

G.I.-30 SEPT. 1976

GEOCRES No. 30M4-58

DIST. 4 REGION

W.P. No. 55-75-08

CONT. No.

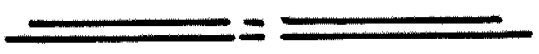
W. O. No.

STR. SITE No. 9-128

HWY. No. 6N

LOCATION CNR SUBWAY ON HAGERSVILLE  
SUBDIVISION, 1.6 MILES South of GRAND RIVER

No of PAGES - —



OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION & DESIGN REPORT

W.P. 55-75-08

DIST. 4

HWY. 6N

STR. SITE 9-128

C.N.R. Subway on Hagersville  
Subdivision, 1.6 Miles South of Grand River

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GEOCREs

30M4-58
GEOCREs No.

DATE

FEB 17 1977

## INTRODUCTION

A foundation investigation was carried out at the intersection of the future Hwy. 6N and C.N.R. tracks to determine the subsurface conditions. This report contains the results of this investigation and the interpreted soil data. The recommendations for the design and construction of the proposed subway foundations and approaches are also included in this report.

The investigation was requested by Mr. G.C.E. Burkhardt, Structural Planning Engineer, Central Region, in a memorandum dated October 12, 1976.

## SITE DESCRIPTION

The site is located some 1000 feet south of the crossing of 6th Line Road and CNR along the railway tracks in the vicinity of Caledonia. The terrain adjacent to the proposed structure site is flat to gently rolling. The land is being used for crop growing purposes. A hydro transmission line tower is located some 60 feet west of the tracks along the future Hwy. 6N median.

Physiographically, the area lies in the Region referred to as the Haldimand Clay Plain. This region in most part is covered by a somewhat irregular intermixture of stratified clay and till. 'Near Caledonia an odd variation is provided by a scattered group of drumlins partially buried in moderately dissected clay beds.'

## FIELD INVESTIGATION

A total of 6 sampled boreholes and 9 dynamic cone penetration tests were carried out during the course of the fieldwork. The borings were advanced by means of Muskeg vehicle mounted flight auger machines using hollow stem augers. During the fieldwork, disturbed samples were obtained by means of a standard split-spoon sampler; the energy used in driving it conformed to the requirements of the Standard Penetration Test.

'Undisturbed' samples were recovered using 2 inch I.D. shelly tubes which were pushed into the soil by hand. Where possible, in situ vane tests were carried out within the cohesive portion of the subsoil.

Dynamic cone penetration tests were carried out adjacent to 5 boreholes and also at 4 other locations. Driving energy to advance the cone was 350 foot/lbs. per blow.

The bedrock was proved at three borehole locations using BXL rock coring equipment.

The groundwater level was determined by recording the water level in the open boreholes during the course of the field investigation.

In addition, Geonor type Piezometers were also installed and were read periodically after the completion of the fieldwork.

The locations and elevations of the borings were surveyed in the field by personnel from the Central Region, Engineering Plans Office.

### SUBSURFACE CONDITIONS

#### General

The subsoil at the site consists of about three different types of deposits. From ground level downward an approximate 38-44 ft. thick stratum of stiff to very stiff, stratified silty clay to clayey silt, trace of sand, is underlain by a compact to very dense glacial till (heterogeneous mixture of gravel, sand, silt and clay) deposit, which in turn is followed by dolomite bedrock at approximate elevation 601-604.

The boundaries of the different deposits are shown on the Record of Borehole Sheets contained in the Appendix, together with descriptions of the soil types. The estimated stratigraphical profile shown on Dwg. 557508-A is based upon this information.

The different deposits as encountered in sequence are described as follows:

#### Silty Clay to Clayey Silt, Trace of Sand (Stratified)

This deposit was encountered at each borehole location immediately from ground level to a maximum depth of 44 feet (B.H. #5), the minimum thickness occurs in B.H. #1 (38.5'). The material in the stratum consists mainly of irregular layers (up to 4") and zones of clayey silt and silty clay, traces of sand. In addition, occasional fissures and silt seams are also present.

Physical properties of the overall deposit, as determined from laboratory tests are as follows:

	<u>Range</u>	<u>Average</u>
Natural Moisture Content (%)	18-34	28.2
Liquid Limit (%)	25-51	34.3
Plastic Limit (%)	14-22	17.8
Bulk Density (PCF)	115-132	122.2

Grain size distribution curves are included on Fig. 1 of the Appendix.

The undrained shear strength of the material with some random variations, decreases with depth being in the excess of 3000 PSF in the upper region (above elev. 660±). At or about elevation 640± the undrained shear strength reaches a minimum value of about 1670 PSF, then increases again with depth to approximate 2500 PSF at the lower boundary.

Laboratory and field tests gave the following undrained shear strength values: (see also Fig. 2)

	<u>Range</u>
Unconfined Compression Test (PSF)	1670-3760
Quick Triaxial Test (PSF)	1210-2870
Field Vane Test (PSF)	1440-over 2000
Sensitivity	2.6-3.6

The consistency of the overall deposit may be described as stiff to very stiff.

In order to provide information for stability analyses for the longterm case, laboratory tests were performed to determine effective stress parameters  $C'$  and  $\phi'$ . The results are as follows:

$$c' = 458 \text{ PSF}$$

$$\phi' = 25^\circ$$

The results of consolidation tests carried out on selected samples indicate that the preconsolidation pressure of the deposit is approximately  $5.0 \pm \text{TSF}$ .

### Heterogeneous Mixture of Gravel, Sand, Silt and Clay (Glacial Till)

Underlying the clayey silt to silty clay deposit across the site is a glacial till stratum down to elev. 600 to elev. 604, which levels are assumed to be the upper surface of bedrock.

The material in the deposit was found to consist of a heterogeneous mixture of gravel (35%), sand (42%), silt (18%) and clay (5%). These above quoted average percentage grain sizes differ a great deal from the percentages obtained for an individual sample. The following percentage ranges were encountered:

Gravel	18-58%
Sand	25-68%
Silt	5-39%
Clay	1-12%

This type of varied grain size distribution indicates that the deposit is glacial in origin. Laboratory tests on samples indicate the natural moisture content of the overall deposit ranges from 6 to 10%.

The Standard Penetration Tests 'N' values in this deposit range randomly between 11 and 72 blows per foot. Based on the obtained 'N' values, the relative density of the deposit may be classified as compact to very dense, being generally dense.

