

GEOCRES No. 41I-79
41I-80DIST. 17 REGION W.P. No. 914-71CONT. No. W. O. No. 73-11003STR. SITE No. 46-145HWY. No. 69LOCATION ESTAIRE TO SUDBURYTWP. OF SECORDNo of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: Mr. J. C. McAllister, (2) FROM: Foundations Office,
Regional Structural Planning Supervisor, Design Services Branch,
Northern Region, West Bldg., Downsview.
North Bay, Ontario.

ATTENTION: DATE: July 30, 1973.

OUR FILE REF. IN REPLY TO AUG - 7 1973

SUBJECT:

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For
Proposed Wanapitei River Crossing
and
Proposed Railway Separation (C.N.R.)
2,800 ft. South of Wanapitei River
on Highway 69
District 17 (Sudbury), Site No. 46-145
W.O. 73-11003 - W.P. 914-71

41 I - 79

Attached we are forwarding to you our report dealing with the results of our foundation investigations at the above-mentioned sites.

We believe that the information contained in the report will enable you to prepare a reasonably accurate estimate of the cost of constructing the structures at the two crossings. It should be noted, however, that additional field information will be necessary before a detailed foundation design can be carried out.

If you have any further queries, please contact this Office.

A. G. Stermac

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ao
Attch.

c.c. E. J. Orr
B. R. Davis
A. Rutka
H. McArthur
D. S. Cornell
B. J. Giroux
J. E. Gruspier
G. A. Wrong
B. A. Singh
J. Ardizzone
J. Cover (Giffels, Davis & Jorgensen Ltd.)

Foundations Files ✓
Documents

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MISCELLANEOUS.

PRELIMINARY
FOUNDATION INVESTIGATION REPORT
For
Proposed Wanapitei River Crossing
and
Proposed Railway Separation (C.N.R.)
2,800 ft. South of Wanapitei River
on Highway 69
District 17 (Sudbury)
W.O. 73-11003 -- W.P. 914-71

1. INTRODUCTION:

A request for a preliminary foundation investigation where Hwy. 69 crosses the Wanapitei River and at the crossing of Hwy. 69 and the C.N.R. Railway, 2,800 feet south of the Wanapitei River, was received from Mr. J. C. McAllister, Regional Structural Planning Supervisor, in a memo dated February 14, 1973.

A field investigation was subsequently carried out by the Foundations Office to determine the subsoil conditions at these sites. This report contains the results of this investigation and our recommendations.

2. SITE CONDITIONS:

2.1) Wanapitei River Crossing:

This site is located on Hwy. 69 about 15 miles south of Sudbury. The surrounding area at this location is hilly and there is a 100-foot-high rock outcrop 200 feet southeast of the crossing.

The existing structure, which is to be twinned, is a three span reinforced concrete bridge founded on piles driven

to bedrock. The approach embankment on the south side is a 10 to 12-foot-high rock fill. No signs of instability of the structure and approach embankments are visible.

2.2) C.N.R. Railway Separation:

This site is located 2,800 feet south of the Wanapitei River on Hwy. 69. The surrounding area is rolling and there is a 100 to 200-foot-high rock outcrop 200 feet south-east of the separation. The railway and highway embankments are 7 feet high at the existing crossing. There are no signs of embankment instability.

3. FIELD AND LABORATORY:

The field work consisted of three sampled boreholes at the river crossing and two sampled boreholes and two dynamic cone penetration tests at the railway separation. The boreholes were advanced using continuous-flight auger, washboring, and diamond drilling equipment mounted on a bombardier or by using diamond drilling equipment modified for soil sampling purposes.

Disturbed samples were obtained using a 2-inch O.D. split-spoon sampler driven according to the specifications for the Standard Penetration Test. Undisturbed samples were taken at the railway separation using 2-inch I.D. Shelby tubes which were pushed into the soil manually. Field vane tests were carried out 18 inches below Shelby tube samples wherever possible. Rock cores were obtained at the ends of two boreholes at the river crossing.

Dynamic cone penetration tests were performed adjacent to one borehole and at one other location. Driving energy to advance the cone was 350 ft.-lbs. per blow.

The locations and elevations of the boreholes and cone tests are marked on Drawing No. 73-11003A accompanying this report.

Samples were examined visually in the field and again in the laboratory. Tests were performed on selected samples to determine the following physical properties:

Grain-Size Distribution
Atterberg Limits
Natural Moisture Content
Bulk Density
Unconfined Shear Strength
Triaxial Shear Strength
Consolidation Characteristics

The results of the field and laboratory tests are given in the Record of Borehole sheets and in Figures 1 to 7, which are contained in the Appendix of this report.

4. SUBSOIL CONDITIONS:

4.1) Wanapitei River Crossing:

4.1.1) General:

The subsoil is basically non-cohesive sand and silt. There are traces of clayey silt in the silt layer. The subsoil is underlain by gneiss bedrock. There are two main strata which are listed from ground level downwards as follows.

4.1.2) Silt with Sand:

This stratum was observed on the south side of the river only in Boreholes 2 & 3. It is a 13-foot-thick layer of very loose to compact silt and some sand to sandy silt, a trace to some clay, and traces of clayey silt.

Standard Penetration 'N' values vary from 2 to 16 blows per foot with an average value of 10 blows per foot. The natural moisture content varies from 21 to 42 percent with an average value of 28 percent.

4.1.3) Sand:

This 22 to 28-foot-thick stratum consists of loose to compact sand, a trace to some silt, and a trace of clay. It is underlain by gneiss bedrock. Frequent cobbles were observed

immediately above bedrock on the north side of the river.

Standard Penetration 'N' values range from 6 to 26 blows per foot with an average value of 14 blows per foot. The natural moisture content varies from 19 to 30 percent with an average value of 23 percent.

4.2) C.N.R. Railway Separation:

4.2.1) General:

The soil strata in the upper 20 feet of the subsoil are non-cohesive except for one cohesive layer. Below these strata are a number of cohesive strata which range from soft to very stiff in consistency. At depths of 140 feet or deeper, very dense silt is encountered. The soil strata are listed from ground level downwards as follows.

4.2.2) Topsoil:

An approximately 1-foot-thick layer of organic topsoil is encountered at the ground surface.

4.2.3) Silty Sand:

This 3.5-foot-thick stratum was encountered on the east side of Hwy. 69. It consists of loose silty sand and some clay.

4.2.4) Clayey Silt (Upper Stratum):

This 5.2-foot-thick stratum was encountered on the west side of Hwy. 69. It consists of soft to firm clayey silt.

4.2.5) Silt (Upper Stratum):

This stratum consists of 5 to 7 feet of very loose to compact silt, a trace to some sand and clay, and a trace of gravel. The natural moisture content is about 25 percent.

4.2.6) Sand:

A 7 to 9-foot-thick stratum of sand underlies the silt. It consists of loose to compact sand and a trace to some silt. The natural moisture content is about 20 percent.

4.2.7) Clayey Silt (Lower Stratum):

This 19 to 40-foot-thick stratum consists of soft to firm clayey silt, frequent silt seams, occasional to frequent clay seams, and occasional silty sand seams. The physical properties of this stratum are as follows:

	<u>Range of Values</u>	<u>Average Value</u>
Liquid Limit	24 - 34	28
Plasticity Index	8 - 15	10
Natural Moisture Content (%)	29 - 37	32
Unconfined & Triaxial Shear Strengths (p.s.f.)	380 - 675	500
Field Vane Shear Strength (p.s.f.)	540 - 1520	1050
Bulk Density (p.c.f.)	116 - 121	--

4.2.8) Clayey Silt to Silt (Upper Stratum):

This stratum was encountered only on the west side of Hwy. 69. It consists of 27 feet of firm to stiff clayey silt to silt. Approximate soil properties are as follows:

	<u>Approximate Value</u>
Liquid Limit	23
Plasticity Index	5
Natural Moisture Content (%)	33
Field Vane Shear Strength (p.s.f.)	1250

4.2.9) Clay:

This 40 to 66-foot-thick stratum consists of firm to very stiff clay and occasional silt seams. The physical properties of this subsoil stratum are as follows:

	<u>Range of Values</u>	<u>Average Value</u>
Liquid Limit	46 - 65	53
Plasticity Index	26 - 37	30
Natural Moisture Content (%)	41 - 47	44
Unconfined Shear Strength (p.s.f.)	1115 - 1455	--
Field Vane Shear Strength (p.s.f.)	960 - 2000	--

The Atterberg Limits indicate that this is a clay of medium to high plasticity. It has a liquidity index of about 0.8. The field vane tests indicate a sensitivity ranging from 3.4 to 9.7 with an average value of 6.4 which indicates that the clay is sensitive.

4.2.10) Clayey Silt to Silt (Lower Stratum):

This stratum consists of very stiff clayey silt to silt and traces of sand and gravel. It varies in thickness from 17 to 35 feet. The field vane shear strength is over 2000 p.s.f. The liquid limit varies from 22 to 27 with a plasticity index of about 5. The natural moisture content varies from 25 to 45 percent.

4.2.11) Silty Clay to Clay:

This stratum consists of very stiff silty clay to clay, a trace of sand and gravel and occasional cobbles. It was encountered on the east side of Hwy. 69 where Borehole 11 was terminated 11.3 feet into this stratum. The liquid limit is about 48 with a plasticity index of about 26. The natural moisture content varies from 25 to 45 percent.

4.2.12) Silt (Lower Stratum):

This stratum was encountered on the west side of Hwy. 69 where Borehole 12 was terminated 40.5 feet into the stratum. It consists of silt and a trace of sand to silt with sand. The Standard Penetration 'N' values vary from 55 to 72 blows per foot with an average of 63 blows per foot thus indicating a very dense relative density. The natural moisture content varies from about 20 to 25 percent.

5. GROUNDWATER CONDITIONS:

The groundwater level was measured in Boreholes No. 1 and 2 at the Wanapitei River crossing and in Borehole No. 12 at the C.N.R. Railway crossing. The groundwater elevations are as follows:

Borehole 1	718.5 feet
Borehole 2	711.8 feet
Borehole 12	697.8 feet

6. BEDROCK CONDITIONS:

Rock core samples taken at the Wanapitei River crossing were examined by Mr. K. Ingham, Geologist, and his report is as follows:

<u>Hole No. 1</u>	Bedrock at 696.2
27.8 - 37.3	Interbanded quartz biotite gneiss and granite gneiss; dip of lineation approximately 45°.

<u>Hole No. 2</u>	Bedrock at 679.1
35.4 - 40.4	Quartz biotite gneiss; minor thin bands of granite gneiss, dip of lineation approximately 40°.

7. DISCUSSION AND RECOMMENDATIONS:

7.1) Wanapitei River Crossing:

7.1.1) General:

It is proposed to twin the existing structure by constructing a bridge immediately to the west of the existing bridge. A 10 to 12-foot-high approach embankment will be required at the south end of the proposed structure if the profile grade is the same as that for the existing structure.

The subsoil consists of very loose to compact sand and silt underlain by bedrock.

7.1.2) Foundations:

Because of the very loose to compact relative density of the subsoil, spread footings are not feasible. For this reason pile foundations are recommended at this site. Piles should be end bearing and driven to bedrock. Bedrock surface elevations are as follows:

<u>Location</u>	<u>Bedrock Elevation (ft.)</u>
Sta. 52+95, 140' LT. of centre-line	696.4
Sta. 50+35, 145' LT. of centre-line	679.1

These elevations indicate that piles will be from 25 to 40 feet long.

The full design capacity of the pile section selected may be used for design purposes.

7.1.3) Embankment Stability and Settlement:

Because of the non-cohesive nature of the subsoil, approach embankments should be stable and all settlement will occur during construction. The magnitude of settlement should not be greater than 1 to 2 inches.

7.1.4) Erosion Protection:

The banks of the river under the existing structure have been protected from scour with rip-rap. It is expected that such protection will be required at the site of the proposed crossing.

7.2) C.N.R. Railway Separation:

7.2.1) General:

It is proposed to construct a railway separation which will necessitate the construction of two structures and 35-foot-high approach embankments to these structures. The subsoil consists of 20 feet of generally non-cohesive material underlain by a deep stratum of cohesive material which is soft to firm in the upper 20 feet.

7.2.2) Foundations:

Because of the low bearing capacity of the subsoil near ground level, footings must be supported on piles. Two possibilities are approximately 50-foot-long friction piles driven into cohesive strata and 180-foot-long end-bearing steel H-piles driven into the very dense stratum of silt to silt with sand. Pile loading tests should be carried out to determine the design capacity of each pile type. It is expected that the H-piles may support 70 tons per pile.

7.2.3) Embankment Stability:

The stability of the proposed embankment has been checked by stability analyses based on shear stress parameters in terms of total stresses. The stability analyses were carried out using an electronic computer assuming that failure occurs along a circular arc immediately after construction.

The results of the stability analyses indicate that the maximum allowable embankment height without berms is 12 feet with 2 horizontal to 1 vertical slopes. To obtain the proposed embankment height of 35 feet two levels of berms are required, one at 12 feet and one at 24 feet above ground level. The computer analyses indicate that a berm length of 60 feet is required for both berms. All slopes should be placed at an angle of 2 horizontal to 1 vertical.

7.2.4) Settlement:

Computation of settlements due to compression of the cohesive strata were carried out using laboratory consolidation curves. Stresses induced by the embankment were calculated by the Boussinesq theory. The results of these calculations indicated that 3 to 5 feet of settlement can be expected under the centre-line of a 35-foot-high embankment. It is estimated that 30 to 35 years will be required to attain 90 percent of this settlement. About 15 years will be needed to attain 50 percent of this settlement.

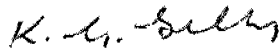
8. MISCELLANEOUS:

The field work, which was carried out during the period of April 10 to 21, 1973, was supervised by Mr. E. A. Wood, Project Foundations Engineer. The equipment was owned and operated by Canadian Longyear Limited.

This report was written by Mr. E. A. Wood and reviewed by Mr. K. Selby, Supervising Foundations Engineer.



E. A. Wood



K. G. Selby, P. Eng.

EAW/ao
July 5, 1973.

APPENDIX I

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 73-11003

LOCATION Sta. 52 + 95 140' Lt. of Exist. Hwy. 69 E

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 10, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cont. flight auger

CHECKED BY M.S.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w w_p — w — w_L WATER CONTENT % 20 40 60				BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
724.0	Ground Level															
0.0	Sand, some silt, Loose to Compact		1	SS	12	720										$\frac{V}{0.75}$ (25) 0 88 (12) 0 81 (19)
			2	SS	14											
			3	SS	11	710										
			4	SS	6											
			5	SS	26	700										
696.4	Sound Gneiss Bedrock		6	RC	85%											
27.6			7	RC	100%	690										
686.7	End of Borehole															
37.3																

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 73-11003

LOCATION Sta. 50 + 35 145' Lt. of Exist. Hwy. 69 Ø

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 16, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE Type Boring

CHECKED BY M.S.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT ——— w_L				BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT				PLASTIC LIMIT ——— w_p					
							SHEAR STRENGTH P.S.F.				WATER CONTENT ——— w					
							○ UNCONFINED + FIELD VANE				w_p ——— w ——— w_L					
							● QUICK TRIAXIAL × LAB VANE				WATER CONTENT %					

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 3

JOB 73-11003

LOCATION Sta. 49 + 65 140' Lt. of Exist. Hwy. 69 Ø

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 16, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY M. S.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				w_p w w_L WATER CONTENT % 20 40 60				
714.0	Ground Level														
0.0	Silt, some sand to sandy silt, trace of clay.		1	SS	2	710									0 15 (85)
			2	SS	16										
	Very Loose to Compact		3	SS	12										
703.5			4	SS	8										0 49 (51)
10.5	End of Borehole					700									
	Note: Groundwater Level not established.														

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 11

JOB 73-11003

LOCATION Sta. 27 + 25 80' Rt. of Exist. Hwy. 69

ORIGINATED BY EW

W.P. 914-71

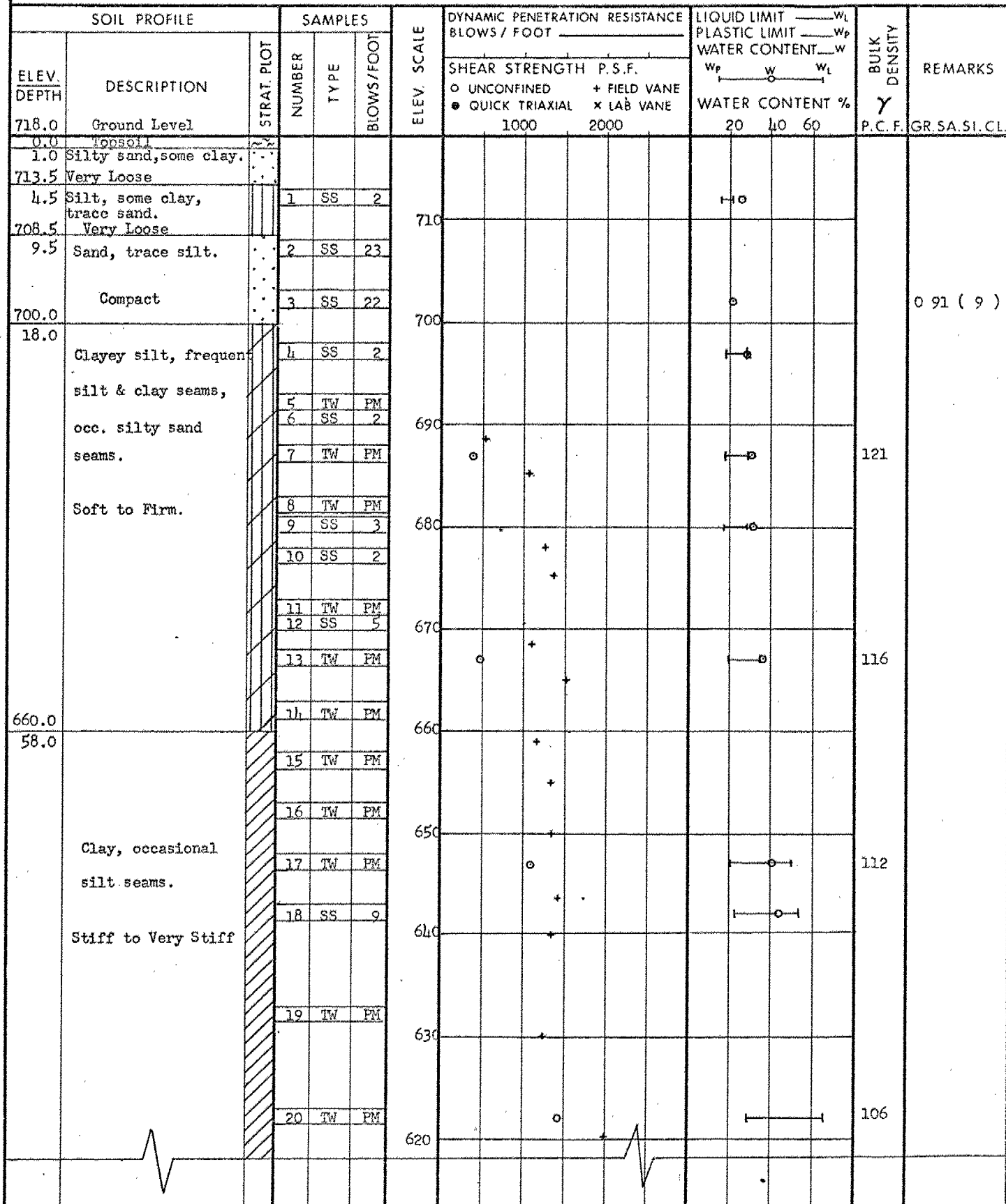
BORING DATE April 12, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger and Washboring

CHECKED BY MS.



DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 11 (cont.)

JOB 73-11003

LOCATION Sta. 27 + 25

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 12, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger & Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F.			WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
618.0							1000	2000						
100.0														
	Clay, occasional silt seams.		21	TW	PM	610								
	Stiff to Very Stiff													
			22	TW	PM	600								
593.5														
124.5	Clayey silt to silt.		23	SS	29	590								
	Very Stiff													
			24	SS	24	580								
577.0														
141.0	Silty clay to clay traces sand & gravel		25	SS	27	570								
	Occ. cobbles													
565.7	Very Stiff		26	RC	30%									
152.3	End of Borehole Probable Boulder					560								
	Note: Groundwater level not established													

OFFICE REPORT SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 12

JOB 73-11003

LOCATION Sta. 25 + 20 80' Lt. of Hwy. 69

ORIGINATED BY EW

W.P. 914-71

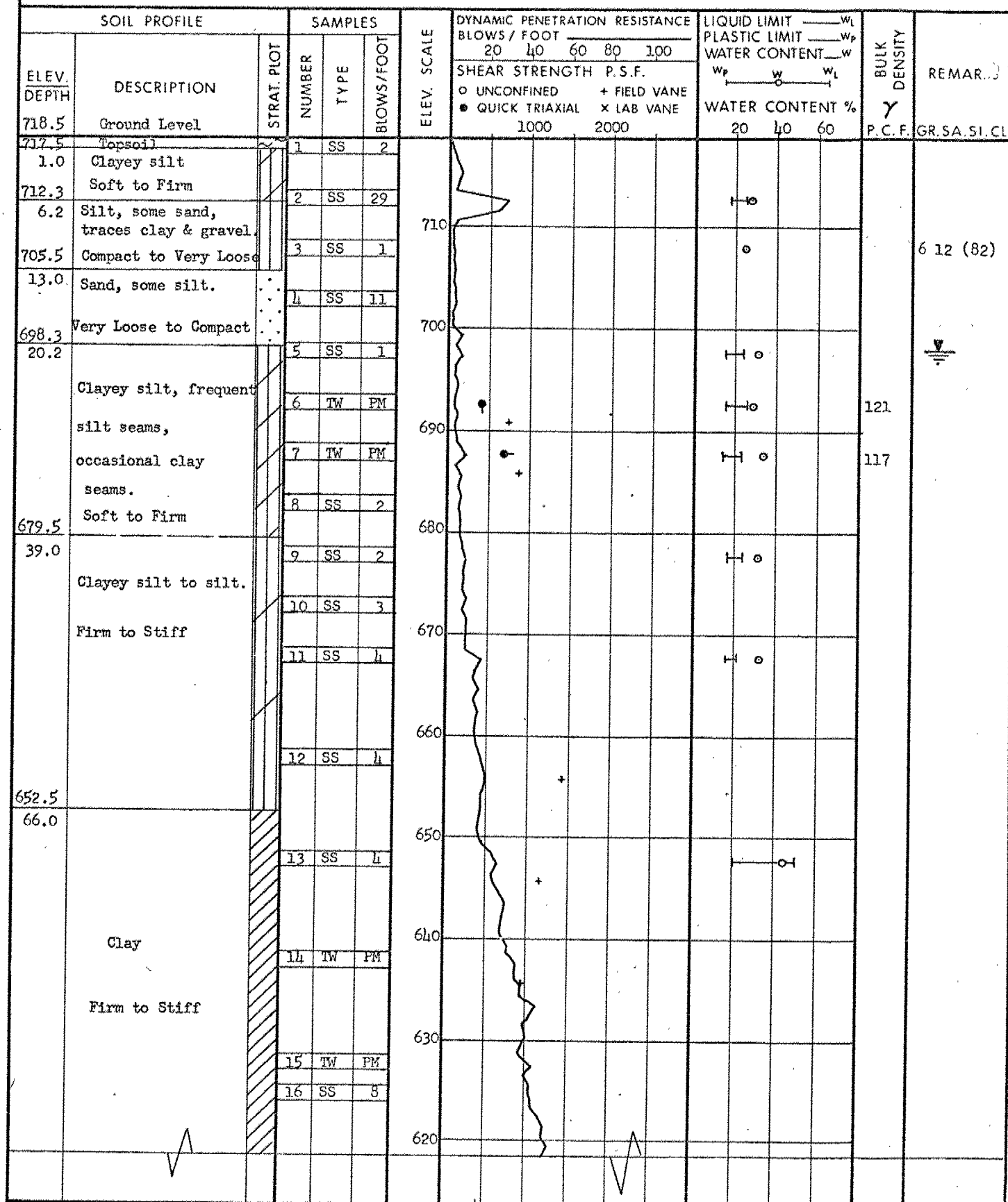
BORING DATE April 17, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Washboring & CONE TEST

CHECKED BY MS



DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 12(cont.)

JOB 73-11003

LOCATION Sta. 25 + 20 80' Lt. of Hwy. 69 E

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 17, 1973

COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY M.S.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT		20	40	60	80	100	w_p	w	w_L		
618.5	Clay		17	SS	9											
612.5	Firm to Stiff															
106.0	Clayey silt to silt, traces of sand and gravel.		18	SS	10	610										
	Very Stiff		19	SS	23	600										
			20	SS	20	590										
577.5			21	SS	55	580										
141.0	Silt, trace to with sand.		22	SS	56	570										
	Very Dense		23	SS	72	560										
			24	SS	58	550										
537.0			25	SS	72	540										
181.5	End of Borehole					530										

FOUNDATIONS OFFICE

JOB 73-11003

LOCATION Sta. 22 + 35 85' Lt. of Exist. Hwy. 69 @

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 19, 1973

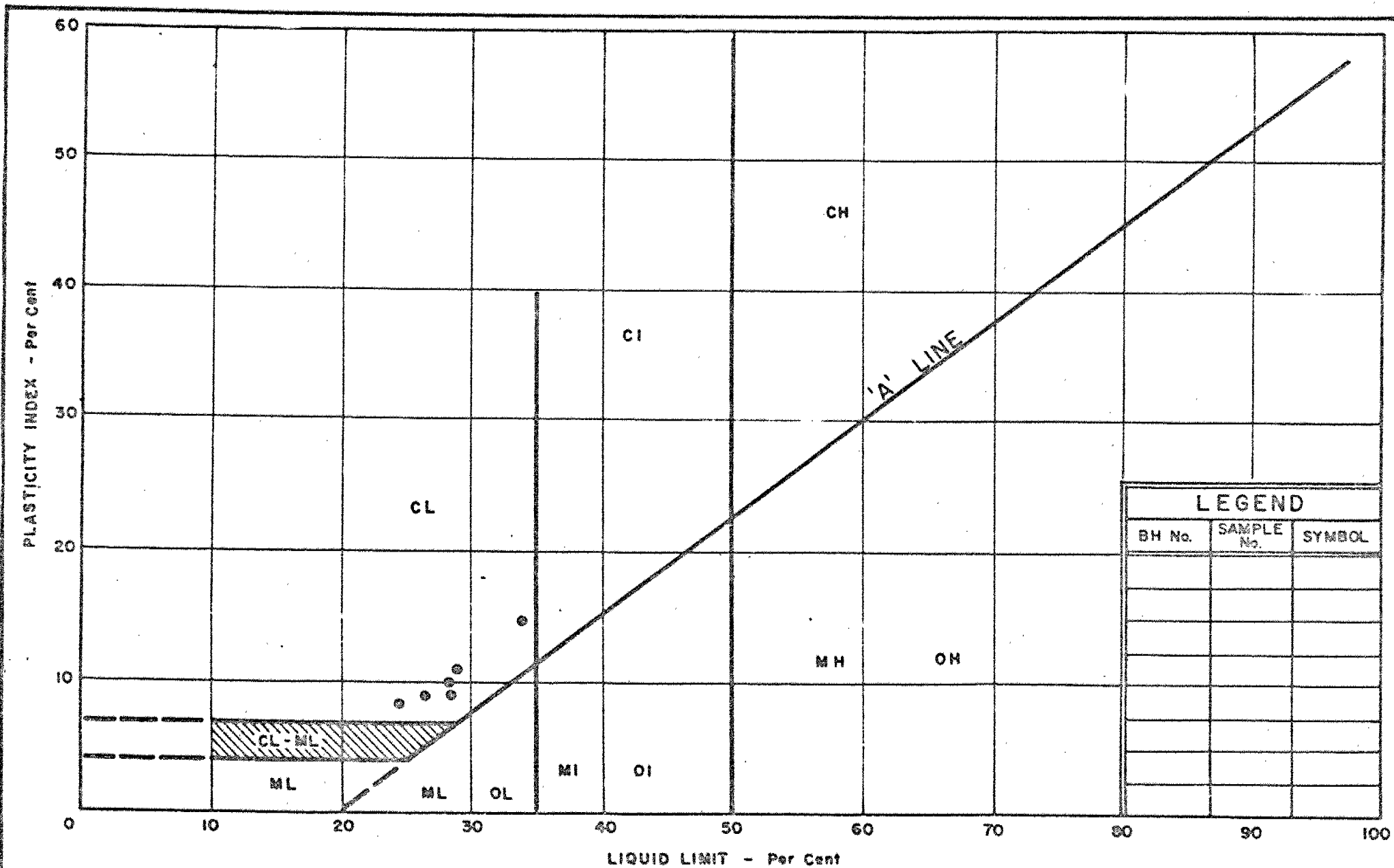
COMPILED BY EW

DATUM Geodetic

BOREHOLE TYPE Cone Test

CHECKED BY M.S.

15 $\overset{20}{\underset{10}{\circ}}$ 5 % STRAIN AT FAILURE



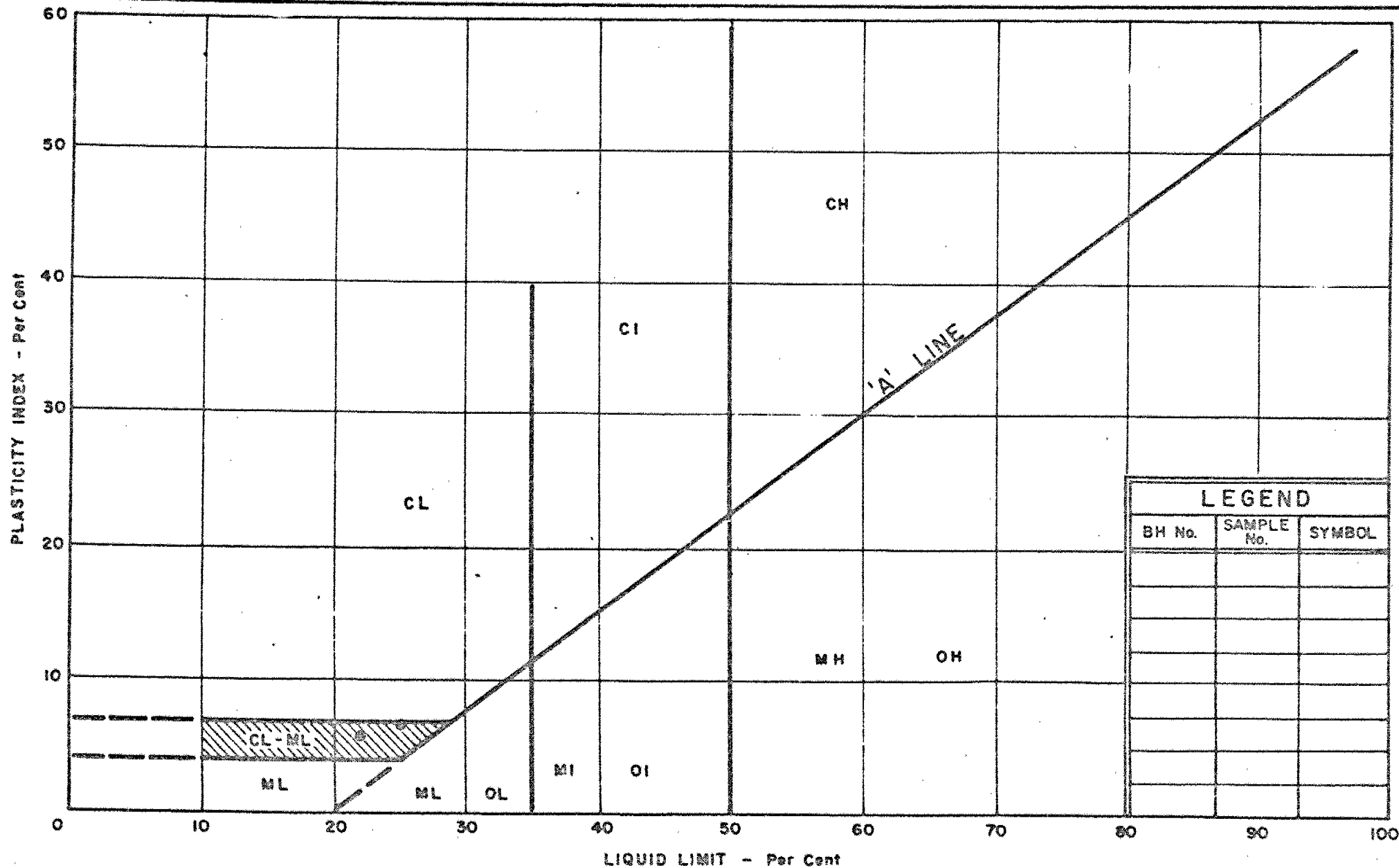
LEGEND		
BH No.	SAMPLE No.	SYMBOL



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAYEY SILT (LOWER STRATUM)

W.P. No. 914-71
JOB No. 73-11003
FIG. 1



LEGEND		
BH No.	SAMPLE No.	SYMBOL



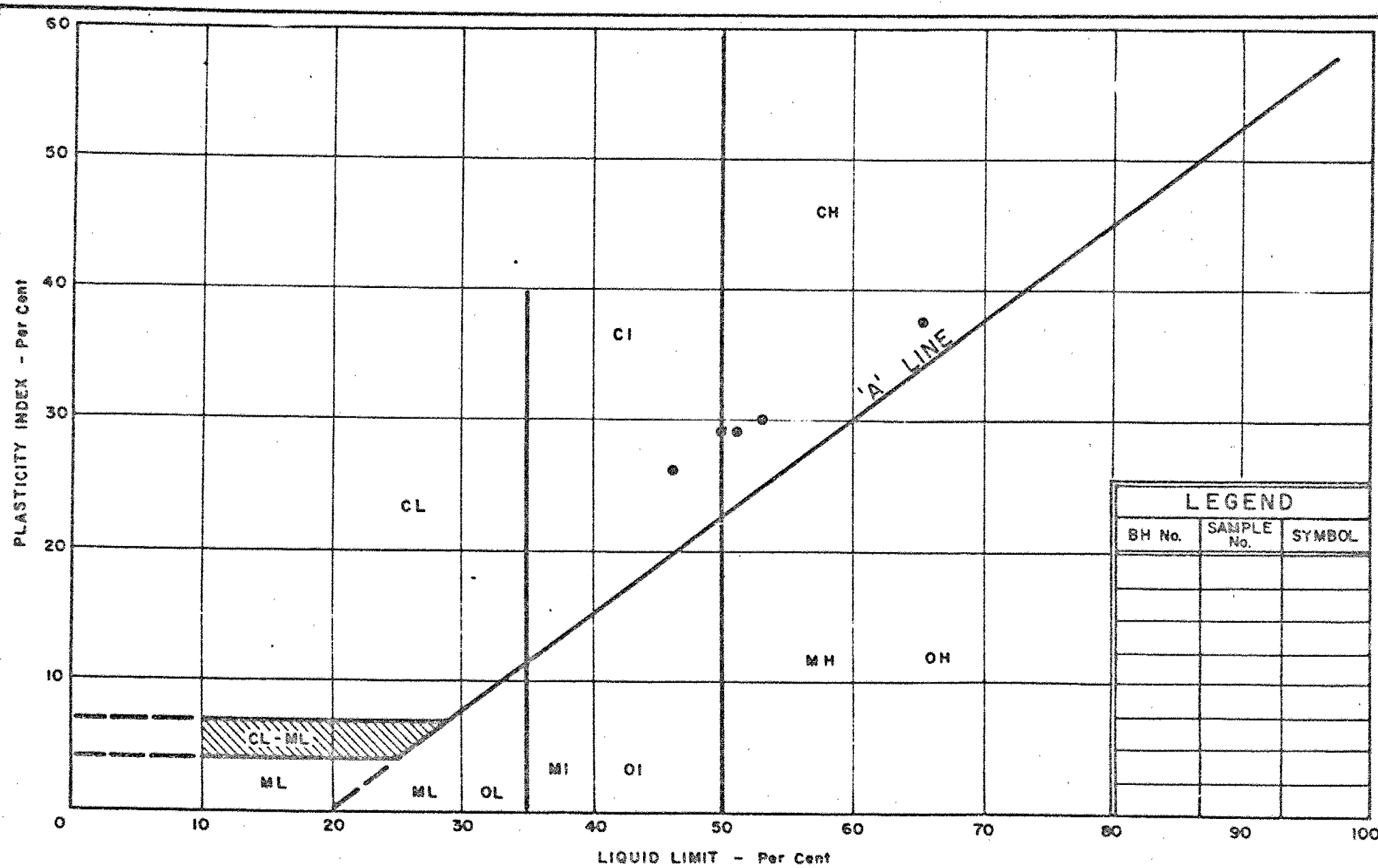
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAYEY SILT TO SILT (UPPER STRATUM)

