

**ENGINEERING MATERIALS OFFICE**  
**FOUNDATION DESIGN SECTION**

**WP 474-91-00**  
**HWY 400**

**REGION Central**  
**SITE 37-128**

Major Mackenzie Drive Bridge Replacement

*CONT 2002-2005*

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**Date: July 14, 2000**

# **FOUNDATION INVESTIGATION REPORT**

**for**

**Major Mackenzie Drive Bridge Replacement**

**Highway 400**

**W.P. 474-91-00 Site 37-128**

**Central Region**

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## ***Introduction***

This report summarizes the factual information obtained from a foundation investigation conducted for the replacement structure proposed at Highway 400 and Major Mackenzie Drive. The investigation was conducted just north of the existing single span structure, approximate Highway 400 Sta 18+334, and extended for 60 m east and west of the Highway 400 centreline. The work was carried out at the request of Central Region, Structural Section.

## ***Site Description***

The site is located at the interchange of Highway 400 and Major Mackenzie Drive in the City of Vaughan. The existing underpass structure requires replacement to accommodate the ultimate widening of Highway 400.

At Major Mackenzie Drive, Highway 400 carries six lanes of traffic divided by a concrete tall wall barrier. Inside and outside shoulders are paved. The highway sits at the original ground elevation, supported by the granular subgrade and pavement structure.

The terrain is generally flat to undulating. Land use is primarily commercial and recreational.

Physiographically, the site lies within the region known as the Peel Plain and consists largely of glacial till deposits and granular outwash (after Putnam and Chapman, 1984, The Physiography of Southern Ontario, 3<sup>rd</sup> Edition).

## ***Investigation Procedures***

### ***i) Field***

The field investigation was carried out by the Foundations Unit between 99 03 22 and 99 03 26. Eight boreholes were advanced using truck and track-mounted auger machines equipped with solid stem augers. Boreholes 4 and 5, located in the median of Highway 400, were advanced

using the truck-mounted power auger with automatic hammer. The track-mounted drill, used to advance the remaining boreholes, was equipped with a manual hammer.

Two boreholes were advanced at each of the proposed footing locations. The boreholes at the footings were advanced to depths of between 14.2 and 20.1 m. Two 8.1 m deep boreholes were drilled at the proposed approaches to the structure.

Disturbed samples were recovered by means of a 50 mm O.D. split spoon sampler driven into the ground according to the specifications of the Standard Penetration Test (ASTM D 1586-8). The samples were retrieved at 0.76 m intervals for a depth of 6 m, followed by a sampling interval of 1.5 m to the borehole termination depth. Vane tests were carried out at representative locations when soft cohesive soils were encountered. The boreholes were backfilled with grout upon completion.

Groundwater elevations were obtained by measuring the water levels in the open boreholes prior to backfilling.

Survey information for the boreholes was provided by MTO Central Region Surveys and Plans Section.

#### ***ii) Laboratory***

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the subsurface deposits including:

- Natural Moisture Content
- Atterburg Limits
- Grain Size Distribution
- Bulk Unit Weight

The results of the laboratory tests are plotted on the Record of Borehole sheets and on Figures 1 through 4.

#### ***Subsurface Conditions***

##### ***General***

The elevation of the Highway 400 in the area of investigation is 230.0. The ground elevation east and west of the highway is in the order of 229.0. The subsurface conditions across the site consist of a surficial deposit of clayey silt that extends to a depth of 11.4 to 13.1 m, El 216.6 to 218.6. Boreholes 4 and 5, carried out along the median of Highway 400, were advanced through approximately 150 mm of asphalt pavement and 450 mm of granular base and sub-base before the clayey silt deposit was encountered.

Beneath the clayey silt deposit lies a sand to silty sand layer. Boreholes 2 and 7 extended beyond the cohesionless deposit where the sand to silty sand terminates at elevations 211.6 and 210.6, respectively, and measures 6.1 to 7.5 m in thickness. It is underlain by a glacial till deposit composed of clayey silt with sand. The extent of the clayey silt glacial till deposit was not fully

explored.

The groundwater level was measured in the open boreholes and was present at depths varying from 1 m to 10.4 m, between El. 218.9 and 229.6.

For the boundaries of the various subsoil types, field and laboratory test results and groundwater levels refer to the appended Record of Borehole Sheets. The locations of the borings in plan and the stratigraphical profile are shown on Drawing Nos. 4749100A and B.

