

BA 745

AN INDEPENDENT ORGANIZATION PROVIDING A COMPLETE SOIL ENGINEERING & INVESTIGATION SERVICE

e. m. peto associates ltd.

YOUR REFERENCE:

OUR REFERENCE: 5857

850 roselawn avenue.

TORONTO, ONTARIO.

RUssel 1-4935.

3rd. June, 1958.

58-6-274C

Department of Highways of Ontario,
C/o Laughlin, Wylie and Ufnal,
53 Kipling Avenue South,
Toronto 18,
Ontario.

Re: Soil Site Investigation
Highway 7 - Humber River Bridge

Dear Sirs,

We take pleasure in enclosing herewith our soils report for the proposed new bridge over the Humber River on Highway 7. The results of the first three test holes were supplied verbally as the field work progressed.

For your convenience, we wish to summarize very briefly the results and recommendations set out in detail in the report.

1. The overburden on this site is a loose to compact sandy loam in a moist to saturated condition and will require support or sheeting in vertical excavation.
2. Bedrock was encountered at elevation 459.5 at the proposed new West abutment location and at 449.5 at the East abutment.
3. The top four to five feet of rock consists of interbedded shale and limestone, with indications of considerable clay-shale seams. If the footings are placed within the top four to five feet of the bedrock, then bearing values should be limited to 4.0 Tons/sq. ft.
4. If the footings are placed below the bedrock surface by some four feet at the West abutment and five feet at the East abutment, (i. e. elevations 455.0 and 444.5 respectively) then bearing values of 5.0 Tons/sq. ft. can be

used without danger of settlement. If some settlement can be tolerated by the bridge design, then higher bearing values of the order of 8 to 10 Tons/sq. ft. may be used.

5. The use of explosives for breaking up the rock is inadvisable since the clay-shale seams will tend to open up under the explosive vibration; water seepage from the river may penetrate to the clay-shale seams, causing them to revert to clay with a lower shear strength.

6. The bedrock excavation should be kept dry, particularly if the higher bearing values are being used.

We understand that the presently proposed bridge design will consist of three spans with piers located close to the existing abutments; no test holes were performed at the pier locations and we understand that the present design calls for excavation to a depth of at least 6 feet into bedrock.

We suggest that careful visual examination of the final pier and abutment excavations be made, perhaps with several "star-drill" holes through the bottom of each excavation, in order to confirm the continuity of the bedrock and the absence of any soft clay-shale layers.

Should you require any additional advice with regard to this report, we shall be pleased to be of further service.

Yours very truly,

E. M. PETO ASSOCIATES LTD.,



EMP:pf

E. M. Peto, P. Eng.

e. m. peto associates ltd.

YOUR REFERENCE:

OUR REFERENCE:

5857

850 roselawn avenue.

TORONTO, ONTARIO.

RUssell 1-4555.

3rd June, 1958.

Report on

SOIL SITE INVESTIGATION

at

HIGHWAY 7 - HUMBER RIVER BRIDGE

for

DEPARTMENT OF HIGHWAYS OF ONTARIO

C/o MESSRS. LAUGHLIN, WYLLIE AND UFNAL.

INTRODUCTION:

We were retained on May 15th, 1958, by verbal order from Mr. M. Laughlin, to perform a soil site investigation for the new bridge to replace the existing old one on this site. We were also provided with the Consulting Engineer's marked site plan, showing four recommended borehole locations, roughly one at each corner of the proposed new structure. Each borehole was to be cored to prove the reliability and soundness of the underlying bedrock.

PROGRAMME OF WORK:

- May 20th, 1958: Crew and equipment moved to site, holes staked out by Field Engineer, field elevations taken, work commenced.
- May 24th, 1958: Field work completed, final check of ground water levels, crew and equipment moved from site.

GENERAL INFORMATION:

(a) Standard soil sampling procedures were followed. These are described in Appendix II.

(b) All four soil test holes on this site encountered early refusal, and a minimum of 15 feet of continuous rock coring was carried out in each hole. At test hole 2, rock core recovery was poor and our Field Engineer did not feel that this was truly indicative of the rock condition. Therefore a second hole, test hole 2A, was put down 2 feet away from the first one, by driving through the overburden without sampling, and then diamond drilling with a smaller size core barrel and bit.

