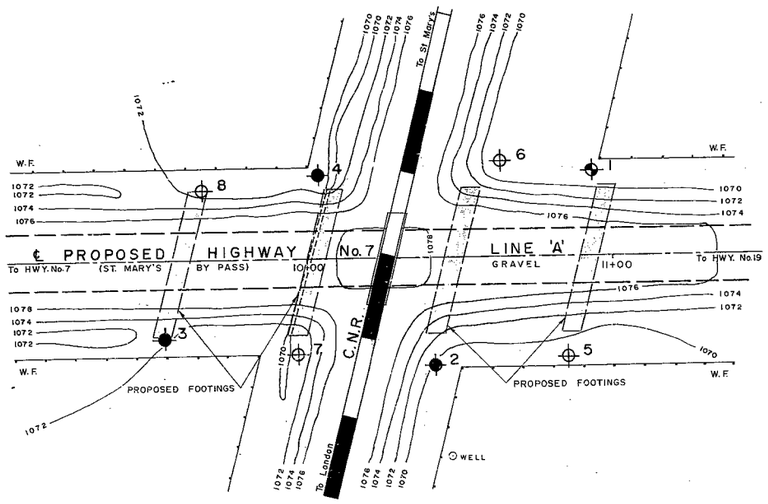
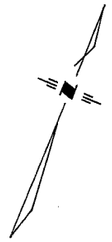
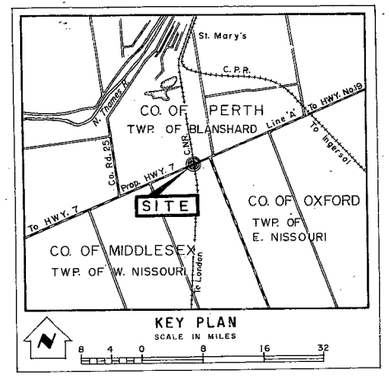
#66-F-219-C
W.P.#20-60
HWY.#7 &
ST. MARY'S
BY-PASS
C.N.R. OVERHEAD



PLAN

SCALE 20 10 0 20 40 FT.





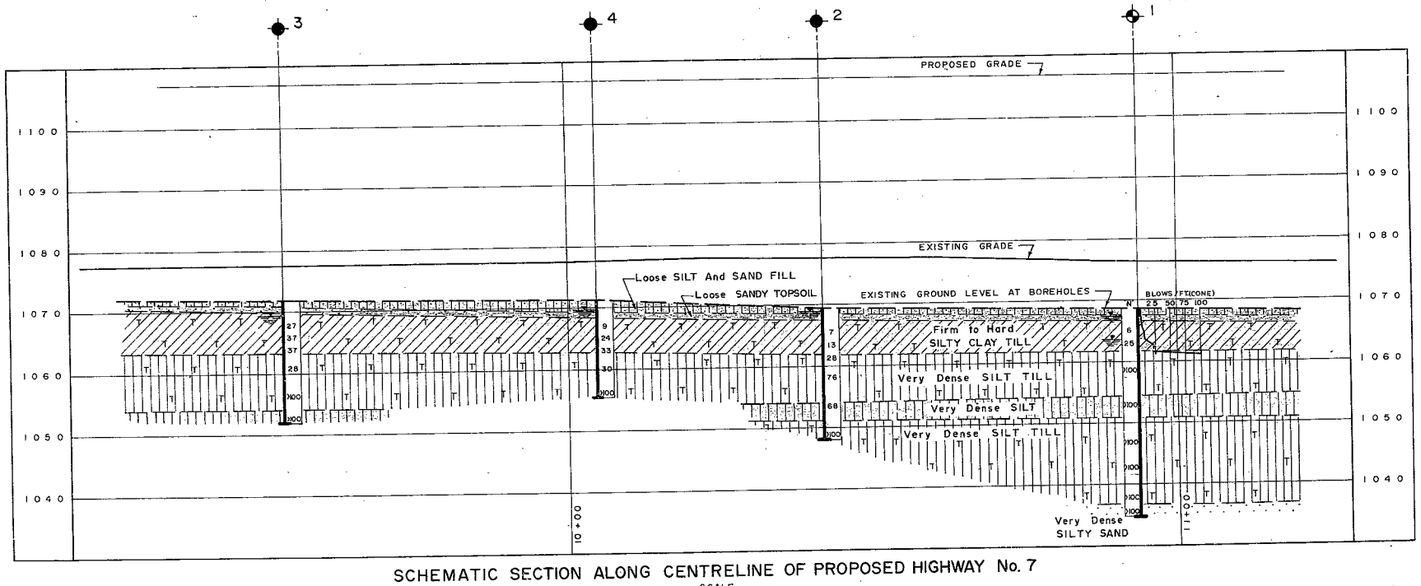
LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation. (Sept. 28, 1966)

NO.	ELEVATION	STATION	OFFSET
1	1068.8	10+94	27' LT.
2	1069.6	10+41	35' RT.
3	1071.8	9+52	26' RT.
4	1071.2	10+03	27' LT.
5	1069.8	10+85	33' RT.
6	1069.2	10+63	31' LT.
7	1070.9	9+96	31' RT.
8	1071.5	9+65	22' LT.

– NOTE –

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.



SCHEMATIC SECTION ALONG CENTRELINE OF PROPOSED HIGHWAY No. 7

SCALE 10 5 0 10 20 FT.

REVISIONS			
DATE	BY	DESCRIPTION	

H. Q. GOLDER & ASSOCIATES LTD.

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING DIVISION – FOUNDATION SECTION

PROPOSED C.N.R. OVERHEAD
HIGHWAY No. 7

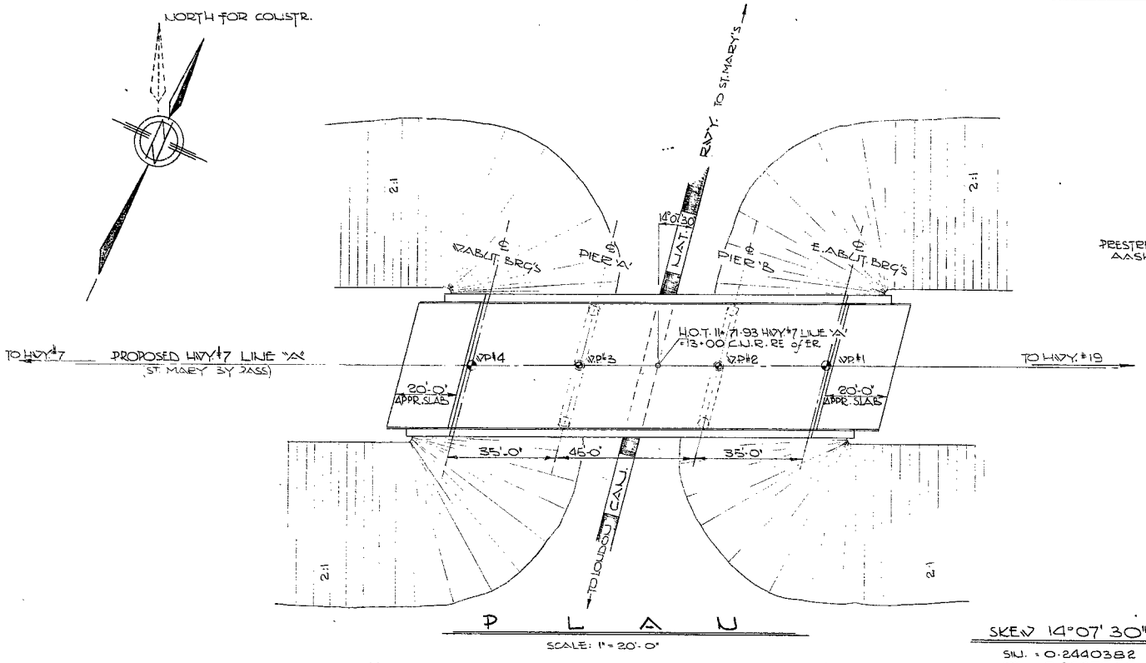
KING'S HIGHWAY NO. 7 DIST. NO. 3
CO. PERTH MIDDLESEX
TWP. W. NISSOURI & BLANSHARD LOT 36-13 & 14 CON. VII – S.B.

