

#67-F-245M

BRIDGE &

2 CULVERTS

CONS. 243

BA 2523
Site 19-C

A. M. SPRIET AND ASSOCIATES LIMITED
CONSULTING ENGINEERS
LONDON ONTARIO

Report on
SOIL INVESTIGATION
for
BRIDGE and TWO CULVERTS
CONCESSIONS 2 & 3
TOWNSHIP OF BIDDULPH

by
DOMINION SOIL INVESTIGATION LIMITED
369 Queens Avenue
LONDON ONTARIO

Reference No. 6-11-L17
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SUMMARY

The four boreholes revealed fill deposits associated with the existing road construction overlying dense to very dense sand and gravel, and glacial sandy silt substrata.

It is recommended that the structures be supported on spread footings, 4 to 5 feet below the respective creek beds, using a maximum net soil pressure of 10,000 p.s.f. for the design. Total settlement is estimated to be less than 1-inch.

Construction problems at each site are discussed separately in the report.

I INTRODUCTION

The soil investigation was authorized by A. M. Spriet & Associates Limited, Consulting Engineers, acting on behalf of the Township of Biddulph, and consisted of 4 boreholes.

The site is located on the road allowance between Concessions 2 and 3 of the Township immediately to the East of Clandeboye where it is proposed to replace an existing steel-truss bridge and two concrete culverts with new structures. The new structures will have the same centre lines as the existing ones.

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

II THE SITE AND GEOLOGY

The site lies in a flood-plain area of the Little Ausable River which ultimately flows into the Ausable River. The topography of the area is undulating with the general drainage and ground contours falling to the south-west.

The physiographic region known as the Stratford Till Plain is an area of ground moraine interrupted by several terminal moraines. The till is usually fairly uniform being a brown calcareous silty clay whether on the ridges or the more level ground moraine.

III FIELD WORK

The field work, consisting of 2 boreholes at the bridge site and one borehole at each of the culvert sites, was carried out during the period December 20 to 23, 1966, at the locations shown on Enclosure 2. The holes were advanced to the sampling depths by washboring methods and were lined with Bx size casing.

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

Elevations were referred to a nail in a tree trunk, 120 feet east of Sta 0+00, which was given the arbitrary value, El. 100 feet.

IV SUBSURFACE CONDITIONS

Detailed descriptions of the strata encountered in each borehole are given 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 following notes are intended only to amplify this data.

Fill

Boreholes 2, 3 and 4 penetrated fill deposits which are associated with the backfill of the existing bridge and culvert footings, and also the construction of the road embankment.

Sandy silt containing some gravel and a trace of clay.

This material is the predominant soil type encountered in each borehole and is classified as a glacial moraine deposit. A grain size analysis of the material, plotted as a distribution curve on Enclosure 5, indicates that the proportions of the soil types are 39% silt, 47% sand, 8% clay and 6% fine gravel size.

The results of standard penetration tests range from 34 blows per foot to values in excess of 100 blows per foot, indicating a 'dense' to 'very dense' relative density.

Sandy gravel and, well-graded sand and gravel.

This material was encountered above the sandy silt till stratum in boreholes 2 and 3. Grain size distribution curves of two samples plotted on Enclosures 6 and 7 indicate the following proportions of the soil types: silt 15%, sand 20% to 37% and gravel 48% to 65%.

The results of standard penetration tests range from 31 blows per foot to a refusal value of 100 blows for a 6-inch penetration of the sampler, indicating a 'dense' to 'very dense' relative density.

Cemented silty sand and gravel (Borehole 4)

A grain size analysis of the material, plotted as a distribution curve on Enclosure 8, indicates that the proportions of the soil types are 14% silt, 48% sand and 38% gravel. These closely resemble the proportions of the sand and gravel stratum encountered in boreholes 2 and 3. However, due to the very dense nature of the deposit the material exhibits some cementation and consequently has a low permeability.

Clayey silt, seams of sand and gravel (Borehole 4)

Due to the clay content this material exhibits some cohesion and plasticity. Standard penetration tests gave 'N' values of 31 blows per foot and 125 blows for a 3-inch penetration of the sampler, indicating a 'very stiff' consistency.

V GROUNDWATER CONDITIONS

Observations of the groundwater in each borehole after completion of the boring gave levels ranging from El. 90.2 to El. 93.0, which are closely related to the water levels in the adjacent creek at the time the field work was carried out.

