

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 41K-42

DIST. 18 REGION

W.P. No. 147-65-00

CONT. No. 83-215

W. O. No.

STR. SITE No. 38S-265

HWY. No. 532

LOCATION Goulain River

No. of PAGES -

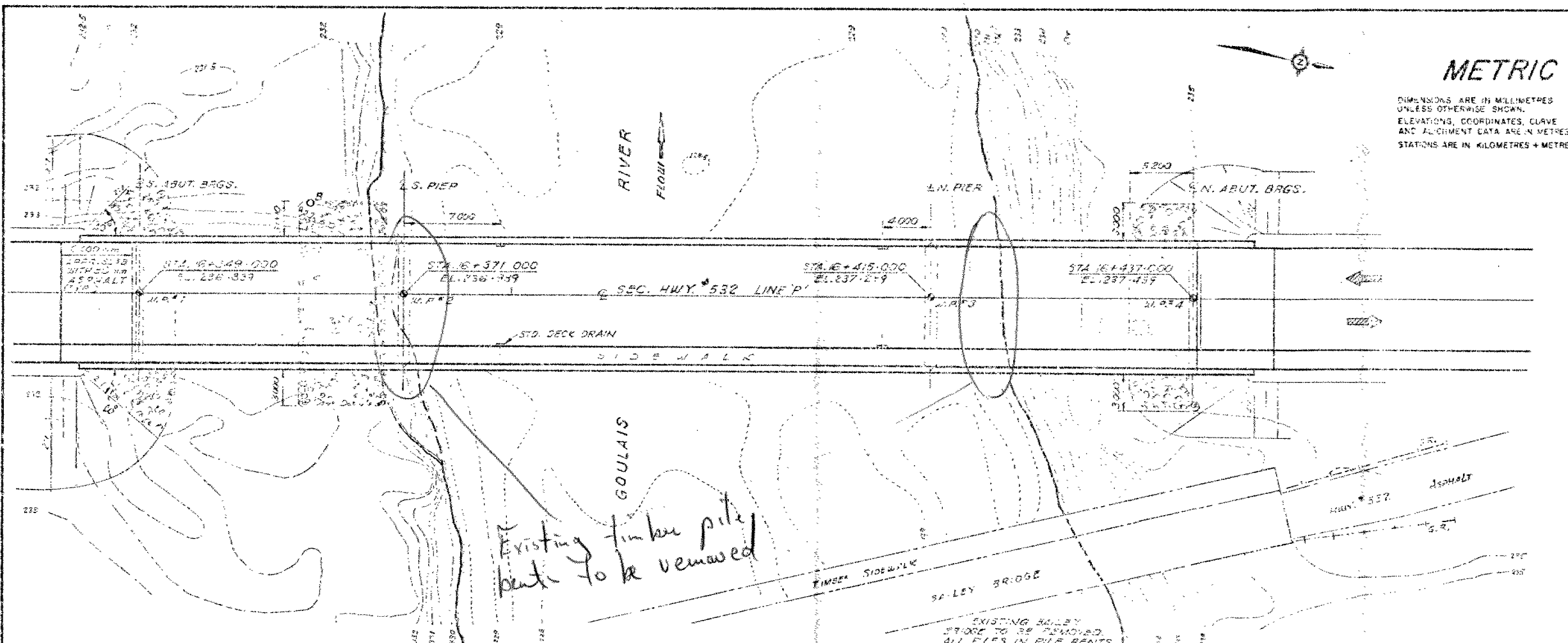
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

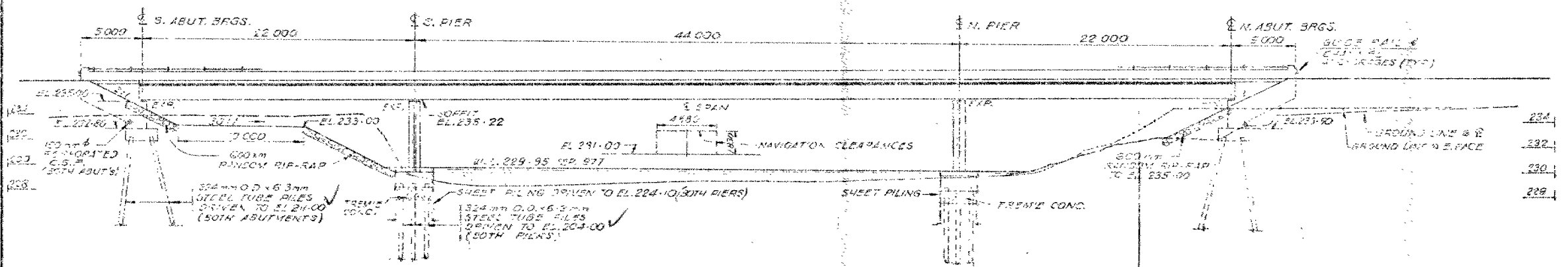
REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

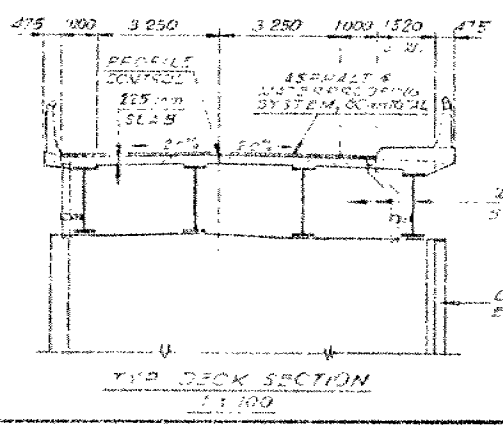
DESIGN 134-13-01



PLAN  
1:200



ELEVATION  
1:200



TYP. DECK SECTION  
1:100

PROFILE @ HWY. 532 LINE 'P'  
N.T.S.



PROJECT NO. 646  
SHEET NO. 705  
P.L.T. N. SOUTH FACE OF  
EAST CONC. PIER  
WHILE OF BRIDGE  
30.5 FT. R+331.0

NOT TO BE SCALED  
FROM ORIGINAL DRAWING

DIST. 18	
CONT No	
WP No	47-65-00
GOULAIS RIVER	
BRIDGE	
GENERAL ARRANGEMENT	
SHEET	

NOTES:

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BARS MARKED WITH THE SUFFIX 'C' SHALL BE COATED BARS.

CLASS OF CONCRETE

DECK, BARRIER WALLS, ABUTMENTS, APPROACHES, PIER FOOTINGS & PIERS 30 MPa. REMAINDER 20 MPa.

CLEAR COVER TO REINFORCING STEEL

FOOTING: 100 mm  
ABUTMENTS: 100 mm  
DECK: 20 mm  
PIERS: 20 mm  
DECK: 20 mm  
BARRIER WALLS: 20 mm  
APPROACH SLABS: 20 mm  
UNLESS OTHERWISE NOTED ON DRAWING

CONSTRUCTION NOTES

THE CONTRACTOR SHALL MAINTAIN THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS TO A TOLERANCE OF  $\pm 3$  mm.

LIST OF DRAWINGS

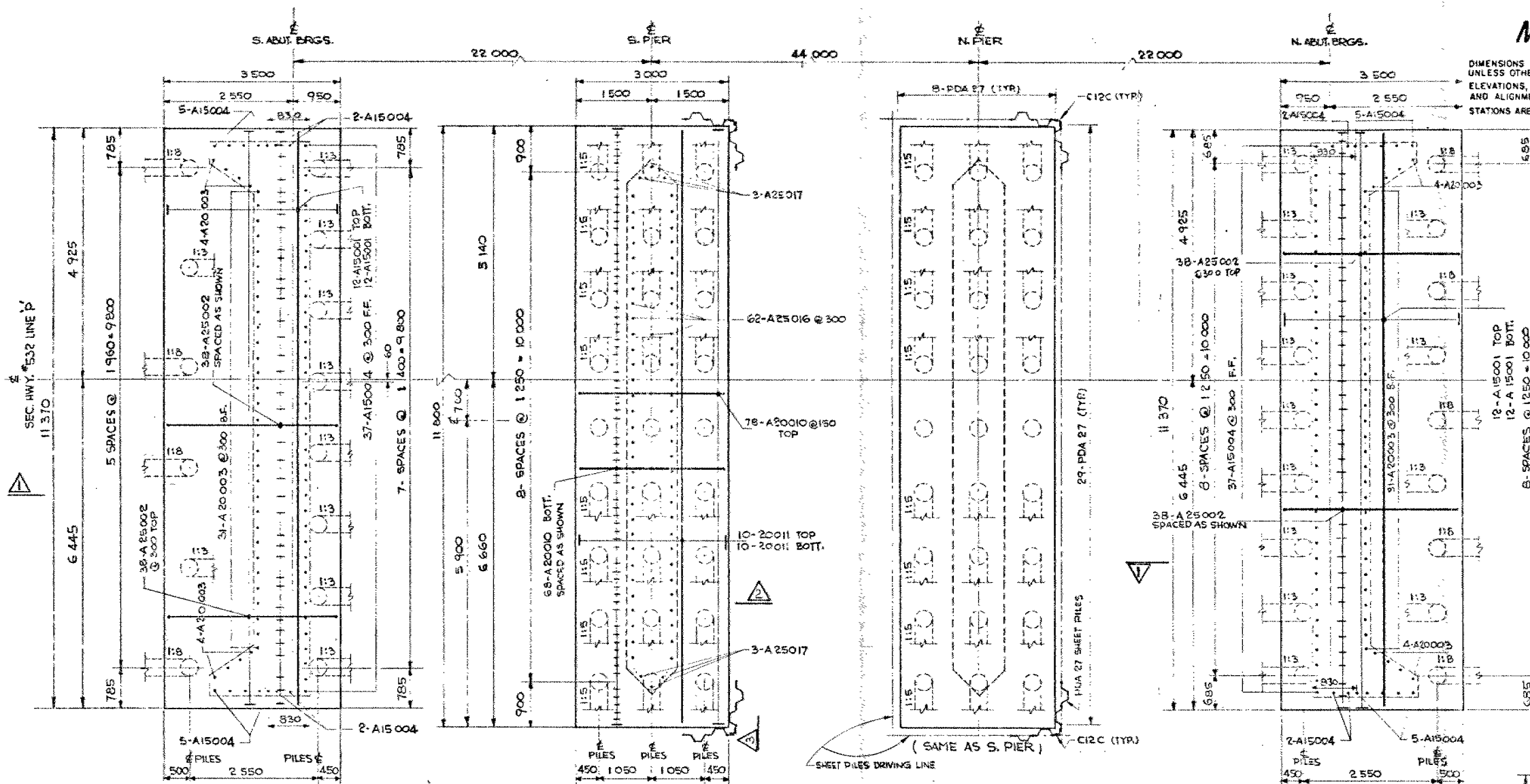
- 385-265-1 GENERAL LAYOUT
- 2305-1015 LOCATIONS & SCALE DATA
- 2305-1015-1 DETAIL
- 2305-1015-2 DETAIL
- 2305-1015-3 DETAIL
- 2305-1015-4 DETAIL
- 2305-1015-5 DETAIL
- 2305-1015-6 DETAIL
- 2305-1015-7 DETAIL
- 2305-1015-8 DETAIL
- 2305-1015-9 DETAIL
- 2305-1015-10 DETAIL
- 2305-1015-11 DETAIL
- 2305-1015-12 DETAIL
- 2305-1015-13 DETAIL
- 2305-1015-14 DETAIL
- 2305-1015-15 DETAIL
- 2305-1015-16 DETAIL
- 2305-1015-17 DETAIL
- 2305-1015-18 DETAIL

DIST. 18  
**CONT No**  
**WP No** 147-65-10  
**GOULAIS RIVER BRIDGE**  
**FOOTING LAYOUT & DETAILS**

**SHEET**

**METRIC**

DIMENSIONS ARE IN MILLIMETRES  
 UNLESS OTHERWISE SHOWN.  
 ELEVATIONS, COORDINATES, CURVE  
 AND ALIGNMENT DATA ARE IN METRES.  
 STATIONS ARE IN KILOMETRES + METRES.

