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DIST. 3 REGION

W.P. No.

CONT. No.

W. O. No. 73-F-201M

STR. SITE No. 23-94

HWY. No.

LOCATION Thames River Bridge
Lot 16/17 Twp of E. Zorra

Notes -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

- 73-F-201 M -

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73-F-201 M

SPRINGBANK CONSULTING ENGINEERS LTD.
35 Springbank Avenue
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40P2-34
GEOCRES No.

Report on
SOIL INVESTIGATION
for
THAMES RIVER BRIDGE
LOT 16 CONCESSIONS 16/17
TOWNSHIP OF E. ZORRA
LOTS 10/11 CONCESSION 9
TOWNSHIP OF BLANDFORD

DIST 2

M.T.C. SITE 23-94.

by

Dominion Soil Investigation Limited
1220 Trafalgar Street
London Ontario

Ref: 73-2-L7

March 13, 1973

STRUCTURE SITE No. 23-94

C O N T E N T S

E N C L O S U R E S

73-2-L7

SUMMARY

The investigation has revealed that the major strata consist of 'compact' to 'very dense' sand and gravel, which extends to a depth of 9 to 10 feet below the river bed, overlying a 'very dense' glacial sandy silt till which was penetrated to a depth of 10 feet.

It is recommended that spread footing foundations be designed using a maximum allowable soil pressure of 7000 p.s.f., and total settlement of the structure is estimated to be 1-inch or less.

The use of driven steel tube or H-piles is also discussed in the report as an alternative type of foundation.

I INTRODUCTION

In accordance with verbal authorization on February 20, 1973, from Springbank Consulting Engineers Limited, a soil investigation has been carried out on the East Zorra-Blandford Townline, where it is proposed to replace an existing road bridge with a new structure and to realign the existing road slightly to the east of the existing structure.

The existing structure is located on the road between Concessions 16-17 of East Zorra Township and Concession 9 of Blandford Township, where it crosses the Thames River. The river is the townline at this point.

It is understood that the proposed structure is a single span bridge with either a span of 100 to 110 feet using stub abutments or a span of 60 to 65 feet using abutments supported by spread footings. The requirements of the project were discussed with Mr. J.B. Chambers, who supplied the foregoing information. The boreholes were put down at locations staked out by Mr. Chambers, which represented the approximate locations of proposed abutments.

The purpose of the investigation was to reveal the sub-surface and groundwater conditions at the site, and to determine the relevant soil properties for the design and construction of the new foundations.

II FIELD WORK

The field work, consisting of two boreholes accompanied by two dynamic cone penetration tests, was carried out on February 26 and 27, 1973, at the locations shown on Enclosure 2. The holes were advanced by a continuous flight auger machine mounted on a bombardier, which was equipped for soil sampling.

Standard penetration tests were performed at 2½ or 5 foot intervals of depth, as detailed in Appendix 'A', and the results are recorded on the borehole logs as 'N' values. The split-spoon samples were stored in air-tight containers and transferred to our London laboratory for classification and testing.

The dynamic cone penetration tests were performed adjacent to the borehole locations to obtain an indication of soil density and strata changes with depth. The energy

used to drive the cone was the same as was used for the standard penetration tests.

The field work was supervised by a soils engineer, who also determined the ground surface elevations. These were referred to two 4 inch nails in the base of a 14-inch diameter ash tree at Station 30+10. The bench-mark was established by the client and given a value, El. 61.58 feet.

III SUBSURFACE CONDITIONS

Detailed descriptions of the strata, which were encountered in the boreholes, are given on the borehole logs comprising Enclosure 3, and a general picture of the soil strati-graphy is presented in the form of a Subsurface Profile on Enclosure 4. The following notes are intended only to amplify this data.

Borehole 1 penetrated a layer of brown silty topsoil to a depth of 2 feet, followed by a 'loose' brown fine sand layer to 5.5 feet. A thin layer of peat containing fragments of wood was penetrated between 5.5 and 6.0 feet.

Borehole 2 penetrated a layer of soft brown and green clayey silt to a depth of 4 feet, followed by a 2 foot thick layer of brown peat.

