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BRIDGE

NORTH & WEST OXFORD

TOWN - LINE

LOT 5 , CON. 5

N. OXFORD

URE AND SMITH  
CONSULTING ENGINEERS  
WOODSTOCK ONTARIO

EA 2641  
IR N° 23-196

Report on  
SOIL INVESTIGATION  
for  
PROPOSED BRIDGE  
NORTH & WEST OXFORD TOWN-LINE,  
LOT 5, CONCESSION 5, N. OXFORD

by  
DOMINION SOIL INVESTIGATION LIMITED  
369 Queens Avenue  
LONDON ONTARIO

Reference No. 7-1-L1  
February 6th, 1967

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SUMMARY

The natural soil profile consists of compact to dense well-graded sand and sandy gravel strata extending to about 8 feet below the river bed, overlying sound limestone bedrock.

It is recommended that the abutments be supported on steel H-piles driven to bedrock and that the centre pier be founded directly on the bedrock. Pile load capacities are discussed in the report, and a maximum allowable bearing pressure of 40,000 p.s.f. is recommended for the design of the centre pier footing.

Problems regarding construction of the approach embankments and dewatering procedures to be used in the construction of the pier footing are also discussed in the report.

## I INTRODUCTION

The soil investigation was authorized by Messrs. Ure and Smith, Consulting Engineers, acting on behalf of the County of Oxford. The proposed bridge will cross the River Thames about 2 miles southwest of Ingersoll, the river at this point marking the boundary between North Oxford and West Oxford Townships.

It is understood that the road will be relocated and that the new bridge will cross the river about 70 feet downstream from the existing steel-truss structure. Also, the proposed structure will consist of two 70 foot spans supported by stub abutments and a centre pier. The requirements of the project were discussed with Mr. H. Walford, P. Eng., who supplied the foregoing information.

The purpose of this investigation was to reveal the subsurface conditions at the pier and abutment locations and to determine the relevant soil properties for the design and construction of the new foundations.

## II DESCRIPTION OF THE SITE AND GEOLOGY

The Thames River is located in a glacial spillway which passes through Woodstock and Ingersoll. The valley is about a mile in width and at times reaches over one hundred feet in depth. At Beachville, immediately to the East of Ingersoll, the limestone bedrock is exposed and is currently being worked in the quarries.

The physiographic region known as the Mount Elgin Ridges is characterized by gently undulating terrain with a local relief of about 100 feet. The ridges generally consist of pale brown calcareous silty clay, while in the vales it is common to find alluvium of gravel, sand or silt.

### III FIELD WORK

The field work, consisting of 3 boreholes, was carried out during the period January 20 to 28, 1967, at the locations shown on Enclosure 2. Boreholes 1 and 3 were put down on the river banks, and borehole 2 in the centre of the river from a raft. The holes were advanced to the bedrock by washboring methods, and were continued using diamond drilling techniques.

Standard penetration tests were carried out at frequent intervals of depth in the overburden, as detailed on Appendix A, and the results are recorded on the Geotechnical Data Sheets as "N" values.

Dynamic cone penetration tests were performed adjacent to boreholes 1 and 3, to obtain an indication of soil density changes with depth. The same source of energy was used to drive the cone as was used for the standard penetration test.

Elevations were referred to a benchmark which was supplied by the client (B.M. #2. Top of curb, southwest corner of existing bridge, El. 79.37 feet).

IV SUBSURFACE CONDITIONS

Detailed descriptions of the strata encountered in the boreholes are presented on the Geotechnical Data Sheets, comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is given in the form of a Subsurface Profile on Enclosure 2.