### Dolomite Bedrock

Dolomite bedrock with gypsum inclusions was encountered in boreholes #1, #6 and #9 immediately below the glacial till deposit, at depths ranging from 65 to 67 feet below the ground surface. The bedrock surface across the site varies randomly between elev. 600± and elev. 604±. Core recoveries were generally in excess of 80%. The cores were examined by Ms. Z. Koniuszy, M.T.C. geologist, and the report is included in the Appendix.

### Groundwater Conditions

Groundwater level observations were carried out during the field investigation in the open boreholes. The following water levels were encountered:

B.H. #1	Elev. 642
#4	Not established
#5	Elev. 642
#6	Elev. 641
#8	Elev. 640
#9	Elev. 638

Two geonor type piezometers were installed during the fieldwork, the tips being at depths 10.5' and 27' below ground level (elev. 656.7 and 640.0 respectively).

The piezometric water levels in about 10 days time (after installation) dropped to elevation 664 and elevation 655. The latest readings (85 days after installation) indicate that the corresponding levels are at elevation 661 and elevation 655. Based on this information it can be concluded that a stabilized condition was reached in the case of the second (deep) piezometer. Only minor fluctuations (0.5 feet) were observed during this period.

A plot of piezometric head versus elevation is shown on Fig. 4 of the Appendix.

### DISCUSSION AND RECOMMENDATIONS

#### General

It is proposed to construct a new 4 lane controlled access highway (Hwy. #6N) within a utility corridor from just north of Caledonia to Nanticoke. This will require grade separations at crossings of other major roads and railways. As part of this project, a 4 span (45'-70'-70'-45') subway structure is proposed at the crossing of Hwy. 6N and C.N.R. (Hagersville Subdivision). At the present time the proposal calls for the construction of the future northbound lane only. Details of the proposed scheme are provided on Plan E-5435-1.

The proposed profile grade of Hwy. #6N, N.B.L. will be at elevation 646± and the base of the median and side ditches at elevation 641-642. The grade of the rail tops will remain unchanged (elev. 670). This means that a 24 foot deep cut will be required to achieve the proposed grade of Hwy. #6N (N.B.L.).

The subsoil at the proposed highway grade level consists of a stratified clayey silt to silty clay deposit which is compressible in nature. Consequently, consolidation settlements will take place due to the superimposed loadings of the structure.

#### Structure Foundations

Piled foundations: All footings (abutments and piers) may be founded on end bearing steel 'H' piles driven to bedrock. It is estimated that the pile tips will reach bedrock or refusal between elevation 600± and elevation 604±. The maximum allowable load for the particular steel section may be assumed

(e.g. 12BP74 steel 'H' piles may be designed for 95 tons/pile). In this case the differential settlement between the abutments and piers will be negligible in magnitude.

Spread footings in original ground: As an alternative, the entire structure may be founded on spread footing type foundations placed within the original ground.

The following allowable bearing values are recommended:

South abutment (above elev. 650):	2.5 TSF
North abutment (above elev. 650):	1.5 TSF
(below elev. 650):	2.0 TSF
Piers (below elev. 640):	2.5 TSF

It is estimated that settlements of about 1 inch and 2 inches will take place at the piers and abutments locations respectively due to the superimposed loads.

Further settlements of the abutments are likely to occur due to groundwater lowering which will occur in the stratified soil below the footings over a longterm period once the cut for the roadway is constructed. A drop in the groundwater level of up to 20 to 22 feet is possible. The magnitude of the settlements due to this is difficult to predict but could be in the order of 3 to 4 inches. A portion of this will occur during construction, however, a maximum differential settlement between the abutments and piers following construction of about 4 inches is possible. A frictional resistance to sliding for the footing bases of 1500 PSF is recommended for design purposes.

#### Approaches

Up to 29 foot deep cuts will be required for the future highway 6N. No stability problems are anticipated for the proposed cuts provided 2:1 slopes are constructed.

#### Other Considerations

Spread footings and/or pile caps should be protected against frost action by at least 4 feet of earth cover.

The base of footing excavations will be located below groundwater level. However, no major dewatering problems are anticipated since the subsoil has sufficient strength, clay content and low permeability to prevent basal heave. Any seepage into the excavations can be handled by conventional methods such



as pumping from sumps. The base of the footing excavations should be protected against softening by a suitable concrete slab poured immediately upon exposure.

MISCELLANEOUS

The field investigation was carried out during the period of November 5-10, 1976 under the supervision of Mr. H. Szymanski, Technician and P. Payer. The equipment used was owned and operated by Master Soil Investigation Ltd.

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



*K. G. Selby*  
K.G. Selby, P. Eng.  
Supervising Engineer

KGS/PP/gs  
February, 1977

## APPENDIX

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 1

WP 55-75-08 LOCATION Sta. 98+69 o/s 18' Rt. (CNR R.E. of E.R.) ORIGINATED BY HS  
 DIST 4 HWY 6N BORING DATE November 8, 1976 COMPILED BY HS  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core & Cone Test CHECKED BY ef

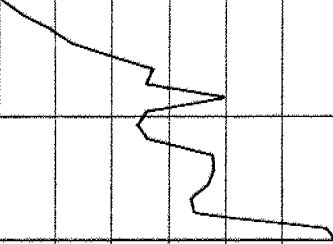
SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_P$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
668.6	Ground Level															
0.0	Silty Clay		1	SS	14											
	to		2	TW	PH											
	Clayey silt		3	TW	PH											
	Trace of		4	TW	PH											
	Sand		5	TW	PH											
	(Stratified)		6	TW	PH											
	Stiff		7	TW	PH											
	to		8	TW	PH											
	Very Stiff		9	TW	PH											
			10	TW	PH											
			11	TW	PH											
			12	SS	13											
630.1																
38.5	Heterogeneous		13	SS	47											
	Mixture of gravel,															
	sand, silt & clay															
	(Glacial Till)															
	Compact		14	SS	36											
	to															
	Dense															
			15	SS	16											
603.0			16	SS	58/1"											
65.6	Dolomite		17	BXL	88%											
598.4	Bedrock Sound		18	BXL	85%											
70.2	End of Borehole															

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

HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 2

WP 55-75-08 LOCATION Sta. 98+81 o/s 21' Lt (CNR R.E. of E.R.) ORIGINATED BY HS  
 DIST 4 HWY 6N BORING DATE November 5, 1976 COMPILED BY HS  
 DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration Only CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT %	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES					
668.4	Ground Level									
0.0						660				
651.4										
17.0	End of Cone Test									

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

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE No 3

WP 55-75-08

LOCATION Sta. 99+14 o/s 18' Rt. (CNR R.E. of E.R.)

