

#66-F-292 M

CTY. RD. # 17

BRIDGES

CONESTOGO RIVER

WATERLOO CTY.

B.A. 2353

MARSHALL MACKLIN MONAGHAN LIMITED

Consulting Professional Engineers

**1480 Don Mills
Don Mills, Ontario**

**REPORT
ON
SOIL INVESTIGATION AND FOUNDATIONS
FOR
PROPOSED BRIDGES
ON
COUNTY ROAD NO. ¹⁷ 13
OVER
THE CONESTOGO RIVER
WATERLOO COUNTY**

SUBMITTED BY

**DOMINION SOIL INVESTIGATION LIMITED
77 Crockford Blvd.**

Scarborough Ontario

Our Ref: 6-6-9 June, 1966

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INTRODUCTION

On June 13th, 1966, Dominion Soil Investigation Limited was retained by Marshall Macklin Monaghan Limited, Consulting Professional Engineers, to investigate the subsurface conditions at the site of two proposed bridges on County Road No. 13 over the Conestogo River in the County of Waterloo.

The site is located about 2 miles west of St. Jacobs on County Road No. 13 where the two channels of the Conestogo River flow in an approximately 50 ft. deep and 1500 ft. wide valley. To improve the vertical and horizontal alignment of the road, the proposed structures will be located about 50 to 100 ft. downstream of the existing bridges. The multiple-span structures will be constructed on a skew angle. The west structure over the main channel will have 3 spans, each 75 ft. long, and on the east side the proposed structure will be a 2-span bridge, also with 75 ft. long spans. The finished grade of the road will be about 10 to 15 ft. above the existing grade.

The purpose of the investigation was to determine the subsurface conditions at the locations of the proposed abutments and piers, to determine the most suitable foundation level and the bearing capacity of the subsoil at these levels. To obtain the necessary information, one borehole was put down at each pier and abutment location. The procedures followed during drilling and sampling, as well as the soil conditions encountered, are discussed in the appropriate sections of this report.

The interpretation of the results and recommendations for the foundation design, as well as construction procedures to be followed, are dealt with in the Discussion part of this report.

FIELD WORK

The boreholes in the field were located by the survey crew of Marshall Macklin Monaghan Limited who have also obtained the ground surface elevations at these locations. The position of the boreholes was marked by a stake and the boreholes were put down at these staked-out locations. Due to a rise in the water level, however, borehole No. 3 had to be relocated to higher ground. The final position of the boreholes are indicated on our site plan (Enclosure No. 2).

The work in the field was carried out during the period between June 14th and 18th, 1966. The boreholes were advanced by a standard diamond drill machine equipped for soil testing and rock drilling. On account of the large number of boulders encountered, the holes had to be advanced by diamond drilling. In view of the granular nature of the subsoil, only disturbed soil samples were recovered, generally at 5 ft. intervals. When recovering the soil samples with a 2-inch diameter split spoon sampler, the sampler was driven into the undisturbed ground by a 140 pound hammer falling freely 30 inches. The number of blows required to drive the sampler 12 inches into the ground was recorded as the Standard Penetration Resistance or "N" value. The results of the borings and Standard Penetration Tests are recorded on the

individual borehole logs.

The samples were visually classified in the field and shipped in airtight jars into the laboratory for further examination and testing. In the laboratory, the particle size distribution of representative samples was determined. The results of these tests are presented on separate enclosures (Enclosures No. 10 to 12).

SUBSURFACE CONDITIONS

Details of the soil conditions encountered are shown on the individual records of the boreholes comprising Enclosures No. 3 to 9 inclusive. The inferred subsurface profile drawn along the centre line of the proposed alignment is shown on Enclosure No. 2.

As shown on the borehole logs and the inferred subsurface profile, the site is underlain by predominantly granular deposits extending to the full depth of the exploration. Generally, the first stratum encountered was an approximately 7 ft. thick dark brown-coloured sandy silt with some gravel, clay and organic matter and occasional boulders. This stratum is believed to be the recent flood plain deposit. It is underlain by a compact to dense silty and gravelly sand, which in its particle size distribution shows great similarity with the underlying till. The structure of the stratum, however, appears to be disturbed and therefore it is believed that it is a glacial outwash material. The significant soil stratum, a very dense sandy silt till, was encountered generally at elevation 1,070 ft.

Dark Brown Sandy Silt

This stratum forms the upper horizon of the subsoil and extends to depth generally 7 or 8 ft. below the present ground surface. Typical grain size distribution curve of the deposit is shown on Enclosure No. 10, indicating that it consists of 15% gravel, 35% sand and 50% silt and clay. It also contains a trace of organic matter which gives the stratum a dark brown-coloured appearance. It is only loosely compacted or where it is more clayey, it has only a soft consistency.

