

**FOUNDATION INVESTIGATION REPORT  
RETAINING WALL FOR PROPOSED WIDENING OF  
SOUTH EMBANKMENT OF BURNHAM STREET BRIDGE  
OVER HIGHWAY 401, COBOURG, ONTARIO  
W.P. 678-90-00  
SITE: 21-243**

**Prepared For:**

**McCORMICK RANKIN CORPORATION**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1018A  
September 6, 2001  
Geocres No. 30M16-35**

**250 Galaxy Boulevard  
Etobicoke, Ontario  
M9W 5R8  
Tel: (416) 213-1255  
Fax: (416) 213-1260**

## Table of Contents

<b>1. INTRODUCTION</b>	<b>1</b>
<b>2. SITE DESCRIPTION AND PHYSIOGRAPHY</b>	<b>1</b>
<b>3. INVESTIGATION PROCEDURE</b>	<b>2</b>
<b>4. SUBSURFACE CONDITIONS</b>	<b>4</b>
4.1 Topsoil .....	4
4.2 Fill .....	5
4.2.1 Granular Fill .....	5
4.2.2 Cohesive Fill .....	5
4.3 Surficial Silty Clay .....	5
4.4 Silty Clay Till .....	6
4.5 Clayey Silt with Sand and Some Gravel(Glacial Till).....	6
4.6 Clayey Silt .....	7
4.7 Heterogeneous Mixture of Silt, Sand and Gravel, Some Clay (Glacial Till).....	8
4.8 Groundwater Conditions .....	9

### DRAWINGS

### DRAWING No.

**BOREHOLE LOCATION PLAN & STRATIGRAPHIC SECTION**

**1**

### APPENDICES

**RECORD OF BOREHOLE SHEETS**

**APPENDIX A**

**LABORATORY TEST RESULTS**

**APPENDIX B**

**EXPLANATION OF TERMS USED IN REPORT**

**APPENDIX C**

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**1. INTRODUCTION**

As part of the Highway 401 – Burnham Street Bridge replacement in Cobourg, a new retaining wall may be constructed to support the east side of south approach fill embankment. Shaheen & Peaker Limited (S&P) was retained by McCormick Rankin Corporation to carry out a foundation investigation for the proposed retaining wall structure.

The site is located at the intersection of Highway 401 and Burnham Street (County Road 18) interchange (Interchange #472), about three km north of the Town of Cobourg in the Township of Hamilton, County of Northumberland.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes.

The findings of the investigation are presented in this report.

**2. SITE DESCRIPTION AND GEOLOGY**

The site is located at the south-east quadrant of the intersection of Highway 401 and Burnham Street in Cobourg, about four km north of Lake Ontario.

Burnham Street is a two-lane roadway at and north of the interchange and a recently upgraded four-lane roadway immediately south of the interchange.

The interchange is located on the boundary of the Town of Cobourg and the Township of Hamilton in the County of Northumberland. This is one of the two interchanges providing access to the Town of Cobourg from Highway 401.

Burnham Street structure over Highway 401 was constructed in 1960 and is a 31.1 m long, 11.2 m wide single span structure and accommodates two lanes of traffic.

The study area is located in the physiographic region known as the "Iroquois Plain." The plain consists of drumlins and sand plains (Ref: Chapman and Putnam, 1984).

The lowest bedrock in the general area (i.e. Northumberland County) consists of Precambrian rock, with upper layers of limestone. These limestone layers are made up of the Trenton Group bedrock formations and were deposited during the Middle Ordovician Period, during the Paleozoic seas, some 480 million years ago.

Glacio-lacustrine lake plain deposits of silt and clay with gently rolling terrain characterize the soils of the area.

The majority of the interchange is located on Schomberg soils. At the interchange site the soil is Smithfield, a silty clay loam of the Gray Brown Podzolic Group. Characteristics of this soil type are imperfect drainage, smooth to gently sloping topography, free of stones.

Cobourg Creek is located about 200 m east of the Burnham Street Bridge and the grade at the site drops from west to east towards the creek valley. The watercourse flows northeast to southwest towards Lake Ontario and crosses under Highway 401 via an existing concrete arch culvert, 65.5 m in length. Highway 401 has a median storm sewer system which outlets to a detention pond, with a sediment forebay immediately adjacent to the creek, in the north-east quadrant of the interchange.

### **3. INVESTIGATION PROCEDURE**

The fieldwork for this investigation consisted of drilling and sampling five boreholes (i.e. Boreholes 101, 102, 106, 107 and 108) at the positions shown on the Borehole Location Plan, Drawing No. 1. The depth of the boreholes ranged between 7.9 and 26.0 m.

The boreholes were advanced using solid stem continuous flight augers with track and truck mounted drilling rigs owned and operated by Groundworks Drilling Inc. under the full-time supervision of our technical personnel. The field work was performed in conjunction with the investigation for the proposed bridge and because of traffic safety requirements in inclement weather conditions

(i.e. snow storms), the field work had to be performed in increments of time (weather permitting) between December 21, 2000 and January 10, 2001.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method (SPT), as specified in ASTM Method D 1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm diameter O.D. split barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil and this gives an indication of the consistency or the compactness condition of the soil deposit.

Where the consistency of the soil permitted, the undrained shear strength of the clayey soils was measured in-situ by means of field vane tests using an MTO type field vane tester and a relatively undisturbed sample was taken by means of a thin-walled Shelby tube sampler.

The borehole locations were established in the field by our engineering staff, in relation to the existing features. The borehole geodetic elevations and coordinates were later taken by surveyors from David Harwood Limited, who provided us with the coordinates and elevations.

In the boreholes, water level observations were made during the drilling and at the completion of each borehole. In Boreholes 106 and 107, piezometers were installed to monitor groundwater levels over a prolonged period of time without interference from surface water. Water levels in the piezometers were recorded at regular intervals of time after their installation.

The results of drilling, in-situ testing and water level measurements are summarized on the Record of Borehole sheets in Appendix A.

Upon their completion, the boreholes were backfilled to about 6 to 8 m below the ground surface with soils brought up from the boreholes by the augers (i.e. by auger cuttings). The upper 6 to 8 m of the boreholes were grouted using a cement/bentonite mixture.

A laboratory testing programme, consisting of natural moisture content, bulk unit weight and Atterberg Limits tests and grain size analyses, was performed

on selected soil samples. The results of the laboratory tests are presented on the Borehole Log Sheets and also in Appendix B.

If deemed necessary, additional information from boreholes drilled in the general area and laboratory test data can be obtained by referring to the investigations carried out in 1958 for the existing bridge, proposed widening of the existing bridge in 1993 and for the replacement of the existing bridge (in conjunction with this present investigation in 2000-2001, Ref No. SPT1018).

