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CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 6

LOCATION Culvert Extensions; Hwy 5
N'ly to 1.2 Km N of Reg. Rd 543

No OF PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

PetoMacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION REPORT
FOR
HIGHWAY 6 CULVERT EXTENSIONS
G.W.P. 163-80-01
FLAMBOROUGH, ONTARIO

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Job No. 98HF060

September, 1998

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FOUNDATION INVESTIGATION REPORT

For
Highway 6 Culvert Extensions
G.W.P. 163-80-01
Flamborough, Ontario

INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the extension of four culverts and construction of a retaining wall required for the Highway 6 resurfacing and widening project between Highway 5 and Concession 6 (Regional Road 543) in Flamborough. The culvert/retaining wall locations and proposed work are as follows:

Station	Existing Culvert	Proposed Extension
13+593	4.2 x 1.7 x 31.8 m concrete	5 m west end
15+006	1.2 m dia. CSP	1 m both ends
15+378	1.5 x 1.2 x 34.8 m concrete	Retaining wall at west end
16+656	4.3 x 1.6 x 37.7 m concrete	1.2 m west and 1.5 m east end
17+414	3.7 x 1.5 x 36.1 concrete	2.6 m east end

SITE DESCRIPTION

The study corridor extends along Highway 6 from Highway 5 northerly to Regional Road 543 (Concession Road 6) in Flamborough. It is located in the transitional area between the Flamborough Plain and the Norfolk Sand Plain physiographic regions. Successive ridges of the Waterdown Moraine (Halton clay/silt till) cross Highway 6. The overburden in the low areas between moraines comprises lacustrine and outwash sands.

The bedrock comprises dolostone of the Amabel Formation. It lies at shallow depth at the south end of the study corridor and at 20 to 25 m depth at the north end of the project area. The bedrock surface slopes gently downward towards the south.

The topography along this section of Highway 6 gently undulates between morainic ridges and the intermediate low areas, with local relief ranging from 4 to 14 m, 28 m at one location. The ground surface level ranges from about elevation 217 at Borers Creek at the south end of the project to elevation 253 at the north end.

The culvert at Station 13+593 is located within the Borers Creek drainage channel which is excavated into bedrock. The remaining culverts are situated in localized low areas/drainage courses vegetated by tall grasses and reeds.

INVESTIGATION PROCEDURES

The fieldwork was carried out on August 5 and 6, 1998 and comprised the following:

Station	Proposed Work	Borehole No.	Depth (m)
13+593	culvert extension, west end	1	0.2 (bedrock)
15+006	culvert extension, both ends	2, 3	5.7, 5.2 (refusal)
15+378	retaining wall, west side	4, 5	5.8, 5.8
16+656	culvert extension, both ends	6, 7	6.6, 5.8
17+414	culvert extension, east end	8	6.6

The borehole locations are shown on Drawings 1 to 5. Boreholes 1 and 3 were terminated upon refusal to auger.

The boreholes were advanced using continuous flight hollow stem augers, powered by a track-mounted CME-55 drillrig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Representative samples of the overburden were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. Dynamic cone penetration testing was carried out at a location adjacent to borehole 8 to further assess the relative density of the soils. The groundwater conditions in the boreholes were closely monitored during the course of the fieldwork.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. Grain size distribution analyses and Atterberg Limits tests were carried out on selected samples of the overburden. The pH and soluble sulphate concentration of four samples were also determined.

SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Log of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test "N" values, dynamic cone penetration test results, groundwater observations and the results of laboratory moisture content determinations.

The results of particle size distribution analyses conducted on selected samples recovered during drilling are presented on Figures 1 to 8. The results of the Atterberg Limits testing conducted on samples of the cohesive deposits are provided on the plasticity chart (Figure 9), and noted on the Log of Borehole sheets. The pH and soluble sulphate concentrations measured in selected samples are listed on Table I.

The stratigraphy revealed in the boreholes varied with each location. The overburden generally comprised thin surficial layers of fill, topsoil and/or alluvium overlying various deposits of silt, sand, silt till and clay till. Locally at Station 13+593, bedrock was contacted at shallow depth.

Free water was typically observed at depths of 0.6 to 1.2 m, locally 2.2 m, below existing grade at the boreholes. Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns. The stabilized groundwater level was not established.

The conditions encountered at each location are summarized below.

Culvert at Station 13+593 (Borehole 1)

The stratigraphy revealed in borehole 1 comprised 230 mm of broken rock in a sandy silt matrix overlying bedrock. The bedrock was contacted at elevation 217.5. This borehole was located within a rock cut for construction of the Borers Creek drainage channel.

Culvert at Station 15+006, West End (Borehole 2)

The stratigraphy revealed in borehole 2 comprised surficial layers of clay fill, topsoil and silt overlying a silt/sand deposit, underlain by silt till.

The surficial fill layer was 300 mm thick and consisted of silty clay. The topsoil layer was 300 mm thick and comprised clayey silt judged to have a medium organic content. A 300 mm thick layer of stiff clayey sandy silt was encountered below the topsoil.

A deposit of silt and fine sand to silty fine sand was encountered below the clayey silt at 0.9 m depth (elevation 239.1). The silt/sand was compact, interrupted by a 250 mm thick layer of silty clay at 1.4 m depth, and became dense below this layer. Moisture contents of 19 and 20% were measured. This unit was 1.2 m thick.

Hard clayey silt till (Figure 1) was contacted below the silt/sand at 2.1 m depth (elevation 237.9). Moisture contents in the till ranged from 7 to 9%. Borehole 2 was terminated in the silt till at 5.7 m depth.

Free water was observed at 0.6 m depth (elevation 239.5) upon completion of drilling.

Culvert at Station 15+006, East End (Borehole 3)

The stratigraphy revealed in borehole 3 comprised a surficial topsoil layer overlying a silt/sand deposit, underlain by clay till. A silt layer was encountered within the till.

The topsoil layer was 130 mm thick and comprised clayey silt judged to have a medium organic content.

A deposit of fine sand and silt to silty fine sand was encountered below the topsoil (Refer to Figure 2 for grain size distribution). The silt/sand was compact with a moisture content of 20%. This unit was 1.6 m thick.

Stiff to very stiff clay till was contacted at 1.8 m depth (elevation 238.0). The till was interrupted by a dense to compact silt layer between 3.3 to 4.4 m depth, and became hard below this layer. Moisture contents in the till ranged from 8 to 14%. Borehole 3 was terminated upon refusal to auger on a possible boulder in the clay till at 5.2 m depth.

The borehole sidewalls caved at 0.8 m depth (elevation 239.0) upon extraction of the augers.

Retaining Wall at Station 15+378 (Boreholes 4 and 5)

The stratigraphy revealed in boreholes 4 and 5 generally comprised a surficial fill layer overlying discontinuous topsoil, silt and/or clay till layers, underlain by a sand deposit, mantling silt/clay till.

Silt fill was encountered surficially in both boreholes. The fill layer was 600 and 300 mm thick in boreholes 4 and 5, respectively.

A 300 mm thick layer of clayey silt topsoil was encountered below the fill in borehole 5. This was underlain by a 300 mm thick layer of clayey sandy silt and a 150 mm thick layer of silty fine sand.

Stiff clay till (Figure 3) was encountered below the fill at 0.6 m depth (elevation 238.8) in borehole 4, and below the sand at 1.1 m depth (elevation 238.4) in borehole 5. This layer was 800 and 350 mm thick in boreholes 4 and 5, respectively. Moisture contents of 11 and 12% were measured in this unit.

A 1.9 and 2.7 m thick (boreholes 4 and 5 respectively) deposit of fine sand (Figure 4) was encountered below the till at 1.4 m depth (elevation 238.0 and 238.1). The sand was compact and fine-grained with moisture contents ranging between 17 to 20%.

Very stiff to hard silt/clay till was contacted at 3.3 m depth (elevation 236.1) in borehole 4 and at 4.1 m depth (elevation 235.4) in borehole 5. Sand layers and a zone of stratified silts and clays were revealed within the till in borehole 4. A zone of layered silts and sands was revealed in the till in borehole 5. Moisture contents ranged from 11 to 13% in the till, 16 to 18% in the interbedded materials. The boreholes were terminated in the till at 5.8 m depth.

Free water was observed at 0.8 m depth (elevation 238.6 and 238.7) in both boreholes upon completion of drilling.

Culvert at Station 16+656, West End (Borehole 6)

The stratigraphy revealed in borehole 6 comprised sand and silt fill overlying silt alluvium underlain by successive deposits of clay till, silt, sand and silt.

The surficial fill comprised fine sand and silt with gravel to cobble size. It was penetrated at 1.0 m depth.

Firm, black clayey silt alluvium was encountered below the fill. The alluvium layer was 1.1 m thick and penetrated at 2.1 m depth (elevation 247.8).

The native overburden comprised stiff clay till (Figure 5) between 2.1 to 3.7 m depth, dense to compact silt between 3.7 to 4.8 m, compact silty fine to medium sand between 4.8 to 6.3 m, and very dense silt below 6.3 m. Moisture contents ranged between 11 to 18%. Borehole 6 was terminated in the silt at 6.6 m depth.

Free water was observed at 4.1 m depth inside the augers and at 2.2 m depth (elevation 247.7) in the uncased borehole upon completion of drilling.

Culvert at Station 16+656, East End (Borehole 7)

The stratigraphy revealed in borehole 7 comprised a topsoil layer over a thin silt layer overlying clay till underlain by silt.

The surficial topsoil layer was 200 mm thick and comprised sandy silt judged to have a medium organic content. A 400 mm thick layer of sandy silt was encountered below the topsoil and

penetrated at 0.6 m depth (elevation 247.6). A 1.0 m thick layer of stiff clay till was revealed below the silt. A moisture content of 11% was measured in the till.

