

B.P. WALKER Associates Limited

GEOCRES No 41I-135

REPORT ON
SOIL INVESTIGATION
NORTHWEST OF EXISTING CAUSEWAY
ON HIGHWAY 64 AT LAVIGNE
WP-89-86-01: SITE 43-57
LAVIGNE DIST. 13 REG. NORTHERN

Consulting Geotechnical
Inspection and
Testing Engineers

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Consulting Geotechnical, Inspection and Testing Engineers

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**REPORT ON
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ON HIGHWAY 64 AT LAVIGNE
WP-89-86-01: SITE 43-57
LAVIGNE DIST. 13 REG. NORTHERN**

**Prepared for:
Ministry of Transportation
Foundation Design Section
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8**

Project No. 2361-0890

October 12, 1990

Geocres No 41 I-135

INTRODUCTION

B. P. Walker Associates Ltd., Consulting Geotechnical, Inspection and Testing Engineers, was authorized by the Ministry of Transportation, Ontario to conduct a geotechnical investigation immediately north west of the existing causeway on Highway 64 at Lavigne. Various rehabilitation/construction alternatives are being considered at this site. However, the type of alternative has not been decided.

The purpose of this geotechnical investigation was to explore the subsurface conditions by means of boreholes and laboratory testing and present factual subsoil data. The borehole locations were discussed with MTO prior to the start of the investigation. This report presents a brief account of the procedures followed in the investigation and the field and laboratory test results.

THE SITE AND GEOLOGY

The existing causeway, part of Highway 64, lies in a North/South direction and crosses the Northwest Bay of Lake Nipissing at Lavigne. The topography of the area is gently rolling with frequent bedrock outcrops. The north eastern portion of the site is generally swampy and is traversed by a creek running north and south. The existing causeway is a two lane highway with each lane approximately 3.05m wide with an average shoulder width of about 0.9m.

Geologically the area is part of the Canadian Shield and the rock formation is classified as Precambrian. Rock outcrops are noticeable at either end of the causeway at about an elevation of 195.9m and the bedrock surface slopes to an elevation of 163.6m (a depth of 32.3m below the present water level of 195.9m) at borehole

5 location. The granitic bedrock is covered with post glacial fluvial deposits of clay, silt and sand.

Average annual daily traffic in 1988 at this location was 950 with projected traffic count of 1300 in 1998.

FIELD AND LABORATORY WORK

Eight boreholes, numbered 1 to 8, were drilled as shown on the borehole location plan, drawing 898601-A, in addition to three dynamic cone penetration tests C9 to C11. Four probes P1 to P4 were also carried out to establish the top of the boulder fill. These borehole locations were selected in agreement with MTO on a site plan transmitted to us.

The eight boreholes were drilled in the interim between July 31 and August 15, 1990, to depths ranging from 18.2m to 32.3m. A diamond drill mounted on a raft and equipped with 75mm casing for wash boring was used for advancing the holes. All boreholes were advanced to refusal using wash boring. At five of the borehole locations, Borehole 1, 3, 5, 7 and 8, samples of silty clay or clayey silt were obtained at 1.5m intervals using 50mm thin wall shelly tubes. Between the thin wall shelly tube samples insitu shear strength of these deposits was obtained using an MTO approved field vane. Sand deposits at the borehole locations were identified by either observing the cuttings from the wash boring or taking a sample with a 51mm o.d. split spoon (SS) in accordance with ASTM D1586-84, Standard Method for Penetration Test and Split Barrel Sampling of soils. At the balance of the boreholes, borehole 2, 4 and 6 split spoon or thinwall shelly tube samples were obtained to confirm the subsoil data obtained at the other five detailed boreholes. No field vane tests were carried out at these boreholes.

Three dynamic cone penetration tests were performed at locations P9 to P11 also shown on Drawing 898601-A. The cone penetration tests were carried out using a 50mm diameter cone, driven with the same energy as the Standard Penetration Tests and were terminated at refusal on probable bedrock.

A series of probes, P1 to P4, was carried out to determine the top the boulder fill at the deepest part of the causeway.

The drilling, sampling and the field testing procedures were supervised and the borings logged by an experienced geotechnical engineer from our office.

Soil samples obtained from each borehole were brought back to our laboratory for testing and classification. All samples were examined by a geotechnical engineer. Laboratory shear vane tests were carried out on the thin wall shelby tube samples in addition to natural moisture contents (W%), natural unit weights and atterberg limits.

Consolidation tests were carried out on three representative samples of silty clay taken from different depths in the boreholes.

SUBSURFACE CONDITIONS

The principal soil strata encountered at the borehole locations consist of a thin deposit of organic silt or organic silt with sand at the lake bed over deposits of silty clay (upper deposit), containing thin layers of clayey silt and silty sand with gravel, followed by a lower silty clay and a second layer of silty sand with gravel underlain by probable bedrock.

A detailed description of the soils encountered in each borehole is given in the Record of Borehole drawings. The estimated

stratigraphic profile shown on Drawing 898601-A is based on this information. From lake bed downwards, the subsurface conditions in detail are as follows:

Organic Silt/Organic Silt with Sand - The thickness of this layer varies from 0.9m at Borehole 4 to 3.3m at Borehole 3. At boreholes 7 and 8, the organic silt with sand contains thin layers of fibrous peat.

The moisture content of this deposit varies from 28% to over 100% depending on the amount of sand in the sample. The shear strength, based on laboratory shear vane test results on thin wall Shelby tube samples gave a value of 11 kPa. Standard penetration tests at borehole 3 gave an 'N'-value of 3. Based on the laboratory shear strength test and the standard penetration test the consistency of the deposit is very soft.

The physical properties of this deposit, as determined from the laboratory testing, are as follows:

			<u>No. of Tests</u>
Liquid Limit (WL) %	-	58	1
Plastic Limit (Wp) %	-	43	1
Plasticity Index (Ip) %	-	15	1
Moisture Content (W) % -Range -		28-120	6

The results of the Atterberg Limit Tests are shown on the Plasticity Chart on Figure 6. These results indicate that the deposit is organic of low plasticity (MH Zone).

The results of grain size distribution testing performed on a representative sample are shown on Figure 5.

UPPER SILTY CLAY

Immediately under the organic silt/organic silt with sand deposit is the upper deposit of silty clay. The thickness of this stratum varies from 8.6m at Borehole 1 to 16.0m at Borehole 7.

The upper silty clay deposit contains minor organic matter near the surface and is dark grey in colour. Examination of the silty clay samples from the shelby tubes indicated that the clay deposit is vaguely fissured and blocky. This suggests that the upper silty clay deposit may have been partially desiccated over the years.

Based on the field and laboratory vane tests, the shear strength of the upper deposit of silty clay varied from 11 kPa to 30 kPa indicating very soft to firm consistency.

The sensitivity of the silty clay, determined from the vane tests, ranged from 1.0 to 4.8.

The physical properties of this deposit, as determined from laboratory testing are summarized below:

		<u>Range</u>	<u>Average</u>	<u>No. of Tests</u>
Liquid Limit (W _L) %	-	40-77	54	6
Plastic Limit (W _p) %	-	18-30	23	6
Plasticity Index (I _p) %	-	23-47	31	6
Moisture Content (W) %	-	41-125	91	30

The results of the Atterberg Limit Tests are shown on the Plasticity chart on Figure 2. The results indicate that the deposit is inorganic of medium to high plasticity (CI-CH range).

The results of grain size distribution testing performed on representative samples from the silty clay deposit are shown on Figure 1.

Natural unit weight determinations gave values ranging from 13 kN/m³ to 17.1 kN/m³ with an average value of 14.5 kN/m³.

Two consolidation tests were performed on samples obtained from depths of 7.6m at borehole 5 and 11.0m at borehole 1 below the water surface. The resulting void ratio-pressure curves are shown on Figures 8 and 10. Laboratory results obtained from the consolidation tests are summarized below:

<u>Borehole No.</u>	<u>Depth Below Water Level</u>	<u>P_o</u>	<u>P_c</u>	<u>C_c</u>
5	7.6m	23kPa	38kPa	1.7
1	11.0m	53kPa	59kPa	1.3

Clayey Silt - Minor clayey silt seams were noticed throughout the silty clay deposit. The most significant deposit of clayey silt, varying in thickness from 1.0m to 2.0m, was encountered at a depth of from 9.1 to 13.3 below lake level between boreholes 5 to 8.

