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GEOCRES No. 31 G - 51

W.P. No. _____

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W. O. No. _____

STR. SITE No. 3 - 145

HWY. No. _____

LOCATION REG. RD. 8 &
MUD CREEK, BRIDGE,
NEPEAN TWP.

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. NONE

REMARKS: _____

31G-51
GEOCRES No.

THE REGIONAL MUNICIPALITY OF
OTTAWA-CARLETON

SOIL INVESTIGATION

PROPOSED MUD CREEK BRIDGE
SITE NO. ~~1782~~

3-145

REGIONAL RD. NO.8 NEPEAN TWP.

Distribution:

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May, 1970

70758D

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SOIL AND FOUNDATION ENGINEERS

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May 27, 1970.

The Regional Municipality of Ottawa-Carleton,
233 Gilmour Street,
Ottawa 4, Ontario.

Attention: Mr. G. F. Wetherall, P. Eng.
Roads Commissioner.

RE: SOIL INVESTIGATION,
PROPOSED MUD CREEK BRIDGE,
REGIONAL RD. NO.8, SITE NO.1782,
NEPEAN TWP., ONTARIO.

3-145

Dear Sirs:

This letter reports the results of an investigation carried out at the bridge crossing of Mud Creek by Regional Road No.8 in Nepean Township, about 1 mile west of Manotick, Ontario. The purpose of the investigation was to determine the subsoil and groundwater conditions at the site, and, based on this information, to make recommendations for the foundation design and construction of a proposed replacement structure.

PROCEDURE

The field work for this structure was carried out between April 28 and 30, 1970. Two boreholes, one each at the east and west abutment locations of the proposed bridge, were put down using a machine drillrig supplied and operated by the F. E. Johnston Drilling Co. Ltd., Ottawa. Standpipes were installed in the boreholes to measure the groundwater level at the site. The field work was supervised throughout by a member of our engineering staff.

The locations of the borings, together with a stratigraphic

section along the centerline of the proposed bridge, are shown on Fig. 1. A detailed log of each borehole is given on the Record of Borehole sheets following the text of this report.

The soil samples were brought to our laboratory for detailed examination. Laboratory testing of representative samples of the overburden at the site was carried out by the Testing Laboratory of the Regional Municipality of Ottawa-Carleton. The results of this testing are shown on Figs. 2 and 3, as well as on the Record of Borehole sheets.

The elevations given in this report are referred to a nail in a tree, 50 feet right of station 1+70. The elevation of this bench mark was given to us as 500.00, as referred to a local datum.

SITE AND GEOLOGY

The site is located at the crossing of Mud Creek by Regional Road No. 8, about 1 mile west of Manotick, Ontario. The topography of the area is fairly flat and Mud Creek has eroded a narrow channel, some 20 feet below the general ground surface elevation.

From available geological information it is known that the site is within the physiographic region known as the Ottawa Valley clay plains. The underlying bedrock is limestone of the Oxford formation.

SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in the boreholes is given on the Record of Borehole sheets and is illustrated on the stratigraphic section on Fig. 1. Following is a summarized account of the subsurface conditions at the site.

The boreholes were put down through the existing approach embankments which were found to consist mainly of brown silty clay. In borehole 1, the clay fill was overlain by 4 ft. of silty sand fill.

The west embankment fill at the location of borehole 1 is underlain by a alluvial deposit of silty sand. The silty sand contains some brown organic material and some pieces of wood. The

thickness of this alluvial deposit at borehole 1 was 7 feet and it extends to some 5 feet below creek bed level.

At borehole 2, put down through the east approach embankment, the fill is underlain by about 10 feet of firm to stiff clayey silt. The clayey silt exists to about 5 feet below creek bed level. The upper 3 feet of the clayey silt has been weathered to a stiff brown crust. An unconfined compression test on a sample of the clayey silt from the upper part of the layer gave a shear strength of 1,250 lb/sq.ft. An in situ vane test carried out a few feet below this tested sample gave a shear strength of 960 lb/sq.ft. The consistency of the layer is considered to be stiff near the stratum surface, decreasing to firm with depth.

