

# 66-F-228

W.P. # 182-66-2

HWY. NO. 2 ,

LAKE ERIE &

NORTHERN

RAILWAY SUBWAY



Mr. B. S. Davis,  
Bridge Engineer,  
Bridge Division.

Foundation Section,  
Materials & Testing Div.,  
Room 107, Lab. Bldg.

Attention: Mr. E. McCombie

October 26, 1966

**OCT 26 1966**

FOUNDATION INVESTIGATION REPORT FOR D.E.O.  
BY: H. Q. Golder and Associates Limited -  
Proposed Lake Erie and Northern Railway Subway,  
Bay. No. 2, Paris, Ontario, Dist. No. 4 (Hamilton)  
W.P. 182-66-2

Attached, please find the above mentioned report prepared and submitted by the consultant, H. Q. Golder and Associates Ltd.

We have reviewed the report and have found the factual information adequate and well presented.

The recommendations are clear and straightforward, and should enable you to continue your further design work.

However, should you wish to discuss any question connected with this project, please feel free to contact this Office.

AGS/446P

Attach.

cc: Messrs. B. S. Davis (2)  
H. A. Tregaskes  
J. E. Farran  
G. K. Hunter (2)  
E. Greenland  
W. S. Melinysky  
I. J. Kovlen  
A. Watt

Foundations Office ✓  
Gen. Files

*Althman*  
A. G. Sternas,  
PRINCIPAL FOUNDATION ENGINEER

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS  
HEAD OFFICE - TORONTO, ONTARIO

H. Q. GOLDER  
V. MILLIGAN  
L. G. SODERMAN  
J. L. SEYCHUK

747 HYDE PARK ROAD  
LONDON, ONTARIO  
471-9600

June 8, 1967.

Department of Highways,  
Materials and Testing Division,  
Highway 401 and Keele St.,  
DOWNSVIEW, Ontario.

ATTENTION: Mr. A. G. Stermac, P.Eng.

RE: Soils Investigation  
Proposed Railway Subway,  
Paris, Ont., WP No. 182-66-2

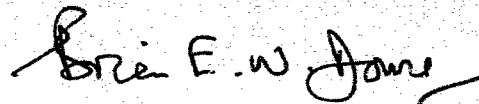
Dear Sirs:

Since completion of the subsurface investigation at the above site, the soil samples have been stored in our London laboratory.

We shall be disposing of these samples at the end of June 1967, and if you have further use for them, please contact our office or arrange to have them picked up at our office before this date.

Yours truly,

H. Q. GOLDER & ASSOCIATES LTD.,



Brian E. W. Dowse, P. Eng.

BEWD:cmm  
66515

**H. Q. GOLDER & ASSOCIATES LTD.**

CONSULTING CIVIL ENGINEERS

H. Q. GOLDER  
V. MILLIGAN  
L. G. SODERMAN  
J. L. SEYCHUK

2444 BLOOR STREET WEST  
TORONTO 9, ONTARIO  
763-4103  
767-9201

May 10, 1967.

Wyllie & Ufnal Limited,  
Consulting Engineers,  
1 Greensboro Drive,  
Rexdale, Ontario.

Attention: Mr. D.C. Batchelor, P. Eng.

RE: L.E. & N.E. RAILWAY SUBWAY,  
HIGHWAY 2,  
PARIS, ONTARIO.

Dear Sirs:

As requested by Mr. A.G. Sternac, Principal Foundations Engineer, Department of Highway, Ontario, we have forwarded to you today under separate cover, 2 additional copies of our report 66515, dated October, 1966, covering the foundation investigation for the above project.

Yours truly,

H.Q. GOLDER & ASSOCIATES LTD.,



J.L. Seychuk, P. Eng.

JLS/jc  
66515

Copy: Mr. A.G. Sternac, P. Eng. ✓  
Department of Highways, Ontario.

