

FOUNDATION INVESTIGATION REPORT FOR
EAST MAIN STREET EMBANKMENT WIDENING
EAST OF HIGHWAY 140
W.O. 01-23003
AGREEMENT No. 2005-A-000432
CITY OF WELLAND, REGION OF NIAGARA

Submitted To:

Ministry of Transportation of Ontario
5th Floor, Building 'D'
1201 Wilson Avenue
Downsview, Ontario, M3M 1J8
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Submitted By:

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Canada

8 November 2002
Ref. No. TT22853

TABLE OF CONTENTS

	PAGE
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND PHYSIOGRAPHY	1
3.0 INVESTIGATION PROCEDURES	2
4.0 SUBSURFACE CONDITIONS	3
4.1 Topsoil	3
4.2 Fill	3
4.3 Clayey silt	4
4.4 Silt	5
4.5 Groundwater Conditions	5
5.0 CLOSURE	6

DRAWINGS

BOREHOLE LOCATIONS
 SOIL STRATA

DWG. NO. 1
 DWG. NO. 2

RECORD OF BOREHOLE SHEETS

RECORD OF BOREHOLES 45, 46, 51 AND 52
 Notes to Borehole Logs

APPENDIX A

GRAIN SIZE DISTRIBUTION CURVES
 PLASTICITY CHARTS
 CONSOLIDATION TEST RESULTS

MTO Central Region
East Main Street Embankment Widening
City of Welland, Region of Niagara
W.O. 01-23003, Agreement No. 2005-A-0000432
Ref No, TT22853; 8 November 2002
Foundation Investigation Report
Page (1)

1.0 INTRODUCTION

AMEC Earth & Environmental Limited, Consulting Geotechnical Engineers, was retained by the Ministry of Transportation of Ontario, Central Region, to conduct a foundation investigation at the site of embankment widening on the south side of East Main Street (EMS), east of Highway 140. The project limits of the proposed embankment widening are from Station 10+090 (90 m east of the EMS/Hwy 140 intersection) and extends easterly by about 200 m to Station 10+290.

The purpose of the investigation has been to obtain information about the sub-surface conditions at the site by means of exploratory boreholes, in-situ tests and laboratory tests on selected samples. This area was identified in the terms of reference of the project issued by the Ministry of Transportation of Ontario in which foundation investigation was to be conducted. The work carried out for this geotechnical investigation was completed in accordance with AMEC's proposal (ref. P-22278, dated 2 July 2002).

Typical cross-section of the existing road embankment was provided by MTO.

The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Sub-surface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations. The elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

2.0 SITE DESCRIPTION AND PHYSIOGRAPHY

The site is located on the east side of Welland, Ontario, approximately 1 km east of the Welland Canal (see Key Map, Figure No. 1). To the east of the tunnel, the grade of East Main Street rises to meet the original grade and then the road grade has been raised further east beyond the intersection with Highway 140 to form an overpass for the existing CNR track that is located approximately 1.3 km east of the Canal.

At the intersection of Highway 140/Farr Road and East Main Street, the road grade lies approximately 3 m above the surrounding overall grade. From the intersection, the grade falls towards the south on Highway 140 and towards the north on Farr Road. The grade at the bottom of the embankment within the foundation investigation area is sloping down towards the east at a rate of about 1 %. At the CNR overpass, the road grade is approximately 10 m higher than the surrounding topography.

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MTO Central Region
East Main Street Embankment Widening
City of Welland, Region of Niagara
W.O. 01-23003, Agreement No. 2005-A-0000432
Ref No, TT22853; 8 November 2002
Foundation Investigation Report
Page (2)

Based on the Quaternary Geology of the Welland Area (from Ontario Division of Mines Preliminary Map), the surficial soils in this area consist of Late Wisconsin glaciolacustrine clay and silt, with minor sand. A generalized geological profile along the Welland Canal By-Pass indicates that the surficial soils are underlain by an upper till unit of predominantly clay till, and are further underlain by a lower glaciolacustrine unit of predominantly clay, silt and sand. Bedrock in this area is anticipated to lie in the order of 35 m below the elevation of the intersection of Highway 140 and East Main Street.

Although unconfirmed, it is believed that the soils used to build the road embankment are from various local clay borrow sources.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this project was performed between the period of 29th of August and 6th of September, 2002, and consisted of drilling and sampling four boreholes. Two of the boreholes (Boreholes 45 and 51) were drilled from the top of the embankment to a depth of about 30 m each and the other two boreholes (Boreholes 46 and 52) were put down at the bottom of the embankment to a depth of about 20 m each. The plan locations of the boreholes and stratigraphic sections are shown on Drawing Numbers 1 and 2, respectively.

The boreholes were advanced using hollow stem continuous flight augers with a truck-mounted power auger drilling rig. The drilling was conducted under the full-time supervision of experienced geotechnical personnel from AMEC Earth & Environmental Limited.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test Method, as specified in American Society for Testing and Materials Method Number: D1586. This consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a nominal 51 mm diameter o.d. split barrel (split-spoon) sampler into the ground. The number of blows of the hammer to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration.

Where the consistency of the clayey soil deposits permitted, undisturbed Shelby tube (TW) samples were obtained. In soft clayey deposits, in-situ vane tests were carried out using a Ministry of Transportation of Ontario's 'N' vane.

The borehole locations were established in the field by our engineering staff from our St. Catharines office, in relation to the centreline of East Main Street. The borehole geodetic elevations of the ground at the borehole locations were determined using a local benchmark. This benchmark is described as cut 'x' on top of the southwest bolt of the traffic control light standard on .../...

MTO Central Region
East Main Street Embankment Widening
City of Welland, Region of Niagara
W.O. 01-23003, Agreement No. 2005-A-0000432
Ref No, TT22853; 8 November 2002
Foundation Investigation Report
Page (3)

the channelization island at the southwest corner of East Main Street / Highway 140 intersection. This benchmark is understood to have a geodetic elevation of 188.585 m.

The soil samples were shipped in sealed containers to our Advanced Soil Laboratory in Toronto (Scarborough) for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, Atterberg Limits tests, consolidation testing, unit weights and grain-size analyses, was performed on selected representative soil samples. The results of the laboratory tests are presented on the appropriate Record of Borehole sheets and also in Appendix 'A'.

A standpipe piezometer was installed in Borehole 46 to monitor the groundwater level over a prolonged period of time without interference from surface water.

The boreholes were backfilled with bentonite/cement mixture.

4.0 SUB-SURFACE CONDITIONS

Descriptions of the sub-surface conditions encountered in the boreholes are presented on the Record of Borehole sheets and on Drawing Number 2. The following paragraphs describe the various strata.

4.1 Topsoil

Boreholes 46 and 52 were drilled at the bottom of the embankment and these encountered 0.15m and 0.08m of surficial topsoil, respectively. In Boreholes 46 and 51, an about 0.3 m thick topsoil layer was encountered below the clayey fill at depths of about 1.6 and 8 m, respectively, below the existing ground surface.

4.2 Fill

Boreholes 45 and 51 were drilled from the gravel shoulder of the road embankment and these encountered pavement granular fill extending to depth of 0.6 to 0.7 m. The granular fill consisted of sand and gravel with traces of silt size particles.

Below the granular fill, the embankment consists of a clayey silt fill as encountered in Boreholes 45 and 51. Measured 'N'-values within the clayey fill ranged from 10 to 28 blows / 0.3 m, typically 20 blows/0.3 m, indicating a fairly compacted fill, or generally very stiff consistency. At the bottom of the embankment, the clayey silt fill was also contacted in Boreholes 46 and 52, extending to a depth of 1.6 to 2 m below existing grade. In Borehole 52, the clayey fill was overlain with about 1 m of silty sand fill

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MTO Central Region
 East Main Street Embankment Widening
 City of Welland, Region of Niagara
 W.O. 01-23003, Agreement No. 2005-A-0000432
 Ref No, TT22853; 8 November 2002
 Foundation Investigation Report
 Page (4)

Laboratory test results from soil samples in the fill are as follows:

Clayey Embankment Fill

Natural Moisture Content (%):	14 - 24
Grain Size (one sample):	
Gravel (%):	5
Sand (%):	46
Silt (%):	22
Clay (%):	27
Unit Weight (kN/m ³):	19.8 – 20.4

The grain size curve for this material is provided in Appendix 'A'.

4.3 Clayey Silt

A clayey silt deposit with occasional silty clay and silt zones was encountered in all the boreholes below the fill and/or topsoil layer. This deposit extends to the full depth of the boreholes.

This clayey silt is composed of a mixture of silt and clay with traces of sand and occasional gravel size particles. The upper 3 to 5 m of the clayey silt has measured 'N'-values ranging from 16 to 41 blows per 0.3 m indicating a very stiff to hard consistency, or described as desiccated crust. Below this crust, the measured 'N' values reduced to generally 5 to 9 blows/ 0.3 m, indicating generally stiff consistency. This consistency was confirmed by the results of the field vane tests which showed undrained shear strength generally between 70 and 90 kPa.

Laboratory test results from soil samples in the cohesive soil deposits are as follows:

Natural Moisture Content (%):	14- 32
Atterberg Limits:	
• Liquid Limit (%):	20 - 33
• Plastic Limit (%):	14 - 18
• Plasticity Index (%):	4 - 17
Unit Weight (kN/m ³):	20.8 – 21.0

Grain Size (3 samples):

Gravel (%):	0 - 2
Sand (%):	3 - 11

.../...

MTO Central Region
East Main Street Embankment Widening
City of Welland, Region of Niagara
W.O. 01-23003, Agreement No. 2005-A-0000432
Ref No, TT22853; 8 November 2002
Foundation Investigation Report
Page (5)

Silt (%):	39 - 74
Clay (%):	23 - 58

The grain size curves and the results of the Atterberg Limits tests are presented in Appendix 'A'.

Consolidation tests were also conducted on two relatively undisturbed thin walled samples (TW) of the clays and the results are shown in Appendix A. Strain energy / work method was used to assess the pre-consolidation pressure of each sample tested. From these results the clayey deposit is considered overconsolidated, with estimated pre-consolidation pressure, σ_p' , of 270 kPa under the existing embankment, and about 220 kPa outside of the embankment. The associated over-consolidation ratio (OCR) is in the range of about 1.1 to 2.7.

4.4 Silt

Underlying the clayey silt in Borehole 45, a silt deposit was encountered at a depth of about 29.0m (or Elevation 161.2m). The borehole was terminated within this deposit at a depth of 31.0m (or Elevation 159.2m). This brown silt deposit was in a saturated condition. A measured 'N'-value of 5 blows per 0.3m was obtained indicating a loose relative density.