#### **4. SUBSURFACE CONDITIONS**

Boreholes 101, 102, 106, 107 and 108 show that, in general, beneath some fill and topsoil, the site is underlain by a surficial silty clay till deposit becoming somewhat coarser clayey silt till with increasing depth. This upper till sheet extends to Elevations ranging between 97 and 94 m and is underlain by a weak and compressible clayey silt/silty clay layer. This unit is 2.4 to 3.4 m thick and is underlain by a lower till sheet. The lower till sheet is a basically granular material (i.e. heterogeneous mixture of silt and sand with gravel and some clay) and was encountered at Elevations 90.5 and 91.6 m in Boreholes 102 and 106, respectively.

Details of the subsurface conditions encountered in the boreholes are given on the Borehole Log Sheets in Appendix A. The individual soil strata encountered in the boreholes are briefly described in the following paragraphs.

##### **4.1 TOPSOIL**

Boreholes 101 and 102, which were drilled from the top of the Burnham Street embankment, contacted fill to depths of 5.5 to 5.7 m or to Elevation 103.8 m. An approximately 400 mm thick layer of topsoil was contacted underlying the fill. This probably represents the original topsoil which was left in place when constructing the existing embankment fill.

Boreholes 106, 107 and 108, which were drilled from near the toe of the Burnham Street embankment (ground Elevations 103.6, 104.4 and 105.4 m, respectively), contacted an approximately 300 mm thick topsoil layer. In Boreholes 106 and 108, the topsoil is underlain by a surficial fill layer, extending to 0.9 m below the ground surface, underlain by a 200 mm thick topsoil layer.

## 4.2 FILL

### 4.2.1 GRANULAR FILL

Boreholes 101 and 102 were drilled from the top of Burnham Street embankment and these boreholes encountered below a 150 mm thick asphaltic concrete, a granular pavement fill extending to depths of 0.9 and 2.1 m, respectively.

The grain size distribution of two samples from the granular fill is given in Appendix B.

### 4.2.2 COHESIVE FILL

The granular fill in Boreholes 101 and 102 is underlain by a silty clay to clayey silt embankment fill which extends to depths of 5.5 m (Elevation 103.8 m) and 5.7 m (Elevation 103.8 m), respectively. This is a basically cohesive soil and was found to be mixed with some topsoil and gravel. The grain-size distribution of a sample from the embankment fill is given in Appendix B. N-values recorded in this fill ranged from 14 to 35 blows/0.3 m, indicating that the fill has received some degree of systemic compaction when the embankment was first built.

Boreholes 106 and 108, drilled from the bottom of the embankment, encountered a surficial cohesive (0.6 m thick) fill consisting of silty clay to clayey silt with traces to some gravel and topsoil.

## 4.3 SURFICIAL SILTY CLAY

Underlying the topsoil in Borehole 107 and the fill and topsoil in Borehole 108, a surficial silty clay layer was contacted at depths of 0.3 m and 1.1 m. The thickness of this deposit was 1.1 m and 0.2 m and it extended to Elevations 103.0 and 104.1 m in Boreholes 107 and 108, respectively.

The silty clay is a cohesive soil and contains traces of topsoil. Based on recorded N-values of 29 to 37 blows/0.3 m, together with a visual and tactile examination of the recovered soil samples from the deposit, its consistency is described as stiff to hard.



#### 4.4 SILTY CLAY TILL

Underlying the surficial silty clay layer in Boreholes 107 and 108 and the fill and topsoil in the remaining boreholes, the site is underlain by a 0.6 to 2.3 m thick silty clay till deposit. This unit was contacted below Elevations ranging from 104.1 to 102.5 m and extended to Elevations 103.3-101.1 m.

This is a cohesive material is considered to have a low permeability. The results of an Atterberg Limits test performed on a sample from the deposit are given in Figure 3, Appendix B.

Standard Penetration tests performed in this deposit yielded N-values ranging from 12 to 48 blows/0.3 m, indicating a stiff to hard consistency.

#### 4.5 CLAYEY SILT WITH SAND AND SOME GRAVEL (GLACIAL TILL)

The silty clay till described in the preceding section attains with increasing depth, a coarser texture and becomes a clayey silt till (i.e. heterogeneous, unsorted mixture of clayey silt with sand and some gravel). Boreholes 101 and 108 were terminated in this deposit at a depth of about 8 m below the ground surface or at Elevations of 101.2 and 97.5 m, respectively. In the remaining boreholes, this deposit was found to be underlain by a clayey silt layer at depths of 15.6 m (Elevation 93.9 m) in Borehole 102; 9.6 m (Elevation 94.0 m) in Borehole 106 and 7.5 m (Elevation 96.9 m) in Borehole 107.

The results of a grain-size distribution analyses carried out on selected samples from this unit is given in Appendix B. They indicate 0-13% gravel, 6-39% sand, 38-61% silt and 9-33% clay size particles. From the observed resistance to augering (i.e. grinding) during the fieldwork, the presence of coarse gravel, cobbles and boulders in the deposit can be inferred. Boulders and cobbles are characteristic components of glacial till deposits.

Atterberg limits tests performed on samples from the deposit yielded the following index values:

Liquid Limit	=	15-24%
Plastic Limit	=	11-16%
Plasticity Index	=	4 – 8 %



These results are representative of clayey soils of low plasticity (as shown on the Plasticity Chart Figure in Appendix B). The measured natural moisture contents generally range from 8 to 20%.

N-values recorded in the deposit ranged from 12 to in excess of 50 blows/0.3 m which indicate a stiff to hard consistency, but generally very stiff to hard.

#### 4.6 CLAYEY SILT

The boreholes show the presence of a clayey silt/silty clay layer, sandwiched between the upper and lower till sheets. This deposit was contacted in the deeper boreholes (i.e. Boreholes 102, 106 and 107) at about elevations ranging from 97 to 94 m. Borehole 107 was terminated in this material at Elevation 94.4 m, after penetrating it for a distance of 2.5 m, while in Boreholes 102 and 106 it extended to Elevation 90.5 and 91.6 m, respectively (i.e. 2.4 to 3.4 m thick). In the boreholes drilled in the general area for the existing bridge and for the proposed bridge structure, the thickness of this unit was found to range from about 2 to 6 m.

Laboratory tests carried out in the boreholes drilled in the general area indicate 0-1% sand, 65-70% silt and 29-35% clay size particles and Atterberg limits tests gave the following results:

Liquid Limit	=	12-29%
Plastic Limit	=	8-17%
Plasticity Index	=	4-14%
Natural Moisture Content	=	7-25%

These results are indicative of clayey soils of low plasticity. An unusual feature of these results is that with most soils, the measured clay size percentages are normally associated with higher plasticity index values than reported. Another unusual feature was that the samples of the material obtained from the boreholes showed a much higher degree of dilatancy than would be expected from soil containing a relatively high percentage of clay sizes as measured. This rather unusual property can perhaps be caused by clay size particles being rather inactive. Chapman and Putnam observed this behaviour many years ago and offered the following hypothesis on similar soils as an explanation, "...Mechanical analyses indicate about 50% clay and 40% silt, but its behaviour is more like that of silt than

clay. It is very slippery when wet and inclined to be mealy when dry. It is probably composed of freshly ground rock flour rather than weathered clay materials."

