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GEOCRES No. 30M5-125, 126, 127

DIST. \_\_\_\_\_ REGION \_\_\_\_\_

W.P. No. 83-74-21, 22, & 23

CONT. No. 82-85

W. O. No. \_\_\_\_\_

STR. SITE No. 10-322

HWY. No. 2

LOCATION Proposed overpass, Burlington

No of PAGES -       

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

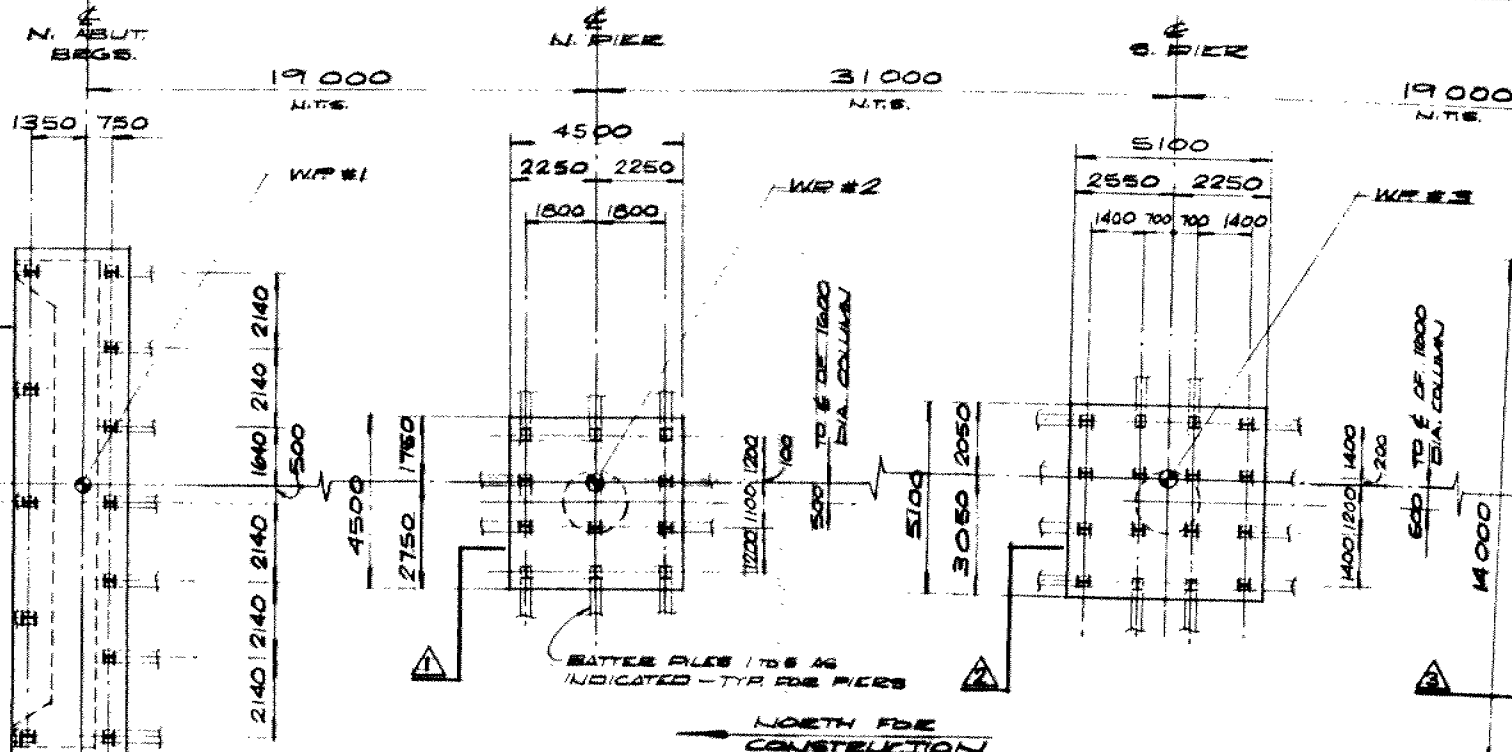
REMARKS: \_\_\_\_\_

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**METRIC**

CONT No  
WP No 83-74-21

RAMP S-EW OVERPASS  
N.B. COLLECTOR  
FOUNDATION LAYOUT

**SHEET**

**DeLCan** 538 LESLIE CAYTHAM CANADA LTD  
GENERAL TIRE & RUBBER CO. 4400 PL. ANNEBROS

## NOTES

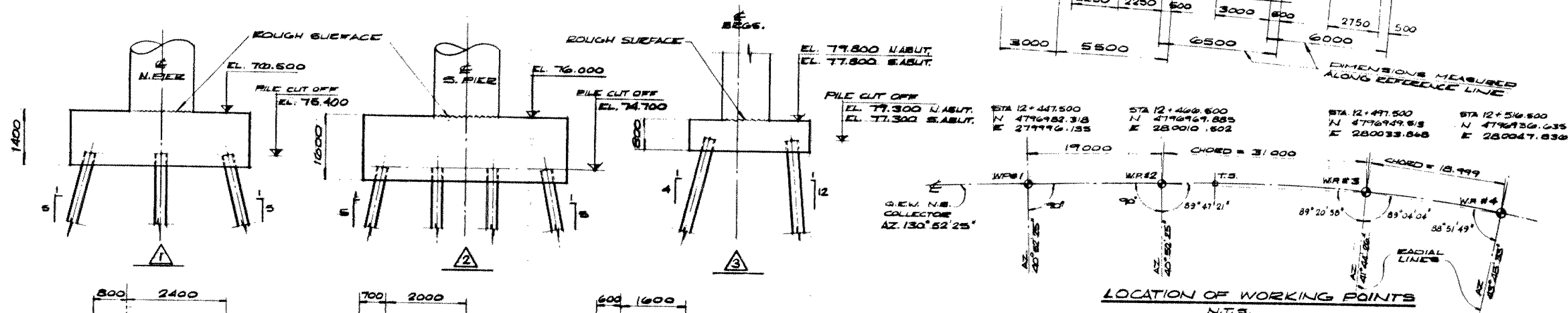
1. PILES TO BE DRIVEN TO BEDROCK.
2. PILE DRIVING ENERGY SHALL NOT BE LESS THAN 50,000 JOULES PER BLOW.
3. PILE SPACING TO BE MEASURED AT THE UNDERSIDE OF FOOTINGS.

ABUT. PILE LAYOUT  
TYPE BOTH ABUTMENTS

FOUNDATION PLAN  
11100

ABUT. ETG. LAYOUT  
TYPE BOTH ABUTMENTS

DIMENSIONS MEASURED  
ALONG REFERENCE LINE.



LOCATION OF WORKING POINTS

STEEL PILE DATA			
LOCATION	N° REQD.	LGTH. - m	TYPE
N. PILE	12	6.5	HP 310 x 110 WITH DRIVE SHOES
S. PILE	16	5.5	
N. ABUT.	12	9.5	
S. ABUT.	12	8.0	
RET. WALL	6	8.0	HP 310 x 110 WITH DRIVE SHOES
	4	9.5	
	4	9.5	

- 1 FILE LENGTHS AS SHOWN ARE THEORETICAL LENGTH BELOW CUT OFF
- 2 FOR DETAILS OF DRIVING SHOES SEE STANDARD DD3301



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE BY		DESCRIPTION
	DESIGN	SC	CHECK JD
DRAWING	SC	CHECK SC	SITE NO. 0-322 DWG 3

SECTIONS 1150



T10439

REPORT TO  
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS  
ONTARIO

*CONJ 82-85*

FOUNDATION INVESTIGATIONS  
PROPOSED OVERPASS STRUCTURES  
QUEEN ELIZABETH WAY/HIGHWAY 2 AREA  
BURLINGTON *W.P. 83-74-2,22 & 23* ONTARIO

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February 1981

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*GEO. N<sup>o</sup>. 30M5-125/26 & 127*

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Rexdale, Ontario  
February 20th, 1981

Ministry of Transportation  
and Communications  
Pavement and Foundation  
Design Section  
Central Building - Room 315  
Downsview, Ontario

Attention: Mr. K. Selby, P. Eng.  
Senior Structural Engineer

Re: Foundation Investigations  
Proposed Overpass Structures  
Queen Elizabeth Way/Highway 2 Area  
Burlington, Ontario

Dear Sirs:

This letter accompanies our report on the foundation investigations carried out at the sites of three proposed Overpass structures in the above-referenced area. The Ministry Work Project Numbers for the structures are 83-74-21, 43-74-22 and 83-74-23, corresponding to Site Numbers 10-322, 10-142A and 10-142B, respectively.

We find that the stratigraphy at the three sites is generally similar, comprising in descending order a surficial layer of fill, a stratum of silty sand to sandy silt and a stratum of silty clay (till) overlying the local shale bedrock. The thicknesses of the individual layers varies between the sites and in the case of Site 10-322, a significant variation in fill thickness occurs across the site due to the presence of an existing ramp embankment which intersects the proposed Overpass structure. Details of the soil, bedrock and groundwater conditions encountered at each site are described in detail in the report.

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Halifax    Fredericton    Montreal    Toronto    Hamilton    Sudbury    Saskatoon    Calgary    Vancouver

Ministry of Transportation  
and Communications  
February 20th, 1981  
Page 2.

Based on the factual data obtained from the investigations, spread foundations supported within the overburden or on bedrock, or piles driven to end-bearing within the shale bedrock, are considered suitable foundation systems as discussed in the report.

We trust that the report contains all the information required for the investigations at this time. Kindly call if elaboration on any point is required.

The co-operation and assistance provided to us throughout the work by involved Ministry of Transportation and Communications personnel is gratefully acknowledged.

Yours very truly,  
GEOCON (1975) LTD.



M.A.J. Matich, P. Eng.  
President

MAJM:smcb  
01511-61  
(T10439)

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## 1.0 INTRODUCTION

Geocon (1975) Ltd. has been retained by the Ministry of Transportation and Communications (M.T.C.), Ontario to carry out a geotechnical investigation at the sites of three proposed Bridges at the intersection of Q.E.W. and Highway 2 in Burlington. The scope of work for this investigation was discussed with staff members of M.T.C. on December 9th, 1980 and confirmed by letter December 16th, 1980. Our proposal was submitted on December 17th, 1980.

The purpose of this investigation was to obtain subsurface information on soil and groundwater conditions for use in design of foundations for the proposed Bridge structures. Progress results by (letters dated December 23rd, 1980 and January 16th, 1981) have been submitted on all three sites for purposes of preliminary design.

This report contains the factual results of the investigation in the form of Records of Boreholes in Appendix II; the location of the boreholes and inferred stratigraphy are given on the drawings at the rear of this report. The report presents a description of the soil, rock and groundwater conditions at each site, combining Sites 10-142A and 10-142B because of their similarity and close proximity, one to the other. The discussion and geotechnical interpretation of the findings of this investigation for foundation design covers all three sites because of basic interpretive similarities.

## 2.0 SITE AND GEOLOGY

The three sites are located at the Highway 2/Queen Elizabeth Way (Q.E.W.) interchange in the City of Burlington. The proposed Northbound Collector and Southbound Collector Bridge structures (Sites 10-142A and 10-142B) would be constructed to the northeast and southwest of the existing ridge at the site carrying Q.E.W. traffic over Highway 2. The preliminary drawings supplied to us show an approximate 10m distance between the limits of the existing Bridge abutments and the proposed abutments. Existing approach

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## 2.0 SITE AND GEOLOGY (continued)

embankments to the Q.E.W. Bridge are approximately five to six metres in height close to the present abutments. Ground surface at both pairs of proposed abutments located on either side of the existing Highway 2 is relatively flat, apart from a slight rise where the outline of the proposed footing coincides with the toe of the existing Q.E.W. Bridge approach embankments.

The proposed Bridge structure at Site 10-322 is some 200m southeastwards of Site 10-142A on the alignment of the proposed Northbound Collector road. Presently, the site is crossed by an existing ramp S-EW on an embankment some 2.0 to 6.0 metres in height above adjoining land. Surficially, the sites are grass covered or have exposed sand and gravel adjacent to Highway 2.

Available geological information<sup>(1)</sup> shows that the area of the investigation is underlain by bedrock of the Queenston Formation, which comprises red shale and mudstone with thin interbedded layers of silty limestone and dolomite. Previous soils investigations by Geocon (and as reported by others) in the neighbourhood of these sites has shown that to the south, the bedrock slopes steeply towards Lake Ontario, probably representing a line of former shoreline cliffs at a time of lowered water level in the lake. Subsequent infilling took place with deposition of organic silty clays and peat. To the north of this earlier shoreline, the bedrock is typically overlain by a silty clay grading to a silty clay till containing dispersed particles of sand and gravel in a fine matrix of clay and silt. In some places, fragments of shale are present particularly towards the base of the silty clay close to the contact with the underlying shale bedrock. The silty clay occasionally extends to close to ground surface but typically is overlain by a stratum of silty sand. Based on available subsurface information it was anticipated that all the boreholes of this investigation would be landward of the bedrock slope and were expected to

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(1) 1969. Geology Toronto-Windsor Area, Ontario Map 1263A. Geol. Survey of Canada, Dept. Energy, Mines and Resources, Compiled by B.V. Sanford.

## 2.0 SITE AND GEOLOGY (continued)

intersect varying thicknesses of silty sand and silty clay overburden soils underlain by the local shale bedrock.

## 3.0 SUBSURFACE CONDITIONS

Descriptions of the soil, bedrock and groundwater conditions encountered during this investigation at the three sites are given on the Records of Boreholes in Appendix II. The inferred stratigraphy at each site, along with the locations of the relevant boreholes are shown on Drawings 837421-A, 837422-A and 837423-A. A summary of the conditions encountered is given in the following Section 3.1 with detailed descriptions given in Section 3.2.

### 3.1 Summarized Subsurface Conditions

The conditions are relatively similar at all three sites. The surficial fill and/or topsoil is generally underlain by a stratum of sandy silt to silty sand, followed by silty clay, or silty clay till, then shale bedrock. Overburden thickness at Sites 10-142A and 10-142B is generally from three to four metres. Site 10-332 has thicker overburden, from six to eight metres within which the silty sand to sandy silt stratum dominates.

As encountered, this stratum ranges in appearance from a silty clay to a till-like texture; for uniformity it has been described in the report as a till formation. Its thickness ranges to 2.3 metres with a consistency generally firm to stiff.

The clay or clay till overlies shale bedrock for the most part with the red weathered shale containing thin interbedded layers that are visually identified as limestone. Generally the shale is weathered to the depths penetrated and consists of softer, friable layers between the harder limestone layers.

### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.1 Summarized Subsurface Conditions (continued)

The groundwater levels as observed, occur at depth within the overburden at Sites 10-142A and 10-142B and are generally within the silty clay stratum, whereas the groundwater level is closer to ground surface at Site 10-322 within the silty sand to sandy silt stratum.

#### 3.2 Detailed Subsurface Conditions

##### 3.2.1 Sites 10-142A and 10-142B (Boreholes 1 to 8)

These sites will be described together because of their close proximity to each other on either side of the Q.E.W.

##### 3.2.1.1 Topsoil/Fill

Ground surface is underlain by topsoil and/or fill which varies in thickness from about 0.2m to 0.9m. The fill consists of the most part of silty sand and gravel, however with evidence of a slightly higher silt and clay content in the area of Borehole 4.

##### 3.2.1.2 Silty Sand to Sandy Silt (SM, ML)

The surficial layer is underlain by a stratum of of sandy silt to silty sand that occurs in all of the Boreholes with the exception of Borehole 5 at site 10-142B. Aside from the differences between Boreholes 5 and 6, elsewhere this stratum is reasonably uniform in thickness within the limits of each site, approximately 1 to 1.5 metres at Site 10-142A and between 2 to 2.5 metres at Site 10-142B.

Grain size distribution analyses on selected samples of this stratum are shown as an envelope on Figure 1 in Appendix II. The samples as tested range from silty sand to sand, some silt, although the stratum is generally described as silty sand to sandy silt from visual and tactile examinations of all the samples.

Standard Penetration Tests carried out within this stratum gave 'N' values ranging from 3 to 35 inferring a range of relative density from very loose to dense.

### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.2 Detailed Subsurface Conditions (continued)

##### 3.2.1 Sites 10-142A and 10-142B (continued)

##### 3.2.1.3 Silty Clay (Till)

In Borehole 6 at Site 10-142B, the clay is for all practical purposes absent. Elsewhere the silty sand to sand to sand stratum described above is underlain by silty clay which contains traces of sand and gravel and in places thin layers or lenses of sand. It is judged that the stratum is a glacial deposit and it is described herein as a till rather than a clay. The colour of the till ranges variously from yellowish-brown to greybrown to grey. At Site 10-142A this stratum is relatively uniform in thickness between about 1.5 to 2 metres; the thickness is somewhat more variable at Site 10-142B, ranging from about 0.8 to 2.3 metres.

