

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M12-163

DIST. 6 REGION

W.P. No. 21-79-09

CONT. No. 85-13

W. O. No.

STR. SITE No. 24-469

HWY. No. 410/7

LOCATION Hwy 410 at New Hwy 7

No. of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

DIST 6 HWY 410
CONT No
WP No 21-79-09



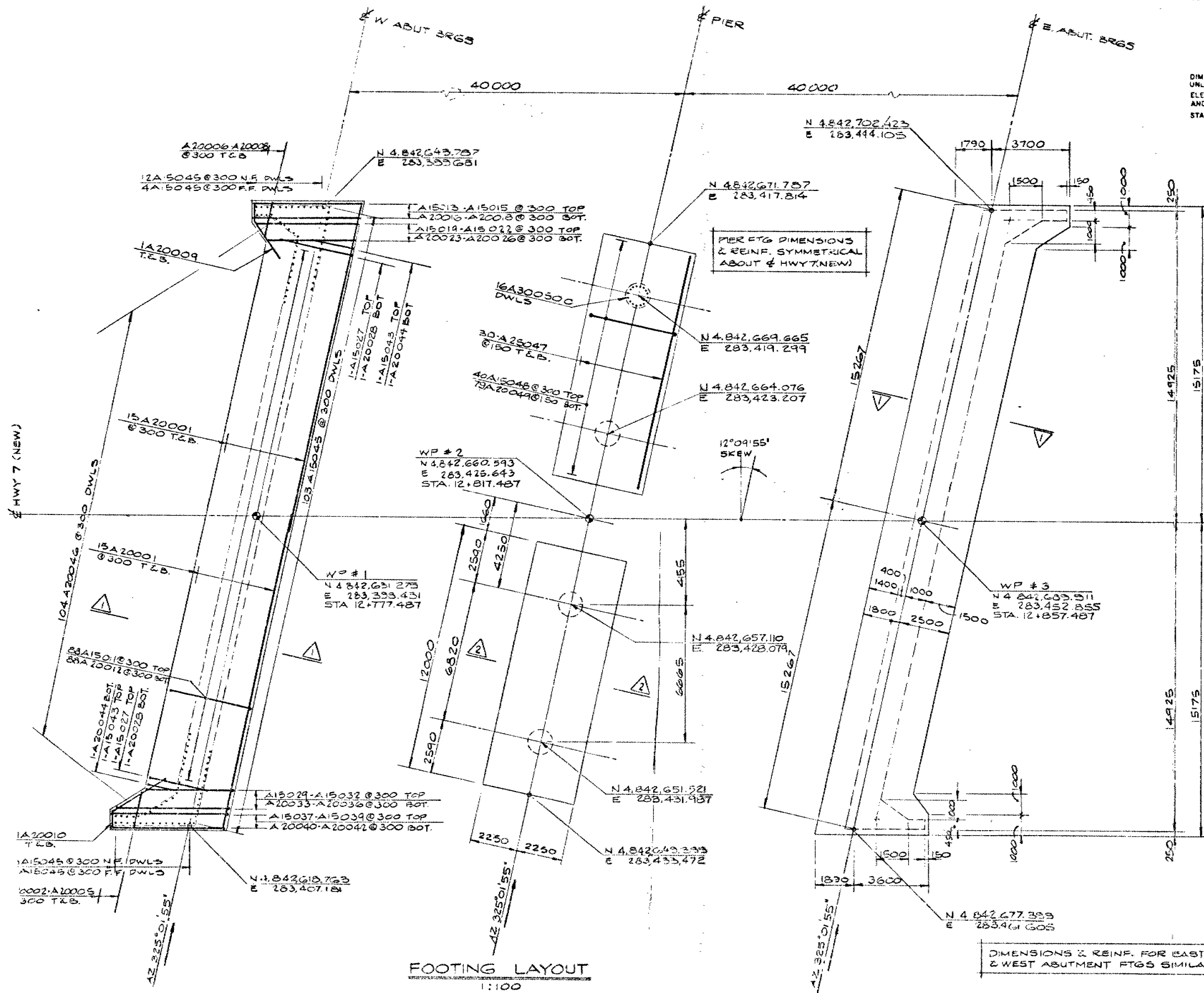
HWY 410 UNDERPASS
AT HWY 7 (NEW)
FOOTING LAYOUT AND DETAILS

SHEET

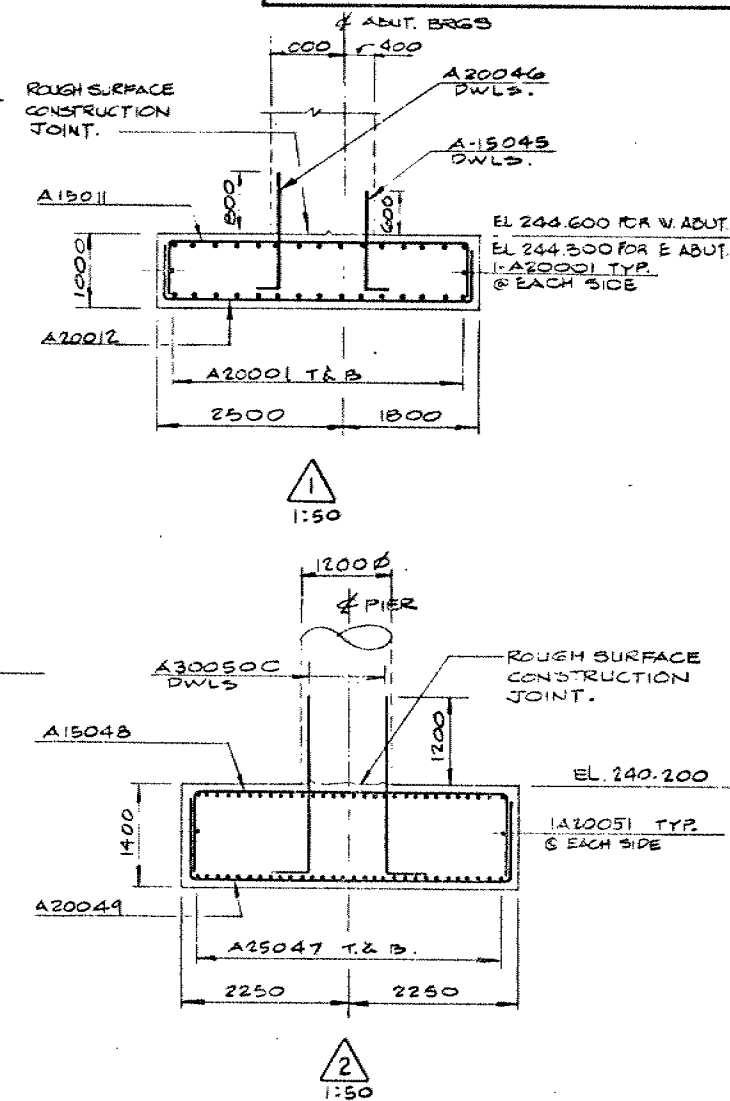
CS COLE,
SHERMAN

METRIC

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



FOOTING LAYOUT
1:100



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
1	NOV 62	CS	DESIGN
2	NOV 62	CS	CHECK
3	NOV 62	CS	LOADING
4	NOV 62	CS	DATE
5	NOV 62	CS	NOV 62

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 85-13



Ministry of
Transportation and
Communications

INDEX

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2	Abbreviations and Symbols
3 - 14	Foundation Investigation Report
	For
	W.P. 21-79-09, Site 24-469
	Hwy. 410 Underpass at Hwy. 7 (New)
	District 6 (Toronto)

NOTE: For purposes of this contract, this report
supersedes all other foundation reports done
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/0.3m)	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
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	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kn/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m ³	SEEPAGE FORCE
γ'	kn/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

for

W.P. 21-79-09 Site 24-469

Hwy. 410 Underpass at New Hwy. 7

District 6 (Toronto) Central Region

Introduction

Warnock Hersey Professional Services Limited have been retained by the Ontario Ministry of Transportation and Communications, under Agreement No. 4242-9081-210, to provide geotechnical services in connection with the above project. The purpose of the investigation was to establish the local subsoil stratigraphy and geotechnical parameters relating to the design and construction of the proposed underpass structure.

Site and Geology

The underpass site is located in Brampton near the existing intersection of Heart Lake Rd. and Bovaird Dr. It is situated primarily on existing farmland with the southerly part encroaching on Bovaird Drive. The surface topography is relatively flat. The flat relief continues east of the site whereas towards the west a marked rise in the grade exists in the form of a prominent north westerly trending ridge.

