

GIFFELS ASSOCIATES LIMITED

FOUNDATION INVESTIGATION
HIGHWAY 416 UNDERPASS
AT VENTNOR ROAD

W.P. 369-89-00, SITE 16-312
HWY. 416, DISTRICT 9, EASTERN
GEOCRES # 31B-69

JANUARY 25, 1991

PROJECT NO. 10187

JACQUES, WHITFORD LIMITED

2285 ST. LAURENT BLVD.
BUILDING C, UNIT 20
OTTAWA, ONTARIO K1G 4Z6

DRAFT

PHONE: (613) 738-0708 FAX: (613) 738-0721



Report

to

Giffels Associates Limited

on

Foundation Investigation

Highway 416 Underpass
at Ventnor Road

W.P. 369-89-00
Site 16-312

Hwy. 416
District 9
Eastern

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Jacques, Whitford Limited

January 25, 1991

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FOUNDATION INVESTIGATION REPORT

for

Highway 416 Underpass at Ventnor Road
(Structures 5A and 5B)

WP 369-89-00 Site #16-312
DISTRICT 9, EASTERN REGION

1.0 INTRODUCTION

This report presents the results of a foundation investigation carried out at the above noted site in the Township of Edwardsburgh, Ontario. The investigation was carried out in accordance with our proposals dated August 1 and October 15, 1990. Authorization to carry out the work was provided by Mr. R.W. Bratty, P.Eng. of Giffels Associates Limited on November 1, 1990.

This report contains factual information together with discussion and recommendations pertaining to the subsurface conditions, structure foundations, approach fills and related earthworks.

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2.0 SITE DESCRIPTION AND GEOLOGY

The site is located along existing Highway 16 some 2.5 kilometres north of Spencerville, Ontario. The topography of the site is generally flat. The existing Ventnor Road is a two-lane paved road with gravel shoulders. Ventnor Road at the site slopes gently downward from west to east, and is in general about 1 m above the surrounding ground. Outside of the right-of-ways of existing Highway 16 and Ventnor Road, the site is in general treed.

Drainage of the site is provided by culverts that are connected to highway ditches.

The existing geotechnical/geological information suggests that the proposed site is within a glacial till plain. Bedrock underlying the overburden consists of Ordovician limestone bedrock of the Oxford Formation. Overburden thickness is in the order of 8 m to 10 m.

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3.0 PROCEDURE

3.1 Field Investigation

Prior to the onset of the drilling investigation, the necessary utility check clearances were obtained by our site personnel.

The field work for this investigation was carried out between November 8 and 14, 1990. A total of eight (8) boreholes, (numbered 90-1 to 90-8) were put down at the site. Boreholes 90-1, 90-2, 90-7 and 90-8 were put down at the approach fill locations. Boreholes 90-3 to 90-6 inclusive were put down at the abutment locations. The test locations and the proposed structures are indicated on Drawing No. 3698900-A provided in Appendix 2.

All boreholes were put down using a track-mounted power auger drill suitably equipped for soil and bedrock sampling. Due to the high cobble and boulder content of the overburden, hollow stem augers, solid stem augers, B-sized casings and rock coring techniques were employed during the course of the investigation to advance the boreholes.

The boreholes were put down to depths ranging from 3.8 m to 14.8 m. Boreholes 90-3, 90-4 and 90-6 were terminated after coring in BQ-size 1.6 m to 4.1 m into bedrock. Boreholes 90-1 and 90-2 were terminated at depths of 4.4 m and 3.8 m respectively, upon hollow stem auger refusal. Boreholes 90-5, 90-7 and 90-8 were terminated at depths ranging from 7.6 m to 9.9 m upon solid stem auger refusal.

The overburden soils encountered were sampled by means of a split tube sampler during the performance of Standard Penetration Tests (SPT) (ASTM D1586). Sampling was intended to be conducted on a near continuous basis (intervals of 0.76 m). Due to the high cobble and boulder content in the overburden below a depth of about 1.5 m, the SPT conducted yielded limited penetration of typically less than 50 mm. Sampling location below a depth of 1.5 m was therefore much restricted.

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

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Standpipe piezometers 19 mm in diameter were installed in Boreholes 90-1 to 90-4, 90-6 and 90-8 between depths of 2.7 m and 14.2 m, as shown on the Record of Boreholes in Appendix 1. The standpipes in Boreholes 90-4 and 90-6 were backfilled with sand and sealed within the bedrock. Soil cuttings were then used to backfill these two boreholes from the seal to the ground surface. All remaining boreholes were backfilled to ground surface with soil cuttings.

3.2 Survey

The borehole locations and ground surface elevations were surveyed by Giffels Associates Limited personnel after completion of the field work. The elevations are referenced to Geodetic datum. The borehole coordinates and elevation data is summarized on Drawing 3698900-A in Appendix 2.

3.3 Laboratory Testing

To identify the behaviour and properties of the soil samples collected during the field investigation, the following laboratory tests were carried out:

- Detailed visual classification,
- Natural moisture content,
- Sieve analysis,
- Atterberg Limits determination.

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

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4.0 RESULTS OF THE INVESTIGATION

4.1 Subsurface Conditions

The subsurface conditions observed in the boreholes are presented in detail on the Records of Boreholes provided in Appendix 1. An Explanation of Terms Used in Report is also provided in Appendix 1. The laboratory test results are summarized in the Records of Boreholes and also on Figures 1 to 3 in Appendix 1.

