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DIST. 9 REGION

W.P. No. 120-87-06

CONT. No. 90-36

W. O. No.

STR. SITE No.

HWY. No. 417

LOCATION E.B. Hwy 417 over Acres Rd.  
(Structure #3)

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 120-87-06

DIST 9

HWY 417

STR SITE 3-52-533

Eastbound Highway 417 Overpass Structure  
at Acres Road, Structure No. 3

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

### SUBSURFACE CONDITIONS

The subsoil conditions are generally consistent across the site. The surficial layer consists of a generally soft to very stiff cohesive silty clay to clayey silt which extends to a maximum thickness of 2.7 metres. Underlying this layer is a deposit of clayey silt interbedded with irregular layers or seams of sandy silt. The maximum thickness of this deposit is about 5.3 metres. A deep deposit of silty sand to sand is the subsequent underlying deposit with a maximum thickness of about 22.7 metres and this in turn underlain by a heterogeneous mixture of sand, gravel and boulders (Glacial Till). Approximately 2.1 to 4.8 metres of the till deposit was found before encountering the silty dolostone bedrock.

It should be noted that in the vicinity of east abutment and approach of the Structure No. 3, upper two layers (silty clay to clayey silty layer and clayey silt with interbedded sandy silt layer) are gradually diminished. In stead, fill material was encountered adjacent to the existing Graham Creek. Fill material consists of organic silty sand or clayey silt as shown on Record of borehole (BH #3-9).

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

### Fill Material

The fill material was encountered in the vicinity of the northeast portion of the site at three borehole locations (BH #3-7, #3-8 and #3-9). This fill consists of a brown Clayey Silt to Silt with some Sand and trace of Gravel or organic Silty Sand. The thickness of this layer varies from 0.8 metres at BH #3-7 to 1.6 metres at BH #3-8 as shown on Record of boreholes. No Atterberg Limit Tests and Grain Size Distribution Analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the surficial material which was found adjacent to the site.

### Silty Clay to Clayey Silt

This stratum was encountered in most of the boreholes except near the east portion of the site (Boreholes #3-1 to #3-6). This material consists of a silty clay to clayey silt ranging in thickness between 2.0 and 2.7 metres. The material changes in colour from brown to grey at approximately elevation 64.0 metres.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 1 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	20.5-44.5
Liquid Limit ( $w_L$ )	25.5-47.5
Plastic Limit ( $w_p$ )	11.0-16.5
Plasticity Index ( $I_p$ )	10.0-32.5
Unit Weight ( $kN/m^3$ )	17.5-20.3

From the plasticity chart (see Figure 1) it is evident that the layer can be classified as an inorganic silty clay to clayey silt with intermediate to low plasticity (CI or CL).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in envelope form.

Undrained shear strength of the soil were determined both by in situ vane tests and by laboratory tests, namely undrained unconsolidate (quick triaxials) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength (<math>C_u</math>)</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	36-100	2.6-5.1
Laboratory Results	25-67	-

As shown on the above table, it can be concluded that the laboratory testing provided lower values possibly attributable to disturbance during sampling, transportation and testing. Recommended shear strength for this deposit can be assumed to be within the range of 60 to 70 kPa. Based on this conclusion, the soil has generally a firm to stiff consistency. The sensitivity of the soil is generally low to moderate.

The results (e-log P curves) of two consolidation tests on representative samples obtained in the silty clay to clayey silt deposit are shown on Figure 5. These tests indicated that this cohesive stratum has been preconsolidated in the past to an effective pressure ranging from 340 kPa to 450 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, $P_c$ (kPa)	340-450 kPa
Initial Void Ratio ( $e_o$ )	0.863-1.250
Compression Index ( $C_c$ )	0.45-0.94

\*Test data of similar soil from adjacent investigations  
(WP 120-87-08) incorporated in results.

#### Clayey Silt with Interbedded Sandy Silt

Underlying the surficial deposit of silty clay to clayey silt, a layer of grey clayey silt with interbedded sandy silt was encountered. This stratum extends to depths ranging from 2.1 metres to 7.8 metres below the ground surface. The thickness of the stratum varies between 1.9 and 5.3 metres.

The results from the Atterberg Limit Test performed on this material are summarized as follows:

<u>Property</u>	<u>Range (%)</u>
Natural Moisture Content (w)	24.0-43.5
Liquid Limit ( $w_L$ )	15.0-30.0
Plastic Limit ( $w_p$ )	11.0-15.0
Plasticity Index ( $I_p$ )	2.5-16.5
Unit Weight ( $kN/m^3$ )	17.9-19.0

From the plasticity chart (Figure 1), it is evident that the layer can be classified as an inorganic clayey silt with interbedded Sandy Silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 2 in the Appendix shows the results in an envelope form.

Undrained shear strength of the soil were determined both by the in situ vane tests and by laboratory tests, namely undrained unconsolidated (quick triaxial) and unconfined compression tests. The results are plotted on the Record of boreholes in the Appendix and summarized as follows:

<u>Undrained Shear Strength</u>	<u>kPa</u>	<u>Sensitivity</u>
Field Vane	54-80	2.7-6.8
Laboratory Results	17-40	-

Due to the irregular nature of the deposit, that reveals numerous seams and layers of Sandy Silt interbedded within the Clayey Silt, the results provided in the above table are not necessarily indicative of the shear strength of the Clayey Silt portion. In view of this consideration, the consistency of the Clayey Silt portion can be described as soft to stiff. The Sandy Silt portion was generally very loose in denseness. For design purposes, an undrained shear strength of 40 kPa can be assumed for this stratum.

The results (e-log P curves) of two consolidation tests on representative samples from the adjacent structure sites (structure 5) are shown on Figure 6. These tests indicated that the Clayey Silt has been preconsolidated in the past to an effective pressure ranging from 190 kPa to 327 kPa in excess of the existing effective overburden pressure. The details of the results are as follows:

<u>Parameters</u>	<u>Ranges*</u>
Preconsolidation pressure, $P_c$ (kPa)	190-327
Initial Void Ratio ( $e_0$ )	0.617-1.111
Compression Index ( $C_c$ )	0.078-0.87

\*Test data of similar soil from adjacent investigations  
(WP 120-87-08) incorporated in results.

#### Silty Sand to Sand

Silty Sand to Sand was encountered below the Clayey Silt with interbedded Sandy Silt layer. The thickness of this layer ranges from 9.9 metres at BH #3-1 to 22.7 metres at BH #3-8.

This deposit contains minor variations in gravel content throughout its thickness. Generally, the deposit contains trace of gravel, but at some locations, considerable gravel (in excess of 40%) was encountered. Grain size distribution analysis indicate that the soil varies between a silty sand to sand. This layer is basically non-plastic. Figure 3 in the Appendix shows the results of grain size distribution tests in an envelope form.

In this stratum, the 'N' values ranged from 2 to over 100 blows/0.3 m indicating a state of compaction described as very loose to very dense.

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

Underlying the silty sand to Sand deposit at a depth ranging from 13.9 to 27.1 metres, a heterogeneous mixture of Sand, Gravel and boulders of glacial origin

was encountered. The thickness of this stratum ranges from about 1.0 m at BH #3-8 to 4.8 metres at BH #3-4. Rock coring techniques were required to penetrate occasional boulders within the stratum. This stratum may be described as a heterogeneous mixture of Sand, Gravel and boulders. Figure 4 shows the result of grain size distribution tests in an envelope form for these materials.

In this stratum, the 'N' values ranged from 44 to over 100 blows/0.3 metres indicating a state of compaction described as dense to very dense.

### Bedrock

The glacial till deposit is directly underlain by bedrock of the Rockcliffe and Gull River Formations and was proven at various locations by obtaining up to 2.0 metres of rock core samples. The bedrock consists mainly of a Silty Dolostone. Minor beds of Sandstone and Limestone were also found interbedded in the rock formation. Detailed description of the rock are attached in the Appendix entitled "Description of Rock Core".

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 to strong rock and predominantly unweathered.

### GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Groundwater level in the boreholes was found to range between 60.3 metres at BH #3-4 and 61.5 metres at BH #3-1 which corresponds to depths of 5.8 metres to 4.1 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 Hwy. 417 Eastbound lanes over the realigned Acres Road. This structure is a component of the proposed Hwy. 416/417 interchange which involves numerous proposed structures.

The new structure No. 3 will be located in the existing corn field slightly south of the existing Hwy. 417 between the Acres Road and Richmond Road. The proposed structure is a two-span structure having an approximate length and width of 68 metres (34 + 34 m) and 21 metres, respectively. The proposed profile grade of the Hwy. 417 EB lanes is approximately at elevation 71.0 metres which is equivalent to approach embankment fill height of approximately 5.0 metres. In addition, an excavation cut of approximately 2.5 metres will be required to achieve the realigned Acres Road profile grade of 63.5 metres.

Recommendations pertaining to the following geotechnical considerations should be included:

### Approach Embankments

- slope stability
- settlements

### Structure Foundations

### Other Considerations

- lateral earth pressure on structure
- dewatering

In view of the presence of the compressible surface layer of Silty Clay to Clayey Silt and the underlying Clayey Silt with interbedded Sandy Silt which is of low shear strength, slope stability and settlement of the approach embankments are the major problems anticipated at this site. Consequently, these will be discussed in detail.

## APPROACH EMBANKMENTS

### Stability Considerations

Stability analyses were carried out to evaluate the effect of the approach fills to the overall stability both in the longitudinal and transverse directions, the internal stability of the fills, and the stability of the excavation cut required for the realigned Acres Road.

A total stress analysis was applied for calculations of slope stabilities pertaining to the fills while an effective stress analysis was used to examine the stability of the cut. A minimum factor of safety of 1.3 was incorporated for all analyses. At this location maximum height of approaches will be in the order of 7.5 m as mentioned previously. Since the grades may be revised at a later date, consequently analyses were carried out for approaches higher than 7.5 m. Based on the analyses, the following conclusions have been derived:

Approach fills up to 8.0 metres in height both in the longitudinal and transverse directions at the east and west approaches will be stable provided they are constructed with standard 2H:1V slopes. For fills exceeding 8.0 metres, nominal mid-height stabilizing berms will be required. The berm length requirements for various heights of fill and the soil parameters, surface geometry and groundwater levels used in the analysis is provided on Figure 7 and 8 in the Appendix for both the longitudinal and transverse directions, respectively.

Any localized softened and/or surficial organic soil should be removed within the planned limits of the fill prior to its placement. The fills should be placed and compacted according to MTO Standards. An adequate surface erosion protection scheme should also be designed to preserve the surficial embankment slopes.

The excavation cut for the proposed realigned Acres Road will penetrate approximately 2.5 metres into the surficial silty clay to clayey silt layer. No stability problems are anticipated both in the short and long term provided the slopes are constructed at 2H:1V. No dewatering problems are anticipated in view

of the fact that the groundwater level is below the excavation cut and the deposit is impervious in nature. The cut slopes should be protected against surface erosion. Topsoil and sodding is one recommended method of achieving this protection.

Earthquake forces were also incorporated in the stability analysis. A value of 0.2 g was used as the peak horizontal ground acceleration. Based on the results the proposed approach fills are considered to be statically and dynamically stable.

#### Settlement Considerations

Anticipated settlements are based on laboratory results obtained from Taylor's (1948) (Square Root Fitting Method) Consolidation testing procedures and employing Osterberg (1957) solution to determine the increase in vertical stress due to embankment loading. The total settlement anticipated as a result of elastic and consolidation settlement of the Silty Clay to Clayey Silt layer, Clayey Silt with interbedded Sandy Silt layer and settlement of the fill under its own weight is approximately 200 mm for embankment approaches 5.0 m in height. The elastic settlements were computed using Steinbrenner's (1934) method and comprise approximately 5-6 percent of the total settlement (15 mm). These settlements will be immediate in nature and will be realized during construction of the embankments. In addition, in view of the slightly preconsolidated nature of both strata, a further 75 mm of settlement will be due to the recompression of the soil and consequently will occur during or immediately after construction. This results in net consolidation (time-dependent) settlements in the order of 60 mm.

Consolidation settlements curves for varying heights of fill are provided on Figure 9 in the Appendix. Estimates of the time rate settlement indicate that the total anticipated consolidation settlements should be realized within a period of 9 years after application of the embankment loading. It is also estimated that about 30 to 40 percent of the total anticipated settlement will be completed within a period of 6-9 months after construction of the embankments. In view of this, consideration should be given in constructing the approach fills as far in advance of the structure foundations as scheduling,

feasibility and economics permit and also in delaying the final paving operations as long as possible.

### Structure Foundations

#### Abutments and Pier Foundations for New Structure and Related Wing Walls

As discussed above, in view of the low shear strength and compressibility of the upper layers of soils, conventional spread footing shallow foundations are not applicable at this site. It is recommended that the abutments and pier foundations may be supported on end-bearing piles, equipped with reinforced tips in order to facilitate pile penetration through the basal glacial till stratum and driven to bedrock.

In consideration of the negative skin friction forces (additional downdrag forces), which will be induced as a result of the consolidation of the underlying cohesive deposits due to the imposed load of embankment, at the abutment locations the following design parameters are suggested, however, no negative skin friction forces are anticipated at pier locations:

<u>Structure</u>	<u>Pile Type</u>	Axial Capacity at S.L.S. Type II	Factored Axial Capacity at U.L.S.	Estimated Pile Tip
		<u>(kN)</u>	<u>(kN)</u>	<u>El. (m)</u>
W. Abutments	HP310x79	800	1050	40.4
	HP310x110	1050	1450	
Piers	HP310x79	900	1150	39.8
	HP310x110	1150	1600	
E. Abutments	HP310x79	800	1050	38.8
	HP310x110	1050	1450	

In view of the extreme denseness of the glacial till stratum located immediately above the bedrock, some piles may not penetrate this dense stratum. In such a case, the pile capacity should be controlled in the field using current MTO pile driving standards. However, attempts should be made in all cases to drive the piles to the bedrock surface.

Lateral strains induced by the settlement of the cohesive deposit shall be accounted for in the design of the abutments. To resist the potential lateral displacement and rotational forces caused by this settlement, it is recommended that the extreme ends of the wing walls should also be supported on end-bearing piles driven to bedrock using values as identified in the above table. Resistance to lateral load shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Pile caps may be perched within the embankment fill provided that particle sizes in the fill immediately beneath the pile locations does not exceed 75 mm. Alternatively, the pile caps may be founded within the surficial cohesive deposit. No dewatering problems are anticipated for this excavation.

#### 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:

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction ( $\phi$ )	35°	30°
Unit Weight ( $\text{kN/m}^3$ ) , $\gamma$	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	0.5

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 and the deposit is relatively impervious in nature. However, if surface water does accumulate in the 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.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 88 07 06 to 88 07 15 under the supervision of Tae C. Kim, Foundation Engineer. The equipment was owned and operated by Marathon Drilling Co. Ltd., Ottawa and F.E. Johnston Drilling Co. Ltd., Ottawa.

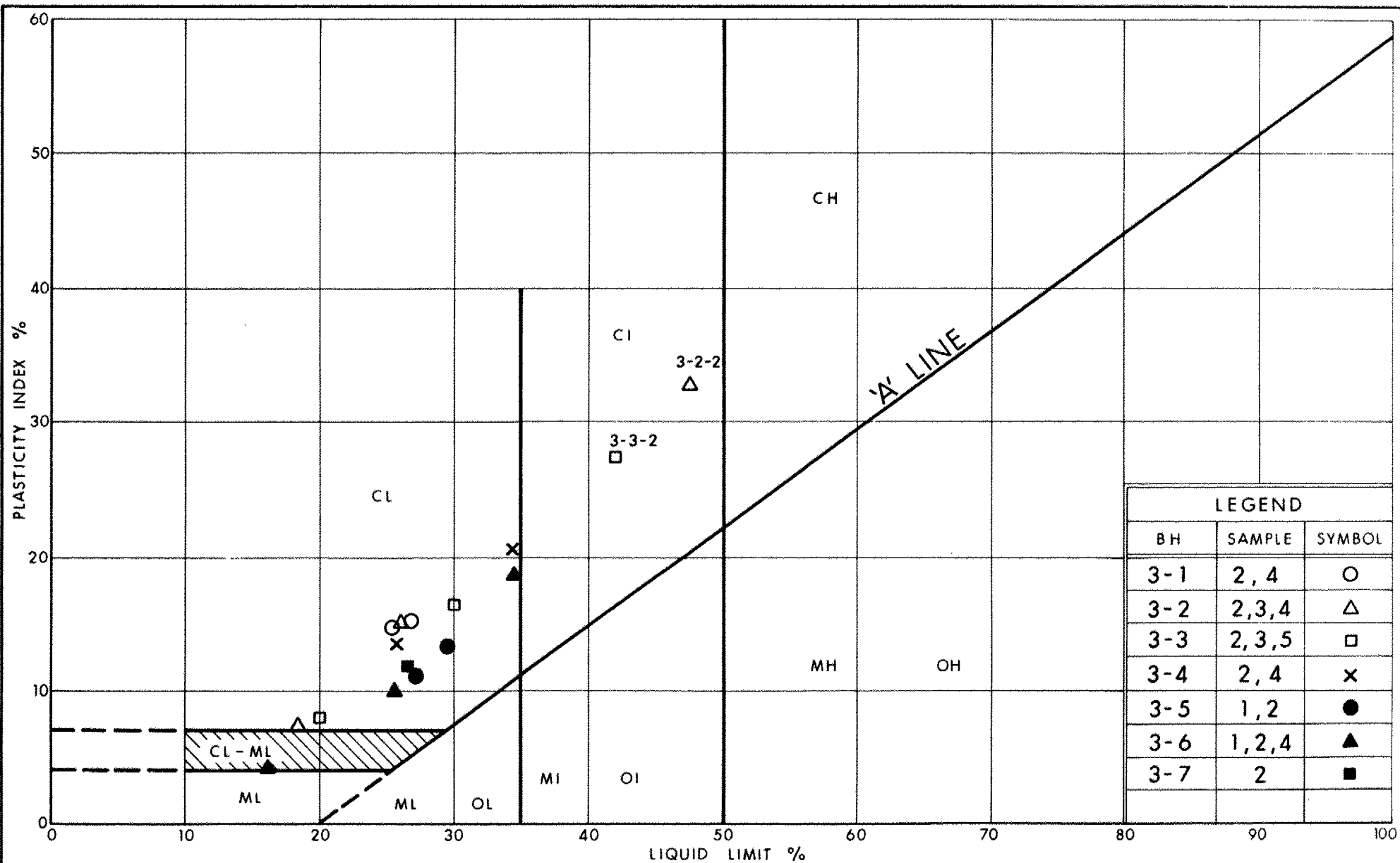
This report was written by Tae C. Kim, Foundation Engineer and reviewed by Murty Devata, Chief Foundation Engineer.



*Tae C. Kim*  
Tae C. Kim, P.Eng.  
Foundation Engineer

*Murty Devata*  
Murty Devata, P.Eng.  
Chief Foundation Engineer

## APPENDIX



Ministry of  
Transportation

Ontario

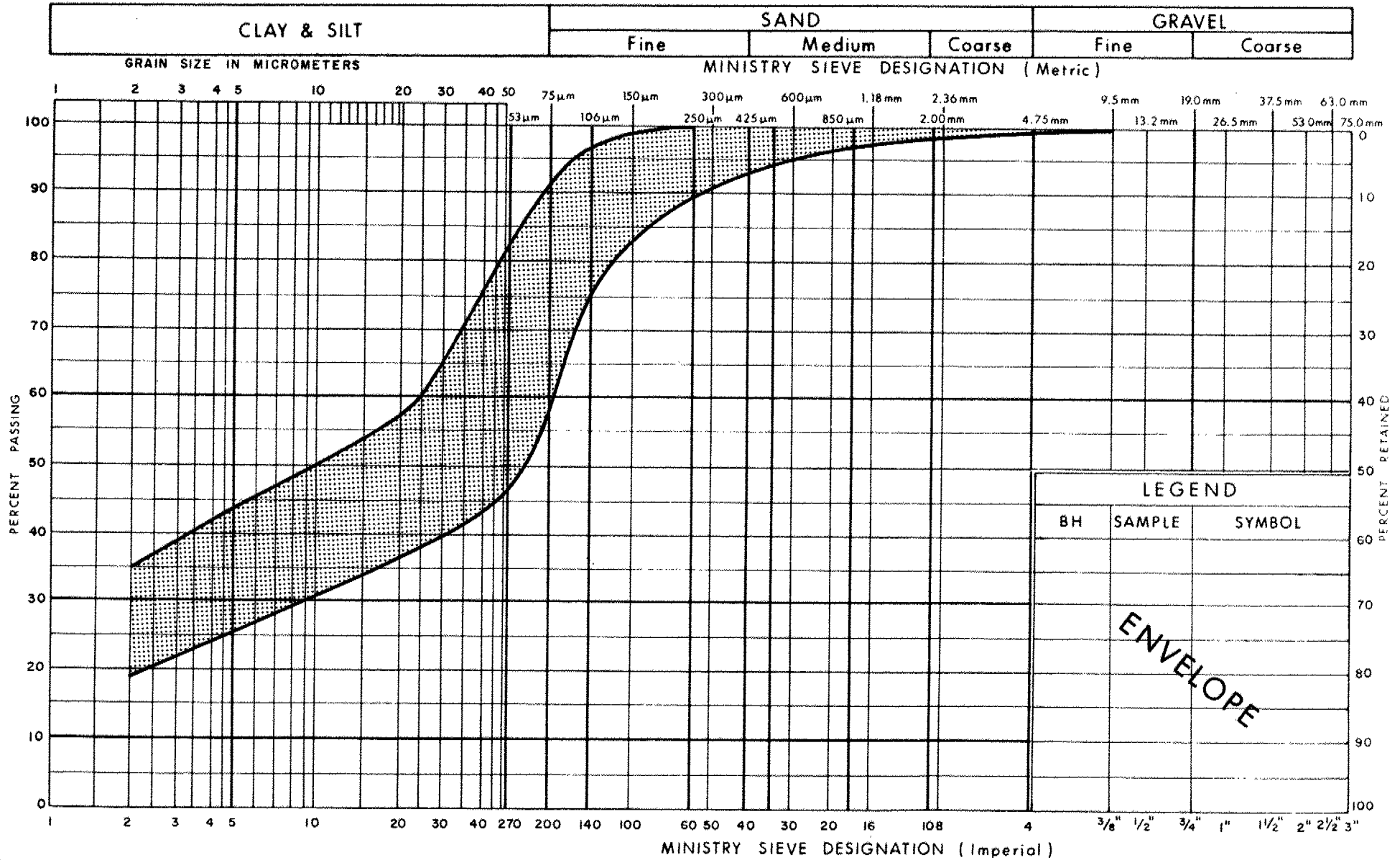
# PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 120-87-06



## UNIFIED SOIL CLASSIFICATION SYSTEM



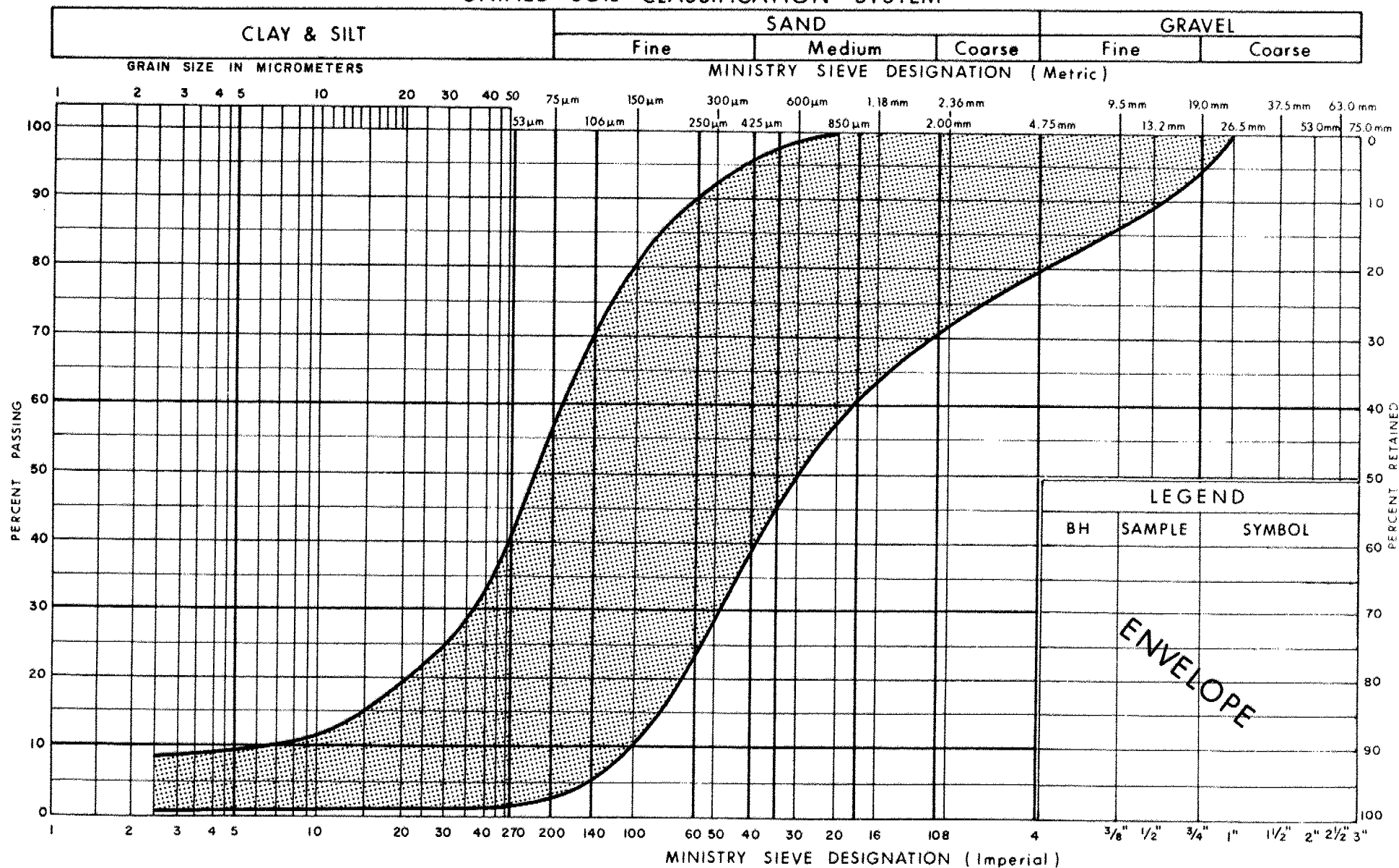
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## GRAIN SIZE DISTRIBUTION SILTY CLAY TO CLAYEY SILT

FIG No 2

W P 120-87-06

## UNIFIED SOIL CLASSIFICATION SYSTEM



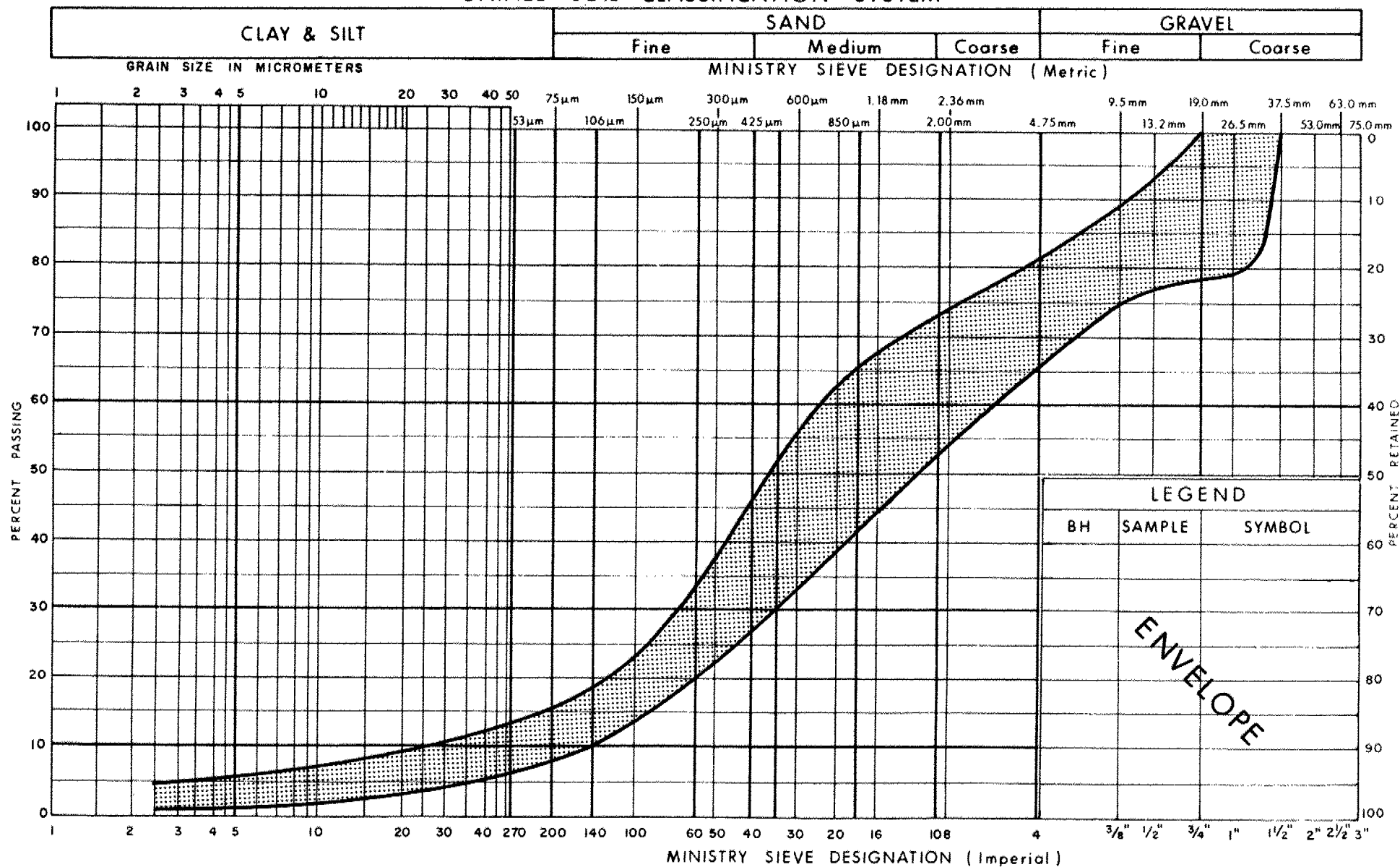
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Transportation

GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SAND, SOME GRAVEL

FIG No 3

W P 120-87-06

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

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

FIG No 4

W P 120-87-06

# VOID RATIO - PRESSURE CURVES

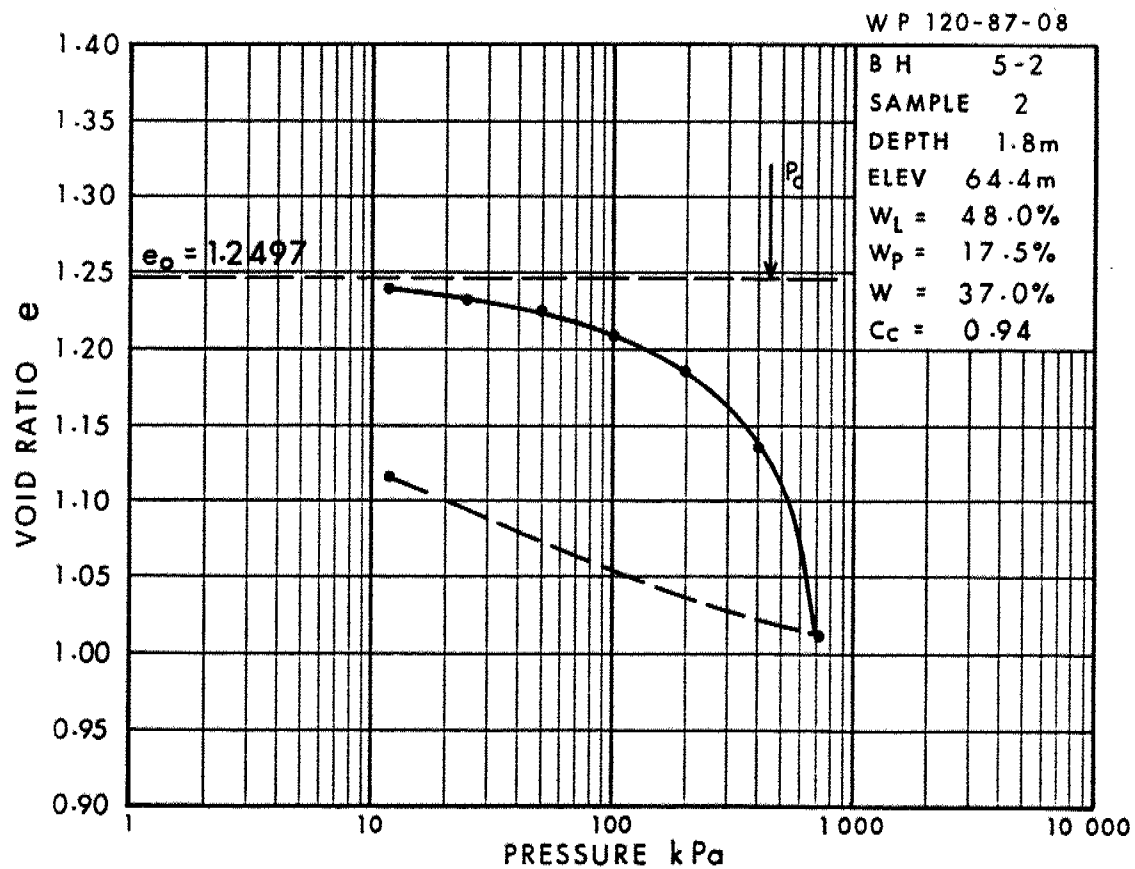
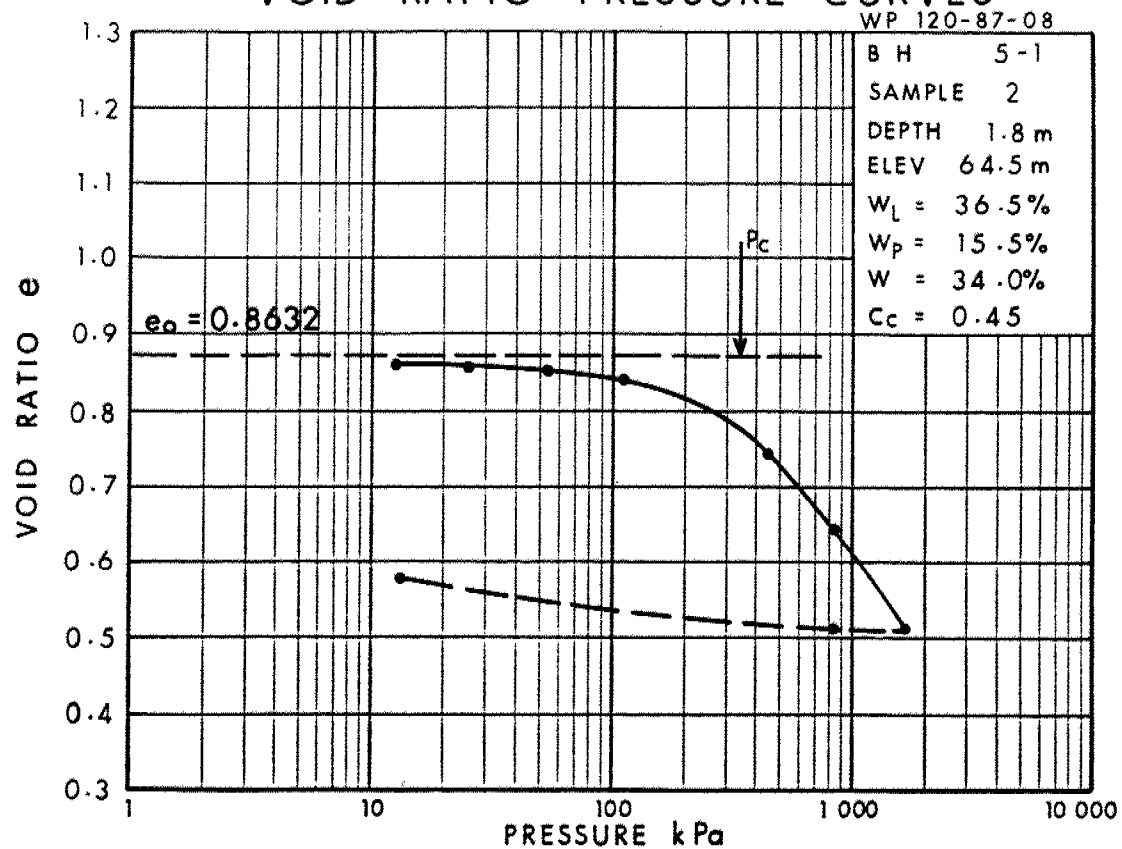


Fig 5

WP 120-87-06

# VOID RATIO - PRESSURE CURVES

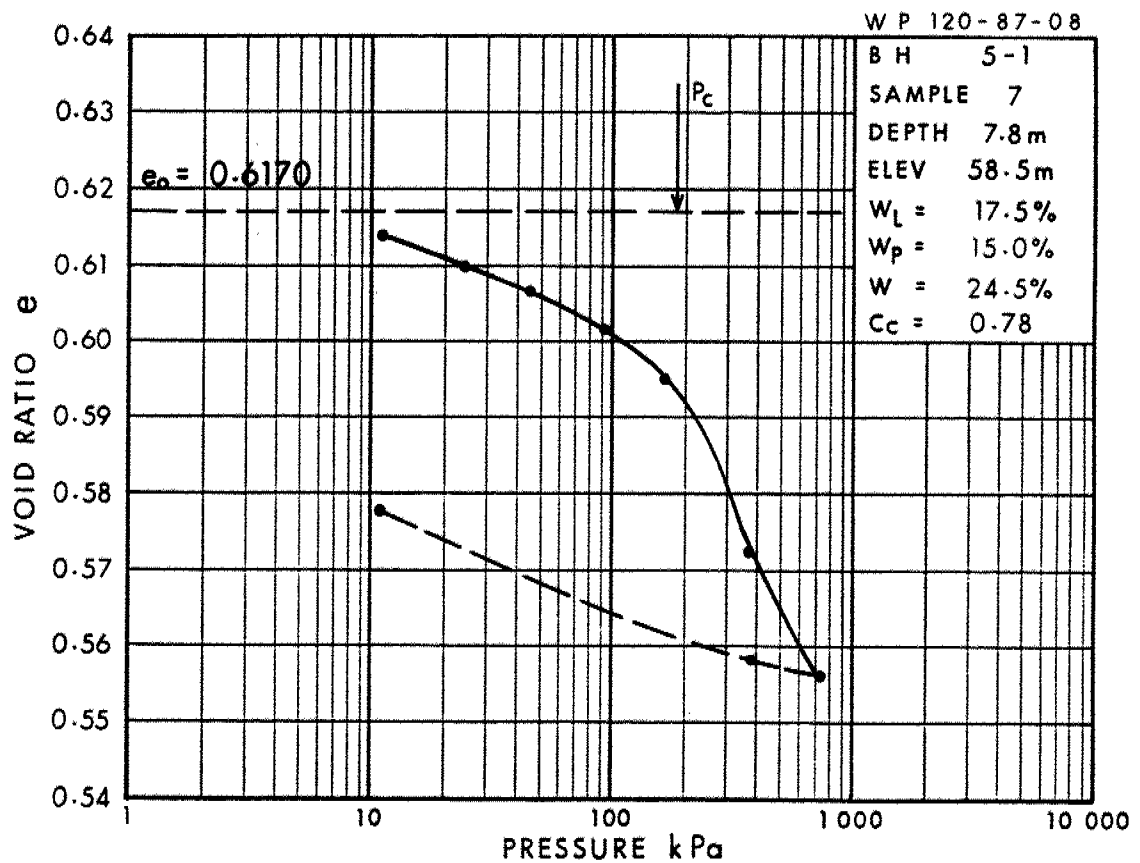
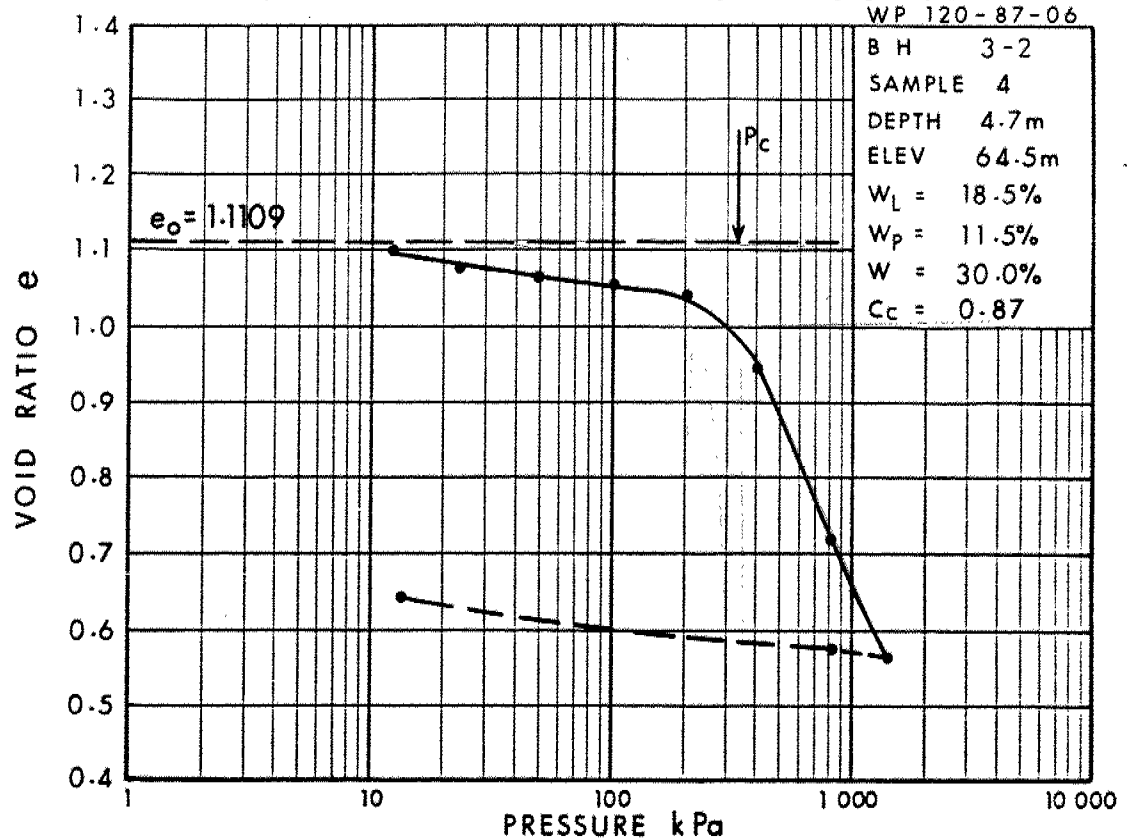
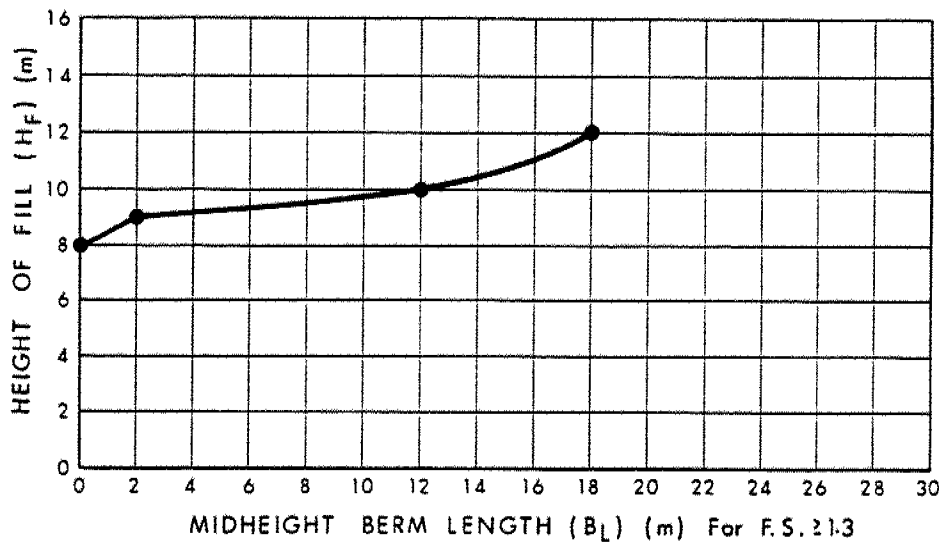
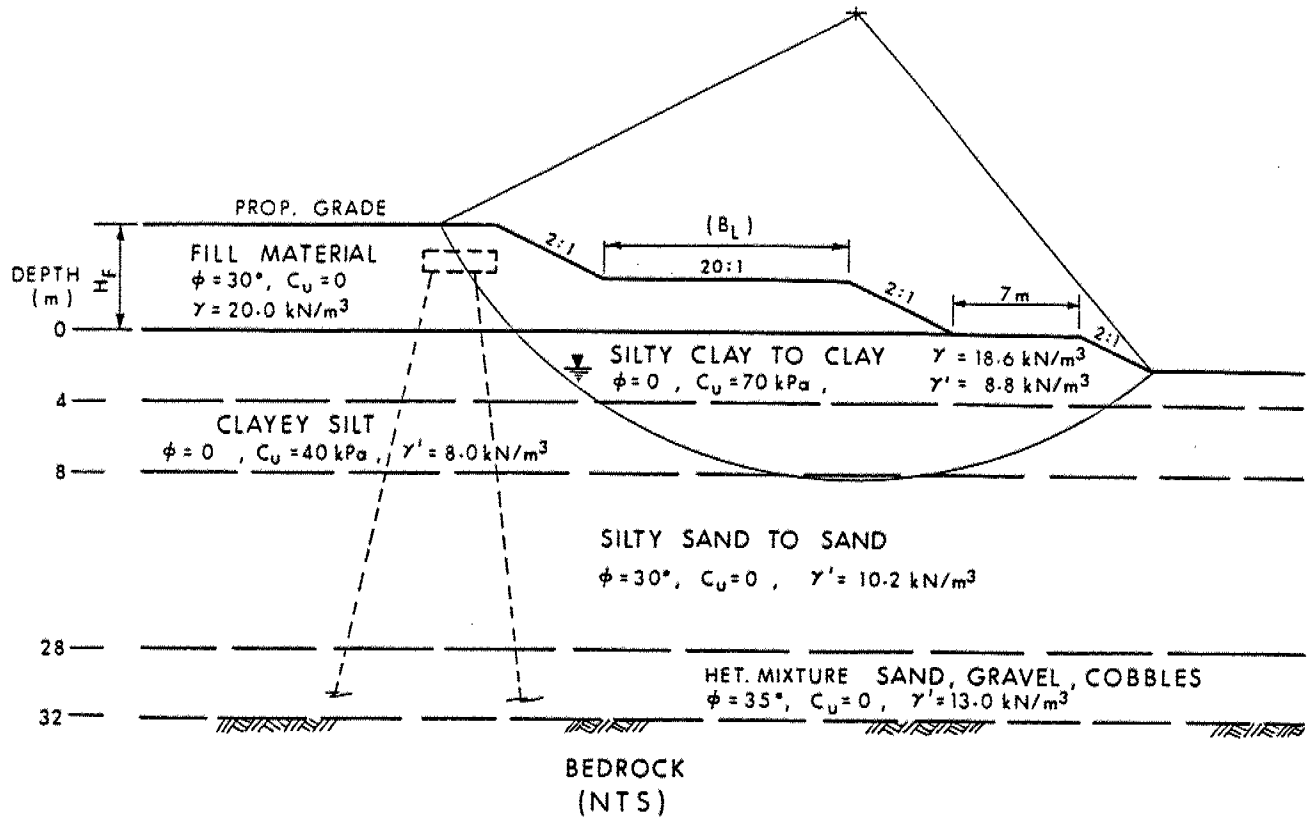


Fig 6

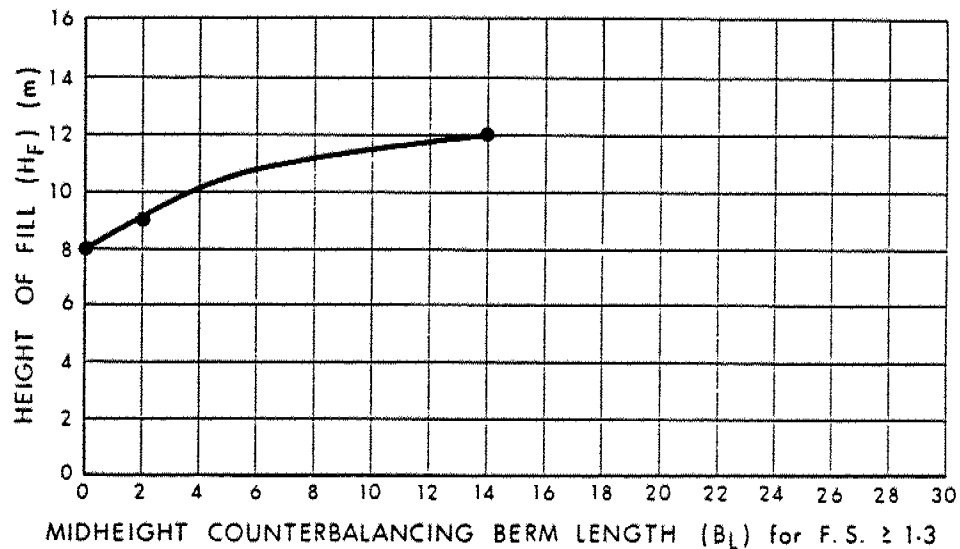
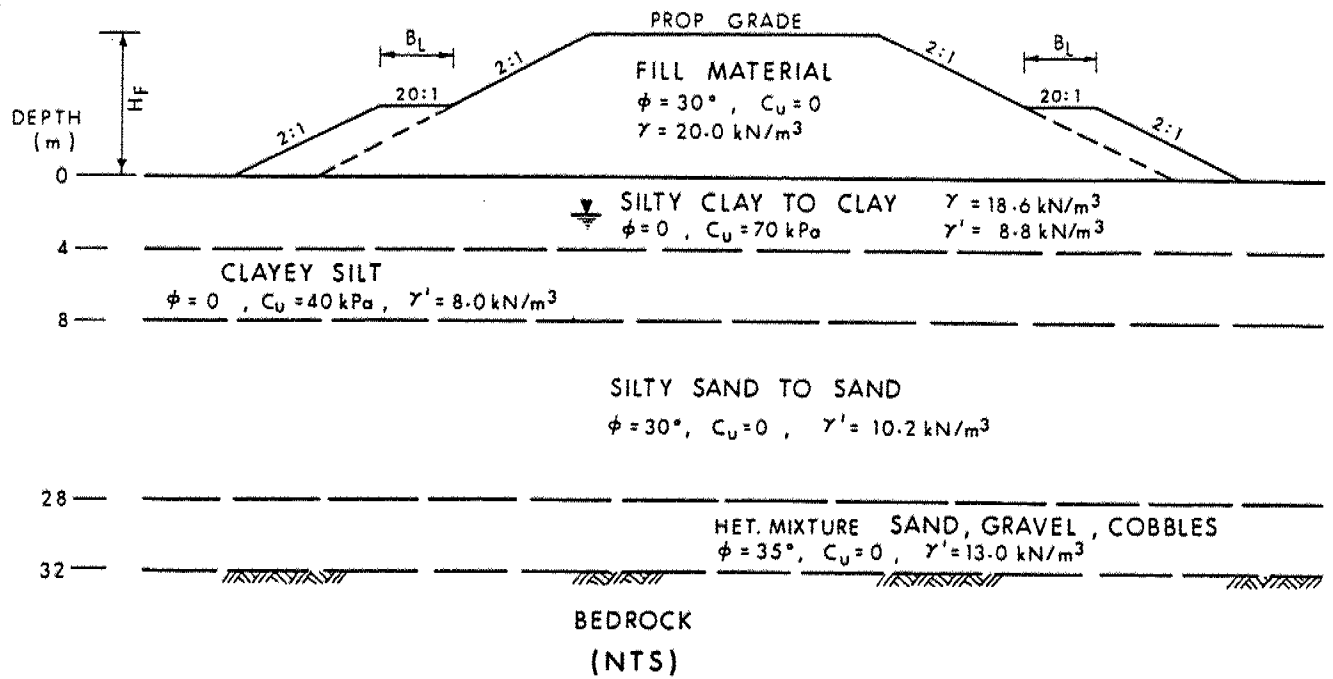
W P 120-87-06



EAST/WEST APPROACH EMBANKMENTS STABILITY ANALYSIS  
 LONGITUDINAL DIRECTION

WP 120-87-06

Fig 7

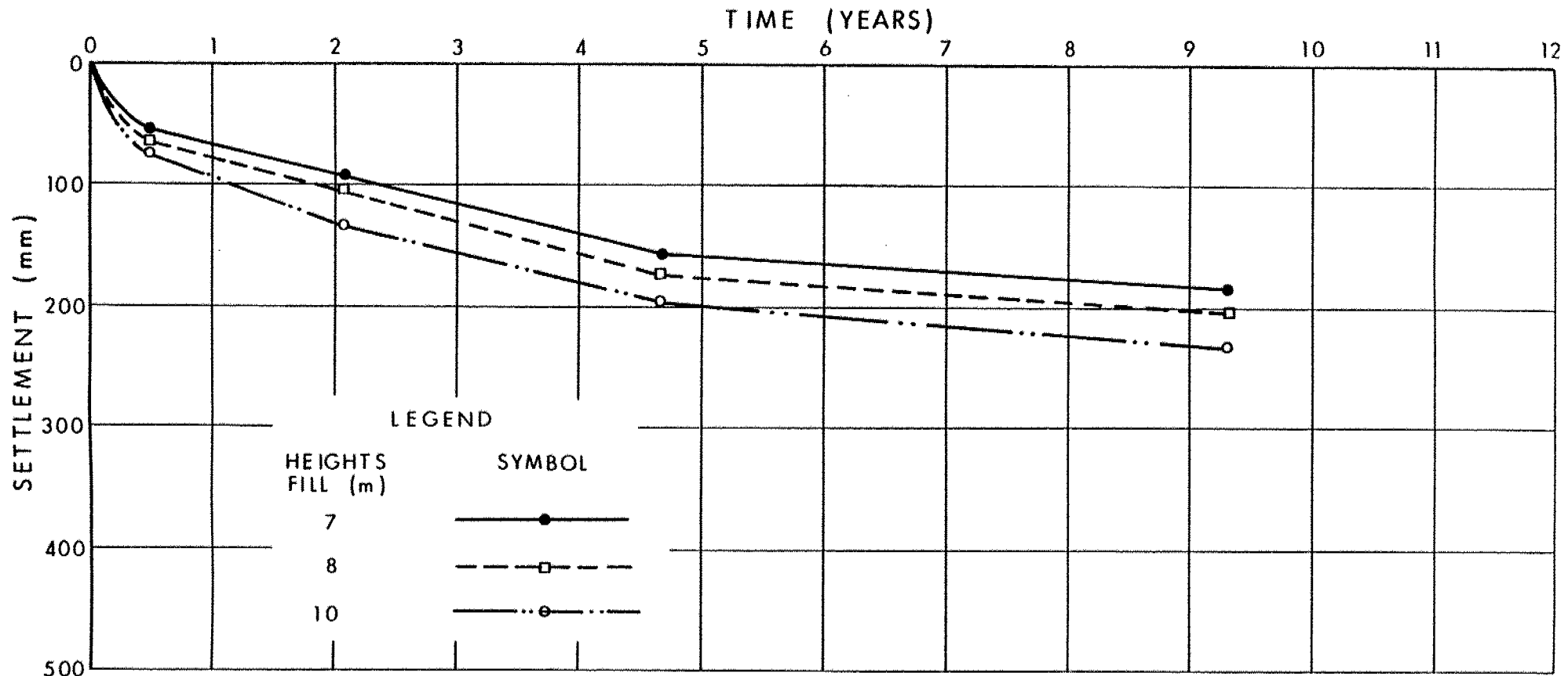


EAST / WEST APPROACH EMBANKMENTS STABILITY ANALYSIS  
TRANSVERSE DIRECTION

WP 120-87-06

Fig 8

Fig 10 - PREDICTED SETTLEMENT-TIME CURVES OF NATIVE SOILS UNDERLYING APPROACH EMBANKMENTS



LEGEND

HEIGHTS  
FILL (m)

SYMBOL

7

—●—

8

- - □ - -

10

- · · ○ · · -

ASSUMPTIONS

1) Unit Weight of Fill =  $20 \text{ kN/m}^3$

2) Osterberg Stress Distribution

3) Single Drainage

4) Coefficient of Consolidation ( $C_v$ )

(a) Silty Clay to Clay ( $0.026 \text{ m}^2/\text{day}$ )

(b) Clayey Silt with interbedded Sand ( $0.040 \text{ m}^2/\text{day}$ )

WP 120-87-06

Fig 9



**DESCRIPTION OF ROCK CORE - WP 120-87-06**

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
3-3	24.94-26.47	88	55	24.94-26.47	<b>SILTY DOLOSTONE</b> , light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: (i) flat, irregular, planar, slightly open, slightly altered; (ii) near vertical, closed, tight, calcite filled.
3-5	25.30-26.21	50	31	25.30-27.25	<b>SILTY DOLOSTONE</b> , light grey to medium dark grey; fine grained, dense; weak to medium strong rock; unweathered; very close to close spaced fractures: flat irregular, planar, slightly open, slightly altered.
	26.21-27.25	95	27		
3-7	27.10-27.89	100	66	27.10-28.65	<b>SILTY DOLOSTONE</b> , medium dark grey; fine grained; thinly bedded, minor argillaceous bands; medium strong rock; unweathered; very close to close spaced fractures: flat rough, planar, slightly open, slightly altered, clean.
	27.89-28.65	100	100		

NOTE: Depths are approximated in zones of poor core recovery.

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

1../1

**DESCRIPTION OF ROCK CORE - WP 120-87-07**

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-3	24.74-25.60	71	-	24.74-26.70	<b>OVERBURDEN</b> , contains foreign and locally derived bedrock material up to 0.35 m diameter.
	25.60-26.34	90	-	26.70-27.53	<b>SILTY DOLOSTONE</b> , medium dark grey; fine grained; thinly bedded; medium strong rock; unweathered to slightly weathered; very close to closely spaced fractures: flat rough, irregular, open, slightly altered.
	26.34-26.44	75	-		
	26.44-26.59	42	-		
	26.59-28.17	100	59	27.53-27.71	<b>SHALE</b> , greyish black to black; very fine grained; dense very thinly bedded; medium strong rock; unweathered; very close to closely spaced fractures: flat, very irregular, slightly open, unaltered, clean.
				27.71-28.17	<b>ARGILLACEOUS DOLOSTONE</b> , medium dark grey to dark grey; thinly bedded with argillaceous material; slightly vuggy; close spaced fractures: rough, planar, closed, clean; interbedded with <b>LIMESTONE</b> , dark grey, weathers to yellow brown; close spaced fractures: irregular, closed.
4-4	25.76-26.14	100	80	25.76-27.46	<b>SILTY DOLOSTONE</b> , medium dark grey; fine to medium grained, dense; medium strong rock; unweathered; very close to closely spaced fractures: rough, flat planar, slightly open, slightly altered; interbedded with <b>LIMESTONE</b> (22%), thinly bedded to 30 cm; undifferentiated from dolostone except for high calcite content.
	26.14-26.75	100	52		
	26.75-27.46	100	79		

NOTE: Depths are approximated in zones of poor core recovery.

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

**DESCRIPTION OF ROCK CORE - WP 120-87-07**

CORE RECOVERY				CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
4-5	24.66-25.55	29	-	24.66-26.29	<b>OVERBURDEN</b> , contains foreign and locally derived bedrock material.
	25.55-26.24	11	-		
	26.24-26.92	100	35	26.29-27.69	<b>SILTY DOLOSTONE</b> , medium dark grey; fine grained thinly bedded; medium strong rock; unweathered; moderately close spaced fractures: (i) flat, rough, planar, slightly altered, slightly open, clean; (ii) near vertical, rough, planar closed to slightly open, calcite filled.
	26.92-27.69	100	94		

NOTE: Depths are approximated in zones of poor core recovery.

