

66-F-254M

MEUX CREEK

LOT 4, CON. VII & VIII

TOWNSHIP OF NORMANBY
c/o A. M. MACKAY & ASSOCIATES LTD.
CONSULTING ENGINEERS
OWEN SOUND, ONTARIO.

SOIL INVESTIGATION
FOR
PROPOSED BRIDGE
OVER
MEUX CREEK
LOT 4, CONCESSIONS VII AND VIII
NORMANBY TWP., ONTARIO

66 - F - 254M

SUBMITTED BY
DOMINION SOIL INVESTIGATION LIMITED
77 CROCKFORD BOULEVARD
SCARBOROUGH - ONTARIO

REFERENCE
6-3-9
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INTRODUCTION

At the request of Messrs. A. M. Mackay and Associates Limited, Consulting Engineers, an investigation of the soil conditions was carried out at the site for a proposed bridge over the Meux Creek in the Township of Normanby, Grey County, Ontario.

Meux Creek is a widely meandering stream at the site and an improvement of the channel alignment is contemplated. An existing narrow bridge will probably be replaced by backfilling the old channel after the improvements to the stream are completed. The new bridge is proposed as a rigid frame structure of span of 55 feet at a skew angle of 25° to the new channel.

The investigation was carried out to determine the soil conditions at the site and their influence on the design and construction of the foundations for the bridge and the channel cross-section.

PROCEDURE

The investigation was carried out during the period 10th to 15th March, 1966. Two boreholes were drilled at the locations shown on the plan of Enclosure No. 2 near the location of the abutments of the proposed bridge to depths of 45 to 50 feet below the ground surface. The boreholes were partly lined with Bx size casing and cleaned out by washboring techniques.

Undisturbed samples of the subsoil were recovered in thin-walled tubes and disturbed samples were obtained in a 2-inch O.D. split-spoon sampler used in the Standard Penetration Resistance Test. In this test the split-spoon sampler was driven into the ground with a 140-lb. hammer falling 30 inches and after an initial penetration of 6 inches,

the number of blows required to cause an additional 12 inches of penetration was recorded as the Standard Penetration Resistance or "N" value.

The samples of soil recovered in the split-spoon sampler were examined and classified in the field then shipped in sealed containers to the laboratory. The thin-walled tubes were waxed for protection of the sample against loss of moisture and also shipped to the laboratory.

Where the consistency of the soil strata permitted, the undrained shear strength of the subsoil was determined in-situ by means of the shear vane apparatus using a 4-inch long, 2-inch diameter vane containing 4 blades. The torque required to cause failure was measured in the undisturbed soil, the vane was rotated about 5 times and the test repeated to determine the remoulded shear strength. The sensitivity of the soil was calculated from the ratio of the undisturbed and the remoulded shear strengths. Adjacent to borehole No. 2, a dynamic cone penetration test was carried out by driving a 2-inch diameter, 60-degree apex cone with the same energy used in driving the split-spoon sampler. A continuous record of the relative density and consistency of the subsoil was thus obtained.

Observations to the free water surface in the boreholes were made and the artesian head which developed in the boreholes below depths of 35 to 40 feet was observed after the sampling operations were completed.

The elevation of the ground surface near each borehole was determined and related to a local bench mark on the top of a bolt 8 ft. right of Sta. 5 + 18 on the existing bridge. The elevation of this bench mark was given as El. 97.80 ft.

LABORATORY TESTS

On the samples obtained in the thin-walled tubes and in the split-spoon sampler, tests were performed in the laboratory in accordance with A. S.T.M. Standard methods to determine the unconfined compressive strength, the Atterberg Limits, natural moisture content, unit weight, consolidation characteristics and the grain size distribution of the soil strata. The results of these tests are plotted on the Geotechnical Data Sheets and are also shown on the tables and curves of Enclosure No. 5 to No. 9.

SOIL CONDITIONS

The details of the soil conditions encountered in each borehole are shown on the Geotechnical Data Sheets of Enclosures No. 3 and No. 4 and the inferred soil profile is shown in section on Enclosure No. 10.

The boreholes were advanced through the existing road embankment and 4 to 5 feet of fill were encountered. Below the fill is a stratum of compact silty fine sand with a trace of gravel overlying an extensive deposit of stiff silty clay to clayey silt. More detailed information on each stratum follows below.

Fill

The fill consists of a brown silty-clay with some sand and gravel and at the surface of the original ground there is an appreciable amount of decomposed organic matter considered to be the original topsoil. The fill extends down to 4 or 5 feet to about Elevation 91+ ft.

Silty Sand with a trace of Gravel

At around El. 91+ ft., a stratum of brown silty sand with traces of gravel is encountered. From the Standard Penetration Resistance of 21 and 22 blows per foot within the soil, it is inferred that the deposit is

of compact relative density.

The grain size distribution curves for this soil are shown on Enclosures No. 5 and No. 7 and the composition of the soil ranges between 10 and 50% gravel, 30 and 60% sand and 20 to 25% silt-and-clay size particles. Occasional boulders were also encountered.

The creek bed is located at around El. 87+ ft. near the bottom of this stratum.