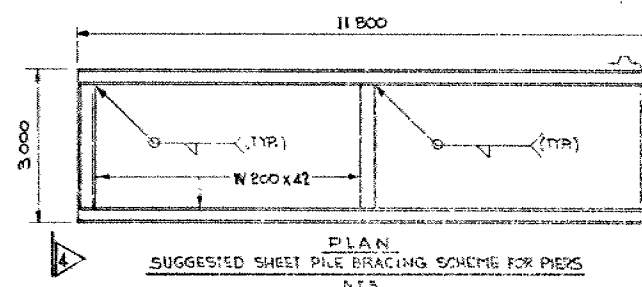


PILE DATA									
LOCATION	NO.	BATTER	LENGTH (mm)	CUT OFF ELEVATION	TYPE	PILE DESIGN DATA	LOAD @ ELS TYPE II @ USL	FACTORED CAPACITY @ USL	REMARKS
S. ABUT.	1	1:3	21 300	332.100	324mm O.D. x 6.3mm	DO	400K	860K	WITH DRIVING SHOES
	10	1:3	22 300	332.100	324mm O.D. x 6.3mm	DO	DO	DO	DO
S. PIER	24	1:3	25 300	228.800	324mm O.D. x 6.3mm	DO	DO	DO	DO
	3	5:1 R.	25 000	228.800	324mm O.D. x 6.3mm	DO	DO	DO	DO
N. PIER	24	1:3	25 300	228.800	324mm O.D. x 6.3mm	DO	DO	DO	DO
	3	5:1 R.	25 000	228.800	324mm O.D. x 6.3mm	DO	DO	DO	DO
N. ABUT.	5	1:3	22 000	332.800	324mm O.D. x 6.3mm	DO	DO	DO	DO
	13	1:3	23 000	332.800	324mm O.D. x 6.3mm	DO	DO	DO	DO

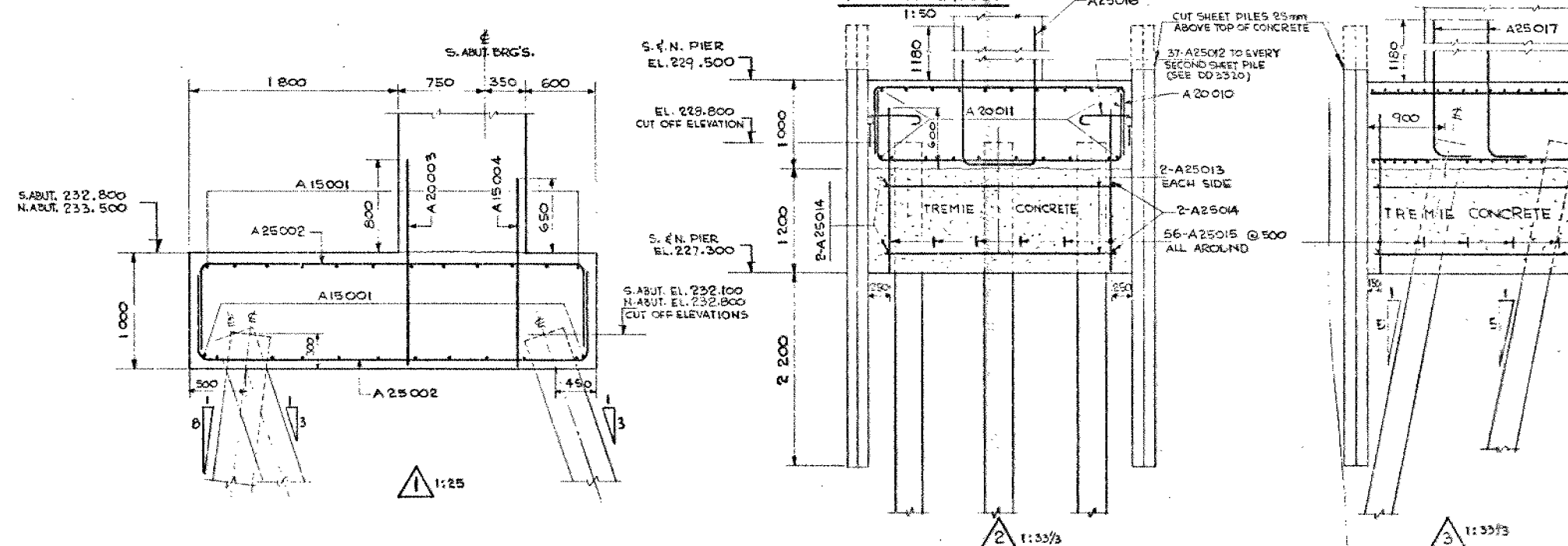
NOTE: PILE LENGTHS SHOWN ARE THEORETICAL LENGTHS BELOW CUT-OFF ELEVATION.

SHEET PILE DATA			
LOCATION	TYPE	NO.	LENGTH
S. PIER	PDA 27 74	4	4 500
	C12 C	4	4 500
N. PIER	PDA 27 74	4	4 500
	C12 C	4	4 500

- NOTES:
- PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTINGS.
  - SHEET PILES ARE NOT DESIGNED TO PENETRATE THE COBBLES, BOULDERS OR ROCK FRAGMENTS. REMOVAL OF COBBLES, BOULDERS AND ROCK FRAGMENTS MIGHT BE NECESSARY TO INSTALL SHEET PILES TO REQUIRED ELEVATION.
  - NO DEWATERING SHALL BE DONE WHEN WATER ELEVATION IS HIGHER THEN 230 m.



**FOOTING LAYOUT.**

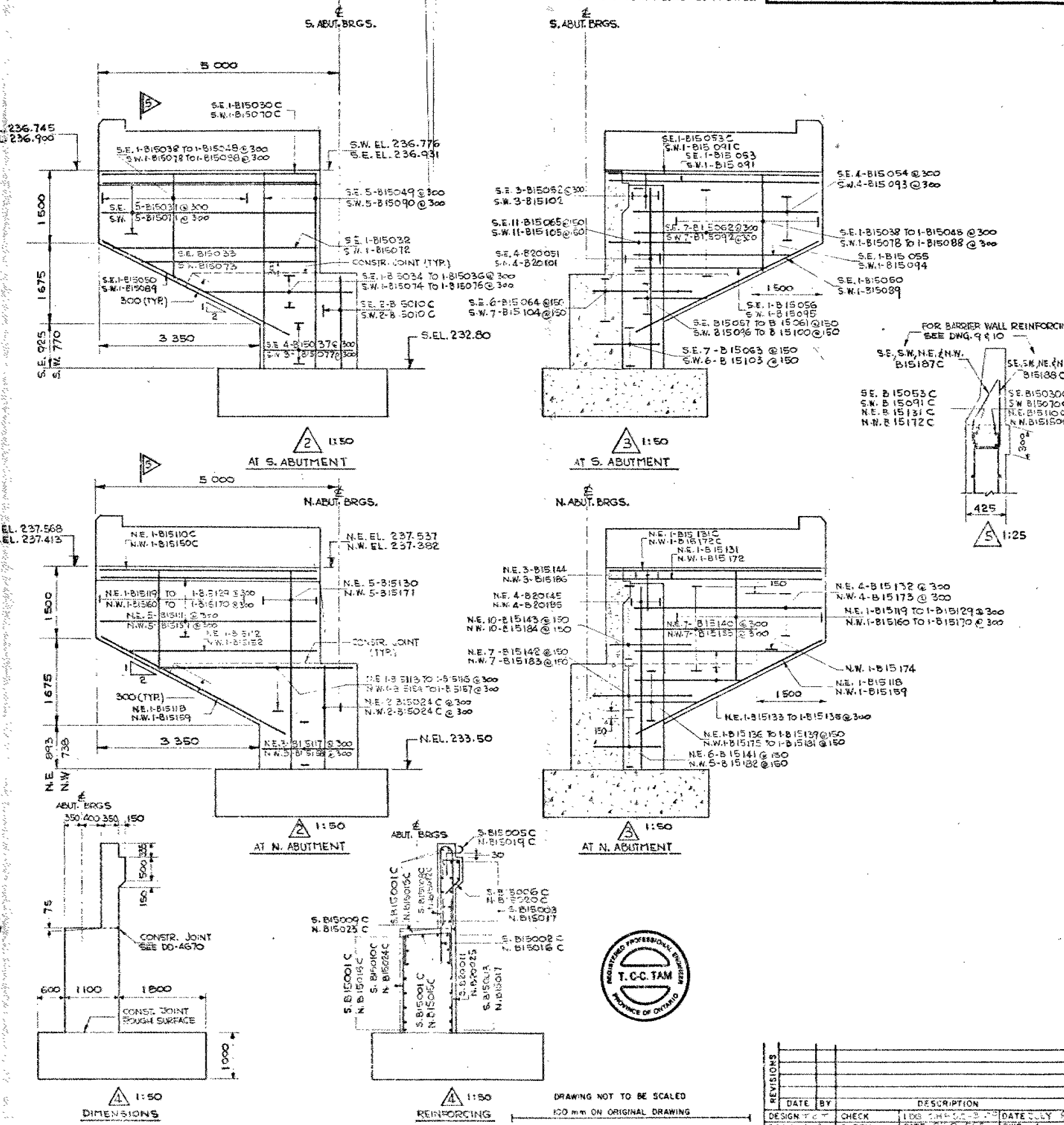
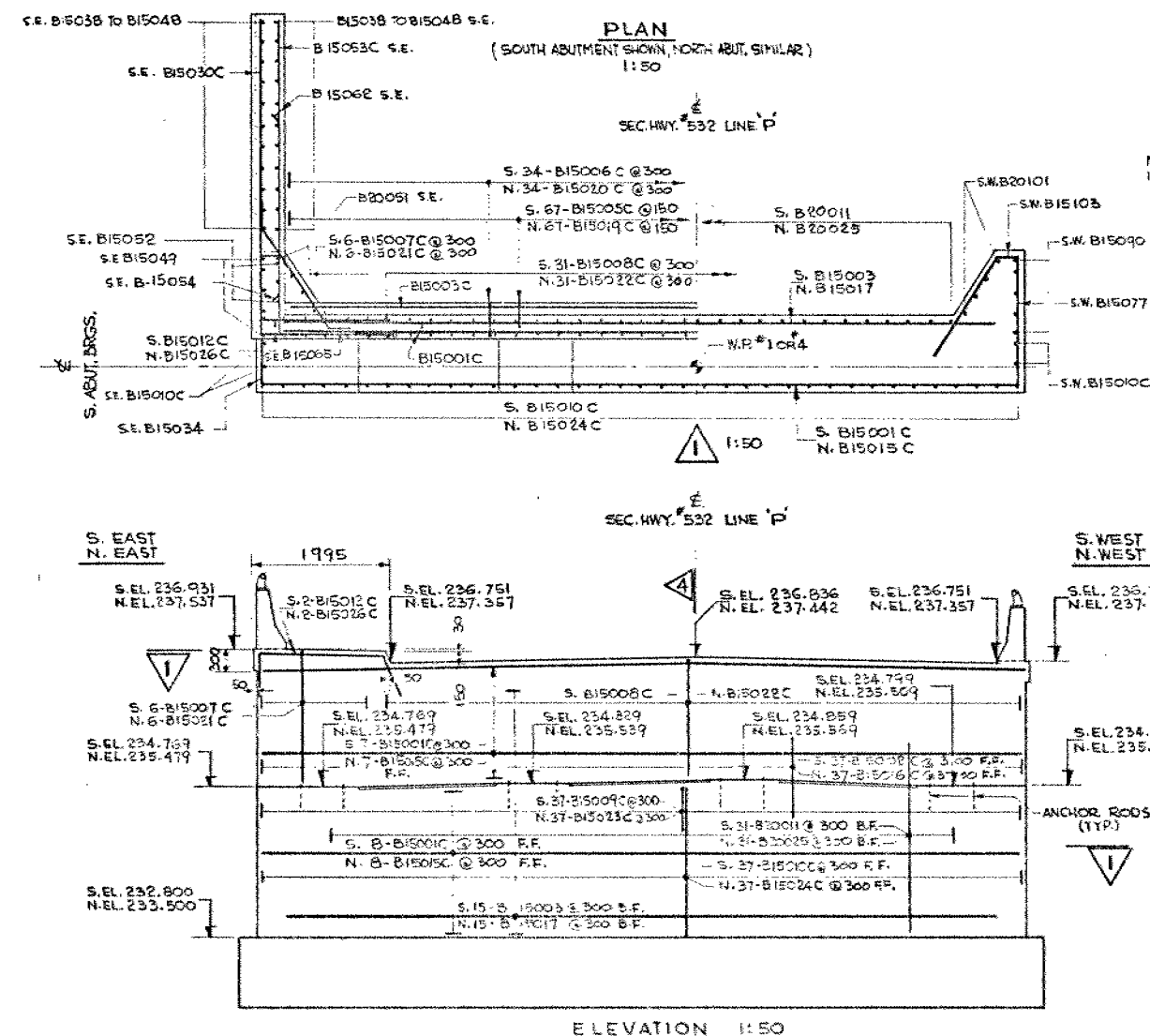
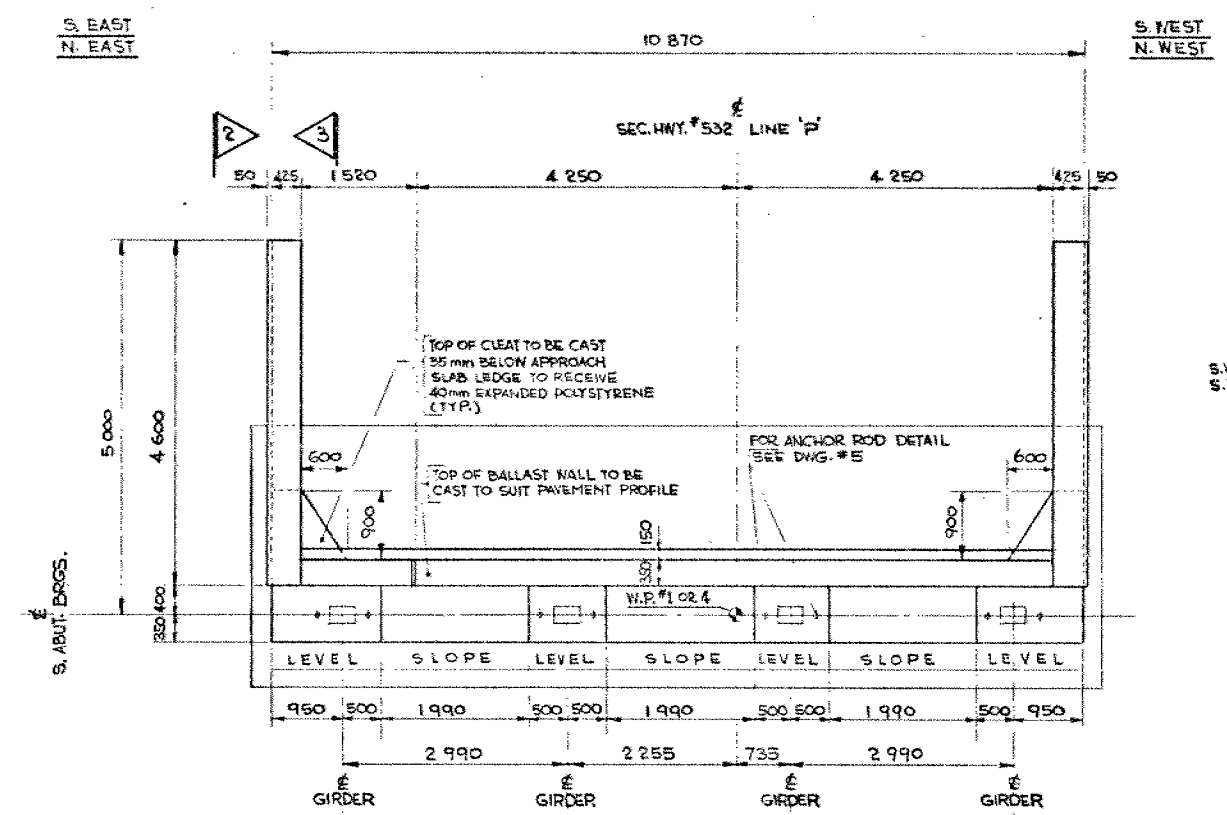


