

## TECHNICAL MEMORANDUM

**DATE** February 8, 2019

**Project No.** 1665765

**TO** Mr. Michael Weldon, P.Eng.  
AECOM

**CC**

**FROM** Nikol Kochmanová, Kevin Bentley

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**FOUNDATION ENGINEERING SERVICES  
CLOSED CIRCUIT TELEVISION POLES  
HIGHWAY 401 REHABILITATION AND RESURFACING, KIPLING AVENUE TO KEELE STREET  
CITY OF TORONTO, ONTARIO  
ASSIGNMENT NO. 2015-E-0026  
GEOCRES NO. 30M11-287**

### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of five Closed Circuit Television (CCTV) poles associated with the rehabilitation and resurfacing of Highway 401 from Kipling Avenue to Keele Street in Toronto, Ontario (2015-E-0026). This technical memorandum incorporates the comments received from MTO Foundations and AECOM in e-mail correspondence on November 29 and December 13, 2018.

This technical memorandum presents a summary of the geotechnical site conditions in the vicinity of the proposed CCTV poles and was developed based on a desktop review of the closest available GEOCRES information, as follows:

- **CCTV1-1: MTO GEOCRES No. 30M11-043:** Borehole 8 from report titled "Foundation Investigation for Proposed Bridge at Highway 401 and Richview Road, Etobicoke Twp., York County, District No. 6 (Toronto), W.J. 66-F-104 A – W.P. 399-65", by Department of Highways, Ontario, Materials & Research Division – Foundation Section, dated March 3, 1967.
- **CCTV1-2: MTO GEOCRES No. 30M11-215:** Borehole C17 from report titled "Foundation Investigation and Design Report, High Mast Lighting Poles, Highway 401 Rehabilitation, Renforth Drive to Highway 427, MTO Central Region, G.W.P. 47-99-00, by DST Consulting Engineers Inc., dated October 19, 2001.
- **CCTV2-1: MTO GEOCRES No. 30M11-121:** Borehole 4 from report titled "Foundation Investigation Report for Proposed New Underpass of Highway No. 401 and Weston Road in Metropolitan Toronto, Township of North York", District No. 6, W. J. 63-F-70 – W.P. 236-60, by Department of Highways, Ontario, Materials & Research Division – Foundation Section, dated August 7, 1963.

- **CCTV2-2: MTO GEOCRES No. 30M11-124:** Borehole 4 from report titled “Foundation Conditions, Bridges at Sta. 12S, Wendell Ave. & C.P.R. Crossing, Proposed Highway #401 Expansion,” by William A. Trow and Associates Ltd., dated October 12, 1962.
- **CCTV2-3: MTO GEOCRES No. 30M11-135:** Borehole 3 from report titled “Foundation Investigation at Proposed Widening of Hwy. #401 Overpass at Jane Street, Toronto, District #6, W.J. 62-F-51 – W.P. 232-60,” by Department of Highways, Ontario, Materials & Research Division – Foundation Section, dated July 1962.

The previous investigation boreholes used in this report have been renumbered to show the MTO GEOCRES reference number followed by the original borehole designation. For example, the borehole from MTO GEOCRES Report No. 30M11-43 has been renumbered as 43-X, where X is the original borehole number.

The Scope of Work for the foundation engineering services and the approximate location of the CCTV poles are outlined in the Change Request letter, dated October 15, 2018.

## 2.0 SITE DESCRIPTION

Two of the CCTV poles (CCTV1-1 and CCTV1-2) are to be replaced as part of Contract 1 and are located along Highway 401 between Renforth Drive and Highway 427, and the remaining three CCTV poles (CCTV2-1 to CCTV2-3) are to be replaced as part of Contract 2 and are located between Weston Road and Jane Street. The approximate location of each pole was provided by AECOM and is shown along with the closest available borehole on Figure 1 - Borehole Location Plan.

The CCTV1-1 pole will be approximately located in the south-west quadrant of the intersection between Renforth Road and Highway 401 on the embankment. A commercial area is present both north and south of Highway 401 at the CCTV1-1 location. The CCTV1-2 will be in the grassy embankment between Highway 401 and Highway 427. A commercial area is present to the north of the Highway 401/427 interchange and a residential area is present south of the Highway 401/427 interchange at the CCTV1-2 location.

The CCTV2-1 pole will be located within the Highway 401-Weston Road N-E ramp loop in the southwest quadrant of the Highway 401 and Weston Road interchange. Humber River crosses under Highway 401 west of the interchange and residential properties are present in the northeast and southwest quadrants of the interchange; a commercial area is present in the southeast quadrant. The CCTV2-2 pole will be located between Highway 401 and the Hwy 401 eastbound off ramp to Highway 400. Commercial properties are located north and south of Highway 401 at this location. The CCTV2-3 pole will be located south of Highway 401 approximately 66 m west of Jane Street. Commercial properties are located north and south of Highway 401 at this location.

## 3.0 SUBSURFACE CONDITIONS

Five boreholes (Boreholes 43-8, 215-C17, 121-4, 124-4 and 135-3) were advanced as part of the previous investigations completed in the vicinity of the proposed CCTV pole locations. The existing boreholes were advanced to depths ranging from about 11 m to 37 m below ground surface and in general accordance with MTO procedures. The Standard Penetration Test (SPT) “N”-values from the previous investigations are based on the use of a manual hammer and the values are reported in this memorandum with no adjustments / corrections. In addition, the depths below ground surface in the discussion below reference the ground surface elevation on the borehole records at

the time of the investigation (typically over 50 years ago) and does not reference the current ground surface / road grade. The following sections summarize the subsurface and groundwater conditions encountered at the closest borehole at the time of the investigation near each of the CCTV locations.