The following soil profile was observed in both boreholes:-

Compact to very dense sand and gravel

This stratum exists between depths of 6 and 16 feet at borehole 1 location, and 6 and 17 feet at borehole 2 location. The material is a well-graded sand and gravel in the upper few feet of the stratum becoming more silty with depth. Cobble sizes were encountered in boreholes 1 and 2 below depths of 12 and 15 feet respectively. Grading analyses were performed on 3 representative samples of this stratum, and the results are shown as grain size distribution curves on Enclosure 5.

The relative density of this stratum is described as 'compact' to 'very dense' based on 'N' values ranging from 21 blows per foot to 100 blows for a 5 inch penetration of the sampler.

Dense to very dense sandy silt, traces of gravel and clay.

The glacial sandy silt stratum underlies the 'compact' to 'very dense' sand and gravel stratum, and was encountered at El. 44 and El. 43 in boreholes 1 and 2 respectively. The boreholes were terminated in the sandy silt at El.35 and El. 40. Sieve and hydrometer analyses were performed on a representative sample from borehole 1, and the results are shown as a grain size distribution curve on Enclosure 5.

The relative density of the sandy silt is described as 'dense' to very dense' based on 'N' values ranging from 34 blows per foot to 100 blows for a 2 inch penetration of the sampler.

IV GROUNDWATER CONDITIONS

Equilibrium water levels were observed at El. 56.1 and El. 56.7 in boreholes 1 and 2 respectively. The river was covered with a 10 to 12 inch thick layer of ice at the time the field work was carried out and the ice level was El. 56.1.

V DISCUSSION AND RECOMMENDATIONS

Spread Footing Foundations

Several depths of ice and water were measured in the vicinity of the existing and proposed bridges. These depths ranged from 2.0 to 3.1 feet for the proposed new bridge and a depth of 5.3 feet was measured under the existing bridge. The location of these points along with their respective depths are designated P1 to P5 and are recorded on Enclosure 2 of this report. It is therefore recommended that spread footing foundations be located at or below El. 49 to provide sufficient protection against frost action, and deeper if a hydrology study indicates that a greater depth of scour may be expected. The sand and gravel material should be considered to be not unduly susceptible to scour.

On the basis of the borehole results a maximum allowable soil pressure of 7000 p.s.f. is appropriate for the design of footings at or below El. 49, and this soil pressure incorporates a factor of safety of at least 3 against shear failure of the underlying soil. Total

settlement of the footings is estimated to be less than 1 inch with no appreciable differential settlement anticipated.

The coefficient of friction between the footings and the underlying sand and gravel stratum may be taken as 0.5, and the factor of safety against horizontal sliding of the abutments must be at least 1.5.

A major problem in the construction of the footings will be to control the groundwater and prevent 'sloughing-in' of the sides of the excavation or disturbance to the subgrade due to 'bottom heave'. This can be achieved by carrying out the excavation inside rigid sheeting which should be driven into the glacial sandy silt stratum to seal the bottom of the excavation and reduce the flow of water below the sheeting. The sheeting may be left in place as a positive means of scour protection.

Piled Foundation

The pile foundation is an alternative to the use of spread footing foundations with the problem of minimising

disturbance to the footing grade.

Driven steel tube or H-piles would appear to be the most suitable type to use and it is estimated that an adequate set will be obtained if they were driven to El. 40 and El. 30 for tube and H-piles respectively. Timber piles are not considered suitable for this site due to the hard driving conditions.

H-piles may be designed to a working stress of 12,000 p.s.f. for the steel, and working loads of 60 and 100 tons may be used for 10.75 inch and 12.75 inch diameter tube piles.

The foregoing estimates of length and bearing capacity of piles are only theoretical predictions. In practice, the piles should be driven to a satisfactory set in accordance with a recognized dynamic pile driving formula.

Yours very truly,

DOMINION SOIL INVESTIGATION LTD.

D.G. McLean, P.Eng.
Project Engineer

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

DGMcL:eg

APPENDIX 'A'

THE STANDARD PENETRATION TEST.

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.