Clayey Silt

At a depth of about 9 feet (El. 87+ ft.) the deposit of stiff grey clayey silt is encountered. This deposit extends down to around depths of 45 to 48 feet (El. 47 - 50 ft.) and appears to be a generally homogeneous mass down to around El. 60 below which there are occasional seams of silt and fine sand and the silt content of the soil becomes higher. From the grain size distribution curve of Enclosure No. 6, the deposit at around El. 85+ is seen to be mainly silt and clay with a trace of sand. The results of the laboratory tests on the soil are summarized below.

Undrained Shear Strength ($\frac{1}{2}$ unconfined compressive strength)	800 to 1,620 p.s.f.
Liquid Limit	19.3 to 29.2%
Plastic Limit	13.7 to 17.7%
Plasticity Index	2.8 to 12.4
Natural Moisture Content	11.7 to 24.8%
Liquidity Index	0.41 to 2.8
Wet Unit Weight	128 to 133.5 p.c.f.
Void Ratio	0.44
Coefficient of Volume Change	0.01 sq. ft. per Ton
Coefficient of Consolidation	0.9 sq. ft. per day

The undrained shear strength measured in-situ by the shear vane test ranges between 700 and 3,070 pounds per square foot and the sensitivity ranges between 1.0 and 3.1. The average of the "N" values in this stratum is about 12 blows per foot.

Since the moisture content of the soil is generally higher than the Plastic Limit, the liquidity index is also in the relatively high range of 0.41 to 2.8. From these values it is concluded that the soil is of low sensitivity and generally of a stiff consistency.

From the consolidation test results of Enclosure No. 8, the estimated coefficient of volume change of the soil is about 0.01 square foot per ton for the range of loading anticipated under the foundations. The soil mass is therefore of moderate compressibility and with an average coefficient of consolidation of 0.9 square foot per day, consolidation in this stratum will take place at a relatively rapid rate.

Boulder or Bedrock and Very Dense Silt Till

Underlying the silty clay in borehole No. 1, at a depth of 45 to 50 feet, the presence of boulders or bedrock was indicated by practical refusal. In borehole No. 2 a very dense silt till was encountered, containing traces of gravel and giving "N" values of 68 to 70 blows per foot.

GROUND WATER CONDITIONS

The ground water conditions are affected by the elevation of the surface of the water in the stream and also by artesian conditions observed below a depth of about 35 feet.

The free water surface in borehole No. 2 rose to El. 92.2 ft., to about the same elevation as the surface of the stream and during the construction of any shallow foundations the main source of ground water

will be from the stream seeping through the permeable silty sand stratum.

Below El. 60 ft., ground water under artesian head was observed, rising to 8.4 feet above the ground surface, i.e. to around El. 105+ ft.

DISCUSSION

The proposed works comprise the construction of a 55 foot single-span rigid frame type structure over the new channel which will be excavated for the Meux Creek to improve the alignment of the stream. It is estimated that the loading will be of the order of 12 tons per linear foot on the foundations at the bridge abutments.

The bed of the existing stream is believed to be founded in the deposit of stiff clayey silt at around El. 86+ and it is understood that the excavation for the new channel will be taken down to around El. 88+ in the vicinity of the new bridge.

The soil profile consists of a 4 foot thick fill for the roadway embankment followed by a 5-foot thick stratum of compact silty sand underlain by a stiff to very stiff clayey silt. Below depths of 45 to 50 feet, at elevations where the effects of the foundations for the proposed works will be negligible, there is a stratum of dense clayey silt with probable boulders or bedrock.

In considering the type of foundations for the bridge, of importance is the depth of scour in the stream, the determination of which does not fall within the scope of this report. However, in view of the cohesive nature of the silty clay deposit, it is believed that the soil is of low susceptibility to erosion and future scour in the stream will probably not be serious enough to have any adverse effects on the foundations. This should however be clarified by considering the hydraulics

of the stream. The foundations should also be located at a depth which will allow a minimum of 5 feet of soil cover for protection against frost action. Assuming that the stream bed is excavated to El. 88 $\frac{1}{2}$ ft. the foundations should be supported at or below El. 83 $\frac{1}{2}$ ft.

The consistency of the clayey silt deposit below El. 83 ft. is generally stiff and an average shear strength of 1,500 pounds per square foot is available in this stratum. Thus normal spread footings can be used for the bridge foundations.

At El. 83 ft. or below, the allowable pressure on the soil may be taken as 1.50 tons per square foot. This value is based on a factor of safety of 3 against rupture of the soil supporting the foundations. Using the estimated abutment loading of 12 tons per linear foot, a footing width of about 8 feet is indicated. Under this size of footing, the total settlement is estimated at about 1.5 inches. Further, because the ground conditions within the depth of influence of the foundations are, for practical purposes, uniform, the differential settlement will likely be small and is estimated to be less than 0.5 inches. Both the total and differential settlements are therefore expected to be within the range of tolerable limits for a rigid frame type structure of 55-foot span.

The stability of the approach embankment and the abutment has been considered and the lowest factor of safety against failure by sliding along circular arc has been found to be about 1.9 which is considered to be satisfactory.

In designing the foundations to resist the action of horizontal forces, the adhesion between the foundations and the underlying soil should be taken as 1,200 pounds per square foot and the factor of safety against

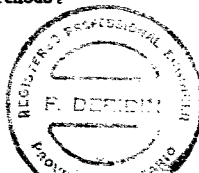
sliding should be at least 1.5.

