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**FOUNDATION INVESTIGATION REPORT
CULVERT EXTENSIONS
STATIONS 13+992 AND 19+484, HIGHWAY 401
TOWNSHIP OF ROCHESTER
HIGHWAY 401 RECONSTRUCTION
GWP 63-00-00, AGREEMENT NO. 3004-E-0006
MINISTRY OF TRANSPORTATION - SOUTHWESTERN REGION**

Submitted to:

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March 1, 2006

05-1130-031-1-9
Geocres No. 40J2-75



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LIST OF SYMBOLS

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PART A

**FOUNDATION INVESTIGATION REPORT
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundations engineering services as part of the detail design work for the section of Highway 401 described by GWP 63-00-00. This section of Highway 401 is some 9.9 kilometres in length and extends from 2.5 kilometres east of Essex Road 27 easterly to 1.2 kilometres west of Highway 77 in the Townships of Rochester and Tilbury West, County of Essex, Ontario.

The purpose of this portion of the foundation investigation was to determine the subsurface conditions for the extensions of the culverts located at Station 13+992 and Station 19+484, Highway 401, Township of Rochester, by drilling boreholes, carrying out in-situ tests and laboratory tests on selected samples. The terms of reference for the scope of work are outlined in the MTO's request for proposal and Golder Associates proposal P41-3106, dated December 24, 2004. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering Detail Design Services dated March 9, 2005.

2.0 SITE DESCRIPTION

2.1 General

GWP 63-00-00 comprises the reconstruction and widening of some 9.9 kilometres of Highway 401 extending from 2.5 kilometres east of Essex Road 27 in the Township of Rochester easterly to 1.2 kilometres west of Highway 77 in the Township of Tilbury West, County of Essex, Ontario. The location of the project is shown on the Key Plan, Figure 1. The project chainage extends from Highway 401 Station 13+000, Township of Rochester to Station 12+700, Township of Tilbury West.

This report addresses the subsurface conditions for the proposed culvert extensions at Station 13+992 and 19+484, Highway 401 in the Township of Rochester. The location of the subject culvert sites are shown on the Key Plan, Figure 1.

This section of Highway 401 is currently a four lane divided freeway with a depressed grass median. In each direction, two 3.35 metre wide lanes with 3.58 metre outer shoulders and 4.57 metre wide inner shoulders are present.

The topography in the area of the site is generally flat. The areas outside of the Highway 401 paved surfaces are well vegetated with grasses. The primary land use in the area is agricultural with some residential areas along French Line Road.

2.2 Site Geology

The project lies within the Essex Clay Plain, a subregion of the physiographic region of southern Ontario known as the St. Clair Clay Plains, identified in “The Physiography of Southern Ontario” by Chapman and Putnam (1984). The clay plain is described as a till plain that has been smoothed by shallow deposits of lacustrine clay which settled in the depressions of the till. The prevailing soil type is reportedly the Brookston clay.

Based on the Ontario Department of Mines and Northern Affairs Preliminary Maps P.749 and P.750 entitled “Quaternary Geology of the Windsor-Essex Area” Western and Eastern Parts, respectively, the project area is reportedly located in predominantly clayey silt till.

Based on the available bedrock geology mapping, the subcropping bedrock consists of limestone of the Dundee formation of Middle Devonian age.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between August 4 and 12, 2005 at which time a total of eight boreholes were drilled at the locations indicated on Drawing 1.

The as-drilled borehole locations, ground surface elevations and borehole depths are as follows:

<u>BOREHOLE</u>	<u>LOCATIONS (m)</u>		<u>GROUND SURFACE</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	<u>ELEVATION</u> (m)	
STATION 13+992				
215	4677270	290752	183.39	8.08
216	4677278	290748	183.55	8.23
220	4677227	290749	183.27	8.23
221	4677218	290748	183.80	7.47
STATION 19+484				
204	4676964	296226	183.18	8.84
205	4676955	296237	181.64	7.32
212	4677009	296229	183.32	8.84
213	4677019	296229	181.78	7.32

The soil stratigraphy encountered in the boreholes is shown on the attached Record of Borehole sheets.

The boreholes were advanced using an all terrain vehicle mounted power auger supplied and operated by a specialist drilling contractor. Samples of the overburden were obtained at suitable intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures. Groundwater conditions were observed in the boreholes throughout the drilling operations. All of the boreholes were backfilled in accordance with current regulations and MTO recommended procedures.

The field work was supervised on a full-time basis by experienced members of our engineering staff who arranged for underground utility locates, directed the drilling, sampling and in situ testing operations, logged the boreholes and cared for the samples obtained. The soil samples were identified in the field, placed in labeled containers and transported to Golder Associates' London laboratory for further examination and routine testing. Index and classification tests consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations were carried out on selected samples. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

Temporary traffic control was provided in accordance with the Ontario Traffic Manual, Book 7, dated March 2001.

4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of the in situ and laboratory testing are provided on the attached Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling resistance and may represent transitions between soil types rather than exact planes of geological change. Further, the subsurface conditions may vary significantly between and beyond the borehole locations.

A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized in the following sections.

4.2 Station 13+992

In summary, the boreholes drilled for the proposed culvert extensions at this location encountered topsoil and fill overlying stiff to hard silty clay till. Layers of soft clayey silt and stiff to very stiff clayey silt till were also encountered in boreholes 215 and 216, respectively.

4.2.1 Topsoil and Fill Materials

Topsoil layers 0.1 to 0.2 metres thick were encountered at ground surface in all of the boreholes.

Beneath the surficial topsoil layers, firm to very stiff clayey fill materials were encountered. The fill materials were from 1.2 to 2.0 metres thick at the borehole locations. The N values in the fill, as determined in the standard penetration testing, were 7 to 22 blows per 0.3 metres with water contents of 11 to 23 per cent.

Very loose sand and gravel fill was encountered at elevation 182.0 metres beneath the clayey fill materials in borehole 215. This fill material was 0.5 metres thick with an N value of 3 blows per 0.3 metres and a water content of 10 per cent.

4.2.2 Clayey Silt

A layer of soft clayey silt about 0.3 metres thick was encountered beneath the granular fill in borehole 215 at elevation 181.6 metres. The clayey silt had an N value of 3 blows per 0.3 metres and a water content of 24 per cent.

4.2.3 Clayey Silt Till

Stiff to very stiff clayey silt till was encountered beneath the fill in borehole 216 at elevation 182.2 metres and also beneath the silty clay till in borehole 216 at elevation 176.1 metres. The upper clayey silt till layer was 1.5 metres thick. Borehole 216 was terminated in the lower clayey silt till layer after exploring it for about 0.8 metres. The clayey silt till had N values of 9 to 23 blows per 0.3 metres with natural water contents of 17 to 23 per cent.

4.2.4 Silty Clay Till

Beneath the clayey silt in borehole 215, beneath the upper clayey silt till in borehole 216, and beneath the fill materials in boreholes 220 and 221, stiff to hard silty clay till was encountered. The surface of the till was encountered between elevation 180.7 and 181.4 metres. Boreholes 215, 220 and 221 were terminated in the silty clay till after exploring it for about 6 metres. Where fully penetrated in borehole 216, the silty clay till was 4.6 metres thick. The silty clay till had N values of 10 to 39 blows per 0.3 metres with natural water contents of 15 to 21 per cent and an average of 18 per cent. The silty clay till had corresponding average plastic and liquid limits of 17 and 31 per cent, respectively, based on six Atterberg limits determinations. The Atterberg limits data are provided on Figure A-2 and indicate an inorganic clay of low plasticity.