N-values recorded in this deposit ranged from 7 to 13 blows/0.3 m and field vane tests gave undrained in-situ shear strength values ranging from 72 to in excess of 100 kPa. Based on these results, the consistency of this cohesive deposit is described as firm to very stiff, but generally stiff. It should be pointed out that in boreholes previously drilled further north for the existing bridge and subsequently for the proposed bridge, field vane tests gave undrained shear strength values as low as 20 kPa.

#### 4.7 HETEROGENEOUS MIXTURE OF SILT, SAND AND GRAVEL, SOME CLAY (GLACIAL TILL)

Boreholes 102 and 106 (i.e. the deeper boreholes) contacted, underlying the clayey silt/silty clay layer (described in the preceding section), a lower till sheet at Elevation 90.5 and 91.6 m, respectively. Both boreholes were terminated in this deposit after penetrating it 7.0 m and 0.7 m, respectively. This lower till sheet was encountered in boreholes drilled further north for the bridge as well and was penetrated for a maximum depth of 8 m or to Elevation of about 81 m. It consists of heterogeneous mixture of silt and sand with gravel and traces to some clay size particles. Grain size distribution analysis on samples from the boreholes drilled in the median of Highway 401 to the north of the proposed retaining wall site gave the following results:

10-28%	gravel
37-46%	sand
33-44%	soil fines (silt & clay size particles)

The presence of cobbles and boulders can always be expected in the glacial till deposits, due to their mode deposition. There is some indication that the deposit contains a greater percentage of gravel and cobbles than exhibited by the samples tested, especially on the south side of the existing bridge.

Standard Penetration tests performed in this deposit in Boreholes 102 and 106 gave N-values ranging from 17 to in excess of 86 blows/0.3 m, indicating a compact to generally very dense condition.

#### 4.8 GROUNDWATER CONDITIONS

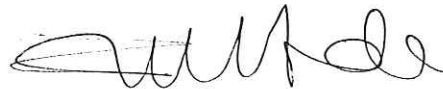
Groundwater conditions in the open boreholes were observed while drilling and at the completion of each borehole. In addition, piezometers were installed in Boreholes 106 and 107 to monitor the groundwater levels over a prolonged period of time without interference from surface water. The observations and the recorded water levels are given on the individual borehole log sheets.

Water levels in the piezometers installed in Boreholes 106 and 107 were measured 1.2 and 2.3 m below the ground surface or at Elevations 102.4 and 102.1 m, respectively.

It should be pointed out that the groundwater level can be expected to fluctuate seasonally and in response to major weather events.

Yours very truly,

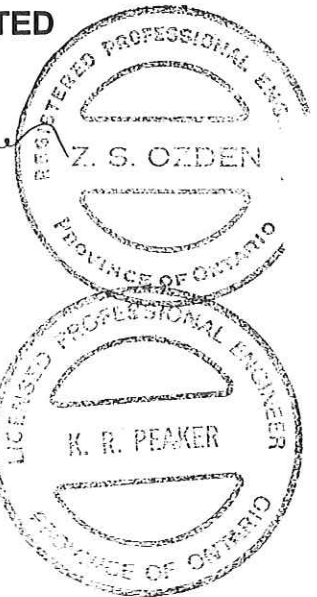
**SHAHEEN & PEAKER LIMITED**



Zuhtu S. Ozden, P.Eng.









K.R. Peaker, Ph.D., P.Eng.



# Drawings



HWY 401 - BURNHAM ST.  
PROPOSED RETAINING WALL  
BORE HOLE LOCATIONS & SOIL STRATA

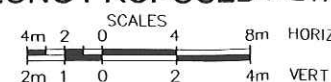
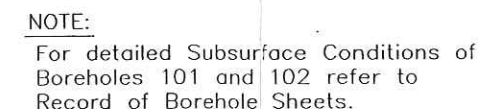
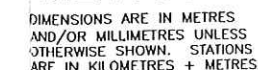
 Bore Hole  
 Dynamic Cone Penetration Test (Cone)  
 Bore Hole & Cone  
 N Blows/0.3m (Std Pen Test, 475 J/blow)  
 CONE Blows/0.3m (60° Cone, 475 J/blow)  
 W L at time of investigation  
 Jan. 2001  
 W L in Piezometer  
 Piezometer

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
101	109.3	4 871 892.2	409 415.8
102	109.5	4 871 910.8	409 408.5
106	103.6	4 871 910.3	409 428.3
107	104.4	4 871 869.6	409 442.7
108	105.4	4 871 837.8	409 450.6

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

REV.				
	DATE	BY	DESCRIPTION	
Geocres No.				
HWY No		401		DIST 21
SUBM'D ZO	CHECKED ZO	DATE Aug., 2001		SITE
DRAWN JTW	CHECKED JP	APPROVED		DWG 1



# Appendix A

## Records of Boreholes

# RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 678-80-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 892.2; E 409 415.9 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT  
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE					W <sub>P</sub>	W	W <sub>L</sub>			
							20	40	60	80	100	20	40	60				
109.3	Ground surface																	
0.0	150 mm Asphalt		1	SS	64							○					32 55 (13)	
108.4	Gravelly Sand (Granular Fill) brown, very dense		2	SS	19								○					20.4
0.9	FILL: Silty Clay and Clayey Silt, trace gravel, some topsoil pockets, very stiff to hard, brown, damp		3	SS	32								○					19.8
			4	SS	30								○					19.5
	----- high topsoil content black, moist -----		5	SS	34								○					19.7
			6	SS	27								○					19.2
			7	SS	35								○					19.4
103.8			8	SS	20								○					20.8
5.5	TOPSOIL, black																	
103.4																		
5.9	SILTY CLAY TILL, stiff, greyish brown		9	SS	12								○					20.8
102.8																		
6.5	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to very stiff, brown	10	SS	27								○					22.6	
101.2		11	SS	16								○					21.0	
8.1	End of borehole * Wet cave at 7.2 m on completion. Water level not stabilized Borehole drilled to 5.0 m on Dec.5/2000. Abandon borehole due to snow storm re-drilled on Jan.10/2001																	



# RECORD OF BOREHOLE No 102

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT  
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
109.5 0.0	Ground surface		1	SS	50/15												
	150 mm Asphalt		2	SS	50/15												
	Gravelly Sand (Granular FILL) brown, very dense		3	SS	75/30												20 72 (8)
107.4 2.1			4	SS	21											20.0	
	FILL: Silty Clay, trace of gravel and topsoil, stiff to very stiff, brown		5	SS	14											20.5	1 7 60 32
			6	SS	24												
103.8 5.7																	
103.4	TOPSOIL, black																
6.1	some organics		7	SS	48												
	SILTY CLAY TILL greyish brown, very stiff to hard		8	SS	28												
101.1 8.4																	
			9	SS	50/15											20.3	
	Clayey Silt with Sand, some gravel (GLACIAL TILL) hard to very stiff, brown to 10 m, grey below		10	SS	42											23.2	
			11	SS	24											22.9	
			12	SS	23											23.9	13 38 39 10

