GEOCRES No:
31G-205

T11688E

REPORT TO

FENCO ENGINEERS INC.
WILLOWDALE ONTARIO

FOUNDATION INVESTIGATION REPORT FOR HIGHWAY 416 UNDERPASS AND INTERCHANGE AT HIGHWAY 43, KEMPTVILLE W.P. 372-89-06, SITE 16-318 DISTRICT 9, KINGSTON

GEOCRES # 31G-205

Distribution:

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Mississauga, Ontario

GEOCON (1991) INC.
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1.0 INTRODUCTION

Presented herein are the results of a geotechnical subsurface investigation conducted at the above site to establish the prevalent subsurface geotechnical conditions for the design and construction of the proposed bridge, approach fills and Highway 43 realignment. Geocon (1991) Inc. (Geocon) was retained by Fenco Engineers Inc. to perform this work.

The field work for this project was conducted between October 29th and November 1st, 1990 using a CME 55 drill rig equipped with 200 mm diameter hollow stem augers. The investigation consisted of 8 boreholes and 1 test pit. The soil overburden was augered and sampled using the Standard Penetration Tests (SPT) and the underlying bedrock was cored using NXL size core. Two standpipe piezometers were installed to monitor the groundwater levels. Finally a test pit was excavated with a backhoe to obtain field densities and confirm the hard nature of the silty sand till subsurface conditions.

The locations of the boreholes and one test pit are shown on Drawing 3728906-A and a record of the encountered subsurface conditions at each borehole and the test pit are given on the Record of Borehole Sheets in Appendix A.

2.0 SITE DESCRIPTION AND GEOLOGY

The proposed Highway 43 underpass is located at the intersection of Highway 43 and Highway 16 approximately 2 kilometers east of Kemptville, Ontario (Figure 1). The proposed underpass will comprise of two spans supported on a central pier and two abutments.

The site of the proposed underpass and interchange is generally undulating with several poorly drained areas. The area of the proposed underpass structure is located on top of a small rise which is surrounded by lower lying areas. Of particular interest in this regard, is the presence of a marshy area in the northeast corner of the intersection of Highway 43 and Highway 16. Other smaller marshy areas may be found throughout the entire interchange. With the exception of the southeast quadrant of the interchange, the area is heavily wooded.

A northward flowing drainage ditch intersects the proposed Highway 43 realignment approximately 400 m east of the underpass.

The proposed Highway 416 is located within the physiographic region of the Ottawa-St. Lawrence lowland. During the last Ice Age this area was glaciated which resulted in the deposition of a layer of till over much of the proposed alignment (Sharpe, 1979). In general the till comprises of a bouldery cobbly silty sand to sandy silt.

Subsequent to glaciation the Ottawa-St. Lawrence lowland was inundated by the Champlain Sea. At the location of the proposed Highway 416 alignment the depth of water was shallow and in general resulted only in minor wave action modification of the surface of the underlying till. However, in localized low lying areas deeper deposits (up to 10 m) of fine grained clayey silt material may be present.

More specifically, available surficial geological information at the site of the proposed Highway 43 underpass and interchange (OGS Map 1492A) indicates that it is underlain by fine to medium grained glaciofluvial sands. However, this is anticipated to overlie finer grained Champlain Sea deposits.

The underlying bedrock at the site is anticipated to comprise of dolostone bedrock of the Oxford Formation of the Beekmonton Group.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions for the underpass structure and the approach embankments are discussed separately because of different subsurface conditions in these areas. These differences are caused by the undulating topography which resulted in additional soil layers in the low lying areas. The factual information which was used to interpret the soil conditions is given in Appendix A and B and Drawing No. 3728906-A.

3.1 UNDERPASS

The underpass proper is located on top of a slight knoll which is underlain by a sandy topsoil followed by very dense gravelly sand and silt (glacial till) and finally dolostone bedrock about 9 m below the ground surface. The groundwater surface was observed to be about 0.9 m below the ground surface.

3.1.1 Topsoil

The topsoil is an organic silty sand containing roots with a thickness varying from 0.2 m to 0.5 m. At Test Pit 12-1 the topsoil was underlain by 0.2 m of sand fill.

3.1.2 Gravelly Sand and Silt Trace Clay (Glacial Till)

By far the dominant material on site, glacial till was encountered below the surficial topsoil (and fill) and was found to extend to bedrock. The thickness of this layer was determined to be 8.4 m and 9.3 m at Boreholes 12-1 and 12-4, respectively.

Based on the results of grain size analysis performed on split spoon samples (Figures B1 and B2 - Appendix B) this material may be described as a gravelly sand and silt with a trace clay. Some cobbles and boulders are also present within this deposit.

SPT 'N' values within this layer are high and variable with refusal recorded at many locations before the full test penetration of the split spoon could be obtained. Based on the measured SPT 'N' values at this and other locations it is concluded that the till can be described as having a very dense relative density. Measured water contents within the glacial till typically varied from 2 to 9%.

The one water content of 28%, measured in Borehole 12-7, was obtained from a sample recovered from near the above lying clayey silt and it is not representative of the glacial till.

3.1.3 Bedrock

Dolostone bedrock was found below El. 83.0 m which is about 9 m below the existing ground surface. The bedrock was proven in two boreholes by coring about 2.5 and 2.0 m into the bedrock in Boreholes 12-1 and 12-4, respectively. The bedrock is judged, by core recovery and RQD percentages to be of good to excellent quality with the exception of the first 0.6 m in Borehole 12-4 which is of a fair quality.

3.1.4 Groundwater

Groundwater was measured by means of two standpipe piezometers in Boreholes 12-1 and 12-3 and visual observations in the remaining boreholes. The groundwater was observed

to be about 0.9 m below the ground surface in the piezometers and as high as 0.3 m below the ground surface in the uncased Borehole 12-5.

3.2 APPROACH EMBANKMENTS

The approach embankments west and east of the underpass structures are located in minor depressions which have fluvial and lacustrine deposits overlying the glacial till and bedrock. The observed soil stratigraphy is as follows:

- Peat/Topsoil
- Sand, compact
- Silty Clay, soft to stiff
- Sand (in Borehole 12-8 only)
- Gravelly Sand and Silt (Glacial Till) Very Dense

The subsurface conditions at the west embankment were investigated by Borehole 12-6 which encountered a 0.3 m thick saturated peat and organic layer at the surface followed by 2.0 m of compact sand and 1.4 m of very stiff silty clay at the bottom of the 3.7 m deep borehole.

The subsurface conditions at the east embankment were investigated by Boreholes 12-7 and 12-8. The boreholes encountered a 0.3 m thick peat and topsoil stratum underlain by about 1.4 m compact sand, variable thickness of soft to firm silty clay (3.7 to 6.9 m) and finally by very dense gravelly sand and silt. At Borehole 12-8 a 1.1 m thick sand layer separated the silty clay and the underlying gravelly sand and silt strata.

At both embankment locations the groundwater was observed to be at the ground surface. Bedrock was not encountered, to the depths drilled, at the approach embankment locations.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 GENERAL

The proposed underpass will have two spans supported on two abutments and a central pier. It is understood that open style abutments perched above the roadway are favoured. At this site, it is anticipated that this will result in the abutments being placed within the 6 to 7 m high approach fills adjacent to the abutments. As discussed in the following sections, the use of spread footings placed on an engineered fill is recommended for both abutments. Spread footings placed within the glacial till are recommended for the central pier.

Slope stability analysis, indicates that embankments constructed with conventional 2 Horizontal to 1 Vertical side slopes will be stable.

4.2 UNDERPASS FOUNDATIONS

4.2.1 Abutments

The subsurface conditions at both abutment locations comprise of a thin layer of topsoil overlying competent glacial till. In light of this and the favoured open abutment concept the following foundation alternatives may be considered.

