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GEOCRES No. 417-39

DIST. 18 REGION

W.P. No. 88-82-02
(formerly: 1513-79-001)

CONT. No. 85-209

W. O. No.

STR. SITE No. 388-266

HWY. No. 561

LOCATION McKinnon Creek

No of PAGES -

=====
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry of
Transportation and
Communications

FILE No. _____ DATE _____

REMARKS

H + P Clarke



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of fieldwork

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 85 - 209



Ministry of
Transportation and
Communications

INDEX

<u>Page</u>	<u>Contents</u>
1	Index
2	Abbreviations and Symbols
3 - 19	Foundation Investigation Report For W.P. 88-82-02; Site 385-266 Mackinnon Creek Culvert Hwy. 561, District 18, Sault Ste. Marie.

Note: For the purpose of the Contract, this report
supersedes all other foundation reports prepared
by or for the Ministry in connection with the
above-noted project.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

Foundation Investigation Report
for
W.P. 88-82-02; Site 38S-266
McKinnon Creek Culvert
Hwy. 561, District 18, Sault Ste. Marie

1.0 INTRODUCTION

This report describes the findings of a geotechnical investigation carried out at the site of a proposed new crossing at McKinnon Creek and Highway 561 (Site No. 38S-266) in the District of Sault Ste. Marie. The investigation was requested by the Ontario Ministry of Transportation and Communications, and authorization to carry out the work was received from the Pavement and Foundation Design Section of the Ministry.

The field work was carried out during the period of November 30 and December 8, 1982, and consisted of drilling four boreholes*to depths ranging between 20 and 24.0 m. A dynamic cone penetration test was also extended from the bottom of one of the boreholes from 20.1 to 21.3 m. The locations of the boreholes are shown on Drawing No.15137900-A,**and the subsurface conditions encountered are presented on the record of Borehole Sheets.

2.0 SUMMARIZED SUBSOIL CONDITIONS

Details of the subsurface conditions encountered in the boreholes are given on the record of borehole sheets and an inferred subsoil profile is presented on Drawing No. 15137900-A. **

.../...

* Note: Refer to Boreholes #1, #2, #4, #5

** Note: Refer to Sheet #15 of the Contract Drawings.

The subsurface conditions can be summarized briefly as follows.

Underlying some topsoil and an approximately 1 to 2 m thick sand or sandy silt layer, the boreholes encountered silt extending to depths ranging between 6.4 and 8.2 m below the ground surface. The silt is underlain by silty clay to 15.4 to 17.4 m below the ground surface which in turn is underlain by a 1.1 to more than 4.7 m thick sand layer which contains water under artesian pressure. Borehole 5 was terminated within this deposit at a depth of 20.1 m below the ground surface. In the other boreholes, at depths ranging between 18.5 and 20.1 m, the sand was found to be underlain by a very dense glacial till. This stratum was penetrated for a distance of 1.4 to 4.9 m before terminating the boreholes.

The relevant index and engineering properties of the principal soil strata are briefly described in the following paragraphs.

2.1 Topsoil

The boreholes encountered a 0.15 to 0.6 m thick layer of topsoil and/or decayed vegetation.

2.2 Upper Sand

Below the topsoil, Boreholes 2, 4 and 5 encountered a 1.1 to 2.0 m thick sand layer. The sand is generally fine or fine to medium grained and contains traces of silt, gravel and occasional organics, suggesting alluvial origins.

From penetration indices of 7 to 13 blows/0.3 m, the sand is described as loose to compact.

.../...

2.3 Silt

The topsoil at Borehole 1 and the surficial sand at the other borehole locations are underlain by a silt deposit extending to 6.4 to 8.2 m below the ground surface. The silt is frequently interbedded with sandy layers and very thin clay seams. It is a generally non-plastic material with some slightly plastic zones below a depth of 3 to 4 m.

The grain size distribution of representative samples of the silt are presented in Figures 1 and 2. The curves indicate 3 to 24% fine sand, 66 to 88% silt and 6 to 10% clay size particles. The silt was wet and generally dilatant and the measured moisture contents ranged from 23 to 29%.

From the grading curves and the visual examination of the soil samples, the coefficient of permeability of the silt is estimated to be of the order of 5×10^{-5} to 10^{-5} cm/sec. although large variations can be expected between the permeability of the deposit in the horizontal and vertical directions.

Penetration indices of 2 to 12 blows/0.3 m indicate a very loose to compact, but generally loose, material.

2.4 Silty Clay

At depths ranging from 6.4 to 8.2 m the silt is underlain by clay extending to 15.4 to 17.4 m below the ground surface. The deposit has a layered structure consisting of individual silty clay and clay layers, with some silt seams.

As summarized on the plasticity chart in Figure 4, the following index properties were measured in the laboratory:

Liquid Limit	- 33 to 38%
Plastic Limit	- 19 to 21%
Plasticity Index	- 12 to 18%
Moisture Content	- 31 to 40%

The fact that the moisture contents are generally very close to the liquid limits indicates that the deposit is probably normally, or very lightly over, consolidated. The consolidation characteristics of the deposit were determined in the laboratory by two consolidation tests and the results are presented on Enclosures 5 and 6. One of the curves indicates a normally consolidated deposit while the other suggests a lightly preconsolidated material. From these test results, the material is considered to have a moderately to highly compressible structure.

The results of penetration tests ('N'-values) range between 3 and 9 blows/0.3m and field vane tests gave in-situ undrained shear strength values of between 58 and 100 kN/m². Undrained (quick) triaxial compression tests carried out in the laboratory indicated shear strengths between 31 and 57 kN/m². Based on these results, together with a visual and tactile examination of the soil samples, the consistency of the deposit is described as firm to stiff.

A 0.6 to 1.0 m thick sand layer was found to be interbedded with the clay near the bottom of the deposit in Boreholes 1, 2 and 4.

2.5 Lower Sand

Underlying the clay, the boreholes encountered a 1.1 m (Borehole 1) to more .../...

than 4.7 m thick (Borehole 5) layer of sand. The sand is water bearing and the water was under artesian pressure. Owing to this, in many cases it was difficult to obtain representative samples and to perform proper penetration tests in this deposit. The results of the available penetration tests range between 9 and 25 blows/0.3 m, indicating a loose to compact relative density. From the recovered samples, the sand is described as fine or fine to medium textured with traces of silt and gravel.

2.6 Glacial Till

Underlying the sand at depths ranging between 18.5 and 20.1 m, Boreholes 1, 2 and 4 encountered glacial till. The till is an unsorted heterogeneous mixture of sand, gravel and silt size particles. The grain size distribution of two samples from the material is shown on Figure 3, indicating a sandy gravel. Due to the small size of the samples, however, they may not be representative of the grading of the stratum, and from the observation that the artesian conditions in the sand stopped after penetrating this deposit it is inferred that the till may contain a larger percentage of soil fines than shown on the grading curves. Observations during the drilling also suggest the presence of frequent cobbles embedded in the till.

Standard Penetration resistances recorded in the till are generally greater than 100 blows/0.3 m, indicating a very dense relative density.

3.0 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and after the boreholes were completed.

.../...

During the drilling, a slight artesian condition was observed in the sand deposit encountered below depths ranging between 15.4 and 17.4 m below the ground surface. The flow of water from the borehole, however, subsided quickly and stopped once the casing was lowered and socketed into the underlying till.

After the completion of the boreholes, the water levels in the open boreholes were generally near the ground surface and very close to the water level in the Creek, which, at the time of the investigation, was recorded at Elevation 209.0 m.

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Dominion Soil Investigation Inc., the consulting geotechnical engineers for this project, under the technical supervision of the M.T.C. Foundation Design Section.

D. H. Dundas

D.H. Dundas, P. Eng.
Foundations Engineer

APPENDIX

RECORD OF BOREHOLE No 1										METRIC						
W P 88-82-02		LOCATION Sta. 19+391 o/s 7.0m Lt C Hwy. 561 Line 'A'						ORIGINATED BY S.D.								
DIST 18 HWY 561		BOREHOLE TYPE Hollow Stem auger, washbore and rock core						COMPILED BY Z.S.O.								
DATUM Geodetic		DATE 82 12 07 and 82 12 08						CHECKED BY I.P.L.								
ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	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
			NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100								
								50 150 250								
209.4	Ground Level															
0.0	0.6 m Topsoil & decayed wood sandy brown		1	SS	2		209									
			2	SS	4											0 7 87 6
			3	SS	7		207									0 24 66 10
			4	SS	10											
			5	SS	11		205									0 4 88 8
	Silt, v. loose to compact grey		6	SS	9											
			7	SS	10											0 3 88 9
	occ. thin clay seams		8	SS	11		203									
								+ 3.8								
201.2			9	SS	13		201									drill ahead with tricone below 7.6 m
8.2								+ 3.8								
	Silty clay, layered firm to stiff, grey		10	SS	6											
			11	TW	-		199								17.7	
								+ 4.2								
								+ 5.0								
	occ. thin sand seams		12	SS	3		197									
								+ 4.2								
			13	SS	4		195									
			14	TW	-											
192.8							193									
189.2	gravelly sand layer		15	SS	9											
188.8																
187.4	sand, some gravel and traces of silt (probably compact)		16	SS	24		191									
190.9			17	RC	-											
18.5	boulder		18	SS	100	0.07m	189									
	Het. mixture of sand, gravel and silt (Glacial Till)		19	SS	100	0.07m										
	v. dense, brown frequent cobbles		20	SS	100	0.03m	187									
186.5																
22.9	END OF BOREHOLE															

RECORD OF BOREHOLE No 2										METRIC				
W P 88-82-02		LOCATION Sta. 19+405 o/s 7.5 m Rt. C Hwy. 561 Line 'A'				ORIGINATED BY S.D.								
DIST 18 HWY 561		BOREHOLE TYPE Hollow Stem auger, Washbore				COMPILED BY Z.S.O.								
DATUM Geodetic		DATE 82 12 02 and 82 12 03				CHECKED BY I.P.L.								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W _p W W _L	WATER CONTENT (%)				
209.4	Ground Level													
0.0	0.3m Topsoil, peaty		1	SS	10									
207.9	Sand, fine, traces of gravel & silt, loose br		2	SS	7									
1.5	Silt		3	SS	10									
	v. loose to compact		4	SS	11									
	grey		5	SS	9									
	some thin		6	SS	5									
	clay seams		7	SS	6									
203.0			8	SS	4									
6.4			9	TW	PH									
	Silty clay		10	SS	4									
	layered		11	TW	PH									
	firm to stiff		12	SS	3									
195.2			13	SS	6									
14.2	Gravelly sand		14	SS	9									
194.2	layer		15	WS	-									
15.2			16	WS	-									
192.9			17	SS	100	0.13m								
16.5	Sand, fine		18	SS	100	0.07m								
	traces of silt, brown													
	(probably compact to													
	dense)													
189.7														
19.7	Het. mixture of sand,													
	gravel and silt													
	(Glacial Till)													
188.0	v. dense, grey													
21.4	END OF BOREHOLE													



RECORD OF BOREHOLE No 4										METRIC				
W P 88-82-02		LOCATION Sta. 19+412 o/s 1.0m Rt Q Hwy. 561 Line 'A'				ORIGINATED BY S.D.								
DIST 18 HWY 561		BOREHOLE TYPE Hollow Stem auger, Washbore				COMPILED BY Z.S.O.								
DATUM Geodetic		DATE 82 12 01 and 82 12 02				CHECKED BY I.P.L.								
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 60 80 100	SHEAR STRENGTH kPa					
							○ UNCONFINED + FIELD VANE							
							● QUICK TRIAXIAL x LAB VANE							
							50 150 250							
209.3	Ground Level													
0.0	0.3m Topsoil & decayed wood		1	SS	7									
207.0	Sand, traces of gravel silt & organics, brown loose to compact		2	SS	13									Sample 2: no recovery
2.3	Silt, loose to compact, grey		3	SS	11									
			4	SS	11									
			5	SS	8									
	some thin clay seams		6	SS	6									
			7	SS	10									
			8	SS	8									
202.3														Dec. 1
7.0														Dec. 2
	Silty Clay, layered firm to stiff, grey		9	SS	5									Drill ahead with tricone below 8.5 m.
			10	SS	5									
			11	SS	5									
			12	SS	7									
			13	SS	6									
194.5														
14.8	sand layer		14	SS	8									Slight artesian pressure
193.9														slight water seepage thru the rods at 15m.
15.4	frequent silt layers		15	SS	13									Lower NW casing @ 16.5 m.
192.8			16	WS	-									Sand back-up 1.2m inside casing.
16.5	Sand, traces of gravel & silt compact, brown													
189.2			17	SS	48	0.15m								Casing to 20.4m tri-cone ahead.
20.1	Het. mixture of sand, gravel & silt (Glacial Till) v. dense, greyish br.		18	SS	50	0.05m								Sample 17 28, 60, 12,0
			19	SS	100	0.13m								Sample 18 No recovery
185.3	frequent cobbles													Refusal to
24.0	END OF BOREHOLE													tricone at 24.0 m probably on a boulder.

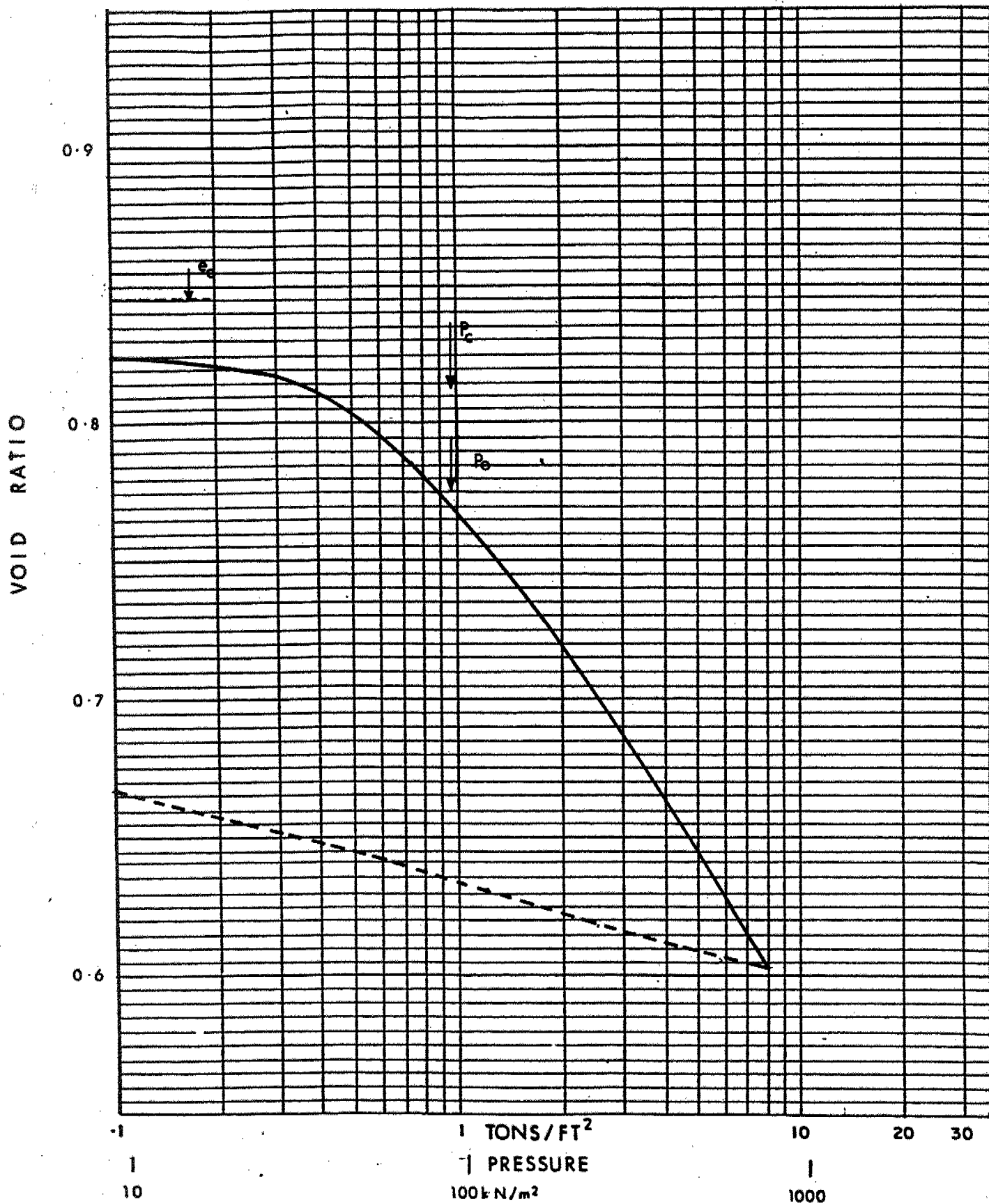
+3, x5 : Numbers refer to
Sensitivity20
15 \div 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 5										METRIC					
W P 88-82-02		LOCATION Sta. 19+423 o/s G Hwy. 561 Line 'A'				ORIGINATED BY S.D.									
DIST 18 HWY 561		BOREHOLE TYPE Hollow Stem auger, Washbore & cone test				COMPILED BY Z.S.O.									
DATUM Geodetic		DATE 82 12 01				CHECKED BY I.P.L.									
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 60 80 100	50 150 250	WATER CONTENT (%)					
209.8	Ground Level														
0.0	0.15m Topsoil														
208.5	Sand, traces of gravel & silt, compact, brown		1	SS	12										
1.3			2	SS	4										
	SILT		3	SS	7										
	v. loose to compact		4	SS	12										
	grey		5	SS	9										
	some thin clay seams		6	SS	8										
			7	SS	6										
			8	SS	11										
202.8															
7.0			9	SS	7										
	Silty clay														
	layered		10	SS	4										
	firm to stiff, grey														
			11	SS	5										
			12	SS	4										
			13	SS	5										
194.4															
15.4			14	SS	9										
	Sand,		15	SS	25										
	traces of gravel & silt														
	compact, brown		16	WS	-										
189.7			17	WS	-										
20.1	END OF BOREHOLE														
188.5	Dynamic Cone test extended from bottom of B.H.														
21.3	END OF DYNAMIC CONE TEST														