### ***Sand (Fill)***

The sand fill deposit describes the subgrade materials encountered in boreholes 4 and 5 that were carried out adjacent the median barrier on the inside paved shoulder of northbound Highway 400. Asphalt pavement is present to a depth of approximately 150 mm in each of the two boreholes. Sand and gravel extend for a thickness of 220 mm beneath the asphalt. Uniformly graded medium coarse sand was encountered beneath the granular base and it extends for a thickness of 1.1 m. The sand contains traces of gravel and silt. From the standard penetration test, N values of 22 and 27 were obtained, indicating that the sand fill is in a compact state.

### ***Clayey Silt***

A clayey silt deposit is present in all borings. It was encountered as the surficial deposits= in Boreholes 1,2 3, 6,7 and 8, carried out within the north ramp loops of Highway 400 and Major Mackenzie Drive. The clayey silt extends to El.217.7 (BH 2) and El. 217.2 (BH 3) west of Highway 400, to El 218.4 (BH 4) and El. 218.6 (BH 5) in the median of Highway 400, and to El. 216.6 (BH 6) and El. 216.4 (BH 7) east of Highway 400. The thickness of the deposit ranges from 11.6 m, west of the highway, to 13.1 m, east of the highway. This cohesive deposit is overconsolidated and glacial in origin. It contains some sand and a trace of gravel. N values for this material range from 6 in the vicinity of a buried Bell cable (BH 6) to greater than 120 blows per 15 cm. Except in the area of the buried utility, N values more typically ranged from 13 to in excess of 120, indicating that the clayey silt is stiff to hard in consistency. The following soil properties were determined from laboratory testing carried out on representative samples:

	<u>Range</u>	<u>Average</u>
Moisture Content (w)	8.7 - 23.2 %	12.0%
Plastic Limit ( $w_p$ )	12.0 - 20.0%	13.9%
Liquid Limit ( $w_L$ )	18.0 - 44.0%	22.3%
Unit Weight ( $\gamma$ )	20.6 - 22.8 kN/m <sup>3</sup>	21.7 kN/m <sup>3</sup>
Field Vane Test (kPa)	55 kPa	
Sensitivity	14	

The Atterburg limits obtained from the laboratory tests are plotted on Figure 1. Refer to Figure 2 for a grain size distribution envelope for this deposit.

### ***Sand to Silty Sand***

A non-cohesive deposit of sand to silty sand was encountered beneath the clayey silt stratum. It was present in all boreholes. The thickness of the deposit was determined in Boreholes 2 and 7

where it was 6.1 m thick in BH 2, advanced on the west side of Highway 400 and 7.5 m thick in BH 7, advanced on the east side of Highway 400. The sand to silty sand deposit extends to El. 211.6 in BH 2 and EL 210.6 in BH 7. N values ranging from 34 to in excess of 120 blows per 30 cm were obtained from Standard Penetration testing, revealing a state of compaction ranging from dense to very dense. The composition of the deposit makes it susceptible to disturbance under conditions of unbalanced hydrostatic head. Laboratory testing carried out on representative samples revealed that the moisture content of this deposit ranges from 11.8% to 18.9%, with an average moisture content of 16.1%.

Figure 3 provides a grain size distribution envelope for the sand to silty sand deposit.

#### ***Clayey Silt (Glacial Till)***

The sand to silty sand deposit is underlain by a cohesive clayey silt glacial till. It was encountered at El. 211.6 in Borehole 2 and El. 210.6 in Borehole 7. The boreholes were terminated in this deposit. The clayey silt till contains a large proportion of sand and a trace of gravel. N values for this material were greater than 120 blows per 30 cm, indicating a hard consistency for the deposit. The following properties were obtained from laboratory testing:

Moisture Content (w)	6.9 and 8.9 %
Plastic Limit ( $w_p$ )	11.0 and 12.0%
Liquid Limit ( $w_L$ )	8.9% and 20.0%

Refer to Figure 4 for the grain size distribution curves for this deposit.

#### ***Groundwater Conditions***

Water levels were measured in the open holes at the completion of each borehole. At the time of the investigation, the following groundwater elevations were measured:

<u>Borehole</u>	<u>Groundwater Elevation</u>
1	224.4
2	218.9 (not stabilized)
3	223.2
4	not established
5	225.7
6	229.6
7	228.1
8	228.3

For the boundaries of the various subsoil types, field and laboratory test results, and groundwater levels at the borehole locations, refer to the appended Record of Borehole Sheets. The locations of the borings in plan and stratigraphic profiles and sections are shown on Drawing No. 4749100-A and B.

