

#66-F-217C
W.P. #253-66
Hwy. #416
(Old Hwy. #16)
PROPOSED By-Pass
SPENCERVILLE
CREEK

SURVEY DWG. SUPPLIED
BY DIST. 8 (KINGSTON)

66 F 217 C

Mr. E. A. Davis,
Bridge Engineer,
Bridge Division.

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

Attention: Mr. E. A. McCoskie

January 5, 1967

JAN - 6 1967

FOUNDATION INVESTIGATION REPORT BY:
Geocon, Limited, Consulting Engineers -

Proposed By-Pass at Spencerville Creek,
Spencerville, Ontario -- Hwy. 15, NOW Hwy. #416
R.F. 253-56 -- District #8 (Kingston).

Attached, please find the above mentioned report prepared and submitted by the Consultant, Geocon, Ltd.

We have reviewed the report and have found the factual information adequate and well presented. As mentioned in the report, the two proposed crossings are considerable from the subsoil point of view. Certain proposals and alternatives for the foundations of the structure are discussed. Prior to commenting on these alternatives, we would like to have some idea of the desirable span or spans and the type of structure that is contemplated for this crossing. We would therefore suggest that you contact this office as soon as more information becomes available.

In view of the presence of the loose layer of organic silty sand, we would like to suggest that staging of construction be given due consideration. A two-months period between embankment and bridge construction would be adequate in this case. However, before more details about the type of structure become available, we feel that it is premature to make any comments or recommendations.

20/ 197
Atchcn.

Afternoon
A. G. Starnes
PRINCIPAL FOUNDATION ENGINEER

cc: Messrs. E. A. Davis (2)
E. A. Truesdale
C. J. Farren
C. J. Jurekiewicz
C. A. Cash
J. A. Graspier
C. Scott
E. A. Singh

Foundations Office
Gen. Files

Note: Spencerville Creek is also known as
"South Nation's River" or as "Nation River"
Jan 10, 1967.

Way. 401 & Leslie St.,
Donnenvitz, Ontario.

November 17, 1964

Materials and Testing Division

Gecon, Limited,
14 Moss Road,
Sarnia, Ontario.

Attention: Mr. A. A. J. Salish, President

Re: Letter of Authority -- Foundation Investigation
L.R. 253-66, Way. 16, Proposed Spencerville By-Pass
at Spencerville Creek, District No. 3 (Kingston).

Dear Sir:

Please consider this your authority to carry out the necessary foundation investigation at the proposed crossing of the Way. 16 - Spencerville By-Pass over the Spencerville Creek.

The requested investigation should be of a preliminary nature since the final decision on this crossing has not been reached yet.

As agreed, you will be carrying out this investigation using the drills and crews now completing the investigation at the proposed crossing of the South Nation River.

The necessary drawing and all other pertinent information will be given to your representative, by Mr. J. L. Forster, Regional Functional Planning Engineer, Kingston, when he calls at his office.

The soil information is urgently needed, and you are therefore requested to proceed with the investigation as soon as possible. According to the information provided by the Regional forces, no difficulties are anticipated at this site.

The field work should, at all times, be supervised by a qualified Geotechnical Engineer. Any deviation from this agreement has to meet our prior approval.

Eleven (11) copies of the completed report will be required for our distribution.

cont'd. /2 ...

Geoson, Limited -

- 3 -

Attn: Mr. W.A.J. Rattich, Pres.

November 17, 1966

Since the drawing accompanying the foundation report, showing the location of borings, the inferred subsoil conditions, etc., is to become a contract drawing, you are requested to prepare it in accordance with the U.S.C. Standards. To enable you to do this, we are supplying you with a sample drawing with all the necessary explanations, together with linen sheet for your drawing. You are also requested to provide us with a Cronaflex copy of the drawing.

Charges for the work will be in accordance with your schedule of rates, dated July 8, 1966, and invoice to be addressed to the attention of the undersigned.

We are attaching Purchase Order A-36887, covering the purchase of any new material required for this work, in order that you may use this as a basis for exemption from the Federal Tax for such purchases. The Exemption Certificate is printed thereon.

Yours very truly,

W.A.J. Rattich

W.A. Rattich,

MATERIALS & TESTING ENGINEER

AGG/LSR
Attach.

cc: Messrs. S. McCombie
E. J. Markiewicz
E. A. Cash
G. Scott
J. E. Graspier
H. Konings
Mrs. I. Steinberg
A. Crowley
H. Rzymanski (2)
Foundations Office
Gen. Files (2)

GEOCON LTD

HEAD OFFICE

420 MICHEL JASMIN, DORVAL, QUEBEC
TELEPHONE 631-9827

Rexdale, Ontario
January 4, 1967.

66 F 217C

DISTRICT OFFICES

14 HAAS ROAD
REXDALE, TORONTO, ONT.
TEL. 244-6476

295 EAST 11TH AVENUE
VANCOUVER 10, B.C.
TEL. 879-2620

Department of Highways, Ontario,
Downsview, Ontario.

W P. 253-66

Attention: Mr. A. G. Stermac, P. Eng.,
Principal Foundation Engineer.

Re: Soil Conditions and Foundations,
Proposed By-Pass at Spencerville Creek,
Alternative Sites (Nos. 1 & 2),
Spencerville, Ontario.

Dear Sirs:

This letter accompanies our report covering the preliminary investigation for crossing of the Spencerville Creek.

The results of this investigation indicate that the soil conditions at both crossings are similar. The overburden at both sites consists generally of about 30 to 40 feet of stiff to hard silty clay and glacial till overlying bedrock. However, at both sites, on the east side of the river the surficial strata include a relatively thick deposit of loose silty sand which contains organic traces. Specifically this stratum was encountered to a depth below ground level of about 12 feet at both sites. A detailed description of the soil and groundwater conditions is given in the report.

Based on the findings of this investigation, the two sites are of more or less equal merit from a foundations standpoint. In both cases, the stiff to hard silty clay and glacial till are considered suitable for the use of spread foundations. However, other considerations such as scour protection and construction requirements, may make a pile foundation more preferable. Further work at the selected site should be considered as part of the final design process, to eliminate any uncertainty regarding soil conditions at pier or abutment locations where these do not coincide with existing boreholes.

We believe that this report provides all the information required from this preliminary investigation. However, should you have any questions or if we can be of further assistance, please do not hesitate to call us.

Yours very truly,

GEOCON LTD

M. A. J. Matich per J.N.B.
M. A. J. Matich, P. Eng.,
President.

MAJM/bm

SPENCERVILLE ONTARIO

Distribution:

11 copies	Department of Highways, Ontario, Downsview, Ontario.
3 copies	Geocon Ltd

GEOCON

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PROCEDURE

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SOIL CONDITIONS

WATER CONDITIONS

APPENDIX II

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Drawing (In pocket at rear of report)

GEOCON

INTRODUCTION

Geocon Ltd has been retained by the Department of Highways, Ontario under the terms of their letter dated November 17, 1966 to carry out a preliminary soil investigation at two alternative sites for the Proposed Bridge which will carry the Highway 416 (Spencerville By-Pass) over the Spencerville Creek, about half a mile north east of Spencerville, Ontario. The sites have been designated as Nos. 1 and 2 in this report with Site No. 1 located north of Site No. 2. The object of the investigation was to obtain and interpret the general subsurface conditions at the two sites as they will affect the selection of one of the Sites as a crossing.

SUMMARIZED SOIL CONDITIONS

The soil conditions at the two proposed sites are essentially similar. However there are certain differences between the east and west banks of the river. The sites as investigated are underlain by about 1 foot of topsoil and by 4 to 6 feet of very stiff brown and grey brown clayey silt. In borehole 1 about 2 feet of brown silty sand overlies the clayey silt. Close to the east bank of the river the clayey silt is underlain by loose grey organic silty sand at both Sites which extends to about 12 feet depth that is between elevations 272 and 275. Underlying the clayey silt or the organic silty sand is a stratum of very stiff to hard grey silty clay which extends to bedrock surface on the east bank

of the river. On the west bank of the river the clay, which extends to elevation 277 and 269 at the Sites No. 1 and No. 2 respectively is underlain by compact to very dense light grey clayey silt till. Bedrock was encountered at about elevation 257 at Site No. 1 and between elevations 249 and 253 at Site No. 2. The bedrock consists of sound grey limestone.

The water level in the river was at elevation 284 to 285 during the time of the investigation. The water level as observed in the boreholes was generally at or slightly above river level. Artesian pressure represented by a water level 3 feet above ground level was observed in the bedrock at the location of borehole 2 at Site No. 1.

DISCUSSION

General

It is understood that Highway 16 is to be relocated to by-pass the town of Spencerville, Ontario. The by-pass is to be called Highway 416. The route of the relocated Highway has not yet been finally established, although it is understood to pass to the east of Spencerville, where it will be necessary to cross Spencerville Creek. The two sites investigated represent the two proposed alternative locations for the Bridge which will span the Spencerville Creek.