CONSOLIDATION TEST

14

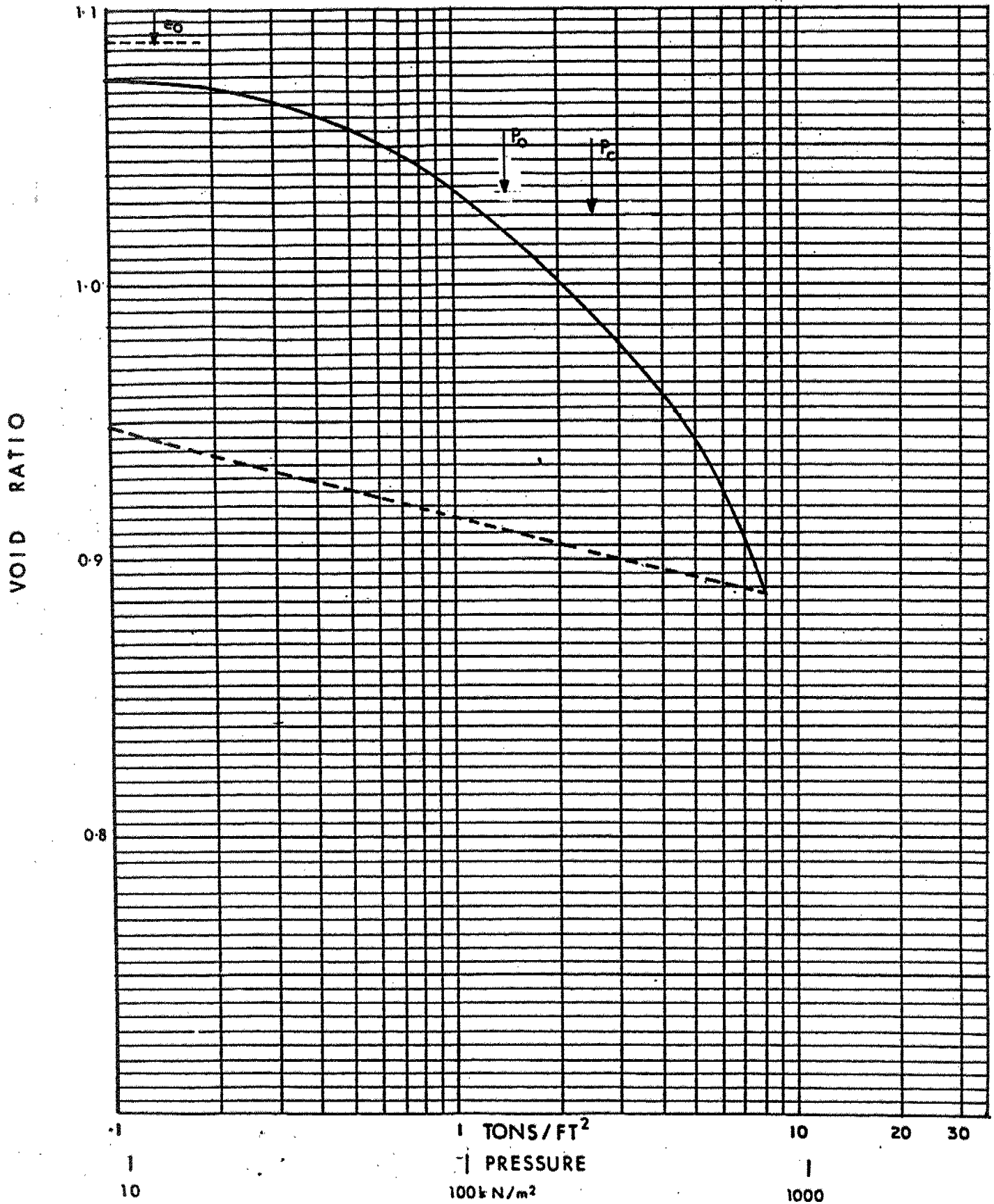


BH. : 1
 SAMPLE: 11
 DEPTH : 10.8 m

L.L. = 33 %
 P.L. = 21 %
 P.I. = 12
 W = 31.3%

CONSOLIDATION TEST

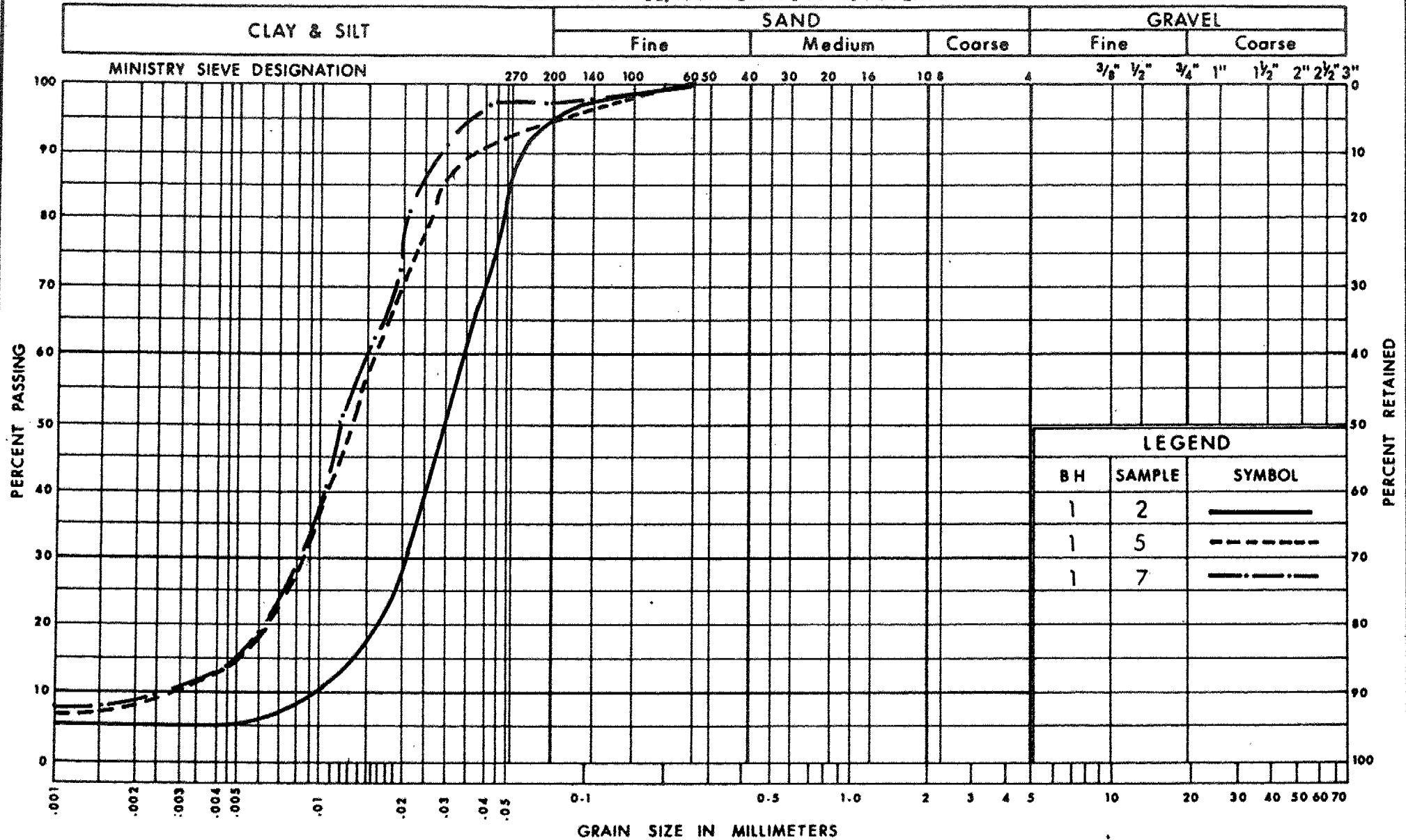
15



BH. : 1
 SAMPLE: 14
 DEPTH : 15.4m

L.L. = 38 %
 P.L. = 21 %
 P.I. 17
 W = 35.4 %

UNIFIED SOIL CLASSIFICATION SYSTEM



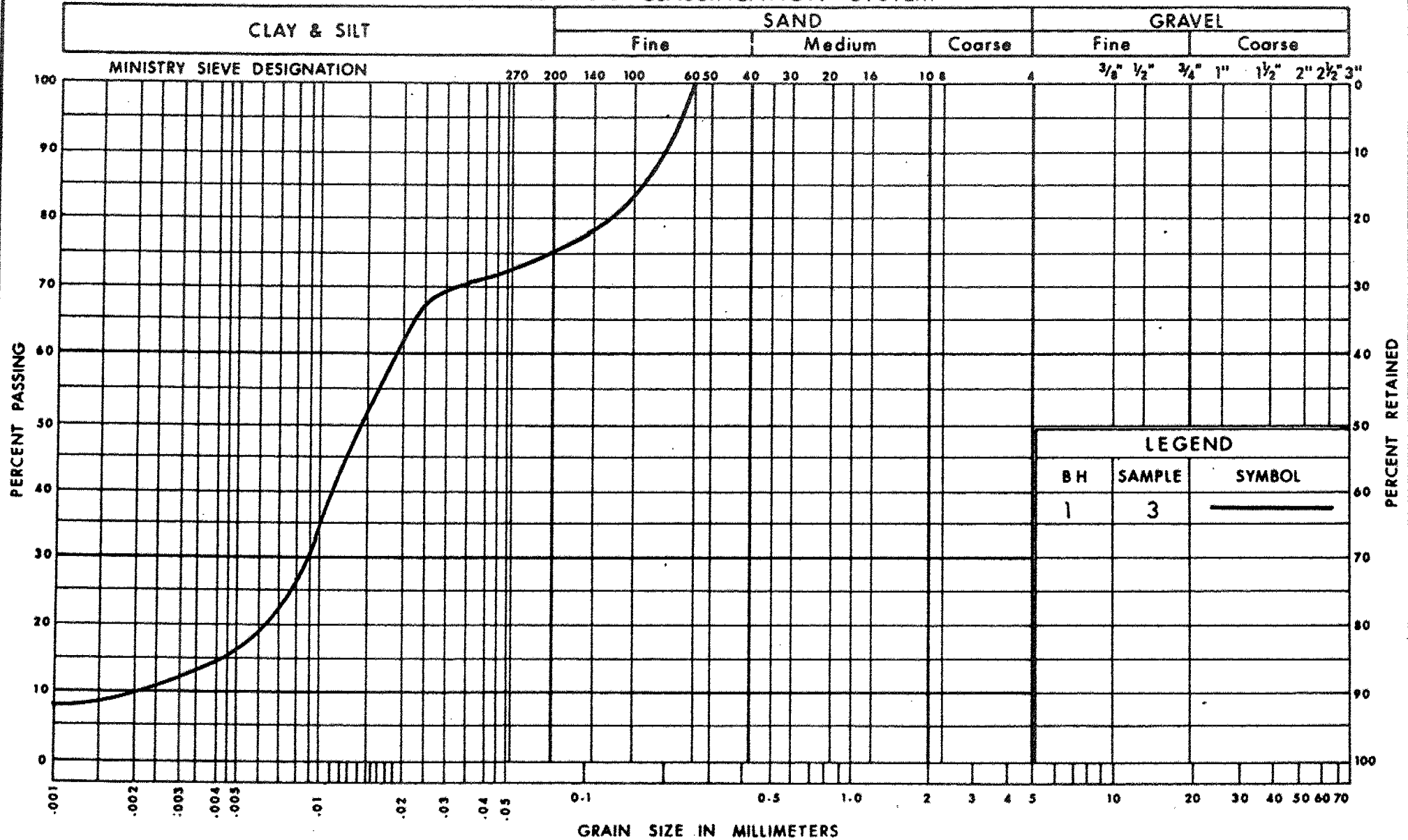
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GRAIN SIZE DISTRIBUTION
SILT

FIG No 1

W P 88 - 82 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



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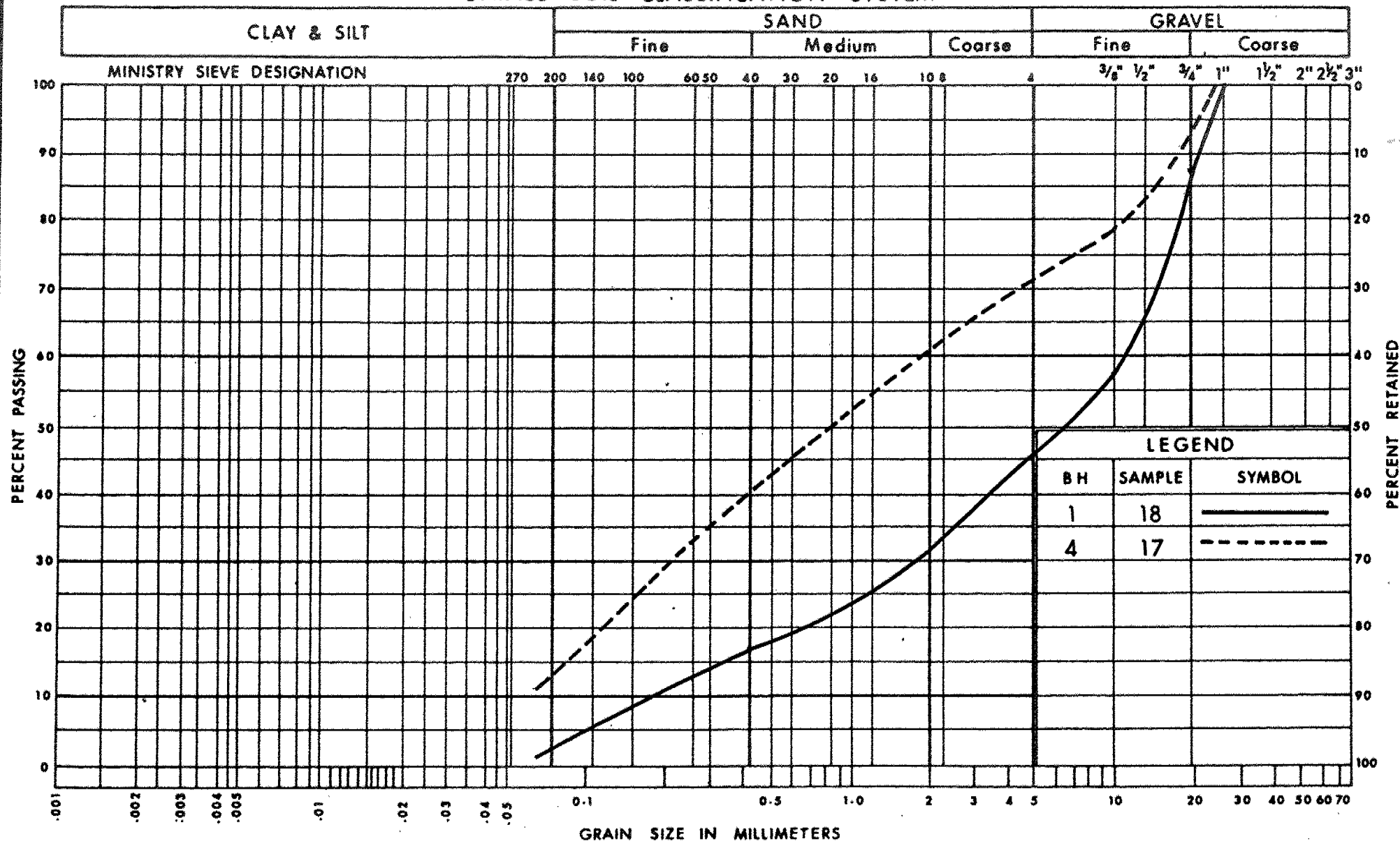
GRAIN SIZE DISTRIBUTION