Grain size distribution curves for samples of the silty clay till recovered from the standard penetration testing are provided on Figure A-1.

4.3 Station 19+484

In summary, the boreholes drilled for the proposed culvert extensions at this location encountered topsoil and/or firm to stiff clayey fill overlying firm to hard silty clay till. Firm silty clay was also encountered beneath the silty clay till in boreholes 204 and 205. In borehole 212, layers of compact sandy silt and silty sand were encountered in the silty clay till at depth. Stiff clayey silt was encountered beneath the silty clay till in borehole 212.

4.3.1 Topsoil and Fill Materials

Topsoil layers 0.1 to 0.2 metres thick were encountered at ground surface in boreholes 204, 205 and 213.

Layers of sand and gravel fill and asphalt were encountered at ground surface in borehole 212. The total thickness of these layers was 0.3 metres.

Beneath the granular fill in borehole 212 and the surficial topsoil layer in borehole 204, firm to stiff clayey fill materials were encountered. These fill materials were 1.1 and 1.9 metres thick at

the borehole locations. The clayey fill had N values, as determined in the standard penetration testing, of 6 to 15 blows per 0.3 metres with water contents of 16 to 22 per cent.

4.3.2 Silty Clay Till

Beneath the surficial topsoil in boreholes 205 and 213 and beneath the clayey fill in boreholes 204 and 212, firm to hard silty clay till was encountered. The surface of the till was encountered between elevation 181.2 and 182.0 metres. Borehole 213 was terminated in the silty clay till after exploring it for about 7.2 metres. Where fully penetrated in the other boreholes, the silty clay till layers were 1.8 to 6.7 metres thick. The silty clay till had N values of 6 to 35 blows per 0.3 metres with natural water contents of 11 to 23 per cent and an average of 18 per cent. The silty clay till had corresponding average plastic and liquid limits of 18 and 36 per cent, respectively, based on three Atterberg limits determinations. The Atterberg limits data are provided on Figure A-5 and indicate an inorganic clay of low to intermediate plasticity.

Grain size distribution curves for samples of the silty clay till recovered from the standard penetration testing are provided on Figure A-3.

4.3.3 Sandy Silt and Silty Sand

Layers of compact sandy silt and silty sand were encountered in the silty clay till in borehole 212 at elevation 178.9 metres. The total thickness of these layers was about 2.0 metres. The sandy silt and silty sand had N values of 17 to 19 blows per 0.3 metres and natural water contents of 11 to 17 per cent.

A grain size distribution curve for a sample of the silty sand recovered from the standard penetration testing is provided on Figure A-4.

4.3.4 Clayey Silt

A layer of stiff clayey silt was encountered beneath the silty clay till in borehole 212 at elevation 175.1 metres. Borehole 212 was terminated in the clayey silt after exploring it for about 0.6 metres. The clayey silt had an N value of 9 blows per 0.3 metres.

4.3.5 Silty Clay

Layers of firm silty clay were encountered beneath the silty clay till in boreholes 204 and 205 at elevation 176.5 and 174.9 metres, respectively. Both boreholes were terminated in the silty clay layers after exploring them for about 0.6 to 2.1 metres. The silty clay had N values of 6 to 10 blows per 0.3 metres with natural water contents of 22 to 24 per cent.

4.4 Groundwater Conditions

Groundwater conditions were observed in the boreholes during drilling. All of the boreholes, except borehole 212, were dry during drilling. This information is summarized below:

<u>BOREHOLE</u>	<u>GROUND SURFACE ELEVATION</u> (m)	<u>ENCOUNTERED GROUNDWATER ELEVATION</u> (m)
STATION 13+992		
215	183.39	Dry
216	183.55	Dry
220	183.27	Dry
221	183.80	Dry
STATION 19+484		
204	183.18	Dry
205	181.64	Dry
212	183.32	178.14
213	181.78	Dry

Based on the conditions encountered in the boreholes, the long-term groundwater level is estimated to be at approximately elevation 180 metres at both culvert sites. Seasonal variations in the groundwater levels should be expected.

5.0 MISCELLANEOUS

This investigation was carried out using equipment supplied and operated by Lantech Drilling Services Inc. and Aardvark Drilling Inc., both of which are Ontario Ministry of Environment licensed well contractors. The field operations were supervised by Mr. Michael Arthur and Mr. Dan Babcock under the direction of Mr. David J. Mitchell. The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by Mr. Michael E. Beadle, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

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MEB/PRB/FJH/jk
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- non structural culverts.doc

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

Consistency

	<u>kPa</u>	<u>psf</u>
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

(b) Cohesive Soils

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength $= (\text{compressive strength})/2$
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

RECORD OF BOREHOLE No 204

1 OF 1

METRIC

PROJECT 05-1130-031-1-9
G.W.P. 63-00-00 LOCATION N 4676963.7 ; E 296225.5 ORIGINATED BY M.A.
DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER/HOLLOW STEM AUGERS COMPILED BY DCH/WDF
DATUM GEODETIC DATE August 4, 2005 CHECKED BY MEB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								20 40 60 80 100	20 40 60 80 100						10 20 30	
183.18	GROUND SURFACE															
0.09	TOPSOIL, clayey Black FILL, silty clay, trace sand, trace gravel Stiff Brown		1	SS	15		183									
							182									
181.20			2	SS	13											
1.98	SILTY CLAY, trace to some sand, trace gravel (TILL) Stiff to hard Brown to grey at elev. 178.9m		3	SS	13		181									
			4	SS	35		180									
			5	SS	15		179									
			6	SS	11		178									
			7	SS	12		177									
			8	SS	11		176									
176.47			9	SS	10		175									
6.71	SILTY CLAY, trace to some sand, trace gravel Firm to stiff Grey		10	SS	10											
			11	SS	6											
174.34	END OF BOREHOLE															
8.84	Borehole dry during drilling August 4, 2005															

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

PROJECT <u>05-1130-031-1-9</u>		RECORD OF BOREHOLE No 205		1 OF 1 METRIC	
G.W.P. <u>63-00-00</u>		LOCATION <u>N 4676955.1 ; E 296236.5</u>		ORIGINATED BY <u>M.A.</u>	
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER/HOLLOW STEM AUGERS</u>		COMPILED BY <u>DCH/WDF</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 4, 2005</u>		CHECKED BY <u>MEB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p	w		w _L				
181.64	GROUND SURFACE																				
0.02	TOPSOIL , clayey Black SILTY CLAY , trace to some sand, trace gravel, (TILL) Stiff to hard Brown to grey at elev. 179.5m																				
			1	SS	31																
			2	SS	27									○							
			3	SS	19									┌───┐					0 15 42 43		
			4	SS	11									○							
			5	SS	11																
			6	SS	12									○							
			7	SS	12																
			8	SS	11									○							
174.94																					
6.70	SILTY CLAY , trace sand, trace gravel Firm Grey																				
174.32			9	SS	7																
7.32	END OF BOREHOLE Borehole dry during drilling August 4, 2005																				