DRAWING NOT TO BE SCALED  
 100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

**METRIC**

DIMENSIONS ARE IN MILLIMETRES  
UNLESS OTHERWISE SHOWN.  
ELEVATIONS, COORDINATES, CURVE  
AND ALIGNMENT DATA ARE IN METRES.  
STATIONS ARE IN KILOMETRES + METRES.



REVISIONS	DATE	BY	DESCRIPTION

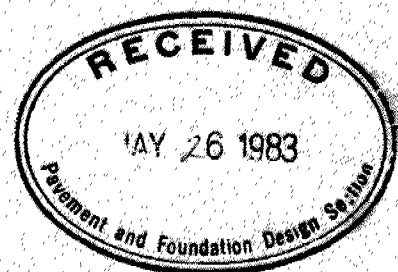
DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 83-215



Ministry of  
Transportation and  
Communications



INDEX

<u>Page No.</u>	<u>Description</u>
1	Index
2	Abbreviations and Symbols
3 - 18	Foundation Investigation Report For: Goulais River Crossing W.P. 147-65-00, Site 38S-265 Hwy. 532, District 18, Sault Ste. Marie

NOTE: For purposes of the contract this report supersedes all other foundation reports prepared by or for the Ministry in connection with the above-mentioned project.

## EXPLANATION OF TERMS USED IN REPORT

2

**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/0.3 m)	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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kn/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kn/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kn/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kn/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## FOUNDATION INVESTIGATION REPORT

For

GOULAIS RIVER CROSSING AND HIGHWAY 532  
W.P. 147-65-00, Site 38S-265  
District 18, Sault Ste. Marie

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### INTRODUCTION

This report contains the results of a foundation investigation that was performed at the above-mentioned site. The investigation was commenced on September 1, 1981 and continued to completion on September 5, 1981. Four boreholes were advanced using a combination of hollow stem continuous flight augers, NX casing, BX casing and washboring techniques. The boreholes ranged in depth from 24.1 metres to 27.9 metres. One dynamic cone penetration test was also conducted and advanced to a depth of 16.8 metres. Bedrock was not encountered in any of the borings to the depths investigated at the site.

### SITE DESCRIPTION AND GEOLOGY

The site is located on Highway 532 at Searchmont, in the Township of Hodgins, District of Algoma.

The existing structure is a single lane, approximately 84 metre long bailey bridge with a timber sidewalk on the west side. The bailey bridge is supported on five evenly spaced timber pile bents which have been reinforced with a system of steel H-piles and bracing.

The Goulais River flows generally in a south-westerly direction with a medium to negligible rate of flow at the time of the investigation. The watershed is long and relatively narrow in shape, with numerous small tributaries.



The topography at the site is relatively flat to gently rolling, and the vicinity of the crossing is heavily wooded although there is a small settlement nearby, i. e., the community of Searchmont.

The Goulais River is located in an ancient glacial valley with the relative relief in the distance greater than 60 metres. The river is approximately 50 metres wide and 1 metre deep at the crossing. The river has a very high flood stage and rises rapidly. According to available information, normal creek water levels are approximately elevation 230.0 with a 4.6 metre flood rise. From discussions with local people, this high and rapid flood rise is a major concern since occasionally the river floods the homes located immediately south of the existing bridge location.

The river banks at the proposed bridge location are quite steep, but do not indicate any deep seated failure. There are, however, many examples of surficial failures caused by erosion and undercutting of the river banks. Generally, the site conditions indicate that scour and undercutting are the main problems requiring remedial measures.

The river valley itself is quite wide and the present river meanders considerably. Local people have confirmed that the river channel has shifted considerably at various locations.

According to available geological information, the bedrock in parts of the Goulais River Valley is covered by extensive deposits of thick overburden. The underlying materials in the Goulais River Valley are of a glaciofluvial landform (outwash) and vary from varved silt and clay to glacial till and bedrock. The bedrock is of the Middle Precambrian era and consists of a felsic intrusive and metamorphic rock.

#### SUBSURFACE CONDITIONS

The predominate deposit underlying the site is a silty sand to sandy silt. This deposit was explored to an approximate elevation of 202.0 which corresponds to a depth of 27.6 metres. The lower boundary of this deposit was not established.

Overlying the above at the north and south banks of the river and encountered to a maximum depth of 7.3 metres below the ground surface is a gravelly sand deposit with traces of silt. This deposit was in turn covered by a surficial stratum of fine sand with silt, varying in depth from 4.3 metres at the south bank to 1.2 metres at the north bank.

Overlying the predominant deposit (silty sand to sandy silt) at the river bed and encountered to a maximum depth of 2.5 metres is a silty sand and gravel and surficial cobbles.

The boundaries between the various soil types, insitu and laboratory test results are shown on the attached Record of Borehole sheets. The locations and elevations of the borings, along with an estimated stratigraphical profile based on the borehole data, are shown

on Drawing No. 2. The various subsoil types are briefly described in the following paragraphs.

#### Fine Sand with Silt

Overlying the site, immediately below a thin layer of topsoil, at the north and south bank of the Goulais River, is a surficial deposit of fine sand with silt. This material was encountered to depths of 1.2 metres and 4.3 metres on the north and south banks respectively.

Based on the interpretation of the 'N' values obtained from the Standard Penetration Test, it can be inferred that the overlying material is in a loose to very loose state.

Typical grain size distribution curves obtained in this strata are shown on Figure 1.

#### Silty Sand and Gravel and Surficial Cobbles

Overlying the site within the river bed is a surficial deposit of silty sand and gravel. This deposit was encountered to a maximum depth of 2.5 metres. Within this deposit in the upper portion, numerous cobbles were present. Due to the presence of the surficial cobbles, much difficulty was encountered while trying to penetrate this layer.

Typical grain size distribution curves obtained in this strata are shown on Figure 2.

#### Gravel with Sand to Sand with some Gravel

Underlying the surficial deposit of fine sand with silt at

the north and south bank is a layer of gravel with sand to sand with some gravel. This deposit was encountered to depths of 6.5 metres and 7.3 metres on the north and south banks respectively. At the south bank, cobbles were encountered throughout this layer.

Based on the interpretation of the 'N' values obtained from the Standard Penetration Test, which ranged from 5 to 33 blows per 0.3 metres, it can be inferred that this deposit is in a dense to loose state. These 'N' values, however, can be quite misleading due to the presence of gravel and cobbles.

Typical grain size distribution curves obtained in this deposit are shown on Figure 3.

#### Silty Sand to Sandy Silt

The predominate deposit underlying the site and explored to a maximum depth of 27.6 metres, i. e., elevation 202.0, is a silty sand to sandy silt. In general, the composition of the material varies randomly across the site.

Standard Penetration Tests carried out within this deposit gave 'N' values ranging from 4 to 49 blows per 0.3 metres. Based on these values, it can be inferred that the relative density of this deposit varies randomly between loose to compact in the upper portion of the deposit, however, this deposit is generally dense in the lower portion.

Typical grain size distribution curves obtained in this deposit are shown in envelope form on Figure 4.

Groundwater Conditions

Groundwater elevations were obtained in both boreholes carried out on the banks and were found to be at approximate elevation 229.6. These groundwater levels generally reflected the prevailing river water levels at the time of the investigation.