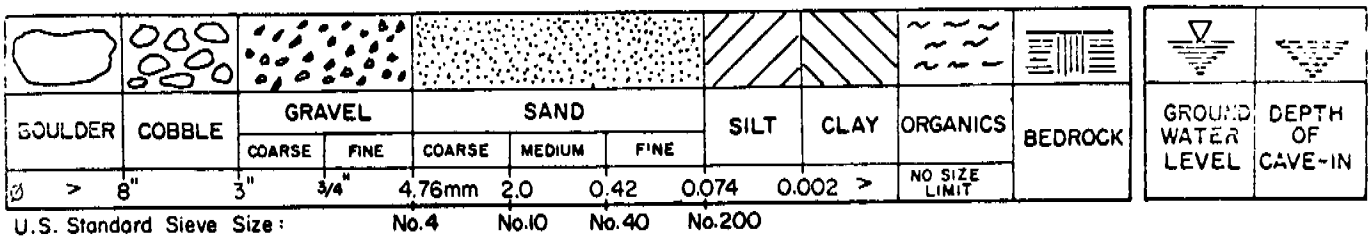
A two inch external diameter thick-walled sample tube is driven into the ground at the bottom of the borehole by means of a 140 lb. hammer falling freely through 30-ins. The tube is first driven an initial 6-inches to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows (N) required to drive the sampler a further 12-in. is recorded. The sample tube is one originally developed by 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

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.



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
ChS	Chunk sample	SS	Split spoon sample	WS	Wash sample

SAMPLER ADVANCED BY static weight : w
" pressure : p
" tapping : t

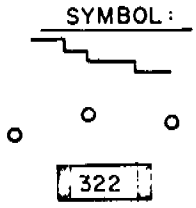
OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure; Washwater returns; Washwater lost

PENETRATION RESISTANCES.

DYNAMIC PENETRATION RESISTANCE : to drive a 2"ϕ, 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.

SYMBOL :



EXTRAPOLATED -N- VALUE

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

SOIL PROPERTIES.

W %	Water content	γ	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	ϕ	Angle of int. friction — in terms of total stress
PI %	Plasticity index	C_v	Coeff. of consolidation	C'	Cohesion — in terms of effective stress
LI	Liquidity index	m_v	Coeff. of volume compressibility	ϕ'	Angle of int. friction — in terms of effective stress

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL COMPRESSION TEST ◎ — UNCONFINED ○ St — LABORATORY VANE TEST X St — FIELD VANE TEST + St — POCKET PENETROMETER TEST - St