4.2.1.1 Spread Footings Placed on Engineered Fill

For the assumed geometry of this foundation solution (Figure 2), the recommended bearing pressures at the Serviceability Limit State (SLS) and factored Ultimate Limit State (ULS) conditions for a 3 m wide footing are 400 kPa and 800 kPa, respectively.

The SLS design load is the load at which the estimated settlement of the footing will be of the order of 25 mm which for the purposes of this design has been assumed as the maximum settlement that may be tolerated. This settlement is comprised of 20 mm within the engineered fill and 5 mm within the overburden materials. It should be noted that both of these elements of settlement will be largely elastic and will occur mostly during initial loading of the foundations. An integral part of this proposed foundation design is the construction of an engineered fill on which to place the footing (Figure 2). Frost protection for the footings should be in accordance with Figure 2.

4.2.1.2 Spread Footings Placed within the Till

Provided the base of the proposed footing is located at least 1.0 m below the existing ground surface an allowable design load of 500 kPa and 900 kPa may be assumed at the SLS and factored ULS conditions, respectively. Settlements at the SLS condition are anticipated to be of the order of 10 mm.

4.2.2 Central Pier

At this location, the subsurface conditions comprise a thin cover of topsoil overlying very dense glacial till. Hence, spread footings placed at least 1.0 m within the glacial till are recommended. Design bearing pressures of 500 kPa and 900 kPa may be used for the

SLS and factored ULS conditions, respectively. Settlements at the SLS condition are anticipated to be of the order of 10 mm. ____77.

4.3 EMBANKMENT RECOMMENDATIONS

Based on the observed subsurface conditions encountered in the area of the proposed underpass abutments and based on the anticipated maximum embankment height of 7 m, it is concluded that embankments constructed with side slopes of 2 Horizontal to 1 Vertical will remain stable. Additional embankment fills to the west and east of the underpass alignment will be required for the west-south and east-north approach ramps to the proposed Highway 416.

Within the area of the west-south approach ramp the subsurface conditions encountered comprise a thin surficial layer of organics overlying 1 m of sand and 2 to 3 m of silty clay. Based on these subsurface conditions it is considered that conventional embankments constructed, with side slopes of 2 Horizontal to 1 Vertical will remain stable.

Within the region of the east-south approach ramp the subsurface conditions encountered comprise a soft clay layer with an upper stiff crust in turn overlying stiff varved clay and glacial till. Based on these subsurface conditions it is considered that conventional embankments constructed with side slopes of 2 Horizontal 1 Vertical will be stable providing the maximum height of the embankments is not greater than 6 m.

Embankment fill should meet the requirements of OPSS 212 for borrow material and should be placed and compacted in accordance with OPSS 206. Slopes of 2 Horizontal to 1 Vertical are applicable for sandy earth borrows, rock borrow or select subgrade fill material. If silty or clayey earth borrow is used, the embankment side slope should be 2.5 Horizontal to 1 Vertical or flatter and are to be confirmed by engineering analyses.

Prior to the placement of any imported fill materials, the receiving area under the base of the fill should be stripped of all topsoil and organics and any other deleterious material which may be present. The receiving foundation, comprising glacial till or sand, should be proof-rolled and any soft areas excavated and replaced with compacted competent material. Settlements of the main approach embankment and the west-south and east-north ramps are estimated to be of the order of 10 mm and which will primarily occur during initial loading of the embankments.

4.4 GENERAL RECOMMENDATIONS

4.4.1 Dewatering

Groundwater was observed near the ground surface at all locations. It is anticipated that the excavation which will only be required at the central pier. At this location the groundwater is located in a low permeability glacial till. It is anticipated that at this location any groundwater can readily handled by a system of ditches leading to a central sump and a pump.

4.4.2 Excavations

Temporary excavations in the natural soils at the site will be within the glacial till layer. Excavations within this layer shall be excavated with 1.5 Horizontal to 1 Vertical slopes if the excavation is deeper than 1.5 m. The excavation slopes shall be in compliance with the Ontario Health and Safety Act regulations or other governing regulations within the area. The base of the excavation shall be inspected for any soft areas. If soft soil is encountered, it shall be excavated and replaced with compacted granular fill.

4.4.3 Earth Backfill Pressures

The earth pressure for the design of the abutments should be computed as per Section 6.1.2 of the O.H.B.D.C., and an unyielding foundation condition may be assumed for the computations. If however, movement of the top of the wall is permitted, and is greater than 0.05% of the overall height of the wall, then a yielding condition may be used in the computations. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill:

	Granular 'A'	Granular 'B'
Angle of Internal Friction	$\phi = 35°$	$\phi = 30°$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

If the footings are placed on compacted granular backfill, an unfactored coefficient of friction value of tan 30° may be assumed for the estimation of the sliding resistance. However, if the footings are placed on the glacial till, an unfactored coefficient of friction of tan 25° may be used.

4.4.4 Frost Penetration

The anticipated maximum depth of frost penetration at the site is 1.8 m (Canadian Foundation Engineering Manual). Because of the moderately frost susceptible nature of the glacial till at the site, all foundation units should be provided with at least this depth of soil or equivalent cover below finished grade. In addition, where approach fill embankments are less than the anticipated depth of frost penetration additional design measures will be required to ensure the satisfactory performance of the pavement. This aspect of the design will be addressed in more detail in the Pavement Design Report.

4.4.5 Site Supervision

The recommendations given in this report are based on the assumptions that the assumed soil conditions will be verified in any engineered fill and excavations and that all construction recommendations are followed. It is recommended, therefore, that the foundation and earthworks construction be carried out under suitably qualified geotechnical engineering supervision.

5.0 CLOSURE

The field work portion for the investigation was done under the supervision of Mr. N. Khan, P.Eng. The report was written by Mr. I. Corbett, P.Eng. with assistance from Mr. N. Khan, P.Eng. and reviewed by Dr. I. Holubec, P.Eng.

This report is subject to the attached General Conditions and Limitations.

Yours very truly
GEOCON (1991) INC.

N. Khan, P.Eng.
Project Engineer

Igor Holubec, Ph.D., P.Eng.
Vice-President

REGISTERED PROFESSIONAL ENGINEER
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PROVINCE OF ONTARIO

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GEOCON (1991) INC.

GEOTECHNICAL REPORT

GENERAL CONDITIONS AND LIMITATIONS

A. USE OF THE REPORT

A.1 The factual data,interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation or if the project is not initiated within eighteen months of the date of the report Geocon (1991) Inc. (Geocon) should be given an opportunity to confirm that the recommendations are still valid.

A.2 The comments given in this report are intended only for the guidance of the design engineer. The number of test holes to determine all the relevant underground conditions which may affect construction costs, techniques and equipment choice, scheduling and sequence of operations would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual test hole data, as to how subsurface conditions may affect their work.

B. FOLLOW-UP

B.1 All details of the design and proposed construction may not be known at the time of submission of Geocon's report. It is recommended that Geocon be retained during the final design stage to review the design drawings and specifications related to foundations, earthworks, retaining systems and drainage, to determine that they are consistent with the intent of Geocon's report.

B.2 Retention of Geocon during construction is recommended to confirm and document that the subsurface conditions throughout the site do not materially differ from those given in Geocon's report and to confirm and document that construction activities did not adversely affect the design intent of Geocon's recommendations.

C. SOIL AND ROCK CONDITIONS

C.1 Soils and rock descriptions in this report are based on commonly accepted methods of classification and identification employed in professional geotechnical practice. Classification and identification of soil and rock involves judgement and Geocon does not guarantee descriptions as exact, but infers accuracy only to the extent that is common in current geotechnical practice.