\*CR = CORE RECOVERY

\*RQD = ROCK QUALITY DESIGNATION

## 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

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	$^\circ$	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	$^\circ$	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 3-1

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 619.2; E 358 552.6 ORIGINATED BY JF  
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY JF  
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
66.3	Ground Level													
0.0	Silty Clay to Clayey Silt, Some Sand	Brown	1	SS	15									
64.2	Soft to Stiff	Grey	2	TW	PH									
2.1	Clayey Silt with interbedded Sandy Silt		3	SS	2									
62.3	Soft to Firm		4	SS	4									
4.0	Silty Sand to Sand Some/Trace of Gravel Compact to Dense		5	SS	25									
			6	SS	24									
			7	SS	20									
			8	SS	41									
52.4														
13.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) V. Dense		9	SS	55/15cm									
50.8														
15.5	End of Borehole													

# RECORD OF BOREHOLE No 3-2

METRIC

W P 120-87-06 LOCATION CO-ORDS. N 5 022 644.2; E 358 595.9 ORIGINATED BY TK  
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY TK  
 DATUM Geodetic DATE 88 07 15 CHECKED BY TCK

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt, Trace Sand	Brown Grey	1	TW	PH		66							
	Soft		2	SS	2		64	5.1					47.5%	0 9 61 30
63.7	Clayey Silt with interbedded Sandy Silt		3	TW	PH		62	2.7					43.5%	0 20 48 32
2.5	Soft		4	TW	PH		60	3.5					19.0	0 31 48 21
60.6	Silty Sand to Sand Trace to some Gravel Compact to Dense		5	SS	13		58							
5.6			6	SS	17		56							
			7	SS	10		54							
			8	SS	42		52							
50.5	End of Borehole													
15.7														

A/

Table 1

<u>AREA</u>	<u>Elevation</u>	<u>Description</u>	<u>Field Vane</u>	<u>Shear Strength</u> <u>Unconfined</u>	<u>UU</u>
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B/

Table 2

<u>AREA</u>	<u>Elevation</u>	<u>Description</u>	<u>Moisture Content</u> <u>(w%)</u>	<u>Liquid Limit</u> <u>(w<sub>L</sub>%)</u>	<u>Plastic Limit</u> <u>(w<sub>p</sub>%)</u>
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C/

Table 3

<u>AREA</u>	<u>Elevation</u>	<u>Description</u>	<u>(preconsolidation pressure)</u> <u>PC</u>	<u>(past overburden pressure)</u> <u>P<sub>0</sub></u>	<u>Compression Index</u> <u>C<sub>e</sub></u>	<u>Expansion Index</u> <u>C<sub>R</sub></u>
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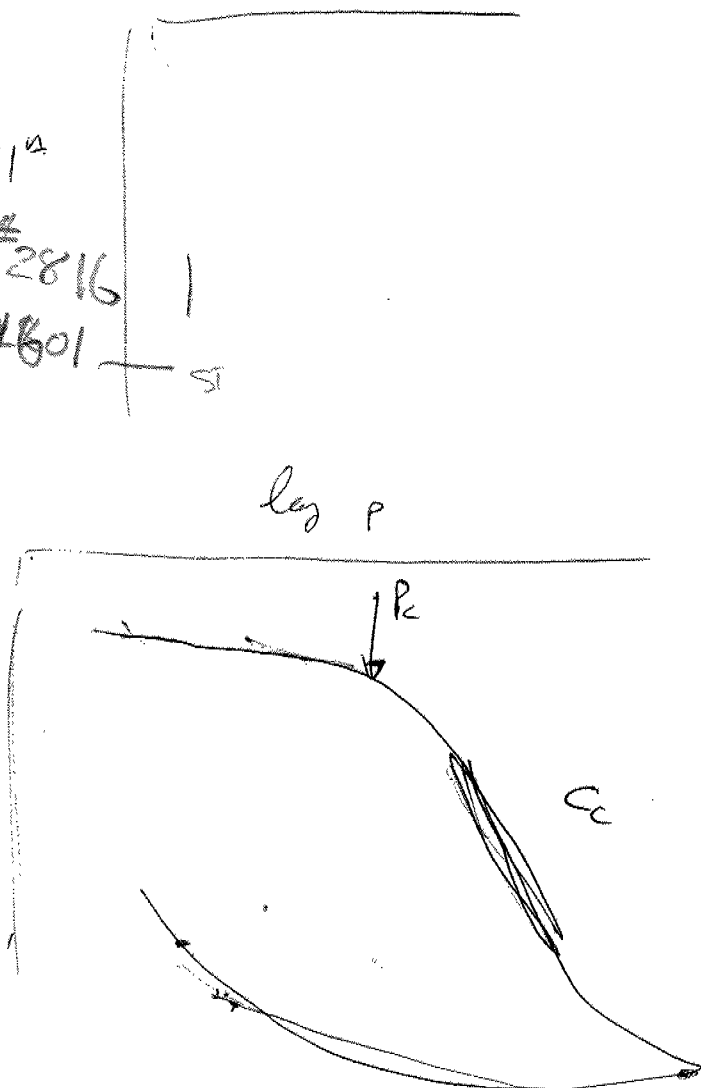
$C_u$

$EI^u$   
#2816 |  
+2601 — SI

$\log P$

$C_o$

$C_c$





# RECORD OF BOREHOLE No 3-3

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 664.5; E 358 609.9 ORIGINATED BY JF  
 DIST 9 HWY 417 BOREHOLE TYPE Washboring, Rock Coring & Cone Test COMPILED BY JF  
 DATUM Geodetic DATE 88 07 12 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.2	Ground Level													
0.0	Silty Clay to Clayey Silt Trace Sand	Brown Grey	1	SS	17		66							
63.7	Soft to Very Stiff		2	TW	PM		64		4.2				17.5	0 2 47 51
2.5	Clayey Silt with interbedded Sandy Silt Soft to Firm		3	TW	PM		62		6.8				18.7	0 37 40 23
58.4			4	SS	2		60							
7.8			5	SS	2		58							1 22 51 26
			6	SS	31		56							
	Silty Sand to Sand Some to trace of Gravel		7	SS	51		54							43 40 13 4
	Occ. Gravelly Sand Layers		8	SS	38		52							
	Dense to Very Dense		9	WS	-		50							
			10	SS	75/	8cm	48							
			11	SS	82		46							
43.4			12	WS	-		44							
22.8	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till)		13	SS	112/	20cm	42							
41.3	Very Dense		14	RC	88%		40							RQD = 55%
24.9	Bedrock													
39.7	Silty Dolostone													
26.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3-4

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 656.9; E 358 629.4 ORIGINATED BY TK  
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK  
DATUM Geodetic DATE 88 07 13 - 14 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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					
66.1	Ground Level													
0.0	Silty Clay to Clayey Silt Some Sand Firm	Brown Grey	1	SS	7		66							
63.6			2	TW	PH		64							0 24 45 31
2.5	Clayey Silt with interbedded Sandy Silt Very Soft		3	TW	PH		62							
			4	TW	PH		60							
59.0			5	SS	1		58							
7.1			6	SS	3		56							
	Silty Sand to Sand Trace to some Gravel Very Loose to Dense		7	SS	30		54							
			8	SS	14		52							
			9	SS	30		50							
			10	SS	44		48							
46.1							46							
20.0	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	46		44							8 78 6 8
41.3			12	SS	44		42							27 57 14 2
24.8	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3-5

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 681.6; E 358 640.8 ORIGINATED BY TK  
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Rock Core & Cone Test COMPILED BY TK  
DATUM Geodetic DATE 88 07 11, 12, 13 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.0	Ground Level													
0.0	Silty Clay to Clayey Silt with Sand	Brown Grey	1	TW	PH			2.6					20.3	0 33 43 24
63.3	Soft to Firm	Grey	2	TW	PH								20.0	2 35 42 21
2.7	Sand with Some Silt, Trace Clay	Brown	3	TW	PH									0 74 20 6
62.0	Clayey Silt with interbedded Sandy Silt		4	SS	2/60 cm									
4.0	Very Soft to Firm		5	SS	5									0 42 40 18
58.9			6	SS	15									
7.1	Silty Sand to Sand Trace Gravel Occ. Silt Seams Compact to Dense		7	SS	13									
			8	SS	30									
			9	SS	36									
			10	SS	43									1 18 77 4
44.4														
21.6	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till) Dense		11	SS	45									26 65 (9)
40.7														
25.3	Bedrock Silty Dolostone		12	RC	REC 50%									RQD = 31%
38.7			13	RC	REC 95%									RQD = 27%
27.3	End of Borehole													

+3, x5: Numbers refer to 20  
Sensitivity 15-5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

## METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 675.2; E 358 657.1 ORIGINATED BY TK  
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring & Cone Test COMPILED BY TK  
DATUM Geodetic DATE 88 07 13, 14 CHECKED BY TCK

[illegible]

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 3-7

METRIC

W P 120-87-06 LOCATION Co-ords. N 5 022 700.2; E 358 667.6 ORIGINATED BY TK  
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Rock Coring, Cone Test COMPILED BY TK  
 DATUM Geodetic DATE 88 07 06, 07 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
66.0	Ground Level													
0.0														
65.2	Clayey Silt (Fill)													
0.8			1	TW	PH									
64.4	Silty Sand		2	TW	PH									
1.6	Clayey Silt		3	SS	13									
	Silty Sand to Sand		4	SS	3									
	Trace to Some Gravel													
	Very Loose to Compact		5	SS	14									
			6	SS	10									
			7	SS	14									
	Brown Grey		8	SS	30									
			9	SS	41									
	Loose to Very Dense		10	SS	8									
			11	SS	57									
			12	SS	59									
42.1														
23.9	Het. Mixt. of Sand, Gravel and Boulders (Glacial Till)		13	SS	57									
	Very Dense		14	SS	52									
38.9														
27.1	Bedrock		15	RC	REC 100%									
37.3	Silty Dolostone		16	RC	REC 100%									
28.7	End of Borehole													

+3, x5: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 3-8

METRIC

W P 120-87-06 LOCATION Co-Ords N 5 022 692.6; E 358 687.1 ORIGINATED BY TK  
 DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger, Washboring, Cone Test COMPILED BY TK  
 DATUM Geodetic DATE 88 07 07 & 08 CHECKED BY TCK

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 <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> 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						
65.5	Ground Level										
0.0	Clayey Silt to Silt	X	1	TW	PH						
63.9	Soft (Fill)		2	TW	PH						
1.6	Silty Sand to Sand		3	SS	5						3 80 (17)
	Trace to Some		4	SS	5						0 94 (6)
	Gravel		5	SS	6						
	Loose		6	SS	2						
	Brown Grey		7	SS	8						
	Very loose to Dense		8	SS	27						
			9	SS	20						
			10	SS	42						0 94 (6)
41.2	Het. Mixture of		11	SS	2/	8cm*					
24.3	Sand, Gravel & Boulders										
40.4	Very Dense										
25.1	(Glacial Till)										
	END OF BOREHOLE										
	*Sampler Bouncing Due to Boulder or Bedrock										

# RECORD OF BOREHOLE No 3-9

METRIC

W P 120-87-06 LOCATION Co-Ords N 5 022 704.2; E 358 694.0 ORIGINATED BY TK  
 DIST 9 HWY 417 BOREHOLE TYPE Hollowstem Auger & Cone Test COMPILED BY TK  
 DATUM Geodetic DATE 88 07 08,09 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
64.5	Ground Level													
0.0	Organic Silty Sand (Fill)		1	SS	5									
63.1	Silty Sand to Sand trace of Gravel		2	SS	7									
1.4	Loose		3	SS	9									
			4	SS	9									
	Brown Grey		5	SS	8									
			6	SS	25									
	Loose to very Dense		7	SS	59									
			8	SS	44									
48.8			9	SS	26									
15.7	END OF BOREHOLE													

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 4-3

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 647.3; E 358 647.5  
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washboring, Rock Core, Cone Test  
 DATUM Geodetic DATE 88 07 11-13  
 ORIGINATED BY JBF  
 COMPILED BY JBF  
 CHECKED BY TCK

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
66.1	Ground Level												
0.0	Silty Clay to Clayey Silt		1	SS	11								
			2	TW	PH								
63.6	Soft to Stiff												0 62 ( 38 )
2.5	Clayey silt with Brown interbedded Sandy Silt		3	SS	3								0 13 57 30
			4	SS	2								0 21 35 44
	Soft		5	SS	2								
59.0													
7.1	Silty Sand to Sand Trace to Some Gravel occ. Boulders occ. Gravelly Sand Layers Compact to very Dense		6	SS	34								
			7	SS	36								
			8	RC	-								
			9	SS	27								34 54 8 4
			10	RC	-								
			11	SS	63								37 54 8 1
			12	SS	35								
			13	SS	70								
43.2													
22.9	Het. Mixture of Sand, Gravel and Boulders Very Dense (Glacial Till)		14	SS	29/20cm								
			15	RC	REC 71%								
			16	RC	REC 90%								
39.5			17	RC	REC 56%								
26.6	Bedrock												
	Silty Dolostone		19	RC	REC 100%								
37.9	END OF BOREHOLE												RQD = 59%
28.2	* Bouncing on Boulder												

+3, x5: Numbers refer to Sensitivity  
 20  
 15  
 10  
 5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 4-4

METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 663.6; E 358 668.4 ORIGINATED BY TCK  
 DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, 'B' Casing, Washbore, Rock Core, Cone Test COMPILED BY JBF  
 DATUM Geodetic DATE 88 07 11-13 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
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		
66.1	Ground Level												
0.0	Clayey Silt to Silty Sand (Fill)		1	SS	10								
			2	TW	PH								
63.6													
2.5	Clayey Silt with Brown Interbedded Grey Sandy Silt		3	TW	PH							18.9	0 20 43 37
			4	TW	PH							19.0	
59.8	Soft												
6.3													
	Silty Sand to Sand		5	SS	10								
			6	SS	18								7 75 11 7
	Trace to Some Gravel Occ. Silt seams		7	SS	23								
	Compact to Dense		8	SS	31								
			9	SS	48								0 30 64 6
44.8													
21.3	Het. Mixture of Sand, Gravel and Boulders Dense (Glacial Till)		10	SS	37								
			11	RC	-								
			12	SS	50								41 51 7 1
40.3													
25.8	Bedrock		13	RC	REC	100%							RQD=80%
			14	RC	REC	100%							RQD=52%
38.6	Silty Dolostone		15	RC	REC	100%							RQD=79%
27.5	END OF BOREHOLE												

OFFICE REPORT ON SOIL EXPLORATION

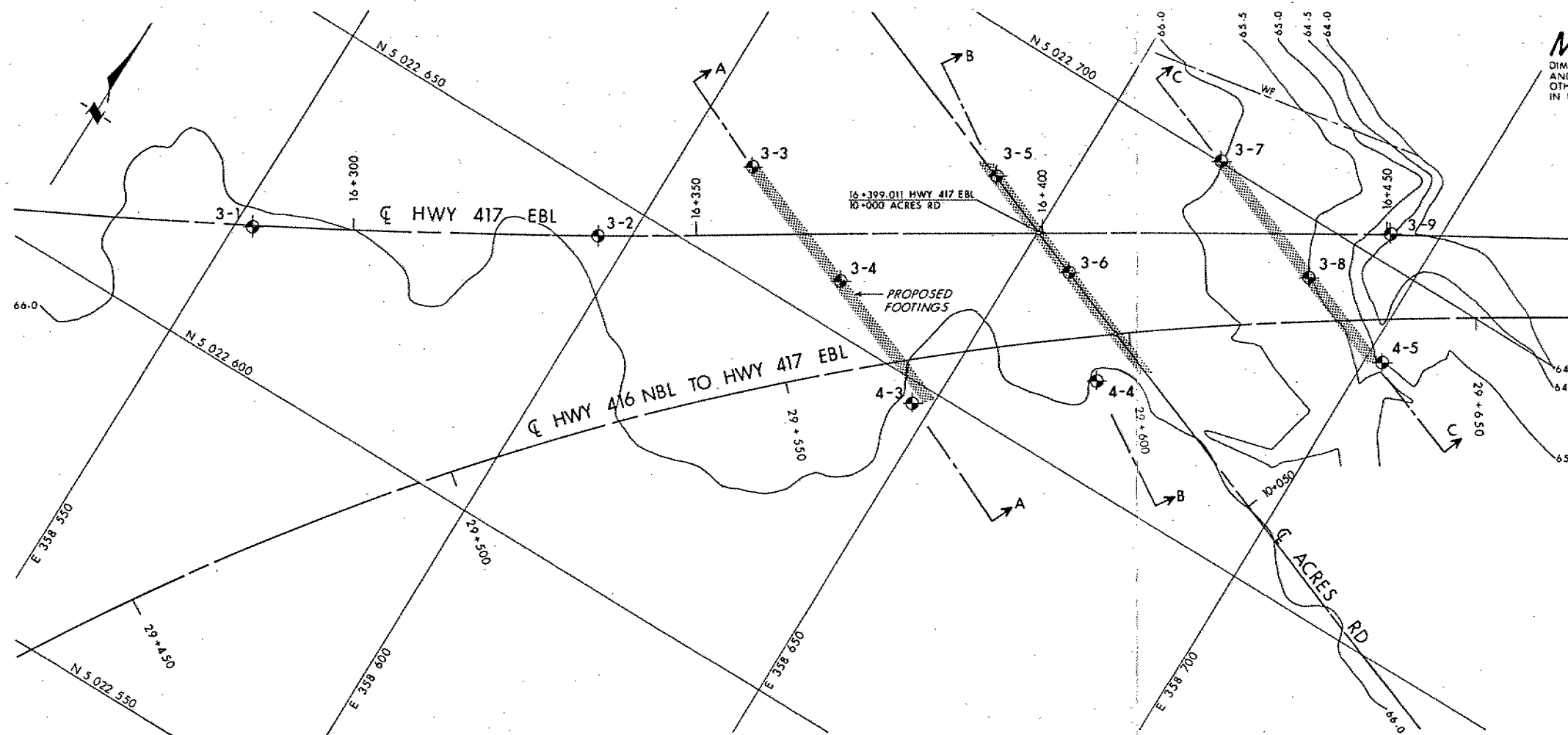
## METRIC

W P 120-87-07 LOCATION Co-Ords N 5 022 687.7; E 358 702.6 ORIGINATED BY BWF/TCK  
DIST 9 HWY 416/417 BOREHOLE TYPE Hollowstem Augers, Washbore, Rock Core, Cone Test COMPILED BY JBF  
DATUM Geodetic DATE 88 07 09-11 CHECKED BY TCK

[illegible]

+3, x5: Numbers refer to Sensitivity

15  $\phi$  5 (%) STRAIN AT FAILURE

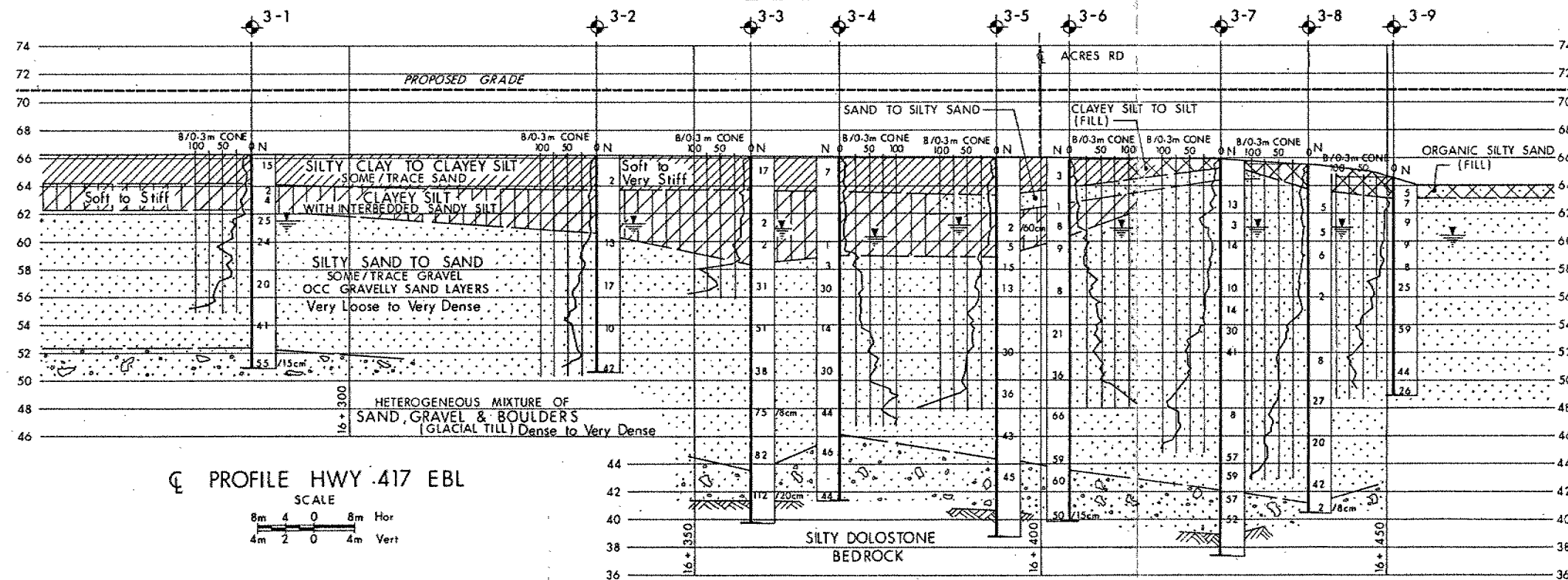


PLAN

SCALE  
8m 4 0 4m 8m

NOTE:

For Sections A-A, B-B and C-C  
Refer to Dwg No 1208706-B



PROFILE HWY 417 EBL

SCALE  
8m 4 0 4m 8m Hor  
4m 2 0 4m Vert

METRIC

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

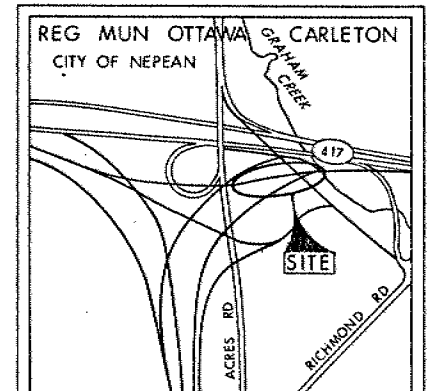
CONT No  
WP No 120-87-06

HWY 417 EBL OVER ACRES RD  
(STRUCTURE-3)

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



KEY PLAN

SCALE  
0.2km 0.1 0 0.1 0.2km

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 88 07

No	ELEVATION	CO-ORDINATES NORTH	EAST
3-1	66.3	5 022 619.2	358 552.6
3-2	66.2	5 022 644.2	358 595.9
3-3	66.2	5 022 664.5	358 609.9
3-4	66.1	5 022 656.9	358 629.4
3-5	66.0	5 022 681.6	358 640.8
3-6	65.9	5 022 675.2	358 657.1
3-7	66.0	5 022 700.2	358 667.6
3-8	65.5	5 022 692.6	358 687.1
3-9	64.5	5 022 704.2	358 694.0
4-3	66.1	5 022 647.3	358 647.5
4-4	66.1	5 022 663.6	358 668.4
4-5	65.0	5 022 687.7	358 702.6

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 31G5-146

HWY No 417	DIST 9
SUBMITTAL CHECKED	DATE 88 10 19
DRAWN DT	SITE 3-533
CHECKED	DWG 1208706-A

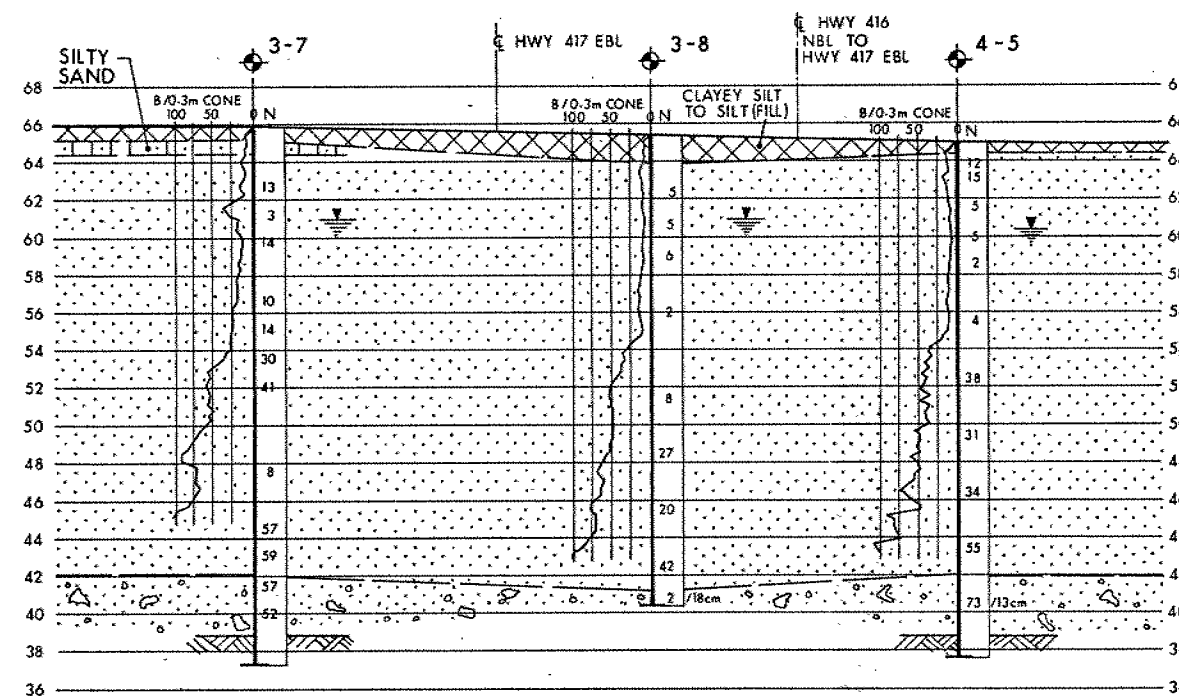
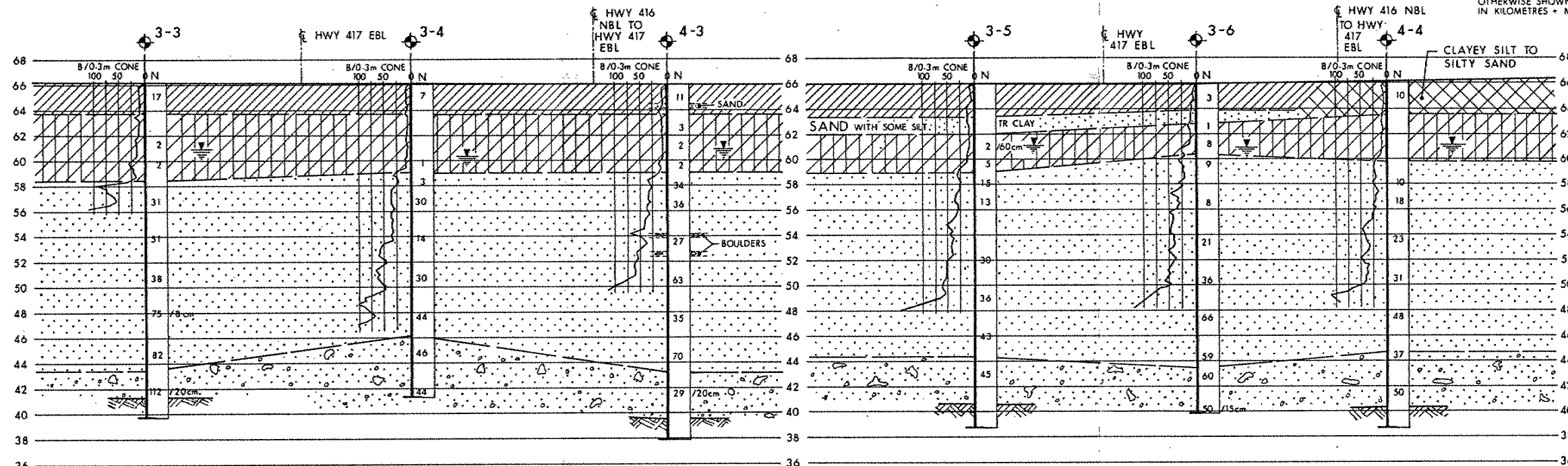
**METRIC**

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

CONT No  
WP No 120-87-06

HWY 417 EBL OVER ACRES RD  
[STRUCTURE -3]  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



SECTIONS

SCALE



NOTE:

For Plan and Profile  
Refer to Dwg. No 1208706-A

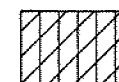
**SOIL STRATIGRAPHY LEGEND**



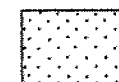
CLAYEY SILT  
(FILL MATERIAL)



SILTY CLAY TO CLAYEY SILT  
SOME / WITH SAND  
Soft to Very Stiff



CLAYEY SILT  
WITH INTERBEDDED SANDY SILT  
Soft to Stiff



SILTY SAND TO SAND  
TRACE/SOME GRAVEL  
OCC SILT SEAMS  
OCC GRAVELLY SAND LAYERS  
OCC BOULDERS  
Very Loose to Very Dense



HETEROGENEOUS MIXTURE  
SAND, GRAVEL & BOULDERS  
(GLACIAL TILL)  
Dense to Very Dense



SILTY DOLOSTONE  
BEDROCK

**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 88 07

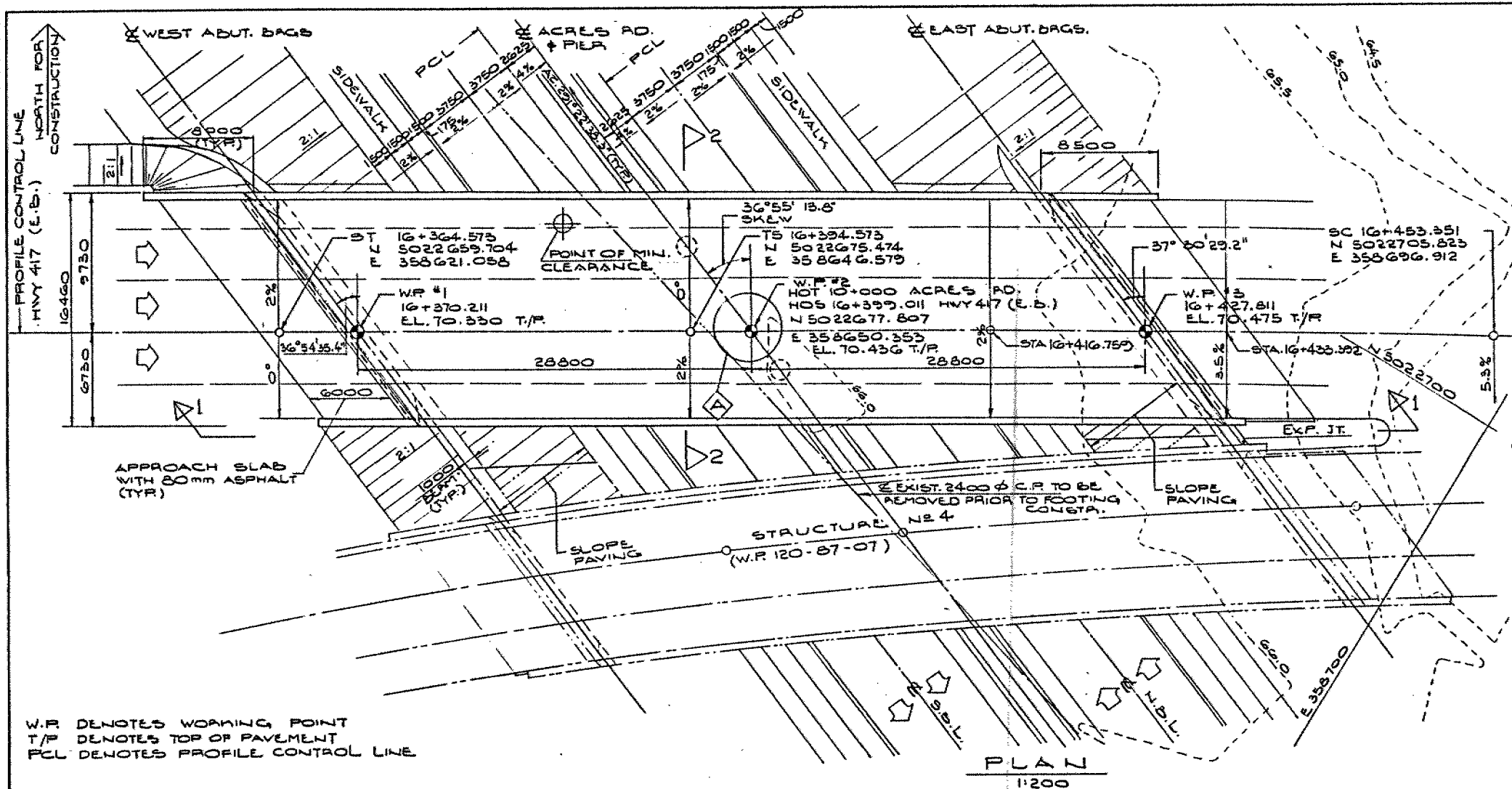
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
3-3	66.2	5 022 664.5	358 609.9
3-4	66.1	5 022 658.9	358 629.4
3-5	66.0	5 022 681.6	358 640.8
3-6	65.9	5 022 675.2	358 657.1
3-7	66.0	5 022 700.2	358 667.6
3-8	65.5	5 022 692.6	358 687.1
4-3	66.1	5 022 647.3	358 647.5
4-4	66.1	5 022 663.6	358 668.4
4-5	65.0	5 022 687.7	358 702.6

