

Mr. A. M. Toye,  
Bridge Engineer.  
Materials & Research Section.

September 22, 1960.

D.H.O. FOUNDATION INVESTIGATION

W.J. 60-P-58 -- (W.P. 111-60.)

Attention: Mr. S. McCombie.

Re: Queen Elizabeth Way and County Road No. 20  
(Approx. 5 Miles West of St. Catharines)  
Twp. of Louth, County of Lincoln, District 4.

This memo accompanies our detailed report on the  
subsoil conditions existing at the above site.

The conclusions and recommendations to be followed  
in your future design work, are summarized in the report,  
and, we believe, are self-explanatory.

However, should any queries arise in connection with  
this project, please contact our Office.

L. G. Soderman,  
PRINCIPAL FOUNDATIONS ENGR.

Per:

AS/MdF  
Attach.

cc: Messrs. A. M. Toye (2)  
H. A. Tregaskes  
D. G. Ramsay  
I. C. Campbell  
H. E. Richardson  
T. J. Kovich  
A. Watt  
Foundations Office  
Gen. Files.

*A. Sternac*  
(A. Sternac,  
FOUNDATIONS OFFICE ENGR.)

## TABLE OF CONTENTS

- 1) INTRODUCTION
- 2) DESCRIPTION OF SITE AND GEOLOGY
- 3) FIELD AND LABORATORY WORK
- 4) SUBSOIL CONDITIONS
  - (4.1) General
  - (4.2) Sandy Silt and Silty Sand
  - (4.3) Clayey, Sandy, Gravelly Silt
- 5) GROUND WATER CONDITIONS
- 6) DISCUSSIONS AND RECOMMENDATIONS
- 7) SUMMARY
- 8) MISCELLANEOUS

## FOUNDATION INVESTIGATION

At

Queen Elizabeth Way and County Road No. 20  
(Approx. 5 Miles West of St. Catharines)  
Twp. of Louth, County of Lincoln, District 4.

W.J. 60-F-58 -- W.P. 111-60.

---

### 1. INTRODUCTION:

It is intended to construct an underpass which would take the County Road No. 20 over the Queen Elizabeth Way. The site of the proposed underpass is located approx. 5 miles West of the Town of St. Catharines, County of Lincoln. At this location The Chainage for The Queen Elizabeth Way and County Road No. 20 are 98 + 00 and 23 + 62.78, respectively.

In order to determine the soil properties and decide on the type of foundation, an investigation was carried out by this section. Results and the discussion of the Field and Laboratory investigations, as well as conclusions and recommendations for the future design work are contained in the following paragraphs of this report.

### 2. DESCRIPTION OF SITE AND GEOLOGY:

The area East and West of County Road No. 20 is fairly flat, and lies in a cherry and peach orchard.

Physiographically, the site is part of The Iroquois Plain.

### 3. FIELD AND LABORATORY WORK:

In order to obtain sufficient information on the types and properties of the subsoil, five sampled boreholes supplemented by the same number of dynamic cone penetration holes, were carried out at this particular site. The density of the cohesionless materials, was determined with the Standard Penetration Test. Samples recovered in the split spoon were used to determine the moisture content, liquid limit, plastic limit, i.e., for classification purposes.

Boreholes No. 1, 3, 4 and 5 were terminated in the underlying medium hard, clayey, sandy, gravelly silt stratum, at a depth of about 41 ft. below ground level. Borehole No. 2 was carried down to a depth of 91 ft. below ground level and terminated in the stratum of very dense clayey, sandy, gravelly silt. The purpose of this borehole was to determine, if possible, the depth to bedrock.

The elevations as well as the locations (chainages) of the boreholes, are given on drawing No. 60-F-58A, attached to this report (Appendix I).

Under Appendix I, borehole logs with penetration results, are also given.

Laboratory testing was confined to the determination of grain size distribution curves, and, where possible, of Atterberg limits, and moisture contents.

All results are given under Appendix I.

cont'd. /3....

#### 4. SUBSOIL CONDITIONS:

##### 4.1 General:

The stratigraphy of the soil at the site was found to be quite uniform. Two main types of soil were encountered and they are:

##### 4.2 Sandy Silt and Silty Sand:

This material forms the top layer on the site and extends to about 18 feet below ground level. The amount of sand in this layer varies from 2% to 56%, also up to 7% of gravel has been found in borehole No. 5 at a depth of 30ft. In places the material is a clay of low plasticity.

From drawing No. 60-F-58A where the relationship of "N" values and depth is given, it looks as if the density of the material increases with depth. This may be so, but only to a certain extent. The lower values of "N" at shallower depth have to be corrected for the lack of sufficient overburden pressure (Gibbs and Holtz, 4th T.C.S.M.F.E. 1957). The corrected values indicate that the relative density of the material varies or rather increases from 80% to about 100%.

The clay bands or interlayers with a higher clay content are very stiff.

##### 4.3 Clay of Low Plasticity with some Gravel:

Underlying the material described above is a layer of silty clay with some gravel particles. The percentage of gravel is up to 6%. The average liquid limit is 22.4%, plastic limit 13.3% and the average natural moisture content is slightly above the plastic limit with the average value of 14.8%. It was determined in the field that the whole layer

cont'd. /4....

4.3 Clay of Low Plasticity with some Gravel: (cont'd.)...

is not homogeneous - i.e. there is a variation in the clay and sand contents. In some places the material is more clayish while in others the material is more sandy, but generally this layer can be considered as a silty clay.

Only one borehole (No.2) was carried down to a greater depth (91.5 feet). Up to this depth no change in the material was found. The only change refers to the density of the material.

At approximately 18 feet below ground level there is a change from cohesionless to cohesive soil. The number of blows naturally decreases because of this change. Throughout the slightly cohesive layer the average number of blows is slightly above 20 indicating a very stiff consistency. At about 75 feet below ground level (El. 213.0') a rather sharp increase of the number of blows was registered indicating an increase in density of the material.

Two soil profiles, one along the East and one along the West side of the County Road No. 2, have been prepared and are shown on drawing No. 60-P-58A.

5. GROUND WATER CONDITIONS:

The ground water table at the site of the proposed underpass is Approx. 6 feet below the exist. ground surface. No Artesian Water Condition has been encountered during the investigation.

6. DISCUSSIONS AND RECOMMENDATIONS:

The properties of the encountered materials as des-

cont'd. /5....



6. DISCUSSIONS AND RECOMMENDATIONS: (cont'd.)....

cribed in the preceding paragraph indicate that spread footings could be used for the structure. The upper sandy silt layer is very dense and can provide adequate bearing capacity. Bearing in mind the large silt content in places an average value of  $36^\circ$  was chosen for the angle of internal friction. The bearing capacity for a typical footing 6 feet wide can be determined by the following expression:

$$q = \frac{1}{2} B \gamma N_\gamma + \gamma D_F N_q$$

where

B = width of footing (6 ft.)

$D_F$  = depth of overburden (6 ft.)

$\gamma$  = unit weight (115 lb/cu.ft.)

$\gamma'$  = submerged unit weight (53 lb/cu.ft.)

$N_\gamma, N_q$  = bearing capacity factors

( $N_\gamma = 46$ ;  $N_q = 43$ )

If the ground water level is assumed at elevation level we have

$$\begin{aligned} q &= \frac{1}{2} \frac{6 \times 53 \times 46}{2000} + \frac{6 \times 115 \times 43}{2000} \\ &= 3.65 + 14.83 = 18.48 \text{ T/sq.ft.} \end{aligned}$$

If a safety factor of 3 is chosen the allowable bearing capacity would be

$$q_{all.} = \frac{18.48}{3} = \underline{6.16} \text{ T/sq.ft. say } \underline{6.0} \text{ T/sq.ft.}$$

This value is based on the shear failure of the subsoil. To allow only 1 - 1½" settlement the above value has to be reduced and 3.0 T/sq.ft. should be used for design purposes.

cont'd. /6....

6. DISCUSSIONS AND RECOMMENDATIONS: (cont'd.)....

Footings for the falsework can be placed on the sandy silty layer some 1 - 2 feet below ground level. Precaution should be taken to ensure that the ground on which it is intended to place the footings, is not softened while exposed, and that it does not contain decayed organic matter. The load on these temporary footings should not be more than 1.0 T/sq.ft.

No stability problems of the approach fills are anticipated provided the organic surface layer is removed prior to the placement of the fill.

7. SUMMARY:

The general stratification of the subsoil was found to be quite uniform. The upper 18-foot thick layer of sandy silt and silty sand is underlain by a very thick layer of clay of low plasticity with some gravel. Both these layers are not homogeneous and there is quite a variation of sand silt, clay and gravel content.

The upper layer is in a very dense state of packing, and spread footings with a safe load of 3.0 T/sq.ft. can be designed for the structure. The bottom of the footings should be at elevation 282.0 or below, the depth being mainly governed by frost action protection.

The maintenance of a dry excavation will not represent any major problem because:-

a) the water level will be approximately at excavation level, and -

b) the permeability of the ground is sufficiently

cont'd. /7....



low, and low-capacity pumps will be adequate to keep the excavation dry.

Footings for the falsework can be placed 1 - 2 feet below ground level, provided the soil does not contain organic matter and is not softened, and a load of 1.0 T/sq.ft. can be used for the design.

No stability problems are anticipated for the approach fills. The top organic surface layer should be removed prior to the placement of the fill.

#### 8. MISCELLANEOUS:

The field work was carried out during the period of July 5th to 11th, 1960 by the Foundation Section of the D.H.O. Skid-mounted core drills, adapted for soil sampling, were used. The field work was carried out under the supervision of Mr. W. Kulmatickas, project engineer, Foundation Section.

