

GEOCRES No. 30M14-296

DIST. \_\_\_\_\_ REGION \_\_\_\_\_

W.P. No. 470-711609

CONT. No. GGE-316

W. O. No. \_\_\_\_\_

STR. SITE No. \_\_\_\_\_

HWY. No. GO-ALRT

LOCATION BROCK ROAD STRUCTURE

Foundation Design & SOIL INVESTIGATION

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

REMARKS: GEOCRES # to be given

\_\_\_\_\_

\_\_\_\_\_



# Geocon

GEOTECHNICAL CONSULTANTS

GEOCON INC.  
3210 AMERICAN DRIVE, MISSISSAUGA  
ONTARIO, CANADA L4V 1B3  
TELEPHONE: (416) 673-1664  
TELEX: 06-968801

February 10th, 1984.

Ministry of Transportation and Communications,  
Pavement and Foundation Design Section,  
Room 315, Central Building,  
1201 Wilson Avenue,  
Downsview, Ontario.

Attention: Mr. M. Maclean.

Re: SUPPLEMENTARY GEOTECHNICAL INVESTIGATION,  
BROCK ROAD STRUCTURE,  
PICKERING, ONTARIO,  
GO ALRT PROJECT 470-711-609.



Dear Sirs:

We are pleased to present a summary of our factual information and our preliminary geotechnical design recommendations for the above supplementary investigation.

During our conversation of January 26th, 1984, we were informed that the proposed retaining wall, located north of the GO ALRT tracks to the west of Brock Road, was to be extended westward to GO ALRT chainage station 11 + 533 metres. As requested four additional boreholes were put down near the proposed centreline of the retaining wall, at GO ALRT chainage 11 + 618.5, 11 + 580.9, 11 + 553 and 11 + 525. The above holes have been identified as Boreholes 12 to 15, respectively, and supplement information obtained during our initial investigation from Boreholes 1 to 4 which were also put down to the west of Brock Road. Copies of preliminary logs for the supplementary boreholes are enclosed.

NOT ISSUED :

ADDITIONAL LENGTH OF RETAINING WALL  
COVERED BY THIS LETTER HAS  
BEEN CANCELLED.

MM 84 02 22

**Lavalin**

## 1.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered in Boreholes 12, 14 and 15 were similar to those of our previous Boreholes 1, 2 and 3. In general a thin layer of topsoil is underlain by fill. A 1.9 metre thickness of silty clay fill, in Borehole 12, was underlain by sand and silt fill to elevation 86.7 metres. Sand and silt fill was encountered in Boreholes 14 and 15 to elevation 91.0 and 88.3 metres respectively. A thin layer of sand, in Borehole 12, and silt some sand and organics in Borehole 14 underlies the fill. Dense to very dense silt and sand, some gravel, trace clay, glacial till was encountered at elevations 86.4, 90.4 and 88.3 metres in Boreholes 12, 14 and 15, respectively.

Subsurface conditions encountered in Borehole 13 differed considerably from those of the above Boreholes. A thin layer of topsoil was underlain by firm silty clay fill to a depth of 3.0 metres at elevation 87.9 metres. The fill was underlain by a 4.6 metre thick stratum of very stiff to stiff, silty clay, trace to some sand. Natural and remoulded field vanes were carried out within this stratum.

Loose to very loose silty sand trace gravel and clay was encountered below the silty clay and extended to about elevation 81.1 metres. Examination of dynamic penetration test results within this stratum indicated an increase in resistance with depth from about 26 blows per 0.3 metre to about 45 blows per 0.3 metre. This suggests the stratum is more dense than indicated by the loose to very loose relative density description assigned from the results of a Standard Penetration test carried out at the base of the stratum. Groundwater flow into the hollow stem augers, prior to carrying out the Standard Penetration test, may have disturbed the silty sand resulting in low "N"

## 1.0 SUBSURFACE CONDITIONS (continued)

values. Very dense silt and sand, some clay, trace gravel till, containing occasional shale bedrock fragments, was encountered to termination of the borehole.

## 2.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

Based on the above subsurface conditions geotechnical design criteria for the west extension of the retaining wall will differ slightly from those given for the initial section of the west retaining wall which was to terminate in the vicinity of Borehole 1. In general conventional spread footings may be used to support the retaining wall from GO ALRT chainage 11 + 640 to 11 + 533 metres. The retaining wall should be constructed on undisturbed glacial till or on the stiff to very stiff silty clay stratum identified in Borehole 13. In all cases the surficial fill should be excavated and the retaining wall founded a minimum of 1.3 metres below final grade to provide sufficient cover for frost protection purposes.

Our previously submitted preliminary report, dated November 7th, 1983 recommends the west retaining wall, located to the east of station 11 +640, be founded at or slightly below elevation 87 metres, on the undisturbed till, for a proposed track elevation of 88.9 metres. Design and construction of the retaining wall foundation to the west of this point should be carried out as outlined below.

## 2.0 GEOTECHNICAL DESIGN RECOMMENDATIONS (continued)

<u>Approximate Retaining Wall Section Chainage</u>	<u>Founding Stratum</u>	<u>Maximum Founding Elevation</u>
11 + 640 to 11 + 635	Glacial Till	87 metres
11 + 635 to 11 + 615	Glacial Till	86 metres
11 + 615 to 11 + 585	Silty Clay	86 metres
11 + 585 to 11 + 555	Silty Clay	87 metres
11 + 555 to 11 + 525	Glacial Till	87 metres

Alternatively the fill may be excavated between stations 11 + 635 to 11 + 585, and raised to elevation 87 metres using engineered granular fill. The fill should consist of free draining granular fill (M.T.C. Type A) placed in lifts of maximum 0.3 metres in thickness, and compacted to 98 percent Modified Proctor maximum dry density.

The following U.L.S. bearing capacity and S.L.S. Type II bearing value, for 25 mm of estimated post construction settlement, should be used in the design of the retaining wall foundations.

<u>Founding Stratum</u>	<u>Bearing Value</u>	
	<u>U.L.S.</u>	<u>S.L.S. Type II</u>
Glacial Till	600 kPa	300 kPa
Engineered Granular Fill founded on Glacial Till	500 kPa	200 kPa
Silty Clay	175 kPa	120 kPa
Engineered Granular Fill founded on Silty Clay	175 kPa	120 kPa

## 2.0 GEOTECHNICAL DESIGN RECOMMENDATIONS (continued)

### 2.1 General Design and Construction Considerations

1. For inclined resultant loads the ultimate bearing capacity should be reduced as specified in the Ontario Highway Bridge Design Code, 1982, Clause 6.7.3.3.5 using the appropriate granular soil curve given in Figure 6.7.3.3.5.
2. It is recommended that a minimum of 1.2 metres of free draining well graded granular fill be provided behind the retaining wall and that suitable positive drainage be provided to prevent build up of excess hydrostatic pressure. Granular backfill should be compacted to 90 percent of Modified Proctor maximum dry density.
3. The lateral earth pressure on the retaining wall will have to take into account the sloping configuration of the backfill. At present the final slope of the backfill is not known. For purposes of preliminary design the earth pressure coefficients should be selected based on an effective angle of internal friction of 30 degrees for the backfill and should be used in conjunction with a drained unit weight of backfill equal to 20 kN/m<sup>3</sup>.
4. Lateral forces on the retaining wall, founded on the glacial till stratum, may be resisted by the friction developed between the base of the footing and the underlying stratum. This frictional resistance should be based on an ultimate coefficient of friction of 0.4.
5. Lateral forces on the retaining wall between stations 11 + 615 and 11 + 555 metres may be resisted by the friction developed between the base of the footing and the underlying silty clay stratum. This frictional resistance

2.0 GEOTECHNICAL DESIGN RECOMMENDATIONS (continued)

2.1 General Design and Construction Considerations (continued)

5. (continued)

should be based on an ultimate coefficient of friction of 0.33. However the magnitude of frictional resistance would be governed by the undrained shear strength of the stratum of 70 kPa. In this instance a factor of safety of 1.5 against horizontal sliding is required.

6. The extent to which passive resistance is developed at the base of the retaining wall should be established when details of the track bed materials are established.
7. Construction joints should be provided within the retaining wall at the transition between foundations supported by the till and the silty clay stratum.
8. A mud mat should be placed on the surface of the silty clay stratum within 12 hours of excavation to the founding elevation.
9. In the event that granular fill is used to raise the founding grade compaction of granular fill should be carried out under engineering supervision to ensure the underlying clay stratum is not disturbed. In the event silty clay disturbance occurs, vibratory compaction should cease, and static compaction carried out until a sufficient depth of granular fill is placed to protect the underlying stratum.

2.4 Slope Stability Conditions

The proposed retaining wall will be underlain by a stratum of silty clay, in the vicinity of chainage stations 11 + 615 to

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## 2.0 GEOTECHNICAL DESIGN RECOMMENDATIONS (continued)

### 2.4 Slope Stability Conditions (continued)

11 + 555, which is described as being of a very stiff to stiff consistency. The silty clay stratum is underlain by silty sand which is considered, from dynamic cone penetration test result, to be of at least compact relative density. The silty clay is in turn underlain by very dense glacial till.

Our assessment of the soil conditions and general slope configuration indicates that the proposed retaining wall structure will not significantly reduce the overall stability of the embankment.

Construction of the retaining wall will require excavation of fill, till and silty clay soils at the base of the slope of the existing embankment. In the subject area the crest of the embankment rises about 7.5 metres above the approximate base of the retaining wall. A suitably designed system of temporary shoring should be constructed to facilitate construction of the retaining wall and to achieve the required configuration of free draining granular material behind the wall.

## 3.0 CLOSURE

The field work for the supplementary investigation was carried out by our Mr. S. R. Prior working under the supervision of Mr. R. W. Browne. This letter has been written by Mr. R. W. Browne, P.Eng. with technical input from Mr. H. L. MacPhie, P.Eng.

We trust this letter contains sufficient detail for your purpose. Please contact us should you require elaboration on any matter.



Ministry of Transportation and Communications,  
February 10th, 1984.  
Page 8.

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Yours very truly,  
GEOCON INC.,

A handwritten signature in cursive script, appearing to read "R. W. Browne".

R. W. Browne, P.Eng.,  
Geotechnical Engineer.

T10702/35285

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# RECORD OF BOREHOLE No 12

METRIC

W P 470-711-609 LOCATION 4 855 165.7 N ; 339 239.1 E ORIGINATED BY SRP  
DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
DATUM Geodetic DATE 1984 01 20 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
91.2	Ground Level										
0.0	Topsoil										
0.2	Silty Clay, some sand, trace gravel (fill) Firm to very stiff Brown		1	SS	25		91				
89.1							90				
2.1	Sand, some silt to Sand and Silt trace gravel, trace clay (fill) Very Dense Brown to Grey Brown		2	SS	68		89				
86.7							88				
4.5	Sand, some gravel trace						87				
86.4	silt Dense Grey		3	SS	46		86				
4.8	Silt and Sand, some gravel, trace clay (till) Dense to Very Dense Grey		4	SS	72		85				
			5	SS	78		84				
							83				
81.6			6	SS	73		82				
9.6	END OF BOREHOLE										

# RECORD OF BOREHOLE No 13

METRIC

W P 470-711-609 LOCATION 4 855 103.2 N ; 339 251.0 E ORIGINATED BY SRP  
DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
DATUM Geodetic DATE 1984 01 20 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH Kpa					
90.9	Ground Level													
0.0	Topsoil													
0.2	Silty Clay, some sand, trace gravel (fill)  Firm  Brown		1	SS	6									
87.9														
3.0	Silty Clay, trace to some sand  Stiff to Very Stiff  Grey		2	TW	PM									
			3	TW	PM									
			4	TW	PM									
83.3														
7.6	Silty Sand, trace gravel, trace clay  Loose to Very Loose  Grey		5	TW	PM									
			6	SS	2									
81.1														
9.8	Silt and Sand, some clay trace of gravel (till) Occasional shale fragments Very Dense Grey													
80.1														
10.8	END OF BOREHOLE		7	SS	100/0, 12									

OFFICE REPORT ON SOIL EXPLORATION

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Ministry of  
Transportation and  
Communications

# RECORD OF BOREHOLE No 14

METRIC

W P 470-711-609 LOCATION 4 855 142.0 N; 399 246.0 E ORIGINATED BY SRP  
DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
DATUM Geodetic DATE 1984 01 31 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
94.1	GROUND LEVEL										
00.0	Sand and Silt, some gravel, trace clay (Fill) Compact  Brown						94	Augered			
			1	SS	27		93				
							92				
91.0	100 mm Sand Layer						91				
3.1	Silt, some sand and organics		2	SS	5		90				
90.4							89				
3.7	Silt and Sand, some gravel, trace clay (Till)  Dense to Very Dense  Grey		3	SS	37		88				
			4	SS	44		87				
							86				
			5	SS	45		85				
84.5			6	SS	83						
9.6	END OF BOREHOLE										

OFFICE REPORT ON SOIL EXPLORATION



Ministry of  
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Communications

# RECORD OF BOREHOLE No 15

METRIC

W P 470-711-609 LOCATION 4 855 055.9 N ; 339 221.2 E ORIGINATED BY SRP  
DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
DATUM Geodetic DATE 1984 01 31 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
91.0	GROUND LEVEL											
00.0	Topsoil											
0.2	Sand and Silt, some gravel, traces clay (Fill) Very Dense Brown		1	SS	55							
88.3												
2.7	Silt and Sand, some gravel, trace clay (Till) Dense to Very Dense Grey		2	SS	57							
			3	SS	42							
			4	SS	49							
84.4												
6.6	END OF BOREHOLE											

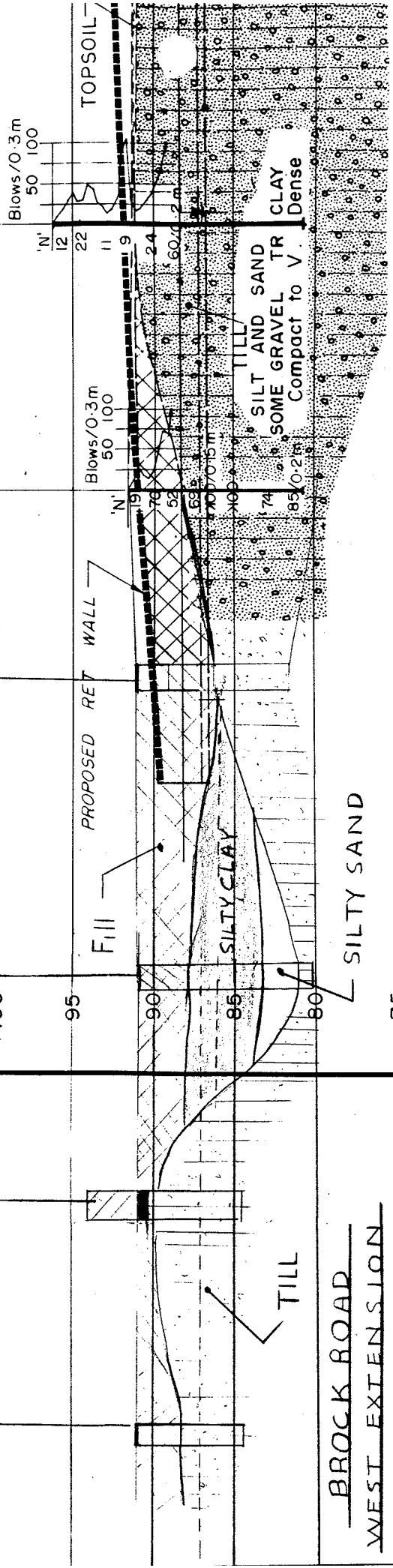
OFFICE REPORT ON SOIL EXPLORATION

**BROCK ROAD  
WEST EXTENSION**

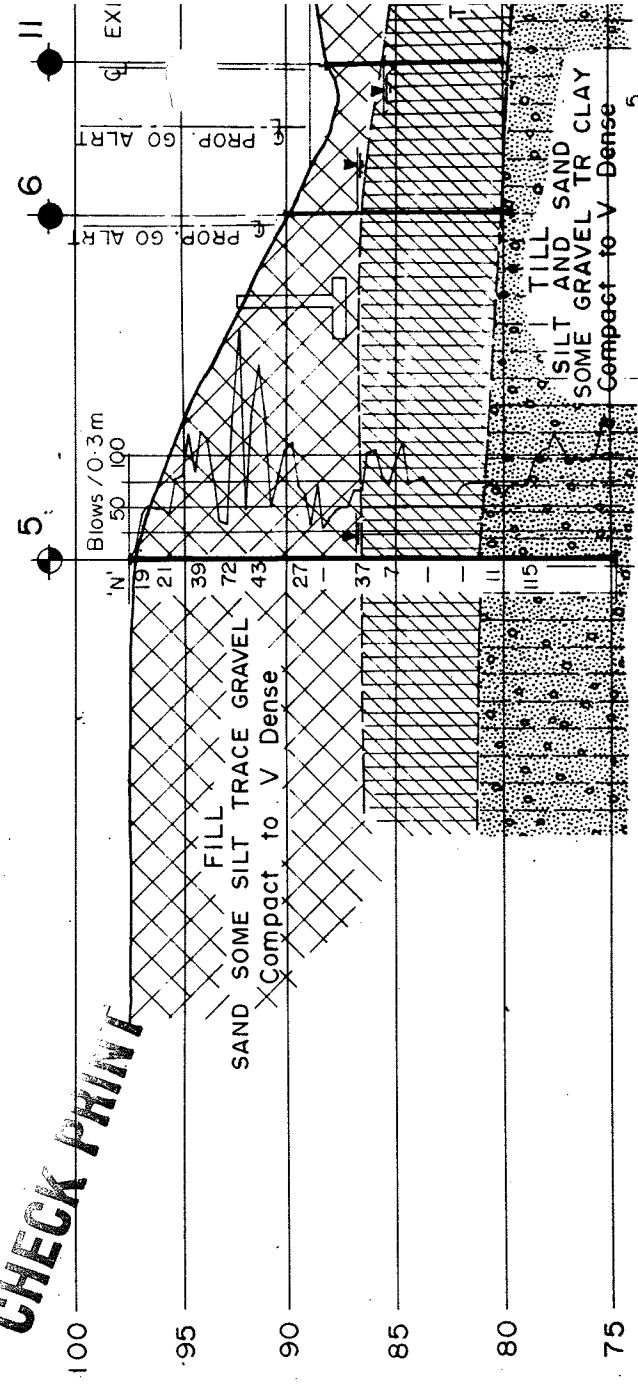
BH 15 11+525  
BH 14 11+553

BH 13 11+585  
11+600  
11+615  
BH 12 11+618  
11+635  
11+641

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**SECTION A - A**

# **PICKERING - OSHAWA SECTION**

**ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION**

**WP 470 711609      DIST 6**

**HWY GO ALRT**

**BROCK ROAD STRUCTURE  
FOUNDATION DESIGN & SOIL INVESTIGATION**

## **DISTRIBUTION**

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T10702

REPORT TO  
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS  
DOWNSVIEW ONTARIO  
GEOTECHNICAL INVESTIGATION  
GO ALRT - BROCK ROAD STRUCTURE  
PICKERING ONTARIO