The clayey silt and the alluvium layers are underlain by a stratum of silty sand till. The boreholes were terminated within this till stratum after penetrating to a maximum depth of 46 feet below existing roadway grade. A grading test was carried out on a representative sample of the silty sand till and the results are shown on Fig. 2. A fine sand layer some 7 ft. thick was encountered within the till in borehole 1 at a depth of 26 feet below roadway grade. The results of a grading test on a sample of this fine sand are shown on Fig. 3. The relative density of the till is compact near the surface (N values of 14, 17 and 21) and becomes very dense with depth (N values in excess of 100 blows/ft.).

The water level in Mud Creek at the time of the investigation was at about local elevation 483. The water level in the boreholes was some 4 feet above the water level in the creek.

PROPOSED BRIDGE STRUCTURE

a) General

The original concrete bridge structure has been subsequently widened towards the north to near standard width. At the east abutment, the widened portion has separated from the original construction. This north portion of the bridge appears to have settled differentially to the original bridge. There is a lateral crack in the pavement above the entire width of the east abutment. The 30 foot span structure is to be replaced with a 56 foot span, simply supported structure, employing concrete beams. The existing grade is to be maintained across the bridge structure.

b) Foundations

The alluvial sand deposit which exists at the west abutment location contains organic material and is an unsuitable bearing material. The silty clay stratum at the east abutment, which is of limited shear strength, would have an allowable bearing value of only about 2,000 lb/sq.ft., which is considered too low to support the abutment loading. It is therefore recommended that the foundation loads be transferred to the underlying silty sand till stratum.

1, Spread Footings

Compact silty sand till exists at about 6 feet below proposed founding level. Based on the N values obtained near the surface of the till which ranged from 14 to 21 blows/ft., an allowable bearing pressure of 4,000 lb/sq.ft. could be used in design of spread footings, provided that the subsoil is not loosened during construction as discussed below. Depending on the groundwater level at the time of construction, the excavations for the abutment footings will be some 5 to 10 feet below the hydrostatic level in the till. Some control of the groundwater will therefore be required for spread footing excavations in this granular soil to prevent a reduction of the in situ density, and therefore the allowable bearing capacity, of the subsoil at and below foundation level. This control could be obtained by excavation within a steel sheet piled cofferdam, the sheeting being driven to a penetration below final excavation grade equal to the depth of the excavation below the water level.

11) Piles

An alternative to spread footing design would be the use of short displacement piles driven closed ended to refusal in the very dense till at about 15 to 20 ft. below creek bed level. For an allowable load of 60 tons for a 12 inch diameter pile, a final penetration of 1 inch under 10 blows using a hammer energy of at least 20,000 ft.lb. per blow can be used as a criterion for design.

Closed end abutments should be backfilled for a distance of at least 5 feet horizontally with a well compacted, free draining and non-frost-susceptible granular material. Provision should be made for drainage from this backfill to prevent hydrostatic or ice pressure build up behind the walls. With full effective drainage of the backfill, the abutments may be designed using a total unit

weight of 135 lb/cu.ft. and a coefficient of lateral earth pressure at rest, K_o , = 0.4. If some minor movement of the top of the abutment wall can be tolerated, an active earth pressure coefficient, K_a , = 0.3 may be used.

c) Approach Embankments

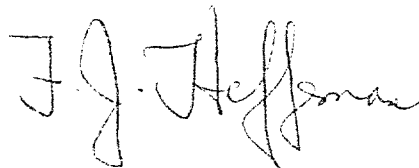
The existing embankments are founded on sandy alluvium at the west abutment and firm to stiff silty clay at the east abutment. The existing grade is to be maintained and some minor widening of the embankment will take place. The roadway grade is some 12 feet above the creek bed. Due to the granular nature of the alluvium and the firm strength of the clayey silt layer (about 1,000 lb/sq.ft.) the stability of the proposed embankments is considered adequate.

There will be little increase in loading on the alluvium and clayey silt layers due to embankment widening and only minor settlement of the embankments is anticipated.

We trust that this report contains sufficient information for your design purposes. If we can be of any further assistance to you on this project, please call us.