Pale Brown Silty and Gravelly Sand

Underlying the organic sandy silt stratum, a pale brown-coloured, 5 to 10 ft. thick, silty sand deposit was encountered. The stratum consists of about 10-50% gravel, 30-50% sand and 20-50% silt. In addition to this, numerous boulders were also encountered. Typical grain size distribution curves of this deposit are shown on Enclosure No. 11. The Standard Penetration Test Results range between 11 and 52 blows per foot, indicating a generally compact to dense relative density.

Sandy Silt Till

The significant soil stratum is a brownish grey-coloured sandy silt till, that is, a glacial deposit in which sand and silt particles predominate. The surface of the till was encountered between elevations 1,074 and 1,067 ft, but it generally lies at about elevation 1,070 ft. The thickness of the stratum is not known, but based on geological evidence and

on previous experience in the same general area, it extends to considerable depth to the surface of the underlying limestone bedrock. It is a well-graded mixture of particles ranging between the clay and gravel or even the boulder sizes as shown on the grain size distribution curves presented on Enclosure No. 12. By virtue of the large amount of the coarse soil particles, the stratum is a cohesionless deposit, although due to the calcareous nature of the particles it is slightly cemented and exhibits some apparent cohesion. The particles of the stratum are densely packed and on the basis of the Standard Penetration Tests which gave "N" values ranging between 43 and 165 blows per foot, the relative density of the stratum is estimated to be very dense.

The free standing water levels in the boreholes were observed at a depth ranging between 1 and 5 ft. below the ground surface, that is, between elevations 1,083 and 1,076 ft. On the average, however, the water level was lying at elevation $1,076.5 \pm$ ft. which coincides with the water level in the river at the time of the investigation.

DISCUSSION

The proposed structures will be of reinforced concrete construction with continuous, pre-stressed girders and a composite deck. The maximum reaction at the seat of the abutments and piers was given by the Consulting Engineers as 20 kips per linear foot on the abutments and 35 kips per linear foot on the piers. Adding to these the dead weight of the abutments and piers, the total load at the base of the

foundations will be of the order of 30 and 45 kips per linear foot respectively.

To utilize the high bearing capacity of the very dense sandy silt till, it is recommended that all footings be founded on or within the till stratum. The depth to which the foundations should be carried below the surface of the till would largely depend on the maximum depth of scour expected, the determination of which is beyond the scope of this report. By virtue of the high relative density and the well-graded nature of the till however, it is believed that the substratum is not particularly susceptible to scour, and probably the normal depth of 5 feet of protecting cover would be adequate. Therefore, it is tentatively assumed that the foundation of the piers in the main channel will be at or below elevation 1,065 ft. and of the centre pier in the east channel at about elevation 1,068 ft. If the sides of the channel are adequately protected against scour and erosion by rip-rap, concrete lining or gabions, then the footings of the abutments could be placed at a higher level, possibly at the surface of the till stratum.

Continuous strip footings founded at any level within the till stratum can be designed for an allowable bearing pressure of 4 tons per square foot. This value incorporates a factor of safety of about 3 against a general shear failure of the underlying soil.

It is estimated that under the given structural loads, the maximum total settlement will not exceed 1.1 inches

and the maximum differential settlement will be of the order of 1/2 inch. Both these values are considered to be within the tolerable limits for the type of structure proposed.

When checking the stability of the structure against horizontal sliding, the coefficient of friction between the foundations and the subgrade can be assumed to be 0.45. The design should incorporate a safety factor of at least 1.75 against sliding.

There are no stability problems expected from the construction of the approximately 15 ft. high approach embankment.

There are no undue construction problems foreseen, although some difficulties from the dewatering of the excavation can be expected. The dense and well-graded till should form a relatively impervious base at the bottom of the excavation and the amount of water infiltrating through the side of the excavation would largely depend on the type and tightness of the sheeting surrounding the excavation. Because of the high ground water table and the granular nature of the subsoil above the till, the sides of the excavation should be shored and adequately braced. To avoid unnecessary disturbance of the subgrade at the foundation level, it is recommended that as soon as the excavation has reached the proposed foundation level a mat of lean concrete or gravel be put down.

CONCLUSIONS

From the results of the borings, it can be concluded that the site is underlain by predominantly granular deposits of generally compact to very dense relative density. The site is considered to be suitable for spread footing foundations and the foundation level will most likely be governed by the requirements for scour protection.

It is recommended that the footings be placed on the dense sandy silt till stratum on which the allowable bearing pressure is given as 4 tons per square foot. Both the maximum total and differential settlements are estimated to be within the tolerable limits.

There are no major construction problems foreseen.