The ground surface elevations at the borehole locations vary from el. 96.9 m to 100.9 m at the time of the investigation. The surficial material at the boreholes consists of topsoil or asphalt or silty gravelly sand fill, overlying sand/silty sand and gravel (where present), overlying a heterogeneous mixture of silt, sand, gravel and boulders (glacial till), underlain by limestone bedrock. The bedrock surface was encountered between about el. 88.5 m and el. 90 m. The groundwater table within the overburden was observed between about el. 96 m and el. 101 m. The water level within the bedrock was observed between about el. 94 m and el. 95 m.

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

4.1.1 Topsoil / Asphalt

A surficial layer of topsoil was encountered in Boreholes 90-1, 90-2, 90-7 and 90-8. Thickness of the topsoil layer encountered ranges from 50 mm to 300 mm.

A layer of asphalt 100 mm in thickness was encountered at ground surface in Borehole 90-6.

4.1.2 Silty Gravelly Sand (Fill)

Silty gravelly sand fill was encountered from ground surface in Boreholes 90-3 to 90-5 inclusive, and underlying the asphalt in Borehole 90-6. The bottom of the fill varies between el. 96.4 m and el. 98.8 m (total thickness of 0.7 m to 2.1 m). The silty gravelly sand fill is believed to have been placed during the construction of Ventnor Road.



The SPT conducted in the silty gravelly sand fill layer yielded N values ranging from 12 to 31, indicating a denseness of compact. The Grain Size Distribution graph obtained from laboratory sieve analysis of a representative fill sample is shown on Figure 1 in Appendix 1. Moisture contents of this material range from 4% to 12% with an average of 6.8%. Based on visual identification and laboratory tests, the silty gravelly sand fill is classified as a cohesionless material.

4.1.3 Sand / Silty Sand and Gravel

Sand, some silt was encountered underlying the surficial topsoil layer in Boreholes 90-7 and 90-8. Thickness of this sand layer is about 0.6 m. Silty sand and gravel about 0.6 m in thickness was encountered underlying the topsoil in Borehole 90-1. The SPT conducted in the sand / silty sand and gravel layers yielded N values ranging from 4 to 8, indicating a denseness of loose. Based on visual identification, the sand / silty sand and gravel materials are classified as cohesionless materials.

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

A heterogeneous mixture of silt, sand, gravel and boulders (glacial till) was encountered underlying the materials described above. The glacial till surface was encountered at elevations ranging from el. 96.1 m and el. 100.2 m (depths of 0.3 m to 2.2 m). Thickness of this stratum ranges from at least 3.5 m to 9.4 m. The glacial till consists of an upper oxidized brown layer underlain by a grey layer.

The majority of the SPT conducted in the glacial till met refusal on cobbles and/or boulders before the required penetration of 450 mm was achieved. The N values obtained are typically over 50 (though most are influenced by the presence of cobbles and boulders), indicating a denseness of very dense. Auger advancement during drilling also collaborated the presence of numerous cobbles and/or boulders. Penetration of this stratum required the application of rock coring techniques in Boreholes 90-4 and 90-6.

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The results of laboratory testing of both the brown and grey glacial till are provided on the Records of Boreholes and on Figures 2 and 3 in Appendix 1, and are summarized below:

<u>Property</u>	<u>Range</u>	<u>#Tests</u>	<u>Average</u>
Moisture Content (%)	2.9 - 15.8	20	6.9
Liquid Limit (%)	14.6 - 23.8	5	16.9
Plastic Limit (%)	10.8 - 16.2	5	13.1
Plasticity Index (%)	2.0 - 7.6	5	3.8
Grain Size			
% Gravel	16 - 36	7	25
% Sand	35 - 42	7	38
% Silt and Clay	25 - 48	7	37

The above grain-size distributions represent the minus 38 mm fraction of the glacial till. Cobbles and boulders are also present in this material. Based on the above tests and visual identification, this till material can be classified as inorganic and cohesionless.

4.1.5 Bedrock

Underlying the glacial till, bedrock was proven by coring in Boreholes 90-3, 90-4 and 90-6. The bedrock surface at these locations was encountered between el. 88.5 m to el. 89.8 m (depths of 10.1 m to 10.7 m). The bedrock is a grey unweathered strong limestone with close to moderately close spaced horizontal fractures. The bedrock is fractured (RQD ranging from 60% to 72%). Core recoveries varied between 69% and 99%.

In Boreholes 90-5, 90-7 and 90-8, solid stem auger refusal was encountered between el. 88.4 m and 89.5 m (depths of 7.6 m to 9.9 m). In Borehole 90-1 and 90-2, hollow stem auger refusal was encountered between el. 96.5 m and el. 96.7 m (depths of 3.8 m to 4.4 m). At borehole locations where bedrock coring was not carried out, it could not be determined whether auger refusal was encountered on glacial till or bedrock.

4.2 Groundwater

Groundwater levels were recorded during drilling and in standpipe piezometers after drilling.

