

FOUNDATION INVESTIGATION  
HIGH MAST LIGHT NUMBER 2

W.P. 374-89-00  
HWY. 401-416 INTERCHANGE  
DISTRICT 9, OTTAWA *File*  
GEOCREs # 31B-76  
MINISTRY OF TRANSPORTATION OF ONTARIO

SUBMITTED TO  
DELCAN CORPORATION

BY

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Report

on

Foundation Investigation  
High Mast Light Number 2

W.P. 374-89-00

Hwy. 401-416 Interchange  
District 9, Ottawa

Jacques, Whitford Limited

July 31, 1991

Project No. 10213



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# **FOUNDATION INVESTIGATION REPORT**

**for**

**High Mast Light Number 2**

**W.P. 374-89-00**

**DISTRICT 9, OTTAWA**

## **1.0 INTRODUCTION**

This report presents the results of a foundation investigation at the above noted site in the Township of Edwardsburg, Ontario. The investigation was carried out in accordance with our proposals dated December 11, 1990 and June 7, 1991. Authorization to carry out the work was provided by Ms. Colleen Conley, P.Eng., of Delcan Corporation.

This report contains factual information obtained from this investigation pertaining to the subsurface conditions.

## **2.0 SITE DESCRIPTION AND GEOLOGY**

The High Mast Light (HML) No. 2 is to be located approximately 2.0 km north of the intersection of Highway 401 and the existing Highway 16. This location is near the intersection of the proposed Ramp N-W and the proposed Hwy 416 SBL Connection. The HML No. 2 will be located 19.0 m right of Ramp N-W (Highway 416 SBL) centreline, Sta. 13+659, as indicated by Totten Sims Hubicki Associates (TSH) on a facsimile transmission dated June 14, 1991.

The topography of the site at the location of HML No. 2 is undulating to flat. The site is located on the edge of an existing gravel haul road, which is surrounded by dense forest.



Existing geological and geotechnical information suggests that the proposed site is located within the Glengarry Till Plain. This area is characterized by long morainic ridges and well-formed drumlins together with intervening clay flats and swamps. Bedrock underlying the overburden consists of Ordovician dolostone/limestone of the Oxford formation. Overburden thickness in the areas is in the order of 15 m.

### **3.0 PROCEDURE**

#### **3.1 Field Investigation**

The borehole location and its ground elevation was established in the field by TSH personnel prior to the field drilling investigation. All utility clearances were obtained by our personnel prior to the commencement of drilling.

The field work for this investigation was carried out on June 25, 1991. One (1) borehole was drilled at the surveyed HML No. 2 location, which has the following coordinates:

N 4 958 685.13  
S 384 030.33

The borehole was put down to a depth of 13.1 m using an all terrain wheel mounted CME 550 drill rig equipped for soil sampling and testing. The borehole was advanced using hollow stem augers. The overburden soils were sampled at regular intervals by means of a split tube sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586).

All soil samples recovered were stored in moisture proof containers and were returned to our Ottawa laboratory for detailed classification and testing.

A 25 mm diameter standpipe piezometer was installed in the borehole and was sealed at the ground surface with bentonite to prevent water infiltration.



### **3.2 Laboratory Testing**

The following laboratory tests were carried out on representative soil samples to determine their properties:

- Detailed visual classification of all samples,
- Natural moisture content,
- Sieve and hydrometer analyses,
- Atterberg Limits determination,
- Soil Chemistry.

Samples remaining after testing will be stored for a period of six months after issuance of the final report. They will then be discarded unless we are directed otherwise.

## **4.0 RESULTS OF THE INVESTIGATION**

### **4.1 Subsurface Conditions**

The subsurface conditions observed in the borehole are presented in detail on the Record of Borehole provided in the Appendix. An Explanation of Terms Used in Report is also provided in the Appendix. The laboratory test results are summarized in the Record of Borehole and also on Figures 1 to 4 in the Appendix.

The ground surface elevation at the borehole location was El. 94.0 m at the time of the investigation. The subsurface soils consist of topsoil overlying sand, overlying silt, underlain by glacial till. The groundwater level was observed at El. 92.0 m (a depth of 2.0 m) at the time of the field investigation.

A brief discussion of the observed subsurface conditions is provided below. Specific details of the subsurface materials should be obtained from the Record of Borehole.



#### 4.1.1 Topsoil

A layer of rootmat, consisting of grass and topsoil was observed from ground surface to a depth of 65 mm.

#### 4.1.2 Sand

A layer of sand trace silt was encountered underlying the topsoil. The thickness of the sand layer at this location is 5.7 m.

The SPT conducted in this sand layer yielded N values ranging from 1 to 22, indicating a denseness ranging from very loose to compact.

The grain size distribution obtained from a laboratory sieve analysis of a representative sand sample is 0% gravel, 91% sand, 9% silt and clay (Figure 1 in the Appendix). Moisture content tests yielded values ranging from 13% to 23%, depending on the location of the sample with respect to the water table.

Based on visual identification and laboratory tests, the sand material is classified as cohesionless.

#### 4.1.3 Silt

A 5.1 m thick layer of silt was encountered underlying the sand. The SPT conducted in the silt yielded N values ranging from 8 to 33, indicating a denseness ranging from loose to dense.

The grain size distribution obtained from laboratory sieve and hydrometer analyses is 0% gravel, 2-9% sand, 76-82% silt, and 9-22% clay (Figure 2 in the Appendix). Atterberg limits testing of several silt samples were attempted and were unsuccessful due to their non-plastic characteristics. Atterberg limits testing of a silt sample with relatively higher clay content indicates a liquid limit of 26% and a plasticity index of 7% (Figure 4 in the Appendix). Moisture contents of the silt samples range from 15% to 27%, with an average of 21%.

Based on visual identification and laboratory testing, the silt is classified as a cohesionless material.



#### **4.1.4 Heterogeneous Mixture of Sandy Silt, some Clay and Gravel, occasional Boulders (Glacial Till)**

A heterogeneous mixture of sandy silt, some clay and gravel, occasional boulders (glacial till) was encountered underlying the silt. The borehole was terminated upon SPT refusal after a penetration of 2.2 m.

The SPT conducted in the glacial till stratum yielded N values greater than 50, indicating a denseness of very dense. These high N values are partially attributed to the presence of cobbles and boulders.

The average moisture content of the glacial till is 8%. The grain size distribution obtained from a laboratory sieve analysis of a representative glacial till sample is 12% gravel, 27% sand, 61% silt and clay (Figure 3 in the Appendix). This grain size distribution represents the minus 38 mm fraction (split spoon sample) of the glacial till. Cobbles and boulders are also present in this material. If the coarser portion is to be included, the actual percentage of fines would be less than that indicated above. Based on previous experience with the till in the surrounding area and on visual identification of the samples, the glacial till is classified as a cohesionless material.

#### **4.2 Groundwater**

Groundwater level was recorded during drilling and in the standpipe piezometer after drilling. The groundwater level was recorded at El. 92.0 m (a depth of 2.0 m).

Groundwater levels are subject to seasonal fluctuations and can vary from the values given in this report.



## 5.0 DISCUSSION AND RECOMMENDATIONS

A foundation investigation was carried out on June 25, 1991 at the above-noted site in order to establish soil parameters for the design of HML No. 2. The investigation consisted of advancing one (1) borehole at the proposed HML location. The borehole was advanced to a depth of 13.1 m below the original ground level.

The borehole location can be referenced to the proposed Highway 416. The borehole was put down 19.0 m right of Station 13+659 of Ramp N-W.

### 5.1 Design Considerations

The HML foundation will likely consist of a single concrete pile or caisson. The foundations must be designed to resist overturning moments caused by wind loading and should be designed in accordance with the method described by B.B. Broms in the following papers:

Broms, B.B. 1964. "Lateral Resistance of Piles in Cohesive Soils." J. of Soil Mech. and Found. Div., ASCE, vol. 90, SM2: 27-63.

Broms, B.B. 1964. "Lateral Resistance of Piles in Cohesionless Soils." J. of Soil Mech. and Found. Div., ASCE, vol. 90, SM3: 123-156.

Broms, B.B. 1965. "Design of Laterally Loaded Piles." J. of Soil Mech. and Found. Div., ASCE, vol. 91, SM3: 79-99.

#### 5.1.1 Soil Design Parameters

The results of the field and laboratory investigation described herein have been utilized to designate soil parameters for use in the design of the HML foundation.

Overburden soils at the site have been classified as cohesive or non-cohesive and have been assigned, as appropriate, unconfined compressive strength ( $q_u$ ) or angle of internal friction ( $\phi$ ) and a bulk unit weight ( $\gamma$ ). The soil design parameters recommended for use on this project are listed in Table 1. When using this table, the following should be considered:

- The soil parameters provided represent ultimate values and will need to be factored during design in accordance with the O.H.B.D.C.
- The unit weights provided are bulk unit weights and should be reduced by  $9.81 \text{ kN/m}^3$  below the groundwater table. The groundwater level may vary from the level reported due to seasonal fluctuations.



TABLE 1  
SOILS PARAMETERS

Borehole 91-1, Coordinates: N 4 958 685.13; E 384 030.33; Elevation 94.0 m

Elevation (m)	Depth (m)	Type of Soil	Denseness or Consistency	$\phi^1$	$q^1$ (kPa)	$\gamma^2$ (kN/m <sup>3</sup> )
94.0-92.0	0.0-2.0	Non-cohesive	Compact	31°	0	19.5
92.0-88.2	2.0-5.8	Non-cohesive	Very Loose to Loose	28°	0	19.0
88.2-83.1	5.8-10.9	Non-cohesive	Loose to Dense	28°	0	18.2
83.1-80.9	10.9-13.1	Non-cohesive	Very Dense	38°	0	22.5

Note: Survey data supplied by Totten Sims Hubicki Associates

1. Soil parameters are ultimate values.
2. Unit weights are bulk unit weights.



### **5.1.2 Frost Considerations**

The material within the zone of frost penetration should not be included in the calculations of lateral resistance. At this site, the frost penetration depth is 1.8 m.