(c) A site plan and detailed individual borehole logs are included at the rear of the report. The results of the limited laboratory tests are shown on the borehole logs. The site plan shows the borehole locations and two soil cross-sections, one at each end of the bridge. All elevations are to Geodetic datum, and are referred to a bench mark in the form of a cut cross on the North-East corner of a concrete gas island 53.0 feet left of station 455 + 90. The gas station has been demolished, and only the concrete pad from the former pump island remains. The elevation of this bench mark was taken to be 466.51.

(d) The rock cores have been examined in detail in our laboratory. The details are given in Appendix I.

SITE AND GEOLOGY:

The topography at this site is gently rolling. The Humber River valley at the site does not at first appear to be well incised, but in the vicinity of Woodbridge it is more than 100 feet deep. The banks upstream from the old bridge are almost vertical, although not very high. The river is shallow and very rapid, and is prone to periodic flooding. At the old bridge large limestone boulders have been placed as rip-rapping to prevent scour and to deter meandering of the stream.

The site is underlain at fairly shallow depth by Ordovician shale and limestone.

SOIL CONDITIONS:

Only two main classes of material were encountered during the course of this investigation. These are:

- (i) sandy loam
- (ii) shale interbedded with limestone.

(i) Sandy Loam

At the test hole locations, the bedrock is covered by 11 to 16 feet of loose to compact sandy loam. This material is comprised of silty fine sand, with organic content in the upper 5 to 7 feet, and some grits and pebbles at depth. The colour is variable, but is generally mixed brown, changing to grey near the lower boundary of the stratum. Natural moisture contents range from 10.5% to 23.1%, and the soil samples were moist to saturated. The wet unit weight may be taken to be 120 p. c. f. for design purposes.

The presence in the sandy loam stratum of organic matter to depths as great as 7 feet, suggests that the upper part of this layer at least, was either deposited by the river in flood time, or is a fill material.

Beneath the sandy loam is a thin stratum, in the order of 1 to 2 feet thick of relatively soft clay-shale, olive-brown in colour, and with a laminated structure. Our investigation unfortunately did not clearly define the clay-shale layer; it is too hard for conventional soil sampling tubes, but tends to wash away when cored with diamond drilling equipment.

(ii) Shale Bedrock

The bedrock underlying this site dips some 10 feet from one end of the proposed bridge to the other, in a West to East direction. The bedrock consists of a dark grey, soft, fine-grained shale interbedded with light grey limestone, the limestone being considerably harder than the shale. There are occasional fossils in the rock, and seams of clay-shale which tended to wash away in the water used for the drilling operation.

(II) Shale Bedrock (contd.)

A compressive crushing strength test was carried out on a cylindrical specimen of dark grey shale which had no initial cracks or limestone seams. The sample failed by crushing under a test load of 2970 p.s.i.

No major water-bearing seams or faults were encountered, and the bedrock can be considered to be of fairly good quality throughout, once the upper 1 to 2 foot thickness of clay-shale has been penetrated.

WATER CONDITIONS:

The river water level at this site May 21st, at the upstream side of the existing bridge was 451.8, slightly higher than the top of bedrock level on the East side of the structure.

The observed ground water levels in holes 1 and 2 correspond very closely to the river level. The measured ground water levels at holes 3 and 4 were higher than the river level, but these are not altogether reliable, since the holes were still partly cased at the time.

RECOMMENDATIONS AND CONCLUSIONS:

1. The soil mantle on this site, consisting of a loose to compact sandy loam in a moist to saturated condition, is an undesirable load-bearing stratum.
2. Flooding and scour are potential problems at this site, and we would therefore recommend that the West abutment for the new bridge be founded a minimum of four feet below the top surface of the bedrock (elevation 455.0), and the East abutment be founded five feet below bedrock surface (elevation 444.5).

The unit loading to be employed on the bedrock at these elevations will be dependent on whether settlement can be tolerated by the structure to be supported. In the event that no settlement can be tolerated we do not recommend a loading exceeding 5.0 tons/sq. ft. However, where such a restriction can be relaxed to permit some settlements, considerably higher unit loads in the order of 8 to 10 tons/sq. ft. may be used.

