

TECHNICAL MEMORANDUM

DATE October 25, 2018

Project No. 1534424 -8002E-M01

TO Brad Schmidt, P.Eng., Dillon Consulting Limited
Tanya Cross, P.Eng., Dillon Consulting Limited

FROM Adam Core, P.Eng., Mike Beadle, P.Eng.,
Fintan J. Heffernan, P.Eng.

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Michael_Beadle@golder.com
Fintan_Heffernan@golder.com

**PRELIMINARY REVIEW OF PILE/FOOTING CAPACITIES
MANNING ROAD UNDERPASS, SITE NO. 6-230
CONTRACT 8, G.W.P. 3097-14-00
ASSIGNMENT 3015-E-0008
MINISTRY OF TRANSPORTATION, ONTARIO – WEST REGION
GEOCRES NO. 40J2-136**

Golder Associates Ltd. (Golder) was retained by Stantec Consulting Ltd. (Stantec) and Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out an assessment of the subsurface conditions at the Manning Road underpass (Site No. 6-230) at Highway 401 as part of the detailed design for GWP 3097-14-00 and to provide preliminary spread footing and pile capacities.

Based on discussions with Dillon, that the detailed design scope of work has been reduced from that originally anticipated in Golder's proposal P1534424 dated September 2, 2015, such that a detailed foundation investigation and design report is not required at this time. We understand that a preliminary review of the existing footing and pile capacities, based on a review of the available geotechnical and geological data from the MTO Geocres Library, is required to facilitate the structural design at this time.

Background Information

A review of the available information from the MTO Geocres Library was carried out in conjunction with the preparation of this memorandum. The information was provided in:

- Geocres Report 40J02-024, Ontario Department of Highways, Materials and Research Division, Downsview ON entitled "Soil Conditions and Foundations, Proposed Crossing at Highway 401 and County Road #7 Interchange, Sandwich S/Maidstone Townline – WP. 130-64" dated July 6th, 1964 prepared by Dominion Soils Investigation Limited.

The Records of Boreholes and related laboratory test data from the above-noted Geocres report are attached to this technical memorandum.

Subsurface Conditions

Five (5) boreholes were previously advanced as indicated in the Geocres documentation and encountered surficial deposits of fill, topsoil, and “organic silt to organic clay” underlain by silty clay till. The silty clay was explored for about 3.1 to 4.6 metres between about elevation 181.4 and 185.9 metres.

The silty clay till deposit had standard penetration test N values, as determined by the standard penetration testing, of 12 to 66 blows per 0.3 metres. Vane testing indicated undrained shear strengths ranging from 135 kilopascals (kPa) to greater than 248 kPa; one vane test at the transition of the organic silty clay to silty clay till deposit was 62 kPa. Samples of the silty clay till had water contents ranging from about 15 to 22 per cent. The silty clay had plastic limits ranging from about 15 to 19 per cent and liquid limits ranging from about 31 to 42 per cent.

Groundwater Conditions

The boreholes from the previous investigation (noted in GEOCREs 40J02-009) were noted to be dry during and upon completion of the drilling.

Background

It is understood that no as-built drawings are available for the bridge; therefore, the evaluation provided in this report has been based on a review of the original design drawing D-5507-P1 (dated August 1965) and data available from the Ministry of Transportation Ontario’s (MTO’s) Geocres library (GEOCREs 40J02-024).

The existing post-tensioned concrete deck structure was constructed in 1966. According to the Structure Maintenance and Repair History, the bridge was rehabilitated in 1996 (1996-0027), 2005 (2005-3001) and 2013 (2013-3286). The bridge has four spans with a total length of approximately 64 metres and no skew. The original design drawing (D-5507-P1) indicates that the foundations at each abutment consist of tube piles with nominal outside diameters of 325 millimetres, nominal wall thicknesses of 5 millimetres and were filled with concrete following driving. The foundation report recommended that the existing fill and organics be removed and replaced with “compacted fill” (unknown composition) to the underside pile cap, Elevation 189.4 metres (621.5 ft), and subsequently the piles were to have been driven to elevation 182.9 metres (600 ft) resulting in approximately 6.5 metre piles.

The design cut off elevation provided is approximately elevation 190.1 metres. The piles were to support a working stress design load of 450 kN per pile (50 tons) as noted in an MTO memorandum dated August 1965 as reported in GEOCREs No. 40J02-024. The piers were constructed on shallow foundations on the very stiff to hard silty clay till with the top of the footing noted to be at about elevation 185.3 metres (608 ft) corresponding to an underside of footing at elevation 184.3 metres (604.5 ft). The piers were reported to be capable of supporting a working stress design load of about 240 kPa (5,000 psf) at Elevation 185.3 metres and 335 kPa (7,000 psf) at Elevation 184.4 metres (605 ft), as reported in Geocres No. 40J02-024.

Foundations

The foundation resistance evaluations for the pier footings and abutment piles were conducted in accordance with Section 6 (Foundations and Geotechnical Systems) of the 2014 Canadian Highway Bridge Design Code (CHBDC). For the pier footings, the historical information from the Geocres Library is considered sufficient for the analyses with typical, limited assumptions, representative of a “Typical” degree of site understanding as defined in Section 6.5.3.2 of the CHBDC. Golder has assumed that this site is classified as “Typical” with respect to the consequence level as defined in Section 6.5.1 of the CHBDC. The applicable Ultimate Limit State (ULS) and Serviceability Limit State (SLS) consequence factor, Ψ , and geotechnical resistance factors at ULS (ϕ_{gu}) and SLS (ϕ_{gs}), used in the analyses were taken from Tables 6.1 and 6.2 of the CHBDC.

Geotechnical Axial Resistance - Shallow Foundations at Piers

Based on the information provided to Golder, the existing spread footings for the piers are supported on shallow foundations at approximately Elevation 184.3 metres (604.5 ft) and are 2.7 metres wide by 10.1 metres long. The allowable bearing capacity (working stress) used in the design was 335 kPa (7,000 psf) as noted on drawing D-5507-4. Based on our analyses, the existing pier footings are capable of providing a geotechnical resistance at SLS of 400 kPa and a factored geotechnical resistance at ULS of 600 kPa. The SLS resistance is based on 25 millimetres of incremental settlement.