SILT
some Sand

FIG No 2

W P 88-82-02

UNIFIED SOIL CLASSIFICATION SYSTEM

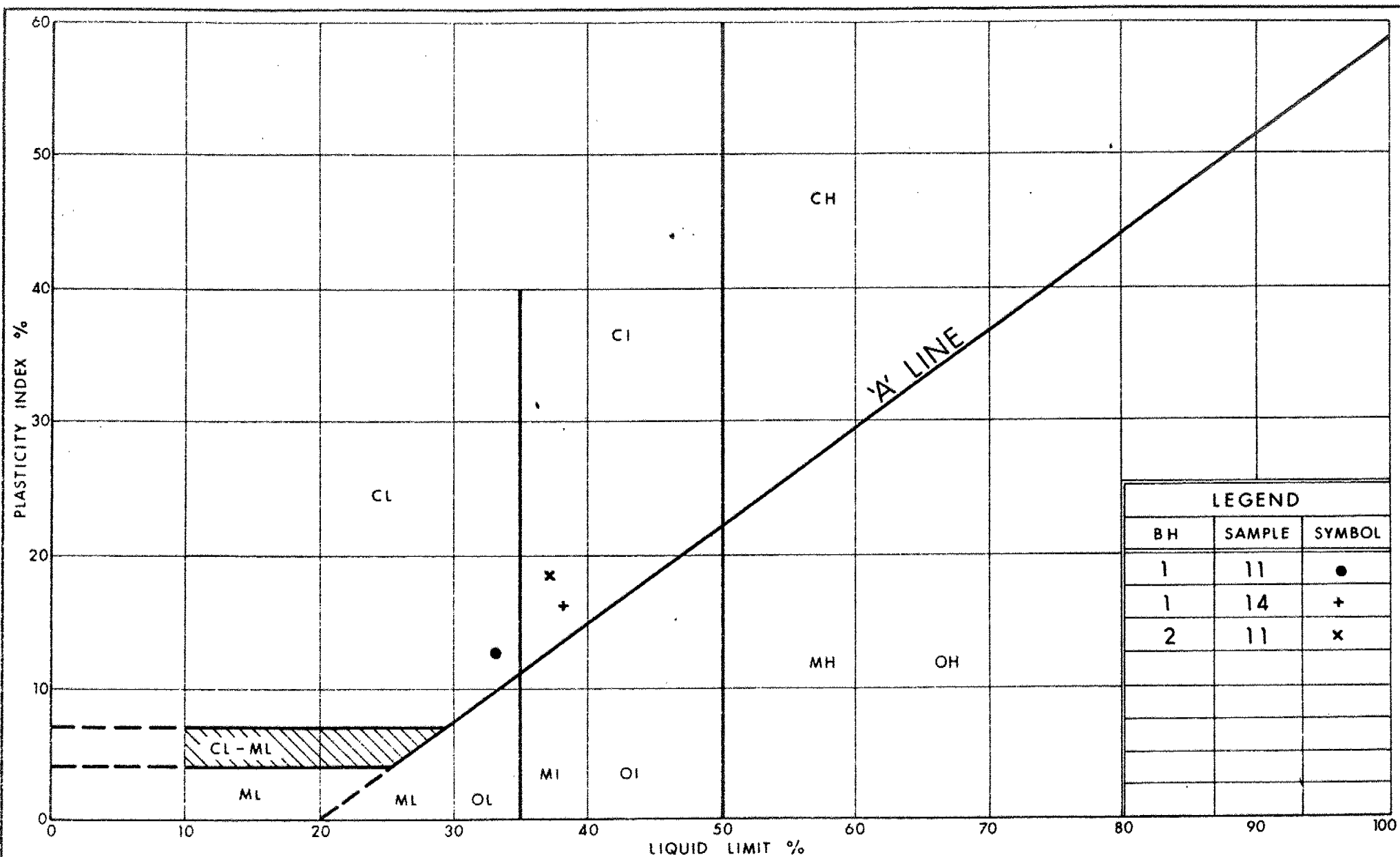


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GRAIN SIZE DISTRIBUTION
SANDY GRAVEL, some Silt.
(GLACIAL TILL)

FIG No 3

W P 88-82-02



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PLASTICITY CHART

SILTY CLAY

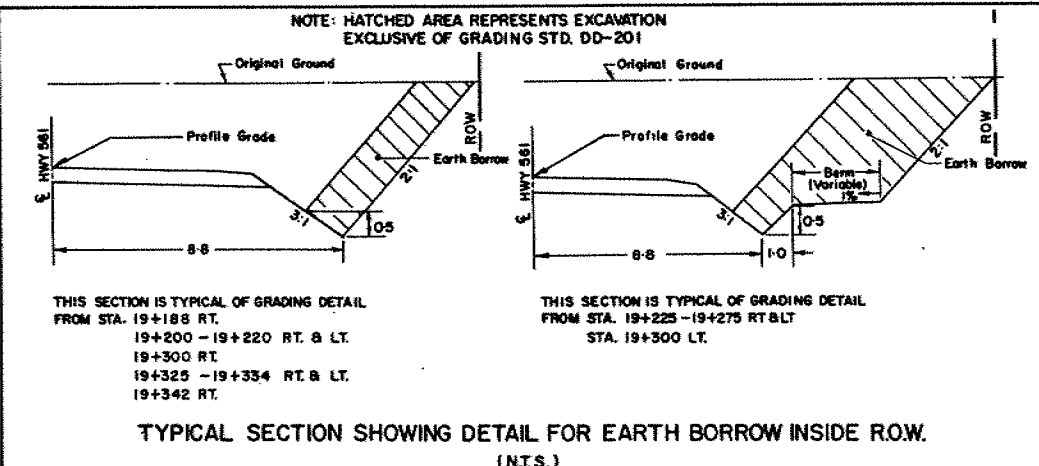
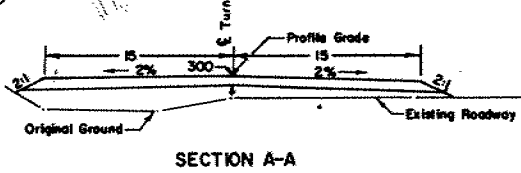
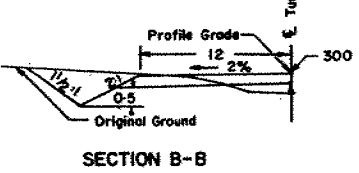
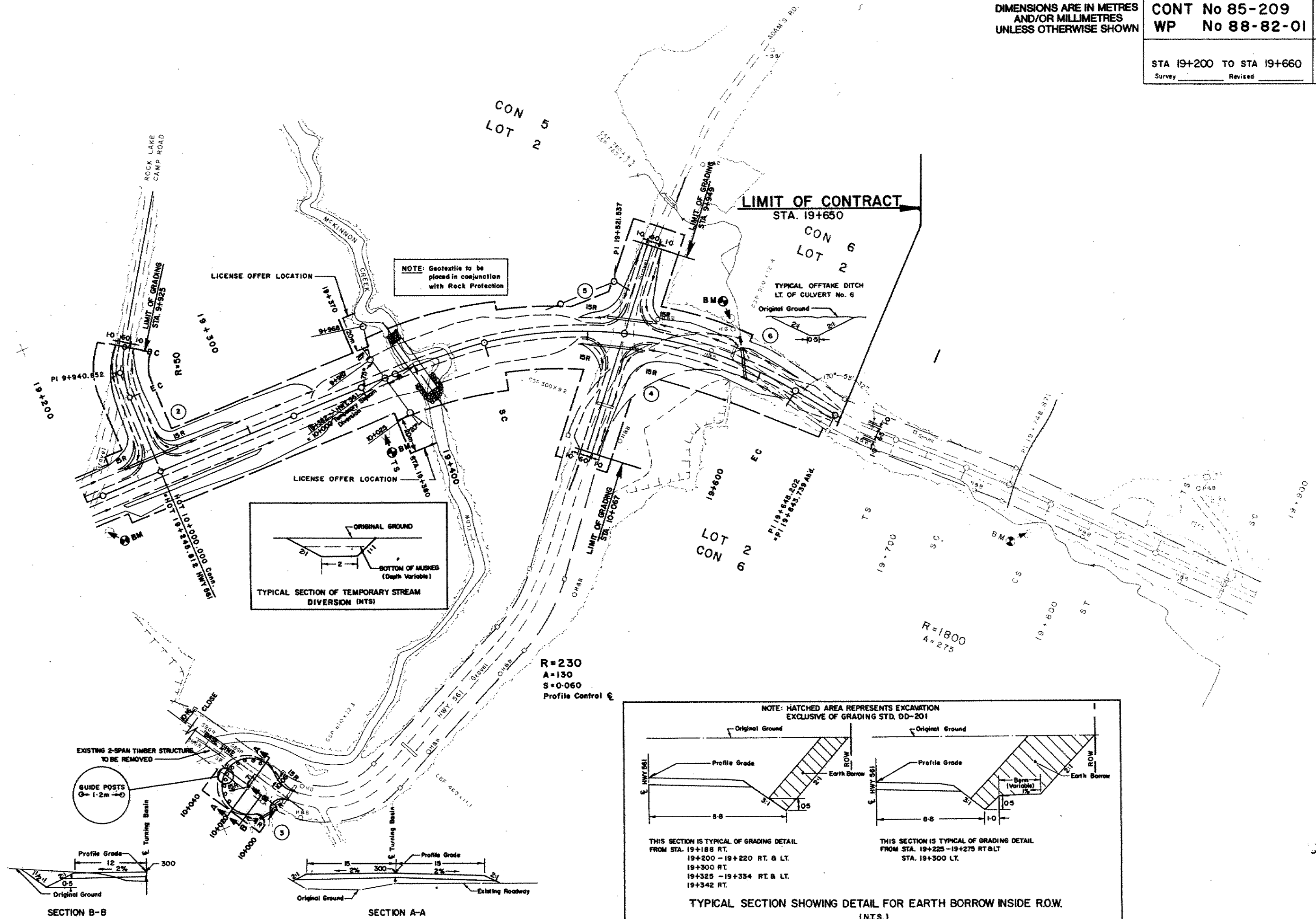
FIG No 4

W P 88-82-02

METRIC
 DIMENSIONS ARE IN METRES
 AND/OR MILLIMETRES
 UNLESS OTHERWISE SHOWN

PLATE No
CONT No 85-209
WP No 88-82-01
 STA 19+200 TO STA 19+660
 Survey _____ Revised _____

SHEET
4



SCALE
 1:1000

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No

CONT No 85-209
WP No 88-82-01

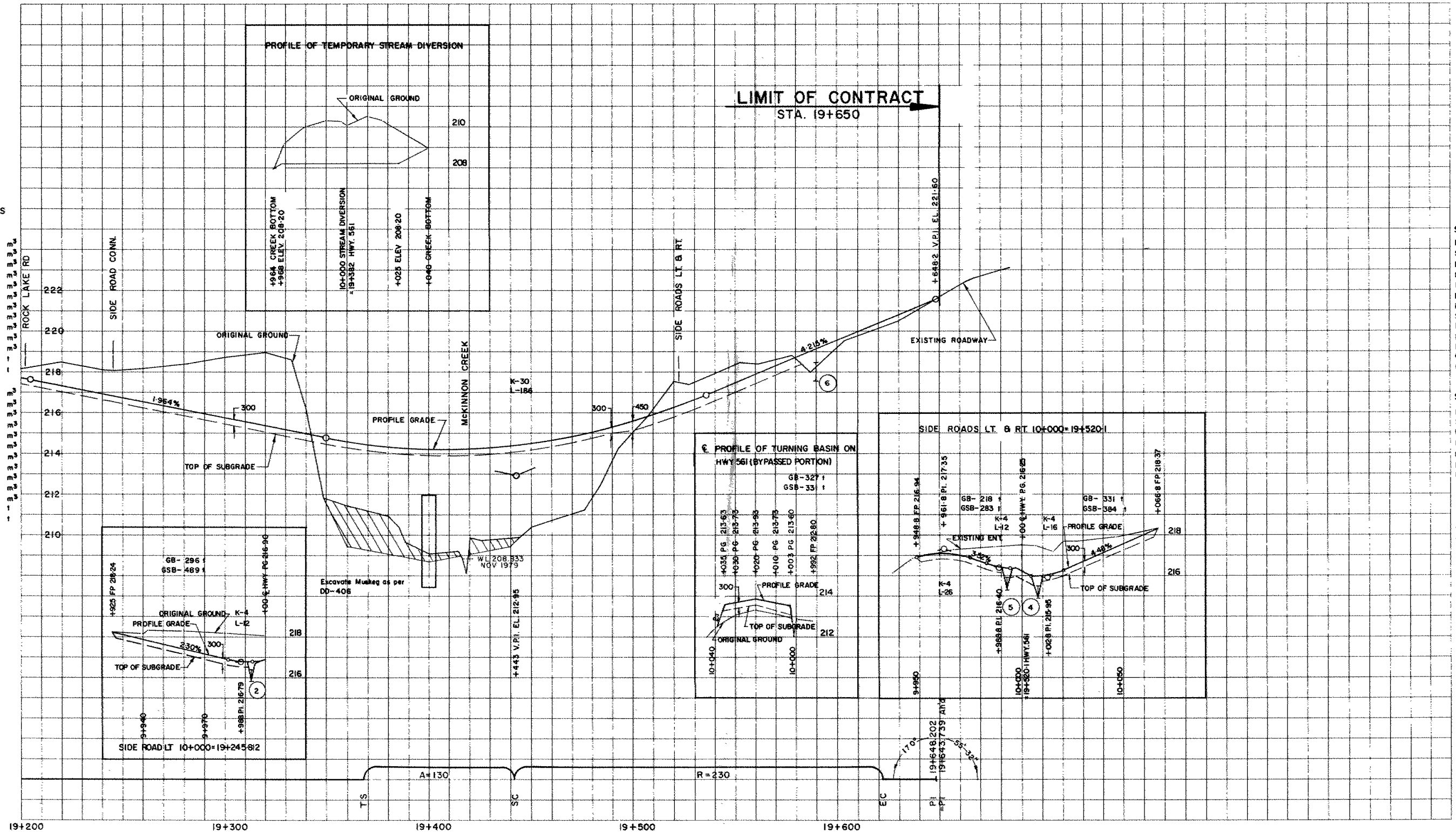
STA 19+200 TO STA 19+660

Survey Revised

SHEET
5

QUANTITIES

EC
SI
ED
ME
MBE
EF
RC
SH
RD
MBR
RF
GB
GSB



QUANTITIES

Sta 19+200 Sta 19+660
EC
SI
ED
ME
MBE
EF
RC
SH
RD
MBR
RF
GB 1825
GSB 2276

Sta Sta
EC
SI
ED
ME
MBE
EF
RC
SH
RD
MBR
RF
GB
GSB

SCALES

10 m 0 20 m
Horizontal

1 m 0 2 m
Vertical



DOMINION SOIL INVESTIGATION INC.

