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W.P. No. 903-72-01

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W. O. No.

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HWY. No. 17

LOCATION FEASIBILITY STUDY OF T.C.

No of PAGES - ~

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ministry of Transportation and Communications
Ontario

Memorandum

41 K - 36
GEOCRES No.

To: Mr. B.J. McKenna (2),
Regional Structural Planning Engr.,
Northwestern Region,
Thunder Bay.

Attention:

From: Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

Date: November 12, 1975.

NOV 17 1975

Our File Ref. W.P. 903-72-18

In Reply to

Subject:

PRELIMINARY FOUNDATION INVESTIGATION REPORT
for
Feasibility Study of T.C. Hwy. No. 17
(Proposed 4 Lanes)
Garden River Indian Reserve
District No. 18 (Sault Ste. Marie)
W.P. 903-72-18

Due to the urgency of this project we are forwarding to you a report containing the subsoil description and the recommendations which are based on the information from the field, which are based on the field data without any laboratory tests to determine the engineering properties of the subsoil. However, in our opinion, the data contained in this report will be adequate for your evaluation with regard to feasibility studies on this project.

It should be noted that the recommendations given in this report are of a preliminary nature. A complete foundation investigation will be necessary once the alignment and geometrics are finalized.

M. DEVATA,
Supervising Engineer.

cc: E.J. Orr,
B.R. Davis,
W.L. Lees (2),
G.E. French,
B.J. Giroux,
R. Morgenroth,
G.A. Wrong,
R. Hore,
McCormick, Rankin & Assoc. Ltd.,
J. Anderson)
N.G. Maluzinsky) memo only
G. Sloan)

Files,
Record Services.

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PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Feasibility Study of T.C. Hwy. No. 17
(Proposed 4 Lanes)
Garden River Indian Reserve
District No. 18 (Sault Ste. Marie)
W.P. 903-72-18

1. INTRODUCTION

The Soil Mechanics Section was requested to undertake a preliminary foundation investigation to investigate the feasibility of two alignments, namely, Scheme 'A' and Scheme 'B' for a proposed crossing of the Garden River by Hwy. 17. This report discusses the findings of this preliminary foundation investigation.

The locations and elevations of the boreholes are approximate, and are obtained from the plans and profiles prepared by McCormick, Rankin & Associates, Consulting Engineers.

Due to the urgency of this project, laboratory tests have not been carried out to determine the engineering properties of the subsoil. The recommendations and other related data contained in this report were already discussed orally between Messrs. M. Devata, W.L. Lees and D. Jarvis in the Thunder Bay Regional Office, on October 8, 1975, immediately after the completion of the field investigation work.

2. SUBSOIL AND GROUNDWATER CONDITIONS

A total of five sampled boreholes were put down during the course of the field investigation. The borings were advanced by means of a bombardier mounted auger machine,commercially known as C.M.E. No. 55, adapted for soil sampling purposes.

The pertinent boreholes for each of the respective preliminary alignments of Scheme 'A' and Scheme 'B' are as follows:

Scheme A (Sta. 287+00 - Sta. 322+00) - Ref. B.H.'s No. 1, 2, & 5
Scheme B (Sta. 287+00 - Sta. 320+00) - Ref. B.H.'s No. 3 & 4

The results of the field investigation are summarized on the Record of Borehole Sheets and on Dwg. No. 9037218-A attached to this report.

The subsoil across both schemes consists generally of granular material ranging in size from sandy silt to sand with trace to some gravel. The granular deposit in the old river valley area (Ref. Scheme 'A', B.H.'s No. 1 & 2) is underlain by a cohesive layer of clay to silty clay. B.H.'s No. 1 & 2 were terminated in the clay layer, and thus the lower boundaries of the cohesive stratum were not established.

3. DISCUSSIONS AND RECOMMENDATIONS

(3.1) General

Two possible preliminary alignments are being considered, namely, Scheme 'A' and Scheme 'B', for the relocation of Hwy. 17 in the Garden River Indian Reserve area. The proposal in this area calls for the construction of a new four lane Hwy. 17 as a divided (100' median) controlled access highway within a 300 foot right-of-way. Preliminary plans and profiles were developed by McCormick, Rankin & Associates, Consulting Engineers, who are involved in the feasibility study of this project.

The centreline of the proposed preliminary Scheme 'A' runs parallel to, and about 250 feet north, from the centreline of the hydro right-of-way (Great Lakes Power Co.). Scheme 'B' runs further north, and within the area concerned, its distance from the hydro right-of-way varies from about 600 to 850 feet.

At this stage, the specific design details of the proposed structures are not available. However, it is understood that a separate three span structure is being considered for E.B.L. and W.B.L. of Scheme 'B'. For Scheme 'A' it is proposed to build a 4 span structure for the W.B.L. and a three span structure for the E.B.L. Each scheme requires construction of embankments, cuts, and structures for the river crossing. Presented below in tabular form are the recommendations pertaining to stability and settlement considerations for the embankments, stability of the cuts, and also recommendations for the structures and immediate approaches needed for the Garden River crossing.

(3.2) EMBANKMENTS

	Subsoil & Design Data			Discussions & Recommendations	Remarks
	B.H. #1	B.H. #2			
Scheme 'A'	(585.0)	(584.5)	Ground elevation	Embankment heights of up to 31 ft. will be required to meet the proposed profile grade. Stability analyses indicate that the proposed fill heights will be stable with 2:1 slopes, provided that the fill material consists of acceptable earth material compacted to the M.T.C. specifications. Clay stratum is compressible & will undergo settlements due to consolidation. For a 31 ft. embankment 4-5 in. settlement are anticipated (50% occur in 6-12 months) Embankment heights in general are in the order of about 15 ft. However, in some localized areas, fill heights of up to 18 ft. will be required to meet the proposed profile grade. No major stability or settlement problems are anticipated.	The area concerned lies in the vicinity of the oxbow lake area. This portion is also part of the old river valley. Any surficial organic material shall be required to be excavated prior to the embankment construction. This aspect was not investigated
Embankments	0-33 ft.	0-17.5 ft.	Sand, trace to some gravel, very loose to compact		
Sta. 287+50 ± to Sta. 304+00 ±	33-44.5 ft.	17.5-49.5 ft.	Silty clay to clay, firm to very stiff		
(Ref. B.H.#1 & 2)	(583.2)	(583.5)	Water level elevs.		
	Existing ground: varies from elevs. 581 to 590				
	Proposed grade: varies from elevs. 600 to 613 (Hwy. 17N)				
Scheme 'B'	No borings were carried out in this area. However, visual observations indicate that the subsoil in this area consists of sand and gravel. This is evident since this area is used as burrow pit by the C.P.R.				
Embankments					
Sta. 287+50 ± to Sta. 301+30 ±	Existing ground: varies from elevs. 600 to 620				
	Proposed Grade: varies from elevs. 617 to 624 (Hwy. 17N)				

(3.3) CUTS

	Subsoil & Design Data	Discussions & Recommendations	Remarks
Scheme 'A' Cuts Sta. 302+40 ± to Sta. 307+60 ±	No borings were carried out in this area. However, visual observations were made to determine the surficial soils encountered in the vicinity of the area concerned. The material to be excavated is expected to consist predominantly of sand to silty sand. Existing ground: elev. 635 Proposed grade: varies from elevs. 598 to 600 (Hwy. 17N)	Cuts of up to 35 ft. will be required to meet the proposed profile grade. Stability problems are not anticipated for the cuts in this localized area, if constructed with 2:1 slopes. Protection of cuts from erosion due to surface water runoff may be required.	
Scheme 'B' Cuts Sta. 301+50 ± to Sta. 309+50 (Ref. B.H. #4)	B.H. #4 (635.0) Ground elevation 0-15.3 ft. Sand, trace to some gravel, loose to compact. 15.3-18 ft. Silty clay to clay, firm. 18-22 ft. Sandy gravel with cobbles, dense. 22 ft. Encountered refusal to augering, probable boulders. B.H. dry Existing ground: elev. 635 Proposed grade: varies from elevs. 617 to 623 (Hwy. 17N)	Cuts of up to 18 ft. will have to be made to achieve the proposed profile grade. Stability problems are not anticipated for the cuts constructed with 2:1 slopes. No major dewatering problems are anticipated for the construction of cuts in this area. Protection of cuts from erosive forces due to surface water runoff may be required.	

(3.4 a) GARDEN RIVER CROSSING

Scheme 'A' (Ref. B.H. #5) - Sta. 310+00± to Sta. 325+00±

Subsoil & Design Data

B.H. #5

(635.0)	Ground elevation
0-96.5 ft.	Sand to silty sand, very loose to compact.
(622.3)	Water level elev.
(587)	River water level elev.

Existing Ground - east approach area: elev. 635.
west approach area: varies from 602 to 613.

Proposed grade - east approach area: varies from 618 to 630
west approach area : varies from 602 to 613.

Structures: 4 span with a total length of about 520 ft. (WBL), and 3 span with a total length of about 255 ft. (EBL). Proposed grade varies from 613 to 619.

Discussion & Recommendations

Structure

Due to the loose nature of the sandy, subsoil, spread footing type foundations are not recommended at this site. In the vicinity of the east abutment an end bearing stratum is not evident in the material sampled.

Foundations for the abutments and piers, if supported on No. 14 timber piles and driven to an embedded depth of 45 ft., will provide an allowable load of 10 tons per pile. Alternatively, end bearing Franki type expanded base piles may be considered at this location. For example, a 16" Ø rammed shaft could develop 75-100 tons per pile provided it is extended some 25 to 30 ft. into the granular deposit.

Approaches

Cuts up to 15 ft. will have to be made on the east bank to meet the proposed profile grade. Fills of up to 23 ft. will be required on the west bank to arrive at the profile grade. No major stability or settlement problems are anticipated.

Remarks

The river meanders at this crossing. The river widths at the proposed structures locations are about 360 ft. (WBL) and 100 ft. (EBL). The banks on the east side of the river are about 53 ft. above the river bed in certain locations. The east bank has natural slopes steeper than 1:1, and has eroded away to quite an extent at places, due to surface runoffs.

(3.4. b) GARDEN RIVER CROSSING

Scheme 'B' (Ref. B.H.#3) - Sta. 305+00± to Sta. 320+00±

Subsoil & Design Data

B.H. #3

(600.0)	Ground elevation.
0-5 ft.	Sandy silt, very loose
5-32.5 ft.	Sand, trace to some gravel, loose.
32.5-41.5 ft.	Sand with gravel dense to very dense.
(587)	Water level elev.
(587)	River water level elev.

Existing Ground - east approach area: elev. 640.
west approach area: elev. 635

Proposed grade - east approach area: varies from elev. 626 to 634.
west approach area: varies from 618 to 623.

Structures: 3 span with a total length of about 320 ft. (a structure each for W.B.L. & E.B.L.). Proposed grade varies from 623 to 626.

Discussion & Recommendations

Structure

Due to the loose nature of the sandy type subsoil, spread footing type foundations are not recommended at this site.

It is recommended that the entire structure be supported on end-bearing steel piles driven into the dense to very dense sand with gravel stratum. For feasibility purposes, it is estimated that the maximum allowable loads for the particular pile section chosen will be achieved at approximate elevation 550.

Approaches

Cuts of up to 18 ft. will have to be made on the west bank to reach the proposed profile grade. Comments on this have been discussed elsewhere under the heading "Cuts".

Shallow cuts of up to about 11 ft. will be required on the east bank. No major stability problems are anticipated for cuts constructed with standard slopes of 2:1.

Fills of up to about 30 ft. will be required in the valley area on the east side of the river. No major stability or settlement problems are anticipated.

Remarks

The river at this crossing follows a fairly straight course. The river valley has a bank to bank width of about 600 ft., while the river itself is about 120 ft. wide. The valley floors on the east side of the river have slopes of about 4:1. The river banks are up to about 54 ft. in height above the river bed.

4. FEASIBILITY OF SCHEMES

Both Schemes 'A' and 'B' are feasible, but from the foundation point of view, Scheme 'B' is a more favourable alignment for the following reasons:

1. Borehole No. 3 (Scheme 'B') indicates a suitable end-bearing stratum for pile foundations at Elev. 550 (50 feet below the ground surface). Borehole No. 5 (Scheme 'A') was terminated at Elev. 538.5 (96.5 feet below the ground surface). No suitable end-bearing stratum was encountered at the location of B.H. No. 5 to this elevation. Therefore, for Scheme 'B', shorter piles (50.0 feet in length) will be required to support the structure. Thus, foundation costs for Scheme 'B' are anticipated to be less than those applying to Scheme "A'.

2. The east bank in the vicinity of Garden River Crossing for Scheme 'A' exhibits signs of extensive erosion on the slopes due to surface runoff. Thus, special measures will be required to insure stability of the bank due to erosion, if Scheme 'A' is adopted.

3. Comparing the existing and proposed profile grades of both schemes, Scheme 'B' would require less embankment heights and depths of cuts.

4. Settlement would probably be greater and long-term in nature in the old river valley area of Scheme 'A', due to the presence of the underlying clay to silty clay stratum. Settlements in Scheme 'B' will take place during and immediately after construction. Thus, maintenance costs for Scheme 'B' will be lesser than Scheme 'A'.

5. MISCELLANEOUS

The various recommendations outlinedin this report are for feasibility purposes based on limited amount of field work. It will be necessary to carry out a detailed investigation when the final design details are available. Recommendations given in this report are, therefore,

to be regarded as conditional only, and as such, are subject to revision at a later date.