Yours very truly,

H. Q. GOLDER & ASSOCIATES LTD.



F. J. Heffernan, P. Eng.

FJH/ml
70758D
May, 1970.



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

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

(b) Cohesive Soils

<i>Consistency</i>	<i>c_u, lb./sq. ft.</i>
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 hydrometer¹
Q undrained triaxial²
R consolidated undrained triaxial²
S drained triaxial
U unconfined compression
V field vane test

NOTES:

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

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

LIST OF SYMBOLS

I. GENERAL

π	= 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 = cv/d^2 (d , drainage path)
U	degree of consolidation

(e) Shear strength

τ_f	shear strength
c'	effective cohesion
ϕ'	effective angle of shearing resistance, or friction
c_u	apparent cohesion*
ϕ_u	apparent angle of shearing resistance, or friction
μ	coefficient of friction
S_f	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

DATUM LOCAL

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

BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.				COEFFICIENT OF PERMEABILITY, K, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	ELEV'N DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS/FT.		20 40 60 80				1x10 1x10 1x10 1x10					
								SHEAR STRENGTH Cu, LB./SQ.FT.				WATER CONTENT, PERCENT NAT. V. - + C. - \oplus REM V. - \ominus U. - O					
WASH BORING BX	492.8 0.0	GROUND SURFACE					495									GROUND SURFACE	
		VERY LOOSE BROWN SILTY SAND, TRACE OF GRAVEL CHANGING AT 4.5' DEPTH TO FIRM BROWN SILTY CLAY, SOME SAND AND GRAVEL (EMBANKMENT FILL)		1	2	2	490										
				2	"	5	485										
	483.9 9.0	VERY LOOSE GREY SILTY SAND, SOME ORGANIC MATERIAL AND WOOD, TRACE OF CLAY (ALLUVIUM)		3	"	3	480										
				4	"	3	475										
	476.7 16.2	COMPACT TO DENSE GREY SILTY SAND, SOME GRAVEL TRACE OF CLAY (SILTY SAND TILL)		5	"	4	470										
				6	"	17	465										
	466.9 26.0	VERY DENSE GREY FINE SAND, SOME SILT TRACE OF GRAVEL		7	"	53	460										
				8	"	>100	455										
	459.9 33.0	VERY DENSE GREY SILTY SAND, SOME GRAVEL, TRACE OF CLAY (SILTY SAND TILL)		9	"	>100	450										
				10	"	>100	445										
446.7 46.2	END OF HOLE		11	"	>100												

DRAWN D.N.
CHECKED E.H.

