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FOUNDATION DESIGN SECTION

foundation investigation and design report

R.D.

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 128-87-04 DIST 9

HWY 416 STR SITE 3-548

Fallowfield Rd. Underpass

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FOUNDATION INVESTIGATION REPORT
For
Highway 416, Fallowfield Rd. Underpass
Structure #20
W.P. 128-87-04, Site 3-548
District 9, Ottawa

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where a two span structure is proposed to carry the Fallowfield Road over the proposed Hwy. 416.

Eight boreholes (BH #20 - 1 to BH #20 - 8) were advanced and sampled as part of this project by means of hollow stem augers with washboring techniques and using a conventional diamond drill (BW Casing and BXL Rock Core barrel) adopted for soil and rock sampling purposes. These boreholes extended down to depths of 2.3 and 8.0 metres below the existing ground surface.

This report contains factual information obtained from this investigation together with discussion and recommendations pertaining to structure foundations, approach embankments and related earthworks for the Structure No. 20 as shown on Drawing No. 1288704-A.

Site Description and Geology

The site is located on the proposed alignment of Hwy. 416 where it crosses the existing Fallowfield Road between Moodie Drive and Cedarview Road in the City of Nepean, Regional Municipality of Ottawa -Carleton. The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for agricultural and dairy farming to the south and Ontario Hydro's stock-piling yard to the north. An abandoned quarry is located further north of the site. Residential development exists northeast of the site.

Physiographically, the site lies in the area known as the Ottawa Valley Clay plains founded in the Lowlands of the St. Lawrence, which are characterized by clay plains interrupted by ridges of rock or sand and gravel. The bedrock in the area is of the Gull River Formation of the Middle Ordovician period. It consists of limestone with interbedded shale layers. The overburden is relatively thin and was deposited during and immediately following the Wisconsin glaciation at which time the area was depressed from the effect of the glaciation. The ground surface elevation varies between 114.0 m at the west approach and 106.0 m at the east approach.

FIELD INVESTIGATION AND LABORATORY ANALYSES

The fieldwork for the site investigation was carried out between May 11 and May 16, 1989 and consisted of eight (8) sampled boreholes accompanied by dynamic cone penetration tests. Soil samples were retrieved at selected intervals by a split spoon sampler with the Standard Penetration Test (ASTM D1586). Samples were identified in the field and then returned to the laboratory for appropriate testing. Bedrock was cored at three borehole locations for about 1.5 metre to 3.0 metre depths using conventional rock coring methods.

A piezometer was installed in BH #20 - 6. Water levels were obtained in the piezometer and open boreholes during the fieldwork. Survey information related to location and elevation of boreholes was provided by Eastern Region Surveys and Plans.

To identify the properties of the soil, the following laboratory testing were performed:

- 1) Atterberg Limit Tests
- 2) Grain Size Analyses
- 3) Natural Moisture Contents

Laboratory test results have been summarized and are included in the Appendix of this report.

SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site, consisting primarily of three distinct deposits. The surficial layer consists of a generally loose to compact silty sand and stiff silty clay top soils which extends to a maximum thickness of 0.8 metres. Underlying this layer is a deposit of heterogeneous mixture of silt, sand and gravel interbedded with irregular layers or seams of sandy silt. The maximum proven thickness of this deposit ranges from 1.1 metres to 2.4 metres. The above stratum was underlain by about 1.2 to 2.4 metres thick layer of glacial till consisting of boulders with sand and gravel. Limestone bedrock was encountered below the glacial deposit.

It should be noted that in the vicinity of Hydro's entrance gate (north side of middle pier for the Structure No. 20), upper top soil is gradually diminished (BH #20 - 3). It should be also noted that near BH #20 - 8 a thin layer of clayey silt (0.8 m in thickness) was encountered underneath the top soil, while in BH #20 - 5 a thin layer of silty sand was found as shown on borehole logs.

The embankment of the existing Fallowfield Drive is composed by approximately 1.1 to 1.6 metres of sand and gravel fill materials.

A detailed description of the subsurface conditions and embankment fill material is given below.

Topsoil

Underlying the site and explored to depths ranging from the original ground surface to depths betweenm 0.3 and 0.8 metres, is a non-cohesive topsoil which is composed of silty sand. However, a cohesive topsoil consisting of silty clay was encountered in BH #20 - 1.

Grain size distribution tests were carried out on non-cohesive materials. Figure 1 in the Appendix shows the results in an envelope form. From the above figure, it is evident that the layer can be classified as a silty sand with some gravel and trace of clay and organics.

The result from the Atterberg Limit test performed on cohesive material is summarized as follows:

	<u>Range (%)</u>
Natural Moisture Content (w)	15.0
Liquid Limit (w_L)	35.5
Plastic Limit (w_P)	22.5
Plasticity Index (I_P)	13.0

From the plasticity chart (Figure 2), the layer can be classified as an organic silty clay with some gravel and trace of clay with intermediate plasticity (CI).

In this stratum, the 'N' values ranged from 8 blows/0.3m to 20 blows/0.2 m.

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

A heterogeneous mixture of silt, sand and gravel of glacial origin was encountered below the topsoils. The thickness of this layer ranges from 1.1 metres at BH #20 - 2, #20 - 3 and #20 - 4 to 2.4 metres at BH #20 - 7.

Figure 4 shows the results of grain size distribution tests in an envelope form for these materials. As shown on the above figure, this stratum may be described as a heterogeneous mixture of silt, sand and gravel.

In this stratum, the 'N' values ranged from 10 to over 100 blows/0.3 m indicating a state of compaction described as compact to very dense.

Within this stratum, occasional silty sand and sandy silt seams were found at BH #20 - 5, #20 - 7 and #20 - 8. The thickness of

the individual layers/or seams varies between 0.2 metres at BH #20 - 7 and 0.9 metres at BH #20 - 5.

Grain Size distribution tests were carried out on these samples. Figure 1 shows the results for silty sand seams, while Figure 5 presents the result for sandy silt.

A clayey silt seam was also encountered between the silty sand topsoil and Het. mixture of silt, sand and gravel in BH #20 - 8. The thickness of this layer is about 0.8 metres.

Atterberg Limit test was performed on this sample and the result is plotted on Figure 2 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture (w)	21.5
Liquid Limit (w_L)	26.5
Plastic Limit (w_P)	11.0
Plasticity Index (I_P)	15.5

From the plasticity chart (Figure 2), it is evident that the layer can be classified as an inorganic clayey silt, some sand with low plasticity (CL).

A grain size distribution test was carried out on this material. Figure 3 in the Appendix shows the result.

Boulders with Sand and Gravel (Glacial Till)

Underlying the Het. mixture of silt, sand and gravel, boulders with sand and gravel of glacial origin was encountered. The proven thickness of this stratum ranges from about 1.2 metres at BH #20 - 1 to 2.4 metres at BH # 20 - 4. Rock coring techniques were required to penetrate boulders within the stratum.

In this stratum, the 'N' values ranged from 78 to over 100 blows/0.3 metres indicating a state of compaction described as very dense.

Embankment Fill Material

The soil in the embankment fills for the existing Fallowfield Road consists of a brown sand and gravel. Through visual observation and a grain size distribution analysis, it is apparent that the embankment fill materials can be classified as sand and gravel with some silt and trace of clay as shown on Figure 6. The fill materials extend from the existing sand surface to a depth of 1.6 metres.

Bedrock

The coarse glacial till deposit (Boulders with sand and gravel layer) is directly underlain by bedrock of the Gull River Formation and was cored at three locations by obtaining up to 3.0 metres of sound rock core samples. The bedrock consists mainly of a limestone with interbedded shale layers. Detailed descriptions of the rock are attached in the Appendix entitled "Rock Core Description".

Core recoveries and Rock Quality Designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results, the rock can be classified as medium strong rock and predominantly unweathered to slightly weathered.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes and a piezometer installed in BH #20 - 6. Boreholes near the proposed middle piers, west abutments and west approach locations, were dry down to boulders layer or to bedrock surface. Higher water level was recorded in BH #20 - 1. However, it appears to be drilling water trapped within impermeable silty clay layers. In the vicinity of east abutment and approach fill area, the groundwater level in the boreholes was found to range between 106.1 metres at BH #20 - 5 and 105.3 metres at BH #20 - 8, which corresponds to depths of 2.6 metres to 4.2 metres below the existing ground surface.

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structure and related approaches.

It is proposed to construct an overpass structure that will carry the Fallowfield Road over the proposed Hwy. 416 Southbound and Northbound lanes. The new structure No. 20 will be located along the existing Fallowfield Road. The proposed structure is a two-span structure having an approximate length and width of 77 metres (40 + 37 m) and 23 metres, respectively. The proposed profile grade of the Hwy. 416 SB and NB lanes is approximately at elevation 111 metres which is equivalent to approach fill height of 7.5 metres above the existing natural ground surface.

Structure Foundations

Abutments and Wingwalls

In consideration of the competent nature of the subsoils and the anticipated fill heights, a perched-type abutment founded on spread footings as high as possible within the approach fills on a zone composed of well compacted Granular 'A' material proposed as per the included current MTO standard (see Figure 7). All surficially softened or loose materials within the plan limits of the granular core must be subexcavated to a minimum elevations of 110.5 metres at the west abutment and 106.8 metres at the east abutments prior to placement of the granular core. For spread footings founded on a Granular 'A' Core and constructed as per MTO standard, the following design parameters are recommended:

	<u>Factored Capacity at U.L.S. (kPa)</u>	<u>Allowable Capacity at S.L.S. Type II (kPa)</u>
Spread Footings	900	350

Alternatively, assuming a close-type of abutment is more desirable, spread footings at or below elevation 109.2 metres for the west abutment and elevation 106.8 metres for the east abutment can be designed for the following design values:

	<u>Factored Capacity at U.L.S. (kPa)</u>	<u>Allowable Capacity at S.L.S. Type II (kPa)</u>
Spread Footings (West Abutment)	900	350
Spread Footings (East Abutment)	900	350

Resistance to sliding of the abutment footings can be calculated assuming a coefficient of friction of 0.7 between the underside

of the concrete footings and the Granular 'A' core or the natural glacial till material.

Piers

Foundations for the centre pier can be supported on spread footings founded at or below elevation 108.8 metres. At this elevation, the following design values are recommended for purpose of the O.H.B.D.C.:

Factored Bearing Capacity at U.L.S.: 1000 kPa
Bearing Capacity at S.L.S. Type II: 550 kPa

Other Considerations

Lateral Earth Pressures on Structures

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up.

Design parameters of the soil are given below for purpose of the O.H.B.D.C.:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (KN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure (K_A)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_0)	0.43	0.50

The earth pressure coefficient at rest is to be used in design if the abutment walls are rigid and unyielding. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

Dewatering

No dewatering problems are anticipated in view of the fact that the groundwater level is below the excavation cut. However, if surface water does accumulate in excavations, it should be removed by means of a sump pump.

Frost Protection

The footings should be placed so as to have a minimum earth cover of 1.8 metres to allow for frost protection.

Approaches and Foundation Excavations

Approach fills and foundation excavations should be constructed with standard 2H:1V side and forward slopes in which, in general, no major stability problems are anticipated.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Bruce Sedgwick, Student Engineer, and Tae C. Kim, Foundation Design Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd., Ottawa.

This report was written by Tae C. Kim, Foundation Design Engineer, under the general supervision of Dr. Balu Iyer and reviewed by Mr. Murty Devata, Chief Foundation Engineer.

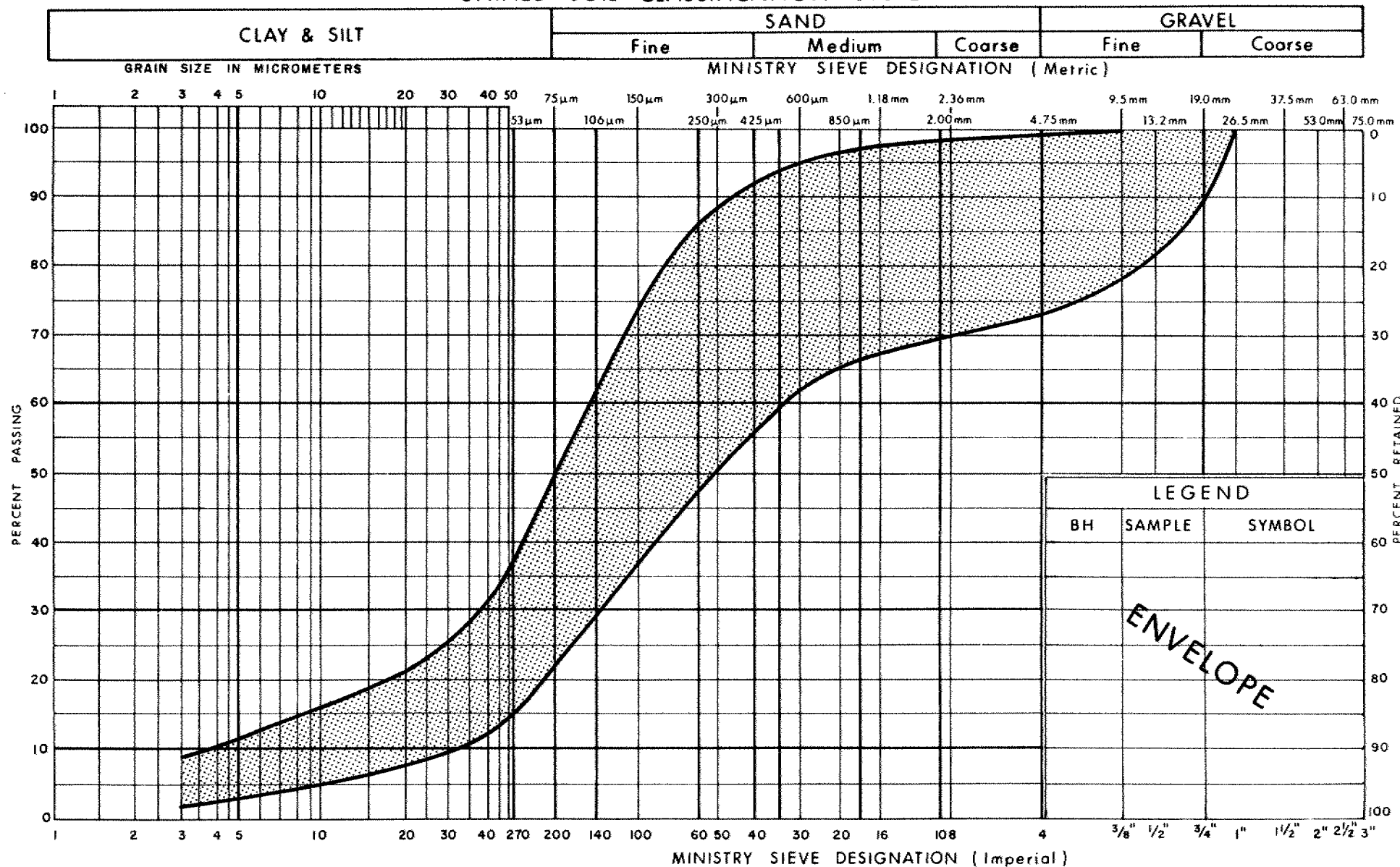


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APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

