GEOCRES No
30M3-189

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 2512-90-00A DIST 4

HWY Q.E.W. STR SITE -

Culvert No. 1

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GEOCRES 30M3-189 DATE SEP 05 1991

FOUNDATION INVESTIGATION REPORT
For
Culvert No. 1
Q.E.W., W.P. 2512-90-00A
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. It is proposed to construct a rigid frame concrete box culvert that abuts adjacent and parallels an existing rigid frame open footing concrete culvert beneath the existing North and South Service Roads and the Q.E.W.. This report describes the subsurface conditions at the site and provides recommendations pertaining to structure foundations and related earthworks.

SITE DESCRIPTION AND GEOLOGY

The site is located within the Q.E.W. corridor, including the North and South Service Roads, approximately 1 km east of the existing Tufford Road in the Town of Lincoln, Regional Municipality of Niagara. An existing 3 m x 1.24 m x 100 m concrete rigid frame open footing culvert at the site transmits the waters of a creek flowing in a northerly direction beneath the aforementioned service roads and highway. The Service Roads are one lane asphaltic divided roadways and the Q.E.W. is a two lane median divided highway. The culvert appears to be generally in good condition but some transverse asphaltic cracking that appears to have been sealed, exists above the culvert at the North and South Service Roads.

Residential dwellings are located in the area of the culvert inlet and outlet located north and south of the North Service Road and South Service Road respectively. The meandering creek is contained in a narrow, shallow valley approximately 2 m wide and 0.5 m deep. The water depth at the time of the investigation was approximately 0.3 metres, although levels did rise to approximately 1 m subsequent to rainfall. The creek side slopes and bed are protected against scour erosion by rip-rap at the culvert inlet.

The terrain surrounding the site is generally flat and is covered by grassland between the roadways and highway. The area north of the site also contains sparse forest. The area is located within the Niagara Fruit Belt area and hence fruit orchards and vineyards dominate the surrounding area. Crops include peaches, pears, cherries and grapes.

Physiographically, the site is located in the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsinan ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). The lowland bordering Lake Ontario, when the last glacier was receding was inundated by the glacial lake called Lake Iroquois at the site. Conditions in the old lake plain vary greatly within the Iroquois Plain. At the site location, overburden consists of a heterogeneous mixture of clayey silt, sand, gravel, boulders and cobbles which is a till deposit of glacial origin. This deposit extends surficially to a depth of approximately 6 to 7 m and overlies shale bedrock of the Queenston Formation.

INVESTIGATION PROCEDURE

Soil and rock data and inherent properties were obtained by in situ and laboratory testing. The procedures employed in the foundation investigation are discussed below.

Field Investigation

The fieldwork for the investigation was carried out between 91 04 08 and 91 04 09 and consisted of four (4) sampled boreholes advanced to depths ranging from 5.5 m to 7.7 m below the existing ground surface. A track mounted Acker drilling rig, equivalent to a CME 75, was used to advance the boreholes employing conventional hollow stem augering techniques.

In general subsoil samples were retrieved at 0.7 m intervals for the surficial 4.5 m and at 1.5 m intervals thereafter. Disturbed subsoil samples were retrieved using a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All samples were identified in the field and

then placed in sealed plastic jars to ensure the preservation of the natural moisture contents. Samples were subsequently transported to the laboratory for applicable testing.

Groundwater levels were determined by monitoring the levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevations of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

To identify the behaviour, gradation and pertinent properties of the soil present at the site, various laboratory testing were conducted. These tests included:

1) Atterberg Limits
2) Grain Size Distributions
3) Natural Moisture Contents
4) Bulk Unit Weights

The tests were carried out in accordance with standard procedures.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions", and are illustrated on the corresponding boreholes and figures included in the Appendix of this report.

Subsoil Conditions

The ground surface elevation at the site varies between 83.9 m and 85.0 m. Subsoil conditions are generally uniform across the site and consists of a surficial deposit comprised of a heterogeneous mixture of clayey silt, sand and gravel. This deposit, which is a glacial till, also contains boulders and cobbles and at lower depths, also contains fragments of shale. The deposit was penetrated for thicknesses ranging from 5.4 m to 6.5 m (elevations 78.4 to 77 m)

and is believed to be underlain by shale bedrock of the Queenston Formation beyond these thicknesses. The bedrock, however, was not confirmed within the scope of the project.