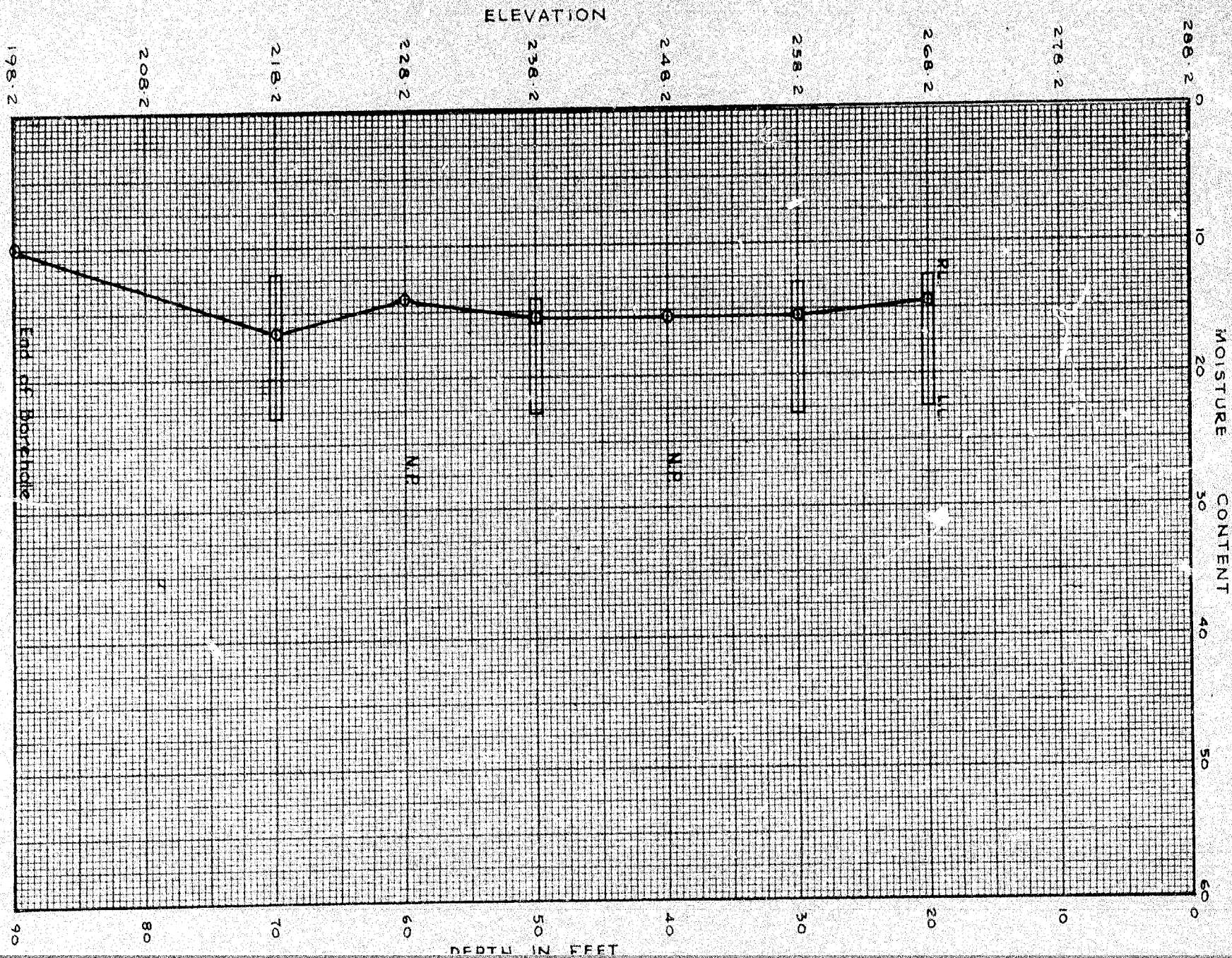
September 1960. REPORT PREPARED BY:

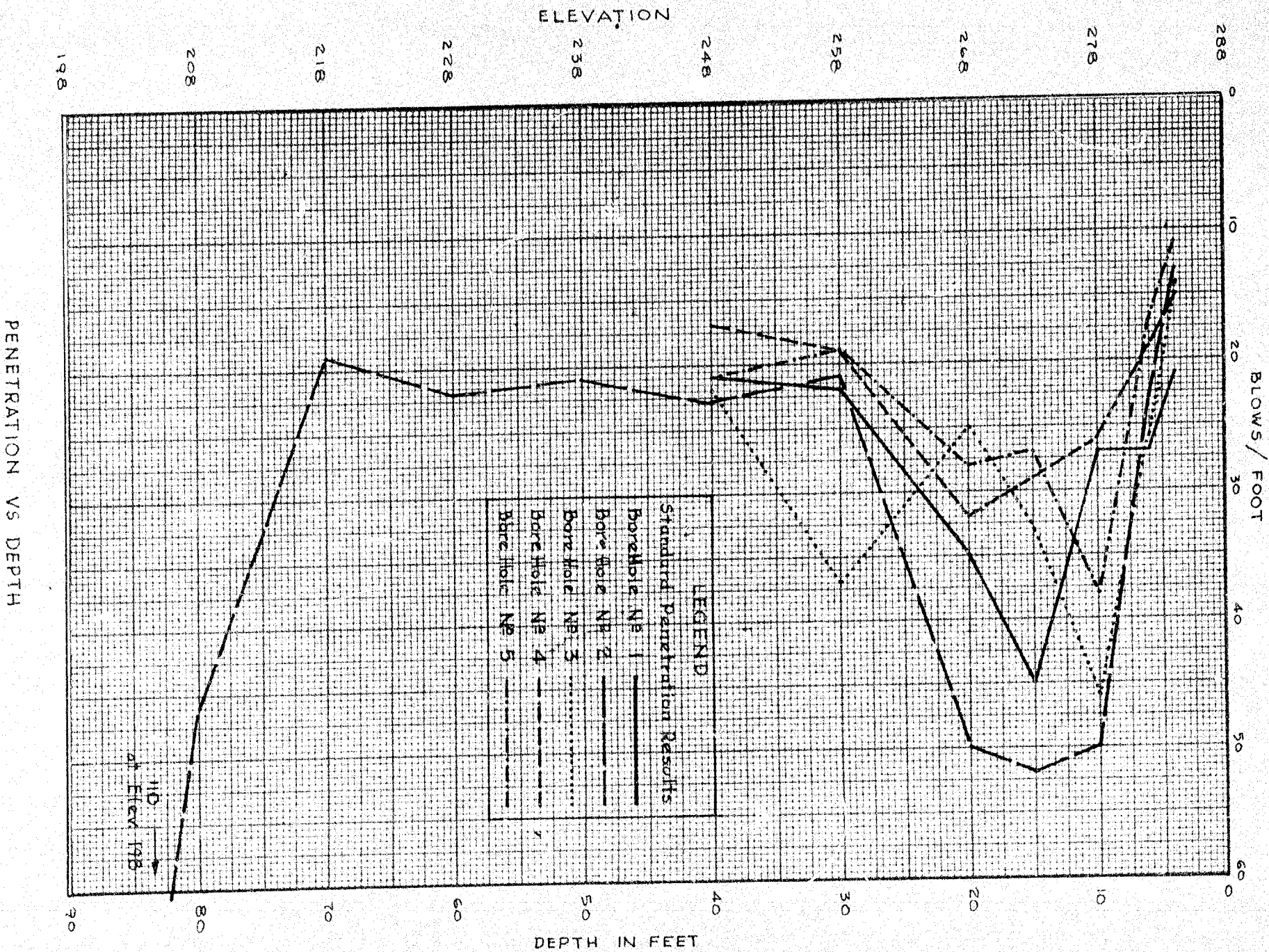
*W. Kulmatickas*  
for W. Kulmatickas,  
Project Foundation Engr

REPORT APPROVED BY:

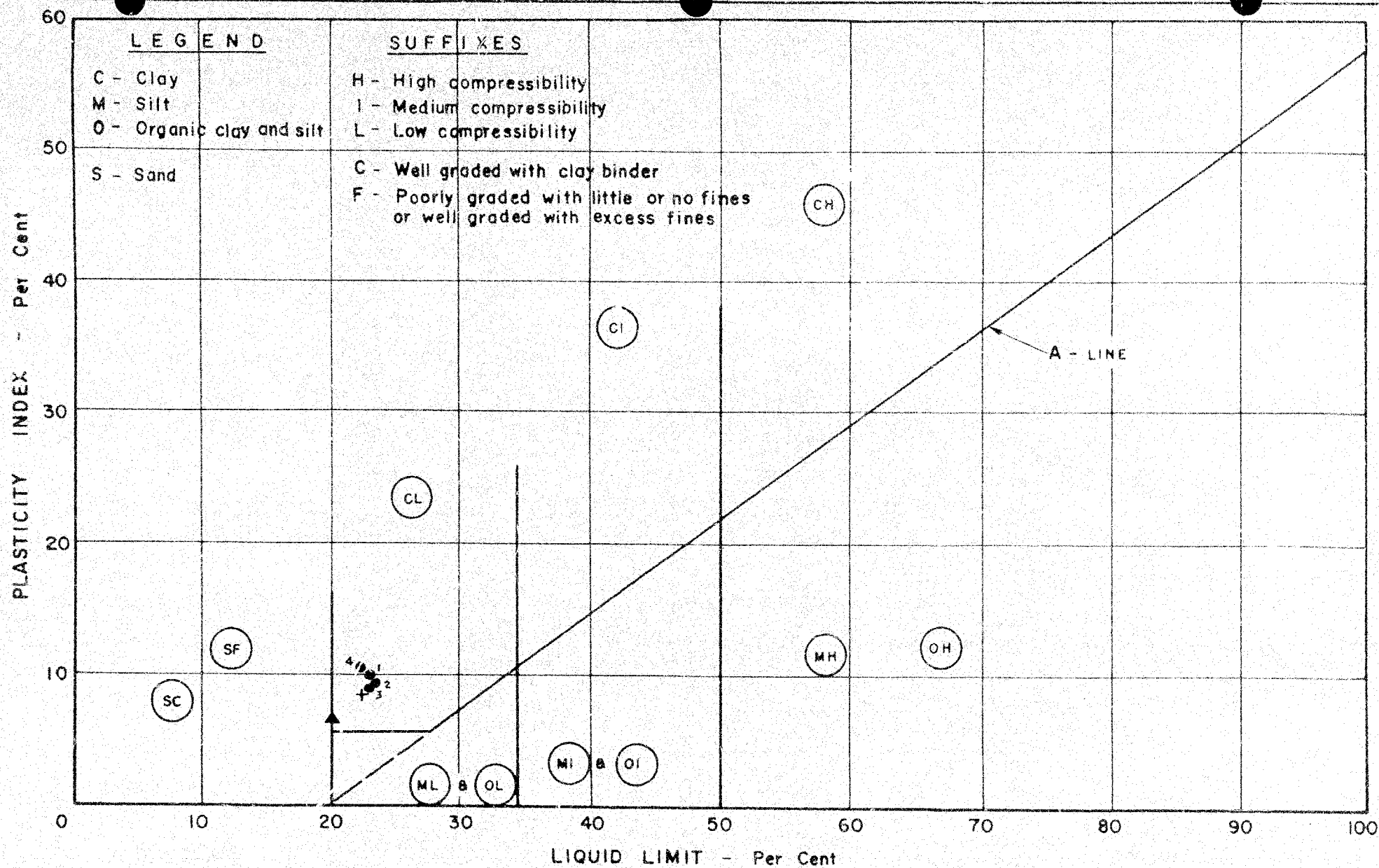
*A. Stermac*  
A. Stermac,  
Foundation Office Engr

