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CONT. No. 88-68

W. O. No.

STR. SITE No. 15-15

HWY. No. 15

LOCATION CPR Subway at Parenham

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 88-68

Ontario

Ministry of
Transportation and
Communications

I N D E X

NOTE: For the purposes of this Contract, this report supersedes all other 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 (R Q D), 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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION INVESTIGATION REPORT

FOR

CPR Subway at Pakenham (Revised)

(Including Proposped Detour Alignment)

W.P. 43-72-02; Site 15-15

Highway 15, District 9, Ottawa

INTRODUCTION

This report summarizes the foundation investigation for the proposed bridge replacement and detour at this site.

The investigation is applicable to the proposed CPR replacement structure, its immediate approaches and the proposed CPR detour alignment. This area extends from Sta. 17 + 760 to Sta. 17 + 860, 20 m left and right of Hwy. 15 centerline.

SITE DESCRIPTION

This site is located at the existing CPR subway over Hwy. 15 in the town of Pakenham, Township of Pakenham, County of Lanark. The CPR subway is approximately 500 m south of the south intersection of Hwy. 15 and County Rd. 20.

The topography of the immediate area is flat, except for the existing 5 $\pm$ m high CPR embankment, extending from the southeast to northwest across the site.

The site is drained by the Mississippi River which flows to the north and is located approximately 200 m east of the site.

Geologically, the site lies near the western extent of an area that was inundated by a post-glacial sea. At this location marine clays were deposited over generally non-cohesive till deposits underlain by limestone bedrock.

The alignment of the proposed structure replacement coincides with the alignment of the existing 6.5 ± m wide structure (stone masonry abutments). The proposed detour alignment is approximately 34 m (along the Hwy. 15 revised alignment) to the south.

FIELD INVESTIGATION

The field investigation for the structure replacement was carried out between 86 08 26 and 86 08 30 utilizing a skid-mounted diamond drill equipped with N and B size casings and a B core barrel. The field investigation for the detour was carried out between 87 08 11 and 87 08 13 utilizing an auger machine equipped with 82 mm I.D. hollow-stem augers, B-casing and B-core barrel.

For the structure replacement investigation, boreholes were advanced at each quadrant, as close as possible to proposed abutment locations, but outside the 20 m restriction imposed by the CPR. The boreholes were located on the slopes of the railway embankments, and required extensive use of cranes and platforms to facilitate placement of the drill. For the detour structure, boreholes were advanced near the proposed edges of each temporary abutment .

Drilling techniques for the replacement structure investigation were subject to CPR restrictions which required careful control of wash water and limited hammering.

Bedrock samples, up to 3 m in length, were collected, using a B-size core barrel at each of the 8 borehole locations. The overburden was sampled using a split spoon to obtain disturbed samples and standard penetration test results in both cohesive and non-cohesive materials. Shelby tube samples were collected and field vane tests were conducted to determine undrained shear strength characteristics of the overburden. The shelby tube samples also provided consolidation characteristics of the overburden.

Groundwater elevations were measured in open holes at each borehole location. At two boreholes, the stabilized groundwater elevations were determined by monitoring the water level over one to three day periods.

As required by the CPR, the existing bridge was monitored for possible movements during the course of the field investigation for the replacement structure. Eight baselines were established to facilitate the monitoring of 44 points on the bridge. No movement of the CPR structure was detected during the field investigation. In addition, the 8 MTC boreholes were surveyed to determine location and elevation. The surveys were conducted by B. L. Madden and G. Ryan of the Eastern Region Surveys and Plans Section.

LABORATORY ANALYSES

Laboratory testing was carried out on representative samples to determine undrained shear strengths, consolidation characteristics, unit weights, Atterberg Limits and grain size characteristics of the overburden material.

The bedrock core samples were evaluated to determine the geological formation and rock quality.

The results of the laboratory analyses are illustrated on the Record of Borehole Sheets.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH #1 to BH #8. Four additional boreholes, prepared by Wilf Ohlmann Geotechnical Services Ltd. for the CPR and provided to the Ministry of Transportation for reference are identified as CPR #1 to CPR #4 and

appended. These boreholes are included for completeness and the Ministry of Transportation does not assume any responsibility for their accuracy. The locations and elevations of the Ministry of Transportation boreholes and stratigraphical profiles based on the borehole data, are shown on Drawing No. 437202-A. **

At the replacement structure alignment the overburden consists essentially of 5.5 ± m of silty clay fill of intermediate plasticity overlying up to 4 ± m of natural overburden consisting of moderately sensitive marine clay and glacial till.

At the detour structure alignment the overburden is up to 4.7 m deep and consists primarily of marine clay and glacial till.

Overburden

FILL MATERIAL

The existing CPR fill extends for depths up to 5.7 m.

Based on the borehole data provided by the CPR, the upper 1.4 m to 2.1 m of the fill is sandy silt (ML) some clay, containing variable amounts of gravel. This material is essentially non-cohesive but it does exhibit slight cohesion. The results of an isolated Standard Penetration Test, ('N' value) indicate that the granular fill is in a very loose state on the slopes. This material is probably in a loose to compact state beneath the CPR tracks.

Underlying the surficial granular material, the remainder of the CPR fill consists of silty clay of intermediate plasticity, trace/some gravel, trace/some sand. This material has been mixed with traces of organics at the lower 0.5 m of the fill at BH #1. Properties of the cohesive fill material, as determined from field and laboratory tests, are summarized as follows:

NOTE: Refer to Drawing No.2 of the Contract Package

	Range	Average	Median
Moisture Content (w)	19.5% - 37.5%	28.9%	32.0%
Liquid Limit (w_L)	34.5% - 52.0%	44.5%	46.0%
Plastic Limit (w_P)	16.5% - 26.0%	21.9%	21.5%
Shear Strengths (c_u)			
- field vane (undisturbed)	68.0 kPa to over 112.0 kPa	N/A	N/A
- field vane (remolded)	6.8 kPa	N/A	N/A

Based on 'N' values ranging from 3 to 7, and the field vane undisturbed shear strength value of 68 kPa, the cohesive fill is in a soft to very stiff (generally firm to stiff) state. Remolded shear strengths indicate a sensitivity value as high as 10.

Figure 1 illustrates a typical grain size distribution for the cohesive CPR fill material.

At the detour alignment, 1.2 m of compact sand fill was encountered at BH #8.

SILTY CLAY (CI); TRACE SAND

This marine clay deposit was encountered at BH #3, #4, #5, #6, #7 and #8 where it extended for thickness ranging from 1.7 m to 4.7 m. Traces of organics were present in the upper 0.5 m of this deposit at BH #4.

This material has intermediate plasticity and moderately high sensitivity.

Properties of the material as determined by field and laboratory tests, are summarized as follows:

	Range
Moisture Content (w)	33.5% - 47.0%
Liquid Limit (w_L)	48.0% - 53.0%
Plastic Limit (w_P)	20.5% - 26.5%
Shear Strengths (c_u)	
- unconfined compression	19.1 - 49.1 kPa
- field vane	30.0 - 76.0 kPa
- unit weight (γ)	16.8 - 17.6 kN/m^3

Based on 'N' values and the undrained unconfined compressive strengths, this materials is in a soft to very stiff state. The typical 2.5% strain at failure illustrates the brittle nature of this sensitive marine clay.

Figure 2 illustrates a typical grain size distribution for this material.

SILTY SAND; TRACE/AND GRAVEL, TRACE/SOME CLAY

This till deposit was encountered beneath the fill material at BH #2 and beneath the silty clay deposit at BH #3, #4 and #8. At these locations it extends for thicknesses ranging from 0.7 m to 3.6 m. Traces of organics were present in the upper 0.5 m of this deposit at BH #2. Higher proportions of gravel were present in BH #4.

Properties of the material as determined by field and laboratory tests, are summarized as follows:

	Range
Moisture Content (w)	7.0% - 11.5%
Liquid Limit (w_L)	12.0% - 17.0%
Plastic Limit (w_P)	10.0% - 11.5%

Based on 'N' values ranging from 14 to over 60, the material is in a compact to very dense state. Portions of the material exhibit slight cohesion.

Figure 3 illustrates a typical grain size distribution for this material.

Bedrock

The bedrock consists of limestone of the Ottawa formation. Detailed descriptions of the core samples are provided in Tables 1 and 2 of the Appendix.

The fill material is directly underlain by bedrock at BH #1. At BH #2, 3, 4 and 8 bedrock underlies the silty sand till deposit. At BH #5, 6 and 7, bedrock underlies the silty clay deposit.

At the proposed replacement structure boreholes, the bedrock elevations range from 87.4 ± m to 93.2 ± m. The bedrock dips gradually towards the south. The core recovery values and the rock quality designation values indicate that the rock is in excellent condition. A shallow weathered bedrock zone, approximately 0.3 m in thickness was encountered at the bedrock interface.

At the proposed detour alignment boreholes, the bedrock elevations range from 87.7 ± m to 88.0 ± m.

GROUNDWATER

The groundwater elevations at the proposed replacement structure that were measured at the time of the field investigation are indicated in the following table:

Borehole	Groundwater Elevation
#1	92.7 m
#2	91.9 m
#3	93.2 m
#4	94.2 m

Due to an inadequate period that was available to maintain open boreholes, the water levels in BH #3 and BH #4 are not considered to be stabilized. However, the water levels in BH #1 and BH #2 are considered to be more representative of stabilized conditions. The stabilized water level is interpreted to coincide with the top of the silty sand till deposit.

At the proposed detour alignment, stabilized groundwater elevations were not determined.

MISCELLANEOUS

The field investigation for the permanent replacement structure was carried out under the supervision of J. Duffield, Engineering Student. The equipment used was owned and operated by Marathon Drilling Co. Ltd. The description of bedrock core samples was carried out by E. Magni, Geologist.

The field investigation for the detour structure was carried out under the supervision of J.M. Jolink, Engineering Student. The equipment used was owned and operated by Johnston Drilling Co. Ltd. The description of the bedrock core samples was carried out by S. Senior, Geologist.

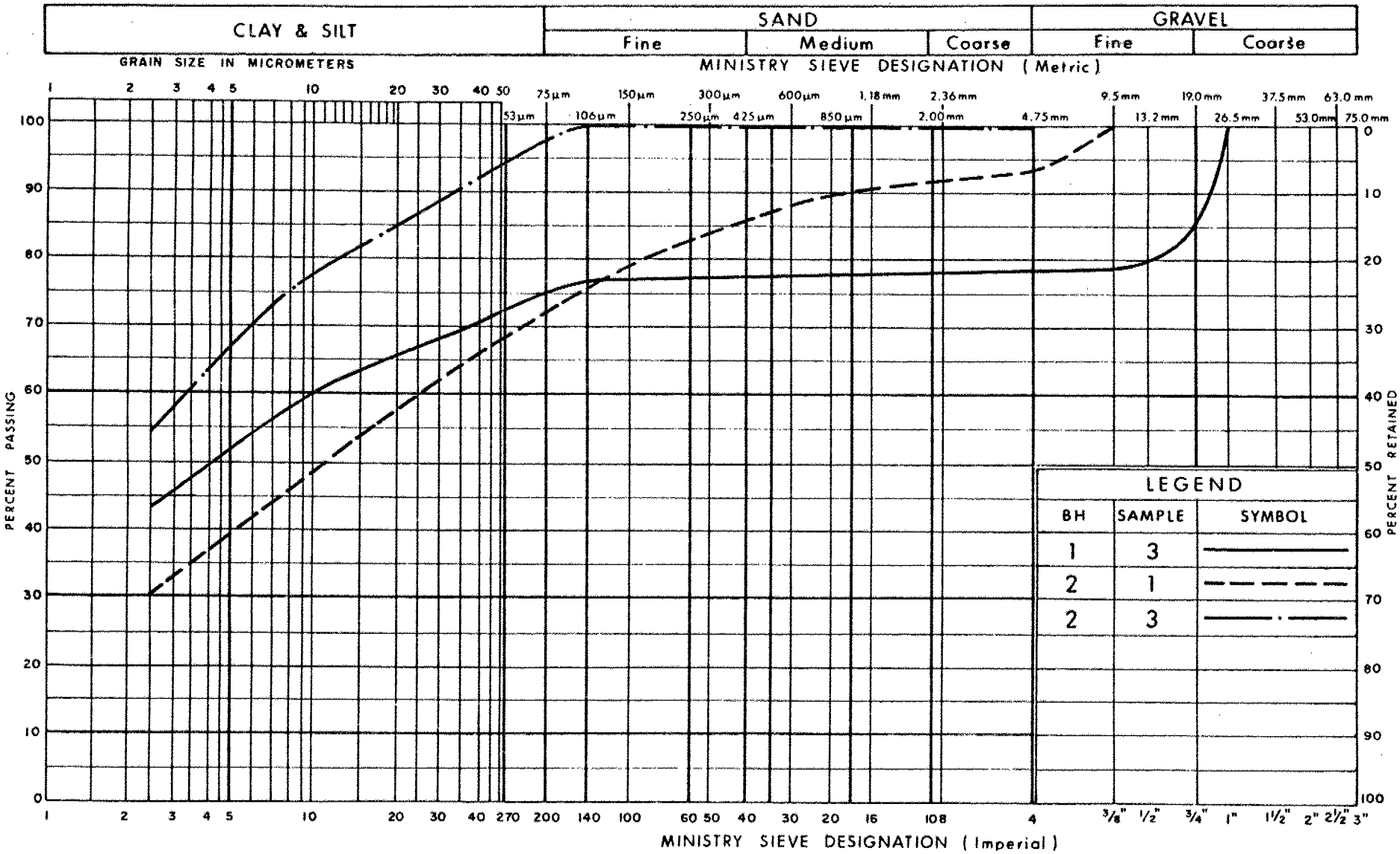
The report was written by D. Dundas, Senior Foundations Engineer and reviewed by M. Devata, Chief Foundations Engineer (East).