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS  
HEAD OFFICE - TORONTO, ONTARIO

H. Q. GOLDER  
V. MILLIGAN  
L. G. SODERMAN  
J. L. SEYCHUK

W.P. 182-66-2

747 HYDE PARK ROAD  
LONDON, ONTARIO  
471-9600

REPORT

TO

DEPARTMENT OF HIGHWAYS, ONTARIO

ON

SOIL CONDITIONS AND FOUNDATIONS

PROPOSED LAKE ERIE AND NORTHERN RAILWAY SUBWAY

HIGHWAY NO. 2

PARIS

ONTARIO

Distribution:

- 12 copies - Department of Highways, Ontario,  
Toronto, Ontario
- 2 copies - H. Q. Golder & Associates Ltd.,  
London, Ontario

October, 1966

66515

# TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	2
PROCEDURE	2
SITE AND GEOLOGY	3
SUBSOIL CONDITIONS	4
GROUNDWATER CONDITIONS	6
DISCUSSION	
General	6
Foundations	7
Approach Embankments	8
ABBREVIATIONS	In Order Following Page 8
RECORD OF BOREHOLES	
FIGURES 1	- Boring Plan and Soil Stratigraphy Section
2	- Grain Size Distribution Curve

### ABSTRACT

The results of an investigation to determine the subsurface conditions at the site of the proposed relocation of the Lake Erie and Northern Railway bridge over Highway No. 2 at Paris, Ontario are reported. Recommendations are made for the foundation design of the proposed structure and south approach embankment.

It was found that the site is underlain by 35 to 40 feet of dense rounded gravel over a hard clayey till. Groundwater is greater than 30 feet below ground surface.

It is recommended that the abutments be founded on spread footings at least 5 feet below ground surface with an allowable bearing pressure of 4 tons per square foot.

The south embankment may be safely widened with side slopes of 2 horizontal to 1 vertical providing all top soil and loose material is completely removed before construction commences.

No groundwater problems are anticipated during construction.



## INTRODUCTION

H. Q. Golder & Associates Ltd. have been retained by the Department of Highways, Ontario, to carry out a soil investigation for the proposed relocation of the Lake Erie and Northern Railway bridge over Highway No. 2 at Paris, Ontario. The purpose of this investigation was to determine the subsoil and ground-water conditions at the site and to provide information for the foundation design of the proposed structure.

## PROCEDURE

The field work for this investigation was carried out from September 15 to 26, 1966. Two boreholes were put down using a diamond machine drillrig supplied and operated by F. E. Johnston Drilling Company Limited, Toronto. Both borings were taken down to about 40 feet below ground surface and water level observation tubes installed in each of the borings following their completion.

A detailed log for each boring is given on the Record of Boreholes following the text of this report. The location of the borings together with sections of the inferred soil stratigraphy are shown on Figure 1.

Samples obtained during the investigation were brought to our laboratory for detailed examination and testing. The results of the laboratory testing are shown on the Record of Boreholes and on Figure 2.

The elevations of the ground surface at each borehole were supplied by the Department of Highways, Ontario and it is understood that they are referred to Geodetic datum.

#### SITE AND GEOLOGY

The Lake Erie and Northern Railway presently crosses Highway No. 2 on a two span steel girder bridge just east of the bridge over the Grand River in the Town of Paris, Ontario. At the location of the existing railway bridge, Highway No 2 is in cut some 20 feet below surrounding ground level forming the eastern approach to the Grand River bridge. The side slopes of the existing cut have been constructed at  $1\frac{1}{2}$  horizontal to 1 vertical and appear to be quite stable.

Based on available geological information it is known that this area forms part of the Grand River spillway system. Recent excavations and gravel pits on the east bank

of the Grand River in the vicinity of the site under investigation indicate the area to be underlain by an extensive gravel deposit, probably being a river terrace deposited during the final retreat of the ice sheets when the Grand River flowed at a higher level. Deep well drilling records in the area indicate these gravels to be underlain by sands. The bedrock in the area is reported to be dolomites and shales of the Salina Formation and occur at depths of greater than 100 feet below ground surface.

#### SUBSOIL CONDITIONS

The detailed stratigraphy encountered in the two boreholes is shown on the Record of Borehole sheets. The stratigraphy interpolated from this data is presented on Figure 1.

The borings indicate the significant stratum at the site is a dense rounded gravel with some silt and sand matrix and occasional cobbles which extended to depths of approximately 35 and 45 feet in boreholes 1 and 2 respectively. Grading curves for the samples obtained using 1½ inch internal diameter sampling equipment are presented as Figure 2.