APPENDIX I.









NOTES + BOREHOLE No 1  
 • BOREHOLE No 2  
 ▲ BOREHOLE No 5

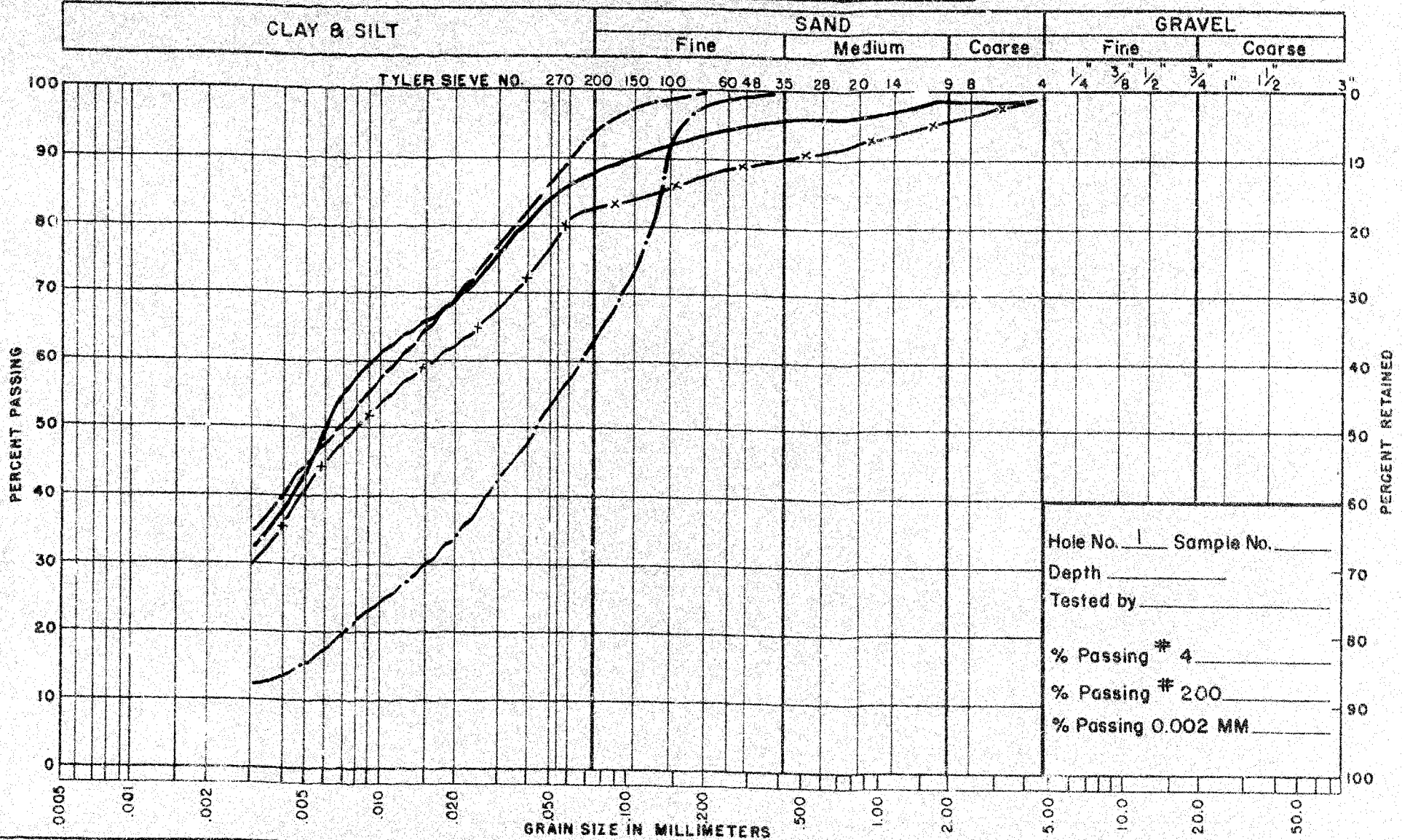
DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & RESEARCH SECTION  
 PLASTICITY CHART

Job No. 60-F-58

W.P. No. III-60

Location Q.E.W. AND COUNTY ROAD No 20

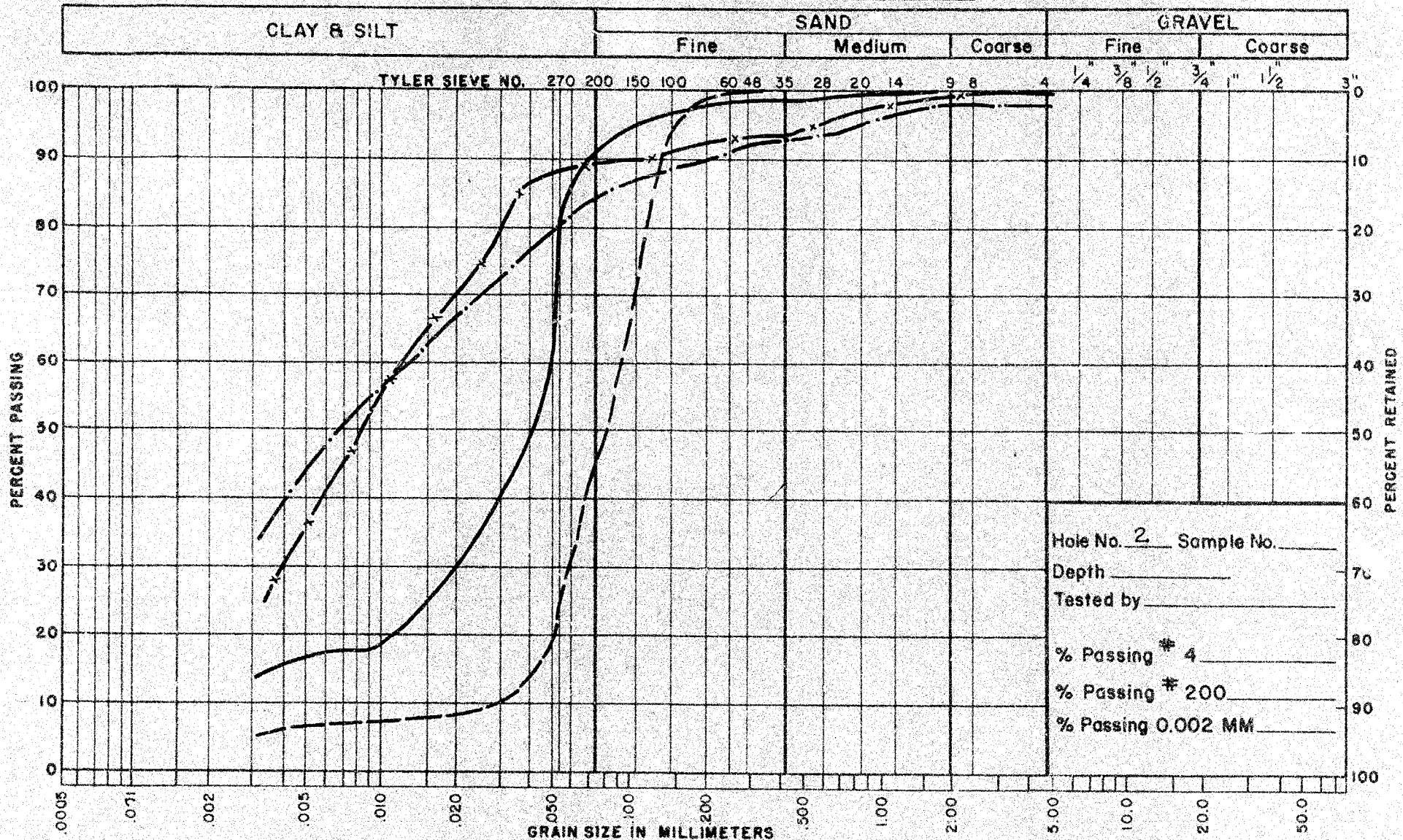
# UNIFIED SOIL CLASSIFICATION SYSTEM



NOTES: --- SAMPLE DEPTH. 6'-0" TO 7'-6"  
 ——— " " " " 10'-0" TO 11'-6"  
 ——— " " " " 15'-0" TO 16'-6"  
 —x— " " " " 20'-0" TO 21'-6"

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & RESEARCH SECTION  
**GRAIN SIZE DISTRIBUTION**  
 Job No. 60-F-58 W.P. No. 111-60  
 Location Q.E.W. & COUNTY RD No. 20

