Geotechnical Investigation Directional Drilling Crossing Highway 404 at Sheppard Ave East Toronto, Ontario – Toronto Hydro Conduit

MTO GEOCRES No. (30M14-517)

Client

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Project Number
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Date Submitted
April 30, 2020

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1. Introduction

EXP Services Inc. (EXP) was retained by Tolossi Group Inc. to conduct a geotechnical investigation for the proposed Hydro conduit crossing Highway 404 at Sheppard Avenue East in the City of Toronto, Ontario.

It is our understanding that the project involves installing a proposed Hydro conduit crossing Highway 404 located to the north of Sheppard Avenue East. The proposed hydro duct will be installed using directional drilling method crossing access ramps and Highway 404.

Based on preliminary project information provide, the conduit diameter will be about 1.2 m and the invert will be set at El. ~171.5 m, approximately 5 and 7 m below grade on the east and west side respectively. Bore pits will be located to the east of the off ramp from north bound Highway 404 to Sheppard Avenue East and to the west of the on ramp from west bound Sheppard Avenue East to south bound Highway 404.

The purpose of this geotechnical investigation was to determine the subsurface soil and groundwater conditions at the site by drilling one (1) borehole in the vicinity of the bore pits on either side of Highway 404 and, based on this information, to provide an engineering report with geotechnical recommendations pertaining to the proposed construction.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2. Site and Geology

The proposed Hydro crossing underneath Highway 404 and the access/exit ramps will be located to the north of Sheppard Avenue East. The area of the investigation is within the Ministry of Transportation Right-of-Way.

The Sheppard Avenue East overpass is elevated over Highway 404. The topography slopes down to Highway 404 from both the east and west sides of Highway 404. The vegetation cover consists of grass and drainage is by way of storm sewers and ditches.

Geological mapping indicates that the site is underlain by Young tills of clayey to sandy silt tills which were deposited during the late Wisconsinan times. The till lies -on shale with interbedded limestone of the Georgian Bay Formation (Ordovician Age).

3. Methodology

The fieldwork for the investigation was carried out on October 25, 2019 when two (2) sampled boreholes (designated as Boreholes EAST and WEST) were drilled at the locations shown on the attached Drawing No. 1.

The boreholes were advanced to depths of about 12.8 m below existing ground surface using a drill rig, which is adapted for soil sampling purposes, owned and operated by a specialist drilling contractor.

In each borehole, representative samples of the subsurface overburden soils were recovered at regular intervals using conventional 50 mm O.D. split barrel sampler driven in accordance with Standard Penetration Test procedures (ASTM D1586). Water level observations were carried out in the open boreholes during the course of the fieldwork. Subsequent water level observations were carried out in a piezometer installed in each borehole.

The fieldwork was supervised throughout by EXP personnel who directed the drilling and sampling operations, logged the borings, made groundwater observations during and upon completion of drilling, processed the recovered samples and prepared the field borehole logs.

The locations of the boreholes were determined by EXP Services Inc. based on design drawings provided by Tolossi Group Inc. The borehole locations and ground surface elevations at the boreholes were determined and surveyed in the field by TELECON's surveyor, J. D. Barnes Limited.

The locations of the boreholes were established in the field by EXP personnel based on drawings provided by Tolossi Group Inc. Ground surface elevations at the borehole locations were derived from SOKKIA TopNET Live RTK Network with the use of a SOKKIA GCX3 Controller.

As noted above two boreholes were drilled at each portal (BH-West and BH-East) for this project. The middle borehole was not drilled because its location would be within the busy intersection and there is no a safe spot for drilling in the middle of Hwy 404. However, EXP obtained from the MTO Geocres library the geotechnical report related to the same site "Site Investigation for Proposed Don Valley Parkway Underpass at Sheppard Ave East, Toronto, Ontario" done by H. Q. Golder & Associate Ltd., dated August 1964 (Geocres No. 30M14-398). The report is attached in Appendix B of this report. The report shows three historical boreholes (BH-20, BH-22 and BH-24) drilled in the vicinity of the proposed hydro crossing. Based on geotechnical data in these boreholes it is evident that the subsurface at the site is similarly described as that in the recently drilled boreholes. Therefore, it is reasonable to anticipate that the subsurface conditions defined in the historical BH-22 do not changed, and can be used in the assessment of the subsurface conditions between BH-West and BH-East.

4. Laboratory Testing Program

All recovered split barrel samples were transported to our laboratory for detailed examination and classification testing. The laboratory testing program consists of the following:

- Moisture content determinations on all recovered soil samples (LS701/22) with results shown on the appended log of borehole sheets.
- Unit weight determination on selected soil samples (LS-705), with result shown on the log of borehole sheets.
- Grain size distribution analyses on selected soil samples (LS702/ASTM B422 and ASTM B1140) with results shown in Table 1, on the log of borehole sheets and in Appendix A.
- Atterberg limit tests on selected samples (LS-704 & 704/ASTM D4318) with results shown in Table 2, on the log of boreholes sheets and in Appendix A.

5. Subsurface Conditions

The detailed soil profiles encountered in each borehole presented on the attached Drawing No.1 and borehole logs, Drawings No. 2 and 3. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.

The "Notes on Sample Description" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

The following is a brief description of the soil conditions encountered during the investigation:

Topsoil

Topsoil with thicknesses of about 175 and 160 mm was encountered at the surface of Boreholes EAST and WEST, respectively.

Fill

Fill was encountered below the topsoil cover at both borehole locations. The fill encountered generally comprised of sand and gravel to clayey silt with some sand pockets and a trace of gravel. It was noted that the fill contains some rootlets and topsoil inclusions. The fill stratum extends to a depth of about 2.2 and 4.5 m below existing ground surface (El. ~174.2 to 173.9 m) in Boreholes EAST and WEST, respectively.

Clayey Silt Till

A clayey silt till was encountered below the fill at both borehole locations. This deposit contains some sand and a trace of gravel with some oxidization zones. With recorded ‘N’-values ranging from 7 to 19, the clayey silt till has a firm to very stiff. This deposit extends to depths of about 5.5 and 7.0 m below existing ground surface (El. ~170.9 to 171.4 m), respectively.

Sandy Silt Till

A sandy silt till was encountered below the clayey silt till in Boreholes EASY and WEST. The sandy silt till contains some clay and a trace of gravel. This deposit is brown to grey in colour, exists in a loose to very dense state of compactness (recorded 'N'-values of 7 to over 100). The sandy silt till extends to depths of about 11.5 and 11.8 m below existing ground surface (El. ~164.9 to 166.6 m), respectively.

Silty Sand

The sandy silt till is underlain by a silty sand deposit at both borehole locations. This deposit is brown in colour and contains a trace of gravel with oxidized zones. The silty sand exists in a very dense state with a recorded 'N'-values of 50 and 69. Boreholes EAST and WEST were terminated in the silty sand at depths of about 12.8 m below existing grade (El. ~163.7 and 165.6 m), respectively.

Grain size analysis and Atterberg limits were carried out on selected samples. The test results are presented in Appendix A and summarized in Tables 1 and 2 below.

Table 1: Summary of Grain Size Analysis

Borehole and Sample No.	Soil Type	Depth (m)	Gravel	Sand	Silt	Clay
BH EAST SS5	Clayey Silt Till	3.0 – 3.7	2	24	50	24
BH EAST SS7	Sandy Silt Till	6.1 – 6.7	4	37	45	14
BH EAST SS10	Sandy Silt Till	10.7 – 11.3	4	41	45	10
BH West SS9	Sandy Silt Till	7.6 – 8.2	1	35	47	17
BH West SS10	Sandy Silt Till	9.1 – 9.8	6	35	45	15

Table 2: Summary of Atterberg Limits

Borehole and Sample No.	Soil Type	Depth (m)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index
BH EAST SS6	Clayey Silt Till	46 – 5.2	23	12	11
BH West SS8	Clayey Silt Till	6.1 – 6.7	21	12	9

Groundwater Conditions

Groundwater conditions were assessed by taking readings in open boreholes during the course of the fieldwork and in piezometers installed in each borehole. Short-term observations are recorded on the attached borehole logs and summarized in Table 3 below.

Table 3: Summary of Observed Groundwater Levels

Borehole Number	**Completion Date**	**Depth to Groundwater Level Below Existing Grade (m)**		
		On Completion	**October 28, 2019**	**October 31, 2019**
EAST	October 25, 2019	~11.3	No Free Water	No Free Water
WEST	October 25, 2019	~11.0	No Free Water	No Free Water

The observed water levels may not be representative of the true groundwater conditions due to the short observation period.

Seasonal fluctuations in groundwater levels should be anticipated.

6. Engineering Discussion and Recommendations

6.1 General

This section of the report provides discussions and geotechnical recommendations for the proposed Hydro crossing under Highway 404. It is understood that the horizontal directional drilling method is selected to install the proposed Hydro conduit.

The interpretations are based on factual data presented in this report.

6.2 Expected Ground Condition along Pipe Alignment

Based on the investigation data, the ground conditions along the pipe alignment are summarized in Table 4 below.

Table 4: Expected Ground Conditions along Pipe Alignment

Borehole	Approximate Elevation of Tunnel invert (m)	Anticipated Soil Conditions	Comments
EAST	171.5	Clayey Silt Till, stiff	Possible boulders
WEST	171.5	Clayey Silt Till, stiff	Possible boulders

6.3 Trenchless Installation Methods

As mentioned before we understand that tunneling is considered for the installation of the Hydro conduit under Highway 404. We further understood that two (2) bore pits will be excavated for launching and receiving the proposed conduit. Boreholes EAST and WEST were located in the vicinity of the respective bore pits. To assess the soil conditions between these two boreholes the historical data provided in Appendix B has been used.

Based on the results of the investigation, it is our opinion that trenchless methods will be feasible for installing the proposed conduit. The procedures should follow OPSS 450 and industrial standards. The advantages, disadvantages and ranking of trenchless methods considered to be applicable at this site are presented in Table 5 for completeness.

Table 5: Trenchless Installation Methods Comparison and Ranking

Installation Method	**Advantages**	**Disadvantages**	**Rank**
Jack and Bore	• Handles wide variety of ground conditions • Minimal surface disruption • Very accurate (slope of 0.2% easily achieved) • Relatively simple operation • Common use in Ontario • Short mobilization time • Suitable for steel pipes up to 1.8 m in diameter	• Requires large area for jacking shaft and support equipment • Relatively high construction costs • Obstructions problematic • Short and long term settlement • Fluid to support annular space • Pipe can be difficult to steer/direct • Dewatering required along route, if the GWL is high	1
Horizontal Directional Drilling (HDD)	• Handles wide variety of ground conditions • Steerable both horizontally and vertically to maintain and adjust alignment • Does not require staging pits if site is able to accommodate maximum entry and exit angles • Suitable for tunneling under groundwater table • Local contractors available • Short mobilization time • Rapid drilling • Only minor settlement if fluid well controlled • Suitable for installation of pipes up to 1.2 m in diameter and longer lengths	• Potential for inadvertent drilling returns • Requires drilling fluid to maintain the bore which could allow subsidence • May require longer bore or staging pits • Obstructions problematic, but alignment can be adjusted to avoid obstructions	2
Microtunneling Technique	• Handles wide variety of ground conditions • Steerable horizontally to maintain and adjust alignment • Suitable for tunneling under groundwater table • Alignment can be adjusted to avoid obstructions • Suitable for installation of pipes with minimum 1.5 m in diameter and 150 m length	• High construction cost • Obstructions problematic • Requires large area for jacking shaft and support equipment • Requires sophisticated equipment	3

6.3.1 Jack and Bore

The jack and bore method involves drilling a borehole from a jacking pit (entry pit) with a rotary cutter head within the confines of a steel casing or liner jacked ahead for support. The casing is pushed through the soil with a hydraulic ram, and soil is removed with an auger. A cutting head is fixed to the leading edge of the pipe. The auger transports spoils from the cutting head back to the jacking pit. The procedures must conform to all relevant OPSS standards and industrial standards.

Based on the information from the boreholes drilled in the vicinity of new conduit, it is expected that the tunnel boring will be carried out mostly in clayey silt till and the groundwater level will be below the pipe invert. Considering these conditions as well as the proposed pipe diameter of 1.2 m, pipe jacking using mechanical means is feasible for the proposed installation.

To reduce loss of ground and groundwater ingress (if any), consideration may be given to jacking the casing across the alignment as far as possible, prior to auguring. Lubricant selected based on the characteristics of the surrounding soil, may be provided to reduce the friction between the casing and the borehole walls. However, obstacles such as deleterious debris, e.g. wood, which should be anticipated in the fill could make this difficult or impractical. EXP recommends the lead auger be kept at least one casing diameter behind the lead end of the casing to minimize the potential for ground losses. Furthermore, any significant voids between the casing and the surrounding soil should be filled with pressurized cementitious grout to prevent / minimize ground loss. In addition, the installation of the proposed conduit must not interfere with existing utilities. Therefore, driving of the pipe has to be fairly accurate noting that there is only limited steering ability, where minor adjustments can be made should it be necessary or to address obstructions. Generally, utility tunneling using pipe jacking method is a relatively slow and labor-intensive process. The actual tunnel advance rate is a function of soil conditions encountered, method of soil excavation, spoil removal, pipe liners materials, and field conditions.

To minimize possible negative impact on the existing roadway due to excavations required for the bore/jacking pits and installation of the pipe using the pipe jack and auger bore method, a protection system might be required for the existing roadway. Excavation shoring for the pits will be addressed in the following sections of this report.

6.3.2 Horizontal Directional Drilling (HDD)

Based on the borehole findings, the tunneling of the Hydro conduit will be confined with the clayey silt till deposit. HDD, considered feasible for this installation, can drill up to about 1,500 m in length with steering capacity for typical pipe diameters ranging between 100 mm and 1,200 mm. The diameter of the proposed tunnel constructed by HDD for the proposed conduit is expected to be around 1,200 mm.

Primary support is not required, as a drilling fluid is used for temporary support and transportation of the cuttings. The risk of loss of drilling fluid is minimal since the tunnel is at least 3 m below the road grade of Highway 404 and located primarily within a glacial till deposit. High density polyethylene or steel pipes can be utilized at this site.

Directional drilling is a two-step process. First, a small diameter pilot hole is drilled the entire length of the proposed pipeline. Behind the bit, the motor is powered by bentonite slurry, which is pumped through the drill string from the bore entrance. The slurry acts as a lubricant and helps force the soil back to the surface. After the pilot hole is complete, pulling back reaming tools, from the pipe insertion point to the rig side, enlarges the pilot hole. To achieve the appropriate bore size it may be necessary to perform several reaming operations. Generally, all reaming procedures prior to the actual product installation are referred to as pre-reams, and the final ream to which the product pipe is attached is referred to as the back-ream. After the pre-reams, the pulling head and connecting product pipe are attached to the reamer using a swivel, a device that isolates the product pipe from the rotation of the drill pipe. The product pipe is then pulled behind the final reamer back through the directional drill path to the exit pit on the rig side. Ontario Provincial Standards Specifications (OPSS 450), Construction Specifications for Pipeline and Utility Installation by HDD should be applied during construction.

According to OPSS 450 the work site for pipeline installation in soil by HDD should be graded or filled to provide a level working area for the drilling rig. However, if the space for the entry and exit points is restricted so bore entry and exit angles exceed the recommended values in ASTM F1962-11 (bore entry angles should be in the range of 8^{o} to 20^{o} from the ground surface, while bore exit angles should be relatively shallow; preferably 10^{o}) the bore would be initiated from bore pits.

One of the risks associated with directional drilling is the escape of drilling mud into the environment as a result of a spill, tunnel collapse or the rupture of mud to the surface, commonly referred to as "frac-out". Frac-outs are caused when excessive drilling pressure results in drilling mud propagating vertically toward the surface. The risk of frac-outs can be reduced through proper mix design and careful monitoring.