RECORD OF BOREHOLE 2

LOCATION See Figure 1

BORING DATE APRIL 30, 1970

DATUM LOCAL

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

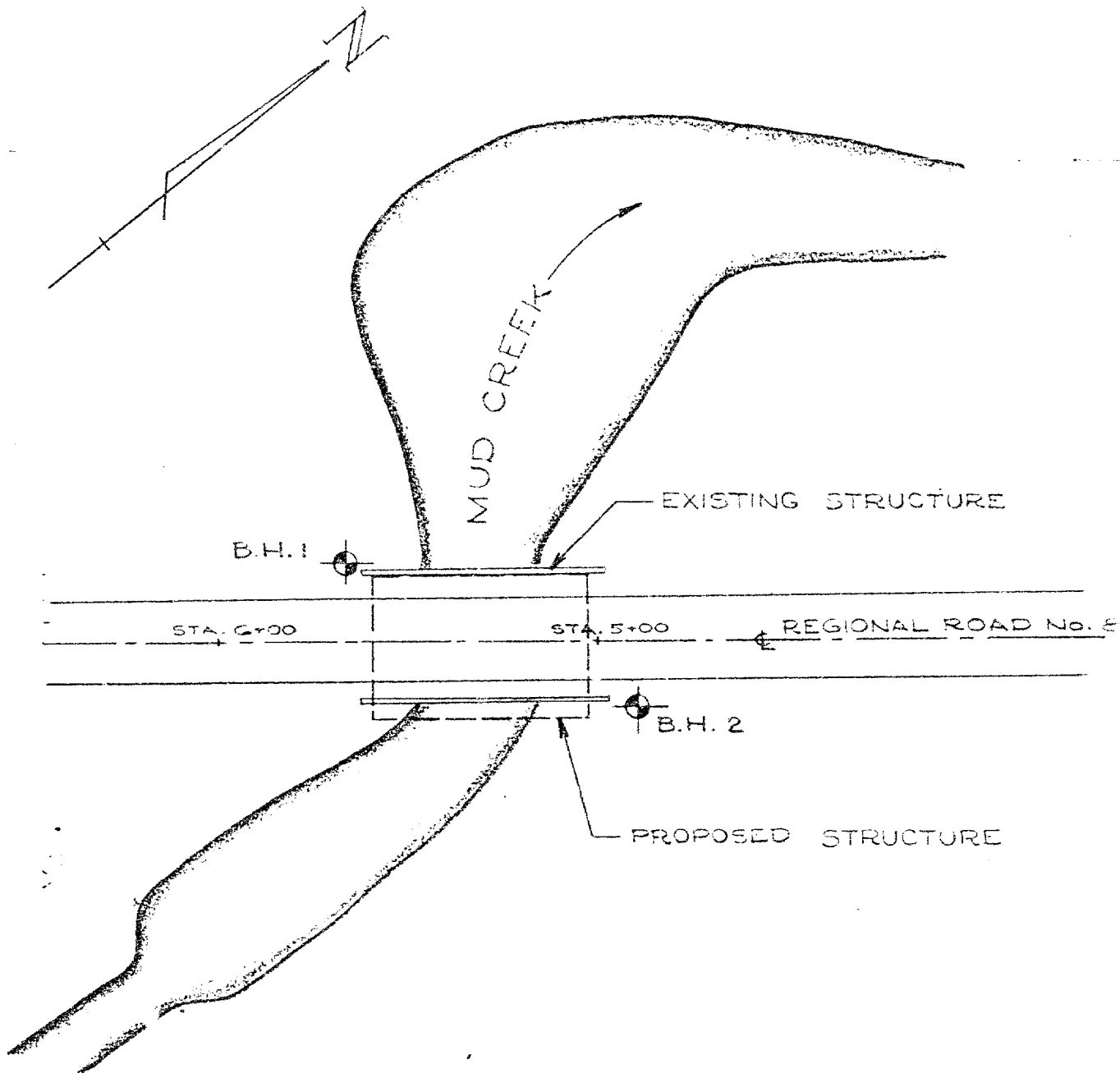
BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.				COEFFICIENT OF PERMEABILITY, K, CM./SEC.				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
	ELEV'N DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE		BLOWS/FT	SHEAR STRENGTH Cu, LB./SQ FT.				WATER CONTENT, PERCENT					
								20	40	60	80	1x10	1x10	1x10			1x10
WASH BORING NX CASING							STA. 4+90, 18' LT.										
	493.4	GROUND SURFACE														GROUND SURFACE	
	492.4	BROWN SAND AND GRAVEL (FILL)		1	2"	3											
	490.0	FIRM BROWN SILTY CLAY, SOME SAND, TRACE OF ROOTS AND ORGANIC MATERIAL (EMBANKMENT FILL)		2	"	3											
	484.0			3	"	8											
	480.0	FIRM TO STIFF BROWN TO GREY CLAYEY SILT WITH SOME SAND, TRACE OF ROOTS		4	2"	PM										PLASTIC TUBING	
	475.4			5	2"	7											
	470.0			6	"	21											
	465.0	COMPACT TO VERY DENSE GREY SILTY SAND, SOME GRAVEL, TRACE OF CLAY (SILTY SAND TILL)		7	"	103										STANDPIPE	
	458.9	END OF HOLE		1	"	103											
																W.L. IN STANDPIPE AT ELEV. 487.6 APRIL 30, 1970	

0
15
10
Percent axial strain at failure

VERTICAL SCALE
1 IN. TO 5 FT.