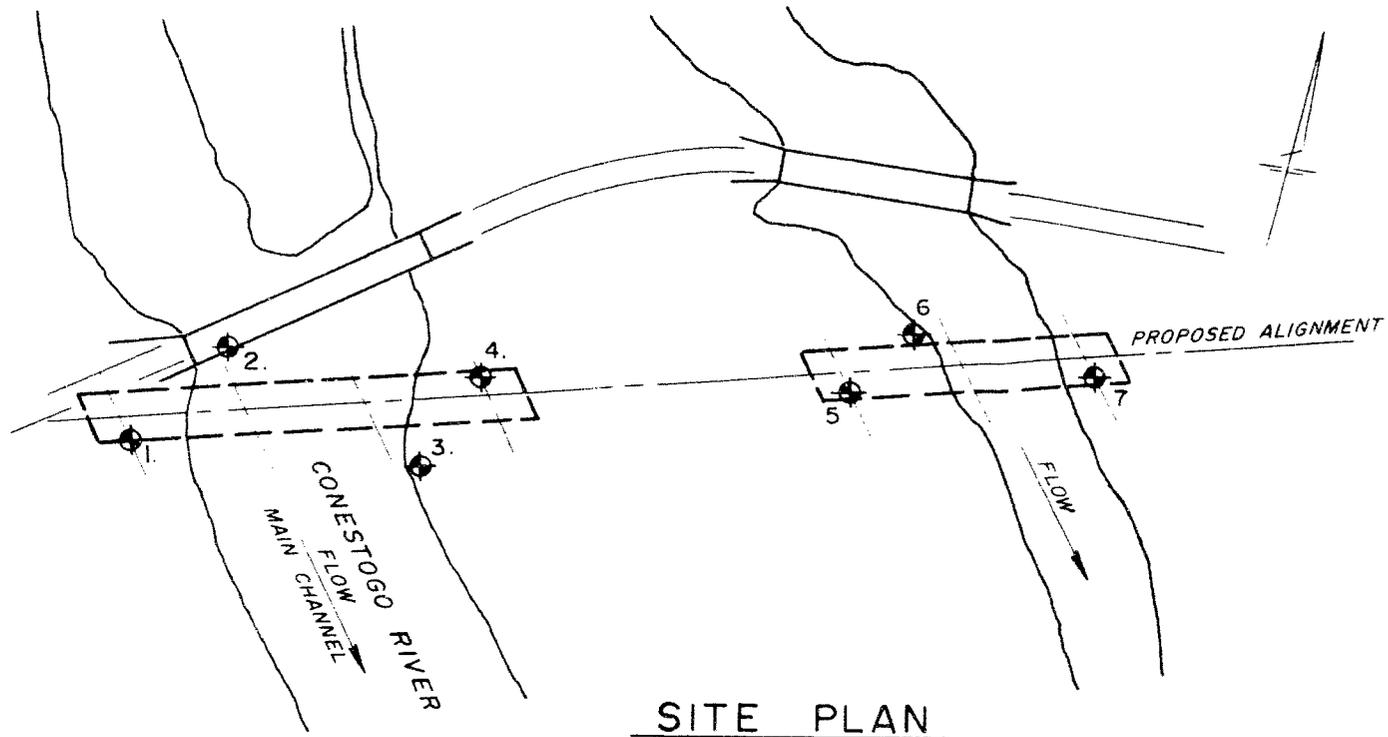
DOMINION SOIL INVESTIGATION LIMITED,

I. P. Lieszkowszky
I. P. Lieszkowszky, P. Eng.,
Project Engineer.

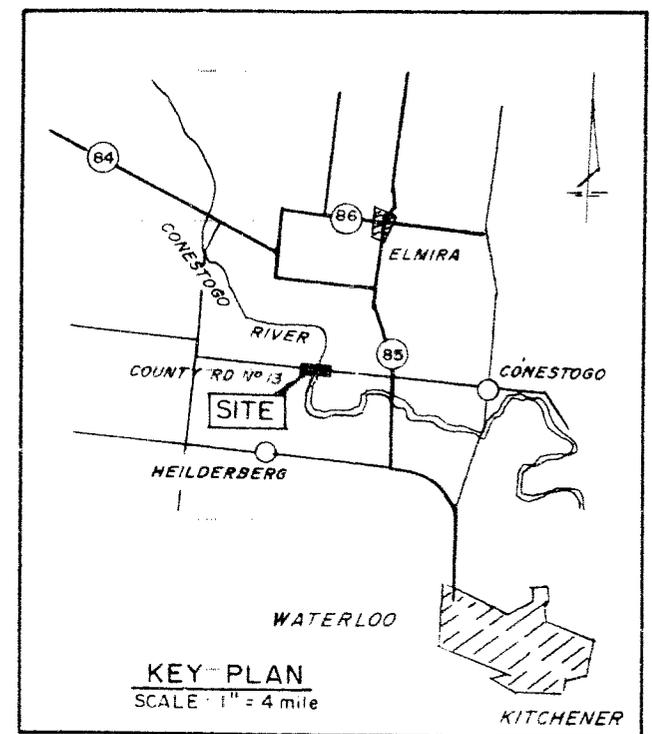
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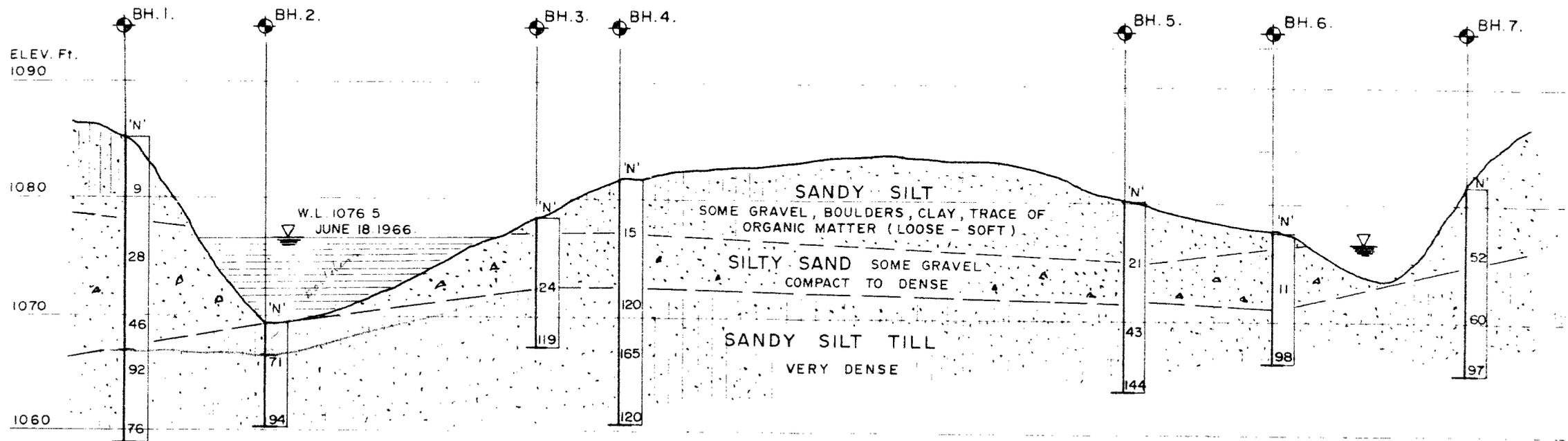
E n c l o s u r e s



SITE PLAN
SCALE: 1" = 100'



KEY PLAN
SCALE: 1" = 4 mile



CENTRE LINE PROFILE
SCALE: HORIZ. 1" = 50'
VERT. 1" = 10'

GEOTECHNICAL DATA SHEET FOR BOREHOLE 1

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD. N° 13 WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 14, 1966.

ENCLOSURE NO 3

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE					CONSISTENCY			REMARKS
				NUMBER	TYPE	Z ₀ Adjustment of Sampler	blows per foot					water content %			
							20 40 60 80 100					PL W LI			
							SHEAR STRENGTH lbs. sq ft								
1085.4	0	GROUND SURFACE													
		8" TOPSOIL													
		LOOSE Reddish brown SANDY SILT													
	5	with some GRAVEL, trace of CLAY and ORGANIC MATTER					1	SS	9						
		(boulders)													
1077.4	8	COMPACT to DENSE													
	10	Brown SAND and SILT with some GRAVEL					2	SS	28						
1075.0															
	15	(boulder)					3	SS	46						
1070.0							4	WS	—						
1066.9	18.5	VERY DENSE SANDY SILT with some GRAVEL and a trace of CLAY													
	20	(GLACIAL TILL)					5	SS	92						
1065.0															
	25														
1080.0	26.5	END OF BOREHOLE					6	SS	76						
1085.0	30														

W.L. 1083.3 Ft.
JUNE 18 1966

Gr. 14% ; Sa. 36% ;
Si. 50%

Gr. 8% ; Sa. 40% ;
Si. 52%

Gr. 18% ; Sa. 40% ;
Si. 37% ; Cl. 5%

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 2 . . .

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD. NO 13, WATERLOO COUNTY
 DATUM ELEVATION: GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 18, 1966.