Silt (Figure 6) was contacted below the clay till at 1.6 m depth (elevation 246.6). The silt was compact, dense between 2.9 to 5.2 m depth. Moisture contents ranged between 16 to 22%. Borehole 7 was terminated in the silt at 5.8 m depth.

Free water was observed at 2.8 m depth inside the augers and at 1.2 m depth (elevation 247.0) in the uncased borehole upon completion of drilling.

Culvert at Station 17+414 (Borehole 8)

The stratigraphy revealed in borehole 8 comprised silt fill overlying clayey silt underlain by sand.

The surficial fill layer was 600 mm thick and comprised sandy silt.

Very stiff clayey silt (Figure 7) was encountered below the fill. Moisture contents of 14 and 16% were measured in this deposit. Lenses of silty fine sand were observed in the silt below 1.4 m depth. The silt layer was 1.5 m thick.

Sand was contacted below the silt at 2.1 m depth (elevation 249.2). The sand was compact and typically fine to medium-grained (Figure 8), with moisture contents ranging from 16 to 21%. A layer of dense silt was encountered within the sand between 4.2 to 4.8 m depth. Moisture contents ranged between 11 to 18%. Borehole 8 was terminated in the sand at 6.6 m depth.

Free water was observed at 1.0 m depth (elevation 250.3) upon completion of drilling.

CLOSURE

The fieldwork was carried out under the supervision of Mr. M. Rapsey, Senior Drillrig Supervisor. The equipment was supplied by Malone's Soil Samples Co. Ltd.

The report was written by Mr. M.R. Anderson, P. Eng. and reviewed by Mr. D.W. Kerr, P. Eng., Manager of Geotechnical and Geo-Environmental Services, Hamilton.

Yours very truly

Peto MacCallum Ltd.

Dennis W. Kerr, M.Eng., P.Eng.
Manager Geotechnical and
Geo-Environmental Services

Brian R. Gray, M.Eng., P.Eng.
Vice President
Geotechnical Engineering and
Geo-Environmental Services

MRA:mma

Our Ref: 98HF060

TABLE I

RESULTS OF pH & SULPHATE ANALYSES OF SOIL SAMPLES

HIGHWAY 6 CULVERT EXTENSIONS
G.W.P. 163-80-01
FLAMBOROUGH, ONTARIO

BOREHOLE	DEPTH (m)	pH	WATER SOLUBLE SULPHATE (%)
4	0.8 – 1.2	7.5	0.058
6	2.3 – 2.7	8.0	0.028
7	0.8 – 1.2	8.0	0.042
8	0.8 – 1.2	8.2	0.006

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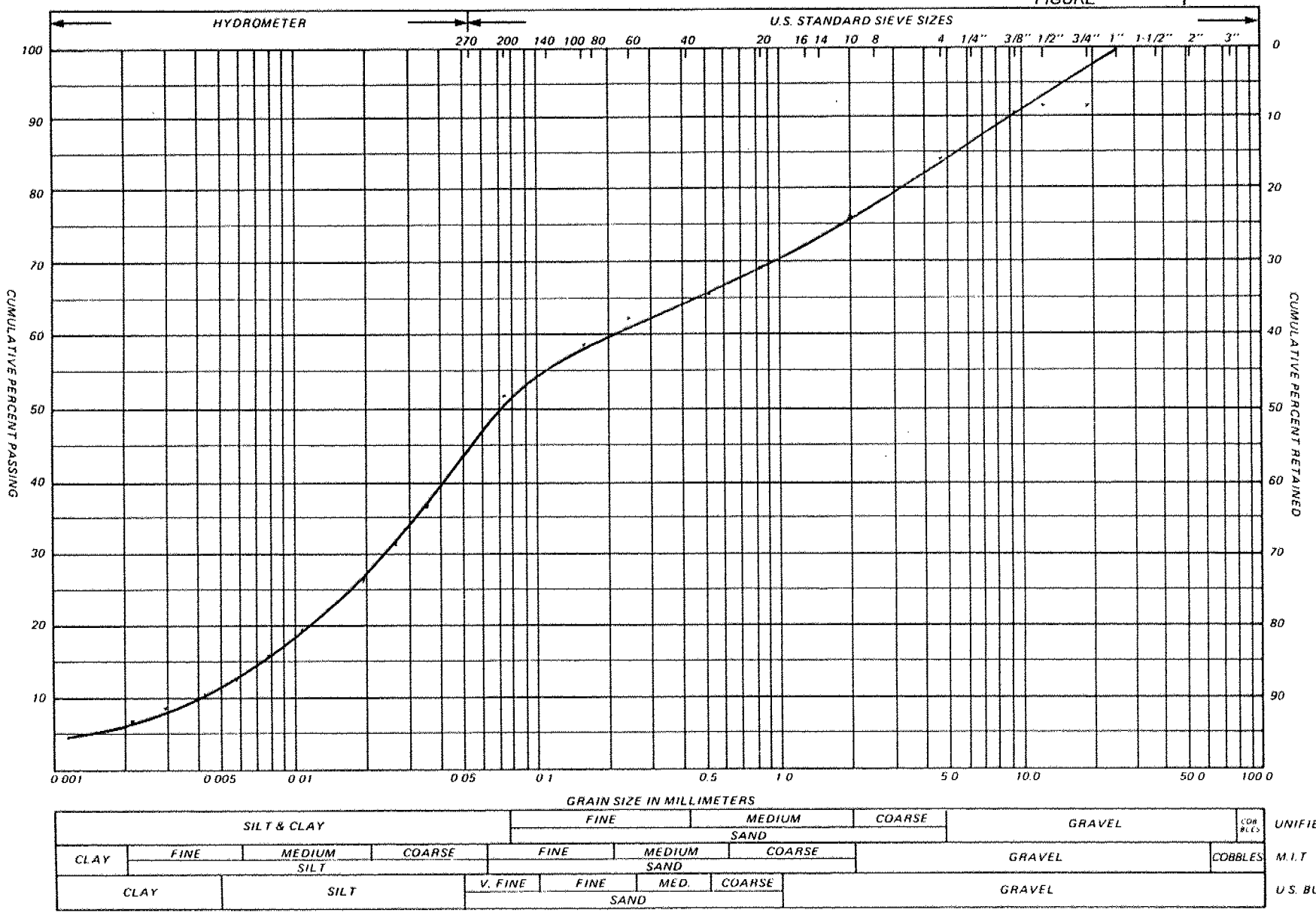
PARTICLE SIZE DISTRIBUTION CHART

PML REF. 98HF060
REPORT NO. 1
FIGURE 1



Borehole 2, Sample 3 at 2.3 to 2.7 m depth

Clayey Silt Till

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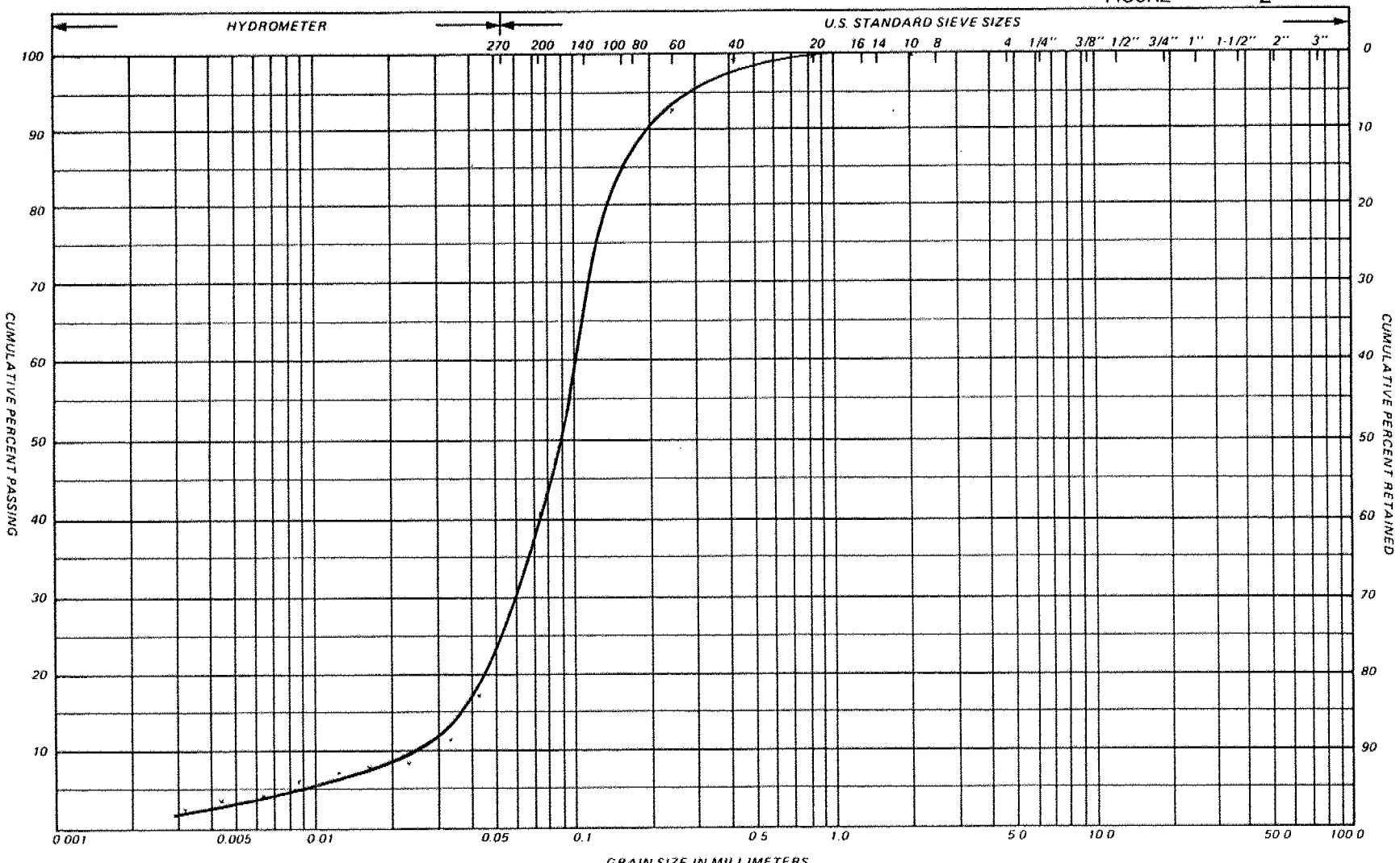
PARTICLE SIZE DISTRIBUTION CHART