## DISCUSSION

The existing underpass structure at Major Mackenzie Drive is a single span rigid frame bridge, 39 m in length and 15 m wide. The widening of Highway 400 requires that a replacement structure be constructed. At the time of writing, the proposed structure will be 80 m in length having a centre pier and two 40 m spans and a width of 34 m. The new structure will be constructed some 30 m north of the existing Major Mackenzie alignment.

The elevation of Highway 400 at the proposed Major Mackenzie structure is 230.0. The profile grade elevation of the existing structure is approximately 237.8.

## RECOMMENDATIONS

### Structure Foundations

The subsurface conditions are suitable for either shallow or deep foundations.

#### *Shallow Foundations*

The following design values are provided for the abutment and pier footings, according to the requirements of the OHBDC 3<sup>rd</sup> Edition. The bearing resistances assume a 3 m wide footing.  
*West Abutment (BH's 2 and 3)*

The West Abutment footing may be founded on the original ground, at El. 227.0, with the following bearing resistances

Factored Bearing Resistance at ULS	475 kPa
Bearing Resistance at SLS	325 kPa

For greater resistances, the footing may be placed at or below El. 226.0:

Factored Bearing Resistance at ULS	750 kPa
Bearing Resistance at SLS	500 kPa

Alternatively, the footing may be perched within the abutment and founded on a Granular A pad having a minimum thickness of 2 m. The base of the granular pad should be placed at or below El. 228.0. The following design values apply:

Factored Bearing Resistance at ULS	700 kPa
Bearing Resistance at SLS	350 kPa

#### *East Abutment (BH's 6 and 7)*

The East Abutment footing may be founded on the original ground, at or below El. 226.0, with the following bearing resistances:

Factored Bearing Resistance at ULS	750 kPa
Bearing Resistance at SLS	500 kPa

An isolated zone of firm clay was encountered in BH 6. Its softness is attributed to the excavation carried out for the Bell underground cable adjacent to the borehole. Perched footings would be uneconomical at this location as it would require a considerable thickness of Granular A.

#### *Centre Pier*

The centre pier footing may be founded on original ground, at or below El. 226.5. The following design values apply:

Factored Bearing Resistance at ULS	750 kPa
Bearing Resistance at SLS	500 kPa

#### *General Recommendations for Shallow Foundations*

For all spread footings, deformations of 25 mm or less are anticipated. Higher bearing resistances may be used if greater differential settlements can be tolerated.

An effective angle of friction of  $28^\circ$  may be assumed as the shearing resistance between the concrete footing and the clayey silt material. For footings on a granular pad, a friction angle of  $35^\circ$  between the base of the concrete footing and the compacted Granular A pad may be used.

A minimum of 1.2 m of earth cover is required for frost protection.

The groundwater level is variable at the site. The excavation of the footings may encounter a perched water table. No unwatering problems are expected. It is anticipated that unwatering may be accomplished using sump pumping techniques to ensure that the footings are placed in the dry.

Upon excavation of the footing base, a 150 mm concrete working slab should be poured within six hours of exposure.

#### *Deep Foundations*

The structure footings may be founded on piles driven to the very dense sand and hard clayey silt till deposits. False or integral abutments could be considered at this site.

Pile driving should be controlled by the Hiley Formula (MTO Standards SS103-10 or SS103-11). The following are estimated pile tip elevations at each footing location:

West Abutment	El. 213.0
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Centre Pier	El. 215.0
East Abutment	El. 211.0

The following design values are recommended for steel HP 310x110 piles:

Factored Axial Resistance at ULS	2000 kN
Axial Resistance at SLS	2000 kN

The horizontal component of battered piles may be used to determine the lateral resistances of the piles.

The piles should be advanced assuming an ultimate resistance of twice the factored ULS resistance per pile. Provision should be made for re-tapping of piles to confirm the set after adjacent piles have been driven.

To facilitate pile installation, it is recommended that the piles be equipped with reinforced tips as per MTO standard drawing DD-3301.

For integral abutment piles, the lateral resistance of the vertical piles may be calculated using the following expressions for horizontal subgrade reaction. The lateral resistance over the length of the CSP liners should be neglected in design.