ENCLOSURE NO 4

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %			REMARKS
				NUMBER	TYPE	N or Advancement of Sampler	20	40	60	80	100	PL	W	LI	
1076.5	0	O WATER LEVEL IN RIVER													
1075.0															
	5														
1070.0															
1069.2	7.3	RIVER BOTTOM													
		BOULDERS	<i>SS</i>												
1066.5	10	VERY DENSE		1	RC	--									
1065.0		Grey SANDY SILT TILL		2	SS	71									Gr. 15%; S ₆₀ 40%; Sl. 40%; Cl. 5%
	15														
1060.0	16.5	END OF BOREHOLE		3	SS	94									
	20														
1055.0															

GEOTECHNICAL DATA SHEET FOR BOREHOLE 3

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD. N° 13. WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 16 1966

ENCLOSURE NO 5

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE				CONSISTENCY		REMARKS
				NUMBER	TYPE	N ₆₀ Advancement of Sampler	20	40	60	80	100	PL	
1078.4	0	GROUND SURFACE											
		6" TOPSOIL Brown (boulder)											
1075.0		SAND and GRAVEL with some SILT (boulder)											
1072.4	6	VERY DENSE Grey SANDY SILT with some GRAVEL (GLACIAL TILL)		1	SS	24							
1070.0	10			2	SS	119							
1065.0	11.5	END OF BOREHOLE											
	15												

WL 1076.7 FT.
JUNE 18. 1966

GEOTECHNICAL DATA SHEET FOR BOREHOLE 4

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD NO 13, WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 16, 1966

ENCLOSURE NO 6

ELEVATION ft.	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE				CONSISTENCY		REMARKS
				NUMBER	TYPE	N- or Advancement of Sampler	20	40	60	80	100	water content %	
							blows per foot				PL W LI		
							SHEAR STRENGTH lbs. sq ft						
1082.1	0	GROUND SURFACE											
		7" TOPSOIL											
1080.0		Reddish brown SILTY FINE SAND with some ORGANIC MATTER											
1077.6	4.5	COMPACT Brown SILTY SAND with some GRAVEL		1	SS	15							W.L. 1077.3 Ft. JUNE 18 1966
1075.0													Gr. 12%; Sa. 48%; Sl. 40%
1072.6	9.5	(boulder)		2	RC	-							
1070.0	10	VERY DENSE Grey SANDY SILT with some GRAVEL		3	SS	120							Gr. 40%; Sa. 40% Sl. 20%
	15	(GLACIAL TILL)		4	SS	165							Gr. 18%; Sa. 37% Sl. 45%
1085.0													
	20												
1060.0	21.5	END OF BOREHOLE		5	SS	120							
	25												
1055.0													

VERTICAL SCALE 1 IN TO 5 FT

GEOTECHNICAL DATA SHEET FOR BOREHOLE 4

OUR REFERENCE NO. 6-6-9

CLIENT: MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT: BRIDGE OVER CONESTOGO RIVER
 LOCATION: COUNTY RD NO 13, WATERLOO COUNTY
 DATUM ELEVATION: GEODETIC

METHOD OF BORING: WASHBORING
 DIAMETER OF BOREHOLE: 2 3/8"
 DATE: JUNE 16, 1966

ENCLOSURE NO. 6

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE					CONSISTENCY		REMARKS	
				NUMBER	TYPE	N or Advancement of Sampler	blows per foot					water content %			
							20 40 60 80 100					PL	W	LI	
							SHEAR STRENGTH lbs. sq ft.								
1082.1	0	GROUND SURFACE													
		7" TOPSOIL													
1080.0		Reddish brown SILTY FINE SAND with some ORGANIC MATTER													
1077.6	4.5	COMPACT													
	5	Brown SILTY SAND with some GRAVEL		1	SS	15									W.L. 1077.3 FT. JUNE 18 1966
1075.0															Gr. 12%; S ₀ 48%; Sl. 40%
1072.6	9.5	(boulder)		2	RC	-									
	10	VERY DENSE Grey SANDY SILT with some GRAVEL		3	SS	120									Gr. 40%; S ₀ 40% Sl. 20%
1070.0		(GLACIAL TILL)													
	15			4	SS	165									Gr. 18%; S ₀ 37% Sl. 45%
1065.0															
	20			5	SS	120									
1060.0	21.5	END OF BOREHOLE													
	25														
1055.0															

VERTICAL SCALE: 1 IN TO 5 FT

GEOTECHNICAL DATA SHEET FOR BOREHOLE 5

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN, LTD
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD N° 13, WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 17, 1966

ENCLOSURE NO 7

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %			REMARKS
				NUMBER	TYPE	N- or Advancement of Sampler	20	40	60	80	100	PI	W	LI	
1080.1	0	GROUND SURFACE													
		6" TOPSOIL LOOSE Brown - black ORGANIC, SILTY FINE SAND.	+ + + + + + + + +												
1075.0	5														
1074.6	5.5	COMPACT Brown SILTY SAND and GRAVEL	+ + + + + + + + +	1	SS	21									
1071.6	8.5														
1070.0	10	VERY DENSE SANDY SILT TILL	+ + + + + + + + +	2	SS	43									
1065.0	15														
	16.5	END OF BOREHOLE													
1060.0	20														

W.L. 1076.6 FT
 JUNE 18 1966

GEOTECHNICAL DATA SHEET FOR BOREHOLE 6

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD.
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD N° 13, WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 17, 1966