C.2 The soils and rock conditions described in this report are those observed at the time of the study. Unless otherwise noted, those conditions form the basis of the recommendations in the report. The condition of the soil and rock may be significantly altered by construction activities (traffic, excavation, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil and rock must be protected from these changes or disturbances during construction.

D. LOGS OF TEST HOLES AND SUBSURFACE INTERPRETATIONS

D.1 Soil and rock formations are variable to a greater or lesser extent. The test hole logs indicate the approximate subsurface conditions only at the locations of the test holes. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the method of boring, the frequency of sampling, the method of sampling and the uniformity of subsurface conditions. The spacing of test holes, frequency of sampling and type of boring also reflect budget and schedule considerations.

D.2 Subsurface conditions between test holes are inferred and may vary significantly from conditions encountered at the test holes.

D.3 Groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or as a consequence of construction activities on the site or adjacent sites.

E. CHANGED CONDITIONS

E.1 Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the use or reliance by the client of this report that Geocon is notified of the changes and provided with an opportunity to review the recommendation of this report. Recognition of changed soil and rock conditions requires experience and it is recommended that an experienced geotechnical engineer be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

F. DRAINAGE

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage can have serious consequences. Geocon can take no responsibility for the effects of drainage unless Geocon is specifically involved in the detailed design and follow-up site services during construction of the system.

REFERENCES

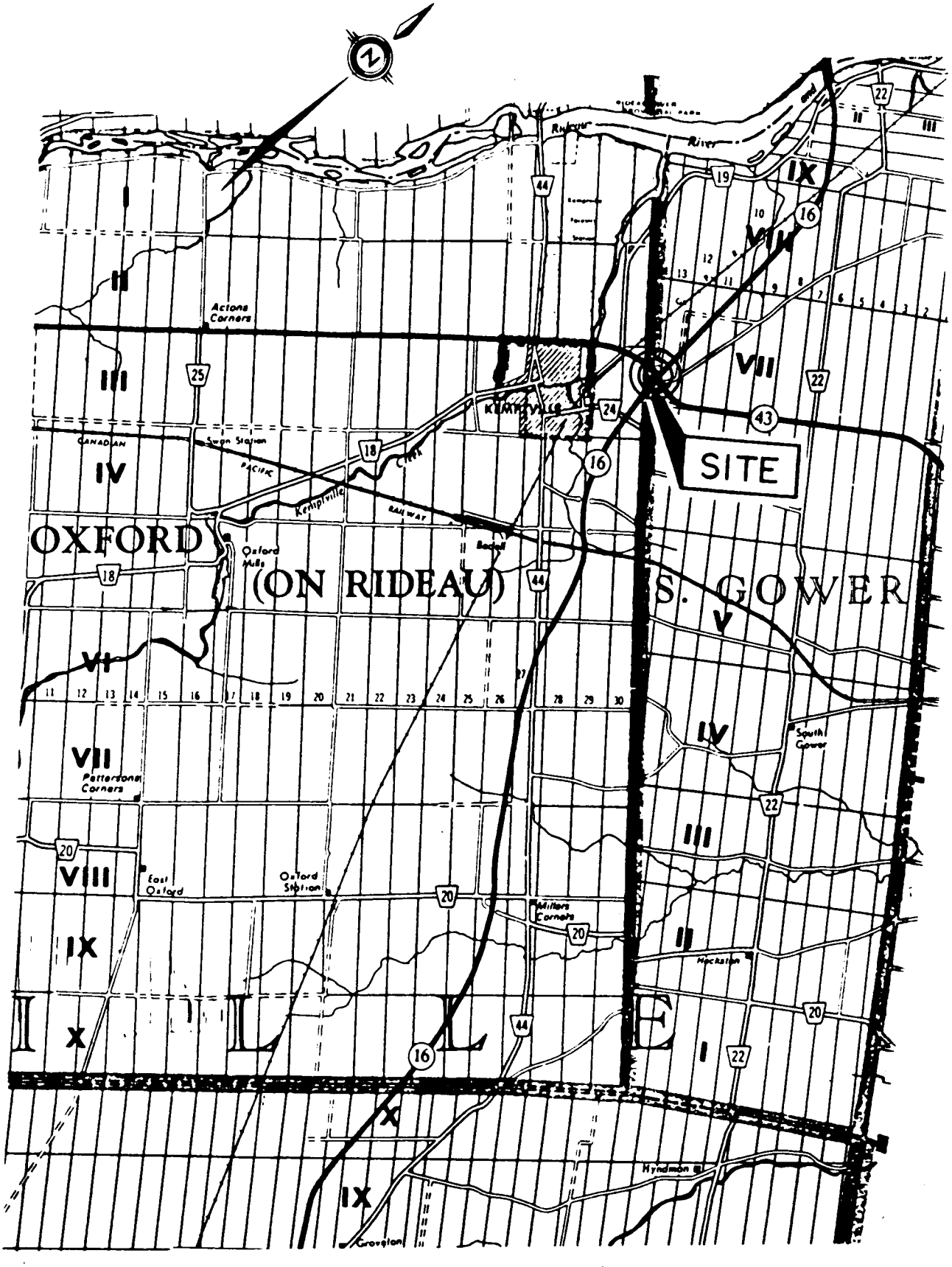
Canadian Foundation Engineering Manual, 1985. Second Edition. Part 1: Fundamentals; Part 2: Shallow Foundations; Part 3: Deep Foundations; Part 4: Excavations and Retaining Structures Part 5: References. Canadian Geotechnical Society, Technical Committee on Foundations, 456 pp.

Sharpe, D.R., 1979. Quaternary Geology of the Merrickville Area, Southern Ontario. Ontario Geological Survey, Report 180, 54P. Accompanied by Maps 2387 and 2388, scale 1:50,000.

Totten Sims Hubicki Associates (1981) Limited Consultants 1990 Structure Data Report, Highway 416 from 0.7 km north of Hwy 401 northerly to 1.0 km north of Hwy 43, District 9 Ottawa. Report prepared for Ministry of Transportation, Ontario.

