FOUNDATION TECHNICAL MEMORANDUM

For

THAMES RIVER BRIDGE EBL AND WBL
HIGHWAY 402
MTO WEST REGION 59 STRUCTURE REHABILITATIONS
SITE 19-536-1 AND 19-536-2, CONTRACT 4
GWP 3102-10-00
DELAWARE AND STRATHROY-CARADOC TOWNSHIP
COUNTY OF MIDDLESEX, ONTARIO

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: toronto@petomaccallum.com

Distribution:
1 cc: WSP for distribution to MTO + 1 digital copy (PDF)
Electronic Copy to MTO (David.Staseff@ontario.ca)
1 Electronic Copy to MTO (maha.almassri@ontario.ca)
1 Electronic Copy to WSP
(Scott.Leitch@wsp.com) + 1 digital copy (PDF)
1 cc: PML Kitchener
1 cc: PML Toronto

PML Ref.: 13KF006D-TR
Index No.: 373FTM
GEOCRES No.: 40I14-93
November 15, 2017

TABLE OF CONTENTS

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION TECHNICAL MEMORANDUM
For
Thames River Bridge EBL and WBL
Highway 402
MTO West Region 59 Structure Rehabilitations
Site 19-536-1 and 19-536-2, Contract 4,
GWP 3102-10-00
Delaware and Strathroy-Caradoc, Ontario

1. INTRODUCTION

The Foundation Engineering Services for the present project involve the detail foundation investigation and design for rehabilitation of 59 structures in the MTO West Region along Highways 4, 6, 401, 402 and 403. Ten (10) Group Work Projects (GWP) are contemplated to be completed between 2014 and 2020.

This technical memorandum summarizes the factual results of the geotechnical data based on the review and compilation of existing subsurface information from relevant reports in the MTO GEOCRES Library for the Thames River Bridge EBL and WBL in Delaware and Strathroy-Caradoc, Ontario. The Foundation Engineering recommendations from the original foundation reports are summarized with reference to the “Canadian Highway Bridge Design Code” (CHBDC) and follow in general the “Guidelines for Professional Engineers providing Geotechnical Engineering Services”.

Based on minutes from Progress Meeting No. 13, dated April 23, 2015, the Thames River Bridge will be rehabilitated in four stages over two construction seasons as follows.

- In the first year the existing concrete barriers on the deck will be replaced with new PL-3 concrete barriers in two stages while maintaining a single 3500 mm lane with 500 mm shoulders in both stages. A temporary concrete barrier (TCB) will be placed back in front of the new barrier walls during the winter shutdown to match the TCB on the approaches.

- In the second year the abutments will be converted to semi-integral in two stages while maintaining a single 3500 mm lane with 300 mm shoulders in both stages.

165 Cartwright Avenue, Toronto, Ontario M6A 1V5
Tel: (416) 785-5110 Fax: (416) 785-5120
E-mail: toronto@petomaccallum.com
BARRIE, HAMILTON, KITCHENER, TORONTO

Based on minutes from Progress Meeting No. 16, dated October 27, 2014, scour protection will be provided at the west pier of the WBL structure and both east and west piers of the EBL structure.

The purpose of this technical memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports for the design project team's reference.

The elevations in this report are expressed in meters, unless otherwise noted.

2. PROJECT SITE BACKGROUND AND GEOLOGY

The Thames River Bridge is located on Highway 402, about 1 km east of the Highway 2 and Highway 402 Interchange. The Thames River Bridge represents the township boundary between Delaware and Strathroy-Caradoc hence the eastern abutments and piers are located in Delaware Township while the western abutments and piers are located in Strathroy-Caradoc Township. A Key Plan is shown on Figure 1. The Thames River Bridge consists of two structures each of which carry two lanes of Highway 402 eastbound and westbound traffic over the River Thames.

The site is located in a flood plain of the Thames River which, in this area, generally flows in a north to south direction. The flood plain at the site is relatively level, sloping very gently towards the river on the west bank and away from the river on the east bank. At the site, the Thames River was about 47.2 m (155.0 ft.) in width at normal stage and was flowing in a bed extending about 6.1 m (20.0 ft.) below the adjacent flood plain. At the time of the Golder investigation, there was about a 0.9 m (3.0 ft.) depth of water in the river with the river water level being at about elevation 203.0 m (666.0 ft.).

Physiographically, the site is situated in the region known as the Caradoc Sand Plains. The Caradoc Sand Plains comprise large water-laid alluvial beach deposits. This plain was formed when the early Thames River discharged into Glacial Lake Warren forming a sand gravel deltaic deposit. Clay plains occur in association with the sand plains and represent the sediment that was deposited in deeper water further off than the alluvial beach deposits (sand plains). The limestone, dolostone or shale bedrock in the area belongs to the Hamilton Group of Middle Devonian period.

Based on the Bedrock Topography Series, St. Thomas (1968) prepared by the Ontario Geological Survey, the bedrock elevation in the vicinity of the bridge is at approximate elevation 179.8 (590.0 ft.), about 22.9 m (75.0 ft.) below the river bed.

3. SOURCE OF INFORMATION

The following reports, documents and plans were available for review and information for the Thames River Bridge and are included in Appendix A. Reference 1 represents the foundation investigation report for the bridge structure.

1. Foundation Investigation Report, for Hwy. 402 & Thames River Crossing, 7.8 Miles West of Hwy. 4, Twps of Delaware & Caradoc, Site #19-536, W.P. 41-66-17 & 18, Dist. #2 (London). GEOCRES No. 40I14-93, dated June 1975. (Reference 1)

2. General Plan DWG 1, Sheet 137, Thames River Bridges, 7.8 Miles West of Hwy. 4, WP No 41-66-17 & 18, dated December 1975. (Reference 2)

3. Foundation Layout & Piers, DWG 3, Sheet 139, Thames River Bridges, 7.8 Miles West of Hwy. 4, WP No 41-66-17 & 18, dated December 1975. (Reference 3)

4. SITE RECONNAISSANCE

As part of the current foundation engineering assessment study, a site reconnaissance of the Thames River Bridge was carried out on September 2, 2015. A photographic record of the site visit is included in Appendix B.

The site photographs present the current condition of the Thames River Bridge including visible portions of the abutments and piers, abutment slope assessment based on visible areas, apparent areas of soil erosion and abutment slope cover.

The north and south slopes of the EBL and WBL east and west abutments were grass covered during the site reconnaissance. The abutment slopes showed no obvious signs of erosion (Photographs 1, 2, and 5). The abutments for both the EBL and WBL structures generally appear to be free of major surficial cracks or defects (Photographs 3 and 7). The visible portion of the piers appear to be free of major surficial cracks or defects (Photographs 4 and 8). Noticeable spalling of the bridge deck concrete was observed on the south wingwall of the east abutment, EBL (Photograph 6).

5. PREVIOUS INVESTIGATION AND SUMMARIZED SUBSURFACE CONDITIONS

A Foundation investigation report was prepared by H.Q. Golder Associates Ltd. dated June 1975. The purpose of the investigation was to establish the subsoil and groundwater conditions at the proposed Thames River Bridge.

The field investigation was carried out during the period May 13 to 27, 1975. The field work included 20 sampled boreholes (boreholes 1 to 20) of which thirteen boreholes were drilled on land while seven boreholes (boreholes 6, 9, 12, 15 and 18 to 20) were drilled in the water. All boreholes except boreholes 1, 2, 13 and 14, were also advanced with a dynamic cone. Sixteen additional cone penetration tests were carried out.

The boreholes were drilled to 5.0 to 17.2 m (16.5 to 56.5 ft.), elevation 192.0 to 204.6 (629.8 to 671.1 ft.). Soil samples were recovered from the boreholes using the standard penetration test (SPT) method.

The borehole locations and a soil profile are shown on a drawing dated June 2, 1975, Borehole Locations & Soil Strata, included in the Appendix (Reference 1).

Samples were visually examined in the field and subsequently in the laboratory. Selected samples were subjected to laboratory tests to determine the physical properties of the various soil types. The results of the field and laboratory tests were presented in the Record of Borehole Sheets, Tables and Figures appended to the original report (Reference 1).

The subsoil conditions have been referenced from boreholes included and inferences made within the available reports and drawings.

5.1 Subsurface Conditions Summary

The subsurface conditions encountered in the boreholes are described in the following sections of this report.

5.1.1 Water

Within seven boreholes (boreholes 6, 9, 12, 15 and 18 to 20) drilled within the river, from the top of the river level, elevation 202.8 to 203.0 (665.3 to 665.9 ft.), the water depth ranged from 0.6 to 1.2 m (2.0 to 4.0 ft.) with the river bed elevation ranging from elevation 201.7 to 202.3 (661.9 to 663.6 ft.).

5.1.2 Topsoil

From the ground surface in the land boreholes, a 0.3 to 0.7 m (1.0 to 2.2 ft.) thick layer of topsoil was contacted and penetrated at elevation 201.7 to 209.0 (661.9 to 685.6 ft.).

5.1.3 Cohesionless Deposits (Sandy Silt/Silty Sand, Sand and Gravel and Sand)

Underlying the topsoil in the land boreholes and from the river bed surface in the water boreholes, except boreholes 15, 18 and 19, at 0.3 to 1.2 m (0.9 to 4.0 ft.), elevation 201.7 to 209.0 (661.9 to 685.6 ft.), a 0.2 to 5.7 m (0.5 to 18.7 ft.) thick cohesionless stratum consisting of sandy silt/silty sand, sand and gravel and/or sand was contacted to 1.4 to 6.0 m (4.5 to 19.8 ft.), elevation 201.2 to 206.6 (660.1 to 677.7 ft.). N values in this stratum ranged from 2 to greater than 100 with typical values ranging from 2 to 20, indicating a very loose to compact compactness condition. Moisture contents ranged from 5 to 35%.

5.1.4 Silty Clay Till

Forming the river bed in boreholes 15, 18 and 19 and below the cohesionless stratum at 0.6 to 6.0 m (2.0 to 19.8 ft.), elevation 201.2 to 206.6 (660.1 to 677.7 ft.), a 3.4 to 8.7 m (11.3 to 28.5 ft.) thick silty clay till stratum was contacted in all boreholes. This stratum extended to 4.4 to 12.0 m (14.5 to 39.5 ft.), elevation 196.9 to 198.8 (645.9 to 652.1 ft.) in all boreholes except boreholes 1, 2, 13 and 14, which were terminated within this stratum at 4.6 to 5.8 m (15.0 to 19.0 ft.), elevation 202.2 to 204.6 (663.4 to 671.1 ft.). N values in this stratum ranged from 9 to 56 indicating a stiff to hard consistency. Moisture content determinations ranged from 12 to 26%.

The silty clay till has an average bulk unit weight of 20.4 kN/m^3 (130 pcf). Nine Atterberg Limits tests indicated Liquid Limits ranging from 25 to 42, Plastic Limits ranging from 15 to 21 and Plasticity Indices ranging from 9 to 22. Laboratory “quick” triaxial tests indicated shear strengths ranging from 57 to 335 kPa (1200 to 7000 psf), with an average value of 144 kPa (3000 psf). One consolidation test conducted on a sample from this stratum indicated an estimated range of pre-consolidation pressure of 862 to 1149 kPa (9 to 12 tsf). A compression Index C_c of 0.27 and a recompression index of C_r of 0.03 were indicated by the consolidation test.

5.1.5 Clayey Silt Till

Below the silty clay till in all boreholes except 1, 2, 13 and 14 at 4.4 to 12.0 m (14.5 to 39.5 ft.), elevation 196.9 to 198.8 (645.9 to 652.1 ft.), a clayey silt till stratum was contacted to borehole termination depths of 6.4 to 15.4 (21.0 to 50.5 ft.), elevation 193.3 to 196.5 (634.3 to 644.6 ft.) in all boreholes except boreholes 11 and 16, where the clayey silt till stratum was approximately 3.0 m (10 ft.) in thickness and extended to 14.9 and 11.9 m (49.0 and 39.0 ft.), respectively.

N values within the glacial clayey silt till ranged from 18 to greater than 100. The upper 0.9 m (3.0 ft.) of clayey silt till had a N value of about 30 while below this depth the till had N values generally greater than 100. Moisture content determinations ranged from 6 to 18%. Eight Atterberg Limits tests indicated Liquid Limits ranging from 20 to 29, Plastic Limits ranging from 12 to 19 and Plasticity Indices ranging from 6 to 14.

5.1.6 Silty Clay

Below the clayey silt till in boreholes 11 and 16, at 14.9 and 11.9 m (49.0 and 39.0 ft.), respectively, a silty clay stratum was contacted to the borehole termination depths of 17.2 and 13.4 m (56.5 and 43.8 ft.), elevation 192.0 and 194.3 (629.8 and 637.3 ft.), respectively. N values in this stratum were greater than 100. Moisture content determinations ranged from 12 to 18%. One Atterberg Limits test indicated a Liquid Limit of 43, a Plastic Limit of 25 and a Plasticity Index of 18.

5.2 Groundwater

During the 1975 field investigation, groundwater levels were noted from 0.6 to 11.3 m (2.0 to 37 ft.) from one to two weeks following installation of piezometers and perforated standpipes.

Two distinct stabilized water levels were interpreted by the 1975 Golder geotechnical investigation report. An upper ground water level exists within the cohesionless soil at about 2.1 m (7.0 ft.) elevation 206.4 (677.0 ft.). A second lower water level was contacted in the clayey silt till at about 4.3 m (14.0 ft.) elevation 204.2 (670.0 ft.), below the ground level in the flood plain and about 1.2 m (4.0 ft.) above the river level at the time of the investigation.

6. FOUNDATION

6.1 Previous Foundation Discussion and Recommendations

Two separate bridge structures, parallel to each other were proposed to carry Highway 402 EBL and WBL over the Thames River. The 1975 Golder report indicates that a three span structure with welded steel plate girders or a five span structure with precast prestressed reinforced girders was proposed. Approach fills of about 8.5 m (28.0 ft.) and 12.2 m (40.0 ft.) were proposed at the east and west approaches, respectively. It was proposed to widen the river bed cross section to provide adequate hydraulic capacity by excavating into the existing banks.

The subsurface soils encountered at the borehole locations were generally uniform in type and extent. Groundwater levels were noted from 0.6 to 11.3 m (2.0 to 37 ft.) from one to two weeks following installation of piezometers and perforated standpipes.

6.1.1 Foundation

Two types of foundations were considered for the project as described in the following sections.

6.1.1.1 Spread Footings

Based on the subsurface factual data, it was recommended that the bridge piers be supported by spread footings supported within the very stiff silty clay till or hard clayey silt till. For footings founded between elevation 196.6 and 202.7 (645.0 and 665.0 ft.), an allowable bearing pressure of 287 kPa (6000 psf) was recommended. For footing founded at or below elevation 196.6 (645.0 ft.), a maximum allowable bearing pressure of 766 kPa (16,000 psf) was recommended.

6.1.1.2 Piles

Steel H piles driven to refusal within the hard clayey silt till were recommended for support of the abutments. For a HP 310 X 110 (12HP74) pile, driven to a set of at least 10 blows per 25 mm (1.0 in.) with a steam or diesel hammer developing at least 27 kJ (20,000 ft.-pounds) of energy an allowable load of 890 kN (100 tons) per pile was recommended. It was recommended that the pile driving data be checked using the Hiley dynamic formula and appropriate allowances for reduction in capacity be made due to negative skin friction induced by embankment and foundation settlement. It was anticipated that the piles would achieve final set by penetrating 0.6 to 2.1 m (2.0 to 7.0 ft.) within the hard clayey silt till.

The anticipated refusal elevations were as shown in the Table below:

STRUCTURE		ELEVATION
Eastbound	East Abutment	196.6 (645.0 ft.)
	West Abutment	195.1 (640.0 ft.)
Westbound	East Abutment	197.2 (647.0 ft.)
	West Abutment	195.7 (642.0 ft.)

As an alternative to spread footings it was recommended that the piers could also be supported on H piles driven to refusal within the hard clayey silt till to a similar capacity as provided for the abutment support piles. It was anticipated that the H piles driven at the piers would achieve final set at about elevation 196.3 (644.0 ft.).

6.1.2 Frost Protection

The report recommended a frost protection of 0.9 m (3.0 ft.) earth cover for pile caps.

6.1.3 Settlement

The anticipated total settlement for spread footings founded on the very stiff silty clay till at elevation 199.6 (655.0 ft.) was 25 mm (1 in.). Spread footings founded at elevation 198.1 (650.0 ft.) were expected to undergo settlement of 12.5 mm (0.5 in.). Settlements of less than 12.5 mm (0.5 in.) were anticipated for footings founded at elevation 196.6 (645.0 ft.). The anticipated differential settlements were less than half of the total settlement in each case.

The total settlement of completed structures supported on pile foundations was anticipated to be less than 12.5 mm (0.5 in.).

6.1.4 Construction Considerations

Free draining and non-frost susceptible granular backfill was recommended behind the abutments to a minimum horizontal distance of 1.8 m (6.0 ft.) from the pile caps and then at a slope of 1H:1V up and away from the pile cap. The Golder report recommended that the granular backfill be placed in 0.5 m (1.5 ft.) maximum lift thickness with vibratory equipment and be uniformly compacted to 100% of the standard Proctor maximum dry density. A coefficient of lateral earth pressure of 0.3 and a total unit weight of 21.2 kN/m^3 (135 pcf) was recommended for the granular backfill to be used in wall design, assuming effective drainage behind the wall. Reinforced concrete approach slabs were recommended at each abutment location to minimize detrimental effects of any differential settlement between the pile supported abutments and the relatively high approach fills.

It was anticipated that the excavations for the pier foundations would be carried out within cofferdams of interlocking steel sheet piling driven into the silty clay till stratum.

Further it was stated that no stability problems were anticipated with the embankment fills (8.5 m to 12.2 m (28.0 to 40.0 ft.) in height), if 2H:1V slopes were employed and locally available material consisting of clayey silt, silty clay for the east approach and granular materials for the west approach were used. At the 12.2 m (40.0 ft.) high east approach fills, total foundation settlements in the order of 150 mm (6 in.) were anticipated in addition to the settlement of the fill material itself. At the 8.5 m (28.0 ft.) high west approach, total foundation settlement in the order of 50 mm (2 in.) was anticipated. It was recommended that that proposed fills be instrumented and monitored, however no records of fill instrumentation or monitoring were available for review.

It was recommended that adequate riprap protection, placed on a suitable filter material, be provided for the approach embankments.

6.2 Assessment of Foundation Parameters

Reference 2 indicates that the embankments approximately 8.5 and 11.3 m (28.0 and 37.0 ft.) in height were constructed at the west and east bridge abutments, respectively. A four span bridge with each span about 32.9 m (108.0 ft.) was constructed.

References 2 and 3 indicate that the bridge structures were supported on HP 310 X 110 (HP12X74) steel H piles. A Table included in Reference 3 indicates that the overall pile lengths ranged from 6.1 to 21.3 m (20.0 to 70.0 ft.). Battered piles were used for lateral resistance. The abutment piles were to be driven to elevations as indicated in the Table provided in Section 6.1.1.2. The Notes on Reference 3 indicate that the piles for pier support were to be driven below elevation 195.7 (642.0 ft.) to achieve a design load of 690 kN (95 tons).

The Limit State pile resistances have been estimated based on the assumption that the piles were driven to the hard clayey silt till stratum below elevation 195.1 (640.0 ft.).

Based on the previous investigation and subsurface conditions encountered, the following table summarizes the foundation design elevations and loads that were recommended in the previous report and design drawings. The updated geotechnical reaction at SLS and factored geotechnical resistance at ULS are also provided.

FOUNDATION DESIGN PARAMETERS

FOUNDATION HP 310 X 110 STEEL H PILE FOR EBL AND WBL	HIGHEST ESTIMATED PILE TIP ELEVATION[1]		PREVIOUS WORKING STRESS VALUES[2]	PREVIOUS EQUIVALENT LIMIT STATE DESIGN VALUES		LIMIT STATE DESIGN VALUES UPDATED TO CURRENT INDUSTRY PRACTICE[3]	
	(ft.)	(m)	SAFE BEARING RESISTANCE / LOAD	SLS BEARING REACTION / LOAD	ULS FACTORED GEOTECHNICAL RESISTANCE LOAD	SLS BEARING REACTION / LOAD	ULS FACTORED GEOTECHNICAL RESISTANCE / LOAD
West Abutment	634.3	193.3	95 tons	890 kN	1068 kN	980 kN	1180 kN
East Abutment	638.1	194.5	95 tons	890 kN	1068 kN	980 kN	1180 kN
Pier 1	638.3	194.6	95 tons	890 kN	1068 kN	980 kN	1180 kN
Pier 2	638.3	194.6	95 tons	890 kN	1068 kN	980 kN	1180 kN
Pier 3	638.3	194.6	95 tons	890 kN	1068 kN	980 kN	1180 kN

Notes: 1. Reference 3, Foundation Layout & Piers includes a Table titled Pile Data which shows the Pile Lengths. The pile tip elevation was computed from the pile cut off elevation and vertical pile component, as applicable. The actual construction records of the pile driving operations were not available for review and accordingly the pile tip elevations should only be considered approximate but nevertheless useful information. Working stress pile load is provided on Reference 3, Notes.

2. Working stress design values. The Serviceability Limit State design values are based on the working stress. No field verifications were made.

3. Resistance Factor = 0.4 for deep foundations (CFEM, 4th edition) for calculation of ULS.

Pile groups effects should be taken into account as per CHDBC during evaluation of pile group capacity.

The Peak Ground Acceleration (PGA) for the site is 0.064 (National Building Code of Canada, 2015). The soil classification for seismic design should be in accordance with Clause 4.4.3.2 of the CHBDC (2014).

The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.

7. DISCUSSION

Rehabilitation of the Thames River Bridge is planned for construction in 2016 and 2017. Based on minutes from Progress Meeting No. 13, dated April 23, 2015, the Thames River Bridge will be rehabilitated in four stages over two construction seasons as follows.

- In the first year the existing concrete barriers on the deck will be replaced with new PL-3 concrete barriers in two stages while maintaining a single 3500 mm lane with 500 mm shoulders in both stages. TCB will be placed back in front of the new barrier walls during the winter shutdown to match the TCB on the approaches.

- In the second year the abutments will be converted to semi-integral in two stages while maintaining a single 3500 mm lane with 300 mm shoulders in both stages.

Based on minutes from Progress Meeting No. 16, dated October 27, 2014, scour protection will be provided at the west pier of WBL and both east and west piers of EBL structure.

A temporary support system may be required for the rehabilitation of the bridge structure and the construction for temporary support system should conform to OPSS 404 and 539. The contractor is responsible for the selection, detailed design and performance of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system.

During the 1975 field investigation, groundwater levels were noted from 0.6 to 11.3 m (2.0 to 37 ft.) from one to two weeks following installation of piezometers and perforated standpipes.

Two distinct stabilized water levels were interpreted by the 1975 Golder geotechnical investigation report. An upper ground water level exists within the cohesionless soil at about 2.1 m (7.0 ft.) elevation 206.4 (677.0 ft.). A second lower water level was contacted in the clayey silt till at about 4.3 m (14.0 ft.) elevation 204.2 (670.0 ft.), below the ground level in the flood plain and about 1.2 m (4.0 ft.) above the river level at the time of the investigation.

Based on the above data, groundwater control is not anticipated during the bridge rehabilitation. Perched water within the embankment, if encountered, can be controlled using sumps and pumps. It should be noted that the groundwater levels are subject to seasonal fluctuations and precipitation patterns.

The slopes adjacent to both abutments are visually stable without sign of erosion. However, the embankments which are greater than 8.0 m in height were constructed with a 2H:1V slope but not benched as per current practice (OPSD 202.010).

Post construction, the faces of the adjacent slopes of the abutments should be suitably rehabilitated to mitigate erosion effects. The central portion of the abutments are protected with a vertical concrete retaining walls, which generally appear to be free of major surficial cracks or defects, however they must be evaluated by a structural engineer for age related deficiencies and general wear and tear. Bridge deck concrete spalling noted on the south wingwall of the east abutment, EBL must be remediated and the bridge deck inspected for structural defects.

The draining provisions behind the abutment walls should be assessed to determine if they are functioning as intended to enhance drainage behind the abutment walls.

8. CLOSURE

This technical memorandum was prepared by Mr. H. Gharegrat, MS., P.Eng, Senior Engineer, Geotechnical Services and was reviewed by Mr. B. R. Gray, MEng, P.Eng., Principal Consultant. Mr. R. Ng, MBA, PhD, P.Eng, MTO Designated Principal Contact conducted an independent review of the report.

We trust this memo is sufficient for your immediate needs. Please, do not hesitate to contact us if you have any inquiries and/or comments.

Yours truly,

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
H. Gharegrat
100078972
Nov 15, 2017
PROVINCE OF ONTARIO

Harry Gharegrat, MS., P.Eng.
Senior Engineer, Geotechnical Services

REGISTERED PROFESSIONAL ENGINEER
B. R. GRAY
Nov. 15/17
PROVINCE OF ONTARIO

Brian R. Gray, M.Eng, P.Eng.
Principal Consultant

LICENSED PROFESSIONAL ENGINEER
R. M. C. NG
Nov. 15, 2017
PROVINCE OF ONTARIO

Robert Ng, MBA, PhD, P.Eng.
MTO Designated Principal Contact

HG/RN/BRG:hg-nk

TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 404	Construction Specification for Support Systems
OPSS 539	Construction Specification for Temporary Protection Systems
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario
OPSD 202.010	Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment

Figure 1 – Key Plan

APPENDIX A

Previous Foundation Investigation Reports (GEOCRES 40I14-93) and Drawings

Reference 1. Foundation Investigation Report, for Hwy. 402 & Thames River Crossing, 7.8 Miles West of Hwy. 4, Twps of Delaware & Caradoc, Site #19-536, W.P. 41-66-17 & 18, Dist. #2 (London), dated June 1975.

Reference 2. General Plan DWG 1, Sheet 137, Thames River Bridges, 7.8 Miles West of Hwy. 4, WP No 41-66-17 & 18, dated December 1975.

Reference 3. Foundation Layout & Piers, DWG 3, Sheet 139, Thames River Bridges, 7.8 Miles West of Hwy. 4, WP No 41-66-17 & 18, dated December 1975.

DOCUMENT MICROFILMING IDENTIFICATION

Reference 1

GEOCRES No. 40I14-93

DIST 2 REGION Southwestern

W.P. No. 41-66-17/18

CONT. No. 78-66

W. O. No.

STR. SITE No. 19-536

HWY. No.

LOCATION Crossing at Thames River and Proposed King's Hwy. 402

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. 3

REMARKS: documents to be unfolded before microfilming

GI-20 SEPT 1976

ABSTRACT

The results of an investigation to determine the subsurface conditions at the site of the proposed Thames River Crossing for the proposed King's Highway 402, Line A, in Lot 23, Range I, South Longwoods Road, Township of Caradoc, County of Middlesex, Ontario and Lot 7, Concession D, Township of Delaware, County of Middlesex, Ontario are reported. Geotechnical engineering recommendations are presented for the design and construction of the foundations, approach embankments, cut slopes and excavations for the proposed twin structures.

It was found that the site is underlain by loose sandy silt, loose silty fine sand and compact sand and gravel overlying an extensive stratum of silty clay till. Beneath the silty clay till, clayey silt till was encountered overlying silty clay. The groundwater level in the surficial granular strata appears to be perched several feet above the water level in the clayey silt till. However, the estimated water levels in the clayey silt till are several feet above the corresponding river water level.

It is recommended that the piers be founded on spread footings bearing on the very stiff silty clay till stratum. The abutments may be founded on end bearing steel H piles driven to refusal in the hard clayey silt till.

No overall stability problems are anticipated with the approach embankments at the site. However, specific recommendations are provided for blanketing and protection of both cut and fill slopes adjacent to the proposed structures.

1. INTRODUCTION

H. Q. Golder & Associates Ltd. has been retained by the Ministry of Transportation and Communications, Ontario to carry out a subsurface investigation at the site of the two proposed structures to be constructed for the proposed Highway 402 crossing of the Thames River. The Thames River represents the township boundaries in this area of the County of Middlesex. As a consequence the easterly abutments and piers will be in Lot 7, Concession D, Township of Delaware with the westerly abutments and piers in Lot 23, Range I, South Longwoods Road, Township of Caradoc. The site is located on the alignment of the proposed Highway 402, Line A, about 0.5 miles east of the Highway 2 crossing as indicated on the Key Plan, Figure 1. The purpose of the investigation was to determine the soil and groundwater conditions at the site of the proposed structures and to provide geotechnical engineering recommendations for the design and construction of the foundations and approach embankments required for the river crossing.

2. PROCEDURE

A total of twenty boreholes, sixteen accompanied by dynamic cone penetration tests, were drilled at the site; concurrently, sixteen additional cone penetration tests were carried out. All drilling and testing was performed at the locations shown on the plan, Figure 1. The boreholes were drilled between May 13 and 27, 1975 using a truck mounted power auger, a crawler mounted power auger and a raft mounted drillrig. The drillrigs and support equipment were supplied and operated by Master Soil Investigations Limited.

The soil stratigraphy encountered in the boreholes is shown in detail on the Record of Borehole sheets following the text of this report and inferred stratigraphic sections across the site are shown together with the plan on Figure 1 and on Figure 2.