The new channel will be excavated mainly in the silty fine sand stratum. The side slopes in the channel should not exceed 1:3 for stability of the banks when submerged.

The construction of the foundations for the bridge will necessitate excavation below the ground water surface. In order to control the water in the excavations, a well point system may be used but the alternative of closed sheeting around the excavation may prove more convenient. In this case the closed sheeting should be driven into the stratum of clayey silt for a few feet or for sufficient penetration to provide an effective cut-off. Any water seeping into the pit may then be removed from sumps in the excavation by normal pumping methods. The artesian conditions observed below El. 60 will not affect the safety of excavations carried to the recommended foundation level.

SUMMARY AND CONCLUSIONS

1. The site has been found to be underlain by a 4 ft. thick silty sand and gravel deposit followed by an extensive deposit of clayey silt of stiff consistency.
2. At El. 83 ft. or below, normal spread footings can be used for the bridge foundations with an allowable pressure on the soil of 1.50 tons per square foot.
3. The total settlement of the foundations will be about 1.5 inches and the differential settlement is not likely to exceed one-half inch.
4. The side slopes for the new channel should be 1:3 or lower.
5. No unusual construction problems are anticipated. Ground water may be best controlled by use of closed sheeting around the excavations and normal pumping methods.



DOMINION SOIL INVESTIGATION LIMITED,

F. Debidin
F. Debidin, P.Eng.,
Soils Engineer.

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: > 8"	3"	COARSE 3/4"	FINE 4.75mm	COARSE 2.0	MEDIUM 0.42	FINE 0.074	0.002	>	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	Steady pressure	Washwater returns
"	"	pressure : p	MADE WHILE CORING	No pressure	Washwater lost
"	"	topping : f		Intermittent pressure	

PENETRATION RESISTANCES.

DYNAMIC PENETRATION RESISTANCE : to drive a 2" dia, 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 :



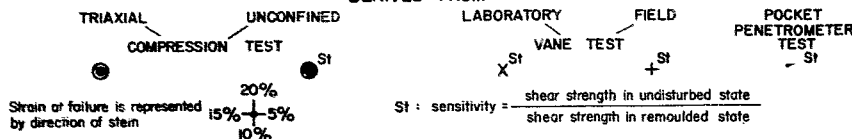
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SOIL PROPERTIES.

W %	Water content	γ	Natural bulk density (unit weight)	k	Coeff. of permeability
LL %	Liquid limit	e	Void ratio	ϕ	Shear strength
PL %	Plastic limit	RD	Relative density	δ	Angle of int. friction
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.

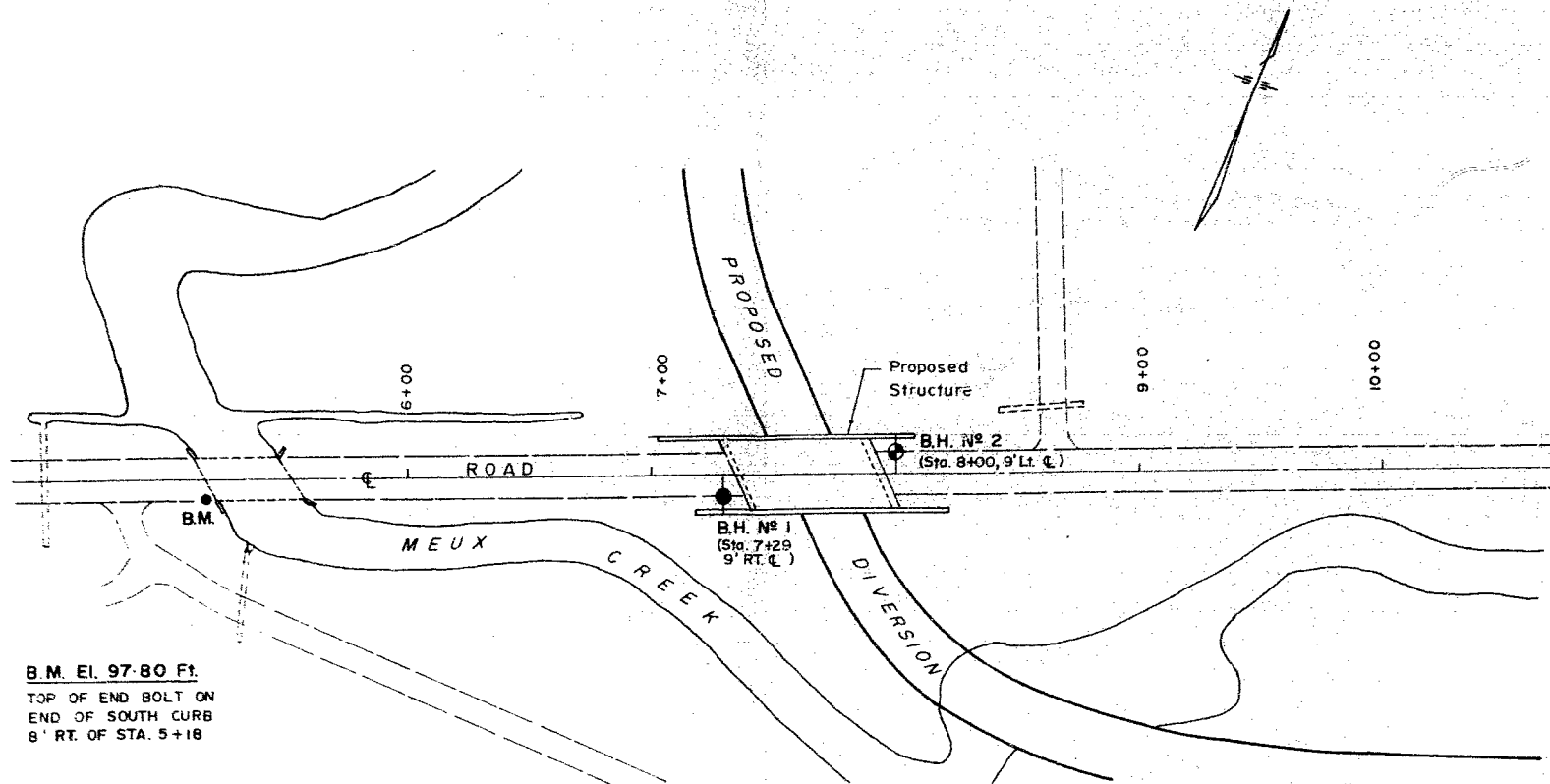
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
SOIL DESCRIPTION.