The boreholes revealed the following general ground succession:-

	<u>Thickness</u>
(a) Topsoil (Boreholes 1 and 3)	1' - 0" to 2' - 0"
(b) Loose organic silty fine sand and soft organic sandy clayey silt (Flood Plain Deposits). These deposits can be attributed to deposition by the existing river during its frequent seasonal flooding periods.	5' - 6" to 7' - 0"
(c) Brown fine to coarse sand. This stratum was encountered in all 3 boreholes and its relative density is described as 'compact' to 'dense' as estimated from standard penetration test results ranging from 13 to 41 blows per foot.	9' - 0" to 13' - 0"
(d) Brown sandy gravel (boreholes 1 and 3). The relative density of this stratum is described as 'dense' as estimated from standard penetration test values of 46 and 54 blows per foot.	3' - 6" to 4' - 6"
(e) Very dense gravel in matrix of sandy clayey silt. This type of deposit is often described as limestone till and consists of gravel size fragments of limestone in a matrix of fine limestone flour. It is formed by the abrasive action of the glacier on the limestone bedrock and is therefore usually found in close proximity to the bedrock.	2' - 6" borehole 1

- (f) Limestone (Bedrock). The upper 6-inches to 1 foot 6-inches of the bedrock was found to be fragmented and gave a core recovery of about 50%. Below this upper weathered layer, the rock was found to be in a sound condition and the average core recovery was 95%.

maximum penetrated  
10' - 0"

## V GROUNDWATER CONDITIONS

The level of the river rose during the time the field work was carried out and was observed at El. 70.3 on January 20 and at El. 73.2 on January 26.

Due to the granular nature of the overburden the groundwater table can be expected to correspond closely to the level of the river at any particular time.

## VI DISCUSSION AND RECOMMENDATIONS

The natural soil profile consists of granular deposits ranging from well-graded sand to sandy gravel overlying bedrock which was encountered 8 feet below the river bed. The two span structure consisting of stub abutments and centre pier will therefore be supported on a piled foundation bearing in the bedrock as in the case of the abutments, and the centre pier will be supported directly on the bedrock to preclude undermining due to scour.



### Abutments

It is understood that the abutments will be supported on piles driven through the approach embankment fill. Under the existing soil conditions the piles should be driven to refusal in the bedrock, and in this case, the maximum working load may be used for the particular pile.

Steel H-piles would appear to be the most suitable type to use because of their low resistance to penetration, and consequently they would penetrate further into the bedrock.

The following are typical working loads which would be appropriate in the design of a steel H-pile foundations:-

<u>Size of Pile</u>	<u>Working Loads (Tons)</u>
8BP36	63
10RP42	74
10BP57	100
12BP53	93

The above working loads are based on an allowable stress of 12,000 p.s.i. which is usually applied to piles driven to refusal in medium hard rock. Many loading tests have proved that when an H-pile is driven to refusal on rock, load at failure will correspond to a stress in the steel in the range 35,000 to 40,000 p.s.i., which will provide a generous factor of safety against the 12,000 p.s.i. stress recommended.

The general rule for refusal of a pile is that 5 blows of an adequate hammer produce a total penetration of 1/4 inch. Driving should then cease, provided that the pile has not hit an obstruction, and has been driven to the depth at which the borings indicate rock. When piles are driven to refusal in rock, pile loading tests are not generally considered necessary.

#### Centre Pier

From the borehole results it may be assumed that the surface of the bedrock is between 8 and 10 feet below the river bed, therefore it would appear to be the logical choice of bearing stratum.

A maximum allowable bearing pressure of 40,000 p.s.f. is recommended by the National Building Code for footings placed on sound sedimentary rock. The coefficient of friction between the rock and the concrete may be taken as 0.5, and the factor of safety against sliding should be at least 1.5. Additional sliding resistance may be generated by means of a key into the rock.

It is most important that the rock surface should be thoroughly clean and roughened when the concrete is poured, all loose, fractured or weathered material being removed.

Due to the permeable nature of the overburden, excavation for the centre pier footing will have to be carried out inside a sheet-pile enclosure, which should be driven down to the surface of the bedrock. Providing that an adequate seal is obtained,

dewatering may be carried out by pumping, however due to the fractured condition of the bedrock surface, the inflow of water may be too great to handle. In this case, tremie concrete will be required to seal the bottom of the enclosure, and prior to pouring the concrete, close attention should be given to ensure that the concrete is poured on a firm base and that no loose or disturbed material exists below the footing.

#### Approach Embankments

The flood plain deposits encountered on each river bank are susceptible to settlement and also provide a weak plane along which slope failures may occur. It is therefore recommended that these deposits be removed over the area of the approach embankment prior to placement of the embankment fill.