The drilling fluid used for the HDD operation should be selected by the HDD contractor taking into account that the drilling fluid should be able to:

- transport all drill cuttings to the surface;
- cleaning off build-up on drill bits and reamer cutters;
- cooling the downhole tools;

- lubricating to reduce the friction between the product pipe and the bore wall; and,
- stabilize the bore path against squeezing by exerting a positive hydraulic pressure against the bore wall.

Proper control of the gel strength is important to minimize the possibility of hydrofracture caused by excessive downhole pressures.

The possible presence of cobbles and boulders within the sandy silt till deposit along the tunnel alignment might create problems for directional drilling construction as well. A high torque capacity boring machine will help in breaking down cobbles and boulders.

Contractors bidding on this project should be required to submit their bore plan and methodology, including specifications for drilling fluid, maximum and minimum pressures utilized for excavation during the HDD process, prevention of hydrofracturing, locations of relief pits, drilling fluid recycling and disposal plan, emergency measures and materials to be used in case of hydrofracture etc., for review by the geotechnical engineer. All components of the drilling fluid must meet the requirements of ANSI (American National Standard Institute) Certified 60.

6.3.3 Microtunneling

Microtunneling should be feasible to install the proposed Hydro conduit. Microtunneling method is a non-entry, remotely controlled, guided 2-stage process, which provides continuous support to the excavation face. In this method a Micro Tunneling Boring Machine (MTBM) is used for soil cutting, while a pipe is jacked into place behind the cutting head with hydraulics. The MTBM is equipped with a slurry spoil removal system to control the groundwater inflow and counterbalance the earth and hydrostatic pressure while tunneling through the mixed face conditions. The cutting tool and the drilling fluid must be able to handle the different materials and the “mixed face” condition. In order to minimize the resistance along the pipe exterior, a bentonite grout lubricant can be injected behind the cutting face. Steel, concrete or fibreglass pipes can be installed with this method.

The major advantage of microtunneling method is that its performance is not affected by high groundwater levels, so the dewatering is not required; which is not a case for this project. Major disadvantage of microtunneling for this project is the relatively high cost. This option may become more attractive if potential bidders have available equipment in house.

For excavation of the launching pit, a protection system might be required to minimize possible negative impact on the stability of the existing roadway.

6.3.4 Discussion of Drilling Methods

The HDD method is a feasible method for installation of Hydro conduit at this site. However, since the proposed conduit diameter is 1.2 m, it might be difficult to achieve the required entry and exit bore angles for the HDD installation.

The microtunneling method is a feasible method and local, experienced contractors have successfully installed pipes using this method. If a qualified and experienced contractor is used for construction, the required alignment/slope can be achieved with minimal risk for short- and long-term settlements. However, the initial installation cost is anticipated to be higher than the alternatives.

Although difficulty in directing the drill head should be anticipated, the jack and bore method of installation is considered the preferred option from a feasibility and cost perspective.

6.4 Bore Pit Excavation

It is understood that the proposed bore pits of the directional drilling will be located in the vicinity of Boreholes EAST and WEST. The depths of the bore pits were not specified in the project drawings provided. It is anticipated that the bore pit excavation will extend up to 1.5 m below the tunnel invert level, i.e. El. ~170.0 m.

Based on the soil conditions revealed from the boreholes, the excavation will generally be carried out through the fill and into the firm to very stiff clayey silt till. It should be noted that the subsurface conditions can be significantly different from those indicated in the boreholes if there are backfilled existing service trenches immediately adjacent to the excavations. If such is the case, more fill material should be anticipated during excavations.

Open cut excavation can be considered if space constraint is not an issue at the pit locations. The side slopes should be cut as per the OSHA regulations. The fill and the clayey silt till can both be considered as Type 3 soil.

If shoring is considered, the overburden soil can be supported by steel sheet piles. The sheet piles should be designed for the lateral earth pressure given in Section 6.5 of this report. Since boulders and other obstructions may exist in the overburden soil, provision may be made in the shoring contractor for their removal. Alternatively, soldier piles and lagging schemes can be considered. Design and installation of temporary shoring is the responsibility of the Contractor.

The overburden materials may be excavated with large conventional equipment such as a mechanical backhoe. It should be noted that the clayey silt till may contain boulders and other obstructions. Provisions must be made in the excavation contract for the removal of possible obstructions.

Seepage from water perched in the fill or upper level of the till deposits should be anticipated. It should be feasible to handle the seepage by gravity drainage and pumping from filtered sumps within the excavation.

6.5 Temporary Shoring

Temporary shoring should be designed for the lateral earth pressures presented in the Canadian Foundation Engineering Manual (4th Edition). A rectangular shaped earth pressure diagram can be considered for the granular soil as per Canadian Foundation Engineering Manual Figure 26.8(a). Water pressure and surcharge loads should be taken into consideration as appropriate. The lateral earth pressure acting at the base of the temporary support system may be calculated from the following equation:

$$p = 0.65K_a\gamma\, h + K_a q$$

where p = lateral earth pressure in kPa acting at depth h;

K_a = earth pressure coefficient, a value of 0.35 is recommended

γ = unit weight of retained soil, a value of 22 kN/m^3 is recommended

h = depth to point of interest in m; and

q = equivalent value of any surcharge on the ground surface in kPa.

The above expression assumes that there will be no hydrostatic pressure behind the shoring/sheeting.

The parameters recommended for horizontal earth pressures are for horizontal back slopes. For sloping backfill, the design requirements outlined in Section C6.91(c) of the Canadian highway Bridge Design Code should be used.

Temporary shoring system should be designed and constructed in accordance with OPSS.PROV 539 as amended by SP105S09. The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539.

It is considered that a sheet pile of sufficiently robust cross section could be driven through glacial till encountered at this site location. Difficulties with installation may occur where occasional boulders are encountered in the till, requiring their removal before further driving. Alternatively, an H-pile with lagging wall can be used as a vertical temporary shoring system. The H-piles are installed, and lagging is inserted between installed H-piles during excavation. Space between the excavation and lagging must be suitably backfilled and drained. Lagging wall material can be selected as wood (timber), steel or concrete.

For design of the timber lagging, earth pressures can be reduced by 25 percent to account for soil arching effects. This is provided if the center-to-center spacing of the soldier piles does not exceed 2.5 m. Soldier piles should extend a minimum depth of 3.0 m below the planned excavation depth. The actual depth of embedment should be determined by balancing moments about the pile tip. Excavation can proceed following installation of the soldier piles. The unshored height of the excavation should not exceed 1.2 m at any given time. No excavation height should remain unshored for more than 24 hours. Any loose zones from behind the shoring should be prevented during installation of the protection system. If required, backfill Granular A should be placed and compacted behind the shoring wall.

For the relatively shallow depth of excavation anticipated, cantilevered systems may be adequate. However, depending on the actual excavation depth and shoring system used, additional anchorage or tiebacks may be required. This must be confirmed by the shoring designer. Conventional practice is to incorporate either buried deadman anchors, rakers or grouted soil anchors.

6.6 Backfilling Operations

It is anticipated that backfilling work will be required at the entry and exit pits to reinstate the site to preconstruction conditions. Backfill for all excavations should be clean compactable fill, i.e. inorganic soil with its moisture content close to its optimum moisture content determined in a standard Proctor test. It is anticipated that the excavated soils from the bore pits will be predominantly clayey materials. This material will have to be sorted to remove any topsoil, organic stained soils, cobbles greater than 150 mm in diameter and/or other unsuitable materials if it is for reuse as backfill. Some moisture content adjustment may be required. Imported granular soils should be considered for backfilling confined areas.

Any organic, excessively wet or otherwise deleterious material should not be used for backfilling purposes. Any shortfall of suitable on-site excavated material can be made up with imported and approved materials. In areas where long term settlements are to be avoided, the backfills should be placed in lifts not exceeding 200 mm and compacted to minimum 98 percent standard Proctor maximum dry density. Alternatively, the use of unshrinkable fill for backfilling can be considered.

All backfill and compaction operations should be monitored by qualified geotechnical personnel to approve material, to evaluate placement operations, and to verify that the specified degree of compaction is being achieved throughout the fill. The drill mud in the annular space should be permitted to solidify to provide support for the pipe and surrounding soils.

6.7 Ground Settlement

Settlement around the tunnel would be due ground loss or “immediate” settlement caused by tunneling.

The immediate settlement is a direct result of the overcut and movement of ground at the heading during tunneling. The factors that influence the immediate settlement include the soil strength and the method of tunneling. Based on soil characteristics of the site, an experienced contractor should be able to keep the settlement under the MTO’s required limit of 10 mm. Technical specifications should ensure that:

- The use of over-cutters (excavating to a diameter greater than the pipe diameter) is kept under 10 mm; and
- The program of instrumentation is carried out as per MTO guidelines.

7. Instrumentation and Monitoring

7.1 General

Monitoring of the impact of trenchless installation of the conduit below the Hwy 404 on other MTO infrastructure such as bridge/retaining wall foundation and underground utilities e.g. sewers, should be carried out. Provided that the unwatering/dewatering, shoring and tunneling are carried out in accordance with specifications and good practice significant impact on the existing bridge/ retaining walls is not anticipated, since the existing bridge is founded on deep foundations. Based on available information about clearances from all MTO and other utilities it is anticipated that none of them will be affected by the construction of this Hydro conduit. However, ground surface settlements along the alignment should be monitored during construction to ensure compliance with MTO guidelines and the contract requirements.

The instrumentation program should adequately verify effects of tunneling on the overlying highway and obtain advance warning of ground movements. The scope and layout of settlement instruments should be in general accordance with the MTO guidelines (Settlement Monitoring Guideline – Tunneling). This should include a series of surface monitoring points placed at a maximum spacing of 5 metres along the entire length of the proposed tunnel. All monitoring points located in the unpaved portion of the right-of-way are to be founded below the frost penetration depth, which is typically 1.2 metres in this area.

A reading schedule should be as follows:

- A minimum two (2) sets of readings prior to construction.
- A minimum of three (3) sets of readings each day during construction provided the movements are within the anticipated limits. Otherwise, the reading frequency may have to be increased.
- Monitoring of movements is required during work stoppages, such as non-operation periods (off-shifts) or weekends, where a minimum of 3 sets of reading shall be taken daily.
- Following the completion of the installation, reading must be taken once per day for seven (7) days and then weekly for one month.
- The frequency of monitoring at any stage can be adjusted based on the magnitude of movements observed during and after the completion of installation.

Instrumentation plans should be finalized once the contractor and installation method are selected. The instrumentation plans and monitoring schedule should be submitted to the MTO for final approval.

Control of ground settlement on this project depends on the behavior of soil at the tunnel face and on the tunneling methodology employed by the contractor. It is recommended that the volume of the material removed from the tunnel be monitored and continuously compared to the rate of tunnel advance. This would provide some indication if any over-excavation was taking place.

7.2 Criteria for Assessment of Roadway Subsidence

The criteria for evaluation of settlement should be based on the following action levels:

1. *Review Level:* If a maximum value of 10 mm relative to the baseline readings is reached, the method, rate or sequence of construction, or ground stabilization measures shall be reviewed or modified to mitigate further ground displacements.

2. *Alert Level:* If a maximum of 15 mm relative to the baseline readings is reached, the contractor shall be required to cease construction operation or to execute pre-planned measures to secure the site to mitigate further unacceptable settlement and to assure safety of public.

8. General Comments

Our comments are restricted to the site evaluated and to the topics discussed in this report. The comments and recommendations given are based on the assumption that the current design concept as described above will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications from a geotechnical viewpoint.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report in no way reflects on the environmental aspects of the soils, which has not been addressed as this is beyond our terms of reference. Should specific information be required, additional drilling and/or testing may be required. More specific information with respect to the conditions between samples, or the lateral and vertical extent of materials may become apparent during excavation operations. The interpretation of the borehole information must, therefore, be validated during excavation operations. Consequently, during the construction phase of the project, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required.

EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in the report.

We trust this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

EXP Services Inc.

LICENSED PROFESSIONAL ENGINEER
K. W. Y. LEUNG
April 30, 2020
PROVINCE OF ONTARIO

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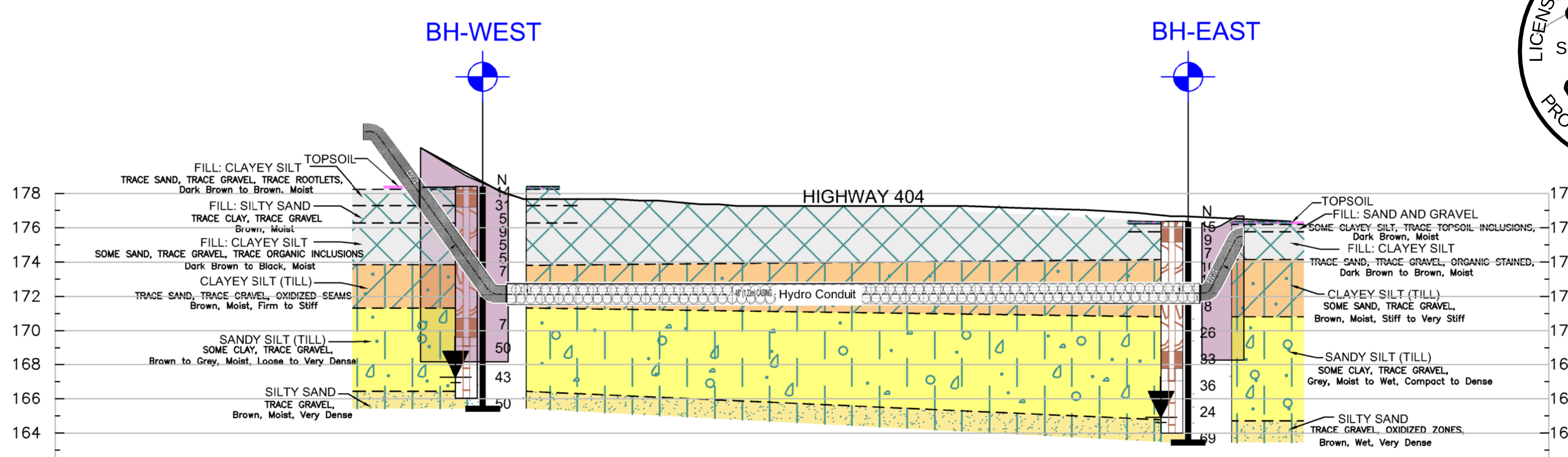
Drawings:
Borehole Location Plans
and Borehole Logs

METRIC

DIMENSIONS ARE IN METERS AND/OR MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS +METERS

PLAN

LICENSED PROFESSIONAL ENGINEER
S.E.M. GONSALVES
April 30, 2020
PROVINCE OF ONTARIO



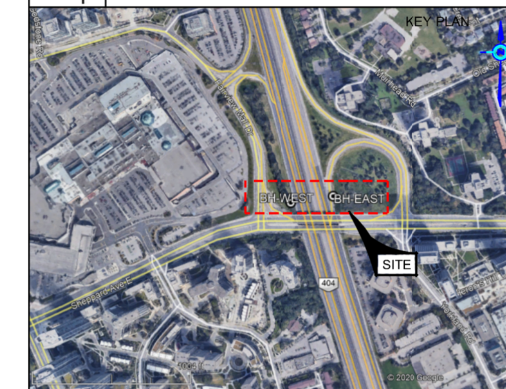
SECTION A-A

DIRECTIONAL DRILLING OF HYDRO CONDUIT
HIGHWAY 404 & SHEPPARD AVENUE EAST
TORONTO, ONTARIO

BOREHOLE LOCATION PLAN AND SOIL STRATA

SHEET 1

EXP Services Inc.