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The standpipes in Boreholes 90-4 and 90-6 were sealed in the bedrock. Groundwater levels recorded at these locations, which represent the levels within the bedrock, ranged from el. 93.9 m and el. 95.1 m (depths of 4.3 m to 4.7 m). In the remaining boreholes, groundwater levels recorded, which represent the levels within the overburden, ranged from el. 96.3 m and el. 100.7 m (depths of 0 m to 1.5 m). Groundwater levels are subject to seasonal fluctuations and can vary from the values given in this report.

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5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Proposed Development

The site is located at the intersection of the existing Highway 16 and Ventnor Road in the Township of Edwardsburgh, Ontario (refer to the Key Plan provided on Drawing No. 3698900-A in Appendix 2).

The proposed bridge structures are part of the Highway 416 development from Highway 401 to Highway 43. The Ventnor Road structures are to consist of the following components:

- Two (2) single 34-metre span fly-over structures spanning over Highway 416 southbound lane (SBL) and northbound lane (NBL).
- The structures will be supported by four (4) abutments with associated approach fills and median fills.
- Fill heights at abutment locations are to range from approximately 5.7 m to 7.3 m.

5.2 Geotechnical Assessment

Abutments may be founded on spread footings perched within compacted Granular 'A' fill. Structure foundations may also consist of conventional spread footings placed below frost depth on undisturbed glacial till.

Due to the very dense nature of the glacial till and its cobble and boulder content, driven piles do not appear to be a viable alternative, especially in view of the relatively high load carrying capability of the glacial till at rather shallow depths.

The approach and median fills of up to about 7.3 m in height may be constructed using side slopes of 2 horizontal to 1 vertical for granular borrow, or side slopes of 2.5 horizontal to 1 vertical for fine-grained borrow. No embankment stability and settlement problem are anticipated.

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This report contains our detailed recommendations in the following areas:

- 1) Structure Foundations
- 2) Abutment Backfill
- 3) Approach / Median Fills
- 4) Construction Considerations

5.3 Structure Foundations

5.3.1 Perched Abutments

The abutments may be founded on spread footings perched within compacted Granular 'A' fills. Prior the placement of the granular fill, the following is recommended:

- Remove all surficial organic/loosened materials and existing fill within the plan limits of the granular core.
- Proof roll the exposed surface. Soft areas revealed under proof rolling should be excavated.
- Construct granular pads using OPSS Granular 'A' material, and in accordance with details shown on Figure 4 in Appendix 1.

Spread footings placed on granular pads constructed as recommended above may be designed based on the following bearing pressures:

Factored Bearing
Capacity at U.L.S.

675 kPa

Bearing Capacity
at S.L.S. Type II

350 kPa

The above bearing pressures have been calculated based on a footing width (B) of 4 m. The S.L.S. Type II bearing pressure has been calculated assuming that a total settlement of 25 mm is satisfactory.

A minimum soil cover of 1.8 m over the footings should be provided for frost protection purposes and has been assumed in the calculations.

Sliding resistance between the concrete footing and the Granular 'A' should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. using an unfactored angle of friction of 35°.

Sliding resistance can be supplemented if necessary by constructing shear keys at the base of the footing.

5.3.2 Spread Footings

As an alternative to the perched abutments, the structures can be supported on conventional spread footings founded on the undisturbed glacial till. All footings must have a minimum earth cover of 1.8 m for frost protection. Spread footings placed on the glacial till may be designed based on the following bearing pressures:

SBL Structure

<u>Footing Location</u>	<u>Foundation Elev. (m)</u>	<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
West Abut.	98.5 and below	1000 kPa	500 kPa
East Abut.	98.0 and below	1000 kPa	500 kPa

NBL Structure

<u>Footing Location</u>	<u>Foundation Elev. (m)</u>	<u>Factored Bearing Capacity at U.L.S.</u>	<u>Bearing Capacity at S.L.S. Type II</u>
West Abut.	97.5 and below	1000 kPa	500 kPa
East Abut.	96.4 and below	1000 kPa	500 kPa

The above bearing pressures have been calculated based on a footing width of 4 m. The S.L.S. Type II bearing pressure has been calculated based on 25 mm of allowable settlement.

Sliding resistance between the concrete and the foundation soil can be calculated using an unfactored angle of friction of 33°.

To protect the cohesionless glacial till from being disturbed due to weather and construction activities, it is recommended that a 150 mm layer of lean concrete working slab be placed on the bearing surfaces within six (6) hours after footing excavation.

To facilitate construction of the footings, a dewatering scheme will be required to lower the water level below the excavation (bearing) level. Refer to Section 5.6 for details.

5.4 Abutment Backfill

The abutments should be backfilled with free draining material such as OPSS Granular 'A' or Granular 'B'. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill. Minimum granular backfill and wall drainage requirements should be in accordance with MTO Highway Engineering Standard Drawing No. DD-3502.

Computation of earth pressures should be in accordance with Section 6-6.1.2.1 of the O.H.B.D.C. For abutments that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied structures, the at rest earth pressure should be used for design, unless the stem can deflect enough (approximately 0.1 percent of the wall height) to establish the active pressure. The following soil parameters are recommended for design:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Bulk unit weight, γ (kN/m ³)	22.8	21.2
Effective friction angle, ϕ'	35°	30°
Coefficient of active earth pressure (Ka)	0.27	0.33
Coefficient of earth pressure at rest (Ko)	0.43	0.50

Compaction of the granular backfill near the walls should be carried out using hand-operated equipment to prevent overstressing the abutment walls.