Due to the limitations of the sampling equipment obviously this only represents the finer fraction of the material adequately. Visual inspection of adjacent gravel pits and pieces of cored gravel and cobbles would indicate that approximately 85 per cent of the material is greater than  $\frac{1}{2}$  inch diameter and that approximately 5 per cent is silt and clay sizes. Based on the results of the standard penetration tests and the resistance to driving of the casing the relative density of this material is considered to be very dense.

The lower  $5\frac{1}{2}$  feet of the gravel appeared to be cemented with calcium carbonate which was partially lost during the drilling operation. This cemented strata does not appear to be continuous across the site as it was not intersected in borehole 2.

The gravel is underlain by a hard clayey till that was intersected in borehole 1. Due to difficulties in drilling through the overlying cobbles, the casing had to be telescoped to Ax size thereby preventing standard sampling. However a modified 1 inch diameter sampler indicated a till of hard consistency.

### GROUNDWATER CONDITION

A perforated standpipe was installed in each borehole following completion of the boring to determine the groundwater level. Details of these installations are given on the Record of Boreholes.

Groundwater observations during drilling and up to two weeks after the completion of drilling indicated the subsoil to be dry to the bottom of the observation tubes.

### DISCUSSION

#### General

It is understood that the existing two span bridge over Highway No. 2 is to be replaced by a relocated single 100 feet clear span structure. The railway alignment is to be offset some 25 feet east of the present railway centreline necessitating the reconstruction of the approach embankment at the south abutment.

### Foundations

The abutments of the proposed relocated bridge may be safely founded on the dense gravel with an allowable bearing pressure of 4 tons per square foot. The foundations should also be at least 5 feet below final ground surface to provide adequate protection against frost action. The settlement of the abutments founded in this manner should be negligible providing the in situ density of the subsoil at or below founding level is not reduced during excavation and construction.

The natural ground-water table is well below the founding level and therefore there should be no problems of water seepage into the excavations.

If retaining type abutments are used, it is recommended that free-draining and non-frost susceptible granular backfill be used behind the abutments. The granular backfill should be compacted in horizontal thin layers and should extend horizontally from the back face of the abutment walls for a minimum distance of 6 feet. A maximum loose layer of 18 inches may be used providing vibratory equipment is used for compaction. It is recommended that, providing there is

effective drainage behind the walls, a co-efficient of earth pressure at rest,  $K_0$ , of 0.4 and a total unit weight,  $\gamma$ , of 135 lb./cu.ft. be used for the compacted granular backfill in the design of the walls.

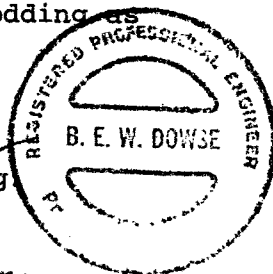
#### Approach Embankments

The relocation of the railway to the east of the existing structure will necessitate the construction of a short approach embankment to the south of the new structure butting onto the existing embankment. The embankment may be constructed using side slopes of 2 horizontal to 1 vertical providing all topsoil and loose material is removed from the side of the existing slopes and the fill is compacted to 95 per cent of Standard Proctor maximum density under conditions of controlled water content.

To prevent surface water erosion and gullyng of the embankment slopes, provision should be made for sodding as soon as possible after construction.

*B. E. W. Dowse*  
B. E. W. Dowse, P.Eng.

*L. G. Soderman*  
L. G. Soderman, P.Eng.



BEWD:mr  
66515

**GOLDER & ASSOCIATES**

## 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

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

<i>WH</i>	sampler advanced by static weight—weight, hammer
<i>PH</i>	sampler advanced by pressure—pressure, hydraulic
<i>PM</i>	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<sub>u</sub>, 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

<i>C</i>	consolidation test
<i>H</i>	hydrometer analysis
<i>M</i>	sieve analysis
<i>MH</i>	combined analysis, sieve and hydrometer <sup>1</sup>
<i>Q</i>	undrained triaxial <sup>2</sup>
<i>R</i>	consolidated undrained triaxial <sup>2</sup>
<i>S</i>	drained triaxial
<i>U</i>	unconfined compression
<i>V</i>	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 = $c_d / d^2$ ( $d$ , drainage path)
$U$	degree of consolidation