LEGEND

EXP Borehole Location (2020)

N Standard Penetration Test (Blows/0.3 m)

Groundwater Level in Piezometer

Piezometer

SIMPLIFIED STRATIGRAPHY

TOPSOIL
CLAYEY SILT (TILL)
SILTY SAND
FILL
SANDY SILT (TILL)

BH No.	ELEV.	UTM COORDINATE (*ZONE UTM17*)	
		NORTHING	EASTING
BH EAST	176.4	4848391.4	633645.4
BH WEST	178.4	4848389.0	633563.8

NOTES

1. THE BOUNDARIES AND SOIL TYPE HAVE BEEN ESTABLISHED ONLY AT THE BOREHOLE LOCATIONS. BETWEEN BOREHOLES THE BOUNDARIES ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR 3 MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES OTHERWISE.
3. TOPSOIL QUANTITIES AND/OR VOLUME OF UNSUITABLE FILL SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATION SHOULD NOT BE USED TO DESIGN BUILDING(S), OR FLOOR SLAB(S), OR PARKING LOT(S) GRADES.
5. THE DRAWING TO BE READ WITH SUBJECT REPORT, PROJECT NUMBER AS SHOWN BELOW.
6. SEE REPORT TEXT FOR SITE DATUM.
7. TEST HOLE LOCATIONS ARE APPROXIMATE.
8. DIMENSION SHOWN ON THIS DRAWING ARE IN METRIC UNITS, UNLESS OTHERWISE NOTED.

SCALE

HOR 0 2 10 m

VERT 0 1 10 m

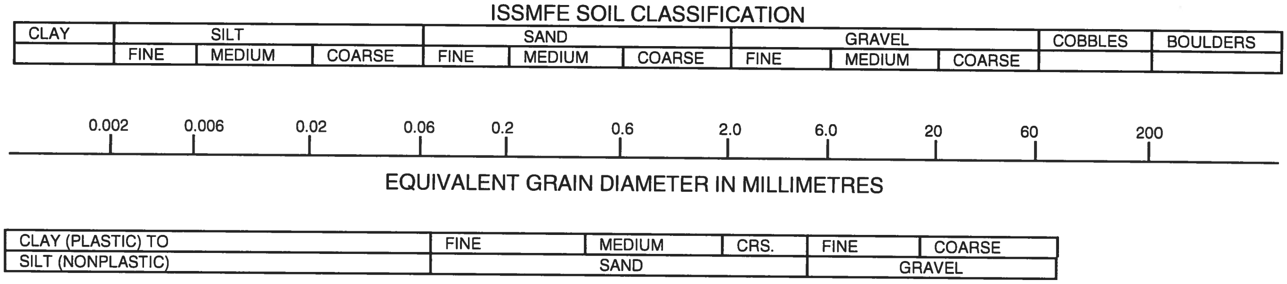
		SUBMISSION FOR MTO REVIEW	
		GEOCRES NO.	**30M14-517**
		PROJECT NO.	BRM-00607084-BE
SUBM'D SH	CHECKED SM	DATE	2020-04-29
DRAWN SH	CHECKED SM	APPROVED SG	DWG. 1

Notes On Sample Descriptions

Drawing 1A

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by EXP Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

ISSMFE SOIL CLASSIFICATION



UNIFIED SOIL CLASSIFICATION

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

RECORD OF BOREHOLE No EAST

SHEET 1 OF 1 **METRIC**

PROJECT NO. BRM-00607084-BE
LOCATION Hydro Crossing Highway 404 at Sheppard Ave East, Toronto
ORIGINATED BY DP

North: East:
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY KL

DATUM Geodetic
DATE 10/25/2019 - 10/25/2019
CHECKED BY KL

SOIL PROFILE

ELEV / DEPTH (m)	DESCRIPTION
176.4 / 0.0	~175 mm **TOPSOIL** over **FILL** - sand and gravel, some clayey silt, trace topsoil inclusions, dark brown, moist
175.8 / 0.6	**FILL** - claye silt, trace sand, trace gravel, organic stained, dark brown to brown, moist
174.2 / 2.2	**CLAYEY SILT TILL** - some sand, trace gravel, brown, moist, stiff to very stiff
170.9 / 5.5	**SANDY SILT TILL** - some clay, trace gravel, grey, moist, becoming wet below ~10 m depth, compact to dense
164.9 / 11.5	**SILTY SAND** - trace gravel, oxidized zones, brown, wet, very dense
163.7 / 12.8	End of Borehole

Water Levels:
On Completion - ~11.3 m
October 28, 2019 - No Water
October 31, 2019 - No Water

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ (kN/m³)	GR	SA	SI	CL
1	SS	15					
2	SS	9					
3	SS	7					
4	SS	10	22.0				
5	SS	19	22.5	2	24	50	24
6	SS	8	21.8				
7	SS	26	22.9	4	37	45	14
8	SS	33	23.7				
9	SS	36	23.2				
10	SS	24		4	41	45	10
11	SS	69					

ELEVATION SCALE: 176, 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164

SPT TEST (N-Value) ●
DYNAMIC CONE PENETRATION 20 40 60 80 100
SHEAR STRENGTH kPa
O UNCONFINED + FIELD VANE
⊗ QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT PL — NATURAL WATER CONTENT w — LIQUID LIMIT LL
WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity O ³% STRAIN AT FAILURE

exp.

1595 Clark Boulevard
Brampton, Ontario L6T 4V1

RECORD OF BOREHOLE No WEST

SHEET 1 OF 1 **METRIC**

PROJECT NO. BRM-00607084-BE	LOCATION Hydro Crossing Highway 404 at Sheppard Ave East, Toronto	ORIGINATED BY DP
North: East:	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY KL
DATUM Geodetic	DATE 10/25/2019 - 10/25/2019	CHECKED BY KL

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
178.4 / 0.0	~160 mm **TOPSOIL** over **FILL** - clayey silt, trace sand, trace gravel, trace rootlets, dark brown to brown, moist
177.3 / 1.1	**FILL** - silty sand, trace clay, trace gravel, brown, moist
176.3 / 2.1	**FILL** - clayey silt, some sand, trace gravel, trace organic inclusions, dark brown to black, moist
173.9 / 4.5	**CLAYEY SILT TILL** - trace sand, trace gravel, oxidized seams, brown, moist, firm to stiff
171.4 / 7.0	**SANDY SILT TILL** - some clay, trace gravel, brown to grey, moist, loose to very dense
166.6 / 11.8	**SILTY SAND** - trace gravel, brown, moist, very dense
165.6 / 12.8	End of Borehole

Water Levels:
On Completion ~11.0 m
October 28, 2019 - No Water
October 31, 2019 - No Water

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	14					
2	SS	31					
3	SS	5					
4	SS	9					
5	SS	5	19.9				
6	SS	5	22.2				
7	SS	7	22.6				
8	SS	10	22.7				
9	SS	7	22.5	1	35	47	17
10	SS	50 (50/125 mm)		6	35	45	15
11	SS	43	23.9 22.5				
12	SS	50					

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (178 to 166); SPT TEST (N-Value) ●; DYNAMIC CONE PENETRATION 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ⊗ QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT PL, NATURAL WATER CONTENT w, LIQUID LIMIT LL; WATER CONTENT (%) 10 20 30; REMARKS & GRAIN SIZE DISTRIBUTION (%).

$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

ON_MOT4KL 607084BE_MTO_LOGS.GPJ ON_MOT.GDT 11/1/19

Appendix A:
Grain Size Analyses and Atterberg Limits

exp Services Inc.
1595 Clark Boulevard, Brampton
Ontario, Canada, L6T 4V1
Telephone: (905) 793-9800
Fax: (905) 793-0641

Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 332233-1 **Report No.:** 1 **Date Reported:** 31-Oct-19

Project No.: brm-00607084-be
Project Name: GEO KL-Hwy 404 & Sheppard Ave East, Toronto,ON-Hydro Crossing

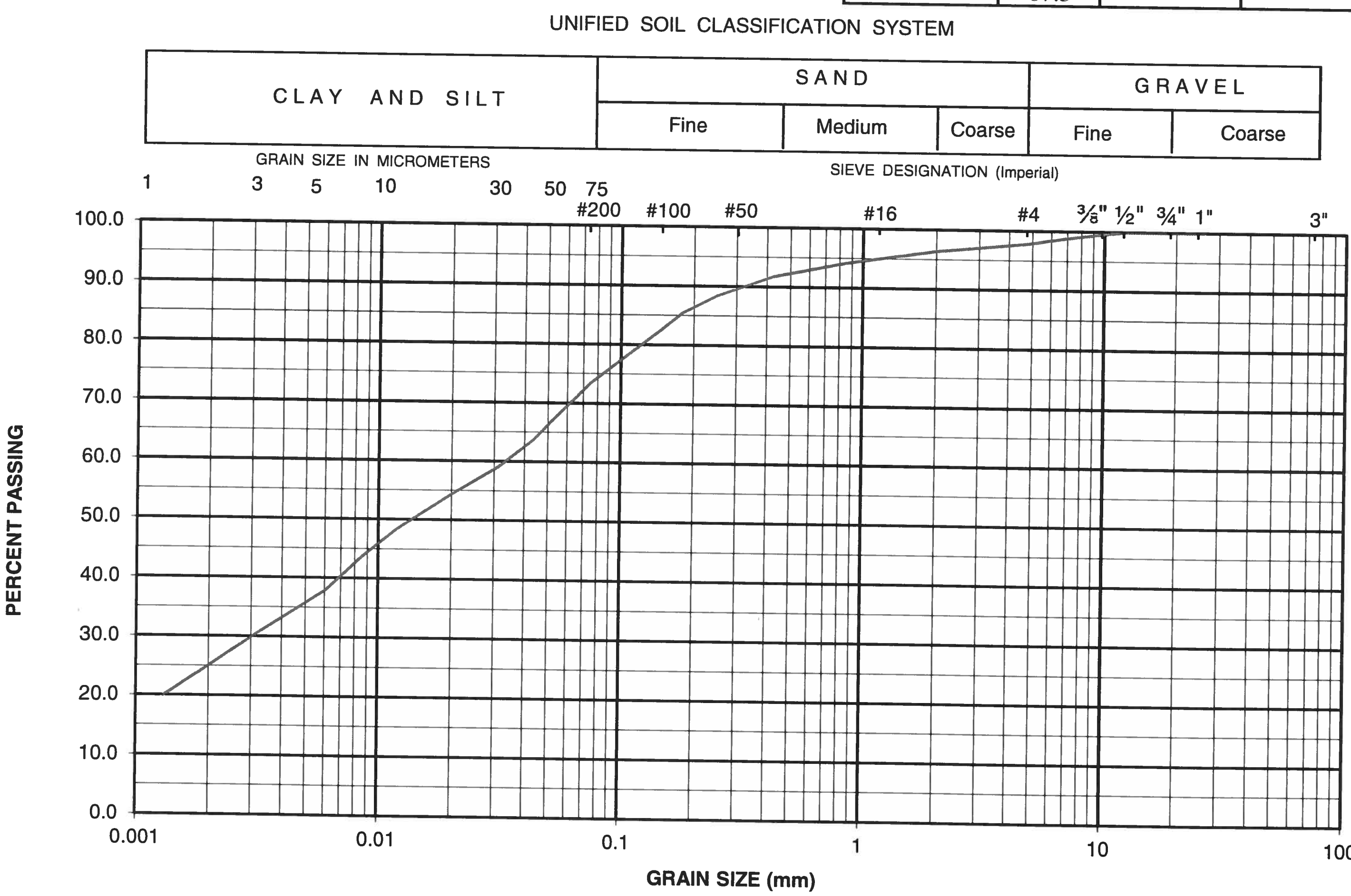
Grain Size Proportion (%)

Gravel (> 4.75mm):	2.2
Sand (> 75μm, < 4.75mm):	24.4
Silt (> 2μm), < 75μm):	49.5
Clay (< 2μm):	23.9
Total:	100.0

Sample Information

Location: Borehole EAST
Sample Method: SS
Sample No.: 5
Depth: 3.0 - 3.7 m
Sample Description: Clayey, Sandy Silt; trace Gravel; Brown
Sampled By: exp Brampton
Sampling Date: 10/25/2019
Date Received: 10/28/2019
Client Sample ID:
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0435	63.7
22.4	100.0	0.0313	59.1
19	100.0	0.0202	54.5
16	100.0	0.0119	48.4
13.2	100.0	0.0086	43.8
12.5	100.0	0.0061	38.0
9.5	99.5	0.0031	30.3
6.7	98.7	0.0013	19.9
4.75	97.8		
2	96.4		
0.85	94.2		
0.425	91.8		
0.25	88.4		
0.18	85.5		
0.15	82.9		
0.075	73.4		
0.053	67.3		



Project Manager: Kevin Leung **Approved By:** *Original Signed By* Willie Rodych, Lab Supervisor **Date Approved:** 31-Oct-19

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Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 332234-1 **Report No.:** 2 **Date Reported:** 31-Oct-19

Project No.: brm-00607084-be
Project Name: GEO KL-Hwy 404 & Sheppard Ave East, Toronto,ON-Hydro Crossing

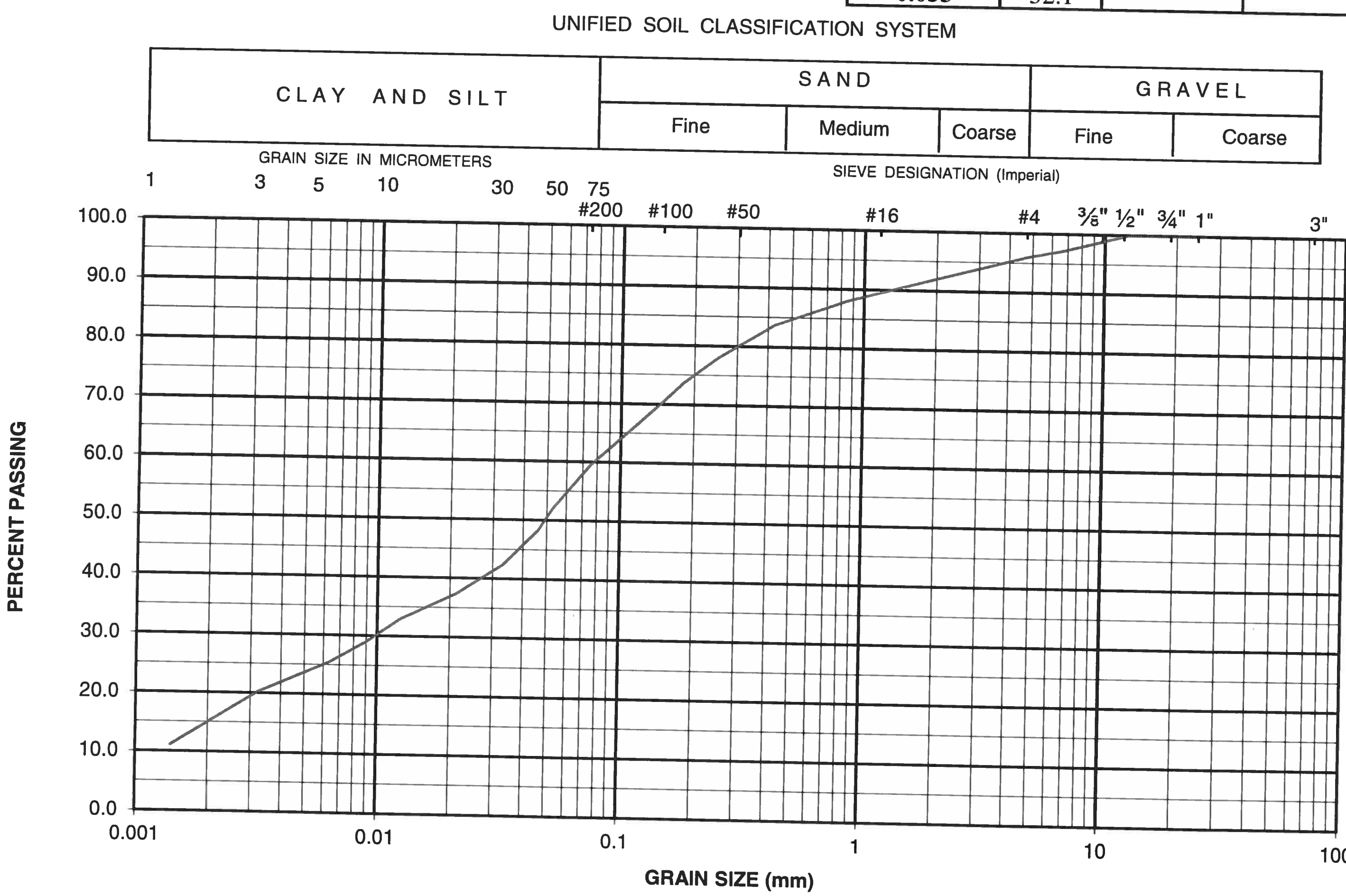
Grain Size Proportion (%)

