+73	58' RT.
8	986.7	113+66	57' RT.
9	983.0	113+13	92' RT.
10	982.1	114+04	89' RT.

— 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

MINISTRY OF TRANSPORTATION & COMMUNICATIONS  
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

**HIGHWAY NO. 401**

HIGHWAY NO. 403 PROP. LINE 'E' DIST. NO. 4  
CO. OXFORD  
TWP. EAST OXFORD LOT 13 CON. 2

**BORE HOLE LOCATIONS & SOIL STRATA**

SUBMD P.K.	CHECKED <input checked="" type="checkbox"/>	W.P. NO. 166-60-0	DRAWING NO.
DRAWN O.L.J.	CHECKED <input checked="" type="checkbox"/>	JOB NO. 72-11048	<b>72-11048A</b>
DATE 11 AUG. 1972	SITE NO.	BRIDGE DRAWING NO.	
APPROVED <i>[Signature]</i>	CONT. NO.		
PRINCIPAL FOUNDATION ENGINEER			

**ENGINEERING MATERIALS OFFICE**  
**PAVEMENT & FOUNDATION DESIGN SECTION**

WP 166-60-01

DIST 2

HWY 403

STR SITE 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

**DISTRIBUTION**

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Files

# FOUNDATION INVESTIGATION REPORT

For

W.P. 166-60-01, Site 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

Hwy. 403, District 2, London

## INTRODUCTION:

This report summarizes the results of the foundation investigation required for the proposed structure and approach embankments at this site.

The fieldwork was conducted during the period from 82 07 21 - 27 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers.

This work consisted of 5 sampled boreholes/dynamic cone penetration tests.

## SITE DESCRIPTION

The site is located east of Co. Rd. 15 along Hwy. 401 at Woodstock (Lot 13, Con. II, Twp. Norwich, Geog. Twp. (East) Oxford, County of Oxford).

Physiographically, the site is located in the Oxford Till Plain.

## SUBSURFACE CONDITIONS

### General

The Record of Borehole Sheets (Appendix) illustrate the conditions at the borehole locations. The location and elevations of the boreholes, and a stratigraphical profile based on the borehole data are shown on Drawing No. 1666001-A.

The overburden at this site is composed of till. A predominantly cohesive silty clay till overlies a predominantly non-cohesive sandy silt to silty sand till. The boundary between these two general soil types dips gradually towards the south (from elev. 290.1 m at BH #1 to elev. 284.7 m at BH #5).

Silty Clay (CL), Some Sand, Trace Gravel

This firm to hard till material extends from the surface for depths ranging from 10.1 m at BH #1 to 21.3 m at BH #5. The deposit is generally silty clay of low plasticity containing some sand and traces of gravel. The sand content generally increases with depth especially at BH #1, #2 and #3. Occasional layers of dense silty sand were encountered within this deposit at BH #1 and BH #4, generally between elev. 300 and elev. 298.

Physical properties of the cohesive portion of this material, as determined from field and laboratory tests, are summarized below:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Water Content (w) %	8.0-14.5%	11.3%	N/A
Liquid Limit (W <sub>L</sub> ) %	14.0-26.0%	20.0%	N/A
Plastic Limit (W <sub>p</sub> ) %	11.0-15.0%	13.0%	N/A

Generally the material did not fail during field vane shear testing, indicating undisturbed shear strengths in excess of 107 kPa. A field vane shear strength value of 34.5 kPa, obtained near elev. 298 m at BH #3, was considered to be non-representative of the general deposit. Shear strength values from unconfined compression tests of similar material in the immediate vicinity of this site led to the selection of 150 kPa as the average shear strength for the silty clay till deposit.

Figure 1 illustrates a typical grain size distribution for the cohesive portion of this deposit.

Sandy Silt to Silty Sand, Some Gravel, Trace Clay

This very dense till deposit underlies the silty clay till across the entire site. As indicated in Drawing No. 1666001-A, occasional layers of cohesive silty clay were encountered between elev. 286 m and elev. 282 m at BH #1 and BH #3. Occasional boulders were encountered while augering within this deposit. The natural water content of the non-cohesive portion of this deposit ranged from 6.0 - 10.5%.

Figure 2 illustrates a typical grain size distribution for the non-cohesive portion of this deposit.

#### Groundwater

The groundwater elevation was estimated at 298 m. This estimate was based on field observations, data from previous foundation investigations in the immediate vicinity, and well records.

## DISCUSSION AND RECOMMENDATIONS

A grade separation is proposed so that the west-bound lanes of Hwy. 403 will overpass Hwy. 401. In order to establish the proposed profile grade of Hwy. 403, approach fills up to 10± m high will be required. A four-span structure is proposed.

### General Recommendations (Applicable To All Alternatives)

- No stability problems are anticipated for the proposed embankment heights with slopes of 2:1 or flatter.
- Total settlements under the embankments will be less than 75 mm, 50% of which should occur during construction. Total settlement for the recommended footing foundation alternatives will be less than 25 mm. The resulting differential settlements will be less than 25 mm. The structure should be designed to accommodate the anticipated settlements.
- Earth pressure acting on abutments and retaining walls should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation with  $k_a = 0.33$  for granular backfill
- For frost protection, cover should be greater than 1.2 m
- Dewatering is not anticipated to be a major problem because of the impermeable nature of the foundation soil

### Foundation Alternatives

The foundation alternative which leads to the least expensive design should be adopted.

#### Alternative 1 - Spread Footings on Silty Clay

The entire structure may be supported on spread footings founded at or below the following elevations:



<u>Station (Hwy. 403 Chainage)</u>	<u>Elevation</u>
Station 11 + 257	297.6
Station 11 + 278	298.6
Station 11 + 320	297.5
Station 11 + 354	300.1
Station 11 + 371	302.0

For resistance to lateral forces, the adhesion between the base of the footings and the foundation soil = 60 kPa.

Cover the foundation soil with a 15 cm pad of mass concrete within 18 hours of exposure.