4.5 Groundwater Conditions

Groundwater in the open boreholes were observed during drilling and upon completion of each borehole. To permit long term monitoring of groundwater levels at the site, a standpipe piezometer was installed in Boreholes 46. The water level observed in this piezometer, six days after completion of the borehole, was at a depth of about 2 m below the bottom of the embankment. Observed groundwater levels are indicated on the individual Record of Borehole sheets.

It should, however, be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events.

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MTO Central Region
East Main Street Embankment Widening
City of Welland, Region of Niagara
W.O. 01-23003, Agreement No. 2005-A-0000432
Ref No, TT22853; 8 November 2002
Foundation Investigation Report
Page (6)

5.0 CLOSURE

AMEC Earth and Environmental Limited



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Assistant Manager,
Geotechnical Services



Kai-Sing Ho, Ph.D., P. Eng.,
Principal Geotechnical Consultant
MTO Designated Contact



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DRAWINGS

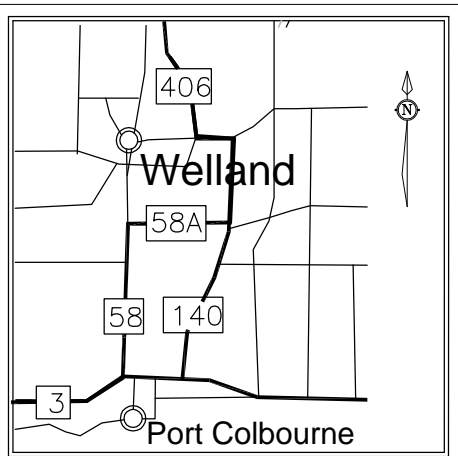
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES, UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES - METRES.

PROJECT NO.
CONT. No.
Change Order No.



EAST MAIN STREET EAST OF HWY 140
BORE HOLE LOCATION PLAN

AMEC Earth & Environmental Ltd.



KEY PLAN
N.T.S.

LEGEND



BOREHOLE

No	ELEVATION (m)	APPROX. CO-ORDINATES STATION	OFFSET
BH45	190.4	10+100	9.5 Rt
BH46	184.4	10+100	31 Rt
BH51	192.2	10+200	9.5 Rt
BH52	183.1	10+200	33.5 Rt

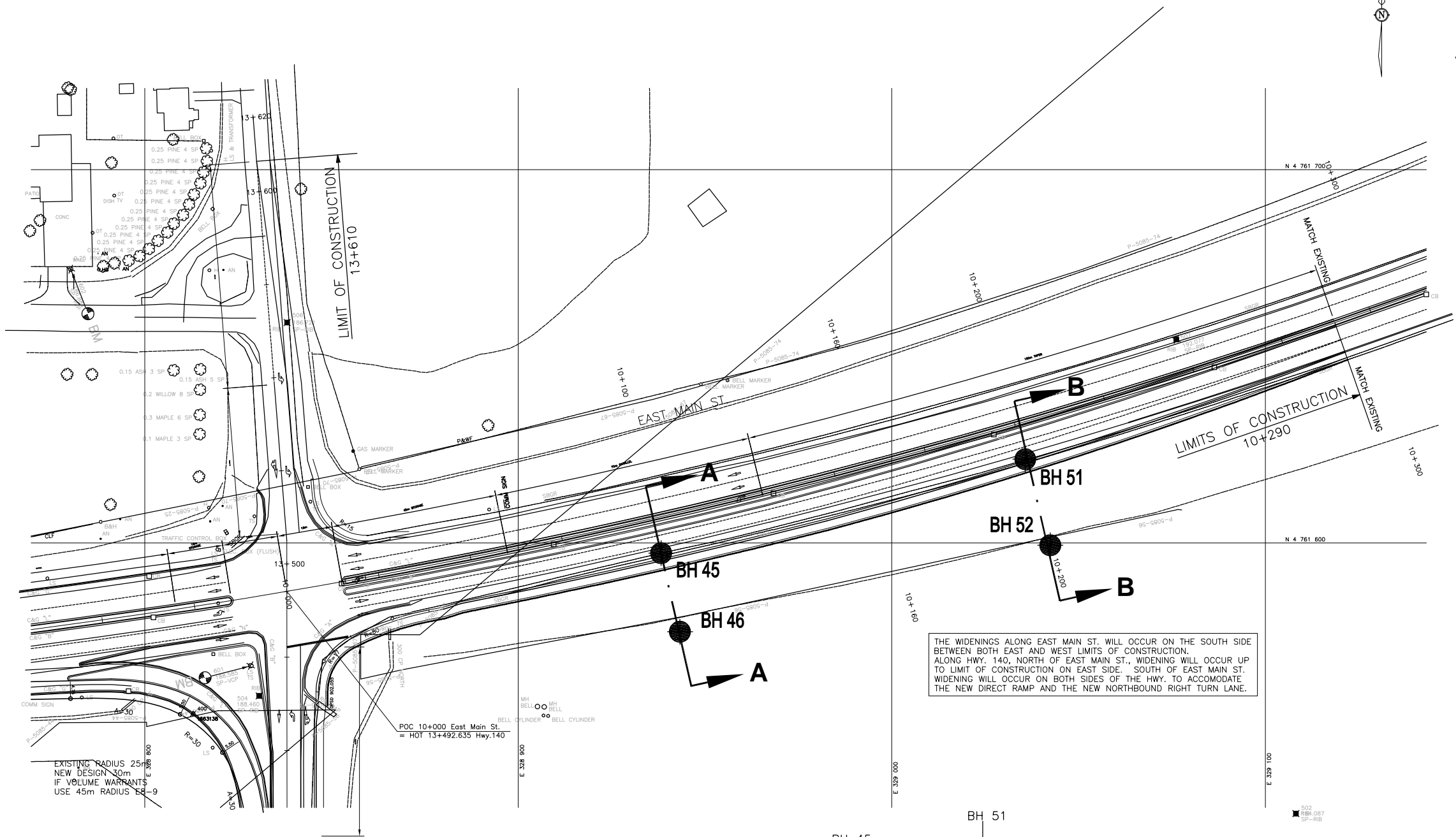
-NOTE-

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

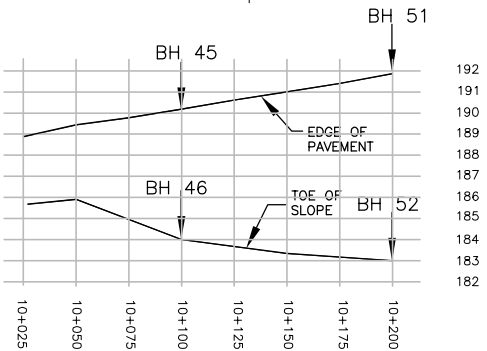
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 2.01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

DATE	BY	JDB No. TT2853
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EAST MAIN STREET, EAST OF HWY 140			DIST
SUBM'D AD	CHECKED AD	DATE OCTOBER 2002	SITE
DRAWN NS	CHECKED	APPROVED	DWG 1




BOREHOLE LOCATION PLAN
N.T.S.

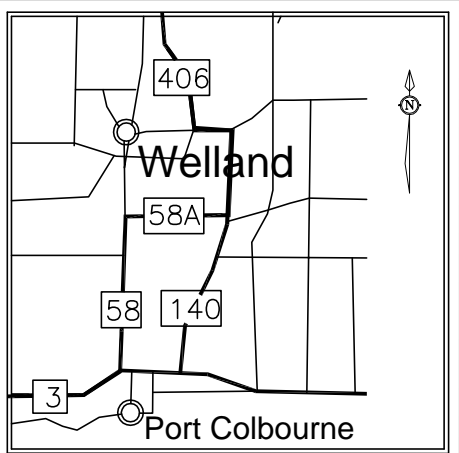


NOTE:
ALL BOREHOLE LOCATIONS ARE
APPROXIMATE.

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





PROJECT NO.	
CONT. No.	
Change Order No.	
EAST MAIN STREET EAST OF HWY 140	SHEET
BORE HOLE LOCATIONS & SOIL STRATA	

AMEC Earth & Environmental Ltd.



KEY PLAN
N.T.S.

LEGEND

-  BOREHOLE
-  GROUNDWATER LEVEL IN
PIEZOMETER ON 04 SEP., 02
-  GROUNDWATER LEVEL ON
COMPLETION IN OPEN BORE
-  PIEZOMETER

No	ELEVATION (m)	APPROX. CO-ORDINATES STATION	CO-ORDINATES OFFSET
BH45	190.4	10+100	9.5 Rt
BH46	184.4	10+100	31 Rt
BH51	192.2	10+200	9.5 Rt
BH52	183.1	10+200	33.5 Rt

