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FOUNDATION INVESTIGATION REPORT
MARTINDALE ROAD UNDERPASS
QEW WIDENING FROM HIGHWAY 406
TO GARDEN CITY SKYWAY
ST CATHARINES, ONTARIO
G.W.P. 607-00-00

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the widening of the Queen Elizabeth Way (QEW) between Highway 406 and the Garden City Skyway in the City of St. Catharines, in the Region of Niagara. Foundation engineering services are required for the widening or replacement of five structures (Third Street overpass, Martindale Road underpass, Lake Street underpass, Geneva Street overpass, and Welland Avenue overpass), new retaining walls and noise barrier walls, culvert extensions, and high mast light poles.

This report addresses the foundation investigation carried out for the Martindale Road underpass structure (MTO Structure Site No. 18-103).

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal for Agreement No. 2005-A-000564, issued in July 2002, and in Section 6.8 of MH's *Technical Proposal* for G.W.P. 607-00-00.

2.0 SITE DESCRIPTION

The QEW/Martindale Road underpass/interchange is located between the QEW/Highway 406 interchange and the bridge across the Twelve Mile Creek/Martindale Pond in St. Catharines, Ontario. The terrain is relatively flat with a gentle slope downwards to the southwest.

The existing Martindale Road grade is between approximately Elevation 94 m to 96 m in the immediate vicinity of the bridge. The QEW has been constructed in a cut in this area and is about 2.5 m to 3 m below the original ground surface, which is at about Elevation 92 m to 93 m. The Martindale Road embankments are about 2 m to 3 m in height relative to the original ground surface.

There are residential/agricultural properties on the north side of the QEW and industrial properties on the south side of the QEW in the immediate vicinity of the interchange.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out at the Martindale Road underpass site in November 2004, at which time eight boreholes (Boreholes 201 to 208) were advanced at the site using a track-mounted drill rig, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The borehole locations are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

The boreholes were advanced using hollow stem augers, to depths ranging from 6.7 m to 27.6 m below the existing ground surface. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure. The water level in the open boreholes was observed throughout the drilling operations, and a piezometer was installed in Borehole 203 and in Borehole 207 to permit monitoring of the groundwater level at the site. The piezometers consist of 50 mm diameter PVC pipe with a 1.5 m long slotted screen installed within a 3 m length sand filter pack. Upon completion, all boreholes were backfilled to ground surface using bentonite pellets.

The field work was supervised on a full-time basis by a member of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and testing. Index and classification tests consisting of water content determinations, Atterberg Limits testing and grain size distribution analyses were carried out on selected soil samples. Organic content tests were also carried out on selected samples.

The northings, eastings and elevations of the as-drilled borehole locations were measured in the field by a member of Golder's technical staff, relative to the locations staked by Morrison Hershfield. The borehole locations (including MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) are summarized in the following table and are shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents.

Borehole Number	*Borehole Locations*	*MTM NAD83 Northing (m)*	*MTM NAD83 Easting (m)*	*Ground Surface Elevation (m)*
201	North Approach	4782038.3	322982.7	94.9
202	North Abutment	4782014.8	322076.9	95.4
203	North Abutment	4782020.1	322990.8	95.1
204	Centre Pier	4781982.5	322973.0	90.5
205	Centre Pier	4781995.3	323008.4	90.1
206	South Abutment	4781957.8	323000.6	95.2
207	South Abutment	4781962.5	323012.9	95.1
208	South Approach	4781939.3	323008.2	94.9

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

This area of the QEW lies within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario*[1] and *Urban Geology of Canadian Cities*[2].

The Iroquois Plain extends around the western shores of Lake Ontario; on the south side of the lake, in the St. Catharines area, the Plain is located between the present Lake Ontario shorebluffs and the foot of the Niagara Escarpment. The Plain is comprised of the flat to undulating lake bed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession.

The surficial soils in the Iroquois Plain are typically comprised of glaciolacustrine clays and silts. However, in the St. Catharines area, surficial deposits of beach sand and gravel are present. The surficial sands, silts and clays are underlain by an extensive till deposit; portions of the till are considered to be "water-lain" (that is, formed by sediment rain-out either from a floating ice margin or from iceberg dumping), resulting in a predominantly massive, matrix-supported structure, as well as relatively thin sand to silt stringers or interlayers. This extensive till deposit may be underlain by or interlayered with a lower glaciolacustrine clay deposit, although this glaciolacustrine layer is absent in some portions of the Iroquois Plain in the St. Catharines area. Finally, the till and/or glaciolacustrine layer may be underlain by a lower till unit, that typically has increasing gravel content with proximity to the underlying bedrock (Menzies and Taylor, 1998).

The overburden soils are underlain by red shale bedrock of the Queenston Formation. This shale formation contains siltstone interlayers as well as "occasional patches of gypsum" (Menzies and Taylor, 1998).

4.2 Subsurface Conditions at Martindale Road Underpass

Eight boreholes (Borehole 201 to 208) were advanced at the Martindale Road underpass at the locations shown on the Borehole Location and Soil Strata drawings contained in the Contract Documents. Six boreholes were drilled in the vicinity of the existing abutments and approach embankments, and another two were drilled adjacent to the existing piers at the centre median on the QEW pavement level.

[1] Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

[2] J. Menzies and E.M. Taylor. "Urban Geology of St. Catharines-Niagara Falls, Region Niagara". In *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are summarized on the Record of Borehole sheets and Figures 1 to 8. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole location.

In brief, the native subsoils underlying the fill materials at the site of Martindale Road underpass replacement consist of the following:

- A surficial clayey silt to silty sand deposit, the base of which was encountered at depths between 3.4 m and 5.5 m, with a thickness of between 0.4 m and 3.2 m, that has a firm to hard consistency/loose to very dense relative density.

- A clayey silt till deposit, found to be up to 18.5 m in thickness, which has a stiff to hard consistency.

- An interlayered silty sand, sandy silt to sand and gravel deposit, which was encountered at depths ranging from 11.6 m to 21.6 m, with a thickness between 1.3 m and 8.2 m and a loose to very dense relative density.

- A till/residual soil deposit, which was encountered at depths greater than 22 m, that has a hard consistency/very dense relative density.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Fill

Fill material was found in all of the boreholes at the site, ranging between 0.8 m and 3.1 m in thickness. In Boreholes 204 and 205, which were drilled at the QEW grade, the fill is comprised of the roadway granular and is about 0.8 m thick. Granular fill was also encountered in the remaining boreholes put down through the embankments; these fill materials range from 0.1 m to 0.8 m in thickness.

In Boreholes 201 to 203 and 206 to 208, the embankment fill underlying the granular fill consists mainly of clayey silt, with some sand, trace gravel and trace topsoil. The results of three grain size distribution tests on samples of this fill are shown on Figure 1.

The measured SPT “N” values of the clayey silt fill material were between 9 and 21 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency.

4.2.2 Surficial Clayey Silt to Silty Sand

In Boreholes 201 to 203 and Boreholes 206 to 208, the embankment fill is underlain by a surficial deposit that varies in composition from clayey silt, to sand and silt to silty sand. This deposit was encountered between Elevations 92.3 m and 92.9 m, and varied from 0.4 m to 3.2 m in thickness. This deposit is typically brownish-black in colour and some samples were noted to contain organics. The organic portion of the clayey silt to silty sand deposit was found in all of the six boreholes (Boreholes 201 to 203 and 206 to 208) located adjacent to the existing bridge abutments, and was 0.4 m to 1.4 m in thickness. Two samples were selected from the deposit for organic content testing. The results are shown on the Record of Borehole sheets and are summarised in the following table.

Borehole Number	***Sample Elevation (m)***	***Organic Content (%)***
202	94.0	5.3
208	92.2	2.2

The results of four grain size distribution tests carried out on samples of this deposit are shown on Figure 2. The results of three Atterberg limits tests conducted on cohesive portions of this surficial deposit are included on Figure 3. The Atterberg limits tests measured plastic limits of 15 to 19 per cent, liquid limits of 27 to 41 per cent, and corresponding plasticity indices of 12 to 22 per cent, which confirm that the cohesive portion of this deposit is a clayey silt of low plasticity. The measured water contents on samples of this deposit were between 15 and 20 per cent.