Standard penetration tests were carried out in all the boreholes and, in addition, several relatively undisturbed thin walled tube samples of the very stiff silty clay till stratum were obtained. All the samples obtained during the investigation were brought to our London laboratory for detailed examination and representative classification testing. In addition, unconfined compression tests and unconsolidated undrained and consolidated undrained triaxial compression tests were carried out together with one consolidation test on the undisturbed samples of the silty clay till stratum. The results of the laboratory tests are shown on the Records of Boreholes and on Figures 3 to 12 inclusive and on Table I.

Groundwater levels were observed in the boreholes during drilling and perforated standpipes and piezometers were installed in the completed boreholes as detailed on the Record of Borehole sheets. The measured groundwater levels are shown on the Records of Boreholes and on the stratigraphic sections, Figures 1 and 2.

Ground surface elevations at borehole locations have been referred to a bench mark located on a nail and washer in a 0.4 foot diameter shaped stump 109 feet right of station 105+16 on the Highway 402 alignment. The elevation of this bench mark was given by the Ministry of Transportation and Communications, Ontario as 748.11 feet referred to geodetic datum.

The field work was supervised throughout by members of our engineering staff who located the boreholes, determined ground surface elevations at borehole locations, logged the boreholes and cared for the samples obtained. The programme of field work was carried out under the guidance of a senior geotechnical engineer.

3. SITE AND GEOLOGY

The proposed structures are located between the proposed Highway 402, Line A, chainage 637+75 in Lot 23, Range I, South Longwoods Road, Township of Caradoc and chainage 102+25 in Lot 7, Concession D of the Township of Delaware, County of Middlesex. This is about 1 mile south of the Village of Delaware and about 0.5 miles east of Highway 2. The site is situated in the flood plain of the Thames River which, in this area, flows generally in a north to south direction; for discussion in this report this line is chosen as nominal north-south. The flood plain at the site is generally level, sloping very gently towards the river on the west bank and away from the river on the east bank. The Thames River at the site is about 155 feet in width at normal stage and flows in a bed extending some 20 feet below the adjacent flood plain. There was about a 3 foot depth of water in the river with the river water level being at about elevation 666 at the time of the investigation.

The apparently stable river bank slopes in the vicinity of the structure have a maximum slope of about 2 horizontal to 1 vertical. However, much of the river bank in the area of the site is unstable and has slopes of up to 1 horizontal to 1 vertical. Such areas exhibit multiple tension cracks and bulging and appear to be sliding into the river as a direct result of erosion of the fine grained cohesionless material at the toe of the slope.

The east river valley wall is located about 300 feet east of the river and rises about 65 feet above the adjacent flood plain. The valley wall in the area of the site has an average existing slope of about 2.5 horizontal to 1 vertical and no overall instability was apparent. The west river valley wall is located west of Highway 2 and some 3800 feet west of the river crossing.

The site is located in the physiographic region knwon as the Caradoc Sand Plain. These beds of clays, silts and fine sands were deposited by the earliest glacial spillways discharging turbid water into a basin in the glacial till. When the standing water level had been lowered to the level of Lake Whittlesey, the early Thames River cut through these depsoits and into the underlying till deposits to create its present valley. The river appears to have eroded away about 10 feet of till in the flood plain with a further 15 feet having bren eroded to create the present river channel.

Artesian pressures have been reported at depth in deep wells drilled adjacent to the general area of the site.

Available geological data indicate that the bedrock surface at the site is at about elevation 590 or some 90 feet below ground surface. The bedrock at the site is understood to consist of grey shale and limestone of the Hamilton formation of Devonian Age.

4. SUBSURFACE CONDITIONS

4.1 Soil Conditions

The soil conditions at the site generally consist of topsoil overlying from 4 to 20 feet of surficial granular layers consisting of loose sandy silt, loose silty fine sand and compact sand and gravel which overly an extensive stratum of very stiff silty clay till to about elevation 650. Beneath the silty clay till, a stratum of hard clayey silt till was penetrated for up to 13 feet. After fully penetrating the clayey silt till boreholes 11 and 16 were terminated in a layer of hard silty clay.

4.1.1 Sandy Silt

Beneath the topsoil in boreholes 3, 5, 8, 11, 13, 16 and 17, and a layer of silty fine sand in boreholes 7 and 10, layers of very loose to loose sandy silt were encountered. These silt layers varied in thickness from 2 to 5 feet at borehole locations and had N values of from 2 to 8 blows per foot. The sandy silt was generally loose with a representative N value of 4 blows per foot. The natural water content of the sandy silt varied from 12 to 29 per cent with an average value of about 21 per cent. Typical grain size distribution curves for the sandy silt layers are shown on Figure 4.

4.1.2 Silty Fine Sand

Underlying the sandy silt in boreholes 3, 11, 16 and 17 and the topsoil in boreholes 4, 7 and 10, layers of very loose to loose silty fine sand were encountered. Additional layers of silty fine sand were found interlayered with the sandy silt in boreholes 7, 10 and 16. The silty fine sand layers varied in thickness from 2 to 8 feet. The measured N values varied from 2 to 15 blows per foot and the silty fine sand was generally loose with a representative N value of 6 blows per foot. The natural water content of the silty fine sand varied from 13 to 35 per cent with an average value of about 22 per cent. Typical grain size distribution curves for the silty fine sand layers are shown on Figure 5.

4.1.3 Sand and Gravel

Below the sandy silt and silty fine sand layers in boreholes 3, 5, 8, 10, 11, 16 and 17 and the topsoil in boreholes 1 and 2 and forming the river bed in boreholes 6, 9 and 12, strata of sand to sand and gravel were found. The sand and gravel strata varied in thickness from 1 to 13 feet at borehole locations and had N values of from 5 to greater than 100 blows per foot. The sand and gravel was generally compact with a representative N value of 23 blows per foot. The natural water content of the sand and gravel varied from 5 to 26 per cent with an average value of about 12 per cent. Typical grain size distribution curves for the sand and gravel strata are shown on Figure 6.

4.1.4 Silty Clay Till

Beneath the surficial granular strata and forming the river bed in boreholes 15, 19 and 20, an extensive stratum of very stiff silty clay till was found. The silty clay till generally extended to about elevation 750 and varied in thickness from 12 to 28 feet where fully penetrated. The silty clay till had measured N values of from 9 to 56 blows per foot with a representative N value of 25 blows per foot. The natural water content of the silty clay till varied from 12 to 26 per cent with an average natural water content of about 19 per cent. The corresponding average liquid and plastic limits were 43 and 25 respectively. The silty clay till had an average bulk unit weight of 130 pounds per cubic foot. The silty clay till is identified on the plasticity chart, Figure 3, as an inorganic clay of low to intermediate plasticity.

The results of the undrained triaxial tests carried out on relatively undisturbed samples of the silty clay till are given in Table I. Based on the results of these tests and the measured N values, the undrained shear strength of this stratum is estimated to range from 1200 to 7000 pounds per square foot and is generally about 3000 pounds per square foot.

The results of a consolidation test carried out on a relatively undisturbed sample of the silty clay till from borehole 11 are shown on Figure 12. The results of this test indicated values for the recompression index C_r and compression index C_c of 0.03 and 0.27 respectively. The estimated range of preconsolida pressure for this sample was 9 to 12 tons per sq oot.

Typical grain size distribution curves for the silty clay till are shown on Figures 7 to 9 inclusive.

4.1.5 Clayey Silt Till

All the boreholes which fully penetrated the silty clay till encountered a stratum of hard clayey silt till. The clayey silt till varied from 9 to 10 feet in thickness where fully penetrated. Borehole 5 was terminated in the stratum after penetrating it for 13 feet. The clayey silt till had measured N values of from 18 to greater than 100 blows per foot. The upper 3 feet of clayey silt till had a representative N value of about 30 blows per foot. Below this depth the till strata had N values generally greater than 100 blows per foot. The natural water content of the clayey silt till varied from 6 to 18 per cent with an average value of about 11 per cent. The corresponding average liquid and plastic limits were 24 and 14 respectively.

The clayey silt till is identified on the plasticity chart, Figure 3, as an inorganic clay to an inorganic clay and silt of low plasticity. Typical grain size distribution curves for the clayey silt till stratum are shown on Figure 10. The clayey silt till contained larger particle sizes than those obtained using the restricted 2 inch O.D. sampling equipment and boreholes 9 and 12 were terminated in cobbles and boulders within this stratum.

4.1.6 Silty Clay

Boreholes 11 and 16 were terminated in a layer of hard silty clay underlying the clayey silt stratum. The silty clay which was penetrated for up to 7 feet had N values consistently greater than 100 blows per foot. The natural water content of the silty clay varied from 12 to 18 per cent with an average value of about 15 per cent. The corresponding liquid and plastic limits were 43 and 25 respectively. The silty clay is identified on the plasticity chart, Figure 3, as an inorganic clay of intermediate plasticity. A typical grain size distribution curve for the silty clay is shown on Figure 11.

4.2 Groundwater Conditions

The groundwater levels measured from one to two weeks following installation of the piezometers and perforated standpipes varied from elevation 681 to elevation 646 or from 2 to 37 feet below existing ground surface. The corresponding water level in the Thames River was at elevation 665.2 on May 30, 1975 having varied from elevation 665.2 to elevation 666.4 during the period of the field investigation.

Based on the water level readings obtained during the limited period of the investigation, the stabilized water level in the surficial granular deposit appears to be at about elevation 677 or about 7 feet below the ground surface. The stabilized water level in the piezometers sealed into the clayey silt till is estimated to be at about elevation 670 which is about 14 feet below ground level in the flood plain and some 4 feet above the river water level at the time of the investigation. Additional groundwater level measurements should be carried out to confirm the estimated static water levels detailed above.

5. DISCUSSION

It is understood that two bridge structures each some 460 feet long by 36 feet wide are to be constructed at the locations shown on the plan, Figure 1, to carry the proposed King's Highway 402 over the Thames River. The bridges will have either 3 spans with welded steel plate girders or 5 spans with precast prestressed reinforced concrete girders. The proposed structure footing locations for both schemes as provided by the Ministry of Transportation and Communications, Ontario are shown on the plan, Figure 1. The abutments are to be perched in the approach fills. The proposed grade at the centreline of the span is at about elevation 716 with a 1.8 per cent grade rising to the east over the full length of the structure. Approach fills of up to 28 and 40 feet in height will be required for the east and west approaches respectively. The river bed cross section at the structure locations is to be increased to provide adequate hydraulic capacity by excavating back into the existing banks as indicated on the stratigraphic section Figure 2.

5.1 Foundations

5.1.1 Spread Footings

The proposed piers may be founded on conventional spread footings bearing on the very stiff silty clay till or hard clayey silt till. From bearing capacity considerations an allowable bearing pressure of 3 tons per square foot may be used for design for footings founded between elevation 665 and elevation 645. For footings founded at or below elevation 645, a maximum allowable bearing pressure of 8 tons per square foot may be used. The computed total settlement for footings founded on the very stiff silty clay till at elevation 655 is 1 inch. Similarly, footings founded at elevation 650 would be expected to undergo settlements of ½ inch. The anticipated differential settlement is approximately one half of the total settlement in each case. Settlements of less than ½ inch are anticipated for footings founded at elevation 645 on the hard clayey silt till.

5.1.2 Piles

The abutments which are to be perched in the approach fills will be founded on steel H piles driven to refusal in the hard clayey silt till. For a typical 12BP74 pile driven to a final set of at least 10 blows per inch with a steam or diesel hammer developing at least 20,000 foot-pounds of energy per blow an allowable load of 100 tons per pile may be used in design. Pile driving data should be carefully recorded and the capacity of each pile checked using the Hiley dynamic formula and making appropriate allowances for reduction in pile capacity due to negative skin friction induced by embankment and foundation settlement. It is anticipated that the required final set can be obtained by the piles penetrating from 2 to 7 feet into the hard clayey silt till or to about the following elevations:

LOCATION	ELEVATION
Eastbound structure	
East Abutment	645
West Abutment	640
Westbound structure	
East Abutment	647
West Abutment	642

The settlement of the completed structures founded on H piles as detailed above should be less than ½ inch.

The outer ring of piles should be battered in all directions and the pile caps should be provided with at least 3 feet of frost cover.

As an alternative to spread footing foundations, the piers may also be founded on steel H piles driven to refusal in the hard clayey silt till as detailed above for the abutments. It is estimated that the average penetration at the pier locations for H piles driven as specified above will be to about elevation 644 for both structures.

5.2 Abutments

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 extend horizontally a minimum distance of 6 feet from the back of the pile cap and then slope up and away from the cap at a slope of 1 horizontal to 1 vertical. The granular backfill should be placed in horizontal lifts with a maximum thickness of 18 inches and compacted using vibratory equipment.

The granular backfill should be uniformly compacted to 100 per cent of standard Proctor maximum dry density in accordance with current Ministry of Transportation and Communications specifications. It is recommended that, providing there is effective drainage behind the walls, a coefficient of lateral earth pressure of 0.3 and a total unit weight of 135 pounds per cubic foot be used for the compacted granular backfill in the design of the walls.

In order to minimize the detrimental effects of any differential settlement between the pile supported abutments and the relatively high approach fills, it is recommended that reinforced concrete approach slabs be constructed at each abutment location.

5.3 Embankments

No major geotechnical problems are anticipated during the construction of the proposed 28 and 40 foot high approach fills for the east and west abutments. Native material may be used to construct these embankments in accordance with the procedures outlined in the Ministry of Transportation and Communications, Ontario Specifications, Form 214. It is understood that excavated material from the proposed cuts in the valley wall east of this site will be used to build the 40 foot high east approach fills. Based on available geological data, the borrow materials will consist primarily of clayey silt and silty clay. Provided that these materials are suitably placed and adequately compacted, standard 2 horizontal to 1 vertical side slopes may be used. Due to the presence of the 10 foot thickness of very loose to loose sandy silt and silty fine sand strata at the east abutment locations, total foundation settlements in the order of 6 inches are anticipated beneath the proposed fills in addition to the settlement within the fill itself.

The west approach fills which will have a maximum height of about 28 feet will be constructed with borrow materials obtained from cuts located to the west of the site. Available geological data suggest that the borrow material for these fills will be essentially granular in nature. Fill foundation settlements of about 2 inches are anticipated for the west approach fills.

Although no overall stability problems for the approach fills are anticipated in the areas of the abutments it is recommended that, in view of the difficulties encountered with poor performance of such fills further downstream, particularly following pile driving operations, the proposed fills be carefully instrumented and monitored.

Adequate rip-rap protection should be provided for the approach embankments. The rip-rap should be placed on a suitably graded filter material to prevent loss of fine grained fill material through the rip-rap.

5.4 Cut Slopes

The excavations required to extend the limits of the river bed as indicated on Figure 2 will extend through the strata of very loose to loose sandy silt and silty fine sand on both sides of the river. Based on the soil and groundwater conditions encountered in the boreholes drilled in the cut areas, considerable difficulty may be experienced in attempting to stabilize construction slopes. In order to stabilize these slopes, it is recommended that the completed cut slopes be carefully and immediately blanketed with a suitably graded filter material as final excavation and grading proceeds. Provided that provision is made for continuous groundwater flows into the river from both sides, standard 2 horizontal to 1 vertical cut slopes may be used.

However, based on the condition and existing slope of the river banks together with the soil and groundwater conditions, in no case should the slope of the river banks in the area of the proposed structures be allowed to exceed 2 horizontal to 1 vertical.

The completed slopes should be provided with suitably sized rip-rap protection. Depending upon the actual size of the rip-rap, a two stage filter may be required between the rip-rap and slope blanket materials.

No consideration has been given to the stability of the cut to be made in the valley wall immediately east of the site which is beyond the scope of this investigation.

5.5 Excavations

The excavations for the pier foundations will probably be carried out within cofferdams of interlocking steel sheet piling driven into the silty clay till stratum. Based on the measured N values, it is considered that relatively heavy sheeting can be driven to an adequate depth. The cofferdams should be adequately strutted and braced to withstand the anticipated earth and water pressures. Particular attention will be required for the design and construction of cofferdams in the area of the river banks to ensure adequate strutting and lateral stability. Based on the estimated water levels no problems due to bottom heave of excavations of limited width open for relatively short periods of time are anticipated at this site provided that the excavations do not extend below elevation 650 and the steel sheet piling does not extend beneath the base of the excavation. If excavations are required below elevation 650, the stability of the excavations should be carefully reviewed prior to construction.

It is recommended that additional water level measurements be obtained over an extended period of time to facilitate any analyses required for the stability of deep excavations at the site.

H. Q. GOLDER & ASSOCIATES LTD.

Philip R. Bedell, P. Eng.

R. A. Gould, P. Eng.

PRB:RAG:meg

TABLE I

RESULTS OF TRIAXIAL TESTING

Silty Clay Till

Proposed Crossing at Thames River
and
Proposed King's Highway 402
Townships of Delaware and Caradoc
County of Middlesex Ontario

BOREHOLE NUMBER	SAMPLE NUMBER	TEST	CELL PRESSURE (psi)	UNDRAINED SHEAR STRENGTH (psf)	NATURAL WATER CONTENT (%)	UNIT WEIGHT (pcf)
11	11	Unconfined	-	2160	20	132
11	11	Unconsolidated Undrained	15	3180	21	130
11	11	Consolidated Undrained	15	3020	19	134
11	13	Unconfined	-	1920	23	128
11	13	Unconsolidated Undrained	15	3020	19	134
11	13	Consolidated Undrained	15	3180	25	125

NOTE: For typical grain size distribution curves see Figures 7, 8 and 9.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLES 1 & 2

LOCATION See Figure 1 BORING DATE MAY 13, 1975 DATUM GEODETIC

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

Column headings: BORING METHOD; SOIL PROFILE (ELEV'N. / DEPTH; DESCRIPTION; STRAT. PLOT); SAMPLES (NUMBER; TYPE; BLOWS/FT.); ELEVATION SCALE; DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80); SHEAR STRENGTH Cu, LB./SQ.FT. (NAT. V. - + Q. - ● REM.V. - ⊕ U. - O); COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10, 1x10, 1x10, 1x10); WATER CONTENT, PERCENT (W_p — W — W_L; 10, 20, 30, 40); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

BH. 1

CO-ORDINATES N 15,587,735 E 1,288,031

Boring method: POWER AUGER, 4.5" DIA. (UNCASED)

ELEV'N. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
687.0	GROUND SURFACE			
0.0	Black sandy TOPSOIL			
1.5	Compact to very dense brown SAND AND GRAVEL trace silt	1	2" D.O.	26
		2	"	63
		3	"	23
		4	"	26
672.5 / 14.5		5	"	27
670.5	Hard grey SILTY CLAY TILL	6	"	41
16.5	END OF BOREHOLE			

Elevation scale: 690, 680, 670

Piezometer or standpipe installation: GROUND SURF.; PLASTIC TUBING; AUGERED MATERIAL; STANDPIPE; CAVED MATERIAL

WATER LEVEL IN STANDPIPE AT ELEV. 681.0 MAY 26, 1975.

BH. 2

CO-ORDINATES N 15,587,627 E 1,287,950

Boring method: POWER AUGER, 4.5" DIA. (UNCASED)

ELEV'N. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
687.6	GROUND SURFACE			
0.0 / 685.6	Black sandy TOPSOIL			
2.0	Compact brown fine to medium SAND	1	2" D.O.	13
681.1		2	"	14
6.5	Compact brown SAND AND GRAVEL trace silt	3	"	19
		4	"	19
673.6		5	"	26
14.0 / 671.1	Hard grey SILTY CLAY TILL	6	"	35
16.5	END OF BOREHOLE			

Elevation scale: 690, 680, 670

Additional lab. testing: PERCENT GRAVEL/SAND/SILT/CLAY 71/24/5/0

Piezometer or standpipe installation: GROUND SURF.; PLASTIC TUBING; AUGERED MATERIAL; STANDPIPE; CAVED MATERIAL

WATER LEVEL IN STANDPIPE AT ELEV. 680.0 MAY 26, 1975.

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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

RECORD OF BOREHOLE 3

CO-ORDINATES N 15,587,554 E 1,288,082

LOCATION See Figure 1

BORING DATE MAY 13 & 14, 1975

DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
	682.9	GROUND SURFACE				
POWER AUGER 7.5" DIA. HOLLOW STEM	0.0	Black sandy TOPSOIL				
	680.9 / 2.0	Loose brown SANDY SILT		1	2" D.O.	5
	678.4 / 4.5	Loose brown SILTY fine SAND		2	"	3
	674.4 / 8.5	Very stiff to hard grey SILTY CLAY trace sand occasional gravel (TILL)		3	"	13
				4	"	27
			T	5	"	26
				6	"	32
				7	"	37
			T	8	"	29
				9	"	20
				10	"	24
				11	"	20
			T	12	"	38
				13	"	28
				14	"	27
	645.9 / 37.0	Hard grey CLAYEY SILT some sand and gravel (TILL)	T	15	"	33
				16	"	>100
				17	"	100/6"
			T	18	"	100/1"
				19	"	100/1"
	634.9 / 48.0	END OF BOREHOLE		20	A.S.	–

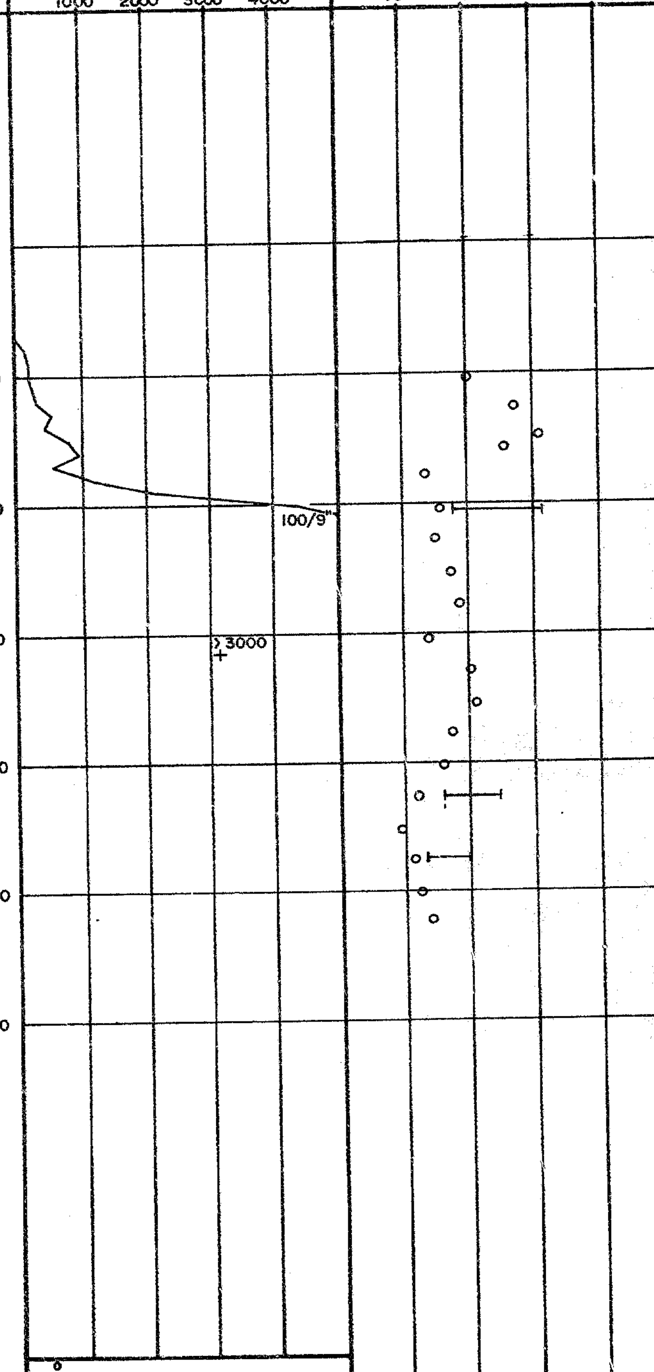
ELEVATION SCALE: 690, 680, 670, 660, 650, 640, 630

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

SHEAR STRENGTH Cu, LB./SQ.FT. NAT. V. - + Q. - ● REM. V. - ● U. - ○ 1000 2000 3000 4000

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

WATER CONTENT, PERCENT Wp W Wl 10 20 30 40



15 ◇ 5 Percent axial strain at failure

ADDITIONAL LAB. TESTING

GRAVE/SAND/SILT/CLAY PERCENT

3/11/44/42

13/20/36/31

14/28/35/23

PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURF.

GRAVEL BACKFILL

CLAY SEAL

PLASTIC TUBING

STANDPIPE

GRAVEL BACKFILL

BENTONITE SEAL

PIEZOMETER

WATER LEVEL IN PIEZOMETER AT ELEV. 642.7 STANDPIPE DRY TO ELEV. 659.0 MAY 26, 1975.

IN PIEZOMETER AT ELEV. 646.0 MAY 30, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 4

CO-ORDINATES N 15,587,565 E 1,288,260

LOCATION See Figure 1

BORING DATE MAY 14, 1975

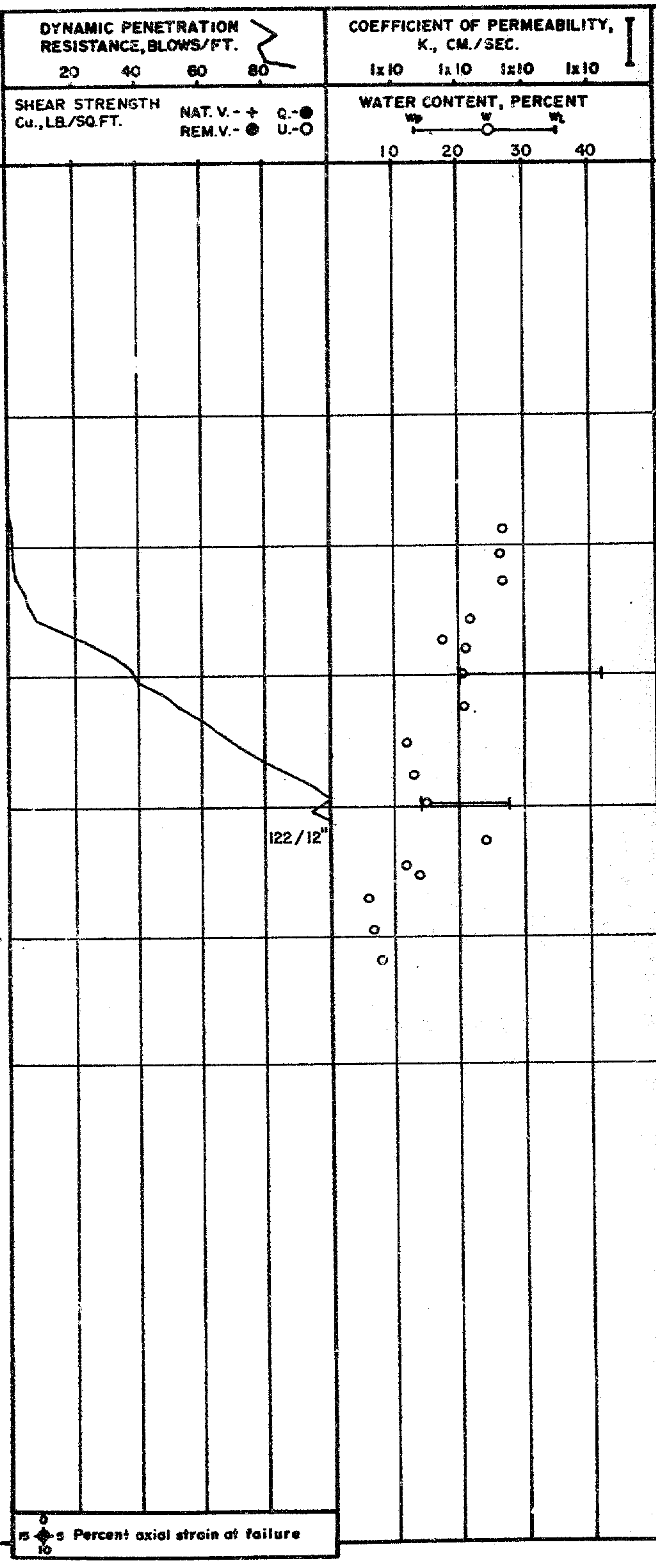
DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
POWER AUGER 4.5" DIA. (UNCASED)	672.5	GROUND SURFACE				
	670.5 / 0.0	Black sandy TOPSOIL		1	A.S.	—
	2.0	Very loose to loose brown SILTY fine SAND trace organics		2	2" D.O.	3
				3	"	5
	664.5 / 8.0	Stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)		4	"	18
				5	"	14
			T	6	"	17
				7	"	44
				8	"	20
			T	9	"	22
				10	"	27
			T	11	"	29
	646.5 / 26.0	Hard grey CLAYEY SILT some sand occasional gravel (TILL)		12	"	97
				13	"	100/4"
			T	14	"	100/2"
	637.9 / 34.6	END OF BOREHOLE		15	"	100/1"

ELEVATION SCALE: 680, 670, 660, 650, 640, 630



ADDITIONAL LAB. TESTING: 7/10/37/46; 5/26/37/32 PERCENT GRAVEL/SAND/SILT/CLAY

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURF., CLAY SEAL, STANDPIPE, GRAVEL BACKFILL, PLASTIC TUBING, AUGERED MATERIAL, GRAVEL BACKFILL, BENTONITE SEAL, GRAVEL, PIEZOMETER

WATER LEVEL IN PIEZOMETER AT ELEV. 658·1, IN STANDPIPE AT ELEV. 664·6 MAY 26, 1975.

IN PIEZOMETER AT ELEV. 660·0 IN STANDPIPE AT ELEV. 665·5 MAY 30, 1975.