Geotechnical Axial Resistance – Driven Piles at Abutments

The pile capacities were estimated using the historical borehole information for this site. The original working stress design load was 450 kilonewtons (kN) per pile corresponding to an ultimate load of about 1350 kN (based on a factor of safety of 3). Our calculations indicate an ultimate pile resistance (unfactored) of 1050 kN is available. Settlement calculations, based on a single pile, indicate that the pile performance will be governed by the ULS load. Using $\phi_{gu} = 0.4$, the factored geotechnical resistance at Ultimate Limit States is 425 kN per pile. It should be noted that the above capacity is preliminary and assumes that “compacted fill” noted on the previous design drawings comprised of compact granular materials.

Given that the piles were reportedly driven in hard silty clay and that the organic soils have been removed from beneath the abutment/approach embankment, downdrag loads on the piles due to settlement of the embankment fill are expected to be nominal. Settlement calculations completed for the interim condition (embankment constructed prior to piling) and the final existing condition, indicate that the consolidation and settlement of the soils due to embankment loading would have occurred primarily below the founding level of the piles. Hence, the piles would have settled concurrently with the embankment at/near the time of the original construction. Therefore, it is considered that downdrag loads can be neglected for the existing structure and can be neglected for nominal grade raises in conjunction with the structure rehabilitation.

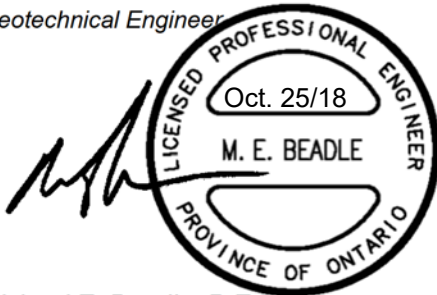
Closure

We trust this memorandum meets your current project requirements, should you require anything further please contact the undersigned.

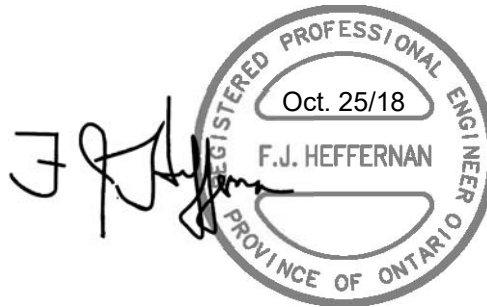
Golder Associates Ltd.



Adam Core, P.Eng.
Geotechnical Engineer



Michael E. Beadle, P.Eng.
Senior Geotechnical Engineer, Associate



Fintan J. Heffernan, P.Eng.
Designated MTO Foundations Contact

AC/MEB/FJH/cr

Attachments: Records of Boreholes and Related Laboratory Data, Geocres 40J02-024

[https://golderassociates.sharepoint.com/sites/14254g/ph 8000 cont 8 gwp 30971400/ph 8002 fdns/2-corr/4-memos/8002e-m01-manning road/1534424-8002e-m01 oct 25 18 \(final\) manning rd up capacity review.docx](https://golderassociates.sharepoint.com/sites/14254g/ph%208000%20cont%208%20gwp%2030971400/ph%208002%20fdns/2-corr/4-memos/8002e-m01-manning%20road/1534424-8002e-m01%20oct%2025%2018%20(final)%20manning%20rd%20up%20capacity%20review.docx)



LEGEND

- Bore Hole
- ⊙ Cone Penetration Hole
- ⊙ Bore & Cone Penetration Hole
- Water Levels established at time of field investigation.

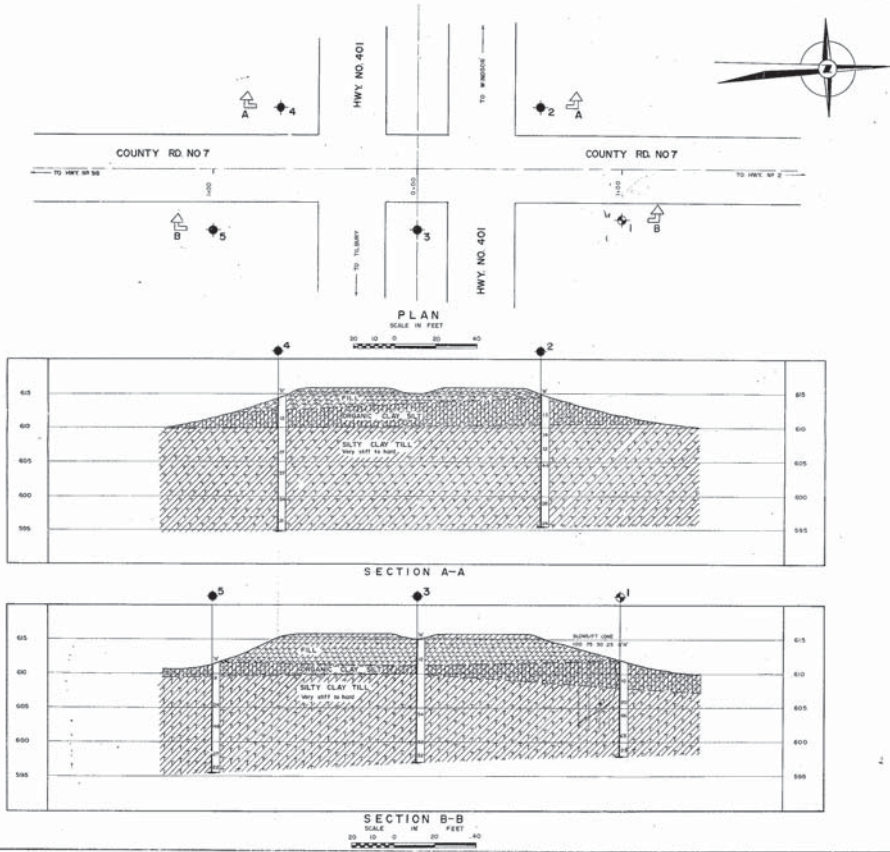
NO.	ELEVATION	STATION	OFFSET
1	60.9	1+00.0	25' RT
2	60.9	0+00.0	30' LT
3	60.9	0+00.0	30' RT
4	60.9	0+00.0	30' RT
5	60.9	1+00.0	30' LT

NOTE
The boundaries between soil types have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

DATE	BY	REVISION

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & RESEARCH DIV. - TRANSPORT SECTION
**PROPOSED CROSSING AT COUNTY ROAD N°7
 AND
 KINGS HIGHWAY N°401**
 CO - ESSEX
 TWP. SANDWICH & MADSTONE, LOT 16, 14 & 15 CON. DK. & 100
 BOREHOLE LOCATION PLAN & SOIL STRATIGRAPHY

DRAWN BY:	CHECKED BY:	APP. NO.	DATE
DATE:	JULY 1984	DATE:	JULY 1984
APPROVED:		DATE:	



DATE	BY	REVISION

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.