### 3.1 CCTV1-1 - Borehole 43-8

Borehole 43-8 was advanced approximately 130 m away from the CCTV1-1 pole location. The ground surface at Borehole 43-8 was at Elevation 163.7 m at the time the investigation was completed (1967). The major soil deposits and groundwater level shown on the borehole record are provided below:

- **Sand and Silt:** An approximately 4.5 m thick sand and silt deposit containing trace clay was encountered immediately below ground surface in Borehole 43-8. The SPT 'N'-values measured within the sand and silt deposit range from 8 blows to 94 blows per 0.3 m of penetration, but are generally over 40 blows per 0.3 m of penetration, indicating a dense to very dense level of compactness.
- **Gravelly Sand:** An approximately 3.4 m thick gravelly sand deposit containing some silt and trace clay was encountered underlying the sand and silt deposit. The surface of this deposit was encountered at approximately Elevation 157.5 m. The SPT 'N'-values measured within the gravelly sand deposit are 100 blows per 0.1 m of penetration, indicating a very dense level of compactness.
- **Clayey Silt:** An approximately 3.4 m thick clayey silt deposit containing some sand, gravel, and shale fragments was encountered underlying the gravelly sand deposit. The surface of this deposit was encountered at approximately Elevation 153.9 m. The SPT 'N'-values measured within the clayey silt deposit are 100 blows per 0.08 m of penetration, suggesting a hard consistency.
- **Shale Bedrock:** Weathered shale bedrock was encountered below the clayey silt deposit, at about Elevation 150.3 m.
- The groundwater level was measured at about Elevation 158.8 m at the time drilling (February 1967).

### 3.2 CCTV1-2 – Borehole 215-C17

Borehole 215-C17 was advanced approximately 30 m away from the CCTV1-2 pole location. The ground surface at Borehole 215-C17 was encountered at Elevation 152.7 m. The major soil deposits and groundwater level shown on the borehole record are provided below:

- **Clayey Silt:** A 5.5 m thick deposit of clayey silt with sand was encountered at ground surface. The SPT 'N'-values measured within the clayey silt deposit range from 62 blows to 182 blows per 0.3 m of penetration, indicating a very dense level of compactness.
- **Silty Sand:** An approximately 2.1 m thick silty sand with gravel deposit was encountered underlying the clayey silt. The silty sand deposit is described as containing occasional boulders. The SPT 'N'-values measured within the silty sand are 77 and 100 blows per 0.3 m of penetration, indicating a very dense state of compactness.
- **Clayey Silt:** An approximately 1.2 m thick deposit of clayey silt containing shale fragments was encountered below the silty sand deposit at approximately Elevation 145.1 m.
- **Shale Bedrock:** Weathered shale bedrock was encountered below the clayey silt deposit, at about Elevation 143.8 m.

- The groundwater level shown on the borehole record is at about 0.6 m below ground surface (Elevation 152.1 m) on the day of drilling (Oct. 7, 1967).

### 3.3 CCTV2-1 – Borehole 121-4

Borehole 121-4 was advanced approximately 65 m away from the CCTV2-1 pole location. The ground surface at Borehole 121-4 was encountered at Elevation 136.9 m at the time the investigation was completed (June 1963), prior to construction of the interchange. The major soil deposits and groundwater level shown on the borehole record are provided below:

- **Sand and Gravel Fill:** An approximately 0.9 m thick sand and gravel fill layer was encountered immediately below ground surface in Borehole 121-4.
- **Clayey Sandy Silt:** An approximately 7.3 m thick clayey sandy silt deposit was encountered underlying the fill layer at approximately Elevation 135.9 m. The SPT 'N'-values measured within the clayey sandy silt deposit were 32 blows and 39 blows per 0.3 m of penetration, suggesting a hard consistency. An Atterberg limits test was carried out on one selected sample within the clayey sandy silt deposit and measured a liquid limit of about 25 per cent, a plastic limit of about 15 per cent, and a corresponding plasticity index of about 10 per cent, indicating that the deposit consists of a clayey silt of low plasticity. The natural water content measured on two selected samples were about 13 and 14 per cent.
- **Clayey Silty Sand Till:** A glacial till deposit comprised of clayey silty sand was encountered underlying the clayey sandy silt deposit at about Elevation 128.6 m. Borehole 121-4 terminated within the glacial till deposit, penetrating it for a thickness of 7.5 m. The SPT 'N'-values measured within the glacial till deposit are 32 blows and 108 blows per 0.3 m of penetration, indicating a dense to very dense consistency. Atterberg limits tests were carried out on two selected samples of the till deposit and measured liquid limits of about 20 and 25 per cent, plastic limits of about 13 and 14 per cent, and corresponding plasticity indices of about 7 and 11 per cent, indicating that the till deposit contains zones of clayey silt of low plasticity. The natural water content measured on two selected samples are about 10 and 12 per cent.
- The groundwater level observed during drilling is shown on the borehole record as 11.9 m below ground surface (Elevation 125.0 m) on the day of drilling (June 24, 1963).