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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - 1

Project No. 753073

RECORD OF BOREHOLE 5

CO-ORDINATES N 15,587,660 E 1,288,162

LOCATION See Figure 1

BORING DATE MAY 14 & 15, 1975

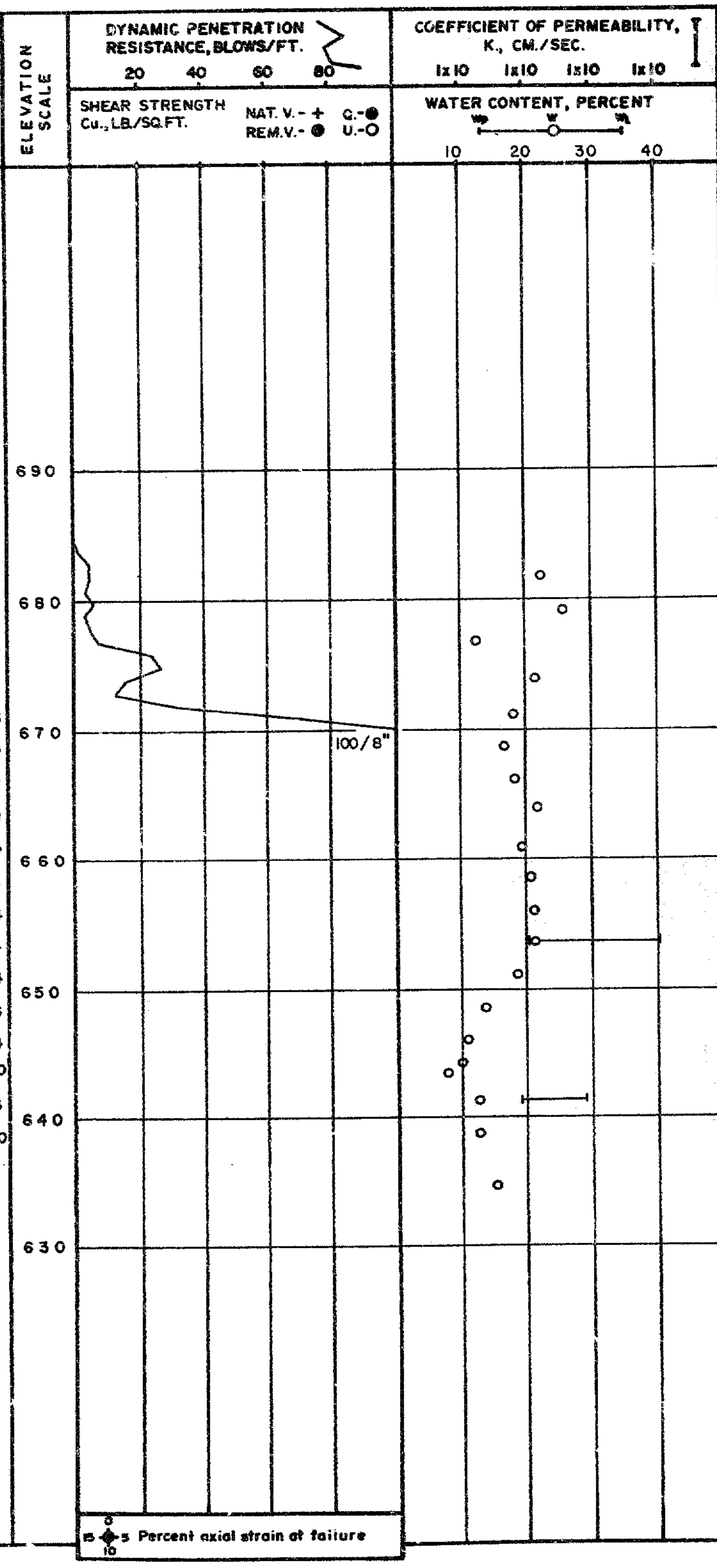
DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD: POWER AUGER 4.5" DIA. (UNCASED)

ELEV'N. / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
684.8	GROUND SURFACE			
0.0 / 682.8	Black sandy TOPSOIL			
2.0 / 680.3	Loose brown SANDY SILT	1	2" D.O.	5
4.5 / 677.8	Loose brown SAND	2	"	5
7.0 / 674.8	Compact brown SAND AND GRAVEL	3	"	23
10.0	Stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)	4	"	12
		5	"	46
		6	"	30
		7	"	27
		8	"	28
		9	"	24
		10	"	23
		11	"	24
		12	"	24
		13	"	24
647.3		14	"	26
37.5	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	15	"	34
		16	"	>100
		17	"	55
		18	"	>100
634.3		19	A.S.	–
50.5	END OF BOREHOLE			



ADDITIONAL LAB. TESTING: PERCENT GRAVEL/SAND/SILT/CLAY 2/8/38/52; 2/14/50/34

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURF.; PLASTIC TUBING; AUGERED MATERIAL; GRAVEL BACKFILL; STANDPIPE; CAVED MATERIAL

WATER LEVEL IN STANDPIPE AT ELEV. 679.8 MAY 26, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753-073

RECORD OF BOREHOLE 6

CO-ORDINATES N 15,587,508 E 1,288,236

LOCATION See Figure 1

BORING DATE MAY 15, 1975

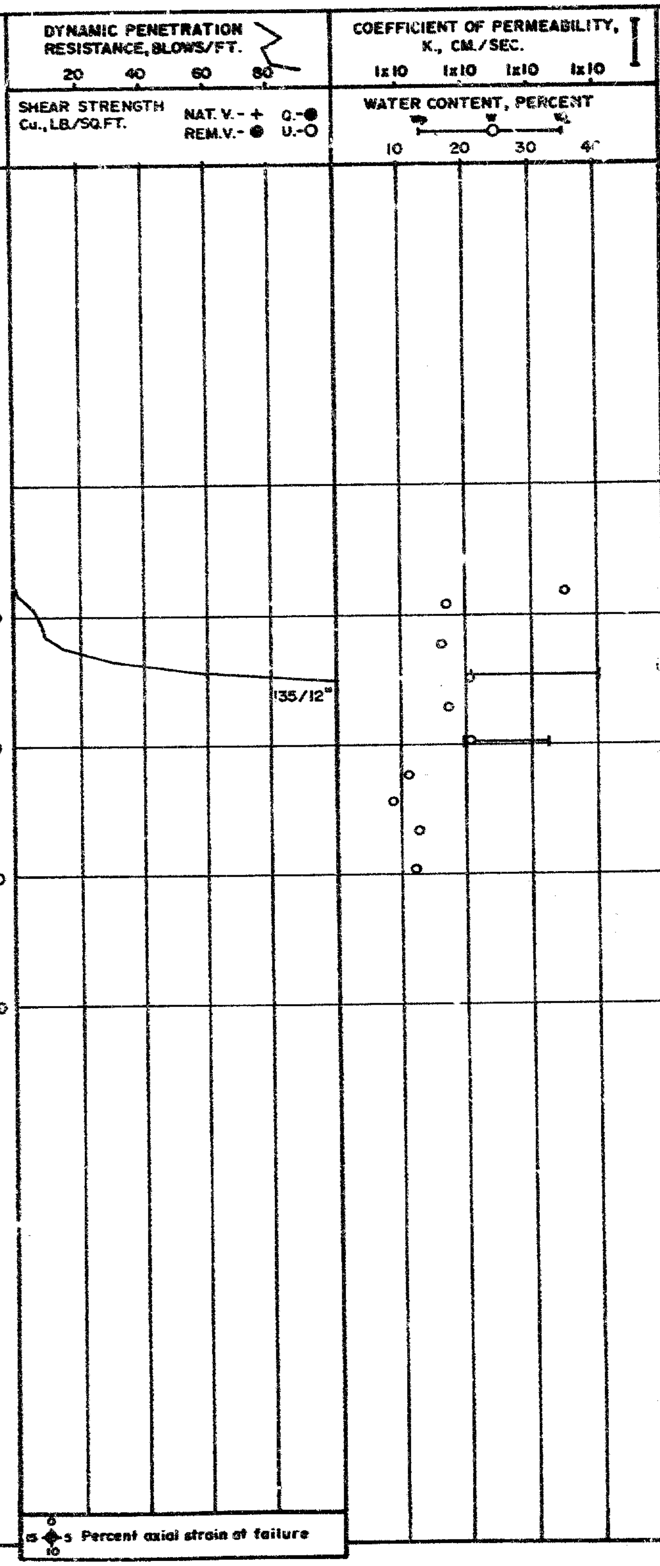
DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FT.
	665.3	RIVER LEVEL				
WASH BORING, NX CASING	0.0	WATER				
	662.3 / 3.0	Loose grey SILTY fine SAND		1	2" D.O.	5
	4.0	Compact brown SAND AND GRAVEL		2	"	14
	5.2	Stiff to very stiff grey SILTY CLAY some sand occasional gravel (TILL)	T	3	"	29
			T	4	"	19
				5	"	18
	648.8			6	"	14
	16.5	Very stiff to hard grey CLAYEY SILT trace sand occasional gravel (TILL)	T	7	"	22
				8	"	>100
			S	9	"	100/3"
	640.0			10	"	100/4"
	25.3	END OF BOREHOLE				

ELEVATION SCALE: 670, 660, 650, 640, 630



ADDITIONAL LAB. TESTING: PERCENT GRAVEL/SAND/SILT/CLAY; 8/8/37/47; 0/14/48/38

PIEZOMETER OR STANDPIPE INSTALLATION: WATER LEVEL IN THAMES RIVER AT ELEV. 665.3 DURING DRILLING MAY 15, 1975.

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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - 1

Project No. 753073

RECORD OF BOREHOLE 7

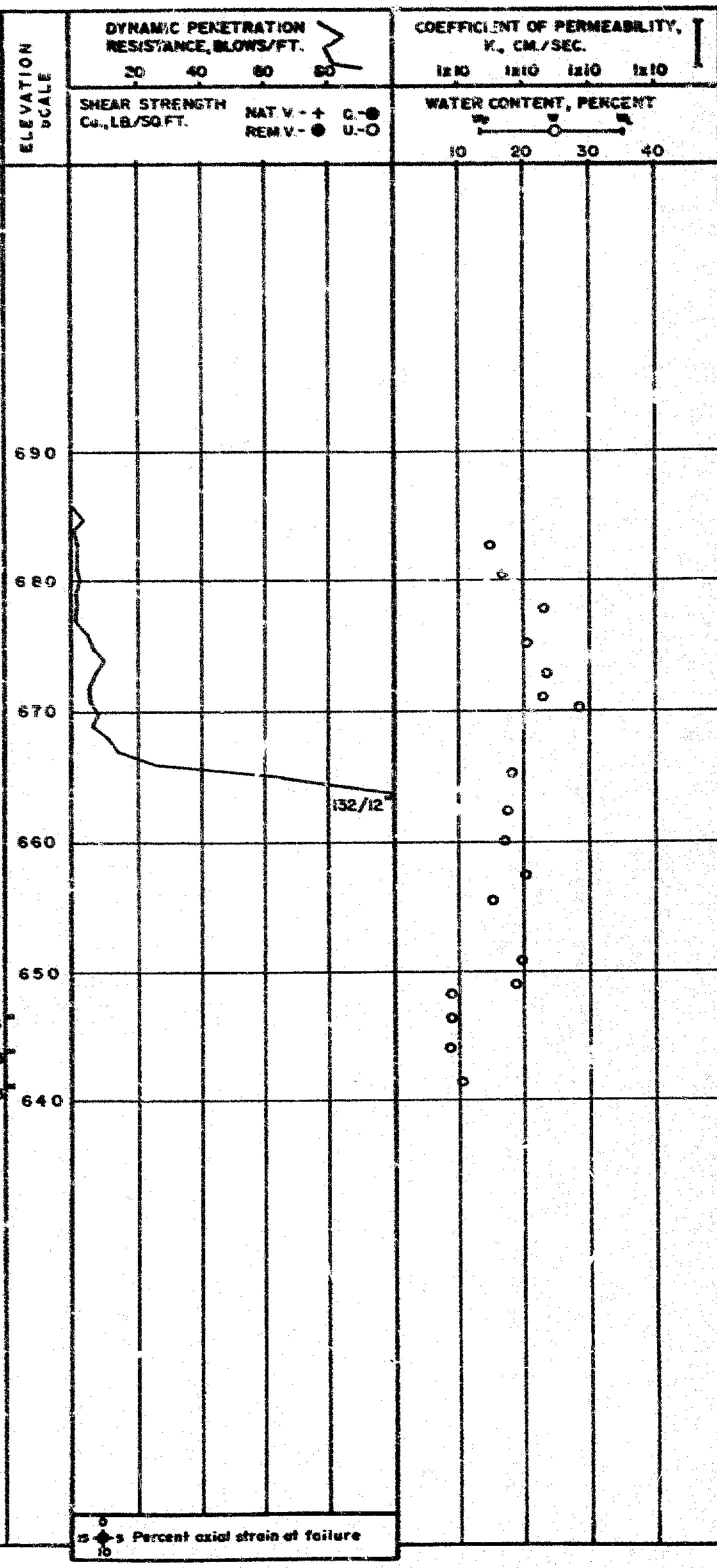
CO-ORDINATES N 15,557,450 E 1,288,457

LOCATION See Figure 1 BORING DATE MAY 15 & 16, 1975 DATUM GEODETIC

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

BORING METHOD	ELEV'N. / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT. PLOT	SAMPLES – NUMBER	TYPE	BLOWS/FT	ADDITIONAL LAB. TESTING
POWER AUGER 4.5" DIA. (UNCASED)	686.0	GROUND SURFACE					
	0.0	Black sandy TOPSOIL		1	A.S.	-	
	1.0 / 679.0	Very loose brown SILTY fine SAND		2	2" D.O.	2	
				3	"	2	0/32/57/11
	7.0 / 674.0	Loose brown SANDY SILT		4	"	4	
				5	"	4	
	12.0 / 670.7	Very loose brown SILTY fine SAND		6	"	3	
	15.3 / 667.0	Very loose grey SANDY SILT		7	"	3	
	19.0	Very stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)	T	8	"	31	
				9	"	36	
			T	10	"	22	9/13/38/40
				11	"	28	
				12	"	20	
				13	"	19	
	648.5		T	14	"	18	
	37.5	Hard grey CLAYEY SILT some sand occasional gravel (TILL)		15	"	57	
			T	16	"	100/6"	
				17	"	100/3"	
	641.2		T	18	"	100/3"	
	44.8	END OF BOREHOLE					

ADDITIONAL LAB. TESTING: PERCENT GRAVEL/SAND/SILT/CLAY



PIEZOMETER OR STANDPIPE INSTALLATION

GROUND SURF.

PLASTIC TUBING

AUGERED MATERIAL

GRAVEL BACKFILL

STANDPIPE

CAVED MATERIAL

WATER LEVEL IN STANDPIPE AT ELEV. 673.8 MAY 22, 1975.

IN STANDPIPE AT ELEV. 678.1 MAY 30, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.E.

CHECKED P.R.B.

Form G.A. - D - 1

Project No. 753073

RECORD OF BOREHOLE 8

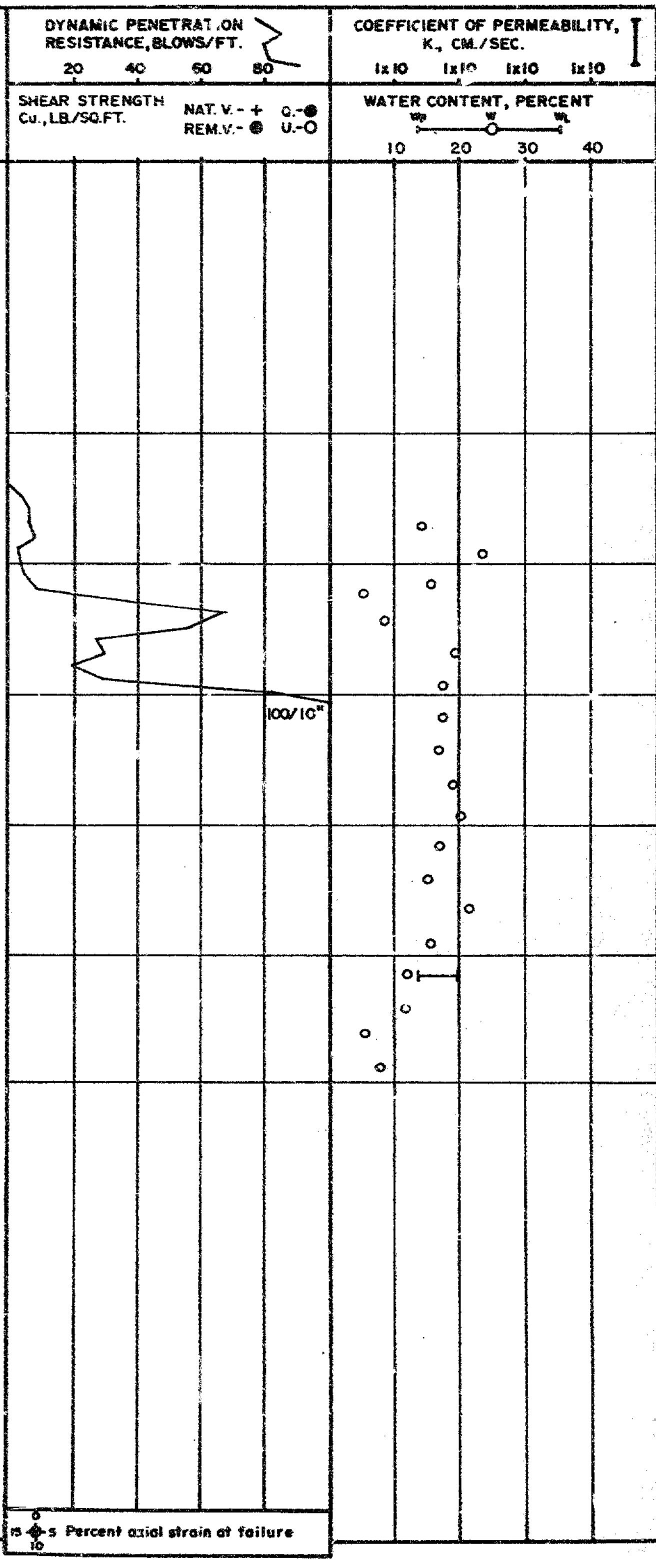
CO-ORDINATES N 15,587,590 E 1,288,210

LOCATION See Figure 1 — BORING DATE MAY 15 & 16, 1975 — DATUM GEODETIC

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

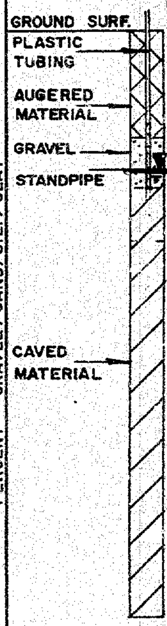
BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT	ADDITIONAL LAB. TESTING
	686.2	GROUND SURFACE				
POWER AUGER 4.5" DIA. HOLLOW STEM	0.0	Black sandy TOPSOIL				
	1.5 – 679.2	Very loose to loose brown SANDY SILT	1	2" D.O.	7	PERCENT GRAVEL/SAND/SILT/CLAY 0/45/45/10
			2	"	3	
	7.0 – 673.7	Compact to dense brown SAND AND GRAVEL	3	"	38	
			4	"	24	
	12.5 – 651.2	Very stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)	5	"	31	56/22/12/0
			6	"	41	
			7	"	38	
			8	"	56	
			9	"	26	
			10	"	26	
			11	"	28	
			12	"	27	
			13	"	40	
	35.0 – 641.0	Very stiff to hard grey CLAYEY SILT some sand occasional gravel (TILL)	14	"	34	13/30/35/22
			15	"	27	
			16	"	75	
			17	"	100/2"	
			18	"	100/3"	
	45.2	END OF BOREHOLE				

ELEVATION SCALE: 690, 680, 670, 660, 650, 640



15 ◆ 5 Percent axial strain at failure 10

PIEZOMETER OR STANDPIPE INSTALLATION



WATER LEVEL IN STANDPIPE AT ELEV. 675.7 MAY 26, 1975

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 9

CO-ORDINATES N 15,587,467 E 1,288,235

LOCATION See Figure 1

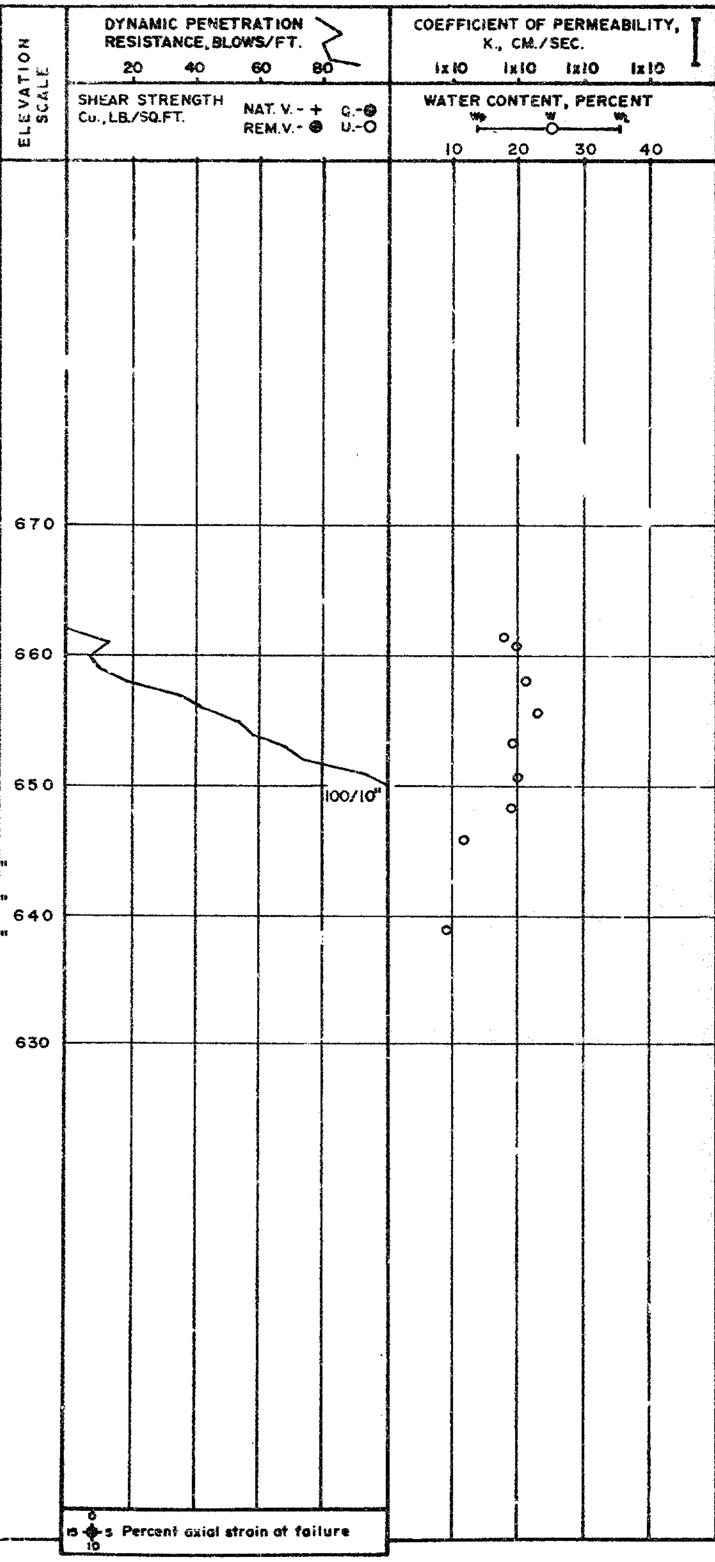
BORING DATE MAY 16 & 20, 1975.

DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	BLOWS/FT.
		Loose grey SAND AND GRAVEL				
	665·9	RIVER LEVEL				
WASH BORING, NX CASING	0·0	WATER				
	661·9 / 4·0			1	2" D.O.	9
	4·5	Very stiff grey SILTY CLAY some sand occasional gravel (TILL)	T	2	"	20
				3	"	18
			T	4	"	21
				5	"	27
UNCASED			T	6	"	25
	646·9 / 19·0	Hard grey CLAYEY SILT some sand occasional gravel and cobbles (TILL)	T	7	"	18
NX TRI-CONE				8	"	100/2"
			T	9	"	100/7"
	638·7 / 27·2	END OF BOREHOLE		10	"	100/2"
		(BOREHOLE TERMINATED IN COBBLE AT ELEV. 638·7)				



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN THAMES RIVER AT ELEV. 665·9 DURING DRILLING MAY 16, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - 1

Project No. 753073

RECORD OF BOREHOLE 10

CO-ORDINATES N 15,587,400 E 1,288,428

LOCATION See Figure 1

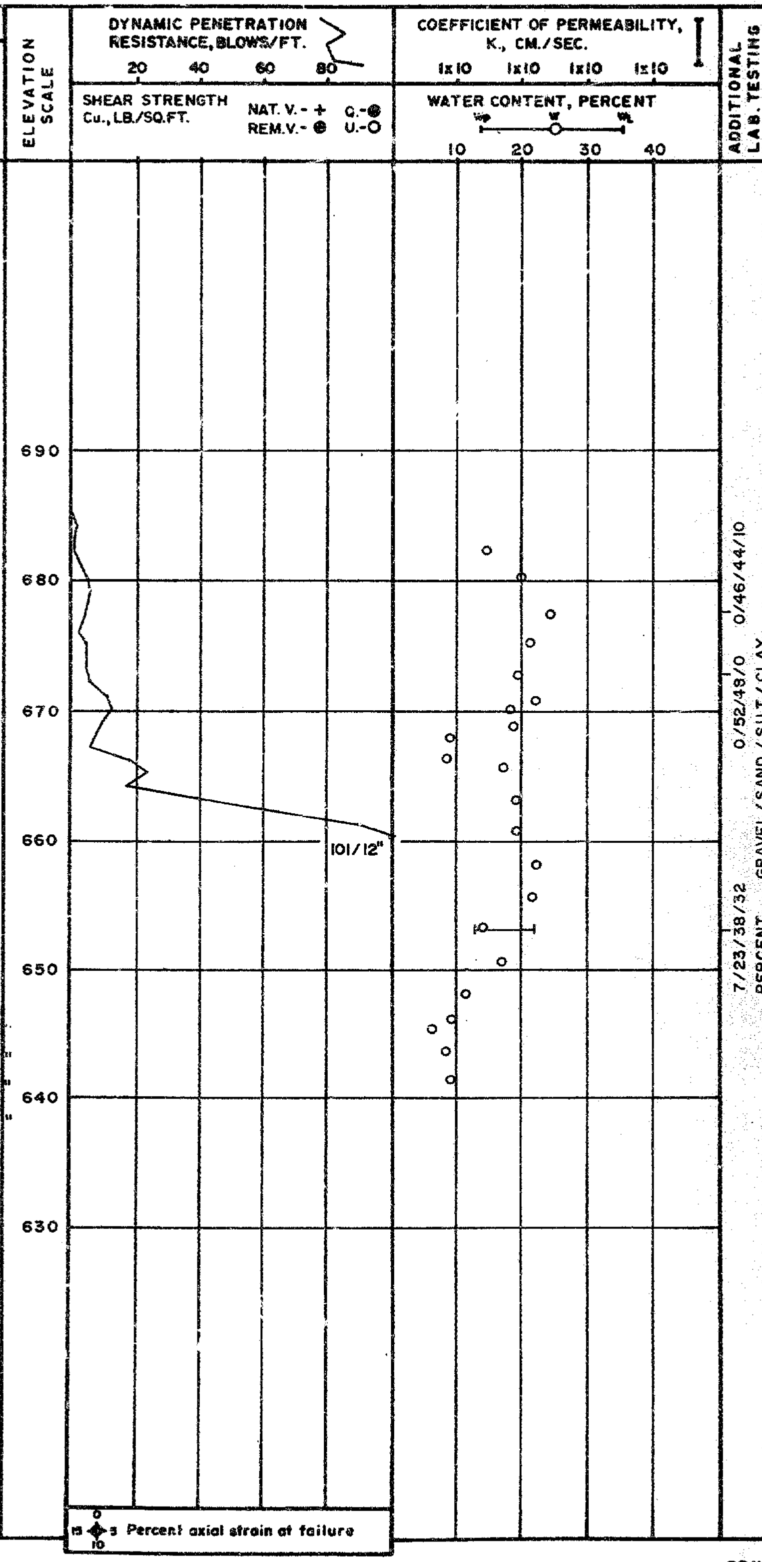
BORING DATE MAY 16, 20 & 21, 1975

DATUM GEODETIC

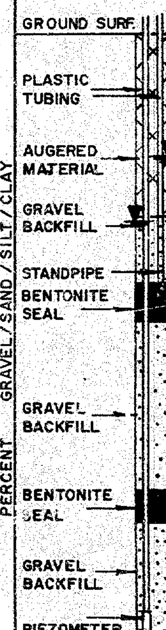
SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
	685.2	GROUND SURFACE			
POWER AUGER 7.5" DIA. HOLLOW STEM	0.0	Black sandy TOPSOIL			
	1.1	Very loose to loose SILTY fine SAND		2" O.D.	3
	678.7			"	9
	6.5	Very loose brown SANDY SILT	3	"	2
	673.7		4	"	4
	11.5	Loose to compact brown SILTY fine SAND	5	"	7
	669.2		6	"	15
	16.0	Compact brown to grey SAND AND GRAVEL	7	"	27
	665.4		8	"	17
	19.8	Very stiff grey SILTY CLAY some sand occasional gravel (TILL)	9	"	27
			10	"	23
			11	"	19
			12	"	22
			13	"	30
	649.2		14	"	30
NX TRI-CONE UNCASED	36.0	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	15	"	80
			16	"	>100
			17	"	100/6"
			18	"	100/4"
	638.6		19	"	100/1"
	46.6	END OF BOREHOLE			