This investigation was preliminary in nature, and it is understood that at the time of writing, the type of Bridge

General (continued)

to be constructed has not yet been determined. Consequently, for purposes of this discussion, it is assumed that the design will involve a single or double span simply-supported structure, about 60 to 100 feet long, with approach embankments up to about 20 feet high.

The preliminary soil investigations at the two Sites have shown that the subsurface conditions are essentially similar. The following discussion and recommendations therefore will apply equally to the two sites. The final site selection at this stage will therefore be determined by considerations of alignment and economics. There are, however, certain factors from a soil mechanics standpoint, which may be pertinent to site selection. In this regard, it is considered that further exploration work is necessary prior to final design, to outline the lateral extent of subsurface strata at the selected site, as discussed below.

The investigation has shown that the very stiff clayey silt extends to between 4 and 9 feet depth at the sites. Further, on the east bank of the river at both sites, the clayey silt is underlain by organic silty sand extending to 12 feet depth; that is, to elevation 272 at Site No. 1 and 275 at Site No. 2. Underlying these strata is a stratum of very stiff to hard grey silty clay.

General (continued)

The grey silty clay is considered a suitable foundation stratum for the bridge using spread footings. However the organic silty sand and the clayey silt, where it overlies the silty sand, in view of their erratic composition are not considered suitable for the use of spread footing foundations. Depending on the final bridge layout, it may be necessary to better define the extent of the organic silty sand and the extent of the overlying deposit of clayey silt, particularly at actual pier or abutment locations. Further exploration may reveal that the sand and clayey silts encountered are localized in or close to the east bank of the river and consequently as design develops, it may be possible to relocate foundations to avoid such poor foundation soil.

Foundations

All footings and pile caps should be provided with a minimum of 5 feet of earth cover for the purposes of frost protection. All topsoil and soil containing a high organic content should be removed from beneath foundations carried on spread footings and from beneath structural fills. Removal of the organic silty sand encountered in boreholes 2 and 4, from beneath the embankments will not be necessary as discussed later.

Foundations (continued)

In addition to the very stiff to hard grey silty clay, the brown clayey silt at Borehole No. 1 is also considered suitable for the use of spread footings. In both cases, however, positive measures will have to be taken to prevent possible undermining by scour. Footings for the abutments or piers founded on or within the grey silty clay or the clayey silt at the west side of the river may be designed using a preliminary net allowable bearing value of 2.0 tons per square foot. However the surcharge created by the embankment fill, where adjacent to foundations, must be considered in design of such foundations. For this reason, and since the surcharge from the embankment could be as high as 1 ton per square foot, consideration could be given to founding abutment footings in the embankment fill and supporting piers on the clay stratum. If this is done and provided the embankment fill underlying abutment foundations consists of select well graded granular material compacted uniformly to at least 100 percent of Modified A.A.S.H.O. density for the full depth of the fill, preliminary design of abutment footings may be based on a net allowable bearing value of 2.0 tons per square foot. It would also be necessary, for footings between 5 and 10 feet wide and at a depth of 5 feet below ground level, to maintain a distance between embankment edge and footing edge

Foundations (continued)

of 10 feet. For footings outside this range, the required distance should be checked.

Because of the incompressible nature of the clay and till, settlement of foundations or embankment due to consolidation of the sub-surface soil strata will be small. However, as discussed later, some settlement of the organic silty sand will occur as result of embankment surcharge, and also abutment loads if these are carried in the embankment. Because of the granular nature of the organic silty sand stratum and the relatively low organic content, settlement will for all practical purposes take place during and shortly after construction. Nevertheless if piers are founded on the clay and abutments within the embankment fill, some differential settlement will take place which will affect the bridge superstructure. It is believed that the amount of differential settlement could be readily accommodate if simply supported construction was used.

Alternatively the abutments or piers may be carried on piled foundations. End bearing piles founded on bedrock at about elevation 257 at Site No. 1 or between elevations 249 and 253 at Site No. 2 would be suitable, as would be friction piles carried in the hard clay or dense till. Suitable friction pile types would be treated timber piles, steel H piles or pipe

Foundations (continued)

piles, cast-in-place or precast concrete piles. Jetting or preaugering would probably be necessary to penetrate the hard grey clay or the very dense clayey silt till encountered at depth in the boreholes, for piles penetrating to bedrock.

All the overburden at the site is susceptible to scour, as indicated by the meanders of the river and possibly the presence of the organic silty sand on the east side of the river. Measures should therefore be taken to protect bridge foundations from undermining due to scour effects. This may mean the provision of rip-rap protection or placing foundations a safe distance below the maximum flood level. The extent of scour in a vertical and lateral direction depends on maximum flood level and the hydraulics of the river channel in the vicinity of the bridge and also the orientation of the piers relative to the direction of flow. The hydraulic considerations involved are beyond the scope of the report. Published data, Terzaghi and Peck (Soil Mechanics in Engineering Practice), indicates that the depth of scour below water level may be as much as 4 times the greatest known rise in water level. It should therefore be assumed that scouring to at least this depth may occur if rip-rap is not provided.

Excavations

Excavations for abutment foundations or pile caps will be carried out partially below the natural ground water

Excavations (continued)

level. To prevent sloughing, the side slopes of unsupported temporary excavations above groundwater level should be cut back at 1 vertical to 1 horizontal, or flatter.

Where excavations extend beneath the natural ground water level in the organic silty sand, special dewatering techniques will be required such as excavation within a close sheeted enclosure and pumping from filter equipped sumps. The sheeting in this case should be driven to suitable embedment in the underlying clay. Alternatively a "sanded-in" vacuum well point system could be used to temporarily lower the ground water level. If excavations are required within the river, berms built to above river level would be required if a well point system is used. Similar berms might also facilitate construction if sheeting is used.

Care should be taken, if spread foundations are used, to avoid disturbance or softening of the clay during excavation and it is recommended that the surface of the clay be protected by a mud mat of lean concrete immediately after final trimming.

Approach Embankments

It is recommended that the surface organic material be stripped from beneath approach embankments. With an assumed grade 20 feet above river level the overall height of

Approach Embankments (continued)

embankment relative to adjacent ground level close to the bridge will be about 20 feet. In view of the generally stiff or compact nature of the subsoil, it is considered that the stability of the approach embankments with side slopes of 1 vertical to 2 horizontal, assuming that the embankment fill is clean granular material, will be adequate.

The approach embankment as planned will experience settlement, caused by consolidation of the underlying clayey silt, silty clay and organic silty sand where this occurs. It is believed that the settlement in the clayey silt and the silty clay will be negligible. It is estimated that settlement of the sand stratum under the assumed load from the embankment, could be as much as 2 inches. Because of the granular nature and relatively low organic content of this material, the settlement will for all practical purposes take place during or shortly after construction. Negative skin friction, due to such settlement, should however be considered if piles are adopted as the foundation solution. This may be minimised by constructing the embankment in advance of pile driving, for the case where a small pile-supported abutment is used.

Approach Embankments (continued)

It is recommended that rip-rap protection for foundations, river bank and embankment be provided where necessary to above maximum high river level, that is, about elevation 289 to prevent scour.

The backfill adjacent to abutments should consist of well compacted, free draining, non-frost susceptible, clean granular material. Provision should be made also for adequate positive drainage of the backfill behind the abutment. With this provision, a coefficient of lateral earth pressure of 0.5 is recommended for the case of pile supported abutments, or where the abutments are integral with the deck slab. For the case of abutments on spread foundations, and a simply supported structure, a coefficient of 0.4 may be used.

CONCLUSIONS AND RECOMMENDATIONS

- 1) The site is underlain by strata of very stiff clayey silt and loose organic silty sand which are underlain by very stiff to hard silty clay and compact to very dense clayey silt till. The organic sand occurs close to the east bank of the river and extends to elevation 272 at Site No. 1 and elevation 275 at Site No. 2. Silt till underlies the clay on the west bank of the river only.

Bedrock occurs at about elevation 257 at Site No. 1 and between elevation 249 and 253 at Site No. 2.

- 2) At the time of investigation the water level in the river was at about elevation 284 to 285. The observed ground water level in the boreholes was generally at or slightly above river level. Artesian pressure with a head of about 3 feet above ground level was encountered at one place within the bedrock.
- 3) The site is considered suitable for the founding of the bridge on spread footings as discussed. However, scour susceptibility of the surficial soil strata at the site and the presence of the relatively deep deposit of organic silty sand may show that a piled foundation is a more suitable solution, as discussed.
- 4) The provision of scour protection for foundations, river bank, and embankments will be necessary, as discussed in the report.
- 5) Construction of piers and pile caps will probably require excavation below water level. Recommendations are given on possible measures to handle dewatering of such excavations.
- 6) Further subsurface investigation may be required at specific foundation locations at the selected site, for reasons given herein.

PERSONNEL

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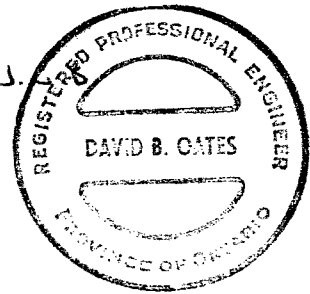
The field work for this investigation was carried out under the supervision of Mr. P. Rosenberg. This report was written by Mr. J. N. Beckett, checked by Mr. D. B. Oates, P. Eng. and reviewed by Mr. M. A. J. Matich , P. Eng.