Continued Next Page

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 102

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.8; E 409 408.5 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT  
DATUM Geodetic DATE 05.12.00 10.01.01 CHECKED BY ZO

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 <sub>s</sub> 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									WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
94.5							20	40	60	80	100	20	40	60						
15.0	Clayey Silt with Sand, some gravel		13	SS	21		94								22.6					
93.9	(GLACIAL TILL)																			
15.6	grey, very stiff																			
	CLAYEY SILT firm to very stiff, grey		14	SS	12			93								20.1				
								92												
			15	SS	7		91								21.3					
90.5																				
19.0	Heterogeneous mixture of Silt, Sand and Gravel, some clay (GLACIAL TILL) dense to 21 m, very dense below, grey		16	SS	35		90								23.6					
								89												
			17	SS	86/25			88								22.9				
								87												
	more sandy with Sand layers below 24 m		18	SS	50/15			86								23.1				
			19	SS	50/13		85								22.6					
83.5							84													
26.0	End of borehole * Wet cave at 4.5 m on completion. Water level not stabilized Borehole drilled to 6.6 m on Dec.5/2000. Borehole had to be abandoned due to snow storm. Borehole re-drilled on Jan.10-11/2001		20	SS	50/8										22.1					

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 106

1 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.3; E 409 428.2 ORIGINATED BY GI  
 DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT  
 DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

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  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									WATER CONTENT (%)		
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
103.6	Ground surface						20	40	60	80	100	20	40	60					
0.0	300 mm Topsoil		1	SS	14											21.7			
	FILL: Silty Clay, some gravel and topsoil, brown, stiff to very stiff																		
102.7																			
102.5	TOPSOIL, black		2	SS	26											20.6			
1.1																			
	SILTY CLAY TILL very stiff to hard, brown		3	SS	17											19.7			
101.1																			
			4	SS	47											21.3			
2.5																			
			5	SS	28											21.8			
	Clayey Silt with Sand, some gravel (GLACIAL TILL) stiff to hard, brown to 4.4 m, grey below		6	SS	27											21.2			
			7	SS	12											20.1	0 6 61 33		
			8	SS	12											20.8			
			9	TW	PH														
			10	SS	13														
			11	SS	13														

Continued Next Page

+ 3 . x 3 : Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 106

2 OF 2

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 910.3; E 409 428.2 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GT  
DATUM Geodetic DATE 21.12.00 04.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ 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						
							20 40 60 80 100	20 40 60 80 100	20 40 60					
	Piezometer installed to 12.1 m Water level in piezometer: Jan.04/2001 - 5.5 m Jan.09/2001 - 1.1 m Jan.10/2001 - 1.0 m Jan.11/2001 - 1.2 m													

# RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 869.6; E 409 442.2 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI  
DATUM Geodetic DATE 04.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
104.4 0.0	Ground surface													
	300 mm Topsoil		1	SS	29		104						18.1	
	Silty Clay		2	SS	37								19.1	
103.0	very stiff to hard, dark brown and organic stained to 0.8 m, brown below						103							
1.4	SILTY CLAY TILL		3	SS	26								21.5	
102.2	very stiff, brown													
2.2			4	SS	52		102						22.1	
			5	SS	71								22.3	
	Clayey Silt with		6	SS	66		101						21.7	
	Sand, some Gravel		7	SS	37		100						21.6	
	(GLACIAL TILL)		8	SS	51		99						22.4	
	hard to 5.8 m,		9	SS	22								22.7	
	very stiff below,		10	SS	18		98						22.0	
	brown to 4.8 m,													
	grey below													
96.9			11	SS	8		97						19.3	
7.5	CLAYEY SILT						96							
	firm to stiff, grey		12	SS	11		95						20.1	
94.4														
10.0	End of borehole													
	Water level at 5.5 m upon completion													
	Piezometer installed to 9.1 m													
	Water level in piezometer:													
	Jan.04/2001 - 5.3 m													
	Jan.09/2001 - 2.0 m													
	Jan.10/2001 - 2.2 m													
	Jan.11/2001 - 2.3 m													

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

# RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 678-90-00 LOCATION Hwy 401-Burnham Street, Cobourg - Co-ords: N 4 871 837.8; E 409 450.8 ORIGINATED BY GI  
DIST 21 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY GI  
DATUM Geodetic DATE 05.01.01 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  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							WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL			× LAB VANE		W <sub>p</sub>
105.4	Ground surface					20	40	60	80	100	20	40	60				
0.0	300 mm Topsoil FILL:		1	SS	15							○		17.6	12 36 43 9		
104.5	Clayey Silt, trace gravel, stiff, brown											○					
0.9	200 mm TOPSOIL		2	SS	32							○		19.3			
104.1	SILTY CLAY : trace organics, very stiff to hard, brown											○		20.0			
1.3	SILTY CLAY TILL very stiff, brown		3	SS	27							○		21.3			
103.3												○		21.9			
2.1			4	SS	42							○		22.4			
	Clayey Silt with Sand, some Gravel (GLACIAL TILL) very stiff to hard brown to 5.5 m, grey below		5	SS	21							○		22.4			
												○					
			6	SS								○					
												○					
			7	SS	41							○					
												○					
97.5			8	SS	50/15												
7.9	End of borehole *Water level at 5.9 m upon completion (not stabilized)																