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D. B.D.	CHECKED E.J.H.	W.P. NO. 20-60	DRAWING NO. 1
DRAWN J.W.A.	CHECKED	JOB NO. 66514	
DATE SEPT. 27, 1966		SITE NO.	BRIDGE DRAWING NO.
APPROVED PRINCIPAL FOUNDATION ENGINEER		CONT. NO.	

REF. NO E 3991-1

PRINT RECORD		
NO.	FOR	DATE

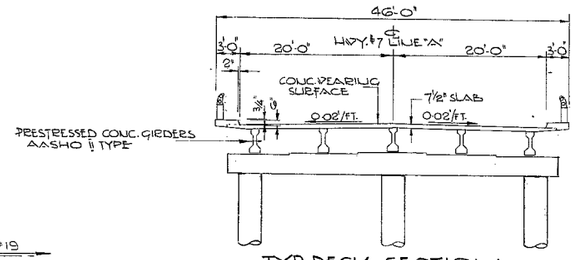


P L A N

SCALE: 1" = 20'-0"

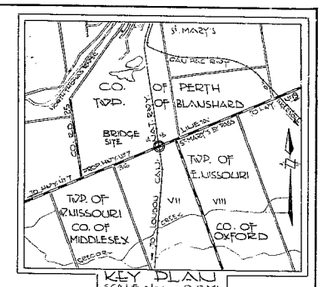
SKEW 14°07' 30"

SIN. = 0·24403882
COS. = 0·96976756
TAN. = 0·25164466
SEC. = 1·03117770



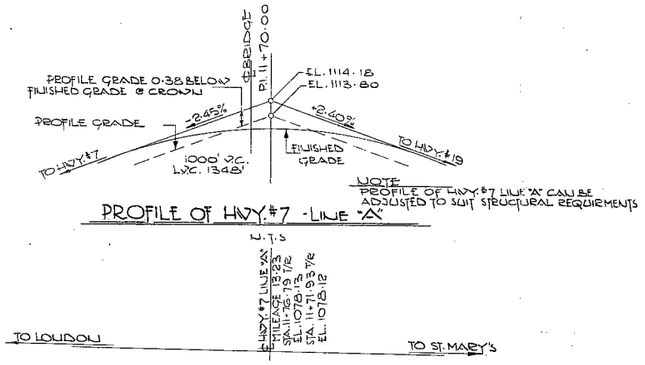
TYP. DECK SECTION

SCALE: ½" = 1'-0"



KEY PLAN

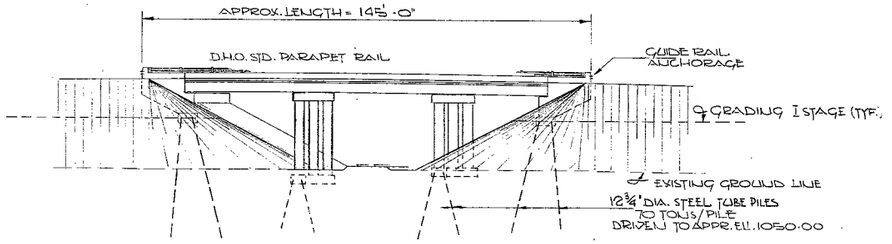
SCALE: 1 IN. = 0·8 MI.



PROFILE OF HWY. #7 - LINE 'A'

U.T.S.

NOTE
PROFILE OF HWY. #7 LINE 'A' CAN BE ADJUSTED TO SUIT STRUCTURAL REQUIREMENTS



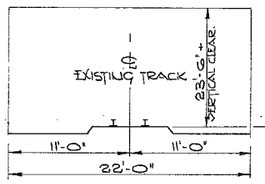
ELEVATION

SCALE: 1" = 20'-0"

PROFILE OF C.N.R. (BASE OF EAST RAIL)

N.T.S.

B.M. ELEV. 1071·82
GEODETIC DATUM
U.§ 17 IN S.W. ROOT OF 2·7 MAPLE
213·0 Rt. of STA. 9+77



CLEARANCE DIAGRAM OF C.N.R. UNDER HWY #7 - LINE "A"

PRINT RECORD		
No.	FOR	DATE

REVISIONS		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

C.N.R. OVERHEAD (ST. MARY'S BYPASS)

3·0 MILES WEST OF HWY. #19

KING'S HIGHWAY No. 7 — DIST. No. 3

CO. MIDDLESEX & PERTH

TWP. W. ILLSSOURI & BLANSHARD — LOT 36, 13 & 14 — CON. 7 & S.B.

PRELIMINARY PLAN

APPROVED	BRIDGE ENGINEER		SITE No. 19-459	W.P. No. 20-60	
DESIGN		CHECK	CONTRACT Nos.	-	
DRAWING	E.A.	CHECK	DRAWING No.	D-6071-P1	
DATE	10/7/66	LOADING	H20-44		

66 F 219 C

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,
Hwy. 401 and Keele St.,
DOWNSVIEW, Ontario.

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

RE: Soils Investigation
Proposed Hwy. 7, St. Marys
(WP 20/60)

/66

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

BEWD:cmm
66514

Brian E. W. Dowse, P. Eng.

cc: Foundations Office (Rm. 110)

H. Q. Golder

Mr. A. P. Watt,
Regional Bridge Location Engr.,
Bridge Section,
Regional Office (London).

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

December 14, 1966

C.N.R. Overhead (St. Mary's Bypass) -
Hwy. No. 7 - District No. 3 (Stratford)
-- W.P. 20-60 --

We have reviewed Preliminary Plan D 6071-P1 for the above mentioned structure.

The designer appears to have complied with the recommendations given to Mr. M. Gvildys by Mr. A. G. Stermac, by 'phone on November 16, 1966.

K. G. Selby,
SUPERVISING FOUNDATION ENGR.
For:
A. G. Stermac,
PRINCIPAL FOUNDATION ENGR.

KGS/MdeF

cc: Foundations Office
Gen. Files

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. A. G. Stermac
Principal Foundation Engineer
Lab Building
D O W N S V I E W

From: A. P. Watt

Date: November 30, 1966

Our File Ref.

In reply to

Subject: W.P. 20-60, Bridge Site 19-454,
C.N.R. Overhead (St. Mary's Bypass),
3.0 miles west of Hwy. 19,
Highway 7,
District 3, Stratford.

Attached please find one copy of the preliminary plan D-6071-P1 for the above noted structure.

Would you kindly review the bridge foundations proposed and inform me if they are satisfactory.

A reply would be appreciated within the next two weeks.

A. P. WATT
REGIONAL BRIDGE LOCATION ENGINEER

APW:gf
ATT'D

NOTE

W.P. 20-60 November 16, 1966

Mr. M. Guildis advised that deep foundations represent serious construction problems because of proximity of railway tracks.

Asked whether piles can be used instead.

Yes. Tube piles are suggested and it is believed that practical refusal will be met at around elevation 1050.

Practical refusal:

Delmag D-22 5 blows/inch for the last 1-2 feet penetration.

A. G. Stermac

P.S.

Footings can be kept at a depth sufficient for frost protection.

Mr. D. R. Davis,
Bridge Engineer,
Bridge Division.

