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DIST. 9 REGION

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STR. SITE No. 3-576

HWY. No. 416

LOCATION Hwy 416 - ~~Century Rd.~~ to Reg. Rd. 6

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

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CONT 96-07

FOUNDATION INVESTIGATION REPORT

for

Regional Road 6

W.P. 187-89-02, District 9, Ottawa
Highway 416, Str. Site: 3-576
GEOCRES # 31G-213

Strata Project E-90-037C

Date of Submission: 1992 08 31

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E-90-037C

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FOUNDATION INVESTIGATION REPORT
for
Regional Road 6

W.P. 187-89-02, District 9, Ottawa
Highway 416, Str. Site: 3-576

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by UMA Engineering Ltd. to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 and Regional Road 6 (Roger Stevens Drive). The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report in accordance with the requirements of the Foundation Design Section of the MTO.

This report, which follows a letter report dated 1991 01 23, complies with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located approximately 30 km south of Ottawa along Highway 16. The location of the site is shown on the key plan in Drawing 1878902-A, appended. The centre line of the new southbound lanes will be located some 30 m west of existing Highway 16. Therefore, the underpass to carry Regional Road 6 across the new highway will be a two span structure with abutments located to the east and west respectively of the existing highway and the proposed southbound lanes of the new highway. The proposed centre pier will be situated west of the west shoulder rounding of the existing highway, which has been widened at this intersection to accommodate turning lanes.

The site lies within the physiographic area known as the North Gower Drumlin Field. The drumlins have a north-south orientation. The area has been inundated by the Champlain Sea which has caused the drumlins to be covered with a mantle of marine soil, predominantly silt and Leda clay. Bedrock in this area has been mapped as magnesium limestone to dolostone of the Oxford Formation, Lower Ordovician age.

3.0 FIELD AND LABORATORY WORK

The field work was carried out in two phases. The initial investigation was conducted between 1990 10 02 to 1990 11 01, and consisted of the drilling of seven boreholes, five of which were accompanied by a dynamic cone penetration test. Four boreholes were drilled at the corners of the proposed abutments and one near the centre pier. The remaining two boreholes were drilled away from the structure to provide information for the approach fills. The second phase of the investigation, from 1991 11 12 to 1991 11 13, was conducted in order to more completely define the soil stratigraphy at the east abutment location. It consisted of the drilling of one additional borehole (BH 8) and a dynamic cone penetration test (BH 9) to the south of the proposed pier location.

Borehole elevations are referenced to Geodetic datum and were supplied by UMA Engineering. The locations of the boreholes and dynamic cone penetration tests are shown on Drawings 1878902-A and -B.

Drilling was conducted with Bombardier mounted CME 55 drill rigs. Hollow stem augers were used to advance the boreholes. Boreholes 2 and 5 for the approach embankments were terminated within the highest competent stratum. Bedrock was proven by coring in three boreholes near the proposed structure abutments and pier.

Standard Penetration Tests were performed to sample very stiff to hard cohesive and all non-cohesive deposits, the accompanying N values being noted in blows/0.3 m. In cohesive strata and in Borehole 3, relatively undisturbed samples were obtained by pushing thin-walled Shelby tubes either manually or hydraulically into the soil. In situ vane shear testing was conducted using a standard MTO A size vane in the cohesive strata. Remoulded shear strengths were also measured to determine sensitivity.

Upon completion, water levels were measured in the uncased holes. In Borehole 6, a standpipe was installed for longer term water level monitoring. The other holes were backfilled with native soil cuttings. The site was then restored to its original condition. Due to its proximity to the travelled roadway, no long term water level observation standpipe was installed in Borehole 8.

Recovered samples were transported to our Don Mills Laboratory for further visual examination, classification and index property testing such as moisture content, grain size distribution and Atterberg limits. One consolidation test was performed. The results are shown on the Record of Boreholes and on Figures 1 to 4, appended.

4.0 SUBSURFACE CONDITIONS

4.1 General

Over most of the site, a dense sandy silt glacial till overlies limestone bedrock. In the southeast area of the site, the till is overlain by a wedge of clayey silt. The groundwater table lies within a metre or so of ground surface.

4.2 Medium Sand (Road Fill)

In Boreholes 2 and 5 for the approaches and in Borehole 8 at the proposed east abutment location, a brown medium sand with traces of asphaltic concrete is present from the surface to depths ranging from 1.7 m to 2.1 m below ground surface. The moisture content ranges from 10 to 25 per cent. A typical grain size distribution curve is shown on Figure 1.

The N values from the Standard Penetration Resistance test ranged from 20 to 4 blows/0.3 m, generally decreasing with depth, indicating a compact to loose relative density of the road fill material.

4.3 Clayey Silt

A brown to grey clayey silt deposit was found in Boreholes 3 and 8 at the south corner of the east abutment. The deposit in Borehole 3 was 5.3 m thick, and in Borehole 8 it was 3.7 m thick.

The moisture content of this material ranged from 30 to 48 per cent. Atterberg limit test results (Figure 2) show the soil to be of low plasticity (CL). The moisture content is generally higher than the liquid limit, indicating a liquidity index of greater than unity.

N values in this deposit ranged from 2 to 7 blows/0.3 m. Field vane tests indicate the undrained shear strength of the deposit to be over 100 kPa above about elev. 86± m, below which the strength decreases to between 45 and 75 kPa around elev. 84± m. The sensitivity of the soil ranged between 6 and 8. Based on these observations the deposit is considered to be very stiff to firm.

One consolidation test on a sample from Borehole 3 is shown on Figure 3. A strict interpretation of the preconsolidation pressure, using the Schmertmann method, gives a preconsolidation pressure, p_c, of about 200 kPa. However, from visual inspection of the e-log p curve, the p_c value ranges between 150 kPa and 180 kPa. The compression index, C_c, is 0.180. The recompression index, C_r, is 0.02. Since the existing effective overburden pressure at the location of the sample is about 30 kPa, the clayey silt appears to be overconsolidated by about 120 to 150 kPa.

4.4 Sandy Silt with some Gravel (Glacial Till)

Below the clayey silt in Boreholes 3 and 8, and the road fill material in Boreholes 2 and 5, and from surface down in the remaining boreholes, there is a sandy silt with some gravel (glacial till), with random boulders and cobbles. Typical grain size curves for the sandier portions of the deposit are shown in envelope form in Figure 4A. Gravelly zones and less silty zones within this deposit are plotted on Figure 4B. N values in this deposit ranged between 7 and in excess of 100 blows/0.3 m, generally increasing with depth. The lower N values were observed within the upper zones of the deposit and may be due to local re-working of the till. The dynamic cone penetration tests all terminated within this deposit. Based on these N values, the deposit is considered to be very dense with localized loose to compact zones near the surface.

4.5 Limestone Bedrock

Limestone bedrock was proven by coring in Boreholes 3, 6 and 7. The core recoveries were between 70 and 100 per cent. The thinly bedded rock has a maximum RQD value of 55 per cent, most values being about 30 per cent. Based on the measured RQD's the bedrock quality is very poor to fair.

5.0 GROUNDWATER CONDITIONS

Groundwater observations are summarized below:

Borehole	W.L. Elev.(m)	Depth (m)	Date
1	87.4	0.7	1990 10 03
2	86.8*	2.8	1990 10 02
3	87.4	0.4	1990 10 16
4	87.9	1.0	1990 10 04
5	87.8	1.8	1990 10 05
6	88.4	0.4	1990 11 02
7	87.9	0.6	1990 11 02
8	86.6	3.2	1991 11 13

* Not stabilized

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to construct southbound lanes to upgrade existing Highway 16 to a 4 lane freeway standard. This will entail raising Regional Road 6 (Roger Stevens Drive) and carrying it across the four lanes of the proposed new Highway by means of a two span underpass. The centre pier will be located in the area of the west ditching of the present two lane highway. Regional Rd. 6 is situated at about elevation 90.0 m. The approach fills are expected to be about 7.0 m in maximum height above prevailing ground surface.

It is presumed that a detour of the present Regional Rd. 6 will be built to facilitate the construction of the new underpass.

The subsurface conditions comprise a variably thick stiff to firm clayey silt deposit in the south half or third of the proposed east abutment overlying a generally dense sandy silt glacial till over limestone bedrock. The glacial till deposit occurs at the surface or just below fill material at the proposed west abutment and centre pier locations. The groundwater table is situated within a metre or so of ground surface.

6.2 Structure Foundation Design

Except for a localized 4 m to 5 m thick compressible clayey silt deposit in the southeastern portion of the site, the subsurface conditions are generally suitable for the support of the proposed structure on spread footings.

For the entire structure the design options are:

1. Spread footing support, with complete excavation and replacement of clayey silt.
2. Spread footing support, except for east abutment, which can be supported on piles.
3. Pile support.

The selection of an appropriate design option will depend on economic considerations and regard for long term maintenance consequences.

All footings and pile caps should be provided with a minimum earth cover of 1.8 m for protection against frost action.

6.2.1 Spread Footing Option

For spread footing support, both proposed abutments may be supported on compacted Granular A (see Figure 5), using the following capacities:

Factored Capacity at ULS	900 kPa
Capacity at SLS Type II	350 kPa

The Granular A core should be built up from elevation 88.0 m for the west abutment and from the glacial till stratum at elev. 82± m for the east abutment. Suggestions for the excavation of the clayey silt at the east abutment location are given in Section 6.6 of this report.

The centre pier, placed on spread footings within the sandy silt glacial till deposit at elevation 86.6 m, below the prevailing water table, may be designed for the following capacities (assumed footing width = 4 m):

Factored Capacity at ULS	1000 kPa
Capacity at SLS Type II	400 kPa

The sliding resistance of spread footings may be computed using the following unfactored values:

Effective Angle of Internal Friction ϕ'	35°
Effective Cohesion Intercept, c'	0 kPa

The unit weight of backfill should be taken as per section 6.3 below.

The total elastic settlement due to compression of the foundation soil below the spread footings is expected to be less than 25 mm; hence, the differential settlement between the Granular A supported abutments and centre pier will likely be in the order of 15 mm.

6.2.2 Pile Foundation Option

The abutments and pier of the entire structure, or the east abutment only, may alternatively be supported on a piled foundation designed for the following axial capacities, for example for HP 310x110 steel H piles:

Factored Axial Capacity in ULS	1600 kN
Axial Capacity in SLS Type II	1150 kN

Downdrag loads on the piles below the proposed east abutment are not considered to be significant to warrant lower capacities for the piles penetrating the clayey silt deposit.

Due to the presence of cobbles and occasional boulders at depth, the piles should be driven with reinforcing toes, using an energy of not less than 50 kJ to achieve the intended axial capacities.

Pile toes are likely to penetrate to the following anticipated elevations:

West Abutment

North Side	76.3	On bedrock
South Side	76.5	On bedrock
Centre Pier	79.5	Within glacial till - use Hiley formula to control pile driving, per MTO practice.
East Abutment		
North Side	81.5	Within glacial till - use Hiley formula to control pile driving.
South Side	75.5	On bedrock

In order to calculate bridge deck support elevations across the proposed east abutment, the elastic shortening of the piles should be computed using the formula:

$$\text{Elastic shortening} = PL/AE$$

where:

P = design load;
L = length of pile, interpolated from Section C-C, Drawing 1878902-B, assuming pile toe to penetrate to bedrock or to depth where N values are >100 blows/0.3 m;
A = cross-sectional area of the pile section chosen;
E = modulus of elasticity of steel

Allowance for a maximum differential settlement of 10 mm should be made between a pile supported east abutment and a spread footing supported centre pier, the centre pier settling relative to the pile supported east abutment.

6.3 Earth Pressures

Earth pressures should be computed as per sub-section 6-6.1.2.2 of the OHBD Code. An unyielding foundation condition should be assumed for a piled foundation and a yielding condition for spread footing support, in the selection of at-rest or active earth pressure coefficients respectively. The Granular A or B backfill should be in accordance with MTO Special Provision No. 109F03 (latest revision).

The following design parameters are recommended for granular backfill to abutments and wing walls:

	Granular A	**Granular B**
Effective Angle of Internal Friction, ϕ'	35.0°	30.0°
Unit Weight (kN/m^3), γ	22.8	21.2

Surcharge effects, if any, should be computed as per Clause 6-6.1.2.4 of the OHBD Code.

6.4 Approach Embankments

The approach grades will be at about elevation 97 m, resulting in fill heights of some 6-7 m. The stability of such fills was checked using total stress analyses for the case of the east approach fill above the clayey silt deposit. The analyses show adequate total factor of safety against deep seated rotational failure, provided the side and forward fill slopes are maintained at 2H : 1V, or flatter.

The settlement of a 6-7 m high fill at the west approach will occur during placement and will be negligible after construction.

The presence of the clayey silt deposit below the east approach fill will result in long term settlements of about 30 mm for a 6-7 m high east approach fill. If the clayey silt soil is excavated, then settlements will be immediate during fill construction, and negligible thereafter.

6.5 Construction of Centre Pier

Construction of the centre pier footing will require dewatering. The presence of cobbles and boulders within the silty sand glacial till deposit precludes the use of sheet piling to serve as a positive seepage cutoff. For the same reason, and for reasons of cost, well point dewatering may not be practical.

Therefore, consideration should be given to gravity drainage of the excavation, by making it larger than the footing. One means of achieving dewatering of the excavation by gravity drainage is shown on Figure 6. The ditching shown on Figure 6 may be taken all around the footing, or be left to one side, depending on traffic control and road protection considerations. As a minimum, the nearest travelled vehicle wheel path should be no closer than the maximum depth of the excavation ditching, or 2 m, whichever is less.

6.6 Excavation and Backfilling of Clayey Silt

The clayey silt deposit extends vertically below the southern portion of the east abutment and laterally probably extends below the existing Regional Road 6 pavement (refer Section C-C, Drawing 1878902-B).

The clayey silt will need to be completely removed from within a trapezoidal zone, as defined by the 1:1 sloping lines of Figure 5, extended down to the glacial till stratum.

After construction of the detour for Regional Rd. 6, excavation of the clayey silt should commence from the north end, working towards the south. There are two methods available for excavation - one in an east-west direction, across the abutment footing width, and the other in a north-south direction spanning the entire length of the abutment footing. The choice should be left up to the contractor who should submit a proposal of the intended excavation and engineered backfill scheme for review from a geotechnical view point. Contract conditions imposed for excavation and backfilling should include:

1. No clayey silt shall be trapped within the limits of excavation defined.

2. Excavation stability shall be maintained at all times.

3. Provisions of the current Ontario Occupational Health and Safety Act relative to excavations shall be complied with.

4. Granular A backfill shall be accomplished in loose lifts not exceeding 200 mm in thickness, with each lift being compacted to 100 per cent of the Standard Proctor density of the material being used.

5. All Granular A placement and compaction shall be in the dry.

The granular fill below the pavement will be stable at temporary slopes of 1:1. The clayey silt will stand up at 1:1 temporary slopes during excavation to the maximum depth of 6 m, for excavations left open for not more than 48 hours. Seepage of groundwater from the clayey silt stratum is expected to be capable of being handled by routine pumping using a submersible pump, with a minimum capacity of 10 L/s.

The contract should specify that no excavation should be left open overnight or at the end of a working day.

For quantity estimating purposes, assume the quantity of clayey silt removal to be 1.1 times the neat excavation quantity and the Granular A to be 1.25 times the neat excavated quantity, due to the high probability of loss through contamination and pick-up of previously placed materials with the excavated material.

The excavated material is not considered suitable for re-use on the project, and should be disposed off.

6.7 Recommended Option

There are numerous problems associated with the excavation of the clayey silt, including not only the consideration of how a 6 m deep hole will be backfilled and compacted with Granular A without encountering severe difficulties, but also through considerations of:

- danger to equipment and workers from potential instability of the excavated side slopes;
- disposal of the clayey silt, which has a liquidity index of greater than unity;
- field control of compaction achieved;
- ensuring all softened material has been removed from within the specified excavation zone;
- Falsework support considerations (the falsework can not be situated within 5 m of the nearest excavation boundary).

Therefore, supporting the east abutment on a piled foundation is the preferred alternative. The decision to use piling also for the central pier (to avoid large excavations and dewatering problems) and for the west abutment will depend on economic and structural design considerations, which are beyond the scope of this report.

7.0 CLOSURE

The drilling was supervised by A. C. Abel. Drill rigs were rented from F. E. Johnston and Marathon Drilling companies, Ottawa.

Several reviews of this report have been conducted between initial issue and this submission. We are grateful for the many constructive suggestions received in its finalization.

Respectfully submitted:
STRATA ENGINEERING CORP.

A. C. Abel, M. Sc.
Project Engineer

C. Mirza, P. Eng.
Senior Principal

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APPENDIX

Explanation of Terms Used in Report

Record of Boreholes 1 to 9

Figures 1 - 6

Drawings 1878902-A and B

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No1

METRIC

W P 187-89-02 LOCATION N: 5 000 806 ; E: 369 238 ORIGINATED BY S.S.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.1	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till)					▽	88.0				W. L. on 1990 10 03
	Compact		1	SS	14		87.0		○		
			2	SS	23				○		11 31 (58)
	Brown		3	SS	18		86.0		○		
			4	SS	19		85.0		○		
			5	SS	50/1cm.				○		11 37 (52)
	Very Dense						84.0				
			6	SS	93				○		
	Grey						83.0				
							82.0				
81.4			7	SS	110				○		
6.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No2 METRIC

W P 187-89-02 LOCATION N: 5 000 809 ; E: 369 258 ORIGINATED BY S. S.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Concrete (Road Fill)						89.0				
	Compact to Loose		1	SS	20				o		0 79 (21)
	Brown		2	SS	4		88.0		o		
87.5											
2.1	Sandy Silt Some Gravel (Glacial Till)		3	SS	7	▽	87.0		o		W.L. on 1990 10 02
	Loose to V.Dense Brown		4	SS	30				o		
			5	SS	25		86.0		o		25 30 (45)
	Grey		6	SS	85		85.0		o		
84.6											
5.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 ; Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No3

METRIC

W P 187-89-02 LOCATION N: 5 000 778 ; E: 369 249 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 03 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
87.8	Ground Surface										
0.0	Clayey Silt					▽					W. L. on 1990 10 16
	V.Stiff to Stiff		1	SS	3		87.0				
	Brown		2	SS	2		86.0				
			3	SS	5		85.0				
			4	TW	PH		84.0			19.3	Consol. Test Fig.3
	Grey										
82.5			5	TW	PM		83.0				
5.3	Sandy Silt		6	SS	30		82.0				
	Some Gravel		7	SS	20		81.0				
	(Glacial Till)										
	Compact to V.Dense		8	SS	35		80.0				13 39 (48)
			9	SS	67		79.0				
	Grey						78.0				
			10	SS	75		77.0				
75.4			11	SS	65/ 7.5cm.		76.0				
12.4	Limestone Bedrock		12	BX RC	Rec 94%		75.0				RQD = 54%
			13	BX	83%		74.0				RQD = 0%
72.8			14	BX RC	Rec 86%		73.0				RQD = 53%

15.0 End of Borehole

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4 — METRIC

W P 187-89-02 — LOCATION N: 5 000 785 ; E: 369 201 — ORIGINATED BY SS

DIST 9 HWY 416 — BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test — COMPILED BY A. K.

DATUM Geodetic — DATE 1990 10 04 — CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT Wl / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.9	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Compact Brown		1	SS	25	▼	88.0				7 35 (58) W. L. on 1990 10 04
			2	SS	14		87.0				
			3	SS	40		86.0				
	Very Dense		4	SS	52		85.0				
			5	SS	52		84.0				17 34 (49)
	Grey		6	SS	92		83.0				
			7	BX	Boulder		82.0				
	Gravelly Zone		8	SS	100		81.0				41 33 (26)
79.3			9	SS	129		80.0				
9.6	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No5

METRIC

W P 187-89-02 LOCATION N: 5 000 742 ; E: 369 162 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger. COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 05 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Conctrete (Road Fill)						89.0				
	Compact		1	SS	15						
88.1	Brown										
1.5	Sandy Silt Some Gravel (Glacial Till)		2	SS	14	▽	88.0				W. L. on 1990 10 05
	Compact to V. Dense		3	SS	21		87.0				12 38 (50)
86.5	Brown		4	SS	100/5cm						
3.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 ; Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No6

METRIC

W P 187-89-02 LOCATION N: 5 000 747 ; E: 369 183 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.8	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till)		1	SS	30/15cm.		88.0				W. L. on 1990 10 31
								Seal			
	Brown		2	SS	41		87.0				
			3	SS	55						16 36 (48)
	Compact to V. Dense		4	BX	Boulder		86.0				
			5	SS	34		85.0				
	Randomly placed Boulders		6	SS	59		84.0				
			7	BX	Boulder						
			8	SS	124/28cm.						
			9	BX	Boulder		83.0				
			10	SS	85/3cm.						
	Grey						82.0				
			11	SS	100/5cm		81.0				
			12	BX	Boulder						
							80.0				
			13	SS	58						
							79.0				
	Sandy Zone		14	SS	60		78.0				13 69 (18)
76.5							77.0				
12.3	Limestone Bedrock		15	BX RC	Rec 83%						RQD = 0%
			16	BX RC	Rec 96%		76.0				RQD = 55%
			17	BX RC	Rec 70%						RQD = 47%
			18	BX RC	Rec 83%		75.0				RQD = 30%
73.9	End of borehole						74.0				

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7

METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.5	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Sandy Silt Some Gravel (Glacial Till) Brown		1	SS	25	▽	88.0				W.L. on 1990 11 02
			2	BX	Boulder		87.0				
			3	SS	14		86.0				16 37 (47)
	Compact to V. Dense						85.0				
	Randomly placed Boulders		4	BX	Boulder						
			5	SS	51		84.0				
			6	BX	Boulder		83.0				
			7	SS	32/20cm						
			8	BX	Boulder		82.0				
	Grey		9	SS	76/10cm		81.0				
			10	BX	Boulder		80.0				
			11	SS	60/5cm.		79.0				
			12	SS	60/5cm		78.0				
			13	SS	75		77.0				
76.3											
12.2	Limestone Bedrock		14	BX RC	Rec 100%		76.0				RQD = 25%
			15	BX RC	Rec 82%		75.0				RQD = 37%
73.5	Cont. on Sheet 2						74.0				
15.0											

$+^3$, x^5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7 cont'd

METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
73.5	Cont. from Sheet 1										
15.0			16	BX RC	Rec 100%		73.0				RQD = 56%
72.5											
16.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 8

METRIC

W P 187-89-02 LOCATION N: 5 000 786.5 E: 369 245.5 ORIGINATED BY G.N.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.A.

DATUM Geodetic DATE 1991 11 13 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED • QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
89.8	Ground Surface										
0.0	Medium Sand Tr. Asphaltic Concrete Compact Brown		1	SS	13		89.0 / 88.0		o		
87.7											
2.1	Clayey Silt Stiff to Firm Brown with Grey Mottlings		2	SS	3	▼	87.0 / 86.0			42.5	W.L on 1991 11 13
			3	SS	7		85.0 / 84.0	6			
84.0											
5.8	Sandy Silt some Gravel (Glacial Till) Compact to Very Dense Grey		4	SS	21		83.0		o		
			5	SS	45		82.0		o		14 40 (46)
80.8			6	SS	120/15cm		81.0				
9.8	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 ; Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 9

METRIC

W P 187-89-02 LOCATION N: 5 000 757.0 E: 369 208.0 ORIGINATED BY G.N.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY A.A.

DATUM Geodetic DATE 1991 11 12 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
88.9	Ground Surface										
0.0	Probable Sandy Silt with Gravel (Glacial Till)						88.0 / 87.0				
86.6											
2.3	End of Conetest										

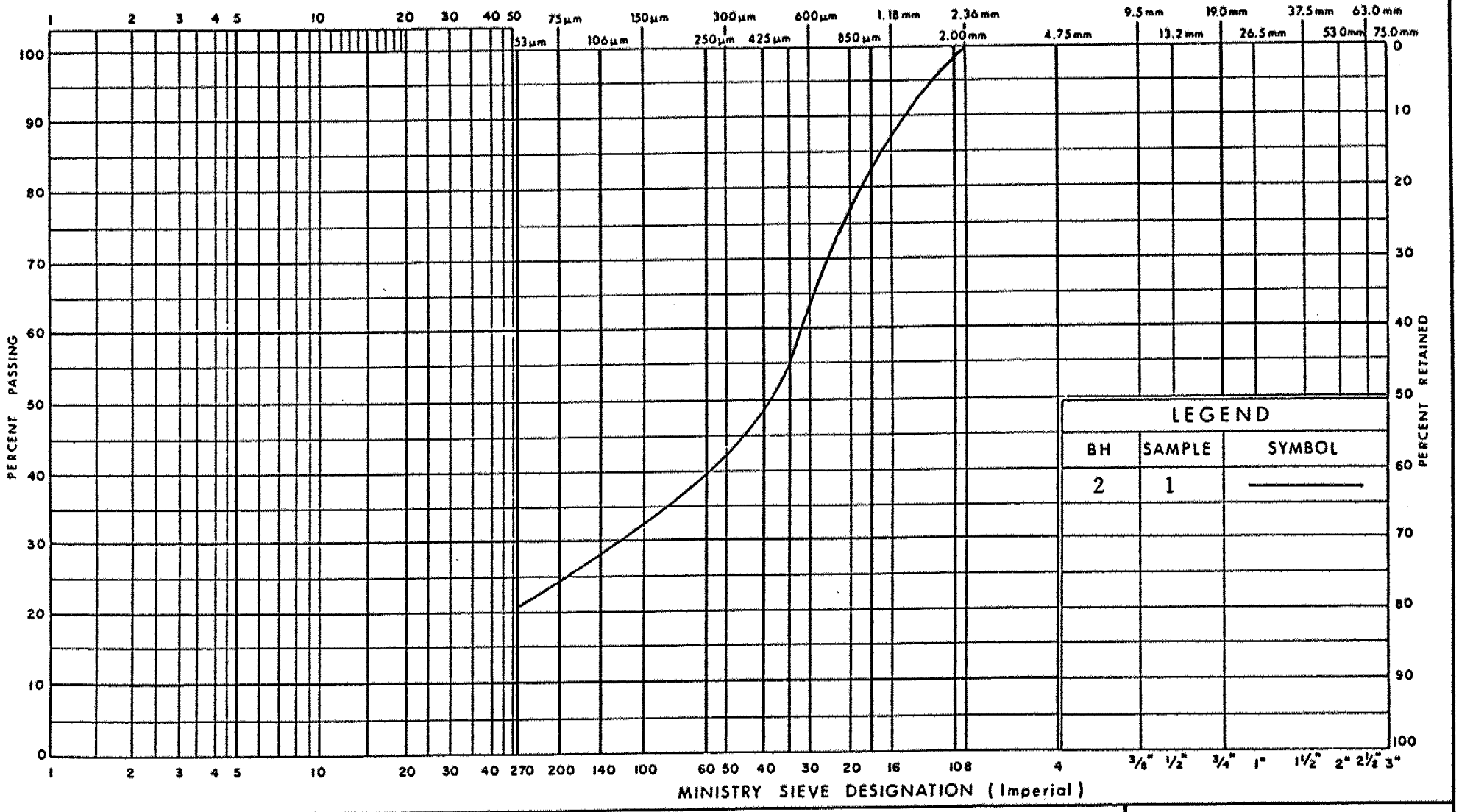
OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



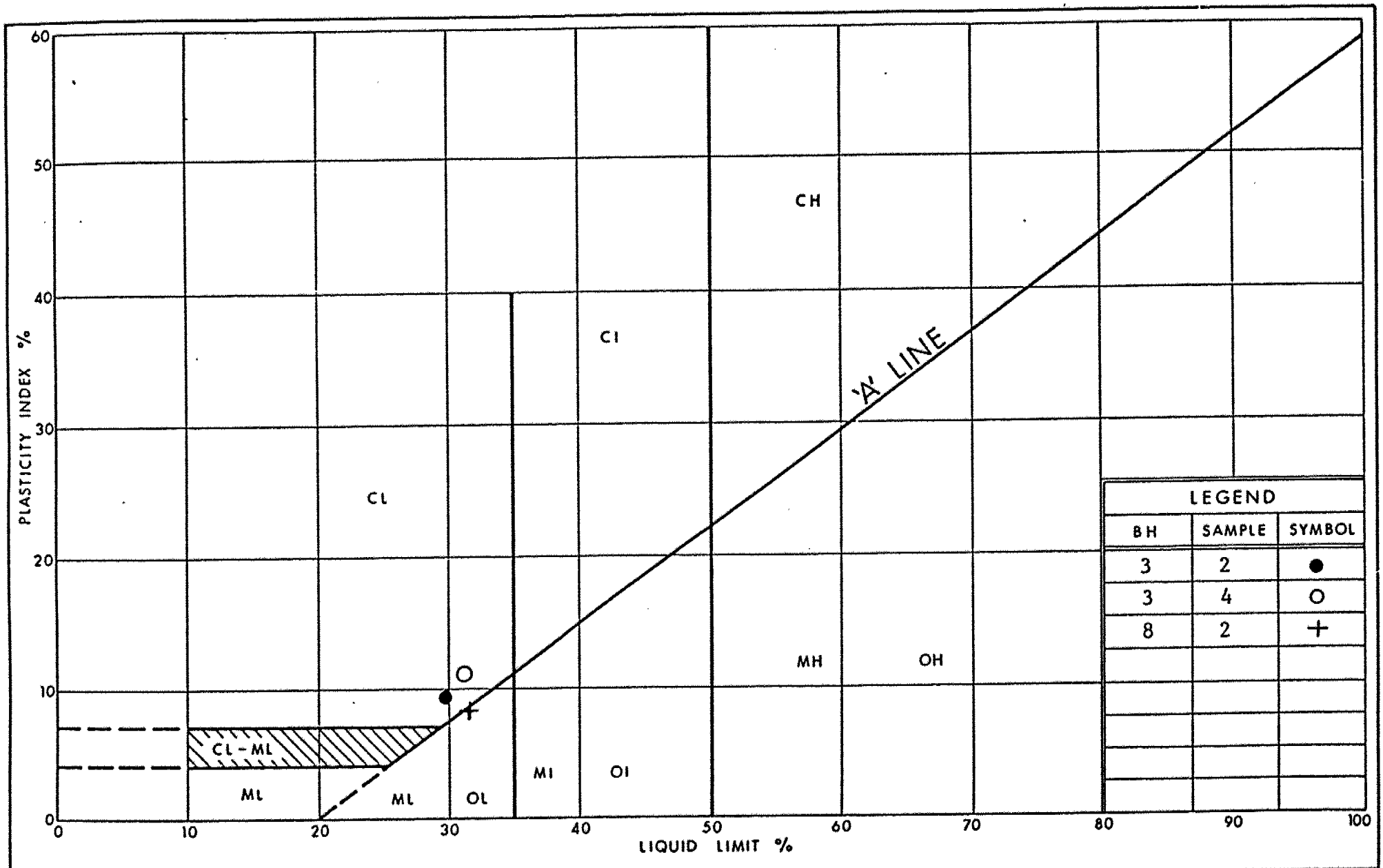
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Medium Sand
(Road Fill)

FIG No 1
W P 187-89-02
Reg. Rd. 6/ Hwy. 416

Oct 75, FF-S-21



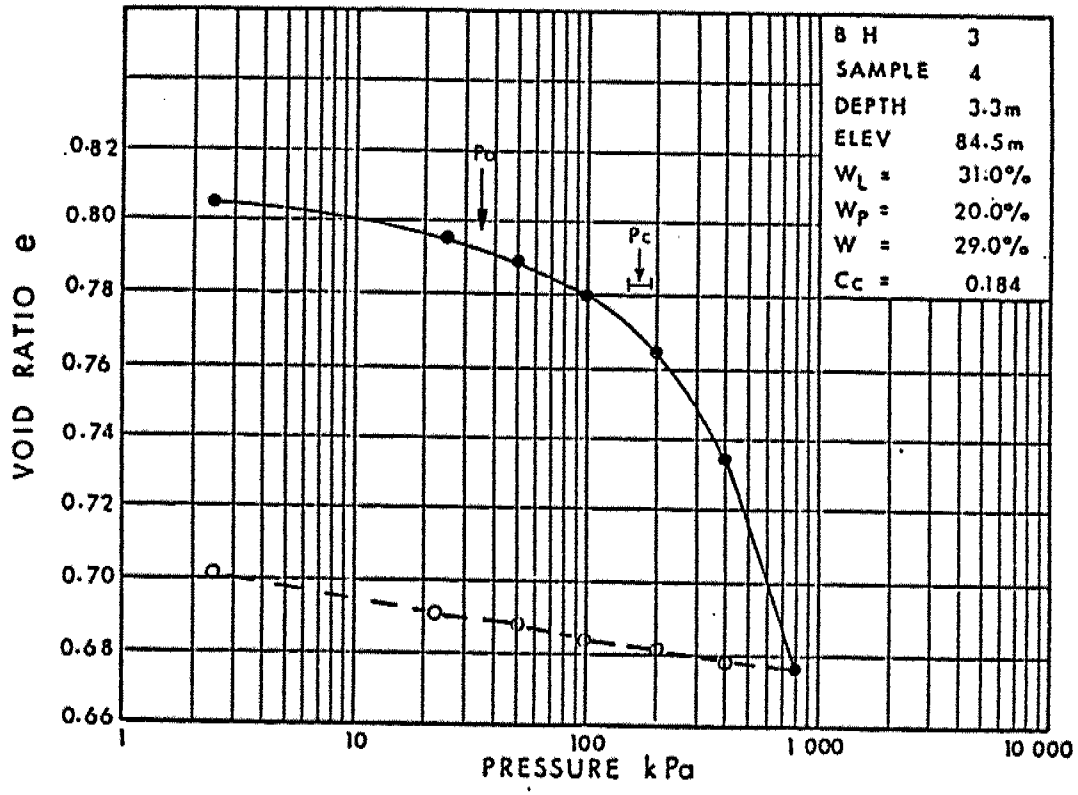
Ministry of Transportation
Ontario

PLASTICITY CHART

Clayey Silt

FIG No 2
W P 187-89-02
Reg. Rd. 6/Hwy. 416

VOID RATIO - PRESSURE CURVES



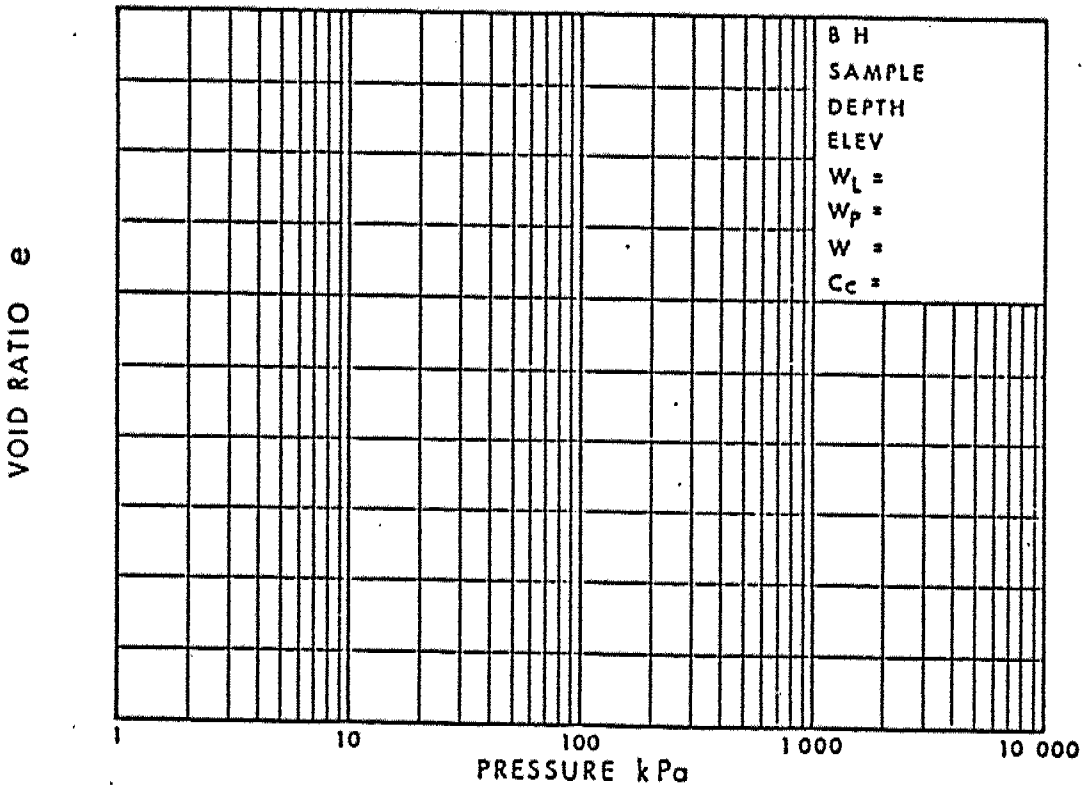
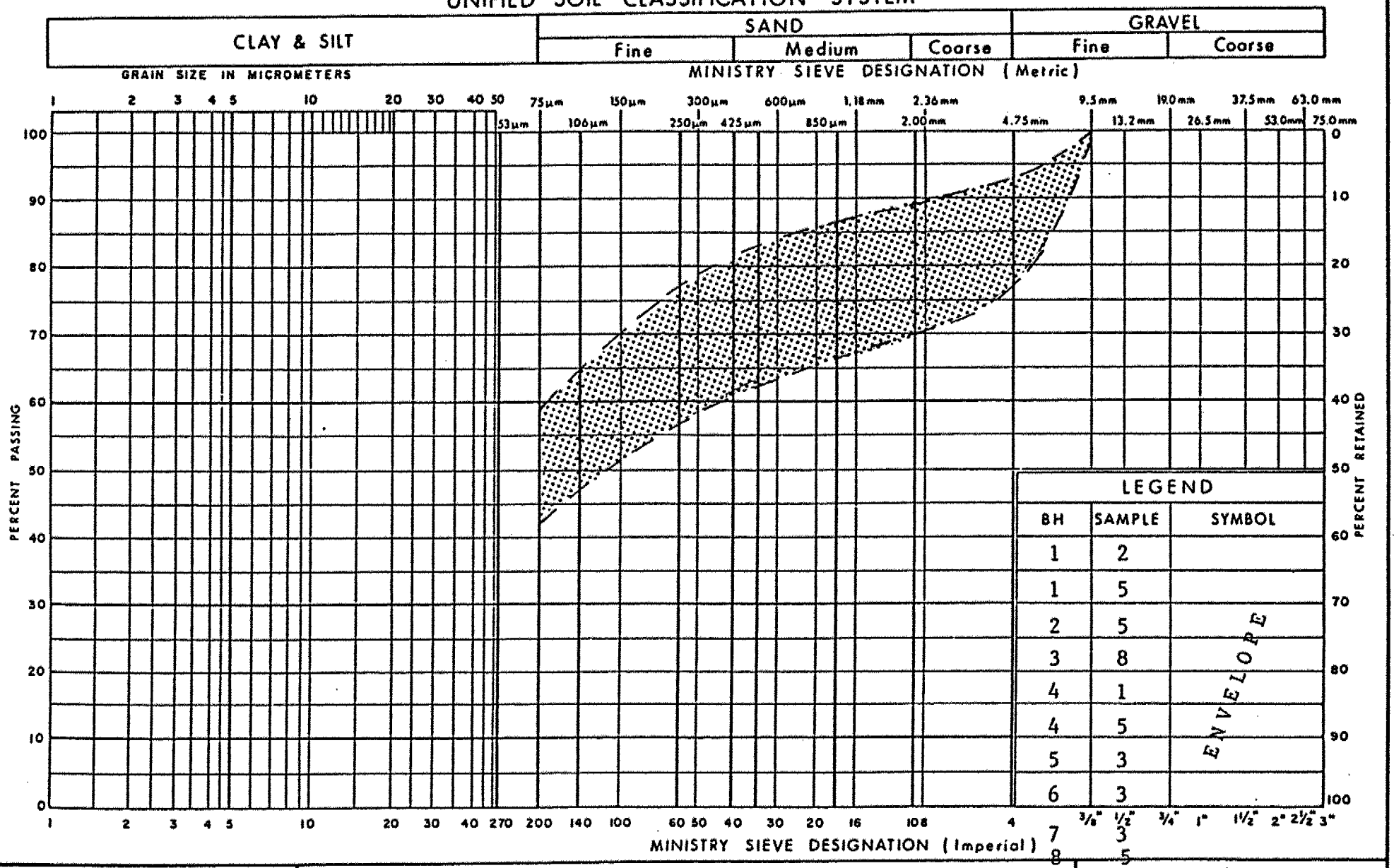