Gravel (> 4.75mm):	4.0
Sand (> 75µm, < 4.75mm):	36.6
Silt (> 2µm), < 75µm):	45.3
Clay (< 2µm):	14.1
Total:	100.0

Sample Information

Location: Borehole EAST
Sample Method: SS
Sample No.: 7
Depth: 6.1 - 6.7 m
Sample Description: Silt and Sand, some Clay; trace Gravel; Grey
Sampled By: exp Brampton
Sampling Date: 10/25/2019
Date Received: 10/28/2019
Client Sample ID:
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0458	48.2
22.4	100.0	0.0331	42.4
19	100.0	0.0213	37.4
16	100.0	0.0125	33.0
13.2	100.0	0.0089	28.9
12.5	100.0	0.0063	25.4
9.5	98.7	0.0032	20.2
6.7	97.2	0.0014	11.1
4.75	96.0		
2	92.0		
0.85	88.0		
0.425	83.7		
0.25	78.0		
0.18	73.6		
0.15	70.5		
0.075	59.4		
0.053	52.1		



Project Manager: Kevin Leung **Approved By:** *Original Signed By*
Willie Rodych, Lab Supervisor
Date Approved: 31-Oct-19

exp.
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Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 332235-1 **Report No.:** 3 **Date Reported:** 31-Oct-19

Project No.: brm-00607084-be
Project Name: GEO KL-Hwy 404 & Sheppard Ave East, Toronto,ON-Hydro Crossing

Grain Size Proportion (%)

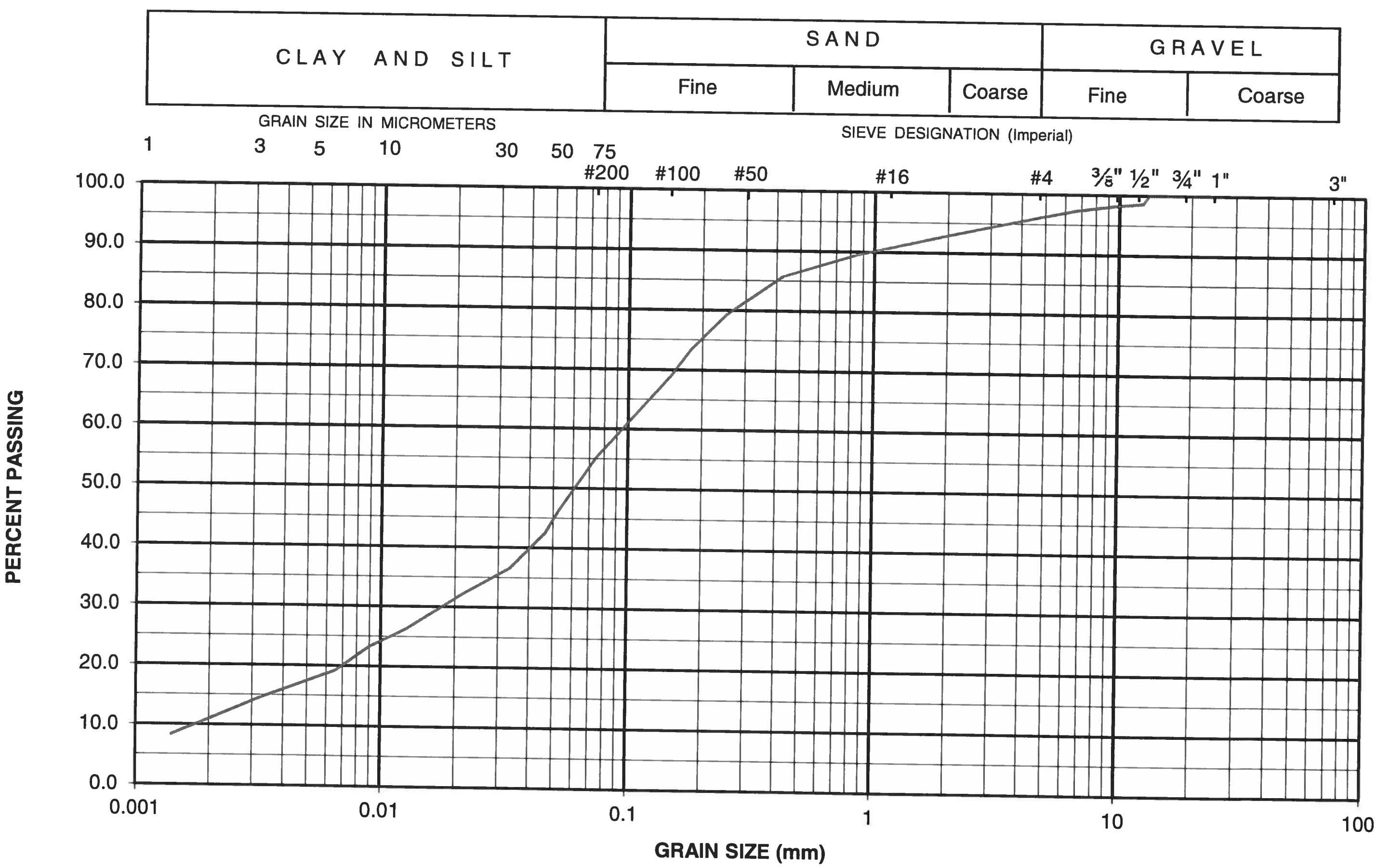
Gravel (> 4.75mm):	3.9
Sand (> 75µm, < 4.75mm):	40.8
Silt (> 2µm), < 75µm):	44.9
Clay (< 2µm):	10.4
Total:	100.0

Sample Information

Location: Borehole EAST
Sample Method: SS
Sample No.: 10
Depth: 10.7 - 11.3 m
Sample Description: Silt and Sand, some Clay; trace Gravel; Grey
Sampled By: exp Brampton
Sampling Date: 10/25/2019
Date Received: 10/28/2019
Client Sample ID:
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0463	42.5
22.4	100.0	0.0335	36.6
19	100.0	0.0215	32.2
16	100.0	0.0127	26.3
13.2	100.0	0.0090	23.3
12.5	98.6	0.0065	19.2
9.5	98.1	0.0032	14.5
6.7	97.3	0.0014	8.3
4.75	96.1		
2	92.9		
0.85	89.5		
0.425	85.8		
0.25	79.3		
0.18	73.5		
0.15	69.2		
0.075	55.3		
0.053	46.5		

UNIFIED SOIL CLASSIFICATION SYSTEM



Project Manager: Kevin Leung **Approved By:** *Original Signed By*
Willie Rodych, Lab Supervisor
Date Approved: 31-Oct-19

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Fax: (905) 793-0641

Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 332236-1 **Report No.:** 4 **Date Reported:** 31-Oct-19

Project No.: brm-00607084-be
Project Name: GEO KL-Hwy 404 & Sheppard Ave East, Toronto,ON-Hydro Crossing

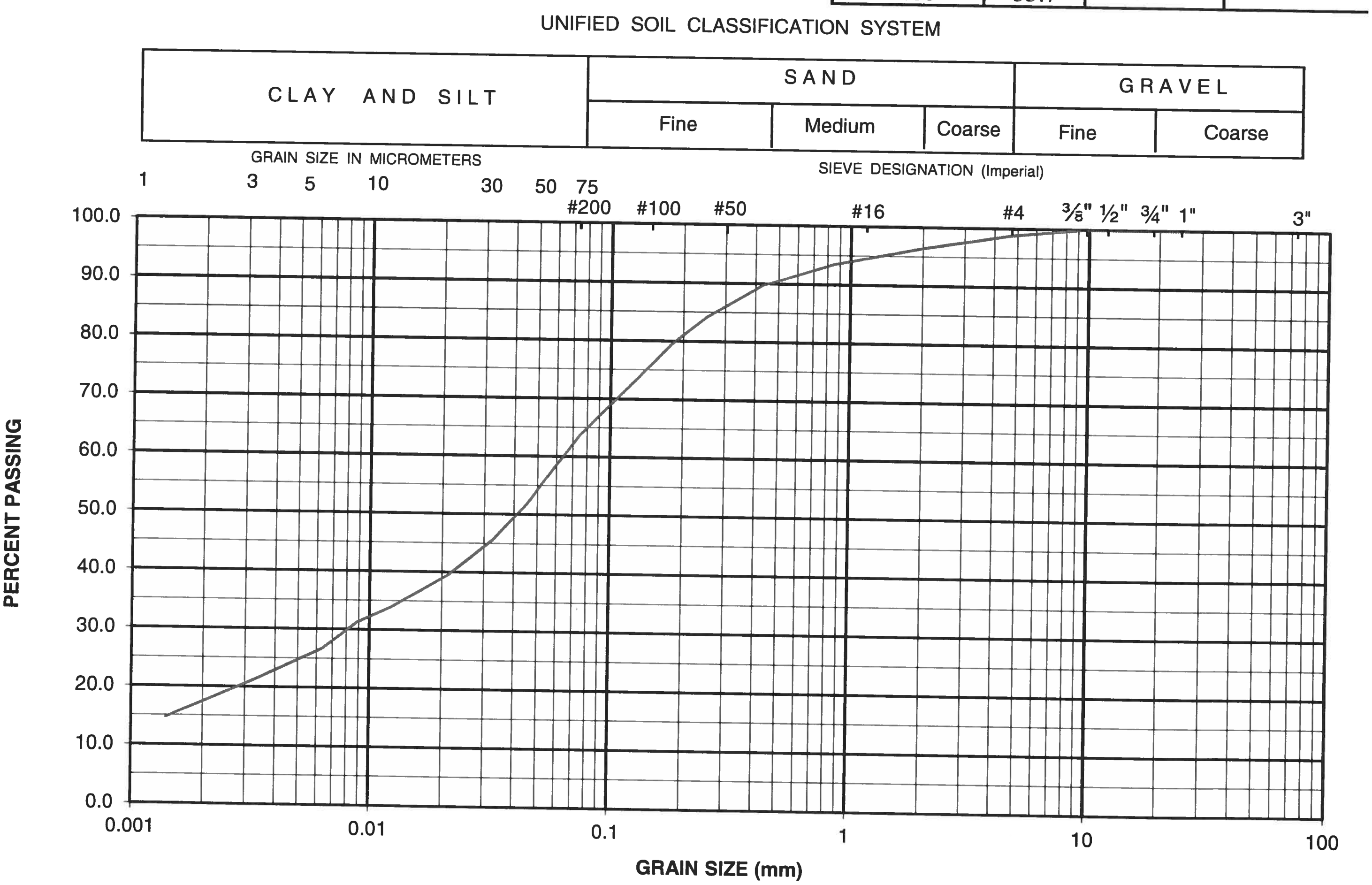
Grain Size Proportion (%)

Gravel (> 4.75mm):	1.2
Sand (> 75µm, < 4.75mm):	35.0
Silt (> 2µm), < 75µm):	47.0
Clay (< 2µm):	16.8
Total:	100.0

Sample Information

Location: Borehole WEST
Sample Method: SS
Sample No.: 9
Depth: 7.6 - 8.2 m
Sample Description: Silt and Sand, some Clay; trace Gravel; Brown
Sampled By: exp Brampton
Sampling Date: 10/25/2019
Date Received: 10/28/2019
Client Sample ID:
Comments:

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0451	51.8
22.4	100.0	0.0326	45.6
19	100.0	0.0211	39.5
16	100.0	0.0124	34.0
13.2	100.0	0.0088	31.2
12.5	100.0	0.0063	26.6
9.5	100.0	0.0032	21.1
6.7	99.4	0.0014	14.7
4.75	98.8		
2	96.4		
0.85	93.5		
0.425	89.6		
0.25	84.1		
0.18	79.6		
0.15	76.3		
0.075	63.8		
0.053	55.7		



Project Manager: Kevin Leung **Approved By:** *Original Signed By* Willie Rodych, Lab Supervisor **Date Approved:** 31-Oct-19

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Ontario, Canada, L6T 4V1
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Fax: (905) 793-0641

Grain Size Analysis & Hydrometer Test Report

ST08

Sample Test No.: 332237-1 **Report No.:** 5 **Date Reported:** 31-Oct-19

Project No.: brm-00607084-be
Project Name: GEO KL-Hwy 404 & Sheppard Ave East, Toronto,ON- Hydro Crossing

Grain Size Proportion (%)

Gravel (> 4.75mm):	5.5
Sand (> 75µm, < 4.75mm):	34.6
Silt (> 2µm), < 75µm):	44.6
Clay (< 2µm):	15.3
Total:	100.0

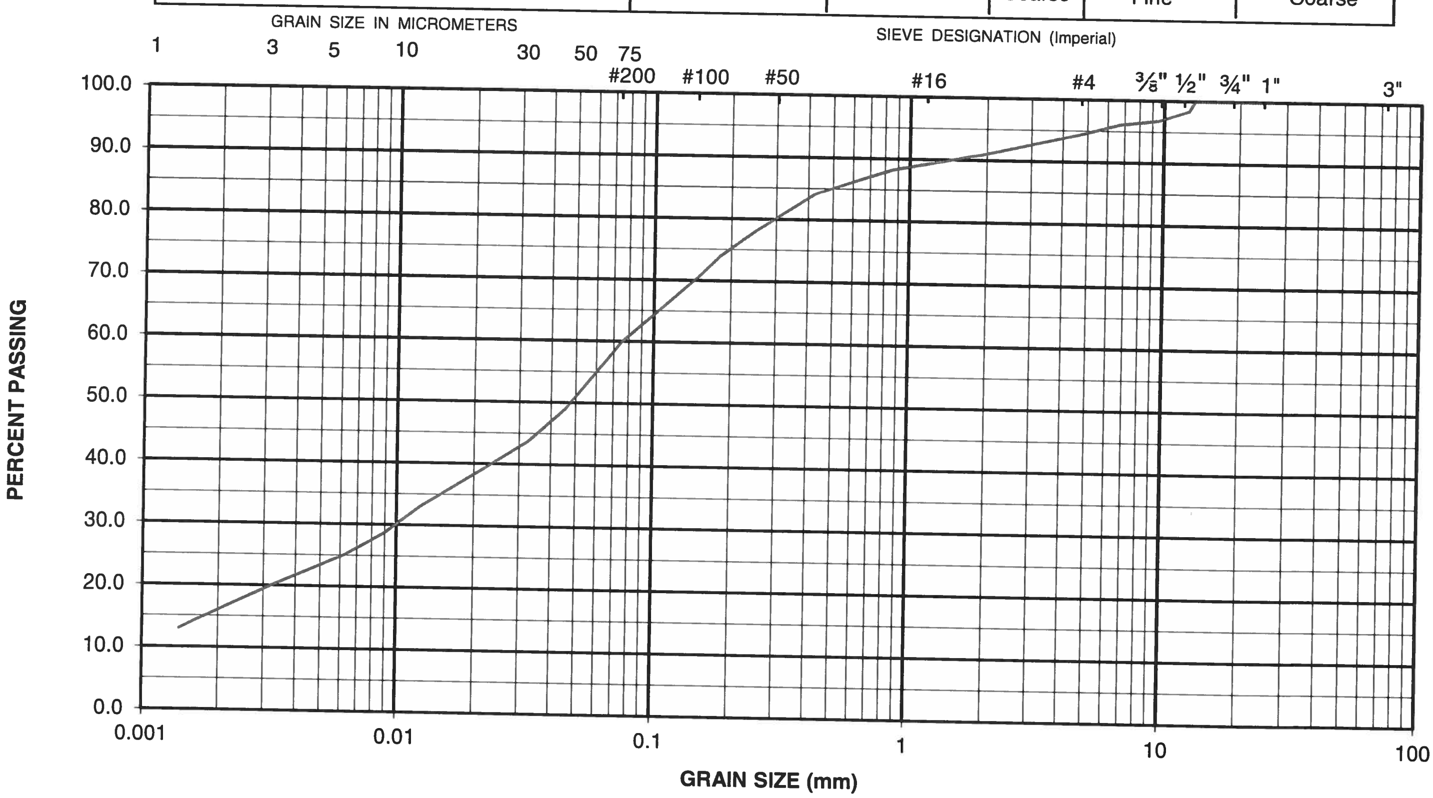
Sample Information

Location:	Borehole WEST
Sample Method:	SS
Sample No.:	10
Depth:	9.1 - 9.8 m
Sample Description:	Sandy Silt, some Clay; trace Gravel; Grey
Sampled By:	exp Brampton
Sampling Date:	10/25/2019
Date Received:	10/28/2019
Client Sample ID:	
Comments:	