RECOMMENDATIONS AND CONCLUSIONS: (contd.)

3. If the foundation design does not require a penetration into the bedrock of 4 to 5 feet for lateral stability or scour protection, it will be possible to place the footings just below the top surface of the bedrock, thus effecting some economy in rock excavation. However, the presence of the clay-shale seams precludes the use of a bearing value in excess of 4.0 T/sq. ft.

4. We are of the opinion that two factors relating to the East abutment render the use of explosives for excavation inadvisable. These are (a) The shale and limestone is interbedded with clay-shale seams (b) The present river level is above the proposed footing elevation on this bank. It is possible for explosive vibration to cause shattering of the rock, with the consequent opening up of seams for the penetration of water, and as a result the soft shale may revert to clay with a lower shear strength.

5. On the East side the bedrock excavation should be kept dry, to avoid the clay-shale seams being affected by water. Accordingly, it may be necessary to provide some sheeting at depth to control the ingress of water to any such excavation. This problem should not arise on the West side where the proposed footing elevation is above the river level, but some seepage may develop from the sandy loam.

6. The very moist to saturated sandy loam will require some form of support or sheeting in vertical excavation.

E. M. PETO ASSOCIATES LTD.,



E. M. Peto, P. Eng.

EMP:pf





e. m. peto associates ltd.
 SOIL ENGINEERING SERVICE - TORONTO, ONTARIO
 BOREHOLE LOG

Job Name **HWY 7 - HUMBER RIVER BRIDGE**
 Client **DEPARTMENT OF HIGHWAYS OF ONTARIO**
 Drawn **GEOPETIC**

Job No. **585T**
 Case **BX(2 1/2")**
 Compiled By **G.T.**

Borehole No. **1**
 Boring Date **MAY 20/21/58**
 Checked By **M.M.**

SAMPLE CONDITION





 **UNDISTURBED**
 **FAIR**
 **DISTURBED**
 **LOOSE**

SAMPLE TYPE

S.S. 2" STANDARD SPLIT TUBE SAMPLE
S.C. SILENT BARREL WITH CONE
S.T. THIN-WALLED SILENT TUBE SAMPLE
W.S. WASH SAMPLE
R.C. ROCK CORE

ABBREVIATIONS

S.T. SILENT TUBE SHEAR TEST
Q/C UNCONSOLIDATED COMPRESSIVE STRENGTH
W.L. WATER LEVEL IN CASING
W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION	DEPTH	DIAMETER	TEST	REMARKS	WATER LEVEL, SOIL MOISTURE & REMARKS
SCALE: SFT. TO 1 IN.					
GROUND SURFACE			0'0"		
TOP SOIL	BLACK		461.2		
SILTY FINE SAND, SOME ORGANIC	MIXED BROWN	LOOSE		1  S.S.	6 NAT. M.C. = 21.4% MOIST.
CONTENT				2  S.S.	2 NAT. M.C. = 19.7% QUITE MOIST.
SILTY FINE SAND	YELLOWISH-BROWN	V. LOOSE	5'0"		
SILTY FINE TO COARSE SAND, GRITS	BROWN	COMPACT		3  S.S.	30 QUITE MOIST TO WET.
& ROCK FRAGMENTS	CHANGE TO GREY	TO DENSE	10'0"	4  S.S.	2 V.L. 9'0" ON MAY 21-58 AFTER PULLING CASING.
SILTY FINE SAND, GRITS & PEBBLES					
SOFT SHALE INTERBEDDED WITH CLAY - SHALE	GREY		11'8" 449.4	CHOPPED WITH BX CHOPPING BIT.	
			15'0"		
			16'0"		
			20'0"		
FROM 16'0" TO 34'6" DIAMOND DRILLED					FOR DETAILS SEE APPENDIX I
SHALE INTERBEDDED WITH SOME LIMESTONE			25'0"		
			30'0"		
			34'6" 426.1		
HOLE TERMINATED.					

e. m. peto associates ltd.
SOIL ENGINEERING SERVICE - TORONTO, ONTARIO
BOREHOLE LOG