KEY PLAN

APPENDIX
FIGURE 1
PROJECT 372-89-06



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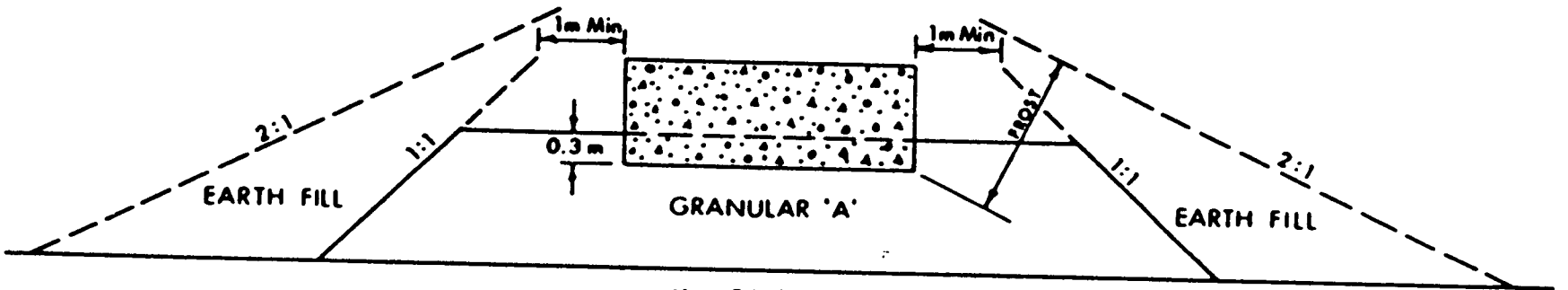
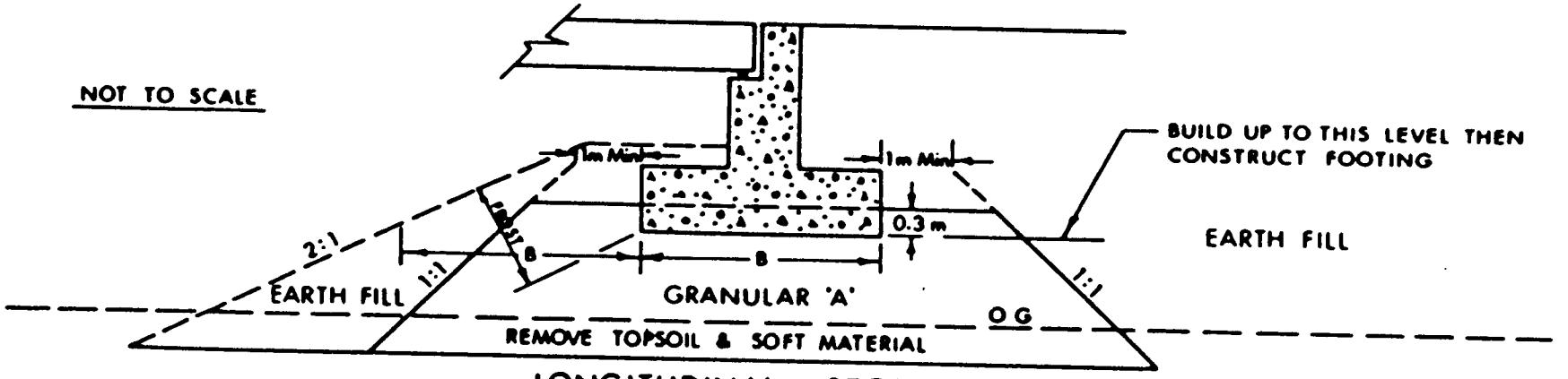
GEOCON



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 O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

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

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 2 WP 372-89-06

APPENDIX A

Explanation of Terms used in this Report
Explanation of the Term Rock Quality Designation (RQD)
Record of Borehole Sheets (12-1 to 12-8)
Test Pit Logs

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

EXPLANATION OF THE TERM

ROCK QUALITY DESIGNATION (RQD)

The description of bedrock quality for engineering purposes can be inferred from a modified core recovery logging procedure designated as RQD, developed by D.U. Deere.* This classification is based on a modified diamond drill core recovery percentage in which only the pieces of sound core over 4 inches (10 cm) long are counted as recovery. The core must be carefully examined to discount fresh irregular breaks caused by the drilling process (fresh broken pieces are fitted together and counted as one piece). The remaining fragments less than 4 inches (10 cm) length are considered to be due to very close bedding, jointing, fracturing, shearing, or weathering in the rock mass and are not counted. The procedure penalizes the rock where recovery is poor. This is appropriate because poor core recovery usually depicts poor quality rock. In the case of certain shaley sedimentary or thinly foliated metamorphic rocks, the method is not as exact as for other rock types and rock quality requires interpretation by a specialist for the particular engineering application. To minimize the occurrence of core breaks from drilling procedures RQD logging is normally run on core obtained by double or triple tube core barrels and generally of "N" size or greater.

The table below may be used as a general indicator to correlate (RQD) and rock mass quality.

RQD	DESCRIPTION OF ROCK QUALITY
90 - 100	Excellent - intact, very sound, massive
75 - 90	Good - moderately jointed or sound
50 - 75	Fair - blocky and seamy, fractured
25 - 50	Poor - shattered and very seamy or blocky, severely fractured
0 - 25	Very poor - crushed, very severely fractured

*See, for instance:

K.G. Stagg and O.C. Zienkiewicz, "Rock Mechanics in Engineering Practice". New York, Wiley, 1968, Chapter I.

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 12-1 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,878.2 N; 373,610.0 E ORIGINATED BY N.K.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tricone, NXL Rock Core COMPILED BY N.K.
DATUM Geodetic DATE October 31, 1990 CHECKED BY I.C.

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 kPo: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3	Ground Surface										
0.00 / 91.9	Silty Sand Topsoil. Some roots.		1	SS	6		92				
0.4	Loose Black										
	Gravelly Sand and Silt. Trace clay (Glacial Till)		2	SS	8				○		
	Loose to Very Dense Brown		3	SS	36/200mm			Bentonite Seal			21 37 37 5
89.9							90				
2.4	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till)		4	SS	50/75mm				○		
	Very Dense Grey		5	SS	97		88				
			6	SS	19/75mm			Backfill			
			7	SS	23/63mm						
			8	SS	86*		86		○		22 38 35 5
			9	SS	92/250mm						
			10	SS	50/150mm		84	Piezometer Tip	○		
83.5					Rec%			RQD%			
8.8	Dolostone Unweathered, fine grained, closely to moderately bedded.		11	RC NXL	98			95			
	Sound Grey						82				
80.9			12	RC NXL	100			100			
11.4	End of Borehole										

Notes:
1. Water level in stand-pipe piezometer measured at elevation 91.3 m on Dec. 9/90.
2. 00* indicates that the quoted 'N' value is based on the first 0.3 m of penetration (full penetration not achieved)
3. Borehole advanced from 4.7 m to bedrock by Triconing inside N casing.

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 12-2 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,860.8 N; 373,604.3 E ORIGINATED BY N.K.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tricone COMPILED BY N.K.
DATUM Geodetic DATE November 31, 1990 CHECKED BY I.C.

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, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.6	Ground Surface										
0.0 / 91.1	Silty Sand Topsoil. Some Roots and Organics Loose Black		1	SS	6	Not Noted					
0.5	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till) Very Dense Grey		2	SS	90		90				
			3	SS	72				o		40 31 25 4
			4	SS	73		88				
			5	SS	60/140mm				o		
85.6			6	SS	42/140mm		86				
	End of Borehole										

Notes:

1) Borehole advanced from 3.10 m to 5.95 m by Triconing inside an N casing.

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 12-3 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,857.4 N; 373,646.6 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tricone COMPILED BY N.K.

DATUM Geodetic DATE October 30, 1990 CHECKED BY I.C.

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 kPo: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
93.0	Ground Surface										
0.0 92.6	Silty Sand Topsoil. Loose Black		1	SS	8						
0.4 92.4	Sand (Fill)										
0.6	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders (Glacial Till). Dense to Very Dense		2	SS	75*		92		○		28 32 35 5
			3	SS	72						
			4	SS	74*		Bentonite Seal		○		
			5	SS	50/110mm		90				
	Brown Grey		6	SS	53*				○		
			7	SS	47		Backfill 88				
			8	SS	87/280mm		Piezometer 86				
85.6			9	SS	97/100mm				○		
7.4	End of Borehole Auger Refusal										

Notes:

1) Water level in standpipe piezometer measured at elevation 92.09 m on Dec. 9/90.

2) 00* indicates that the quoted 'N' value is based on the first 0.3 m penetration (full penetration not achieved)

3) Borehole advanced from 5.90 m to 7.42 m by Triconing inside N casing.

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 12-4 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,848.9 N; 373,685.8 E ORIGINATED BY N.K.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tricone, NXL Rock Core COMPILED BY N.K.
DATUM Geodetic DATE October 29, 30 and November 2, 1990 CHECKED BY I.C.