D. H. Dundas

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
SILTY CLAY (CI), TRACE/SOME SAND, GRAVEL (Fill)

FIG No 1
WP 43-72-02

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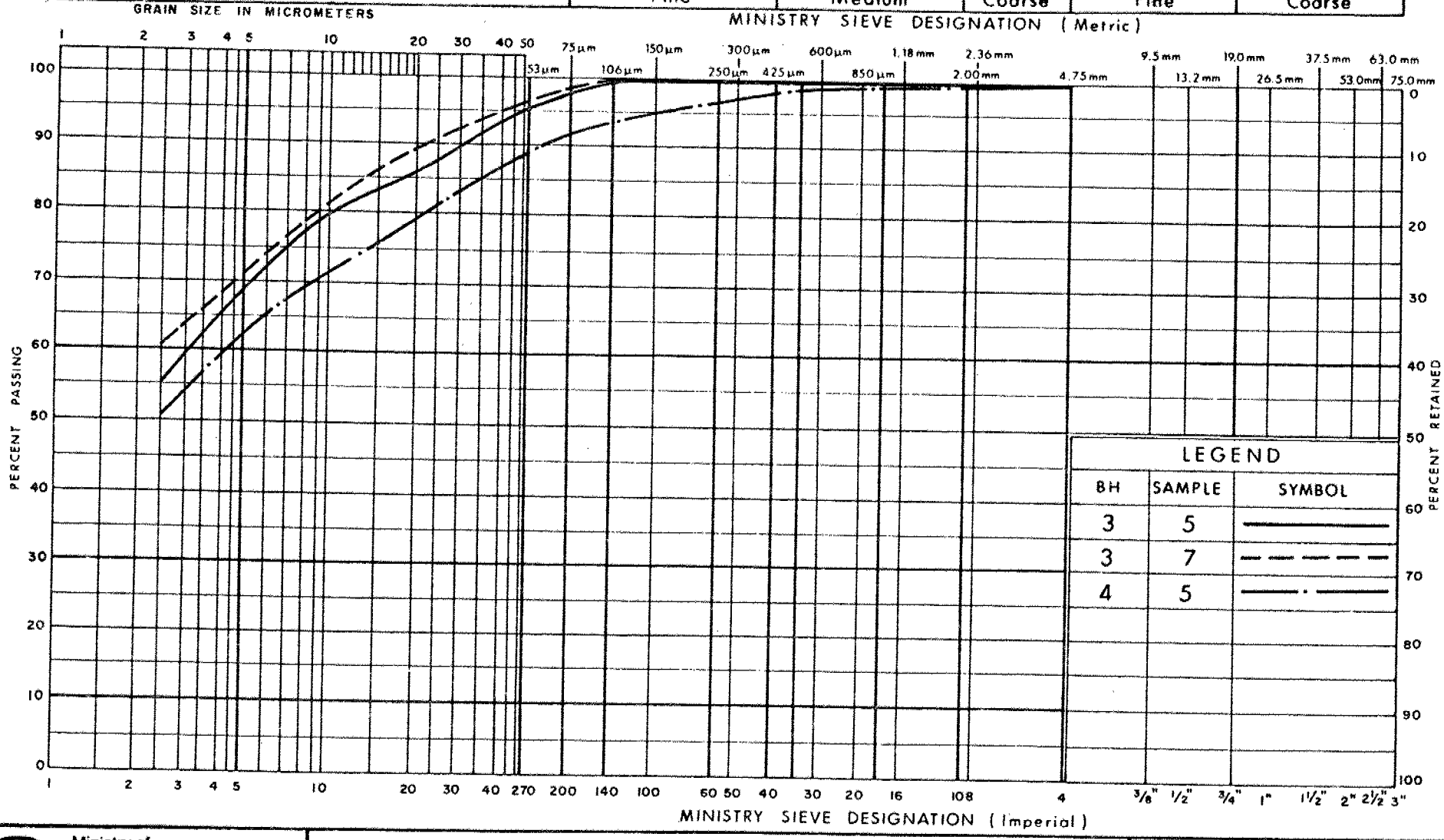
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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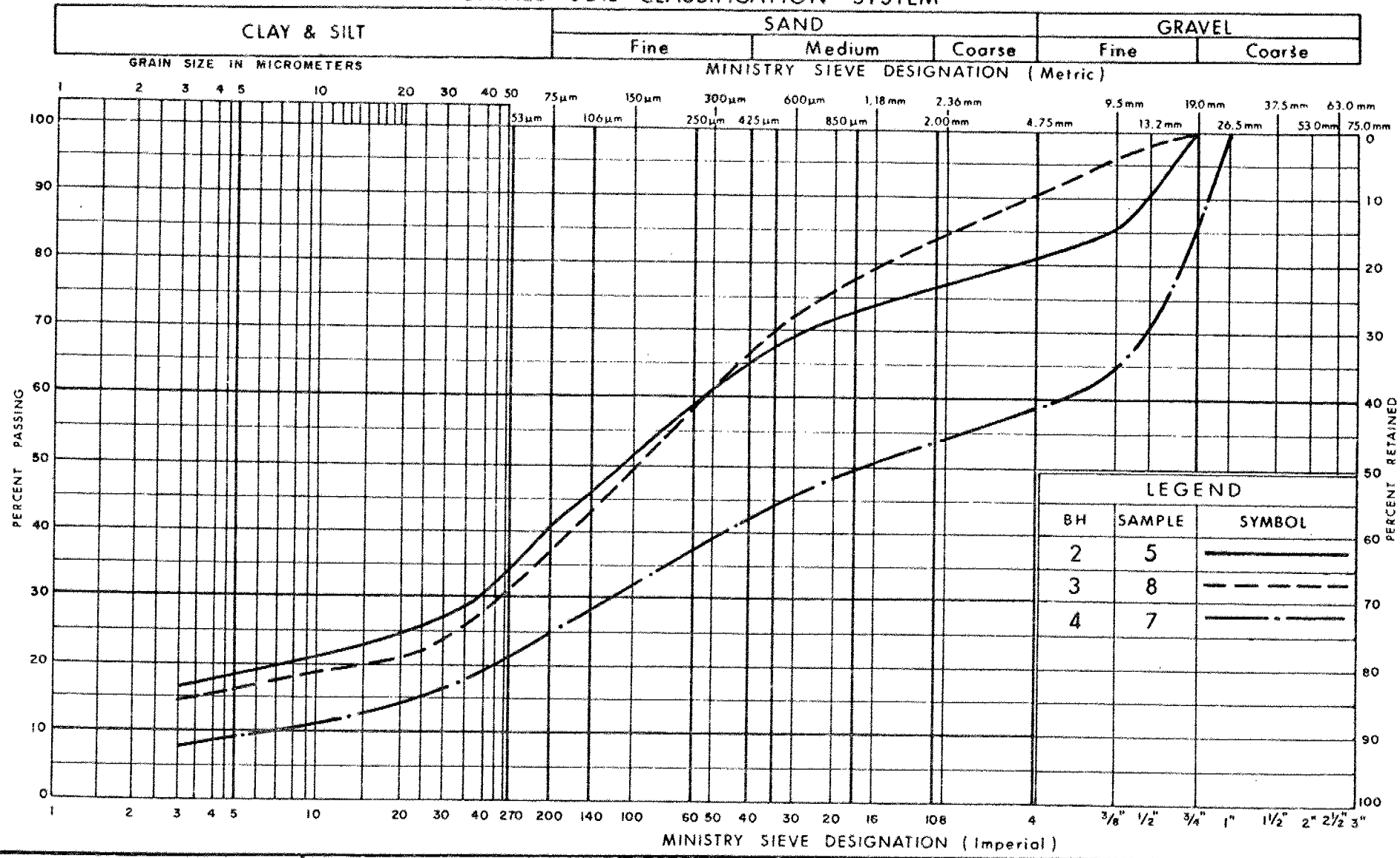
GRAIN SIZE DISTRIBUTION
SILTY CLAY (C I) , TRACE SAND (Marine)

FIG No 2
W P 43-72-02

13

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

SILTY SAND, TRACE/AND GRAVEL, TRACE/SOME CLAY
(Till)

FIG No 3
WP 43-72-02

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DESCRIPTION OF ROCK CORE - W.P. 43-72-02

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	2.90 - 3.05	50	0	2.90 - 3.05	LIMESTONE, buff, moderately weathered
	3.05 - 4.30	88	57	3.05 - 3.44	LIMESTONE, grey, slightly weathered, with oxidized, closely spaced, horizontal joints
	4.30 - 5.87	92	88	3.44 - 5.87	LIMESTONE, grey, unweathered, closely to medium spaced joints
2	6.61 - 7.95	89	60	6.61 - 6.81	LIMESTONE, weathered, core loss
	7.95 - 9.48	100	43	6.81 - 9.48	LIMESTONE, grey, unweathered, closely to medium spaced joints
3	7.01 - 7.14	60	0	7.01 - 7.32	BOULDERS
	7.14 - 7.32	57	57	7.32 - 7.55	LIMESTONE, weathered, core loss
	7.32 - 8.12	78	78	7.55 -10.14	LIMESTONE, grey, unweathered, closely to medium spaced joints
	8.12 - 8.69	82	82		
	8.69 -10.14	93	42		
4	5.62 - 6.59	84	37	5.62 - 5.79	BOULDERS and possibly weathered limestone, core loss
	6.59 - 7.99	98	70	5.79 - 7.99	LIMESTONE, grey, unweathered, closely to medium spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

TABLE 1

DESCRIPTION OF ROCK CORE - WP 43-72-02

	CORE RECOVERY			CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
5	4.72- 6.25 6.25- 7.77	100 100	61 45	4.72- 7.77	LIMESTONE, grey to grey brown, banded dark grey, spotted white; dense, fine grained; medium strong rock; unweathered; very close to closely spaced fractures.
6	4.27- 5.79 5.79- 7.32	93 83	26 23	4.27- 7.32	LIMESTONE, light tan brown to medium blue-grey, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; unweathered; very close to closely spaced fractures.
7	4.27- 5.79 5.79- 7.32	100 100	63 78	4.27- 7.32	LIMESTONE, medium grey brown to dark grey, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; unweathered; closely spaced fractures.
8	4.57- 6.10 6.10- 7.62	95 100	28 48	4.57- 7.62	LIMESTONE, light grey to medium grey brown, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; closely spaced fractures.