### **5.1.3 Construction Considerations**

Open holes drilled within both the sand and silt overburden materials at this site are not expected to remain open for any period of time, particularly below the groundwater table. The use of casing or slurry stabilization techniques will likely be required if a cast-in-place concrete caisson is used for this project. Furthermore, concrete placement below the groundwater table will likely require tremie techniques. The contractor should be advised of these potential difficulties by a Special Provision.

Upon completion of the foundation installation, it is recommended that the ground surface surrounding the HML structure be graded to prevent surface water from ponding at the base of the structure.

## **5.2 Soil Chemistry**

A representative sample of the sand at a depth of 1.0 m was tested for soil chemistry. The pH was found to be 7.71, with a chloride concentration of 2.4 ppm and a sulphate concentration of 3.0 ppm. These results suggest that chlorides and sulphates are present only in very small amounts and that the soil has a neutral pH level. Therefore, no special precautions are necessary in the type of cement used or in the protection of the reinforcing steel.



## 6.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Corbett, Engineer in Training, utilizing equipment owned and operated by George Downing Estate Drilling Limited.

The report was written by M. Corbett and C. Kwok, Project Engineer, and approved by G. Kack, Project Manager.

Respectfully submitted,

**JACQUES, WHITFORD LIMITED**



A handwritten signature in black ink, appearing to read "C. C. Kwok".

Charles C.K. Kwok, M.Sc., P.Eng.  
Project Engineer

A handwritten signature in black ink, appearing to read "G. Kack".

A small handwritten signature in black ink, appearing to read "G. Kack".

Gordon J. Kack, M.E.Sc., P.Eng.  
Project Manager



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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 91-1

METRIC

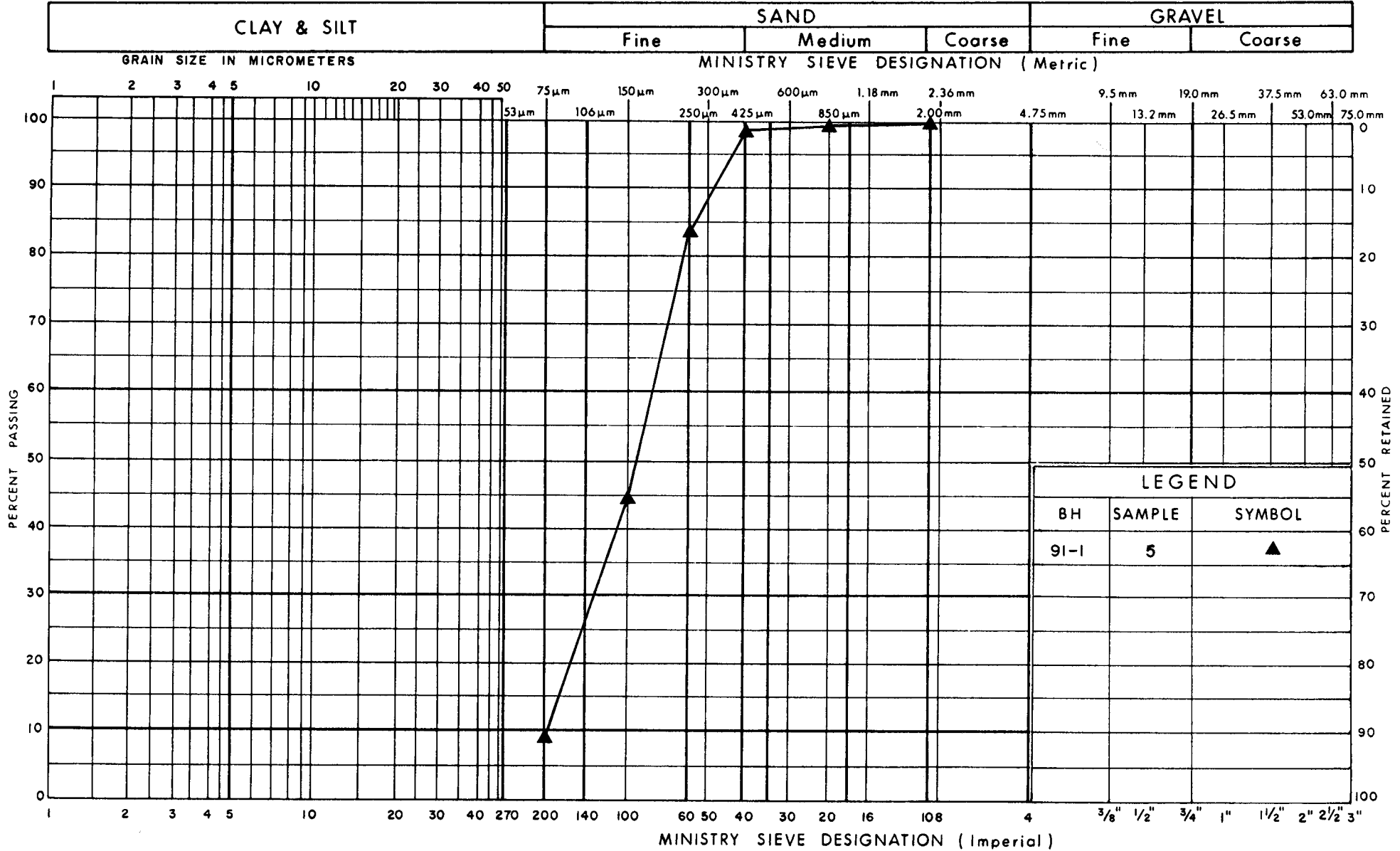
W P 374-89-00 LOCATION Co-ords: N 4 958 685.1; E 384 030.3 ORIGINATED BY M.A.C.  
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.A.C.  
DATUM Geodetic DATE June 25, 1991 CHECKED BY C.K.K.

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100						
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
94.0	Ground Surface													
0.1	Topsoil (65mm)					Seal								
	Sand trace Silt													
	Very Loose to Compact		1	SS	22									
			2	SS	13									
			3	SS	9									
	Brown		4	SS	7									
	Brown grey		5	SS	1									
			6	SS	11									
			7	SS	5									
88.2														
5.8	Silt some clay trace sand		8	SS	8									
	Loose to dense		9	SS	33									
	Grey		10	SS	12									
			11	SS	10									
83.1														
10.9	Het. Mixture of sandy silt, some clay and gravel, occ. boulders (Glacial Till)		12	SS	50/100mm									
	Very Dense		13	SS	50/75mm									
80.9	Grey													
13.1	End of Borehole (SPT Refusal)		14	SS	50/100mm									