#### (e) Shear strength

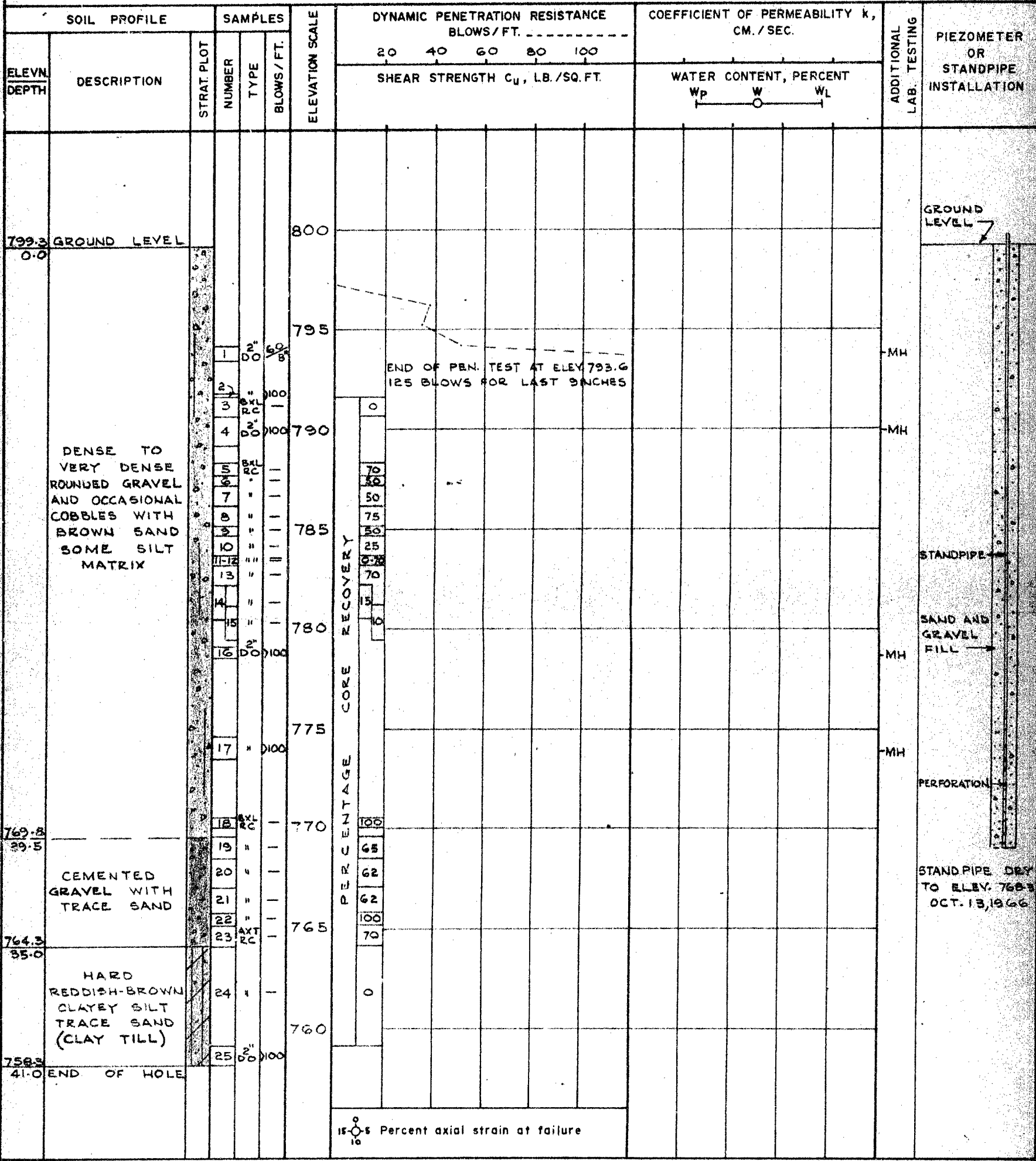
$\tau_f$	shear strength
$c'$	effective cohesion intercept
$\phi'$	effective angle of shearing resistance, or friction
$c_u$	apparent cohesion*
$\phi_u$	apparent angle of shearing resistance, or friction
$\mu$	coefficient of friction
$S_f$	sensitivity