**NOTE**

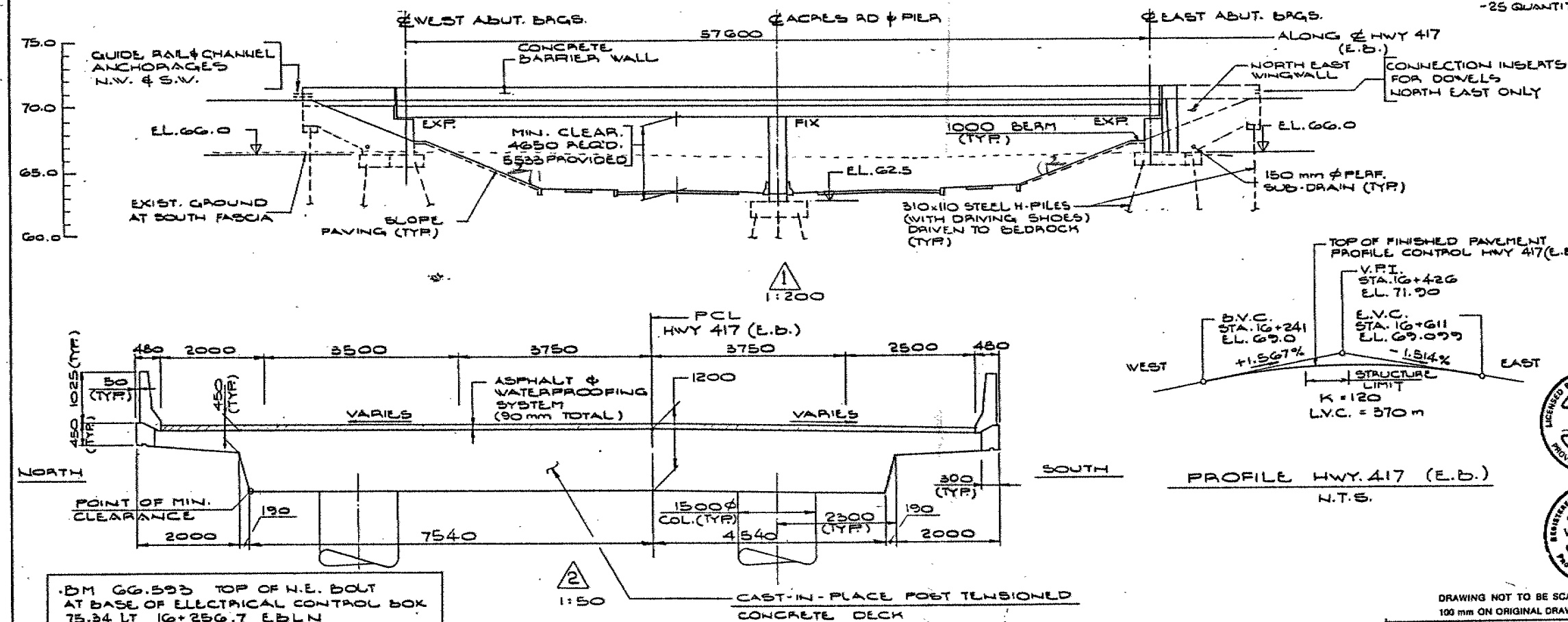
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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 31G5-146			
HWY No 417		DIST 9	
SUBMD TCK CHECKED		DATE 88 10 24	
DRAWN DT CHECKED		SITE 3-533	
		DWG 1208706-B	



W.P. DENOTES WORKING POINT  
T/P DENOTES TOP OF PAVEMENT  
PCL DENOTES PROFILE CONTROL LINE



METRIC

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

**DIST. 9**

CONT No

WP No 120-87-06

HWY 417 E.B.L. OVER  
ACRES RD. 0' PASS (STR.#3)  
GENERAL ARRANGEMENT

## Enco

**FENCO ENGINEERS INC.**

GENERAL NOTES:

CLASS OF CONCRETE

COLUMNS & DECK	35 MFA
REMAINDER	30 MFA

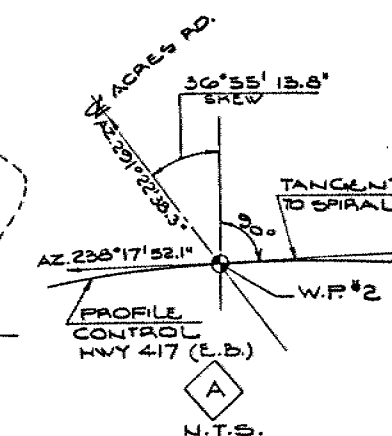
CLEAR COVER TO REINF. STEEL	
FOOTINGS	100 ± 25

ABUTMENTS, MINGWALLS	80 ± 20
FRONT FACE	70 ± 20
BACK FACE	80 ± 20
COLUMNS	70 ± 20
DECK	50 ± 10
TOP	
BOTTOM & SIDES	

REINFORCING STEEL

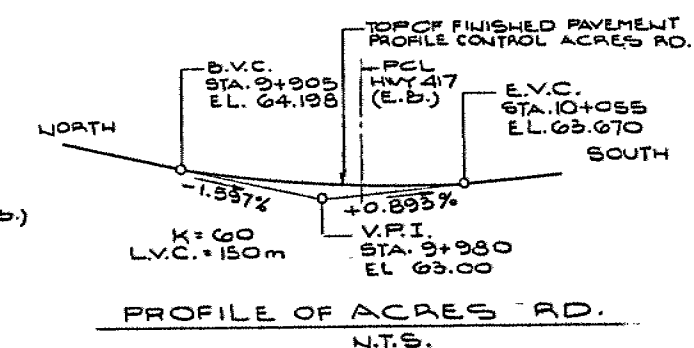
REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX C DENOTE COATED BARS.

CONSTRUCTION NOTES  
IF THE ACTUAL BEARING HEIGHTS ARE  
DIFFERENT FROM THE ASSUMED HEIGHT  
GIVEN WITH THE BEARING DESIGN  
DATA THE CONTRACTOR SHALL ADJUST  
THE BEARING SEAT ELEVATIONS AND  
THE REINFORCING STEEL TO SUIT THE  
ACTUAL HEIGHTS.



LIST OF DRAWINGS:

- 03-533-1 GENERAL ARRANGEMENT
- 2 BOREHOLE LOCATION & SOIL STRATA
- 3 FOUNDATION LAYOUT
- 4 FOUNDATION REINFORCEMENT
- 5 WEST ABUTMENT I
- 6 WEST ABUTMENT II
- 7 EAST ABUTMENT
- 8 PIER DETAILS
- 9 DECK LAYOUT & DETAILS
- 10 LONGITUDINAL STRESSING
- 11 TRANSVERSE STRESSING I
- 12 TRANSVERSE STRESSING II
- 13 DECK REINFORCEMENT I
- 14 DECK REINFORCEMENT II
- 15 NORTH BARRIER WALL
- 16 SOUTH BARRIER WALL
- 17 JOINT ANCHORAGE & ARMOURING
- 18 6000mm APPROACH SLAB
- 19 FLAGSTONE/CONC. SLOPE PAVING
- 20 STANDARD DETAILS
- 21 BRIDGE DATE & SITE NUMBERS
- 22 AS CONSTRUCTED ELEV. & DIMS
- 23 EMBEDDED WORK IN STRUCTURE
- 24 QUANTITIES - STRUCTURE I
- 25 QUANTITIES - STRUCTURE II



PROFILE OF ACRES RD.  
N.T.S.

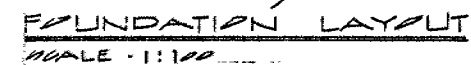
### APPLICABLE STANDARDS

DD-3503 MINIMUM GRANULAR BACKFILL  
REQUIREMENTS  
OPSD-508.02 BRIDGE DECK WATERPROOFING

OPSD-508.02 BRIDGE DECK WATERPROOFING

REVISIONS									
DATE		BY		DESCRIPTION					
DESIGN		P. T. CHK W.Y.C.		CODE		CHD-DC-83		LOAD CLASS A DATE NOV. 1985	
DRAWN		M. K. CHK W.Y.C.		SITE		C3-533		STRUCT SCHEME DWG. 1	

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING



REVISIONS							
DATE	BY	DESCRIPTION					
DESIGN <u>PT</u>	CHK <u>B.H.</u>	CODE <u>MOD 53</u>	<u>LOAD</u>			DATE <u>NOV 59</u>	
DRAWN <u>J.J.</u>	CHK <u>P.T.</u>	SITE <u>05-533</u>	ISTRUCT			SCHEME	DWG. <u>5</u>

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING



DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 31C-146

DIST. 8 REGION

W.P. No. 89-84-02

CONT. No. 90-40

W. O. No.

STR. SITE No. 7-79

HWY. No. 401

LOCATION Hwy 401 & Sir John A. MacDonaldd  
Blod

No of PAGES -

=====  
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry of  
Transportation and  
Communications

FILE No. \_\_\_\_\_ DATE \_\_\_\_\_

REMARKS \_\_\_\_\_

MAINTENANCE SUPER MIKE GRIFF

BILL BARRE PATROL SUPER



METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

DISTRICT 8

HWY.401

CONT No

WP No 89-84-02

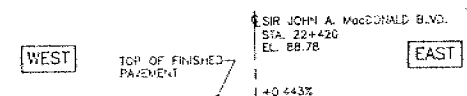
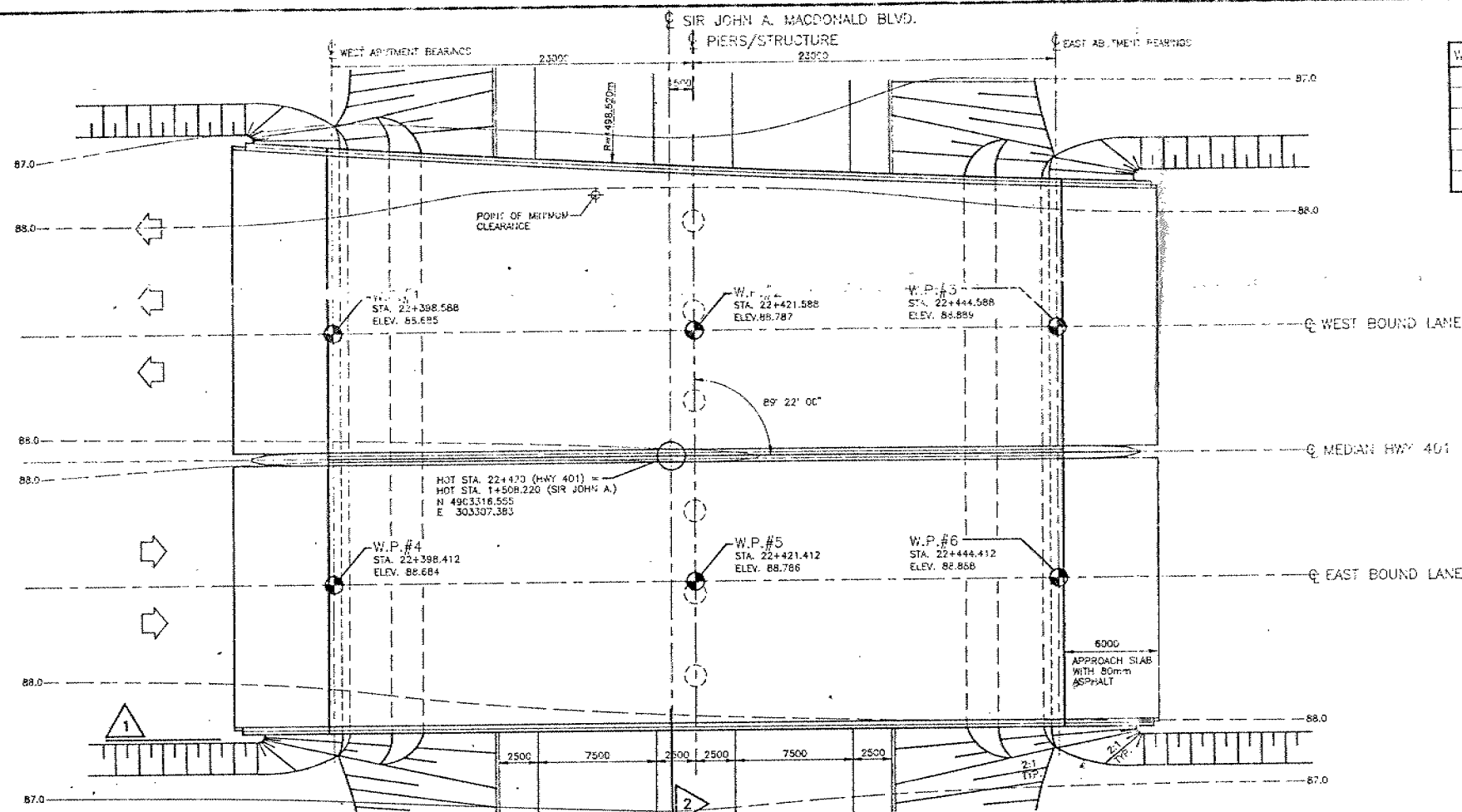
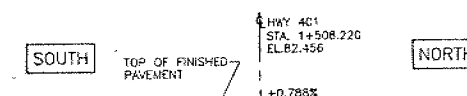
SIR JOHN A. MACDONALD BLVD.  
OVERPASS AT HWY.401

GENERAL ARRANGEMENT

**McNEELY ENGINEERING  
& STRUCTURES LTD.**  
CONSULTING ENGINEERS  
815 PRINCESS STREET  
KINGSTON, ONTARIO K7L 1G6  
PHONE (613) 549-0500

SHEET

W.P.#	NORTHING	EASTING
1	4903331.850	303290.218
2	4903320.488	303311.714
3	4903315.284	303333.208
4	4903316.760	303284.350
5	4903308.576	303305.858
6	4903300.393	303327.350

PROFILE OF E.B.L. & W.B.L. HWY.401  
N.T.S.PROFILE OF N.B.L. & S.B.L.  
SIR JOHN A. MACDONALD BLVD.  
N.T.S.

## GENERAL NOTES:

## CLASS OF CONCRETE

DECK AND PIER COLUMNS-----35 MPa  
REMAINDER (UNLESS NOTED OTHERWISE)-----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 AND SIDES-----50±10  
REMAINDER UNLESS NOTED OTHERWISE-----70±20

## REINFORCING STEEL

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

## CONSTRUCTION NOTE

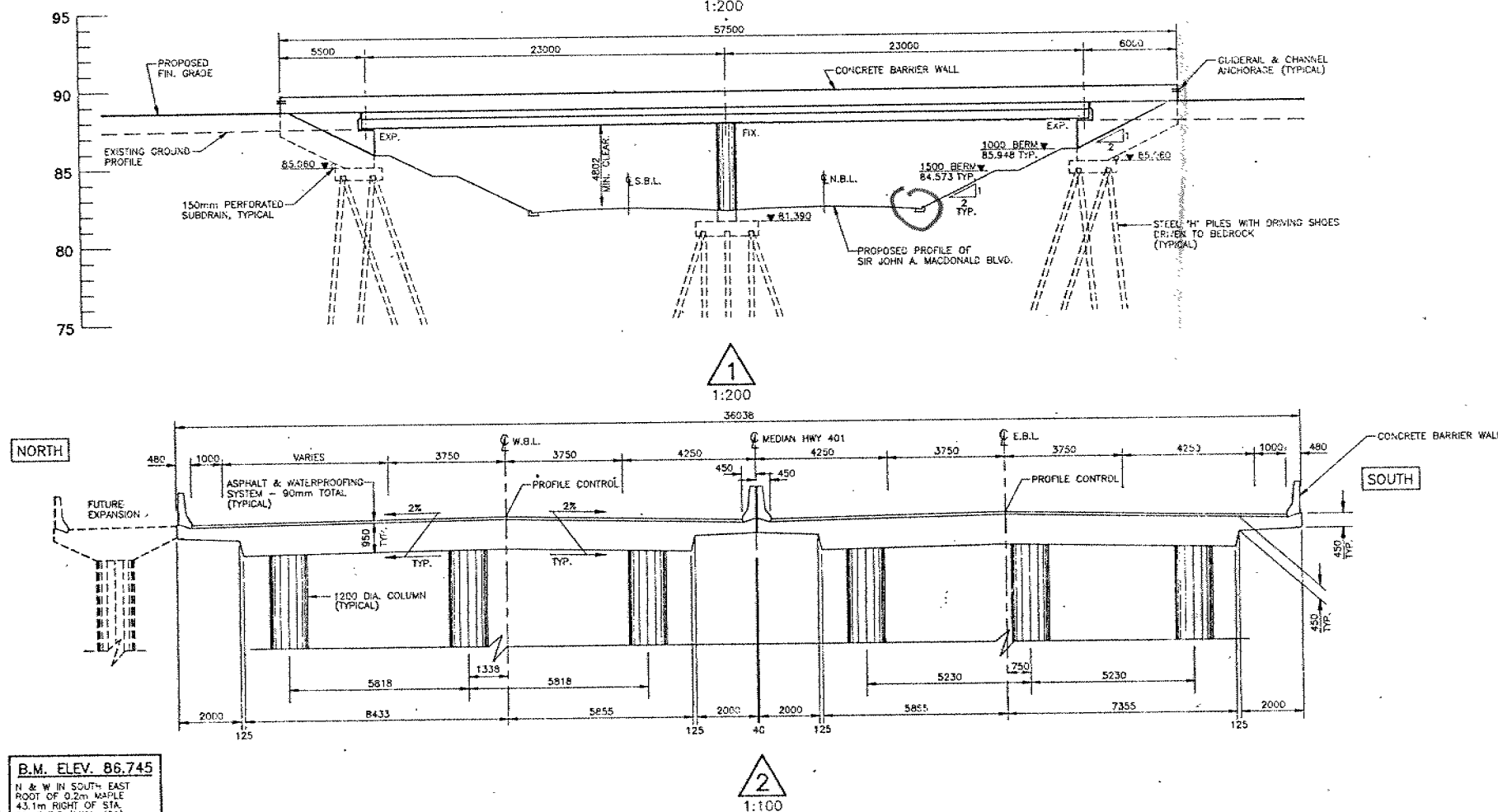
IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED HEIGHTS  
GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE  
BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTUAL  
HEIGHTS.

## LIST of DRAWINGS

- 1 - GENERAL ARRANGEMENT
- 2 - BORE HOLE LOCATION AND SOIL DATA
- 3 - DETOUR SHORING
- 4 - ABUTMENT FOOTINGS
- 5 - PIER AND PIER FOOTINGS
- 6 - WEST ABUTMENT (E.B.L.)
- 7 - WEST ABUTMENT (W.B.L.)
- 8 - EAST ABUTMENT (E.B.L.)
- 9 - EAST ABUTMENT (W.B.L.)
- 10 - DECK LAYOUT AND BEARINGS
- 11 - PRESTRESSING (LONGITUDINAL)
- 12 - PRESTRESSING (TRANSVERSE)
- 13 - PRESTRESSING (DETAILS)
- 14 - DECK REINFORCING (E.B.L.)
- 15 - DECK REINFORCING (W.B.L.)
- 16 - DECK - DETAILS
- 17 - JOINT ANCHORAGE AND ARMOURING
- 18 - 6000mm APPROACH SLAB
- 19 - BARRIER WALL (E.B.L.)
- 20 - BARRIER WALL (W.B.L.)
- 21 - BARRIER WALL TRANSITION
- 22 - STANDARD DETAILS
- 23 - BRIDGE DATE & SITE NUMBER DATA
- 24 - AS CONSTRUCTED ELEV & DIM
- 25 - QUANTITIES
- 26 - QUANTITIES

## APPLICABLE STANDARD DRAWINGS

- DD 3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS
- OPS0 508.02 ASPHALT & WATERPROOFING SYSTEM

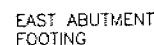


B.M. ELEV. 86.745

N & W IN SOUTH EAST  
ROOT OF 0.2m MAPLE  
43.1m RIGHT OF STA.  
22+347.3 (HWY. 401)DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	F.J.P.	CHK S.T.R.	CODE 04677-A-83 LOAD CLASS A DATE 02 JAN 89
DRAWN	P.C.M.	CHK S.T.R.	SITE 7-79 STRUCT SCHEME DWG. 1

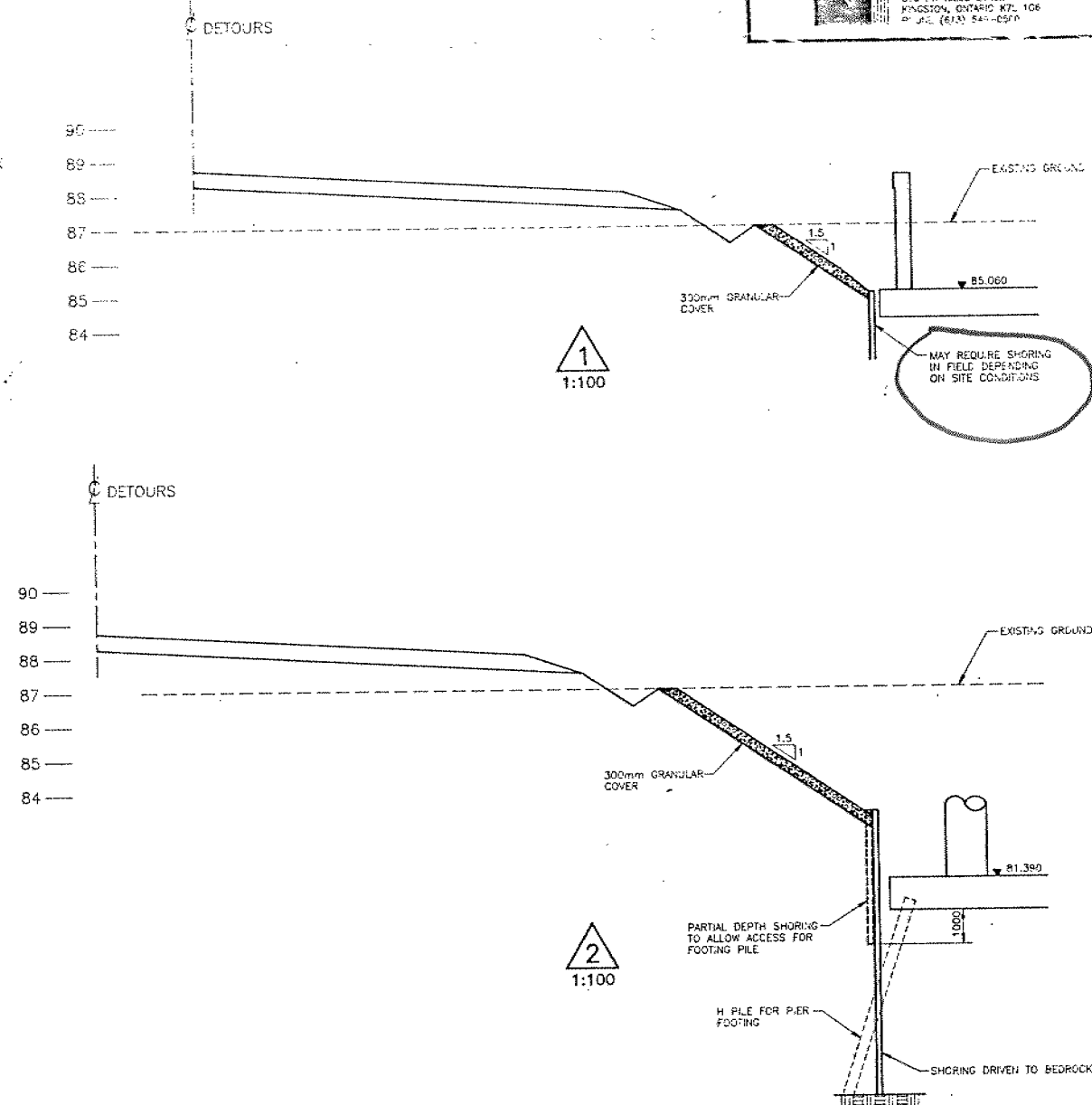
SHEET



Technical drawing of a sheet pile wall cross-section. The drawing shows a wall with a total width of 12000 mm and a height of 3900 mm. A central vertical section is highlighted with a width of 2000 mm and a height of 1000 mm. A label "SHEET PILING" points to the wall structure.

- MINIMUM PROPERTIES FOR SHEET PILING TO BE AS FOLLOWS:
  - $(S_x \cdot F_y)_{\min} = 250 \times 10^6 \text{ N} \cdot \text{mm}$  (PER METRE WIDTH)
  - $I_{x \min} = 100 \times 10^6 \text{ mm}^4$  (PER METRE WIDTH)

3  
1:100



2  
1:10

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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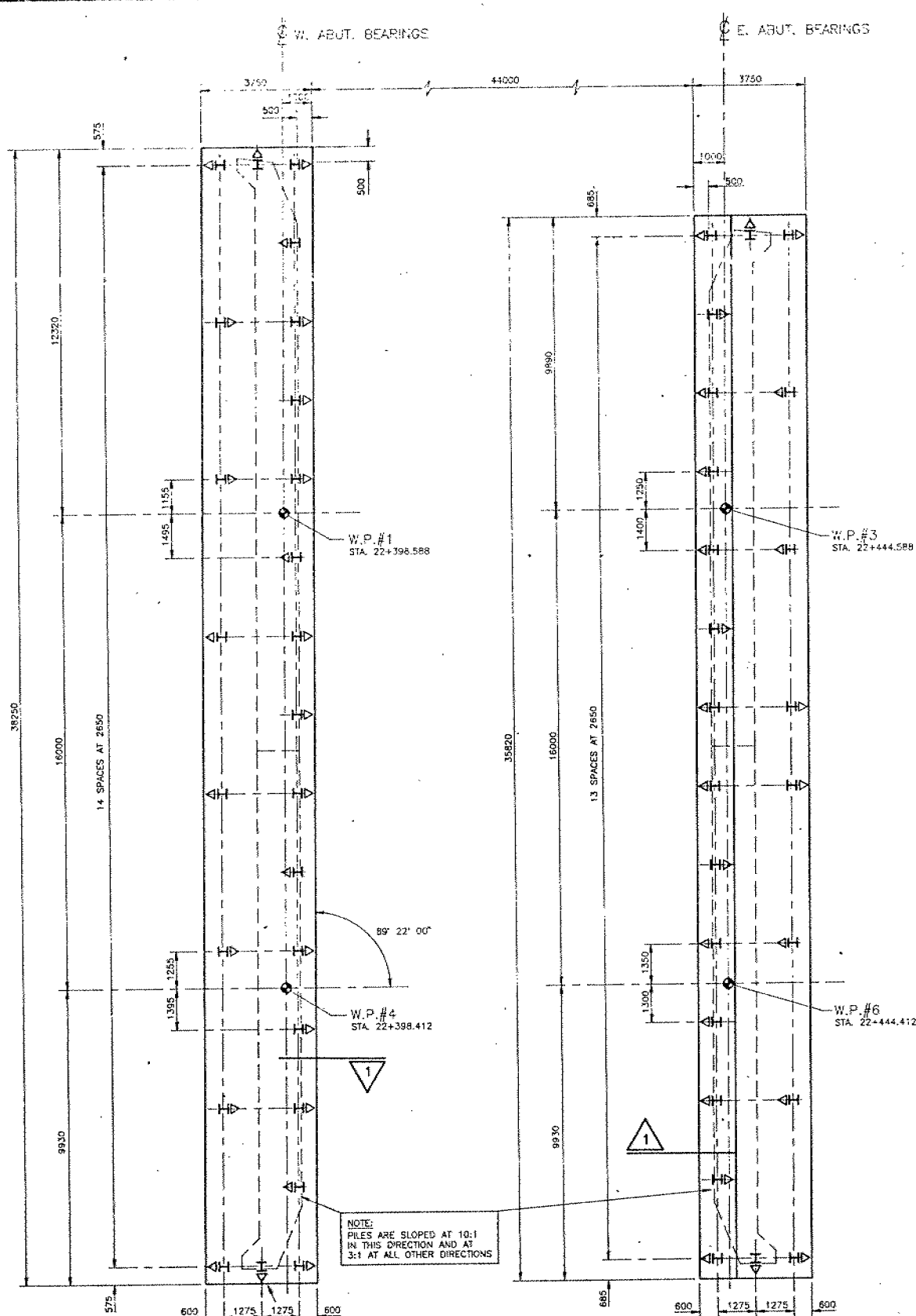
**METRIC**  
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SIR JOHN A. MACDONALD BLVD.  
OVERPASS AT HWY.401  
**ABUTMENT FOOTINGS**