VI DISCUSSION AND RECOMMENDATIONSBridge Site (Boreholes 1 and 2)

The bed of the river extends to El. 88.0 therefore allowing 4 feet of cover for frost protection, it is recommended that the footings should bear at or below El. 84. The footing depth should be decided after a hydrological study has been made to determine the maximum depth of scour. The above level lies within the very

dense sandy silt till stratum at borehole 1 location, and within the very dense sandy gravel stratum at borehole 2 location, and on the basis of the borehole results, a maximum net soil pressure of 10,000 p.s.f. is appropriate for the design of footings. Furthermore the footings will have a factor of safety of at least 3 against shear failure of the underlying soil.

It is estimated that total settlement of footings mobilizing the above soil pressure will not exceed 1-inch and in view of the similar conditions encountered in the two boreholes no appreciable differential settlement is anticipated.

The coefficient of friction between the footings and the underlying soil may be taken as 0.35 and the factor of safety against horizontal sliding of the abutments should be at least 1.5.

After the river has been diverted away from the excavation it is anticipated that seepage into the north abutment excavation will be controlled by pumping from sumps dug below the footing grade. At the south abutment location the sandy gravel stratum will require lateral support to prevent a flow of soil and water into the excavation. To achieve this, sheeting should be driven into the underlying sandy silt stratum to seal the bottom of the excavation and enable the seepage to be controlled by pumping.

North Culvert (Borehole 3)

The bed of the creek extends to El. 91.6, therefore the standard culvert design will require a footing grade at about El. 87.0. This level lies within the stratum of very dense sand and gravel

and on the basis of the borehole results, a maximum net soil pressure of 10,000 p.s.f. is appropriate for the design of the footings.

Total settlement of footings mobilizing the above soil pressure is estimated to be less than 1-inch.

A major problem in the construction of the footings will be to control the groundwater since the excavation for the footings will be carried out below the water table in a pervious granular soil. It will therefore be necessary to use close sheeting around the excavations combined with the removal of seepage by means of pumping from sumps. Since the sheeting will be driven through very dense granular soils, it will be advisable to use steel sheeting which should be driven into the sandy silt till to avoid piping or heaving in the bottom of the excavation during removal of the seepage water.

An alternative method of controlling the groundwater would be to use a well-point system to lower the water table below the footing grade during the construction period. Due to the dense nature of the subsoil however, it may be necessary to pre-auger the holes prior to installation of the points.

South Culvert (Borehole 4)

The bed of the creek extends to El. 92.0 therefore the standard culvert design will require a footing grade at about El. 88.0. This level lies within the stratum of very dense cemented silty sand and gravel and on the basis of the borehole results a

maximum net soil pressure of 10,000 p.s.f. is appropriate for the design of the footings.

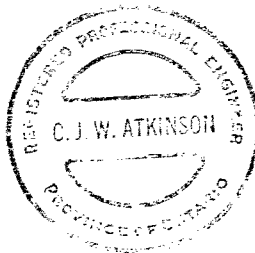
Total settlement of footings mobilizing the above soil pressure is estimated to be less than 1/2 inch.

Construction of footings below the water table and within the granular stratum will lead to some dewatering difficulties as discussed for the north culvert, therefore the possibility of using a box-culvert design should be considered.

This type of design would enable a higher footing grade to be used and consequently the problem of controlling the groundwater would be reduced.

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

D O M I N I O N S O I L I N V E S T I G A T I O N L I M I T E D

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
Ø	> 8"	3"	3/4"	4.76mm	2.0	0.42	0.074	0.002	>
U.S. Standard Sieve Size :		No. 4	No. 10	No. 40	No. 200	NO SIZE LIMIT			

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	OBSERVATIONS MADE WHILE CORING	Steady pressure	Washwater returns
"	pressure : p		No pressure	
"	tapping : t		intermittent pressure	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.

EXTRAPOLATED -N- VALUE

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

SYMBOL :



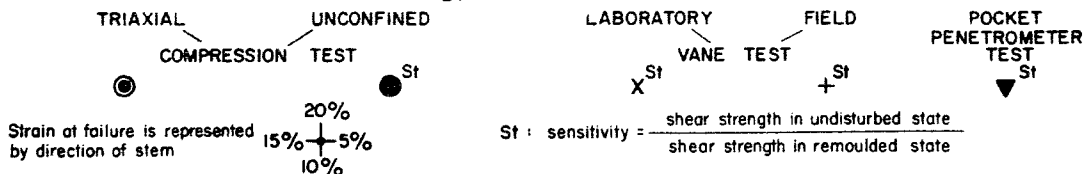
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SOIL PROPERTIES.