The physical properties of this deposit, as determined from laboratory testing, are summarized below:

	<u>Range</u>	<u>Average</u>	<u>No. of Tests</u>
Liquid Limit (WL) % -	26-30	29	3
Plastic Limit (Wp) % -	18-19	19	3
Plasticity Index (Ip) % -	8-12	10	3

The results of the Atterberg Limit Tests are shown on the Plasticity chart on Figure 4. These results indicate that the deposit is inorganic of low plasticity (CL range).

The results of grain size distribution testing performed on representative samples from the clayey silt deposit are shown on Figure 3.

Upper Silty Sand with Gravel - Underlying the upper silty clay and the clayey silt deposits is a stratum of silty sand with gravel varying in thickness from 0.5m to 2.0m. The stratum is generally composed of fine to medium coarse sand sizes with fine to medium gravel sizes.

Standard Penetration resistance gave N-values of 5 to 34 blows per 30cm. Based on these N-values the silty sand with gravel is loose to dense, generally in the loose range.

LOWER SILTY CLAY

Underlying the upper silty sand with gravel is the lower deposit of silty clay. The thickness of this stratum varies from 1.7m at borehole 1 to 12.9m at borehole 6. Examination of the silty clay samples from the shelby tubes indicated that this deposit is vaguely varved.

Based on the field and laboratory vane tests, the shear strength of the lower deposit of silty clay varies from 19 kPa to more than 105 kPa indicating soft to stiff consistency.

The physical properties of this deposit, as determined from the laboratory testing are summarized below:

	<u>Range</u>	<u>Average</u>	<u>No. of Tests</u>
Liquid Limit (W _L) % -	46-50	48	2
Plastic Limit (W _p) % -	18-21	20	2
Plasticity Index (I _p) % -	48-20	28	2
Moisture Content (W) % -	39-79	59	26

The results of the Atterberg Limit Tests indicate that the deposit is inorganic of medium to high plasticity (CI-CH range), similar to the upper silty clay deposit. The results are, therefore, included in the Plasticity Chart for the upper silty clay deposit in Figure 2.

The results of grain size distribution testing performed on representative samples from the lower silty clay are shown with the upper silty clay deposit results on Figure 1.

A consolidation test was performed on a sample obtained from this stratum. The resulting void ratio - pressure curve is shown on Figure 9. Laboratory results obtained from the consolidation test are:

$$P_o = 130 \text{ kPa}$$

$$P_c = 130 \text{ kPa}$$

$$C_c = 0.44$$

Lower Silty Sand with Gravel - Immediately above the probable bedrock is a lower deposit of silty sand with gravel. The thickness of this deposit varied from a few centimetres to 3.4m. This stratum is composed of medium to coarse sand with gravel sizes. However at boreholes 3 and 4, this silty sand with gravel deposit contains silty clay/clayey silt layers.

Standard Penetration resistance gave N values in the range of 14 to over 100 blows per 30cm indicating that this stratum is compact to very dense, mostly in the very dense range.

The results of grain size distribution testing performed on representative samples from the upper and lower deposits of silty sand with gravel are shown on Figure 7.

Bedrock

Bedrock outcrops on either side of the causeway indicate that the bedrock is granitic. However this was not proven by coring at the borehole locations.

Dynamic Cone Penetration Tests

Three dynamic cone penetration tests, cones 9 to 11, respectively, indicate similar penetration values up to a depth of 15.5m, the depth of the shallow cone. The cone penetration resistance below the upper silty sand and gravel deposit at cone location #11 ranged from 30 blows per 0.3m to over 50 blows per 0.3m (the higher values of over 80 blows per 0.3m are probably in the lower silty sand with gravel deposit at the bottom of the cone hole).

OBSERVATIONS

The Project

1. Existing Conditions

The present causeway was constructed in the early 1900's. The existing timber structure was built in 1952 to replace the previous timber truss. The present structure spans 63.2m and is 10.1m wide and is founded on timber piles.

The existing pavement width is 6.1m, 2 lanes of 3.05m each, with an average shoulder width of 0.9m. The width of the shoulder increases to approximately 2.0m at the approach to the structure.

3. Observations

Noticeable settlement was observed between the existing bridge approaches and the north and south banks of the bay. The settlement north of the structure appears to be greater than south of the structure due to the greater depth of silty clay to bedrock. However the road surface does not show significant distress, except for a localized longitudinal crack south of the existing bridge.

Some washout and loss of ground has been reported at the bridge approaches due either to movement of the timber piles or loss of fines through the very open boulder fill used for the causeway construction.

No accurate settlement records are available for the causeway and the structure. However, no major settlement has been reported since the early seventies when the approaches to the structure were padded to improve visibility.

No boreholes were carried out through the existing rockfill of the present embankment. The geometry of the existing rockfill and the total depth are, therefore, not known.

Considerable settlement of the silty clay stratum has taken place due to the load from the rock fill. However, no data is available on the amount of consolidation and increase in strength of these deposits.

CLOSURE

The soil stratigraphy and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations and subsurface conditions may become apparent during construction which could not be detected or anticipated from the site investigation.

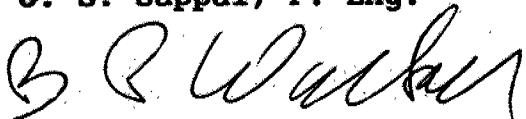
Please contact this office if you have any questions regarding the contents of this report.

Yours very truly,

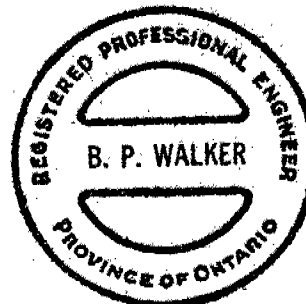
B. P. WALKER ASSOCIATES LTD.



U. S. Sappal, P. Eng.



B. P. Walker, Ph.D., P. Eng.



OVERSIZE
DRAWING(S)

RECORD OF BOREHOLE No 1

METRIC

W P 89-86-01 LOCATION STN. 21+571.0; O/S 22.5m Lt. ORIGINATED BY T.O.
DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
DATUM Geodetic DATE July 31, 1990 CHECKED BY U.S.S.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80					
195.9	WATER SURFACE															
0.0																
191.7																
4.2	SILTY CLAY-vaguely fissured; blocky; dark grey; high plasticity; very soft		1	SS	PM											
			2	TW	PM										15.3	
			3	TW	PM										13.6	50 50
			4	TW	PM										15.5	
			5	TW	PM										14.8	63 37
			6	TW	PM										18.0	
182.8																
13.1	SILTY SAND WITH GRAVEL- trace clay; fine to medium grained															
181.5																
14.4	SILTY CLAY-vaguely varved; grey; high; plasticity; very soft		7	SS	6											
179.8																
16.1	SILTY SAND WITH GRAVEL- trace clay; fine to medium grained; very dense		8	SS	93											
177.6			9	SS	100/	18 cm	178									19 51 17 13
18.3	PROBABLE BEDROCK															

RECORD OF BOREHOLE No 2

METRIC

W P 89-86-01 LOCATION STN. 21+602.5; O/S 37.5m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.B.
 DATUM Geodetic DATE August 15, 1990 CHECKED BY U.S.B.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										10 20 30 40 50		
195.9	WATER SURFACE																GR SA SI CL			
0.0																				
192.8																				
3.7	SILTY CLAY-vaguely fissured; blocky; dark grey to grey; high plasticity; very soft		1	SS	2															
			2	TW	PH											13.0	54 46			
			3	SS	1															
182.0			4	TW	PH*															
13.9	SILTY SAND WITH GRAVEL-		5	SS	1															
181.3	trace clay; loose																			
14.6	SILTY CLAY-vaguely varved; grey; high plasticity; very soft		6	TW	PH											14.0				
177.1																				
18.8	SILTY SAND WITH GRAVEL-		7	SS	94															
176.3	very dense																			
19.6	PROBABLE BEDROCK																			
	No Recovery																			