The following design values are recommended:

- net safe bearing pressure = 300 kPa

and for purposes of the O.H.B.D.C.:

- Factored Bearing Capacity at U.L.S. = 450 kPa
- Bearing Capacity at S.L.S. Type II = 300 kPa

#### Alternative 2 - Perched Footings on Compacted Fill

The abutments may be supported on perched abutments on compacted granular fill. Refer to the enclosed Figure 2 for design details.

All loose or soft material beneath the approach embankment in the vicinity of the abutment locations should be removed.

For computing sliding resistance between the base of the concrete footing and the compacted fill, the friction coefficient = 0.6.

The following design values are recommended:

- net safe bearing capacity = 340 kPa

and for purposes of the O.H.B.D.C.:

- Factored Bearing Capacity at U.L.S. = 600 kPa
- Bearing Capacity at S.L.S. Type II = 340 kPa

Alternative 3 - Steel H-Piles in Overburden

The entire structure may be supported on Steel H-Piles equipped with reinforced tips and driven in accordance with M.T.C. Standards SS103-10 or SS103-11. For calculation purposes the following values are recommended:

<u>Pile Type</u>	<u>Ultimate Capacity</u>
310 HP 110	3000 kN
310 HP 79	2150 kN

For estimation purposes, it may be assumed that the recommended pile capacities will be achieved at the following elevations:

<u>Station (Hwy. 403 Chainage)</u>	<u>Elevation</u>
Station 11 + 257	287
Station 11 + 278	285
Station 11 + 320	285
Station 11 + 354	283
Station 11 + 371	281

If desired, the abutment footings (supported on Steel H-Piles) may be perched within the embankment fill. In this case, to facilitate pile driving, particle sizes in the fill immediately beneath the pile locations should not exceed 75 mm.

The following design values are recommended:

<u>Pile Type</u>	<u>Safe Capacity</u>
310 HP 110	1000 kN
310 HP 79	720 kN

and for the purposes of the O.H.B.D.C.:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type</u>
310 HP 110	1350 kN	1000 kN
310 HP 79	970 kN	720 kN

#### Alternative 4 - Combination of Previous Alternatives

If desired, the previous alternatives may be combined so that different alternatives are employed at different footing locations.

For example, the centre pier footing may be supported on Steel H-piles while the abutment footings are perched on compacted granular fill.

#### MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Mr. B. Yiu (student field technician). The report was written by Mr. D. H. Dundas, Project Foundations Engineer, and reviewed by Mr. K. G. Selby, Senior Foundations Engineer. The equipment used was owned and operated by Atcost Soil Drilling Inc.



*D. H. Dundas*

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

*K. G. Selby*

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

## A P P E N D I X

# RECORD OF BOREHOLE No 1

METRIC

W P 166-60-01 LOCATION Sta. 11 + 257 & W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 22 CHECKED BY DD

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					
300.2	Ground Surface															
0.0	occ. layers of Silty Sand, Compact	Δ	1	SS	16	**										5 42 43 10
		Δ	2	SS	17											9 40 37 14
	Silty Clay (CL)	Δ	3	SS	29											
	Some Sand	Δ	4	SS	24											
	Trace Gravel	Δ	5	SS	11											
	Stiff to Very Stiff (Till)	Δ	6	SS	10											
	with Sand	Δ	7	SS	20											
		Δ	8	SS	18											5 43 38 14
290.1	Sandy Silt to Silty Sand	Δ	9	SS	100/	24 cm										19 37 37 7
	Some Gravel	Δ	10	SS	100/	22 cm										15 37 42 6
	Trace Clay	Δ	11	SS	100/	22 cm										
	Very Dense (Till)	Δ	12	SS	100/	18 cm										
	occ. layers of Silty Clay (CL) Hard	Δ	13	SS	100/	24 cm										
281.9		Δ	14	SS	100/	19 cm										
18.3	End of Borehole															*Cu > 107kPa
	** Stabilized ground water level estimated from well records															

# RECORD OF BOREHOLE No 2

METRIC

W P 166-60-01 LOCATION Sta. 11 + 278 & W.B.L. ORIGINATED BY HY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DP  
DATUM Geodetic DATE 82 07 23 CHECKED BY DP

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					
300.7	Ground Surface																
0.0	Silty Clay (CL)																
	Some Sand		1	SS	13												
	Trace Gravel		2	SS	18												
	Stiff to Hard		3	SS	33												
	(Till)		4	SS	34												
			5	SS	29												
			6	SS	10												
			7	SS	20												
	with Sand		8	SS	15												
			9	SS	16												
289.1																	
11.6	Sandy Silt to Silty Sand, Some Gravel		10	SS	1007	18 cm											
	Trace Clay																
	Very Dense (Till)		11	SS	1007	17 cm											
286.7																	
14.0	End of Borehole																
	** Stabilized ground water level estimated from well records																*C <sub>u</sub> > 107kPa

+3, x<sup>5</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL BAWLOCATION

# RECORD OF BOREHOLE No 3

METRIC

W P 166-60-01 LOCATION Sta. 11 + 320 ± W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 21 CHECKED BY DD

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						20 40 60 80 100	10 20 30				
302.1	Ground Surface												GR SA SI CL						
0.0	Silty Clay (CL) Some Sand Trace Gravel Firm to Hard (Till)	A	1	SS	16	** ↓					4 11 55 30								
		A	2	SS	18														
		A	3	SS	15														
		A	4	SS	5														
		A	5	SS	22														
		A	6	SS	24														
		A	7	SS	17														
		A	8	SS	20														
		A	9	SS	21														
		A	10	SS	12														
289.0	with Sand	A																	
13.1	Sandy Silt to Silty Sand Some Gravel Trace Clay Very Dense (Till)  occ. layers of Silty Clay (CL) Hard	A	11	SS	100/	15 cm	288 286 284 282	20 40 60 80 100	10 20 30			27 33 36 4							
		A	12	SS	100														
		A																	
		A	13	SS	100														
280.3		A	14	SS	100														
21.8	End of Borehole  ** Stabilized ground water level estimated from well records												*Cu > 107kPa						

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



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Communications

# RECORD OF BOREHOLE No 4

METRIC

W P 166-60-01

LOCATION Sta. 11 + 354 @ W.B.L.