The field investigation was carried out during the period of October 1, 1975, to October 9, 1975, under the supervision of Mr. H. Shah, Project Engineer.

The drilling equipment used was owned and operated by Atcost Drilling Co., Concord, Ontario.

This report was prepared by Mr. H. Shah, and was reviewed by Mr. M. Devata, Supervising Engineer.

H. Shah

H. Shah,
Project Engineer.

M. Devata

M. Devata,
Supervising Engineer.

November, 1975

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

WP 903-72-18 LOCATION Co-ords. 916,885 N; 962,628 E. Scheme 'A' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 1 & 2, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
585.0	Ground Level					
0.0	Topsoil					
	Sand - fine to very fine.		1	SS	5	
			2	SS	4	
	some gravel		3	SS	6	
			4	SS	6	
			5	SS	5	
	Loose / Compact		6	SS	7	
			7	SS	12	
552.0			8	SS	16	
33.0	Silty clay to clay.		9	SS	11	
	Very Stiff		10	SS	12	
540.5						
44.5	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

400 800 1200 1600 2000

LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W (W_P — W — W_L)

WATER CONTENT %

UNIT WEIGHT γ

REMARKS

% GR SA SI CL

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

WP 903-72-18 LOCATION Co-ords. 917,277 N; 961,942 E. Scheme 'A' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 3 & 4, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w)	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
584.5	Ground Level						20 40 60 80 100 / 400 800 1200 1600 2000	w_P w w_L / WATER CONTENT %		
0.0	Topsoil					▼				
	Sand, trace to some gravel		1	SS	2	580				
	V.Loose / Loose		2	SS	4					
	trace of organics in the upper 7 ft.		3	SS	21	*				*Coarse gravel obstructed the advancement of the spoon in sample No.3, thus its blows/ft. count is considered non-representative.
567.0			4	SS	6	570				
17.5	Silty clay to clay, occasional thin layers of sand		5	SS	4		+ s10.7			
							+s3.0			
			6	TW	PH	560	+s5.6			
							+ s3.4			
			7	TW	PH					
	some pockets & thin layers of silt		8	SS	6	550	+ s5.6			
			9	SS	4		+ s6			
	Firm to Stiff						+ s3.2			
			10	SS	4	540	+ s4.7			
535.0							+ s3.2			
49.5	End of Borehole					530				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

WP 903-72-18 LOCATION Co-ords. 916,805 N; 963,978 E. Scheme 'B' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 6, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 400 800 1200 1600 2000)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
600.0	Ground Level									
0.0	Topsoil									
	Sandy silt		1	SS	3					
595.0	Very Loose									
5.0	Sand - Fine to Medium		2	SS	82	*				
	Trace to some gravel.		3	SS	7	590				
	Loose		4	SS	4					
			5	SS	6	580	+ s3.2			
	silty clay to clay - Stiff		6	SS	9					
567.5			7	SS	8	570				
32.5	Sand with gravel		8	SS	50					
	Dense to Very Dense									
558.5			9	SS	100/10"	560				
41.5	End of Borehole					550				

Note: Three attempts were made to set up the borehole, in order to avoid cobbles and/or boulders which are present in th upper 5 ft. of the granular deposit.

* Coarse gravel obstructed the advancement of the spoon in sample No.2, thus its blows/foot count is considered non-representative.

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

WP 903-72-18 LOCATION Co-ords. 917,138 N; 963,340 E. Scheme 'B' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 7, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE 3¼" Hollow Stem Augers CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (400 800 1200 1600 2000)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
635.0	Ground Level									
0.0	sand, trace of gravel									
	Loose		1	SS	5					
	Compact		2	SS	18	630				
			3	SS	14					
619.7										
15.3 / 617.0	Silty clay to clay Firm		4	SS	4	620	+			
18.0	Sandy gravel with									
613.0	cobbles. Dense		5	SS	100 *					
22.0	End of Borehole					610				B.H. Dry
	Refusal to augering probable boulders.									

* Coarse gravel obstructed the advancement of the spoon in sample No.5, thus its blows/foot count is considered non-representative

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

WP 903-72-18 LOCATION Co-ords. 915,822 N; 964,467 E. Scheme 'A' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 8 & 9, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE 3¼" Hollow Stem Augers CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
635.0	Ground Level									
	topsoil									
	Sand - fine to very fine. Loose		1	SS	10					
			2	SS	7	630				
			3	SS	5					During sampling water was first encountered at about 622.3 where the B H also caved in after the removal of the augers.
620.0						620				
15.0	Silty Sand Very Loose		4	SS	2					
			5	SS	2					
			6	SS	2	610				
	org.silt, some wood chips V. Loose		7	SS	4					
594.5	Loose to Compact		8	SS	11	600				
40.5	Sand - fine to very fine some gravel		9	SS	15					
			10	SS	31	590				
	Loose to Compact		11	SS	7					
			12	SS	5	580				
			13	SS	8					
			14	SS	9	570				
			15	SS	16					
	(some pockets and layers of silty clay to clay encountered below El.575)					560				
538.5			16	SS	12	550				
96.5	End of Borehole					540				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

FF-A-24 (c) (Rev. Jan 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' = STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS : -

CONSISTENCY	c LB./SQ.FT.
VERY SOFT	0 - 250
SOFT	250 - 500
FIRM	500 - 1000
STIFF	1000 - 2000
VERY STIFF	2000 - 4000
HARD	> 4000

DENSENESS	'N' BLOWS / FT.
VERY LOOSE	0 - 4
LOOSE	4 - 10
COMPACT	10 - 30
DENSE	30 - 50
VERY DENSE	> 50

TERMS TO BE USED IN DESCRIBING SOILS :-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

FF-A-24(b) (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta \sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

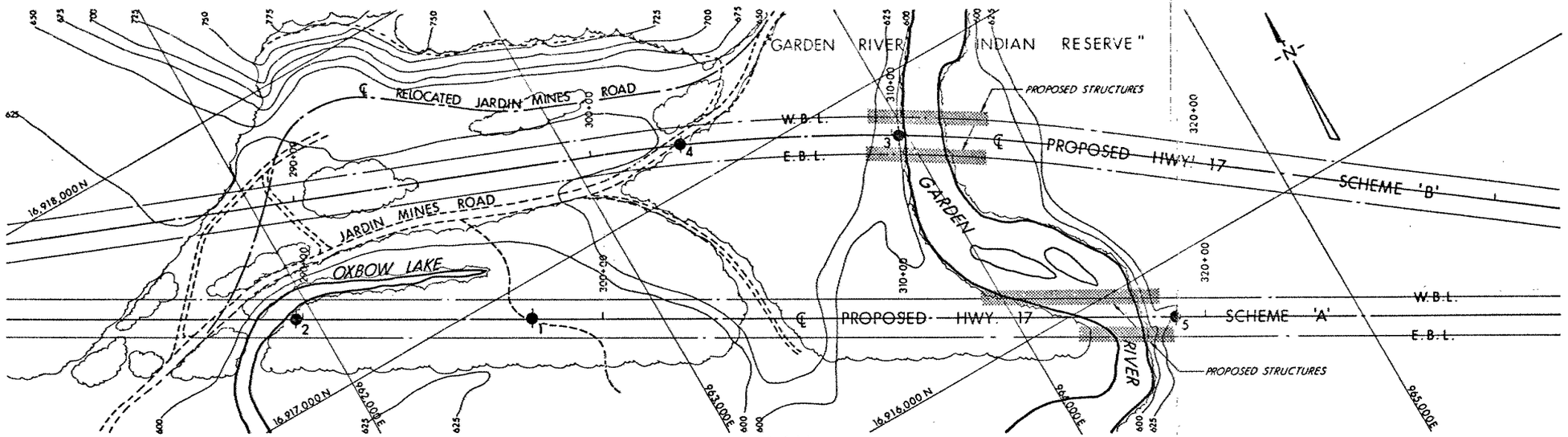
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

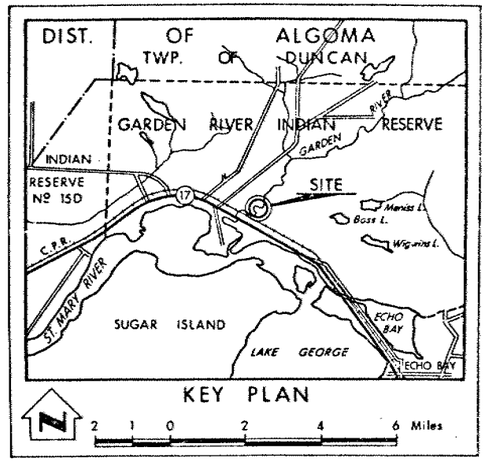
FOUNDATIONS

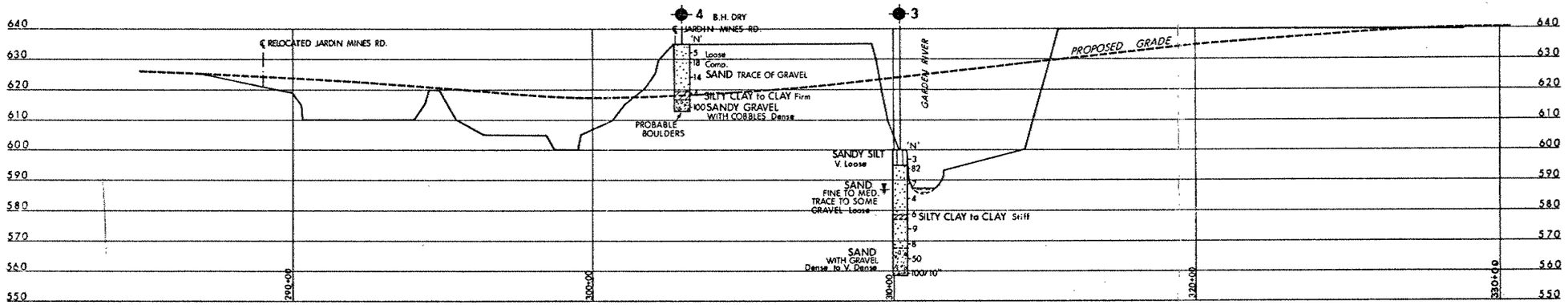
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

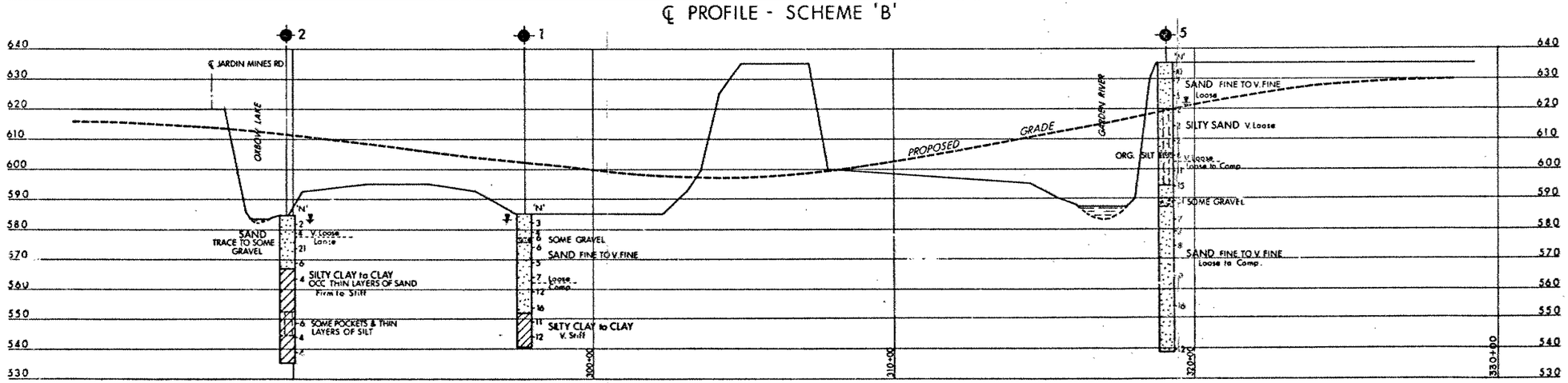
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL









LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test B/F CONE - Blows/Ft Cone Test (350 ft. lbs. energy/blow)
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. OCT. 1975

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	585·0	916,885	962,628
2	584·5	917,277	961,942
3	600·0	916,805	963,978
4	635·0	917,138	963,340
5	635·0	915,822	964,467