PML REF. 98HF060
REPORT NO. 1
FIGURE 2



Borehole 3, Sample 1 at 0.8 to 1.2 m depth

Fine Sand and Silt

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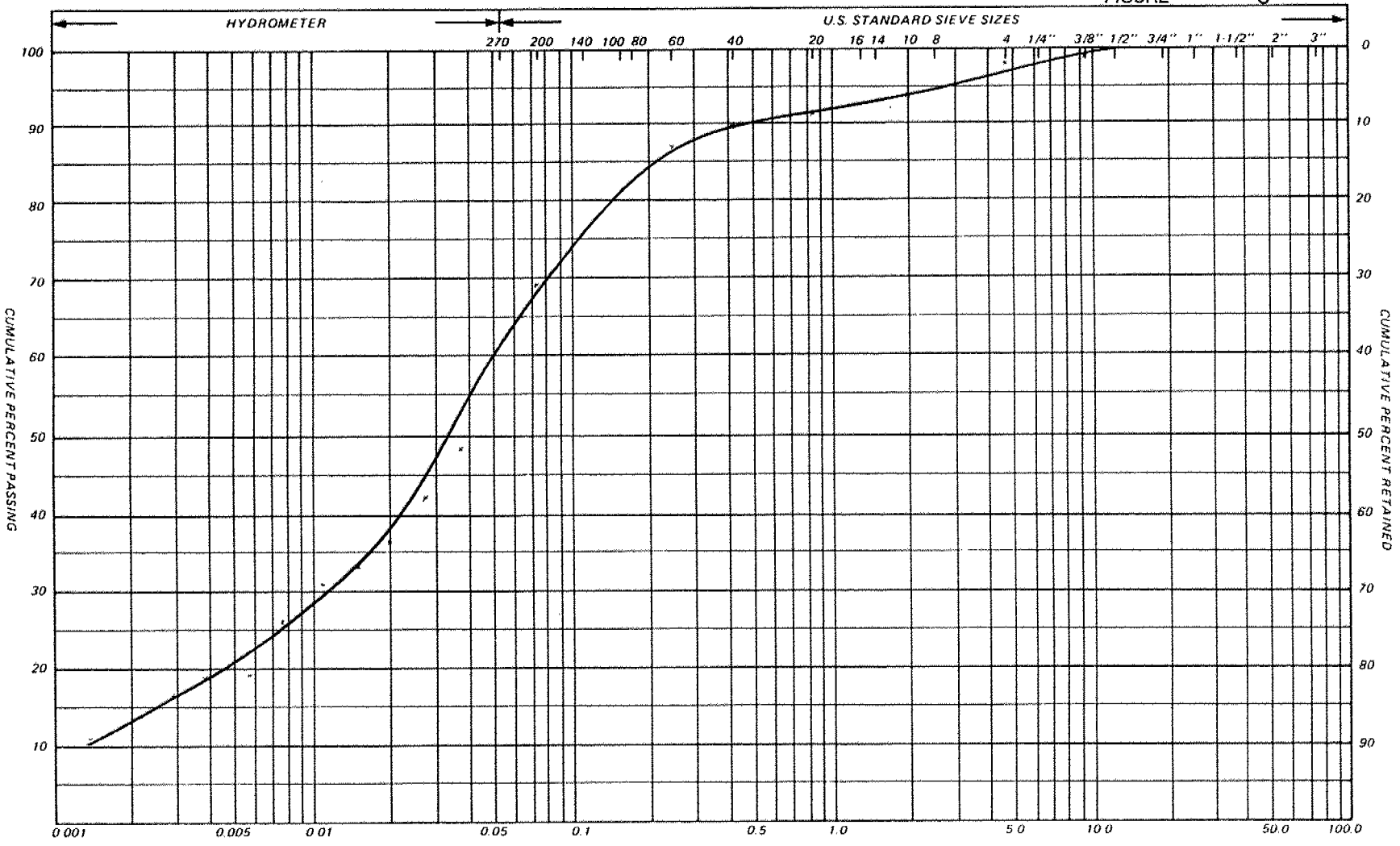
PML REF. 98HF060
REPORT NO. 1
FIGURE 3

PARTICLE SIZE DISTRIBUTION CHART



Borehole 4, Sample 1 at 0.8 to 1.2 m depth

Silty Clay Till

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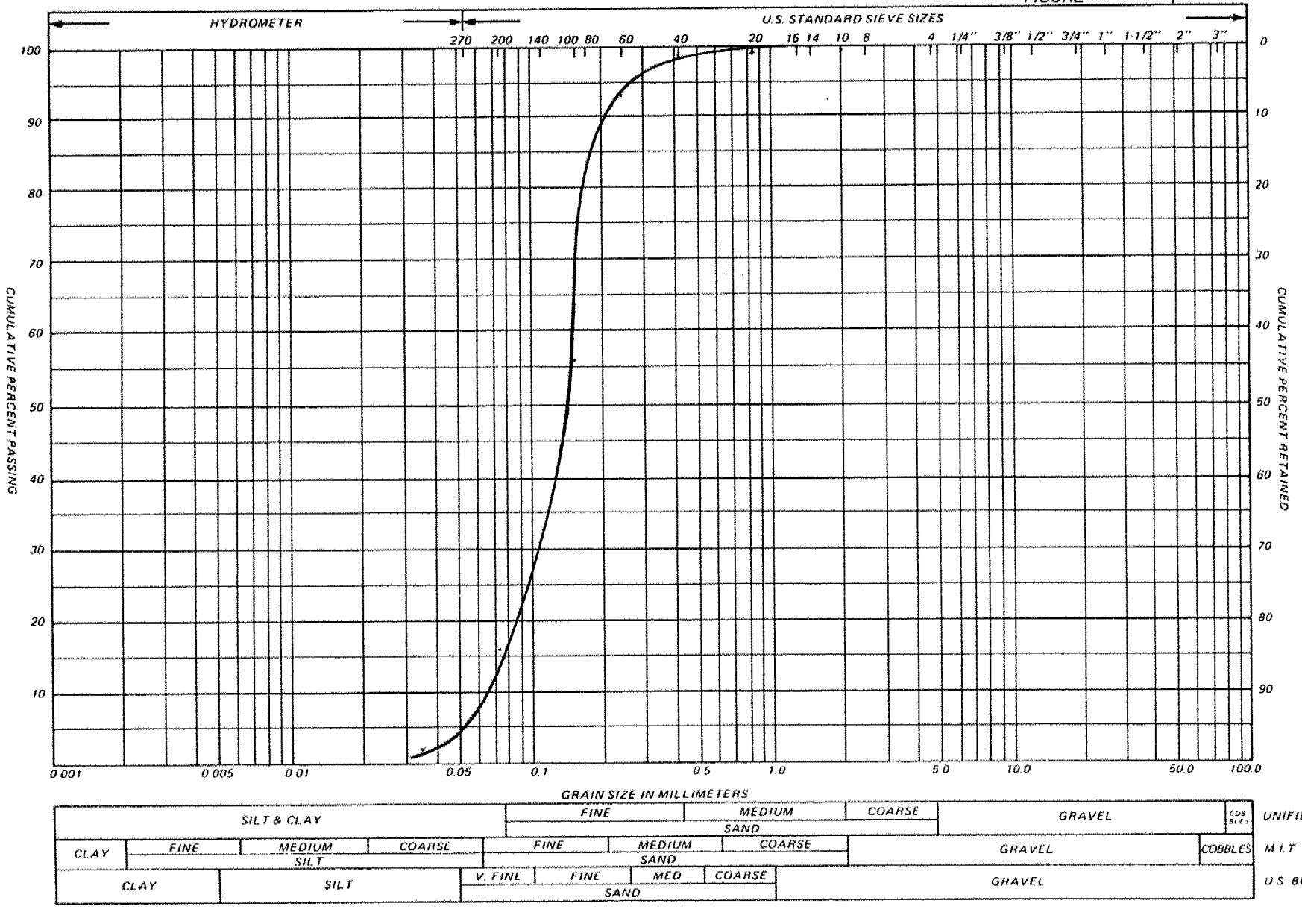
CONSULTING ENGINEERS