Fig 3

WP 187-89-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

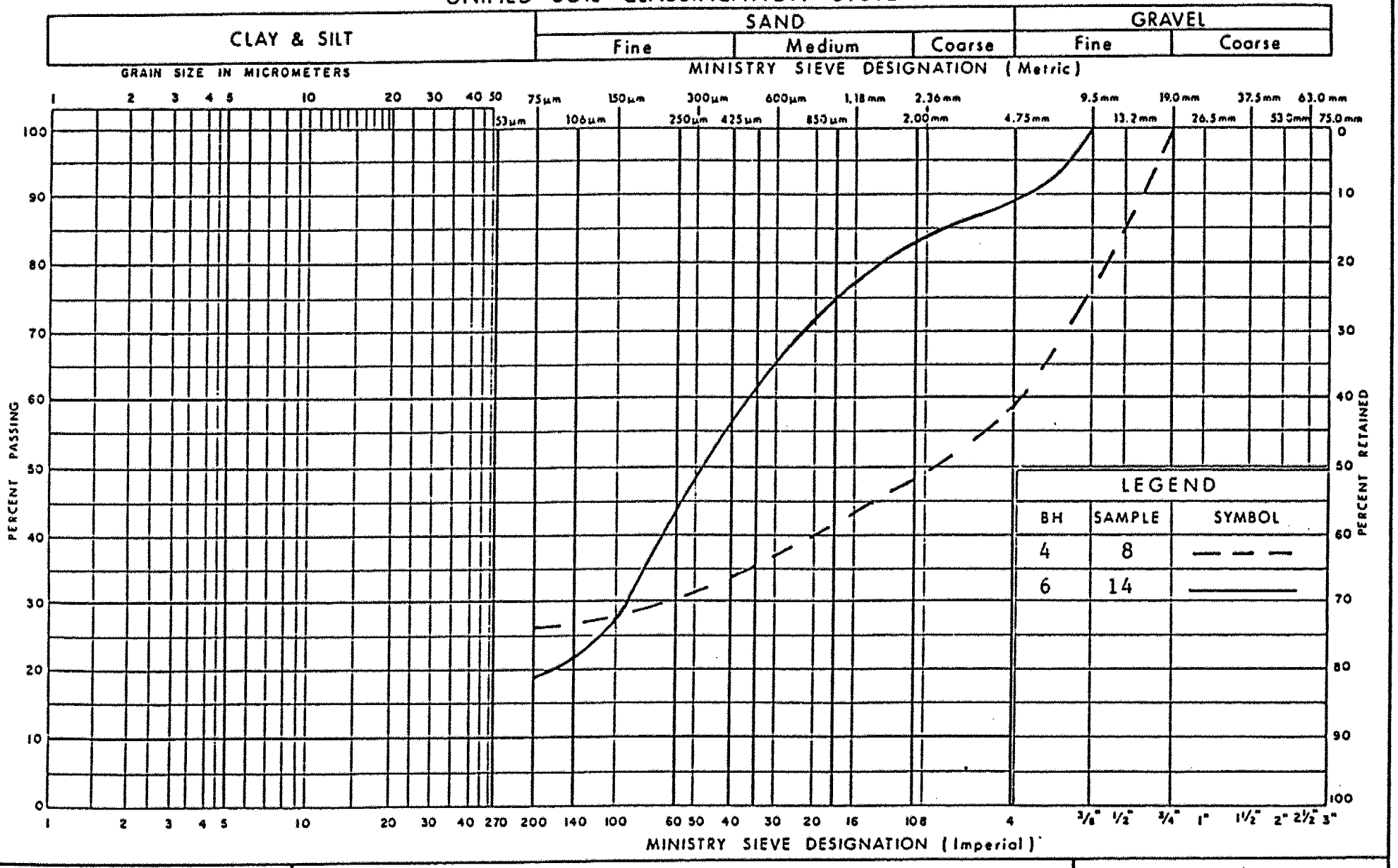
GRAIN SIZE DISTRIBUTION

Sandy Silt, some Gravel
(Glacial Till)

FIG No 4A
W P 187-89-02
Reg. Rd. 6/Hwy. 416

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
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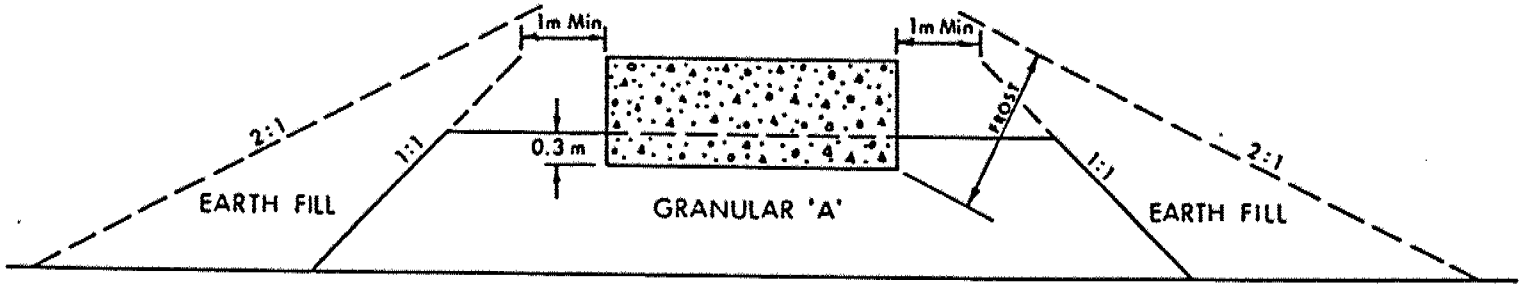
GRAIN SIZE DISTRIBUTION

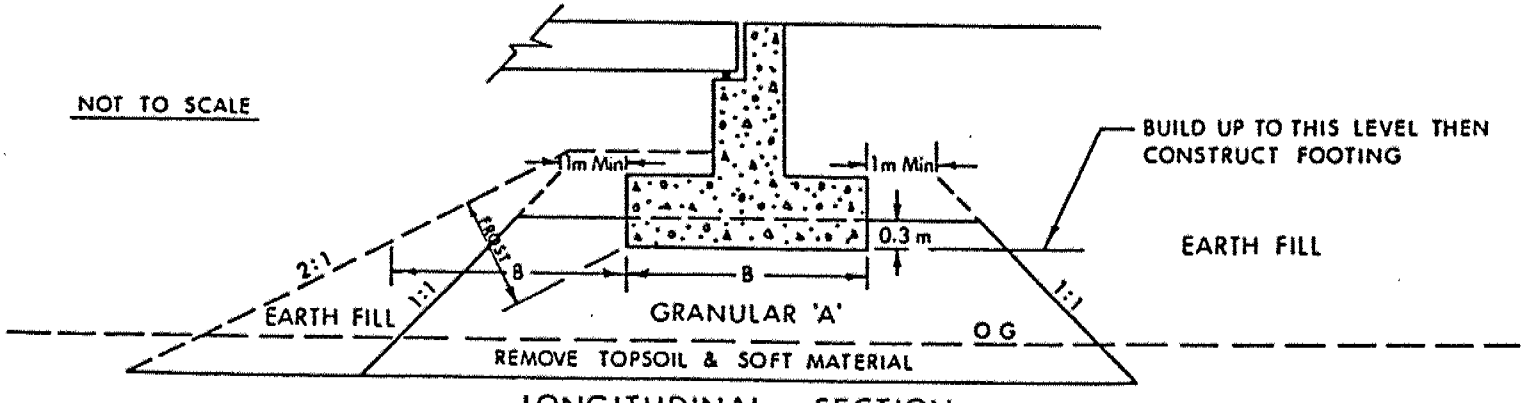
Sandy and Gravelly Zones within Glacial Till

FIG No 4B
W P 187-89-02
Reg. Rd. 6/Hwy. 416



X SECTION

NOT TO SCALE



LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

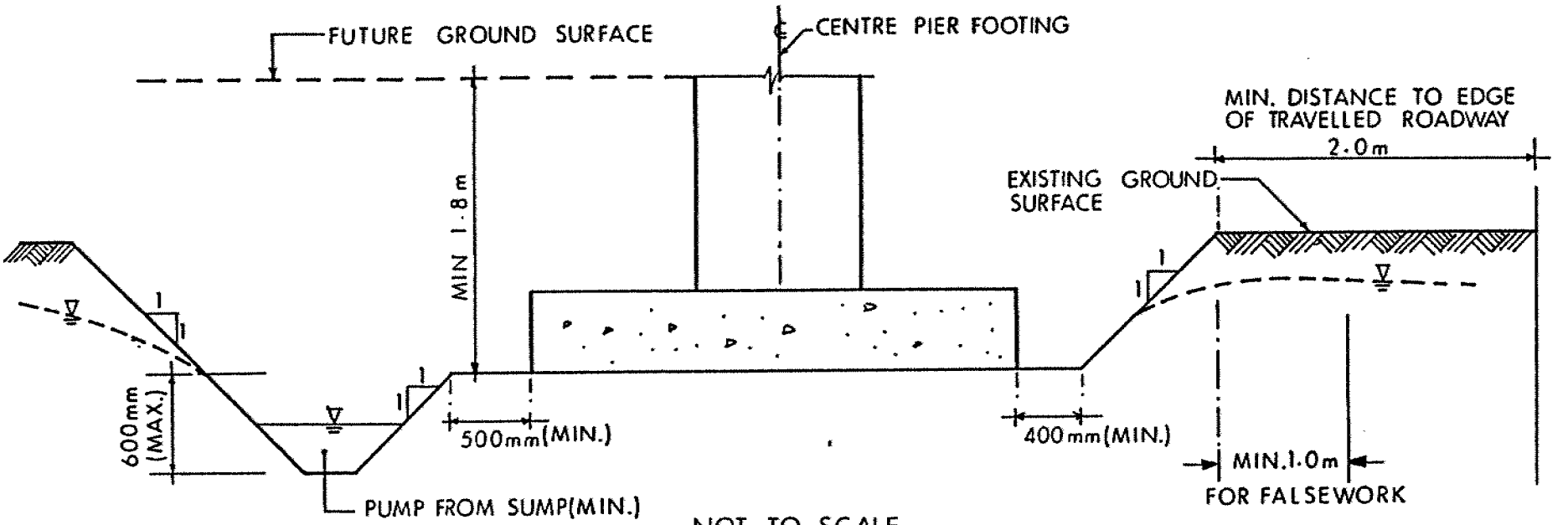
2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

M.T.O W.P 187-89-02

STRATA ENGINEERING CORP.	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 5 Hwy. 416 / Regional Rd. 6



NOT TO SCALE

NOTE:

BACKFILL EXCAVATION WITH GRANULAR 'A' PLACED IN MAX 300mm THICK LOOSE LIFTS AND COMPACTED TO 100% STD. PROCTOR DENSITY TO A LEVEL FLUSH WITH TOP OF FOOTING.

M.T.O W.P 187-89-02

STRATA ENGINEERING CORP.	DEWATERING OF CENTRE PIER FOOTING	FIG No. 6
		Hwy. 416 / Regional Rd. 6

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88 10

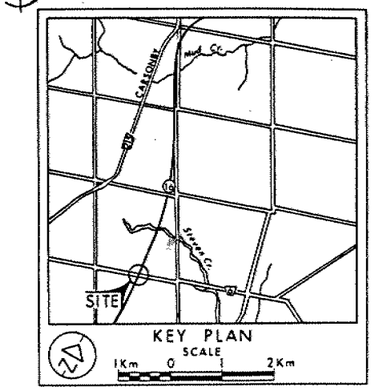
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

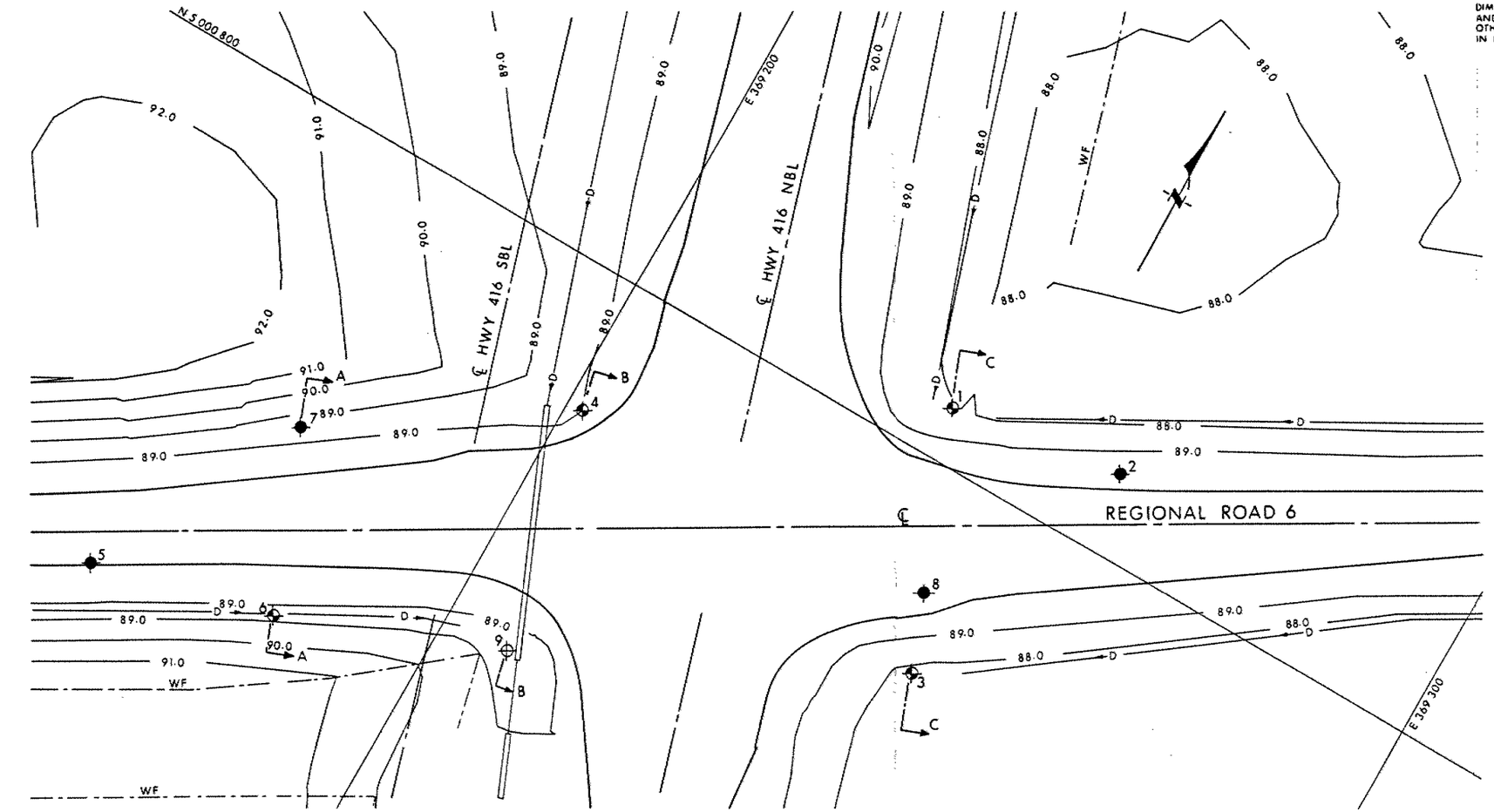
CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

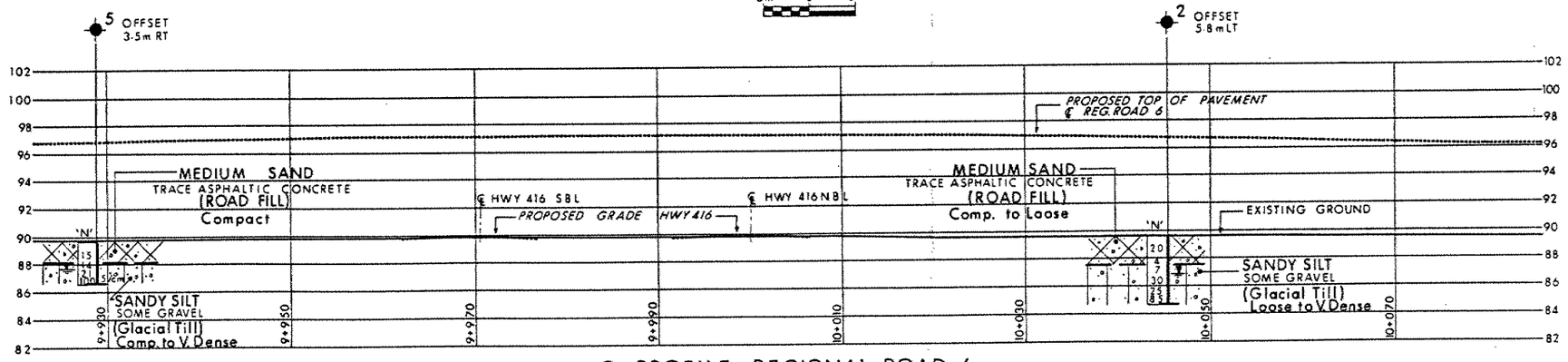
SHEET

STRATA ENGINEERING CORP.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

REF No E-55-416-2, 1991 01

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-A

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10

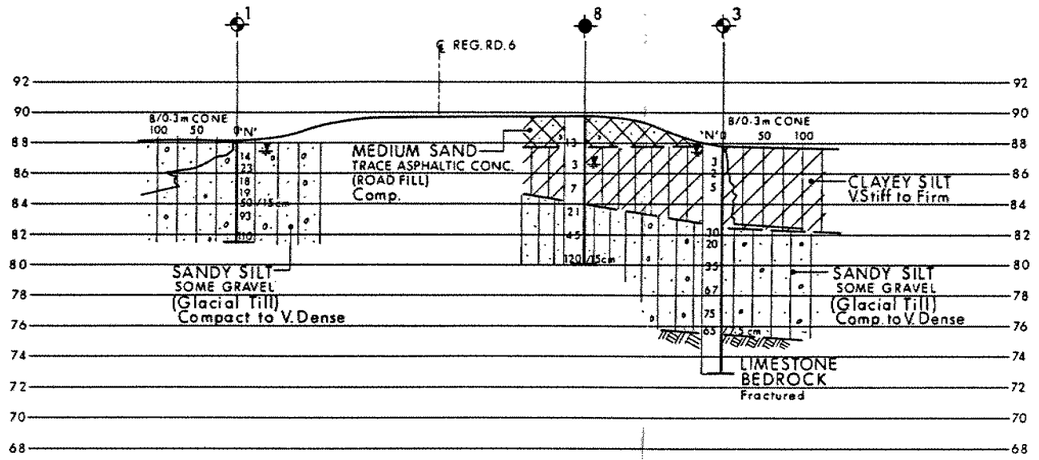
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

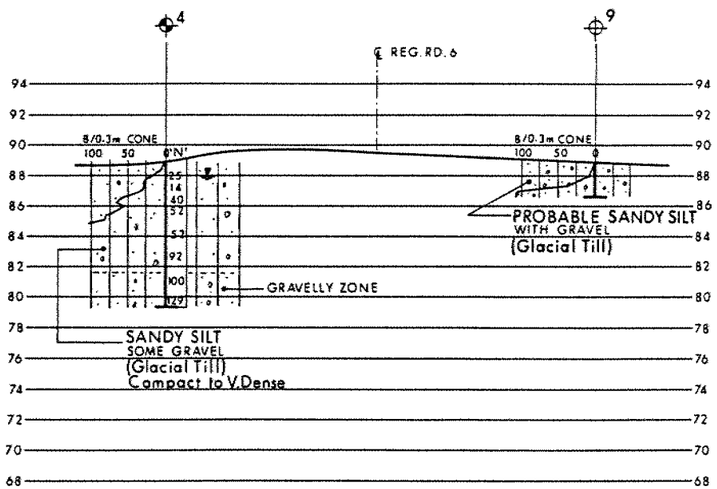
SHEET

STRATA ENGINEERING CORP.

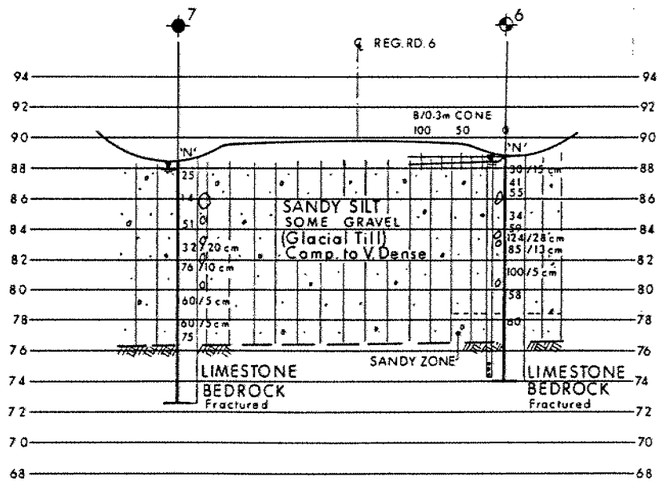


SECTION C-C

SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A

KEY PLAN
SCALE

SEE
DWG. No 1878902-A

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation Oct. & Nov. 1990, Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

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

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REV.	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 07 1992	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-B

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 88 10

METRIC

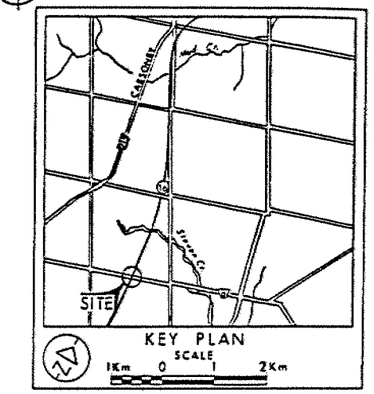
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

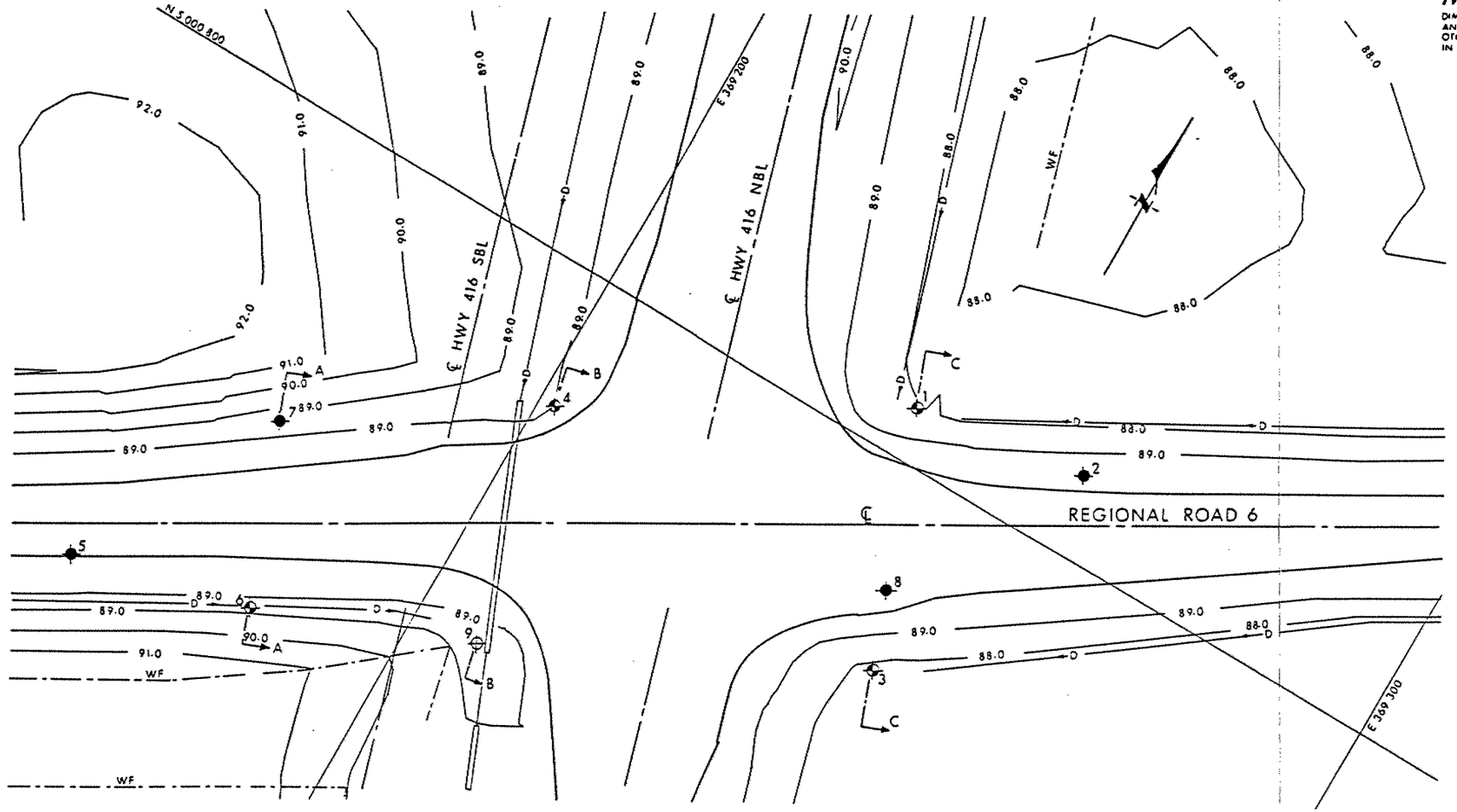
CONT No
WP No 187-89-02

SHEET

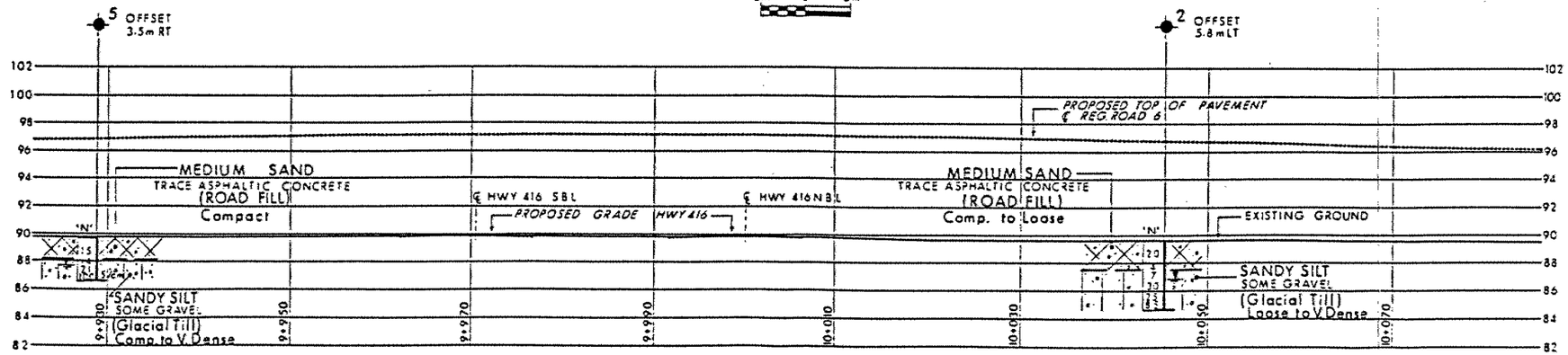
REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

STRATA ENGINEERING CORP.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

REF No E-55-416-2, 1991 01

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

NOTE
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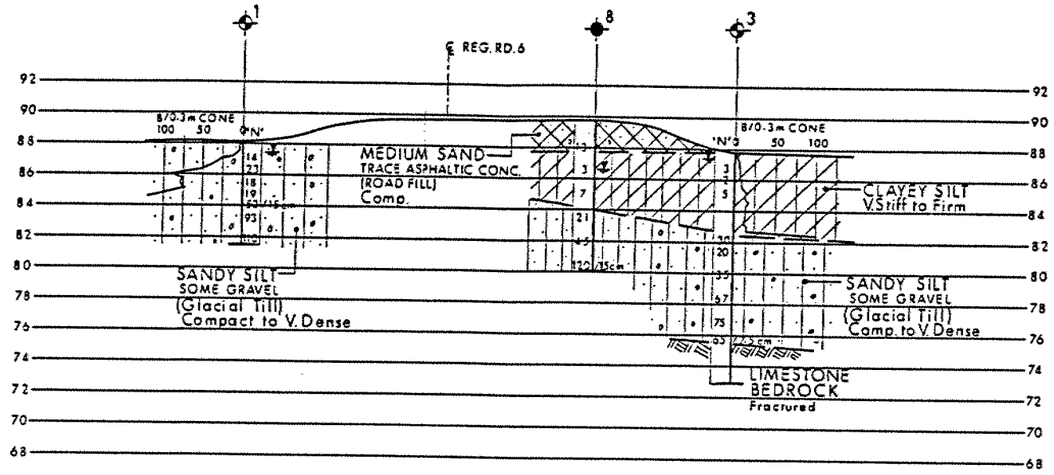
REV	DATE	BY	DESCRIPTION

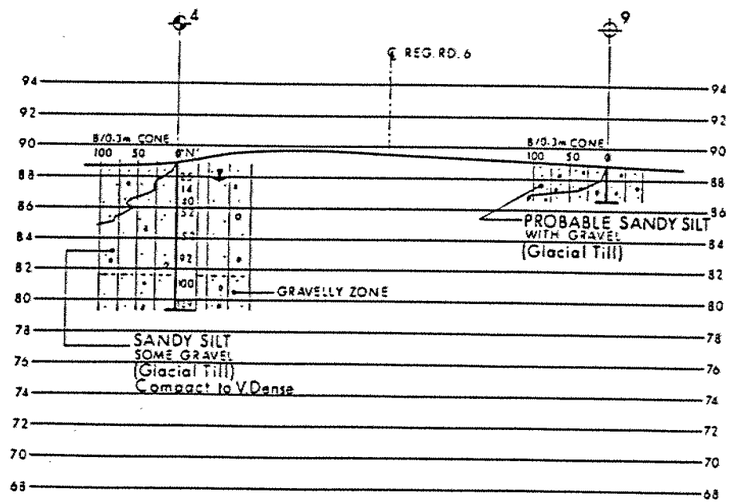
Geocres No 31G-213

HWY No 416		DIST 9	
SUBM'D A.A.	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A.K.	CHECKED	APPROVED	

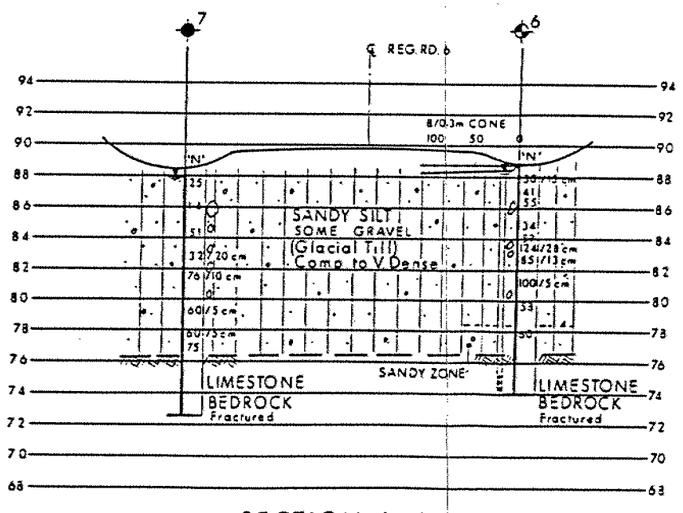


SECTION C-C

SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A

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

CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

STRATA ENGINEERING CORP.

SEE
DWG. No 1878902-A

KEY PLAN
SCALE

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation Oct.& Nov. 1990, Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
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9	88.9	5 000 757.0	369 208.0

NOTE
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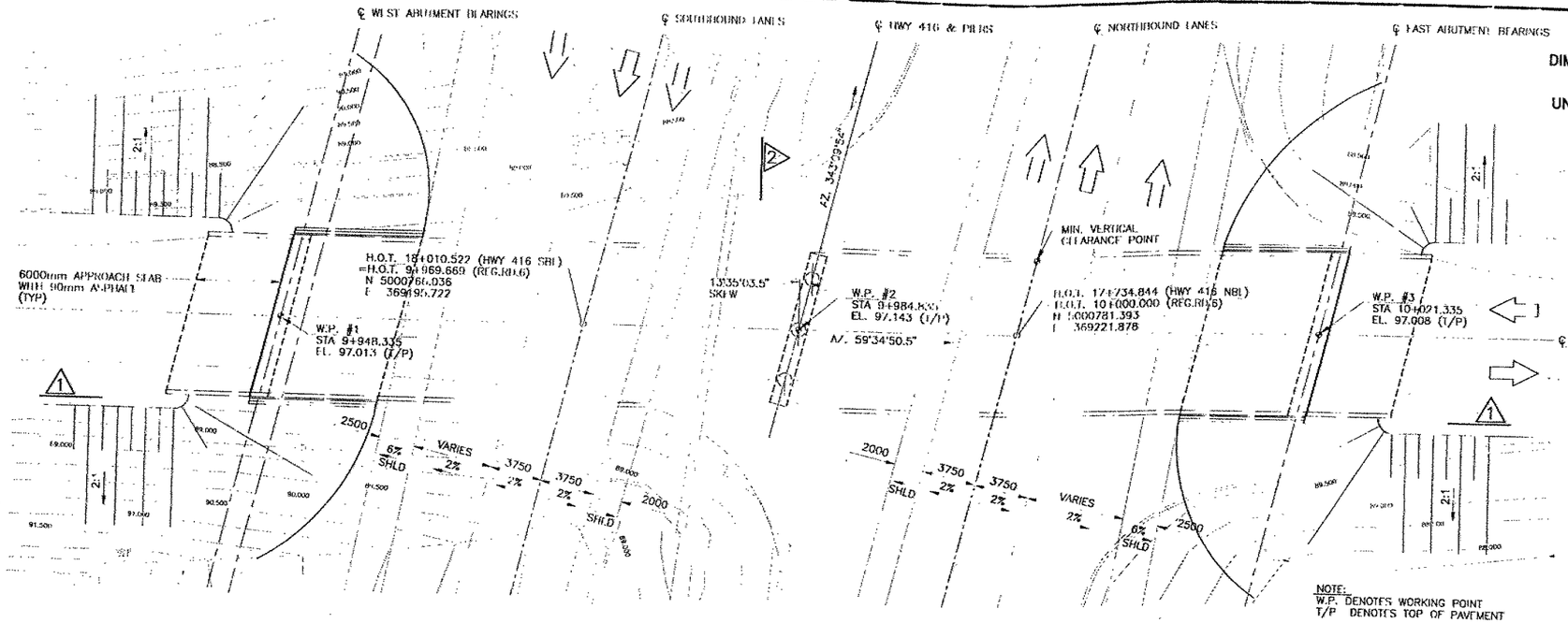
REV	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416 DIST 9

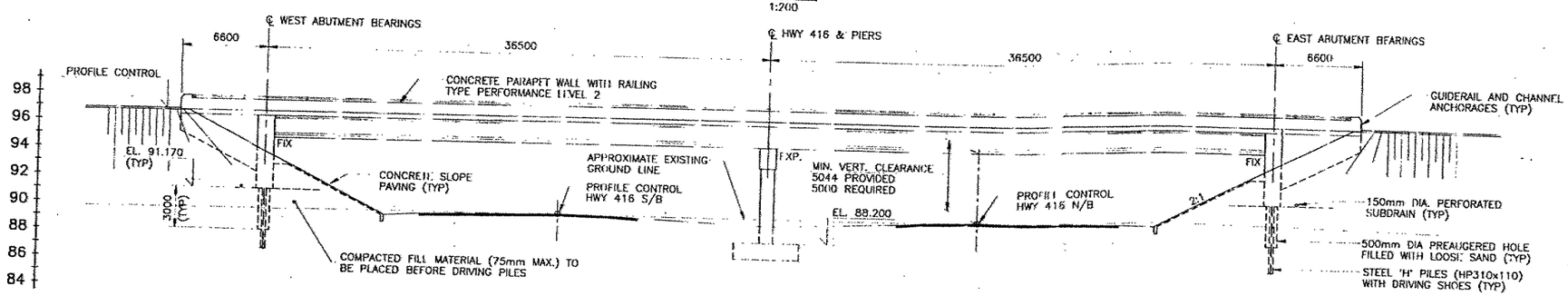
OVERSIZE DRAWING

NORTH FOR CONSTRUCTION



NOTE:
W.P. DENOTES WORKING POINT
T/P DENOTES TOP OF PAVEMENT

PLAN
1:200



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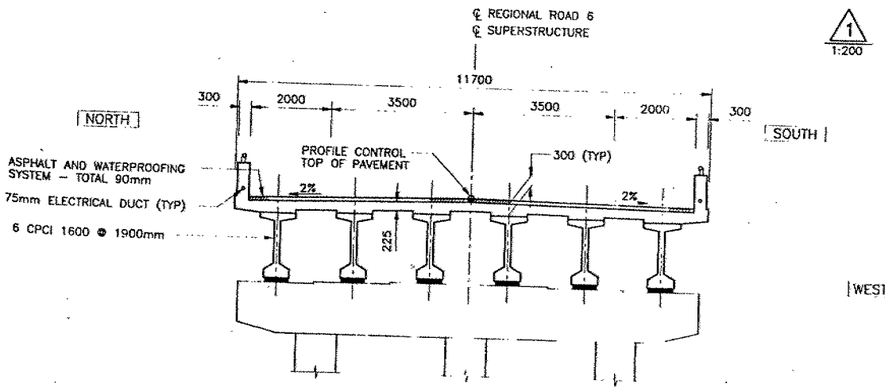

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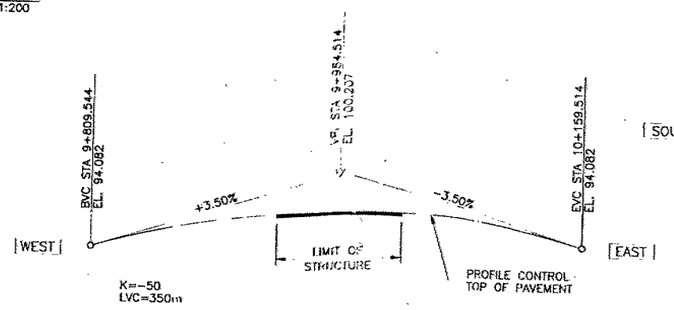
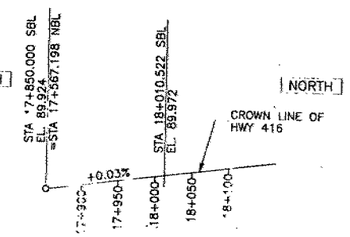
1:75



PROFILE OF REGIONAL ROAD 6
N.T.S.