# UNIFIED SOIL CLASSIFICATION SYSTEM



NOTES \_\_\_\_\_ SAMPLE DEPTH 6'-0" TO 7'-6"

\_\_\_\_\_ " " " " 10'-0" TO 11'-6"

\_\_\_\_\_ " " " " 15'-0" TO 16'-6"

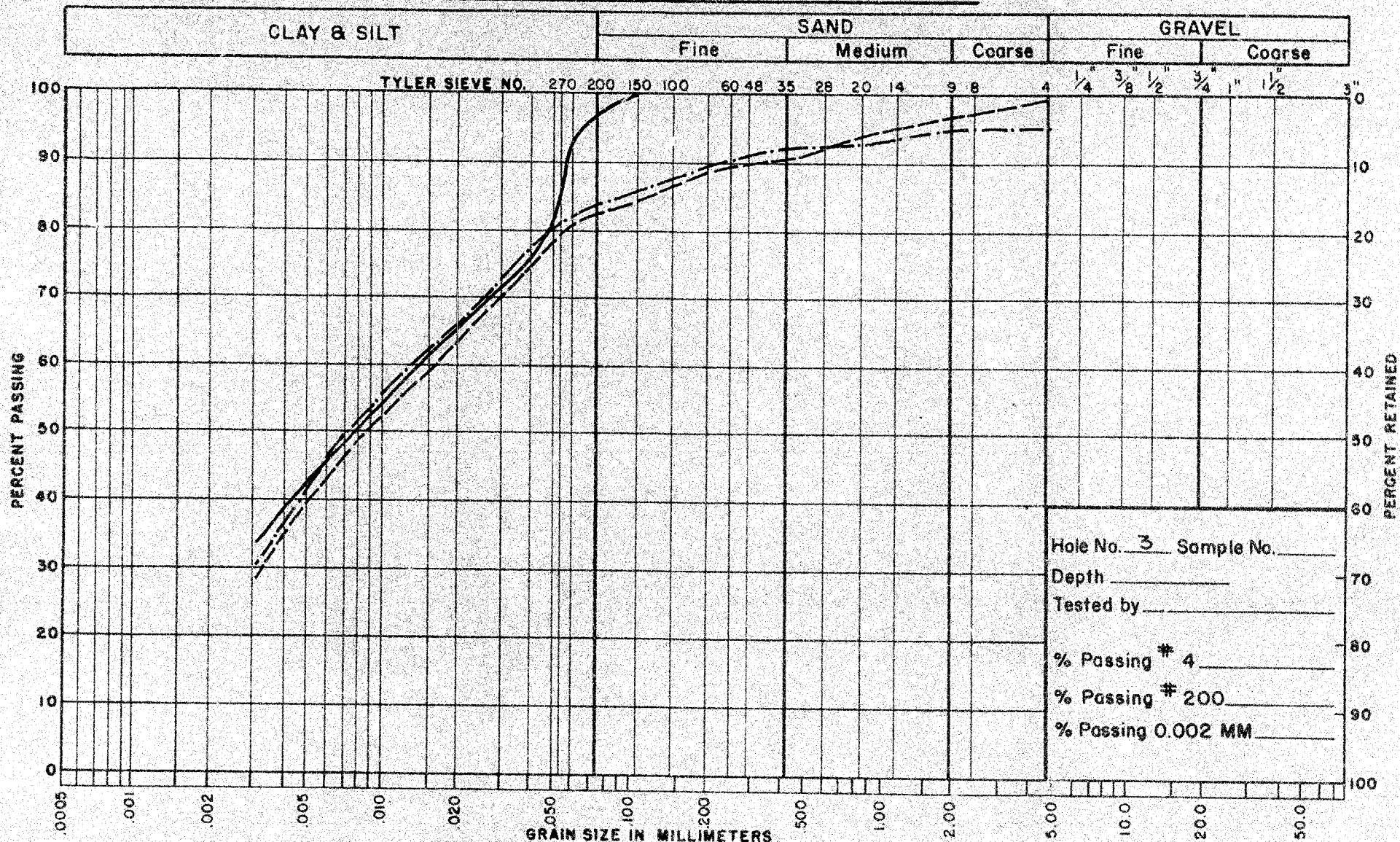
\_\_\_\_\_ " " " " 20'-0" TO 21'-6"

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH SECTION  
**GRAIN SIZE DISTRIBUTION**

Job No. 60-F-58 W.P. No. 111-60  
Location Q.E.W. AND COUNTY ROAD No. 20



# UNIFIED SOIL CLASSIFICATION SYSTEM

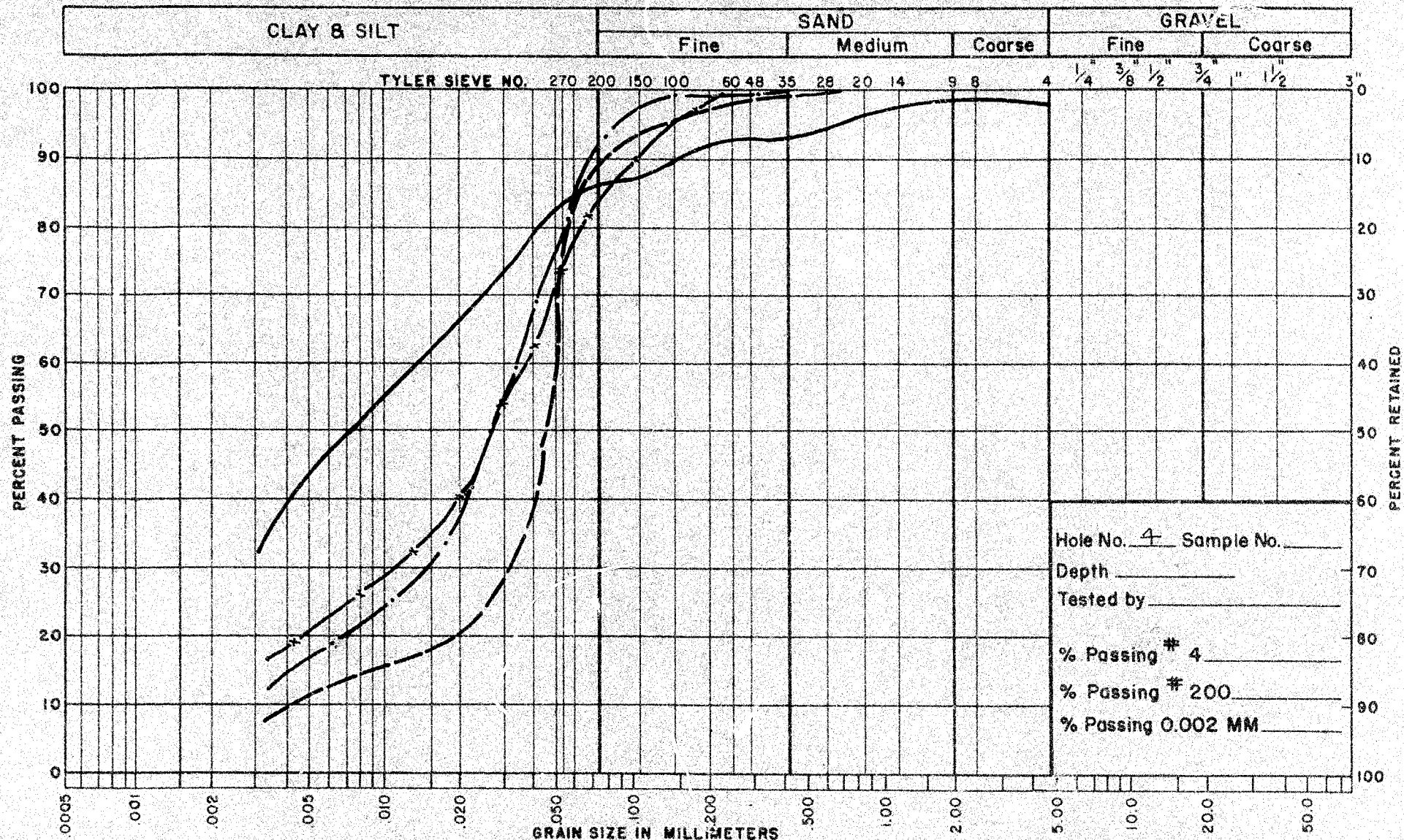


NOTES: ——— SAMPLE DEPTH 6'-0" TO 7'-6"  
 - - - - - " " 15'-0" TO 16'-6"  
 - . - . - " " 20'-0" TO 21'-6"