The area is located on the northern edge of the physiographic region known as the Peel Plain. The region is characterized by a level to undulating glaciated surface which slopes gradually downward towards Lake Ontario. Stream valleys tend to be shallow and at an early stage of development. Locally, the prominent ridge west of the site is a partly buried esker which serves as a source of aggregate material and as an aquifer for water wells.

Field and Laboratory Work

The field work consisted of the drilling and sampling of three borholes to depths of approximately 12.5 and 15.5 meters below the existing grade. The boreholes were drilled with a bombardier mounted drill rig (MTC type 5.2.i) employing either standard or hollow stem type augers. The locations and elevations of the boreholes are shown on the accompanying drawing 217909-A. *

Standard penetration tests were performed at regular intervals of depth in each of the boreholes. The recovered split spoon samples were visually logged in the field, and returned to our laboratory for further confirmatory testing and classification. The laboratory tests included a total of seven grain size analyses on representative samples, and two Atterberg limit tests. The borehole records and gradation curves are included in the appendix of this report.

SUBSOIL CONDITIONS

General

The subsoil conditions are generally uniform across the site. The topsoil layer and roadway aggregate are underlain by a hard slightly cohesive glacial till to depths of 3.8 to 4.6 meters. The till is underlain by very dense silts and fine sands explored to a maximum depth of 13.2 meters. The silts and sands are saturated below depths of 8.4 to 9.2 meters and are underlain by a very dense sand and gravel till which continues below a depth of 15 meters.

Details of each stratum are given below.

* Refer to Drawing No. 2 of the Contract Drawings

Silty Clay (of Low Plasticity) to Silt (Slightly Cohesive) with Sand,
Trace Gravel (Glacial Till)

This deposit occurs from the base of the topsoil to depths of approximately 3.8 to 4.6 meters. It is a cohesive glacial till subsoil consisting primarily of silt, with lesser amounts of clay and fine sand (Figure 2). It occurs in a very stiff to hard state with N values ranging from 20 to 83 blows/0.3 m. Natural moisture contents of this material range from 9 to 21 percent with an average of 13 percent. Atterberg limit tests (Figure 1) yielded liquid limits of 18 and 25 percent, with corresponding plasticity indices of 5 and 7. On the basis of these tests, the soil is classified as CL-ML.

Sandy Silt to Silty Sand

An extensive deposit of silts and fine sands underlies the upper cohesive glacial till deposit and continues to depths of approximately 13 meters. The soil is generally uniformly graded, ranging from fine sandy silt to silty sand. It occurs in a very dense state throughout with N values ranging from approximately 50 to 150 blows/0.3 m. A decrease in the N values was generally noted below the water table, possibly due to localized unbalancing of hydrostatic heads.

The natural moisture contents of the deposit above the water table ranges from 6 to 13 percent and below the water table from 14 to 28 percent.

Well Graded Sand and Gravel (Glacial Till)

A well graded sand and gravel till underlies the silt and fine sand subsoil, and continues below a depth of 15 meters. The till is comprised of a well graded mixture of sand and gravel sizes (Figure 4) including cobble and boulder sizes (as inferred from the field drilling). It occurs in a very dense state with N values in excess of 100 blows/0.3 m. The till occurs in a saturated state with an average moisture content of about 7 percent.

Groundwater

The groundwater table, as measured by three unsealed piezometers installed in each borehole, is located within the silt and fine sand deposit at depths of 8.4 to 9.2 meters below grade. The corresponding elevation is 236.5 meters. Above this level the soils are generally free of excess moisture except for a minor local wet seam at a depth of approximately 3 meters in Borehole 2.

Note: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Warnock Hersey Professional Services Ltd., the consulting geotechnical engineers for this project, under the technical supervision of the M.T.C. Foundation Design Section.

D.H. Dundas

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

APPENDIX



RECORD OF BOREHOLE No 1

METRIC ⁸

W P 21-79-09 LOCATION CO-ORDS N 4842 644.3 ; E 283 389.8 ORIGINATED BY B D
DIST 6 HWY 410 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B D
DATUM Geodetic DATE 1982 02 11 CHECKED BY C M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE	10	20	30			
245.7	Ground Surface																
0.0	200mm TOPSOIL																
	SILTY CLAY (of low plasticity) to SILT (slightly cohesive) with Sand, trace Gravel (Glacial Till) Brown Hard		1	SS	42		244										
			2	SS	47												
			3	SS	59												
			4	SS	76		242										
			5	SS	72												
241.3			6	SS	95												
4.4	SANDY SILT TO SILTY SAND Grey Very Dense		7	SS	95		240										
			8	SS	110		238										
			9	SS	69		236										
			10	SS	65												
							234										
233.1			11	SS	78												
12.6	END OF BOREHOLE																

+3, x5: Numbers refer to
Sensitivity

20
15 - 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC 9

W P 21-79-09 LOCATION CO-ORDS N 4 842 660.2 ; E 283 425.3 ORIGINATED BY B.D.
DIST 6 HWY 410 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B.D.
DATUM Geodetic DATE 1982 02 11 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT WL	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH				WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE	10 20 30				
245.4	Ground Surface															
0.0	220 mm TOPSOIL ---															
	SILTY CLAY (of low plasticity) to SILT (slightly cohesive) with Sand, trace Gravel (Glacial Till) Very Stiff to Hard		1	SS	20		244					○			5 33 49 13	
			2	SS	37							○				
			3	SS	39							○	—			
			4	SS	160		242					○				
241.6																
3.8	SANDY SILT TO SILTY SAND Brown - Grey Very Dense		5	SS	152		240					○			0 78 (22)	
			6	SS	118							○				
			7	SS	83		238					○				
			8	SS	61		236						○			
			9	SS	62		234						○			
			10	SS	56								○			
232.2																
13.2	Well Graded SAND and GRAVEL trace of Silt (Glacial Till) Very Dense , Grey		11	SS	103		232					○			50 45 (5)	
230.0																
15.4	END OF BOREHOLE		12	SS	90	15 cm						○				