— 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

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

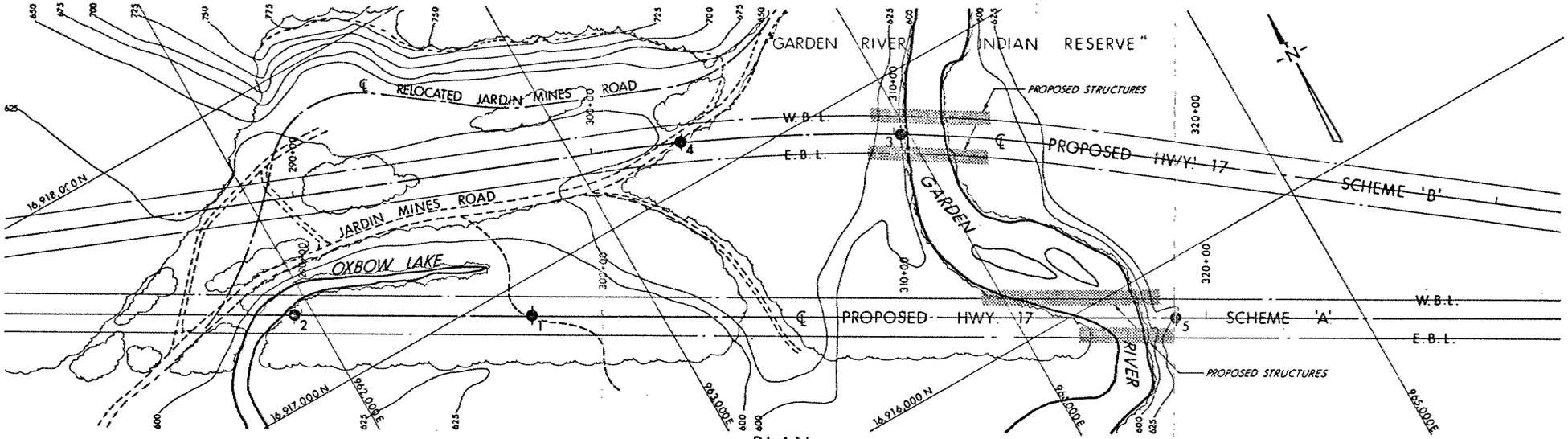
PRELIMINARY INVESTIGATION
FEASIBILITY STUDY

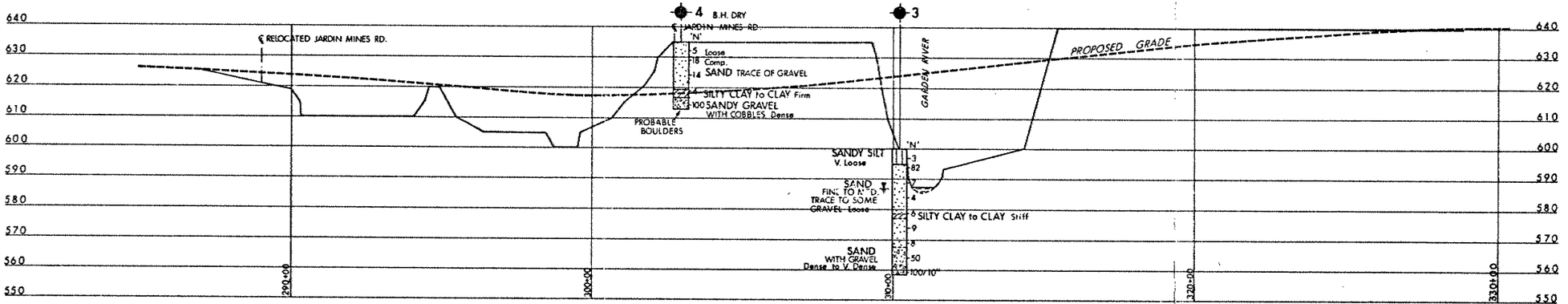
HWY. 17 & GARDEN RIVER INDIAN RESERVE

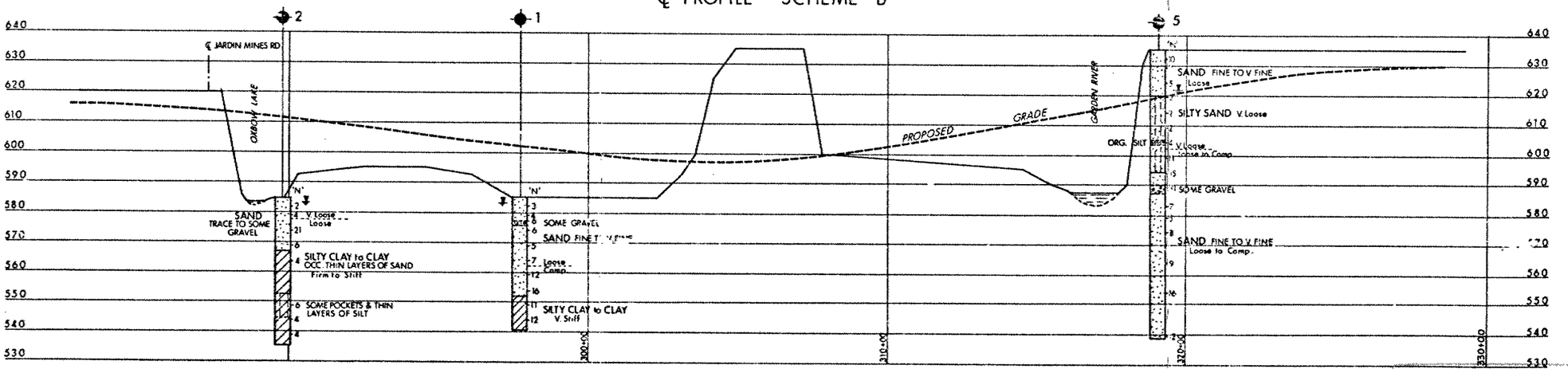
HIGHWAY NO 17 DIST NO 18
~~co~~ DIST. OF ALGOMA GARDEN RIVER INDIAN RESERVE
TWP LOT CON

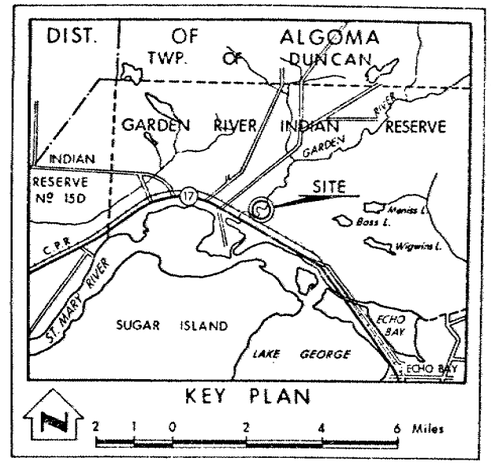
BORE HOLE LOCATIONS & SOIL STRATA

SUBMD H.S.	CHECKED	W.P. NO 903-72-18	DRAWING NO 9037218-A
DRAWN S.O.	CHECKED	W.O. NO	
DATE 16 OCT. 1975		SITE NO	BRIDGE DRAWING NO
APPROVED		CONT NO	









LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test B/F CONE - Blows/Ft. Cone Test (350 ft lbs. energy/blow)
- Bore Hole & Cone Test
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5	635·0	915,822	964,467

— 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

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

PRELIMINARY INVESTIGATION
FEASIBILITY STUDY

HWY. 17 & GARDEN RIVER INDIAN RESERVE

HIGHWAY NO 17 DIST NO 18
~~CO~~ DIST. OF ALGOMA GARDEN RIVER INDIAN RESERVE
TWP LOT CON

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD H.S.	CHECKED	W.P. NO 903-72-18	DRAWING NO 9037218-A
DRAWN S.O.	CHECKED	W.O. NO	
DATE 16 OCT. 1975		SITE NO	BRIDGE DRAWING NO
APPROVED		CONT NO	

41K - 36
CASCADES No.

Ontario Ministry of Transportation and Communications

Memorandum

To: Mr. W. L. Lees
Manager, Systems Design
Northwestern Region
Thunder Bay, Ontario

From: Soil Mechanics Section
Geotechnical Office
West Building, Downsview

Attention:

Date: May 7, 1975

MAY - 9 1975

Our File Ref. W.P. 903-72-01

In Reply to

Subject:

ADDENDUM

PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Feasibility Study of T.C. Hwy. No. 17 (Proposed 4 Lanes)
from Echo River to Bar River Road
W.P. 903-72-01, District No. 18 (Sault Ste. Marie)

PART I

Proposed CPR Overhead at Hwy. No. 17
(Lines A, B, C, D, 4 & 5)

We have carried out a foundation investigation at the proposed crossing of the CPR tracks and Hwy. 17, Lines 4 and 5, as requested by Mr. W. D. Neilipovitz, Regional Director, Northwestern Region. We are forwarding to you a report containing the subsoil description and the recommendations which are based on the information from the field. No laboratory tests have been carried out to determine the engineering properties of the subsoil. However, in our opinion, the data contained in this Report will be adequate for your evaluation with regard to feasibility study of this project.

It should be noted that the recommendations given in this Report are of a preliminary nature. A complete foundation investigation will be necessary once the alignment and geometrics are finalized.

for: M. DEVATA
Supervising Engineer.

c.c. W. D. Neilipovitz
B. R. Davis
B. McKenna
G. E. French
B. J. Giroux
R. Morgenroth
G. A. Wrong
R. Hore
McCormick Rankin & Associates Ltd.
Attn: Mr. John Sutherns

Files
Record Services

ADDENDUM

PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Feasibility Study of T.C. Hwy. No. 17 (Proposed 4 Lanes)
from Echo River to Bar River Road
W.P. 903-72-01, District No. 18 (Sault Ste. Marie)

PART I

Proposed CPR Overhead at Hwy. No. 17 (Schemes 4 & 5)

INTRODUCTION

The Soil Mechanics Section completed a foundation investigation for the proposed crossing of CPR track and Highway 17 (Lines A, B, C & D), and the findings were summarized in a report dated March 5, 1975. Subsequently, a meeting was held in the MTC Northwestern Regional Office, Thunder Bay to review progress on the preliminary design study. At the above meeting, three alternative types of crossings were discussed:

1. An overhead on existing CPR alignment (cost $5.8 million);
2. An overhead on relocated CPR alignment (cost $2.8 million);
3. A subway on existing CPR alignment (cost $2.2 million)

The Regional Director requested this Section to undertake the field investigation of two further alignments; one about 2500 ft. north (Line 4) and the other about 900 ft. south-east (Line 5), of the original proposal. A field investigation was carried out and the findings were transmitted to the Consultant over the telephone.

This Report contains a brief description of the subsoil conditions and our preliminary comments regarding the suitability of the alignment, the structure foundations and the stability of the approach embankments.

SUBSOIL CONDITIONS

The additional fieldwork at the two proposed crossings consisted or ten boreholes (No. 10 to 19). One borehole (No. 9) which was put down along Lines A, B, C & D, at the foot of the hill, is also included. The stratigraphy and the results of in situ tests are shown on the Record of Borehole sheets attached herewith. The locations of boreholes are shown on the accompanying plan.

Line 4 (Boreholes 10 & 11)

The subsoil conditions encountered in both boreholes are briefly as follows:

Borehole No. 10 (Ground Elev. 614 ft.)	Borehole No. 11 (Ground Elev. 615 ft.)	
0 - 4.5 ft.	0 - 11 ft.	Silty sand to sand.
4.5 - 11		Organic clay, very soft.
	11 - 15.5	Clayey silt, soft to firm.
11 - 140	15.5 - 138	Silty clay to clay, soft to stiff.
140 -	138 -	Sand and gravel.
143	140	End of borehole.

The in situ vane tests indicate that the undrained shear strength of the silty clay to clay stratum gradually increases with depth and varies from 400 p.s.f. in the upper position to about 1000 p.s.f. at a depth of about 100 ft.

Line 5 (Boreholes 12 to 19)

Boreholes 12 to 17 were carried out in the vicinity of the proposed crossing. Boreholes 18 and 19 were put down for investigating the stability of the embankment (400 to 1000 ft.) south of Maple Leaf Road.

Subsoil in Boreholes 12 to 17 consists of a 16.5 to 40 ft. thick deposit of silty sand to sand overlying a sand and gravel with cobbles stratum. The Boreholes were terminated at depths varying from 26.5 ft. to 47.0 ft., when refusal to augering was met.

In Borehole 14, which was put down in a ploughed field, the uppermost 9 ft. consisted of topsoil and firm clay overlying silty sand to sand. The relative density of the silty sand to sand deposit ranges from very loose to dense, but is in general very loose to loose. The relative density of the sand and gravel deposit is generally compact to very dense.

In Boreholes 18 and 19, the upper 19 to 37 ft. consists of soft to firm silty clay to clay, followed by loose to very loose silty sand to sand. The thickness of the silty clay to clay stratum increases in a southerly direction, i.e. away from the hill. The in situ vane tests indicate that the undrained shear strength of the silty clay to clay ranges from 400 to 600 p.s.f., generally in the order of 400 p.s.f.

DISCUSSION AND RECOMMENDATIONS

Line 4

The original investigation at the crossing of Hwy. 17 (Lines A, B, C & D) and the CPR tracks revealed that the soft to firm silty clay to clay deposit is the predominant soil type in this area. The thickness of this deposit at the crossing of Lines A, B, C & D is in the order of 60 ft., while at the crossing of Line 4, it is in the order of 140 ft. The shear strength pattern at both crossings are essentially similar. Therefore, the recommendations contained in our Report of March 5, 1975 regarding the stability and settlement considerations of approach embankments and the structure foundations, are applicable to Line 4 crossing with the following modifications:

The recommendations with respect to the stability of embankments remain unaltered. In other words, the safe embankment height with 2:1 side slopes is about 14 ft., if locally available material (γ = 125 p.c.f.) is used, and 20 ft. if light weight material (γ = 90 p.c.f.) is used for the fills. Embankments higher than the above heights will require counter-balancing berms as explained in the original Report. The length of berms will depend upon the height of embankment.

The thickness of the compressible silty clay to clay deposit at the crossing of Hwy. 17, Line 4 and the CPR tracks, is about 140 ft., while at the crossing of Lines A, B, C & D, and the CPR tracks it is only 60 ft. As a result, under the same height of fill, the long term consolidation settlements along Line 4 will be even greater than the settlements along Lines A, B, C & D. It was estimated that along Lines A, B, C & D, a 30 ft. high embankment constructed with locally available material, which will require double counter-balancing berms, each 60 ft. long, will settle in the order of 6 ft. It is estimated that a similar embankment (30 ft. high) along Line 4 will settle in the order of 7 ft.