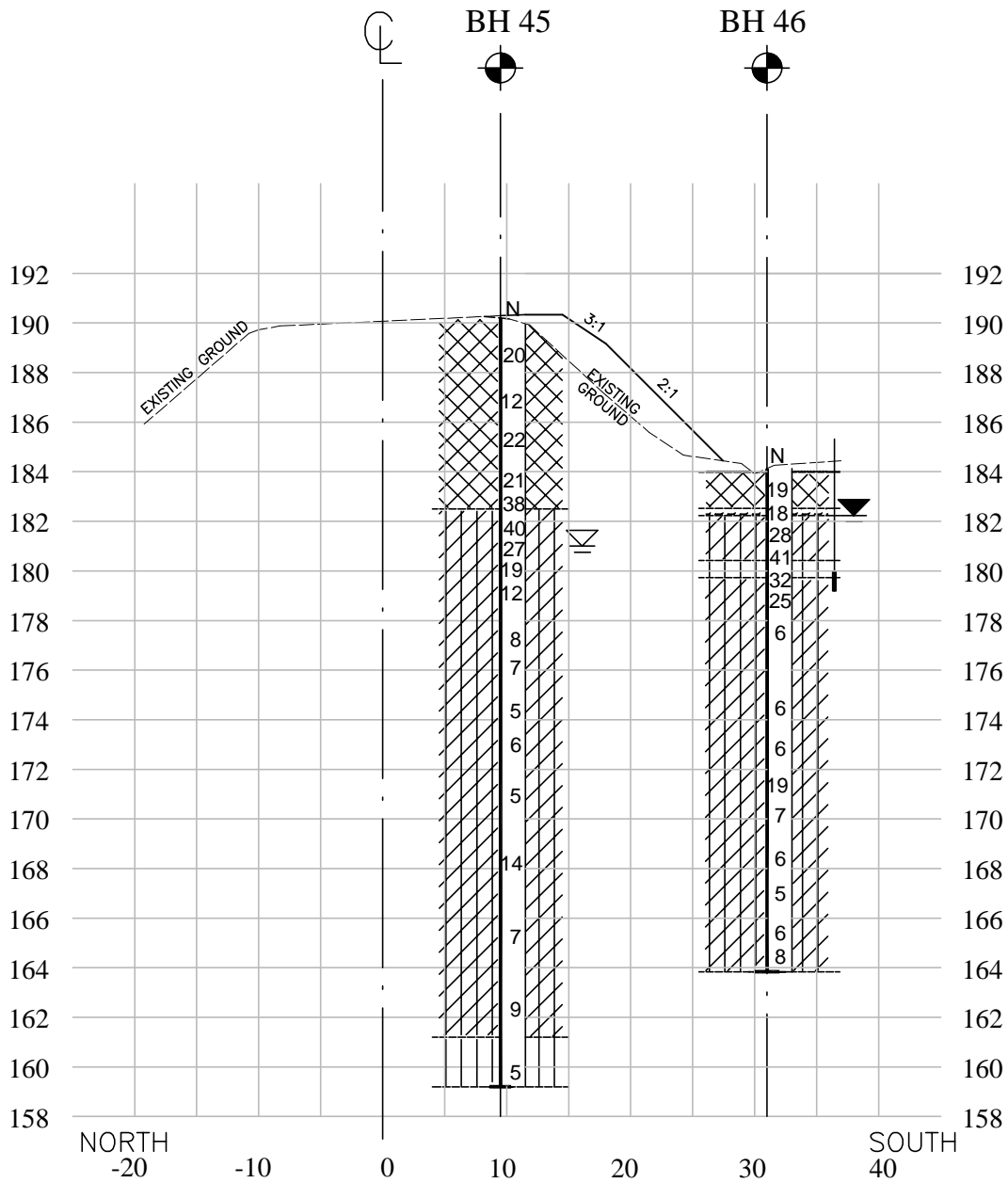
—NOTE—

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

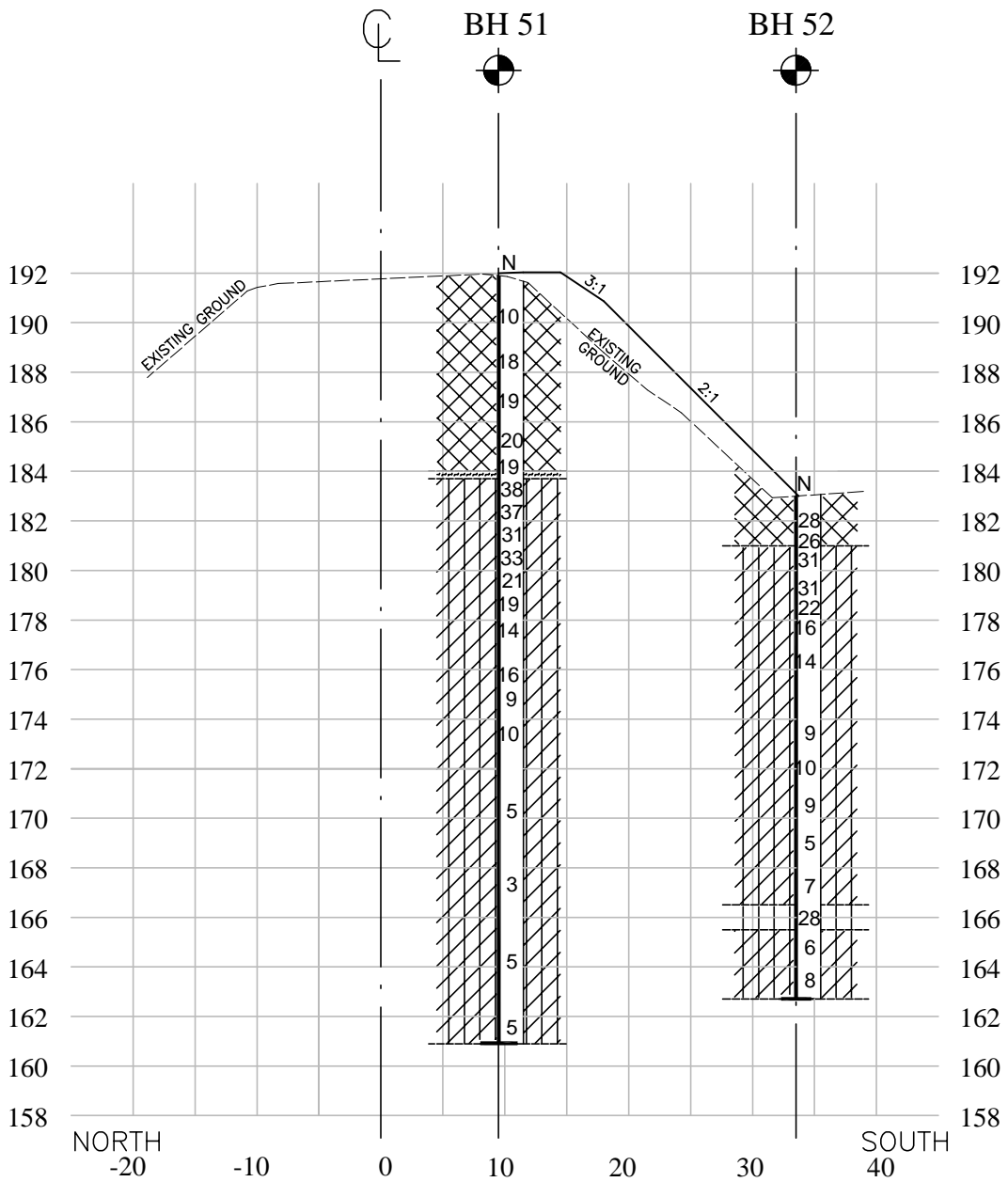
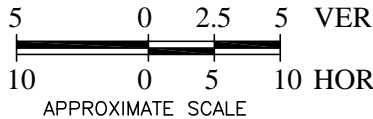
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REV.			
DATE	BY	JOB No.	TT22853

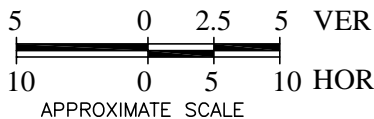
EAST MAIN STREET, EAST OF HWY 140			DIST
SUBM'D AD	CHECKED AD	DATE OCTOBER 2002	SITE
DRAWN KW	CHECKED	APPROVED	DWG 2




SECTION A-A at STATION 10+100



SECTION B-B at STATION 10+200



SOIL STRATIGRAPHY

-  FILL
Clayey Silt, very stiff
-  CLAYEY SILT
stiff to hard
-  SILT
-  TOPSOIL



RECORD OF BOREHOLE SHEETS

RECORD OF BOREHOLE No 45



1 OF 2

W.O. 01-23003 LOCATION Station 10+100, 9.5m Rt C/L East Main Street
 DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering
 DATUM Geodetic DATE 4 September 2002 - 4 September 2002
 PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario

ORIGINATED BY RS
 COMPILED BY PPM
 CHECKED BY RM
 JOB NO. TT22853

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa							WATER CONTENT (%)
									○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
190.2									20 40 60 80 100	10 20 30						
0.0	Sand and Gravel (FILL)							190								
189.6								189								
0.6	Clayey Silt, trace gravel (FILL) brown, damp		1	AS	-		1	189								
			2	SS	20		2	188								
							3	188								
			3	SS	12		4	187								
							5	187								
							6	186								
			4	SS	22		7	186								
							8	185								
							9	185								
			5	SS	21		10	184								
							11	184								
							12	183								
			6	SS	38		13	183								
							14	182								
			7	SS	40		15	182								
							16	181								
			8	SS	27		17	181								
							18	180								
			9	SS	19		19	180								
							20	179								
			10	SS	12		21	179								
							22	178								
			11	TW	-		23	178								
							24	177								
			12	SS	8		25	177								
							26	176								
							27	176								
			13	SS	7		28	175								
							29	175								
			14	SS	5		30	175								

Continued Next Page

+³, x³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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ORIGINATED BY RS

W.O. 01-23003 LOCATION Station 10+100, 9.5m Rt C/L East Main Street

DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering

COMPILED BY PPM

DATUM Geodetic DATE 4 September 2002 - 4 September 2002

- CHECKED BY RM

PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario

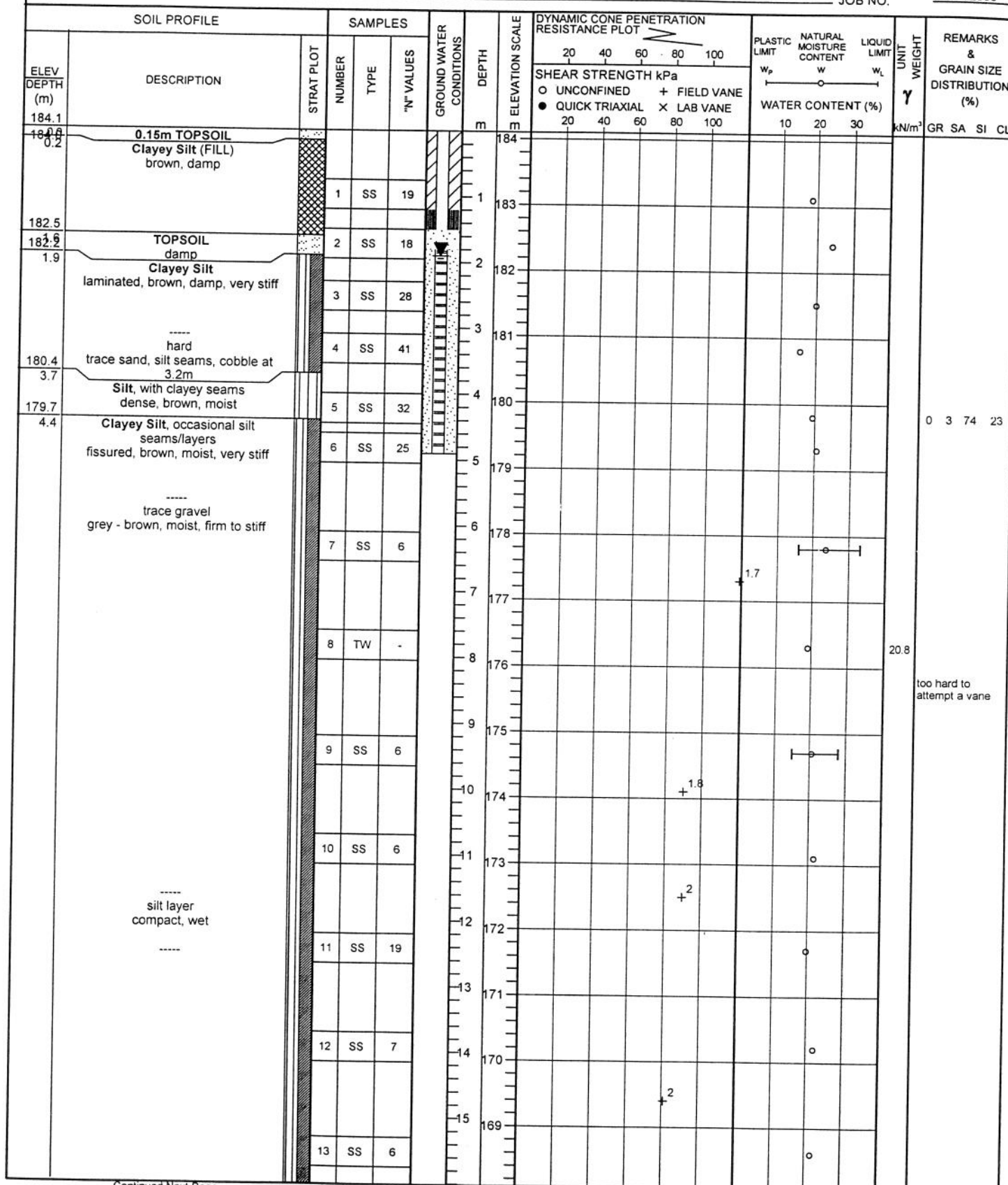
JOB NO. TT22853

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No 46

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W.O. 01-23003 LOCATION Station 10+100, 31m Rt C/L East Main Street 1 OF 2
 DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering ORIGINATED BY RS
 DATUM Geodetic DATE 29 August 2002 - 29 August 2002 COMPILED BY PPM
 PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario CHECKED BY RM
 JOB NO. TT22853