The native heterogeneous mixture of clayey silt, sand and gravel is overlain by fill material at the locations of the North and South Service Roads. The fill material consists of a cohesionless sand and gravel at the North Service Road for a thickness of approximately 0.8 m. At the North Service Road, approximately 0.8 m of the cohesionless sand and gravel fill material overlies approximately 1.5 m of an irregular mixture of a cohesive clayey silt with traces of sand, gravel and organics.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section are provided on Dwg. No. 25129000A-A also included in the Appendix.

A detailed description of the subsurface conditions encountered is given below.

Sand and Gravel (Fill Material)

A brown, cohesionless sand and gravel with a trace of silt exists as the base material for the existing North and South Service Roads. The thickness of this granular material was found to be approximately 0.8 m.

Irregular mixture of Clayey Silt, Sand and Gravel (Fill Material)

Underlying the cohesionless sand and gravel fill material, a cohesive fill material consisting of an irregular mixture of clayey silt, sand and gravel was encountered at the existing North Service Road along the proposed culvert location. Traces of black organic inclusions are also present within the brown fill material. This fill material has a thickness of approximately 1.5 m.

A grain size distribution as determined by hydrometer and mechanical sieve analyses on a representative sample of the fill material (see Record of Borehole 1-1 in the Appendix) reveals that approximately 80% of the material is finer than 75 micrometre.

An Atterberg Limit Test was carried out on the fine grained portion of the fill material (less than 75 micrometre) to define the behaviour and plasticity of the material. The results reveal that the material has a liquid limit (w_L) of 34% and a plasticity index (I_P) of 14%. Consequently, the material is classified as a clayey silt of low plasticity. The natural moisture content of the material is 21%.

The 'N' values as determined by the Standard Penetration Test (SPT) revealed a range of 6 blows/0.3 m to 13 blows/0.3 m for the two samples retrieved in this material. This reveals a probable consistency ranging from firm to stiff.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

Underlying the fill material and occurring surficially elsewhere at the site, a native deposit consisting of a cohesive heterogeneous mixture of clayey silt, sand and gravel exists. Random zones of a cohesionless mixture of silt, sand and gravel are also present, generally in thicknesses less than 1 m. Boulders and cobbles as inferred in the augering process during the borehole advancement, also comprise this deposit. In addition, shale fragments are present in the lower 1 to 2 m depths of the deposit. The deposit has a thickness ranging from 5.4 m to 6.5 m extending to an elevation of 77 to 78.5 m. The extent of this deposit is based on the observed refusal of the split spoon penetration as conducted in accordance with the Standard Penetration Test (SPT) and the presence of the shale fragments which infers a probable bedrock surface.

The upper 1.7 to 4.1 m of the deposit has been oxidized and hence is brown in colour. The lower thickness of the deposit is red in colour.

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analyses is given in Figure 1 in the Appendix. The envelope includes particle sizes up to 75 mm (coarse gravel) and hence excludes the boulder and cobble sizes. The envelope does reveal that the fine grained portions (less than 75 micrometres) contribute to more than approximately 60% of the material of this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2. A summary of the indices is provided in Table 1 below. Bulk Unit Weights are also included in the table.

Table 1 - Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

	Range	# of Tests
Natural Moisture Content (w%)	8-19	8
Liquid Limit (w_L%)	17-34	8
Plasticity Index (Ip%)	4-10	8
Unit Weight (kN/m^3)	19.7-23.3	6

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is defined as clayey silt. Natural Moisture Contents are generally less than the plastic limit of the soil indicating that the soil is in a plastic to semi-soild state.