The embankment fill should be placed in layers not exceeding 6-inches in thickness, and compacted to at least 95% of its maximum Proctor dry density. The maximum particle size of the fill should be restricted to 3-inches diameter to ensure proper alignment of the piles.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED



*C.J.W. Atkinson*  
 C.J.W. Atkinson, M.Sc., P.Eng.,  
 Branch Manager

CJWA:jms

## APPENDIX A

### STANDARD PENETRATION TESTS

In order to determine the relative density of non-cohesive soils, such as sands and gravels, the standard penetration test has been adopted. The test also gives an indication of the consistency of cohesive soils.

A two-inch external diameter thick-walled sample tube is driven into the ground at the bottom of the borehole by means of a 140 lb. hammer falling freely through 30 in. The tube is first driven an initial 6 in. to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows (N) required to drive the sampler a further 12 in. is recorded. The sample tube used is one originally developed by the Raymond Concrete Pile Company in the United States, where a sufficient number of tests have been made in conjunction with field investigations to show that the results, although essentially empirical, may be applied to foundation design.

For sands:

Values of N	Density
Less than 10	Loose
Between 10 and 30	Compact
Between 30 and 50	Dense
Greater than 50	Very dense

Enclosures

# LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

## SOIL COMPONENTS AND GROUND WATER CONDITIONS.

BOULDER	COBBLE	GRAVEL	SAND	SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
U.S. Standard Sieve Size:									
> 4"	3"	4"	4.75mm	2.0	0.42	0.075	0.002		
			No. 4	No. 10	No. 40	No. 200			

## SAMPLE TYPES.

AS Auger sample	RC Rock core	TP Piston, thin walled tube sample
CS Sample from casing	% Recovery	TW Open, thin walled tube sample
CNS Chunk sample	SS Split spoon sample	WS Wash sample
SAMPLER ADVANCED BY	static weight : w	OBSERVATIONS MADE WHILE CORING
"	pressure : p	Steady pressure
"	tapping : t	No pressure
		Intermittent pressure
		Washwater returns
		Washwater lost

## PENETRATION RESISTANCES.

**DYNAMIC PENETRATION RESISTANCE** : to drive a 2"  $\phi$ , 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

**STANDARD PENETRATION RESISTANCE, -N-** : to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

**EXTRAPOLATED -N- VALUE**

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

SYMBOL :

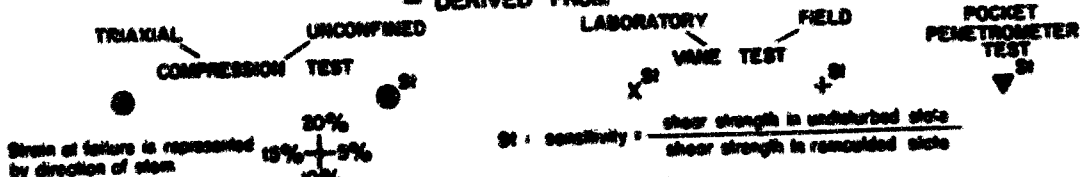


## SOIL PROPERTIES.

W % Water content	$\gamma$ Natural bulk density (unit weight)	k Coeff. of permeability
LL % Liquid limit	e Void ratio	C Shear strength in terms of total stress
PL % Plastic limit	RD Relative density	$\phi$ Angle of int. friction in terms of effective stress
PI % Plasticity index	Cv Coeff. of consolidation	C Cohesion
LI Liquidity index	$m_v$ Coeff. of volume compressibility	$\phi'$ Angle of int. friction