W.P. No. 914-71

JOB No. 73-11003

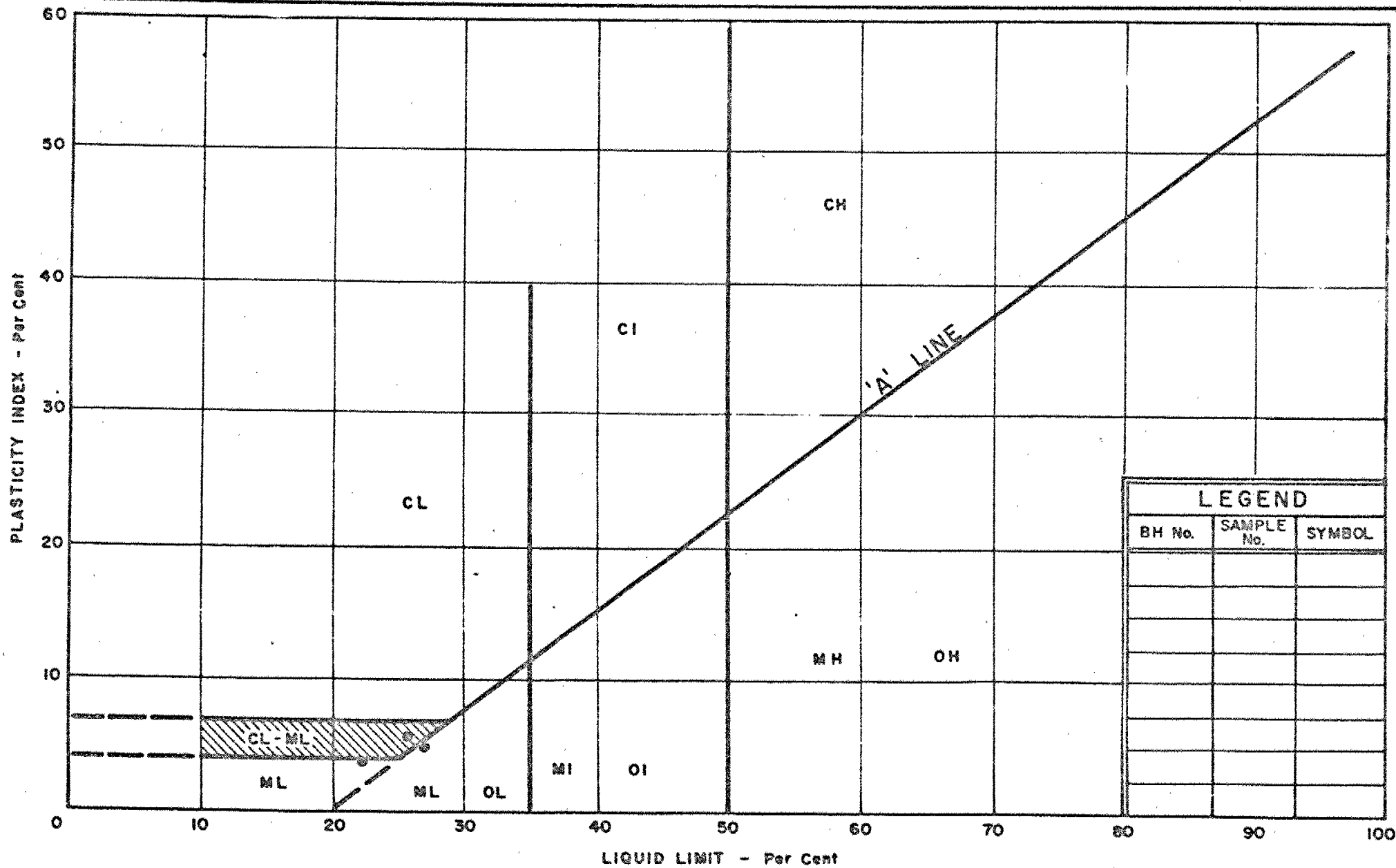
FIG. 2



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAY

WP No. 914-71
JOB No. 73-11003
FIG. 3



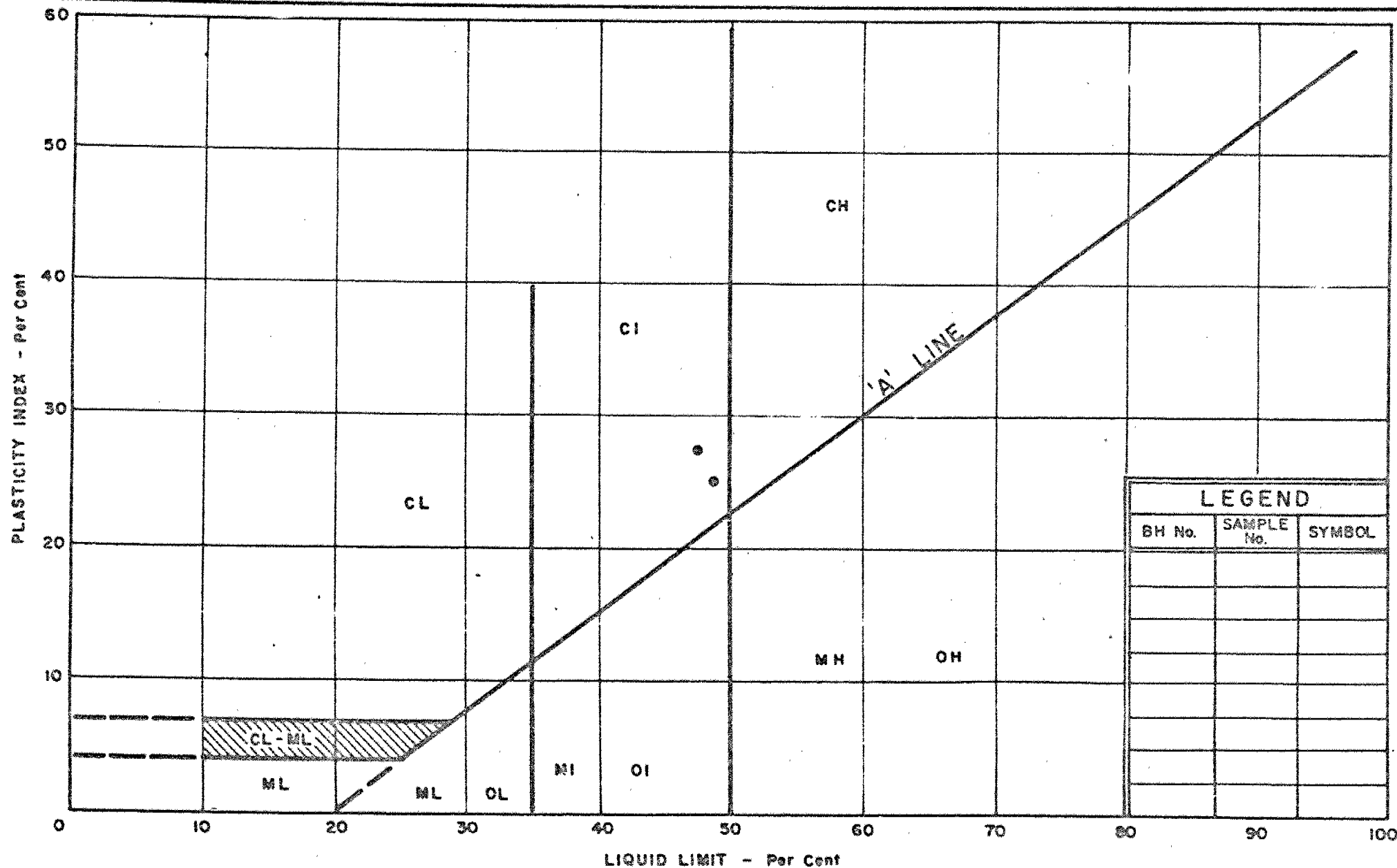
LEGEND		
BH No.	SAMPLE No.	SYMBOL



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAYEY SILT TO SILT (LOWER STRATUM)

WP. No. 914 - 71
JOB No. 73-11003
FIG. 4



LEGEND		
BH No.	SAMPLE No.	SYMBOL

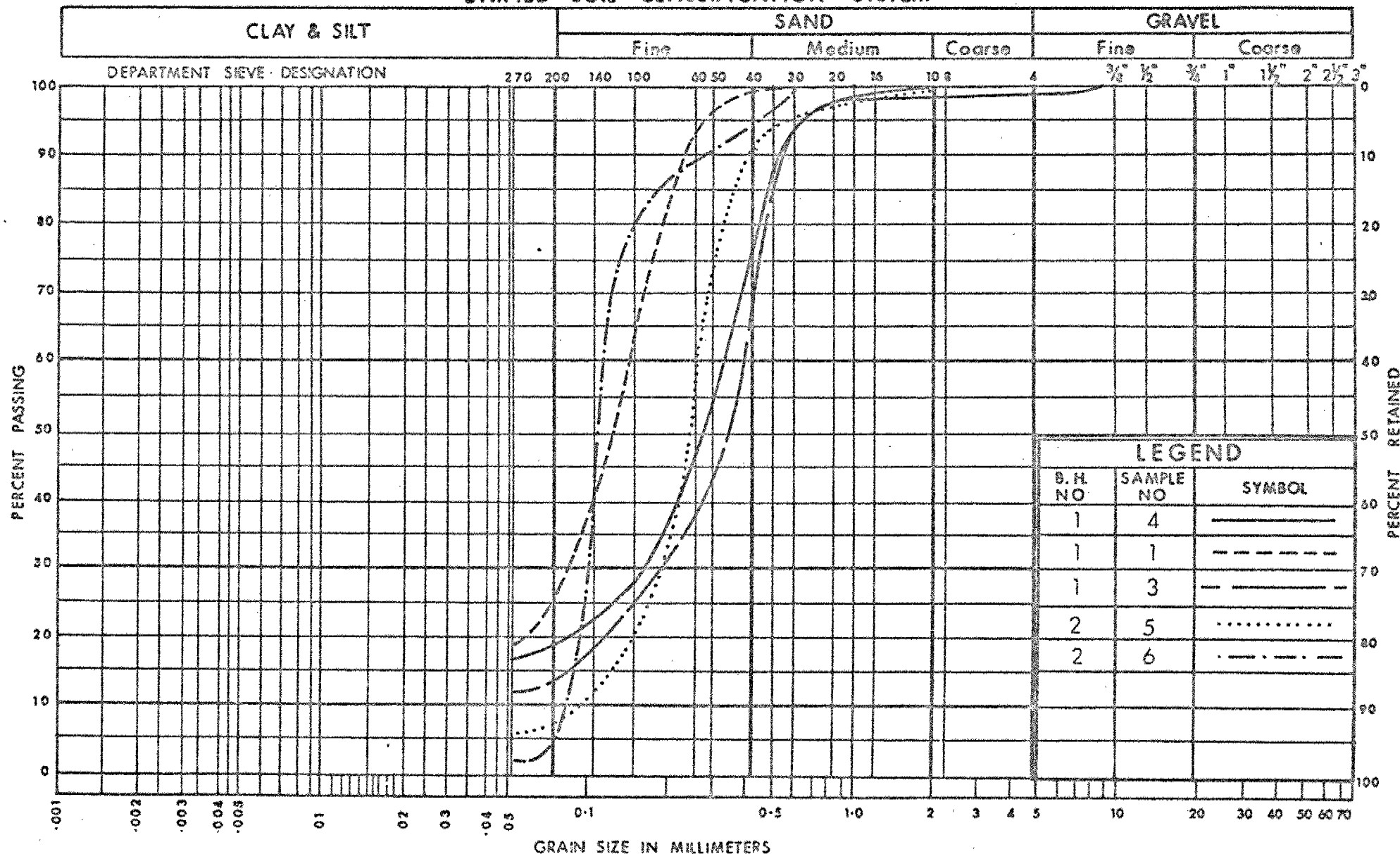


DEPARTMENT OF HIGHWAYS
 MATERIALS and
 TESTING
 DIVISION

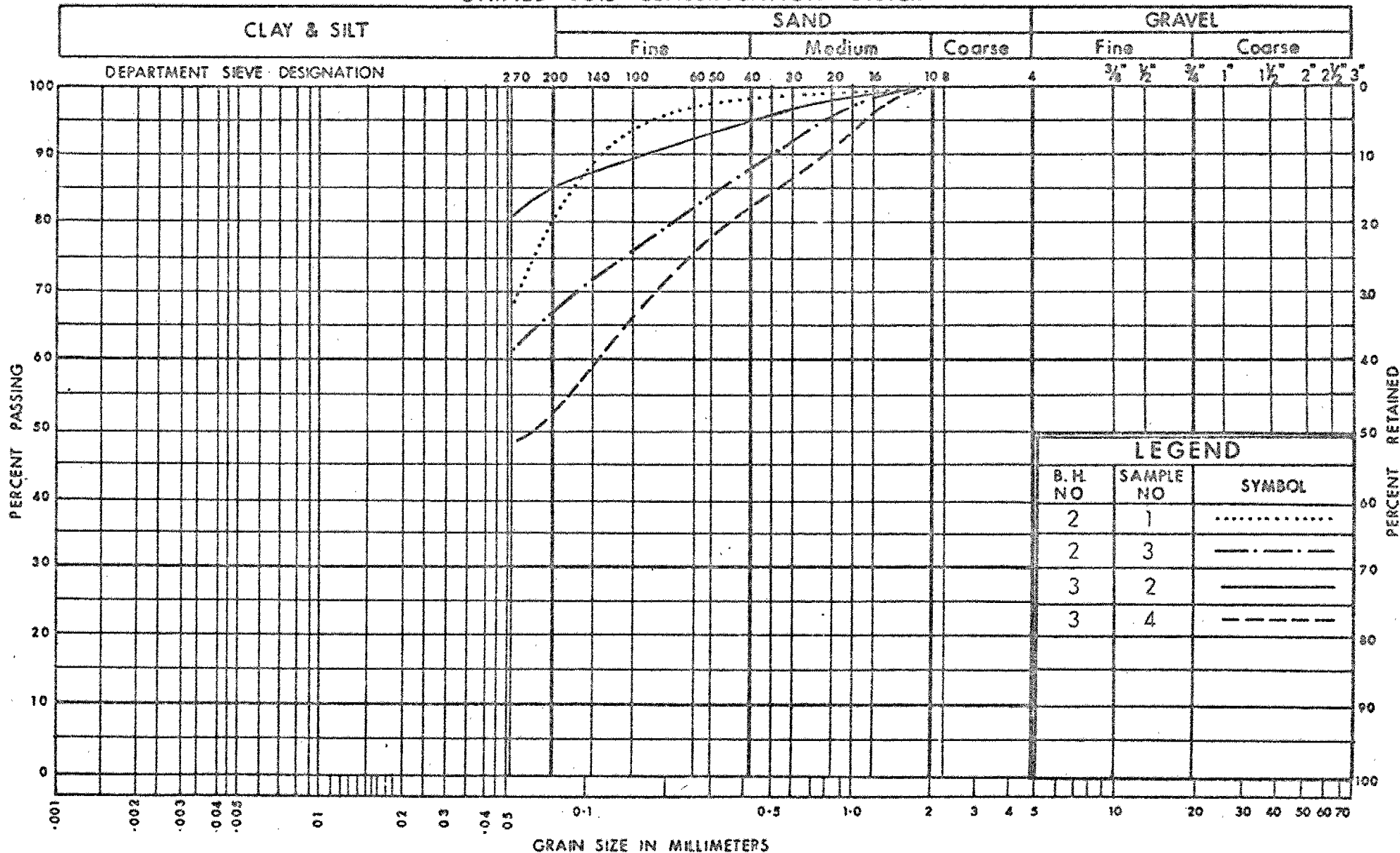
PLASTICITY CHART SILTY CLAY TO CLAY

WP. No. 914-71
 JOB No. 73-11003
 FIG. 5

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



ABBREVIATIONS & SYMBOLS USED IN THIS REPORTPENETRATION RESISTANCE

'N'-STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX $= \frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	$= 3.1416$
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

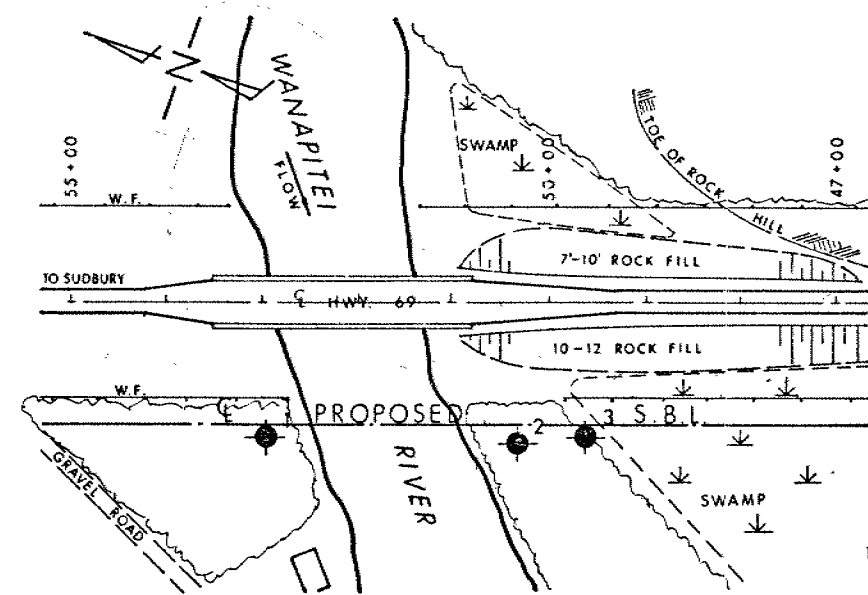
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

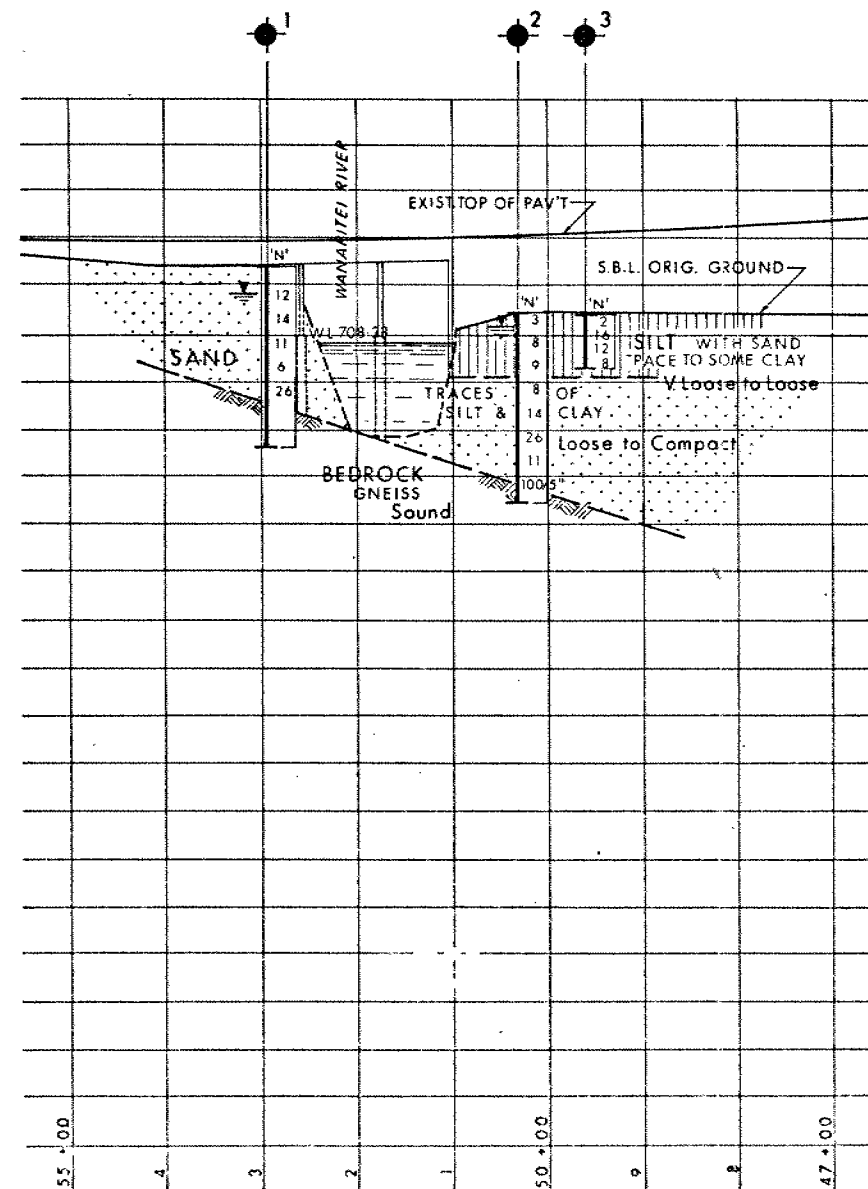
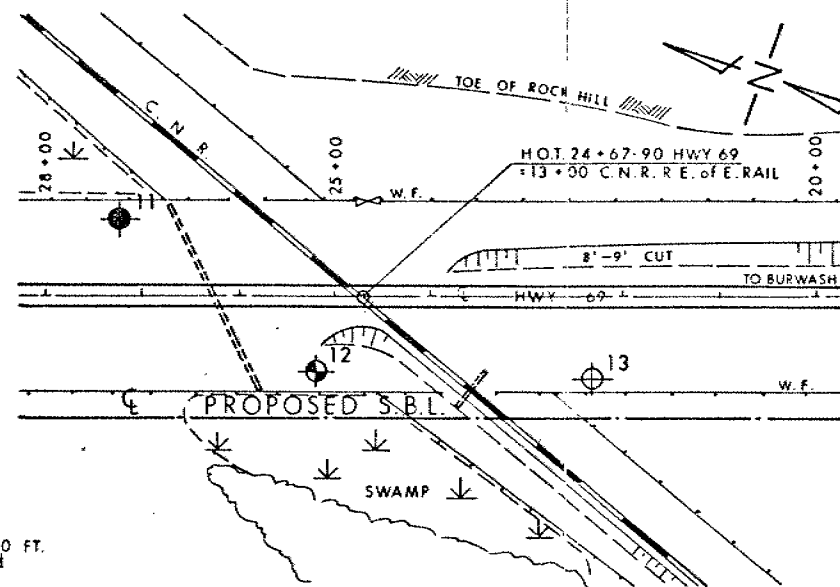
B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