ORIGINATED BY BY

DIST 2 HWY 403/401

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY DD

DATUM Geodetic

DATE 82 07 27

CHECKED BY DD

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	W' VALUES			20	40	60	80						100	SHEAR STRENGTH kPa			WATER CONTENT (%)			
											○ UNCONFINED	+ FIELD VANE	○ QUICK TRIAXIAL	x LAB VANE	20	40	60	80	100	10	20	30		
301.9	Ground Surface																							
0.0																								
			1	SS	31																			
			2	SS	29																			
	occ. layers of Silty Sand, Compact		3	SS	19																			
			4	SS	15																			
	Silty Clay (CL)																							
	Some Sand		5	SS	21																			
	Trace Gravel																							
	Stiff to Hard (Till)		6	SS	26																			
			7	SS	29																			
			8	SS	36																			
			9	SS	47																			
			10	SS	32																			
288.0			11	SS	57																			
13.9	Sandy Silt to Silty Sand																							
	Some Gravel		12	SS	100																			4 30 56 10
	Trace Clay																							
	Very Dense (Till)																							9 43 42 6
284.7			13	SS	100																			
17.2	End of Borehole																							*C <sub>u</sub> > 107kPa
	** Stabilized ground water level estimated from well records																							

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



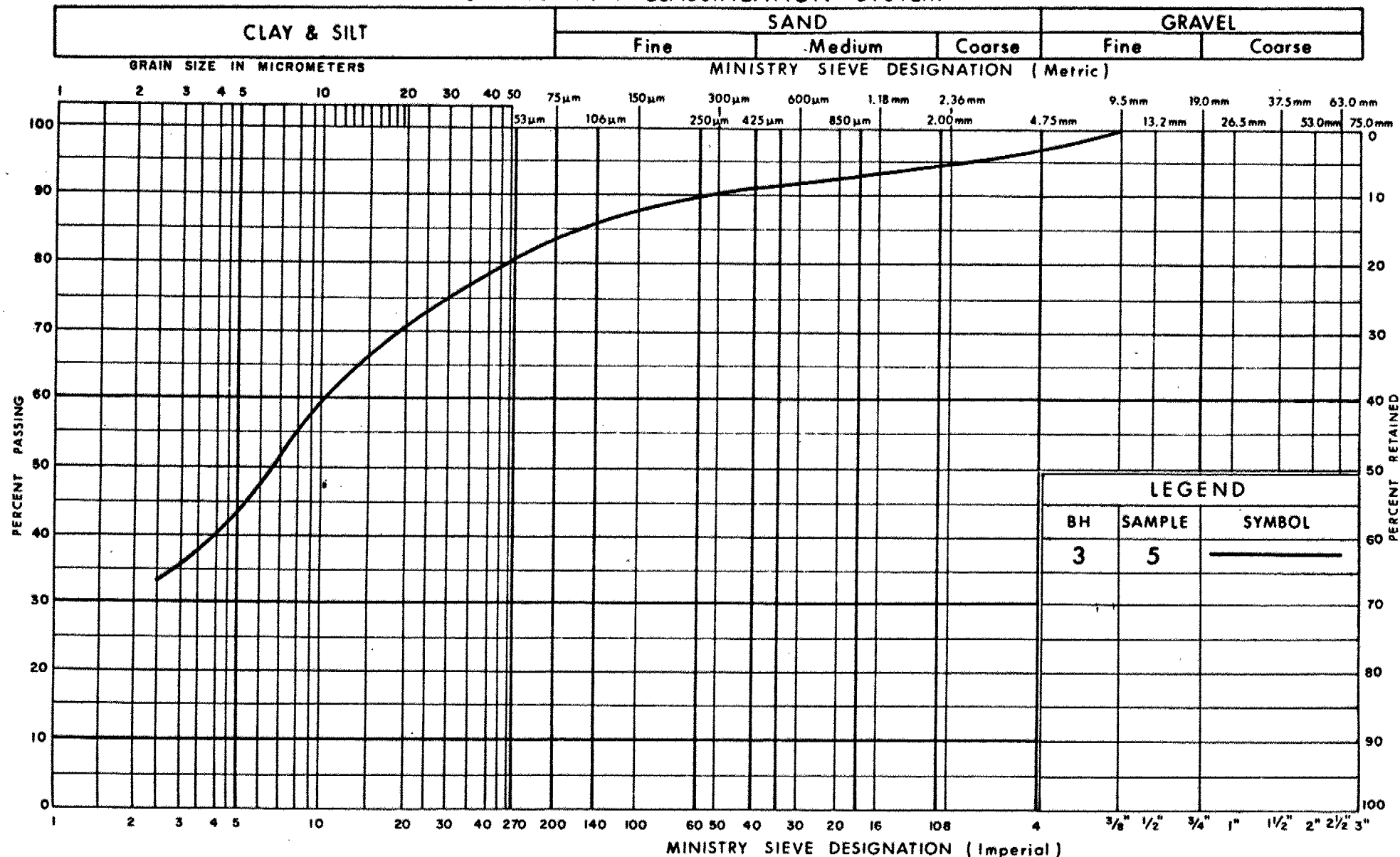
# RECORD OF BOREHOLE No 5

METRIC

W P 166-60-01 LOCATION Sta. 11 + 375, 5.0 m Rt. of W.B.L. ORIGINATED BY BY  
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD  
DATUM Geodetic DATE 82 07 23-26 CHECKED BY DD

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					
306.0	Ground Surface												
0.0	Silty Clay (CL) Some Sand Trace Gravel Stiff to Hard (Till)		1	SS	29								
			2	SS	37								
			3	SS	29								
			4	SS	15								
			5	SS	19								
			6	SS	17								
			7	SS	17								
			8	SS	27								
			9	SS	19								
			10	SS	25								
			11	SS	27								
			12	SS	29								
			13	SS	31								
284.7			14	SS	100	20 cm							
21.3	Sandy Silt to Silty Sand Some Gravel, Trace Clay Very Dense (Till)		15	SS	100	28 cm							
282.5	Probable Boulder Refusal to Auger End of Borehole  ** Stabilized ground water level estimated from well records												*Cu > 107 kPa