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

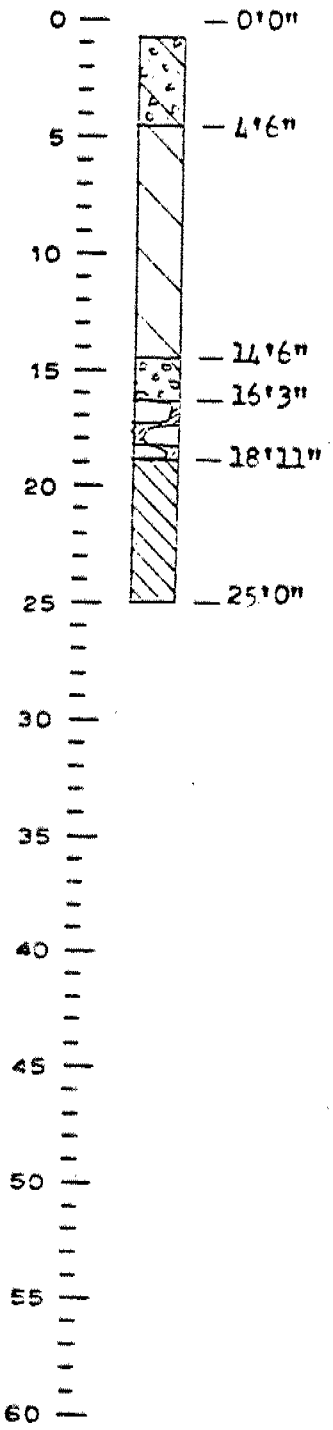
TABLE 2

CPR *

B.H. No. 1 DEPTH	DESCRIPTION	% CORE RECOVERY
0 —	— 0'0" Base of Fill	
5	Clay and gravel, some sand	
	— 7'0"	
10	Brown Clay	
15		
20	— 21'0"	
	Dense glacial till; grey silty, clayey fine to coarse sand with gravel and small boulders. Water level 22'1"	
25	— 27'9"	
30	Sound limestone bedrock ¼" mud seam at 29'11"	27'9" to 33'9" Cored 6'0" Recovered 5'11½" 99% Recovery R.Q.D.=52%
	— 33'9"	
35		
40		
45		
50	* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.	
55		
60		

CPR *
B.H. No.2

DEPTH	DESCRIPTION	% CORE RECOVERY



DEPTH	DESCRIPTION	% CORE RECOVERY
0'0"	Base of rail	
	Clay and gravel, some sand	
4'6"		
	Brown clay	
14'6"		
	Clay and stones	
16'3"		
	Stone masonry wall	
18'11"		
	Sound limestone bedrock	18'11" to 25'0" Cored 6'1" Recovered 5'11½" 98% Recovery R.Q.D.=70%
25'0"		

* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

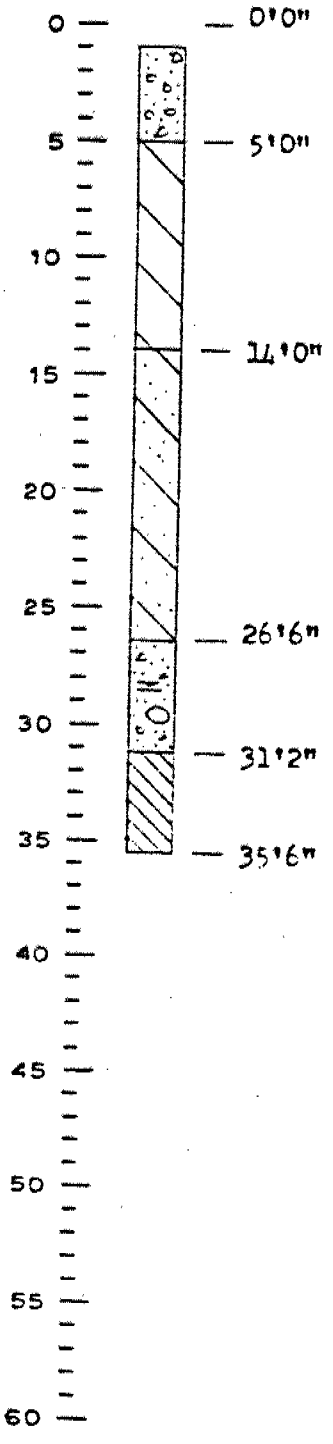
CPR *
B.H. No. 3

DEPTH	DESCRIPTION	% CORE RECOVERY
— 0'0"	Base of rail	
	Cinders, gravel, sand	
— 5'6"		
	Brown clay	
— 12'6"		
	Stone masonry wall with lime morter	
— 17'0"		
	Morter and pieces of limestone, some grout.	
— 22'8"		
— 23'6"	Brown clay	
	Water level 24'2"	
	Compact glacial till: grey silty to coarse sand: some gravel, trace clay, occasional boulders.	
— 31'6"		31'6" to 37'9"
	Sound limestone bedrock	Cored 6'3"
		Recovered 6'0"
		96% recovery
— 37'9"		R.Q.D. =59%

* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

CPR *
B. H. No. 4

DEPTH	DESCRIPTION	% CORE RECOVERY
		20
0'0"	Base of rail	
	Cinders, gravel and sand	
5'0"		
	Brown clay	
14'0"		
	Brown and grey sandy clay	
	Water level 18'0"	
26'6"		
	Compact glacial till; grey silty fine to coarse sand with some gravel and clay, occasional boulders.	
31'2"		
	Sound limestone bedrock	31'2" to 35'6" Cored 4'4" Recovered 4'4" 100% recovery R.Q.D.=65%
35'6"		



* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1 METRIC

W P 43-72-02 LOCATION STA. 17 + 854.5; O/S 11.9 m Lt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE N Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 26-27 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.1	GROUND SURFACE										
0.0	Silty Clay (CI) trace/some gravel trace/some sand firm to stiff (FILL) grey		1	SS	5		96				
			2	SS	7		95	+10			6 9 44 41
			3	SS	5		94				21 4 34 41
93.2	trace organics										
2.9	weathered		4	RC	rec 50%		93				
	unweathered Bedrock Limestone		5	RC	rec 88%	86 08 27	92				
	occ. fissures		6	RC	rec 92%		91				
90.2											
5.9	END OF BOREHOLE										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ S (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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Ontario

RECORD OF BOREHOLE No 2 METRIC

W P 43-72-02 LOCATION STA. 17 + 812.5; O/S 18.6 m Rt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE B Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 27 CHECKED BY DD

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.9	GROUND SURFACE										
0.0	Silty Clay (CI) trace/some sand trace gravel soft to stiff (FILL) grey		1	SS	3		94				7 20 45 28
			2	SS	5						
			3	SS	6		93				0 2 48 50
91.9			4	SS	15		92				
3.0	trace organics					86 08 30					
	Silty Sand some gravel trace/some clay compact (TILL)		5	SS	19		91				19 41 26 14
			6	SS	17						
			7	SS	28		90				19 49 22 10
	slightly cohesive noncohesive		8	SS	19		89				
88.3											
6.6	weathered unweathered		9	RC	rec 89%		88				
	Bedrock Limestone						87				
			10	RC	rec 100%		86				
85.5											
9.4	END OF BOREHOLE										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 43-72-02 LOCATION STA. 17 + 797.2; O/S 12.0 m Rt. ℄ Hwy. 15 ORIGINATED BY JD

DIST 9 HWY 15 BOREHOLE TYPE B Casing, B Core COMPILED BY DD

DATUM Geodetic DATE 86 08 27-28 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.7	GROUND SURFACE										
0.0	CL to CI Silty Clay (CI) trace/some gravel trace/some sand soft to firm (FILL) grey		1	SS	7		94				21 8 39 32
			2	SS	3	86 08 26	93				
			3	SS	7						13 11 37 39
91.8							92				
2.9	Silty Clay (CI) trace sand soft to stiff (MARINE) grey		4	SS	11						
			5	SS	7		91				0 2 46 50
			6	SS	4						
89.2			7	TW	PH		90			16.8	0 2 40 58
5.5	Silty Sand some clay trace gravel compact to very dense (TILL) brown		8	SS	14		89				10 54 22 14
			9	RC	rc60 %		88				
87.4	boulders		10	RC	rc57 %						
7.3	weathered unweathered Bedrock Limestone		11	RC	rec 78%		87				
			12	RC	rec 82%		86				
			13	RC	rec 93%		85				
84.6											
10.1	END OF BOREHOLE										

*probably not a stabilized ground-water elevation

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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Ontario

RECORD OF BOREHOLE No 4 METRIC

W P 43-72-02 LOCATION STA. 17 + 841.6; O/S 18.1 m Lt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE N Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 30 CHECKED BY DD

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.6 GROUND SURFACE											
0.0	Sandy silt (ML) some clay, trace gravel very loose (FILL) slightly cohesive		1	SS	3		95		○ H		5 34 42 19
94.5											
1.1	Silty Clay (CI) trace sand firm to very stiff (FILL) brown		2	SS	6	▼ 86 08 30	94				
			3	SS	6		93				0 4 46 50
92.4									+2		
3.2	trace organics brown		4	SS	11						
	Silty clay (CI) trace sand stiff to very stiff (MARINE) grey		5	SS	21		92				0 8 46 46
90.7			6	SS	12		91				
4.9	Silty sand and gravel trace clay		7	SS	60	/8 cm					41 33 21 5
90.0	** boulders						90				
5.6	weathered / unweathered		8	RC	rec 84%						
	Bedrock Limestone						89				
			9	RC	rec 98%						
87.6							88				
8.0	END OF BOREHOLE										

*probably not a stabilized groundwater elevation

**very dense (TILL) brown

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

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RECORD OF BOREHOLE No 5 METRIC

W P 43-72-02 LOCATION Sta. 17 + 776.7: O/S 1.8 m Rt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 11 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.4	Ground Surface										
0.0	Silty Clay (CI) Trace Sand Soft to Very Stiff (Marine) Grey		1	SS	11	*	92				0 1 43 56
			2	TW	PH		91				
			3	SS	1		90	+6			24 1 31 44
			4	SS	1		89	+12			
87.7							88	+18			
4.7	Bedrock Limestone Unweathered		5	RC	REC 100%		87				
			6	RC	REC 100%		86				
84.8							85				
7.6	End of Borehole										

* Groundwater Elevation Not Stabilized

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No 6 METRIC

W P 43-72-02 LOCATION Sta. 17 + 791.8; O/S 2.4 m Rt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 12 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3	Ground Surface							
0.0	Silty Clay (CI) Trace Sand Soft to Stiff (Marine) Grey		1	SS	5	*		
			2	TW	PH		17.6	2 2 40 56
			3	TW	PH		17.2	1 2 37 60
88.0								
4.3	Bedrock Limestone Unweathered		4	RC	REC 93%			
			5	RC	REC 83%			
85.0								
7.3	End of Borehole							

ELEVATION SCALE: 92, 91, 90, 89, 88, 87, 86

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

* Groundwater Elevation Not Stabilized

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 7 METRIC

W P 43-72-02 LOCATION Sta. 17 + 798.9; O/S 11.1 m Lt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
92.3 / 0.0	Ground Surface										
	Silty Clay (CI) Trace Sand Soft to Stiff (Marine) Grey		1	SS	10	*	92 91 90 89	+5 +9			
			2	SS	4						
			3	TW	PH						
88.0			4	TW	PM		88				
4.3	Bedrock Limestone Unweathered		5	RC	REC 100%		87				
			6	RC	REC 100%		86				
85.0 / 7.3	End of Borehole										

* Groundwater Elevation Not Stabilized

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

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Ontario

RECORD OF BOREHOLE No 8 METRIC

W P 43-72-02 LOCATION Sta. 17 + 817.9; O/S 6.6 m Lt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY NJ
DATUM Geodetic DATE 87 08 13 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
92.3	Ground Surface						
0.0	Sand Compact (Fill)		1	SS	6	*	92
91.1							
1.2	Silty Clay (CI) Trace Sand Stiff (Marine) Grey		2	SS	PH		91
89.3							90
3.0	Silty Sand Some Gravel Some Clay Compact (Till)		3	TW	PH		89
87.7							88
4.6	Bedrock Limestone Unweathered		4	RC	REC 95%		87
			5	RC	REC 100%		86
84.7							85
7.6	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT Wp | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL
25 43 22 10

* Groundwater Elevation Not Stabilized

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

D. DUNDAS

Ministry of
Transportation and
Communications

Ontario

FOUNDATION DESIGN SECTION

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 88-68

WP 43-72-02 DIST 9

HWY 15 STR SITE 15-15

CPR Subway at Pakenham Revised
(Including Detour Structure)

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FOUNDATION INVESTIGATION REPORT

FOR

CPR Subway at Pakenham (Revised)

(Including Proposped Detour Alignment)

W.P. 43-72-02; Site 15-15

Highway 15, District 9, Ottawa

INTRODUCTION

This report summarizes the foundation investigation for the proposed bridge replacement and detour at this site.

The investigation is applicable to the proposed CPR replacement structure, its immediate approaches and the proposed CPR detour alignment. This area extends from Sta. 17 + 760 to Sta. 17 + 860, 20 m left and right of Hwy. 15 centerline.