BOULDER	COBBLE	GRAVEL		SAND			SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
$\phi > 8"$	$3" - 8"$	COARSE	FINE	COARSE	MEDIUM	FINE	0.074	0.002	>	NO SIZE LIMIT		
U.S. Standard Sieve Size:		No. 4	No. 10	No. 40	No. 200							

SAMPLE TYPES.

AS Auger sample	RC Rock core	TP Piston, thin walled tube sample
CS Sample from casing	% Recovery	TW Open, thin walled tube sample
ChS Chunk sample	SS Split spoon sample	WS Wash sample

SAMPLER ADVANCED BY	static weight : w	OBSERVATIONS MADE WHILE CORING	Steady pressure	Washwater returns
"	pressure : p		No pressure	Washwater lost
"	tapping : t		Intermittent pressure	

PENETRATION RESISTANCES.

DYNAMIC PENETRATION RESISTANCE : to drive a 2" ϕ , 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot

STANDARD PENETRATION RESISTANCE, -N- : to drive a 2" outside dia. split spoon sampler 1 foot into the ground, expressed in blows per foot.

EXTRAPOLATED -N- VALUE

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

SYMBOL :



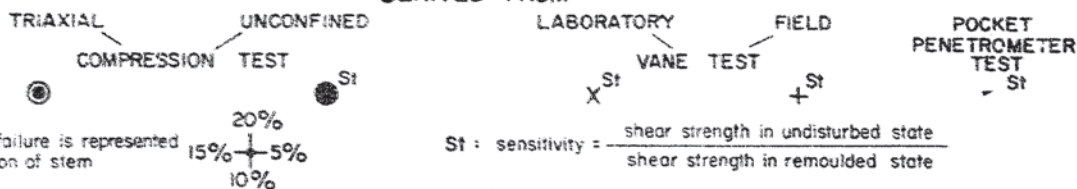
322

SOIL PROPERTIES.

W % Water content	γ^* Natural bulk density (unit weight)	k Coeff. of permeability
LL % Liquid limit	e Void ratio	C Shear strength in terms of total stress
PL % Plastic limit	RD Relative density	ϕ Angle of int. friction in terms of effective stress
PI % Plasticity index	C_v Coeff. of consolidation	C' Cohesion
LI Liquidity index	m_v Coeff. of volume compressibility	ϕ' Angle of int. friction

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —



SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS :	C lbs./sq.ft.
Very loose	0 - 15 %	Very soft	less than 250
Loose	15 - 35 %	Soft	250 - 500
Compact	35 - 65 %	Firm	500 - 1000
Dense	65 - 85 %	Stiff	1000 - 2000
Very dense	85 - 100 %	Very stiff	2000 - 4000
		Hard	over 4000

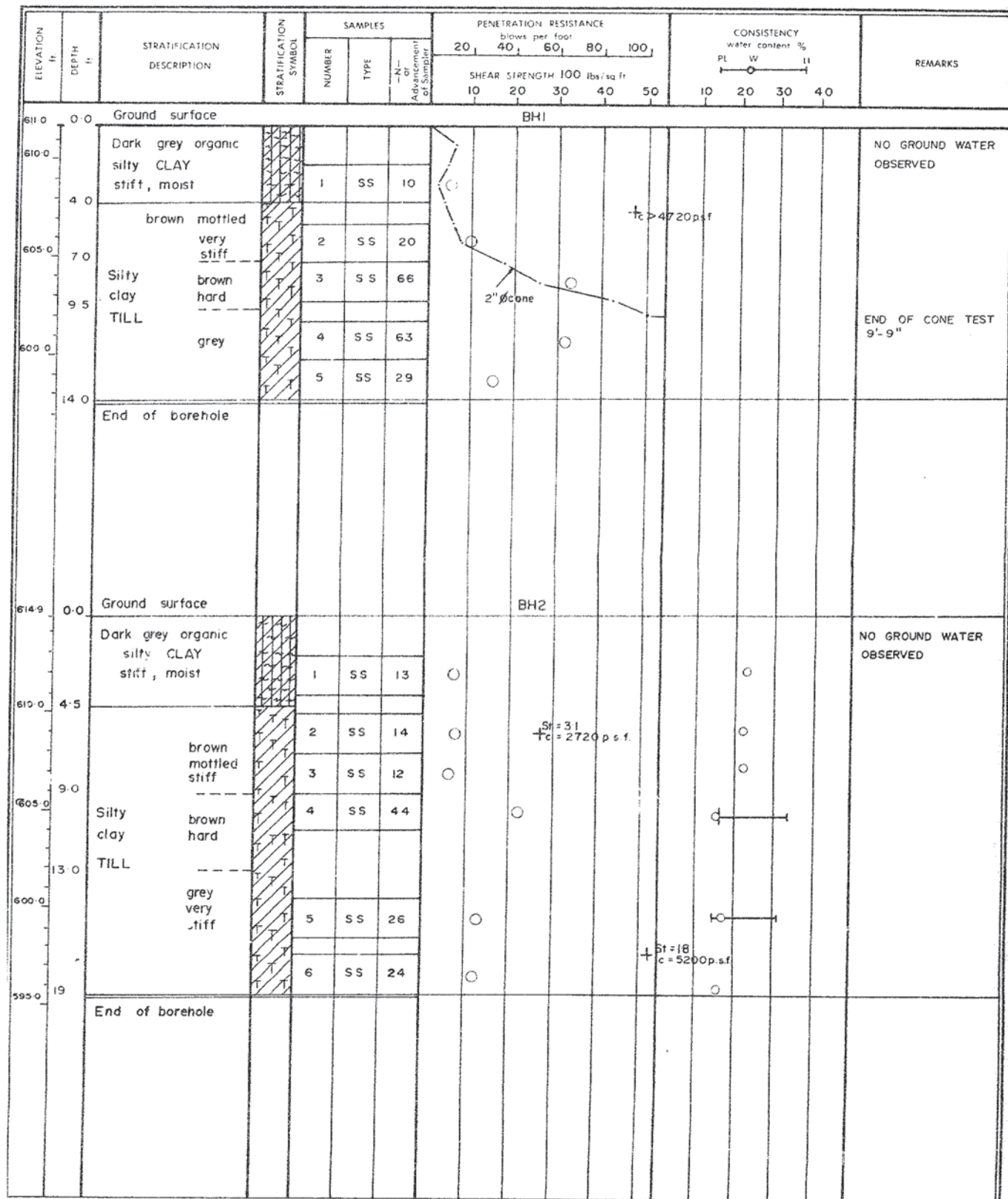
GEOTECHNICAL DATA SHEET FOR BOREHOLE 182..

