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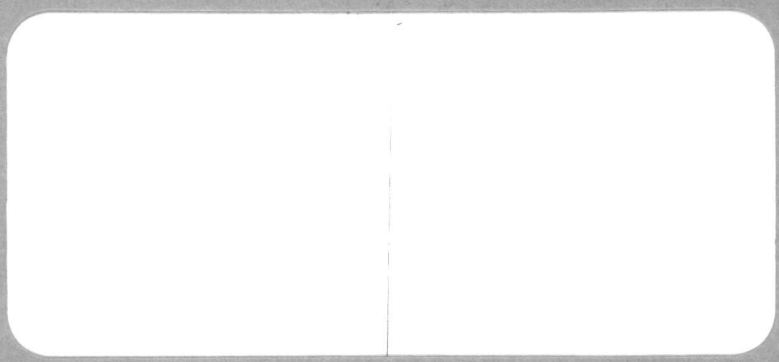

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

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SUPPLEMENTARY REPORT

ON

75-32

EMBANKMENT FILL RECONSTRUCTION

HIGHWAY #12

VICTORIA HARBOUR ONTARIO

Oct.'76

(2)

FOR

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

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October 1, 1976 761175

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

October 1, 1976

Ministry of Transportation and
Communications
Soil Mechanics Section
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M 1J8

ATTENTION: Mr. K.G. Selby, P.Eng.
Supervising Engineer

RE: EMBANKMENT RECONSTRUCTION
HIGHWAY #12
VICTORIA HARBOUR, ONTARIO

Dear Sirs:

This supplementary report summarizes the results of laboratory tests carried out on samples of the subsoils at the above site, (refer to Figure 1 for Key Plan). The progress of the ongoing reconstruction program is reviewed and preliminary recommendations for future construction procedures given.

SUBSURFACE CONDITIONS

The results of the recently completed laboratory testing program confirm our earlier interpretation of the subsurface conditions at the site* and provide additional information on the engineering properties of the various subsoil strata. The results of laboratory tests are summarized on the attached

*refer to Golder Associates report no. 761175, dated August, 1976.

Record of Borehole sheets and on Figures 3 to 11, inclusive. The inferred subsoil stratigraphy across the site is shown on the stratigraphic sections on Figure 2.

CONSTRUCTION PROGRESS REVIEW

Reconstruction of the embankment fill began on July 26, 1976 in accordance with the recommendations outlined in Golder Associates report no. 761175, dated August, 1976. Progress has been reported weekly by our on-site supervisor in the form of weekly memoranda. The following is a brief summary of the general construction procedures and progress to date.

(i) The embankment fill was lowered to about elevation 663 prior to reconstruction.

(ii) A 2 cu.yd. dragline was used to excavate the north key trench starting in the northwest corner of the site.

(iii) Because of the presence of boulders in the fill and instability of the excavation side slopes, a backhoe was used to excavate the original embankment fill ahead of the dragline operations. To avoid instability on the embankment side of the excavation, fill was removed to within about 20 ft. of the embankment centreline.

(iv) Following completion of subexcavation and during backfilling of each section of key trench on the northern side of the embankment, the dragline was used to subexcavate for the south key trench. This procedure of advancing both key trenches simultaneously, avoided standby time for equipment and has been adopted throughout the reconstruction work.

(v) A survey of the settlement of backfill placed in sections II and III in the north key trench indicated that the backfill material was relatively stable.

(vi) Following an initially slow start up period, progress was satisfactory and by about the end of August, the north and south key trenches had been completed to about stations 432+20. However, heavy rainstorms at about this time had caused a significant rise in water levels in the excavations causing local instabilities within the backfill which required repair. Considerable effort was also required to maintain haul roads after periods of heavy precipitation. These factors resulted in less productivity throughout most of September. A pump was employed to control the water level in excavations in the latter part of September.

(vii) When the key trench backfill had progressed a sufficient distance from the west end of the valley, good quality original embankment fill was placed outside the key trenches ajdacent to the backfill to act as stabilizing berms for the completed embankment. Poor quality fill was wasted.

(viii) The removal of fill ahead of the key trench subexcavation by the backhoe is now essentially complete. Both the north and south key trenches have been backfilled to about station 431+50. The dragline is currently subexcavating the next section of the south key trench to about station 431+10.

Because the lower till surface slopes upward towards the east side of the valley (section C-C, Figure 2), it is anticipated that the excavation and backfilling of the south key trench should proceed relatively quickly. Subexcavation and backfilling of the north key trench is between 50 and 75 per cent complete. Depending on weather conditions and satisfactory operation of equipment, it is currently estimated that construction of the embankment to about elevation 660 can be completed within 2 to 4 weeks.

FUTURE CONSTRUCTION PROCEDURES

It is understood that some 110,000 cu.yd. of fill will be available from lowering the road grade in the approach cuts to the embankment section. It is currently estimated

that about 30,000 cu.yd. of fill will be required as backfill in the key trenches and general raising of the embankment to about elevation 660. Raising the embankment to final design height (including surcharge) will require an additional 30,000 cu.yd., leaving about 50,000 cu.yd. for berm construction. Preliminary estimates indicate that this quantity of material will be sufficient for construction of 50 ft. wide berms along both sides of the embankment.

When the key trenches have been completed, the embankment fill and outer stabilizing berms should be raised simultaneously. The final dimensions of the outer berms will depend on the quantity of fill which is not required for embankment construction as discussed above. Because of their beneficial effect with respect to final embankment stability, the final width of berms need not be restricted and can be as much as 50 ft. or 100 ft.; however, the final berm elevation should be at about mid-height of the final embankment slope.

The embankment fill should be surcharged for a minimum period of 6 months. This procedure will minimize long term settlement of the completed embankment and reduce future maintenance costs. It is essential that an embankment failure does not result due to surcharging operations and, at this time, it is recommended that a maximum of 3 to 4 ft. of surcharge (above final proposed grade) be employed. The performance of the surcharged embankment should be monitored by observing the settlement of the embankment fill and porewater pressure dissipation within the foundation subsoils. The settlement of the surcharged embankment due to consolidation of the 20 to 30 ft. thick soft foundation soils will vary across the site and could be as much as 1 to 3 ft.

Settlement within the softened till deposits should occur relatively quickly. However, the rate of consolidation of the sensitive clay deposit will be considerably slower and will result in long term settlement of the embankment. The magnitude of long term settlement will depend to a large extent on the thickness of this material and on the degree to which it has been displaced during the recent construction operations.

Because of the magnitude of anticipated settlements, it will be necessary to widen the proposed embankment profile to ensure the design road allowance is achieved. Thus the width of the surcharged zone should be not less than the design road allowance. It is considered that this can be carried out by a modest steepening of the embankment side slope as opposed to widening the embankment for its full height. Following the surcharge period, excess fill should be removed and placed in the berm areas. Because of the settlements which are anticipated during surcharging operations, it will not be possible to pave the embankment section of the roadway until the spring of 1977 at the earliest, when the performance of the embankment has been assessed.

The stability of the surcharged embankment and the estimated settlement of the embankment given above must be assessed in relation to the actual subsurface conditions following the key trench construction, and in particular, the final berm profile to ensure stability of the interim surcharged embankment must be defined. To effect this definition, additional information on the strength and compressibility characteristics of the subsoils underlying the embankment and in particular the thickness of the soft sensitive clayey deposit is required. It is suggested that an investigation program consisting of 2 sampled

boreholes with accompanying vane tests be carried out, the borings being located along the centreline of both the north and south key trench and along the centreline of the completed embankment. The boreholes should be put down before the embankment is raised above elevation 670.

We trust that the information contained in this report is sufficient for your present requirements. If you have any questions regarding the results of laboratory tests or the recommendations for future construction procedures, please call us.

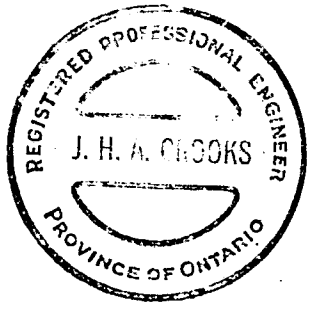
Yours truly,

H.Q. GOLDER & ASSOCIATES LTD.

JHA Crooks

J.H.A. Crooks, P.Eng.

V. Milligan, P.Eng.



JHAC:VM:hs
761175

Encl: Record of Borehole Sheets
Figures 1 to 11, inclusive

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*N, blows/ft.*
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:

[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P)/I_P$
I_C	consistency index $= (w_L - w)/I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

Form G.A.-D-1.

Project No. 761175

STA. 13+35, 76' RT. OF ℄

RECORD OF BOREHOLE 1

LOCATION See Figure 2 BORING DATE JUNE 15, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.	ELEVATION SCALE
WASH BORING NX CASING	656.8 / 0.0	GROUND SURFACE		ST	SPLIT SPOON 2" SHELBY TUBE		655
	651.3 / 5.5	VERY SOFT DARK BROWN AMORPHOUS PEAT	1	S1	2" D.O.	1/18"	
	649.6 / 7.2	VERY SOFT BROWN ORGANIC SILT, NUMEROUS SHELLS	2	S2	"	0	650
	642.8 / 14.0	VERY LOOSE GREY SILTY SAND, TRACE CLAY AND ORGANIC MATTER	3	S3	"	0	
				S4	"	2	645
				S5	"	0	
	630.3 / 26.5	SOFT GREY SENSITIVE SILTY CLAY, OCCASIONAL THIN SILT AND SAND LAYERS OR LENSES	4	T1	2" T.O	PM	640
				T2	"	PM	635
	627.3 / 29.5	FIRM GREY STRATIFIED CLAYEY SILT, SOME SAND	5	T3	"	PM	630
	622.8 / 34.0	LOOSE (?) GREY SILTY SAND TO SANDY SILT, TRACE CLAY OCCASIONAL THIN CLAY LAYERS.	6	T4	"	0	625
	620.8 / 36.0	SENSITIVE LAYERED GREY SILTY CLAY AND RED GREY SILT	7	T5	"	PM	
	617.8 / 39.0	LOOSE GREY SILTY SAND, TRACE CLAY SOME GRAVEL (SOFTENED TILL)	8	S6	2" D.O.	4	620
	610.3 / 46.5	VERY DENSE BROWN COARSE SAND / END OF HOLE	9	S7	"	55	615
				S8	"	>100	610

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) FIELD NAT. V. - + Q. -● REM.V. - ⊕ U. -○

LAB VANE NAT.V. X REM.V ⊗

COEFFICIENT OF PERMEABILITY, k., CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (20, 40, 60, 80) Wp W WL

486 → ⊙

141 → ⊙

1600 →

CLAYEY LAYER

F CLAY & SILT

100 BLOWS FOR LAST 4"

H

H γ=107

H

MH

MH

MH

M

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

▽ WATER LEVEL IN OPEN HOLE AT ELEV. 656.4 ON JUNE 24, 1976

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

15 ◆ 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHAC

Form G.A.-D-1.

Project No. 761175

STA. 431+56, 170' RT. OF ℄

RECORD OF BOREHOLE 2

LOCATION See Figure 2 BORING DATE JUNE 18, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
	659.0	GROUND SURFACE			SPLIT SPOON 2" SHELBY TUBE		660
WASH BORING NX CASING	0.0 / 654.0	VERY SOFT BROWN TO BLACK AMORPHOUS PEAT WITH PIECES OF WOOD	1	S1	2" D.O.	2/18"	655
	5.0 / 648.0	VERY SOFT BROWN ORGANIC SILT, OCCASIONAL ROOTS AND FIBRES.	2	S2	"	0	
				S3	"	0	650
	11.0			S4	"	0	
		LAYERED CLAY AND SILT WITH 1" THICK SILTY SAND LAYER		T1	2" T.O.	PM	645
		VERY SOFT TO FIRM GREY LIGHTLY BANDED SENSITIVE SILTY CLAY OCCASIONAL THIN SILT AND SAND LAYERS OR LENSES (UP TO 1/2" THICK)	4	T2	"	PM	640
				T3	"	PM	
				T4	"	PM	635
	631.0			T5	"	PM	
	28.0 / 628.0	FIRM GREY STRATIFIED CLAYEY SILT, TRACE SAND AND GRAVEL	5	S5	2" D.O.	—	630
	31.0 / 624.0	VERY LOOSE GREY SILTY SAND TO SANDY SILT, TRACE CLAY	6	S6	"	—	625
	35.0 / 621.0	VERY LOOSE GREY SILTY SAND, TRACE TO SOME CLAY, SOME GRAVEL (SOFTENED TILL)	8	S7	"	3/18	
	38.0 / 618.0	SENSITIVE THINLY (1/16") LAYERED GREY SILTY CLAY AND SILT	7	S8	"	0	620
	41.0 / 613.5	COMPACT TO VERY DENSE GREY SILTY SAND, TRACE CLAY SOME GRAVEL (TILL)	10	S9	"	11	
				S10	"	>100	615
	45.5	END OF HOLE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. — 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. — FIELD: NAT. V. - + Q. - ● REM. V. - ⊕ U. - O — 200 400 600 800

LAB VANE: NAT. V. X; REM. V. ⊗

COEFFICIENT OF PERMEABILITY, k, CM./SEC. — 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT — Wp W WL — 20 40 60 80

347 → ⊙

1015 → ⊙

⊙ 201 →

O

127 → ⊙

WATER CONTENT PROFILE

H γ=95

H γ=95

CLAY LAYER

CLAYEY SILT LAYER

MH

MH

57 BLOWS FOR LAST 8"

15 0 5 Percent axial strain at failure 10

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN OPEN HOLE AT ELEV. 658.0 ON JUNE 24, 1976

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHK

Form G.A.-D-1. Project No. 761175

STA. 430+90, 156' RT. OF ℄

RECORD OF BOREHOLE 3

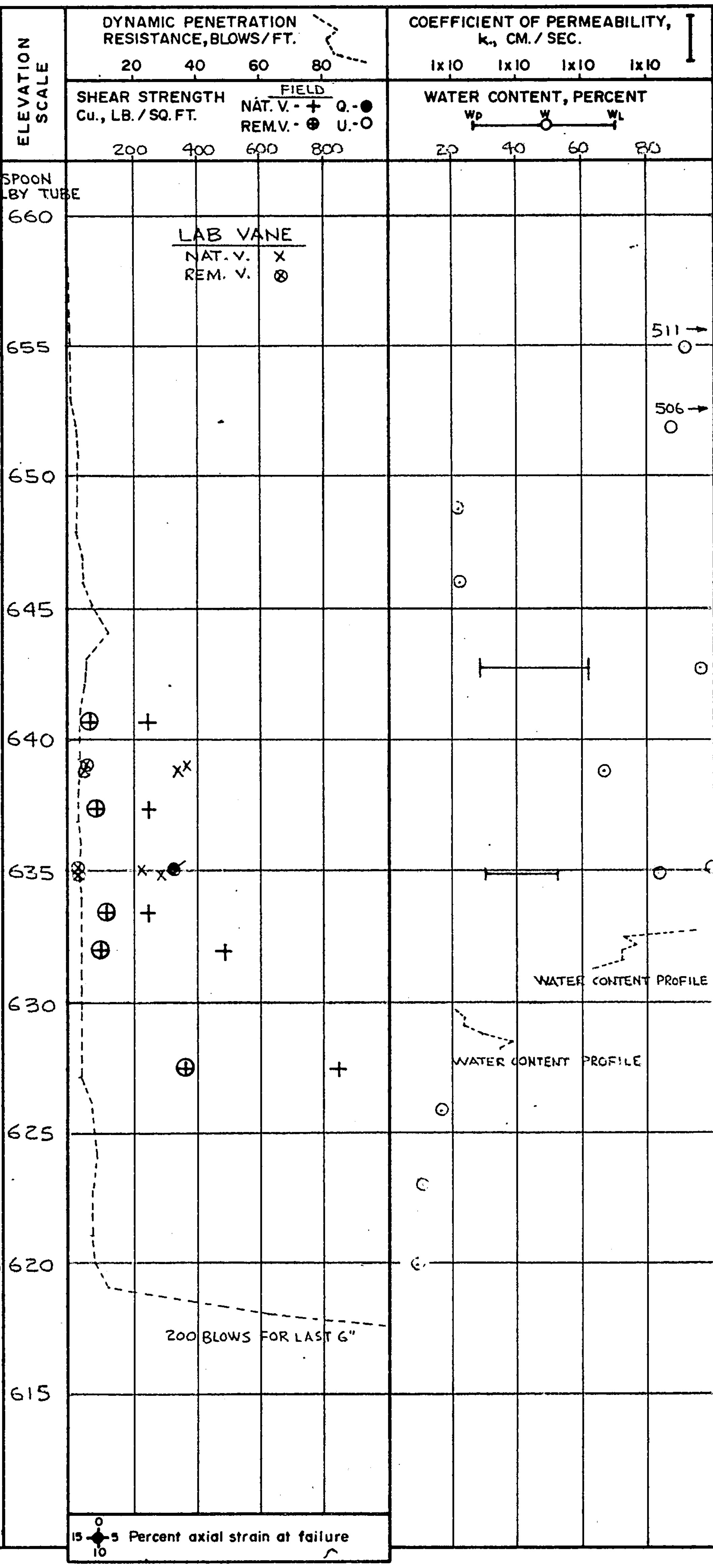
LOCATION See Figure 2 BORING DATE JUNE 23, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

Boring method: WASH BORING, NX CASING

Sample types: S – SPLIT SPOON; T – 2" SHELBY TUBE

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	TYPE	BLOWS/FT.	ADDITIONAL LAB. TESTING
658.6	GROUND SURFACE					
0.0 – 653.6	VERY SOFT BROWN TO BLACK AMORPHOUS PEAT, WITH PIECES OF WOOD	1	S1	2" D.O.	2	ORGANIC CONTENT = 79%
5.0 – 648.6	VERY SOFT DARK BROWN TO GREY BROWN ORGANIC SILT WITH NUMEROUS SHELLS	2	S2	"	1/18"	
			S3	"	1/18"	
10.0 – 644.6	LOOSE GREY SILTY SAND, TRACE CLAY	3	S4	"	4	MH
14.0 – 630.6	VERY SOFT TO FIRM GREY (LIGHTLY BANDED) SENSITIVE SILTY CLAY, OCCASIONAL THIN SILT AND SAND LAYERS OR LENSES	4	S5	"	1/18"	H
			T1	2" T.O.	PM.	
			T2	"	PM	H, γ=98
			T3	"	PM	
28.0 – 627.6	FIRM GREY CLAYEY SILT, TRACE FINE GRAVEL, OCCASIONAL THIN SAND LAYERS	5	T4	"	PM	
31.0 – 621.6	LOOSE GREY SILTY SAND, TRACE CLAY SOME GRAVEL (SOFTENED TILL)	8	T5	"	PM	MH
			S6	2" D.O.	5	MH
37.0 – 619.1	VERY DENSE GREY SILTY SAND, TRACE CLAY SOME GRAVEL (TILL)	10	S7	"	>100	
39.5	END OF HOLE					



PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN OPEN HOLE AT ELEV. 657.7 ON JUNE 24, 1976.

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHHC

Form G.A.-D-1.

Project No. 761175

STA. 431+85, ON ℄

RECORD OF BOREHOLE 100

LOCATION See Figure 2 BORING DATE JUNE 10, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER, HOLLOW STEM (?)

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
671.4 / 0.0	GROUND SURFACE		S T	SPLIT SPOON 2" SHELBY TUBE	
	LOOSE TO COMPACT GREY SAND AND GRAVEL TO SANDY /CLAYEY SILT SOME GRAVEL, NUMEROUS BOULDERS (FILL)		S1	2" D.O.	21
			S2	"	9
			S3	"	8
			S4	"	4
			S5	"	5
			S6	"	11
647.4 / 24.0	LOOSE GREY SILTY SAND, TRACE CLAY	3	S7	"	6
643.4 / 28.0	FIRM TO SOFT GREY (LIGHTLY BANDED) SENSITIVE SILTY CLAY, OCCASIONAL SAND LAYERS OR LENSES (UP TO 1" THICK)	4	T8	2" T.O.	PH
			T9	"	PM & PH
			S10	2" D.O.	0
627.4			S11	"	0
44.0	VERY SOFT GREY CLAYEY SILT, WITH SAND LAYERS OR LENSES.	5	S12	"	PM
623.4					
48.0	VERY LOOSE GREY SILTY SAND, TRACE CLAY, SOME GRAVEL (SOFTENED TILL)	8	S13	"	2
614.9					
56.5	END OF HOLE				

ELEVATION SCALE: 670, 665, 660, 655, 650, 645, 640, 635, 630, 625, 620, 615

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. -● REM.V. - ⊕ U. -○ 200 400 600 800

COEFFICIENT OF PERMEABILITY, k_v, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT W_P W W_L 20 40 60 80

ADDITIONAL LAB. TESTING: MH

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN OPEN HOLE AT ELEV. 639.4 ON JUNE 10, 1976

15 0 5 10 Percent axial strain at failure

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C LOGS
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED J.H.C.

Form G.A.-D-1.