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 (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.5	Ground Surface										
0.0 / 92.2	Silty Sand Topsoil Some roots. Black		1	SS	8		92		○		
0.3	Gravelly Sand and Silt. Trace clay. Some cobbles and boulders. (Glacial Till) Very Dense Brown		2	SS	35/150mm	▽			○		
	Grey		3	SS	83/265mm		90				
			4	SS	84				○		
			5	SS	R						
			6	SS	R		88				
			7	SS	83*				○		
			8	SS	42/150mm		86		○		27 35 33 5
			9	SS	42/150mm		84				
82.9					Rec%			RQD%			
9.6	Dolostone Unweathered, fine grained closely to moderately bedded. Some calcite intrusions. Sound Grey		10	RC NXL	100			55			
			11	RC NXL	100			85			
80.9			12	RC NXL	100			93			
11.6	End of Borehole										

Notes:
1) Water level in open borehole measured at elevation 91.69 m on October 30, 1990.
2) 00* indicates quoted N value based on the first 0.3 m penetration (full penetration not achieved).
3) Borehole advanced from 3.43 m to top of bedrock by Triconing inside N casing.
4) R = SPT Refusal

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-5

METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,840.6 N; 373,683.6 E ORIGINATED BY N.K.

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers, Tricone, NXL Rock Core COMPILED BY N.K.

DATUM Geodetic DATE October 29 and 30, 1990 CHECKED BY I.C.

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 (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.2	Ground Surface										
0.0 / 92.0	Silty Sand Topsoil		1	SS	7	▽	92		o		
0.2	Some clay and roots Black										
	Sandy Silt. Some gravel. Trace clay. Some cobbles and boulders (Glacial Till)		2	SS	95/ 250mm						
			3	SS	26/ 150mm		90				
	Very Dense Brown		4	SS	100						
	Grey										
			5	SS	61		88		o		15 36 58 7
							86				
							84				
83.3											
8.9	End of Borehole Casing Refusal Inferred Bedrock										

Notes:

1) Water in open borehole measured at elevation 91.9 m on morning of Oct. 30/90.

2) Borehole advance from 3.56 m to 8.92 m by Triconing inside N casing.

+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 12-6

METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,897.3 N; 373,517.2 E ORIGINATED BY GY

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY IC

DATUM Geodetic DATE February 28, 1991 CHECKED BY IC

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 kPo (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
91.0	Ground Surface										
0.0 / 90.7	Peat and Organics Soft Black										
0.3 / 89.6	Medium Sand. Some silt. Compact Brown		1	SS	14		90				
1.4 / 88.7	Coarse Sand. Trace silt Compact Grey		2	SS	15						
2.3 / 87.3	Silty Clay. Some sand. Very Stiff Grey		3	SS	20		88		•		0 25 54 21
			4	SS	28						
3.7	End of Borehole Auger Refusal										

Notes:

Water level in open borehole measured at elevation 91.0 m upon completion of drilling.

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 No 12-7 METRIC

W P 372-89-06 LOCATION Co-ords: 4,987,764.7 N; 373,921.0 E ORIGINATED BY GY

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY IC

DATUM Geodetic DATE March 6, 1991 CHECKED BY IC

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
91.3	Ground Surface										
0.0	Peat and Topsoil Black										
91.0											
0.3	Sand										
	Compact Grey		1	SS	22		90				
89.6											
1.7	Silty Clay. Trace to Some Sand. (Weathered Crust)		2	SS	5						
	Firm Grey		3	SS	4						0 23 29 48
			4	SS	1		88				
86.7											
4.6	Clayey Silt (Varved)		5	SS	15						
86.0	Stiff Grey						86				
5.3	Gravelly Sand and Silt Trace clay. (Glacial Till)		6	SS	11						
	Compact Grey		7	SS	25						
84.7											
6.6	End of Borehole										

Notes:

1) Water level in open borehole measured at elevation 91.3 upon completion of drilling.

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12-8 METRIC

W P 372-89-06 LOCATION Co-ord's: 4,987,734.9 N; 374,016.4 E ORIGINATED BY GY

DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Augers COMPILED BY IC

DATUM Geodetic DATE March 1, 1991 CHECKED BY IC

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 / SHEAR STRENGTH kPo (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
90.7	Ground Surface										
0.0	Peat and Topsoil Black										
90.5 / 0.2	Sand. Some Silt. Compact Brown		1	SS	19		90				0 82 18 0
89.0											
1.7	Silty Clay Some Sand (Weathered Crust) Stiff Grey		2	SS	3			+ (>96)			0 16 44 40
88.0							88				
2.7	Silty Clay. Trace Sand. Silt content increases with depth. Soft to Firm Grey		3	SS	1/ 450mm			+ 8			
			4	SS	1/ 450mm		86	+ 8			
			5	SS	1/ 450mm						0 7 61 32
							84	+ 4			
			6	SS	1/ 450mm			+ 7			
81.1			7	SS	1/ 450mm	▽	82	See Note 1.			
9.6	Coarse Sand Grey										
80.0							80				
10.7 / 79.9 / 10.8	Gravelly Sand and Silt Trace Clay (Glacial Till) Very Dense Grey		8	SS	70/ 75mm						
	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

Geocon

TEST PIT LOG

PROJECT Highway 416 - Highway 43 Underpass TEST PIT 12-1

Location Co-ords: 4,987,858.9 N; 373,690.8 E PAGE 1 OF 1

CONTRACT NO. WP 372-89-06 DATE Dec. 13/91

DATUM Geodetic

SAMPLE CONDITION: ☒ DISTURBED

W_N - WATER CONTENT - %
GS - GRAIN SIZE ANALYSIS
γ - UNIT WEIGHT - kN/m^3

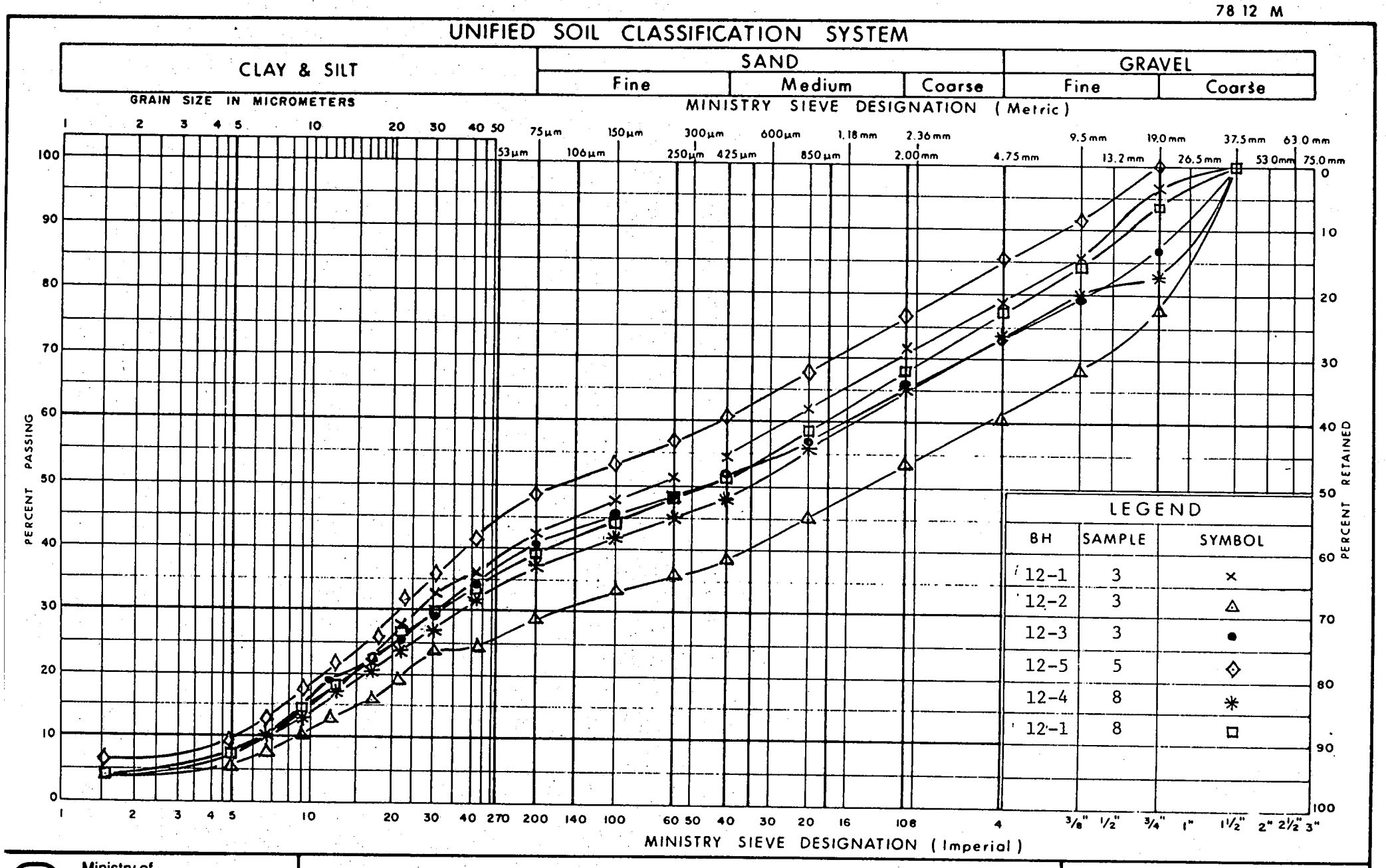
TYPE OF TEST
P - MODIFIED PROCTOR TEST
W_{OPT} - OPTIMUM WATER CONTENT - %
γ_{MAX} - MAX. DRY UNIT WEIGHT - kN/m^3