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

B.M. El. 97.80 Ft.
TOP OF END BOLT ON
END OF SOUTH CURB
8' RT. OF STA. 5+18



LEGEND

-  BOREHOLE
-  BORE & CONE PENETRATION HOLE

BOREHOLE LOCATION PLAN

SCALE: 1" = 50 Feet

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . . ! . . .

OUR REFERENCE NO. 6 - 3 - 9

CLIENT: A. M. MACKAY & ASSOC.
PROJECT: PROPOSED BRIDGE
LOCATION: AYTON, ONTARIO
DATUM ELEVATION: SEE PLAN

METHOD OF BORING: WASHBORING
DIAMETER OF BOREHOLE: 2 3/8"
DATE: MAR. 10, 1966

ENCLOSURE NO. 3

ELEVATION #	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %				REMARKS
				NUMBER	TYPE	21 Advancement of Sampler	2.0	4.0	6.0	8.0	10.0	PL	W	LI		
96.1	0	GROUND SURFACE														
95.0		SILTY CLAY FILL		1	C.S.											
90.0	5	Brown, Compact SILTY SAND traces of gravel		2	S.S.	22										
85.0	10			3	S.S.	17										
				4	S.S.	10										
80.0	15	Grey, Stiff		5	T.W.	P									Y = 131.0 P.C.F.	
				6	S.S.	13										
75.0	20	CLAYEY		7	T.W.	P									Y = 135.0 P.C.F.	
		SILT		8	S.S.	10										
70.0	25			9	T.W.	P									Y = 133.5 P.C.F.	
65.0	30			10	S.S.	12										
60.0	35			11	S.S.	8									ARTESIAN HEAD 8' - 4" ABOVE GROUND SURFACE MAR. 16, 1966	
55.0	40			12 ^A _B	S.S.	11										
				13	S.S.	12										
50.0	45	seams or pockets of silt and fine sand		14	T.W.	P										
46.0	46.0	END OF BOREHOLE													HAMMER BOUNCING AT 46' - 0"	
50																
45.0																

VERTICAL SCALE: 1 IN. TO 5 FT.