+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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[illegible]

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No 51



1 OF 2

W.O. 01-23003 LOCATION Station 10+200, 9.5m Rt C/L East Main Street ORIGINATED BY RS
 DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering COMPILED BY PPM
 DATUM Geodetic DATE 5 September 2002 - 6 September 2002 CHECKED BY RM
 PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario JOB NO. TT22853

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa						
191.9									20 40 60 80 100						
0.0	Sand and Gravel (FILL)								○ UNCONFINED + FIELD VANE						
191.2									● QUICK TRIAXIAL X LAB VANE						
0.7	Clayey Silt, trace gravel (FILL) brown, damp								20 40 60 80 100						
			1	SS	10		1	191							
							2	190							
			2	SS	18		3	189						19.8	
							4	188							
			3	SS	19		5	187							
							6	186							
			4	SS	20		7	185							
184.0							8	184							
183.9	TOPSOIL moist		5	SS	19		9	183							
8.2	Silty Clay, occasional silt seams laminated, hard, brown, damp		6	SS	38		10	182						0 3 39 58	
182.9							11	181							
9.0	Clayey Silt, trace gravel, occasional silt seams laminated, hard, brown, damp		7	SS	37		12	180						20.8	
			8	SS	31		13	179							
							14	178							
			9	SS	33		15	177							
	trace gravel grey-brown, moist, very stiff		10	SS	21										
			11	SS	19										
			12	SS	14										
			13	TW	-										
			14	SS	16										

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 51

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2 OF 2

W.O. 01-23003 LOCATION Station 10+200, 9.5m Rt C/L East Main Street ORIGINATED BY RS
 DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering COMPILED BY PPM
 DATUM Geodetic DATE 5 September 2002 - 6 September 2002 CHECKED BY RM
 PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario JOB NO. TT22853

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES										
	Clayey Silt, trace gravel grey-brown, moist, stiff to very stiff ----- firm to stiff		15	SS	9		17	175							too hard to turn the vane at 17.5m
								18	174						
								19	173						
								20	172						
								21	171						
								22	170						
								23	169						
								24	168						
								25	167						
								26	166						
						27	165								
						28	164								
						29	163								
						30	162								
160.9															
31.0	End of Borehole														
	Groundwater in open bore on completion: none														

+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

amec

1 OF 2

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No 52



W.O. 01-23003 LOCATION Station 10+200, 33.5m Rt C/L East Main Street 2 OF 2
 DIST HWY 140 BOREHOLE TYPE Hollow Stem Augering ORIGINATED BY RS
 DATUM Geodetic DATE 3 September 2002 - 3 September 2002 COMPILED BY PPM
 PROJECT Embankment Widening on East Main Street, East of HWY 140, Welland, Ontario CHECKED BY RM
 JOB NO. TT22853

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	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		
166.5															
16.5	Silt, with silty clay layers red - brown, wet, compact		14	SS	28		17	166							
165.5															
17.5	Clayey Silt, occasional silt seams grey-brown, moist to wet, stiff		15	SS	6		18	165							
							19	164							
162.7			16	SS	8		20	163							
20.3	End of Borehole														
	Groundwater in open bore on completion: none														

AMEC EARTH AND ENVIRONMENTAL LIMITED

NOTES TO BOREHOLE LOGS

DRILLING DATA

Method:
SolSt Augering - Solid Stem Augering
HolSt Augering - Hollow Stem Augering
WB - Washed Boring

SAMPLES

TYPE:
SS - Split Spoon
AS - Auger Sample
TW - Thinwall Open
TP - Thinwall Piston
WS - Washed Sample
BS - Block Sample
RC - Rock Core
PH - Sample Advanced Hydraulically
PM - Sample Advanced Manually

LABORATORY DATA

WP - Plastic Limit (%)
W - Water Content (%)
WL - Liquid Limit (%)
Y - Natural Unit Weight (kN/m³)
UNDR STRNG or C_u - Undrained Shear Strength (kPa)
Field Vane: St-sensitivity
pp - Pocket Penetrometer
UC - Unconfined Compression
UU - Unconsolidated Undrained at Overburden Pressure
CU - Consolidated Undrained
CD - Consolidated Drained
TOV - Total Organic Vapours

Standard Penetration Test: The Standard Penetration Test (SPT) 'N'-values are the number of blows required to cause a standard 51 millimetre o.d. split barrel sample to penetrate 0.3 metres into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kilograms falling freely a distance of 0.76 metres. For penetrations of less than 0.3 metres, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimetre penetration).

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51 millimetre 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 0.3 metres advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency or compactness.

CONSISTENCY: Cohesive soils are described on the basis of their undrained shear strength (C_u) or 'N'-values as follows:

C _u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD
N (blows/0.3 metres)	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	> 30

COMPACTNESS: Cohesionless soils are described on the basis of compactness as indicated by 'N'-values as follows:

N (blows/0.3 metres)	0 - 4	4 - 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.

ROCK QUALITY

DESIGNATION (RQD): Sum of those intact core pieces, 100 millimetres in length expressed as a percent of the length of the coring run. Classification of a rock based on the RQD value as follows:

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

JOINTING AND BEDDING:

SPACING	50 millimetres	50 - 300 millimetres	0.3 - 1.0 millimetres	1.0 - 3.0 millimetres	> 3.0 millimetres
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

APPENDIX 'A'
LABORATORY TEST RESULTS



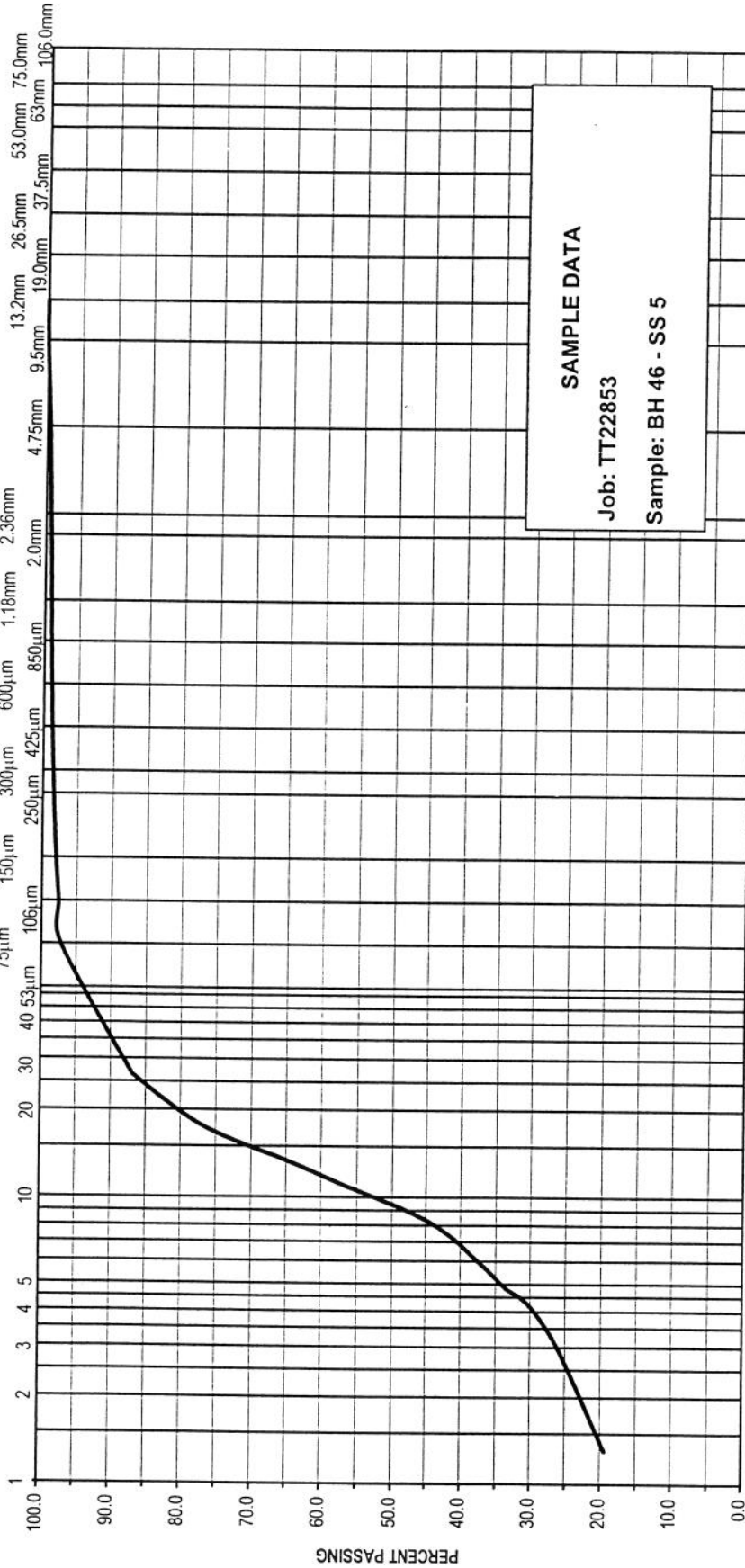
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

MINISTRY SIEVE DESIGNATION (Metric)

GRAIN SIZE IN MICROMETERS

1	2	3	4	5	10	20	30	40	53µm	75µm	106µm	150µm	250µm	300µm	425µm	600µm	850µm	2.0mm	2.36mm	4.75mm	9.5mm	13.2mm	19.0mm	26.5mm	37.5mm	53.0mm	75.0mm	106.0mm
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SAMPLE DATA