(W.P. 470-711-609)

March 6th, 1984

**GEOCON**



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APPENDIX I

## RECORD OF BOREHOLES

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Table 1	Summary of Stability Analyses Results Stability Analysis Section Embankment East of Brock Road
Figure 1	Case 1 Existing Slope Conditions Total Stress Analysis
Figure 2	Case 2 1.5H:1V Cut Slope Total Stress Analysis
Figure 3	Case 3 Sheet Pile Wall 6.3 m North of Centreline of North GO ALRT Track Total Stress Analysis
Figure 4	Case 4 Sheet Pile Wall 2.8 m North of Centreline of North GO ALRT Track Total Stress Analysis

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Figure 5	Case 5 Existing Slope Conditions Effective Stress Analysis
Figure 6	Case 6 Permanent Retaining Wall 6.3 m North of Centreline of North GO ALRT Track Effective Stress Analysis
<u>Drawing</u>	(at rear of report) 470-711-609-A

## 1.0 INTRODUCTION

Geocon Inc. has been retained by the GO ALRT Program to carry out a geotechnical investigation in the area of the existing Brock Road structure along the proposed alignment of the GO ALRT system. The above investigation has been carried out under the technical direction of Mr. M. Devata, Senior Foundation Engineer, Ministry of Transportation and Communications (M.T.C.). The scope of the work for this investigation was discussed with staff members of M.T.C. on July 14th, 1983. The work was carried out in accordance with our proposal, dated July 29th, 1983. The investigation was authorized by GO ALRT by their letter dated July 27th, 1983 which identified the project by Agreement No. EGG 000-5 and Reference No. 470-711-609.

The purpose of this investigation was to obtain subsurface information for use in the design and construction of sheet pile walls and retaining walls. The above walls are required to retain the embankments of the Brock Road structure and Highway 401 access ramps thereby providing sufficient clearance for the installation of the GO ALRT lines. The geotechnical information is also required for the assessment of the overall stability of the modified embankments.

This report contains the factual results of the investigation in the form of Records of Boreholes in Appendix I. The locations of the boreholes and soil stratigraphy is given on Drawing 470-711-609-A at the rear of this report. The report presents a description of the soil and groundwater conditions and discussion of geotechnical parameters and required procedures for the design and construction of the proposed structures.

## 2.0 PROCEDURE AND EQUIPMENT

The initial field work for this investigation was carried out from July 20th to July 28th, 1983. A total of 9 boreholes, numbered

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## 2.0 PROCEDURE AND EQUIPMENT (continued)

consecutively 1 to 9 from west to east, were put down.

Boreholes 1 to 4 were located on the south slope and berm of Highway 401 Ramp W-NS which approaches Brock Road from the west. Boreholes 1 and 3 were located on the embankment berm north of the existing Canadian National Railway (C.N.R.) tracks. Boreholes 2 and 4 were put down from the top of the ramp.

Boreholes 5 to 9 were located on the south slope of Highway 401 Ramp NS-E which leads east from Brock Road. Boreholes 5, 7 and 9 were put down from the top of the ramp while Boreholes 6 and 8 were situated part way down the south slope of the embankment.

Following review of our preliminary report, of August 19, 1983, it became apparent that detailed stability analyses would be required along the south slope of Highway 401 Ramp NS-E. Following discussions with yourselves it was agreed that two additional boreholes be put down to better define the strength characteristics of the soft silty clay stratum located above the glacial till in Boreholes 5 to 9.

Borehole 10 and 11, located 3 metres west and 7 metres south of Borehole 6, respectively were put down on August 30th and 31st, 1983.

Following submission of our preliminary report of November 7th, 1983, we were informed that consideration was being given to extending the west retaining wall approximately 100 metres beyond its initially proposed location. Boreholes 12 to 15 were put down on January 20th and 31st, 1984 to investigate the above area. A brief letter dated February 10th, 1984, summarizing the findings of the supplementary boreholes and

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## 2.0 PROCEDURE AND EQUIPMENT (continued)

providing general geotechnical recommendations for retaining wall design was submitted.

It is understood that the retaining wall extension is presently not required and alternate methods of slope stabilization will be used in the subject area. We have, therefore, limited the revision of this report to the additional of the factual information for the west extension area.

All boreholes, with the exception of Boreholes 6, 8, 10 and 11 were put down using a track mounted CME 55 power auger drill, (M.T.C. Drill Type 5-2(I)) using hollow stem augers. Due to the steepness of the south slope of Ramp NS-E a portable motorized tripod drill was used to put down Boreholes 6, 8, 10 and 11. Casing, of BW size, was driven into the soil and standard wash boring techniques were used to advance the borehole. Undisturbed and remoulded field vane tests were carried out throughout the silty clay stratum in Boreholes 10, 11 and 14.

Samples were recovered in non cohesive strata using a 51 mm O.D. standard split spoon sampler in conjunction with the Standard Penetration Test. Cohesive soils were recovered using 51 mm and 73 mm O.D. thin wall steel tubes advanced by manual and hydraulic push. Samples were generally recovered at 1.2 metre intervals.

All boreholes encountered underlying compact to very dense strata. Borehole 2 met refusal upon contacting cobbles at a shallow depth into the till. The above auger hole was continued as Borehole 2A which was located about 2 metres to the east.

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## 2.0 PROCEDURE AND EQUIPMENT (continued)

Uncased dynamic cone penetration tests (pentests) were performed adjacent to all boreholes with the exception of Boreholes 6, 8, 10 and 11. A standard 51 mm diameter, 60 degree cone tip was used for each pentest. In general the pentests were driven to refusal (greater than 100 blows per 0.3 metres). The pentests advanced to depths ranging from 2.5 metres in Borehole 3 to 22.6 metres in Borehole 5.

Perforated rigid P.V.C. plastic standpipes were installed in 10 of the boreholes and piezometers were installed in Boreholes 2A and 5. No water level installations, were placed in Boreholes 1, 2, 10, 12 and 15. Water level readings were taken in the standpipes and piezometers at regular intervals during the investigation. The elevation of the above installations and the depth to water level are given in Table 1 in Appendix II.

The samples were transported to our Toronto Soil Mechanics Laboratory for detailed examination and testing. The samples remaining after testing will be stored at this location until January 1st, 1985, at which time they will be disposed of unless otherwise instructed.

The locations of the boreholes of this investigation are shown on a Drawing 470711609-A which accompanies this report. Locations were obtained, by Geocon personnel, by tape measurements which were referenced to the chainage stations marked by stakes on the proposed centreline of the GO ALRT system. Borehole elevations were obtained by levelling referenced to a GO ALRT benchmark, supplied by M.T.C., located 27.3 metres south of Station 11+961.1 and assigned a Geodetic elevation of 88.680 metres.

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### 3.0

#### SITE AND GEOLOGY

The proposed GO ALRT line is to cross the south portion of Durham County, in Pickering Township, about 2 Km north of Lake Ontario. The site is located about 1.7 Km south of the Town of Pickering immediately south of the intersection of the MacDonald Cartier Freeway (Hwy. 401) at Brock Road. The borehole investigation was carried out immediately north of the existing C.N.R. lines at locations ranging from 125 metres west to 100 metres east of Brock Road along the south access ramps to the Freeway.

The topography of the general area is flat with the surrounding land being grass covered or in industrial use. The local drainage has been altered to follow shallow to deep drainage ditches which run parallel to the east-west C.N.R. lines.

The Hwy. 401 access ramps rise about 10 metres above the general level of the railway lines. The sides of the embankments have been constructed at about 2H:1V.

In general the site is underlain by fill and silty clay soil. These strata are underlain by glacial till. Bedrock has been encountered at an elevation of about 76.5 metres in boreholes previously put down throughout the site. The bedrock is a grey to black shale of the Whitby (Billings) formation.

### 4.0

#### SUBSURFACE CONDITIONS

The individual strata and the ground water conditions encountered at the boreholes are described in the following sections.

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#### 4.0 SUBSURFACE CONDITIONS (continued)

##### 4.1 Topsoil

A surficial stratum of topsoil was encountered in Boreholes 1, 2, 3, 6, 7, 9, 12, 13 and 15. This stratum ranges from 0.1 to 0.3 metres in thickness. The topsoil is typically brown to dark brown silty clay with trace to some sand. Roots and organics are present throughout. The topsoil consistency is estimated to range from very soft to stiff.

##### 4.2 Sand, Some Silt to Sand and Silt (Fill)

The surficial topsoil in Boreholes 1, 2, 6, 7, 9 and 15 was underlain by a fill stratum. The fill was encountered as a surficial stratum in Boreholes 4, 5, 8, 10, 11 and 14. The above fill was encountered underlying silty clay in Borehole 12. The stratum ranged in thickness from 0.9 metres in Borehole 8 to 11.0 metres in Borehole 5.

The sand, some silt to sand and silt fill contained trace gravel and trace clay. Occasional layers of silty clay up to 0.6 metres in thickness were encountered within the stratum. Coarse gravel to cobbles was also occasionally encountered in the stratum.

Grain size distribution analyses on selected samples of this stratum are shown as an envelope on Figure 5 in Appendix II. The samples as tested ranged from sand, some silt, trace clay, trace gravel to sand and silt trace gravel.

Recovered samples of the fill were generally dry to moist. The natural moisture content of selected samples as tested ranged from 3.2 to 17.2 percent.

4.0 SUBSURFACE CONDITIONS (continued)

4.2 Sand, Some Silt to Sand and Silt (Fill) (continued)

Standard Penetration Tests carried out in this stratum gave "N" values of 4 to 70 blows per 0.3 metres indicating the relative density of this deposit to be loose to very dense.

4.3 Silty Clay, Some Sand, Trace Gravel (Fill)

The sand, some silt, trace gravel (fill) stratum was underlain by silty clay, some sand, trace gravel (fill) in Boreholes 2 and 6. The subject stratum underlay topsoil in Boreholes 12 and 13. The stratum was 1.9 to 3.0 metres thick in the respective boreholes.

The stratum was generally cohesive however some silt and sand layers were observed. The stratum was brown in colour.

The results of Atterberg Limit Tests are shown on the Plasticity Chart of Figure 1 of Appendix II and indicate the soil to be a low plasticity clay.

Standard Penetration Tests carried out in the stratum yielded values ranging from 6 to 30 blows per 0.3 metres indicating the stratum is of a firm to very stiff consistency.

4.4 Silty Clay, Some Sand and Organics

A stratum of silty clay, some sand and organics was encountered underlying the fill strata at 8 of the borehole locations. The stratum as investigated ranged in thickness from 0.1 to 0.6 metres.

#### 4.0 SUBSURFACE CONDITIONS (continued)

#### 4.4 Silty Clay, Some Sand and Organics (continued)

The stratum was generally dark brown to black in colour however dark green samples were also recovered. The stratum contained a trace to some clay. Roots, grass and other organic fibre in various states of decay were present in the recovered samples. The stratum probably represents the original topsoil stratum which was present at the site prior to the placement of the fill.

The results of Atterberg Limit Tests carried out on samples from Boreholes 2A and 14 indicate the soil to be a low plasticity clay, however the silty clay classification is considered to be more representative of the stratum in general. The test results have been plotted on Figure 2 of Appendix II.

The results of Standard Penetration Tests, carried out within the stratum, indicate that the soil is generally firm to very stiff. A Quick Triaxial Test was carried out on a sample of the stratum recovered from Borehole 2A and yielded an undrained shear strength value of about 205 kPa. The shear strength value measured in this test indicates a hard consistency which is not considered representative of the stratum in general.

#### 4.5 Silty Clay, Trace Sand and Gravel (CL)

The sand and silt fill in Boreholes 8 and 11, and the silt clay, some sand and organics in Boreholes 4, 5, 6, 7, 9 and 10 and the silty clay fill in Borehole 13 is underlain by silty clay, trace sand and gravel. The stratum ranges in thickness from 3.7 metres in Boreholes 7 and 8 to 6.3 metres in Boreholes 6 and 10.

The stratum ranges in colour from brown to grey. Brown and

4.0 SUBSURFACE CONDITIONS (continued)

4.5 Silty Clay, Trace Sand and Gravel (CL) (continued)

grey varves, typically 4 to 8 mm in thickness were frequently encountered in the upper two metres of the stratum.

The results of Atterberg Limit Tests, carried out on selected samples of this stratum, have been plotted on the Records of Boreholes and on the Plasticity Chart of Figure 3 of Appendix II. The results of the tests indicate that the stratum consists of a low plasticity silty clay (CL).

The natural moisture content of samples of the stratum, as tested, ranged from 16.1 to 38.7 percent.

A total of four Quick Triaxial tests were carried out on samples of the stratum and the results of these tests have been plotted on the Record of Boreholes in Appendix I. The undrained shear strength of the samples ranged from 26.8 to 46.4 kPa indicating a firm soil consistency.

In situ vane tests, carried out within the stratum in Boreholes 10 and 11, yielded values of undrained shear strength ranging from 60 to 21 kPa, indicating a stiff to soft soil consistency. In general the shear strength of the soil reduced with depth of penetration into the stratum. Sensitivity of the soil typically ranged from 2 to 6 as determined by a comparison of natural and remoulded shear strength values. Results of the in situ vane tests, and the above quick triaxial tests, have been plotted as undrained shear strength versus depth on Figure 5 in Appendix II.

In situ vane tests carried out within the stratum in Borehole 13 yielded values of undrained shear strength ranging from 65 to 122 kPa, indicating a stiff to very stiff consistency. The

4.0 SUBSURFACE CONDITIONS (continued)

4.5 Silty Clay, Trace Sand and Gravel (CL) (continued)

local deposit of silty clay encountered to the west of Brock Road in the immediate vicinity of Borehole 13 was generally stiffer than the silty clay to the east of the structure. The test results have been plotted on the Record of Borehole 13.

Standard Penetration tests carried out in the stratum yielded "N" values ranging from 45 to 2 blows per 0.3 metres. Very soft to firm soil was encountered over the lower 5 metres of the stratum in Borehole 6.

The unit weight of four samples of the stratum ranged from 17.9 to 21.4 kN/m<sup>3</sup> and are plotted on the Record of Boreholes.

4.6 Silty Sand, Trace Gravel, Trace Clay

The silty clay stratum, in Borehole 13, is underlain by silty sand, trace gravel, trace clay. The stratum is grey in colour and is about 2.2 metres in thickness.

The relative density of the stratum is described as very loose to loose.

4.7 Sand, Some Gravel, Trace Silt

A thin stratum of sand, some gravel, trace silt underlies sand and silt fill in Borehole 12. The relative density of the stratum is described as dense and the soil colour was grey.

4.0 SUBSURFACE CONDITIONS (continued)

4.8 Silt and Sand, Some Gravel, Trace Clay (Till)

Silt and sand, some gravel, trace clay (till) was the deepest stratum encountered in all boreholes. The stratum was present at elevations ranging from 91.1 metres in Borehole 2 to 80.0 metres in Borehole 11. The stratum was penetrated for variable depths, to elevations as low as 78.9 metres, however underlying bedrock was not encountered.

