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REPORT

TO

STRUCTURE SITE No. 10-103

PHILIPS & ROBERTS LIMITED

ON

SOIL INVESTIGATION

PROPOSED FOURTH SIDEROAD BRIDGE

TOWN OF BURLINGTON ONTARIO

65-F-272M

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July, 1965

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REPORT ON SOIL INVESTIGATION FOR PROPOSED FOURTH SIDEROAD BRIDGE

TOWN OF BURLINGTON,      ONTARIO

INTRODUCTION

At the request of Philips & Roberts Limited, Consulting Engineers, we have carried out a soil investigation for a proposed bridge crossing of Bronte Creek by the Fourth Side-road, in the Town of Burlington. The existing bridge which is about 50 years old, suffered structural collapse. The purpose of this investigation was to determine the subsoil conditions at the site and to provide information for the foundation design of the proposed bridge replacement.

PROCEDURE

The field work for this investigation was carried out during the period July 5 to 7, 1965. Two boreholes with accompanying dynamic penetration tests were put down at the site using a

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machine drillrig supplied and operated by the F. E. Johnston Drilling Co. Ltd. The bedrock was cored in BXL size for a depth of 10 feet in borehole 2. A test pit was dug to creek bed elevation along the proposed creek diversion. The field work was supervised throughout by an engineer from our staff.

A detailed log for each boring is given on the Records of Boreholes following the text of this report. The locations of the borings together with a section of inferred soil stratigraphy across the bridge site are shown on Figure 1.

The samples obtained during the investigation were brought to our laboratory for detailed examination and testing. The results of the tests carried out are shown on the Records of Boreholes and on Figures 2 and 3.

The elevations given in this report are referred to a "Lewell and Lewell" survey monument located near the south bridge abutment. The elevation of the survey monument was taken as 100.0. The elevation of the creek at this location is 525 as referred to Geodetic datum and the conversion to Geodetic datum is approximately 430 feet.

#### SITE AND GEOLOGY

The site of the proposed bridge is located about 4 miles northwest of the Town of Palermo. The topography of the

general area is rolling. In the vicinity of the bridge site the stream has carved a valley some 200 feet wide and about 25 feet deep. The valley floor is relatively flat with the stream bed some 5 feet below the flood plain.

The site is located near the base of the Niagara escarpment. From available geological information it is known that the area is within the Peel Plain physiographic region of which the overburden is a glacial till containing large amounts of Paleozoic shale and limestone. The underlying bedrock is shale of the Queenston series.

#### SOIL CONDITIONS

The detailed stratigraphy encountered in each boring is given on the Records of Boreholes. Following is a summary account of the inferred soil conditions at the site.

The boreholes were put down through the existing roadway and encountered up to about 5 feet of fill, consisting of sandy to clayey silt with some gravel. The fill is underlain in borehole 2, by about one foot of loose silty sand and gravel which is believed to be recent alluvium deposited by the stream. A typical grain size curve for the alluvium is shown on Figure 2. Similar surface soil conditions exist at the test pit.

The fill and recent granular deposits are underlain by reddish brown clayey silt till which is the significant stratum at the site and is up to 20 feet thick. Some layers or lenses of silty sand and clay were encountered within the till at about a 10 foot depth. Typical grain size curves for the till are shown on Figure 3 and these indicate that the material is principally a clayey silt with some sand and gravel. Cobble and boulder size material would also be expected in this glacial deposit.

Two Atterberg limits carried out on samples of the till gave liquid limits of 20 and 23 and plasticity indices of 7 and 9. The natural water contents are at about the plastic limit.

Standard penetration tests carried out in the till gave "N" values ranging from 49 to greater than 100 blows/ft. Based on these values the consistency of the till is considered to be hard.

The till is underlain by reddish brown shale of the Queenston series which is also the rock in the valley walls along the lower reaches of Bronte Creek.

WATER CONDITIONS

At the time of the investigation, the water level in Bronte Creek at this bridge location was at about elevation 525 as referred to Geodetic datum or about elevation 93 as referred to local datum.

Piezometers were installed in the boreholes after completion of the field work. The water level in the piezometers on July 9, 1965 was at elevation 96 to 97, that is about 3 feet above creek water level.