Atterberg limit tests were carried out on selected samples from this stratum. These results, along with corresponding moisture contents are plotted on the Records of Boreholes in Appendix II. Triaxial compression tests were carried out on samples from Borehole 1.

Grain size distribution analyses carried out on selected samples of the silty clay (till) stratum are shown as an envelope on Figure 3 in Appendix II.

Standard Penetration Tests carried out in all the boreholes gave 'N' values ranging from 3 to 33 within the silty clay stratum. Based on these values, visual and tactile examination of the samples recovered it is judged that the consistency of the clay varies from firm to hard. Low 'N' values of 3 and 4 in Borehole 1 and triaxial shear strengths of 50 to 55 kPa indicate a firm to stiff consistency for the till at this location.

### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.2 Detailed Subsurface Conditions (continued)

##### 3.2.1 Sites 10-142A and 10-142B (continued)

##### 3.2.1.4 Shale Bedrock

The bedrock was penetrated by a combination of augering and diamond drilling; most of the investigation was by the latter means, using BV triple tube and BXL core barrels. Core recoveries were extremely variable and appeared to be a function of equipment type as well as condition of the shale at individual locations. Nevertheless, based on the core recoveries obtained, and estimated Rock Quality Designation (R.Q.D.) values, both of which varied between 0 and 59 percent, the condition of the bedrock is estimated to range from very poor to fair.

Depths to bedrock at the boreholes ranged from 2.9m to 4.0m, or between elevations 75.4 and 74.1.

The bedrock is described as weathered shale with occasional interbedded, harder limestone layers which range in thickness up to 75mm. Typically, the recovered shale core samples have numerous partings along the near horizontal beddings, and some thin sections are fragmented, possibly by the drilling operations. A very slow rate of penetration was employed in conjunction with the use of the BV size core barrel in order to maximize recovery in the weathered shale bedrock.

The extent of weathering appears to diminish with depth (as in Boreholes 3 and 4), although estimated R.Q.D. criteria used to describe the condition of bedrock vary throughout the depths investigated.

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### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.2 Detailed Subsurface Conditions (continued)

##### 3.2.1 Sites 10-142A and 10-142B (continued)

###### 3.2.1.5 Water Conditions

Observations of groundwater levels were taken during and since the completion of investigation; all the observations are presented on Table 1 in Appendix II. During the investigation at these two sites, the groundwater level occurred within the silty clay (till) stratum, fairly close to bedrock, generally between elevations 74 to 76m. At other times of the year, the groundwater level would probably be higher and perched conditions could be expected in the surficial fill and sand.

##### 3.2.2 Site 10-322 (Boreholes 9 to 14)

###### 3.2.2.1 Topsoil/Fill

Somewhat in contrast to the previous two sites described, the extent of fill at this site and at the borehole locations is influenced by their position with respect to the existing embankments and ramps that occupy the site. The fills probably represent structural fill used for construction of the ramps. It consists of silty sand and gravel, some clay for the most part as shown on the grain size distribution curve on Figure 4 in Appendix II. 'N' values ranged from 13 to 38 indicating a compact to dense relative density. In Borehole 11, fill is underlain by a thin asphalt layer followed by 0.7 feet of sand and silty clay, judged to be fill.

In Boreholes 12, 13 and 14 the fill is absent and ground surface is overlain by a thin covering of topsoil.

### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.2 Detailed Subsurface Conditions (continued)

##### 3.2.2 Site 10-322 (continued)

##### 3.2.2.2 Silty Sand to Sandy Silt (SM, ML)

The fill and/or topsoil is underlain by a stratum of silty sand to sandy silt, judged to be the same formation encountered at the previous two sites although in this case, its thickness varies from about four to five metres.

Grain size distribution analyses carried out on selected samples of the silty sand to sandy silt stratum are shown as envelopes on Figures 1 and 2 in Appendix II.

Standard Penetration Tests carried out within this stratum gave 'N' values ranging from 13 to 38 indicating a compact to very dense relative density; in Borehole 14, in the upper two metres 'N' values of 6 and 7 were recorded.

##### 3.2.2.3 Silty Clay (Till)

The silty sand to sandy silt stratum is underlain by a thin, generally less than two metres, stratum of silty clay which generally contains traces of sand and gravel and in some places shale fragments. For reasons discussed previously, this formation is believed to be a till rather than a clay, and is therefore described accordingly.

A grain size distribution analysis carried out on one selected sample from this stratum is included in the envelope on Figure 3 in Appendix II.

Based on the recorded 'N' values and tactile examination of the samples recovered it is judged that the consistency ranges from firm to stiff, and generally stiff.

### 3.0 SUBSURFACE CONDITIONS (continued)

#### 3.2 Detailed Subsurface Conditions (continued)

##### 3.2.2 Site 10-322 (continued)

##### 3.2.2.4 Shale Bedrock

The bedrock was penetrated variously by augering and by diamond drilling. All the diamond drilling at this site was carried out using a BXL core barrel, no loss of water was observed, although wash water colour changed from the usual brown to grey, apparently when penetrating the limestone layers. In addition, the penetration rate slowed slightly at the harder limestone layers. The core recoveries were generally in excess of 70 percent, except surficially in Borehole 11 to a depth of about one metre. Estimated R.Q.D. values ranged from 11 to 82 percent and are indicative of very poor to good quality.

Depths to bedrock ranged from 5.1m to 9.5m, corresponding elevations ranged from 70.8 to 71.3m.

The bedrock is described as weathered shale with occasional interbedded, harder layers of limestone which range up to some 150mm in thickness. Based on percent recovery, estimated R.Q.D. values and visual inspection, the extent of weathering decreases with depth and the majority of the recovered core samples at this site have been classified as slightly weathered from about 1m or less below the top of bedrock.

##### 3.2.2.5 Groundwater Conditions

Readings to date of groundwater levels are shown on Table 1 in Appendix II. At the time of this investigation the groundwater occurs within the silty sand to sandy silt stratum close to elevation 75; in Borehole 9 the observed water level is some three metres higher than in the other boreholes at the site and this may reflect differences in the



3.0 SUBSURFACE CONDITIONS (continued)

3.2 Detailed Subsurface Conditions (continued)

3.2.2 Site 10-322 (continued)

3.2.2.5 Groundwater Conditions (continued)

surface drainage. Borehole 9 is located within the confines of three embankments.

4.0 DISCUSSION

As mentioned earlier, preliminary recommendations for foundation design have been presented in the correspondence dated December 23rd, 1980 and January 16th, 1981. This report supercedes details given in the information in the preliminary reports, although it confirms the basic alternative foundation treatments at each site presented previously.

It is understood that the proposed structures will be of reinforced concrete construction, with Sites 10-142A and 10-142B having single span rigid frame structures approximately 20 metres in length, and at Site 10-322 a three-span simply-supported structure approximately 60 metres in overall length.

The sequence of soil types at each of the sites are essentially the same. Surficial fill and/or topsoil is underlain by a generally compact silty sand to sandy silt stratum, then by clay till and shale bedrock. The main differences between the sites are the softer consistency of the clay till component of the overburden at Site 10-142A, and the greater overall thickness of overburden at Site 10-322.

Individual strip footings founded at suitable depth within the overburden, or on bedrock, are considered satisfactory foundations for the proposed structures. At Sites 10-142A and 10-142B, the minimum founding depth is two metres below present ground level. At this depth, there would be greater than the 1.25m approximately recommended for protection of footings and pile caps against frost action. At this depth, allowable bearing values of 100 to 150 kPa may be used in design; the lower value should be used at Site 10-142A, the higher value at Site 10-142B. At Site 10-322, regrading would probably require removal of some of the existing embankment fill so

## 4.0 DISCUSSION (continued)

for the present, the founding stratum is considered to be the natural silty sand to sandy silt. Subject to an earth cover of at least 1.3m being provided for purposes of frost protection, an allowable bearing value of 150 kPa may be used in design of spread foundations for the abutments and piers of this structure. At the east abutment (at the location represented by Borehole 14) the founding level should be at least 2.5m below present ground level since the silty sand/sandy silt is mostly in a loose condition above this elevation.

As an alternative, spread foundations at Sites 10-142A and 10-142B could be carried either directly on bedrock or on lean concrete fill used to raise founding grade. In either case, immediately after final trimming at foundation level, a thin mud mat of lean concrete should be placed to protect the exposed shale bedrock from disturbance. An allowable bearing value of 400 kPa may be used for design of spread foundations carried directly on the bedrock. Given the depth of six to seven metres to bedrock at Site 10-322, it is probable that spread foundations carried on bedrock would not be economical as footings carried in the overburden as described above, or an alternative involving piles.

Should piles be considered, they could comprise either (i) the 'Franki' type i.e. cast-in-place concrete piles with compacted base formed in silty sand/sandy silt stratum or on bedrock surface, or (ii) piles driven to end-bearing in the shale. A variety of driven pile types would be suitable such as steel H or tube piles, pre-cast concrete or treated timber piles. For the displacement type piles, jetting assistance may be required to facilitate penetration to bedrock.

Although based on the core recovered, the shale appears to be of relatively low permeability, there is local experience for high concentrated water flows from the shale sufficient to create construction and inspection difficulties for drilled caissons, particularly where an end-bearing design was used. For the case of driven piles, and particularly the H-pile type, the shale consists of harder and softer layers, and is weathered to varying extents and depths.

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## 4.0 DISCUSSION (continued)

Therefore some penetration into the bedrock can be expected. The extent of penetration will depend on a variety of factors such as pile type, driving energy and the particular distribution of layering and their thicknesses at each pile location. To properly offset the effects of possible shatter of the intermittent harder layers, provision for re-driving should be made, particularly where steel H-piles are involved.

Given the rock conditions, steel H-piles should be provided with a suitable drive point. If 12BP53 steel H-piles are selected it is expected that the maximum allowable pile capacity would be developed using a pile driving hammer with a minimum energy rating of 30 kJ and a set comprised of three sequences of 5 blows with the penetration of each sequence not greater than 5mm.

The design of excavations for pile caps or footings should take into account surcharge effects from existing embankments where these are close by. The design of support systems will require suitable dewatering measures where excavations extend below groundwater levels. At the time of this investigation, the groundwater level at Sites 10-142A and 10-142B was generally at depth in the overburden within the clay till; at other times of year perched water may exist, however, in the upper sand layer. At Site 10-322 the groundwater appears close to surface within the silty sand to sandy silt stratum, however with evidence of somewhat higher level under areas where embankment configurations would disrupt normal surface runoff. At Sites 10-142A and 10-142B, if either founding at about 2 metres below ground level or founding on bedrock are selected, such dewatering as will be required would be expected to be handled by the procedure of pumping from engineered sumps within a sheeted excavation. At Site 10-322, depending on the extent of removal of the existing fill, dewatering could similarly be carried out by pumping from engineered sumps within a close sheeted excavation, or with a suitably designed well-point system. We would be pleased to provide more specific details of dewatering measures which might be adopted, once the basic foundation systems have been selected.

## 4.0 DISCUSSION (continued)

Backfill around foundations and for the abutments should comprise well-compacted select granular materials. For design of abutments founded directly on bedrock, or on piles driven to adequate end-bearing on bedrock, a coefficient of lateral earth pressure at rest of 0.5 may be used, with due allowance for surcharge and lateral loads. The design of abutment foundations should also be checked for resistance to sliding. In the event that spread foundations are selected, a friction factor of 0.50 for concrete on clean shale rock, and 0.30 for concrete on silty sand to sandy silt. Where piles are used, resistance to sliding can be provided by batter piles.

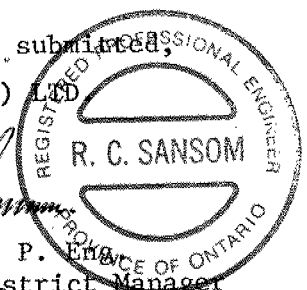
In the immediate area of the proposed abutments, assuming M.T.C. standard 2 horizontal to 1 vertical side slopes are used, the approach embankments should have an adequate Factor of Safety against base failure. Providing satisfactory subgrade preparation is carried out, by removal of topsoil, proofrolling, excavation and replacement of any softer or looser areas, and the like, embankment settlements will be largely limited to the effects of self-weight and thus expected to be within tolerable limits for the anticipated heights of fill involved.

## 5.0 CLOSURE

The interpretive comments given in this report are somewhat general, and we would be pleased to liase with you further as the designs of the structures are firmed up, so that further geotechnical input can be made in respect to design of foundations and construction planning. In the meantime, we trust that this report which was written by the undersigned, and reviewed by Mr. M.A.J. Matich, P. Eng., is sufficient for your purposes at present. Kindly call should elaboration on any point be required.

Respectfully submitted,

GEOCON (1975) LTD

R.C. Sansom, P. Eng.  
Assistant District Manager

RCS:smcb  
01511-61  
(T10439)

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APPENDIX I

PROCEDURE AND FIELD EQUIPMENT

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## 1.0 PROCEDURE AND FIELD EQUIPMENT

The field work for this investigation was carried out during the period between 1980-12-15 and 1980-12-23. A total of 14 boreholes were put down to depths ranging from 3.8m to 13.0m for a cumulative depth of 112.4m. In addition, uncased dynamic cone penetration tests (pentests) were carried out adjacent to each of the boreholes. All the boreholes were put down by CME 75 power auger drills (M.T.C. Drill Type 5.3.i). Continuous flight solid and hollow stem augers were used to penetrate the soil overburden. Diamond drilling was carried out in selected boreholes to obtain core samples of the bedrock.

Sampling was carried out at intervals of not greater than 1.5m using standard 51mm diameter O.D. split spoon samplers in the non-cohesive soils. Standard Penetration Tests were performed in conjunction with the use of the split spoon samplers.

Thin wall tube samples were also obtained in the cohesive silty clay soil for laboratory testing. Rock was cored in nine of the holes using BV triple and BXL 1.52m core barrels for depths ranging from 1m to 7m. Perforated plastic standpipes were installed in 11 boreholes and piezometers in two boreholes (Boreholes 10 and 14) at varying elevations. These elevations and the water level observations during the period of the field work are given in Table 1 in Appendix II.

The samples were transported to our Toronto Soil Mechanics Laboratory for detailed examination and testing. The samples remaining after testing will be stored at this location until January 1981, at which time you will be contacted for instructions regarding their retention or disposal.

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1.0 PROCEDURE AND FIELD EQUIPMENT (continued)

The locations of the boreholes were established in the field by a surveyor from Fenco Consultants Ltd. and Geocon's field engineer, using the centre lines of the proposed roads established in the field by the M.T.C. The ground elevations at the boreholes were obtained by levelling referenced to the Geodetic Bench Mark #3487, the elevation which was given as 78.565m by Mr. Leon Ellis of M.T.C.

Details of stratigraphy and results of field and laboratory testing are given on the individual Records of Boreholes in Appendix II. Some of the laboratory test results are also presented on Figures 1 to 5 in Appendix II.

## APPENDIX II

- i) RECORDS OF BOREHOLES
- ii) TABLE 1 - GROUNDWATER LEVELS
- iii) FIGURES - LABORATORY TEST RESULTS  
1 to 5



## 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
$i_u$	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

$m_v$	$\text{kPa}^{-1}$	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
$\phi'$	-°	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

$\rho_s$	$\text{kg}/\text{m}^3$	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						



# RECORD OF BOREHOLE No 1

METRIC

W P 43-74-22

LOCATION Q.E.N. N.E. COLLECTOR - HWY. 2 OVERPASS

ORIGINATED BY RRB

DIST 4 HWY 2/015

BOREHOLE TYPE CONTINUOUS FLIGHT AUGER

COMPILED BY PAD

DATUM GEODETIC

DATE 1980 12 18

CHECKED BY ESS

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 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
78.3	GROUND LEVEL																
0.0	Fill - Mixture Sand and Gravel						78										
0.3	Silty Sand to Sandy Silt Compact Brown (SM, ML)		1	SS	11		77										
76.8	Silty clay, trace gravel (till)		2	SS	3		WL									19.08	0 3 63 24
1.5	Firm Grey		3	SS	4		76									19.96	
75.4	Shale Bedrock Weathered Red		4	SS	100/0.25		75										Bedrock Penetrated By Augering
2.9																	
74.4																	
3.9	END OF BOREHOLE																
Another hole located at 0.9m west of Borehole No. 1 was augered to a depth of 1.68m. A 51mm diameter thin wall open sample was taken from 1.68m to 2.29m and a 76mm diameter thin wall open sample was taken from 2.29m to 2.84m. The results of the laboratory tests on these samples are also given above.																	