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MADE D. A. M. CND

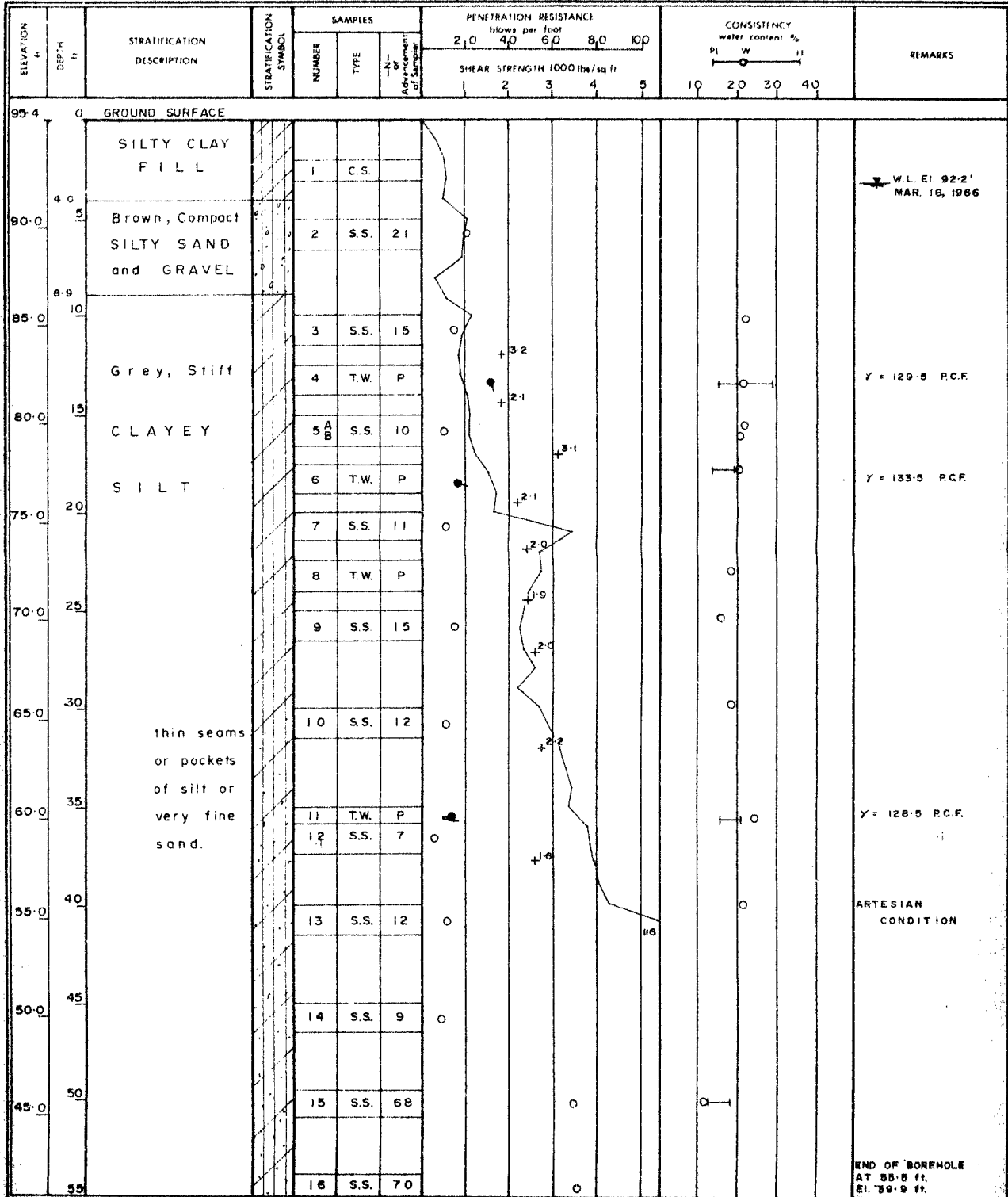
GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 2 . . .

OUR REFERENCE NO. 6-3-9

CLIENT A. M. MACKAY & ASSOC.
PROJECT PROPOSED BRIDGE
LOCATION AYTON, ONTARIO
DATUM ELEVATION SEE PLAN

METHOD OF BORING WASHBORING
DIAMETER OF BOREHOLE 2 5/8"
DATE MAR. 15, 1966

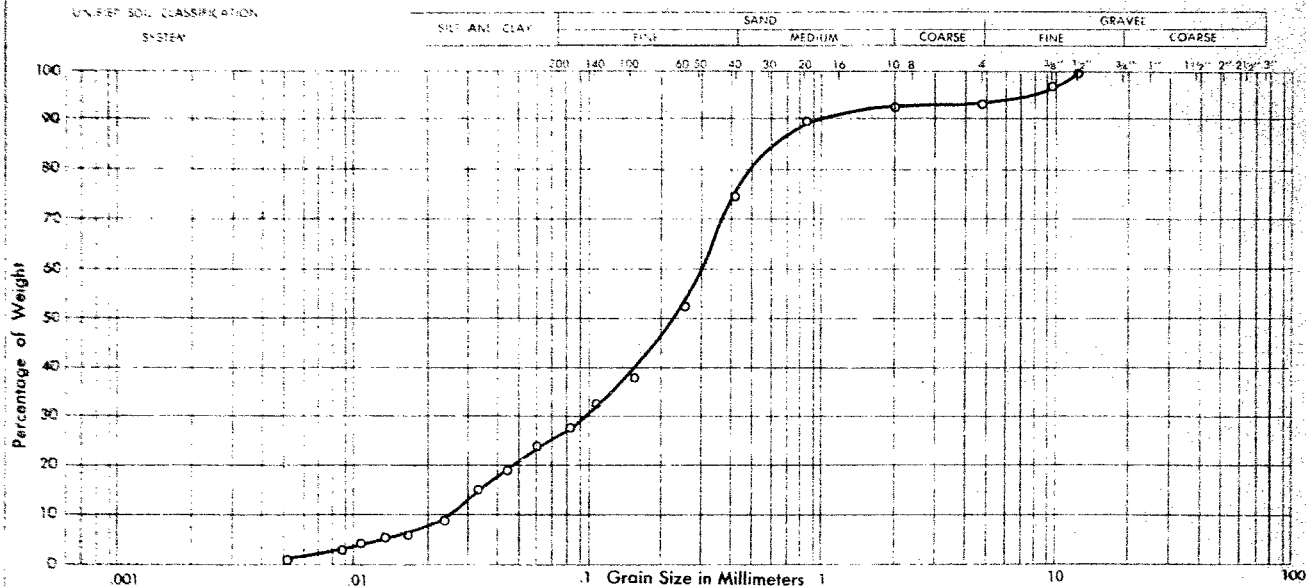
ENCLOSURE NO. 4



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GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-3-9



PROJECT PROPOSED BRIDGE
 LOCATION AYTON, ONTARIO
 BORING NO. 1
 SAMPLE NO. 2
 DEPTH OF SAMPLE 5' - 6.5'
 ELEVATION OF SAMPLE 91 ± ft.