**SHEET**

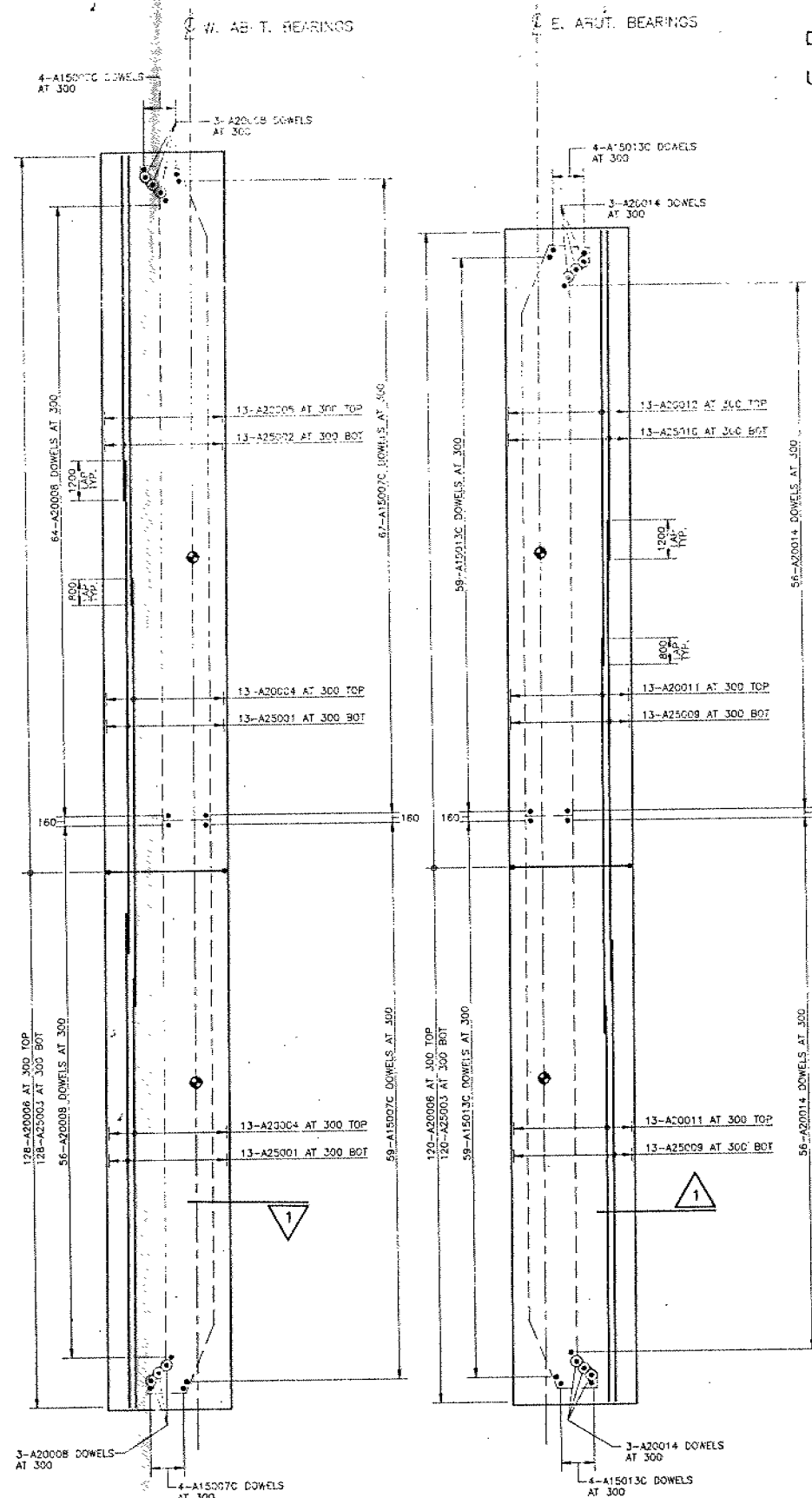
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**PLAN SHOWING  
DIMENSIONS & PILE LAYOUT**

**PLAN**  
**1:100**

**NOTE:**  
SEE DRAWING NO. 5 FOR  
PER FOOTINGS

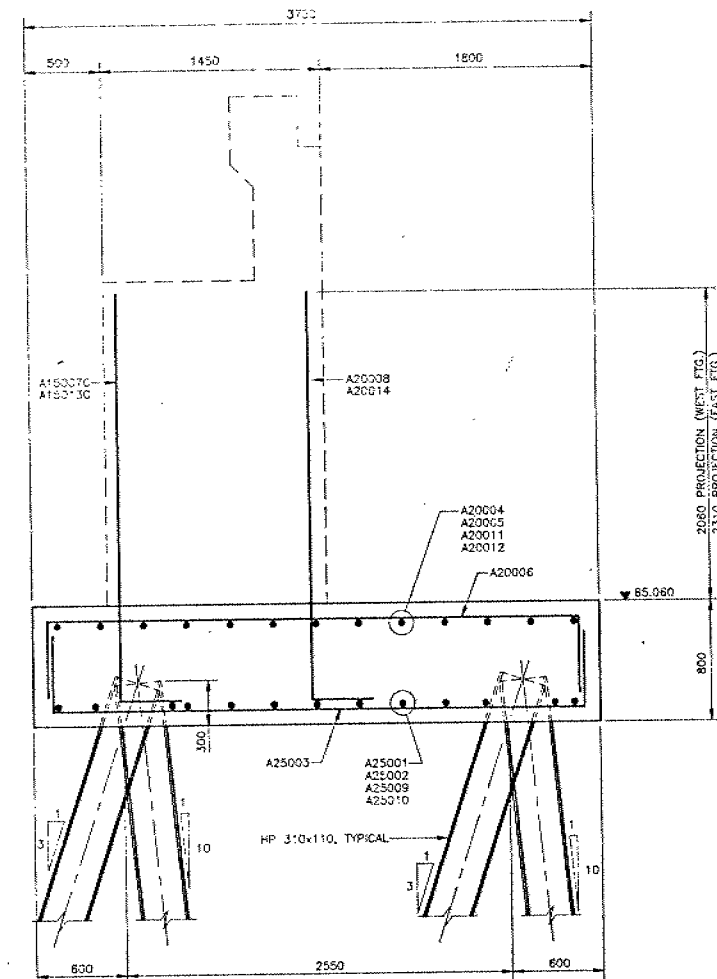


**PLAN SHOWING  
REINFORCING LAYOUT**

**APPLICABLE STANDARD DRAWINGS**

-00-3301 SPLICE AND DRIVING SHOE DETAILS  
FOR STEEL 'H' PILES

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING



**PILE DESIGN DATA:**

**MAX. COMB. FACTORED LOADS:**

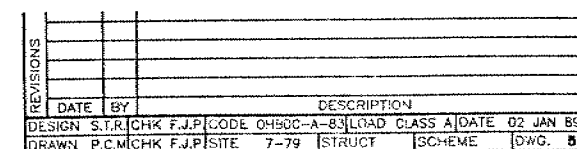
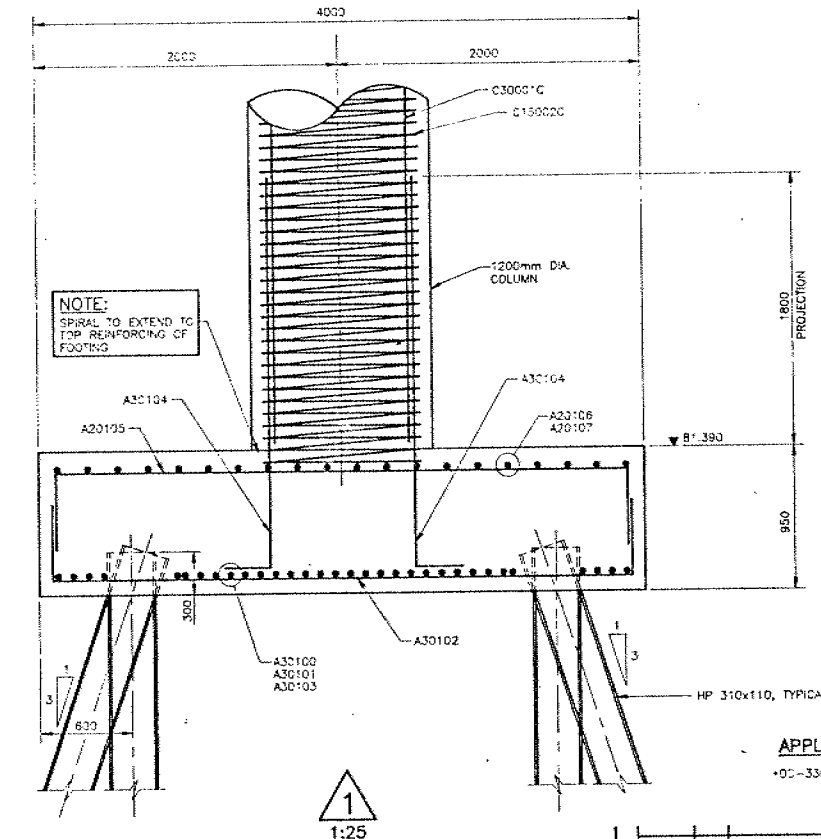
U.L.S.: 1440 kN  
S.L.S.: 930 kN

PILE DATA (HP 310x110)				
LOCATION	BATTER! No.	REQ'D	LENGTH	CUT OFF ELEV.
WEST ABUT.	1:10	8	8900mm	84.56
	1:3	16	9340mm	84.56
EAST ABUT.	1:10	8	9810mm	84.56
	1:3	17	10290mm	84.56

**NOTES:**

- PILES TO BE DRIVEN TO BEDROCK
- PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTING
- PILE LENGTHS SHOWN ARE THEORETICAL LENGTHS BELOW CUT OFF ELEVATION
- ALL PILES TO HAVE DRIVING SHOES
- ALL CENTRE LINES ARE PARALLEL
- ALL DIMENSIONS ARE PERPENDICULAR TO CENTER LINE OF HWY 401

REVISIONS	DATE	BY	DESCRIPTION
DESIGN S.T.R.	CHK F.J.P.	CODE 01-BCC-A-83	LOAD CLASS A DATE 02 JAN 89
DRAWN P.C.M.	CHK F.J.P.	SITE 7-79	STRUCT SCHEME DWG. 4



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

*CONT 90-40*  
ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WP 89-84-02 DIST 8  
HWY 401 STR SITE 7-79

Sir John A. MacDonald Blvd.  
Overpass and Approaches

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# FOUNDATION INVESTIGATION REPORT

for

Sir John A. MacDonald Blvd. Overpass and Approaches

W.P. 89-84-02, Site 7-79

Hwy. 401, District 8, Kingston

## INTRODUCTION

This report contains the results of a foundation investigation for the proposed crossing of Sir John A. MacDonald Blvd. under the existing Hwy. 401 alignment. This report applies to the structure and the immediate approach fills. The investigation was conducted at the request of the Eastern Region Structural Section. The majority of the investigation was carried out between 89 05 01 to 89 05 05 however, BH 5 was drilled on 89 05 17.

## Site Description

The site is located approximately midway between the Sydenham Road and Division street interchanges of Hwy. 401 at Kingston.

The surrounding area consists of marsh and vacant land south of Hwy. 401 and reforested conservation land north of Hwy. 401.

Water flows into the marshy area through a culvert draining under Hwy. 401 from north to south. The marsh drains southward through the vacant land.

According to Chapman and Putnam (1984), the site is located on a flat-to-undulating plain of limestone with a thin overburden of glacial till.

#### Investigation Procedures

The investigation was done using a continuous flight auger machine mounted on a muskeg vehicle, equipped with hollow stem augers, NW Casing and BXL core barrels.

The investigation consisted of 5 sampled boreholes accompanied by dynamic cone penetration tests at BH's 1, 2 and 4. Sampling was done to a maximum depth of 15.0 m (EL. 73.0 m) and the dynamic cone tests to a maximum depth of 12.6 m (EL. 75.8 m). Bedrock cores were obtained in 2 boreholes.

Survey details were provided by the Eastern Region Surveys and Plans Section.

The sampling program for the overburden consisted of split spoon samples at 0.8 m to 1.5 m intervals. These samples provided Standard Penetration Test (N) values for the assessment of the in situ state of compaction of the

non-cohesive materials, and for an indication of the shear strength of the cohesive materials. In situ vane tests were also used to measure shear strength where possible. These samples also provided material for identification purposes.

The split spoon samples were supplemented by shelby tube samples collected at strategic locations within the cohesive deposits. These samples provided relatively undisturbed material for more complex laboratory evaluations.

The sampling program for the bedrock consisted of collecting cores of 2.8 m at BH 1 and 0.1 m at BH 3. These samples permitted an evaluation of the type and quality of the bedrock.

Groundwater measurements were made by several different methods. Two piezometers were installed, one piezometer in the clay to silty clay layer and the other piezometer in the glacial till. The groundwater was also measured directly in the boreholes and water perched on the surface was observed.

The laboratory testing program for representative samples consisted of

- grain size analyses
- natural moisture content determination
- Atterberg limit determination
- unconfined compression tests



- unit weight tests
- triaxial tests

### Subsurface Conditions

The embankment fill consists of about 4.5 m of clayey silt to clay with some granular or sandy deposits at the surface. Beneath the fill there is a 5 m thick cohesive layer of lacustrine clay to silty clay with seams of silt. There are frequent silt seams below EL. 82.0 m. The clay to silty clay is underlain by a 4 m thick glacial till deposit. The glacial till overlies the bedrock and consists of a heterogeneous mixture of silt, sand, gravel and clay. The bedrock consists of interbedded dolomitic siltstone and silty dolostone. Bedrock dips in a Southeast to Northwest direction.

The boundaries of the different deposits together with the field and lab test results are shown on the Record of Borehole sheets No's 1 to 5 contained in the appendix of this report. The stratigraphical sections are shown on Drawing No. 898402-A. This drawing also shows the locations and elevations of the borings. A description of the different strata encountered is given below:

Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics  
(fill)

This cohesive material consists of a fill with varying

quantities of clay. In the median and on the shoulders there is a surficial layer of silty sand and gravel. The thickness of this layer ranges from 2.9 to 4.4 m with the bottom of the fill dipping from south to north.

Measured in situ and laboratory properties are as follows:

	<u>Range</u>	<u>Mean</u>
Natural Moisture Content $w$ (%)	10 - 32	27
Liquid Limit $w_L$ (%)	27 - 62	44
Plastic Limit $w_p$ (%)	12 - 23	18
Plasticity Index $I_p$ (%)	12 - 39	26
Undrained Shear Strength $C_u$ (kPa)	58 - >120	NA
SPT Blows 'N'	6 - 28	17
Bulk Density (kN/m <sup>3</sup> )		19.3

The standard penetration 'N' values and the measured undrained shear strengths indicates the consistency of the fill varies from stiff to hard. In general, a vane measurement could not be taken because the fill is too stiff and could not be sheared by the vane. The clay was somewhat softer at and below the phreatic water surface.

The typical plasticity characteristics of the material are shown in Figure 1. The plasticity increases with depth.

The grain size distribution is shown in Figure 2. The clay content increases with depth while the amount of sand and gravel decreases with depth.

Clay to Silty Clay, Trace Sand, Occ. Seams of Plastic Silt (lacustrine)

The fill is underlain by a lacustrine deposit of clay to silty clay with thin silt seams. This deposit is 4 to 6 m thick with the bottom of this layer relatively flat at EL. 79. The lacustrine clays decrease in plasticity with depth from a clay to a silty clay. The silt seams are frequent below EL. 82.0 with increasing thickness and frequency as the bottom of this cohesive deposit is approached. Occasional sand seams were detected below EL. 80 as the deposit becomes less cohesive and gradually transitions into the underlying glacial till.

The measured in situ and laboratory properties are as follows:

	<u>Range</u>	<u>Mean</u>
Natural Moisture Content $w$ (%)	23 - 39	30
Liquid Limit $w_L$ (%)	18 - 52	38
Plastic Limit $w_P$ (%)	14 - 22	17
Plasticity Index $I_P$ (%)	1 - 32	20
Undrained Shear Strength $C_u$ (kPa)	103 - >120	NA
SPT Blows 'N'	6 - 25	13
Bulk Density ( $\text{kN/m}^3$ )	18.4 - 20.1	19.3

The standard 'N' values and the measured undrained shear strengths indicate that the consistency of this deposit varies from stiff to very stiff. As in the fill vane measurements could not always be taken as the clay is too stiff. The low plasticity values were obtained in areas where the frequency of the silt seams made it impossible to test the clay separately. Due to the addition of the silt in the sample, the resulting measured plasticity was lower.

Above EL. 82, this deposit should not pose serious unwatering problems. Below EL. 82, the frequent silt seams may allow water into the excavation.

The typical plasticity characteristics of the material are shown in Figure 3.

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

This basically non-cohesive deposit overlies the bedrock and ranges in thickness from 3 to 4 m. The till consists of a heterogeneous mixture of grain sizes with increasing granular content with depth. The fines exhibit slight cohesion.

The standard penetration values ranged from 5 to 28 blows per 30 cm with the average value being 18 blows. The deposit is therefore loose to compact.

Figure 4 illustrates the grain size distribution for this material.

#### Siltstone and Dolostone Bedrock

The bedrock was proven by obtaining a BXL cores at BH 1 and BH 3. The bedrock dips to the northwest starting at EL. 75.8 at the south corner of the east abutment and falling to EL. 73.8 at the north corner of the west abutment.

The bedrock in general is sound with nominal weathering at the surface. The rock cores were examined by Mr. S.A. Senior, Geological Engineer and his description is appended to this report.

#### Groundwater

Groundwater was observed to be perched north of the embankment on the surface at about EL. 86.5 m and south of the embankment to EL. 85.5 m . Groundwater surfaces in the lacustrine deposit were at EL. 84.0 m. The groundwater surface in the glacial till was 81.6 at the time of this investigation. Therefore water could come into the excavation from 2 different sources. Surface water may drain into the excavation and groundwater could enter the excavation below elevation 84.0. It should be noted that groundwater levels may vary seasonally.

## DISCUSSION AND RECOMMENDATIONS

It is proposed to construct an overpass structure consisting of two 23 m long spans with closed abutments to carry the existing Hwy. 401 alignment over the proposed extension of Sir John A. MacDonald Blvd. The elevation of Hwy. 401 is 88.8 m while the surrounding natural ground surface is  $85 \pm$  m to  $86.5 \pm$  m. The proposed elevation of the Sir John A. MacDonald Blvd. is  $82.5 \pm$  m which will require a 2.5 m to 4.0 m cut below natural ground and 6.3 m below the Hwy. 401 embankment.

### Recommendations

#### Structure Foundation

The recommendations are similar to those in the preliminary report. The structure should be founded on deep foundations consisting of HP 310 X 110 steel H-Piles, equipped with driving shoes and driven to bedrock. For the purposes of the O.H.B.D.C. the following design values are recommended:

Factored Axial Capacity at U.L.S. = 1600 kN per pile

Axial Capacity at S.L.S. Type II = 1150 kN per pile

The estimated bedrock surface levels are:

	Elevation (m)		
	<u>North Corner</u>	<u>Centreline</u>	<u>South Corner</u>
West Abutment	73.8	----	75.8
Pier	----	74.7	----
East Abutment	75.6	----	75.8

### Earth Pressure

Backfill to structures should consist of granular material in accordance with Ministry of Transportation Standard Special Provision #109F03.

Computation of earth pressures should be in accordance with Section 6-6.1.2 of the O.H.B.D.C. The active condition will govern earth pressure design for the yielding condition while the at-rest condition will govern earth pressure design for the unyielding condition. The following properties for backfill are recommended for design.

<u>Material</u>	<u><math>\phi</math></u>	<u><math>\gamma</math></u>	$K_A$	$K_O$
Granular 'A'	35°	22.8 kN/m <sup>3</sup>	0.27	0.43
Granular 'B'	30°	21.2 kN/m <sup>3</sup>	0.33	0.50

### Lateral Resistance

The resistance to lateral load for piles should be calculated in accordance with Section 6-8.3.8 of the O.H.B.D.C. The horizontal component of battered piles may be used to resist lateral loads.

### Frost Protection

A minimum earth cover of 1.5 m, or equivalent, to the base of pile caps is required for frost protection.

### Slope Stability

A slope stability analysis was carried out using both Bishop's simplified total and effective stress method. It was found that a 2H:1V slope will be stable for a height of 6.5 m. Details of these analyses are shown in Figure 5.

### Settlement

Since the proposed structure will be founded on deep foundations, and since the proposed interchange will be primarily in cut and the existing embankment for Hwy. 401 has been in place for many years, no settlements are anticipated for this proposal. However, some minor heaving may be anticipated due to unloading.

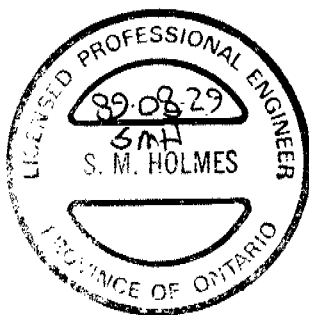
### Unwatering

This proposal requires cuts 2.5 m to 4 m below natural ground to EL. 82.5. As the anticipated groundwater elevation is 84.0 m and the perched water table is at 86.5 m, a temporary unwatering scheme may be required to facilitate construction and a permanent gravity drainage scheme will be required. In view of the relatively impermeable nature of the subsoil at the cut level, sump pumping will probable provide adequate temporary unwatering. If a gravity drainage system was constructed, progressing in the upstream direction, temporary drainage would be facilitated.



### Miscellaneous

The fieldwork for this project was supervised by Mr. S. Holmes, Foundation Engineer for BH's 1 to 4. Ms. B. Bennett, Foundation Engineer and Mr. J. White, Engineering Student supervised BH 5. The equipment used in BH's 1 to 4 was owned and operated by Atcost Soil Investigation Ltd. The equipment used for BH 5 was owned and operated by Master Soil Investigations Ltd. This report was prepared by Mr. S. Holmes, Foundation Engineer in conjunction with D. Dundas, Senior Foundation Engineer, and reviewed by Mr. M. Devata, Chief Foundation Engineer.



S. Holmes, P. Eng.  
Foundation Engineer

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

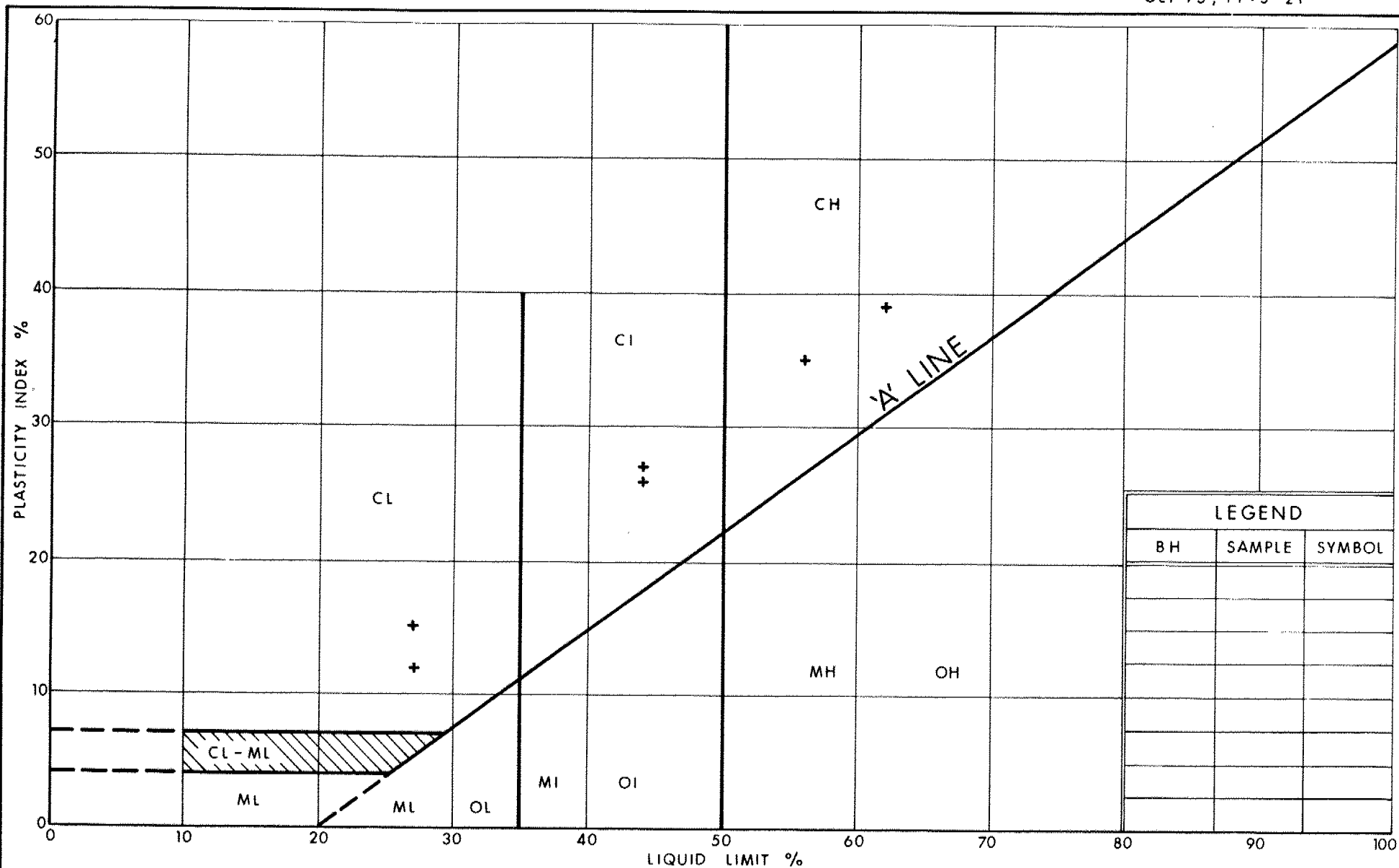
$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						



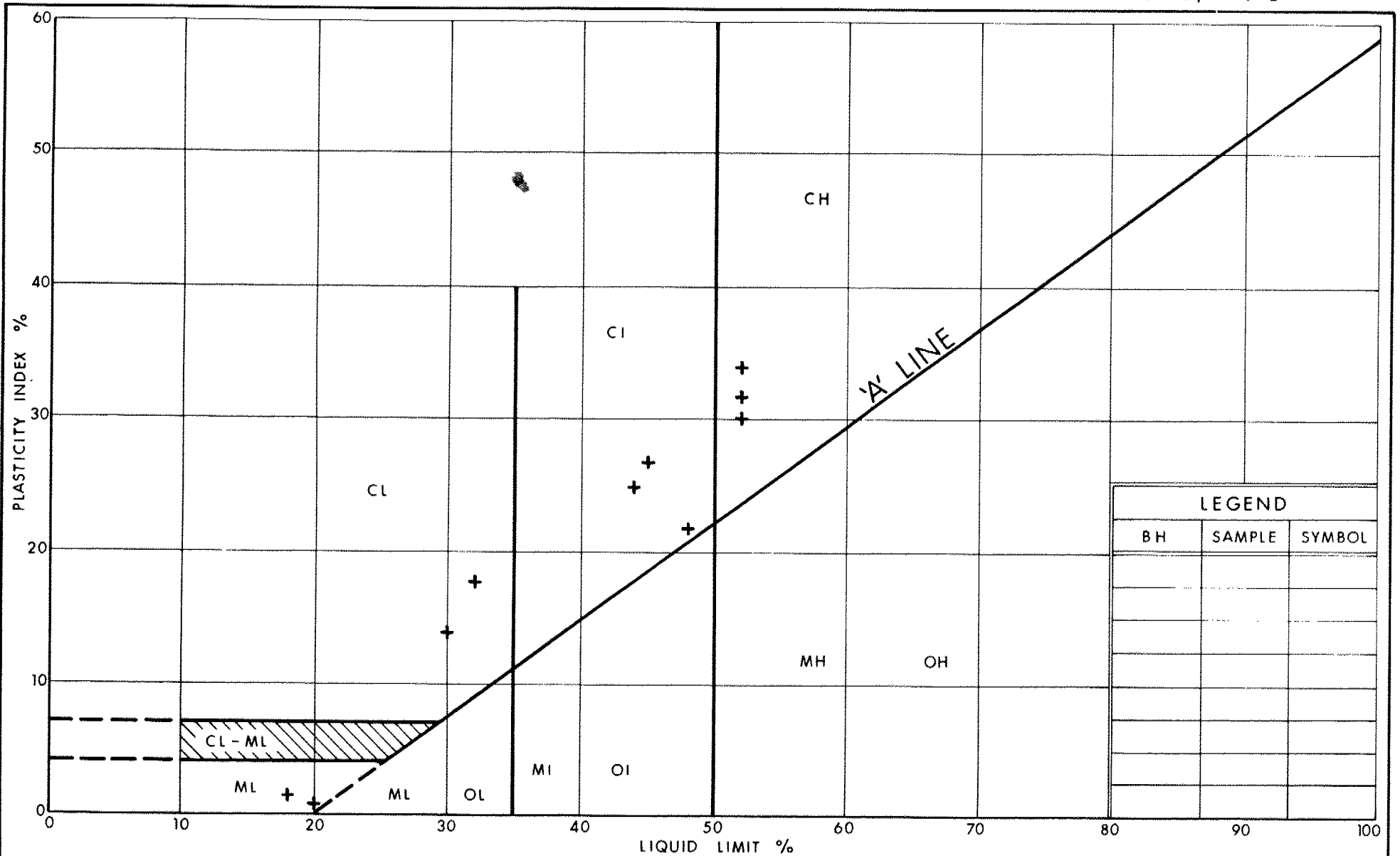
Ministry of  
Transportation  
Ontario

PLASTICITY CHART  
CLAYEY SILT TO CLAY (Fill)  
SOME SAND, TRACE GRAVEL, TRACE ORGANICS

FIG No 1

W P 89-84-02





Ministry of  
Transportation

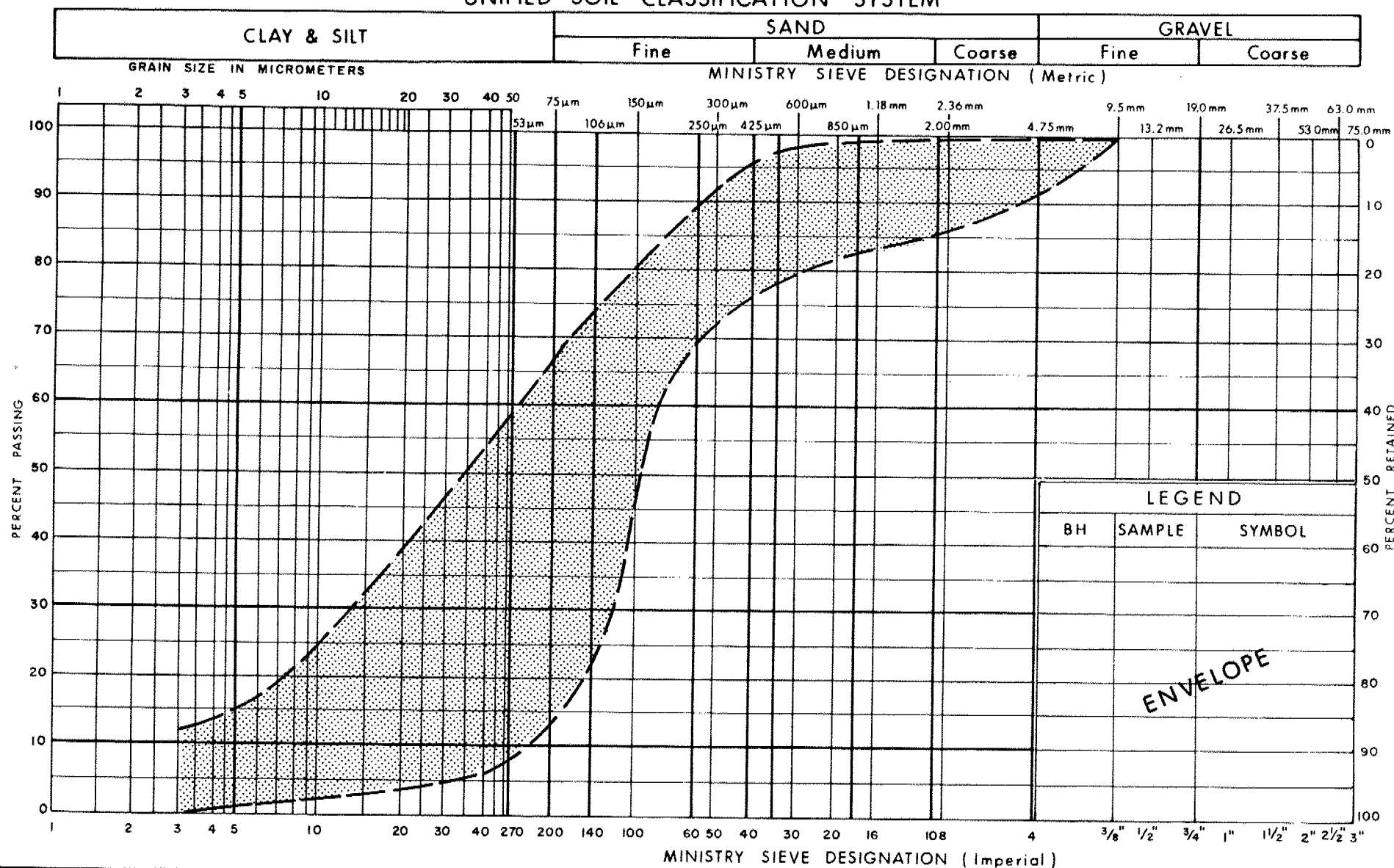
Ontario

PLASTICITY CHART  
CLAY TO SILTY CLAY  
TRACE SAND WITH OCC SEAMS OF PLASTIC SILT

FIG No 3

W P 89-84-02

## UNIFIED SOIL CLASSIFICATION SYSTEM

Ministry of  
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GRAIN SIZE DISTRIBUTION  
HETEROGENEOUS MIXTURE OF SILT, SAND,  
GRAVEL & CLAY (Glacial Till)