RECORD OF BOREHOLE No 3

METRIC

W P 89-86-01 LOCATION STN. 21+626.5; O/S 24.5m Lt. ORIGINATED BY T.O.
DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.B.
DATUM Geodetic DATE August 1, 2 and 3, 1990 CHECKED BY U.S.B.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
195.9	WATER SURFACE																
0.0																	
193.9																	
2.0	ORGANIC SILT-black/ dark grey; slight odour; wood fragments at 3.6m		1	TW	PM		194										
190.6			2	TW	PM		192									13.2	13 76 11
5.3	SILTY CLAY-trace organics to 7.0m; vaguely fissured; grey; blocky; very soft; high plasticity		3	TW	PM		190										
			4	TW	PM		188									13.2	
			5	TW	PM		186										
			6	TW	PM		184									14.8	
			7	TW	PM		182										
	SILTY SAND WITH GRAVEL-grey		8	TW	PM		180										
	SILTY CLAY-vaguely varved; grey; very soft to stiff		9	SS	4		178									16.9	2 43 55
			10	SS	2		176										
			11	SS	2		174										
			12	TW	PM		172										
			13	TW	PM												
			14	TW	PM												
			15	TW	PM												
171.9			16	SS	14												
24.0	SILTY SAND WITH GRAVEL- silty clay layers; grey; compact																
170.7																	
25.2	PROBABLE BEDROCK																

RECORD OF BOREHOLE No 4

METRIC

W P 89-86-01 LOCATION STN. 21+663.5; O/S 40.0m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
 DATUM Geodetic DATE August 12 and 13, 1990 CHECKED BY U.S.S.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
195.9	WATER SURFACE																
0.0																	
194.1																	
1.8	ORGANIC SILT & SAND-		1	SS	PM		194										
193.2	black/dark grey; loose																
2.7	SILTY CLAY-vaguely		2	TW	PM		192	x 2.3								14.2	
	fissured; grey; very																
	soft		3	SS	1		190										
			4	TW	PM		188										
			5	SS	1		186										
			6	TW	PM		184	x 2.3								15.7	
			7	SS	1		182										
			8	TW	PM		180										
			9	SS	*		178										
180.4			10	SS	PM*		176										
15.5	SILTY SAND WITH GRAVEL-		11	SS	34		174										
179.6	grey; dense		12	SS	2		172										
16.3	SILTY CLAY-fissured;		13	TW	PM		170										
	vaguely varved; grey;		14	SS	2												
	very soft		15	TW	PM												
			16	SS	3												
			17	TW	PM												
170.8			18	SS	10												
25.1	SILTY SAND WITH GRAVEL-		19	SS	100/1cm												
	clayey silt layers;																
	compact																
168.6																	
27.3	PROBABLE BEDROCK																
	*SS Penetrated under																
	weight of rods.																
	*No Recovery																

+3, x5: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 Sheet 1 of 2 METRIC

W P 89-86-01 LOCATION STW. 21+702.5/ O/B 29.0m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
 DATUM Geodetic DATE August 3, 4, 5 and 6, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE	WATER CONTENT (%)					
						10 20 30 40 50					50 100 150					GR SA SI CL	
195.9	WATER SURFACE																
0.0																	
194.2																	
1.7	ORGANIC SILT AND SAND- dark grey; piece of wood at 2.7m		1	TW	PM*		194										
192.8																	
3.1	SILTY CLAY-vaguely fissured; dark grey to grey; some organics in upper 4.0m; very soft		2	TW	PM		192			x 2.3						14.0	
			3	TW	PM		190										
			4	TW	PM		188									15.3	65 35
			5	TW	PM		186									14.5	
			6	TW	PM		184			x 1.5							
			7	TW	PM		182									17.1	0 2 76 22
182.6	CLAYEY SILT-trace sand; grey; very soft		8	TW	PM		180										
180.9			9	SS	42		178										
15.0	SILTY SAND WITH GRAVEL- trace clay; fine to medium grained; dense		10	SS	25		176										
179.0			11	TW	PM		174										
16.9	SILTY CLAY-blocky; vaguely fissured; soft		12	SS	13		172										
177.9			13	TW	PM		170										
18.0	SILTY SAND WITH GRAVEL- trace clay; fine to medium grained; grey; compact		14	TW	PM		168										
176.1			15	TW	PM		166										
19.8	SILTY CLAY-fissured; vaguely varved; grey; soft to very stiff		16	TW	PM												
			17	TW	PM												
			18	TW	PM												
166.9	SILTY SAND WITH GRAVEL-trace clay; grey; compact to very dense		19	SS	22												
29.0																	

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE No 5 Cont'd

METRIC

Sheet 2 of 2

W P 89-86-01 LOCATION STN. 21+702.5; O/S 29.0m Lt.

ORIGINATED BY T.O.

DIST 13 HWY 64 BOREHOLE TYPE WASH BORING

COMPILED BY U.S.S.

DATUM Geodetic DATE August 3, 4, 5 and 6, 1990

CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
	Continued		20	SS	12															
163.5	SILTY SAND WITH GRAVEL- trace clay; grey; compact to very dense		21	SS	122		164													
32.4	PROBABLE BEDROCK																			
	*No Recovery																			

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 89-86-01 LOCATION STW. 21+741.0; O/S 53.0m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
 DATUM Geodetic DATE August 11 and 12, 1990 CHECKED BY U.S.S.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
195.9	WATER SURFACE													
0.0														
194.2							194							
1.7	ORGANIC SILT WITH SAND- black/dark grey; loose		1	SS	3									
192.6			2	TW	PM		192	x 2.0					13.3	
3.3	SILTY CLAY-minor organics to 5.0m; dark grey/grey; vaguely fissured; blocky; very soft		3	SS	2									
			4	TW	PM		190							
			5	SS	1		188							
			6	TW	PM		186	x					14.0	
			7	SS	1		184							
182.9			8	TW	PM		182							
13.0	CLAYEY SILT-trace of sand; grey; very soft		9	SS	4									0 3 80 17
180.9			10	SS	4		180							
15.0	SILTY SAND WITH GRAVEL- clay layer; loose		11	SS	12		178	x 2.5					17.1	
179.9			12	TW	PM									
16.0	SILTY CLAY-vaguely varved; some vertical fissures; grey; very soft		13	SS	2		176							
	SILTY SAND WITH GRAVEL-loose		14	SS	6		174							
			15	TW	PM*		172							
			16	SS	10		170							
			17	SS	PM*		168							
			18	SS	10									
			19	TW	PM*									
			20	SS	12									
			21	SS	7									
167.0	SILTY SAND WITH		22	SS	27		166							
28.9	GRAVEL-trace clay; compact to very dense													
165.7														
30.2	PROBABLE BEDROCK													