Job Name **HWY. 7 - HUMBER RIVER BRIDGE**

Job No. **5857**

Borehole No. **2**

Client **D.H.O.**

Core Log **BX(2 1/2")**

Boring Date **MAY 21 & 22, 1958.**

Datum **GEODETIC**





Compiled By **G.T.**

Checked by **M.M.**

SAMPLE CONDITION

SAMPLE TYPE

ABBREVIATIONS

-  UNDISTURBED
-  FAULT
-  DISTURBED
-  LOSS

- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH THERM.
- S.T. THIN-WALLED SPECIMEN TUBE SAMPLE
- W.S. WATER SAMPLE
- R.C. ROCK CORE

- V.T. IN SITU VANE SHEAR TEST
- Q.U. UNCONFINED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION

COLOR

MOISTURE

DEPTH (Feet)

DEPTH (Meters)

DEPTH (Feet)

DEPTH (Meters)

SCALE: 5 FT. TO 1 IN.

GROUND SURFACE

TOP SOIL

0'0"

466.9

CLAY & SILTY FINE SAND, SOME ORGANIC CONTENT.

MIXED BROWN

LOOSE

5'0"

FINE SAND, SOME ORGANIC MATTER

PALE YELLOWISH-BROWN

LOOSE

10'0"

ORGANIC SILTY FINE SAND

MIXED GREY-BROWN

LOOSE

15'0"

SANDY & SILTY CLAY WITH GRAVEL & SHALE FRAGMENTS. 15'0"-16'3" CLAY-SHALE 16'3"-17'0"

LT. GREENISH GREY
OLIVE BROWN GREY

STIFF TO V. STIFF
HARD

17'0"

448.9

FROM 17'0" TO 34'6"

SHALE INTERBEDDED WITH SOME LIMESTONE

GREY

25'0"

30'0"

34'6"

432.4

1 S.S. 5

SLIGHTLY MOIST.

2 S.S. 6

SLIGHTLY MOIST. M.C.=11.5%

3 S.S. 8

NAT. M.C.=23.1% QUITE MOIST.

S.S. 18

S.S. 15/6"

W.L. 15'3" ON MAY 22 AT 8 A.M.
CASING TO 17' HOLE TO 24'.
W.T. SLIGHTLY MOIST.

Arm. Fib.

LOSS OF WATER NOTED AT THIS DEPTH.

FOR DETAILS, PLEASE SEE APPENDIX I

HOLE TERMINATED.

e. m. peto associates ltd.
SOIL ENGINEERING SERVICE - TORONTO, ONTARIO
BOREHOLE LOG

Job Name **HWY. 7 - HUMBER RIVER BRIDGE**

Lot No. **5857**

Drillhole No. **2A**

Client **D.H.O.**

Coring **AX (1 1/2" DIAM.)**





Dating Date **MAY 22&23, 1958**

Datum **CEODETIC**

Compiled by **C.T.**

Checked by **M.M.**

SAMPLE CONDITION

-  UNDISTURBED
-  FAIR
-  DISTURBED
-  LOST

SAMPLE TYPE

- S. 1. 1" STANDARD TEST CORE SAMPLE
- S. L. SOIL BAKED WITH LINUM
- S. Y. THIN-WALLED SHELLY CORE SAMPLE
- W. S. WASH SAMPLE
- R. C. ROCK CORE

ABBREVIATIONS

- "T. UNITS LANE SHEAR TEST
- Q. UNCONFINED COMPRESSIVE STRENGTH
- W. L. WATER LEVEL IN CASING
- W. T. GROUND WATER TABLE IN SOIL

SOIL DESCRIPTION

SCALE: SET TO 1 IN.

GROUND SURFACE

0'0"

466.9

5'0"

10'0"

15'0"

16'0"

450.9

FROM 16'0" TO 32'6"
DIAMOND DRILLED

SHALE INTERBEDDED
WITH SOME LIMESTONE

GREY

20'0"

25'0"

30'0"

32'6"

434.4

HOLE TERMINATED

DROVE AX
CASING DOWN TO
16'0" BELOW SURFACE
& WASHED INSIDE.
NO SAMPLING.

FOR DETAILS PLEASE SEE
APPENDIX I

CRUSHING STRENGTH OF
SHALE SAMPLE = 2970. P.S.I.

e. m. peto associates ltd.