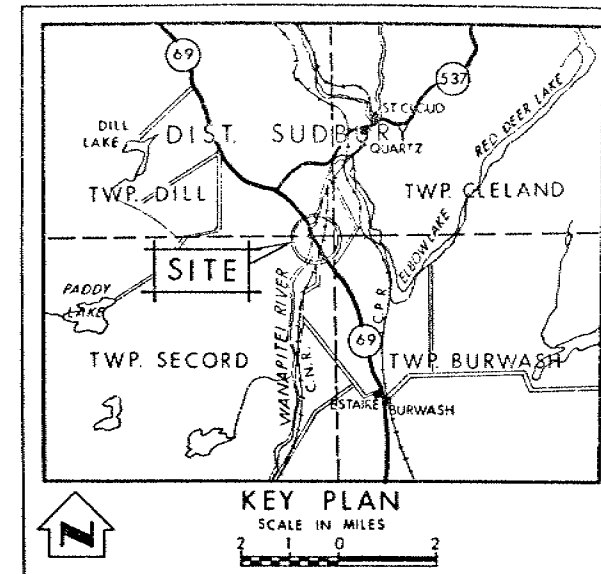
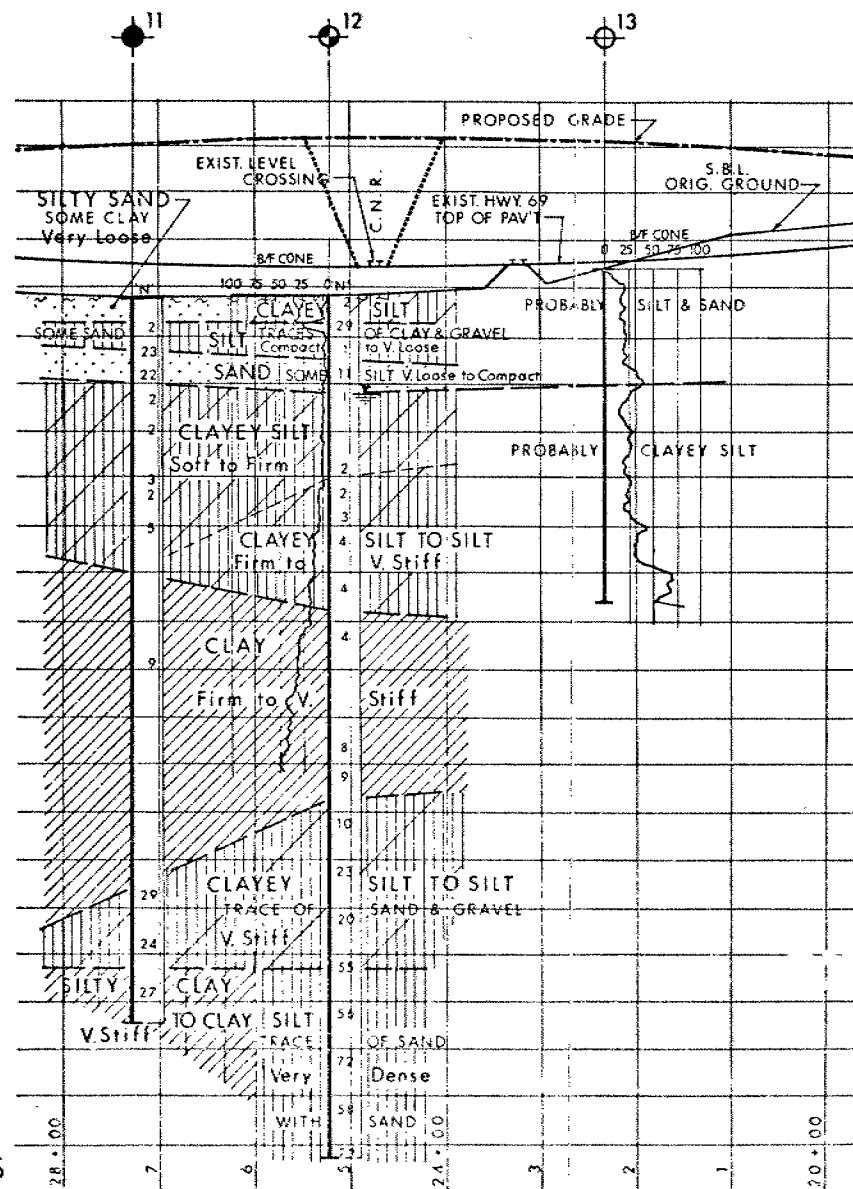


PLANS
SCALE
100 50 0 100 FT.



PROFILES

SCALE
HOR. 100 50 0 100 FT.
VER. 20 10 0 20 FT.



LEGEND			
	Bore Hole		
	Cone Penetration Test		
	Bore Hole & Cone Test		
	Water Levels established at time of field investigation, APR. 1973		
	Water Levels not established in B.H. No. 3 & 11		
NO.	ELEVATION	STATION	OFFSET
1	724.0	52+95	140' LT.
2	714.5	50+35	145' LT.
3	714.0	49+65	140' LT.
11	718.0	27+25	80' RT.
12	718.5	25+20	80' LT.
13	724.0	22+35	85' LT.

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
DESIGN SERVICES BRANCH—FOUNDATIONS OFFICE

WANAPITEI RIVER & C.N.R.
HIGHWAY NO. 69 PROPOSED S.B.L. DIST. NO. 17
DIST. SUDBURY
TWP. DILL & SECORD LOT 1 & 1 CON 1 & 6
BORE HOLE LOCATIONS & SOIL STRATA

SUBMIT E.W. CHECKED	WP NO. 914-71	DRAWING NO.
DRAWN O.L.J. CHECKED	WO NO. 73-11003	73-11003A
DATE 7 JUNE 1972	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	

REF. B-751-1

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

41 I - 80

TO: Mr. J. McAllister,
Regional Structural Planning
Supervisor,
Northern Region,
ATTENTION: North Bay, Ontario.

FROM: Soil Mechanics Section,
Geotechnical Office,
West Building, Downsview.

DATE: August 14, 1974.

OUR FILE REF.

IN REPLY TO SEP 3 - 1974

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For

Proposed Railway Separation
(C.N.R.) on Hwy. #69,
District of Sudbury, Twp. of Secord,
District #17, Sudbury.

W.P. 914-71

W.O. 73-11058.

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

K. G. Selby

K.G. Selby,
Supervising Engineer.

KGS/rb

c.c. E.J. Orr
B.R. Davis
H. McArthur
D.S. Cornell
B.J. Giroux
J.E. Gruspier
G.A. Wrong
P. Lewycky
S. McCombie

Foundation Files ✓
Documents

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FOUNDATION INVESTIGATION REPORT
For

Proposed Railway Separation
(C.N.R.) on Hwy. #69,
District of Sudbury, Twp. of Secord,
District #17, Sudbury.

W.P. 914-71

W.O. 73-11058.

1. INTRODUCTION:

A request for a preliminary foundation investigation at the crossing of Hwy. 69 and the C.N.R. tracks was received from Mr. J.C. McAllister, Regional Structural Planning Supervisor, Northern Region. Subsequently, a field investigation was carried out by the Soil Mechanics Section in April, 1973, and the results were contained in the Foundation Report W.O. 73-11003. It was found at that time that the subsoil conditions at the existing grade crossing locations are very unfavourable and will require two level berms for the proposed 35 ft. (10.7 m) high embankment. Also, it was found that end-bearing piles will be very long. Therefore, it was suggested by the consultant retained by the Ministry (Giffels, Davis & Jorgensen Ltd.) that alternative crossing sites to the north of the present crossing should be investigated, for more favourable subsoil conditions.

A field investigation was subsequently carried out by this Section to determine the subsoil conditions at these sites. This report contains the results of this investigation and our recommendations.

2. DESCRIPTION OF THE SITE:

This site is located some 2800 ft. (853.4 m) south of the Wanapetei River on Hwy. 69. The surrounding area is rolling and there is a 100 to 150 ft. (45.7 m) high rock outcrop about 200 ft. (61.0 m) south-east of the present grade crossing, which extends for a long distance southerly. There is another rock outcrop on the north side of the tracks, and about 300 ft. (91.4 m) east of line H-1. The railway embankment at this place crosses a relatively low lying swampy area. The railway and highway embankment are 7 ft. high at the existing crossing. There are no signs of embankment instability.

3. FIELD AND LABORATORY INVESTIGATION PROCEDURES:

The field work consisted of 13 sampled boreholes and 7 dynamic cone penetration tests. Five of the cone penetrations were adjacent to the sampled boreholes. The boreholes were advanced using a hollow stem auger mounted on a bombardier and modified for diamond drilling.

In addition, two sampled boreholes and two dynamic cone penetration tests done in April 1973 have also been included, which were advanced using a continuous flight auger mounted on a bombardier and a diamond drilling equipment modified for soil sampling purposes.

Disturbed samples were obtained using a 2-inch O.D. split-spoon sampler driven according to the specifications for the Standard Penetration Test. Undisturbed samples were taken at the railway separation using 2-inch O.D. Shelby tubes which were pushed into the soil manually. Field vane tests were carried out 18 inches below Shelby tube samples wherever possible. Rock cores were obtained at the ends of two boreholes at the river crossing.

Dynamic cone penetration tests were performed adjacent to one borehole and at one other location. Driving energy to advance the cone was 350 ft.-lbs. per blow.

The locations and elevations of the boreholes and cone tests are marked on Drawing No. 73-11058 A accompanying this report.

Samples were examined visually in the field and again in the laboratory. Tests were performed on selected samples to determine the following physical properties:

- Grain-size Distribution
- Atterberg Limits
- Natural Moisture Content
- Organic Content
- Bulk Density
- Unconfined Shear Strength
- Triaxial Shear Strength
- Consolidation Characteristics

The results of the field and laboratory tests are given in the Record of Borehole Sheets and in Figures 1 to 8, which are contained in the Appendix of this report.

4. SUBSOIL CONDITIONS:

4.1) General.

In general, the upper 0-20 ft. (0-6.1 m) of overburden, depending upon the location, consists of a mixture of organic silt and peat and/or a deposit of fine sand to silt. This is followed by a relatively thick and predominant deposit of soft to firm clayey silt. At the existing grade crossing this was underlain by a clayey silt to silt layer. In some places north of the tracks this is underlain by a firm to generally stiff deposit of clay. At the present grade crossing these strata are underlain by very stiff clayey silt to silt followed by either silty clay to clay or very dense silt layers. In some other boreholes, a heterogeneous mixture of sand and gravel was intersected, followed by quartzite and biotite bedrock. In six boreholes, bedrock was proven by coring, while in two boreholes, boulders were encountered. The depth to bedrock varied from 33 to 78 ft. (10.1 to 23.8 m) and the depth to boulders varied from 63 to 91 ft. (19.2 to 27.7 m). The soil strata are listed from ground level downwards, as follows:

4.2) Mixture of Organic Silt and Peat.

This was the surficial deposit in all boreholes except #8, 13 and 18, and varied in depths from 1.0 ft. (0.3 m) to 15.0 ft. (4.6 m). In some places the material is soft, organic silt while in other boreholes, it is mixed with peat. In some boreholes it consists entirely of peat. As already mentioned, the railway tracks traverse a low lying swampy area. If an embankment is constructed, this material will have to be replaced with suitable granular material.

4.3) Silty Sand to Sandy Silt.

This 3-6 ft. (0.9-1.8 m) thick stratum was encountered in Boreholes 11 and 18, and consists of very loose to compact silty sand to sandy silt and some clay.

4.4) Clayey Silt (Upper Stratum).

This 1-7 ft. (0.3-2.1 m) thick layer was encountered in Boreholes 12, 15, 16, 17 and 18 on the west side of Hwy. 69 and the north side of the tracks. It consists of generally soft to firm clayey silt.

4.5) Silt (Upper Stratum).

This stratum found in Boreholes 11 and 12 consists of 5 to 7 ft. (1.5-2.1 m) of very loose to compact silt, a trace to some sand and clay, and a trace of gravel. The natural moisture content is about 25%.

4.6) Sand.

This layer was encountered in Boreholes 1, 11, 12, 15, 16, 17 and 18. In Borehole 1 it occurred from ground surface downwards to a depth of 17 ft. (5.2 m), and consists of compact fine sand with traces of silt and clay. In Boreholes 11 and 12 it was 7 to 9 ft. (2.1 to 2.7 m) thick and was overlain by the silt stratum. In Boreholes 15, 16, 17 and 18 it was overlain by the clayey silt layer and was 4 to 8 ft. (1.2 to 2.4 m) thick. Its relative density in all boreholes, except Borehole 1, was very loose.

4.7) Clayey Silt (Lower Stratum).

This is the predominant deposit at this place, and was encountered in all boreholes. Some holes were terminated in this deposit, but where it was fully intersected its thickness varied from 19 to 55 ft. (5.8 to 16.8 m). The material in this stratum can be described as clayey silt with occasional silt or sand seams. The natural moisture content is very close to the liquid limit and the consistency of the material varies from soft to firm. The low shear strength of this stratum contributes to the potential instability of high fills and the compressive nature contributes to anticipated relatively large settlements under these fills. The physical properties of this material are as follows:

Liquid Limit	24 - 37%
Plasticity Index	6 - 15%
Natural Moisture Content	28 - 37%
Bulk Density	116 - 121 p.c.f.
Field Vane Shear Strength	480 -1520 p.s.f.
Unconfined & Triaxial Shear Strength	330 - 750 p.s.f.

4.8) Clayey Silt to Silt (Upper Stratum):

This stratum was encountered only on the west side of Hwy. 69 in Borehole 12. It consists of 27 feet (8.2 m) of firm to stiff clayey silt to silt. Approximate soil properties are as follows:

	<u>Approximate Value</u>
Liquid Limit	23%
Plasticity Index	5%
Natural Moisture Content	33%
Field Vane Shear Strength	1250 p.s.f.

4.9) Clay.

This deposit was found in Boreholes 1, 3, 4, 5, 9, 10, 11 and 12 and varied from 10 to 66 ft. (3.0 to 20.1 m) in thickness. The material consists of firm to very stiff clay. The physical properties of the material are as follows:

Liquid Limit	46 - 65%
Plasticity Limit	24 - 37%
Natural Moisture Content	41 - 53%
Bulk Density	105 -112 p.c.f.
Field Vane Shear Strength	960 -2000 p.s.f.
Unconfined Shear Strength	935 -1455 p.s.f.

The Atterberg Limits indicate that this is a clay of medium to high plasticity. It has a liquidity index of about 0.8. The field vane tests indicate a sensitivity ranging from 3.4 to 9.7 with an average value of 6.4 which indicates that the clay is sensitive.

4.10) Clayey Silt to Silt (Lower Stratum):

This stratum found in Boreholes 11 and 12 consists of very stiff clayey silt to silt and traces of sand and gravel. It varies in thickness from 17 to 35 (5.2 to 10.1 m). The field vane shear strength is over 2000 p.s.f. The liquid limit varies from 22 to 27 with a plasticity index of about 5. The natural moisture content varies from 25 to 45 percent.

4.11) Silty Clay to Clay.

This stratum consists of very stiff silty clay to clay, a trace of sand and gravel and occasional cobbles. It was encountered on the east side of Hwy. 69 where Borehole 11 was terminated 11.3 feet (3.4 m) into this stratum. The liquid limit is about 48 with a plasticity index of about 26. The natural moisture content varies from 25 to 45 percent.

4.12) Silt (Lower Stratum).

This stratum was encountered on the west side of Hwy. 69 where Borehole 12 was terminated 40.5 feet (12.3 m) into the stratum. It consists of silt and a trace of sand to silt with sand. The Standard Penetration 'N' values vary from 55 to 72 blows per foot with an average of 63 blows per foot thus indicating a very dense relative density. The natural moisture content varies from about 20 to 25 percent.

4.13) Mixture of Sand, Silt and Gravel.

This layer was intersected in Boreholes 3,4,5,6 and 10, and was 2 to 10 ft. (0.6 to 3.0 m) in thickness. The material consists of various amounts of sand, silt and gravel with traces of clay. The relative density varies from very loose to very dense.

4.14) Boulders.

Boulders were encountered in Boreholes 4 and 5 at depths of 64 and 91 ft. (19.5 to 27.7 m).

4.15) Bedrock.

Bedrock was encountered in Boreholes 2, 3, 6, 7, 9 and 10 and the elevation varied from 740.1 to 685.7 ft. (195.1 to 209.0 m). The rock core samples were examined by Mrs. Z. Koriuszy, Geologist, and her report is attached in the Appendix of this report.

5. GROUNDWATER CONDITIONS:

The groundwater level was at or near ground surface in all boreholes, except Boreholes 1 and 12. In Boreholes 4 and 5 artesian water was encountered when bouldery stratum was encountered. The artesian water rose to elevation 721-722 ft. (219.8-220.1 m) i.e. 3 to 4 ft. (0.9-1.2 m) above ground surface.

6. DISCUSSION AND RECOMMENDATIONS:

6.1) General.

It is proposed to construct a railway separation at this location to carry Hwy. 69 over the C.N.R. tracks. This will necessitate approach fills with maximum heights of 35 ft. (10.7 m). Various alignments have been suggested, and they will be dealt with individually in paragraphs 6.5 to 6.10.

6.2) Foundations.

Because of the low bearing capacity of the subsoil near ground level, footings must be supported on piles. Two possibilities are 50-foot (15.2 m) long friction piles driven into cohesive strata and end-bearing steel H-piles driven into the very dense stratum of silt to silt with sand, boulders or bedrock. Pile loading tests may be carried out to determine the design capacity of each pile type, if they are not driven to bedrock. It is expected that the H-piles may support 70 tons per pile.

6.3) Embankment Stability.

The stability of the proposed embankment has been checked by stability analyses based on shear stress parameters in terms of total stresses. The stability analyses were carried out using an electronic computer assuming that failure occurs along a circular arc immediately after construction.

The results of the stability analyses indicates that the maximum allowable embankment height without berms is 12 feet (3.7 m) with 2 horizontal to 1 vertical slopes. To obtain the proposed embankment height of 35 feet (10.1 m), two levels of berms are required, one at 12 feet (3.7 m) and one at 24 feet (7.3 m) above ground level. The computer analyses indicates that a berm length of 60 feet (18.3 m) is required for both berms for all slopes placed at an angle of 2 horizontal to 1 vertical.

6.4) Settlement.

Computation of settlements due to compression of the cohesive strata were carried out using laboratory consolidation curves. Stresses induced by the embankment were calculated by the Boussinesq theory. The results of these calculations indicated that 1.5 to 5 feet (0.5 to 1.5 m) of settlement can be expected under the centreline of a 35-foot (10.7 m) high embankment. It is estimated that 30 to 35 years will be required to attain 90 percent of this settlement. About 15 years will be needed to attain 50 percent of this settlement.

6.5) Alignment H-1 (Borehole 1).

At this location the compressive, cohesive strata are at least 100 ft. (30.5 m) deep. The H-piles for foundations will be at least 125 ft. (35.1 m) long, because the cone was driven to a depth of 121 ft. (36.9 m). The settlements, will be in the order to 3 to 5 ft. (0.9 to 1.5 m). Moreover, it will require a new bridge on Wanapetui River and a long rock cut on the south side of the tracks. For the abovementioned reasons it is felt that it is the least suitable alignment of all the proposals.