*No sample recovery

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7

METRIC

W P 89-86-01 LOCATION STN. 21+778.5; O/S 32.0m Lt ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
 DATUM Geodetic DATE August 6, 7 and 8, 1990 CHECKED BY U.S.S.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
195.9	WATER SURFACE																
0.0																	
194.5																	
1.4	ORGANIC SILT WITH SAND- occasional fibrous peat layers; soft		1	SS	PM		194										
193.4																	
2.5	SILTY CLAY-some organics near surface; blocky; vaguely fissured; dark grey to grey; very soft		2	TW	PM		192			4.0						14.0	
			3	TW	PM				x 1.9								
							190										
			4	TW	PM												
			5	TW	PM		188									16.8	72 28
									x 3.8								
							186										
			6	TW	PM												
			7	TW	PM		184									16.4	
			8	TW	PM												
							182										
	CLAYEY SILT- trace of sand; soft		9	TW	PM		180										
	SILTY CLAY-some organics near surface; blocky; vaguely fissured; dark grey to grey; stiff		10	TW	PM												
			11	TW	PM		178									17.1	
177.6																	
18.3	SILTY SAND WITH GRAVEL-		12	SS	4		176										
177.0																	
18.9	SILTY CLAY-trace sand; grey; vaguely varved; occasional clayey silt layers; soft to stiff		13	TW	PM												
							174									15.7	
			14	TW	PM												
			15	TW	PM		172										
			16	TW	PM												
							170									15.9	
			17	SS	8												
			18	TW	PM												
169.1																	
26.8	SILTY SAND WITH GRAVEL- silty clay layers; grey; very dense		19	SS	67		168										
166.8			20	SS	54												
29.1	PROBABLE BEDROCK																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 89-86-01 LOCATION STM. 21+843.5; O/S 38.5m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE WASH BORING COMPILED BY U.S.S.
 DATUM Geodetic DATE August 9 and 10, 1990 CHECKED BY U.S.S.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L		
195.9	WATER SURFACE															GR SA SI CL
0.0																
194.2																
1.7	ORGANIC SILT AND SAND- occasional fibrous, peat layers; black; loose		1	SS	PM											
192.1			2	SS	PM*											
3.8	SILTY CLAY-trace sand; blocky; vaguely fissured; grey; very soft		3	TW	PM										14.8	
186.8			4	TW	PM											
9.1	CLAYEY SILT-trace of sand; grey; very soft		5	TW	PM											
184.8			6	TW	PM										17.2	2 83 15
11.1	SILTY CLAY-fissured; grey; very soft		7	TW	PM											
183.1			8	TW	PM											
12.8	SILTY SAND WITH GRAVEL		9	SS	5											
182.5	grey; loose		10	TW	PM										16.6	
13.4	SILTY CLAY-vaguely varved; grey; very soft to stiff		11	TW	PM											
177.0			12	TW	PM											
19.2	PROBABLE BEDROCK		13	TW	PM											
	*No Recovery															

METRIC

W P 89-86-01 LOCATION STN. 21+529.0; O/S 20.5m Lt. ORIGINATED BY T.O.
DIST 13 HWY 64 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY U.S.S.
DATUM Geodetic DATE August 14, 1990 CHECKED BY U.S.S.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to Sensitivity

20
15 \diamond 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 10

METRIC

W P 89-86-01 LOCATION STN. 21+869.0; O/S 19.0m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY U.S.S.
 DATUM Geodetic DATE August 10, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
195.9	WATER SURFACE													
0.0														
194.3							194							
1.6							192							
							190							
							188							
							186							
							184							
							182							
							180							
178.9														
17.0	PROBABLE BEDROCK													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11 Sheet 1 of 2 METRIC

W P 89-86-01 LOCATION STN. 21+702.5; O/S 21.5m LT. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE DYNAMIC CONE TEST COMPILED BY U.S.S.
 DATUM Geodetic DATE August 14, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
195.9	WATER SURFACE												
0.0													
194.0							194						
1.9							192						
							190						
							188						
							186						
							184						
							182						
							180						
							178						
							176						
							174						
							172						
							170						
							168						
							166						

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x³: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued



METRIC

LOCATION STW. 21+702.5; O/S 21.5m Lt.

Sheet 2 of 2

ORIGINATED BY T.O.

DIST 13 HWY 64

BOREHOLE TYPE DYNAMIC CONE TEST

COMPILED BY D.S.S.

DATUM Geodetic

DATE August 14, 1990

CHECKED BY D.S.S.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

15 20 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P1

METRIC

W P 89-86-01 LOCATION STN. 21+702.5; O/S 12.3m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE PROBE COMPILED BY U.S.S.
 DATUM Geodetic DATE August 14, 1990 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
195.9	WATER SURFACE																
0.0																	
194.9																	
1.0	BOULDER FILL																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No P2

METRIC

W P 89-86-01 LOCATION STN. 21+702.5; O/S 15.4m L.L. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE PROBE COMPILED BY D.S.S.
 DATUM Geodetic DATE August 14, 1990 CHECKED BY D.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
195.9	WATER SURFACE																
0.0																	
194.9																	
1.0	BOULDER FILL																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No P3

METRIC

W P 89-86-01 LOCATION STM. 21+702.5; O/S 18.4m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE PROBE COMPILED BY U.S.S.
 DATUM Geodetic DATE August 14, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
195.9	WATER SURFACE																
0.0																	
194.9																	
1.4	BOULDER FILL																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No P4

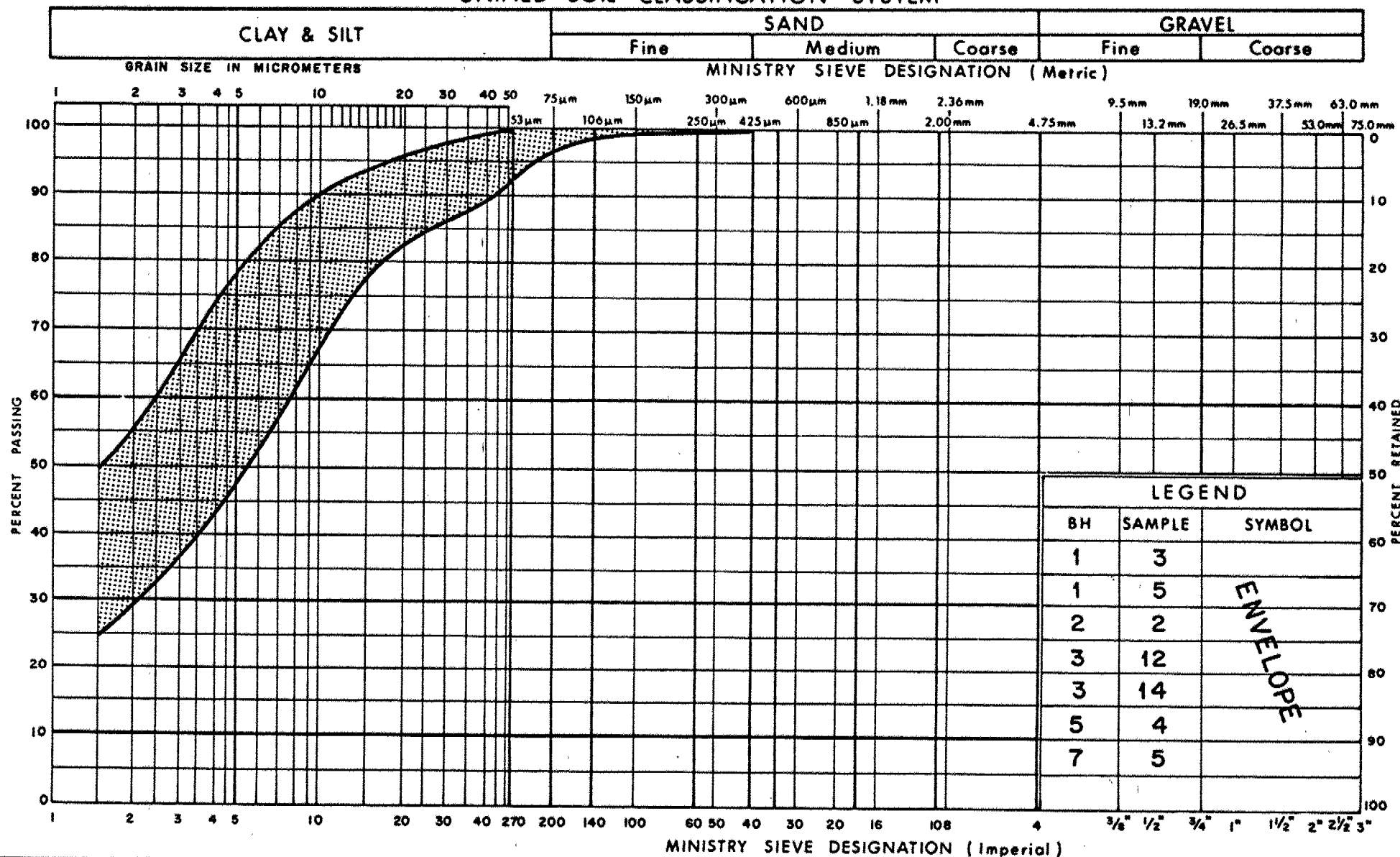
METRIC

W P 89-86-01 LOCATION STM. 21+702.5; O/S 19.7m Lt. ORIGINATED BY T.O.
 DIST 13 HWY 64 BOREHOLE TYPE PROBE COMPILED BY U.S.S.
 DATUM Geodetic DATE August 14, 1990 CHECKED BY U.S.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION - (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
195.9	WATER SURFACE																
0.0																	
194.2																	
1.7	BOULDER FILL																