+3, x5 : Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 3

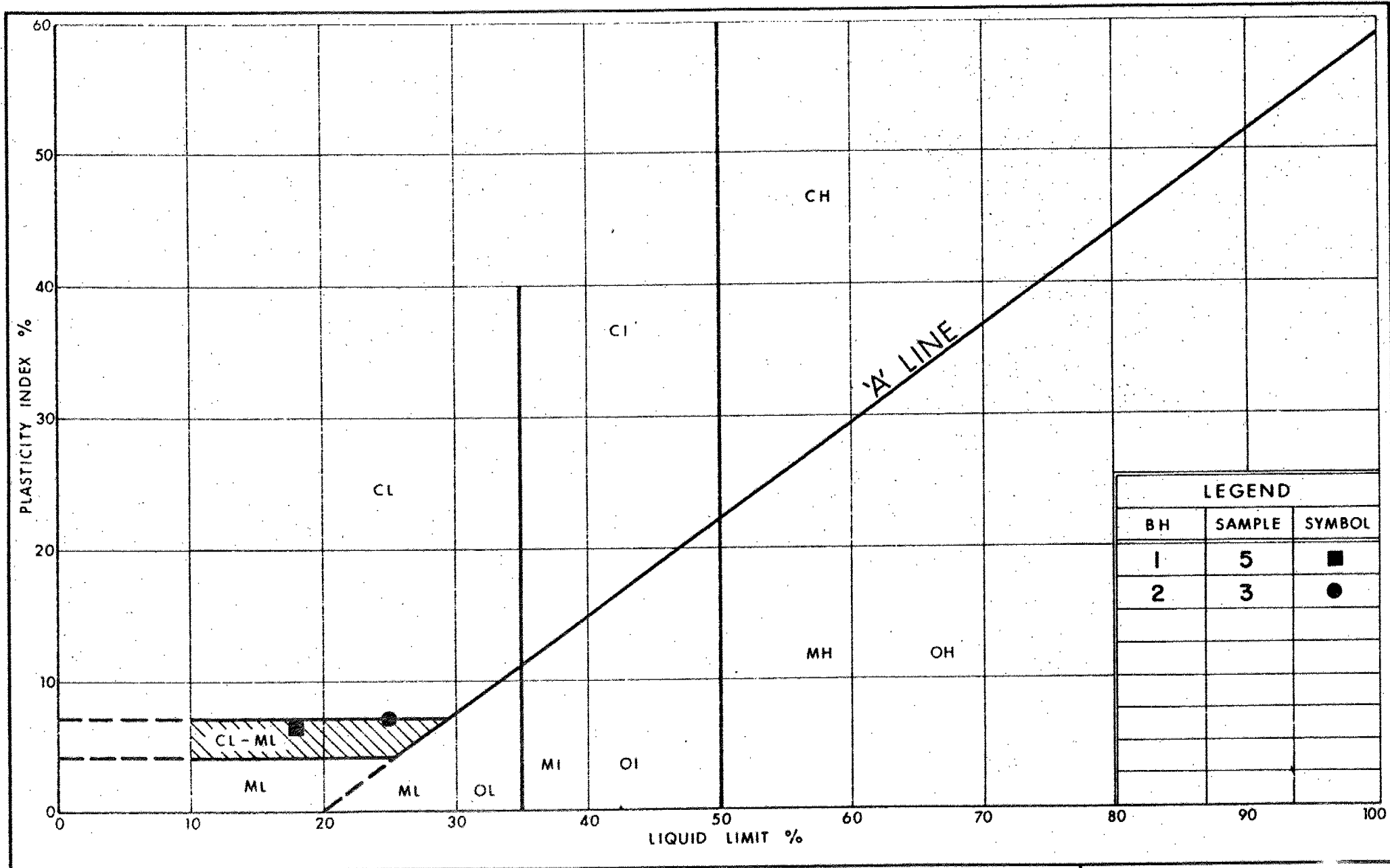
METRIC ¹⁰

W P 21-79-09 LOCATION CO-ORDS N 4842673.8 ; E 283464.0 ORIGINATED BY B D
DIST 6 HWY 410 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B D
DATUM Geodetic DATE 1982 02 11 CHECKED BY C M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
244.9	Ground Surface																
0.0	200mm TOPSOIL --																
	SILTY CLAY (of low plasticity) to SILT (slightly cohesive) with Sand, trace Gravel (Glacial Till) Brown Hard		1	SS	72		244										
			2	SS	66												
			3	SS	46		242										
			4	SS	68												
			5	SS	83												
240.3			6	SS	120		240										
4.6			7	SS	110												
	SANDY SILT TO SILTY SAND Very Dense Grey		8	SS	110		238										
			9	SS	99		236										
			10	SS	85		234										
232.3			11	SS	69												
12.6	END OF BOREHOLE																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Ministry of
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PLASTICITY. CHART

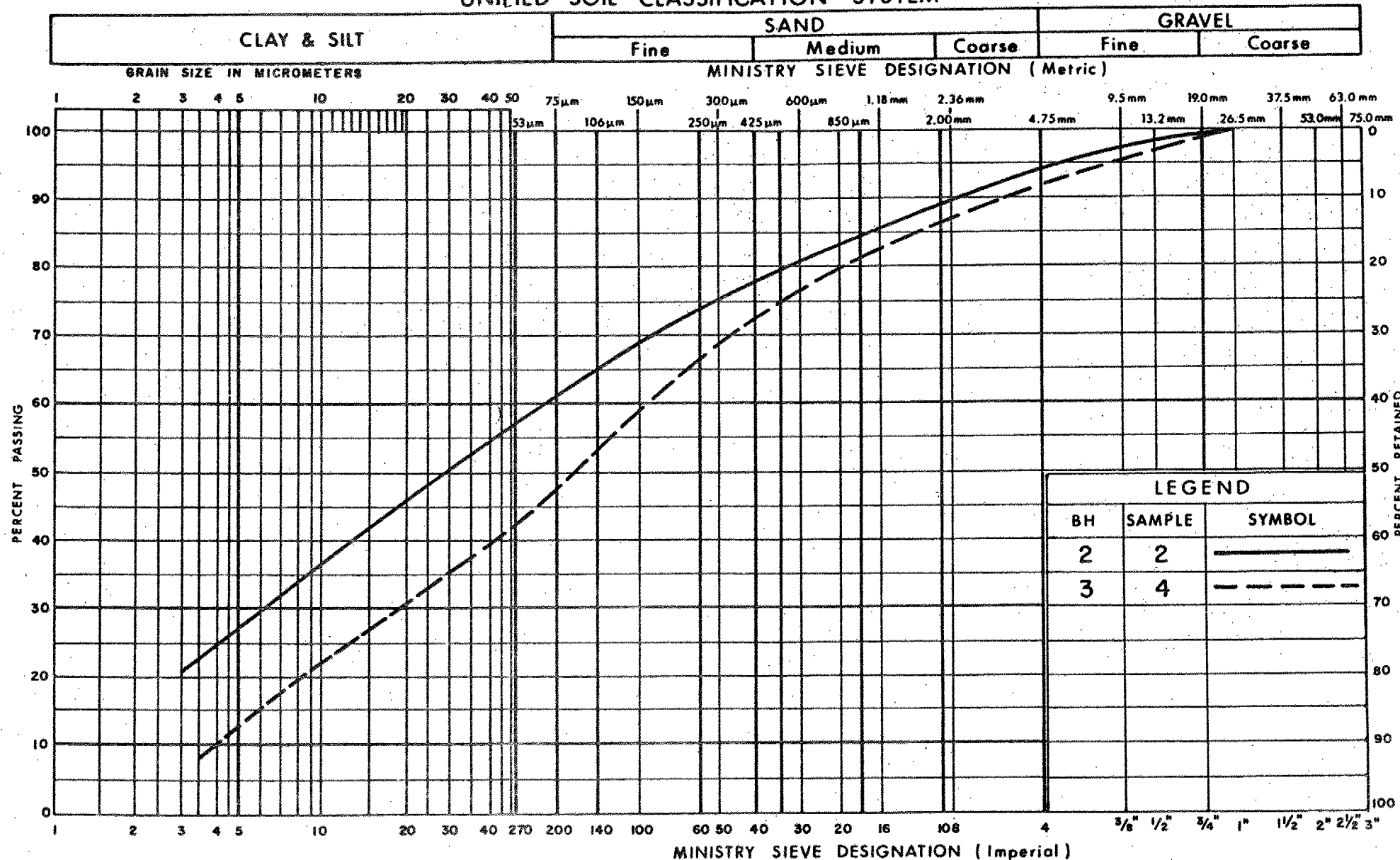
SILTY CLAY OF LOW PLASTICITY (Glacial Till)

FIG No 1

W P 21-79-09

Hwy 410 & 7N

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY OF LOW PLASTICITY (Glacial Till)