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 2

METRIC

W P 43-74-22 LOCATION Q.E.W. S.D. COLLECTOR - HWY. 2 OVERPASS ORIGINATED BY RWB  
DIST 4 HWY 2/Q.E.W. BOREHOLE TYPE CME 75 - CONTINUOUS FLIGHT AUGER - BW CASING COMPILED BY PAD  
DATUM GEODETIC DATE 1980 12 19 & 22 CHECKED BY KSS

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					
78.3	GROUND LEVEL																
0.0	Fill - Silty Sand & Gravel																
0.2	Silty Sand to Sandy Silt Compact Brown (SM, ML)		1	SS	20		78						0				
76.6			2	SS	14		77						0				2 16 55 27
1.7	Silty Clay, Trace to Some Sand and Gravel (Till) Firm Grey		3	SS	13		76						0				
75.2			4	SS	65/0	19.7	WL	81	01	08			0				ROD
3.1	Shale Bedrock		5	RC BV	90%		75										27%
	Red		6	RC BV	18%		74										0%
	Weathered		7	RC/BV	100%		73										0%
72.5			8	RC/BV	43%												0%
5.3	Slightly Weathered		9	RC BXL	96%		72										13%
71.0	END OF BOREHOLE																
7.3																	

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 3

METRIC

W P 43-74-22 LOCATION CO-ORDS. 4797082.5N; 279895.5E Q.E.W. N.B. COLLECTOR - REV. 2 OVERPASS ORIGINATED BY RWB  
 DIST 4 HWY 2/0.E.W. BOREHOLE TYPE CME 75 - CONTINUOUS FLIGHT AUGER - BW CASING COMPILED BY MCZ  
 DATUM GEODETIC DATE 1980 12 18 CHECKED BY ESS

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					
78.5	GROUND LEVEL																
0.0	Topsoil																
77.9	(a)		1	SS	12		78										
0.6	Silty Sand - Fine, Compact																
76.9	Reddish Brown (SM)		2	SS	15		77										
1.6	Silty Clay Trace Sand and Gravel (Till) Occasional Brown Layer, Silty Sand Firm to Stiff		3A	SS	19		76										
	Yellow, Grey, Brown Mottled		4	SS	6		75										
75.0	Shale Bedrock		5	SS	60/0	0.06m											
3.5			6	SS	80/0	0.13m											
	Red		7	RC BV	12%		74										RQD
			8	RC BV	20%		73										0%
72.8	Weathered		9	RC BV	87%		72										0%
5.7	Slightly Weathered																36%
71.6	END OF BOREHOLE																
6.9	(a) Fill - Sand and Gravel																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 4

METRIC

W P 43-74-22

LOCATION CO-ORDS. 4797074, 5N: 279862.6E

ORIGINATED BY RWB

DIST 4 HWY 2/0.E.W. BOREHOLE TYPE CME 75 - CONTINUOUS FLIGHT AUGER - BW CASING

COMPILED BY MCZ

DATUM GEODETIC

DATE 1980 12 18

CHECKED BY KSS

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			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
							20 40 60 80 100					20 40 60						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
72.3	GROUND LEVEL													GR SA SI CL				
0.0	Fill - Silt, Sand & Gravel						78											
0.2	Fill - Mixture of Clay Silt and Sand, Compact Grey & Brown		1	SS	9													
77.5																		
0.8	Silty Sand to Sandy Silt Loose to Compact Brown (SM, ML)		2	SS	3		77							0 68 28 4				
			3	SS	13		76											
75.4																		
2.9	Silty Clay, Trace Sand And Gravel (Till) Firm Grey Brown		4	SS	8		75							RQD				
74.5			5	SS	5/0.5 Sm		WL 81 00 01											
3.8			6	RC BXL	100%		74							0%				
	Shale Bedrock -  Red		7	RC BXL	100%		73							23%				
			8	RC BXL	100%		72							23%				
			9	RC BXL	100%		71							25%				
69.8	Weathered						70											
8.5			10	RC BXL	100%		69							59%				
	Slightly Weathered		11	RC BXL	100%		68							36%				
67.6			12	RC BXL	100%									0%				
10.7	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 5

METRIC

W P 83-74-23 LOCATION CO-ORDS. 4797061.2N; 279819.4E ORIGINATED BY RWB  
DIST 4 HWY 2/Q.E.W. BOREHOLE TYPE CME 75 - HOLLOW STEM AUGER COMPILED BY PAD  
DATUM GEODETIC DATE 1980 12 16 CHECKED BY RSS

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					
78.2	GROUND LEVEL																
0.3	Fill - Silty Sand & Gravel		25	Topsoil			78										
77.3	Fill - Sand, Some Silt and Gravel, Compact Brown		1	SS	18												
0.9	Silty Clay, Trace Sand and Gravel (Till)		2	SS	33		77										
	Very Stiff to Hard Reddish Brown						76										
75.0							WL	81	61	68							
3.2	Shale Bedrock Weathered		3	SS	51		75										
	Red		4	SS	120/0.15m		74										
			5	SS	110/0.13m		73										
72.1	END OF BOREHOLE																
6.1																	



# RECORD OF BOREHOLE No 6

METRIC

W P 83-74-23

LOCATION Q.E.W. S.B. COLLECTOR - HWY. 2 OVERPASS  
CO-ORDS. 4797055.4N; 279806.0E

ORIGINATED BY RMB

DIST 4 HWY 2/Q.E.W. BOREHOLE TYPE CME 75 - HOLLOW STEM AUGER - BW CASING

COMPILED BY PAD

DATUM GEODETIC DATE 1980 12 15

CHECKED BY KSS

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					
77.9	GROUND LEVEL																
77.1	Fill - Silty Sand and Gravel, Compact Brown		1	SS	27								0				
0.8	Silty Sand to Sand Some Silt Compact to Dense Brown (SM)		2	SS	30								0				
			3	SS	35								0				0 88 11 1
74.8			4A	SS	98/0								0				RQD
74.5	a)		4B	SS	98/0	24m							0				
3.4	Shale Bedrock Weathered Red		5	RC BV	41%												0%
			6	RC BV	100%												27%
			7	RC BV	99%												0%
69.8	END OF BOREHOLE																
8.1	a) Silty Clay, Traces Sand, Gravel and Shale Fragments (Till) Brown																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 7

METRIC

W P 83-74-23

LOCATION Q.E.W. S.B. COLLECTOR - HWY. 2 OVERPASS  
CO-ORDS. 4797047.4N; 279834.6E

ORIGINATED BY RWR

DIST 4 HWY 2/Q.E.W.

BOREHOLE TYPE CME 75 - HOLLOW STEM AUGER - BW CASING

COMPILED BY PAD

DATUM GEODETIC

DATE 1980 12 17

CHECKED BY KSS

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					
78.2	GROUND LEVEL																
0.0	Fill - Gravel, Compact		1A	SS	11		78										
0.3	Fill - Silty Sand & Gravel		1B	SS													
0.5	Silty Sand to Sandy Silt Loose to Compact																
	Brown		2	SS	5		77										
	(SM, ML)		3	SS	25		76										
75.0			4	SS	25		75										
3.2	Silty Clay, Trace Sand and Gravel (Till)																
74.2	Very Stiff to Hard Grey Brown		5	SS	76/0	22m	74										
4.0	Shale Bedrock		6	SS	62/0	09m											
	Reddish Brown and Grey		7	RC BV	92%		73										RQD 7%
			8	RC BV	92%		72										
70.4	Weathered						71										30%
7.8	END OF BOREHOLE																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE





RECORD OF BOREHOLE No 8

METRIC

W P 83-74-23

LOCATION Q.E.W. S.B. COLLECTOR - HWY. 2 OVERPASS  
CO-ORDS. 4797042.3N; 279822.0E

ORIGINATED BY RWB

DIST 4 HWY 2/Q.E.W.

BOREHOLE TYPE CME 75 - HOLLOW STEM AUGER

COMPILED BY PAD

DATUM GEODETIC

DATE 1980 12 17

CHECKED BY

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					
78.1	GROUND LEVEL													
0.0	Fill - Silty Sand & Gravel	X					78							
0.3	Silty Sand to Sandy Silt - Compact		1	SS	20									
76.5	Brown (SM, ML)					DRY								
1.6	Sand - Fine to Medium, Compact		2	SS	26									
75.4	Grey Brown													
2.7	Silty Clay, Trace Sand and Gravel (Till) Mottled Grey Very Stiff to Hard		3	SS	29									1 12 53 34
74.1	Brown		4	SS	100/0.15m									
4.0	Shale Bedrock Weathered						74							Bedrock Penetrated By Augering
73.4	Red		5	SS	100/0.1m									
4.7	END OF BOREHOLE													

+3, x5: Numbers refer to  
Sensitivity

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

# RECORD OF BOREHOLE No 9

METRIC

W P 83-74-21 LOCATION Q.E.W. N.B. COLLECTOR RAMP S-EN OVERPASS  
CO-ORDS. 4796975.8M: 279996.1E  
DIST 4 HWY Q.E.W. BOREHOLE TYPE CME 75 BOMBARDIER MOUNTED AUGER DRILL,  
HOLLOW STEM AUGER - BW CASING  
DATUM GEODETIC DATE 1980 12 16 to 17  
ORIGINATED BY JZ  
COMPILED BY PAD  
CHECKED BY KSS

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				
78.8	GROUND LEVEL															
25	Topsoil															
	Fill - Sandy Silt, Organics, Traces of Clay and Gravel, Compact Brown, Grey		1	SS	20		WL	81	0	08			0			
			2	SS	17		78						0			
76.1							77									
2.7	Silty Sand to Sandy Silt - Fine, Dense to Compact  Brown to Grey (SM, ML)		3	SS	49		76						0			
			4	SS	27		75									
			5	SS	13		74						0			0 17 79 4
			6A	SS	138		73						0			
71.6			6B	SS	100/0.25m		72									
7.2 (a)			7	SS	100/0.25m		71									
7.5	Shale Bedrock		8	RC BXL	72%		70									RQD
70.3	Weathered Red		9	RC BXL	100%		69									32%
8.5	Slightly Weathered						68									58%
67.5	END OF BOREHOLE															
11.3	(a) Silty Clay, Trace Sand and Gravel (Till)  Brown															

+3, x5: Numbers refer to  
Sensitivity

20  
15  
5

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 10

METRIC

W P 83-74-21

LOCATION Q.E.W. N.B. COLLECTOR RAMP - S-EW OVERPASS  
CO-ORDS. 4796964.2N: 280006.2E

ORIGINATED BY JZ

DIST 4 HWY 2/O.E.W.

BOREHOLE TYPE CME 55 - HOLLOW STEM AUGER

COMPILED BY PAD

DATUM GEODETIC

DATE 1980 12 23

CHECKED BY KSS

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 (%)			
								20 40 60 80 100										
								20 40 60 80 100										
							UNCONFINED + FIELD VANE											
							QUICK TRIAXIAL x LAB VANE											
							20 40 60 80 100											
80.8	GROUND LEVEL																	
0.0	Fill - Sand and Gravel		1	SS	13				287									
0.6	Fill - Silty Sand and Gravel, Trace of Clay, Compact  Grey Brown		2	SS	19		80											
			3	SS	17		79											
			4	SS	80		78							23 46 20 11				
76.9			5	SS	48		77		168									
3.9	Silty Sand to Sandy Silt Dense  Brown  (SM, ML)		6	SS	50		76							0 23 69 8				
			7	SS	16		75	81 01 08										
			8	TW	PH		74											
73.2			9A	SS	106		73											
7.5	Silty Clay - Traces of Shale, Sand and Gravel (Till) Firm to Stiff  Grey		9B	SS	100		72											
71.3	Shale Bedrock, Weathered		10	SS	100									Bedrock Penetrated By Augering				
9.8	END OF BOREHOLE																	

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 11

METRIC

W P 83-74-21

LOCATION Q.E.W. N.B. COLLECTOR CAMP - S-LV OVERPASS  
CO-ORDS. 4796974.1N; 280014.6E

ORIGINATED BY JZ

DIST 4 HWY 2/O.E.W.

BOREHOLE TYPE CME 55 - HOLLOW STEM AUGER

COMPILED BY PAD

DATUM GEODETIC

DATE 1980 12 22 to 23

CHECKED BY KSS

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	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
80.8	GROUND LEVEL															
0.0	Fill - Sand and Gravel, Compact to Dense  Grey		1	SS	16		80									
			2	SS	38		79									
77.8	Asphalt						78									
3.0	Silty Clay and Sand Compact		3	SS	121/0.15m		77									
77.1	(Probable Fill) Brown						76									
3.7	Silty Sand to Sandy Silt Dense to Compact Brown (SM, ML)		4	SS	58		75									
			5	SS	36		74									
			6	SS	22		73									
73.3							72									
7.5	Silty Clay Trace Sand and Gravel (Till) Firm to Stiff Grey		7	SS	14		71									
			8	SS	21		70									
71.7							69									
9.1	Reddish Grey		9A	SS	71		68									
71.3			9B													
9.5	Shale Bedrock -  Weathered Red		10	RC BXL	38%											ROD
																11%
70.1																
10.7	Slightly Weathered		11	RC BXL	100%											82%
			12	RC BXL	88%											53%
67.8																
13.0	END OF BOREHOLE															

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 12

METRIC

W P 83-74-21 LOCATION Q.E.W. N.B. COLLECTOR RAMP - S-EW OVERPASS  
DIST 4 HWY 2/O.E.W. BOREHOLE TYPE CME 55 - HOLLOW STEM AUGER  
DATUM GEODETIC DATE 1980 12 18 and 19

ORIGINATED BY JZ  
COMPILED BY PAD  
CHECKED BY SS

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	VALUES			20	40	60	80	100					
76.4	GROUND LEVEL		1A														
0.1	Silty Sand to Sandy Silt  Dense to Compact  Brown  (SM, ML)		1B	SS	19		76										
			2	SS	44		75	81	01	08							
			3	SS	35		74										
			4	SS	31		73										
							72										
71.6							71										
5.1	Silty Clay - Traces of Sand & Gravel (Till)		5A	SS	27		70										
70.8	Firm to Stiff Grey		5B	SS	27		69										
5.9	Weathered		6	SS	128	0.18m	68										
70.4	Slightly Weathered		7	RC BXL	100%												
6.3	Red		8	RC BXL	92%												
67.3																	
9.4	END OF BOREHOLE																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

W P 83-74-21 LOCATION Q.E.W. N.B. COLLECTOR RAMP S-EW OVERPASS  
CO-ORDS. 4796954.2N; 280037.5E ORIGINATED BY JZ  
 DIST 4 HWY 2/Q.E.W. BOREHOLE TYPE CME 55 HOLLOW STEM AUGER COMPILED BY PAD  
 DATUM GEODETIC DATE 1980 12 18 CHECKED BY KSS

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					
76.1	GROUND LEVEL												
76	Topsoil		1A 1B	SS	14		WL	81 01 08					
	Silty Sand to Sandy Silt Dense to Compact Brown (SM, ML)		2	SS	49								
			3	SS	23								
71.8													
4.3	Silty Clay, Trace to Some Gravel (Till)		4A 4B	SS	10								3 13 51 33
71.0	Firm Weathered Shale		5	SS	108/0.25m								
5.1	END OF BOREHOLE							117/0.18m					

+3, x5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 14

METRIC

W P 83-74-21 LOCATION CO-ORDS. 4796940, 5N: 280045.8E O.E.M. N.B. COLLECTOR - RAMP S- EN OVERPASS  
DIST 4 HWY 2/0.E.W. BOREHOLE TYPE CNE 55 - HOLLOWSTEM AUGER - BW CASING ORIGINATED BY JZ  
DATUM GEODETIC DATE 1980 12 15 and 16 COMPILED BY PAD  
CHECKED BY SSS

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					
76.0	GROUND LEVEL																
0.0	Silty Sand to Sandy Silt - Fine, Trace of Clay																
	Loose to Compact		1	SS	7		75										
	Brown to Grey		2	SS	6		74	81	01	08							
	(SN, NL)																
							73										0 30 63 7
			3	SS	18		72										
71.2																	0 46 48 6
4.7	Silty Clay - Traces of		4A	SS	55		71										
70.8	Shale, Sand & Gravel		4B	SS	50/0.13m												
5.2	Weathered		5	SS													ROD
5.5	Slightly weathered		6	RC BXL	98%		70										61%
	Shale Bedrock						69										
			7	RC BXL	96%		68										64%
67.7																	
8.3	END OF BOREHOLE																