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 effective stress
PI % Plasticity index	C_v Coeff. of consolidation	C' Cohesion
LI Liquidity index	m_v Coeff. of volume compressibility	ϕ' Angle of int. friction

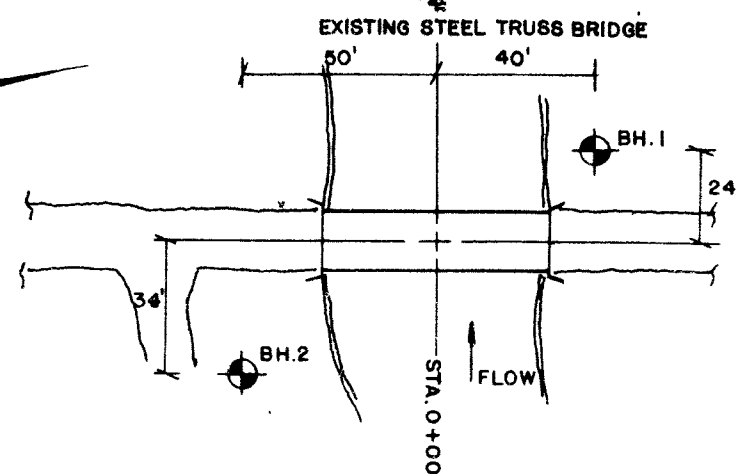
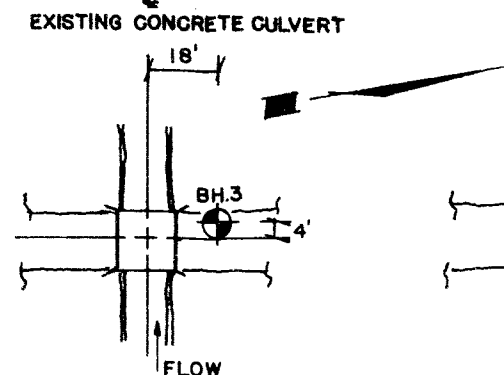
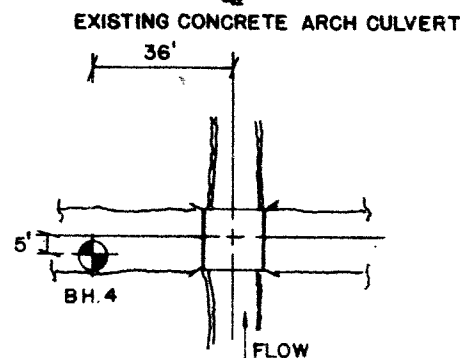
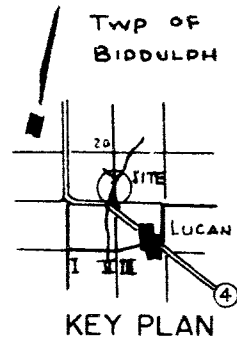
UNDRAINED SHEAR STRENGTH.