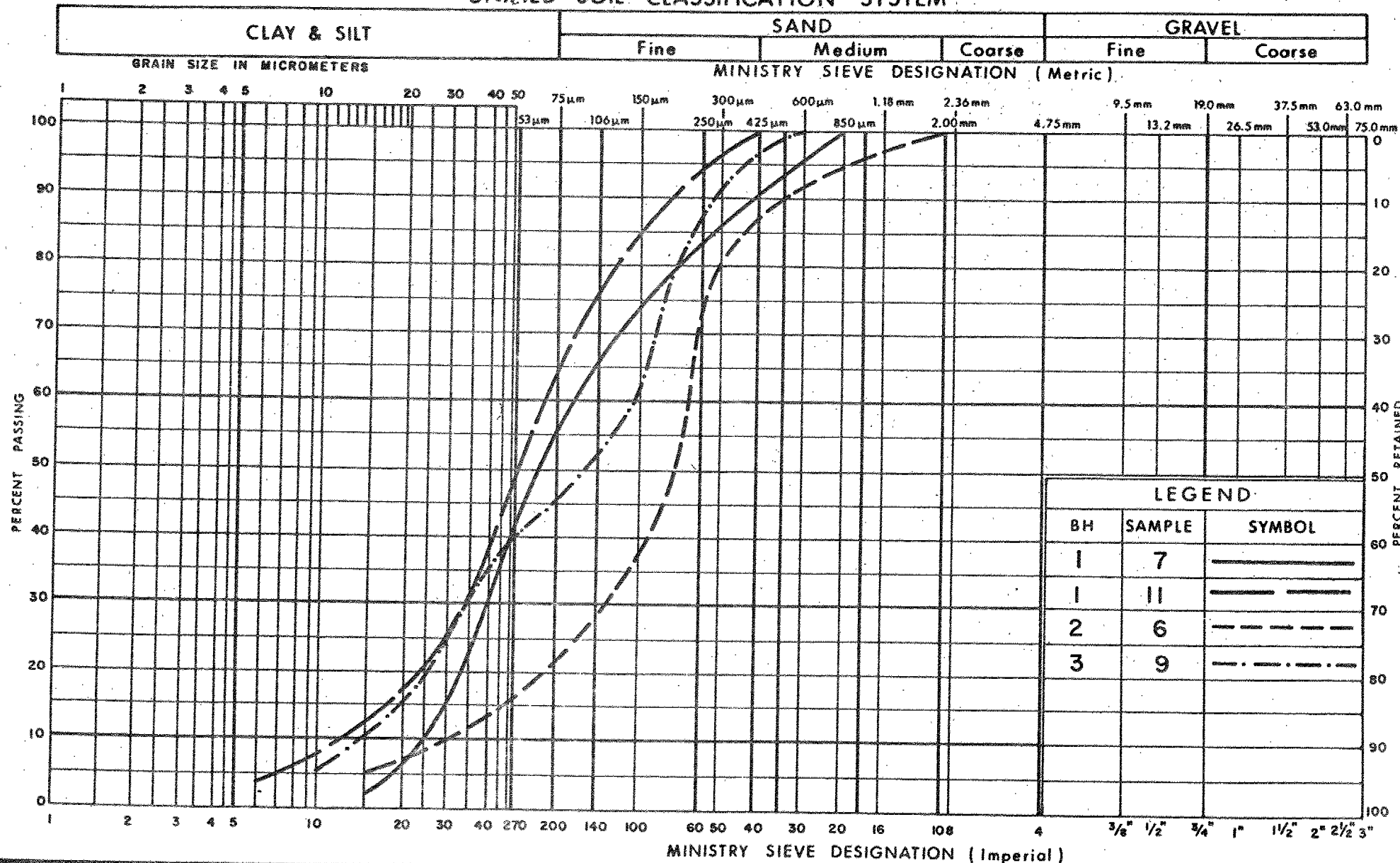
FIG No 2

WP 21-79-09

Hwy 410 & 7N

2

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
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Communications

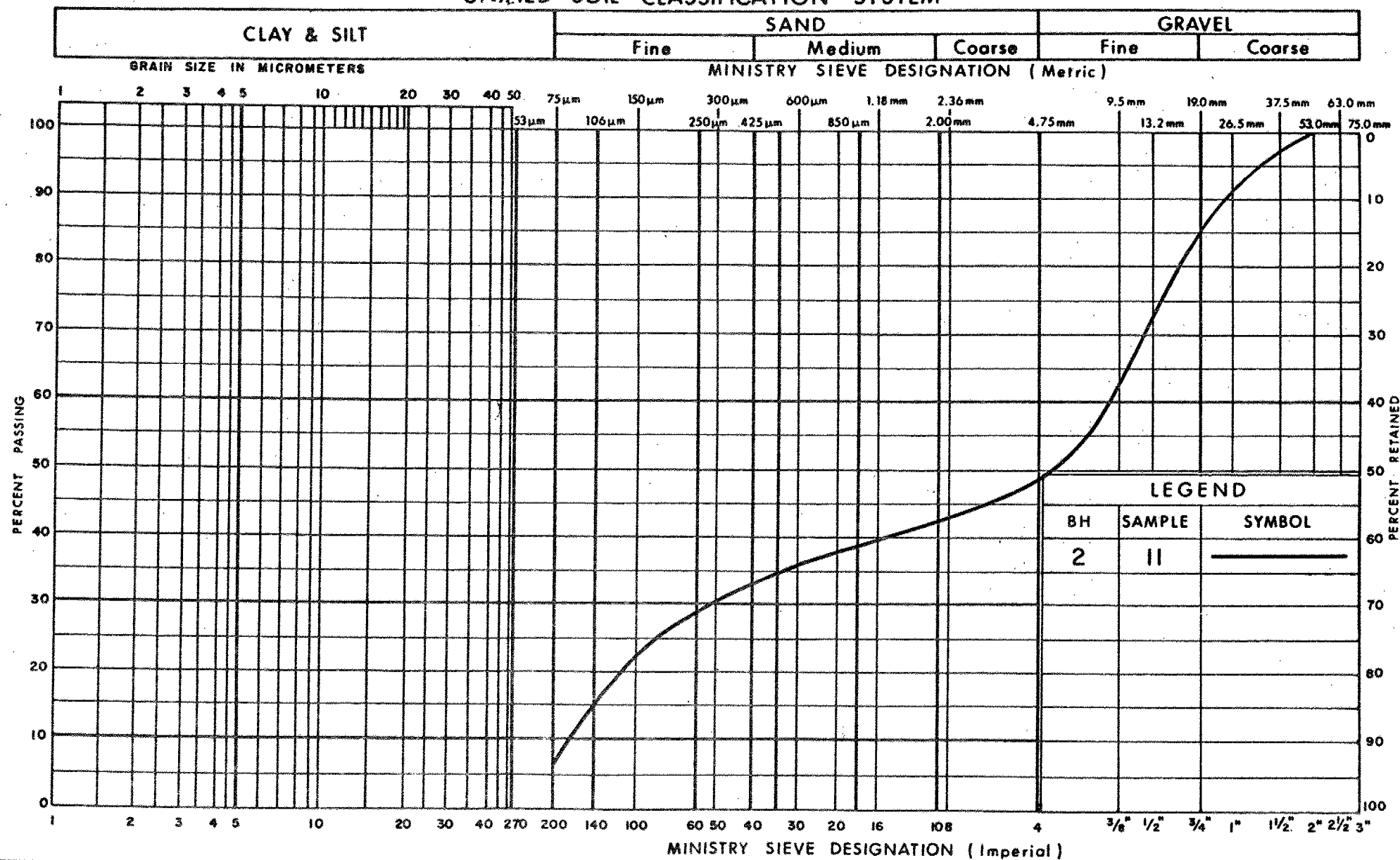
GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

FIG No 3

WP 21-79-09

Hwy 410 & 7N

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

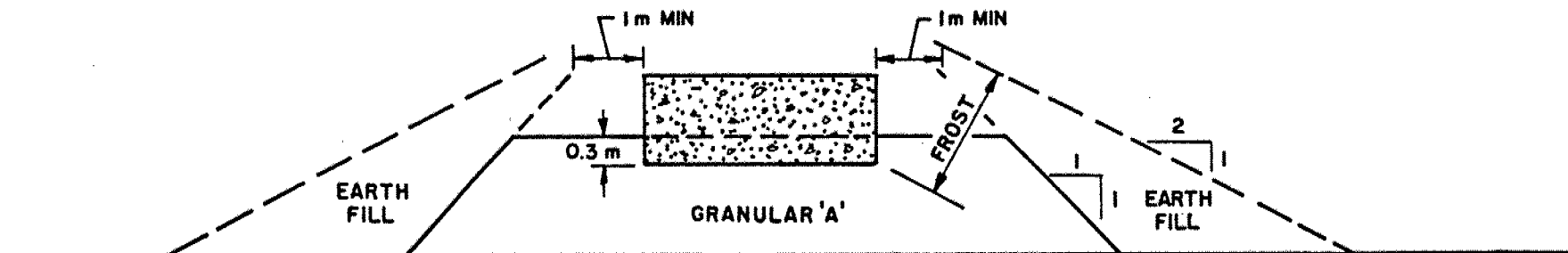
GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL (Glacial Till)

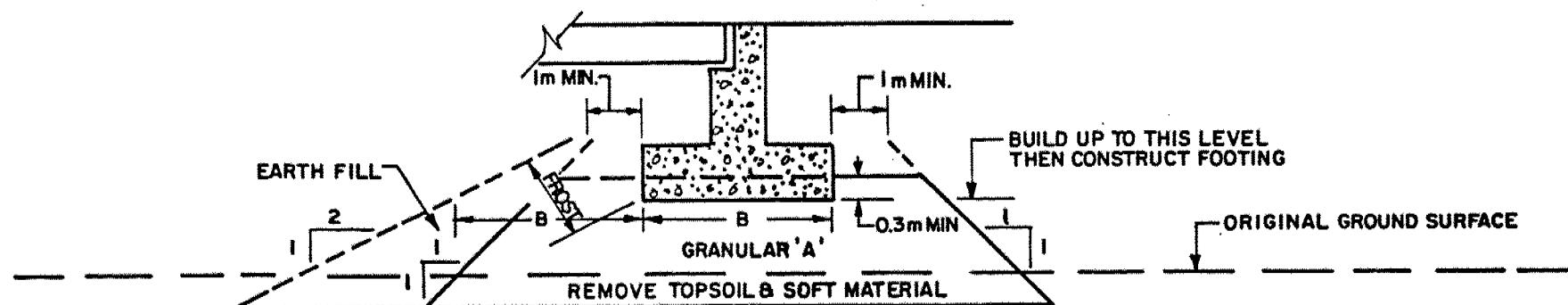
FIG No 4

W P 21-79-09

Hwy 410 & 7N



CROSS - SECTION



LONGITUDINAL SECTION

NOT TO SCALE

- NOTES :
1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
 2. PLACE GRANULAR 'A' AND 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' AND EARTH FILL AS REQUIRED



Ministry of
Transportation and
Communications

ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR 'A' CORE

FIG No 1

W P 21-79-09

FOUNDATION INVESTIGATION REPORT
for
W.P. 21-79-09 Site 24-469
Hwy 410 at New Hwy. 7
District 6 (Toronto) Central Region

1982 03 31

Distribution:

13 - MTC
2 - WHPSL



GEOC. 30M12-163

FOUNDATION INVESTIGATION REPORT

for

W.P. 21-79-09 Site 24-469

Hwy. 410 Underpass at New Hwy. 7

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Details of each stratum are given below.