J. N. Beckett

J. N. Beckett

D. B. Oates p. J.

D. B. Oates



APPENDIX I

PROCEDURE

SITE AND GEOLOGY

SOIL CONDITIONS

WATER CONDITIONS

OFFICE REPORTS ON SOIL EXPLORATION

GEOCON

PROCEDURE

The field work for this project was commenced on November 30th and completed on December 13th, 1966. A total of 5 boreholes was put down to depths ranging from 38 to 54 feet using a mobile power auger. Bedrock was core drilled in AXT size in all the boreholes. Two Proposed Bridge sites were investigated, (called Sites Nos. 1 and 2), representing two alternative routes for the proposed Spencerville By-Pass. Three of the boreholes were put down at Site No. 1 while the other two were put down to investigate the possible alternate location for the river crossing (Site No. 2).

The boreholes 1, 2, and 3 at Site No. 1 were put down on the centre line of the proposed road. They were located longitudinally using the centre line chainage stakes established by the Department of Highways, Ontario. The locations of boreholes 4 and 5 at Site No. 2 were determined after completion of the field work, by the Department of Highways, Ontario Survey Staff, since the centre line had not been established at the time of drilling. These locations, together with the inferred soil stratigraphy are shown on Drawing T7966-1 at the rear of this report. A detailed log of each borehole is given on the Office Reports on Soil Exploration in this Appendix.

The soil testing was carried out in the Toronto Soil Mechanics Laboratory of Geocon Ltd and the results are

plotted on the Office Reports in this Appendix and on the Figures in Appendix II. The soil samples remaining after testing will be stored until January 1968, at which time you will be contacted for instructions regarding their disposal.

The elevations of ground level at the borehole locations have been referenced to Geodetic Datum. The bench mark used is a nail in the centre line of County Road No. 22 at the centre line of the proposed By-Pass (Site No. 1). The elevation of this nail as determined by the Department of Highways, Ontario, is 296.35. At Site No. 1 the ground elevations were established by ourselves. At Site No. 2 they were established by the Survey Staff of the Department of Highways, Ontario.

SITE AND GEOLOGY

The proposed Bridge is to carry Highway 16 over the Spencerville Creek, north east of Spencerville, Ontario. At the time of writing the alignment of the proposed Spencerville By-Pass, (to be called Highway 416) may take one of two alternate routes. The two sites investigated are located about one half mile north east of Spencerville and Site No. 2 is about 1400 feet south of Site No. 1. The water elevation in the South Nation River is generally about 484 to 485 with the river about 60 to 100 feet wide. The surrounding land is

relatively flat with some local shallow depressions and is only a few feet above river level. The river meanders through this flat land and within the curves of the river the land is somewhat swampy.

From available geological information it is believed that the overburden consists of a silty clay stratum, known as the Winchester clay plain which overlies glacial till. Bedrock occurs at a relatively shallow depth. The clay may be overlain by variable deposits of sand or silt.

SOIL CONDITIONS

Because of the similarity of the soil conditions at each site, the principal soil strata encountered by the boreholes at the two sites are described together in this Appendix as follows:

Topsoil

A stratum of topsoil was encountered at ground surface in all boreholes. The thickness of the topsoil was found to be between 1.0 and 1.5 feet. The upper few inches of the topsoil are dark brown and highly organic. Below this the stratum becomes generally brown and increasingly silty or clayey with depth.

Compact Brown Silty Sand

Underlying the topsoil and encountered in borehole 1 only is a thin stratum of silty sand. This stratum was found to be 2 feet in thickness extending to about elevation

Compact Brown Silty Sand (continued)

284. The sand is generally brown in colour. It is believed to be a recent alluvial deposit although no evidence of stratification was observed in the sample obtained.

A grain size analysis was carried out on a sample of the silty sand and the results of this test are presented as a grain size distribution curve on Figure 1 in Appendix II. As tested the sample contained 85 percent sand and 15 percent silt and clay sized particles.

A standard penetration resistance or "N" value of 15 blows per foot was obtained in the silty sand. On the basis of this result the relative density of the sand may be considered to be compact.

Very Stiff Brown & Grey-Brown Clayey Silt

Underlying the topsoil in boreholes 2, 3, 4, and 5 and beneath the silty sand in borehole 1 is a stratum of clayey silt. The clayey silt was found to extend to between 4 feet depth in borehole 4 and 9 feet depth in borehole 1, that is to between elevations 283 and 278. The thickness of the stratum ranges from 4 to 6 feet. The stratum is generally brown in colour and contains grey brown layers and mottling in places. For the purposes of a general description the stratum has been called a clayey silt. However it contains layers and pockets

Very Stiff Brown & Grey-Brown Clayey Silt (continued)

of silty clay and sandy silt. The variation from borehole to borehole is quite marked. In some boreholes and samples the silty clay is predominant. Elsewhere the stratum is predominantly sandy silt. It is believed that this stratum is probably an alluvial deposit also.

To illustrate the range of materials present in the clayey silt grain size analyses were carried on representative samples and the resulting grain size distribution curves are presented on Figure 2 in Appendix II. These show that the stratum ranges from a sandy silt containing 30 to 40 percent sand, 55 to 65 percent silt and about 5 percent clay sized particles to a silty clay containing 55 percent silt and 45 percent clay.

Atterberg limit tests carried out on samples of the clayey portions of this stratum gave liquid and plastic limits ranging from 41 to 55 and 20 to 24 respectively. The corresponding natural water contents ranged from 21 to 36 percent. These test results are plotted on the "A" line chart Figure 6 in Appendix II. This plot shows that the samples tested were in organic clays of medium to high plasticity.

Unconfined compression tests were carried out on samples of this stratum. The compressive strength ranged from 2.2 to 3.0 tons per square foot. The corresponding wet unit

Very Stiff Brown and Grey-Brown Clayey Silt (continued)

weight was 131 pounds per cubic foot. Based on these results and on visual examination of the samples it is believed that the consistency of the stratum is generally very stiff.

Standard penetration resistances or "N" values obtained in this stratum in boreholes 2 to 5 ranged from 6 to 17 blows per foot. In borehole 1 however the "N" values ranged from 17 to 26 blows per foot.

Loose Grey Organic Silty Sand

Underlying the brown and grey brown clayey silt in borehole 2 at Site No. 1 and borehole 4 at Site No. 2 only is stratum of silty sand. This stratum was found to be 8 feet in thickness extending to elevation 272 in borehole 2 and elevation 275 in borehole 4. The two boreholes in which this stratum was encountered are located close to the Spencer-ville Creek on the east bank. The silty sand is generally grey in colour and contains organic pockets and decomposed wood and shells. In general the organic content is small. Occasional thin silt layers also occur within the sand.

Four grain size analyses were carried out on representative samples of the silty sand. The resulting grain size distribution curves are shown on Figure 3 in Appendix II. The samples as tested contained between 65 and 90 percent sand and 10 to 35 percent silt sized particles.

Loose Grey Organic Silty Sand (continued)

Standard penetration resistances or "N" values of 4 and 6 blows per foot were obtained in this stratum indicating that its relative density is generally loose.

Very Stiff to Hard Grey Silty Clay

The organic silty sand in boreholes 2 and 4 and the clayey silt in the other boreholes are underlain by a stratum of grey silty clay.

The surface of this stratum was encountered between elevations 278 and 281 in those boreholes where no organic silty sand occurs. In borehole 2 and 4 the stratum was encountered between elevations 272 and 275. The silty clay was fully penetrated in all boreholes. It was found to extend to the surface of bedrock on the east side of the river at both sites; that is elevation 257 at Site No. 1 and elevation 249 at Site No. 2. On the west side of the river a stratum of glacial till underlies the clay. The clay on the west bank was found to extend to elevation 277 at Site No. 1 and 269 at Site No. 2. Thus on the east bank of the river the clay ranges from 15 to 26 feet in thickness while on the west bank the clay ranges from 4 to 10 feet in thickness.

The clay is grey in colour. Only minor evidence of stratification was noted in the recovered samples. Generally

Very Stiff to Hard Grey Silty Clay (continued)

the clay contains small irregular silt pockets and some black sub angular sand and gravel sized particles. Some parts of the stratum are predominantly clayey silt. The gravel particles as noted were up to about one inch in size. Based on the appearance and high degree of consolidation of the clay it is believed that it may be of glacial origin. Particularly since the underlying soil at the same elevation on the west bank of the river is of glacial origin. Immediately above the bedrock the clay becomes increasingly sandy and gravelly in borehole No. 2.

Six grain size analyses were carried out on samples of the silty clay and the resulting grain size distribution curves are shown on Figure 4 in Appendix II. These show that the stratum is composed of from between 50 to 80 percent silt and 50 to 20 percent clay sized particles, illustrating the range of grain sizes within the stratum.