- DERIVED FROM -



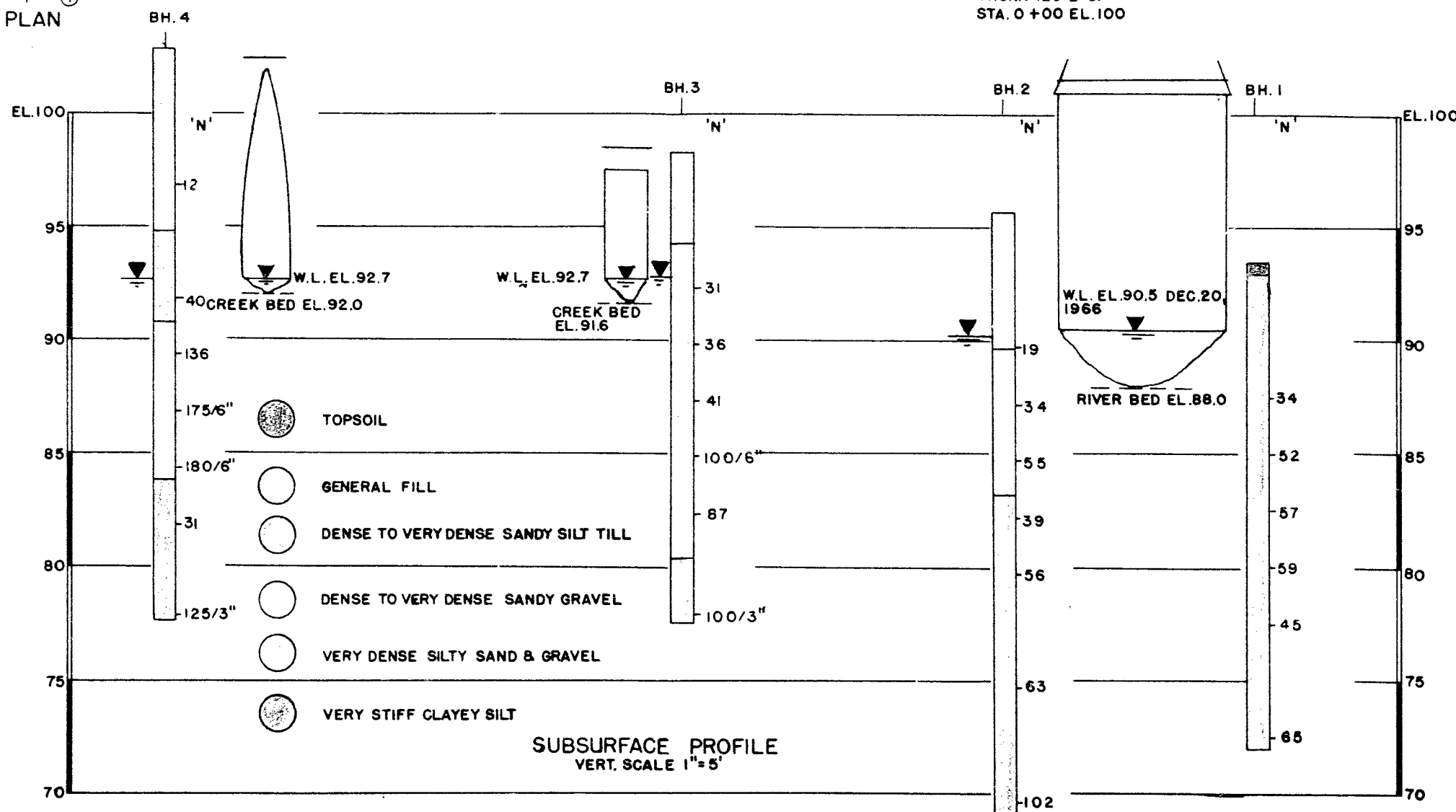
SOIL DESCRIPTION.

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



LOCATION OF BOREHOLES
SCALE 1" = 40'

B.M. NAIL IN TREE
TRUNK 120' E OF
STA. 0+00 EL. 100



OUR REFERENCE NO. 6-11-L17 GEOTECHNICAL DATA SHEET FOR BOREHOLE S.1 & 2.

CLIENT A. M. Spriet & Associates Ltd.
 PROJECT Bridge
 LOCATION Township of Riddulph
 DATUM ELEVATION 100 feet

METHOD OF BORING Washboring
 DIAMETER OF BOREHOLE Bx (3-inch)
 DATE December 20 to 23, 1966

ENCLOSURE NO 3

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %			REMARKS
				NUMBER	TYPE	ADDITIONAL NOTES	20	40	60	80	100	PL	W	U	

93.5	0.0	Ground Surface		Borehole 1													
	0.5	Topsoil	~ ~														W. L. El. 92.5
90		Dense to very dense brown sandy silt, some gravel trace of clay. (Glacial Till)		1	SS	34											
85				2	SS	52											
				3	SS	57											
80				4	SS	59											
				5	SS	45											
75																	
				6	SS	65											
	21.5	End of Borehole															
95.7	0.0	Ground Surface		Borehole 2													
		Brown clayey sand, some gravel. (Fill)															
90	6.0	Dense to very dense brown sandy gravel, trace of silt.		1	SS	19											W. L. El. 90.2
				2	SS	34											
85				3	SS	55											
				4	SS	39											
80		Dense to very dense brown sandy silt, some gravel trace of clay. (Glacial Till)		5	SS	56											
75				6	SS	63											
				7	SS	102											
70																	
	26.5	End of Borehole															

OUR REFERENCE NO 6-11-L17 GEOTECHNICAL DATA SHEET FOR BOREHOLE^S 3. & 4.