ON_MTO 05-1130-031-1-9.GPJ ON_MOT.GDT 3/1/06

RECORD OF BOREHOLE No 212

1 OF 1

METRIC

PROJECT 05-1130-031-1-9
G.W.P. 63-00-00 LOCATION N 4677008.7 ; E 296229.3 ORIGINATED BY M.A.
DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER/HOLLOW STEM AUGERS COMPILED BY DCH/WDF
DATUM GEODETIC DATE August 9, 2005 CHECKED BY MEB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	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	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
183.32	GROUND SURFACE							20	40	60	80	100								
0.16	FILL, sand and gravel, some silt																			
0.27	ASPHALT																			
	FILL, sand and gravel, some silt																			
	FILL, clayey silt, some sand, trace gravel																			
	Firm																			
	Brown																			
181.95			1	SS	6															

PROJECT <u>05-1130-031-1-9</u>		RECORD OF BOREHOLE No 213		1 OF 1 METRIC	
G.W.P. <u>63-00-00</u>		LOCATION <u>N 4677019.0 ; E 296229.2</u>		ORIGINATED BY <u>D.B.</u>	
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER/HOLLOW STEM AUGERS</u>		COMPILED BY <u>DCH/WDF</u>	
DATUM <u>GEODETIC</u>		DATE <u>August 9, 2005</u>		CHECKED BY <u>MEB</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID MOISTURE LIMIT CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100	w _p	w		w _L				
181.78	GROUND SURFACE																				
0.00	TOPSOIL, clayey																				
0.15	Black																				
	SILTY CLAY, trace to some sand, trace gravel, (TILL) with silt seams at 2.4m depth Firm to hard Brown to grey at elev. 179.4m		1	SS	19									○							
			2	SS	31									○							
			3	SS	17									○							
			4	SS	11									○							
			5	SS	8									○							
			6	SS	8									○							
			7	SS	9									○							
			8	SS	17									○							
			9	SS	6									○							
174.46	END OF BOREHOLE																				
7.32	Borehole dry during drilling August 9, 2005																				

ON_MTO 05-1130-031-1-9.GPJ ON_MOT.GDT 3/1/06

RECORD OF BOREHOLE No 215

1 OF 1

METRIC

PROJECT 05-1130-031-1-9
G.W.P. 63-00-00 LOCATION N 4677269.7 ; E 290751.7 ORIGINATED BY M.A.
DIST 1 HWY 401 BOREHOLE TYPE POWER AUGER/HOLLOW STEM AUGERS COMPILED BY DCH/WDF
DATUM GEODETIC DATE August 10, 2005 CHECKED BY MEB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	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		× LAB VANE		WATER CONTENT (%)						
183.39	GROUND SURFACE					20	40	60	80	100	10	20	30			
0.00	TOPSOIL, clayey															
0.12	Black															
	FILL, silty clay, trace sand, trace gravel															
	Very stiff															
	Brown		1	SS	15											
182.02																
1.37	FILL, sand and gravel, trace silt															
181.57	Very loose		2	SS	3											
1.82	Brown															
181.26	CLAYEY SILT, trace sand															
2.13	Soft															
	Brown															
	SILTY CLAY, trace to some sand, trace gravel, (TILL)		3	SS	25											
	Stiff to hard															
	Brown to grey at elev. 179.8m		4	SS	39											
			5	SS	17											
			6	SS	15											
			7	SS	12											
			8	SS	10											
			9	SS	13											
			10	SS	13											
175.31	END OF BOREHOLE															
8.08	Borehole dry during drilling August 10, 2005															

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

PROJECT 05-1130-031-1-9		RECORD OF BOREHOLE No 216		1 OF 1		METRIC	
G.W.P. 63-00-00		LOCATION N 4677277.9 ; E 290748.1		ORIGINATED BY D.B.			
DIST 1 HWY 401		BOREHOLE TYPE POWER AUGER/HOLLOW STEM AUGERS		COMPILED BY DCH/WDF			
DATUM GEODETIC		DATE August 10, 2005		CHECKED BY MEB			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w _p w w _L				GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE					WATER CONTENT (%)							
								● QUICK TRIAXIAL × LAB VANE												
183.55	GROUND SURFACE						20	40	60	80	100									
0.00	TOPSOIL, clayey																			
0.15	Black FILL, clayey silt, trace sand, trace gravel Very stiff Brown																			
182.18																				
1.37	CLAYEY SILT, trace sand, trace gravel, (TILL) Stiff to very stiff Brown		1	SS	22															
			2	SS	9															
			3	SS	23															
180.65																				
2.90	SILTY CLAY, trace to some sand, trace gravel, (TILL) with fine sand pockets Stiff to hard Brown to grey at elev. 180.0m		4	SS	39															
			5	SS	21															
			6	SS	14															
			7	SS	13															
			8	SS	13															
			9	SS	18															
176.09																				
7.46	CLAYEY SILT, trace sand, trace gravel, (TILL) Very stiff Grey		10	SS	22															
175.32																				
8.23	END OF BOREHOLE																			
	Borehole dry during drilling August 10, 2005																			