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & RESEARCH SECTION  
**GRAIN SIZE DISTRIBUTION**

Job No. 60-F-58 W.P. No. \_\_\_\_\_  
 Location Q.E.W. & COUNTY ROAD NO 20

# UNIFIED SOIL CLASSIFICATION SYSTEM



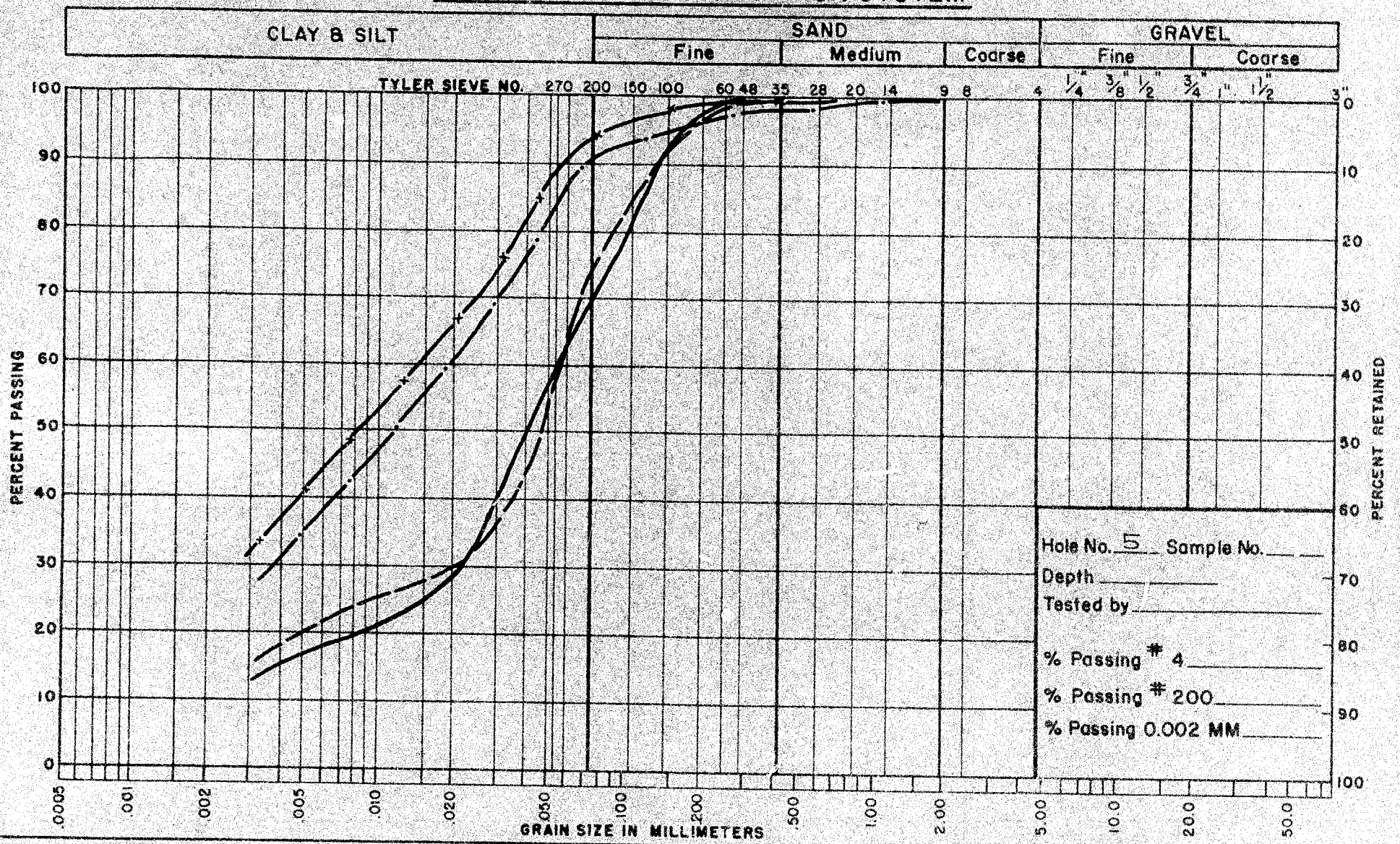
NOTES	---	SAMPLE DEPTH	6'-0" To 7'-6"
	---	"	10'-0" To 11'-6"
	---	"	15'-0" To 16'-6"
	---	"	20'-0" To 21'-6"

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH SECTION  
**GRAIN SIZE DISTRIBUTION**

Job No. 60-F-58 W.P. No. 111-60  
Location Q.E.W. AND COUNTY RD. No. 20



# UNIFIED SOIL CLASSIFICATION SYSTEM



**NOTES**

—	SAMPLE DEPTH 6'-0" to 7'-6"
- - -	10'-0" to 11'-6"
- - - - -	15'-0" to 16'-6"
· · · · ·	20'-0" to 21'-6"

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & RESEARCH SECTION  
**GRAIN SIZE DISTRIBUTION**

Job No. 60-F-58 W.P. No. 111-60

Location Q. E. W. & COUNTY ROAD No. 20

# SUMMARY OF FIELD & LABORATORY TESTS

JOB 60-F-58

W.P. 111-60

HOLE NO.	SAMP. NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS/FT.	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
1	S1	3'-4.5'	Silty sand & sandy silt, dense to very dense.	21	-	-	-	-	-	
	S2	6'-7.5'	" " " "	27	-	-	-	-	-	
	S3	10'-11.5'	" " " "	27	-	-	-	-	-	
	S4	15'-16.5'	" " " "	45	-	-	-	-	-	
	S5	20'-21.5'	Clay of low plasticity some gravel stiff.	35	-	-	-	-	-	
	S6	30'-31.5'	" " " "	22	15.5	13.8	22.2	-	-	
	S7	40'-41.5'	" " " "	21	14.8	-	-	-	-	
2	S1	3'-4.5'	Silty sand & sandy silt, dense to very dense.	13	-	-	-	-	-	
	S2	6'-7.5'	" " " "	23	-	-	-	-	-	
	S3	10'-11.5'	" " " "	50	-	-	-	-	-	
	S4	15'-16.5'	" " " "	52	-	-	-	-	-	
	S5	20'-21.5'	Clay of low plasticity some gravel stiff.	50	14.3	12.6	22.6	-	-	
	S6	30'-31.5'	" " " "	21	15.2	13.1	22.8	-	-	
	S7	40'-41.5'	" " " "	23	16.0	-	-	-	-	
	S8	50'-51.5'	" " " "	21	15.4	14.0	22.8	-	-	
	S9	60'-61.5'	" " " "	24	14.1	-	-	-	-	

# SUMMARY OF FIELD & LABORATORY TESTS

JOB 60-F-58

W.P. 111-60

HOLE NO.	SAMP. NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS/FT.	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
2	S10	70'-71.5'	Clay of low plasticity some gravel stiff.	19	16.2	12.4	22.7	-	-	
	S11	80'-81.5'	" " " "	46	-	-	-	-	-	
	S12	90'-91.5'	" " " "	110	10.0	-	-	-	-	
3	S1	3'-4.5'	Silty sand & sandy silt, dense to v. dense.	14	-	-	-	-	-	
	S2	6'-7.5'	" " " "	26	-	-	-	-	-	
	S3	10'-11.5'	" " " "	46	-	-	-	-	-	
	S4	15'-16.5'	" " " "	33	-	-	-	-	-	No Recovery
	S5	20'-21.5'	Clay of low plasticity, some gravel stiff.	25	-	-	-	-	-	
	S6	30'-31.5'	" " " "	37	-	-	-	-	-	
	S7	40'-41.5'	" " " "	22	-	-	-	-	-	
4	S1	3'-4.5'	Silty sand & sandy silt, dense to v. dense.	15	-	-	-	-	-	
	S2	6'-7.5'	" " " "	19	-	-	-	-	-	
	S3	10'-11.6'	" " " "	26	-	-	-	-	-	
	S4	15'-16.5'	" " " "	29	-	-	-	-	-	
	S5	20'-21.5'	Clay of low plasticity, some gravel stiff.	32	-	-	-	-	-	



# SUMMARY OF FIELD & LABORATORY TESTS

JOB 60-F-58

W.P. 111-60

HOLE NO.	SAMP. NO.	SAMPLE DEPTH (FEET)	MATERIAL DESCRIPTION	PENET'N RESIST. BLOWS/FT.	MOIST. CONT. %	PLASTIC LIMIT %	LIQUID LIMIT %	SHEAR STRENGTH p.s.f.	UNIT WEIGHT p.c.f.	REMARKS
4	S6	30'-31.5'	Clay of low plasticity, some gravel stiff.	19	-	-	-	-	-	
	S7	40'-41.5'	" " " "	17	16.1	-	-	-	-	
5	S1	3'-4.5'	Silty sand & sandy silt, dense to v. dense.	11	-	-	-	-	-	
	S2	6'-7.5'	" " " "	18	-	-	-	-	-	
	S3	10'-11.5'	" " " "	38	-	-	-	-	-	
	S4	15'-16.5'	" " " "	27	-	-	-	-	-	
	S5	20'-21.5'	Clay of low plasticity, some gravel stiff.	28	-	-	-	-	-	
	S6	30'-31.5'	" " " "	19	-	13.6	20.1	-	-	
	S7	40'-41.5'	" " " "	21	15.3	-	-	-	-	
			S denotes Split Spoon Sample							