OUR REFERENCE NO 4-5-L7

CLIENT: DEPARTMENT OF HIGHWAYS ONTARIO
 PROJECT: PROPOSED CROSSING OF HIGHWAY #401 AT
 LOCATION: SANDWICH SOUTH & MAIDSTONE TOWNLINE
 DATUM ELEVATION: GEODETIC

METHOD OF BORING: DRYBORING
 DIAMETER OF BOREHOLE: 2 7/8"
 DATE: MAY 1964

ENCLOSURE NO. 3



VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: L.K.

CHD:JP

GEOTECHNICAL DATA SHEET FOR BOREHOLE 3 & 4.

OUR REFERENCE NO. 4-5-L7

CLIENT: DEPARTMENT OF HIGHWAYS ONTARIO
 PROJECT: PROPOSED CROSSING OF HIGHWAY #401 AT
 LOCATION: SANDWICH SOUTH & MAIDSTONE TOWNLINE
 DATUM ELEVATION: GEODETTIC

METHOD OF BORING: DRYBORING
 DIAMETER OF BOREHOLE: 2 7/8"
 DATE: MAY 1964

ENCLOSURE NO. 4

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot				CONSISTENCY water content %				REMARKS
				NUMBER	TYPE	N ₆₀ or Advancement of Sampler	20	40	60	80	100	PL	W	LI	
							SHEAR STRENGTH 100 lbs/sq ft								
							10	20	30	40	50	10	20	30	40
615.0	0.0	Ground surface					BH3								
		Clayey silt													
		FILL													
	3.8	stiff, moist		1	SS	12									
610.0	5.0	Dark grey organic clayey SILT		2	CS										
				3	CS										
		brown mottled very stiff		4	TW	P/T									
605.0	10.0	Silty clay													
		brown hard		5	SS	54									
600.0	14.0	TILL		6	SS	32									
		grey		7	SS	32									
18.0		End of borehole													
614.0	0.0	Ground surface					BH4								
		Brown mottled clay FILL													
	1.8	Dark grey organic silty CLAY		1	SS	12									
610.0	4.4	stiff, trace of organics		2	CS										
	6.0	very stiff brown mottled		3	SS	17									
605.0	10.0	Silty clay		4	SS	57									
		brown hard													
600.0	13.5	TILL		5	SS	34									
		grey													
	16.5	very stiff		6	SS	21									
595.0	19.5	End of borehole													

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: L.K. CH'D: J.P.







OUR REFERENCE NO. 4-5-L7

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 5. . . .

CLIENT: DEPARTMENT OF HIGHWAYS ONTARIO
 PROJECT: PROPOSED CROSSING OF HIGHWAY #401 AT
 LOCATION: SANDWICH SOUTH & TOWNLIN
 DATUM ELEVATION: GEODETIC

METHOD OF BORING: DRYBORING
 DIAMETER OF BOREHOLE: 2 7/8"
 DATE: MAY 1964

ENCLOSURE NO. 5

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content w_0				REMARKS
				NUMBER	TYPE	N of Advance to boundary	20	40	60	80	100	PL	W	LI		
							SHEAR STRENGTH 100 lbs to ft									
							10 20 30 40 50					10 20 30 40				
611.5	0.0	Ground surface		BH 5												
610.0	1.8	Dark grey organic clayey SILT		1	SS	9										NO GROUND WATER OBSERVED
		brown mottled very stiff		2	CS											
605.0	6.0	Silty clay		3	SS	24										
	8.0	TILL		4	SS	48										
		hard		5	SS	27										
600.0	11.0	grey very stiff		6	SS	22										
595.0	16.0	End of borehole														