+3, x5: Numbers refer to  
Sensitivity

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

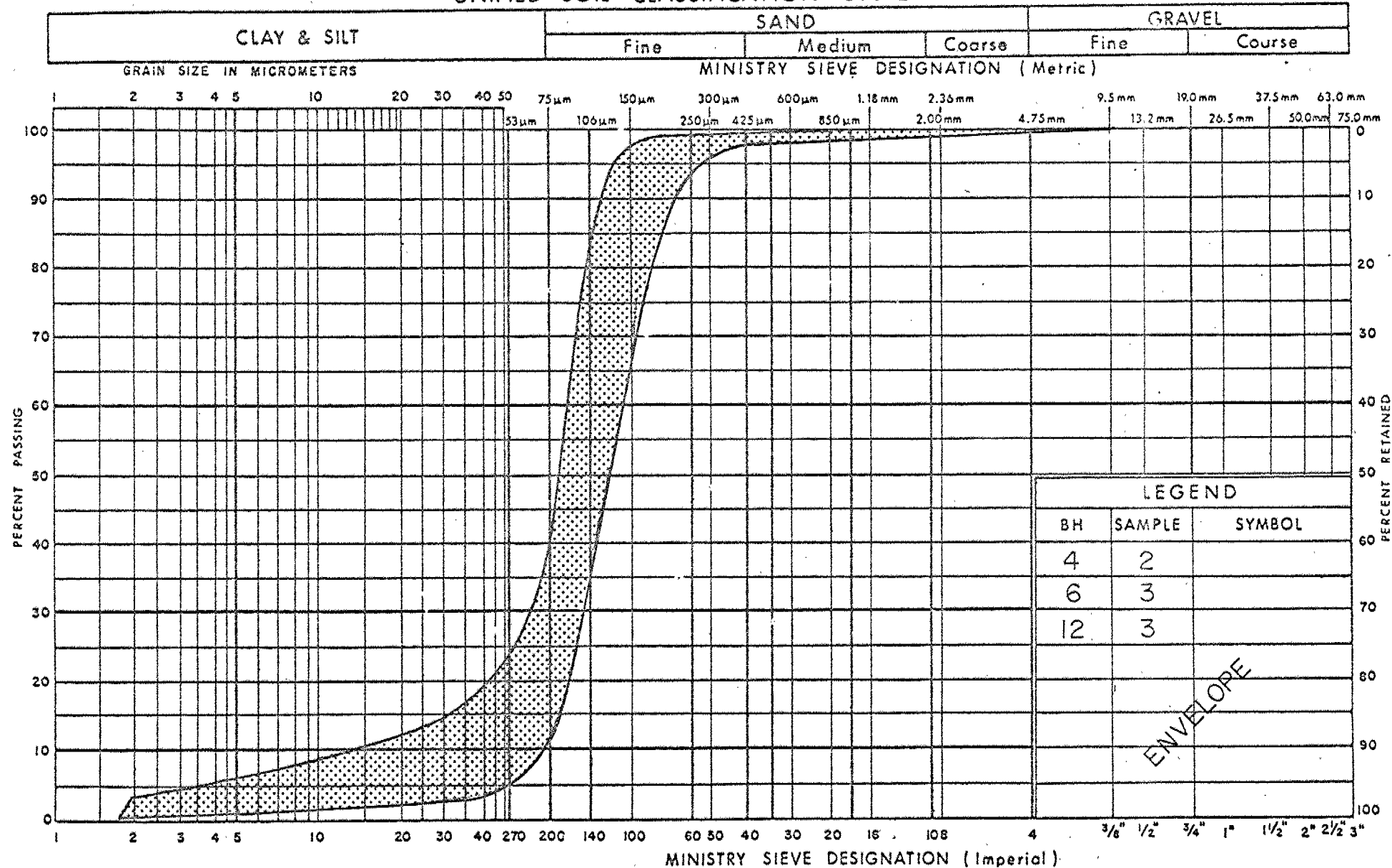
TABLE 1

GROUNDWATER LEVELS

Borehole	Ground Elevation	Elevation of Standpipe (Bottom)	Elevation Piezometer (Bottom)	Depth to Water Level (m)						
				1980						1981
				12/16	12/17	12/18	12/19	12/22	12/24	01/08
1	78.26	75.42							2.90	2.41
2	78.30	75.40							2.90	3.02
3	78.54	75.58						2.31	2.31	2.46
4	78.29	70.98							3.38	3.51
5	78.15	73.79			1.61	1.62	2.96	3.08	3.05	3.04
6	77.94	74.74		2.23	2.46	2.59	2.65	2.72	2.77	2.79
7	78.21	73.64			2.96	3.12	3.09	3.15	3.15	3.23
8	78.14									
9	78.80	72.09				0.42	0.53	0.63	0.81	0.84
10	80.76		71.01						5.77	5.72
11	80.76	70.40							5.44	5.54
12	76.72	71.84						1.70	1.68	1.74
13	76.12	72.16				0.88	0.88	1.02	0.38	1.18
14	75.97		67.64		1.27		1.30	1.26	1.52	1.32
14	75.97	71.40			0.90		0.94	1.07	1.09	1.19



## UNIFIED SOIL CLASSIFICATION SYSTEM



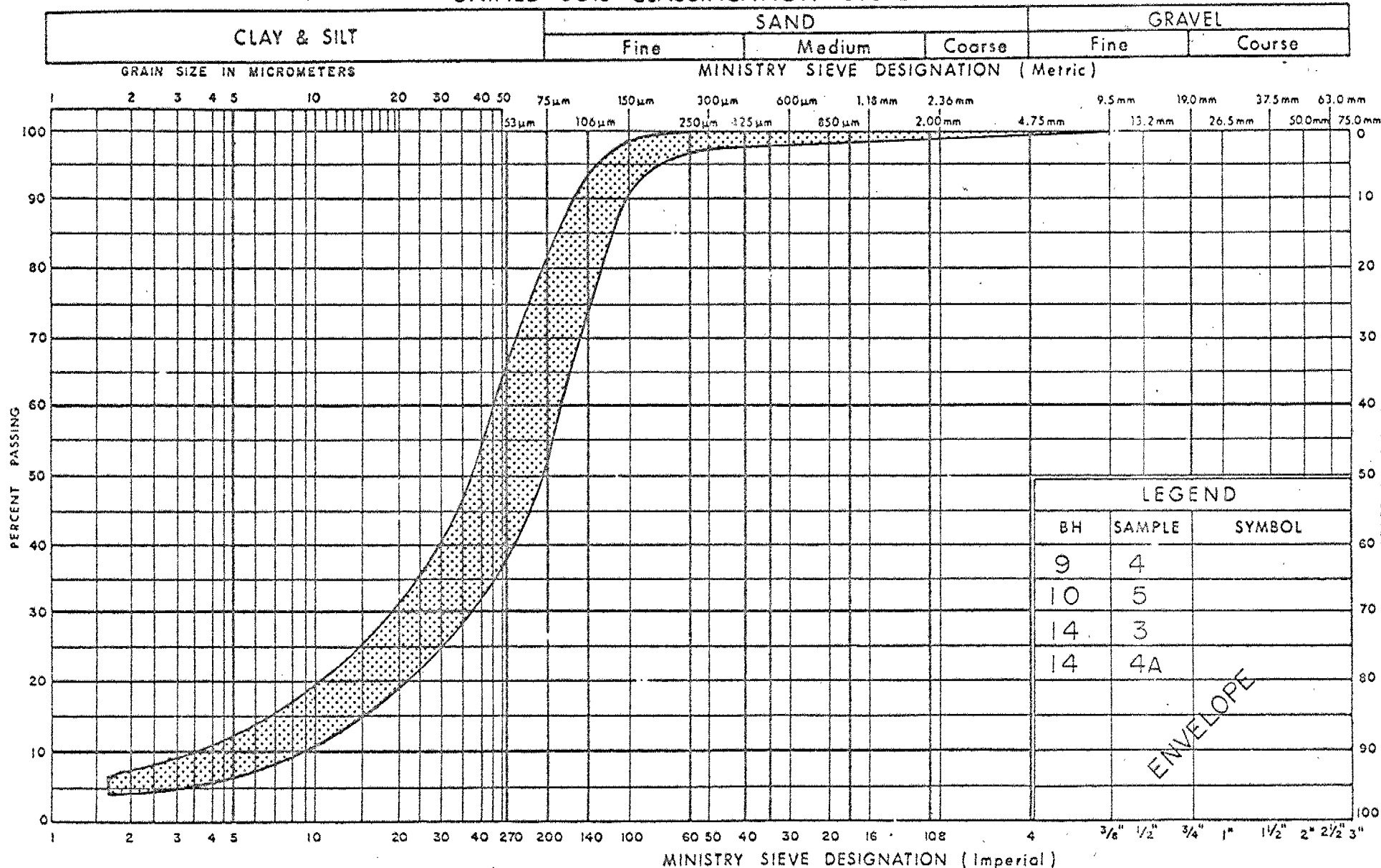
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SAND, SOME SILT  
TRACE CLAY

FIG No 1

W P 83-74-21

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

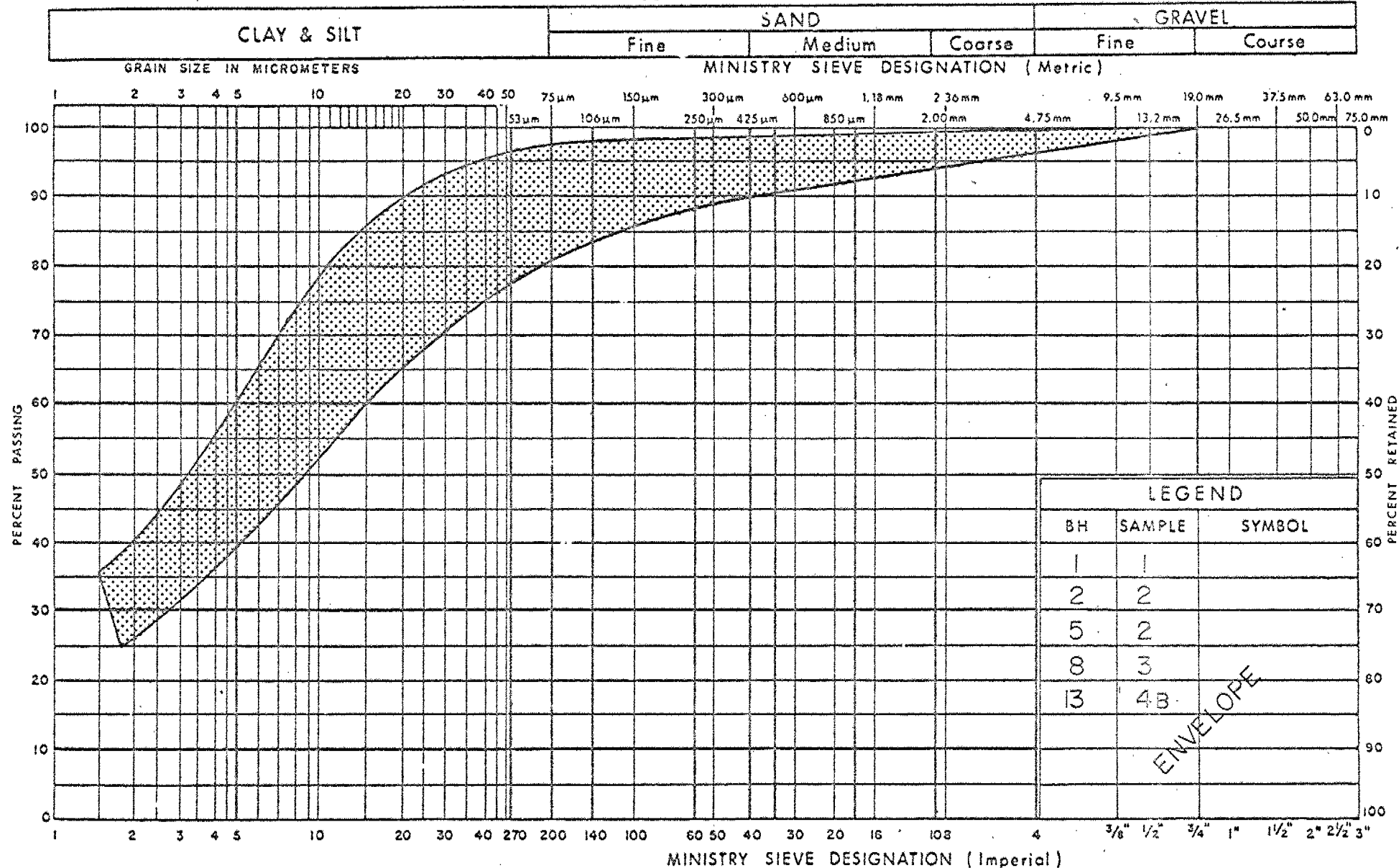
 Ministry of  
Transportation and  
Communications

 GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SANDY SILT  
TRACE CLAY

FIG No 2

W P 83-74-21

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of  
Transportation and  
Communications

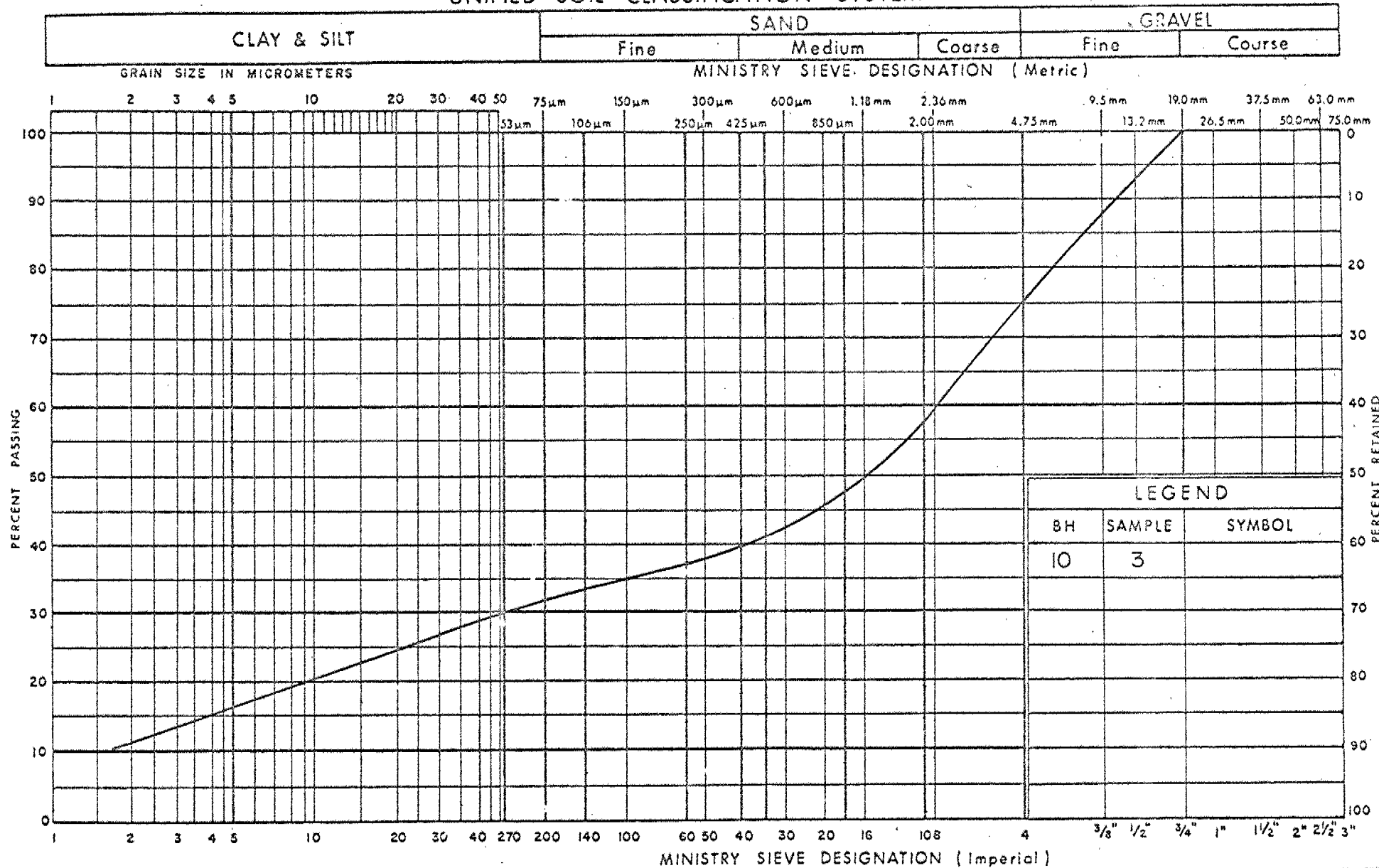
GRAIN SIZE DISTRIBUTION  
SILTY CLAY

TRACE TO SOME SAND, TRACE GRAVEL (TILL)