It will be necessary to excavate the very soft organic clay, which was found on the west side of the CPR tracks (Borehole 10), to its full depth (11 ft.) within the plan limits of the approach embankment, and replace it with suitable material.

Because of the soft and compressible subsoil at this location, spread footing type foundations in the original ground are not recommended. The entire structure may be supported on end-bearing steel piles driven to refusal. It is estimated that refusal will be achieved at about 150 ft. (vs. 70 ft. for Lines A, B, C & D) below the ground level.

The negative frictional forces exerted on the piles will be greater at Line 4 because of the greater depth of compressible stratum at this site. Therefore, the piles will have to be designed with a correspondingly lower load carrying capacity.

Furthermore, the abutments founded on long end-bearing piles driven through such deep, soft and compressible deposit have a tendency to undergo rotational movements.

Line 5

At the proposed crossing of the CPR tracks and Hwy. 17, Line 5, the subsoil consists of a very loose to loose silty sand to sand stratum underlain by a compact to very dense sand and gravel with cobbles deposit. A cohesive stratum does not exist at this site. Therefore, no stability problems are anticipated for embankments constructed with 2:1 slopes. Because the underlying subsoil is of a

non-cohesive nature, the settlements under the embankments will be elastic and will occur instantaneously as the construction proceeds.

The silty sand to sand deposit is very loose to loose. Therefore, spread footing type foundations in the original ground are not recommended. It is recommended that the entire structure be supported on end-bearing steel piles driven in the sand and gravel stratum. It is estimated that the maximum allowable loads will be achieved at approximate elevation 570 ft., i.e. about 50 ft. below the ground level.

A soft to firm silty clay to clay deposit was found south of the Maple Leaf Road. This stratum is cohesive and compressible in nature. An embankment constructed in this area will undergo long term consolidation settlements. The thickness of this stratum increases in a southerly direction. However, it is anticipated that the height of embankment decreases in a southerly direction. Because of the above reasons, the settlements along Line 5 will be much smaller than along Lines A, B, C & D.

CONCLUSIONS

A comparison of subsoil conditions along Lines A, B, C, D, 4 and 5, indicates that the cohesive stratum does not exist in the vicinity of the proposed crossing of the CPR tracks and Hwy. 17, Line 5. The problems associated with the approach embankments, namely, long counter-balancing berms and several feet of long term consolidation settlements, which are present along Lines A, B, C, D and 4, are not present at the proposed crossing of Line 5. Therefore, Line 5 is preferable to all other Lines in this area, from a soil mechanics point of view.

A. PRAKASH
Senior Engineer.

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 9

W.P. 903-72-01 LOCATION CPR & HWY. 17 (AS SHOWN ON PLAN) ORIGINATED BY C.McP

DIST. 18 HWY. 17 BORING DATE MARCH 22, 1975 COMPILED BY C.McK.

DATUM GEODETIC BOREHOLE TYPE AUGER AND SAMPLE WITH CME 55 MACHINE CHECKED BY

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.
620.0	GROUND LEVEL					
	Topsoil		1	SS	8	
	Clay, some sand					
615.0	V. Stiff		2	SS	13	
5.0	Silty Clay to clay		3	SS	5	
	V. Stiff					
	Soft to Firm		4	TW	PH	
			5	SS	2	
			6	TW	PH	
			7	SS	1/18"	
			8	TW	PH	
			9	SS	1/18"	
581.5						
38.5	Sand & Gravel		10	SS	27	
	Compact to V.Dense					
568.5			11	SS	100/3.5"	
51.5	End of Borehole					
	Refusal					

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

610 600 590 580 570 560

End of Cone Test

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P w w_L
WATER CONTENT %

UNIT WEIGHT γ

REMARKS
% GR SA SI

20
15 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] No 10

W.P. 903-72-01 LOCATION HWY. 17 & CPR (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 23-24, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM - 2 3/4" CHECKED BY [redacted]

ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.
614.0	GROUND LEVEL					
0.0	Topsoil					
609.5	Silty Sand Very Loose		1	SS	2	
4.5	Organic Clay, Occ. silty sand layers		2	SS	3	
603.0	Very Soft		3	SS	10	
11.0	Silty Clay to Clay — Stiff / Soft		4	SS	1/18"	
			5	TW	PM	
			6	SS	1/18"	
			7	SS	1/18"	
			8	SS	2/18"	
	Firm		9	TW	PM	
			10	SS	2	
			11	SS	1	
	Stiff		12	SS	2	
			13	SS	4	
514.0						
100.0	continued....					

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P W W_L
WATER CONTENT %

UNIT WEIGHT γ

REMARKS
% GR SA SI

+S=2
+S=4.2
+S=2.8
+S=4
+S=4.0
+S=4.8
+S=4.5
+S=3.9
+S=4.2
+S=4.0
+S=1.8
+S=3.2
+S=4.3
+S=4.3
+S=2.8
+S=2.5
+S=3.0
+S=2.8
+S=2.5
+S=2.6
+S=2.8
+S=2.7

610 600 590 580 570 560 550 540 530 520

15 20 10 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] Nº 11

W.P. 903-72-01 LOCATION HWY. 17 & C.P.R. (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 25, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM -2 3/4" CHECKED BY [illegible]

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMA
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV.	20 40 60 80 100 — SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE — 400 800 1200 1600 2000	w_P — w — w_L — WATER CONTENT %	γ	% GR SA
615.0	GROUND LEVEL									
0.0	Topsoil		1	SS	11					
	Silty Sand to Sand		2	SS	8					
	Loose to Compact		3	SS	11					
604.0			4	SS	13					
11.0	Clayey Silt — Soft — Firm		5	SS	1		+S=2.5			
599.5							+ S=2.3			
15.5	Silty Clay to Clay		6	TW	PM					
			7	TW	PM		+ S=6.2 + S=4.9			
			8	TW	PM		+ S=6.3 + S=5.3			
			9	SS	2/18"		+ S=6.0 + S=4.0			
			10	TW	PM		+ S=5.9 + S=4.0 + S=4.9 + S=7.3 + S=3.4			
	Firm — Stiff		11	TW	PM					
			12	SS	4		+S=3.7 +S=3.4			
							+S=2.3 +S=2.3			
							+S=2.3 +S=2.0			
515.0										
100.0	continued									

15 20 10 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH — TECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 12

W.P. 903-72-01 LOCATION HWY. 17 & C.P.R. (AS SHOWN [illegible] PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 26, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM - 2 3/4" CHECKED BY [illegible]

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.
617.0	GROUND LEVEL					
0.0	Topsoil					
	Silty Sand to Sand Very loose to loose		1	SS	10	
			2	SS	4	
			3	SS	2	610
			4	SS	4	
			5	SS	2	
			6	SS	6	600
596.0						
21.0	Sand & Gravel compact to v.dense		7	SS	11	
			8	SS	71	
	with cobbles					590
			9	SS	100/ 6"	
	and few boulders		10	SS	76/ 3"	
						580
			11	SS	200/ 3"	
570.0						570
47.0	End of Borehole Refusal to Augering probable boulder					560

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT —— W_L
PLASTIC LIMIT —— W_P
WATER CONTENT —— W
W_P W W_L
WATER CONTENT %

UNIT WEIGHT γ

REMAR
% GR SA SI

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] No 13

W.P. 903-72-01 LOCATION HWY. 17 & C.P.R. (AS SHOWN ON PLAN) ORIGINATED BY HS

DIST. 18 HWY. 17 BORING DATE APRIL 28, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY [redacted]

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w	UNIT WEIGHT	REMAR
ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	ELEV.	20 40 60 80 100 SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 400 800 1200 1600 2000	w_P — w — w_L WATER CONTENT %	γ	% GR. SA. SI
615.0	GROUND LEVEL									
0.0	Topsoil		1	SS	10					
	Silty Sand to Sand		2	SS	2/18"	610				
	Very Loose to loose		3	SS	4					
						600				
			4	SS	4					
590.5			5	SS	4					
24.5	Sand & Gravel Compact to V. Dense with cobbles		6	SS	12	590				
			7	SS	96					
579.5			8	SS	180/6"	580				
35.5	End of Borehole Refusal to Augering Probable Boulder					570				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] Nº 14

W.P. 903-72-01 LOCATION HWY. 17 & CPR (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 28, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY [redacted]

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.
616.0	GROUND LEVEL					
0.0 / 613.0	Topsoil					
3.0 / 617.0	Clay, Trace of Sand Firm		1	SS	7	610
			2	SS	2	
9.0 / 592.0	Silty Sand to Sand Very Loose		3	SS	2	
			4	SS	4	600
24.0 / 583.5	Sand and Gravel with cobbles V. Loose / V. Dense		5	SS	2	590
			6	SS	69	
32.5	End of Borehole Refusal to Augering Probable Boulder					580

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

+S=8.0
+S=5.9

LIQUID LIMIT W_L
PLASTIC LIMIT W_P
WATER CONTENT W
W_P — W — W_L
WATER CONTENT %

UNIT WEIGHT γ

REMARKS
% GR SA SI

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] No 15

W.P. 903-72-01 LOCATION HWY. 17 & CPR (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 28, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY [redacted]

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR. SA. SI
ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	ELEV.				
617.0	GROUND LEVEL									
0.0	Topsoil									
	Silty Sand to Sand V. Loose to Compact		1	SS	12					
			2	SS	4					
			3	SS	3	610				
			4	SS	3	600				
591.0										
26.0	Sand and Gravel		5	SS	100					
588.5	with cobbles V. Dense					590				
28.5	End of Borehole Refusal to Augering Probable Boulder					580				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREH[redacted] Nº 16

W.P. 903-72-01 LOCATION HWY. 17 & C.P.R. (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 28-29, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2-3/4" CHECKED BY [illegible]

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) / WATER CONTENT %	UNIT WEIGHT γ	REMA % GR SA
618.0	GROUND LEVEL									
0.0	Topsoil									
	Silty Sand to Sand Very Loose		1	SS	4					
			2	SS	3	610				
601.5										
16.5	Sand & Gravel With cobbles Compact to V. Dense		3	SS	19	600				
			4	SS	140/4"					
589.0						590				
29.0	End of Borehole Refusal to Augering Probable Boulder					580				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE [redacted] Nº 17

W.P. 903-72-01 LOCATION HWY. 17 & C.P.R. (AS SHOWN ON PLAN) ORIGINATED BY [redacted]

DIST. 18 HWY. 17 BORING DATE APRIL 29, 1975 COMPILED BY HS

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY [redacted]

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT		UNIT WEIGHT	REMA
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV.	20 40 60 80 100	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	γ	% GR. SA. S
623.0	GROUND LEVEL						SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE	WATER CONTENT %		
0.0	Topsoil									
	Sand, Some gravel		1	SS	31	620				
			2	SS	17					
613.5	Compact to Dense		3	SS	34					
9.5	Silty Sand to Sand, Some Gravel Loose to Compact		4	SS	15	610				
			5	SS	10					
			6	SS	12	600				
			7	SS	6					
			8	SS	10					
	Cobbles					590				
593.0										
40.0	End of Borehole Refusal to Auger probable boulder					580				

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREH[redacted] Nº 18

W.P. 903-72-01 LOCATION ECHO BAY (AS SHOWN ON PLAN) ORIGINATED BY H.S.

DIST. 18 HWY. 17 BORING DATE APRIL 29, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY [illegible]

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / GR SA S
615.0	GROUND LEVEL						20 40 60 80 100 / 400 800 1200 1600 2000	w_P w w_L		%
0.0 / 612.0	Topsoil									
3.0	Silty Clay to Clay — Soft — Firm		1	SS	2	610	+S=3.5			
			2	SS	1		+ S=2.4 +S=2.6			
			3	TW	PM		+S=7.5 +S=6.2			
596.0			4	SS	2	600	+S=5.7			
19.0	Silty Sand to Sand Very Loose		5	SS	4					W.L. not establis
			6	SS	4	590				
581.8			7	SS	2					
33.2	End of Borehole Refusal to Augering Probable Boulder		8	SS	140/1"	580				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 19

W.P. 903-72-01 LOCATION ECHO BAY (AS SHOWN ON PLAN) ORIGINATED BY H.S.