W_L - LIQUID LIMIT - %
W_P - PLASTIC LIMIT - %

DEPTH - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	SAMPLES: CONDITION	SAMPLES: NUMBER	TESTS: RESULTS Gr Sa Si Cl
	93.5	Ground Surface				
0.0	93.3	Silty Fine Sand, Some roots (Topsoil) Dark Brown				
0.2	93.1	Sand, medium to fine grained, Some silt, Tr organics Brown				
0.4		Heterogeneous mixture of Gravel, Sand and Silt. Trace clay. Some Cobbles and Boulders (Glacial Till). Max. size of Boulder encountered - 1.0 m diameter Grey/Brown		X	1	34 28 32 6
	89.8					
3.7		Heterogeneous mixture of Gravel, Sand and Silt. Trace clay. Some Cobbles and Boulders (Glacial Till). Blue/Grey		X	2	26 32 34 8
	88.8					
4.7		End of Test Pit Machine Refusal				

APPENDIX B

Figures B1 to B4 - Grain Size Curves



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Ontario

GRAIN SIZE DISTRIBUTION

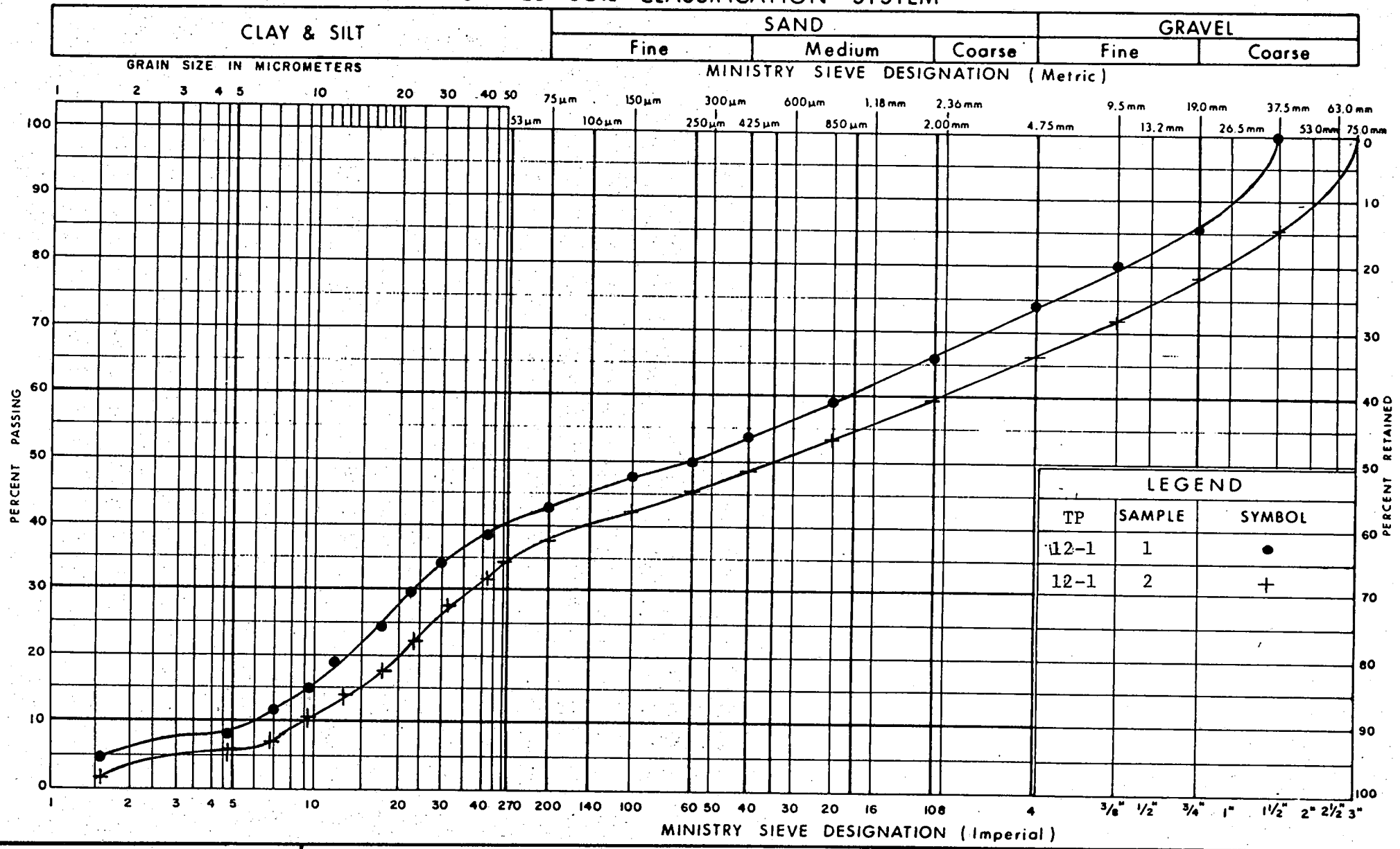
Gravelly Sand and Silt, Trace Clay (Glacial Till)