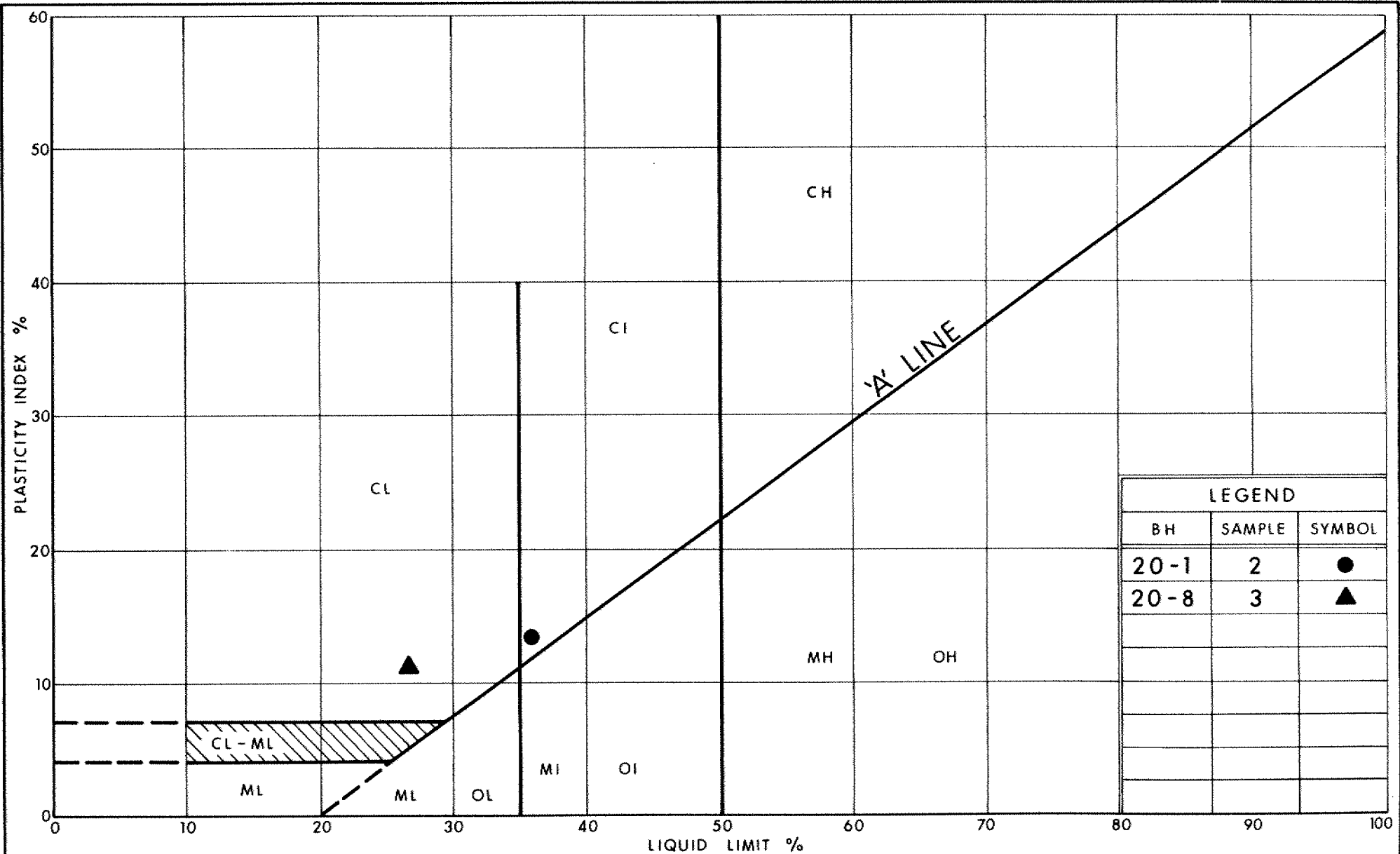


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GRAIN SIZE DISTRIBUTION SILTY SAND

FIG No 1

W P 128-87-04



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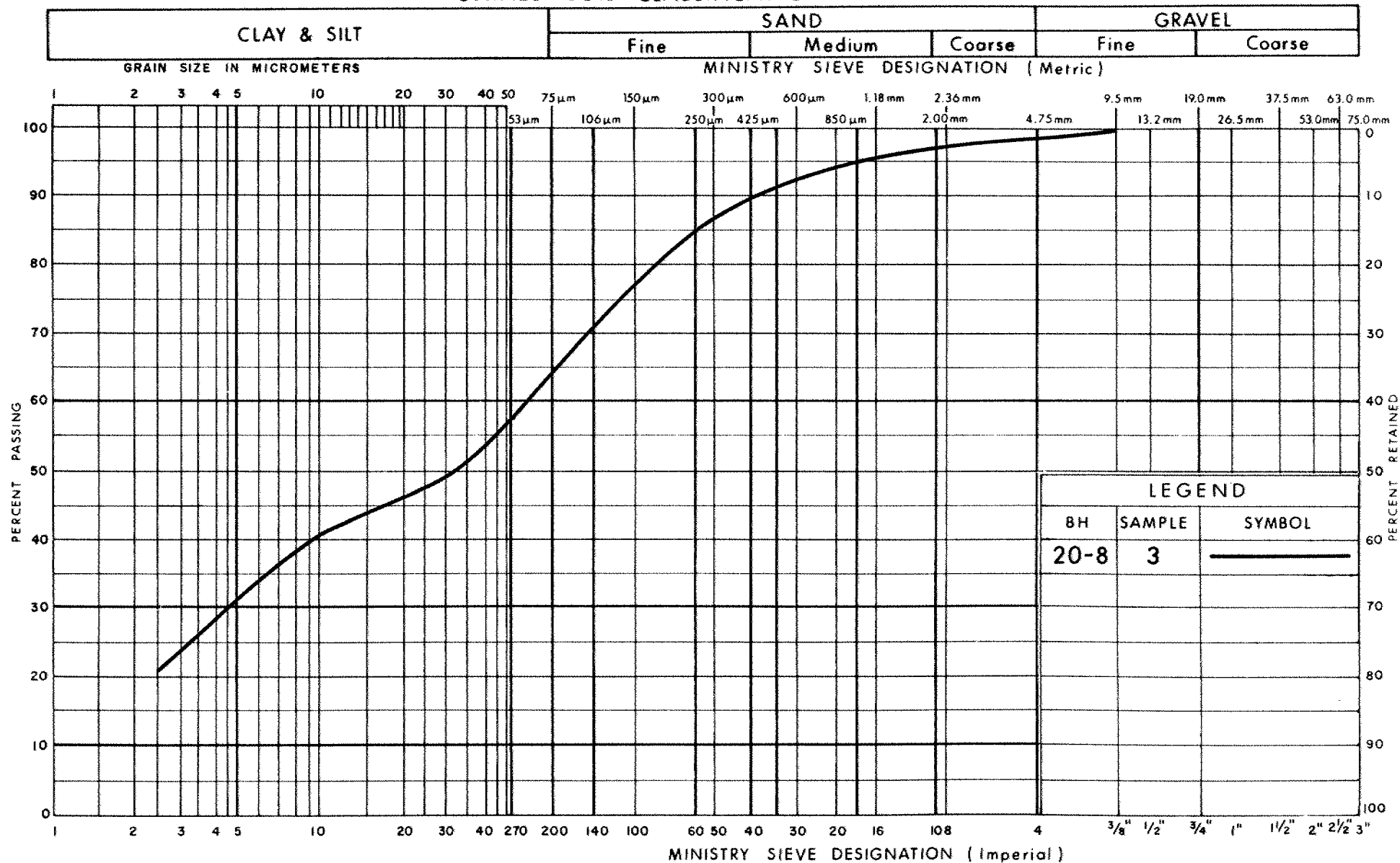
Ontario

PLASTICITY CHART CLAYEY SILT / SILTY CLAY

FIG No 2

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UNIFIED SOIL CLASSIFICATION SYSTEM



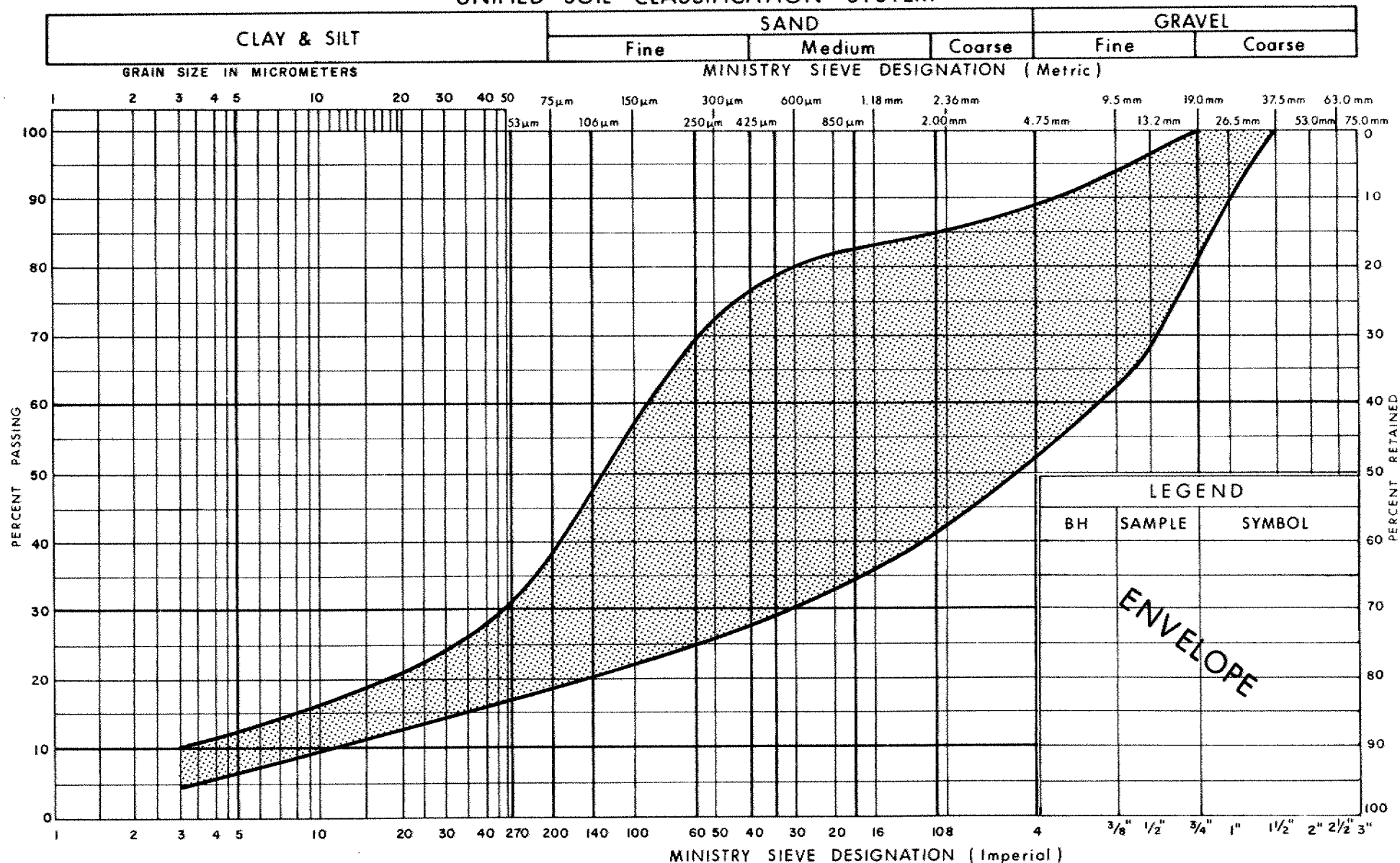
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GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No 3

W P 128 - 87 - 04

UNIFIED SOIL CLASSIFICATION SYSTEM



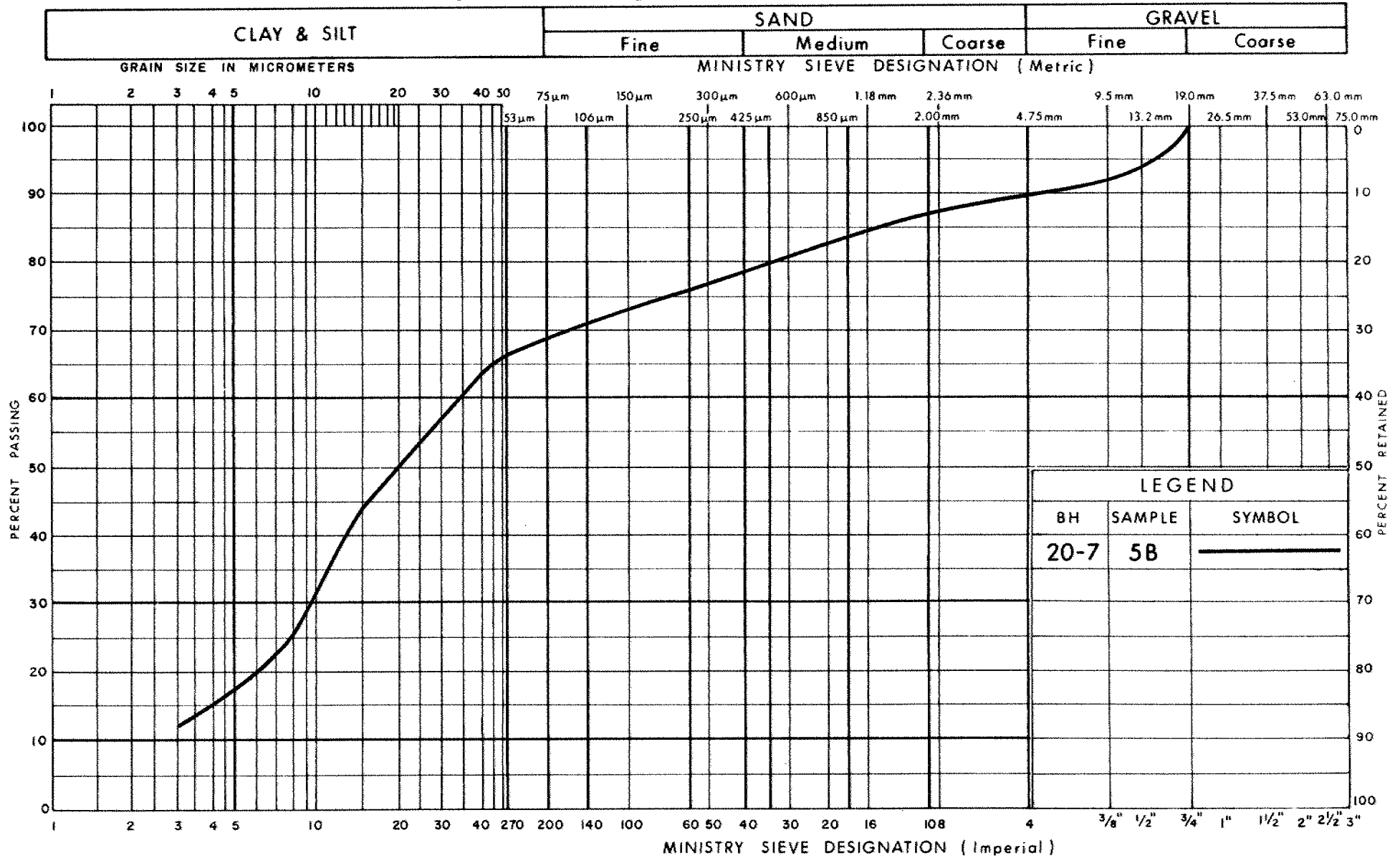
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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SILT, SAND & GRAVEL (Glacial Till)

FIG No 4

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UNIFIED SOIL CLASSIFICATION SYSTEM



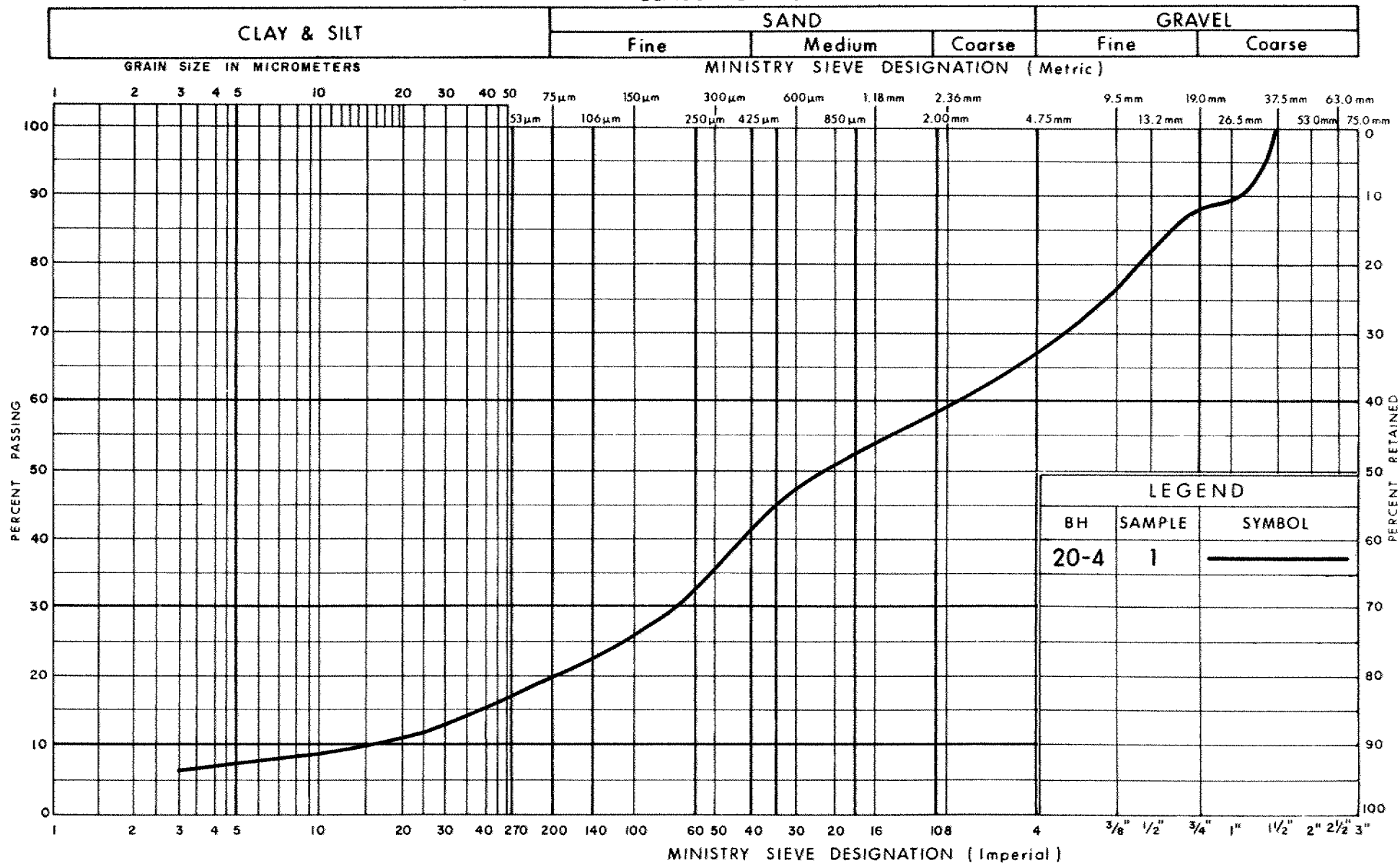
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GRAIN SIZE DISTRIBUTION SANDY SILT