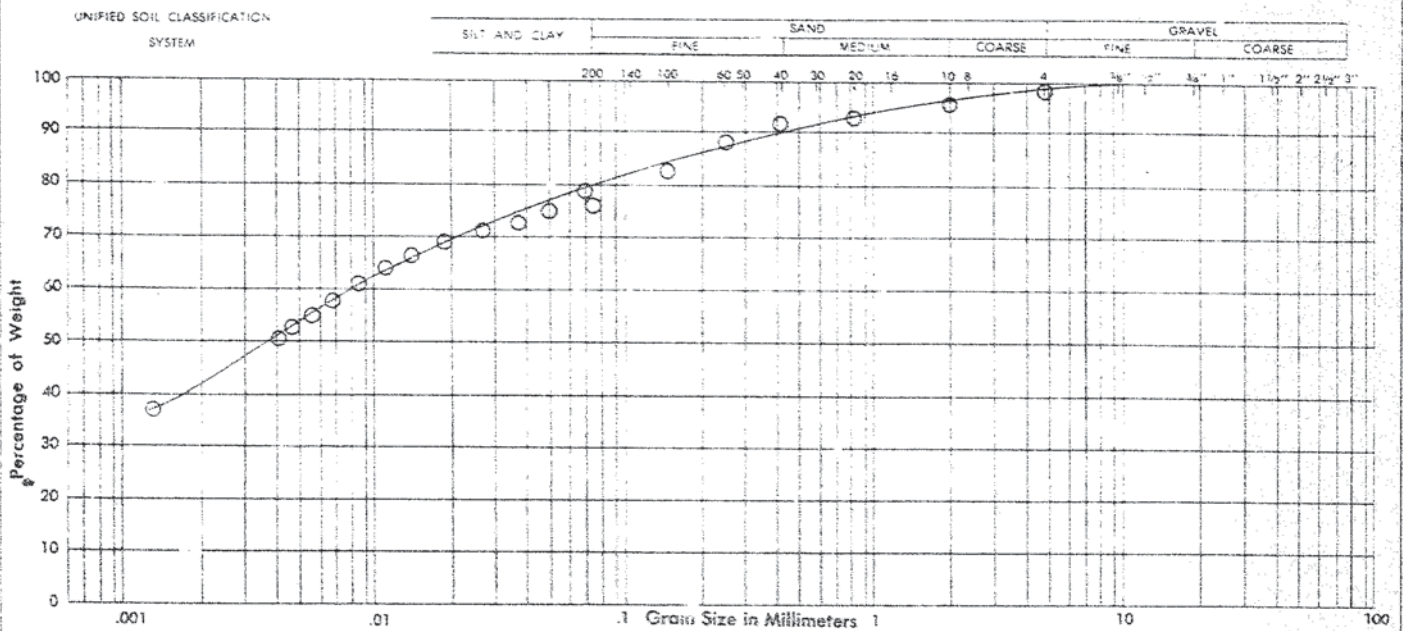
BH 5

+ $S_r = 3.0$
 $c = 2840$ psf.

NO GROUND WATER
OBSERVED

DOMINION SOIL INVESTIGATION LIMITED GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO 4-5-L7



PROJECT: Hwy. #401 Overpass at
LOCATION: Sandwich S/Maldstone
Borehole NO. 2 Townline
SAMPLE NO.: 4
DEPTH OF SAMPLE 10 feet
ELEVATION OF SAMPLE: 605 feet

COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
Sandy silty clay (CL)

PLASTIC PROPERTIES:
LIQUID LIMIT % = 32.5
PLASTIC LIMIT % = 16.4
PLASTICITY INDEX % = 16.1
MOISTURE CONTENT % = 15.1
ACTIVITY = 0.58

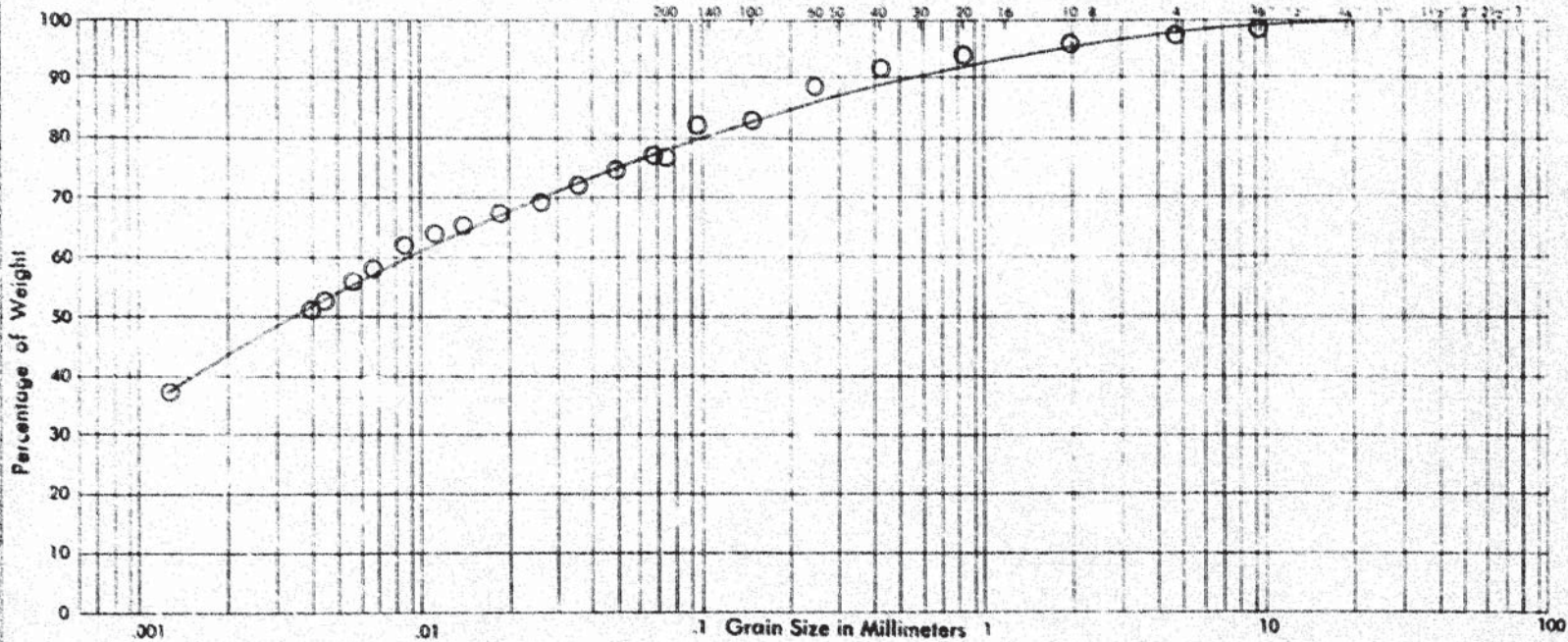
Enclosure No. 6

DOMINION SOIL INVESTIGATION LIMITED **GRAIN SIZE DISTRIBUTION**

OUR REFERENCE NO. 4-5-L7

UNIFIED SOIL CLASSIFICATION
SYSTEM

SILT AND CLAY	SAND		GRAVEL	
	FINE	MEDIUM	FINE	COARSE



PROJECT Hwy. #401 Overpass at
 LOCATION Sandwich S/Maidstone
 BOREHOLE NO. 2 Townline
 SAMPLE NO. 3
 DEPTH OF SAMPLE 15.5 feet
 ELEVATION OF SAMPLE 529.5 feet

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
 Sandy silty clay (CL)

PLASTIC PROPERTIES:

LIQUID LIMIT	% = 30.5
PLASTIC LIMIT	% = 14.2
PLASTICITY INDEX	% = 16.3
MOISTURE CONTENT	% = 16.2
ACTIVITY	= 0.57

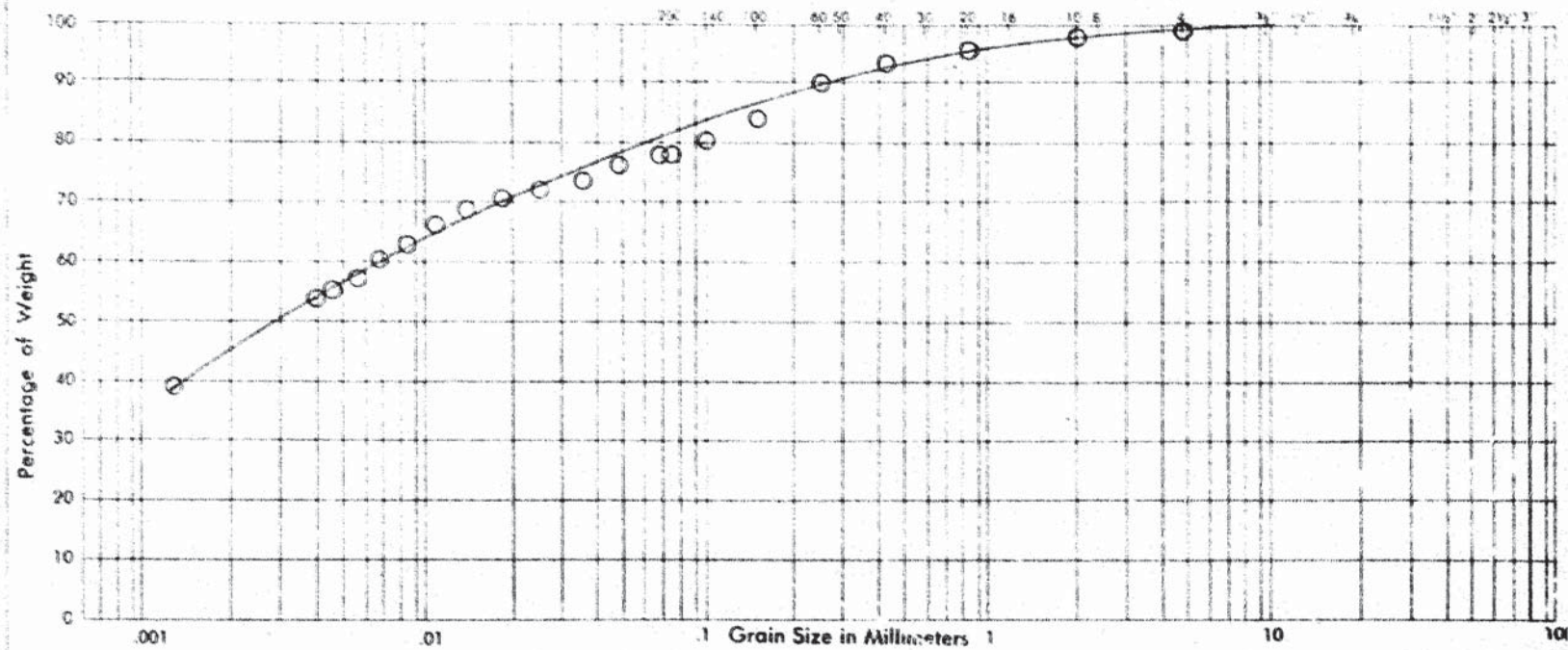
Enclosure No.

DOMINION SOIL INVESTIGATION LIMITED **GRAIN SIZE DISTRIBUTION**

OUR REFERENCE NO 4-5-67

UNIFIED SOIL CLASSIFICATION
 SYSTEM

SILT AND CLAY		FINE SAND		MEDIUM SAND		COARSE SAND		FINE GRAVEL		COARSE GRAVEL	
200	140	100	60	50	40	30	20	16	10	5	3



PROJECT Hwy. #401 Overpass at
 LOCATION Sandwich S/Maidstone
 BOREHOLE NO. 4 Townline
 SAMPLE NO. 4
 DEPTH OF SAMPLE 11.0 feet
 ELEVATION OF SAMPLE 603.5 feet

COEFFICIENT OF UNIFORMITY
 COEFFICIENT OF CURVATURE

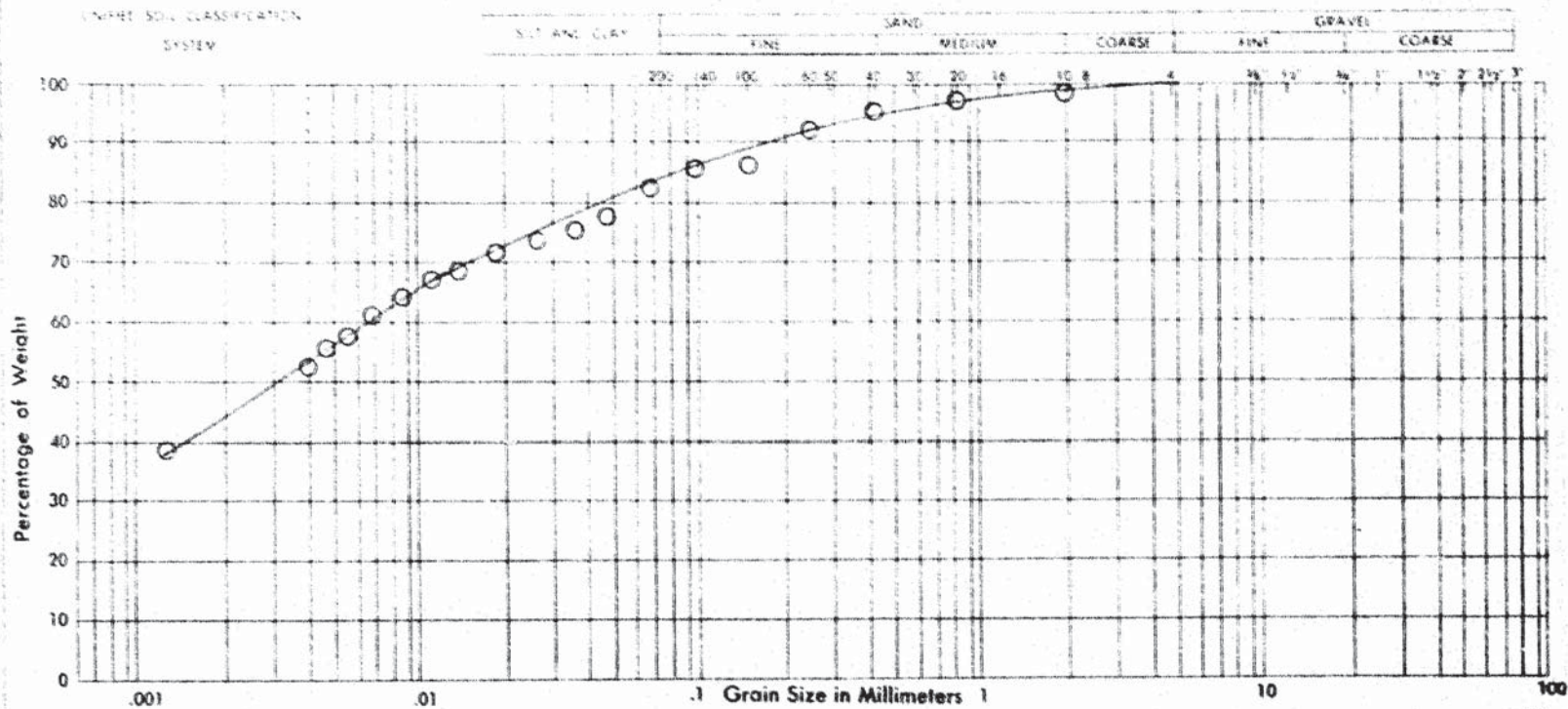
Classification of Sample and Group Symbol:
 Sandy silty clay (CL-CI)