ON_MTO 05-1130-031-1-9.GPJ ON_MOT.GDT 3/1/06

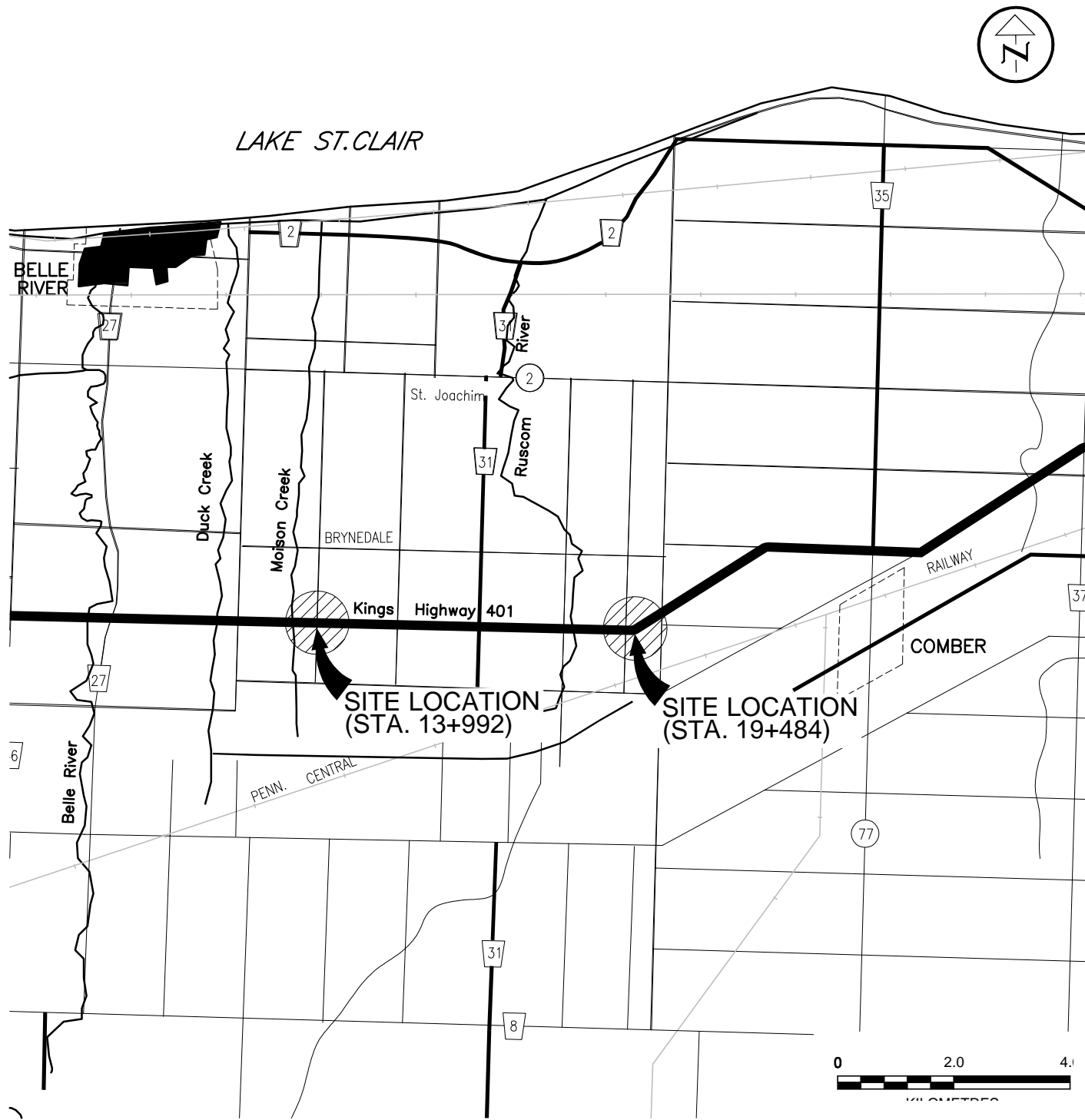
PROJECT <u>05-1130-031-1-9</u>		RECORD OF BOREHOLE No 220		1 OF 1	METRIC
G.W.P. <u>63-00-00</u>	LOCATION <u>N 4677227.3 ; E 290748.5</u>	ORIGINATED BY <u>M.A.</u>			
DIST <u>1</u> HWY <u>401</u>	BOREHOLE TYPE <u>POWER AUGER/HOLLOW STEM AUGERS</u>	COMPILED BY <u>DCH/WDF</u>			
DATUM <u>GEODETIC</u>	DATE <u>August 10, 2005</u>	CHECKED BY <u>MEB</u>			


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	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	20	40	60	80	100	w _p	w			w _L
183.27	GROUND SURFACE																	
0.00	TOPSOIL, clayey																	
0.12	Black																	
	FILL, clayey silt, trace sand, trace gravel																	
	Firm to stiff																	
	Brown		1	SS	9													
			2	SS	7													
181.14																		
2.13	SILTY CLAY, trace to some sand, trace gravel, (TILL)		3	SS	29													
	Stiff to hard		4	SS	39													
	Brown to grey at elev. 179.7m		5	SS	18													
			6	SS	13													
			7	SS	13													
			8	SS	10													
			9	SS	12													
			10	SS	10													
175.04	END OF BOREHOLE																	
8.23	Borehole dry during drilling August 10, 2005																	

ON_MTO 05-1130-031-1-9.GPJ ON_MOT.GDT 3/1/06

PROJECT <u>05-1130-031-1-9</u>		RECORD OF BOREHOLE No 221		1 OF 1		METRIC	
G.W.P. <u>63-00-00</u>		LOCATION <u>N 4677217.8 ; E 290747.7</u>		ORIGINATED BY <u>M.A.</u>			
DIST <u>1</u> HWY <u>401</u>		BOREHOLE TYPE <u>POWER AUGER/HOLLOW STEM AUGERS</u>		COMPILED BY <u>DCH/WDF</u>			
DATUM <u>GEODETIC</u>		DATE <u>August 10, 2005</u>		CHECKED BY <u>MEB</u>			