## UNIFIED SOIL CLASSIFICATION SYSTEM



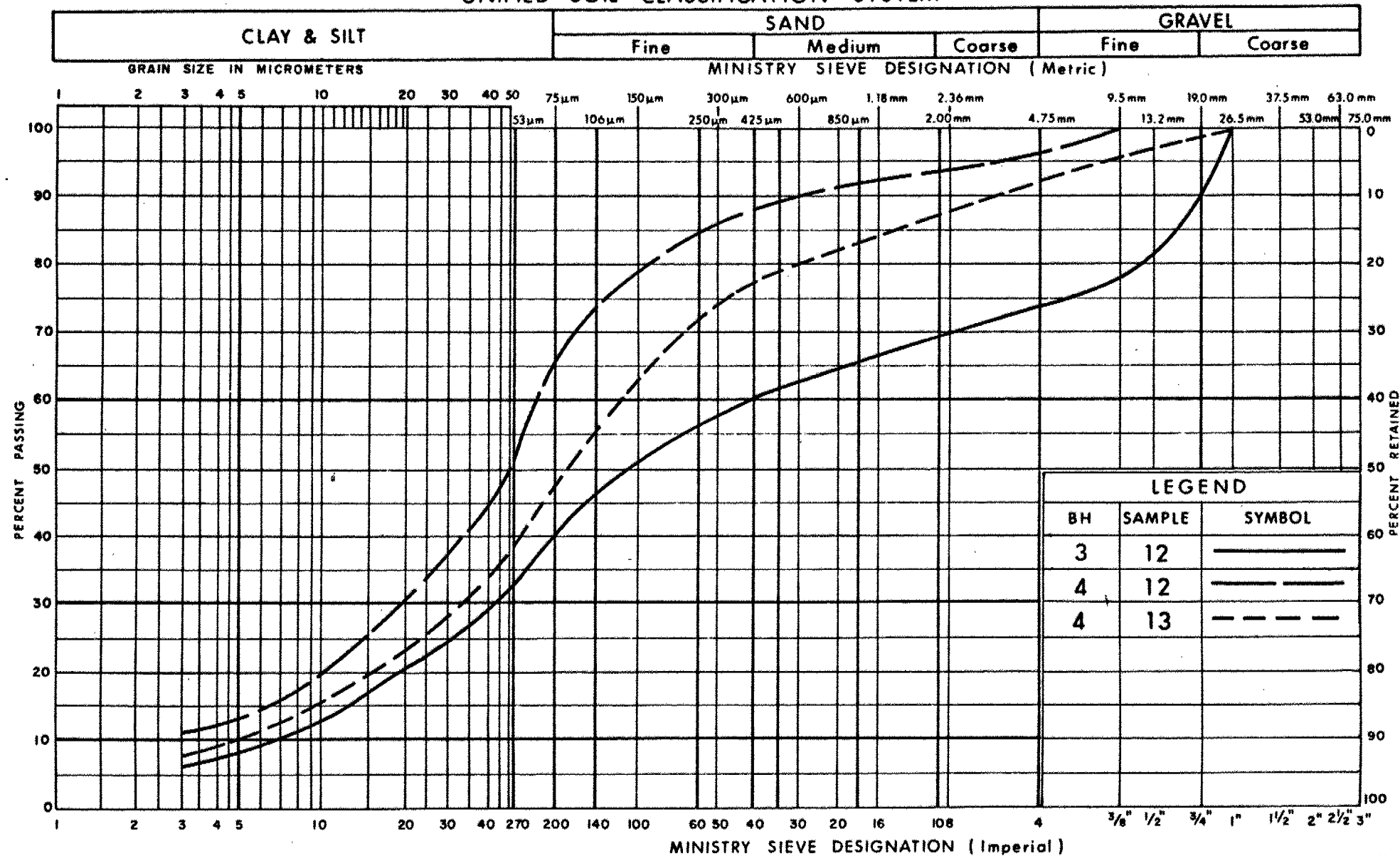
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GRAIN SIZE DISTRIBUTION  
SILTY CLAY (Till)  
SOME SAND TRACE GRAVEL

FIG No 1

W P 166-60-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



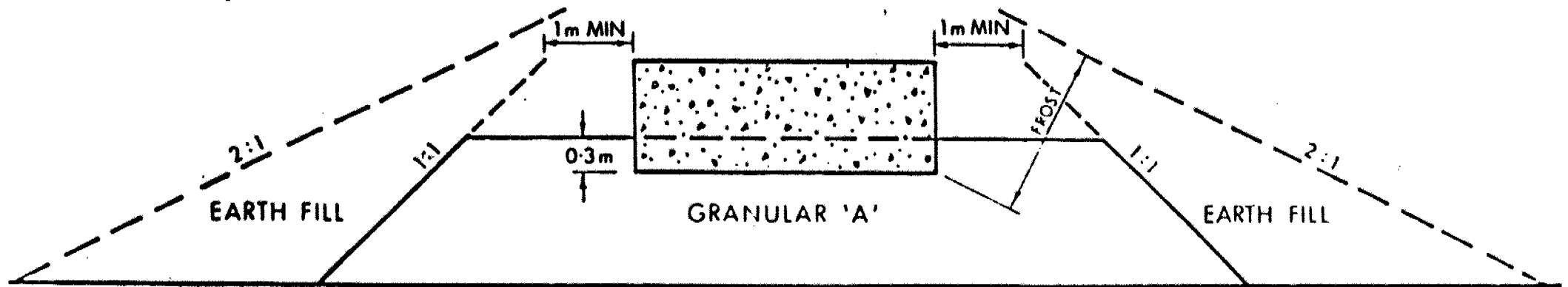
Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**SANDY SILT TO SILTY SAND**  
**SOME GRAVEL TRACE CLAY**