### 3.4 CCTV2-2 – Borehole 124-4

Borehole 124-4 was advanced approximately 100 m west of the CCTV2-2 pole location. The ground surface at Borehole 124-4 was encountered at Elevation 130.8 m when drilled on September 19, 1962. The major soil deposits and groundwater information indicated on the borehole record and/or factual report are provided below:

- **Topsoil:** An approximately 100 mm thick layer of topsoil was encountered immediately below ground surface in Borehole 124-4.
- **Clay (Silty Clay):** An approximately 4.2 m thick deposit of clay was described as being encountered underlying the topsoil. The SPT "N"-values measured within the clay deposit range between about 16 blows to 30 blows per 0.3 m of penetration. Undrained triaxial tests were carried out on a sample of the clay deposit and measured undrained shear strengths of about 180 kPa and over 200 kPa. The test results indicate that the deposit has a very stiff to hard consistency. The natural water content measured on selected samples are between about 20 and 26 per cent. Atterberg Limits tests on two samples gave liquid limits of 42 and 44,

plastic limits of 19 and 20, and a corresponding plasticity index of 23 and 24 indicating a silty clay of medium plasticity.

- **Silty Clay Till (Clayey Silt Till):** An approximately 24.7 m thick silty clay till deposit was described as being encountered below the clay deposit at approximately Elevation 126.5 m. The till was described as containing sand and gravel and a boulder was encountered at a depth of 9.1 m below ground surface during drilling operations. The SPT 'N'-values measured within the till deposit range between about 8 blows and 36 blows per 0.3 m of penetration. Twelve field vane tests were carried out within the till deposit and measured undrained shear strengths ranging between about 53 kPa and 105 kPa, with an average of about 85 kPa. The test results indicate that the till deposit has a stiff to very stiff, but typically stiff consistency. The natural water content measured on selected samples is between about 15 and 24 per cent. Eight Atterberg Limit tests performed on samples of the till gave plastic limits ranging from 23 to 36, plastic limits ranging from 13 to 20, and plasticity index values ranging from 8 to 18 indicating a clayey silt to silty clay of low to medium plasticity.
- **Silty Sand:** A wet silty sand deposit was encountered underlying the till deposit at approximately Elevation 101.8 m. The borehole terminated within the sand deposit, penetrating it for a thickness of 2.1 m. An SPT 'N'-value measured within the sand deposit was 12 blows per 0.3 m of penetration, indicating a compact level of compactness. The natural water content measured on one selected sample was 26 per cent.
- The borehole was described as remaining dry when left open overnight at a drilled depth of 28 m below ground surface, and a water level was measured at a depth of 23 m bgs upon completion of drilling the next day on September 19, 1962. The factual report indicates that groundwater was measured in the borehole at a depth of 7.6 m below ground surface (Elevation 123.2 m) within 2 weeks after completion of drilling on October 4, 1962.

### 3.5 CCTV2-3 – Borehole 135-3

Borehole 135-3 was advanced approximately 220 m east of the CCTV2-3 pole location. The ground surface at Borehole 135-3 was encountered at Elevation 123.7 m when drilled on May 29, 1962. The major soil deposits and groundwater information indicated on the borehole record are provided below

- **Silty Sand:** A 2.3 m thick deposit of silty sand was encountered immediately below the ground surface. The SPT 'N'-values measured within the sand deposit are between 3 blows and 7 blows per 0.3 m of penetration, indicating a loose level of compactness.
- **Sand:** A 3.8 m thick sand deposit was encountered underlying the silty sand deposit at approximately Elevation 121.4 m. The sand deposit contained trace silt, trace gravel. The SPT 'N'-values measured within the sand deposit range between 7 blows and 30 blows per 0.3 m of penetration, indicating a loose to compact level of compactness.
- **Clayey Silt:** A 16.8 m thick clayey silt deposit was encountered underlying the sand deposit at approximately Elevation 117.7 m. The SPT 'N'-values measured within the clayey silt deposit were 28 and 37 blows per 0.3 m of penetration. Field vane tests were carried out within this deposit and measured shear strengths between 60 kPa and 93 kPa. Seven laboratory triaxial tests were carried out on selected samples of this deposit and measured undrained shear strengths between about 45 kPa and 120 kPa, with an average of 80 kPa. The test results indicate that the deposit has a firm to very stiff, but typically stiff consistency. Atterberg Limits testing carried out on samples of the clayey silt gave liquid limits ranging from 24 to 35, plastic limits

ranging from 14 to 20, and a corresponding plasticity index ranging from 8 to 16, confirming the deposit is a clayey silt of low to medium plasticity. The natural water content measured on selected samples ranges from 19 to 25 percent.

- **Silt to Silty Sand:** A silt to silty sand deposit was encountered underlying the clayey silt deposit at approximately Elevation 100.9 m. The borehole was terminated within this deposit, penetrating it for a thickness of 13.7 m. SPT “N”-values were not measured within the sand deposit, however, a thin walled sample of the deposit was collected and the borehole record suggests the deposit has a compact level of compactness.
- **Inferred Bedrock:** Cone refusal was described as being encountered at Elevation 87.2 m on probable shale bedrock; however, no bedrock coring or sampling was carried out.
- The groundwater level was measured to be about 2.1 m below ground surface (Elevation 121.6 m) on completion of borehole drilling on May 29, 1962.