Attention: Mr. S. McCombie

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

October 4, 1966

OCT - 4 1966

FOUNDATION INVESTIGATION REPORT FOR D.H.O.
BY: H. G. Colder and Associates, Limited -
Proposed C.N.R. Overhead, Highway No. 7,
St. Mary's, Ontario -- District 3 (Stratford)
-- W.P. 20-60 --

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

We have reviewed the report and have found the factual information adequate and well presented. Regarding the foundations, we would recommend a slight change in the consultant's recommendations. We feel that the foundation elevation could be 2 - 3 ft. higher - i.e., 1062 to 1063. The west footings could be higher than the East ones. This slight change will decrease somewhat the excavation depth, making the work easier and more economical.

We believe that you will now have enough information to proceed with your design work. Should you, however, have any additional questions or problems that you would like to discuss, please feel free to contact this Office.

A. G. Sternac,
PRINCIPAL FOUNDATION ENGINEER

AGS/dds?
Attach.
cc: Messrs. D. R. Davis (2)
H. A. Tregunnas
D. W. Farren
A. Suter
A. F. Watt
J. C. Tillcock
J. Hoy
A. Watt

Foundations Office
-en. Files

BRIDGE INSPECTION REPORT

SUFFICIENCY RATING _____ INDEX NO. Middlesex - 454

HIGHWAY NO. 7 DISTRICT NO. 3 COUNTY) DISTRICT) Middlesex

NUMBER AND NAME OF STRUCTURE C.N.R. Overhead

TYPE OF STRUCTURE Three span semi-continuous prestressed concrete beams

INSPECTED BY C. Rahn DATE OF INSPECTION April - 19 70

MILEAGE FROM 5.0 miles West of East Entrance to St. Mary's

BRIDGE DIMENSIONS BRIDGE PLAN NO. D6071

SPAN 35' - 45' - 35' LENGTH OF BRIDGE 116'-6"

WIDTH OF BRIDGE ROADWAY 40' WIDTH OF BRIDGE 46'

CLEARANCE _____ DATE OF CONSTRUCTION 1968

APPROACH GEOMETRICS
Structure on crest vertical curve and straight alignment.

WATERWAY ADEQUACY
N/A

RETURN TO D.H.O.
BRIDGE MAINTENANCE
SECTION

CONDITION OF BRIDGE

ABUTMENTS
Reinforced concrete - good

BALLAST WALLS
Reinforced concrete - good

PIERS
Two three column reinforced concrete with reinforced concrete caps - good

BEARINGS
$\frac{3}{4}$" neoprene pads - good

MAIN GIRDERS, TRUSSES OR RIBS
Prestressed concrete beams - semi-continuous

FLOOR BEAMS
Nil. Reinforced concrete diaphragms only - good

19-454

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. W. D. Birch,
Bridge Maintenance and Inspection
Engineer - Maintenance Office,
Admin. Bldg.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

Attention: Mr. H. W. C. Rahn

Date: May 19, 1970

Our File Ref.

In reply to

Subject: C.N.R. Overhead (St. Mary's Bypass)
Hwy. 7, Site Index Middlesex - 454,
District No. 3 (Stratford).

With respect to your memorandum of May 13, 1970, to Mr. A. Rutka, Materials and Testing Engineer, Attention: Mr. G. A. Wrong, Principal Soils Engineer, we wish to advise you of the following:

On May 20, 1969, the undersigned discussed the distress signs, which have appeared at the above mentioned crossing, with Mr. J. McKeown from the Regional Materials Office.

Attached is a photostat copy of the note of this telephone discussion, which we believe is self-explanatory.

We do not know whether any remedial or maintenance measures were carried out after the mentioned discussion. We would suggest that you contact Mr. J. McKeown and obtain from him, all the available records and information.

Should you wish to discuss this matter further, please feel free to contact this office.

A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

AGS/MdeF
Attach.

cc: Mr. G. A. Wrong
Foundations Files
Gen. Files

Note - Pressure grout under slab
W-13
June - 2 '70

May 20th, 1969

C.N.R. Overhead (St. Mary's Bypass
Hwy. 7, District 3, W.P. 20-60

Note:
Telephone conversation with Jack McKeown, London-Mat. and Testing

Approach fills have settled, there is a 2½" void under approach slabs. Curb is pulling away from the slab. There is a tension crack at the end of approach slab where it meets the pavement. Jack has carried out a number of borings within the fill area where problems have occured. Under 31" of granular a layer of soft clay was formed (w_L -30.6% ρ_L = 14.2% Pl = 16.4 W = 15.8%) which varied in thickness from about 3 ft. to 7 ft. It has a consistency that with little effort it can be squeezed through the fingers. Below this soft layer the fill is firm to hard. It can hardly be drilled with the power auger.

Conclusion

It is obvious that the upper part of the approach fills was not built as specified. The material is too wet and consequently settles. It will probably settle even more once it is exposed to highway traffic. A failure could not be completely ruled out.

The very best remedial measure would be to remove and replace this material with a properly compacted fill placed at opt. moisture content. All else will be only temporary and long lasting maintenance measures have to be reckoned with.

A.G. Stermac

C.N.R. O'Leary (St. Mary's Bypass) May 20th 1960
Hwy 7. District 3; W.P. 20-60.

Note:
Telephone conversation with Jack McKeown
London - Mat & Testing.

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Conclusion
It is obvious that the upper parts of the approach fills was not built as specified. The material is too wet and consequently settles. It will probably settle more once it is opened to highway traffic. If failure should not be completely ruled out.

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

The very best remedial measure would be to remove and replace the material with a properly compacted fill placed at opt. moisture content. All else will be only temporary and long lasting ~~remedial~~ maintenance measures have to be reckoned with.

A Gitterman

1 copy
Jean file
Jim file

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

Bridge Maintenance Section

Mr. A. Rutka,
Materials & Testing Engineer,
Downsview.

Mr. C.A. Armstrong,
Principal Soils Engineer.

B.W.C. Kuhn,
for W.D. Birch.

May 13, 1970.

Re: C.N.R. Overhead (St. Mary's Bypass), Highway 7
Site Index Middlesex-49A, District 1, Stratford

It was noted during a recent inspection of the subject structure, that settlement voids and erosion undermining have occurred under the concrete approach slabs at each abutment. Settlement of the slabs was also evident. Pavement on the west approach fill adjacent to the structure was recently patched, in a longitudinal fissure of up to eighteen inches wide, to the north of the highway centre line. The fissure in upwards of twenty feet in length. The structure was constructed in 1964.

Please arrange for the necessary tests and studies of the site, which will enable us to determine what, if any, corrective measures may be undertaken to avoid failure of the approaches and approach slabs.

B.W.C. Kuhn,
for W.D. Birch,
Bridge Maintenance and Inspection Engineer.

BWCK/rm
c.c. E.J. Orr
T.E. Murphy

RETURN TO D.H.O.
BRIDGE MAINTENANCE
SECTION

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

STRINGERS

Nil

DECK

Reinforced concrete - good

WEARING SURFACE

Nil - deck surface only

EXPANSION JOINTS

Rodofoam, styrofoam, hot poured paraplastic

HANDRAIL POSTS

Aluminum parapet rail posts, reinforced concrete end posts

HANDRAILS

Reinforced concrete parapet wall
Two lines galvanized pipe rail

WINGWALLS

Reinforced concrete - good

CURBS

Reinforced concrete - good

SIDEWALKS

Nil

DRAINAGE

Structure self draining on vertical curve

RETAINING WALLS

Nil

EMBANKMENT SLOPES

Steep seeded granular slopes

SUPER IMPOSED DOCUMENT MAY APPEAR AS MULTI-FEED ON FILM.