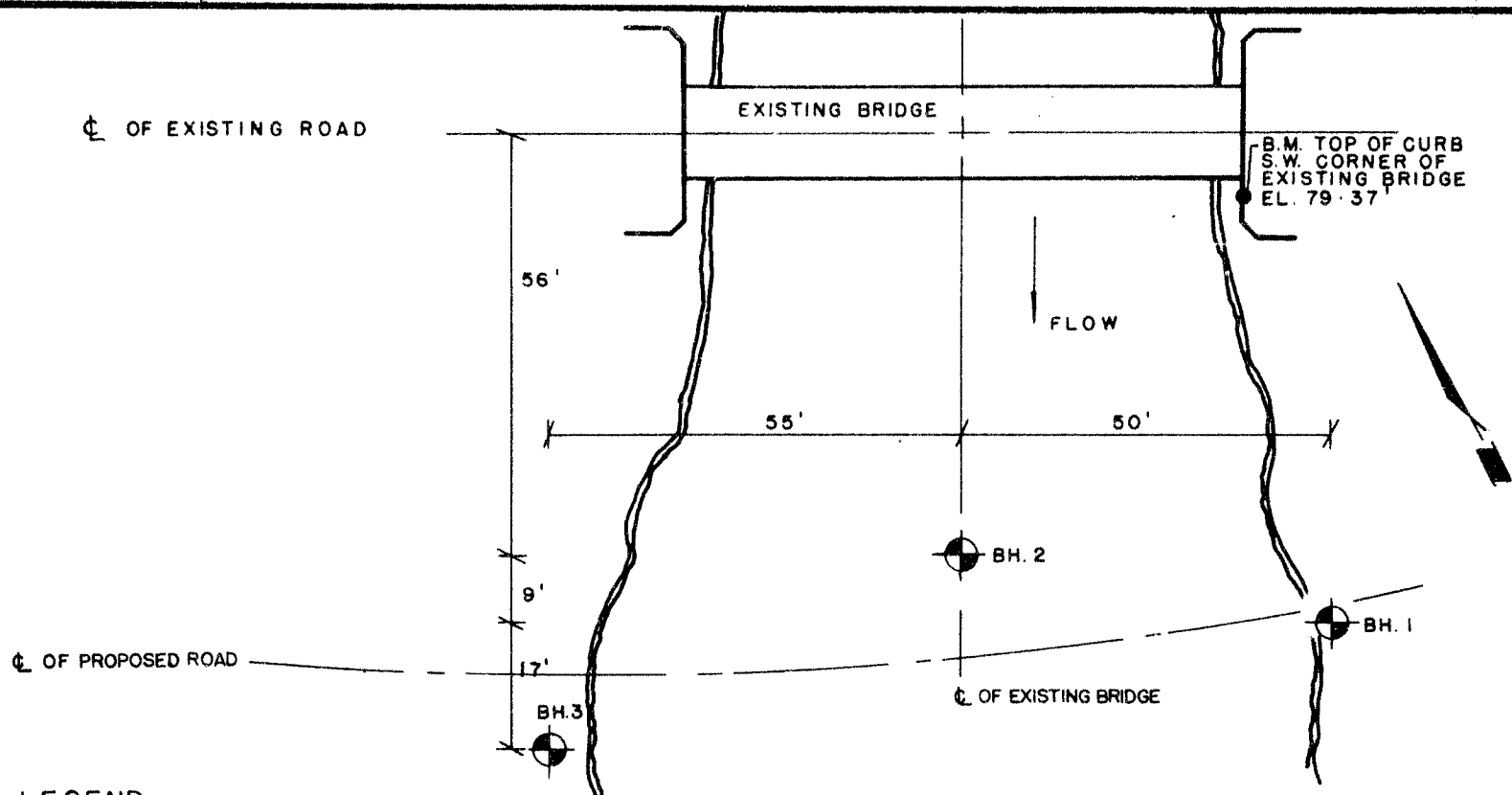
## UNDRAINED SHEAR STRENGTH.

- DERIVED FROM -



## SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS :	C lbs./sq. ft.
Very loose	0 - 15 %	Very soft	less than 250
Loose	15 - 35 %	Soft	250 - 500
	35 - 60 %	Firm	500 - 1000