FIG No 5

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UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION SAND & GRAVEL (Fill)

FIG No 6

W P 128-87-04

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

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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
γ_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

PHYSICAL PROPERTIES OF SOIL

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

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CORE RECOVERY					CORE DESCRIPTION	
BH - RC # #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION	
20-1	7	5.08-5.23	83	0	5.08-5.21 5.21-6.78	OVERBURDEN, limestone boulder, fragments. LIMESTONE, light grey, thick bedded, fine grained with minor shale seams; medium strong rock; unweathered to slightly weathered; close to moderately close spaced fractures (8-28 cm spacing, avg. 15 cm): horizontal, rough, irregular, usually occurring along the shale seams.
	8	5.23-6.78	95	88		
20-4	4	2.16-3.05	57	14	2.16-4.95 4.95-5.61	OVERBURDEN, limestone and sandstone boulders, fragments. LIMESTONE, very light grey to light grey, very fine grained, sublithographic; medium strong rock; slightly weathered to unweathered; close spaced fractures (3-18 cm spacing, avg. 8 cm): horizontal, very rough, irregular, some shale coating on fracture surfaces.
	5	3.05-3.53	37	0		
	6	3.53-3.63	100	0	5.61-7.47	LIMESTONE, very light grey to light grey, weathers light tan brown, very fine grained, lithographic to sublithographic; medium strong rock; slightly weathered; very close to extremely close spaced fractures (1-9 cm, avg. 4 cm): horizontal, rough, irregular; subhorizontal, irregular; very intensely fractured zones form 6.22-6.45 m, and from 6.86-6.96m.
	7	3.63-3.71	100	0		
	8	3.71-3.84	70	0		
	9	3.84-4.14	42	0		
	10	4.14-4.32	65	35		
	11	4.32-4.93	50	27		
	12	4.93-4.98	100	0		
	13	4.98-5.54	75	34		
	14	5.54-6.22	100	18		
	15	6.22-6.35	80	0		
	16	6.35-6.88	100	0		
	17	6.88-8.03	98	56	7.47-8.03	LIMESTONE, medium light grey, fine grained with shaley laminations; unweathered; medium strong rock; very close to close spaced fractures (3-20 cm spacing, avg. 7 cm): horizontal, rough , irregular.

*CR = CORE RECOVERY (NOTE: Depths are approximated in zones of poor core recovery.)

*RQD = ROCK QUALITY DESIGNATION

Logged by: S. A. Senior, Soils and Aggregates Section.

ROCK CORE DESCRIPTION
WP 128-87-04

2../2

CORE RECOVERY				CORE DESCRIPTION	
BH - RC # #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION
20-6 6	4.52-5.03	63	25	4.52-6.45	OVERBURDEN, limestone boulder and fragments.
	5.03-5.05	100	0		LIMESTONE, medium light grey to medium grey; very fine
	5.05-5.28	100	56		grained with shaley laminations; medium strong rock;
	5.28-6.10	78	47		unweathered to slightly weathered; close to moderately
	6.10-6.43	100	0		close spaced fractures (3-55 cm spacing, avg. 50 cm):
	6.43-7.95	100	89		horizontal, rough, irregular.

*CR = CORE RECOVERY (NOTE: Depths are approximated in zones of poor core recovery.)

*RQD = ROCK QUALITY DESIGNATION

Logged by: S. A. Senior, Soils and Aggregates Section.

RECORD OF BOREHOLE No 20-1

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 644.0; E 359 931.4 ORIGINATED BY TK
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BXL Rock Coring & Cone Test COMPILED BY BWS
 DATUM Geodetic DATE 89 05 15 CHECKED BY TK

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 kPa ○ 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						
112.8	Ground Surface										
0.0	Sand & Gravel Brown		1	SS	10	8 cm					
111.6	(Fill)										
1.2	Organic Silty Clay (Topsoil)		2	SS	8						
110.8	Het. Mixture of Silt, Sand and Gravel Brown Compact to Very Dense		3	SS	20						
2.0	(Glacial Till)		4	SS	17						
108.8	Boulders with Sand And Gravel		5	SS	55						
4.0	(Glacial Till)		6	SS	78						
107.6	Limestone Bedrock with Interbedded Shale Layers Sound		7	RC	83%	Rec					
5.2			8	BXL RC	95% Rec						
105.7	End of Borehole										
7.1	*Note: Water Must Have Been Trapped in Silty Clay Layer Resulting in a High Water Level										

RECORD OF BOREHOLE No 20-2

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 631.2; E 359 939.1 ORIGINATED BY TK
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY BWS
 DATUM Geodetic DATE 89 05 16 CHECKED BY TK

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 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
112.6	Ground Surface										
0.0	Sand & Gravel Brown					*	112				
	(Fill)		1	SS	40						
111.2							111				
1.4	Silty Sand (Topsoil)		2	SS	10						
110.5											
2.1	Het. Mixture of Silt, Sand & Gravel Brown, Very Dense		3	SS	60 / 15 cm		110				14 54 26 6
	(Glacial Till)		4	SS	50 / 15 cm						
109.4											
3.2	End of Borehole										25 39 30 6
	Refusal (Probable Boulders)										
	*Borehole Dry										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 20-3

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 661.0; E 359 960.8 ORIGINATED BY BWS
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY TK
 DATUM Geodetic DATE 89 05 15 CHECKED BY TK

SOIL PROFILE		SAMPLES			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	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
111.2	Ground Surface											
0.0	Sand & Gravel Brown					*	111					
110.0	(Fill)		1	SS	13	8 cm Bouncing	110					
1.2	Het. Mixture of Silt, Sand & Gravel Very Dense		2	SS	22	23 cm Bouncing						12 49 34 5
108.9	(Glacial Till)						62 / 22 cm					
2.3	End of Borehole						Refusal					
	Refusal (Probable Boulders) *Borehole Dry											

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 20-4

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 651.8; E 359 973.4 ORIGINATED BY TK
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BXL Rock Coring & Cone Test COMPILED BY BWS
 DATUM Geodetic DATE 89 05 11-12 CHECKED BY TK

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 kPa ○ 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							
111.0	Ground Surface											
0.0	Sand & Gravel Brown (Fill)		1	SS	19	10 cm	110					33 46 16 5
109.9	Silty Sand (Topsoil)		2	SS	16		109					
109.5	Het. Mixture of Silt, Sand & Gravel Compact to V. Dense		3	SS	29	10 cm						
108.4	(Glacial Till)		4	BXL	57%	Bouncing	108					14 49 33 4
2.6	Boulders with Sand & Gravel (Glacial Till)		5	RC	Rec							RQD = 27%
			6	BXL	37%							RQD = 0%
			7	RC	90%	Rec						RQD = 0%
			8	RC	42%	Rec	107					RQD = 0%
			9	RC	65%	Rec						RQD = 35%
			10	BXL	50%							RQD = 27%
106.0			11	RC	Rec		106					RQD = 0%
5.0	Limestone Bedrock with Interbedded Shale Layers		12	RC	100%	Rec						RQD = 34%
			13	BXL	75%							RQD = 18%
			14	RC	Rec		105					RQD = 0%
			15	BXL	100%							RQD = 0%
			16	RC	80%	Rec						RQD = 56%
			17	BXL	98%	Rec	104					
103.0	End of Borehole											
8.0	Notes: 1. Borehole Dry at 2.6 m below Ground Surface 2. Drilling Water Lost at 6.2 m below Ground Surface (Probable Fracture Zone in Bedrock)											

+3, x5: Numbers refer to Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 20-5

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 682.8; E 359 997.7 ORIGINATED BY TK
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY BWS
 DATUM Geodetic DATE 89 05 15 CHECKED BY TK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa						WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE							
109.7	Ground Surface									10 20 30				GR SA SI CL		
0.0	Sand & Gravel Brown															
	(Fill)		1	SS	39		109									
108.2																
1.5	Silty Sand (Topsoil)		2	SS	20 /	8 cm	108									
107.7																
2.0	Silty Sand Loose		3	SS	5		107							1 46 45 8		
106.8																
2.9	Het. Mixture of Silt, Sand and Gravel Dense to Very Dense		4	SS	48		106							14 52 29 5		
			5	SS	50 /	9 cm										
	(Glacial Till)															
104.5			6	SS	55		105							47 34 14 5		
5.2	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-6

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 671.4; E 360 004.6 ORIGINATED BY TK
DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger, BXL Rock Coring & Cone Test COMPILED BY BWS
DATUM Geodetic DATE 89 05 12 CHECKED BY TK

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 kPa ○ 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						
109.8	Ground Surface										
0.0	Sand & Gravel Brown (Fill)		1	SS	46						
108.4	Silty Sand with Gravel, Trace Organics (Topsoil)		2	SS	15						27 44 24 5
107.7	Het. Mixture of Silt, Sand and Gravel Compact to Very Dense (Glacial Till)		3	SS	10						
2.1			4	SS	52						21 45 30 4
			5	SS	50						
105.4	Boulders with Sand & Gravel (Glacial Till) Sand Seam		6 & 7	BXL RC	63% Rec						RQD = 25%
4.4			8	RC	100% Rec						RQD = 56%
			9	BXL RC	78% Rec						RQD = 78%
103.3			10	RC	100% Rec						RQD = 0%
6.5	Limestone Bedrock with Interbedded Shale Layers Sound		11	BXL RC	100% Rec						RQD = 89%
101.8											
8.0	End of Borehole										

RECORD OF BOREHOLE No 20-7

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 632.4; E 359 915.0
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test
 DATUM Geodetic DATE 89 05 16
 ORIGINATED BY TK
 COMPILED BY BWS
 CHECKED BY TK

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 x LAB VANE	PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT Wl WATER CONTENT (%) 10 20 30	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
113.6	Ground Surface										
0.0	Sand & Gravel Brown (Fill)		1	SS	20		113				
112.2							112				
1.4	Silty Sand (Topsoil)		2	SS	51		111				
111.9							110				
1.7	Het. Mixture of Silt, Sand and Gravel Very Dense (Glacial Till)		3	SS	86						
			4	SS	105						
109.5	Sandy Silt		5	SS	12 / 10 cm						
4.1	End of Borehole										
	Refusal (Probable Boulders) *Borehole Dry										

OFFICE REPORT ON SOIL EXPLORATION

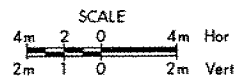
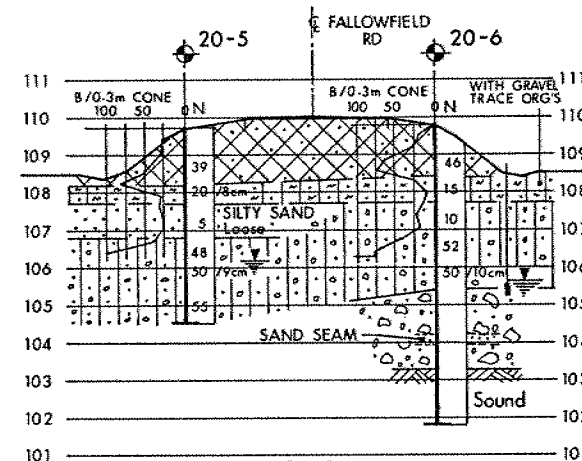
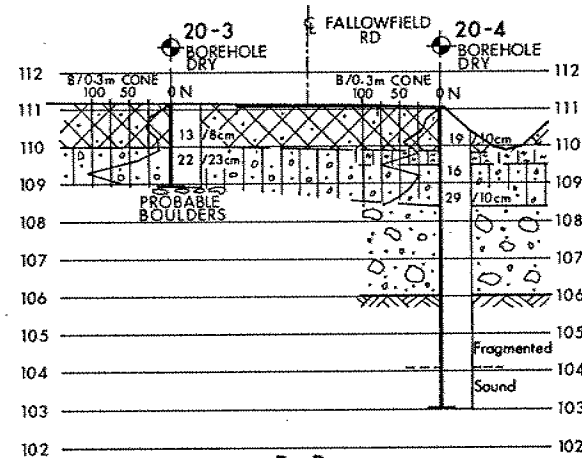
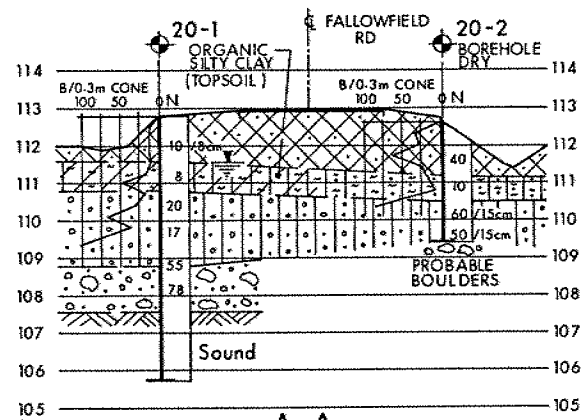
RECORD OF BOREHOLE No 20-8

METRIC

W P 128-87-04 LOCATION Co-ords: N 5 014 697.2; E 360 047.5 ORIGINATED BY TK
 DIST 9 HWY 416 BOREHOLE TYPE H.S. Auger & Cone Test COMPILED BY BWS
 DATUM Geodetic DATE 89 05 12 CHECKED BY TK

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 x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
107.9 0.0	Ground Surface													
	Sand & Gravel Brown													
	(Fill)		1	SS	27									
106.3 1.6	Silty Sand (Topsoil)		2	SS	10									
105.8 2.1	Clayey Silt with Sand		3	SS	6									
105.0 2.9	Het. Mixture of Silt, Sand and Gravel Very Dense		4	SS	Refusal									2 33 47 18
	Silty Sand		5	SS	69									18 46 26 10
103.3 4.6	(Glacial Till)		6	SS	15 / 5 cm									0 74 24 2
	End of Borehole													
	Refusal (Probable Boulders)													

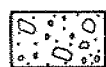
OFFICE REPORT ON SOIL EXPLORATION



SOIL STRATIGRAPHY LEGEND



SAND & GRAVEL
(FILL)