FIG No 3

W P 83-74-21

## UNIFIED SOIL CLASSIFICATION SYSTEM

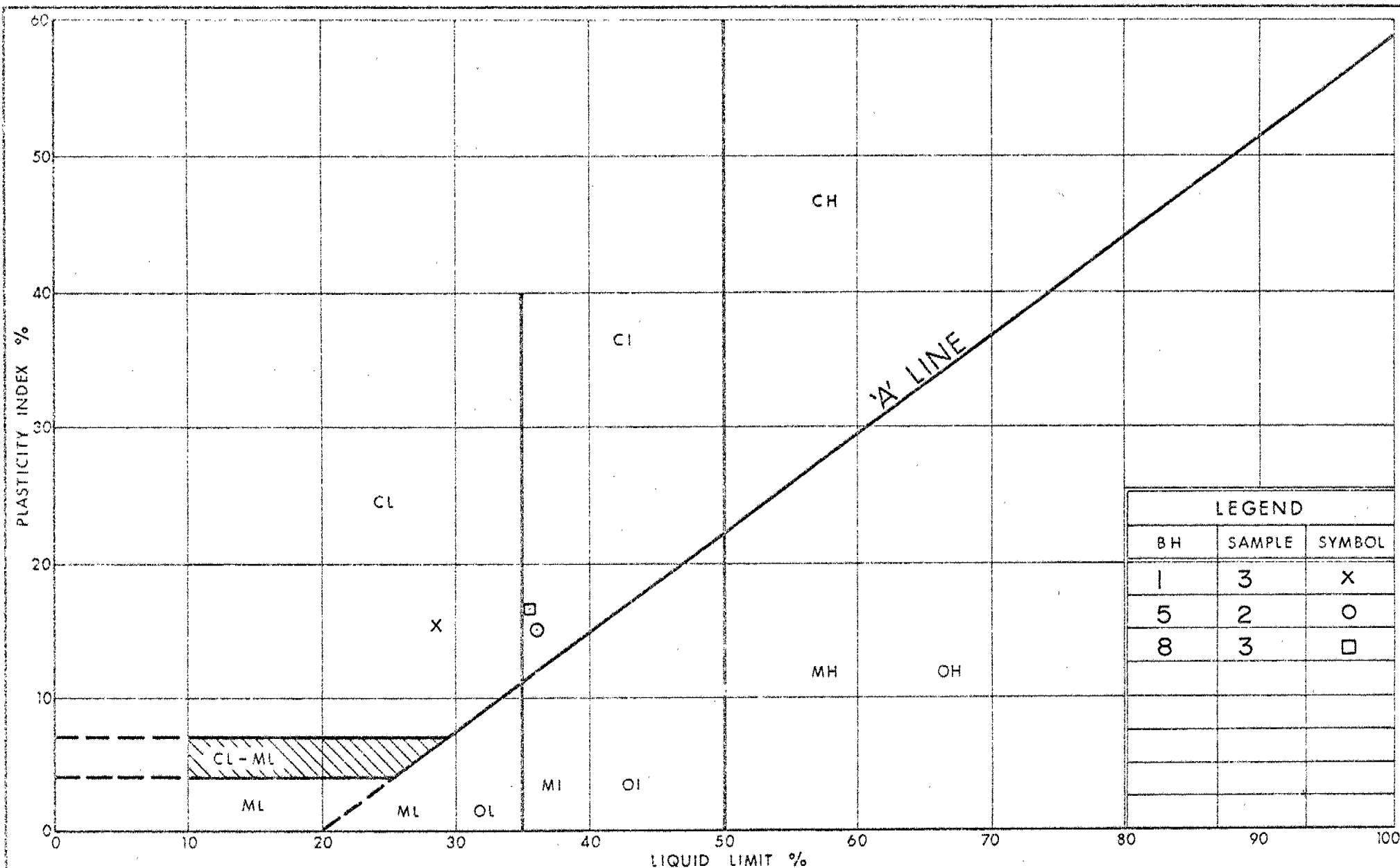


Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**SILTY SAND & GRAVEL**  
SOME CLAY - FILL

FIG No 4

W P 83-74-21



Ontario

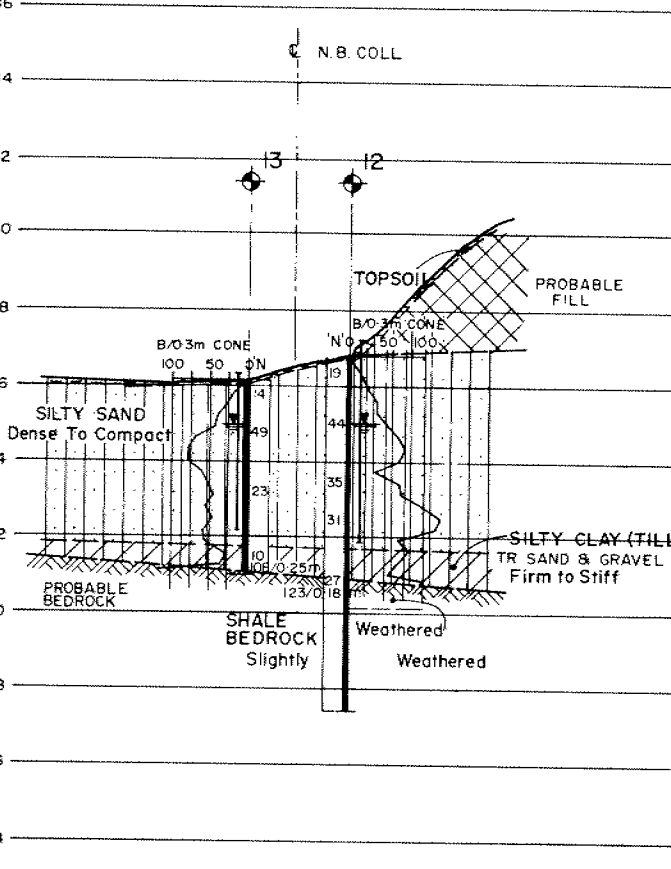
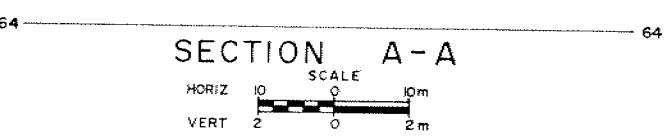
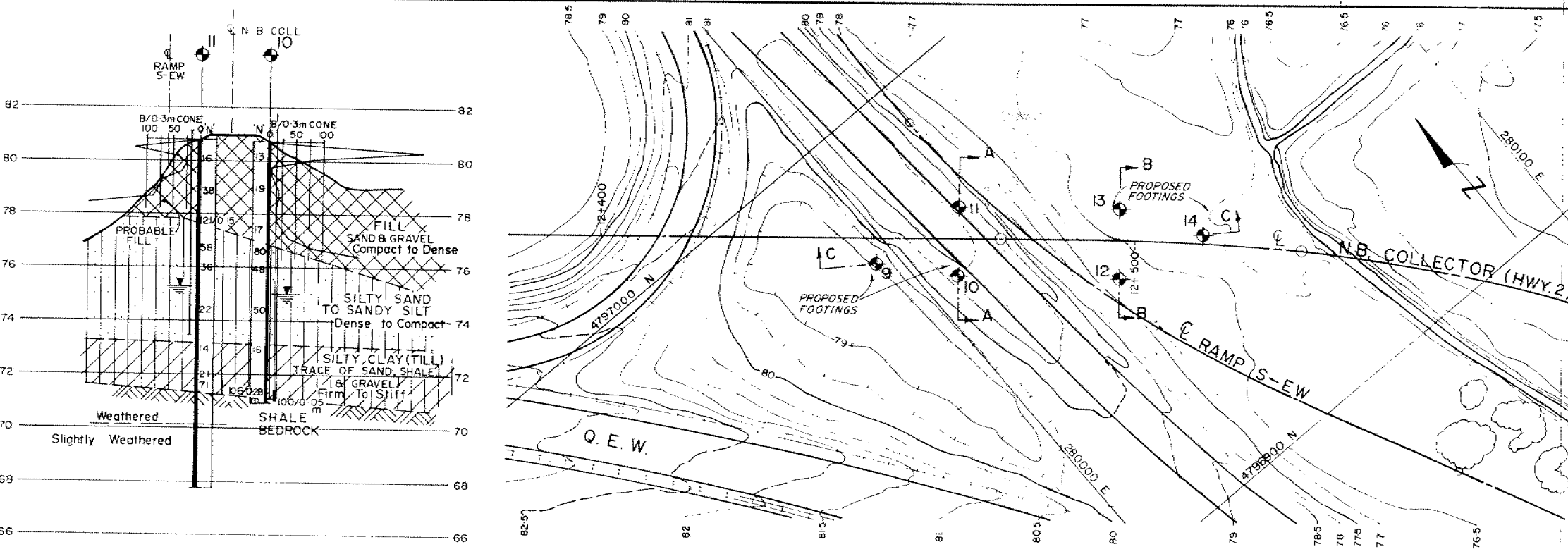
Ministry of  
Transportation and  
Communications

# PLASTICITY CHART SILTY CLAY (TILL)

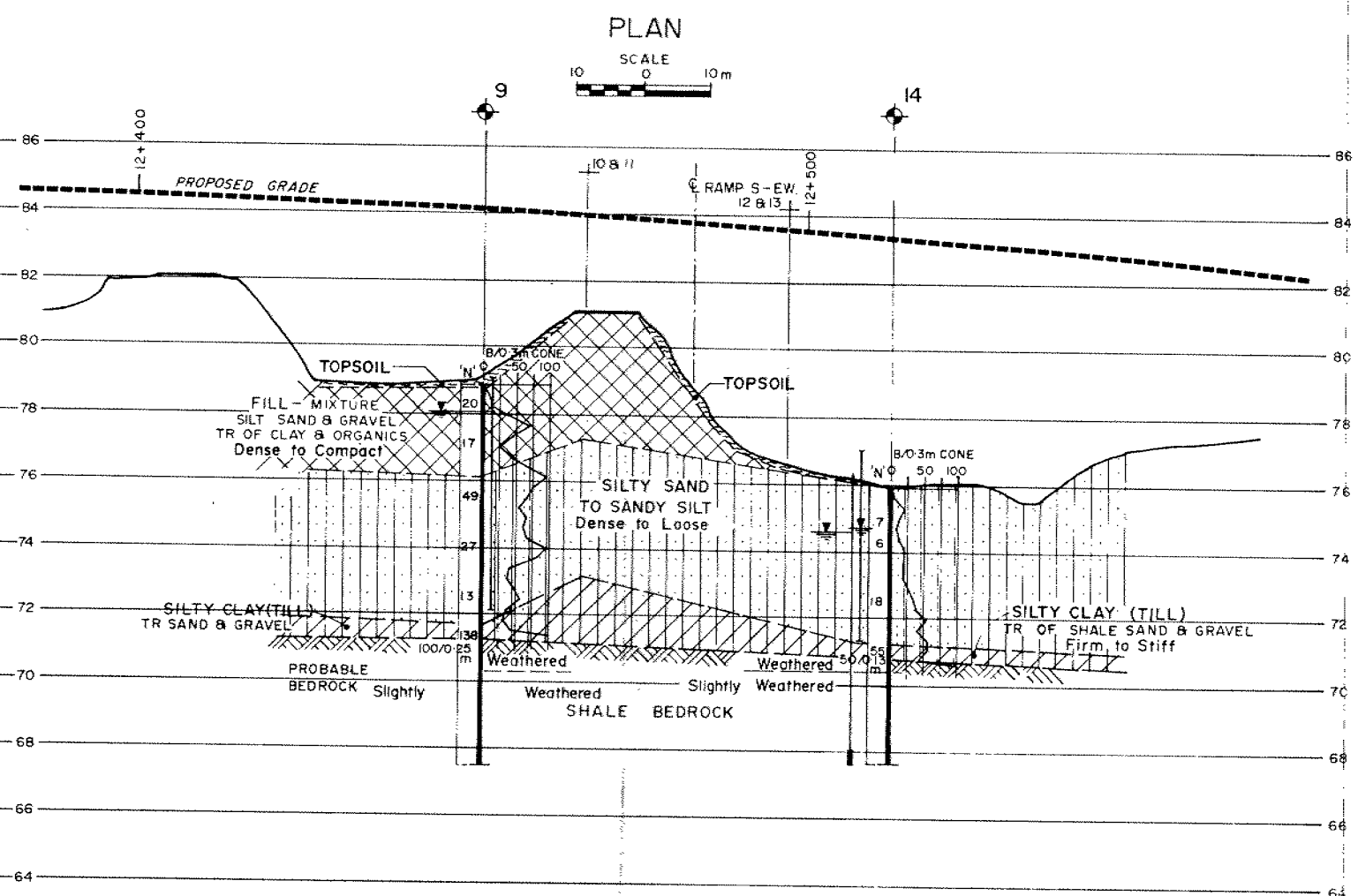
NOTE: TESTS RUN ON MINUS 425 mm  
MATRIX OF THE SAMPLE

FIG No 5

W P 43-74-22  
83-74-23



SECTION B - B



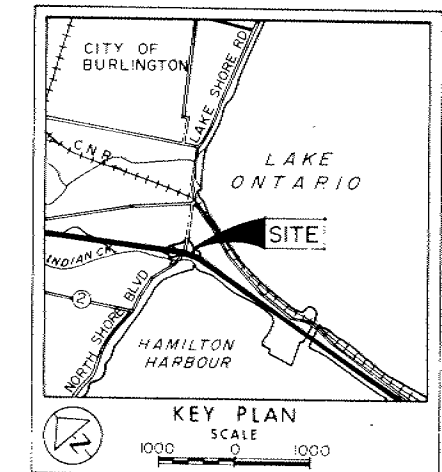
SECTION C - C

**METRIC**  
DIMENSIONS ARE IN METRES UNLESS OTHERWISE SHOWN.

CONT No  
WP No 83-74-21  
Q.E.W. N.B. COLLECTOR  
RAMP S-EW  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

GEOCON (1975) LTD.



LEGEND				
●	Bore Hole			
⊕	Dynamic Cone Penetration Test (Cone)			
⊙	Bore Hole & Cone			
N	Blows/0.3m (Std Pen Test, 475 J/blow)			
CONE	Blows/0.3m (60° Cone, 475 J/blow)			
—	WL at time of investigation 80 12			
—	PIEZOMETER			
—	STANDPIPE			
No	ELEVATION	CO-ORDINATES		
		NORTH	EAST	
9	78.80	4796975.8	279996.1	
10	80.760	4796964.2	280006.2	
11	80.760	4796974.1	280014.6	
12	76.722	4796944.3	280028.8	
13	76.122	4796954.2	280037.5	
14	75.972	4796940.5	280045.8	

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No	
HWY No	Q.E.W.
SUBM'D RCS	CHECKED
DRAWN GAB	CHECKED
DATE	80 12 17
SITE	10-322
DWG	83742-A
DIST	4