Project No. 761175

STA. 431+85, 118' RT OF ℄

RECORD OF BOREHOLE 101

LOCATION See Figure 2 BORING DATE JUNE 11, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER; HOLLOW STEM(?)

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.
663.3	GROUND SURFACE		S	SPLIT SPOON 2" SHELBY TUBE	
0.0	GRANULAR FILL CONTAMINATED WITH PEAT		S1	2" D.O.	1/24"
			S2	"	2
656.8					
6.5	PROBABLY VERY LOOSE SILTY SAND	3			
655.0			S3	"	0
8.3	DISTURBED(?)	4	T4	2" T.O.	PM
	UNDISTURBED		T5	"	PM
	VERY SOFT TO SOFT GREY (LIGHTLY BANDED) SENSITIVE SILTY CLAY WITH SILT AND SAND LENSES OR LAYERS.		T6	"	PM
		4	T7	"	PM
			T8	"	PM
630.3					
33.0	GREY SILTY SAND TRACE TO SOME CLAY	6	T9	"	PM
625.3					
38.0	PROBABLY GREY SILTY SAND, TRACE CLAY, SOME GRAVEL (SOFTENED TILL)	8?			
611.8					
51.5	END OF HOLE REFUSAL TO AUGER				

ELEVATION SCALE: 660, 655, 650, 645, 640, 635, 630, 625, 620, 615, 610

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) FIELD NAT. V. - + Q. -● REM. V. - ⊕ U. -○

LAB VANE NAT. V X REM. V. ⊗

69 BLOWS FOR LAST 3"

0 / 15 / 10 / 5 Percent axial strain at failure

COEFFICIENT OF PERMEABILITY, k, CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL) (20, 40, 60, 80)

H γ=97

H ORGANIC CONTENT=2-3%

MH

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JH/C

Form G.A.-D-1.

Project No. 761175

STA. 432+65, 94' LT. OF ℄

RECORD OF BOREHOLE 102

LOCATION See Figure 2 BORING DATE JUNE 14, 1976 DATUM . GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER; HOLLOW STEM(?)

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.
663.9	GROUND SURFACE		S1	SPLIT SPOON 2" SHELBY TUBE	
0.0	PROBABLY COMPACT GRANULAR FILL		S1	2" D.O.	10
658.9					
5.0	VERY SOFT DARK BROWN AMORPHOUS PEAT	1	S2	"	1
654.9			S3	"	1
9.0	VERY SOFT BROWN ORGANIC SILT, NUMEROUS SHELLS	2	S4	"	1/18"
651.9					
12.0	VERY LOOSE GREY SANDY SILT, TRACE CLAY	3	S5	"	0
			S6	"	1/18"
			S7	"	0
642.7					
21.0	VERY SOFT TO SOFT GREY SENSITIVE SILTY CLAY, OCCASIONAL THIN SAND AND SILT LENSES OR LAYERS	4	S8	"	1/18"
			T8A	2" T.O.	PM
			T9	"	PM
629.9					
34.0	LOOSE GREY SILTY SAND, TRACE TO SOME CLAY, TRACE TO SOME GRAVEL BECOMING SOFT GREY CLAYEY SILT TRACE SAND AND GRAVEL BELOW ELEV. 618.0 (SOFTENED TILL)	8	T10	"	PM
			S11A	2" D.O.	PM
			S12	"	5
610.9					
53.0	VERY HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL (TILL)	10	S13	"	>100
607.4					
56.5	END OF HOLE				

ELEVATION SCALE: 665, 660, 655, 650, 645, 640, 635, 630, 625, 620, 615, 610, 605

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) FIELD NAT. V. - + Q. - ● REM. V. - ⊕ U. - O

LAB VANE NAT. V. × REM. V. ⊗

AUGERED

COEFFICIENT OF PERMEABILITY, k_v, CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL) (20, 40, 60, 80)

451 ⊙ 684 ⊙ 626 ⊙

SPECIFIC GRAVITY = 1.74

MH; MH; γ=100; H; MH γ=126; MH

146 BLOWS FOR LAST 12"

15 ← 0 → 5 Percent axial strain at failure; 10

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN OPEN HOLE AT ELEV. 660.9 ON JUNE 24, 1976

NOTES
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHTC

Form G.A.-D-1.

Project No. 76175

STA. 431+00, 96' LT. OF ℄

RECORD OF BOREHOLE 103

LOCATION See Figure 2 BORING DATE JUNE 16, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER, HOLLOW STEM(?)

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FT.
659.8	GROUND SURFACE				
0.0	GRANULAR FILL CONTAMINATED WITH ORGANIC MATTER		S1	2" D.O.	1½
			S2	"	=
652.8					
7.0	LOOSE TO COMPACT GREY BROWN SAND, TRACE SILT AND GRAVEL.	9	S3	"	8
			S4	"	12
			S5	"	10
643.8			S6	"	3
16.0 / 642.8	VERY SOFT SENSITIVE SILTY CLAY	4			
17.0	VERY LOOSE GREY SILTY SAND, TRACE CLAY AND GRAVEL (SOFTENED TILL)	8	S7	"	3
			S8	"	2
636.8					
23.0	VERY DENSE GREY SILTY SAND, TRACE TO SOME SAND AND GRAVEL (TILL)	10	S9	"	97
633.3					
26.5	END OF HOLE				

ELEVATION SCALE: 665, 660, 655, 650, 645, 640, 635, 630, 625

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) NAT. V. - + Q. - ● REM.V. - ⊕ U. - O

131 BLOWS FOR LAST 12"

COEFFICIENT OF PERMEABILITY, k., CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL) (20, 40, 60, 80)

MH

MH

MH

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

▽ WATER LEVEL IN OPEN HOLE AT ELEV. 658.8 ON JUNE 24, 1976.

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

15 ◆ 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JLW

Form G.A.-D-1.

Project No. 761175

STA. 432+34, 170' LT. OF ℄

RECORD OF BOREHOLE 104

LOCATION See Figure 2 BORING DATE JUNE 17 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.
	661.1	GROUND SURFACE				
POWER AUGER HOLLOW STEM (?)	0.0	GRANULAR FILL		S1	2" D.O.	40
	654.1 7.0	VERY SOFT BLACK AMORPHOUS PEAT	1	S2	"	1
	650.1 11.0	VERY SOFT GREY BROWN ORGANIC SILT	2	S3	"	1/22"
	647.6 13.5	VERY LOOSE TO LOOSE GREY SANDY SILT TO SILTY SAND, TRACE CLAY	3	S4	"	1/18"
	643.1 18.0	VERY SOFT GREY SENSITIVE SILTY CLAY	4	S5	"	7
	639.1 22.0	LOOSE GREY SILTY SAND TO SANDY SILT	6	S6	"	1/22"
	636.1 25.0	FIRM GREY (LIGHTLY BANDED) SENSITIVE SILTY CLAY, WITH THIN SILT AND SAND LAYERS OR LENSES	4	T7	2" T.O.	PH
	626.1 35.0	END OF HOLE		S8	2" D.O.	1/18"
				T9	2" T.O.	PM

ELEVATION SCALE: 660, 655, 650, 645, 640, 635, 630, 625, 620

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. FIELD NAT. V. - + Q. -● REM.V. - ⊕ U. -○ 200 400 600 800

LAB VANE: NAT. V. X; REM.V. ⊗

COEFFICIENT OF PERMEABILITY, k, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT Wp W WL 20 40 60 80

89 → ○

○ 148 →

ADDITIONAL LAB. TESTING: MH, H

100 BLOWS FOR LAST 11"

0 15 5 10 Percent axial strain at failure

PIEZOMETER OR STANDPIPE INSTALLATION

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHAZ

Form G.A.-D-1.

Project No. 761175

STA. 411+56, 72' RT OF ℄

RECORD OF BOREHOLE 105

LOCATION See Figure 2 BORING DATE JUNE 18, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE
	659.5 / 0.0	GROUND SURFACE					660
POWER AUGER HOLLOW STEM(?)		VERY SOFT DARK BROWN PEAT		S1	2" O.D. SPLIT SPOON 2" SHELBY TUBE	1/18"	655
		SAMPLE MISSING		S2	"	1/19"	650
	646.5 / 13.0	VERY LOOSE GREY SILTY SAND, TRACE CLAY	3	S3	"	1	645
	641.5 / 18.0	SOFT TO FIRM GREY SENSITIVE SILTY CLAY, OCCASIONAL THIN SILT AND SAND LENSES OR LAYERS	4	S4	"	0	640
				T5	2" TO	PM	635
				T6	"	PM	630
	626.5 / 33.0	PROBABLY SILTY SAND (SOFTENED TILL)	8?				625 / 620
	612.5 / 47.0	VERY DENSE GREY SANDY SILT, SOME CLAY, TRACE GRAVEL (TILL)	0	S7	2" O.D.	70	615 / 610 / 605
	604.5 / 55.0	END OF HOLE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. FIELD NAT. V. - + Q. -● REM. V. - ⊕ U. -○ 200 400 600 800

LAB VANE NAT. V. X REM. V. ⊗

AUGERED 2 ft.

COEFFICIENT OF PERMEABILITY, k, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT W_P W W_L 20 40 60 80

MH

H

X=107

MH

0

MH

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

15 0 5 10 Percent axial strain at failure

NOTES:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS.
2) LABORATORY TESTS CARRIED OUT BY GOLDER ASSOCIATES.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN R.M.

CHECKED JHAC

Form G.A.-D-1.

Project No. 761175

STA. 433+16, 111' LT. OF ℄

RECORD OF BOREHOLE 106

LOCATION See Figure 2 BORING DATE JUNE 21, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE
	661.1	GROUND SURFACE		S T	SPLIT 2" SHELBY TUBE		660
POWER AUGER HOLLOW STEM(?)	0.0	GRANULAR FILL CONTAMINATED WITH ORGANIC MATTER		S1	2" D.O.	6	
	654.1						655
	7.0	VERY SOFT DARK BROWN FIBROUS PEAT		S2	"	1/18"	
	649.1						650
	12.0	LOOSE GREY SILTY SAND, TRACE CLAY	3	S3	"	6	
	643.1						645
	18.0	SOFT TO FIRM GREY (LIGHTLY BANDED) SENSITIVE SILTY CLAY, OCCASIONAL THIN SILT AND SAND LAYERS. OCCASIONAL ZONES WITH A TRACE TO SOME SAND AND GRAVEL	4	S4	"	0	640
				T5	2" T.O	PM	635
				T6	"	PM	630
				T7	"	PM	625
	624.1						
	37.0	VERY LOOSE GREY SANDY SILT TO SILTY SAND, TRACE TO SOME CLAY.	6	T8	"	PM	620
				S9	2" D.O.	0	
				S10	"	0	615
	611.1						
	50.0	END OF HOLE					610

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) — FIELD NAT. V. - + Q. - ● REM. V. - ⊕ U. - O

LAB VANE NAT. V. X REM. V. ⊗

AUGERED 4'

COEFFICIENT OF PERMEABILITY, k, CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL) (20, 40, 60, 80)

715 →

ADDITIONAL LAB. TESTING: MH; H γ=105; H; γ=101; MH

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL AT GROUND SURFACE ON JUNE 24, 1976

NOTE:
1) FIELD DATA OBTAINED FROM M.T.C. LOGS
2) LABORATORY DATA CARRIED OUT BY GOLDER ASSOCIATES.

15 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

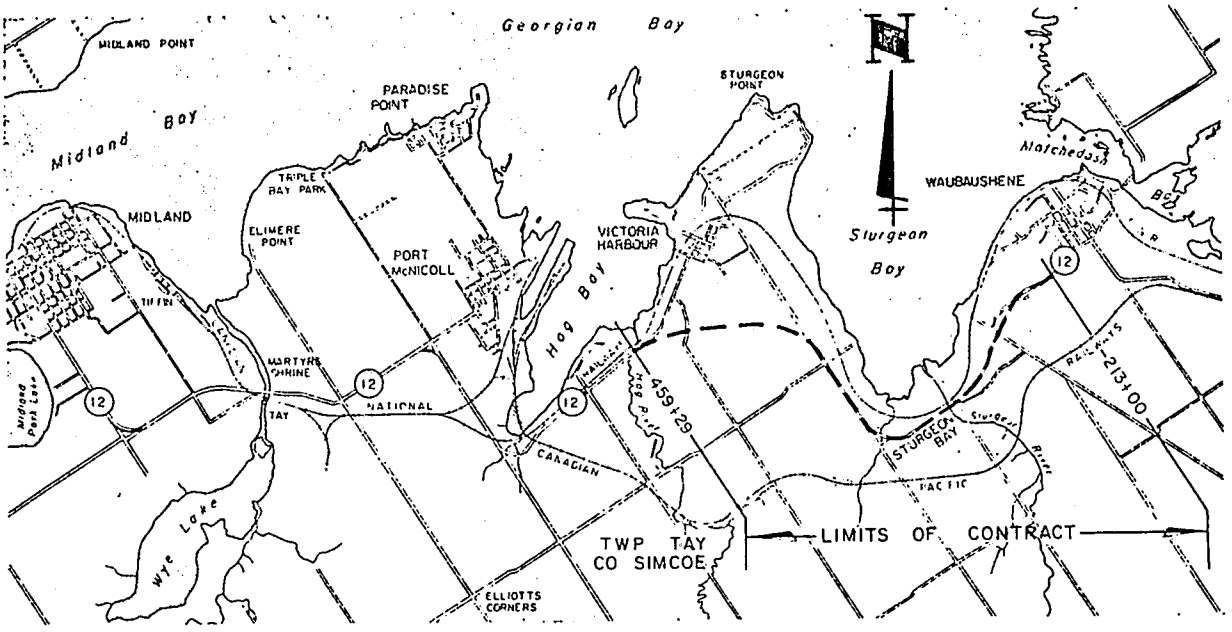
Golder Associates

DRAWN D.M.

CHECKED JHK

KEY PLAN

FIGURE 1



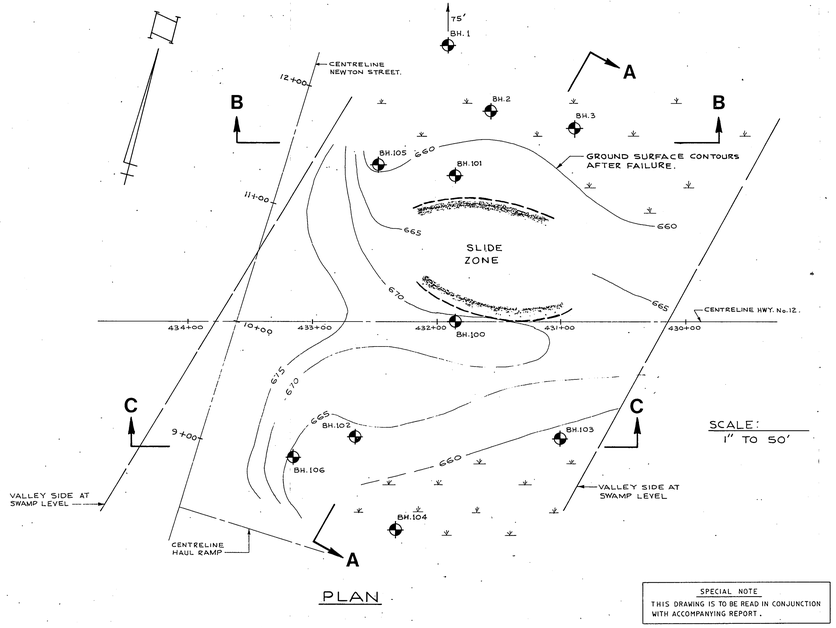
SCALE

MILES 2 1·5 1 0·5 0 1 2 MILES

Date JULY 26,1975

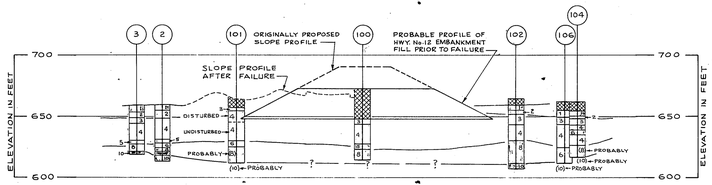
Golder Associates

Drawn M.Y.B.
Chkd. JHHC
Appd.

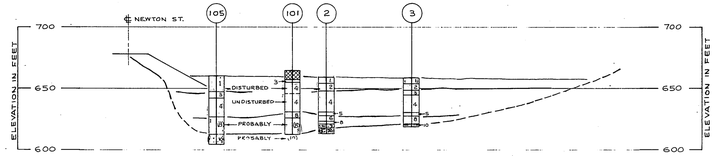


PLAN

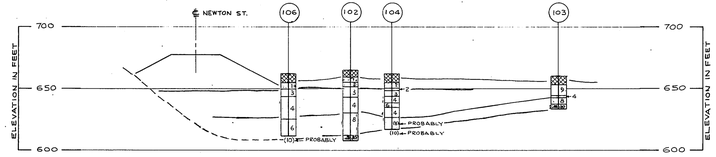
SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.



SECTION A-A



SECTION B-B



SECTION C-C

BORING PLAN AND STRATIGRAPHIC SECTIONS

FIGURE 2

LEGEND

- BOREHOLE LOCATION IN PLAN
- 3 — BOREHOLE IN ELEVATION
- GROUND SURFACE AT BOREHOLE
- 4 — SOIL TYPE (REFER TO STRATIGRAPHY LEGEND)

STRATIGRAPHY

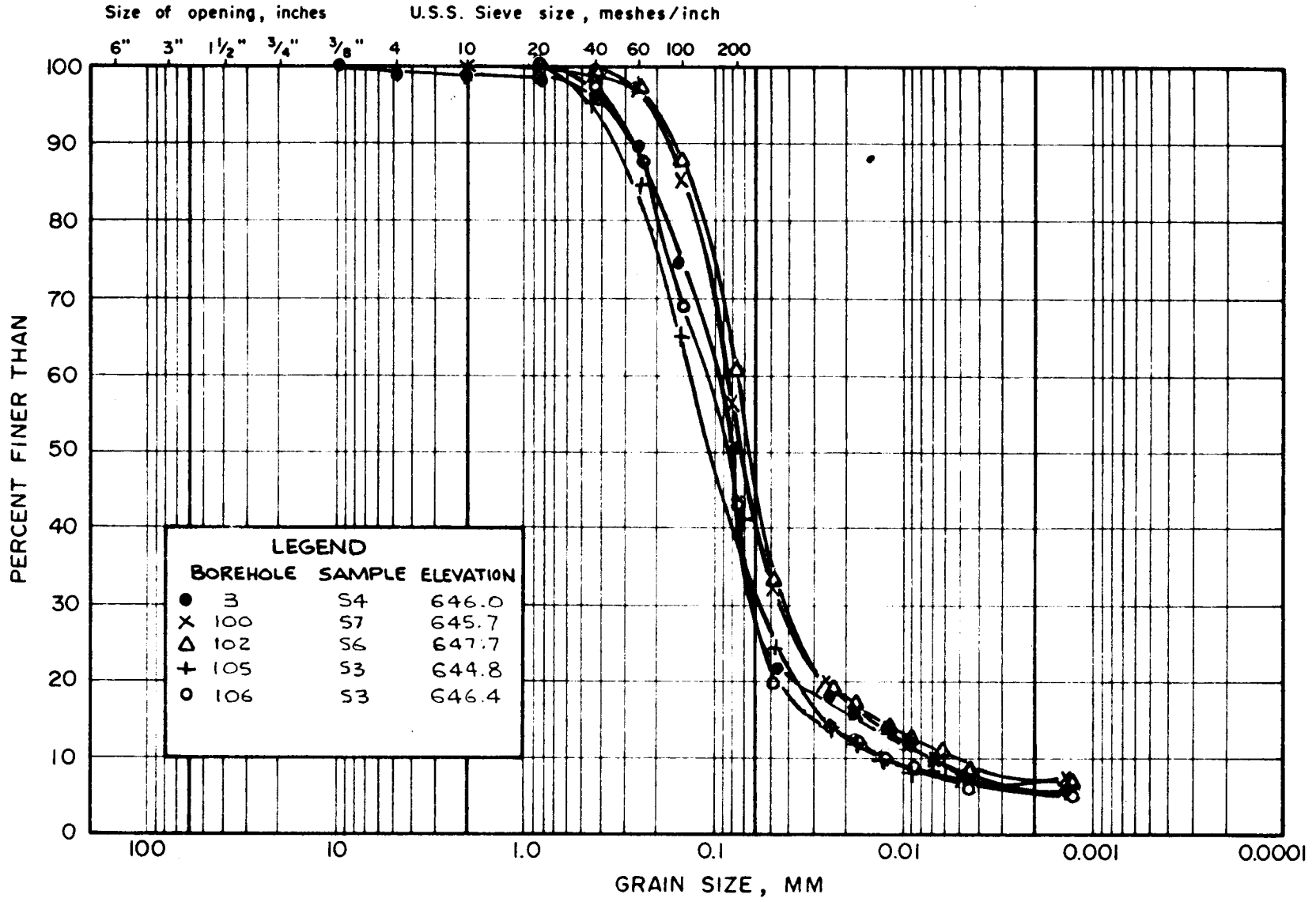
- FILL.
- 1 — VERY SOFT BLACK AMORPHOUS TO FIBROUS PEAT. — SWAMP DEPOSITS
- 2 — VERY SOFT SENSITIVE GREY BROWN ORGANIC SILT. — SWAMP DEPOSITS
- 3 — VERY LOOSE TO LOOSE SANDY SILT TO SILTY SAND, TRACE CLAY — LACUSTRINE DEPOSITS
- 4 — VERY SOFT TO FIRM GREY SENSITIVE SILTY CLAY, WITH SILT AND SAND LAYERS OR LENSES. — LACUSTRINE DEPOSITS
- 5 — FIRM GREY STRATIFIED CLAYEY SILT, TRACE SAND AND GRAVEL, OCCASIONAL SAND LAYERS. — LACUSTRINE DEPOSITS
- 6 — VERY LOOSE SANDY SILT TO SILTY SAND, TRACE TO SOME CLAY
- 7 — SOFT TO FIRM GREY SILTY CLAY TRACE GRAVEL TO INTERLAYERED CLAY AND SILT.
- 8 — SOFT TO FIRM GREY CLAYEY SILT, SOME SAND TRACE GRAVEL TO SILTY SAND, TRACE TO SOME CLAY AND GRAVEL. (SOFTENED TILL)
- 9 — VERY DENSE BROWN SAND TO SAND AND GRAVEL.
- 10 — VERY DENSE SANDY SILT, TRACE CLAY, TRACE TO SOME GRAVEL TO HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL. (BASAL TILL)

Date JULY 28, 1976

Golder Associates

Drawn M.Y.B.
Chkd. H.H.K.
Appd.