FIG No 4

W P 89-84-02

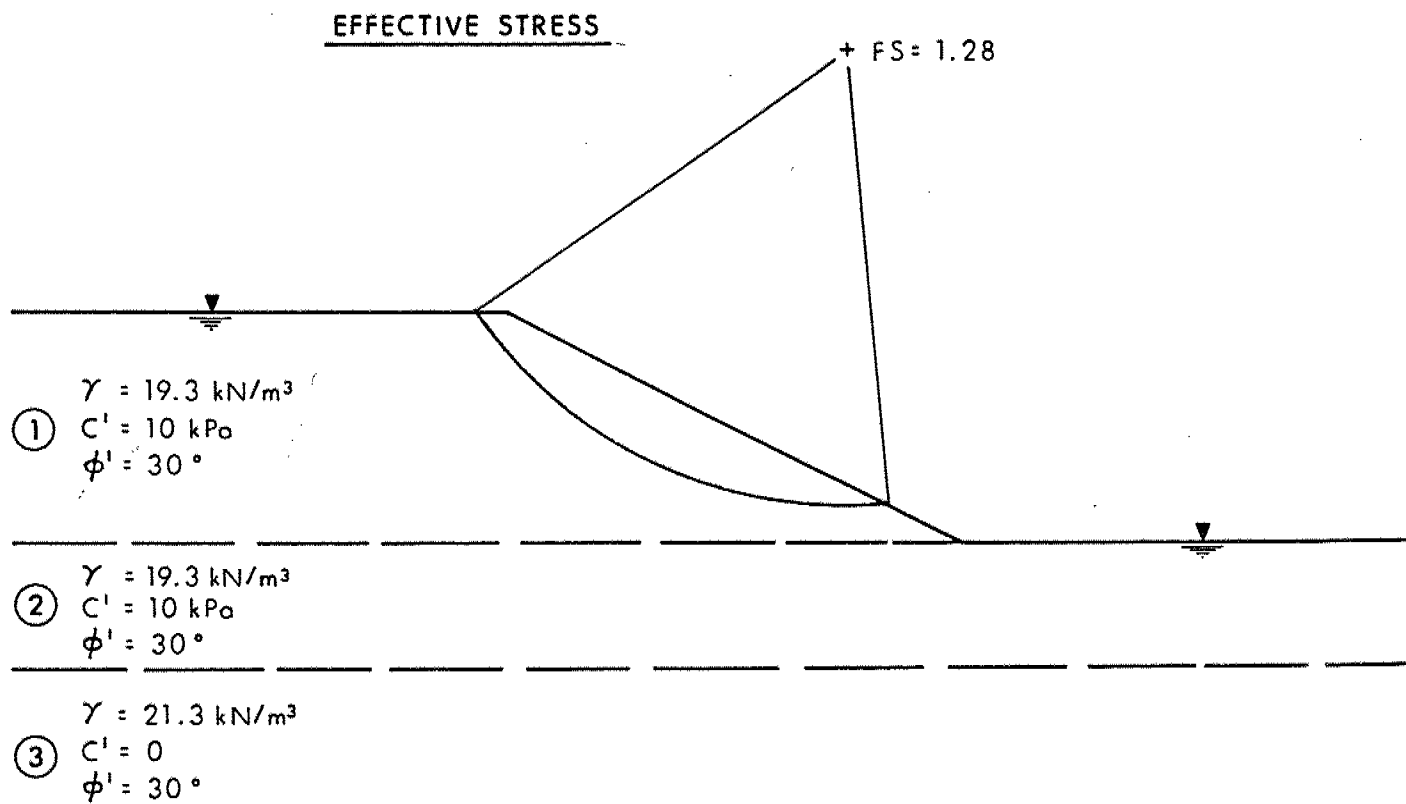
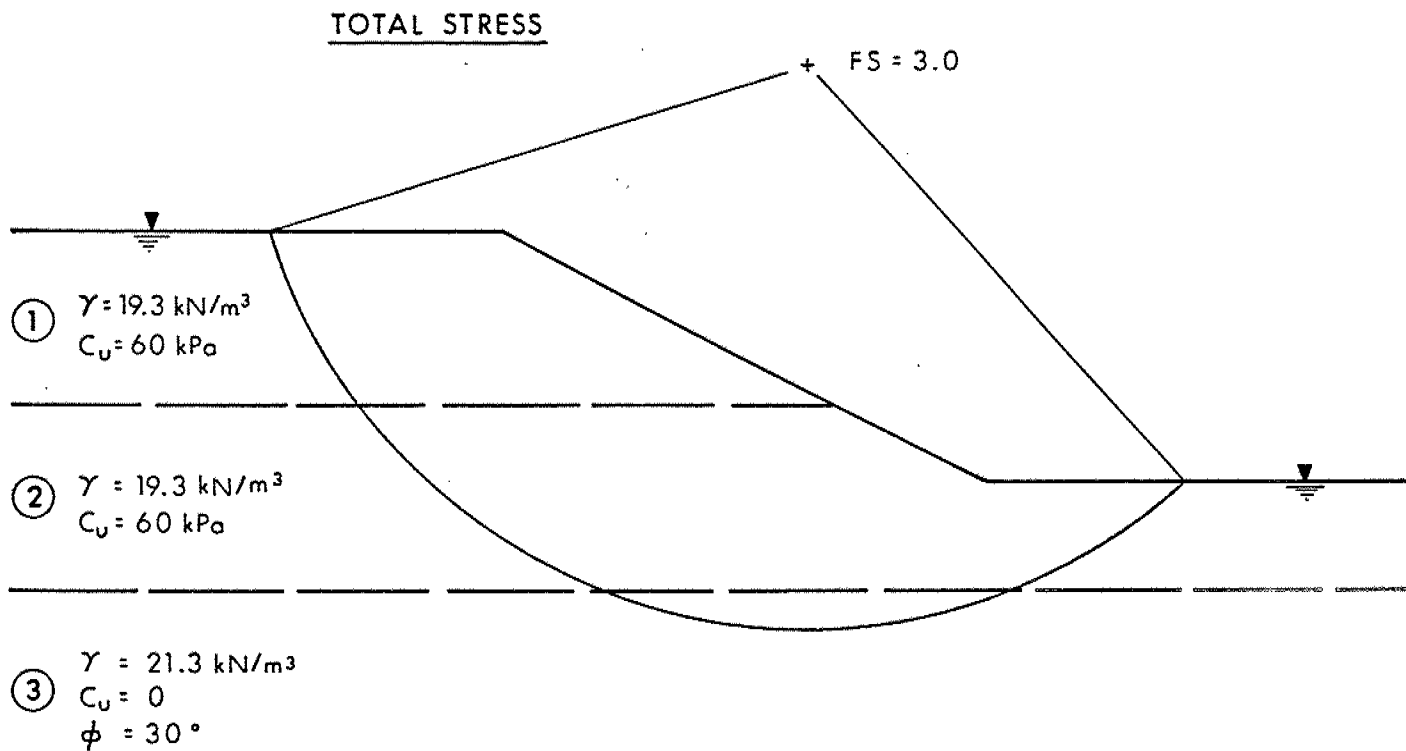


FIG 5 - SLOPE STABILITY

WP 89-84-02



**ROCK CORE DESCRIPTION**  
**WP 89 04 02**

1../1

CORE RECOVERY					CORE DESCRIPTION	
BH #	RC #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION
1	10	12.22-13.74	100	45	12.22-14.96	DOLOMITIC SILTSTONE with minor interbeds of <b>SILTY</b> DOLOSTONE, light to medium grey; very fine grained; very thickly bedded; weak to medium strong rock; slightly weathered to unweathered; very close to moderately close spaced fractures: horizontal bedding joints; average spacing $\approx$ 15-20 cm.
	11	13.74-14.96	100	89		
2	12	10.77-10.85	-	-	10.77-10.85	Possible bedrock: 4 pieces, 2-3 cm diameter, broken, angular - insufficient sample for positive identification.

\*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 1

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 309.6; E 303 280.7 ORIGINATED BY SH  
 DIST 8 HWY 401 BOREHOLE TYPE Cone Test, H S Auger, NW Casing, BXL Rockcore COMPILED BY JW  
 DATUM Geodetic DATE 1989 05 01-02 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
88.0 0.0	Ground Surface												
	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics Stiff (Fill)		1	SS	14								
			2	SS	6								
84.3 3.7			3	SS	16								
	Clay to Silty Clay, Trace Sand, Occ. Seams of Plastic Silt Stiff to v. Stiff		4	TW	PH							19.3	0 4 24 72
			5	SS	10								
	Frequent Silt Seams		6	TW	PH							19.3	0 0 (100) 0 1 (99)
	(Lacustrine)		7	SS	11								
79.0 9.0			8	SS	28								
	Heterogeneous Mixture of Silt, Sand, Gravel and Clay Compact to Dense (Glacial Till)		9	SS	41								6 25 59 10
75.8 12.2	Sound		10	RC BXL	90% REC								RQD = 53%
	Siltstone and Dolostone Bedrock		11	RC BXL	100% REC								RQD = 89%
73.0 15.0	End of Borehole												

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 2

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 293.3; E 303 324.9  
DIST 8 HWY 401 BOREHOLE TYPE Cone Test, H S Auger  
DATUM Geodetic DATE 89 05 02-03

ORIGINATED BY SH

COMPILED BY JW

CHECKED BY *SH*

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
88.4	Ground Surface												
0.0	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics Stiff to Hard (Fill)		1	SS	14								0 19 49 32
			2	SS	25								
			3	SS	11								
			4	TW	PH								
84.0			5	SS	14							19.3	0 2 50 48
4.4	Clay to Silty Clay, Trace Sand Occ. Seams Plastic Silt Very Stiff Frequent Silt Seams  (Lacustrine)		6	SS	22								3 3 (94)
			7	SS	10								
			8	SS	10								0 0 (100)
			9	TW	PH							18.4	
78.8			10	SS	12								
9.6	Heterogeneous Mixture of Silt, Sand, Gravel and Clay Loose to Compact  (Glacial Till)		11	SS	6								9 25 55 11
75.8			12	SS	50/	0cm							
12.6	End of Borehole Probable Bedrock												

+3, -5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 3

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 329.3; E 303 338.5 ORIGINATED BY SH  
 DIST 8 HWY 401 BOREHOLE TYPE H S Auger, NW Casing, BXL Rockcore COMPILED BY JW  
 DATUM Geodetic DATE 89 05 04-05 CHECKED BY SH

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)
86.4	Ground Surface																	
0.0	Clayey Silt to Clay Some Sand, Trace Gravel, Trace Organics Stiff to v. Stiff  (Fill)		1	SS	21													
			2	SS	17													
			3	TW	PH													
83.5																		
2.9	Clay to Silty Clay, Trace Sand Occ. Seams of Plastic Silt  Very Stiff  Lacustrine		4	SS	20													
			5	SS	11													
			6	SS	10													
			7	TW	PH													
			8	SS	13													
79.2																		
7.2	Heterogeneous Mixture of Silt, Sand, Gravel and Clay  Loose to Compact  (Glacial Till)		9	SS	21													
			10	SS	5													
75.7	Weathered Bedrock		11	SS	50	0.0 cm												
			12	RC	0.0	Rec												
10.8	End of Borehole																	

# RECORD OF BOREHOLE No 4

: METRIC

W P 89-84-02

LOCATION Co-ords: N 4 903 316.1; E 303 308.9

ORIGINATED BY SH

DIST 8

HWY 401

BOREHOLE TYPE Cone Test, H S Auger

COMPILED BY JW

DATUM Geodetic

DATE 89 05 04

CHECKED BY

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 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES								
88.1	Ground Surface												
0.0	Silty Sand Trace Gravel		1	SS	18								5 55 26 4
	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics Stiff		2	SS	28								
	(Fill)		3	SS	22								
85.1	Clay to Silty Clay		4	SS	13								1 3 36 60
3.0	Trace Sand		5	SS	9								
	Occ. Seams of Plastic Silt Very Stiff (Lacustrine)		6	SS	6								
	Frequent Silt Seams		7	SS	2								0 0 60 40
			8	SS	5								
79.0	Heterogeneous Mixture of Silt, Sand, Gravel and Clay		9	SS	12								
9.1	Compact (Glacial Till)		10	SS	14								
			11	SS	13								
74.7	End of Borehole Probable Bedrock		12	SS	120/5cm								
13.4													

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 5

METRIC

W.P. 89-84-02

LOCATION Co-ords: N 4 903 339.3; E 303 293.1

ORIGINATED BY BB

DIST 8 HWY 401

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY JW

DATUM Geodetic

DATE 89 05 17

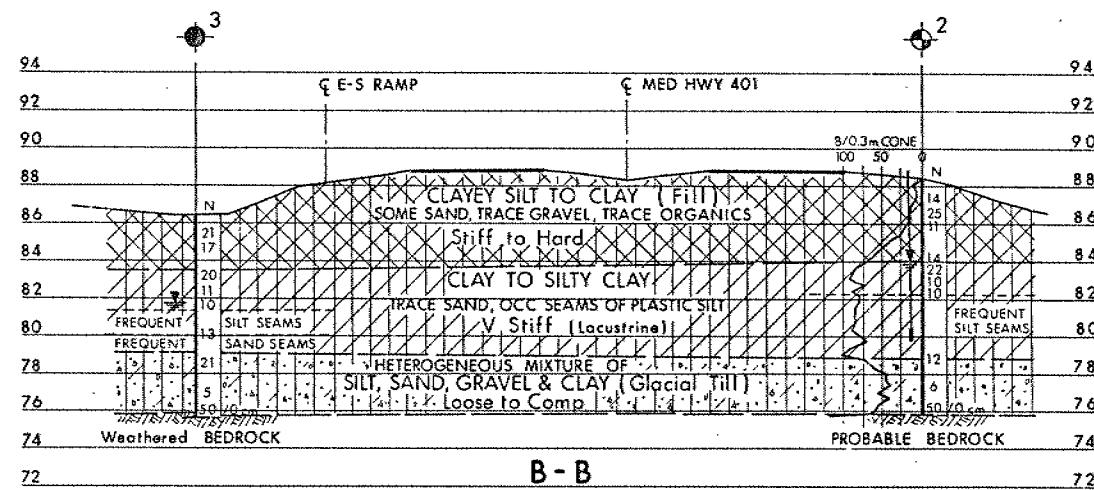
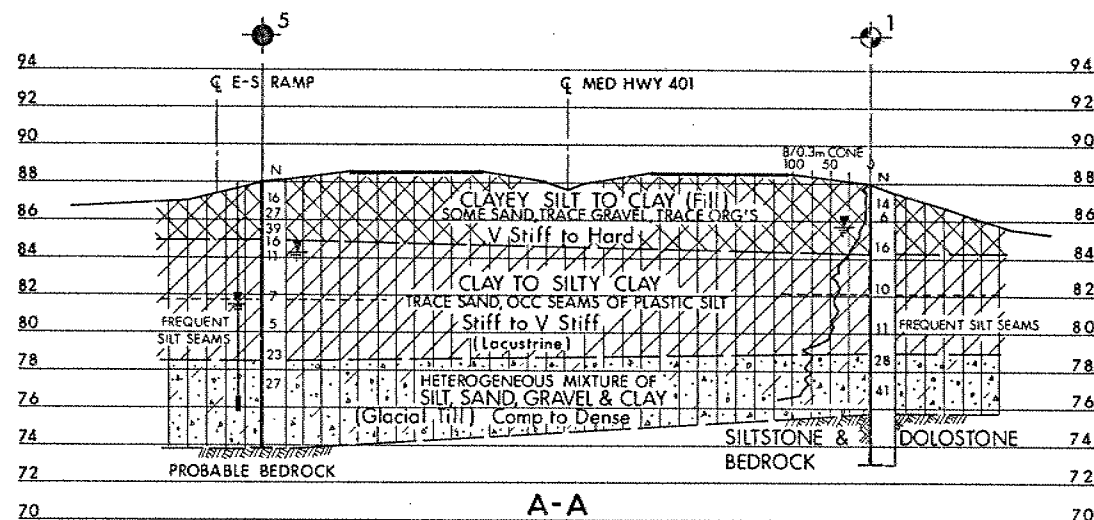
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OFFICE REPORT ON SOIL EXPLORATION

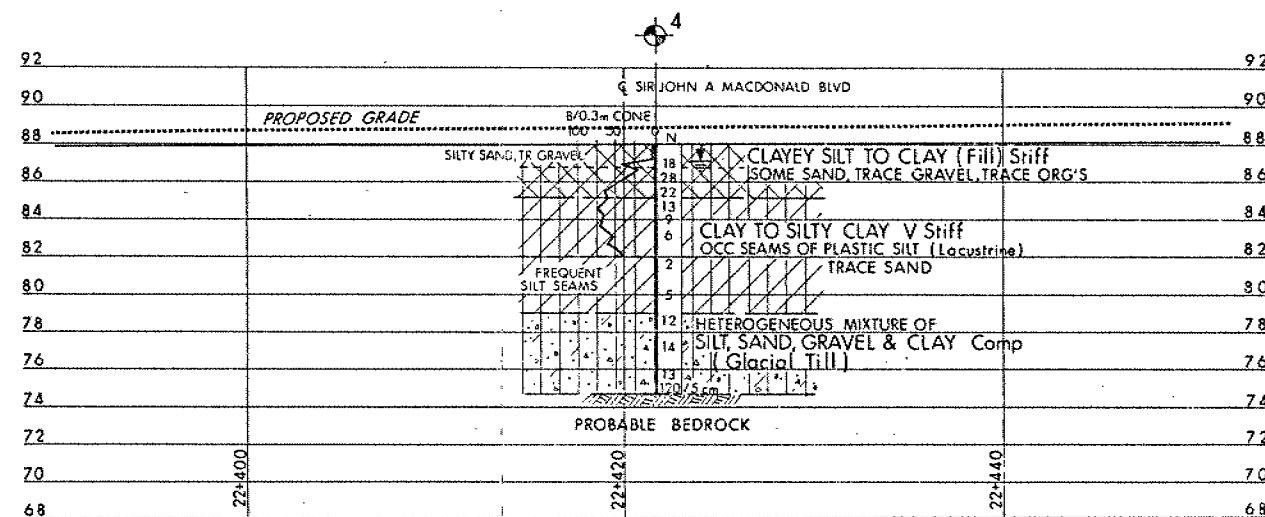
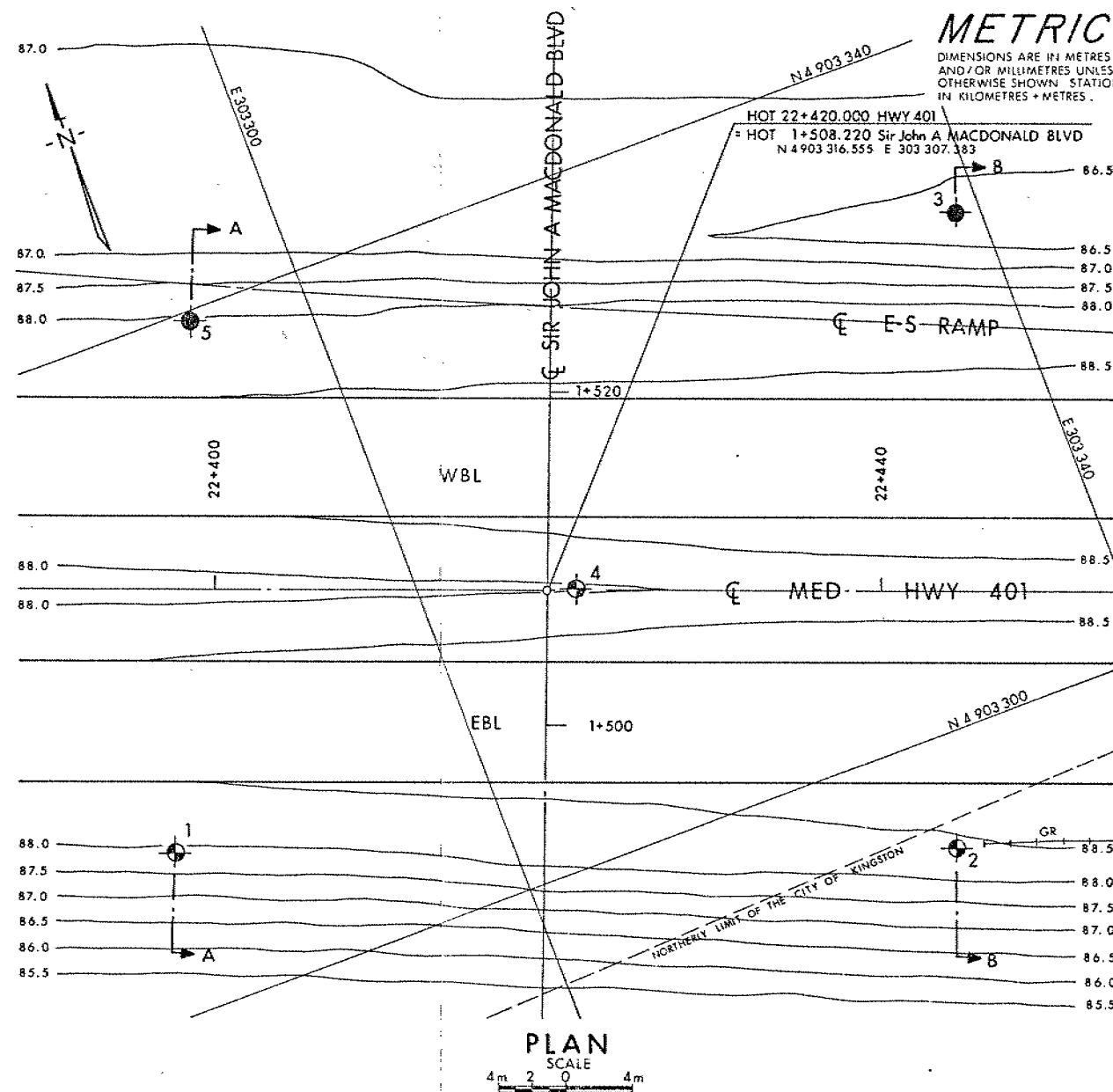
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
88.1	Ground Surface						88									
0.0	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics		1	SS	16		87									
	Very Stiff to Hard		2	SS	27		86									
	(Fill)		3	SS	39		85									
85.0	Clay to Silty Clay		4	SS	16		84									
3.1	Trace Sand, Occ. Seams of Plastic Silt Very Stiff		5	SS	11		83									
	(Lacustrine)		6	TW	PH		82									
	Frequent Silt Seams		7	SS	7		81									
			8	SS	5		80									
			9	SS	23		79									
78.5	Heterogeneous Mixture of Silt, Sand, Gravel and Clay		10	SS	27		78									
9.6	Compact		11	WS			77									
	(Glacial Till)						76									
							75									
73.8 *							74									
14.3	End of Borehole Probable Bedrock *Auger Refusal															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



SECTIONS  
SCALE  
4m 2 0 2 4m



PROFILE MED HWY 401  
SCALE  
4m 2 0 2 4m

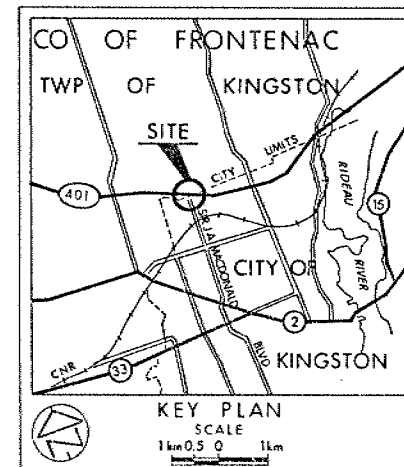
CONT No  
WP No 89-84-02

SIR JOHN A MACDONALD BLVD

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 8905
- Piezometer

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	88.0	4 903 309.6	303 280.7
2	88.4	4 903 293.3	303 324.9
3	86.4	4 903 329.3	303 338.5
4	88.1	4 903 316.1	303 308.9
5	88.1	4 903 339.3	303 293.1

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 31C-146

HWY No 401	SUBM'D SH [CHECKED]	DATE 1989 10 05	DIST 8
DRAWN SO [CHECKED]	APPROVED	SITE 7-79	DWG 896402-A

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 90-40



Ministry of  
Transportation and  
Communications



## I N D E X

<u>page</u>	<u>description</u>
1	Index
2	Legend of Symbols and Terms
3 - 51	Foundation Investigation Reports
	For
	- Sir John A. MacDonald Overpass and Approaches W.P. 89-84-02, Site: 7-79 Hwy. 401, District 8, Kingston
	- High Mast Lighting Sir John A. MacDonald Overpass Interchange W.P. 89-84-02 Hwy. 401, District 8, Kingston

**NOTE:** For the purposes of the contract, these reports supersede all other Foundation Design Reports prepared by or for the Ministry in connection with the above-noted projects.

**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

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**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

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### 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

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

## FOUNDATION INVESTIGATION REPORT

for

Sir John A. MacDonald Blvd. Overpass and Approaches

W.P. 89-84-02, Site 7-79

Hwy. 401, District 8, Kingston

### INTRODUCTION

This report contains the results of a foundation investigation for the proposed crossing of Sir John A. MacDonald Blvd. under the existing Hwy. 401 alignment. This report applies to the structure and the immediate approach fills. The investigation was conducted at the request of the Eastern Region Structural Section. The majority of the investigation was carried out between 89 05 01 to 89 05 05 however, BH 5 was drilled on 89 05 17.

### Site Description

The site is located approximately midway between the Sydenham Road and Division street interchanges of Hwy. 401 at Kingston.

The surrounding area consists of marsh and vacant land south of Hwy. 401 and reforested conservation land north of Hwy. 401.

Water flows into the marshy area through a culvert draining under Hwy. 401 from north to south. The marsh drains southward through the vacant land.

According to Chapman and Putnam (1984), the site is located on a flat-to-undulating plain of limestone with a thin overburden of glacial till.

#### Investigation Procedures

The investigation was done using a continuous flight auger machine mounted on a muskeg vehicle, equipped with hollow stem augers, NW Casing and BXL core barrels.

The investigation consisted of 5 sampled boreholes accompanied by dynamic cone penetration tests at BH's 1, 2 and 4. Sampling was done to a maximum depth of 15.0 m (EL. 73.0 m) and the dynamic cone tests to a maximum depth of 12.6 m (EL. 75.8 m). Bedrock cores were obtained in 2 boreholes.

Survey details were provided by the Eastern Region Surveys and Plans Section.

The sampling program for the overburden consisted of split spoon samples at 0.8 m to 1.5 m intervals. These samples provided Standard Penetration Test (N) values for the assessment of the in situ state of compaction of the

non-cohesive materials, and for an indication of the shear strength of the cohesive materials. In situ vane tests were also used to measure shear strength where possible. These samples also provided material for identification purposes.

The split spoon samples were supplemented by shelby tube samples collected at strategic locations within the cohesive deposits. These samples provided relatively undisturbed material for more complex laboratory evaluations.

The sampling program for the bedrock consisted of collecting cores of 2.8 m at BH 1 and 0.1 m at BH 3. These samples permitted an evaluation of the type and quality of the bedrock.

Groundwater measurements were made by several different methods. Two piezometers were installed, one piezometer in the clay to silty clay layer and the other piezometer in the glacial till. The groundwater was also measured directly in the boreholes and water perched on the surface was observed.

The laboratory testing program for representative samples consisted of

- grain size analyses
- natural moisture content determination
- Atterberg limit determination
- unconfined compression tests

- unit weight tests
- triaxial tests

### Subsurface Conditions

The embankment fill consists of about 4.5 m of clayey silt to clay with some granular or sandy deposits at the surface. Beneath the fill there is a 5 m thick cohesive layer of lacustrine clay to silty clay with seams of silt. There are frequent silt seams below EL. 82.0 m. The clay to silty clay is underlain by a 4 m thick glacial till deposit. The glacial till overlies the bedrock and consists of a heterogeneous mixture of silt, sand, gravel and clay. The bedrock consists of interbedded dolomitic siltstone and silty dolostone. Bedrock dips in a Southeast to Northwest direction.