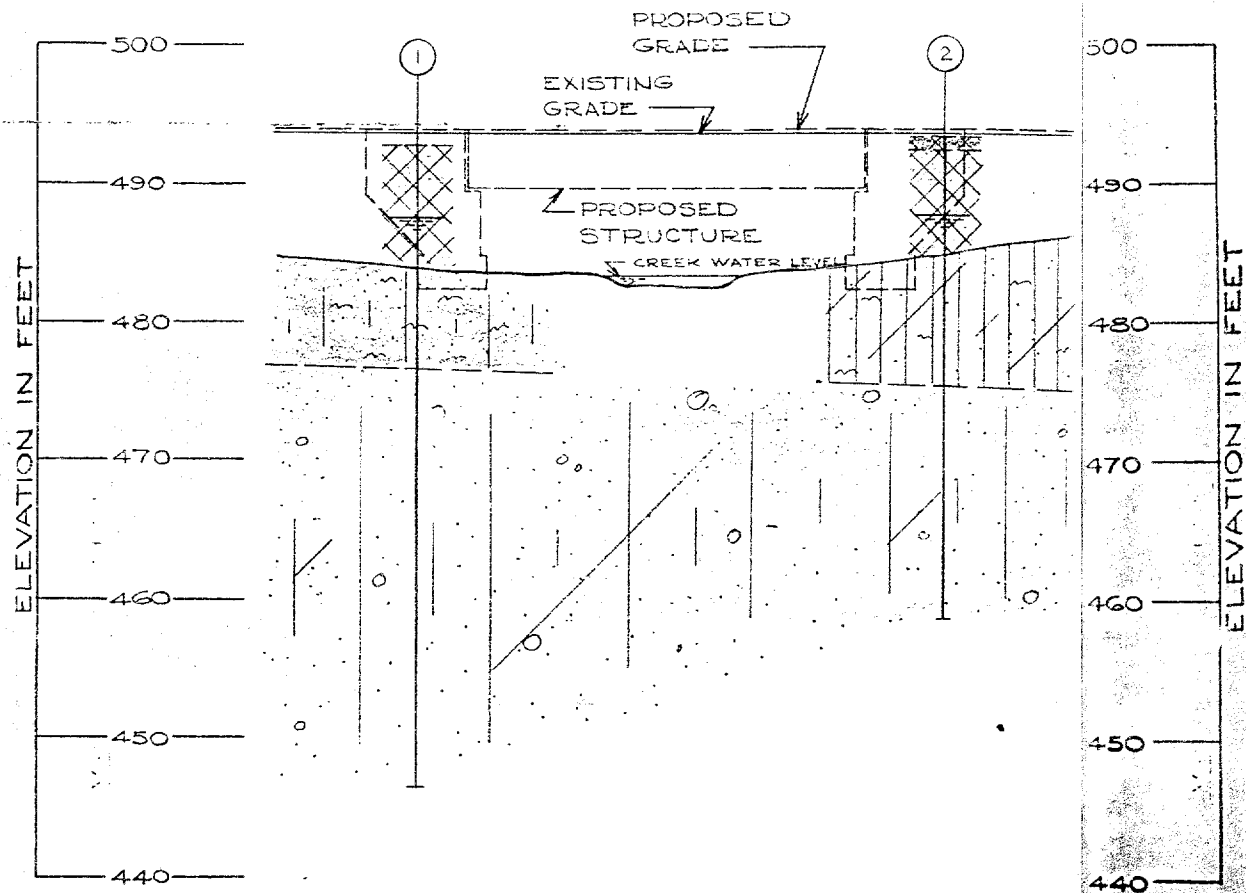
Golder Associates

DRAWN D.N.
CHECKED S.Y.