*Brian Ruck*

Brian Ruck  
Trainee Engineer



*M. Devata*  
M. Devata, P. Eng.  
Senior Foundations Engineer

A P P E N D I X

# RECORD OF BOREHOLE No 1

METRIC 10

W P 147-65-00 LOCATION Sta. 16+438.5; o/s 6.2 m Rt. of Hwy 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Hollow Stem Continuous Flight Augers - BX casing COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 01 to 02 CHECKED BY *CP*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
235.1	Ground Surface														
0.0	Fine sand with silt		1	SS	6										0 72 27 1
233.9	Brown Loose		2	SS	23										42 54 (4)
1.2	Gravelly sand to sand with some gravel with traces of silt		3	SS	19										
			4	SS	29										
			5	SS	14										
228.6	Compact to Loose		6	SS	5										11 79 (10)
6.5	Sandy silt to silt with varying amounts of sand with traces of gravel and clay		7	SS	5										0 45 51 4
			8	SS	6										
			9	SS	7										
			10	SS	6										
			11	SS	11										
			12	SS	8										
	Loose		13	SS	18										0 45 54 1
			14	SS	6										
			15	SS	9										16 21 62 1
			16	SS	5										
			17	SS	8										
	Compact to Dense		18	SS	35										
			19	SS	13										
207.2			20	SS	27										0 6 88 6
27.9	End of Borehole														

\*Water level obtained  
on 81 09 02  
Augered 0-12 m

BX Casing 12 m-25 m  
Wash Boring 25 m-27.9 m

3, x 5; Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No 2

METRIC 11

W P 147-65-00 LOCATION Sta. 16+350.0; Q Highway 532 Line 'P' ORIGINATED BY N. S.  
 DIST 18 HWY 532 BOREHOLE TYPE Hollow Stem Continuous Flight Augers - BX Casing COMPILED BY N. S.  
 DATUM Geodetic DATE 81 09 03 CHECKED BY SP.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH					
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL			x LAB VANE
233.8	Ground Surface												
0.0	Fine sand with silt and traces of organics		1	SS	8								
			2	SS	4								
	Brown		3	SS	3								
	Loose to very loose		4	SS	3								
229.5													
4.3	Gravel with sand and cobbles throughout		5	SS	16								
			6	SS	33								
			7	SS	8								
226.5													
7.3	Silty sand to sandy silt with traces of gravel		8	SS	6								
			9	SS	9								
			10	SS	5								
			11	SS	8								
			12	SS	4								
			13	SS	6								
			14	SS	9								
	Loose to compact		15	SS	8								
			16	SS	13								
			17	SS	20								
209.0													
24.8	End of Borehole *Water level obtained on 81 09 03  Augered 0-8m BX casing 8m-24.8 m												

+3, x5: Numbers refer to  
Sensitivity

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





# RECORD OF BOREHOLE No 3

METRIC 12

W P 147-65-00 LOCATION Sta. 16+416.5; o/s 2.3 m Rt. of C Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE NX Casing - BX Casing - Wash Boring COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 02 to 03 CHECKED BY P.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
229.6	Water Surface																
229.1	Water																
0.5	Silty sand and gravel and surficial cobble		1	SS	60/5		228										10 64 24 2
227.1			2	SS	11												
2.5	Silty sand to sandy silt		3	SS	9		226										0 55 44 1
			4	SS	9												
			5	SS	10												
			6	SS	8		224										
			7	SS	10												
			8	SS	18		222										0 93 (7)
			9	SS	7												
			10	SS	14		220										0 27 72 1
			11	SS	11												
			12	SS	11		218										0 44 51 5
			13	SS	6												
			14	SS	13		214										
			15	SS	12												
			16	SS	29		212										0 34 65 1
			17	SS	26												
			18	SS	37		206										
			19	SS	49		204										0 40 59 1
202.0																	
27.6	End of Borehole Nx Casing 0-11 m Bx Casing 11 m-18 m Wash Boring 18 m-27.6 m																

+3, x<sup>5</sup>: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10



# RECORD OF BOREHOLE No 4

METRIC 13

W P 147-65-00 LOCATION Sta. 16+373.8; o/s 1.0 m Rt. of Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Bx Casing - Wash Boring COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 05 CHECKED BY *JP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>			
								SHEAR STRENGTH		WATER CONTENT (%)				
							○ UNCONFINED    + FIELD VANE							
							● QUICK TRIAXIAL    x LAB VANE							
229.6	Water Surface										10 20 30		GR SA SI CL	
228.9	Water													
0.7	Silty sand and gravel and surficial cobbles		1	SS	70	13 cm	228				○		0 32 66 2	
227.6			2	SS	10						○			
2.0	Silty sand and sandy silt		3	SS	9		226							
			4	SS	11									
			5	SS	7		224				○		0 46 48 6	
			6	SS	7		222							
			7	SS	13						○		0 81 18 1	
			8	SS	13		220							
	Traces of gravel		9	SS	15		218							
			10	SS	12		216				○		0 80 19 1	
	Loose to compact		11	SS	14		214							
			12	SS	17									
			13	SS	20		212							
			14	SS	19		210							
							208							
205.5	Dense		15	SS	48		206				○		0 32 65 1	
24.1	End of Borehole Bx Casing 0-17 m Wash Boring 17 m-24.1 m													

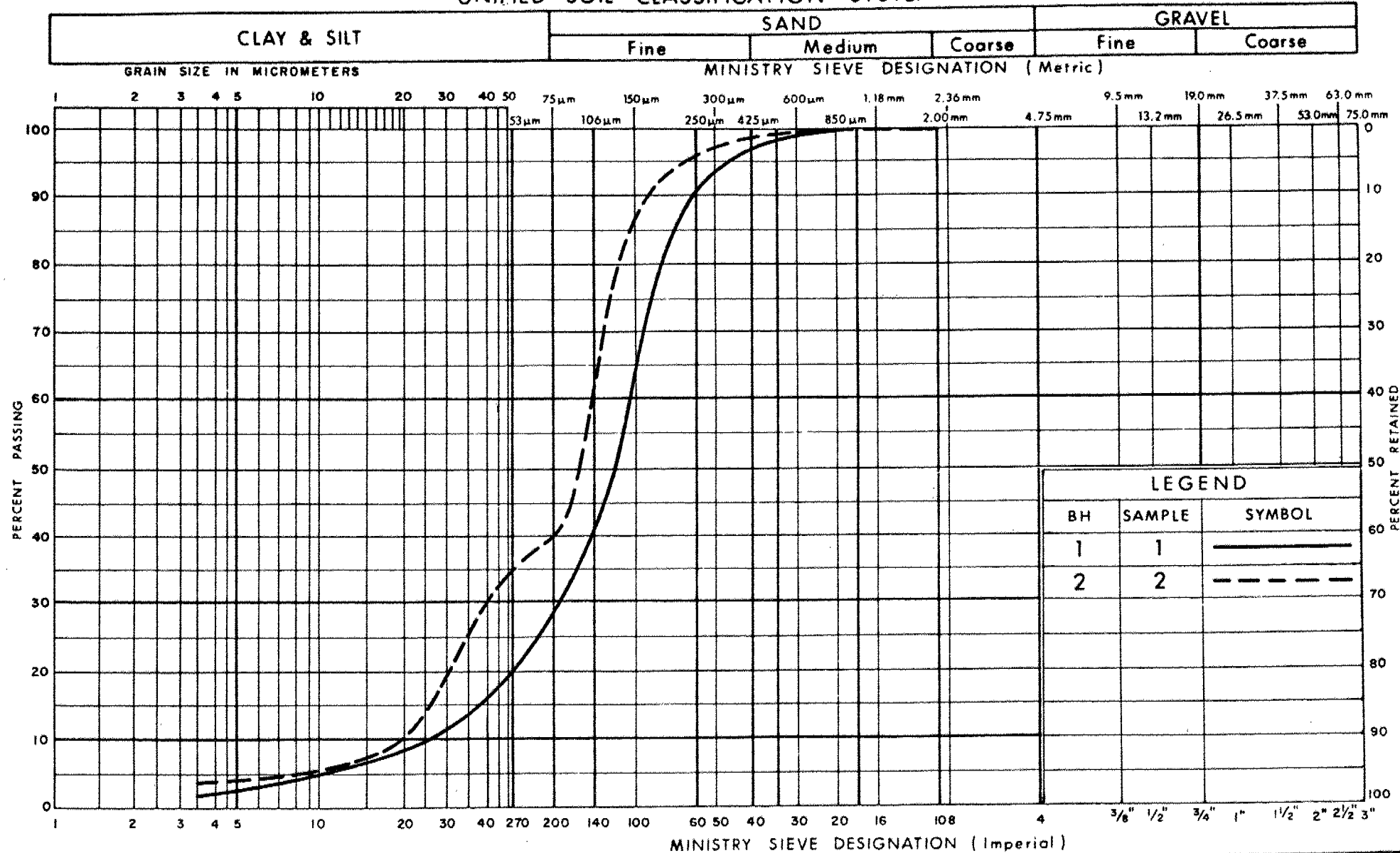
+3, x5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

+3, x<sup>5</sup>: Numbers refer to Sensitivity

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

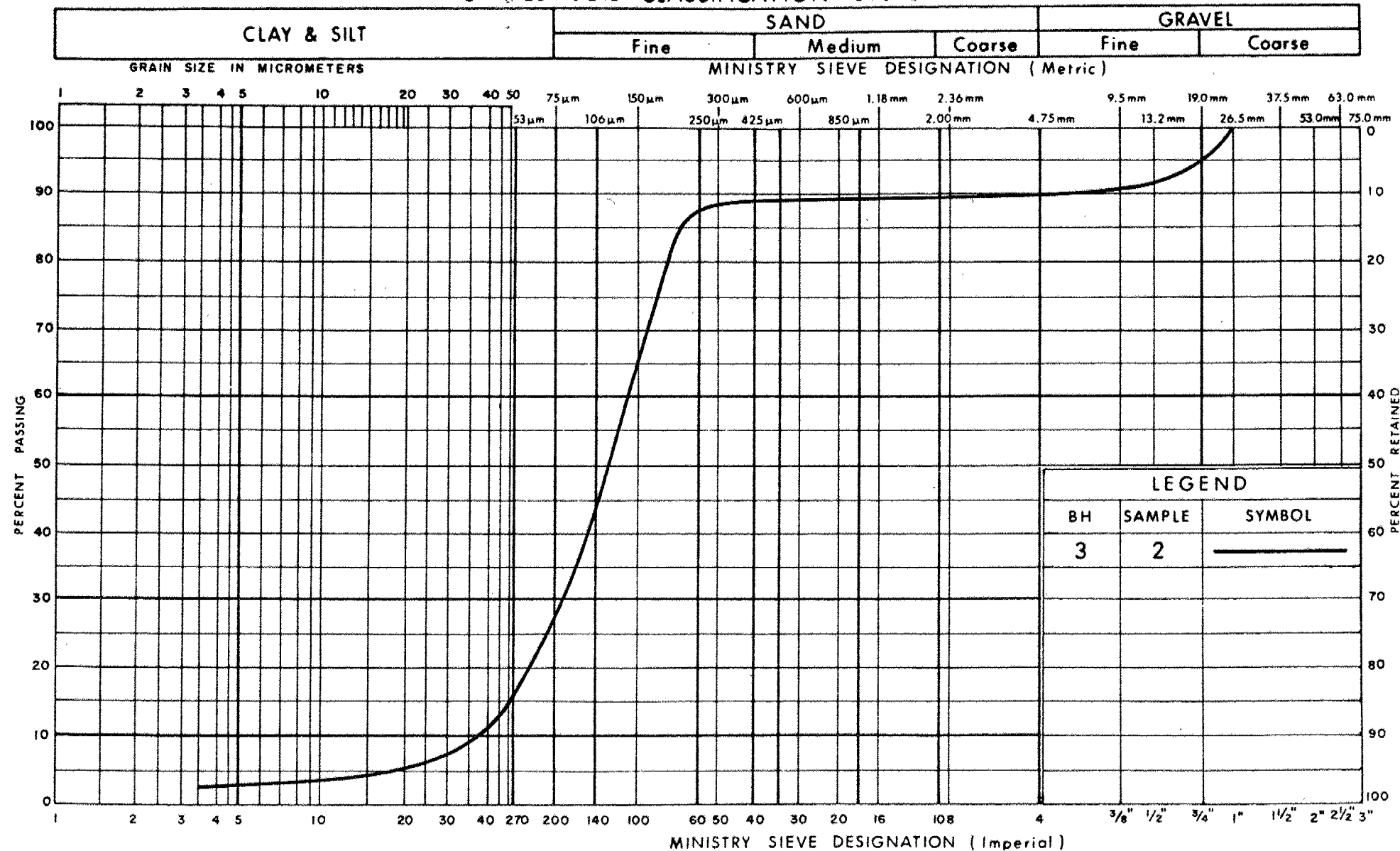
 Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
FINE SAND, WITH SILT