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

# Appendix B

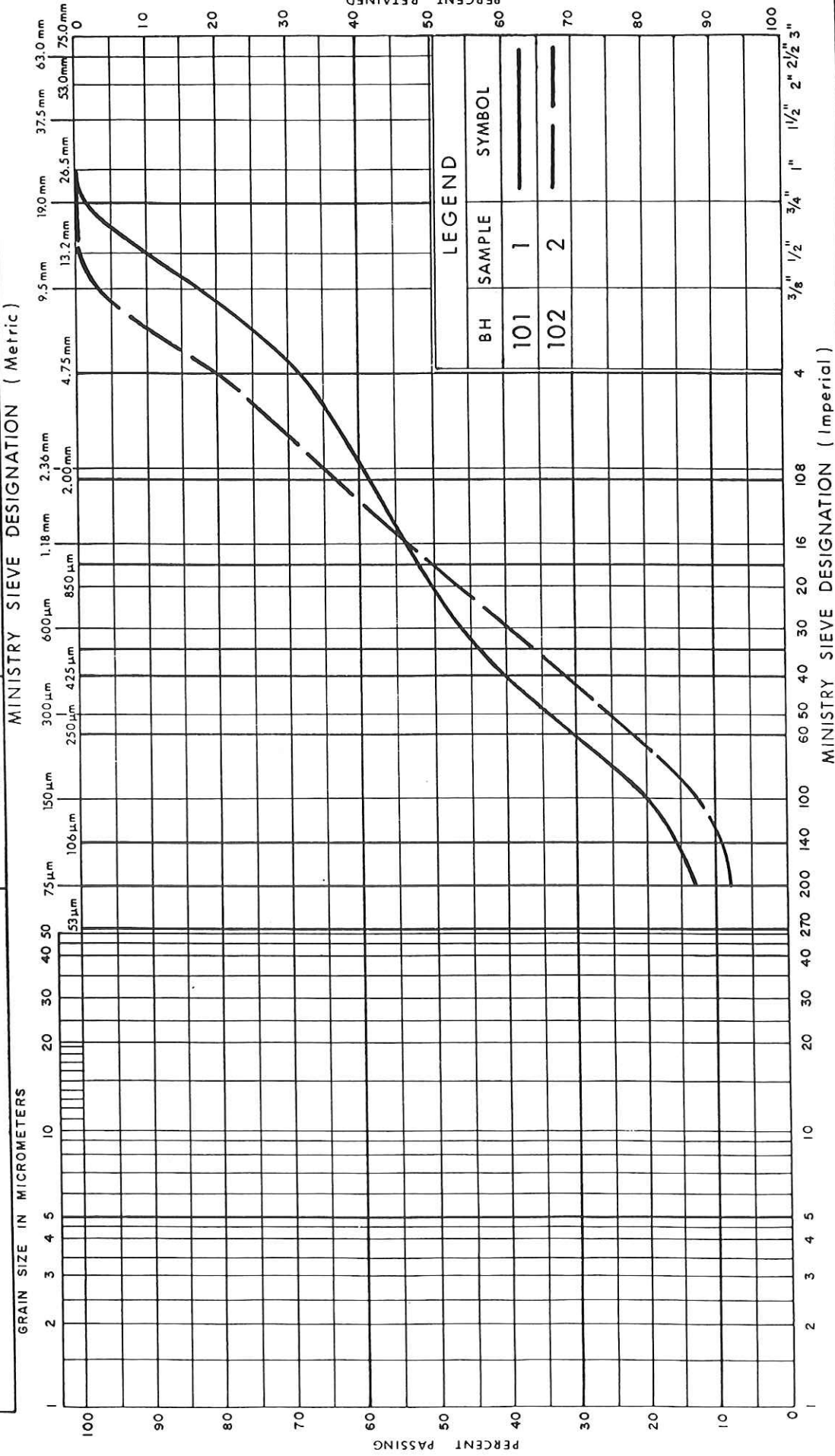
## Laboratory Test Results



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

GRAIN SIZE IN MICROMETERS



## GRAIN SIZE DISTRIBUTION

GRAVELLY SAND (Granular Fill)