M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

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GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND - TYPE 3

FIGURE 3

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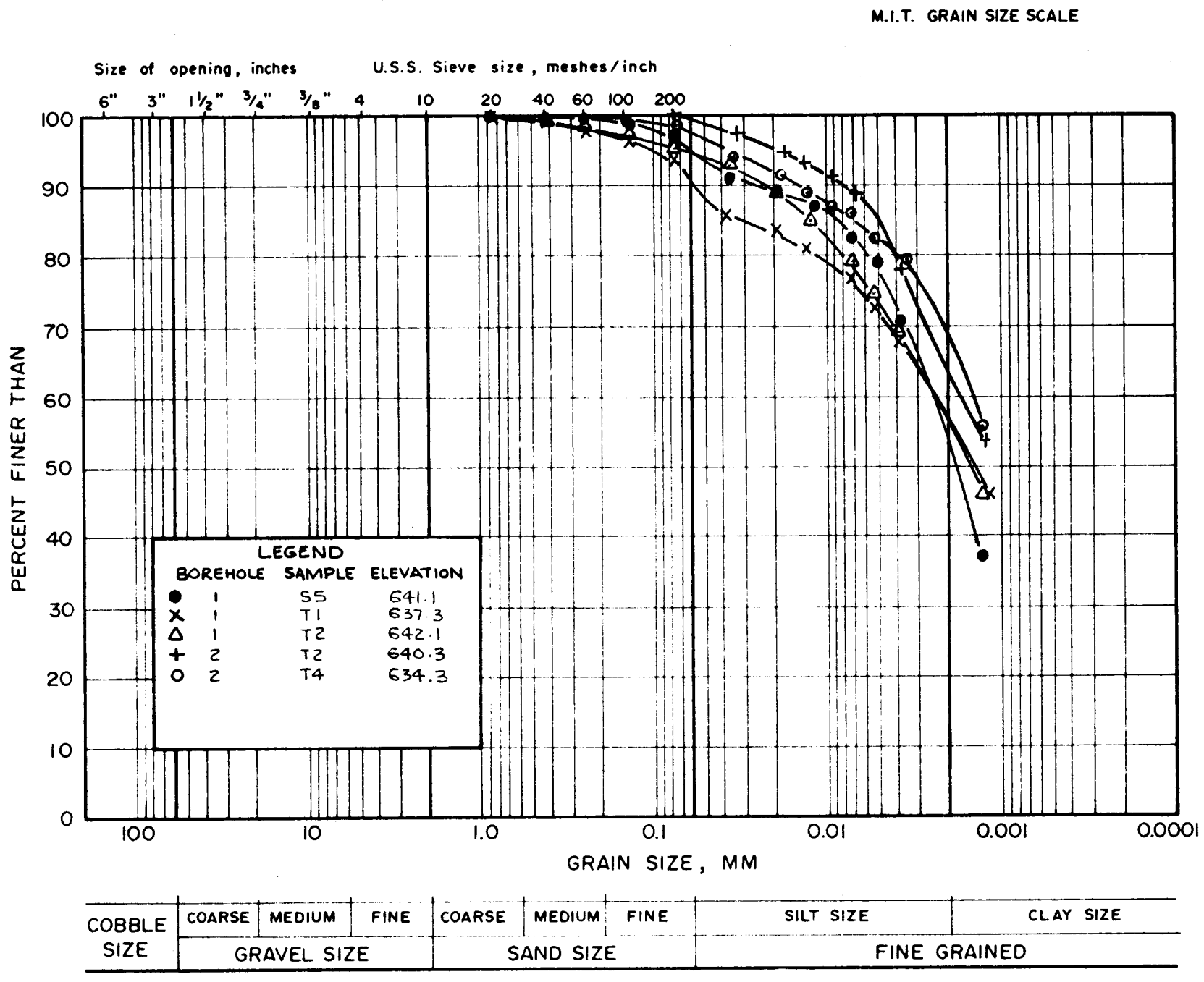
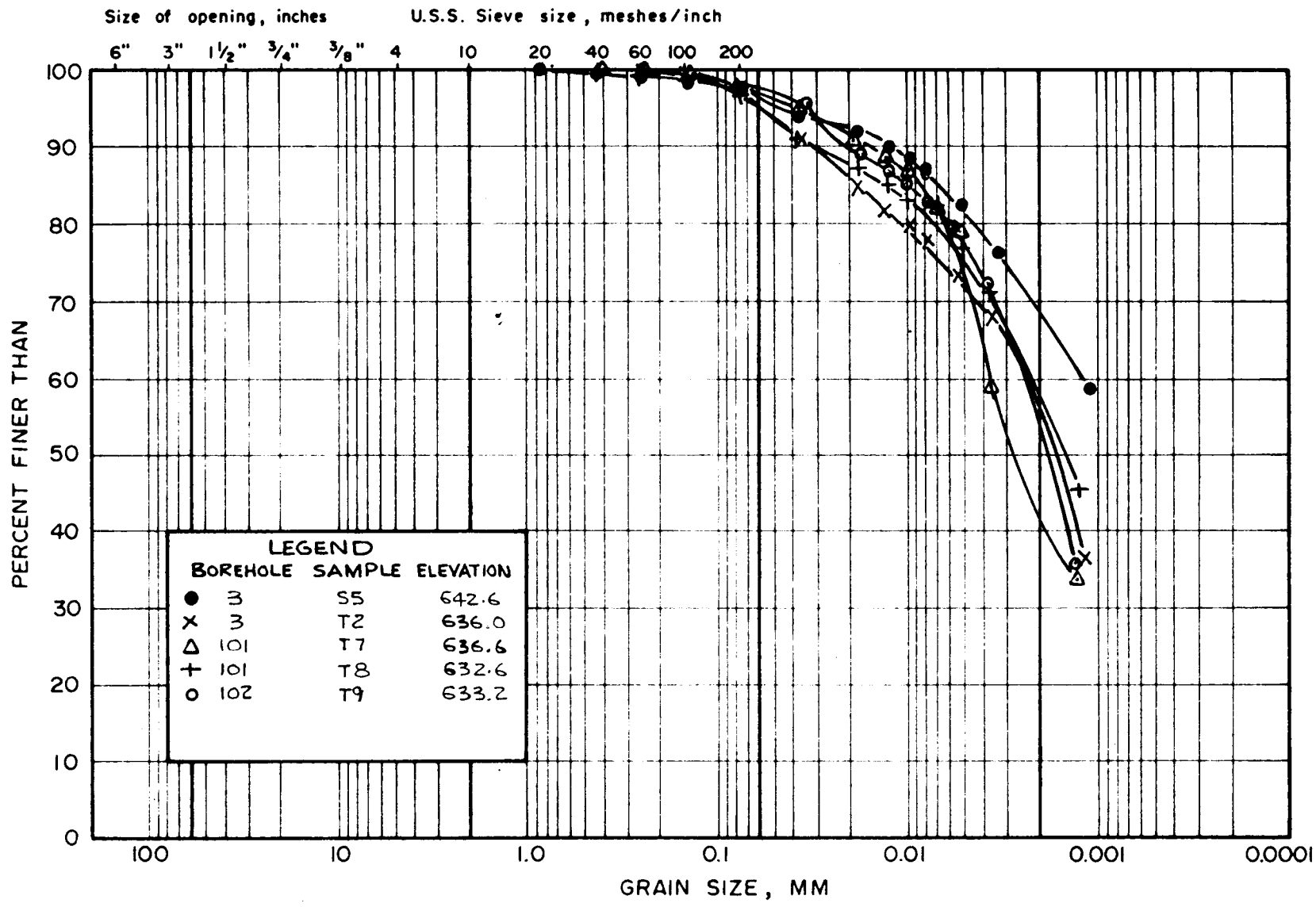
GRAIN SIZE DISTRIBUTION
SENSITIVE SILTY CLAY-TYPE 4

FIGURE 4



M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

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GRAIN SIZE DISTRIBUTION
SENSITIVE SILTY CLAY-TYPE 4

FIGURE 5

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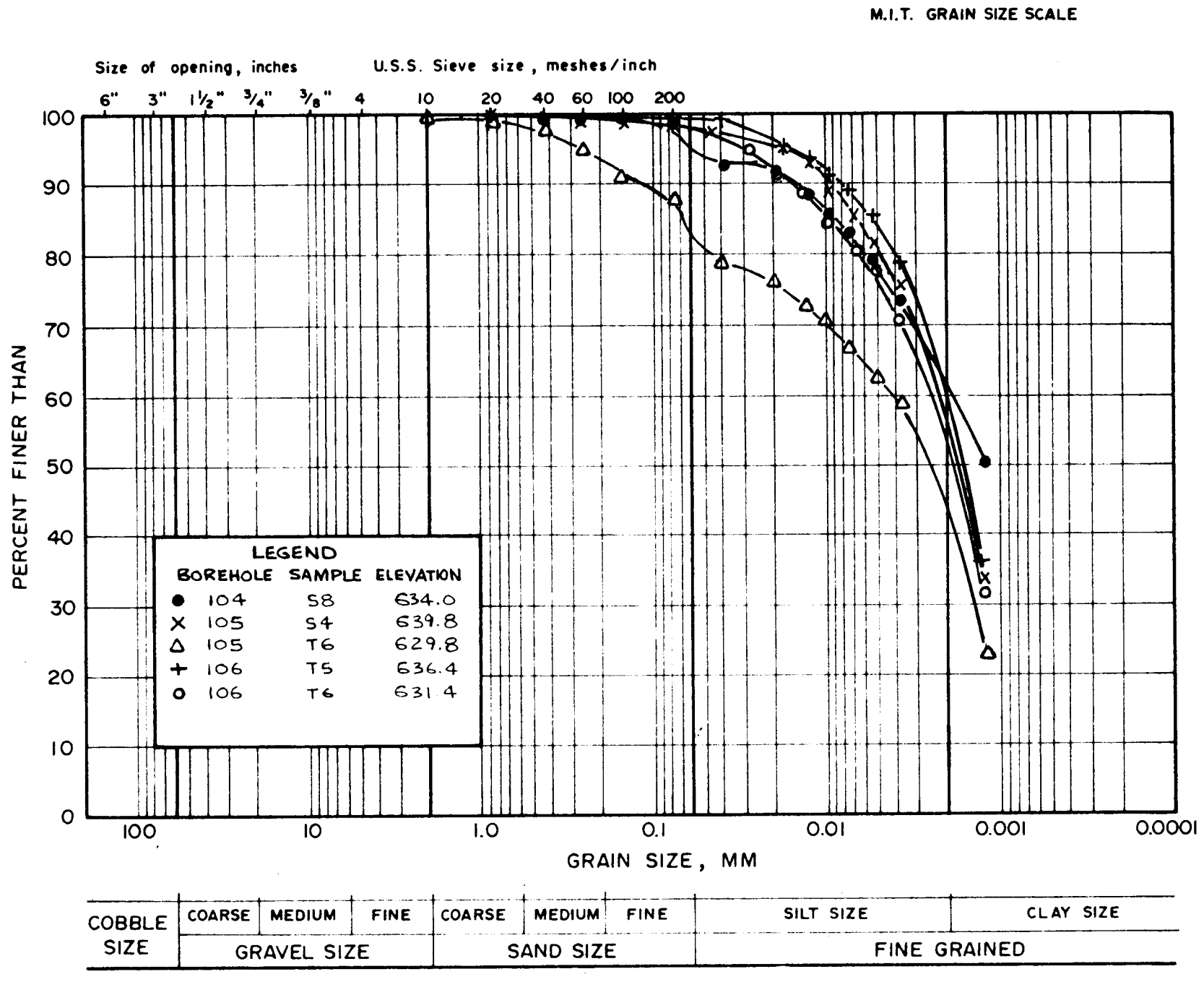
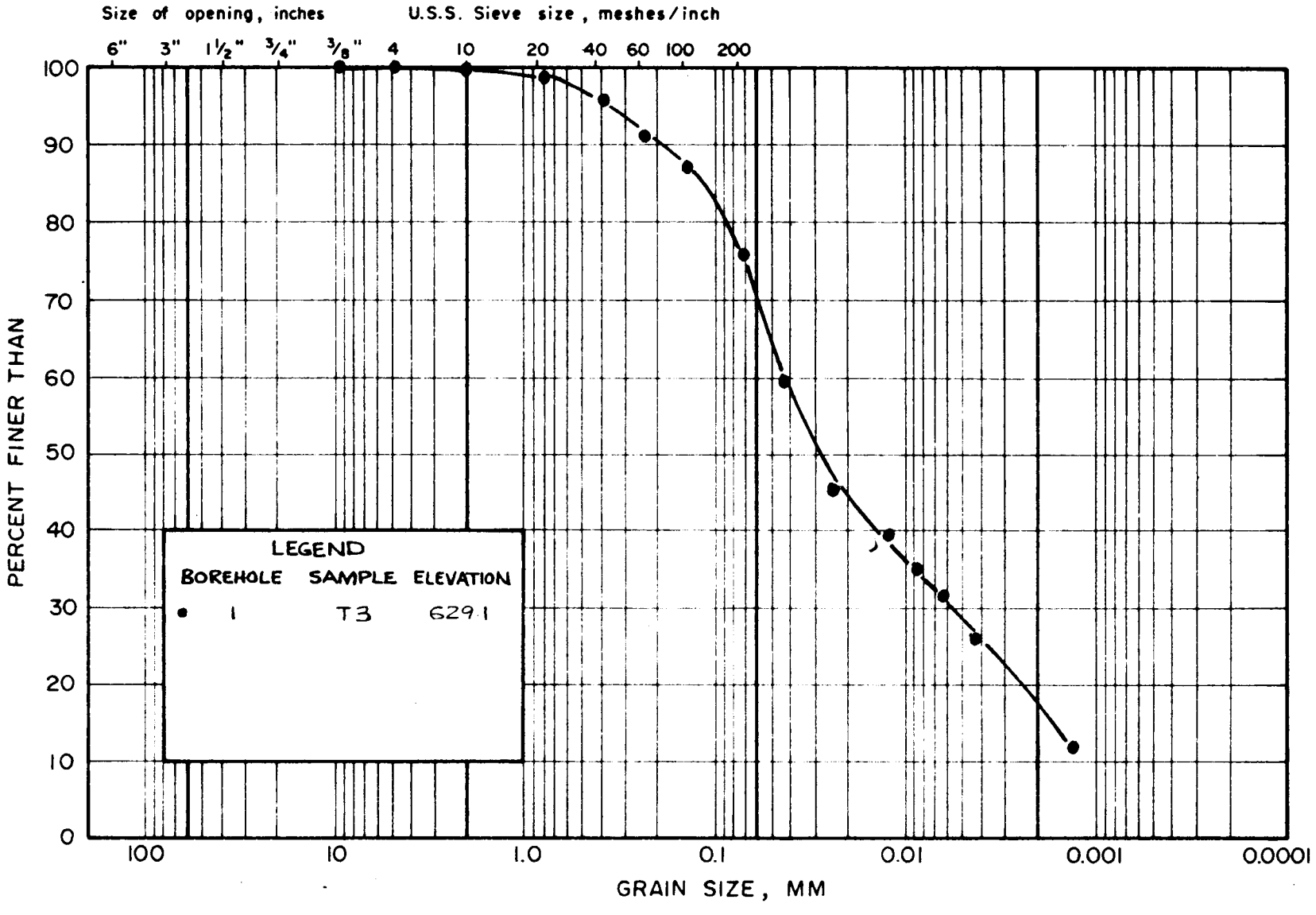
GRAIN SIZE DISTRIBUTION
SENSITIVE SILTY CLAY-TYPE 4