FIG No 1

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



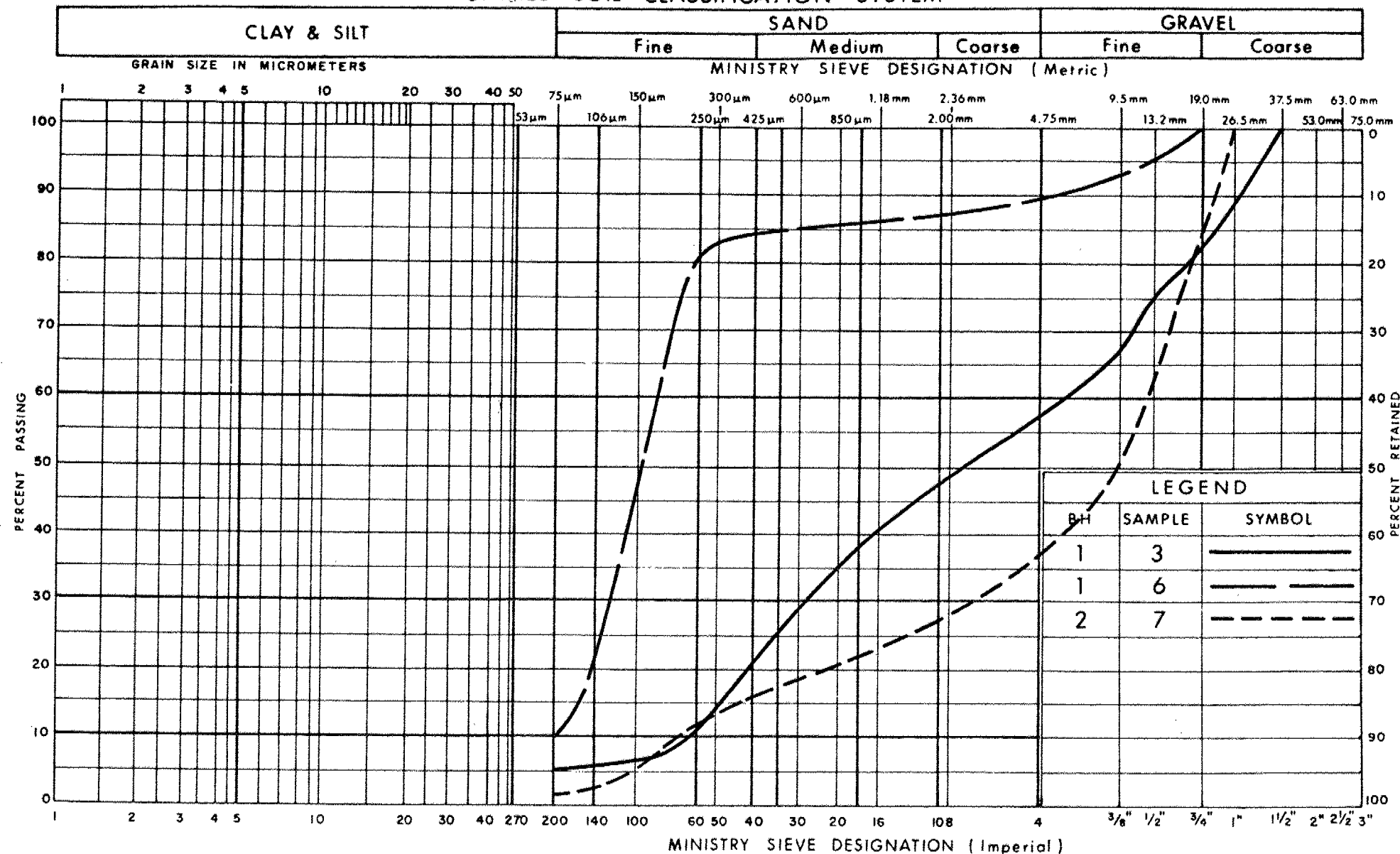
Ministry of  
Transportation and  
Communications

**GRAIN SIZE DISTRIBUTION**  
**SILTY SAND AND GRAVEL AND SURFICIAL COBBLES**

FIG No 2

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



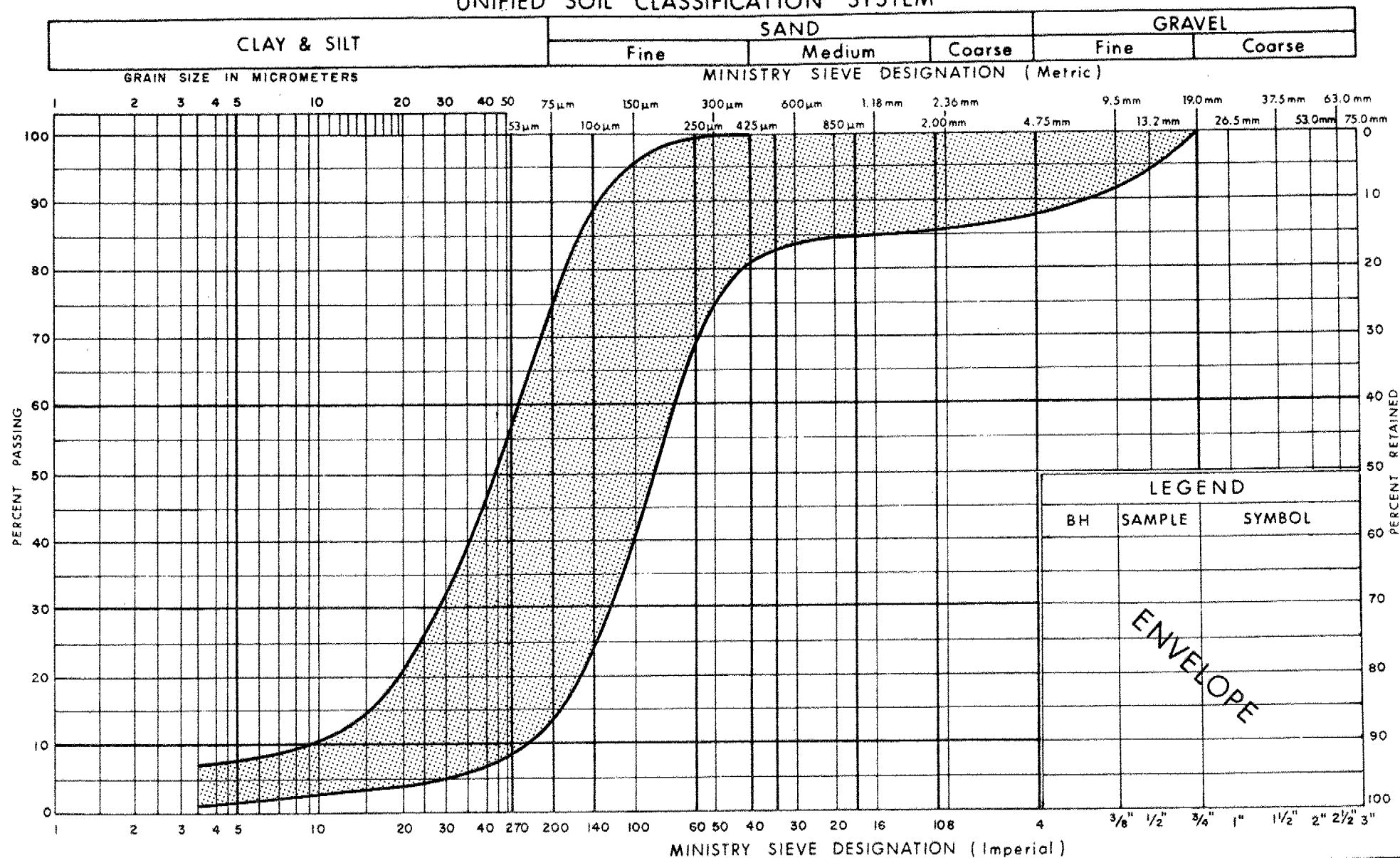
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
GRAVEL WITH SAND TO SAND WITH SOME GRAVEL

FIG No 3

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SANDY SILT  
TRACES OF GRAVEL AND CLAY

FIG No 4

W P 147-65-00

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 147-65-00

DIST 18

HWY 532

STR SITE 38s-265

GOULAIS RIVER CROSSING AND HIGHWAY 532

DISTRIBUTION

W. W. Kulmatickas (2)  
R. Girard  
D. Aspinwall (2)  
W. A. Stewart (2)  
C. Grebski  
B.J. Giroux  
R. Hore

K. Maluzinsky Cover only  
J. Anderson Cover only  
T. J. Kovich Cover only

Files



FOUNDATION INVESTIGATION REPORT  
For  
Goulais River Crossing and Highway 532  
W. P. 147-65-00, Site 38S-265  
District 18, Sault Ste. Marie

INTRODUCTION

This Report contains the results of a foundation investigation that was performed at the above-mentioned site and provides recommendations to the structure foundations and the related earthworks. The investigation was commenced on September 1, 1981 and continued to completion on September 5, 1981. Four boreholes were advanced using a combination of hollow stem continuous flight augers, NX casing, BX casing and washboring techniques. The boreholes ranged in depth from 24.1 metres to 27.9 metres. One dynamic cone penetration test was also conducted and advanced to a depth of 16.8 metres. Bedrock was not encountered in any of the borings to the depths investigated at the site.

SITE DESCRIPTION AND GEOLOGY

The site is located on Highway 532 at Searchmont, in the Township of Hodgins, District of Algoma.

The existing structure is a single lane, approximately 84 metre long bailey bridge with a timber sidewalk on the west side. The bailey bridge is supported on five evenly spaced timber pile bents which have been reinforced with a system of steel H-piles and bracing.

The Goulais River flows generally in a south-westerly direction with a medium to negligible rate of flow at the time of the investigation. The watershed is long and relatively narrow in shape, with numerous small tributaries.

The topography at the site is relatively flat to gently rolling, and the vicinity of the crossing is heavily wooded although there is a small settlement nearby, i. e., the community of Searchmont.

The Goulais River is located in an ancient glacial valley with the relative relief in the distance greater than 60 metres. The river is approximately 50 metres wide and 1 metre deep at the crossing. The river has a very high flood stage and rises rapidly. According to available information, normal creek water levels are approximately elevation 230.0 with a 4.6 metre flood rise. From discussions with local people, this high and rapid flood rise is a major concern since occasionally the river floods the homes located immediately south of the existing bridge location.

The river banks at the proposed bridge location are quite steep, but do not indicate any deep seated failure. There are, however, many examples of surficial failures caused by erosion and undercutting of the river banks. Generally, the site conditions indicate that scour and undercutting are the main problems requiring remedial measures.

The river valley itself is quite wide and well-incised. However, the present river meanders considerably and has a number of characteristics of a fairly young stream. Local people have confirmed that the river channel has shifted considerably at various locations. Such conditions suggest that a major river flowed here at the time of the retreat of the last glaciers, and the river has now been rejuvenated.

According to available geological information, the bedrock in parts of the Goulais River Valley is covered by extensive deposits of thick overburden. The underlying materials in the Goulais River Valley are of a glaciofluvial landform (outwash) and vary from varved silt and clay to glacial till and bedrock. The bedrock is of the Middle Precambrian era and consists of a felsic intrusive and metamorphic rock.

#### SUBSURFACE CONDITIONS

The predominate deposit underlying the site is a silty sand to sandy silt. This deposit was explored to an approximate elevation of 202.0 which corresponds to a depth of 27.6 metres. The lower boundary of this deposit was not established.

Overlying the above at the north and south banks of the river and encountered to a maximum depth of 7.3 metres below the ground surface is a gravelly sand deposit with traces of silt. This deposit was in turn covered by a surficial stratum of fine sand with silt, varying in depth from 4.3 metres at the south bank to 1.2 metres at the north bank.

Overlying the predominant deposit (silty sand to sandy silt) at the river bed and encountered to a maximum depth of 2.5 metres is a silty sand and gravel and surficial cobbles.

The boundaries between the various soil types, insitu and laboratory test results are shown on the attached Record of Borehole sheets. The locations and elevations of the borings, along with an estimated stratigraphical profile based on the borehole data, are shown

on Drawing No. 1476500-A. The various subsoil types are briefly described in the following paragraphs.

Fine Sand with Silt

Overlying the site, immediately below a thin layer of topsoil, at the north and south bank of the Goulais River, is a surficial deposit of fine sand with silt. This material was encountered to depths of 1.2 metres and 4.3 metres on the north and south banks respectively.

Based on the interpretation of the 'N' values obtained from the Standard Penetration Test, it can be inferred that the overlying material is in a loose to very loose state.

Typical grain size distribution curves obtained in this strata are shown on Figure 1.

Silty Sand and Gravel and Surficial Cobbles

Overlying the site within the river bed is a surficial deposit of silty sand and gravel. This deposit was encountered to a maximum depth of 2.5 metres. Within this deposit in the upper portion, numerous cobbles were present. Due to the presence of the surficial cobbles, much difficulty was encountered while trying to penetrate this layer.

Typical grain size distribution curves obtained in this strata are shown on Figure 2.