ORIGINATED BY HS

DIST 4 HWY 6N

BORING DATE November 5, 1976

COMPILED BY HS

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Penetration Only

CHECKED BY *Q.*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT %	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
668.5	Ground Level									
0.0										
660										
650										
641.5										
27.0	End of Cone Test									

20  
15  $\diamond$  5 % STRAIN AT FAILURE  
10

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 4

WP 55-75-08

LOCATION Sta. 99+26 o/s 21' Lt (CNR R.E. of E.R.)

ORIGINATED BY HS


DIST 4 HWY 6N



BORING DATE November 8, 1976

COMPILED BY HS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core &amp; Dyn Cone Penetr.

CHECKED BY 

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT —WL PLASTIC LIMIT —WP WATER CONTENT —w			UNIT WEIGHT γ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	wp	w	wL		
668.1	Ground Level															
0.0	Silty Clay to Clayey Silt  Trace of Sand  (Stratified)  Stiff to Very Stiff		1	TW	PH	660										
			2	TW	PH	650										
			3	TW	PH											
			4	SS	11										121	0 1 55 44
			5	TW	PH											
			6	TW	PH											
			7	TW	PH	640									122 123	0 1 42 57
			8	TW	PH										123	
			9	TW	PH											
627.6			10	SS	26	630										
40.5	Heterogeneous Mixture of gravel, sand, silt & clay  (Glacial Till)  Compact to Dense		11	SS	37	620										
			12	SS	43											
			13	SS	46	610										41 25 22 12
603.5																
64.6	End of Borehole Refusal  Note: Water Level Not Established															

20  
15 5 % STRAIN AT FAILURE  
10

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 5

WP 55-75-08 LOCATION Sta. 99+84 o/s 17' Rt. (CNR R.E. of E.R.) ORIGINATED BY HS  
 DIST 4 HWY 6N BORING DATE November 9, 1976 COMPILED BY HS  
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Dynamic Cone Penetration CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT % 15 30 45	UNIT WEIGHT $\gamma$ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N' VALUES		20	40	60	80	100			
668.0	Ground Level													
0.0	Silty Clay to Clayey Silt  Trace of Sand (Stratified)  Stiff to Very Stiff		1	TW	PH									
			2	TW	PH								120	0 4 54 42
			3	SS	16									
			4	SS	10									
			5	TW	PH								117	
			6	SS	11									0 1 54 45
			7	TW	PH								124	0 1 52 47
			8	SS	9									
			9	TW	PH								132	
624.0			10	SS	58									23 46 22 9
44.0	Heterogeneous Mixture of Gravel, sand, silt & clay (Glacial Till)  Compact to Very Dense		11	SS	-									19 54 21 6
600.8			12	SS	11									
67.2	End of Borehole Refusal													

20  
 15  $\diamond$  5 % STRAIN AT FAILURE  
 10

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 6

WP 55-75-08

LOCATION Sta. 99+96 o/s 20' Lt. (CNR R.E. of E.R.)

ORIGINATED BY HS

DIST 4 HWY 6N

BORING DATE November 9, 1976

COMPILED BY HS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger &amp; BXL Rock Core

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$		UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			
667.4	Ground Level														
0.0	Probable Silty Clay to Clayey Silt														
						660									
						650									
						640									
						630									
624.0															
43.4	Probable Glacial Till					620									
						610									
600.4						600									
67.0	Dolomite														
595.4	Bedrock Sound		1	RC BXL	80%										
72.0	End of Borehole														

 20  
15  $\diamond$  5 % STRAIN AT FAILURE  
10

 W.L. IN  
PIEZOMETER  
661.2 FEB. 2, 1977

P-6-2

 W.L. IN PIEZOMETER  
655.2 FEB. 2/77

P-6-1



## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 7

WP 55-75-08 LOCATION Sta. 100+53 o/s 20' Rt. (CNR R.E. of E.R.) ORIGINATED BY HS  
 DIST 4 HWY 6N BORING DATE November 10, 1976 COMPILED BY HS  
 DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration Only CHECKED BY ef.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$ $w_p$ — $w$ — $w_L$ WATER CONTENT %	UNIT WEIGHT $\gamma$	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES					
666.9	Ground Level									
0.0										
660										
650										
646.9										
20.0	End of Cone Test									

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

W P 55-75-08

LOCATION Sta. 100+66 o/s 20' Lt. (CNR R.E. of E.R.)

ORIGINATED BY HS

DIST 4 HWY 6N

BORING DATE      November 10, 1976

COMPILED BY HS

DATUM      Geodetic

BOREHOLE TYPE Hollow Stem Auger &amp; Dynamic Cone Penetration

CHECKED BY GP.

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

## HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

## RECORD OF BOREHOLE NO 9

WP 55-75-08

LOCATION Sta. 100+98 o/s 20' Rt. (CNR R.E. of E.R.)

ORIGINATED BY HS

DIST 4 HWY 6N

BORING DATE November 10, 1976

COMPILED BY HS

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BXL Rock Core &amp; Dyn Cone

CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_P$ WATER CONTENT — $w$			UNIT WEIGHT $\gamma$ PCF	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	N <sup>o</sup> VALUES		20	40	60	80	100	$w_p$	$w$	$w_L$		
666.7	Ground Level															
0.0	Silty Clay to Clayey silt		1	SS	14											
			2	SS	15											
	Trace of Sand (Stratified)		3	TW	PH											
			4	SS	8											
	Stiff		5	TW	PH											
	to		6	TW	PH											
	Very Stiff		7	TW	PH											
			8	TW	PH											
			9	TW	PH											
628.7			10	TW	PH											
38.0	Heterogeneous Mixture of gravel, sand, silt & clay (Glacial Till)		11	SS	22											
			12	SS	40											
	Compact to Very Dense		13	SS	61											
601.7																
65.0	Dolomite Bedrock		14	RC	100%											
598.2	Sound			BXL												
68.5	End of Borehole															