$\left. \begin{array}{l} c' \\ \phi' \end{array} \right\} \begin{array}{l} \text{in terms of effective stress} \\ \tau_f = c' + \sigma' \tan \phi' \end{array}$   
 $\left. \begin{array}{l} c_u \\ \phi_u \end{array} \right\} \begin{array}{l} \text{in terms of total stress} \\ \tau_f = c_u + \sigma \tan \phi_u \end{array}$

\*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 SEPT. 15 - 23, 1966 DATUM GEODETIC  
BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER NX CASING  
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES



## RECORD OF BOREHOLE 2

LOCATION See Figure 1

BORING DATE SEPT. 23 &amp; 26, 1966

DATUM GEODETIC

BOREHOLE TYPE WASH BORING

BOREHOLE DIAMETER NX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES

PEN. TEST HAMMER WEIGHT — LB. DROP — INCHES

SOIL PROFILE		SAMPLES		ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----	COEFFICIENT OF PERMEABILITY K, CM./SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	BLOWS/FT.	WATER CONTENT, PERCENT Wp      W      WL		
798.0	GROUND LEVEL								
0.0									
			1	2"	25				
			2	"	55				
			3	"	>100				
			4	"	>100				
			5	"	>100				
			6	"	>100				
			7	"	>100				
			8	"	>100				
			9	BXL RC	—				
			10	2"	>100				
			11	AX CA	—				
758.5	END OF HOLE								
39.5									

COMPACT TO VERY DENSE BELOW ELEV. 792.0  
ROUNDED GRAVEL AND OCCASIONAL COBBLES WITH BROWN SAND SOME SILT MATRIX

PERCENT CORREL. RECOVERY

30

33

15-10-5 Percent axial strain at failure

GROUND LEVEL

STANDPIPE

SAND AND GRAVEL FILL

PERFORATION

STANDPIPE DRY TO ELEV. 759.3  
OCT. 13, 1966

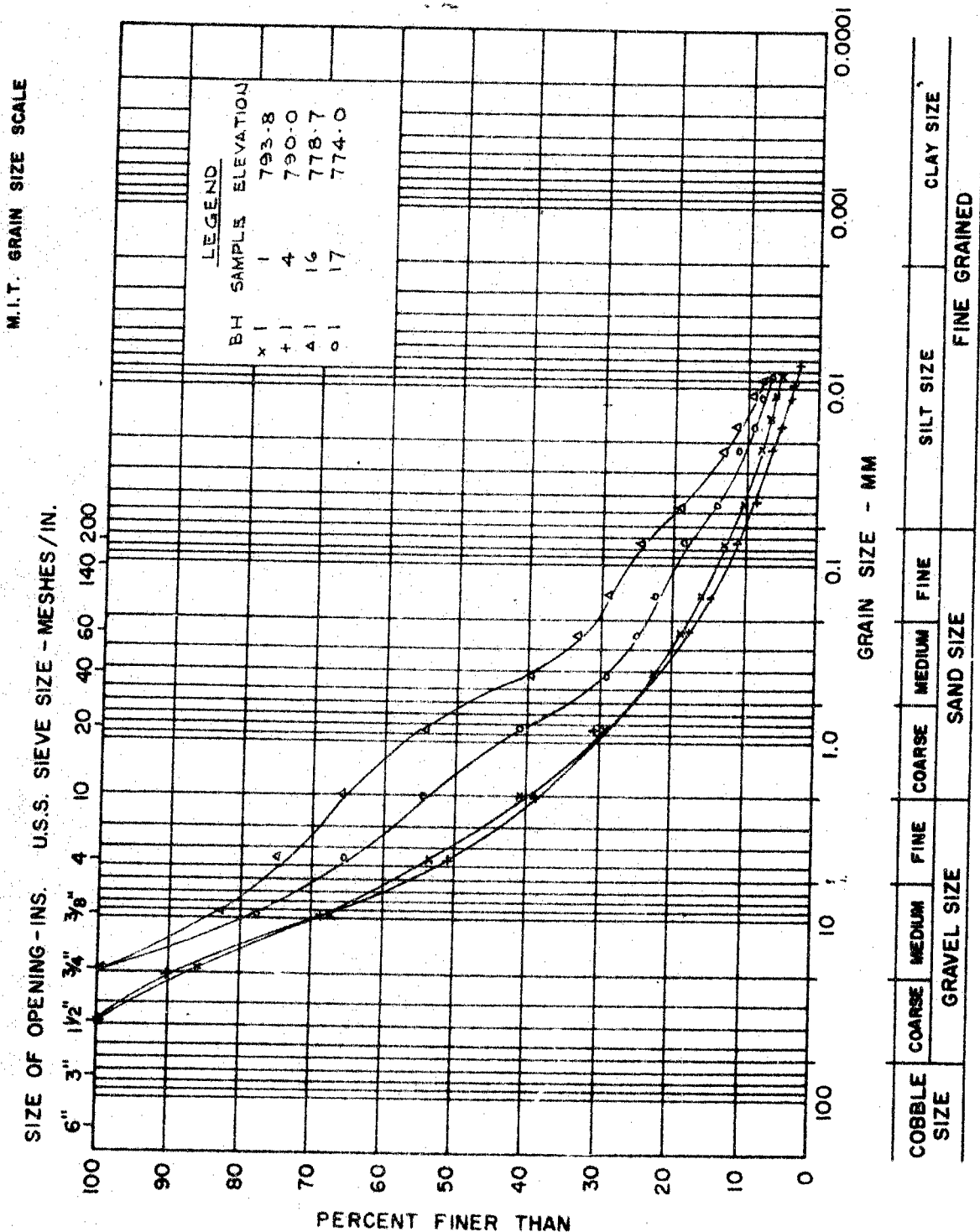
VERTICAL SCALE  
1 INCH TO 5.0'