## 4.0 DISCUSSION

This section of the technical memorandum provides engineering recommendations for the replacement of the five Closed Circuit Television (CCTV) poles associated with the rehabilitation and resurfacing of Highway 401 from Kipling Avenue to Keele Street in Toronto, Ontario (Assignment 2015-E-0026). This foundation desktop study with the interpretation and recommendations contained herein are for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The factual data was obtained from the closest existing boreholes advanced by others in the vicinity of the CCTV poles as part of previous investigations. The interpretation and geotechnical parameters provided in this memorandum are intended to provide the design engineers with information for preliminary design of the CCTV pole foundations and to assess feasible construction approaches and constraints that may be related to the ground conditions encountered in the boreholes. The contractor must make their own interpretation based on the factual data, and supplement with additional investigation as necessary, in order to confirm the CCTV pole foundations (including embedment depth) are designed to meet the necessary lateral deflection tolerance criteria.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required during construction. The contractor should make their own interpretation of the factual information provided as such interpretation may affect the level of additional investigation needed, equipment selection, proposed construction methods and scheduling.

### 4.1 Design of CCTV Pole Foundations

Based on the information provided by AECOM, the existing 18.3 m high CCTV poles will be replaced with 24.4 m high direct buried concrete poles. It is understood that a standard MTO design for new CCTV poles is not available and a detailed analysis is needed to estimate lateral deflections of the proposed CCTV poles to ensure they are within a specified serviceability limit criteria. This memorandum presents a summary of the estimated geotechnical soil and groundwater parameters to support the lateral analysis of the poles to meet serviceability limits for lateral deflection. It is important to note that the “buried” portion of the concrete poles must be in intimate contact with the surrounding ‘undisturbed’ soil, similar to a caisson or driven pile installation, in order for the soil resistance values provided in this technical memorandum to be valid and representative. If there is a ‘void’ or ‘loosened’ backfill



material placed in the annulus between the buried concrete pole and surrounding soils, this must be taken into consideration during design.

## 4.2 Axial Capacity of Direct Buried Concrete Poles

The design for the CCTV poles will be governed by the lateral resistance requirements and axial geotechnical resistance is not considered to be a concern given the that no additional axial loads are to be applied (other than self-weight of the hollow concrete poles) and provided competent founding soils are encountered and remain relatively undisturbed during installation.

## 4.3 Lateral Resistance of Direct Buried Concrete Poles

The resistance to lateral loading of vertical buried concrete poles may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction ( $k_h$  in kPa/m) is determined based on the equations given below:

For cohesionless soils:

$$k_h = \frac{n_h z}{B} \quad \text{where} \quad \begin{array}{l} n_h \text{ is the constant of horizontal subgrade reaction (kPa/m);} \\ z \text{ is the depth (m); and} \\ B \text{ is the buried concrete or caisson diameter (m)} \end{array}$$

For cohesive soils:

$$k_h = \frac{67 S_u}{B} \quad \text{where} \quad \begin{array}{l} S_u \text{ is the undrained shear strength of the soil (kPa); and} \\ B \text{ is the buried concrete or caisson diameter (m)} \end{array}$$

The above equations and recommended parameters may be used to analyse the interaction between a buried concrete pole or caisson and the surrounding soil (i.e. for serviceability limit state design) provided that lateral displacements within the soil do not exceed about 10 mm. If deflections exceed 10 mm, a non-linear analysis method should be used to model the behaviour of the soil (e.g. p-y curves). The upper 1.2 m of soil resistance should not be included in the design to account for frost action.

The spring constant,  $K$ , for analysis may be obtained by the expression,  $K = k_h \times L \times B$  (kN/m), where  $k_h$  is the coefficient of horizontal subgrade reaction (kPa/m),  $B$  is the buried concrete pole or caisson diameter (m) and  $L$  is the length (m) of the buried concrete pole or caisson segment used in the analysis. Table 1 provides the recommended geotechnical parameters for use in the design approach outlined above.

Details of the CCTV poles and site-specific locations were not available at the time this technical memorandum was prepared. Considering this is a non-standard MTO design, it is understood that a detailed soil-structure analysis will be carried out by the proprietary CCTV pole designer to meet the specified deflection tolerances and provide associated details on foundation design / embedment and installation procedures to meet the requirements in Special Provision SP682S30.

The lateral pressures obtained from the analysis must not exceed the ultimate lateral geotechnical resistance or the factored structural flexural shear resistance and/or bending moment of the buried concrete pole / caisson. The ultimate resistance should be checked by the structural engineer and the ultimate lateral geotechnical resistance can be

checked using the conventional Broms' equation, based on the stratigraphy and geotechnical design parameters given in Table 1 following the text of this technical memorandum.

Alternatively, the unfactored lateral geotechnical resistance can be calculated using passive lateral earth pressure,  $P_p$  (kPa) as defined below, distributed along the length of the caisson/buried pole based on the stratigraphy and geotechnical design parameters given in Table 1.

$$P_p = K_p \gamma d_w \quad \text{above the groundwater table (kPa), and}$$

$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \quad \text{below the groundwater table (kPa)}$$

where  $K_p$  is the passive earth pressure coefficient;

$\gamma$  is the bulk unit weight (kN/m<sup>3</sup>);

$\gamma'$  is the effective unit weight below the groundwater level (kN/m<sup>3</sup>);

$d$  is the depth below the ground surface (m); and

$d_w$  is the depth to the groundwater level (m).