PML REF. 98HF060
REPORT NO. 1
FIGURE 4

PARTICLE SIZE DISTRIBUTION CHART



Borehole 5, Sample 2 at 1.5 to 2.0 m depth

Fine Sand

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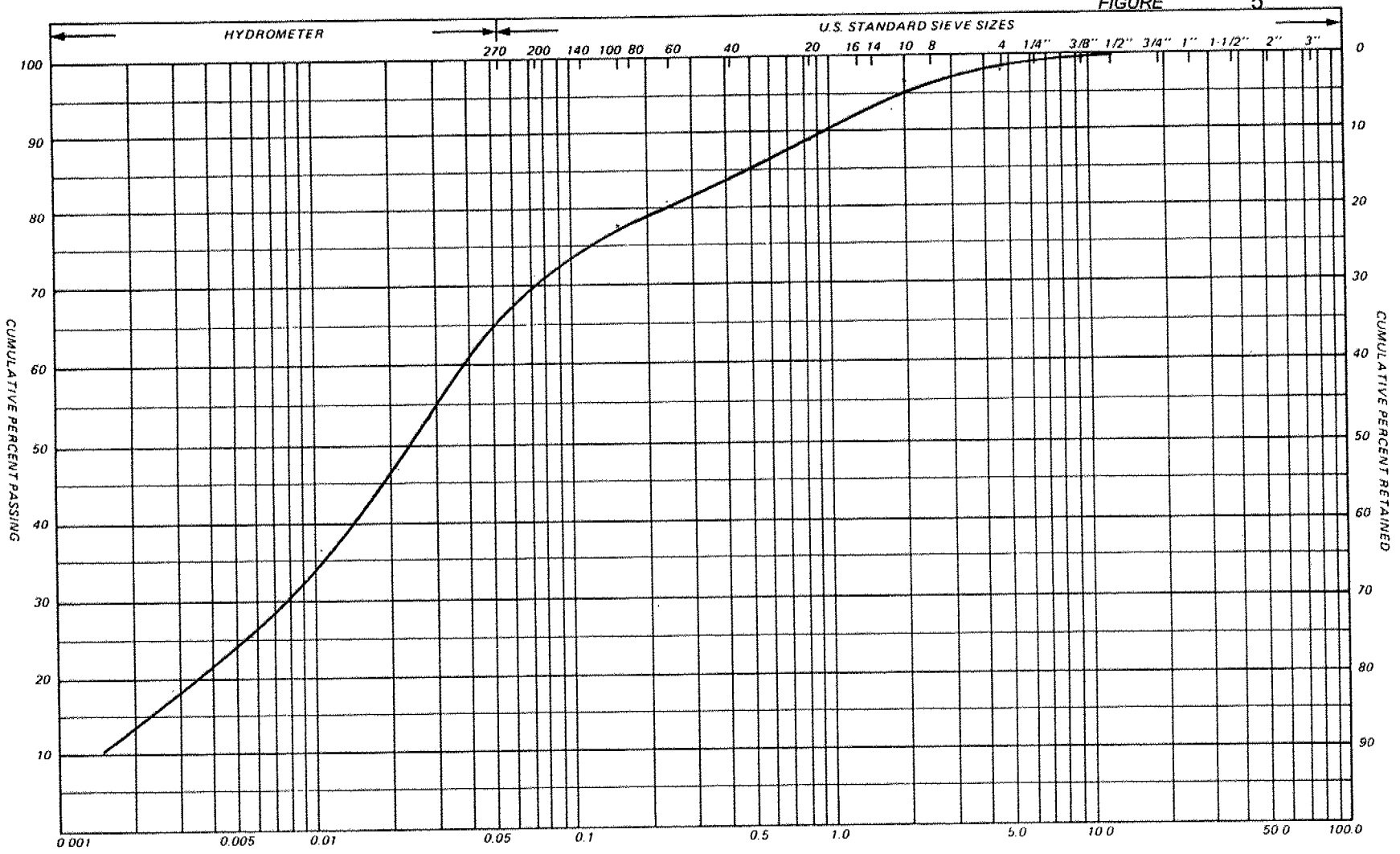
PARTICLE SIZE DISTRIBUTION CHART

PML REF. 98HF060
REPORT NO. 1
FIGURE 5



Borehole 6, Sample 3 at 2.3 to 2.7 m depth

Silty Clay Till

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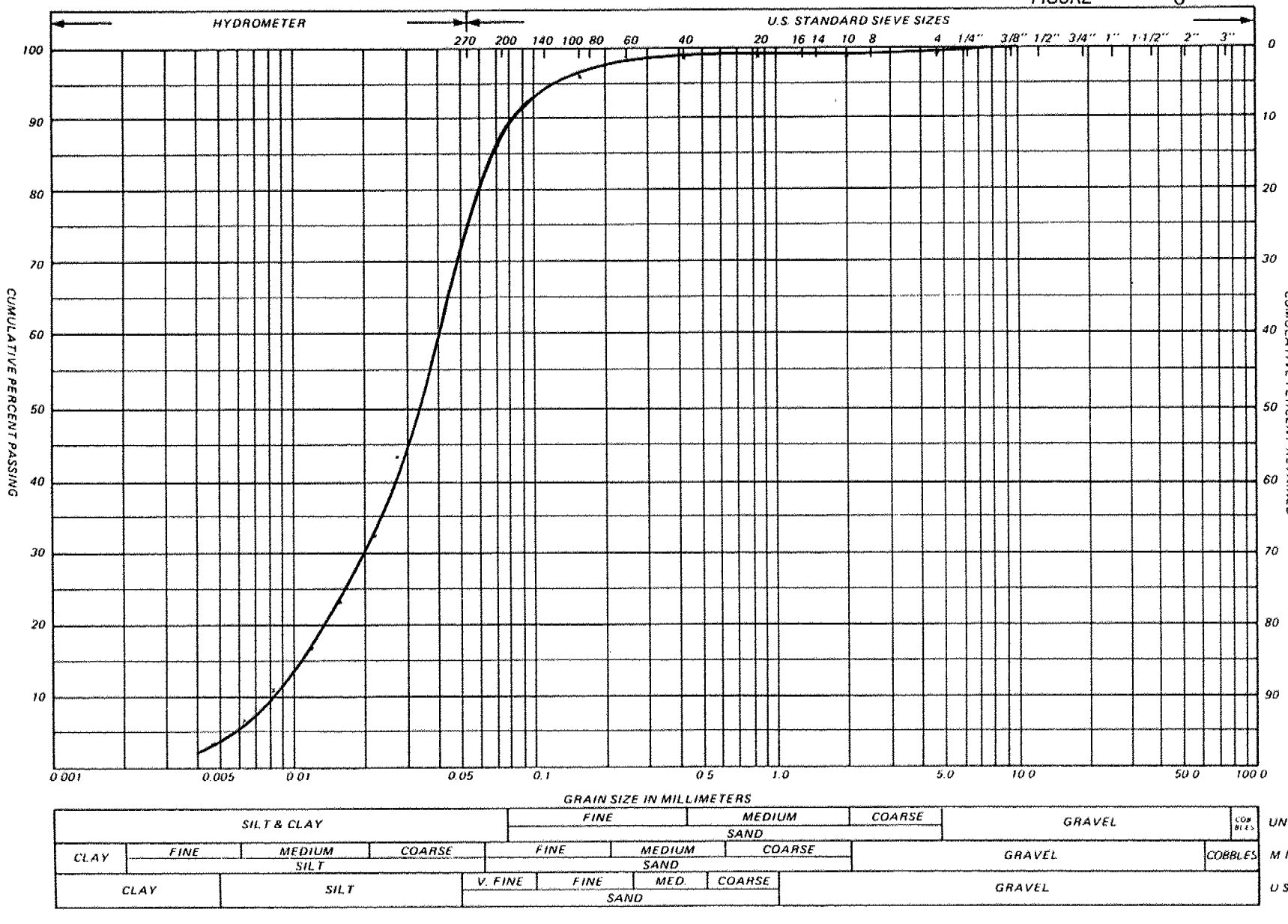
CONSULTING ENGINEERS

PARTICLE SIZE DISTRIBUTION CHART

PML REF. 98HF060
REPORT NO. 1
FIGURE 6



Borehole 7, Sample 2 at 1.6 to 2.0 m depth

Silt

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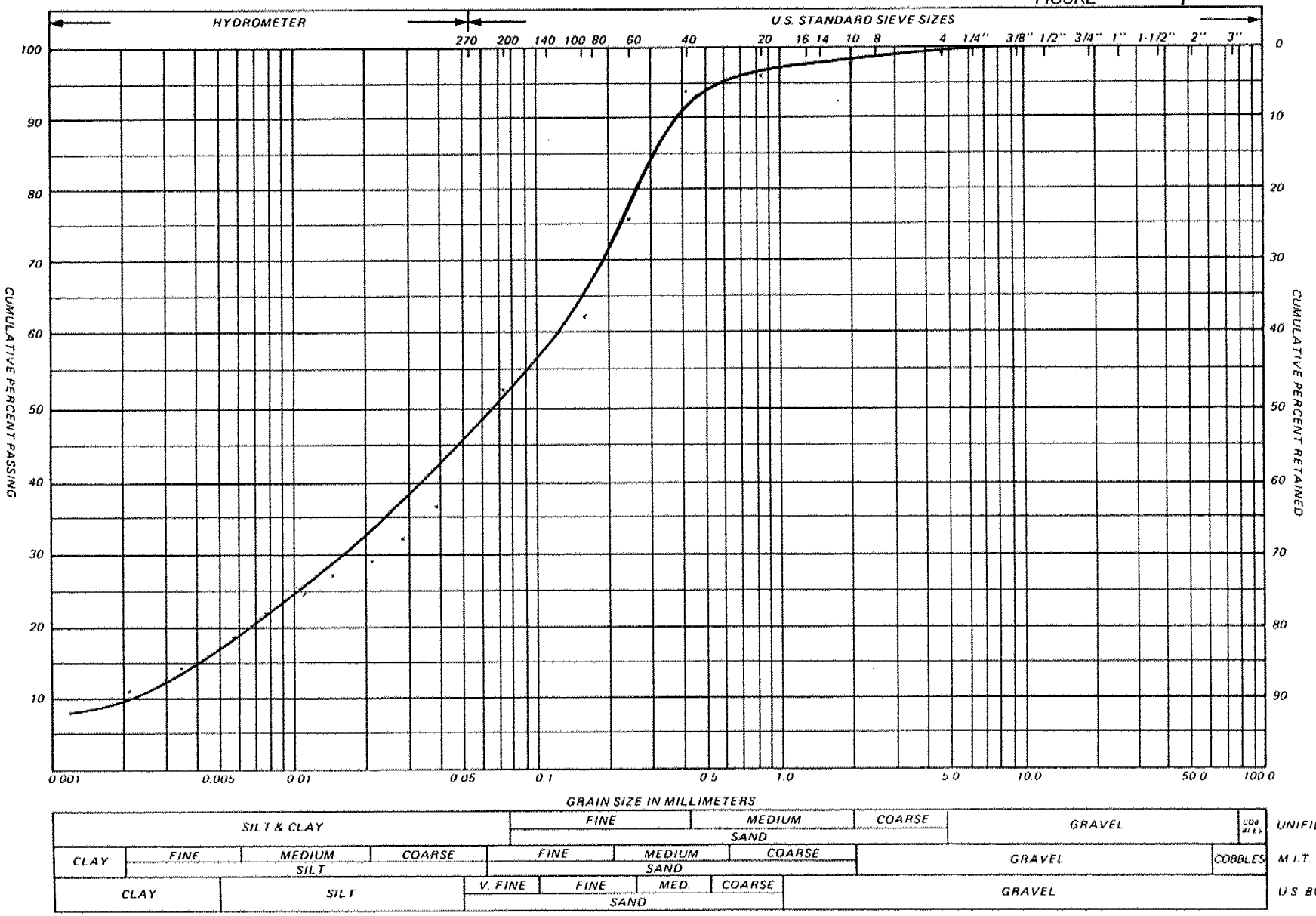
PML REF. 98HF060
REPORT NO. 1
FIGURE 7