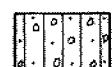
BOULDERS
WITH SAND & GRAVEL
{GLACIAL TILL}



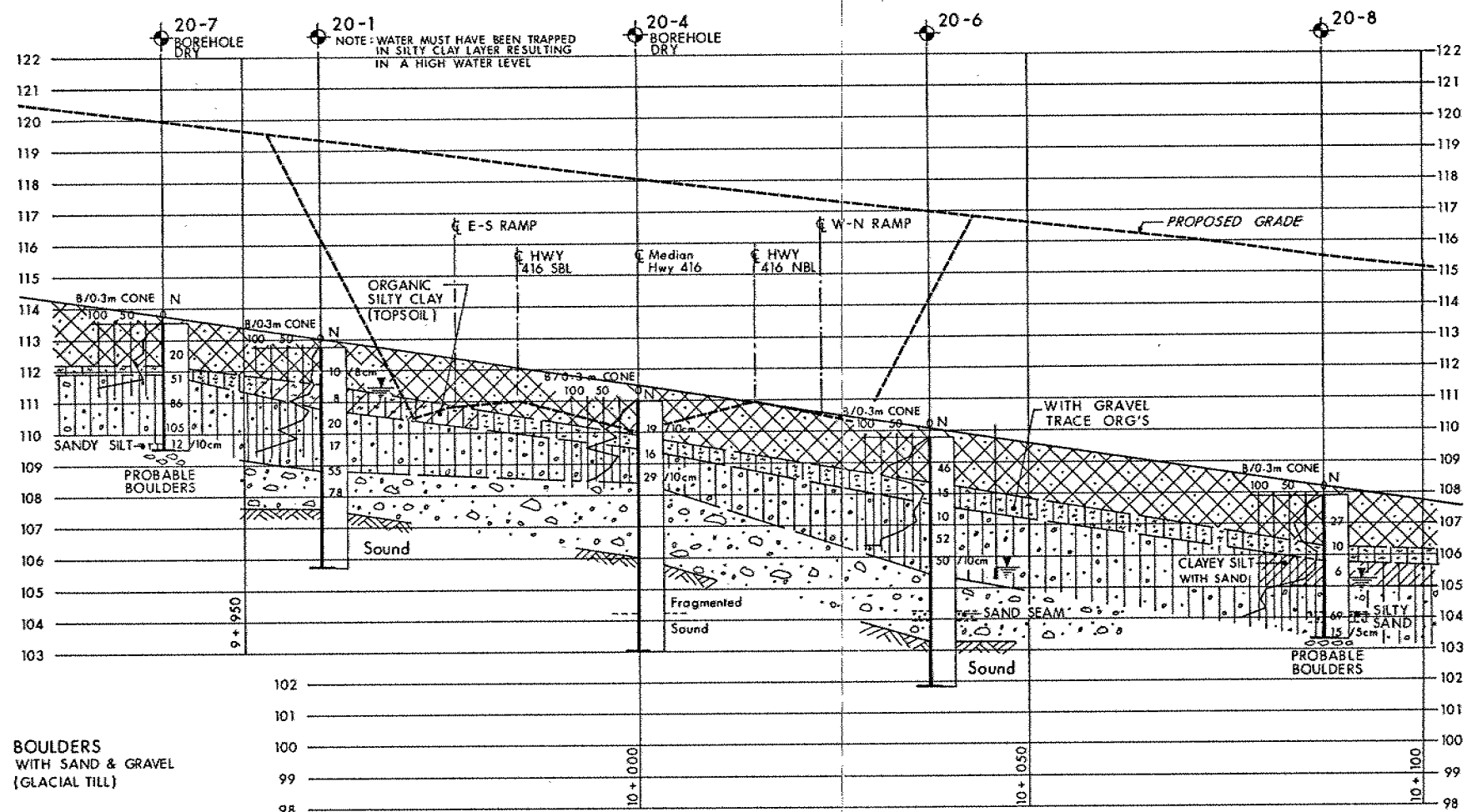
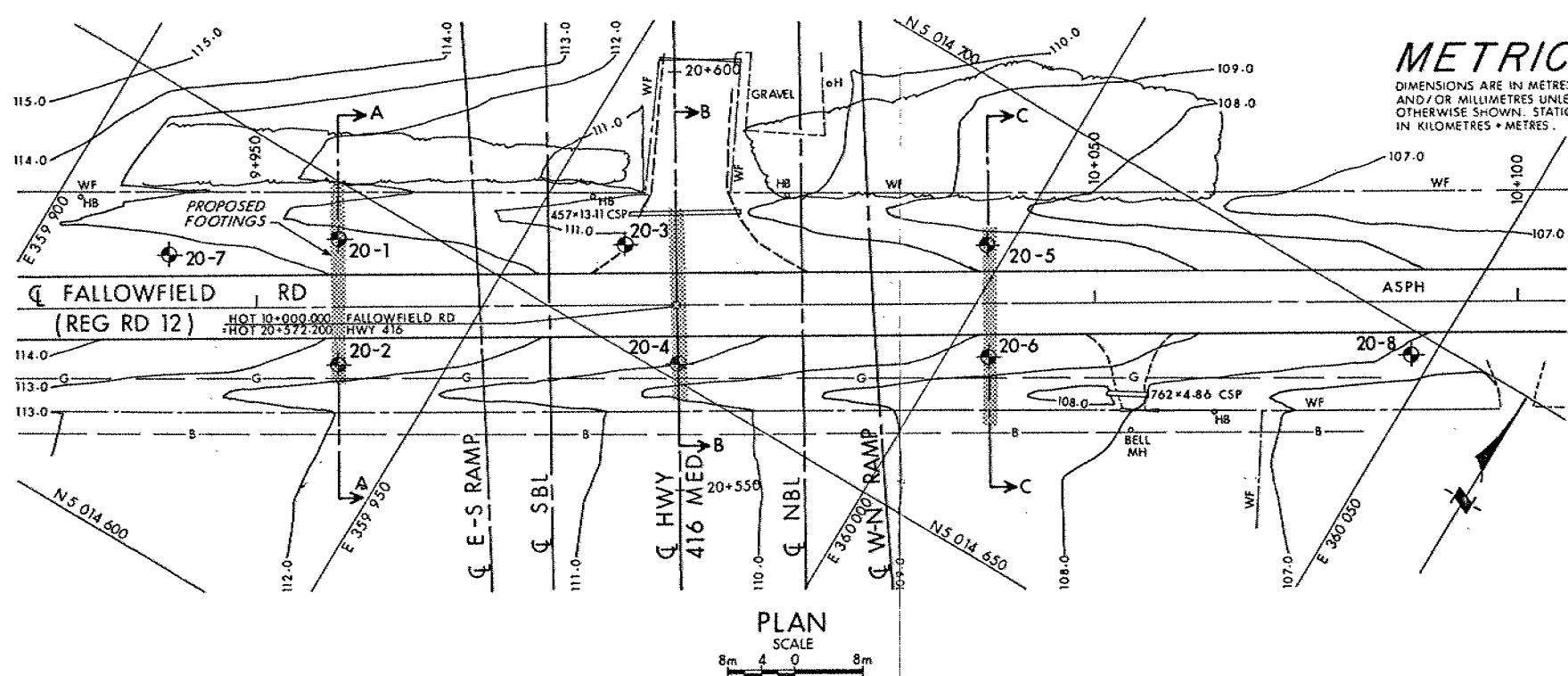
SILTY SAND
(TOPSOIL)



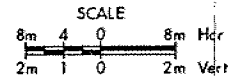
LIMESTONE BEDROCK
WITH INTERBEDDED
SHALE LAYERS



HETEROGENEOUS MIXTURE OF
SILT, SAND & GRAVEL
Compact to Very Dense
(GLACIAL TILL)

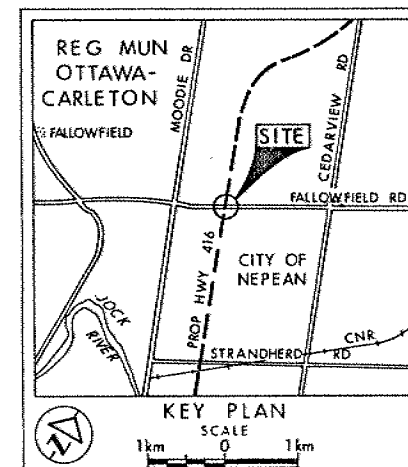


© PROFILE FALLOWFIELD RD









CONT No
WP No 128-87-04

FALLOWFIELD RD UNDERPASS
[STRUCTURE - 20]
BORE HOLE LOCATIONS & SOIL STRATA



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 89.05 |
|  | WL in Piezometer |
|  | Piezometer |

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
20-1	112.8	5 014 644.0	359 931.4
20-2	112.6	5 014 631.2	359 939.7
20-3	111.2	5 014 661.0	359 960.8
20-4	111.0	5 014 651.8	359 973.4
20-5	109.7	5 014 682.8	359 997.7
20-6	109.8	5 014 671.4	360 004.6
20-7	113.6	5 014 632.4	359 915.0
20-8	107.9	5 014 697.2	360 047.5

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 31G5-160				
HWY No 416				DIST 9
SUBMIT TCK	CHECKED	DATE 89 07 18	SITE 3-548	
DRAWN DT	CHECKED 8	APPROVED	DWG 1288704-A	

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 3165-160

DIST. 9 REGION

W.P. No. 128-87-04

CONT. No.

W. O. No.

STR. SITE No. 3-548

HWY. No. 416

LOCATION HWY 416 & FALLOWFIELD RD.

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

DIST No 9
CONT No
WP No 128-87-04



**PARKER
CONSULTANTS**

FALLOWFIELD ROAD
INTERCHANGE UNDERPASS
GENERAL ARRANGEMENT

SHEET 1

CLASS OF CONCRETE

DECK	35 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100 ± 25
ABUTMENTS AND WINGWALLS	
FRONT FACE	80 ± 20
BACK FACE	70 ± 20
PIERS	80 ± 20

DECK	TOP	70 ± 20
	BOTTOM	50 ± 10
	WEBS	50 ± 10

REMAINDER _____ 70 ± 20
UNLESS NOTED OTHERWISE

REINFORCING STEEL

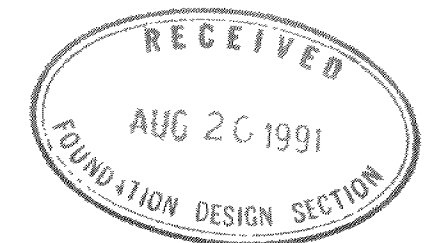
REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE. BAR MARKS WITH SUFFIX "C" DENOTE COATED BARS.

CONSTRUCTION NOTES

IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOOTING LAYOUT & REINFORCING
4. WEST ABUTMENT
5. WEST ABUTMENT REINFORCING
6. EAST ABUTMENT
7. EAST ABUTMENT REINFORCING
8. PIER DETAILS
9. DECK DETAILS & SCREED ELEVATIONS
10. LONGITUDINAL TENDONS
11. TRANSVERSE TENDONS
12. DECK REINFORCING I
13. DECK REINFORCING II
14. BARRIER WALLS
15. 600 mm APPROACH SLABS
16. DETAILS OF CONCRETE SLOPE PAVING
17. JOINT ANCHORAGE & ARMOURING
18. AS CONSTRUCTED ELEV. & DIM
19. ELECTRICAL EMBEDDED WORK
20. STANDARD DETAILS
21. QUANTITIES - STRUCTURE



STANDARD DRAWINGS

DD-3503 MIN GRANULAR BACKFILL REQUIREMENTS.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

 LICENSED PROFESSIONAL ENGINEER
M. L. TRADER
PROVINCE OF ONTARIO

REASON									
	DATE	BY	DESCRIPTION						
DESIGN	G.A.M.	CHK	M.L.T.	LOADING	CH-BDC-B3 CLASS A				DATE FEB. 1991
DRAWN	G.V.	CHK	G.A.M.	SITE No	03-548				DWG 1



Ministry
of
Transportation

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 128-87-04

DIST 9

HWY 416

STR SITE 3-548

Hwy. 416 and Fallowfield Road Relocation

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FOUNDATION INVESTIGATION REPORT
For
Hwy. 416 and Fallowfield Road Relocation
W.P. 128-87-04
Hwy. 416, District 9, Ottawa, Nepean

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. A two span structure has been proposed to carry the re-aligned Fallowfield Road over Hwy. 416. The subsurface conditions encountered at the site and recommendations pertaining to structure foundations and related earthworks are included in the scope of this report.

SITE DESCRIPTION

The site is located south of the existing Fallowfield Road between Moodie Drive and Cedarview Road in the City of Nepean, Regional Municipality of Ottawa - Carleton.

The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for agricultural and dairy farming. An abandoned quarry is located further north of the site. Residential development exists north east of the site. The natural ground level sloped downwards from the west approach to the east approach with elevations of 111.3 m to 101.6 m respectively. The area is generally bouldery with randomly placed boulders outcropping from the surface. The relocation of Fallowfield Road places it south within a farmers field.

Physiographically the site lies in the area known as the Ottawa valley clay plains founded in the lowlands of the St. Lawrence, which are characterized by clay plains interrupted by ridges of rock or sand and gravel. The bedrock in the area is of the Gull River Formation of the middle ordovician period. It consists of limestone with interbedded shale layers. The overburden is relatively thin and was deposited during and immediately following the wisconsinan glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the champlain sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

INVESTIGATION PROCEDURES

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

FIELD INVESTIGATION

The fieldwork for this investigation was carried out between 90 08 08 to 90 08 09 and consisted of a total of five sampled boreholes. Two holes at the east/west approach ramps, one east abutment, one centreline pier and one west abutment borehole. The surficial deposit was relatively shallow with a boulder till (bedrock) lying 4.8 to 5 metres below ground surface. The boreholes were advanced using a trackmounted CME55 drill rig employing hollow stem augering techniques.

In general, subsoil samples were retrieved at 0.7 m intervals, with two 1.5 m rock core samples retrieved at structural foundation locations. Core sampling was performed for the abutment and pier holes down to 3.5 m into bedrock, while the approach ramp borehole locations were terminated upon auger refusal. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All subsoil samples were identified in the field and returned to the laboratory for further examination and applicable testing.

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by MTO Surveys and Plans, Eastern Region.

Laboratory Analysis

The following laboratory tests were carried on select soil samples.

- 1) Atterberg Limit Test
- 2) Grain Size Analysis
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on figures and borehole logs included in the appendix.

SUBSURFACE CONDITIONS

General

The subsoil conditions consist of a non-cohesive heterogeneous mixture of silt, sand and gravel, trace clay which is underlain by a bouldery till (bedrock). The surficial layer is 4.8 m to 5.2 metres thick and approximately follows the slope of the ground surface. The bouldery till slopes down towards the east from an elevation of 106.2 m to 102.4 m. Bedrock (dolostone) was confirmed only in one borehole (west abutment location) at an elevation of 104.8 metres.

Patterns in the stratigraphy and a previous investigation in the area indicate that bedrock will slope down towards the east following the surficial slope.

It should be noted that in the vicinity of BH 8, east ramp the above material was mixed with slight traces of clayey silt.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 1288704-A in the attached Appendix. the results of all field and laboratory tests are plotted on the Record of Borehole sheets, also in the Appendix of this report. A brief description of the different soil strata is given below.

Heterogeneous Mixture of Silt, Sand, Gravel, trace Clay (Glacial Till)

Underlying the site and explored to depths ranging from the original ground surface to depths between 4.8 to 5.2 metres, is a non-cohesive deposit which is composed of a heterogeneous mixture of silt, sand and gravel, trace clay encountered at all boreholes.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 1 in the Appendix, in envelope form. It is evident that the layer contains a high percentage of silt and sand with some gravel and a trace of clay. The deposit comprised primarily of 18-63% gravel, 27-54% sand, 3-30% silt and 3-10% clay. A greater proportion of gravel was encountered near to the layer of bouldery till.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	2.5-11	9
Liquid Limit (w _L)	14-19	9
Plastic Limit (w _p)	12-14	9
Plasticity Index (I _p)	2-5	9

From the plasticity chart (Figure 2) the layer can be classified as being non-cohesive. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of 22.9 kg/m³ to 24.5 kg/m³.

In this stratum the Standard Penetration resistance, 'N' values ranged from 29 blows/0.3 m to >120 blows/0.28 m indicating that the state relative density ranged from compact to very dense.

Boulders

Underlying the heterogeneous mixture of silt, sand and gravel, trace of clay, boulders were encountered at depths ranging from 4.8 to 5.2 metres. The extent of this layer in one borehole (west abutment location) was found to be 1.1 metres, while at all other boreholes the layer extended down to their terminated depths. Rock coring techniques were required to penetrate boulders in this stratum.

Bedrock

Bedrock was only encountered at the west abutment location. The bedrock consists of a dolostone. Detailed descriptions of the rock are attached in the Appendix entitled "Rock Core Description".

Core recoveries and rock quality designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results the rock can be classified as medium strong and predominantly unweathered to slightly weathered.

Groundwater Conditions

Observations of the groundwater level was carried out measuring the water level in the open boreholes. The water level determined at the time of the investigation varied from 2 m to 3.5 m below natural ground surface staying at an elevation of 108-106.5 m, basically following parallel to the ground surface. Trapped drilling water may have a noticeable affect of water table heights. BH's 1 and 6 remained dry.

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

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structure and related approaches.

It is proposed to construct an overpass structure that will carry the realigned Fallowfield Road over the proposed Hwy. 416 east and west bound lanes. The proposed structure is a two span structure having an approximate length and width of 77 m and 23 metres respectively. The proposed profile grade of centreline Fallowfield Road is approximately at elevation 117 m which is equivalent to approach fill heights of 5-8 metres and a small 1.5 metre cut at the pier location.

A previous investigation for the original alignment was written in July 1989 recommending shallow spread footings.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the approach ramps, the following foundation and geotechnical recommendations are provided in the scope of this report.

- 1) Structure Foundation
- 2) Lateral Earth Pressure
- 3) Slope Stability
- 4) Construction Considerations

1) Structure Foundations

Abutment and Wingwalls

In consideration of the competent nature of the subsoils and the anticipated fill heights either a perched type abutment founded within the approach fills as high as possible or abutments placed on native soils can be considered. Perched abutments would be founded on a zone of well compacted Granular 'A' material.