The unfactored lateral resistance,  $p_{ult}$  (kN) for non-cohesive soils should be calculated assuming an equivalent width equal to three times the caisson/buried pole diameter, and an equivalent length equal to six times the caisson/buried pole diameter (Section C6.8.7.1 of CHBDC (2006)), as outlined below:

$$p_{ult} = P_p A_e \text{ (kN)}$$

where  $A_e$  is the equivalent area equal to  $3D \cdot 6D = 18D^2$  (m<sup>2</sup>)

$D$  is the caisson/buried pole diameter (m)

Where an undrained shear strength,  $S_u$ , is provided for a cohesive soil layer in Table 1, the undrained capacity of the caisson/buried pole should also be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson/buried pole within the cohesive soil should be calculated assuming an internal angle of friction,  $\Phi' = 0$  degrees, and an unfactored passive lateral pressure distribution varying from  $2 S_u$  at ground surface and increase linearly to  $9 S_u$  at and below a depth equivalent to three caisson/buried pole diameters, acting over the actual width of the caisson/buried pole (Section C6.8.7.1 of CHBDC (2006)), as outlined below.

$$p_{ult} = P_p A_e \text{ (kN)}$$

where  $P_p = 2 S_u$  at ground surface to  $9 S_u$  at and below a depth equivalent to  $3D$  (kPa)

$A_e$  is the equivalent area equal to  $L \times D$  (m<sup>2</sup>)

$L$  is the caisson/buried pole length (m)

$D$  is the caisson/buried pole diameter (m)

In accordance with CHBDC (2014), the product of the consequence factor,  $\Psi$ , and the geotechnical resistance factor,  $\phi_{gu}$  should be applied to this unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States ( $p_{ULS}$ ) as shown below.

$$p_{ULS} = p_{ult} \cdot \Psi \cdot \phi_{gu} \text{ (kN)}$$



where  $\Psi = 1 - 1.15$  (typical to low consequence factor as per Table 6.1 in CHBDC (2014))  
 $\phi_{gu} = 0.5$  (passive resistance factor for typical degree of understanding, as per Table 6.2 in CHBDC (2014))

## 4.4 Design and Construction Considerations

We understand the CCTV poles will be “direct buried”. According to SP682S30, the concrete pole will be inserted directly into a steel lined auger hole and the annulus surrounding the concrete poles will be filled with grout / concrete to form the foundation that is to be in intimate contact with the surrounding soils. Alternatively, it is assumed sufficient space will be provided (e.g. oversize hole / excavation) to allow for suitable compaction of granular material (e.g. OPSS.PROV 1010 Granular ‘A’ or ‘B’ Type II) around the entire buried portion of the concrete poles / foundation.

The CCTV poles are to be designed and constructed in accordance with OPSS 615 (*Construction Specification for Erection of Poles*) and Special Provision 682S30 (*Concrete Poles, Direct Buried in Earth with Camera Raising and Lowering System*). The foundation diameter and embedment depth will be designed by the proprietary CCTV pole designer to ensure that deflection limits (i.e. 30 mm for poles up to 24.4 m high) specified in SP682S30 are achieved.

Based on the factual information from the previous boreholes near the proposed CCTV locations, groundwater may be encountered within the non-cohesive deposits (where present), and may be perched on top of the underlying native cohesive soils. In addition, there is potential for water-bearing non-cohesive soils lenses or interlayers to be encountered within the cohesive till deposits at the CCTV pole sites. Wet non-cohesive soils should be expected to run or flow into the buried pole / caisson hole during or after drilling the auger hole. Specifically, wet granular deposits (with higher groundwater levels) were encountered at CCTV1-2, CCTV1-2, and CCTV2-3. After the embedment lengths have been designed, the potential for encountering saturated granular soils during augering / excavation for placement of the poles should be reassessed. Therefore, steel liners are recommended and required to minimize ground loss during drilling and concrete placement / filling and compaction of the annulus between the buried portion of the pole and the surrounding soil.

Although not typically noted on the borehole records, cobbles and/or boulders may be present in the glacial till and silty sand deposits. Boulders were noted to be encountered within 10 m below ground surface at CCTV1-2 and CCTV2-2 locations. Appropriate equipment and procedures will be required to penetrate the cobbles and/or boulders as part of the drilling / excavation for installation of the direct buried pole foundations. It is recommended that a Notice to Contractor be included in the Contract Documents to alert the Contractor of the presence of obstructions such as cobbles and/or boulders within the overburden soils; an example is provided in Appendix F.

Corrosive potential of the soil will need to be considered for detail design of the concrete foundations and any buried steel components. The long-term performance and durability of the foundations are directly related to their respective corrosion resistance. Generally, the corrosivity potential of buried structures can be directly related to soil resistivity / electrical conductivity, hydrogen ion concentration (pH), and salts (chloride and sulphate) concentrations. As the assessment for the CCTV poles is based on existing subsurface information, no analytical testing was carried out. However, given that the CCTV pole foundations are located adjacent to the roadway shoulder and will be exposed to de-icing salt, consideration must be given to the effects of using exposed steel and selection of a “C” type exposure class of concrete as defined by CSA A23.1 Table 1. It is ultimately up to the

structural designer to determine the appropriate design and exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 "Durability Requirements" are followed when designing the structure and foundations.

## 5.0 CLOSURE

This technical memorandum was prepared by Ms. Nikol Kochmanová, P.Eng.. Mr. Kevin Bentley, an Associate of Golder and a Designated MTO Foundations Contact, conducted an independent technical and quality control review of this memorandum.