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:

SILTY SAND with traces of gravel

PLASTIC PROPERTIES:

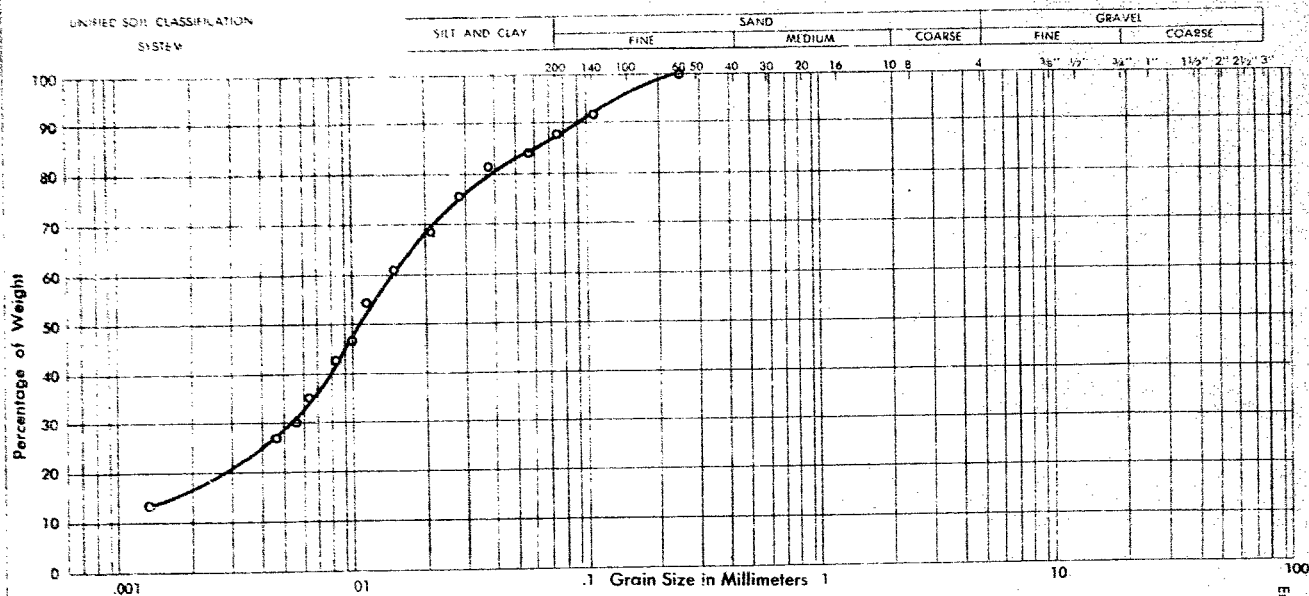
LIQUID LIMIT $w_p =$
 PLASTIC LIMIT $w_L =$
 PLASTICITY INDEX $I_p =$
 MOISTURE CONTENT $w =$
 ACTIVITY $A =$

Enclosure No. 5

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-3-9



PROJECT PROPOSED BRIDGE
 LOCATION AYTON, ONTARIO
 BOREHOLE NO 1
 SAMPLE NO 3
 DEPTH OF SAMPLE 10 - 11.5'
 ELEVATION OF SAMPLE 86 ± ft.

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
 CLAYEY SILT trace of fine sand

PLASTIC PROPERTIES:

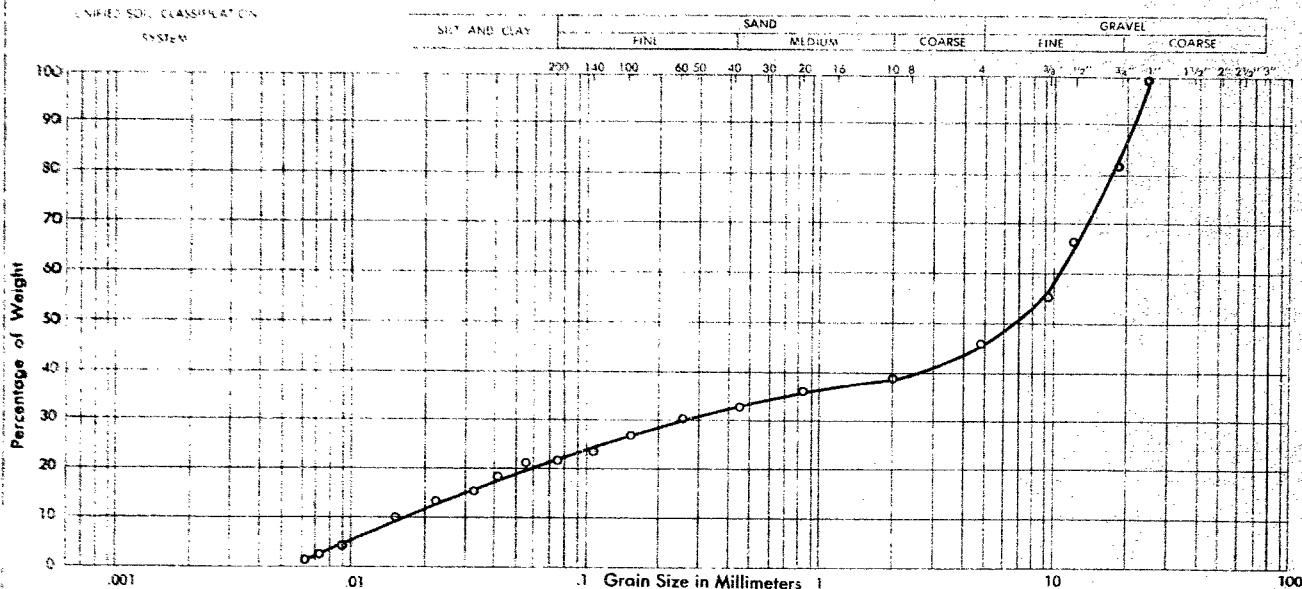
LIQUID LIMIT % =
 PLASTIC LIMIT % =
 PLASTICITY INDEX % =
 MOISTURE CONTENT % =
 ACTIVITY =