FIG No 1

W P 678-90-00

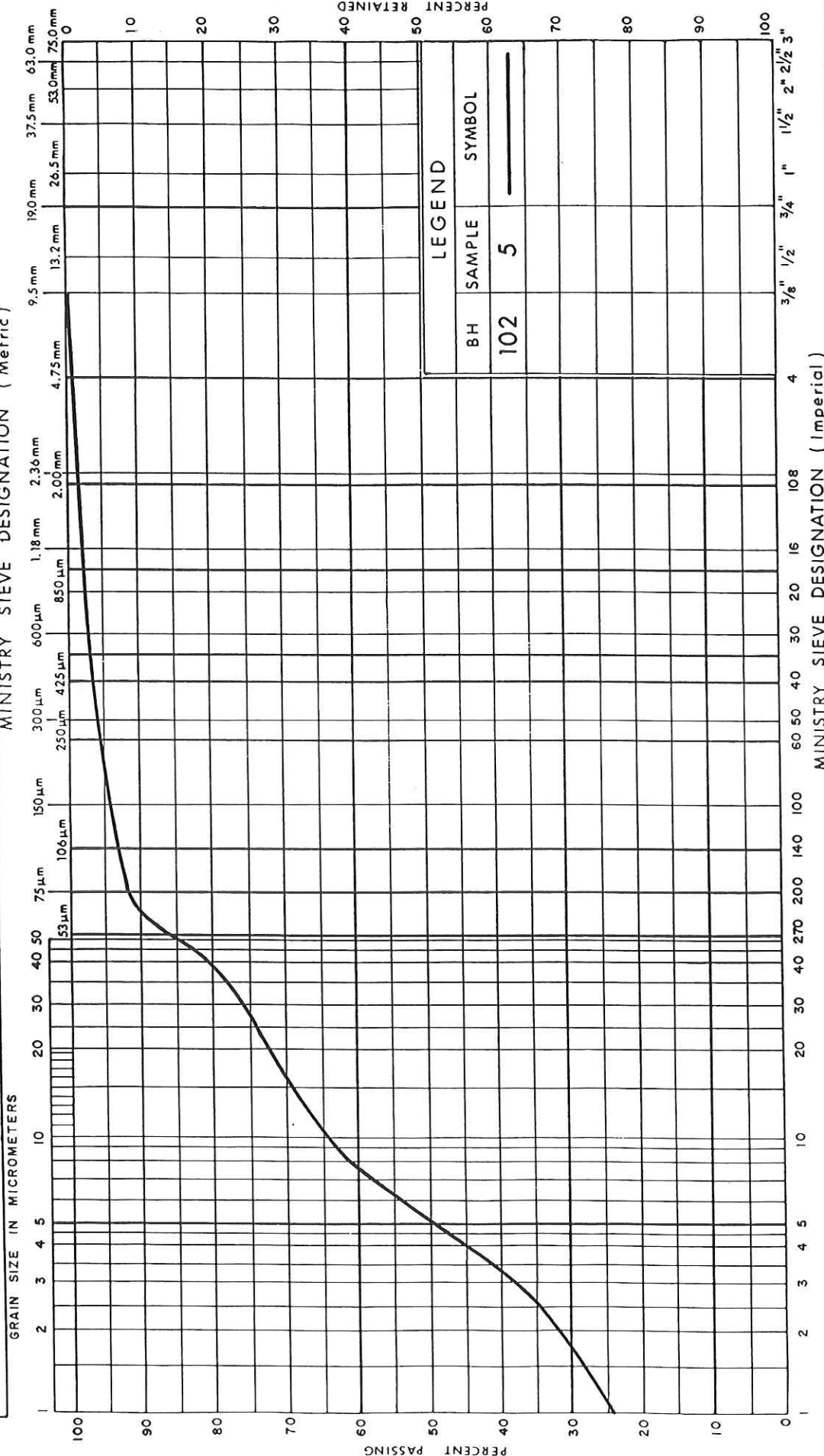
SPT 1018A

Ministry of  
Transportation



# UNIFIED SOIL CLASSIFICATION SYSTEM

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



## GRAIN SIZE DISTRIBUTION FILL: SILTY CLAY

FIG No 2

W P 678-90-00

SPT 1018A

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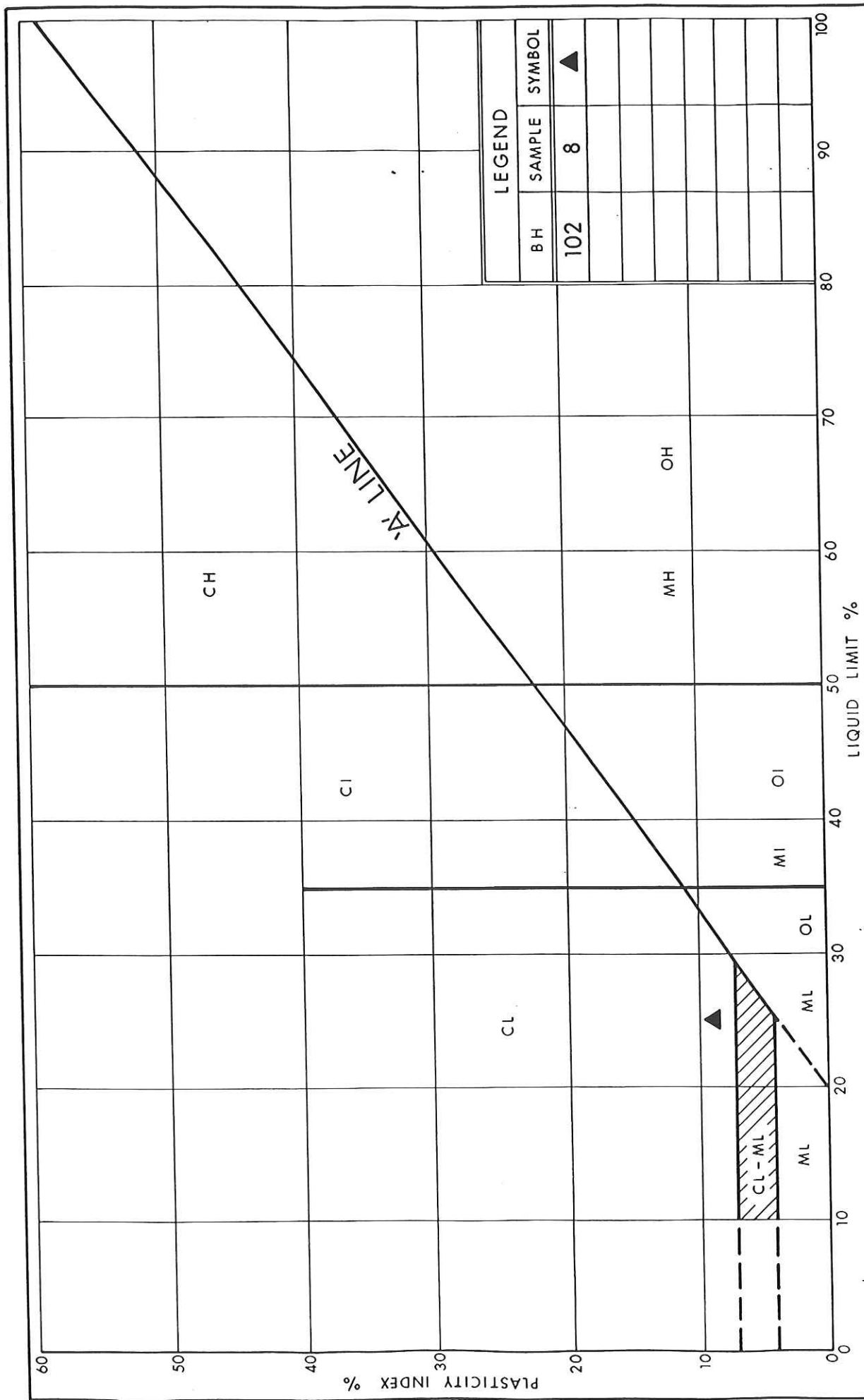