### GOLDER ASSOCIATES LTD.



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JP/NK/KJB/rb

Attachments Table 1 – Geotechnical Design Parameters for CCTV Pole Structures  
Figure 1 – Borehole Location Plan  
Appendix A – CCTV1-1  
Appendix B – CCTV1-2  
Appendix C – CCTV2-1  
Appendix D – CCTV2-2  
Appendix E – CCTV2-3  
Appendix F – Notice to Contractor - Obstructions

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**Table 1 – Geotechnical Design Parameters for CCTV Pole Structures**

CCTV Pole No.	Borehole No.	Soil Stratum	Depth / [Elevation] (m)	Groundwater Depth / [Elevation] (m)	Soil Parameters					
					S <sub>u</sub> (kPa)	φ' (degrees)	γ (kN/m³)	γ' (kN/m³)	n <sub>h</sub> value (kPa/m)	K <sub>p</sub>
CCTV 1-1	43-8	Dense to very dense sand and silt	0 – 6.2 [163.7 - 157.5]	4.9 [158.8]	-	34	19	9	10,000	3.5
		Very dense gravelly sand	6.2 – 9.8 [157.5 - 153.9]		-	35	20	10	10,000	3.7
		Hard clayey silt	9.8 – 13.4 [153.9 - 150.3]		200	30	20	10	-	3.0
		Shale bedrock	Below 13.4 [Below 150.3]		n/a	40	23	23	n/a	4.6
CCTV 1-2	215-C17	Hard clayey silt	0 -5.5 [152.7 - 147.2]	0.6 [152.1]	200	30	20	10	-	3.0
		Very dense silty sand	5.5 – 7.6 [147.2 – 145.1]		-	34	19	9	8,000	3.5
		Clayey silt	7.6 - 8.9 [145.1 – 143.8]		150	30	20	10	-	3.0
		Shale bedrock	Below 8.9 [Below 143.8]		n/a	40	23	23	-	4.6
CCTV 2-1	121-4	Sand and gravel fill	0 – 1 [136.9 - 135.9]	11.9 [125.0]	-	28	19	9	3,000	2.8

CCTV Pole No.	Borehole No.	Soil Stratum	Depth / [Elevation] (m)	Groundwater Depth / [Elevation] (m)	Soil Parameters					
					S <sub>u</sub> (kPa)	φ' (degrees)	γ (kN/m <sup>3</sup> )	γ' (kN/m <sup>3</sup> )	n <sub>h</sub> value (kPa/m)	K <sub>p</sub>
		Hard sandy clayey silt	1 – 8.3 [135.9 - 128.6]		200	30	20	10	-	3.0
		Dense to very dense clayey silty sand till	8.3 – 15.8 [128.6 – 121.1]		-	34	21	11	10,000	3.5
CCTV 2-2	124-4	Very stiff to hard silty clay	0 - 4.3 [130.8 – 126.5]	7.6 [123.2]	180	30	20	10	-	3.0
		Stiff to very stiff clayey silt till	4.3 – 29 [126.5 – 101.8]		75	28	19	9	-	2.8
		Compact silty sand	29 – 31.1 [101.8 – 99.7]		-	30	19	9	5,000	3.0
CCTV 2-3	135-3	Loose silty sand	0 – 2.3 [123.7 - 121.4]	2.1 [121.6]	-	28	19	9	2,000	2.8
		Loose to compact sand	2.3 – 6.0 [121.4 - 117.7]		-	30	19	9	4,000	3.0
		Firm to very stiff clayey silt	6.0 – 22.8 [117.7 - 100.9]		60	28	19	9	-	2.8
		Compact silt to silty sand	22.8 – 36.5 [100.9 – 87.2]		-	32	20	10	5,000	3.3

**NOTES:**

1. Depths are given relative to the ground surface elevation at the borehole location at the time of the investigation (typically during the 1960's); the ground surface elevation from the borehole record(s) should be compared to the ground surface elevation at the actual CCTV pole location, and the depths to various soil strata and groundwater adjusted accordingly.
2. Design parameters:
  - $s_u$  = undrained shear strength (kPa);
  - $\phi'$  = effective friction angle (degrees);
  - $\gamma$  = bulk unit weight (kN/m<sup>3</sup>);
  - $\gamma'$  = effective unit weight below the groundwater level (kN/m<sup>3</sup>);
  - $n_h$  = constant of horizontal subgrade reaction (kPa/m); and
  - $K_p$  = passive earth pressure coefficient.