The measured SPT "N" values within the clayey silt to silty sand deposit range from 5 to 63 blows per 0.3 m of penetration, indicating a firm to hard consistency/loose to very dense relative density.

4.2.3 Clayey Silt Till

The granular fills in Boreholes 204 and 205 (in the centre median) and the surficial deposit in the remaining boreholes are underlain by an extensive till deposit. The base of the till deposit was encountered between Elevations 73.3 m and 74.1 m. The till consists typically of clayey silt with sand to trace sand, and trace gravel. Seams of sand and/or silt were noted within some of the recovered samples, and an approximately 2.1 m thick lens or interlayer of silt was encountered within the till in Borehole 205. The result of five grain size distribution tests carried out on selected clayey silt till samples are shown on Figure 4.

Boulders and cobbles were not encountered in this deposit during the borehole investigation. However, these glacially-derived soils may contain boulders and cobbles.

The measured SPT "N" values within the glacial till deposit range from 7 to 55 blows per 0.3 m of penetration, but typically range from about 20 to 55 blows indicating a very stiff to hard

consistency. The till was found to become softer in the lower parts of the deposit at the locations of Boreholes 202 to 207; the measured SPT "N" values within this softer portion ranged from 7 to 15 blows per 0.3 m of penetration, indicating a firm to stiff consistency.

Two field vane tests were conducted within the softer portion of the till deposit, and the results are as follows:

Borehole Number	*Sample Elevation (m)*	*In Situ (kPa)*	*Remoulded (kPa)*
202	78.0	90	70
204	75.3	109	60

The results of twenty-three Atterberg limits tests are shown on Figures 5A and 5B. The measured plastic limits are between 12 and 18 per cent and the liquid limits are between 18 and 34 per cent, with corresponding plasticity indices of 6 to 15 per cent. These results confirm that the soil is a clayey silt of low plasticity. The measured water contents on samples of the till were between approximately 11 and 29 per cent.

4.2.4 Lower Sands, Silts and Gravels

In the six boreholes where the till deposit was fully penetrated (Boreholes 202 to 207), a 1.5 m to 5.2 m thick interlayered deposit consisting of silty sand to sandy silt to sand and gravel was encountered below the till deposit and above the lower till/residual soil deposit. The surface of this interlayered deposit was encountered between Elevations 73.3 m and 74.1 m.

The results of two grain size distribution tests carried out on samples of this deposit are shown on Figure 6. Boulders and cobbles were not encountered in this deposit during the borehole investigation. However, these glacially-derived soils may contain boulders and cobbles.

The measured SPT "N" values range from 6 to greater than 100 blows per 0.3 m of penetration, indicating a loose to very dense relative density.

4.2.5 Till/Residual Soil

Boreholes 202 to 207 were terminated within a clayey to sandy silt deposit which has been classified as till/residual soil. The surface of this lower till was encountered between approximately Elevation 70.3 m and 72.2 m. This deposit is red in colour and consists mainly of clayey silt with some sand and trace gravel (limestone and shale fragments), which is considered indicative of weathered shale. At a few locations, the deposit consists of sandy silt till which is likely indicative of weathered sandstone or siltstone.

The results of two grain size distribution tests carried out on samples of the till are shown on Figure 7. Atterberg limits tests were also carried out on two samples and the results are shown on

Figure 8. The measured plastic limits are 12 and 15 per cent, the liquid limits are 18 and 22 per cent, and the corresponding plasticity indices are 6 and 7 per cent.

Based on the measured SPT "N" values which range from 51 to greater than 100 blows per 0.3 m of penetration, the till/residual soil deposits have a hard consistency/very dense relative density.

4.2.6 Groundwater Conditions

The water level observed in the open boreholes on completion of drilling operations was at depths ranging from 12.8 m to 25.9 m below ground surface, which corresponds to elevations ranging from 69.2 m to 77.3 m.

Two piezometers were installed, one each in Boreholes 203 and 207, which are in the vicinity of the existing abutments of the Martindale bridge structure. The following table summarizes the water level measurements for these piezometers:

Borehole Number	***Ground Surface Elevation***	***Piezometer Tip Elevation***	***Measured Groundwater Elevation***		
			26 Nov 2004	***13 May 2005***	***06 Dec 2005***
203	95.1 m	72.2 m	81.9 m	82.2 m	82.1 m
207	95.1 m	67.7 m	81.3 m	81.9 m	81.7 m

It should be noted that groundwater levels are expected to fluctuate seasonally and are expected to rise during wet periods of the year. Perched groundwater conditions should be anticipated within the surficial deposits above the fine-grained till deposit, especially during the wetter months of the year.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Beng Lay Teh and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Fintan Heffernan, Golder's Designated MTO Contact for this project, conducted an independent quality review of the report.

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BLT/LCC/ASP/FJH/blt
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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
DO	Drive open
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

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.) drive open sampler for a distance of 300 mm (12 in.)

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, 60º 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 cm^2 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.

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

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
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

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.

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LIST OF SYMBOLS

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

I. General

π	3.1416
in 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 = σ'_p/σ'_{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 δ
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 = (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)

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Golder Associates

RECORD OF BOREHOLE No 201

1 OF 1 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4782038.3 ;E 322982.7 | ORIGINATED BY PKS

DIST Central | HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 10, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.9	GROUND SURFACE										
0.0	Sand and gravel (FILL)										
0.2	Compact Brown		1	SS	20						
	Clayey silt, some sand, trace gravel, trace organics (FILL) Stiff to very stiff Brown Moist		2	SS	9		94		○		
92.9			3	SS	10		93				
2.0	CLAYEY SILT, some sand, trace to some gravel, trace organics and rootlets Firm to stiff Blackish grey Moist		4	SS	5		92				
91.5			5	SS	11						7 26 50 17
3.4	CLAYEY SILT with sand to some sand, trace gravel (TILL) Stiff to hard Brown Moist		6	SS	39		91		○		
			7	SS	29		90				
							89				
88.2			8	SS	27						
6.6	END OF BOREHOLE Note: 1. Borehole dry on completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 202

1 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4782014.8 ;E 322976.9 | ORIGINATED BY PKS

DIST Central | HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 18, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.4	GROUND SURFACE										
0.0	Sand and gravel (FILL)										
0.2	Compact Clayey silt, some sand, trace gravel (FILL) Stiff to very stiff Brown Moist		1	SS	16		95				
			2	SS	12		94				4 15 58 23
			3	SS	9		93		○		
			4	SS	14						
92.3											
3.1	CLAYEY SILT, trace sand, containing organics Stiff Grey/brown Moist		5	SS	9		92		⊢○⊣		O.C. 5.3%
91.6											
3.8	CLAYEY SILT, some sand Hard Brown Moist		6	SS	45		91		○		0 12 76 12
90.5											
4.9	CLAYEY SILT, trace to some sand, trace gravel, containing sand/silt seams (TILL) Stiff to hard Brown to grey Moist to wet		7	SS	44		90				
			8	SS	14		89		⊢○⊣		1 12 53 34
			9	SS	24		88				
			10	SS	21		87				
			11	SS	34		86		○⊢⊣		
			12	SS	29		85				
			13	SS	23		84				
							83				
							82				
							81				

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

Golder Associates

RECORD OF BOREHOLE No 202

2 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4782014.8 ;E 322976.9 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 18, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace to some sand, trace gravel, containing sand/silt seams (TILL) Stiff to hard Brown to grey Moist to wet		14	SS	31		80		○		
			15	SS	20		79				
							78				
			16	SS	15	▽	77		○		1 3 59 27
							76				
			17	SS	9				⊢○⊣		
74.1							75	+ 1.2			
21.3	Silty SAND, containing clay seams/pockets Compact to very dense Grey Wet		18	SS	18		74				
							73				
			19	SS	100				○		
71.6							72				
23.8	CLAYEY SILT, some sand, trace to some gravel, containing pockets of sandy silt (TILL/RESIDUAL SOIL) Very dense Grey to red Wet		20	SS	100/.13		71		○⊢⊣		
							70				
69.2			21	SS	100						
26.2	END OF BOREHOLE Note: 1. Water encountered at 18.9 m depth (Elevation 76.5 m) during drilling.										