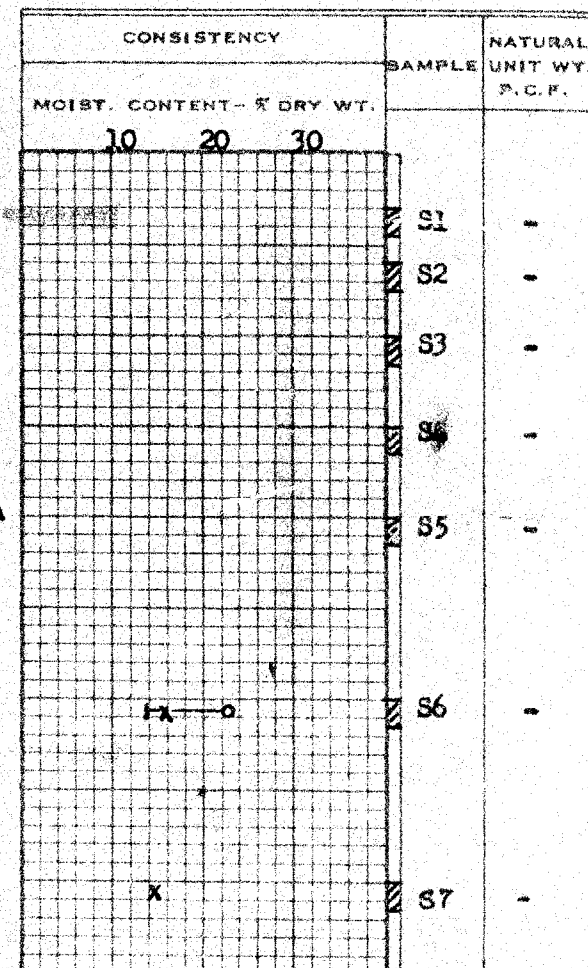
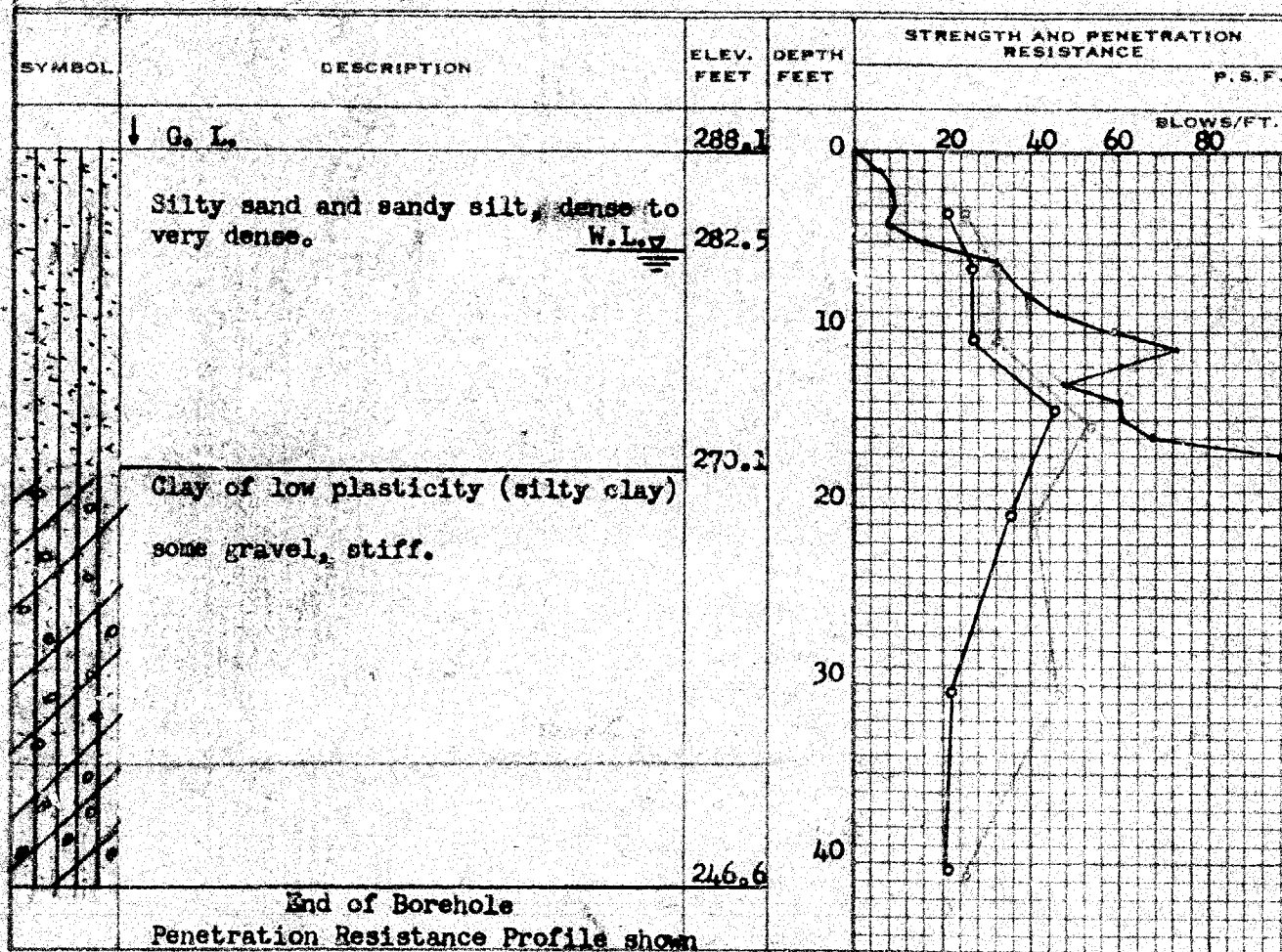
# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 111-60 BORE HOLE NO. 1  
 JOB 60-P-58 STATION See Drawing  
 DATUM 288.1 COMPILED BY H. S.  
 BORING DATE July 5/60. CHECKED BY W. W. K.

2" DIA. SPLIT TUBE  
 2" SHELBY TUBE  
 2" SPLIT TUBE  
 2" DIA. CONE  
 2" SHELBY  
 CASING

## LEGEND

1/2 UNCONFINED COMPRESSION (Qu)  $\bigcirc$   
 VANE TEST (C) AND SENSITIVITY (S)  $+$   
 NATURAL MOISTURE AND LIQUIDITY INDEX  $\times$   
 LIQUID LIMIT  $\bigcirc$   
 PLASTIC LIMIT  $\bigcirc$





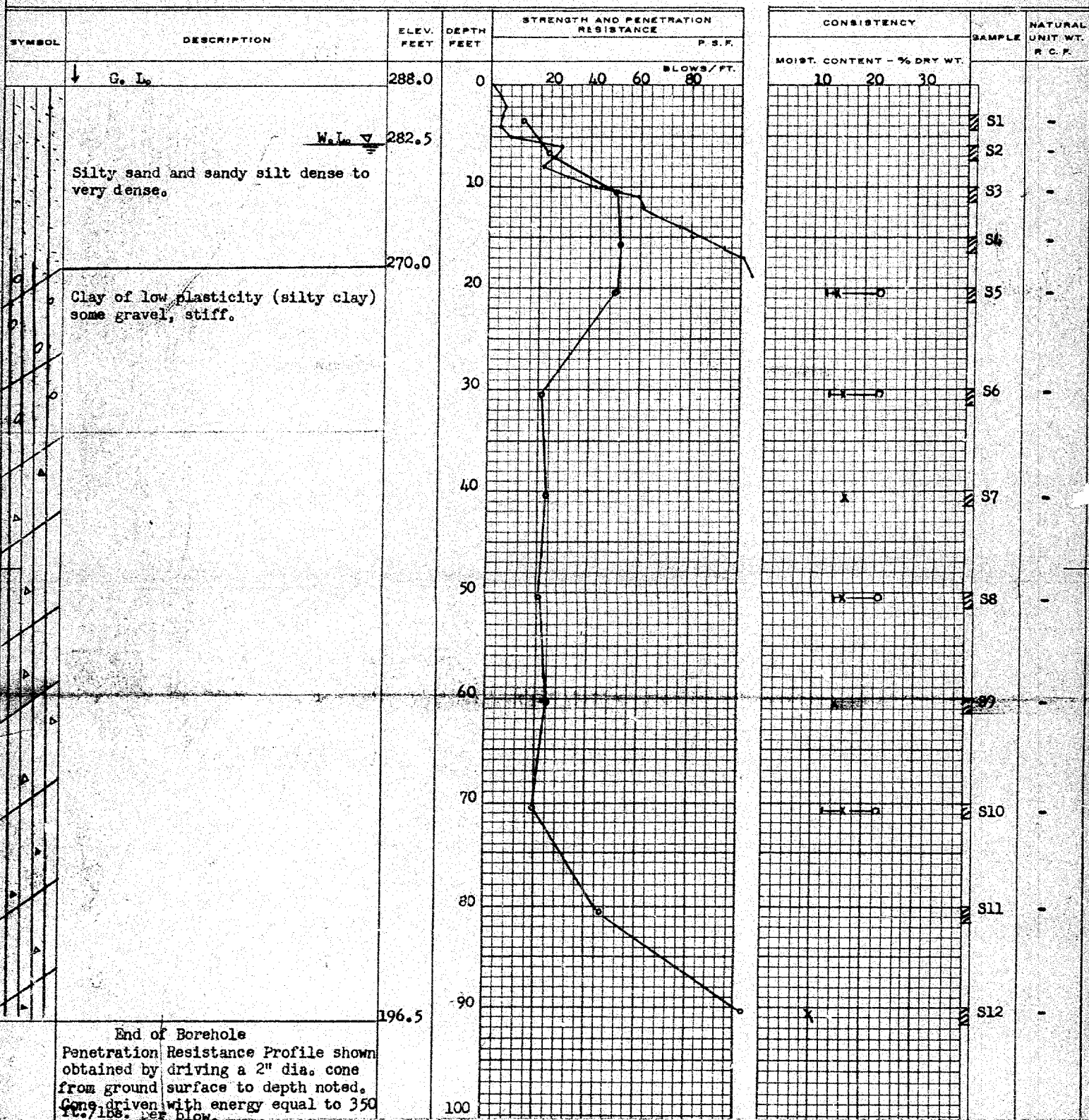
# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 111-60 BORE HOLE NO. 2  
JOB 60-F-58 STATION See Drawing  
DATUM 288.0' COMPILED BY H. S.  
BORING DATE July 5/60 CHECKED BY W. W. K.