5.5 Approach / Median Fills

Fill placement of up to 7.3 metres is proposed for the approach and median fills within the investigated area. Side slopes of 2 horizontal to 1 vertical would be appropriate for fills constructed of granular borrow or select subgrade materials. If fine-grained borrow materials are to be used, side slopes of 2.5 horizontal to 1 vertical would be appropriate.

All organic and deleterious materials should be stripped and removed prior to fill placement within the entire fill area. Based on the approach fill boreholes (Borehole 90-1, 90-2, 90-7 and 90-8), the anticipated depth of stripping varies from 50 mm to 300 mm.

The exposed surface should be proof rolled and soft areas removed prior to fill placement. The fills should be placed and compacted in accordance with MTO specifications and standards (OPSS 501).

Settlement of the embankment and the underlying soil are not expected to exceed 25 mm and will be largely complete after construction.

To protect against surficial instability, normal slope vegetation should be established in accordance with MTO standards as soon as possible after construction.

5.6 Construction Considerations

5.6.1 Dewatering

Excavations for spread footings at this site are expected to be near the groundwater table. Due to their cohesionless nature, both the fill and the glacial till may become unstable under saturated or seepage conditions. Dewatering may be achieved by a combination of conventional ditches and pumping from sumps techniques. However, it is the responsibility of the contractor to lower the groundwater below the excavation base, and to construct the footings in the dry without disturbing the underlying foundation soils.

5.6.2 Temporary Excavations

In view of the high groundwater table present at the time of the investigation, and the cohesionless nature of the surficial native soil, temporary excavations up to 3 m high should be undertaken using slopes no steeper than 1H:1V. Under heavy seepage conditions, flatter side slopes may be required or alternatively a shoring system may be utilized.

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5.7 Groundwater Chemistry

A selected number of groundwater samples were submitted for chemical testing. The results and our recommendations in this aspect will be submitted in a separate letter as soon as the test results become available.

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6.0 MISCELLANEOUS

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

The project was carried out under the general supervision of G. Kack, Project Manager. The report was written by both undersigned.

Respectfully submitted

JACQUES, WHITFORD LIMITED

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

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

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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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	T W ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	T W 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_i	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						

RECORD OF BOREHOLE No 90-1

METRIC

W P 369-89-00 LOCATION Co-ords: N 4 970 091.1; E 379 495.9 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE November 8, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
100.9	Ground Surface												
100.8	Topsoil (75 mm)												
0.1	Silty Sand and Gravel		1	SS	7		Nov. 22, 1990						
100.2	Loose Brown												
0.7	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till)		2	SS	56/	15cm	Standpipe						
	Very Dense		3	SS	50/	8cm	100						
			4	SS	53/	10cm	Native Backfill						
			5	SS	98/	23cm	99						
	Brown Grey		6	SS	50/	8cm	98						
96.5			7	SS	50/	0cm	97						
4.4	End of Borehole (Auger refusal)												

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RECORD OF BOREHOLE No 90-3

METRIC

W P 369-89-00 LOCATION Co-ords: N 4 970 088.5; E 379 515.9 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Solid Stem Auger, BW-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE November 9, 13, 1990 CHECKED BY G.J.K.

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					
100.5	Ground Surface												
0.0	Silty Gravelly Sand (Fill) Compact Brown		1	SS	26								
			2	SS	31								
98.8			3	SS	50								
1.7	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Very Dense Brown Grey		4	SS	50								
			5	SS	50								
			6	SS	50								
89.8													
10.7	Bedrock Limestone Fractured Unweathered Grey		7	BQ RC	REC 99%								
			8	BQ RC	REC 69%								
85.7													
14.8	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

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+3, x5: Numbers refer to
Sensitivity

20
15 x 5 (%) STRAIN AT FAILURE
10

RQD = 72%

RQD = 63%

RECORD OF BOREHOLE No 90-4

METRIC



W P 369-89-00 LOCATION Co-ords: N 4 970 109.5; E 379 544.1 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Solid Stem Auger, BW-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE November 8, 9, 1990 CHECKED BY G.J.K.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
99.4	Ground Surface													
0.0	Silty Gravelly Sand (Fill)		1	SS	16		99							
98.7	Compact Brown						Standpipe							
0.7	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till)		2	SS	28		98							18 42 (40)
	Very Dense		3	SS	60/	10cm								
			4	SS	50/	0cm	97							
	Brown Grey		5	SS	50/	0cm	Native Backfill							
							96							
			6	SS	62/	13cm	Nov. 22, 1990							
			7	SS	50/	8cm	94							23 35 (42)
							93							
							92							
							91							
							90							
89.3	Cobbles and Boulders		8	RC	REC 30cm		Seal							
10.1	Bedrock Limestone Fractured Unweathered		9	BQ RC	REC 95%		Sand Backfill							RQD = 64%
87.7	Grey						88							
11.7	End of Borehole													

DRAFT

METRIC

W P 369-89-00 LOCATION Co-ords: N 4 970 128.4; E 379 565.8 ORIGINATED BY A.M.
DIST 9 HWY 416 BOREHOLE TYPE Solid Stem Auger COMPILED BY C.K.K.
DATUM Geodetic DATE November 9, 1990 CHECKED BY G.J.K.