Enclosure No. 6

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6-3-9



PROJECT PROPOSED BRIDGE
 LOCATION AYTON, ONTARIO
 BORROW NO. 2
 SAMPLE NO. 2
 DEPTH OF SAMPLE 5' - 6' 5"
 ELEVATION OF SAMPLE 90 ± ft.

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:

SILTY & SANDY GRAVEL

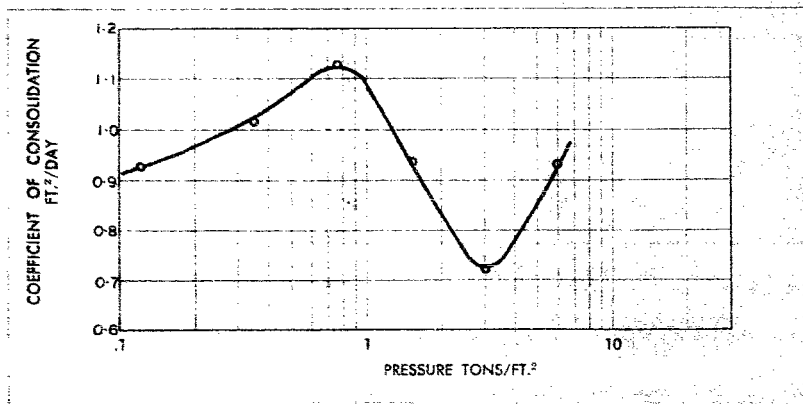
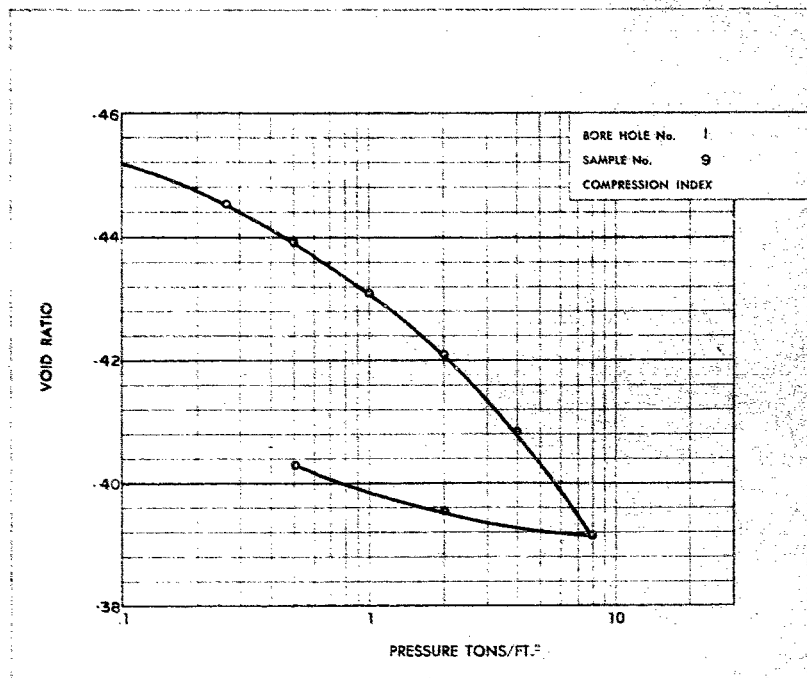
PLASTIC PROPERTIES:

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

Enclosure No. 7

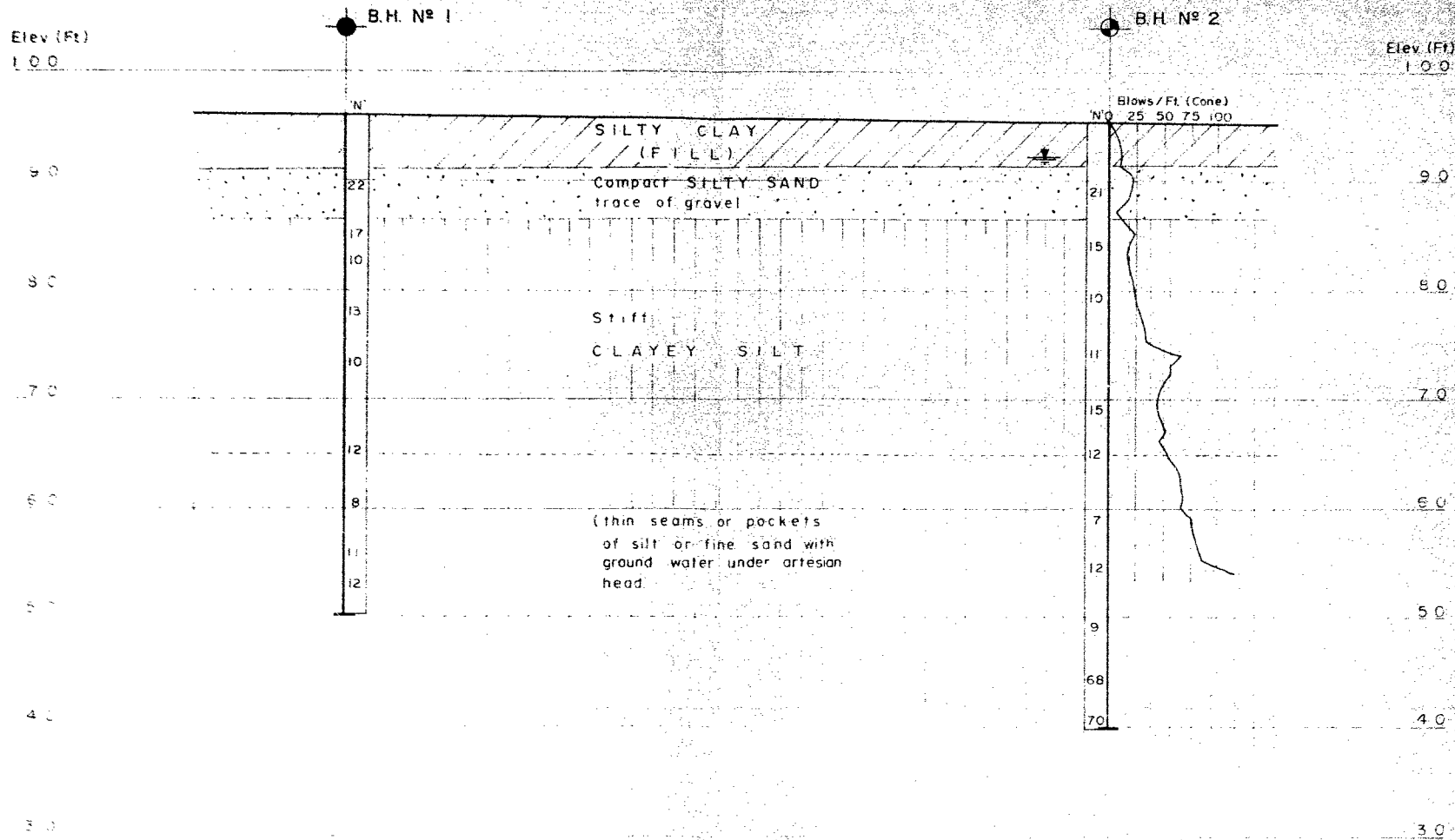
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CONSOLIDATION TEST



SAMPLE DETAILS				CONSISTENCY					UNDRAINED COMPRESSION		UNIT WEIGHT	REMARKS
BOREHOLE	SAMPLE	TYPE	AVERAGE DEPTH (FEET)	NATURAL WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX	LIQUIDITY INDEX	SHEAR STRENGTH (P.S. FT.)	AXIAL STRAIN AT FAILURE (%)	(P.C. FT.)	
1	2	S.S.	6.0									Grain Size Distribution (Encl. N° 5)
	3	S.S.	11.0	19.4	22.1	16.4	5.7	0.53				Grain Size Distribution (Encl. N° 6)
	4	S.S.	13.0	18.2								
	5	T.W.	16.0	21.6	24.3	15.5	8.8	0.69	1,320	3.1	131.0	
	7	T.W.	21.0	18.8	19.6	15.5	4.1	0.81	804	10.0	135.0	
	8	S.S.	23.0	20.0								
	9	T.W.	26.0	17.5	19.6	14.4	5.2	0.59	1,435	11.9	133.5	Consolidation Test Results (Encl. N° 8)
	10	S.S.	31.0	23.1								
	11	S.S.	36.0	21.4	22.8	18.8	4.0	0.65				
	12	S.S.	41.0	20.6								
	14	T.W.	45.0	26.2								
2	2	S.S.	6.0									Grain Size Distribution (Encl. N° 7)
	3	S.S.	11.0	22.2								
	4	T.W.	13.0	21.9	29.2	16.8	12.4	0.41	1,620	8.1	129.5	
	5 A	S.S.	16.0	22.0								
	5 B	S.S.	16.5	20.6								
	6	T.W.	18.0	20.3	19.6	15.6	4.0	1.18	870	6.3	133.5	
	8	T.W.	23.0	18.4								Non Plastic
	9	S.S.	26.0	16.7								
	10	S.S.	31.0	19.6								
	11	T.W.	36.0	24.8	20.5	17.7	2.8	2.5	789	15.0	128.5	
	13	S.S.	41.0	21.2								
	15	S.S.	50.0	11.7	19.3	5.6	13.7	0.45				

TABLE OF LABORATORY TEST RESULTS



SUBSURFACE PROFILE

SCALE 1" = 10 Feet