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

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 203

1 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4782020.1 ;E 322990.8 | ORIGINATED BY PKS

DIST Central | HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 18, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
95.1	GROUND SURFACE						95
0.0 / 94.3	Crushed limestone (FILL) Compact Grey Moist		1	SS	23		
0.8 / 92.8	Clayey silt, some sand, trace gravel, trace organics (FILL) Firm Blackish brown Moist		2	SS	7		94
			3	SS	7		93
2.3 / 92.0	SAND and SILT, trace clay, trace gravel, trace organics Loose Mottled brown and grey Moist		4	SS	6		92
3.1 / 91.3	CLAYEY SILT, some sand, trace gravel Stiff Mottled brown and grey Moist		5	SS	14		
3.8 / 89.6	Sandy SILT, trace clay Dense to very dense Brown Wet		6	SS	45		91
			7	SS	63		90
5.5	CLAYEY SILT, some sand, trace gravel, containing sand/silt seams (TILL) Very stiff to hard Brownish grey to grey Moist		8	SS	24		89
			9	SS	27		88
			10	SS	27		87
			11	SS	31		86
			12	SS	29	▽	85
			13	SS	27		84
							83
							82
							81

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	4	34	55	7
	0	28	66	6
	2	13	55	30

Continued Next Page

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

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 203

2 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4782020.1 ;E 322990.8 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 18, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						80				
	CLAYEY SILT, some sand, trace gravel, containing sand/silt seams (TILL) Very stiff to hard Brownish grey to grey Moist		14	SS	33		79				
			15	SS	23		78				
			16	SS	20		77				
76.0											
19.1	CLAYEY SILT, some sand, trace gravel (TILL) Stiff Grey-brown to grey Moist		17	SS	11		76				
73.8							75				
21.3	Sandy SILT, containing clayey seams Loose Grey Wet		18	SS	6		74				
72.2							73				
22.9	SAND and SILT, trace clay, trace gravel (TILL/RESIDUAL SOIL) Very dense Grey, becoming red below Elevation 71.9 m Wet		19	SS	100/.25		72				
			20	SS	100/.15		71				5 38 54 3
69.2							70				
25.9	CLAYEY SILT, some sand, trace gravel, containing shale fragments (TILL/RESIDUAL SOIL) Hard Red Wet		21	SS	100/.18		69				
67.5							68				
27.6	END OF BOREHOLE Notes: 1. Water level at 25.9 m depth (Elev. 69.2 m) on completion of drilling. 2. Water level measured at 13.2 m depth (Elevation 81.9 m) on Nov. 26, 2004, at 12.9 m depth (Elev. 82.2 m) on May 13, 2005 and at 13.0 m depth (Elev. 82.1 m) on Dec. 6, 2005.		22	SS	100/.13						

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 204

1 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781982.5 ;E 322973.0 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE December 8, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
90.5	GROUND SURFACE					
0.0	Sand, some gravel (FILL) Dense Brown Moist		1	SS	35	
89.7						
0.8	CLAYEY SILT, trace to some sand, trace gravel (TILL) Very stiff to hard Brown to grey Moist		2	SS	22	
			3	SS	19	
			4	SS	22	
			5	SS	16	
			6	SS	27	
			7	SS	48	
			8	SS	29	
			9	SS	29	
			10	SS	25	
			11	SS	21	
			12	SS	25	
77.6						
13.0	CLAYEY SILT, trace to some sand, trace gravel (TILL) Firm to stiff Brown to grey Moist		13	SS	7	

ELEVATION SCALE: 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × REMOULDED

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

× >100

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 204

2 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781982.5 ;E 322973.0 | ORIGINATED BY PKS

DIST Central | HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE December 8, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace to some sand, trace gravel (TILL) Firm to stiff Brown to grey Moist		14	SS	9	▽	75				
73.7							74				
16.8	Sandy SILT, trace clay, trace gravel Loose Grey Wet		15	SS	9		73		○		
72.2											
18.3	CLAYEY SILT, some sand, trace gravel, containing shale and limestone pieces (TILL/RESIDUAL SOIL) Hard Red Wet		16	SS	64		72		○ ⊢		
			17	SS	77		71				
			18	SS	100/.13		70				11 50 30 9
							69				
							68				
							67				
66.0			19	SS	100/.10				○		
24.5	END OF BOREHOLE Note: 1. Water level at 15.2 m depth (Elev. 75.3 m) on completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 205

1 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781995.3 ;E 323008.4 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE December 7, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.1	GROUND SURFACE						90				
0.0	Sand and gravel (FILL) Dense Brown Moist		1	SS	36						
89.3							89				
0.8	CLAYEY SILT, some sand, trace gravel, containing shale fragments (TILL) Very stiff to hard Grey Moist		2	SS	22						
			3	SS	19		88				
			4	SS	23						
			5	SS	29		87				
			6	SS	29		86				
			7	SS	29		85				
			8	SS	37		84				
			9	SS	35		83				
			10	SS	35		82				
			11	SS	30		81				
78.5							80				
11.6	SILT, trace to some sand Very dense Grey Moist to wet		12	SS	71	▽	79				0 9 80 11
76.4							78				
13.7	CLAYEY SILT, some sand, trace gravel, containing sandy silt pockets/seams (TILL) Stiff Grey Wet		13	SS	15		77				
							76				

Continued Next Page

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

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 205

2 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781995.3 ;E 323008.4 | ORIGINATED BY PKS
DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT
DATUM Geodetic | DATE December 7, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, some sand, trace gravel, containing sandy silt pockets/seams (TILL) Stiff Grey Wet		14	SS	9		75				
73.3							74				
16.8	SAND and GRAVEL, some silt Compact to very dense Red/grey Wet		15	SS	19		73				
			16	SS	101		72				
70.3							71				
19.8	CLAYEY SILT, some sand, containing shale pieces (TILL/RESIDUAL SOIL) Hard Red Wet		17	SS	100/.25		70				
68.6			18	SS	100/.2		69				
21.5	END OF BOREHOLE Note: 1. Water encountered at 12.8 m depth (Elevation 77.3 m) during drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 206

1 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781957.8 ;E 323000.6 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 16, 17, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.2	GROUND SURFACE						95				
0.0	Sand and gravel (FILL)										
0.1	Clayey silt, some sand, trace gravel, trace topsoil (FILL) Firm to stiff Brown Moist		1	SS	14						
			2	SS	9		94		○		
			3	SS	8						
92.5			4	SS	11		93		○		
92.1	CLAYEY SILT, some sand, trace gravel, rootlets, containing organics										
3.1	CLAYEY SILT, trace to some sand, trace gravel, containing sandy silt seams (TILL) Stiff to hard Brownish grey to grey Moist		5	SS	19		92				
			6	SS	24		91		○		
			7	SS	31		90				
			8	SS	30		89		⊢●		
			9	SS	21		88				
			10	SS	25		87		○		
			11	SS	21		86				2 8 69 21
			12	SS	24		85		○ ⊢		
			13	SS	23		84				
							83				
							82				
							81				