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 (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
98.9	Ground Surface									0	10	20	30	40	
0.0	Silty Gravelly Sand (Fill)		1	SS	15	*	Nov. 9, 1990								
	Compact														
97.5			2	SS	22										
1.4	Het. Mixture of Sand, Silt, Gravel and Boulders (Glacial Till)		3	SS	50/	3cm									
	Very Dense						8cm								
			4	SS	50/										
	</														

DRAFT

+³, x⁵ : Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 90-7

METRIC

W P 369-89-00 LOCATION Co-ords: N 4 970 176.2; E 379 606.7 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Solid Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE November 14, 1990 CHECKED BY G.J.K.

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 (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
97.1	Ground Surface													
97.0	Topsoil (50 mm)													
0.1	Sand, some silt		1	SS	4									
96.4	Loose	Brown												
0.7	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Very Dense	Brown Grey	2	SS	50/ 8cm									
			3	SS	50/ 10cm									
			4	SS	50/ 15cm									
			5	SS	80									
			6	SS	50/ 8cm									
89.5														
7.6	End of Borehole (Auger refusal) * No standpipe installed, borehole caved in upon completion													

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RECORD OF BOREHOLE No 90-8

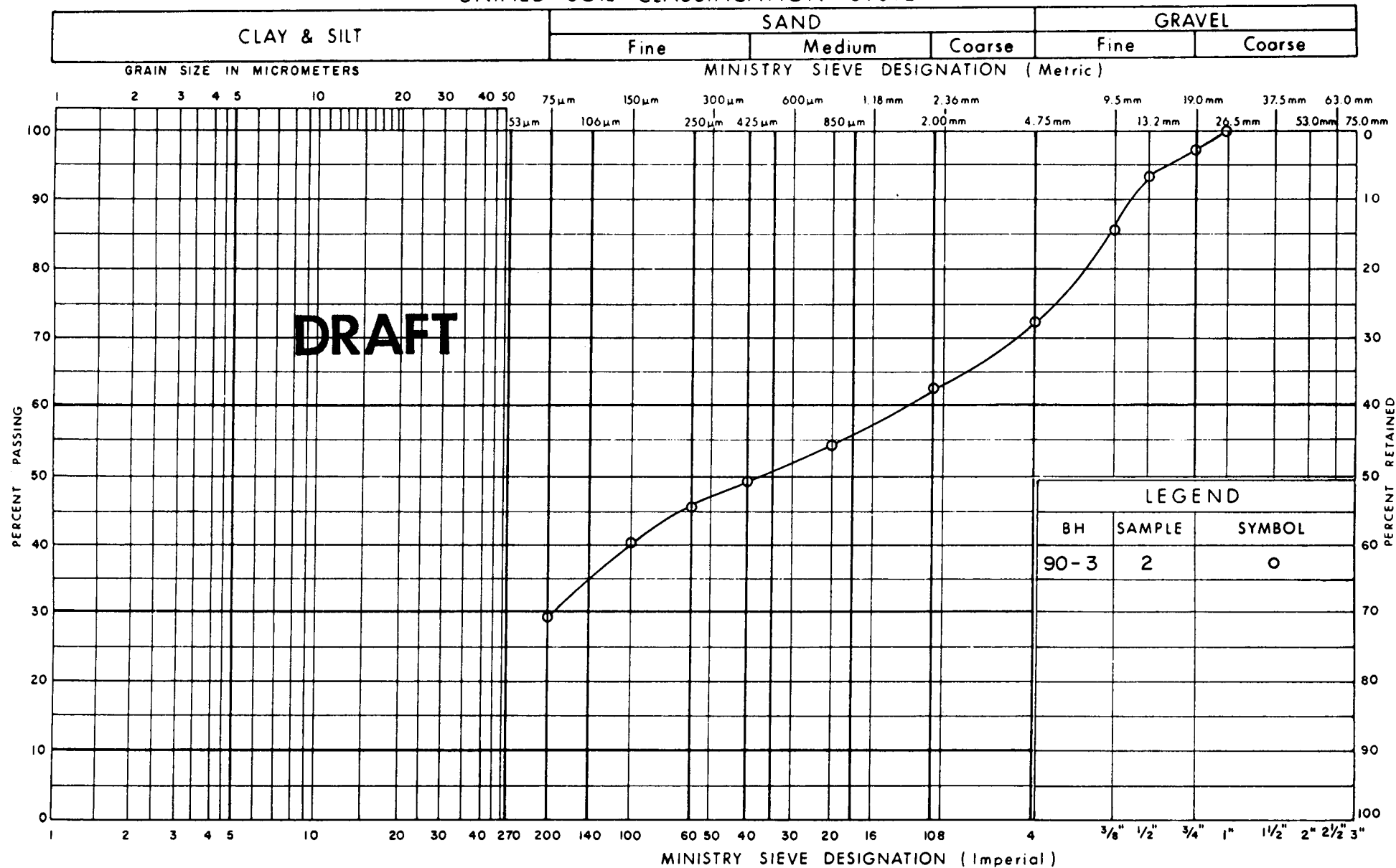
METRIC

W P 369-89-00 LOCATION Co-ords: N 4 970 147.9; E 379 624.8 ORIGINATED BY A.M.
 DIST 9 HWY 416 BOREHOLE TYPE Solid Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE November 14, 1990 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p W W _L	WATER CONTENT (%)	0 10 20 30 40			
96.9	Ground Surface													
96.7	Topsoil (200 mm)		1	SS	6									
0.2	Sand, some silt													
96.1	Loose Brown		2	SS	50/	8m								
0.8	Het. Mixture of Silt, Sand, Gravel and Boulders (Glacial Till) Very Dense		3	SS	72/25									
	Brown Grey		4	BS	-									
88.4	End of Borehole (Auger refusal)													