PIEZOMETER OR STANDPIPE INSTALLATION



WATER LEVEL IN PIEZOMETER AT ELEV. 670.9, IN STANDPIPE AT ELEV. 675.9 MAY 26, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.P.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 11

CO-ORDINATES N 15,587,540 E 1,288,175

LOCATION See Figure 1 BORING DATE MAY 20 & 21, 1975 DATUM GEODETIC

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

BORING METHOD	ELEV'N / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT. PLOT	SAMPLE NUMBER	TYPE	BLOWS/FT.
	686·3	GROUND SURFACE				
POWER AUGER, 7·5" DIA. HOLLOW STEM	0·0	Black sandy TOPSOIL				
	1·5 / 681·8	Loose brown SANDY SILT		1	2" D.O.	8
	4·5 / 679·3	Loose brown SILTY fine SAND		2	"	5
	7·0	Dense brown SAND AND GRAVEL trace silt		3	"	38
				4	"	31
	673·0			5	"	23
	13·3	Very stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)	T	6	"	29
				7	"	42
				8	"	38
			T	9	"	39
				10	"	22
			T	11	3" T.O.	P.H.
				12	2" D.O.	24
				13	3" T.O.	P.H.
			T	14	2" D.O.	24
	646·8			15	"	19
	39·5	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	T	16	"	25
				17	"	>100
			T	18	"	100/3"
NX TRI-CONE, UNCASED	637·3		T	19	"	100/3"
	49·0	Hard grey SILTY CLAY		20	"	>100
				21	"	>100
	629·8			22	"	>100
	56·5	END OF BOREHOLE				

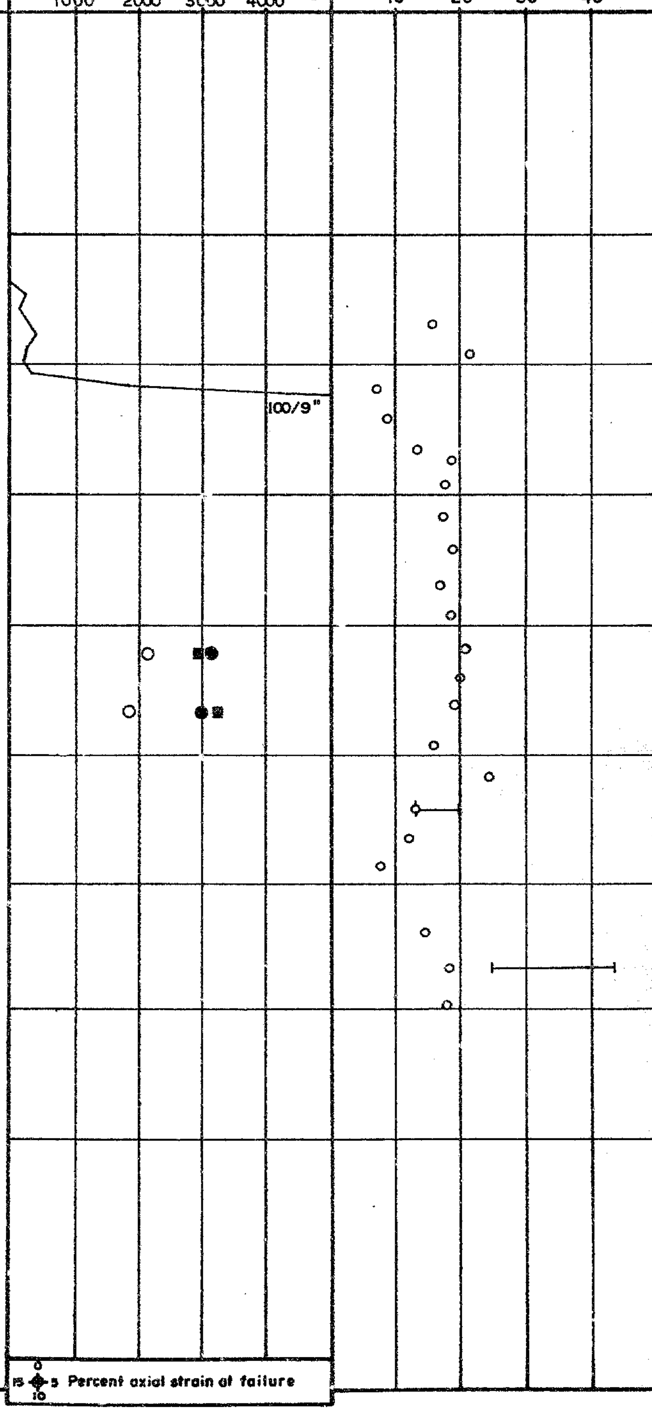
ELEVATION SCALE: 690, 680, 670, 660, 650, 640, 630, 620

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

SHEAR STRENGTH Cu., LB./SQ.FT. (1000, 2000, 3000, 4000) NAT. V. - + REM.V. - ● Q. - ● U. - O R. - ■

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

WATER CONTENT, PERCENT W_P — W — W_L (10, 20, 30, 40)



ADDITIONAL LAB. TESTING: CONSOLIDATION TEST; PERCENT GRAVEL/SAND/SILT/CLAY 7/28/39/26; 0/6/56/38

PIEZOMETER OR STANDPIPE INSTALLATION:
GROUND SURF.
PLASTIC TUBING
AUGERED MATERIAL
GRAVEL BACKFILL
STANDPIPE
BENTONITE SEAL
GRAVEL BACKFILL
PIEZOMETER

WATER LEVEL IN PIEZOMETER AT ELEV. 678·8, IN STANDPIPE AT ELEV. 675·3 MAY 26, 1975.

IN PIEZOMETER AT ELEV. 675·3 IN STANDPIPE AT ELEV. 677·9 MAY 30, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 12

CO-ORDINATES N 15,587,418 E 1,288,320

LOCATION See Figure 1 BORING DATE MAY 20 & 21, 1975 DATUM GEODETIC

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

BORING METHOD	SOIL PROFILE: ELEV'N. / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE	PIEZOMETER OR STANDPIPE INSTALLATION
							670	
	665·6	RIVER LEVEL						
WASH BORING NX CASING	0·0 / 663·1	WATER						WATER LEVEL IN THAMES RIVER AT ELEV. 665·6 DURING DRILLING MAY 20, 1975.
	2·5 / 661·1	Compact brown SAND AND GRAVEL		1	2" D.O.	13		
	4·5	Very stiff grey SILTY CLAY some sand occasional gravel (TILL)	T	2	"	15	660	
				3	"	16		
			T	4	"	25		
				5	"	22		
	649·1		T	6	"	17	650	
	16·5	Hard grey CLAYEY SILT some sand occ. gravel (TILL)	T	7	"	25		
	644·6			8	"	>100		
				9	W.S.	–		
	21·0	END OF BOREHOLE (BOREHOLE TERMINATED IN BOULDER AT ELEV. 644·6)					640	

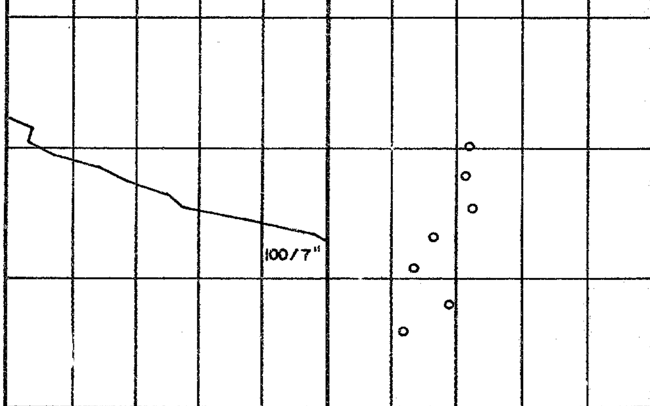
DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. 20 40 60 80

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

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

WATER CONTENT, PERCENT Wp W WL 10 20 30 40

ADDITIONAL LAB. TESTING



Percent axial strain at failure

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLES 13 & 14

LOCATION See Figure 1 BORING DATE MAY 21, 1975 DATUM GEODETIC

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

Column headings: BORING METHOD | SOIL PROFILE: ELEV'N. DEPTH, DESCRIPTION, STRAT. PLOT | SAMPLES: NUMBER, TYPE, BLOWS/FT. | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80); SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ⊕ U. - O | COEFFICIENT OF PERMEABILITY, K., CM./SEC. (1x10, 1x10, 1x10, 1x10); WATER CONTENT, PERCENT W_p — W — W_L (10, 20, 30, 40) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

BH. 13

CO-ORDINATES N 15,587,366 E 1,288,665

Boring method: POWER AUGER 4.5" DIA. (UNCASED)

ELEV'N. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
683.0	GROUND SURFACE			
0.0	Black silty TOPSOIL	1	2" D.O.	3
680.8 / 2.2	Loose brown SANDY SILT	2	"	4
677.7 / 5.3		3	"	10
	Stiff to hard brown becoming grey about elev. 676 SILTY CLAY TILL	4	"	22
		5	"	23
		6	"	28
668.0		7	"	33
15.0	END OF BOREHOLE			

Elevation scale: 690, 680, 670, 660

Piezometer or standpipe installation: GROUND SURF. PLASTIC TUBING AUGERED MATERIAL STANDPIPE

WATER LEVEL IN STANDPIPE AT ELEV. 681.6 MAY 26, 1975.

BH. 14

CO-ORDINATES N 15,587,252 E 1,288,735

Boring method: POWER AUGER 4.5" DIA. (UNCASED)

ELEV'N. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
682.4	GROUND SURFACE			
0.0	Black silty TOPSOIL	1	2" D.O.	3
680.4 / 2.0	Very loose brown SILTY fine SAND	2	"	2
		3	"	3
		4	"	2
672.1 / 10.3		5	"	12
	Stiff to hard brown becoming grey about elev. 670 SILTY CLAY TILL	6	"	34
		7	"	34
663.4		8	"	35
19.0	END OF BOREHOLE			

Elevation scale: 690, 680, 670, 660

Additional lab. testing: PERCENT GRAVEL/SAND/SILT/CLAY 0/50/41/9

Piezometer or standpipe installation: GROUND SURF. PLASTIC TUBING AUGERED MATERIAL STANDPIPE

WATER LEVEL IN STANDPIPE AT ELEV. 675.4 MAY 26, 1975.

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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 15

CO-ORDINATES N 15,587,437 E 1,288,358

LOCATION See Figure 1 | BORING DATE MAY 21 & 22, 1975 | DATUM GEODETIC

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

BORING METHOD	ELEV'N. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
	665·6	RIVER LEVEL			
WASH BORING, NX CASING	663·6 / 0·0	WATER			
	2·0	Stiff to very stiff grey SILTY CLAY some sand occasional gravel (TILL)	1	2" D.O.	9
			2	"	12
			3	"	14
			4	"	22
			5	"	20
			6	"	18
	648·6 / 17·0	Very stiff to hard grey CLAYEY SILT some sand occasional gravel (TILL)	7	"	24
			8	"	100/7"
			9	"	100/4"
			10	"	100/3"
	640·3 / 25·3	END OF BOREHOLE			

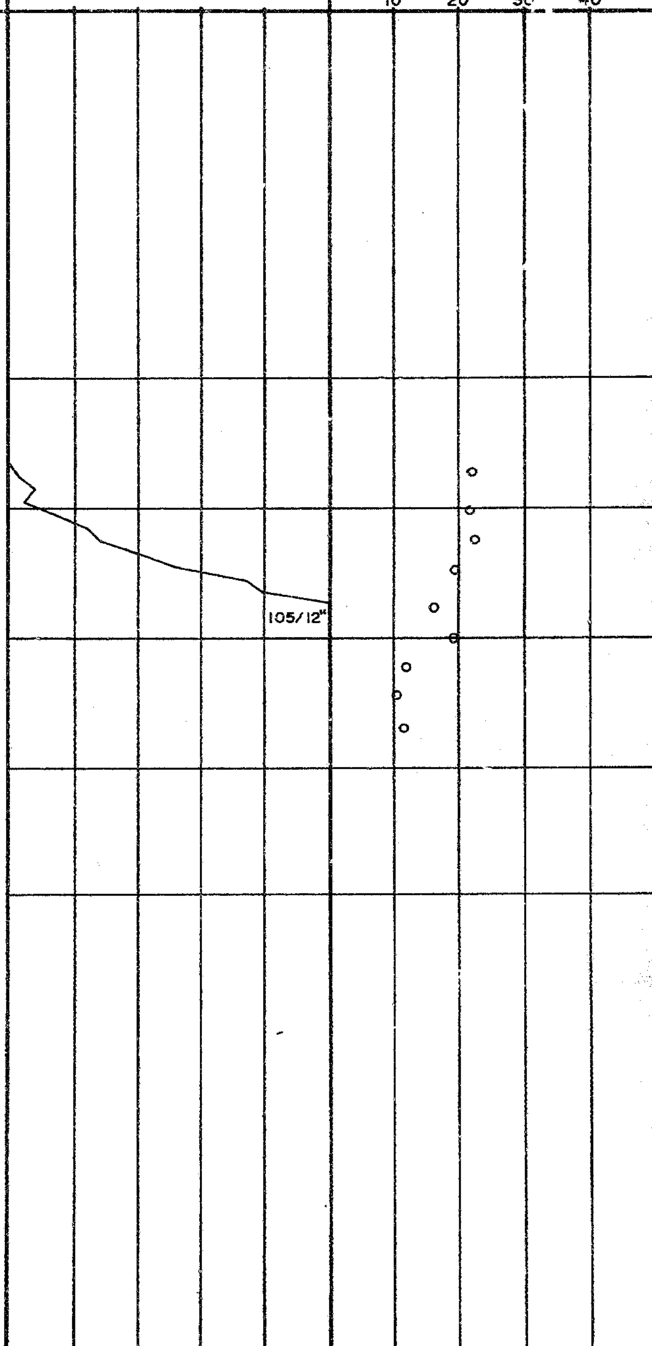
ELEVATION SCALE: 670, 660, 650, 640, 630

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

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM. V. - ● U. - O

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

WATER CONTENT, PERCENT W_P W W_L 10 20 30 40



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN THAMES RIVER AT ELEV. 665·6 DURING DRILLING MAY 21, 1975.

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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 16

CO-ORDINATES N 15,587,333 E 1,288,472

LOCATION See Figure 1

BORING DATE MAY 22, 1975

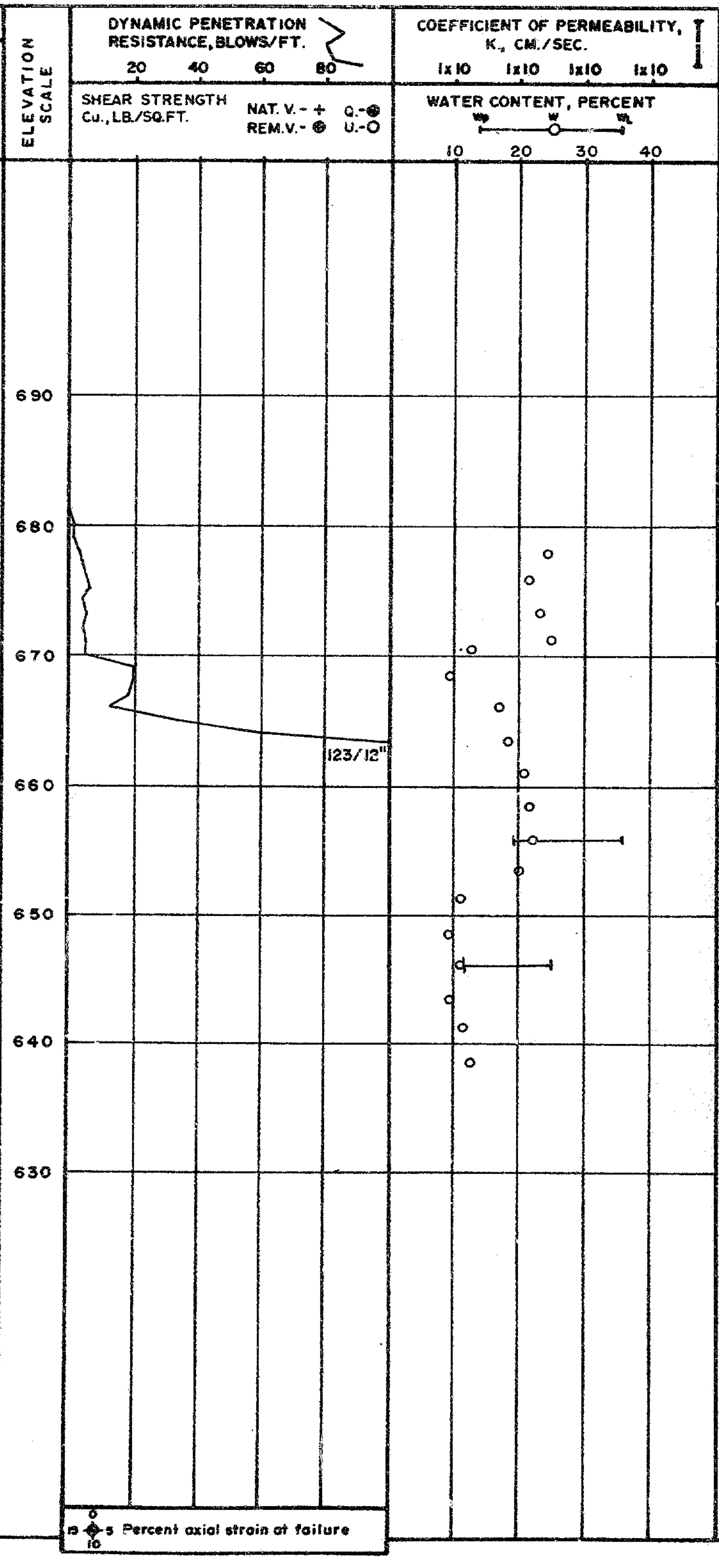
DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD: POWER AUGER 4.5" DIA. (UNCASED)

ELEV'N / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS/FT.
681.1	GROUND SURFACE			
0.0	Black sandy TOPSOIL			
2.0 / 677.1	Very loose brown SANDY SILT	1	2" D.O.	3
4.0 / 673.6	Very loose brown SILTY fine SAND	2	"	3
7.5	Very loose SANDY SILT	3	"	2
9.0 / 670.3	Loose SILTY fine SAND	4	"	6
10.8 / 667.4	Very dense grey SAND AND GRAVEL	5	"	>100
13.7	Very stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)	6	"	33
		7	"	36
		8	"	21
		9	"	17
		10	"	20
652.1		11	"	24
29.0	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	12	"	37
		13	"	32
		14	"	>100
642.1		15	"	>100
39.0	Hard grey SILTY CLAY	16	"	>100
637.3		17	"	>100
43.8	END OF BOREHOLE			



ADDITIONAL LAB. TESTING: 2/9/42/47; 22/23/33/22 PERCENT GRAVEL/SAND/SILT/CLAY

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURF.; PLASTIC TUBING; AUGERED MATERIAL; STANDPIPE; CAVED MATERIAL

WATER LEVEL IN STANDPIPE AT ELEV. 665.7 MAY 26, 1975

IN STANDPIPE AT ELEV. 668.6 MAY 30, 1975.

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 17

CO-ORDINATES N 15,587,440 E 1,288,550

LOCATION See Figure 1

BORING DATE MAY 23 & 26, 1975.

DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

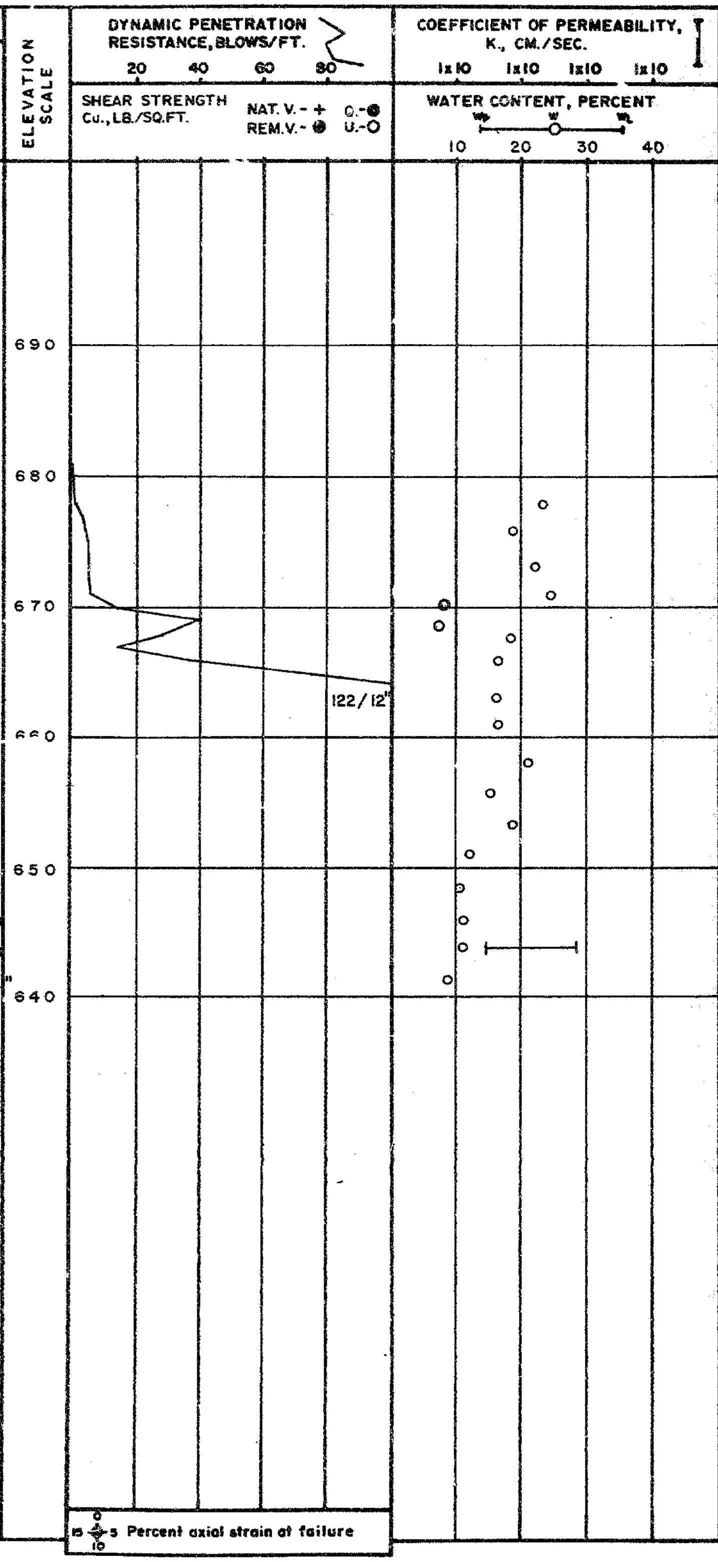
BORING METHOD: POWER AUGER (UNCASED) 4.5" DIA.

SOIL PROFILE

ELEV'N. DEPTH	DESCRIPTION
	Black sandy TOPSOIL
681.0 / 0.0	GROUND SURFACE
0.9	Very loose brown SANDY SILT
675.0 / 6.0	Loose brown SILTY fine SAND
670.4 / 10.6	Compact brown SAND AND GRAVEL
668.2 / 12.8	Very stiff to hard grey SILTY CLAY some sand occasional gravel (TILL)
649.5 / 31.5	Hard grey CLAYEY SILT some sand occasional gravel (TILL)
641.2 / 39.8	END OF BOREHOLE

SAMPLES

NUMBER	TYPE	BLOWS/FT.
1	2" DO.	2
2	"	3
3	"	5
4	"	13
5	"	21
6	"	28
7	"	25
8	"	30
9	"	19
10	"	20
11	"	52
12	"	29
13	"	>100
14	"	>100
15	"	>100
16	"	100/4"



ADDITIONAL LAB. TESTING: PERCENT GRAVEL/SAND/SILT/CLAY 0/60/32/8

PIEZOMETER OR STANDPIPE INSTALLATION: GROUND SURF., PLASTIC TUBING, AUGERED MATERIAL, PIEZOMETER, CAVED MATERIAL

WATER LEVEL IN PIEZOMETER AT ELEV. 679.0 MAY 26, 1975

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - 0 - 1

Project No. 753073

RECORD OF BOREHOLE 18

CO-ORDINATES N 15,587,485 E 1,288,400

LOCATION See Figure 1

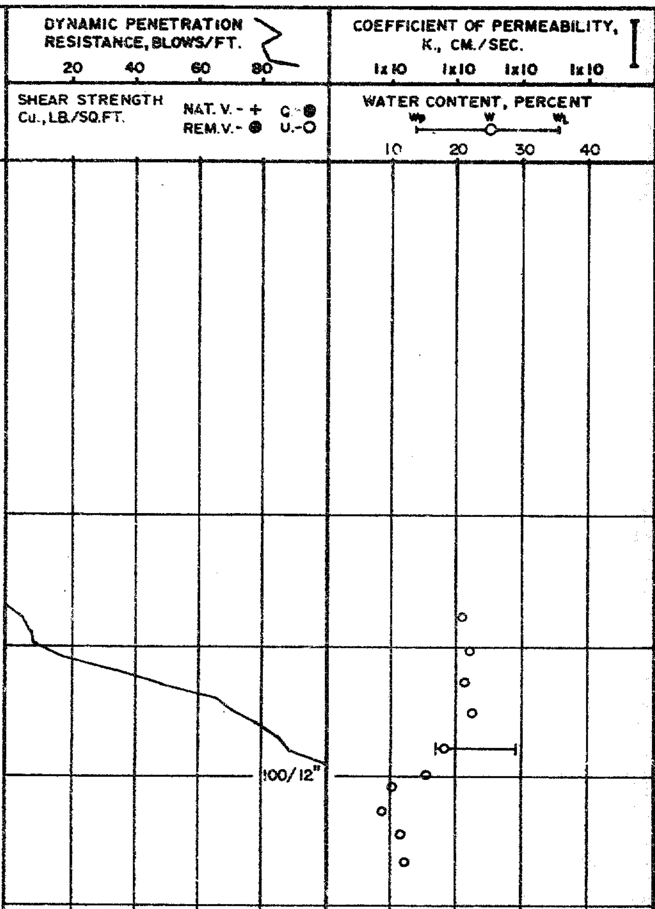
BORING DATE MAY 22, 1975.

DATUM GEODETIC

SAMPLER HAMMER WEIGHT 140 LB., DROP 30 IN.

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

BORING METHOD	ELEV'N. / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
						670		
	665.6	RIVER LEVEL						WATER LEVEL IN THAMES RIVER AT ELEV. 665.6 DURING DRILLING MAY 22, 1975.
WASH BORING, NX CASING	0.0 / 663.1	WATER						
	2.5	Stiff to very stiff grey SILTY CLAY some sand occasional gravel (TILL)	1	2" D.O.	18			
			2	"	12	660		
			3	"	16			
			4	"	16			
			5	"	25		7/12/37/44 PERCENT GRAVEL/SAND/SILT/CLAY	
	649.6 / 16.0	Hard grey CLAYEY SILT TILL	6	"	25	650		
			7	"	93			
			8	"	100/10"			
	643.0 / 22.6	END OF BOREHOLE	9	"	100/1"			
						640		



15 5 Percent axial strain at failure 10

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - D - I

Project No. 753073

RECORD OF BOREHOLE 19

CO-ORDINATES N 15,587,527 E 1,288,398

LOCATION See Figure 1 BORING DATE MAY 23 & 26, 1975 DATUM GEODETIC

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

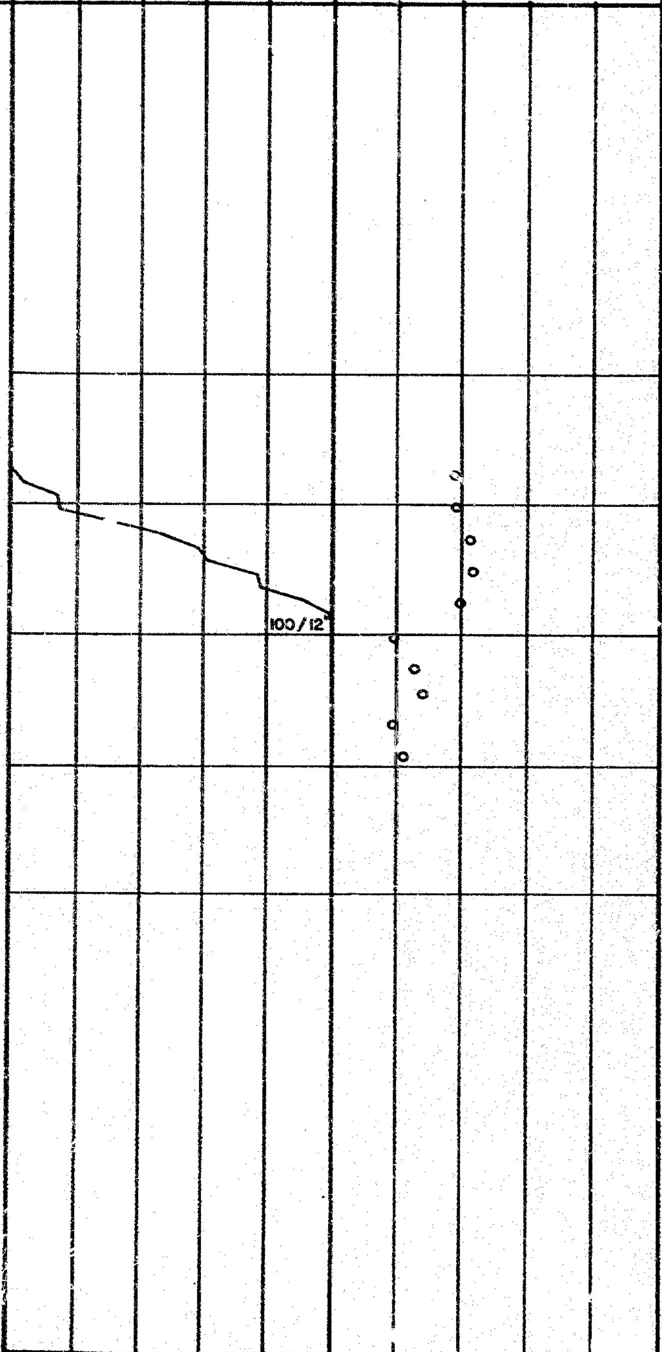
BORING METHOD	SOIL PROFILE ELEV'N / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE
							670
	665.6	RIVER LEVEL					
WASH BORING / BX CASING	0.0 / 663.1	WATER					
	2.5	Very stiff grey SILTY CLAY some sand occasional gravel (TILL)	T	1	2" D.O.	17	
				2	"	25	660
			T	3	"	16	
				4	"	15	
			T	5	"	28	
	651.1 / 14.5	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	T	6	"	27	650
			T	7	"	27	
				8	"	100	
			T	9	"	100/5"	
	640.4			10	"	100/2"	640
	25.2	END OF BOREHOLE					
							630

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

SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q. - ● REM.V. - ● U. - O

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

WATER CONTENT, PERCENT W_p W W_L 10 20 30 40



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL IN THAMES RIVER AT ELEV. 665.6 DURING DRILLING MAY 23, 1975.