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

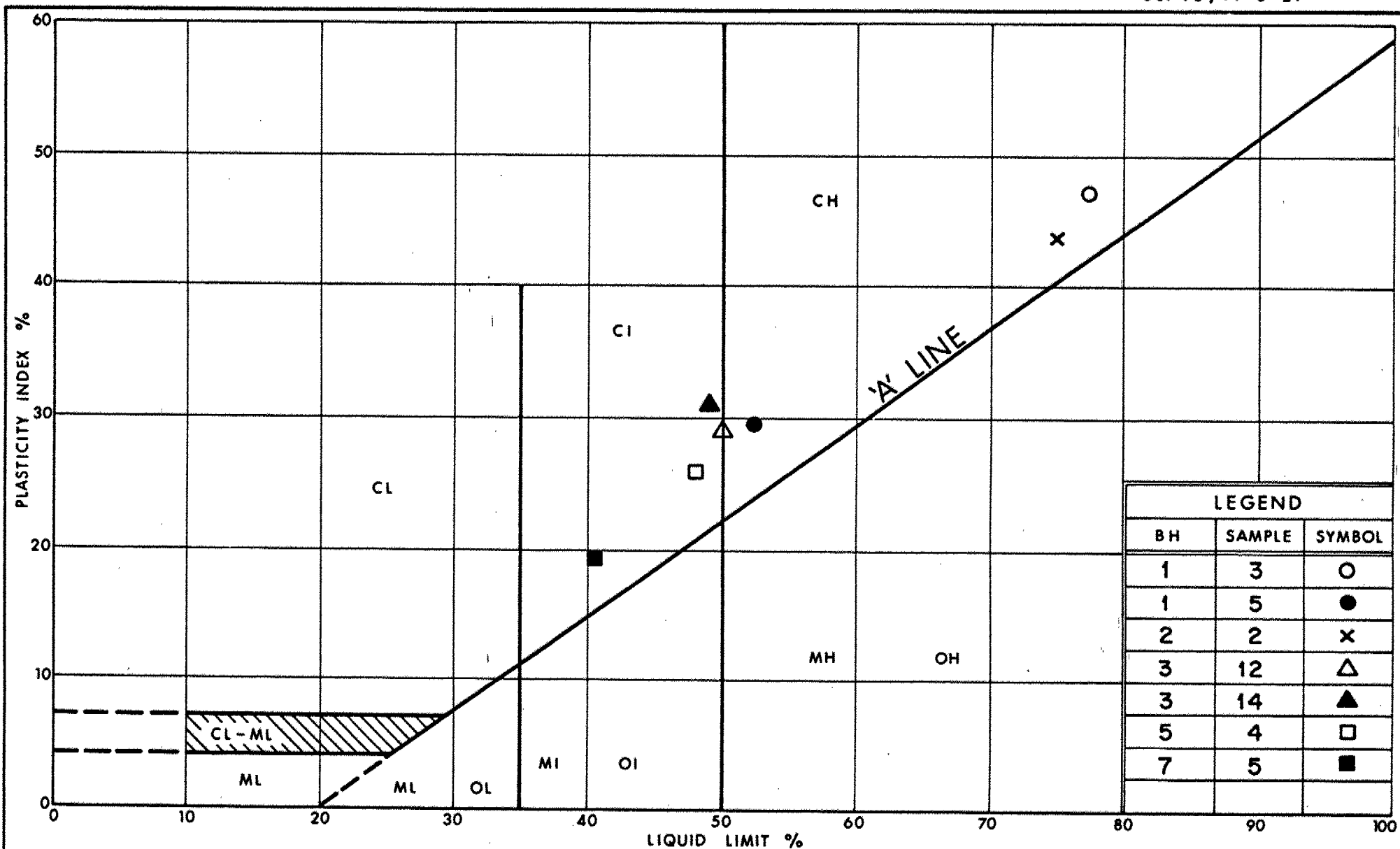


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SILTY CLAY

FIG No 1

WP 89-86-01



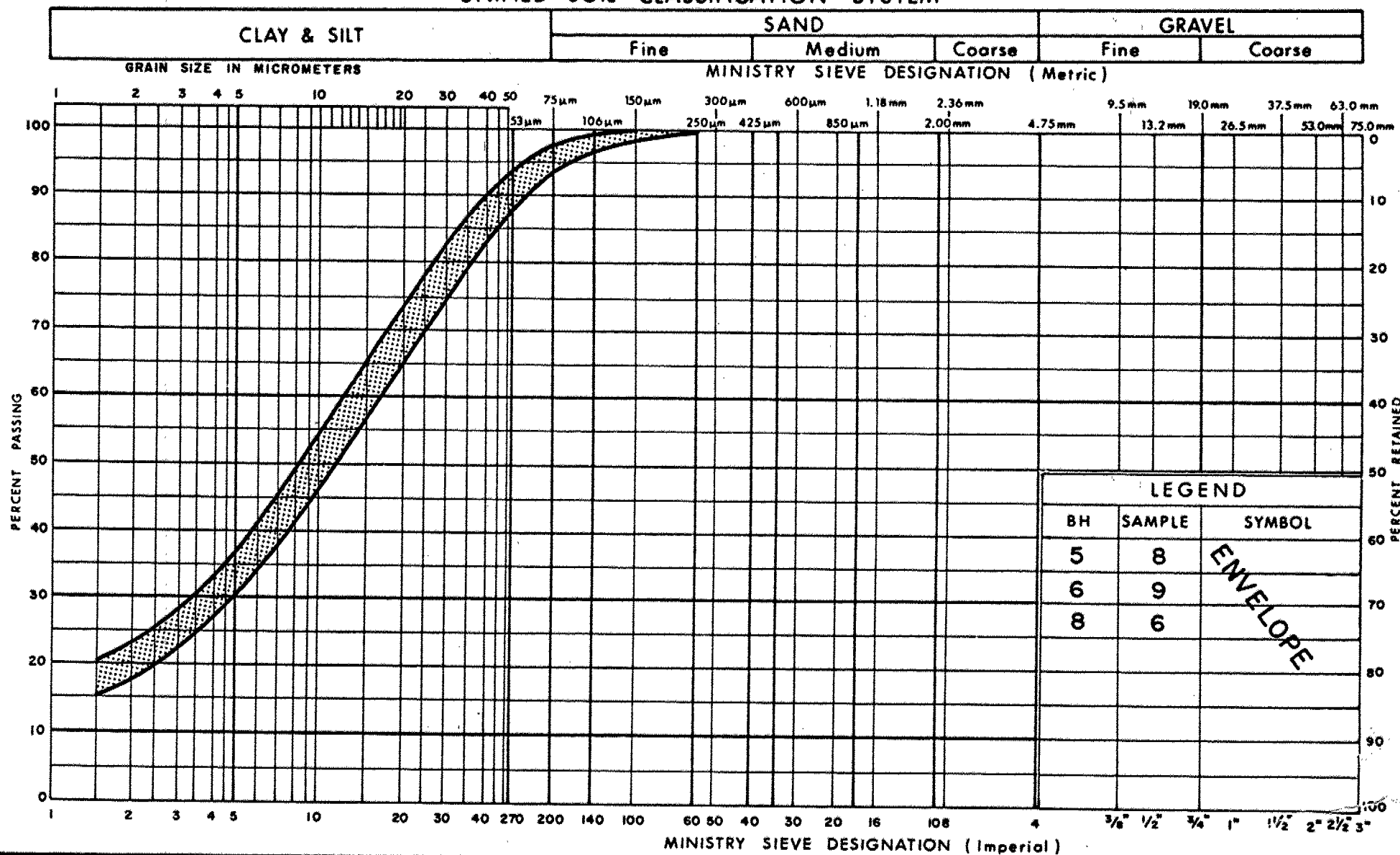
Ministry of
Transportation
Ontario