Five atterberg limit tests were carried out on samples of the silty clay. The liquid and plastic limits ranged from 25 to 51 and 15 to 24 respectively. The corresponding natural water contents ranged from 14 to 33 percent. The liquid and plastic limits have been plotted on the "A" line chart, Figure 6 in Appendix II, and it may be seen that the clay falls into the range of a clay of low to medium plasticity.

Very Stiff to Hard Grey Silty Clay (continued)

Standard penetration resistances or "N" values obtained on the clay varied from 16 to 85 blows per foot. The "N" values however were generally in the range of 20 to 60 blows per foot.

Unconfined compression tests were carried out on samples of the grey clay. The results of these tests are presented on the Office Reports in this Appendix. The compressive strengths ranged generally from about 2.3 to 4.5 tons per square foot. The consistency of the clay is therefore considered to be in the range of very stiff to hard. The corresponding natural water content and unit weights ranged from 14 to 33 percent and from 125 to 135 pounds per cubic foot.

Compact to Very Dense Light Grey Clayey Silt Till

Underlying the silty clay and encountered in borehole 3 at Site No. 1 and borehole 5 at Site No. 2 (that is those boreholes on the west bank of the river) is a stratum of clayey silt till. This material was fully penetrated in the boreholes and was found to extend to the surface of the bedrock. The stratum was encountered at elevation 277 at Site No. 1 and elevation 269 at Site No. 2 and was 20 feet and 16 feet in thickness respectively. The till is light grey in colour. It consists of clayey silt which contains all sand and gravel sizes as subangular particles. The till differs in both colour and granular content from the overlying clay.

Compact to Very Dense Light Grey Clayey Silt Till
(continued)

A grain size analysis was carried out on a representative sample of the till. The resulting grain size distribution curve is presented on Figure 5 in Appendix II. As tested the till contained 20 percent gravel, 20 percent sand, 45 percent silt and 15 percent clay sized particles. Boulders may be present within the till, although they were not encountered during drilling.

Natural water contents carried out on samples of the till gave values of 7 and 12 percent.

Standard penetration resistances or "N" values obtained in the till ranged from 10 to greater than 100 blows per foot indicating that the relative density of the stratum ranges from compact to very dense with depth.

Sound Grey Limestone Bedrock

Bedrock was core drilled in AXT size in all the boreholes. At Site No. 1 in boreholes 1, 2, and 3 the bedrock was encountered at about elevation 257 in all the boreholes. At Site No. 2 the bedrock was encountered at elevation 249 on the east bank of the river and elevation 253 on the west bank.

The bedrock is a dolomitic limestone of the Oxford formation.

WATER CONDITIONS

XI

Water level observation pipes were installed in boreholes 1 and 2 at Site No. 1 and in boreholes 4 and 5 at Site No. 2. Water level observations were made in these pipes and in the uncased borehole No. 3. Water level in the river was at about elevation 284 to 285 during the period of the investigation at both sites. With the exception of borehole 2 the recorded water levels were between elevations 284 and 285 at both sites. That is they were at or slightly above river level. In borehole 2 the recorded water level was 3 feet above ground level, elevation 287.5. This artesian pressure was first encountered during drilling of the bed-rock. It appears to be a localized area of artesian pressure at a shallow depth within the rock.

EXPLANATION OF THE FORM "OFFICE REPORT ON SOIL EXPLORATION"

The object of this form is to enable a comprehensive study of the soil to be made by combining on one sheet all of the information obtained from the boring. An explanation of the various columns of the report follows.

ELEVATION AND DEPTH

This column gives the elevation and depth of boundaries between the various soil strata. The elevation is referred to the datum shown in the general heading.

WATER CONDITIONS

In this column the water level in the casing at the time of boring or the water table in the ground, determined by a series of observations in a piezometer or standpipe, is indicated to scale by a horizontal line with the symbol W.L. or W.T. above the line. A notation of any complicated groundwater conditions will be made in this column.

DESCRIPTION

A description of the soil, using standard terminology, is contained in this column. The consistency of cohesive soils and the relative density of non-cohesive soils are described by the following terms:

<u>Consistency</u>	<u>U-Strength Tons/sq. ft.</u>	<u>Relative Density</u>	<u>Standard Penetration Resistance. Blows/ft.</u>
Very soft	0.03 to 0.25	Very loose	0 to 4
Soft	0.25 to 0.5	Loose	4 to 10
Firm	0.5 to 1.0	Compact	10 to 30
Stiff	1.0 to 2.0	Dense	30 to 50
Very stiff	2.0 to 4.0	Very dense	over 50
Hard	over 4.0		

STRATIGRAPHIC PLOT

The stratigraphic plot follows the standard symbols of the National Research Council, Canada.

ELEVATION SCALE

The information in all columns is plotted to a true elevation scale which is shown in this column.

GRAPHS

The main body of the report forms a graph which is used to plot to correct elevation the important soil properties which are obtained through field and laboratory tests. The scales and symbols for the plotting are shown at the head of the column.

OTHER TESTS

In this column are shown, by symbol, the other field or laboratory tests which have been performed on the soil and for which the results have not been plotted on the above graph.

SAMPLES

The first three columns describe the condition, type and number of each sample obtained from the boring. The location and extent of each sample is plotted to scale.

In the last column is shown the penetration resistance in blows of 4200 inch-pounds required to drive one foot of the sampler into the ground. When a 2 inch Drive Sampler is used the result obtained is termed the "Standard Penetration Resistance".

GEOCON

GEOCON

OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T7966 BORING # 1 DATUM GEODETIC CASING BX
 BORING DATE DEC. 4-5/66 REPORT DATE DEC. 19, 1966 COMPILED BY AEL CHECKED BY JNS
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

SAMPLE CONDITION



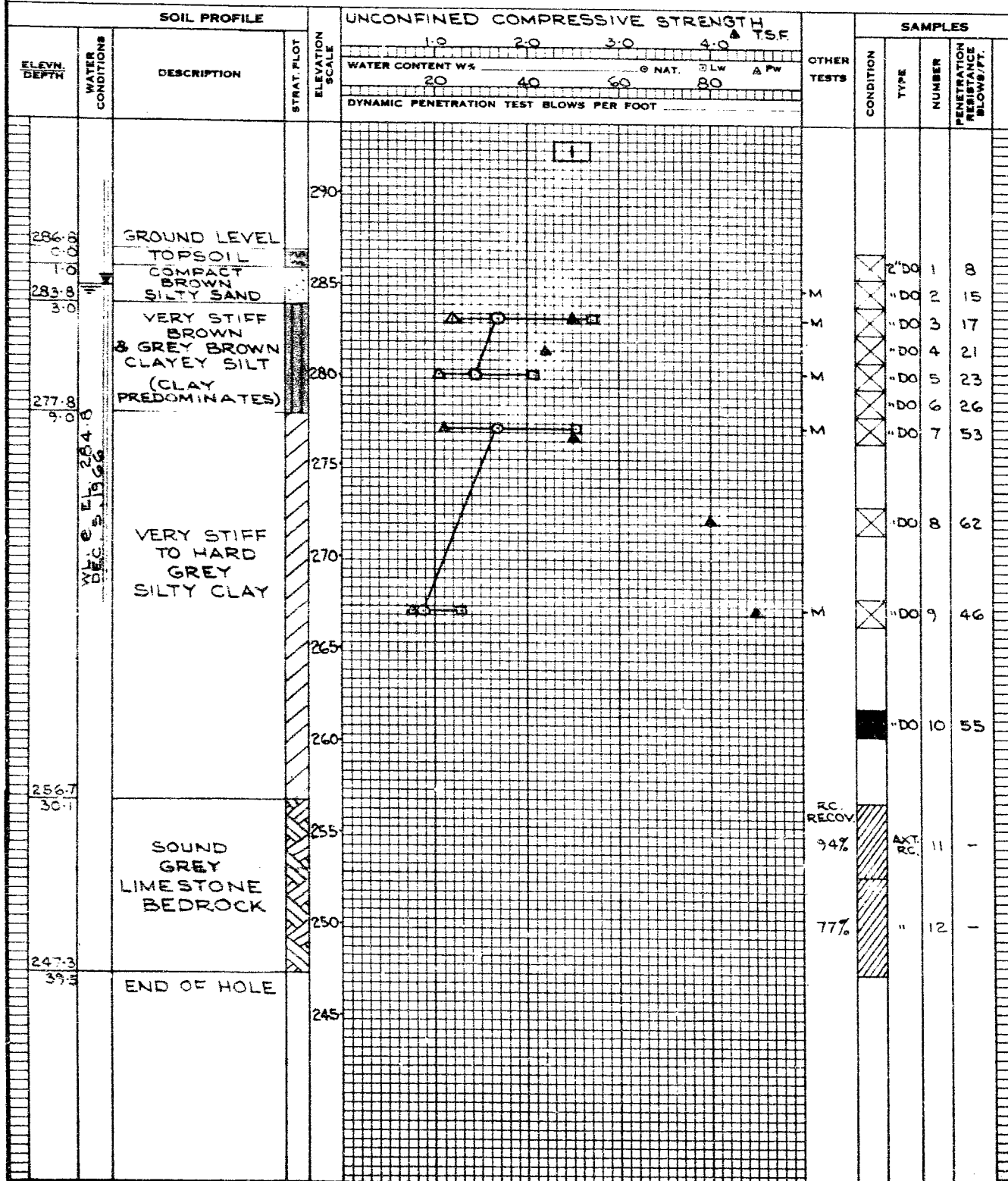
A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE

SAMPLE TYPES

F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED UNDRAINED
 Q - TRIAXIAL UNDRAINED
 S - TRIAXIAL DRAINED
 T - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



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OFFICE REPORT ON SOIL EXPLORATION

CONTRACT 77966 BORING # 2 DATUM GEODETIC CASING Bx
 BORING DATE DEC 5-6/66 REPORT DATE DEC 19, 1966 COMPILED BY AEL CHECKED BY JNB
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

SAMPLE CONDITION



A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE

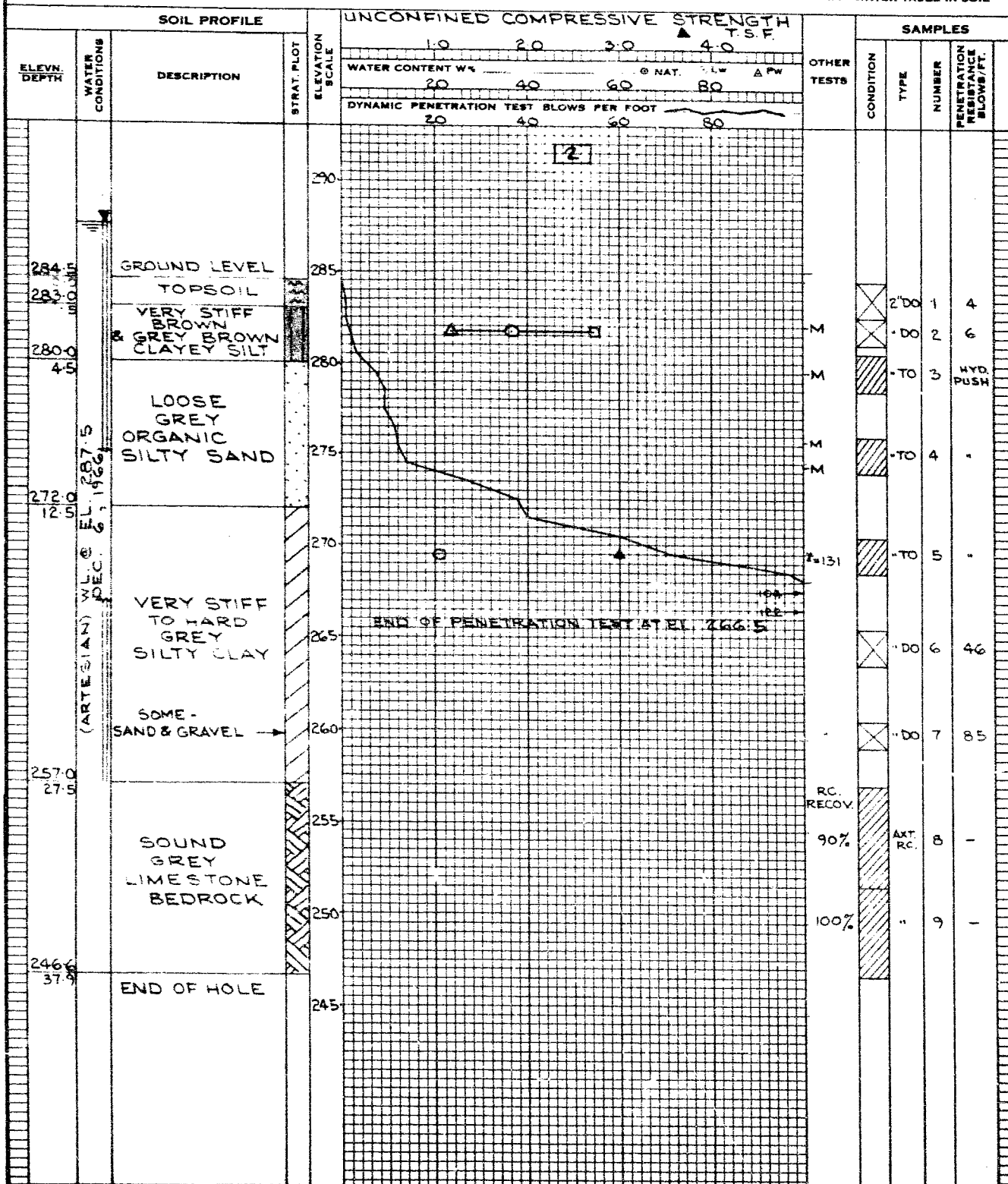
SAMPLE TYPES

F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED UNDRAINED
 Q - TRIAXIAL UNDRAINED
 S - TRIAXIAL DRAINED

ABBREVIATIONS

γ - WET UNIT WEIGHT PCF
 K - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



GEOCON

OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T7966 BORING # 3 DATUM GEODETIC CASING BX
 BORING DATE DEC 13/66 REPORT DATE DEC 19, 1966 COMPILED BY AEL CHECKED BY JNB
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

SAMPLE CONDITION



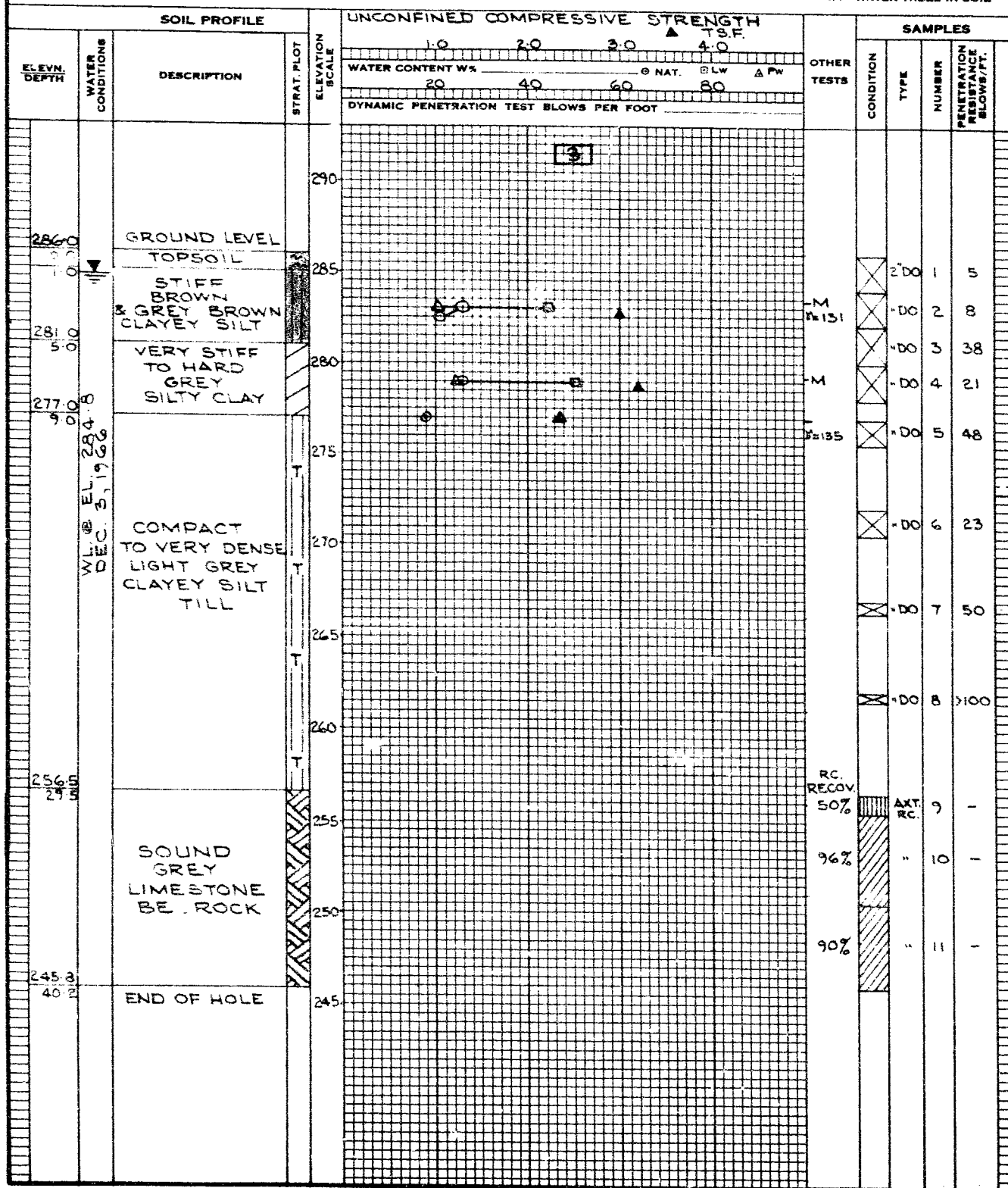
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 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE

SAMPLE TYPES

F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.F. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED UNDRAINED
 Q - TRIAXIAL UNDRAINED
 S - TRIAXIAL DRAINED
 γ - WET UNIT WEIGHT PCF
 K - PERMEABILITY
 C - CONSOLIDATION
 WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



GEOCON

OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T7966 BORING # 4 DATUM GEODETIC CASING BX
 BORING DATE DEC 7-8/66 REPORT DATE DEC 19, 1966 COMPILED BY AEL CHECKED BY JS
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN - LBS. ENERGY)

SAMPLE CONDITION



DISTURBED
FAIR
GOOD
LOST

SAMPLE TYPES

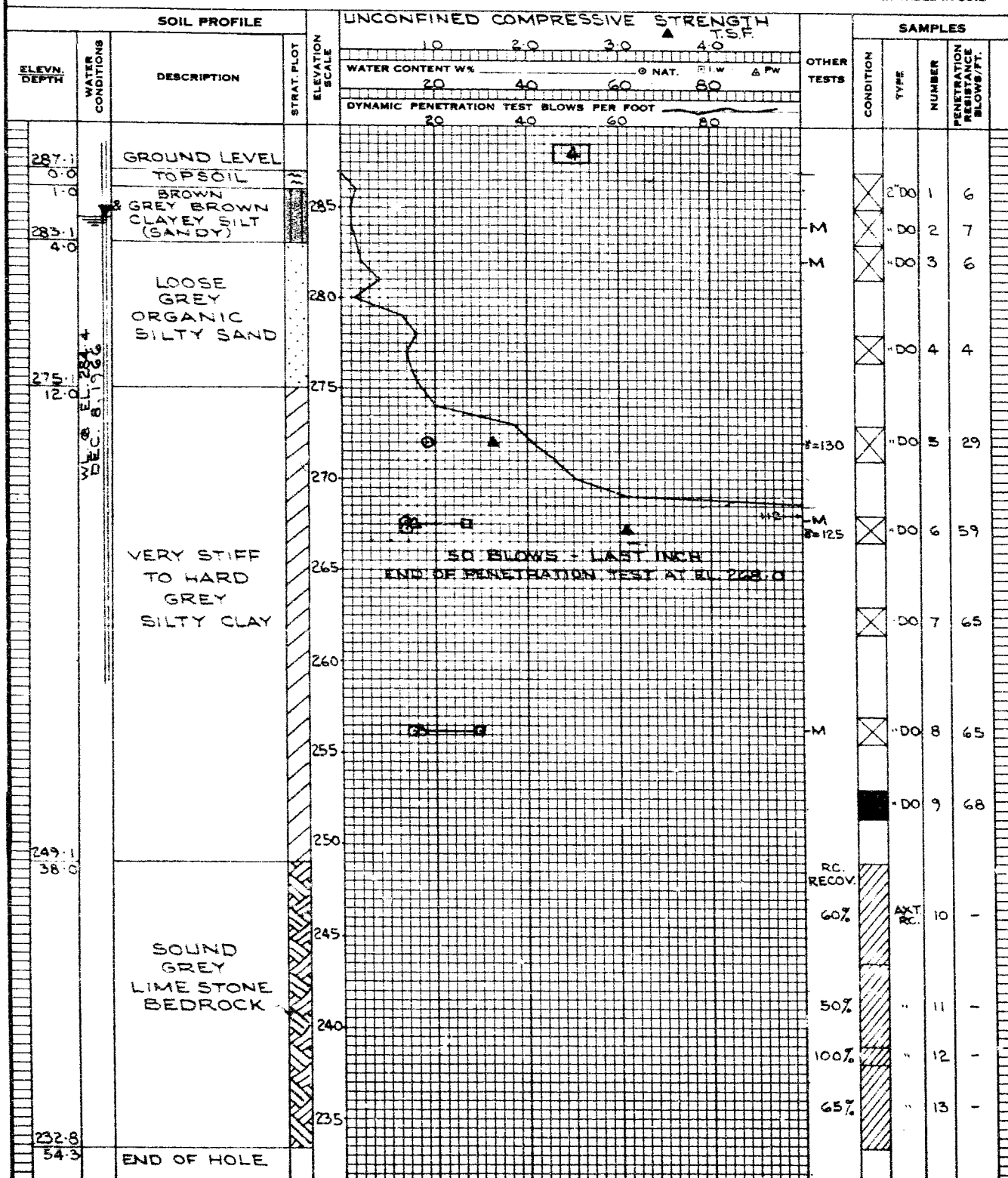
A.S. - AUGER SAMPLE
S.T. - SLOTTED TUBE
W.S. - WASHED SAMPLE
D.O. - DRIVE-OPEN
D.F. - DRIVE-FOOT VALVE
C.S. - CHUNK SAMPLE

F.S. - FOIL SAMPLE
S.O. - SLEEVE-OPEN
S.F. - SLEEVE-FOOT VALVE
T.O. - THIN WALLED OPEN
R.C. - ROCK CORE

V. - IN-SITU VANE TEST
M. - MECHANICAL ANALYSIS
U. - UNCONFINED COMPRESSION
OC - TRIAXIAL CONSOLIDATED UNDRAINED
Q. - TRIAXIAL UNDRAINED
S. - TRIAXIAL DRAINED

ABBREVIATIONS

γ - WET UNIT WEIGHT PCF
K - PERMEABILITY
C - CONSOLIDATION
WL - WATER LEVEL IN CASING
WT - WATER TABLE IN SOIL



GEOCON

OFFICE REPORT ON SOIL EXPLORATION

CONTRACT T 7966 BORING # 5 DATUM GEODETIC CASING BX
 BORING DATE DEC. 12-13/66 REPORT DATE DEC. 19, 1966 COMPILED BY AEL CHECKED BY JNR
 SAMPLER HAMMER WT. 140 LBS. DROP 30 INCHES (PENETRATION RESISTANCES CONVERTED TO BLOWS OF 4200 IN. LBS. ENERGY)

SAMPLE CONDITION

 DISTURBED
 FAIR
 GOOD
 LOST

SAMPLE TYPES

A.S. - AUGER SAMPLE
 S.T. - SLOTTED TUBE
 W.S. - WASHED SAMPLE
 D.O. - DRIVE-OPEN
 D.F. - DRIVE-FOOT VALVE
 C.S. - CHUNK SAMPLE

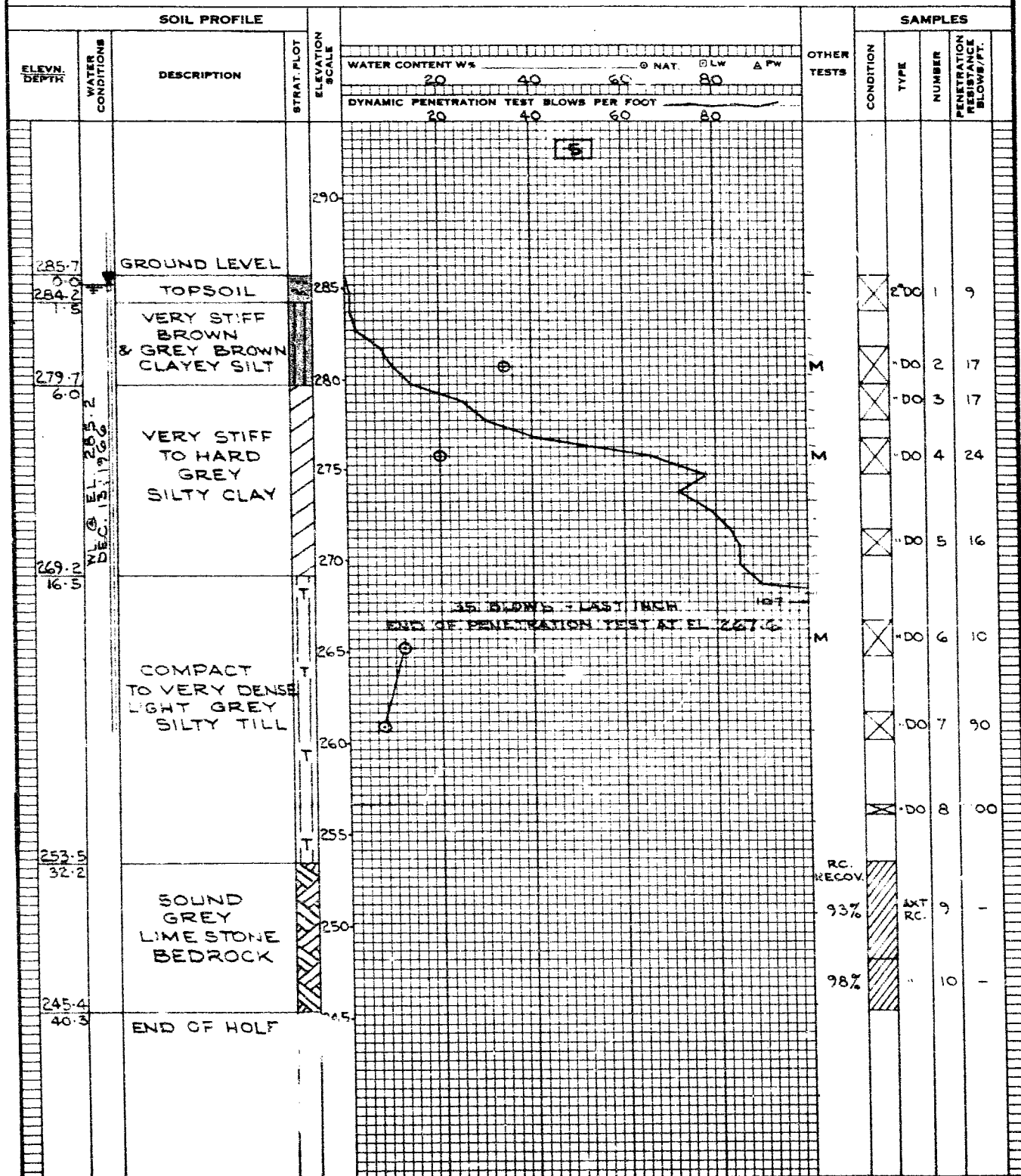
F.S. - FOIL SAMPLE
 S.O. - SLEEVE-OPEN
 S.P. - SLEEVE-FOOT VALVE
 T.O. - THIN WALLED OPEN
 R.C. - ROCK CORE