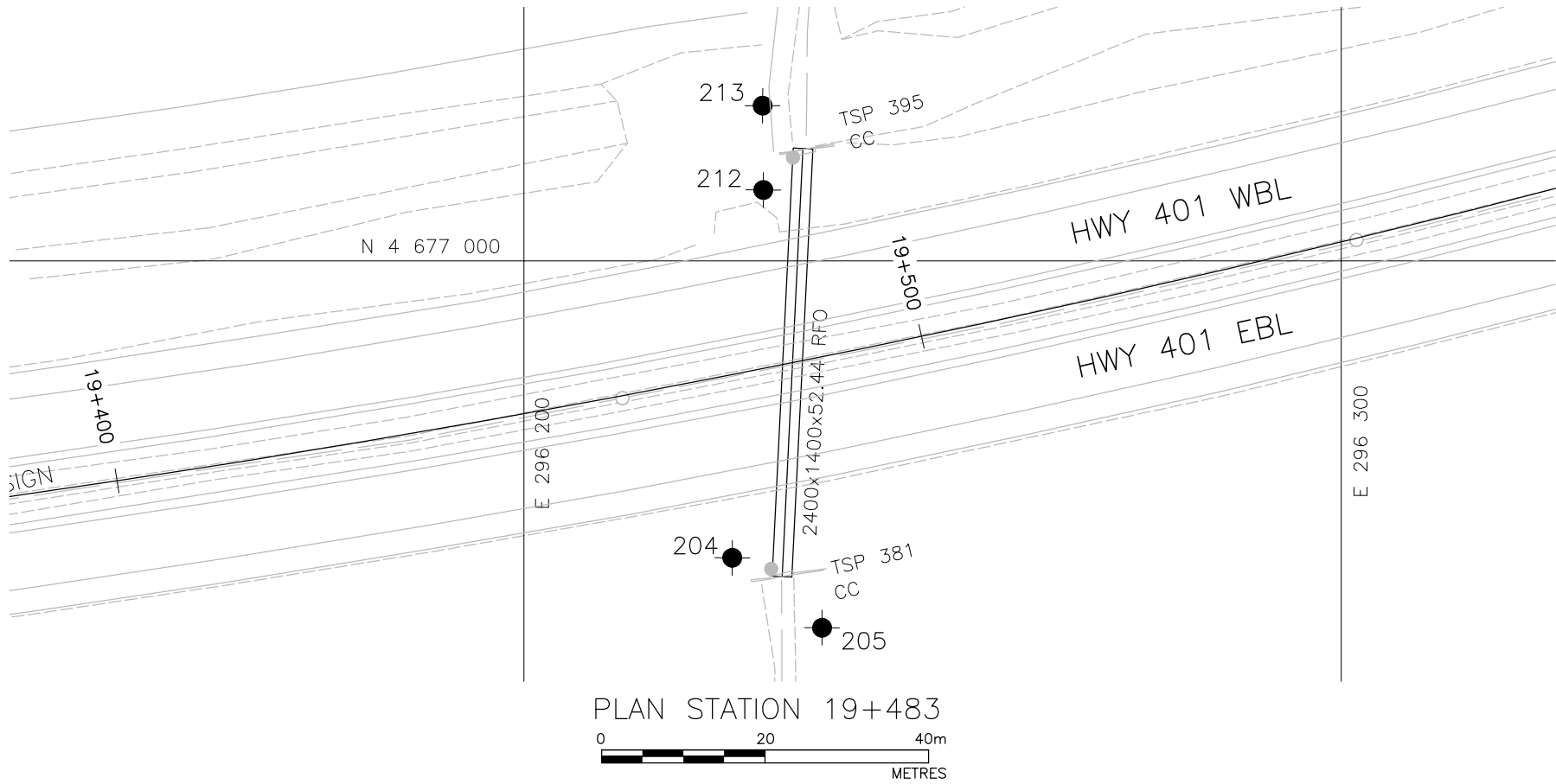
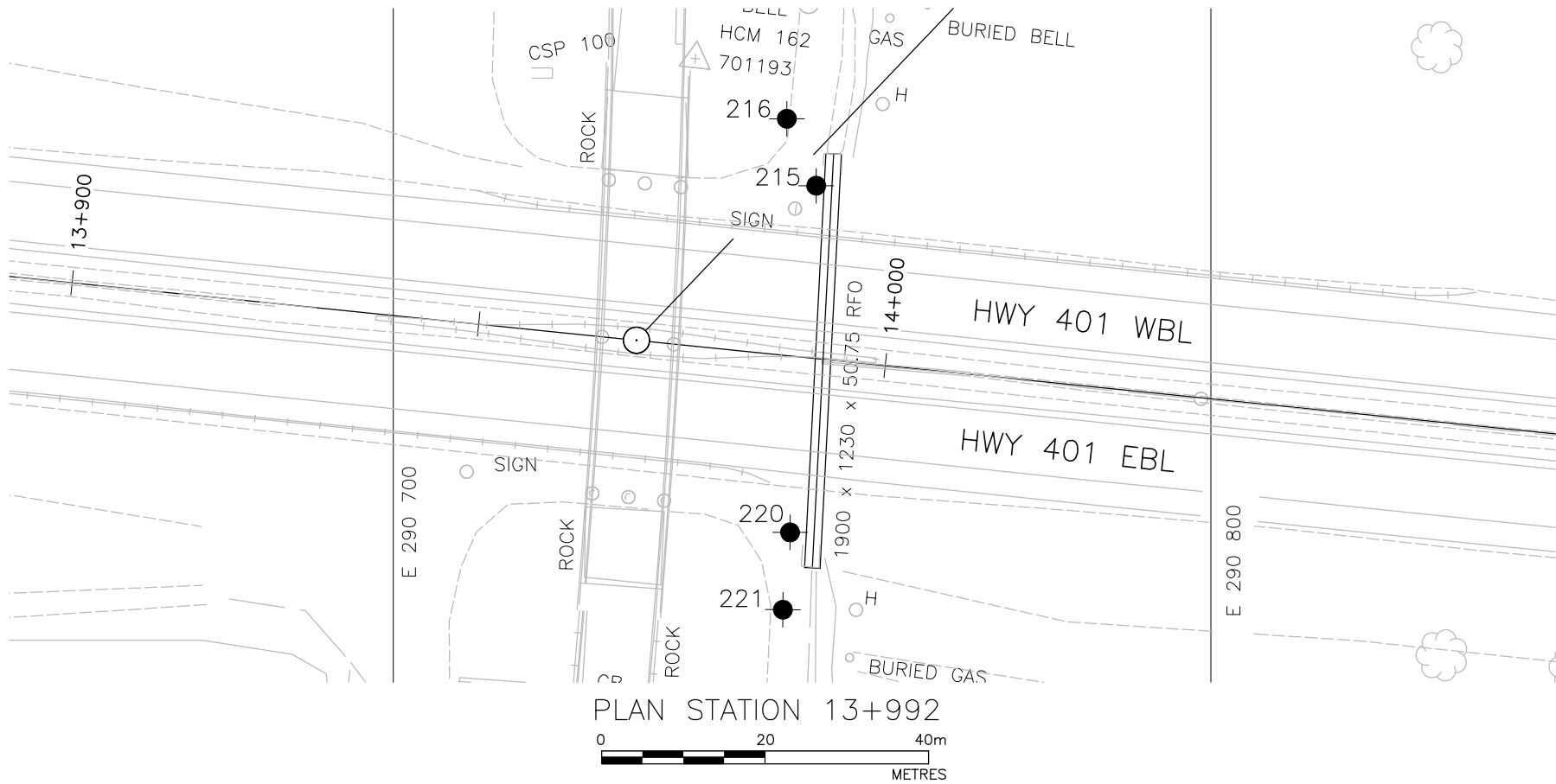
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L				
182.80	GROUND SURFACE						20	40	60	80	100						
0.00	TOPSOIL, clayey																
0.18	Black FILL, silty clay, trace sand, trace gravel Stiff Brown																
181.43			1	SS	13								○				
1.37	SILTY CLAY, trace to some sand, trace gravel, (TILL) Stiff to hard Brown to grey at elev. 179.2m		2	SS	14								○				
			3	SS	36								○				
			4	SS	27								○	—		0 17 44 39	
			5	SS	13								○				
			6	SS	12								○				
			7	SS	12								○				
			8	SS	11												
			9	SS	13												
175.33	END OF BOREHOLE																
7.47	Borehole dry during drilling August 10, 2005																



PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER GWP 63-00-00, HIGHWAY 401 RECONSTRUCTION			
TITLE			
KEY PLAN			
PROJECT No. 05-1130-031-1		FILE No. 051130031-1-1399219484F001	
CADD	WDF/DCH	Sept. 15/05	SCALE AS SHOWN
CHECK			REV. 0
 Golder Associates LONDON, ONTARIO			FIGURE 1

1 = 1 metric
D size dwg 22" x 32" 11" x 17" plot half scale

051130031-1-9-D001.dwg

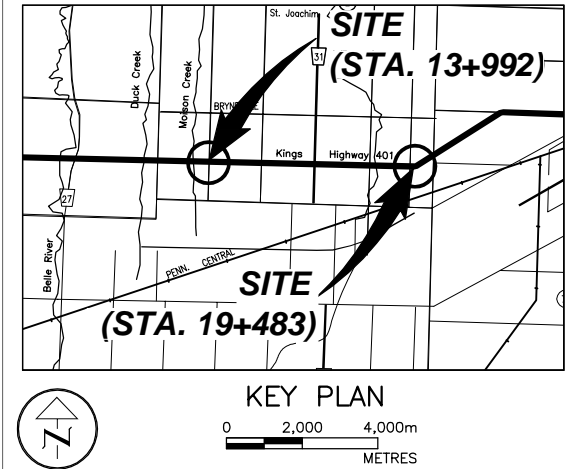


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST	HWY. 401
CONT. No.	
WP No.	63-00-00
HIGHWAY 401 STA. 13+992 AND STA. 19+483 BOREHOLE LOCATIONS	
SHEET	