Standard Penetration Tests carried out in this deposit revealed 'N' values ranging from 10 blows/0.3 m to 48 blows/0.3 m for the surficial 1 to 2 m indicating a very stiff to hard consistency. Below this surficial depth, 'N' values are consistently over 100 blows/0.3 m revealing the hard consistency of this strongly overconsolidated material.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. Groundwater levels determined at the time of investigation ranged from 2.7 m to 4.3 m below ground surface (elevation 81.3 m to 80.4 m). The water level of the flowing creek at the site was approximately at elevation 82 m during the investigation.

Groundwater levels and flowing creek levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

DISCUSSION AND RECOMMENDATIONS

As part of the planned widening of the Q.E.W. from 4 lanes to 6 lanes and also to satisfy hydrological requirements at the site, it has been proposed to construct a 7.5 m wide by 1.5 m high rigid frame reinforced concrete box culvert that parallels and abuts against an existing 3 m wide by 1.24 m high rigid frame open footing type culvert structure at the site. The new and existing culverts are located in a northerly alignment beneath the Q.E.W. and the North and South Service Roads. The culvert is however, skewed in a "jog-like" fashion at the culvert inlet. The double culvert will not only serve to transmit the creek water flowing in a northerly direction beneath the aforementioned highway and roadways, but it will also provide a discharge channel for the highway stormwater. A plan illustrating the proposed culvert is given on Dwg. No. 25129000A-A in the Appendix.

The proposed invert elevation varies from elevation 83.0 m to 82.3 m at the culvert inlet and outlet respectively. The proposed profile grade is at approximately elevation 85.7 m. Consequently, backfill cover on top of the culvert roof will range approximately from 1 m to 2 m. The proposed invert elevations are similar to the invert elevations of the existing culvert but the proposed profile grades reflect an increase of up to 1 metre along the Q.E.W.

The existing culvert is generally in good condition and no remedial work is anticipated. However, some transverse cracking was observed in the asphaltic roadway above the roof of the culvert at the North and South Service Roads. Construction records reveal that the existing culvert was constructed in two phases. The original section beneath the existing Q.E.W. was constructed in the late 1930's. The culvert was later extended in the late 1960's in conjunction with the construction of the North and South Service Roads.

Recommendations pertaining to the following foundation and geotechnical considerations are included in the purview of this report.

1) Structure Foundations
2) Backfill to Structure
3) Construction Considerations

Structure Foundations

In view of the competent nature of the heterogeneous mixture of clayey silt, sand and gravel deposit, the culvert foundation can be founded on conventional spread footings at the proposed invert elevations (83 m to 82.3 m). For purposes of the O.H.B.D.C., the bearing capacities as tabulated in Table 2 below are given.

Table 2 - Spread Footing Soil Capacity

Factored Capacity at U.L.S. (kPa)	1000
Bearing Capacity at S.L.S. (kPa)	N/A*

*In view of the highly overconsolidated nature of this soil, the material is considered unyielding and consequently the bearing capacity at S.L.S. will not govern the design.

All softened and/or organic material encountered at the founding elevation shall be removed and replaced with mass concrete or granular material such as Granular 'A'. Any granular material must be placed and compacted to achieve 100% of the Proctor maximum dry density as outlined in OPSS 501.08.02.

To protect the founding soil from disturbance as a result of weathering, and construction related activities, it is recommended that a concrete working slab be placed on the founding soil.

The footings must be protected against the scouring forces of the creek water. This can be obtained by constructing aprons and rip-rap at the culvert inlet and outlet. The design of the scour protection shall be made in conjunction with applicable hydrological parameters.

Adequate frost protection cover shall be provided for footings subject to frost penetration as for instance during winter construction.

Backfill and Cover to Structure

Fill material in the order of 1.5 m will be required at the culvert sides and an additional 1 to 2 m will be required above the culvert roof elevation. Recommendations pertaining to the selection of material type, stability and settlement of the approach fills and method of construction are given below.

Material

It is recommended that the backfill material against the culvert wall consist of a free draining material such as Granular 'A' or Granular 'B' to prevent hydrostatic pressure build-up on the culvert walls. Design parameters of the soil are given in Table 3 below. Weep holes should also be designed in the walls to facilitate the drainage.