For cohesionless soils  $k_s = \frac{z \times n_h}{d}$

where,

- $k_s$  = coefficient of horizontal subgrade reaction (kPa/m)
- $d$  = pile diameter (m)
- $n_h$  = constant of horizontal subgrade reaction (kPa/m) based on soil density
- $z$  = depth (m)

For cohesive soils  $k_s = \frac{67 c_u}{d}$

where,  $c_u$  = undrained shear strength (kPa)

Abutment	Elevation	Soil Type	$c_u$ (kPa)	$n_h$ (kPa/m)
West	229.0 - 226.0	Clayey Silt Very Stiff	100	-
	226.0 - 217.5	Clayey Silt Hard	250	-
	217.5 - 211.0	Sand to Silty Sand Very Dense	-	10 000
East	230.0 - 226.0	Clayey Silt Stiff to V. Stiff	60	-
	226.0 - 216.5	Clayey Silt Hard	250	-
	216.5 - 211.0	Sand to Silty Sand Very Dense	-	10 000



There is a group effect associated with lateral loading when pile spacing, in the direction of loading, is less than 8 pile diameters. The following reductions to  $k_s$  apply:

Pile Spacing in Direction of Loading	Subgrade Reaction Reduction Factor
8 d	1.00
6 d	0.70
4 d	0.40
3 d	0.25

The installation of integral abutment piles will require pre-augering at each pile location. This measure will ensure the flexibility of the integral abutment system. The pre-augered holes should be 3m in depth. It is recommended that the pre-augered holes be lined with two CSP, 600 mm and 800 mm in diameter. The annular space between the H-Pile and inner CSP should be filled with uniformly graded, coarse and uncompacted sand having the following gradations:

Sieve Size	Percentage Passing
2 mm	100
600 $\mu\text{m}$	80 – 100
425 $\mu\text{m}$	40 – 80
250 $\mu\text{m}$	4 – 25
150 $\mu\text{m}$	0 – 6

The annular space between the pipes is left unfilled to enable pile/pipe deflection.

### ***Lateral Earth Pressures***

Backfill to the ramp structures should consist of granular material in accordance with MTO Special Provision 109F03. Computation of earth pressures should be carried out in accordance with Section 6-7.4.2 of the OHBDC, 3<sup>rd</sup> Edition. Design parameters of the acceptable granular backfill materials are provided as follows:

	Angle of Internal Friction	Unit Weight ( $\text{kN/m}^3$ )
Granular A	35°	22.8
Granular B	30°	21.2

The active earth pressure applies where the structure is yielding and movements within the soil mass are permitted. It is expected that this condition will exist.

***Slope Stability***

No stability problems are anticipated provided 2H:1V slopes are maintained and vegetated as soon as possible. Where fill embankments exceed 8 m in height, a 2 m wide mid-height berm should be incorporated in the slope.

Topsoil should be stripped for the entire plan area of the embankments. Any soft areas should be subexcavated and replaced with well-compacted granular materials. The base of the excavation should be proof-rolled prior to fill placement. Embankment material should consist of clean fill as outlined in OPSS 212 or OPSS 1010, depending upon availability. Fill should be placed in lifts not exceeding 300 mm in thickness and be compacted to at least 95% Standard Proctor maximum dry density.

## Miscellaneous

The fieldwork for this investigation was carried out between March 22 and 26, 1999 under the supervision of B. Bennett, Foundation Engineer. The report was prepared by B. Bennett, and was reviewed by D. Dundas, Senior Foundation Engineer.