FIGURE 6



M.I.T. GRAIN SIZE SCALE



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GRAIN SIZE DISTRIBUTION

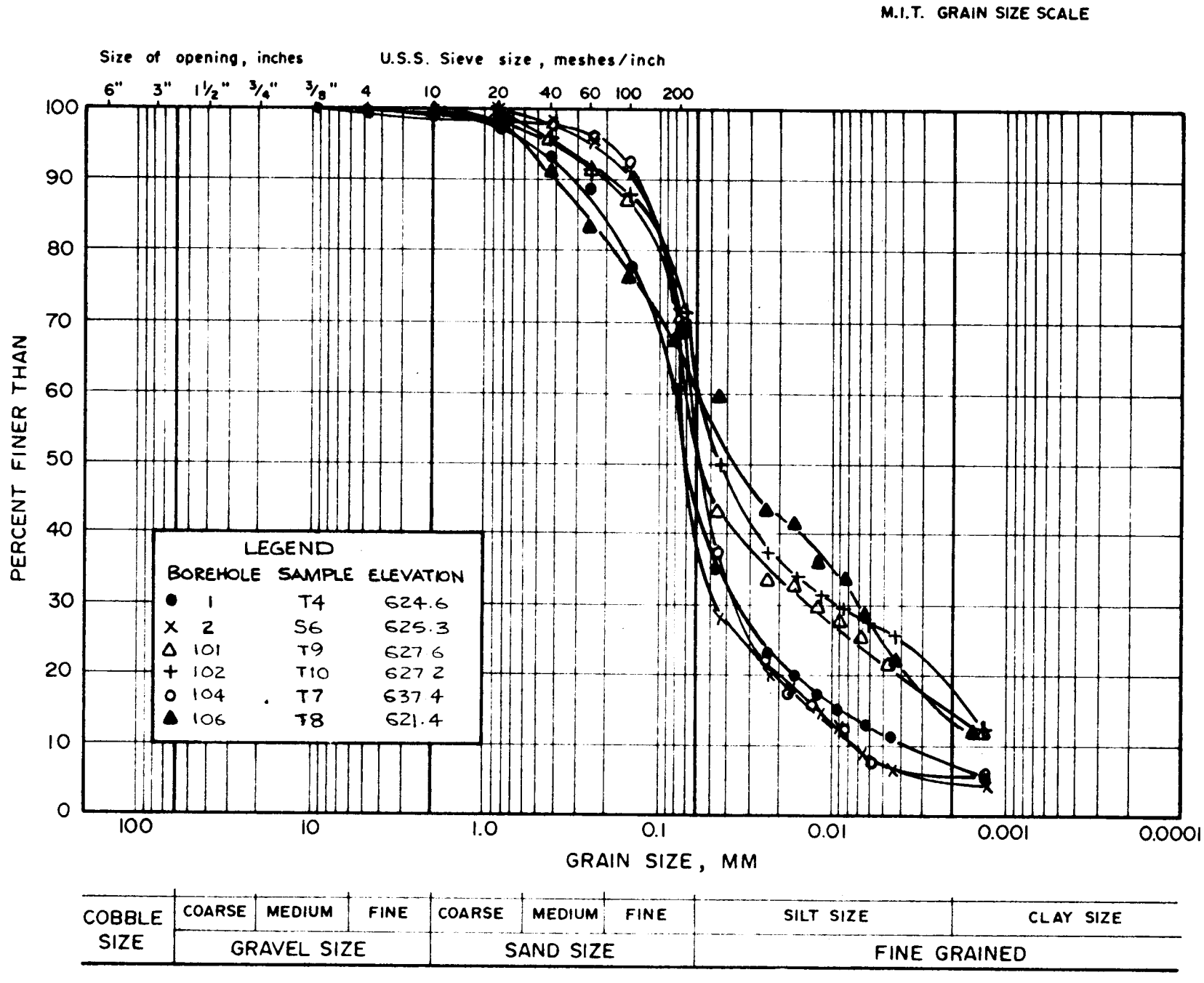
STRATIFIED CLAYEY SILT-TYPE 5

FIGURE 7

Golder Associates

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND - TYPE 6

FIGURE 8



GRAIN SIZE DISTRIBUTION
SILTY SAND (SOFTENED TILL) TYPE 8

FIGURE 9

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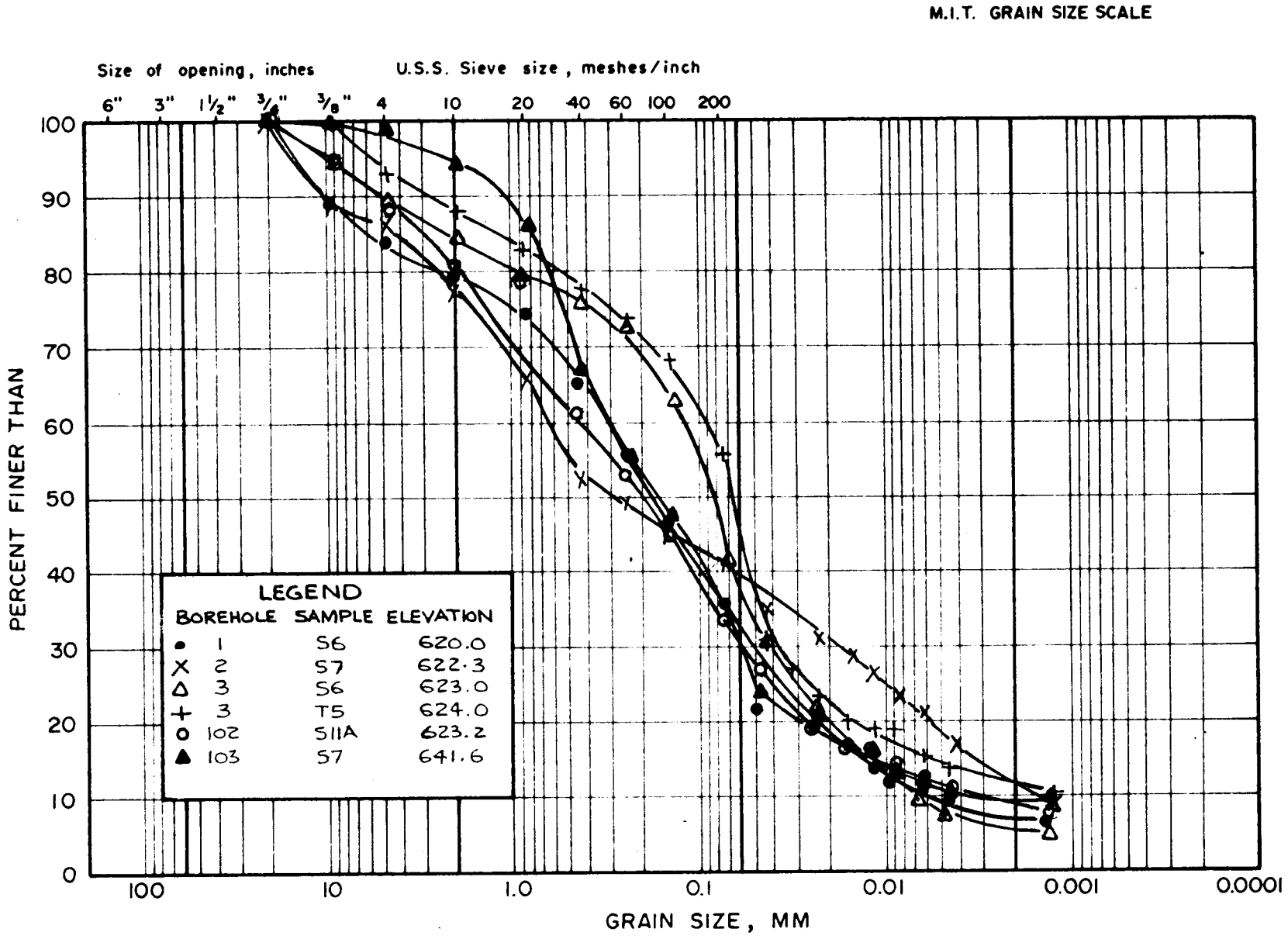
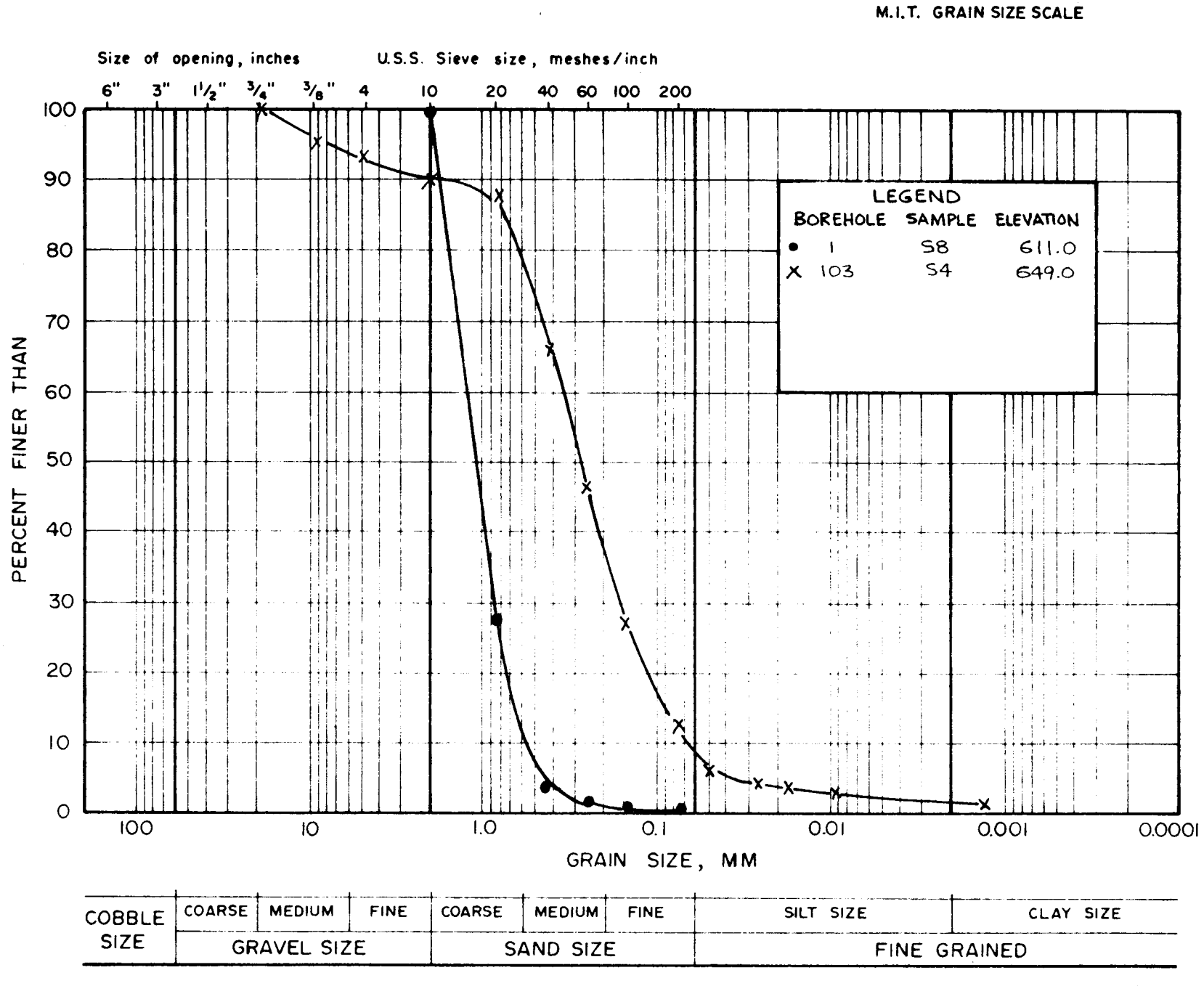


[redacted] PROJECT No. 781175

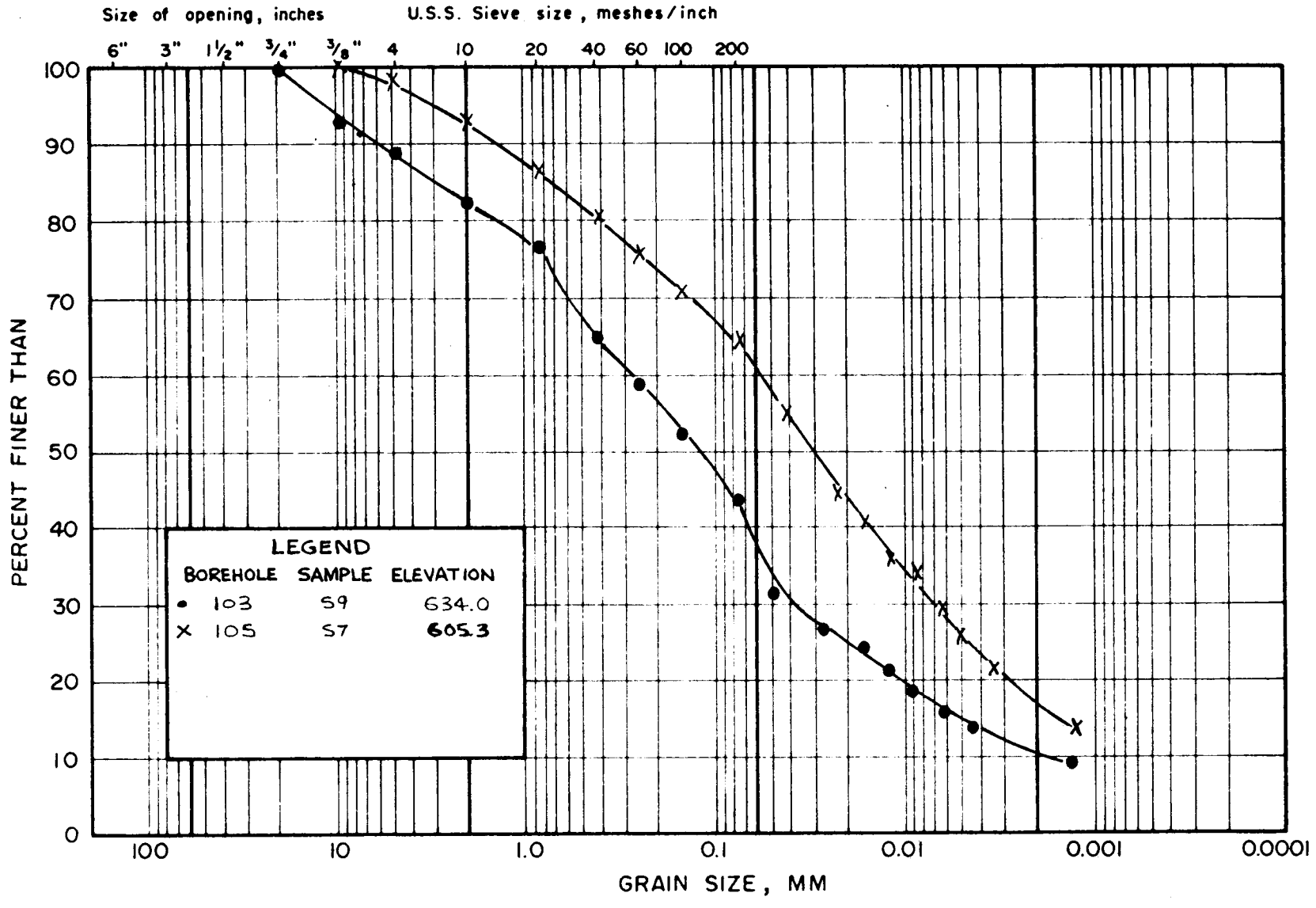
Golder Associates

GRAIN SIZE DISTRIBUTION
SAND TO SAND AND GRAVEL-TYPE 9

FIGURE 10



M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

Golder Associates

GRAIN SIZE DISTRIBUTION
SANDY SILT (BASAL TILL) - TYPE IO

FIGURE 11

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

REPORT

ON

75-32

SURCHARGED EMBANKMENT STABILITY
HIGHWAY #12 FILL
VICTORIA HARBOUR ONTARIO

Jan. '77

(3)

FOR

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

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Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

January 4, 1977

Ministry of Transportation
and Communications
1201 Wilson Avenue
West Building
DOWNSVIEW, Ontario
M3M 1J8

ATTENTION: Mr. K.G. Selby, P.Eng.
Supervising Engineer

RE: EMBANKMENT RECONSTRUCTION
HIGHWAY #12
VICTORIA HARBOUR, ONTARIO

Dear Sirs:

This letter reports the results of boreholes put down recently at the above site, (see Figure 1 for Key Plan). The purpose of the borings was to determine the in situ strength of the foundation subsoils below the embankment. Based on this information, the stability of the proposed surcharged embankment was to be assessed.*

FIELDWORK PROCEDURE

A total of six boreholes were put down at the locations shown on the attached Figure 2. Boreholes 201 and 202 were put down between October 12 and 15, 1976, with the remaining

*This phase of the project was actually carried out in October/November, 1976, prior to the recent completion of the embankment to surcharge elevation. The purpose of this report is to complete M.T.C. records with respect to geotechnical aspects of the reconstruction work.

four borings being completed between November 8 and 12, 1976. The delay in completing the program was necessary to avoid disruption of construction operations. The boreholes were put down using a CME-75 drillrig equipped with 7 in. dia. hollow stem augers. The drilling equipment was supplied and operated by Site Investigation Ltd., of Peterborough under contract to the M.T.C.

All borings were advanced from the surface of the embankment fill and were taken into the lower very dense till deposits, (i.e. depths ranging between 46 and 55 ft.). Samples were taken at 5 ft. depth intervals using standard 2 in. O.D. split spoon sampling equipment supplemented by 2 and 3 in. Shelby tube samples. All samples obtained during the drilling program were sealed in air tight containers and transported to our laboratory for detailed examination and testing. In cohesive soil stata, two field vane tests (NX size) were carried out between samples to determine the in situ shear strength of these materials.

The field work was supervised throughout by one of our senior field technicians who was already present on site directing reconstruction operations. The locations and ground surface elevations were provided to us by on site M.T.C. survey personnel. It is understood that the elevations are referred to Geodetic datum.

SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each borehole is shown on the attached Record of Borehole sheets. The results of laboratory tests carried out on representative samples of the various strata are shown on the Record of Borehole sheets and on Figures 4 to 8. The following

interpretation of the subsurface conditions is based on the results of boreholes put down at the locations shown on Figure 2 and uses our existing numbering system for soil strata, (refer to our report No. 761175 dated October 1, 1976).

In all boreholes, grey sensitive silty clay (soil type 4) was encountered directly below the silty sand (till) embankment fill. The base of the sensitive silty clay deposit was found to be generally at about elevation 630 and is underlain locally (boreholes 2, 3 and 204) by thin pockets of stratified grey clayey silt. In those boreholes closest to the western edge of the swamp (section AA, Figure 3), these upper cohesive lacustrine materials are underlain by a sandy silt to silty sand deposit (soil type 6) which is between 3 and 10 ft. thick. This material was not encountered in the majority of boreholes put down within the eastern portion of the site and on which the inferred stratigraphy shown on section B-B (Figure 3) is based. In this area, the sensitive silty clay is directly underlain by a softened silty sand till (soil type 8) which directly overlies very dense basal silty sand till, (soil type 10). The silty sand to sandy silt deposit present within the western portion of the site was also found to be underlain by softened till immediately to the north of the embankment centerline. However, to the south of the embankment centerline the softened till deposit is absent and the silty sand to sandy silt deposit is directly underlain by a deposit of thinly layered clay and silt (soil type 7) which overlies the very dense basal till.

The sequence and distribution of soil strata described above broadly confirms and refines our previous understanding of the origin of soil strata which overlie the basal till deposits, (see our report No. 761175, dated August, 1976). However, the extent of the thinly layered clay and silt

deposits (soil type 7), which occur at depth within the western portion of the site, is greater than originally anticipated. Further, it appears that the sequence of soil strata deposited during the immediate post glacial period (i.e. soil types 6, 7 and 8) can be reasonably defined depending on location (east or west) within the general site area.

STABILITY CONSIDERATIONS

Based on our review of available data, it was considered that the initial embankment failure occurred along a shallow failure surface within the upper portion of the sensitive silty clay deposit. Because of the significant loss in strength within the failure zone, it was concluded that reconstruction of the embankment must involve removal of the failed (weakened) material. Therefore key trenches were sub-excavated to about elevation 637 parallel to the embankment centerline as shown on Figure 3. In this way the possibility of further shallow-seated failures was avoided and because of the geometry of the subsurface fill, potential failure surfaces were forced to greater depth in more competent materials. Further, because a potential deep seated failure would involve more rotational than translational movements, outer beams would be more effective in maintaining stability.

From the relationship between undrained shear strength and depth shown on Figure 9, it appears that the undrained strength of the sensitive silty clay below the embankment fill is between 400 and 600 lb/sq.ft. In general this range is slightly higher than the average values measured in boreholes put down immediately after the failure. The results of stability analyses carried out on a typical section (section 431+50) of the proposed embankment (plus 4 ft. surcharge) are shown on Figure 10. From these results, it can be seen that

for the range in average values of undrained shear strength (400 to 600 lb/sq.ft.) the minimum width of berm required at this section would be about 70 ft. To the west the required berm width decreases as the surcharged embankment elevation decreases. Although the surcharged embankment elevation increases to the east, wider berms were only required up to about stations 431+00 (south) and 430+50 (north), the locations at which subexcavation for key trenches penetrated through the sensitive silty clay deposit.

We trust that this letter provides an adequate summary of the analyses carried out to assess the stability of the surcharged embankment. If you have any questions regarding the information contained in this letter, please contact us.

Yours truly,

H.Q. GOLDER & ASSOCIATES LTD.

J.H.A. Crooks, P.Eng.

REGISTERED PROFESSIONAL ENGINEER J. H. A. CROOKS PROVINCE OF ONTARIO

JHAC:ys
761175

Encl: List of Abbreviations and Symbols
Record of Borehole sheets (Nos. 201 to 206 inclusive)
Figures 1 to 10

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	*N, blows/ft.*
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer[1]
Q undrained triaxial[2]
R consolidated undrained triaxial[2]
S drained triaxial
U unconfined compression
V field vane test

NOTES:

[1]Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

[2]Undrained triaxial tests in which pore pressures are measured are shown as $\bar{Q}$ or $\bar{R}$.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P)/I_P$
I_C	consistency index $= (w_L - w)/I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

Form G.A.-D-1.

Project No. 761175

CHAINAGE 432+81, 48 ft. SOUTH OF CENTRELINE OF HWY. 12

RECORD OF BOREHOLE 201

LOCATION See Figure 2 BORING DATE OCT. 12 AND 13, 1976 DATUM GEODETIC.

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
	663.3 / 0.0	GROUND SURFACE					665
POWER AUGER 7" DIAM. HOLLOW STEM		DENSE TO LOOSE GREY AND BROWN SILTY SAND AND GRAVEL, TRACE TO SOME CLAY, OCCAS. COBBLES AND BOULDERS (FILL)		1	2" D.O.	40	660
				2	"	6	
				3	2" D.F.	5	655
				4	2" D.O.	7	
	638.3 / 25			5	2" D.F.	2	650
		FIRM GREY SENSITIVE SILTY CLAY	4	6	2" T.O.	WH	645
	630.3 / 33						640
		LOOSE GREY SILTY SAND, TRACE TO SOME CLAY, TRACE GRAVEL	6	7	3" T.O.	PH	635
	625.3 / 38			8	2" D.F.	WH	630
		SOFT TO FIRM GREY SENSITIVE LAYERED SILTY CLAY AND SILT WITH SANDY LAYERS	7	9	3" T.O.	PH	625
				10	2" T.O.	PH	620
	612.1 / 51.2	VERY DENSE GREY SILTY SAND AND GRAVEL, SOME CLAY (TILL)	10				615
	608.5 / 54.8	END OF HOLE REFUSAL TO AUGER		11	2" D.O.	100/1"	610

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ⊕ U. - O 200 400 600 800

COEFFICIENT OF PERMEABILITY, k, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT W_P W W_L 20 40 60 80

NOTE:
INITIAL BOREHOLE TERMINATED AT ELEV. 644.0. AUGERS TWISTED ON BOULDERS. MOVED 7 ft. EAST AND 1 ft. SOUTH TO LOCATION RECORDED ABOVE. CONTINUED BELOW ELEV. 644.0.

WATER LEVEL IN HOLLOW STEM AUGERS AT ELEV. 657.5 DURING DRILLING.

1040

>2000

COULD NOT PUSH VANE AHEAD

MH

Percent axial strain at failure (0, 5, 10, 15)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHAC

Form G.A.-D-1.