Job: TT22853

Sample: BH 46 - SS 5

MINISTRY SIEVE DESIGNATION (Imperial)

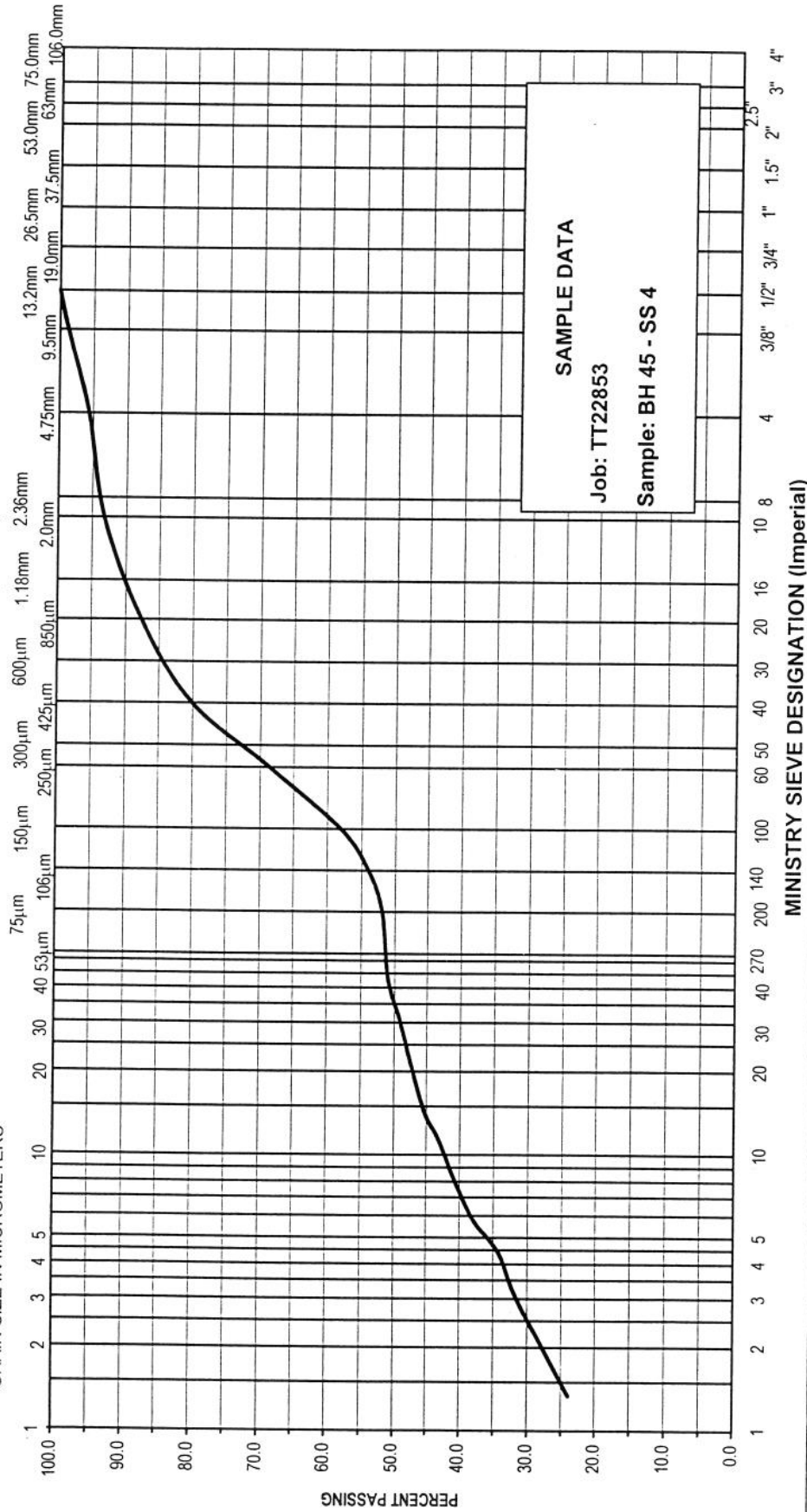
AMEC Earth & Environmental Limited 104 Crockford Blvd., Scarborough, Ontario Canada, M1R 3C3 Tel +1 (416) 751 6565, Fax +1 (416) 751 7592 www.amec.com	GRAIN SIZE DISTRIBUTION		Client :- Ministry of Transportation Ontario	
	SILT with Clay seams		Project:- Embankment widening of East Main Street	
			Location:- Welland, Ontario	
			Depth :- 4.0 - 4.4 m	
		Date :- 23 Sep 2002		



UNIFIED SOIL CLASSIFICATION SYSTEM

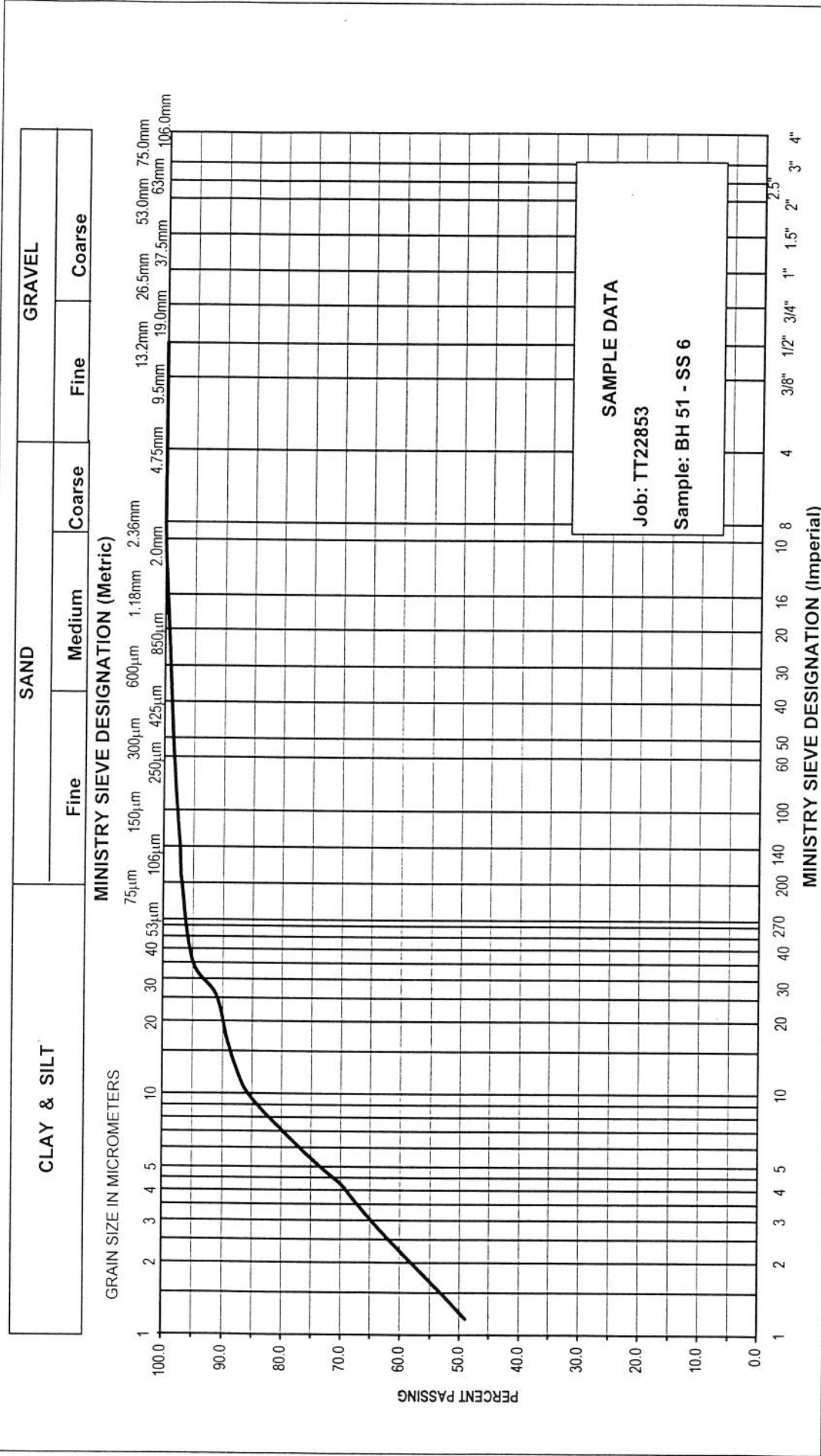
CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

MINISTRY SIEVE DESIGNATION (Metric)



AMEC Earth & Environmental Limited 104 Crockford Blvd., Scarborough, Ontario Canada, M1R 3C3 Tel +1 (416) 751 6565, Fax +1 (416) 751 7592 www.amec.com	GRAIN SIZE DISTRIBUTION	Client :- Ministry of Transportation Ontario
	Clayey Silt (FILL) with Sand, trace Gravel	Project:- Embankment widening of East Main Street
		Location:- Welland, Ontario
		Depth :- 4.6 - 5.0 m