PROFILE OF HWY 416 NORTHBOUND & SOUTHBOUND
N.T.S.

B.M. 89.403m
GEODETIC DATUM
...m EAST OF THE CENTRELINE OF ...WAY No. 16 3.5 km NORTH OF ...REGIONAL ROAD 6

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

CONT No 96-07
WP No 187-89-02
HWY 416 UNDERPASS
REGIONAL ROAD 6
GENERAL ARRANGEMENT

SHEET 143

UMA Engineering Ltd.
Engineers & Planners

GENERAL NOTES

1. CLASS OF CONCRETE

PRECAST CONCRETE GIRDERS	40 MPa
REMAINDER	30 MPa

2. CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100± 25
DECK	
TOP	70± 20
BOTTOM AND SIDES	40± 10
REMAINDER	70± 20

3. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

4. CONSTRUCTION NOTE.

a) THE CONTRACTOR SHALL ESTABLISH THE ACTUAL BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.

b) NO BACKFILL SHALL BE PLACED UNTIL DECK CONCRETE HAS REACHED 75% OF ITS SPECIFIED STRENGTH. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWINGS

OPSD 4010.00 GUIDERAIL AND CHANNEL ANCHORAGE

899

LICENSED PROFESSIONAL ENGINEER LESLIE A. MARTIN 24 96 PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER G. L. REID 24 Apr 96 PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	S.M.	CHKG	L.R	CODE	OHBDC-91	LOAD CLASS	'A'
DRAWN	M.P.	CHK	L.M.	SITE	03-576	STRUCT	SCHEME

DATE FEB 96
DWG. 1

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 48

P&D

(139)

WP 187-89-00

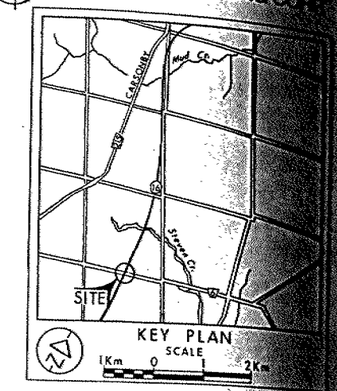
METRIC

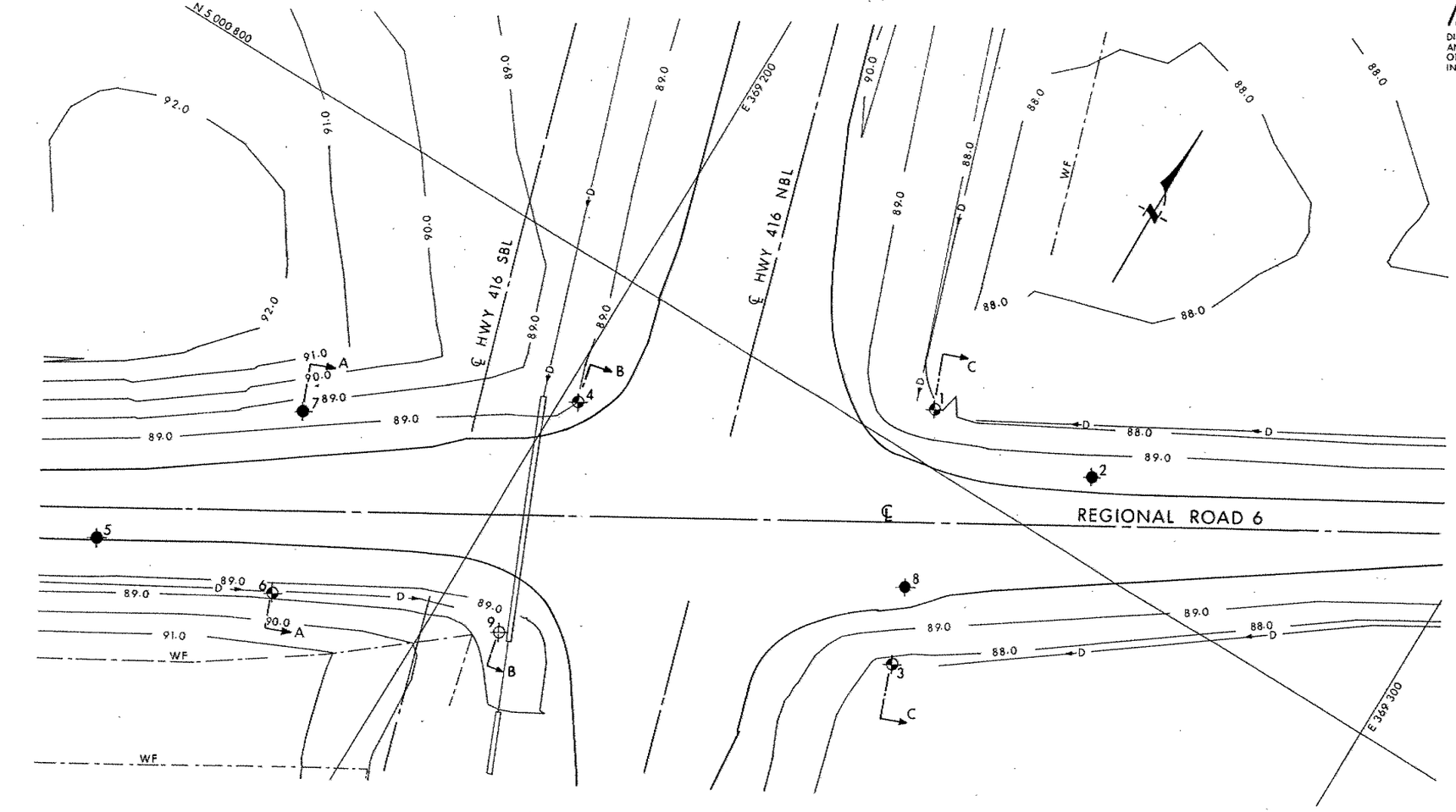
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No 96-07
WP No 187-89-02

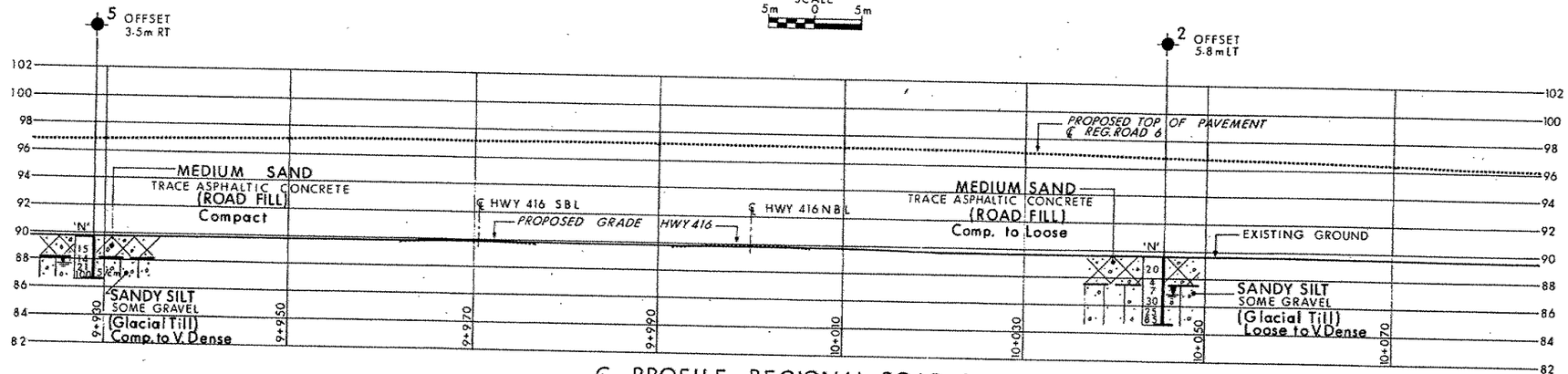
REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

STRATA ENGINEERING CO.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation Oct 1991

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 236.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 269.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
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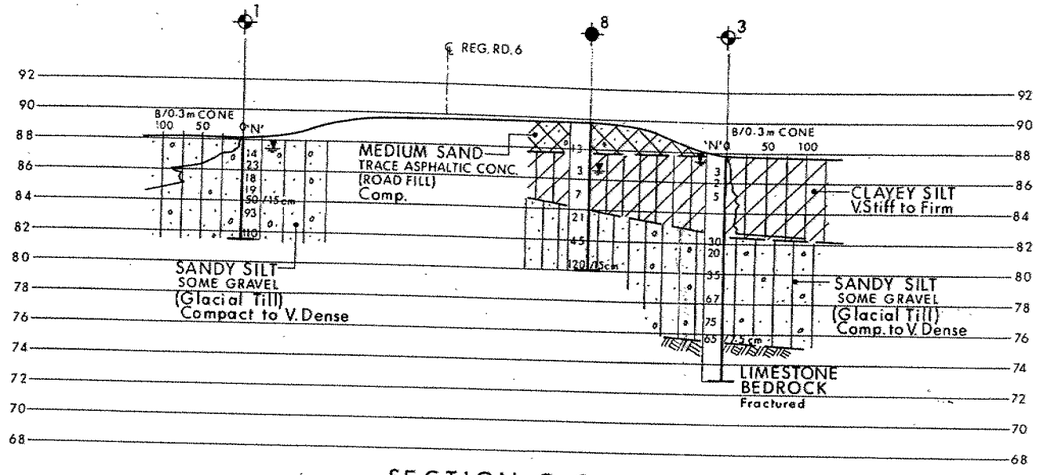
REV.	DATE	BY	DESCRIPTION

Geocres No

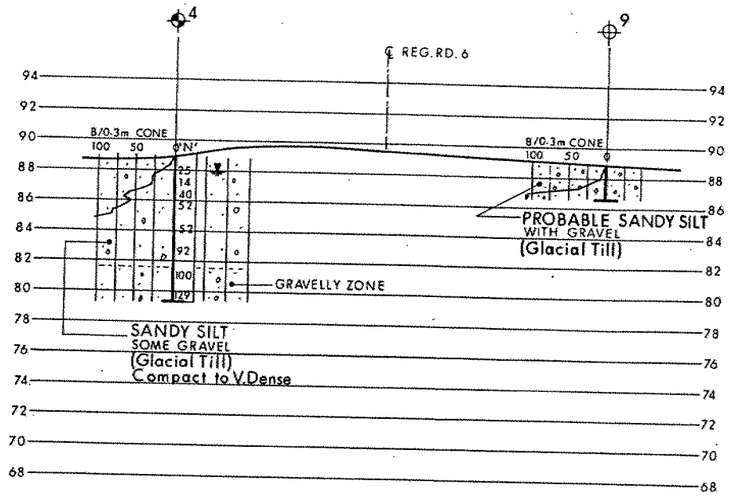
HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-A

REF No E-55-416-2, 1991 01

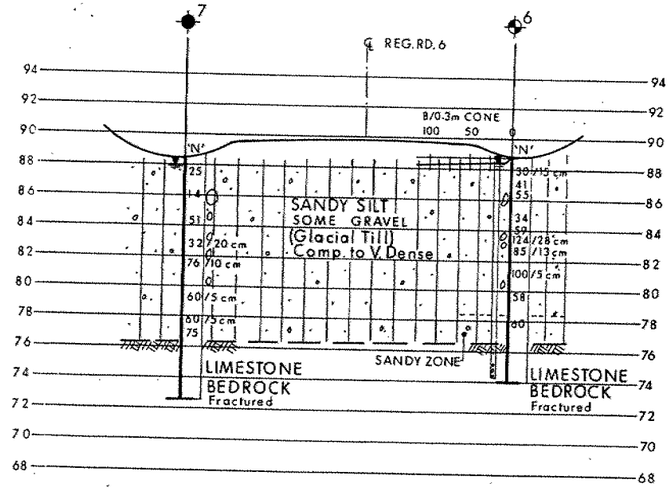


SECTION C-C

SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A

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

CONT No 96-07
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

SHEET 145

STRATA ENGINEERING CORP.

SEE DWG. No 1878902-A

KEY PLAN
SCALE

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L at time of investigation Oct. & Nov. 1990, Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
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REV.	DATE	BY	DESCRIPTION

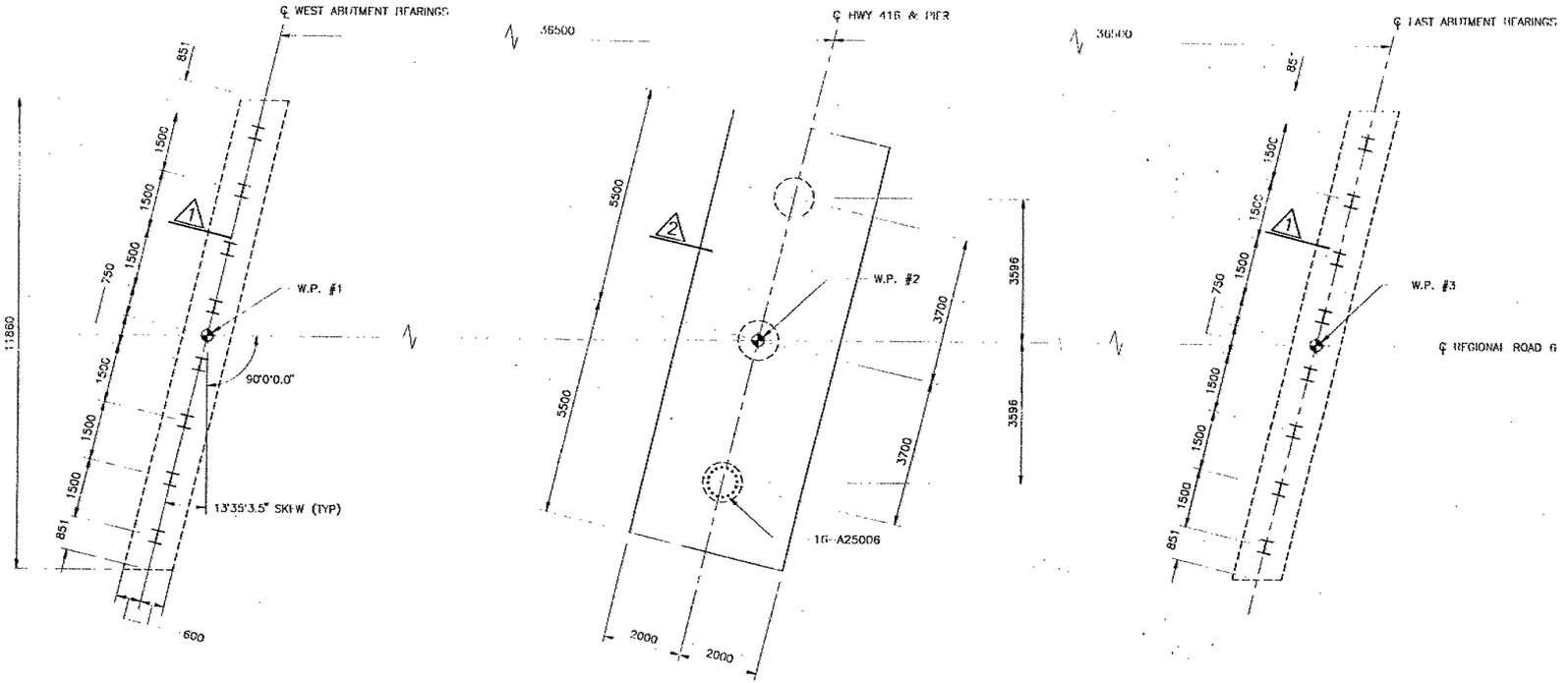
Geocres No

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 07 1992	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-B

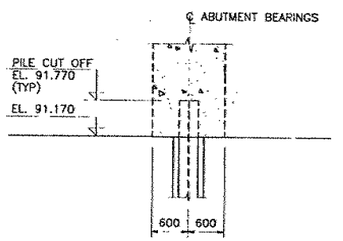
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 96-07
WP No 187-89-02
HIGHWAY 416 UNDERPASS
REGIONAL ROAD 6
FOUNDATION LAYOUT & FOOTING REINFORCEMENT
SHEET 146

UMA Engineering Ltd.
Engineers & Planners



FOUNDATION LAYOUT
1:75



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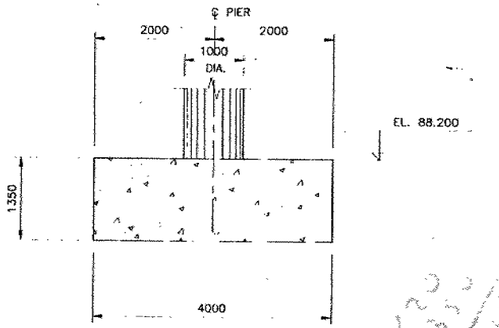

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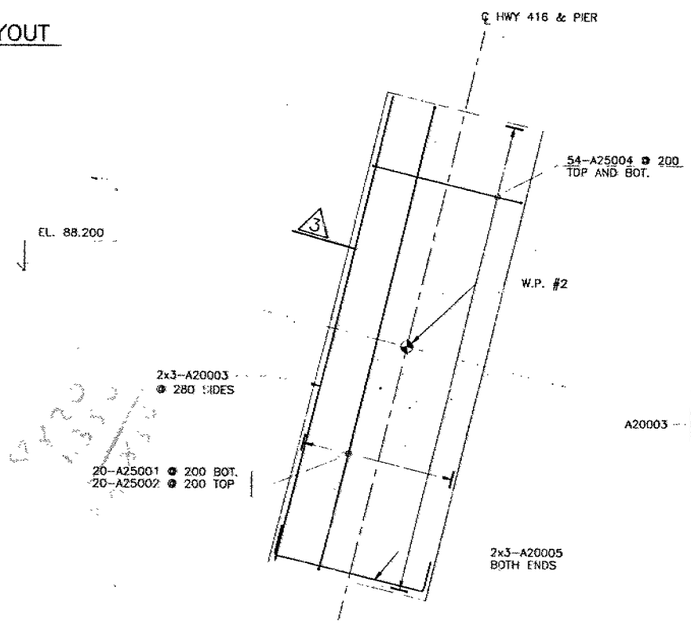
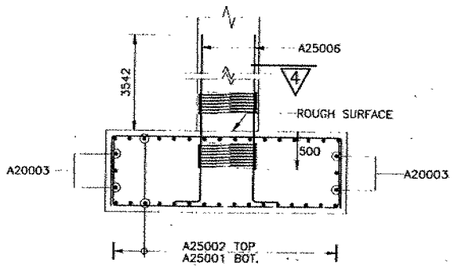


FOOTING REINFORCEMENT
1:75



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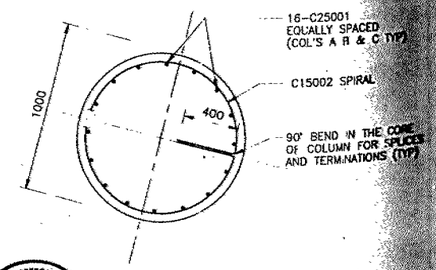

N.T.S.

NOTES:

1. ALL PILES TO BE HP 310x110 STEEL "H" PILES.
2. PILE SPACING TO BE MEASURED AT THE UNDERSIDE OF FOOTINGS.
3. PILE LENGTHS SHOWN ARE THEORETICAL LENGTH BELOW CUT-OFF ELEVATION.
4. ALL PILES SHALL HAVE DRIVING SHOES.
5. PILE DESIGN DATA:

   MAXIMUM COMBINED FACTOR LOADS:

   WEST ABUTMENT PILES:
   U.L.S. 1600 kN
   S.L.S. 1150 kN

   EAST ABUTMENT PILES:
   U.L.S. 1400 kN
   S.L.S. 950 kN

6. PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS103-11 USING AN ULTIMATE CAPACITY OF 3450 kN AT WEST ABUTMENT AND 3450 kN AT EAST ABUTMENT.

PILE DATA				
LOCATION	POSITION	No.	LENGTH	BATTER
EAST ABUT.	N. SIDE	4	9270	VERTICAL
	S. SIDE	4	16370	VERTICAL
WEST ABUT.	N. SIDE	4	9770	VERTICAL
	S. SIDE	4	9770	VERTICAL

WORKING POINT DATA			
WORK POINT	STATIONS	COORDINATES NORTH	EAST
#1	9+948.335	5000755.234	369177.323
#2	9+984.835	5000773.715	369208.801
#3	10+021.335	5000792.196	369240.277

APPLICABLE STANDARD DRAWINGS

OPSD 3301.00 SPLICE AND DRIVING SHOE DETAILS FOR STEEL 'H' PILES

LICENCED PROFESSIONAL ENGINEER
LESLIE A. MARTIN
2/9/96
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
G. L. REID
Apr 96
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN S.M.	CHK G.L.R	CODE OHBDC 91	LOAD CLASS 'A'	DATE FEB 96
DRAWN M.P.	CHK L.M.	SITE 03-576	STRUCT	SCHEME	DWG. 4

DRAWING NAME: FOUNDATION LAYOUT & FOOTING REINFORCEMENT
CREATED: 96/1/5 MODIFIED:

MINISTRY OF TRANSPORTATION, ONTARIO 85-75 PC-5-727

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 31G-213

DIST. 9 REGION

W.P. No. 187-89-02

CONT. No. 96-07

W. O. No.

STR. SITE No. 3-576

HWY. No. 416

LOCATION Hwy 416 - ~~Century Rd.~~ To Reg. Rd. 6

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

STRATA ENGINEERING CORP.
RESEARCH • ENGINEERING • SCIENCE
Tel.: (416) 441-2560
Fax: (416) 441-4161
Suite 120, 170 The Donway West,
Don Mills, Ontario, Canada M3C 2G3

FOUNDATION INVESTIGATION REPORT

for

Regional Road 6

W.P. 187-89-02, District 9, Ottawa
Highway 416, Str. Site: 3-576

Strata Project E-90-037C

Date of Submission: 1992 08 31

Report Distribution :

UMA Engineering	15 copies
Strata File E-90-037C	1 copy

E-90-037C

TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT
for
Regional Road 6

W.P. 187-89-02, District 9, Ottawa
Highway 416, Str. Site: 3-576

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by UMA Engineering Ltd. to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 and Regional Road 6 (Roger Stevens Drive). The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report in accordance with the requirements of the Foundation Design Section of the MTO.

This report, which follows a letter report dated 1991 01 23, complies with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located approximately 30 km south of Ottawa along Highway 16. The location of the site is shown on the key plan in Drawing 1878902-A, appended. The centre line of the new southbound lanes will be located some 30 m west of existing Highway 16. Therefore, the underpass to carry Regional Road 6 across the new highway will be a two span structure with abutments located to the east and west respectively of the existing highway and the proposed southbound lanes of the new highway. The proposed centre pier will be situated west of the west shoulder rounding of the existing highway, which has been widened at this intersection to accommodate turning lanes.

The site lies within the physiographic area known as the North Gower Drumlin Field. The drumlins have a north-south orientation. The area has been inundated by the Champlain Sea which has caused the drumlins to be covered with a mantle of marine soil, predominantly silt and Leda clay. Bedrock in this area has been mapped as magnesium limestone to dolostone of the Oxford Formation, Lower Ordovician age.

3.0 FIELD AND LABORATORY WORK

The field work was carried out in two phases. The initial investigation was conducted between 1990 10 02 to 1990 11 01, and consisted of the drilling of seven boreholes, five of which were accompanied by a dynamic cone penetration test. Four boreholes were drilled at the corners of the proposed abutments and one near the centre pier. The remaining two boreholes were drilled away from the structure to provide information for the approach fills. The second phase of the investigation, from 1991 11 12 to 1991 11 13, was conducted in order to more completely define the soil stratigraphy at the east abutment location. It consisted of the drilling of one additional borehole (BH 8) and a dynamic cone penetration test (BH 9) to the south of the proposed pier location.

Borehole elevations are referenced to Geodetic datum and were supplied by UMA Engineering. The locations of the boreholes and dynamic cone penetration tests are shown on Drawings 1878902-A and -B.

Drilling was conducted with Bombardier mounted CME 55 drill rigs. Hollow stem augers were used to advance the boreholes. Boreholes 2 and 5 for the approach embankments were terminated within the highest competent stratum. Bedrock was proven by coring in three boreholes near the proposed structure abutments and pier.

Standard Penetration Tests were performed to sample very stiff to hard cohesive and all non-cohesive deposits, the accompanying N values being noted in blows/0.3 m. In cohesive strata and in Borehole 3, relatively undisturbed samples were obtained by pushing thin-walled Shelby tubes either manually or hydraulically into the soil. In situ vane shear testing was conducted using a standard MTO A size vane in the cohesive strata. Remoulded shear strengths were also measured to determine sensitivity.

Upon completion, water levels were measured in the uncased holes. In Borehole 6, a standpipe was installed for longer term water level monitoring. The other holes were backfilled with native soil cuttings. The site was then restored to its original condition. Due to its proximity to the travelled roadway, no long term water level observation standpipe was installed in Borehole 8.

Recovered samples were transported to our Don Mills Laboratory for further visual examination, classification and index property testing such as moisture content, grain size distribution and Atterberg limits. One consolidation test was performed. The results are shown on the Record of Boreholes and on Figures 1 to 4, appended.

4.0 SUBSURFACE CONDITIONS

4.1 General

Over most of the site, a dense sandy silt glacial till overlies limestone bedrock. In the southeast area of the site, the till is overlain by a wedge of clayey silt. The groundwater table lies within a metre or so of ground surface.

4.2 Medium Sand (Road Fill)

In Boreholes 2 and 5 for the approaches and in Borehole 8 at the proposed east abutment location, a brown medium sand with traces of asphaltic concrete is present from the surface to depths ranging from 1.7 m to 2.1 m below ground surface. The moisture content ranges from 10 to 25 per cent. A typical grain size distribution curve is shown on Figure 1.

The N values from the Standard Penetration Resistance test ranged from 20 to 4 blows/0.3 m, generally decreasing with depth, indicating a compact to loose relative density of the road fill material.

4.3 Clayey Silt

A brown to grey clayey silt deposit was found in Boreholes 3 and 8 at the south corner of the east abutment. The deposit in Borehole 3 was 5.3 m thick, and in Borehole 8 it was 3.7 m thick.

The moisture content of this material ranged from 30 to 48 per cent. Atterberg limit test results (Figure 2) show the soil to be of low plasticity (CL). The moisture content is generally higher than the liquid limit, indicating a liquidity index of greater than unity.

N values in this deposit ranged from 2 to 7 blows/0.3 m. Field vane tests indicate the undrained shear strength of the deposit to be over 100 kPa above about elev. 86± m, below which the strength decreases to between 45 and 75 kPa around elev. 84± m. The sensitivity of the soil ranged between 6 and 8. Based on these observations the deposit is considered to be very stiff to firm.

One consolidation test on a sample from Borehole 3 is shown on Figure 3. A strict interpretation of the preconsolidation pressure, using the Schmertmann method, gives a preconsolidation pressure, p_c, of about 200 kPa. However, from visual inspection of the e-log p curve, the p_c value ranges between 150 kPa and 180 kPa. The compression index, C_c, is 0.180. The recompression index, C_r, is 0.02. Since the existing effective overburden pressure at the location of the sample is about 30 kPa, the clayey silt appears to be overconsolidated by about 120 to 150 kPa.

4.4 Sandy Silt with some Gravel (Glacial Till)

Below the clayey silt in Boreholes 3 and 8, and the road fill material in Boreholes 2 and 5, and from surface down in the remaining boreholes, there is a sandy silt with some gravel (glacial till), with random boulders and cobbles. Typical grain size curves for the sandier portions of the deposit are shown in envelope form in Figure 4A. Gravelly zones and less silty zones within this deposit are plotted on Figure 4B. N values in this deposit ranged between 7 and in excess of 100 blows/0.3 m, generally increasing with depth. The lower N values were observed within the upper zones of the deposit and may be due to local re-working of the till. The dynamic cone penetration tests all terminated within this deposit. Based on these N values, the deposit is considered to be very dense with localized loose to compact zones near the surface.

4.5 Limestone Bedrock

Limestone bedrock was proven by coring in Boreholes 3, 6 and 7. The core recoveries were between 70 and 100 per cent. The thinly bedded rock has a maximum RQD value of 55 per cent, most values being about 30 per cent. Based on the measured RQD's the bedrock quality is very poor to fair.

5.0 GROUNDWATER CONDITIONS

Groundwater observations are summarized below:

Borehole	W.L. Elev.(m)	Depth (m)	Date
1	87.4	0.7	1990 10 03
2	86.8*	2.8	1990 10 02
3	87.4	0.4	1990 10 16
4	87.9	1.0	1990 10 04
5	87.8	1.8	1990 10 05
6	88.4	0.4	1990 11 02
7	87.9	0.6	1990 11 02
8	86.6	3.2	1991 11 13

* Not stabilized

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to construct southbound lanes to upgrade existing Highway 16 to a 4 lane freeway standard. This will entail raising Regional Road 6 (Roger Stevens Drive) and carrying it across the four lanes of the proposed new Highway by means of a two span underpass. The centre pier will be located in the area of the west ditching of the present two lane highway. Regional Rd. 6 is situated at about elevation 90.0 m. The approach fills are expected to be about 7.0 m in maximum height above prevailing ground surface.

It is presumed that a detour of the present Regional Rd. 6 will be built to facilitate the construction of the new underpass.

The subsurface conditions comprise a variably thick stiff to firm clayey silt deposit in the south half or third of the proposed east abutment overlying a generally dense sandy silt glacial till over limestone bedrock. The glacial till deposit occurs at the surface or just below fill material at the proposed west abutment and centre pier locations. The groundwater table is situated within a metre or so of ground surface.

6.2 Structure Foundation Design

Except for a localized 4 m to 5 m thick compressible clayey silt deposit in the southeastern portion of the site, the subsurface conditions are generally suitable for the support of the proposed structure on spread footings.

For the entire structure the design options are:

1. Spread footing support, with complete excavation and replacement of clayey silt.
2. Spread footing support, except for east abutment, which can be supported on piles.
3. Pile support.

The selection of an appropriate design option will depend on economic considerations and regard for long term maintenance consequences.

All footings and pile caps should be provided with a minimum earth cover of 1.8 m for protection against frost action.

6.2.1 Spread Footing Option

For spread footing support, both proposed abutments may be supported on compacted Granular A (see Figure 5), using the following capacities:

Factored Capacity at ULS	900 kPa
Capacity at SLS Type II	350 kPa

The Granular A core should be built up from elevation 88.0 m for the west abutment and from the glacial till stratum at elev. 82± m for the east abutment. Suggestions for the excavation of the clayey silt at the east abutment location are given in Section 6.6 of this report.

The centre pier, placed on spread footings within the sandy silt glacial till deposit at elevation 86.6 m, below the prevailing water table, may be designed for the following capacities (assumed footing width = 4 m):

Factored Capacity at ULS	1000 kPa
Capacity at SLS Type II	400 kPa

The sliding resistance of spread footings may be computed using the following unfactored values:

Effective Angle of Internal Friction ϕ'	35°
Effective Cohesion Intercept, c'	0 kPa

The unit weight of backfill should be taken as per section 6.3 below.

The total elastic settlement due to compression of the foundation soil below the spread footings is expected to be less than 25 mm; hence, the differential settlement between the Granular A supported abutments and centre pier will likely be in the order of 15 mm.

6.2.2 Pile Foundation Option

The abutments and pier of the entire structure, or the east abutment only, may alternatively be supported on a piled foundation designed for the following axial capacities, for example for HP 310x110 steel H piles:

Factored Axial Capacity in ULS	1600 kN
Axial Capacity in SLS Type II	1150 kN

Downdrag loads on the piles below the proposed east abutment are not considered to be significant to warrant lower capacities for the piles penetrating the clayey silt deposit.

Due to the presence of cobbles and occasional boulders at depth, the piles should be driven with reinforcing toes, using an energy of not less than 50 kJ to achieve the intended axial capacities.

Pile toes are likely to penetrate to the following anticipated elevations:

West Abutment

North Side	76.3	On bedrock
South Side	76.5	On bedrock
Centre Pier	79.5	Within glacial till - use Hiley formula to control pile driving, per MTO practice.
East Abutment		
North Side	81.5	Within glacial till - use Hiley formula to control pile driving.
South Side	75.5	On bedrock

In order to calculate bridge deck support elevations across the proposed east abutment, the elastic shortening of the piles should be computed using the formula:

$$\text{Elastic shortening} = PL/AE$$

where:

P = design load;
L = length of pile, interpolated from Section C-C, Drawing 1878902-B, assuming pile toe to penetrate to bedrock or to depth where N values are >100 blows/0.3 m;
A = cross-sectional area of the pile section chosen;
E = modulus of elasticity of steel

Allowance for a maximum differential settlement of 10 mm should be made between a pile supported east abutment and a spread footing supported centre pier, the centre pier settling relative to the pile supported east abutment.

6.3 Earth Pressures

Earth pressures should be computed as per sub-section 6-6.1.2.2 of the OHBD Code. An unyielding foundation condition should be assumed for a piled foundation and a yielding condition for spread footing support, in the selection of at-rest or active earth pressure coefficients respectively. The Granular A or B backfill should be in accordance with MTO Special Provision No. 109F03 (latest revision).

The following design parameters are recommended for granular backfill to abutments and wing walls:

	Granular A	**Granular B**
Effective Angle of Internal Friction, ϕ'	35.0°	30.0°
Unit Weight (kN/m^3), γ	22.8	21.2

Surcharge effects, if any, should be computed as per Clause 6-6.1.2.4 of the OHBD Code.

6.4 Approach Embankments

The approach grades will be at about elevation 97 m, resulting in fill heights of some 6-7 m. The stability of such fills was checked using total stress analyses for the case of the east approach fill above the clayey silt deposit. The analyses show adequate total factor of safety against deep seated rotational failure, provided the side and forward fill slopes are maintained at 2H : 1V, or flatter.

The settlement of a 6-7 m high fill at the west approach will occur during placement and will be negligible after construction.

The presence of the clayey silt deposit below the east approach fill will result in long term settlements of about 30 mm for a 6-7 m high east approach fill. If the clayey silt soil is excavated, then settlements will be immediate during fill construction, and negligible thereafter.

6.5 Construction of Centre Pier

Construction of the centre pier footing will require dewatering. The presence of cobbles and boulders within the silty sand glacial till deposit precludes the use of sheet piling to serve as a positive seepage cutoff. For the same reason, and for reasons of cost, well point dewatering may not be practical.

Therefore, consideration should be given to gravity drainage of the excavation, by making it larger than the footing. One means of achieving dewatering of the excavation by gravity drainage is shown on Figure 6. The ditching shown on Figure 6 may be taken all around the footing, or be left to one side, depending on traffic control and road protection considerations. As a minimum, the nearest travelled vehicle wheel path should be no closer than the maximum depth of the excavation ditching, or 2 m, whichever is less.

6.6 Excavation and Backfilling of Clayey Silt

The clayey silt deposit extends vertically below the southern portion of the east abutment and laterally probably extends below the existing Regional Road 6 pavement (refer Section C-C, Drawing 1878902-B).

The clayey silt will need to be completely removed from within a trapezoidal zone, as defined by the 1:1 sloping lines of Figure 5, extended down to the glacial till stratum.

After construction of the detour for Regional Rd. 6, excavation of the clayey silt should commence from the north end, working towards the south. There are two methods available for excavation - one in an east-west direction, across the abutment footing width, and the other in a north-south direction spanning the entire length of the abutment footing. The choice should be left up to the contractor who should submit a proposal of the intended excavation and engineered backfill scheme for review from a geotechnical view point. Contract conditions imposed for excavation and backfilling should include:

1. No clayey silt shall be trapped within the limits of excavation defined.

2. Excavation stability shall be maintained at all times.

3. Provisions of the current Ontario Occupational Health and Safety Act relative to excavations shall be complied with.

4. Granular A backfill shall be accomplished in loose lifts not exceeding 200 mm in thickness, with each lift being compacted to 100 per cent of the Standard Proctor density of the material being used.