PLASTICITY CHART SILTY CLAY

FIG No 2

W P 89-86-01

UNIFIED SOIL CLASSIFICATION SYSTEM



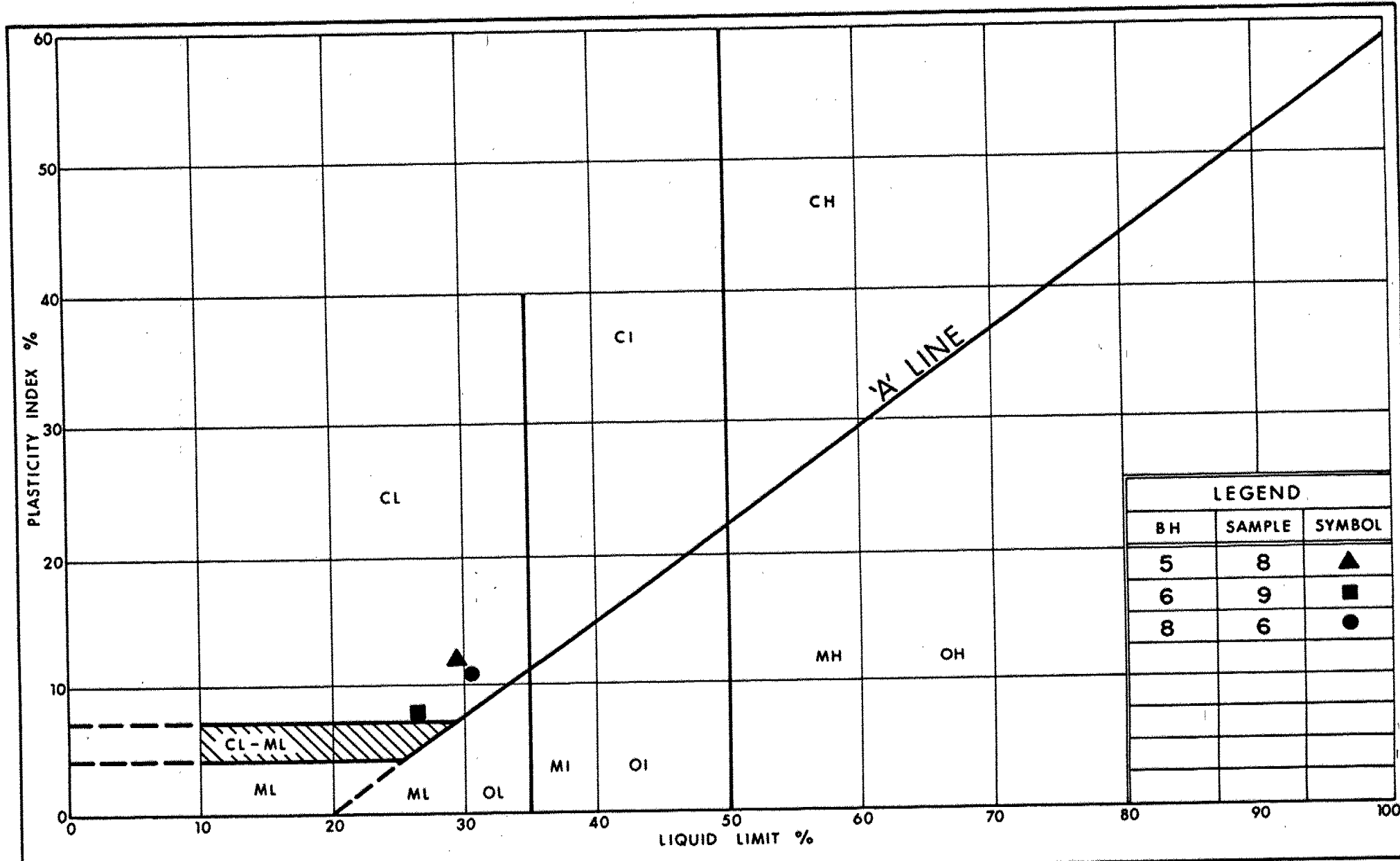
Ontario

Ministry of
Transportation

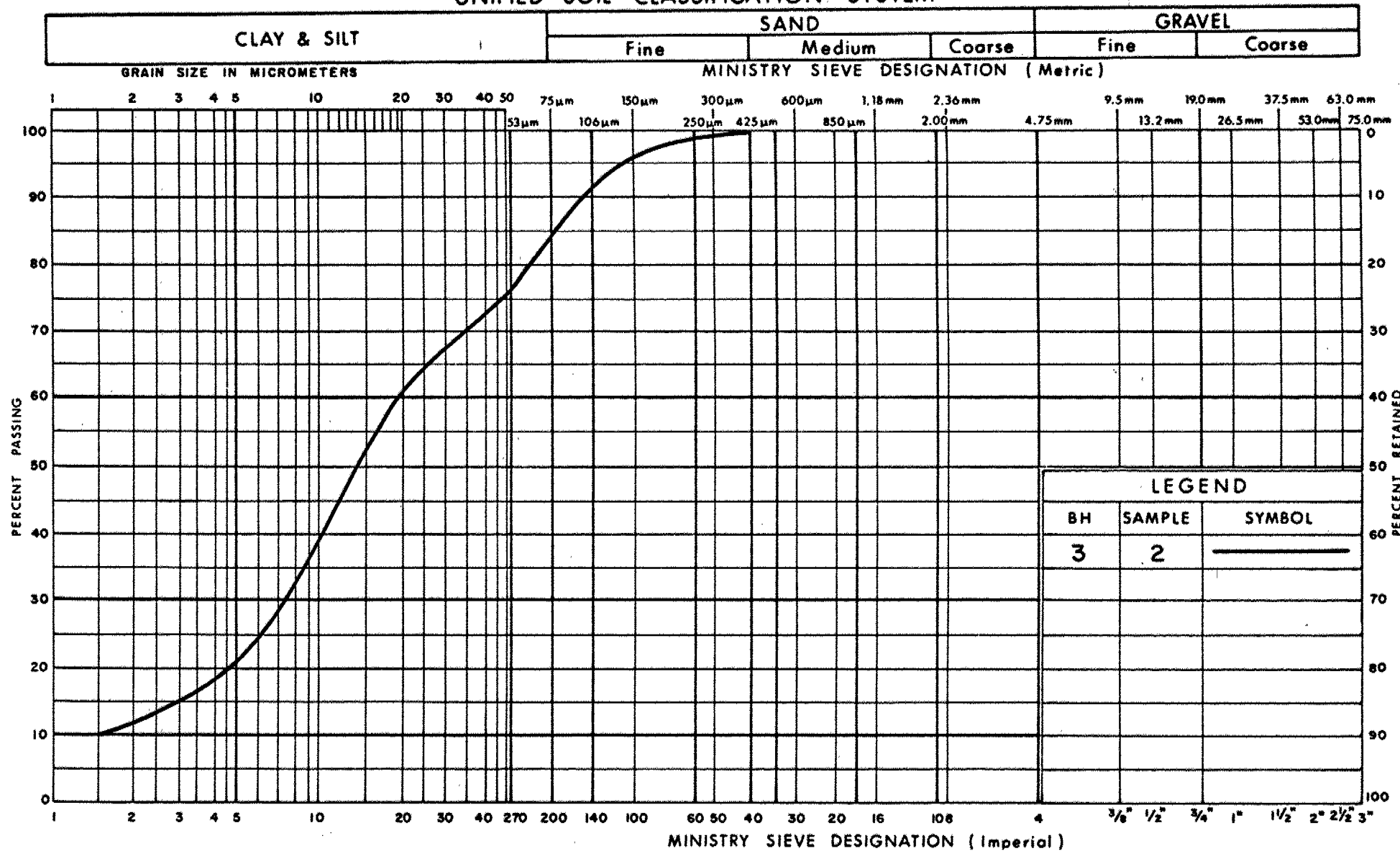
GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE OF SAND