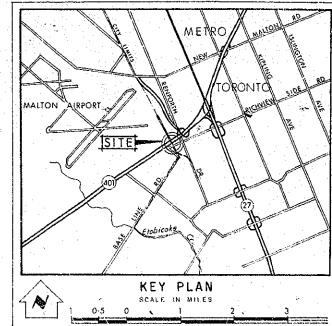





**APPENDIX A**


**CCTV1-1: Borehole 8 from  
GEOCRES No. 30M11-043**


PROFILE ALONG PROPOSED RENFORTH DRIVE




**LEGEND**

 Bore Hole

 Cone Penetration Hole

 Bore A Cone Penetration Hole

 Water Levels established at time of field investigation, FEB. 1967

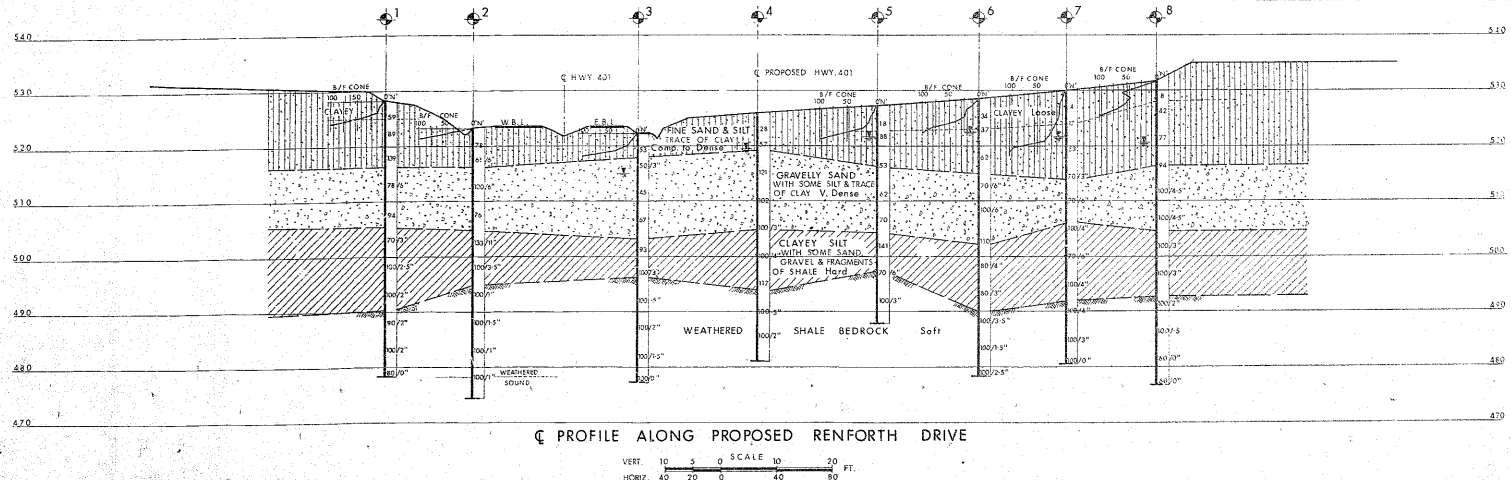
NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	528.3	867,415	975,740
2	523.4	867,322	975,712
3	522.7	867,340	975,600
4	526.0	867,140	975,790
5	527.3	867,080	975,855
6	528.5	867,000	975,852
7	530.0	866,952	975,915
8	531.7	866,870	975,885

**NOTE**

The complete soil investigation report for this structure may be examined at the Bridge Office and Foundation Office, Downsview, and at the Toronto District Office.

- NOTE -

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

[illegible][illegible]

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

HIGHWAY 401 & RICHVIEW EXPRESSWAY UNDER  
RENFORTH DRIVE  
BRIDGE NO. 29

KING'S HIGHWAY NO. 27 IMPROVEMENT CONT. 6 DIST. NO. 6

CO. YORK METRO. TORONTO

TWP. ETOBICOKE LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA			
SUBM'D A.B.	CHECKED <i>2/7</i>	W.P. NO. 399-65	M.B.T. DRAWING NO.
DRAWN S.C.	CHECKED <i>12</i>	JOB NO. 66-F-10A <sup>2</sup>	66-F-104 A <sup>1</sup>
DATE 3 MAR 1967		SITE NO. 37-822	BRIDGE DRAWING NO.
APPROVED <i>[Signature]</i>		CONT. NO.	D-6242-2