Continued Next Page

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

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 206

2 OF 2 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781957.8 ;E 323000.6 | ORIGINATED BY PKS
DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT
DATUM Geodetic | DATE November 16, 17, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	CLAYEY SILT, trace to some sand, trace gravel, containing sandy silt seams (TILL) Stiff to hard Brownish grey to grey Moist		14	SS	37		80	○ at ~20			
			15	SS	24		79				
			16	SS	12		78				
			17	SS	12		77				
73.6			18	SS	16		76				
21.6	SILT, some sand, trace clay, trace to some gravel Compact to very dense Grey Wet		19	SS	51		75				
71.7							74				
23.5	CLAYEY SILT, some sand, trace gravel (TILL/RESIDUAL SOIL) Hard Red Wet		20	SS	101		73				2 13 61 24
			21	SS	100/.13	▽	72				
67.6			22	SS	100/.13		71				
27.7	END OF BOREHOLE Note: 1. Water level at 25.9 m depth (Elev. 69.3 m) on completion of drilling.						70				
							69				
							68				

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 207

1 OF 3 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781962.5 ;E 323012.9 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 11, 12, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.1	GROUND SURFACE						95				
0.0	Sand and gravel (FILL) Compact Brown Moist		1	SS	18						
94.3							94				
0.8	Clayey silt, some sand, trace gravel, trace organics (FILL) Stiff to very stiff Brown Moist		2	SS	13				○		
			3	SS	16		93				
92.5			4	SS	17				○		2 18 58 22
2.6	Silty SAND, trace clay, containing organics Compact Blackish brown Moist						92				
92.0			5	SS	27						
3.1	CLAYEY SILT, some sand, trace to some gravel, containing sand/silt seams (TILL) Stiff to hard Greyish brown to grey Moist to wet		6	SS	35		91		○ —		11 33 41 15
			7	SS	31		90				
			8	SS	20		89		○		
			9	SS	22		87				
			10	SS	18		86		○ —		
			11	SS	27		85				
			12	SS	23	▽	83		○ —		
			13	SS	31		82				
							81				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 207

2 OF 3 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781962.5 ;E 323012.9 | ORIGINATED BY PKS
DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT
DATUM Geodetic | DATE November 11, 12, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---						80				
	CLAYEY SILT, some sand, trace to some gravel, containing sand/silt seams (TILL) Stiff to hard Greyish brown to grey Moist to wet		14	SS	29		79				
			15	SS	30		78				
			16	SS	12		77				
			17	SS	10		76				
73.8							75				
21.2	Sandy SILT Compact Grey Wet		18	SS	18		74				
72.2							73				
22.9	Silty SAND, some gravel Compact to dense Grey/red Wet		19	SS	30		72				
70.8							71				
24.5	CLAYEY SILT, some sand, trace gravel Hard Grey		20	SS	100/.18		70				
69.2	Silty SAND, trace gravel (TILL/RESIDUAL SOIL) Very dense Red Wet										
25.9	CLAYEY SILT, some sand, trace gravel and shale pieces (TILL/RESIDUAL SOIL) Hard Red Moist		21	SS	100.13		69				
67.7							68				
27.6	Silty SAND, trace gravel, containing shale pieces (TILL/RESIDUAL SOIL) Very dense Red Wet		22	SS	100/.15						
	END OF BOREHOLE										

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 207

3 OF 3 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781962.5 ;E 323012.9 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 11, 12, 2004 | CHECKED BY ASP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Notes: 1. Water level at 25.9 m depth (Elev. 69.2 m) on completion of drilling. 2. Water level measured at 13.85 m depth (Elevation 81.3 m) on Nov. 26, 2004, at 13.2 m depth (Elev. 81.9 m) on May 13, 2005, and at 13.4 m depth (Elev. 87.1 m) on December 6, 2005.										

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

Golder Associates

RECORD OF BOREHOLE No 208

1 OF 1 **METRIC**

PROJECT 04-1111-002 | W.P. 607-00-00 | LOCATION N 4781939.3 ;E 323008.2 | ORIGINATED BY PKS

DIST Central HWY QEW | BOREHOLE TYPE 108 mm Diameter Solid Stem Augers | COMPILED BY BLT

DATUM Geodetic | DATE November 16, 2004 | CHECKED BY ASP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.9	GROUND SURFACE										
0.0 / 0.1	Sand and gravel (FILL) Compact Moist		1	SS	21						
	CLAYEY SILT, some sand, trace gravel, trace organics (FILL) Firm to very stiff Brown Moist		2	SS	16		94		○		
			3	SS	6		93				0 15 62 23
92.3			4	SS	8				○ —	41	O.C. 2.2%
2.6 / 91.8	SILTY CLAY, some sand, trace gravel, containing organics and rootlets						92				
3.2	Blackish brown CLAYEY SILT, some sand, trace gravel (TILL) Very stiff to hard Brownish grey to grey Moist		5	SS	25						
			6	SS	37		91		○		
			7	SS	27		90				
							89				
			8	SS	55				○ —		
							88				
			9	SS	23		87				
							86				
85.1			10	SS	31				○		
9.9	END OF BOREHOLE										

Note:

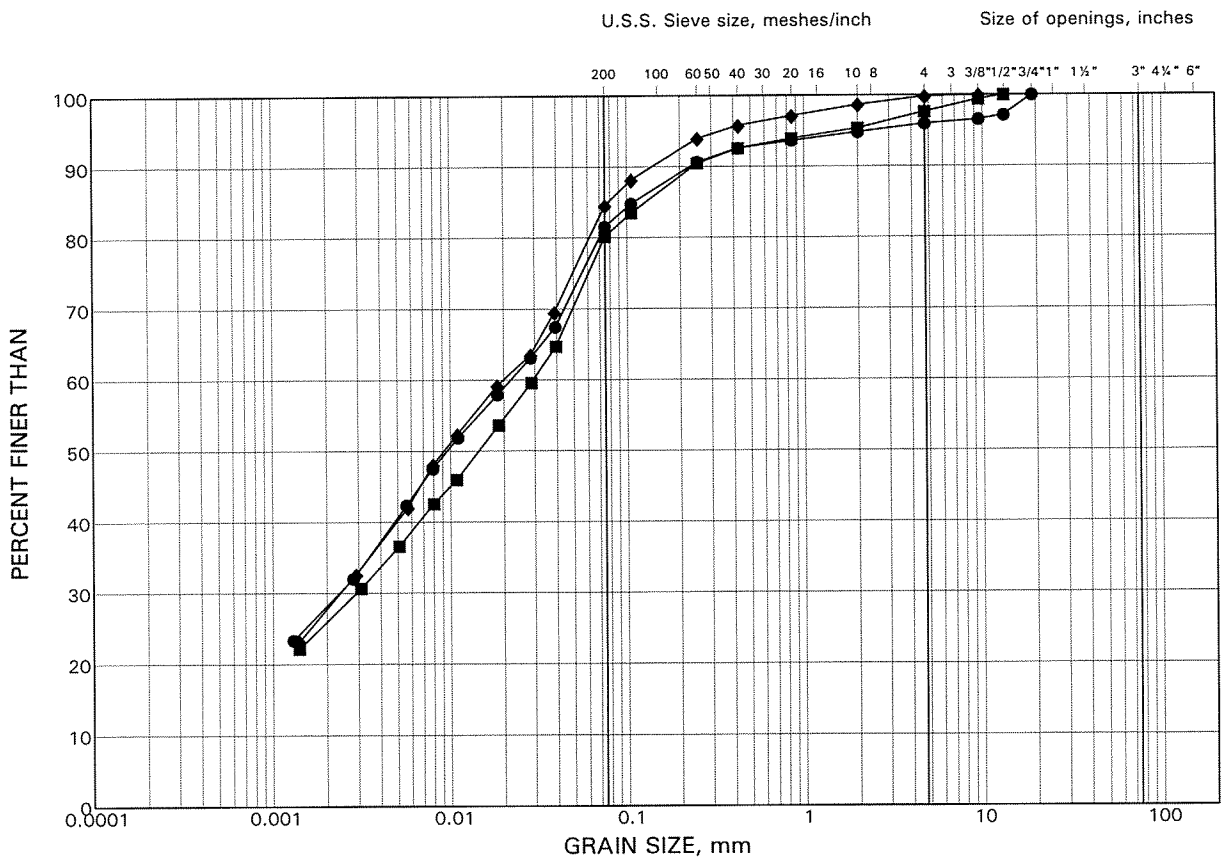
1. Borehole dry on completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 041111002AAMTO.GPJ GAL-MISS.GDT 16/10/06