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



LEGEND			
Borehole			
No.	ELEVATION (metres)	CO-ORDINATES	
		NORTH	EAST
STA. 13+992			
215	183.39	4 677 269.7	290 751.7
216	183.55	4 677 277.9	290 748.1
220	183.27	4 677 227.3	290 748.5
221	183.80	4 677 217.8	290 747.7
STA. 19+484			
204	183.18	4 676 963.7	296 225.5
205	181.64	4 676 955.1	296 236.5
212	183.32	4 677 008.7	296 229.3
213	181.78	4 677 019.0	296 229.2

NOTES

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. The proposed structure details are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents

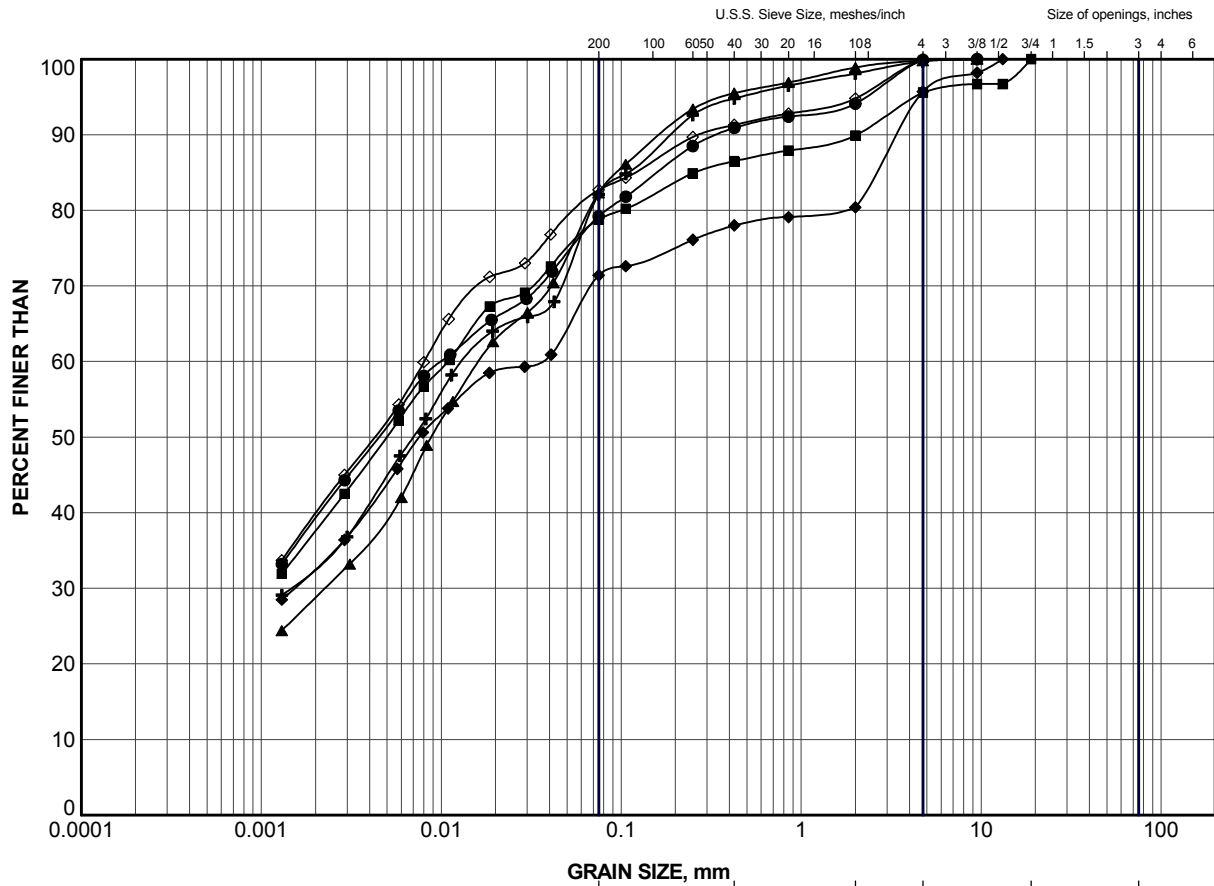
REFERENCE

REFERENCE : BASE DRAWINGS SUPPLIED BY DILLON CONSULTING

NO.	DATE	BY	REVISION
Geocres No. 40J2-75			
HWY. No.	401	PROJECT NO.: 051-130031-1-9	
SUBM'D.	MEB	CHKD: MEB	DATE: Oct. 17/05
DRAWN:	DCH	CHKD: MEB	APPD. DWG. 1


APPENDIX A

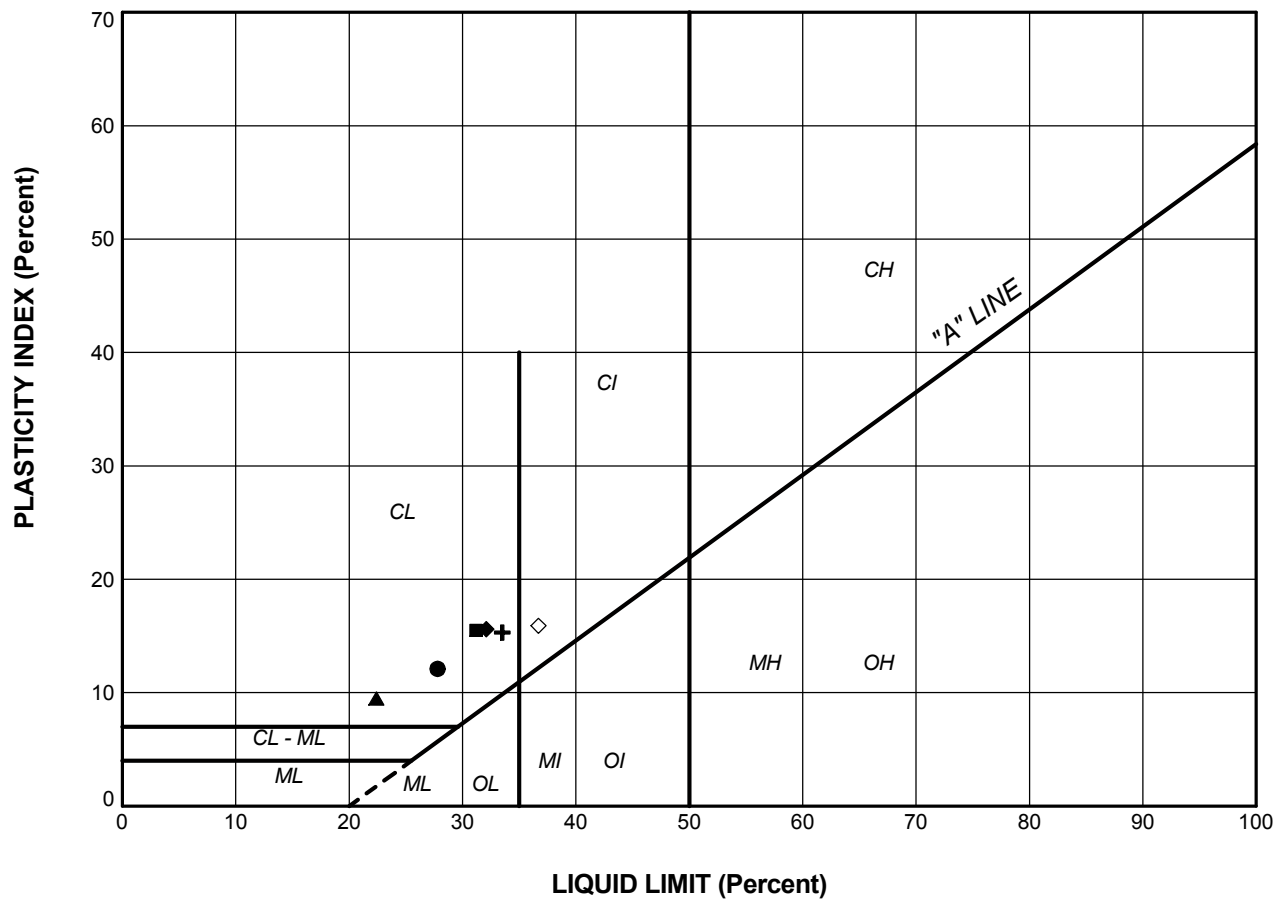
LABORATORY TEST DATA (FIGURES A-1 TO A-5)



LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	215	5	179.4
■	215	8	177.1
▲	216	6	178.8
+	220	4	180.0
◆	220	7	177.7
◇	221	4	179.5

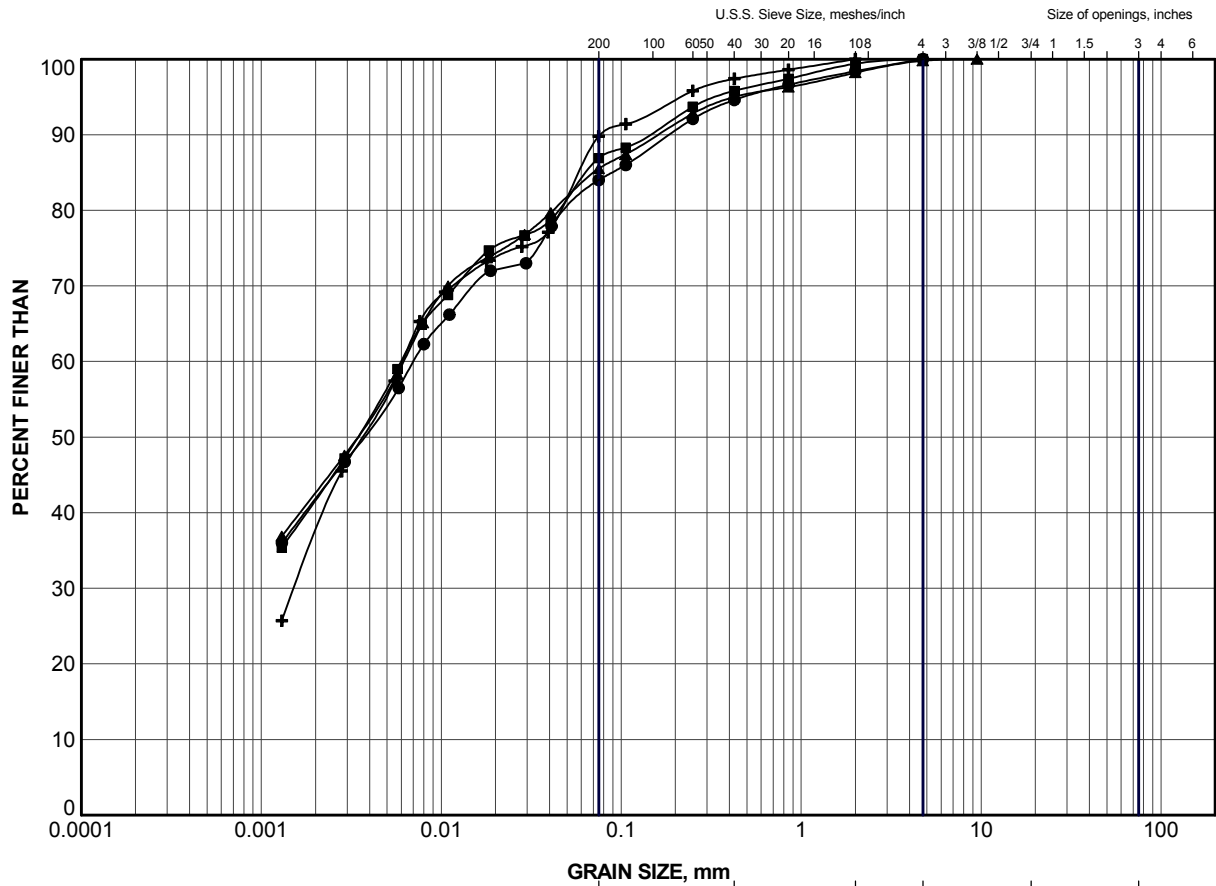
PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER WP 63-00-00, HWY 401 RECONSTRUCTION			
TITLE			
GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No. 05-1130-031-1-9		FILE No. 05-1130-031-1-9.GPJ	
DRAWN	DCH	Sep 15/05	SCALE N/A
CHECK	MEB		REV.
 Golder Associates LONDON, ONTARIO			FIGURE A-1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	215	5	27.8	15.7	12.1
■	215	8	31.2	15.7	15.5
▲	216	6	22.4	12.9	9.5
+	220	4	33.5	18.2	15.3
◆	220	7	32.1	16.5	15.6
◇	221	4	36.7	20.8	15.9


PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER WP 63-00-00, HWY 401 RECONSTRUCTION			
TITLE			
PLASTICITY CHART			
PROJECT No. 05-1130-031-1-9		FILE No. 05-1130-031-1-9.GPJ	
DRAWN	DCH	Sep 15/05	SCALE N/A REV.
CHECK	MEB		
 Golder Associates LONDON, ONTARIO			FIGURE A-2