FIG No 2

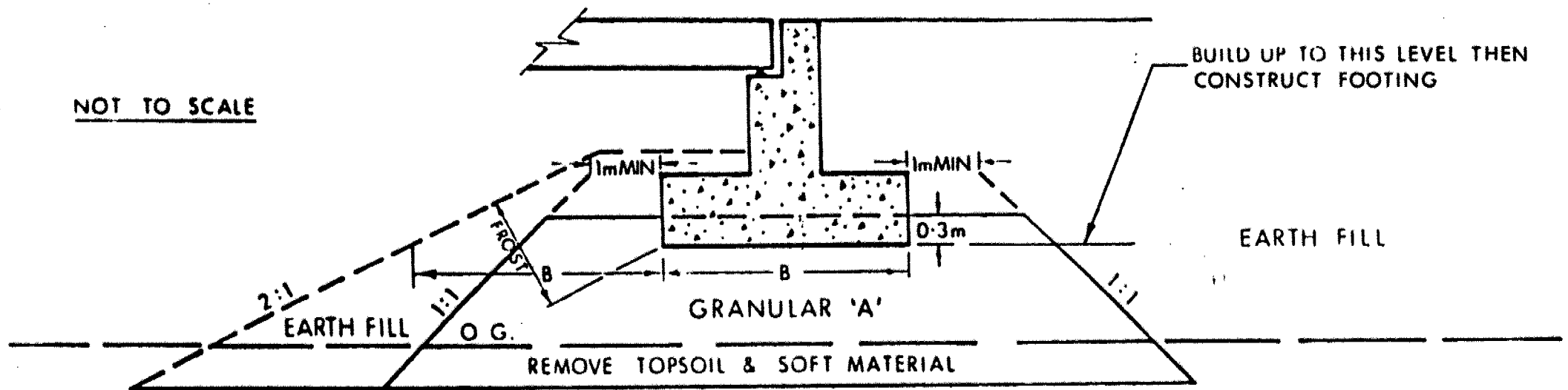
W P 166-60-01

# ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



X SECTION

NOT TO SCALE



LONGITUDINAL SECTION

## NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.C. STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED

## 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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	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

$m_v$	$kPa^{-1}$	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
$\sigma'_{v0}$	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

$\rho_s$	$kg/m^3$	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	$kn/m^2$	SEEPAGE FORCE
$\gamma'$	$kn/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

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

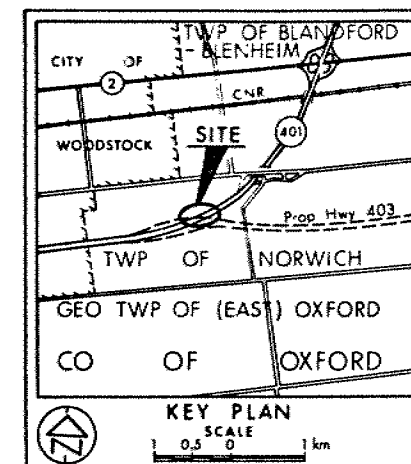
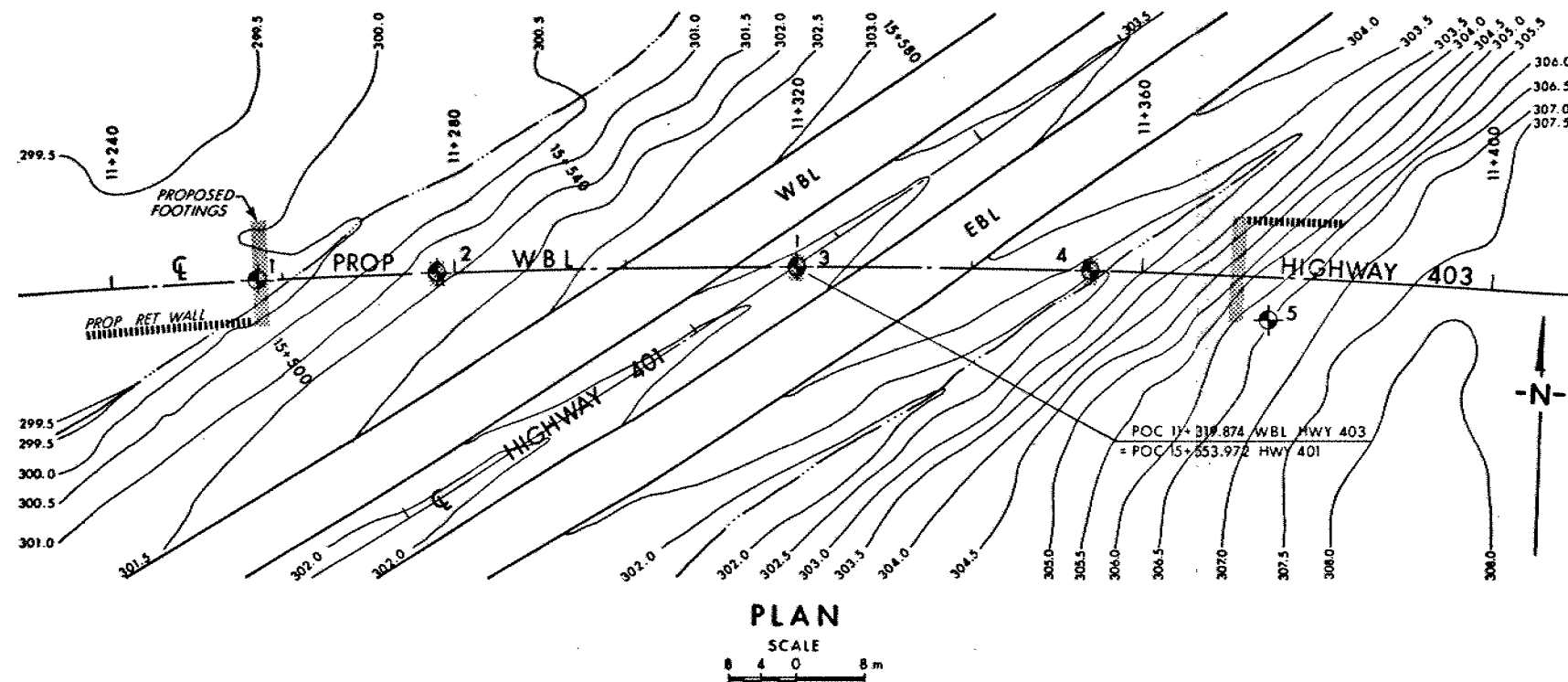
CONT No  
WP No 166-60-01