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

OFFICE REPORT ON SOIL EXPLORATION

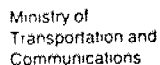
HIGHWAY ENGINEERING DIVISION - ENGINEERING MATERIALS OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 10

WP 55-75-08 LOCATION Sta. 101+11 o/s 20' Lt. (CNR R.E. of E.R.) ORIGINATED BY HS  
 DIST 4 HWY 6N BORING DATE November 10, 1976 COMPILED BY HS  
 DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration Only CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT $w_L$ PLASTIC LIMIT $w_p$ WATER CONTENT $w$			UNIT WEIGHT $\gamma$	REMARKS			
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT % $w_p$ $w$ $w_L$		
666.4	Ground Level																		
0.0																			
651.4																			
15.0	End of Cone Test																		

20  
15  $\diamond$  5 % STRAIN AT FAILURE  
10



## DIP

PROPERTY \_\_\_\_\_ W.P. 55-75-08  
LOCATION \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
LATITUDE \_\_\_\_\_  
DEPARTURE \_\_\_\_\_  
BEARING \_\_\_\_\_

TOTAL FOOTAGE

ELEV. COLLAR \_\_\_\_\_  
 DATUM \_\_\_\_\_  
 DATE STARTED \_\_\_\_\_  
 DATE COMPLETED \_\_\_\_\_  
 DRILLED BY \_\_\_\_\_  
 LOGGED BY \_\_\_\_\_

[illegible]

DATE OF EXAMINATION December 7, 1976

Z. Koniuszy



Ministry of  
Transportation and  
Communications

# DIAMOND DRILL RECORD

HOLE NO. 6, 9 SHEET NO. \_\_\_\_\_

DIP

PROPERTY W.P. 55-75-08  
LOCATION \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
LATITUDE \_\_\_\_\_  
DEPARTURE \_\_\_\_\_  
BEARING \_\_\_\_\_

TOTAL FOOTAGE \_\_\_\_\_

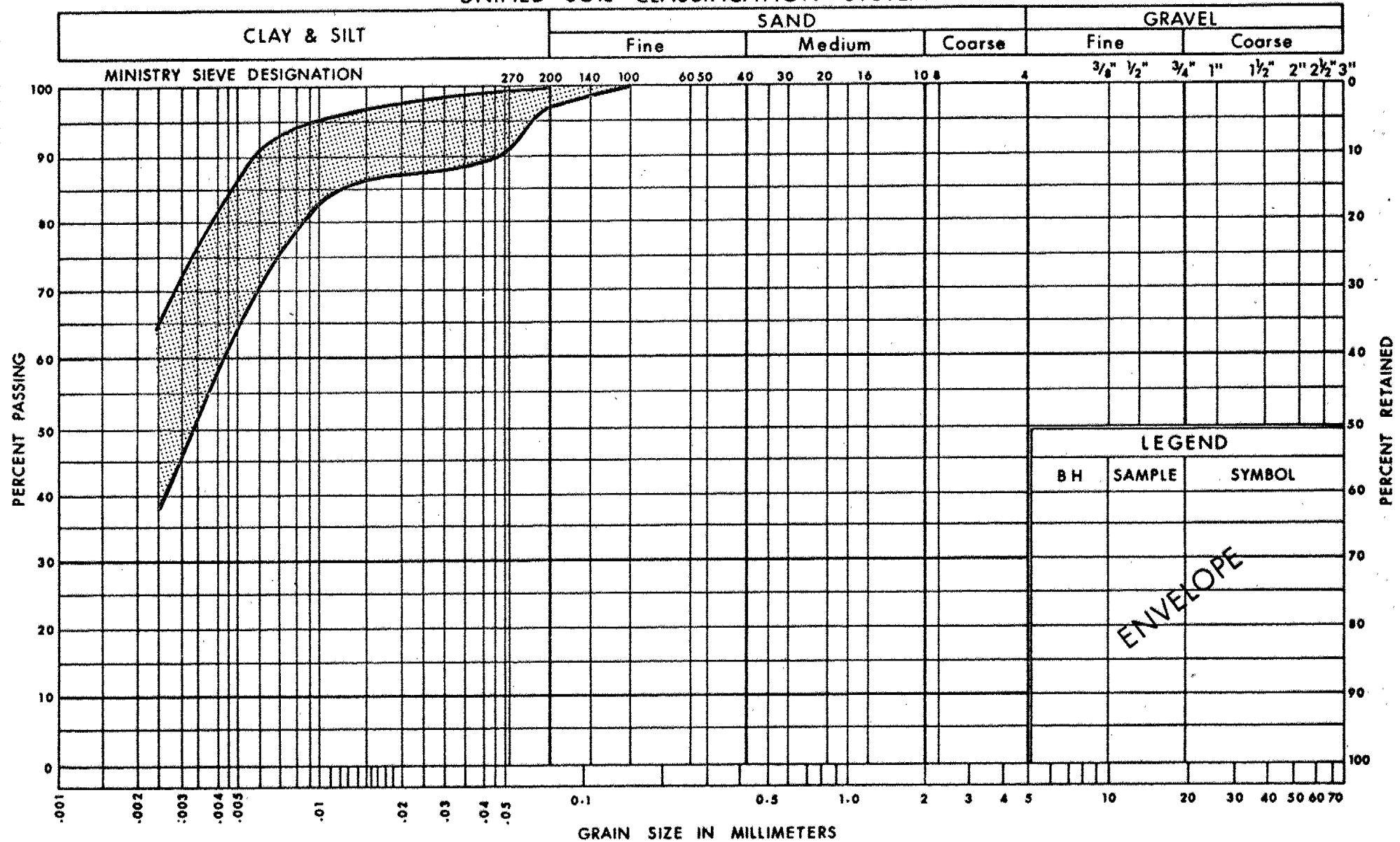
ELEV. COLLAR \_\_\_\_\_  
DATUM \_\_\_\_\_  
DATE STARTED \_\_\_\_\_  
DATE COMPLETED \_\_\_\_\_  
DRILLED BY \_\_\_\_\_  
LOGGED BY \_\_\_\_\_