Table 3 - Backfill Properties

	Granular 'A'	Granular 'B'
Unfactored Angle of Internal Friction (Ø)	35°	30°
Unit Weight (kN/m^3) γ	22.8	21.2
Coefficient of Earth Pressure at Rest (Ko)*		
- S.L.S. Type II	0.43	0.5
- U.L.S.	0.51	0.58

*Horizontal surface backfill only.

The backfill beyond the granular wedge as illustrated on OPSD series can consist of acceptable borrow material as defined in OPSS 212.05.

Stability

There are no longitudinal fill slope instabilities anticipated for slopes constructed at 2H:1V. All slopes should be protected against surface erosion using conventional methods.

Settlement

It is anticipated that approximately 10 mm of settlement within the fill itself and as a result of the elastic recompression of the surficial 1 to 2 metres of the native subsoil at the site can be realized. These settlements will be realized during or immediately following construction.

Backfill Construction

In the placement of the backfill material, all softened and/or organic material should be excavated for their full depth within the plan limits prior to fill placement.

The backfill required on the one side of the proposed culvert shall be constructed in accordance with OPSS 902 series and applicable OPSD 803 series. The backfill shall be compacted to achieve the target maximum dry density as mentioned earlier.

Construction Considerations

Dewatering

No dewatering problems are anticipated in the construction of the structure foundations in view of the impervious nature of the native subsoil. Furthermore, the groundwater table at the time of the investigation was below the proposed culvert invert elevation. Conventional sump pump techniques will suffice in discharging any surface runoff or localized seepage from the excavation.

Inflow from the existing creek must be prevented to enable construction in the "dry". The contractor shall take any special measures to ascertain this flow impediment. One such method can include the construction of impervious earth dikes composed of suitable clay material (see OPSS 1205).

Temporary Slopes

Temporary slopes to facilitate the excavation and construction of the culvert shall not be steeper than 1½H:1V.

Excavation

The excavation for the proposed concrete culvert shall be carefully controlled to avoid undermining the existing culvert foundations.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Longyear Canada Inc.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by Mr. M.S. Devata, Chief Foundation Engineer.

T. Sangiuliano, P.Eng.
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LICENSED PROFESSIONAL ENGINEER
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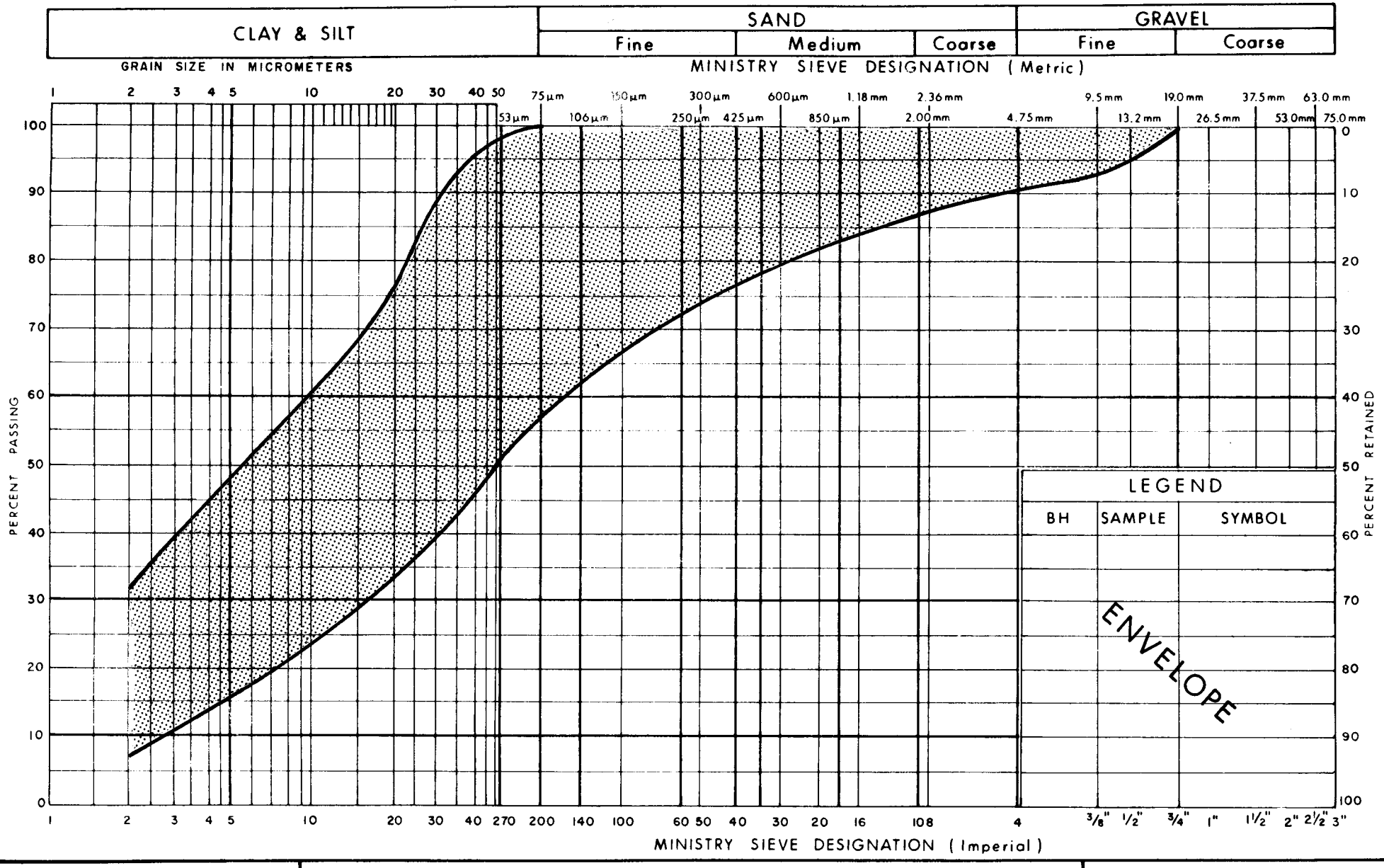
APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