Grain Size (mm)	% Passing	Grain Size (mm)	% Passing
26.5	100.0	0.0451	48.9
22.4	100.0	0.0325	43.7
19	100.0	0.0209	38.8
16	100.0	0.0123	33.0
13.2	100.0	0.0089	28.6
12.5	98.4	0.0063	25.2
9.5	96.8	0.0032	20.0
6.7	96.1	0.0014	13.0
4.75	94.5		
2	91.1		
0.85	88.2		
0.425	84.2		
0.25	78.1		
0.18	73.9		
0.15	70.7		
0.075	59.9		
0.053	52.3		

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Project Manager: Kevin Leung **Approved By:** *Original Signed By* Willie Rodych, Lab Supervisor **Date Approved:** 31-Oct-19

exp.
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Plasticity Index Test Report

ST03

Project No.: BRM-00607084-BE
Sample Number: 332238-1
Date Sampled: October 25, 2019
Date Received: October 28, 2019
Sample Location: Depth: 4.6 - 5.2 m

Date Reported: October 30, 2019
Borehole No: BH East / SS6

Liquid Limit

Trial Number	1	2	3	4	
Number of Blows	31	24	15		
Moisture Tin No.	25	29	32		
Mass of Soil and Tin, g	25.460	28.062	30.839		
Mass of Dry Soil and Tin, g	23.843	25.946	27.930		
Mass of Tin, g	16.631	16.676	15.626		
Mass of Water, g	1.617	2.116	2.909		
Mass of Dry Soil, g	7.212	9.270	12.304		
Water Content	22.4%	22.8%	23.6%		

Plastic Limit

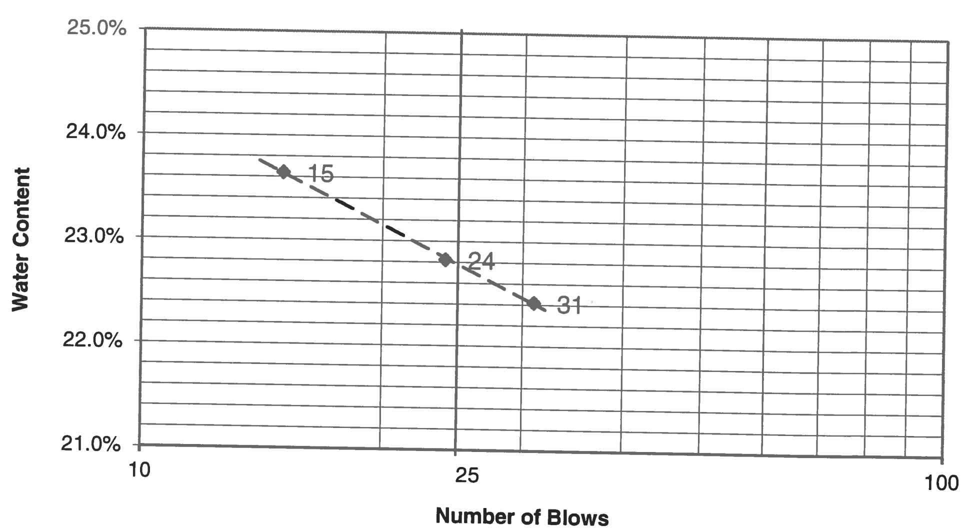
Trial Number	1	2	3
Moisture Tin No.	31	26	14
Mass of Soil and Tin, g	20.842	22.192	23.249
Mass of Dry Soil and Tin, g	20.268	21.588	22.535
Mass of Tin, g	15.522	16.756	16.586
Mass of Water, g	0.574	0.604	0.714
Mass of Dry Soil, g	4.746	4.832	5.949
Water Content	12.1%	12.5%	12.0%

Summary of Results

Liquid Limit *(LL)*: 23
Plastic Limit *(PL)*: 12
Plasticity Index *(PI)*: 11

CL

Flow Curve



Tested By: **Matt Perri**

Checked By: **Arcadio Petrola, CET**
Senior Lab. Technician

exp.
exp Services Inc.
1595 Clark Boulevard, Brampton
Ontario, Canada, L6T 4V1
Telephone: (905) 793-9800
Fax: (905) 793-0641

Plasticity Index Test Report

ST03

Project No.: BRM-00607084-BE
Sample Number: 332240-1
Date Sampled: October 25, 2019
Date Received: October 28, 2019
Sample Location: Depth: 6.1 - 6.7 m

Date Reported: October 30, 2019
Borehole No: BH West / SS8

Liquid Limit

Trial Number	1	2	3	4	
Number of Blows	32	24	14		
Moisture Tin No.	23	22	9		
Mass of Soil and Tin, g	22.942	25.842	31.167		
Mass of Dry Soil and Tin, g	21.748	24.188	28.448		
Mass of Tin, g	15.836	16.473	16.782		
Mass of Water, g	1.194	1.654	2.719		
Mass of Dry Soil, g	5.912	7.715	11.666		
Water Content	20.2%	21.4%	23.3%		

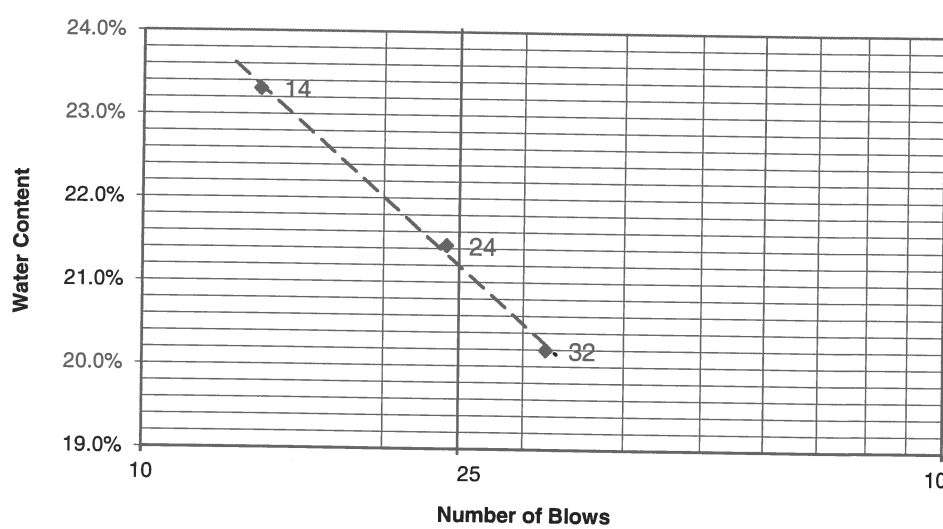
Plastic Limit

Trial Number	1	2	3
Moisture Tin No.	17	4	2
Mass of Soil and Tin, g	21.817	20.823	23.513
Mass of Dry Soil and Tin, g	21.273	20.261	22.798
Mass of Tin, g	16.702	15.503	16.826
Mass of Water, g	0.544	0.562	0.715
Mass of Dry Soil, g	4.571	4.758	5.972
Water Content	11.9%	11.8%	12.0%

Summary of Results

Liquid Limit *(LL)*:	21
Plastic Limit *(PL)*:	12
Plasticity Index *(PI)*:	9
	CL

Flow Curve



Tested By: **Matt Perri**

Checked By: **Arcadio Petrola, CET**
Senior Lab. Technician

Appendix B:

H.Q. Golder & Associate Ltd., (1964) "Site Investigation for Proposed Don Valley Parkway Underpass at Sheppard Ave East, Toronto, Ontario" (Geocres No. 30M14-398)

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS

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REPORT

TO

EWBANK PILLAR AND ASSOCIATES LTD.

ON

SITE INVESTIGATION

FOR

PROPOSED DON VALLEY PARKWAY UNDERPASS

AT

SHEPPARD AVE. EAST

TORONTO ONTARIO

Distribution:

6 copies - Ewbank Pillar and Associates Ltd.

2 copies - H. Q. Golder & Associates Ltd.

August, 1964 64065

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ABSTRACT

The results of a site investigation for a proposed structure to carry Sheppard Ave. East over the proposed Don Valley Parkway are reported. Recommendations are made for the foundations of the structure and the stability of the approach embankments is considered.

The soil in the area under consideration is topsoil or pavement with underlying fill for depths up to 3.5 feet. Beneath the surface deposits is a silt till 12 to 18 feet thick in a very stiff to hard condition. A layer of stiff silty clay about 3 feet thick underlies the till. Beneath the clay is a lower till 9 to 14 feet thick which, except for the top few feet, is in a hard to very hard state. Very dense sand underlies this lower till.

It is recommended that the central pier be founded on a spread footing with a design net bearing pressure of 3 tons/sq. ft. The abutments may be founded on piles driven through the embankment to practical refusal in the lower till. Twelve in. circular piles driven to practical refusal in the lower till may be loaded to 35 tons each or Franki type piles in the lower till to 100± tons.

It is anticipated that foundations as above will result in a differential settlement of from ½ to 3/4 inches. Other methods of founding are recommended in the report if this differential settlement is too great for the structure.

No stability problem is anticipated for embankments built of good quality fill at the usual slopes of two horizontal to one vertical.

INTRODUCTION

H. Q. Golder and Associates Ltd. were retained by Ewbank, Pillar and Associates Limited to carry out a site investigation for the grade separation at the proposed Don Valley Parkway (now Woodbine Ave) and Sheppard Ave in the municipality of Metropolitan Toronto. The purpose of the investigation was to determine the subsoil conditions at the site, to make recommendations for the foundations of the structure that will provide the grade separation and to assist in determining the stability of the approach embankments for the structure.

At this location the Don Valley Parkway will run in a north-south direction with the pavement surface one to two feet above the pavement level of the existing Woodbine Ave. Sheppard Ave. East will be carried over the Parkway by a structure. A site plan and cross sections are given on Figure 1.

PROCEDURE

The field work for this investigation was carried out during the period June 4, 1964 to June 9, 1964 using a power auger for the borings. A total of 6 boreholes were put down at this site to depths ranging between 30.5 and 50.5 feet. Dynamic cone penetration tests were carried out at each borehole.

The locations of the borings are given on the accompanying Figure 1 and a detailed log for each boring is given on the Records of Boreholes following the text of this report.

The samples obtained during the investigation were brought to our laboratory for examination and testing. The results of the testing are shown on the Records of Boreholes and on Figures 2, 3 and 4 which give the grain size distribution of selected samples.

SITE GEOLOGY AND CONDITIONS

The site lies on what is known geologically as the "Peel Plain". This plain is largely composed of a till resulting from the most recent glaciation of the area. The till overlies interglacial and interstadial sands and is itself overlain in places by post glacial sands and clays.

The area of the site is relatively flat with less than three feet difference in elevation between any two points in the vicinity of the structure and under a considerable proportion of the approach embankments. No usual drainage or surface conditions are evident.

SOIL CONDITIONS

The general soil conditions are shown schematically on the cross sections on Figure 1.

The surface of the site is covered by pavement and fill varying in thickness from 0.4 to 3.5 feet with some areas of topsoil up to at least two feet thick in the west portion of the site.

Beneath the pavement, fill and topsoil is a clayey silt till containing some sand and a trace of gravel. This till stratum varies in thickness from 12 to 18 feet and is generally in a very stiff to hard condition. The upper portion of the stratum is weathered and brown in colour and in all boreholes except No. 24 the lower part of the stratum, varying in thickness from 2.5 to 6 feet, is grey.

Underlying the till is a stratum of grey silty clay two to three feet thick that was encountered in all boreholes. This clay is in a stiff to very stiff consistency.

Grey clayey silt till containing some sand and a trace of gravel occurs beneath the silty clay stratum. This lower till which varies in thickness from 9 to 14 feet, is similar to the unweathered portion of the upper till but is generally in a hard to very hard condition except for the top few feet of the stratum which is very stiff.

Very dense brown silty fine to medium sand was encountered under the lower till in four of the six boreholes at depths varying from 31 to 27 feet below the surface.

WATER CONDITIONS

Standpipes were installed in the six boreholes and readings of water level taken on five occasions between June 9 and August 5, 1964. The highest water level measured during that period is shown on the Record of Boreholes. The measured water elevations indicate that the water table is four or five feet from the surface at the west end of the site, boreholes 20 and 21, and from 17 to 42 feet from the surface at the remainder of the site. It is noticable that the deeper standpipes give a lower water elevation indicating that there is probably a hydraulic gradient acting downward at this site and possibly a perched water table above the silty clay layer.

In general the water table elevation and soil at this site is such that no water problems are likely to be encountered in excavations for spread footings founded at the usual depths of four or five feet.

DISCUSSION

It is understood that the structure proposed for this site is to consist of two spans of 125 feet each and is to be of prestressed concrete. The center support is to be a pier and the abutments will be in the approach embankment. At the center line of Sheppard Ave. East the pavement surface of the Parkway will be about one foot above the level of the present pavement.

The foundation conditions at the site may be summarized as an upper till up to 18 feet thick which has a moderately good load carrying capacity, a layer of silty clay about three feet thick that has only a fair load carrying capacity and a lower till and sand, the top few feet of which is only fair but below that is excellent for foundation purposes.

It is recommended that the central pier be founded on a spread footing in the upper till at the minimum depth necessary for frost protection using a net unit loading of 3 tons/sq. ft. In order to avoid possible settlement of the abutments if they were founded in the approach fill it is recommended that they be founded on displacement piles driven through the embankment and upper till to practical refusal in the lower till at or below elevation 555 feet, about 25 feet below the present road surface. For displacement piles driven to practical refusal in the lower till allowable pile loads would be of the order of 35 tons for 12 in. circular piles driven closed end and 100± tons for Franki type piles. Capacity of the latter type piles would usually be based on a test of one pile.

It is estimated that for the allowable loads given above, the pier footing will settle a slight amount and the settlement of the abutment will be smaller resulting in a differential settlement between the pier and abutments of the order of ½ to 3/4 inches. A considerable proportion of this settlement will be complete by the time construction is complete.

Should the above settlement be too great for the proposed structure the alternatives are to found the central pier on piles driven to the same elevation and with the same allowable loads as for the abutments or to found the abutments on a spread footing at the same elevation as the pier footing and use a spill through type abutment. If the latter alternative is used the net load brought to the soil by the footing should be of the order of 2 tons/sq. ft. in order that this foundation load plus the load brought in by the embankment will cause the same amount of settlement as the 3 tons/sq. ft. under the pier.

The shearing strength of the soil near the surface is high enough that no stability problems are anticipated for the slopes of embankments at the usual angle of two horizontal to one vertical and for the heights proposed.