ENCLOSURE NO 8

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %			REMARKS	
				NUMBER	TYPE	N- or Advancement of Sampler	20	40	60	80	100	PL	W	LI		
1077.4	0	GROUND SURFACE														
		7" TOPSOIL														
1075.0	5	COMPACT Brown - Grey SILTY SAND and GRAVEL		1	SS	11										W.L. 1076.3 Ft. JUNE 18 1966 Gr. 50%; Sa. 32% Si. 18%
1070.0	7	VERY DENSE Grey SANDY, GRAVELLY SILT (GLACIAL TILL)		2	SS	98										Gr. 28%; Sa. 28% Si. 44%
1065.0	11.5	END OF BOREHOLE														
	15															

GEOTECHNICAL DATA SHEET FOR BOREHOLE 7

OUR REFERENCE NO 6-6-9

CLIENT MARSHALL MACKLIN MONAGHAN LTD
 PROJECT BRIDGE OVER CONESTOGO RIVER
 LOCATION COUNTY RD. N°13 WATERLOO COUNTY
 DATUM ELEVATION GEODETIC

METHOD OF BORING WASHBORING
 DIAMETER OF BOREHOLE 2 3/8"
 DATE JUNE 17, 1966

ENCLOSURE NO 9

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE					CONSISTENCY			REMARKS
				NUMBER	TYPE	N- or Advancement of Sampler	blows per foot					water content %			
							20	40	60	80	100	PL	W	LI	
							SHEAR STRENGTH					lbs./sq ft			
1081.9	0	GROUND SURFACE													
		7" TOPSOIL													
1080.0		COMPACT TO DENSE Brown SAND and GRAVEL													
	5	Some SILT			1	SS									
1075.0	7	VERY DENSE SANDY SILT TILL													
	10				2	SS									
1070.0															
	15														
1065.0	16.5	END OF BOREHOLE			3	SS									
	20														
1060.0															