PLASTIC PROPERTIES

LIQUID LIMIT	% =	34.2
PLASTIC LIMIT	% =	16.4
PLASTICITY INDEX	% =	17.8
MOISTURE CONTENT	% =	16.1
ACTIVITY	=	0.39

DOMINION SOIL INVESTIGATION LIMITED GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 4-S-L7



PROJECT Hwy. #401 Overpass at
LOCATION Sandwich S/Maldstone
BOREHOLE NO. 4 Townline
SAMPLE NO. 5
DEPTH OF SAMPLE 15.0 feet
ELEVATION OF SAMPLE 599.5 feet

COEFFICIENT OF UNIFORMITY
COEFFICIENT OF CURVATURE

Classification of Sample and Group Symbol:
Sandy silty clay (CL-CI)

PLASTIC PROPERTIES

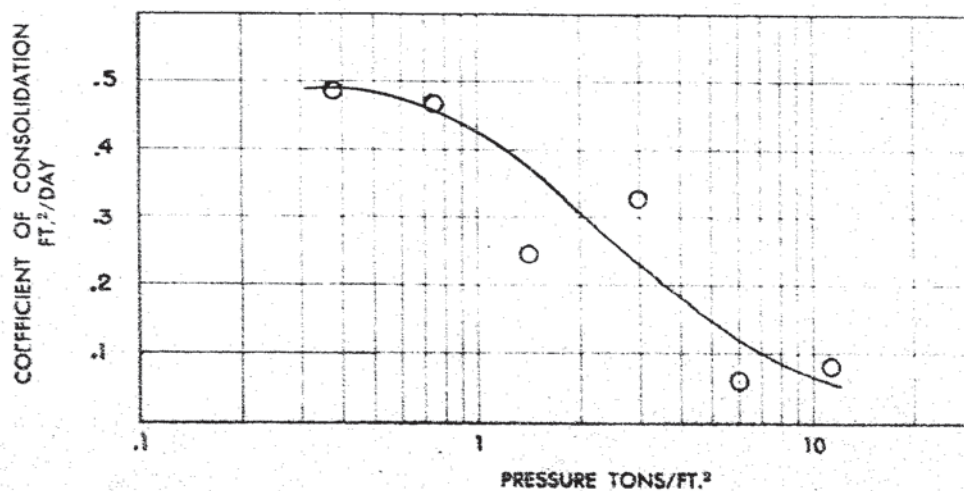
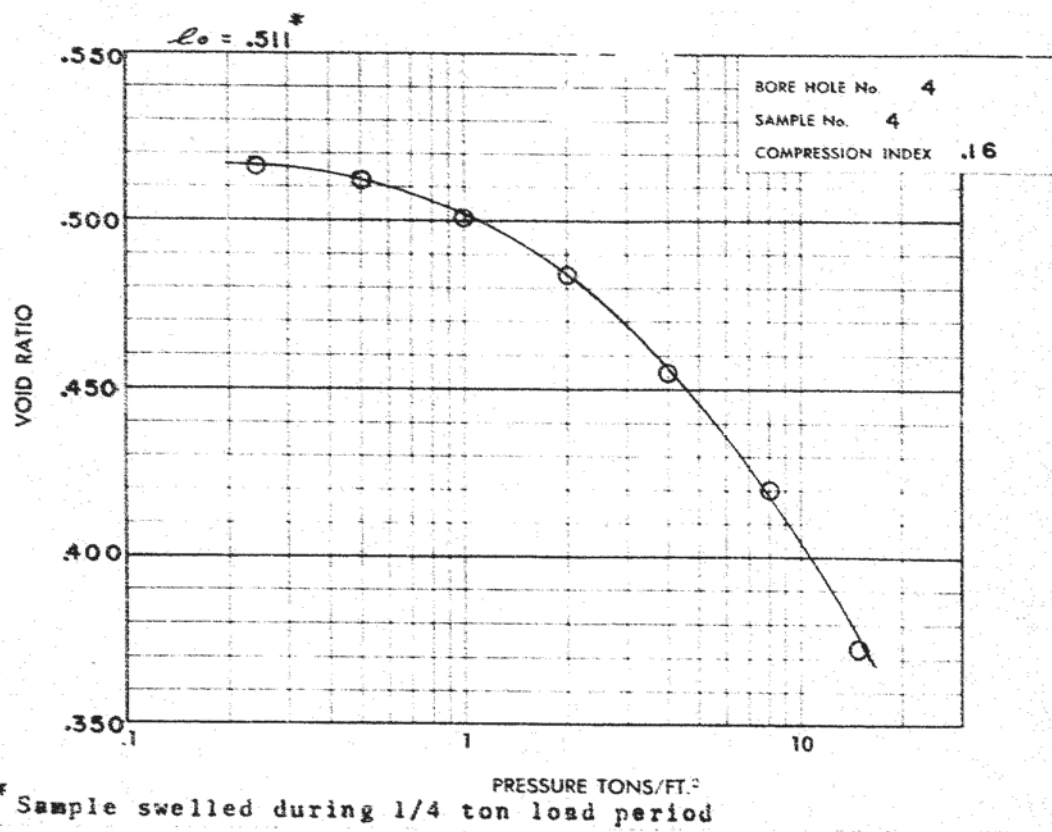
LIQUID LIMIT	% = 34.9
PLASTIC LIMIT	% = 16.9
PLASTICITY INDEX	% = 18.0
MOISTURE CONTENT	% = 16.9
ACTIVITY	= 0.40