6.6) Alignment H-2 (Borehole 2 & 8).

In Borehole 2 about 15 ft. (4.6 m) of organic silt and peat was encountered which must be removed and replaced with suitable granular material. The removal of organic material may prove to be a tedious process and it will require proper track protection for the C.N.R. tracks. Moreover, this alignment will require a long massive rock-cut on the south side of the tracks. However, bedrock was encountered at depths varying from 32 ft. (9.8 m) to 57 ft. (17.4 m). Therefore, the entire structure may be supported on steel H-piles driven to bedrock. Maximum allowable load for the particular section chosen may be used for design purposes. The settlements are expected to be 1.5 to 3.0 ft. (0.5 to 0.9 m).

6.7) Alignment H-3 (Boreholes 7,8,9 & 15).

In Borehole 15 about 100 ft. (30.5 m) north of the C.N.R. tracks 10 ft. (3.0 m) of organics was found from ground surface downwards. In Borehole 9, close to the tracks, the depth of organics was 7.5 ft. (2.3 m). This organic material should be removed and replaced with suitable granular material. In this case, track protection will be required. However, bedrock was encountered at depths varying from 32 ft. (9.8 m) to 48 ft. (14.6 m). Therefore, the entire structure may be supported on steel H-piles driven to bedrock. Maximum allowable load for the particular section chosen may be used for design purposes. The anticipated settlement will be in the order of 1.5 to 2.5 ft. (0.5 to 0.8 m). However, this alignment also requires long massive rock cuts to the south of the tracks.

6.8) Between Alignments H-3 and H-4 (Boreholes 6,10,16 & 18).

This case is very similar to Alignment H-3, except that the depths to bedrock are slightly greater, therefore the lengths of piles will be correspondingly greater. The settlements are expected to be in the order of 1.5 to 3.0 ft. (0.5 to 0.9 m). All other comments contained in Section 6.7 are applicable here.

6.9) Alignment H-4 (Boreholes 3,4,5 & 17).

Along this alignment, the depth of the organic deposit varies from 2 to 4 ft. (0.6 to 1.2 m), therefore no problem will be encountered in its excavation. The depth to end-bearing stratum varies from about 60 to 90 ft. (18.3 to 27.4 m). Therefore, the entire structure may be supported on steel H-piles driven to the bouldery stratum. Maximum allowable design load for the particular section chosen may be used for design purposes. Because of the greater thickness of the compressible layers, the anticipated settlements will be in the order of 2 to 5 ft. (0.6 to 1.5 m). However, this alignment also requires rock cuts to the south of the tracks.

6.10) Present Alignment (Boreholes 11, 12, 13 and 14).

Here the excavation of organics will be minimal. Also no rock cut will be required. However, the depth to endbearing stratum is well in excess of 100 ft. and up to 170 ft. in Borehole 12. Also, the endbearing stratum is not distinct, therefore, it may be necessary to carry out a pile loading test. At this location the thickness of the compressible deposit is the maximum, therefore the anticipated settlements will be in the order to 3 to 5 ft. (0.9 to 1.5 m).

6.11) CONCLUSION.

All alignments, except the present alignment require massive rock cuts for a long distance to the south of the tracks. It is felt that the cost of rock cuts would be prohibitive. The only advantages offered by alignments H-2, H-3 and H-4 are shorter piles and lesser settlements. However, the berm requirements for all alignments will be almost the same, because of the soft to stiff clayey silt deposit. Alignment H-1 is the most unsatisfactory one, because in addition to the rock cuts, it requires a new bridge over Wanapetei River, and offers no advantage in return. The present alignment requires no rock cuts but the settlements are greater than elsewhere, and the piles are excessively long. It is suggested that an alignment along Boreholes 5, 3 and 17 may be considered. It will require an S-Curve to the north and the south of the tracks, but will not require a new bridge on Wanapetei River. The line may be so chosen that the amount of rock cut is either nil or nominal. In that case, piles in the order of 100 ft. (30.5 m) will be required, but the bridge will be at a larger skew. However, in the design of any bridge at this location, provision will have to be made to jack the bearings.

7. MISCELLANEOUS:

The fieldwork for this project was carried out by Mr. E.A. Wood; Project Foundation Engineer from April 10th to 21st, 1973 and by Mr. W.J. Alcock; Project Engineer from March 11th to April 5th, 1974. The equipment was owned and operated by Canadian Longyear Ltd.

The entire project was under the supervision of Mr. A. Prakash, Senior Engineer, who also prepared this report. This report was reviewed by Mr. K.G. Selby, Supervising Engineer.

A. Prakash

A. Prakash, P. Eng.,
Senior Engineer.

K. G. Selby

K.G. Selby, P. Eng.,
Supervising Engineer.

AP/mj

August, 1974.



A P P E N D I X

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 1

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 28+40 25'lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE March 11, 12, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ft/m	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/EGOT (0.3 m)	ELEV. SCALE ELEV.	SHEAR STRENGTH P.S.F./kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 400 800 1200 1600 2000					WATER CONTENT % w_p w w_L			P.C.F.	
m. 220.1	722.0	Ground Level				720						20	40	60	T/m ³	GR.SA.SI.CL.
0.0	0.0					219.5										
	Some Clay		1	SS	12											
	Fine Sand					710										
	Traces of Silt & Clay		2	SS	13	216.4										
	Compact															
214.9	705.0		3	SS	3	700										
5.2	17.0					213.4										
			4	TW	PM	690									121	
	Clayey Silt					210.3									1.94	
	Firm		5	TW	PM	680										
						207.3										
			6	TW	PM	670									116	
						204.2									1.86	
202.7	665.0		7	TW	PM	660										
17.4	57.0					201.2										
	Clay															
	Traces of Sand					650										
						198.1										
	Firm to Stiff		8	SS	9	640										
						195.1										
						630										
						192.0										
188.7	619.0		9	SS	8	620										
						189.0										

ORIGINATED BY WJA

COMPILED BY WJA

CHECKED BY

20
15 ϕ 5 % STRAIN AT FAILURE
10

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 2

JOB 73-11058

LOCATION C.N.R. E.E. of E. Rail Sta. 20+44 31' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE March 13, 1974.

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BW Casing

CHECKED BY

SOIL PROFILE				SAMPLES		ELEV. SCALE ft./m	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)		LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w		BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT % w_p w w_L			
m. 219.1	718.9	Ground Level										
0.0	0.0	Mixture of Organic Silt and Peat										
		Soft		1	SS	1	710					
				2	SS	1	715.4			WC = 273	Org. 23.4	
214.5	703.9						700					
4.6	15.0	Clayey Silt		3	TW	PM	213.4	+ s=5				
		Firm		4	SS	2	210.3	+ s=4.5				0 1 57 42
				5	TW	PM	207.3	○ +s=5.8			116 1.86	0 0 65 35 0 0 62 38
				6	SS	4	204.2	+s=2.6				
201.7	661.8			7	SS	100/0"	660					
17.4	57.1	quartzite bedrock		8	RC	100/0"	201.2					
200.6	658.3	Sound										
18.5	60.0	End of borehole						50 kPa 100				

OFFICE REPORT ON SOIL EXPLORATION

CHECKED BY

20
15 ϕ 5 % STRAIN AT FAILURE
10

ORIGINATED BY WJA

COMPILED BY WJA

CHECKED BY

15 $\frac{20}{10}$ 5 % STRAIN AT FAILURE

RECORD OF BOREHOLE № 5

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 15+67 39' Rt.

ORIGINATED BY W.J.A.

W.P. 914-71

BORING DATE March 26, 27, 28, 1974

COMPILED BY W.J.A.

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, RW Casing

CHECKED BY

SOIL PROFILE				SAMPLES		ELEV. SCALE ELEV. FEET	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 in)	LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w w_p — w — w_L WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS Head 722.1 220.1 GR. SA. SI. CL.
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
m.										
219.0	718.4	Water Level								
218.4	716.4	Ground Level								
217.8	714.4	Organics								
1.8	4.0	Sand								
1.5	5.0			1	SS	2				
						710	+ s=5.8			
				2	SS	2				
		Clayey Silt				216.1	+ s=8.0			
		Occasional								
		layers of				700				
		Silt.		3	TN PM	213.4	+ s=6.0			
									119	
									1.91	
				4	SS	2	+ s=4.0			
		Soft				690				
		Firm				210.3				
				5	TN PM	207.3	+ s=1.4			
									117	
									1.87	
				6	SS	4	+ s=6.0			
						670				
						204.2				
200.7	658.4			7	TN PM	201.2	+ s=4.5			
18.3	60.0								105	
									1.68	
		Clay				650				
						198.1				
		Stiff								
						640				
				8	SS	8	+ s=3.6			
						195.1				
191.9	629.4					630				
27.1	69.0	Mix. of Sa. & Gr. trace of sil. & cl. (fill) M.A.K.		9	CS	192.0				
19.2	62.4									
27.8	71.0	Boulder		10	RC	74				
20.1	623.6									
19.8	622.6	Probable Sand		11	RC	67				
19.2	622.0	End of Borehole								
							50 kPa 100			

15 $\overset{20}{\underset{10}{\circ}}$ 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 6

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 17+84 37' Rt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE March 28, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BW Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 ft)		20	40	60	80	100	w_p	w	w_L		
m. 219.4	719.6	Ground Level														
0.2	0.5	Some Sand Traces of organics Clayey Silt Soft to Firm	1	SS	15	710										
			2	SS	1	216.4										
			3	TW	PM	700 213.4										
			4	SS	2	600 210.3										
208.1	682.6	Mix. of sand & silt Traces of Gravel & Clay (Till)	5	RC	634	660 207.3										
11.3	37.0		6	RC	634											
206.9	678.7	Quartzite and Biotite Bedrock Sound	7	RC	100%	670										
12.5	40.9		8	RC	100%											
203.3	666.9		9	RC	100%	670 204.2										
16.1	52.7	End of Borehole														

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE NO 7

FOUNDATIONS OFFICE

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 18+68 40' Rt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE March 29, April 1, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger, BW Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F. T/m ³	REMARKS
ELEV. DEPTH m. ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		20	40	60	80	100	w_p	w	w_L	
219.2	Ice Level														
219.3	Ground Level														
218.3	Organics														
0.9	3.0	Layers of Silt	1	SS	5	71.0									719.3
						216.4									219.2
		Clayey Silt	2	TW	PM										0 4 82 14
		Soft to Firm				700									119
			3	SS	1	213.4									1.91
						690									
209.0	685.7		4	TW	PM	207.3									111
10.2	33.6	Quartzite	5	RC	90%										1.78
		Bedrock	6	RC	100%	660									
205.7	675.0	Sound	7	RC	100%	204.2									
13.5	44.3	End of Borehole													

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 9

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 19+17 32' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 1, 2, 1974.

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger BW Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (10.3 m)					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FOOT (10.3 m)		20	40	60	80	100	w_p	w	w_L		
m. 219.1	718.9	Ground Level														
0.0	0.0	Mixture of Organic Silt and Peat Soft	1	SS	1	710										
216.8	711.3		2	TW	PM	216.4										
2.3	7.6	Clayey Silt Occ. Sandy Silt Seams. Soft to Firm	3	SS	3	700 213.4										
		Roots	4	TW	PM	690 210.3										
207.5	680.9		5	SS	3	680 207.3										
11.6	38.0	Silty Clay to Clay Firm	6	RC	55%	670 204.2										
204.5	671.1	Fractured Quartzite Sound Bedrock	7	RC	100%	660										
14.6	47.8		8	RC	100%	201.2										
200.5	657.8															
18.6	61.1	End of Borehole														

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 10

JOB 73-11058

LOCATION C.N.R. E.E. of E. Rail Sta. 18+08 35' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 2, 3, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow-Stem Auger, BW Casing

CHECKED BY

SOIL PROFILE				SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ P.C.F.	REMARKS	
m. ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	20		40	60	80	100	SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE			WATER CONTENT % w_p w w_L			
219.1	718.7	Ground Level																
0.0	0.0	Organic Silt with sand		1	CS													
217.9	714.7	Clayey Silt Soft to Firm		2	SS	5	710											
1.2	4.0			3	TW	PM	216.4											
				4	SS	1	700											
				5	TW	PM	213.4											
				6	SS	2	690											
				7	TW	PM	210.3											
				8	SS	3	680											
				9	RC	100%	670											
				10	RC	100%	204.2											
				11	RC	100%	660											
206.3	676.7	Clay Stiff																
12.8	42.0																	
202.9	665.7	Mixture of sand & gr Some Silt V. Loose																
16.2	53.0	Quartzite Bedrock Sound																
201.8	662.0																	
17.3	56.7																	
197.8	649.0	End of Borehole																
21.3	69.7																	

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 11

JOB 73-11058

LOCATION C.N.R. R.E. of East Rail Sta. 15+45 o/s 100' Lt.

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 12-17, 1973

COMPILED BY GP

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger and Washboring

CHECKED BY CRP

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)		LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w		BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH m. ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 400 800 1200 1600 2000		w_p — w — w_L WATER CONTENT % 20 40 60			
218.9	718.0	Ground Level										GR.SA.SI.CL
0.0	0.0											
0.3	1.0	Silty sand some clay										
217.5	713.5	Very Loose										
1.4	4.5	Silt, some clay Trace of Sand	1	SS	2	710						
216.0	708.5	Very Loose				216.4						
2.9	9.5	Sand Trace of Silt Compact	2	SS	23							
			3	SS	22	700						
213.4	700.0					213.4						
5.5	18.0	Clayey Silt. Frequent Silt and Clay Seams, Occ. silty sand seams Soft to Firm	4	SS	2							
			5	TW	PM	690						
			6	SS	2	210.3						
			7	TW	PM							
			8	TW	PM	680						
			9	SS	3	207.3						
			10	SS	2							
			11	TW	PM	670						
			12	SS	5	204.2						
			13	TW	PM							
			14	TW	PM	660						
201.2	660.0					201.2						
17.7	58.0	Clay Occ. Silt Seams Stiff to Very Stiff	15	TW	PM							
			16	TW	PM	650						
			17	TW	PM	198.1						
			18	SS	9	640						
						195.1						
			19	TW	PM	630						
						192.0						
			20	TW	PM	620						
						189.0						
187.2	614.0											
31.7	104.0											

20 50 100 kPa
15 5 10 % STRAIN AT FAILURE

Continued

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 11 Continued

JOB 73-11058

LOCATION C.N.R. P.E. of East Rail Sta. 15+45 o/s 100' L.

ORIGINATED BY Ew

W.P. 914-71

BORING DATE April 12-17, 1973

COMPILED BY GP

DATUM Geodetic

BOREHOLE TYPE Cont. Flight Auger and Washboring

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F. kPa	WATER CONTENT %	WATER CONTENT %	WATER CONTENT %			
m.	ft.													
187.2	614.0	Continued												
31.7	104.0		21	TW	PM	610								
						185.9								
			22	TW	PM	600								
						182.9								
180.9	593.5		23	SS	27	590								
38.0	124.5					179.8								
			24	SS	24	580								
						176.8								
175.9	577.0		25	SS	27	570								
43.0	141.0					173.7								
			26	BXL	30%									
				RC										
172.5	565.7													
46.4	152.3													

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 12

JOB 73-11058

LOCATION C.N.R. R.E. of East Rail Sta. 12+88 o/s 90' Lt.

ORIGINATED BY EW

W.P. 914-71

BORING DATE April 17-19, 1973

COMPILED BY GP

DATUM Geodetic

BOREHOLE TYPE Washboring & Cone Test

CHECKED BY

SOIL PROFILE				SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	20		40	60	80	100	SHEAR STRENGTH P.S.F./kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
m. 219.0 0.0	718.5 0.0	Ground Level															
0.3	1.0	Clayey Silt				1	SS	2									
217.1	712.3	Soft to Firm				2	SS	29									
1.9	6.2	Silt, some clay traces sand & gravel							710								
215.0	705.5	Compact to Very Loose				3	SS	1	216.4								
4.0	13.0	Sand, some silt Very Loose to Compact.				4	SS	11	700								
212.8	698.3	Clayey Silt				5	SS	1	213.4								
6.2	20.2	Frequent Silt Seams				6	TW	PM									
		Occasional Clay Seams				7	TW	PM	690								
		Soft to Firm				8	SS	2	210.3								
207.1	679.5								680								
1.9	39.0					9	SS	2	207.3								
		Clayey Silt to Silt				10	SS	3									
		Firm to Stiff				11	SS	4	670								
									204.2								
						12	SS	4	660								
									201.2								
198.9	652.5																
20.1	66.0					13	SS	4	650								
		Clay							198.1								
		Firm to Stiff				14	TW	PM	640								
									195.1								
						15	TW	PM	630								
						16	SS	8	192.0								
						17	SS	9	620								
									189.0								
187.3	614.5																
31.7	104.0																

20
15 5 % STRAIN AT FAILURE
10

Continued

ORIGINATED BY EW

COMPILED BY GP

CHECKED BY

20
15 ϕ 5 % STRAIN AT FAILURE
10

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 13

JOB 73-11058 LOCATION C.N.R. R.E. of East Rail Sta. 10-63 o/s 87th ORIGINATED BY EW
 W.P. 914-71 BORING DATE April 19, 1973 COMPILED BY GP
 DATUM Geodetic BOREHOLE TYPE Cone Test Only CHECKED BY GP

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m) 20 40 60 80 100 SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w w_p — w — w_L WATER CONTENT %	BULK DENSITY γ P C F	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)					
m. 220.6 0.0	724.0 0.0	Ground Level								
		Probable Silt & Sand								
						720 219.5				
						710 216.4				
						700 213.4				
		Probable Clayey Silt				690 210.3				
						680 207.3				
						670 204.2				
						660 201.2				
199.3 21.3	654.0 70.0	End of Cone Test								

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE NO 14

FOUNDATIONS OFFICE

JOB 73-11058

LOCATION C.N.R. P.E. of East Rail Sta. 14+66 o/s 43' Rt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 5, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Penetration Test

CHECKED BY

SOIL PROFILE				SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT w_L			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	BLOWS / FOOT (0.3 m)		SHEAR STRENGTH P.S.F.					PLASTIC LIMIT w_p				
m.							20	40	60	80	100	WATER CONTENT w					
							O UNCONFINED + FIELD VANE					w_p w w_L					
							● QUICK TRIAXIAL × LAB VANE					WATER CONTENT %					
219.9	721.4	Ground Level															
0.3	719.4	Probable Organics															
0.6	2.0	Probable Fine Sand with Silt															
216.8	711.4																
3.1	10.0																
		Probable Clayey Silt															
202.2	663.4																
17.7	58.0																
		Probable Clay															
189.4	621.4																
30.5	100.0	Probable Mixture of Sand & Gravel															
188.2	617.6																
31.7	103.8	End of Cone Test															

RECORD OF BOREHOLE NO 15

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 20+01 105' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 4, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE NO 16

FOUNDATIONS OFFICE

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 19+05 125' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 4, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY C.C.