PROPOSED BRIDGE STRUCTURE

It is understood that the existing bridge which has failed will be replaced by a single span bridge some 90 feet in total length and located at or about 50 feet downstream from the present crossing. It is also understood that the existing roadway grade and bridge deck level will be maintained.

a) Foundation Design

It is recommended that the abutments of the proposed bridge be founded on spread footings placed in the clayey silt till stratum which underlies the site at about creek bed level, that is, below about elevation 92. To provide adequate frost protection the footings should be taken down at least 4 feet

below the creek bed. This would also provide some scour protection. The foundation level will therefore be no higher than about elevation 88.

The "N" values for a significant depth below this elevation range between 50 and greater than 100 blows/ft. Based on these values an allowable bearing pressure of up to 4 tons/sq. ft. may be used in design of footings founded in the clayey silt till. With this allowable bearing pressure there should be no detrimental settlement of the bridge abutment footings, provided precautions are taken during construction, as discussed below, to prevent softening of the clayey silt till at and below foundation grade.

In computation of sliding resistance between a rough concrete footing base and the undisturbed clayey silt till subsoil, a coefficient of friction of 0.35, which is a limiting value, may be used.

It is recommended that free draining and non-frost-susceptible granular backfill be provided behind the bridge abutments. The granular backfill should be compacted in horizontal lifts of about 9 inches and should extend horizontally from the back face of the abutment walls a minimum distance of 4 feet. Provision for drainage from this material should be made.

In the design of the abutment walls it is recommended that an active earth pressure coefficient,  $K$ , equal to 0.3 be used for the compacted granular backfill, provided some movement of the top of the bridge abutments can be accommodated. For rigid frame design an at rest earth pressure coefficient,  $K_0$ , equal to 0.5 should be used.

Rip-rap should be placed in the bottom of the creek channel and on the embankment side slopes in the vicinity of the bridge to prevent scour.

#### CONSTRUCTION PROCEDURES

No major construction problems are envisaged for the bridge abutments to be founded in the relatively impervious clayey silt till. However, to prevent entry of creek water into the foundation excavations through previous portions of the fill or recent alluvium overlying the till, close braced sheeting driven several feet below foundation level should be employed or an earth dyke constructed above the till surface.

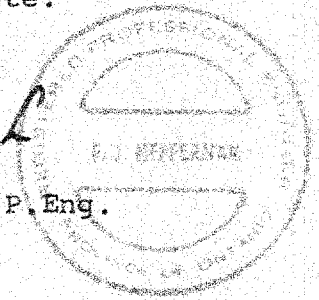
To prevent softening of the till due to surface water or construction operations, it is recommended that the base of footings excavations, once foundation grade is reached,



be immediately covered by a mud mat of lean concrete.

F.J.H./gje  
65074

*[Signature]*  
for F. J. Heffernan, P. Eng.



## 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	<i>N</i> , 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	<i>c<sub>u</sub></i> , 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<sup>1</sup>  
Q undrained triaxial<sup>2</sup>  
R consolidated undrained triaxial<sup>2</sup>  
S drained triaxial  
U unconfined compression  
V field vane test

### NOTES:

<sup>1</sup>Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

<sup>2</sup>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
$\sigma$	normal stress
$\sigma'$	normal effective stress ( $\bar{\sigma}$ is also used)
$\tau$	shear stress
$\epsilon$	linear strain
$\epsilon_{xy}$	shear strain
$\nu$	Poisson's ratio ( $\mu$ is also used)
$E$	modulus of linear deformation (Young's modulus)
$G$	modulus of shear deformation
$K$	modulus of compressibility
$\eta$	coefficient of viscosity

### III. SOIL PROPERTIES

#### (a) Unit weight

$\gamma$	unit weight of soil (bulk density)
$\gamma_s$	unit weight of solid particles
$\gamma_w$	unit weight of water
$\gamma_d$	unit dry weight of soil (dry density)
$\gamma'$	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 = $-\Delta e / \Delta \log_{10} \sigma'$
$c_c$	coefficient of consolidation
$T_v$	time factor = $c_v t / d^2$ ( $d$ , drainage path)
$U$	degree of consolidation