5. All Granular A placement and compaction shall be in the dry.

The granular fill below the pavement will be stable at temporary slopes of 1:1. The clayey silt will stand up at 1:1 temporary slopes during excavation to the maximum depth of 6 m, for excavations left open for not more than 48 hours. Seepage of groundwater from the clayey silt stratum is expected to be capable of being handled by routine pumping using a submersible pump, with a minimum capacity of 10 L/s.

The contract should specify that no excavation should be left open overnight or at the end of a working day.

For quantity estimating purposes, assume the quantity of clayey silt removal to be 1.1 times the neat excavation quantity and the Granular A to be 1.25 times the neat excavated quantity, due to the high probability of loss through contamination and pick-up of previously placed materials with the excavated material.

The excavated material is not considered suitable for re-use on the project, and should be disposed off.

6.7 Recommended Option

There are numerous problems associated with the excavation of the clayey silt, including not only the consideration of how a 6 m deep hole will be backfilled and compacted with Granular A without encountering severe difficulties, but also through considerations of:

- danger to equipment and workers from potential instability of the excavated side slopes;
- disposal of the clayey silt, which has a liquidity index of greater than unity;
- field control of compaction achieved;
- ensuring all softened material has been removed from within the specified excavation zone;
- Falsework support considerations (the falsework can not be situated within 5 m of the nearest excavation boundary).

Therefore, supporting the east abutment on a piled foundation is the preferred alternative. The decision to use piling also for the central pier (to avoid large excavations and dewatering problems) and for the west abutment will depend on economic and structural design considerations, which are beyond the scope of this report.

7.0 CLOSURE

The drilling was supervised by A. C. Abel. Drill rigs were rented from F. E. Johnston and Marathon Drilling companies, Ottawa.

Several reviews of this report have been conducted between initial issue and this submission. We are grateful for the many constructive suggestions received in its finalization.

Respectfully submitted:
STRATA ENGINEERING CORP.

A. C. Abel, M. Sc.
Project Engineer

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Senior Principal

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APPENDIX

Explanation of Terms Used in Report

Record of Boreholes 1 to 9

Figures 1 - 6

Drawings 1878902-A and B

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No1

METRIC

W P 187-89-02 LOCATION N: 5 000 806 ; E: 369 238 ORIGINATED BY S.S.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
88.1	Ground Surface						88.0				
0.0	Sandy Silt Some Gravel (Glacial Till)					▼					W. L. on 1990 10 03
	Compact		1	SS	14		87.0				
			2	SS	23						11 31 (58)
	Brown						86.0				
			3	SS	18						
			4	SS	19		85.0				
			5	SS	50/15cm.						11 37 (52)
	Very Dense						84.0				
			6	SS	93						
	Grey						83.0				
							82.0				
81.4			7	SS	110						
6.7	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No2 METRIC

W P 187-89-02 LOCATION N: 5 000 809 ; E: 369 258 ORIGINATED BY S. S.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, * QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Concrete (Road Fill)						89.0				
	Compact to Loose		1	SS	20				o		0 79 (21)
	Brown		2	SS	4		88.0		o		
87.5											
2.1	Sandy Silt Some Gravel (Glacial Till)		3	SS	7	▽	87.0		o		W.L. on 1990 10 02
	Loose to V.Dense Brown		4	SS	30				o		
			5	SS	25		86.0		o		25 30 (45)
	Grey										
84.6			6	SS	85		85.0		o		
5.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 ; Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No3

METRIC

W P 187-89-02 LOCATION N: 5 000 778 ; E: 369 249 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 03 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
87.8	Ground Surface										
0.0	Clayey Silt V.Stiff to Stiff		1	SS	3	▽	87.0				W. L. on 1990 10 16
	Brown		2	SS	2		86.0				
			3	SS	5		85.0				
	Grey		4	TW	PH		84.0			19.3	Consol. Test Fig.3
82.5			5	TW	PM		83.0				
5.3	Sandy Silt Some Gravel (Glacial Till)		6	SS	30		82.0				
			7	SS	20		81.0				
	Compact to V.Dense		8	SS	35		80.0				13 39 (48)
			9	SS	67		79.0				
	Grey						78.0				
			10	SS	75		77.0				
75.4			11	SS	65/ 7.5cm.		76.0				
12.4	Limestone Bedrock		12	BX RC	Rec 94%		75.0				RQD = 54%
			13	BX	83%		74.0				RQD = 0%
72.8			14	BX RC	Rec 86%		73.0				RQD = 53%

15.0 End of Borehole

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No4

METRIC

W P 187-89-02 LOCATION N: 5 000 785 ; E: 369 201 ORIGINATED BY SS

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 04 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT N (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
88.9	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Compact Brown		1	SS	25	▼	88.0				7 35 (58) W. L. on 1990 10 04
			2	SS	14		87.0				
			3	SS	40		86.0				
	Very Dense		4	SS	52		85.0				
			5	SS	52		84.0				17 34 (49)
	Grey		6	SS	92		83.0				
			7	BX	Boulder		82.0				
	Gravelly Zone		8	SS	100		81.0				41 33 (26)
79.3			9	SS	129		80.0				
9.6	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No5

METRIC

W P 187-89-02 LOCATION N: 5 000 742 ; E: 369 162 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger. COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 05 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Conctrete (Road Fill)						89.0				
	Compact		1	SS	15				e		
88.1	Brown										
1.5	Sandy Silt Some Gravel (Glacial Till)		2	SS	14	▽	88.0		o		W. L. on 1990 10 05
	Compact to V. Dense		3	SS	21		87.0		o		12 38 (50)
86.5	Brown		4	SS	100/5cm				o		
3.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

15 (20/10) 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No6

METRIC

W P 187-89-02 LOCATION N: 5 000 747 ; E: 369 183 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	WATER CONTENT (%) PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.8	Ground Surface							SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE			
0.0	Sandy Silt Some Gravel (Glacial Till)		1	SS	30/15cm.	Seal	88.0				W. L. on 1990 10 31
	Brown		2	SS	41		87.0				
			3	SS	55						16 36 (48)
	Compact to V. Dense		4	BX	Boulder		86.0				
			5	SS	34		85.0				
	Randomly placed Boulders		6	SS	59		84.0				
			7	BX	Boulder						
			8	SS	124/28cm.						
			9	BX	Boulder		83.0				
			10	SS	85/13cm.						
	Grey						82.0				
			~~11~~	~~SS~~	~~100/5cm~~		81.0				
			12	BX	Boulder						
			13	SS	58		80.0				
							79.0				
	Sandy Zone		14	SS	60		78.0				13 69 (18)
76.5							77.0				
12.3	Limestone Bedrock		15	BX RC	Rec 83%						RQD = 0%
			16	BX RC	Rec 96%		76.0				RQD = 55%
			17	BX RC	Rec 70%						RQD = 47%
			18	BX RC	Rec 83%		75.0				RQD = 30%
73.9							74.0				
14.9	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 (20/10) 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7

METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.5	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Brown		1	SS	26	▽	88.0		o		W.L. on 1990 11 02
			2	BX	Boulder		87.0				
			3	SS	14		86.0		o		16 37 (47)
	Compact to V. Dense						85.0				
			4	BX	Boulder						
	Randomly placed Boulders		5	SS	51		84.0		•		
			6	BX	Boulder		83.0				
			7	SS	32/10cm				•		
			8	BX	Boulder		82.0				
	Grey		9	SS	76/10cm				o		
			10	BX	Boulder		81.0				
			11	SS	60/5cm.		80.0		o		
			12	SS	60/5cm		79.0				
			13	SS	75		78.0		o		
76.3							77.0				
12.2	Limestone Bedrock		14	BX RC	Rec 100%		76.0				RQD = 25%
			15	BX RC	Rec 82%		75.0				RQD = 37%
73.5	Cont. on Sheet 2						74.0				
15.0											

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

RECORD OF BOREHOLE No 7 cont'd

METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa: o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
73.5	Cont. from Sheet 1										
15.0 / 72.5			16	BX RC	Rec 100%		73.0				RQD = 56%
16.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9

METRIC

W P 187-89-02 LOCATION N: 5 000 757.0 E: 369 208.0 ORIGINATED BY G.N.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY A.A.

DATUM Geodetic DATE 1991 11 12 CHECKED BY C.M.

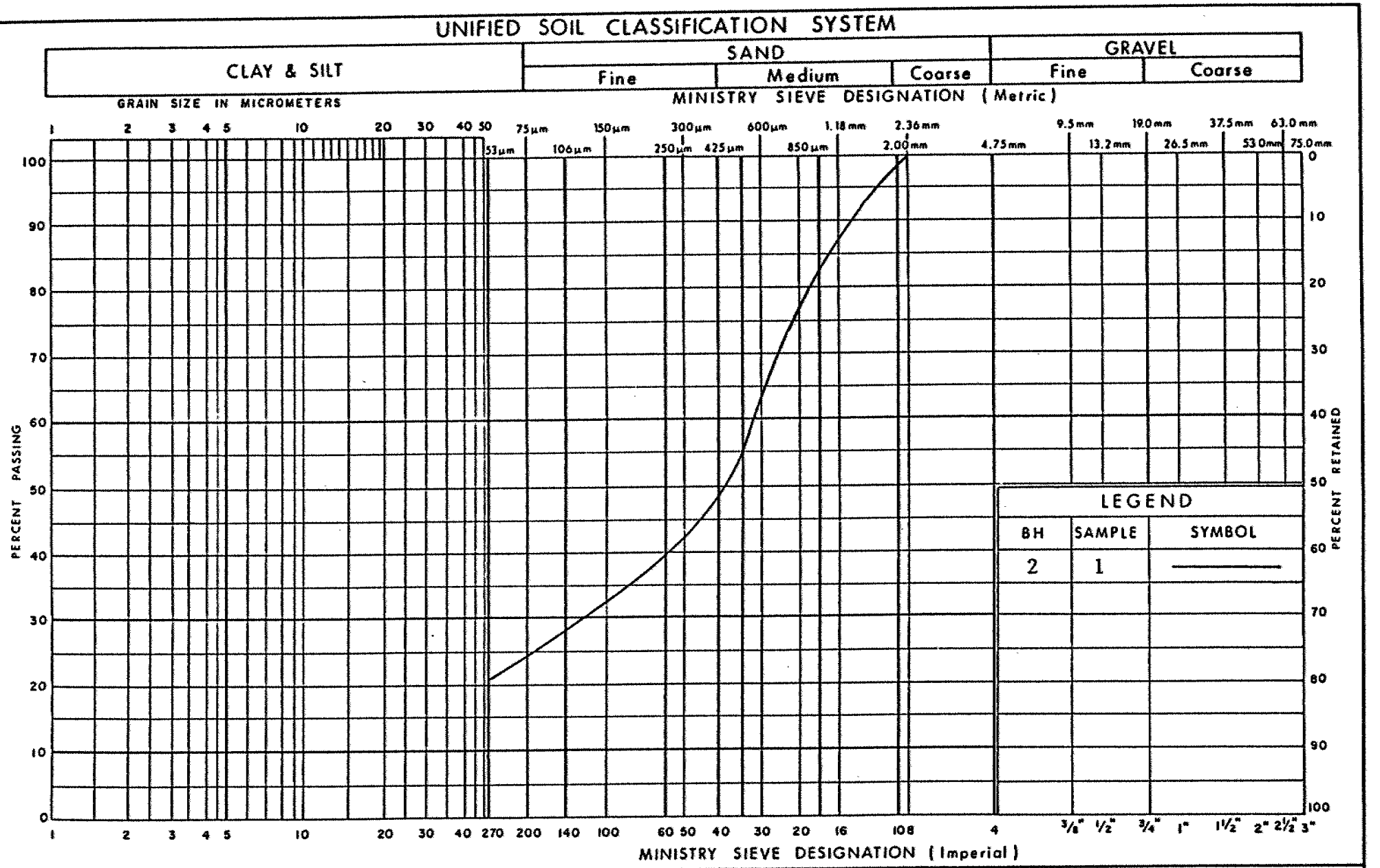
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT Wl WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
88.9	Ground Surface										
0.0	Probable Sandy Silt with Gravel (Glacial Till)						88.0				
86.6							87.0				
2.3	End of Conetest										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

78 12 M



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

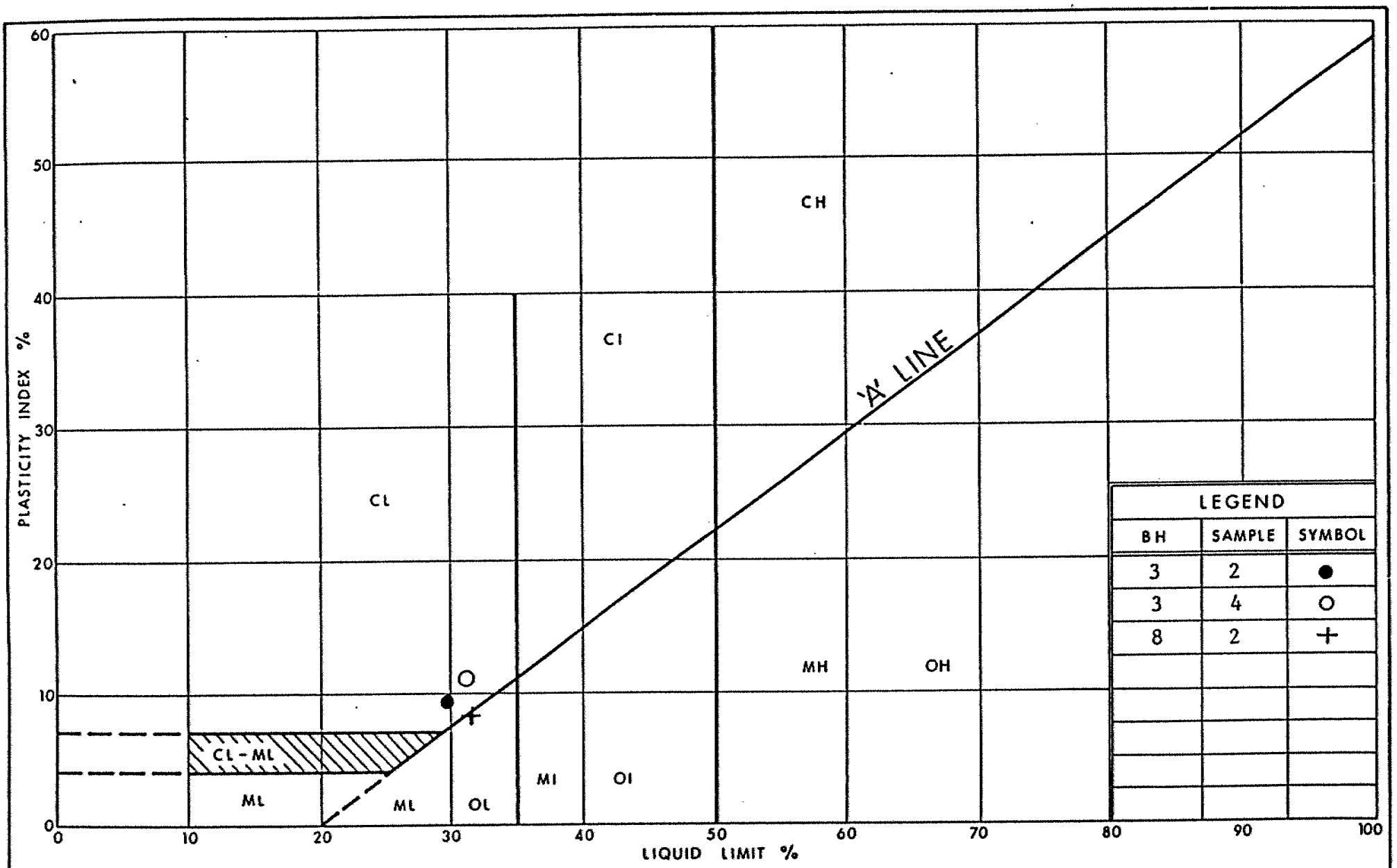
Medium Sand
(Road Fill)

FIG No 1

W P 187-89-02

Reg. Rd. 6/ Hwy. 416

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

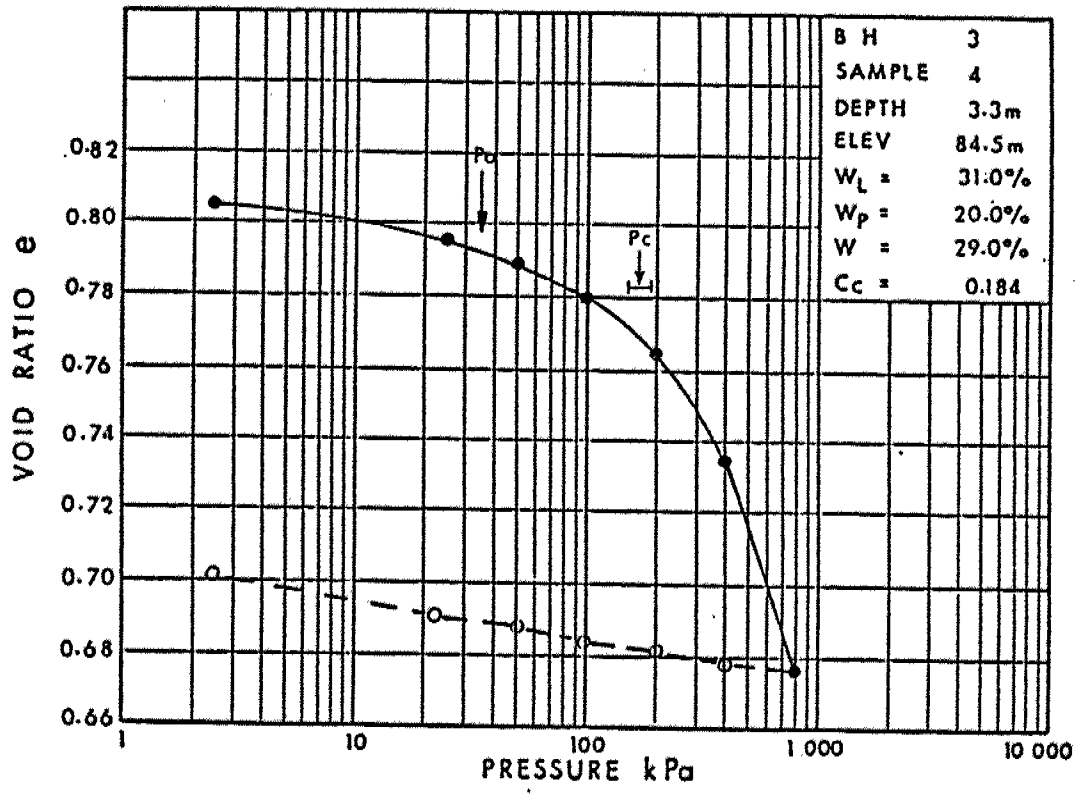
Clayey Silt

FIG No 2

W P 187-89-02

Reg. Rd. 6/Hwy. 416

VOID RATIO - PRESSURE CURVES



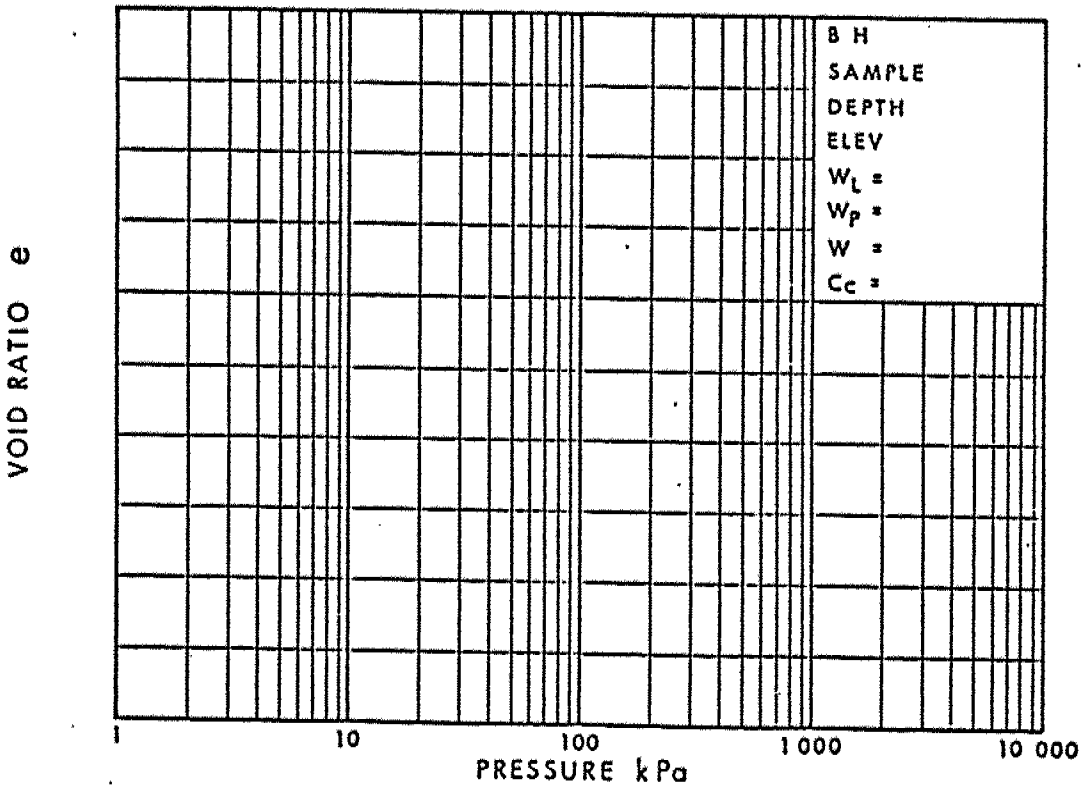
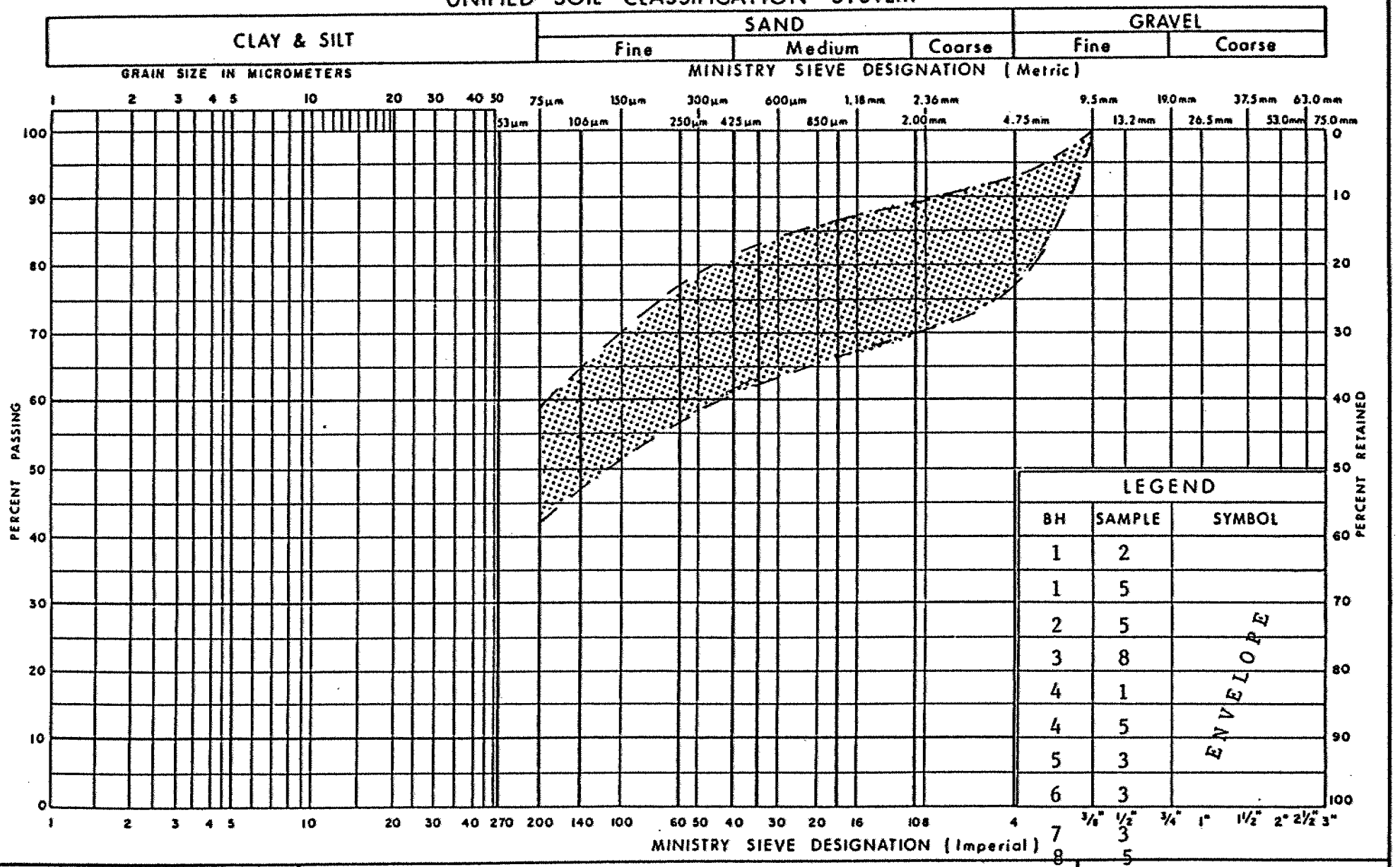


Fig 3

WP 187-89-02

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

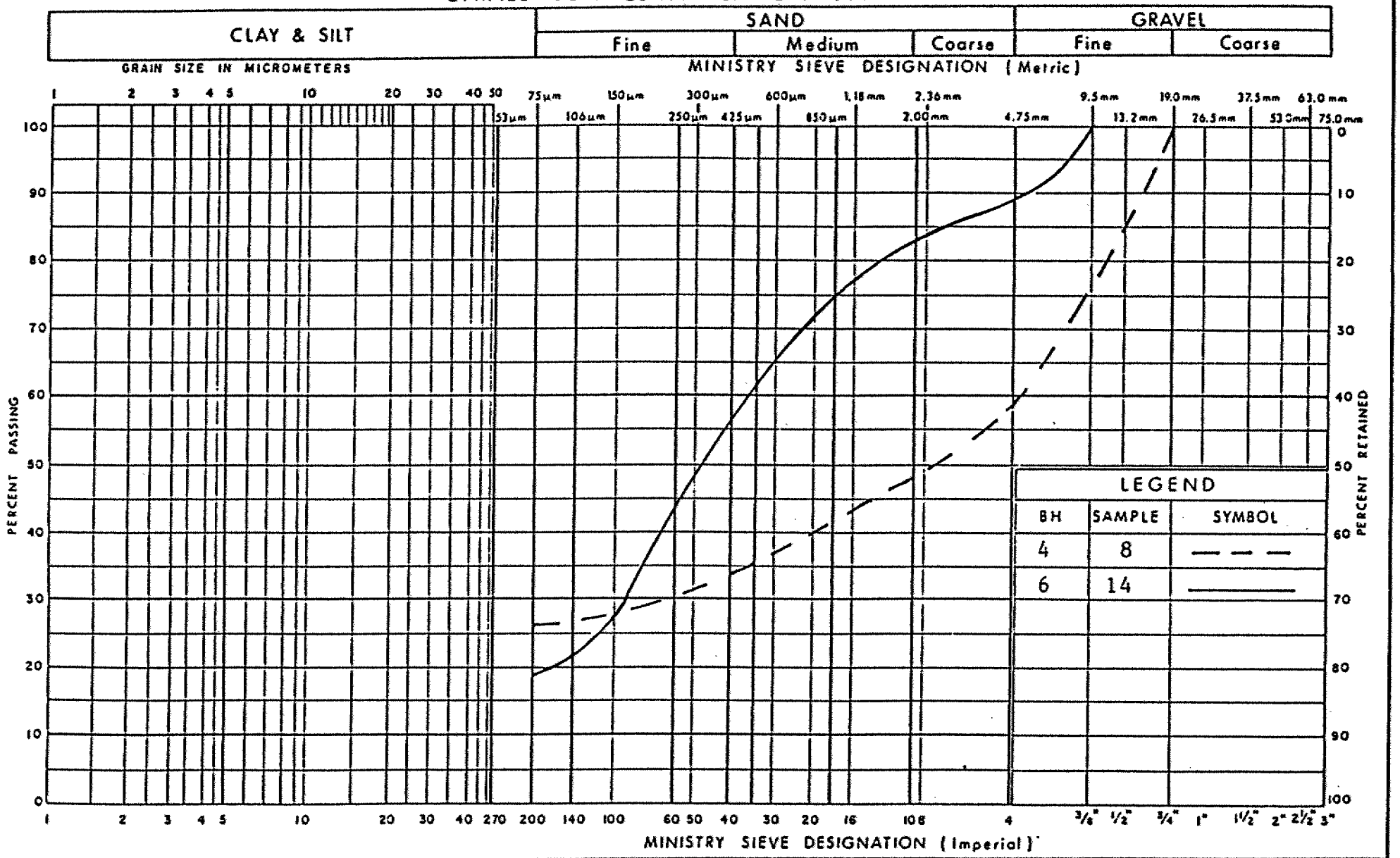
GRAIN SIZE DISTRIBUTION

Sandy Silt, some Gravel
(Glacial Till)

FIG No 4A
W P 187-89-02
Reg. Rd. 6/Hwy. 416

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM

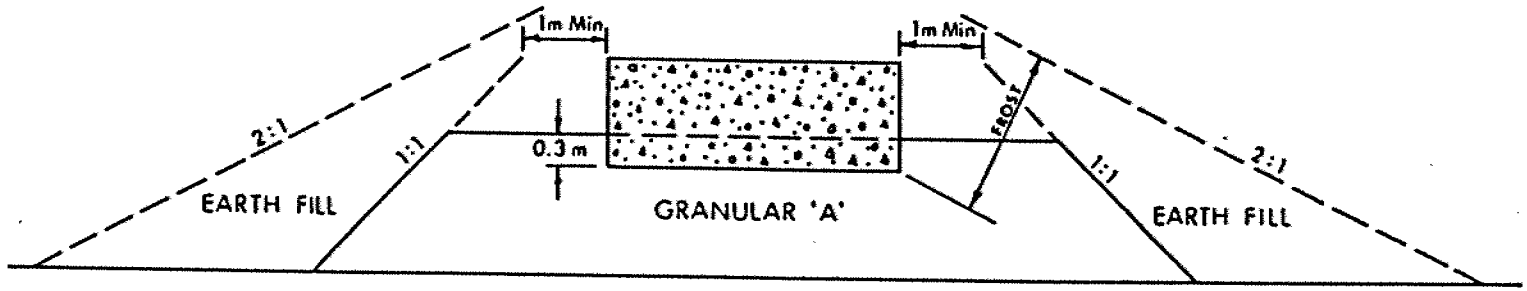


Ministry of Transportation
Ontario

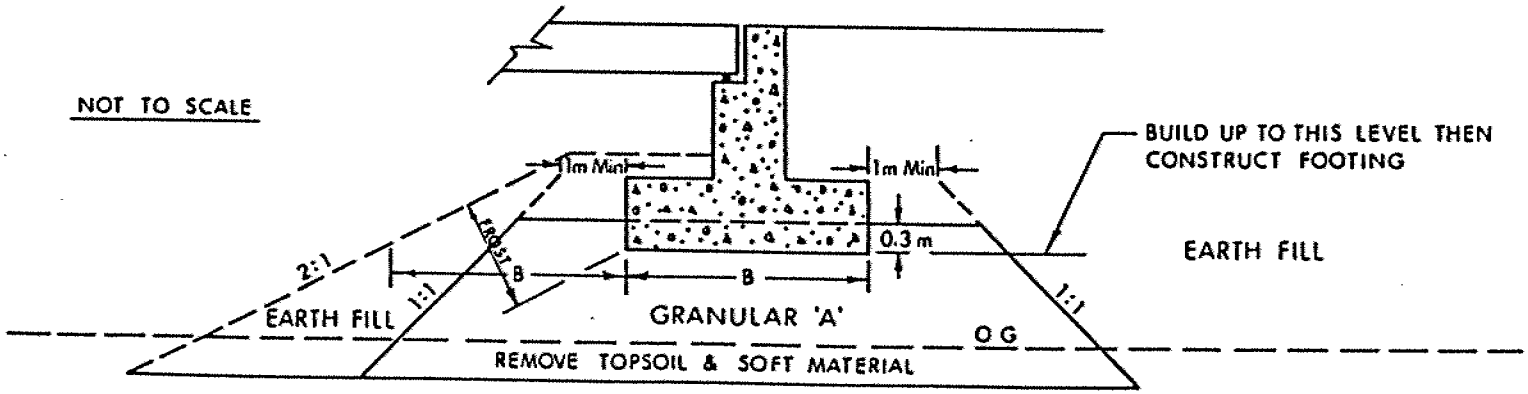
GRAIN SIZE DISTRIBUTION

Sandy and Gravelly Zones within Glacial Till

FIG No 4B
W P 187-89-02
Reg. Rd. 6/Hwy. 416



X SECTION



LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

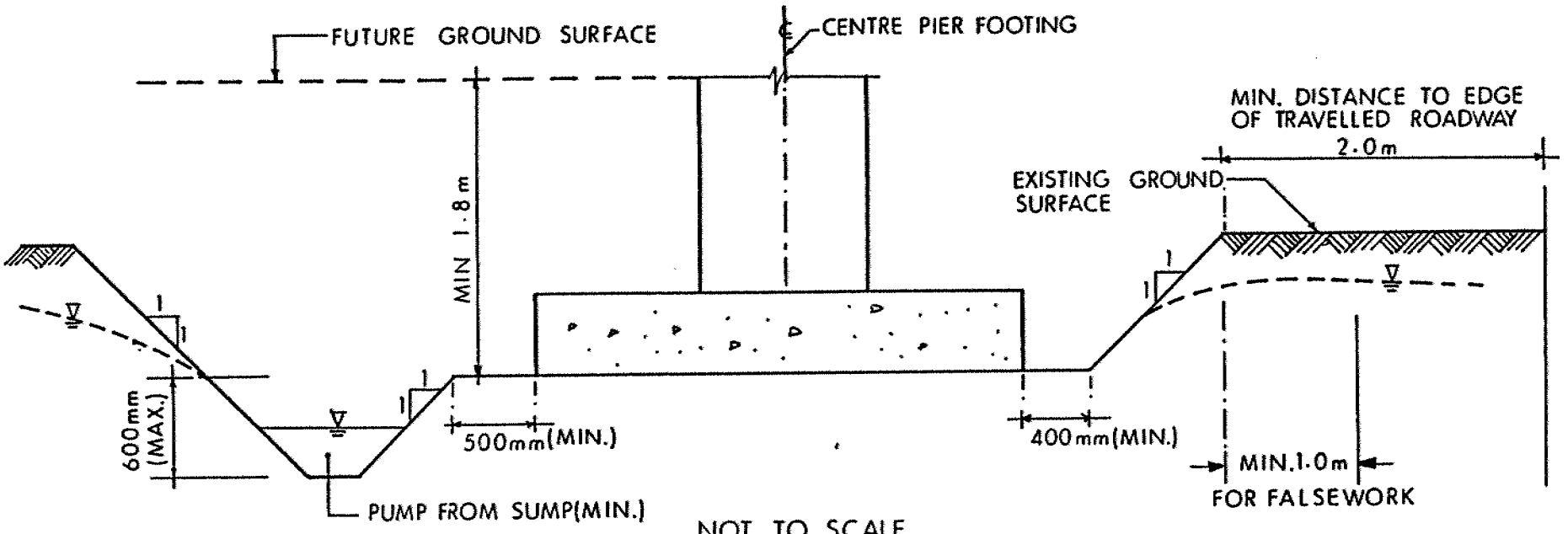
M.T.O W.P 187-89-02

STRATA ENGINEERING CORP.

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE

FIG No 5

Hwy. 416 / Regional Rd. 6



NOT TO SCALE

NOTE:

BACKFILL EXCAVATION WITH GRANULAR 'A' PLACED IN MAX 300mm THICK LOOSE LIFTS AND COMPACTED TO 100% STD. PROCTOR DENSITY TO A LEVEL FLUSH WITH TOP OF FOOTING.