15 ◆ 5 Percent axial strain at failure 10

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A. - O - I

Project No. 753073

RECORD OF BOREHOLE 20

CO-ORDINATES N 15,387,575 E 1,268,314

LOCATION See Figure 1 BORING DATE MAY 26 & 27, 1975 DATUM GEODETIC

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

BORING METHOD	SOIL PROFILE: ELEV'N / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FT.	ELEVATION SCALE	PIEZOMETER OR STANDPIPE INSTALLATION
	665.4	RIVER LEVEL				670	
WASH BORING 3X CASING	0.0	WATER					WATER LEVEL IN THAMES RIVER AT ELEV. 665.4 DURING DRILLING MAY 26, 1975.
	662.4 / 3.0	Compact brown SAND AND GRAVEL	1	2" D.O.	26		
	4.8	Stiff to very stiff grey SILTY CLAY some sand occasional gravel (TILL)	2	"	10	660	
			3	"	11		
			4	"	16		
			5	"	21		
	648.4		6	"	18	650	
	17.0	Hard grey CLAYEY SILT some sand occasional gravel (TILL)	7	"	33		
			8	"	>100		
			9	"	>100		
	639.9 / 25.5	END OF BOREHOLE	10	"	>100	640	
						630	

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

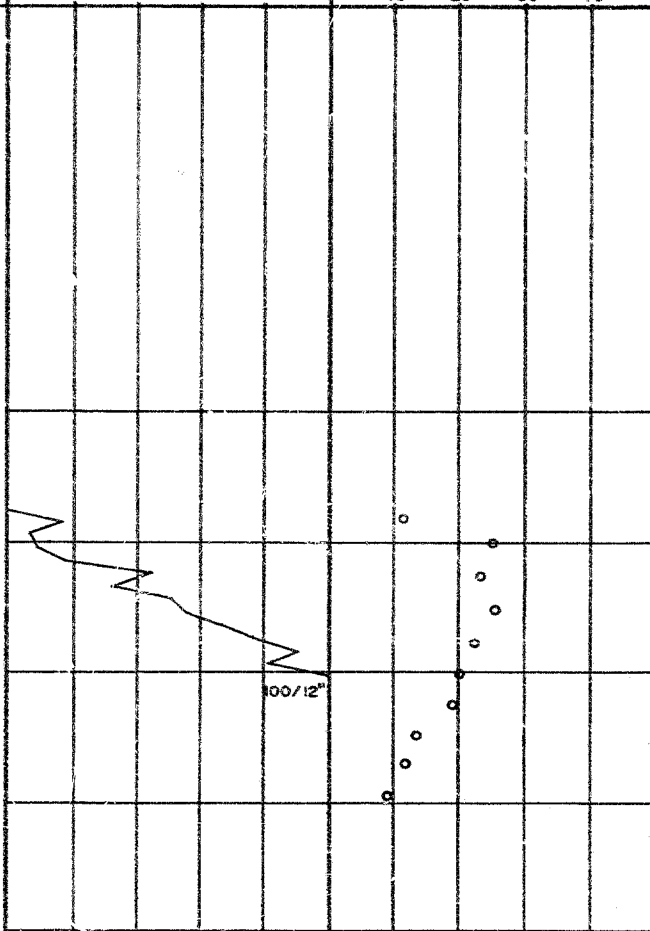
SHEAR STRENGTH Cu., LB./SQ.FT. NAT. V. - + Q - ● REM. V. - ⊕ U - O

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

WATER CONTENT, PERCENT W_P — W — W_L 10 20 30 40

ADDITIONAL LAB. TESTING

STRAT. PLOT



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

VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A.-C.-2

PROJECT No. 753073

RECORD OF PENETRATION TESTS 21 TO 24

LOCATION See Figure 1 DRIVING DATE MAY 14 & 15, 1975 DATUM GEODETIC

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

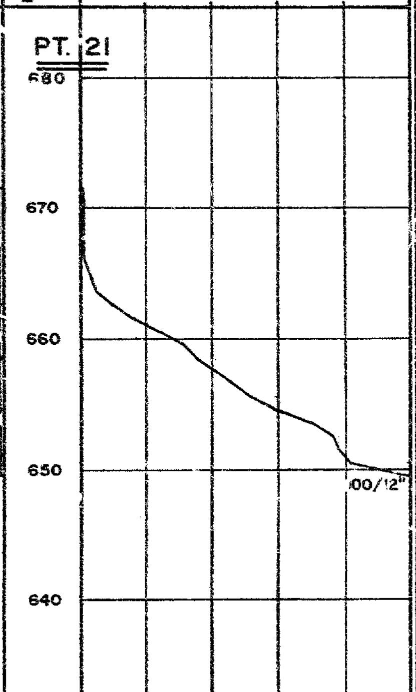
PENETRATION TEST No. 21 & 22

ELEVN. / DEPTH | INFERRED SOIL PROFILE | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

PT. 21

CO-ORDINATES
N 15,587,594
E 1,288,260

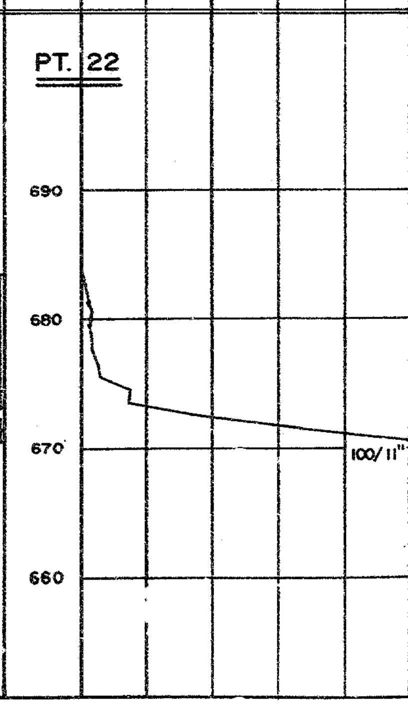
ELEVN. / DEPTH	INFERRED SOIL PROFILE
671·5	GROUND SURFACE
0·0	PROBABLY loose SILTY fine SAND
662·5 / 9·0	PROBABLY very stiff SILTY CLAY TILL
649·5 / 22·0	END OF PEN. TEST



PT. 22

CO-ORDINATES
N 15,587,582
E 1,288,104

ELEVN. / DEPTH	INFERRED SOIL PROFILE
683·5	GROUND SURFACE
0·0	PROBABLY loose SANDY SILT
674·5 / 9·0	PROBABLY very stiff SILTY CLAY TILL
670·6 / 12·9	END OF PEN. TEST



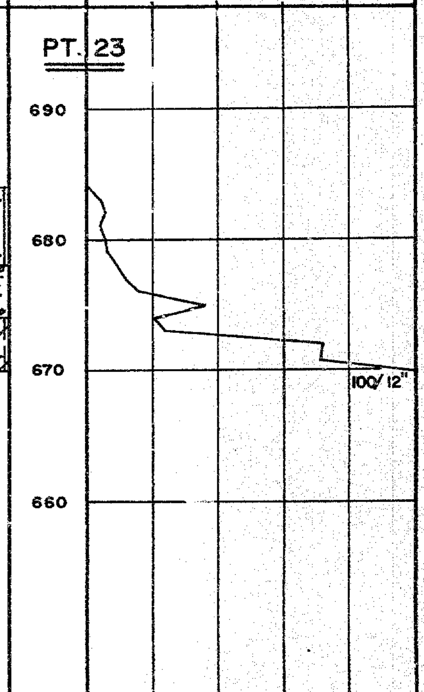
PENETRATION TEST No. 23 & 24

ELEVN. / DEPTH | INFERRED SOIL PROFILE | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT. (20, 40, 60, 80)

PT. 23

CO-ORDINATES
N 15,587,632
E 1,288,140

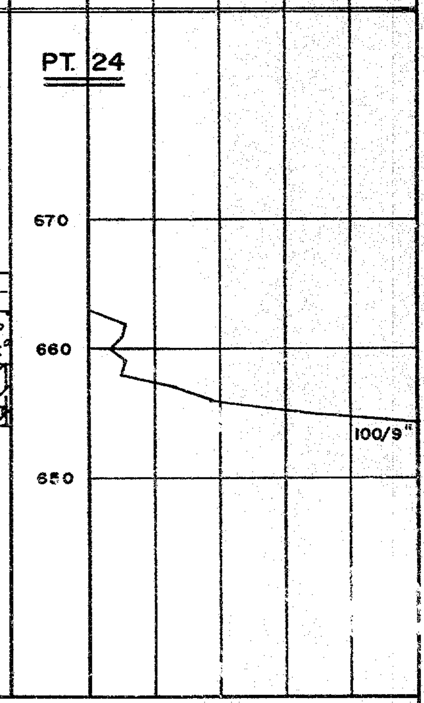
ELEVN. / DEPTH	INFERRED SOIL PROFILE
684·1	GROUND SURFACE
0·0	PROBABLY loose SANDY SILT
678·1 / 6·0	PROBABLY compact SAND AND GRAVEL
674·1 / 10·0	PROBABLY very stiff SILTY CLAY TILL
670·1 / 14·0	END OF PEN. TEST



PT. 24

CO-ORDINATES
N 15,587,478
E 1,288,215

ELEVN. / DEPTH	INFERRED SOIL PROFILE
665·9	RIVER LEVEL
0·0	WATER
662·9 / 3·0	PROBABLY compact SAND AND GRAVEL
658·9 / 7·0	PROBABLY very stiff SILTY CLAY TILL
654·1 / 11·8	END OF PEN. TEST



VERTICAL SCALE
1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.
CHECKED P.R.B.

Form G.A.-D.-2

PROJECT No. 753073

RECORD OF PENETRATION TESTS 25 TO 28

LOCATION See Figure 1 DRIVING DATE MAY 14, 15 & 21, 1975 DATUM GEODETIC

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

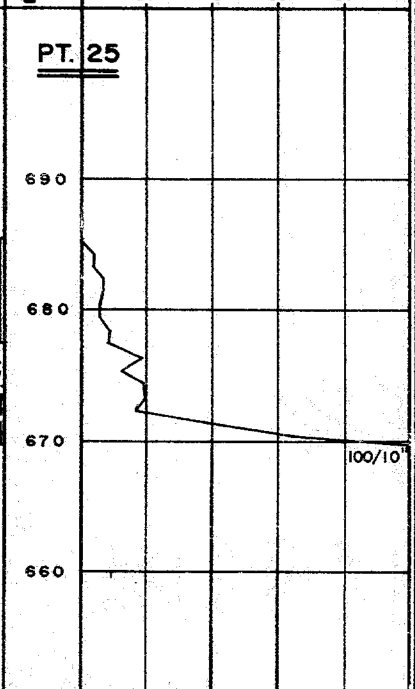
PENETRATION TEST No. 25 & 26

ELEVN. DEPTH | INFERRED SOIL PROFILE | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.

PT. 25

CO-ORDINATES
N 15,587,620
E 1,288,232

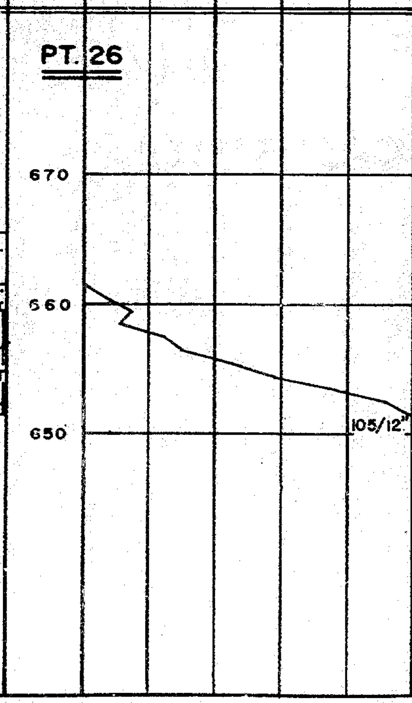
ELEVN. DEPTH	INFERRED SOIL PROFILE
685.4	GROUND SURFACE
0.0	PROBABLY loose SANDY SILT
677.4 / 8.0	PROBABLY compact SAND AND GRAVEL
673.4 / 12.0	PROBABLY very stiff SILTY CLAY TILL
669.6 / 15.8	END OF PEN. TEST



PT. 26

CO-ORDINATES
N 15,587,495
E 1,288,258

ELEVN. DEPTH	INFERRED SOIL PROFILE
665.3	RIVER LEVEL
0.0	WATER
661.3 / 4.0	PROBABLY compact SAND AND GRAVEL
659.3 / 6.0	PROBABLY very stiff SILTY CLAY TILL
651.3 / 14.0	END OF PEN. TEST



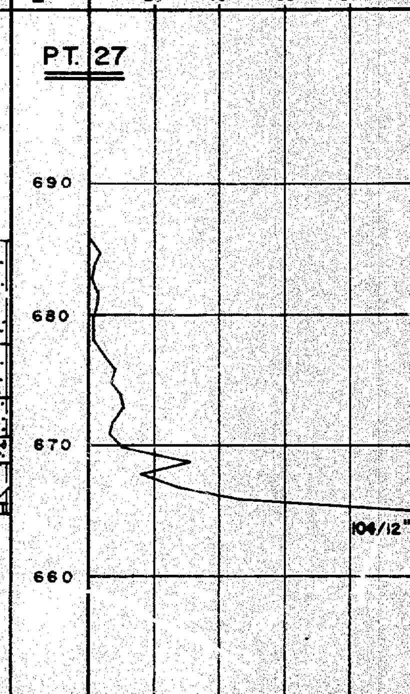
PENETRATION TEST No. 27 & 28

ELEVN. DEPTH | INFERRED SOIL PROFILE | ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.

PT. 27

CO-ORDINATES
N 15,587,480
E 1,288,480

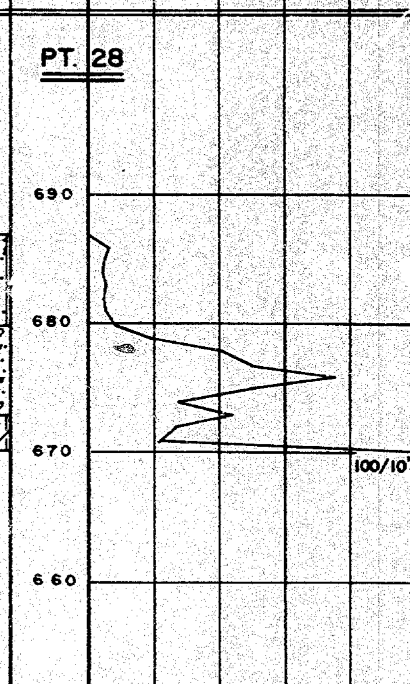
ELEVN. DEPTH	INFERRED SOIL PROFILE
685.7	GROUND SURFACE
0.0	PROBABLY very loose SILTY fine SAND
677.7 / 8.0	PROBABLY loose SANDY SILT
673.7 / 12.0	PROBABLY very loose SILTY fine SAND
670.7 / 15.0	PROBABLY compact SAND AND GRAVEL
668.7 / 17.0	PROBABLY hard SILTY CLAY TILL
664.7 / 21.0	END OF PEN. TEST



PT. 28

CO-ORDINATES
N 15,587,503
E 1,288,154

ELEVN. DEPTH	INFERRED SOIL PROFILE
686.8	GROUND SURFACE
0.0	PROBABLY loose SANDY SILT
679.8 / 7.0	PROBABLY compact to dense SAND AND GRAVEL
672.8 / 14.0	PROBABLY hard SILTY CLAY TILL
670.0 / 16.8	END OF PEN. TEST



VERTICAL SCALE 1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.

Form G.A.-D.-2

PROJECT No. 753073

RECORD OF PENETRATION TESTS 29 TO 32

LOCATION See Figure 1 DRIVING DATE MAY 15, 21 & 22, 1975 DATUM GEODETIC

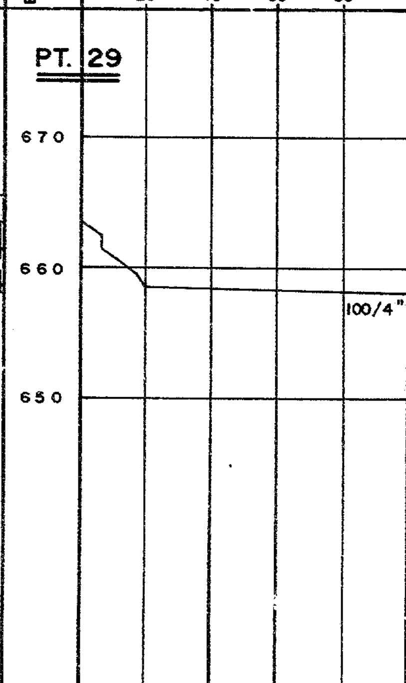
PENETRATION TEST HAMMER WEIGHT 140 LB., DROP 30 IN.

PENETRATION TEST No. 29 & 30

PT. 29

CO-ORDINATES
N 15,587,448
E 1,288,342

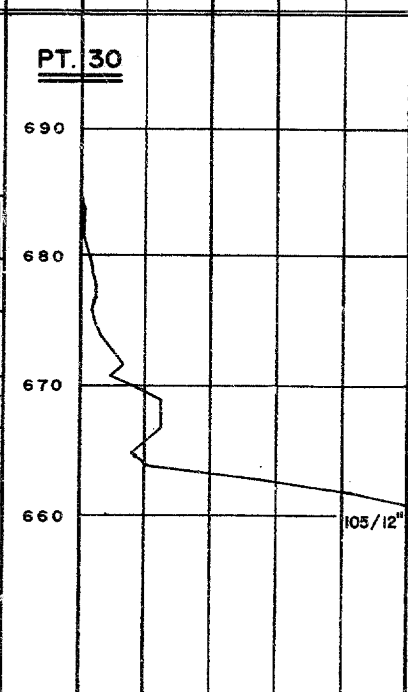
ELEVN. / DEPTH	INFERRED SOIL PROFILE
665.3	RIVER LEVEL
663.3 / 0.0	WATER
2.0	PROBABLY very stiff SILTY CLAY TILL
658.0 / 7.3	END OF PEN. TEST



PT. 30

CO-ORDINATES
N 15,587,372
E 1,288,403

ELEVN. / DEPTH	INFERRED SOIL PROFILE
684.7	GROUND SURFACE
0.0	PROBABLY very loose SILTY fine SAND
679.7 / 5.0	PROBABLY very loose SANDY SILT
675.7 / [illegible]	PROBABLY compact SILTY fine SAND
670.7 / 14.0	PROBABLY compact SAND AND GRAVEL
666.7 / 18.0	PROBABLY very stiff SILTY CLAY TILL
660.7 / 2[illegible]	END OF PEN. TEST

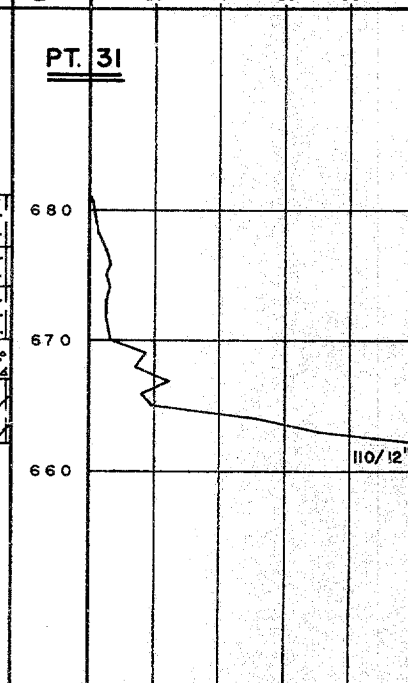


PENETRATION TEST No. 31 & 32

PT. 31

CO-ORDINATES
N 15,587,362
E 1,288,492

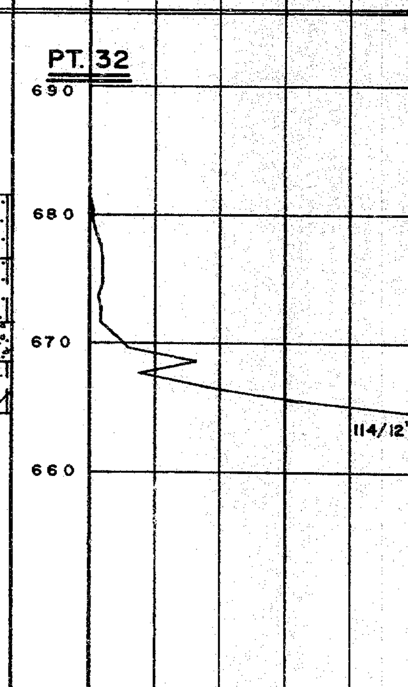
ELEVN. / DEPTH	INFERRED SOIL PROFILE
681.0	GROUND SURFACE
0.0	PROBABLY very loose SILTY fine SAND
677.0 / 4.0	PROBABLY very loose SANDY SILT
674.0 / 7.0	PROBABLY loose SILTY fine SAND
670.0 / 11.0	PROBABLY compact SAND AND GRAVEL
667.0 / 14.0	PROBABLY very stiff SILTY CLAY TILL
662.0 / 19.0	END OF PEN. TEST



PT. 32

CO-ORDINATES
N 15,587,412
E 1,288,530

ELEVN. / DEPTH	INFERRED SOIL PROFILE
681.4	GROUND SURFACE
0.0	PROBABLY very loose SANDY SILT
676.4 / 5.0	PROBABLY loose SILTY fine SAND
671.4 / 10.0	PROBABLY compact SAND AND GRAVEL
668.4 / 13.0	PROBABLY very stiff SILTY CLAY TILL
664.4 / 17.0	END OF PEN. TEST



VERTICAL SCALE
1 IN. TO — FT.

Golder Associates

DRAWN W.D.F.
CHECKED P.R.B.

Form G.A.-D.-2

PROJECT No. 753073

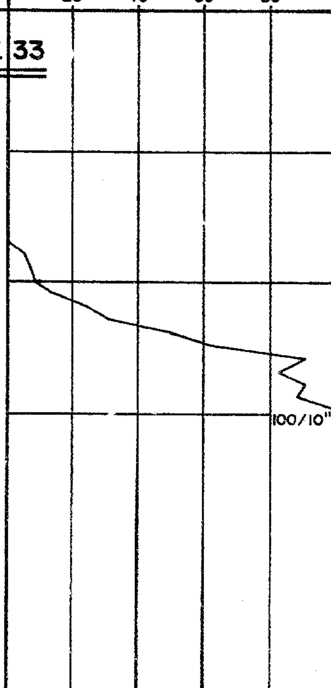
RECORD OF PENETRATION TESTS 33 TO 36

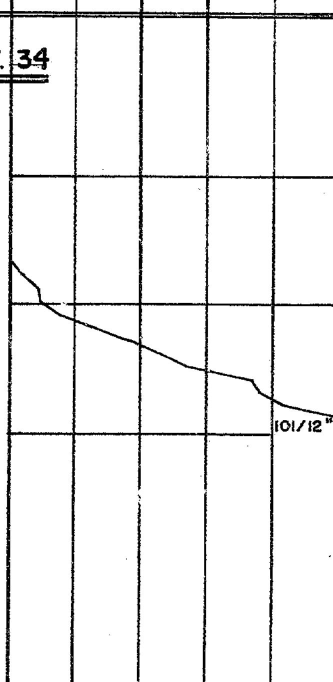
LOCATION See Figure 1 DRIVING DATE MAY 21,23 & 27, 1975 DATUM GEODETIC

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

PENETRATION TEST No. 33 & 34

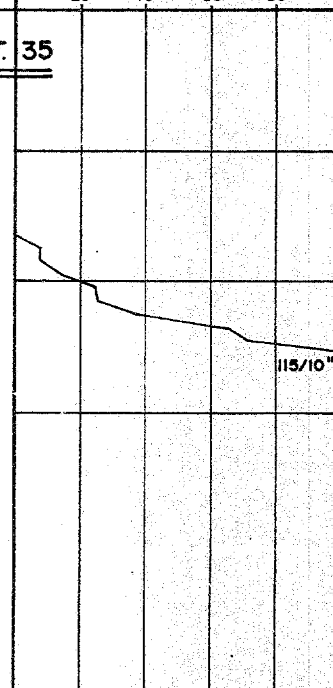
ELEV'N. / DEPTH	INFERRED SOIL PROFILE	ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.
	CO-ORDINATES N 15,587,517 E 1,288,415	PT. 33	
665·6	RIVER LEVEL		
0·0 / 663·3	WATER		
2·3	PROBABLY very stiff SILTY CLAY TILL		
650·5 / 15·1	END OF PEN. TEST		100/10"
	CO-ORDINATES N 15,587,500 E 1,288,374	PT. 34	
665·6	RIVER LEVEL		
0·0 / 663·1	WATER		
2·5	PROBABLY very stiff SILTY CLAY TILL		
651·1 / 14·5	END OF PEN. TEST		101/12"

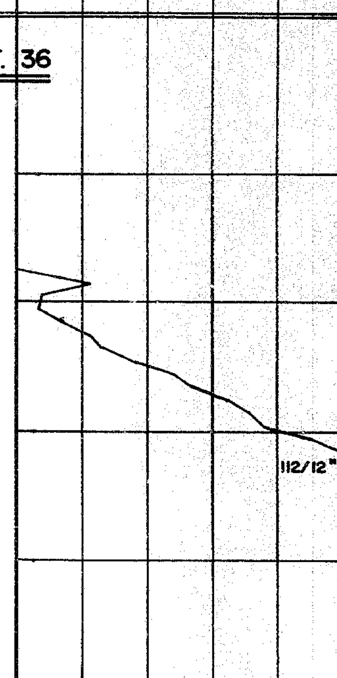




PENETRATION TEST No. 35 & 36

ELEV'N. / DEPTH	INFERRED SOIL PROFILE	ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE, BLOWS/FT.
	CO-ORDINATES N 15,587,407 E 1,288,343	PT. 35	
665·6	RIVER LEVEL		
0·0 / 663·6	WATER		
2·0	PROBABLY very stiff SILTY CLAY TILL		
654·8 / 10·8	END OF PEN. TEST		115/10"
	CO-ORDINATES N 15,587,547 E 1,288,296	PT. 36	
665·4	RIVER LEVEL		
0·0 / 662·4	WATER		
3·0 / 660·4	PROBABLY compact SAND AND GRAVEL		
5·0	PROBABLY very stiff SILTY CLAY TILL		
648·4 / 17·0	END OF PEN. TEST		112/12"