VERTICAL SCALE: 1 IN TO 5 FT

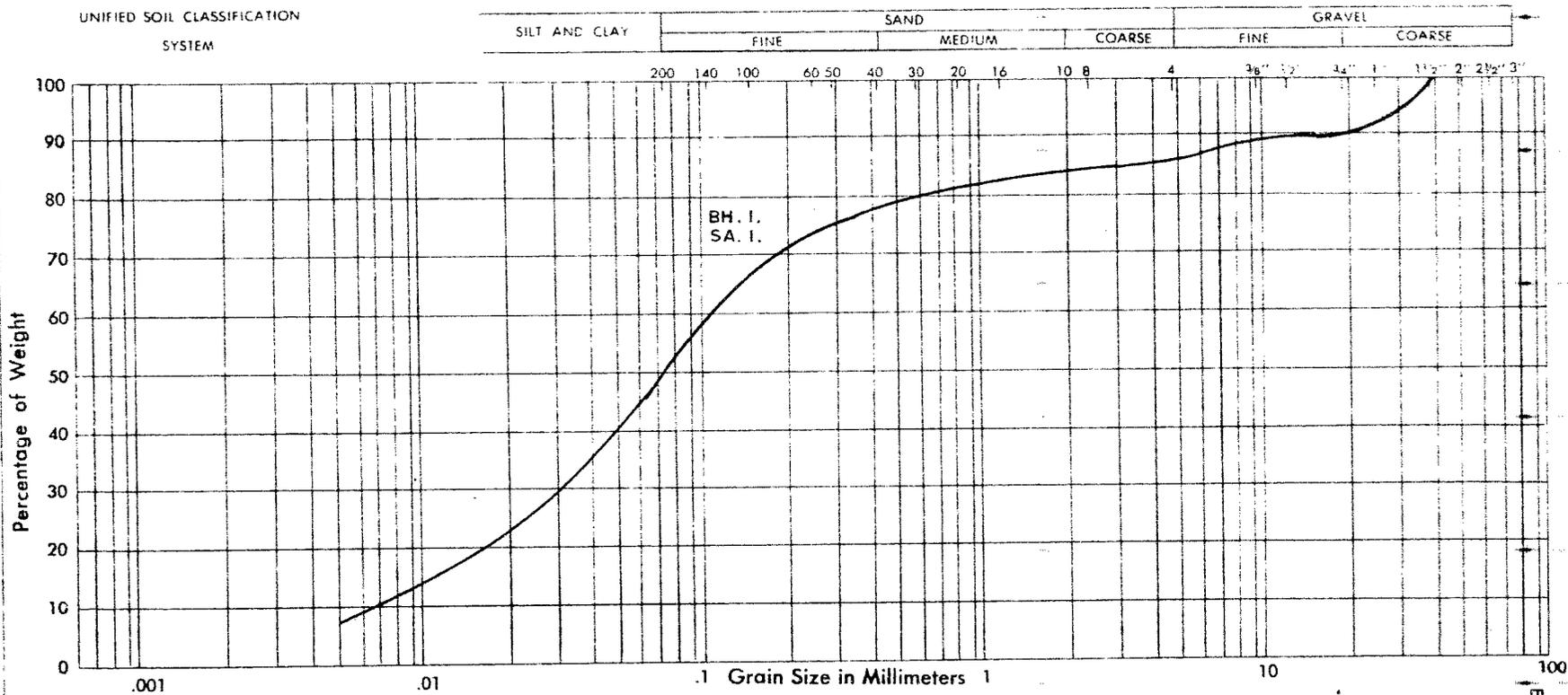
DOMINION SOIL INVESTIGATION LIMITED

MADE V. G. H. CH'D

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 6-6-9



PROJECT: BRIDGE OVER CONESTOGO RIVER COEFFICIENT OF UNIFORMITY
 LOCATION: COUNTY RD. N° 13. WATERLOO COUNTY COEFFICIENT OF CURVATURE
 BOREHOLE NO.: 1
 SAMPLE NO.: 1
 DEPTH OF SAMPLE:
 ELEVATION OF SAMPLE:

Classification of Sample and Group Symbol:
 SANDY SILT with some GRAVEL
 and trace of CLAY
 ORGANIC MATTER

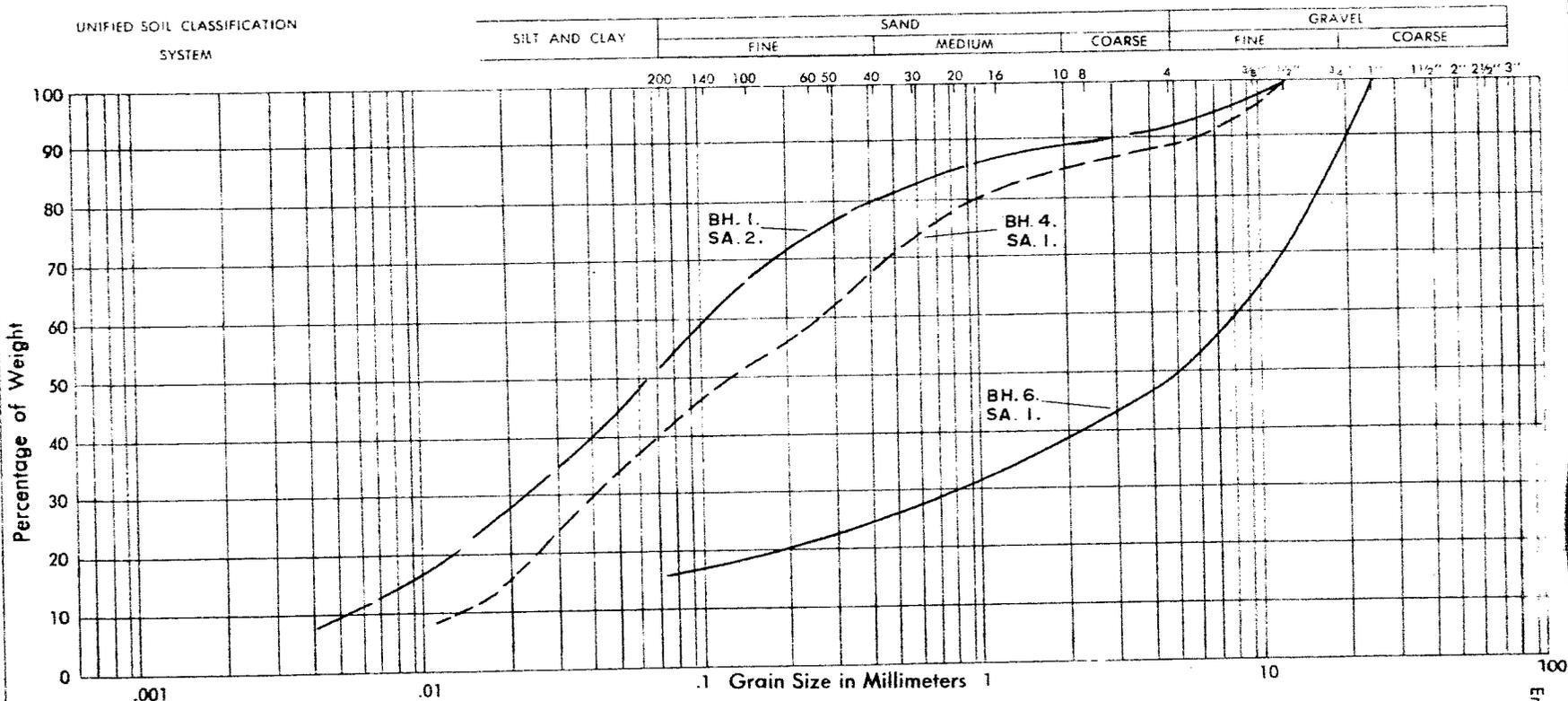
PLASTIC PROPERTIES:
 LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % =
 ACTIVITY =

Enclosure No. 10.