PLAN

SCALE: 1" To 40'



SECTION ALONG \perp ROAD

SCALE: HOR. 1" TO 20'
VER. 1" TO 10'



STRATIGRAPHY

BROWN SAND AND GRAVEL (FILL)



VERY LOOSE BROWN SILTY SAND,
TRACE OF GRAVEL AND FIRM BROWN
SILTY CLAY, SOME SAND, TRACE OF
ROOTS AND ORGANIC MATERIAL
(EMBANKMENT FILL)



VERY LOOSE GREY SILTY SAND, SOME
ORGANIC MATERIAL AND WOOD, TRACE
OF CLAY (ALLUVIUM)



FIRM TO STIFF BROWN TO GREY CLAYEY
SILT WITH SAND, TRACE OF ROOTS



COMPACT TO VERY DENSE GREY SILTY
SAND, SOME GRAVEL TRACE CLAY WITH
LAYERS OF FINE SAND
(SILTY SAND TILL)

LEGEND

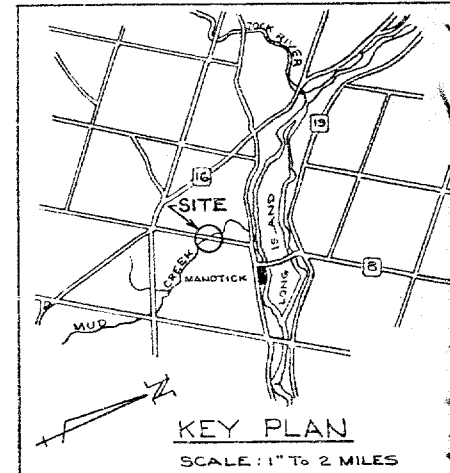
BOREHOLE IN PLAN



BOREHOLE IN ELEVATION



WATER LEVEL IN ELEVATION
AT TIME OF INVESTIGATION

REFERENCES:

STRUCTURE No. 1782, REGIONAL
SURVEY PLAN AND PROFILE
DRAWING No. B-178201, DATED
AND PRELIMINARY DESIGN
DATED JAN. 22, 1970, SUPPLY
THE REGIONAL MUNICIPALITY OF
OTTAWA-CARLETON, ROAD

NOTE

Data concerning the various strata have been obtained from borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and may vary from that shown.

For detailed stratigraphy at each borehole location refer to the record of borehole sheets.

Date MAY 25, 1970

Golder Associates

ELEVATION IN FEET

STRATIGRAPHY

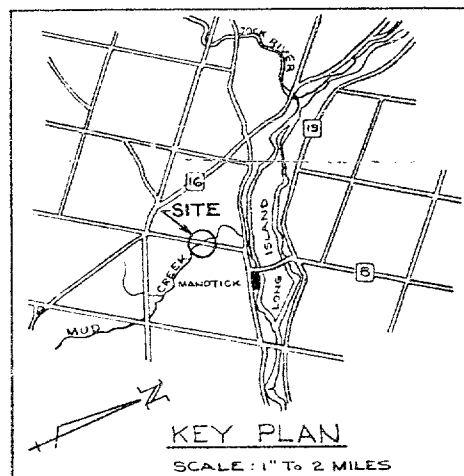
IN SAND AND GRAVEL (FILL)

LOOSE BROWN SILTY SAND,
E OF GRAVEL AND FIRM BROWN
CLAY, SOME SAND, TRACE OF
S AND ORGANIC MATERIAL
(ANKMENT FILL)

LOOSE GREY SILTY SAND, SOME
NIC MATERIAL AND WOOD, TRACE
AY (ALLUVIUM)

TO STIFF BROWN TO GREY CLAYEY
WITH SAND, TRACE OF ROOTS

ACT TO VERY DENSE GREY SILTY
, SOME GRAVEL TRACE CLAY WITH
RS OF FINE SAND
TY SAND TILL)

LEGEND

CHOLE IN PLAN

CHOLE IN ELEVATION

ER LEVEL IN ELEVATION
IME OF INVESTIGATION

REFERENCES:

STRUCTURE No. 1782, REGIONAL ROAD No. 8
SURVEY PLAN AND PROFILE
DRAWING No. B-178201, DATED JAN. 22, 1970
AND PRELIMINARY DESIGN SCHEME I
DATED JAN. 22, 1970, SUPPLIED BY
THE REGIONAL MUNICIPALITY OF
OTTAWA-CARLETON, ROADS DEPARTMENT

NOTE

Data concerning the various strata have been obtained at
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boreholes has been inferred from geological evidence and so
may vary from that shown.