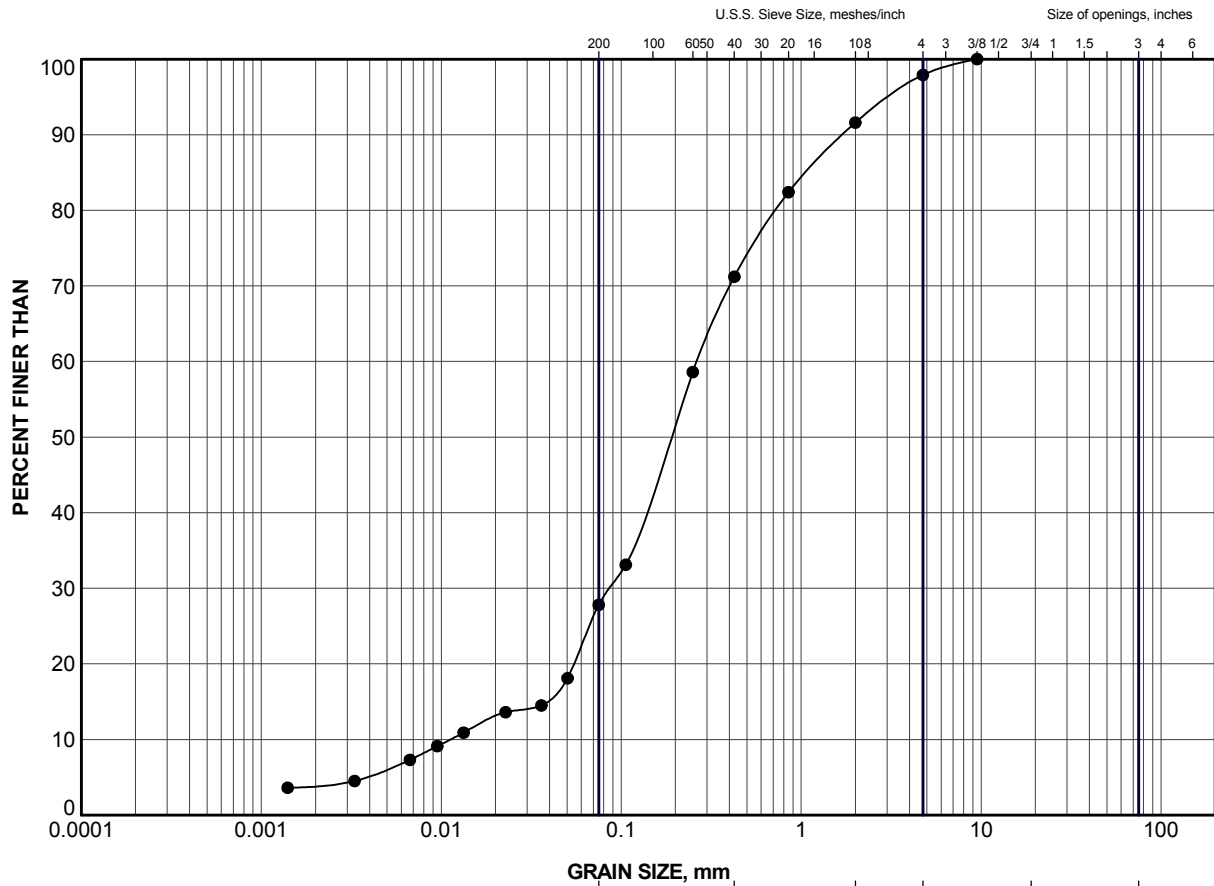


CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	204	5	179.1
■	204	8	176.9
▲	205	3	179.1
+	213	5	177.7


PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER WP 63-00-00, HWY 401 RECONSTRUCTION			
TITLE			
GRAIN SIZE DISTRIBUTION SILTY CLAY TILL			
PROJECT No. 05-1130-031-1-9		FILE No. 05-1130-031-1-9.GPJ	
DRAWN	DCH	Sep 15/05	SCALE N/A
CHECK	MEB		REV.
 Golder Associates LONDON, ONTARIO			FIGURE A-3

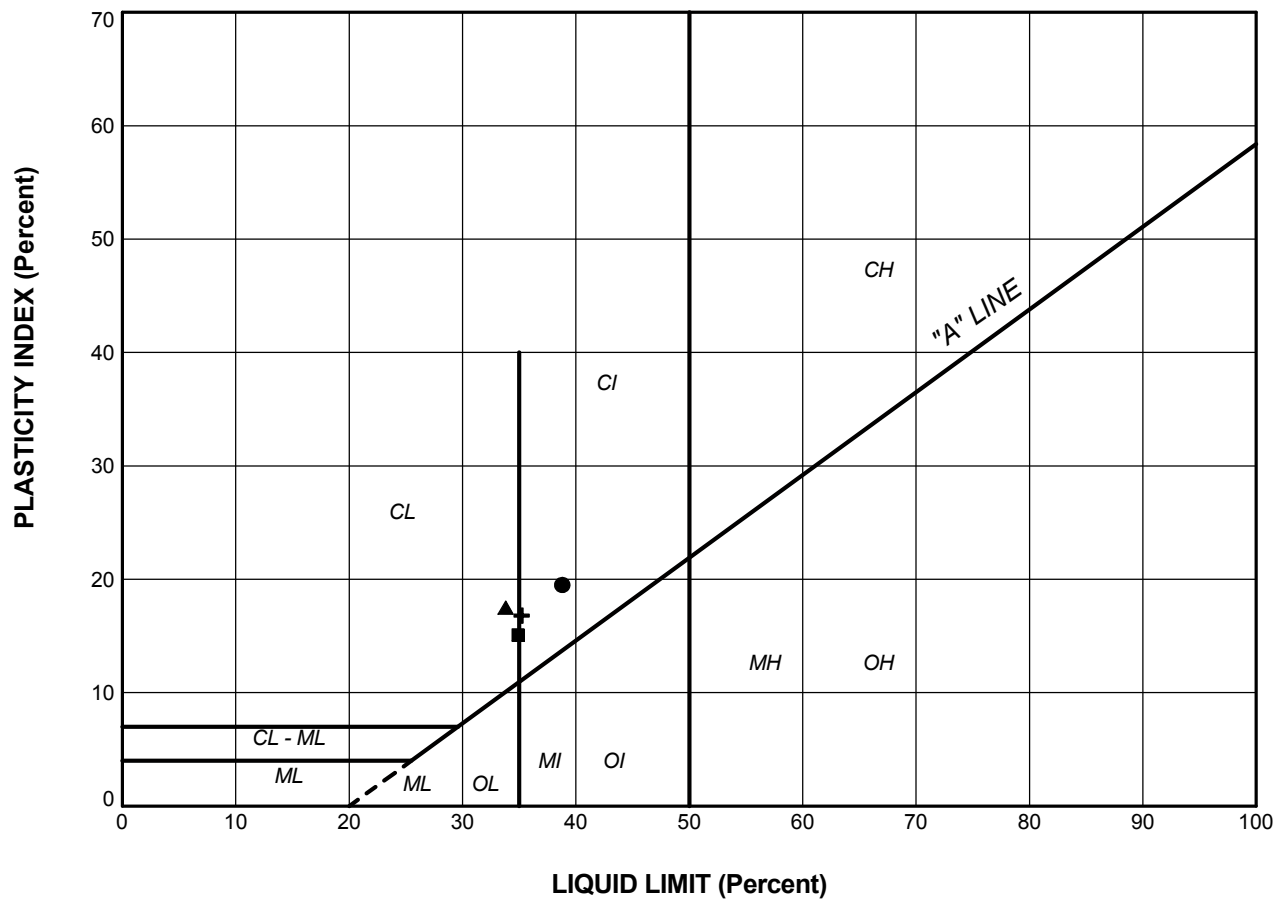



GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	212	7	177.8

PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER WP 63-00-00, HWY 401 RECONSTRUCTION			
TITLE			
GRAIN SIZE DISTRIBUTION SILTY SAND			
PROJECT No. 05-1130-031-1-9		FILE No. 05-1130-031-1-9.GPJ	
DRAWN	DCH	Sep 15/05	SCALE N/A
CHECK	MEB		REV.
 Golder Associates LONDON, ONTARIO			FIGURE A-4



PROJECT			
CULVERT EXTENSIONS STA. 13+992 & STA. 19+484 TWP OF ROCHESTER WP 63-00-00, HWY 401 RECONSTRUCTION			
TITLE			
PLASTICITY CHART			
PROJECT No. 05-1130-031-1-9		FILE No. 05-1130-031-1-9.GPJ	
DRAWN	DCH	Sep 15/05	SCALE N/A REV.
CHECK	MEB		
 Golder Associates LONDON, ONTARIO			FIGURE A-5