Project No. 761175

CHAINAGE 432+50 ON CENTRELINE HWY 12

RECORD OF BOREHOLE 202

LOCATION See Figure 2 BORING DATE OCT. 14 AND 15, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER, 7" DIAM. HOLLOW STEM

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.	ELEVATION SCALE
660.0 / 0.0	GROUND SURFACE					660
	COMPACT TO LOOSE GREY BROWN SILTY SAND, SOME CLAY, TRACE TO SOME GRAVEL, OCCASIONAL COBBLES AND BOULDERS (FILL)		1	2" D.O.	17	655
			2	"	7	650
			3	"	8	645
641.0 / 19			4	"	WH	640
	SOFT TO FIRM GREY SENSITIVE SILTY CLAY (COLOUR BANDING AND 'BLOCKY' STRUCTURE EVIDENT)	4	5	3" T.O.	PH	635
			6	2" T.O.	PH	630
625.0 / 35	LOOSE GREY SANDY SILT TO SILTY SAND, TRACE CLAY	6	7	2" D.F.	9	625
621.0 / 39	FIRM GREY SENSITIVE THINLY LAYERED SILTY CLAY AND SILT WITH SANDY LAYERS,	7	8	2" D.F.	WH	620
			9	2" D.F.	3	615
611.0 / 49	HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL (TILL)	10	10	2" D.O.	100/6"	610
607.3 / 52.7	END OF HOLE REFUSAL TO AUGERS					605

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

SHEAR STRENGTH Cu., LB./SQ.FT. (200, 400, 600, 800) NAT. V. - + Q. - ● REM.V. - ⊕ U. - O

COEFFICIENT OF PERMEABILITY, k., CM./SEC. (1x10, 1x10, 1x10, 1x10)

WATER CONTENT, PERCENT (Wp, W, WL) (20, 40, 60, 80)

1040 +

1160 +

⊙ SAND

O SILTY CLAY

SAMPLE LOST USING 2" T.O. RECOVERED USING 2" D.F.

COULD NOT PUSH VANE AHEAD

ADDITIONAL LAB. TESTING: MH; MH; MH

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN HOLLOW STEM AUGERS BETWEEN ELEV. 654 AND ELEV 653 DURING DRILLING.

15 — 0 / 10 — 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED J.H.A.C.

Form G.A.-D-1.

Project No. 761175

CHAINAGE 431+70, 60 ft SOUTH OF CENTRELINE OF HWY. 12.

RECORD OF BOREHOLE 203

LOCATION See Figure 2 BORING DATE NOV. 8 AND 9, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER, 7" DIAM. HOLLOW STEM.

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.	ELEVATION SCALE
665.2 / 0.0	GROUND SURFACE					665
	COMPACT TO LOOSE GREY AND BROWN SANDY SILT, TRACE TO SOME CLAY, SOME GRAVEL, NUMEROUS COBBLES AND BOULDERS (FILL)		1	2" D.O.	10	660
			2	"	27	655
			3	"	5	650
			4	"	3	645
			5	"	4	640
636.2 / 29	SOFT TO FIRM GREY SENSITIVE SILTY CLAY WITH THIN (1/16") SAND LAYERS (COLOUR BANDING AND BLOCKY STRUCTURE EVIDENT)	4	6	3" T.O.	PM	635
630.2 / 35	COMPACT GREY CLAYEY TO SANDY SILT, SOME GRAVEL AND ROCK FRAGMENTS (SOFTENED TILL)	8	7	2" T.O.	PM	630
			8	2" D.O.	13	625
621.8 / 43.4	VERY HARD GREY CLAYEY TO SANDY SILT, SOME GRAVEL (TILL)	10	9	"	89	620
614.6			10	"	72/9"	615
50.6	END OF HOLE REFUSAL TO AUGERS					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ⊕ U. - O
200 400 800 1000.

COEFFICIENT OF PERMEABILITY, k, CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT Wp W WL
20 40 60 80

> 2000 (→)

COULD NOT PUSH VANE AHEAD

COULD NOT PUSH VANE AHEAD

15 0 5 10 Percent axial strain at failure

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

▽ WATER LEVEL IN HOLLOW STEM AUGERS AT ABOUT ELEV. 657.0 IMMEDIATELY AFTER COMPLETION OF DRILLING.

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JMAC

Form G.A.-D-1.

Project No. 761175

CHAINAGE 431+00 ON CENTRELINE HWY.12

RECORD OF BOREHOLE 204

LOCATION See Figure 2 BORING DATE NOV. 9 AND 10, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.
	667.1 / 0.0	GROUND SURFACE				
POWER AUGER 7" DIAM. HOLLOW STEM		VERY LOOSE TO COMPACT BROWN SILTY SAND AND GRAVEL AND GREY CLAYEY SILT, SOME GRAVEL, NUMEROUS COBBLES AND BOULDERS THROUGHOUT (FILL)		1	2" D.O.	5
				2	"	17
				3	"	3
				4	"	53/1"
	642.4 / 24.7	SOFT TO FIRM GREY SENSITIVE SILTY CLAY WITH THIN SANDY LAYERS OR LENSES (COLOUR BANDING AND "BLOCKY" STRUCTURE EVIDENT)	4	5	"	WH
				6	3" T.O.	PM
	632.1 / 35	FIRM GREY CLAYEY SILT, TRACE GRAVEL	5	7	2" T.O.	PM
	628.1 / 39	LOOSE GREY CLAYEY TO SANDY SILT SOME GRAVEL (REWORKED TILL)	8	8	2" D.O.	2
	621.6 / 45.5	VERY STIFF TO HARD GREY SANDY SILT, TRACE CLAY SOME GRAVEL (TILL)	10	9	"	16
	619.1 / 48.0	END OF HOLE REFUSAL TO AUGER				

ELEVATION SCALE: 665, 660, 655, 650, 645, 640, 635, 630, 625, 620

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. — 20, 40, 60, 80

SHEAR STRENGTH Cu., LB./SQ.FT. — NAT. V. - + Q. - ● REM.V. - ⊕ U. - O — 200, 400, 600, 800

COEFFICIENT OF PERMEABILITY, k, CM./SEC. — 1x10, 1x10, 1x10, 1x10

WATER CONTENT, PERCENT — W_P, W, W_L — 20, 40, 60, 80

SAMPLE LOST

(COBBLE OR BOULDER?)

COULD NOT PUSH VANE AHEAD

2000

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN HOLLOW STEM AUGERS AT ELEV. 659.6 AFTER COMPLETION OF DRILLING

19 — 0 / 10 — 5 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHAT

Form G.A.-D-1.

Project No. 761175

CHAINAGE 431+30, 55 ft. NORTH OF CENTRELINE OF HWY. 12.

RECORD OF BOREHOLE 205

LOCATION See Figure 2 BORING DATE NOV. 10 AND 11, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.	ELEVATION SCALE
POWER AUGER 7" DIAM. HOLLOW STEM	664.5 / 0.0	GROUND SURFACE					665
		COMPACT TO VERY LOOSE CLAYEY TO SANDY SILT, SOME GRAVEL, OCCASIONAL COBBLES AND BOULDERS (FILL)		1	2" D.O.	15	660
				2	"	4	655
				3	"	2	650
		ZONE OF VERY SOFT SILTY CLAY MIXED WITH TILL FILL		4	"	2	645
				5	"	5	640
	637.5 / 27	SOFT TO FIRM GREY SENSITIVE SILTY CLAY	4	6	"	WR	635
	631.5 / 33	LOOSE GREY SANDY SILT SOME CLAY AND GRAVEL OCCAS. SMALL COBBLES (REWORKED TILL)	8	7	3" T.O.	PH	630
				8	2" D.O.	4	625
	621.0 / 43.5	VERY DENSE GREY SILTY SAND, TRACE CLAY, SOME GRAVEL (TILL)	10	9	"	>100	620
	618.5 / 46.0	END OF HOLE					

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ⊕ U. - O 200 400 600 800

COEFFICIENT OF PERMEABILITY, k., CM./SEC. 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT Wp W WL 20 40 60 80

COULD NOT PUSH VANE AHEAD

MH

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

▽ WATER LEVEL IN HOLLOW STEM AUGERS AT ELEV. 655.0 AFTER COMPLETION OF DRILLING.

15 ◆ 0 5 10 Percent axial strain at failure

VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M.

CHECKED JHAC

Form G.A.-D-1. Project No. 76117-S

CHAINAGE 432+08 55 ft. NORTH OF CENTRELINE OF HWY 12.

RECORD OF BOREHOLE 206

LOCATION See Figure 2 BORING DATE NOV. 11 AND 12, 1976 DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN. PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

BORING METHOD: POWER AUGER, 7" DIAM. HOLLOW STEM

ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FT.
663.4 / 0.0	GROUND SURFACE				
	COMPACT TO VERY LOOSE GREY AND BROWN SANDY TO CLAYEY SILT, SOME GRAVEL, OCCASIONAL COBBLES AND BOULDERS (FILL)		1	2" D.O.	18
			2	"	28
			3	"	33
			4	"	3
			5	"	2
634.4 / 29	SOFT TO FIRM GREY SENSITIVE SILTY CLAY WITH THIN SAND LAYERS (COLOUR BANDING AND "BLOCKY" STRUCTURE EVIDENT)	4	6	2" T.O.	PM
630.4 / 33	VERY LOOSE TO LOOSE GREY SANDY SILT TO SILTY SAND, TRACE TO SOME CLAY, TRACE GRAVEL.	6	7	2" D.O.	WR
			8	"	9
619.4 / 44	VERY LOOSE TO LOOSE GREY CLAYEY TO SANDY SILT SOME GRAVEL (REWORKED TILL)	8	9	"	6
			10	"	WR
611.0 / 52.4	VERY DENSE GREY SANDY SILT, TRACE CLAY SOME GRAVEL (TILL)	10	11	"	95/6"
608.9 / 54.5	END OF HOLE				

ELEVATION SCALE: 665, 660, 655, 650, 645, 640, 635, 630, 625, 620, 615, 610, 605

DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.: 20 40 60 80

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ⊕ U. - ○: 200 400 600 800

COEFFICIENT OF PERMEABILITY, k., CM./SEC.: 1x10 1x10 1x10 1x10

WATER CONTENT, PERCENT: Wp W WL; 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

▽ WATER LEVEL IN HOLLOW STEM AUGERS AT ELEV. 657.5 AFTER COMPLETION OF DRILLING

COULD NOT PUSH VANE AHEAD

15 (0 / 10) 5 Percent axial strain at failure

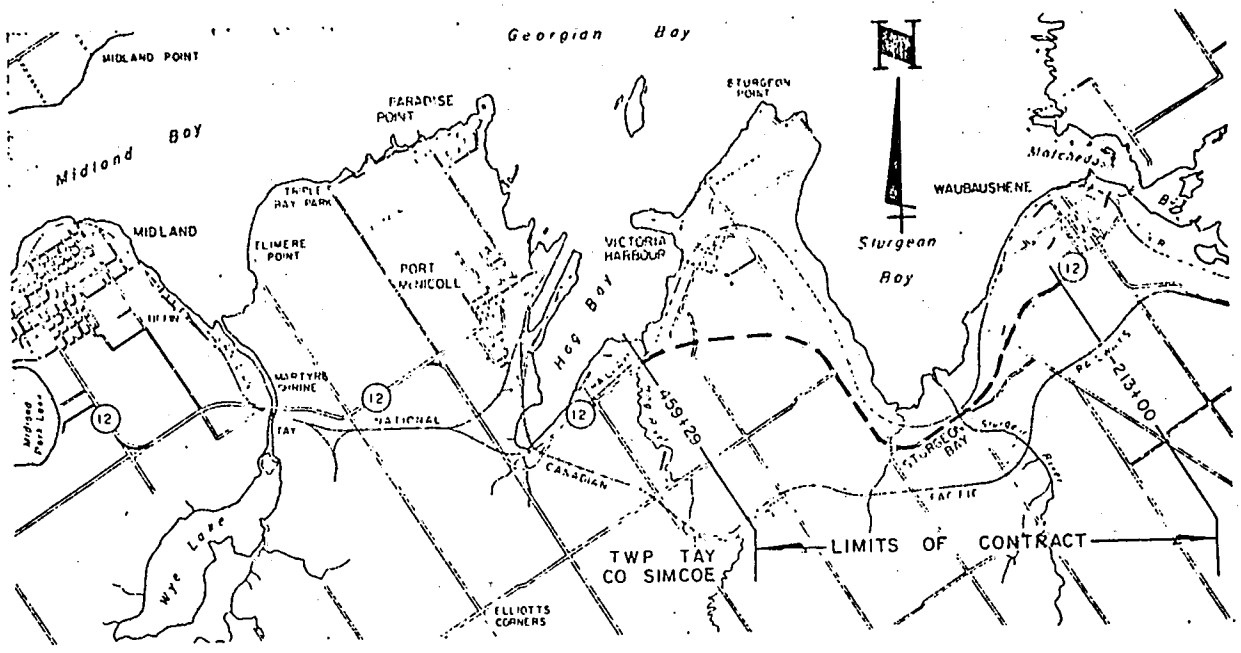
VERTICAL SCALE 1 IN. TO 5 FT.

Golder Associates

DRAWN D.M. CHECKED JHAL

KEY PLAN

FIGURE 1



SCALE

MILES 2 1·5 1 0·5 0 1 2 MILES

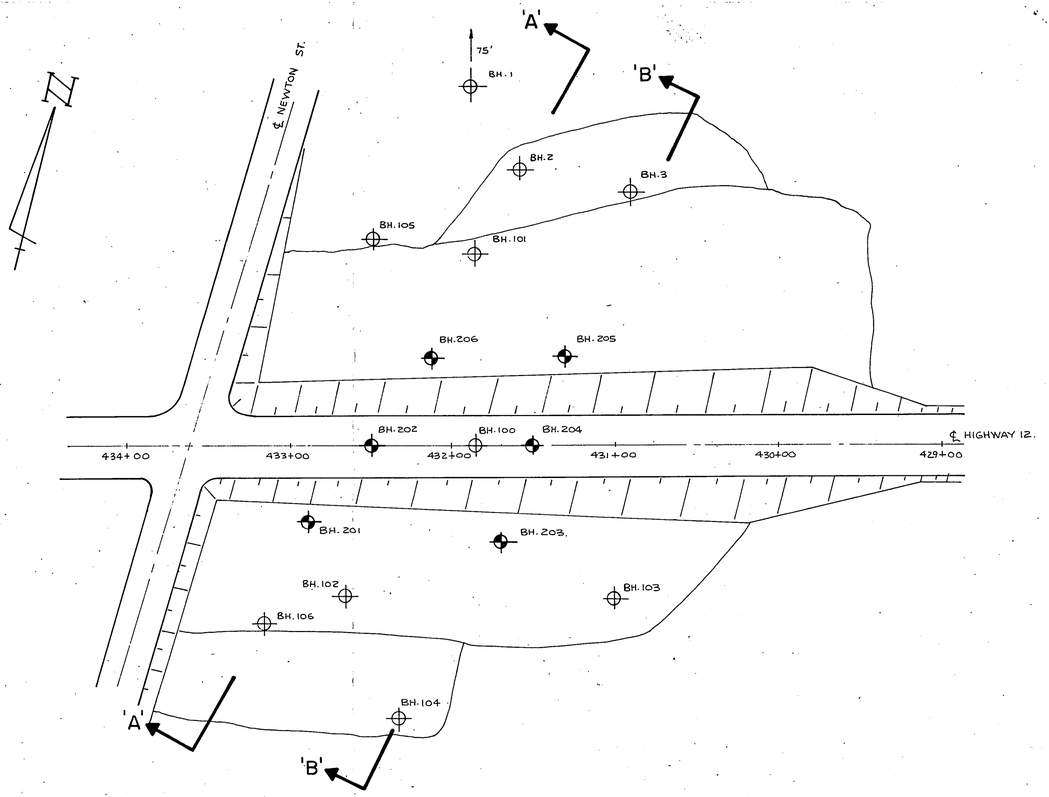
Date JULY 26,1975

Golder Associates

Drawn M.Y.B.
Chkd. JHHC
Appd

BORING PLAN

FIGURE 2



LEGEND

- BOREHOLE LOCATION IN PLAN (BH's. 1 TO 3 AND 100 TO 106 INCL.) PREVIOUS INVESTIGATION BY M.T.C. REPORTED IN GOLDER ASSOCIATES REPORT No. 761175, DATED OCTOBER 1976.
- BOREHOLE LOCATION IN PLAN (BH's. 201 TO 206 INCL.) PRESENT INVESTIGATION.

NOTE

FOR STRATIGRAPHIC SECTIONS A-A AND B-B, REFER TO FIG. 3

SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

SCALE: 1" TO 50'

Date: DEC. 13, 1976

Golder Associates

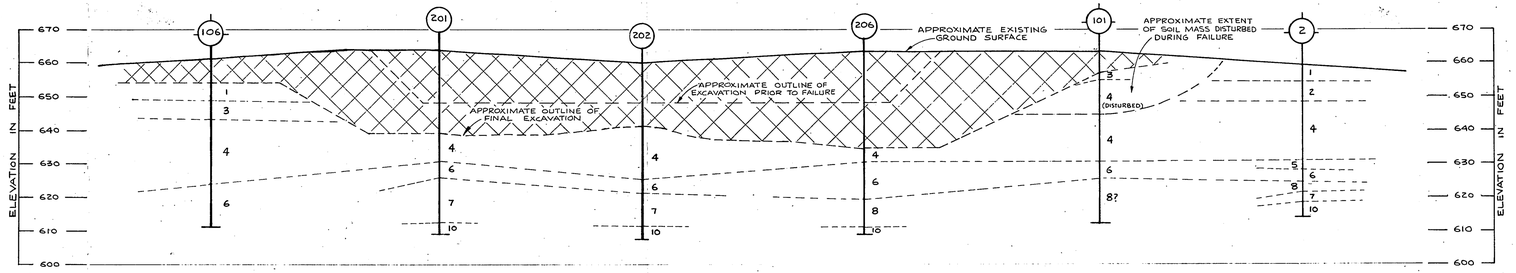
Drawn: D.M.

Chkd:

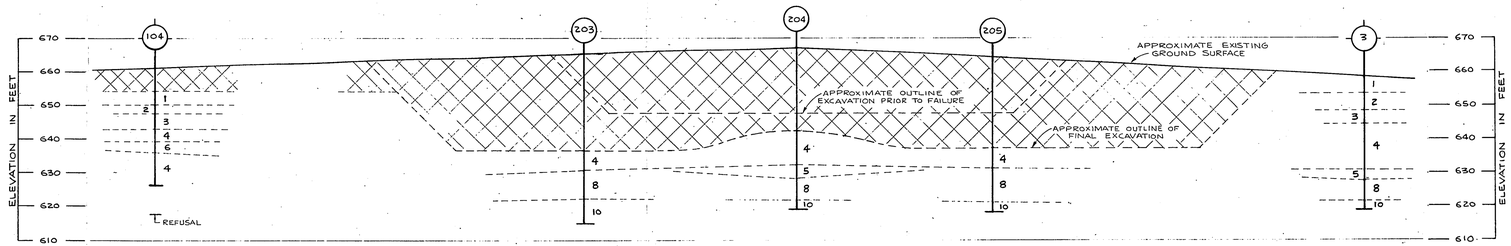
Appd:

STRATIGRAPHIC SECTIONS

FIGURE 3



SECTION A - A



SECTION B - B

NOTE

Data concerning the various strata have been obtained at borehole locations only. The soil stratigraphy between the boreholes has been inferred from geological evidence and so may vary from that shown.
For detailed stratigraphy at each borehole location refer to the record of borehole sheets.

SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

LEGEND

106 — BOREHOLE IN ELEVATION PREVIOUS INVESTIGATION BY M.T.C. REPORTED IN GOLDER ASSOCIATES REPORT No. 761175, DATED OCTOBER 1976.

201 — BOREHOLE IN ELEVATION PRESENT INVESTIGATION BY GOLDER ASSOCIATES.

GROUND SURFACE AT BOREHOLE

1 ← SOIL TYPE (REFER TO STRATIGRAPHY LEGEND)

STRATIGRAPHY

	FILL	
1	VERY SOFT BLACK AMORPHOUS TO FIBROUS PEAT	SWAMP DEPOSITS
2	VERY SOFT SENSITIVE GREY BROWN ORGANIC SILT	SWAMP DEPOSITS
3	VERY LOOSE TO LOOSE SANDY SILT TO SILTY SAND, TRACE CLAY	LACUSTRINE DEPOSITS
4	VERY SOFT TO FIRM GREY SENSITIVE SILTY CLAY, WITH SILT AND SAND LAYERS OR LENSES.	LACUSTRINE DEPOSITS
5	FIRM GREY STRATIFIED CLAYEY SILT, TRACE SAND AND GRAVEL, OCCASIONAL SAND LAYERS.	LACUSTRINE DEPOSITS
6	VERY LOOSE SANDY SILT TO SILTY SAND, TRACE TO SOME CLAY	
7	SOFT TO FIRM GREY SILTY CLAY TRACE GRAVEL TO INTERLAYERED CLAY AND SILT.	
8	SOFT TO FIRM GREY CLAYEY SILT, SOME SAND TRACE GRAVEL TO SILTY SAND, TRACE TO SOME CLAY AND GRAVEL (SOFTENED TILL)	
10	VERY DENSE SANDY SILT, TRACE CLAY, TRACE TO SOME GRAVEL TO HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL (BASAL TILL)	

FOR LOCATION OF STRATIGRAPHIC SECTIONS A-A AND B-B REFER TO FIGURE 2.