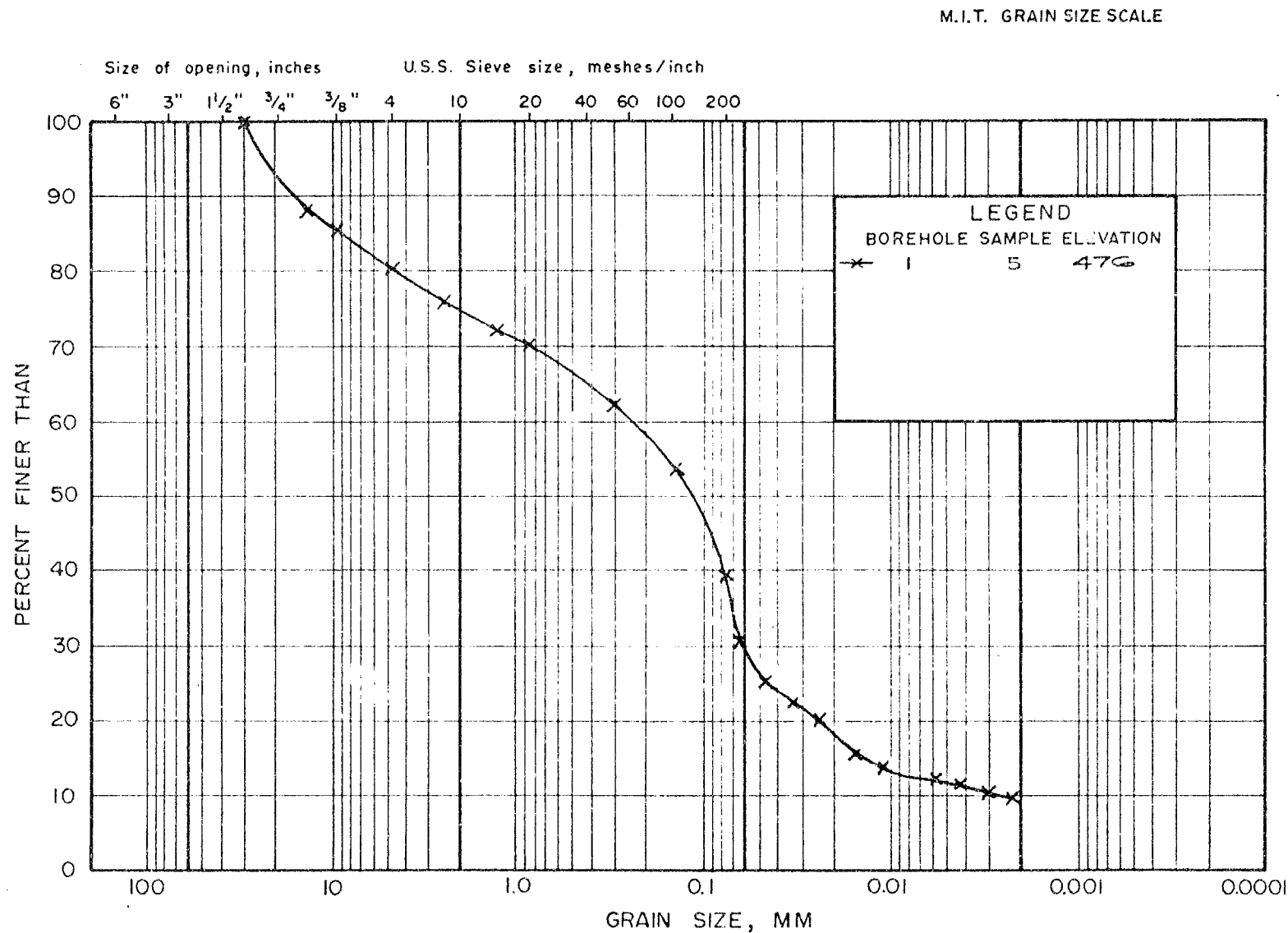
For detailed stratigraphy at each borehole location refer
to the record of borehole sheets.

Date MAY 25, 1970

Goldr Associates

Drawn D.N.
Chkd. J.F.
Appd. J.F.