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W.P. 88-82-02

85-209

GEOTECHNICAL INVESTIGATION

PROPOSED CROSSING AT McKINNON CREEK

HIGHWAY 561, SITE 38S-266

DISTRICT OF SAULT STE. MARIE

W.P. 1513-79-00



Ref. No. 82-11-9

January 1983

Prepared for:

Ministry of Transportation & Communications
Pavement & Foundation Design Section
Central Building
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

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GEOCRES No. 41 J-39

C O N T E N T S

	<u>Page No.</u>
1.0 INTRODUCTION	1
2.0 SUMMARIZED SUBSOIL CONDITIONS	1
2.1 Topsoil	2
2.2 Upper Sand	2
2.3 Silt	3
2.4 Silty Clay	3
2.5 Lower Sand	4
2.6 Glacial Till	5
3.0 GROUNDWATER CONDITIONS	5
4.0 DISCUSSION OF THE RESULTS	7
4.1 Box Culvert	7
4.2 Rigid Frame Concrete Culvert	8
4.3 Lateral Earth Pressures	10
4.4 Approach Fills	10
4.5 Construction	11
5.0 STATEMENT OF LIMITATION	11

A P P E N D I C E S

Appendix 'A' - Procedures
Appendix 'B' - Statement of Limitation

E N C L O S U R E S

BOREHOLE LOGS	Enclosures 1 to 4 inclusive
CONSOLIDATION TESTS	Enclosures 5 & 6
GRAIN SIZE DISTRIBUTION CURVES	Figures 1 to 4 inclusive
BOREHOLE LOCATION PLAN & G _L PROFILE LINE A	Drawing 15137900-A



1.0 INTRODUCTION

This report describes the findings of a geotechnical investigation carried out at the site of a proposed new crossing at McKinnon Creek and Highway 561 (Site No. 38S-266) in the District of Sault Ste. Marie. The investigation was requested by the Ontario Ministry of Transportation and Communications, and authorization to carry out the work was received from the Pavement and Foundation Design Section of the Ministry.

The purpose of the investigation was to determine the subsoil and ground-water conditions at the site; to establish the engineering properties of the substrata; to make recommendations pertaining to the design of the foundations of the proposed structure; and to evaluate the construction conditions.

The field work was carried out during the period of November 30 and December 8, 1982, and consisted of drilling four boreholes to depths ranging between 20 and 24.0 m. A dynamic cone penetration test was also extended from the bottom of one of the boreholes from 20.1 to 21.3 m. The locations of the boreholes are shown on Drawing No. 15137900-A, and the subsurface conditions encountered are presented on the record of Borehole Sheets.

2.0 SUMMARIZED SUBSOIL CONDITIONS

Details of the subsurface conditions encountered in the boreholes are given on the record of borehole sheets and an inferred subsoil profile is presented on Drawing No. 15137900-A.

.../...



The subsurface conditions can be summarized briefly as follows.

Underlying some topsoil and an approximately 1 to 2 m thick sand or sandy silt layer, the boreholes encountered silt extending to depths ranging between 6.4 and 8.2 m below the ground surface. The silt is underlain by silty clay to 15.4 to 17.4 m below the ground surface which in turn is underlain by a 1.1 to more than 4.7 m thick sand layer which contains water under artesian pressure. Borehole 5 was terminated within this deposit at a depth of 20.1 m below the ground surface. In the other boreholes, at depths ranging between 18.5 and 20.1 m, the sand was found to be underlain by a very dense glacial till. This stratum was penetrated for a distance of 1.4 to 4.9 m before terminating the boreholes.

The relevant index and engineering properties of the principal soil strata are briefly described in the following paragraphs.

2.1 Topsoil

The boreholes encountered a 0.15 to 0.6 m thick layer of topsoil and/or decayed vegetation.

2.2 Upper Sand

Below the topsoil, Boreholes 2, 4 and 5 encountered a 1.1 to 2.0 m thick sand layer. The sand is generally fine or fine to medium grained and contains traces of silt, gravel and occasional organics, suggesting alluvial origins.

From penetration indices of 7 to 13 blows/0.3 m, the sand is described as loose to compact.

.../...

2.3 Silt

The topsoil at Borehole 1 and the surficial sand at the other borehole locations are underlain by a silt deposit extending to 6.4 to 8.2 m below the ground surface. The silt is frequently interbedded with sandy layers and very thin clay seams. It is a generally non-plastic material with some slightly plastic zones below a depth of 3 to 4 m.

The grain size distribution of representative samples of the silt are presented in Figures 1 and 2. The curves indicate 3 to 24% fine sand, 66 to 88% silt and 6 to 10% clay size particles. The silt was wet and generally dilatant and the measured moisture contents ranged from 23 to 29%.

From the grading curves and the visual examination of the soil samples, the coefficient of permeability of the silt is estimated to be of the order of 5×10^{-5} to 10^{-5} cm/sec. although large variations can be expected between the permeability of the deposit in the horizontal and vertical directions.

Penetration indices of 2 to 12 blows/0.3 m indicate a very loose to compact, but generally loose, material.

2.4 Silty Clay

At depths ranging from 6.4 to 8.2 m the silt is underlain by clay extending to 15.4 to 17.4 m below the ground surface. The deposit has a layered structure consisting of individual silty clay and clay layers, with some silt seams.

.../...



As summarized on the plasticity chart in Figure 4, the following index properties were measured in the laboratory:

Liquid Limit	- 33 to 38%
Plastic Limit	- 19 to 21%
Plasticity Index	- 12 to 18%
Moisture Content	- 31 to 40%

The fact that the moisture contents are generally very close to the liquid limits indicates that the deposit is probably normally, or very lightly over, consolidated. The consolidation characteristics of the deposit were determined in the laboratory by two consolidation tests and the results are presented on Enclosures 5 and 6. One of the curves indicates a normally consolidated deposit while the other suggests a lightly preconsolidated material. From these test results, the material is considered to have a moderately to highly compressible structure.

The results of penetration tests ('N'-values) range between 3 and 9 blows/0.3m and field vane tests gave in-situ undrained shear strength values of between 58 and 100 kN/m². Undrained (quick) triaxial compression tests carried out in the laboratory indicated shear strengths between 31 and 57 kN/m². Based on these results, together with a visual and tactile examination of the soil samples, the consistency of the deposit is described as firm to stiff.

A 0.6 to 1.0 m thick sand layer was found to be interbedded with the clay near the bottom of the deposit in Boreholes 1, 2 and 4.

2.5 Lower Sand

Underlying the clay, the boreholes encountered a 1.1 m (Borehole 1) to more .../...

than 4.7 m thick (Borehole 5) layer of sand. The sand is water bearing and the water was under artesian pressure. Owing to this, in many cases it was difficult to obtain representative samples and to perform proper penetration tests in this deposit. The results of the available penetration tests range between 9 and 25 blows/0.3 m, indicating a loose to compact relative density. From the recovered samples, the sand is described as fine or fine to medium textured with traces of silt and gravel.

2.6 Glacial Till

Underlying the sand at depths ranging between 18.5 and 20.1 m, Boreholes 1, 2 and 4 encountered glacial till. The till is an unsorted heterogeneous mixture of sand, gravel and silt size particles. The grain size distribution of two samples from the material is shown on Figure 3, indicating a sandy gravel. Due to the small size of the samples, however, they may not be representative of the grading of the stratum, and from the observation that the artesian conditions in the sand stopped after penetrating this deposit it is inferred that the till may contain a larger percentage of soil fines than shown on the grading curves. Observations during the drilling also suggest the presence of frequent cobbles embedded in the till.

Standard Penetration resistances recorded in the till are generally greater than 100 blows/0.3 m, indicating a very dense relative density.

3.0 GROUNDWATER CONDITIONS

Groundwater levels in the open boreholes were observed during the drilling and after the boreholes were completed.

.../...

During the drilling, a slight artesian condition was observed in the sand deposit encountered below depths ranging between 15.4 and 17.4 m below the ground surface. The flow of water from the borehole, however, subsided quickly and stopped once the casing was lowered and socketed into the underlying till.

After the completion of the boreholes, the water levels in the open boreholes were generally near the ground surface and very close to the water level in the Creek, which, at the time of the investigation, was recorded at Elevation 209.0 m.

.../...

4.0 DISCUSSION OF THE RESULTS

The subsurface investigation has indicated that underlying some topsoil and surficial sand layer, the site is underlain by relatively weak and compressible silt and clay strata extending to depths ranging between about 15 and 17 m or to Elevations between 194 and 192 m. Below this level the boreholes encountered a layer of sand which contains water under artesian head, and a glacial till, the surface of which lies between about Elevations 191 and 189 m.

We understand that the proposed structure will most likely be a culvert which will be constructed at about Sta. 19+400. This will result in the excavation of a new channel for the creek and the backfilling of a sharp bend in the existing creek bed at this location. The invert of the culvert will be at about Elevation 208 m which corresponds to the general creek bed elevation in the area. The proposed profile grade is approximately 5 m above the present ground surface at about Elevation 214 m.

The following discussion and recommendations are based on the above information.

4.1 Box Culvert

In our opinion a box culvert structure, the base of which is designed as a raft, could be founded at Elev. 208 m. The factored bearing capacity at Ultimate Limit State for a raft founded at this elevation is 126 kPa. The pressure at the base of the culvert under maximum dead and live load conditions is estimated to be about 70 kPa, and therefore no bearing capacity problems are foreseen for this type of design.

.../...



The settlement of the structure, however, will be governed by the deformation and consolidation of the silt and clay strata under the weight of the embankment. Based on the results of the two consolidation tests, performed on samples from the clay, it is estimated that the settlement of the embankment and the mid point of the culvert will be of the order of 0.38 m. Of this, approximately 0.08 m will take place shortly after the load was applied, and about 0.3 m settlement will be due to the long term consolidation of the silty clay. It is also estimated that the total settlement at both ends of the culvert will be approximately 0.18 m and therefore the differential settlement between the ends and the mid point of the culvert is estimated to be about 0.2 m. It is therefore recommended that the culvert be constructed with an appropriate camber. It is estimated that about 90% of the consolidation settlement will be completed in about 3 years.

To prevent the loss of material from underneath the culvert as a result of subsurface erosion, it is recommended that an approximately 1.5 m deep cut-off wall be constructed at both ends of the culvert. As an added precaution the silty creek bed should be lined with rip-rap to a distance of approximately 6 m upstream and downstream. It is also recommended that on the upstream face of the embankment a clay blanket be placed around the culvert and then covered with rip-rap. The silty subgrade is highly frost susceptible but if there is a continuous flow of water in the creek and through the culvert, then in our opinion special measures for frost protection of the material below the base of the culvert will not be required.

.../...



4.2 Rigid Frame Concrete Culvert

As an alternative to a box culvert structure, an open rigid frame concrete culvert could be constructed, which however would have to be supported on end bearing piles. The dense glacial till encountered at about Elev. 190 m is a suitable bearing stratum for end bearing piles. The piles can be expected to penetrate this deposit about 1.5 to 3.0 m before reaching adequate set, that is the tip of the piles will probably rest between Elev. 188.5 and 187.0 m.

The estimated capacity for some common steel pile sections driven to a final set of about 20 blows/25 mm penetration with a hammer capable to deliver a minimum energy of 50 thousand Joules per blow are tabulated below:

<u>ESTIMATED PILE CAPACITY (kN)</u>			
<u>Pile Type</u>	<u>Size</u>	<u>Factored Capacity at Ultimate Limit States (Q_f)</u>	<u>Capacity at Serviceability Limit States Type II (Q_s)</u>
Steel H	HP 310x110	1760	1160
	HP 310x 79	1250	850
	HP 250x 62	1000	660
	HP 200x 54	850	540
Steel Pipe	323x 9.5	1175	780
	273x 9.3	1000	640

To protect the piles from damage by boulders, the piles should be equipped with driving shoe. It is recommended that the driving of the piles in the field be controlled by a recognized pile driving formula, such as the Hiley formula.

.../...



Unbalanced horizontal forces should be resisted by battered piles and the underside of the pile caps should be established at least 1.5 m below finished grade.

The piles will also have to be designed to carry the downdrag forces caused by the consolidation of the silt and clay strata under the weight of the embankment. To evaluate the downdrag forces, the following unit negative skin friction values are proposed:

Silt - 13 kPa
Silty Clay - 40 kPa

4.3 Lateral Earth Pressures

Assuming that free draining granular material is used for embankment construction and adequate drainage is provided behind the walls of the culvert, the unit weight of the backfill can be taken as 21 kN/m^3 .

The walls of the culvert should be designed to withstand the at-rest earth pressures for which condition the following equivalent fluid pressures can be used:

At Ultimate Limit States = 10 kPa/m
At Servicibility Limit States type II = 8.5 kPa/m

4.4 Approach Fills

There are no stability problems foreseen for the proposed 5 m high approach fills. The sides of the approach embankment could therefore be constructed with 2 horizontal in 1 vertical side slopes. As discussed in Section 4.1 settlements of the order of 0.38 m can be expected.

..../...



The slopes of the embankment should be adequately protected against surface erosion and on the upstream side of the culvert rip-rap should be placed to a distance of about 3 m on either side and to a height of about 1 m above the high water level.

4.5 Construction

As the underside of a box culvert structure or the pile caps will be below the creek level and the groundwater table both excavation and dewatering problems can be expected. When excavating below the water table, both the sand and silt will be unstable and both will have to be stabilized by proper and adequate groundwater control. This could possibly be achieved by a vacuum wellpoint system or by surrounding the excavation with tight interlocking sheeting which extends to a depth approximately equal to twice the water head above the bottom of the excavation. In case of a sheet piled enclosure, the water seepage through the base of the excavation could be controlled by pumping from filtered sumps established inside the excavation.

5.0 STATEMENT OF LIMITATION

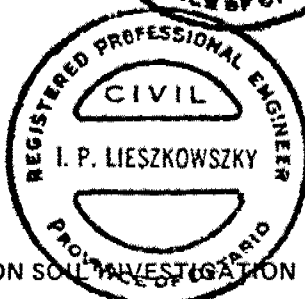
The Statement of Limitation, as quoted in Appendix 'B', is an integral part of this report.

DOMINION SOIL INVESTIGATION INC.

Z.S. Ozden, P. Eng.

I.P. Lieszkowsky, P. Eng.

ZSO/IPL:1t



DOMINION SOIL INVESTIGATION INC.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_P}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

APPENDICES

APPENDIX "A"

PROCEDURES

The field work was carried out during the period of November 30 and December 8, 1982. During this period four boreholes were drilled at the positions shown on the Borehole Location Plan, Drawing No. 1537900-A. A fifth borehole (Borehole 3) was cancelled due to difficult access.

The boreholes were advanced to depths ranging between 20.1 and 24.0 m below the ground surface, using a track mounted power auger drill rig equipped with hollow stem augers. The boreholes were generally extended by hollow-stem augering to depths ranging between 6 and 9 m below the ground surface. Below this, the boreholes were extended ahead of the augers by washboring methods. When the depth of the borehole reached to 15⁺ m, NW size casing was lowered until the till stratum was reached below which it was possible to extend the borehole ahead by washboring methods.

Sampling in the boreholes was effected by the Standard Penetration test method and from the test results, recorded as 'N'-values or penetration indices, the relative density or the consistency of the strata was inferred. In addition, in the cohesive stratum, relatively undisturbed samples were obtained by open end thin-walled (Shelby) tube samplers, and the undrained shear strength of the soil was measured in-situ by field vane tests. A dynamic penetration test was also extended from the bottom of Borehole 5 from 20.1 to 21.3 m.

The drilling equipment was owned and operated by D.S.I.L. Drilling Inc., and the field work was carried out under the supervision of the engineering



staff of Dominion Soil Investigation Inc., who located the borings in the field, directed the drilling and sampling operations and logged the borings.

The ground surface elevations at the borehole locations were determined with respect to a local benchmark (spike and nail in 0.25 m cedar at 29.2 m right of Station 19+370.6). It is understood that this benchmark has a geodetic elevation of 211.484 m.

Following the field identification, all samples were shipped to our laboratory where they were classified and laboratory testing was carried out on a number of samples. The laboratory testing program consisted of moisture content, Atterberg limit, quick triaxial compression, and consolidation tests, and grain size analyses. The test results are plotted on the Record of Borehole sheets and are also presented on Enclosures 5 and 6, and Figures 1, 2, 3 and 4.

Si

A P P E N D I X 'B'
STATEMENT OF LIMITATION

The conclusions and recommendations in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation.

We recommend that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis.

In cases where these recommendations are not followed, the company's responsibility is limited to report accurately the information encountered in the testholes.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.