CLIENT A. M. Spriet & Associates Ltd.
PROJECT Culverts
LOCATION Township of Biddulph
DATUM ELEVATION 100 feet

METHOD OF BORING Washboring
DIAMETER OF BOREHOLE Bx (3-inch)
DATE December 20 to 23, 1966

ENCLOSURE NO 4

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE Blows per foot					CONSISTENCY water content %			REMARKS
				NUMBER	TYPE	NO. of Advances of Sampler	20	40	60	80	100	PI	W	LI	

98.4	0.0	Ground Surface														Borehole 3	
95	4.0	Sand and gravel. (Fill)															
		Dense to very dense brown well-graded sand and gravel with some silt content.		1	SS	31											W. L. El. 93.0
				2	SS	36											
				3	SS	41											
				4	SS	100/	6"										
		5	SS	87													
90																	
85																	
80	18.0	Very dense brown sandy silt, some gravel.		6	SS	100/	3"										
	21.5	End of Borehole															

102.9	0.0	Ground Surface														Borehole 4
100		Compact brown clayey silt some gravel (Fill).		1	SS	12										
		Dense brown sandy silt, some gravel, trace of clay (Till).		2	SS	40										W. L. El. 92.7
95	8.0															
90		Very dense brown cemented silty sand and gravel.		3	SS	136										
				4	SS	175/	6"									
				5	SS	180/	6"									
85	19.0															
80		Very stiff clayey silt, seams of sand and gravel.		6	SS	31										
				7	SS	125/	3"									
	26.5	End of Borehole														

VERTICAL SCALE 1 IN 10 5 FT

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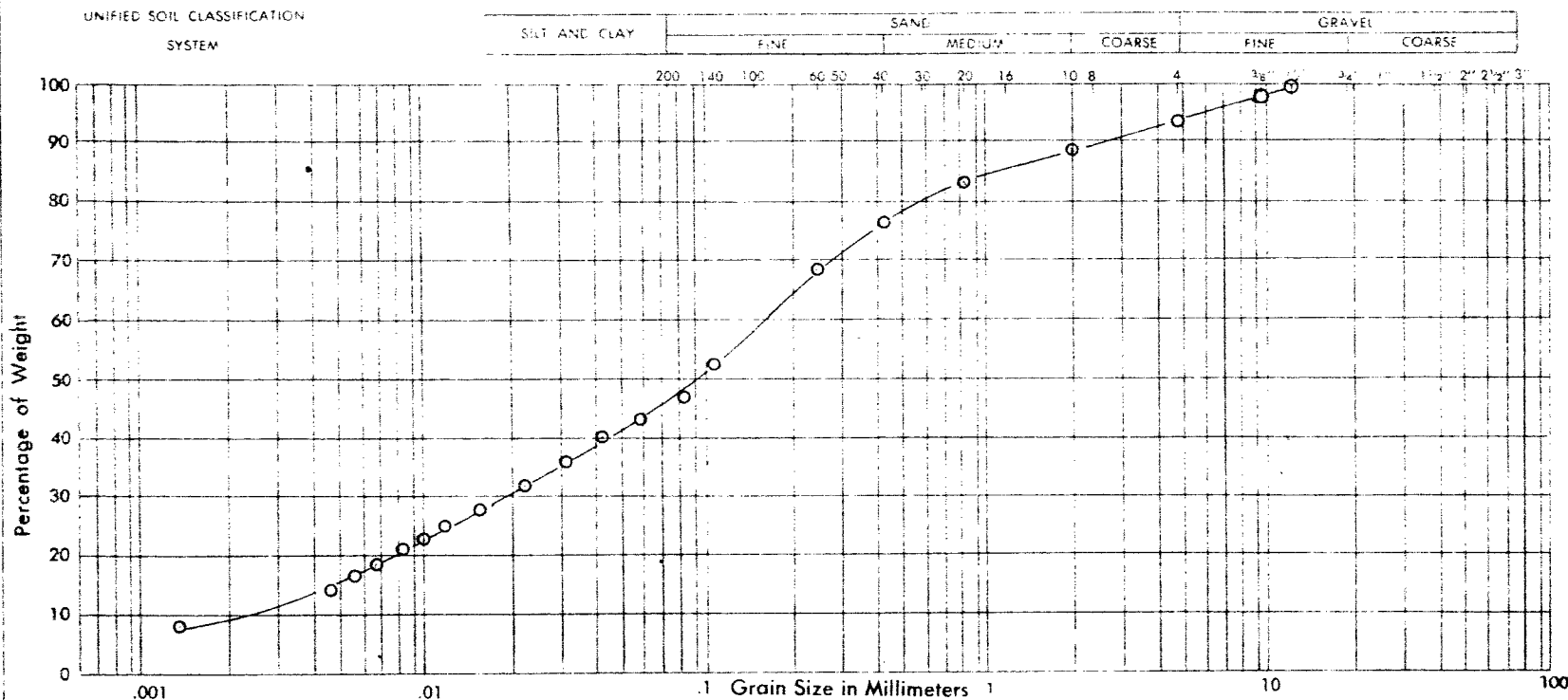
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DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 6-11-L17