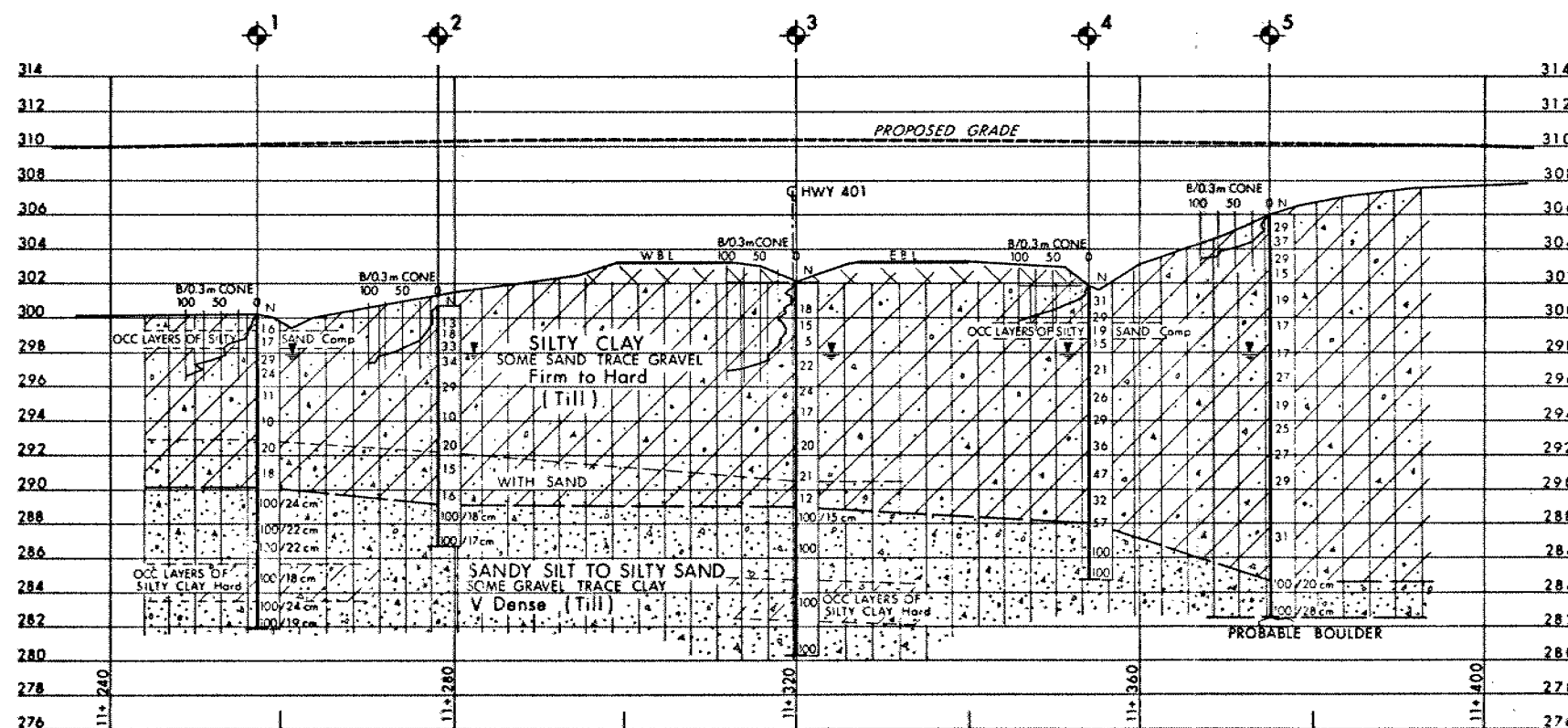
HWY 401 INTERCH O'PASS

SHEET

BORE HOLE LOCATIONS & SOIL STRATA



- 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 82.07  
NOTE: Stabilized Ground Water Level  
Estimated from Well Records



No	ELEVATION	STATION	OFFSET
1	300.2	11+257	CL
2	300.7	11+278	CL
3	302.1	11+320	CL
4	301.9	11+354	CL
5	306.0	11+375	5 m RT

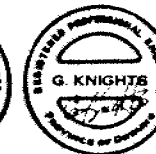
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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.