ADDITIONAL OBSERVATIONS

1. Approach slabs settled and undermining.
2. Approach pavement badly cracked and breaking up.
3. Considerable collected gravel on deck along curbs.

GENERAL CONDITION OF STRUCTURE

Good

STRUCTURAL STRENGTH

DESIGN LOAD

HS 20-44

PRESENT POSTING

None

OVERLOAD PERMIT

RECOMMENDATIONS

1. Clear deck of debris.
2. Recommendation concerning approaches will be made following a study by Materials and Testing as requested in memo of May 13, 1970. - See May 19 '70 -
3. Pressure grout under slab

DATE _____ 196 _____ SIGNATURE _____

cc: Foundations Office - Rm.110

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

To: Mr. W. D. Birch,
Bridge Maintenance and Inspection Engineer - Maintenance Office,
Admin. Bldg.

From: Foundation Section,
Materials & Testing Office,
Room 107, Lab. Bldg.

Attention: Mr. H. W. C. Rahn

Date: May 19, 1970

Our File Ref.

In reply to

Subject: C.N.R. Overhead (St. Mary's Bypass)
Hwy. 7, Site Index Middlesex - 45½,
District No. 3 (Stratford).

With respect to your memorandum of May 13, 1970, to Mr. A. Rutka, Materials and Testing Engineer, Attention: Mr. G. A. Wrong, Principal Soils Engineer, we wish to advise you of the following:

On May 20, 1969, the undersigned discussed the distress signs, which have appeared at the above mentioned crossing, with Mr. J. McKeown from the Regional Materials Office.

Attached is a photostat copy of the note of this telephone discussion, which we believe is self-explanatory.

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AGS/MdeF
Attach.

A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

cc: Mr. G. A. Wrong
Foundations Files
Gen. Files

DEPARTMENT OF HIGHWAYS ONTARIO

MEMORANDUM

TO: Mr. A. Rutka,
Materials & Testing Engineer,
Downsview.

FROM: Bridge Maintenance Section
H.W.C. Rahn,
for W.D. Birch.

ATTENTION: Mr. G.A. Wrong,
Principal Soils Engineer.

DATE: May 13, 1970.

OUR FILE REF.

IN REPLY TO

SUBJECT: Re: C.N.R. Overhead (St. Mary's Bypass), Highway 7
Site Index Middlesex-454, District 3, Stratford

It was noted during a recent inspection of the subject structure, that settlement voids and erosion undermining have occurred under the concrete approach slabs at each abutment. Settlement of the slabs was also evident. Pavement on the west approach fill adjacent to the structure was recently patched, in a longitudinal fissure of up to eighteen inches wide, to the north of the highway centre line. The fissure is upwards of twenty feet in length. The structure was constructed in 1968.

Please arrange for the necessary tests and studies of the site, which will enable us to determine what, if any, corrective measures may be undertaken to avoid failure of the approaches and approach slabs.

H.W.C. Rahn,
for W.D. Birch,
Bridge Maintenance and Inspection Engineer.

HWCR/mm
c.c. E.J. Orr
T.W. Murphy

C.N.R. O'Lead (St. Mary's Bypass — May 20th 1969
Hwy 7. District 3; W.P. 20-60.

Note:
Telephone conversation with Jack McKeown London - Mat & Testing.

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Conclusion
It is obvious that the upper part of the approach fills was not built as specified. The material is too wet and consequently settles. It will probably settle even more once it is exposed to highway traffic. A failure could not be completely ruled out.

The very best remedial measure would be to remove and replace this material with a properly compacted fill placed at opt. moisture content. All else will be only temporary and long lasting; ~~remedial~~ maintenance measures have to be reckoned with.

Ofstermann

2 copies
from files
from files

LT TO M. CLAY CLAY TILL

Sept. 1968 Approach slab

(1) 31" 3-4 soft material
31" - 9½'
9½ - 12' LT Clay Stiff
w 12.5%
30.2 - 13.7

att. LL 30.6 PL 14.2%
16.4
w = 15.8 11.5%

(2) Center of
31 - 5' soft material

(3) 31 - 5' v. soft

(4) 30' from BH 1

(5) B2'

East End

(6) Bed rock at
1½

2½" void

McKeown
Jack McKeown

ST MARY'S C.N.R O'HEAD

MAY 1969.

66-F-219C

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

W.P. 20 - 60

REPORT

TO

DEPARTMENT OF HIGHWAYS, ONTARIO

ON

SOIL CONDITIONS AND FOUNDATIONS

PROPOSED CANADIAN NATIONAL RAILWAY CROSSING
PROPOSED HIGHWAY NO. 7 - LINE 'A'

ST. MARY'S ONTARIO

Distribution:

11 copies - Department of Highways, Ontario, Toronto, Ontario

2 copies - H. Q. Golder & Associates Ltd., London, Ontario

September, 1966 66514

TABLE OF CONTENTS

ABSTRACT

The results of an investigation to determine the subsurface conditions at the site of the proposed grade separation of the proposed Highway No. 7, Line 'A', and the Canadian National Railway, St. Mary's, Ontario are reported. Recommendations are made for the foundation design of the proposed structure and approach embankments.

It was found that the site is underlain by glacial till. The upper 5 to 6 feet of the till consists of a light brown silty clay. Below this level the till is a grey silt with zones of stratified silt and of sand. Groundwater was found to be within a few feet of the ground surface.

It is recommended that the abutments and the piers be founded on spread footings on the grey till at or below elevation 1060 with an allowable bearing pressure of 4 tons per square foot. The embankments may be constructed to full height in one stage providing the recommendations are followed. The groundwater may be controlled by pumping from sumps.

INTRODUCTION

H. G. Golder & Associates Ltd have been retained by the Department of Highways, Ontario, to carry out a soil investigation at the site of the proposed grade separation at the Canadian National Railway on proposed Highway No 7, Line 'A', for the proposed St. Mary's Bypass, Ontario. The purpose of the investigation was to determine the sub-soil and ground-water conditions at the proposed pier and abutment locations and to make recommendations for foundation design and the construction of the approach embankments.

PROCEDURE

The field work for this investigation was carried out between September 9 and 14, 1966. A total of 4 boreholes, one accompanied by a dynamic cone penetration test and 4 additional cone penetration tests were put down using a skid-mounted diamond drillrig supplied and operated by the F. E. Johnston Drilling Company Ltd. The borings which were generally put down in BX casing size, penetrated to depths ranging from 16 to 34 feet. The cone tests were driven to refusal at shallower depths.

The ground-water level at the site was observed during drilling and for two weeks after completion of the investigation by readings taken in the piezometer and standpipes installed in the borings. The field work was supervised throughout by an engineer from our staff.

A detailed log for each of the borings and dynamic cone penetration tests is given in the Record of Borehole and the Record of Penetration Test sheets following the text of this report. The locations of the borings carried out during this investigation, together with a section of the inferred soil stratigraphy along the centre line of the proposed crossing, are shown in Figure 1.

Samples obtained during the investigation were returned to our laboratory for detailed examination and testing. The results of the laboratory tests are shown on the Records of Boreholes and on Figures 2 to 5, inclusive.

The elevations given in this report are referred to the top of track elevation on the centre line of the existing road where it crosses the Canadian National Railway line. The elevation of the top of track at this point was given as 1078.13, referred to geodetic datum, on the Department of Highways, Ontario, Plan E-3991-1.

SITE AND GEOLOGY

The present gravel road along which it is proposed to relocate Highway No. 7 follows the boundary between the counties of Middlesex and Perth. The road presently crosses the Canadian National Railway track on a level crossing where the railway embankment is raised some 10 feet above the surrounding rolling land.