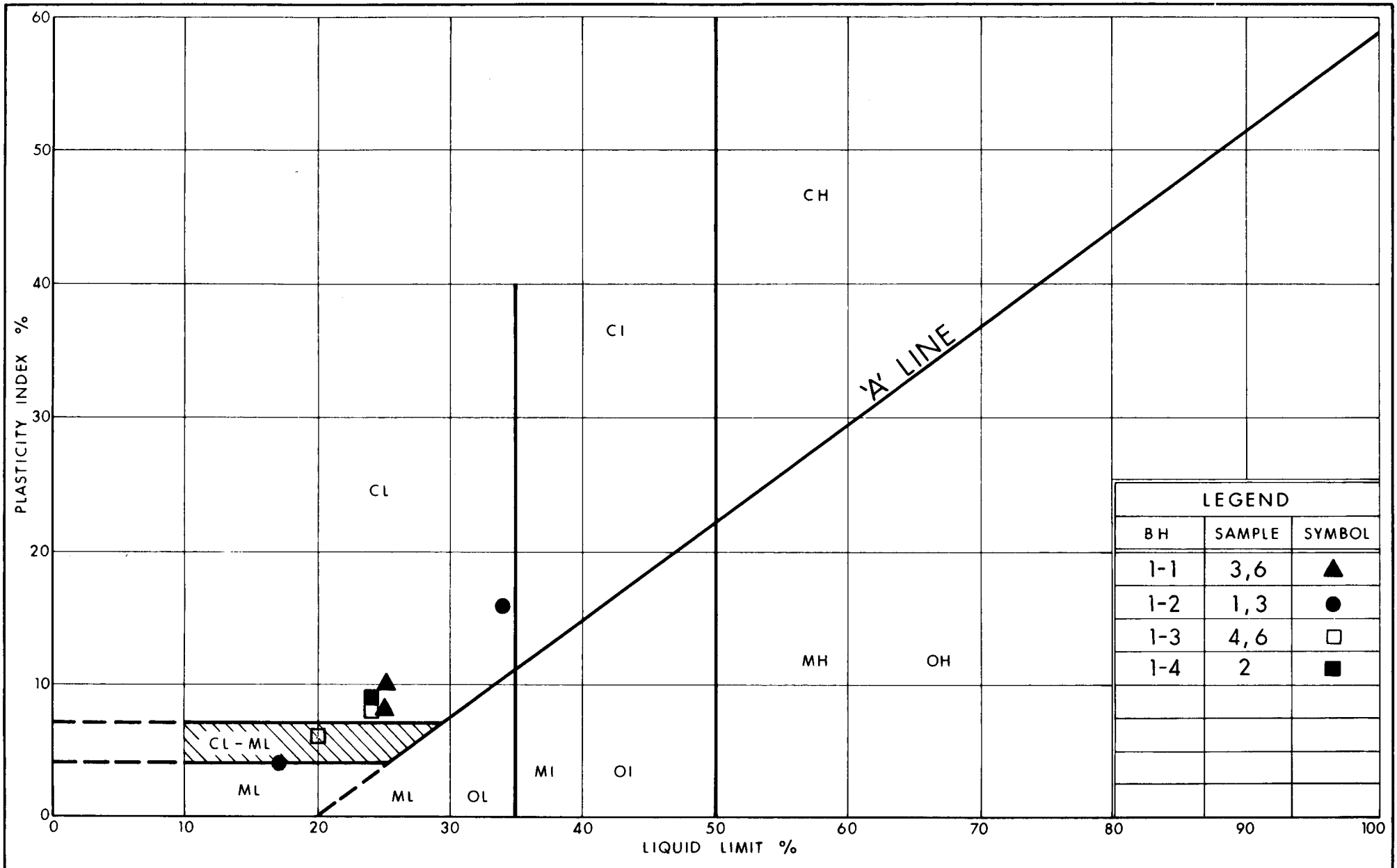
HET MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 2512 - 90 - 00A