F. A. De Lory

F. A. De Lory, P.Eng.

V. Milligan

V. Milligan, P.Eng.

LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

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

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, N: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer

PH sampler advanced by pressure—pressure, hydraulic

PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

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

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
Very soft	Less than 250
Soft	250 to 500
Firm	500 to 1,000
Stiff	1,000 to 2,000
Very stiff	2,000 to 4,000
Hard	over 4,000

IV. SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	combined analysis, sieve and hydrometer[1]
Q	undrained triaxial[2]
R	consolidated undrained triaxial[2]
S	drained triaxial
U	unconfined compression
V	field vane test

NOTES:

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

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

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

e = base of natural logarithms 2.7183

$\log_e a$ or $\ln a$, natural logarithm of a

$\log_{10} a$ or $\log a$, logarithm of a to base 10

t	time
g	acceleration due to gravity
V	volume
W	weight
M	moment
F	factor of safety

II. STRESS AND STRAIN

u	pore pressure
σ	normal stress
σ'	normal effective stress ($\bar{\sigma}$ is also used)
τ	shear stress
ϵ	linear strain
ϵ_{xy}	shear strain
ν	Poisson's ratio (μ is also used)
E	modulus of linear deformation (Young's modulus)
G	modulus of shear deformation
K	modulus of compressibility
η	coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ	unit weight of soil (bulk density)
γ_s	unit weight of solid particles
γ_w	unit weight of water
γ_d	unit dry weight of soil (dry density)
γ'	unit weight of submerged soil
G_s	specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e	void ratio
n	porosity
w	water content
S_r	degree of saturation

(b) *Consistency*

w_L	liquid limit
w_P	plastic limit
I_P	plasticity index
w_S	shrinkage limit
I_L	liquidity index $= (w - w_P)/I_P$
I_C	consistency index $= (w_L - w)/I_P$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
D_r	relative density $= (e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h	hydraulic head or potential
q	rate of discharge
v	velocity of flow
i	hydraulic gradient
k	coefficient of permeability
j	seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v	coefficient of volume change $= -\Delta e/(1+e)\Delta\sigma'$
C_c	compression index $= -\Delta e/\Delta \log_{10} \sigma'$
c_v	coefficient of consolidation
T_v	time factor $= c_v t/d^2$ (d, drainage path)
U	degree of consolidation

(e) *Shear strength*

τ_f	shear strength	
c'	effective cohesion intercept	in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
ϕ'	effective angle of shearing resistance, or friction	
c_u	apparent cohesion*	in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
ϕ_u	apparent angle of shearing resistance, or friction	
μ	coefficient of friction	
S_t	sensitivity	

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.

64065

RECORD OF BOREHOLES 20 & 21

LOCATION See Figure 1 BORING DATE JUNE 4 & 9, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES

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

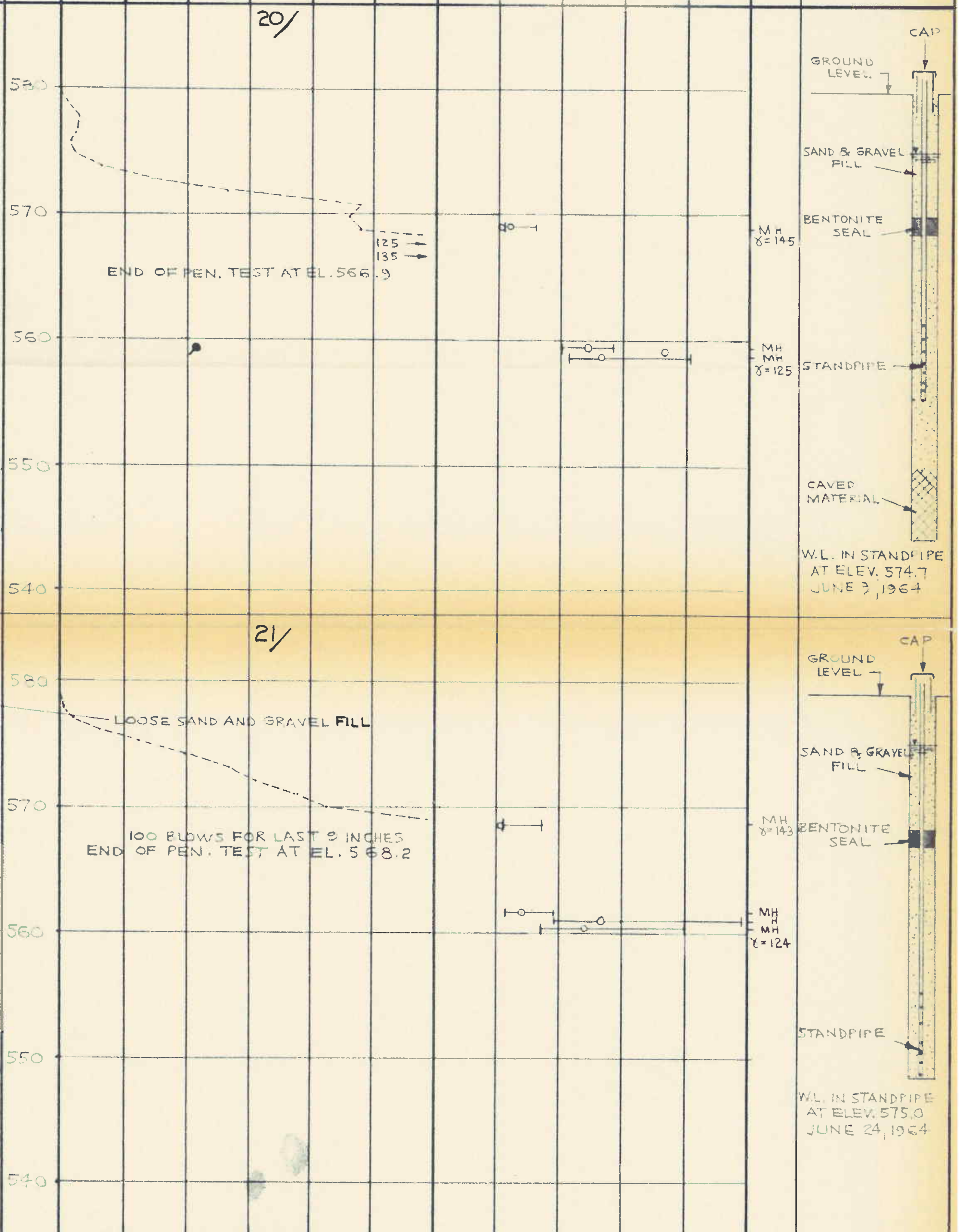
Borehole 20

ELEVN. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.
573.9	GROUND LEVEL			
0.0	TOPSOIL			
2.0	VERY STIFF TO HARD BROWN CLAYEY SILT SOME SAND, TRACE GRAVEL. (TILL)	1	2" DO	14
		2	"	31
		3	"	56
		4	"	47
		5	"	59
		6	"	61
563.6 / 16.3	STIFF GREY CLAYEY SILT SOME SAND, TRACE GRAVEL (TILL)	7	"	29
560.9 / 19.0	STIFF GREY SILTY CLAY, TRACE SAND	8	TO	PH
557.9 / 22.0	HARD GREY CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	9	"	100
		10	DO	>100
548.9 / 31.0	VERY DENSE BROWN SILTY FINE TO MEDIUM SAND.	11	"	>100
544.5 / 35.4	END OF HOLE			

Borehole 21

ELEVN. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.
579.0	GROUND LEVEL			
0.4	VERY STIFF TO HARD BROWN CLAYEY SILT SOME SAND, TRACE GRAVEL (TILL)	1	2" DO	21
		2	"	39
		3	"	40
		4	"	59
567.0 / 12.0	VERY STIFF GREY CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	5	"	20
		6	"	22
561.0 / 18.0	STIFF GREY SILTY CLAY	7	"	15
19.0	VERY STIFF TO HARD CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	8	"	17
		9	"	>100
548.5 / 30.5	END OF HOLE	10	"	>100

ELEVATION SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS/FT. (20, 40, 60, 80, 100) | SHEAR STRENGTH C_u, LB./SQ.FT. ● – Q (1000, 2000, 3000, 4000, 5000) | COEFFICIENT OF PERMEABILITY k, CM./SEC. | WATER CONTENT, PERCENT W_P W W_L (10, 20, 30, 40) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION



15-◇-5 Percent axial strain at failure (10)

VERTICAL SCALE

1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN

RECORD OF BOREHOLE 22

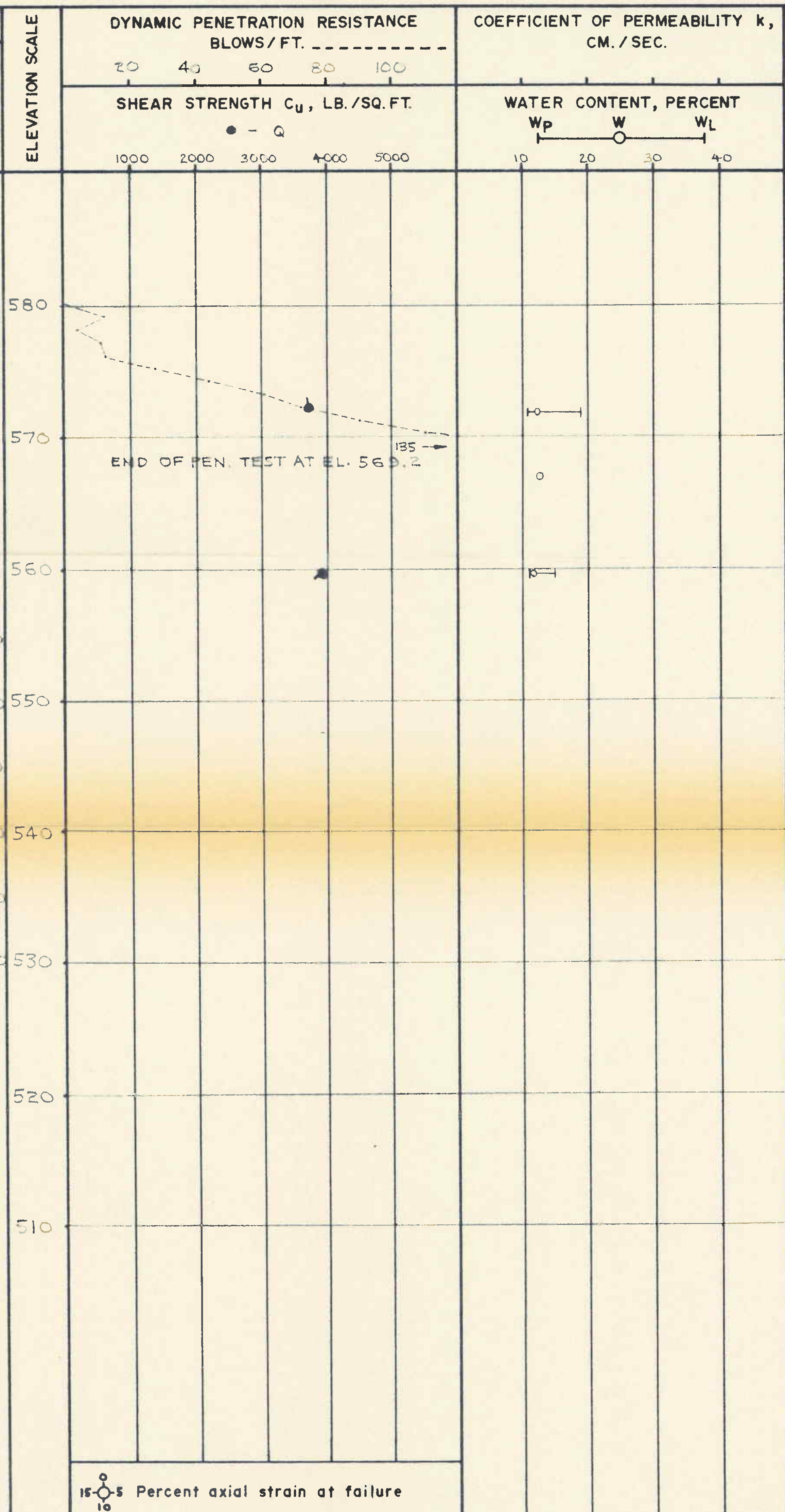
64065

LOCATION See Figure 1 BORING DATE JUNE 4-5, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5"

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

ELEVN. / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING
580.2	GROUND LEVEL				
0.0	CLAY, SILTY SAND AND GRAVEL MIXTURE. (FILL)				
576.7 / 3.5	VERY STIFF TO HARD BROWN CLAYEY SILT SOME SAND, TRACE GRAVEL. (TILL)	1	2" DO	17	
		2	TO	PH	
		3	"	PH	MH γ=141
		4	"	PH	
		5	DO	52	MH γ=144
		6	"	36	
564.2 / 16.0	VERY STIFF GREY SILTY CLAY, TRACE SAND.	7	"	21	
561.7 / 18.5	VERY STIFF TO HARD GREY CLAYEY SILT, SOME SAND, TRACE GRAVEL. (TILL)	8	TO	PH	MH γ=140
		9	DO	>100	
549.2 / 31.0	VERY DENSE BROWN SILTY FINE SAND TO FINE TO MEDIUM SAND SOME SILT.	10	"	>100	
		11	"	>100	
		12	"	>100	
		13	"	>100	
529.7 / 50.5	END OF HOLE	14	"	>100	



PIEZOMETER OR STANDPIPE INSTALLATION

CAP

GROUND LEVEL

SAND & GRAVEL FILL

BENTONITE SEAL

STANDPIPE

CAVED MATERIAL

WATER TABLE BELOW ELEV. 538.2 DURING PERIOD JUNE 9 TO AUG. 5, 1964.

VERTICAL SCALE 1 INCH TO ... 5'

GOLDER & ASSOCIATES

DRAWN M.W.

CHECKED ...

RECORD OF BOREHOLES 23 & 24

64065

LOCATION See Figure 1 BORING DATE JUNE 8-9, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5 INCHES

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

23

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING
578.7	GROUND LEVEL				
0.0	SOFT SANDY SILT TO DENSE SAND AND GRAVEL (FILL)				
2.6	VERY STIFF TO HARD BROWN CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	1	2" DO	32	
		2	"	23	MH γ=134
		3	"	45	
		4	"	42	
565.2 / 13.5	VERY STIFF TO STIFF GREY CLAYEY SILT, SOME SAND (TILL)	5	"	31	
		6	"	17	
560.7 / 18.0	VERY STIFF GREY SILTY CLAY.	7	"	11	H
557.7 / 21.0	STIFF TO HARD CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	8	"	15	
		9	"	>100	
		10	"	57	
541.7	VERY DENSE GREY FINE TO MEDIUM SAND, SOME SILT, TRACE GRAVEL	11	"	>100	
37.5	END OF HOLE				