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE NOTED

CONT No **83**  
WP No **45-74-22**

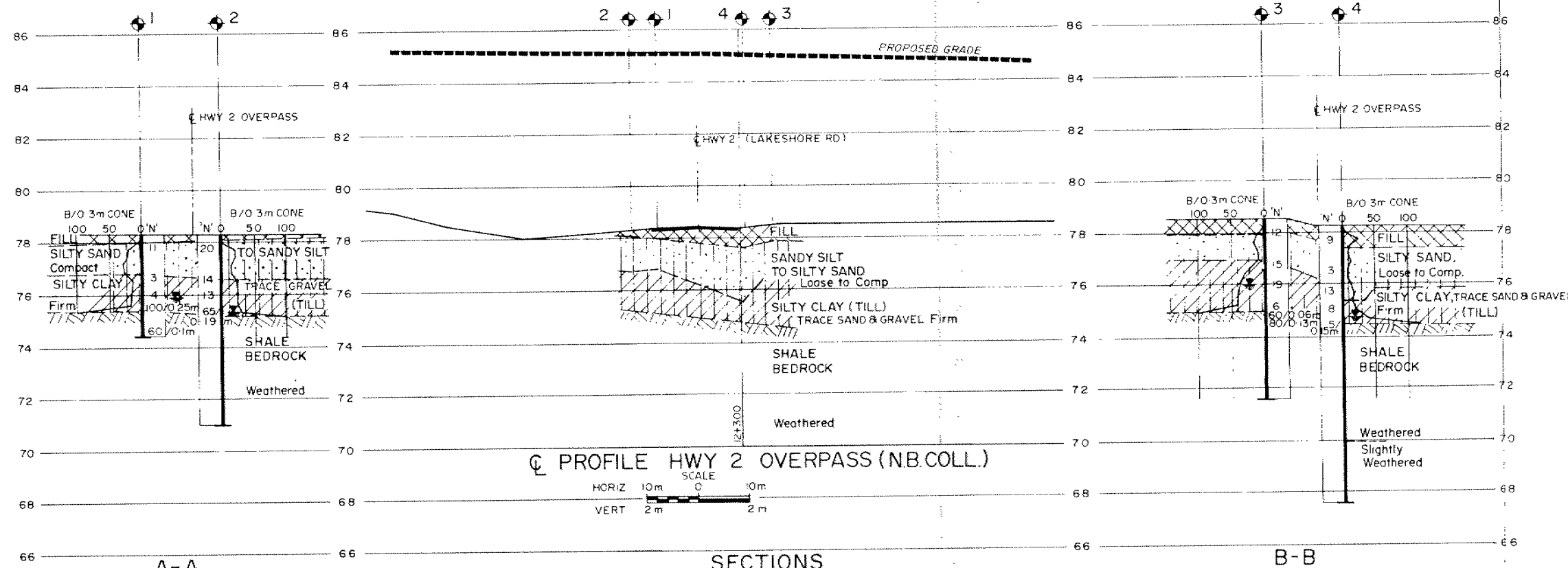
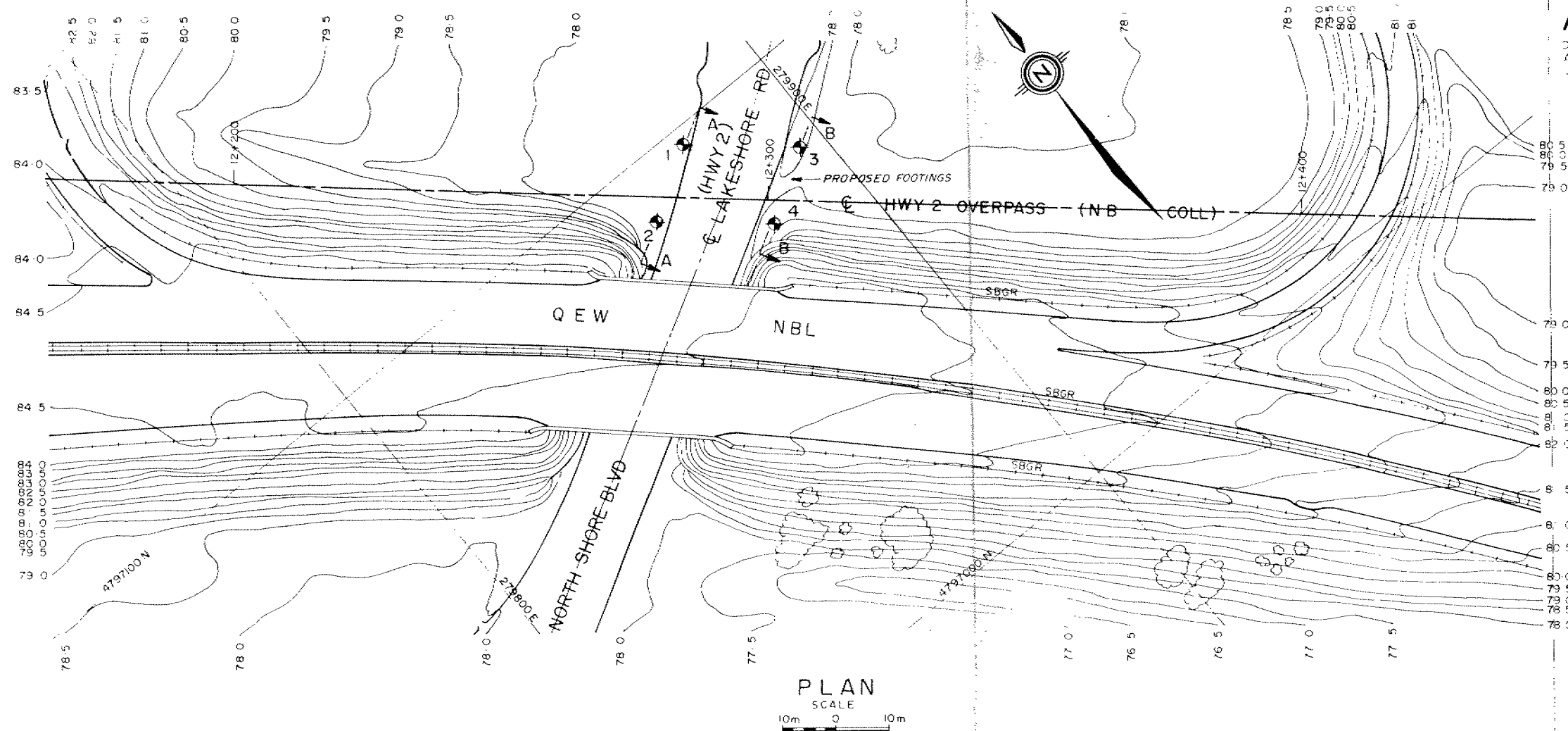
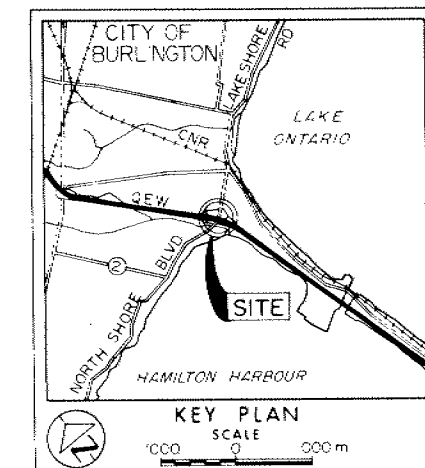
Q.E.W. N.B. COLLECTOR-  
HWY. 2 OVERPASS (N.B. COLL.)

BORE HOLE LOCATIONS & SOIL STRATA



SHEET

GEOCON (1975) LTD.



**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

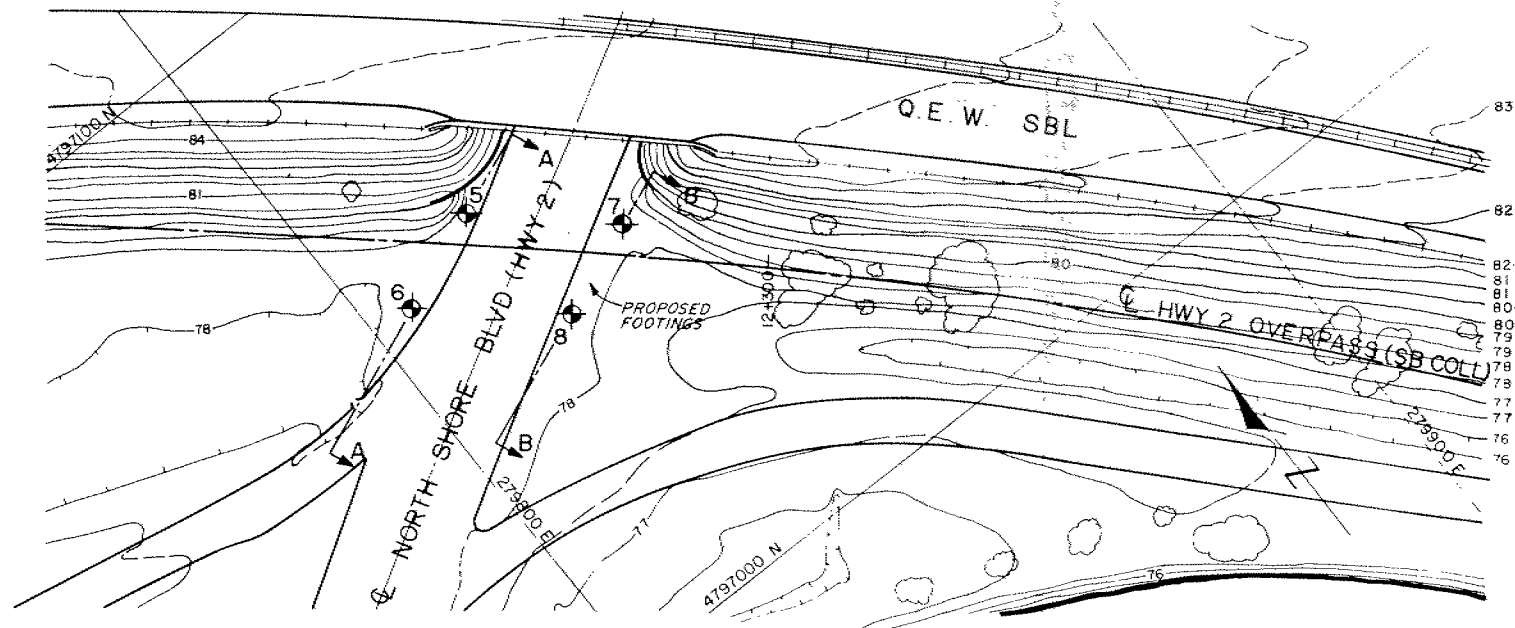
No	ELEVATION	CO-ORDINATES NORTH	EAST
1	78.26	4797097.00	279878.75
2	78.30	4797088.75	279865.75
3	78.54	4797082.50	279835.50
4	78.29	4797074.50	279882.60

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

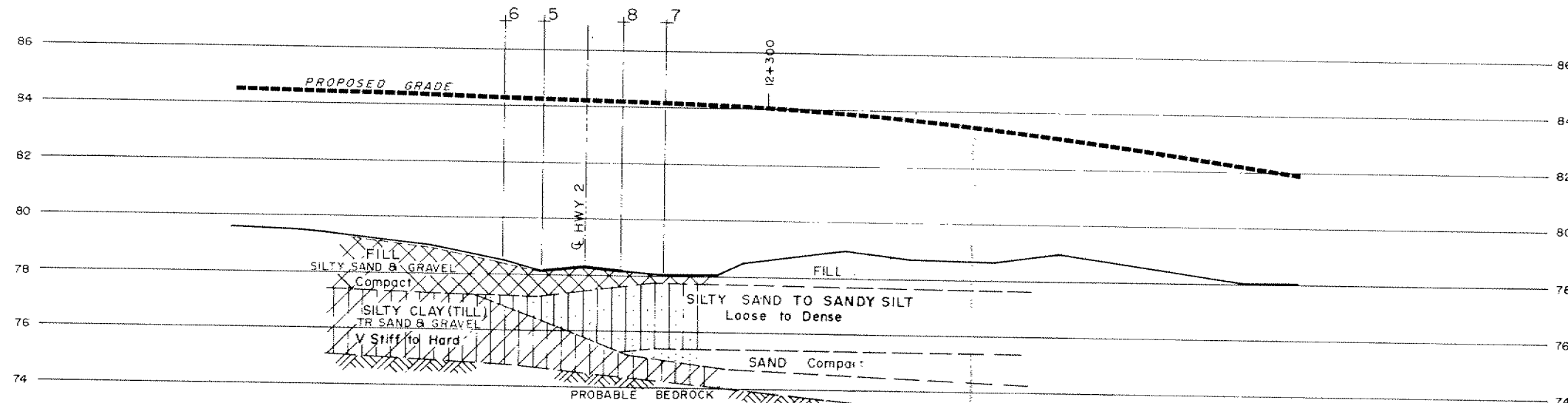
REVISIONS	DATE	BY	DESCRIPTION

Geocres No	HWY No 2/Q.E.W.	DIST 4
SUBMD RCS CHECKED	DATE 80.12.18	SITE 10-142A
DRAWN BY 717	CHECKED	DWG 437422-A

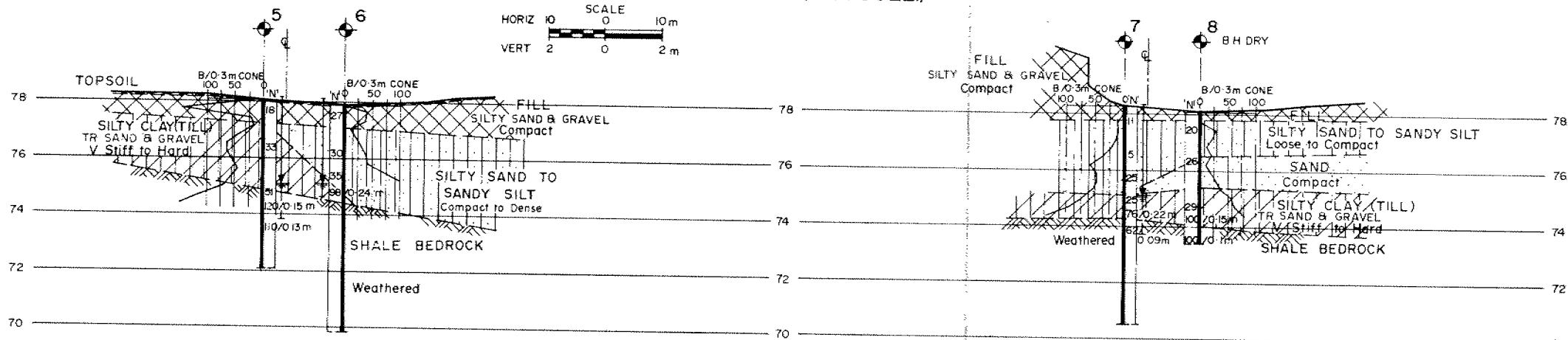




PLAN  
SCALE  
10 0 10 m



PROFILE HWY 2 OVERPASS (S.B. COLL.)



SECTIONS

HORIZ 10 0 10 m  
VERT 2 0 2 m

B-B

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

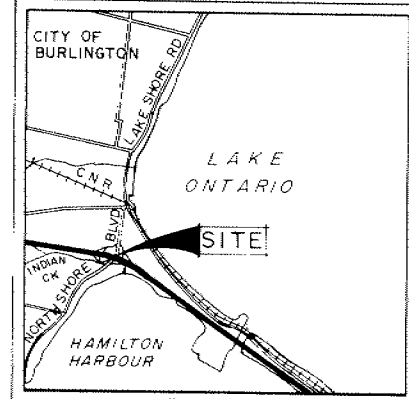
CONT No  
WP No 83-74-23

Q.E.W. S.B. COLLECTOR  
HWY 2 OVERPASS (S.B. COLL.)  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

GEOCON (1975) LTD.



KEY PLAN

SCALE  
0 1000

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- WL at time of investigation 80 (2)
- I STAND PIPE

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
5	78.150	47 970 61.2	27 988 9.4
6	77.940	47 970 55.4	27 980 6.0
7	76.210	47 970 47.4	27 983 4.6
8	78.140	47 970 42.3	27 982 2.0

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No	HWY No	Q.E.W. / HWY 2	DIST 4
SUBM'D R.C.S. CHECKED	DATE	80/12/19	SITE 10-142 B



Mr. G.C.E. Burkhardt  
Head, Structural Section  
Central Region

Pavement & Foundation Design Section  
Room 313, Central Building

Mr. M.D. Bendayan

81 01 20

Q.E.W. N.B. Collector - Hwy. 2 O/P  
Site 10-142A, W.P. 43-74-22  
District 4, Hamilton

---

The foundation investigation program for the above mentioned project has now been completed by Geocon Ltd., geotechnical consulting engineers. Attached, please find their letter summarizing the subsurface conditions encountered across the site and the design recommendations pertaining to the structure foundations and related earthworks. The complete foundation investigation report and drawing for this site will be forwarded to you upon its receipt and review by this Section.

Additional comments with regards to the foundation recommendations are as follows:

- 1) Foundations for full height abutments founded on weathered bedrock at elevations ranging from 75.0 to 74.5 can be designed for an allowable bearing capacity of 500 kPa. Spread footing should be carried on mass concrete to effectively raise the founding elevation to an economic level.
- 2) Alternatively, perched abutments can be founded on endbearing piles driven to refusal in competent bedrock. For design estimating purposes, steel 'H' section piles equipped with reinforced tips driven to an approximate elevation ranging from 74.5 to 74.0 into bedrock can be designed for the maximum allowable sectional compressive loading.
- 3) Provided groundwater levels continue to occur in the silty clay deposit, no serious dewatering problems are anticipated.
- 4) For excavations carried down to shale bedrock, provisions should be made to place a slab of lean concrete over the shale in the base of the excavation, immediately after excavation operations.
- 5) Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

continued...../2

We trust the information provided is sufficient in scope for your immediate requirements. Should further discussions be warranted, please feel free to contact this Section.

TK:ea

Attach.

cc: R. Fitzgibbon

T. Kazmierowski  
Project Foundations Engineer

14 Haas Road  
Rexdale, Ontario  
M9W 3A2  
Phone: (416) 743-3031  
Telex: 06-989367

# GEOCON

Applied Soil Mechanics  
Foundations  
Offshore Geotechnics  
Geotechnical Processes  
Earthworks

Rexdale, Ontario  
- January 16th, 1981

Ministry of Transportation  
and Communications  
Pavement and Foundation  
Design Section  
Central Building - Room 315  
Downsview, Ontario

Attention: Mr. K. Selby, P. Eng.  
Senior Structural Engineer

Re: Geotechnical Investigation  
Q.E.W. N.B. Arterial - Highway 2  
Overpass, Site 10-142A, W.P. 43-74-22  
District 4, Hamilton

Dear Sirs:

Further to your request, we submit herewith the available factual data obtained in the four boreholes put down at the above referenced site, together with preliminary geotechnical recommendations pertinent to foundation design of the proposed single span rigid frame reinforced concrete structure.

The enclosed extracts from the plan drawing (Figures 1 & 2) show the locations of the boreholes at the site and the proposed footing locations as supplied by the Ministry on the Delcan Consulting Engineers Drawing No. 306-3 at a scale of 1:500.

Overburden soils encountered range in thickness from 2.9m to 3.8m overlying bedrock comprising interbedded shale and limestone (Queenston Formation, Ordovician Age). Samples in the



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overburden and near the top of bedrock were taken using standard 51mm O.D. split spoon samplers, generally at intervals of less than one metre. Standard Penetration Tests were carried out in conjunction with the split spoon sampling. In addition, two thin wall tube (Shelby) samples were also taken in the cohesive soil at Borehole No. 1.

Bedrock was penetrated by augering one metre in Borehole 1. In Boreholes 2, 3 and 4, diamond core drilling was carried out, using BV triple tube and BXL core barrels, below the split spoon samples taken in the top of the bedrock. The bedrock penetration was one metre in Borehole 1, 4.2m in Borehole 2, 3.4m in Borehole 3 and 6.9m in Borehole 4.