Silty Clay (of Low Plasticity) to Silt (Slightly Cohesive) with Sand,
Trace Gravel (Glacial Till)

This deposit occurs from the base of the topsoil to depths of approximately 3.8 to 4.6 meters. It is a cohesive glacial till subsoil consisting primarily of silt, with lesser amounts of clay and fine sand (Figure 2). It occurs in a very stiff to hard state with N values ranging from 20 to 83 blows/0.3 m. Natural moisture contents of this material range from 9 to 21 percent with an average of 13 percent. Atterberg limit tests (Figure 1) yielded liquid limits of 18 and 25 percent, with corresponding plasticity indices of 5 and 7. On the basis of these tests, the soil is classified as CL-ML.

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An extensive deposit of silts and fine sands underlies the upper cohesive glacial till deposit and continues to depths of approximately 13 meters. The soil is generally uniformly graded, ranging from fine sandy silt to silty sand. It occurs in a very dense state throughout with N values ranging from approximately 50 to 150 blows/0.3 m. A decrease in the N values was generally noted below the water table, possibly due to localized unbalancing of hydrostatic heads.

The natural moisture contents of the deposit above the water table ranges from 6 to 13 percent and below the water table from 14 to 28 percent.

Well Graded Sand and Gravel (Glacial Till)

A well graded sand and gravel till underlies the silt and fine sand subsoil, and continues below a depth of 15 meters. The till is comprised of a well graded mixture of sand and gravel sizes (Figure 4) including cobble and boulder sizes (as inferred from the field drilling). It occurs in a very dense state with N values in excess of 100 blows/0.3 m. The till occurs in a saturated state with an average moisture content of about 7 percent.

Groundwater

The groundwater table, as measured by three unsealed piezometers installed in each borehole, is located within the silt and fine sand deposit at depths of 8.4 to 9.2 meters below grade. The corresponding elevation is 236.5 meters. Above this level the soils are generally free of excess moisture except for a minor local wet seam at a depth of approximately 3 meters in Borehole 2.

DISCUSSION AND RECOMMENDATIONS

General

It is understood that the proposed structure will be a two span ($39\pm$ m, $39\pm$ m), cast-in place type of post-tensioned slab with a width of approximately $31\pm$ meters, (symmetrical about Hwy. 7N). The profile grade of Highway 410 will be established at approximate elevation 242 which is some 3.0 to 3.5 meters below the existing surface. The bridge abutments will likely be composite retaining walls extending the full height of bridge clearance.

It is believed the final location of Hwy. 410 centre line could be shifted easterly or westerly by 1 to 2 meters from the location shown on plan.

Foundation Design

The hard or dense subsoils at this site are conducive to the use of spread footing type foundations. Given the proposed profile grades, it is expected that footings can be established at approximately elevation 240.5 where the founding subsoil will consist of very dense silt and fine sand subsoil. A minimum earth cover of 1.2 m should be provided to the underside of the footings for protection against frost action.

For design purposes the following values are recommended:

Capacity at SLS Type II:	600 kPa
Factored Capacity at U.L.S.:	850 kPa
Coefficient of Friction Between Soil and Base:	0.5

Earth pressures on the abutment retaining walls may be computed by using the following equivalent fluid pressures:

at ULS: active state 8.0 kPa/m

at SLS: active state 6.5 kPa/m

The load factors of OHBDC Section 2 should be applied to the pressures shown, as applicable.

Approach Fills

The proposed profile grade indicates an embankment height of approximately 4 meters for the west approach and a maximum of 3 meters for the east approach. Since these heights are relatively nominal with respect to the dense character and high bearing capacity of the underlying soils, the embankments can be supported with little or effectively no associated settlement. Basal type slope failure is also not a consideration and as such a nominal 2:1 side slope ratio is recommended.

Dewatering

No major dewatering is expected due to the low prevailing groundwater levels.

Backfill

Backfill behind retaining walls should consist of a good quality Granular "B" material which is placed in uniform 200 mm lifts and compacted to 95 percent of the Standard Proctor density. The use of light weight compaction equipment is required immediately adjacent to the structure to avoid excessive horizontal forces. Appropriate drains and openings should be provided behind and through the abutment walls to prevent the buildup of hydrostatic forces.

Embankment Construction

Preparation for embankment construction should consist of complete stripping of the topsoil layer and proof rolling of the exposed subgrade with a heavy vibratory sheepsfoot compactor. Any weak or spongy areas thus revealed should be excavated and replaced with a well compacted sand fill.

Excavated soil from the Hwy. 410 cut will be well-suited for embankment construction since its moisture content is believed to be relatively close to the optimum moisture value. The soil should be placed in maximum 200 mm lifts and compacted to 95 percent of the standard proctor density.

Cut Slope Protection


Beyond the abutment walls, the Hwy. 410 excavation should be cut back at 2:1 for support and maintenance of a vegetative surface cover.

The silt and fine sand deposit is likely to erode more readily than the overlying glacial till. Therefore, any exposed sandy silt to silty sand portions of the cut slopes should be dressed with a 150 mm thick layer of Granular B or C prior to topsoiling and seeding or sodding. If a sandy type of Granular B is used, there is no need for a geotextile filter.

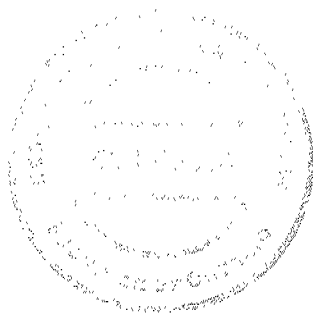
Report by B. D'Onofrio, P.Eng.

Respectfully submitted

Warnock Hersey Professional Services Limited


C. Mirza, P.Eng.,
Manager,
Geotechnical Services.

CM:cc
Attach.



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



RECORD OF BOREHOLE No 1

METRIC

W P 21-79-09 LOCATION CO-ORDS N 4842 644.3 ; E 283 389.8 ORIGINATED BY B D
DIST 6 HWY 410 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B D
DATUM Geodetic DATE 1982 02 11 CHECKED BY C M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH					WATER CONTENT (%)				
245.7	Ground Surface																
0.0	200mm TOPSOIL																
	SILTY CLAY (of low plasticity) to SILT (slightly cohesive) with Sand, trace Gravel (Glacial Till) Brown Hard		1	SS	42		244										
			2	SS	47												
			3	SS	59												
			4	SS	76												
			5	SS	72		242										
241.3			6	SS	95												
4.4	SANDY SILT TO SILTY SAND Grey Very Dense		7	SS	95		240										
			8	SS	110		238										
			9	SS	69		236										
			10	SS	65												
			11	SS	78		234										
233.1																	
12.6	END OF BOREHOLE																