END OF PEN. TEST AT EL. 568.7

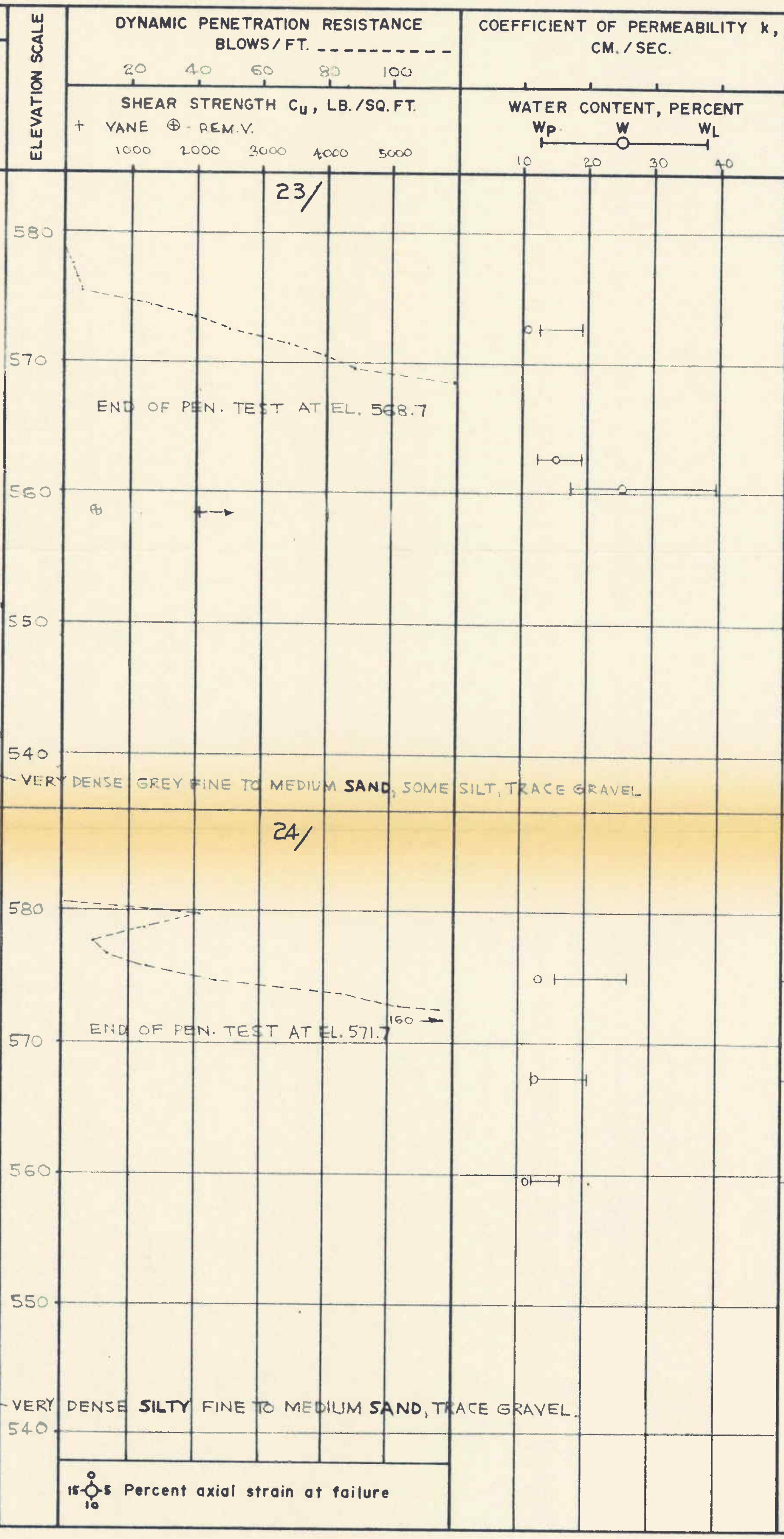
PIEZOMETER OR STANDPIPE INSTALLATION: CAP; GROUND LEVEL; SAND & GRAVEL FILL; BENTONITE SEAL; STANDPIPE. W.L. IN STANDPIPE AT ELEV. 552.2 JUNE 9, 1964.

24

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING
	PAVEMENT				
580.7	GROUND LEVEL				
0.0	SAND AND GRAVEL FILL				
2.0	VERY STIFF TO HARD BROWN CLAYEY SILT SOME SAND, TRACE GRAVEL (TILL)	1	2" DO	22	
		2	"	45	MH γ=135
		3	"	61	
		4	"	45	
		5	"	45	γ=141
		6	"	46	
563.2 / 17.5	STIFF GREY SILTY CLAY	7	"	14	
19.0	STIFF TO HARD CLAYEY SILT, SOME SAND, TRACE GRAVEL. (TILL)	8	"	12	MH
		9	"	74	
		10	"	>100	
544.6	VERY DENSE SILTY FINE TO MEDIUM SAND, TRACE GRAVEL.	11	"	>100	
36.5	END OF HOLE				

END OF PEN. TEST AT EL. 571.7

PIEZOMETER OR STANDPIPE INSTALLATION: CAP; GROUND LEVEL; SAND & GRAVEL FILL; BENTONITE SEAL; STANDPIPE. W.L. IN STANDPIPE AT ELEV. 565.0 JUNE 24, 1964.



15-○-5 10 Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 10'-0"

GOLDER & ASSOCIATES

DRAWN M.W.

RECORD OF BOREHOLE 25

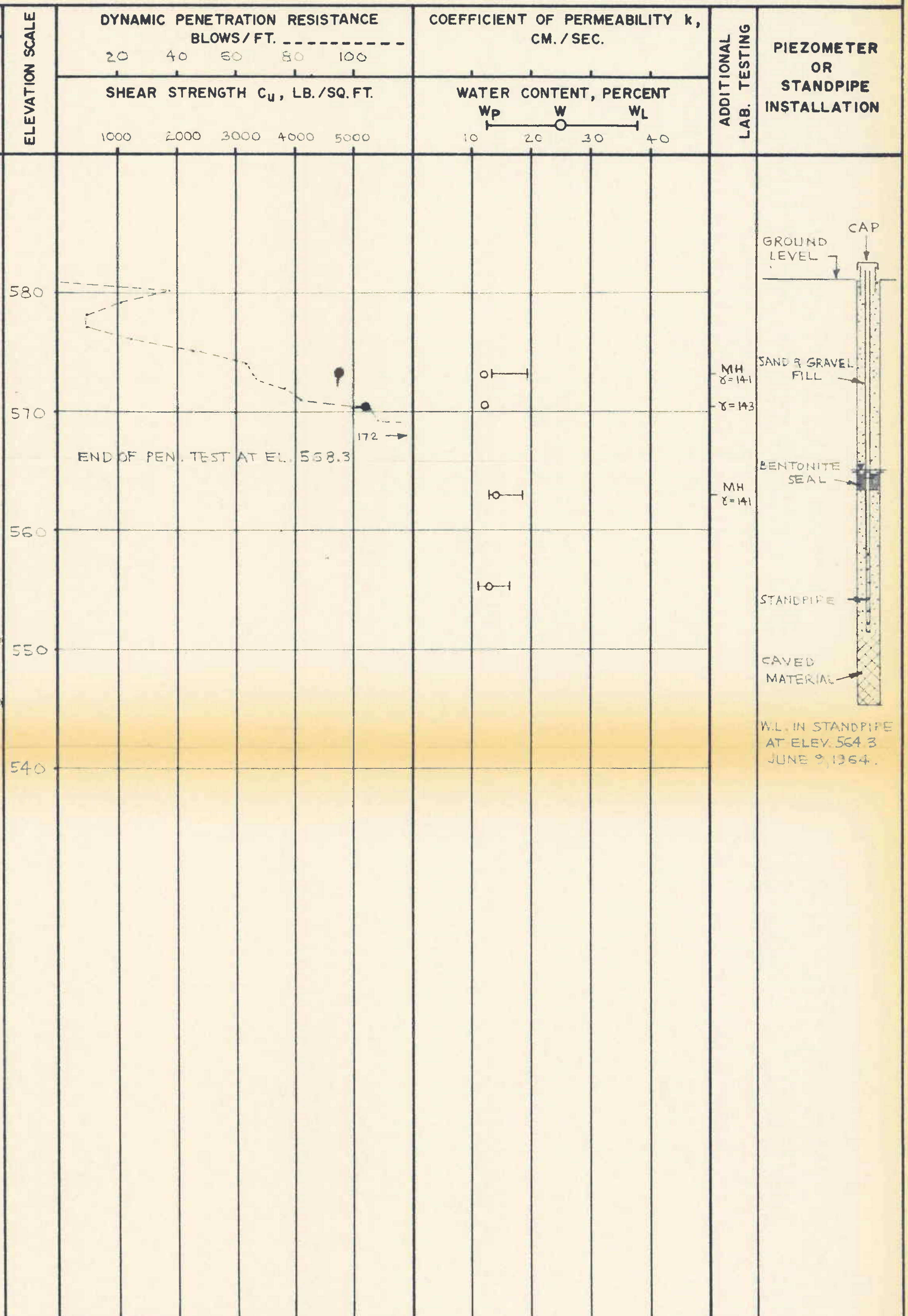
64065

LOCATION See Figure 1 **BORING DATE** JUNE 8, 1964 **DATUM** GEODETIC

BOREHOLE TYPE POWER AUGER BORING **BOREHOLE DIAMETER** 4.5 INCHES

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

ELEVN. / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FT.
581.3	GROUND LEVEL (PAVEMENT)			
0.0	SAND AND GRAVEL FILL AND TOPSOIL			
2.0	VERY STIFF TO HARD BROWN CLAYEY SILT, SOME SAND, TRACE GRAVEL (TILL)	1	2" DO	10
		2	"	29
		3	TO	PH
		4	"	PH
		5	"	PH
566.3 / 15.0	HARD TO VERY STIFF CLAYEY SILT, SOME SAND (TILL)	6	DO	41
		7	"	25
561.3 / 20.0	STIFF GREY SILTY CLAY	8	"	13
22.0	HARD GREY CLAYEY SILT, SOME SAND, TRACE GRAVEL. (TILL)	9	"	39
		10	"	>100
		11	"	>100
545.3 / 36.0	END OF HOLE			



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

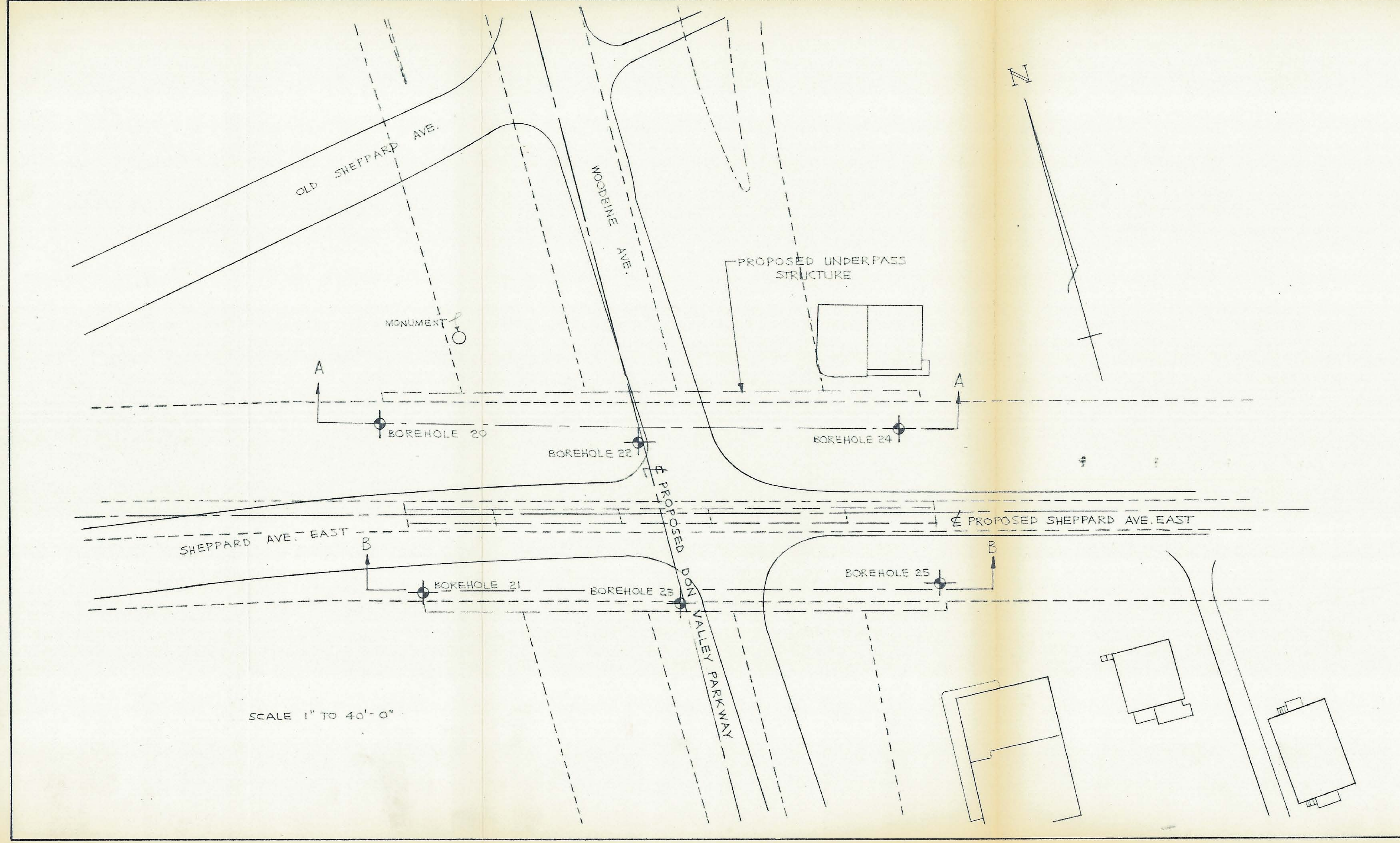
VERTICAL SCALE

GOLDER & ASSOCIATES

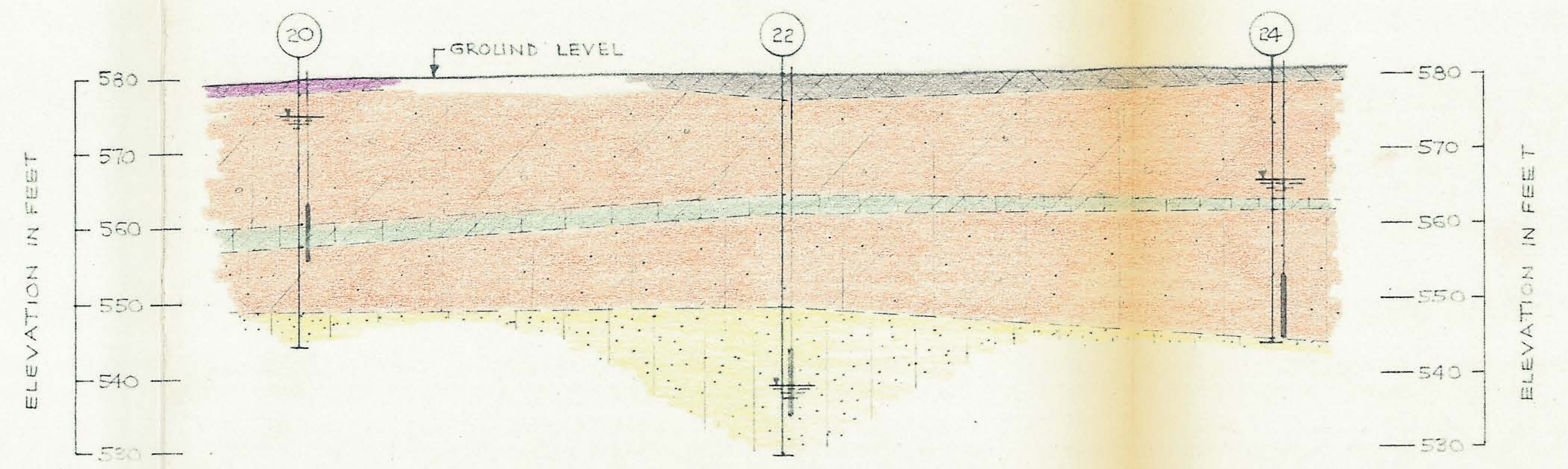
DRAWN M.W.