Strain at failure is represented by direction of stem: 20% / 15% — 5% / 10%

St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

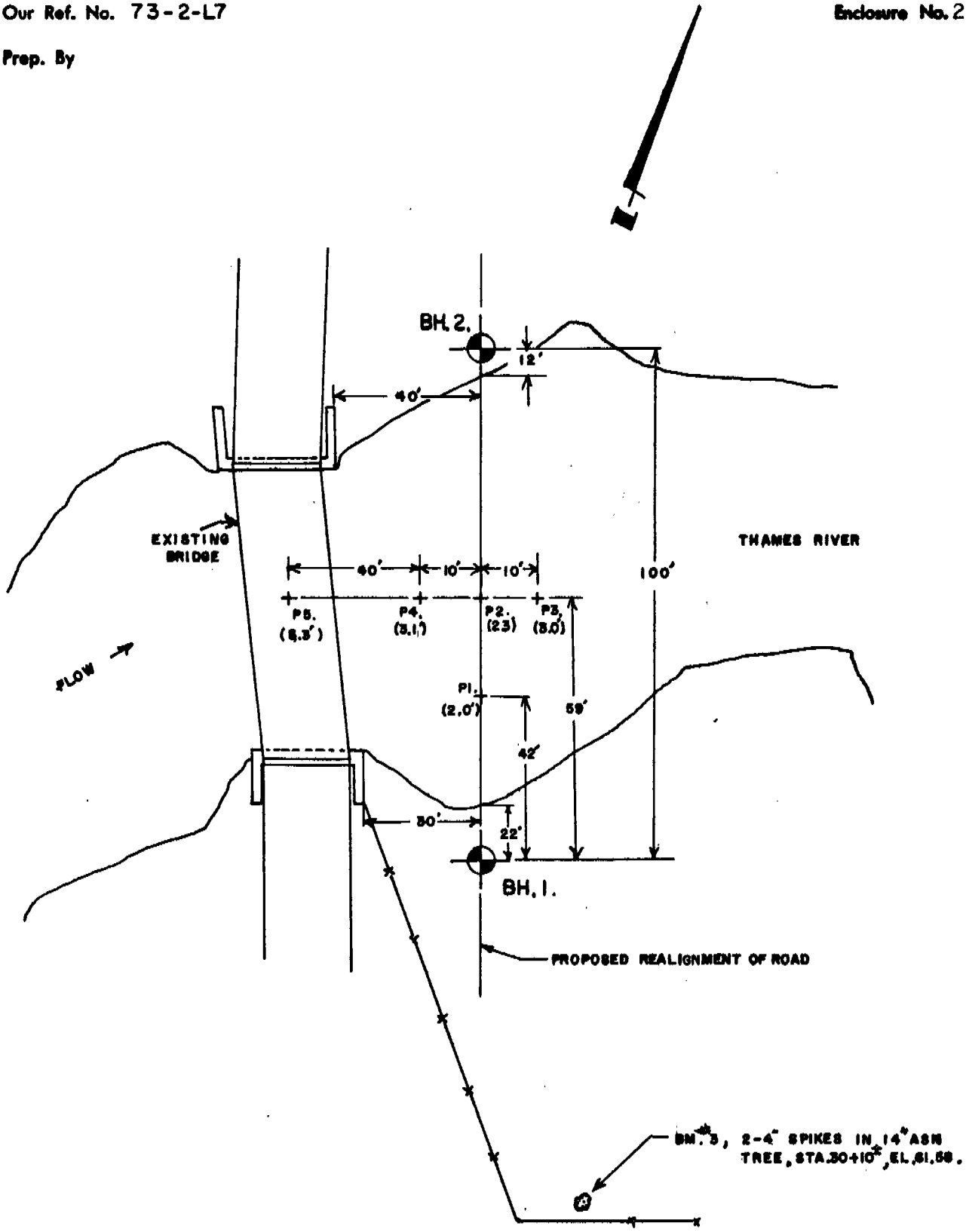
SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS	C lbs/sq.ft
Very loose	0 - 15 %	Very soft	less than 250
Loose	15 - 35 %	Soft	250 - 500
Compact	35 - 65 %	Firm	500 - 1000
Dense	65 - 85 %	Stiff	1000 - 2000
Very dense	85 - 100 %	Very stiff	2000 - 4000
		Hard	over 4000

Our Ref. No. 73-2-L7

Enclosure No. 2.

Prep. By



LOCATION OF BOREHOLES

(N.T.S.)

DOMINION SOIL INVESTIGATION LIMITED

LOG OF BOREHOLE 1 & 2

Our Reference Nº 73-2-L7

Enclosure Nº 3

CLIENT: Springbank Consulting Engineers Ltd.
PROJECT: Proposed Bridge & Road Realignment.
LOCATION: East Zorra & Blandford Townline.
DATUM ELEVATION: See Enclosure 2.

DRILLING DATA
Method: Auger.
Diameter: 4.5 inches.
Date: February 26 & 27, 1973.

ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Foot	PENETRATION RESISTANCE Blows/Foot (20 40 60 80 100) / UNDRAINED SHEAR STRENGTH lbs/sq.ft. + FIELD VANE TEST ● COMPRESSION TEST (20 40 60 80 100)	WATER CONTENT % PLASTIC LIMIT W_P NATURAL W LIQUID LIMIT W_L (10 20 30 40 50)	REMARKS
Borehole 1										
601	0.0	Ground Surface								
	2.0	Brown silty topsoil.								
		Loose brown fine sand, some silt and gravel.		▼				2 inch diameter dynamic cone.		
55	5.5	Peat.			1	SS	19			
	6.0	Compact to dense silty sand & gravel, occasional cobbles.			2	SS	30			
50					3	SS	21			
					4	SS	38			
45					5	SS	34			Samples 3 & 6 grain size distribution curves. See Enclosure 4.
	16.0	Very dense brown sandy silt, with traces of gravel & clay. (Glacial till)								
40					6	SS	120			
35	25.5	End of Borehole			7	SS	100/6½"			
Borehole 2										
602	0.0	Ground Surface								
		Soft brown and green clayey silt.		▼				2 inch diameter dynamic cone.		
	4.0	Peat.			1	SS	31			
55		Very dense sand and gravel, trace of silt, occasional cobbles.			2	SS	55			
50					3	SS	71			Samples 2 & 3 grain size distribution curves. See Enclosure 4.
					4	SS	104			
45					5	SS	100/5"			
	17.0	Very dense br. sandy silt, traces of gravel and clay.								
40	20.2	End of Borehole			6	SS	100/2"			