ENCLOSURES

RECORD OF BOREHOLE No 1

METRIC

W P 1513-79-00 LOCATION Sta. 19+391 o/s 7.0m Lt C Hwy. 561 Line 'A' ORIGINATED BY S.D.
DIST 18 HWY 561 BOREHOLE TYPE Hollow Stem auger, washbore and rock core COMPILED BY Z.S.O.
DATUM Geodetic DATE 82 12 07 and 82 12 08 CHECKED BY J.P.I.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
209.4	Ground Level																
0.0	0.6 m Topsoil & decayed wood sandy.. brown		1	SS	2		209										0 7 87 6
			2	SS	4												0 24 66 10
			3	SS	7		207										0 4 88 8
			4	SS	10												0 3 88 9
	Silt, v. loose to compact grey		5	SS	11		205										
			6	SS	9												
			7	SS	10												
	occ. thin clay seams		8	SS	11		203										
			9	SS	13												drill ahead with tricone below 7.6 m
201.2							201										
8.2			10	SS	6												
	Silty clay, layered firm to stiff, grey		11	YW	-		199									17.7	
			12	SS	3												
	occ. thin sand seams		13	SS	4		197										
			14	YW	-												
			15	SS	9		195										
192.8																	
189.5	gravelly sand layer		16	SS	24		193										
188.9																	
187.4	sand, some gravel and traces of silt (probably compact)		17	RC	-		191										
185.5	boulder		18	SS	100	/0.07m											
	Het. mixture of sand, gravel and silt (Glacial Till)		19	SS	100	/0.07m	189										
	v. dense, brown frequent cobbles		20	SS	100	/0.03m	187										
186.5																	
22.9	END OF BOREHOLE																

+3, x5: Numbers refer to Sensitivity
20
15 ϕ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 1513-79-00 LOCATION Sta. 19+405 o/s 7.5 m Rt C Hwy. 561 Line 'A' ORIGINATED BY S.D.
DIST 18 HWY 561 BOREHOLE TYPE Hollow Stem auger, Washbore COMPILED BY J.S.O.
DATUM Geodetic DATE 82 12 02 and 82 12 03 CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	W _p W W _L	SHEAR STRENGTH kPa			WATER CONTENT (%)				
209.4	Ground Level																
0.0	0.3m Topsoil, peaty						209										
207.9	Sand, fine, traces of gravel & silt, loose br		1	SS	10												
1.5	Silt		2	SS	7												
	v. loose to compact		3	SS	10		207										
	grey		4	SS	11												
	some thin		5	SS	9		205										
	clay seams		6	SS	5												
			7	SS	6		203										
203.0			8	SS	4												
6.4			9	TW	PH		201										
	Silty clay		10	SS	4												
	layered		11	TW	PH		199										
	firm to stiff		12	SS	3		197										
			13	SS	6		195										
195.2			14	SS	9		193										
14.2	Gravelly sand		15	WS	-		191										
194.2	layer		16	WS	-		189										
15.2			17	SS	100	0.13m											
192.9			18	SS	100	0.07m											
16.5	Sand, fine																
	traces of silt, brown																
	(probably compact to																
	dense)																
189.7	Het. mixture of sand,																
19.7	gravel and silt																
	(Glacial till)																
188.0	v. dense, grey																
21.4	END OF BOREHOLE																

+3, x5: Numbers refer to
Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

drill ahead
with tricone
below 6 m.

Sample 9:
No recovery

Dec. 2
Dec. 3

NW casing to
16 m.
Sand backed
up 1.2 m in
casing, un-
able to per-
form pene-
tration test
@ 16.8 and
18.3 m.
Casing to
20m, tricone
ahead.

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4										METRIC					
W P 1513-79-00		LOCATION Sta. 19+412 o/s 1.0m Rt C Hwy. 561 Line 'A'				ORIGINATED BY S.D.									
DIST 18 HWY 561		BOREHOLE TYPE Hollow Stem auger, Washbore				COMPILED BY Z.S.O.									
DATUM Geodetic		DATE 82 12 01 and 82 12 02				CHECKED BY I.P.L.									
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	60					
209.3	Ground Level														
0.0	0.3m Topsoil & de- cayed wood		1	SS	7										Sample 2: no recovery
207.0	Sand, traces of gravel silt & organics, brown loose to compact		2	SS	13										
2.3	Silt, loose to compact, grey		3	SS	11										
	some thin clay seams		4	SS	11										
			5	SS	8										
			6	SS	6										
			7	SS	10										
			8	SS	8										
202.3															Dec. 1 Dec. 2
7.0			9	SS	5										
	Silty Clay, layered firm to stiff, grey		10	SS	5										Drill ahead with tricone below 8.5 m.
			11	SS	5										
			12	SS	7										
			13	SS	6										
194.5															Slight arte- sian pressure slight water seepage thru the rods at 15m. Lower NW casing @ 16.5 m.
14.8	Sand layer		14	SS	8										
193.8															Sand back-up 1.2m inside casing.
15.4	frequent silt layers		15	SS	13										
192.8															Casing to 20.4m tri- cone ahead. Sample 17 28, 60, 12, 0
16.5	Sand, traces of gravel & silt compact, brown		16	WS	-										
189.2															Sample 18 No recovery Refusal to tricone at 24.0 m probably on a boulder.
20.1	Het. mixture of sand, gravel & silt (Glacial Till) v. dense, greyish br.		17	SS	48	0.15m									
			18	SS	50	0.05m									
			19	SS	100	0.13m									
185.3	frequent cobbles														
24.0	END OF BOREHOLE														

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 1513-79-00 LOCATION Sta. 19+423 o/s Q Hwy. 561 Line 'A' ORIGINATED BY S.D.
DIST 18 HWY 561 BOREHOLE TYPE Hollow Stem auger, Washbore & cone test COMPILED BY Z.S.O.
DATUM Geodetic DATE 82 12 01 CHECKED BY I.P.L.

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	60	80	100					
209.8	Ground Level																
0.0	0.15m Topsoil						209										
208.5	Sand, traces of gravel & silt, compact, brown		1	SS	12												
1.3			2	SS	4												
	SILT		3	SS	7		207										
	v. loose to compact		4	SS	12												
	grey		5	SS	9												
	some thin		6	SS	8		205										
	clay seams		7	SS	6												
			8	SS	11												
202.8							203										
7.0			9	SS	7												
	Silty clay		10	SS	4		201										
	layered																
	firm to stiff, grey		11	SS	5												
			12	SS	4		199										
			13	SS	5												
			14	SS	9		197										
194.4																	
15.4			15	SS	25		195										
	Sand,																
	traces of gravel & silt		16	WS	-		193										
	compact, brown																
189.7			17	WS	-		191										
20.1	END OF BOREHOLE						189										
188.5	Dynamic Cone test ex-																
21.3	tended from bottom of B.H.																
	END OF DYNAMIC CONE TEST																