FOOTAGE		FORMATION	SAMPLE NUMBER			REMARKS
FROM	TO					
		HOLE #6				
67.0'	69.0'	Dolomite, buffy grey, medium to coarse textured, hard, lenses of shale at bedding planes impregnated by gypsum				Fractured horizontally every 2 - 3"
69.0'	69.9'	Dolomite, grey, fine textured, hard				Broken and ground core
69.9'	72.0'	Shaly dolomite, grey, fine textured, med. hard				core broken and ground
		HOLE #9				
65.0'	65.4'	Dolomite, impregnated with gypsum				core broken
65.4'	66.0'	Dolomite, grey, fine textured, hard				core broken
66.0'	68.5'	Dolomite, buffy grey, medium textured, hard				core broken every 2"

DATE OF EXAMINATION December 7, 1976

Z. Koniuszy

# UNIFIED SOIL CLASSIFICATION SYSTEM



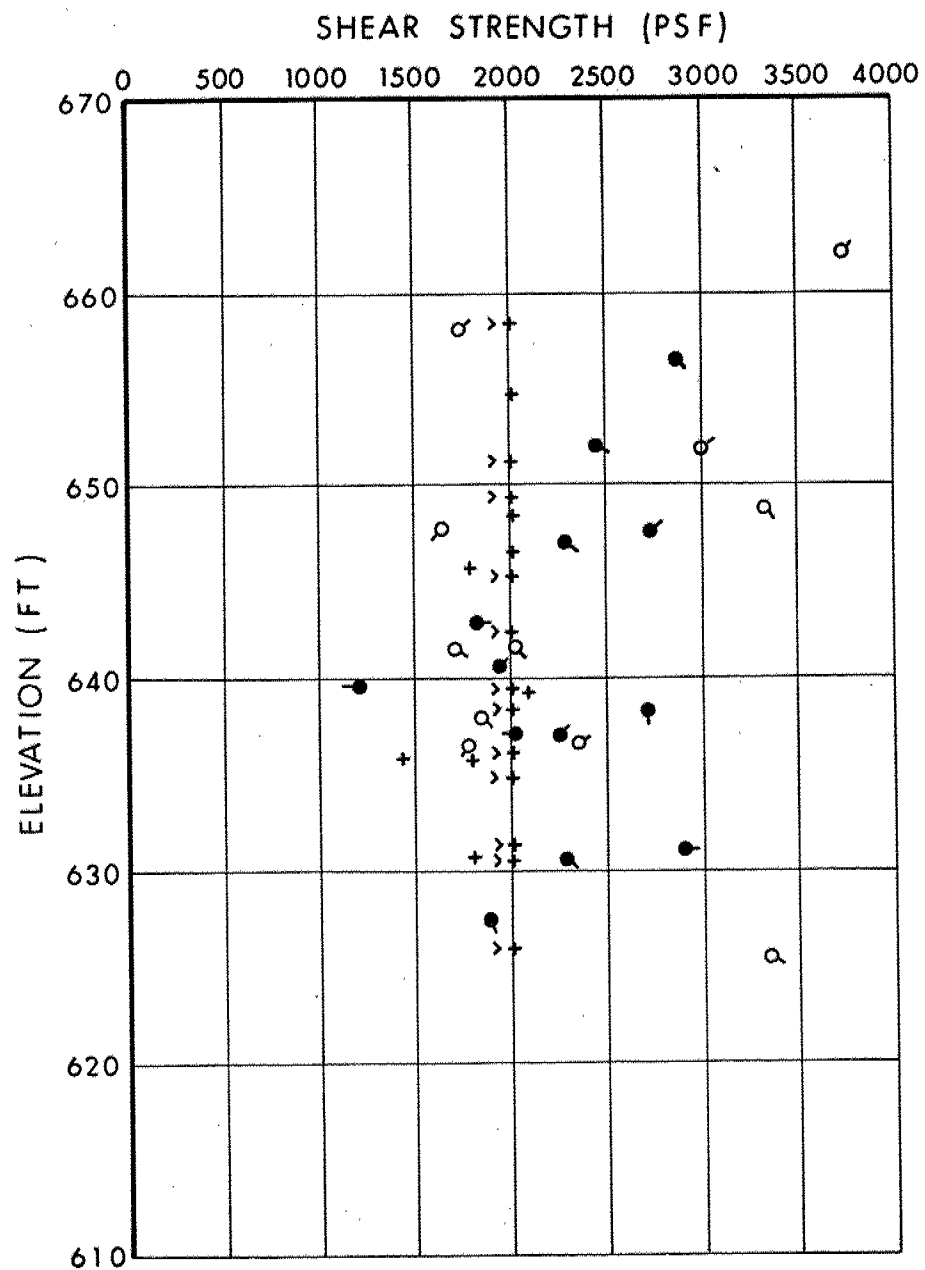
Ministry of  
Transportation and  
Communications  
Ontario  
**ENGINEERING SERVICES BRANCH**