The major soil type found in this part of Ontario is glacial till overlying bedrock. The glacial till interbedded with outwash deposits underlies the site to a depth of 40-50 feet as observed in the St. Mary's Cement Company's quarry located just north of the site. The bedrock in the area is limestone of the Delaware formation.

SUBSOIL CONDITIONS

The detailed stratigraphy encountered in the 4 boreholes and inferred in the penetration tests is shown on the Record of Boreholes and the Record of Penetration Test sheets. The stratigraphy interpolated from this data is presented on Figure 1. The soil conditions at the site may be summarized in the following manner.

Each borehole encountered 1 to 2 feet of loose sand or gravel fill overlying the original topsoil. The fill forms the edge of the embankment that carries the present county road over the level crossing.

The predominant stratum at the site is glacial till which is a stiff light brown silty clay with traces of sand and gravel for the upper 5 to 6 feet and in the major stratum is a very dense grey silt with some fine and coarse gravel and with a trace of clay. The upper and the lower tills show considerable localized zoning with layers and pockets of stratified silts and of sands which have possibly been laid down and subsequently enveloped in the till during minor retreats and re-advances of the ice front during advance of the ice sheets.

Standard Penetration Tests carried out in the upper clayey till stratum and reported on the Records of Boreholes give 'N' values that range from 6 to 37 with an average value of 23. The liquid limit of this stratum was measured as 23 per cent and the natural water content ranged from 18.3 to 22.9 per cent with an average value of 21.0 per cent. The grain size distribution curves for samples tested from this stratum are presented in Figure 2.

The lower till is basically a very dense grey silt with sub-angular gravel throughout and a trace of clay. The pockets of sands and silts can be as great as 3 feet thick and vary in colour from brown to light grey. Standard Penetration tests carried out in the grey till give 'N' values that are generally greater than 100 except in two pockets where the values were 28. The measured liquid limit of this stratum varied from non-plastic to 26.3 per cent with an average value of 23.0 per cent and the natural water content ranged from 11.3 per cent to 15.8 per cent with an average value of 12.5 per cent. Grain size distribution curves for samples tested at various depths in the grey till are presented in Figure 3. Grain size distribution curves for samples tested from the silt and from the sand zones are presented in Figures 4 and 5 respectively.

GROUND-WATER CONDITIONS

One piezometer and 4 standpipes were installed in the boreholes and sealed as sketched on the Records of Boreholes. Readings taken up to two weeks after completion of drilling showed the groundwater to have stabilized at

between elevation 1069 to 1070 in the standpipes and elevation 1064 in the piezometer that was sealed into the lower till. Observations of the water level in the well, located near the southeast corner of the crossing and marked on Figure 1, showed that when it was pumped out to approximately elevation 1055 it took almost 24 hours to come back up to its original level of approximately elevation of 1065. No artesian water pressure was encountered at the site.

DISCUSSION

General

It is understood that the proposed Canadian National Railway crossing is to be a triple-span structure, each span being 45 feet long. The proposed highway grade is to be approximately elevation 1107 necessitating roadway approach embankments as high as 39 feet above the surrounding land.

Foundations

The abutments and piers of the bridge may be safely founded on the very dense grey silty till with an allowable bearing pressure of 4 tons per square foot at or below elevation 1060. The settlement of the bridge founded as recommended should be negligible. Excavations for the

abutments and piers should be carried out in the dry to prevent softening of the subsoil. It is recommended that, in order to prevent softening of the subsoil at founding elevation due to surface water construction operations, the base of the excavations should be immediately covered by a thin working mat of lean concrete as soon as foundation grade is reached.

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, Ko, of 0.4 and a total unit weight, γ , of 135 lb./cu.ft. be used for the compacted granular backfill in the design of the walls.

Excavations

The excavations for the abutment and pier foundations shall be cut back to a natural slope and where restricted (i.e. close to the railway embankment) shall be supported to prevent loss of ground from under the railway tracks.

Approach Embankments

The approach embankments may be safely constructed to their required height in one stage providing the top soil is removed where it exists before any fill is placed and providing the embankment is constructed of compacted fill, properly controlled in the field with a maximum side slope of 2 horizontal to 1 vertical. Material in the embankment should be compacted to 100 per cent of Standard Proctor maximum density under conditions of controlled water content.

The settlement of the embankments built as recommended should be small with the majority of the settlement taking place during construction.

Groundwater

It was noted during drilling that when the well was pumped out considerable time was required for it to refill; therefore it was concluded that the water seepage into the excavations will be minor, probably only from seams of sand or gravel, and can be simply and efficiently controlled during construction by pumping from sumps in the bottom of the excavations. It is anticipated that there will be no major ground-water construction problems.

Brian E.W. Dowse

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

L. G. Soderman

L. G. Soderman, P.Eng.

BEWD:mr
66514
30 September, 1966

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.

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE SEPT. 9-12, 1966 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FT.
1068.8 / 0.0	GROUND LEVEL				
1067.8 / 1.0	LOOSE BROWN SAND AND GRAVEL (FILL)				
1066.8 / 2.0	LOOSE DARK BROWN SANDY TOPSOIL				
	STIFF TO HARD LIGHT BROWN SILTY CLAY TRACE SMALL GRAVEL OCCASIONAL LAYERS OF FINE TO MEDIUM SAND AND CLAYEY SILT (TILL)		1	2" DO	6
			2	"	25
1061.8 / 7.0	VERY DENSE GREY SILT, WITH SOME FINE TO COARSE GRAVEL AND TRACE OF CLAY. OCCASIONAL MORE SANDY LAYERS (TILL)		3	"	>100
1054.8 / 14.0	VERY DENSE GREY SILT WITH OCCASIONAL FINE GRAVEL		4	"	>100
1051.0 / 17.8			5	AXT RC	—
	VERY DENSE GREY SILT, WITH SOME FINE TO COARSE GRAVEL AND TRACE OF CLAY. OCCASIONAL MORE SANDY LAYERS (TILL)		6	2" DO	>100
			7	"	>100
			8	"	>100
1036.8 / 32.0	VERY DENSE GREY SILTY SAND TRACE OF GRAVEL		9	"	>100
1034.8 / 34.0	END OF HOLE				

ELEVATION SCALE: 1070, 1065, 1060, 1055, 1050, 1045, 1040, 1035

DYNAMIC PENETRATION RESISTANCE BLOWS/FT. 20 40 60 80 100

SHEAR STRENGTH C_u, LB./SQ.FT.

END OF PEN. TEST ELEV. 1061.1
100 BLOWS FOR LAST 3 INCHES

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_P W W_L 10 20 30 40

ADDITIONAL LAB. TESTING: MH MH MH MH MH

PIEZOMETER OR STANDPIPE INSTALLATION: CAP, GROUND LEVEL, STANDPIPE, BENTONITE SEAL, PIEZOMETER, SAND AND GRAVEL FILL

W.L. IN PIEZOMETER AT ELEV. 1063.6 SEPT. 28, 1966

W.L. IN STANDPIPE AT ELEV. 1067.5 SEPT. 28, 1966

15 10 5 Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.W.A.

CHECKED J.J.

RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE SEPT. 12, 1966 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.
1069.6 / 0.0	GROUND LEVEL				
1068.6 / 1.0	LOOSE BROWN AND GREY SILT (FILL)				
1067.6 / 2.0	LOOSE DARK BROWN SANDY TOPSOIL				
	FIRM TO STIFF LIGHT BROWN SILTY CLAY WITH OCCASIONAL GRAVEL (TILL)		1	2" DO	7
			2	"	13
1062.1 / 7.5			3	"	28
	COMPACT TO VERY DENSE GREY SILT WITH OCCASIONAL FINE TO COARSE GRAVEL AND TRACE OF CLAY (TILL)		4	"	76
1054.1 / 15.5	VERY DENSE LAYERED BROWN CLAYEY SILT AND LIGHT BROWN SILT WITH TRACE OF GRAVEL		5	"	68
1051.1 / 18.5	VERY DENSE GREY SILT WITH OCCASIONAL FINE TO COARSE GRAVEL (TILL)		6	"	>100
1048.1 / 21.5	END OF HOLE				

ELEVATION SCALE: 1070, 1065, 1060, 1055, 1050, 1045

DYNAMIC PENETRATION RESISTANCE BLOWS/FT.