SOIL PROFILE			SAMPLES			ft/m ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)					LIQUID LIMIT — w _L PLASTIC LIMIT — w _p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH m. ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 400 800 1200 1600 2000					WATER CONTENT % w _p — w — w _L 20 40 60				
219.1	718.9	Ground Level														
0.0	0.0	Mixture of Organic silt and Peat Soft		1	SS	2							MC + 526		T/m3 Org. 74.7 P.C.F. GR 5A SI. CL 718.9 219.1	
216.7	710.9			2	SS	2										
2.4	8.0	Clayey Silt					710								0 60 32 8	
215.8	707.9	Firm		3	TW	PM	216.4									
3.3	11.0	Fine Sand with Silt													0 0 65 35	
214.5	703.9	Very Loose														
4.6	15.0	Clayey Silt Soft to Firm					700								117 1.87 0 0 57 43	
				4	SS	2	213.4									
				5	TW	PM	690 210.3									
							680								116 1.84	
		6		TW	PM	207.3										
							670								116 1.84	
		7		TW	PM	204.2										
203.0	665.9	End of Borehole													116 1.84	
16.1	53.0															

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

RECORD OF BOREHOLE NO 17

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 18+10 115' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 4, 1974

COMPILED BY WJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE ft./m	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (0.3 m)					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			BULK DENSITY γ	REMARKS
ELEV. DEPTH ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)		SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 400 800 1200 1600 2000					WATER CONTENT % w_p w w_L 20 40 60				
m.																
219.1	718.9	Ground Level													GRY S. SI. CL	
0.0	0.0	Mixture of Organic Silt & Peat		1	SS	1									718.9	
217.9	714.9	Soft		2	TW	PM									219.1	
1.2	4.0	Clayey Silt														
216.4	709.9	Traces of Organics					710									
2.7	9.0	Fine Sand		3	SS	1	216.1								0 93 (7)	
		Some Silt														
		Very Loose		4	SS	3									0 77 (23)	
214.1	702.4															
5.0	16.5	End of Borehole							50		100					
									kPa							

RECORD OF BOREHOLE № 18

JOB 73-11058

LOCATION C.N.R. R.E. of E. Rail Sta. 19+54 217' Lt.

ORIGINATED BY WJA

W.P. 914-71

BORING DATE April 4, 1974

COMPILED BY NJA

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION, RESISTANCE BLOWS / FOOT (0.3 m)		LIQUID LIMIT — w _L PLASTIC LIMIT — w _P WATER CONTENT — w		BULK DENSITY γ	REMARKS					
ELEV. DEPTH m. ft.	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT (0.3 m)	ELEV. SCALE	SHEAR STRENGTH P.S.F. kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT % w _P — w — w _L								
219.2 0.0	Ground Level Sandy Silt, traces of Clay		1	SS	13	710 216.4 700 213.4		+ s=6.3		20 40 60	P.C.F. GRA. S.I. CL. T/m³ 121 1.94	719.1 219.2 0 33 67.2 0 0 100 0 2 43 55				
217.4 1.8	Compact Clayey Silt		2	TW	PM									○	○	
215.2 4.0	Stiff Fine Sand		3	SS	3										+ s=6.5	
212.6 6.5	Very Loose		4	TW	PH									○		
6.5	End of Borehole		5	SS	23									○		
							50	kPa	100							

OFFICE REPORT ON SOIL EXPLORATION

FORM 08-ML-113
REVISED FEB. 1963

DEPARTMENT OF HIGHWAYS ONTARIO

DIAMOND DRILL RECORD

HOLE NO. 2, 3A, 4 SHEET NO. _____

DIP

PROPERTY 73-11058
LOCATION W.P. 914-71
Hwy. 69, CNR South of the
Wanapitei River
LATITUDE _____
DEPARTURE _____
BEARING _____

All holes at
90°

TOTAL FOOTAGE _____

ELEV. COLLAR _____
DATUM _____
DATE STARTED _____
DATE COMPLETED _____
DRILLED BY _____
LOGGED BY Z. Koniuszy

FOOTAGE		FORMATION	SAMPLE NUMBER			REMARKS
FROM	TO					
		HOLE NO. 2				
57.1	60.6	Quartzite, light grey, coarse grained, hard, joints 45°. have thin seams of sericite schist				
		HOLE NO. 3A				
78.8	79.5	Quartzite, light grey, coarse grained, hard,				All core broken
79.5	79.9	Biotite gneiss, black, hard				
79.9	86.6	Quartzite, light grey to pink, coarse grained, hard				83.7 - 8.6 vertical joint
86.6	87.3	Biotite gneiss, black, hard				
		HOLE NO. 4				
63.6	67.3	Quartzite, grey to pink, coarse grained, hard,				core broken, joints 45° 2.7' of the core missing
67.3	68.8	missing core				
68.8	73.8	Quartzite, grey, coarse grained, hard				

DATE OF EXAMINATION _____

FORM OB-ML-113
REVISED FEB. 1963

DEPARTMENT OF HIGHWAYS ONTARIO

DIAMOND DRILL RECORD

HOLE NO. 5, 6, 7 SHEET NO. _____

DIP

PROPERTY 73-11058
LOCATION W. P. 914-71
Hwy. 69, CNR South of the
Wanapitei River
LATITUDE _____
DEPARTURE _____
BEARING _____

All holes at _____
90° _____

TOTAL FOOTAGE _____

ELEV. COLLAR _____
DATUM _____
DATE STARTED _____
DATE COMPLETED _____
DRILLED BY _____
LOGGED BY Z. Koniuszy

FOOTAGE		FORMATION	SAMPLE NUMBER			REMARKS
FROM	TO					
		HOLE NO. 5				
91.0	91.6	Diorite, black, med. grained, hard				broken core
91.6	92.0	Granite, grey to pink, med. grained, hard				0.5' of the core missing
92.6	95.8	Quartzite, grey to pink, med. to coarse grained, hard				45° lineation
		HOLE NO. 6				
40.9	43.1	Quartzite, grey, med. to coarse grained, hard				every 1.5 ft. joints
43.1	43.5	Biotite schist, black, med. hard				horizontal and 45° inclined
43.5	45.1	Quartzite, grey, med. to coarse grained, hard				
45.1	45.9	Biotite, schist, black, med. hard				
45.9	52.7	Quartzite, grey, med. to coarse grained, hard				
		HOLE NO. 7				
33.6	44.3	Quartzite, light grey, coarse grained, hard, Inclined and horizontal joints every 6 inches.				

DATE OF EXAMINATION _____

FORM OB-MT-113
JANUARY 1970

DEPARTMENT OF HIGHWAYS ONTARIO

DIAMOND DRILL RECORD

HOLE NO. 9, 10 SHEET NO.

DIP

PROPERTY 73-11058
LOCATION W. P. 914-71
Hwy. 69, CNR South of the
Wanapitei River
LATITUDE
DEPARTURE
BEARING

TOTAL FOOTAGE _____

ELEV. COLLAR _____
 DATUM _____
 DATE STARTED _____
 DATE COMPLETED _____
 DRILLED BY _____
 LOGGED BY _____

[illegible]