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%): STRAIN AT FAILURE

CONSOLIDATION TEST

VOID RATIO

0.9

0.8

0.7

0.6

1

10

1 TONS/FT²

PRESSURE

100 kN/m²

10

20

30

1000

BH. : 1

SAMPLE: 11

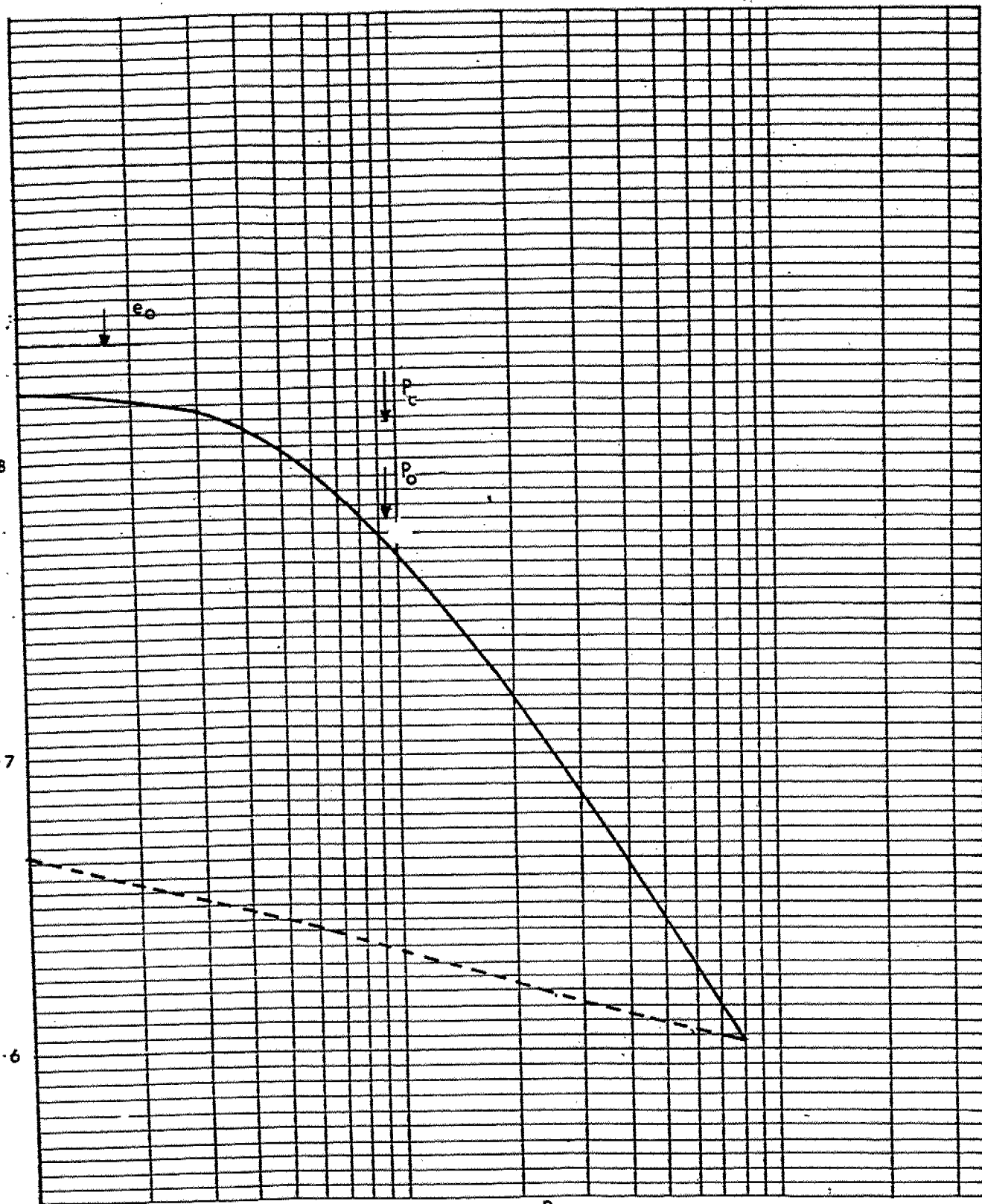
DEPTH : 10.8 m

L.L. = 33 %

P.L. = 21 %

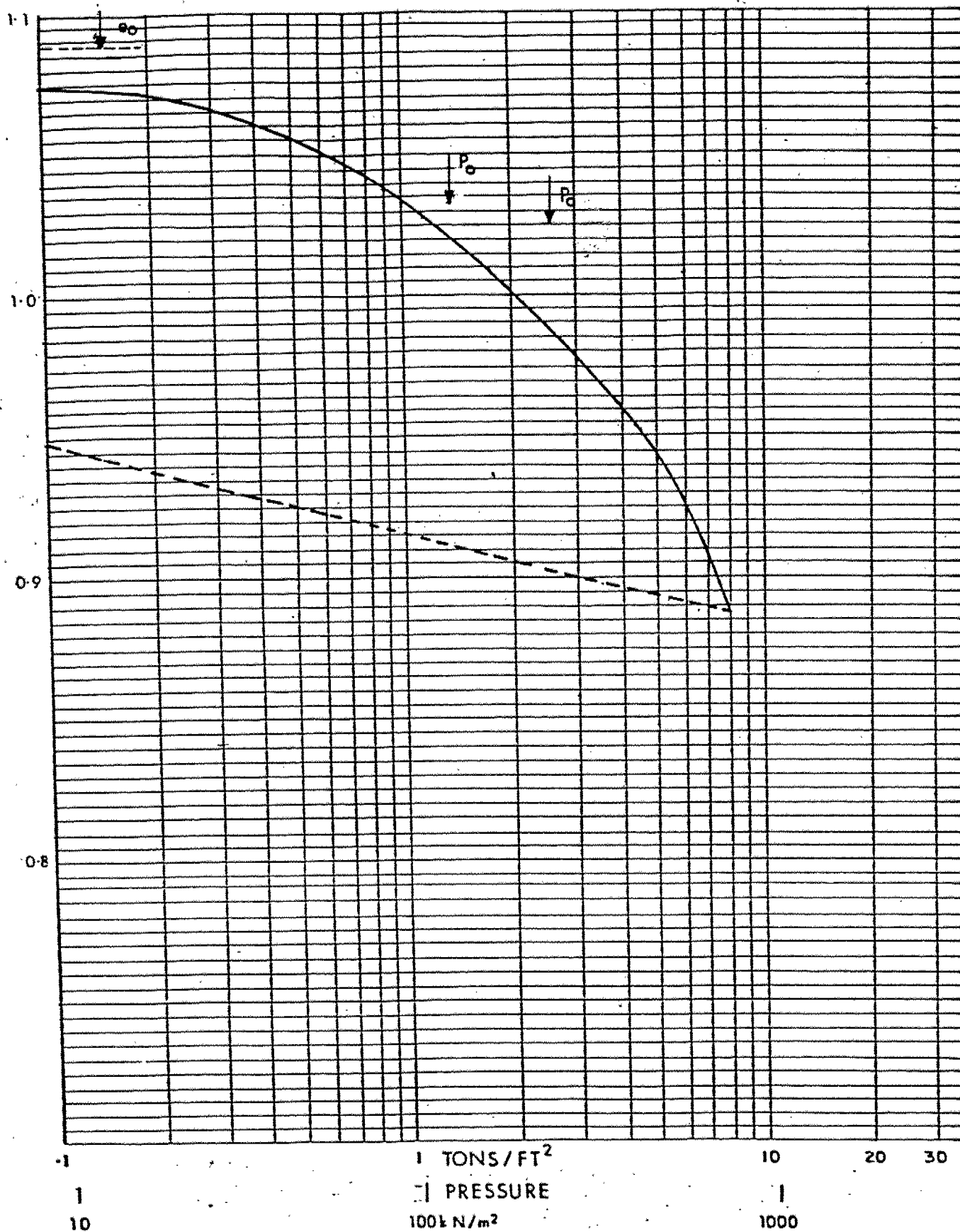
P.I. = 12

w = 31.3%



CONSOLIDATION TEST

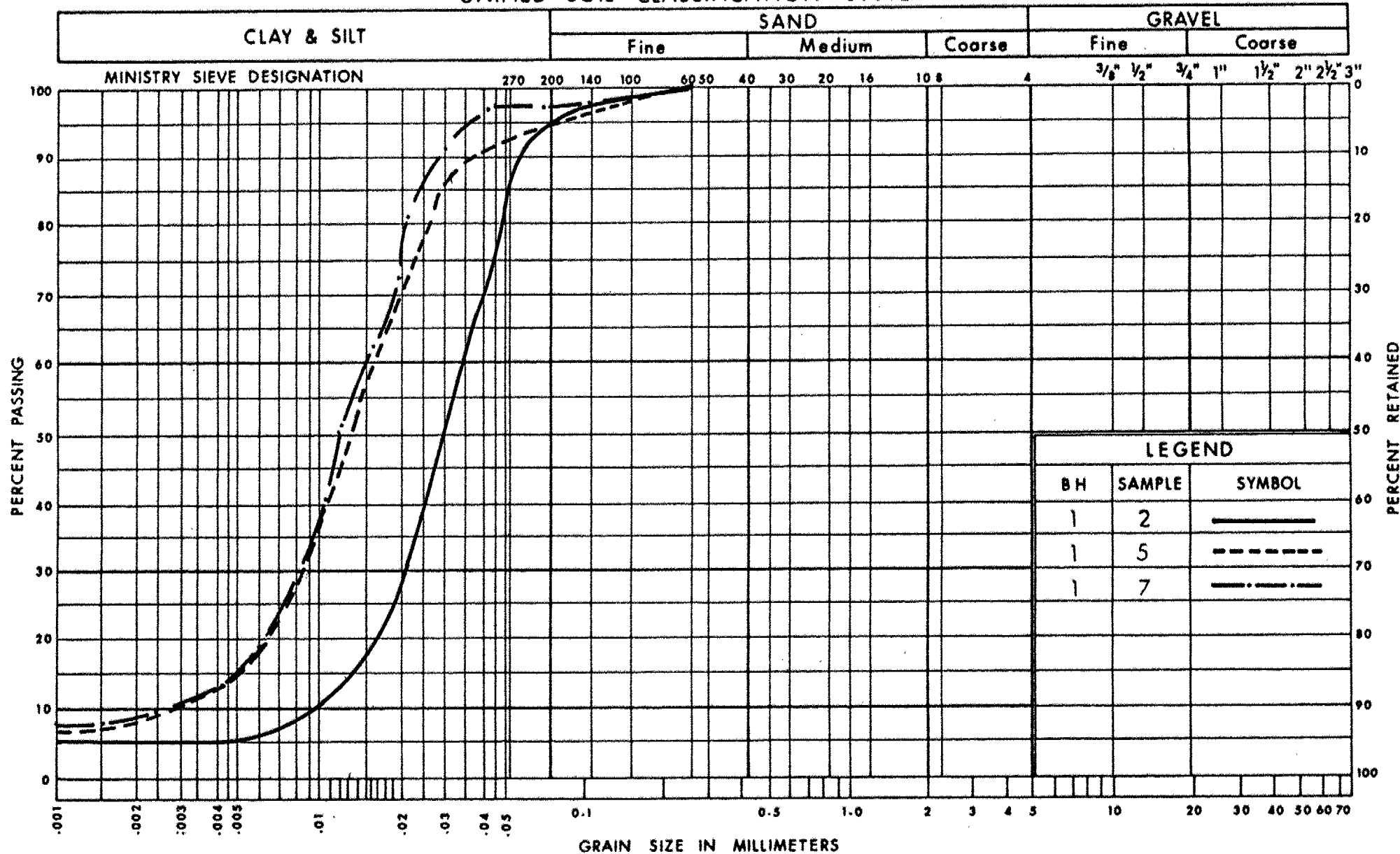
VOID RATIO



BH. : 1
 SAMPLE : 14
 DEPTH : 15.4m

L.L. = 38 %
 P.L. = 21 %
 P.I. = 17
 W = 35.4 %

UNIFIED SOIL CLASSIFICATION SYSTEM



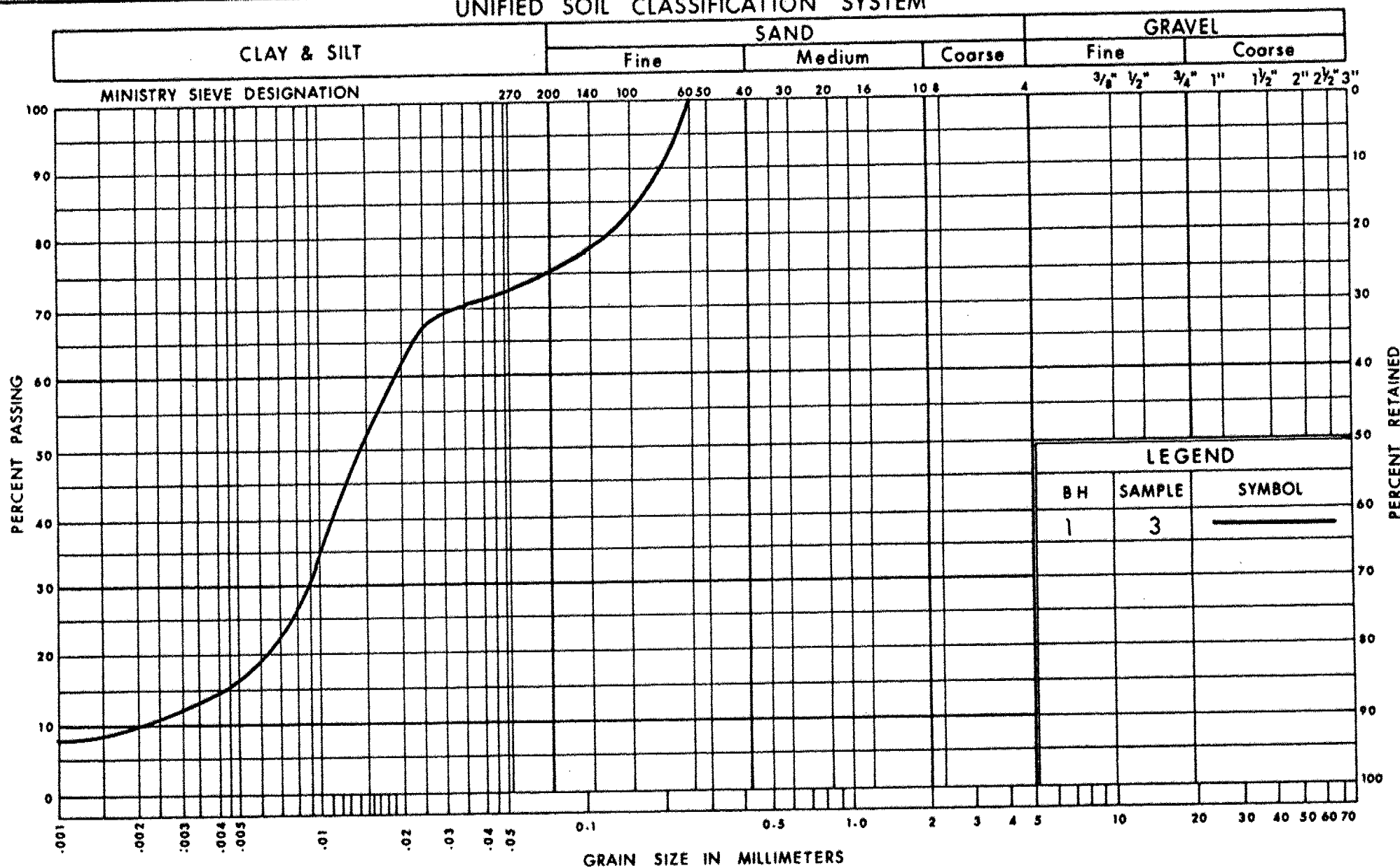
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT

FIG No 1

W P 1513-79-00

UNIFIED SOIL CLASSIFICATION SYSTEM



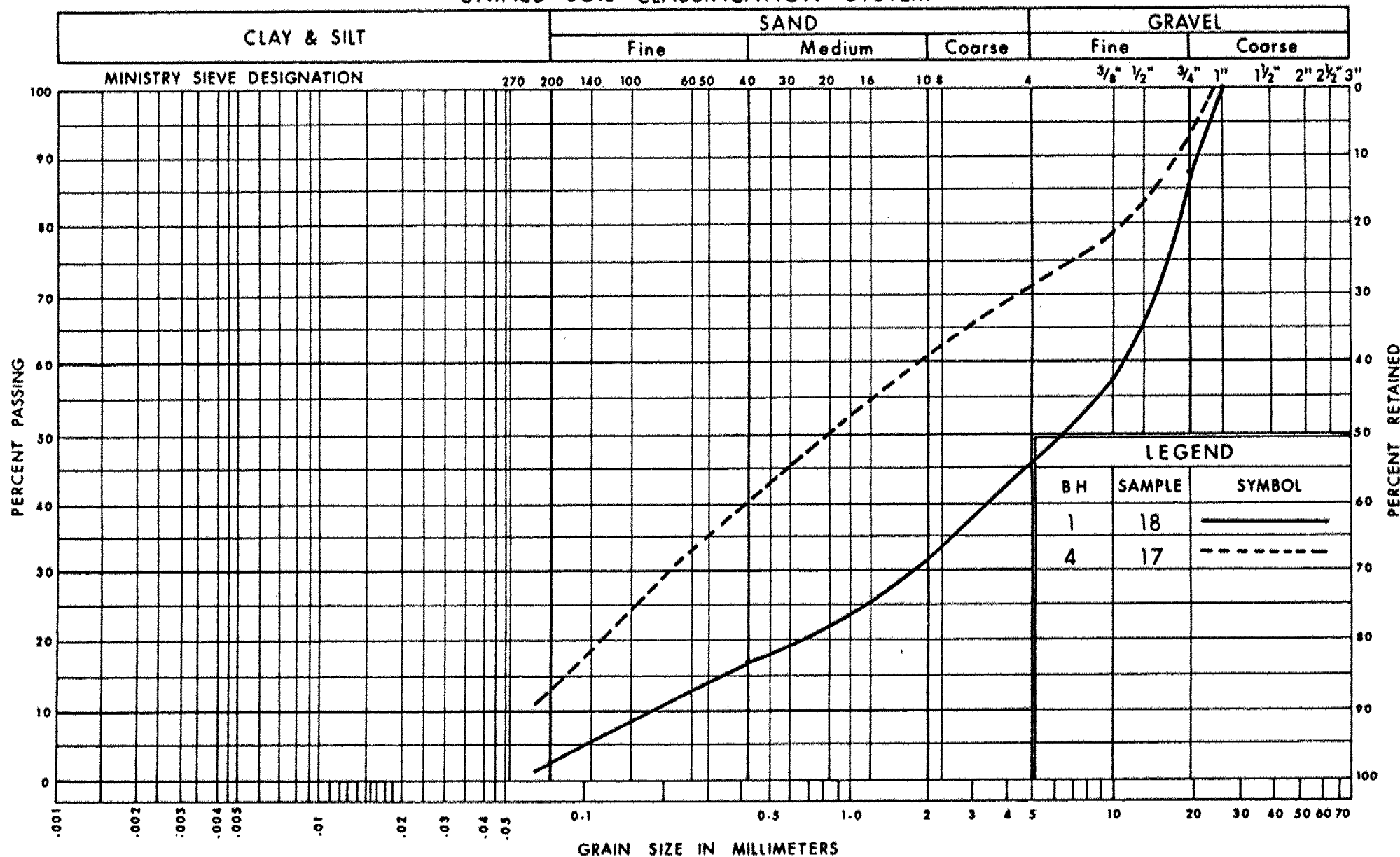
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILT
some Sand

FIG No 2

W P 1513-79-00

UNIFIED SOIL CLASSIFICATION SYSTEM

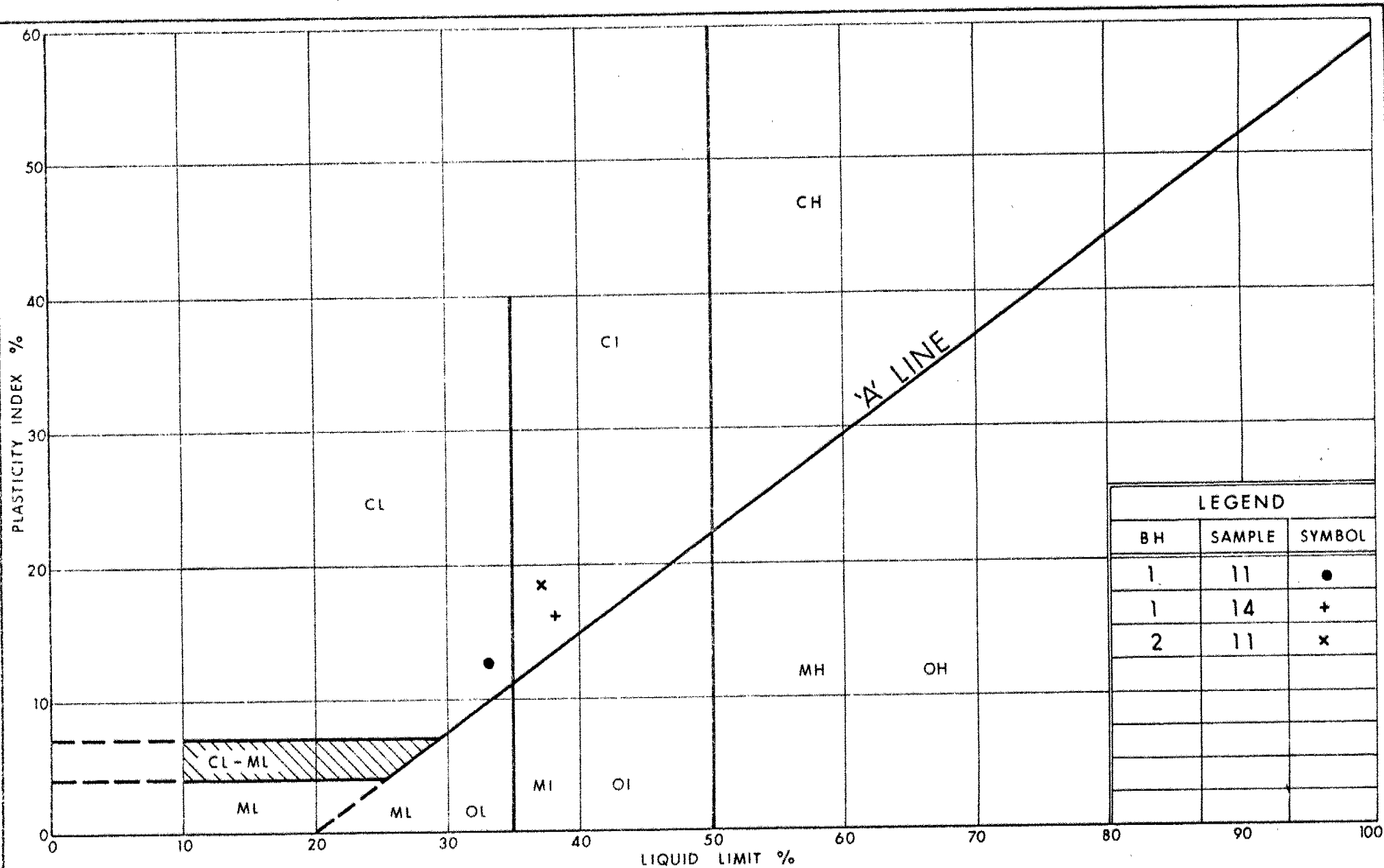


Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SANDY GRAVEL, some Silt.
(GLACIAL TILL)

FIG No 3

W P 1513-79-00



Ontario

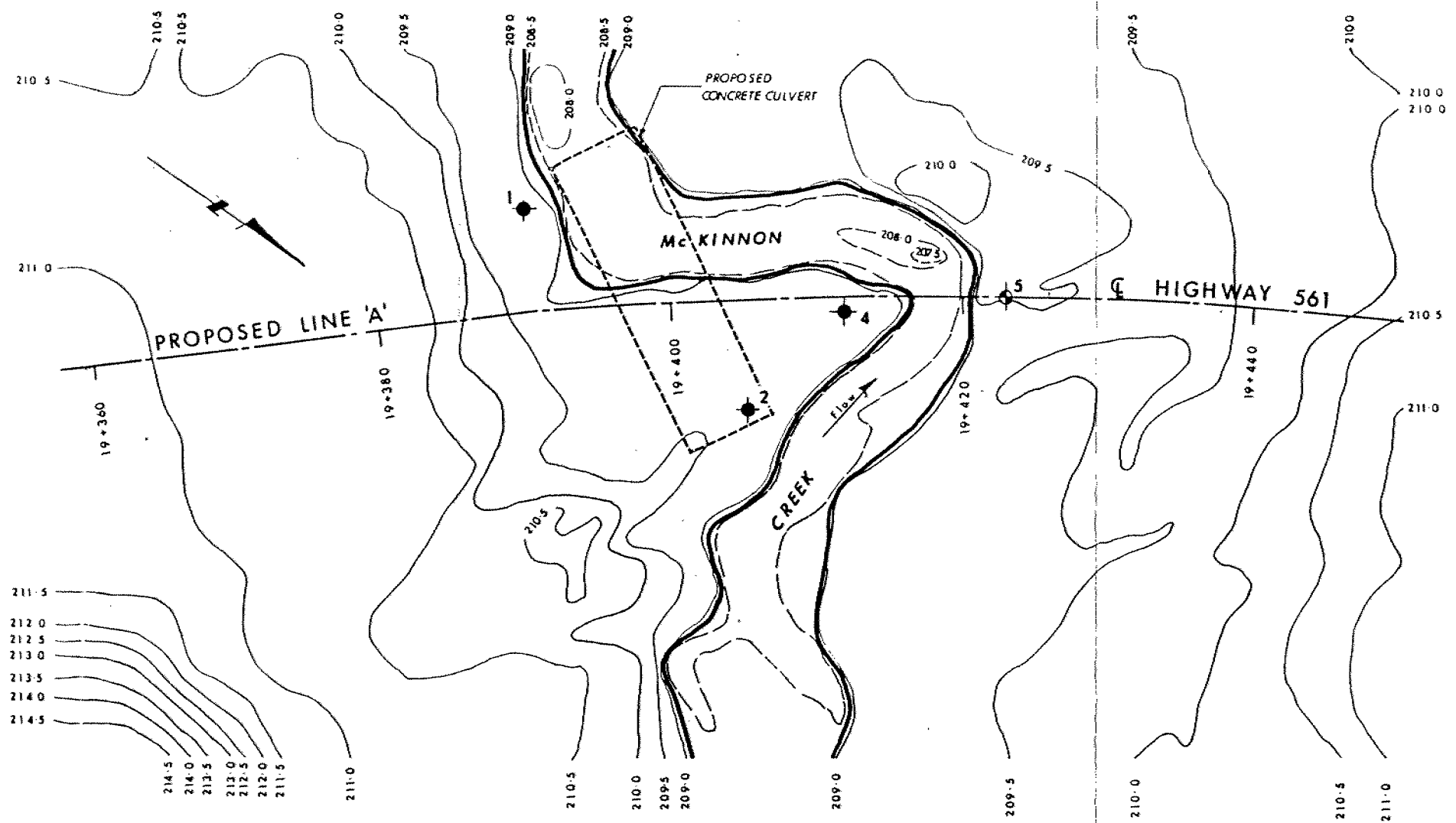
Ministry of
Transportation and
Communications