GRAIN SIZE DISTRIBUTION  
SILTY CLAY TO CLAYEY SILT  
(STRATIFIED) TRACE OF SAND

FIG No 1

W P 55-75-08

# SHEAR STRENGTH Vs ELEVATION



## LEGEND

+ FIELD VANE TEST

• QUICK TRIAXIAL COMPRESSION TEST

o UNCONFINED COMPRESSION TEST

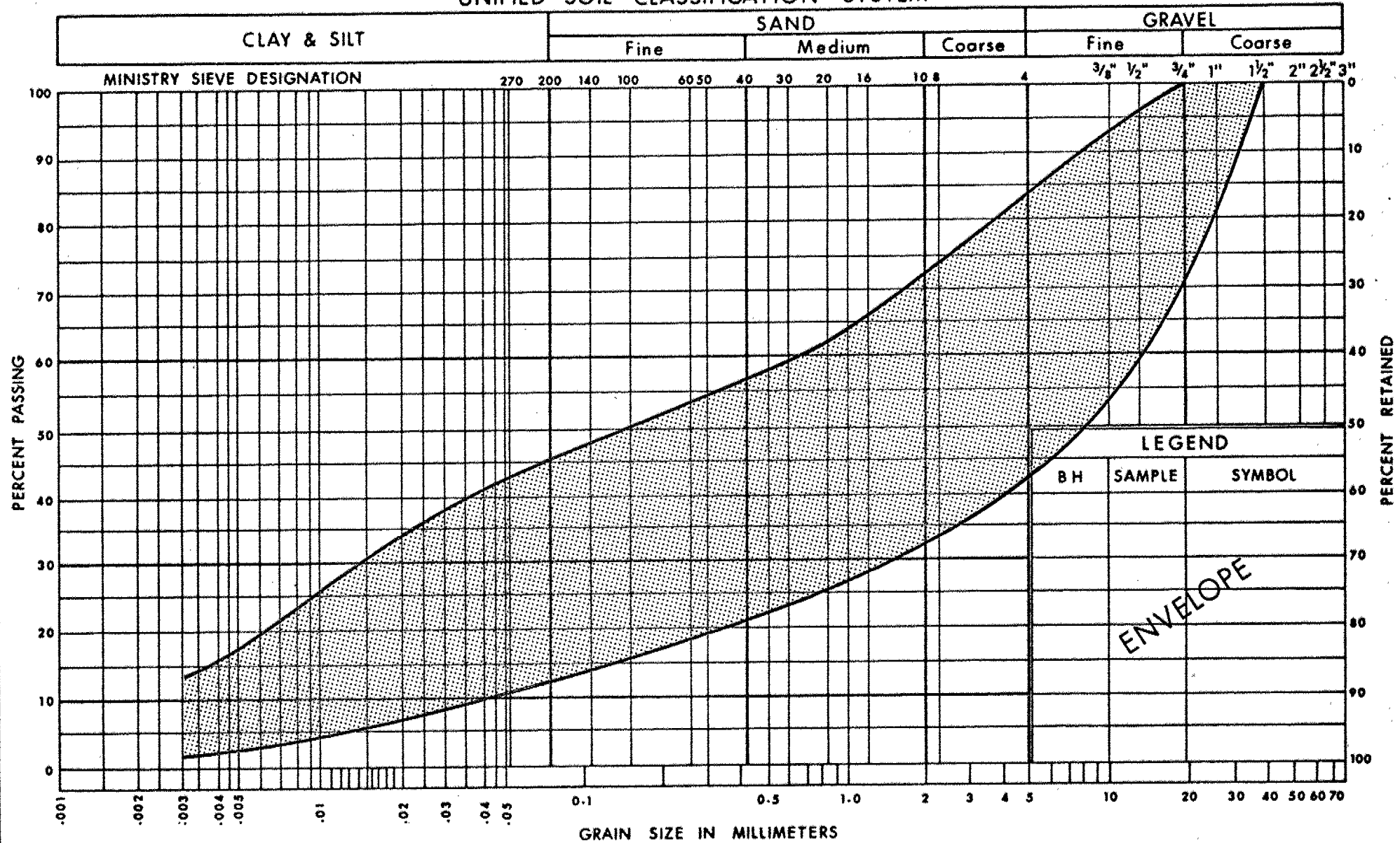
20  
15  $\phi$  5 % STRAIN AT FAILURE  
10

Fig 2

WP 55-75-08



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario  
ENGINEERING SERVICES BRANCH

Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
HET. MIXTURE OF GRAVEL, SAND, SILT & CLAY  
(GLACIAL TILL)

FIG No 3

W P 55-75-08

# PIEZOMETRIC HEAD Vs ELEVATION

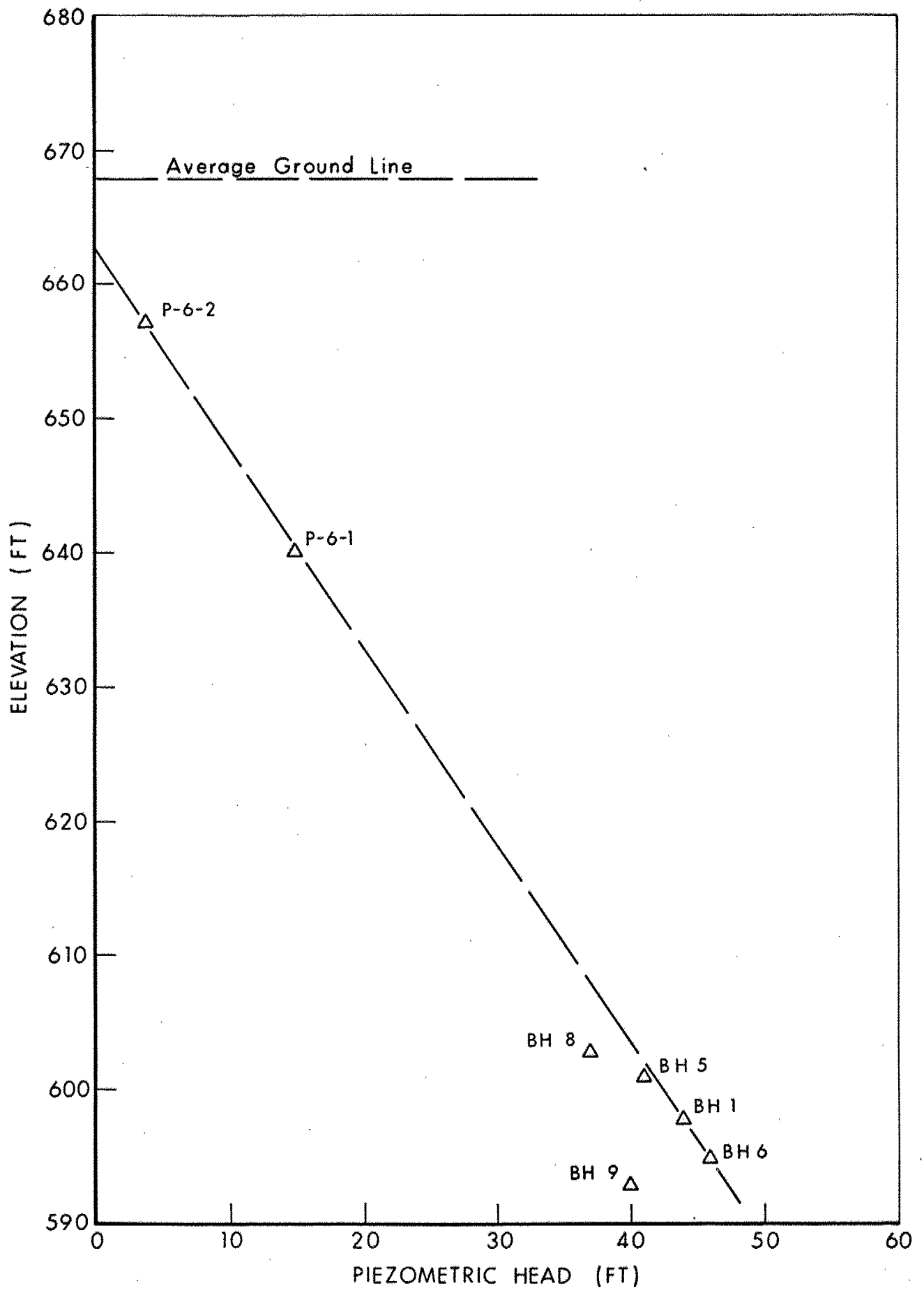


Fig 4

WP 55-75-08

## ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

### PENETRATION RESISTANCE

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

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

### TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

### SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED " "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED " "		