GRAIN SIZE DISTRIBUTION TEST RESULTS
Fill

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	202	2	94.3
■	207	4	92.5
◆	208	3	93.1

Date October, 2006
Project 04-1111-002-2

Golder Associates

Prepared by LG
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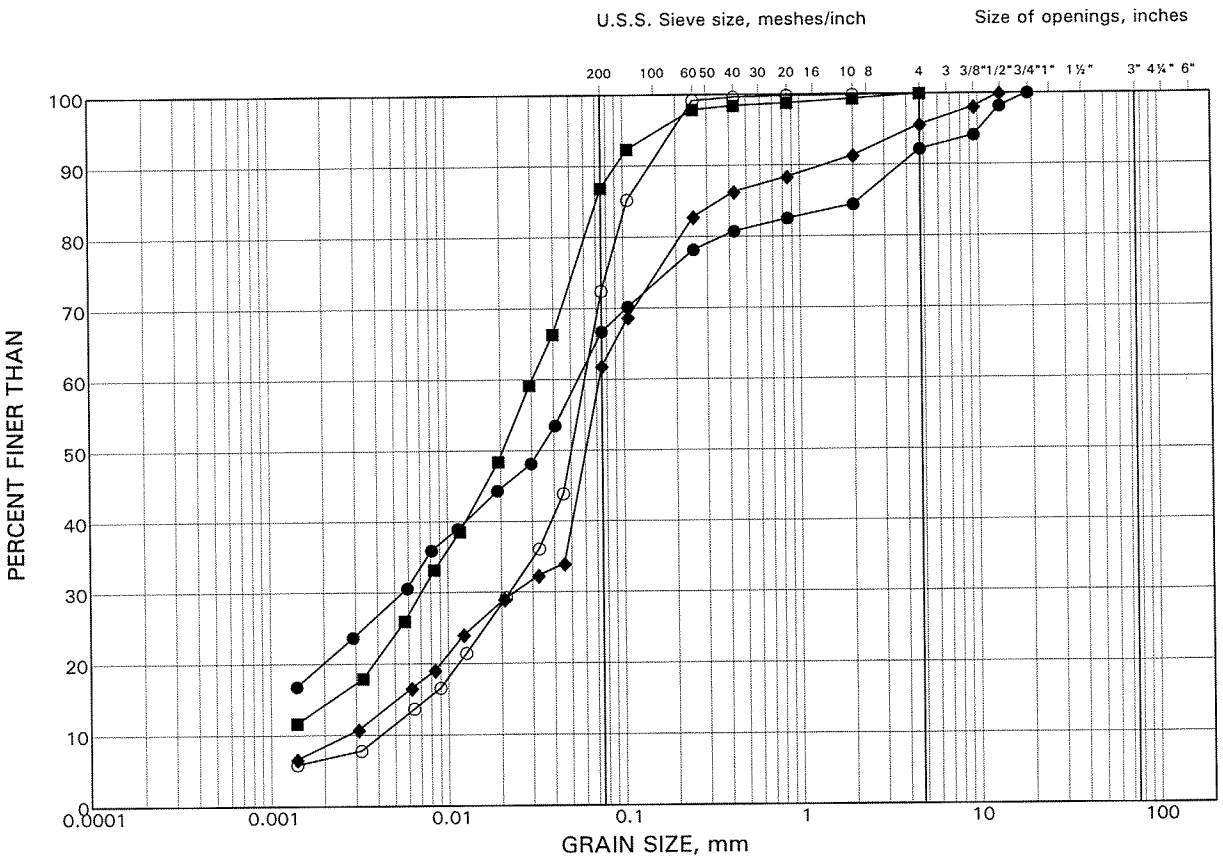
GRAIN SIZE DISTRIBUTION TEST RESULTS
Clayey Silt to Silty Sand

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	201	5	91.6
■	202	6	91.3
◆	203	4	92.5
○	203	7	90.2

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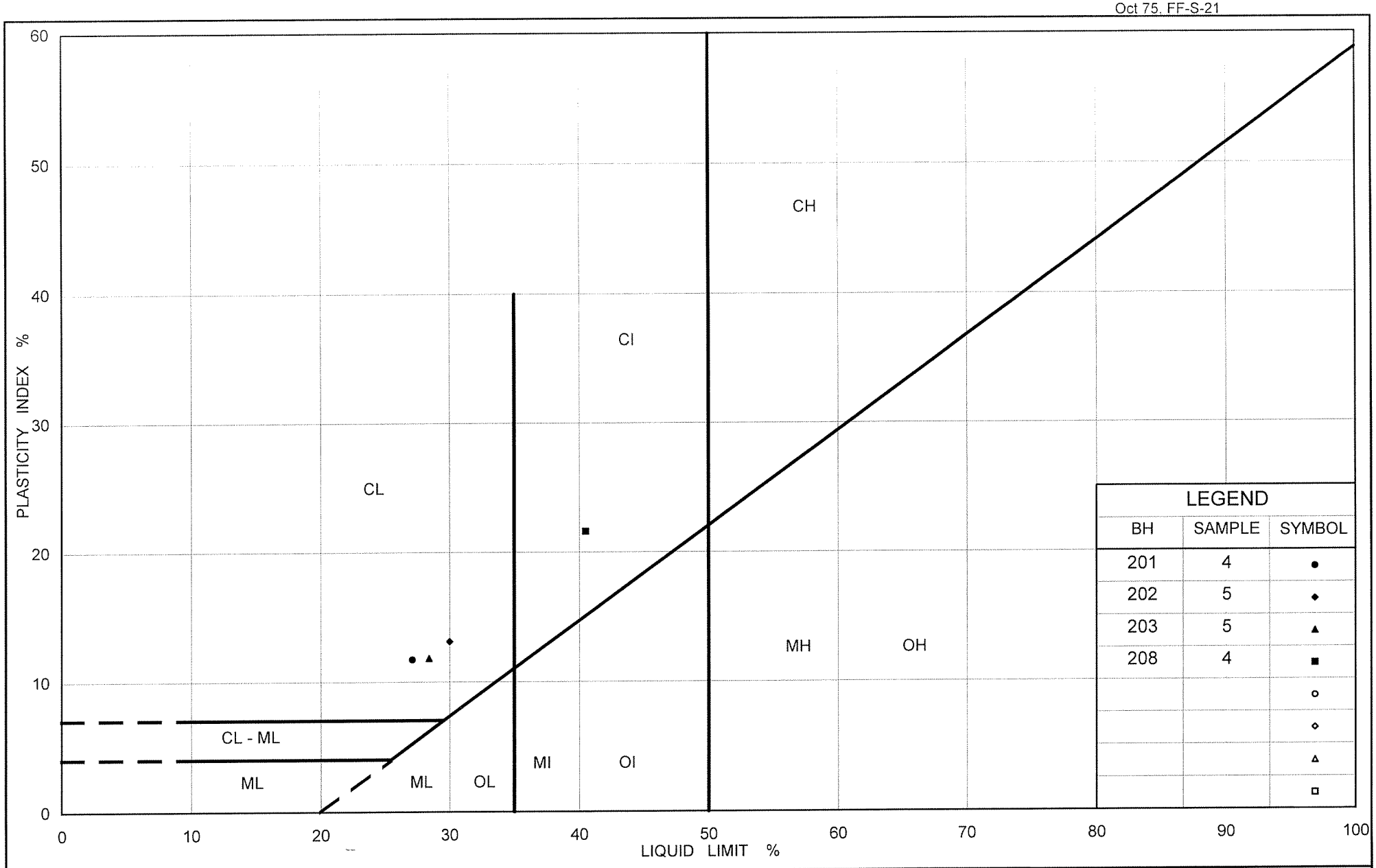