M.T.O W.P 187-89-02

STRATA ENGINEERING CORP.	DEWATERING OF CENTRE PIER FOOTING	FIG No. 6
		Hwy. 416 / Regional Rd. 6

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88 10

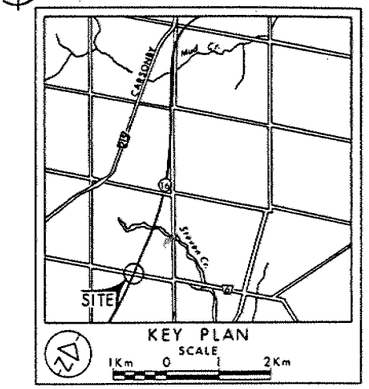
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

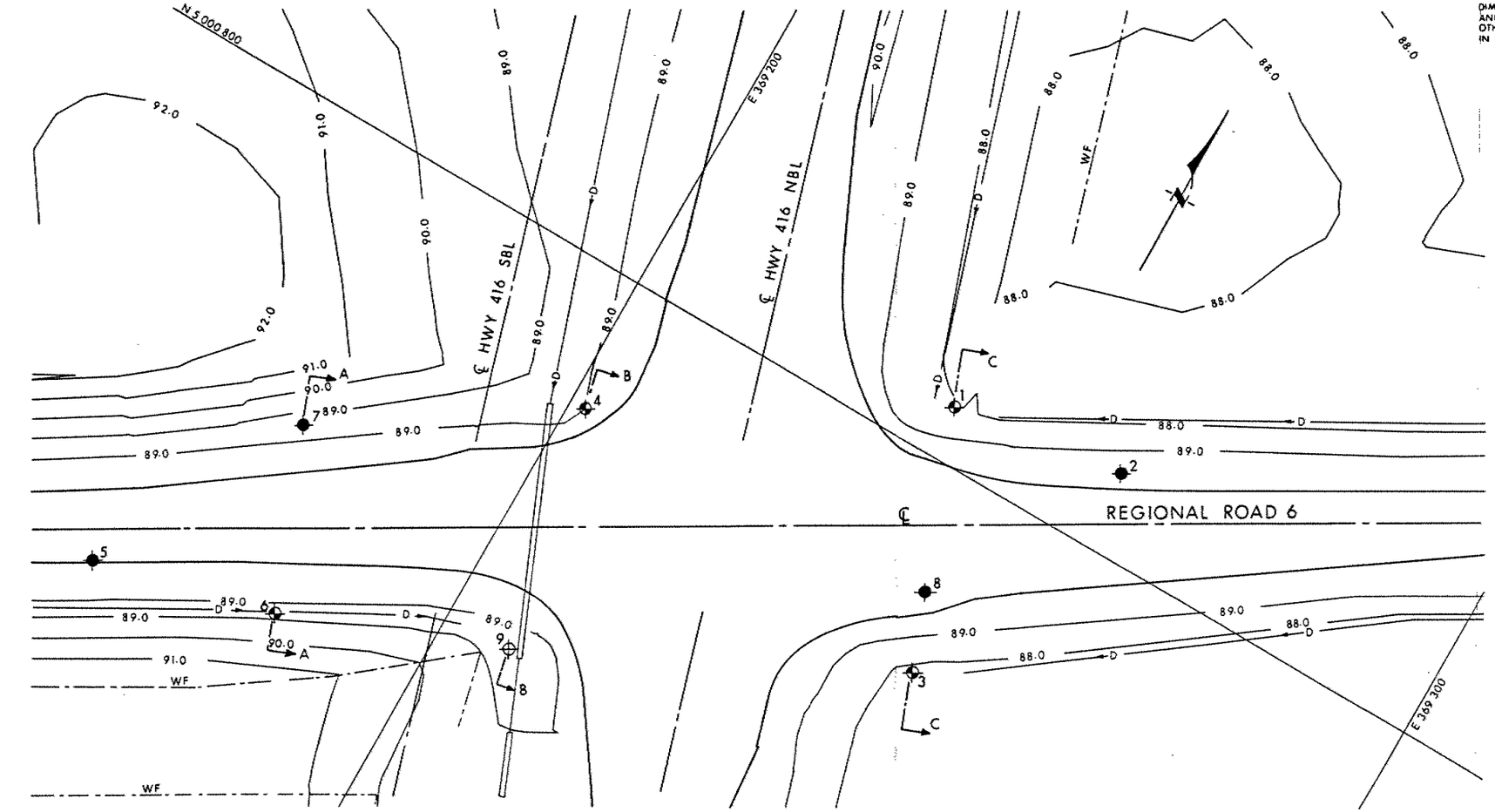
CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

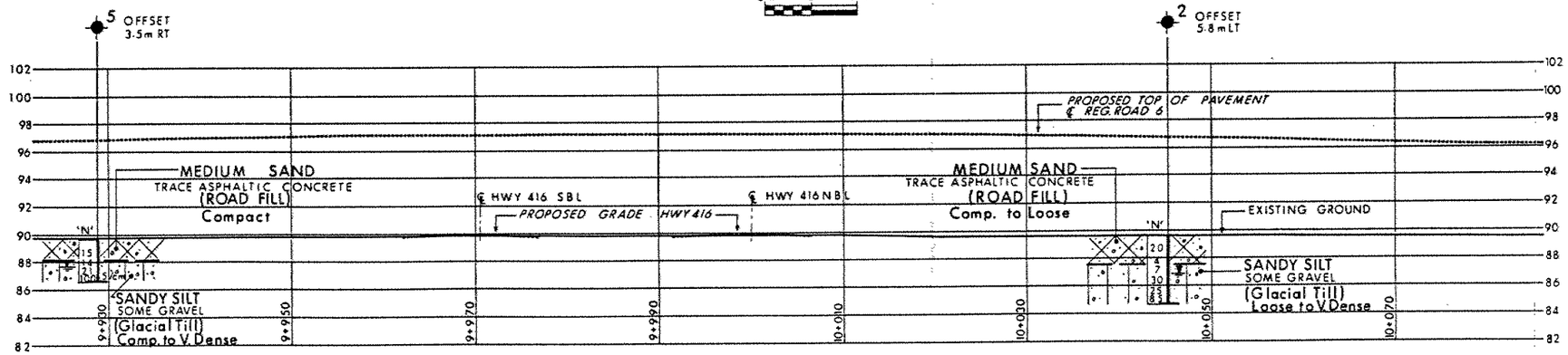
SHEET

STRATA ENGINEERING CORP.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

REF No E-55-416-2, 1991 01

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 742.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-A

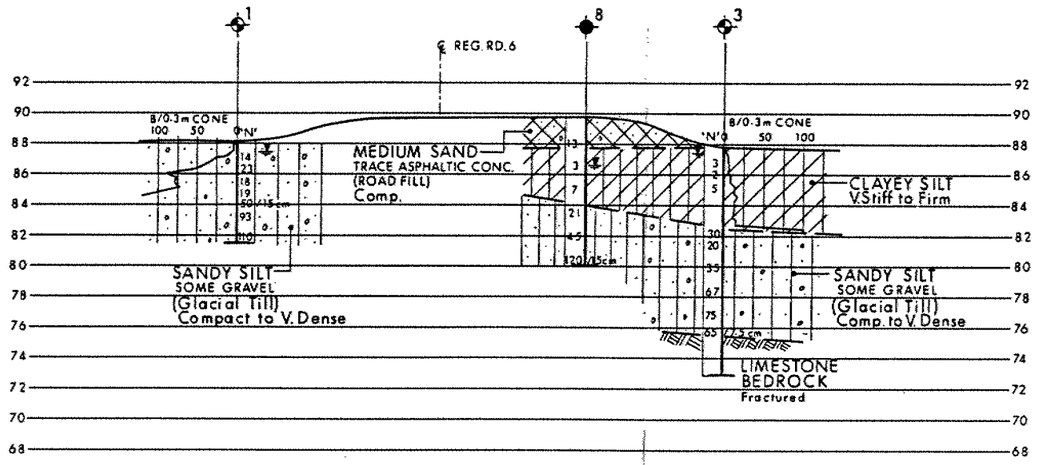
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

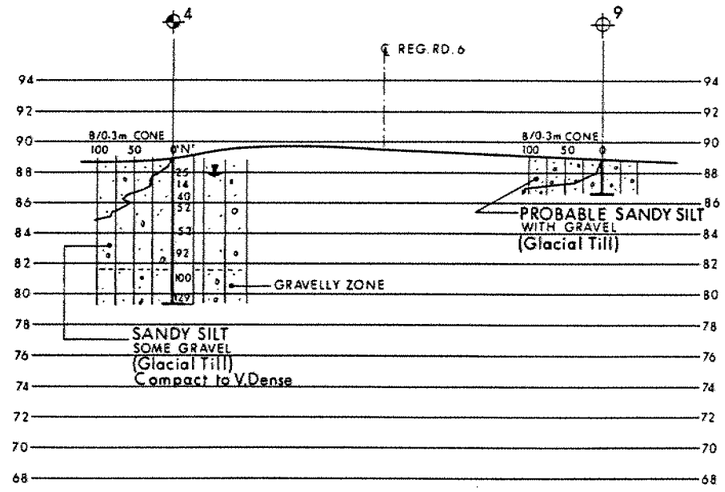
SHEET

STRATA ENGINEERING CORP.

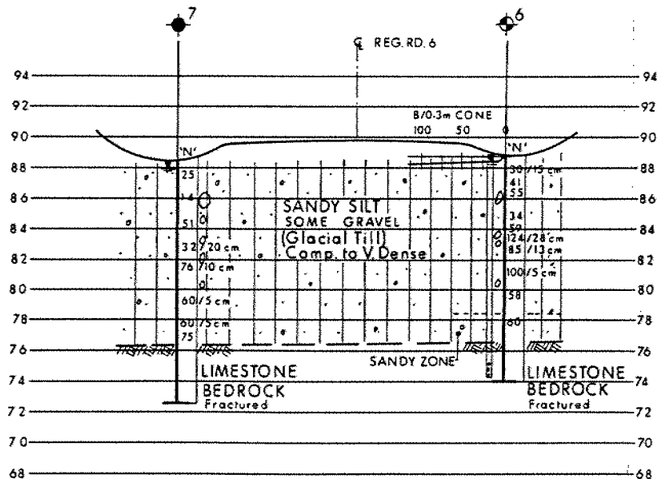


SECTION C-C

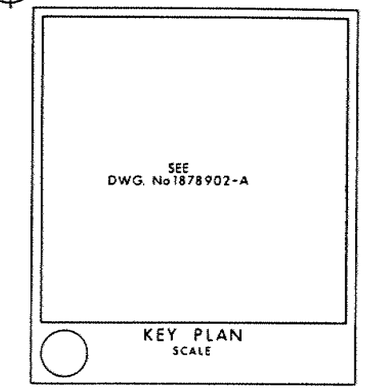
SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A



KEY PLAN
SCALE

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation Oct. & Nov. 1990; Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 07 1992	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-B

MINISTRY OF TRANSPORTATION, ONTARIO PH-D-207 (8/10)

METRIC

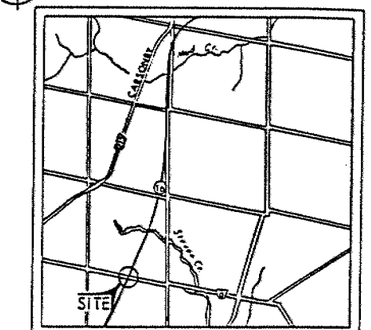
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

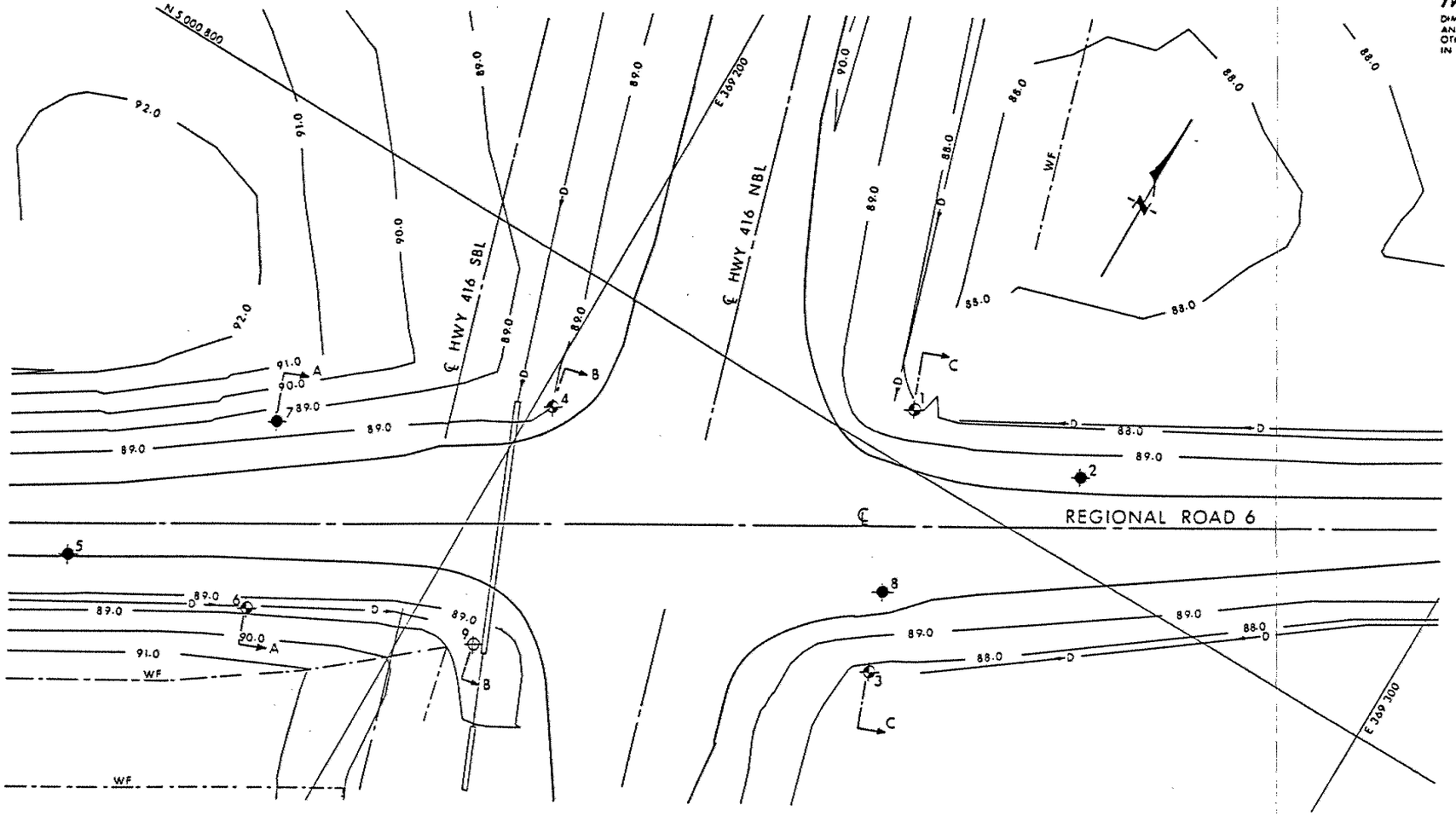
CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

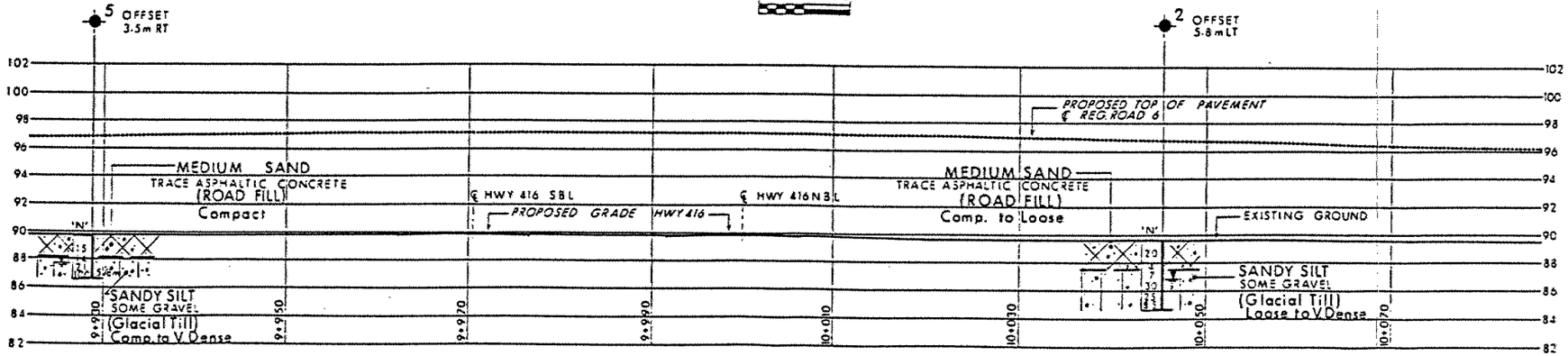
SHEET

STRATA ENGINEERING CORP.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

REF No E-55-416-2, 1991 01

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

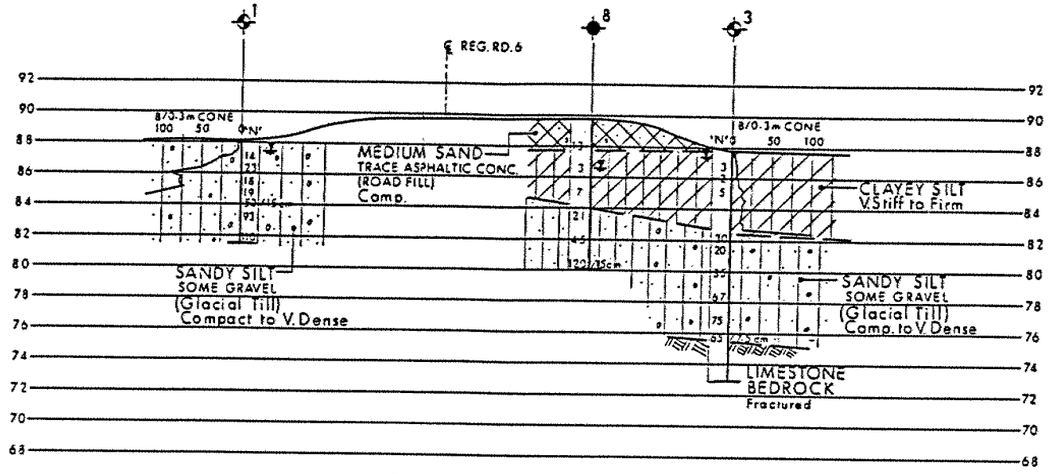
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

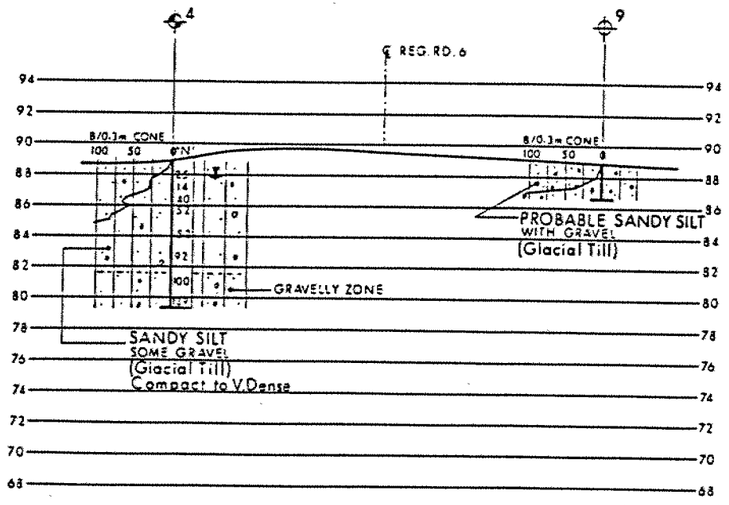
Geacres No 316-213

HWY No 416			DIST 9
SUBMD A.A.	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A.K.	CHECKED	APPROVED	

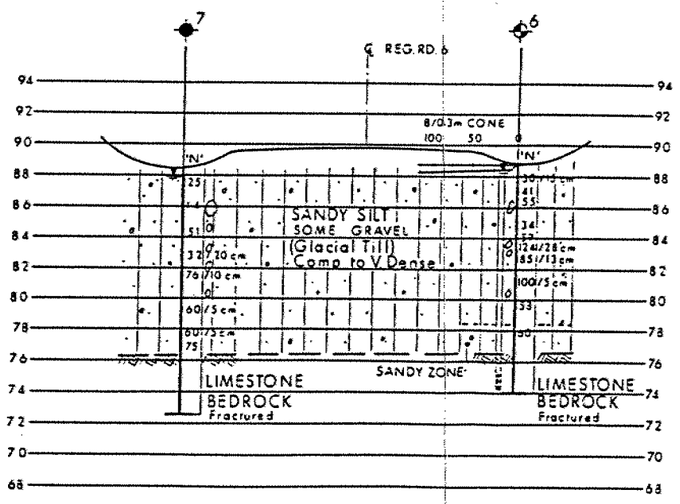


SECTION C-C

SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A

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

CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

STRATA ENGINEERING CORP.

SEE
DWG. No 1878902-A

KEY PLAN
SCALE

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L at time of investigation Oct.& Nov. 1990; Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.8	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

NOTE
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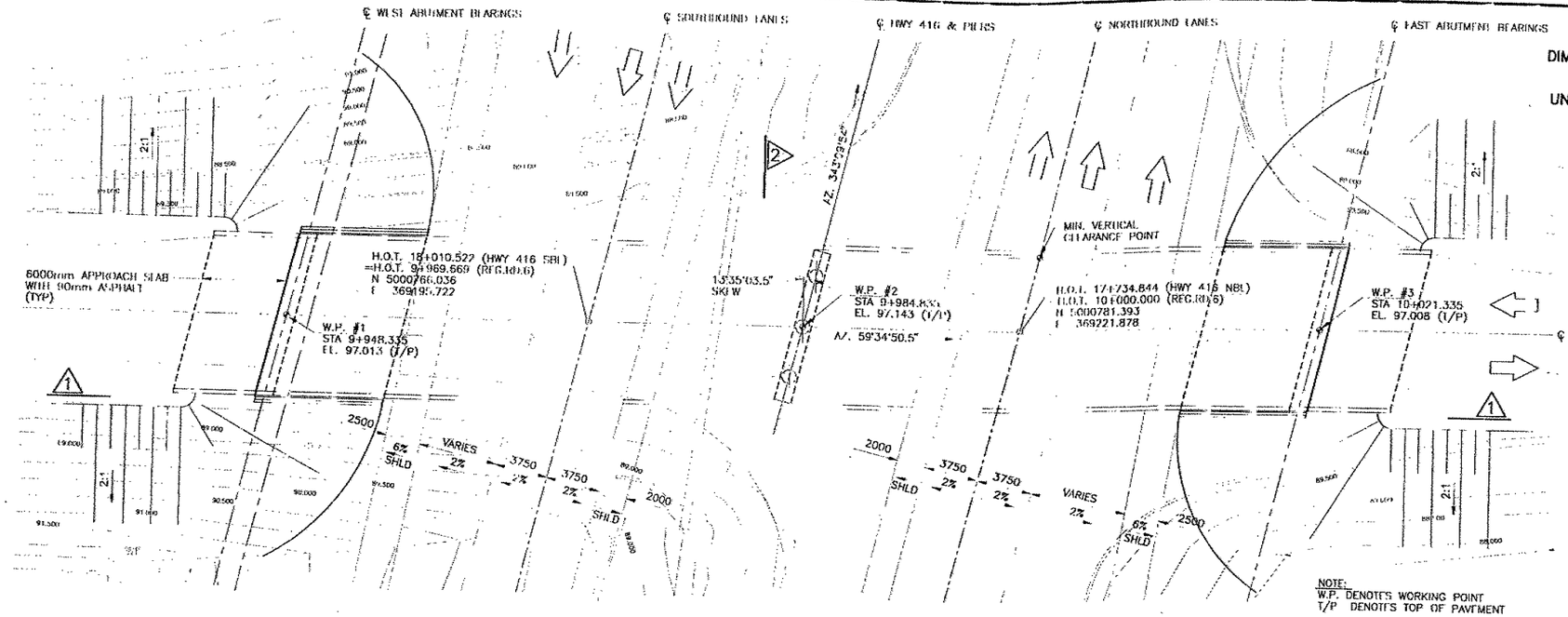
REV'S	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416	DIST 9

NORTH FOR CONSTRUCTION



METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

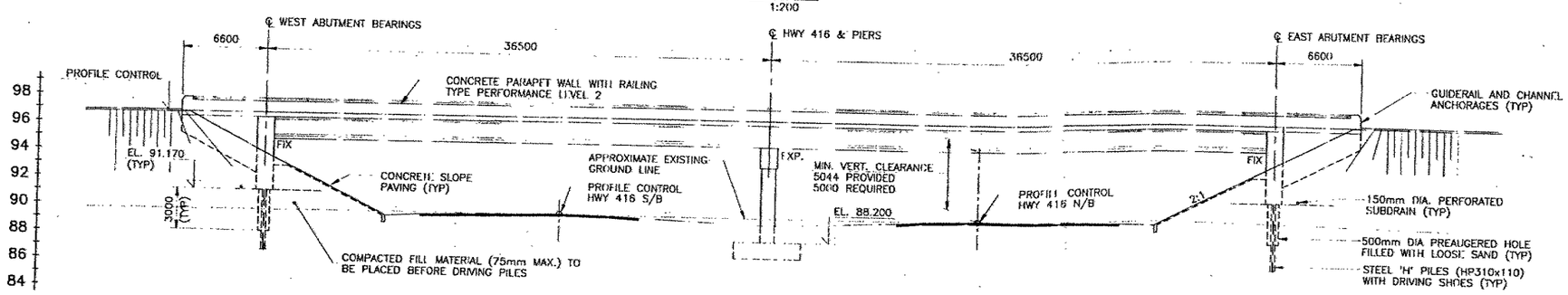
CONT No 96-07
WP No 187-89-02

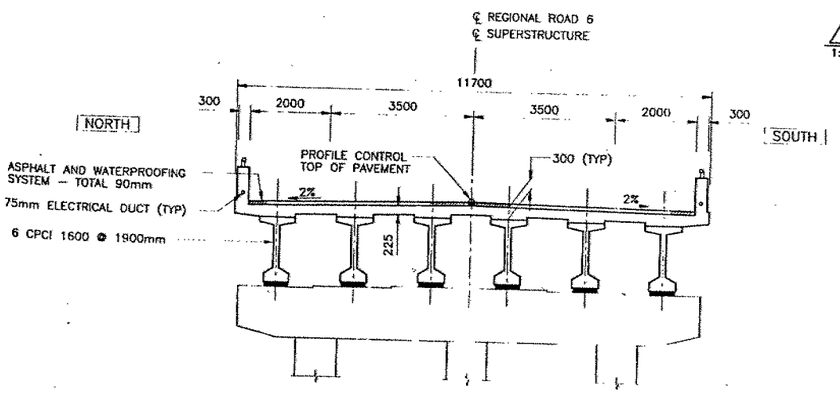
HWY 416 UNDERPASS
REGIONAL ROAD 6
GENERAL ARRANGEMENT

SHEET 143

UMA Engineering Ltd.
Engineers & Planners

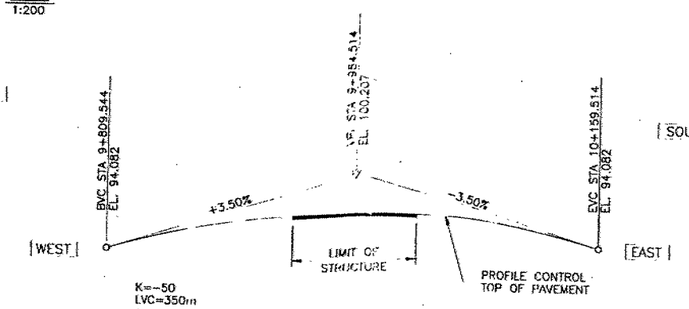
PLAN
1:200



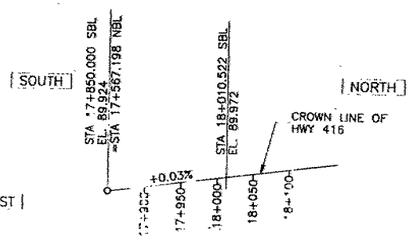


1
1:200

2
1:75



PROFILE OF REGIONAL ROAD 6
N.T.S.



PROFILE OF HWY 416 NORTHBOUND & SOUTHBOUND
N.T.S.

B.M. 89.403m
GEODETIC DATUM
[illegible]m EAST OF THE CENTRELINE OF HWY No. 16 3.5 km NORTH OF REGIONAL ROAD 6

GENERAL NOTES

1. CLASS OF CONCRETE

PRECAST CONCRETE GIRDERS	40 MPa
REMAINDER	30 MPa

2. CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100± 25
DECK	
TOP	70± 20
BOTTOM AND SIDES	40± 10
REMAINDER	70± 20

3. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

4. CONSTRUCTION NOTE.

a) THE CONTRACTOR SHALL ESTABLISH THE ACTUAL BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.

b) NO BACKFILL SHALL BE PLACED UNTIL DECK CONCRETE HAS REACHED 75% OF ITS SPECIFIED STRENGTH. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWINGS

OPSD 4010.00 GUIDERAIL AND CHANNEL ANCHORAGE

LICENSED PROFESSIONAL ENGINEER — LESLIE A. MARTIN — 2/4/96 — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — G. L. REID — 2 Apr 96 — PROVINCE OF ONTARIO

REVISIONS		
NO.	DATE	BY	DESCRIPTION

DESIGN S.M.	CHKD.L.R	CODE OHBDC-91	LOAD CLASS'A'	DATE	FEB 96
DRAWN M.P.	CHK L.M.	SITE 03-576	STRUCT	SCHEME	DWG. 1

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 81

P&D

(139)

WP 187-89-00

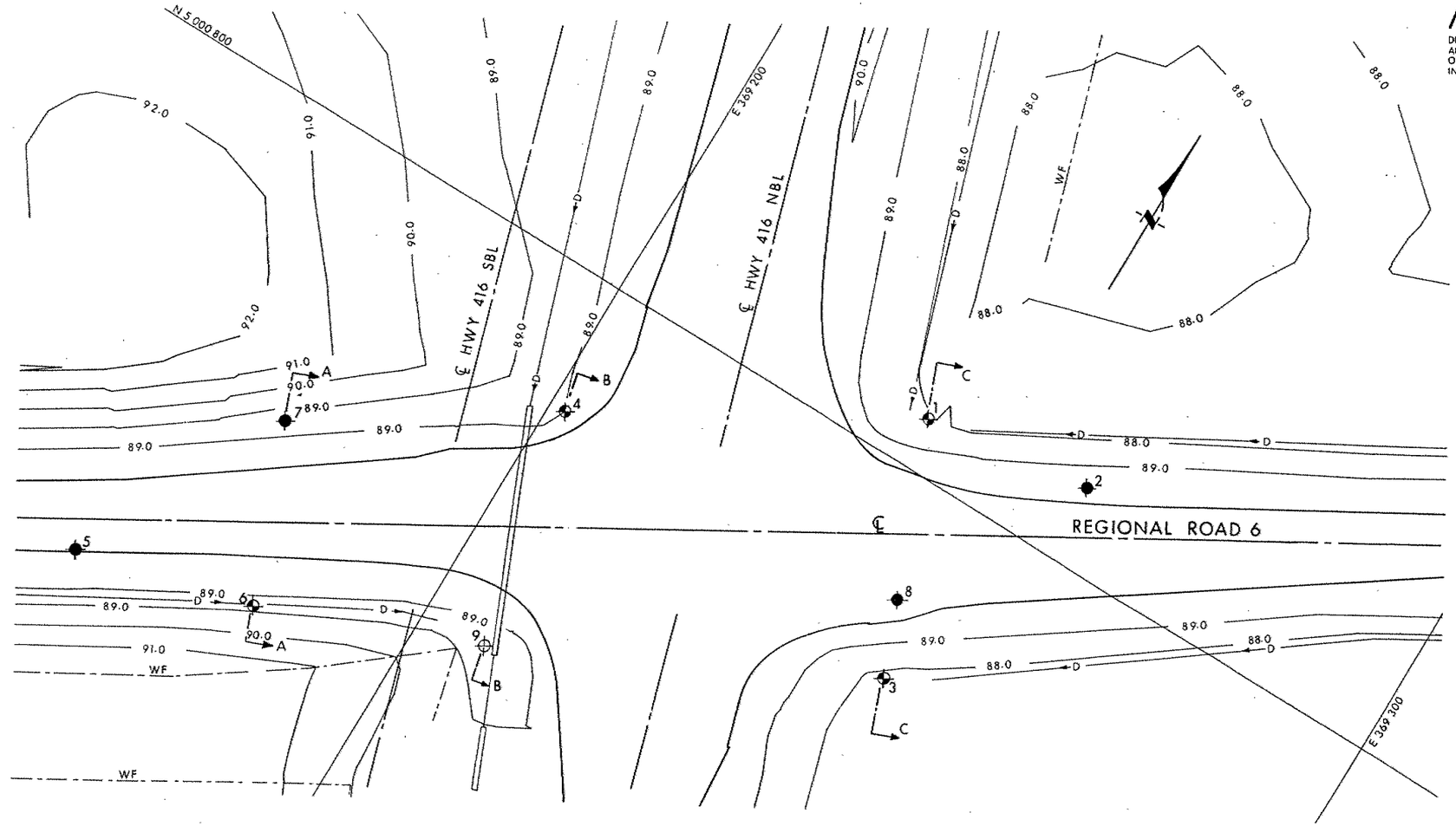
METRIC

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

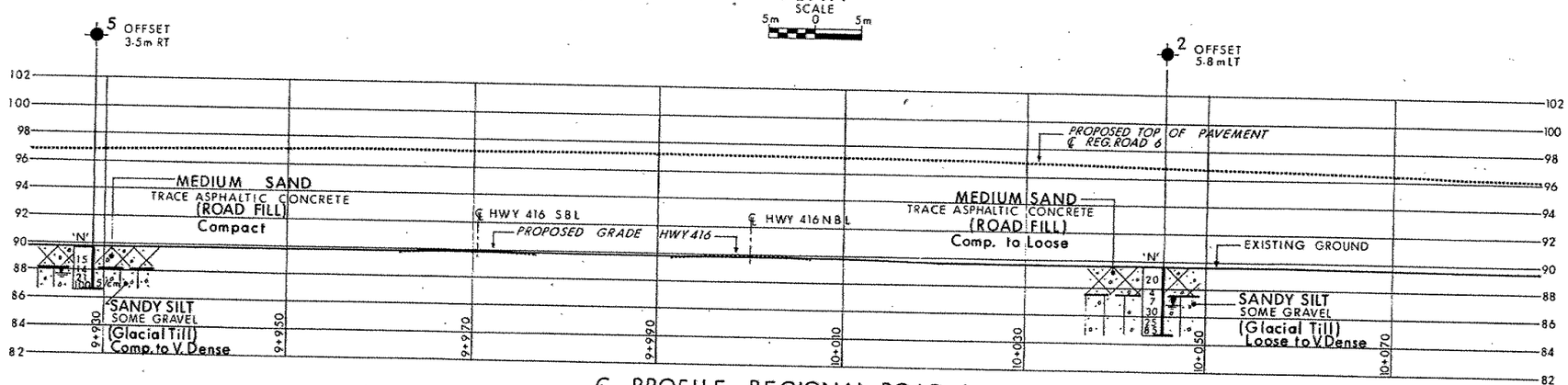
CONT No 96-07
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

STRATA ENGINEERING CO.

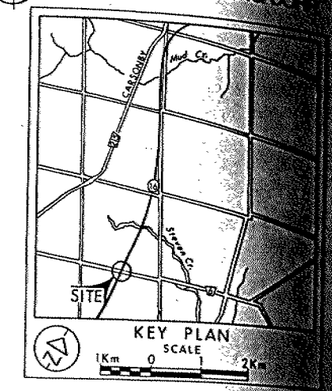


PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 231.0
3	87.8	5 000 778.0	369 248.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
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REV.	DATE	BY	DESCRIPTION

Geocres No

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 02 1991	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-A

REF No E-55-416-2, 1991 01

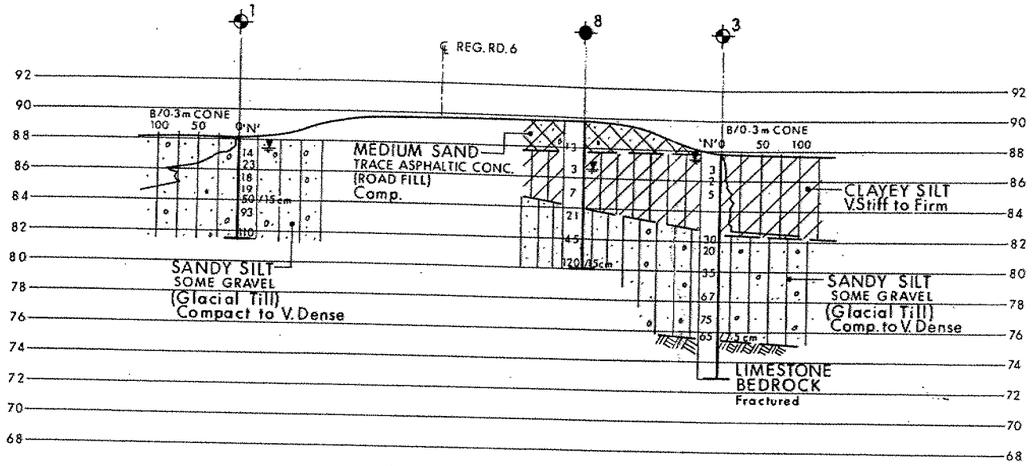
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No 96-07
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

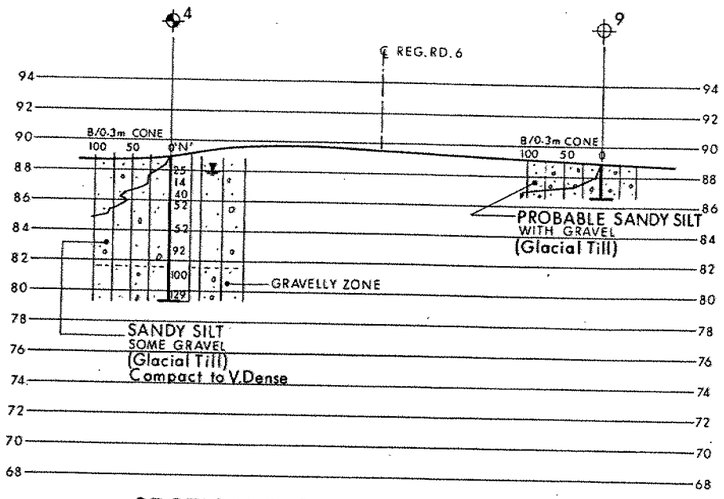
SHEET 145

STRATA ENGINEERING CORP.