# ABBREVIATIONS & SYMBOLS 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
$w_g$	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

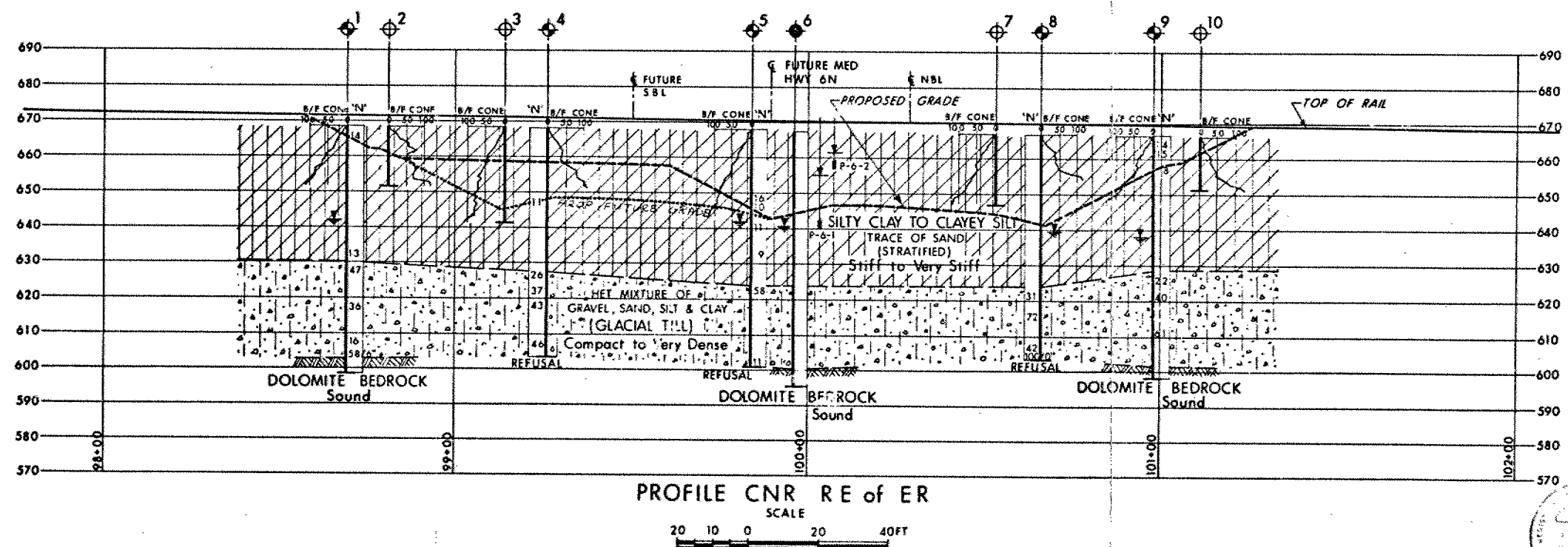
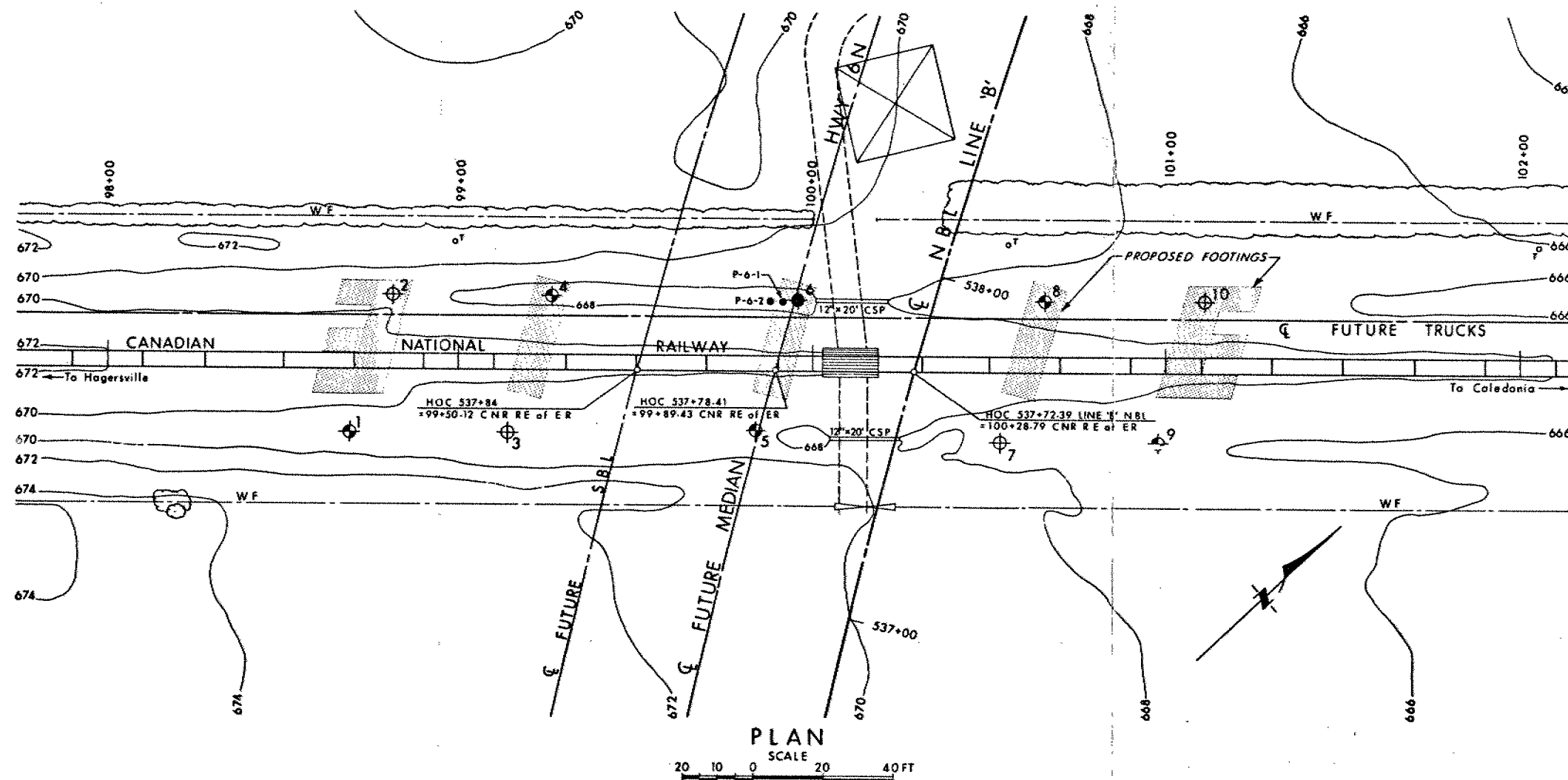
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