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UNIFIED SOIL CLASSIFICATION SYSTEM



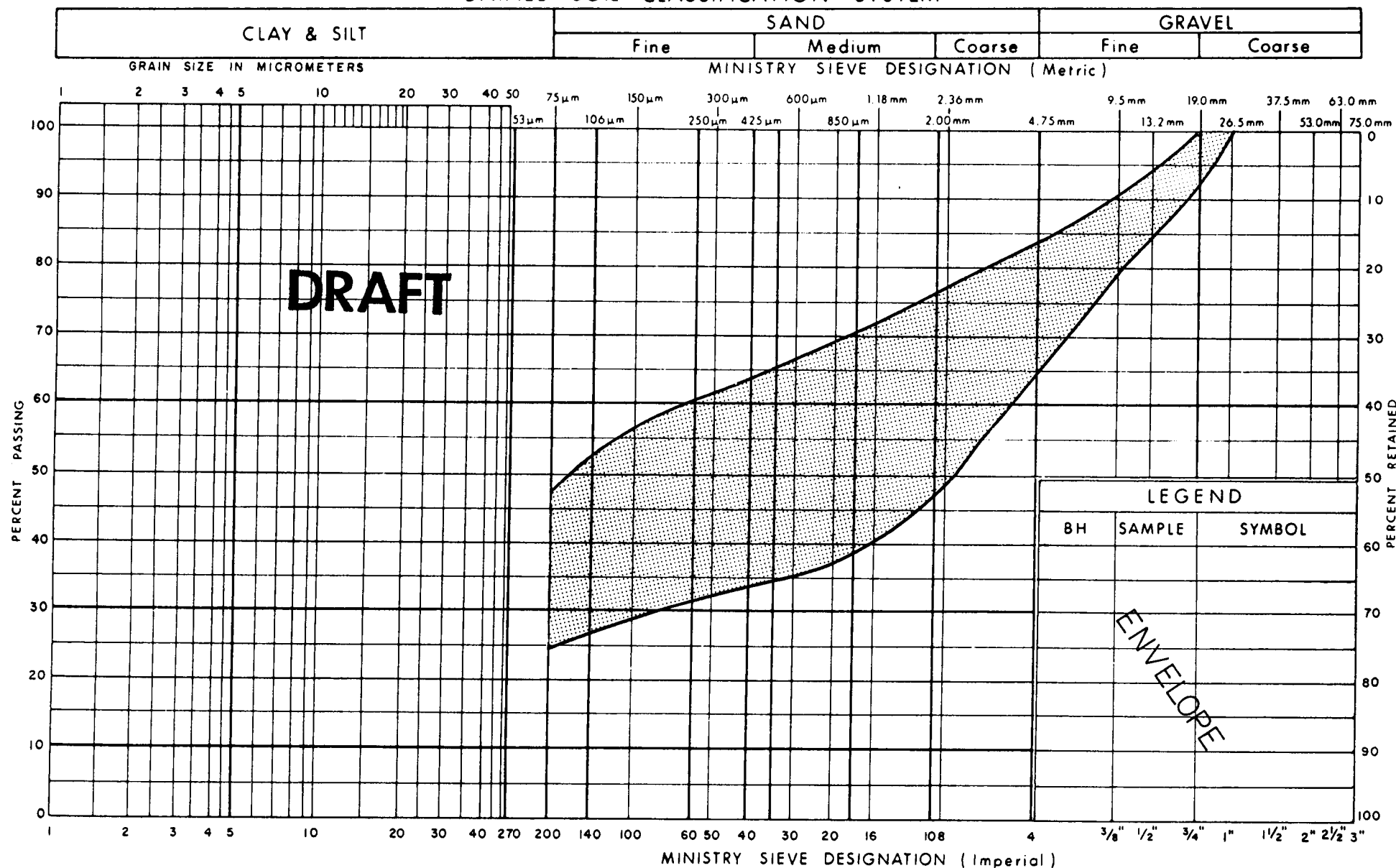
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND AND GRAVEL(Fill)