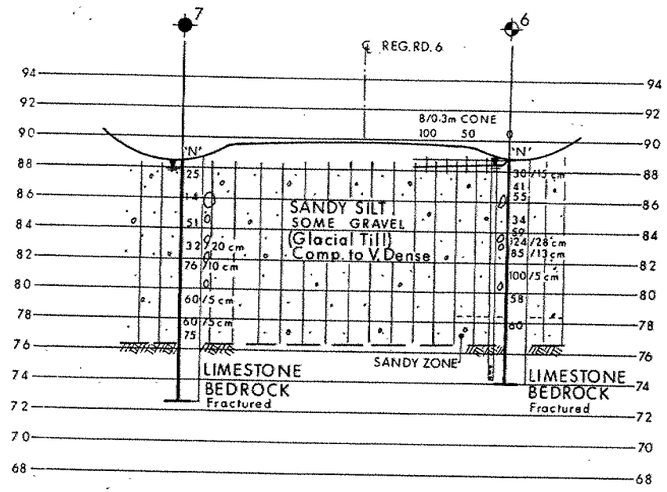


SECTION C-C

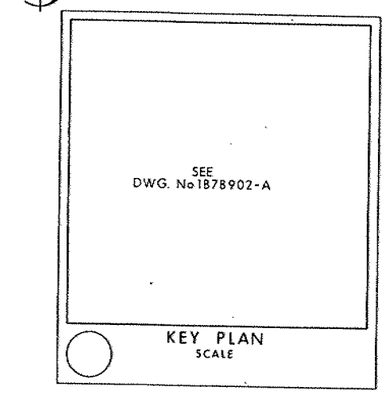
SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A



KEY PLAN
SCALE

LEGEND

- Bore Hole
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- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
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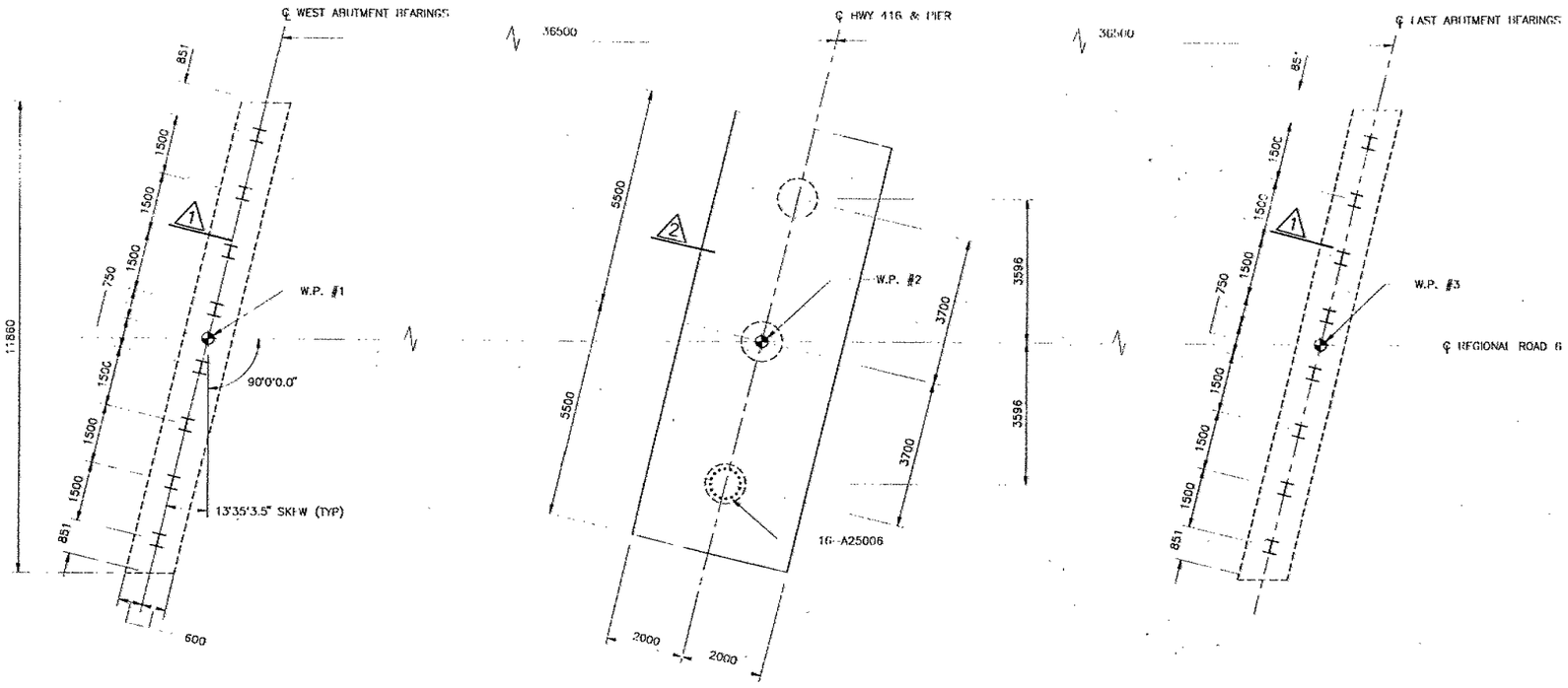
Geocres No

HWY No 416			DIST 9
SUBM'D A A	CHECKED	DATE Jan 07 1992	SITE 3-576
DRAWN A K	CHECKED	APPROVED	DWG 1878902-A

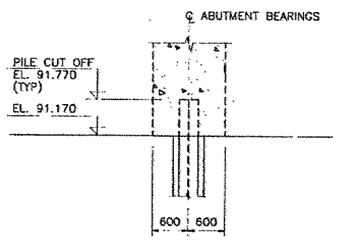
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No 96-07
WP No 187-89-02
HIGHWAY 416 UNDERPASS
REGIONAL ROAD 6
FOUNDATION LAYOUT & FOOTING REINFORCEMENT
SHEET 146

UMA Engineering Ltd.
Engineers & Planners



FOUNDATION LAYOUT
1:75



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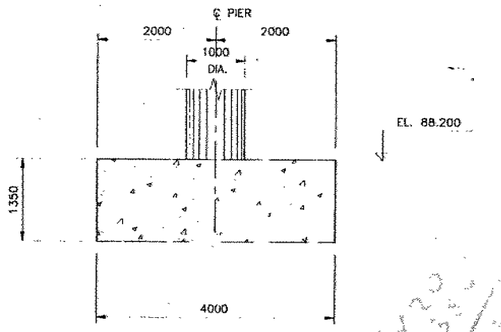

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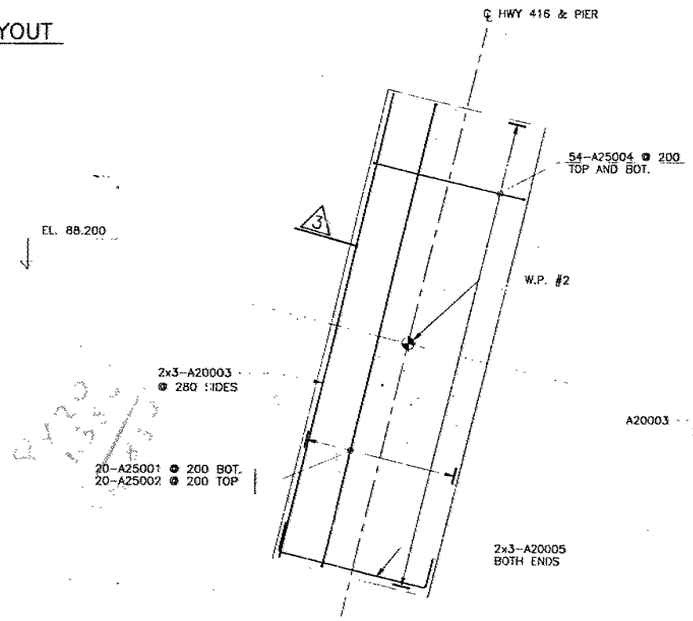
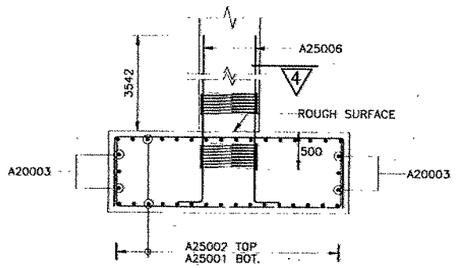
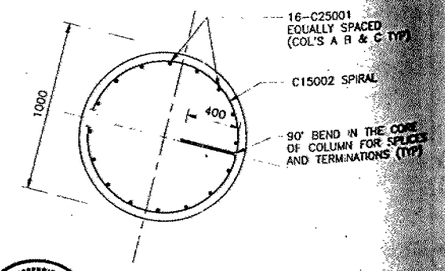
1:50



FOOTING REINFORCEMENT
1:75



3
1:50



4
N.T.S.

NOTES:

1. ALL PILES TO BE HP 310x110 STEEL "H" PILES.
2. PILE SPACING TO BE MEASURED AT THE UNDERSIDE OF FOOTINGS.
3. PILE LENGTHS SHOWN ARE THEORETICAL LENGTH BELOW CUT-OFF ELEVATION.
4. ALL PILES SHALL HAVE DRIVING SHOES.
5. PILE DESIGN DATA:

   MAXIMUM COMBINED FACTOR LOADS:

   WEST ABUTMENT PILES:
   U.L.S. 1600 kN
   S.L.S. 1150 kN

   EAST ABUTMENT PILES
   U.L.S. 1400 kN
   S.L.S. 950 kN

6. PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS103-11 USING AN ULTIMATE CAPACITY OF 3450 kN AT WEST ABUTMENT AND 3450 kN AT EAST ABUTMENT.

PILE DATA				
LOCATION	POSITION	No.	LENGTH	BATTER
EAST ABUT.	N. SIDE	4	9270	VERTICAL
	S. SIDE	4	16370	VERTICAL
WEST ABUT.	N. SIDE	4	9770	VERTICAL
	S. SIDE	4	9770	VERTICAL

WORKING POINT DATA			
WORK POINT	STATIONS	COORDINATES NORTH	EAST
#1	9+948.335	5000755.234	369177.325
#2	9+984.835	5000773.715	369208.801
#3	10+021.335	5000792.196	369240.277

APPLICABLE STANDARD DRAWINGS

OPSD 3301.00 SPLICE AND DRIVING SHOE DETAILS FOR STEEL 'H' PILES

LICENSED PROFESSIONAL ENGINEER
LESLIE A. MARTIN
2/4/96
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
G. L. REID
2 Apr 96
PROVINCE OF ONTARIO

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN S.M.	CHK G.L.R	CODE OHBDC 91	LOAD CLASS 'A'
DRAWN M.P.	CHK L.M.	SITE 03-576	STRUCT
			SCHEME
			DATE FEB 96
			DWG. 4

DRAWING NAME: FOUNDATION LAYOUT & FOOTING REINFORCEMENT
CREATED: - 96/1/5 MODIFIED:

MINISTRY OF TRANSPORTATION ONTARIO

GEOCRES No. 31G-213, 31G-214, 31G-215

DIST. 9 REGION

W.P. No. 187-89-00

CONT. No. 96-07

W. O. No.

STR. SITE No.

HWY. No. 416

LOCATION Hwy 416 Reg Rd 6

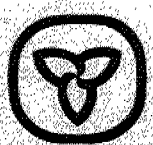
No. of Pages -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 96-07



Ontario Ministry of Transportation

INDEX

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above-mentioned project.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (S.P.T.) '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 S.P.T. 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:

R.Q.D. (%)	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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_l	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
for
Regional Road 6

W.P. 187-89-02, District 9, Ottawa
Highway 416, Str. Site: 3-576

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by UMA Engineering Ltd. to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 and Regional Road 6 (Roger Stevens Drive). The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report in accordance with the requirements of the Foundation Design Section of the MTO.

This report, which follows a letter report dated 1991 01 23, complies with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located approximately 30 km south of Ottawa along Highway 16. The location of the site is shown on the key plan in Drawing 1878902-A, appended.* The centre line of the new southbound lanes will be located some 30 m west of existing Highway 16. Therefore, the underpass to carry Regional Road 6 across the new highway will be a two span structure with abutments located to the east and west respectively of the existing highway and the proposed southbound lanes of the new highway. The proposed centre pier will be situated west of the west shoulder rounding of the existing highway, which has been widened at this intersection to accommodate turning lanes.

The site lies within the physiographic area known as the North Gower Drumlin Field. The drumlins have a north-south orientation. The area has been inundated by the Champlain Sea which has caused the drumlins to be covered with a mantle of marine soil, predominantly silt and Leda clay. Bedrock in this area has been mapped as magnesium limestone to dolostone of the Oxford Formation, Lower Ordovician age.

3.0 FIELD AND LABORATORY WORK

The field work was carried out in two phases. The initial investigation was conducted between 1990 10 02 to 1990 11 01, and consisted of the drilling of seven boreholes, five of which were accompanied by a dynamic cone penetration test. Four boreholes were drilled at the corners of the proposed abutments and one near the centre pier. The remaining two boreholes were drilled away from the structure to provide information for the approach fills. The second phase of the investigation, from 1991 11 12 to 1991 11 13, was conducted in order to more completely define the soil stratigraphy at the east abutment location. It consisted of the drilling of one additional borehole (BH 8) and a dynamic cone penetration test (BH 9) to the south of the proposed pier location.

* Sheet No 144 of the Contract Drawings.

Borehole elevations are referenced to Geodetic datum and were supplied by UMA Engineering. The locations of the boreholes and dynamic cone penetration tests are shown on Drawings 1878902-A and -B. *

Drilling was conducted with Bombardier mounted CME 55 drill rigs. Hollow stem augers were used to advance the boreholes. Boreholes 2 and 5 for the approach embankments were terminated within the highest competent stratum. Bedrock was proven by coring in three boreholes near the proposed structure abutments and pier.

Standard Penetration Tests were performed to sample very stiff to hard cohesive and all non-cohesive deposits, the accompanying N values being noted in blows/0.3 m. In cohesive strata and in Borehole 3, relatively undisturbed samples were obtained by pushing thin-walled Shelby tubes either manually or hydraulically into the soil. In situ vane shear testing was conducted using a standard MTO A size vane in the cohesive strata. Remoulded shear strengths were also measured to determine sensitivity.

Upon completion, water levels were measured in the uncased holes. In Borehole 6, a standpipe was installed for longer term water level monitoring. The other holes were backfilled with native soil cuttings. The site was then restored to its original condition. Due to its proximity to the travelled roadway, no long term water level observation standpipe was installed in Borehole 8.

Recovered samples were transported to our Don Mills Laboratory for further visual examination, classification and index property testing such as moisture content, grain size distribution and Atterberg limits. One consolidation test was performed. The results are shown on the Record of Boreholes and on Figures 1 to 4, appended.

4.0 SUBSURFACE CONDITIONS

4.1 General

Over most of the site, a dense sandy silt glacial till overlies limestone bedrock. In the southeast area of the site, the till is overlain by a wedge of clayey silt. The groundwater table lies within a metre or so of ground surface.

4.2 Medium Sand (Road Fill)

In Boreholes 2 and 5 for the approaches and in Borehole 8 at the proposed east abutment location, a brown medium sand with traces of asphaltic concrete is present from the surface to depths ranging from 1.7 m to 2.1 m below ground surface. The moisture content ranges from 10 to 25 per cent. A typical grain size distribution curve is shown on Figure 1.

The N values from the Standard Penetration Resistance test ranged from 20 to 4 blows/0.3 m, generally decreasing with depth, indicating a compact to loose relative density of the road fill material.

* Sheets No 144 and 145 of the Contract Drawings.

4.3 Clayey Silt

A brown to grey clayey silt deposit was found in Boreholes 3 and 8 at the south corner of the east abutment. The deposit in Borehole 3 was 5.3 m thick, and in Borehole 8 it was 3.7 m thick.

The moisture content of this material ranged from 30 to 48 per cent. Atterberg limit test results (Figure 2) show the soil to be of low plasticity (CL). The moisture content is generally higher than the liquid limit, indicating a liquidity index of greater than unity.

N values in this deposit ranged from 2 to 7 blows/0.3 m. Field vane tests indicate the undrained shear strength of the deposit to be over 100 kPa above about elev. 86± m, below which the strength decreases to between 45 and 75 kPa around elev. 84± m. The sensitivity of the soil ranged between 6 and 8. Based on these observations the deposit is considered to be very stiff to firm.

One consolidation test on a sample from Borehole 3 is shown on Figure 3. A strict interpretation of the preconsolidation pressure, using the Schmertmann method, gives a preconsolidation pressure, p_c, of about 200 kPa. However, from visual inspection of the e-log p curve, the p_c value ranges between 150 kPa and 180 kPa. The compression index, C_c, is 0.180. The recompression index, C_r, is 0.02. Since the existing effective overburden pressure at the location of the sample is about 30 kPa, the clayey silt appears to be overconsolidated by about 120 to 150 kPa.

4.4 Sandy Silt with some Gravel (Glacial Till)

Below the clayey silt in Boreholes 3 and 8, and the road fill material in Boreholes 2 and 5, and from surface down in the remaining boreholes, there is a sandy silt with some gravel (glacial till), with random boulders and cobbles. Typical grain size curves for the sandier portions of the deposit are shown in envelope form in Figure 4A. Gravelly zones and less silty zones within this deposit are plotted on Figure 4B. N values in this deposit ranged between 7 and in excess of 100 blows/0.3 m, generally increasing with depth. The lower N values were observed within the upper zones of the deposit and may be due to local re-working of the till. The dynamic cone penetration tests all terminated within this deposit. Based on these N values, the deposit is considered to be very dense with localized loose to compact zones near the surface.

4.5 Limestone Bedrock

Limestone bedrock was proven by coring in Boreholes 3, 6 and 7. The core recoveries were between 70 and 100 per cent. The thinly bedded rock has a maximum RQD value of 55 per cent, most values being about 30 per cent. Based on the measured RQD's the bedrock quality is very poor to fair.

5.0 GROUNDWATER CONDITIONS

Groundwater observations are summarized below:

Borehole	W.L. Elev.(m)	Depth (m)	Date
1	87.4	0.7	1990 10 03
2	86.8*	2.8	1990 10 02
3	87.4	0.4	1990 10 16
4	87.9	1.0	1990 10 04
5	87.8	1.8	1990 10 05
6	88.4	0.4	1990 11 02
7	87.9	0.6	1990 11 02
8	86.6	3.2	1991 11 13

* Not stabilized

7.0 CLOSURE

The drilling was supervised by A. C. Abel. Drill rigs were rented from F. E. Johnston and Marathon Drilling companies, Ottawa.

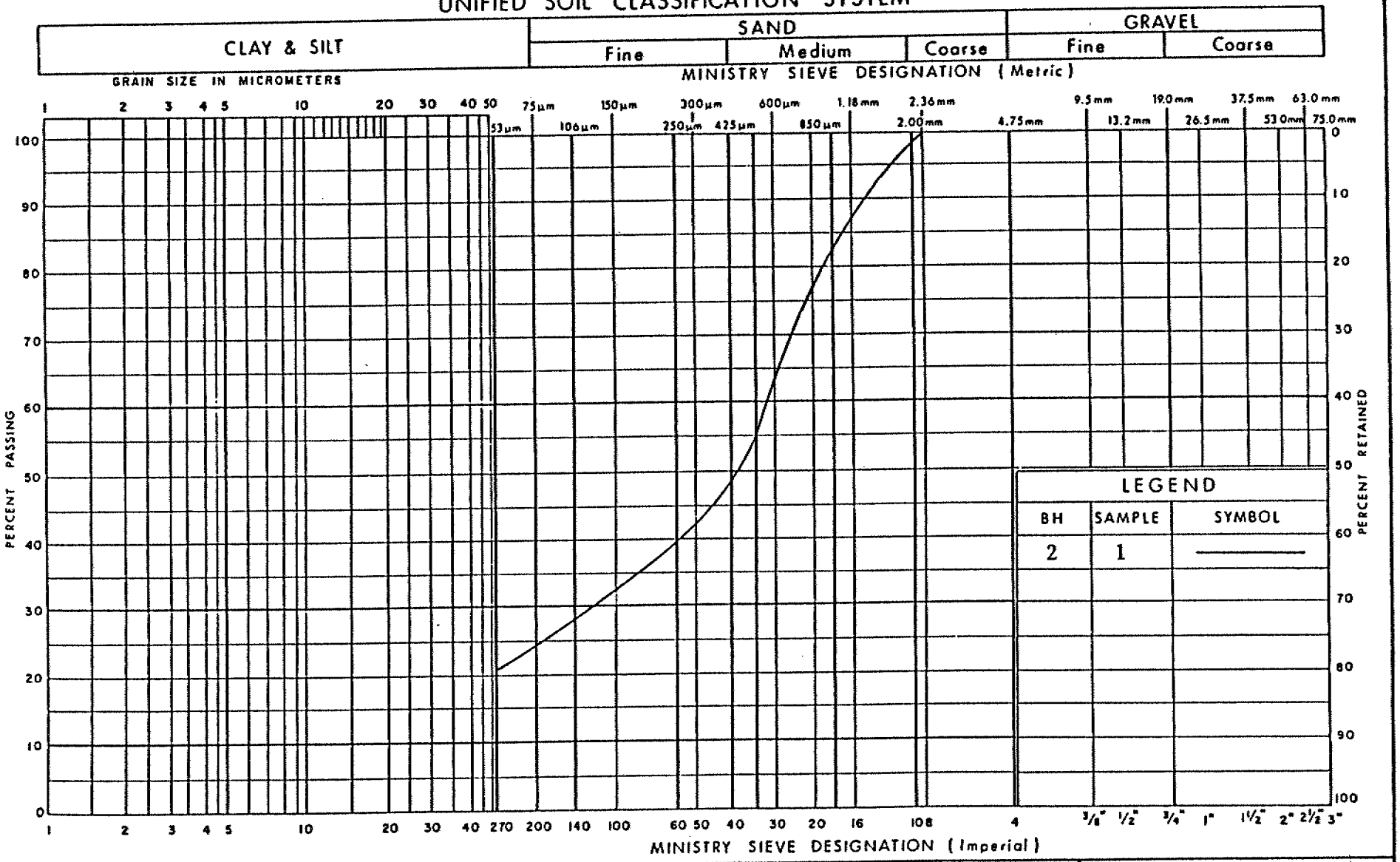
Several reviews of this report have been conducted between initial issue and this submission. We are grateful for the many constructive suggestions received in its finalization.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. The project was carried out under the technical supervision of UMA Engineering Ltd., the supervising consultant for this project.

D. Dundas, P. Eng.
Sr. Foundation Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

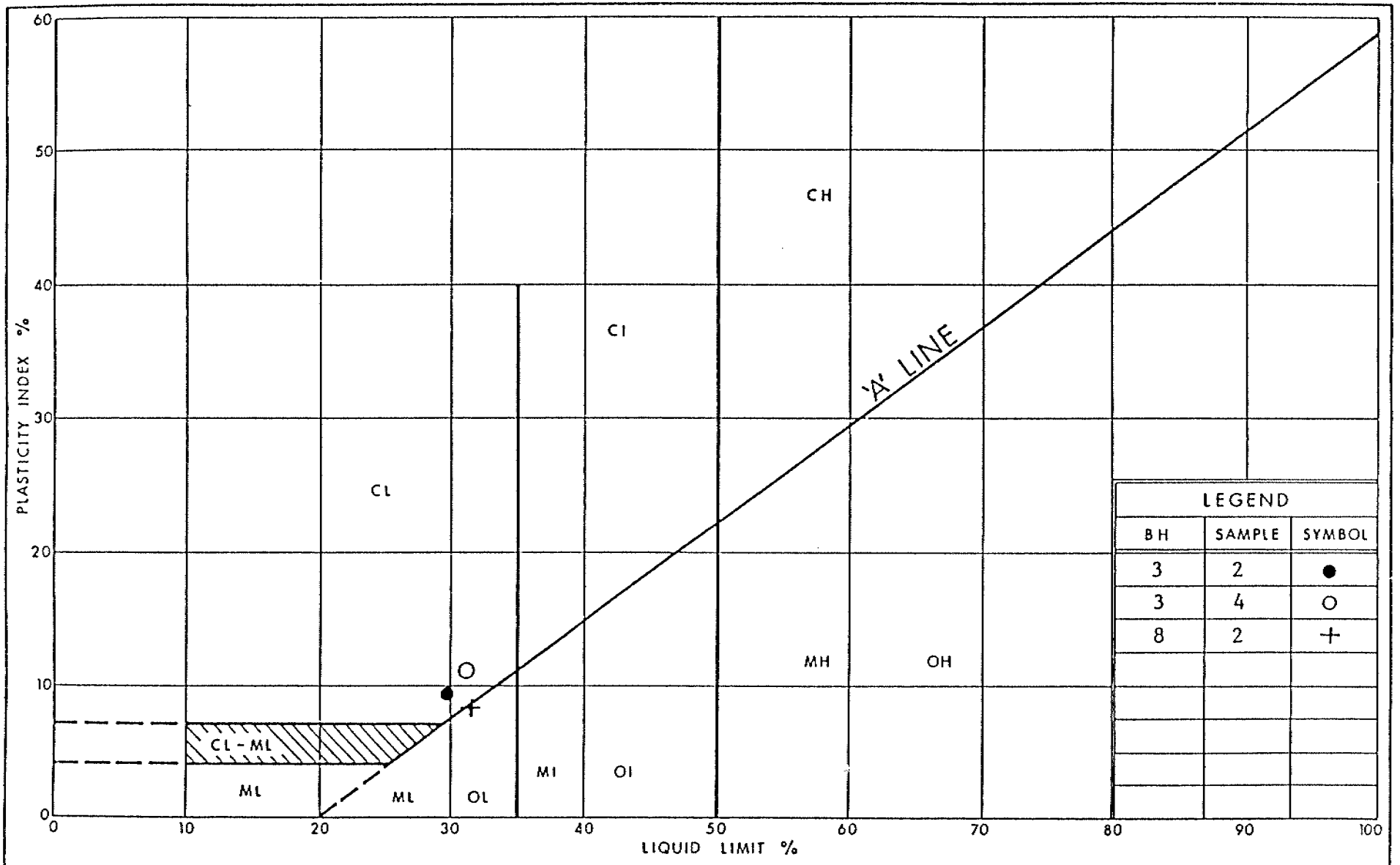


Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Medium Sand
(Road Fill)

FIG No 1
W P 187-89-02
Reg. Rd. 6/ Hwy. 416



Ministry of Transportation
Ontario

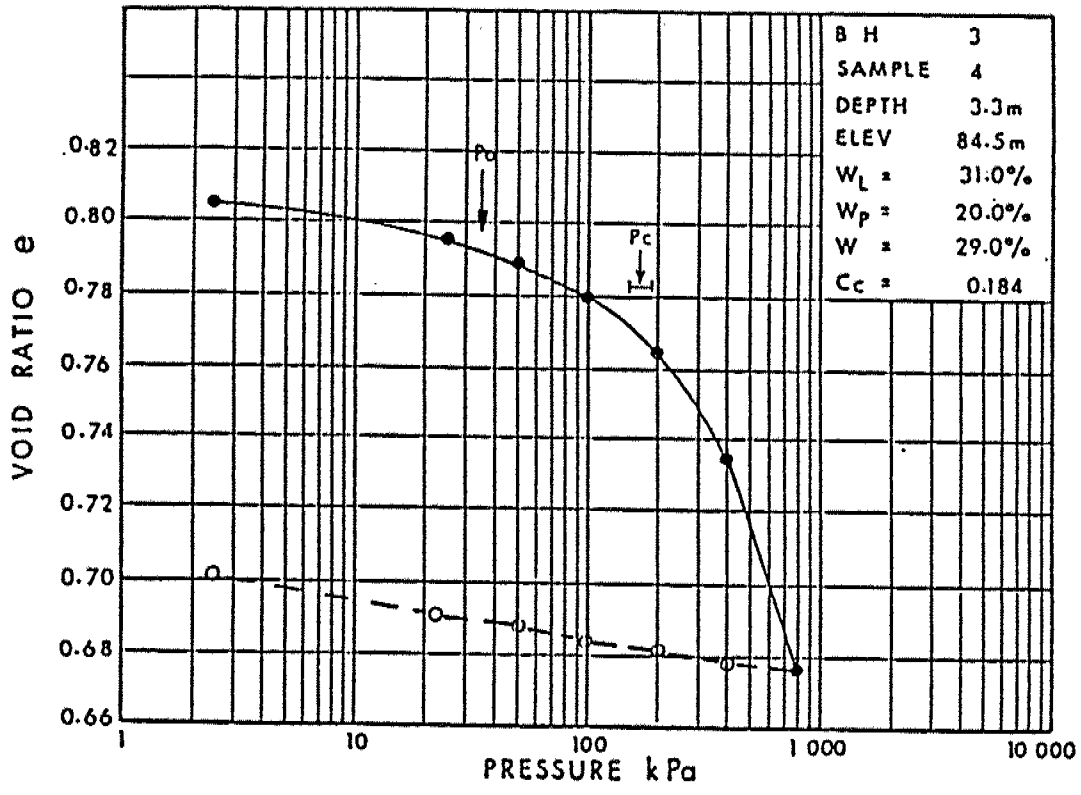
PLASTICITY CHART

Clayey Silt

FIG No 2
W P 187-89-02
Reg. Rd. 6/Hwy. 416

10

VOID RATIO - PRESSURE CURVES



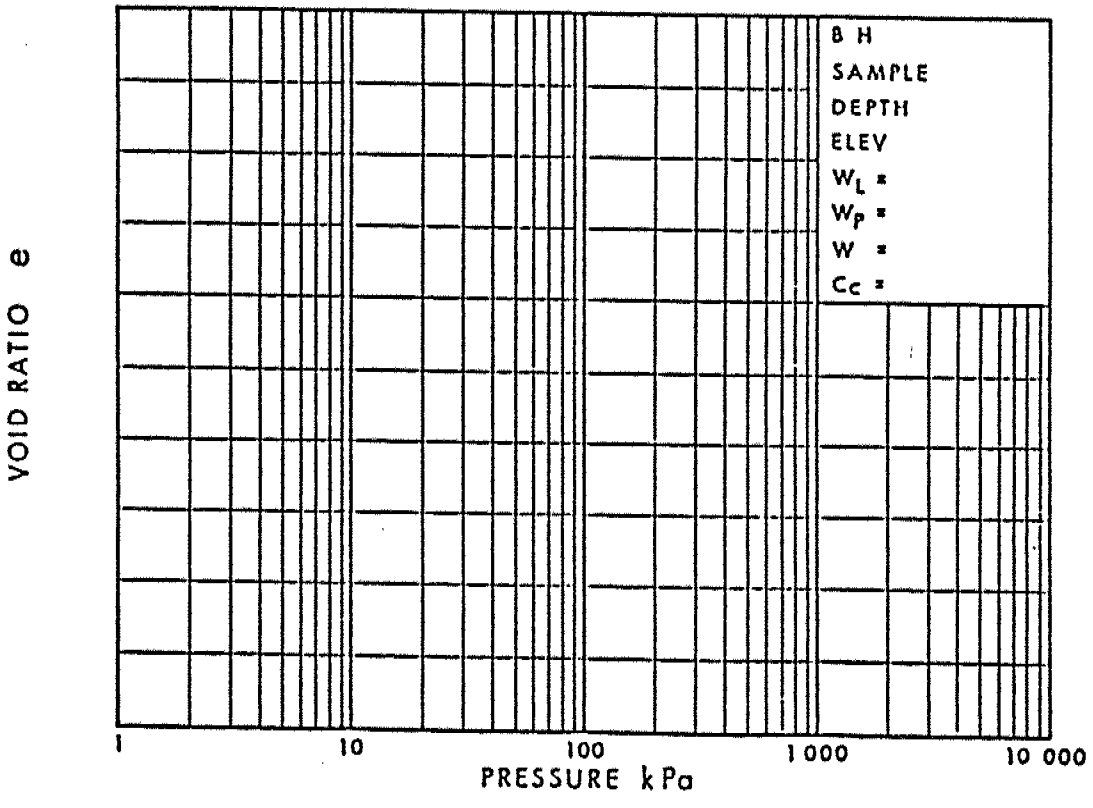
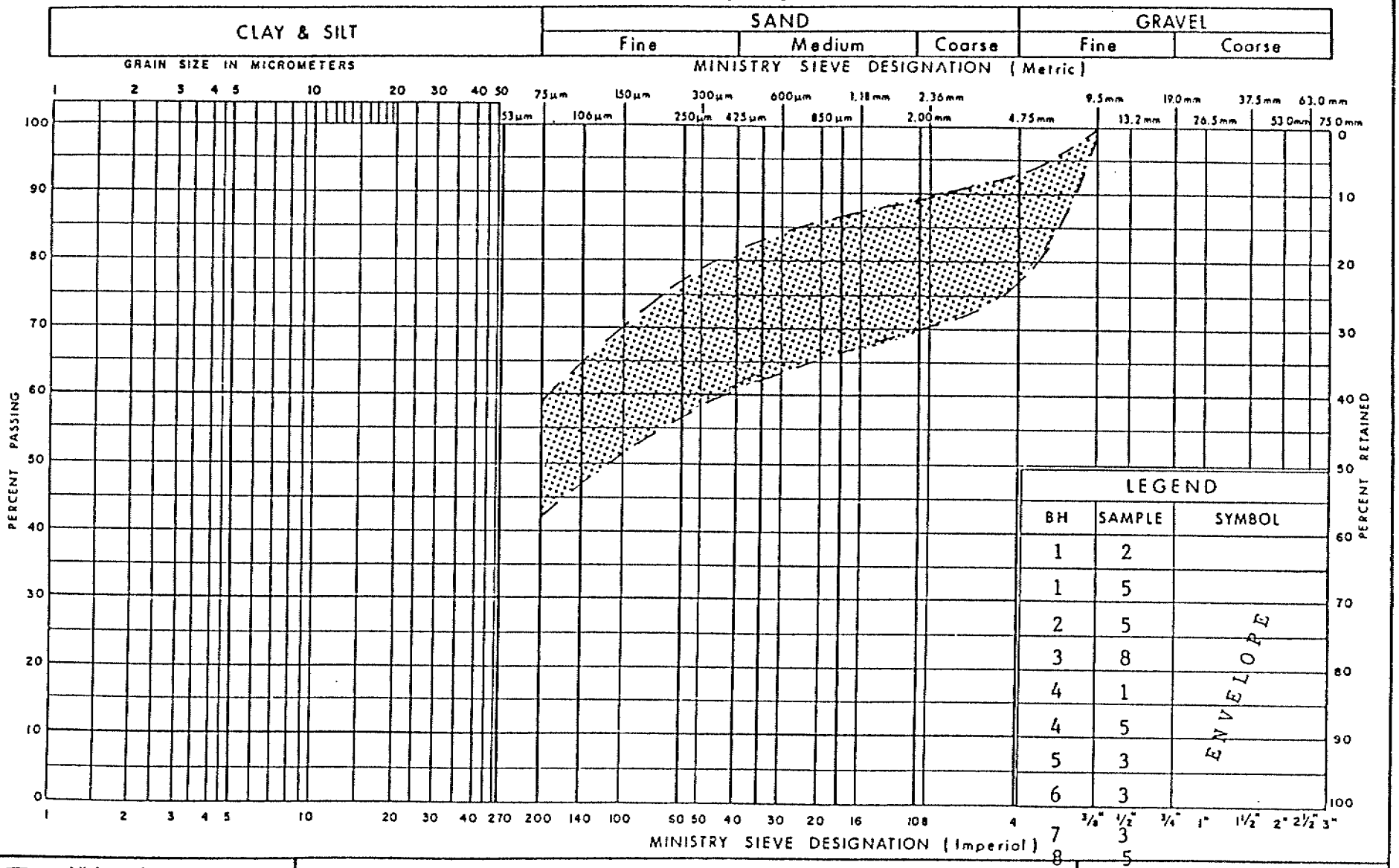


Fig 3

WP 187-89-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

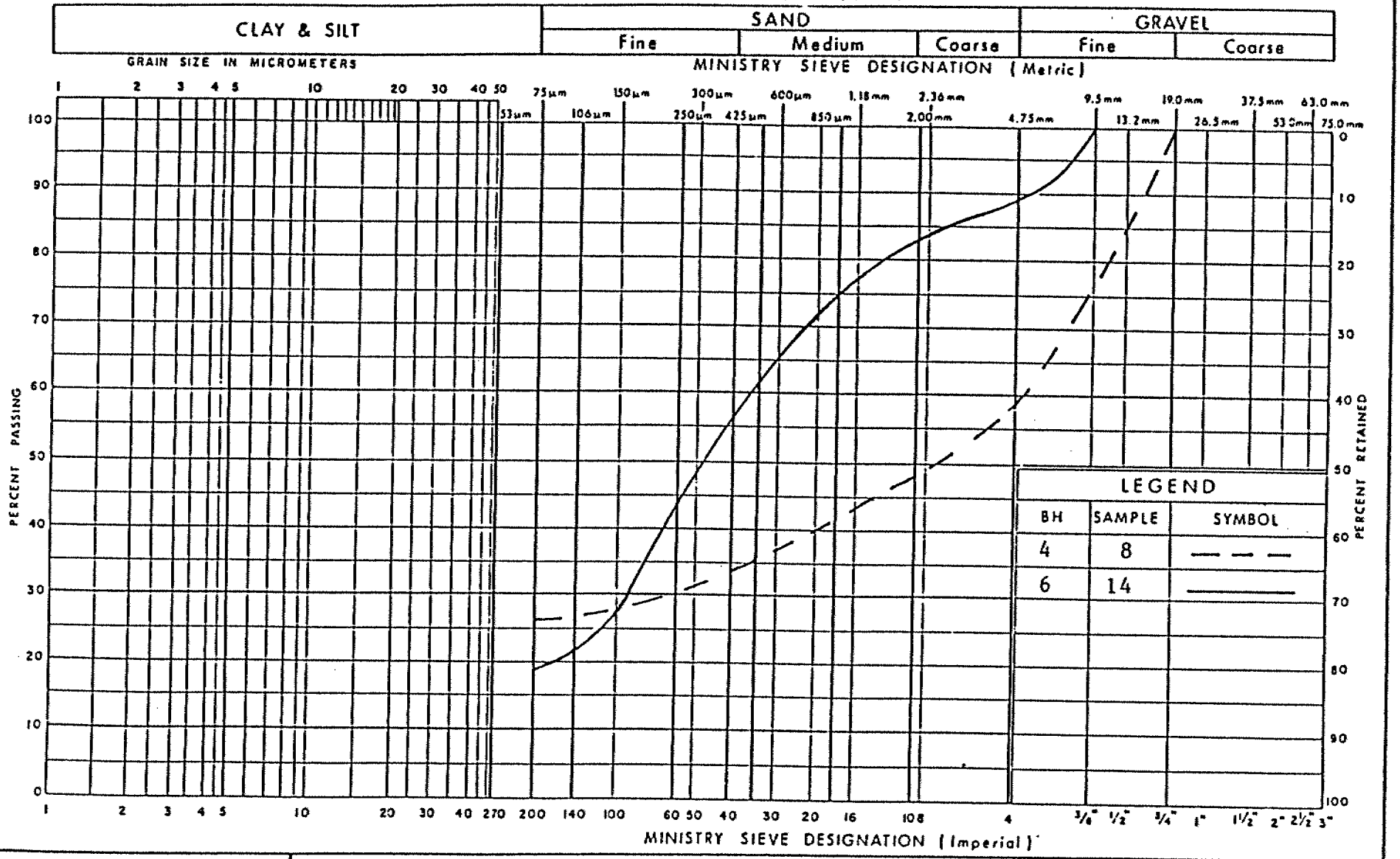
Sandy Silt, some Gravel
(Glacial Till)

FIG No 4A
W P 187-89-02
Reg. Rd. 6/Hwy. 416

12

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Sandy and Gravelly Zones within Glacial Till