Oct 75, FF-S-21



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PLASTICITY CHART

HET MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 2512-90-00A

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 (RQD), 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

RECORD OF BOREHOLE No 1-1 1 OF 1 METRIC

W.P. 2512-90-00A LOCATION Co-ords: N 4 782 905 E 310 450 ORIGINATED BY TS

DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 04 09 CHECKED BY PP

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 + 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 (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
84.7	Ground Surface										
0.0	Sand and Gravel Brown, Compact										
83.9	(Fill Material)						84				
0.8	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material)		1	SS	13						
			2	SS	6					19.3	1 20 54 25
82.4	Brown, Firm to Stiff										
2.3	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Hard		3	SS	48		82			23.3	9 19 48 24
			4	SS	100	/15cm					
	Brown		5	SS	100	/15cm *					
	Red										
			6	SS	120		80			22.3	0 1 79 20
			7	SS	100	/15cm					
							78				
77.0	trace shale fragments		8	SS	100	/8cm					
7.7	End of Borehole										
	* 91 04 10										

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

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 1-2 1 OF 1 METRIC

W.P. 2512-90-00A LOCATION Co-ords: N 4 782 825 E 310 450 ORIGINATED BY TS

DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 04 08 CHECKED BY PP

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 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
85.0	Ground Surface										
0.0	Sand and Gravel Brown, Compact										
84.2	(Fill Material)										
0.8	Stiff		1	SS	10		84			19.7	1 13 54 32
	Hard		2	SS	32						
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		3	SS	120				○		9 27 56 8
			4	SS	100	/15cm	82				
			5	SS	100	/15cm					
	Brown Red, trace shale fragments		6	SS	100	/15cm	80				
			7	SS	100						
77.7			8	SS	100	/3cm**	78				
7.3	End of Borehole										

* 91 04 09

** Sampler Bouncing (Probable Bedrock)

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

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

RECORD OF BOREHOLE No 1-3 1 OF 1 METRIC

W.P. 2512-90-00A LOCATION Co-ords: N 4 782 867 E 310 452 ORIGINATED BY TS

DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 04 08 CHECKED BY PP

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 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
84.0	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)										
	Stiff		1	SS	15						
	Hard		2	SS	100		82				
			3	SS	100	/15cm ▼					
			4	SS	100	/15cm			○		6 36 43 15
	Brown		5	SS	100	/15cm	80				
	Red		6	SS	100	/15cm			○	22.6	1 7 71 21
77.9					**		78				
6.1	End of Borehole										