The stratum was brown to grey in colour and frequently exhibited a brown mottled appearance within the upper portion of the stratum. Occasional sand seams were observed in the recovered samples. In general the till becomes more coarse grained with depth. Angular dark grey shale fragments were frequently present in samples recovered from near the base of the sampled stratum. Coarse gravel and cobbles were occasionally encountered during the advance of the auger hole.

Grain size distribution analyses on selected samples of this stratum are shown as an envelope on Figure 6 in Appendix II. The samples as tested ranged from silty sand to silt and sand (till), trace to some gravel and some clay.

The results of one Atterberg Limit Test carried out on the till matrix are plotted on the Plasticity Chart of Figure 4 of Appendix II. The results of the test indicate that the sample is a borderline CL to ML soil which is described as a silt of low plasticity.

The natural moisture content of six samples as tested ranged from 6.1 to 23 percent.

#### 4.0 SUBSURFACE CONDITIONS (continued)

#### 4.8 Silt and Sand, Some Gravel, Trace Clay (Till) (continued)

Standard Penetration Tests carried out in this stratum gave "N" values ranging from 7 to over 100 blows per 0.3 metres indicating the relative density of the stratum ranges from loose to very dense. The relative density of the till generally increases with depth and is typically dense to very dense at depths of 1 to 2 metres below the till surface.

#### 4.9 Ground Water Conditions

At the time of the investigation the ground water level was observed at elevations ranging from 85.5 metres to 89.2 metres. The ground water surface was located within the till stratum in Boreholes 2, 3, 4 and 15 located to the west of Brock Road. The ground water surface was present within the silty clay, trace sand and gravel stratum in Boreholes 5, 8 and 11. Ground water surface was encountered within the fill or in the underlying silt, some sand and organic strata in Boreholes 6, 7, 9, 12 and 13.

A piezometer was installed at elevation 87.3 metres within the fill stratum in Borehole 5. No water level was present within the piezometer during the period of the investigation. In general the fill, located to the west of Brock Road, was moist.

Final water levels were recorded about one month following installation of standpipes and piezometers in Boreholes 2 to 10. The recorded water level is typically at about elevation 87 metres however water levels at elevations 88.1 and 89.4 metres were recorded in Boreholes 7 and 9 respectively.

#### 4.0 SUBSURFACE CONDITIONS (continued)

##### 4.9 Ground Water Conditions (continued)

Water levels in Boreholes 12, 13 and 15 were recorded during the January field investigations, and were encountered at elevations ranging from 87.3 to 88.5 metres.

The groundwater level may be expected to vary seasonally throughout the site.

The depth to ground water and the depth of the piezometer and standpipe installations have been tabulated on Table 1 in Appendix II.

#### 5.0 DISCUSSION AND RECOMMENDATIONS

It is understood that the proposed GO ALRT transit line is to be located between the north piers and north abutment of the Brock Road structure which presently crosses the existing C.N.R. lines. East and west of Brock Road, the north limit of the double track transit line encroaches upon the slope of the embankments which serve as access ramps for Hwy. 401. The above slopes, and the lower portion of the bridge abutment fill, are to be excavated to allow construction of the transit line at a track elevation of about 88.9 metres.



## 5.0 DISCUSSION AND RECOMMENDATIONS (continued)

The structures proposed for the modification of the site, to facilitate the GO ALRT transit line, are as follows:

1. Sheet Pile Wall - North Abutment of Structure
2. Retaining Wall - Embankment West of Brock Road
3. Retaining Wall - Embankment East of Brock Road

In view of the different structures involved and considering the variations in soil conditions throughout the site, the above structures are discussed under separate sections below.

### 5.1 Sheet Pile Wall - North Abutment of Structure

Permanent steel sheet piles, faced with concrete, have been proposed for installation about 9.0 metres north of the centreline of the north piers within the abutment fill of the Brock Road structure. The sheet piles would be situated about 1.9 metres north of the centreline of the proposed north tracks and would be located about 3.4 metres south of the face of the north abutment of the existing structure. The north abutment and the concrete piers of the existing structure are supported by vertical and/or battered steel H piles driven into the underlying till stratum.

The subsurface conditions in the general area of the proposed sheet pile wall were investigated by means of Boreholes 4 and 5 which were located west and east of the north abutment, respectively. Boreholes have been put down previously at the above site, for purposes of design of the existing structures, under M.T.C. W.P. 29-67-07. The approximate locations of the above boreholes are shown on Drawing 470-711-609A at the rear of

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.1 Sheet Pile Wall - North Abutment of Structure (continued)

this report. Based on the above boreholes the proposed sheet piling would penetrate abutment fill consisting of sand some silt to sand and silt of compact to very dense relative density. The fill is underlain by a thin black layer of silt, some sand and organics. Silty clay of a firm to hard consistency was encountered at elevations of 89.6 and 86.5 metres in Boreholes 4 and 5, respectively, underlying the silt stratum. The silty clay is underlain by glacial till of compact to very dense relative density which was encountered at elevation 87.2 and 81.1 metres in the respective boreholes. The till surface slopes downward from west to east in the area of the structure and the till stratum is understood from boreholes previously put down within the site to extend to the underlying bedrock to an elevation of about 76.5 metres.

The depth of penetration of the sheet piling will have to be established during detailed design based on the soil parameters discussed later. However for purposes of discussion and illustration of the subsurface conditions it is assumed that the sheet piling would extend to about elevation 85. On this basis the sheet piling would extend into silty clay and till at the west end, silty clay in the central part and in the east part the sheet piling would extend into fill and silty clay. Therefore the soil profile which provides passive resistance below track level would be variable and would also be affected by the depth and nature of backfill provided below the track. In the same fashion the soil profile and the active earth pressures acting on the back of the sheet pile wall would be variable.

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5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.1 Sheet Pile Wall - North Abutment of Structure (continued)

The following soil parameters are recommended for computation of active and passive earth pressures on the sheet piling for the long term effective stress case.

Material	Estimated Angle of Internal Friction	Effective Cohesion	Unit Weight (kN/m <sup>3</sup> )		
			Soil Above Groundwater Level	Saturated Soil	Submerged Soil
Fill	30°	0	20	21	11.2
Silty Clay	25°	0	20	20	10.2
Till	35°	0	21	22	12.2

For short term conditions at end of construction the above parameters may be used for the fill and till materials in conjunction with an undrained shear strength of 40 kPa for the silty clay stratum.

It is recommended that the groundwater level be assumed to range from elevation 86 to 88.5 and due allowance would have to be made for the sloping configuration of the fill retained by the sheet pile wall.

Construction of the sheet pile wall will involve driving the steel sheet piles with limited overhead clearance. It may therefore be desirable to carry out excavation so that overhead clearance is increased to facilitate sheet pile installation. This would involve excavation adjacent to the pile supported north abutment of the existing Brock Road structure. It is considered feasible to carry out limited excavation to a depth of about 2 to 3 metres below the existing abutment foundation using a temporary excavation slope no steeper than 1 horizontal to 1 vertical. At the west end of the sheet pile wall penetration

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5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.1 Sheet Pile Wall - North Abutment of Structure (continued)

of the sheet piles into the glacial till stratum would probably be required. The till stratum is very dense below the upper 1 to 2 metres and thus some difficulty should be expected in obtaining significant sheet pile penetration into the till.

It is understood that the sheet pile wall will be tied back to the north abutment of the existing Brock Road structure. We would be pleased to provide geotechnical comments in respect to the tie backs as required during detailed design.

5.2 Retaining Wall - Embankment West of Brock Road

5.2.1 General

A concrete retaining wall has been proposed for construction along the south slope of Hwy 401 Ramp W-NS. The face of the wall is to be located about 3.9 metres north of the centreline of the proposed north GO ALRT track. The retaining wall is to turn southeast, immediately west of the Brock Road Structure, to join the proposed sheet pile wall at 1.9 metres north of the above track. The following discussion refers to the proposed retaining wall to be constructed between Brock Road and GO ALRT station 11+640.

The subsurface conditions along the alignment of the west retaining wall were investigated in Boreholes 1 to 4. In addition a review of available geotechnical reports for the structure and adjoining intersection was carried out. The above information indicates that the access ramp consists of compacted sand and silt fill to clayey silt fill which is separ-

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.2.1 General (continued)

ated from underlying glacial till in Boreholes 2 and 4 by a thin layer of silt, some sand and organics. The glacial till was generally of a compact to very dense relative density and, from boreholes previously put down throughout the site, extends to the underlying bedrock. The till stratum was encountered at elevations ranging from 91.1 to 87.5 metres in Boreholes 1 to 4. The till surface slopes downward to the east between Borehole 2 and Borehole 4. Boreholes carried out under M.T.C. W.P. 29-67-07 for the initial design of the Brock Road structure indicate that the till surface is present at about elevation 86 metres at the west side of the north abutment.

5.2.2 Geotechnical Design

In general the proposed retaining wall may be supported on conventional spread footings founded on the glacial till stratum. The retaining wall foundation should be constructed on undisturbed dense, glacial till founded a minimum of 1.2 metres below final grade to provide sufficient cover for frost protection purposes. Therefore the retaining wall foundation would be founded at or slightly below elevation 87 metres for a proposed track elevation of about 88.9 metres.

The spread foundation of the retaining wall should be designed using a bearing capacity at the S.L.S. Type II of 300 kPa for an estimated post construction settlement of about 25 mm. The factored bearing capacity at the U.L.S., based on the effective foundation width, should be taken as 600 kPa.

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.2.2 Geotechnical Design (continued)

For inclined resultant loads the ultimate bearing capacity should be reduced as specified in the Ontario Highway Bridge Design Code, 1982, Clause 6.7.3.3.5 using the appropriate granular soil curve given in Figure 6.7.3.3.5.

It is recommended that a minimum of 1.2 metres of free draining well graded granular fill be provided behind the retaining wall and that suitable positive drainage be provided to prevent build up of excess hydrostatic pressure. Granular backfill should be compacted to 90 percent of Modified Proctor maximum dry density.

The lateral earth pressure on the retaining wall will have to take into account the sloping configuration of the backfill. At present the final slope of the backfill is not known. For purposes of preliminary design the earth pressure coefficients should be selected based on an effective angle of internal friction of 30 degrees for the backfill and should be used in conjunction with a drained unit weight of backfill equal to 20 kN/m<sup>3</sup>.

Lateral forces on the retaining wall may be resisted by the friction developed between the base of the footing and the natural glacial till stratum. This frictional resistance should be based on ultimate coefficient of friction of 0.4. The extent to which passive resistance is developed at the base of the retaining wall should be established when details of the track bed materials are established.

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.2.2 Geotechnical Design (continued)

Examination of the available subsurface information indicates that the glacial till surface is at elevations ranging from 87.2 at Borehole 4 to 86.0 metres at the west edge of the north abutment. In order to avoid excavation of a deep cut adjacent to the north abutment to reach the till surface it is recommended that the proposed sheet pile wall be extended slightly westward to about Borehole 4 where the retaining wall may be constructed and founded on the glacial till at an elevation of about 87 metres. Our assessment of the soil conditions and general slope configuration indicate that the proposed retaining wall structure will not significantly reduce the overall stability of the embankment. The existing ramp is founded on competent glacial till which has sufficient strength to resist overall or deep-seated instability of the proposed retaining wall structure.

5.2.3 Construction

Construction of the retaining wall will require excavation of both fill and till soils at the slope of the existing embankment. The existing embankment crest rises to about 10 metres above the approximate base of the retaining wall and the existing slopes have been constructed at about 2 horizontal to 1 vertical. The retaining wall will be about 4 to 5 metres in height and safe working space is required at the back of the proposed retaining wall.

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.2.3 Construction (continued)

Consideration was given to carrying out excavation using an unsupported cut slope. This would involve a slope height of about 10 metres mainly within the existing embankment fill. A temporary cut slope of about 1.5 horizontal to 1 vertical or flatter would be required in this instance and the excavation would thus encroach significantly on the paved surface of the access ramp. It therefore appears that a suitably designed system of temporary shoring would be preferable to facilitate construction of the retaining wall and to achieve the required configuration of free draining granular material behind the wall. We would be pleased to provide geotechnical parameters for design of temporary shoring as required during detailed design studies.

5.3 Retaining Wall - Embankment East of Brock Road

5.3.1 General

A concrete retaining wall has been proposed for construction along the south slope of Hwy 401 Ramp NS-E. The wall is to be located at the same offset from the proposed GO ALRT north track as the similar west retaining wall and angles southwest immediately east of Brock Road to join the sheet pile wall discussed earlier in Section 5.1 of this report.

The subsurface conditions at the subject area vary considerably from those underlying the west retaining wall. The subsurface conditions were investigated in Boreholes 5 to 11. The borehole information indicates that the access ramp embankment is constructed of sand and silt fill of generally compact to



5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3 Retaining Wall - Embankment East of Brock Road (cont'd)

5.3.1 General (continued)

very dense relative density. Occasional layers of silty clay were encountered in the fill and clayey silt, of hard consistency, was encountered at the base of the fill stratum in Borehole 6.

The fill is generally underlain by a thin stratum of silt, some sand and organics, dark brown to black in colour, at an elevation of about 86 to 87 metres. A stratum of silty clay of 3.5 to 6.3 metres in thickness underlies the silt stratum. The silty clay is of a very stiff to soft consistency and generally decreases in strength with depth. Soft silty clay was encountered throughout much of the stratum immediately below a very stiff crust in Boreholes 6, 10 and 11. The silty clay stratum is underlain by glacial till, the surface of which was encountered at elevations ranging from 83.5 to 80.1 metres.

5.3.2 Stability Considerations

The stability of the south embankment slope, located to the east of Brock Road, has been analysed in detail. For the purposes of analyses the critical section of the slope was identified in the area of Borehole 6. At this location the silty clay stratum, underlying the embankment fill, is generally of the greatest thickness and typically exhibits the lowest values of undrained shear strength.

A survey was carried out to define the configuration of the slope through Borehole 6 along the section identified on Drawing 470-711-609A. The section analysed extends from south

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.2 Stability Considerations (continued)

of the north set of existing CNR tracks to the north side of the crest of the ramp where the embankment slopes downward to the level of Highway 401.

The slope was analysed, using the ICES LEASE-1 program, for both the total and effective stress case. Stability of the slope was considered to be most critical along deep failure circles which were predominantly within the low strength silty clay stratum and secondarily through the embankment fill. The underlying dense to very dense till was not considered to be a stratum in which critical slope failure circles would be located.

The soil parameters used in the stability analyses are tabulated below. The silty clay stratum has been separated into two layers for the total stress case based on interpretation of standard penetration test results and field vane test results which are plotted as undrained shear strength versus elevation on Figure 7 of Appendix II.

Summary of Soil Parameters

<u>Total Stress Analysis</u>	<u>Unit Weight Above ground- water level (kN/m<sup>3</sup>)</u>	<u>Estimated Angle of Internal Friction (Degrees)</u>	<u>Undrained Shear Strength (kPa)</u>
Sand and Silt Fill	20	30	0
Upper ± 2.5 m of Silty Clay	20	0	50
Lower ± 4.0 m of Silty Clay	20	0	30
Glacial Till	21	35	0

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5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.2 Stability Considerations (continued)

Summary of Soil Parameters (continued)

<u>Effective Stress Analysis</u>	Unit Weight Above ground- water level (kN/m <sup>3</sup> )	Estimated Angle of Internal Friction (Degrees)	Undrained Shear Strength (kPa)
Sand and Silt Fill	20	30	0
Silty Clay	20	25	0
Glacial Till	21	35	0

The results of the stability analyses have been summarized on Table 1 in Appendix III at the rear of this report. The various slope configurations analysed and the related deep seated critical failure circle computed are shown on Figures 1 to 6 in Appendix III. The various total stress and effective stress cases analysed are discussed in detail in the following sections.

5.3.2.1 Total Stress Analyses

A variety of open cut slope configurations and temporary sheet pile wall arrangements were analysed for the total stress condition to examine the stability of the embankment during construction.

The embankment was first analysed for the existing slope conditions which are referred to as Case 1 (see Figure 1 in Appendix III). A factor of safety of 1.22 was computed for the soil parameters selected.

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.2.1 Total Stress Analyses (continued)

Stability analyses were then carried out for cut slopes and temporary sheet pile walls employing a wide excavation at the base of the slope for construction of a permanent retaining wall at the originally proposed location of 3.9 metres north of the centreline of the north set of GO ALRT tracks. The excavation was typically founded at elevation 86.5 metres and extended well within the area proposed for the GO ALRT tracks. The analyses gave computed factors of safety of less than unity and thus the approach of using a wide temporary excavation in the vicinity of the retaining wall and the existing ditch is not recommended.

The general slope configuration was then modified to include infilling of the existing ditch, located between the existing CNR rail lines and the base of the south slope, and the raising of a small berm to elevation 89.0 metres. Three separate cases were analysed for this revised configuration as discussed below.