SITE DESCRIPTION

This site is located at the existing CPR subway over Hwy. 15 in the town of Pakenham, Township of Pakenham, County of Lanark. The CPR subway is approximately 500 m south of the south intersection of Hwy. 15 and County Rd. 20.

The topography of the immediate area is flat, except for the existing 5 $\pm$ m high CPR embankment, extending from the southeast to northwest across the site.

The site is drained by the Mississippi River which flows to the north and is located approximately 200 m east of the site.

Geologically, the site lies near the western extent of an area that was inundated by a post-glacial sea. At this location marine clays were deposited over generally non-cohesive till deposits underlain by limestone bedrock.

The alignment of the proposed structure replacement coincides with the alignment of the existing 6.5 ± m wide structure (stone masonry abutments). The proposed detour alignment is approximately 34 m (along the Hwy. 15 revised alignment) to the south.

FIELD INVESTIGATION

The field investigation for the structure replacement was carried out between 86 08 26 and 86 08 30 utilizing a skid-mounted diamond drill equipped with N and B size casings and a B core barrel. The field investigation for the detour was carried out between 87 08 11 and 87 08 13 utilizing an auger machine equipped with 82 mm I.D. hollow-stem augers, B-casing and B-core barrel.

For the structure replacement investigation, boreholes were advanced at each quadrant, as close as possible to proposed abutment locations, but outside the 20 m restriction imposed by the CPR. The boreholes were located on the slopes of the railway embankments, and required extensive use of cranes and platforms to facilitate placement of the drill. For the detour structure, boreholes were advanced near the proposed edges of each temporary abutment .

Drilling techniques for the replacement structure investigation were subject to CPR restrictions which required careful control of wash water and limited hammering.

Bedrock samples, up to 3 m in length, were collected, using a B-size core barrel at each of the 8 borehole locations. The overburden was sampled using a split spoon to obtain disturbed samples and standard penetration test results in both cohesive and non-cohesive materials. Shelby tube samples were collected and field vane tests were conducted to determine undrained shear strength characteristics of the overburden. The shelby tube samples also provided consolidation characteristics of the overburden.

Groundwater elevations were measured in open holes at each borehole location. At two boreholes, the stabilized groundwater elevations were determined by monitoring the water level over one to three day periods.

As required by the CPR, the existing bridge was monitored for possible movements during the course of the field investigation for the replacement structure. Eight baselines were established to facilitate the monitoring of 44 points on the bridge. No movement of the CPR structure was detected during the field investigation. In addition, the 8 MTC boreholes were surveyed to determine location and elevation. The surveys were conducted by B. L. Madden and G. Ryan of the Eastern Region Surveys and Plans Section.

LABORATORY ANALYSES

Laboratory testing was carried out on representative samples to determine undrained shear strengths, consolidation characteristics, unit weights, Atterberg Limits and grain size characteristics of the overburden material.

The bedrock core samples were evaluated to determine the geological formation and rock quality.

The results of the laboratory analyses are illustrated on the Record of Borehole Sheets.

SUBSURFACE CONDITIONS

The Record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The boreholes are referenced as BH #1 to BH #8. Four additional boreholes, prepared by Wilf Ohlmann Geotechnical Services Ltd. for the CPR and provided to the Ministry of Transportation for reference are identified as CPR #1 to CPR #4 and

appended. These boreholes are included for completeness and the Ministry of Transportation does not assume any responsibility for their accuracy. The locations and elevations of the Ministry of Transportation boreholes and stratigraphical profiles based on the borehole data, are shown on Drawing No. 437202-A.

At the replacement structure alignment the overburden consists essentially of 5.5 ± m of silty clay fill of intermediate plasticity overlying up to 4 ± m of natural overburden consisting of moderately sensitive marine clay and glacial till.

At the detour structure alignment the overburden is up to 4.7 m deep and consists primarily of marine clay and glacial till.

Overburden

FILL MATERIAL

The existing CPR fill extends for depths up to 5.7 m.

Based on the borehole data provided by the CPR, the upper 1.4 m to 2.1 m of the fill is sandy silt (ML) some clay, containing variable amounts of gravel. This material is essentially non-cohesive but it does exhibit slight cohesion. The results of an isolated Standard Penetration Test, ('N' value) indicate that the granular fill is in a very loose state on the slopes. This material is probably in a loose to compact state beneath the CPR tracks.

Underlying the surficial granular material, the remainder of the CPR fill consists of silty clay of intermediate plasticity, trace/some gravel, trace/some sand. This material has been mixed with traces of organics at the lower 0.5 m of the fill at BH #1. Properties of the cohesive fill material, as determined from field and laboratory tests, are summarized as follows:

	Range	Average	Median
Moisture Content (w)	19.5% - 37.5%	28.9%	32.0%
Liquid Limit (w_L)	34.5% - 52.0%	44.5%	46.0%
Plastic Limit (w_P)	16.5% - 26.0%	21.9%	21.5%
Shear Strengths (c_u)			
- field vane (undisturbed)	68.0 kPa to over 112.0 kPa	N/A	N/A
- field vane (remolded)	6.8 kPa	N/A	N/A

Based on 'N' values ranging from 3 to 7, and the field vane undisturbed shear strength value of 68 kPa, the cohesive fill is in a soft to very stiff (generally firm to stiff) state. Remolded shear strengths indicate a sensitivity value as high as 10.

Figure 1 illustrates a typical grain size distribution for the cohesive CPR fill material.

At the detour alignment, 1.2 m of compact sand fill was encountered at BH #8.

SILTY CLAY (CI); TRACE SAND

This marine clay deposit was encountered at BH #3, #4, #5, #6, #7 and #8 where it extended for thickness ranging from 1.7 m to 4.7 m. Traces of organics were present in the upper 0.5 m of this deposit at BH #4.

This material has intermediate plasticity and moderately high sensitivity.

Properties of the material as determined by field and laboratory tests, are summarized as follows:

	Range
Moisture Content (w)	33.5% - 47.0%
Liquid Limit (w_L)	48.0% - 53.0%
Plastic Limit (w_P)	20.5% - 26.5%
Shear Strengths (c_u)	
- unconfined compression	19.1 - 49.1 kPa
- field vane	30.0 - 76.0 kPa
- unit weight (γ)	16.8 - 17.6 kN/m^3

Based on 'N' values and the undrained unconfined compressive strengths, this materials is in a soft to very stiff state. The typical 2.5% strain at failure illustrates the brittle nature of this sensitive marine clay.

Figure 2 illustrates a typical grain size distribution for this material.

SILTY SAND; TRACE/AND GRAVEL, TRACE/SOME CLAY

This till deposit was encountered beneath the fill material at BH #2 and beneath the silty clay deposit at BH #3, #4 and #8. At these locations it extends for thicknesses ranging from 0.7 m to 3.6 m. Traces of organics were present in the upper 0.5 m of this deposit at BH #2. Higher proportions of gravel were present in BH #4.

Properties of the material as determined by field and laboratory tests, are summarized as follows:

	Range
Moisture Content (w)	7.0% - 11.5%
Liquid Limit (w_L)	12.0% - 17.0%
Plastic Limit (w_P)	10.0% - 11.5%

Based on 'N' values ranging from 14 to over 60, the material is in a compact to very dense state. Portions of the material exhibit slight cohesion.

Figure 3 illustrates a typical grain size distribution for this material.

Bedrock

The bedrock consists of limestone of the Ottawa formation. Detailed descriptions of the core samples are provided in Tables 1 and 2 of the Appendix.

The fill material is directly underlain by bedrock at BH #1. At BH #2, 3, 4 and 8 bedrock underlies the silty sand till deposit. At BH #5, 6 and 7, bedrock underlies the silty clay deposit.

At the proposed replacement structure boreholes, the bedrock elevations range from 87.4 ± m to 93.2 ± m. The bedrock dips gradually towards the south. The core recovery values and the rock quality designation values indicate that the rock is in excellent condition. A shallow weathered bedrock zone, approximately 0.3 m in thickness was encountered at the bedrock interface.

At the proposed detour alignment boreholes, the bedrock elevations range from 87.7 ± m to 88.0 ± m.

GROUNDWATER

The groundwater elevations at the proposed replacement structure that were measured at the time of the field investigation are indicated in the following table:

Borehole	Groundwater Elevation
#1	92.7 m
#2	91.9 m
#3	93.2 m
#4	94.2 m

Due to an inadequate period that was available to maintain open boreholes, the water levels in BH #3 and BH #4 are not considered to be stabilized. However, the water levels in BH #1 and BH #2 are considered to be more representative of stabilized conditions. The stabilized water level is interpreted to coincide with the top of the silty sand till deposit.

At the proposed detour alignment, stabilized groundwater elevations were not determined.

DISCUSSION AND RECOMMENDATIONS

It is proposed to replace the existing single span CPR subway (stone masonry abutments) with a single span simply-supported structural steel bridge along the same CPR alignment. The existing bridge is 6.5 ± m wide, with skewed abutments, and crosses Hwy. 15 at a grade of 97.5 ± m. This bridge shows signs of distress, in that there is cracking and some differential movements evident between the masonry blocks. The existing embankment is approximately 5.0 m high with side slopes as steep as 1.6H:1V. These slopes appear to be in good condition although there is evidence of occasional ballasting beneath the CPR tracks.

The proposed bridge will be 10.0 ± m wide at a grade of 98.2 ± m. Embankment heights will be in the order of 5.7 m and 2H:1V side slopes are recommended for the immediate approaches. This proposal also involves a small realignment of Hwy. 15, although the centre point of the new bridge will be similar to that of the old bridge. A detour located approximately 34 m along Hwy. 15 to the south of the existing structure is proposed to carry CPR traffic while the permanent replacement structure is being constructed.

PERMANENT STRUCTURE FOUNDATIONS

Due to the inadequate strength and compressibility characteristics of the overburden, the proposed structure should be founded on bedrock. Estimated bedrock elevations are illustrated in Figure 4.

This may be accomplished with spread footings, steel H-piles, or reinforced caissons. The alternative, or combination, which leads to the least expensive design is recommended.

1) SPREAD FOOTINGS

The abutments and wing walls may be suppored on spread footings founded on either weathered or unweathered bedrock.

The following O.H.B.D.C. bearing capacity loadings are recommended:

Foundation Material	Factored Bearing Capacity at U.L.S.	Bearing Capacity at S.L.S. TYPE II
Unweathered Bedrock	3000 kPa	N/A*
Weathered Bedrock	1000 kPa	N/A*

*As the bedrock will not settle, S.L.S. Type II values will not govern design.

If the abutment footings are to be constructed directly on bedrock while the wingwall footings are on a compacted pad of Granular 'A', differential settlements may occur and the structure would have to be designed with a construction joint to accommodate such movements. Otherwise, mass concrete could be used to pad underneath the wingwall footings.

If a compacted Granular 'A' pad is used, it must be constructed in the dry in accordance with the geometry shown in Figure 5. The following loading recommendations apply to footings on such a pad.

Factored Bearing Capacity at U.L.S.	900 kPa
Bearing Capacity at S.L.S. Type II	375 kPa

2) STEEL H-PILES

The abutments and wing walls may be supported on steel H-piles, equipped with reinforced tips, and driven to bedrock.

In consideration of the possibility of negative skin friction effects the following design values are recommended:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. TYPE II
310 HP 79	1000 kN per pile	750 kN per pile
310 HP 110	1440 kN per pile	1000 kN per pile

For this alternative, the abutment pile caps may be perched within the embankment fill. In this case, to facilitate pile driving, particle sizes in the fill immediately beneath the pile locations should not exceed 75 mm.

3) REINFORCED CAISSONS

The abutments and wing walls may be supported on reinforced concrete caissons founded on unweathered bedrock.

The caissons may be constructed by advancing a steel liner through the overburden and socketing it a minimum of 0.15 m into the bedrock. If additional frictional resistance is required, the caisson can be socketed deeper into the bedrock. This operation will require drilling in order to penetrate the boulders and bedrock. After the liner has been cleaned out and the required reinforcing has been installed, the concrete should be placed in the dry. The steel liner should remain in place below the ground surface, after construction of the caisson has been completed.

In consideration of the possibility of negative skin friction effects caused by settlement, the following design values are recommended:

Caisson Diameter	Factored Capacity at U.L.S.	Capacity at S.L.S. Type II
0.76 m	1600 kN per caisson	N/A*

* The capacity at S.L.S. Type II will not govern design as the bedrock will not settle. However, the allowable structural capacity of the caisson should not exceed the recommended U.L.S. capacity.