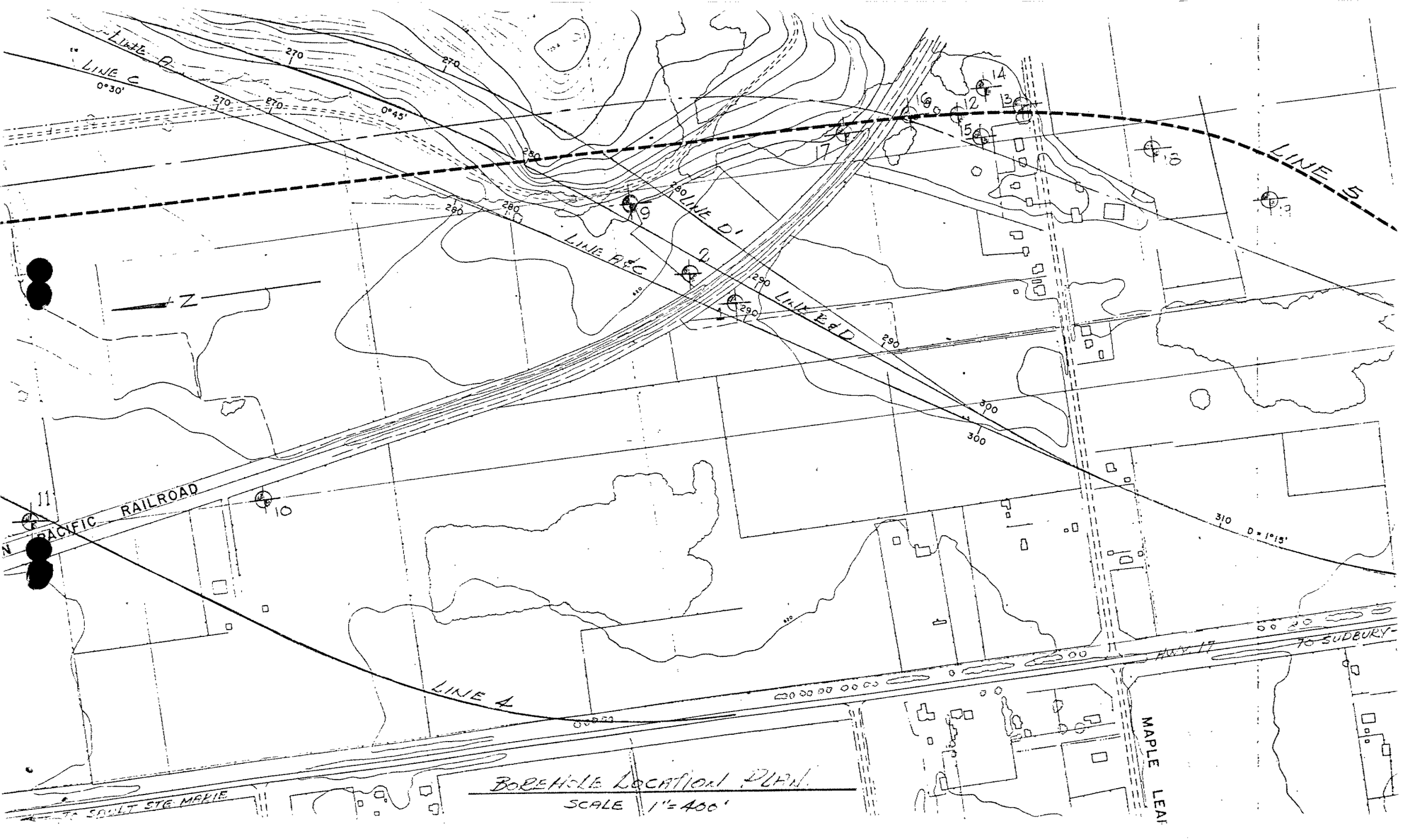
DIST. 18 HWY. 17 BORING DATE APRIL 29, 1975 COMPILED BY H.S.

DATUM GEODETIC BOREHOLE TYPE HOLLOW STEM AUGERS - 2 3/4" CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH P.S.F. (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_p / WATER CONTENT w / WATER CONTENT %	UNIT WEIGHT γ	REMARKS
615.0	GROUND LEVEL						20 40 60 80 100 / 400 800 1200 1600 2000			
0.0	Topsoil									
	Silty Clay to Clay		1	SS	2	610	+S=13.5			
			2	SS	1/18"		+S=13.3, +S=3.7, +S=4.0, +S=2.4			
			3	SS	1/18"	600	+S=6.9, +S=4.5			
			4	SS	1/18"		+S=3.3, +S=4.0			
	Soft / Firm		5	SS	2/18"	590	+S=8.5, +S=5.1			W.L. not established
578.0			6	SS	3	580				
37.0	Sand, some gravel									
568.5	Loose		7	SS	6	570				
46.5	End of Borehole					560				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



BOREHOLE LOCATION PLAN
SCALE 1"=400'

Ministry of Transportation and Communications
Ontario

Memorandum

To: Mr. B. McKenna (2)
Regional Structural Planning Engr.
Northwestern Region
Thunder Bay, Ontario

From: Soil Mechanics Section
Geotechnical Office
Downsview, Ontario

Attention:

Date: March 5, 1975

Our File Ref. W.P. 903-72-01

In Reply to

MAR - 6 1975

Subject:

PRELIMINARY FOUNDATION INVESTIGATION REPORT
for Feasibility Study of
T.C. Hwy. No. 17 (Proposed 4 lanes)
from Echo River to Bar River Road
W.P. 903-72-01, Dist. 18 (Sault Ste. Marie)

PART I
Proposed CPR Overhead at Hwy. No. 17
(Line A, B, C & D)

Due to the urgency of this project we are forwarding to you a report containing the subsoil description and the recommendations which are based on the information from the field, transmitted by telephone. No laboratory tests have been carried out to determine the engineering properties of the subsoil. However, in our opinion, that data contained in this report will be adequate for your evaluation with regard to feasibility studies on this project. The field work for the other areas of this project is still in progress and we will be forwarding to you the preliminary data for the other sections upon completion of the field investigation.

It should be noted that the recommendations given in this report are of a preliminary nature. A complete foundation investigation will be necessary once the alignment and geometrics are finalized.

M. DEVATA
Supervising Engineer.

c.c. E. J. Orr
B. R. Davis
W. L. Lees
G. E. French
B. J. Giroux
R. Morgenroth
G. A. Wrong
P. Lewycky
McCormick Rankin & Associates Ltd., Attn: Mr. John Sutherns
Files
Record Services

PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Feasibility Study of T.C. Hwy. No. 17 (Proposed 4 Lanes)
from Echo River to Bar River Road
W.P. 903-72-01, Dist. No. 18 (Sault Ste. Marie)

PART I

Proposed CPR Overhead at Hwy. 17 (Line A, B, C & D)

1. INTRODUCTION

We have recently completed the field work for the feasibility study of the proposed CPR overhead at the new alignment of Hwy. 17. The site is located about 2 miles south of Echo Bay, 1300 ft. north of Maple Leaf Road and 1600 ft. east of the existing Hwy. 17. At this site, the CPR tracks are on a curve. The land on both sides of the tracks is flat, agricultural land. However, about 500 ft. north-east of the proposed crossing, the land gradually rises in the form of a hill to an ultimate height of 120 ft.

The field work consisted of two boreholes accompanied by dynamic cone penetration tests. Borehole No. 1 was put down about 100 ft. south-west, and Borehole No. 2 about 100 ft. north-east, of the CPR tracks, and between the two proposed lines at this crossing. (See Borehole Location Plan).

This report contains a brief description of the subsoil conditions, and our preliminary comments regarding the structure foundations and the stability of the approach embankments.

2. SUBSOIL CONDITIONS

The stratigraphical profile in the two boreholes and the results of in situ tests are shown on the Record of Borehole Sheets attached herewith.

The subsoil conditions encountered in both boreholes are similar and, briefly, are as follows:

Borehole No. 1 (Ground Elev. 617 ft.)	Borehole No. 2 (Ground Elev. 619 ft.)	
0 - 3 ft.	0 - 3 ft.	Topsoil and sandy silt
3 - 6 ft.	3 - 6 ft.	Clay to silty clay - desicated zone
6 - 61 ft.	6 - 59 ft.	Clay to silty clay - soft to firm
61 - 70 ft.	59 - 68 ft.	Silty fine sane to sandy silt
70 ft.	68 ft.	Refusal

The in situ vane tests indicate that the undrained shear strength of the clay to silty clay deposit gradually increases with depth and varies from 400 p.s.f. in the upper portion to about 1000 p.s.f. at the bottom of the deposit. The boreholes were terminated when refusal was met. No attempt was made to determine the type of deposit below this level.

It is estimated that ground water level is about 7 ft. below ground surface.

3. DISCUSSION AND RECOMMENDATIONS

(3.1) General

It is proposed to construct an overhead structure at the crossing of new Highway No. 17 (lines A, B, C or D) and the CPR tracks. The proposed grade of the Highway along any one of the alignments will require embankments with a maximum height of about 30 ft.

At this location, lines A & C merge together and lines B & D merge as another line. Because of the uniform subsoil conditions in this area, our recommendations will be equally applicable for all four alignments from the foundation point of view, provided that the grades for those alignments will be similar. Based on the subsoil information, no particular line has any significant preference over other lines; therefore, the final selection of the alignment at this crossing should be based on other considerations.

Our recommendations for the structure foundations and the approach embankments are given in the following subsections.

(3.2) Structure Foundations

Due to the following reasons, spread footing type foundations in the original ground are not recommended at this site:

(i) the shear strength of the clay to silty clay deposit is as low as 400 p.s.f. in the upper portion. This means a maximum allowable bearing capacity of 800 p.s.f. only, which is impractical;

(ii) the clay to silty clay stratum is very compressible and relatively deep (about 60 ft.). The footings will settle excessively in this material when subjected to loading.

It is recommended that the entire structure be supported on end-bearing steel piles driven to refusal. It is estimated that refusal will be achieved at approximate elevation 545, i.e. about 70 ft. below the ground level.

Perched abutments founded on spread footings placed in compacted granular fills are not recommended, because of excessive settlements of the fills. The footings placed in the fills will settle by the same amount as the fills themselves. The settlement aspect of the approach embankments is dealt with in paragraph (3.3.3).

(3.3) Approach Embankments

(3.3.1) General

The proposed grade of Highway No. 17 is such that it will require embankments up to 30 ft. in height. These fills will be underlain by 60 ft. of soft to firm compressible clay to silty clay (layered) stratum.

The presence of this compressible cohesive stratum, at a relatively shallow depth below ground surface, requires that steps must be taken to ensure the overall stability of the fill sections as well as limit the settlements to a tolerable magnitude.

(3.3.2) Stability Considerations

The critical condition for stability of an embankment on normally or slightly overconsolidated clays, as is the case with this clay stratum, generally occurs during or immediately after construction. This being the case, a total stress analysis ($\emptyset = 0$) provides a suitable means of assessing the stability of the fill sections. In this method of analysis, stability is governed by the applied loads and the stress-strain and undrained shear strength properties of the foundation and fill material.

Analyses have been carried out, therefore, in terms of total stresses, to determine the stability of the fill sections. The soil properties for the fill and natural subsoil, assumed for computation purposes, are as follows:

Fill Material - Granular Type

Bulk Density	γ = 125 p.c.f.
Angle of Shearing Resistance	$\emptyset = 30^{o}$
Slopes for the Fill	2:1

Subsoil

0 - 5 ft.	Cu = 1000 p.s.f.
5 - 18 ft.	Cu = 400 p.s.f.
18 - 48 ft.	Cu = 500 p.s.f.
48 - 58 ft.	Cu = 1000 p.s.f.

The results of the stability analyses carried, are summarized below: (See Fig. 1)

- for a fill height of 20 ft., a single mid-height berm of 50 ft. will be required.
- for a fill height of 30 ft., double berms, each approximately 60 ft. in width, should be incorporated into the design. These berms should be located at equi-distances along the slope (i.e. at the third points).

A smooth transition should be effected between the varying berm sections required along the relocation.

Based on the computations carried out, the following comments are presented:

(i) It may be advantageous to minimize the berm requirements by keeping the heights of fill as low as possible.

(ii) If lightweight fill, such as slag, is available from the local steel mill, consideration could be given to the utilization of such material for embankment construction.

Since the induced surcharge loading would be reduced, the stability computations carried out, indicate the following:

- Fills less than 20 ft. in height, may be constructed with standard 2:1 slopes.
- Fills 30 ft. in height would require a single mid-height berm 55 ft. in width.

In these computations it was assumed that the unit weight of the lightweight fill was 90 p.c.f.

In order to minimize the embankment heights and consequently the berm requirements and associated settlements, consideration should be given to a longer, multi-span structure over this area.

All the proposals discussed are feasible with respect to stability of the fills. The ultimate choice will, however, be based on economic considerations.

(3.3.3) Settlement Considerations

The underlying highly compressible cohesive stratum will undergo excessive settlements due to consolidation, over a long-term period, under the weight of the approach embankments. Settlements calculations were done using the results of the tests conducted, in the past, on similar soil in this general area.

The consolidation settlement, estimated for various heights of fill, are summarized in the following table:

Height of Fill	Fill Material	Berm Requirements	Estimated Settlement Consolidation Ft.	
30 ft.	Locally Available (γ = 125 p.c.f.)	Double - Ea. 60' in Width	3	- 4 yrs.
			6 (Max.)	- 25 yrs.
30 ft.	Lightweight (γ = 90 p.c.f.)	Single 50' in Width	2.5	- 4 yrs.
			5 (Max.)	- 25 yrs
20 ft.	Locally Available (γ = 125 p.c.f.)	Single 50' in Width	2.5	- 4 yrs.
			5 (Max.)	- 25 yrs.
20 ft.	Lightweight (γ = 90 p.c.f.)	Nil	1.5	- 4 yrs.
			3 (Max.)	- 25 yrs.
14 ft.	Locally Available (γ = 125 p.c.f.)	Nil	1.5	- 4 yrs.
			3	- 25 yrs.

It is considered that the estimated settlements may occur at a faster rate than that theoretically computed, because of the probable presence of the occasional permeable silt layers within the cohesive stratum, which would accelerate the drainage in the lateral direction. In view of this, it would, therefore, be advantageous to construct the embankments first and leave them in place for as long a period as possible, prior to constructing the structure.