SCALE : 1" TO 20'

Date DEC. 15, 1976

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Chkd. JHMC
Appd.

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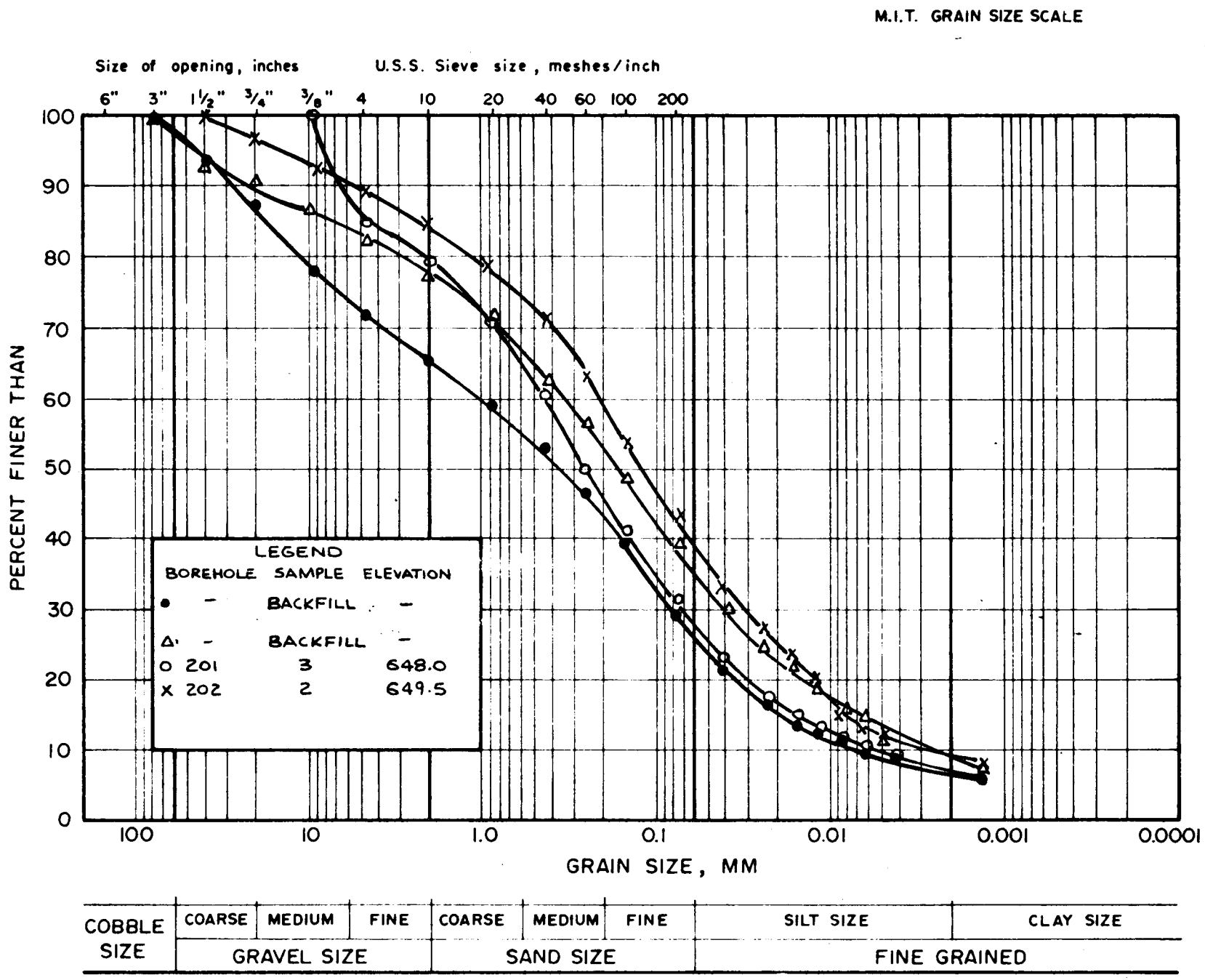
GRAIN SIZE DISTRIBUTION
FILL

FIGURE 4



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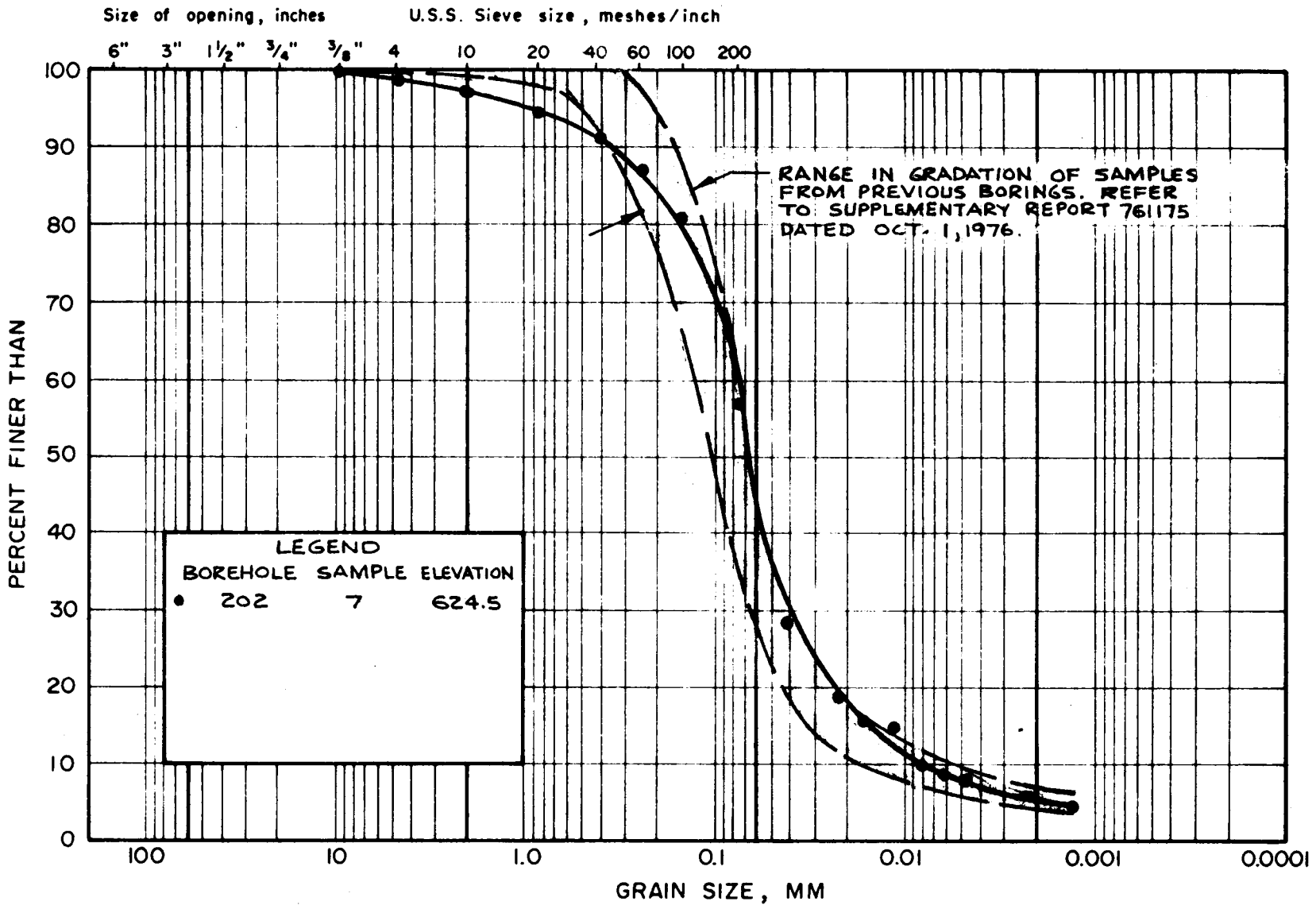
M.I.T. GRAIN SIZE SCALE



GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND - TYPE 3

FIGURE 5

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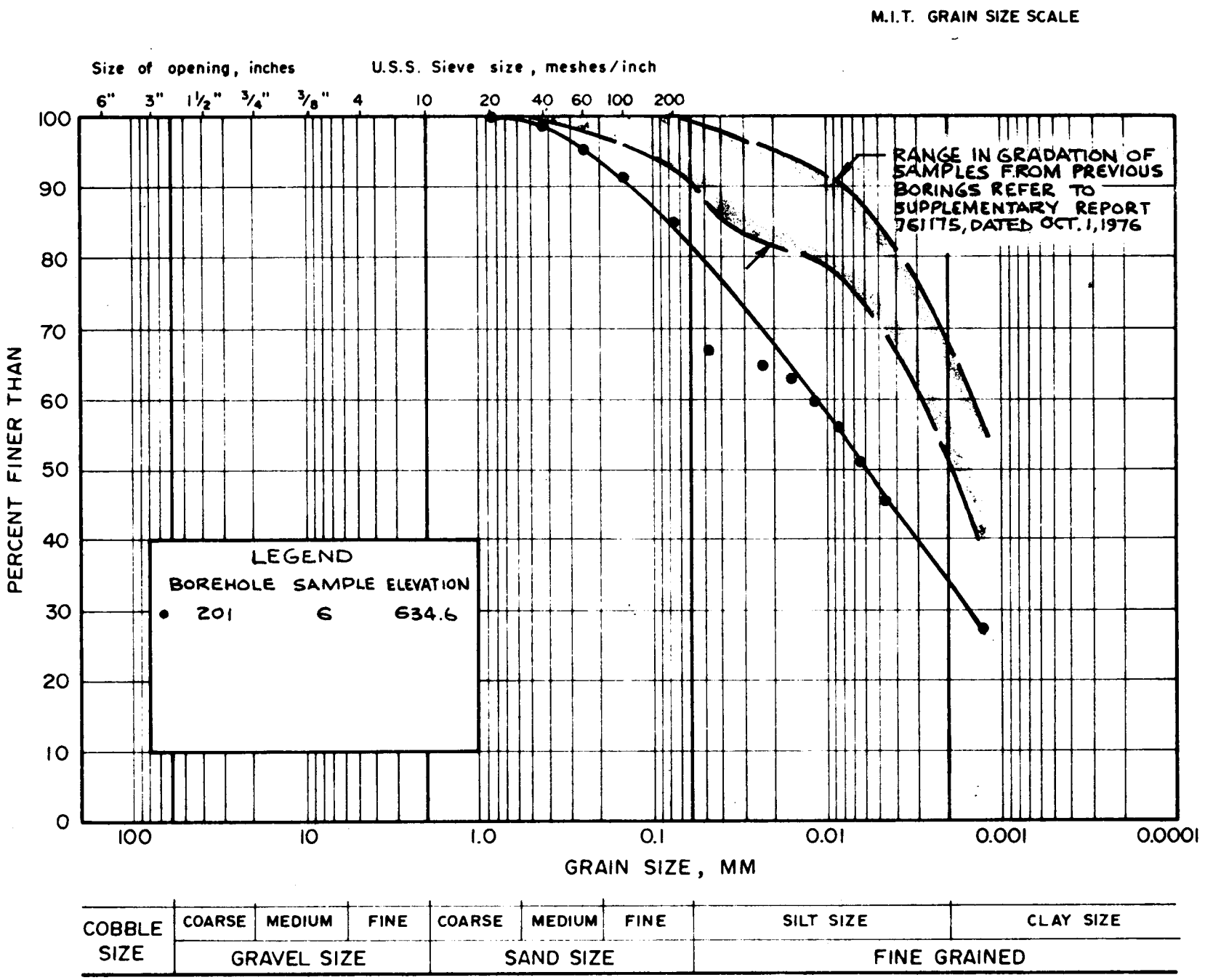
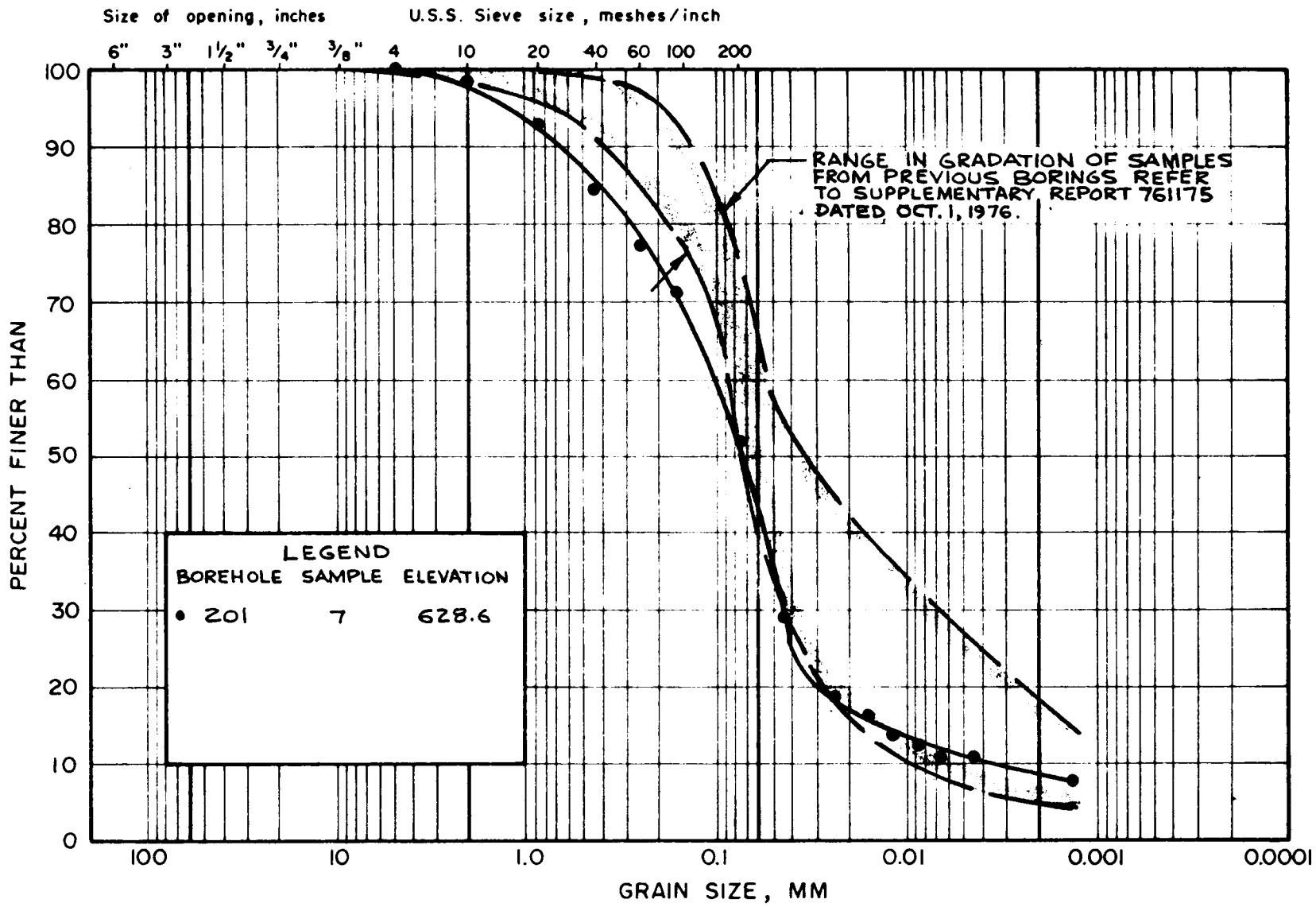
GRAIN SIZE DISTRIBUTION
SENSITIVE SILTY CLAY-TYPE 4

FIGURE 6



M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

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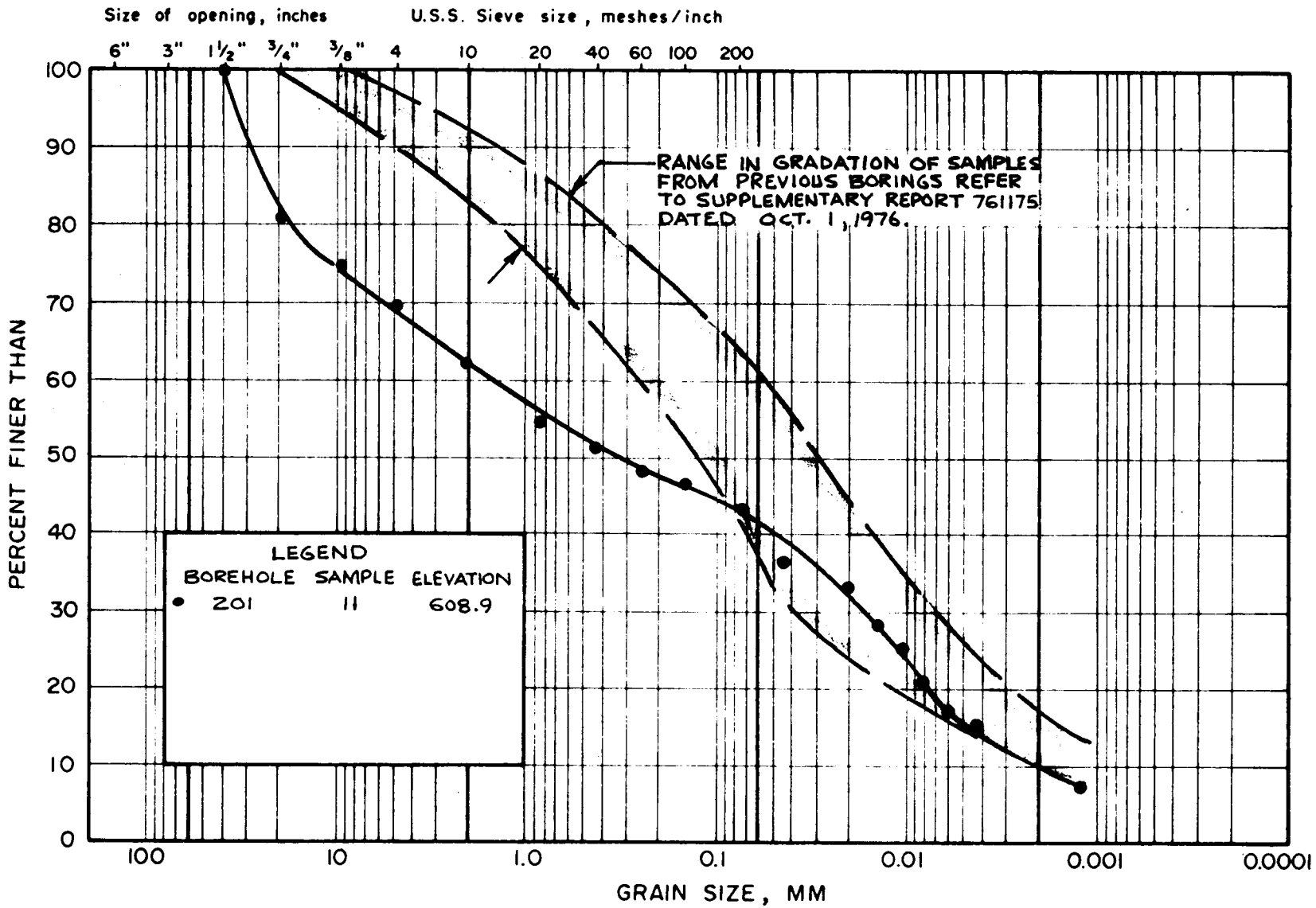
GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND - TYPE 6

FIGURE 7

M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

GRAIN SIZE DISTRIBUTION
SANDY SILT (BASAL TILL)-TYPE IO

FIGURE 8

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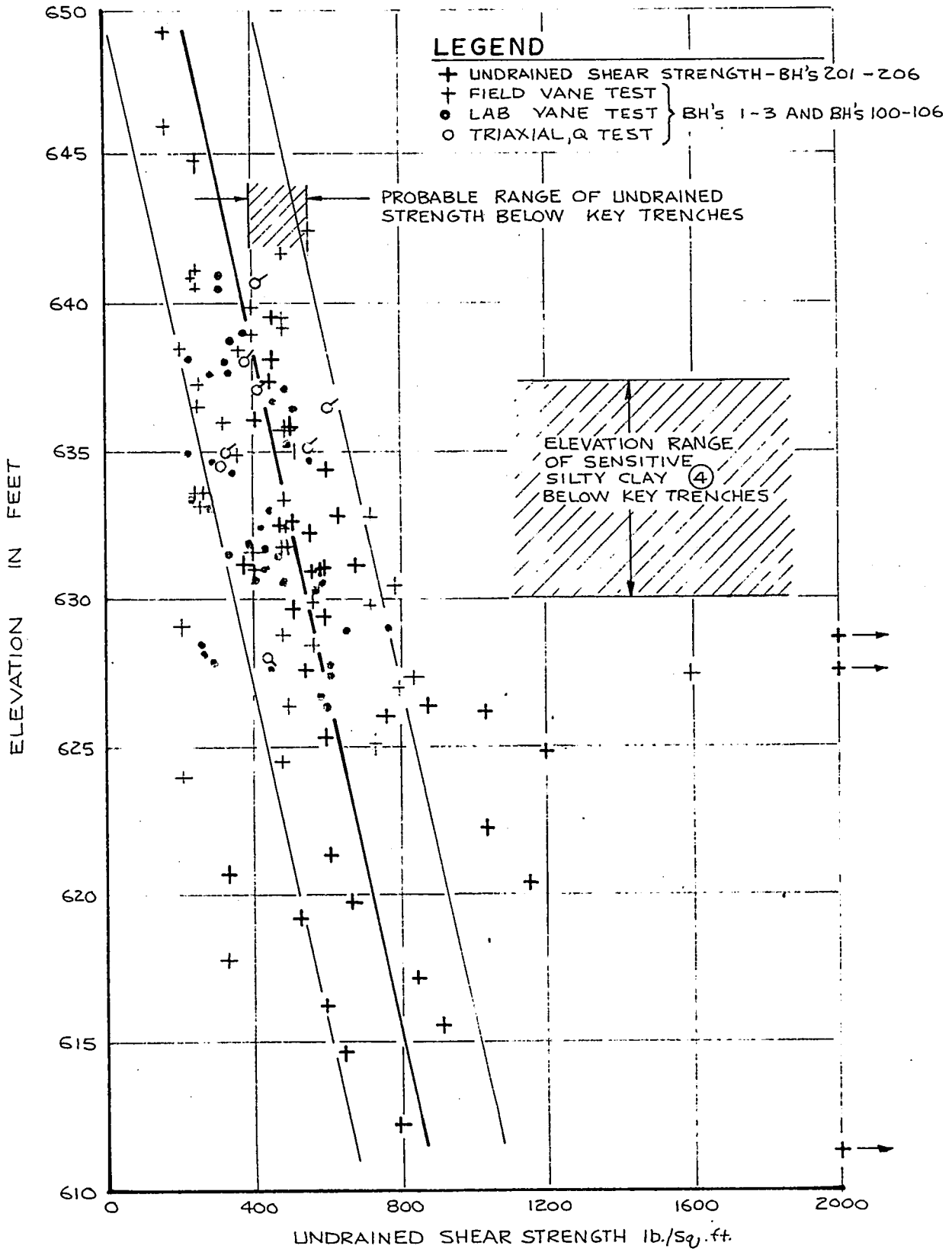
SUMMARY OF UNDRAINED SHEAR STRENGTH

FIGURE 9



Date DEC. 23, 1976.