* 91 04 09

** Sampler Bouncing (Probable Bedrock)

+³, ×⁵ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 1-4 1 OF 1 METRIC

W.P. 2512-90-00A LOCATION Co-ords: N 4 782 880 E 310 446 ORIGINATED BY TS

DIST 4 HWY Q.E.W. BOREHOLE TYPE HS Auger COMPILED BY TS

DATUM Geodetic DATE 91 04 09 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × 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 (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
83.9	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)										
	Stiff		1	SS	14						
	Hard		2	SS	41		82	○	○	23.3	2 24 50 24
			3	SS	100	/8cm ▼					
			4	SS	100	/15cm					
	Brown										
	Red		5	SS	100		80	○	○	22.5	1 5 71 23
			6	SS	120						
78.4			7	SS	**						
5.5	End of Borehole										

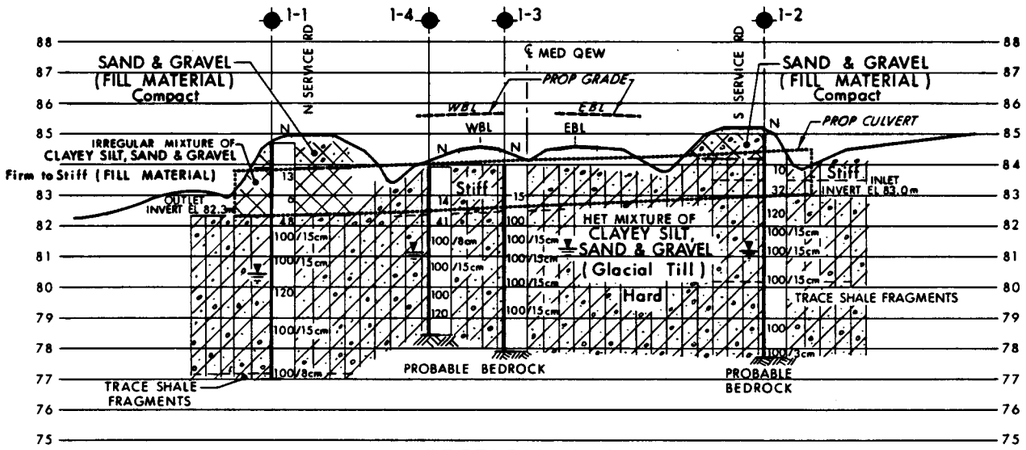
* 91 04 10

** Sampler Bouncing (Probable Bedrock)

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

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