ABBREVIATIONS

V - IN-SITU VANE TEST
 M - MECHANICAL ANALYSIS
 U - UNCONFINED COMPRESSION
 QC - TRIAXIAL CONSOLIDATED UNDRAINED
 Q - TRIAXIAL UNDRAINED
 S - TRIAXIAL DRAINED

γ - WET UNIT WEIGHT
 K - PERMEABILITY
 C - CONSOLIDATION

WL - WATER LEVEL IN CASING
 WT - WATER TABLE IN SOIL



APPENDIX II

FIGURES - LABORATORY TESTING

GEOCON

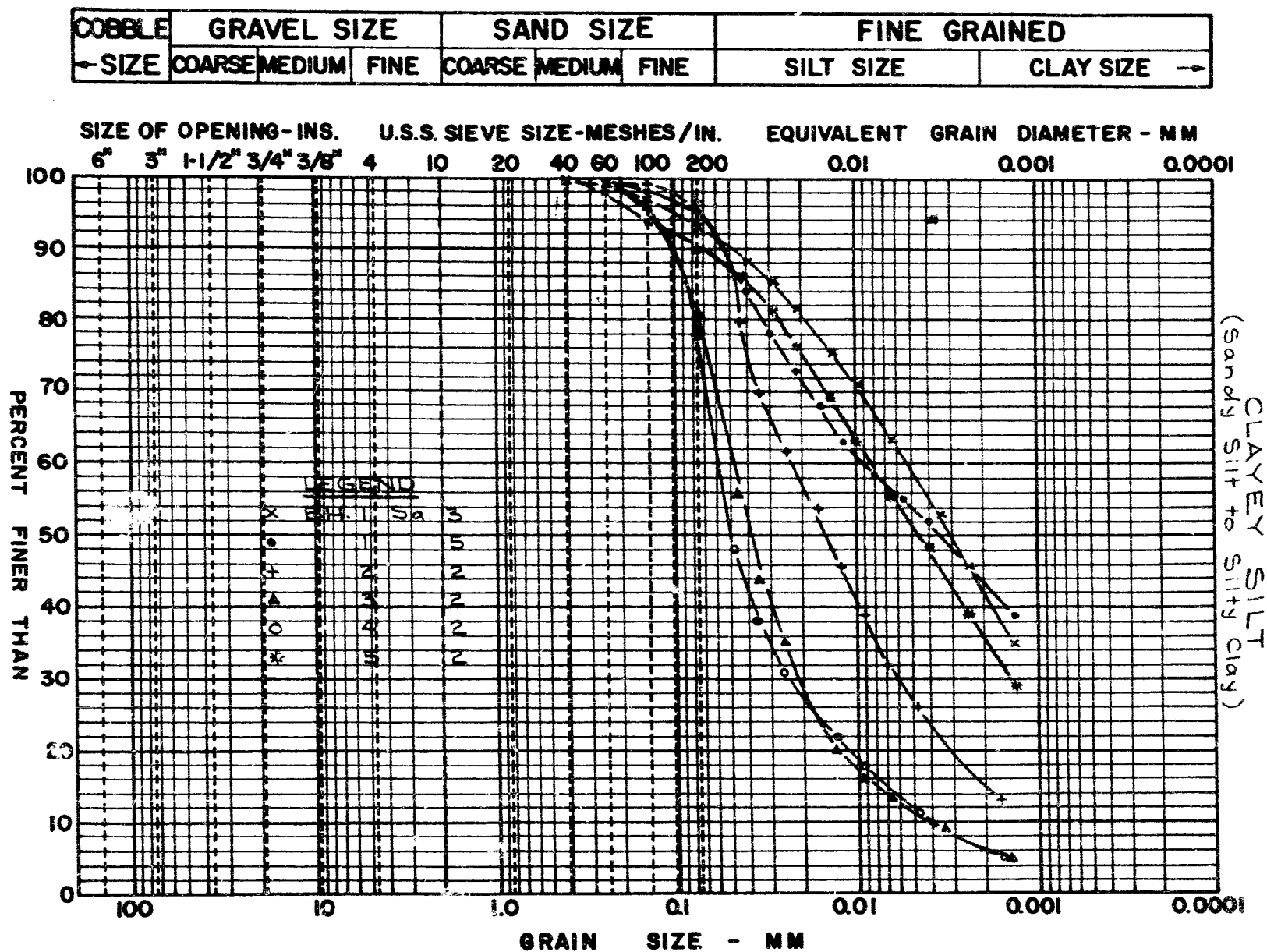
APPENDIX II
FIGURE 1
PROJECT T7966



GRAIN SIZE DISTRIBUTION

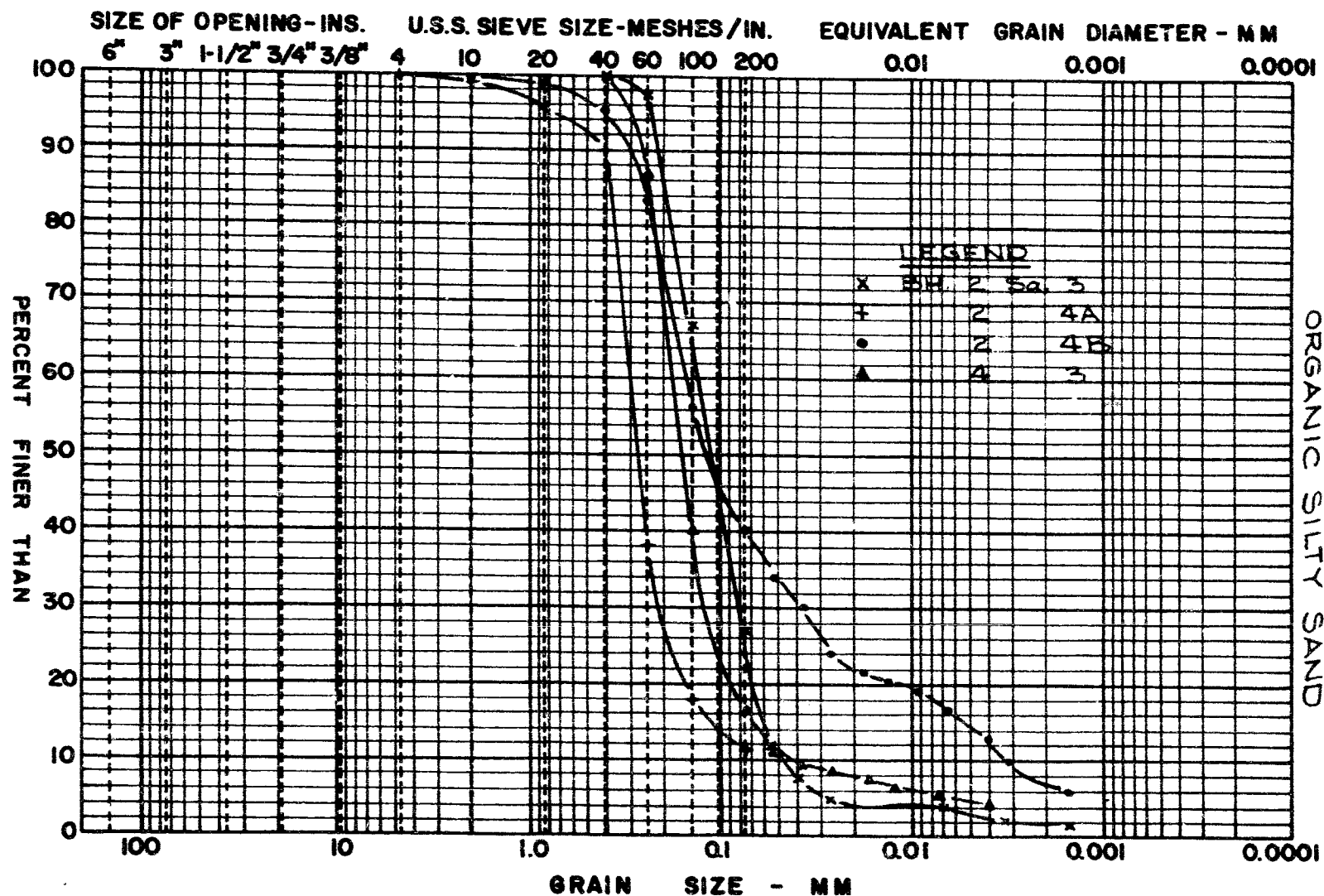
APPENDIX II
FIGURE 2
PROJECT T7966

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M.I.T. GRAIN SIZE SCALE