PLASTICITY CHART SILTY CLAY

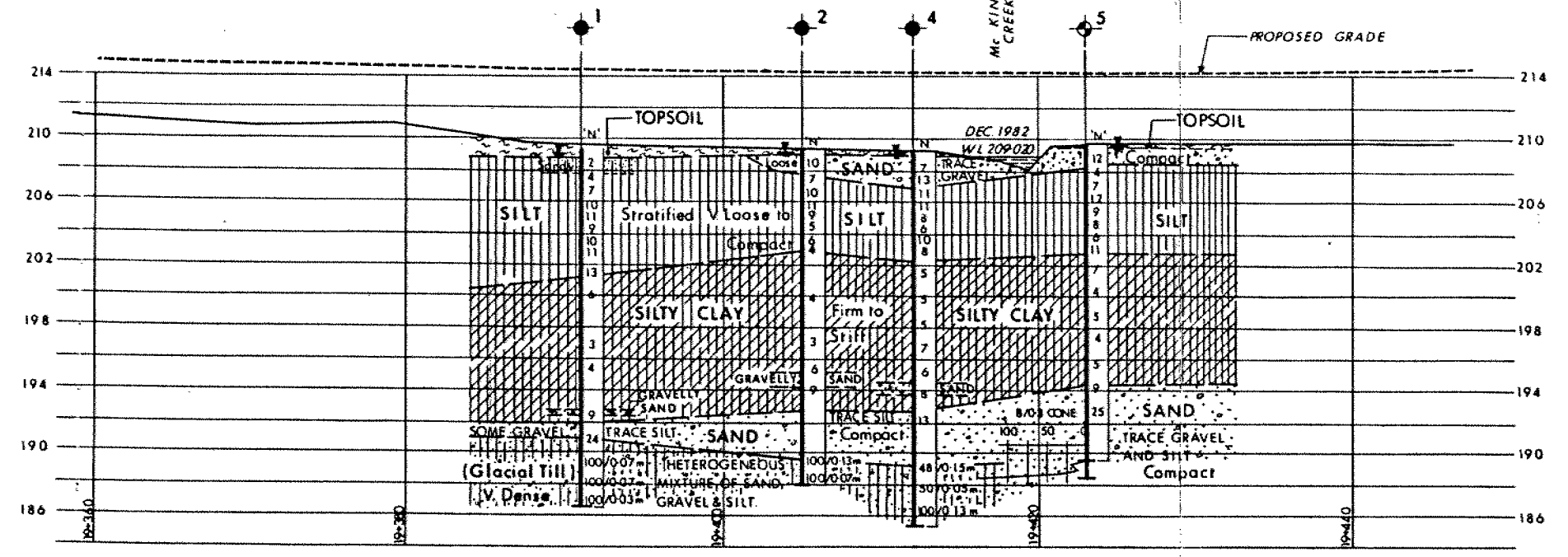
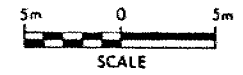
FIG No 4

W P 1513-79-00

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO, OM-MT-308M 8-79



PLAN



PROFILE LINE 'A'



METRIC

DIMENSIONS ARE IN METRES
AND OR MILLIMETRES UNLESS
OTHERWISE SHOWN

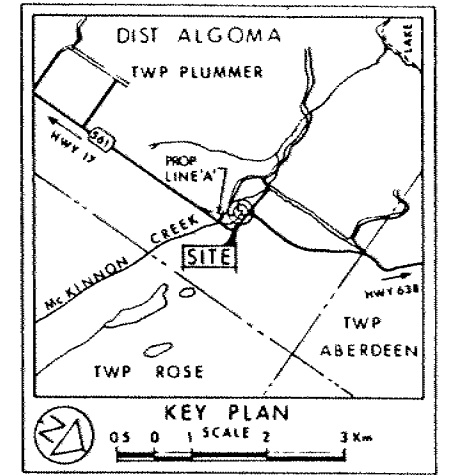
CONT No
WP No1513-79-00

CROSSING AT McKINNON
CREEK AND HWY 561 LINE 'A'
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

DOMINION SOIL INVESTIGATION INC.



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 1/blow)
- CONE Blows/0.3m (60° Cone, 475 1/blow)
- Wt at time of investigation 1982 12

No	ELEVATION	STATION	OFFSET
1	209.4	19+391	7.0 Lr
2	209.4	19+405	7.5 Rr
4	209.3	19+412	1.0 Rr
5	209.8	19+423	℄

BOREHOLE No 3 WAS NOT DRILLED

NOTE

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



DATE	BY	DESCRIPTION

Geocres No 31J-39
HWY No 561 LINE 'A'
SUBMD 5.0 CHECKED 20 DATE 1983 01 11 SITE 385-266
DRAWN FL CHECKED 20 APPROVED 220 DWG 15137900-A

memorandum



To: C. McKercher
Area Construction Engineer
Northwestern Region

Date: 1985 08 13

From: Foundation Design Section
Room 315, Central Building

Re: Contract No. 85-209
W.P. 88-82-02 (Previously W.P. 1513-79-00)
Site 38S-266, McKinnon Creek Culvert
Hwy. 561, District 18, Sault Ste. Marie
Well Water Claim (Mr. Corbeitt)

Further to your memo of 85 07 31, and our telephone conversation of 85 08 13, it is our understanding that Mr. Corbeitt of RR #2, Bruce Mines, has claimed that the dewatering operations at Contract 85-209 have affected his well water supply.

We have reviewed the foundation investigation for this project, and in our opinion, the drawdown effect caused by the dewatering operation should not influence Mr. Corbeitt's well because of the distance to the well and the nature of the aquifer. However, if you require conclusive evidence that such a drawdown could not occur, further subsurface investigations, in the vicinity of Mr. Corbeitt's well, would be required. It is estimated that such an investigation would cost in the order of \$3,000.

If there are any questions, please contact this office.

D. H. Dundas

D.H. Dundas, P. Eng.
Foundations Engineer

DHD/pet

memorandum



To: File

Date: 85 07 31



From: Construction Office
Northwestern Region

Re: Well Water Claim
Contract 85-209
McKinnon Creek Culvert

Background

It has been recommended by the Foundations Office that unwatering of structure excavation be carried out to ensure stable subsoil conditions during construction. Specifically well points have been provided.

Mr. M. Corbeit, R.R. #2, Bruce Mines became aware of this Ministry's proposal to install well points, and on approximately June 14, Mr. Corbeit approached this Ministry's Project Supervisor and indicated he was concerned that the well point proposal would deplete his well supply. (It is appropriate to note that Mr. Corbeit approached this Ministry prior to installation of the well point system).

Mr. Corbeit submitted a letter July 22 claiming that this Ministry depleted his well supply (see attached).

Investigations

- i) Installation of the well points were completed on June 23, 1985. The well points were installed approximately 15 feet below the McKinnon Creek water level.
- ii) Dewatering volumes are as follows:

June 23	15 gallons/min
June 26	10 gallons/min
June 26 - present	6-10 gallons/min
- iii) Mr. Corbeit's residence is more than $\frac{1}{2}$ mile from the site. There have been no complaints from other residents living closer to the site than Mr. Corbeit.
- iv) It is expected that the dewatering system will be removed approximately August 6, 1985.
- v) Adjacent residents have advised that Mr. Corbeit has run short of water on previous occasions.
- vi) Well Level measurements were as follows:

July 8	- 48" below top casing
July 22	- 67" below top casing

Meeting with Mr. Corbeit

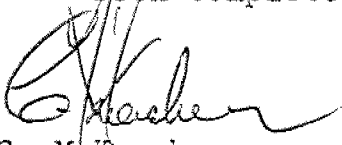
On July 23 a short meeting was held with Mr. Corbeit. Those present included:

M. Corbeit
R. Bruneau, MTC
R. MacMichael, MTC
C. McKercher, MTC

- i) Mr. Corbeit advised that he is continually running short of water. The well does recover after running dry. He, therefore, has adequate drinking water. Mr. Corbeit claims he cannot take a shower without running the well dry.
- ii) Mr. Corbeit did advise that his well has run dry in the past.
- iii) Mr. Corbeit did not object to this Ministry measuring well levels on a regular basis.
- iv) Mr. Corbeit was advised that dewatering at the McKinnon Creek site is expected to be completed August 6, 1985.

Future Course of Action

- i) Mr. Lou Politango from this Ministry's Foundation Office will investigate subsoil conditions and comment on the possibility that the dewatering of the McKinnon Creek site affected Mr. Corbeit's water supply.
- ii) Field staff will monitor Mr. Corbeit's well water level during dewatering operations on a regular basis. Well water levels will be recorded after the dewatering system has been removed to determine the recovery in water levels.
- iii) Well levels of other adjacent properties will be recorded on a regular basis.
- iv) Mr. Corbeit will be contacted after investigations have been completed.


C. McKercher
Area Construction Engineer

CM/br
attach.


c.c. R. Speiran
R. Bruneau
D. A. Sawyer
L. Politango

JULY 22/85

MR. RICHARD BRUNEAU
PROJECT SUPERVISOR
M.T.C. CONTRACT 85-209

THE WATER LEVEL IN MY WELL HAS
SUBSTANTIALLY DROPPED LATELY. THIS LEVEL
DROP STARTED THE SAME TIME AS PUMPS
WERE STARTED TO DRAIN WATER ON YOUR
PROJECT. I BELIEVE THE TWO ARE
BASICALLY CAUSE & EFFECT. COULD YOU
PLEASE SET UP A MEETING WITH
YOUR SUPERVISOR(S) TO DISCUSS THIS
MATTER WITH MYSELF.

THANK YOU FOR YOUR CONCERN


M. CORBETT
RR2 BRUCE MINES
(705) 736-2324



M E M O R A N D U M

To: File

Date: 85 07 08

From: Regional Construction
Office
Northwestern Region

Re: Unwatering Structure Excavation
McKinnon Creek Culvert
Contract 85-209 - Hwy. 561

Background

A concrete box culvert is proposed at the Hwy. 561 crossing of McKinnon Creek.

During the earth excavation for structure it became apparent that the foundations were very unstable.

Prior to proceeding with structure excavation the Foundation Office was contacted and a field investigation was carried out. It was subsequently recommended by Dave Dundas of the Foundation Office, that unwatering of the structure, excavation would be required to insure stable subsoil conditions during construction. Specifically the provision of well points was recommended.

These recommendations are consistent with statement made in the Foundations Report, dated January 1983, which states:

"As the underside of the box culvert structure will be below the creek level and the ground waters table, both excavation and dewatering problems can be expected. When excavating below the water table both the sand and silt will be unstable and both will have to be stabilized by proper and adequate ground water control. This possibly could be achieved by a vacuum well point system or by surrounding the excavation with tight interlocking sheeting which extends to a depth approximately equal to twice the water head above the bottom of the excavation."

Since the culvert has been designed as a raft, dewatering will not be required after construction is complete.

Although it was noted in the Foundation Report that both excavation and dewatering problems can be expected, there was no mention of these problems in the contract. Specifically it is appropriate to note there was no item for unwatering structure excavations.

Alternatives

Several alternatives for the unwatering of structure excavations were discussed with M.Devata and D.Dundas of the Foundation Office.

These alternatives included:

1. 600 mm of Granular 'A' bedding underlaid by a filter blanket over 200 mm + coarse gravel. A sump would be provided at the low end of culvert.

Although this was the cheapest alternative it was felt in view of the highway pore pressures that fines would quickly be pumped up through the coarse gravel and bedding and the investment would be lost.

2. Provide a perimeter ditch around the proposed culvert excavation to lower the water table.

It was felt that a perimeter ditch would intercept water flow from McKinnon Creek since the culvert site is basically a flood plain. If the perimeter ditches are running full of water it is questioned if they would be effective as a method of lowering the water table.

It is also suggested that this alternative would have a significant impact on the environment. (See Environmental Constraints Special Provisions)

3. Mr. Tim Miles of Stang Engineering, reviewed the site to determine the feasibility of using well points.

Mr. Miles advised that approximately 77 well points, approximately 20' long, would be required. It would take 3 labours and a supervisor from Stang Engineering, approximately 1 week to dewater prior to excavation. The pumping system would remain in place until the structure was complete. It would take 4 men approximately 2 days to remove the well point system. Stang Engineering quoted a price of \$17,800 for:

- Equipment for dewatering of foundations including shipping
- Engineering expertise regarding method of dewatering
- Supervision of well point installation

This estimate does not include the cost of labour and equipment to install and remove the system as well as fuel and labour required to maintain the pumps for the duration of the contract.

July 8, 1985

In discussions with M. Devata of the Foundations Office and Gary Greene of the Estimating Office, it was agreed that this estimate was reasonable. It was also concluded the dewatering using the well point method would provide the required results.

Financial Responsibilities

It states in Ontario Provincial Standard Specification 902, that "the contractor shall carry out all work necessary to prevent disturbance of the foundation" and that "payment at the contract price for earth excavation for structure shall be full compensation for any unwatering ect."

It is appropriate to note once again, that an unwatering structure excavation item was not included in this contract.

With regards to the above the following Ministry representatives were contacted to discuss whether payment for unwatering is included under the earth excavation for structure item or whether the dewatering should be considered extra work.

Those contacted included:

O. Ramakko	-	Regional Structural Office
S. Dunham	-	Contract Management Office
L. Curtis	-	Claims Office

All were in agreement that:

- It was unreasonable to assume that the contractor could anticipate the structure excavation problems, or, more specifically, the need for 77 well points, based on the soils borehole data provided in the contract.
- In consideration of the anticipated dewatering problems as documented in the foundation report, an unwatering structure excavation item should have been provided.
- The provision of well points should be paid as extra work.

Negotiated Price

This Ministry's estimate for carrying out the work is \$42,328 (see Appendix A)

Belanger Construction quotes a price of \$38,815. The quoted price was discussed with G. Greene of the Estimating Office and based on the cost of similar unwatering schemes, it was agreed to accept Belangers price and proceed with the work.

July 8, 1985

Work Progress/Future Course of Action

The unwatering system has been installed and foundations have been successfully unwatered.

R. Brunneau (Engineer in Training) who is the Project Supervisor for this contract has agreed to prepare a report documenting

- The actual cost of the unwatering of foundations
- Installation procedures
- Effectiveness of the well point system.

This report will be distributed to those who assisted in resolving this problem for their interest and information.

By copy of this submission, I thank all those involved.



C. McKercher
Area Construction Engineer

CM/km

Attach.

c.c. M. Devata/~~D. Dundas~~

S. Dunham
G. Greene
O. Ramakko
R. Speiran
R. Brunneau

memorandum



To: C. McKercher
Area Construction Engineer
Northwestern Region

Date: 1985 06 21

From: Foundation Design Section
Room 315, Central Building

RE: Contract No. 85-209
W.P. 88-82-02 (Previously W.P. 1513-79-00)
Site 38S-266, McKinnon Creek Culvert
Hwy. 561, District 18, Sault Ste. Marie
Construction Problem - De-watering

As you requested in our telephone conversation of 85 06 11, we have investigated the foundation construction problem at this site.