The subsurface conditions at the two proposed abutments are described separately as follows:

## 1.0 SOIL CONDITIONS

### 1.1 North Abutment (Boreholes 1 and 2)

A surficial layer of sand and gravel fill ranging in thickness from 0.2m to 0.3m was encountered from ground surface at the boreholes. This material was probably placed during construction of the existing Highway 2. Underlying this fill is a stratum of sands and silts. It consists predominantly of fine sand with some silt in Borehole 1 and fine sandy silt in Borehole 2. The 'N' value was 11 in Borehole 1 and 20 in Borehole 2. The corresponding moisture contents were 21% and 13% respectively. This stratum is described as compact sandy silt to silty sand. A 1.4m thick stratum of silty clay underlies the sandy silt to silty sand stratum in both boreholes.

1.0 SOIL CONDITIONS (continued)

1.1 North Abutment (Boreholes 1 and 2) (continued)

In Borehole 2 the silty clay contains traces of sand and gravel and thin sand layers, and could be classified as till. In Borehole 1, the granular content appears to be absent.

Shear strengths of 49.5 kPa and 55.3 kPa were determined by undrained triaxial tests and 33.4 kPa by laboratory vane shear tests were obtained from samples obtained in thin walled steel tube samplers at Borehole 1. 'N' values ranging from 4 to 13 were obtained from Standard Penetration Tests carried out in the silty clay stratum. Based on the 'N' values and strength test results, the consistency of the silty clay is considered to be firm.

Weathered shale bedrock underlies the silty clay. It was penetrated one metre by augering in Borehole 1 and 4.2m by rock coring in Borehole 2. The top 2.7m of this bedrock is considered to be of poor quality, with core recovery of 90 percent and 18 percent and estimated Rock Quality Designation (R.Q.D.) values of 27 percent and 0 percent. Harder core sections of interbedded limestone are present. The depth to the top of bedrock ranges from 2.9m to 3.2m and corresponding to elevations from 75.2m to 75.4m (Geodetic Datum).

1.0 SOIL CONDITIONS (continued)

1.2 South Abutment (Boreholes 3 and 4)

A surficial layer of sand and gravel fill, 0.3m to 0.08m in thickness and with 50mm of topsoil in Borehole 3, was encountered at both boreholes. This fill is compact. Underlying the fill is a stratum of silty sand to sandy silt. It consists mainly of 1.3m of compact silty sand in Borehole 3. In Borehole 4 the top 1.5m of this stratum is loose silty sand and the lower 0.6m is compact sandy silt to silty sand with trace of clay. Below the sands and silts is a stratum of stiff silty clay till with trace of sand and gravel and thin sand layers. The thickness of this stratum ranges from 0.9m to 1.9m. Underlying the silty clay till is weathered shale bedrock at depth ranging from 3.5m to 3.9m and elevation varying from 74.5 to 75.0 metres. In Borehole 3, the bedrock was penetrated 3.4m by diamond coring. The recoveries were 12 percent, 20 percent and 87 percent, and the corresponding estimated R.Q.D. values were 0 percent, 0 percent and 36 percent. The bedrock in this borehole is weathered and of poor quality to the depth penetrated. In Borehole 4, the bedrock penetration by diamond coring was 6.9m. The recovery in the seven runs was 100 percent but the corresponding estimated R.Q.D. values were 0 percent, 23 percent, 23 percent, 25 percent, 59 percent, 36 percent and 0 percent. These results and visual examination of cores indicate that the upper 4.7m of the bedrock is weathered and of poor to fair quality and that the quality improves in the lower part, although evidence of weathering is present to the depth penetrated.

## 2.0 GROUNDWATER CONDITIONS

Information available to date on the groundwater conditions is shown on the appended Table 1.

## 3.0 PRELIMINARY RECOMMENDATIONS FOR FOUNDATION DESIGN

It is understood that the proposed bridge structure will be of reinforced concrete rigid frame construction with a single span of approximately 20 metres. The tentative plan is to use single strip footings under each abutment.

Based on the soil conditions encountered, the following alternative foundation systems could be considered:

- a) Strip footings at about 1.5m depth will be underlain variously by clay and sand. It is expected that the clay is the same formation as the till described for the proposed structure at Site 10-142B; the granular content appears to be less or missing and the consistency is softer. An allowable bearing value of 100 kPa is recommended for use in preliminary design. Some adjustment of founding elevation or the use of fill concrete to replace remnants of sand below footing elevation is recommended and to provide uniform founding on the clay stratum.
- b) Footings on bedrock for both abutments. As the bedrock surface is only 2.9m to 3.1m below existing ground surface at the north abutment and 3.5m to 3.8m at the south abutment, strip footings bearing on the bedrock may also be considered as an alternative. After clearing of any surfaces disturbed by excavation, the strip footings under each abutment could be carried directly on the bedrock or on lean concrete fill used to raise the founding elevation if desired. For preliminary

3.0 PRELIMINARY RECOMMENDATIONS FOR FOUNDATION DESIGN (continued)

b) (continued)

design, an allowable bearing value of 400 kPa may be used for this alternative.

- c) Piled foundations: Relatively short piles driven to end-bearing in the shale such as steel H or tube piles, pre-cast or cast-in-place concrete piles would be a third alternative.

Although the shale as recovered appears dry, and of low permeability, there is local experience of high localized water flow from the shale which can create construction difficulties for drilled caissons. In view of the harder and softer layering in the shale, driven piles (particularly steel H-piles) will penetrate some distance into the bedrock and careful judgment will be required in establishing final set criteria. To compensate for the effects of possible shatter of the intermittent harder layers, provision for redriving should be made, particularly where steel H-piles are involved.

The design of excavations for pile caps or footings, particularly if footings on rock are selected, would have to take into account surcharge effects from the existing Q.E.W. approach embankments. The design of a support system for the above conditions will require suitable dewatering measures where excavations extend below groundwater. At the time of investigation, the measured water levels occurred at depth in the clay; at the time of construction perched water may exist in the sand layer.



3.0 PRELIMINARY RECOMMENDATIONS FOR FOUNDATION DESIGN (continued)

- d) Spread foundations or pile caps should have a minimum of 1.25m of earth cover for frost protection purposes.

4.0 CLOSURE

We trust the content of this letter is satisfactory for your present purposes. If we can be of any further assistance for your planning needs while preparation of the geotechnical report is in progress, please do not hesitate to call us. This letter has been reviewed by Mr. D.B. Oates, P. Eng.

Respectfully submitted,  
GEOCON (1975) LTD.



R.C. Sansom, P. Eng.  
Assistant District Manager

RCS:smcb  
T10439

TABLE 1

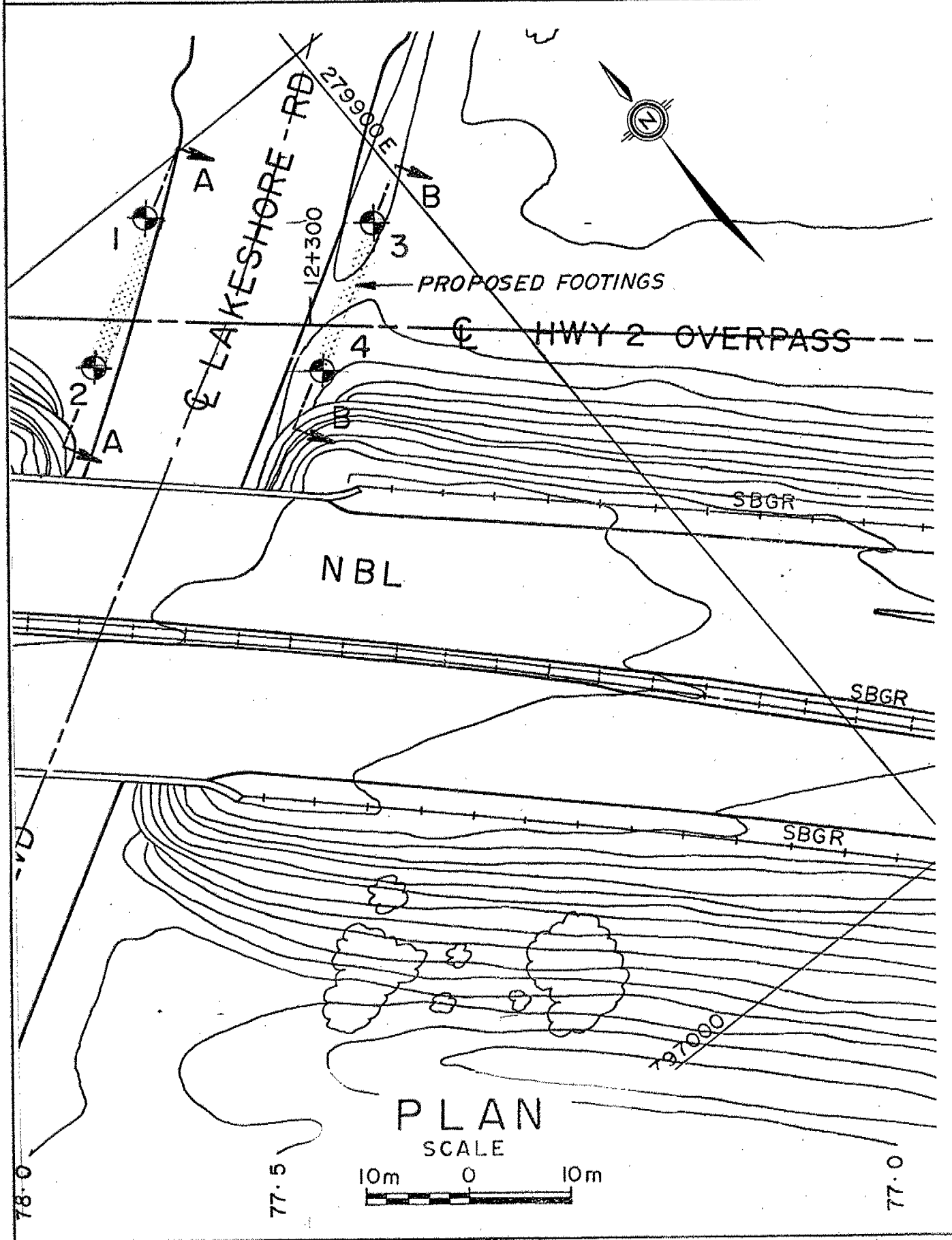
GROUNDWATER LEVELS

Borehole	Ground Elevation	Elevation of Standpipe (Bottom)	Elevation Piezometer (Bottom)	Depth to Groundwater (m)						
				1980						1981
				12/16	12/17	12/18	12/19	12/22	12/24	01/08
1 *	78.26	75.42							2.90	2.41
2 *	78.30	75.40							2.90	3.02
3 *	78.54	75.58						2.31	2.31	2.46
4 *	78.29	70.98							3.38	3.51
5	78.15	73.79			1.61	1.62	2.96	3.08	3.05	3.04
6	77.94	74.74		2.23	2.46	2.59	2.65	2.72	2.77	2.79
7	78.21	73.64			2.96	3.12	3.09	3.15	3.15	3.23
8	78.14									
9	78.80	72.09				0.42	0.53	0.63	0.81	0.84
10	80.76		71.01						5.77	5.72
11	80.76	70.40							5.44	5.54
12	76.72	71.84						1.70	1.68	1.74
13	76.12	72.16				0.88	0.88	1.02	0.38	1.18
Piez 14	75.97		67.64	1.27			1.30	1.26	1.52	1.32
SP 14	75.97	71.40		0.90			0.94	1.07	1.09	1.19

\* Site 10-142A, Groundwater information.

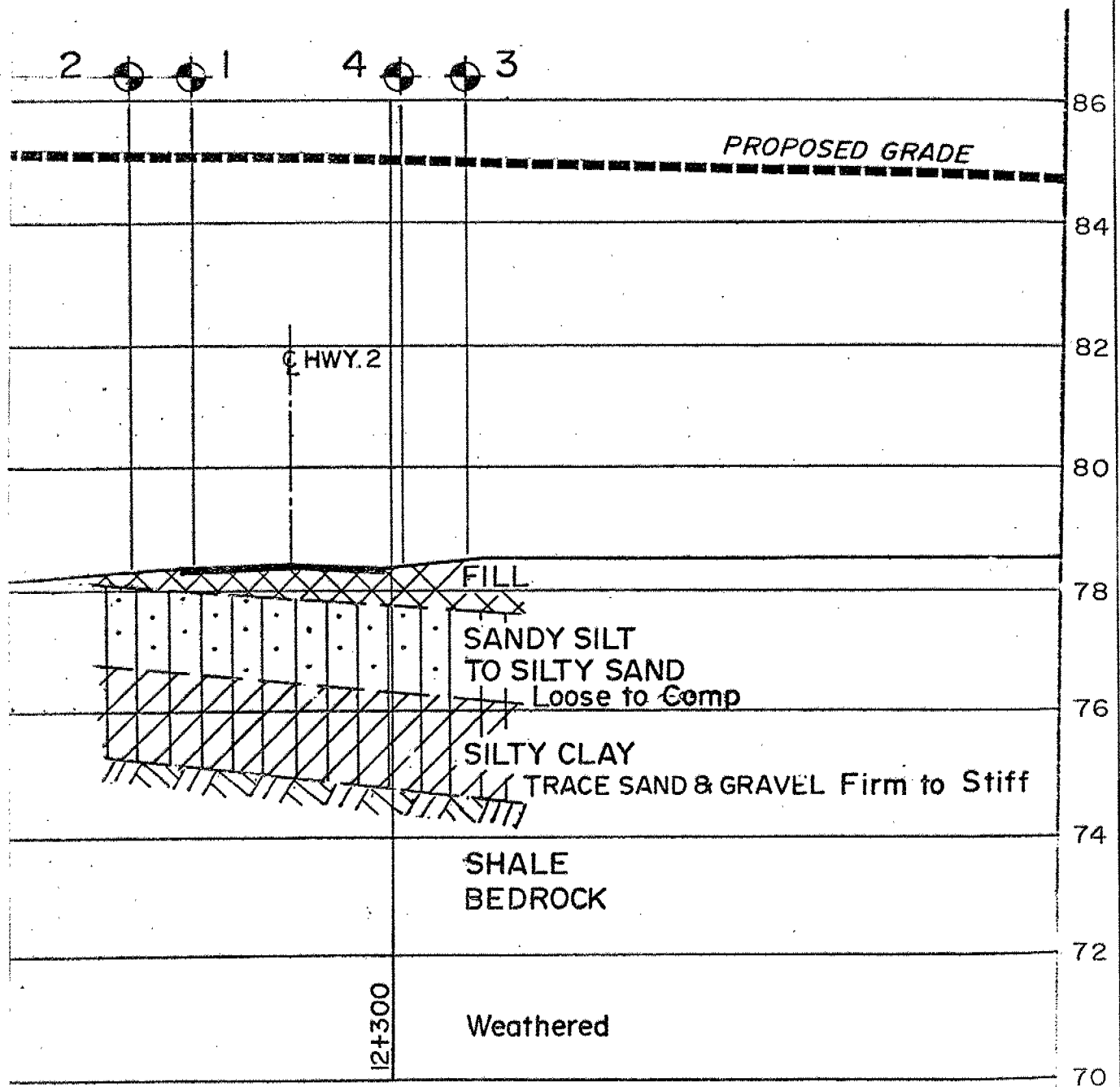
SITE 10-142 A  
To Accompany Letter of Jan. 16, 1981

FIGURE 1  
PROJECT T10439

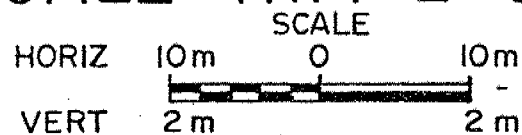


SITE 10-142 A  
To Accompany Letter of Jan. 16, 1981

FIGURE 2  
PROJECT T 10439



PROFILE HWY 2 OVERPASS



Mr. G.C.E. Burkhardt  
Head, Structural Section  
Central Region

Pavement & Foundation Design Section  
Room 313, Central Building

Mr. M.D. Bendayan

81 01 20

Q.E.W. N.B. Collector - Ramp S-E, W O/P  
Site 10-322, W.P. 83-74-21  
District 4, Hamilton

---

Geocon Ltd., geotechnical consulting engineers, have now completed the foundation investigation program for the above mentioned project. Please find attached their letter summarizing the subsurface conditions encountered across the site and design recommendations pertaining to the structure foundations and related earthworks. The final foundation report for this site will be forwarded to you in the near future upon receipt and review by this Section.

Our comments with regards to the foundation recommendations are as follows:

- 1) In consideration of the proximity of bedrock to ground surface, foundations for the piers and abutments should be founded on endbearing piles driven to bedrock. For design estimating purposes, steel 'H' section piles equipped with reinforced tips, driven to refusal in competent bedrock, approximate tip elevation of 70.5, can be designed for the maximum allowable sectional compressive loading.
- 2) No serious dewatering problems are anticipated for pile cap excavations. Local seepage into the excavations can be controlled by pumping from perimeter sumps.
- 3) Minimal settlement/stability problems are anticipated for the immediate approach embankment slopes provided they are constructed to a 2:1 geometry.