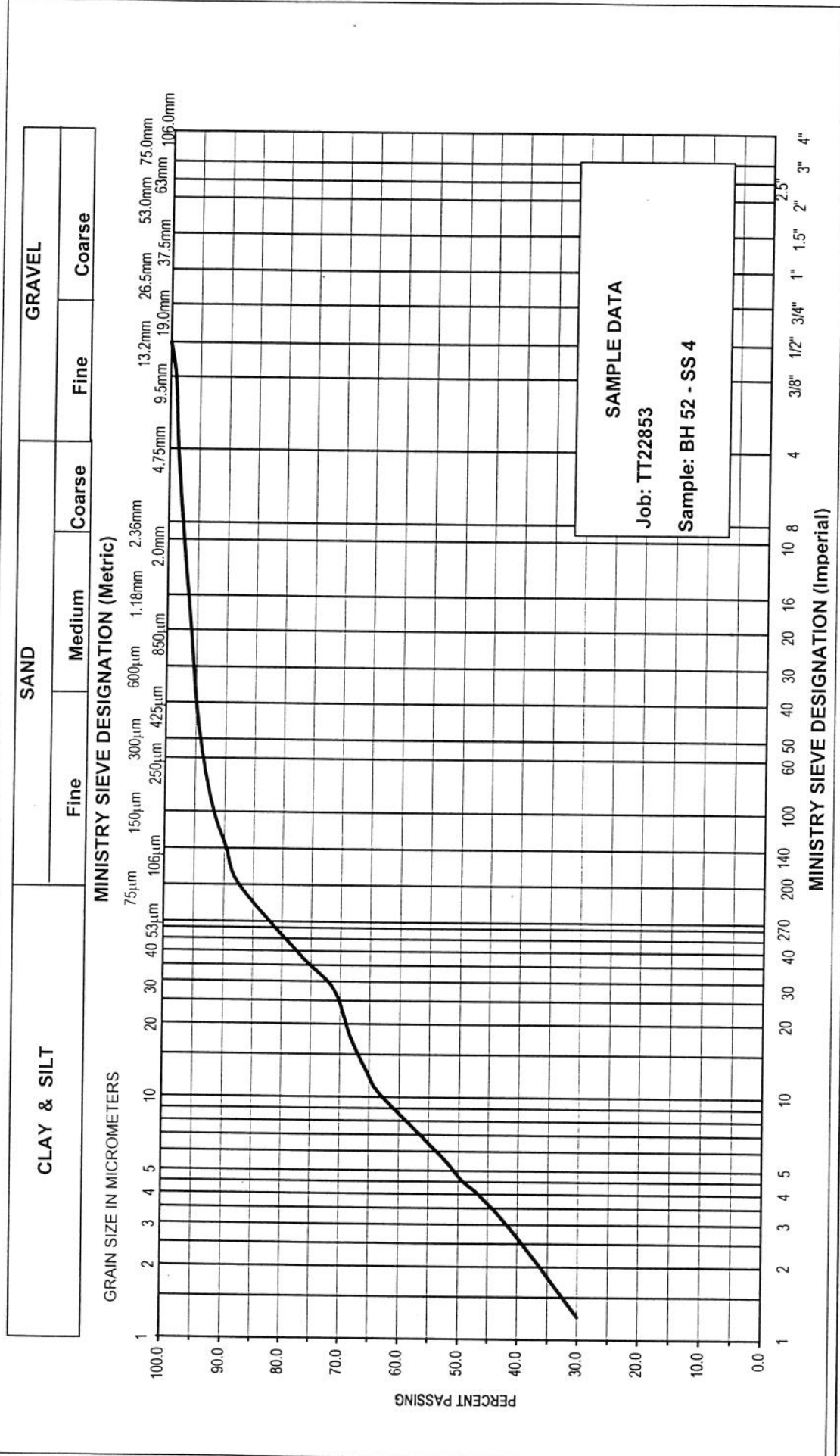
UNIFIED SOIL CLASSIFICATION SYSTEM



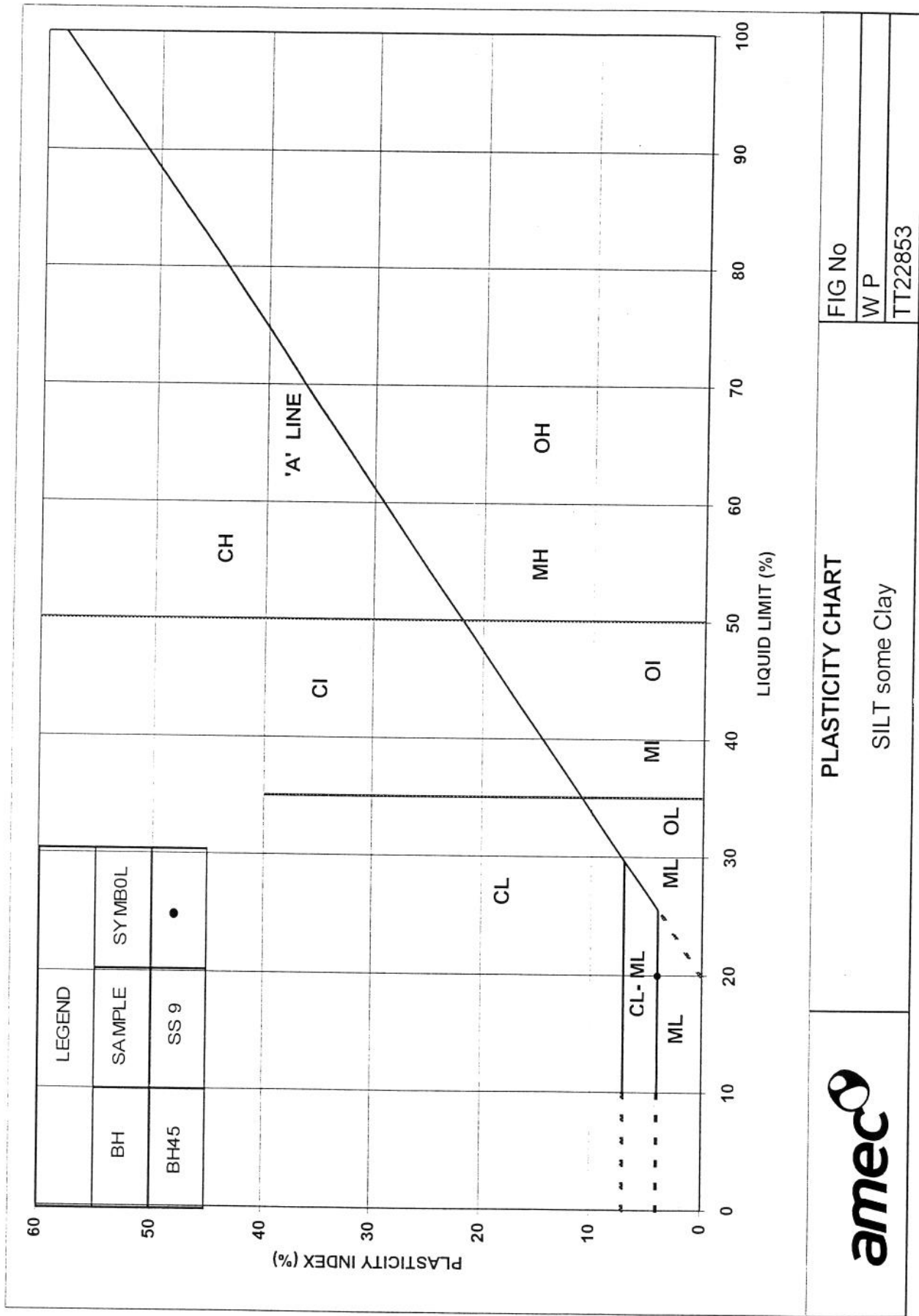
AMEC Earth & Environmental Limited 104 Crockford Blvd., Scarborough, Ontario Canada, M1R 3C3 Tel +1 (416) 751 6565, Fax +1 (416) 751 7592 www.amec.com	GRAIN SIZE DISTRIBUTION		Client :- Ministry of Transportation Ontario
	SILTY CLAY trace Sand		Project:- Embankment widening of East Main Street
			Location:- Welland, Ontario
			Depth :- 8.4 - 8.8 m
			Date :- 23 Sep 2002

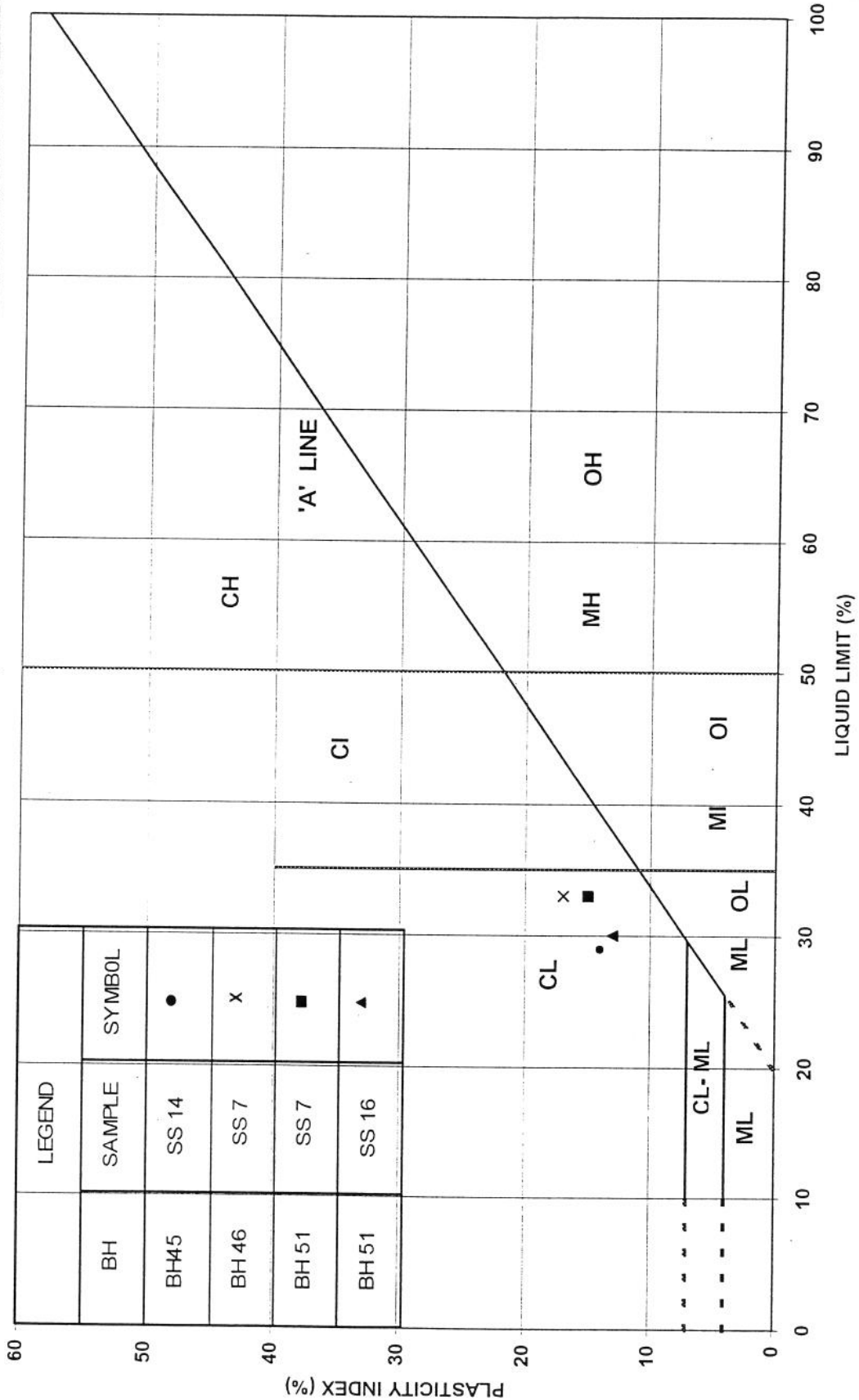


UNIFIED SOIL CLASSIFICATION SYSTEM



AMEC Earth & Environmental Limited 104 Crockford Blvd., Scarborough, Ontario Canada, M1R 3C3 Tel +1 (416) 751 6565, Fax +1 (416) 751 7592 www.amec.com	GRAIN SIZE DISTRIBUTION		Client :- Ministry of Transportation Ontario
	CLAYEY SILT trace Sand and Gravel		Project:- Embankment widening of East Main Street
			Location:- Welland, Ontario
			Depth :- 3.1 - 3.5 m
			Date :- 23 Sep 2002