RECORD OF BOREHOLE No 2

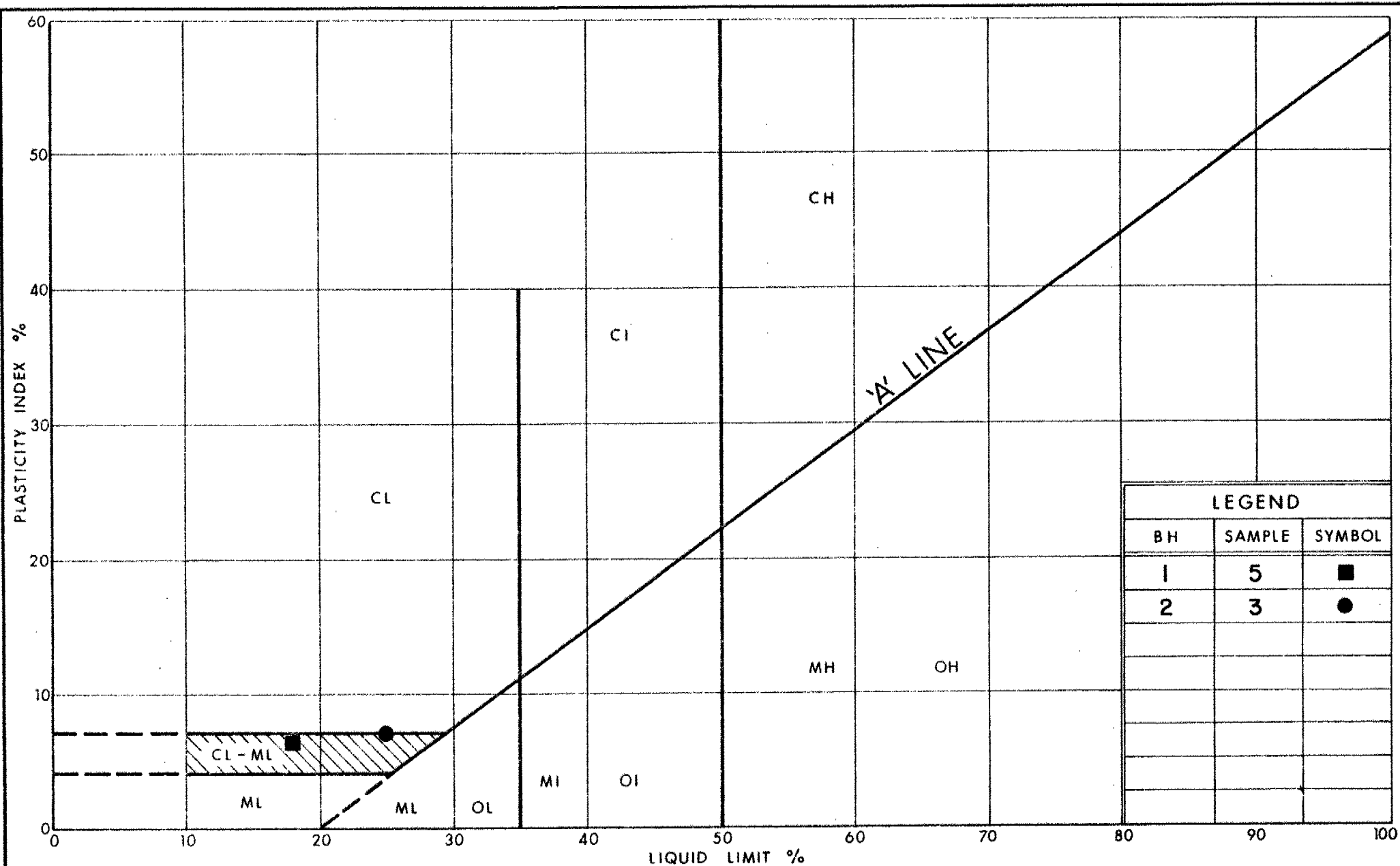
METRIC

W P 21-79-09 LOCATION CO-ORDS N 4 842 660.2 ; E 283 425.3 ORIGINATED BY B D
 DIST 6 HWY 410 BOREHOLE TYPE Hollow Stem Auger COMPILED BY B D
 DATUM Geodetic DATE 1982 02 11 CHECKED BY C M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
245.4	Ground Surface																
0.0	220 mm TOPSOIL																
	SILTY CLAY (of low plasticity) to SILT (slightly cohesive) with Sand, trace Gravel (Glacial Till) Very Stiff to Hard		1	SS	20		244							o			5 33 49 13
			2	SS	37									o			
			3	SS	39									o			
			4	SS	160		242							o			
241.6																	0 78 (22)
3.8			5	SS	152		240							o			
			6	SS	118									o			
	SANDY SILT TO SILTY SAND Brown - Grey Very Dense		7	SS	83		238							o			
			8	SS	61		236								o		
			9	SS	62										o		
			10	SS	56		234								o		
232.2							232							o			50 45 (5)
13.2	Well Graded SAND and GRAVEL trace of Silt (Glacial Till) Very Dense, Grey		11	SS	103									o			
230.0																	
15.4	END OF BOREHOLE		12	SS	90	15 cm								o			

+3, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10



Ministry of
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Communications

PLASTICITY CHART

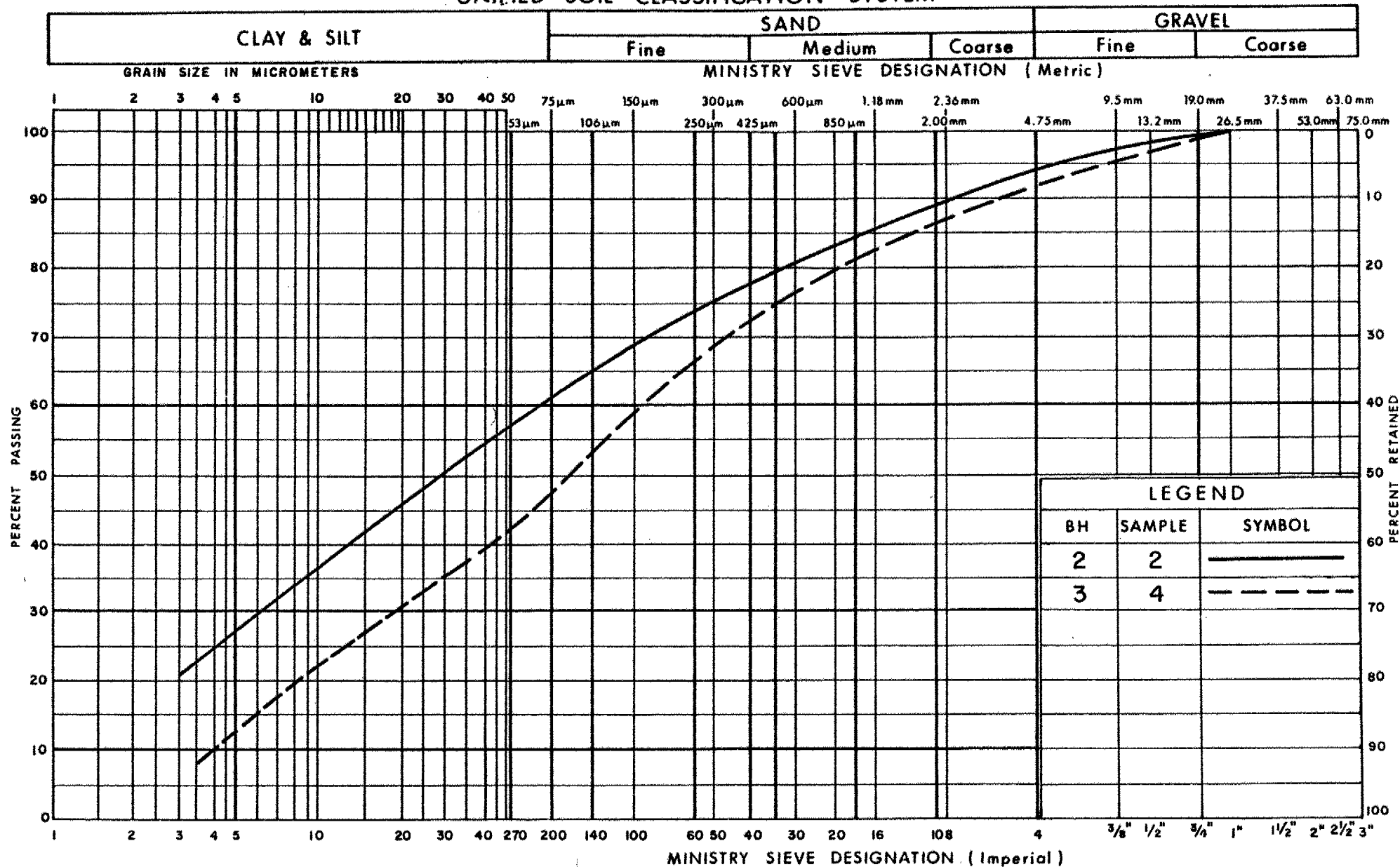
SILTY CLAY OF LOW PLASTICITY (Glacial Till)