REV.	DATE	BY	DESCRIPTION

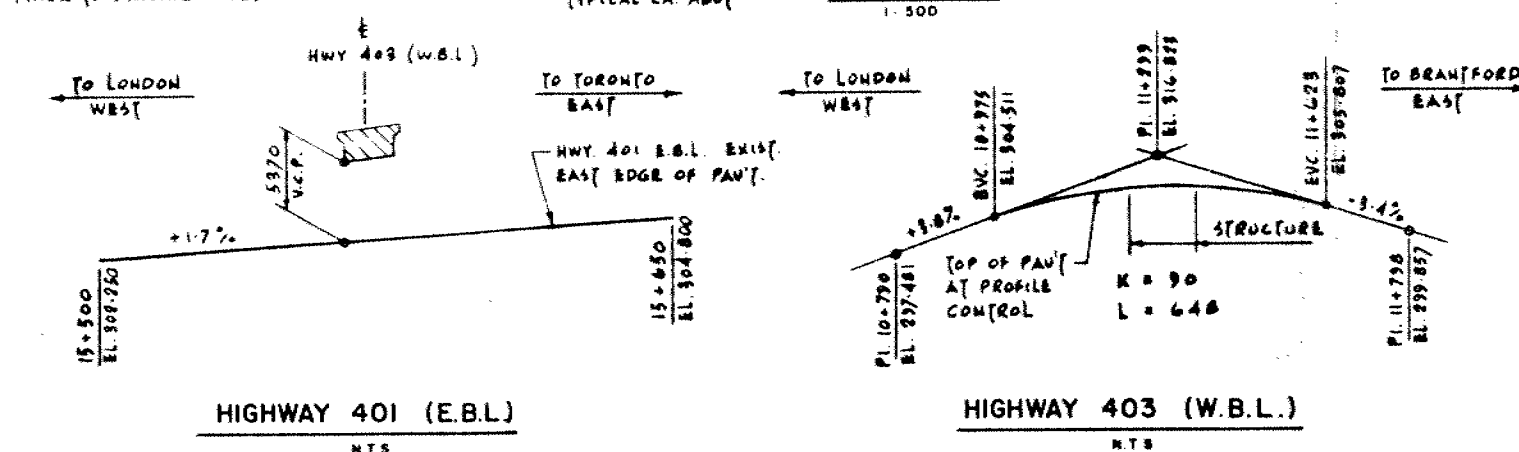
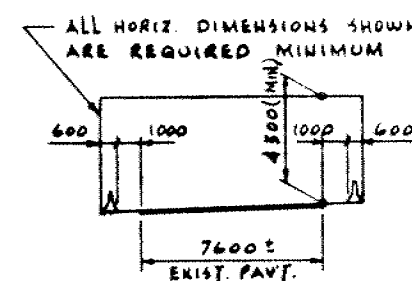
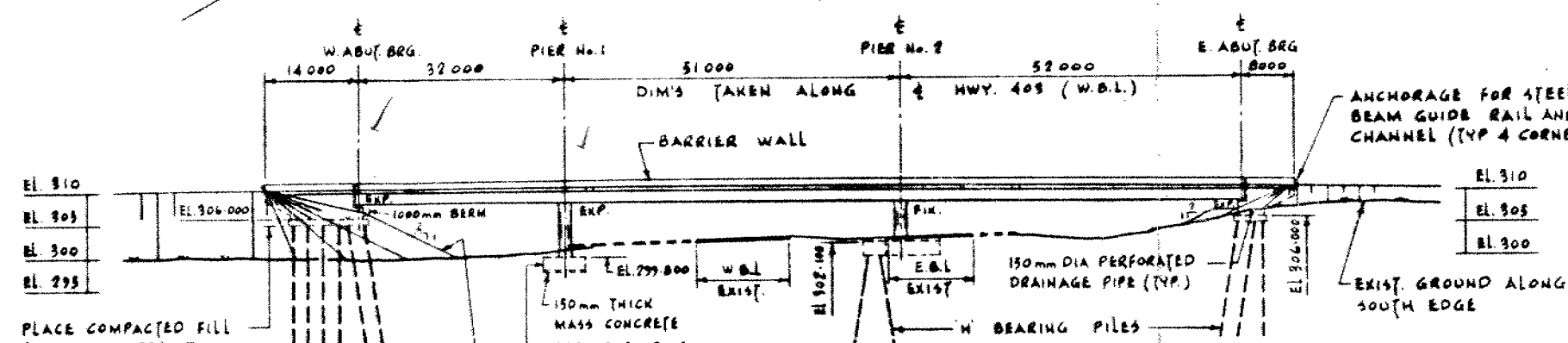
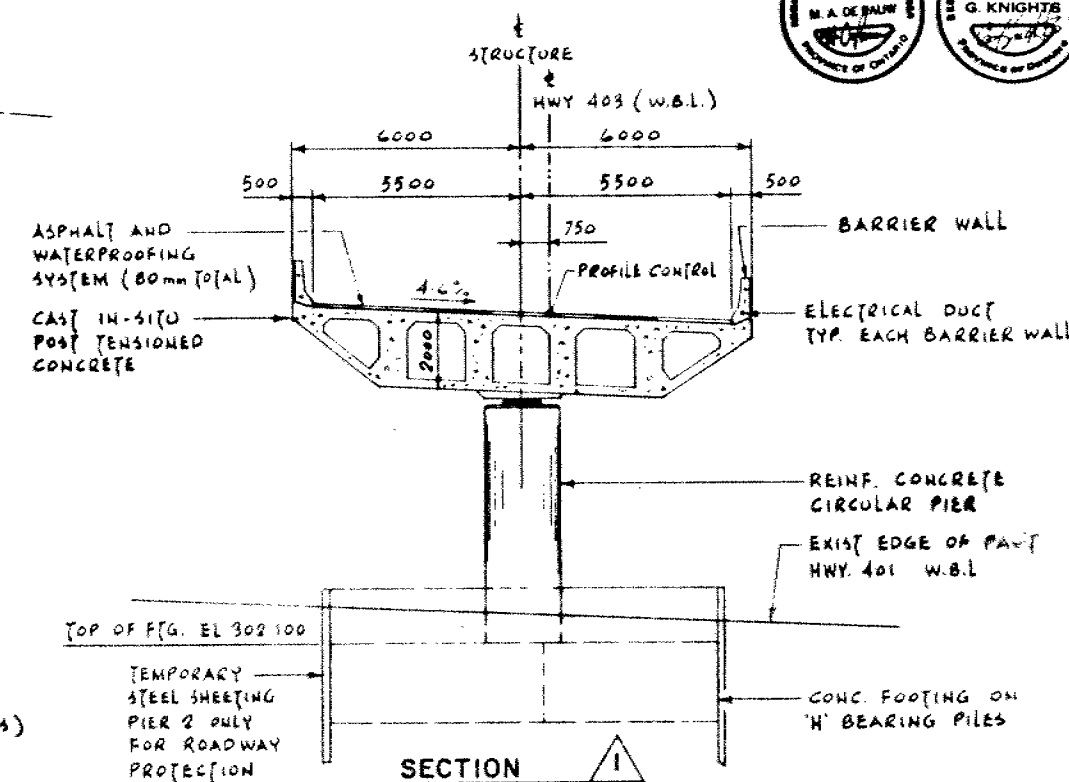
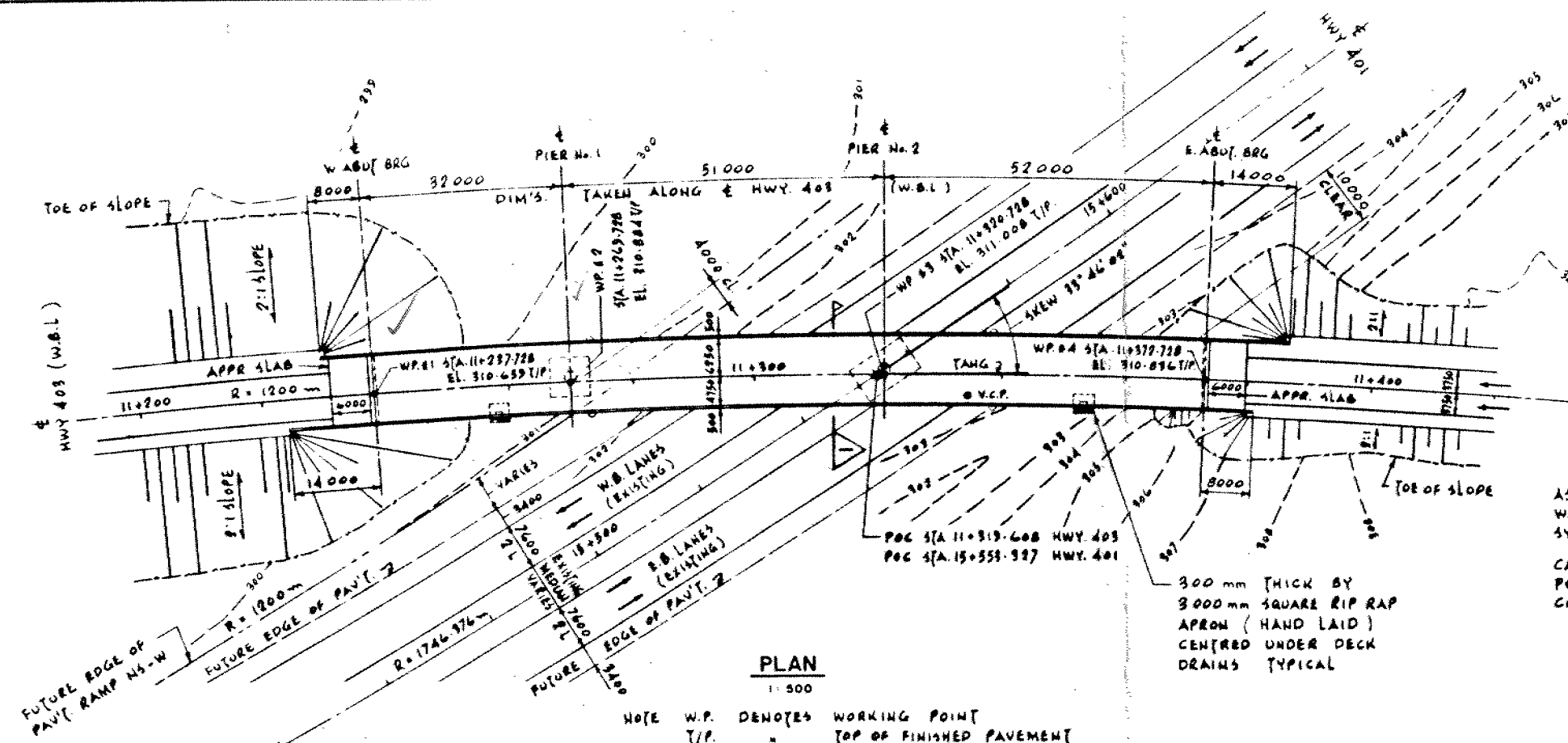
Geocres No 40P2-40