+3, x5: Numbers refer to Sensitivity  
20  
15 5 (%) STRAIN AT FAILURE  
10

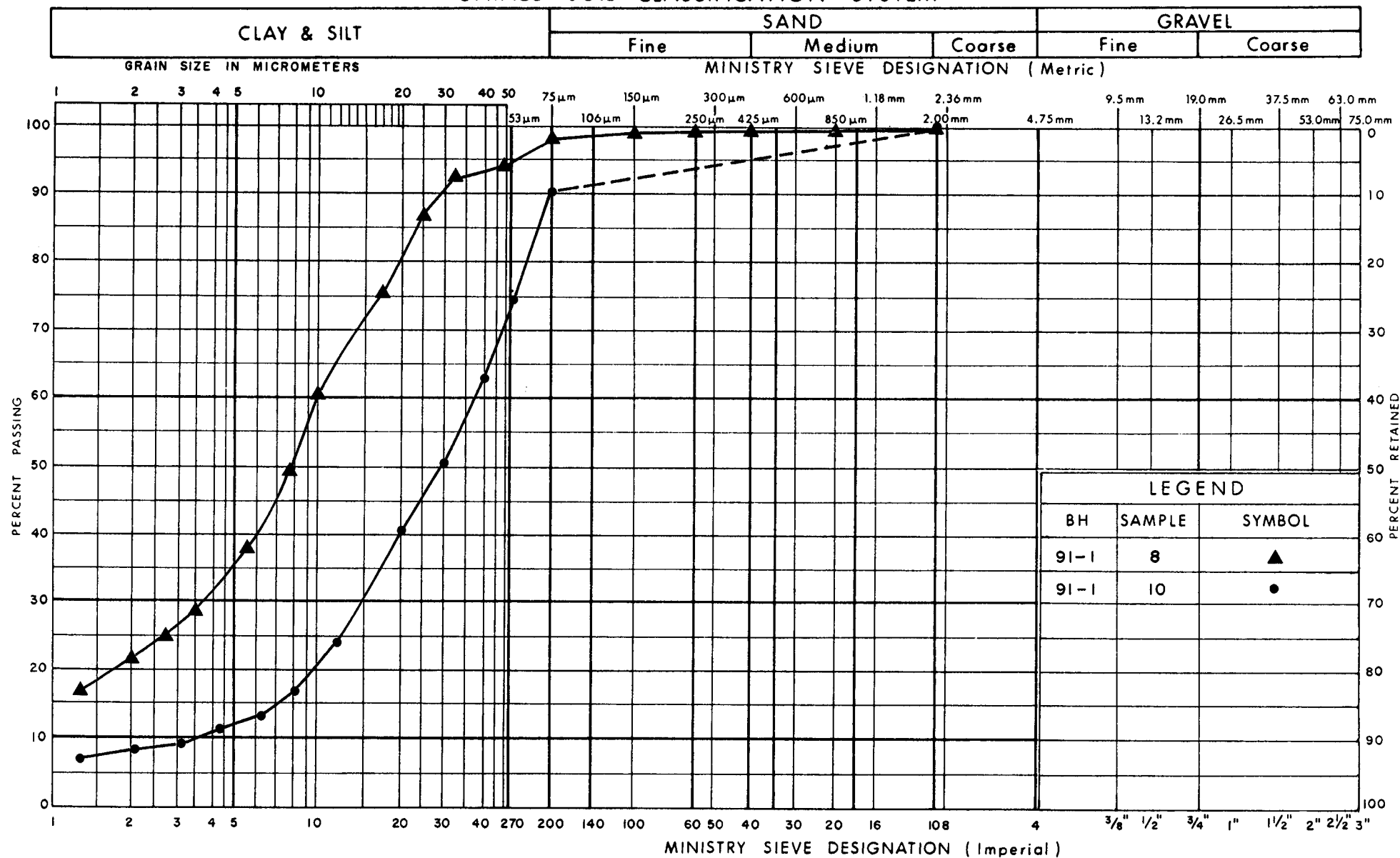
OFFICE REPORT ON SOIL EXPLORATION

# UNIFIED SOIL CLASSIFICATION SYSTEM





## UNIFIED SOIL CLASSIFICATION SYSTEM



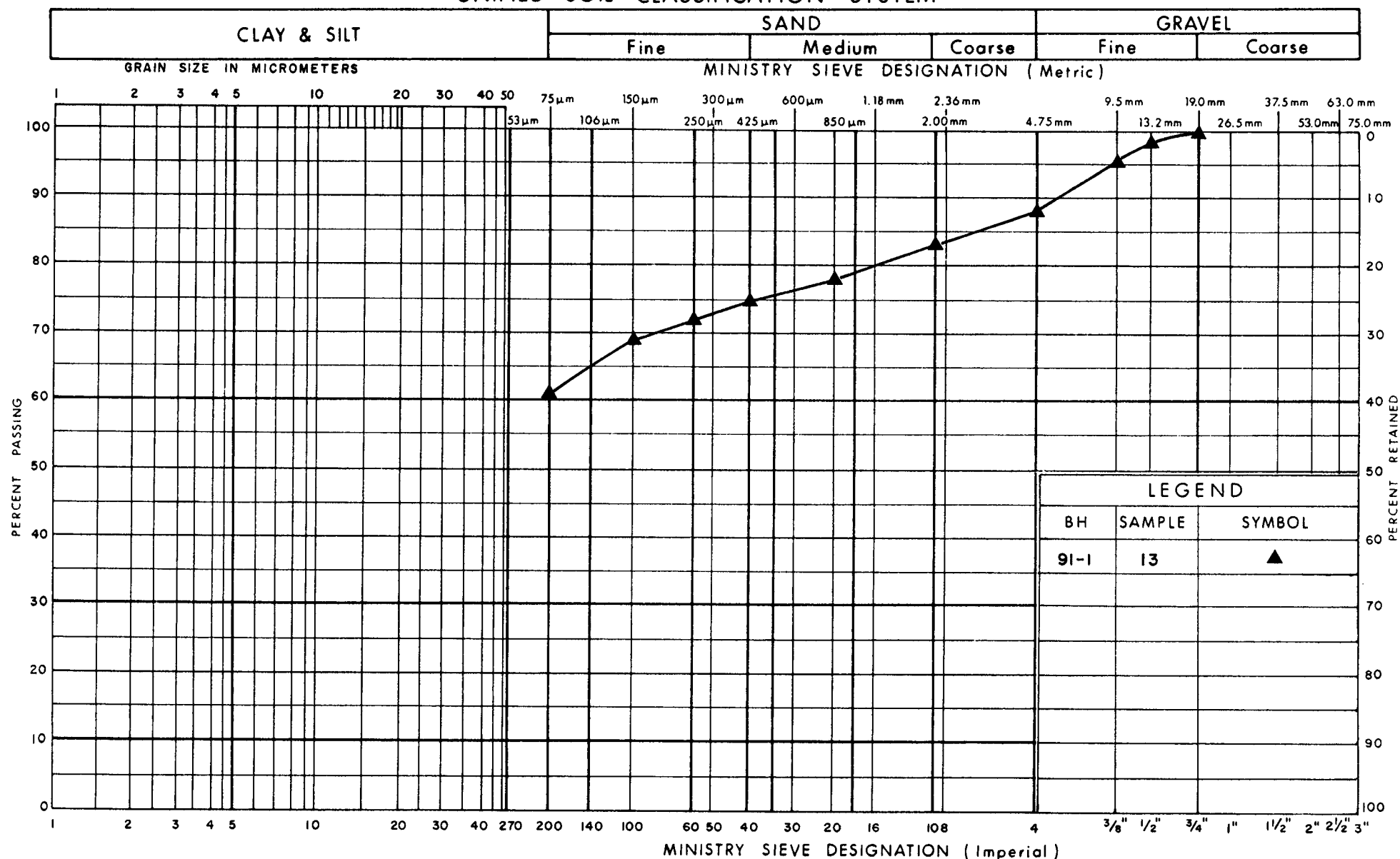
Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SILT, SOME CLAY, TRACE SAND

FIG No 2

W P 374-89-00

## UNIFIED SOIL CLASSIFICATION SYSTEM

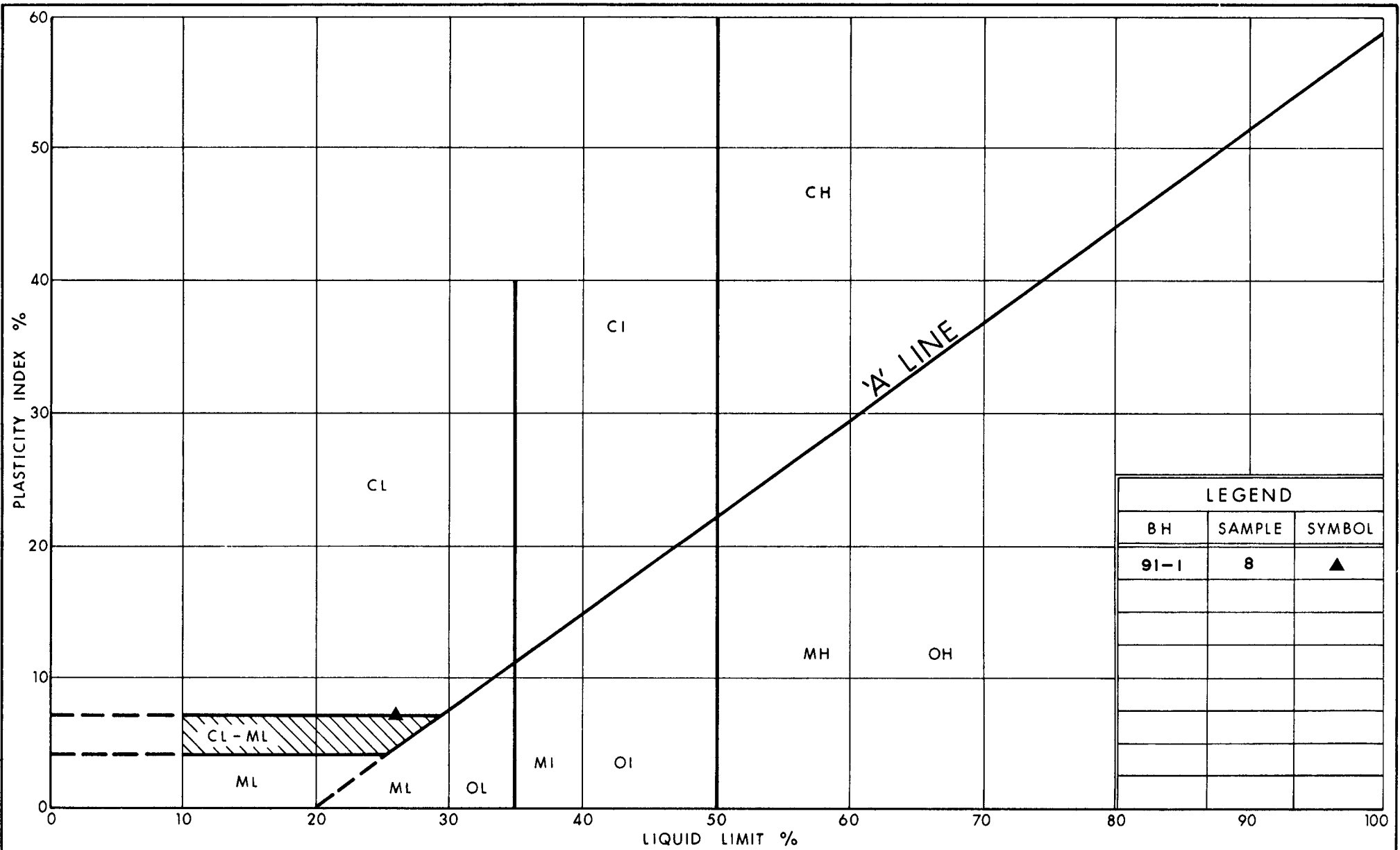


Ministry of  
Transportation

**GRAIN SIZE DISTRIBUTION**  
**HET MIXTURE OF SANDY SILT,**  
**SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)**

FIG No 3

W P 374-89-00



LEGEND		
BH	SAMPLE	SYMBOL
91-1	8	▲



Ministry of  
Transportation

Ontario

# PLASTICITY CHART SILT, SOME CLAY, TRACE SAND

FIG No 4

W P 374-89-00

**FOUNDATION INVESTIGATION**

**W.P. 374-89-00**

**HIGH MAST LIGHT NUMBER 1**

**GROUND SIGNS NUMBER 1 - 3**

**OVERHEAD SIGNS NUMBER 1 - 5**

**HWY. 401-416 INTERCHANGE**

**DISTRICT 9, OTTAWA**

*File*  
**GEOCRETS # 31B-76**

**MINISTRY OF TRANSPORTATION OF ONTARIO**

**SUBMITTED TO**

**DELCAN CORPORATION**

**BY**

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*File*

Report

on

Foundation Investigation

for

W.P. 374-89-00  
High Mast Light Number 1  
Ground Signs Number 1 - 3  
Overhead Signs Number 1 - 5

Hwy. 401-416 Interchange  
District 9, Ottawa

Jacques, Whitford Limited

August 5, 1992

Project No. 10213



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### Appendix

Explanation of Terms Used in Report

Records of Borehole

Figures 1-4: Grain Size Distribution

Figure 5 : Plasticity Chart - Silty Clay

Drawing 10213-1: Key Plan



# **FOUNDATION INVESTIGATION REPORT**

**for**

**W.P. 374-89-00  
High Mast Light Number 1  
Ground Signs Number 1 - 3  
Overhead Signs Number 1 - 5**

**District 9, Ottawa**

## **1.0 INTRODUCTION**

This report presents the results of a foundation investigation at the above noted site in the Township of Edwardsburg, Ontario. The investigation was carried out in accordance with our proposals dated December 11, 1990 and November 15, 1991. Authorization to carry out the work was provided by Ms. Colleen Conley, P.Eng., of Delcan Corporation.

This report contains factual information obtained from this investigation pertaining to the subsurface conditions.