PARTICLE SIZE DISTRIBUTION CHART



Borehole 8, Sample 1 and 2 at 0.8 to 2.0 m depth

Clayey Silt Till

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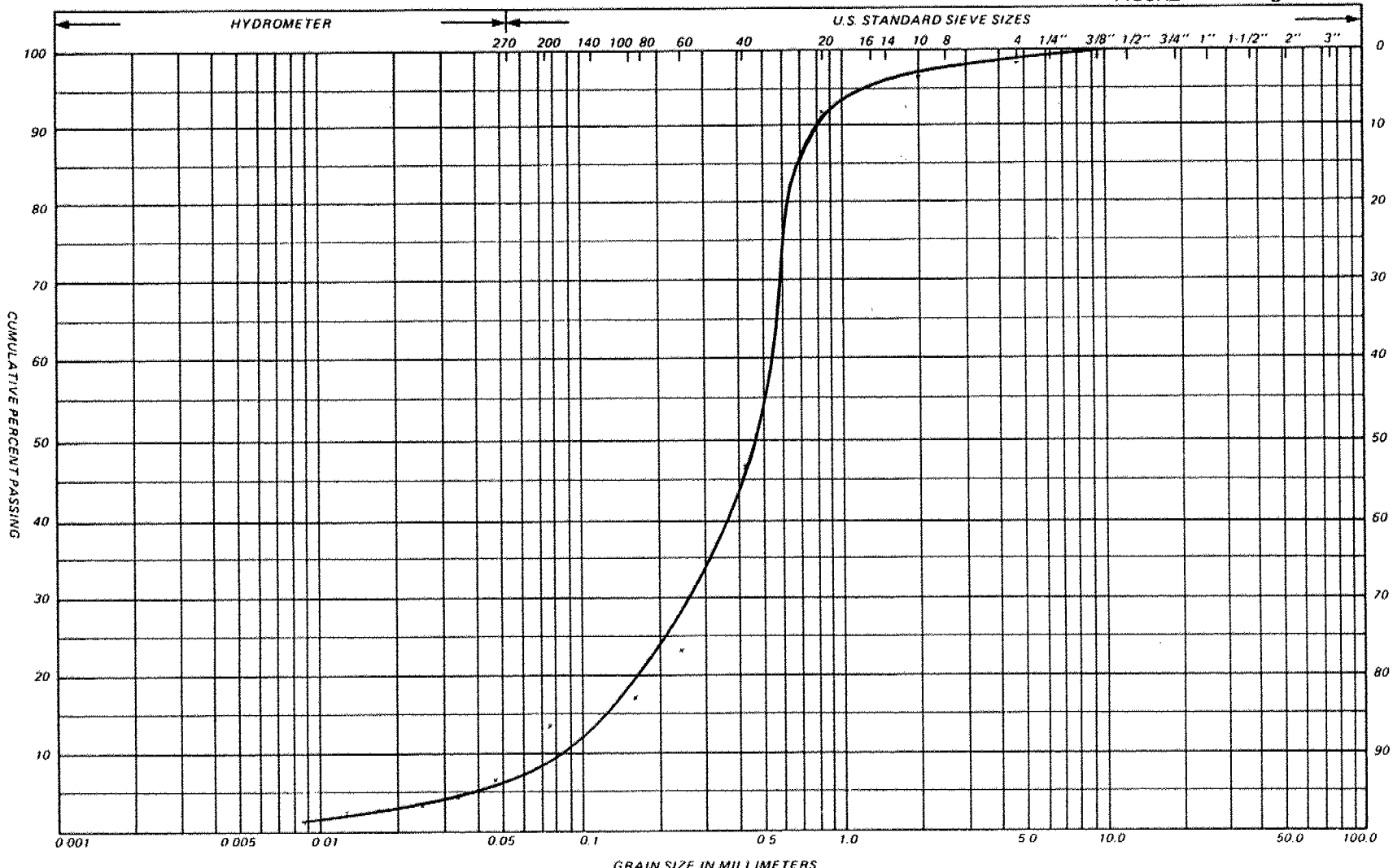
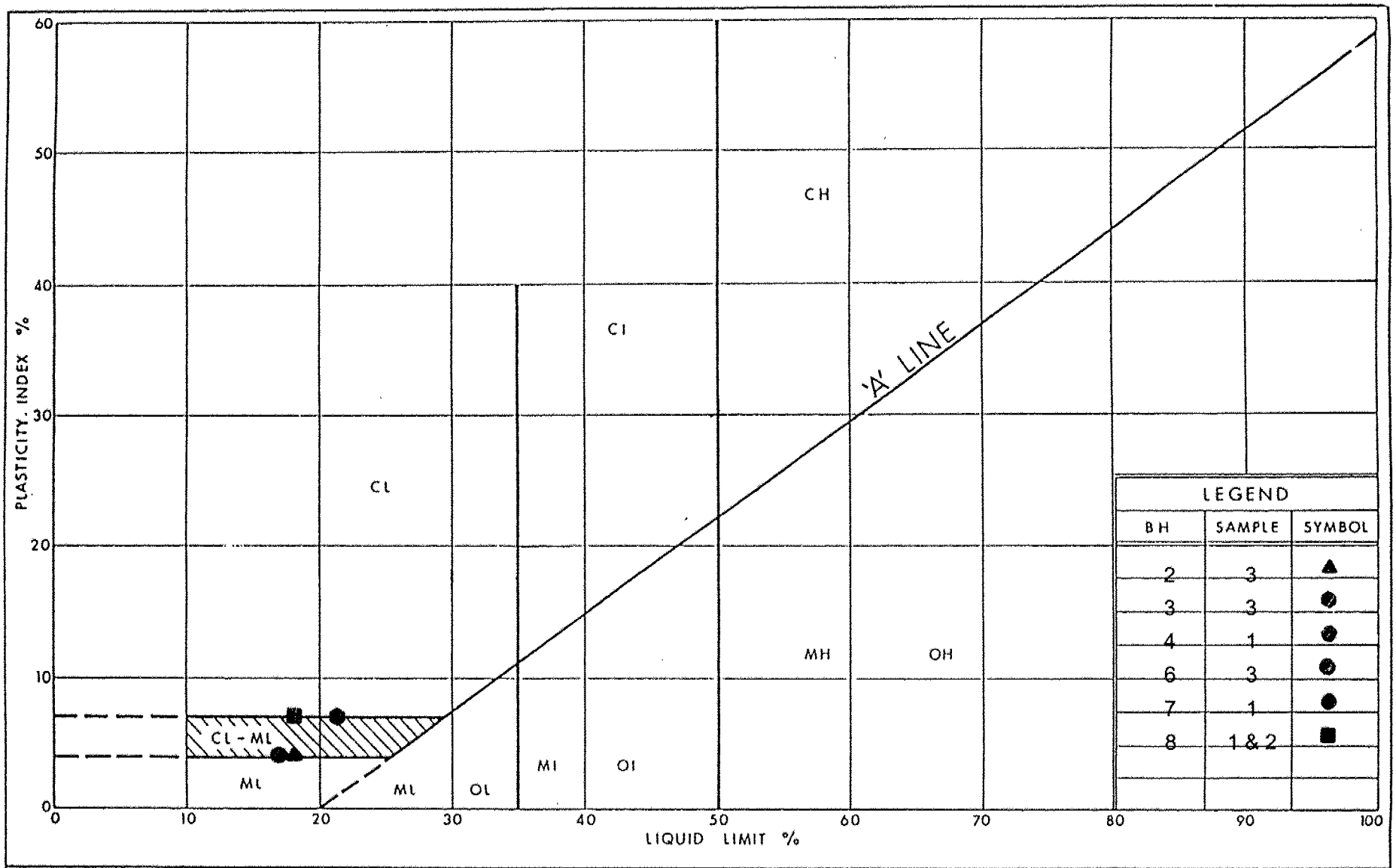
PML REF. 98HF060
REPORT NO. 1
FIGURE 8

PARTICLE SIZE DISTRIBUTION CHART



Borehole 8, Sample 3 at 2.3 to 2.7 m depth

Fine to Medium Sand



Ministry of Transportation
Ontario

PLASTICITY CHART

FIG No 9
GWP163-80-01
PML Ref. 98HF060

LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N', - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 0.3m INTO THE SUBSOIL. DRIVEN BY MEANS OF A 63.5kg HAMMER FALLING FREELY A DISTANCE OF 0.76m.