SHEAR STRENGTH C_u, LB./SQ.FT.

Percent axial strain at failure

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT

W_P W W_L

10 20 30 40

ADDITIONAL LAB. TESTING: MH

PIEZOMETER OR STANDPIPE INSTALLATION

CAP

GROUND LEVEL

CONCRETE

STANDPIPE

SAND AND GRAVEL FILL

W.L. IN STANDPIPE AT ELEV. 1068.8 SEPT. 28, 1966

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.W.A.

CHECKED J.J.N.

RECORD OF BOREHOLES 3 & 4

LOCATION See Figure 1 BORING DATE SEPT. 13-14, 1966 DATUM GEODETIC

BOREHOLE TYPE WASH BORING BOREHOLE DIAMETER BX CASING

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

BOREHOLE 3 / 1

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.
1071.8 / 0.0	GROUND LEVEL			
1070.8 / 1.0	LOOSE BROWN AND GREY SILT (FILL)			
1069.8 / 2.0	LOOSE DARK BROWN SANDY TOPSOIL			
	STIFF LIGHT BROWN SILTY CLAY WITH OCCASIONAL GRAVEL, OCCASIONAL LAYERS OF FINE TO MEDIUM SAND AND CLAYEY SILT (TILL)	1	2" DO	27
		2	"	37
1063.0 / 8.8		3	"	37
	VERY DENSE GREY SILT WITH OCCASIONAL FINE TO COARSE GRAVEL AND TRACE OF CLAY. OCCASIONAL MORE SANDY LAYERS (TILL)	4	"	28
		5	"	>100
1054.0 / 17.8	VERY DENSE GREY SILT WITH TRACE OF FINE GRAVEL	6	"	>100
1051.8 / 20.0	END OF HOLE			

ELEVATION SCALE: 1070, 1065, 1060, 1055, 1050

DYNAMIC PENETRATION RESISTANCE BLOWS/FT. ----------

SHEAR STRENGTH C_u, LB./SQ.FT.

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT

W_P W W_L

10 20 30 40

ADDITIONAL LAB. TESTING: MH, MH

PIEZOMETER OR STANDPIPE INSTALLATION: CAP, GROUND LEVEL, CONCRETE, STANDPIPE, SAND AND GRAVEL FILL

W.L. IN STANDPIPE ELEV. 1069.4 SEPT. 28, 1966

BOREHOLE 4 / 1

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	SAMPLE TYPE	BLOWS/FT.
1071.2 / 0.0	GROUND LEVEL			
1069.2 / 2.0	LOOSE BROWN AND GREY SILT (FILL)			
1068.2 / 3.0	LOOSE DARK BROWN SANDY TOPSOIL			
	STIFF LIGHT BROWN SILTY CLAY WITH TRACE OF GRAVEL, OCCASIONAL LAYERS OF FINE TO MEDIUM SAND AND CLAYEY SILT (TILL)	1	2" DO	9
		2	"	24
1062.7 / 8.5		3	"	33
	VERY DENSE GREY SILT WITH OCCASIONAL FINE TO COARSE GRAVEL AND TRACE OF CLAY OCCASIONAL MORE SANDY LAYERS (TILL)	4	"	30
1055.2 / 16.0	END OF HOLE	5	"	>100

ELEVATION SCALE: 1070, 1065, 1060, 1055

ADDITIONAL LAB. TESTING: MH

PIEZOMETER OR STANDPIPE INSTALLATION: CAP, GROUND LEVEL, CONCRETE, STANDPIPE, SAND AND GRAVEL FILL

W.L. IN STANDPIPE ELEV. 1069.8 SEPT. 28, 1966

15 10 5 Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.W.A.

CHECKED J.J.

RECORD OF PEN. TESTS 5 & 6

LOCATION See Figure 1 BORING DATE SEPT. 12, 1966 DATUM GEODETIC

BOREHOLE TYPE PENETRATION TESTS BOREHOLE DIAMETER —

SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT 140 LB. DROP 30 INCHES

ELEVN. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE
5/						
1069.8 / 0.0	GROUND LEVEL					1070
	PROBABLY LOOSE FILL AND TOPSOIL					
1065.3 / 4.5	PROBABLY STIFF SILTY CLAY (TILL)					1065
						1060
1058.8 / 11.0	END OF PEN. TEST					
	PROBABLY VERY DENSE SILT (TILL)					1055
6/						
1069.2 / 0.0	GROUND LEVEL					1070
	PROBABLY LOOSE FILL AND TOPSOIL					
1065.2 / 4.0	PROBABLY STIFF SILTY CLAY (TILL)					1065
1061.1 / 8.1	END OF PEN. TEST					1060
	PROBABLY VERY DENSE SILT (TILL)					

DYNAMIC PENETRATION RESISTANCE BLOWS/FT. 20 40 60 80 100

SHEAR STRENGTH C_u, LB./SQ.FT.

100 BLOWS FOR LAST 1 INCH

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

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_P W W_L

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

VERTICAL SCALE 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.W.A.

CHECKED J.J.

RECORD OF PEN. TESTS 7 & 8

LOCATION See Figure 1 BORING DATE SEPT. 13-14, 1966 DATUM GEODETIC

BOREHOLE TYPE PENETRATION TESTS BOREHOLE DIAMETER —

SAMPLER HAMMER WEIGHT — LB. DROP — INCHES PEN. TEST HAMMER WEIGHT 140LB DROP 30 INCHES

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS/FT. (20 40 60 80 100) / SHEAR STRENGTH C_u, LB./SQ.FT.	COEFFICIENT OF PERMEABILITY k, CM./SEC. / WATER CONTENT, PERCENT (W_P W W_L)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE				
1070.9 / 0.0	GROUND LEVEL					1075	7/			
	PROBABLY LOOSE FILL AND TOPSOIL					1070				
1068.9 / 2.0	PROBABLY STIFF SILTY CLAY (TILL)					1065				
1060.9 / 11.0	END OF PEN. TEST					1060	130 →			
	PROBABLY VERY DENSE SILT (TILL)									
1071.5 / 0.0	GROUND LEVEL					1075	8/			
	PROBABLY LOOSE FILL AND TOPSOIL					1070				
1067.5 / 4.0	PROBABLY STIFF SILTY CLAY (TILL)					1065				
1060.2 / 11.3	END OF PEN. TEST					1060	100 BLOWS FOR LAST 4 INCHES			
	PROBABLY VERY DENSE SILT (TILL)									