Case 2 (see Figure 2 in Appendix III) involved the cutting of the existing embankment to a 1.5H:1V slope to allow sufficient room for construction of a permanent retaining wall at the originally proposed location. Stability analyses for this configuration yielded a computed factor of safety of 1.37 for deep seated failure. As previously discussed for construction of the west retaining wall the above configuration requires the excavation of large quantities of earth and consequently a significant portion of the embankment crest would be removed. The remaining road surface would be adjacent to a steep slope of about 10 metres in height. During the construction period increment weather could be expected to result in sloughing of the sand and silt fill slope. For the above reasons it was

## 5.0 DISCUSSION AND RECOMMENDATIONS (continued)

### 5.3.2.1 Total Stress Analyses (continued)

decided to examine alternative methods of providing adequate stability of excavations during construction of the retaining wall.

Case 3 (see Figure 3 in Appendix III) examined the construction of a sheet pile wall, located 6.3 metres north of the centreline of the north set of GO ALRT tracks, to allow construction of the permanent retaining wall at the originally proposed location. This configuration involves a narrow excavation, located immediately south of the sheet pile wall, with a founding elevation of 87.3 metres and the raising of a berm to elevation 89 metres in the area immediately north of the existing CNR lines. The stability analyses for this configuration yielded a computed factor of safety of 1.20 for deep seated failure.

Case 4 (see Figure 4 in Appendix III) examined the construction of a sheet pile wall, located 2.8 metres north of the centreline of the north GO ALRT tracks, and excavation and fill operations similar to those of Case 3. This alternative location would require the design of a non-conventional retaining wall to allow its construction in the limited space remaining between the sheet pile wall and the GO ALRT tracks. Alternatively the sheet pile wall could be designed and constructed as a permanent structure. The results of the stability analysis of this configuration yielded a computed factor of safety of 1.20 for deep seated failure.

The results of stability analyses indicate that special measures are required to maintain an adequate factor of safety with respect to embankment stability during construction of the retaining wall. It appears that the use of a sheet pile wall,

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.2.1 Total Stress Analyses (continued)

as described in Cases 3 and 4 would represent the least suitable approach to excavation in this instance. However the computed factor of safety for these cases may be considered adequate only if the recommended construction procedures discussed later are followed.

5.3.2.2 Effective Stress Analysis

Effective stress analyses were carried out for various final slope configurations to investigate the long term stability of the overall embankment and retaining wall in confirmation.

Case 5 (see Figure 5 in Appendix III) examined the stability of the existing slope. A factor of safety of 1.59 was computed for a potential failure surface extending below the level of the proposed retaining wall. Shallower potential failure surfaces would give somewhat lower factors of safety for the soil parameters selected, but would not be representative for comparison to Case 6 which is discussed below.

Case 6 (see Figure 6 in Appendix III) examined the stability of a permanent retaining wall located 3.9 metres north of the centreline of the north set of GO ALRT tracks. A general ground surface elevation of 88.5 metres south of the retaining wall was used in the analysis. A computed factor of safety of 1.50 was obtained for a failure circle passing immediately below the base of the retaining wall at elevation 86.5. Computed factors of safety greater than 1.50 were obtained for deep or potential failure surfaces.

## 5.0 DISCUSSION AND RECOMMENDATIONS (continued)

### 5.3.2.2 Effective Stress Analysis (continued)

Based on the above analyses it is concluded that adequate long term slope stability will be achieved with the construction of a permanent retaining wall or sheet pile wall located between 3.9 and 1.9 metres north of the centreline of the north set of proposed GO ALRT tracks and provided that the finished grade of the wall is maintained at or above elevation 88.5 metres.

### 5.3.3 Geotechnical Design

The significant soil stratum for support of the retaining wall on spread foundations is the deposit of silty clay. This stratum, below the surficial crust, has an undrained shear strength of about 30 kPa. If the effect of the crust is conservatively neglected and the above undrained shear strength value is used for the silty clay, the factored bearing capacity for the U.L.S. is 75 kPa for strip loading. The bearing capacity for the S.L.S. Type II would be about 60 kPa. It is likely that the above bearing capacities would not be sufficiently high for practical design using spread foundations for the retaining wall.

If spread foundations are not practical, the retaining wall could be supported by piles deriving their support in the glacial till stratum or on the underlying bedrock. As discussed later, it is recommended that low displacement piles, such as H piles, be used to minimize disturbance and remoulding of the clay stratum.

## 5.0 DISCUSSION AND RECOMMENDATIONS (continued)

### 5.3.3 Geotechnical Design (continued)

Based on the Ontario Highway Bridge Design Code 1982 and assuming 310 HP 79 steel H pile sections the factored structural capacity at U.L.S. would be about 1100 KN. The factored capacity of these piles at S.L.S. Type II may be taken as 800 KN for a maximum differential settlement of 25 mm. The above parameters assume that the piles are driven using a diesel hammer rated for a driving energy of about 40,000 to 45,000 joules per blow to a minimum set of 20 blows per 25 mm for the final 75 mm of pile advance.

The piles should be driven to positive end bearing in the till stratum or on bedrock and suitable pile tip protection should be provided. It is possible that the piles would extend to bedrock surface. For estimating purposes the piles may be expected to penetrate to elevations in the range of 78.5 to 76.5 metres.

In general it is recommended that lateral loads be resisted by battered piles.

Lateral earth pressures on the retaining wall and backfill requirements should be in accordance with the criteria for the retaining wall west of Brock Road discussed earlier in Section 5.2 of this report.

### 5.3.4 Construction

Construction of the proposed retaining wall will involve excavation in the lower part of the embankment slope. Excavation using temporary unsupported cut slopes is not considered practical for reasons previously discussed. It is therefore



5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.4 Construction (continued)

suggested that excavation be carried out using a suitably designed system of temporary shoring. We would be pleased to provide geotechnical parameters in respect to design of temporary shoring as required.

Construction of the proposed east retaining wall using temporary shoring must be carried out as per the following sequence and procedure.

- 1) The existing ditch, located between the south slope of the embankment and the existing CNR track, should be infilled and a soil berm should be constructed, to a minimum elevation of 89.0 metres, which extends continuously from the south slope to the edge of the existing CNR tracks. Prior to infilling of the part of the ditch within the limits of the GO ALRT tracks, the requirements of the track bed in respect to stripping and subgrade preparation should be satisfied. Also fill used to raise grade should be of suitable quality for the track bed.
- 2) Temporary sheet piles or shoring should be provided on the existing slope, a distance of no greater than 6.3 metres north of the centreline of the north set of proposed GO ALRT tracks.
- 3) Excavation for construction of the permanent retaining wall should be carried out in alternating sections, of about 15 metres maximum length to provide a favourable three-dimensional effect in respect to embankment stability during construction. Grade within sections of 15 metres in minimum length, located on either side

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5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.4 Construction (continued)

3) (continued)

of the section being excavated, shall remain at or above elevation 88.5 metres, until the excavated section has been permanently backfilled to an elevation at or above 88.5 metres.

- 4) Excavation for construction of the retaining wall foundation should not extend below elevation 87.3 metres. The excavation should have a maximum base width of about 4 metres and should not be wider than 6 metres at elevation 89.0.

In the event that piles are driven along the base of the east embankment to support the retaining wall it is anticipated that the underlying silty clay stratum will be disturbed. The remoulding of the stratum will result in a reduction in the shear strength of the soil which could affect the stability of the temporary shoring. It is therefore recommended that low displacement piles be used for the retaining wall foundation and that consideration be given to the reduced strength of the silty clay in the design of the temporary shoring.

It is recommended that pile installation be carried out under full time engineering supervision. The final set for the piles should be reviewed with respect to the rated energy of the selected hammer prior to construction.

The pattern of pile penetration resistance should be recorded, particularly during final set, to confirm positive end bearing in the till. Provision should be made for redriving piles to verify seating in the till.

**GEOCON**

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.3.4 Construction (continued)

It is also recommended that the allowable pile load be confirmed by load testing.

If the proposed retaining wall is not founded on piles and is supported on a spread type foundation, removal of the silt, some sand and organics stratum, which was typically encountered at elevations of about 86 to 87 metres would be required. However, as discussed above excavation below elevation 87.3 is not recommended for slope stability reasons and thus excavation procedures would have to be reviewed from a geotechnical standpoint if the retaining wall foundation is supported as a strip foundation on the overburden.

5.4 General Design and Construction Considerations

- (i) Spread foundations and pile caps subject to frost action should be provided with at least 1.2 metres of earth cover for frost protection purposes. Special insulation should be provided in the design if the minimum earth cover is not present.
- (ii) Excavation to founding level for the retaining wall west of Brock Road may extend slightly below the groundwater level. The natural glacial till is highly susceptible to disturbance under the effects of seepage pressures and the combination of ponded water and construction traffic. It is therefore recommended that filter equipped sumps be provided to maintain the water level at all times below excavation level and that

5.0 DISCUSSION AND RECOMMENDATIONS (continued)

5.4 General Design and Construction Considerations  
(continued)

the glacial till at founding level be protected by a thin mudmat of lean concrete placed as soon as final excavation level is reached.

- (iii) Compaction of backfill behind retaining walls and within 1.2 metres of the wall should be carried out with light hand operated compaction equipment.

6.0 CLOSURE

The field work for this investigation was carried out by Messrs. T. Hawrysh, J. Zoras and S. Prior. This report was written by Mr. R. W. Browne, P. Eng. and reviewed by Mr. H. L. MacPhie, P. Eng.

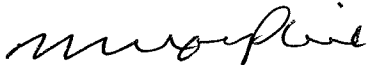
We trust this report is in sufficient detail for your purpose.

In closing, may we express our appreciation for the cooperation extended to us by the M.T.C. Personnel involved on this project.

Yours very truly,  
GEOCON INC.,



R. W. Browne, P.Eng.  
Geotechnical Engineer.



H. L. MacPhie, P.Eng.  
Vice President

RWB/pw  
T10702/35285

**GEOCON**

APPENDIX I

RECORD OF BOREHOLES

**GEOCON**

# EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$kPa^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$m^2/s$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	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 = $\frac{w_L - w_p}{w - w_p}$	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	1, %	VOID RATIO IN LOOSEST STATE	j	$kn/m^3$	SEEPAGE FORCE
$\gamma'$	$kn/m^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 1

METRIC

W P 470-711-609 LOCATION 4 855 178.5N : 339 259.0E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 20 CHECKED BY RWB

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								
91.6	Ground Level												
0.0	Topsoil		1	SS	19								
0.3	Sand, some silt, trace gravel (fill) Very Dense Brown		2	SS	70								
87.9			3	SS	52								
3.7			4	SS	69								
	Silt and Sand, some Gravel, trace clay (till) Very dense Brown to Grey		5	SS	110/0.15m								
			6	SS	115								
			7	SS	74								
80.7			8	SS	85/0.2m								
10.9	End of Borehole												

# RECORD OF BOREHOLE No 2

METRIC

W P 470-711-609 LOCATION 4 855 205.0N ; 339 281.5E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 21 CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH	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									
96.3	Ground Level													
0.0	Topsoil		1	SS	12									
0.2	Sand, some silt, trace gravel (fill)													
94.6	Compact Brown		2	SS	22									
1.7	Silty Clay, some sand trace gravel (fill) occasional sand layers		3	SS	11									
	Stiff to Very Stiff													
91.6	Brown		4	SS	9									
4.7	Silty Clay, some Sand and Organics													
5.2	Silt and Sand some Gravel, trace clay (till)		5	SS	24									
	Compact to Very Dense													
88.2	Brown to Grey		6	SS	60/0.2m									
8.1	End of Borehole													
<p>Note: Borehole 2 terminated upon auger refusal in cobbles. See Record of Borehole 2A for continuation of stratigraphy.</p>														



## RECORD OF BOREHOLE No 2A

METRIC

W P 470-711-609 LOCATION 4 855 205.0N ; 339 281.5E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 22 CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					W <sub>p</sub>	W	W <sub>L</sub>		
96.3	Ground Level							20	40	60	80	100					
0.0	Not Sampled. See Borehole No. 2						96										
							94										
91.1	Silty Clay, some Sand and Organics		7	TW	PH		92				205					18.46	
5.2							90										
							88										
			8	SS	104		86										
	Silt and Sand some Gravel, trace clay (till)		9	SS	54		84										
	Dense to Very Dense		10	SS	38		82										
	Brown to Grey		11	SS	40		80										
			12	SS	86												
79.5																	
16.8	End of Borehole																
	Note: Borehole 2A located adjacent to Borehole 2. See Record of Borehole 2 for stratigraphy from 0.0 to 8.1 metres																

## RECORD OF BOREHOLE No 3

METRIC

W P 470-711-609 LOCATION 4 855 210.0N ; 339 315.8E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 21 CHECKED BY RWB

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	20 40 60 80 100					
90.9	Ground Level													
0.0	Topsoil		1	SS	16									
0.3			2	SS	40									
			3	SS	29									
	Silt and Sand, some gravel, trace clay (till)		4	SS	30									
	Compact to Very Dense		5	SS	31									
	Brown to Grey		6	SS	85									
			7	SS	74									
79.8			8	SS	100/0.2m									
11.1	End of Borehole													

## RECORD OF BOREHOLE No 5

METRIC

W P 470-711-609

LOCATION 4 855 266.5N ; 339 375.5E

ORIGINATED BY TH

DIST 6 HWY GO ALRT

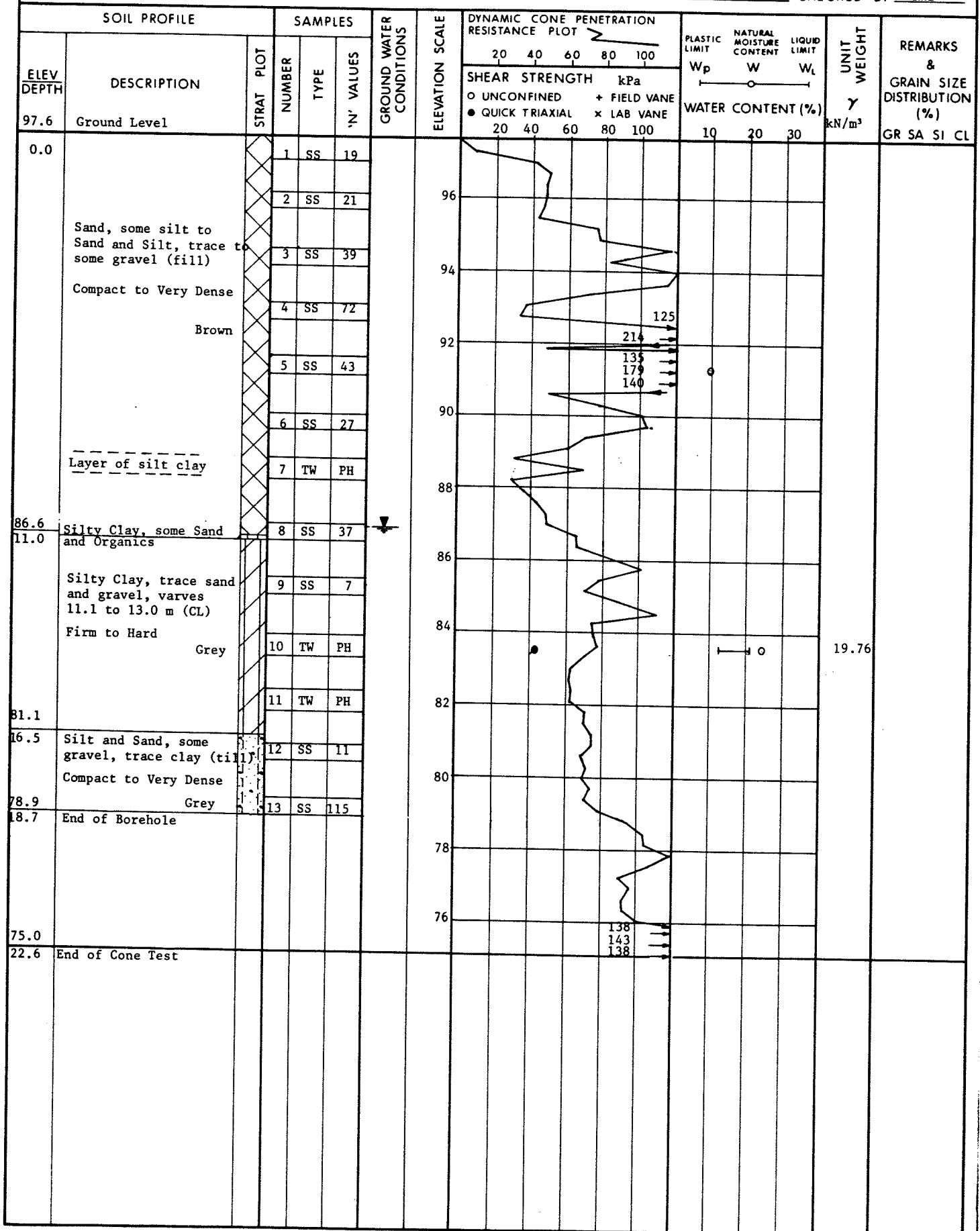
BOREHOLE TYPE Hollow Stem Auger &amp; Cone Test