## 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

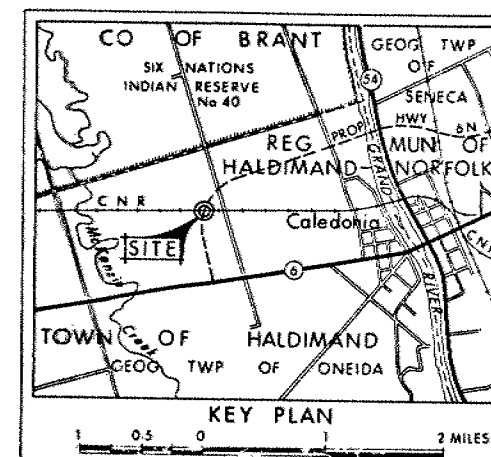


CONT No  
WP No 55-75-08

CANADIAN NATIONAL RAILWAY  
(1.6 Mi South of Grand River)  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET



### LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- 'N' Blows/ft (Std Pen Test 350 ft lbs energy)
- 'CONE' Blows/ft (60° Cone, 350 ft lbs energy)
- W.L. at time of investigation Nov 1976
- W.L. Not established in B.H. No 4
- ⊕ PIEZOMETRIC HEAD
- ⊕ PIEZOMETER

No.	ELEVATION	STATION	OFFSET CNR RE of ER
1	668.6	98+69	18' RT
2	668.4	98+81	21' LT
3	668.5	99+14	18' RT
4	668.1	99+26	21' LT
5	668.0	99+84	17' RT
6	667.4	99+96	20' LT
7	666.9	100+53	20' RT
8	667.0	100+66	20' LT
9	666.7	100+98	20' RT
10	666.4	101+11	20' 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.

REVISIONS	DATE	BY	DESCRIPTION



REF No E-5435-1, July 1976

HWY No Prop Hwy 6N LINE 'B' NBL POST 4  
SUBMITTED P.P. CHECKED DATE Feb 10, 1977 SHEET 9-128  
DRAWN BY CHECKED BY APPROVED DWG 557508-A

Mr. G. C. E. Burkhardt,  
Regional Structural Planning Engineer,  
Central Region,  
3501 Dufferin Street, Downsview

Soil Mechanics Section,  
Engineering Materials Office,  
West Building, Downsview

January 27th, 1977

Mr. W. M. Killin

RE: PRELIMINARY RECOMMENDATIONS FOR PROJECTS  
W.P. 55-75-07 AND 55-75-08  
HWY. # 6N, DISTRICT #4, HAMILTON

In order to comply with your request to submit our written recommendations before the Foundation Investigation and Design reports are completed, our assessments of the subsurface conditions and recommendations are as follows:

W.P. 55 - 75 - 07  
Site: 9 - 131  
C.N.R. Crossing

A four span subway structure is proposed at this location. The proposed grades are as follows:

C.N.R. Elevation 683±  
Hwy. 6N; Elevation 659±  
Collector Ditches; Elevation 655±  
Ground Level; Elevation 681 - Elevation 686

The encountered subsoil conditions at the west portion of the structure was found to consist of a 14' thick deposit of very stiff clayey silt to silty clay, followed by 5' to 15' of very dense silty sand, followed by 18' to 25' of hard glacial till.

On the east side, the subsoil consists of a 45' deep deposit of very stiff clayey silt to silty clay, followed by 3' to 5' of hard glacial till.

Dolomite type bedrock was encountered between elevation 631± - elevation 637±.

The groundwater level across the site in general was at or below elevation 655.

It is recommended that the entire structure be supported on end-bearing steel 'H' piles driven to bedrock. The maximum allowable design loads for the particular pile section adopted may be assumed.

Frost protection should be provided for the piles caps. (4' of earth cover). No stability problems are anticipated for the cut constructed with 2:1 slopes.

W.P. 55 - 75 - 08  
Site: 9 - 128  
C.N.R. Crossing

The proposed subway at this location will consist of a four-span structure. The following grades are proposed:

cont'd.....

C.N.R. Elevation 670±  
Hwy. #6N; Elevation 646±  
Collector Ditches; Elevation 641 - Elevation 645  
Ground Level; Elevation 666 - Elevation 670

The following subsoil conditions were encountered:

From ground level to Elevation 627±: Firm to very stiff (Cu: 1000 - 3700 psf)  
Clayey silt to silty clay.

From elevation 627± to bedrock: Mixture of gravel, sand, silt and clay (basically granular) - glacial till compact to very dense.

Dolomite type bedrock was encountered between elevation 601 and elevation 603.

The groundwater level was at approx. elevation 643±.

It is recommended, that the structure abutments and piers be supported on end-bearing steel 'H' piles driven to bedrock. The allowable capacity of the piles will depend on the pile section chosen. For estimating purposes, it can be assumed that the piles will meet refusal at approx. elevation 601 - 603.

The pile caps should be protected against frost action by at least 4' of earth cover.

No stability problems are anticipated for the proposed cuts, provided with 2:1 slopes.

The detailed Foundation Investigation Reports for these projects will be issued in the near future.

P. Payer,  
Senior Engineer

for K.G. Selby,  
Supervising Engineer

PP/km

C.C. C. S. Grebski  
R. D. Fitzgibbon  
J. Anderson  
Files  
Record Services