Gravel with Sand to Sand with some Gravel

Underlying the surficial deposit of fine sand with silt at

the north and south bank is a layer of gravel with sand to sand with some gravel. This deposit was encountered to depths of 6.5 metres and 7.3 metres on the north and south banks respectively. At the south bank a number of cobbles were encountered within this layer.

Based on the interpretation of the 'N' values obtained from the Standard Penetration Test, which ranged from 5 to 33 blows per 0.3 metres, it can be inferred that this deposit is in a dense to loose state. These 'N' values, however, can be quite misleading due to the presence of gravel and cobbles.

Typical grain size distribution curves obtained in this deposit are shown on Figure 3.

#### Silty Sand to Sandy Silt

The predominate deposit underlying the site and explored to a maximum depth of 27.6 metres, i. e., elevation 202.0, is a silty sand to sandy silt. In general, the composition of the material varies randomly across the site.

Standard Penetration Tests carried out within this deposit gave 'N' values ranging from 4 to 49 blows per 0.3 metres. Based on these values, it can be inferred that the relative density of this deposit varies randomly between loose to compact in the upper portion of the deposit, however, this deposit is generally dense in the lower portion.

Typical grain size distribution curves obtained in this deposit are shown in envelope form on Figure 4.

Groundwater Conditions

Groundwater elevations were obtained in both boreholes carried out on the banks and were found to be at approximate elevation 229.6. These groundwater levels generally reflected the prevailing river water levels at the time of the investigation.

## DISCUSSION AND RECOMMENDATIONS

A new permanent structure, along a new alignment slightly west of the old alignment (Line 'P'), is proposed to replace the existing single-lane bailey bridge carrying Highway 532 over Goulais River. This new alignment is consistent with the alignment of an older previous structure at this site, of which cut off timber pile remnants can still be seen. The proposed three-span structure will be approximately 90 metres long and 10 metres wide, this includes a 1.5 metre wide sidewalk on the east side of the proposed structure. A grade raise in the order of 1 metre at the north embankment to 2 metres at the south embankment (i. e., profile elevation of 236.4 at the north embankment and 236.0 at the south embankment) is also contemplated for the proposed bridge.

Recommendations to the foundations of the replacement structure and related earthworks follow.

### Structure Foundations

It is recommended that the proposed structure be supported on friction piles driven a sufficient depth in order to mobilize the recommended capacities. Two types of friction piles are considered to be suitable from a foundation point of view at this site.

### Option 1: Abutment Locations

A size 36 treated timber pile driven to a minimum embedment of 15.0 metres can be designed for a safe design loading of 100 kN/pile.

Net settlements of the pile foundations under these recommended loads should not exceed 25 mm.

Recommended design parameters based on the O. H. B. D. C. are as follows:

<u>Size 36 Treated Timber Pile Embedded</u>	<u>Factored Capacity at U. L. S.</u>	<u>Capacity at S. L. S. Type II</u>
15 metres	210 kN	100 kN

Pier Locations

A size 36 treated timber pile driven to a minimum embedment of 15.0 metres can be designed for a safe design loading of 315 kN/pile. Net settlements of the pile foundations under these recommended loads should not exceed 25 mm.

Recommended design parameters based on the O. H. B. D. C. are as follows:

<u>Size 36 Treated Timber Pile Embedded</u>	<u>Factored Capacity at U. L. S.</u>	<u>Capacity at S. L. S. Type II</u>
15 metres	315 kN	160 kN

Option 2: Abutment and Pier Locations

A size 324 mm O. D. x 6.3 mm wall thickness steel tube pile driven to a specified tip elevation (tip elevations to follow) can be designed for a safe design loading of ~~160~~<sup>400</sup> kN/pile. Net settlements of the pile foundations under these recommended loads should not exceed 25 mm.

Recommended design parameters based on the O. H. B. D. C. are as follows.



<u>Size 324 mm x 6.3 mm</u> <u>Steel Tube Pile</u>	<u>Factored Capacity</u> <u>at U. L. S.</u>	<u>Capacity at S. L. S.</u> <u>Type II</u>
	860 kN	400 kN

The recommended tip elevations at the abutment locations is 211.0 and at the pier locations is 204.0.

### Option 3

Because of the presence of the loose to dense sand, an alternative scheme that may also be considered for this location, is a Franki type displacement caisson with an expanded base formed at an appropriate elevation.

From our previous experience with Franki type displacement caissons, typical shaft diameters could range from 14 inches (0.35 m), 18 inches (0.45 m) and 22 inches (0.55 m). Depending on the size and length of the caisson, the safe load that can be supported by such a caisson can vary from 620 kN to 1300 kN.

If such a scheme can be adopted, for this particular structure, pertinent recommendations such as tip elevation, caisson diameter and capacity of caisson can be provided on request.

### Construction Considerations

#### Option 1 Size 36 Treated Timber Piles

Some difficulty is anticipated in advancing the timber piles through the gravelly sand at both abutment locations and through the silty sand and gravel and surficial cobbles at both pier locations. In order to facilitate pile penetration through the aforementioned material, and prevent any damage to the timber piles, the following is recommended:

North abutment - pre-auger to elevation 231

South abutment - pre-auger to elevation 228

North and south piers - remove the silty sand and gravel and surficial cobbles. This material extends to approximate elevation 227 at the north pier and to approximate elevation 227.5 at the south pier.

If required (i. e., if pile caps are to be constructed at a somewhat higher than the subexcavated ground elevation) this area should be backfilled with well compacted granular material having a maximum gradation of 75 mm.

If Option 2, size 324 mm O. D. x 6.3 mm wall thickness steel tube pile is chosen, the above-mentioned pre-augering and subexcavation is not necessary.

Dewatering difficulties are anticipated for excavation of the pier caps since excavations will be carried out below the river water levels in a pervious material. In order to reduce water infiltration and thereby prevent the boiling of the foundation material due to the unbalanced hydrostatic head, sheet piles can be driven into the silty sand to sandy silt stratum to a depth of twice the prevailing head. The aforementioned can be easily incorporated if sheeting is used for scour protection for the pier caps.

Removal of the existing piles in the vicinity of the proposed piers is required before placement of the new piles.

### Other Considerations

The action of scour at this site is a serious one and it is most likely to have adverse effects on the river banks. In order to ensure the long-term stability of this area, it is recommended that revetment at the bridge crossing should be extended both upstream and downstream of the site. The following specific measures are recommended:

- (i) The steeper portions of the banks should be flattened to 2:1 slopes.
- (ii) New earth fills should be constructed with 2:1 slopes.
- (iii) The new earth fills and the flattened natural slopes should be protected against river erosion by providing a suitably placed rip rap scheme.

Subject to erosion and undercutting of the river banks being overcome by extensive rip-rapping, and provided that the embankments are constructed no steeper than 2:1, there should be no slope stability problems at this site.

The above recommendations should be incorporated along with recommendations provided by the Hydrology Section.

Earth pressures should be computed as per Subsection 6.6.1.2.2 of the O. H. B. D. C.

For frost protection purposes, the underside of the pile caps should have a minimum 1.8 metres of earth cover.

MISCELLANEOUS

The fieldwork for this investigation was carried out and written by Mr. N. Stea, Project Foundations Engineer and reviewed by Mr. M. Devata, Senior Foundations Engineer.

The equipment used for the investigation was owned and operated by Master Soil Investigation Ltd., Sudbury.

A handwritten signature in black ink, appearing to read "Nick Stea". The signature is stylized with a large, sweeping "S" and a long vertical line extending upwards from the "N".

N. Stea, P. Eng.,  
Project Foundations Engineer

A handwritten signature in black ink, appearing to read "M. Devata". The signature is written in a cursive style with a large "M" and a long, sweeping "D".

M. Devata, P. Eng.,  
Senior Foundations Engineer

A P P E N D I X



# RECORD OF BOREHOLE No 1

METRIC

W P 147-65-00 LOCATION Sta. 16+438.5; c/s 6.2 m Rt. of C Hwy 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Hollow Stem Continuous Flight Augers - BX casing COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 01 to 02 CHECKED BY *CP*

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
235.1	Ground Surface												
0.0	Fine sand with silt												
233.9	Brown Loose		1	SS	6	234							0 72 27 1
1.2	Gravelly sand to sand with some gravel with traces of silt		2	SS	23								
			3	SS	19	232							42 54 (4)
			4	SS	29								
			5	SS	14	230							
228.6	Compact to Loose		6	SS	5								11 79 (10)
6.5	Sandy silt to silt with varying amounts of sand with traces of gravel and clay		7	SS	5	228							0 45 51 4
			8	SS	6								
			9	SS	7	226							
			10	SS	6	224							
			11	SS	11								
			12	SS	8	222							
			13	SS	18	220							0 45 54 1
			14	SS	6	218							
			15	SS	9	216							16 21 62 1
			16	SS	5								
	Loose		17	SS	8	214							
						212							
			18	SS	35	210							
			19	SS	13								
207.2	Compact to Dense		20	SS	27	208							0 6 88 6
27.9	End of Borehole												
	*Water level obtained on 81 09 02 Augered 0-12 m												

BX Casing 12 m-25 m  
Wash Boring 25 m-27.9 m

+3, x5: Numbers refer to  
Sensitivity

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



Ministry of  
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Communications  
Ontario

## RECORD OF BOREHOLE No 2

METRIC

W P 147-65-00 LOCATION Sta. 16+350.0; Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Hollow Stem Continuous Flight Augers - BX Casing COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 03 CHECKED BY *GP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100								WATER CONTENT (%)		
								SHEAR STRENGTH								10 20 30		
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
233.8	Ground Surface														GR SA SI CL			
0.0	Fine sand with silt and traces of organics	.	1	SS	8	* ▽	232								0 60 37 3			
			2	SS	4		230											
	Brown		3	SS	3													
	Loose to very loose		4	SS	3													
229.5		.																
4.3	Gravel with sand and cobbles throughout	.	5	SS	16		228								64 34 (2)			
			6	SS	33													
			7	SS	8													
226.5		.																
7.3	Silty sand to sandy silt with traces of gravel	.	8	SS	6		226								4 44 49 3			
			9	SS	9		224									0 89 (11)		
			10	SS	5		222											
			11	SS	8		220									13 65 21 1		
			12	SS	4		218											
			13	SS	6		216											
			14	SS	9		214											
	Loose to compact		15	SS	8		212									0 38 61 1		
			16	SS	13	210												
209.0		.	17	SS	20													
24.8	End of Borehole *Water level obtained on 81 09 03  Augered 0-8m BX casing 8m-24.8 m																	

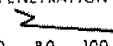
+3, x5: Numbers refer to  
Sensitivity

20  
15 - 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 3

METRIC

W P 147-65-00 LOCATION Sta. 16+416.5; o/s 2.3 m Rt. of Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE NX Casing - BX Casing - Wash Boring COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 02 to 03 CHECKED BY *SP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
229.6	Water Surface																
229.1	Water																
0.5	Silty sand and gravel and surficial cobbles		1	SS	60/5 cm		228							o			10 64 24 2
227.1			2	SS	11												
2.5	Silty sand to sandy silt		3	SS	9		226							o			0 55 44 1
			4	SS	9												
			5	SS	10												
			6	SS	8		224										
			7	SS	10												
			8	SS	18		222							o			0 93 (7)
			9	SS	7												
			10	SS	14		220							o			0 27 72 1
			11	SS	11												
			12	SS	11		218							o			0 44 51 5
			13	SS	6												
			14	SS	13		214										
			15	SS	12												
			16	SS	29		212							o			0 34 65 1
							210										
			17	SS	26		208										
							206										
			18	SS	37												
							204										
202.0			19	SS	49									o			0 40 59 1
27.6	End of Borehole Nx Casing 0-11 m Bx Casing 11 m-18 m Wash Boring 18 m-27.6 m																

+3, x<sup>5</sup>; Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10





# RECORD OF BOREHOLE No 4

METRIC

W P 147-65-00 LOCATION Sta. 16+373.8; o/s 1.0 m Rt. of Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Bx Casing - Wash Boring COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 05 CHECKED BY EP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
229.6	Water Surface															
228.9	Water															
0.7	Silty sand and gravel and surficial cobbles		1	SS	70	13 cm										
227.6			2	SS	10											
2.0	Silty sand and sandy silt		3	SS	9											
			4	SS	11											
			5	SS	7											
			6	SS	7											
			7	SS	13											
	Traces of gravel		8	SS	13											
			9	SS	15											
	Loose to compact		10	SS	12											
			11	SS	14											
			12	SS	17											
			13	SS	20											
			14	SS	19											
205.5	Dense		15	SS	48											
24.1	End of Borehole Bx Casing 0-17 m Wash Boring 17 m-24.1 m															