HWY No 403 WBL		DIST 2
SUBM'D DD CHECKED	DATE 82 11 12	SITE 23-89-311
DRAWN SO CHECKED	APPROVED	DWG 1666001-A



**METRIC**

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



## LIST OF DRAWINGS

- 1 GENERAL ARRANGEMENT
- 2 BOREHOLE LOCATION & SOIL STRATA
- 3 FOUNDATION LAYOUT
- 4 FOUNDATION REINFORCEMENT
- 5 WEST ABUTMENT LAYOUT
- 6 WEST ABUTMENT REINFORCEMENT
- 7 EAST ABUTMENT LAYOUT
- 8 EAST ABUTMENT REINFORCEMENT
- 9 PIERS AND BEARINGS
- 10 DECK LAYOUT & SCREED ELEVATIONS
- 11 LONGITUDINAL CABLE DETAILS I
- 12 LONGITUDINAL CABLE DETAILS II
- 13 TRANSVERSE CABLES I
- 14 TRANSVERSE CABLES II
- 15 DECK REINFORCEMENT I
- 16 DECK REINFORCEMENT II
- 17 DECK REINFORCEMENT III
- 18 EXPANSION JOINTS
- 19 BARRIER WALL
- 20 APPROACH SLABS
- 21 DETAILS OF CONC. SLOPE PAVING
- 22 STANDARD DETAILS
- 23 EMBEDDED ELECTRICAL I
- 24 EMBEDDED ELECTRICAL II
- 25 PILE DRIVING
- 26 BRIDGE DATE AND SITE NO
- 27 AS CONSTRUCTED ELEVATIONS  
AND DIMENSIONS
- 28 QUANTITIES - STRUCTURE
- 29 QUANTITIES - STRUCTURE

## GENERAL NOTES

CLASS OF CONCRETE	
PIERS, DECK	35 MPa
BARRIER WALLS, ABUTMENTS	30 MPa
REMAINDER	20 MPa

CLEAR COVER TO REINFORCING STEEL			
FOOTINGS			100 ± 25
PIERS			80 ± 20
ABUTMENTS AND RETAINING WALLS	FF	80 ± 20	
	BF	70 ± 20	
DECK TOP SLAB		70 ± 20	
		40 ± 10	
BOT SLAB & WEBS		40 ± 10	

REMAINDER 70± 20 OR AS SHOWN  
ON STANDARD DRAWINGS  
GRADE OF REINFORCING STEEL

GRADE OF REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400  
REINFORCING BARS MARKED WITH THE SUFFIX "C"  
SHALL BE EPOXY COATED.

CONSTRUCTION NOTES

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF  $\pm 3$ mm.

NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED, STRESSED AND GROUTED.

REVISIONS				
	DATE	BY	DESCRIPTION	
	DESIGN M D P	CHECK GK	LOADING OHBDC-R79	DATE FEB 1986
	DRAWING LTL	CHECK GK	SITE 23-89-311	DWG