FIG No 4B

W P 187-89-02

Reg. Rd. 6/Hwy. 416

13

RECORD OF BOREHOLE No1

METRIC

W P 187-89-02 LOCATION N: 5 000 806 ; E: 369 238 ORIGINATED BY S.S.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED • QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.1	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Compact Brown		1	SS	14	▽	88.0		o		W. L. on 1990 10 03
			2	SS	23		87.0		o		1 31 (58)
			3	SS	18		86.0		o		
			4	SS	19		85.0		o		
	Very Dense Grey		5	SS	50/1 cm.		84.0		o		11 37 (52)
			6	SS	93		83.0		o		
81.4			7	SS	110		82.0		o		
6.7	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No2 METRIC

W P 187-89-02 LOCATION N: 5 000 809 : E: 369 258 ORIGINATED BY S. S.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 02 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Concrete (Road Fill)						89.0				
	Compact to Loose		1	SS	20				o		0 79 (21)
	Brown		2	SS	4		88.0		o		
87.5											
2.1	Sandy Silt Some Gravel (Glacial Till)		3	SS	7	▽	87.0		o		W.L. on 1990 10 02
	Loose to V.Dense		4	SS	30				•		
	Brown						86.0				
			5	SS	25				o		25 30 (45)
	Grey										
84.6			6	SS	85		85.0		o		
5.0	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20 15 ◇ 5 (%) STRAIN AT FAILURE 10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No3 METRIC

W P 187-89-02 LOCATION N: 5 000 778 ; E: 369 249 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 03 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
87.8	Ground Surface										
0.0	Clayey Silt V.Stiff to Stiff Brown		1	SS	3	▽	87.0				W. L. on 1990 10 16
			2	SS	2		86.0				
			3	SS	5		85.0				
	Grey		4	TW	PH		84.0			19.3	Consol. Test Fig.3
82.5			5	TW	PH		83.0				
5.3	Sandy Silt Some Gravel (Glacial Till)		6	SS	30		82.0				
			7	SS	20		81.0				
	Compact to V.Dense		8	SS	35		80.0				13 39 (48)
			9	SS	67		79.0				
	Grey						78.0				
			10	SS	75		77.0				
75.4			11	SS	65/ 7.5cm.		76.0				
12.4	Limestone Bedrock		12	BX RC	Rec 94%		75.0				RQD = 54%
			13	BX	83%		74.0				RQD = 0%
72.8			14	BX RC	Rec 86%		73.0				RQD = 53%

15.0 End of Borehole

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 [%] STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 187-89-02 LOCATION N: 5 000 785 ; E: 369 201 ORIGINATED BY SS

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 04 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.9	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Compact Brown		1	SS	25	▽	88.0		o		7 35 (53) W. L. on 1990 10 04
			2	SS	14		87.0		o		
			3	SS	40		86.0		o		
	Very Dense		4	SS	52		85.0		o		
			5	SS	52		84.0		o		17 34 (49)
	Grey		6	SS	92		83.0		o		
			7	RX	Boulder		82.0				
	Gravelly Zone		8	SS	100		81.0		o		41 33 (26)
79.3			9	SS	129		80.0		o		
9.6	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 187-89-02 LOCATION N: 5 000 742 ; E: 369 162 ORIGINATED BY S.S

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger. COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 05 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa: o UNCONFINED, • FIELD VANE, ● QUICK TRIAXIAL, x LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
89.6	Ground Surface										
0.0	Medium Sand Tr.Asphaltic Concrete (Road Fill)						89.0				
	Compact		1	SS	15						
88.1	Brown										
1.5	Sandy Silt Some Gravel (Glacial Till)		2	SS	14	▽	88.0				W. L. on 1990 10 05
	Compact to V. Dense		3	SS	21		87.0				12 30 (50)
86.5	Brown		4	SS	100/5cm						
3.1	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No6 METRIC

W P 187-89-02 LOCATION N: 5 000 747 ; E: 369 183 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.8	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till)		1	SS	107/15cm.		88.0				W. L. on 1990 10 31
								Seal			
	Brown		2	SS	41		87.0				
			3	SS	55						16 36 (48)
	Compact to V. Dense		4	BX	Boulder		86.0				
							85.0				
	Randomly placed Boulders		5	SS	34						
			6	SS	59		84.0				
			7	BX	Boulder						
			8	SS	124/28cm.						
			9	BX	Boulder		83.0				
			10	SS	85/13cm.						
	Grey						82.0				
			11	SS	100/5cm		81.0				
			12	BX	Boulder		80.0				
			13	SS	59						
							79.0				
	Sandy Zone		14	SS	60		78.0				13 69 (18)
							77.0				
76.5											
12.3	Limestone Bedrock		15	BX RC	Rec 85%						RQD = 0%
			16	BX RC	Rec 96%		76.0				RQD = 55%
			17	BX RC	Rec 70%						RQD = 47%
			18	BX RC	Rec 83%		75.0				RQD = 30%
73.9											
14.9	End of Borehole						74.0				

+3, x5 : Numbers refer to Sensitivity

15 20 10 S (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED • QUICK TRIAXIAL + FIELD VANE x LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
88.5	Ground Surface										
0.0	Sandy Silt Some Gravel (Glacial Till) Brown		1	SS	25	▽	88.0				W.L. on 1990 11 02
			2	BX	Boulder		87.0				
			3	SS	14		86.0				16 37 (47)
	Compact to V. Dense						85.0				
			4	BX	Boulder						
	Randomly placed Boulders		5	SS	51		84.0				
			6	BX	Boulder						
			7	SS	327/10cm		83.0				
			8	BX	Boulder		82.0				
	Grey		9	SS	767/10cm		81.0				
			10	BX	Boulder		80.0				
			11	SS	60/5cm.		79.0				
			12	SS	60/5cm		78.0				
			13	SS	75		77.0				
76.3											
12.2	Limestone Bedrock		14	BX RC	Rec 100%		76.0				RQD = 25%
			15	BX RC	Rec 82%		75.0				RQD = 37%
73.5	Cont. on Sheet 2						74.0				
15.0											

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7 cont'd — METRIC

W P 187-89-02 LOCATION N: 5 000 767 ; E: 369 175 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.

DATUM Geodetic DATE 1990 11 01 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
73.5	Cont. from Sheet 1										
15.0 / 72.5			16	BX RC	Rec 100%		73.0				RQD = 56%
16.0	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 ◇ 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 187-89-02 LOCATION N: 5 000 786.5 E: 369 245.5 ORIGINATED BY G.N.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.A.

DATUM Geodetic DATE 1991 11 13 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.8	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Medium Sand Tr. Asphaltic Concrete Compact Brown		1	SS	13		89.0 88.0		o		
87.7											
2.1	Clayey Silt Stiff to Firm Brown with Grey Mottlings		2	SS	3	▼	87.0 86.0	+		22.5	W.L on 1991 11 13
			3	SS	7		85.0	6			
84.0											
5.8	Sandy Silt some Gravel (Glacial Till) Compact to Very Dense Grey		4	SS	21		84.0 83.0		o		
			5	SS	45		82.0		o		14 40 (46)
80.8			6	SS	120/15cm		81.0				
9.8	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+³, ×⁵ : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 / 10)

RECORD OF BOREHOLE No 9

METRIC

W P 187-89-02 LOCATION N: 5 000 757.0 E: 369 208.0 ORIGINATED BY G.N.

DIST 9 HWY 416 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY A.A.

DATUM Geodetic DATE 1991 11 12 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
88.9	Ground Surface										
0.0	Probable Sandy Silt with Gravel (Glacial Till)						88.0				
							87.0				
86.6											
2.3	End of Conetest										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

FOUNDATION INVESTIGATION REPORT
for
Steven Creek Bridge

W.P. 187-89-03, District 9, Ottawa
Highway 416, Str. Site: 3-356/2

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by UMA Engineering to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 and Steven Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report.

This report, which follows a letter report dated 1990 12 20, is submitted in compliance with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located in Rideau Township, some 35 km south of Ottawa along Highway 16. The location is shown in the key plan on Drawing 1878903-A, appended.* The proposed bridge centreline is approximately 30 m west of the existing 20 m single span structure on Highway 16. At this location Steven Creek is approximately 12 m wide and 3 m deep. The flow is in an easterly direction towards the Rideau River. The south approach to this site is flat and clear of vegetation. The north approach is bush covered. A tributary stream flows from the northwest to join Steven Creek to the west of the existing bridge.

The site lies within the physiographic area known as the North Gower Drumlin Field. The drumlins have a north-south orientation. The area has been inundated by the Champlain Sea which has caused the drumlins to be covered with a mantle of marine soil, predominantly silt and Leda clay.

Bedrock in this area has been mapped as magnesium limestone to dolostone of the Oxford Formation, Lower Ordovician age.

Due to the undulating nature of the topography there are springs within the area. Water enters the soil in high ground, usually a glacial landform where the mantle of marine soil is relatively thin. Springs are frequently found where erosion has removed much of the cohesive overburden material. Artesian pressures exist at depth.

3.0 FIELD AND LABORATORY WORK

The field work, carried out between 1990 10 22 and 25, consisted of the drilling of six boreholes, each accompanied by a dynamic cone penetration test. Four boreholes were drilled at the corners of the proposed structure. The other two holes were drilled for the north and south approach fills. The borehole elevations, referenced to Geodetic datum, were supplied by UMA Engineering. The locations of the boreholes are shown on Drawing 1878903-A.*

* Sheet No 161 of the Contract Drawings.

Drilling was performed with bombardier mounted CME 55 drill rigs. Hollow stem augers were used to advance the boreholes. Boreholes 1 and 6 for the approaches were terminated within the highest competent stratum. Boreholes 3 and 4 for the structure were terminated at auger refusal. Bedrock was proven in Borehole 5 by diamond coring. It was intended to prove bedrock in Borehole 2, however artesian conditions required its premature termination.

Standard Penetration Tests were used to sample very dense or non-cohesive strata. In cohesive strata relatively undisturbed samples were obtained by pushing thin walled Shelby tubes either manually or hydraulically into the soil. After the recovery of each thin walled tube sample standard MTO A size vane tests were carried out to measure the undrained shear strength. Remoulded strengths were also determined to assess the sensitivity of the soil.

Upon completion of each borehole, water levels were measured in the uncased hole. Boreholes 1, 5 and 6 were backfilled with native soil cuttings. Bentonite sealed perforated standpipes were installed in Boreholes 3 and 4. The water level in these boreholes was monitored over a period of a week.

Borehole 2, in which high artesian pressures were present, was sealed with a polymer additive to stop the flow. Considerable difficulties were encountered in stemming the flow of water. Initial attempts resulted in the water finding a new path to the nearby cone test location, and upwards of two days were required to effect proper closure of all artesian conditions near this borehole.

Recovered soil samples were transported to our Don Mills Laboratory where they were visually examined and classified. Tests for index properties such as moisture contents, Atterberg Limits, and grain size analyses were performed on selected samples. Unconfined compression tests were conducted on seven of the thin walled samples. One consolidation test was also performed. The test results are given on the Record of Boreholes and on Figures 1 to 4 in the Appendix.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil stratigraphy consists of silt with trace organics overlying a sensitive silty clay to clay deposit above a silt stratum. The silt is underlain by a very dense sand and gravel glacial till. Limestone bedrock is fractured.

Details are provided below.

4.2 Silt, Trace Organics

Where present, there is some 400 mm of topsoil. Closer to the banks of the creek there is up to 1.4 m of brown silt with trace of organics. The moisture content ranged from 22 to 36 per cent. N values ranged from 2 to 17 blows/0.3 m indicating the consistency to range between soft and stiff.

4.3 Silty Clay to Clay

A silty clay to clay deposit was found below the topsoil or surficial silt with trace of organics. Its thickness varied from 6.2 m to 9.1 m, with its base between 76 m and 78 m. The silt content increases with depth.

The moisture content of this material generally increases with depth down to elev. 81±m below which the moisture content decreases. A desiccated crust is present in Boreholes 4, 5 and 6. Atterberg limit tests (Figure 1) indicate a medium to high plasticity for this soil. Below the desiccated crust, the moisture content is generally higher than the liquid limit, resulting in a liquidity index of 1 or greater.

N values ranged from 0 to 10 blows/0.3 m. The higher values being in the upper desiccated crust which has a lower moisture content.

Field vane tests indicate undrained shear strengths of 15 kPa to 48 kPa, generally increasing with depth at a c_u/p_o ratio of about 0.28. The sensitivity of the silty clay was found to be between 5 and 9 with a couple extreme values of 3 and 22. Unconfined compression test values ranged from 12 kPa to 30 kPa. Based on the measured undrained shear strengths, the deposit has an overall consistency ranging from soft to firm.

The result of one consolidation test carried out on a 75 mm sized thin walled tube sample is shown on Figure 2. The preconsolidation pressure, p_c, is 160 kPa±. The recompression index, C_r is 0.04 and the compression index, C_c, is 1.7.

4.4 Silt

Silt, ranging in thickness from 1.4 m to 3.0 m, is present below the silty clay to clay stratum. This deposit is non homogenous and contains inclusions of silty clay which diminish with depth. The sand content increases with depth.

The moisture content of the silt ranged from 20 to 38 per cent, the higher values being associated with the presence of the clay inclusions. Atterberg limit tests show the soil to be non-plastic. One grain size curve is shown on Figure 3.

Vane tests were attempted in this deposit in the belief that it was a plastic soil. However the thin walled tube samples taken in this stratum reveal the soil to be silt. Therefore, the reported vane shear strength values are not an appropriate indicator of strength for this deposit. N values of 0 to 13 blows/0.3 m indicate the soil to be very loose to compact.

4.5 Sand and Gravel (Glacial Till)

Below elev. ±75 m the silt deposit is underlain by a glacial till consisting of a mixture of sand and gravel with traces of silt and clay. The moisture content ranged from 5 to 20 per cent, with an average of 10 per cent. Grain size distribution curves are shown on Figure 4 and indicate a composition ranging from uniform fine to medium sand to well graded sand and gravel. N values in this glacial till deposit ranged from 10 to 59 blows/0.3 m indicating it to be compact to very dense.

4.6 Limestone Bedrock

Limestone bedrock was encountered at elevations of 71 m to 72 m and was proven by coring in Borehole 5. It is thinly bedded with recoveries ranging from 77 % to 100 %, the RQD values were all below 18 % indicating very poor quality.

5.0 GROUNDWATER CONDITIONS

In boreholes close to the stream, the water levels were the same as those of the stream, which was at elev. 86.1 m on 1991 10 24.

The sand and gravel deposit above the bedrock is under artesian pressure, with the water level rising to elev. 87.0 m, some 1+m above ground surface.

Water level observations are summarized below:

Borehole	W.L. Elev. (m)	Art. W.L. (m)	Date
1	86.2	-	1990 10 22
2	86.0	87.0	1990 10 23
3	86.1	87.0	1990 10 24
4	86.2	-	1990 10 26
5	86.0	87.0	1990 10 26
6	86.0	-	1990 10 26

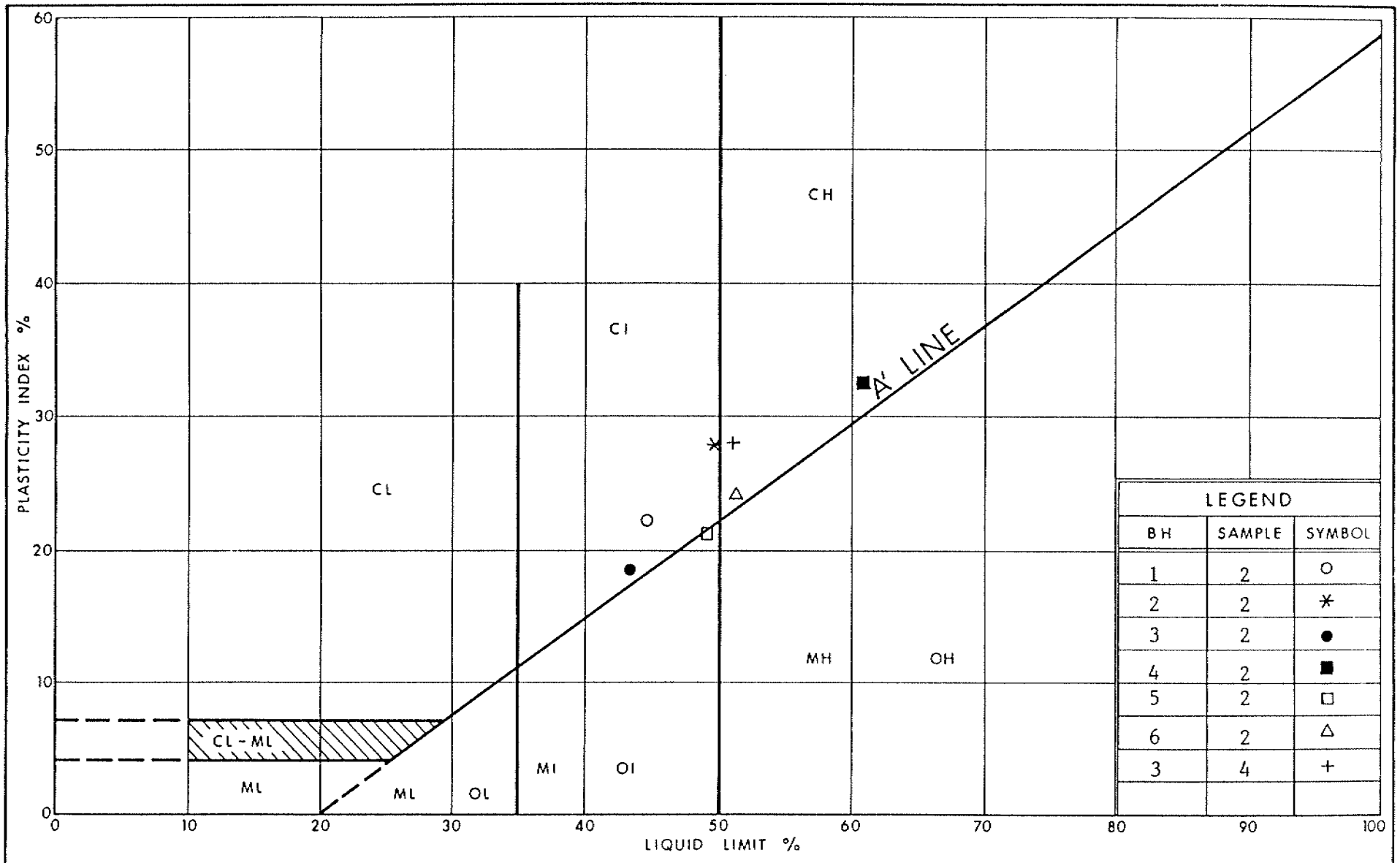
7.0 CLOSURE

The field work was supervised by A. C. Abel. The drilling equipment was rented from F. E. Johnston and Marathon Drilling companies, Ottawa.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. The project was carried out under the technical supervision of UMA Engineering Ltd., the supervising consultant for this project.

D. Dundas, P. Eng.
Sr. Foundation Engineer

APPENDIX

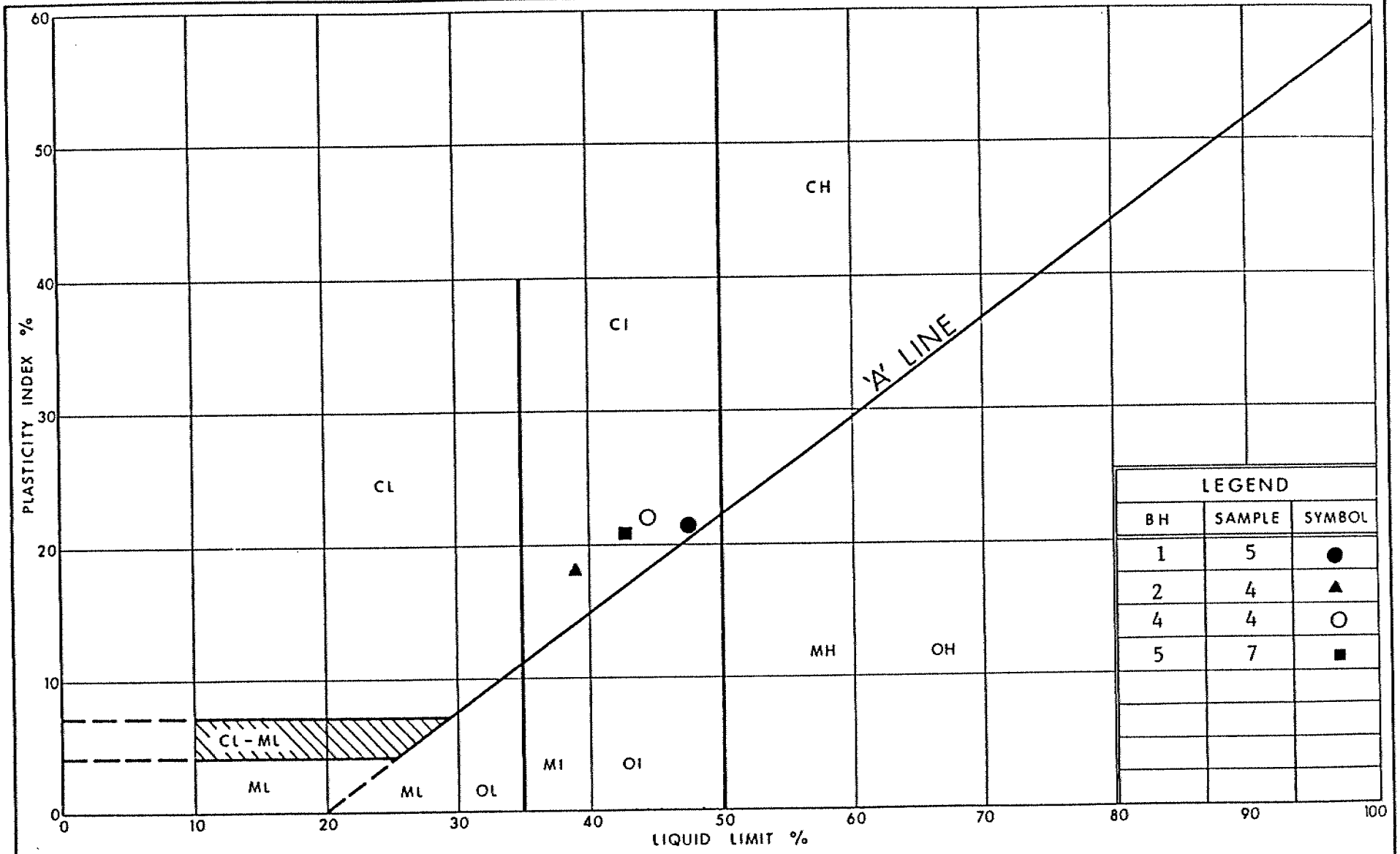


Ministry of Transportation
Ontario

PLASTICITY CHART

Silty Clay to Clay

FIG No 1A
W P 187-89-03
Steven Creek Bridge

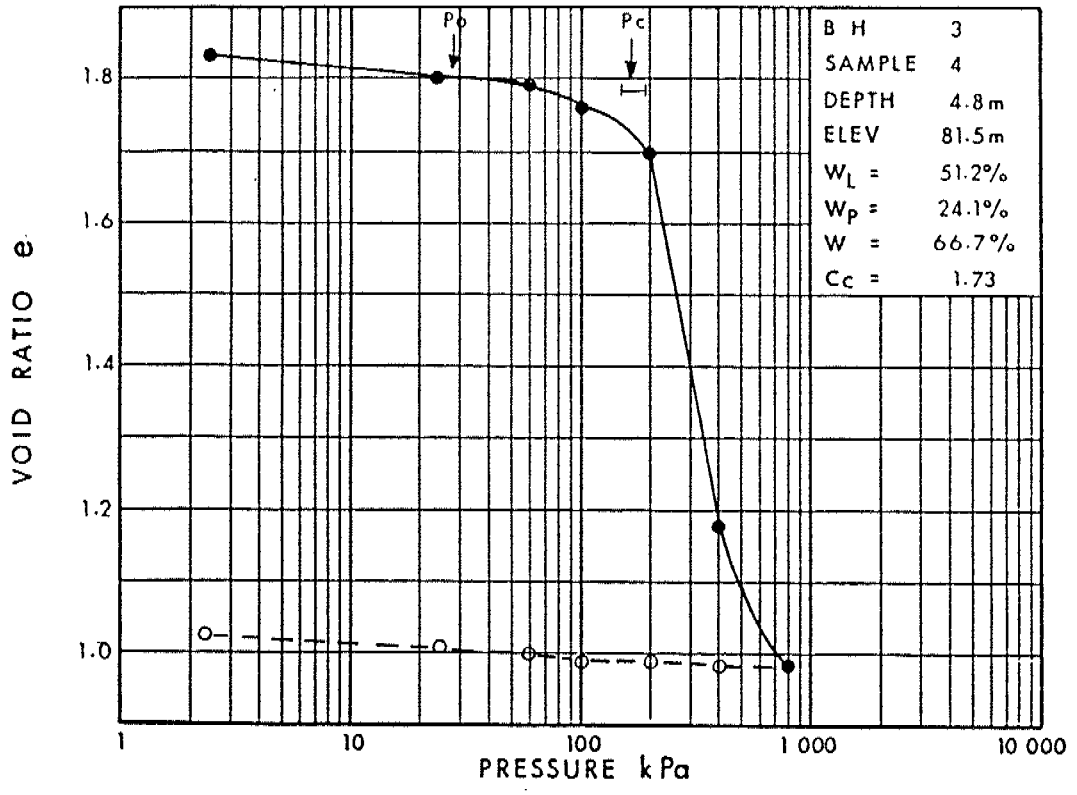


Ministry of Transportation
Ontario

PLASTICITY CHART
Silty Clay

FIG No 1B
W P 187-89-03
Steven Creek Bridge

VOID RATIO - PRESSURE CURVES



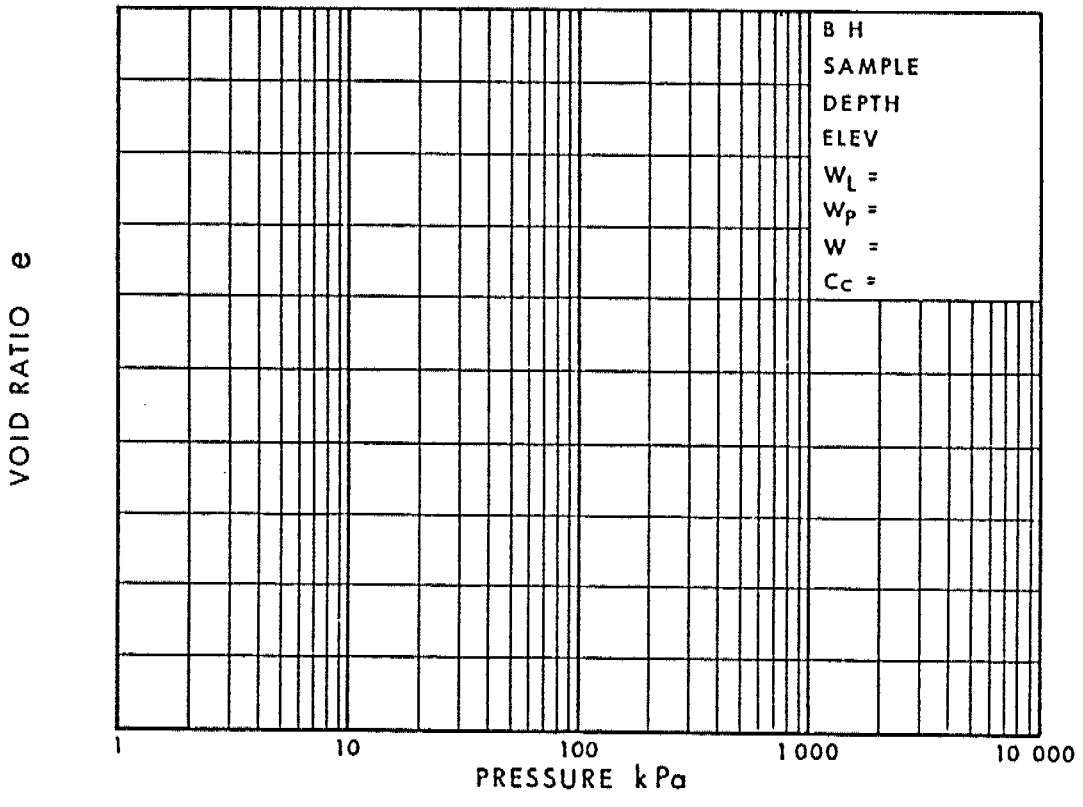
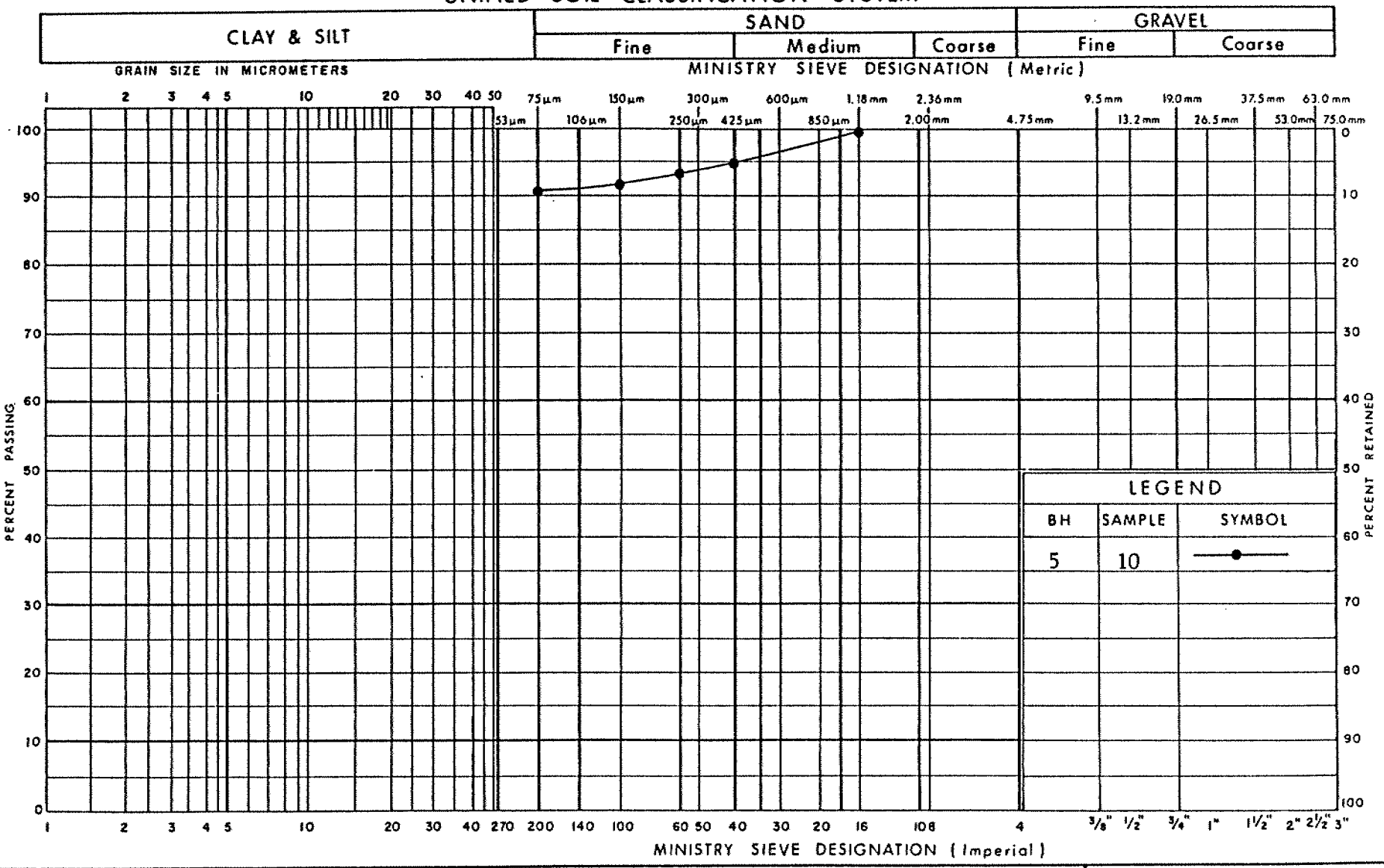


Fig 2

WP 187-89-03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

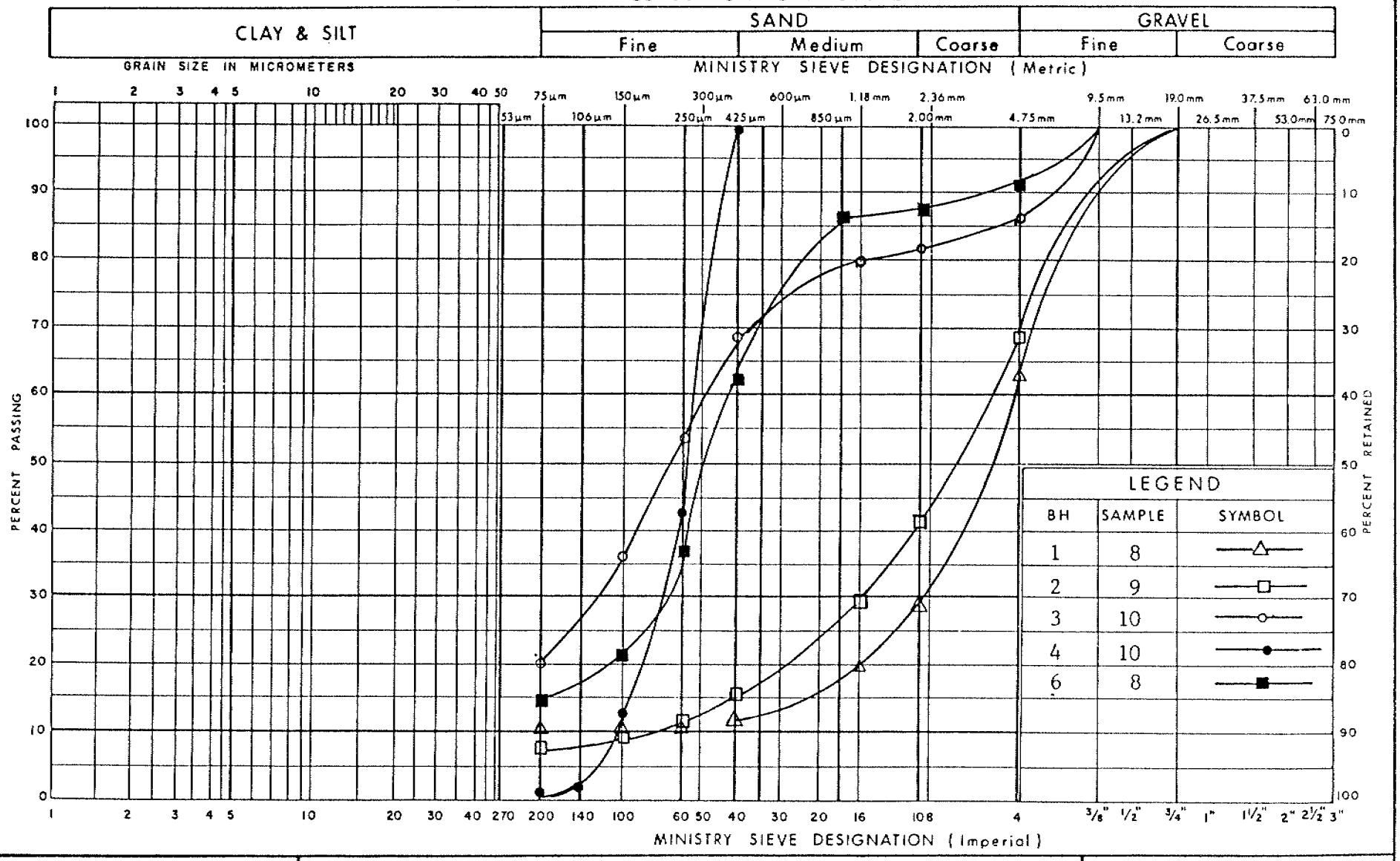
Silt

FIG No 3

W P 187-89-03

Steven Creek Bridge

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Glacial Till)

FIG No 4

W P 187-89-03

Steven Creek Bridge

Ministry of Transportation Ontario

RECORD OF BOREHOLE No1 METRIC

W P 187-89-03 LOCATION N: 5 001 962.8 ; E: 368 833.0 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 22 CHECKED BY C.N.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.5	Ground Surface										
0.0	350mm Topsoil						86.0				W. L. on 1990 10 22
	Silty Clay to Clay		1	SS	2				o		
			2	SS	2		85.0	5	o		
			3	TW	PM		84.0		o		
	Soft to Firm						83.0	9 9			
			4	TW	PM		82.0	o 10	o	15.2	
	Grey		5	TW	PH		81.0		o		
77.4							80.0	7			
9.1	Silt with Clay Inclusions V. Loose		6	TW	PH		79.0		o		
76.0	Grey		7	SS	*		78.0	7			
10.5	Sand and Gravel (Glacial Till)						77.0		oNP		
75.2	Dense Grey		8	SS	46		76.0		o		37 53 (10)
11.3	End of Borehole * Penertrated by weight of Hammer and Rods										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 187-89-03 LOCATION N: 5 001 982.5 E: 368 832.5 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 23 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.1	Ground Surface					Art Head	86.0	20 40 60 80 100	20 40 60		
0.0	Silt trace Organics										W. L. on 1990 10 23
	Soft										
84.8	Brown		1	SS	2		85.0		o		
1.3	Silty Clay to Clay		2	SS	*				o		
							84.0	+5 +6			
	Firm		3	TW	PM		83.0		o		
								+22			
			4	TW	PM		82.0	σ	o	15.4	
	Grey						81.0	+7			
			5	TW	PH		80.0		o		
78.6							79.0	+6			
7.5	Silt with Clay Inclusions		6	TW	PH				oNP		
	Loose						78.0				
77.2	Grey										
8.9	Sand and Gravel trace Silt (Glacial Till) Occ. Cobbles Compact to V. Dense		7	SS	30		77.0		o		
							76.0				
						Art. Encountered					
	Grey		8	SS	36		75.0		o		30 62 (8)
74.2			9	SS	59				o		
11.9	End of Borehole										
	* Penetrated by weight of Hammer and Rods										

+3, ×5 : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 / 10)

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No3

METRIC

W P 187-89-03 LOCATION N: 5 001 980.4 ; E: 368 820.4 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 23 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.3	Ground Surface										
0.0	Silt trace Organics Firm Brown					Art. Gradual	86.0				W.L. on 1990 10 24
85.0			1	SS	6		85.0		○		
1.3	Silty Clay to Clay		2	SS	1				○		
							84.0	7, +8			
	Soft		3	TW	PM		83.0				
								+8, +2			
							82.0				
			4	TW	PM				○	15.5	Consol. Test Figure 2
							81.0	+4, +5			
	Grey		5	TW	PM		80.0		○		
								+6, +4			
			6	TW	PM		79.0	σ	○	19.1	
							78.0	+16, +6			
			7	TW	PM		77.0		○		
76.1								+5, +2			
10.2	Silt with Clay Inclusions Loose		8	TW	PH		76.0		○ NP		
74.7	Grey					Seal	75.0				
11.6	Sand and Gravel some Silt (Glacial Till) Occ Cobbles Compact to Very Dense		9	SS	22	Art. Encount.	74.0		○		
						Standpipe	73.0				
72.4	Grey		10	SS	100/15cm				○		14 66 (20)
13.9	End of Borehole Probable Bedrock										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 187-89-03 LOCATION N: 5 002 012.5; E: 368 828.0 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 24 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.2	Ground Surface							SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60		
0.0	Silt trace Organics Stiff Brown		1	SS	11		86.0				W.T. on 1990 10 26
84.8							85.0				
1.4	Silty Clay to Clay Desiccated		2	SS	5		84.0				
			3	SS	1		83.0				
	Soft to Firm		4	TW	PM		82.0				
			5	TW	PM		81.0			17.3	
	Grey		6	TW	PM		80.0				
			7	TW	PM		79.0			17.6	
77.4							78.0				
8.8	Silt with Clay Inclusions V. Loose to Compact Grey		8	TW	PM		77.0				
			9	SS	13	Seal	76.0				
74.4							75.0				
11.8	Sandy Zone		10	SS	32	Standpipe	74.0				0 99 (1)
	Sand and Gravel (Glacial Till) Occ. Cobbles Dense						73.0				
71.3	Grey						72.0				
14.9	End of Borehole Probable Bedrock										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 5

METRIC

W P 187-89-03 LOCATION N: 5 002 011.0 ; E: 368 812.0 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 25 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W_p / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_l WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
87.6	Ground Surface							SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100			
0.0	Silt trace Organics					Sub Art. Head	87.0				W. L. on 1990 10 26
	Very Stiff		1	SS	17				o		
86.2	Brown						86.0				
1.4	Silty Clay to Clay		2	SS	10				o		
	Stiff Desiccated										
			3	SS	3		85.0		o		
			4	TW	PM		84.0	+4 +5	o		
	Soft to Firm										
			5	TW	PM		83.0			o	
							82.0	+4 +3			
			6	TW	PM		81.0	+1 +5 +4		o	15.2
	Grey										
			7	TW	PM		80.0		o		
							79.0	+4 +2			
			8	TW	PM		78.0			o	
77.1								+11 +4			
10.5	Silt		9	TW	PM		77.0		ND o		
	with Clay Incusions										
	V. Loose						76.0	+9 +3			
	Grey		10	SS	*				o		0 9 (91)
74.6							75.0				
13.0	Sand and Gravel (Glacial Till)						74.0				
	Occ. Cobbles		11	SS	10				o		
	Compact					Sub Art. Encountered					
	Grey						73.0				
72.6	Cont. on Page 2										
15.0											

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5 cont'd

METRIC

W P 187-89-03 LOCATION N: 5 002 011.0 ; E: 368 812.0 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 25 CHECKED BY C.M.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
72.6	Cont from Page 1										
72.4											
15.2	Limestone Bedrock Thinly Bedded		12	BX RC	Rec 77		72.0				RQD = 0 %
			13	BX RC	Rec 71%						RQD = 0%
			14	BX RC	Rec 83%		71.0				RQD = 0 %
			15	BX RC	Rec 98%		70.0				RQD = 0 %
69.0			16	BX RC	Rec 100%						RQD = 18%
18.6	End of Borehole * Penetrated by weight of Hammer and Rods										

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 6 METRIC

W P 167-89-03 LOCATION N: 5 002 037.8; E: 368 811.0 ORIGINATED BY A.A.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1990 10 25 CHECKED BY C.N.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kp/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.3	Ground Surface								
0.0	400 mm Topsoil					▽	86.0		W.L. on 1990 10 26
	Silty Clay to Clay		1	SS	2				
	Desiccated						85.0		
			2	SS	1				
							84.0		
			3	TW	PM		83.0		
	Soft to Firm								
							82.0		
			4	TW	PM			15.1	
							81.0		
			5	TW	PM		80.0		
	Grey								
78.0			6	TW	PM		79.0		
8.3	Silt with Clay Inclusions						78.0		
	Loose		7	TW	PH		77.0		
	Grey								
75.7							76.0		
10.6	Sand and Gravel some Silt (Glacial Till) Occ. Cobbles Dense Grey		8	SS	40		75.0		10 76 (14)
73.5							74.0		
12.8	End of Borehole								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

FOUNDATION INVESTIGATION REPORT
for
Mud Creek Bridge

W.P. 187-89-04, District 9, Ottawa
Highway 416, Str. Site: 3-358/2

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by UMA Engineering Ltd. to carry out a foundation investigation for the crossing of the proposed southbound lanes of Highway 416 and Mud Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests and to provide a full geotechnical report.