SOIL ENGINEERING SERVICE - TORONTO, ONTARIO

BORSHOLE LOG

Job Name: HWY. 7 - HUMBER RIVER BRIDGE

Job No. 5857

Project No. 3

Client: D.H.O.

Drawn by: BX & AX

Report Date: MAY 23/24 1953

Design: GEODETIC

Completed by: C.T.

Checked by: M.M.

SAMPLE CONDITION

- UNALTERED
- RAIN
- DISTURBED
- LOST

SAMPLE TYPE

- S. 1. STANDARD TEST TUBE SAMPLE
- S. 2. STEEL BUCKET WITH LINES
- S. 3. THREAILED SHEET PILE SAMPLE
- S. 4. WASTE SAMPLE
- S. 5. ROCK CORE

ABBREVIATIONS

- U.C. UNIFORM SAND TEST
- Q. UNIFORMED COMPRESSIVE STRENGTH
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL

SCALE: 5 FT. TO 1 IN.

GROUND SURFACE

TOP SOIL

FINE TO COARSE SAND, ROCK FRAGMENTS, BROWN
MILDLY ORGANIC.

LOOSE TO COMPACT.

AS ABOVE, BUT SAND IS SILTY

BROWN

VERY LOOSE

CLAY-SHALE WITH SOME SAND, GRITS & MOTLED OLIVE
SHALE FRAGMENTS, 10'0"-10'6" & GREY
10'6"-11'3" CLAY-SHALE
(LAMINATED STRUCTURE)

MOTLED OLIVE
& GREY
OLIVE & GREY

HARD

DIAMOND DRILLED FROM 11'3"
TO 30'0"

SHALE INTERBEDDED WITH SOME GREY
LIMESTONE

0'0"

470.3

5'0"

10'0"

11'5"

435.0

15'0"

20'0"

25'0"

30'0"

30'0"

439.55

HOLE TERMINATED

1

2

3

3A

S.S.

S.S.

S.S.

S.S.

11

3

44

24/3"

SLIGHTLY MOIST.

SATURATED

SLIGHTLY MOIST.

W.T. 13'10" ON MAY 24 AT 8 A.M.
CASING TO 12'

FOR DETAILS SEE
APPENDIX I

e. m. pelo associates ltd.

SOL. ENGINEERING SERVICE - TORONTO, ONTARIO

BOREHOLE LOG

Job No. HWY 7 - HUMBER RIVER BRIDGE

Drawn 5857

Revised No. 4

Client D.H.O.

Design BX & AX

Period MAY 24 - 1958

Down GEODETIC

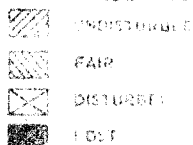
Notes G.T.

Checked By M.M.

SAMPLES LOG

SAMPLES LOG

ABBREVIATIONS



1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

W.T. IN FEET AND INCHES
Q.U. UNIFORMITY COEFFICIENT
W.L. WATER LEVEL IN FEET
W.T. GROUNDWATER TABLE IN FEET

Color

Texture

Depth

Location

Sample No.

Sample Type

Size of Hole

Water Table in Feet and Inches

SCALE: 5 FT TO 1 IN.

0'0"

470.9

3'0"

10'10"

460.1

15'0"

20'0"

25'0"

28'6"

442.4

HOLE TERMINATED

NAT. M.C. = 16.7% MOIST.

NAT. M.C. = 20.5% SATURATED.

W.T. 11'6" ON MAY 24 AT 7 P.M.
CASING TO 12'

FOR DETAILS PLEASE SEE
APPENDIX I.

APPENDIX I

ROCK CORE EXAMINATION

Bedrock at this site consists basically of a dark-grey, soft fine-grained shale interbedded with light grey limestone, which is considerably harder than shale. In addition, there are occasional fossils in the rock, and seams of clay-shale, which tended to wash away in the water used for the drilling operation. No major water-bearing seams or faults were encountered. The bedrock is of fairly good quality throughout.

HOLE 1

1st Run from 16'0" - 20'3". Core recovery 91.2%.

16'0" - 17'11" Shale, occasional fossils.

17'11" - 18'1-1/2" - Light Grey, dolomitic limestone.
(crystalline texture).

18'1-1/2" - 20'3" - Shale, odd 1/2" limestone seams.

2nd Run from 20'3" - 21'1". Core recovery 75.0%.