COMPILED BY GAB

DATUM Geodetic

DATE 1983 07 26

CHECKED BY RWB



## RECORD OF BOREHOLE No 6

METRIC

W P 470-711-609

LOCATION 4 855 260.5N ; 339 396.5E

ORIGINATED BY TH

DIST 6 HWY GO ALRT

BOREHOLE TYPE Motorized Tripod Drill

COMPILED BY GAB

DATUM Geodetic

DATE 1983 07 26

CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
90.1	Ground Level																
0.1	100 Topsoil		1	SS	4												
88.9	Sand, some silt, trace gravel (fill) Loose Brown																
1.2	Silty Clay, some sand trace gravel (fill) Hard Brown		2	S	34												
86.7			3	SS	10												
3.4	Silty Clay, some Sand and Organics																
3.7			4	SS	19												
	Silty Clay, trace sand and gravel, varves 3.7 to 5.7 m (CL) Very Stiff to Very Soft Grey		5	SS	2												
			6	TW	PM												
			7	SS	2												
80.1																	
10.0																	
79.5	Silt and Sand (till)		8	SS	29												
10.6	End of Borehole																

## RECORD OF BOREHOLE No 7

METRIC

W P 470-711-609 LOCATION 4 855 285.0N ; 339 406.0E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 27 CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
96.6	Ground Level													
0.0	100 Topsoil		1	SS	19									
			2	SS	23									
	Sand, some silt to Sand and Silt, trace gravel (fill) Compact to Dense Brown		3	SS	23									
			4	SS	41									
			5	SS	33									
			6	SS	20									
87.2	Silty Clay, some Sand and Organics		7	SS	18									
9.4			8	SS	17									
	Silty Clay, trace sand and gravel (CL) Firm to Very Stiff Brown to Grey		9	TW	PH									
83.5			10	SS	38									
13.1	Silt and Sand, some gravel, trace clay (till) Dense to Very Dense Grey		11	SS	72									
79.4			12	SS	56									
17.2	End of Borehole													

## RECORD OF BOREHOLE No 8

METRIC

W P 470-711-609 LOCATION 4 855 286.4N ; 339 430.0E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Motorized Tripod Drill COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 27 CHECKED BY RWB

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					
88.0	Ground Level																
0.0	Sand, some silt, trace gravel (fill)		1	SS	5												
87.1	Loose Brown																
0.9	Silty Clay, trace sand and gravel (CL)		2	SS	11												
	Stiff																
	Brown to Grey		3	SS	8												
83.4																	
4.6	Silt and Sand, some gravel, trace clay (til)		4	SS	7												
82.1	Loose to Dense Grey		5	SS	44												
5.9	End of Borehole																

## RECORD OF BOREHOLE No 9

METRIC

W P 470-711-609 LOCATION 4 855 306.5N ; 339 437.4E ORIGINATED BY TH  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY GAB  
 DATUM Geodetic DATE 1983 07 28 CHECKED BY RWB

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
95.4	Ground Level														
0.0	90 Topsoil		1	SS	25										
	Sand, some silt to sand and silt, trace gravel (fill)  Compact to Dense  Brown		2	SS	26										
			3	SS	31										
			4	SS	42										
			5	SS	36										
			6	SS	16										
86.3		Silty Clay, some Sand and Organics		7	SS	20									
9.1	Silty Clay, trace sand and gravel (CL)  Firm to Very Soft  Grey		8	SS	4										
9.4			9	TW	PH										
			10	SS	17										
81.4	Silt and Sand, some gravel trace clay (till)														
14.0	Very Dense Grey														
79.8			11	SS	50/0	0.08m									
15.6	End of Borehole														

# RECORD OF BOREHOLE No 10

METRIC

W P 470-711-609 LOCATION 4 855 259.5N ; 339 393.2E ORIGINATED BY JZ  
 DIST 6 HWY GO ALRT BOREHOLE TYPE MOTORIZED TRIPOD DRILL COMPILED BY GAB  
 DATUM Geodetic DATE 1983 08 30 CHECKED BY RWB

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					
90.3	Ground Level																
0.0	Sand, some silt trace gravel (fill) Compact Brown		1	SS	18	No Water Level Recorded	90										
			2	SS	38		88										
86.8			3	SS	13												
3.5	Silty Clay, some Sand and Organics		4	SS	45		86										
3.7	Silty Clay, trace sand and gravel (CL) Very Stiff to Firm Brown to Grey		5	SS	21		84										
			6	SS	6		82										
80.3																	
10.0	End of Borehole																



## RECORD OF BOREHOLE No 11.

METRIC

W P 470-711-609 LOCATION 4 855 255.7N ; 339 401.5E ORIGINATED BY JZ  
DIST 6 HWY GO ALRT BOREHOLE TYPE MOTORIZED TRIPOD DRILL COMPILED BY GAB  
DATUM Geodetic DATE 1983 08 31 CHECKED BY RWB

[illegible]

# RECORD OF BOREHOLE No 12

METRIC

W P 470-711-609 LOCATION 4 855 165.7 N ; 339 239.1 E ORIGINATED BY SRP  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
 DATUM Geodetic DATE 1984 01 20 CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	Wp	W	W <sub>L</sub>	10 20 30		
91.2	Ground Level													
0.0	Topsoil						91							
0.2	Silty Clay, some sand, trace gravel (fill) Firm to very stiff Brown		1	SS	25		90							
89.1							89							
2.1	Sand, some silt to Sand and Silt trace gravel, trace clay (fill) Very Dense Brown to Grey Brown		2	SS	68		88							
86.7							87							
4.5	Sand, some gravel trace		3	SS	46		86							
86.4	silt Dense Gray						85							
4.8	Silt and Sand, some gravel, trace clay (till) Dense to Very Dense Grey		4	SS	72		84							
			5	SS	78		83							
							82							
81.6			6	SS	73									
9.6	End of Borehole													

## RECORD OF BOREHOLE No 13

METRIC

W P 470-711-609 LOCATION 4 855 103.2 N ; 339 251.0 E ORIGINATED BY SRP  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
 DATUM Geodetic DATE 1984 01 20 CHECKED BY RWB

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			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
90.9	Ground Level							20 40 60 80 100							
0.0	Topsoil														
0.2	Silty Clay, some sand, trace gravel (fill)														
	Firm														
	Brown		1	SS	6										
87.9															
3.0	Silty Clay, trace to some sand		2	TW	PM										
	Stiff to Very Stiff														
	Grey		3	TW	PM										
			4	TW	PM										
83.3															
7.6	Silty Sand, trace gravel, trace clay		5	TW	PM										
	Loose to Very Loose														
	Grey														
			6	SS	2										
81.1															
9.8	Silt and Sand, some clay trace of gravel (till)														
	Occasional shale fragments														
80.1	Very Dense														
	Grey														
			7	SS	100/0.12m										
10.8	End of Borehole														

# RECORD OF BOREHOLE No 14

METRIC

W P 470-711-609 LOCATION 4 855 142.0 N; 339 246.0 E ORIGINATED BY SRP  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AEL  
 DATUM Geodetic DATE 1984 01 31 CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT		UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		W <sub>p</sub>	W			W <sub>L</sub>
								SHEAR STRENGTH kPa						
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		20 40 60 80 100		10 20 30				
94.1	Ground Level													
0.0	Sand and Silt, some gravel, trace clay (Fill) Compact  Brown					No Water Level Recorded	94	Augered						
			1	SS	27		93							
							92							
91.0	100 mm Sand Layer				91									
3.1	Silty Clay, some Sand and Organics		2	SS	5									
90.4														
3.7	Silt and Sand, some gravel, trace clay (Till)  Dense to Very Dense  Grey													
			3	SS	37	90								
						89								
			4	SS	44	88								
						87								
			5	SS	45									
			6	SS	83									
84.5														
9.6	End of Borehole													

## RECORD OF BOREHOLE No 15

METRIC

W P 470-711-609

LOCATION 4 855 055.9 N ; 339 221.2 E

ORIGINATED BY SRP

DIST 6 HWY GO ALRT

BOREHOLE TYPE Hollow Stem Auger and Cone Test

COMPILED BY AEL

DATUM Geodetic

DATE 1984 01 31

CHECKED BY RWB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
91.0	Ground Level													
0.0	Topsoil													
0.2	Sand and Silt, some gravel, trace clay (Fill)  Very Dense  Brown		1	SS	55									
88.3														
2.7	Silt and Sand, some gravel, trace clay (Till)  Dense to Very Dense  Grey		2	SS	57									
			3	SS	42									
84.4			4	SS	49									
6.6	End of Borehole													

# RECORD OF BOREHOLE No 1 (Previous Investigation)

METRIC

W P 29-67-07 (470-711-609) LOCATION 4 855 249.1N; 339 359.7E ORIGINATED BY Others  
 DIST 6 HWY GO ALRT BOREHOLE TYPE Washboring - NX Casing; Cone COMPILED BY  
 DATUM Geodetic DATE 1969 08 08 (1984 02 23) CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>		
87.9	Ground Level												
0.0	Topsoil											kg/m <sup>3</sup>	GR SA SI CL
0.3	Silty Clay with some sand trace gravel. Stiff to Very Stiff		1	SS	12		86						
			2	SS	16								
84.8			3	TW	PM							2290	9 44 39 8
3.1	Glacial Till, Het-mix. silt, sand & gravel, trace to some clay Compact to Very Dense Grey		4	SS	14		84						12 43 41 4
			5	SS	38		82						24 48 (28)
			6	SS	79		80						
			7	SS	99								
79.3			8	SS	100/0.1m								
8.6	with occ. boulders up to 240 mm size & shale fragments		10	SS	150/0.2m		78						6 44 44 6
77.2													
76.8	Weathered		12	SS	100/0.1m								
11.1	Shale Bedrock Sound		13	RC AXT	80%		76						
75.1			14	RC AXT	90%								
12.8	End of Borehole												

# RECORD OF BOREHOLE No 1A

METRIC

 W P 29-67-07 (470-711-609) LOCATION 4 855 236 N; 339 346.0E

 ORIGINATED BY Others

 DIST 6 HWY GO ALRT BOREHOLE TYPE Dynamic Cone Test

COMPILED BY \_\_\_\_\_

 DATUM Geodetic DATE 1969 08 08 (1984 02 23)

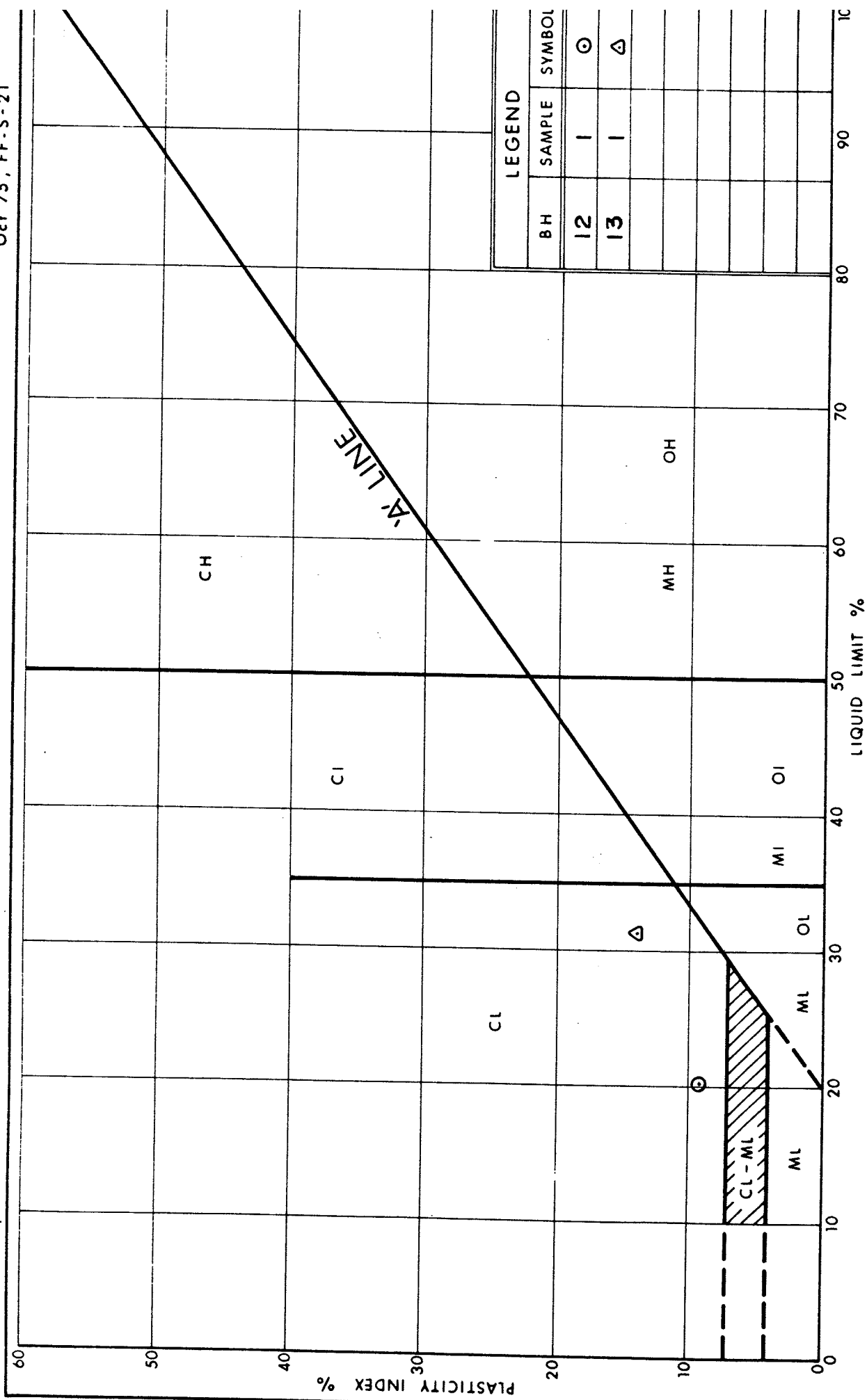
CHECKED BY \_\_\_\_\_

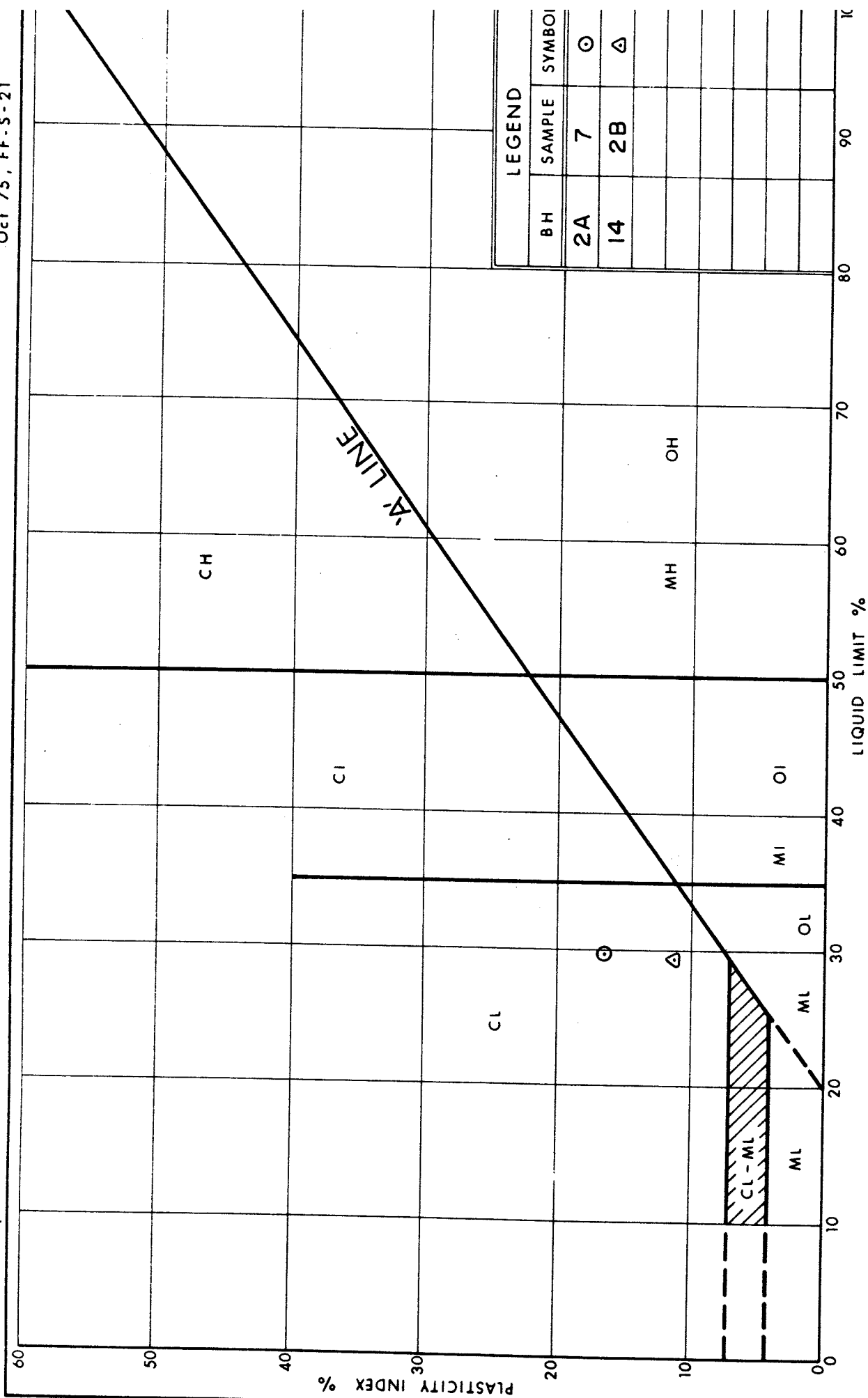
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
88.8	Ground Level												
0.0	Probably Silty Clay						88						
86.3													
2.4	Probably Glacial Till						86						
84.3													
4.5	End of Cone Test												Practical refusal