GOLDER &amp; ASSOCIATES

DRAWN J.W.A.  
CHECKED BO

# GRAIN SIZE DISTRIBUTION GRAVEL

FIGURE 2



GOLDER & ASSOCIATES

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING ENGINEERS  
SOILS ENGINEERS - TORONTO, CANADA

H. Q. GOLDER  
F. GOLDER  
L. G. GOLDER  
J. L. GOLDER

RECEIVED  
LONDON, ONTARIO  
27 1966

November 10, 1966

Department of Highways,  
Materials and Testing Division,  
Highway 401 and Keele Street,  
Downsview, Ontario

Attention: Mr. A. G. Sternac, P.Eng

Re: Soils Report, Proposed Lake Erie and Northern  
Railway Subway, Paris, Ontario  
WP No. 182-66-2

Dear Sirs:

We enclose twelve (12) copies of drawing  
No. 1 for the above mentioned report that was inadvertently  
sent out with the location of borehole shown as 20+75  
instead of 20+57.

Also forwarded today under separate cover is  
a corrected master copy of the same drawing.

We greatly regret the error and trust it has  
caused no inconvenience.

Yours truly,  
H. Q. GOLDER & ASSOCIATES LTD

*Brian E. W. Dowse*  
Brian E. W. Dowse, P.Eng.

Enclosures:  
BEWD:mr  
66515

Drawings

*Revisions  
sent out  
Nov. 15/66*

DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS  
HEAD OFFICE - TORONTO, ONTARIO

H. Q. GOLDER  
V. MILLIGAN  
L. G. SODERMAN  
J. L. SEYCHUK

747 HYDE PARK ROAD  
LONDON, ONTARIO  
471-9600

October 21, 1966

Department of Highways Ontario,  
Materials and Testing Division,  
Highway 401 and Keele Street,  
Downsview, Ontario.

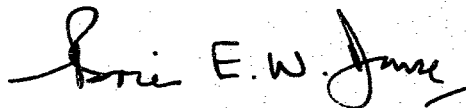
Attention Mr. A. G. Stermac, P.Eng

Dear Sir:

We enclose herewith 12 copies of a report  
on the soil conditions and foundations at the proposed  
Lake Erie and Northern Railway Subway Highway No. 2.  
(W.P. 182-66-2).

Assuring you of our best services and attention  
at all times.

Yours truly,  
H.Q. GOLDER & ASSOCIATES LTD.,



Brian E. W. Dowse, P.Eng.

BEWD:mr  
66515

Enclosures - 12 copies of Report No. 66515