We trust that the information presented is sufficient for your immediate requirements, however if further discussion is warranted, feel free to contact this Section.

TK:ea  
Attach.  
cc: R. Fitzgibbon

T. Kazmierowski  
Project Foundations Engineer

14 Haas Road  
Rexdale, Ontario  
M9W 3A2  
Phone: (416) 743-3031  
Telex: 06-989367

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Applied Soil Mechanics  
Foundations  
Offshore Geotechnics  
Geotechnical Processes  
Earthworks

Rexdale, Ontario  
January 16th, 1981

Ministry of Transportation  
and Communications  
Pavement and Foundation  
Design Section  
Central Building - Room 315  
Downsview, Ontario

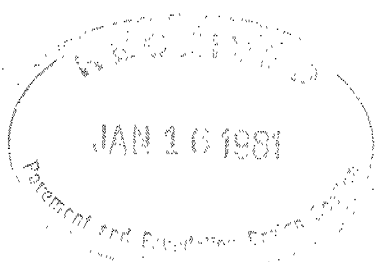
Attention: Mr. K. Selby, P. Eng.  
Senior Structural Engineer

Re: Geotechnical Investigation  
Q.E.W. N.B. Collector - Ramp S-EW  
Overpass, Site 10-322, W.P. 83-74-21  
District 4, Hamilton

Dear Sirs:

Further to your telephone request, we submit herein the available factual data obtained at six boreholes put down at the above referenced site, together with preliminary geotechnical recommendations pertinent to foundation design of the proposed three span (+15m, +30m, 15+m) post-tensioned type of bridge structure.

The enclosed extracts from the plan drawing (Figures 1 & 2) show the locations of the boreholes at the site and the proposed footing locations as supplied by the Ministry on the Delcan Consulting Engineers Drawing No. 306-3 at scale 1:500.



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The overburden soils encountered range in thickness from 5.1m to 9.5m. However, this overburden also contains 2.7m to 3.9m of embankment fill in the area of Boreholes 9, 10 and 11. The natural overburden thickness ranged from 4.8m to 6.5m. The bedrock underlying the overburden soils comprises interbedded shale and limestone (Queenston Formation, Ordovician Age). Samples in the overburden and near the top of bedrock were obtained using standard 51mm O.D. split spoon samplers, generally at intervals of less than 1.0m. Standard Penetration Tests were carried out in conjunction with the split spoon sampling. Bedrock was penetrated 0.3m in Borehole 10 by augering, and 25mm in Borehole 13 by the split spoon sampler. In the other boreholes the bedrock was diamond cored to thicknesses ranging from 2.8m to 3.8m.

The subsurface conditions at the two proposed abutments and the two proposed piers are described separately as follows:

#### 1.0 SOIL CONDITIONS

##### 1.1 North Abutment (Borehole 9)

Below 25mm of topsoil, the surficial layer of compact fill consisting of sandy silt with organics and traces of clay and gravel was encountered down to a depth of 2.7m. Underlying the fill is a 4.5m thick stratum of compact silty sand to sandy silt. Below this stratum is a layer of silty clay till, only 0.3m thick. It is underlain by shale bedrock proved to a thickness of 3.8m. The top one metre of this bedrock is weathered and of poor quality. The underlying shale is in fair condition with a core recovery of 72 percent and R.Q.D. value of 32 percent to 58 percent.

1.0 SOIL CONDITIONS (continued)

1.2 North Pier (Boreholes 10 and 11)

These two boreholes are located on an existing embankment and the surficial layer consists of fill, 3.0m to 3.9m in thickness. The fill is a mixture of silty sand and gravel with trace of clay. The 'N' values from the Standard Penetration Tests were 13, 19, 17, 16 and 38, indicating that it is compact. Below the fill is a stratum of silty sand to sandy silt with 'N' values versus depth of 80, 48, 50 in Borehole 10 and 58, 36, 22 in Borehole 11. It is dense to very dense except at the lower part of the stratum in Borehole 11 where it was compact. Underlying the silty sand to sandy silt stratum is a firm to stiff silty clay till. Its thickness is about two metres. It is underlain by shale bedrock, 3.5m of which was diamond drilled in Borehole 11. The core recovery with depth was 38 percent, 100 percent, 88 percent and R.Q.D. values were 11 percent, 82 percent, and 53 percent, indicating a quality variation from very poor to generally fair.



1.0 SOIL CONDITIONS (continued)

1.3 South Pier (Boreholes 12 and 13)

These holes are located on natural ground. The surficial layer, below 75mm to 100mm of topsoil, is dense to compact silty fine sand. Its thickness varies from 4.3m to 5.1m. The 'N' values, with depth are 44, 35, 31 in Borehole 12 and 49, 23 in Borehole 13. Below the silty sand is a 0.8m thick stratum of silty clay till, underlain by shale bedrock. The bedrock was diamond drilled to a depth of 3.5m. The bedrock is of fair quality except in the top 0.4m where it is poor.

1.4 South Abutment (Borehole 14)

The surficial stratum at this location is a silty sand to sandy silt. It extends from the ground surface down to a depth of 4.7m. The top three metres of the stratum is loose with 'N' values of 7 and 6; below, the relative density improves to compact with a measured 'N' value of 18. Underlying this stratum is a silty clay till stratum, 0.8m in thickness, then shale bedrock. The top three metres of the bedrock was diamond drilled. Core recoveries of 98 percent and 96 percent and R.Q.D. values of 61 percent and 64 percent were obtained indicating a fair quality.

2.0 GROUNDWATER CONDITIONS

Information available to date on the groundwater conditions is shown on the appended Table 1.

### 3.0 PRELIMINARY RECOMMENDATIONS FOR FOUNDATION DESIGN

Based on the soil conditions encountered, the following alternative foundation systems could be considered:

#### 3.1 Strip Footings

Depending on requirements for re-grading below the proposed structure, conventional footings would be founded in the upper part of the silty sand stratum, close to or slightly above measured groundwater level. Water level observations indicate a general regime at about elevation 75 except in the vicinity of the north abutment where a high level was observed, at elevation 78; the enclosed configuration of existing embankments may have created a localized entrapment condition for precipitation. This being so, the excavation will require provision for dewatering to protect the silty sand from disturbance.

Within the silty sand, an allowable bearing value of 150 kPa may be used for preliminary design.

Given the depth to bedrock and the generally thin mantle of till over the shale, and requirements for dewatering, strip footings founded on till or bedrock would not appear to be an economical alternative.

3.0 PRELIMINARY RECOMMENDATIONS FOR FOUNDATION DESIGN (continued)

3.2 Piled Foundations - Both Piers and Abutments

Piles driven to end-bearing in the shale such as steel H or tube piles, pre-cast or cast-in-place concrete piles would be an alternative to strip footings.

Although the shale as recovered appears dry, and of low permeability, there is local experience of high localized water flow from the shale which can create construction difficulties for drilled caissons. In view of the harder and softer layering in the shale, driven piles (particularly steel H-piles) will penetrate some distance into the bedrock and careful judgment will be required in establishing final set criteria. To compensate for the effects of possible shatter of the intermittent harder layers, provision for redriving should be made, particularly where steel H-piles are involved.

The design of excavations for pile caps or footings, may have to take into account surcharge effects from existing ramps depending on proposed re-grading, if any. The design of a support system for the above conditions may require suitable dewatering measures where excavations extend below the groundwater level.

Spread foundations of pile caps should have a minimum of 1.25m of earth cover for frost protection purposes.

Ministry of Transportation  
and Communications  
January 16th, 1981  
Page 7.

4.0 CLOSURE

We trust the content of this letter is satisfactory for your present purposes. If we can be of any further assistance for your planning needs while preparation of the geotechnical report is in progress, please do not hesitate to call us. This letter has been reviewed by Mr. D.B. Oates, P. Eng.

Respectfully submitted,  
GEOCON (1975) LTD.



R.C. Sansom, P. Eng.  
Assistant District Manager

RCS:smcb  
T10439

**GEOCON**

TABLE 1

GROUNDWATER LEVELS

Borehole	Ground Elevation	Elevation of Standpipe (Bottom)	Elevation Piezometer (Bottom)	Depth to Groundwater (m)							1981 01/08
				1980	12/16	12/17	12/18	12/19	12/22	12/24	
1	78.26	75.42								2.90	2.41
2	78.30	75.40								2.90	3.02
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7	78.21	73.64			2.96	3.12	3.09	3.15	3.15	3.23	
8	78.14										
9 *	78.30	72.09				0.42	0.53	0.60	0.81	0.84	
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11 *	80.76	70.40								5.44	5.54
12 *	76.72	71.84							1.70	1.68	1.74
13 *	76.12	72.16					0.88	0.88	1.02	0.38	1.18
Piez 14 *	75.97		67.64		1.27			1.30	1.26	1.52	1.32
SP 14 *	75.97	71.40			0.90			0.94	1.07	1.09	1.19

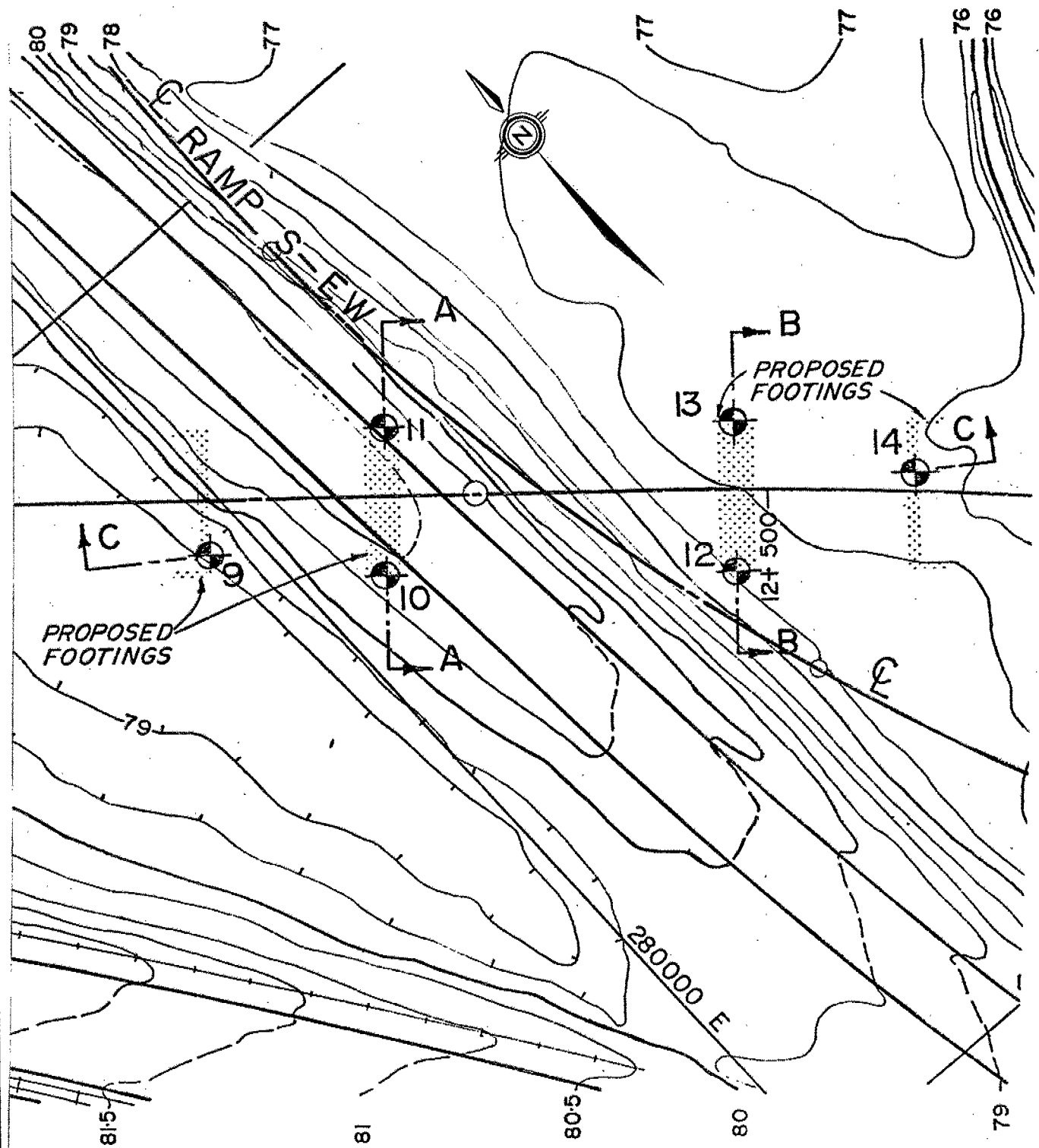
\* Site 10-322 groundwater conditions.

SITE 10-322

To Accompany Letter of Jan. 16, 1981

FIGURE 1

PROJECT T10439



PLAN

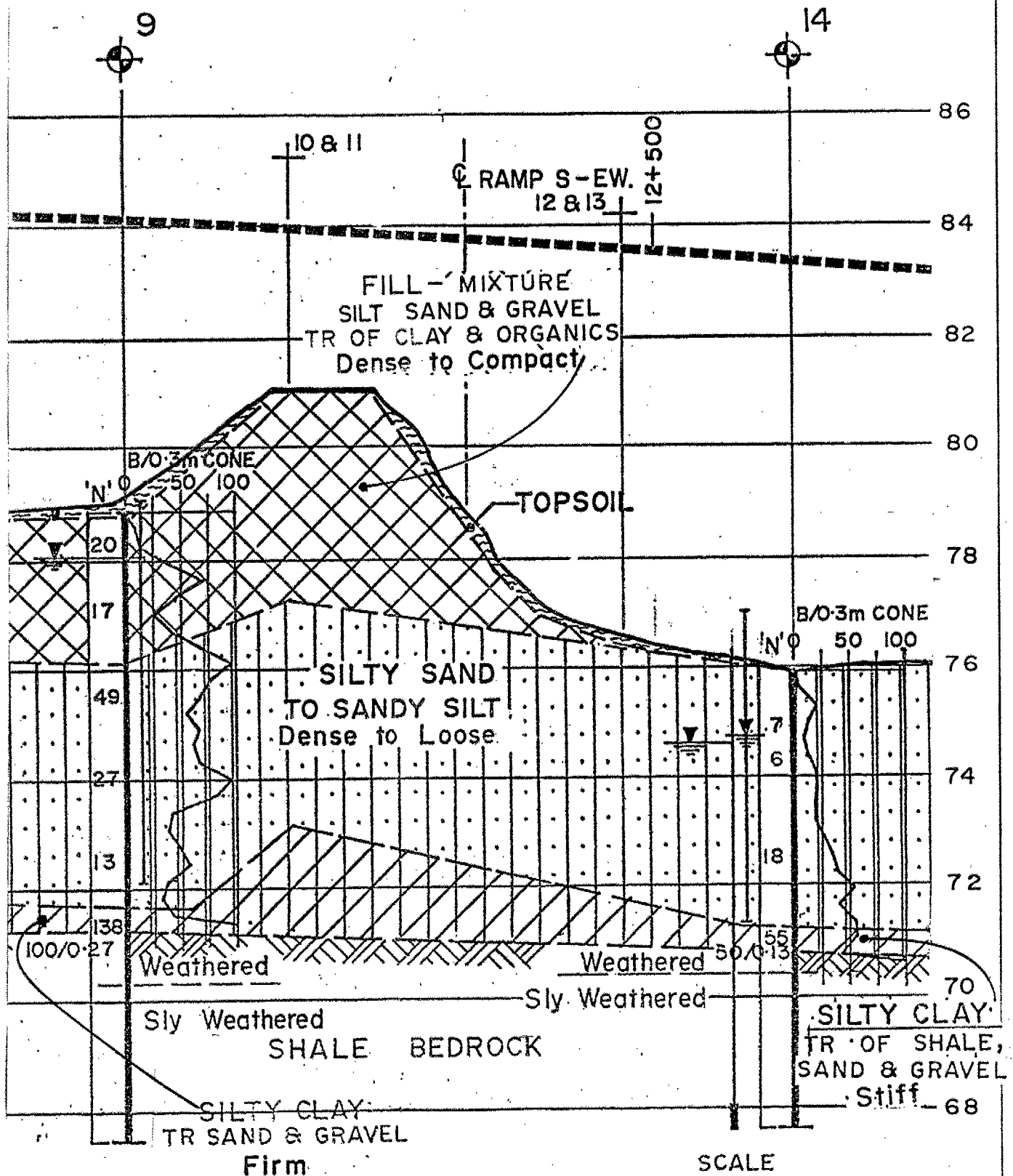
SCALE



SITE 10-322

To Accompany Letter of Jan. 16, 1981

FIGURE 2  
PROJECT T10439



SECTION C - C