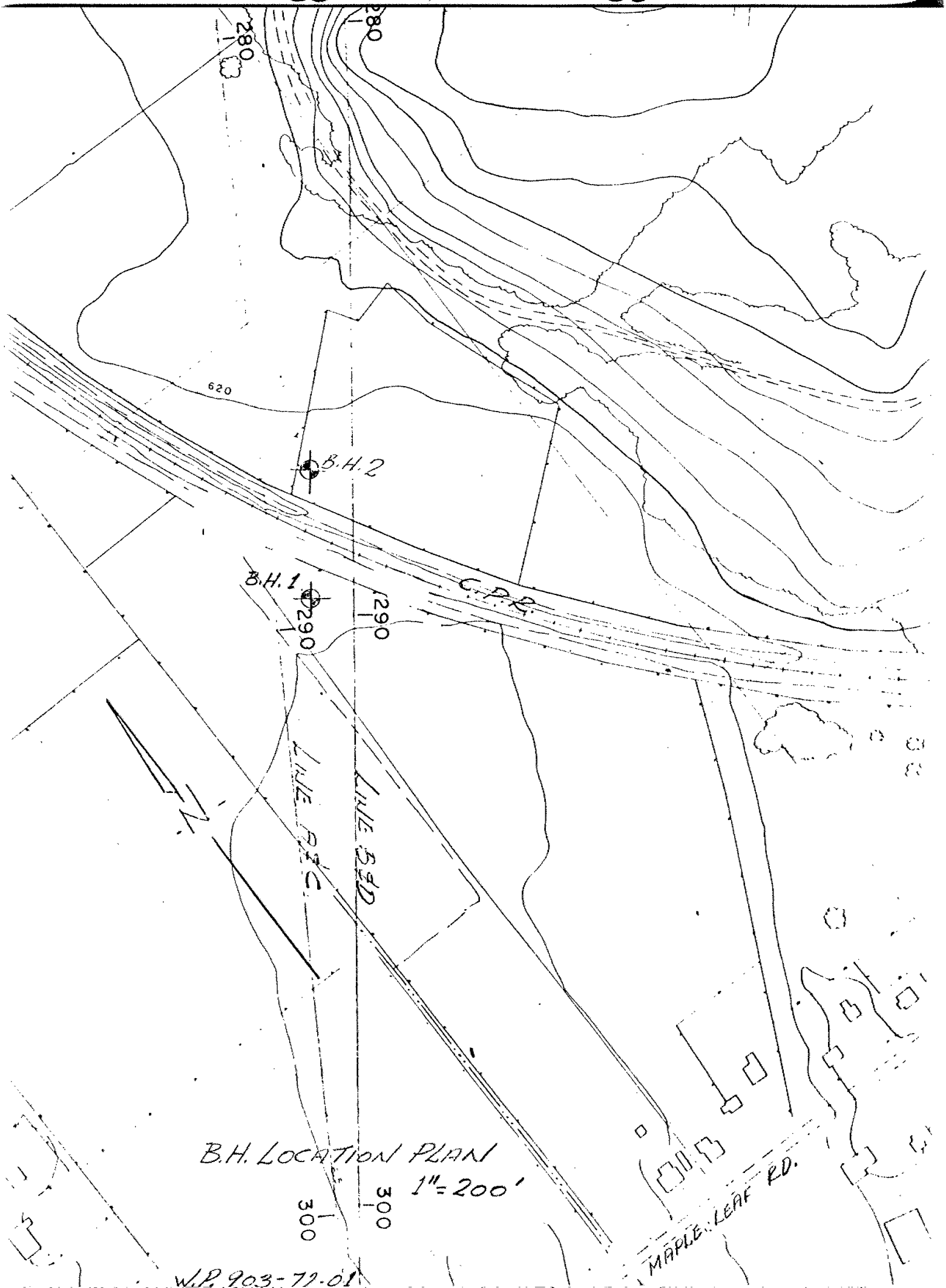
It should be noted that recommendations given above are only preliminary in nature, and it will be necessary to carry out a detailed foundation investigation when the final alignment and geometrics are known.

4. MISCELLANEOUS

The field work was carried out under the supervision of Mr. H. Shah, Project Engineer, during the period February 24 - 28, 1975, using the equipment owned and operated by Master Soil Investigation Ltd.

A. PRAKASH, P. Eng.
Senior Engineer.

March 5, 1975



B.H. LOCATION PLAN
1" = 200'

W.P. 903-72-01

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH - GEOTECHNICAL OFFICE - SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

W.P. 903-72-01 LOCATION Hwy. 17 & C.P.R. (As shown on Plan) ORIGINATED BY HS

DIST. 18 HWY. 17 BORING DATE Feb. 24 -26, 1975 COMPILED BY MM

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger & Cone Test CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV.
617.±	Ground Level					
0.0	Topsoil					
614.0	Sandy Silt					
3.0	Desiccated or Frozen		1	SS	2	▼610
			2	TW	PH	
			3	SS	1	600
	Soft Clay to Silty Clay		4	SS	1	
			5	SS	1	590
			6	SS	1	
			7	TW	PH	580
	Firm		8	SS	1	
			9	SS	1	570
			10	TW	PH	
556.0						560
61.0	Silty fine sand to sandy silt. Compact to Dense		11	SS	22	
			12	SS	29	550
547.2			13	SS	70	
69.8	End of Borehole Refusal					540

DYNAMIC CONE PENETRATION RESISTANCE PLOT

20 40 60 80 100

SHEAR STRENGTH

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL × LAB VANE

400 800 1200 1600 2000

End of Cone Test Refusal

LIQUID LIMIT w_L

PLASTIC LIMIT w_P

WATER CONTENT w

w_P w w_L

WATER CONTENT %

UNIT WEIGHT γ

REMARKS

% GR. SA. SI. CL

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

W.P. 903-72-01 LOCATION Hwy. 17 & C.P.R. (As shown on Plan) ORIGINATED BY HS

DIST. 18 HWY. 17 BORING DATE February 26-28, 1975 COMPILED BY MM

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger and Cone Test CHECKED BY [illegible]

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV.
619.±	Ground Level					
0.0	Topsoil					
616.0	Sandy Silt					
3.0	Desiccated or Frozen Firm		1	SS	4	
			2	SS	1	
	Soft		3	SS	1	
			4	TW	PH	
	Clay to Silty Clay		5	SS	1	
			6	SS	1	
	Firm		7	SS	1	
			8	TW	PH	
			9	SS	2	
			10	SS	3	
560.0						
59.0	Silty fine sand to sandy silt. Compact to Dense		11	SS	34	
551.3			12	SS	30	
67.7	End of Borehole Refusal					

DYNAMIC CONE PENETRATION RESISTANCE PLOT

20 40 60 80 100

SHEAR STRENGTH

○ UNCONFINED + FIELD VANE

● QUICK TRIAXIAL × LAB VANE

400 800 1200 1600 2000

610 600 590 580 570 560 550

End of Cone Test Refusal

LIQUID LIMIT —— w_L

PLASTIC LIMIT —— w_P

WATER CONTENT —— w

w_P w w_L

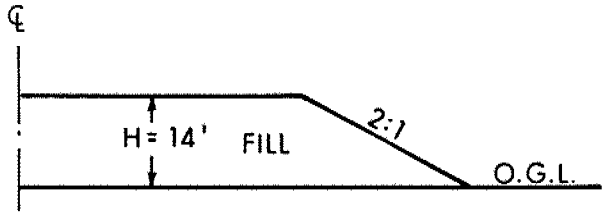
WATER CONTENT %

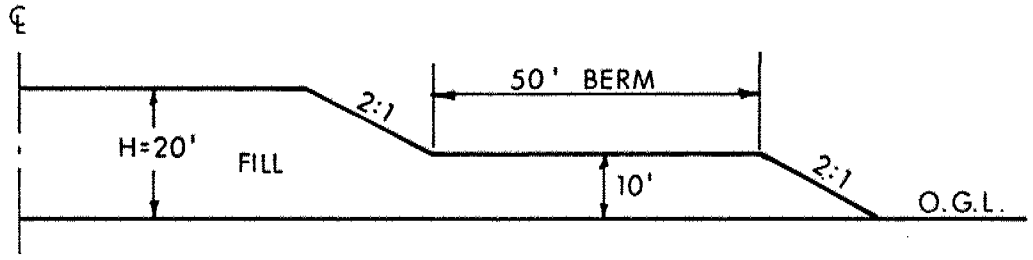
UNIT WEIGHT γ

REMARKS

% GR SA SI CL

20 15 ◇ 5 10 % STRAIN AT FAILURE





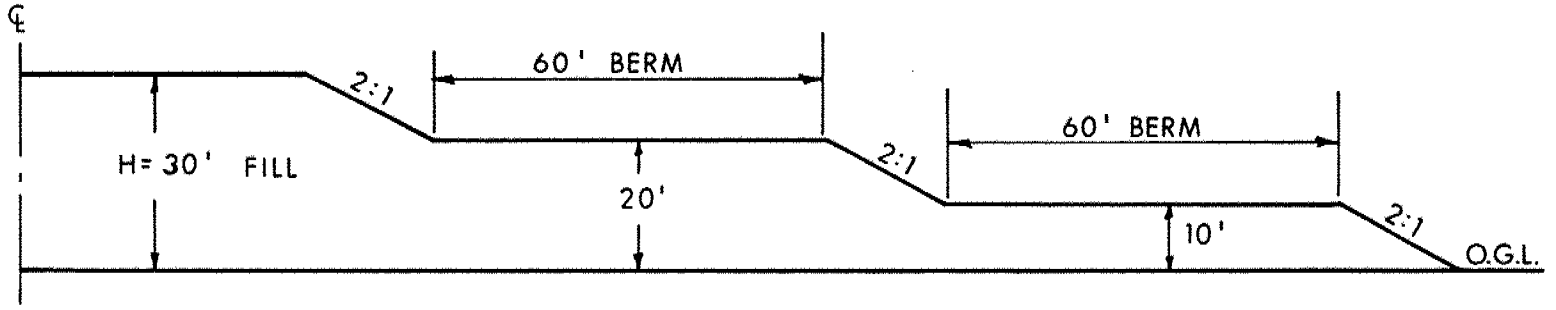


FIG. 1

W.P. 903-72-01

TCI490 04181433
TRA781
DNA

MR M DEVATA SOIL MECHANICS SECT APRIL 18/75 2:30 PM

RE: WP 903-72-01 HWY 17
ECHO RIVER TO BAR RIVER ROAD

FURTHER TO OUR TELEPHONE CONVERSATION OF TODAY REGARDING COMPACTED UNIT WEIGHT OF GRANULAR FILL, PLEASE BE ADVISED AS FOLLOWS:

MATERIAL IN LOCAL PITS VARIES FROM SAND WITH A COMPACTED UNIT WEIGHT OF 130 P.C.F. TO GRAVEL WITH A COMPACTED UNIT WEIGHT OF 145 P.C.F.

H MEYER M & T 233
KM

18 IV 1975 14:45

ELETYPE TELETYPE

WP 903-72-01

Ministry of Transportation and Communications
Ontario

Memorandum

To: Mr. C. Mirza, Head, Soils Mechanics Section, Downsview.

From: Manager, Regional Planning and Design Office, Northwestern Region.

Attention: Mr. M. Devata.

Date: April 2, 1975.

Our File Ref.

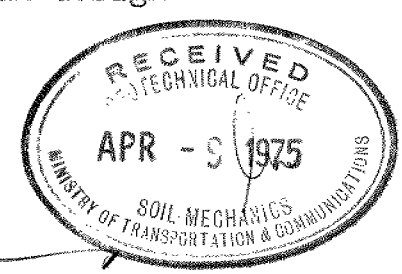
In Reply to

Subject:

Highway 17 Four Laning
Sault Ste. Marie Easterly

I wish to convey the appreciation of this Region for your very prompt and efficient response to our request for assistance with respect to foundation conditions liable to be encountered on this high priority project.

Your findings and recommendations will be of great assistance in determining the optimum design solution.



W. L. LEES, Manager,
Regional Planning and
Design Office.

WLL:jc

cc Mr. W. Wigle
Mr. W. D. Neilipovitz
Mr. B. J. McKenna

Munty:

Both you and Anand Prakash have proven on this job that project management in our type of work is a feasible idea.

My congratulations to both of you.

And, I think we all owe a round of ~~hand~~ applause to Has Shah who did his very best in the field.

Cam.

cc: A.R.
A.P.
H.S.
file

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 41K-36

DIST. 18 REGION

W.P. No. 903-72-18

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 17

LOCATION GARDEN RIVER BRIDGE

No of PAGES - ~

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ministry of Transportation and Communications
Ontario

Memorandum

41K-36
GEOCRES No.

To: Mr. B.J. McKenna (2),
Regional Structural Planning Engr.,
Northwestern Region,
Thunder Bay.

Attention:

From: Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

Date: November 12, 1975.

NOV 17 1975

Our File Ref. W.P. 903-72-18

In Reply to

Subject:

PRELIMINARY FOUNDATION INVESTIGATION REPORT
for
Feasibility Study of T.C. Hwy. No. 17
(Proposed 4 Lanes)
Garden River Indian Reserve
District No. 18 (Sault Ste. Marie)
W.P. 903-72-18

Due to the urgency of this project we are forwarding to you a report containing the subsoil description and the recommendations which are based on the information from the field, which are based on the field data without any laboratory tests to determine the engineering properties of the subsoil. However, in our opinion, the data contained in this report will be adequate for your evaluation with regard to feasibility studies on this project.