Job No. 4-5-L7

SUMMARY OF LABORATORY TEST DATA

BH no.	Sample number	Depth (feet)	Elevation (feet)	Unit weight (p.c.f.)	w (%)	LL (%)	PL (%)	PI (%)	LI	Shear* strength (p.s.f.)	Compression index
2	1	3.0	612.0	-	25.4	-	-	-	-	-	-
	2	6.0	609.0	-	22.3	-	-	-	-	-	-
	3	8.0	607.0	-	22.4	-	-	-	-	-	-
	4	10.0	605.0	135.5	15.1	52.5	16.4	16.1	-0.1	-	-
	5	15.5	599.5	137.0	16.2	50.5	14.2	16.3	+0.1	-	-
	6	18.5	596.5	-	16.0	-	-	-	-	-	-
3	4a	7.0	608.0	132.5	16.7	-	-	-	-	-	.16
	4b	7.0	608.0	127.0	20.3	12.4	19.5	22.9	0.0	2650	-
4	1	3.0	611.5	-	15.7	-	-	-	-	-	-
	2	5.3	609.2	-	19.0	-	-	-	-	-	-
	3	8.0	606.5	-	15.3	-	-	-	-	-	-
	4	11.0	603.5	134.0	16.1	34.2	16.4	17.8	0.0	-	-
	5	15.0	599.5	139.0	16.9	34.9	16.9	18.0	0.0	-	-
	6	18.0	596.5	-	17.5	-	-	-	-	-	-

* As determined by unconfined compression test.

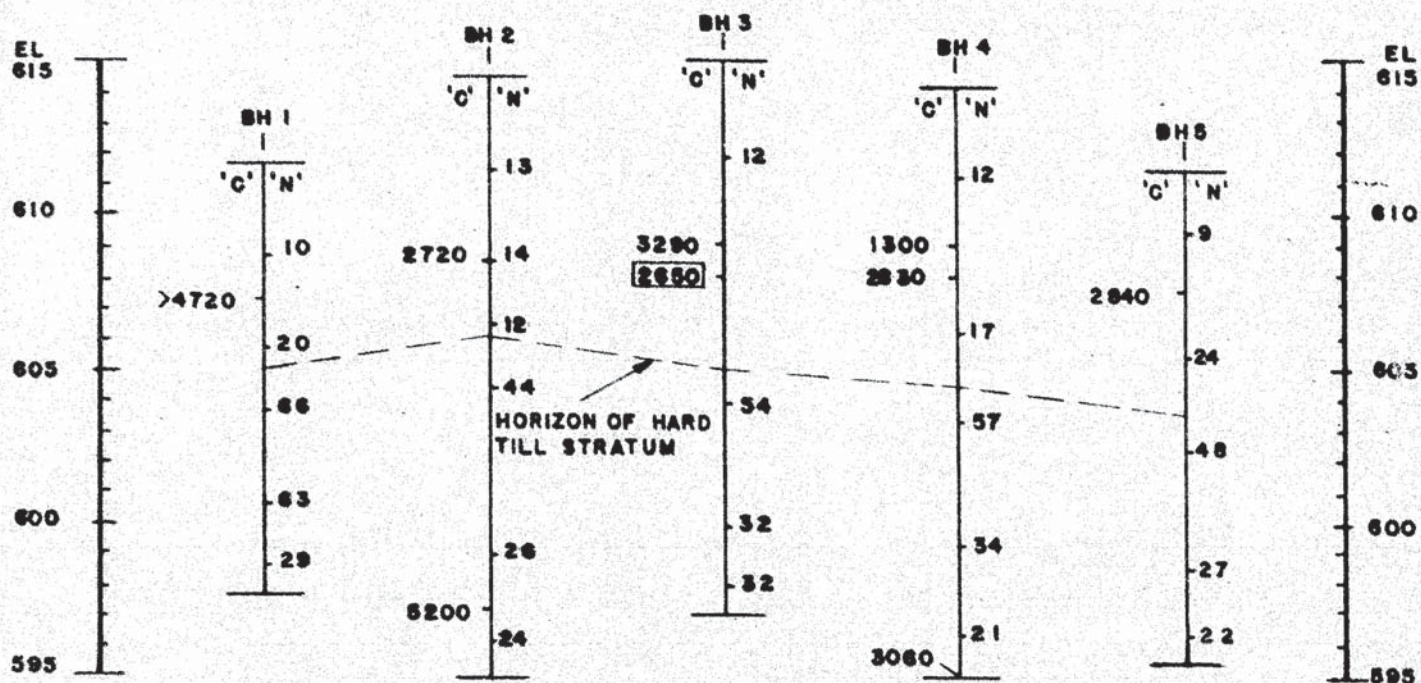
Dominion Soil Investigation Ltd.**CONSOLIDATION TEST**

'N' DENOTES BLOW COUNT IN
STANDARD PENETRATION TEST.

'C' DENOTES UNDRAINED SHEAR STRENGTH
AS MEASURED IN FIELD VANE SHEAR TEST.

2650 DENOTES UNCONFINED COMPRESSION TEST RESULT.

Our Ref. No. 4-5-L7
Prep. by MKF



GRAPHICAL SUMMARY OF FIELD TEST RESULTS

VERTICAL SCALE: 1 INCH TO 5 FEET