15-5 / 10 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

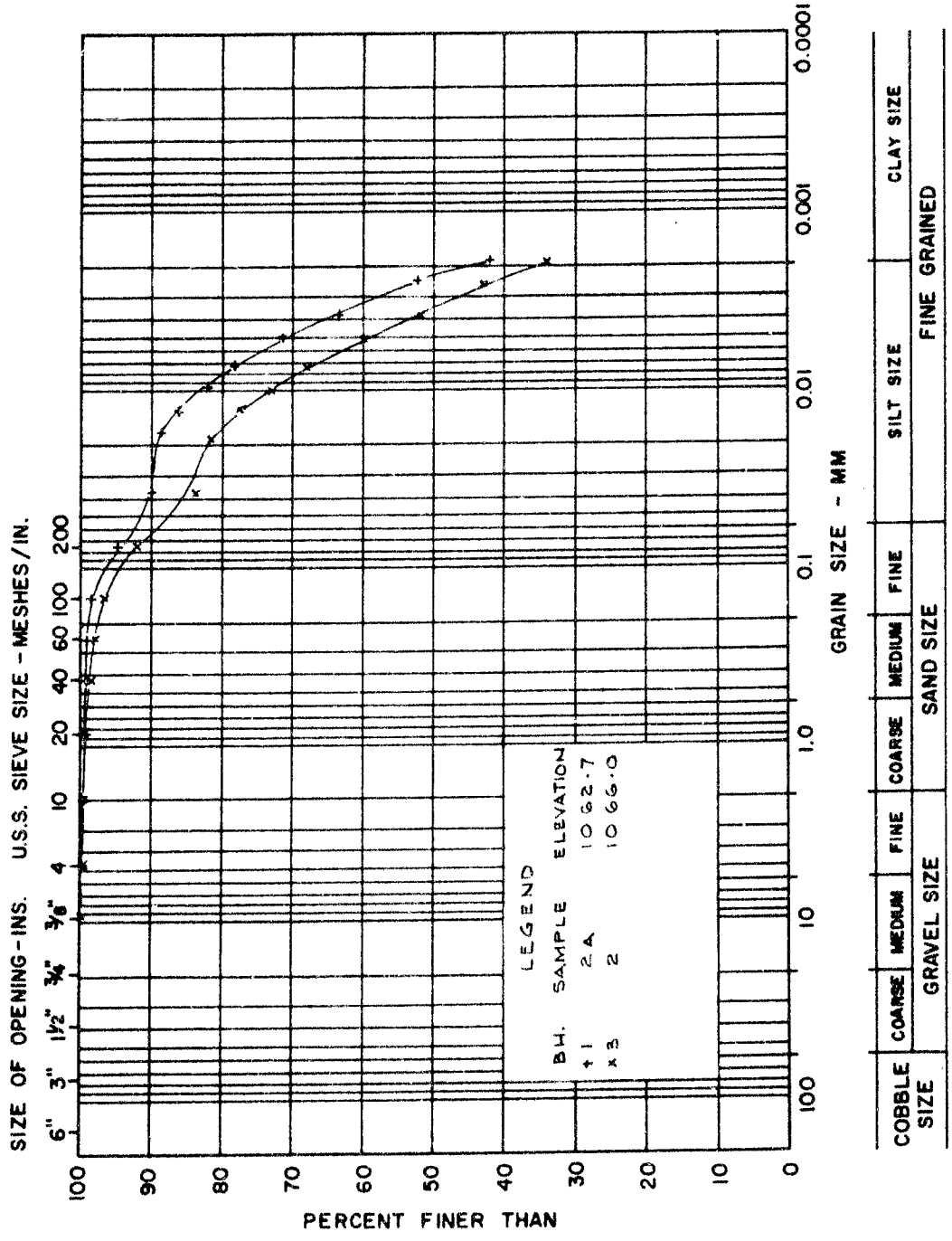
DRAWN J.W.A.
CHECKED T.J.N.