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10



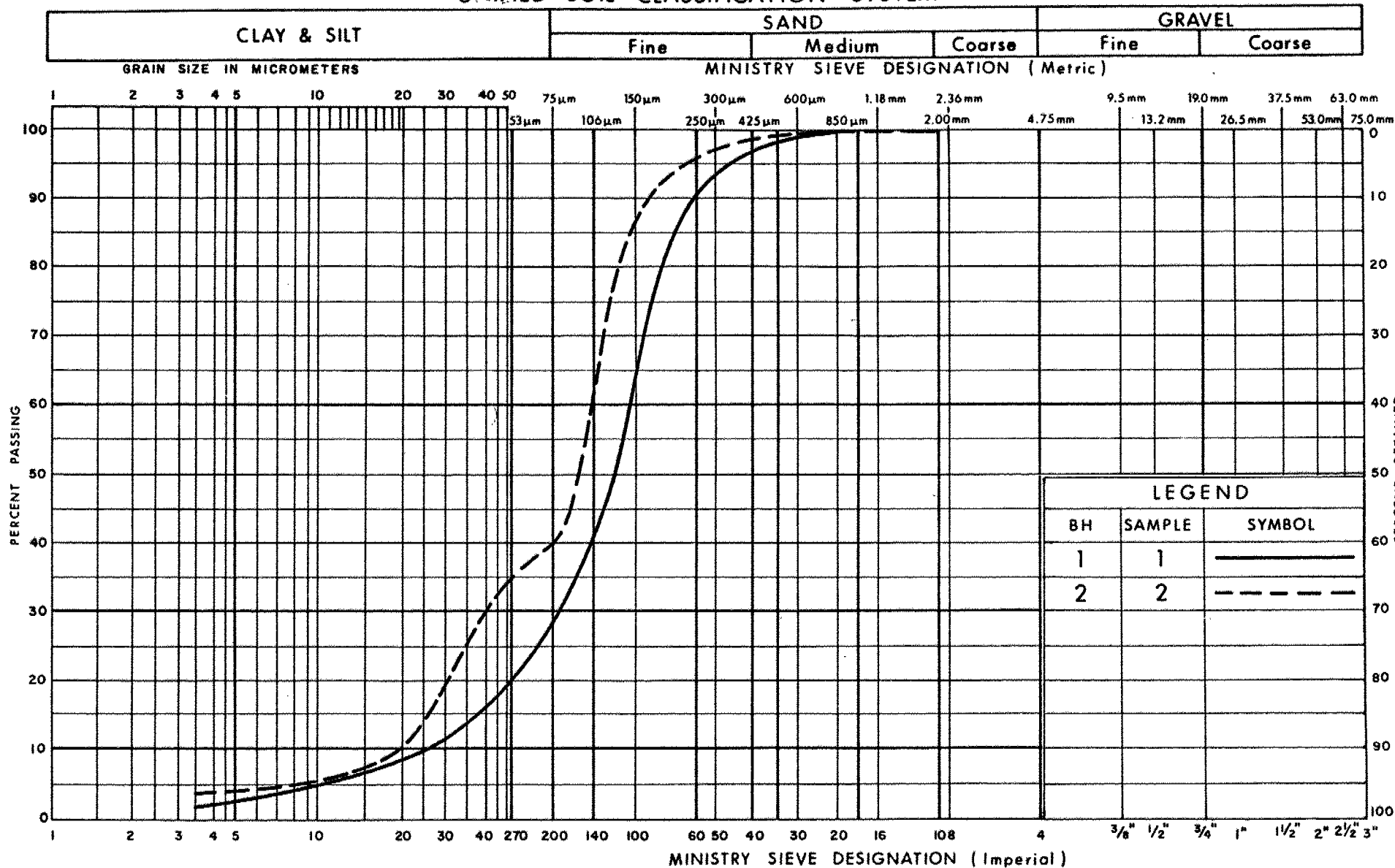
## METRIC

W P 147-65-00 LOCATION Sta. 16+438.3; o/s 5.0 m Lt. of ¢ Highway 532 Line 'P' ORIGINATED BY N. S.  
DIST 18 HWY 532 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY N. S.  
DATUM Geodetic DATE 81 09 02 CHECKED BY Q

[illegible]

+3, x5: Numbers refer to Sensitivity

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of  
Transportation and  
Communications

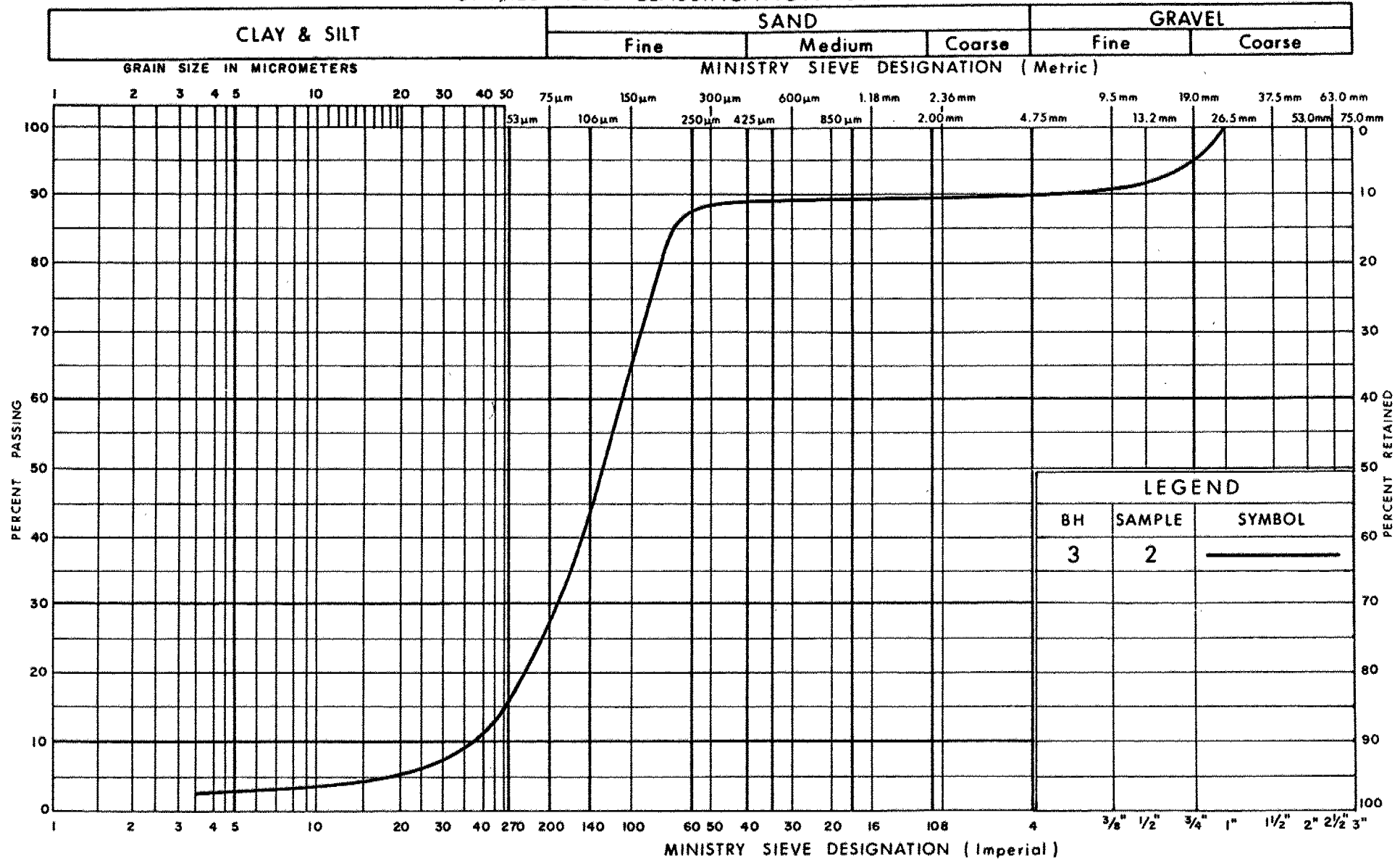
## GRAIN SIZE DISTRIBUTION

FINE SAND, WITH SILT

FIG No 1

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



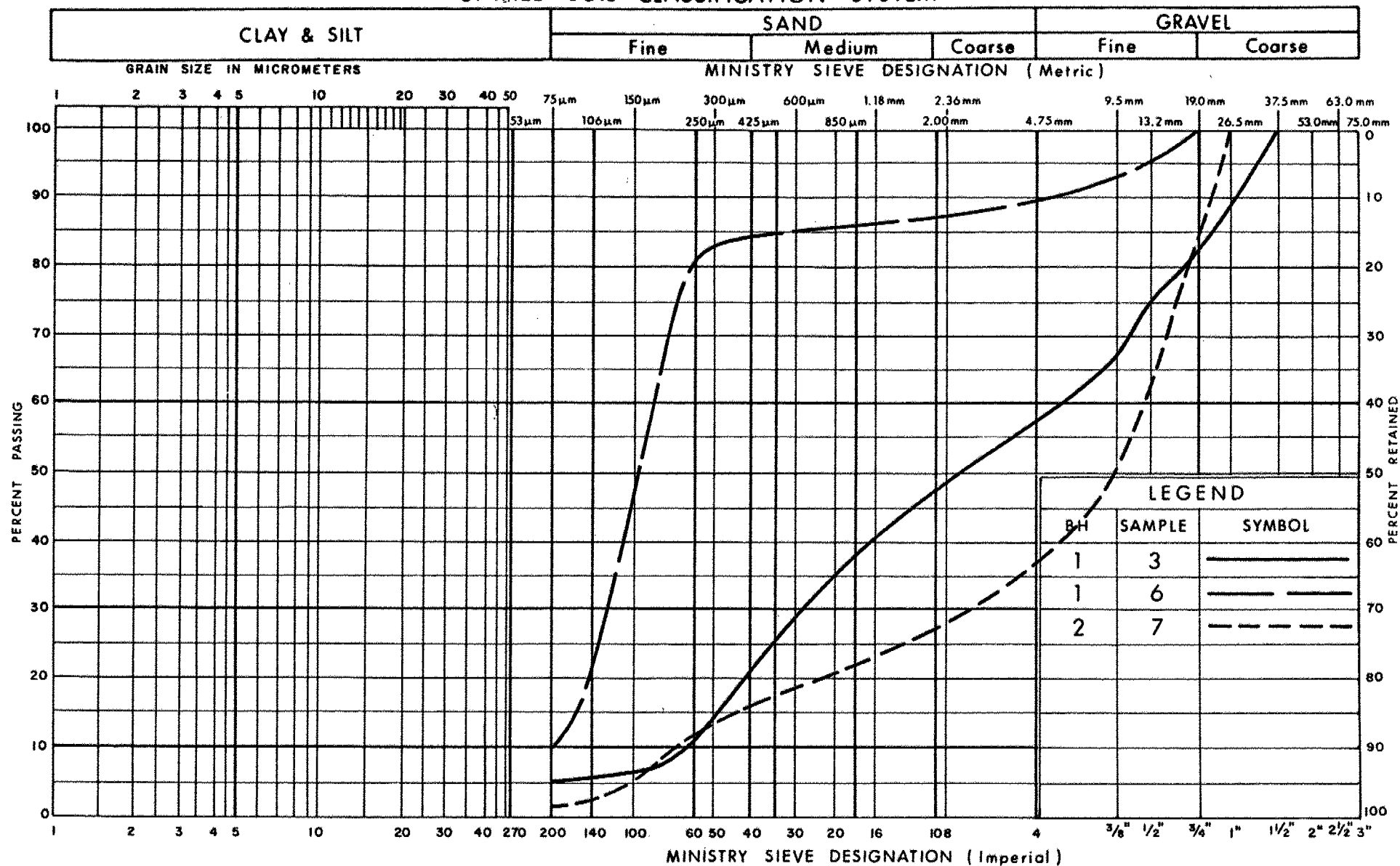
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND AND GRAVEL AND SURFICIAL COBBLES