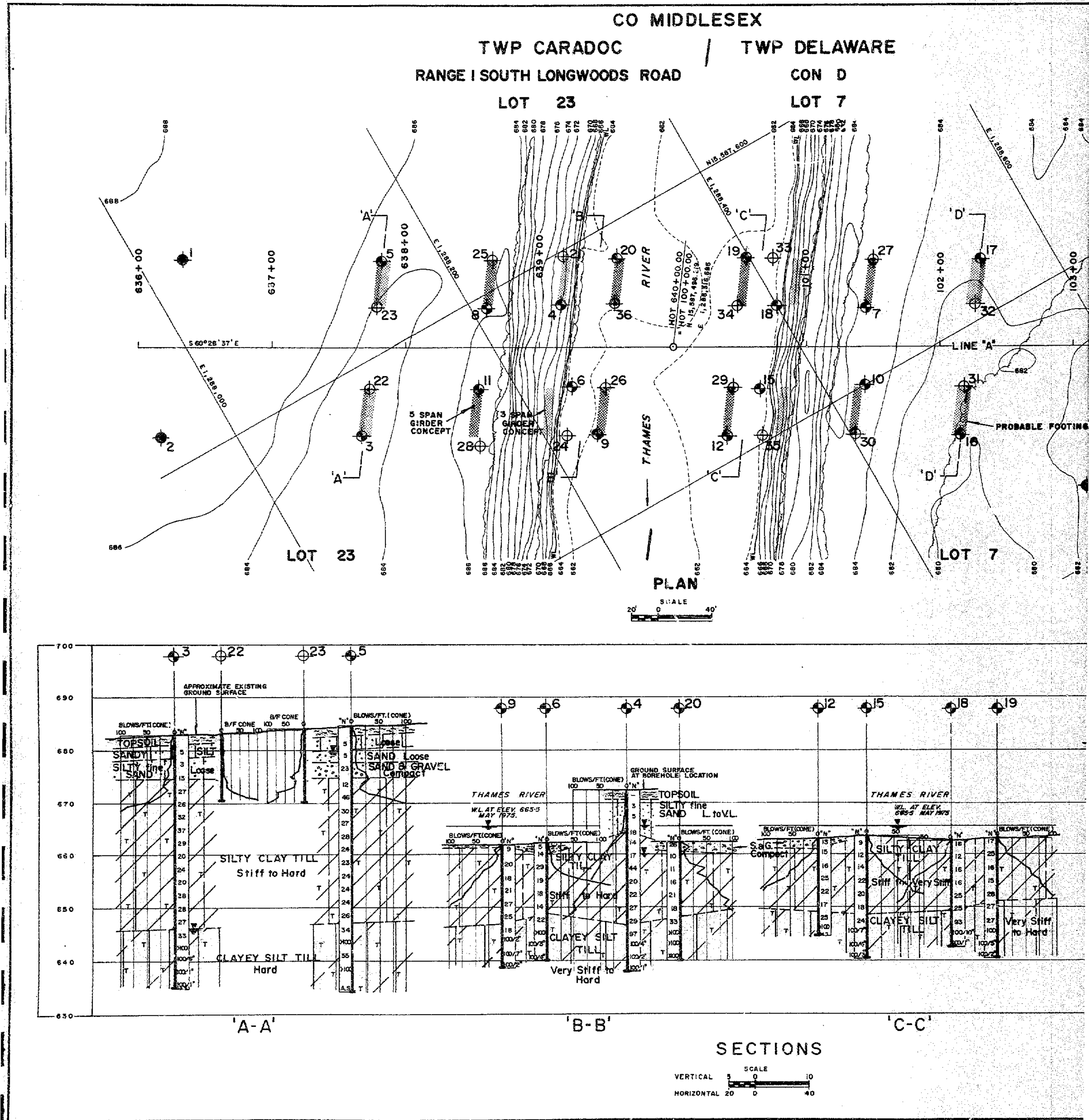


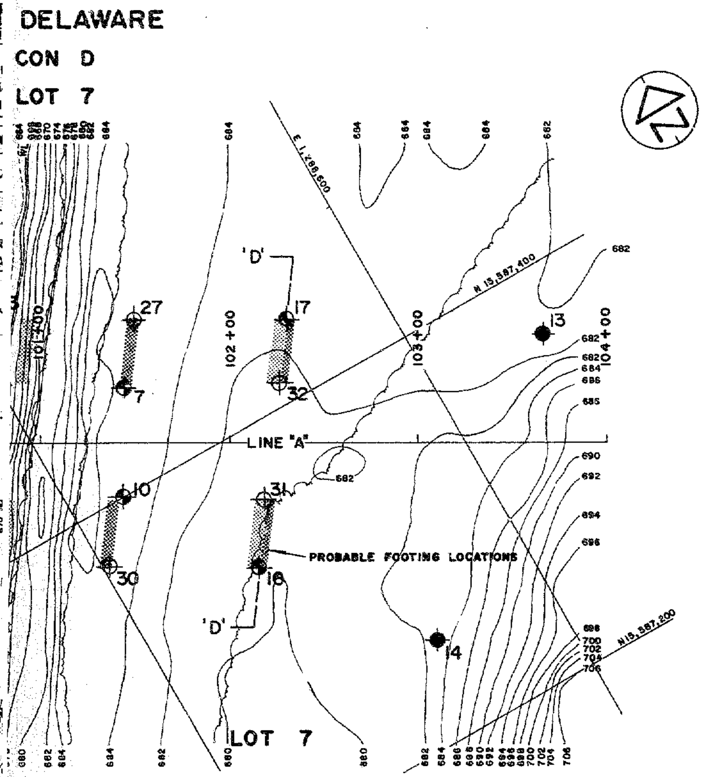
VERTICAL SCALE 1 IN. TO — FT.

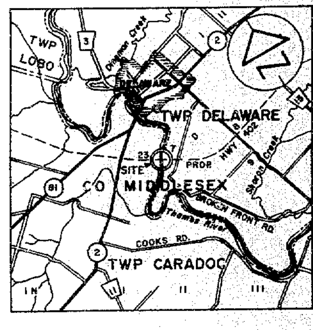
Golder Associates

DRAWN W.D.F.

CHECKED P.R.B.


CO MIDDLESEX
TWP CARADOC
TWP DELAWARE
RANGE I SOUTH LONGWOODS ROAD
CON D
LOT 23
LOT 7
THAMES RIVER
LINE "A"
5 SPAN GIRDER CONCEPT
3 SPAN GIRDER CONCEPT
PROBABLE FOOTING
PLAN
SCALE
APPROXIMATE EXISTING GROUND SURFACE
TOPSOIL
SANDY SILTY fine SAND
SILT Loose
SAND Loose
SAND & GRAVEL Compact
SILTY CLAY TILL Stiff to Hard
CLAYEY SILT TILL Hard
GROUND SURFACE AT BOREHOLE LOCATION
SILTY fine SAND L. to V.L.
W.L. AT ELEV. 665.3 MAY 1975
SILTY CLAY TILL Stiff to Hard
CLAYEY SILT TILL Very Stiff to Hard
S.&G. Compact
SILTY CLAY TILL Stiff to Very Stiff
CLAYEY SILT TILL
Very Stiff to Hard
'A-A'
'B-B'
'C-C'
SECTIONS
SCALE
VERTICAL
HORIZONTAL





KEY PLAN

LEGEND

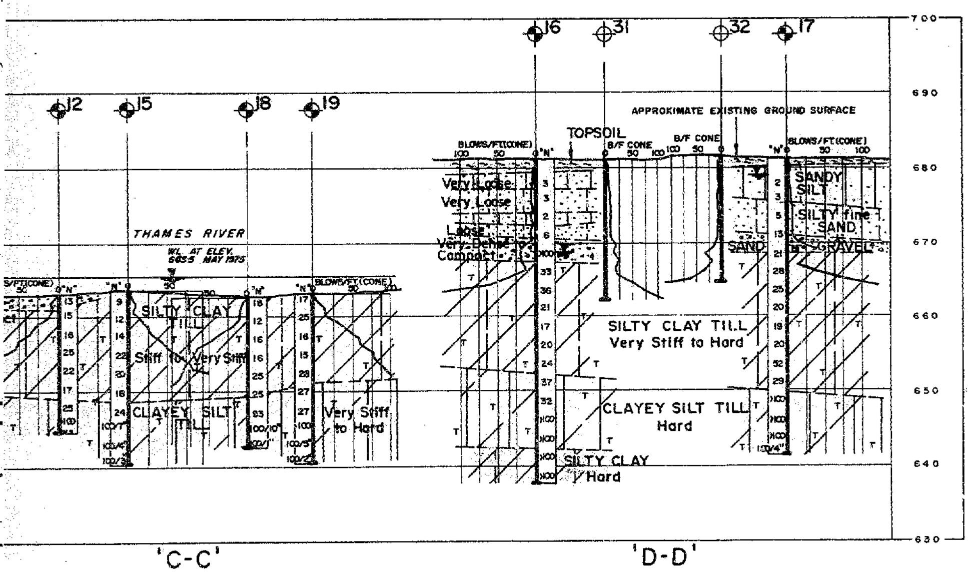
- Bore Hole
- Dynamic Cone Penetration Resistance Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation.

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
1	687·0	15,587,735	1,288,031
2	687·6	15,587,627	1,287,950
3	682·9	15,587,554	1,288,082
4	672·5	15,587,565	1,288,260
5	684·8	15,587,660	1,288,162
6	665·3	15,587,508	1,288,236
7	586·0	15,587,450	1,288,457
8	686·2	15,587,590	1,288,210
9	665·9	15,587,467	1,288,235
10	685·2	15,587,400	1,288,428
11	686·3	15,587,540	1,288,175
12	665·6	15,587,418	1,288,320
13	683·0	15,587,366	1,288,665
14	682·4	15,587,252	1,288,735
15	665·6	15,587,437	1,288,358
16	681·1	15,587,333	1,288,472
17	681·0	15,587,440	1,288,550
18	665·6	15,587,485	1,288,400

(LOCATIONS CONTINUED ON DRAWING NO. 2)

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.



ONS

REVISIONS	DATE	BY	DESCRIPTION

H.Q. GOLDER & ASSOCIATES LTD.

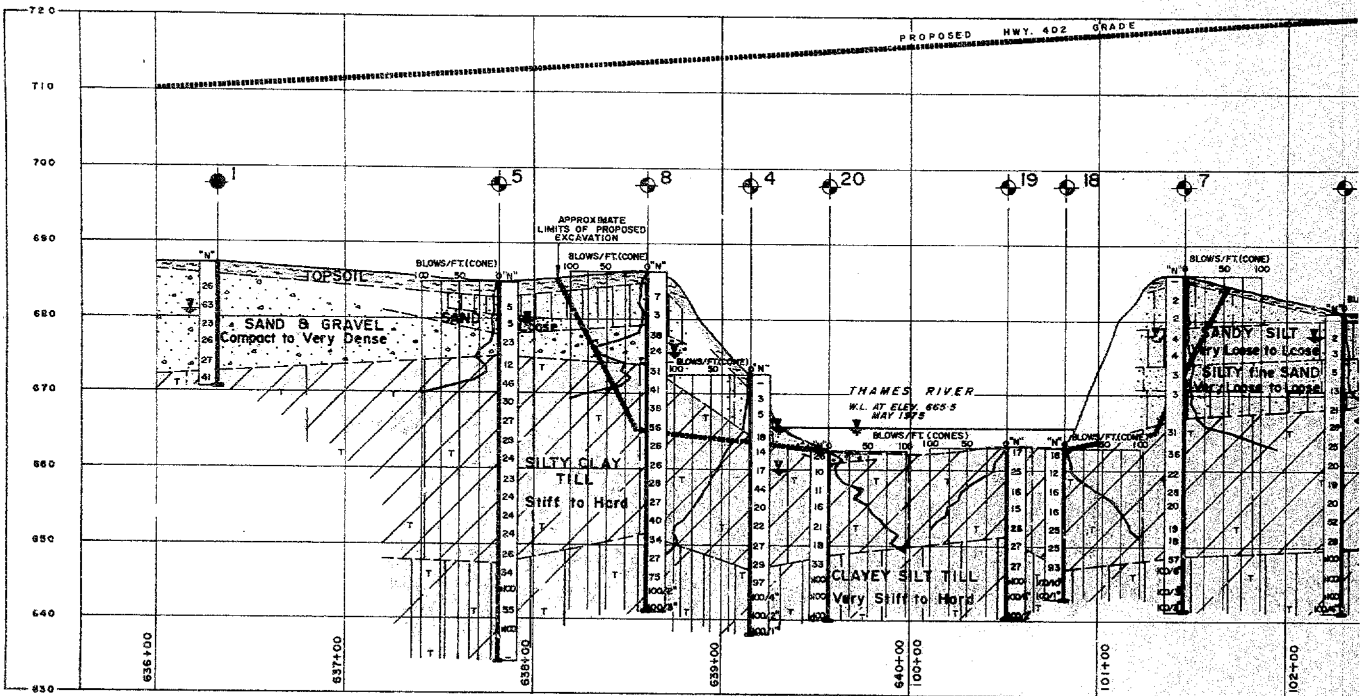
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

PROPOSED CROSSING AT THAMES RIVER
AND
PROPOSED KING'S HWY. 402 LINE "A"

HIGHWAY NO 402 LINE 'A' PROPOSED DIST NO 2
CO. MIDDLESEX
TWP CARADOC DELAWARE LOT 23 7 CON RANGE I SLR D

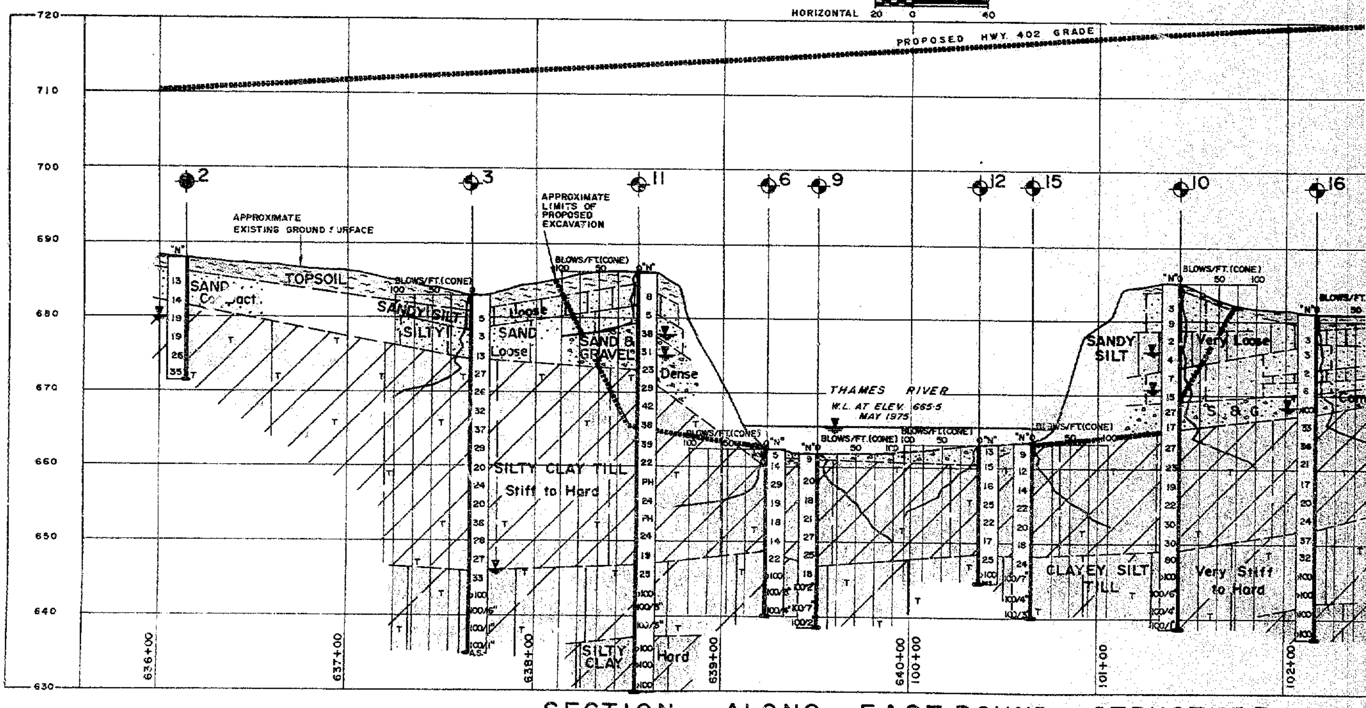
BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D	CHECKED P.R.B.	W.P. NO 41-66-17/18	DRAWING NO 1
DRAWN W.D.F.	CHECKED P.R.S.	W.O. NO	
DATE JUNE 2, 1975		SITE NO 19-535	BRIDGE DRAWING NO.
APPROVED		CONT NO	



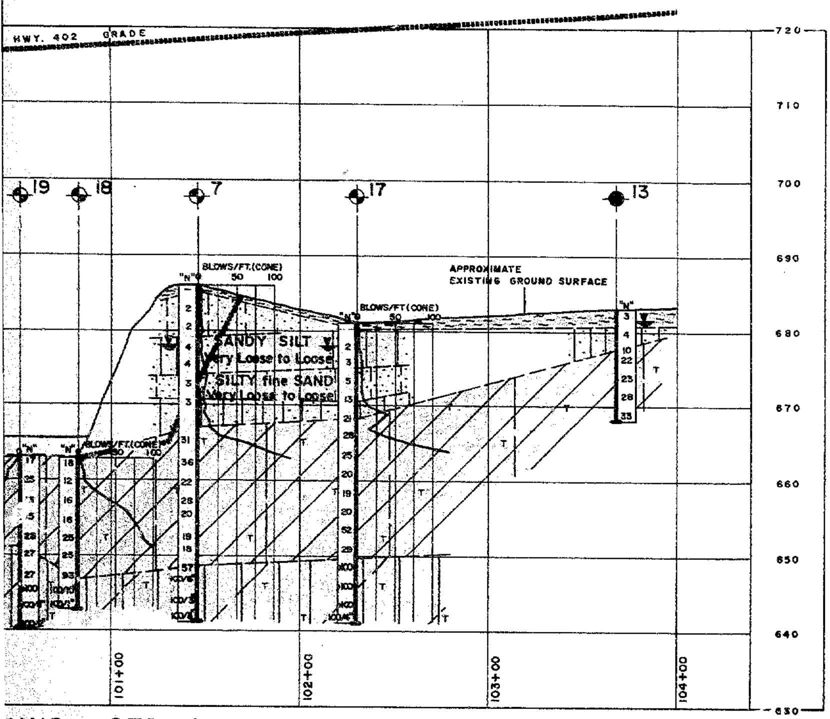
SECTION ALONG WEST·BOUND STRUCTURE

SCALE
VERTICAL 5 0 10
HORIZONTAL 20 0 40

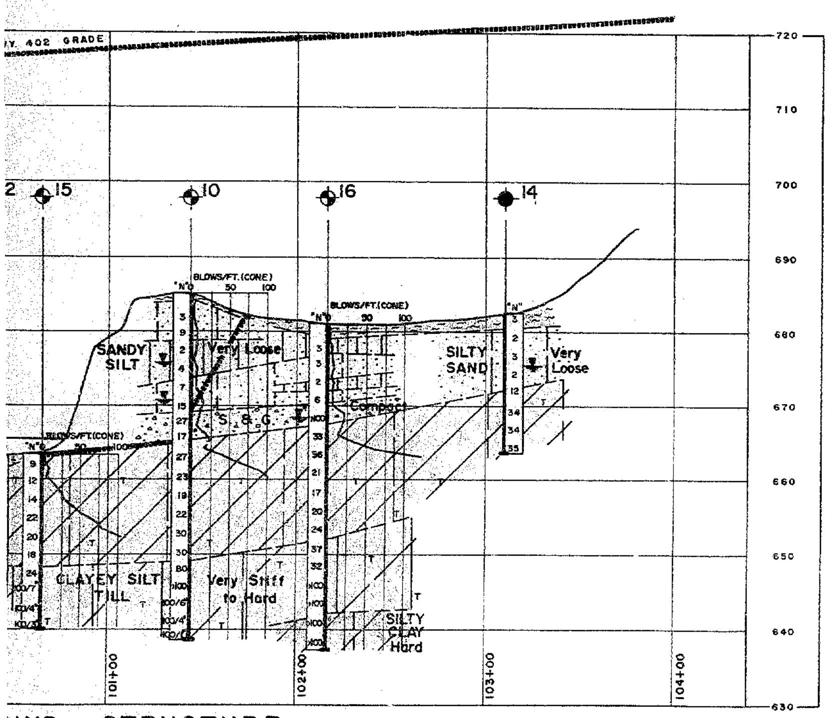


SECTION ALONG EAST·BOUND STRUCTURE

SCALE
VERTICAL 5 0 10
HORIZONTAL 20 0 40



UND STRUCTURE



UND STRUCTURE

NOTE:
FOR K... PLAN
REFE... DRAWING NO. 1

KEY PLAN

LEGEND

- Bore Hole
- Dynamic Cone Penetration Resistance Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation. MAY 1975

(LOCATIONS CONTINUED)

NO.	ELEVATION	CO-ORDINATES NORTH	CO-ORDINATES EAST
19	665·6	15,587,527	1,288,398
20	665·4	15,587,575	1,288,314
21	671·5	15,587,594	1,288,280
22	683·5	15,587,582	1,288,104
23	684·1	15,587,632	1,288,140
24	665·9	15,587,478	1,288,215
25	695·4	15,587,620	1,288,232
26	665·3	15,587,495	1,288,258
27	685·7	15,587,480	1,288,480
28	686·8	15,587,503	1,288,154
29	665·3	15,587,448	1,288,342
30	684·7	15,587,372	1,288,403
31	681·0	15,587,362	1,288,492
32	681·4	15,587,412	1,288,530
33	665·6	15,587,517	1,288,415
34	665·6	15,587,500	1,288,374
35	665·6	15,587,407	1,288,343
36	665·4	15,587,547	1,288,296

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS DATE	BY	DESCRIPTION

H.Q. GOLDER & ASSOCIATES LTD.

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

PROPOSED CROSSING AT THAMES RIVER AND PROPOSED KING'S HWY. 402 LINE "A"

HIGHWAY NO. 402 LINE "A" PROPOSED DIST. NO. 2
CO. MIDDLESEX
TWPs. CARADOC DELAWARE LOT 23/7 CON RANGE I SLR/n

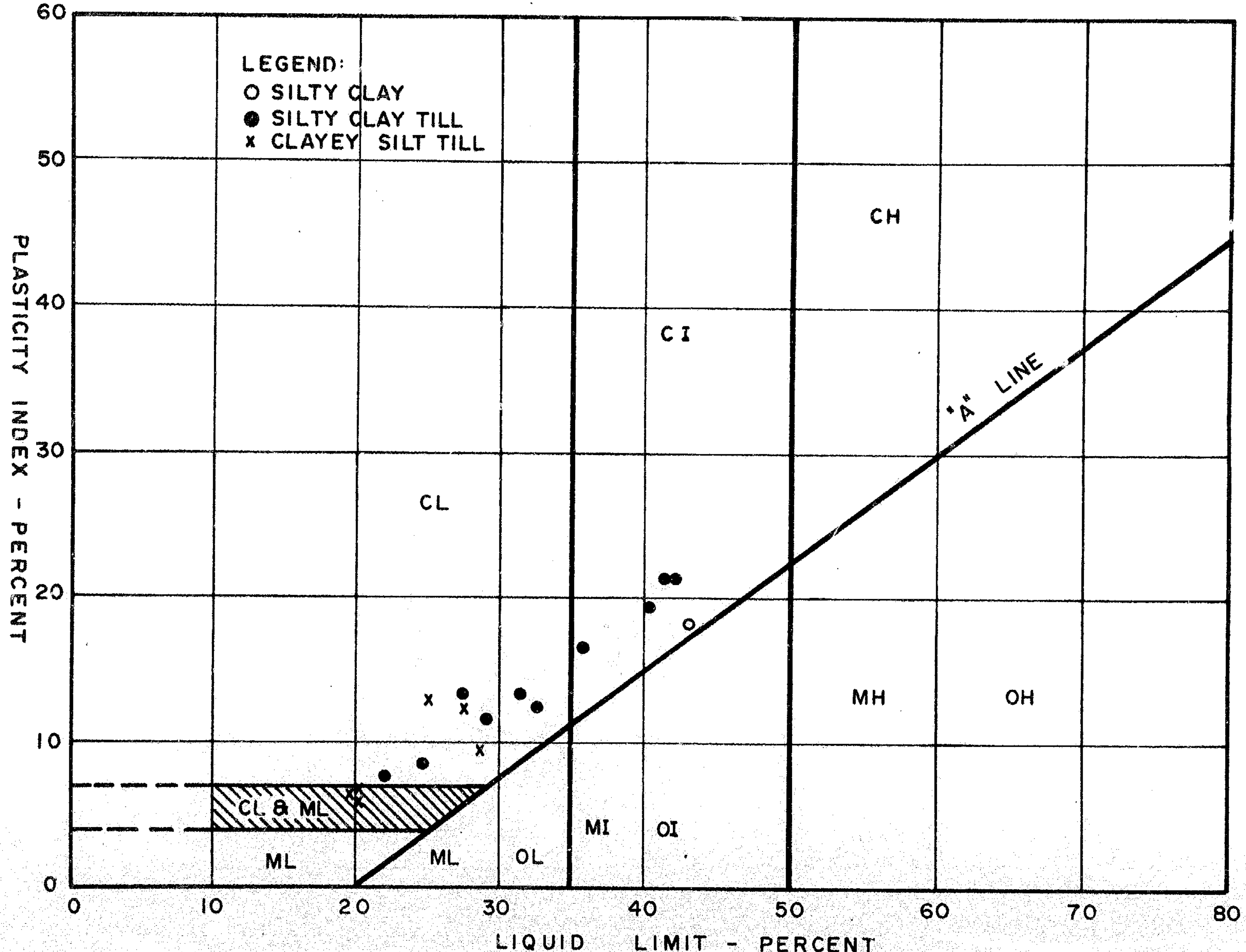
BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D.	CHECKED P.R.B.	W.P. NO. 41-66-17/18	DRAWING NO. 2
DRAWN W.D.F.	CHECKED P.R.B.	W.O. NO.	
DATE MAY 31, 1975		SITE NO. 19-536	BRIDGE DRAWING NO.
APPROVED		CONT. NO.	