FIG No 3

W P 89-86-01



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

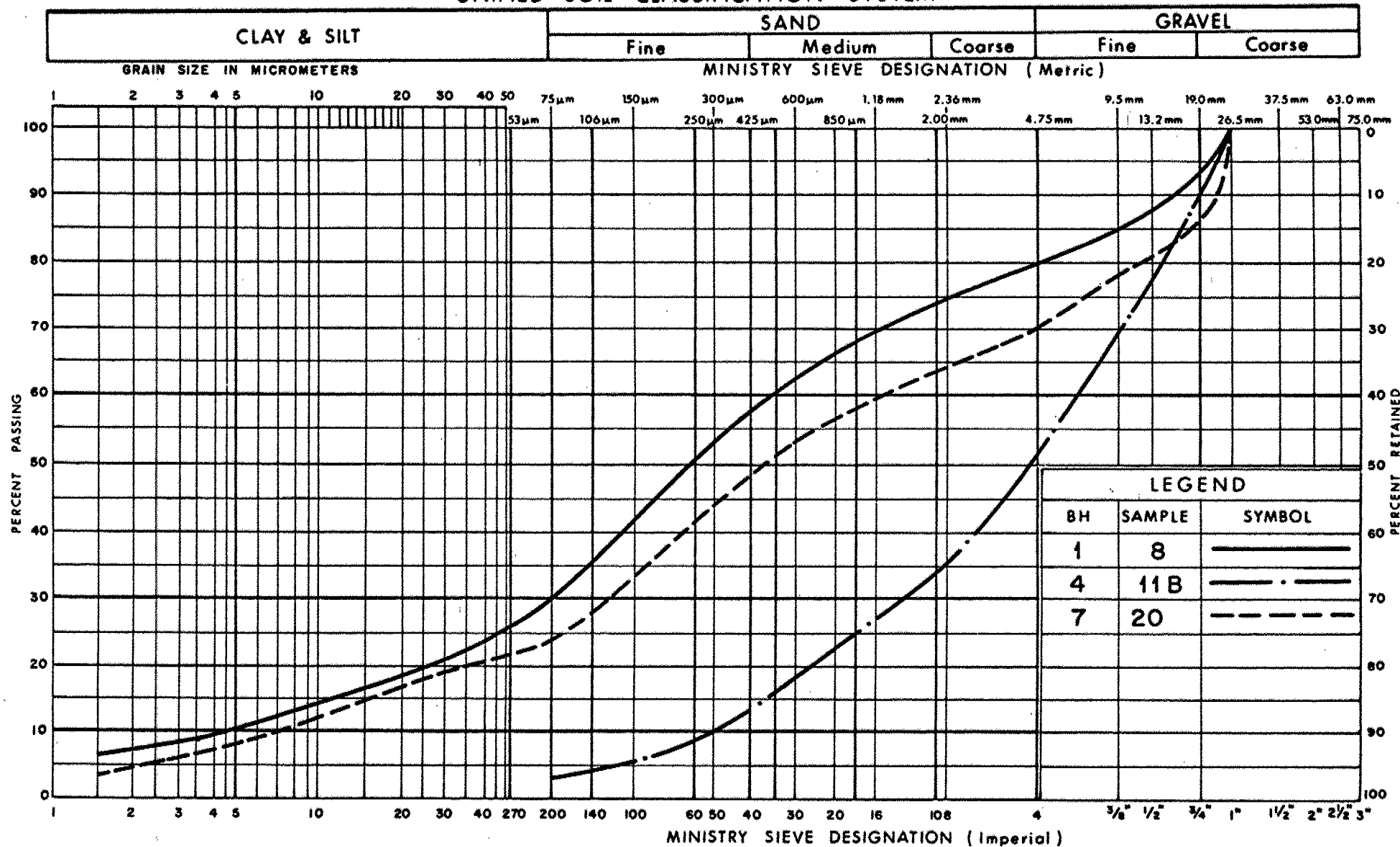
GRAIN SIZE DISTRIBUTION
ORGANIC SILT

FIG No 5

W P 89-86-01



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND WITH GRAVEL

FIG No 7