PROJECT **Bridge**
 LOCATION **Township of Biddulph**
 BOREHOLE NO. **1**
 SAMPLE NO. **3**
 DEPTH OF SAMPLE: **10' ± to 11'-6"**
 ELEVATION OF SAMPLE **83 ±**

COEFFICIENT OF UNIFORMITY **70**
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
SANDY SILT WITH TRACES OF FINE GRAVEL
AND CLAY

PLASTIC PROPERTIES.

LIQUID LIMIT	%	==
PLASTIC LIMIT	%	==
PLASTICITY INDEX	%	==
MOISTURE CONTENT	%	==
ACTIVITY		==

Enclosure No. 5

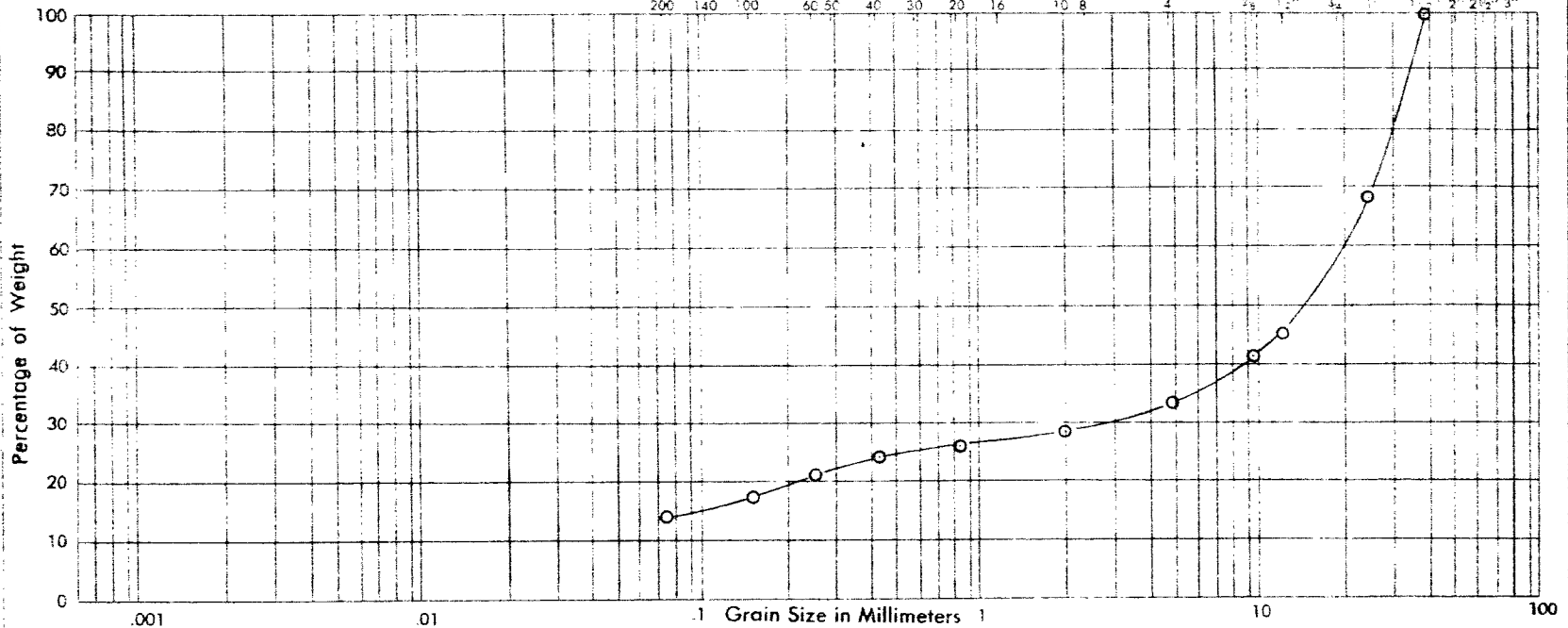
DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 6-11-L17

UNIFIED SOIL CLASSIFICATION
SYSTEM

SILT AND CLAY	SAND				GRAVEL		
	FINE		MEDIUM	COARSE	FINE		COARSE



PROJECT **Bridge**
 LOCATION **Township of Biddulph**
 BOREHOLE NO. **2**
 SAMPLE NO. **3**
 DEPTH OF SAMPLE: **10'-0" to 11'-6"**
 ELEVATION OF SAMPLE: **85±**

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
SANDY FINE TO COARSE GRAVEL, WITH
SOME SILT.