FIG No 1

W P 369-89-00

UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of
Transportation

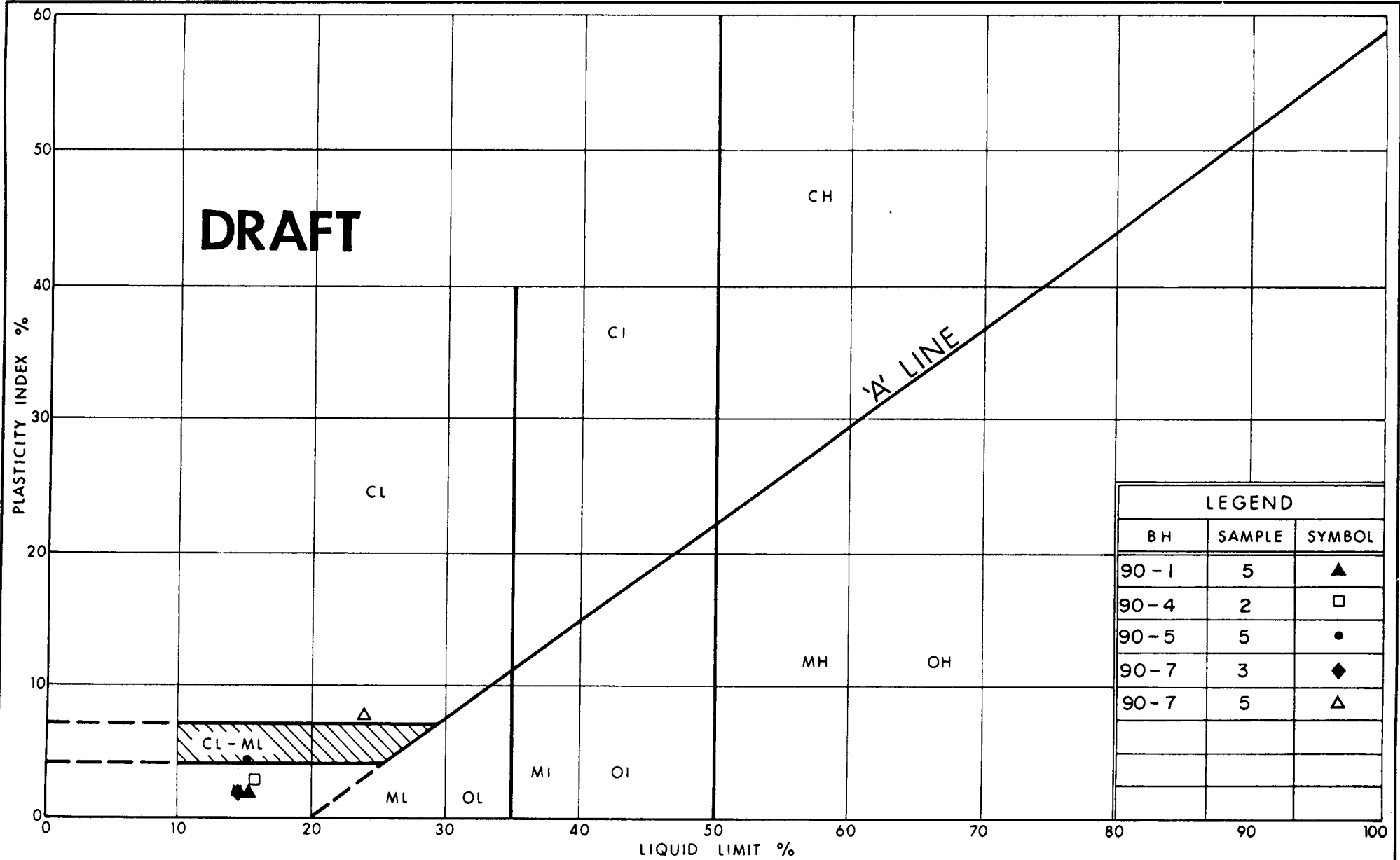
GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