W P 89-86-01

VOID RATIO Vs PRESSURE

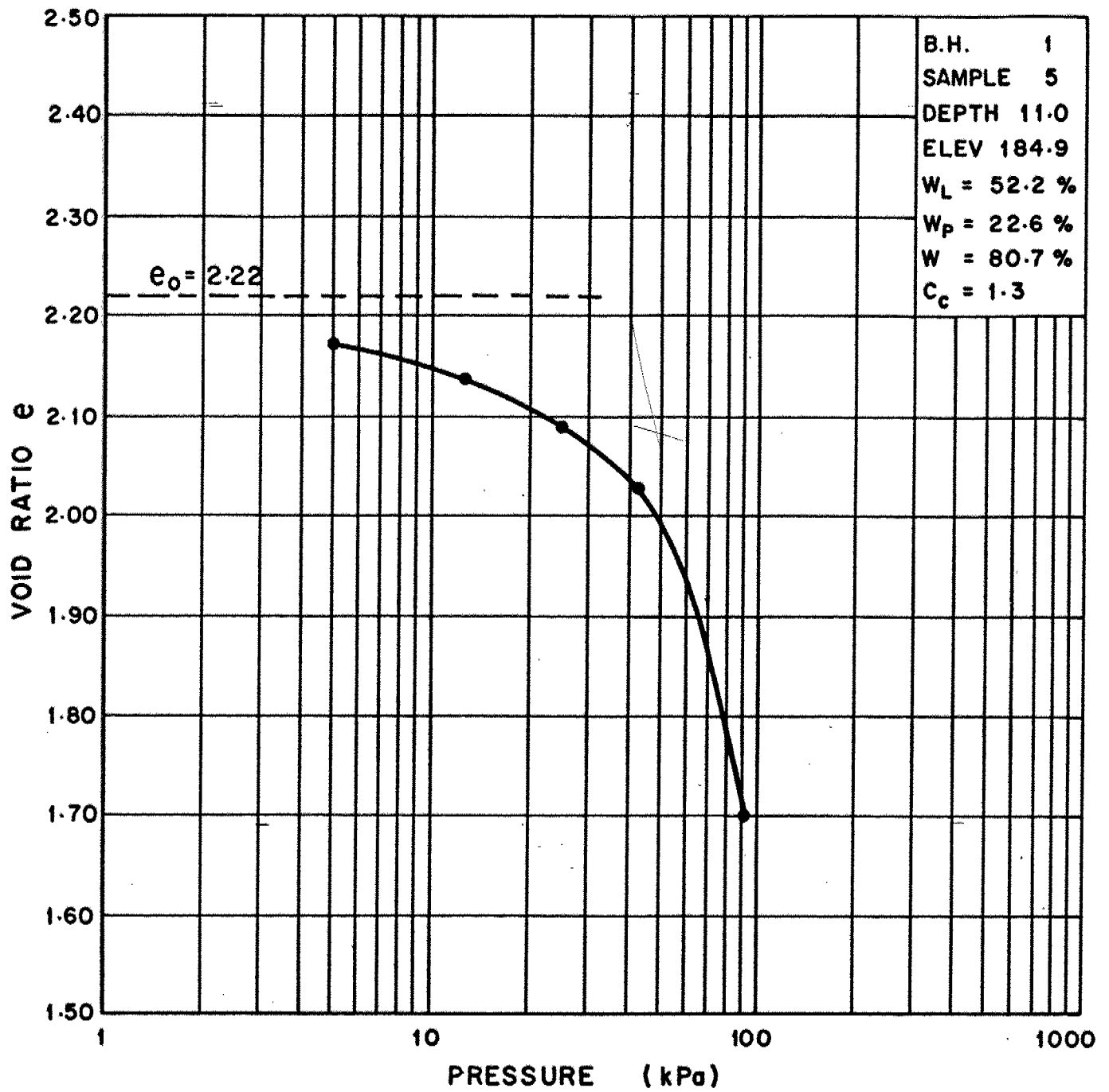


Fig. 8

WP 89-86-01

VOID RATIO Vs PRESSURE

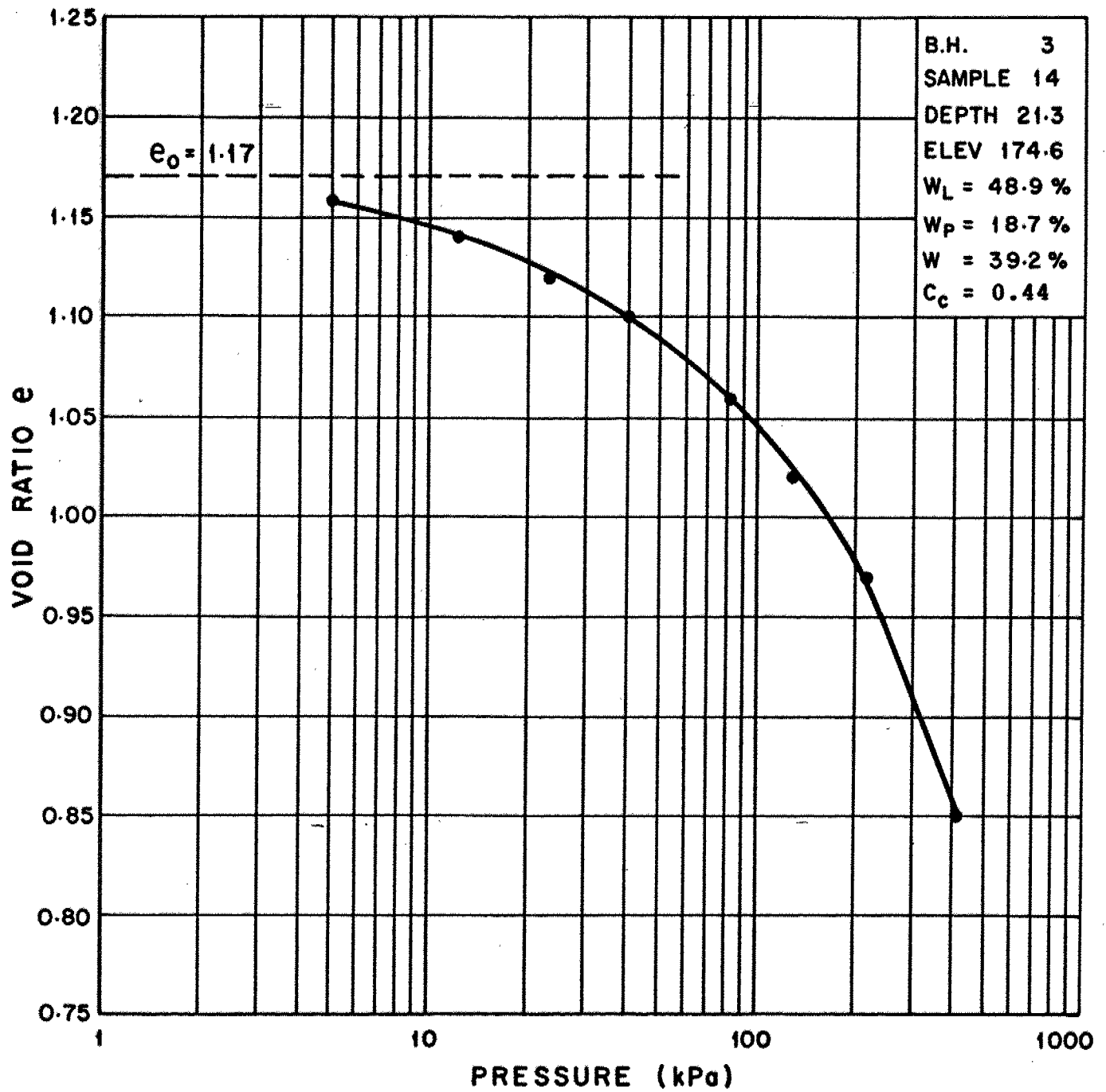


Fig. 9

WP 89-86-01

VOID RATIO Vs PRESSURE

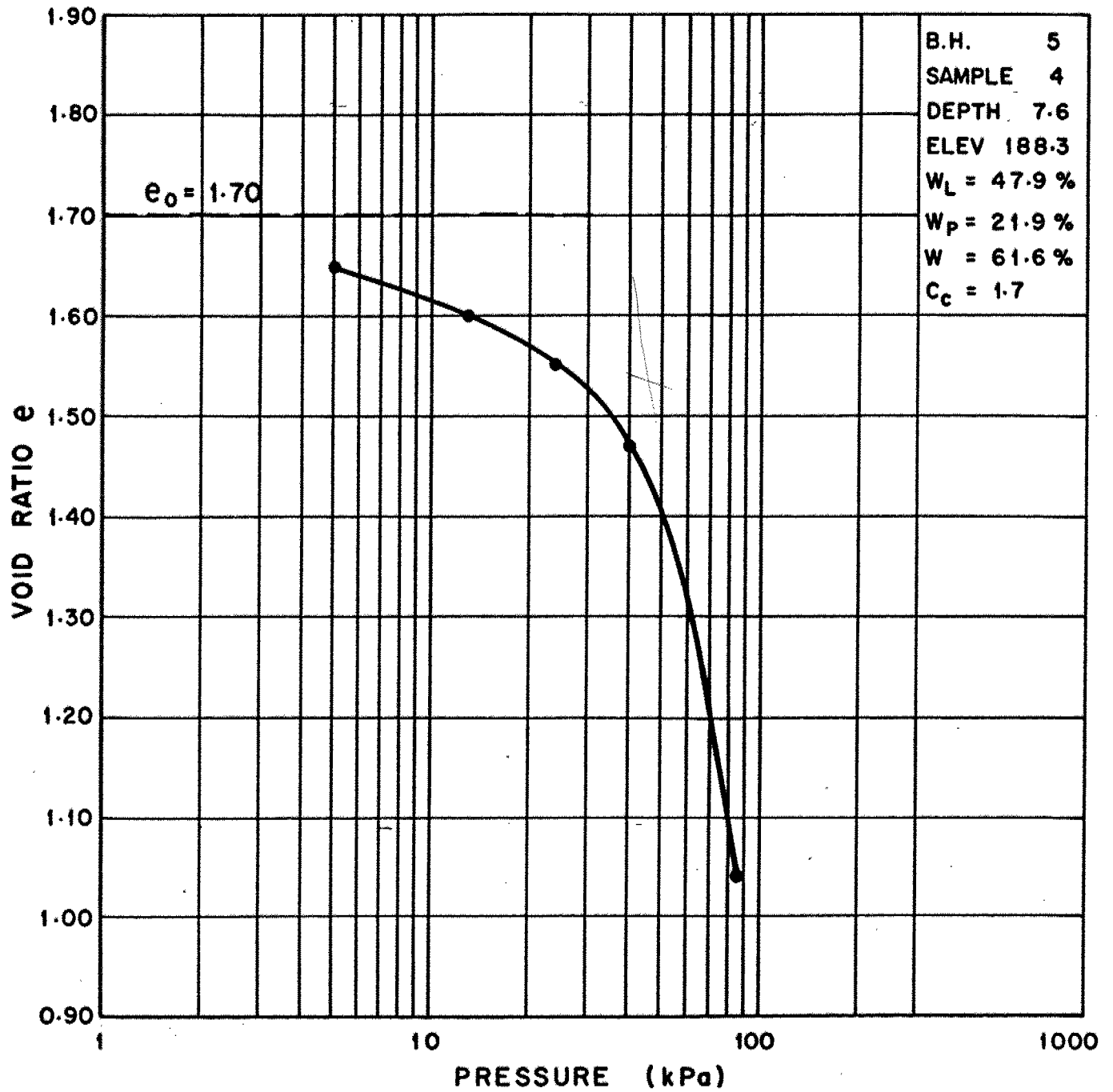


Fig. 10

WP 89-86-01