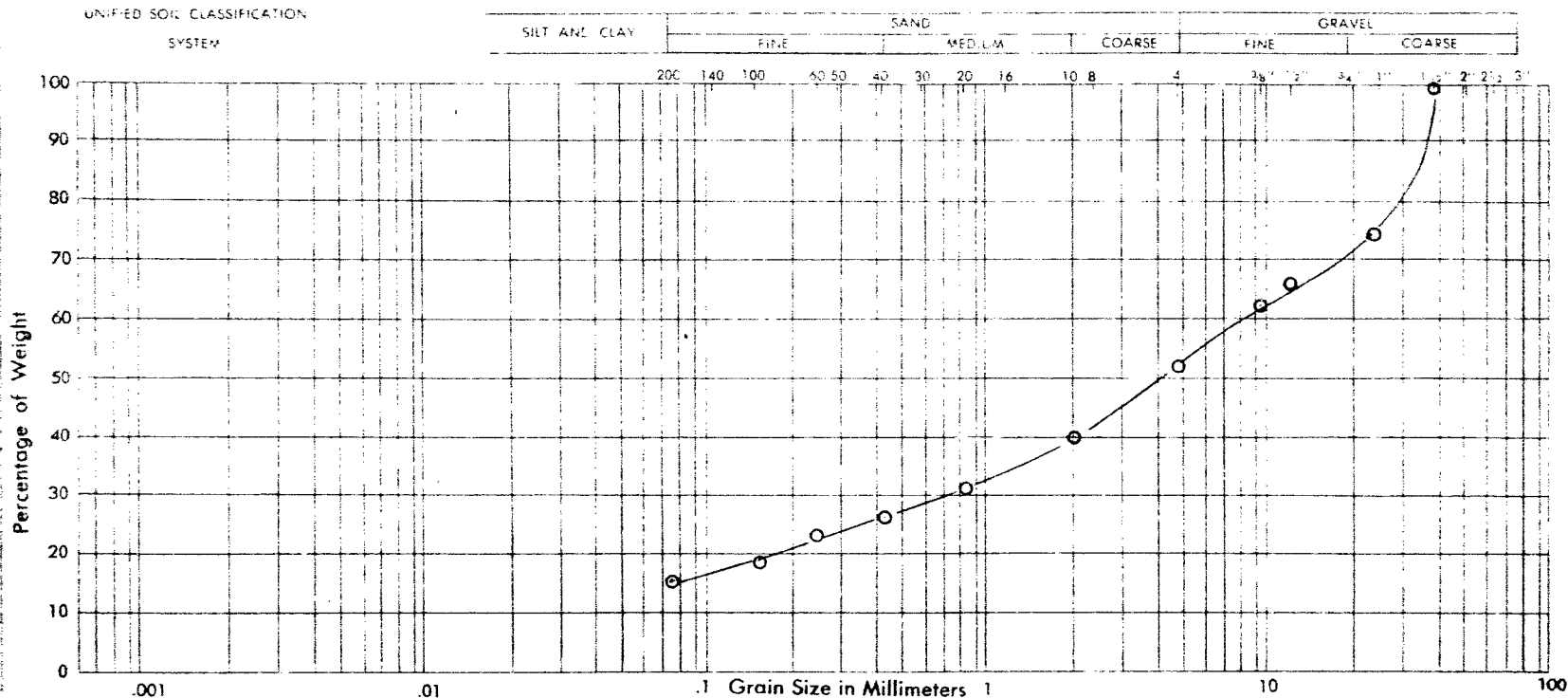
PLASTIC PROPERTIES
 LIQUID LIMIT % ==
 PLASTIC LIMIT % ==
 PLASTICITY INDEX % ==
 MOISTURE CONTENT % =
 ACTIVITY ==

Enclosure No. 6

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-11-L17



PROJECT: Culvert
 LOCATION: Township of Biddulph
 BOREHOLE NO.: 3
 SAMPLE NO.: 4
 DEPTH OF SAMPLE: 12'-6" to 14'-0"
 ELEVATION OF SAMPLE: 85±

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
 WELL-GRADED SAND AND GRAVEL WITH SOME SILT,

PLASTIC PROPERTIES:

LIQUID LIMIT	%	=
PLASTIC LIMIT	%	=
PLASTICITY INDEX	%	=
MOISTURE CONTENT	%	=
ACTIVITY		=

Enclosure No. 7

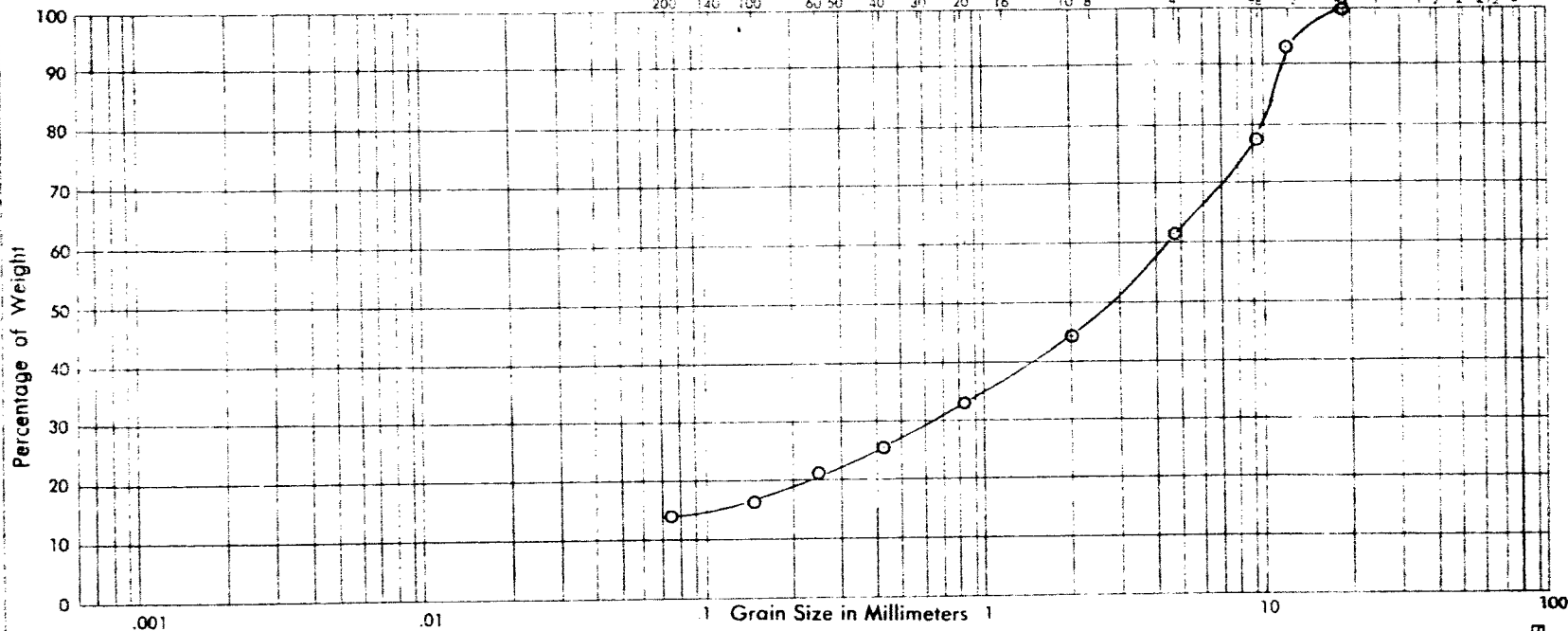
DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-14-L17

UNIFIED SOIL CLASSIFICATION
SYSTEM

SILT AND CLAY	SAND									GRAVEL											
	FINE			MEDIUM			COARSE			FINE	COARSE										
	200	140	100	60	50	40	30	20	16	10	8	4	3/4	3/8	1/4	1/2	3/4	1 1/2	2	2 1/2	3



PROJECT **Culvert**
 LOCATION **Township of Biddulph**
 BOREHOLE NO. **4**
 SAMPLE NO. **4**
 DEPTH OF SAMPLE **15'-0" to 16'-6"**
 ELEVATION OF SAMPLE **87 ±**

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
WELL-GRADED SAND AND FINE GRAVEL WITH
SOME SILT.

PLASTIC PROPERTIES:

LIQUID LIMIT $\frac{0}{100}$ =
 PLASTIC LIMIT $\frac{0}{100}$ =
 PLASTICITY INDEX $\frac{0}{100}$ =
 MOISTURE CONTENT $\frac{0}{100}$ =
 ACTIVITY =

Enclosure No. 8