FIG No 3

WP 678-90-00

SPT 1018A

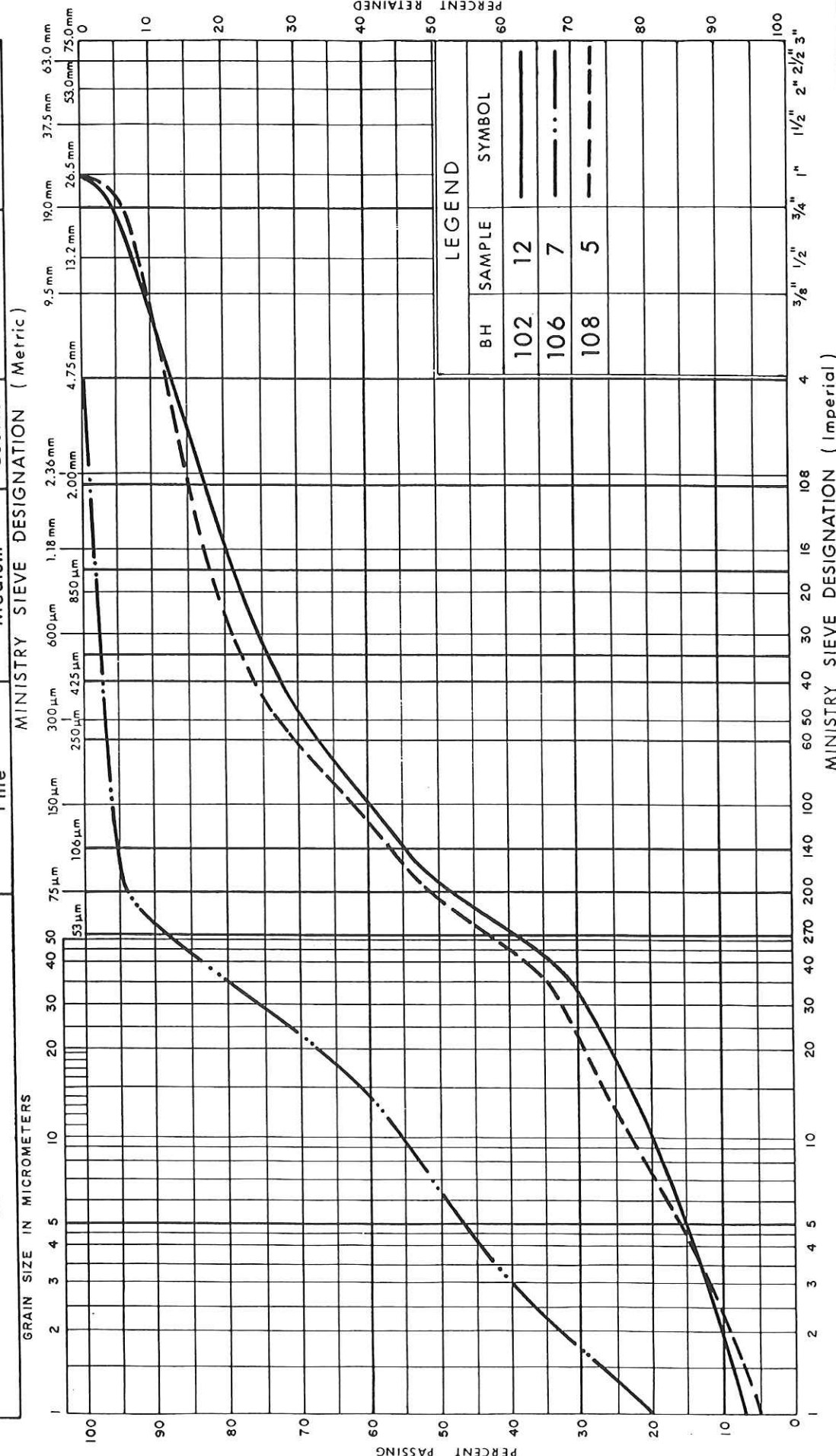
## PLASTICITY CHART SILTY CLAY TILL

Ministry of  
Transportation

Ontario

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION  
CLAYEY SILT WITH SAND, SOME GRAVEL  
(Glacial Till)

FIG No 4

W P 678-90-00

SPT 1018A

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Transportation



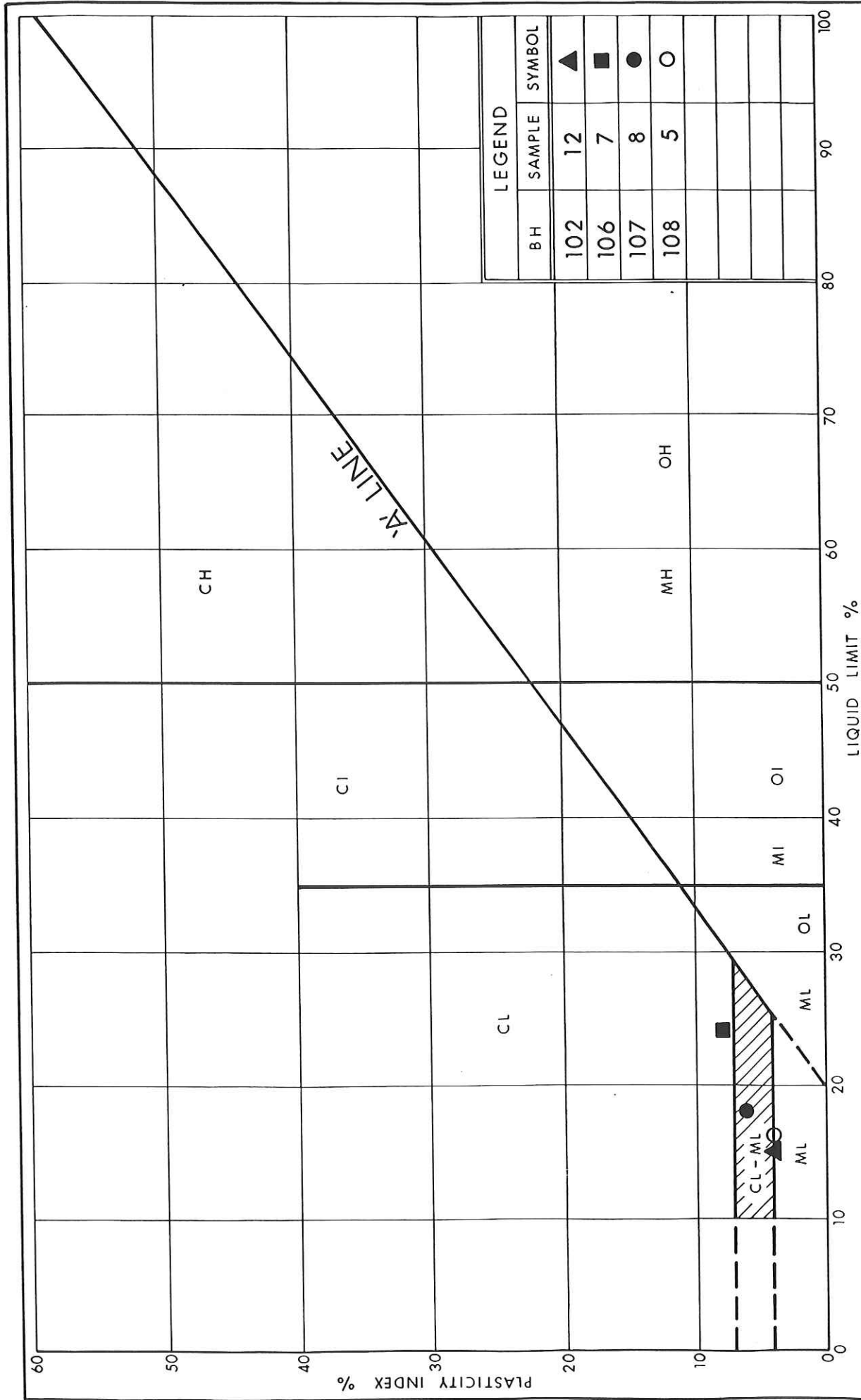


FIG No 5

# PLASTICITY CHART CLAYEY SILT WITH SAND, SOME GRAVEL (Glacial Till)

Ministry of  
Transportation



W P 678-90-00

SPT 1018A

# Appendix C

## Explanation of Terms Used in Report

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR.	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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



**FOUNDATION DESIGN REPORT  
RETAINING WALL FOR PROPOSED WIDENING OF  
SOUTH EMBANKMENT OF BURNHAM STREET BRIDGE  
OVER HIGHWAY 401, COBOURG, ONTARIO  
W.P. 678-90-00  
SITE: 21-243**

**Prepared For:**

**McCORMICK RANKIN CORPORATION**

**Prepared by:**

**SHAHEEN & PEAKER LIMITED**

**Project: SPT1018A  
September 6, 2001  
Geocres No. 30M16-35**

**250 Galaxy Boulevard  
Etobicoke, Ontario  
M9W 5R8  
Tel: (416) 213-1255  
Fax: (416) 213-1260**

## Table of Contents

<b>5.</b>	<b>DISCUSSION AND RECOMMENDATIONS</b>	<b>10</b>
5.1	General.....	10
5.2	Conventional Retaining Wall.....	11
5.2.1	Foundations.....	11
5.2.2	Sliding Resistance .....	12
5.2.3	Lateral Earth Pressures.....	12
5.3	Retained Soil System.....	12
5.4	Other Types of Retaining Structures.....	15
5.5	Construction Comments .....	15
5.6	Frost Protection .....	18
<b>6.</b>	<b>CLOSURE</b>	<b>18</b>

### APPENDICES

REMOVAL OF UNSUITABLE SOILS FROM BENEATH APPROACH FILLS  
LIMITATIONS OF REPORT

APPENDIX D  
APPENDIX E

**FOUNDATION DESIGN REPORT  
RETAINING WALL FOR PROPOSED WIDENING OF  
SOUTH EMBANKMENT OF BURNHAM STREET BRIDGE  
OVER HIGHWAY 401, COBOURG, ONTARIO  
W.P. 678-90-00  
SITE: 21-243**

**5. DISCUSSION AND RECOMMENDATIONS**

**5.1 GENERAL**

Property limitations may necessitate the construction of a retaining structure to support the east side of the south approach of Burnham Street embankment which will be widened in conjunction with the construction of a proposed new bridge structure over Highway 401.