FIG No 1

W P 21-79-09

Hwy 410 & 7N

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

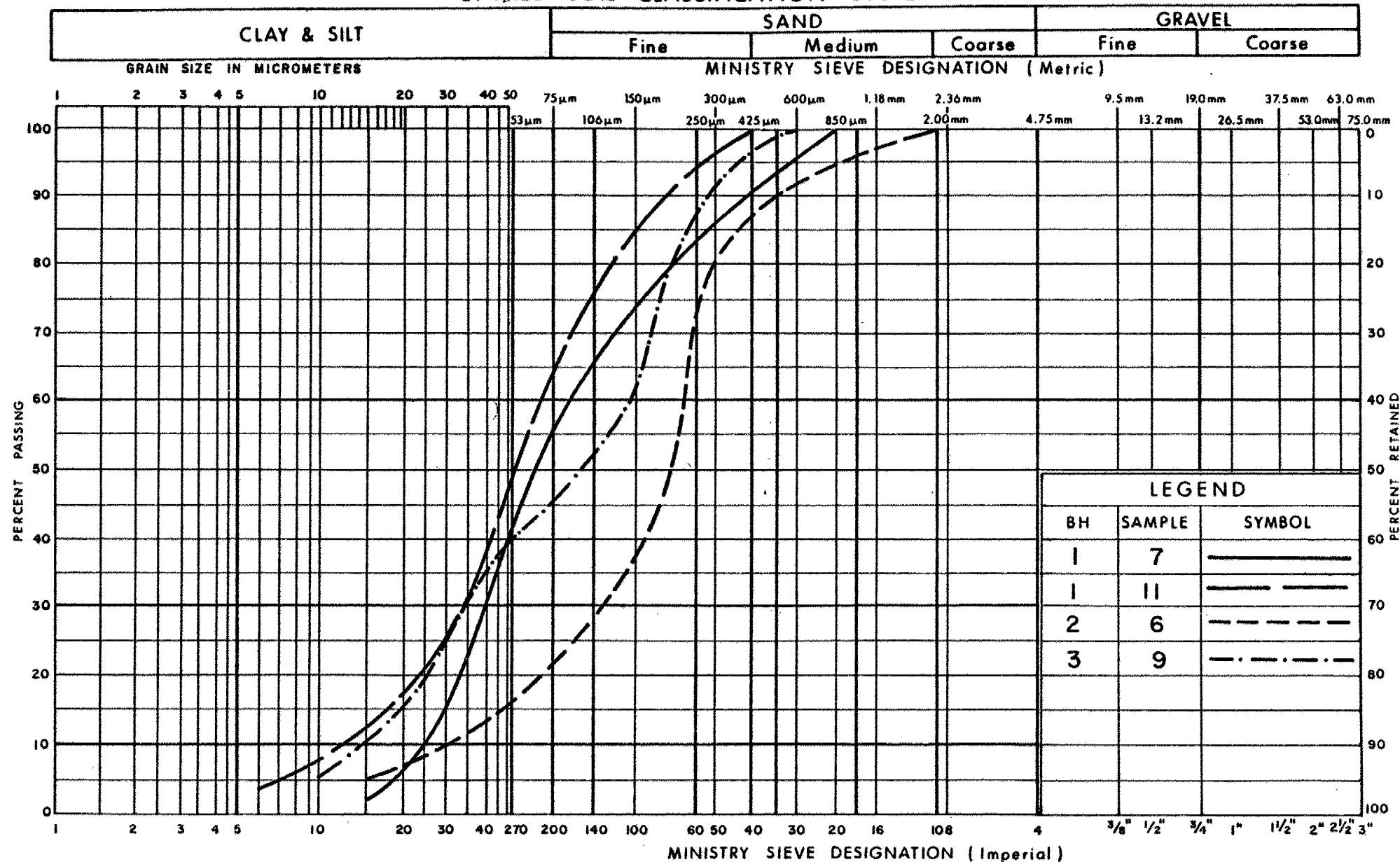
GRAIN SIZE DISTRIBUTION
SILTY CLAY OF LOW PLASTICITY (Glacial Till)