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



GEOCON

M.I.T. GRAIN SIZE SCALE

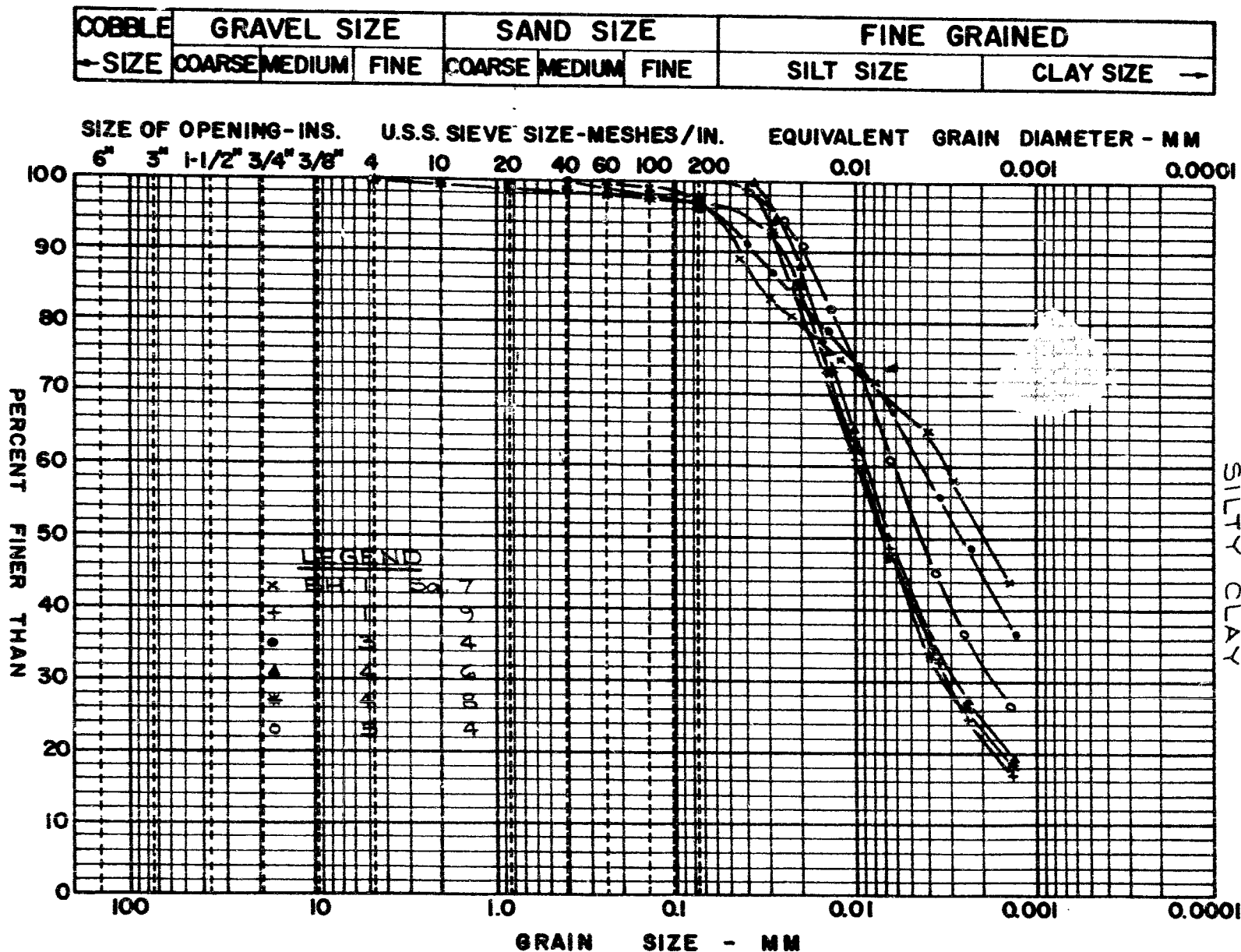
GRAIN SIZE DISTRIBUTION

APPENDIX II
FIGURE 3
PROJECT T7966

GRAIN SIZE DISTRIBUTION

APPENDIX 11
FIGURE 4
PROJECT T79666

GEOCON

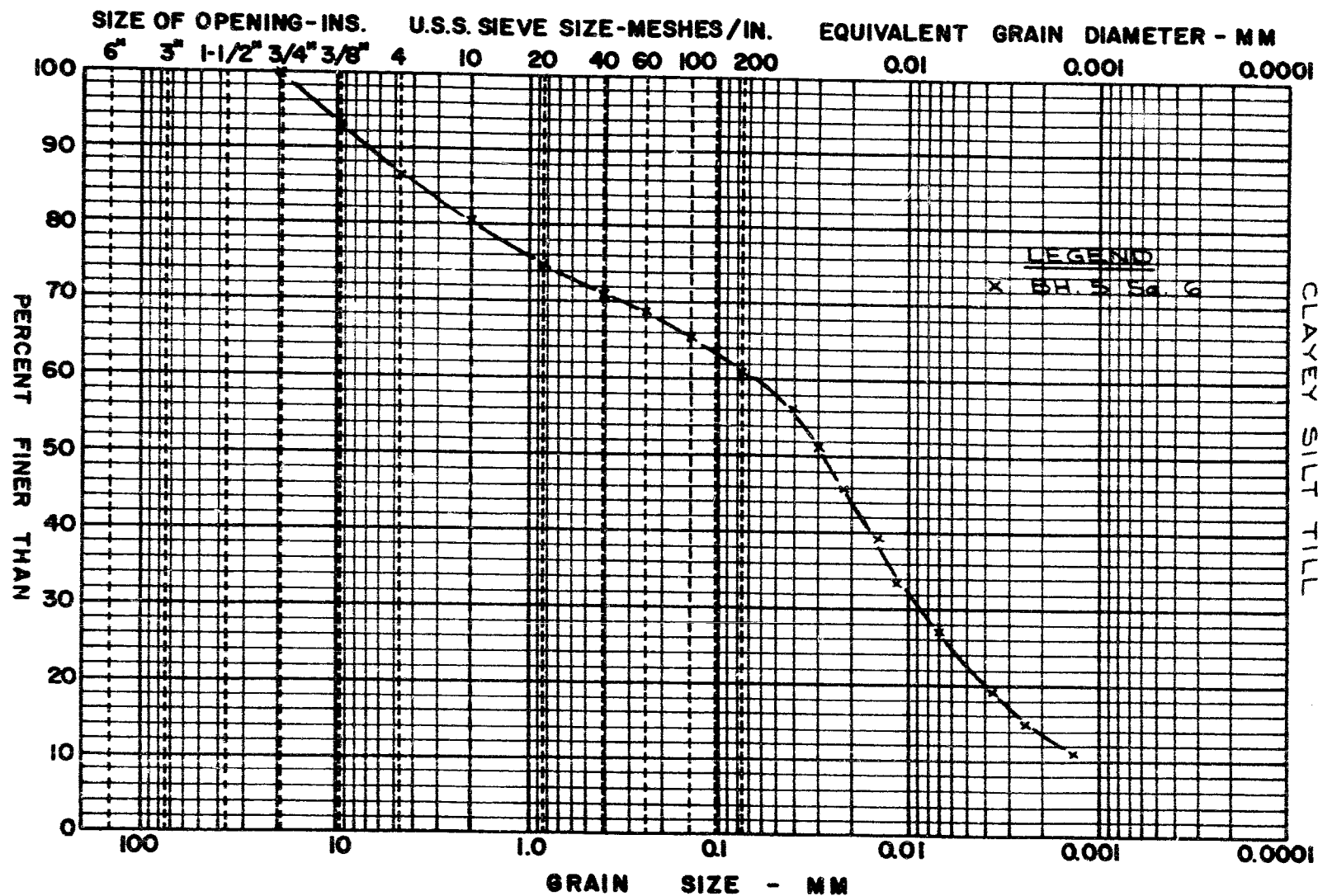


M.I.T. GRAIN SIZE SCALE

GRAIN SIZE DISTRIBUTION

APPENDIX 11
FIGURE 5
PROJECT T7966

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



M.I.T. GRAIN SIZE SCALE

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PLASTICITY CHART

APPENDIX II
FIGURE 6
PROJECT T7966