## **2.0 SITE DESCRIPTION AND GEOLOGY**

The 401-416 Interchange involves the construction of new roadways and overpass structures within an area extending from the existing intersection of Highways 401 and 16 to approximately 2.5 km west and about 2 km north. The locations of the High Mast Light (HML), Ground Signs (GS) and Overhead Signs (OH) are shown on the attached Drawing 10213-1 in the Appendix.

Physiographically, the site lies in the area known as the Glengarry Till Plain. The surface consists of morainic ridges and drumlins together with intervening clay flats and swamps. Bedrock underlying the overburden consists of Ordovician dolostone of the Oxford Formation. Overburden thickness in the area ranges from about 15 m to less than 2 m, and generally decreases in thickness in a southerly direction.



### 3.0 PROCEDURE

#### 3.1 Field Investigation

The field work for this investigation was performed May 12 to 15, 1992. One (1) borehole was drilled at the HML #1 location. One (1) borehole was drilled at each of the Ground Sign locations, and two (2) boreholes were drilled at each of the Overhead Sign locations. Prior to the onset of the drilling investigation, necessary utility clearances were obtained by our site personnel.

The locations and ground surface elevations of the proposed boreholes were established in the field by Delcan Corporation personnel. Due to site conditions, some boreholes were not put down at the surveyed locations. Boreholes relocated due to site conditions, were surveyed by our personnel relative to the original surveyed locations. The actual boreholes locations, elevations and depths drilled are summarized in Table 1.

**TABLE 1  
BOREHOLE LOCATIONS**

Location	BH	Station	Reference	Offset	Surface Elevation (m)	Depth Drilled (m)
HML #1	92-1	71+962	401 EBL	28 m Rt.	89.86 m	8.8 m
GS #1	92-2	11+130	401 MED	16.8 m Rt	93.92	4.6
GS #2	92-3	10+820	401 MED	20.16 m Rt	88.38	4.0
GS #3	92-4	10+520	401 MED	20.16 m Rt	90.50	5.2
OH #1	92-5	71+400	401 EBL	5.65 m Rt	95.37	6.7
	92-6	71+400	401 EBL	7.87 m Lt	94.92	6.1
OH #2	92-7	71+849.55	401 EBL	18.73 m Rt	89.25	6.3
	92-8	71+850	401 EBL	5.75 m Lt	89.91	5.9
OH #3	92-9	13+700	401 MED	23.89 m Rt	87.49	5.8
	92-10	13+700	401 MED	0.22 m Lt	85.59	4.6
OH #4	92-11	14+200	Ramp N-W	6.87 m Rt	109.25	6.1
	92-12	14+200	Ramp N-W	8.37 m Lt	110.21	6.2
OH #5	92-13	13+750	Ramp N-W	6.913 m Rt	95.80	6.1
	92-14	13+749.2	Ramp N-W	14.423 m Lt	95.84	6.7



All of the boreholes were put down using a track-mounted power auger drill rig equipped for soil and bedrock sampling. The boreholes were advanced using hollow stem augers where possible. The overburden soils were sampled at regular intervals by means of a split spoon sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586). The presence of boulders in the soil profile necessitated the use of coring techniques in the overburden in Borehole 92-1 at HML #1. Bedrock was encountered and proven by coring in NQ size in Boreholes 92-1 at HML #1, and 92-9 at OH #3.

All soil samples recovered were stored in moisture proof containers and were returned to our laboratory for detailed classification and testing.

Standpipe piezometers 25 mm in diameter were installed in the boreholes with the exception of Boreholes 92-4 to 92-6, and 92-12. Each piezometer was separated from surface water infiltration with a bentonite seal.

### **3.2 Laboratory Testing**

All samples were subjected to detailed visual identification and classification. In addition, the following laboratory tests were carried out on representative soil samples.

- Natural moisture content,
- Sieve and hydrometer analyses,
- Atterberg Limits determination,
- Soil Chemistry.

Samples remaining after testing will be stored for a period of six months after issuance of the final report. They will then be discarded unless we are otherwise directed.

## **4.0 RESULTS OF THE INVESTIGATION**

### **4.1 Subsurface Conditions**

The subsurface conditions observed in the boreholes are presented in detail on the Records of Borehole provided in the Appendix 1. An Explanation of Terms Used in Report is also provided in the Appendix. The laboratory test results are summarized in the Records of Borehole and also on Figures 1 to 5 in Appendix 1.



A brief discussion of the observed subsurface conditions is provided below. Specific details of the subsurface materials should be obtained from the Records of Borehole.

#### **4.1.1 Topsoil**

A layer of topsoil was observed in the boreholes with the exception of Boreholes 92-4 to 92-6, 92-8, and 92-14. The topsoil, where observed, ranged in thickness from 50 to 200 mm.

#### **4.1.2 Fill**

Fill was encountered from ground surface or immediately underneath the topsoil in Boreholes 92-4 to 92-6, and 92-8 to 92-10. The thickness of the fill ranges from 0.9 m to over 6.7 m.

The fill generally consist of sand, trace silt to sand and gravel, trace silt. The SPT conducted in the fill layer yielded N values ranging from 3 to 31, indicating a denseness of very loose to dense, and generally in the loose to compact range. The grain size distribution of a representative sand fill material is 0% gravel, 93% sand, 7% silt and clay (Figure 1 in Appendix 1).

Based on visual identification and laboratory tests, the fill material is classified as cohesionless.

#### **4.1.3 Sand / Silty Sand**

Sand, trace to some silt was encountered underneath the topsoil in Boreholes 92-2, 92-3, 92-13 and 92-14. The thickness of this sand layer ranges from 2.2 m to 6.1 m. The SPT conducted in this material yielded N values from 2 to 29, indicating a denseness ranging from very loose to compact, and generally in the loose to compact range.

Silty sand was encountered underlying the fill in Boreholes 92-9 and 92-10. The thickness of this material ranges from 0.4 m to 0.8 m. The denseness of this material is loose to compact.

The average grain size distribution of the sand, trace silt material is 0% gravel, 91% sand, 9% silt and clay (Figure 2 in Appendix 1). Moisture content tests yielded values ranging from 4% to 22%, depending on the location of the sample with respect to the water table.

Based on visual identification and laboratory tests, the sand and silty sand materials are classified as cohesionless.

#### **4.1.4 Silty Clay**

In Boreholes 92-2, 92-3, 92-9 and 92-10 a layer of silty clay with a occasional beds of sandy silt was encountered underlying the sand or silty sand materials. The thickness of the silty clay ranges between 1.5 and 2.9 m.

The SPT conducted in the silty clay layer yielded N values ranging from 4 to 16, with an average of 11, indicating a consistency ranging from firm to very stiff. A field vane shear test conducted in this layer indicated an undrained shear strength greater than 160 kPa.

The average grain size distribution obtained from laboratory sieve and hydrometer analyses on representative samples is 0% gravel, 2% sand, 48% silt, and 50% clay (Figure 3 in Appendix 1). Atterberg limits tests conducted on two representative samples of the silty clay yielded liquid limits of 31.5% and 49%, with Plasticity Indices of 15% and 27% (Figure 5 in Appendix 1).

Moisture contents of the silty clay range from 27% to 39%, with an average of 31%. Based on visual classification and laboratory testing, the silty clay is classified as a cohesive material.

#### **4.1.5 Heterogeneous Mixture of Sand and Silt with some Gravel and Clay, occasional Cobbles and Boulders (Glacial Till)**

A heterogeneous mixture of sand and silt, some gravel and clay, occasional cobbles and boulders (glacial till) was encountered in Borehole 92-1 and Boreholes 92-7 through 92-14. In two of these holes the glacial till was observed to be overlying bedrock. The thickness of the till layer encountered varied between 0.1 and 7.2 m.

The SPT conducted in the glacial till stratum yielded values ranging from 7 to over 50, indicating a denseness of dense to very dense. The high SPT values recorded are partially attributable to the presence of cobbles and boulders within the till.

The average grain size distribution of the glacial till is 21% gravel, 39% sand, 40% silt and clay (Figure 4 in Appendix 1). This grain size distribution represents the minus 38 mm fraction (split spoon sample) of the glacial till. Cobbles and boulders are also present in this material. If the coarser portion is to be included, the actual percentage of fines would be less than that indicated above. The moisture contents of the till samples range from 5% to 9% with an average of 7%.

Based on previous experience with the till in the surrounding area, on visual identification and laboratory test results, the glacial till is classified as a cohesionless material.

#### **4.1.6 Bedrock**

Bedrock was encountered and proven by coring for 1.5 m in Boreholes 92-1 and 92-9. The rock is limestone and dolostone with shaley partings and some calcite. The bedrock is of excellent quality with RQD ranging from 94% to 97%. Core recoveries varied between 98% to 100%.

#### **4.2 Groundwater**

Groundwater level was observed during drilling and measured in the standpipe piezometers after drilling. The groundwater elevations are summarized in Table 2.

Groundwater levels are subject to seasonal fluctuations and can vary from the values given in this report.

**TABLE 2**  
**GROUNDWATER ELEVATIONS**

Location	Borehole	Recorded May 15, 1992	
		Groundwater Elevation (m)	Depth (m)
HML #1	92-1	87.0	2.9
GS #1	92-2	92.2	1.7
GS #2	92-3	87.5	0.9
GS #3	92-4	< 85.3	dry
OH #1	92-5	< 88.7	dry
OH #1	92-6	< 88.8	dry
OH #2	92-7	89.0	0.3
OH #2	92-8	88.8	1.1
OH #3	92-9	86.1	1.4
OH #3	92-10	83.9	1.7
OH #4	92-11	< 103.2	dry
OH #4	92-12	< 104.0	dry
OH #5	92-13	93.2	2.7
OH #5	92-14	93.4	2.5



## **5.0 DISCUSSION AND RECOMMENDATIONS**

A foundation investigation was carried out on May 12 to 15, 1992 at the above-noted site in order to establish soil parameters for the design of the following components:

High Mast Light Number 1  
Ground Signs Number 1 - 3  
Overhead Signs Number 1 - 5

### **5.1 Design Considerations**

The foundations for the High Mast Light, the Ground and Overhead Signs will likely consist of concrete piles or caissons. The foundations must be designed to resist overturning moments caused by wind loading and should be designed in accordance with the method described by B.B. Broms in the following papers:

Broms, B.B. 1964. "Lateral Resistance of Piles in Cohesive Soils." J. of Soil Mech. and Found. Div., ASCE, vol. 90, SM2: 27-63.