For this alternative, the abutment caisson caps may be perched within the embankment fill.

TEMPORARY STRUCTURE FOUNDATIONS

It is proposed to construct soldier pile-timber lagging walls as abutments for the temporary detour. A pile bent design, utilizing rock anchors for lateral resistance is recommended.

The soldier piles may consist of steel H-piles drive to bedrock.

The following design values are recommended:

Pile Type	Factored Capacity at U.L.S.	Capacity at S.L.S. TYPE II
310 HP 79	1000 kN per pile	750 kN per pile
310 HP 110	1440 kN per pile	1000 kN per pile

Lateral resistance can be provided by rock anchors. A safe bond stress of 500 kPa can be assumed for design purposes. However, this value must be verified by proof testing each anchor to 150% of design load.

The required anchor zone length in bedrock for a known required load can be calculated by the following formula:

$$\text{Stress} = \frac{\text{Load}}{\text{Area}}$$

The minimum allowable bond zone length is 3 m.

To facilitate installation of the rock anchors, the anchors should be installed before fill is placed behind the soldier piles. Connector may be used for anchor tendons if required. The sequence will permit the rock anchor drill to operate without the necessity of constructing a working berm in front of the soldier piles, and also will permit anchoring and stressing of the soldier pile wall as backfilling progresses.

GENERAL RECOMMENDATIONS

(Applicable to Both Permanent and Temporary Structures)

Lateral Resistance

Sliding resistance between concrete and bedrock should be calculated in accordance with Section 6-7.3.3.2 of the O.H.B.D.C. assuming an unfactored value of 30°. The horizontal component of battered piles may be used to resist lateral forces.

For piles and caissons, resistance to lateral load shall be computed in accordance with Section 6-8.3.8 of the O.H.B.D.C.

Sliding resistance can be supplemented by keying into bedrock or utilizing dowels. If this option is considered, please contact this office for details.

Earth Pressures

Backfill to structures should consist of granular material in accordance with MTC Standard Special Provision #121 (83 10).

Computation of earth pressures should be in accordance with Section 6.6.1.2 of the O.H.B.D.C. For design purposes, the following physical properties can be assumed for backfill:

Material	ϕ	γ
Granular 'A'	35°	22.0 kN/m^3
Granular 'B'	30°	21.2 kN/m^3

The following parameters are suggested for calculation of earth pressures for native materials and non-granular fill material with an assumed groundwater elevation of 93 m.

Material	Shear Strength C_u (kPa)	Angle of Int. Friction ϕ (°)	Unit Weight γ (kN/m^3)
Silty Clay (CI) (Embankment Fill)	50	0	20
Silty Clay (CI) (Natural Overburden)	50	0	19
Silty Sand Till (Natural Overburden)	0	35	21

As the foundations are to be founded on bedrock, the foundation is considered to be non-yielding and the at-rest case applies for lateral earth pressure calculations.

Slope Stability

The grade of the proposed bridges will require approach embankments heights in the order of 5.7 m.

No stability problems are anticipated for 2H:1V permanent slopes for approach embankments up to 10 m high.

Construction of spread footings may require equivalent fill heights of up to 10 m. For temporary slopes, no stability problems are anticipated for 1H:1V embankments up to 10 m high.

Settlement

Total and differential settlements will be negligible for structure foundations constructed in accordance with recommendations provided in this report.

For the approach embankments, assuming fill weight will not exceed 22.0 kN/m^3, and the embankment elevation will not exceed 98.2 m, total settlements will not exceed 15 cm. This settlement can be reduced by utilizing embankment fill with lighter unit weights.

It is anticipated that 50% of this settlement would occur within one year after loading while, 90% of the settlement would occur within 10 years.

It is recommended that the approach embankments to the proposed structure should be preloaded for as long a period as possible before the new track is placed, in order to reduce the effects of the anticipated settlements.

Frost Protection

Frost protection is not a requirement for foundations on limestone bedrock. For foundations on earth materials, 1.8 m of earth cover or equivalent (to the underside of footing) is required for frost protection.

Dewatering

It is anticipated that any required dewatering can be carried out with routine procedures such as sump pumping.

Construction Considerations

The marine silty clay deposit is moderately sensitive and its shear strength is drastically reduced once disturbed. For this reason, special attention is required during construction to prevent disturbance of this material. It is advisable to protect the sensitive material by covering the silty clay exposed during construction with 15 cm blanket of concrete.

An alternative to maintaining temporary excavation slopes of 1H:1V is to provide shoring.

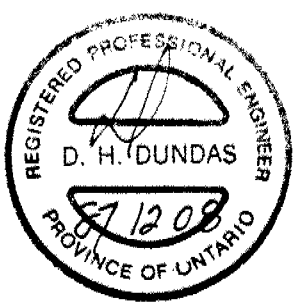
The slope between the existing embankment and the proposed embankment should be benched as per MTC standards.

MISCELLANEOUS

The field investigation for the permanent replacement structure was carried out under the supervision of J. Duffield, Engineering Student. The equipment used was owned and operated by Marathon Drilling Co. Ltd. The description of bedrock core samples was carried out by E. Magni, Geologist.

The field investigation for the detour structure was carried out under the supervision of J.M. Jolink, Engineering Student. The equipment used was owned and operated by Johnston Drilling Co. Ltd. The description of the bedrock core samples was carried out by S. Senior, Geologist.

The report was written by D. Dundas, Senior Foundations Engineer and reviewed by M. Devata, Chief Foundations Engineer (East).



D. H. Dundas

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

M. Devata

M. Devata, P.Eng.
Chief Foundations Engineer
(East)

APPENDIX

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 (R Q D), 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_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

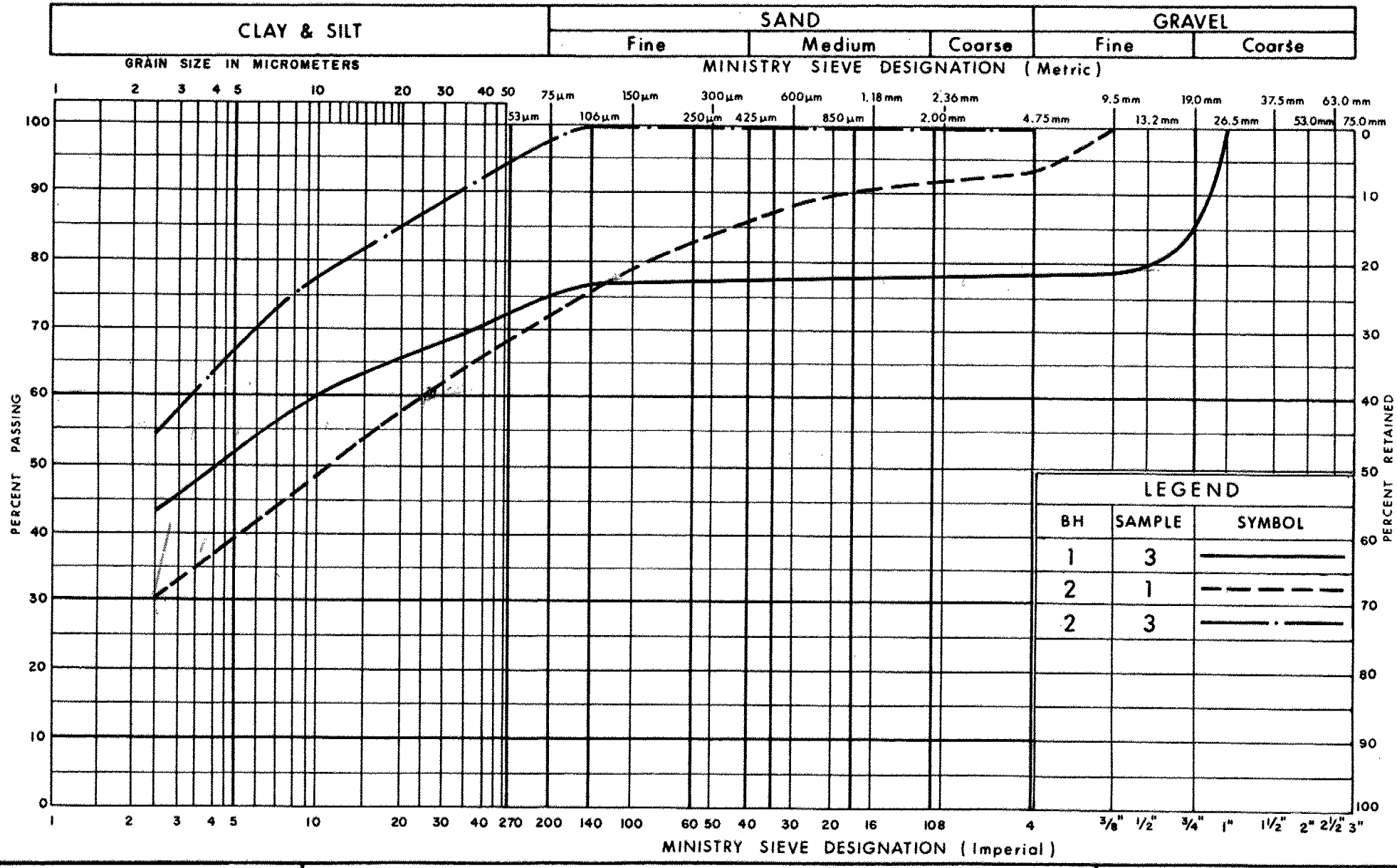
PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

UNIFIED SOIL CLASSIFICATION SYSTEM



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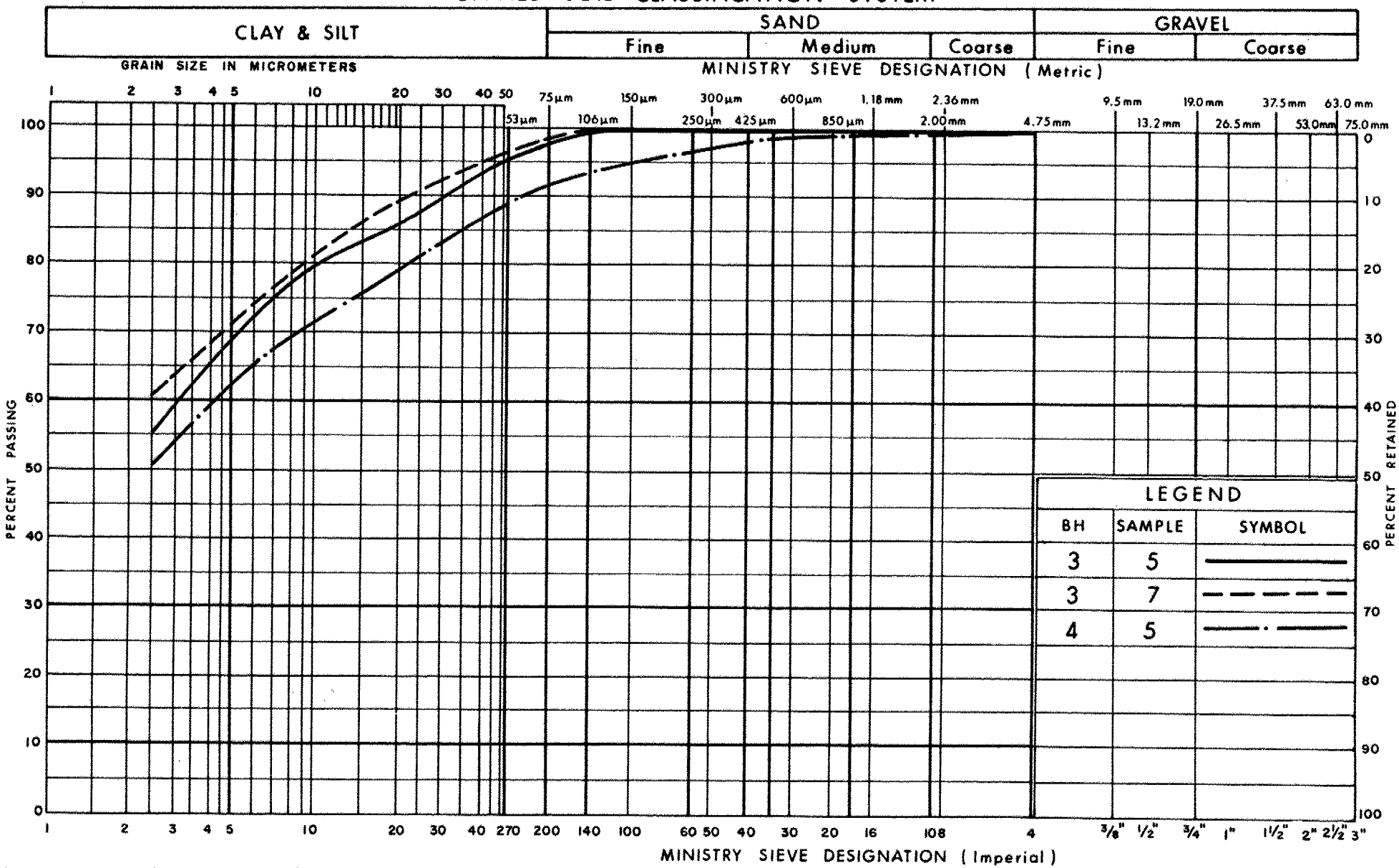
GRAIN SIZE DISTRIBUTION
SILTY CLAY (C I), TRACE / SOME SAND, GRAVEL
(Fill)