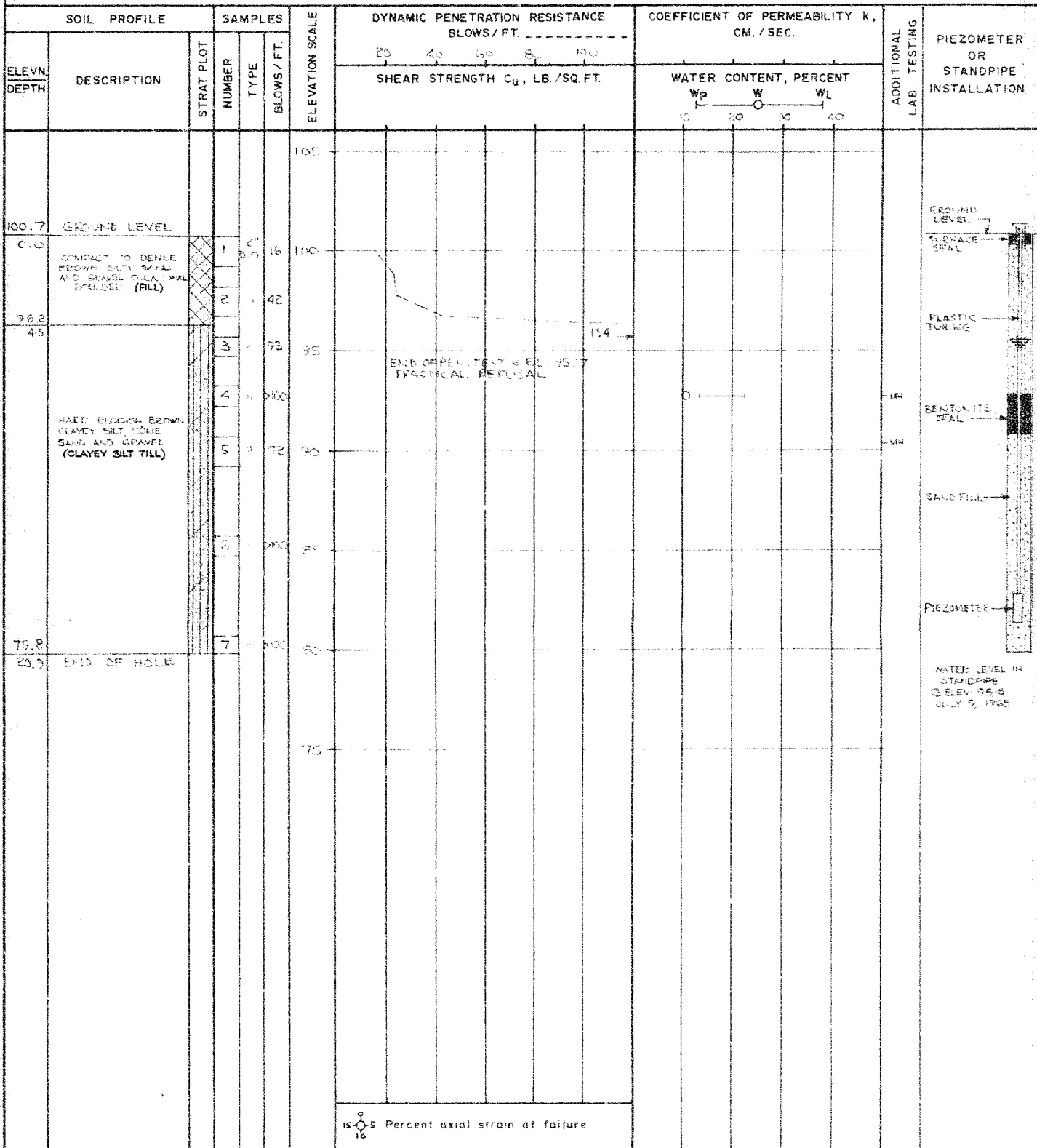
#### (e) Shear strength

$\tau_f$	shear strength
$c'$	effective cohesion
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_i$	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.

## RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE JULY 6-7, 1965 DATUM LOCAL  
 BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER 5.75 CASING  
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



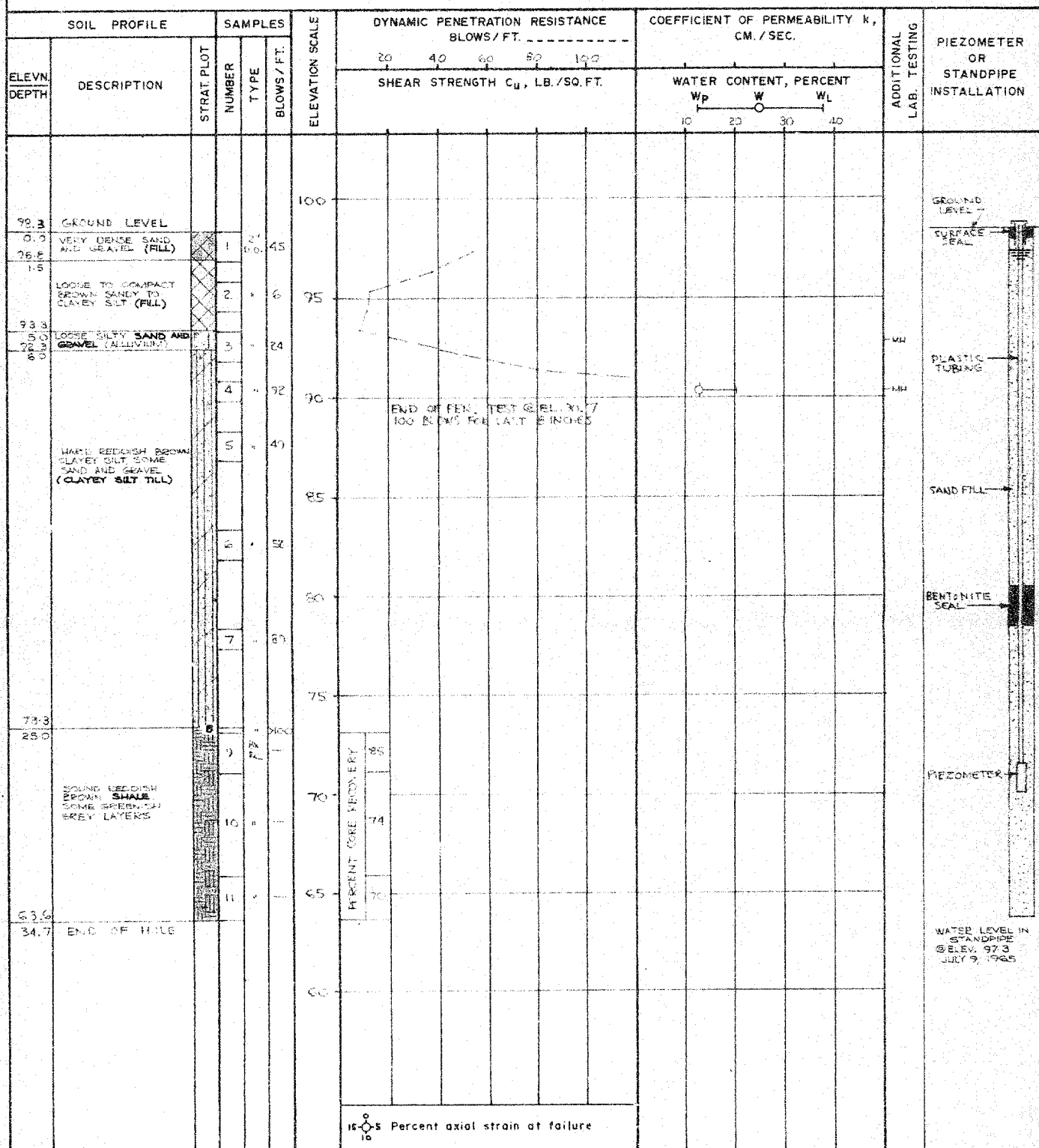
VERTICAL SCALE  
 1 INCH TO 5'-0"

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DRAWN N.A.  
 CHECKED S.T.V.

## RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE JULY 5-6, 1965 DATUM LOCAL  
 BOREHOLE TYPE WATH BORING BOREHOLE DIAMETER 8X CASING  
 SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



VERTICAL SCALE  
1 INCH TO 50'

GOLDER &amp; ASSOCIATES

DRAWN J.A.  
CHECKED E.H.