## APPENDIX II

- Figure 1 Plasticity Chart  
Silty Clay  
Some Sand, Trace Gravel  
(Fill)
- Figure 2 Plasticity Chart  
Silty Clay  
Some Sand and Organics
- Figure 3 Plasticity Chart  
Silty Clay
- Figure 4 Plasticity Chart  
Silt and Sand (Till)
- Figure 5 Grain Size Distribution  
Sand (Fill)
- Figure 6 Grain Size Distribution  
Silty Sand to Silt and Sand  
(Till)
- Figure 7 Undrained Shear Strength  
versus Elevation  
Silty Clay
- Table 1 Groundwater Levels

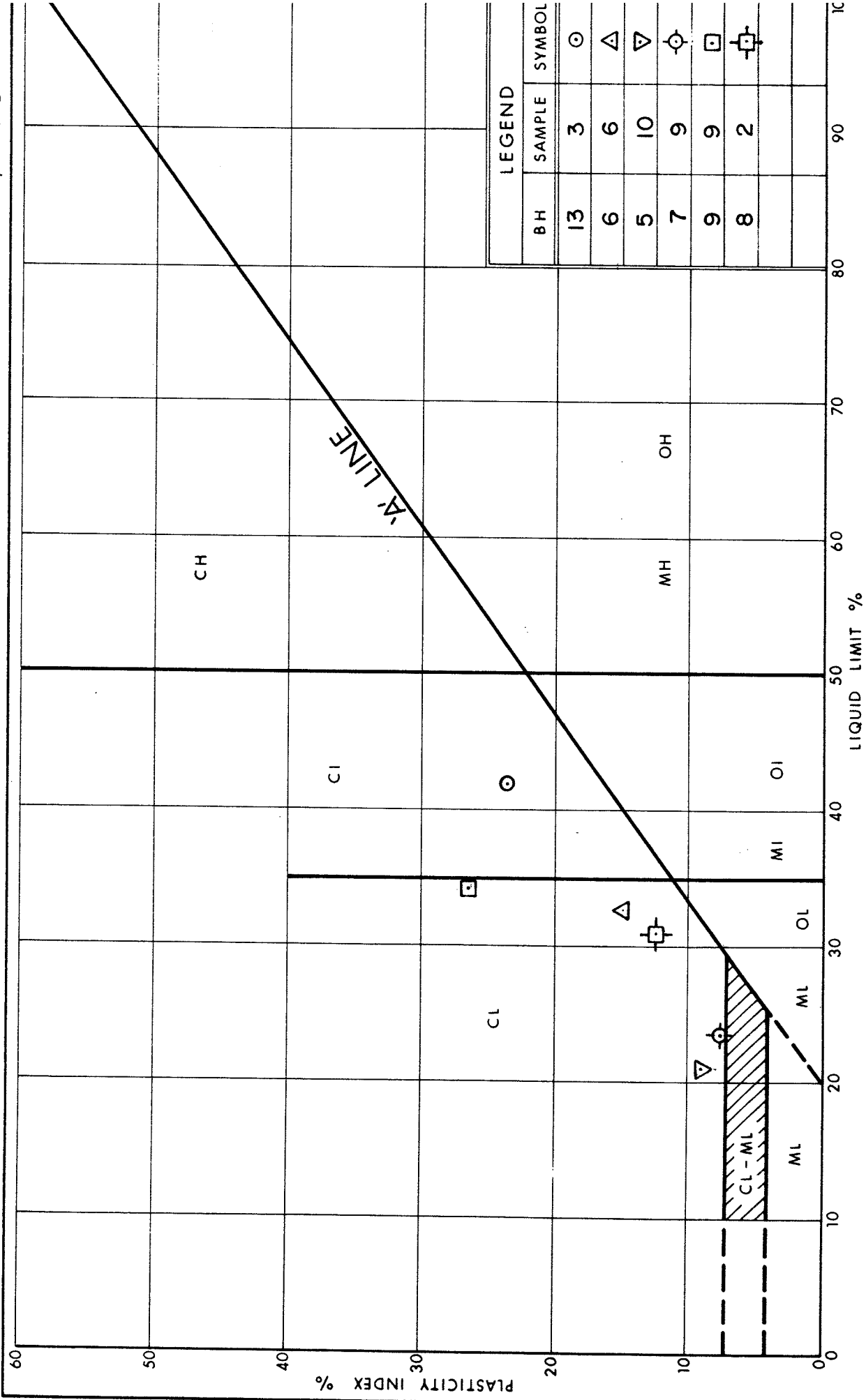






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Transportation and  
Communications

PLASTICITY CHART  
SILTY CLAY  
SOME SAND & ORGANICS

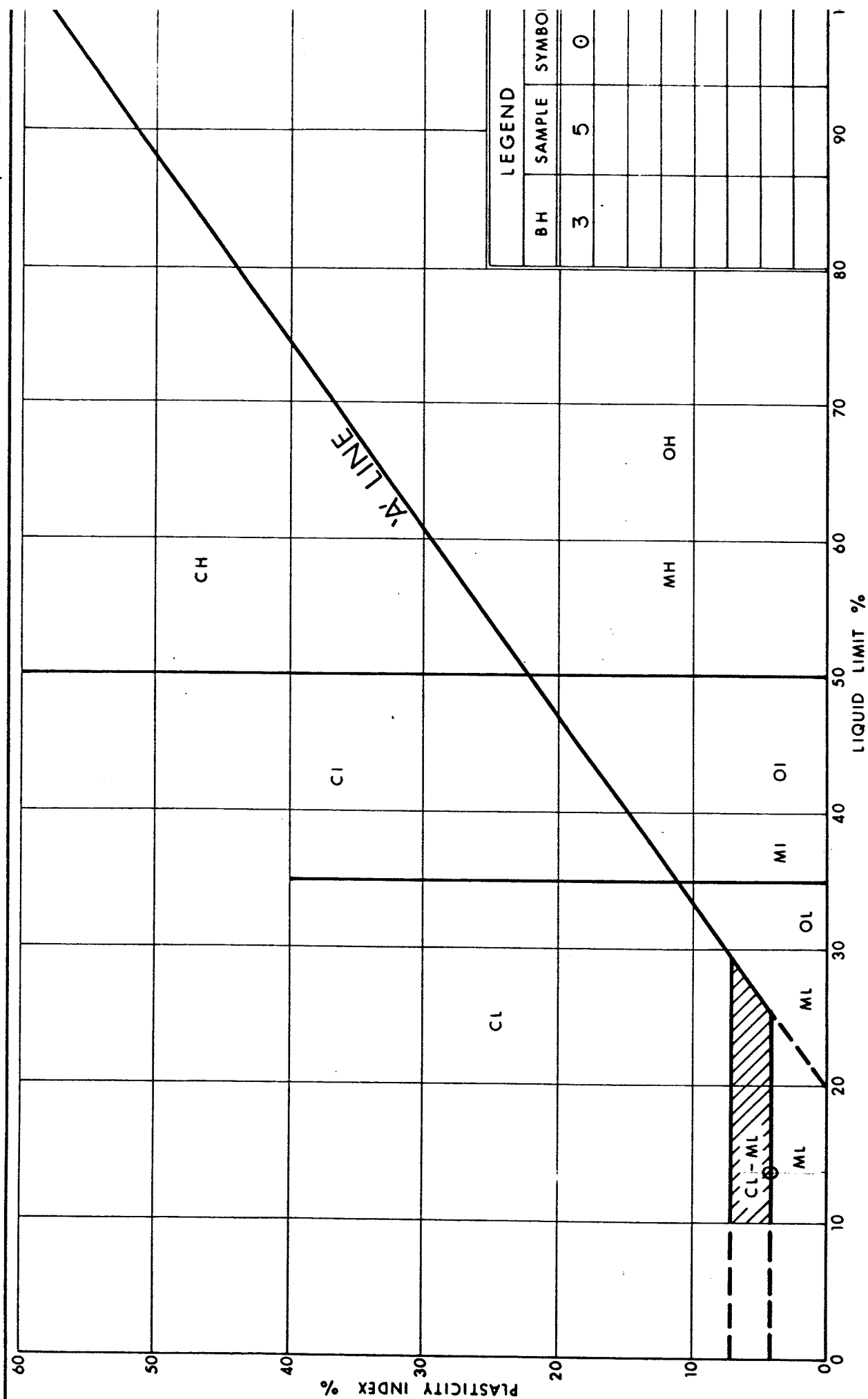


LEGEND		
BH	SAMPLE	SYMBOL
13	3	Circle with a dot
6	6	Triangle
5	10	Inverted Triangle
7	9	Circle with a cross
9	9	Square with a cross
8	2	Square with a cross

**PLASTICITY CHART**  
**SILTY CLAY**  
**TRACE SAND AND GRAVEL**

FIG No 3

W P 470-711-609

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PLASTICITY CHART  
SILT AND SAND (TILL),  
SOME GRAVEL, TRACE CLAY

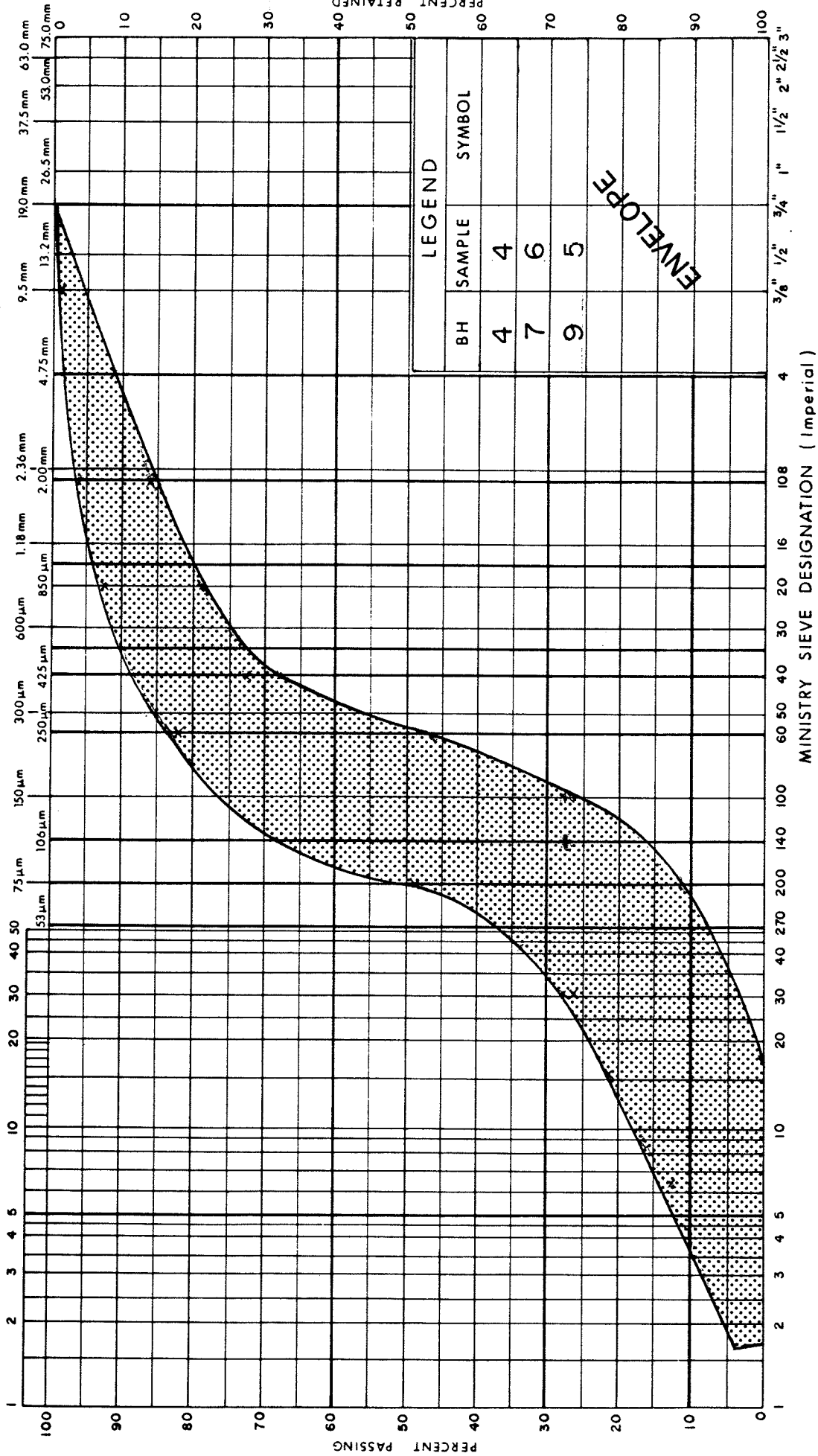
FIG No 4

WP 470-711-609

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse
MINISTRY SIEVE DESIGNATION (Metric)						