SNO-TRACE 1994-74

Form G.A.-D.-5

PROJECT No. 753073



Golder Associates

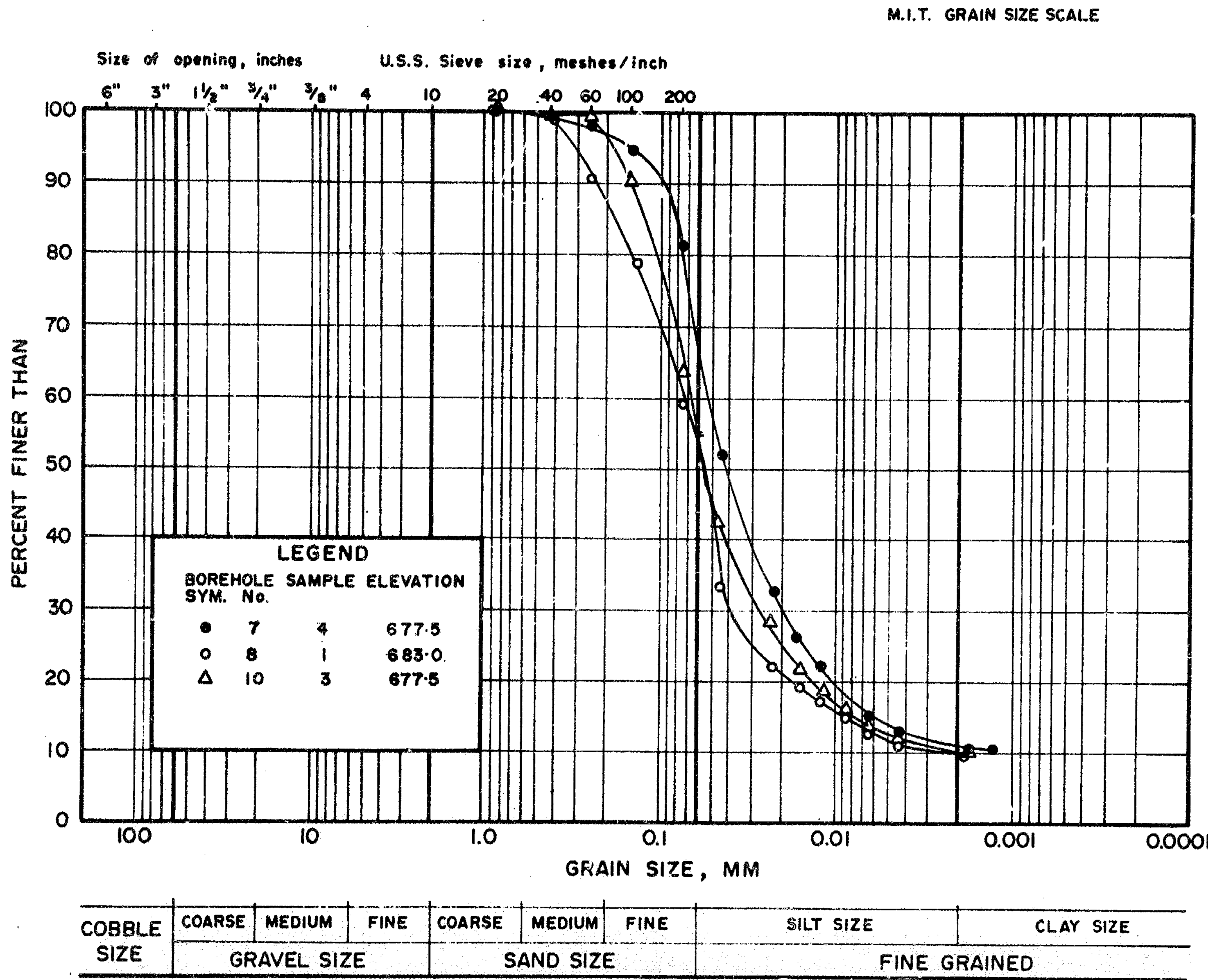
PLASTICITY CHART

FIGURE 3

PROJECT No. 753073

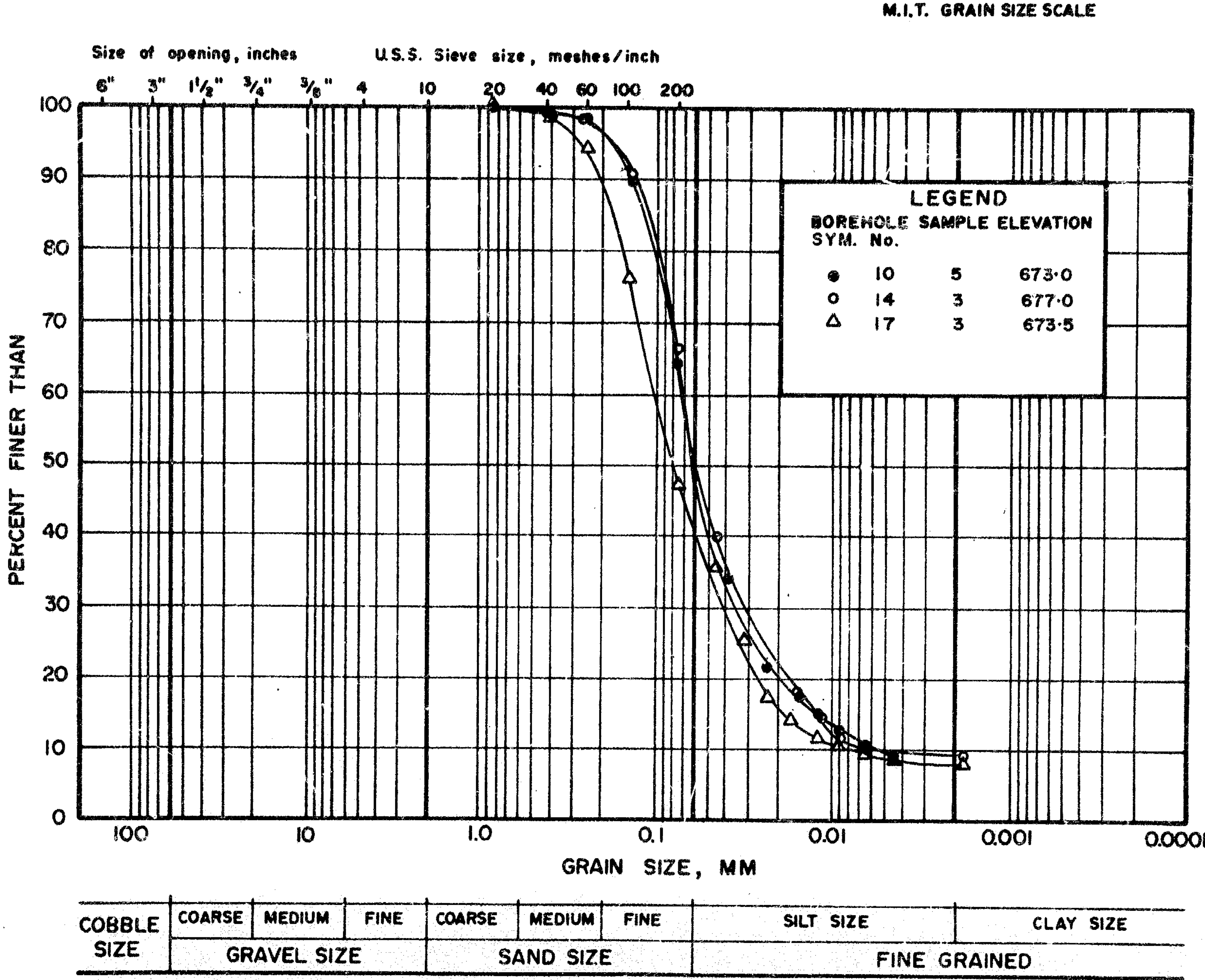
GRAIN SIZE DISTRIBUTION

SANDY SILT



Golder Associates

FIGURE 4

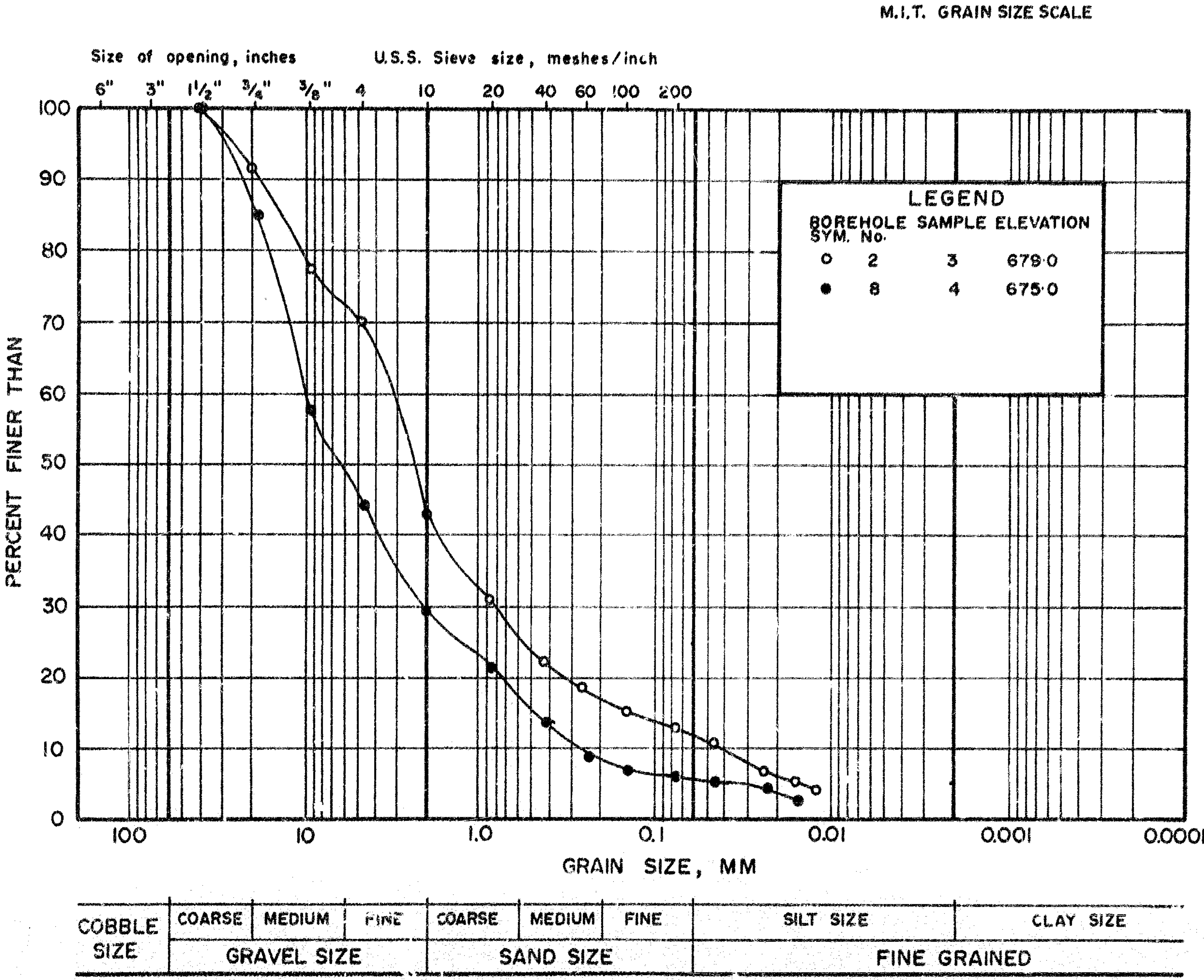


Golder Associates

GRAIN SIZE DISTRIBUTION

SILTY fine SAND

FIGURE 5



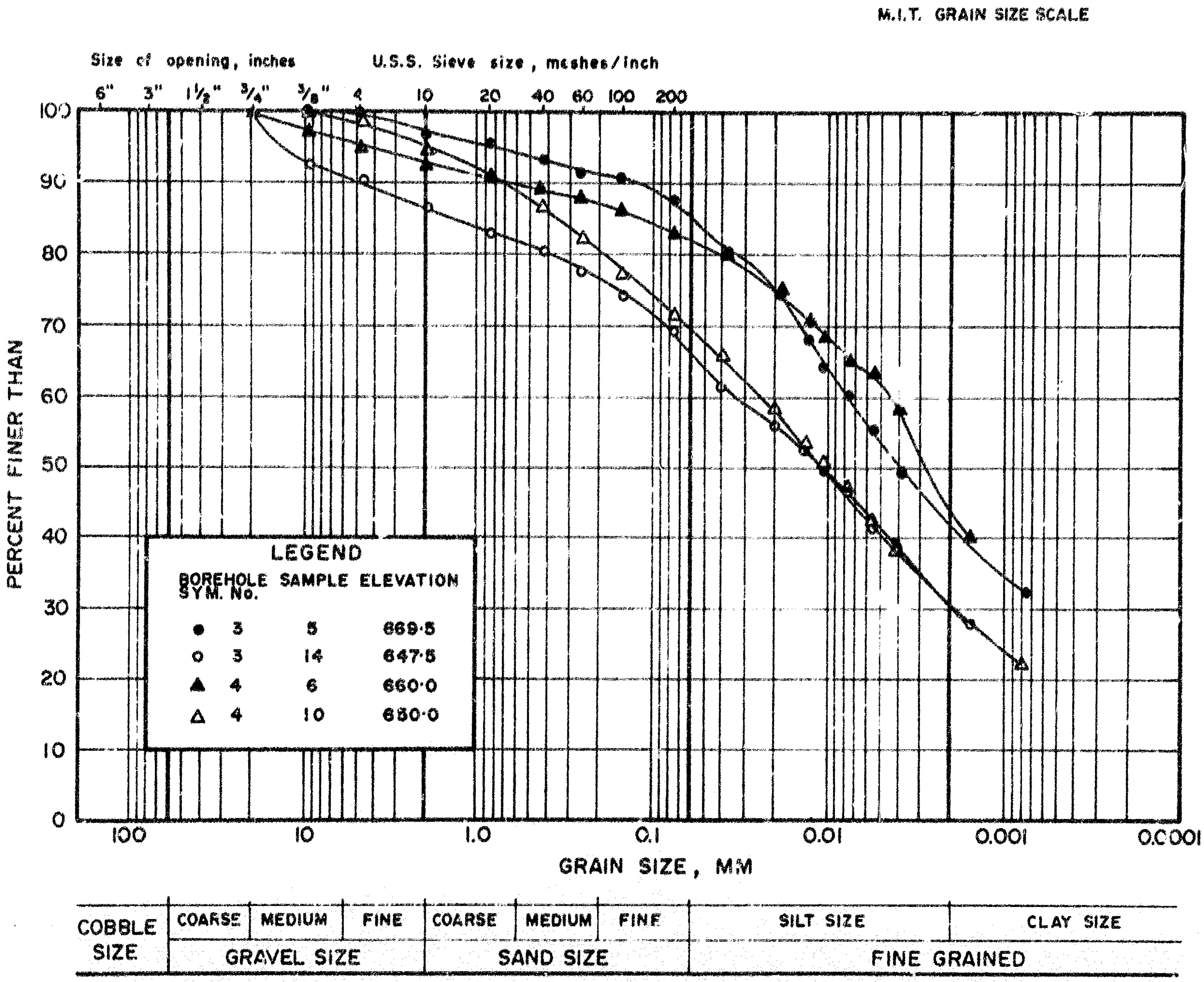
Golder Associates

GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL

FIGURE 6

PROJECT No. [redacted]

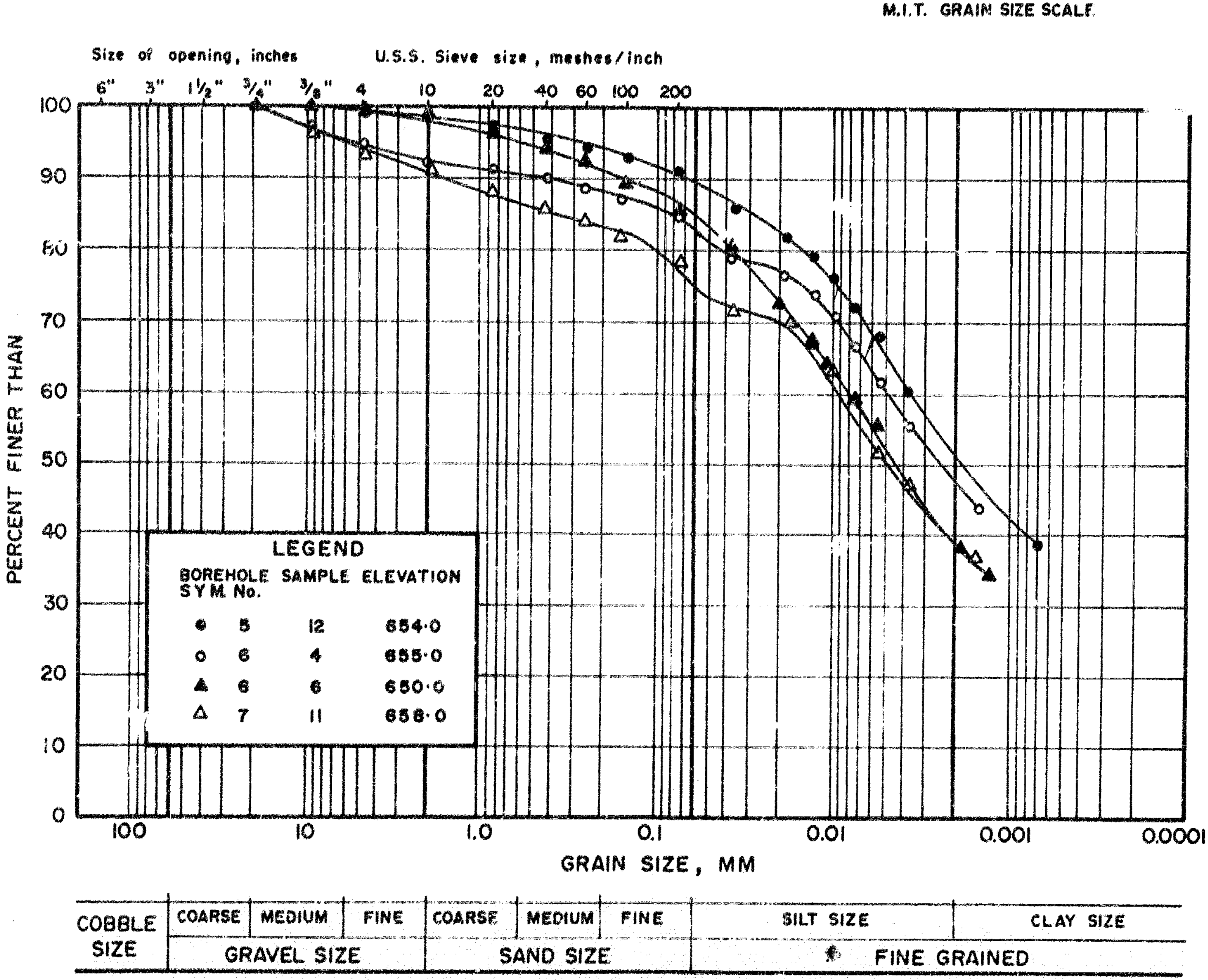


Golder Associates

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

FIGURE 7

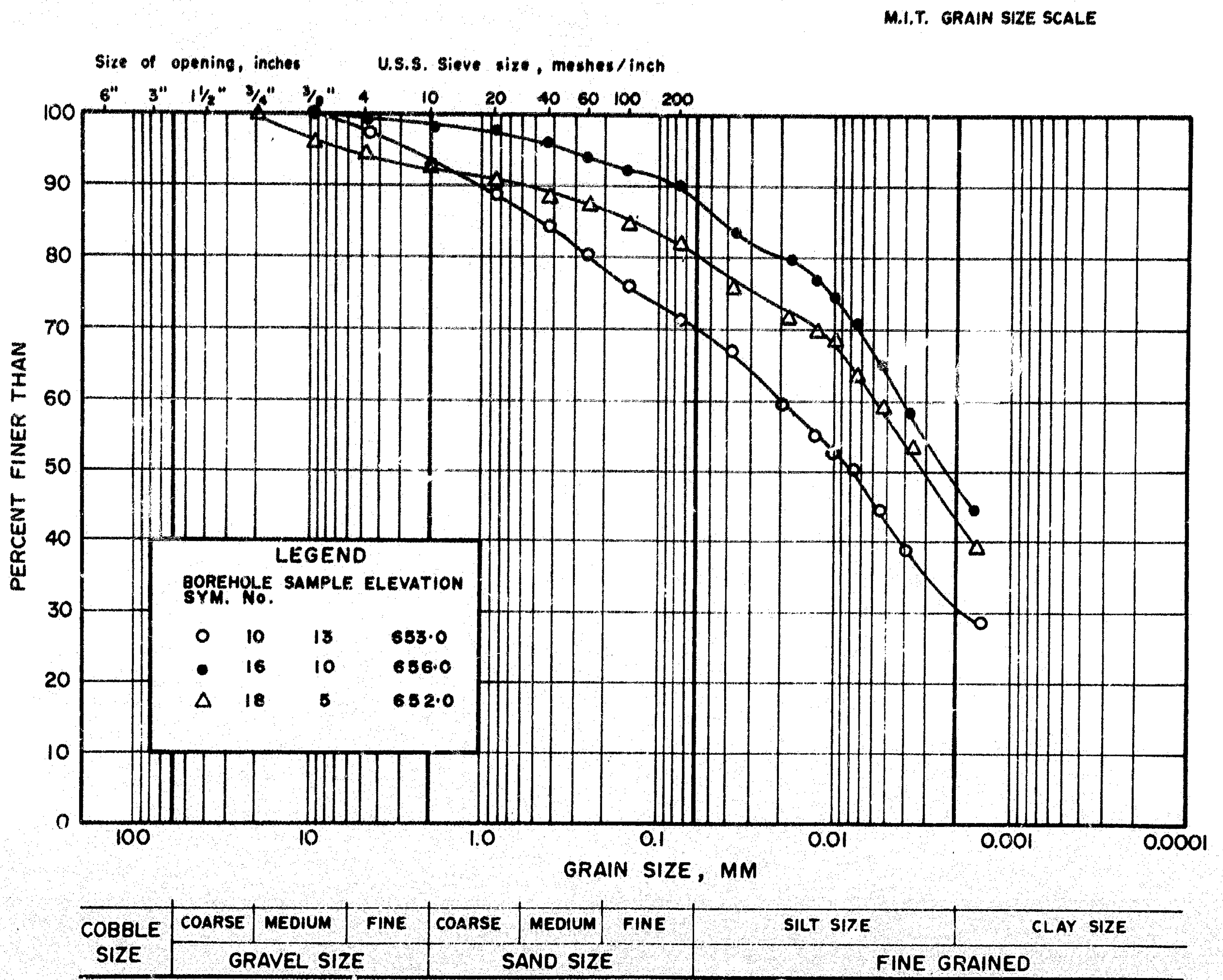


Golder Associates

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

FIGURE 8



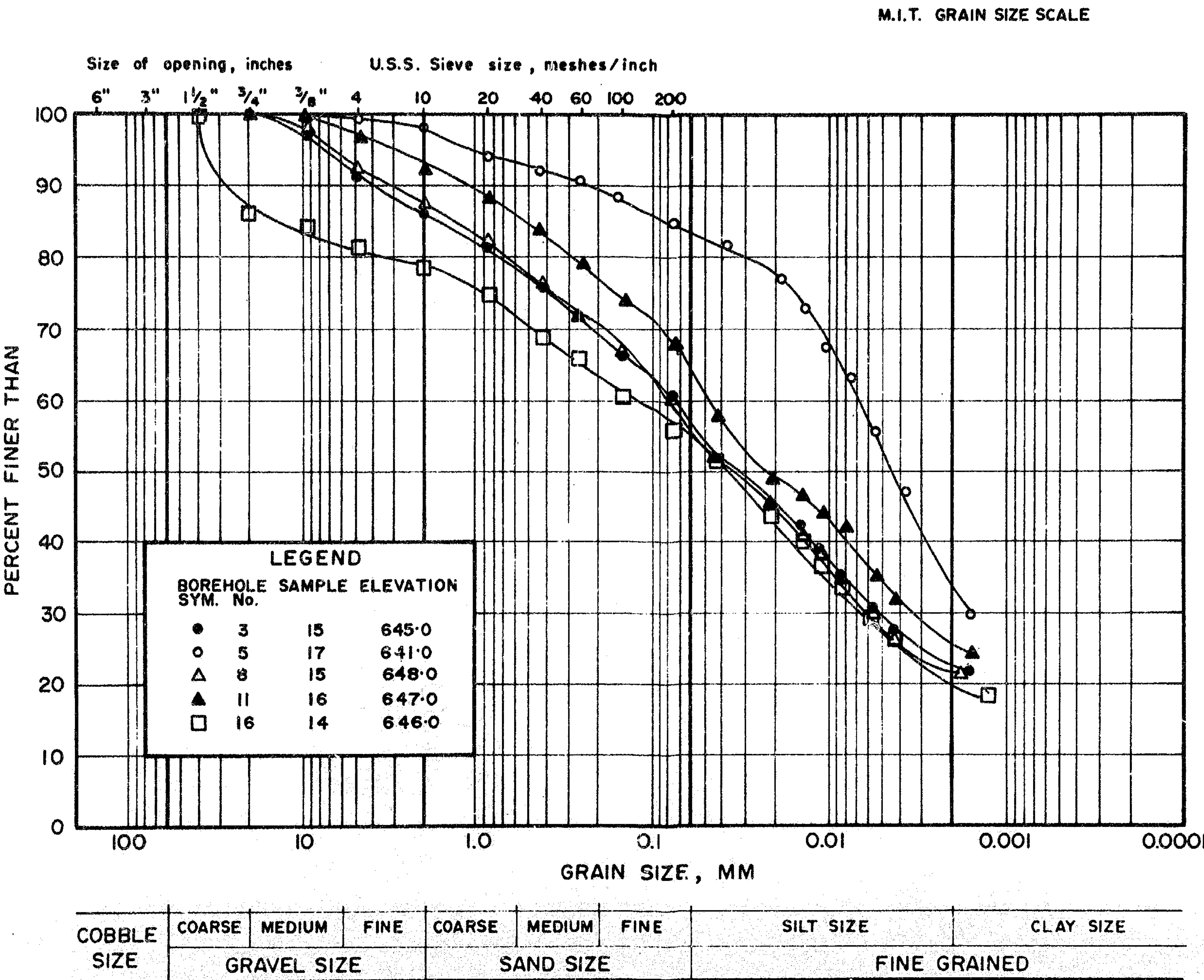
Golder Associates

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL

FIGURE 9

PROJECT No. 307



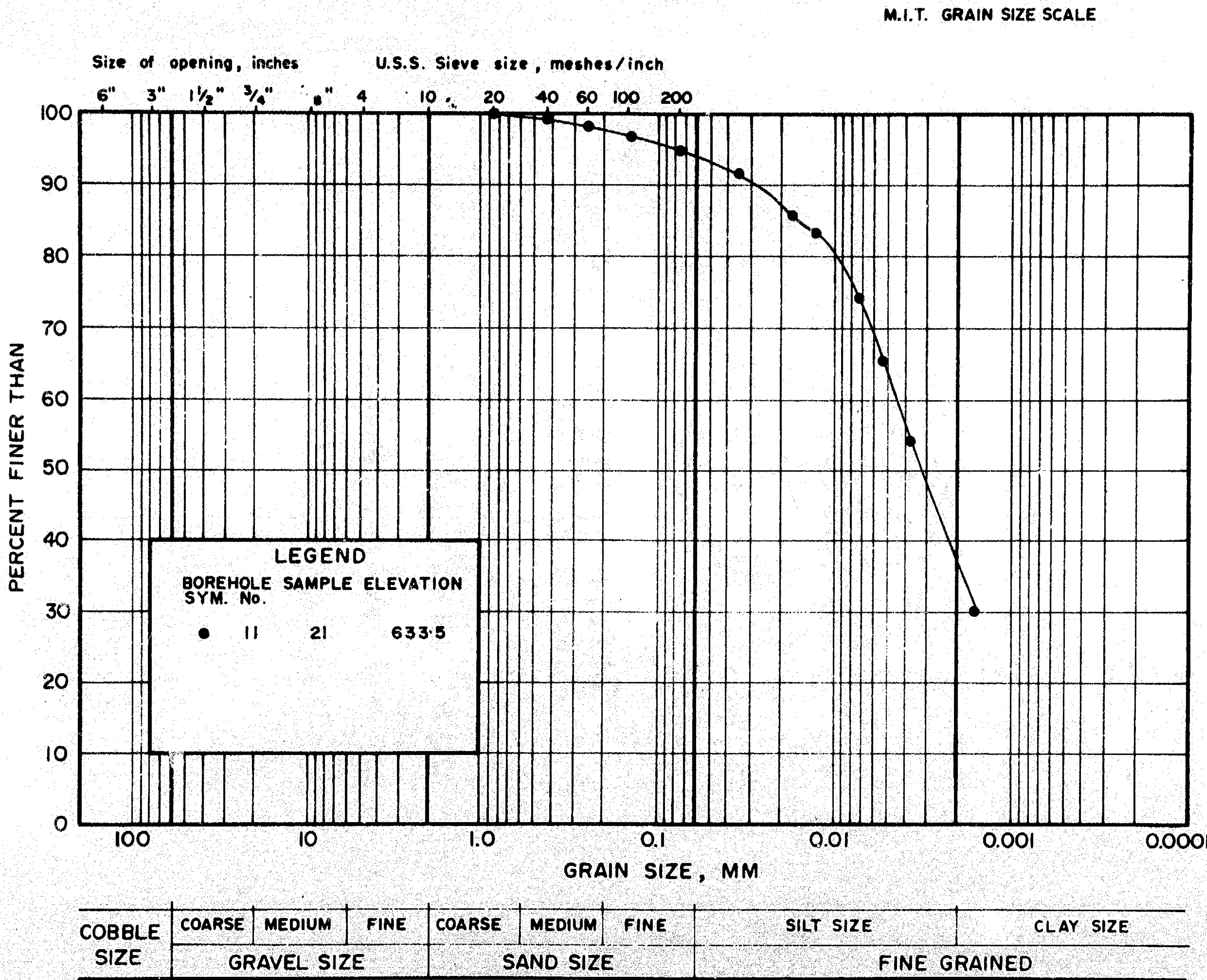
Golder Associates

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIGURE 10

Golder Associates



GRAIN SIZE DISTRIBUTION

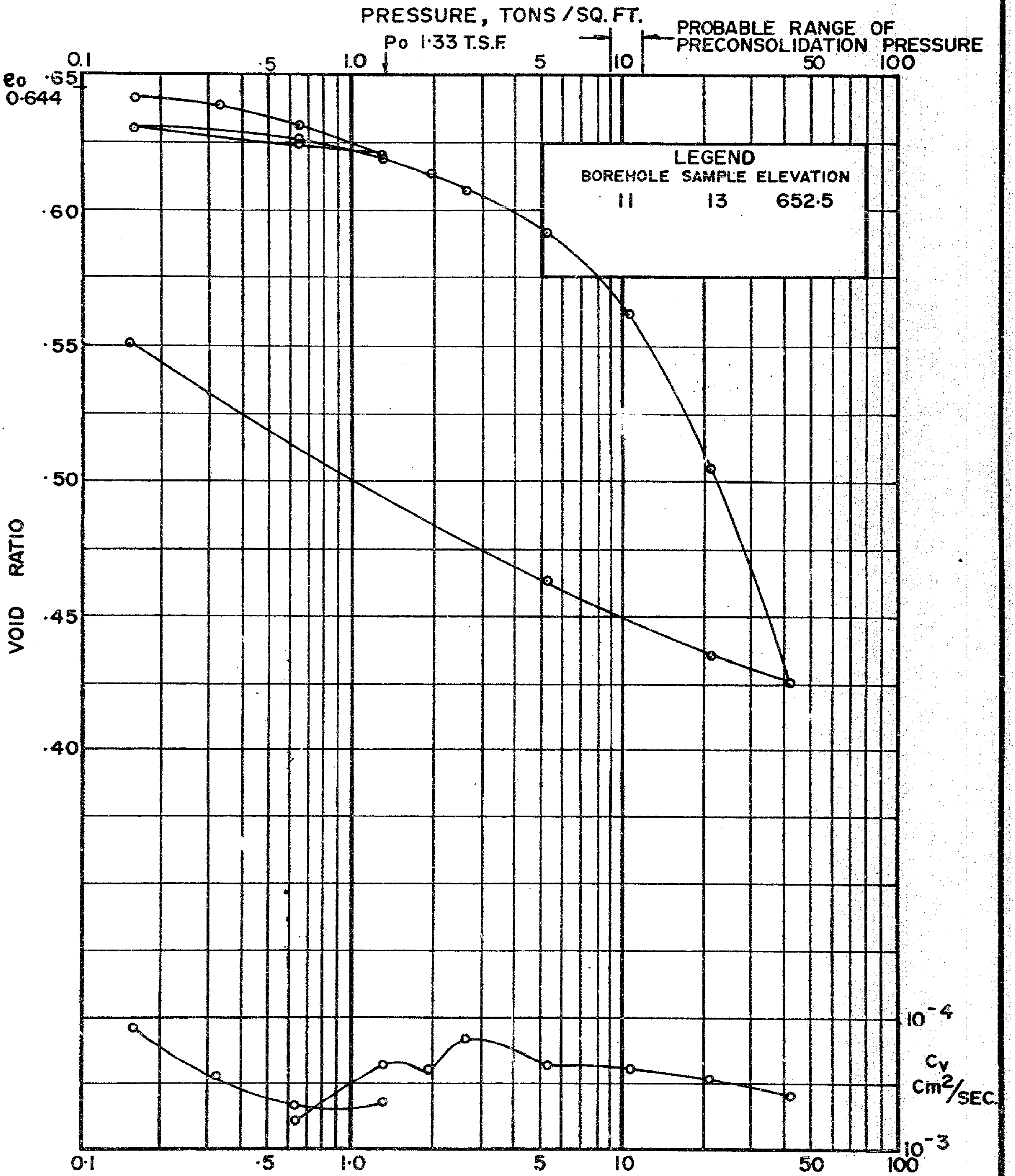
SILTY CLAY

FIGURE 11

PRO[redacted] No[redacted]630[redacted]

VOID RATIO - PRESSURE CURVES
CONSOLIDATION TEST

FIGURE 12



Golder Associates

A. P. Watt (2)
Reg. Structural Planning Engineer
Southwestern Region, London

Soil Mechanics Section
Geotechnical Office
West Building, Downsview

June 3, 1975

JUN - 5 1975

FOUNDATION INVESTIGATION REPORT

for

Hwy. 402 & Thames River Crossing
7.8 Miles West of Hwy. 4
Twps. of Delaware & Caradoc
Site #19-536 W.P. 41-66-17 & 18
Dist. #2 (London)

Attached please find your copy of the foundation investigation report for the above mentioned projects, which was carried out by H.Q. Golder & Associates Ltd. We have reviewed the report and consider the contents in general to be sufficient for your purposes. You will note that the report recommends alternatives of spread footings and piled foundations for the piers: the decision as to which method to use should of course be based on economics. It would appear to us that the piled foundations will prove to be the most economical, however, since driving equipment will be mobilized in any event for the abutment foundations, and since the size and depth of excavations will be less than for spread footings. Cover for frost protection is recommended as 3 feet in the report: for the area in question it is our practice to use 4 feet. Please direct any queries you may have concerning this report to this Office.