DYNAMIC PENETRATION RESISTANCE : - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 51mm, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 0.3m INTO THE SUBSOIL. THE DRIVING ENERGY BEING 475 J PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS : -

CONSISTENCY	'N' BLOWS/0.3 m	c kPa	DENSENESS	'N' BLOWS/0.3 m
VERY SOFT	0 - 2	0 - 12	VERY LOOSE	0 - 4
SOFT	2 - 4	12 - 25	LOOSE	4 - 10
FIRM	4 - 8	25 - 50	COMPACT	10 - 30
STIFF	8 - 15	50 - 100	DENSE	30 - 50
VERY STIFF	15 - 30	100 - 200	VERY DENSE	> 50
HARD	> 30	> 200		

W.T.P.L. WETTER THAN PLASTIC LIMIT

D.T.P.L. DRIER THAN PLASTIC LIMIT

A.P.L. ABOUT PLASTIC LIMIT

TYPE OF SAMPLE

S.S	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F S	FOIL SAMPLE
C S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T	SLOTTED TUBE SAMPLE		

P H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL		

▲,△ - Undisturbed and remoulded shear strength determined from in situ vane test.

■ - Undrained shear strength determined from pocket penetrometer test.

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LOG OF BOREHOLE NO. 1

N 4 797 138
E 270 532
Station 13+593

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

SOIL PROFILE				SAMPLES			SHEAR STRENGTH C_u ▲ / DYNAMIC CONE PENETRATION x / STANDARD PENETRATION TEST ● BLOWS/0.3M (20 40 60 80)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W (W_P — W — W_L) WATER CONTENT % (10 20 30)	REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)
DEPTH in METRES	DESCRIPTION	LEGEND	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES			GR SA SI CL
	GROUND ELEVATION 217.74								
0	0.23 SILT/ROCK FILL : Broken rock in a sandy silt matrix		217						
	BOREHOLE TERMINATED UPON REFUSAL TO AUGER BEDROCK AT 0.23m.								Upon completion of augering, no free water, no cave.
1.5									

NOTES:

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LOG OF BOREHOLE NO. 2

N 4 798 137
E 269 535
Station 15+005

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 240.05				
0.30	**CLAY FILL** : Brown silty clay				
0.60					
0.90	**TOPSOIL** : Dark brown clayey silt, medium organic	239	1	SS	15
1.40					
1.65	**SILT** : Stiff, brown clayey sandy silt		2	SS	34
2.10	**SILT AND SAND** : Compact, brown silt and fine sand, mottled, wet	238			
	layer of grey silty clay (till-like)		3	SS	76
	becoming dense, silty fine sand	237	4	SS	64
	SILT TILL : Hard, brown clayey silt, some sand and gravel, low plastic, D.T.P.L.	236	5	SS	61
		235			
5.65			6	SS	100
	BOREHOLE TERMINATED AT 5.65m.	234			

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
16	32	44	8

Upon completion of augering, free water at 0.60m.

NOTES:

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LOG OF BOREHOLE NO. 3

N 4 798 165
E 269 564
Station 15+005

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 239.83				
0					
0.13	**TOPSOIL** : Dark brown clayey silt, medium organic	239			
	SAND AND SILT : Compact, brown to grey, fine sand and silt, faintly stratified, wet		1	SS	13
1.40					
1.5					
1.75	becoming brown silty fine sand, saturated	238	2	SS	11
2.10					
	CLAY TILL : Stiff, grey silty clay, some sand, trace of gravel, low plastic, A.P.L.	237	3	SS	29
2.90					
3.0			4	SS	39
3.30	becoming very stiff, D.T.P.L.				
3.65	becoming stiff, medium plastic, W.T.P.L., bouldery	236			
			5	SS	22
4.40	**SILT** : Dense, grey fine sandy silt, saturated				
4.5		235	6	SS	38
5.15	becoming compact, occasional thin layers of silty clay				
	CLAY TILL : Hard, brown silty clay, some sand and gravel, slightly to low plastic, D.T.P.L.	234			
6.0	**BOREHOLE TERMINATED UPON REFUSAL TO AUGER AT 5.15m.**				

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
0	59	39	2

Upon completion of augering, borehole sidewalls caved at 0.80m.

NOTES:

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LOG OF BOREHOLE NO. 4

N 4 798 394
E 269 278
Station 15+369

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 6, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N-VALUES
	GROUND ELEVATION 239.36				
0		239			
0.60	**SILT FILL** : Brown clayey sandy silt, occasional wood				
1.40	**CLAY TILL** : Stiff, grey silty clay, some sand and gravel, low plastic, A.T.P.L.	238	1	SS	10
1.5			2	SS	18
	SAND : Compact, stratified grey and reddish brown, fine sand, some silt, saturated	237	3	SS	11
3.0					
3.30		236	4	SS	27
3.65	**SILT TILL** : Very stiff to hard, brown clayey silt, some sand and gravel, slightly plastic, A.P.L.				
4.40	with layers of fine sand	235	5	SS	30
4.5					
4.80	zone of thin stratified silts and clays		6	SS	44
	with layers of fine sand, some silt, saturated	234			
5.80			7	SS	34
6.0	**BOREHOLE TERMINATED AT 5.80m.**	233			

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ..... W_L
PLASTIC LIMIT ..... W_P
WATER CONTENT ..... W
W_P W W_L
WATER CONTENT %
10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	3	28	52	17

Upon completion of augering, free water at 0.80m.

NOTES:

CHECKED BY:

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 5

N 4 798 404
E 269 267
Station 15+383

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 6, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

GROUND ELEVATION 239.48

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
0.30	**SILT FILL** : Brown sandy silt	239			
0.60	**TOPSOIL** : Black clayey silt, medium organic				
0.90					
1.05	**SILT** : Stiff, brown clayey sandy silt, mottled		1	SS	10
1.40		238			
	SAND : Compact, brown silty fine sand, saturated		2	SS	17*
		237			
	CLAY TILL : Stiff, grey silty clay, some sand and gravel, low plastic, A.P.L.		3	SS	18
			4	SS	44**
	SAND : Compact, brown fine sand, some silt, saturated	236			
4.05			5	SS	37
	CLAY TILL : Hard, brown silty clay, some sand and gravel, slightly to low plastic, D.T.P.L.	235			
4.80			6	SS	52
5.20	zone of layered, grey to brown, silts and silty fine sands	234			
5.80			7	SS	46
	BOREHOLE TERMINATED AT 5.80m.	233			

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %
10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

* 13 for last 150mm
0 85 15 0

** High N-Value due to gravel particle

Upon completion of augering, free water at 0.80m.

NOTES:

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CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 6

N 4 799 308
E 288 366
Station 16+660

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 249.87				
0	**SAND AND SILT FILL** : Dark brown, fine sand and silt, some gravel to cobble size	249	1	SS	10/150mm & bouncing
1.00					
1.5	**SILT ALLUVIUM** : Firm, black clayey silt	248	2	SS	7*
2.10					
	CLAY TILL : Stiff, grey silty clay, some sand, trace of gravel, low plastic, W.T.P.L.	247	3	SS	12
3.0			4	SS	15
3.65					
	SILT : Dense, greyish brown silt, some fine sand, moist	246	5	SS	40
4.40					
4.5	becoming compact	245	6	SS	19
4.80					
	SAND : Compact, brown silty fine to medium sand, saturated	244			
6.0			7	SS	88**
6.25					
6.55	**SILT** : Very dense, grey silt, trace of sand, occasional thin partings of clay	243			
	BOREHOLE TERMINATED AT 6.55m.				
7.5					
9.0					

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ____ W_L
PLASTIC LIMIT ____ W_P
WATER CONTENT ____ W
W_P W W_L
WATER CONTENT %
10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
2	28	52	18

* No Recovery

** 50 for last 125mm

Upon completion of augering, free water at 4.10m inside augers; 2.20m in uncased borehole.

NOTES:

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Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 7

N 4 799 343
E 268 402
Station 16+660

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N - VALUES
	GROUND ELEVATION 248.18				
0					
0.20	**TOPSOIL** : Dark brown sandy silt, medium organic				
0.60	**SILT** : Brown sandy silt, trace of gravel	247	1	SS	13
1.5			2	SS	21
1.60	**CLAY TILL** : Stiff, grey silty clay, some sand and gravel, slightly to low plastic, D.T.P.L.	246			
2.10	**SILT** : Compact, brownish grey silt, some fine sand, wet		3	SS	28
2.90					
3.0	with thin layers of grey silty clay and wet silty sand	245	4	SS	49
	becoming dense, grey silt, faintly stratified, wet	244	5	SS	55
4.5			6	SS	42
5.20		243			
	becoming compact, with some fine sand		7	SS	20
5.80					
6.0	**BOREHOLE TERMINATED AT 5.80m.**	242			
7.5					
9.0					

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION × STANDARD PENETRATION TEST ●
BLOWS/0.3M: 20 40 60 80

LIQUID LIMIT ——— W_L
PLASTIC LIMIT ——— W_P
WATER CONTENT ——— W
W_P W W_L
WATER CONTENT %: 10 20 30

REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
1	12	86	1

Upon completion of augering, free water at 2.85m inside augers; 1.20m in uncased borehole.