## LEGEND

1/2 UNCONFINED COMPRESSION (Qu) 0  
VANE TEST (C) AND SENSITIVITY (S) +1  
NATURAL MOISTURE AND LIQUIDITY INDEX L1  
LIQUID LIMIT X  
PLASTIC LIMIT —

2" DIA. SPLIT TUBE —  
2" SHELBY TUBE —  
2" SPLIT TUBE —  
2" DIA. CONE —  
2" SHELBY CASING —



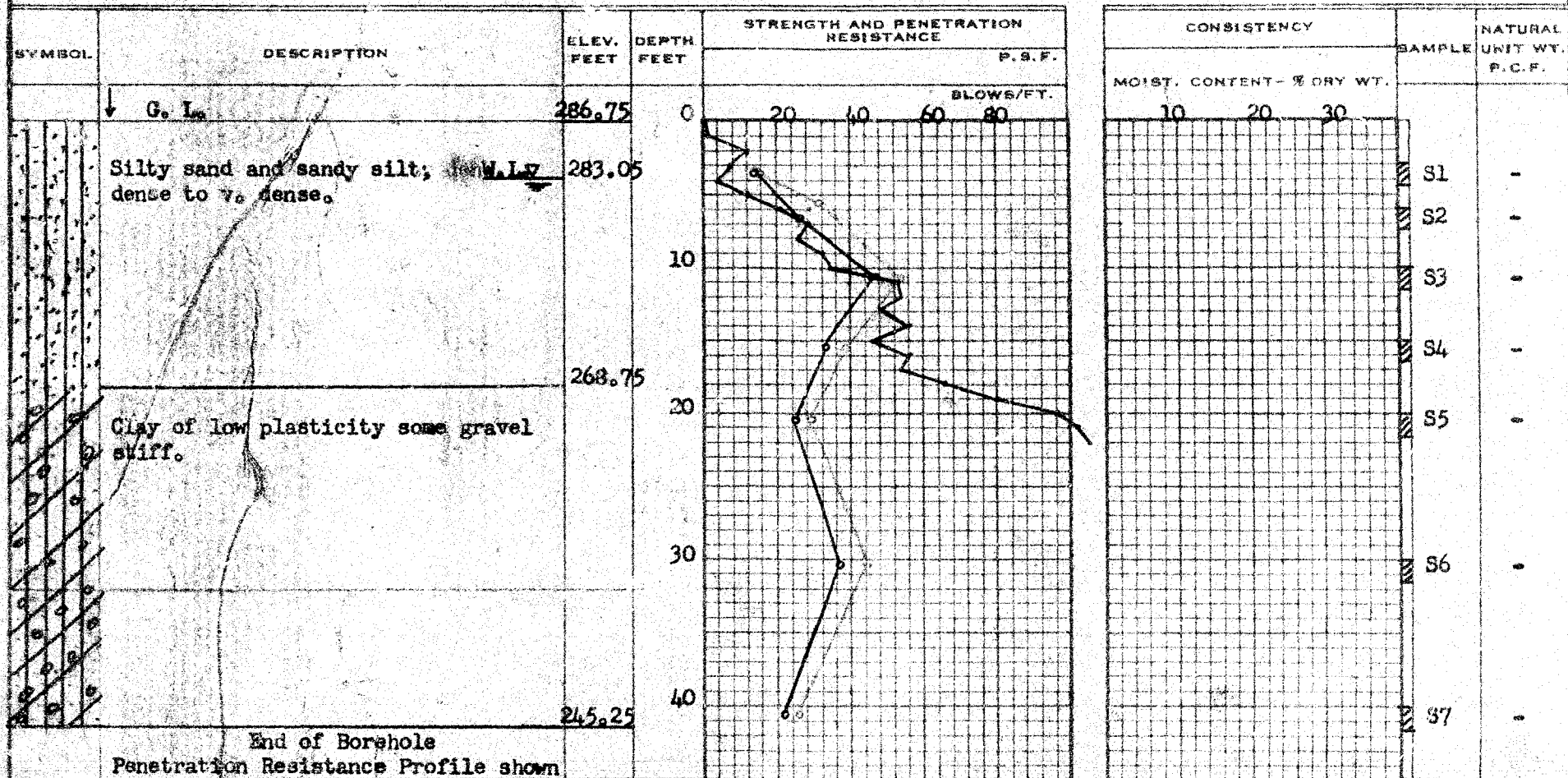
# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.P. 111-60 BORE HOLE NO. 3  
 JOB 60-F-58 STATION See Drawing  
 DATUM 286.75' COMPILED BY H. S.  
 BORING DATE July 6/60. CHECKED BY W. W. K.

2" DIA. SPLIT TUBE  
 2" SHELBY TUBE  
 2" SPLIT TUBE  
 2" DIA. CONE  
 2" SHELBY  
 CASING

## LEGEND

1/2 UNCONFINED COMPRESSION ( $Q_u$ )  
 VANE TEST (C) AND SENSITIVITY (S)  
 NATURAL MOISTURE AND LIQUIDITY INDEX  
 LIQUID LIMIT  
 PLASTIC LIMIT



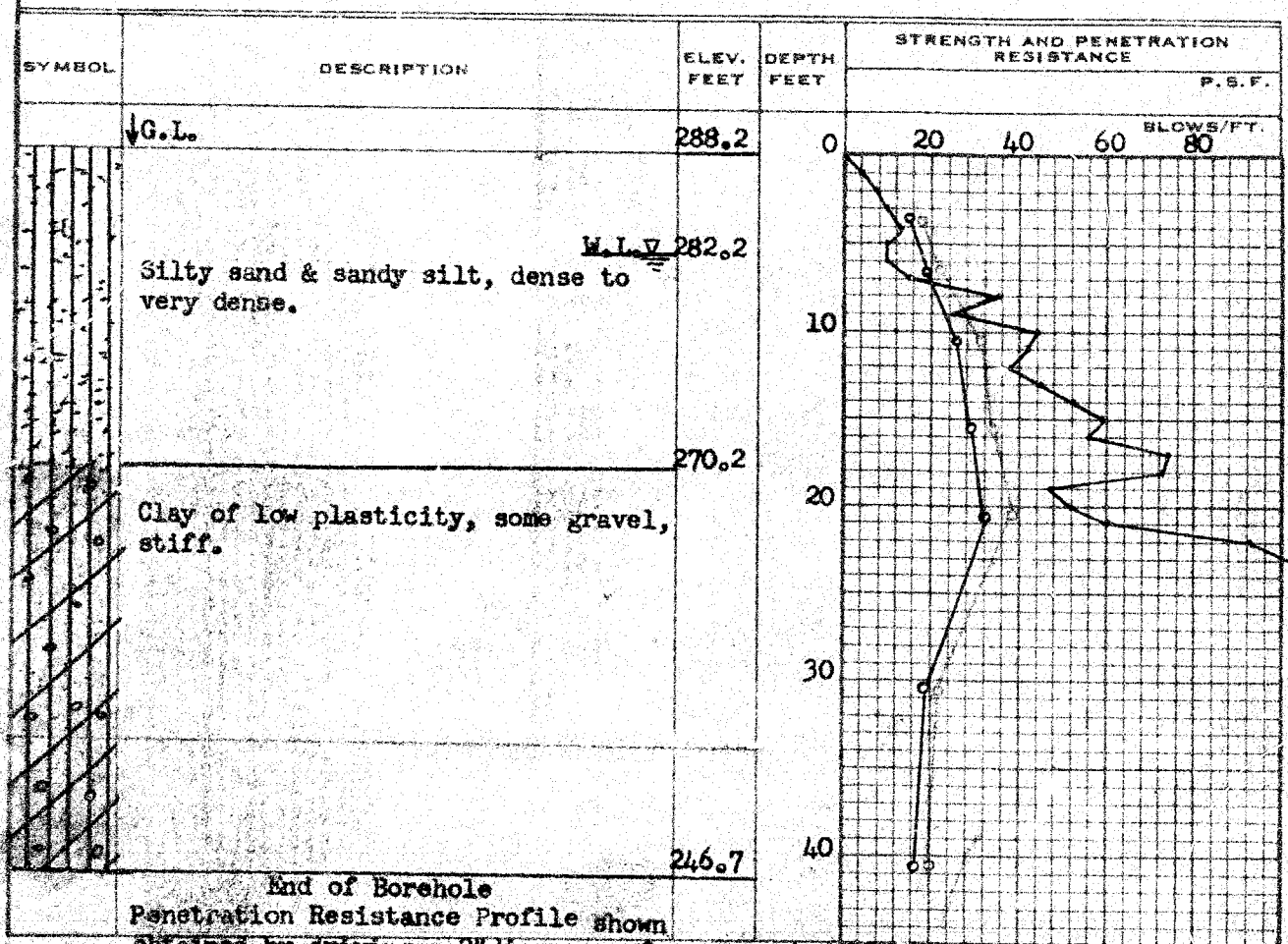
# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

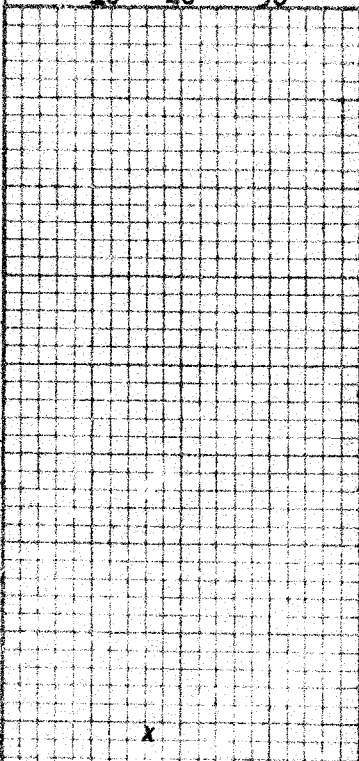
W.P. 111-60 BORE HOLE NO. 4  
 JOB 60-F-58 STATION See Drawing  
 DATUM 288.2' COMPILED BY H. S.  
 BORING DATE July 7/60. CHECKED BY W. W. K.