Ministry of Transportation

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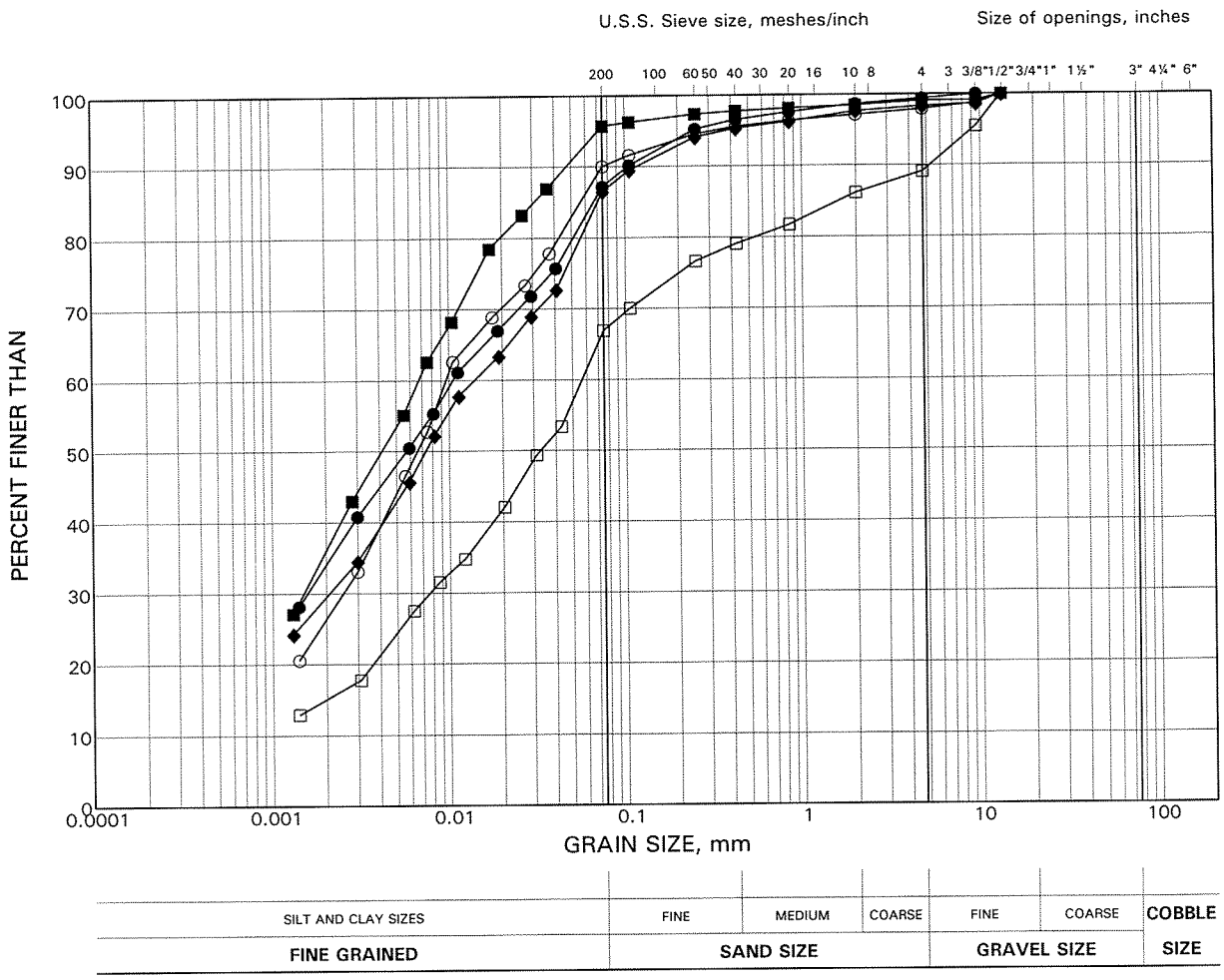
PLASTICITY CHART
Clayey Silt to Silty Sand

FIG No. 3

Project No. 04-1111-002-2

GRAIN SIZE DISTRIBUTION TEST RESULTS
Clayey Silt Till

FIGURE 4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	202	8	89.0
■	202	16	76.8
◆	203	9	87.2
○	206	11	84.2
□	207	6	91.0

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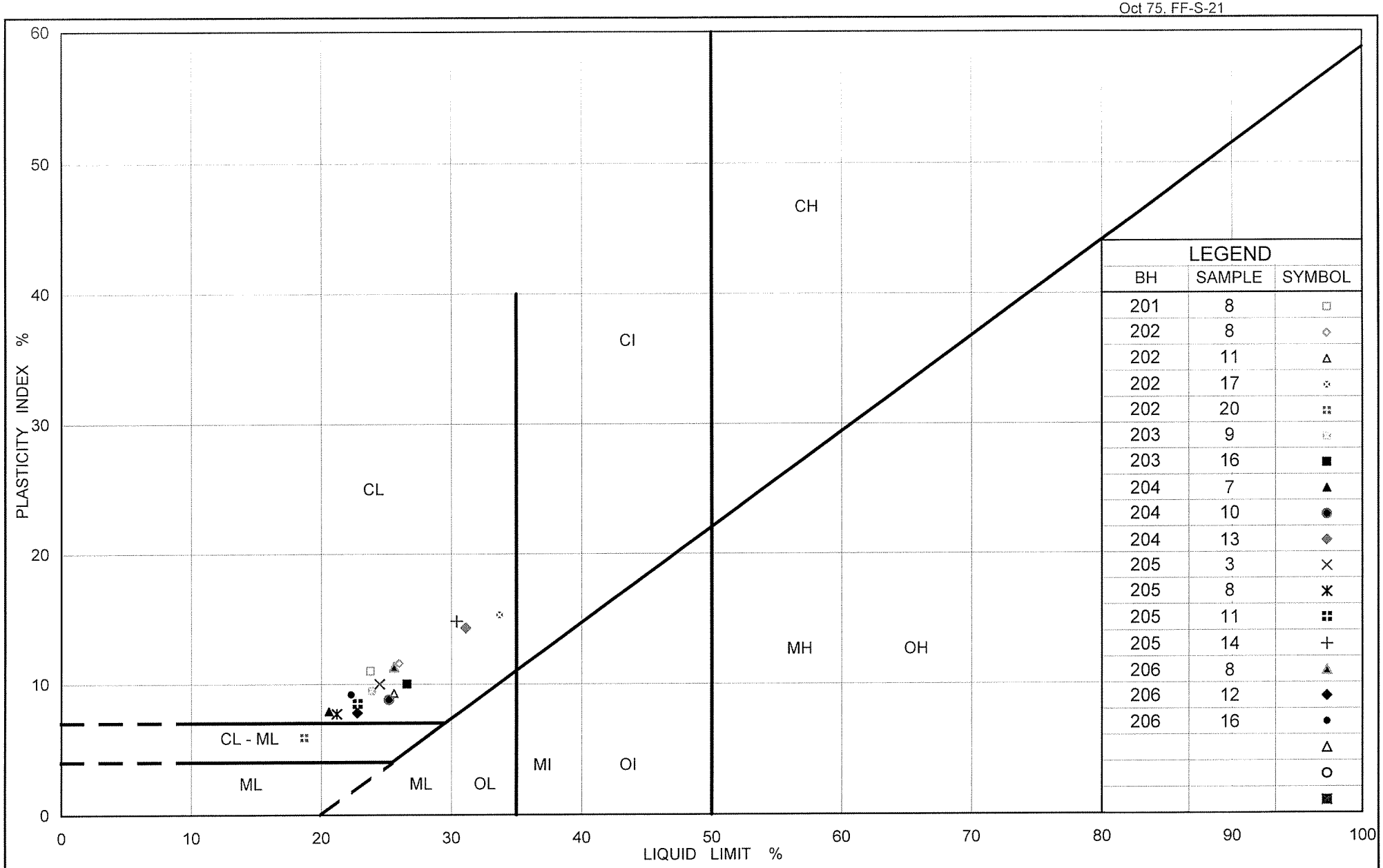