The boundaries of the different deposits together with the field and lab test results are shown on the Record of Borehole sheets No's 1 to 5 contained in the appendix of this report. The stratigraphical sections are shown on Drawing No. 898402-A.\* This drawing also shows the locations and elevations of the borings. A description of the different strata encountered is given below:

#### Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics (fill)

This cohesive material consists of a fill with varying

\* DWG NO 2 OF THE CONTRACT DWG'S

quantities of clay. In the median and on the shoulders there is a surficial layer of silty sand and gravel. The thickness of this layer ranges from 2.9 to 4.4 m with the bottom of the fill dipping from south to north.

Measured in situ and laboratory properties are as follows:

	<u>Range</u>	<u>Mean</u>
Natural Moisture Content $w$ (%)	10 - 32	27
Liquid Limit $w_L$ (%)	27 - 62	44
Plastic Limit $w_p$ (%)	12 - 23	18
Plasticity Index $I_p$ (%)	12 - 39	26
Undrained Shear Strength $C_u$ (kPa)	58 - >120	NA
SPT Blows 'N'	6 - 28	17
Bulk Density ( $\text{kN/m}^3$ )		19.3

The standard penetration 'N' values and the measured undrained shear strengths indicates the consistency of the fill varies from stiff to hard. In general, a vane measurement could not be taken because the fill is too stiff and could not be sheared by the vane. The clay was somewhat softer at and below the phreatic water surface.

The typical plasticity characteristics of the material are shown in Figure 1. The plasticity increases with depth.

The grain size distribution is shown in Figure 2. The clay content increases with depth while the amount of sand and gravel decreases with depth.

Clay to Silty Clay, Trace Sand, Occ. Seams of Plastic Silt (lacustrine)

The fill is underlain by a lacustrine deposit of clay to silty clay with thin silt seams. This deposit is 4 to 6 m thick with the bottom of this layer relatively flat at EL. 79. The lacustrine clays decrease in plasticity with depth from a clay to a silty clay. The silt seams are frequent below EL. 82.0 with increasing thickness and frequency as the bottom of this cohesive deposit is approached. Occasional sand seams were detected below EL. 80 as the deposit becomes less cohesive and gradually transitions into the underlying glacial till.

The measured in situ and laboratory properties are as follows:

	<u>Range</u>	<u>Mean</u>
Natural Moisture Content $w$ (%)	23 - 39	30
Liquid Limit $w_L$ (%)	18 - 52	38
Plastic Limit $w_p$ (%)	14 - 22	17
Plasticity Index $I_p$ (%)	1 - 32	20
Undrained Shear Strength $C_u$ (kPa)	103 - >120	NA
SPT Blows 'N'	6 - 25	13
Bulk Density ( $\text{kN/m}^3$ )	18.4 - 20.1	19.3



The standard 'N' values and the measured undrained shear strengths indicate that the consistency of this deposit varies from stiff to very stiff. As in the fill vane measurements could not always be taken as the clay is too stiff. The low plasticity values were obtained in areas where the frequency of the silt seams made it impossible to test the clay separately. Due to the addition of the silt in the sample, the resulting measured plasticity was lower.

Above EL. 82, this deposit should not pose serious unwatering problems. Below EL. 82, the frequent silt seams may allow water into the excavation.

The typical plasticity characteristics of the material are shown in Figure 3.

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

This basically non-cohesive deposit overlies the bedrock and ranges in thickness from 3 to 4 m. The till consists of a heterogeneous mixture of grain sizes with increasing granular content with depth. The fines exhibit slight cohesion.

The standard penetration values ranged from 5 to 28 blows per 30 cm with the average value being 18 blows. The deposit is therefore loose to compact.

Figure 4 illustrates the grain size distribution for this material.

#### Siltstone and Dolostone Bedrock

The bedrock was proven by obtaining a BXL cores at BH 1 and BH 3. The bedrock dips to the northwest starting at EL. 75.8 at the south corner of the east abutment and falling to EL. 73.8 at the north corner of the west abutment.

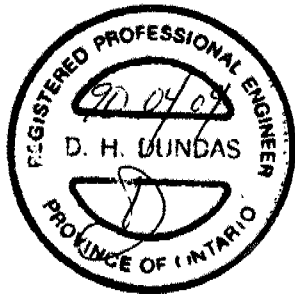
The bedrock in general is sound with nominal weathering at the surface. The rock cores were examined by Mr. S.A. Senior, Geological Engineer and his description is appended to this report.

#### Groundwater

Groundwater was observed to be perched north of the embankment on the surface at about EL. 86.5 m and south of the embankment to EL. 85.5 m . Groundwater surfaces in the lacustrine deposit were at EL. 84.0 m. The groundwater surface in the glacial till was 81.6 at the time of this investigation. Therefore water could come into the excavation from 2 different sources. Surface water may drain into the excavation and groundwater could enter the excavation below elevation 84.0. It should be noted that groundwater levels may vary seasonally.

Miscellaneous

The fieldwork for this project was supervised by Mr. S. Holmes, Foundation Engineer for BH's 1 to 4. Ms. B. Bennett, Foundation Engineer and Mr. J. White, Engineering Student supervised BH 5. The equipment used in BH's 1 to 4 was owned and operated by Atcost Soil Investigation Ltd. The equipment used for BH 5 was owned and operated by Master Soil Investigations Ltd. This report was prepared by Mr. S. Holmes, Foundation Engineer in conjunction with D. Dundas, Senior Foundation Engineer, and reviewed by Mr. M. Devata, Chief Foundation Engineer.



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

*M. Devata*  
M. Devata, P. Eng.  
Chief Foundation Engineer

## APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 309.6; E 303 280.7

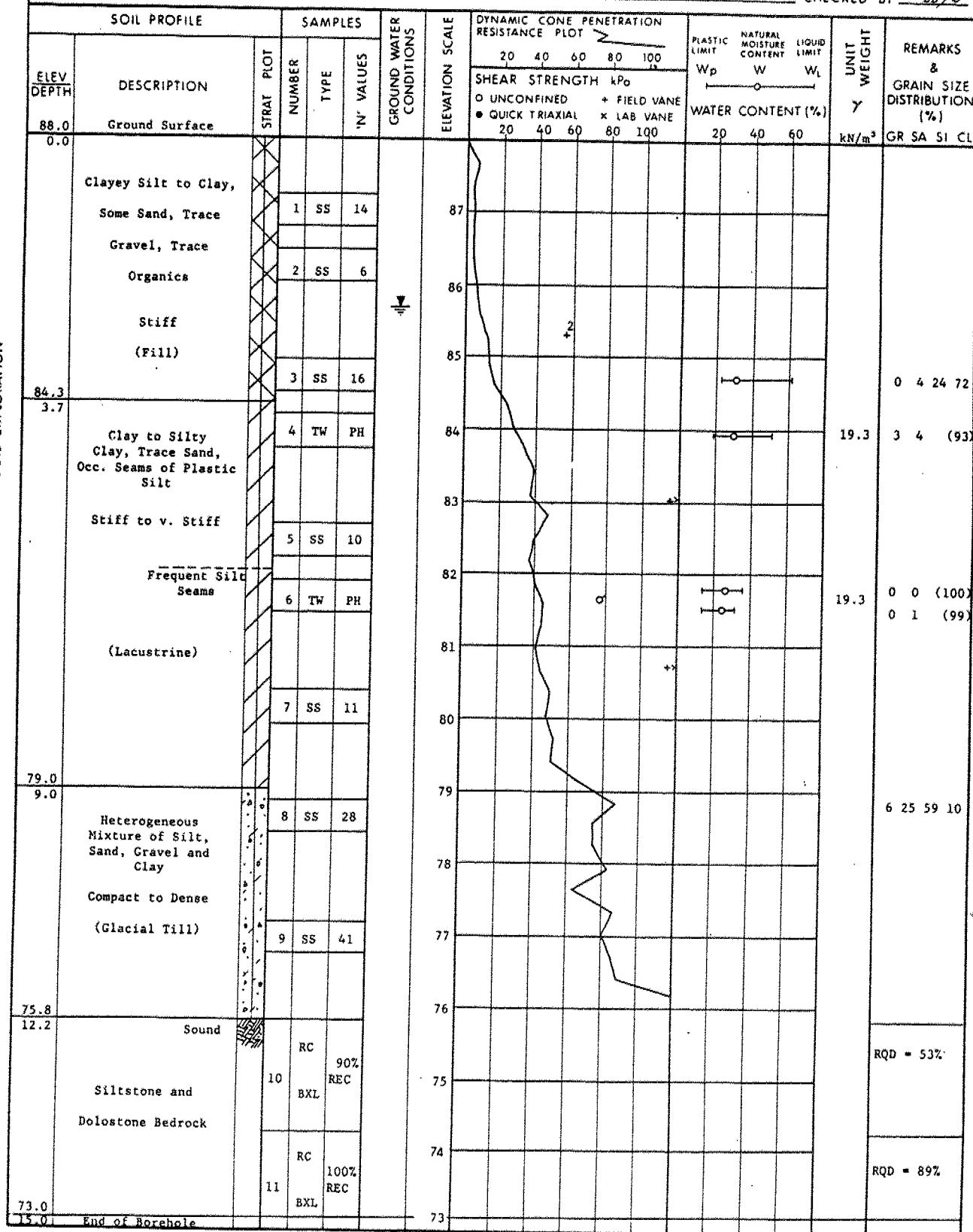
ORIGINATED BY SH

DIST 8 HWY 401 BOREHOLE TYPE Cone Test, H S Auger, NW Casing, BXL Rockcore

COMPILED BY JW

DATUM Geodetic DATE 1989 05 01-02

CHECKED BY DD



OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 293.3; E 303 324.9 ORIGINATED BY SH  
DIST 8 HWY 401 BOREHOLE TYPE Cone Test, H S Auger COMPILED BY JW  
DATUM Geodetic DATE 89 05 02-03 CHECKED BY *so*

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
88.4 0.0	Ground Surface												
	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics Stiff to Hard (Fill)	1	SS	14		88							0 19 49 32
		2	SS	25		87							
		3	SS	11		86							
		4	TW	PH		85						19.3	0 2 50 48
84.0 4.4	Clay to Silty Clay, Trace Sand Occ. Seams Plastic Silt Very Stiff Frequent Silt Seams  (Lacustrine)	5	SS	14		84							3 3 (94)
		6	SS	22		83							
		7	SS	10		82							0 0 (100)
		8	SS	10		81							
		9	TW	PH		80						18.4	
78.8 9.6	Heterogeneous Mixture of Silt, Sand, Gravel and Clay  Loose to Compact  (Glacial Till)	10	SS	12		79							
		11	SS	6		78							9 25 55 11
75.8 12.6	End of Borehole Probable Bedrock	12	SS	50/	0cm	76							

# RECORD OF BOREHOLE No 3

METRIC

W P 89-84-02 LOCATION Co-ords: N 4 903 329.3; E 303 338.5  
 DIST 8 HWY 401 BOREHOLE TYPE H S Auger, NW Casing, BXL Rockcore  
 DATUM Geodetic DATE 89 05 04-05  
 ORIGINATED BY SH  
 COMPILED BY JW  
 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100				
86.4	Ground Surface														
0.0	Clayey Silt to Clay Some Sand, Trace Gravel, Trace Organics Stiff to v. Stiff  (Fill)		1	SS	21	86									
			2	SS	17	85									
			3	TW	PH	84									
83.5			4	SS	20	83									
2.9	Clay to Silty Clay, Trace Sand Occ. Seams of Plastic Silt  Very Stiff  Lacustrine		5	SS	11	82									
			6	SS	10	81									
	Frequent Silt Seams		7	TW	PH	80									
			8	SS	13	79									
	Frequent Sand Seams		9	SS	21	78									
79.2			10	SS	5	77									
7.2	Heterogeneous Mixture of Silt, Sand, Gravel and Clay  Loose to Compact  (Glacial Till)					76									
75.7	Weathered Bedrock														
10.8	End of Borehole														

+3, x5: Numbers refer to  
Sensitivity

20  
15 ± 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

W P 89-84-02

LOCATION Co-ords: N 4 903 316.1; E 303 308.9

ORIGINATED BY SH

DIST 8 HWY 401

BOREHOLE TYPE Cone Test, H S Auger

COMPILED BY JW

DATUM Geodetic

DATE 89 05 04

CHECKED BY

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 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
88.1	Ground Surface											
0.0	Silty Sand Trace Gravel		1	SS	18							5 55 26 4
	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics Stiff (Fill)		2	SS	28							
			3	SS	22							
85.1	Clay to Silty Clay		4	SS	13							1 3 36 60
3.0	Trace Sand		5	SS	9							
	Occ. Seams of Plastic Silt Very Stiff (Lacustrine)		6	SS	6							
	Frequent Silt Seams		7	SS	2							0 0 60 40
			8	SS	5							
79.0	Heterogeneous Mixture of Silt, Sand, Gravel and Clay Compact (Glacial Till)		9	SS	12							
9.1			10	SS	14							
			11	SS	13							
74.7	End of Borehole Probable Bedrock		12	SS	120	5cm						
13.4												

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 5

METRIC

W.P. 89-84-02 LOCATION Co-ords: N 4 903 339.3; E 303 293.1

DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Auger

DATUM Geodetic DATE 89 05 17

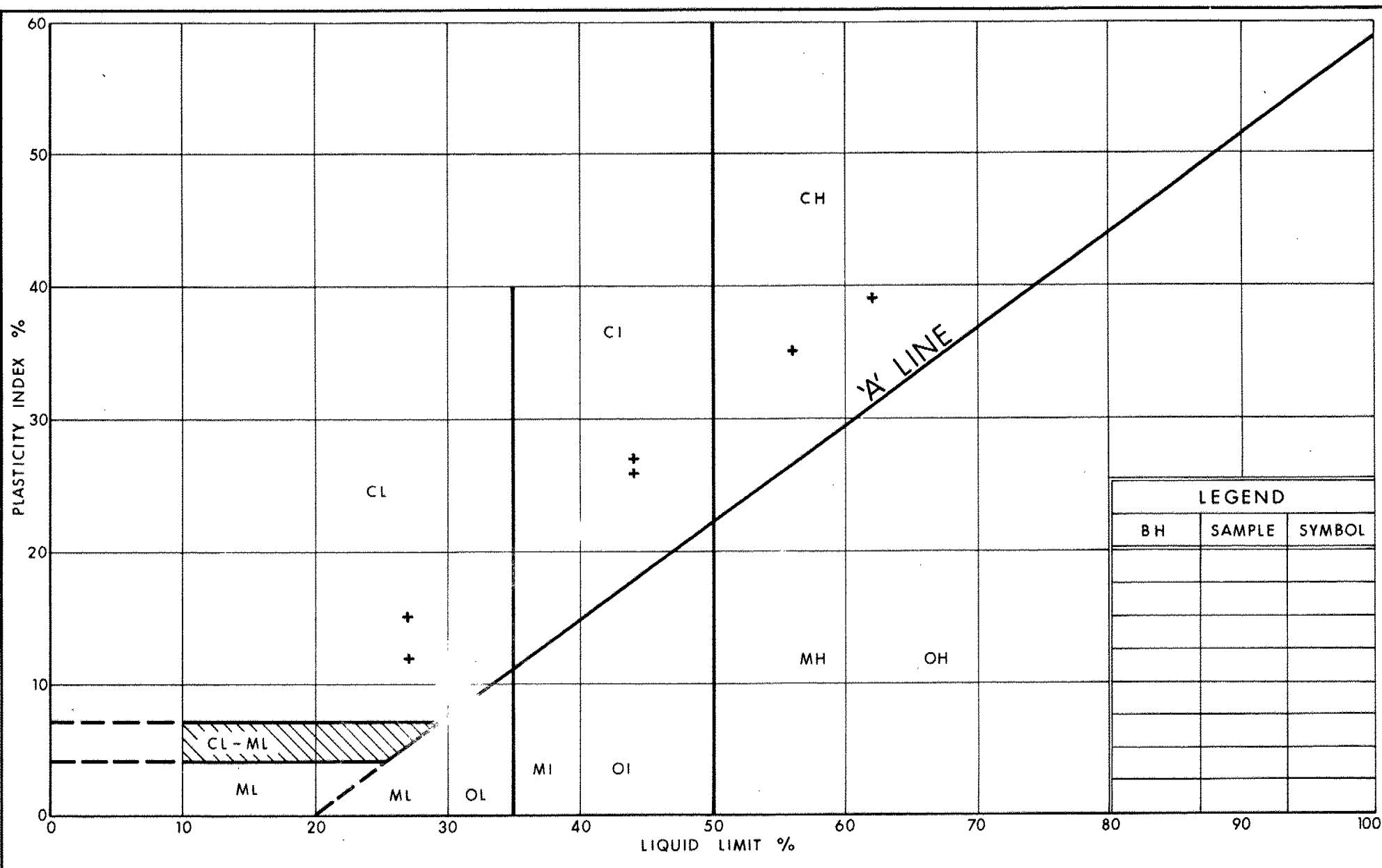
ORIGINATED BY BB

COMPILED BY JW

CHECKED BY

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 × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
88.1 0.0	Ground Surface						88					
	Clayey Silt to Clay, Some Sand, Trace Gravel, Trace Organics		1	SS	16		87					
	Very Stiff to Hard (Fill)		2	SS	27		86					
			3	SS	39		85					
85.0 3.1	Clay to Silty Clay Trace Sand, Occ. Seams of Plastic Silt Very Stiff (Lacustrine)		4	SS	16		84					
			5	SS	11		83					
			6	TW	PH		82					
	Frequent Silt Seams		7	SS	7		81					
			8	SS	5		80					
78.5 9.6	Heterogeneous Mixture of Silt, Sand, Gravel and Clay Compact (Glacial Till)		9	SS	23		79					
			10	SS	27		78					
			11	WS			77					
							76					
							75					
73.8 *							74					
14.3	End of Borehole Probable Bedrock *Auger Refusal											



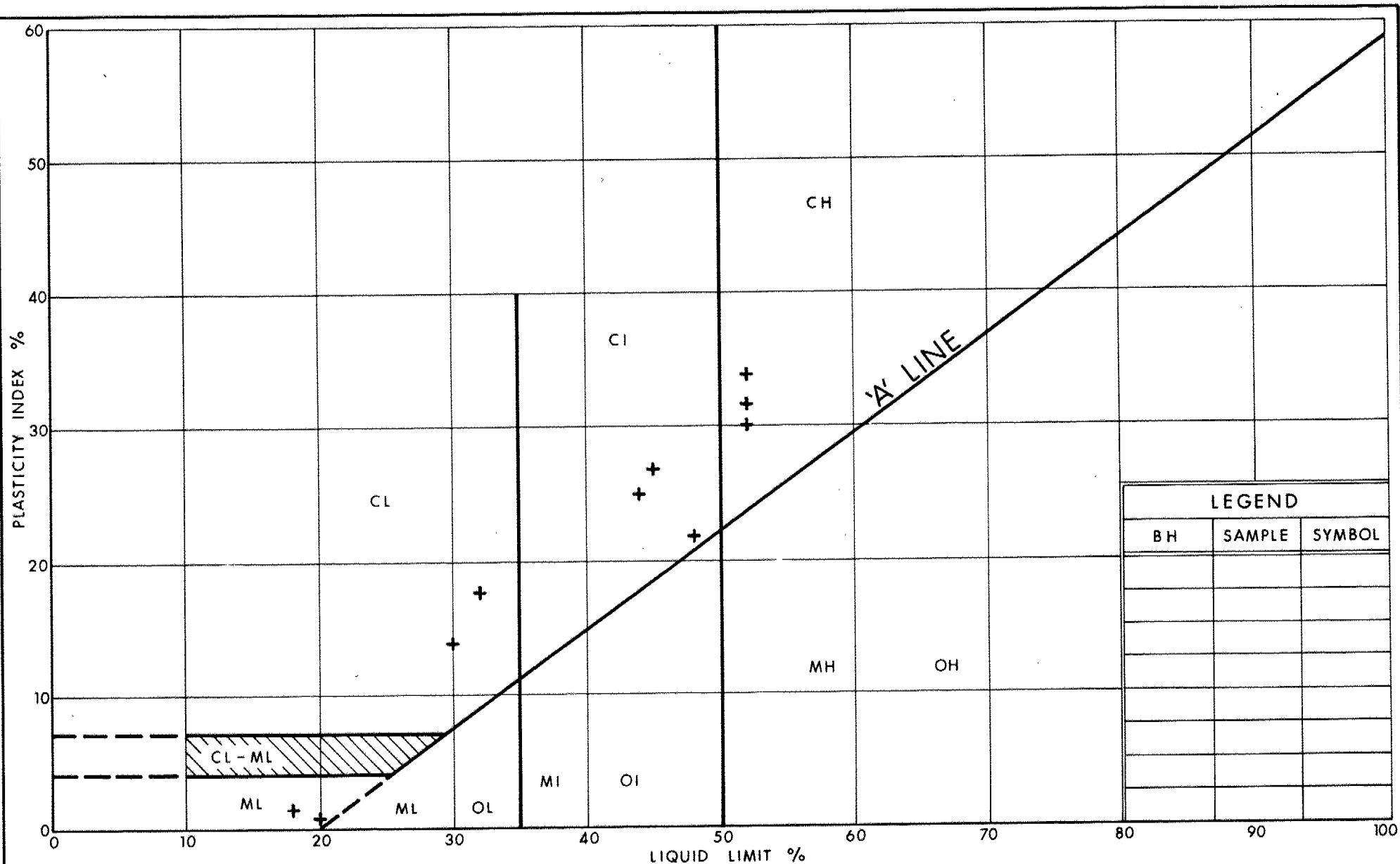
Ministry of  
Transportation

**PLASTICITY CHART**  
**CLAYEY SILT TO CLAY (Fill)**  
**SOME SAND, TRACE GRAVEL, TRACE ORGANICS**

FIG No 1

W P 89-84-02





Ministry of  
Transportation

Ontario

PLASTICITY CHART  
CLAY TO SILTY CLAY  
TRACE SAND WITH OCC SEAMS OF PLASTIC SILT

FIG No 3

W P 89-84-02



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

W.P. 89-84-02

**ROCK CORE DESCRIPTION**  
**WP 89 04 02**

1../1

CORE RECOVERY					CORE DESCRIPTION	
BH #	RC #	DEPTH (m)	CR* (%)	RQD* (%)	DEPTH (m)	DESCRIPTION
1	10	12.22-13.74	100	45	12.22-14.96	DOLOMITIC SILTSTONE with minor interbeds of <b>SILTY DOLOSTONE</b> , light to medium grey; very fine grained; very thickly bedded; weak to medium strong rock; slightly weathered to unweathered; very close to moderately close spaced fractures: horizontal bedding joints; average spacing $\approx$ 15-20 cm.
	11	13.74-14.96	100	89		
2	12	10.77-10.85	-	-	10.77-10.85	Possible bedrock: 4 pieces, 2-3 cm diameter, broken, angular - insufficient sample for positive identification.

\*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.

**FOUNDATION INVESTIGATION REPORT  
FOR  
W.P. 89-84-02 SITE  
HIGH MAST LIGHTING  
(Highway 401 & Sir John A. MacDonald Blvd.)  
KINGSTON, ONTARIO**

**PART 1 - FACTUAL INFORMATION**

**1. INTRODUCTION**

Trow Ontario Ltd. was retained to conduct a geotechnical investigation for the proposed high mast lighting posts to be located at the intersection of Highway 401 and Sir John A. MacDonald Blvd. in Kingston, Ontario. The investigation was verbally authorized by the Foundation Section of the Ministry of Transportation of Ontario.

This geotechnical investigation was undertaken to:

- a) Establish the geotechnical and groundwater conditions at the locations of the proposed lighting masts.
- b) Make recommendations regarding the geotechnical parameters that may be used in the design of the masts.   \*\*
- c) Assess the corrosion potential of the on-site soils on subsurface concrete.   \*\*

**2. PROCEDURE**

The fieldwork was undertaken with a CME 55 bombardier mounted drill rig equipped with continuous flight hollow stem augers. The fieldwork was conducted from January 2 to 9, 1990 and supervised on a full-time basis by a geotechnician from Trow Ontario Ltd. (Ottawa).

The fieldwork consisted of drilling a total of twelve boreholes. Initially, thirteen boreholes were planned, however Borehole No. P12 was eliminated prior to undertaking

**\*\* NOTE:** For the purposes of the contract these portions of the report have not been included as per MTO policy.

the fieldwork. All boreholes were located at the proposed high mast lighting post locations in the vicinity of the Highway 401/Sir John A. MacDonald Boulevard intersection situated northeast of Kingston, Ontario. Borehole Nos. P1 to P3, P5, P8, P9 to P11 and P13 were located on the south side of Highway No. 401. Borehole Nos. P4, P6 and P7 were put down on the north side of Highway No. 401. The locations of the boreholes are shown on Site Plan, Drawing No. 1. \*

The borehole drilling program comprised of drilling each borehole to auger refusal depths which ranged from 0.2m to 20.7m (Elevation 89.4m to 59.4m) below existing grade.

The bedrock was proven by core drilling the rock in selected boreholes at depths and elevations shown below.

Borehole Nos.	Depth (m)		Elevation (m)	
	From	To	From	To
P3	7.9	11.0	75.9	72.8
P6	5.4	8.5	83.6	80.5
P8	3.9	6.2	80.8	78.5
P11	2.1	4.9	83.9	81.1
P13	0.2	4.2	89.4	85.4

The sampling program of the overburden material in all boreholes consisted of performing standard penetration tests (SPT) at a 0.75m interval to a 4.6m depth. Below a 4.6m depth, SPT's were conducted at 1.5m depth intervals. In addition, relatively undisturbed thin wall tube samples of cohesive material were obtained. In-situ field vane tests were carried out in the cohesive material to establish the undrained shear strength. A dynamic cone test was performed in Borehole No. P1 from a depth of 18.4m to 20.7m to ascertain the bedrock depth.

The bedrock sampling program in Borehole Nos. P3, P6, P8, P11 and P13 comprised of coring 2.3m to 4.0m of the bedrock with an NQ3 core barrel and NW casing.

The borehole locations and elevations were established in the field by representatives of the Ministry of Transportation of Ontario. All borehole elevations refer to the Geodetic datum.

\* NOTE: Refer to Drawing No. 898402-A of the Contract Drawings.



All the soil samples were examined in the field, logged, preserved in plastic bags and identified by the Trow representative on site. The bedrock cores were also identified and stored in standard rock core boxes. On completion of the fieldwork, all the soil samples and rock cores were transported to the Trow laboratory in the City of Nepean, Ontario. Visual examination of the soil samples and rock cores were made by a geotechnical engineer and geologist respectively. Laboratory testing consisted of performing natural moisture content tests on all soil samples and unit weight determination tests on selected soil and rock samples. Grain size analysis, Atterberg Limits determination and pH/sulphate tests were performed on representative soil samples. \*

### **3. SITE DESCRIPTION**

The site under investigation is situated at the intersection of Highway No. 401 and Sir John A. MacDonald Boulevard interchange outside of Kingston, Ontario.

The topography is variable throughout the site. The general surface elevation generally decreases from Elevation 89.6m in the east end of the site to Elevation 80.1m in the west end of the site.

The site is covered by vegetation ranging from high grass to young trees.

### **4. SUBSURFACE SOIL AND BEDROCK DESCRIPTION**

A detailed description of the subsurface soil and bedrock conditions encountered throughout the site is given on Borehole Log Records, Borehole Nos. P1 to P11 and P13.

In general, the overburden at the site consists of a surficial topsoil veneer or fill deposit underlain by silty clay/clayey silt grading to a medium grained silt till overlying coarse grained sand and gravel and limestone bedrock.

#### **a) Topsoil**

A dark brown to black medium organic sandy silt topsoil was encountered in all boreholes except Borehole Nos. P3, P6 to P8. The topsoil ranged from 0.1m to 0.2m below existing grade.

\* NOTE: Refer to Table III for results of pH/sulphate tests.

**b) Heterogeneous Silty Clay Fill**

A surficial fill deposit was contacted in Borehole Nos. P3, P6 to P8 extending to depths of 0.7m to 3.0m (Elevation 89.0m to 80.8m). The fill is a mixture of silty clay, some sand and gravel and wood pieces. The natural moisture content of the fill is 31 to 87 percent.

**c) Silty Clay to Clayey Silt**

The surficial topsoil and fill was underlain by a variably graded silty clay to clayey silt. Within the upper portion of this unit occasional rootlets were detected. The silty clay/clayey silt stratum extended to depths of 1.5m to 10.6m below existing grade (Elevation 86.7m to 74.0m). Possible boulders may exist within this stratum, specifically in Borehole Nos. P8 and P10. The consistency of the cohesive clay/silt strata is soft to stiff based on undisturbed shear strength values of 37 kPa to 94 kPa. The sensitivity of the clay from vane tests ranges from 3 to 16 indicating a low to high sensitivity. The natural moisture contents and unit weights of the clay/silt are 20 percent to 44 percent and 17.5 kN/m<sup>3</sup> to 20 kN/m<sup>3</sup> respectively.

An Atterberg Limit test conducted on Borehole No. P1 at a 1.5m to 2.1m depth and Borehole No. P10 at a 3.8m to 4.2m depth indicated a plasticity index of 24 and 14 percent and a liquid limit of 47 and 44 percent respectively. The plasticity chart is shown on Drawing No. 2. \*

A grain size analysis performed on material from Borehole No. P3 at a 3.8m to 4.4m depth indicated a soil composition of 91 percent clay and silt and 9 percent sand. The distribution curve is shown on Drawing No. 3. \*\*

**d) Sandy Silt to Silty Sand**

The clay/silt strata are underlain by a sandy silt/silty sand in Borehole Nos. P1, P2, P3, P4, P6, P7, P9 and P10. In general, the coarse grained sand is overlain by the fine grained silt. The silt extended to depths ranging from 4.6m to 13.7m (Elevation 66.4m to 84.4m). The sand contacted in Borehole Nos. P1 and P2 continued to a depth of 15.2m and 20.7m (Elevation 59.4m to 67.4m).

\* NOTE: Refer to Figure No. 2.

\*\* NOTE: Refer to Figure No. 3.