VERTICAL SCALE: 1 inch to 5 feet

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MADE: CHECKED:

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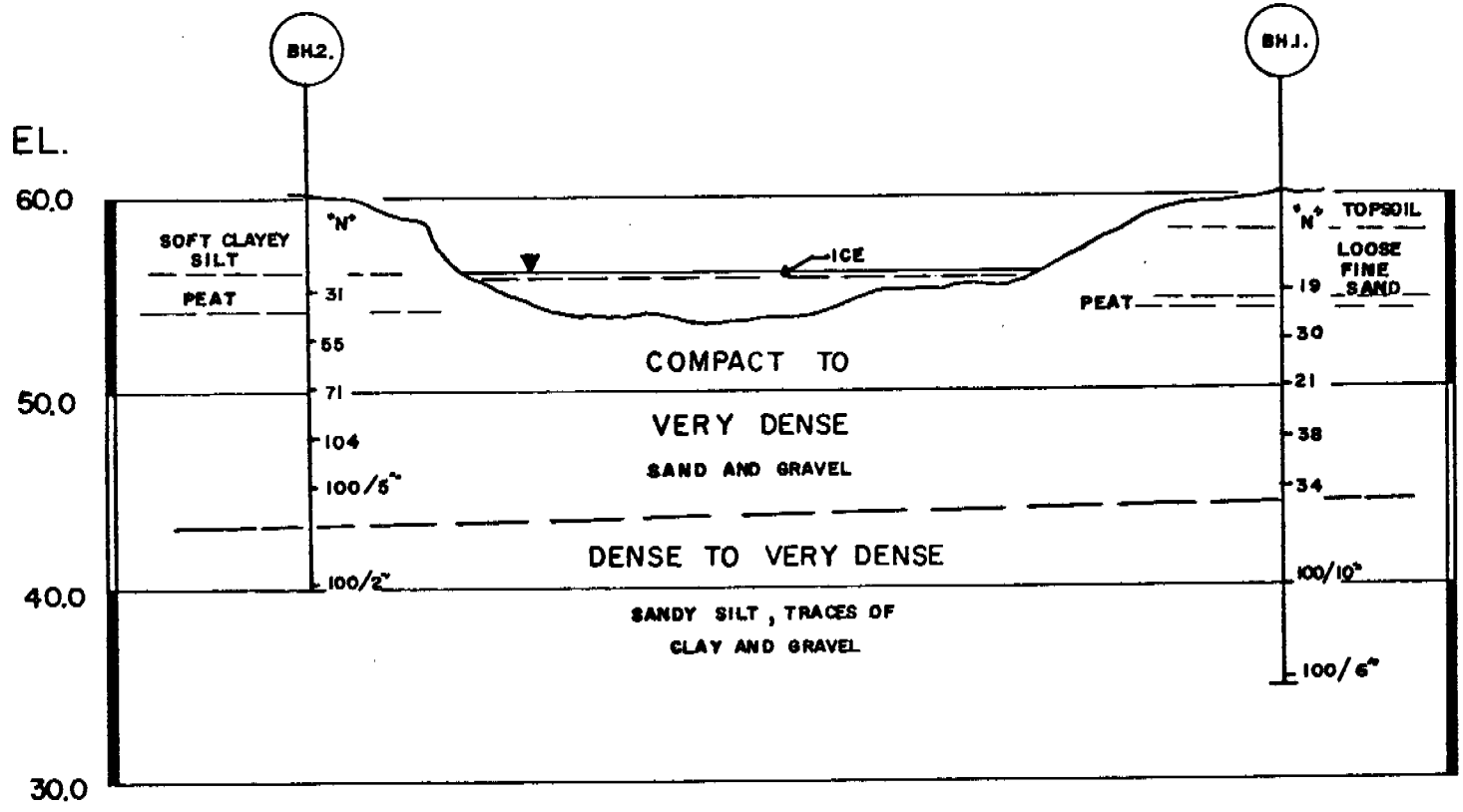