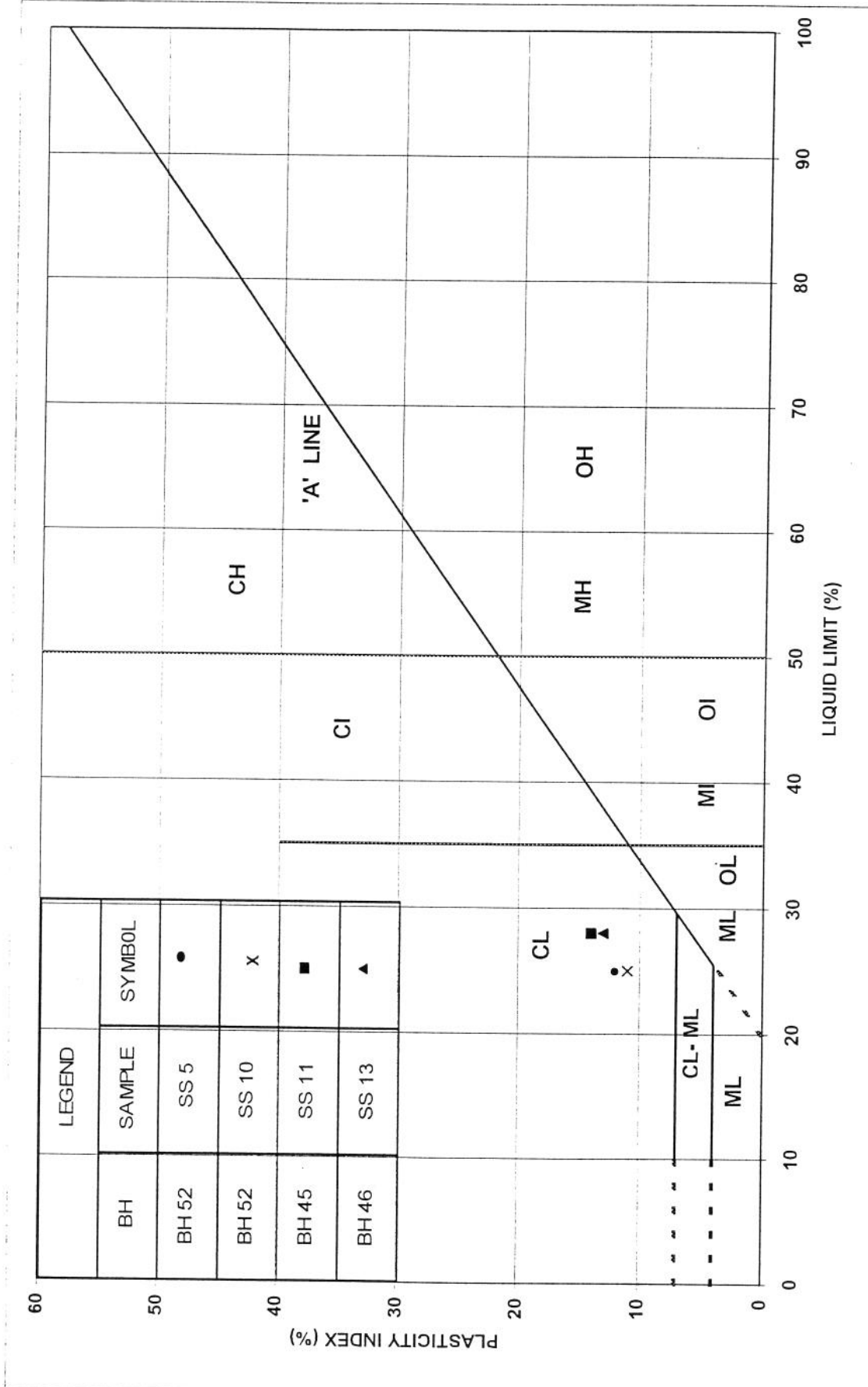
PLASTICITY CHART

CLAYEY SILT

FIG No

W P

TT22853



	PLASTICITY CHART		FIG No
	CLAYEY SILT		W P
			TT22853

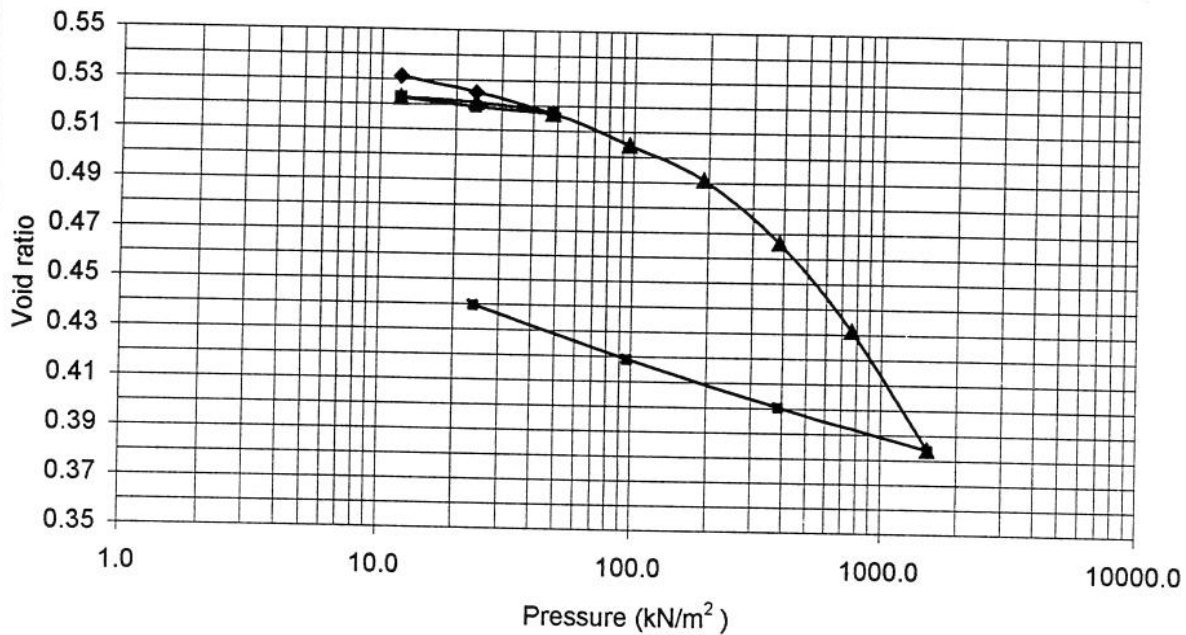
Project: Embankment Widening of East Main Street, Welland, Ontario

Job#: TT22853

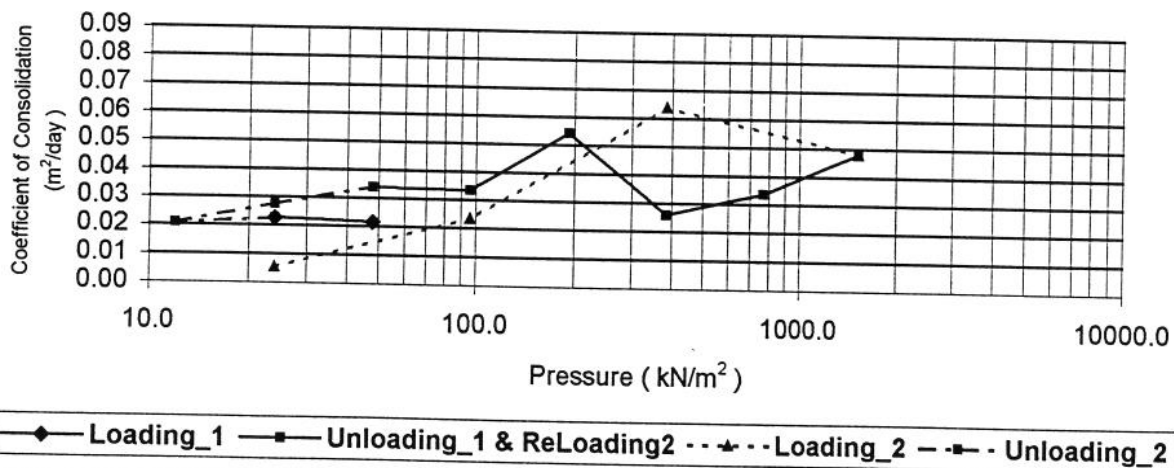
Date: September 22, 2002 BH No. 46 Sample No. TW 8