It should be noted that the recommendations given in this report are of a preliminary nature. A complete foundation investigation will be necessary once the alignment and geometrics are finalized.

M. DEVATA,
Supervising Engineer.

cc: E.J. Orr,
B.R. Davis,
W.L. Lees (2),
G.E. French,
B.J. Giroux,
R. Morgenroth,
G.A. Wrong,
R. Hore,
McCormick, Rankin & Assoc. Ltd.,
J. Anderson)
N.G. Maluzinsky) memo only
G. Sloan)

Files,
Record Services.

TABLE OF CONTENTS

PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

Feasibility Study of T.C. Hwy. No. 17
(Proposed 4 Lanes)
Garden River Indian Reserve
District No. 18 (Sault Ste. Marie)
W.P. 903-72-18

---

1. INTRODUCTION

The Soil Mechanics Section was requested to undertake a preliminary foundation investigation to investigate the feasibility of two alignments, namely, Scheme 'A' and Scheme 'B' for a proposed crossing of the Garden River by Hwy. 17. This report discusses the findings of this preliminary foundation investigation.

The locations and elevations of the boreholes are approximate, and are obtained from the plans and profiles prepared by McCormick, Rankin & Associates, Consulting Engineers.

Due to the urgency of this project, laboratory tests have not been carried out to determine the engineering properties of the subsoil. The recommendations and other related data contained in this report were already discussed orally between Messrs. M. Devata, W.L. Lees and D. Jarvis in the Thunder Bay Regional Office, on October 8, 1975, immediately after the completion of the field investigation work.

2. SUBSOIL AND GROUNDWATER CONDITIONS

A total of five sampled boreholes were put down during the course of the field investigation. The borings were advanced by means of a bombardier mounted auger machine,commercially known as C.M.E. No. 55, adapted for soil sampling purposes.

The pertinent boreholes for each of the respective preliminary alignments of Scheme 'A' and Scheme 'B' are as follows:

Scheme A (Sta. 287+00 - Sta. 322+00) - Ref. B.H.'s No. 1, 2, & 5
Scheme B (Sta. 287+00 - Sta. 320+00) - Ref. B.H.'s No. 3 & 4

The results of the field investigation are summarized on the Record of Borehole Sheets and on Dwg. No. 9037218-A attached to this report.

The subsoil across both schemes consists generally of granular material ranging in size from sandy silt to sand with trace to some gravel. The granular deposit in the old river valley area (Ref. Scheme 'A', B.H.'s No. 1 & 2) is underlain by a cohesive layer of clay to silty clay. B.H.'s No. 1 & 2 were terminated in the clay layer, and thus the lower boundaries of the cohesive stratum were not established.

3. DISCUSSIONS AND RECOMMENDATIONS

(3.1) General

Two possible preliminary alignments are being considered, namely, Scheme 'A' and Scheme 'B', for the relocation of Hwy. 17 in the Garden River Indian Reserve area. The proposal in this area calls for the construction of a new four lane Hwy. 17 as a divided (100' median) controlled access highway within a 300 foot right-of-way. Preliminary plans and profiles were developed by McCormick, Rankin & Associates, Consulting Engineers, who are involved in the feasibility study of this project.

The centreline of the proposed preliminary Scheme 'A' runs parallel to, and about 250 feet north, from the centreline of the hydro right-of-way (Great Lakes Power Co.). Scheme 'B' runs further north, and within the area concerned, its distance from the hydro right-of-way varies from about 600 to 850 feet.

At this stage, the specific design details of the proposed structures are not available. However, it is understood that a separate three span structure is being considered for E.B.L. and W.B.L. of Scheme 'B'. For Scheme 'A' it is proposed to build a 4 span structure for the W.B.L. and a three span structure for the E.B.L. Each scheme requires construction of embankments, cuts, and structures for the river crossing. Presented below in tabular form are the recommendations pertaining to stability and settlement considerations for the embankments, stability of the cuts, and also recommendations for the structures and immediate approaches needed for the Garden River crossing.

(3.2) EMBANKMENTS

	Subsoil & Design Data			Discussions & Recommendations	Remarks
	B.H. #1	B.H. #2			
Scheme 'A'	(585.0)	(584.5)	Ground elevation	Embankment heights of up to 31 ft. will be required to meet the proposed profile grade. Stability analyses indicate that the proposed fill heights will be stable with 2:1 slopes, provided that the fill material consists of acceptable earth material compacted to the M.T.C. specifications.	The area concerned lies in the vicinity of the oxbow lake area. This portion is also part of the old river valley. Any surficial organic material shall be required to be excavated prior to the embankment construction. This aspect was not investigated
Embankments	0-33 ft.	0-17.5 ft.	Sand, trace to some gravel, very loose to compact		
Sta. 287+50 ± to Sta. 304+00 ±	33-44.5 ft.	17.5-49.5 ft.	Silty clay to clay, firm to very stiff		
(Ref. B.H.#1 & 2)	(583.2)	(583.5)	Water level elevs.		
	Existing ground: varies from elevs. 581 to 590			Clay stratum is compressible & will undergo settlements due to consolidation. For a 31 ft. embankment 4-5 in. settlement are anticipated (50% occur in 6-12 months)	
	Proposed grade: varies from elevs. 600 to 613 (Hwy. 17N)				
Scheme 'B'	No borings were carried out in this area. However, visual observations indicate that the subsoil in this area consists of sand and gravel. This is evident since this area is used as burrow pit by the C.P.R.			Embankment heights in general are in the order of about 15 ft. However, in some localized areas, fill heights of up to 18 ft. will be required to meet the proposed profile grade.	
Embankments					
Sta. 287+50 ± to Sta. 301+30 ±	Existing ground: varies from elevs. 600 to 620			No major stability or settlement problems are anticipated.	
	Proposed Grade: varies from elevs. 617 to 624 (Hwy. 17N)				

(3.3) CUTS

	Subsoil & Design Data	Discussions & Recommendations	Remarks
Scheme 'A' Cuts Sta. 302+40 ± to Sta. 307+60 ±	No borings were carried out in this area. However, visual observations were made to determine the surficial soils encountered in the vicinity of the area concerned. The material to be excavated is expected to consist predominantly of sand to silty sand. Existing ground: elev. 635 Proposed grade: varies from elevs. 598 to 600 (Hwy. 17N)	Cuts of up to 35 ft. will be required to meet the proposed profile grade. Stability problems are not anticipated for the cuts in this localized area, if constructed with 2:1 slopes. Protection of cuts from erosion due to surface water runoff may be required.	
Scheme 'B' Cuts Sta. 301+50 ± to Sta. 309+50 (Ref. B.H. #4)	B.H. #4 (635.0) Ground elevation 0-15.3 ft. Sand, trace to some gravel, loose to compact. 15.3-18 ft. Silty clay to clay, firm. 18-22 ft. Sandy gravel with cobbles, dense. 22 ft. Encountered refusal to augering, probable boulders. B.H. dry Existing ground: elev. 635 Proposed grade: varies from elevs. 617 to 623 (Hwy. 17N)	Cuts of up to 18 ft. will have to be made to achieve the proposed profile grade. Stability problems are not anticipated for the cuts constructed with 2:1 slopes. No major dewatering problems are anticipated for the construction of cuts in this area. Protection of cuts from erosive forces due to surface water runoff may be required.	

(3.4 a) GARDEN RIVER CROSSING

Scheme 'A' (Ref. B.H. #5) - Sta. 310+00± to Sta. 325+00±

Subsoil & Design Data

B.H. #5

(635.0)	Ground elevation
0-96.5 ft.	Sand to silty sand, very loose to compact.
(622.3)	Water level elev.
(587)	River water level elev.

Existing Ground - east approach area: elev. 635.
west approach area: varies from 602 to 613.

Proposed grade - east approach area: varies from 618 to 630
west approach area : varies from 602 to 613.

Structures: 4 span with a total length of about 520 ft. (WBL), and 3 span with a total length of about 255 ft. (EBL). Proposed grade varies from 613 to 619.

Discussion & Recommendations

Structure

Due to the loose nature of the sandy, subsoil, spread footing type foundations are not recommended at this site. In the vicinity of the east abutment an end bearing stratum is not evident in the material sampled.

Foundations for the abutments and piers, if supported on No. 14 timber piles and driven to an embedded depth of 45 ft., will provide an allowable load of 10 tons per pile. Alternatively, end bearing Franki type expanded base piles may be considered at this location. For example, a 16" Ø rammed shaft could develop 75-100 tons per pile provided it is extended some 25 to 30 ft. into the granular deposit.

Approaches

Cuts up to 15 ft. will have to be made on the east bank to meet the proposed profile grade. Fills of up to 23 ft. will be required on the west bank to arrive at the profile grade. No major stability or settlement problems are anticipated.

Remarks

The river meanders at thi crossing. The river widths at the proposed structures locations are about 360 ft. (WBL) and 100 ft. (EBL). The banks on the east side of the river are about 53 ft. above the river bed in certain locations. The east bank has natural slopes steeper than 1:1, and has eroded away to quite an extent at places due to surface runoffs.

(3.4. b) GARDEN RIVER CROSSING

Scheme 'B' (Ref. B.H.#3) - Sta. 305+00± to Sta. 320+00±

Subsoil & Design Data

B.H. #3

(600.0)	Ground elevation.
0-5 ft.	Sandy silt, very loose
5-32.5 ft.	Sand, trace to some gravel, loose.
32.5-41.5 ft.	Sand with gravel dense to very dense.
(587)	Water level elev.
(587)	River water level elev.

Existing Ground - east approach area: elev. 640.
west approach area: elev. 635

Proposed grade - east approach area: varies from elev. 626 to 634.
west approach area: varies from 618 to 623.

Structures: 3 span with a total length of about 320 ft. (a structure each for W.B.L. & E.B.L.). Proposed grade varies from 623 to 626.

Discussion & Recommendations

Structure

Due to the loose nature of the sandy type subsoil, spread footing type foundations are not recommended at this site.

It is recommended that the entire structure be supported on end-bearing steel piles driven into the dense to very dense sand with gravel stratum. For feasibility purposes, it is estimated that the maximum allowable loads for the particular pile section chosen will be achieved at approximate elevation 550.

Approaches

Cuts of up to 18 ft. will have to be made on the west bank to reach the proposed profile grade. Comments on this have been discussed elsewhere under the heading "Cuts".

Shallow cuts of up to about 11 ft. will be required on the east bank. No major stability problems are anticipated for cuts constructed with standard slopes of 2:1.

Fills of up to about 30 ft. will be required in the valley area on the east side of the river. No major stability or settlement problems are anticipated.

Remarks

The river at this crossing follows a fairly straight course. The river valley has a bank to bank width of about 600 ft., while the river itself is about 120 ft. wide. The valley floors on the east side of the river have slopes of about 4:1. The river banks are up to about 54 ft. in height above the river bed.

4. FEASIBILITY OF SCHEMES

Both Schemes 'A' and 'B' are feasible, but from the foundation point of view, Scheme 'B' is a more favourable alignment for the following reasons:

1. Borehole No. 3 (Scheme 'B') indicates a suitable end-bearing stratum for pile foundations at Elev. 550 (50 feet below the ground surface). Borehole No. 5 (Scheme 'A') was terminated at Elev. 538.5 (96.5 feet below the ground surface). No suitable end-bearing stratum was encountered at the location of B.H. No. 5 to this elevation. Therefore, for Scheme 'B', shorter piles (50.0 feet in length) will be required to support the structure. Thus, foundation costs for Scheme 'B' are anticipated to be less than those applying to Scheme "A'.

2. The east bank in the vicinity of Garden River Crossing for Scheme 'A' exhibits signs of extensive erosion on the slopes due to surface runoff. Thus, special measures will be required to insure stability of the bank due to erosion, if Scheme 'A' is adopted.

3. Comparing the existing and proposed profile grades of both schemes, Scheme 'B' would require less embankment heights and depths of cuts.

4. Settlement would probably be greater and long-term in nature in the old river valley area of Scheme 'A', due to the presence of the underlying clay to silty clay stratum. Settlements in Scheme 'B' will take place during and immediately after construction. Thus, maintenance costs for Scheme 'B' will be lesser than Scheme 'A'.

5. MISCELLANEOUS

The various recommendations outlinedin this report are for feasibility purposes based on limited amount of field work. It will be necessary to carry out a detailed investigation when the final design details are available. Recommendations given in this report are, therefore,

to be regarded as conditional only, and as such, are subject to revision at a later date.

The field investigation was carried out during the period of October 1, 1975, to October 9, 1975, under the supervision of Mr. H. Shah, Project Engineer.

The drilling equipment used was owned and operated by Atcost Drilling Co., Concord, Ontario.

This report was prepared by Mr. H. Shah, and was reviewed by Mr. M. Devata, Supervising Engineer.