Broms, B.B. 1964. "Lateral Resistance of Piles in Cohesionless Soils." J. of Soil Mech. and Found. Div., ASCE, vol. 90, SM3: 123-156.

Broms, B.B. 1965. "Design of Laterally Loaded Piles." J. of Soil Mech. and Found. Div., ASCE, vol. 91, SM3: 79-99.

#### **5.1.1 Soil Design Parameters**

The results of the field and laboratory investigation described herein have been utilized to designate soil parameters for use in the design of the foundations.

Overburden soils at the site have been classified as cohesive or non-cohesive and have been assigned, as appropriate, unconfined compressive strength ( $q_u$ ) or angle of internal friction ( $\phi$ ) and a bulk unit weight ( $\gamma$ ). The soil design parameters recommended for use on this project are listed in Table 3. When using this table, the following should be considered:

- The soil parameters provided represent ultimate values and will need to be factored during design in accordance with the O.H.B.D.C.
- The unit weights provided are bulk unit weights and should be reduced by  $9.81 \text{ kN/m}^3$  below the groundwater table. The groundwater level may vary from the level reported due to seasonal fluctuations.

### **5.1.2 Frost Considerations**

The material within the zone of frost penetration should not be included in the calculations of lateral resistance. At this site, the frost penetration depth is 1.8 m.

### **5.1.3 Construction Considerations**

Open holes drilled within both the sand and fill materials are not expected to remain open for any period of time, particularly below the groundwater table. The use of casing or slurry stabilization techniques will likely be required if cast-in-place concrete caissons are to be used for this project. Furthermore, concrete placement below the groundwater table will likely require tremie techniques. Caisson installation may encounter cobbles and boulders in some locations. The contractor should be advised of these potential difficulties by a Special Provision.

Upon completion of the foundation installation, it is recommended that the ground surface surrounding each structure be graded to prevent surface water from ponding at the base of the structure.



**TABLE 3  
SOIL PARAMETERS**

Structure Component	Borehole	Elevation (m)	Depth (m)	Type of Soil	Denseness or Consistency	$\phi$	$q_u$ (kPa)	$\gamma$ (kN/m <sup>3</sup> )
HML #1	92-1	89.9-87.0	0-2.9	Non-cohesive	Compact to Very Dense	35°	-	21.0
		87.0-82.6	2.9-7.3	Non-cohesive	Dense to Very Dense	38°	-	22.0
		82.6-81.1	7.3-8.8	Sound Limestone		-	40 MPa	25.0
GS #1	92-2	93.9-92.2	0-1.7	Non-cohesive	Loose	29°	-	17.5
		92.2-90.8	1.7-3.1	Non-cohesive	Very Loose	28°	-	17.5
		90.8-89.3	3.1-4.6	Cohesive	Stiff to Very Stiff	-	100	19.0
GS #2	92-3	88.4-87.5	0-0.9	Non-cohesive	Loose	29°	-	17.5
		87.5-86.1	0.9-2.3	Non-cohesive	Compact	32°	-	18.0
		86.1-84.4	2.3-4.0	Cohesive	Stiff to Very Stiff	-	100	19.0
GS #3	92-4	90.5-85.3	0-5.2	Non-cohesive	Very Loose	28°	-	17.5
OH #1	92-5	95.4-88.7	0-6.7	Non-cohesive	Very Loose to Compact	30°	-	17.5
	92-6	94.9-88.8	0-6.1	Non-cohesive	Very Loose to Compact	30°	-	17.5
OH #2	92-7	89.3-89.0	0-0.3	Non-cohesive	Compact	35°	-	21.0
		89.0-83.0	0.3-6.3	Non-cohesive	Dense to Very Dense	38°	-	22.0
	92-8	89.9-89.0	0-0.9	Non-cohesive	Loose	30°	-	17.5
		89.0-88.8	0.9-1.1	Non-cohesive	Compact	35°	-	21.0
		88.8-84.0	1.1-5.9	Non-cohesive	Dense to Very Dense	38°	-	22.0
OH #3	92-9	87.5-85.7	0-1.8	Non-cohesive	Very Loose to Compact	28°	-	17.5
		85.7-83.3	1.8-4.2	Cohesive	Stiff to Very Stiff	-	100	18.5
		83.3-83.2	4.2-4.3	Non-cohesive	Dense to Very Dense	38°	-	22.0
		83.2-81.7	4.3-5.8	Sound Limestone		-	40 MPa	25.0
	92-10	85.6-84.2	0-1.4	Non-cohesive	Very Loose to Compact	29°	-	17.5
		84.2-81.3	1.4-4.3	Cohesive	Stiff to Very Stiff	-	100	18.5
		81.3-81.0	4.3-4.6	Non-cohesive	Dense to Very Dense	38°	-	22.0
OH #4	92-11	109.3-108.3	0-1.0	Non-cohesive	Loose to Compact	30°	-	20.5
		108.3-103.2	1.0-6.1	Non-cohesive	Compact to Very Dense	38°	-	22.0
	92-12	110.2-109.2	0-1.0	Non-cohesive	Loose to Compact	30°	-	20.5
		109.2-104.0	1.0-6.2	Non-cohesive	Compact to Very Dense	38°	-	22.0





Structure Component	Borehole	Elevation (m)	Depth (m)	Type of Soil	Denseness or Consistency	$\phi$	$q_u$ (kPa)	$\gamma$ (kN/m <sup>3</sup> )
OH #5	92-13	95.8-93.1	0-2.7	Non-cohesive	Very Loose to Loose	28°	-	17.5
		93.1-90.0	2.7-5.8	Non-cohesive	Loose to Compact	30°	-	18.5
		90.0-89.7	5.8-6.1	Non-cohesive	Compact	32°	-	20.0
	92-14	95.8-93.3	0-2.5	Non-cohesive	Very Loose to Loose	28°	-	17.5
		93.3-89.7	2.5-6.1	Non-cohesive	Loose to Compact	30°	-	18.5
		89.7-89.1	6.1-6.7	Non-cohesive	Compact	32°	-	20.0

- Notes: Survey Data supplied by Delcan Ltd.
1. Soil Parameters are ultimate values.
  2. Unit weights are Bulk unit weights.



## 5.2 Soil Chemistry

Representative samples of the overburden soils were tested for soil chemistry. The results are listed in Table 4. The results show that sulphates and chlorides are present only in small amounts and that the soil has a neutral pH level. Therefore, no special precautions are necessary in the type of cement used or in the protection of the steel reinforcing.

**TABLE 4**  
**SOIL CHEMISTRY**

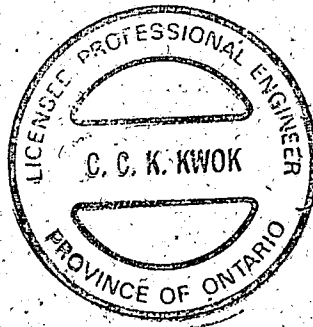
Location	Sample Depth (m)	pH	Chloride (ppm)	Sulphate (ppm)
GS # 1	2.6	7.22	96.2	18
OH # 3	2.6	6.89	45.1	11
OH # 5	2.6	7.55	0.8	<5

## 6.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Y. Laroche, P. Eng., utilizing equipment owned and operated by Marathon Drilling Company Limited. The report was written by both undersigned.

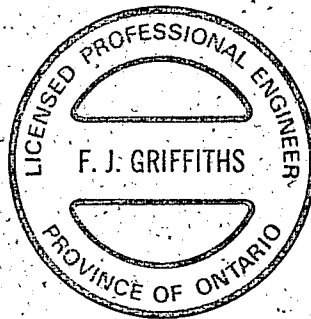
Respectfully submitted,

JACQUES WHITFORD LIMITED



A handwritten signature in cursive script, appearing to read "C. C. Kwok".

Charles C.K. Kwok, M.Sc., P.Eng.



A handwritten signature in cursive script, appearing to read "F. J. Griffiths".

Fred Griffiths, Ph.D., Eng.



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

### MECHANICAL PROPERTIES OF SOIL

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

### 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

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No 92-1

METRIC

W P 374-89-00 LOCATION HML #1 Sta. 71+962, HWY 401 EBL, 28m Rt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger, Rock Coring COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 12, 1992 CHECKED BY CLIR

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						
								SHEAR STRENGTH kPa						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%)					
89.9	Ground Surface									10	20	30		GR SA SI CL
	Rootmat (50mm)													
0.1	Het. Mixture of Sand and Silt, some gravel, occ. cobbles and boulders		1	SS	23		Seal							
	(Glacial Till) Compact to dense		2	SS	32		89 Native Backfill							24 33 (43)
			3	SS	71/180mm									
							88							
							May 15, 1992							
			4	SS	60/180mm		87							
							86							
	Brown Grey													
	Frequent cobbles and boulders.						85							
							Piezometer							
							84							
							83							
82.6														
7.3	Bedrock Limestone and Dolostone with shaley partings													
	Excellent		5	RC NQ	REC =98%		82							RQD = 97%
81.1														
8.8	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 92-2

METRIC

W P 374-89-00 LOCATION GS #1, Sta. 11+130, HWY 401 MED, 16.8m Rtc. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY C.R.R.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80					
93.9	Ground Surface Topsoil (100mm)														
0.1	Sand, trace silt Very loose to loose Brown														
		1	SS	7											
		2	SS	4											
		3	SS	2											
90.8															
3.1	Silty Clay, occ. Sandy silt interbeds Very Stiff Grey with some black	4	SS	4											
		5	SS	12											
89.3															
4.6	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-3

METRIC

W P 374-89-00 LOCATION GS #2 Sta. 10+820, 401 MED, 20.16 m Rt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY C.R.R.

OFFICE REPORT ON SOIL EXPLORATION

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	40 80 120 160 200					
88.4	Ground Surface Topsoil (50mm)													
0.1	Sand, trace silt Loose to Compact		1	SS	7		88							
			2	SS	23		87 Native Backfill							
			3	SS	29									
86.1														
2.3	Silty Clay, Occ sandy silt interbeds Very stiff Grey		4	SS	9		86							
			5	SS	6		85							
84.4														
4.0	End of Borehole													



# RECORD OF BOREHOLE No 92-4

METRIC

W P 374-89-00 LOCATION GS #3, Sta. 10+520, 401 MED, 20.16 m Rt.