For spread footings founded on a Granular 'A' core and constructed as per MTO Standards based on an assumed footing width of 3 m, the following design parameters are recommended:

Table 1 - Perched Spread Footings

	Factored Capacity at U.L.S. (kPa)	Allowable Capacity at S.L.S. Type II (kPa)
Spread Footings	900	350

For spread footings founded on competent native soil, based on an assumed footing width of 3 m. The following soil parameters are recommended:

Table 2 - Spread Footings on Native Soil

	Factored Capacity at U.L.S. (kPa)	Allowable Capacity at S.L.S. Type II	Elevation (m)	
			West Abut.	East Abut.
Spread Footings	900	350	±111	±109

All softened/loosened and/or organic material encountered at the founding elevation shall be removed and replaced with granular material such as MTO Granular 'A'.

Piers

Foundations for the centre pier can be supported on spread footings which would have to be placed below the natural ground level beneath a 1 m cut. Assuming 1.8 m of frost cover below the invert of the drainage ditch the founding elevation would be at an elevation of 107 metres. This thus places them below the water table elevation leading to the conclusion that the site should be drained by pumping from well points to prevent any decrease in soil capacity. At this elevation the following design values are recommended for purpose of the O.H.B.D.C.

Factored Bearing Capacity at U.L.S. 1000 kPa
Bearing Capacity at S.L.S. Type II 550 kPa

2) Lateral Earth Pressures on Structures

Free draining material such as Granular 'A' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up.

Design parameters of the soil are given below for purposes of the O.H.B.D.C.:

Table 3 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (θ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
*Coefficient of Active Earth Pressure (K _a)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (K _o)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

*Horizontal surface backfill only. Appropriate consideration must be given to sloping backfill.

The earth pressure coefficient at rest is to be used in design if the abutments are rigid and unyielding. The tabulated earth pressure coefficients are applicable to horizontal surfaces only. The valves must be modified to represent sloping surfaces. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill. The backfill should be constructed in 300 mm lifts on alternating sides of the rigid frame structure so that a maximum differential in backfill heights at no time exceeds 300 m. OPSD 803 series illustrates the applicable backfill standards and specifications.

The footings should be placed so as to have a minimum earth cover of 1.8 metres for frost protection.

3) Approach Embankments

The proposed finished grade is set at approximately 5-7 metres above the existing grade. No stability problems are anticipated for the approach embankment constructed with 2H:1V side slopes. The fill material should consist of well compacted acceptable material.

It is anticipated that approximately 50 mm of total settlement can be realized as a result of elastic settlements induced within the fill itself and the elastic recompression of the native subsoil. It is expected that the majority of these settlements will be realized during or immediately following construction.

4) Construction Considerations

Based on an evaluation of founding soils in this area, it is recommended that advanced dewatering should be provided for the construction of pier foundation, to lower the GWL to a minimum elevation of 105 m.

Excavation of the whole 1-3 m cut down to the centreline of the proposed Hwy. 416 could intersect the watertable. Some softening of the side slopes are to be expected, therefore ditches should be trimmed as soon as possible, a dewatering scheme may become necessary to implement throughout the cut. If surface water accumulates in excavations, it should be removed by means of a sump pump.

The footings should be placed so as to have a minimum earth cover of 1.8 metres for frost protection.

Within the limits of the approach fills, if soft soil is encountered, this should be excavated and replaced by compact granular fill. Excavations to about

1 m depth will be involved in the area of pier locations. Such excavations and any temporary excavation may be carried out at 1.5H:1V slopes.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. C. Kim, Foundation Engineer, Martin Michalek, Foundation Engineer Trainee, and John LeMessurier, Mike Iampietro, Student Engineers. The equipment was owned and operated by Marathon Drilling Co. Ltd., and F.E. Johnston Drilling Co. Ltd., Ottawa.

This report was written by Martin Michalek, Foundation Trainee Engineer, under the general supervision of Dr. B. Iyer and reviewed by Mr. M. Devata, Chief Foundation Engineer.



MARTIN MICHALEK

M. Michalek

Foundation Trainee Engineer

M. Devata

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63 kg, 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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

ROCK CORE DESCRIPTION

WP 128-87-04

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	7	5.03-6.10	32	32	5.03-6.10	OVERBURDEN (boulder till).
	8	6.10-7.64	100	80	6.10-7.64	DOLOSTONE (calcitic), greenish grey to medium dark grey; fine crystalline; medium strong; unweathered to slightly weathered; moderately close to very close spaced fractures (flat, planar to undulating, smooth to rough), laminated.
4	7	4.78-5.49	96	48	4.78-7.57	OVERBURDEN (boulder till).
	8	5.49-6.61	100	52		
	9	6.61-7.57	100	67		
6	6	5.23-5.69	100	53	5.23-6.76	OVERBURDEN (boulder till).
	7	5.69-6.15	53	0		
	8	6.15-6.76	31	0		

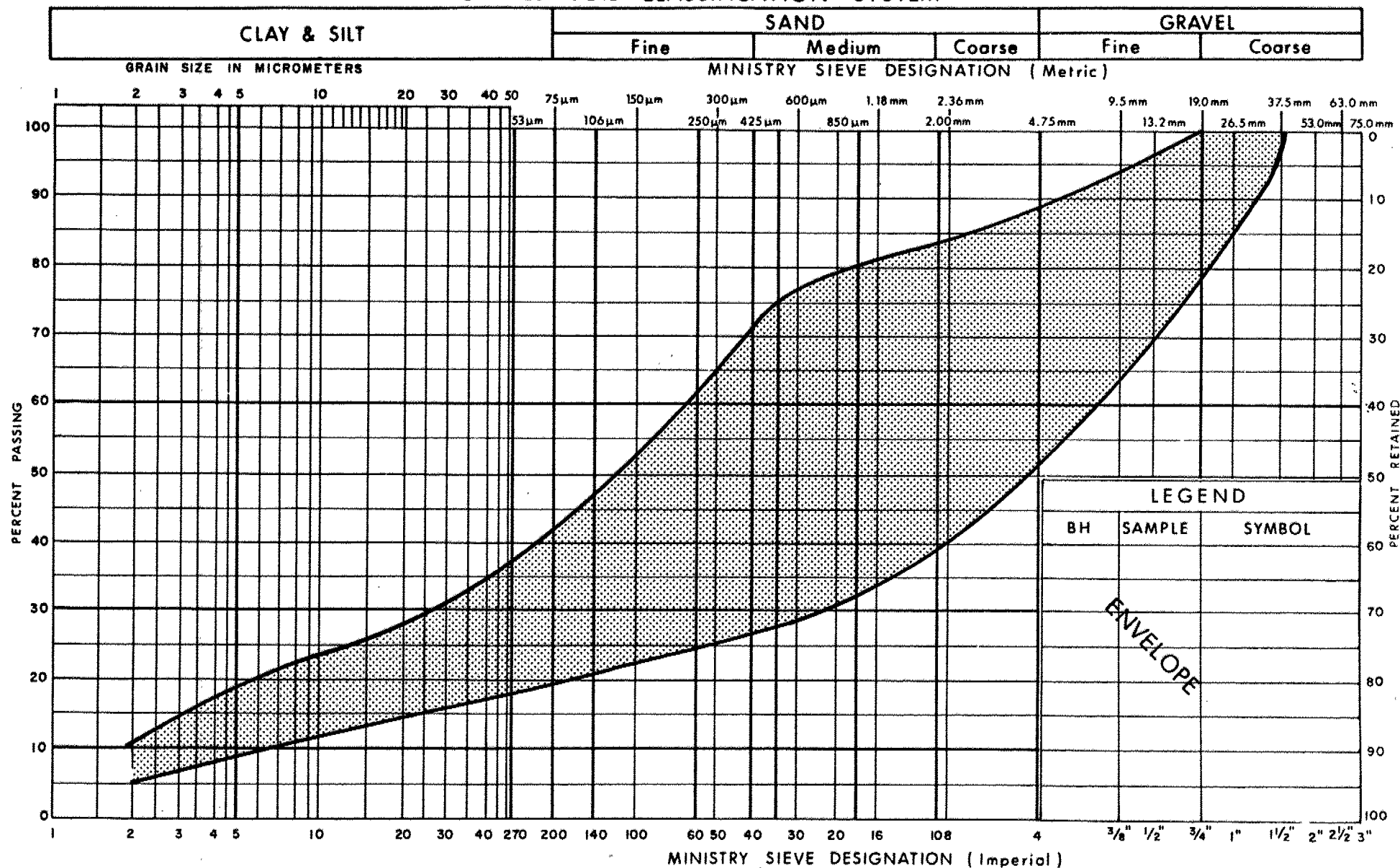
*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

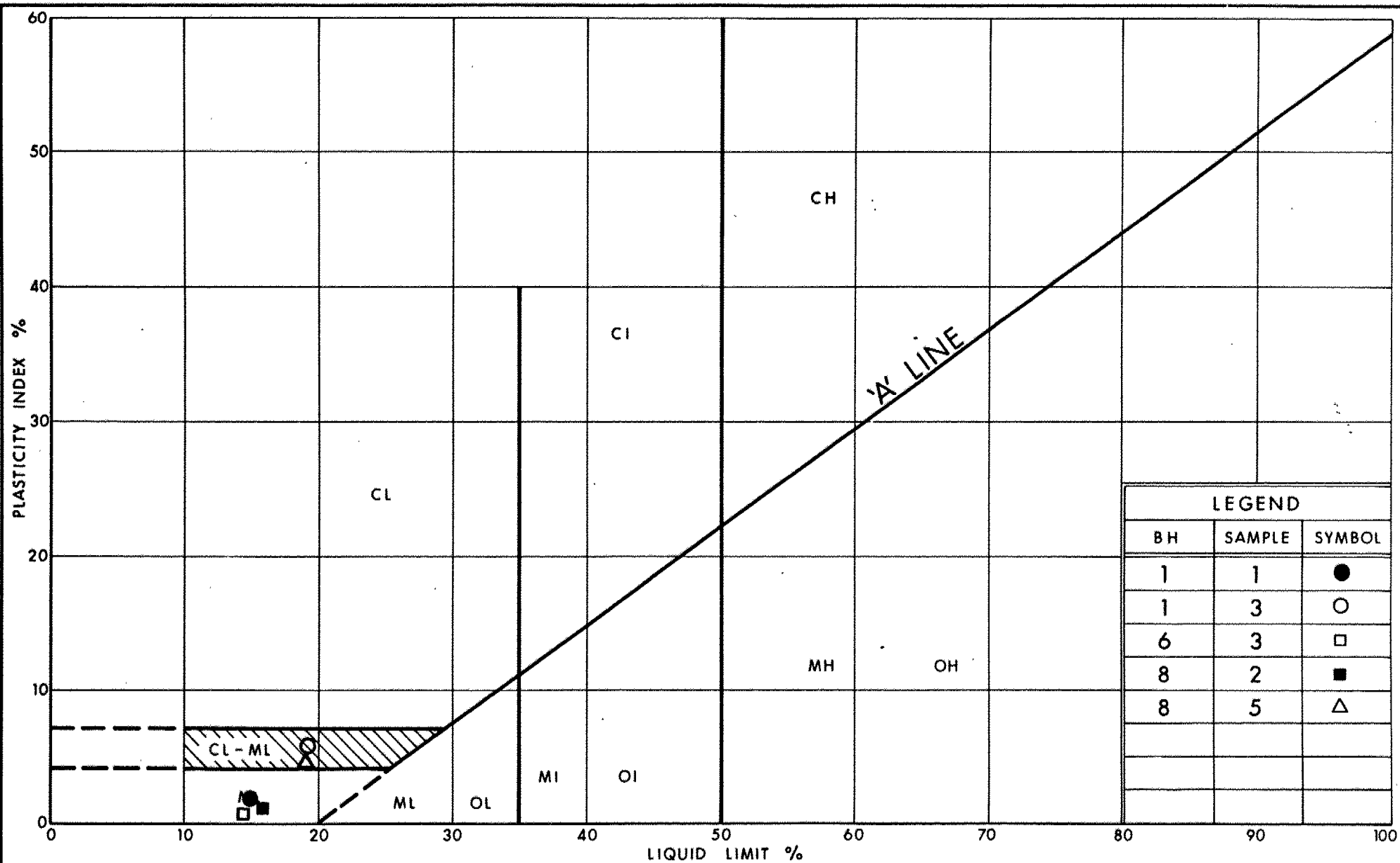
UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
TRACE CLAY, (GLACIAL TILL)

FIG No 1

W P 128-87-04



Ministry of
Transportation

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
 TRACE CLAY, (GLACIAL TILL)

FIG No 2

W P 128-87-04

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 567.4, E 359 984.0 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ 7 kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
110.8	Ground Surface															
0.0																
	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense		1	SS	*											17 48 27 8
			2	SS	*											
			3	SS	88											35 34 23 8
			4	SS	114											34 32 24 10
			5	SS	99											
	Gravel		6	SS	79											63 23 9 5
	Boulders		7	RC	REC 32%											RQD 32%
104.8																
6.0																
	Dolostone Bedrock Unweathered to Slightly Unweathered		8	RC	REC 100%											RQD 80.3%
103.2																
7.6	End of Borehole * Sampler bouncing, probable boulders															

RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 128-87-04 LOCATION Coords: N 5 014 556.4, E 360 031.7 ORIGINATED BY M.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
109.5	Ground Surface																
0.0	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense		1	SS	78	/28cm	109										
			2	SS	*		108										49 37 7 7
			3	SS	*		107										
	No Sample Retrieved		4	SS	*		106										
	Brown Grey/Brown		5	SS	*		105										
	Gravel		6	SS	80	/5cm	104										61 33 3 3
	Boulders		7	RC	REC	96%	103										RQD 48%
			8	RC	REC	100%	102										RQD 52%
			9	RC	REC	100%											RQD 67%
102.0	End of Borehole																
7.6	* Sampler bouncing, probable boulders																

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Coords: N 5 014.563.6, E 360 066.6 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
108.5	Ground Surface																
0.0	Heterogeneous mixture of Silt, Sand and Gravel trace Clay Brown Brown/Grey (Glacial Till) Very Dense		1	SS	75												
			2	SS	37												
			3	SS	*											9 54 30 7	
			4	SS	*												
			5	SS	*												
			6	SS	*												
			7	RC	REC 100%											RQD 53%	
			8	RC	REC 53%											RQD 0%	
			9	RC	REC 31%											RQD 0%	
101.7	End of Borehole																
6.8	* Sampler bouncing, probable boulders																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 583.2, E 360 088.1 ORIGINATED BY M.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
107.6	Ground Surface																
0.0																	
	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense	Dense V. Dense Boulders	7	SS	32		107									24.6	30 43 21 6
			2	SS	24		106										
			3	SS	*		105										
			4	SS	50	/15cm	104										
							103										
102.4																	
8.2	End of Borehole																
	* Sampler bouncing, probable boulders																