FIG No 2

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



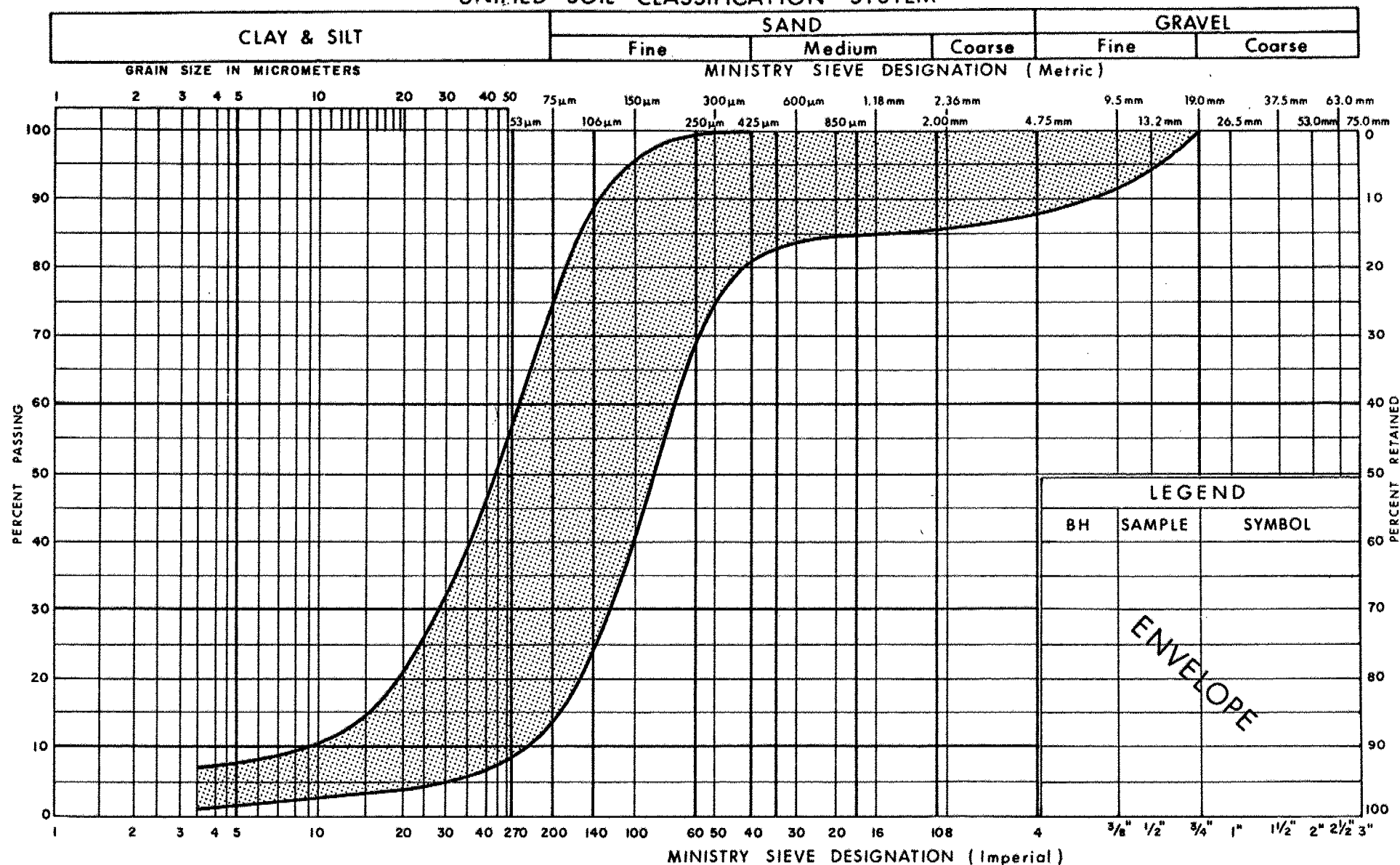
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
GRAVEL WITH SAND TO SAND WITH SOME GRAVEL

FIG No 3

W P 147-65-00

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND TO SANDY SILT  
TRACES OF GRAVEL AND CLAY

FIG No 4

W P 147-65-00

## 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

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

### STRESS AND STRAIN

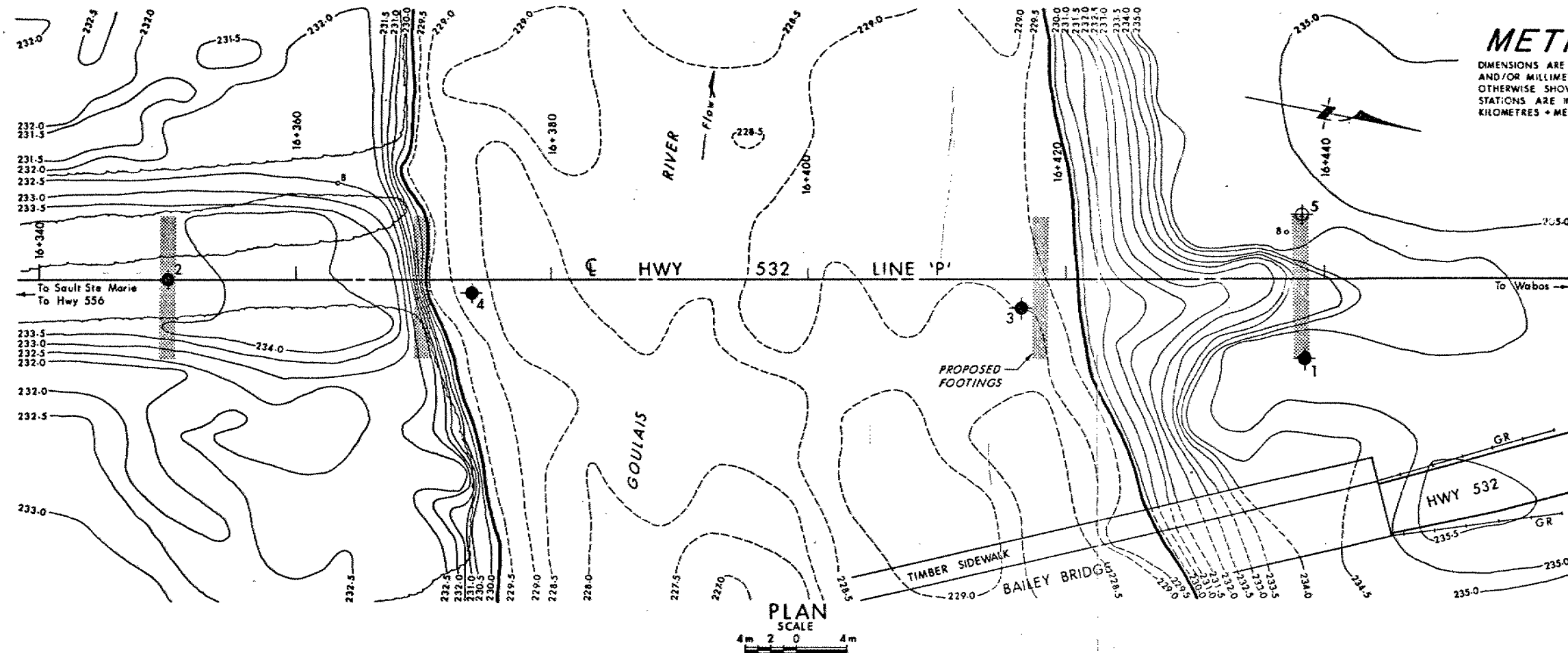
$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kn/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kn/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kn/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kn/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

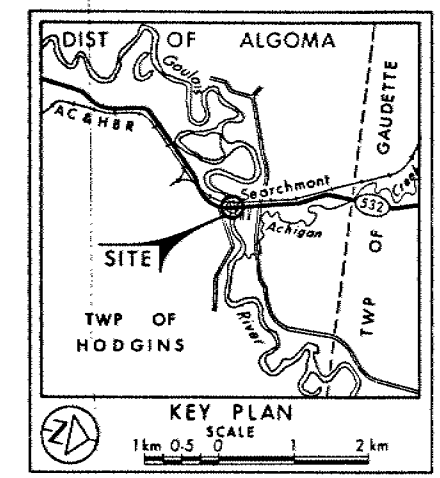


CONT No  
WP No 147-65-00

GOULAIS RIVER BRIDGE  
(AT SEARCHMONT)  
BORE HOLE LOCATIONS & SOIL STRATA

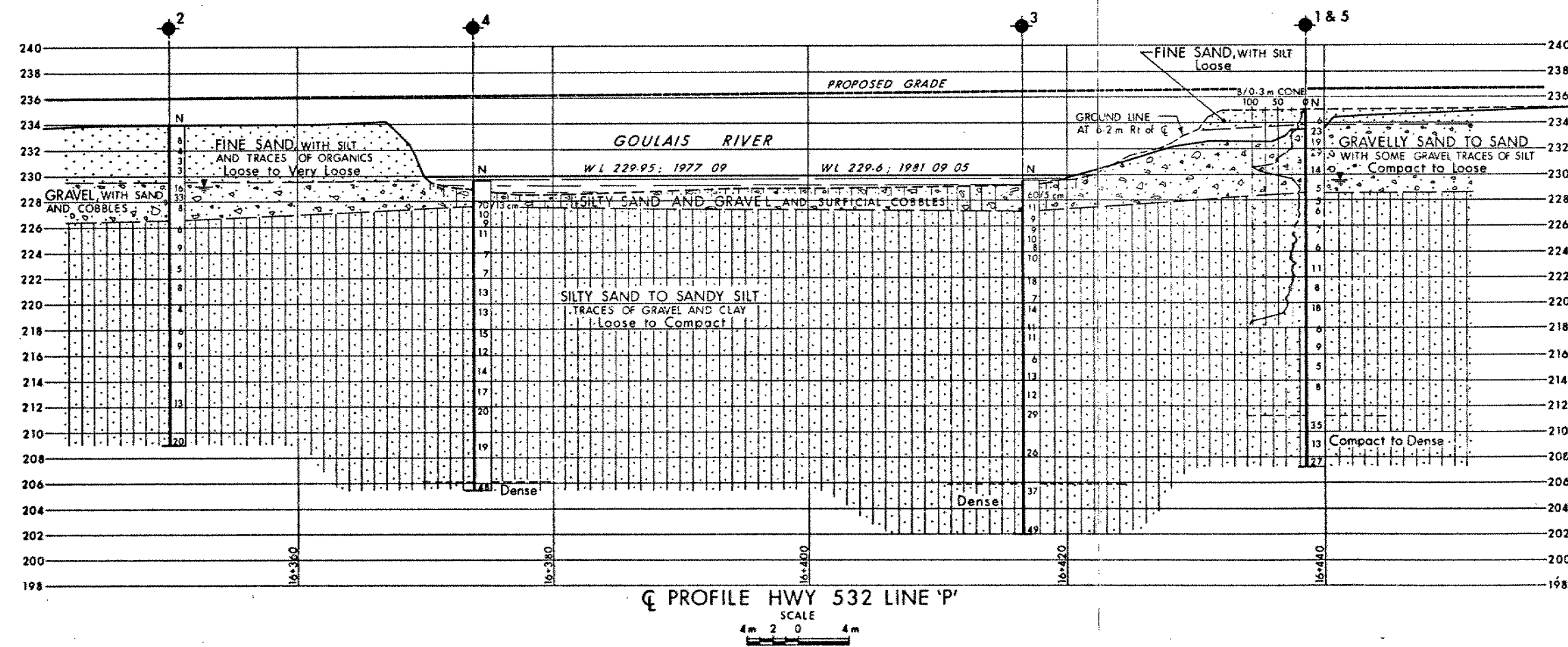


SHEET



**LEGEND**

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ✚ WL at time of investigation 1981 09



No	ELEVATION	STATION	OFFSET
1	235.1	16+438.5	6.2 m Rt
2	233.8	16+350.0	℄
3	229.6	16+416.5	2.3 m Rt
4	229.6	16+373.8	1.0 m Rt
5	235.0	16+438.3	5.0 m Lt

**NOTE**

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 41K-42

HWY No 532	CHECKED	DATE 1981 11 06	DIST 18
SUBM'DNS	CHECKED	SITE 385-265	
DRAWN	CHECKED	APPROVED	OWG 1476500-A

REF No E-8000-1; 1981 04