DATE OF EXAMINATION April 29/74

Z. Koniuszy

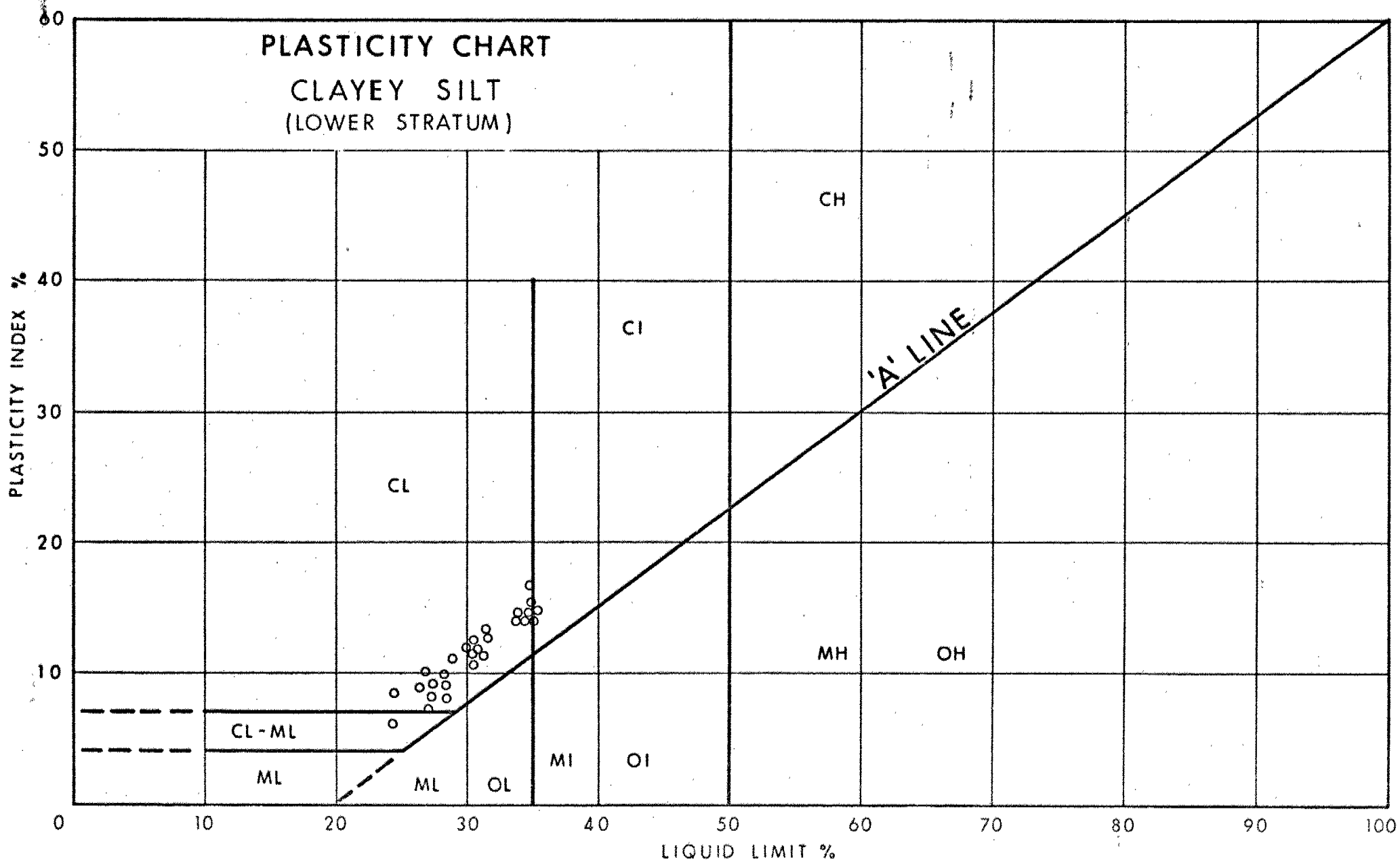


FIG. 1

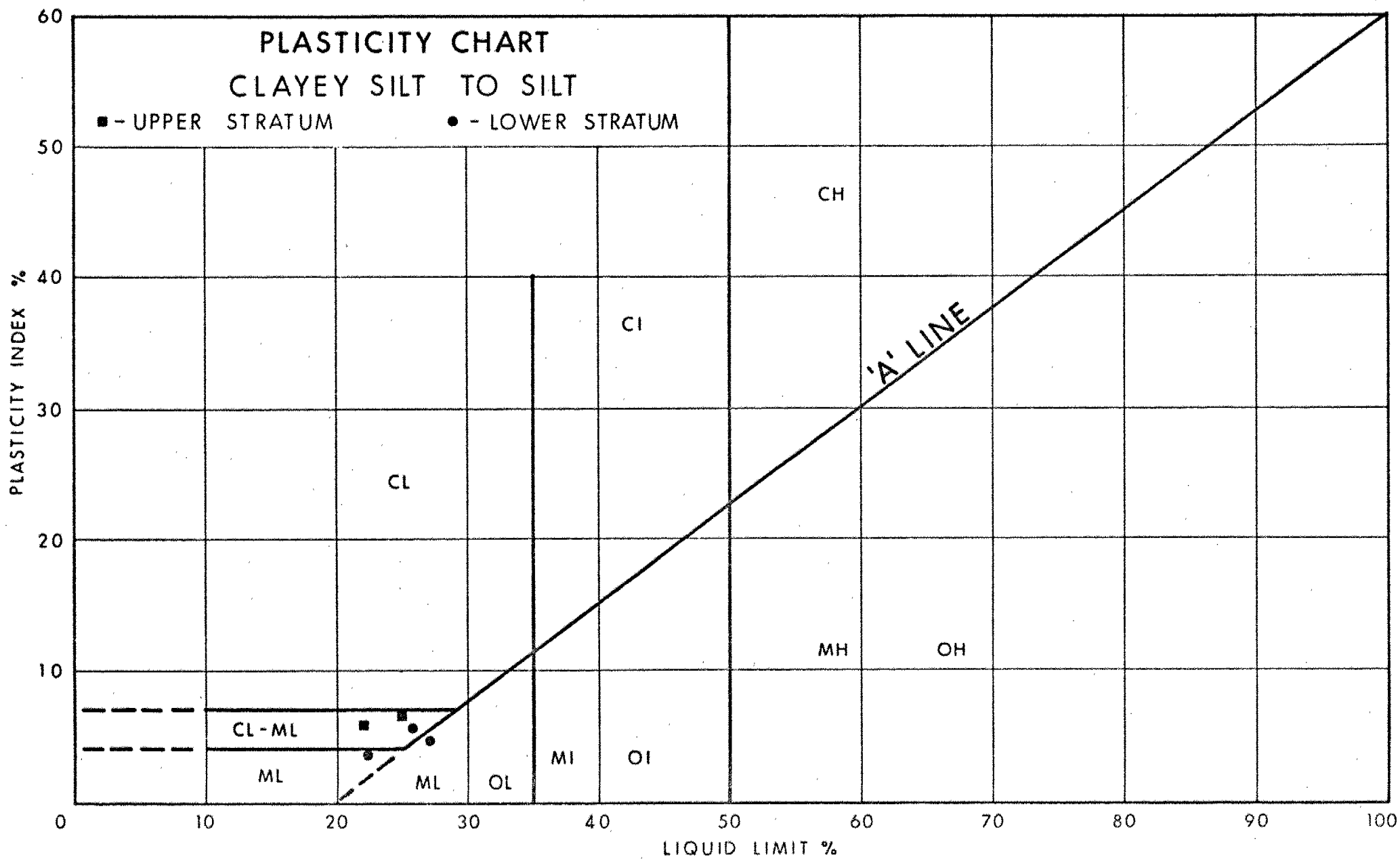


FIG. 2

W.O. 73-11058

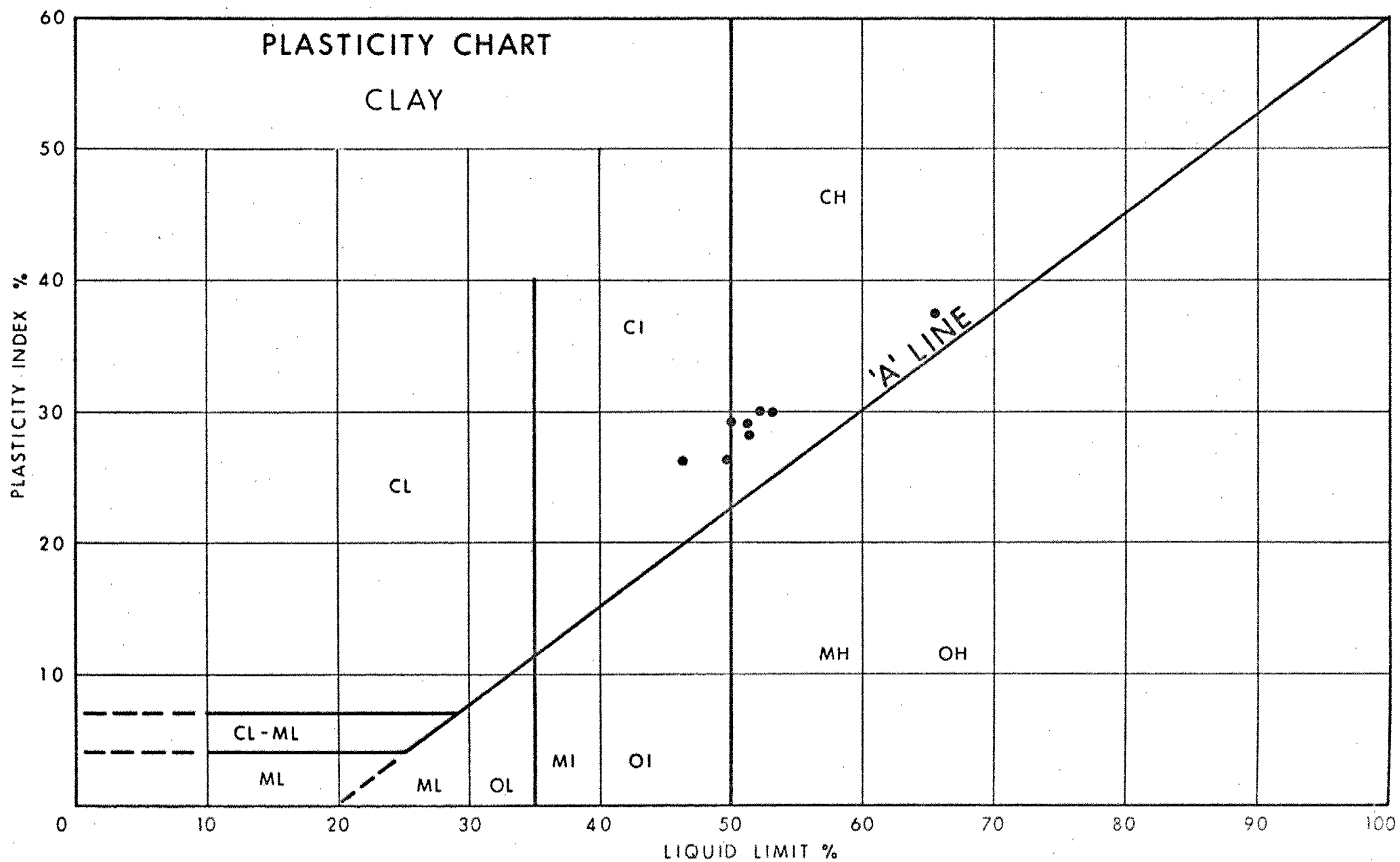


FIG. 3

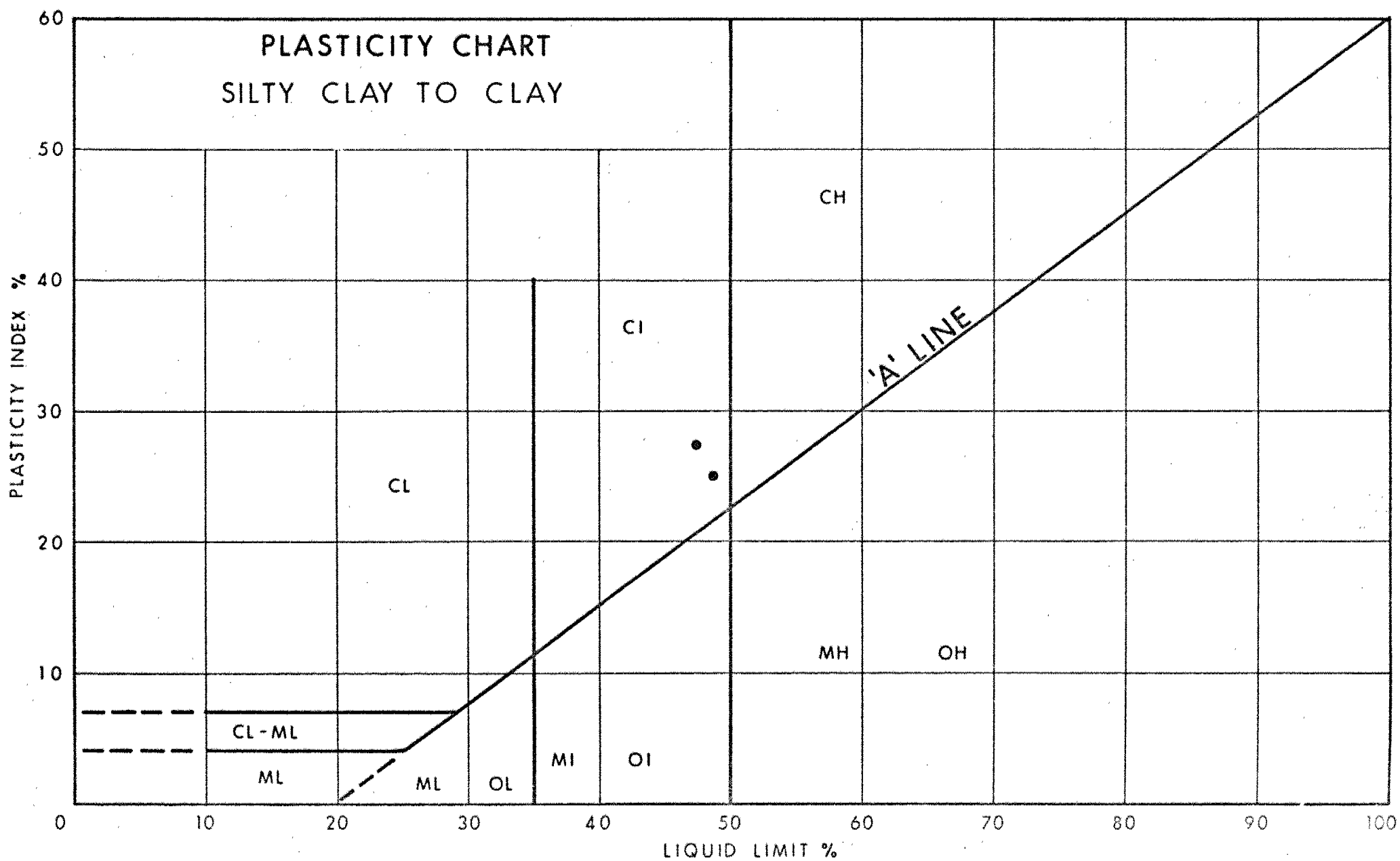


FIG. 4

GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

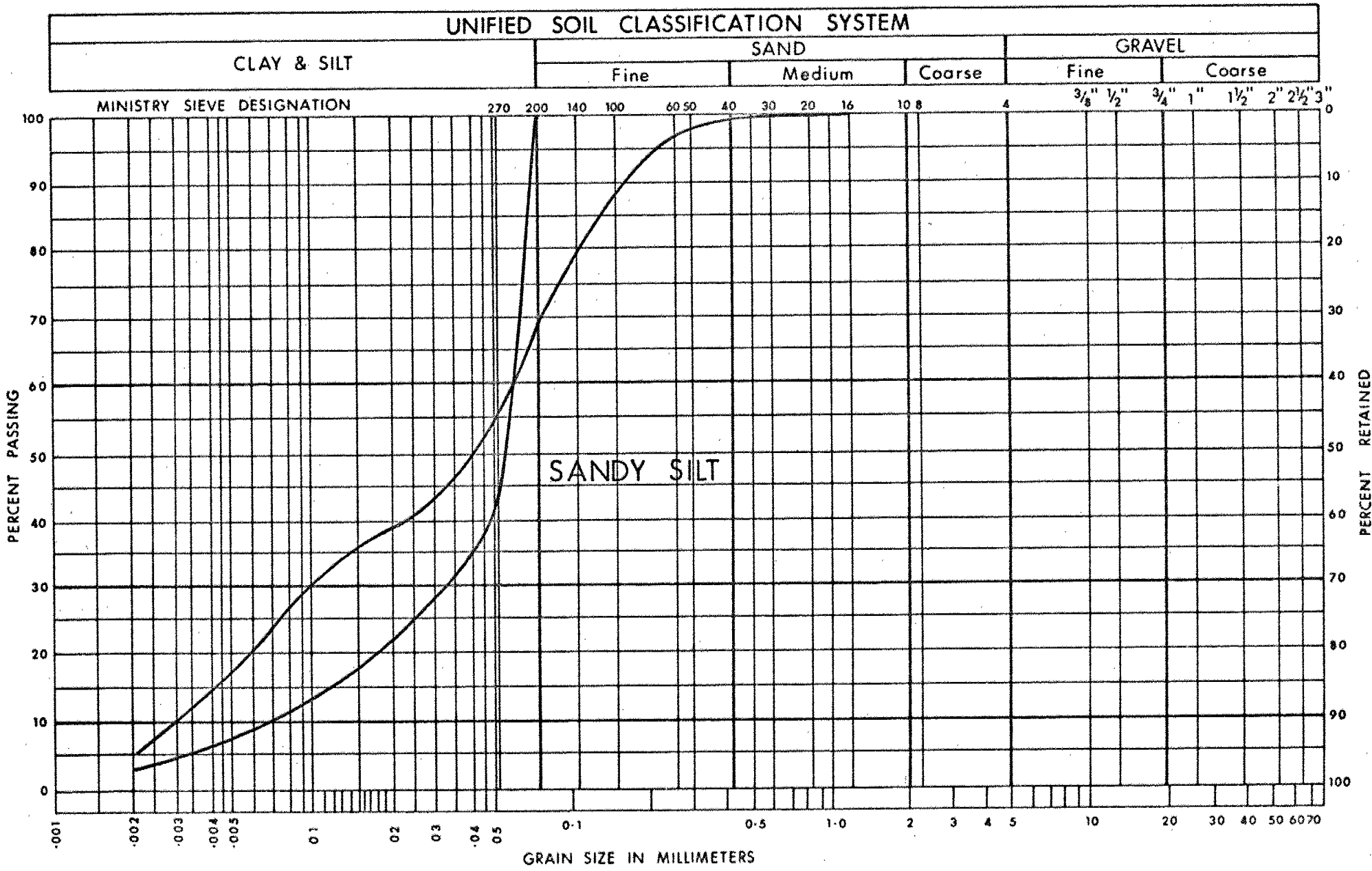


FIG. 5

GRAIN SIZE DISTRIBUTION

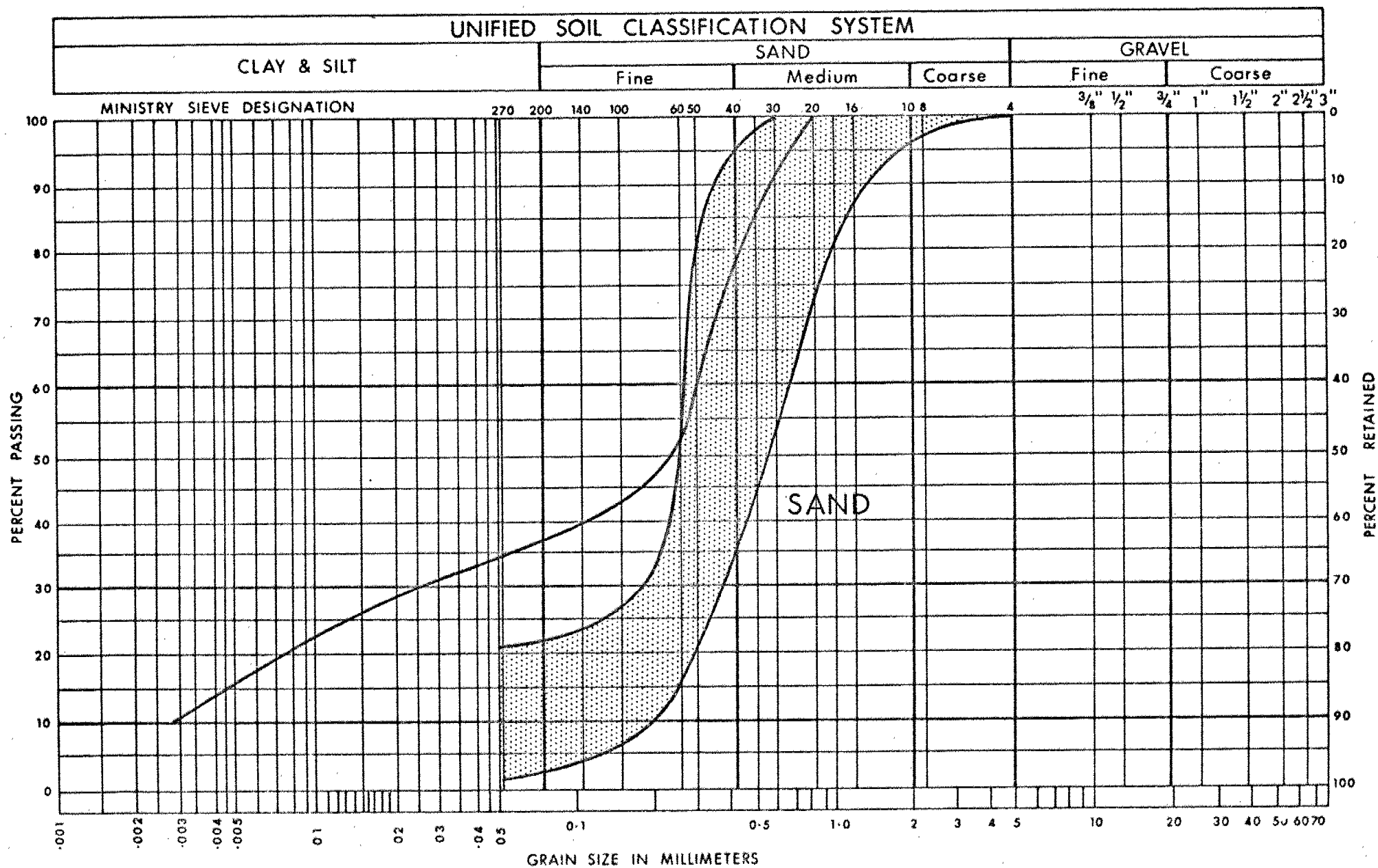


FIG. 6

GRAIN SIZE DISTRIBUTION

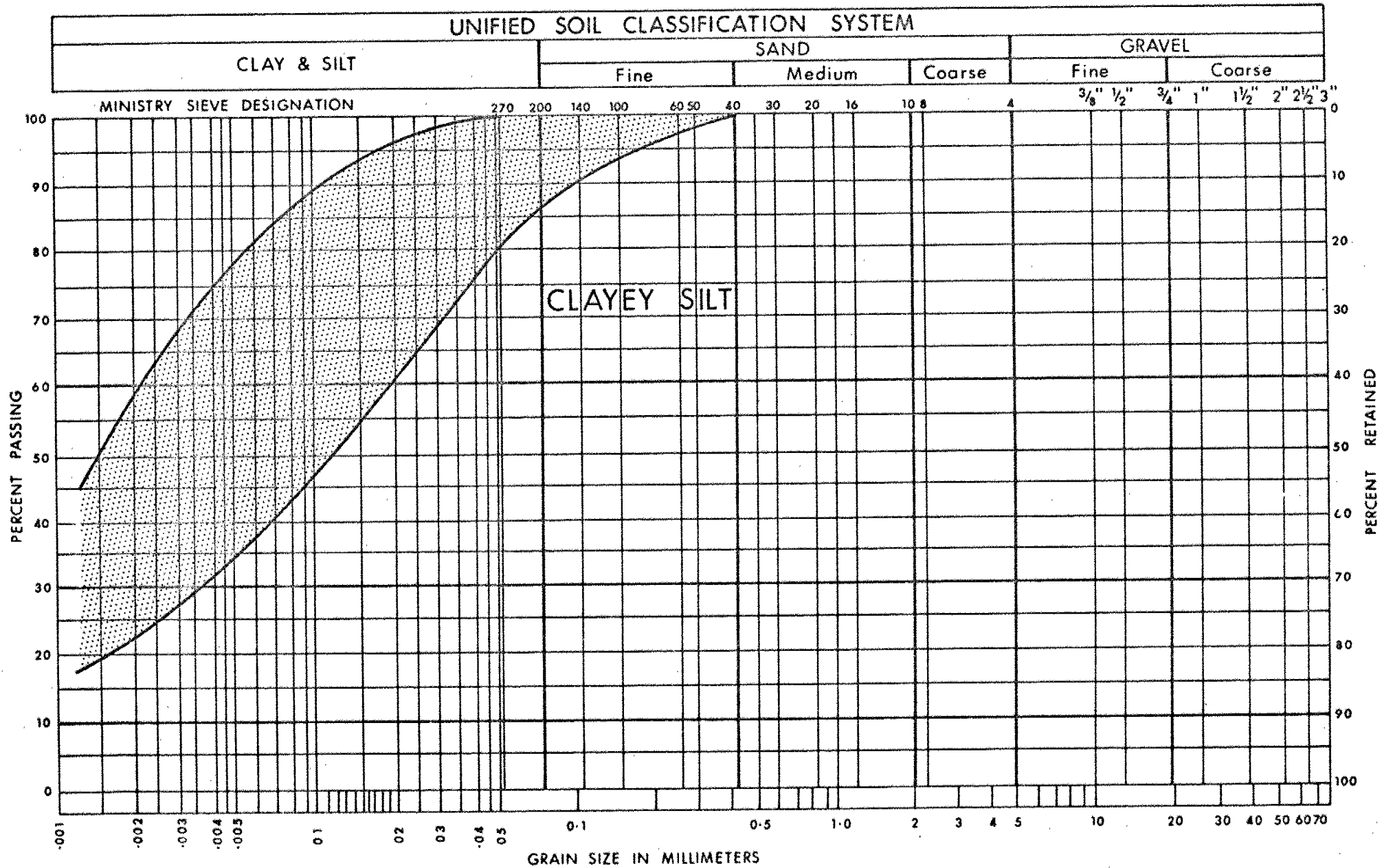


FIG. 7

GRAIN SIZE DISTRIBUTION

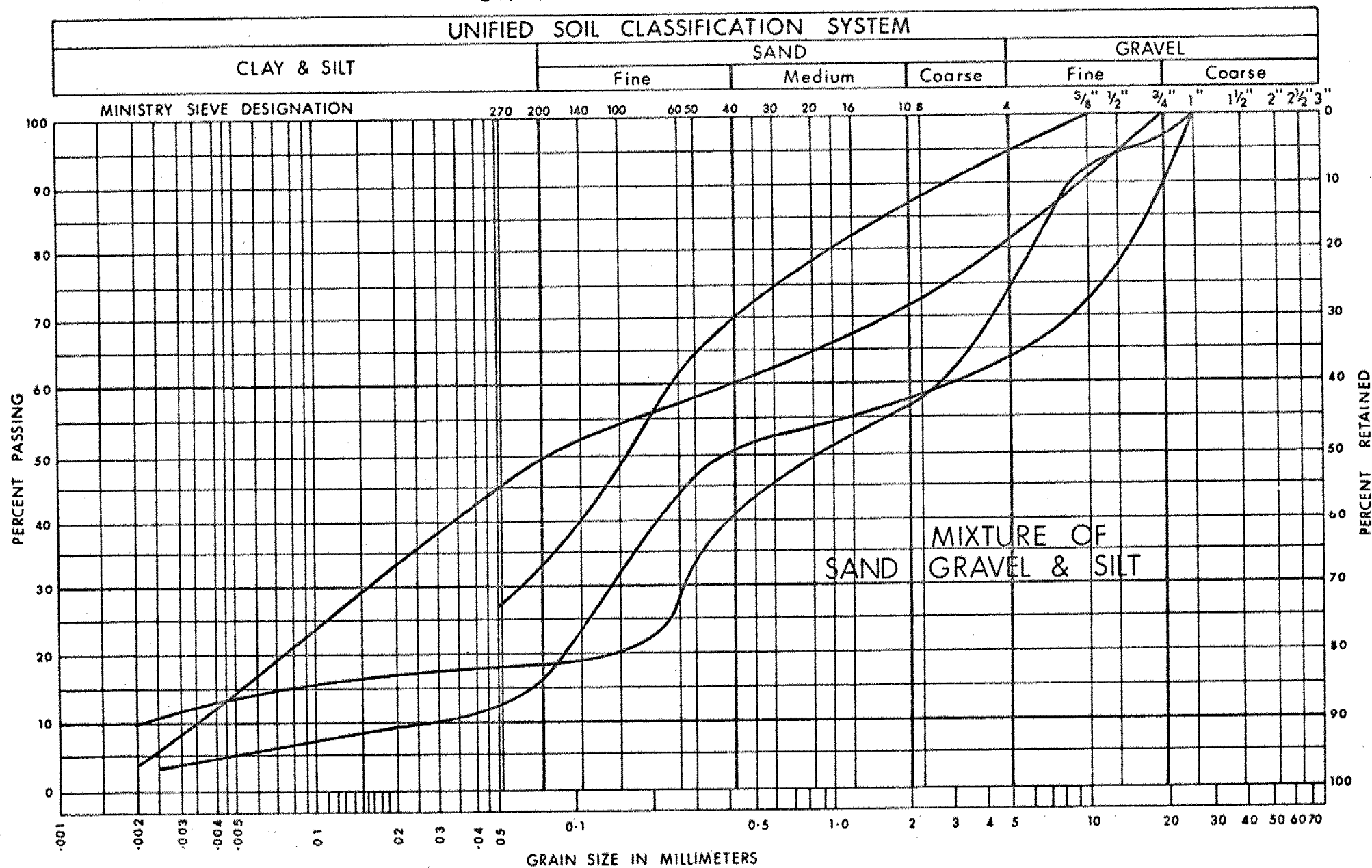


FIG. 8

W.O. 73-11058

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

PENETRATION RESISTANCE

'N' STANDARD PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 250	VERY LOOSE	0 - 4
SOFT	250 - 500	LOOSE	4 - 10
FIRM	500 - 1000	COMPACT	10 - 30
STIFF	1000 - 2000	DENSE	30 - 50
VERY STIFF	2000 - 4000	VERY DENSE	> 50
HARD	> 4000		

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
w_s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

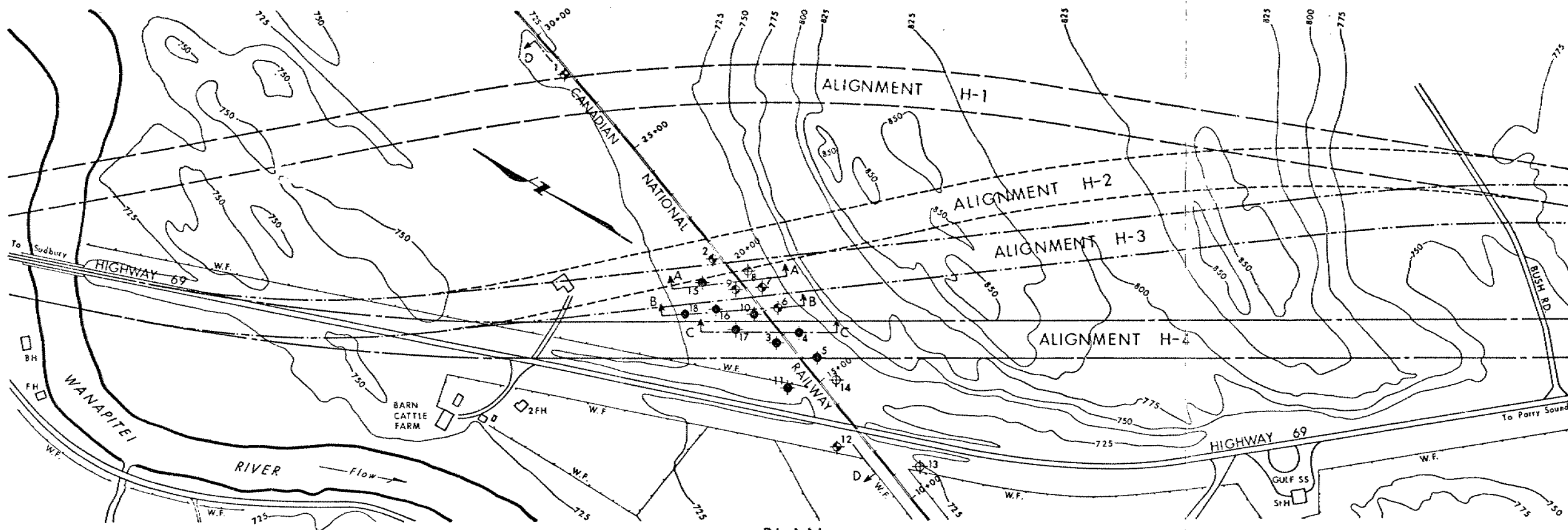
d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