TEST PIT  
RECORD OF BOREHOLE 3

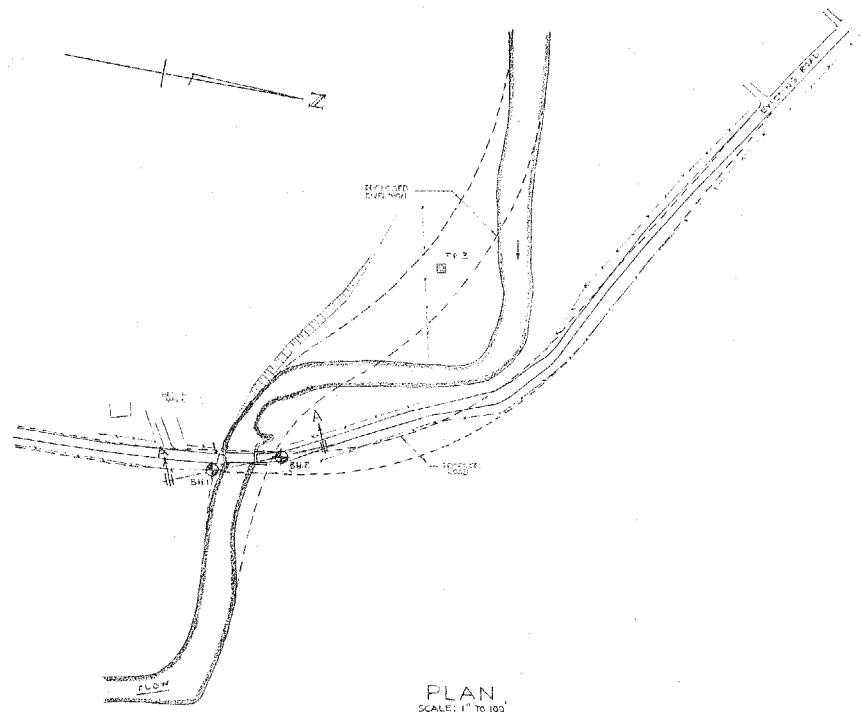
LOCATION	See Figure 1	BORING DATE	JULY 6, 1965	DATUM		LOCAL	
BOREHOLE TYPE		TEST PIT		BOREHOLE DIAMETER			
SAMPLER HAMMER WEIGHT --- LB.	DROP --- INCHES			PEN. TEST HAMMER WEIGHT --- LB.	DROP --- INCHES		

[illegible]

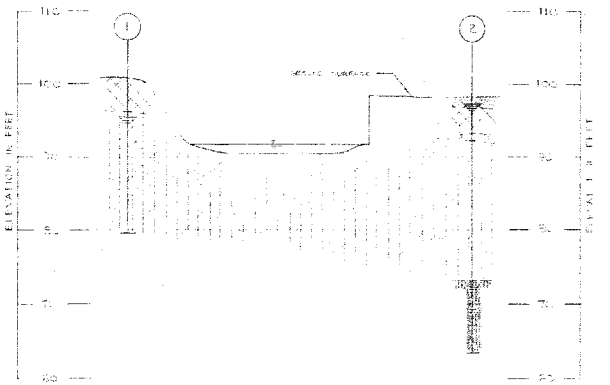
VERTICAL SCALE  
1 INCH TO 500'

**GOLDER & ASSOCIATES**

DRAWN J.A.  
CHECKED F.H.



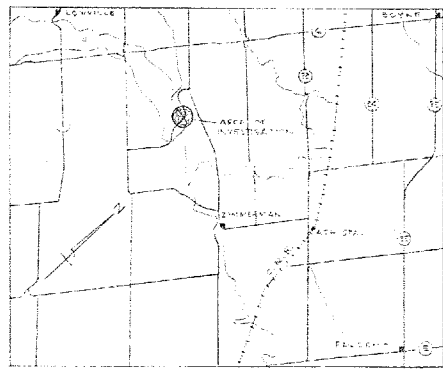
PLAN  
SCALE: 1" TO 100'



SECTION A-A  
SCALE: HORIZ. 1" TO 20'  
VERT. 1" TO 10'  
STRATIGRAPHY

- |  |                                                                |  |                                                               |
|--|----------------------------------------------------------------|--|---------------------------------------------------------------|
|  | VERY DENSE SAND AND GRAVEL (FILL)                              |  | SAND WITH THIN CLAYEY SILT (CLAYEY SAND)                      |
|  | SAND TO COARSE SAND, SAND WITH CLAYEY SILT, SOME GRAVEL (FILL) |  | COARSE TO MEDIUM SAND, SOME SHALE (CLAYEY SAND, SILET CLAYEY) |
|  | FINE TO VERY FINE SAND AND GRAVEL (Assumed)                    |  |                                                               |

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED BY TESTABLE LOCATIONS ONLY. THE SOIL BEHAVIOR BETWEEN BORINGS HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.