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

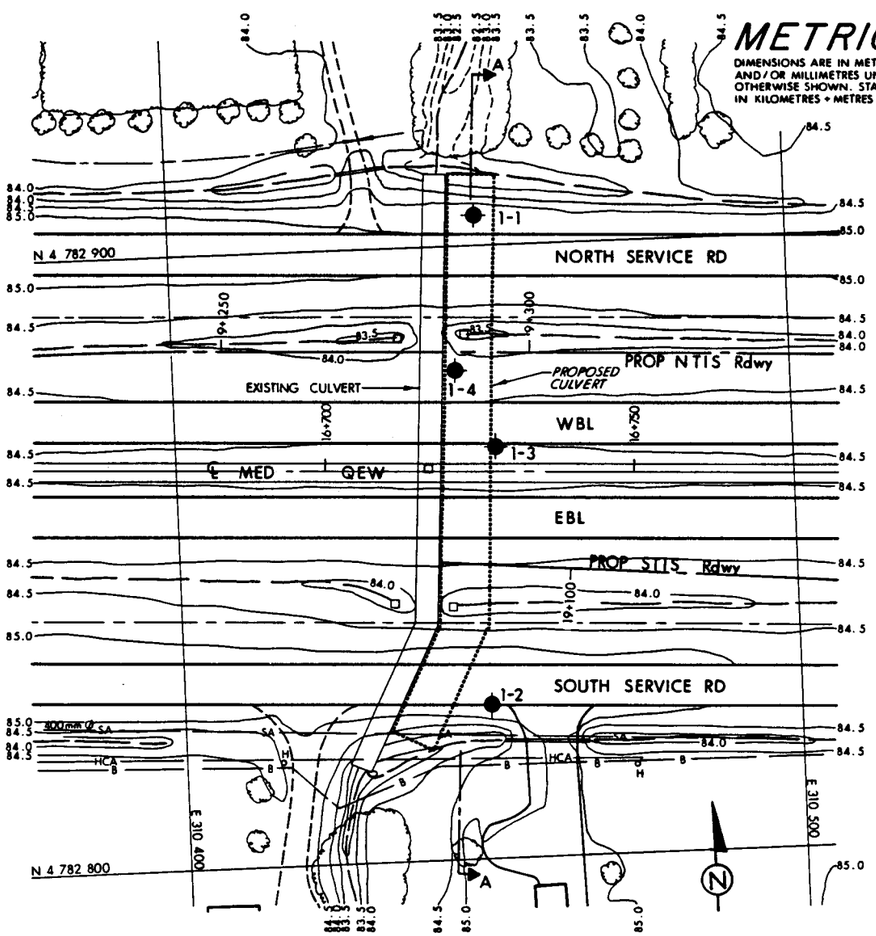


SECTION A-A

SCALES
10m 0 10m HOR
2m 1 0 2m VERT

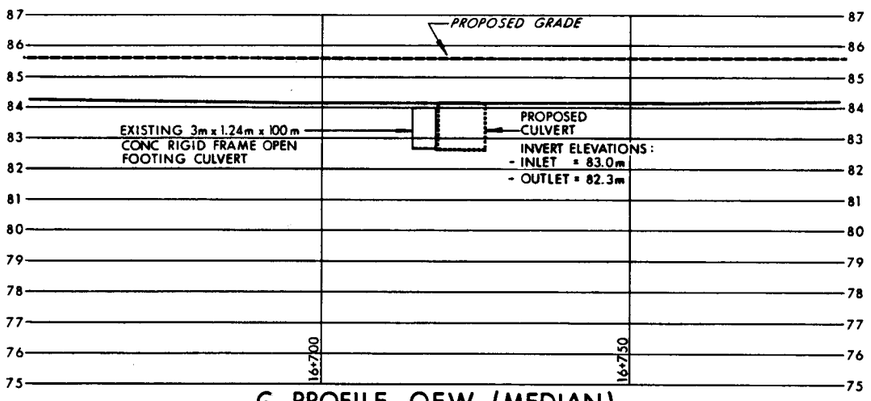
METRIC

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



PLAN

SCALE
10m 0 10m



℄ PROFILE QEW (MEDIAN)

SCALES
10m 0 10m HOR
2m 1 0 2m VERT

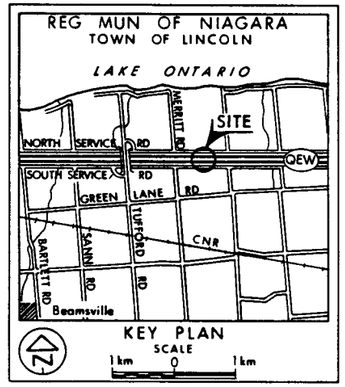
REF No B-137-QEW-12; 1988 11.
Marshall Macklin Monaghan Limited, (VINELAND T.I.S. Sheet 1)

CONT No
WP No 2512-90-00A

QEW CULVERT No 1

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



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 1991 04

No	ELEVATION	CO-ORDINATES NORTH	EAST
1-1	84.7	4 782 905	310 450
1-2	85.0	4 782 825	310 450
1-3	84.0	4 782 867	310 452
1-4	83.9	4 782 880	310 446

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 30M3-189

HWY No QEW			DIST 4
SUBM'D TS	CHECKED TS	DATE 1991 07 19	SITE
DRAWN RS	CHECKED	APPROVED	DWG 25129000A-A