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 6-6-9



PROJECT: BRIDGE OVER CONESTOGO RIVER COEFFICIENT OF UNIFORMITY

LOCATION: COUNTY RD. NO 13. WATERLOO COUNTY COEFFICIENT OF CURVATURE

BOREHOLE NO.: 1 ; 4 ; 6

SAMPLE NO.: 2 1 1

DEPTH OF SAMPLE:

ELEVATION OF SAMPLE:

Classification of Sample and Group Symbol:

SILTY GRAVELLY SAND

PLASTIC PROPERTIES:

LIQUID LIMITED % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

ACTIVITY =

Enclosure No. 11.

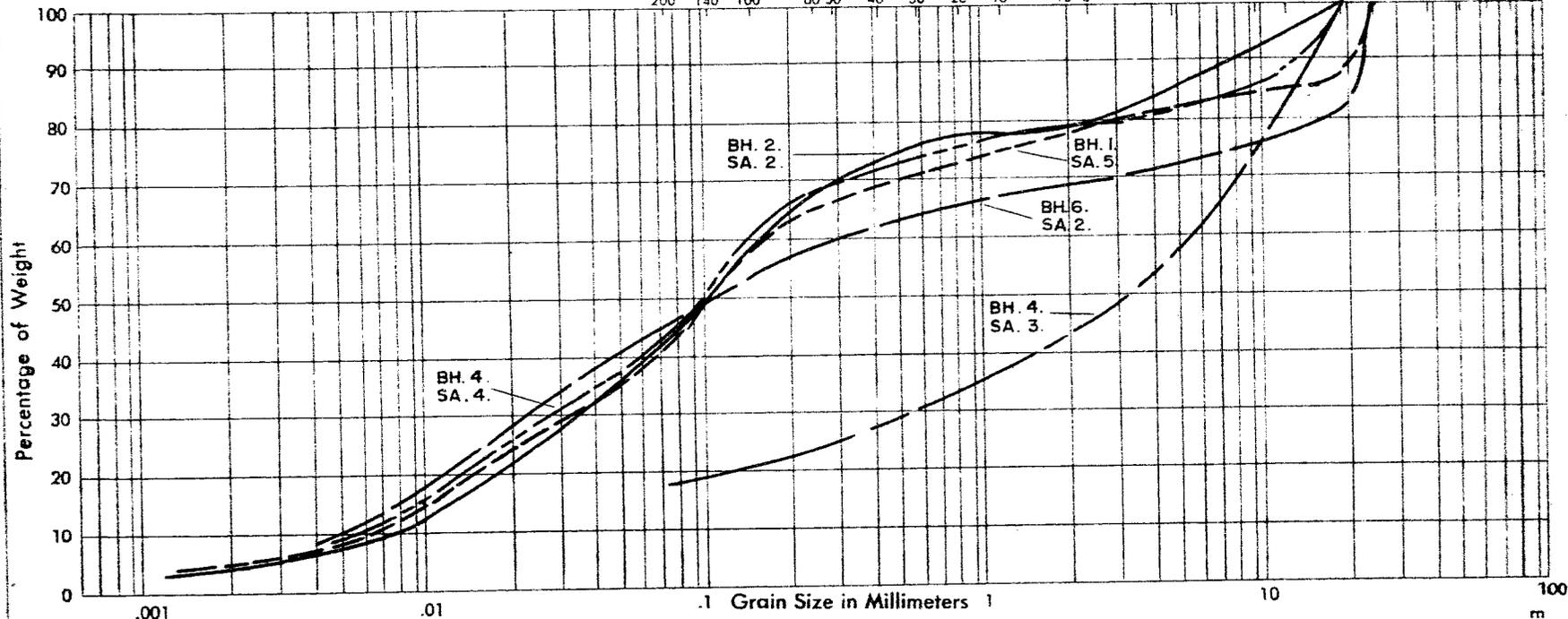
DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-6-9

UNIFIED SOIL CLASSIFICATION
SYSTEM

SILT AND CLAY	SAND				GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE	



PROJECT: BRIDGE OVER CONESTOGO RIVER COEFFICIENT OF UNIFORMITY
 LOCATION: COUNTY RD. N°13. WATERLOO COUNTY COEFFICIENT OF CURVATURE
 BOREHOLE NO.: 1 ; 2 ; 4 ; 4 ; 6
 SAMPLE NO.: 5 2 3 4 2
 DEPTH OF SAMPLE:
 ELEVATION OF SAMPLE:

Classification of Sample and Group Symbol:
 SANDY SILT with some GRAVEL
 trace of CLAY
 (GLACIAL TILL)

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

Enclosure No. 12.