Depth(m): 7.6m

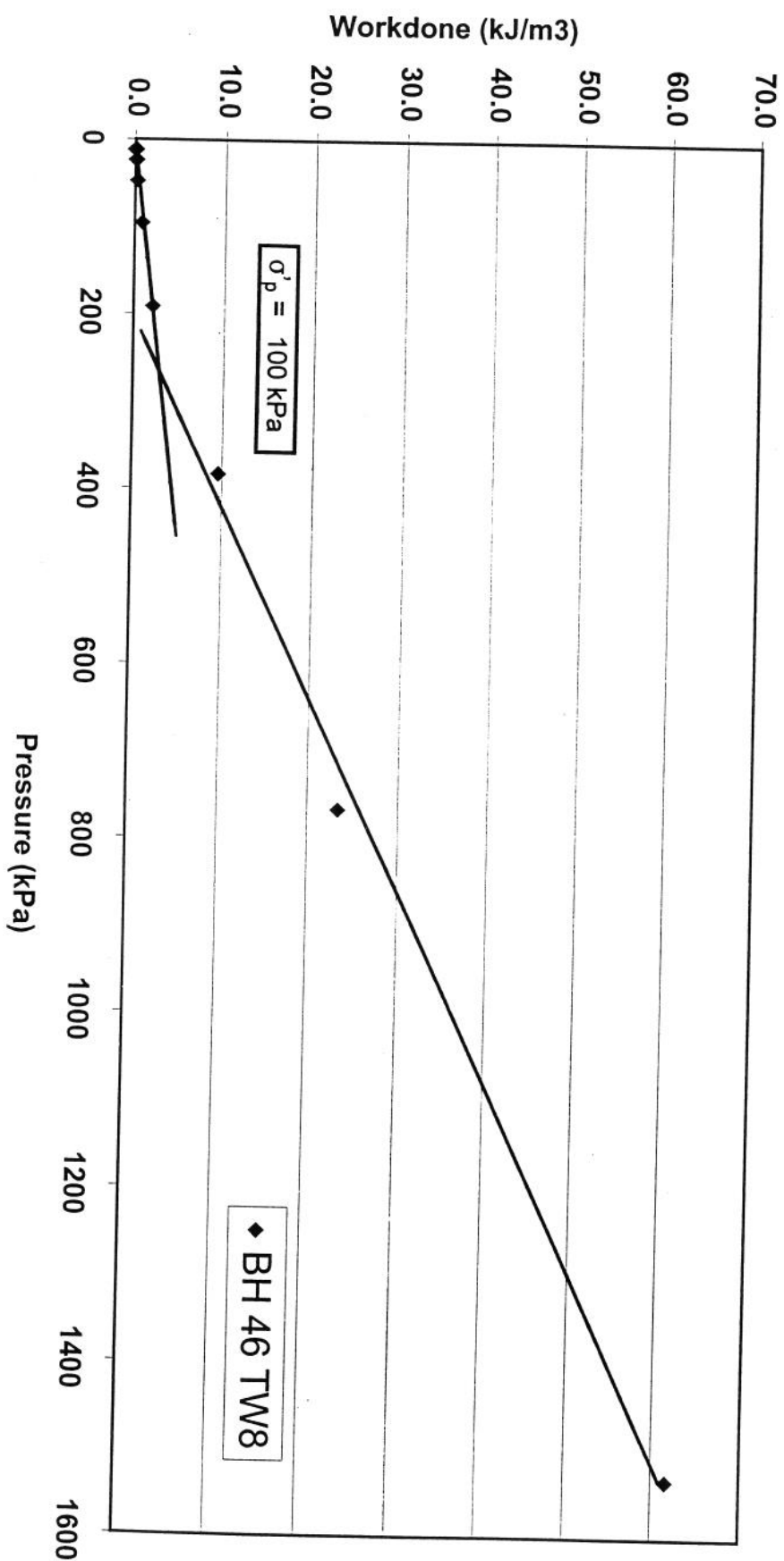
Void Ratio Vs Pressure



Coefficient of Consolidation Vs Pressure



Strain Energy Method for Preconsolidation Pressure

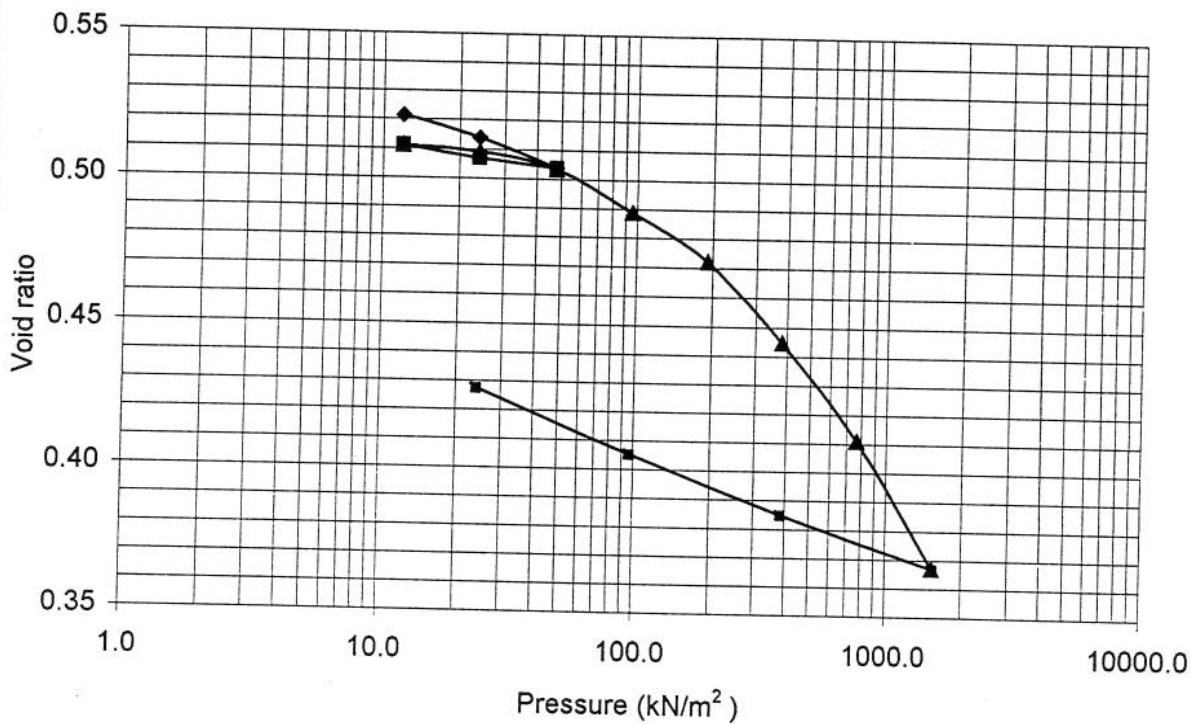


Project: Embankment Widening of East Main Street, Welland, Ontario

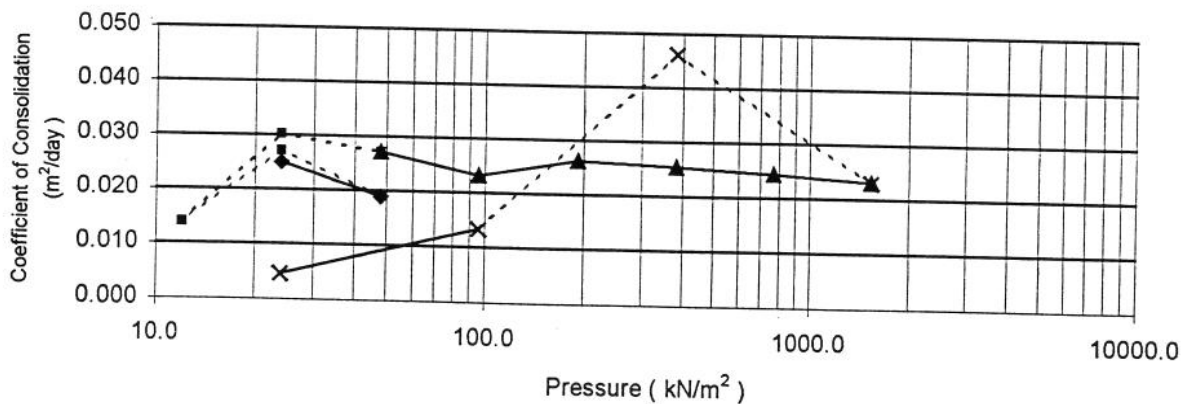
Job#: TT22853

Date: September 22, 2002 BH No. 45 Sample No. TW 11 Depth(m): 11.4 m

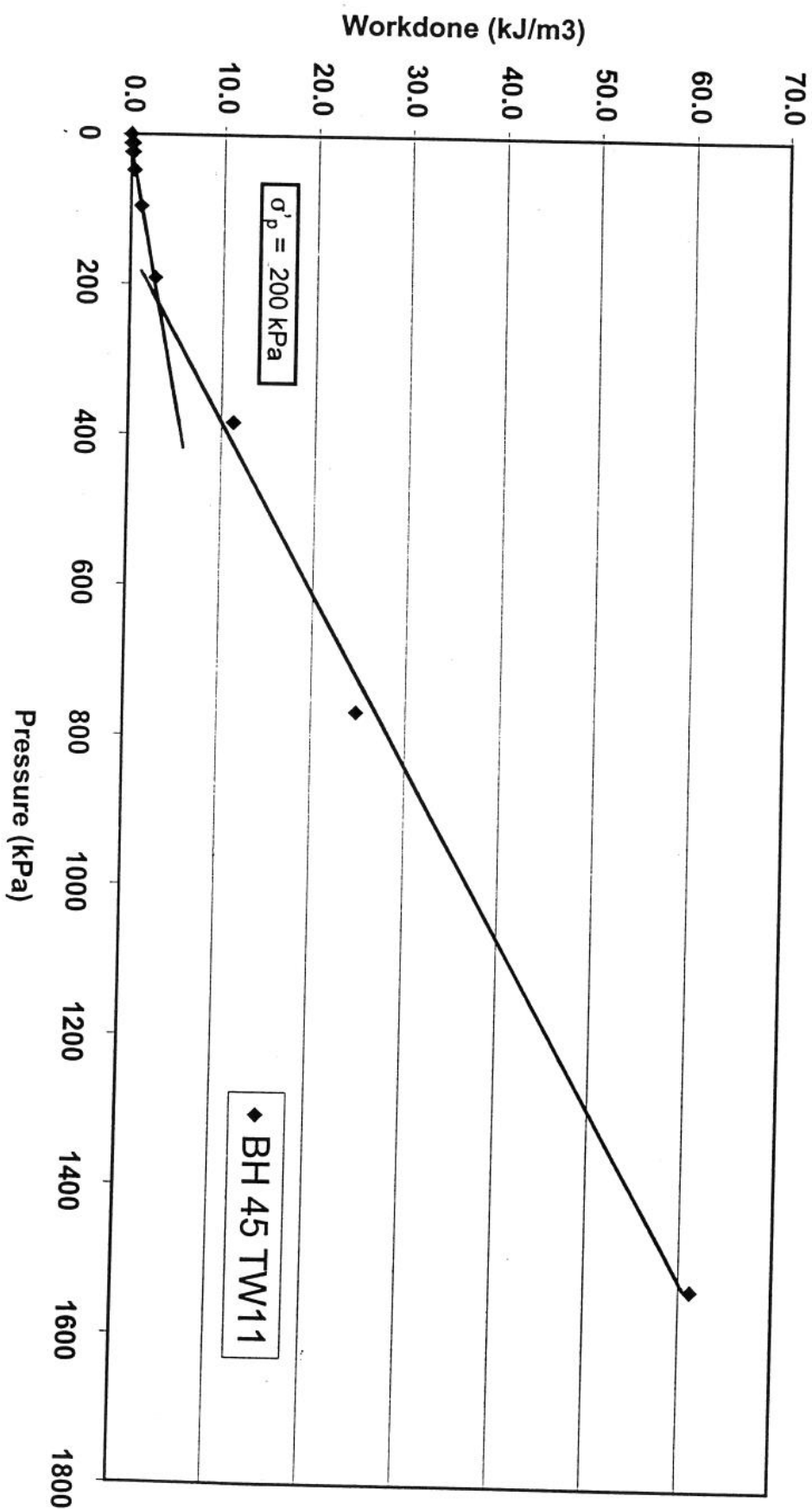
Void Ratio Vs Pressure



Coefficient of Consolidation Vs Pressure



Strain Energy Method for Preconsolidation Pressure



APPENDIX 'C'
SITE PHOTOGRAPHS



Looking west along East Main Street at top of embankment in the Foundation Investigation Area



Slope Treatment consisting of crushed stone surrounding PVC drainage pipe.



Looking east from Hwy. 140 at Foundation Investigation Area for embankment widening of East Main Street