H. Shah

H. Shah,
Project Engineer.

M. Devata

M. Devata,
Supervising Engineer.

November, 1975

APPENDIX

MINISTRY OF TRANSPORTAT N AND COMMUNICATIONS-ONTARIO

ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE Nº 1

WP 903-72-18 LOCATION Co-ords. 916,885 N; 962,628 E. Scheme 'A' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 1 & 2, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY JO

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	UNIT WEIGHT	REMARKS
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV	20 40 60 80 100 SHEAR STRENGTH: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 400 800 1200 1600 2000	W_P — W — W_L WATER CONTENT %	γ	% GR SA SI CL
585.0	Ground Level									
0.0	Topsoil									
	Sand - fine to very fine.		1	SS	5					
			2	SS	4	580				
	some gravel		3	SS	6					
			4	SS	6					
			5	SS	5	570				
	Loose		6	SS	7					
	Compact		7	SS	12	560				
552.0			8	SS	16					
33.0	Silty clay to clay.		9	SS	11	550				
	Very Stiff		10	SS	12		>+ >+			
540.5										
44.5	End of Borehole					540				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTAT N AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2

WP 903-72-18 LOCATION Co-ords. 917,277 N; 961,942 E. Scheme 'A' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 3 & 4, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (400 800 1200 1600 2000)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P — w — w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
584.5	Ground Level									
0.0	Topsoil									
	Sand, trace to some gravel		1	SS	2					
	V.Loose / Loose		2	SS	4	580				
	trace of organics in the upper 7 ft.		3	SS	21	*				*Coarse gravel obstructed the advancement of the spoon in sample No.3, thus its blows/ft. count is considered non-representative.
567.0			4	SS	6	570				
17.5	Silty clay to clay, occasional thin layers of sand		5	SS	4		+ s10.7 + s3.0			
			6	TW	PH	560	+ s5.6 + s3.4			
	some pockets & thin layers of silt		7	TW	PH					
			8	SS	6	550	+ s5.6			
			9	SS	4		+ s6 + s3.2			
	Firm to Stiff		10	SS	4	540	+ s4.7 + s3.2			
535.0										
49.5	End of Borehole					530				

20
15 ⊙ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTAT. J AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

WP 903-72-18 LOCATION Co-ords. 916,805 N; 963,978 E. Scheme 'B' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 6, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE Washboring, NX Casing CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w / WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
600.0	Ground Level						20 40 60 80 100 / 400 800 1200 1600 2000			
0.0	Topsoil									
	Sandy silt		1	SS	3					
595.0	Very Loose		2	SS	82	*				
5.0	Sand - Fine to Medium									
	Trace to some gravel.		3	SS	7	590				
	Loose		4	SS	4					
			5	SS	6	580	+ s3.2			
	silty clay to clay - Stiff									
			6	SS	9					
567.5			7	SS	8	570				
32.5	Sand with gravel									
			8	SS	50					
558.5	Dense to Very Dense		9	SS	100/10"	560				
41.5	End of Borehole									
						550				

Note: Three attempts were made to set up the borehole, in order to avoid cobbles and/or boulders which are present in th upper 5 ft. of the granular deposit.

* Coarse gravel obstructed the advancement of the spoon in sample No.2, thus its blows/foot count is considered non-representative.

20
15 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4

WP 903-72-18 LOCATION Co-ords. 917,138 N; 963,340 E. Scheme 'B' ORIGINATED BY HS

DIST 18 HWY 17 BORING DATE October 7, 1975 COMPILED BY HS

DATUM Geodetic BOREHOLE TYPE 3½" Hollow Stem Augers CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV
635.0	Ground Level					
0.0	sand, trace of gravel					
	Loose		1	SS	5	
	Compact		2	SS	18	630
			3	SS	14	
619.7						
15.3 / 617.0	Silty clay to clay Firm		4	SS	4	620
18.0 / 613.0	Sandy gravel with cobbles. Dense		5	SS	100 *	
22.0	End of Borehole					610
	Refusal to augering probable boulders.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
400 800 1200 1600 2000

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P — w — w_L
WATER CONTENT %

UNIT WEIGHT γ

REMARKS

% GR	SA	SI	CL

B.H. Dry

* Coarse gravel obstructed the advancement of the spoon in sample No.5, thus its blows/foot count is considered non-representative

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

ENGINEERING SERVICES BRANCH – GEOTECHNICAL OFFICE – SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

WP 903-72-18 | LOCATION Co-ords. 915,822 N; 964,467 E, Scheme 'A' | ORIGINATED BY HS

DIST 18 HWY 17 | BORING DATE October 8 & 9, 1975 | COMPILED BY HS

DATUM Geodetic | BOREHOLE TYPE 3¼" Hollow Stem Augers | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P w w_L) / WATER CONTENT %	UNIT WEIGHT γ	REMARKS / % GR SA SI CL
635.0	Ground Level									
	Topsoil									
	Sand - fine to very fine.		1	SS	10					
			2	SS	7	630				
	Loose		3	SS	5					During sampling water was first encountered at about 622.3 where the B H also caved in after the removal of the augers.
620.0						▼				
15.0	Silty Sand		4	SS	2	620				
	Very Loose		5	SS	2					
			6	SS	2	610				
	org. silt, some wood chips		7	SS	4					
	V. Loose									
	Loose to Compact		8	SS	11	600				
594.5										
40.5	Sand - fine to very fine		9	SS	15					
	some gravel		10	SS	31	590				
	Loose to Compact		11	SS	7					
			12	SS	5	580				
			13	SS	8					
						570				
			14	SS	9					
						560				
			15	SS	16					
	(some pockets and layers of silty clay to clay encountered below El. 575)					550				
538.5			16	SS	12	540				
96.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

11-A-24(a) (Rev. Jan. 73)

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N'=STANDARD PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	c LB./SQ.FT.
VERY SOFT	0 - 250
SOFT	250 - 500
FIRM	500 - 1000
STIFF	1000 - 2000
VERY STIFF	2000 - 4000
HARD	> 4000

DENSENESS	'N' BLOWS / FT.
VERY LOOSE	0 - 4
LOOSE	4 - 10
COMPACT	10 - 30
DENSE	30 - 50
VERY DENSE	> 50

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10 % , SOME 10-25 % , WITH 25-40 % , > 40 % SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
w_S	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta \sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

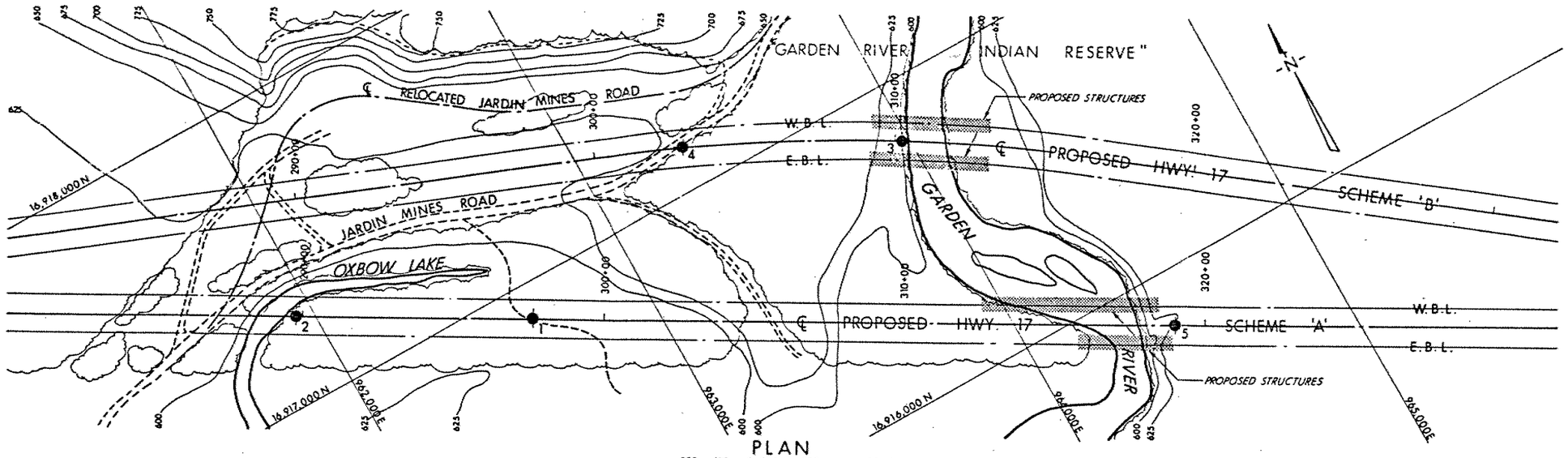
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

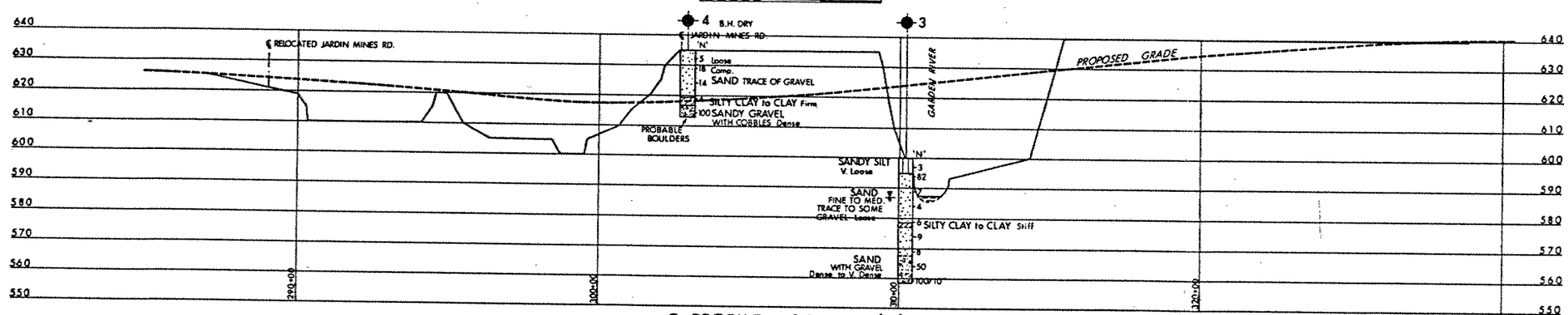
FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

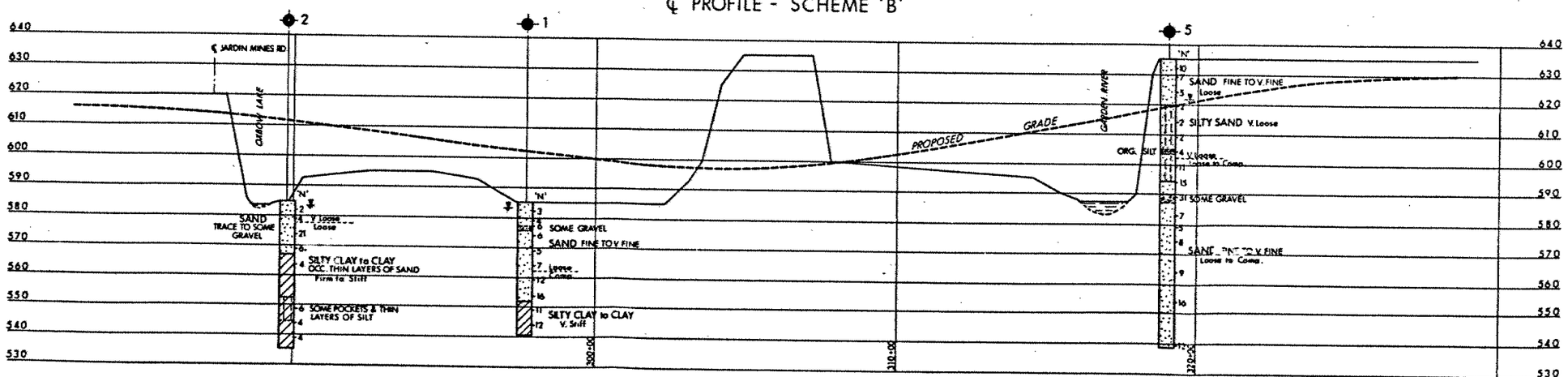
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



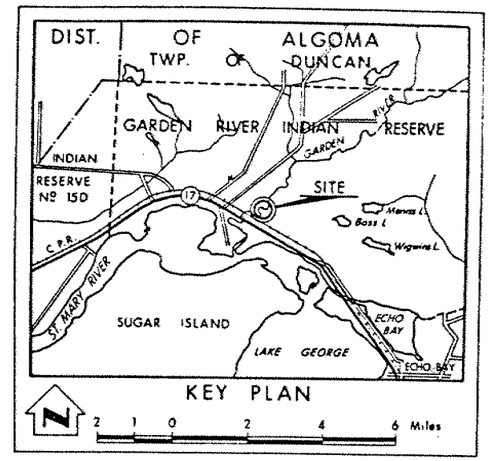


℄ PROFILE - SCHEME 'B'



℄ PROFILE - SCHEME 'A'

VERT. 20 10 0 SCALE 20 40 FT.
HORIZ 200 100 0 200 400



LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test B/F CONE - Blows/Ft. Cone Test (350 ft.lbs. energy/blow)
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. OCT. 1975

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	585·0	916,885	962,628
2	584·5	917,277	961,942
3	600·0	916,805	963,978
4	635·0	917,138	963,340
5	635·0	915,822	964,467

— 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

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

PRELIMINARY INVESTIGATION
FEASIBILITY STUDY

HWY. 17 & GARDEN RIVER INDIAN RESERVE

HIGHWAY NO 17 DIST NO 18
DIST. OF ALGOMA GARDEN RIVER INDIAN RESERVE
TWP LOT CON

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD H.S.	CHECKED	W.P.NO 903-72-18	DRAWING NO 9037218-A
DRAWN S.O.	CHECKED	W.O. NO	
DATE 16 OCT. 1975		SITE NO	BRIDGE DRAWING NO
APPROVED		CONT NO	