FIG No 1
W P 43-72-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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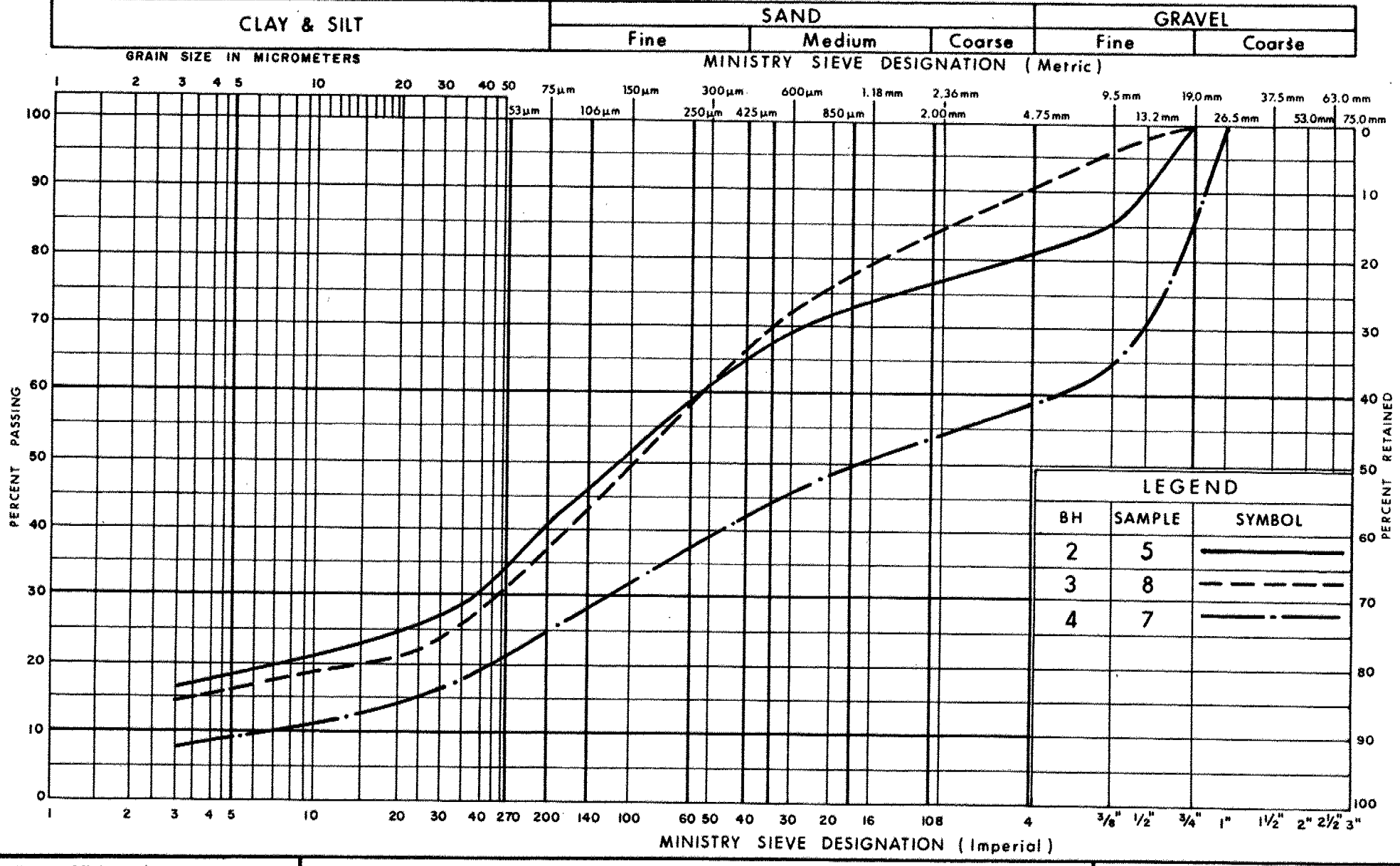
GRAIN SIZE DISTRIBUTION
SILTY CLAY (C I) , TRACE SAND (Marine)

FIG No 2
W P 43-72-02

UNIFIED SOIL CLASSIFICATION SYSTEM



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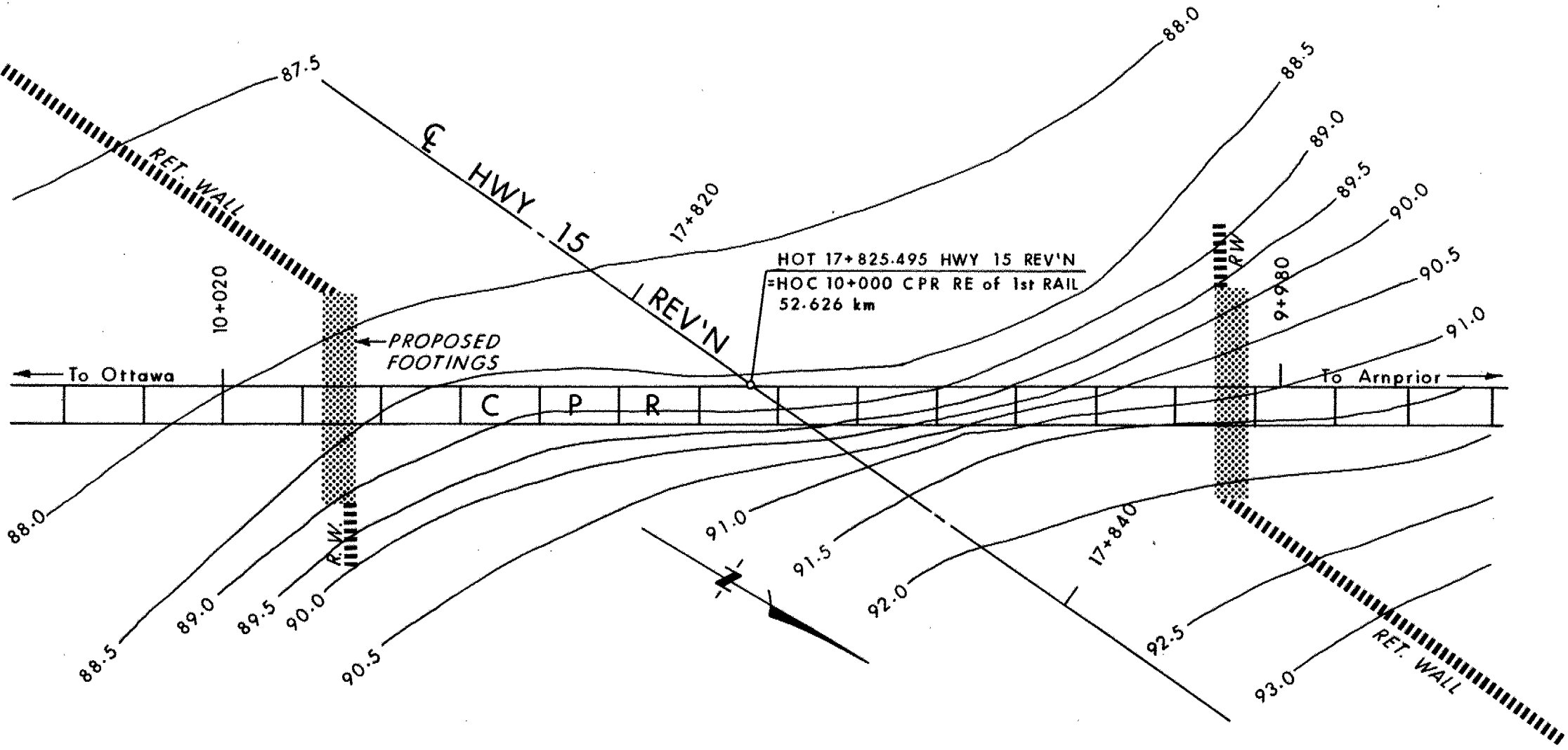
GRAIN SIZE DISTRIBUTION

SILTY SAND, TRACE/AND GRAVEL, TRACE/SOME CLAY
(Till)

FIG No 3
WP 43-72-02

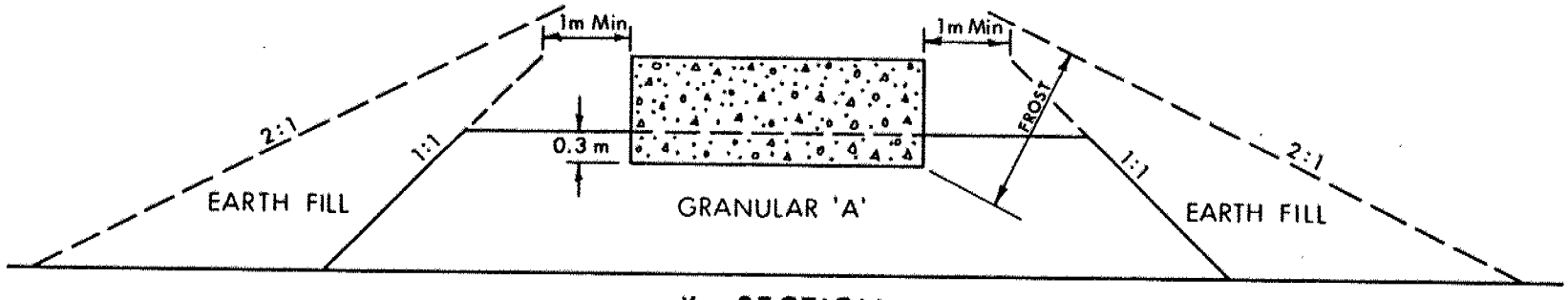


PLAN SHOWING ESTIMATED BEDROCK ELEVATION CONTOURS

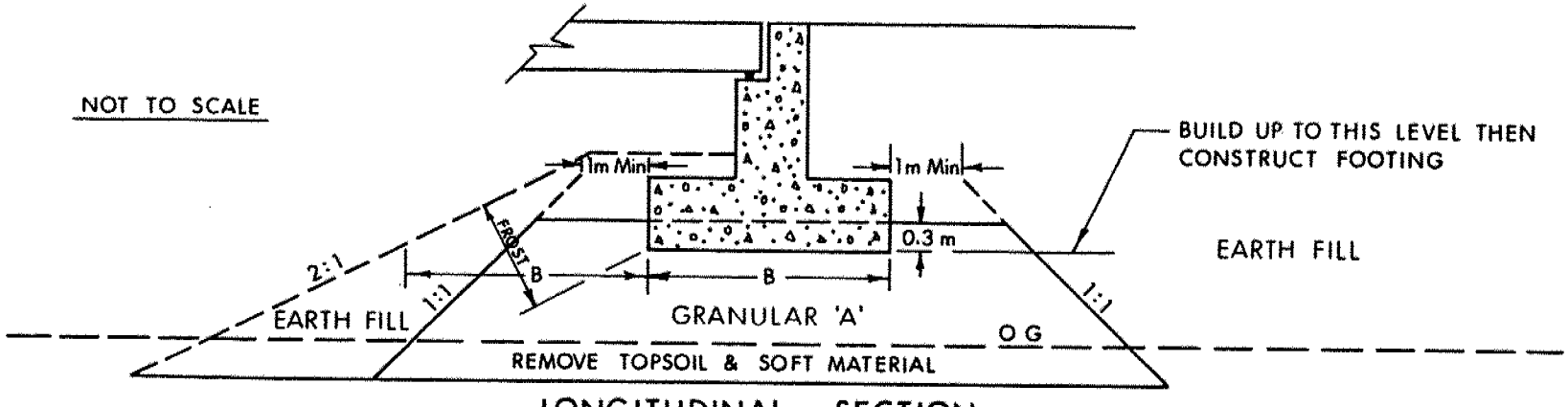
SCALE 1: 200

Fig 4

WP 43-72-02



X SECTION



LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No 5 W P 43-72-02

DESCRIPTION OF ROCK CORE - W.P. 43-72-02

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	2.90 - 3.05 3.05 - 4.30 4.30 - 5.87	50 88 92	0 57 88	2.90 - 3.05 3.05 - 3.44 3.44 - 5.87	LIMESTONE, buff, moderately weathered LIMESTONE, grey, slightly weathered, with oxidized, closely spaced, horizontal joints LIMESTONE, grey, unweathered, closely to medium spaced joints
2	6.61 - 7.95 7.95 - 9.48	89 100	60 43	6.61 - 6.81 6.81 - 9.48	LIMESTONE, weathered, core loss LIMESTONE, grey, unweathered, closely to medium spaced joints
3	7.01 - 7.14 7.14 - 7.32 7.32 - 8.12 8.12 - 8.69 8.69 -10.14	60 57 78 82 93	0 57 78 82 42	7.01 - 7.32 7.32 - 7.55 7.55 -10.14	BOULDERS LIMESTONE, weathered, core loss LIMESTONE, grey, unweathered, closely to medium spaced joints
4	5.62 - 6.59 6.59 - 7.99	84 98	37 70	5.62 - 5.79 5.79 - 7.99	BOULDERS and possibly weathered limestone, core loss LIMESTONE, grey, unweathered, closely to medium spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