The project involves on the south side of the proposed new bridge, the widening of the existing embankment by abutting into it, as well as raising the existing embankment grade by about 0.5 to 1.0 m. The existing grade at the east toe area of the embankment is about 104 m and since the new grade at the south end of the bridge will be about 109.5 m, the widening will involve raising the grade immediately near the new bridge by about 5.5 m, gradually reducing in height further south to match the existing grade levels. We understand that due to property restrictions the east side of the embankment may be retained by means of a vertical or a near vertical structure, rather than sloping the fill at conventional 2H:1V side slopes. The height of the embankment to be retained can, therefore, be expected to be about 5.5 m, gradually reducing in height in the southerly direction. The anticipated maximum height of the retaining wall on the north end is about 3 m, rapidly reducing to about 2 m and less towards the south side.

The boreholes show that, in general, beneath some fill and topsoil, the site is underlain by silty clay till which becomes somewhat coarser with increasing depth (i.e. clayey silt till). This upper till sheet is a cohesive deposit and in general has a very stiff to hard consistency. It extends to Elevations ranging between 97 and 94 m and is underlain by a weaker (i.e. generally stiff) and practically impermeable clayey silt/silty clay layer, which is sandwiched between the upper and lower till sheets. This layer is about 3 m thick and is in turn underlain by another

(lower) till deposit. The lower till sheet is basically a granular material and has a compact to dense relative density immediately below the interface with the clayey silt/silty clay layer (i.e. Elevations 91.6 and 90.5 m in Boreholes 106 and 102, respectively) but becomes very dense with increasing depth.

The groundwater level in the piezometers installed in Boreholes 106 and 107 were measured at 1.2 and 2.3 m below the ground surface, or at Elevations 102.4 and 102.1 m, respectively, at the time of our investigation.

## 5.2 CONVENTIONAL RETAINING WALL

### 5.2.1 FOUNDATIONS

Both shallow and deep foundation alternatives have been considered. The preferred solution is a shallow foundation based on technical feasibility and cost. The boreholes show that the subsurface conditions are suitable for the use of a conventional reinforced concrete retaining wall supported on shallow spread foundations. For this purpose, all foundations should be extended below any fill, topsoil and upper weak and organic rich zones of the soil, into the undisturbed natural hard silty clay till or the underlying clayey silt till. The recommended founding elevations and soil bearing resistances at the borehole locations are presented in Table 5.2.1.1.

Table 5.2.1.1

Borehole No.	Existing Ground Surface Elevation (m)	Recommended Footing Base (m)		Geotechnical Resistance (kPa)		Subgrade Material
		Depth Below Existing Ground	Elevation (m)	At S.L.S.	At U.L.S.*	
106	103.6	1.5 - 2.4	102.1-101.2	300	450	silty clay till
107	104.4	1.5 - 2.2	102.9-102.2	300	450	silty clay till
		2.3 - 2.8	102.1-101.6	300	450	clayey silt till
108	105.4	1.4 - 2.1	104.0-103.3	300	450	silty clay till
		2.2 - 2.5	103.2-102.9	300	450	clayey silt till

\*Incorporating a resistance factor of 0.5 as per Ontario Highway Bridge Design Code (OHBD) 3<sup>rd</sup> Edition.

The serviceability condition is based on the premise that the maximum total and differential settlements will not exceed 25 mm and 18 mm, respectively. This can be achieved provided that the founding subgrade is undisturbed during the construction.

All footing excavations should be carefully inspected by the geotechnical engineer to ensure that the footings are founded on natural undisturbed soils, which are capable of supporting the design pressures.

Under inclined loading conditions, the Bearing Resistance at U.L.S. should be reduced in accordance with Clause 6-8-4.2 of O.H.B.D.C.

Based on the subsoil conditions encountered in the boreholes and the height of the retaining wall, global stability is not considered a problem.

For frost protection, the footings should have a permanent earth cover of at least 1.5 m, or equivalent artificial insulation.

#### 5.2.2 SLIDING RESISTANCE

The sliding resistance of the footings should be checked. The unfactored horizontal resistant against sliding between concrete and undisturbed, competent, native founding soil (i.e. silty clay till/clayey silt till) can be calculated using a friction angle of 26 degrees.

#### 5.2.3 LATERAL EARTH PRESSURES

The lateral earth pressures acting on the retaining wall will depend on the type and method of placement of the backfill materials and on the subsequent lateral movement of the structure. The lateral earth pressures to be used in the design should be computed in accordance with Section 6-7 of the OHBDC.

Granular backfill should be placed behind the retaining walls to conform to the minimum requirements illustrated in OPSD 3504.00. The granular backfill should conform to OPSS Form 1010 for either Granular 'A' or 'B' Type 1. To maintain free draining characteristics in these granular fill materials, the maximum percentage passing the No. 200 sieve (75  $\mu$ m) should be limited to 5%.



NOTE:  $K_a$  is the coefficient of active earth pressure

$K_b$  is the backfill earth pressure coefficient for an unrestrained structure including compaction efforts

$K_o$  is the coefficient of earth pressure at rest

$K^*$  is the earth pressure coefficient for a soil loading a fully restrained structure and includes compaction effects

These values are based on the assumption that the backfill behind the retaining structure is free-draining granular material and adequate drainage is provided. Allowance should be made for traffic loads.

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or some movement can occur such that the active state of earth pressure can develop. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients. The use of vibratory compaction equipment behind the culvert and the retaining walls should be restricted in size as per current MTO practice and as specified in OPSS 501.

### 5.3 RETAINED SOIL SYSTEM

A Retained Soil System (RSS) may be used for the retaining walls. The supplier of the RSS should be responsible for design of the structure such as backfill, reinforcement, and internal and external stability. The following information should be included in the contract drawings:

- The length and location
- Height and space constraints
- Elevation of top and bottom of RSS
- Performance requirement (High Performance)
- Appearance requirement (High Appearance)

If excavated clean, selected basically clayey silt fill materials (free of organics) from the adjacent site are to be used to build the embankment (i.e. materials selectively used from the presently stockpiled soils from the southwest