# LEGEND

TOPSOIL

## LOCATION OF BOREHOLES SCALE 1" = 20'

LOOSE ORGANIC SILTY FINE SAND

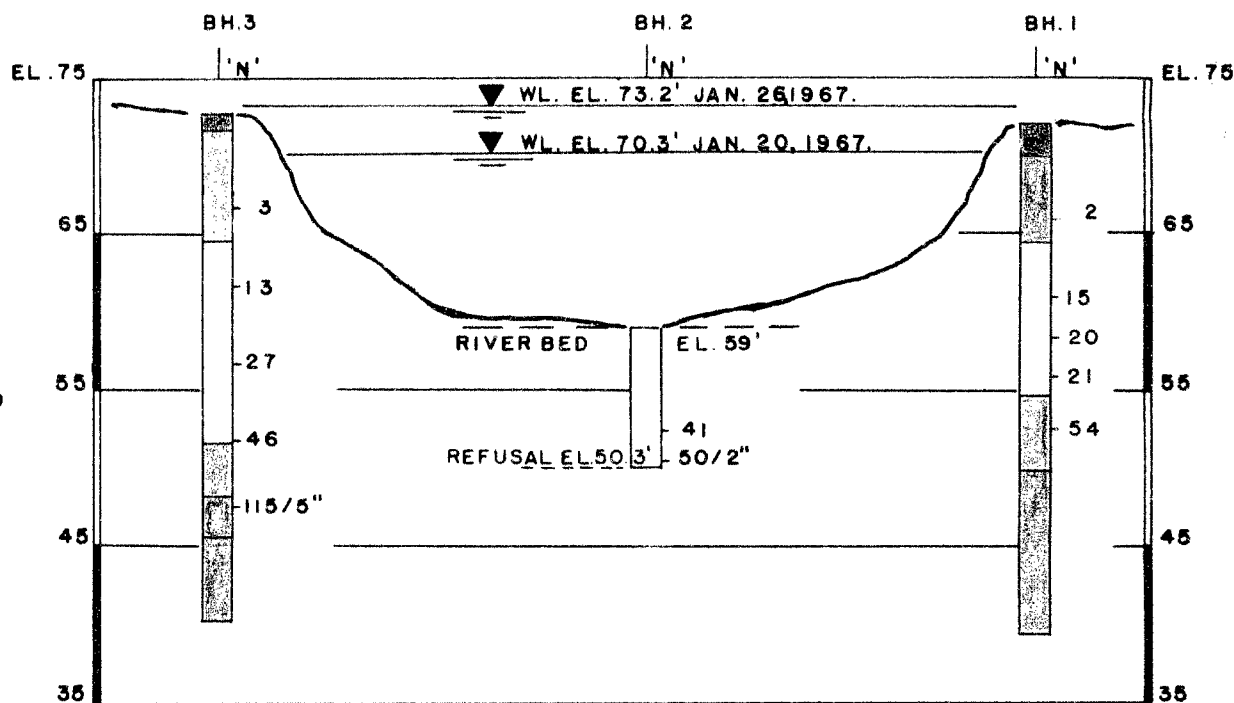
SOFT ORGANIC SANDY CLAYEY SILT

COMPACT TO DENSE FINE TO COARSE SAND

DENSE SANDY GRAVEL

VERY DENSE GRAVEL IN A MATRIX OF CLAYEY SANDY SILT

BED ROCK



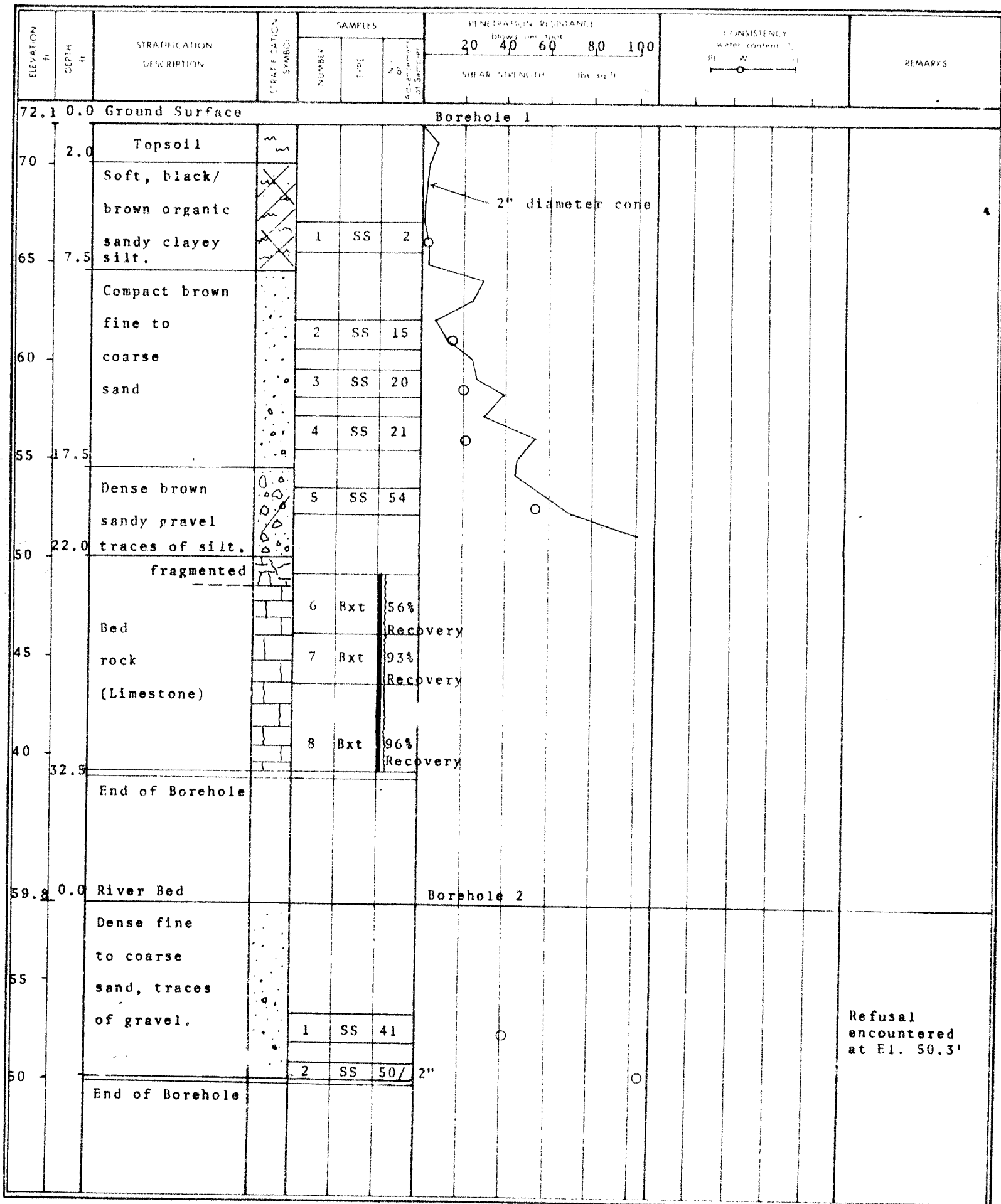
## SUBSURFACE PROFILE VERT. SCALE 1" = 10'

# GEOTECHNICAL DATA SHEET FOR BOREHOLES 1 & 2

OUR REFERENCE NO. 7-1-11

CLIENT Ure & Smith Limited  
 PROJECT Proposed Bridge  
 LOCATION Townline of West & North Oxford  
 DATUM ELEVATION 79.37 (See Enclosure 2)

METHOD OF BORING Washboring and Diamond Coring  
 DIAMETER OF BOREHOLE Bx (3-inch)  
 DATE January 19 - 24, 1967.  
 ENCLOSURE NO 3



VERTICAL SCALE: 1 IN TO

5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE

CHD



# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . . 3 . . .

OUR REFERENCE NO. 7-1-L1

CLIENT Ure & Smith Limited  
 PROJECT Proposed Bridge  
 LOCATION Townline of West & North Oxford.  
 DATUM ELEVATION 79.37 (See Enclosure 2)

METHOD OF BORING Washboring & Diamond coring 4  
 DIAMETER OF BOREHOLE Bx (3-inch)  
 DATE January 24 - 28, 1967

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE Blows per foot					CONSISTENCY water content %		REMARKS
				NUMBER	TYPE	or Advancement of Sampler	20	40	60	80	100	PI	W	
72.8	0.0	Ground Surface												
	1.0	Topsoil												
70		Loose brown organic silty fine sand.		1	SS	3								
65	8.0	Compact brown fine to coarse sand		2	SS	13								
60				3	SS	27								
55														
21.0				4	SS	46								
50	24.5	Dense brown sandy gravel												
27.0		Very dense grey gravel in a matrix of sandy clayey/fragmentary silt.		5	SS	115	5"							
45		Bed rock (Limestone)		6	Bxt	96%	Recovery							
40	32.5	End of Borehole												

VERTICAL SCALE 1 IN TO 5 FT

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