SUBSURFACE PROFILE

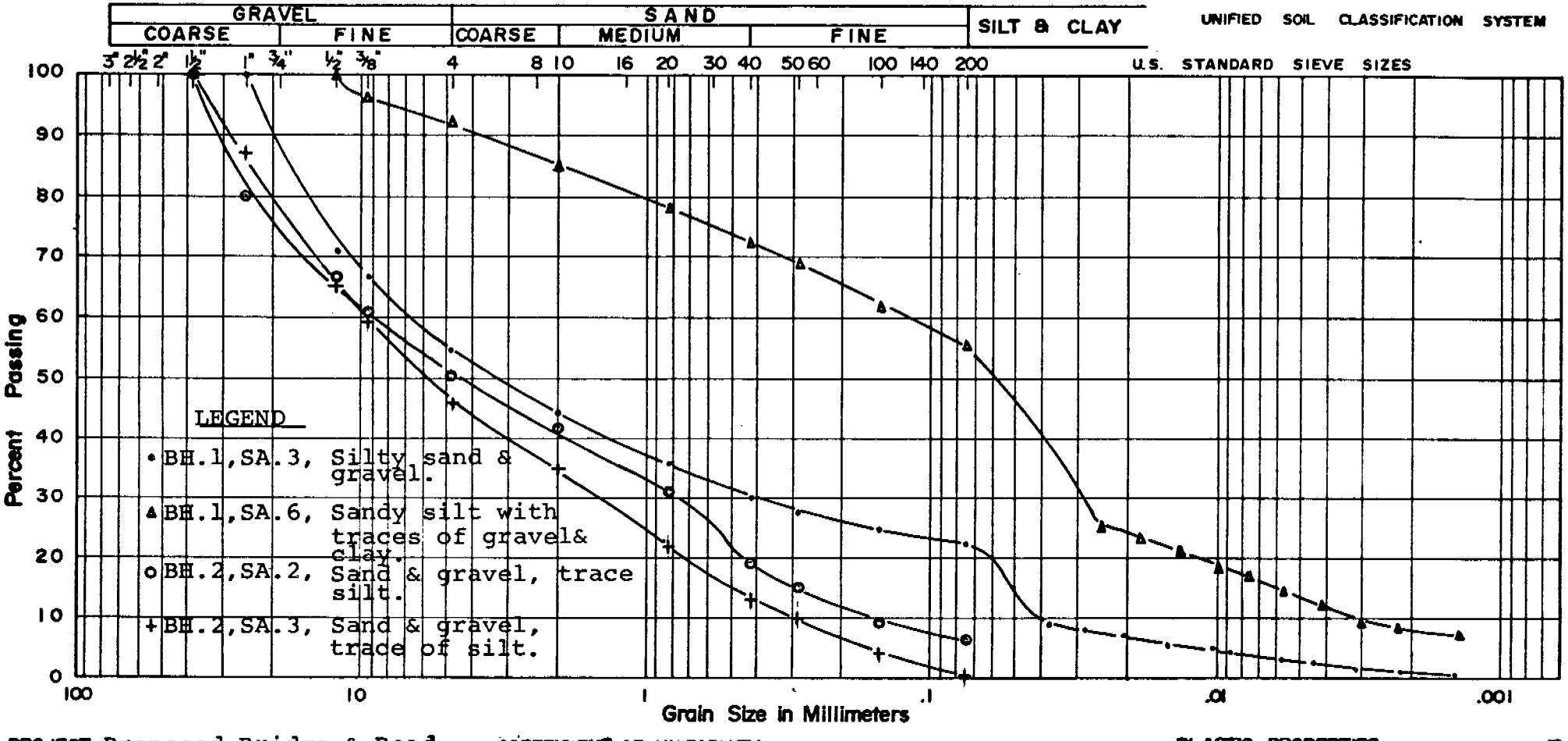
SCALE: HOR.: 1" = 20'
VERT: 1" = 10'

Enclosure No. 4.

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 73-2-L7



PROJECT: Proposed Bridge & Road Realinement.

LOCATION: East Zorra & Blandford Townline.

BOREHOLE Nº:

SAMPLE Nº:

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

ENCLOSURE Nº 5