GRAIN SIZE IN MICROMETERS



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GRAIN SIZE DISTRIBUTION  
SAND (FILL)  
SOME SILT TO SAND AND SILT,

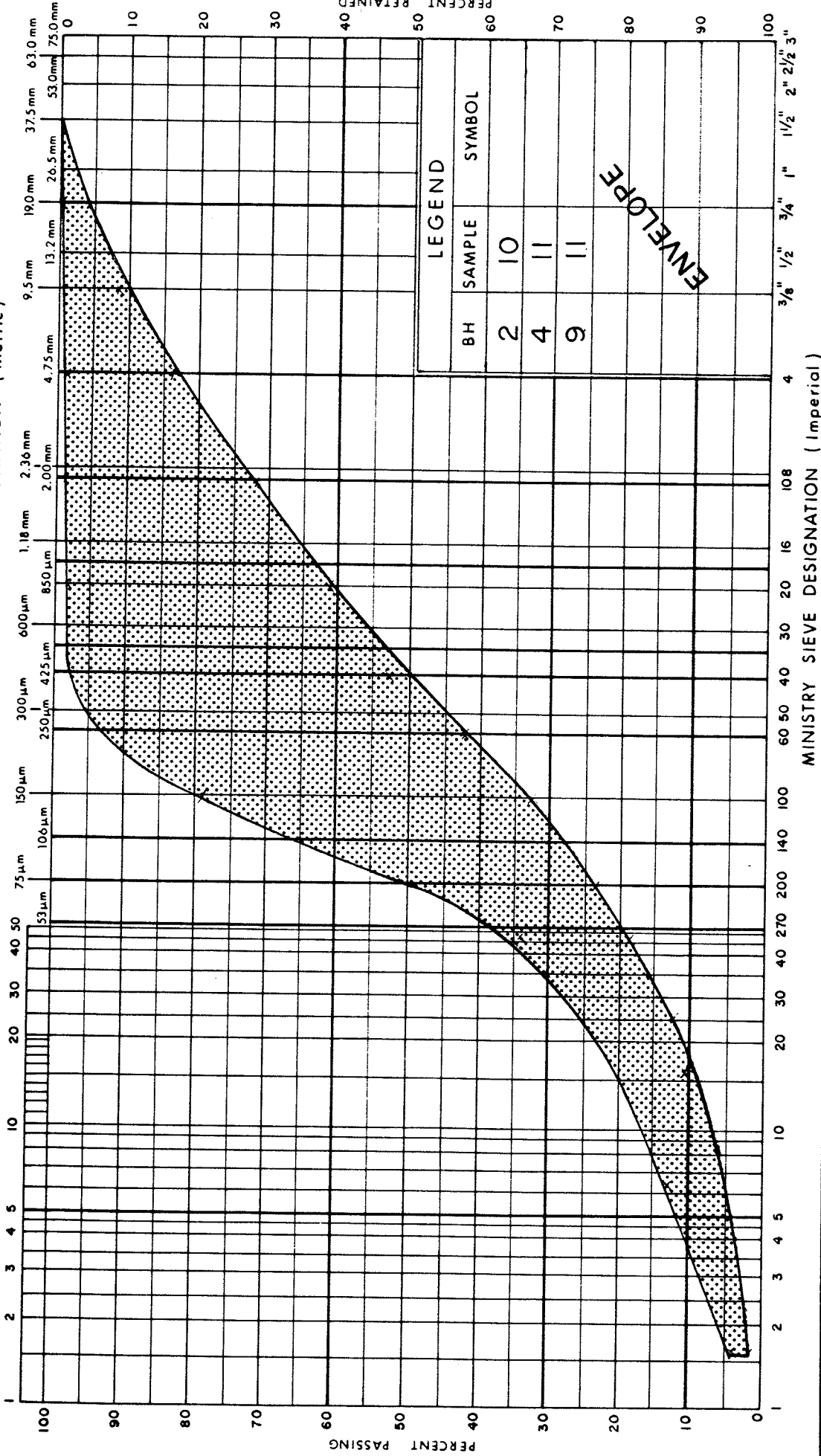
FIG No 5  
W P 470-711-609

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## LEGEND

BH	SAMPLE	SYMBOL
2	10	
4	11	
9	11	

ENVELOPE

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Communications



GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SILT AND SAND (TILL)  
TRACE TO SOME GRAVEL, TRACE CLAY

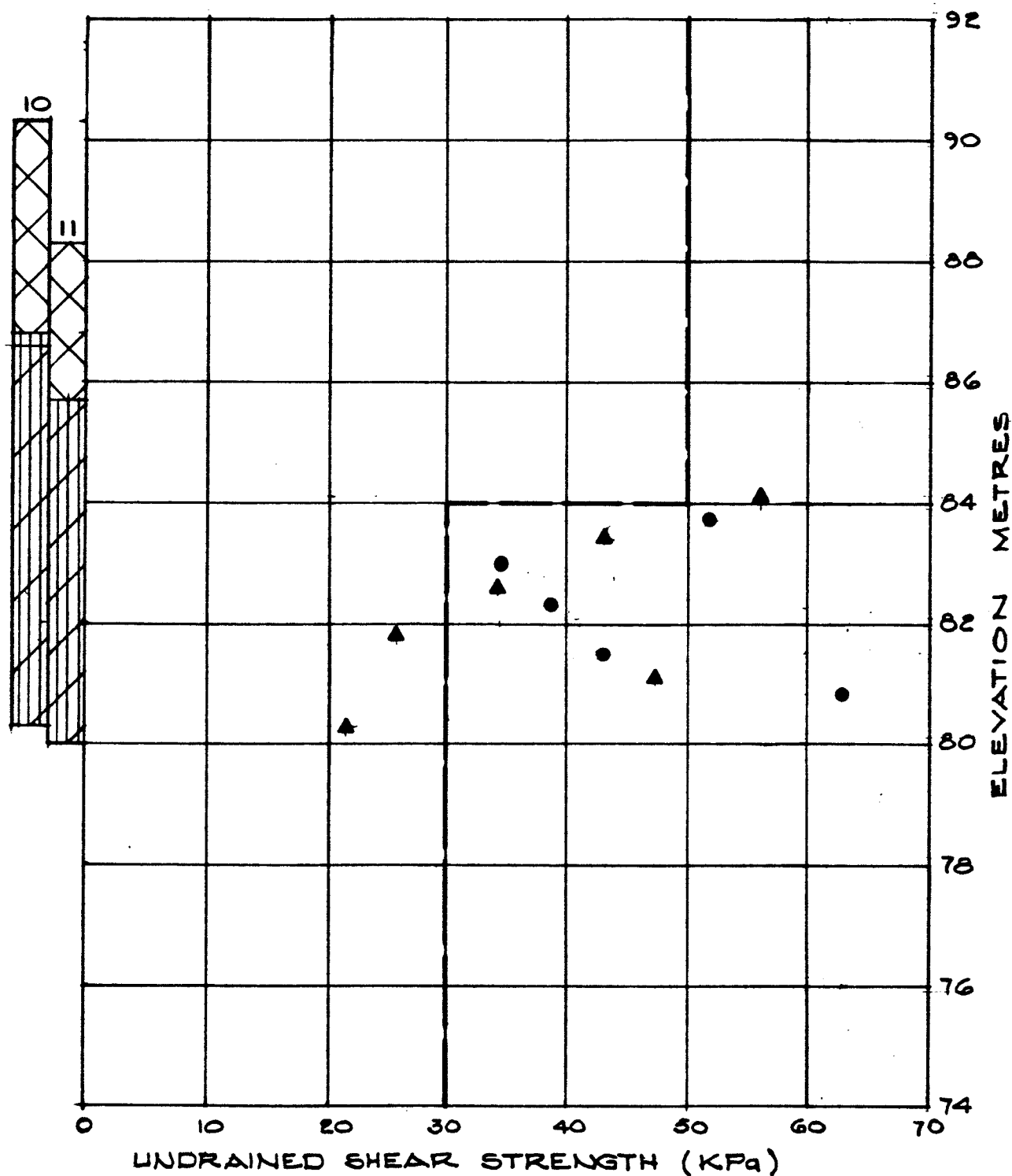
FIG No 6

W P 470-711 - 609

# UNDRAINED SHEAR STRENGTH VERSUS ELEVATION SILTY CLAY

APPENDIX II  
FIGURE 7  
WP 470-711-690

FIELD VANE  
BOREHOLE 10  
BOREHOLE 11



GEOCON

TABLE 1

GROUNDWATER LEVELS

Borehole Number	Ground Elevation	Depth (m)		Depth to Water Level (m)						
		To Bottom of Standpipe	To Bottom of Piezometer	1983						
				07/22	07/25	07/26	07/27	07/28	08/02	08.31
1	91.63	*	*							
2A	96.29		12.47		9.17	9.24	9.27	9.27	9.24	9.35
3	90.90	8.89		6.07	3.89	3.96	3.89	3.86	3.86	3.94
4	97.56	13.92				10.08		10.13	10.19	10.24
5	97.62		10.36					Dry	Dry	Dry
5	97.62	18.64						12.17	12.17	10.72
6	90.16	10.59						3.40	3.48	3.51
7	96.65	9.14						6.20	8.51	8.56
8	88.02	5.44						1.42	1.47	1.37
9	95.40	6.10						Dry	6.20	6.05
10	90.30	*	*							
11	88.30	3.20								2.77
				Depth to Water Level (m)						
				01/20	01/31	1984				
12	91.20	*	*			4.00**				
13	90.90	10.50				2.40				
14	94.10	*	*							
15	91.00							3.65**		

\* No Standpipe or Piezometer installed in Boreholes 1, 10, 12, 14 and 15

\*\* Water level in open hole



### APPENDIX III

- Table 1    Summary of Stability Analyses Results  
          Stability Analysis Section  
          Embankment East of Brock Road
- Figure 1   Case 1  
          Existing Slope Conditions  
          Total Stress Analysis
- Figure 2   Case 2  
          1.5H:1V Cut Slope  
          Total Stress Analysis
- Figure 3   Case 3  
          Sheet Pile Wall  
          6.3 m North of Centreline of  
          North GO ALRT Track  
          Total Stress Analysis
- Figure 4   Case 4  
          Sheet Pile Wall  
          2.8 m North of Centreline of  
          North GO ALRT Track  
          Total Stress Analysis
- Figure 5   Case 5  
          Existing Slope Conditions  
          Effective Stress Analysis
- Figure 6   Case 6  
          Permanent Retaining Wall  
          6.3 m North of Centreline of  
          North GO ALRT Track  
          Effective Stress Analysis

SUMMARY OF STABILITY ANALYSES RESULTS

STABILITY ANALYSIS SECTION

EMBANKMENT EAST OF BROCK ROAD

	<u>Case No.</u>	<u>Case Description</u>	<u>Computed Factor of Safety</u>
Total Stress Analysis			
	1	Existing Slope Conditions	1.22
	2	1.5H:1V Cut Slope	1.37
	3	Sheet Pile Wall 6.3 m North of Centreline of North GO ALRT Track	1.20
	4	Sheet Pile Wall 2.8 m North of Centreline of North GO ALRT Track	1.20
Effective Stress Analysis			
	5	Existing Slope Conditions	1.59
	6	Permanent Retaining Wall 6.3 m North of Centreline of North GO ALRT Track	1.50

# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD

## CASE . 1

EXISTING SLOPE CONDITIONS

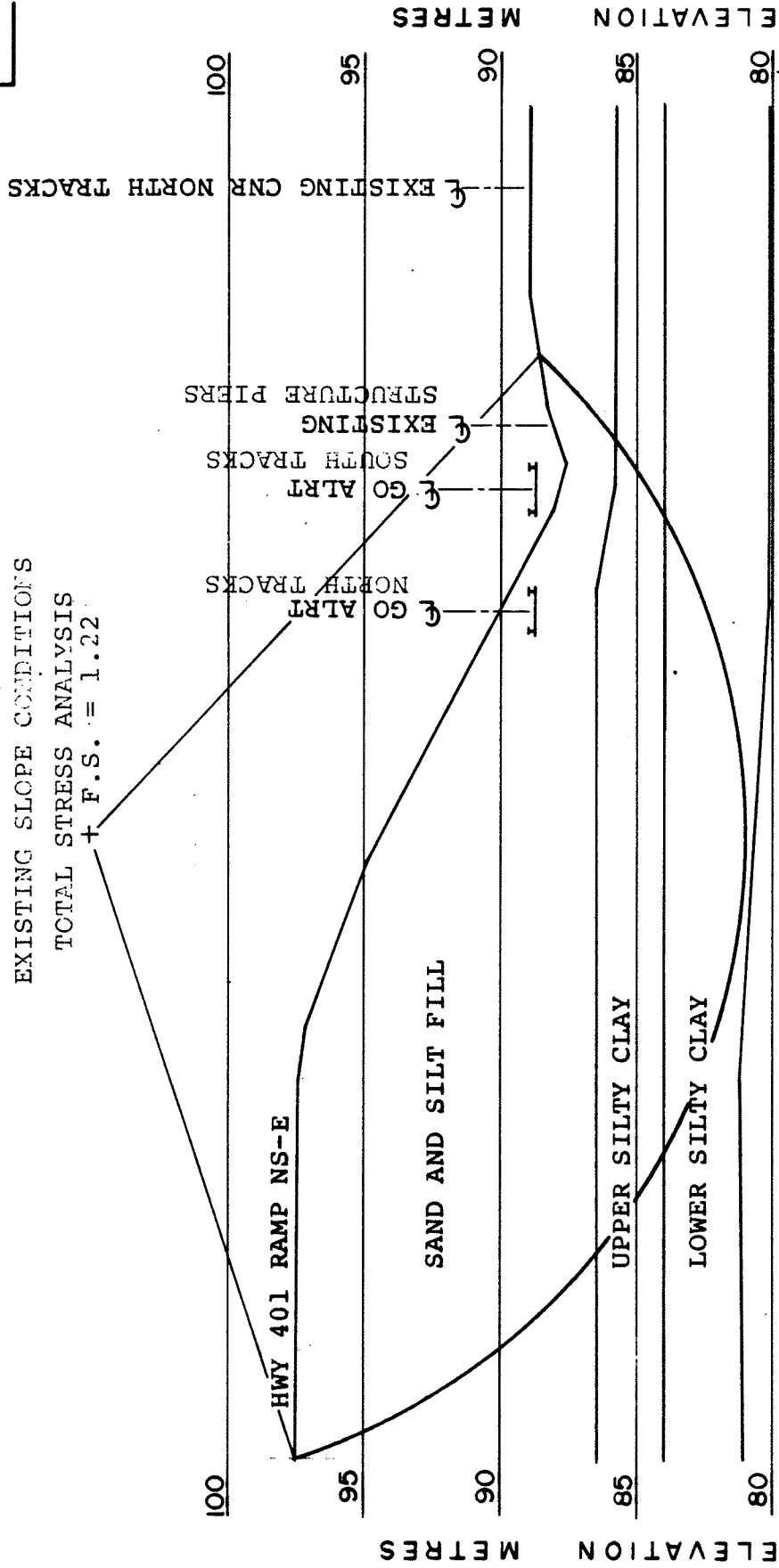
TOTAL STRESS ANALYSIS

+ F.S. = 1.22

APPENDIX III

FIGURE I

W.P. 470-711-609



NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

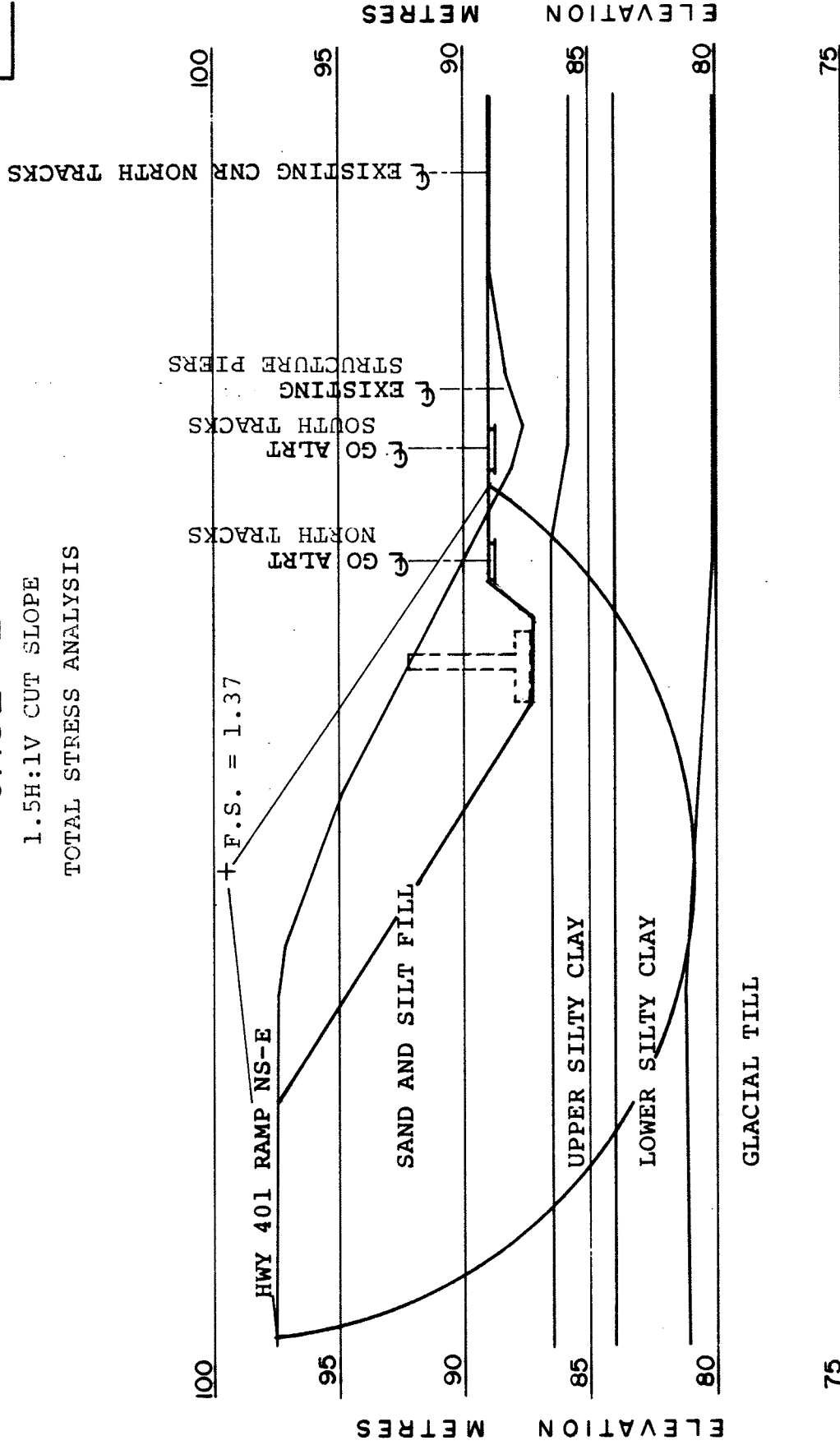
SCALE 1 : 250

# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD CASE 2

APPENDIX III  
FIGURE 2

W.P. 470-711-609

1.5H:1V CUT SLOPE  
TOTAL STRESS ANALYSIS



NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

SCALE 1 : 250

# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD

## CASE 3

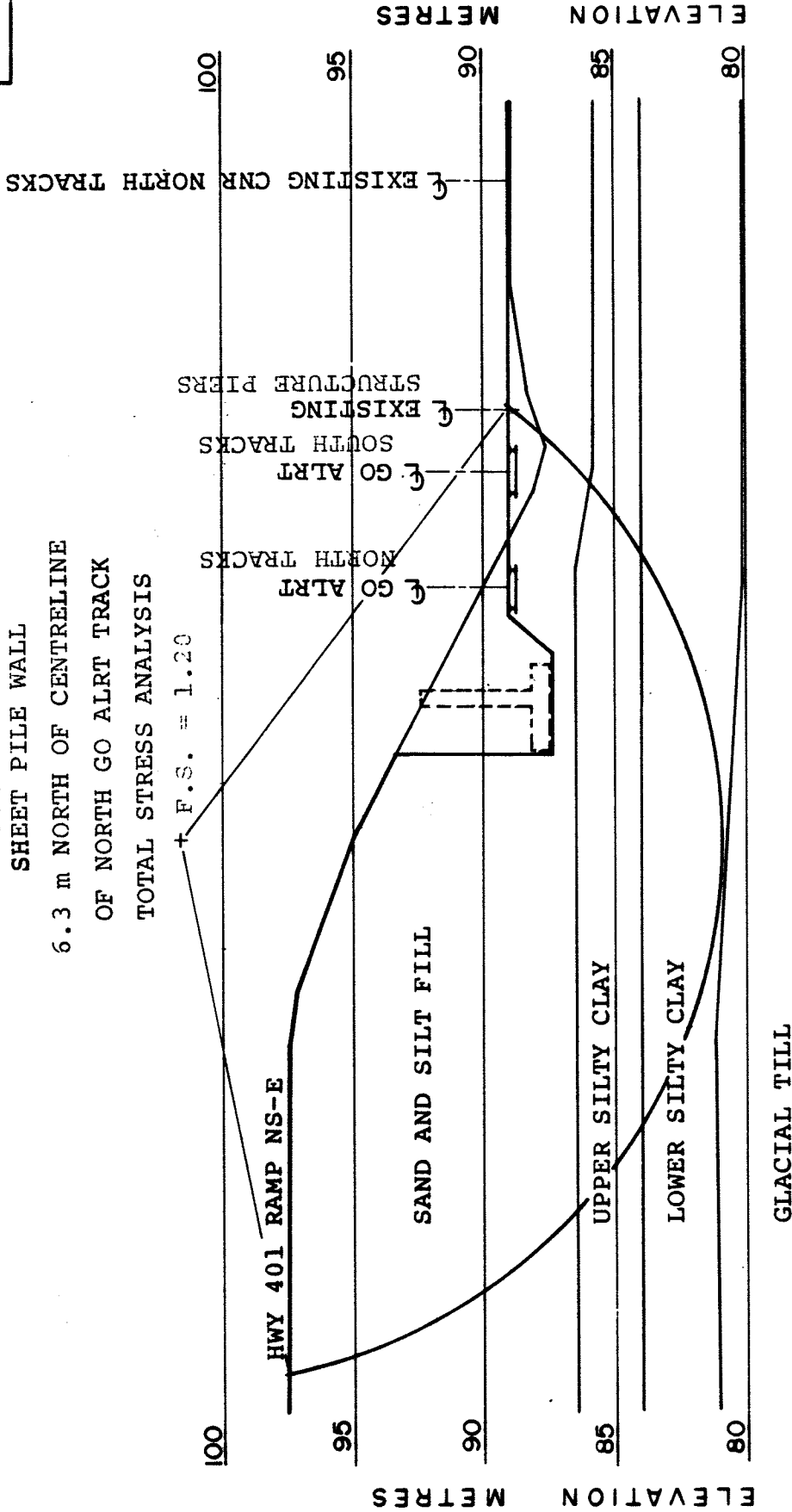
SHEET PILE WALL

6.3 m NORTH OF CENTRELINE

OF NORTH GO ALRT TRACK

TOTAL STRESS ANALYSIS

+ F.S. = 1.20



NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

SCALE 1 : 250

APPENDIX III

FIGURE 3

W.P. 470-711-609

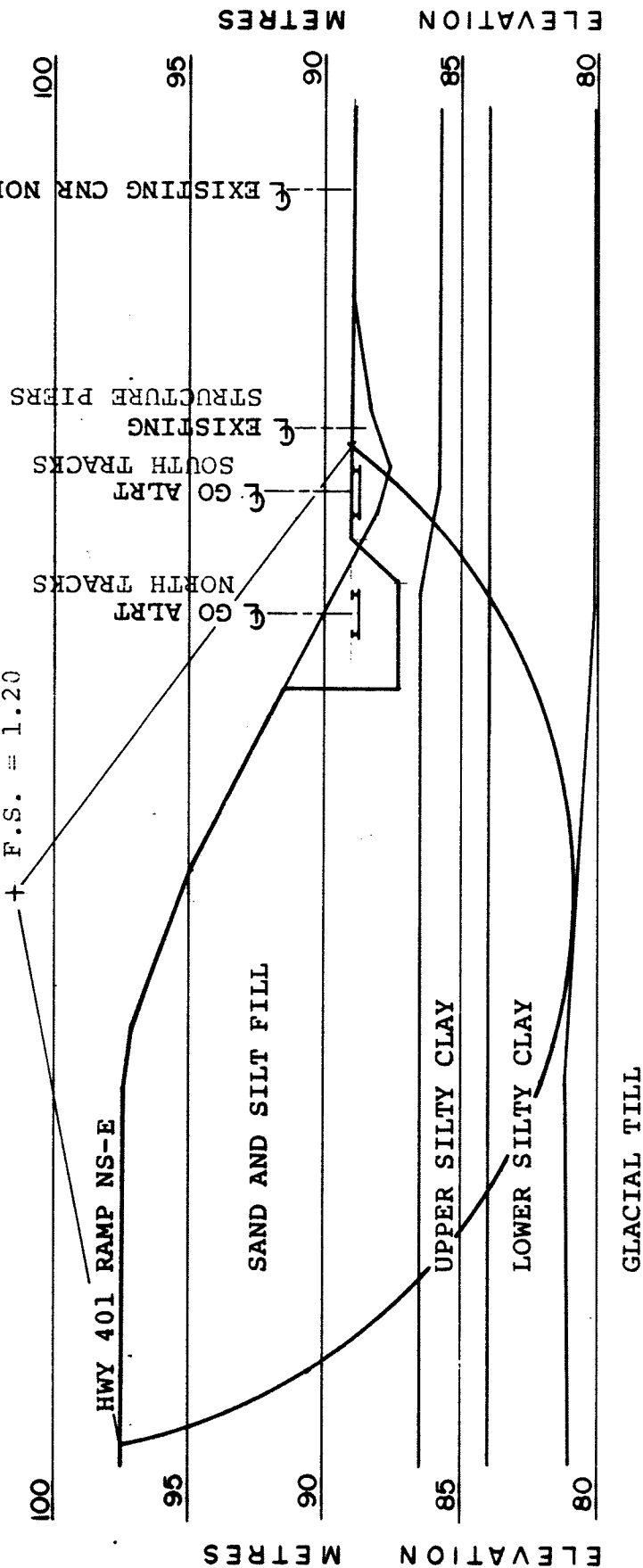
# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD CASE 4

APPENDIX III  
FIGURE 4

W.P. 470-711-609

SHEET PILE WALL  
2.8 m NORTH OF CENTRELINE  
OF NORTH GO ALRT TRACK  
TOTAL STRESS ANALYSIS

+ F.S. = 1.20



NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

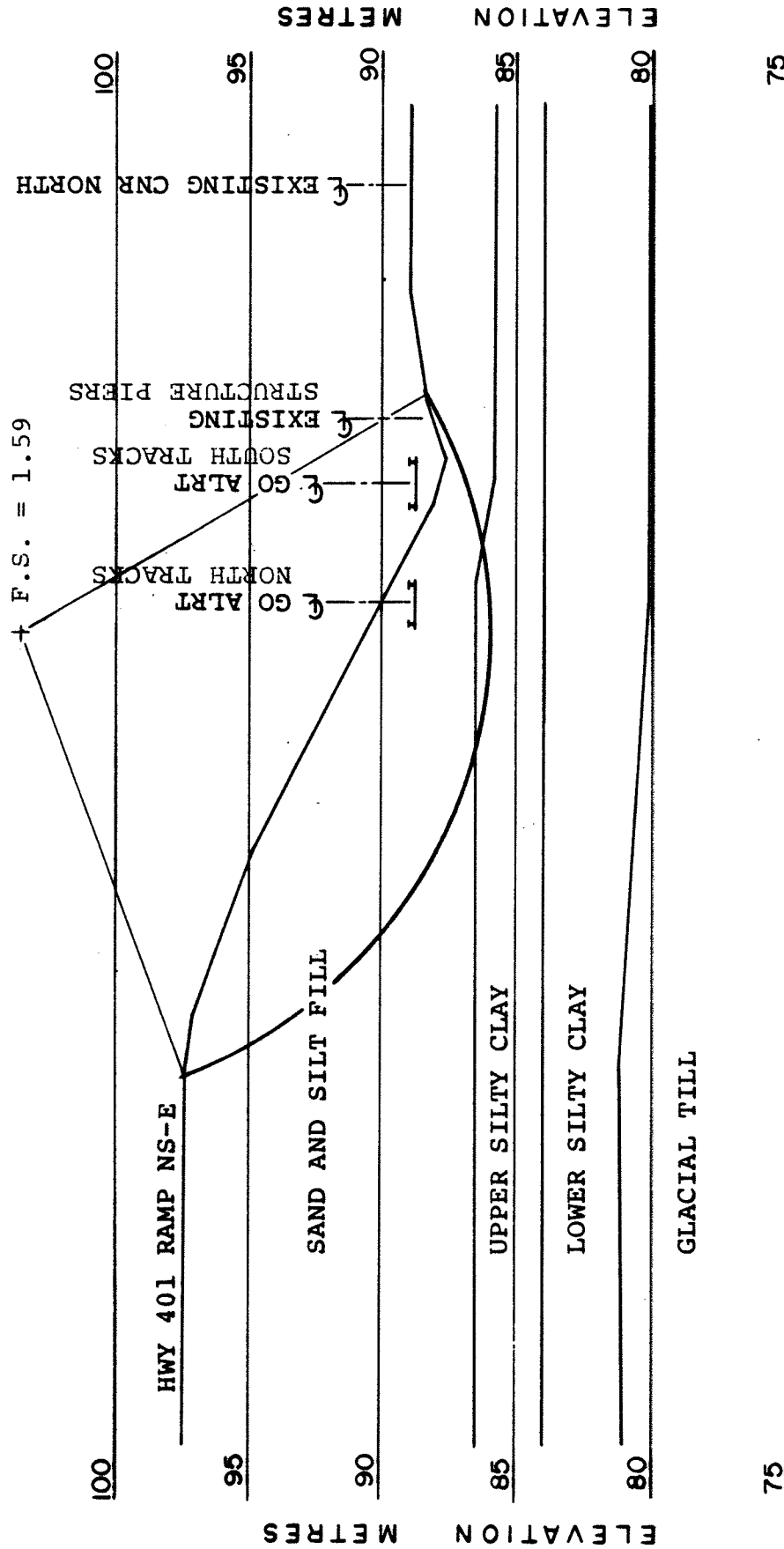
SCALE 1 : 250

# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD CASE 5

APPENDIX III  
FIGURE 5

W.P. 470-711-609

EXISTING SLOPE CONDITIONS  
EFFECTIVE STRESS ANALYSIS



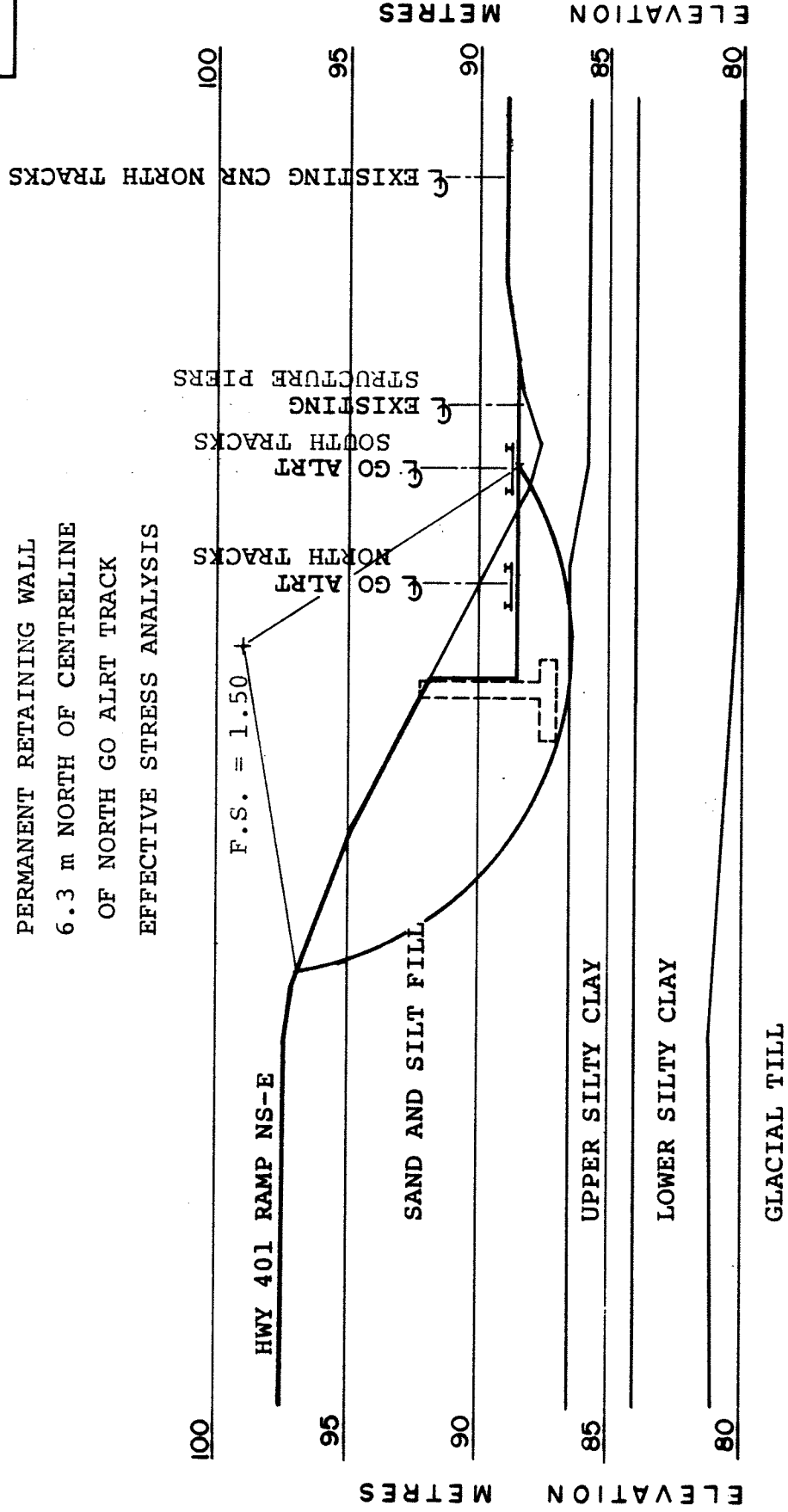
NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

SCALE 1 : 250

# STABILITY ANALYSIS EMBANKMENT EAST OF BROCK ROAD CASE 6

PERMANENT RETAINING WALL  
6.3 m NORTH OF CENTRELINE  
OF NORTH GO ALRT TRACK  
EFFECTIVE STRESS ANALYSIS

APPENDIX III  
FIGURE 6  
W.P. 470-711-609



NOTE: FOR LOCATION OF SECTION IN PLAN  
SEE DRAWING 407-711-609

SCALE 1 : 250



ALL DIMENSIONS SHOWN ARE  
IN METRES AND/OR MILLI-  
METRES UNLESS OTHERWISE  
NOTED.



- | No | ELEVATION | CO-ORDINATES |           |
|----|-----------|--------------|-----------|
|    |           | NORTH        | EAST      |
| 1  | 91-6      | 4 855 178-5  | 339 259-0 |
| 2  | 96-3      | 4 855 205-0  | 339 281-5 |
| 2A | 96-3      | 4 855 205-0  | 339 281-5 |
| 3  | 90-9      | 4 855 210-0  | 339 315-8 |
| 4  | 97-6      | 4 855 235-0  | 339 327-0 |
| 5  | 97-6      | 4 855 266-5  | 339 375-5 |
| 6  | 90-1      | 4 855 260-5  | 339 398-5 |
| 7  | 96-6      | 4 855 285-0  | 339 406-0 |
| 8  | 88-0      | 4 855 286-4  | 339 430-0 |
| 9  | 95-4      | 4 855 306-5  | 339 437-4 |
| 10 | 90-3      | 4 855 259-5  | 339 393-2 |
| 11 | 88-3      | 4 855 255-7  | 339 401-5 |
| 12 | 91-2      | 4 855 165-7  | 339 239-1 |
| 13 | 90-9      | 4 855 103-2  | 339 251-0 |
| 14 | 94-1      | 4 855 142-0  | 339 246-0 |
| 15 | 91-0      | 4 855 055-9  | 339 221-2 |
| 1  | 87-9      | 4 855 249-1  | 339 359-7 |
| 1A | 88-8      | 4 855 236-0  | 339 346-0 |

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.

RE HOLE LOCATION & SOIL STRATA  
GO ALRT EXTENTION  
OCK ROAD RETAINING WALL

REFERENCE DRAWINGS	
1	STANDARD PLANNING REPORT
2	GO ALRT EXTENTION
3	BROCK RD. RETAINING WALL

## REVISIONS

**DRAWN BY:**  
**A. E. LOCKHART**  
**84 02 23**

DESIGNED BY:  
P.B.

CHK'D BY:

APPROVED BY:

SCALE: FULL SIZE ONLY

**AS SHOWN**



**GEOCON INC.**



**PROJECT MANAGER**