Golder Associates



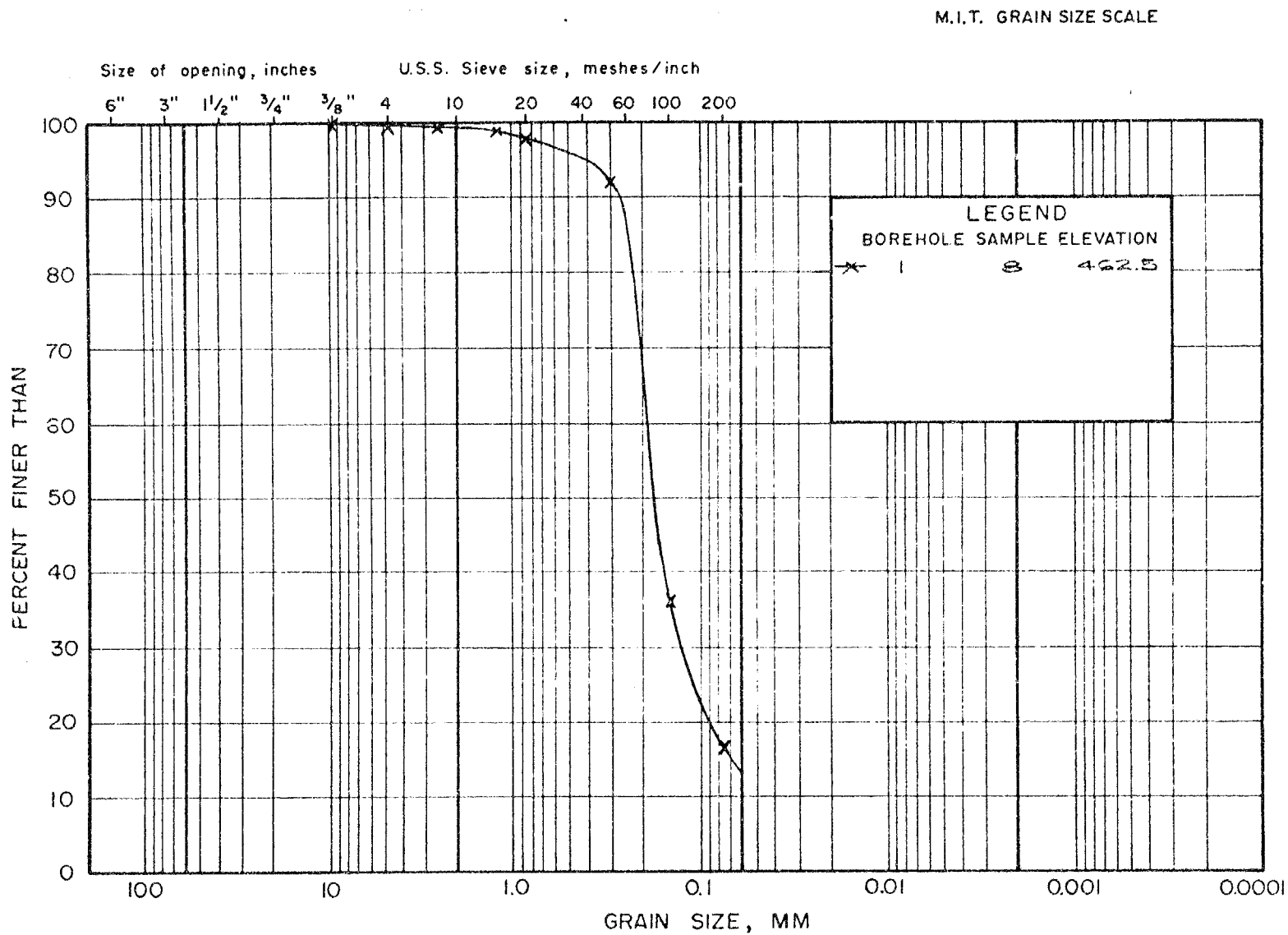
SILTY SAND TILL

GRAIN SIZE DISTRIBUTION

FIGURE 2

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

Golder Associates



FINE SAND, SOME SILT

GRAIN SIZE DISTRIBUTION

FIGURE 3

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