2" DIA. SPLIT TUBE \_\_\_\_\_  
 2" SHELBY TUBE \_\_\_\_\_  
 2" SPLIT TUBE \_\_\_\_\_  
 2" DIA. CONE \_\_\_\_\_  
 2" SHELBY \_\_\_\_\_  
 CASING \_\_\_\_\_

## LEGEND

1/2 UNCONFINED COMPRESSION ( $Q_u$ ) \_\_\_\_\_ O  
 VANE TEST (C) AND SENSITIVITY (S) \_\_\_\_\_ +  
 NATURAL MOISTURE AND LIQUIDITY INDEX \_\_\_\_\_ LI  
 LIQUID LIMIT \_\_\_\_\_ L  
 PLASTIC LIMIT \_\_\_\_\_ P



CONSISTENCY			SAMPLE	NATURAL UNIT WT. P.C.F.
MOIST. CONTENT-- % DRY WT.				
10	20	30		
			S1	-
			S2	-
			S3	-
			S4	-
			S5	-
			S6	-
			S7	-

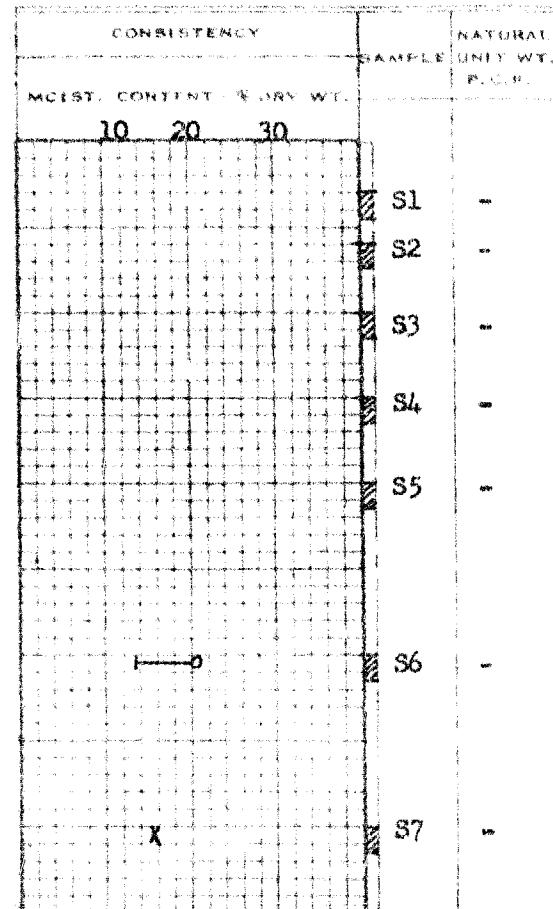
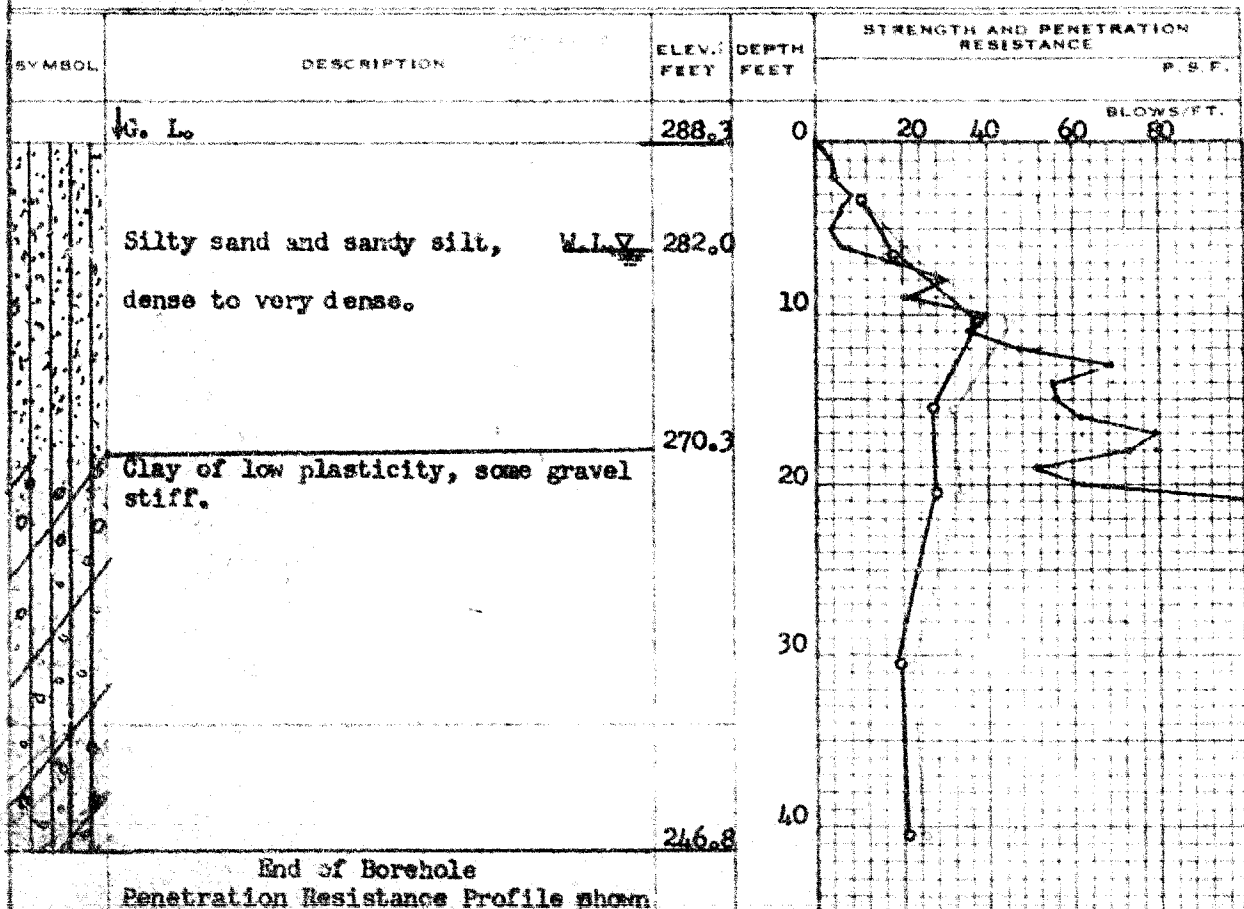
Penetration Resistance Profile shown obtained by driving a 2" dia. cone from ground surface to depth noted. Cone driven with energy equal to 350 ft./lbs. per blow.

# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.F. 111-60 BORE HOLE NO. 5  
 JOB 60-F-58 STATION See Drawing  
 DATUM 288.3' COMPILED BY H. S.  
 BORING DATE July 7/60. CHECKED BY W. W. K.

## LEGEND

1/2 UNCONFINED COMPRESSION ( $Q_u$ ) 0  
 VANE TEST (C) AND SENSITIVITY (S) 4\*  
 NATURAL MOISTURE AND LIQUIDITY INDEX 11  
 LIQUID LIMIT 40  
 PLASTIC LIMIT 10



obtained by driving a 2" dia. cone from ground surface to depth noted. Cone driven with energy equal to 350 ft./lbs. per blow.

#60-F-58

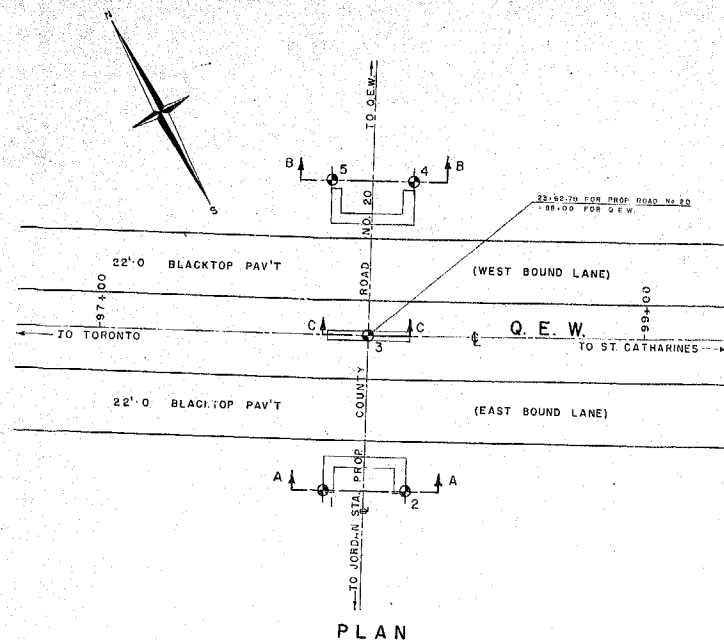
W.P. # 111-60

Q.E.W. ε'

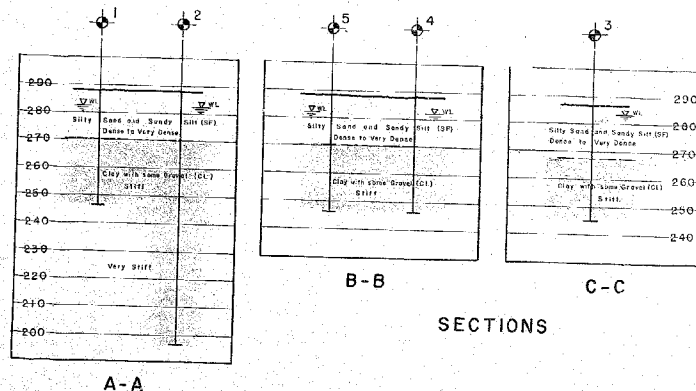
CTY. RD. # 20

5 MILES W. OF

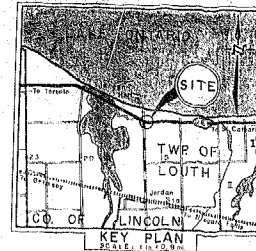
ST. CATHARINES



PLAN



SECTIONS



# LEGEND

BORE & PENETRATION

HOLE	ELEVATION	STATION	DISTANCE FROM C.
1	288.1	97+65	56' RT.
2	288.0	98+15	56' RT.
3	286.75	98+00	C.
4	288.2	98+15	56' LT.
5	288.3	97+65	56' LT.

## NOTE

THE BOUNDARIES BETWEEN R.O.D. DATA HAVE BEEN REVISIONED ONLY AT THE TIME OF THE REVISION. THE BOUNDARIES ARE SUBJECT TO CHANGE WITHOUT NOTICE AND MAY BE SUBJECT TO CERTAIN RISK.

DEPARTMENT OF HIGHWAYS - ONTARIO  
HIGHWAYS & BRIDGES DIVISION

## COUNTY ROAD No. 20 (PROPOSED REVISION)

SHOWING PROPOSED ELEVATIONS OF HOLES  
 HIGHWAY: Q.E.W. DISTRICT: 4 LOT: 6 TOWNSHIP: LINCOLN  
 STATION: LOUTH  
 LOCATION: APPROX. 3 MILES WEST OF ST. CATHARINES.  
 DRAWN BY: D. MUMFORD CHECKED BY: P. H. 50  
 DATE: 28 SEPT. 1960 APPROVED BY:  
 SCALE: (1 inch = 20 feet) 60-F-58A