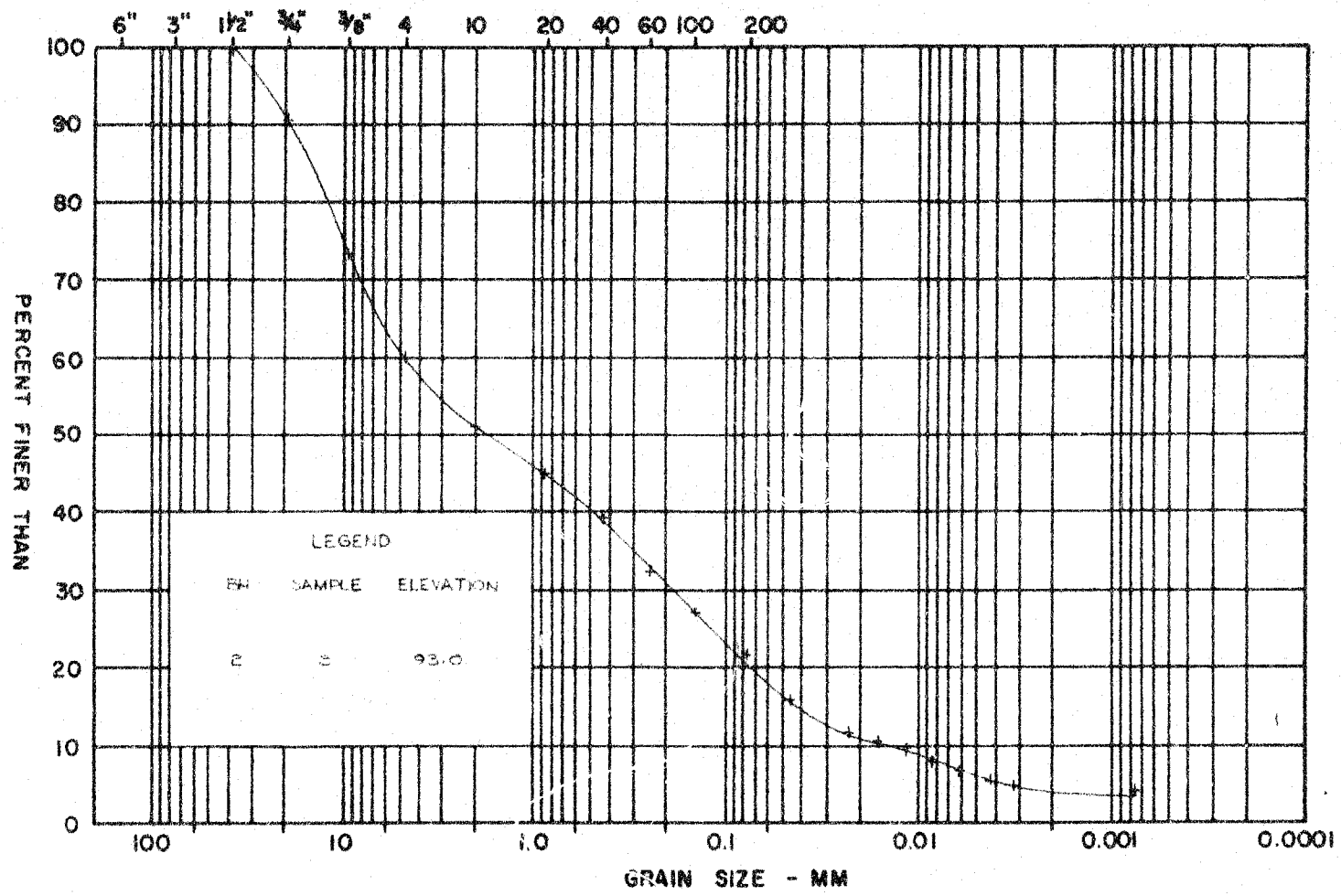
KEY PLAN  
SCALE: 1" TO 1 MILE

LEGEND  
UNDESIGNED AND UNDESIGNED  
BORINGS OF THE PROJECT  
INDICATED BY THE FOLLOWING SYMBOLS

- LEGEND
- BOREHOLE IN PLAN
  - TEST PIT IN PLAN
  - BOREHOLE IN ELEVATION
  - AERIAL PHOTO IN STRATIGRAPHY