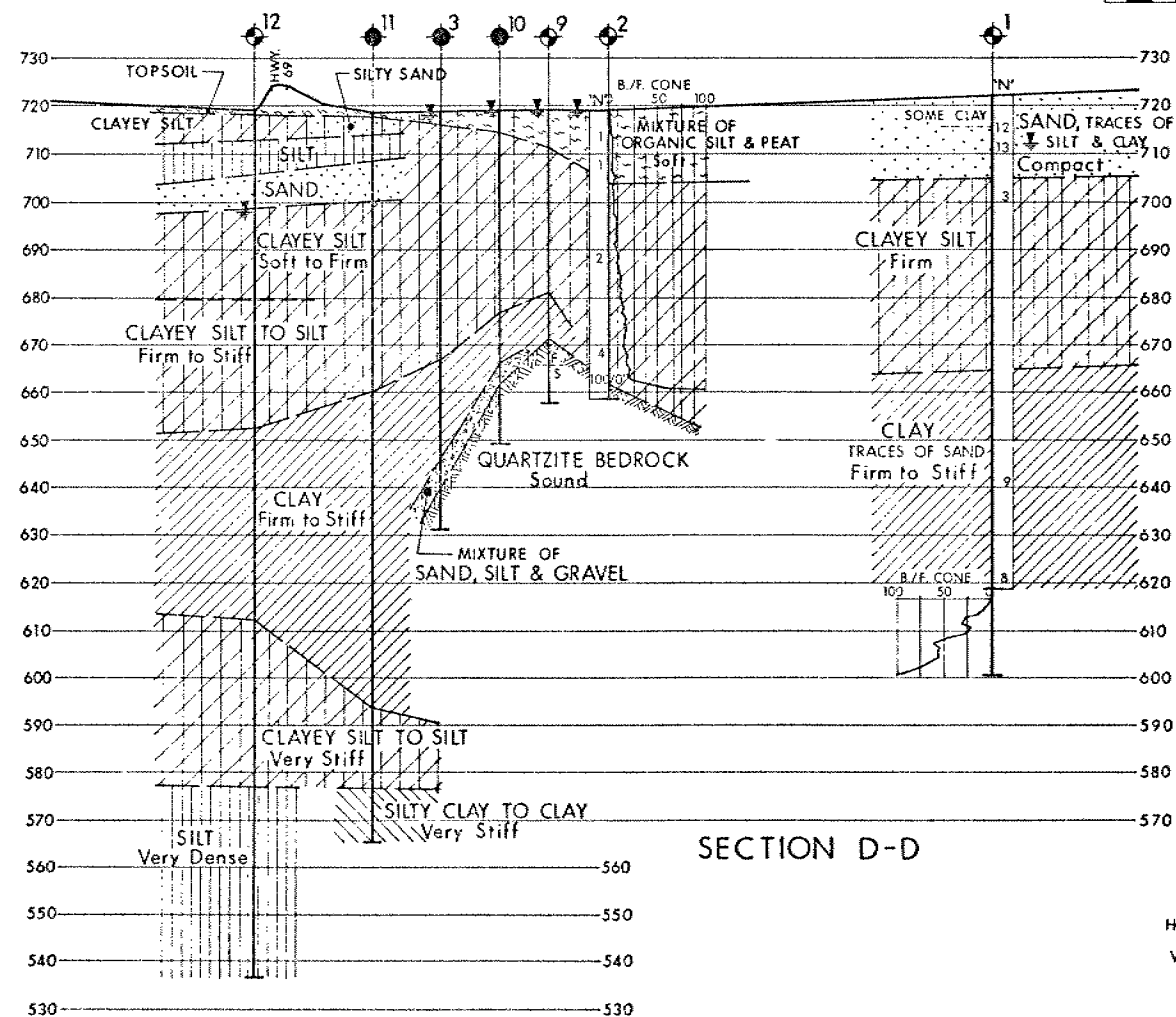
SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL



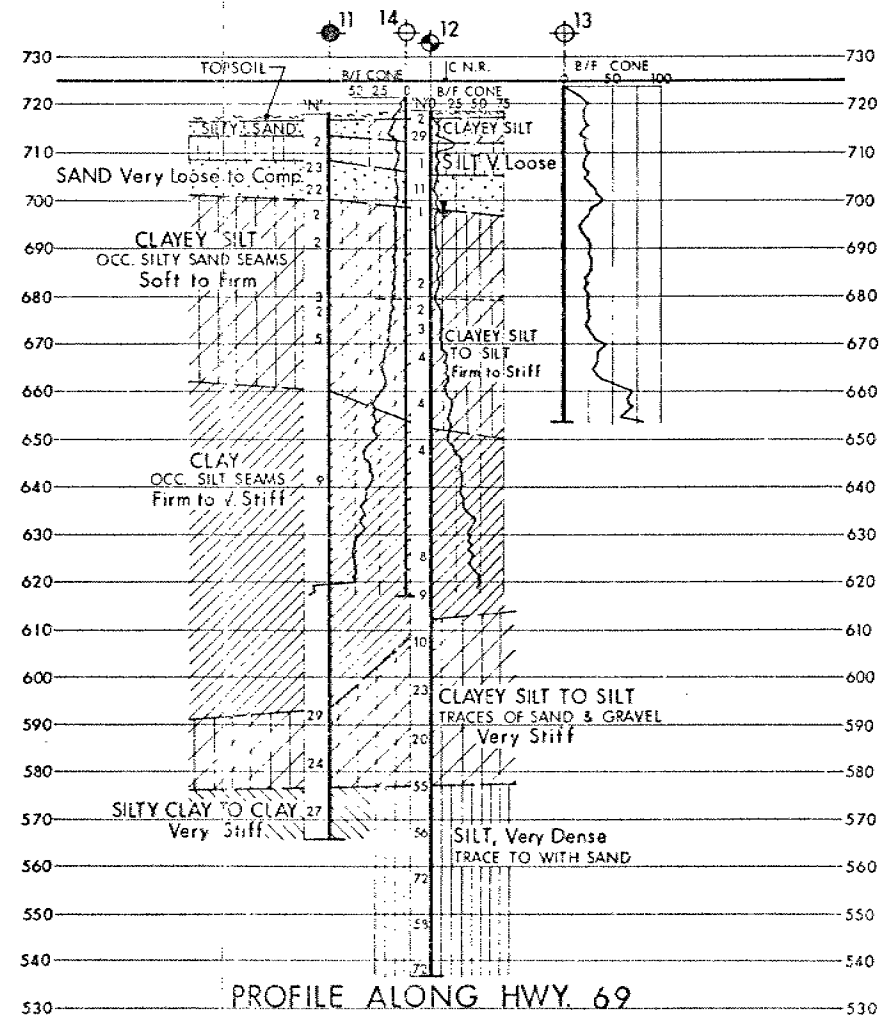
PLAN

SCALE
200 100 0 200 400FT.

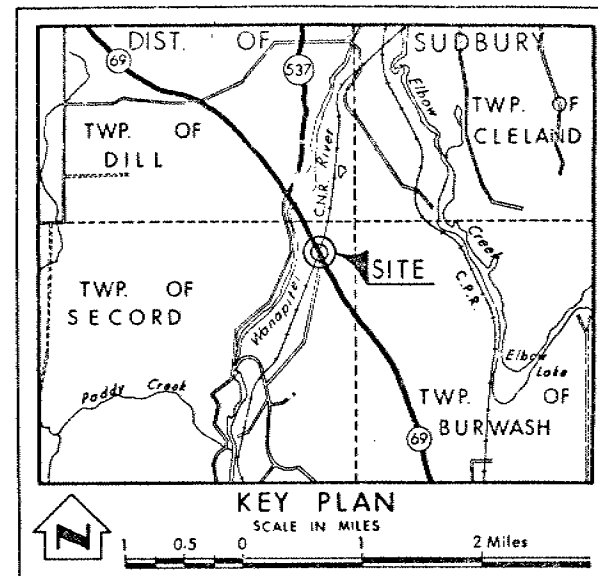


SECTION D-D

SCALE FOR SECTION & PROFILE
HORIZ. 200 100 0 200 400FT.
VERT. 20 10 0 20 40FT.



PROFILE ALONG HWY. 69



LEGEND

- Bore Hole
- ⊕ Cone Penetration Test
- ⊕ Bore Hole & Cone Test
- Water Levels established at time of field investigation, April 1973
- Water Level not established March 1974
- in B.H. #11 at time of field investigation

NO	ELEVATION	STATION C.N.R.	OFFSET R.E. of E. Rail
1	722.0	28+40	25' LT.
2	718.9	20+44	31' LT.
3	718.6	16+91	34' LT.
4	718.9	16+71	41' RT.
5	718.4	15+67	39' RT.
6	719.6	17+84	37' RT.
7	719.3	18+68	40' RT.
8	719.4	19+45	35' RT.
9	718.9	19+17	32' LT.
10	718.7	18+08	35' LT.
11	718.0	15+45	100' LT.
12	718.5	12+88	90' LT.
13	724.0	10+63	87' RT.
14	721.4	14+66	43' RT.
15	719.1	20+01	105' LT.
16	718.9	19+05	125' LT.
17	718.9	18+10	115' LT.
18	719.1	19+54	217' LT.

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

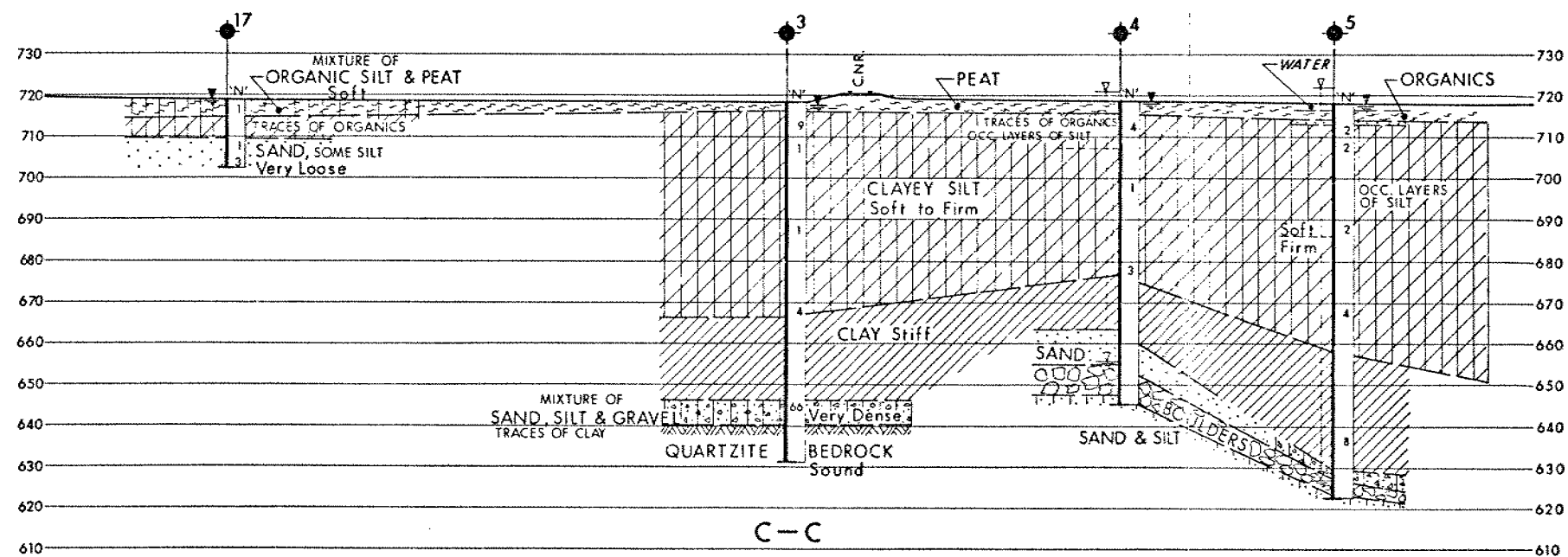
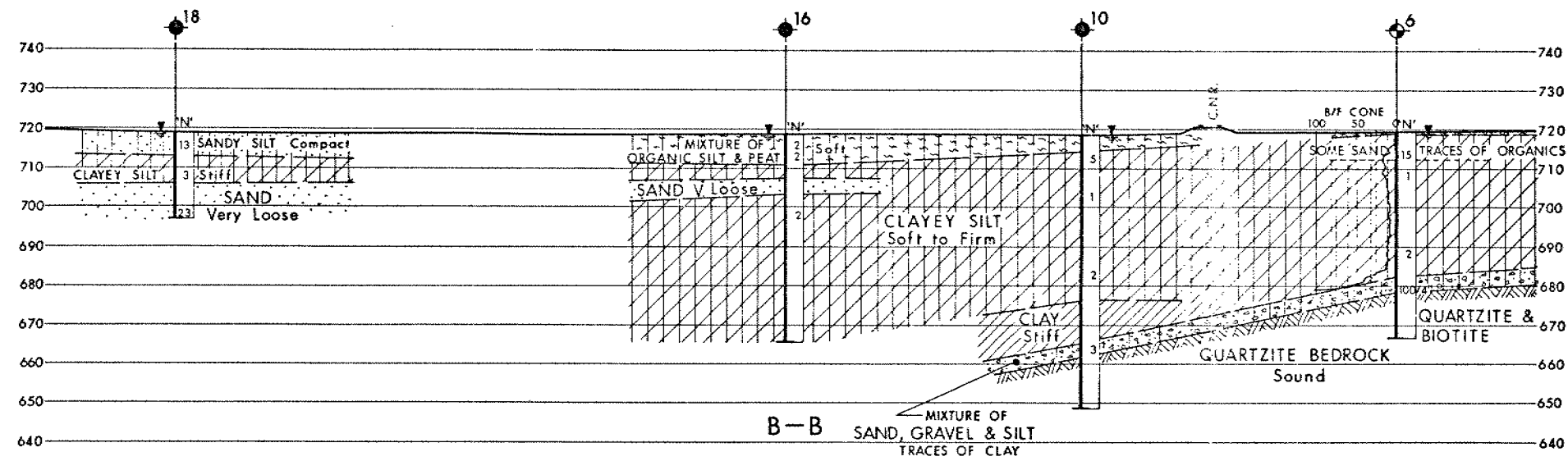
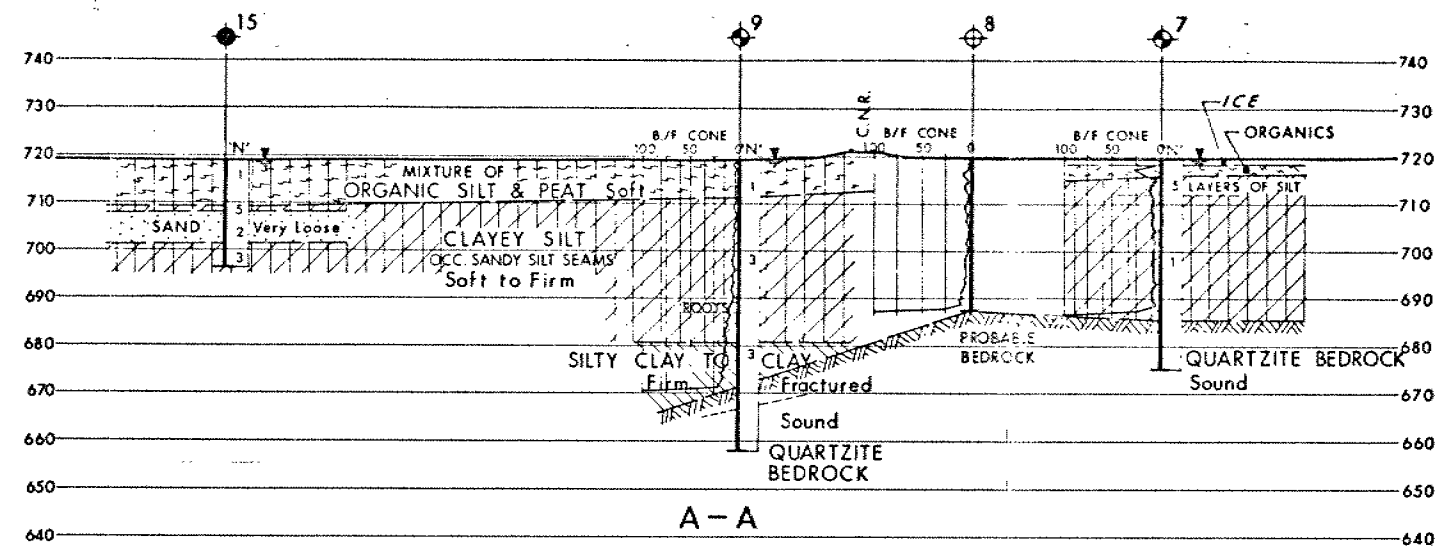
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE

CANADIAN NATIONAL RAILWAY

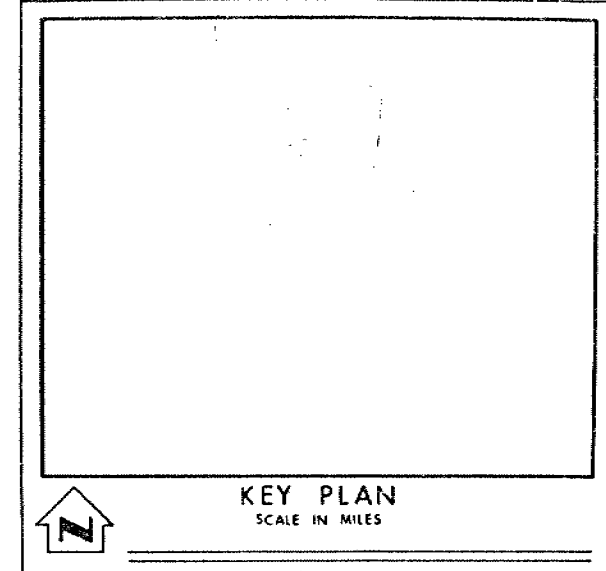
HIGHWAY NO. 69 DIST. NO. 17
Dist. of SUDBURY
TWP. SECORD LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD A.P.	CHECKED	W.P. NO. 914-71	DRAWING NO.
DRAWN	CHECKED	W.O. NO. 73-11058	73-11058A
DATE Aug 23, 1974	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		



C-C
SECTIONS
SCALE
20 10 0 20 40 FT.



LEGEND		
	Bore Hole	
	Cone Penetration Test	
	Bore Hole & Cone Test	
	Water Levels established at time of field investigation. March & April 1974	
	Head	
	ARTESIAN CONDITION Encountered	
NO.	ELEVATION	

— NOTE —
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS	DATE	BY	DESCRIPTION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH—GEOTECHNICAL OFFICE

CANADIAN NATIONAL RAILWAY

HIGHWAY NO. 69 DIST. NO. 17
Dist. of SUDBURY
TWP. SECORD LOT CON.

SECTIONS & SOIL STRATA			
SUBMD A.P.	CHECKED	WP NO 914-71	DRAWING NO.
DRAWN	CHECKED	WO NO 73-11058	73-11058B
DATE Aug. 23, 1974	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		