20'3" - 21'1" - Shale, some clay-shale seams.

3rd Run from 21'1" - 25'0". Core recovery 78.7%.

21'1" - 21'9" - Shale.

21'9" - 22'0" - Limestone.

22'0" - 24'0" - Shale.

24'0" - 24'7" - Limestone

24'7" - 25'0" - Shale

4th Run from 25'0" - 26'4". Core recovery 62.5%.

25'0" - 25'7" - Shale

25'7" - 26'4" - Limestone.

HOLE 1 (Cont'd)

5th Run from 26'4" - 30'0". Core recovery 81.8%.

26'4" - 26'8" - Shale.

26'8" - 26'10" - Limestone

26'10" - 27'6" - Shale

27'6" - 27'9" - Limestone

27'9" - 30'0" - Shale, thin band of fossils at 29'6"

6th Run from 30'0" - 34'6". Core recovery 94.5%.

30'0" - 32'8" - Shale with some limestone.

32'8" 32'11" - Limestone.

32'11" - 33'6" - Shale

33'6" - 34'6" - Dolomitic and fossiliferous limestone.

HOLE 2

1st Run from 17'0" - 19'5". Core recovery 34.5%.

17'0" - 19'5" - Shale, some clay-shale seams.

2nd Run from 19'5" - 21'7". Core recovery 73.1%.

19'5" - 21'7" - Shale.

3rd Run from 21'7" - 24'6". Core recovery 54.3%.

21'7" - 24'3" - Shale with seams of limestone.

24'3" - 24'6" - Limestone.

HOLE 2 (Cont'd)

4th Run from 24'6" - 29'6". Core recovery 75.0%.

24'6" - 24'10" - Limestone

24'10" - 25'2" - Shale

25'2" - 25'10" - Limestone

25'10" - 26'11" - Shale, minor limestone seams.

26'11" - 27'7" - Limestone.

27'7" - 29'6" - Shale, minor limestone seams.

5th Run from 29'6" - 34'6". Core recovery 40.7%.

29'6" - 30'0" - Shale with minor limestone seams.

30'0" - 30'7" - Limestone.

30'7" - 34'6" - Shale with minor limestone seams.

Note: Poor core recoveries in this hole were not truly indicative of the soundness of the bedrock. Therefore borehole 2A, 2 ft. away, was cored, using smaller diameter equipment.

HOLE 2A

1st Run from 16'0" - 22'3". Core recovery 72.0%.

16'0" - 16'2" - Limestone

16'2" - 22'3" - Shale, odd thin limestone seam.

HOLE 2A (Cont'd)

2nd Run from 22'3" - 27'3". Core recovery 80.0%.

22'3" - 23'6" - Shale, odd thin limestone seam.

23'6" - 23'9" - Fossiliferous Limestone

23'9" - 24'0-1/2" - Shale.

24'0-1/2" - 24'4" - Limestone.

24'4" - 24'6" - Shale.

24'6" - 25'3" - Limestone, some shale seams.

25'3" - 25'7" - Shale.

25'7" - 26'0" - Limestone.

26'0" - 27'3" - Shale with fossils.

3rd Run from 27'3" - 32'6". Core recovery 92.9%.

27'3" - 27'4-1/2" - Shale.

27'4-1/2" - 27'7-1/2" - Limestone, some fossils.

27'7-1/2" - 27'11-1/2" - Shale.

27'11-1/2" - 28'1" - Limestone.

28'1" - 28'1-1/2" - Shale.

28'1-1/2" - 28'5" - Limestone, with two 1/4" shale seams

28'5" - 28'7-1/2" - Shale.

28'7-1/2" - 28'8-1/2" - Limestone.

28'8-1/2" - 29'8-1/2" - Shale.

29'8-1/2" - 30'0" - Fossiliferous limestone.

30'0" - 30'7" - Shale, some limestone seams.

HOLE 2A

3rd Run from 27'3" - 32'6". Core recovery 92.9%. (Cont'd).

30'7" - 31'2-1/2" - Dolomitic limestone, with fossils.

31'2-1/2" - 31'10-1/2" - Shale, with two 1/2" seams of limestone.

31'11-1/2" - 32'1-1/2" - Limestone.