ORIGINATED BY Y.P.L.

DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger

COMPILED BY Y.P.L.

DATUM Geodetic DATE May 14, 1992

CHECKED BY CRK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
90.5	Ground Surface																
	Sand, trace silt (Fill) Very loose Brown																
			1	SS	3												
			2	SS	3												
			3	SS	3												
85.3	End of Borehole Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-5

METRIC

W P 374-89-00 LOCATION OH #1 Sta. 71+400, 401 EBL, 5.65m RT ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY CLK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
95.4	Ground Surface																
95.1	Sand and gravel, trace silt (Fill)																
0.3	Compact Grey																
	Sand, Trace silt (Fill)																
	Very loose to compact																
	Brown																
			1	SS	17												
			2	SS	12												
			3	SS	8												
			4	SS	9												
			5	SS	3												
			6	SS	15												
			7	SS	15												
88.7																	
6.7	End of Borehole Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-6

METRIC

W P 374-89-00 LOCATION OH #1, Sta 71+400, 401 EBL, 7.87m Lt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY CKR

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
94.9	Ground Surface																
	Sand and gravel, trace silt (Fill) Very loose to compact Brown		1	SS	11												
			2	SS	31												
			3	SS	11												
			4	SS	16												
			5	SS	11												
			6	SS	8												
			7	SS	4												
			8	SS	23												
88.8																	
6.1	End of Borehole Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-7

METRIC

W P 374-89-00 LOCATION OH #2, Sta. 71+849.55, 401 EBL, 18.73m Rt ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 13, 1992 CHECKED BY CBR

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					
89.3	Ground Surface													
	Topsoil (50mm)													
0.1	Het. Mixture of Silt and Sand, some gravel, occ. cobbles and boulders (Glacial Till)		1	SS	9		May 15, 1992							
	Loose to very dense		2	SS	36									
			3	SS	51									
			4	SS	87									
			5	SS	120									
	Brown Grey		6	SS	109/250mm									
			7	SS	81/280mm									
83.0	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-8

METRIC

W P 374-89-00 LOCATION OH #2, Sta. 71+850, 401 EBL, 5.75 m Lt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY CKK

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo								
89.9	Ground Surface							20	40	60	80	100				
	Sand and Gravel, some silt (Fill) Compact Brown		1	SS	9											
89.2																
0.7	Sand, trace silt (Fill)															
0.9	Compact Brown		2	SS	27		May 15, 1992									
	Het. Mixture of Silt and Sand, some gravel, occ., cobbles and boulders (Glacial Till) Dense to very dense Brown		3	SS	38											
			4	SS	38		Native Backfill									
			5	SS	76/240 mm											
			6	SS	157/280 mm											
							Piezometer									
84.0																
5.9	End of Borehole Auger refusal on Boulder															

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 92-10

METRIC

W P 374-89-00 LOCATION OH#3, Sta. 13+700, 401 MED, 0.22 m Lt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 14, 1992 CHECKED BY CLK

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					
85.6	Ground Surface																
	Topsoil (50mm)																
0.1	Sand, some gravel, trace silt (Fill) Loose to compact		1	SS	7												
84.6	Brown		2	SS	14												
1.0	Silty Sand loose																
84.2	Brown																
1.4	Silty Clay, occ. pockets of Sandy Silt Very Stiff to Hard		3	SS	9												
	Brown		4	SS	14												
			5	SS	15												
			6	SS	15												
81.3	Het. Mixture of Sand and Silt, some gravel																
81.0	(Glacial Till) Compact, Brown																
4.6	End of Borehole on Inferred Bedrock																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-II

METRIC

W P 374-89-00 LOCATION OH #4, Sta. 14+200, Ramp N-W, 6.87 m Rt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 15, 1992 CHECKED BY C.R.R.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
109.3	Ground Surface																
	Topsoil (150mm)																
0.2	Het. Mixture of Silt and Sand, some gravel, occ., cobbles and boulders (Glacial Till) Compact to very dense		1	SS	7		109										
			2	SS	50		108										
			3	SS	92		107										
			4	SS	112/230mm		106										
			5	SS	100/230mm		105										
			6	SS	60/125mm		104										
			7	SS	50/75mm												
103.2	End of Borehole Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION



# RECORD OF BOREHOLE No 92-12

METRIC

W P 374-89-00 LOCATION OH #4, Sta. 14+200, Ramp N-W, 8.37m Lt ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 15, 1992 CHECKED BY C.R.R.

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
110.2	Ground Surface																
0.2	Topsoil (200mm) Het. Mixture of Silt and Sand, some gravel, occ cobbles and boulders (Glacial Till) Compact to very dense Brown		1	SS	7												
			2	SS	20												
			3	SS	61												
			4	SS	65												
			5	SS	98/250mm												
			6	SS	101/200mm												
			7	SS	83/175mm												
			8	SS	88/210mm												
104.0	End of Borehole Borehole Dry																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-13

METRIC

W P 374-89-00 LOCATION OH #5, Sta. 13+750, Ramp N-W, 6.913m Rt. ORIGINATED BY Y.P.L.  
DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
DATUM Geodetic DATE May 15, 1992 CHECKED BY *CKR*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)	10 20 30				
95.8	Ground Surface																
0.1	Rootmat (50mm) Sand, some silt Very loose to compact Brown		1	SS	3												
			2	SS	5												
			3	SS	5												
			4	SS	8												
			5	SS	10												
			6	SS	18												
			7	SS	18												
90.0			8	SS	3												
5.8	Het. Mixture of Sand																
89.7	and Silt some gravel																
6.1	(Glacial Till)																
	Dense Grey																
	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 92-14

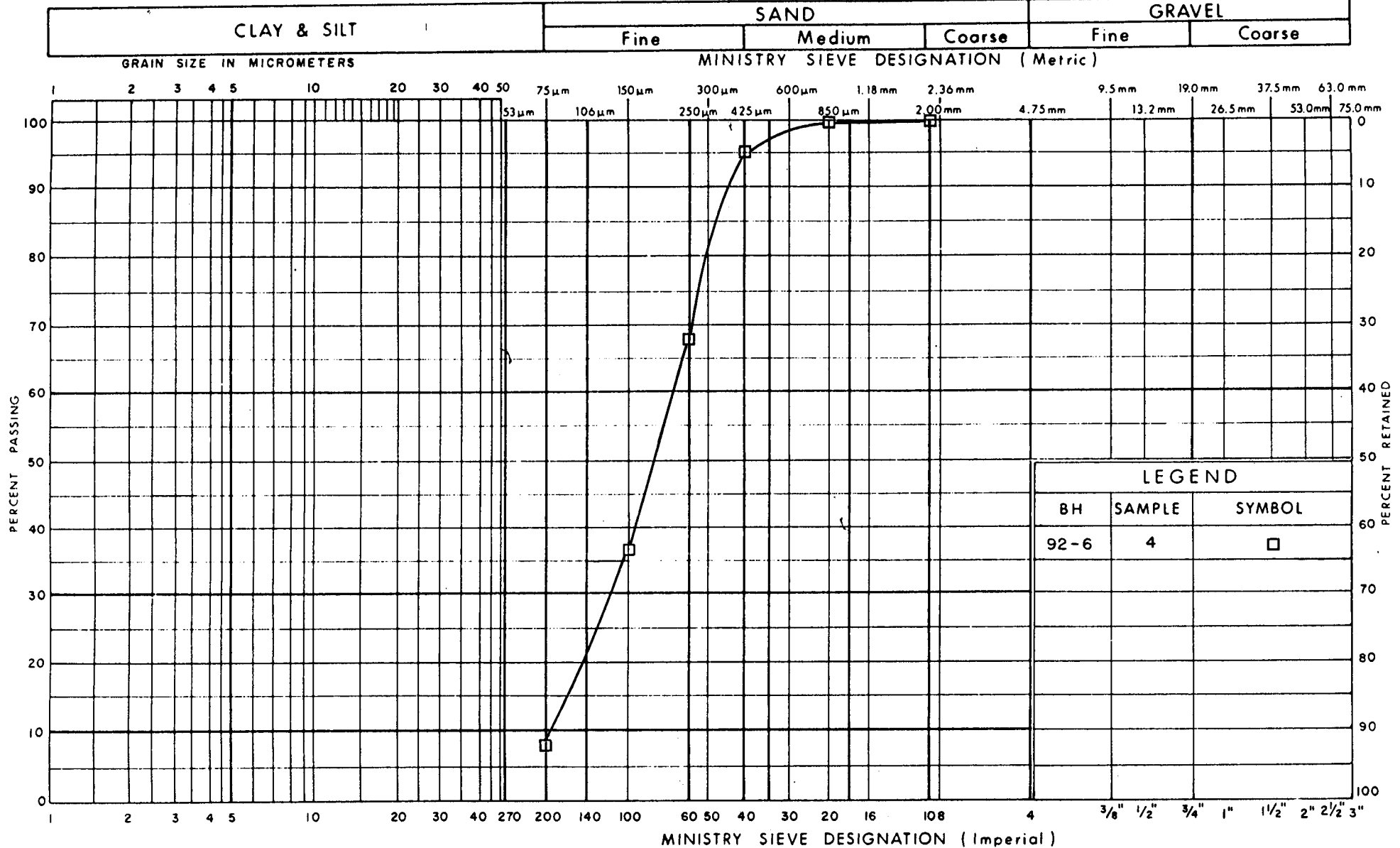
METRIC

W P 374-89-00 LOCATION OH #5, Sta. 13+749.2, Ramp N-W, 14.423 m Lt. ORIGINATED BY Y.P.L.  
 DIST 9 HWY 401/416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Y.P.L.  
 DATUM Geodetic DATE May 15, 1992 CHECKED BY GLR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
95.8	Ground Surface																
	Sand, trace to some silt very loose to compact		1	SS	3												
			2	SS	5												
			3	SS	9												
			4	SS	11												
			5	SS	8												
			6	SS	16												
			7	SS	7												
89.7																	
6.1	Het. Mixture of Sand and Silt, some gravel (Glacial Till)		8	SS	17												
89.1	Compact Grey																
6.7																	