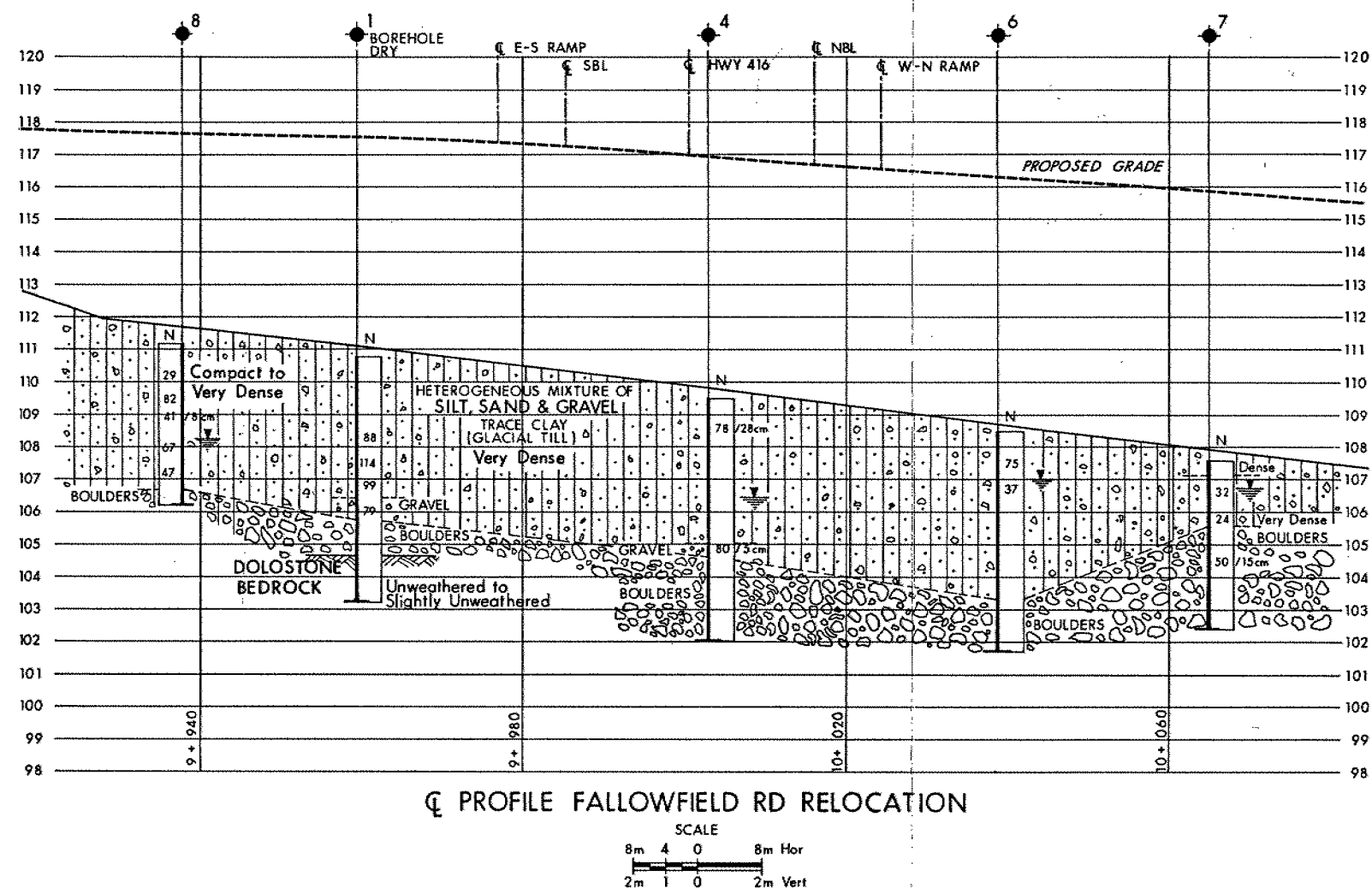
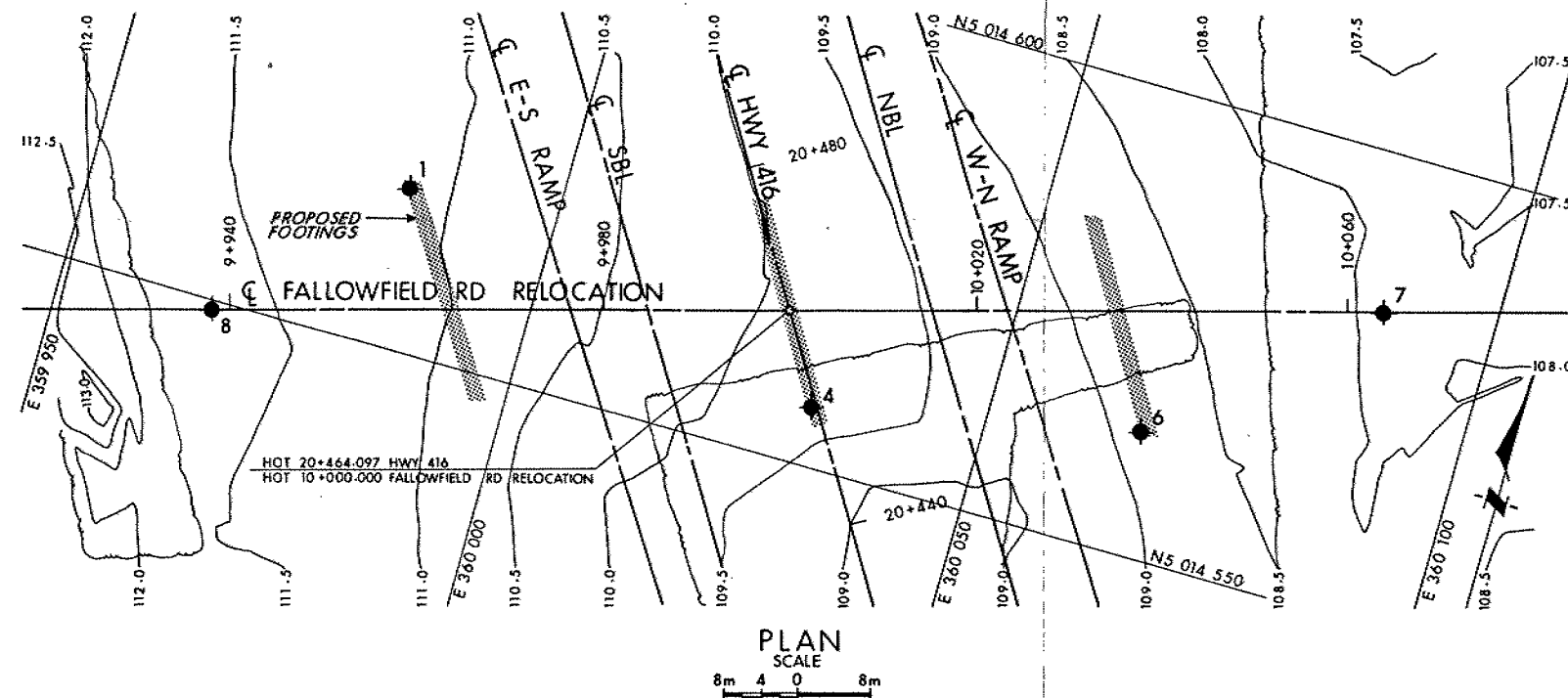
RECORD OF BOREHOLE No 8

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 548.0, E 359 966.8 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY D.T.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
111.2	Ground Surface															
0.0	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Compact to Very Dense		1	SS	29											
			2	SS	82											
			3	SS	41	/8cm										
			4	SS	67											
			5	SS	47											
106.2	Boulders															
5.0	End of Borehole															



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

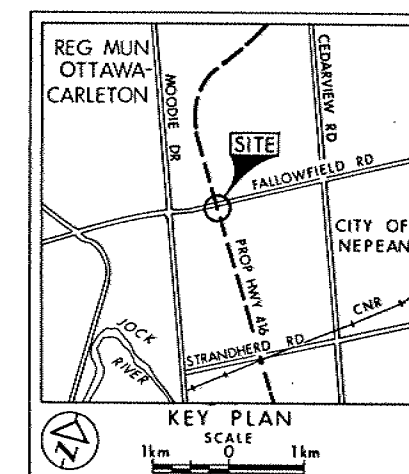
CONT No
WP No 128-87-04

FALLOWFIELD RD RELOCATION





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} |
|  | WL at time of investigation 90 08 |

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	110.8	5 014 567.4	359 984.0
4	109.5	5 014 556.4	360 031.7
6	108.5	5 014 563.6	360 066.6
7	107.6	5 014 583.2	360 088.1
8	111.2	5 014 549.0	359 966.8

==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			

Geacres No 31G5-160

HWY No 416		DIST 9	
SUBA'D MM	CHECKED	DATE 91 04 09	SITE 3-548
DRAWN DT	CHECKED //	APPROVED	DWG 12BA70A-A

REF No E-52-416-12.90 05

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 3165-160

DIST. 9 REGION

W.P. No. 128-87-04

CONT. No.

W. O. No.

STR. SITE No. 3-548

HWY. No. 416

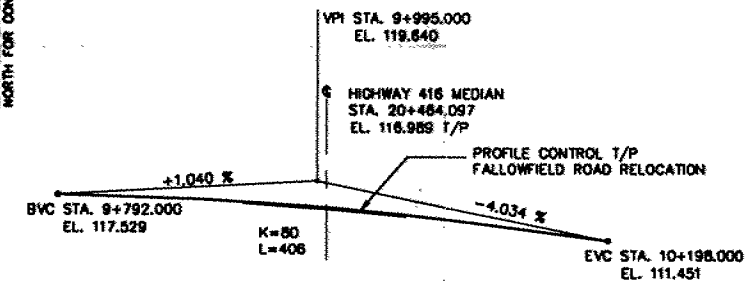
LOCATION HWY 416 & FALLOWFIELD RD.

No. of PAGES -

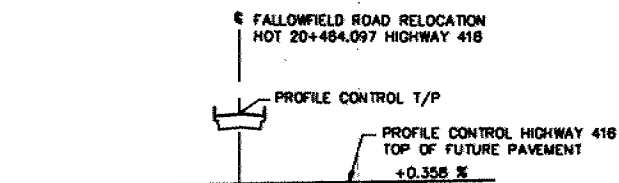
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

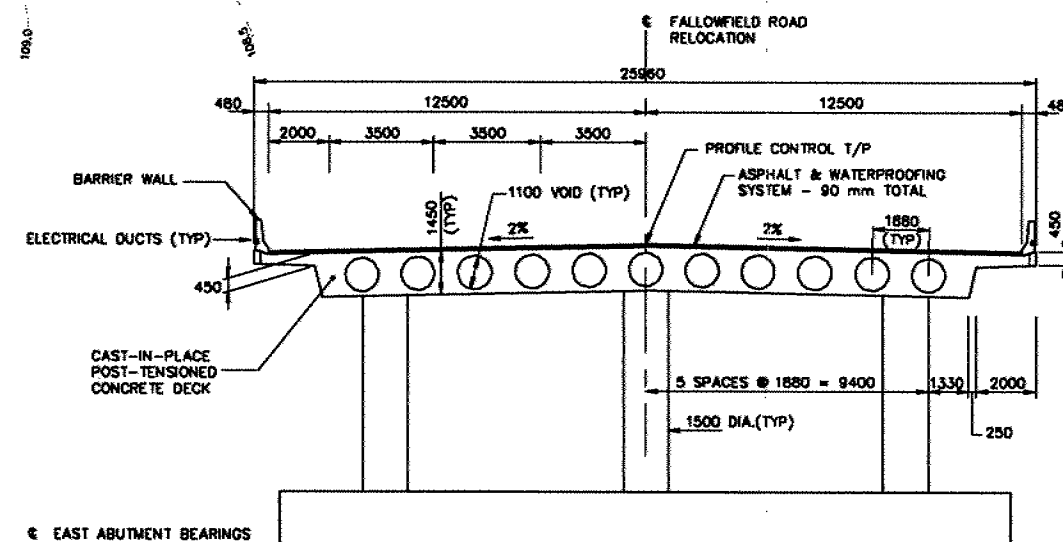
REMARKS:



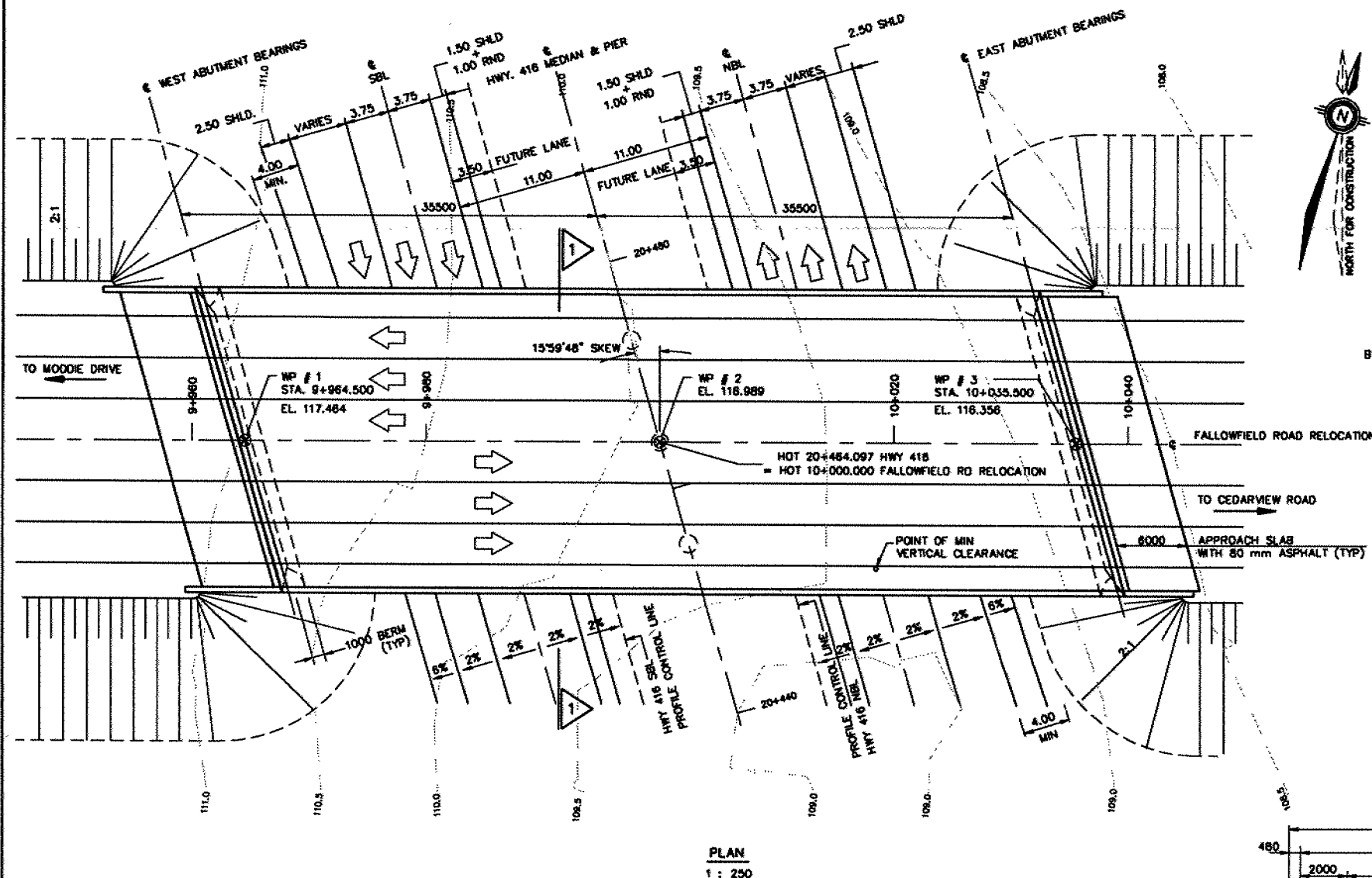
FALLOWFIELD ROAD RELOCATION PROFILE
N.T.S.



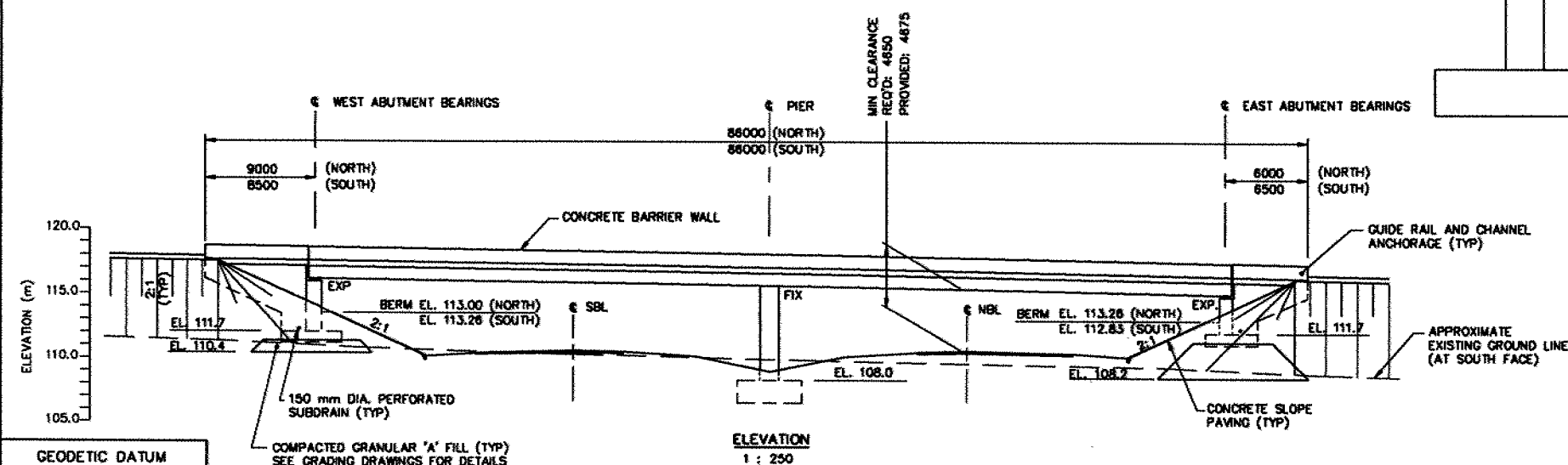
HIGHWAY 416 PROFILE
N.T.S



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



PLAN
1 : 250



ELEVATION
1 : 250

GEODETIC DATUM
BM ELEV. 112.443
NHW IN ROOT OF Q.3 MAPLE
97.18 LT 20+366.5

GENERAL NOTES

CLASS OF CONCRETE

DECK	35 MPa
REMAINDER	30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS	_____	100 ± 25
ABUTMENTS AND	_____	
FRONT FACE	_____	80 ± 20
BACK FACE	_____	70 ± 20
PIERS	_____	80 ± 20
DECK	_____	
TOP	_____	70 ± 20
BOTTOM	_____	50 ± 10
WEBS	_____	50 ± 10

REMAINDER _____ 70 ± 20
UNLESS NOTED OTHERWISE

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS NOTED OTHERWISE. BAR MARKS WITH SUFFIX "C" DENOTE COATED BARS.