K.G. Selby

K.G. Selby
Supervising Engineer

c.c. E.J. Orr
B.R. Davis
B.J. Giroux
G.A. Wrong
A. Wittenberg
J.R. Roy
L.E. Walker
R. Hore

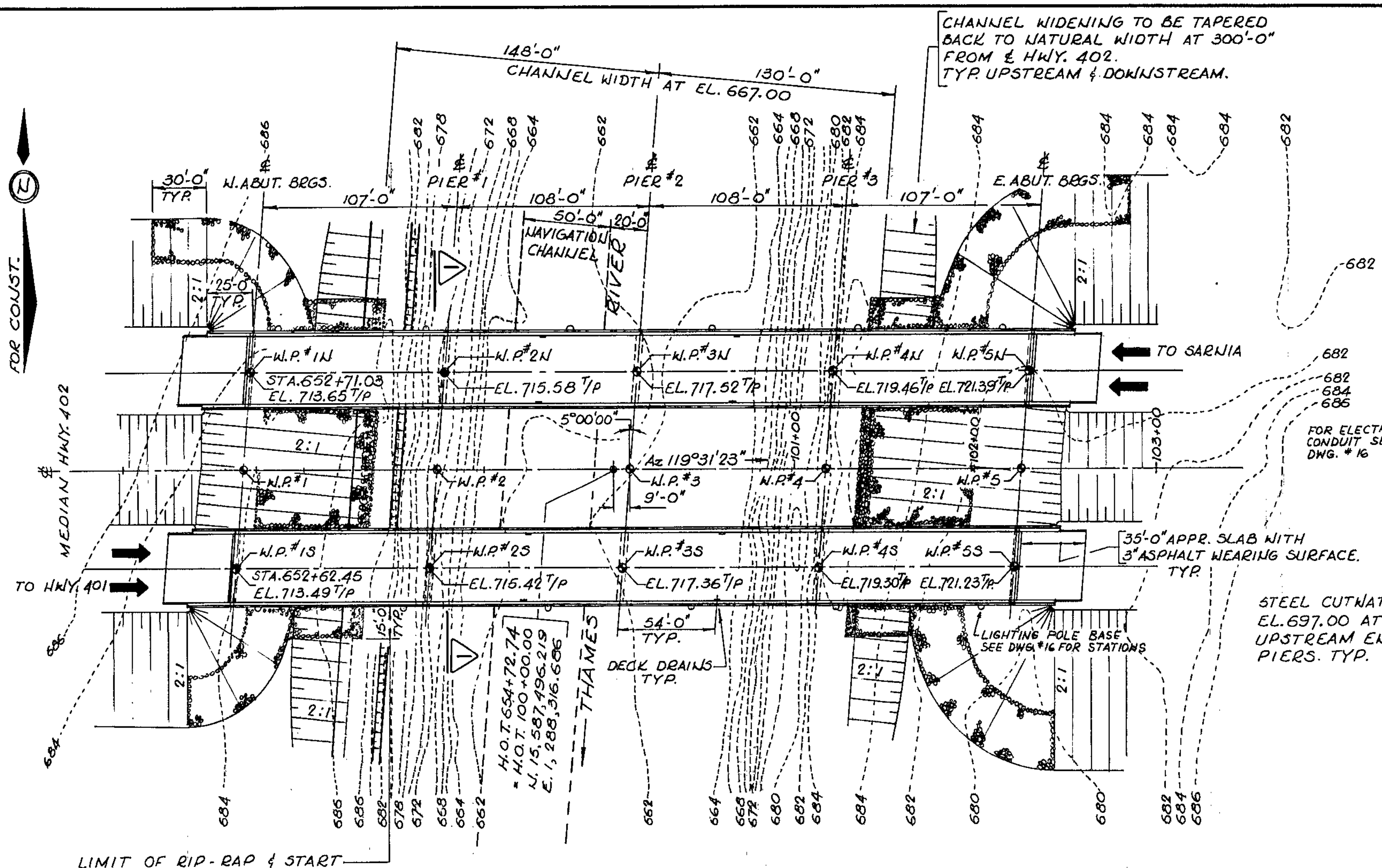
J. Anderson) memo only
A. Crowley)

Files
Record Services

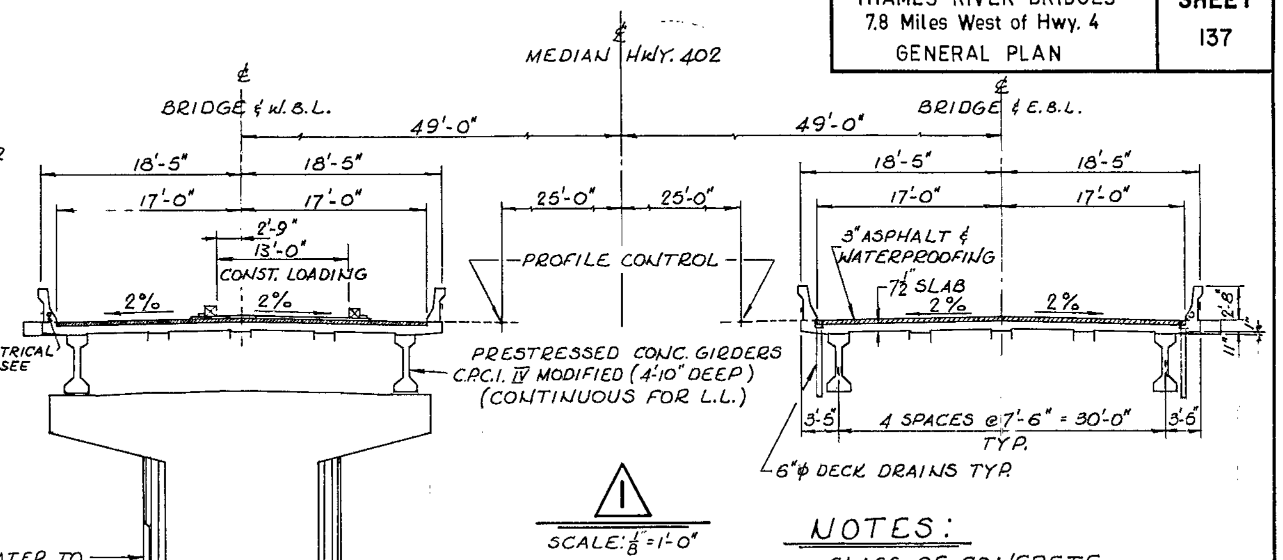
DIST. 2	SHEET
CONT No. 78-66	137
WP No. 41-66-17 & 18	

THAMES RIVER BRIDGES
7.8 Miles West of Hwy. 4
GENERAL PLAN

NOTE: FOR MAX. CONSTR. EQUIPMENT LOADING SEE SS 2-1 ON DWG. # 12



PLAN
SCALE: 1" = 40'-0"



NOTES:

CLASS OF CONCRETE.
- PRESTRESSED GIRDERS ---5000 P.S.I.
- DECK, BARRIER WALLS, PIERS & APPR. SLABS ---4000 P.S.I.
- ABUTMENTS & FOOTINGS ---3000 P.S.I.

REINF. STEEL GRADE (C.S.A. G30 SERIES)
- PIERS ---------- 60
- PRECAST GIRDERS ------ 60W
- REMAINDER ------ 50

CLEAR COVER ON REINF. STEEL
- FOOTINGS, ABUTMENTS & PIERS ----3"
- TOP OF DECK--2" BOTTOM--1½"
- DIAPHRAGMS & BARRIER WALLS ----1½"
- APPROACH SLABS ----2"
- AND/OR AS NOTED ON DRAWINGS.

CONSTRUCTION NOTES:

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ±1/8".

NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

CONCRETE QUANTITIES

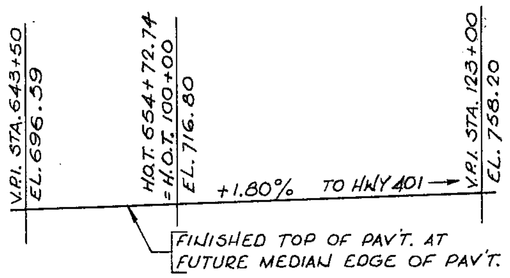
CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS.

		E.B.L.	W.B.L.
1. CONCRETE IN PIERS, ABUTMENTS AND WINGWALLS.	4000 P.S.I.	384 Cu.Yds	385 Cu.Yds.
	3000 P.S.I.	166	168
2. CONCRETE IN DECK AND DIAPHRAGMS.		483	483
3. CONCRETE IN BARRIER WALLS.		84	84
4. CONCRETE IN APPROACH SLABS.		97 Cu.Yds.	97 Cu.Yds.

SKEW DATA 5°00'00"

SIN. = 0.0871557
TAN. = 0.0874887
SEC. = 1.0038198
COS. = 0.9961947

NOTES:
- T/P DENOTES TOP OF FINISHED PAVEMENT.
- W.P. DENOTES WORKING POINT.

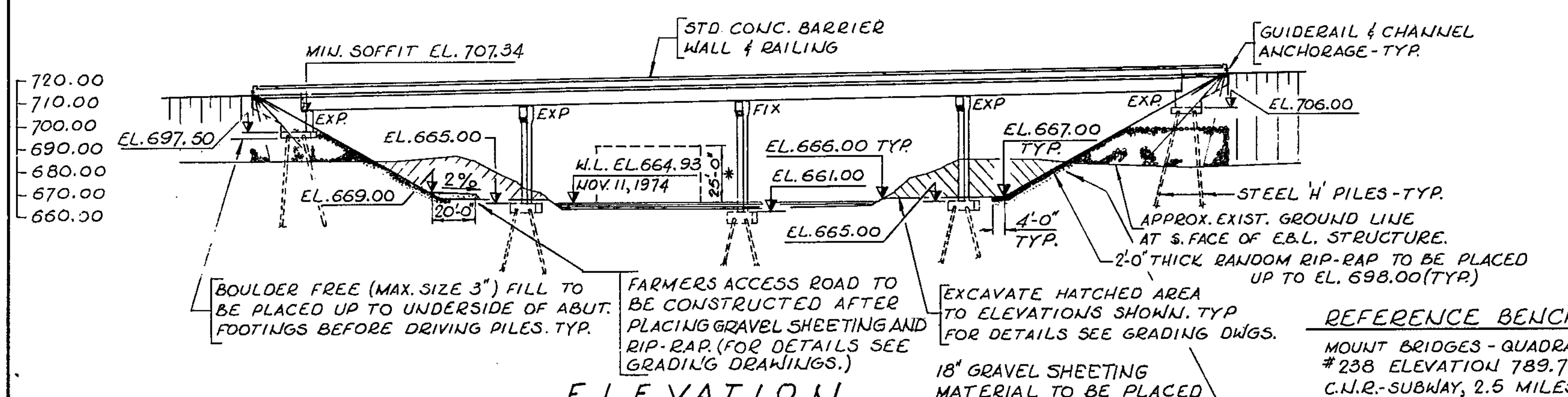


PROFILE OF HWY. 402
N.T.S.

LIST OF DRAWINGS

DWG.
1. GENERAL PLAN
2. BORE HOLE LOCATIONS & SOIL STRATA
3. FOUDATION LAYOUT & PIERS
4. ABUTMENTS
5. PRESTRESSED GIRDERS & BEARINGS
6. DECK
7. EXPANSION JOINT DETAIL
8. CONCRETE BARRIER WALL
9. STEEL PARAPET RAILING
10. 35 FT. APPROACH SLAB
11. STANDARD DETAILS I
12. STANDARD DETAILS II
13. STANDARD DETAILS III
14. AS CONST. ELEV. & EXP. JT. GAPS.
15. AS CONST. ELEV. & EXP. JT. GAPS.
16. EMBEDDED WORK IN STRUCTURE.

DWG 17. ELECTRICAL STANDARDS.



ELEVATION
SCALE: 1" = 40'-0"

THE APPROACH SLABS, DECK WATERPROOFING AND PAVING ARE NOT PART OF THE BRIDGE PORTION OF THE CONTRACT.

REFERENCE BENCH MARK

MOUNT BRIDGES - QUADRANT 42081
238 ELEVATION 789.73 ('33) 240.71 METRES
C.N.R.-SUBWAY, 2.5 MILES NORTHEAST OF STATION AND AT MILEAGE 2.3 FROM KOMOKA, BOLT IN SOUTHEAST FACE OF NORTHEAST STONE ABUTMENT, FIRST COURSE BELOW BRIDGE SEAT, IN CENTRE OF SECOND ALTAR STEP BELOW TOP.

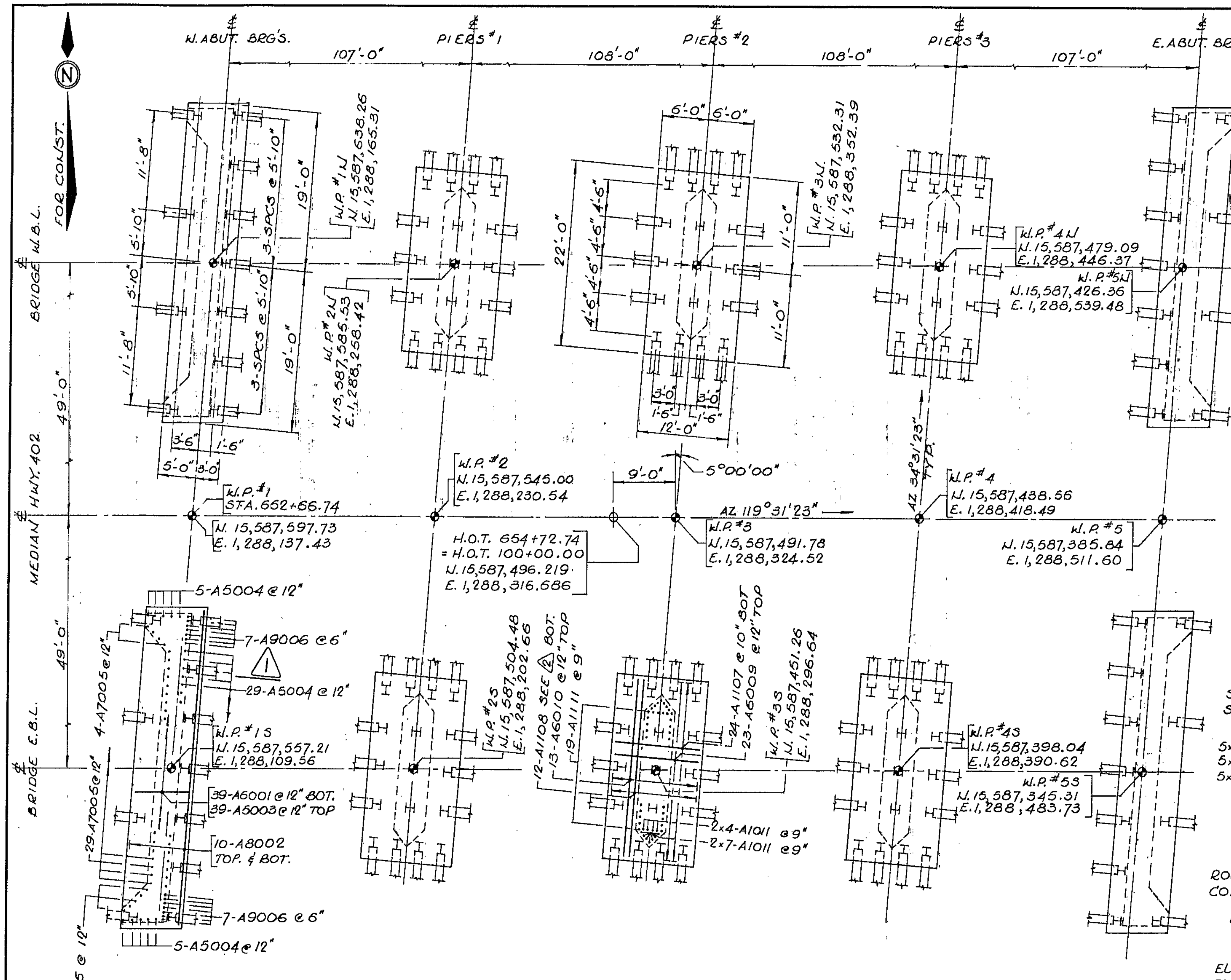
FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REGISTERED PROFESSIONAL ENGINEER H. K. JAGASIA PROVINCE OF ONTARIO

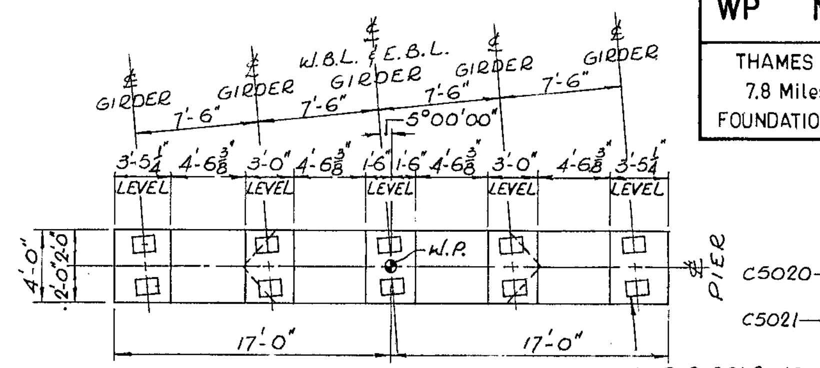
REVISIONS	DATE	BY	DESCRIPTION	
DESIGN H.K.J.	CHECK K	LOADING #520-44	DATE DEC/75	
DRAWING B.S.	CHECK H.K.J.	SITE No 19-536	DWG 1	

Reference 3

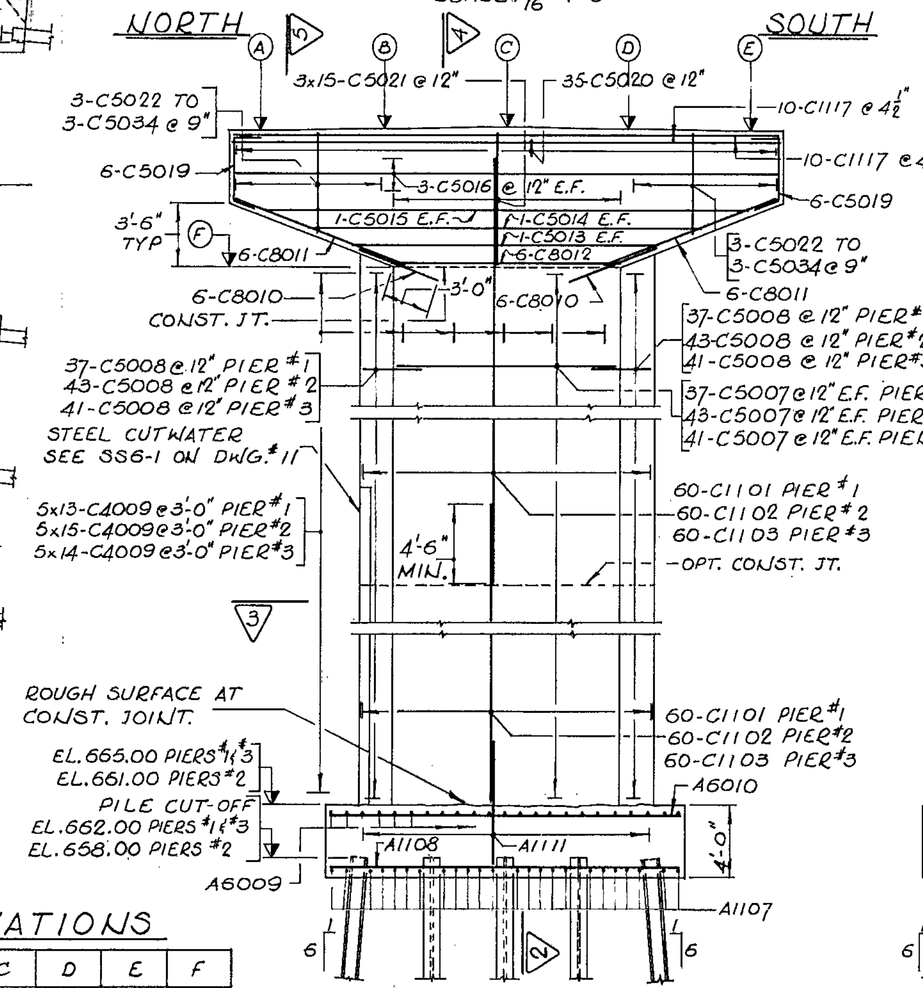
CONT No 78-66 WP No 41-66-17 & 18	
THAMES RIVER BRIDGES 7.8 Miles West of Hwy.4 FOUNDATION LAYOUT & PIERS	SHEET 139



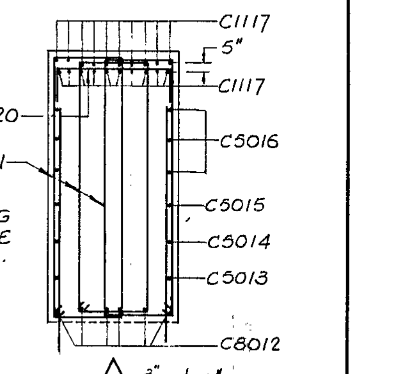
FOUNDATION LAYOUT
SCALE: 1/8" = 1'-0"



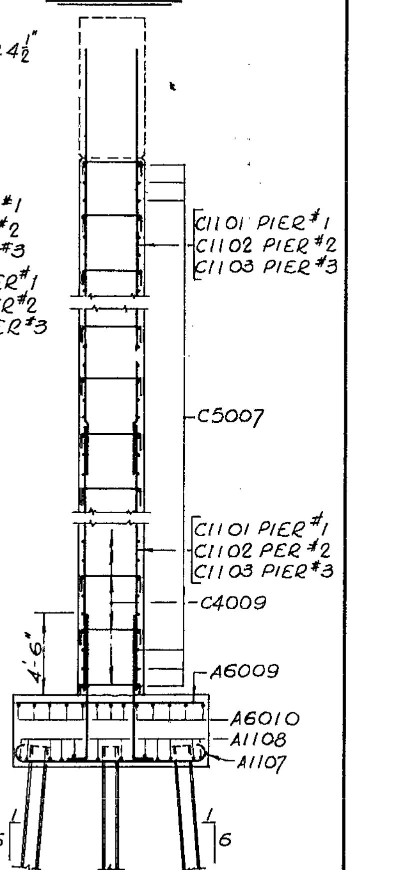
PLAN OF PIER CAP
SCALE: 3/16" = 1'-0"



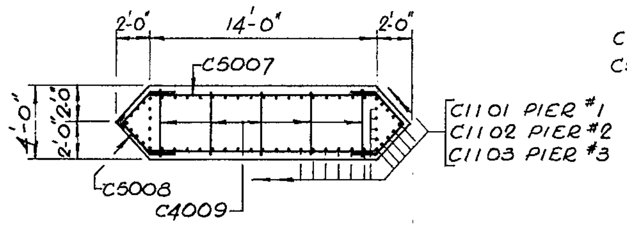
TYP. PIER ELEVATION
SCALE: 3/16" = 1'-0"



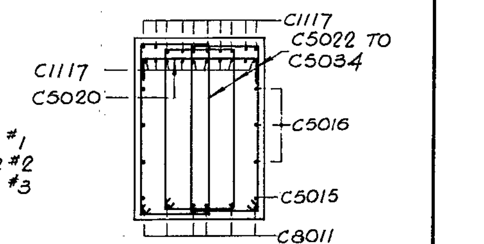
4 3/16" = 1'-0"



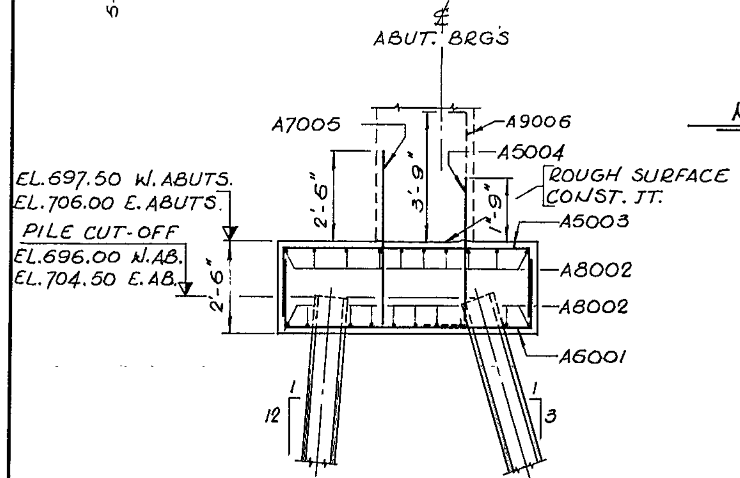
2 3/16" = 1'-0"



3 3/16" = 1'-0"



5 3/16" = 1'-0"



1 3/16" = 1'-0"

NOTES:

- DIMENSIONS, REINFORCEMENT & PILE LAYOUT SIMILAR FOR ALL ABUTMENTS & PIERS.
- PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTINGS.
- PILES TO BE DRIVEN IN ACCORDANCE WITH STD. SS3-11 USING DESIGN LOAD OF 95 TONS/PILE BUT PIER PILES MUST BE DRIVEN BELOW EL.642.00.
- BOTTOM REINF. IN FOOTINGS TO BE SPACED TO AVOID PILES.
- A1111, C1101, C1102 AND C1103 FOR PIERS SHALL BE 60 K.S.I. GRADE. ALL OTHER REINF. STEEL SHALL BE 50 K.S.I. GRADE.

ELEVATIONS

		A	B	C	D	E	F
PIER #1	W.B.L	709.26	709.40	709.54	709.38	709.22	701.76
	E.B.L.	709.10	709.24	709.38	709.22	709.06	701.60
PIER #2	W.B.L.	711.28	711.42	711.56	711.40	711.24	703.78
	E.B.L.	711.12	711.26	711.40	711.24	711.08	703.62
PIER #3	W.B.L.	713.14	713.28	713.42	713.26	713.10	705.64
	E.B.L.	712.98	713.12	713.26	713.10	712.94	705.48

PILE DATA

LOCATION	No REQ'D.	LENGTH	TYPE	DESIGN LOAD
W. ABUTS.	22	65'-0"	HP12x74	95 TONS PER PILE
PIERS #1	34	24'-0"		
PIERS #2	34	20'-0"		
PIERS #3	34	24'-0"		
E. ABUTS.	22	70'-0"		

REGISTERED PROFESSIONAL ENGINEER H. K. JAGASIA PROVINCE OF ONTARIO

FOR REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN H.K.J.	CHECK K.V.	LOADING HS20-44	DATE DEC/75
DRAWING B.S.	CHECK H.K.J.	SITE No 19-536	DWG 3

APPENDIX B

Site Photographs

Photograph 1: Westbound Lane, East Abutment and North Wingwall. Abutment slopes are grass covered and no obvious signs of erosion observed on slope (September 2, 2015).

Photograph 2: Westbound Lane, West Abutment. Abutment side slopes are grass covered and no obvious signs of erosion observed on abutment side slopes (September 2, 2015).

Photograph 3: Westbound Lane, East Abutment (September 2, 2015).

Photograph 4: Westbound Lane, Bridge Deck and Piers (September 2, 2015).

Photograph 5: Eastbound Lane, East Abutment and North Wingwall. Abutment side slopes are grass covered and no obvious signs of erosion observed on abutment side slopes (September 2, 2015).

Photograph 6: Eastbound Lane, East Abutment and South Wingwall. Spalling of Bridge Deck Concrete observed (September 2, 2015).

Photograph 7: Eastbound Lane, East Abutment (September 2, 2015).

Photograph 8: Eastbound Lane, Bridge Deck and Piers (September 2, 2015).