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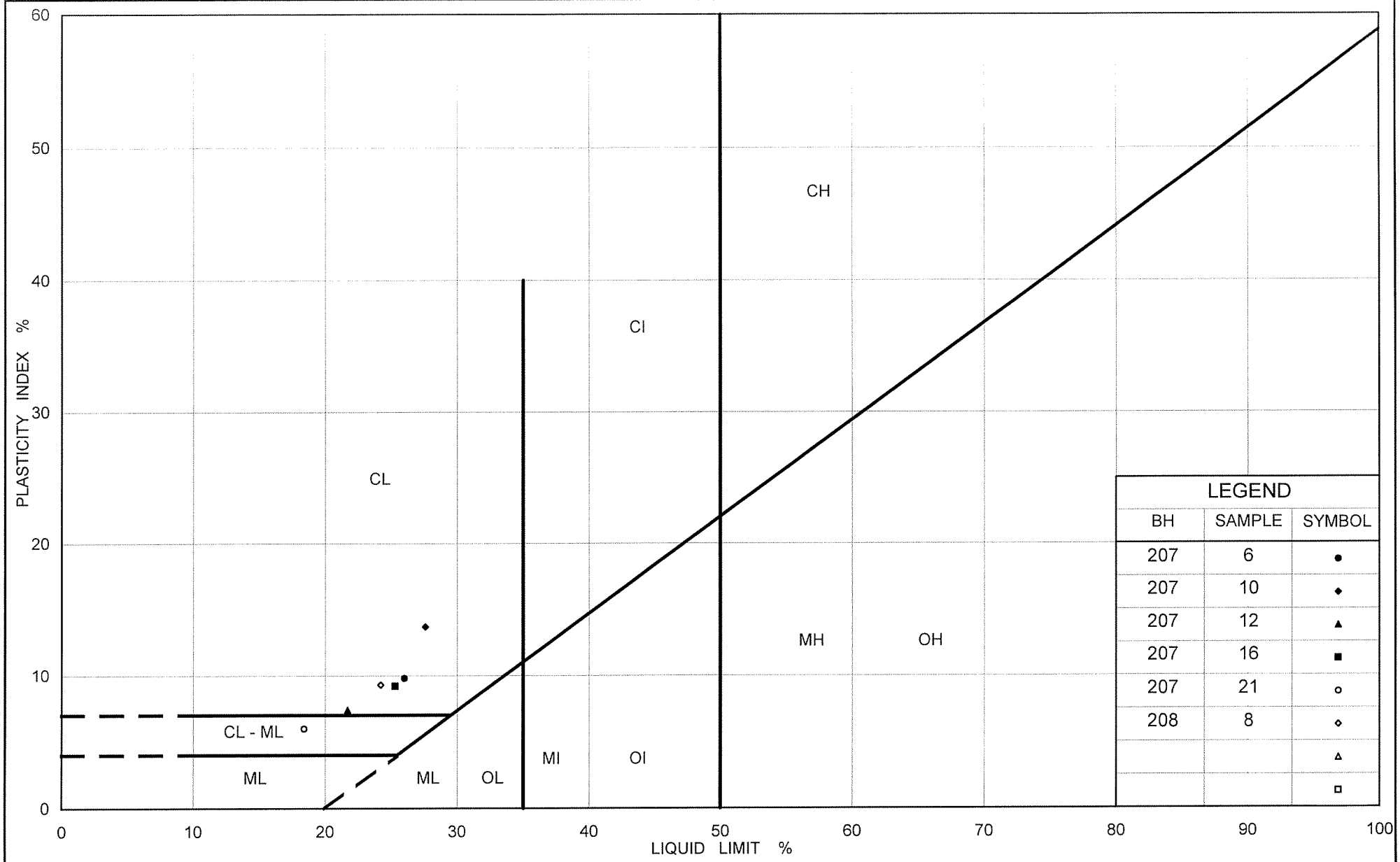
PLASTICITY CHART
Clayey Silt Till

FIG No. 5A

Project No. 04-1111-002-2



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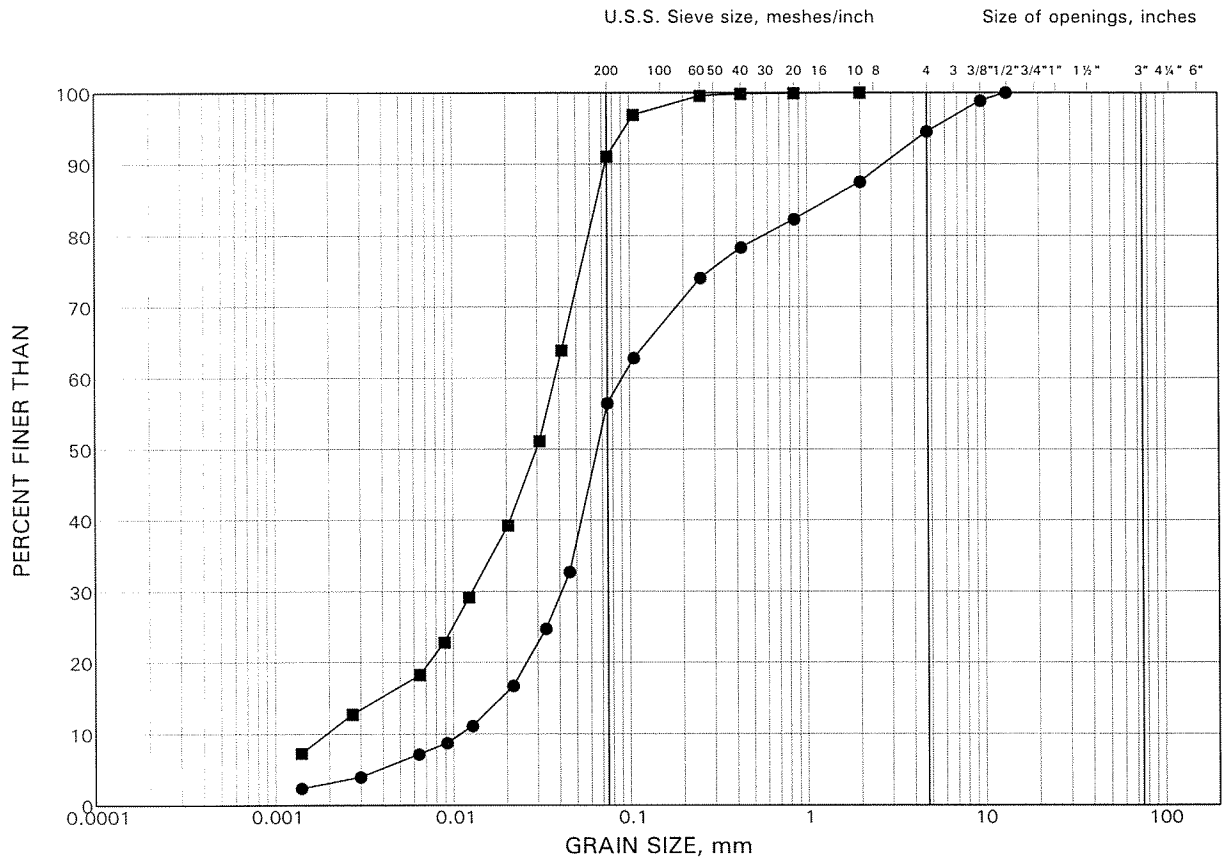
Clayey Silt Till

FIG No. 5B

Project No. 04-1111-002-2

GRAIN SIZE DISTRIBUTION TEST RESULTS
Lower Sands and Silts

FIGURE 6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	203	20	70.5
■	205	12	77.6