The standard penetration tests carried out in the silt/sand resulted in "N" values of 3 to 26 indicating a very loose to compact relative density. The natural moisture content of silt/sand ranges from 10 to 30 percent and the natural unit weight is  $19.3 \text{ kN/m}^3$  to  $19.5 \text{ kN/m}^3$ . Grain size analysis conducted on the material from Borehole No. P1 at a 7.6m to 8.2m depth indicated a soil composition of 92 percent clay and silt, and 8 percent sand (based on the Unified Soil Classification System). The distribution curve is shown on Drawing No. 4\* From Borehole No. P2 grain size analysis conducted on a sample from a depth of 12.2m to 12.8m revealed a soil composition of 29 percent clay and silt and 71 percent sand (based on the Unified Soil Classification System). The grain size distribution curve is shown on Drawing No. 5. \*\*

**e) Clayey Silt to Silty Sand Till**

The silty clay, silt and sand are underlain by a clayey silt/silty sand till in Borehole Nos. P4, P6, P9 and P11 contacted at depths of 1.5m to 9.1m (Elevation 77.8m to 84.5m) and extending to depths of 2.1m to 10.7m (Elevation 75.4m to 83.9m). The till was encountered at a shallow depth of 1.5m in Borehole No. P11. Cobbles and boulders were detected in the till at Borehole Nos. P4 and P9 from 7.6m to 9.8m depths. The natural moisture content of the till ranges from 10 to 20 percent. The natural unit weight of the till is estimated to be  $19.0 \text{ kN/m}^3$ . A grain size analysis of the till from Borehole No. P9 at a 7.6m to 8.2m depth indicated a soil composition of 54 percent silt and clay, 29 percent sand and 17 percent gravel based on the Unified Soil Classification System. The grain size distribution curve is shown on Drawing No. 6. \*\*\*

**f) Sand and Gravel**

A coarse grained sand and gravel unit underlies the sand and till of Borehole Nos. P2 and P4. This coarse unit was contacted at a depth of 15.2m and 10.7m (Elevation 67.4m to 76.2m) respectively extending to 18.3m and 10.9m (Elevation 64.3m to 76.0m) respectively. Possible cobbles were detected within the sand and gravel in Borehole No. P3 from 15.9m to 18.3m depths.

**g) Limestone Bedrock**

Based on auger refusal criterion, bedrock was encountered in all boreholes at depths of 3.3m to 20.7m (Elevation 59.4m to 83.9m). In Borehole P13, weathered

\*NOTE: Refer to Figure No. 4.

\*\*NOTE: Refer to Figure No. 5.

\*\*\*NOTE: Refer to Figure No. 6.

bedrock exists to a 1.7m depth (Elevation 87.9m). Along Highway No. 401, the bedrock becomes shallow increasing from Elevation 59.4m in the west to Elevation 89.4m in the east. Along the Sir John A. MacDonald interchange, the bedrock rises in a northeasterly direction from Elevation 78.5m in the southwest to Elevation 80.5m in the northeast.

A review of available local geologic information defines the bedrock in the area to be limestone with minor dolomite originating from the Gull River Formation. \*

The Total Core Recovery (T.C.R.) and Rock Quality Designation (R.Q.D.) of the bedrock was established to be 85 percent to 100 percent and 51 percent to 97 percent respectively. In Borehole No. P13, the T.C.R. was 32 percent up to a 1.7m depth from which it increased to 83 and 100 percent for T.C.R.. Similarly, the R.Q.D. increased from 0 percent to 100 percent in Borehole No. P13. The low T.C.R. and R.Q.D. of Borehole No. P13 is indicative of a very highly weathered bedrock from 0.2m to 1.7m depths. Below a 1.7m depth the bedrock is comparatively of good quality.

In general, the R.Q.D. range of 51 percent to 97 percent indicates a fair to excellent quality of rock from the upper depths of the bedrock to the end of the rock core.

The bedrock unit weight was established to be  $26.5 \text{ kN/m}^3$  in Borehole No. P8 at a 5.0m depth and  $27.4 \text{ kN/m}^3$  in Borehole Nos. P3 and P13 at 9.4m and 3.7m depths respectively.

#### **h) Groundwater**

Upon completion of drilling, water was detected in all boreholes except Borehole Nos. P8 and P13 ranging from 1.5m to 7.6m depths. Standpipes were installed in Borehole Nos. P2, P6, P8 and P13 for long term monitoring of groundwater levels. One week after the drilling date, groundwater levels ranged from 0.8m to 3.6m (Elevation 81.6m to 86.8m).

\* NOTE: Refer to Table II for descriptions of the bedrock.

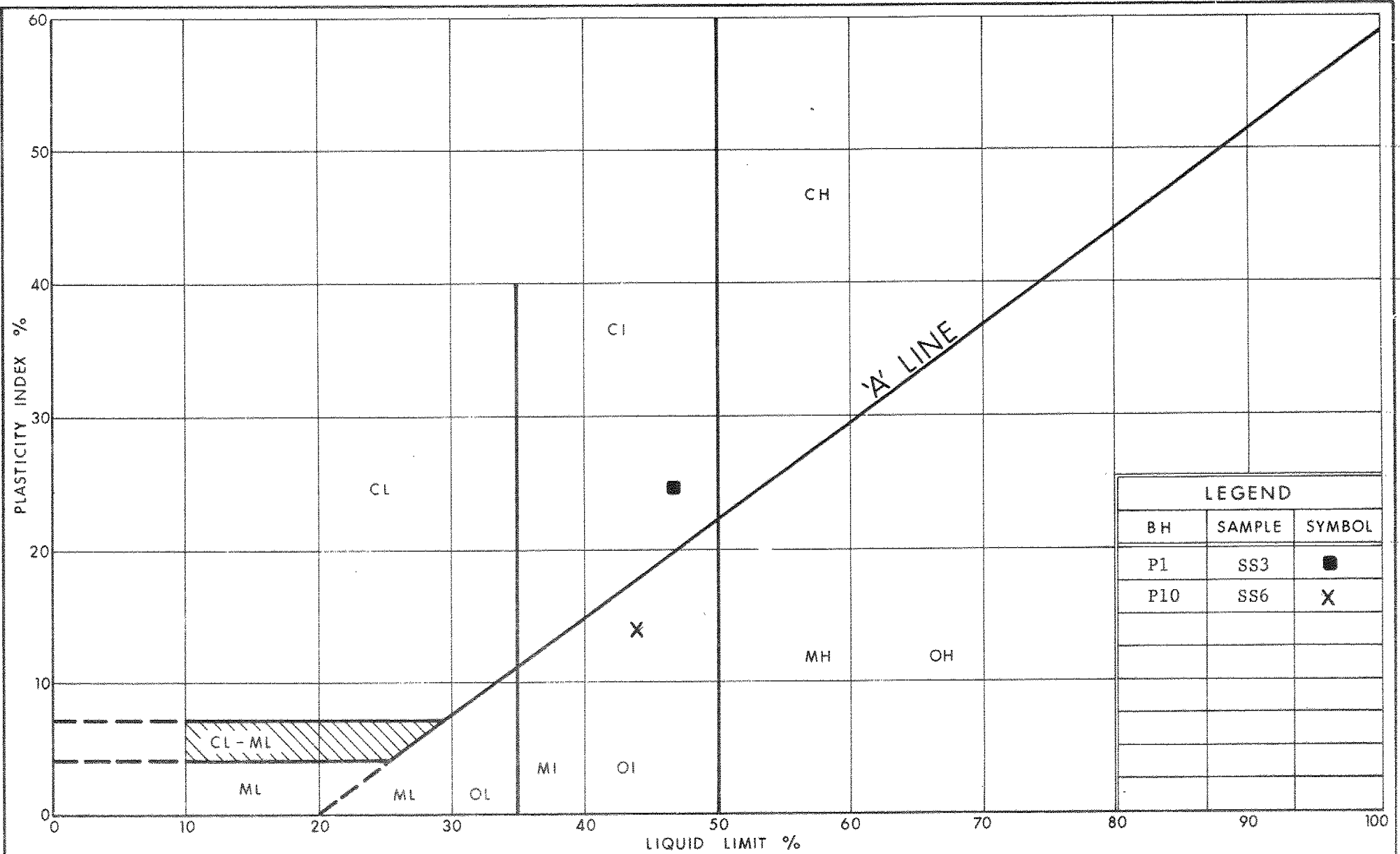
NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Trow Ontario Ltd. (consulting geotechnical engineers for this project), under the supervision of the MTO Foundation Design Section.



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

*M. Devata*  
M. Devata, P. Eng.  
Chief Foundation Engineer

**A P P E N D I X**



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Ontario

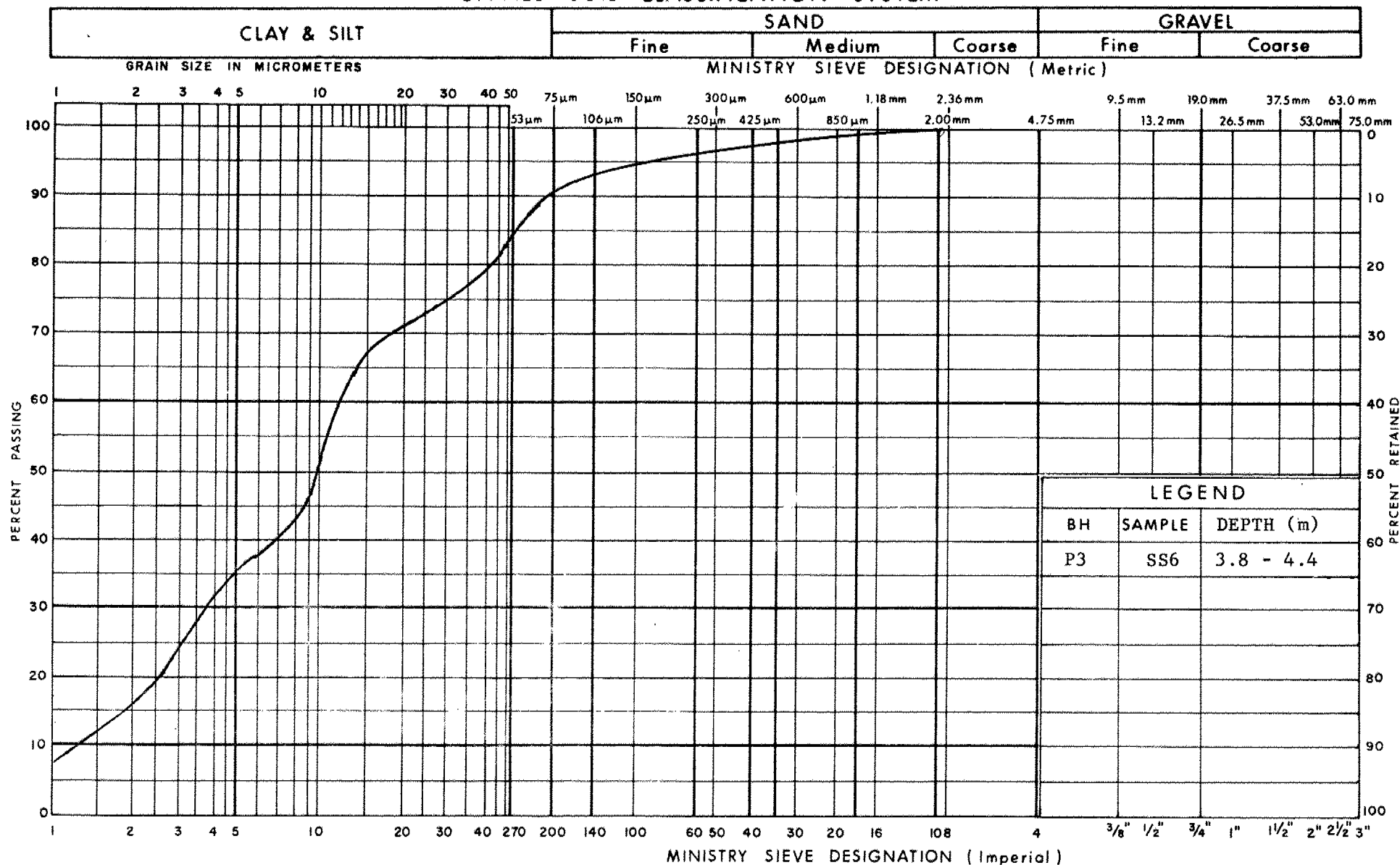
## PLASTICITY CHART

\* NOTE: Should Read 'Silty Clay to Clayey Silt'

FIG No 2

W P 89-84-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

Clay, silt, trace of sand

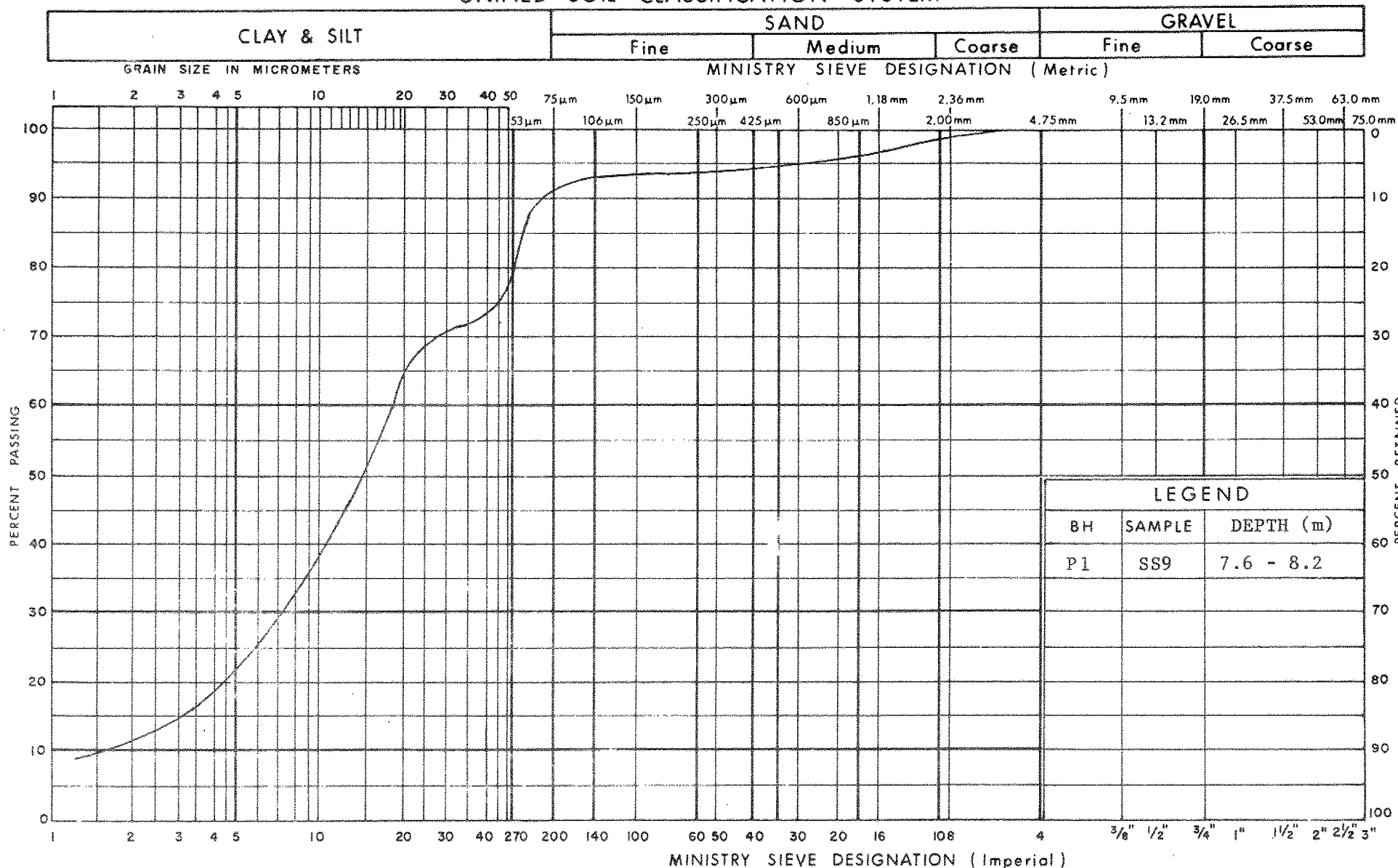
\* NOTE: Should Read 'Silty Clay to Clayey Silt'

FIG No 3

W P 89-84-02



## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

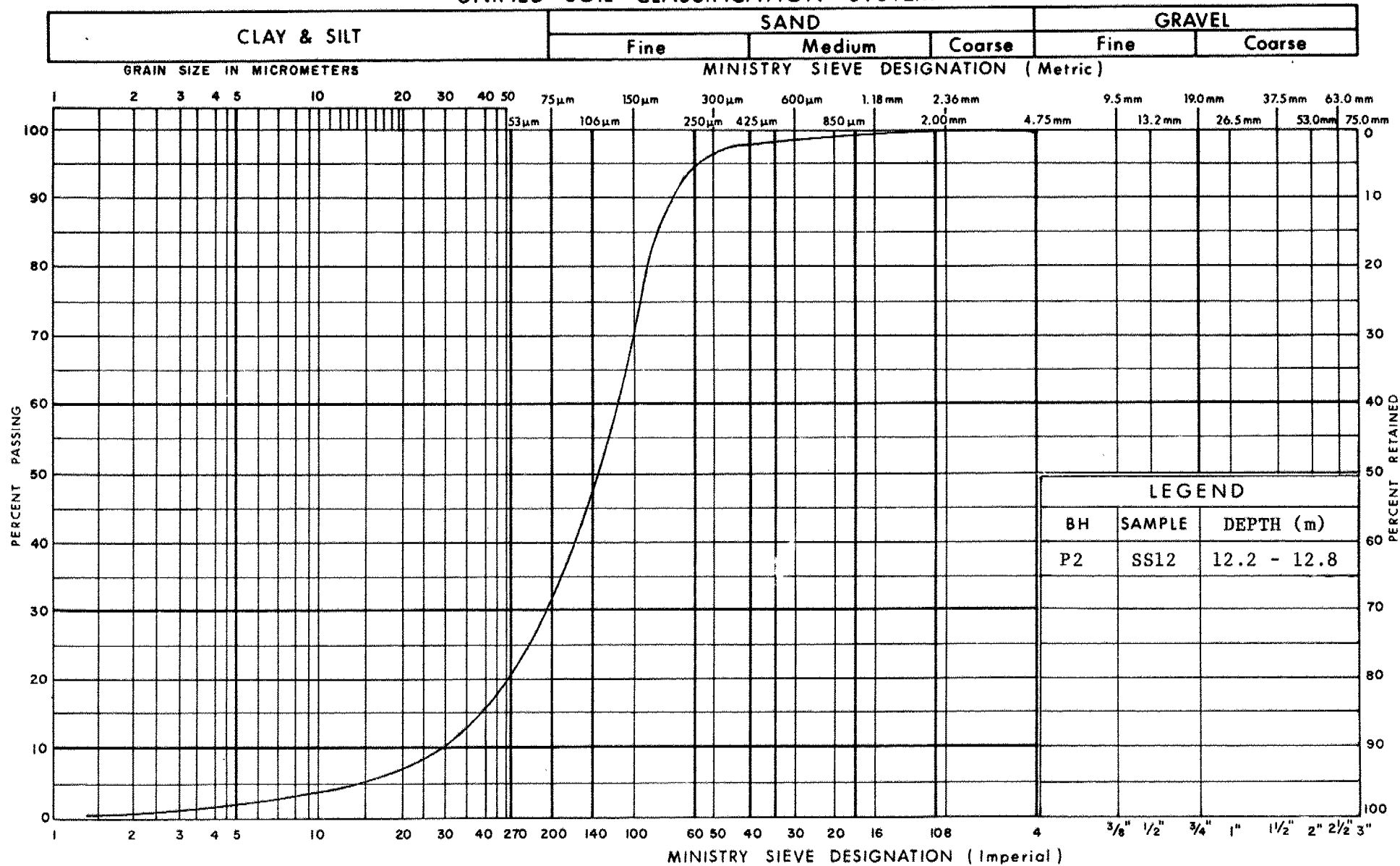
Silt trace of sand, and clay

\*NOTE: Should Read 'Sandy Silt to Silty Sand'

FIG No 4

W P 89-84-02

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

Sand, some clays and silts

\*NOTE: Should Read 'Sandy Silt to Silty Sand'

FIG No 5

W P 89-84-02



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**TABLE II**  
**DESCRIPTION OF ROCK CORES**

<b>Borehole No.</b>	<b>Rock Core No.</b>	<b>Rock Core Depth(m)</b>	<b>Rock Core Recovery (%)</b>	<b>Rock Quality Designation (%)</b>	<b>Depth of Rock (m)</b>	<b>Elevation (m)</b>	<b>Description</b>
P3	1	7.9 - 9.0	100	91	7.9 - 11.0	75.9 - 72.8	<b><u>Limestone Bedrock:</u></b> Massive, bluish grey, excellent quality.
	2	9.0 - 9.7	100	85			<b><u>Limestone Bedrock:</u></b> Massive, 150mm fine bed of greenish grey limestone, bluish grey, good quality.
	3	9.7 - 11.0	100	92			<b><u>Limestone Bedrock:</u></b> Massive, bluish grey, excellent quality. Bottom 0.3m moderate fracturing, light grey.
P6	1	5.4 - 6.2	100	97	5.4 - 8.5	83.6 - 80.5	<b><u>Limestone Bedrock:</u></b> Interbedded light grey/dark grey, finely laminated, close spaced joints, bluish grey, excellent quality.
	2	6.2 - 7.5	100	93			<b><u>Limestone Bedrock:</u></b> Interbedded light grey/greenish grey, finely laminated, bluish grey, excellent quality.

**TABLE II**  
**DESCRIPTION OF ROCK CORES**

Borehole No.	Rock Core No.	Rock Core Depth(m)	Rock Core Recovery (%)	Rock Quality Designation (%)	Depth of Rock (m)	Elevation (m)	Description
P6	3	7.5 - 8.5	100	97	5.4 - 8.5	83.6 - 80.5	<b><u>Limestone Bedrock:</u></b> Massive, light grey/greenish grey laminated in sections, slightly fractured, green, excellent quality.
P8	1	3.9 - 4.7	100	77	3.9 - 6.2	80.8 - 78.5	<b><u>Limestone Bedrock:</u></b> Laminated, moderately spaced joints, grey, good quality.
	2	4.7 - 6.2	100	85			<b><u>Limestone Bedrock:</u></b> Massive, to laminated, grey, good quality.
P11	1	2.1 - 3.4	85	51	2.1 - 4.9	83.9 - 81.1	<b><u>Limestone Bedrock:</u></b> Massive, bedding joints, locally fractured, grey fair quality.
	2	3.4 - 4.9	100	83			Moderately fractured, well developed stylolites, grey, good quality.
P13	1	0.2 - 0.8	32	0	0.2 - 4.2	89.4 - 85.4	<b><u>Limestone:</u></b> Highly weathered, severely fractured, grey, very poor quality.

**TABLE II**  
**DESCRIPTION OF ROCK CORES**

<b>Borehole No.</b>	<b>Rock Core No.</b>	<b>Rock Core Depth(m)</b>	<b>Rock Core Recovery (%)</b>	<b>Rock Quality Designation (%)</b>	<b>Depth of Rock (m)</b>	<b>Elevation (m)</b>	<b>Description</b>
P13	2	0.8 - 1.2	38	0	0.2 - 4.2	89.4 - 85.4	<b><u>Limestone:</u></b> Highly weathered, severely fractured, grey, very poor quality.
	3	1.2 - 1.7	32	0			<b><u>Limestone:</u></b> Highly weathered, severely fractured, grey, very poor quality.
	4	1.7 - 3.3	89	67			<b><u>Limestone Bedrock:</u></b> Highly weathered, moderately fractured, grey, fair quality.
	5	3.3 - 4.2	100	100			<b><u>Limestone Bedrock:</u></b> Massive, grey, excellent quality.

**TABLE III**  
**CHEMICAL TEST RESULTS ON SOIL SAMPLES**

<u>Borehole No.</u>	<u>Depth (m)</u>	<u>pH</u>	<u>Sulphate (%)</u>
P1	0.8 - 1.4	7.72	0.08
P4	3.8 - 4.4	8.14	0.08
P7	4.6 - 5.2	8.47	0.14
P10	6.1 - 6.7	8.21	0.08

## RECORD OF BOREHOLE No P1

METRIC

W P 89-84-02 LOCATION Co-ords: N4903601.7; E302484.0 ORIGINATED BY B.R  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY SMP  
DATUM Geodetic DATE January 9, 1990 CHECKED BY SMP

[illegible]

+3, x5: Numbers refer to Sensitivity.



## RECORD OF BOREHOLE No P2

**METRIC**

W P 89-84-02 LOCATION Co-ords: N4903511.7; E302706.5 ORIGINATED BY B.R.  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SMP  
DATUM Geodetic DATE January 8, 1990 CHECKED BY SMP

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x<sup>5</sup>: Numbers refer to Sensitivity

## RECORD OF BOREHOLE No P3

METRIC

W P 89-84-02 LOCATION Co-ords: N4903429.0; E302917.9 ORIGINATED BY B.R.  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Auger: NW Casing, NOS Rock Core COMPILED BY SMP  
DATUM Geodetic DATE January 5, 1990 CHECKED BY SMP

[illegible]

+3, x5 : Numbers refer to Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

## RECORD OF BOREHOLE No P4

METRIC

W P 89-84-02 LOCATION Co-ords: N4903452.7; E303129.7 ORIGINATED BY B.R.  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SMP  
DATUM Geodetic DATE January 9, 1990 CHECKED BY SMP

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P5

METRIC

W P 89-84-02 LOCATION Co-ords: N4903321.5; E303125.8 ORIGINATED BY B.R.  
 DIST 8 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SMP  
 DATUM Geodetic DATE January 5, 1990 CHECKED BY SMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
86.5	Ground Surface																
	Topsoil		1	SS	17											17.9	
0.2	Clayey Silt		2	SS	7												
	Low organics.																
85.0	Firm						85.0										
1.5	Silty Clay		3	SS	16											18.2	
	Slight to medium																
	plastic, thin partings		4	SS	14											18.0	
	of silt, friable.																
	Firm to Very Stiff		5	SS	8											18.0	
			6	SS	6		83.0										
			7	SS	7												
							81.0										
80.4																	
6.1	Clayey Silt		8	SS	4												
	Slight to non-plastic,																
	light brown stains.																
	Stiff		9	SS	4		79.0										
			10	SS	3		77.0										
75.9																	
10.6	End of Borehole						75.0										
	Auger Refusal																
	Probable Bedrock																
	Limestone of the																
	Gull River Formation																
							73.0										
							71.0										
							69.0										
							67.0										
							65.0										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity  
 20  
 15 5 (%) STRAIN AT FAILURE  
 10

# RECORD OF BOREHOLE No P6.

METRIC

W P 89-84-02 LOCATION Co-ords: N4903476.7; E303288.6 ORIGINATED BY B.R.  
 DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems; NW Casing, NO3 Core Barrel COMPILED BY SMP  
 DATUM Geodetic DATE January 8, 1989 CHECKED BY SMP

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
89.0	Ground Surface													
0.2	Silty Clay Medium organics, wet. Stiff (Possible Fill)		1	SS	7									
			2	SS	8								17.4	
			3	SS	15								19.5	
86.7	Silt Some fine grained sand, medium to low plastic, moist.  Very Stiff		4	SS	19								19.4	
2.3			5	SS	17								19.1	
			6	SS	26									
84.4			7	SS	41									
4.6	Silty Sand Till Fine grained Dense													
83.6	Limestone Bedrock		9	RC	100% rec									RQD = 97%
5.4			10	RC	100% rec									RQD = 93%
			11	RC	100% rec									RQD = 97%
80.5	End of Borehole													
8.5														

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\div$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No P7

METRIC

W P 89-84-02 LOCATION Co-ords: N4903410.4; E303243.6 ORIGINATED BY B.R.  
 DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems COMPILED BY SMP  
 DATUM Geodetic DATE January 9, 1990 CHECKED BY SMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE										
87.7	Ground Surface							20	40	60	80	100						
0.2	Clayey Silt Some fine grained sand, slightly plastic, dry. Very Stiff		1	SS	11									0				
			2	SS	17									0		18.9		
			3	SS	17											19.2		
85.4	(Possible Fill)																	
2.3	Silty Clay Mottled, inclusions of silt, Very Stiff		4	SS	16									0		19.3		
84.7																		
3.0	Clayey Silt Medium plastic, Stiff		5	SS	15									0				
83.9														0		19.3		
3.8	Sandy Silt Fine grained, oxidized stains, dilatent, non- plastic. Compact		6	SS	16									0		19.5		
82.5			7	SS	23													
5.2	End of Borehole Auger Refusal Probable Bedrock Limestone of the Gull River Formation							82.0										
								80.0										
								78.0										
								76.0										
								74.0										
								72.0										
								70.0										
								68.0										
								66.0										

OFFICE REPORT ON SOIL EXPLORATION

## RECORD OF BOREHOLE No P8

METRIC

W P 89-82-02 LOCATION Co-ords: N4903194.0; E303217.4 ORIGINATED BY B.R.  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems; NW Casing, NQ3 Core Barrel COMPILED BY SMP  
DATUM Geodetic DATE January 3, 1990 CHECKED BY SMP

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No P9

METRIC

W P 89-84-02 LOCATION Co-ords: N4903277.2; E303336.3 ORIGINATED BY B.R.  
 DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems COMPILED BY SNP  
 DATUM Geodetic DATE January 4, 1990 CHECKED BY SMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.4	Ground Surface																
	Topsoil		1	SS	3												
0.2	Silty Clay Thin partings of silt, medium plastic, dry.		2	SS	13		84.0									18.2	
	Firm to Stiff		3	SS	9												
			4	SS	6												
82.4																	
3.0	Clayey Silt Some fine grained sand and gravel, medium plastic.		5	PH	0.6m rec		82.0										
	Firm		6	SS	6												
							80.0										
79.3																	
6.1	Silty Sand Medium to coarse grained sand, non- dilatant, wet.		7	SS	6		78.0										
77.8	Loose																
7.6	Sandy Gravelly Silt Till Trace of clay, non- dilatant, wet. Possible cobbles from 7.6m to 8.2m depth.		8	SS	11												17 29 54
76.4	Compact						76.0										
9.0	End of Borehole Auger Refusal Probable Bedrock Limestone of the Gull River Formation						74.0										
							72.0										
							70.0										
							68.0										
							66.0										
							64.0										

OFFICE REPORT ON SOIL EXPLORATION



## RECORD OF BOREHOLE No P10.

METRIC

W P 89-84-02 LOCATION Co-ords: N4903212.3; E303411.1 ORIGINATED BY B.R.  
DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems COMPILED BY SMP  
DATUM Geodetic DATE January 3, 1989 CHECKED BY SMP

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x<sup>S</sup>: Numbers refer to Sensitivity



# RECORD OF BOREHOLE No PI3

METRIC

W P 89-84-02 LOCATION Co-ords: N4903064.9; E304095.3 ORIGINATED BY B.R.  
 DIST 8 HWY 401 BOREHOLE TYPE Hollow Stems, NW Casing, NQ3 Core Barrel COMPILED BY SMP  
 DATUM Geodetic DATE January 2, 1990 CHECKED BY SMP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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 kPo					
89.6	Ground Surface													
89.4	Topsoil		1	RC	32% rec									RQD = 0%
0.2	Weathered Limestone Bedrock		2	RC	38% rec									RQD = 0%
87.9			3	RC	32% rec		88.0							RQD = 0%
1.7	Limestone Bedrock		4	RC	89% rec									RQD = 67%
85.4			5	RC	100% rec		86.0							RQD = 100%
4.2	End of Borehole													
							84.0							
							82.0							
							80.0							
							78.0							
							76.0							
							74.0							
							72.0							
							70.0							
							68.0							

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