FIG No 2

WP 21-79-09

Hwy 410 & 7N

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION

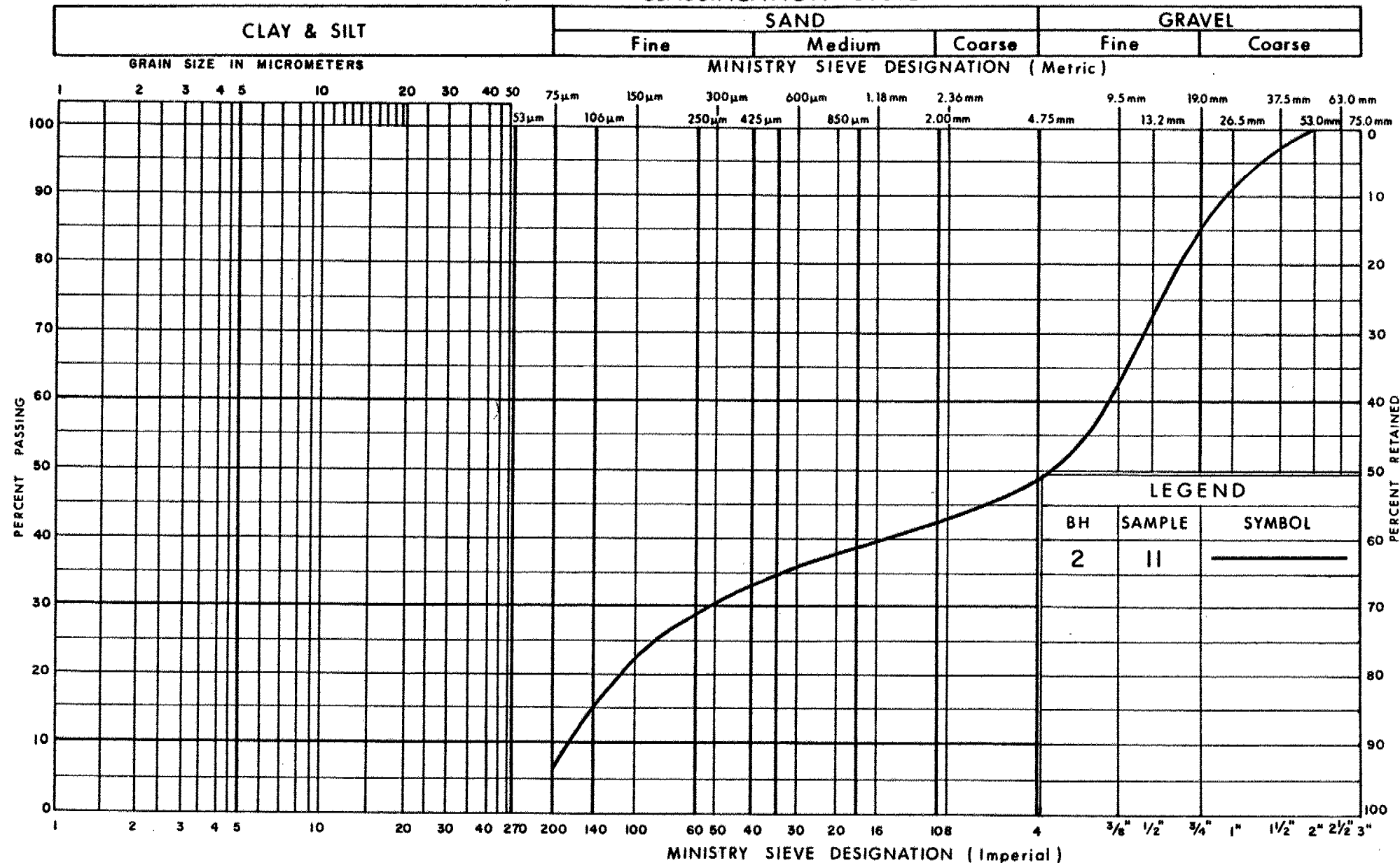
SANDY SILT TO SILTY SAND

FIG No 3

WP 21-79-09

Hwy 410 & 7N

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

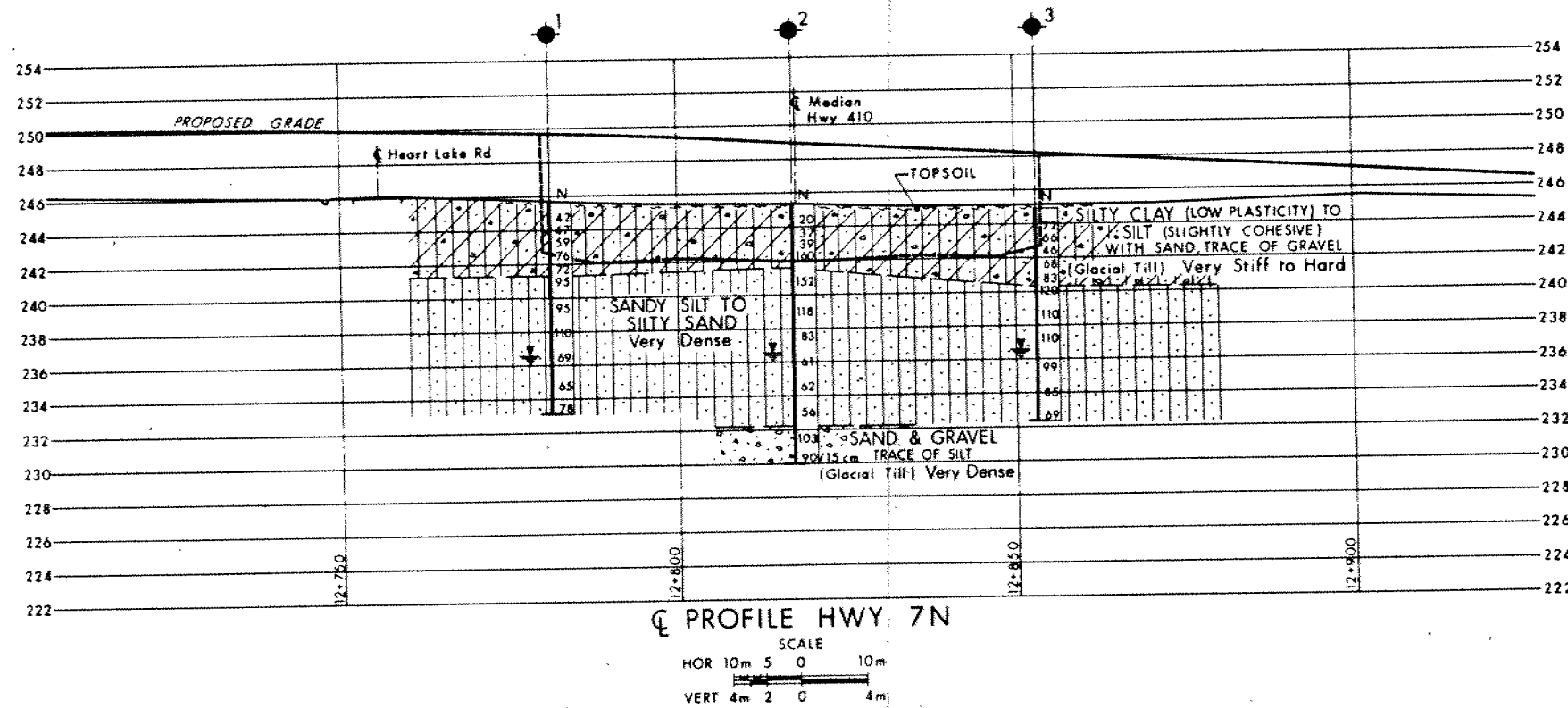
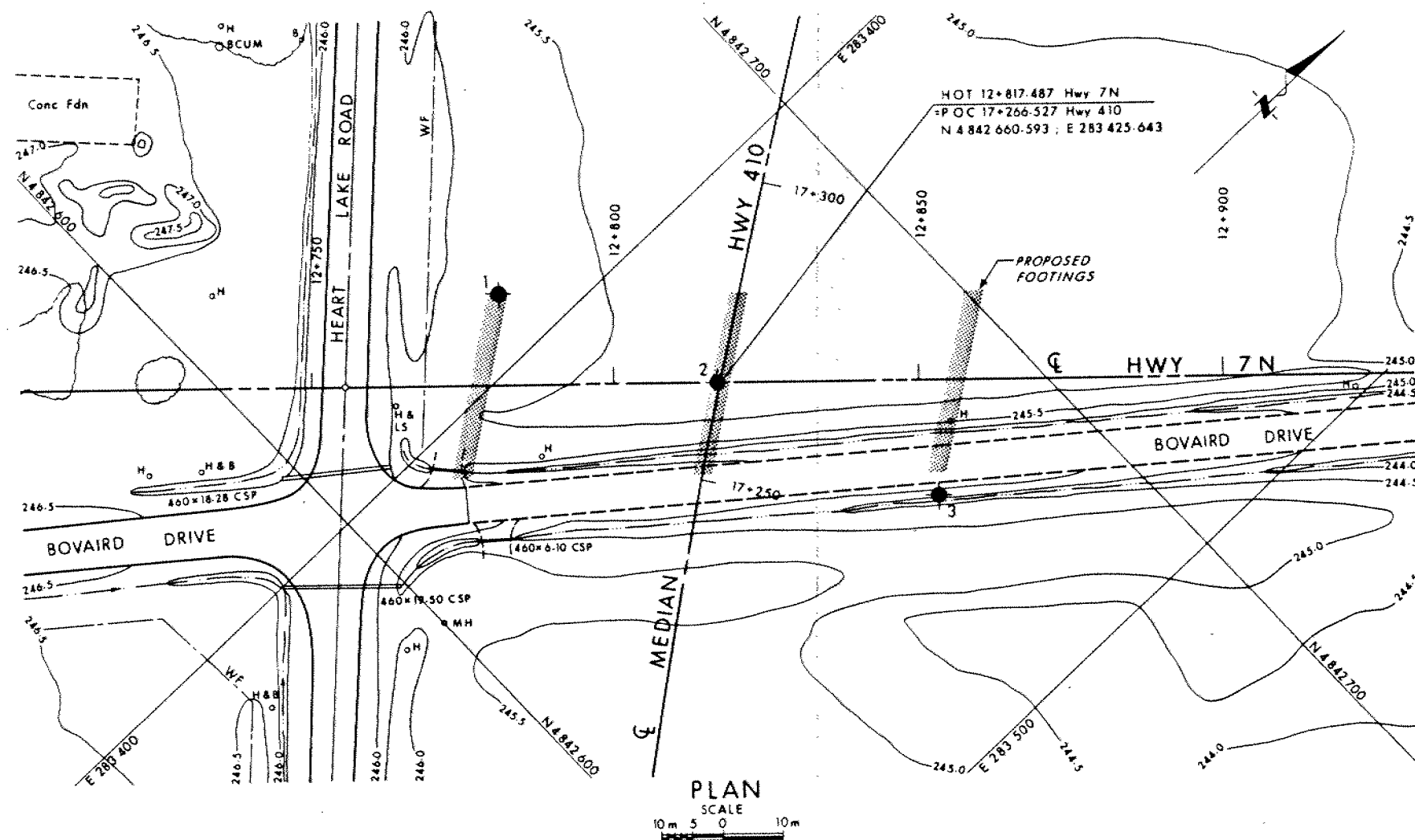
GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL (Glacial Till)

FIG No 4

W P 21-79-09

Hwy 410 & 7N



METRIC

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

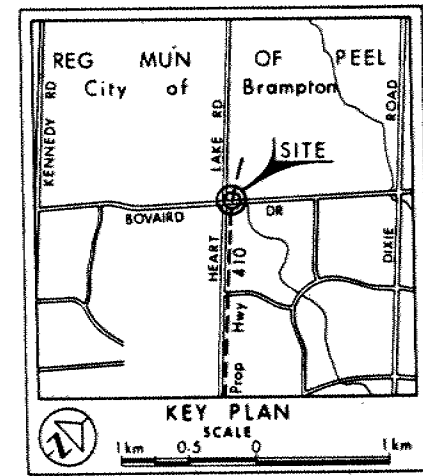
CONT No
WP No 21-79-09

HWY 410 UNDERPASS
AT HWY 7N (BOVAIRD DRIVE)
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

**Warnock Hersey
Professional Services Ltd.**



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 1982 02

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	245.7	4 842 644.3	2 833 89.8
2	245.4	4 842 660.2	2 834 25.3
3	244.9	4 842 673.8	2 834 64.0

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		DESCRIPTION	
DATE	BY		
Geocres No 30412-163			
HWY No 410		DIST 6	
SUBM'D C/M	CHECKED	DATE 1982 03 30	SITE 24-469
DRAWN J.T.	CHECKED	DATE 1982 03 30	DWG 217909-A