CONSTRUCTION NOTES:

IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BENCHMARK LOCATIONS & SOIL STRATA
3. FOOTING LAYOUT & REINFORCING
4. WEST ABUTMENT
5. WEST ABUTMENT REINFORCING
6. EAST ABUTMENT
7. EAST ABUTMENT REINFORCING
8. PIER DETAILS
9. DECK DETAILS & SCREED ELEVATIONS
10. LONGITUDINAL TENDONS
11. TRANSVERSE TENDONS
12. DECK REINFORCING I
13. DECK REINFORCING II
14. BARRIER WALLS
15. 8000 mm APPROACH SLABS
16. DETAILS OF CONCRETE SLOPE PAVING
17. JOINT ANCHORAGE & ARMOURING
18. AS CONSTRUCTED ELEV. & DIM
19. ELECTRICAL EMBEDDED WORK
20. STANDARD DETAILS
21. QUANTITIES – STRUCTURE



STANDARD DRAWINGS

DO-3503 MIN GRANULAR BACKFILL REQUIREMENTS

REVISION							
	DATE	BY	DESCRIPTION				
DESIGN	G.A.M.	CWK	M.L.T.	LOADING	OHBOC-B3 CLASS A		DATE FEB. 1981
DRAWN	G.V.	CWK	G.A.M.	SITE No	03-648		DWC 1



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FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 128-87-04

DIST 9

HWY 416

STR SITE 3-548

Hwy. 416 and Fallowfield Road Relocation

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FOUNDATION INVESTIGATION REPORT
For
Hwy. 416 and Fallowfield Road Relocation
W.P. 128-87-04
Hwy. 416, District 9, Ottawa, Nepean

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. A two span structure has been proposed to carry the re-aligned Fallowfield Road over Hwy. 416. The subsurface conditions encountered at the site and recommendations pertaining to structure foundations and related earthworks are included in the scope of this report.

SITE DESCRIPTION

The site is located south of the existing Fallowfield Road between Moodie Drive and Cedarview Road in the City of Nepean, Regional Municipality of Ottawa - Carleton.

The topography of the area is generally flat to gently undulating with the land in the immediate vicinity being used for agricultural and dairy farming. An abandoned quarry is located further north of the site. Residential development exists north east of the site. The natural ground level sloped downwards from the west approach to the east approach with elevations of 111.3 m to 101.6 m respectively. The area is generally bouldery with randomly placed boulders outcropping from the surface. The relocation of Fallowfield Road places it south within a farmers field.

Physiographically the site lies in the area known as the Ottawa valley clay plains founded in the lowlands of the St. Lawrence, which are characterized by clay plains interrupted by ridges of rock or sand and gravel. The bedrock in the area is of the Gull River Formation of the middle ordovician period. It consists of limestone with interbedded shale layers. The overburden is relatively thin and was deposited during and immediately following the wisconsinan glaciation at which time the area was depressed from the effect of the glaciation. Following the retreat of the glacier, the brackish waters of the champlain sea flooded the area and then gradually receded as the land rebounded with the deposition of sediments to its present level.

INVESTIGATION PROCEDURES

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

FIELD INVESTIGATION

The fieldwork for this investigation was carried out between 90 08 08 to 90 08 09 and consisted of a total of five sampled boreholes. Two holes at the east/west approach ramps, one east abutment, one centreline pier and one west abutment borehole. The surficial deposit was relatively shallow with a boulder till (bedrock) lying 4.8 to 5 metres below ground surface. The boreholes were advanced using a trackmounted CME55 drill rig employing hollow stem augering techniques.

In general, subsoil samples were retrieved at 0.7 m intervals, with two 1.5 m rock core samples retrieved at structural foundation locations. Core sampling was performed for the abutment and pier holes down to 3.5 m into bedrock, while the approach ramp borehole locations were terminated upon auger refusal. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). All subsoil samples were identified in the field and returned to the laboratory for further examination and applicable testing.

Water levels were monitored throughout the duration of the investigation in open boreholes. All boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by MTO Surveys and Plans, Eastern Region.

Laboratory Analysis

The following laboratory tests were carried on select soil samples.

- 1) Atterberg Limit Test
- 2) Grain Size Analysis
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory test results are given in the following section of this report and are illustrated on figures and borehole logs included in the appendix.

SUBSURFACE CONDITIONS

General

The subsoil conditions consist of a non-cohesive heterogeneous mixture of silt, sand and gravel, trace clay which is underlain by a bouldery till (bedrock). The surficial layer is 4.8 m to 5.2 metres thick and approximately follows the slope of the ground surface. The bouldery till slopes down towards the east from an elevation of 106.2 m to 102.4 m. Bedrock (dolostone) was confirmed only in one borehole (west abutment location) at an elevation of 104.8 metres.

Patterns in the stratigraphy and a previous investigation in the area indicate that bedrock will slope down towards the east following the surficial slope.

It should be noted that in the vicinity of BH 8, east ramp the above material was mixed with slight traces of clayey silt.

The plan and location of borings and the stratigraphical profile are shown on Drawing No. 1288704-A in the attached Appendix. the results of all field and laboratory tests are plotted on the Record of Borehole sheets, also in the Appendix of this report. A brief description of the different soil strata is given below.

Heterogeneous Mixture of Silt, Sand, Gravel, trace Clay (Glacial Till)

Underlying the site and explored to depths ranging from the original ground surface to depths between 4.8 to 5.2 metres, is a non-cohesive deposit which is composed of a heterogeneous mixture of silt, sand and gravel, trace clay encountered at all boreholes.

Results of Grain Size Distribution Tests carried out on select samples are shown on Figure 1 in the Appendix, in envelope form. It is evident that the layer contains a high percentage of silt and sand with some gravel and a trace of clay. The deposit comprised primarily of 18-63% gravel, 27-54% sand, 3-30% silt and 3-10% clay. A greater proportion of gravel was encountered near to the layer of bouldery till.

The results from the Atterberg Limit Tests performed on the fine fraction of this report is summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	2.5-11	9
Liquid Limit (w _L)	14-19	9
Plastic Limit (w _p)	12-14	9
Plasticity Index (I _p)	2-5	9

From the plasticity chart (Figure 2) the layer can be classified as being non-cohesive. Unit weight measurements carried out on samples from this stratum yielded dry unit weights of 22.9 kg/m³ to 24.5 kg/m³.

In this stratum the Standard Penetration resistance, 'N' values ranged from 29 blows/0.3 m to >120 blows/0.28 m indicating that the state relative density ranged from compact to very dense.

Boulders

Underlying the heterogeneous mixture of silt, sand and gravel, trace of clay, boulders were encountered at depths ranging from 4.8 to 5.2 metres. The extent of this layer in one borehole (west abutment location) was found to be 1.1 metres, while at all other boreholes the layer extended down to their terminated depths. Rock coring techniques were required to penetrate boulders in this stratum.

Bedrock

Bedrock was only encountered at the west abutment location. The bedrock consists of a dolostone. Detailed descriptions of the rock are attached in the Appendix entitled "Rock Core Description".

Core recoveries and rock quality designation (RQD) were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Based on these results the rock can be classified as medium strong and predominantly unweathered to slightly weathered.

Groundwater Conditions

Observations of the groundwater level was carried out measuring the water level in the open boreholes. The water level determined at the time of the investigation varied from 2 m to 3.5 m below natural ground surface staying at an elevation of 108-106.5 m, basically following parallel to the ground surface. Trapped drilling water may have a noticeable affect of water table heights. BH's 1 and 6 remained dry.

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

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structure and related approaches.

It is proposed to construct an overpass structure that will carry the realigned Fallowfield Road over the proposed Hwy. 416 east and west bound lanes. The proposed structure is a two span structure having an approximate length and width of 77 m and 23 metres respectively. The proposed profile grade of centreline Fallowfield Road is approximately at elevation 117 m which is equivalent to approach fill heights of 5-8 metres and a small 1.5 metre cut at the pier location.

A previous investigation for the original alignment was written in July 1989 recommending shallow spread footings.

To facilitate the design and construction of the proposed structure foundations and related earthworks for the approach ramps, the following foundation and geotechnical recommendations are provided in the scope of this report.

- 1) Structure Foundation
- 2) Lateral Earth Pressure
- 3) Slope Stability
- 4) Construction Considerations

- 1) Structure Foundations

Abutment and Wingwalls

In consideration of the competent nature of the subsoils and the anticipated fill heights either a perched type abutment founded within the approach fills as high as possible or abutments placed on native soils can be considered. Perched abutments would be founded on a zone of well compacted Granular 'A' material.

For spread footings founded on a Granular 'A' core and constructed as per MTO Standards based on an assumed footing width of 3 m, the following design parameters are recommended:

Table 1 - Perched Spread Footings

	Factored Capacity at U.L.S. (kPa)	Allowable Capacity at S.L.S. Type II (kPa)
Spread Footings	900	350

For spread footings founded on competent native soil, based on an assumed footing width of 3 m. The following soil parameters are recommended:

Table 2 - Spread Footings on Native Soil

	Factored Capacity at U.L.S. (kPa)	Allowable Capacity at S.L.S. Type II	Elevation (m)	
			West Abut.	East Abut.
Spread Footings	900	350	±111	±109

All softened/loosened and/or organic material encountered at the founding elevation shall be removed and replaced with granular material such as MTO Granular 'A'.

Piers

Foundations for the centre pier can be supported on spread footings which would have to be placed below the natural ground level beneath a 1 m cut. Assuming 1.8 m of frost cover below the invert of the drainage ditch the founding elevation would be at an elevation of 107 metres. This thus places them below the water table elevation leading to the conclusion that the site should be drained by pumping from well points to prevent any decrease in soil capacity. At this elevation the following design values are recommended for purpose of the O.H.B.D.C.

Factored Bearing Capacity at U.L.S. 1000 kPa
Bearing Capacity at S.L.S. Type II 550 kPa

2) Lateral Earth Pressures on Structures

Free draining material such as Granular 'A' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up.

Design parameters of the soil are given below for purposes of the O.H.B.D.C.:

Table 3 - Backfill Properties

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction (θ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2
*Coefficient of Active Earth Pressure (Ka)		
- S.L.S.	0.27	0.33
- U.L.S.	0.33	0.4
*Coefficient of Earth Pressure at Rest (Ko)		
- S.L.S.	0.43	0.5
- U.L.S.	0.5	0.58

*Horizontal surface backfill only. Appropriate consideration must be given to sloping backfill.

The earth pressure coefficient at rest is to be used in design if the abutments are rigid and unyielding. The tabulated earth pressure coefficients are applicable to horizontal surfaces only. The valves must be modified to represent sloping surfaces. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill. The backfill should be constructed in 300 mm lifts on alternating sides of the rigid frame structure so that a maximum differential in backfill heights at no time exceeds 300 m. OPSD 803 series illustrates the applicable backfill standards and specifications.

The footings should be placed so as to have a minimum earth cover of 1.8 metres for frost protection.

3) Approach Embankments

The proposed finished grade is set at approximately 5-7 metres above the existing grade. No stability problems are anticipated for the approach embankment constructed with 2H:1V side slopes. The fill material should consist of well compacted acceptable material.

It is anticipated that approximately 50 mm of total settlement can be realized as a result of elastic settlements induced within the fill itself and the elastic recompression of the native subsoil. It is expected that the majority of these settlements will be realized during or immediately following construction.

4) Construction Considerations

Based on an evaluation of founding soils in this area, it is recommended that advanced dewatering should be provided for the construction of pier foundation, to lower the GWL to a minimum elevation of 105 m.

Excavation of the whole 1-3 m cut down to the centreline of the proposed Hwy. 416 could intersect the watertable. Some softening of the side slopes are to be expected, therefore ditches should be trimmed as soon as possible, a dewatering scheme may become necessary to implement throughout the cut. If surface water accumulates in excavations, it should be removed by means of a sump pump.

The footings should be placed so as to have a minimum earth cover of 1.8 metres for frost protection.

Within the limits of the approach fills, if soft soil is encountered, this should be excavated and replaced by compact granular fill. Excavations to about

1 m depth will be involved in the area of pier locations. Such excavations and any temporary excavation may be carried out at 1.5H:1V slopes.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. C. Kim, Foundation Engineer, Martin Michalek, Foundation Engineer Trainee, and John LeMessurier, Mike Iampietro, Student Engineers. The equipment was owned and operated by Marathon Drilling Co. Ltd., and F.E. Johnston Drilling Co. Ltd., Ottawa.

This report was written by Martin Michalek, Foundation Trainee Engineer, under the general supervision of Dr. B. Iyer and reviewed by Mr. M. Devata, Chief Foundation Engineer.



MARTIN MICHALEK

M. Michalek

Foundation Trainee Engineer

M. Devata

M. Devata, P.Eng.

Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT, CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

ROCK CORE DESCRIPTION

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Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	7	5.03-6.10	32	32	5.03-6.10	OVERBURDEN (boulder till).
	8	6.10-7.64	100	80	6.10-7.64	DOLOSTONE (calcitic), greenish grey to medium dark grey; fine crystalline; medium strong; unweathered to slightly weathered; moderately close to very close spaced fractures (flat, planar to undulating, smooth to rough), laminated.
4	7	4.78-5.49	98	48	4.78-7.57	OVERBURDEN (boulder till).
	8	5.49-6.61	100	52		
	9	6.61-7.57	100	67		
6	6	5.23-5.69	100	53	5.23-6.76	OVERBURDEN (boulder till).
	7	5.69-6.15	53	0		
	8	6.15-6.76	31	0		

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

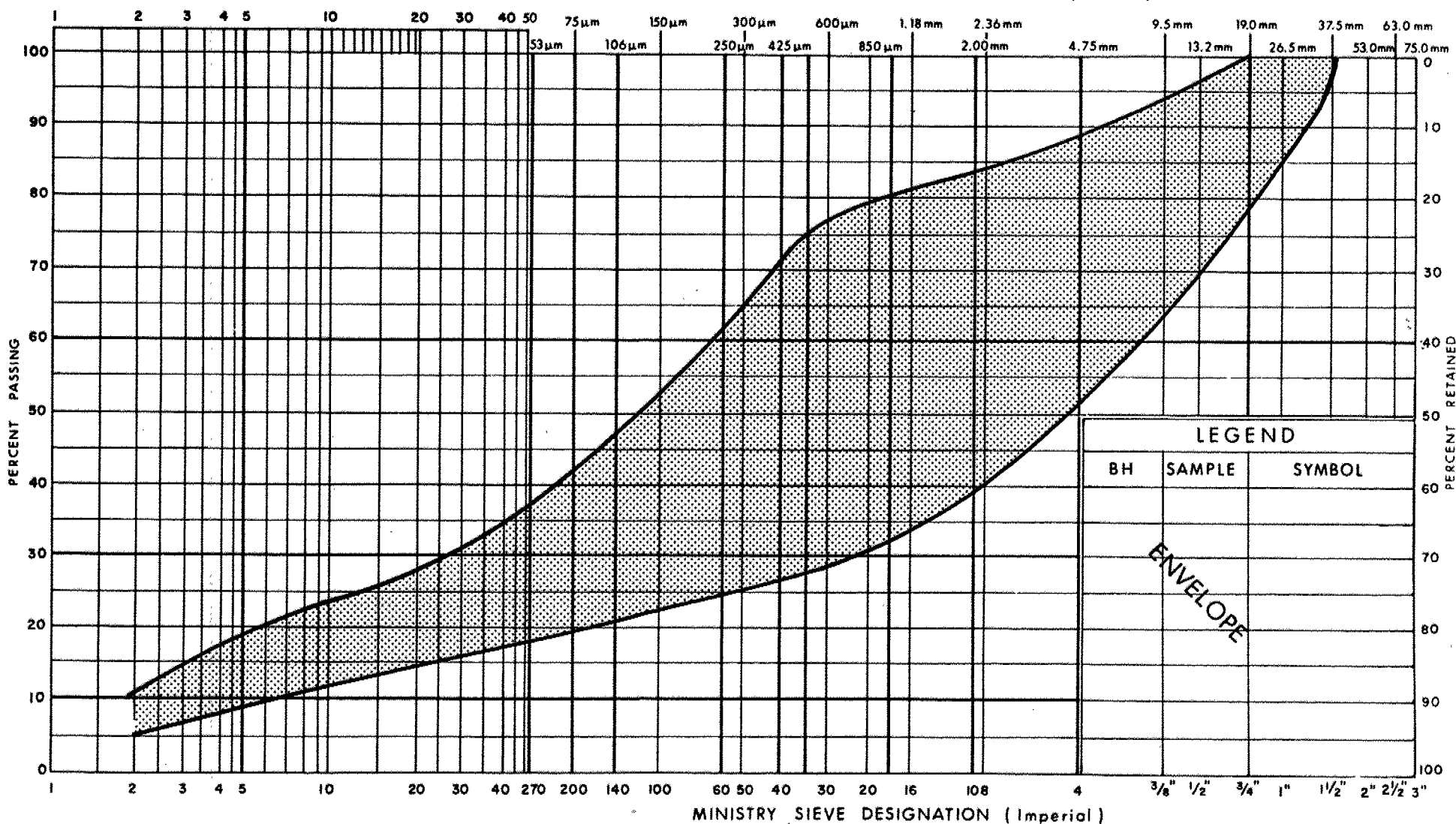
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