NOTES:

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Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 8

N 4 799 867
E 267 865
Station 17+409

PROJECT HIGHWAY 6 CULVERT EXTENSIONS, MTO GWP 163-80-01 — OUR PROJECT 98HF060
LOCATION Flamborough, Ontario — BORING DATE August 5, 1998 — ENGINEER M. R. Anderson
BORING METHOD Continuous Flight Hollow Stem Augers — TECHNICIAN M. Rapsey

DEPTH in METRES	DESCRIPTION	ELEVATION	NUMBER	TYPE	BLOWS/0.3m N VALUES	GR	SA	SI	CL
	GROUND ELEVATION 251.31								
0	**SILT FILL** : Dark brown sandy silt, occasional metal pieces	251							
0.60									
	SILT : Very stiff, brown clayey silt (till-like), some sand, trace of gravel, slightly plastic, A.P.L.		1	SS	15	1	47	40	12
1.40		250							
1.5	with lenses of brown silty fine sand, wet		2	SS	16				
2.10		249							
	SAND : Compact, brown fine to medium sand, trace of silt, saturated		3	SS	13	1	90	9	0
3.0		248	4	SS	15				
4.20		247							
4.5	layer of dense, brown silt		5	SS	57*				
4.80	becoming fine to coarse-grained, some silt and gravel	246							
5.50	becoming grey, fine-grained, some silt								
6.0		245	6	SS	14				
6.55	**BOREHOLE TERMINATED AT 6.55m.**	244							
7.5									
9.0									

SHEAR STRENGTH C_u ▲
DYNAMIC CONE PENETRATION x
STANDARD PENETRATION TEST ●
BLOWS/0.3M
20 40 60 80

LIQUID LIMIT ..... W_L
PLASTIC LIMIT ..... W_P
WATER CONTENT ..... W
W_P W W_L
WATER CONTENT %
10 20 30

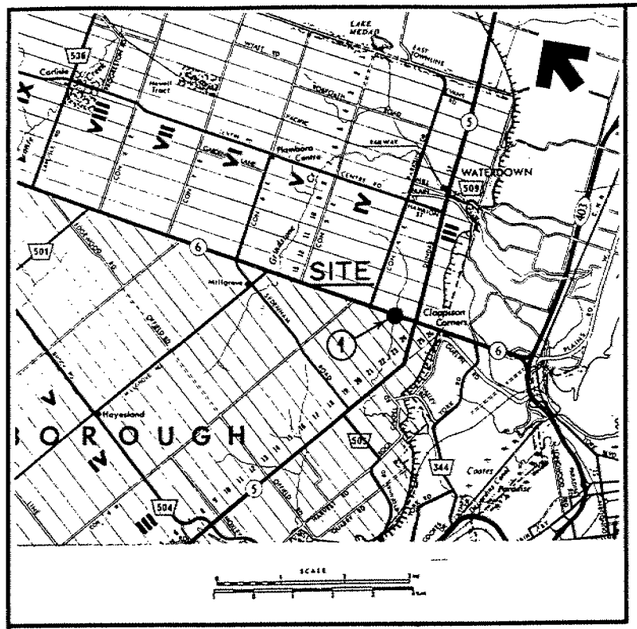
REMARKS, GROUNDWATER OBSERVATIONS AND GRAIN SIZE DISTRIBUTION (%)

* High N-Value suspected; spoon overfilled.

Upon completion of augering, free water at 0.95m.

NOTES:

CHECKED BY:



KEY PLAN

METRIC

SCALE 5m 0 10m

PLATE No

CONT No
WP No 163-80-01

CONSTRUCTION
STA 13+400 TO STA 13+750
Survey Revised

totten sims hubicki associates
ENGINEERS ARCHITECTS AND PLANNERS

SHEET 2

RICHARD W. GIDDINS
MELISSA K. GIDDINS

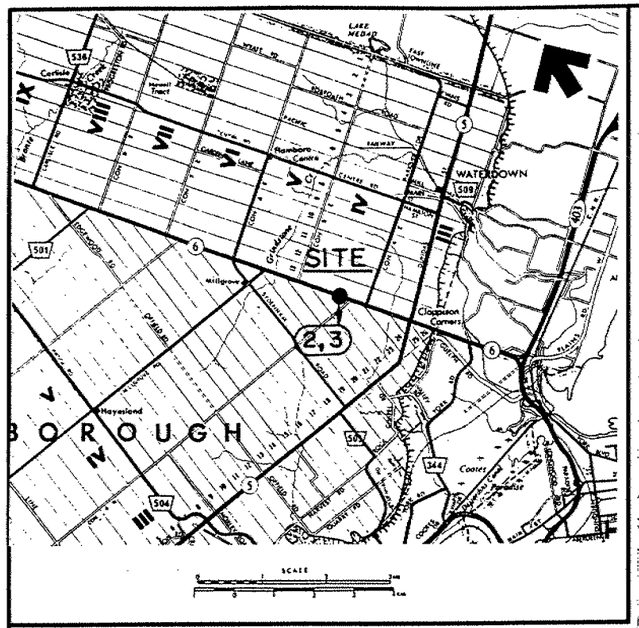
BH 1

BOREHOLE	LOCATION	ELEVATION
1	N 4 797 138 E 270 532	217.74

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED		AUG. 1998	AS SHOWN	98HF060	1
APPROVED					



KEY PLAN

METRIC

SCALE 5m 0 10m

PLATE No

CONT No

WP No 163-80-01

CONSTRUCTION

STA 14+800 TO STA 15+150

Survey Revised

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ENGINEERS ARCHITECTS AND PLANNERS

SHEET 6

CONCESSION 4

LOT 22

BH 2

BH 3

LOT 13

CONCESSION 4

R = 3500

NEW CULVERT

NEW CULVERT

14+900

15+028.333

15+100

2.0m EXTEN

BOREHOLE	LOCATION	ELEVATION
2	N 4 798 137 E 269 535	240.05
3	N 4 798 165 E 269 564	239.83

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
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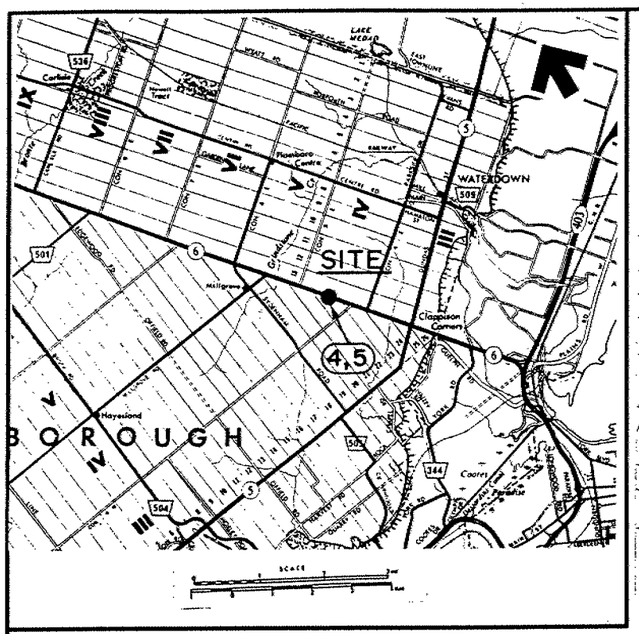
APPROVED					



KEY PLAN

METRIC

SCALE 5m 0 10m

PLATE No

CONT No

WP No 163-80-01

CONSTRUCTION

STA 15+150 TO STA 15+500

Survey Revised

SHEET 7

totten sims hubicki associates
ENGINEERS ARCHITECTS AND PLANNERS

CONCESSION 4

LOT 22

LOT 13

CONCESSION 4

BH 4

BH 5

15+300

15+400

15+500

NEW CULVERT

OLD NURSERY

BOREHOLE	LOCATION	ELEVATION
4	N 4 798 394 E 269 278	239.36
5	N 4 798 404 E 269 267	239.48

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED		AUG. 1998	AS SHOWN	98HF060	3
APPROVED					

PLATE No

CONT No

WP No 163-80-01

CONSTRUCTION

STA 16+550 TO STA 16+900

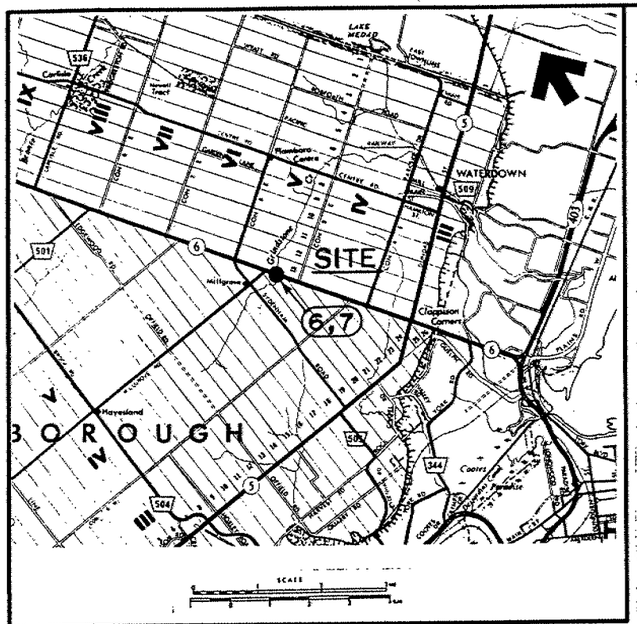
Survey Revised

SHEET 11

totten sims hubicki associates
ENGINEERS ARCHITECTS AND PLANNERS

METRIC

SCALE 5m 0 10m



KEY PLAN

CONCESSION 4

LOT 20

ANTHONY KASTRICH
MARY F. KASTRICH

BH 6

BH 7

NEW CULVERT

75.0m TAPER

1.0m EXTENSION

3.5m EXTENSION

LOT 13

CONCESSION 5

BOREHOLE	LOCATION	ELEVATION
6	N 4 799 308 E 268 366	249.87
7	N 4 799 343 E 268 402	248.18

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
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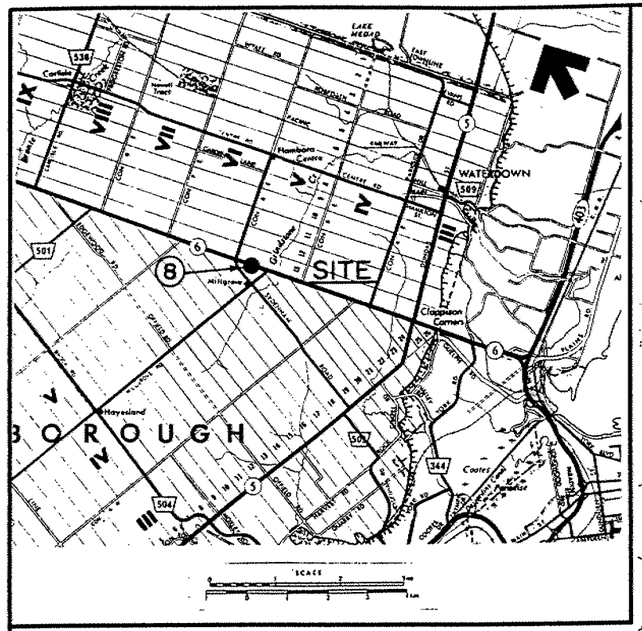
APPROVED					