TABLE 1

DESCRIPTION OF ROCK CORE - WP 43-72-02

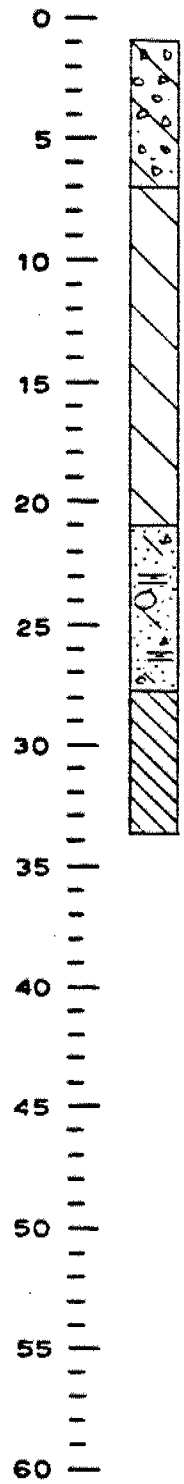
	CORE RECOVERY			CORE DESCRIPTION	
HOLE #	DEPTH (m)	%CR*	%RQD*	DEPTH (m)	DESCRIPTION
5	4.72- 6.25 6.25- 7.77	100 100	61 45	4.72- 7.77	LIMESTONE, grey to grey brown, banded dark grey, spotted white; dense, fine grained; medium strong rock; unweathered; very close to closely spaced fractures.
6	4.27- 5.79 5.79- 7.32	93 83	26 23	4.27- 7.32	LIMESTONE, light tan brown to medium blue-grey, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; unweathered; very close to closely spaced fractures.
7	4.27- 5.79 5.79- 7.32	100 100	63 78	4.27- 7.32	LIMESTONE, medium grey brown to dark grey, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; unweathered; closely spaced fractures.
8	4.57- 6.10 6.10- 7.62	95 100	28 48	4.57- 7.62	LIMESTONE, light grey to medium grey brown, banded dark grey brown, spotted white; dense, fine grained; medium strong to strong rock; closely spaced fractures.

*CR = CORE RECOVERY
*RQD = ROCK QUALITY DESIGNATION

TABLE 2

CPR *

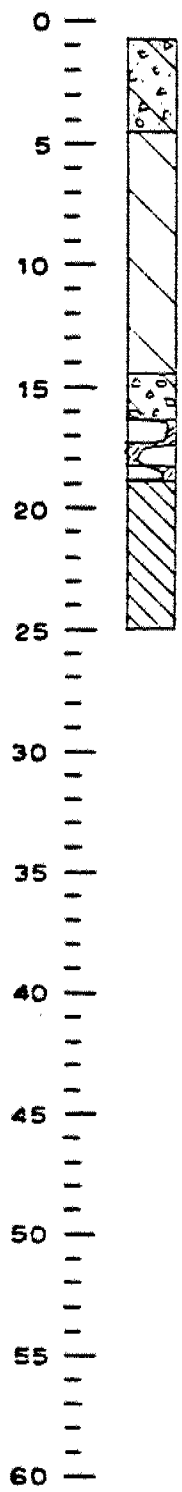
B. H. No. 1	DEPTH	DESCRIPTION	% CORE RECOVERY
	0'0"	Base of Rail	
		Clay and gravel, some sand	
	7'0"		
		Brown Clay	
	21'0"		
		Dense glacial till; grey silty, clayey fine to coarse sand with gravel and small boulders. Water level 22'1"	
	27'9"		27'9" to 33'9" Cored 6'0" Recovered 5'11½" 99% Recovery R.Q.D.=52%
		Sound limestone bedrock ¼" mud seam at 29'11"	
	33'9"		



* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

CPR *
B.H. No.2

DEPTH	DESCRIPTION	% CORE RECOVERY
0'0"	Base of rail	
	Clay and gravel, some sand	
4'6"		
	Brown clay	
14'6"	Clay and stones	
16'3"		
	Stone masonry wall	
18'11"		
	Sound limestone bedrock	18'11" to 25'0" Cored 6'1" Recovered 5'11½" 98% Recovery R.Q.D.=70%
25'0"		



* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

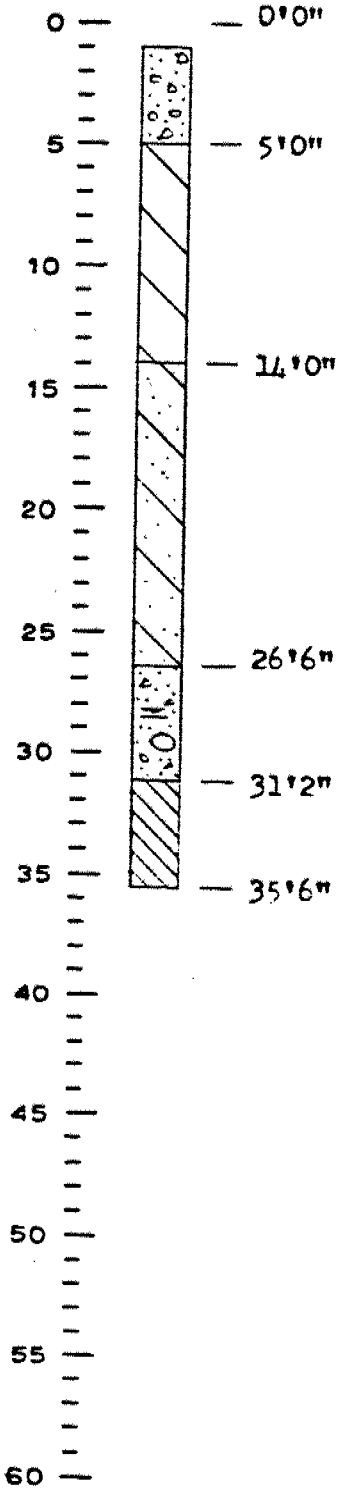
CPR *
B.H. No. 3

DEPTH	DESCRIPTION	% CORE RECOVERY
0'0"	Base of rail	
	Cinders, gravel, sand	
5'6"		
	Brown clay	
12'6"		
	Stone masonry wall with lime mortar	
17'0"		
	Mortar and pieces of limestone, some grout.	
22'8"		
23'6"	Brown clay	
	Water level 24'2"	
	Compact glacial till: gray silty to coarse sand: some gravel, trace clay, occasional boulders.	
31'6"		31'6" to 37'9"
	Sound limestone bedrock	Cored 6'3"
37'9"		Recovered 6'0"
		96% recovery
		R.Q.D. =59%

* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

CPR *
B.H. No. 4

DEPTH	DESCRIPTION	% CORE RECOVERY
0'0"	Base of rail	
	Cinders, gravel and sand	
5'0"		
	Brown clay	
14'0"		
	Brown and grey sandy clay	
	Water level 18'0"	
26'6"		
	Compact glacial till; grey silty fine to coarse sand with some gravel and clay, occasional boulders.	
31'2"		
	Sound limestone bedrock	31'2" to 35'6" Cored 4'4" Recovered 4'4" 100% recovery R.Q.D.=65%
35'6"		



* Prepared by Wilf Ohlmann Geotechnical Services Ltd. for CPR.

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RECORD OF BOREHOLE No 1 METRIC

W P 43-72-02 LOCATION STA. 17 + 854.5; O/S 11.9 m Lt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE N Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 26-27 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
96.1	GROUND SURFACE										
0.0	Silty Clay (CI) trace/some gravel trace/some sand firm to stiff (FILL) grey		1	SS	5		96				
			2	SS	7		95	+10			6 9 44 41
			3	SS	5		94				21 4 34 41
93.2	trace organics										
2.9	weathered		4	RC	rec50%		93				
	unweathered Bedrock Limestone occ. fissures		5	RC	rec 88%	86 08 27	92				
			6	RC	rec 92%		91				
90.2											
5.9	END OF BOREHOLE										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2 METRIC

W P 43-72-02 LOCATION STA. 17 + 812.5; O/S 18.6 m Rt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE B Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
94.9	GROUND SURFACE										
0.0	Silty Clay (CI) trace/some sand trace gravel soft to stiff (FILL) grey		1	SS	3		94				7 20 45 28
			2	SS	5						
			3	SS	6		93				0 2 48 50
91.9			4	SS	15		92				
3.0	trace organics					86 08 30					
	Silty Sand some gravel trace/some clay compact (TILL)		5	SS	19		91				19 41 26 14
			6	SS	17						
	slightly cohesive noncohesive		7	SS	28		90				19 49 22 10
88.3			8	SS	19		89				
6.6	weathered ___ unweathered		9	RC	rec 89%		88				
	Bedrock Limestone		10	RC	rec 100%		87				
85.5							86				
9.4	END OF BOREHOLE										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 3 METRIC

W P 43-72-02 LOCATION STA. 17 + 797.2; O/S 12.0 m Rt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE B Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 27-28 CHECKED BY DD

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
94.7	GROUND SURFACE										
0.0	CL to CI		1	SS	7		94				21 8 39 32
	Silty Clay (CI) trace/some gravel trace/some sand soft to firm (FILL) grey		2	SS	3	* 86 08 29					
91.8			3	SS	7		93				13 11 37 39
2.9	Silty Clay (CI) trace sand soft to stiff (MARINE) grey		4	SS	11		92				
			5	SS	7		91				0 2 48 50
			6	SS	4		90				
89.2			7	TW	PH					16.8	0 2 40 58
5.5	Silty Sand some clay trace gravel compact to very dense (TILL) brown		8	SS	14		89				10 54 22 14
			9	RC	rc60 %		88				
87.4	boulders		10	RC	rc57 %						
7.3	weathered / unweathered		11	RC	rec 78%		87				
	Bedrock Limestone		12	RC	rec 82%		86				
			13	RC	rec 93%		85				
84.6											
10.1	END OF BOREHOLE										

*probably not a stabilized ground-water elevation

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 4 METRIC

W P 43-72-02 LOCATION STA. 17 + 841.6; O/S 18.1 m Lt. ℄ Hwy. 15 ORIGINATED BY JD
DIST 9 HWY 15 BOREHOLE TYPE N Casing, B Core COMPILED BY DD
DATUM Geodetic DATE 86 08 30 CHECKED BY DD

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
95.6	GROUND SURFACE										
0.0	Sandy silt (ML) some clay, trace gravel very loose (FILL) slightly cohesive		1	SS	3		95		O H		5 34 42 19
94.5											
1.1	Silty Clay (CI) trace sand firm to very stiff (FILL) brown		2	SS	6	▽ 86 08 30	94				
			3	SS	6		93				0 4 46 50
92.4								$>+^2$			
3.2	trace organics brown		4	SS	11		92				
	Silty clay (CI) trace sand stiff to very stiff (MARINE) grey		5	SS	21						0 8 46 46
90.7			6	SS	12		91				
4.9	Silty sand and gravel trace clay		7	SS	60/8 cm				O H		41 33 21 5
90.0	** boulders						90				
5.6	weathered unweathered		8	RC	rec 84%						
	Bedrock Limestone		9	RC	rec 98%		89				
87.6							88				
8.0	END OF BOREHOLE										