FIG No B1

W P 372-89-06

78 12 M

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

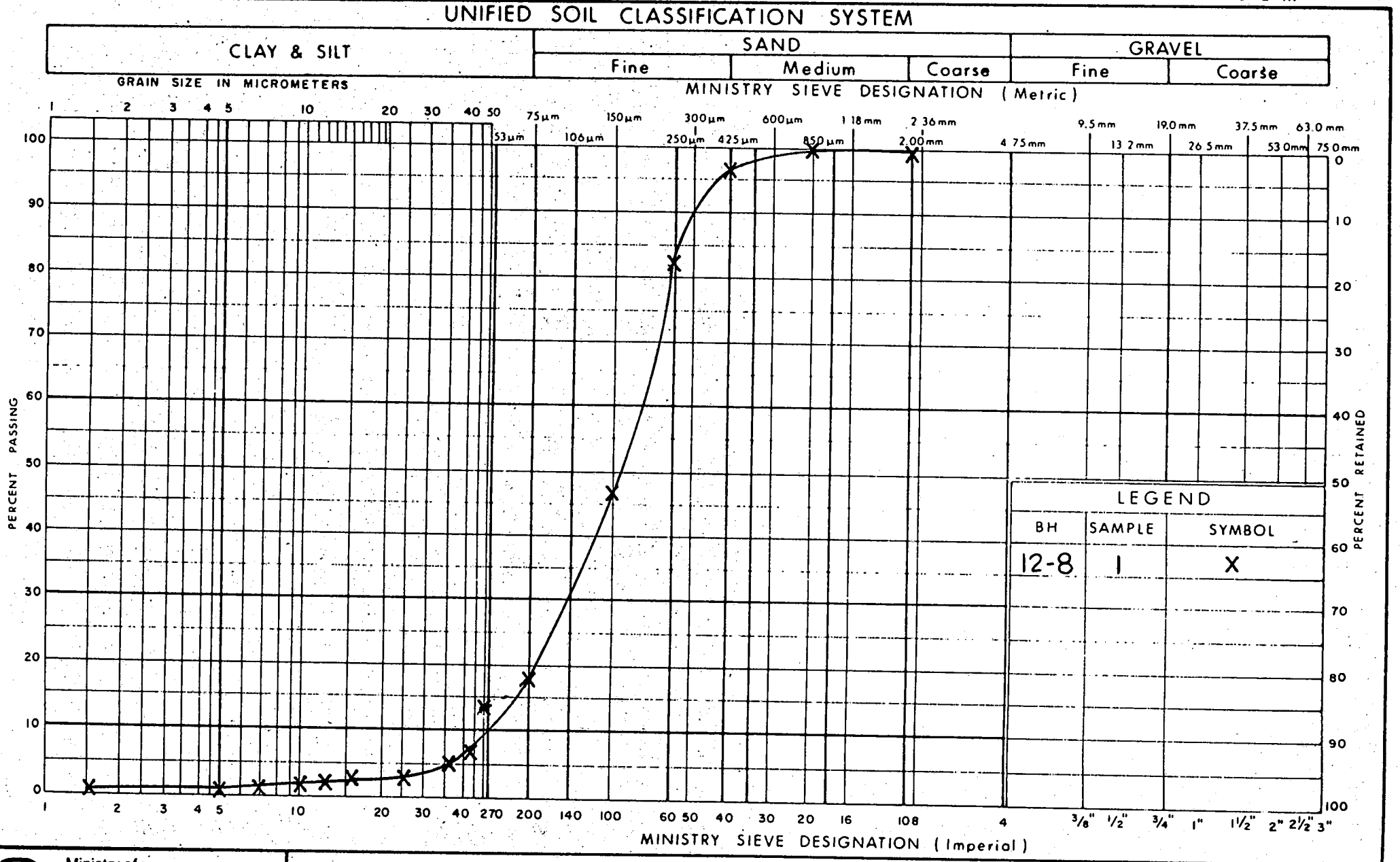
GRAIN SIZE DISTRIBUTION

Heterogenous mixture of Gravel, Sand and Silt

FIG No 1 B2

W P 372-89-06

78 12 M



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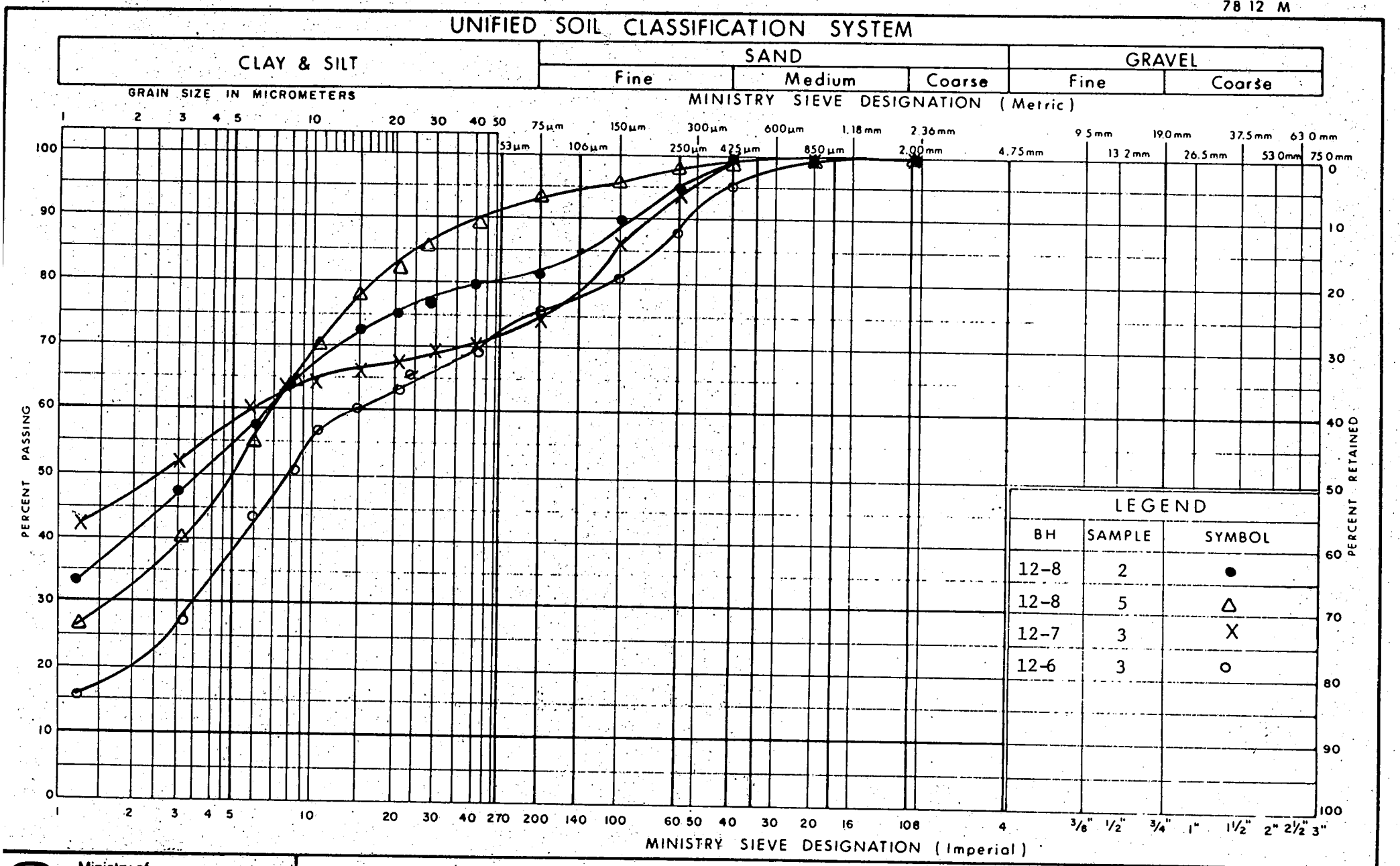
GRAIN SIZE DISTRIBUTION