PROJECT No. 66514

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

FIGURE 2



GOLDER & ASSOCIATES

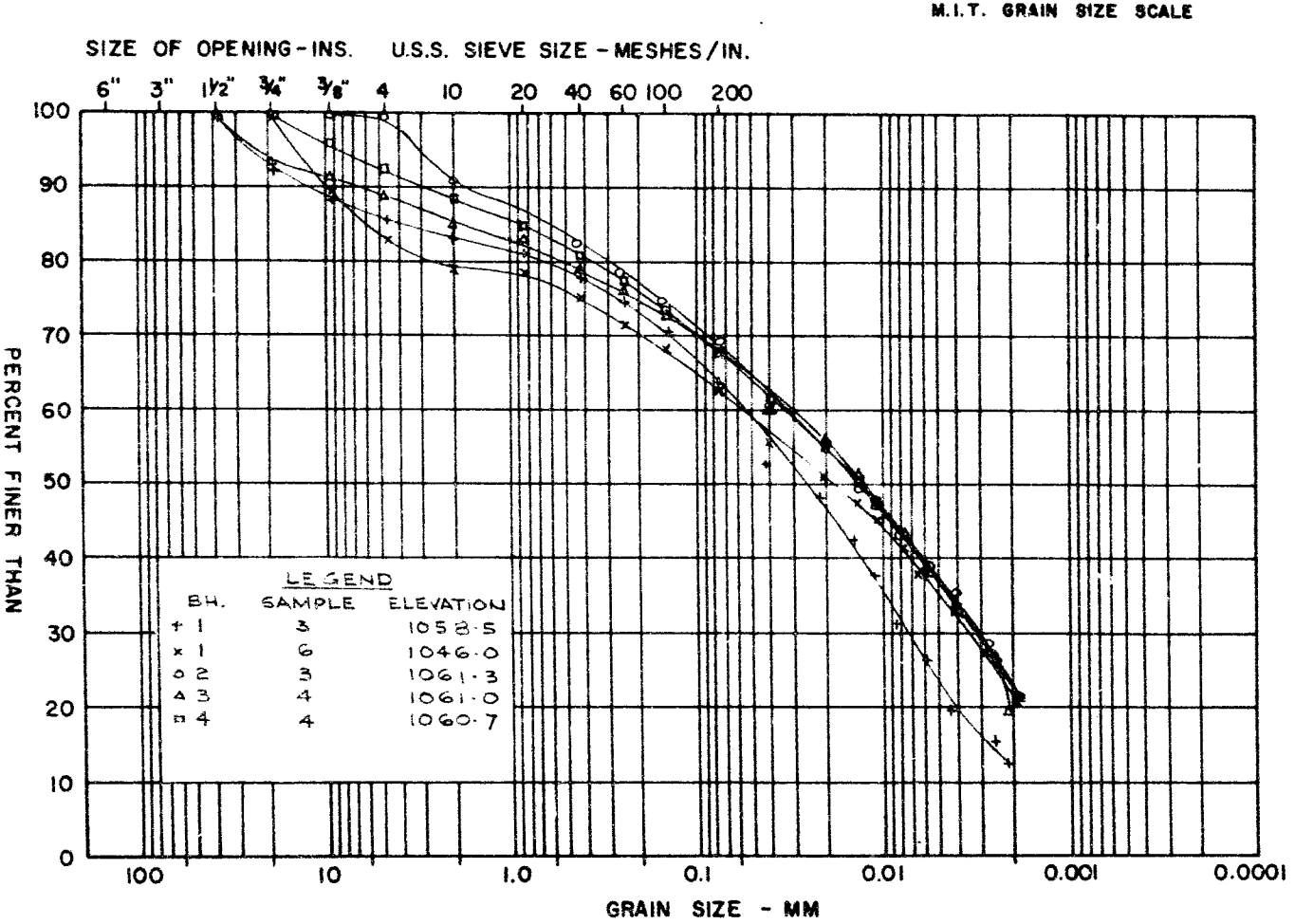
PROJECT No. 66514

GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

SILT TILL

FIGURE 3

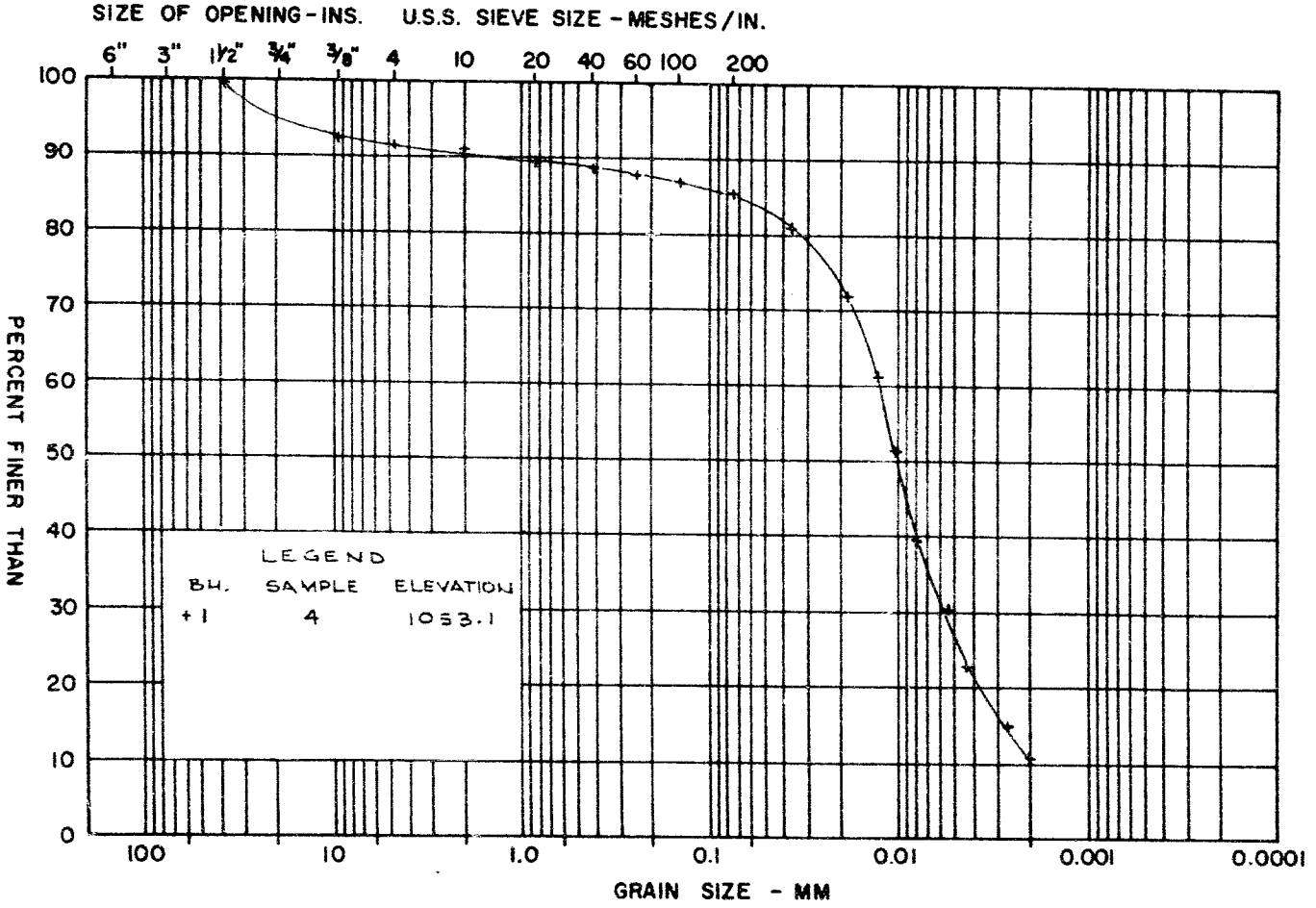


COBBLE SIZE	GRAVEL SIZE			SAND SIZE			FINE GRAINED	
	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE

PROJECT No. 66514

GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE



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

GRAIN SIZE DISTRIBUTION

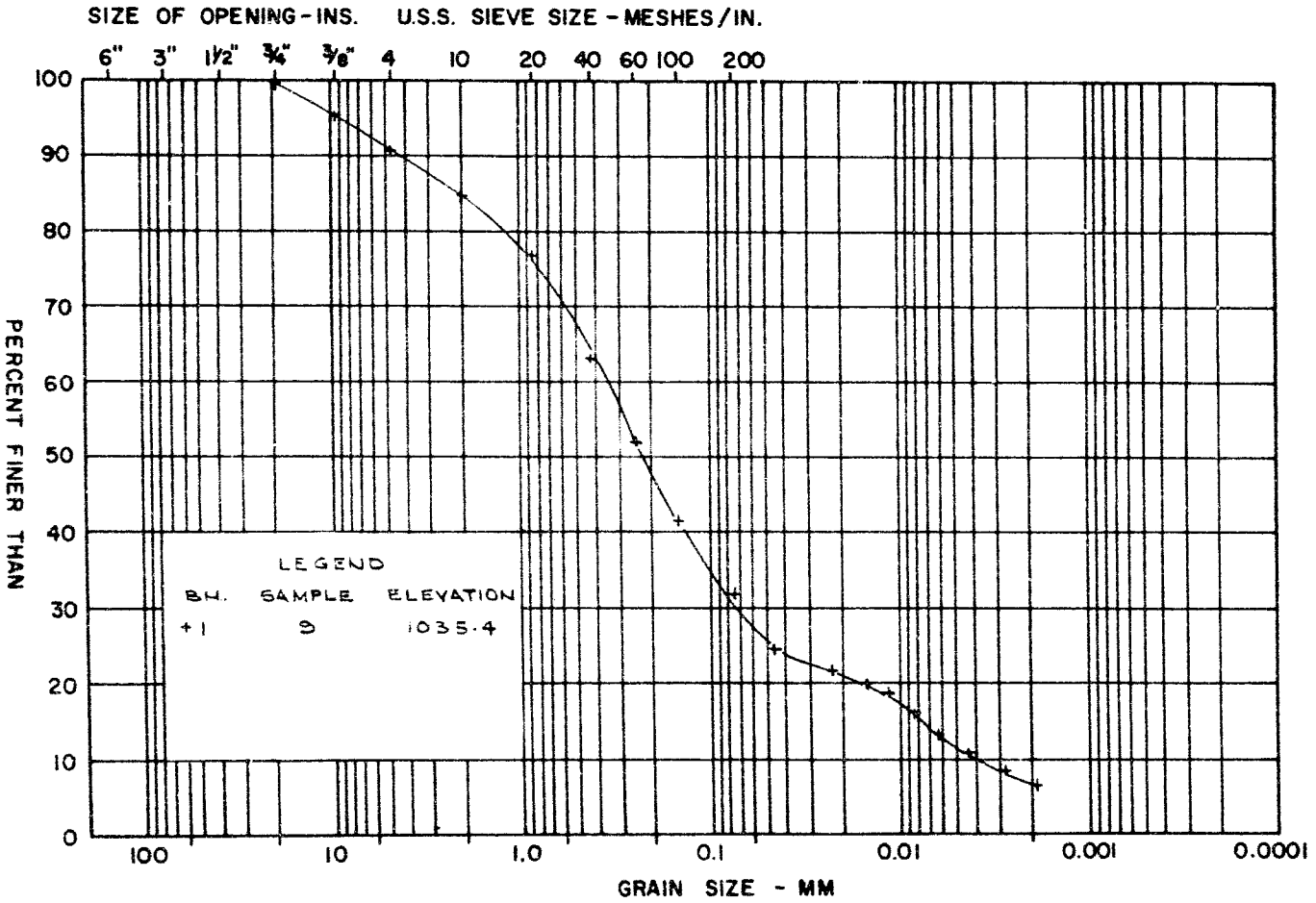
SILT LAYER

FIGURE 4

PROJECT No. 66514

GOLDER & ASSOCIATES

M.I.T. GRAIN SIZE SCALE



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

GRAIN SIZE DISTRIBUTION

SILTY SAND

FIGURE 5