During our site visit of 85 06 12, it was determined that the soft foundation conditions reported were caused by an unbalanced hydrostatic head in the silt foundation material.

At that time, R. Bruno, Project Supervisor, was advised that the solution to the problem was to lower the prevailing groundwater elevation a sufficient depth ($1\frac{1}{2}$ m) below any excavation in order to eliminate the boiling conditions to which the silt material is highly susceptible. It was suggested that the Contractor should be advised to prepare a proposal to accomplish the required lowering of the groundwater level and that possible alternatives were:

- 1) oversized excavations with deeper perimeter ditches dewatered by sump pumping,
- 2) perimeter sheet piling sealed in the underlying clay layer (tip elev. $201\frac{1}{2}$ m) combined with sump pumping,
- 3) vacuum well-points

It was also recommended that any disturbed material below the foundation should be removed and replaced by properly compact free-draining granular material, and that the granular material could be brought up to the proposed footing level.

We wish to bring to your attention that dewatering was recommended for this project in both the Foundation Investigation and Design Report (Dominion Soil Investigation Inc. report Pg. 11) and the accompanying covering letter (M. Devata to W. Kulmattickas, dated 83 03 30). However, this recommendation was deleted, without our knowledge, during the Regional Technical Review meeting of 83 12 13 (minutes to meeting Pg. 3) Also, no preliminary design or final design drawings were submitted to this Section for our review. It appears that this construction problem could have been avoided if the original foundation recommendations were followed.

.....2

If there are any questions, please contact this office.

DHD/mmj

D.H. Dundas, P. Eng.
Foundations Engineer

Attach.

c.c. - C. Pritchard
O. Ramakko
K.G. Bassi

memorandum



To: Mr. W. W. Kulmatickas
Head, Structural Office
Northwestern (Thunder Bay) Region

Date: 83 03 30

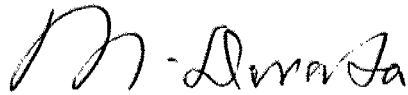
From: Pavement & Foundation Design Section
Room 315, Central Bldg.
Downsview

Re: Geotechnical Investigation
Proposed Crossing at McKinnon Creek & Hwy. 561
Site No. 38S-266
W.P. No. 153-79-00 - District of Sault Ste. Marie
North-West Region

Dominion Soil Investigation Inc. has been retained by the Ministry to carry out a foundation investigation at the above-mentioned site and provide factual subsurface data together with recommendations for the design and construction of foundation and associated earthworks. Attached please find their final report and drawings describing the subsurface conditions and foundation recommendations. We have reviewed the report for the technical content and format and our comments are as follows:

In our opinion a dewatering scheme will be required for the construction of the box culvert or the pile caps for the rigid frame concrete culvert since the foundations will be situated below ground water level. The estimated settlement of the embankment will be in the order of 0.38 metre and about 0.3 metre settlement will be due to the long term consolidation of the silty clay. It is therefore recommended that a camber of 0.3 metre should be provided at the middle of the culvert in order to provide a smooth hydraulic gradient at all times. In addition, a clay blanket be placed on the upstream face of the embankment up to the high high water level. In the case of rigid frame concrete culvert the base of the pile caps should be situated well below the possible frost penetration depth.

We believe the aforementioned comments together with information contained in the enclosed foundation report will be adequate for your requirements. Should you require further clarification or additional information, please feel free to contact us.



M. Devata, P. Eng.
Senior Foundation Engineer

MB:bg

Encls.

cc: W.W. Kulmatickas (2)
R. Girard
D. Thomas (2)
R.E. Thompson
K. Bassi
B.J. Giroux
R. Hore

K. Maluzinsky (Cover Only)
T.J. Kovich (Cover only)

CONTRACT No 85-209

WP 88-82-02 (old WP 1513-79-001)

McKinnon Creek Culvert

Clark McKercher 577-6451 Thunder Bay Construction Eng

Bob Spieran Construction Super

Richard Bruno 882 (705) 736-2835 (Sec) Project Super

- Mr. McKercher phoned D. Dundas on 85.06.11
regarding a foundation problem at this site.

- box culvert excavation had been
advanced to elev. 208^{\pm} m where
unstable silt was encountered.

- he requested our advice and a
site visit if possible

- he considered problem urgent as
contractor was being held up

- The Foundation Investigation report was written
by Dominion Soils and submitted with
a covering letter by M. Devata on 83.03.30

- ground surface ~ 210 m

- water elev. ~ 209 m

- 2 m of organics (to elev. 208)

then silt to elev. 202

the silty clay

- a box culvert was one of the recommendations with Factored Bearing Capacity of U.L.S. $\sim 126 \text{ kPa}$
& estimated culvert load 70 kPa ?
according to R. Bruno design load is actually 80 kPa .
- Both covering letter and Fdn Report recommended dewatering schemes

- D. Dundas visited site with R. Bruno on 85 06 12

- R. Bruno was advised that
 - ① problem was dewatering
 - ② solution is to lower water table 1 m below excavation limit
 - ③ this could be accomplished by
 - a) oversized excavation & perimeter ditching with sump pumping
 - b) sheet piling sealed in clay layer $\sim 20 \text{ m}$ and sump pumping
 - c) vacuum well-pump
 - ④ disturbed material should be removed after dewatering
 - ⑤ backfill should be properly compacted free-draining material

It was suggested that the Contractor should be advised to lower water table and that Contractor should make proposal of how to accomplish this.

- Estimated Cost of project = ⁸¹290,000
- there was no dewatering item (apparently removed in technical review of 83 12 13)
- prelim designs & final design were probably not submitted to this office for review
- the Contractor is Belanger Construction of Sudbury.
- Project - box culvert
 - 34 m long
 - 7.1 m wide
 - 6 m high
 - final road grade = 214 m
 - culvert invert = 208 m
- location near Bruce Mines on Hwy 561 at McKinnon Creek
- problem noted on 85 06 06 when creek diversion constructed
- excavation (20' x 20') for box culvert was made on 85 06 10
- the depth of disturbed material was 4' on Monday 85 06 10, ~ 2' on 85 06 12
- there was a pump operating on 85 06 12 and water table was being held at surface
- the material at excavation base is NP silt

→ It was also suggested that sump pumping in disturbed excavation wasn't helping and could be stopped



DOMINION SOIL INVESTIGATION INC.

CONSULTING SOIL & FOUNDATION ENGINEERS

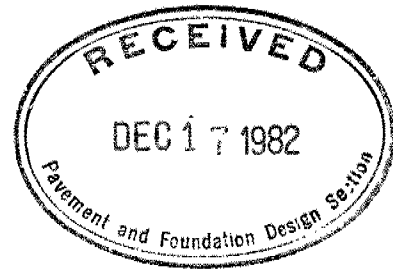
104 CROCKFORD BLVD., SCARBOROUGH, ONTARIO, CANADA, M1R 3C6

(416) 751-6565

December 16, 1982

Ref. No. 82-11-9

Ministry of Transportation & Communications
Pavement and Foundation Design Section
Central Building
1201 Wilson Avenue
Downsview, Ontario
M3N 1J8



Attention: Mr. M. Devata, P. Eng.
Senior Foundations Engineer

Re: Interim Report
Geotechnical Investigation
Proposed Crossing at McKinnon Creek & Hwy. 561
Site No. 38S-266
W.P. No. 153-79-00 - District of Sault Ste. Marie
North-West Region

Dear Sirs:

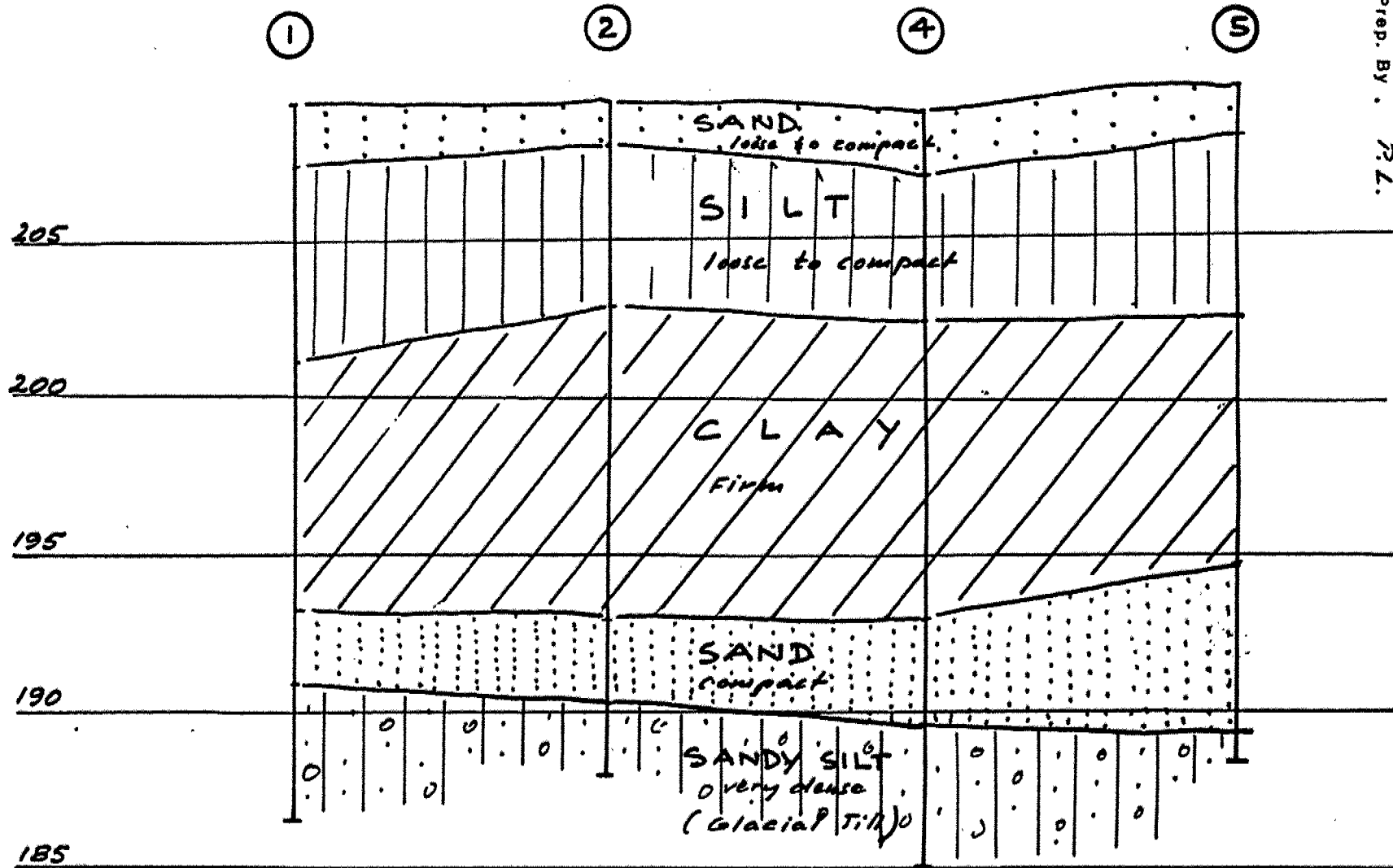
We have completed the site investigation at the above site and we are now in the process of compiling the data and performing the necessary laboratory and engineering analyses. Due to the urgency of the project however, you have requested that we provide you with preliminary data so that the Bridge Office can proceed with the design.

Subsurface Conditions

The investigation consisted of drilling four boreholes at the following locations:

.../...

DOMINION SOIL INVESTIGATION INC.



INFERRED SOIL PROFILE

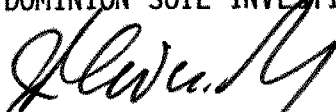
can be expected to penetrate this deposit to about El. 188 m and to develop their full structural capacity.

The factored capacity at ultimate limit state of a 310 x 79 steel H pile section is estimated to be 1250 kN, and the capacity of the same pile at serviceability limits state Type II is 700 kN. The piles will have to be designed to carry the downdrag forces caused by the consolidation of the clay under the weight of the embankment. Values for the negative skin friction will be presented in our final report.

We trust that this interim report contains sufficient information for your present requirements, however if you need further data, we shall be pleased to be of assistance.

Yours very truly,

DOMINION SOIL INVESTIGATION INC.



I.P. Lieszkowszky, P. Eng.

IPL:lt

Encl.

3 copies - Ministry of Transportation & Communications



Based on the field test results we have reached the following tentative conclusions.

In our opinion, a box culvert structure, the base of which is designed as a raft, could be founded at El. 208 m. The factored bearing capacity at ultimate limit state at this elevation is 126 kPa. The pressure at the base of the culvert under maximum dead and live load conditions is estimated to be about 70 kPa, and therefore there should be an adequate safety factor for this type of design.

The settlement of the structure, however, will be governed by the deformation and consolidation of the silt and clay strata under the weight of the embankment. Tentatively it is estimated that the settlement of the embankment and the midpoint of the culvert will be of the order of 0.25 m. This value, however, will have to be confirmed by laboratory tests. It is also estimated that the settlement at the two ends of the culvert will be approximately 40 to 50% of this value and therefore differential settlements of the order of 125 to 150 mm can be expected.

As the base of the culvert will have to be constructed on the loose and dilatant silt some construction problems can also be expected.

As an alternative to a box culvert structure an open rigid frame concrete culvert could be constructed which, however, would have to be supported on end bearing piles. The dense glacial till encountered at about El. 190 m is a suitable bearing stratum for end bearing piles. Piles

.../...



Clay

The clay stratum is 8 to 10 m thick and has a layered, varved structure. Standard penetration resistances range from 3 to 8 with an average value of 5 blows/0.3 m. The in-situ vane tests carried out in the deposit gave undrained shear strength values ranging between 55 and 80 kPa with an average value of 65. Sensitivity values range between 3 and 5.

Lower Sand Deposit

This stratum lies about 16 m below the ground surface and is 2 to 5 m thick. It consists of predominantly fine sand and water under artesian pressure was encountered in this stratum in all boreholes except Borehole No. 1. Penetration resistances range from 9 to 24 blows/0.3 m with an average value of 15.

Sandy Silt Till

The surface of the till was encountered at depths ranging between 18.5 and 20 m. This stratum was penetrated to a maximum depth of 4.5 m in Boreholes 1 and 4 and between 1 and 2 m in Boreholes 2 and 5. The till is a well graded mixture of gravel, sand and silt with some cobbles and boulders. Penetration resistances were in excess of 100 blows/0.3 m.

Groundwater

As mentioned earlier, water under artesian pressure was encountered in the lower sand deposit which overlies the glacial till. The water head in this stratum was observed about 1 m above the ground surface. The artesian conditions were stopped by sealing the boreholes within the clay and the groundwater level in the upper sand was observed at 0.15 to 0.3 m below the ground surface. The water level in the creek at the time of the investigation was at El. 209.02 m.

Discussion of the Results

We understand that the proposed structure will most likely be a culvert which will be constructed at about Station 19+400. This will result in excavating a new channel for the creek and backfilling a sharp bend in the existing creekbed at this location. The invert of the culvert will be at about El. 208 m which corresponds to the general creek bed elevation in the area. The proposed profile grade is approximately 5 m above the present ground surface.

.../...



<u>Borehole No.</u>	<u>Station</u>	<u>Offset</u>	<u>Elevation (m)</u>
1	19+391	7m Lt.	209.41
2	19+405	7.5m Rt.	209.40
3	not drilled		
4	19+412	1m Rt.	209.30
5	19+423	On C _L	209.83

The boreholes indicate fairly uniform conditions consisting of the following deposits.

1. Surficial Sand, loose to compact.
2. Silt, loose to compact.
3. Clay, firm.
4. Lower Sand, loose to compact.
5. Sandy Silt Till, very dense

The inferred soil stratification is summarized on the attached Enclosure No. 1 and the main properties of the deposits are described very briefly below:

Upper Sand

This deposit is 1 to 2 m thick and standard penetration indices ('N'-values) range between 2 and 13 blows/0.3 m with an average value of 8.

Silt

This 5 to 6 m thick deposit consists of predominantly cohesionless silt with occasional slightly plastic zones. Penetration indices range between 5 and 12 with an average value of 8.

.../...