6065

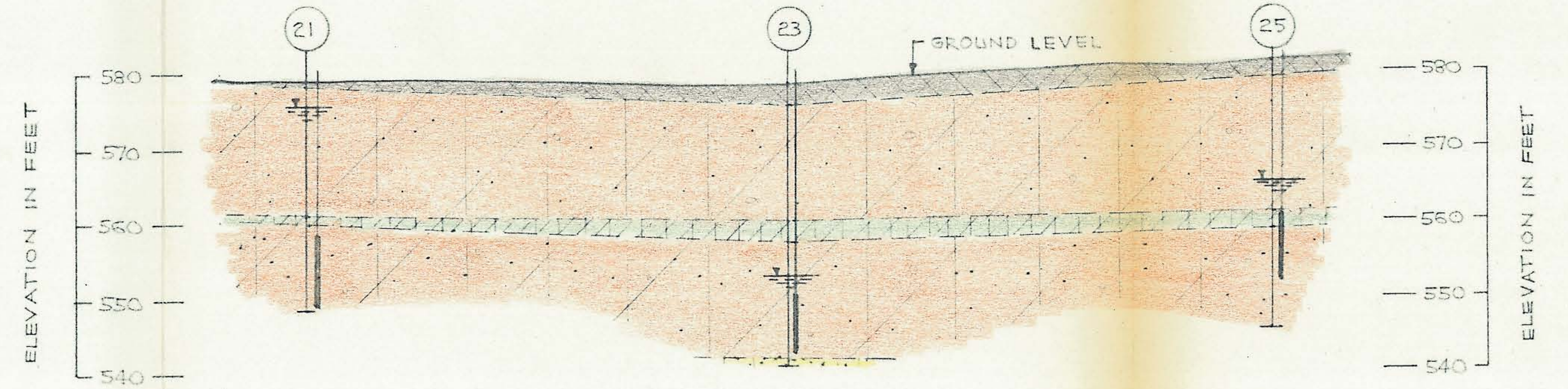
BORING PLAN AND SECTIONS	FIGURE 1



SCALE 1" TO 40'-0"

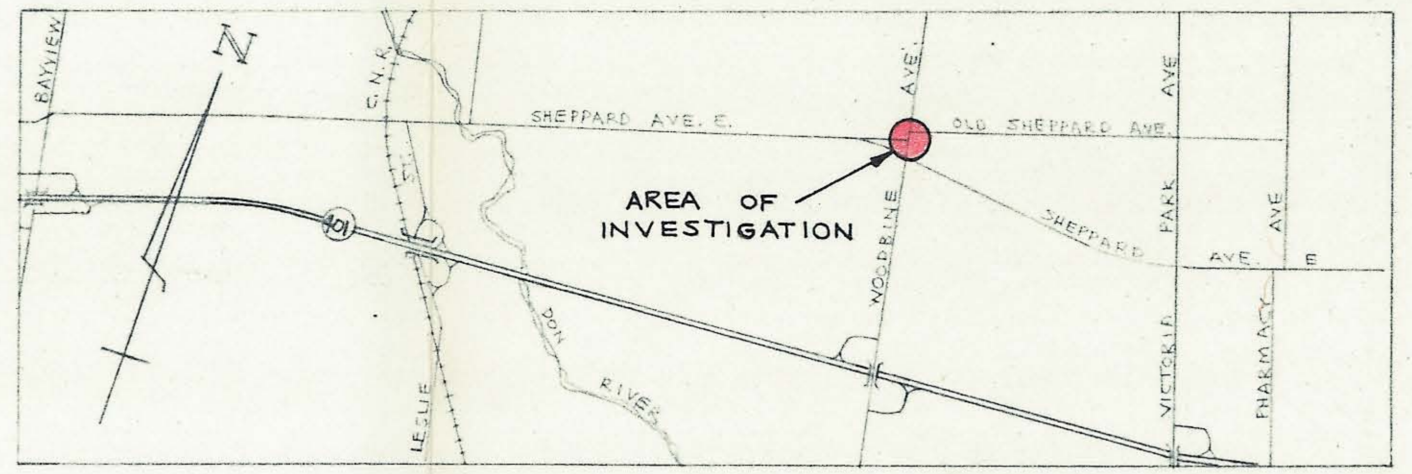


SECTION A-A



SECTION B-B

HORIZ. SCALE 1" TO 40'-0" VERT. SCALE 1" TO 20'-0"



KEY PLAN

SCALE 1" TO 0.6 MILES

LEGEND

- BOREHOLE IN PLAN
- (20) BOREHOLE IN ELEVATION
- HIGHEST W.L. IN STANDPIPE, JUNE-JULY/64.
- LOCATION OF STANDPIPE
- END OF HOLE

STRATIGRAPHY

- **TOPSOIL**
- LOOSE SAND AND GRAVEL, SOME SILT & CLAY **(FILL)**
- STIFF TO HARD BROWN TO GREY CLAYEY SILT, SOME SAND, TRACE GRAVEL **(TILL)**
- STIFF TO VERY STIFF GREY **SILTY CLAY**
- VERY DENSE BROWN AND GREY **SILTY** FINE TO MEDIUM **SAND**, TRACE GRAVEL.

REFERENCE: EWBANK, TUPPER & ASSOC.
DRAWING Nº. 1762-SK-21, DATED. JAN. 14/64.
FROM HUNTING SURVEY CORP. PROJ. Nº 2304/2/62.

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.

AUG. 24, 1964

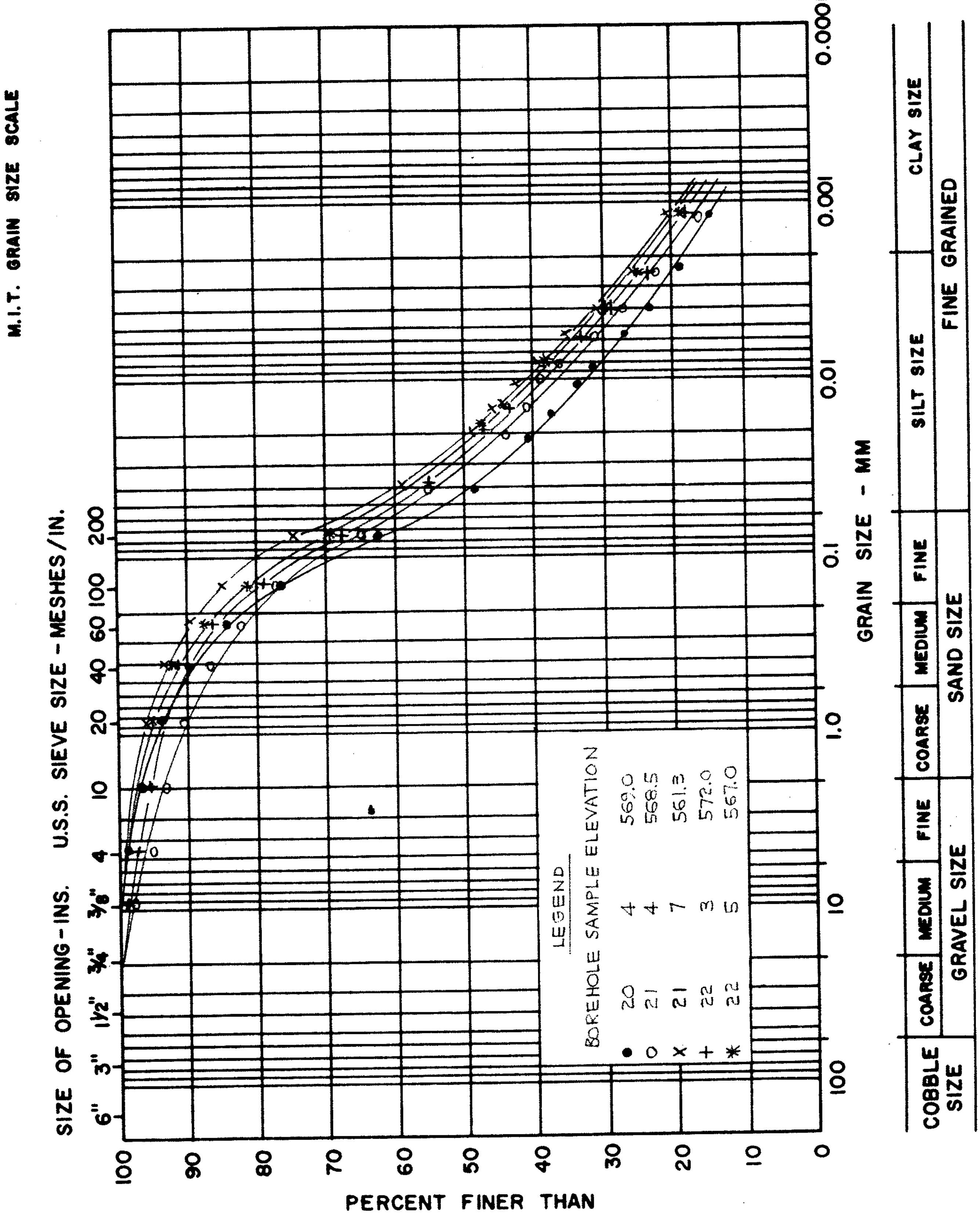
GOLDER & ASSOCIATES

Made M.W.
Chkd. F.D.L.
Appd. H.A.

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIGURE 2

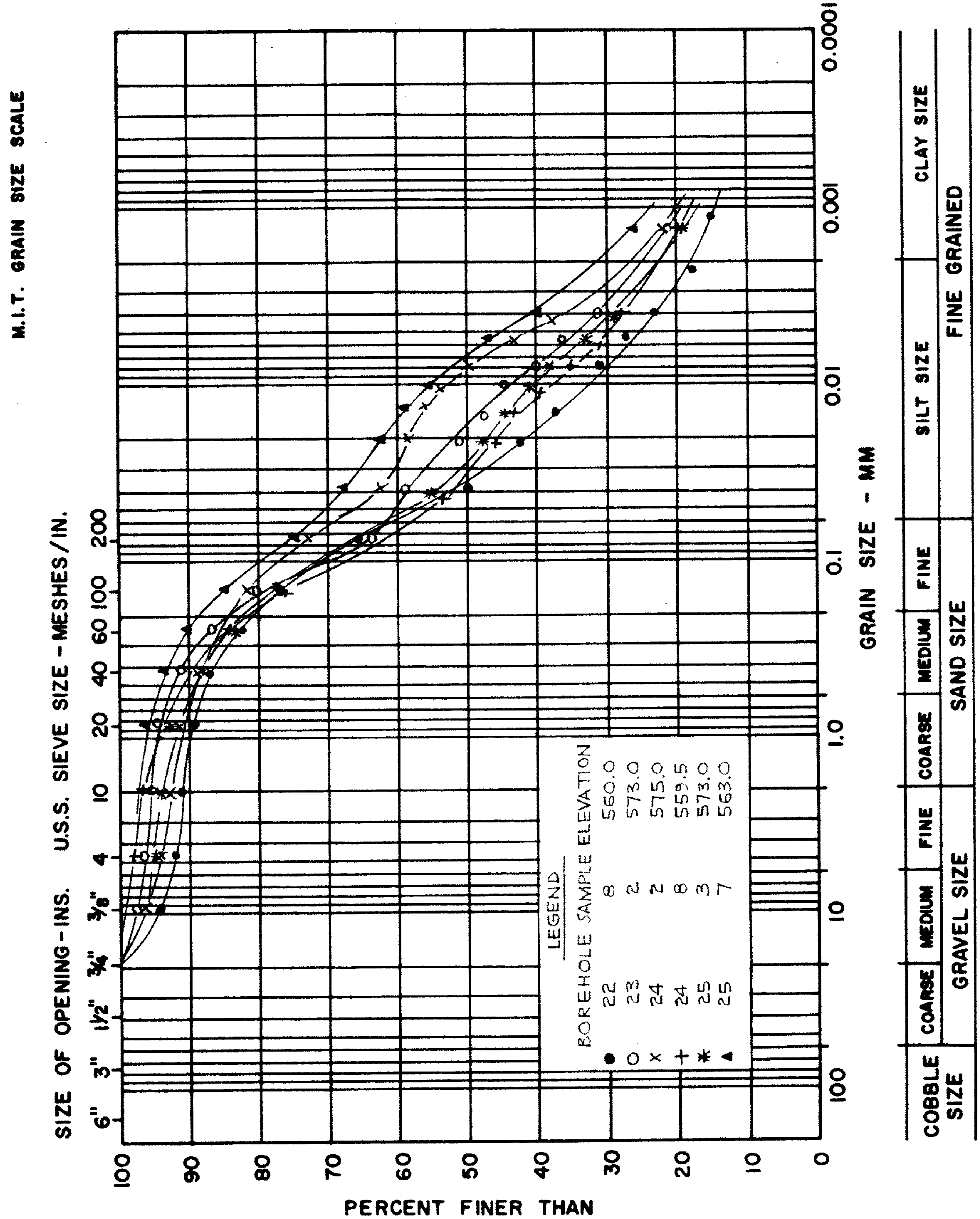


GOLDER & ASSOCIATES

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIGURE 3



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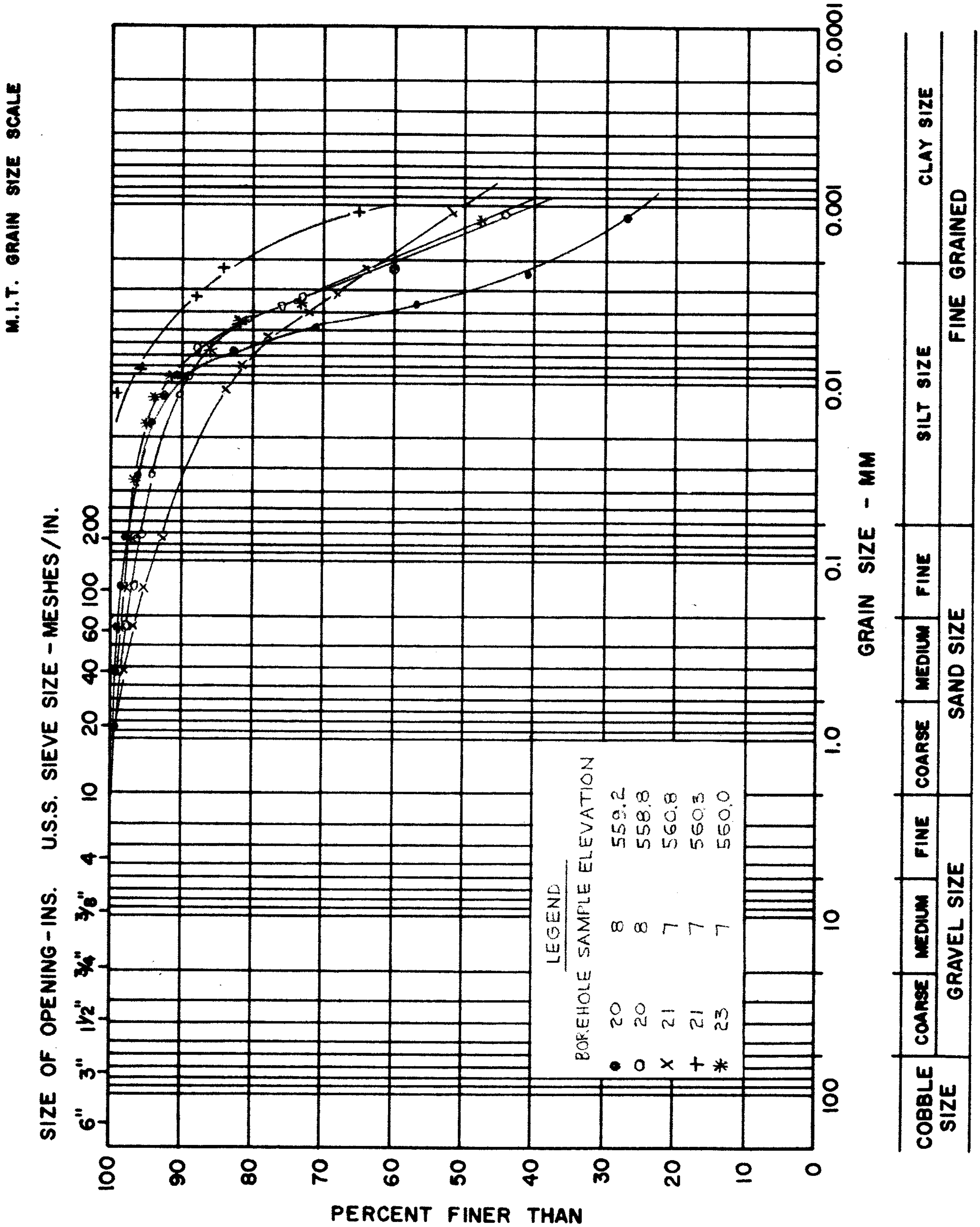
GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIGURE 4



GOLDER & ASSOCIATES