OFFICE REPORT ON SOIL EXPLORATION

# UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

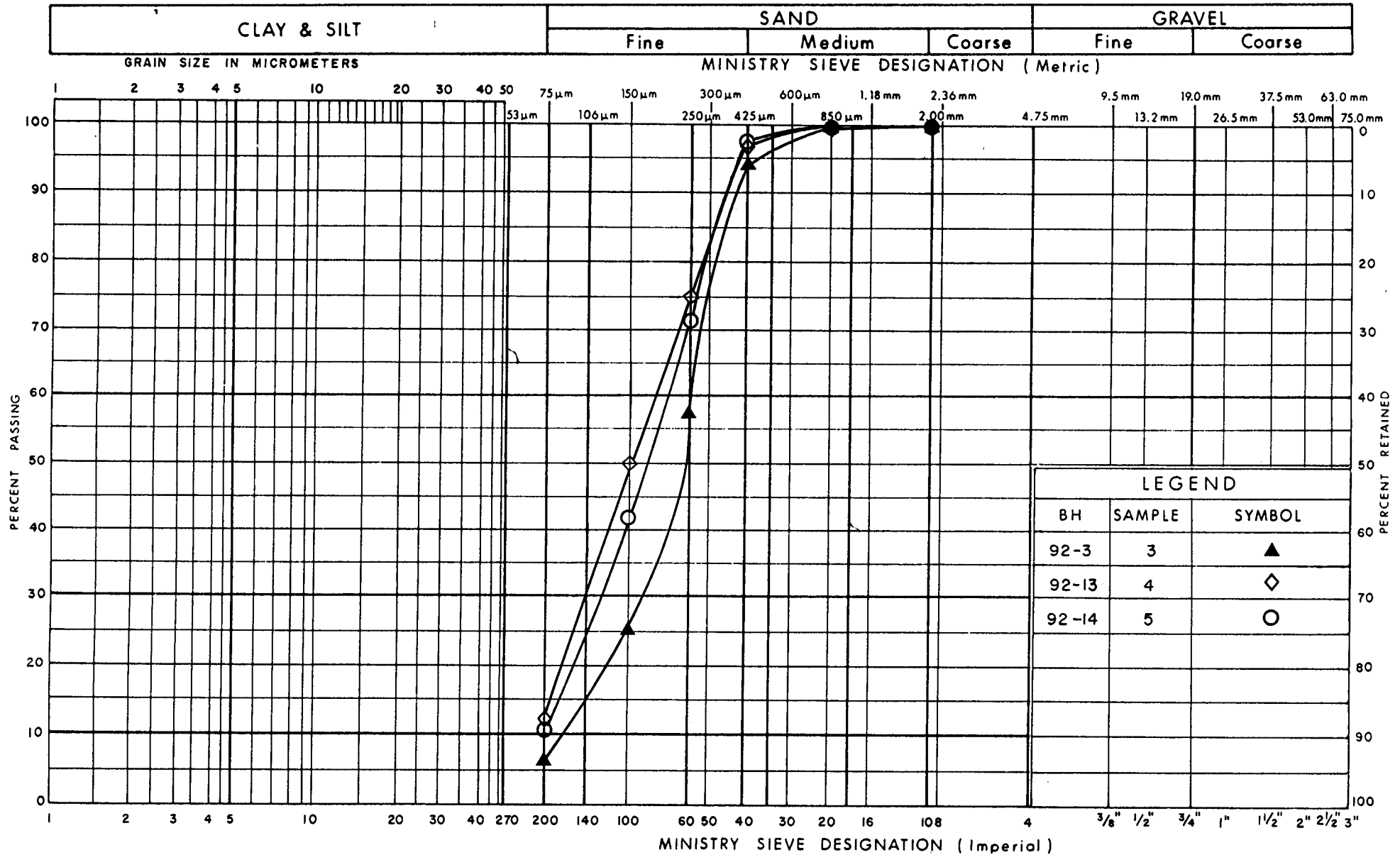
Ministry of  
Transportation

GRAIN SIZE DISTRIBUTION  
SAND, TRACE SILT (Fill)

FIG No 1

W P 374-89-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION  
SAND, TRACE TO SOME SILT

FIG No 2

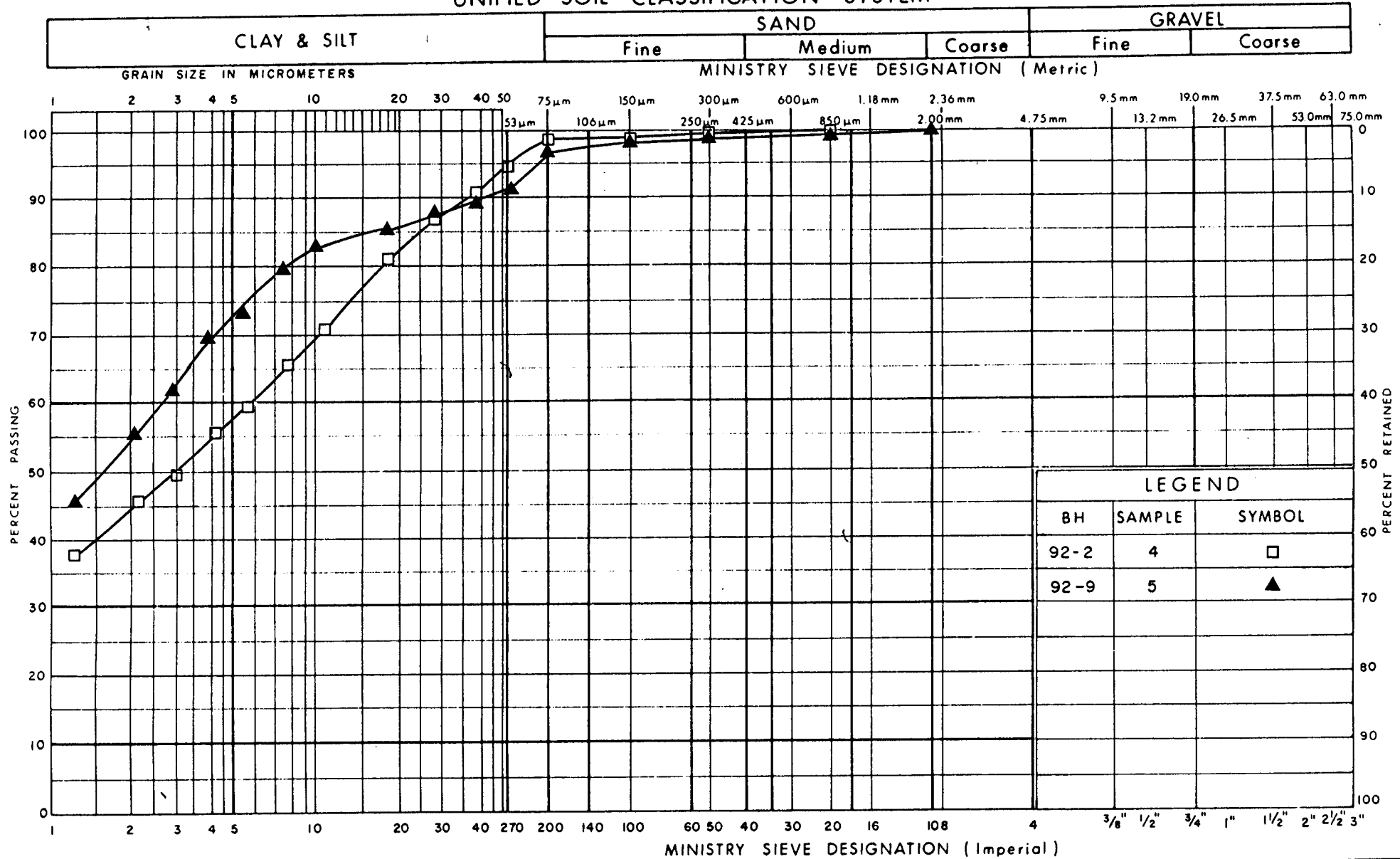
W P 374-89-00



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## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of  
Transportation

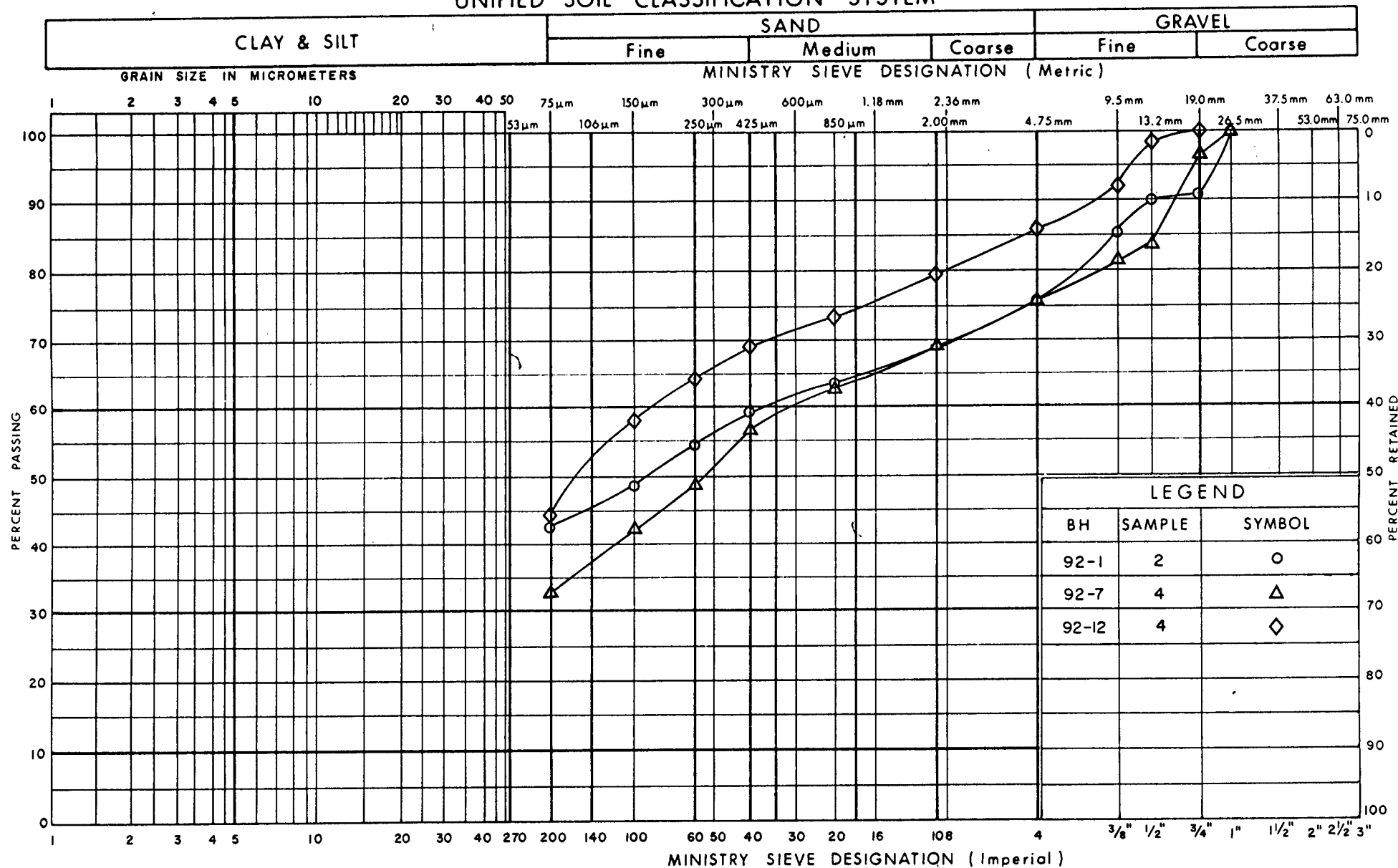
GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No 3