Betty Bennett, P.Eng.  
Foundation Engineer



David Dundas, P.Eng.  
Sr. Foundation Engineer

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## APPENDIX

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

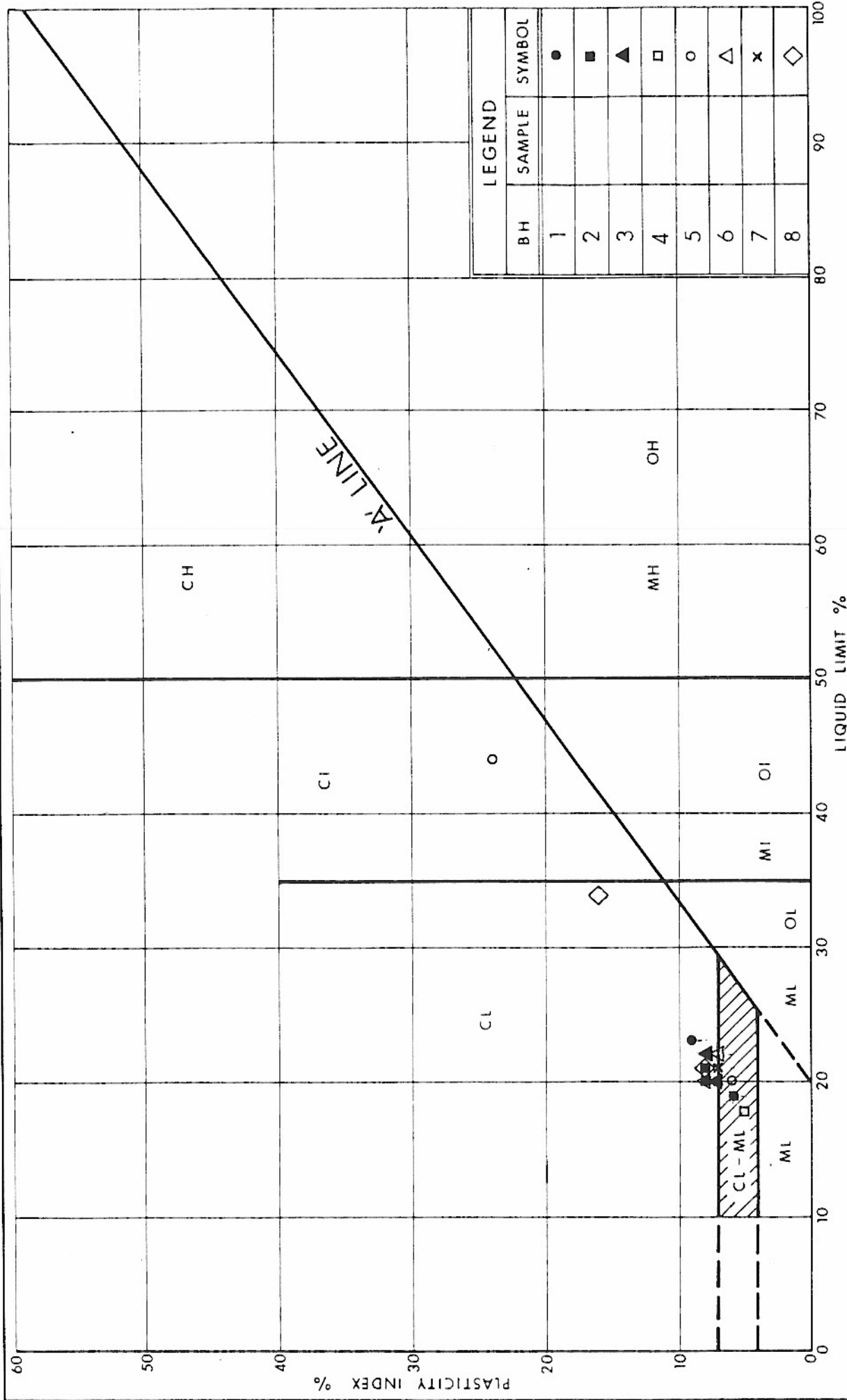
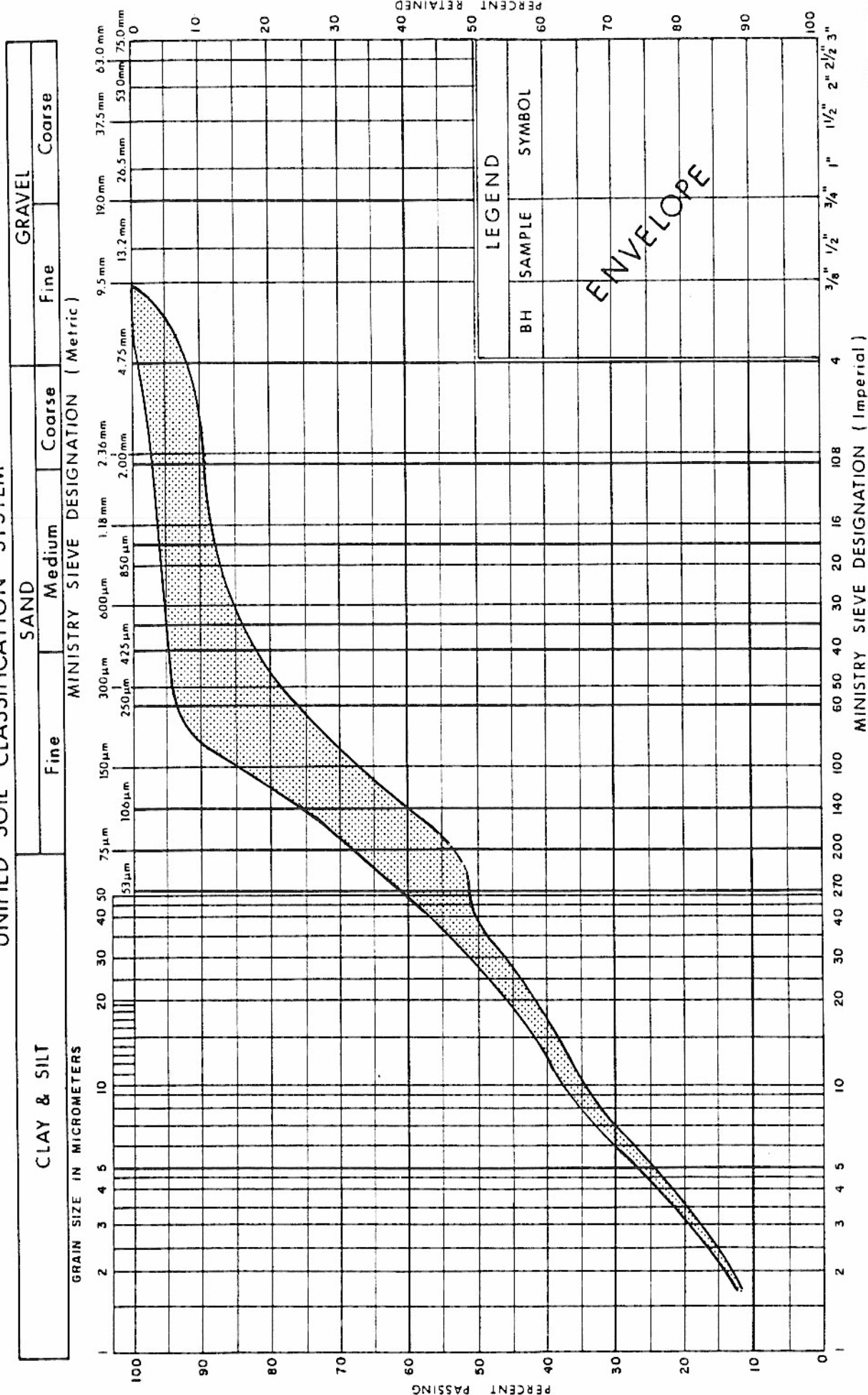