Sand, Some Silt

FIG No B3

W P 372-89-06



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Ontario

GRAIN SIZE DISTRIBUTION

Silty Clay

FIG No B4

W P 372-89-06

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

METRIC

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

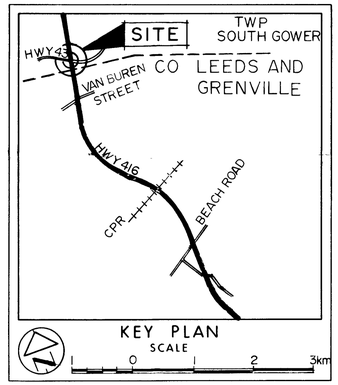
CONT No
WP No 372-89-06

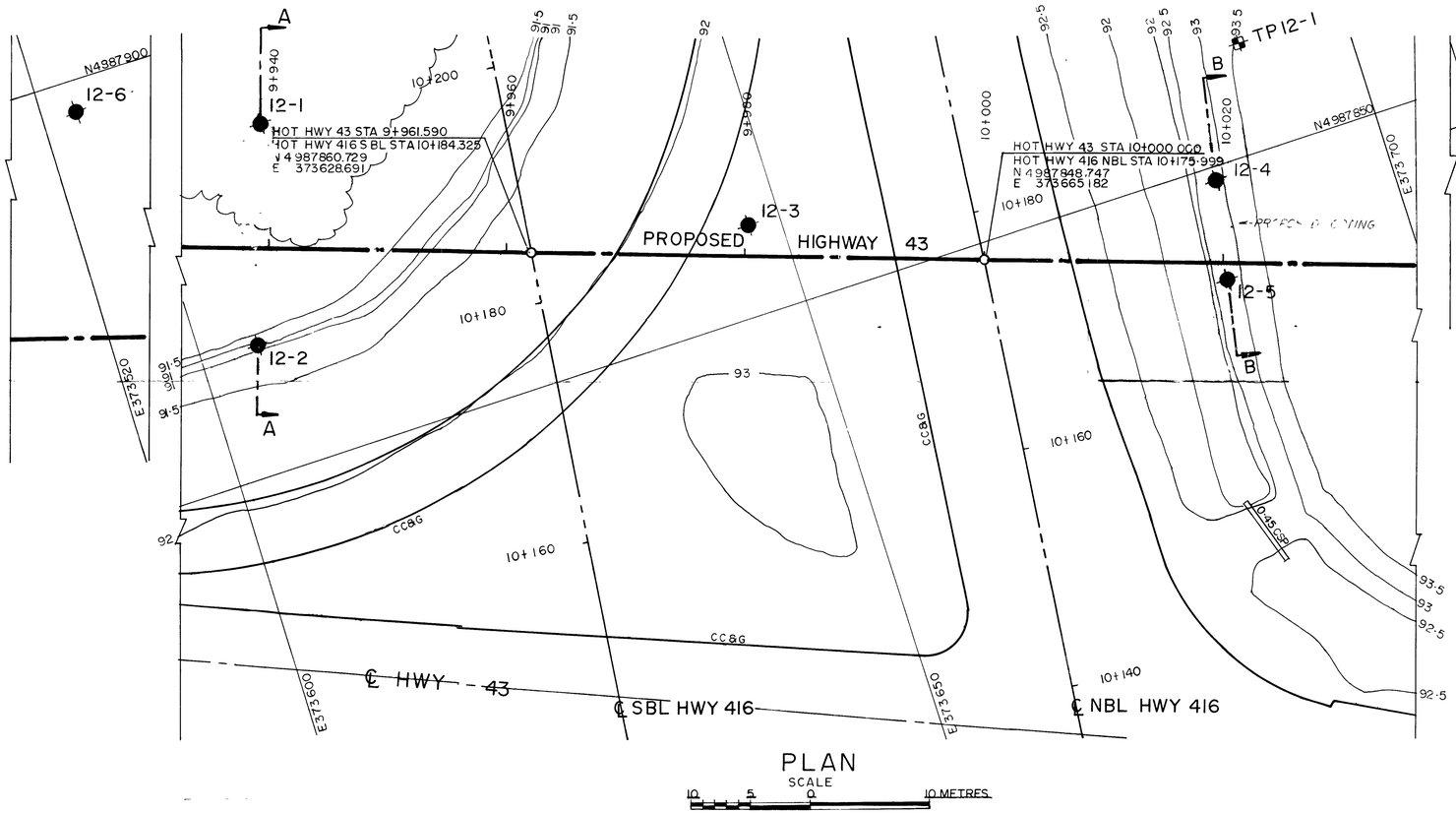
HIGHWAY 416 UNDERPASS
AT HIGHWAY 43

BORE HOLE LOCATIONS & SOIL STRATA

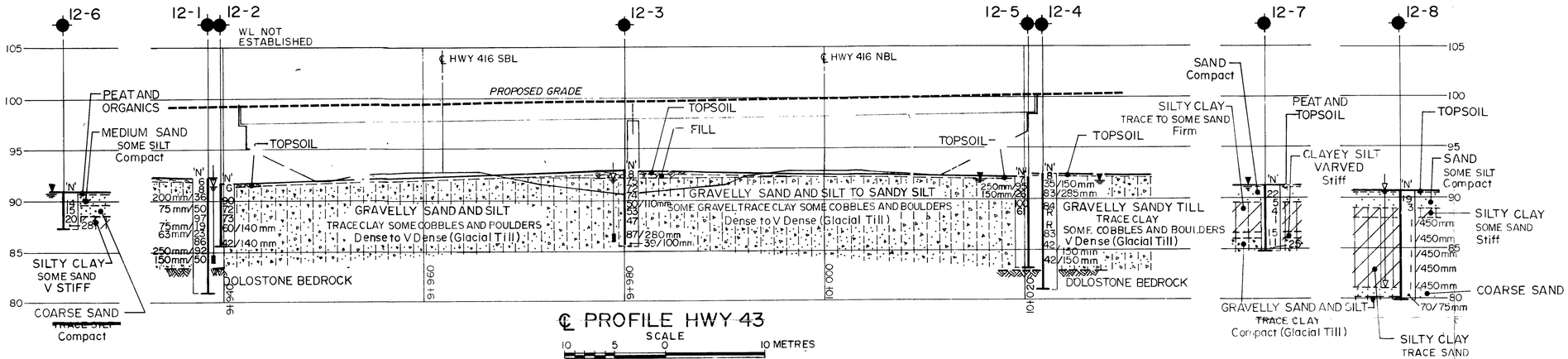
SHEET A

GEOCON(1991) INC

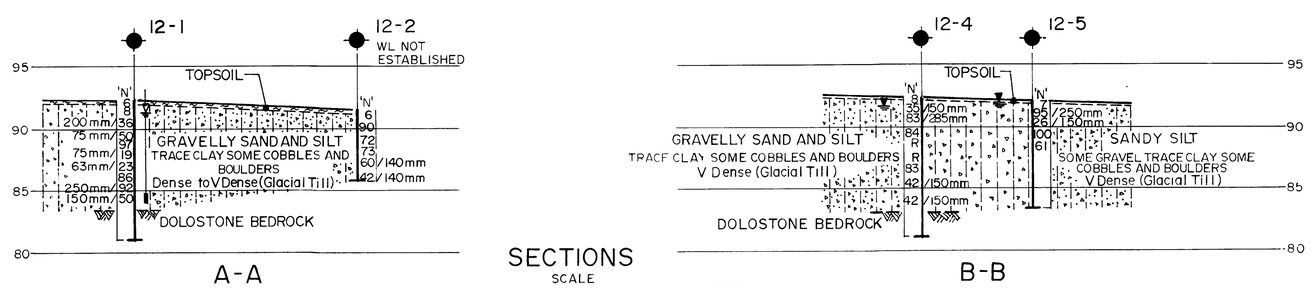




PLAN
SCALE
10 5 0 10 METRES



℄ PROFILE HWY 43
SCALE
10 5 0 10 METRES



SECTIONS
SCALE
10 5 0 10 METRES

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
- Piezometer
- Test Pit

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	92 3	4 987 878·2	373 610 0
2	91 6	4 987 860 5	373 604·3
3	93·0	4 987 857 4	373 646·6
4	92·5	4 987 846·9	373 685 8
5	92 2	4 987 840 6	373 683·6
6	91 0	4 987 897·3	373 517 2
7	92 3	4 987 764·7	373 921·0
8	90·7	4 987 734·9	374 016 4
TP12-1	93 5	4 987 858·9	373 690·8

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 31 - .

HWY No 416			DIST 9
SUBM'D NK	CHECKED RB	DATE 1991 08 26	SITE 16-318
DRAWN MZ	CHECKED NK	APPROVED	DWG 37205 06-A

REF No E-844-416-2; 1991 05 17