W P 374-89-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



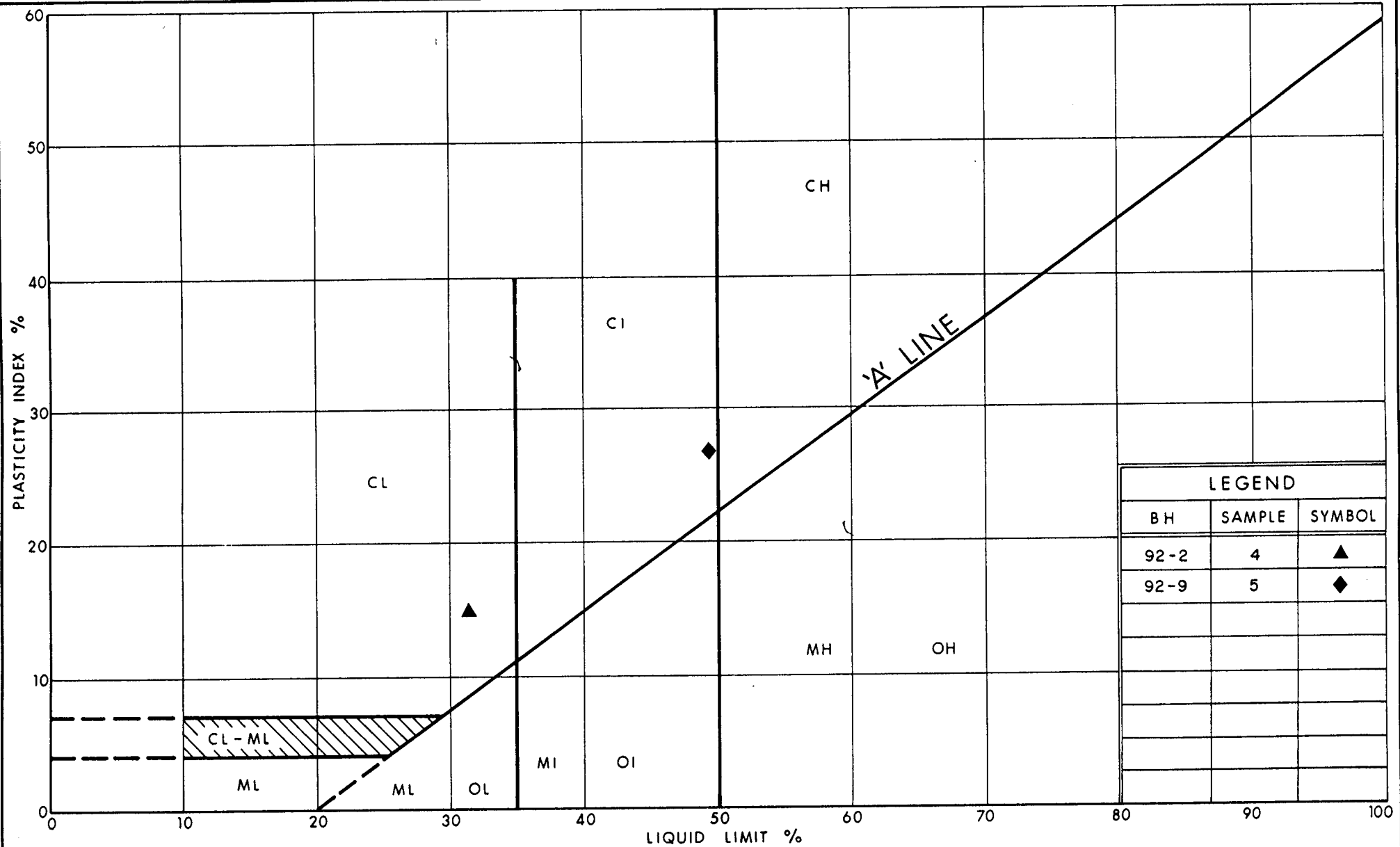
Ministry of  
Transportation

Ontario

GRAIN SIZE DISTRIBUTION  
HET MIXTURE OF SILT & SAND,  
SOME GRAVEL, OCC COBBLES & BOULDERS (Glacial Till)

FIG No 4

W P 374-89-00



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Transportation

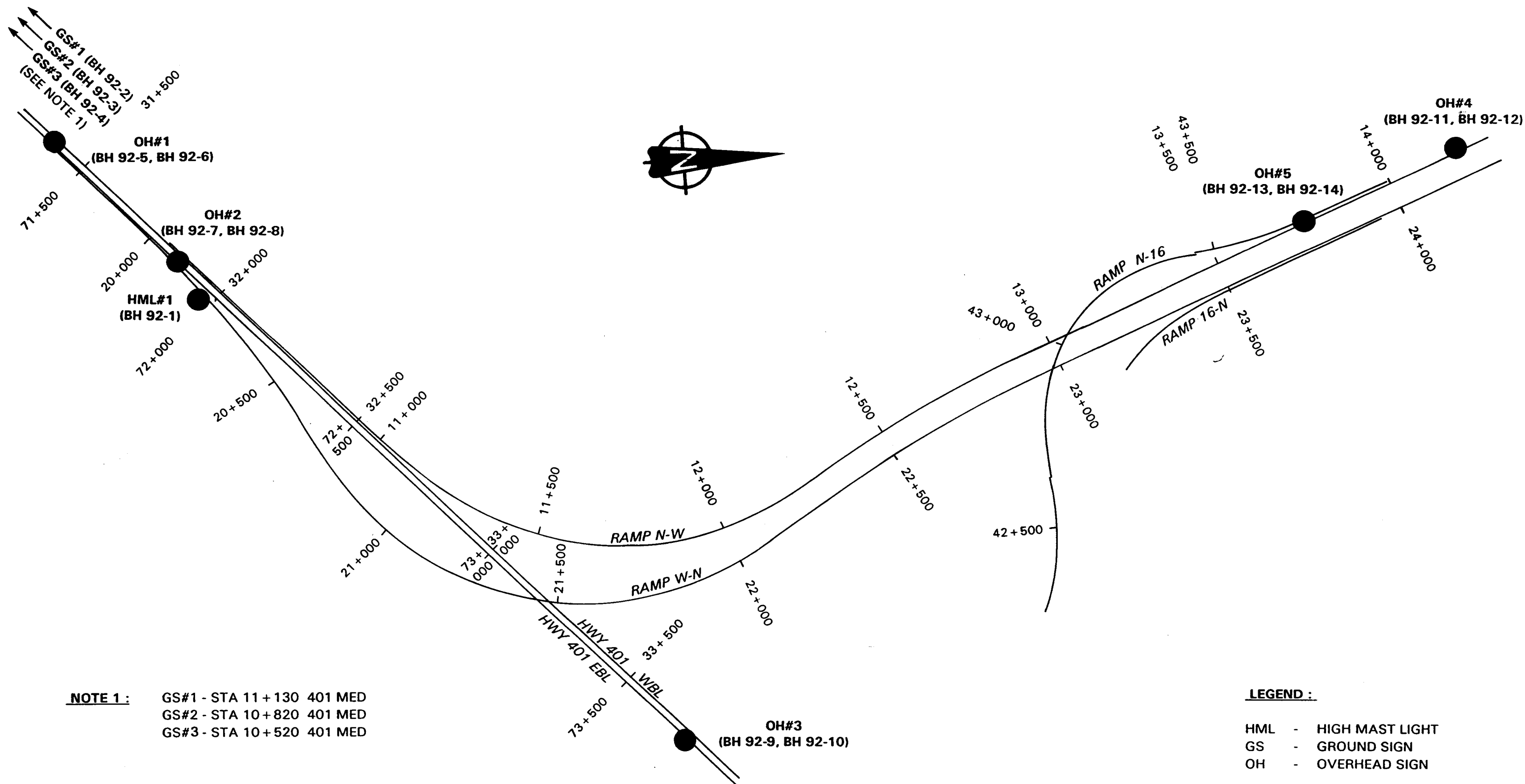
Ontario

# PLASTICITY CHART SILTY CLAY

FIG No 5

W P 374-89-00





**NOTE 1 :**  
 GS#1 - STA 11+130 401 MED  
 GS#2 - STA 10+820 401 MED  
 GS#3 - STA 10+520 401 MED

**LEGEND :**  
 HML - HIGH MAST LIGHT  
 GS - GROUND SIGN  
 OH - OVERHEAD SIGN

GEOCRE# 31B-76

**KEY PLAN**  
 SCALE 1 : 10 000

DWG No. 10213-1  
 WP 374-89-00