FIG No 1  
PLASTICITY CHART  
CLAYEY SILT



GRAIN SIZE DISTRIBUTION  
CLAYEY SILT

FIG No 2

WP 474-91-00

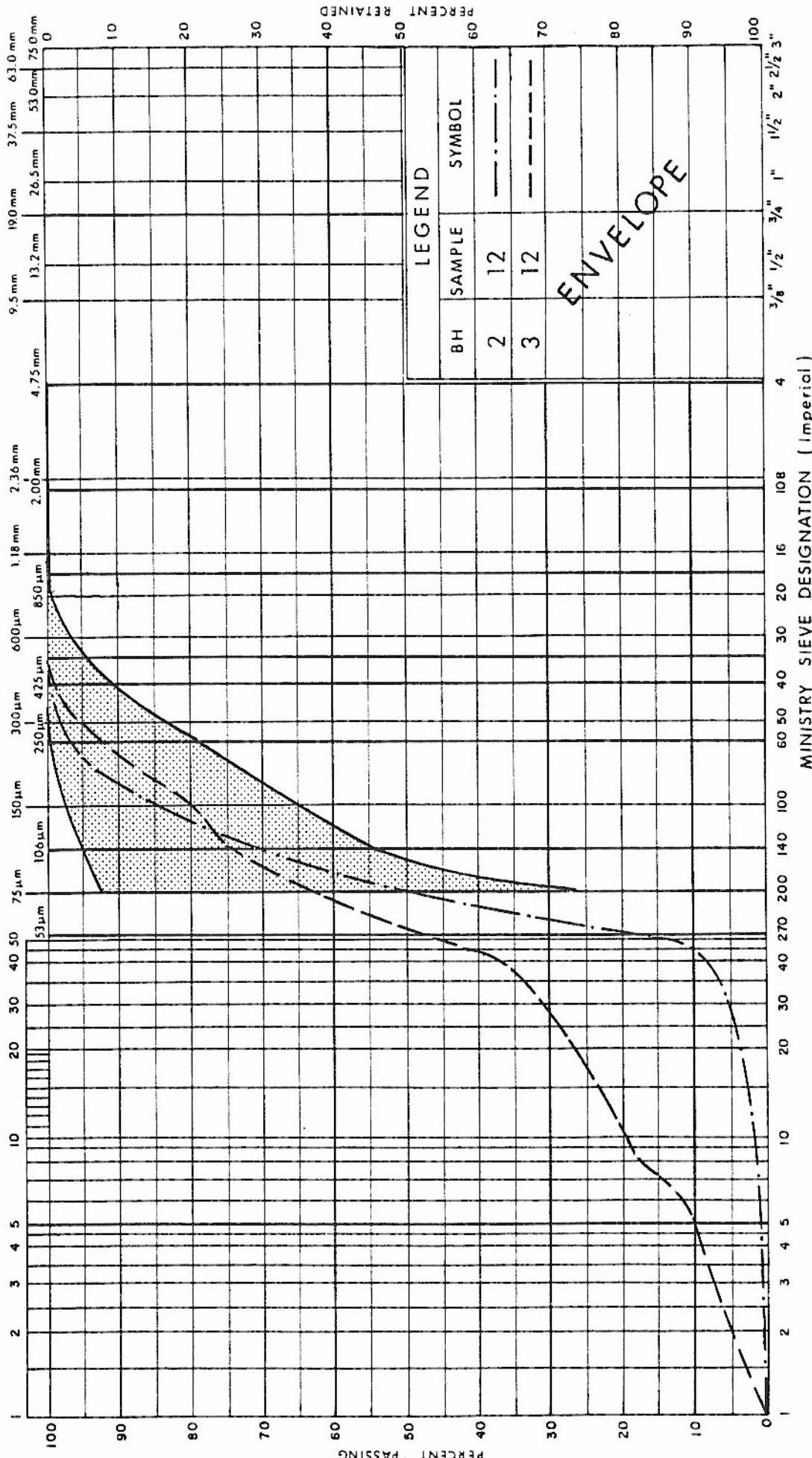


# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse

MINISTRY SIEVE DESIGNATION (Metric)

GRAIN SIZE IN MICROMETERS



## GRAIN SIZE DISTRIBUTION SAND TO SILTY SAND

Ministry of  
Transportation



FIG No 3

W P 474-91-00





# RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 474-91-00 LOCATION N 4 856 312; E 300 830 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY BB/DT  
 DATUM Geodetic DATE 1999 03 24 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									SHEAR STRENGTH kPa			WATER CONTENT (%)		
																	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				10 20 30	
228.9	Ground Surface																					
0.0	CLAYEY SILT Trace Gravel Trace/Some Sand Firm to Hard		1	SS	9		228									5 33 (62)						
			2	SS	34																	
			3	SS	83																	
			4	SS	95																	
			5	SS	127																	
			6	SS	65																	
			7	SS	87																	
			8	SS	110																	
			9	SS	78																	
220.8																						
8.1																						

# RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 474-91-00 LOCATION N 4 856 317; E 300 850 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY BB  
 DATUM Geodetic DATE 1999 03 23 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
229.3	Ground Surface													
0.0			1	SS	28		229							
			2	SS	38									
			3	SS	90		227						20.6	4 28 56 12
	Brown Gray		4	SS	132	/23cm								
			5	SS	87		225							2 24 (74)
	CLAYEY SILT		6	SS	128	/28cm								
	Trace Gravel		7	SS	88		223							
	Some Sand		8	SS	124									
	Very Stiff to Hard		9	SS	78		221							
			10	SS	54		219						21.5	4 21 (75)
217.7			11	SS	40									
11.6			12	SS	49		217							0 54 44 2
	SAND to SILTY SAND		13	SS	90		215							
	Gray		14	SS	100	/15cm	213							
	Dense to Very Dense		15	SS	75	/8cm								
211.6			16	SS	105	/13cm	211							9 39 (52)
17.7	CLAYEY SILT		17	SS	81	/15cm								
	With Sand													
	Trace Gravel													
209.2	Hard (Glacial Till)													
20.1	End of Borehole													
	• Groundwater not stabilized													

# RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 474-91-00 LOCATION N 4 856 341; E 300 847 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY DT/BB  
 DATUM Geodetic DATE 1999 03 24 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
229.0	Ground Surface																
0.0			1	SS	18		228										
			2	SS	23												
	CLAYEY SILT		3	SS	34												
	Trace to Some Sand		4	SS	52		226										1 23 (76)
	Trace Gravel		5	SS	69												
			6	SS	82												
	Brown		7	SS	56		224										1 22 (77)
	Grey		8	SS	110												
	Very Stiff to Hard						222										
			9	SS	95												
			10	SS	55		220										
			11	SS	103		218										
217.2																	
11.8			12	SS	84		216										0 38 58 4
			13	SS	120												
	SAND TO SILTY SAND						214										
	Very Dense		14	SS	113												
			15	SS	85		212										
210.6			16	SS	100												0 7 (93)
18.4	End of Borehole																

# RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 474-91-00 LOCATION N 4 856 314.5; E 300 895 ORIGINATED BY BB  
DIST CR HWY 400 BOREHOLE TYPE SS Auger, Automatic Hammer COMPILED BY DT/BB  
DATUM Geodetic DATE 1999 03 22 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
229.8	Asphalt																
0.0	SAND					*	229										
228.4	Trace Gravel, Trace Silt Compact (FILL MATERIAL)		1	SS	27												
1.4	CLAYEY SILT		2	SS	25												1 29 (70)
	Some Sand		3	SS	37		227										
			4	SS	46												
	Brown Grey		5	SS	44												
			6	SS	38		225										
	Very Stiff to Hard		7	SS	45												
			8	SS	52												
			9	SS	50		223										
			10	SS	42		221										
218.4			11	SS	23		219										
11.4	SAND to SILTY SAND		12	SS	154		217										0 15 (85)
	Dense																
215.6			13	SS	34**												
14.2	End of Borehole																
	* Groundwater level not established																
	** disturbed																

# RECORD OF BOREHOLE No 5

1 OF 1 METRIC

W.P. 474-91-00 LOCATION N 4 856 349; E 300 889 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY QT  
 DATUM Geodetic DATE 1999 03 23 CHECKED BY BB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				NATURAL MOISTURE CONTENT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
230.2	Asphalt												
0.0													
228.8	SAND, Trace Gravel, Trace Silt (Fill Material), Compact		1	SS	22								
1.4			2	SS	22								
			3	SS	13								
			4	SS	15								
	CLAYEY SILT Trace to Some Sand Trace Gravel Stiff to Hard		5	SS	54								
			6	SS	95								
			7	SS	82								
			8	SS	95								
	Brown Grey		9	SS	68								
			10	SS	54								
			11	SS	31								
218.8			12	SS	152	/23cm							
11.8	SAND TO SILTY SAND Very Dense		13	SS	158								
214.5			14	SS	151	/24cm							
15.7	End of Borehole												

# RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 474-91-00 LOCATION N 4 856 337; E 300 930 ORIGINATED BY BB  
DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY DT/BB  
DATUM Geodetic DATE 1999 03 25 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
229.7	Ground Surface																
0.0			1	SS	17		229										
			2	SS	6												
			3	SS	7		227										2 29 58 11
			4	SS	25												
			5	SS	73	/15cm										22.3	2 28 (70)
			6	SS	73	/15cm	225										
			7	SS	70	/15cm											
			8	SS	125	/23cm	223										
			9	SS	119		221										3 24 (73)
			10	SS	108												
			11	SS	68	/15cm	219										
			12	SS	90		217										
216.6			13	SS	50		215										
13.1			14	SS	107												0 59 (41)
			15	SS	70	/10cm	213										
211.2			16	SS	65	/5cm											
18.5	End of Borehole																

# RECORD OF BOREHOLE No 7

1 OF 1 METRIC

W.P. 474-91-00 LOCATION N 4 856 357; E 300 927 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY DT/BB  
 DATUM Geodetic DATE 1999 03 25 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
220.5	Ground Surface																
0.0	CLAYEY SILT Some Sand Trace Gravel Very Stiff to Hard		1	SS	23		229										
			2	SS	25												2 28 (70)
			3	SS	36		227										
			4	SS	88												2 26 (72)
			5	SS	91												
			6	SS	70	/13cm	225									21.8	2 24 (74)
			7	SS	110	/28cm											
			8	SS	64	/15cm	223										
			9	SS	51		221										
			10	SS	57												
			11	SS	60		219										5 22 (73)
217.9																	
11.6			12	SS	77	/15cm	217										0 50 (50)
			13	SS	38		215										
			14	SS	106		213										
			15	SS	81	/13cm											
			16	SS	97	/15cm	211										
210.6																	
18.9	CLAYEY SILT																
209.4	Hard (Glacial Till)		17	SS	93	/15cm											3 32 (55)
20.1	End of Borehole																

# RECORD OF BOREHOLE No 8

1 OF 1 METRIC

W.P. 474-91-00 LOCATION N 4 856 346.5; E 300 948.5 ORIGINATED BY BB  
 DIST CR HWY 400 BOREHOLE TYPE SS Auger, Manual Hammer COMPILED BY DT/BB  
 DATUM Geodetic DATE 1999 03 26 CHECKED BY BB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
229.3	Ground Surface													
0.0	CLAYEY SILT Trace to Some Sand Trace Gravel Stiff to Hard		1	SS	13		229							1 8 (91)
			2	SS	28									
			3	SS	14		227							
			4	SS	51									
			5	SS	86		225							9 22 (69)
			6	SS	117	/27cm								
			7	SS	94									
			8	SS	611	/8cm	223							
221.2			9	SS	117									
0.1	End of Borehole													