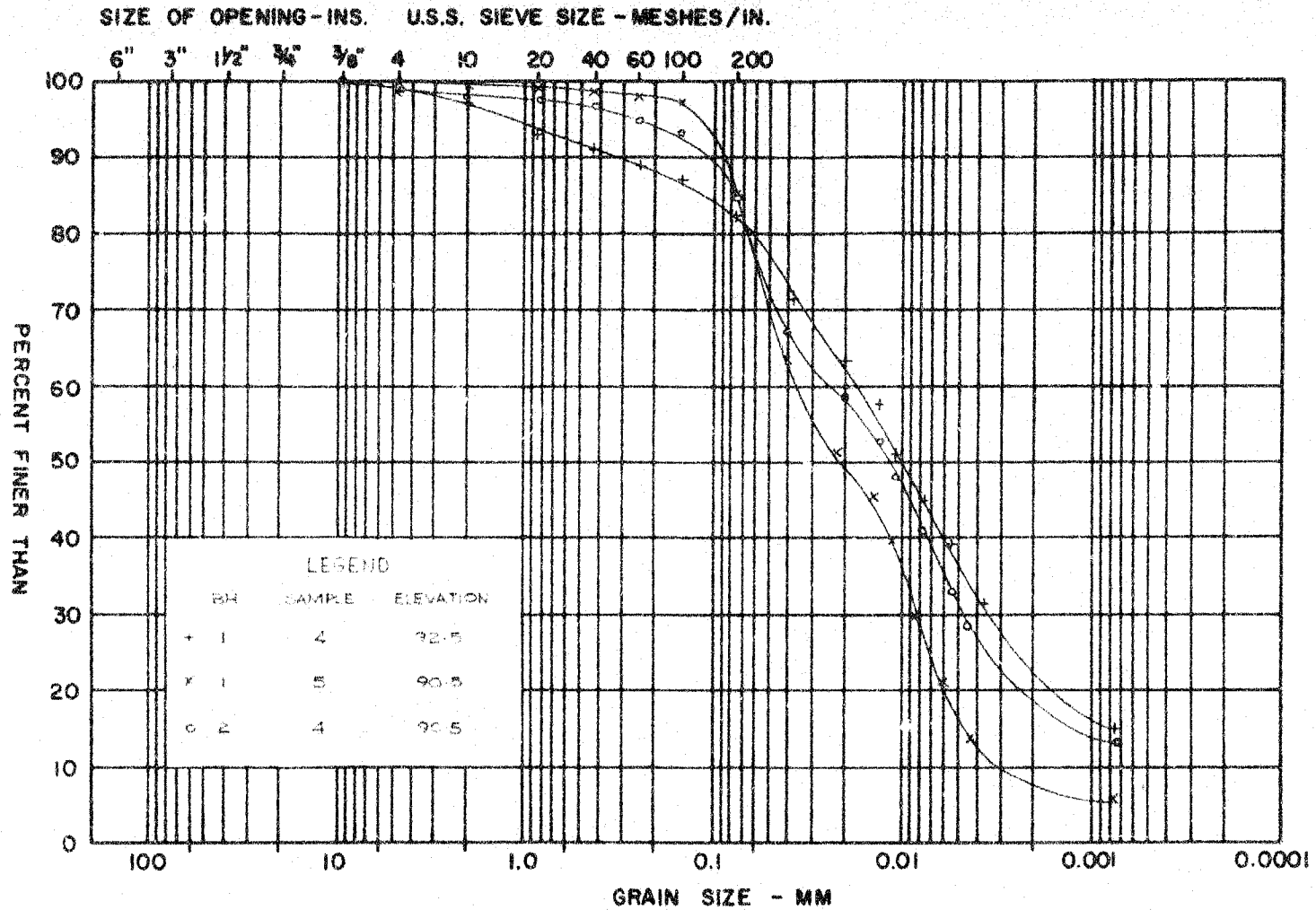
M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.





## M.I.T. GRAIN SIZE SCALE



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GRAIN SIZE DISTRIBUTION  
CLAYEY SILT TILL

FIGURE 3

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