KEY PLAN

METRIC

SCALE

5m 0 10m

PLATE No

CONT No

WP No 163-80-01

CONSTRUCTION

STA 17+250 TO STA 17+600

Survey Revised

SHEET 13

totten sims hubicki associates
ENGINEERS ARCHITECTS AND PLANNERS

CONCESSION 5

LOT 19

LOT 13

CONCESSION 5

BH 8

OLGA F. BRAJKOVIC
ENIO BRAJKOVIC

STEPHEN W. HEWICK
LAURA E. HEWICK

WILLIAM A. ST
FRANCIS A. S

BOREHOLE	LOCATION	ELEVATION
8	N 4 799 867 E 267 865	251.31

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS
45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6

DRAWN	CB	DATE	SCALE	JOB NO.	DRAWING NO.
CHECKED		AUG. 1998	AS SHOWN	98HF060	5
APPROVED					

PetoMacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION DESIGN REPORT
FOR
HIGHWAY 6 CULVERT EXTENSIONS
G.W.P. 163-80-01
FLAMBOROUGH, ONTARIO

Distribution:

3 cc: Totten Sims Hubicki Associates
1 cc: Ministry of Transportation
1 cc: PML Hamilton
1 cc: PML Toronto

Job No. 98HF060

September, 1998

TABLE OF CONTENTS

FOUNDATION DESIGN REPORT

For
Highway 6 Culvert Extensions
G.W.P. 163-80-01
Flamborough, Ontario

INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of extensions to four culverts and the retaining wall required for the Highway 6 resurfacing and widening project between Highway 5 and Concession 6 (Regional Road 543) in Flamborough. The culvert/retaining wall locations and proposed work are as follows:

Station	Existing Culvert	Proposed Extension
13+593	4.2 x 1.7 x 31.8 m concrete	5 m west end
15+006	1.2 m dia. CSP	1 m both ends
15+378	1.5 x 1.2 x 34.8 m concrete	Retaining wall at west end
16+656	4.3 x 1.6 x 37.7 m concrete	1.2 m west and 1.5 m east end
17+414	3.7 x 1.5 x 36.1 concrete	2.6 m east end

The stratigraphy revealed in boreholes drilled at the culverts varied with each location. The overburden generally comprised thin surficial layers of fill, topsoil and/or alluvium overlying various deposits of silt, sand, silt till and clay till. Locally at Station 13+593, bedrock was contacted at shallow depth.

FOUNDATIONS

Construction of the culvert extensions and retaining walls on the native inorganic soils below all fill, topsoil and alluvial material is considered to be feasible. The factored bearing capacities at

ultimate (ULS) and serviceability (SLS) limit states at the anticipated/recommended founding level of each structure are as follows:

Station	Anticipated Founding Elevation	Anticipated Founding Material	Factored Capacity (kPa) ULS	SLS
13+593	217.5	Bedrock	3000	-
15+006 West	239.4	Stiff Silt/Compact Sand	300	125
15+006 East	239.4	Compact Silt	300	125
15+378 South	237.6	Compact Sand	500	160
	236.1	Very Stiff Clay Till	600	400
15+378 North	237.6	Compact Sand	550	200
16+656 West	246.8	Very Stiff Clay Till	300	200
	246.2	Dense to Compact Silt	600	200
16+656 East	246.5	Stiff Clay Till/Compact Sand	500	230
17+414	249.5	Very Stiff Silt	300	150
	249.2	Compact Sand	600	150

The capacity at serviceability limit states normally allows for 25 mm of compression of the founding medium. Differential settlement of footings in the overburden is expected to be less than 75% of this value. Considering the bedrock to be non-yielding, the design at Station 13+593 is not expected to be governed by settlement since the loading required to produce deformation will be much larger than the factored capacity at the ultimate limit state.

In general, the founding level of the proposed culvert extensions should be at the same level as the existing culverts. Where founding levels vary, the founding elevation should be stepped in maximum 600 mm steps at a maximum inclination of 10 horizontal to 7 vertical.

All footings subject to frost action should be provided with the normal 1.2 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

Subgrade preparation, pipe bedding, cover, backfill and frost treatment for the CSP extension at Station 15+006 should be carried out in accordance with Ontario Provincial Standards specifications. The OPSD granular backfill requirements should be appropriate for the box culvert extensions. A frost penetration depth of 1.2 m should be employed.

Prior to placement of structural concrete, all foundation excavations should be examined by qualified geotechnical personnel to verify the competency of the founding surface.

The overburden soils are prone to disturbance by the weather elements and construction traffic. Accordingly, a 50 mm skim slab of lean concrete should be provided over the base of the approved subgrade if structural concrete cannot be provided within 24 hours of approval of the foundation base.

The measures to deal with erosion (inlet/outlet treatment, headwalls, cut off walls etc) included in the Ontario Provincial Standards are considered to be appropriate.

RETAINING WALL DESIGN

The retaining wall should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p, may be computed using the equivalent fluid pressures presented in Section 6-7.4 of the Ontario Highway Bridge Design Code (OHBDC, 3rd Edition, 1991) or employing the following equation, assuming a triangular pressure distribution:

$$p = K(\gamma h + q)$$

where K = coefficient of lateral earth pressure

γ = unit weight of free-draining granular material

h = depth below final grade (m)

q = surcharge load (kPa), if present

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	Granular "A"	Granular "B"
Angle of Internal Friction (degrees)	35	32
Unit Weight (kN/m^3)	22.8	21.2
Active Earth Pressure Coefficient (K_a)	0.27	0.31
At Rest Earth Pressure Coefficient (K_o)	0.43	0.47
Passive Earth Pressure Coefficient (K_p)	3.69	3.25

A weeping tile system and/or weeping holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

The horizontal force will be resisted in part by the friction force developed between the underside of footing and the founding soil. An unfactored friction factor of 0.35 is recommended for footings on the stiff clay till or compact fine sand.

Use of a reinforced soil structure could be considered. The founding soil for this structure is expected to comprise stiff clay till or compact fine sand. The following geotechnical parameters may be assumed for the foundation soil during stability analyses:

Friction Angle	32°
Cohesion	0 kPa
Unit Weight	20 kN/m^3

The supplier of this type of system is normally responsible for the design of the reinforcement and backfill to ensure internal stability as well as verification of the external stability of the wall.

APPROACH FILL/ROAD EMBANKMENT

Backfilling adjacent to the structures should be carried out in conformance with Ontario Provincial Standards specifications. Backfill should be brought up simultaneously on each side of the culverts to minimize the potential for movement of the culvert.

No problems with respect to bearing capacity or settlement are anticipated. Standard sideslopes inclined no steeper than 2 horizontal to 1 vertical should be stable for the roadside embankments.

Measures to control surface runoff and minimize erosion of the embankment slopes should be established. Protective measures should be incorporated in the design to minimize erosion or loss of materials adjacent to the culvert.

All topsoil, alluvium or otherwise deleterious material within 1.2 m of the finished pavement subgrade level should be stripped prior to fill placement.

EXCAVATION AND GROUNDWATER CONTROL

Shallow excavation for installation of the culverts and retaining wall footings is expected to be relatively straightforward using conventional equipment and open cut procedures. The in situ materials are classified as Type 3 soils according to Occupational Health and Safety Act criteria. Temporary cut slopes inclined at 1 horizontal to 1 vertical should generally be stable.

Free water was typically observed at depths of 0.6 to 1.2 m, locally 2.2 m, in the boreholes. If excavation extends below the groundwater level, some sloughing in the cohesionless sand/silt deposits should be anticipated. For the relatively shallow depth of excavation envisioned, sump pumping techniques and/or local flattening of the sideslopes is expected to be adequate to handle these conditions.

Observed groundwater levels are subject to seasonal fluctuations and rainfall patterns. It is recommended that construction take place during the dry summer months when the amount of water to be diverted from the construction area should be at a minimum.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

SOIL AGRESSIVENESS

Laboratory testing conducted on selected samples of the overburden from the culvert sites indicates water soluble sulphate concentrations ranging between 0.01 to 0.06%. The test results indicate that buried concrete structures will be subject to a negligible degree of exposure to sulphate attack.

CLOSURE

This report was written by M.R. Anderson, P. Eng. and reviewed by D.W. Kerr, P. Eng., Manager of Geotechnical and Geo-Environmental Services, Hamilton.

Yours very truly

Peto MacCallum Ltd.

Dennis W. Kerr, M.Eng., P.Eng.
Manager of Geotechnical and
Geo-Environmental Services

Brian R. Gray, M.Eng., P.Eng.
Vice President
Geotechnical Engineering and
Geo-Environmental Services

MRA:mma