Golder Associates

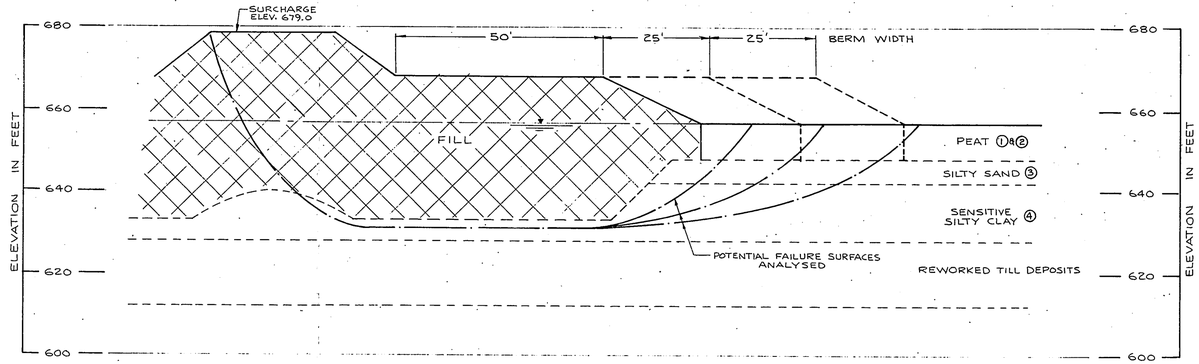
Drawn D.M.
Chkd. JHMC
Appd

PROJECT No. 761175

FORM A-1

SUMMARY OF STABILITY ANALYSES

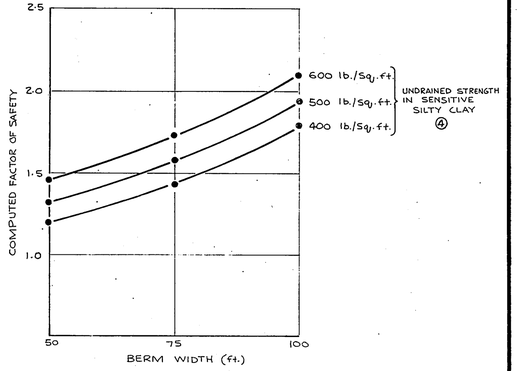
FIGURE 10



SECTION AND STRATIGRAPHY USED IN ANALYSES

SCALE : 1" TO 20'

SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.



SUMMARY OF RESULTS

FILL AND SILTY SAND	γ = 135 lb./cu.ft. ABOVE G.W.L. γ' = 63 lb./cu.ft. BELOW G.W.L. C' = 0 ϕ' = 30°
PEAT	γ' = 30 lb./cu.ft. Cu = 150 lb./Sq.ft. ϕ_u = 0°
SENSITIVE CLAY	γ' = 40 lb./cu.ft. Cu = VARIABLE ϕ_u = 0°

SOIL PROPERTIES USED IN ANALYSES

Date DEC. 23, 1976

Golder Associates

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Chkd. JHAC
Appd.

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

INTERIM REPORT

ON

75-32

MONITORING PROGRAM
SURCHARGED EMBANKMENT FILL
HIGHWAY 12
VICTORIA HARBOUR ONTARIO

Feb.'77
(4)

FOR

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

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February, 1977 761175

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

February 17, 1977

Ministry of Transportation
and Communications
1201 Wilson Avenue
West Building
DOWNSVIEW, Ontario
M3M 1J8

ATTENTION: Mr. K. G. Selby, P.Eng.

RE: EMBANKMENT MONITORING PROGRAM
HIGHWAY 12
VICTORIA HARBOUR, ONTARIO

Dear Sirs:

This letter reports the results to date of a monitoring program being carried out at the site of the recently re-constructed embankment on Highway 12, Victoria Harbour (refer to previous Golder Associates reports numbered 761175, dated August and October, 1976 and January, 1977). The purpose of the monitoring program is to determine the behaviour of the fill and foundation subsoils during the current surcharge period and to provide a basis for engineering recommendations for completion of the embankment following the spring breakup in 1977.

This report includes details of monitoring installations, factual results to date and interim comments on these results.

INSTALLATION PROCEDURES

The monitoring instrumentation was installed in the period between December 20 and 23, 1976 and consists of 6 settlement plates, 2 settlement augers, 2 piezometers and 2 surface control lines. The locations of the monitoring installations are shown on the attached Figure 1.

Settlement Plates (See Figure 2)

Six steel plates were installed in pits at depths of about 5 to 6 ft. below existing grade. The pits were excavated in the embankment fill using a backhoe supplied and operated by the general contractor at the site. The plates were placed on a

levelled, nominally compacted, sand layer about 1 ft. thick. The purpose of the settlement plates is to define the overall settlement in both the fill and the foundation subsoils.

Settlement Augers (See Figure 3)

Two settlement augers were installed in two augered boreholes at the locations shown on Figure 1. The augers are located immediately below the fill in the upper portion of the sensitive silty clay deposit. Following installation, protective plastic pipes were placed over the steel tubing to which the augers were attached, to ensure that the augers would not be subject to downward forces caused by friction between the tubing and the fill. The purpose of the settlement augers is to determine the settlement which is occurring in the natural foundation subsoils. In conjunction with the settlement plate readings, these data provide an assessment of the amount of settlement which is occurring in the fill.

Piezometers (See Figure 4)

Two Geonor piezometers were installed in the foundation subsoils under the centre of the embankment. The piezometers were pushed manually from the bottom of boreholes augered through the fill. The first piezometer was pushed to about the centre of the sensitive silty clay stratum while the second piezometer tip was pushed to refusal in the underlying reworked till deposits. Follow installation, the tubing attached to each piezometer were filled with antifreeze.

Lateral Control Lines

Two lateral control lines were established at about the centre of each primary berm. Each control line consists of two fixed points on natural ground at each side of the valley and a series of stakes on the berms aligned with the fixed points. The purpose of these control lines is to determine how much, if any, lateral movement of the embankment occurs.

The installation program was supervised throughout by one of our senior field technicans. The drilling equipment was supplied and operated by Site Investigation Services Limited of Peterborough, Ontario. Surveying was carried out by on-site M.T.C. staff. Locations are referred to Highway 12 chainage with offsets and elevations are referred to Geodetic datum.

RESULTS

Monitoring of the installations described above has been carried out by on-site M.T.C. personnel. The results obtained up to the end of January, 1977 are shown on Figures 5 to 8 and

are summarized below:

(i) The settlement plates along the central portion of the fill indicate that total settlements (i.e. fill and foundation subsoils) of between 1.5 and 4.5 in. have occurred.

(ii) Total settlement of the berms is relatively uniform at about 2 in.

(iii) Settlements within the compressible foundation subsoils under the central portion of the embankment and under the northern berm are approximately equal ($\sim$ 1.5 in.).

(iv) Water levels in the two piezometers are between 681 and 682 (i.e. artesian relative to the top of the central portion of the embankment fill).

The following are interim comments on the results obtained to date:

(i) Settlements are generally smaller than anticipated. However, some unrecorded settlement will have occurred during construction and in the 2 to 3 weeks period between end of construction and start of monitoring.

(ii) The piezometric water pressures in the foundation subsoils are high. However, there is evidence of slight dissipation of piezometric pressure in the silty clay. The trend for increasing piezometric pressures in the lower reworked till probably reflects the equalization of porewater pressures within the foundation subsoils and appears to be levelling off.

We trust that the information contained in this letter is sufficient for your immediate requirements. We will continue to assimilate the monitoring results and will forward the results to you on a monthly basis. If you have any questions regarding the information and data contained in this letter, please call us.

Yours truly,

H.Q. GOLDER & ASSOCIATES LTD.

JHA Crooks

J. H. A. Crooks, P.Eng.

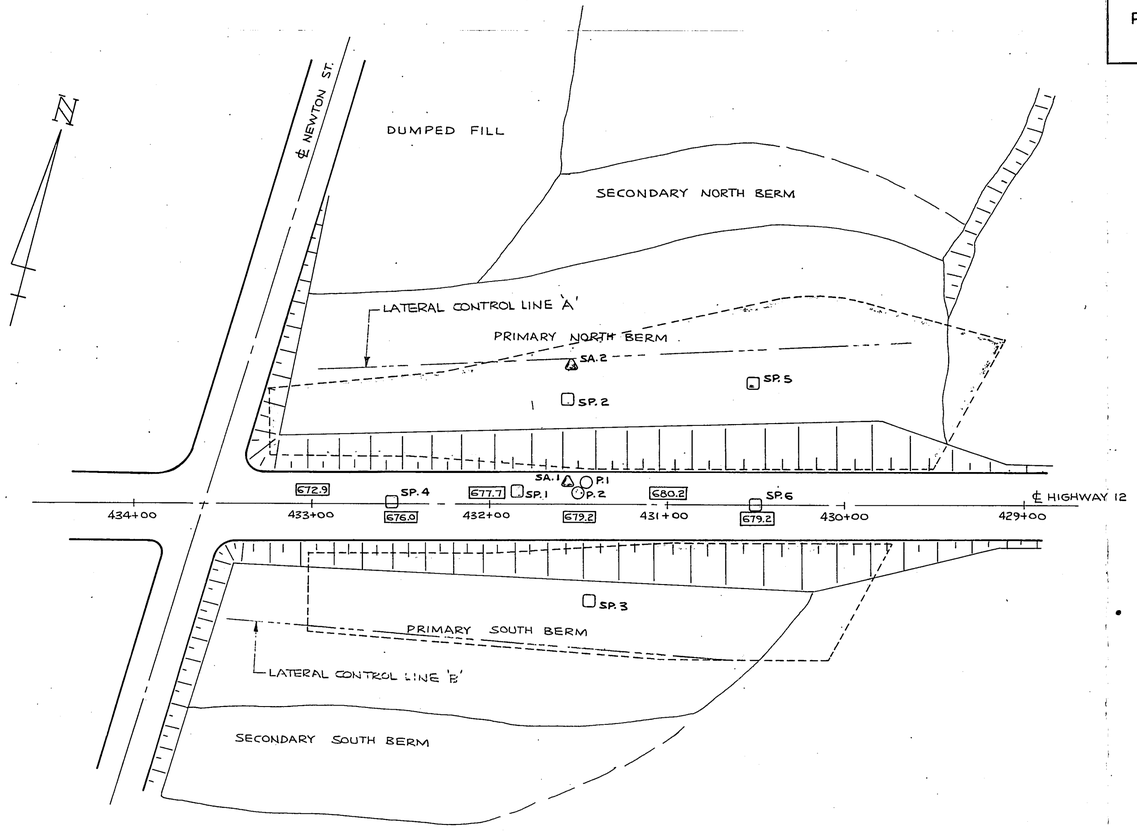
REGISTERED PROFESSIONAL ENGINEER J. H. A. CROOKS PROVINCE OF ONTARIO

JHAC:ys
761175

Encl: Figures 1 to 8

PLAN SHOWING LOCATIONS OF MONITORING INSTRUMENTATION

FIGURE 1



LEGEND

- APPROXIMATE OUTLINE OF SUBEXCAVATED AND BACKFILLED KEY TRENCHES
- SETTLEMENT PLATE (SP.1 TO SP.6 INCL.)
- SETTLEMENT AUGER (SA.1 AND SA.2)
- PIEZOMETER (P.1 AND P.2)
- 679.2 ELEVATION OF TOP OF FILL (DEC.'76)

NOTE: LOCATION OF LATERAL CONTROL LINES APPROXIMATE ONLY (TO BE VERIFIED)

SCALE: 1" TO 50' (APPROX.)

Date FEB. 15 / 77

Golder Associates

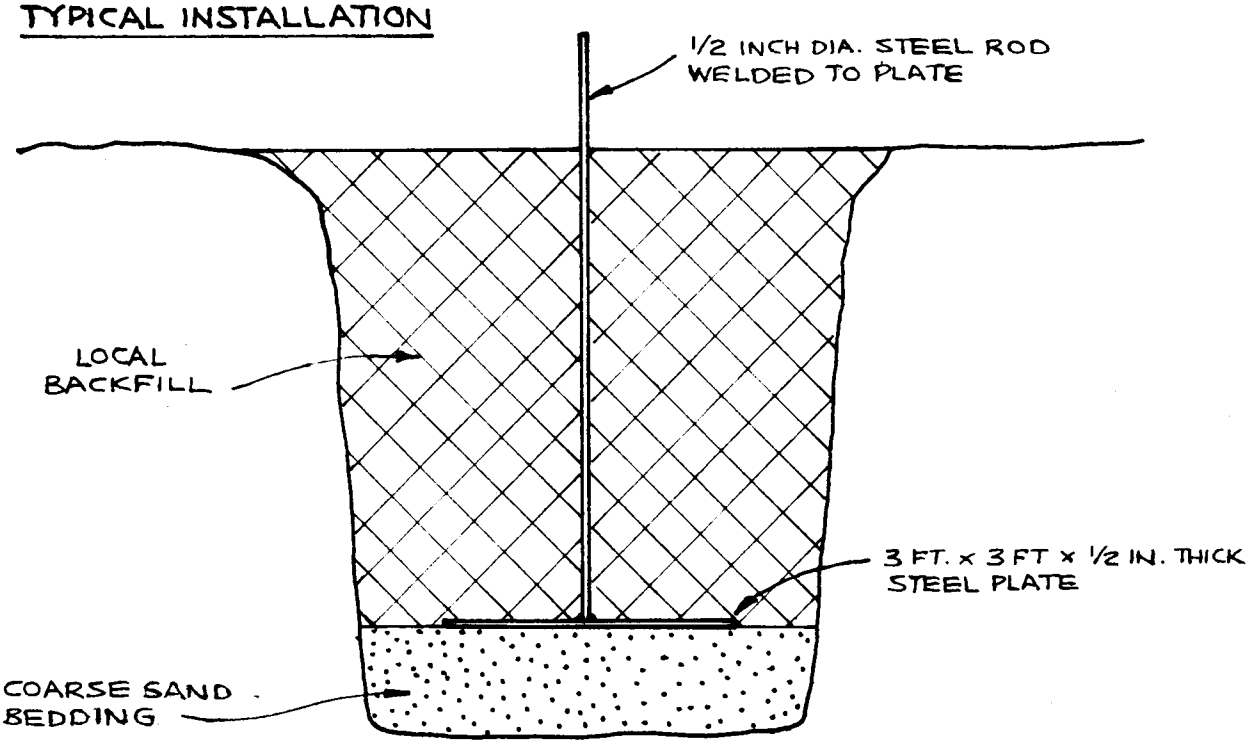
Drawn MH.W.
Chkd
Appd JTRC

PROJECT No. 77-2

SETTLEMENT PLATE INSTALLATIONS

FIGURE 2

TYPICAL INSTALLATION



SCALE 1" TO 2' (APPROX.)

SP. #	LOCATION		INITIAL ELEVATION OF TOP OF ROD (DEC. 22, 1976)
	CHAINAGE	OFFSET	
1	431+85	8' RT. ℄	677.96
2	431+55	60' RT. ℄	666.88
3	431+44	55' LT. ℄	670.41
4	432+55	1' RT. ℄	676.25
5	430+50	69' RT. ℄	667.37
6	430+50	℄	680.71

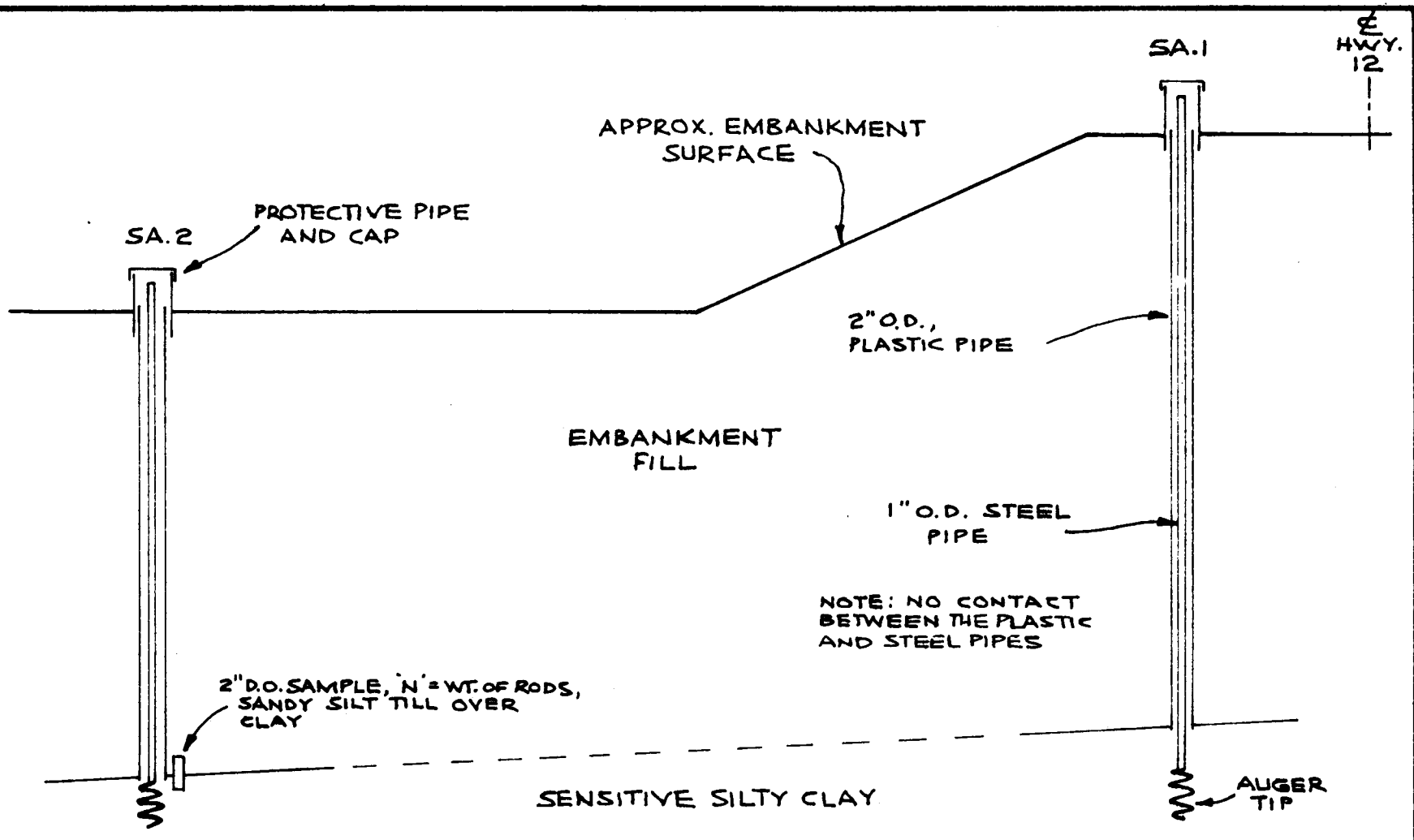
Date FEB. 15/77.