SILT, SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 2

W P 369-89-00

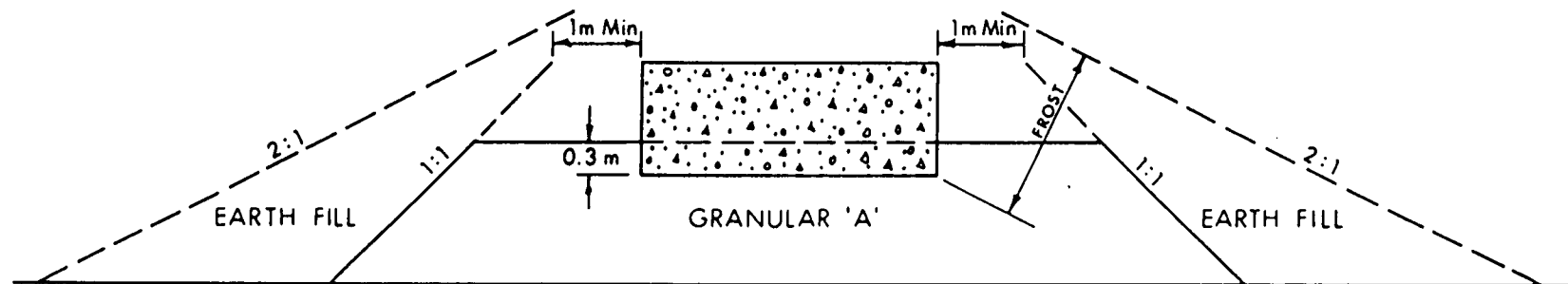


Ministry of
Transportation
Ontario

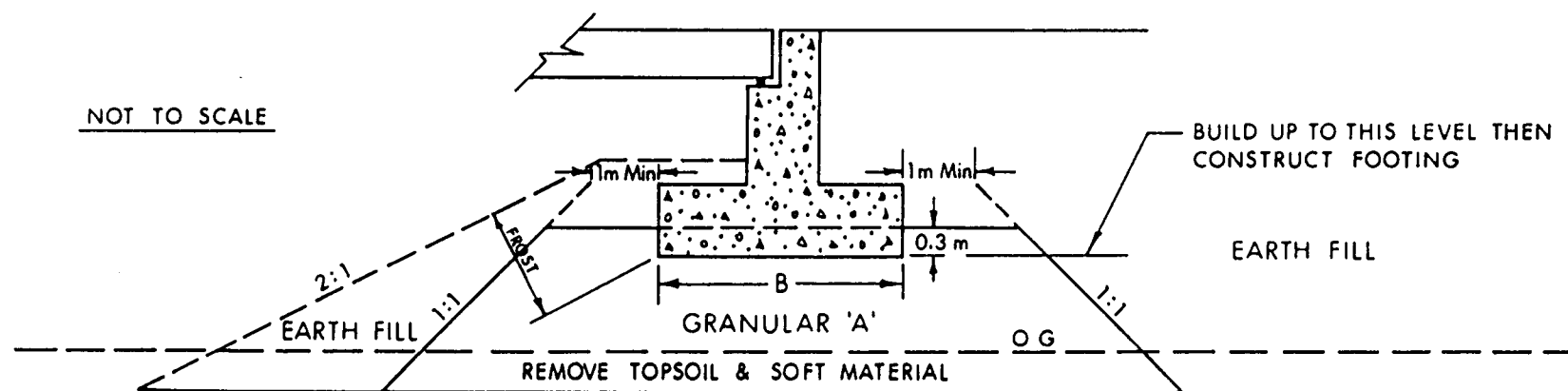
PLASTICITY CHART
HET MIXTURE OF
SILT, SAND, GRAVEL & BOULDERS (Glacial Till)

FIG No 3

W P 369-89-00



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

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Transportation

ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

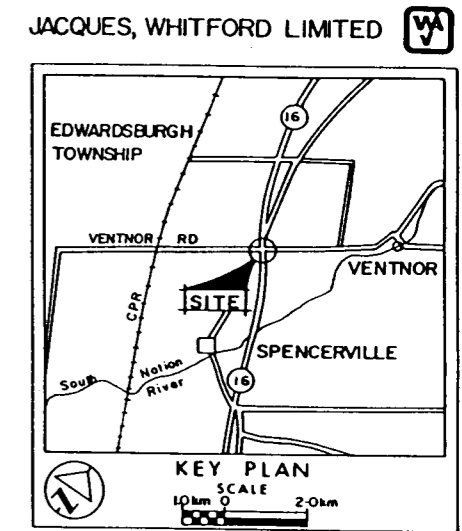
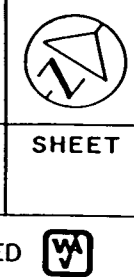
FIG No 4

W P 369 - 89-00



CONT No
WP No 369-89-00

HWY 416 UNDERPASS
AT VENTNOR RD
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)
 - W.L. at time of investigation 90 11

No	ELEVATION	COORDINATES NORTH	EAST
90-1	100.9	4 970 091.1	379 495.9
90-2	100.5	4 970 063.7	379 508.7
90-3	100.5	4 970 088.5	379 515.9
90-4	99.4	4 970 109.5	379 544.1
90-5	98.9	4 970 128.4	379 565.8
90-6	98.6	4 970 147.7	379 595.1
90-7	97.1	4 970 176.2	379 606.7
90-8	96.9	4 970 147.9	379 624.8

NOTE

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

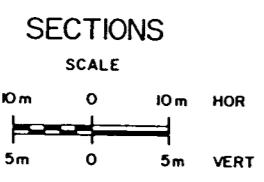
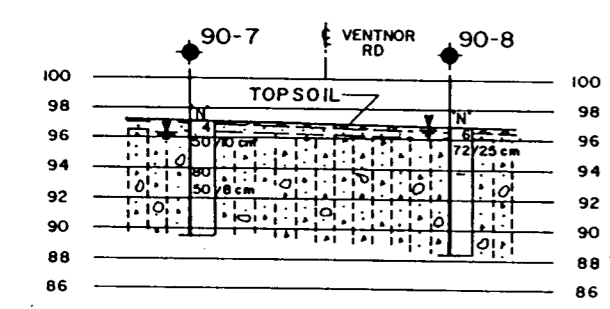
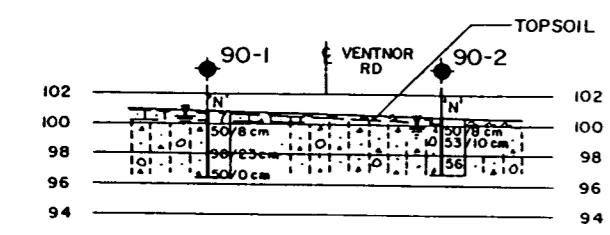
NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2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

REV	DATE	BY	DESCRIPTION

Geocres No 318-69

HWY No 416	SUBM'D CKD/CHECKED	DATE JAN 25, 1991	DIST 9
DRAWN GBB	CHECKED	APPROVED	SITE 16-312
			DWG 3698900-A

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- SOIL STRATIGRAPHY LEGEND**
- SILTY GRAVELLY SAND Compact (FILL)
 - SAND, SOME SILT Loose
 - SILTY SAND & GRAVEL Loose
 - LIMESTONE BEDROCK Fractured
 - HET MIXTURE OF SILT, SAND, GRAVEL & BOULDERS Very Dense (GLACIAL TILL)