*probably not a stabilized groundwater elevation

**very dense (TILL) brown

$+^3$, $\times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 5 METRIC

W P 43-72-02 LOCATION Sta. 17 + 776.7; O/S 1.8 m Rt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 11 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.4	Ground Surface										
0.0	Silty Clay (CI) Trace Sand Soft to Very Stiff (Marine) Grey		1	SS	11	*	92				0 1 43 56
			2	TW	PH		91				
			3	SS	1		90	+6			24 1 31 44
			4	SS	1		89	+12			
87.7							88	+18			
4.7	Bedrock Limestone Unweathered		5	RC	REC 100%		87				
			6	RC	REC 100%		86				
84.8							85				
7.6	End of Borehole * Groundwater Elevation Not Stabilized										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 6 METRIC

W P 43-72-02 LOCATION Sta. 17 + 791.8; O/S 2.4 m Rt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60	kN/m³	GR SA SI CL
92.3	Ground Surface						92				
0.0	Silty Clay (Cl) Trace Sand Soft to Stiff (Marine) Grey		1	SS	5	*	91				
			2	TW	PH					17.6	2 2 40 56
							90				
			3	TW	PH		89			17.2	1 2 37 60
88.0											
4.3	Bedrock Limestone Unweathered		4	RC	REC 93%		88				
			5	RC	REC 83%		87				
85.0							86				
7.3	End of Borehole										

* Groundwater Elevation Not Stabilized

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 7

METRIC

W P 43-72-02 LOCATION Sta. 17 + 798.9; O/S 11.1 m Lt. ℄ Hwy. 15 ORIGINATED BY MJ

DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ

DATUM Geodetic DATE 87 08 12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
92.3	Ground Surface										
0.0	Silty Clay (CI) Trace Sand Soft to Stiff (Marine) Grey		1	SS	10	*	92 91 90 89	+5 +9			
			2	SS	4						
			3	TW	PH						
88.0			4	TW	PM		88				
4.3	Bedrock Limestone Unweathered		5	RC	REC 100%		87				
			6	RC	REC 100%		86				
85.0											
7.3	End of Borehole										

* Groundwater Elevation Not Stabilized

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 8 METRIC

W P 43-72-02 LOCATION Sta. 17 + 817.9; O/S 6.6 m Lt. ℄ Hwy. 15 ORIGINATED BY MJ
DIST 9 HWY 15 BOREHOLE TYPE Cone Test, H-S Auger, B-Core COMPILED BY MJ
DATUM Geodetic DATE 87 08 13 CHECKED BY DD

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
92.3	Ground Surface						
0.0 / 91.1	Sand, Compact (Fill)		1	SS	6	*	
1.2 / 89.3	Silty Clay (CI), Trace Sand, Stiff (Marine), Grey		2	SS	PH		
3.0 / 87.7	Silty Sand, Some Gravel, Some Clay, Compact (Till)		3	TW	PH		25 43 22 10
4.6 / 84.7	Bedrock, Limestone, Unweathered		4	RC	REC 95%		
			5	RC	REC 100%		
7.6	End of Borehole						

* Groundwater Elevation Not Stabilized

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100
ELEVATION SCALE 92 91 90 89 88 87 86 85
+6
OH

PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

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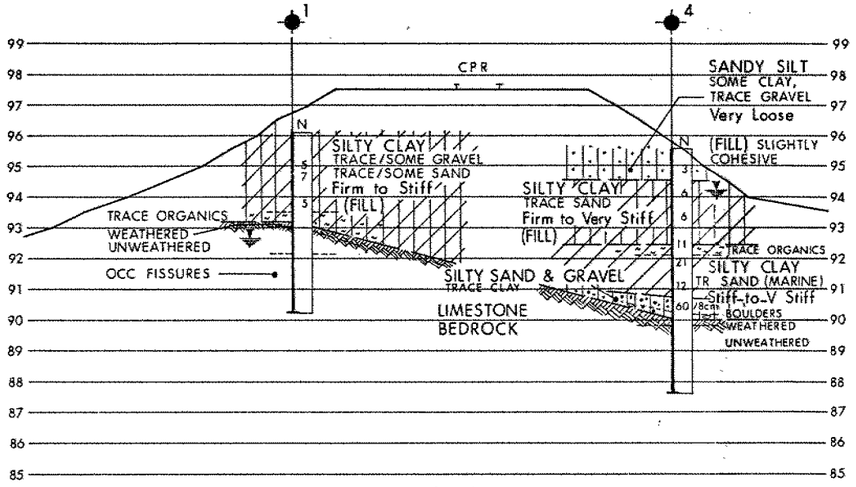
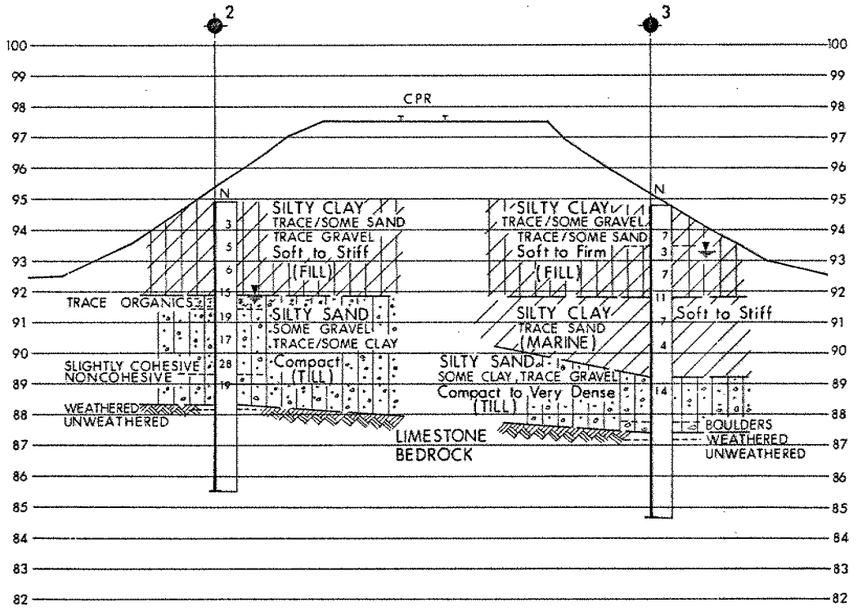


A-A

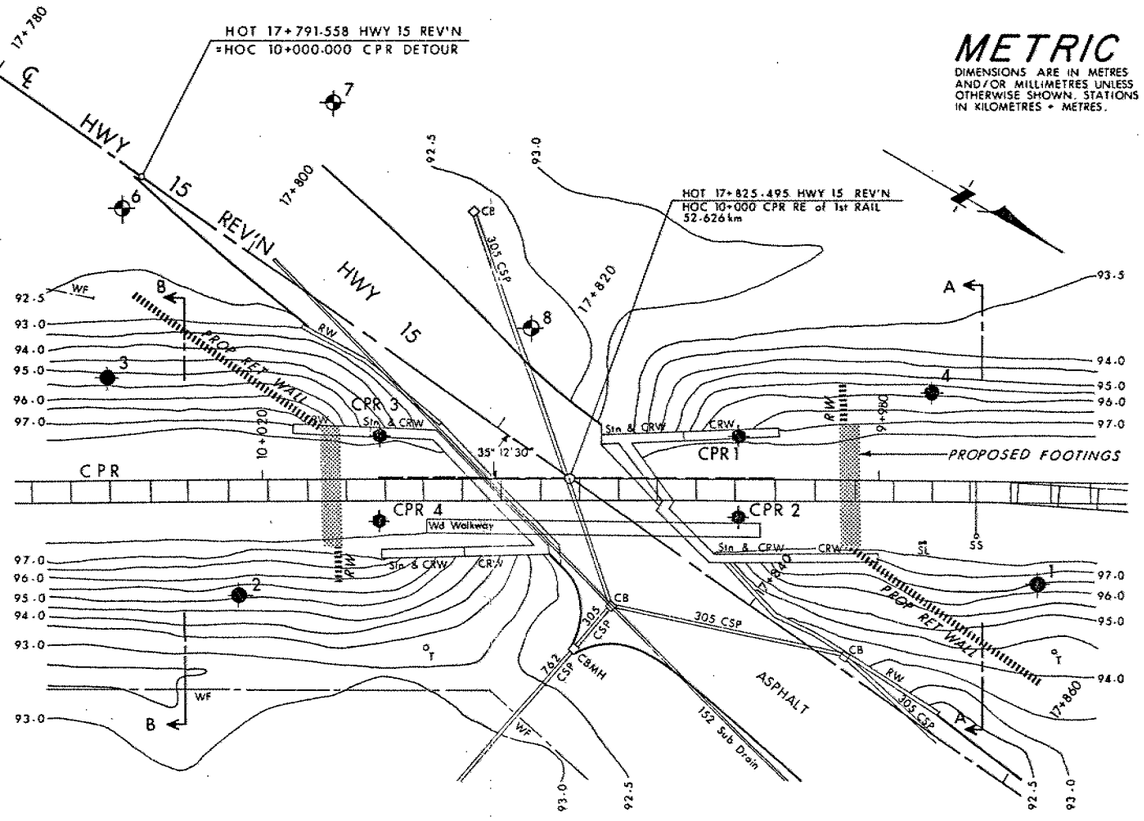


B-B

SECTIONS

SCALE

2m 1 0 2m



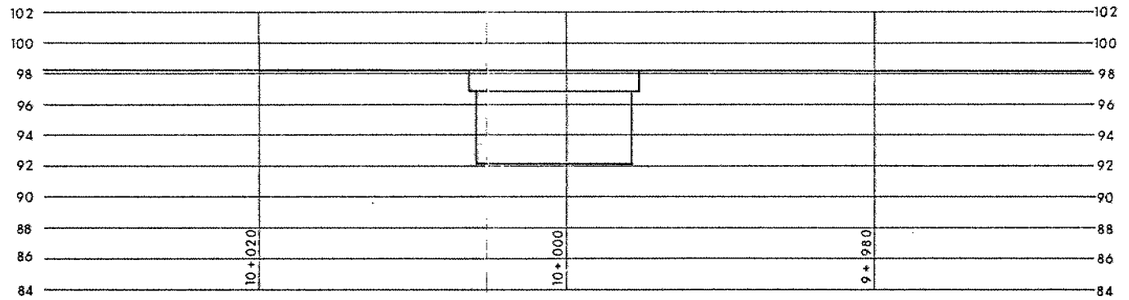
PLAN

SCALE

4m 2 0 4m

NOTE

Subsoil information for
Detour Alignment (BH 5, 6, 7 and 8)
Refer to Record of Borehole Sheets.



℄ PROFILE CPR TRACK

SCALE

4m 2 0 4m

METRIC

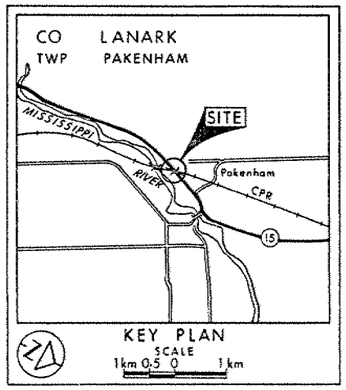
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 43-72-02

CPR SUBWAY AT PAKENHAM

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)
- W L at time of investigation 86 08
- CPR Bore Hole

No	ELEVATION	STATION	OFFSET
1	96.1	17+854.5	11.9 m Lt
2	94.9	17+812.5	18.6 m Rt
3	94.7	17+797.2	12.0 m Rt
4	95.6	17+841.6	18.1 m Lt
5	92.4	17+776.7	1.8 m Rt
6	92.3	17+791.8	2.4 m Rt
7	92.3	17+798.9	11.1 m Lt
8	92.3	17+817.9	6.6 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.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
	87 12 08	G P	BOREHOLES 5, 6, 7 & 8 ADDED ON PLAN

Geocres No 31F-106

HWY No 15			DIST 9
SUBM'D DD	CHECKED	DATE 86 12 01	SITE 15-15
DRAWN DT	CHECKED / APPROVED		DWG 437202-A

REF No E-7006-1, 82 07