BH SAMPLE SYMBOL

ENVELOPE

PERCENT RETAINED

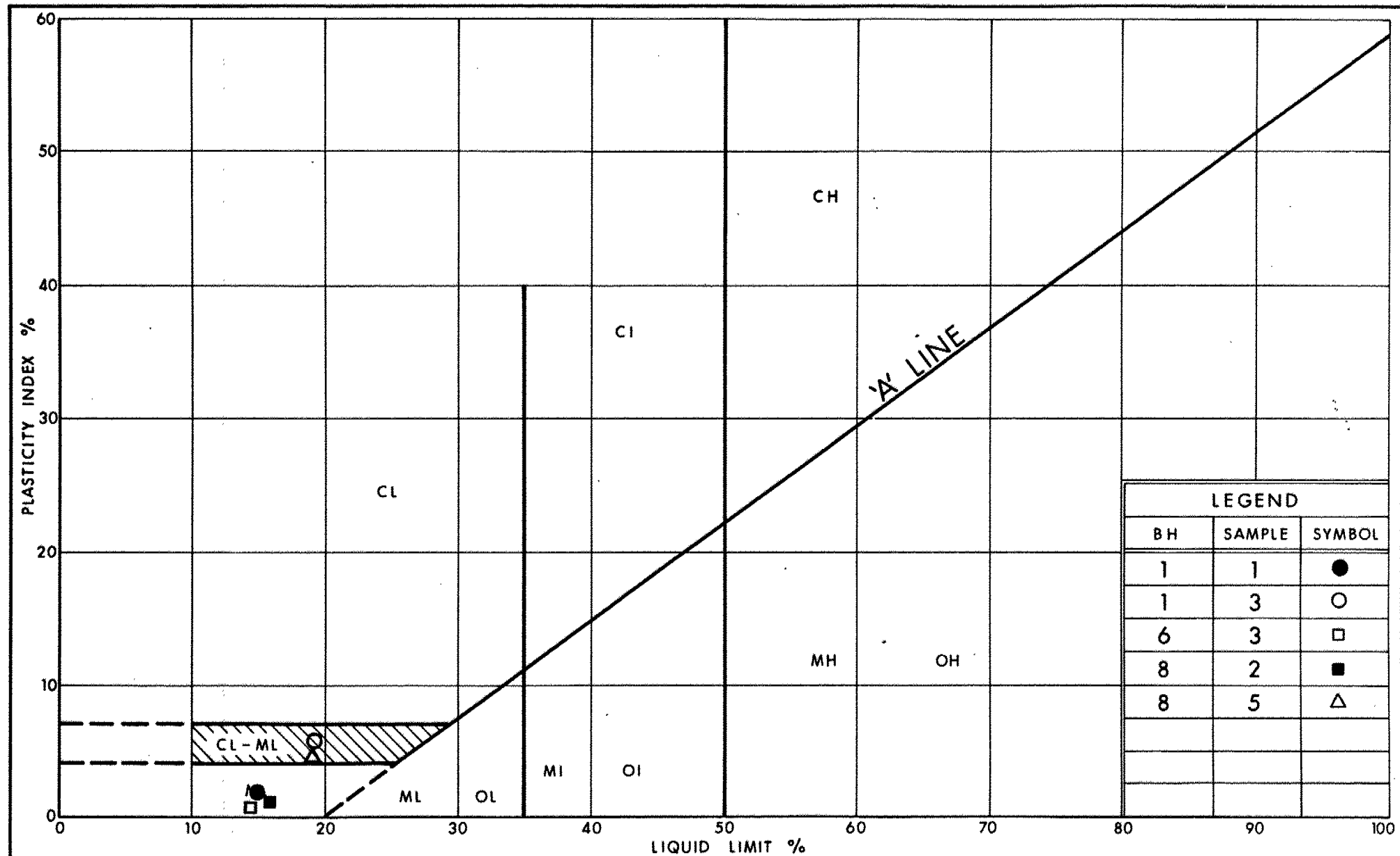
MINISTRY SIEVE DESIGNATION (Imperial)

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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
TRACE CLAY, (GLACIAL TILL)

FIG No 1

W P 128-87-04



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PLASTICITY CHART
HETEROGENEOUS MIXTURE OF SILT, SAND & GRAVEL
TRACE CLAY, (GLACIAL TILL)

FIG No 2

W P 128-87-04

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 567.4, E 359 984.0 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
110.8	Ground Surface																
0.0	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense		1	SS	*	DRY	110						0H				17 48 27 8
			2	SS	*		109										
			3	SS	88		108						0H				35 34 23 8
			4	SS	114		107										34 32 24 10
			5	SS	99		106										
	Gravel		6	SS	79		105										63 23 9 5
	Boulders		7	RC	REC 32%		104										RQD 32%
104.8																	
6.0	Dolostone Bedrock Unweathered to Slightly Unweathered		8	RC	REC 100%												RQD 80.3%
103.2																	
7.6	End of Borehole * Sampler bouncing, probable boulders																

RECORD OF BOREHOLE No 4

1 OF 1 METRIC

W.P. 128-87-04 LOCATION Coords: N 5 014 556.4, E 360 031.7 ORIGINATED BY M.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 90/08/30 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
109.5	Ground Surface													
0.0	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense		1	SS	78	/28cm	109							
			2	SS	*		108							49 37 7 7
			3	SS	*		107							
	No Sample Retrieved		4	SS	*		106							
	Brown		5	SS	*		105							61 33 3 3
	Grey/Brown		6	SS	80	/5cm	104							RQD 48%
	Gravel		7	RC	REC	96%	103							RQD 52%
	Boulders		8	RC	REC	100%	102							RQD 67%
102.0			9	RC	REC	100%								
7.6	End of Borehole • Sampler bouncing, probable boulders													

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Coords: N 5 014 563.6, E 360 066.6 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
108.5	Ground Surface													
0.0	Heterogeneous mixture of Silt, Sand and Gravel trace Clay Brown Brown/Grey (Glacial Till) Very Dense		1	SS	75		108							
			2	SS	37		107							
			3	SS	*		106							9 54 30 7
			4	SS	*		105							
			5	SS	*		104							
			6	SS	*		103							
			7	RC	REC 100%		102							RQD 53%
			8	RC	REC 53%									RQD 0%
			9	RC	REC 31%									RQD 0%
101.7														
6.8	End of Borehole * Sampler bouncing, probable boulders													

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 583.2, E 360 088.1 ORIGINATED BY M.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 90/08/30 CHECKED BY B.I.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
107.6	Ground Surface															
0.0																
	Heterogeneous mixture of Silt, Sand and Gravel trace Clay (Glacial Till) Very Dense		7	SS	32										24.6	30 43 21 6
			2	SS	24											
			3	SS	.											
			4	SS	50	/15cm										23 48 15 14
102.4																
5.2	End of Borehole															
	* Sampler bouncing, probable boulders															

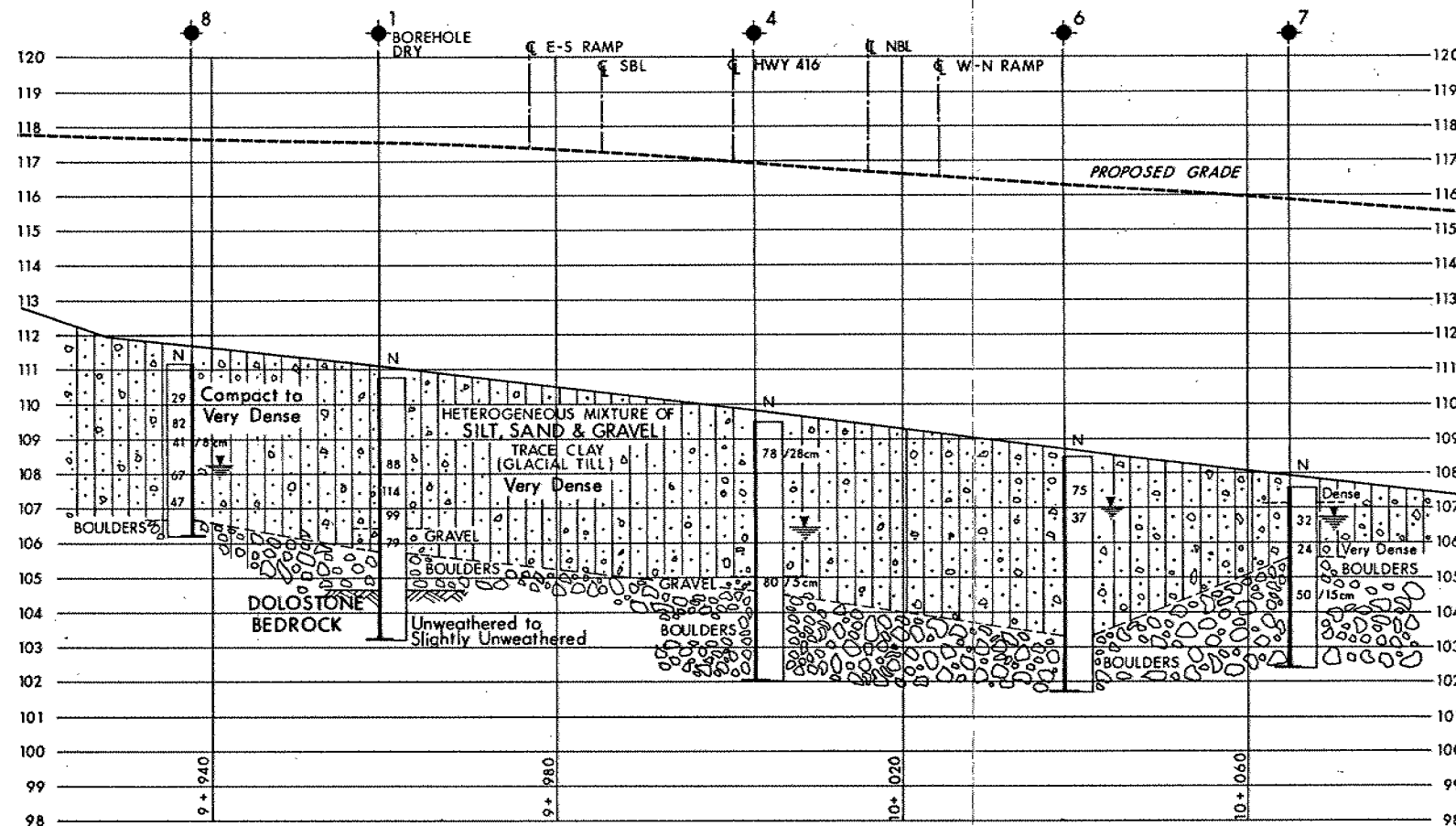
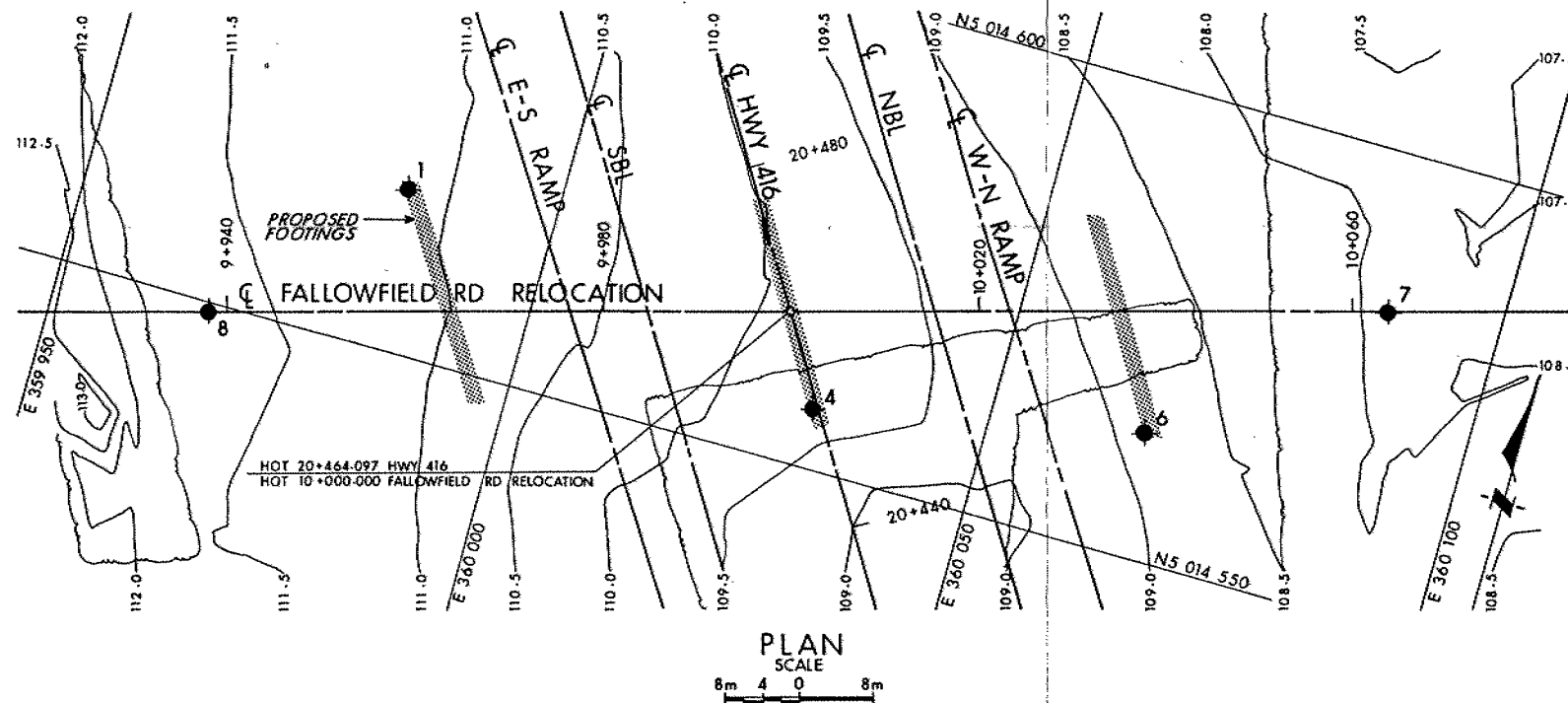
RECORD OF BOREHOLE No 8

1 OF 1

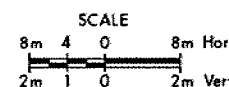
METRIC

W.P. 128-87-04 LOCATION Co-ords: N 5 014 549.0, E 359 966.8 ORIGINATED BY M.M.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
DATUM Geodetic DATE 90/08/30 CHECKED BY D.T.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
111.2	Ground Surface																
0.0	Heterogeneous mixture of Silt, Sand and Gravel (Glacial Till) Compact to Very Dense		1	SS	29	/8cm 	110									23.0	25 41 27 7
			2	SS	82		109										
			3	SS	41		108										
			4	SS	67		107										
			5	SS	47												
106.2	Boulders																
5.0	End of Borehole																



Q PROFILE FALLOWFIELD RD RELOCATION



METRIC

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

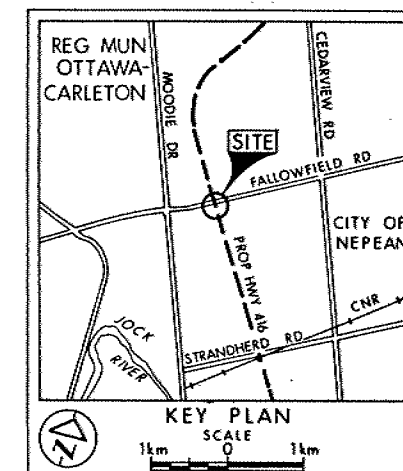
CONT No
WP No 128-87-04

FALLOWFIELD RD RELOCATION

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 90 08

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	110.8	5 014 567.4	359 984.0
4	109.5	5 014 556.4	360 031.7
6	108.5	5 014 563.6	360 066.6
7	107.6	5 014 583.2	360 088.1
8	111.2	5 014 549.0	359 966.8

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
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Geocres No 31G5-160

HWY No 416	DIST 9
SUBWD MM CHECKED	DATE 91 04 09
DRAWN DT CHECKED	APPROVED
	SITE 3-548
	DWG 1288704-A