This report, which follows a letter report dated 1990 12 20, is submitted in compliance with these terms of reference.

2.0 SITE AND GEOLOGY

The site is located within Rideau Township approximately 30 km south of Ottawa along Highway 16. The location of the site is shown on the key plan in Drawing 1878904-A, appended.* The proposed bridge centreline is approximately 30 m to the west of centreline of the existing structure at Highway 16.

The topography of the immediate area is flat. With the exception of a small wooded area to the west of the site, the land use is primarily agricultural. The creek flows within a channel some 4 m deep. The creek is approximately 10 m wide and 2 m deep in the vicinity of this site.

The site lies in the physiographic region known as the North Gower Drumlin field. The drumlins are oriented more or less north-south. A mantle of marine soils is draped over the drumlins and other glacial landforms. The marine soils are the result of inundation by the Champlain Sea. Therefore, silt and Leda clay are common in this area.

3.0 FIELD AND LABORATORY WORK

The field work, carried out from 1990 10 26 to 30, consisted of the drilling of six boreholes, each accompanied by a dynamic cone penetration test. Four boreholes were drilled at the corners of the proposed structure. The remaining two boreholes were drilled along centreline away from the structure to provide information for the approach fills. The borehole elevations, referenced to Geodetic datum, were supplied by UMA Engineering. The locations of the boreholes are shown on Drawing 1878904-A.*

Drilling was conducted with two bombardier mounted CME 55 drill rigs. Hollow stem augers were used to advance the boreholes. Boreholes 1 and 6 for the approach embankments were terminated within the highest competent stratum. Boreholes 2 and 5 were terminated at auger refusal. Bedrock was cored in Boreholes 3 and 4.

* Sheet No 176 of the Contract Drawings.

Standard Penetration Tests were used to sample very dense materials as well as non-cohesive deposits, the accompanying N values being noted in blows/0.3 m. In cohesive strata, relatively undisturbed samples were obtained by pushing thin walled Shelby tubes either manually or hydraulically into the soil.

After the recovery of each thin walled tube sample, standard MTO A size vane tests were conducted to determine the undrained shear strength of the deposit. Remoulded shear strengths were also measured to determine the sensitivity of the soil.

Upon completion of each borehole the water levels were measured in the uncased holes. Boreholes 1, 2, 5 and 6 were backfilled with native soil cuttings. Bentonite sealed perforated standpipes were installed in Boreholes 3 and 4. The water level in these instrumented holes was monitored over a period of time. The site was restored to its original condition.

Recovered samples were transported to our Don Mills Laboratory for further visual examination, classification and index property testing such as moisture content, grain size distribution and Atterberg limits. Unconfined compression tests were performed on six thin walled tube samples. The results are shown on the Record of Boreholes and on Figures 1, 2A and 2B.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil stratigraphy consists of a silty clay to clay deposit overlying loose silt above a silty sand glacial till. Fractured limestone bedrock lies 11 m to 14.2 m below prevailing ground surface.

4.2 Surficial Organics

Topsoil (200 mm to 400 mm) was present at all borehole locations.

4.3 Silty Clay to Clay

A 4.2 m to 5.6 m thick deposit of silty clay to clay occurs below the topsoil.
The upper 1.5 m to 2.0 m of this deposit is desiccated. This upper desiccated crust is mottled brown and fissured. The moisture content in the crust ranged from 25 to 50 per cent, and lies between the liquid and plastic limits of the soil. One field vane test within the crust gave an undrained shear strength value of 68 kPa.

Below the desiccated zone the silty clay to clay is grey. The moisture content ranged from 70 to 40 per cent, generally decreasing with depth. Atterberg limits (Figure 1) indicate medium to high plasticity.

Field vane test undrained shear strength values ranged from 24 kPa to 58 kPa generally increasing with depth and decreasing moisture content, indicating a soft to firm consistency. The sensitivity of the soil is about 6 with extreme values of 2 and 11.

4.4 Silt

At about elevation 85 m to 86 m the silty clay to clay deposit is underlain by a grey silt deposit with thin clay seams. This stratum was 2.9 m to 4.6 m in total thickness at the drilled locations.

Field vane tests were carried out in this deposit in the belief that the soil was cohesive. However, when the recovered samples were examined, it was seen that the deposit was predominantly silt. Hence, any field vane values shown for this deposit have been discounted in stability analyses. The natural moisture content of the silt ranged from 20 to 50 per cent, the average being about 30 per cent. N values of 0 to 10 blows/0.3 m indicate the silt is very loose to compact.

4.5 Silty Sand (Glacial Till)

The silt stratum is underlain at a depth of about 9m below the prevailing ground surface by a silty sand with some gravel (glacial till). This deposit was fully penetrated in Borehole 3 where the thickness was 4.7 m and in Borehole 4 where it was 6.9 m.

Grain size curves are shown in envelope form in Figure 2A. A sandy zone is plotted on Figure 2B. N values in this deposit were between and 2 and 114 blows/0.3 m, generally increasing with depth. The lower N values were observed within the upper zones of the deposit and may be due to local re-working of the till. The dynamic cone penetration tests all terminated within this deposit. Based on these N values, the deposit is considered to be very dense with localized loose to compact zones near its surface. Cobbles are suspected to be present on the basis of observations in the field during drilling.

4.6 Limestone Bedrock

Limestone bedrock was proven in Boreholes 3 and 4. It is badly fractured with core recoveries of between 37% and 90%. The maximum RQD value was 30%, most values being 0% for each core run.

5.0 GROUNDWATER CONDITIONS

The phreatic level at the site corresponds more or less to the creek level. Observations are listed below:

Borehole	Ground Elev. (m)	W.L. Elev. (m)	Date
1	89.8	88.5	1990 10 30
2	90.4	88.3	1990 10 29
3	89.9	89.9	1990 10 29
4	90.7	90.3	1990 10 30
5	90.6	88.2	1990 10 30
6	90.8	88.5	1990 10 30

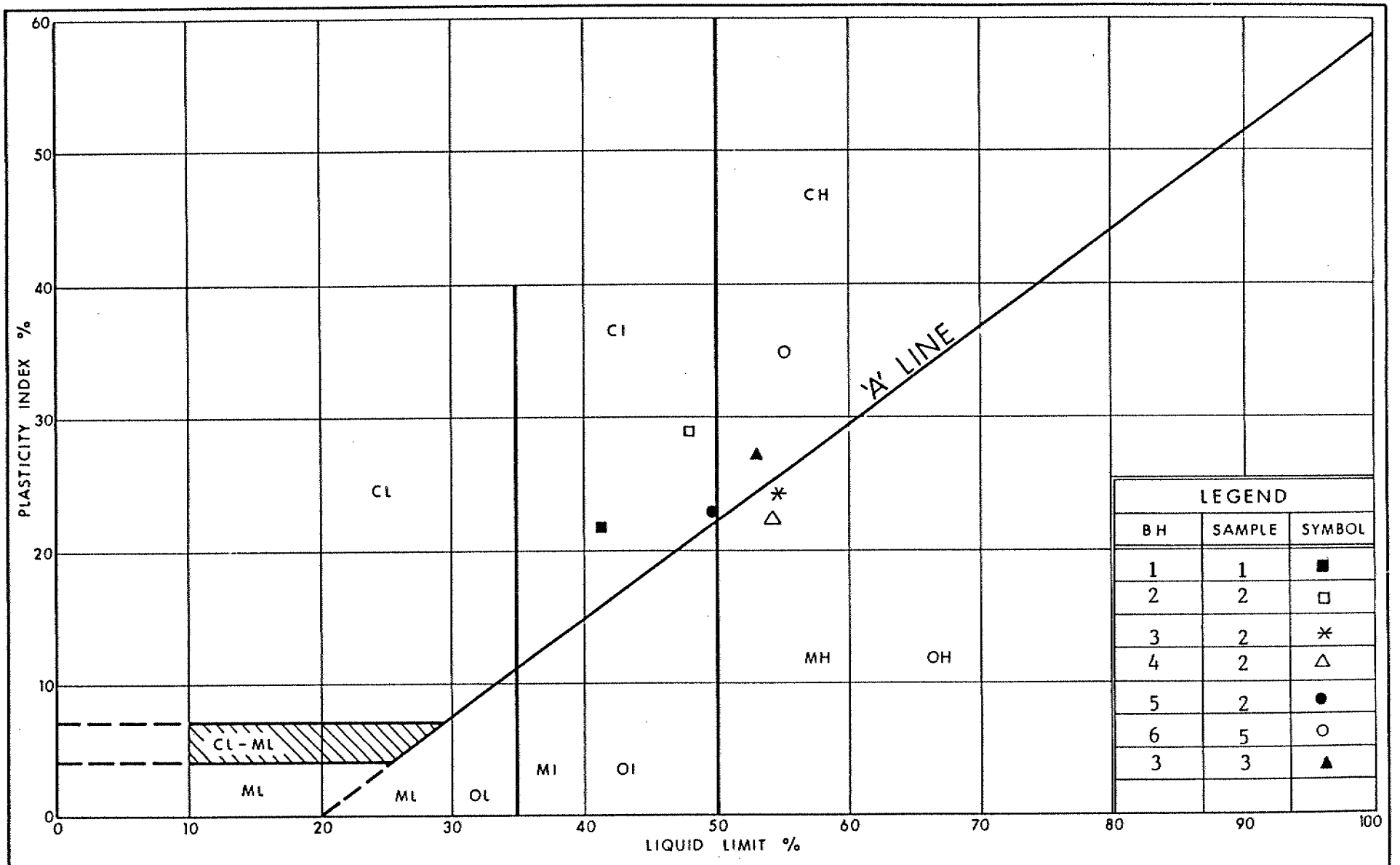
7.0 CLOSURE

The drilling was supervised by A. C. Abel. Drill rigs were rented from F. E. Johnston and Marathon Drilling companies, Ottawa.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation and Design Report prepared by Strata Engineering Corp. (consulting geotechnical engineers for this project), and signed and sealed by C. Mirza, P. Eng. The project was carried out under the technical supervision of UMA Engineering Ltd., the supervising consultant for this project.

D. Dundas, P. Eng.
Sr. Foundation Engineer

APPENDIX



LEGEND		
BH	SAMPLE	SYMBOL
1	1	■
2	2	□
3	2	*
4	2	△
5	2	●
6	5	○
3	3	▲

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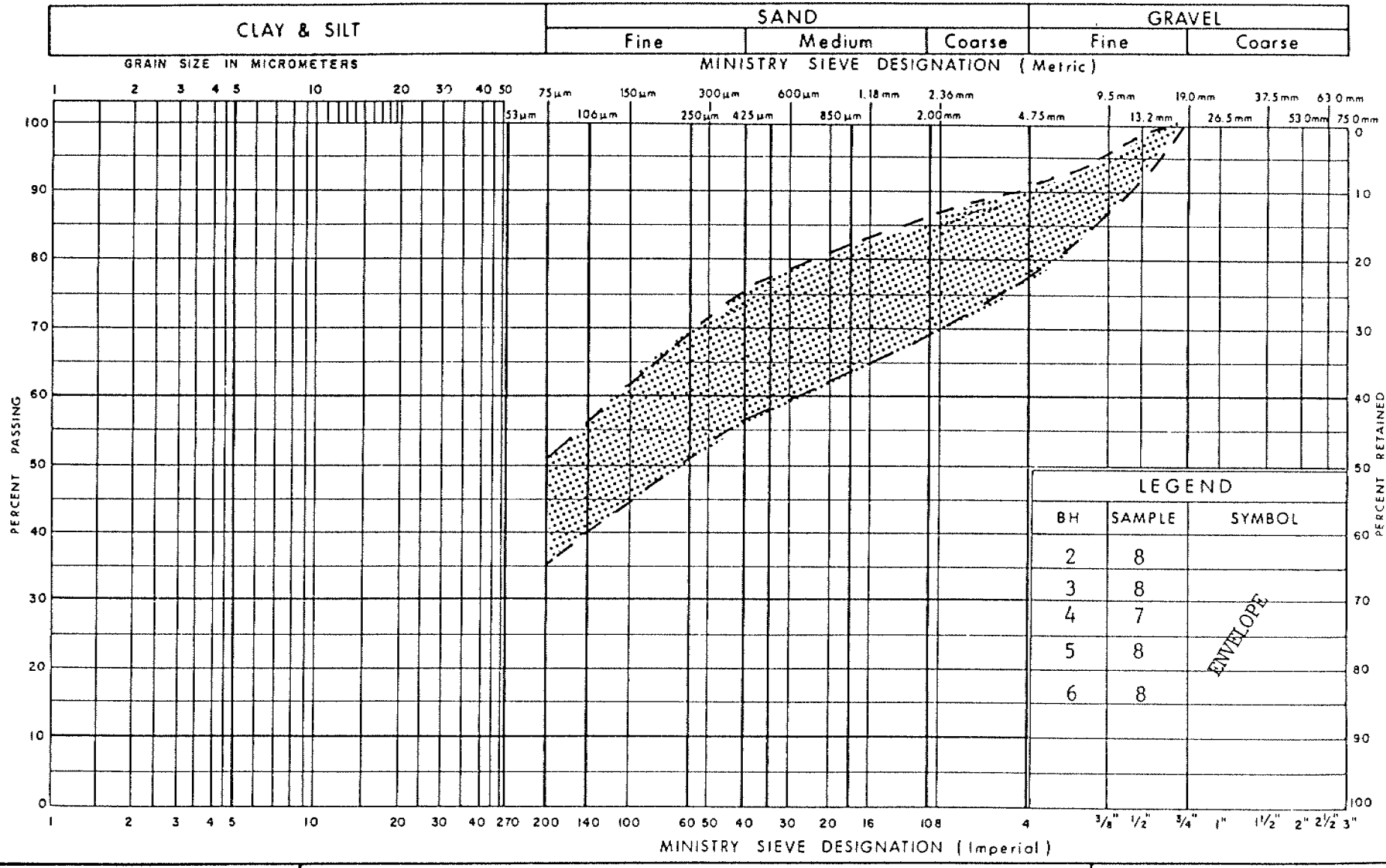
PLASTICITY CHART

Silty Clay to Clay

FIG No 1
W P 187-89-04
Mud Creek Bridge

UNIFIED SOIL CLASSIFICATION SYSTEM



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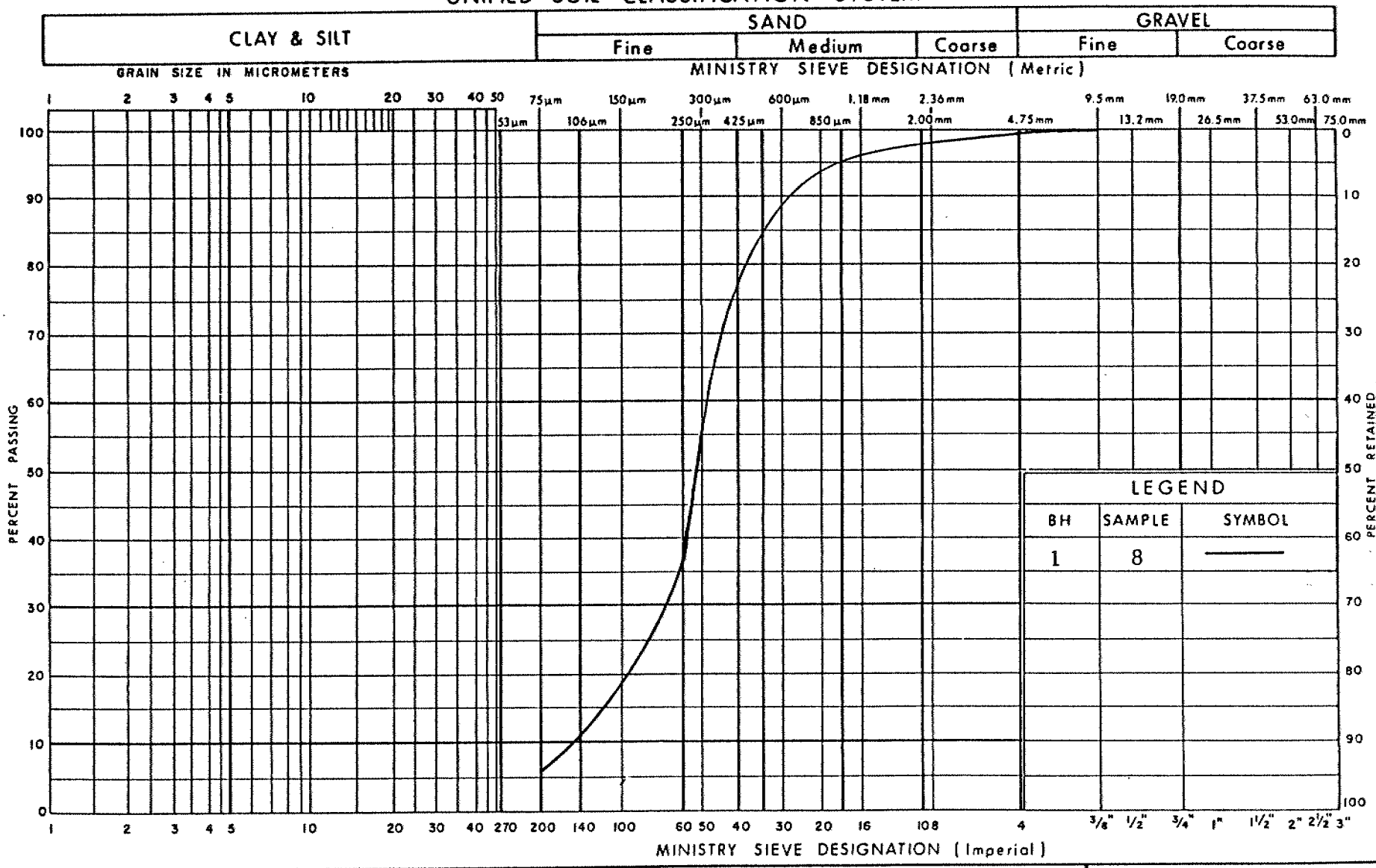
GRAIN SIZE DISTRIBUTION

Silty Sand with some Gravel
(Glacial Till)

FIG No 2A
W P 187-89-04
Mud Creek Bridge

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

Silty Sand trace Gravel
(Glacial Till)

FIG No 2B
W P 187-89-04
Mud Creek Bridge

RECORD OF BOREHOLE No1 METRIC

W P 187-89-04 LOCATION N: 5 005 065 ; E: 366 407-5 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 26 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) Wp W WL	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.8	Ground Surface										
0.0	200mm Topsoil Silty Clay to Clay Stiff Desiccated Mottled Brown		1	SS	10	▼	89.0				W.L. on 1990 10 30
			2	SS	5		88.0				
	Firm to Stiff Grey		3	TW	PM		87.0				
			4	TW	PM		86.0			18.9	
84.2							85.0				
5.6	Silt Occ. Clay Seams Loose		5	TW	PM		84.0		NP		
			6	TW	PM		83.0				
80.6	Grey						82.0				
9.2	Silty Sand trace Gravel (Glacial Till) Compact to Very Dense		7	SS	12		81.0				
78.7	Grey		8	SS	101		80.0				1 92 (7)
11.1	End of Borehole						79.0				

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 187-89-04 LOCATION N: 5 005 086 ; E: 366 398 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 29 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%)	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.4	Ground Surface							20 40 60 80 100	20 40 60		
0.0	250 mm Topsoil						90.0				
	Silty Clay to Clay		1	SS	19				o		
	Very Stiff to Stiff						89.0				
	Desiccated		2	SS	11				o		
	Mottled Brown					▼	88.0				W.L. on 1990 10 29
	Firm		3	SS	4				o		
	Grey		4	TW	PM		87.0	6 11	o	15.1	
			5	TW	PM		86.0		o		
84.6							85.0	2			
5.8	Silt		6	SS	4		84.0		o		
	Occ.Clay Seams							2			
	Loose		7	SS	4		83.0		o NP		
81.5	Grey						82.0	4			
8.9	Silty Sand with Gravel (Glacial Till)		8	SS	32		81.0		o		22 46 (32)
	Compact to Very Dense		9	SS	23		80.0		o		
			10	SS	100/17cm		79.0		o		
	Grey						78.0				
			11	SS	100/17cm		77.0		o		
75.7							76.0				
14.7	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 187-89-04 LOCATION N: 5 005 061 ; E: 366 393 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 26 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kp/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
89.9	Ground Surface										
0.0	250mm Topsoil						Sub Art. Head				
	Silty Clay to Clay										
	Stiff to Firm		1	SS	10		89.0		o		
	Desiccated										
	Mottled Brown		2	SS	4	▽	88.0	+5	o		W. L. on 1990 10 29
	- - - - - - -										
	Soft to Firm						87.0				
	Grey		3	TW	PM				o	15.1	
85.4							86.0	+2			
4.5			4	TW	PH		85.0		o		
	Silt							8			
	Occ. Clay Seams						84.0				
	Loose to Compact		5	TW	PH				o		
							83.0	+3			
	Grey										
			6	SS	10		82.0		NP		
81.0						Seal					
8.9							81.0				
	Silty Sand some Gravel (Glacial Till)		7	SS	51				o		
	Very Dense		8	SS	100/10cm		79.0		o		14 45 (41)
							78.0				
	Grey		9	SS	100/20cm				o		
76.3							77.0				
13.6	Limestone Bedrock		10	B X RC	Rec 75%						RQD = 30%
	Fractured						76.0				
74.9	Cont. on page 2		11	BX RC	Rec 90%		Sub Art. Encountered 75.0				RQD = 22%
15.0											

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3 cont'd METRIC

W P 187-89-04 LOCATION N: 5 005 061 E: 366 393 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 26 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
74.9	Cont. from page 1										
15.0 / 74.1	Limestone Bedrock Fractured		12	BX RC	Rec 80%	Piezometer					RQD = 0%
15.8	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4

METRIC

W P 187-89-04 LOCATION N: 5 005 104 ; E: 366 380 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger , Dynamic Cone Penetration Test COMPILED BY A. K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.7	Ground Surface							20 40 60 80 100	20 40 60		
0.0	200mm Topsoil Silty Clay to Clay Firm Desiccated Mottled Brown		1	SS	5	Sub Art. Head	90.0		o		W.L. on 1990 10 30
	Soft to Firm		2	SS	6		89.0		o		
	Grey		3	SS	2		88.0		o		
			4	TW	PM		87.0	5 +5	o	15.4	
86.3											
4.4	Silt Occ. Clay Seams Very Loose		5	TW	PM		86.0		o		
			6	SS	1		85.0	3	NP o		
83.4	Grey					Seal	84.0				
7.3	Silty Sand with Gravel (Glacial Till)		7	SS	2		83.0		o		22 41 (37)
	V. Loose to V.Dense		8	SS	36		82.0		o		
			9	SS	114/17cm		81.0		o		
	Grey		10	BX	Boulder		80.0		o		
			11	SS	58/23cm		79.0		o		
76.5							78.0				
14.2	Limestone Bedrock Fractured		12	BX RC	Rec 37%	Sub Art. Encountered	77.0				RQD = 0 %
75.7	Continued on page 2						76.0				
15.0											

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 $\frac{20}{10}$ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 4 cont'd METRIC

W P 187-89-04 LOCATION N: 5 005 104 ; E: 366 380 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
75.7	Cont. from page 1										
15.0	Limestone Bedrock Fractured		12	BX RC	Rec 37%		75.0				RQD = 0%
							74.0				
			13	BX RC	Rec 48%		73.0				RQD = 0%
			14	BX RC	Rec 50%	Standpipe	72.0				RQD = 0 %
71.3											
19.4	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 ; Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 5 METRIC

W P 187-89-04 LOCATION N: 5 005 094.5 ; E: 366 374 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetrarion Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 30 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.6	Ground Surface								
0.0	350mm Topsoil Silty Clay to Clay Firm Desiccated Mottled Brown		1	SS	6		90.0		
	Soft to Firm Grey		2	SS	6		89.0		
			3	SS	2	▼	88.0		W.L. on 1990 10 30
			4	TW	PM		87.0	15.5	
86.2									
4.4	Silt occ. Clay Seams Very Loose		5	TW	PM		86.0		
			6	SS	2		85.0 84.0		
	Grey		7	SS	*		83.0		
81.6							82.0		
9.0	Silty Sand some Gravel (Glacial Till) Compact		8	SS	12		81.0		15 45 (40)
79.4	Grey						80.0		
11.2	End of Borehole Probable Bedrock * Penetrated by weight of Hammer and Rods								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
• QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

NP

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 6 METRIC

W P 187-89-04 LOCATION N: 5 005 111 : E: 366 366 ORIGINATED BY A.A.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.

DATUM Geodetic DATE 1990 10 26 CHECKED BY C.M.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
90.8	Ground Surface								
0.0	300mm Topsoil Silty Clay to Clay Firm Desiccated Mottled Brown		1	SS	6		90.0		
			2	SS	6		89.0		
	Firm		3	SS	4	▼	88.0		W.L. on 1990 10 30
			4	TW	PM		87.0	15.8	
	Grey						86.0		
85.6			5	SS	4				
5.2	Silt Occ. Clay Seams Loose Grey		6	TW	PM		85.0		
			7	SS	5		84.0		
81.9							83.0		
8.9	Silty Sand some Gravel (Glacial Till) Compact Grey		8	SS	18		82.0		10 53 (37)
78.6							81.0		
							80.0		
							79.0		
12.2	End of Borehole								

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT W_p NATURAL MOISTURE CONTENT W LIQUID LIMIT W_l
WATER CONTENT (%) 20 40 60

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION, ONTARIO 741-9-207 88 10

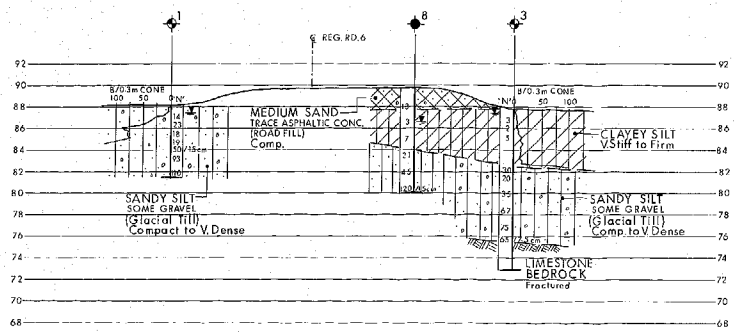
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 187-89-02

REGIONAL RD. 6 U'PASS
BORE HOLE LOCATIONS & SOIL STRATA

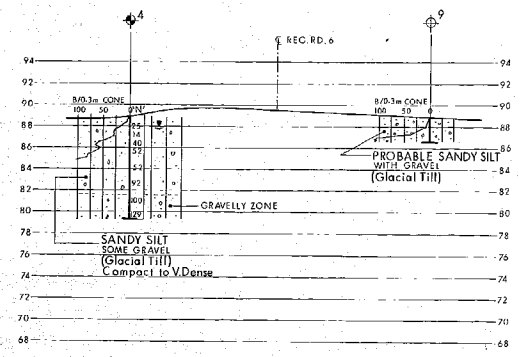
SHEET

STRATA ENGINEERING CORP.

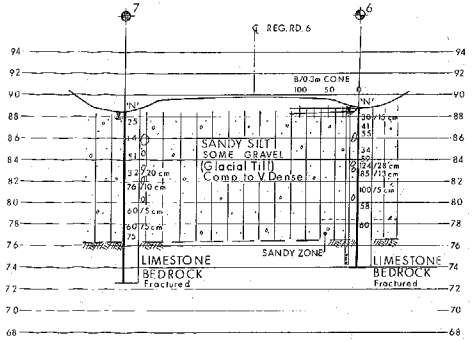


SECTION C-C

SCALE FOR SECTIONS
5m 0 5m



SECTION B-B



SECTION A-A

SEE DWG. No 1878902-A

KEY PLAN
SCALE

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L at time of investigation Oct. & Nov. 1990, Nov. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
6	88.8	5 000 747.0	369 183.0
7	88.5	5 000 767.0	369 175.0
8	89.8	5 000 786.5	369 245.5
9	88.9	5 000 757.0	369 208.0

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 31G-213

HWY No 416			DIST 9
SUBMD A.A	CHECKED	DATE Jan 07 1992	SITE 3-576
DRAWN A.K	CHECKED	APPROVED	DWG 1878902-B

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-267 88 10

METRIC

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

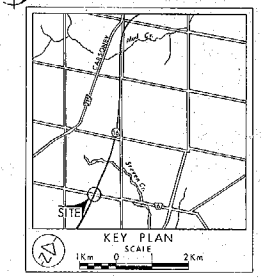
CONT No
WP No 187-89-02

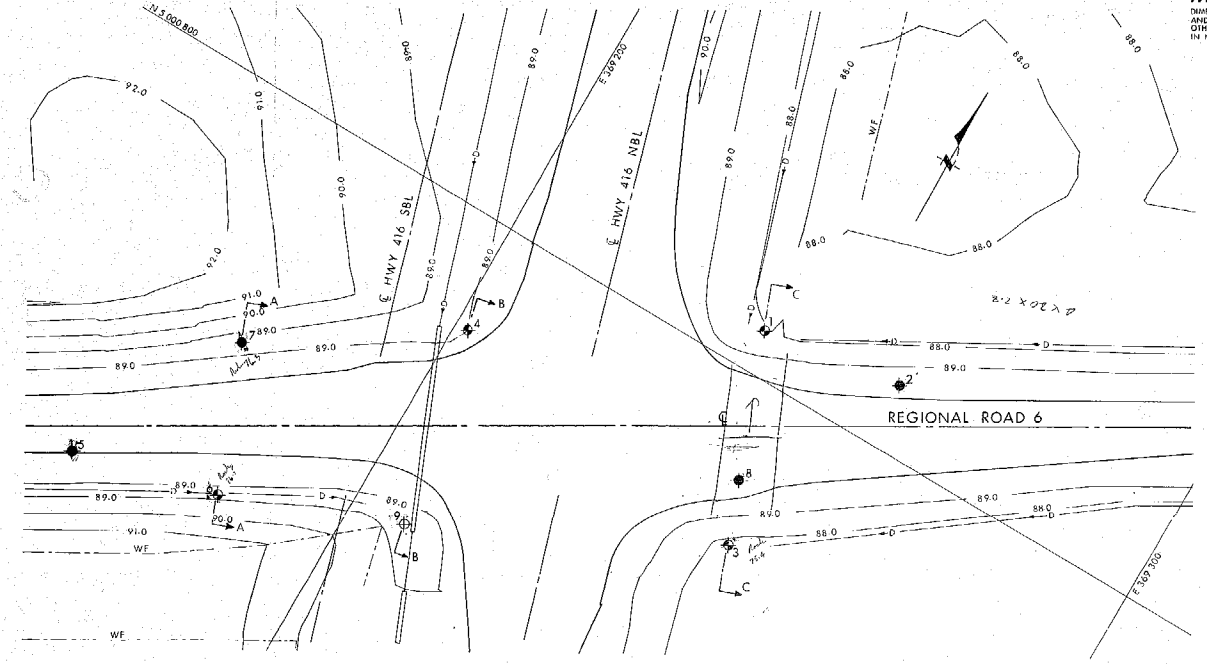
REGIONAL RD. 6 U-PASS

BORE HOLE LOCATIONS & SOIL STRATA

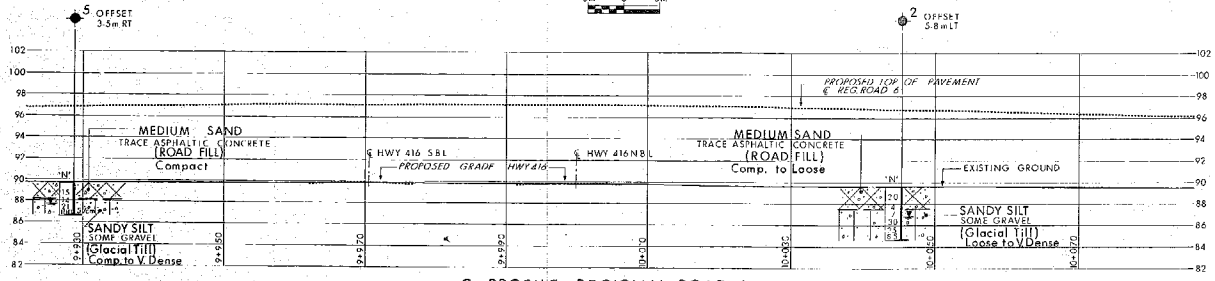
SHEET

STRATA ENGINEERING CORP.





PLAN
SCALE 5m 0 5m



℄ PROFILE REGIONAL ROAD 6

SCALE
HOR. 5m 0 5m
VERT. 5m 0 5m

REF No E-55-416-2, 1991 01

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation Oct 1990

No	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	88.1	5 000 806.0	369 238.0
2	89.6	5 000 809.0	369 258.0
3	87.8	5 000 778.0	369 249.0
4	88.9	5 000 785.0	369 201.0
5	89.6	5 000 742.0	369 162.0
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NOTE

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REV	DATE	BY	DESCRIPTION

Geocres No. 31G-213

HWY No. 416			DIST 9
SUBMITTED A.A.	CHECKED	DATE Jan 02 1991	SITE 2-576
DRAWN A.K.	CHECKED	APPROVED	DWG 187B902-A