Date August, 2005
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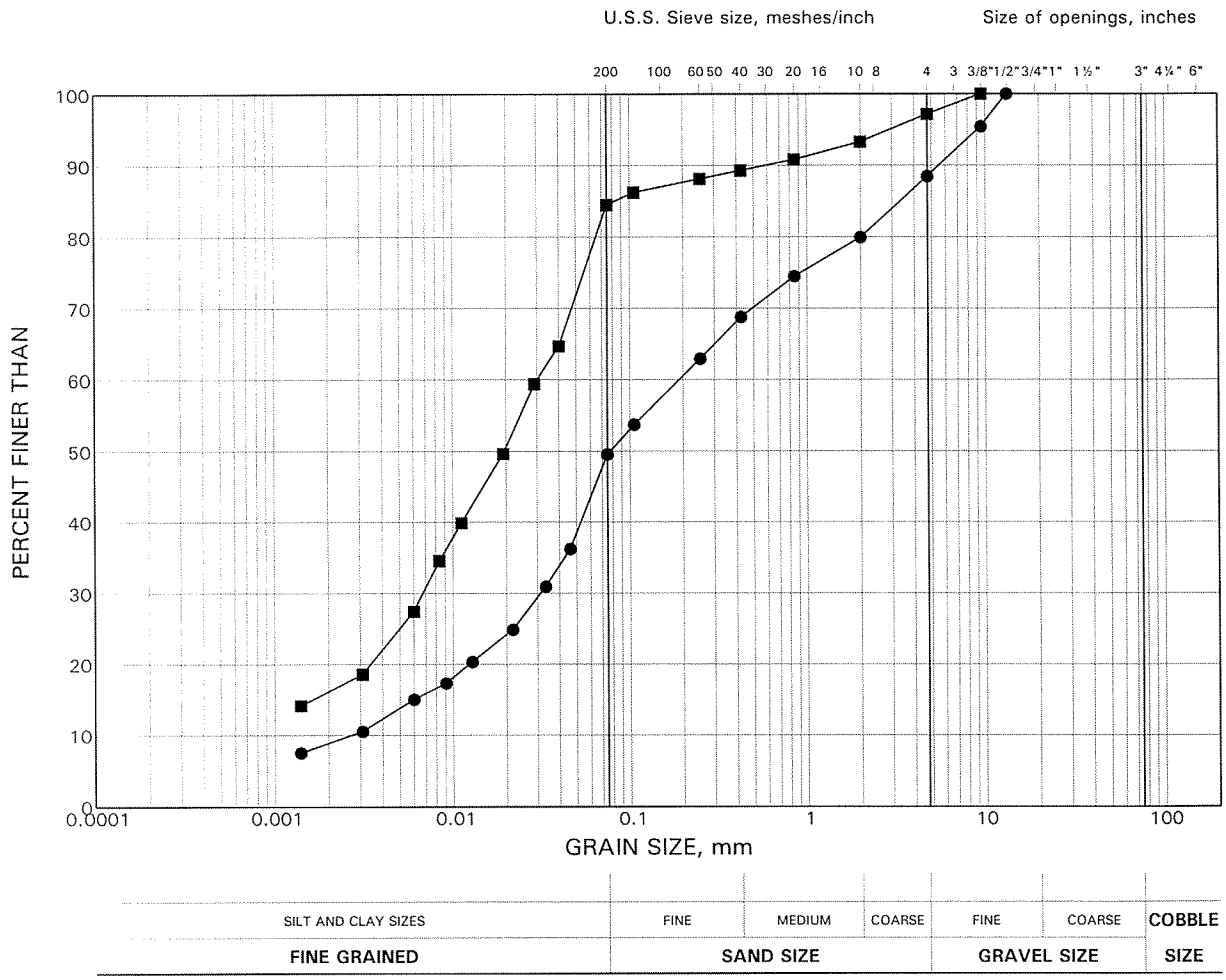
GRAIN SIZE DISTRIBUTION TEST RESULTS
Till / Residual Soil

FIGURE 7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION (m)
●	204	18	68.9
■	206	20	70.7

Date October, 2005
Project 04-1111-002-2

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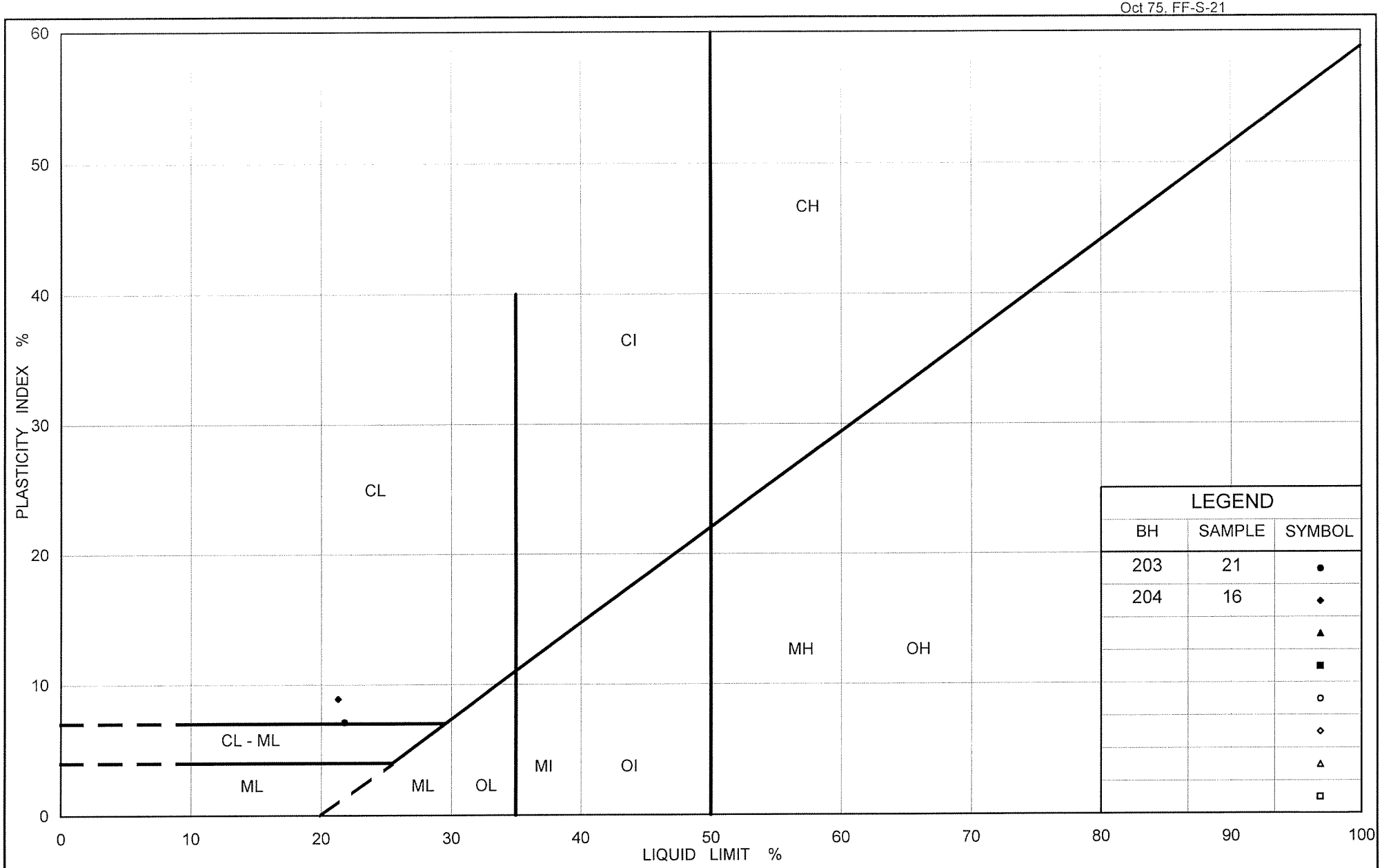

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PLASTICITY CHART
Till / Residual Soil

FIG No. 8

Project No. 04-1111-002-2