Golder Associates

Drawn MHW.
Chkd. JHK
Appd.

Form G.A. - D - 4

SETTLEMENT AUGER INSTALLATIONS



SCALE 1" TO 10' (APPROX.)

SA. #	LOCATION		INITIAL ELEVATION OF TOP OF ROD (DEC. 23, 1976)
	CHAINAGE	OFFSET	
1	431+55	12' RT. ℄	681.45
2	431+53	78' RT. ℄	669.30

FIGURE 3

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Date FEB. 15/77

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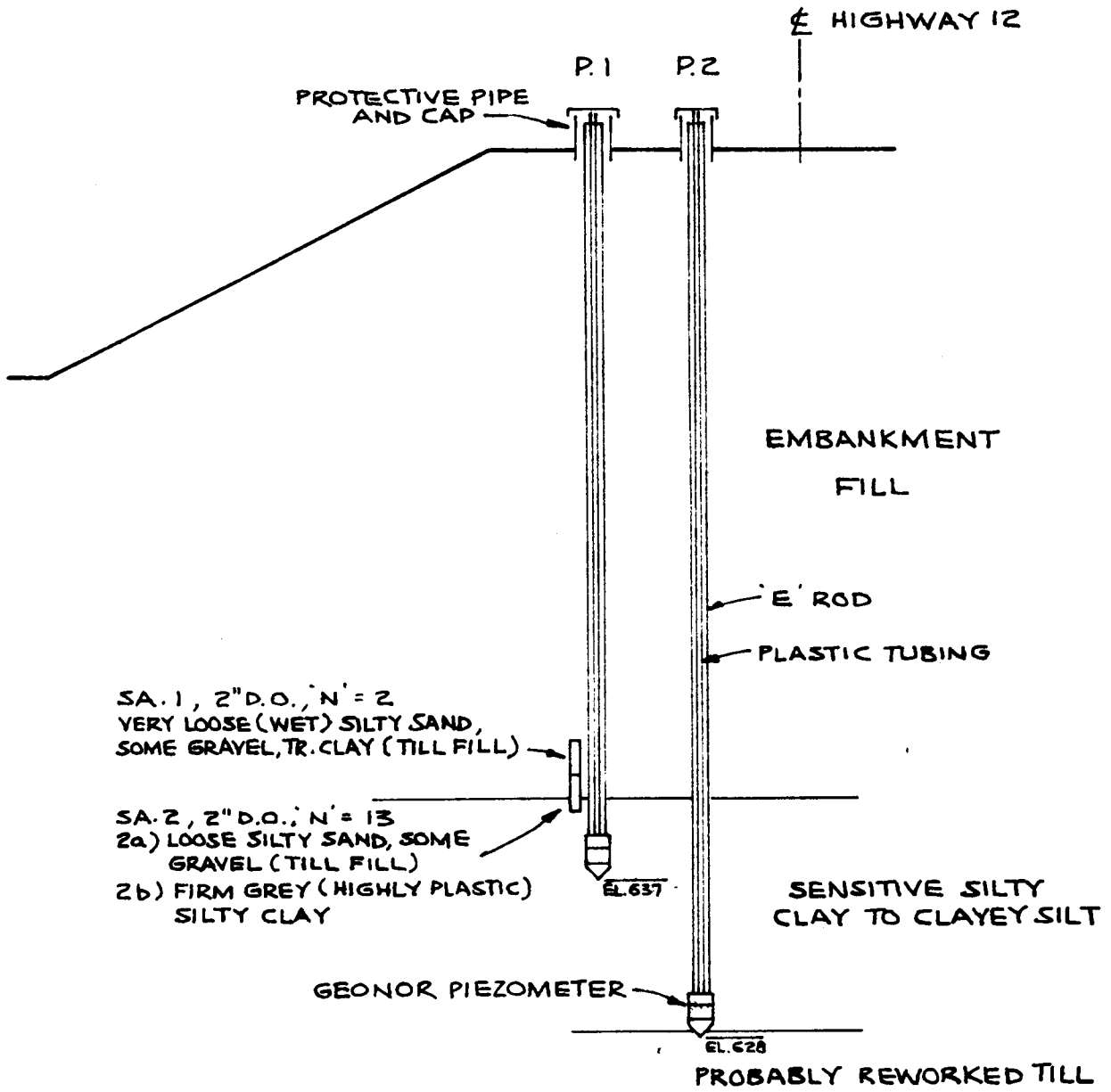
Chkd.
Appd.

PROJECT No. 761175

PIEZOMETER INSTALLATIONS

FIGURE 4



NOTE: PIEZOMETER TUBING FILLED WITH ANTIFREEZE.

SCALE 1" TO 10' (APPROX.)

Date FEB. 16/77

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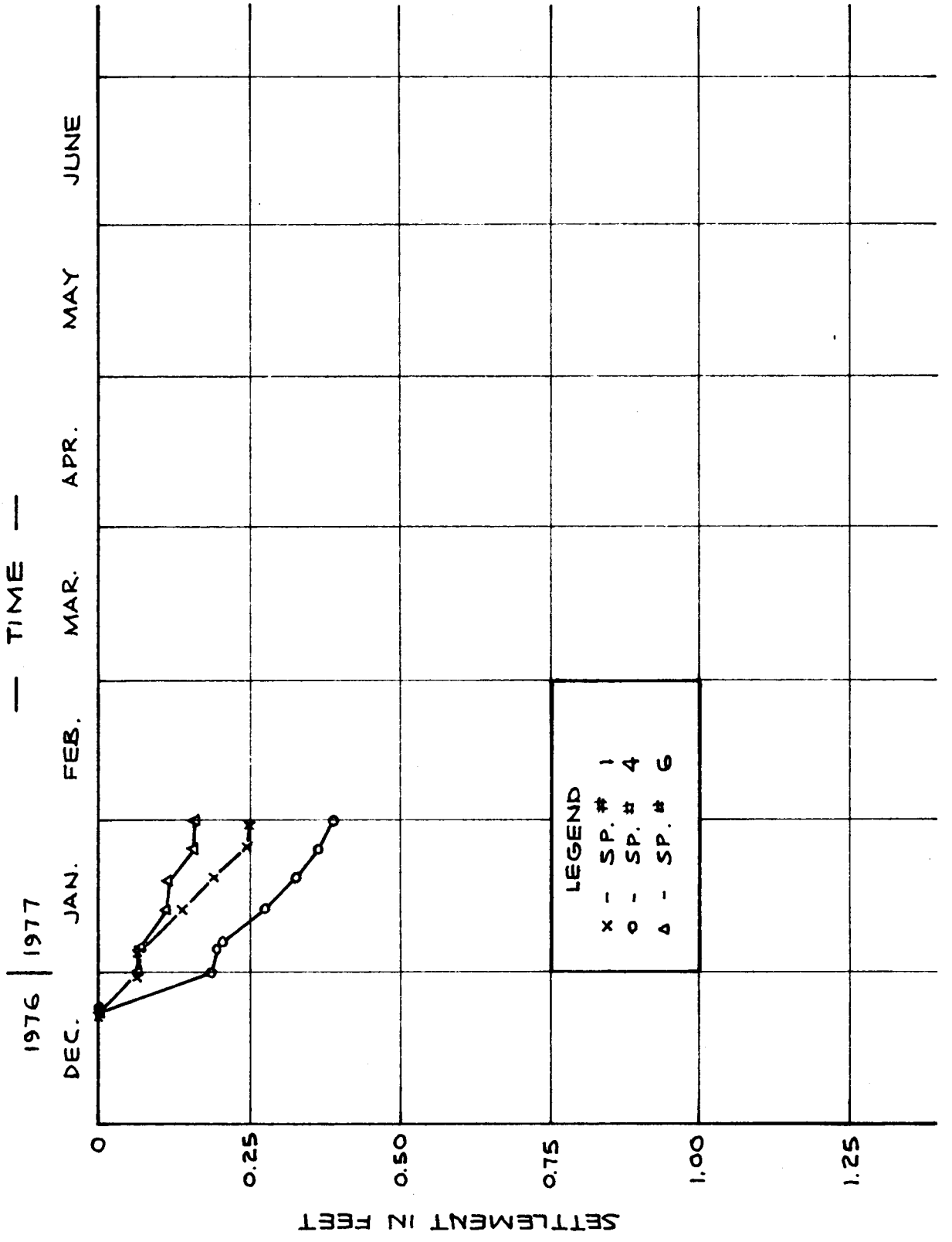
Chkd. JKM
Appd. JKM

Form 1A - 1

PROJECT No. 761175

SETTLEMENT PLATES 1, 4 & 6

FIGURE 5



Date FEB.16/77

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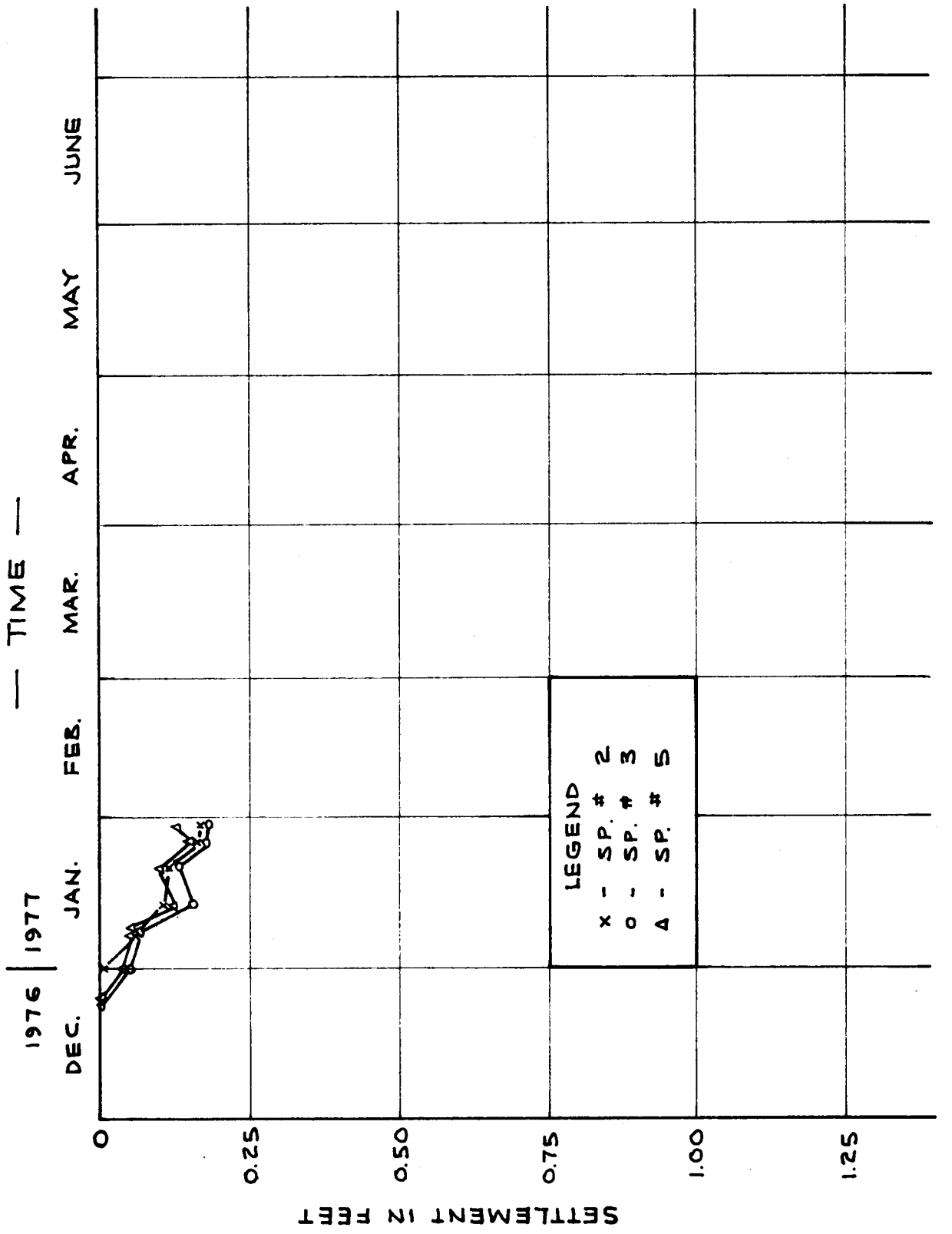
Chkd.
Appd. JHK

Form G.A.-2

PROJECT No. 761175

SETTLEMENT PLATES 2, 3 & 5

FIGURE 6



Date FEB. 16/77.

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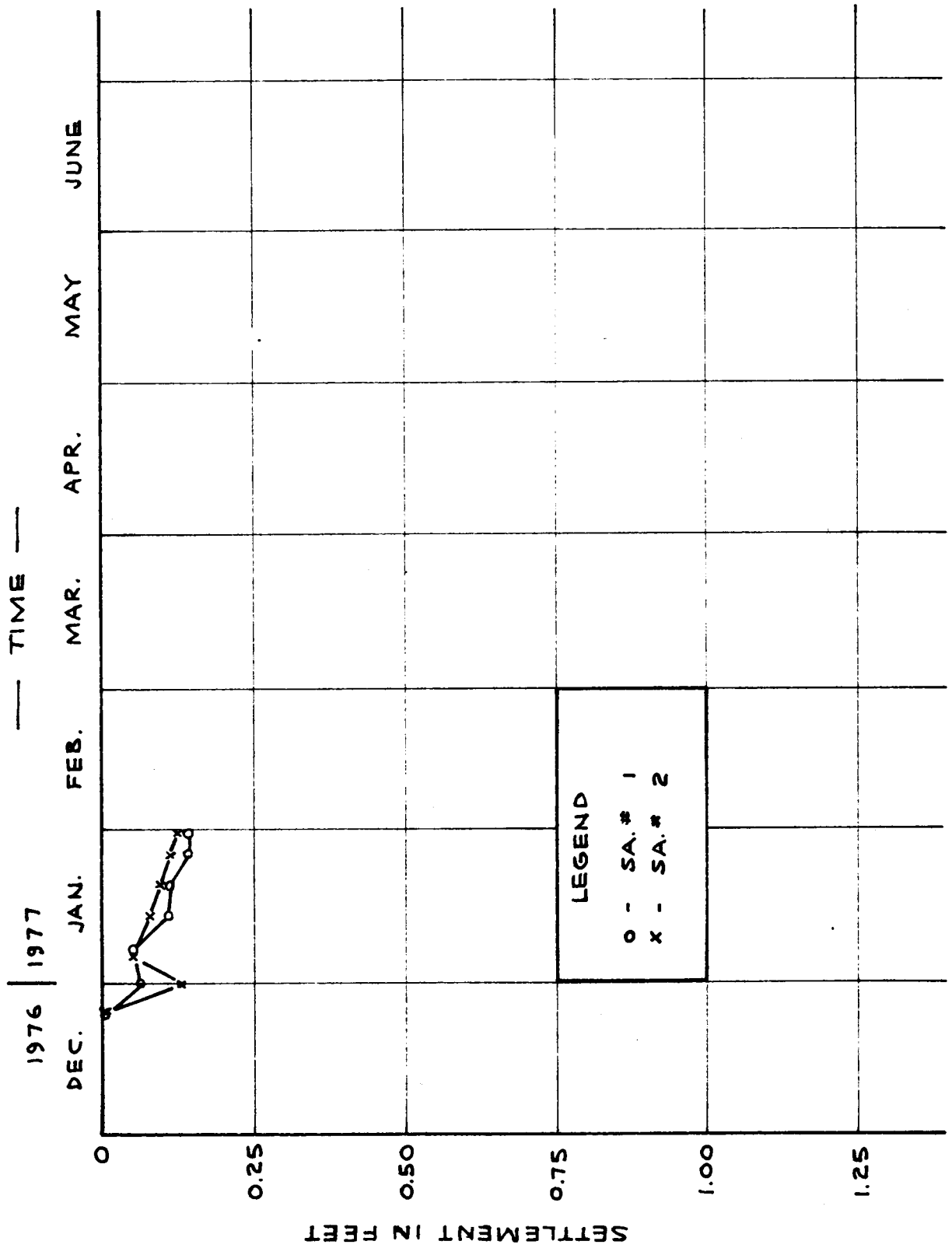
Chkd. JHC
Appd.

Form 6A-0

PROJECT No. 76-1175

SETTLEMENT AUGERS 1 & 2

FIGURE 7



Date FEB 15/77

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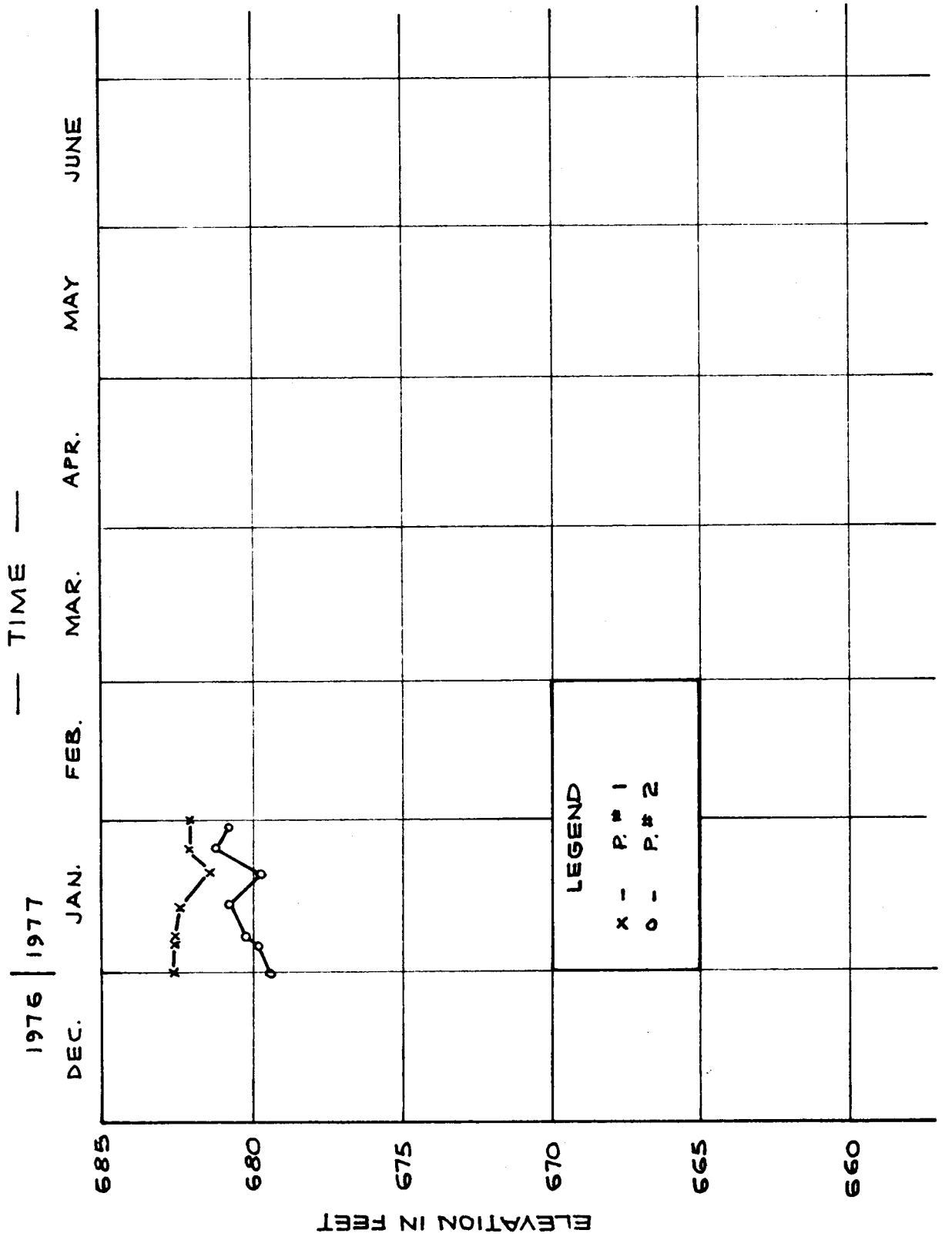
Chkd. AHC
Appd.

Form C.A.-0

PROJECT No. 761175

PIEZOMETERS 1 & 2

FIGURE 8



Date FEB.15/77

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Chkd. JMC
Appd.

Form G.A.-6