32'1-1/2" - 32'6" - Shale.

HOLE 3

1st run from 12'0" - 18'4". Core recovery 74.3%.

12'0" - 13'4" - Stones or boulders.

13'4" - 15'10-1/2" - Shale with odd thin band of limestone.

15'10-1/2" - 16'1-1/2" - Light grey Dolomitic limestone.

16'1-1/2" - 18'4" - Shale.

2nd Run from 18'4" - 20'0". Core recovery 97.5%.

18'4" - 18'7-1/2" - Shale.

18'7-1/2" - 18'10" - Limestone.

18'10" - 20'0" - Shale.

3rd Run from 20'0" - 25'6". Core recovery 83.3%.

20'0" - 24'9" - Shale, odd thin limestone seams.

24'9" - 24'11" - Limestone.

24'11" - 25'6" - Shale.

HOLE 3 (Cont'd)

4th Run from 25'6" - 30'9". Core recovery 93.6%.

25'6" - 25'7" - Limestone.

25'7" - 26'7" - Shale

26'7" - 26'9" - Limestone.

26'9" - 27'4" - Shale.

27'4" - 27'6" - Limestone.

27'6" - 28'7-1/2" - Shale, odd limestone seam.

28'7-1/2" - 28'11" - Limestone.

28'11" - 29'9" - Shale.

29'9" - 30'1" - Limestone.

30'1" - 30'5" - Shale.

30'5" - 30'9" - Limestone.

HOLE 4

1st Run from 12'0" - 18'0". Core recovery 73.6%.

12'0" - 12'5" - Light grey dolomitic limestone.

12'5" - 12'11" - Dark grey fine-grained shale.

12'11" - 13'1-1/2" - Limestone, light-grey dolomitic.

13'1-1/2" - 13'8" - Shale

13'8" - 13'9-1/2" - Limestone, some fossils.

13'9-1/2" - 14'9" - Shale.

14'9" - 15'2-1/2" - Limestone.

15'2-1/2" - 16'0" - Shale, with occasional very thin limestone seams.

16'0" - 17'0" - Limestone.

17'0" - 18'0" - Shale.

HOLE 4 (Cont'd)

2nd Run from 18'0" - 23'6". Core recovery 84.1%.

18'0" - 23'6" - Dark grey fine-grained shale, odd thin seam of limestone.

3rd Run from 23'6" - 28'6". Core recovery 94.2%.

23'6" - 23'7" - Limestone.

23'7" - 24'10" - Shale.

24'10" - 24'11" - Limestone.

24'11" - 25'3" - Shale (some grinding of the core noted here).

25'3" - 25'8" - Limestone.

25'8" - 27'9" - Shale, minor limestone seams.

27'9" - 28'4-1/2" - Limestone.

28'4-1/2 - 28'6" - Shale.

APPENDIX II

METHOD OF OPERATION

The field investigation work is carried out by means of a skid-mounted diamond drill rig.

Standard sampling procedures are followed. Casing is driven and cleaned, either by tubes or by wash water.

Samples are recovered ahead of the casing at frequent intervals, with either a 2" or 3" O.D. split barrel sampling tube, Shelby tube, or split barrel sampling tube fitted with brass liners and special sharp cutting nose.

The standard penetration test results are recorded when sampling with the regular 2" O.D. split barrel sampler, these being the number of blows of a 140 pound hammer falling 30 inches, required to drive the sampling tube a distance of one foot into undisturbed soil.

The Dutch cone probe test is made by driving the drill rods into the ground with a 2-1/4" - 90° cone tip. The number of 4200 inch pound blows per foot of penetration are recorded, as in the standard penetration test.

Where required, "in situ" shear strength tests are made ahead of the casing, using modified Acker vane test equipment.

Disturbed samples are visually classified in the field, sealed in sample jars, and are re-examined and tested as necessary, in the soils laboratory. Undisturbed samples are returned to the laboratory for later examination and testing, as required.

The test holes are bailed at the end of the day and on completion. Subsequent water level readings are taken for the duration of the field work. Water pressure readings are recorded when artesian water conditions are encountered. Moisture content samples are recovered at frequent intervals to assist in the soil classification and the interpretation of water table results.

58-F-274C

Hwy. # 7

HUMBER RIVER