**APPENDIX B**

**CCTV1-2: Borehole C17 from  
GEOCRES No. 30M11-215**

METRIC

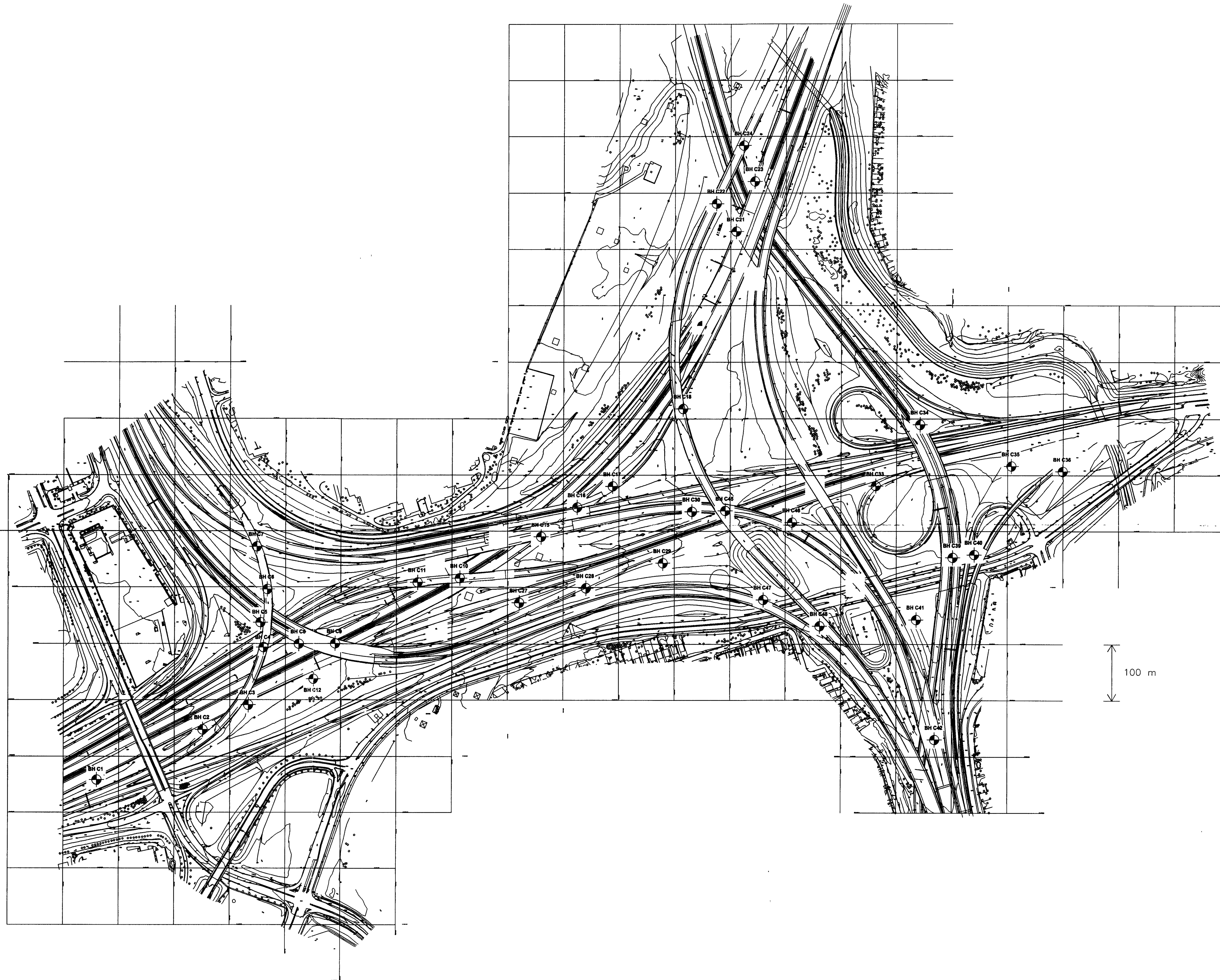
PLATE No PLATE  
CONT No  
WP No 47-99-00



HIGHWAY 401 REHABILITATION,  
RENFORTH DRIVE TO HIGHWAY 427  
BORE HOLE LOCATIONS

SHEET

**DST**  
CONSULTING ENGINEERS



No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
C1	162.52	4 836 457.9	297 360.1
C2	159.14	4 836 547.5	297 550.9
C3	157.43	4 836 591.1	297 633.2
C4	157.15	4 836 693.5	297 660.3
C5	156.24	4 836 737.7	297 654.8
C6	163.83	4 836 796.3	297 667.0
C7	159.41	4 836 872.2	297 648.1
C8	157.19	4 836 699.6	297 724.0
C9	157.43	4 836 700.3	297 789.8
C10	157.64	4 836 816.1	298 014.2
C11	157.06	4 836 808.5	297 938.3
C12	157.40	4 836 636.9	297 750.5
C13	156.76	4 836 836.8	297 970.6
C14	156.18	4 836 882.8	298 084.9
C15	154.14	4 836 889.8	298 160.2
C16	151.97	4 836 942.6	298 225.1
C17	152.67	4 836 980.1	298 288.8
C18	154.84	4 837 117.8	298 415.0
C19	152.19	4 837 264.1	298 448.5
C20	140.60	4 837 342.1	298 542.1
C21	142.59	4 837 431.8	298 510.1
C22	149.90	4 837 481.5	298 474.4
C23	144.00	4 837 520.8	298 543.6
C24	143.59	4 837 583.9	298 523.5
C25	144.69	4 837 656.7	298 557.6
C26	158.74	4 836 721.3	297 975.8
C27	155.66	4 836 772.8	298 120.9
C28	152.20	4 836 798.7	298 241.0
C29	151.24	4 836 843.2	298 379.3
C30	153.31	4 836 934.9	298 431.5
C31	153.71	4 836 980.1	298 654.0
C32	154.35	4 837 036.1	298 619.8
C33	146.82	4 836 981.0	298 762.8
C34	139.08	4 837 089.8	298 842.3
C35	139.08	4 837 016.3	299 006.6
C36	139.81	4 837 006.9	299 099.3
C37	139.20	4 837 070.6	299 180.0
C38	152.31	4 836 798.7	298 727.1
C39	151.36	4 836 853.3	298 901.5
C40	150.05	4 836 858.4	298 940.1
C41	148.59	4 836 743.2	298 835.9
C42	148.13	4 836 530.5	298 869.1
C43	156.33	4 836 823.1	298 095.3
C44	152.64	4 836 865.5	298 436.9
C45	150.11	4 836 936.5	298 491.2
C46	150.48	4 836 915.7	298 611.9
C47	150.14	4 836 778.0	298 560.4
C48	150.00	4 896 732.2	298 661.9

Rev.			HIGHWAY 401/427 INTERCHANGE				DIST 6
	DATE	BY	DESCRIPTION		SUBM'D IC	CHECKED IC	
							SITE
							DWG 1

# RECORD OF BOREHOLE No C17

1 OF 1

METRIC

W.P. 47-99-00 LOCATION 4836980.1 N; 298228.8 E ORIGINATED BY MK  
DIST 6 HWY 401/427 Interchange BOREHOLE TYPE Cont. Flight Auger COMPILED BY KN  
DATUM Geodetic DATE 10.7.67 CHECKED BY IC

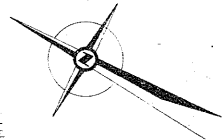
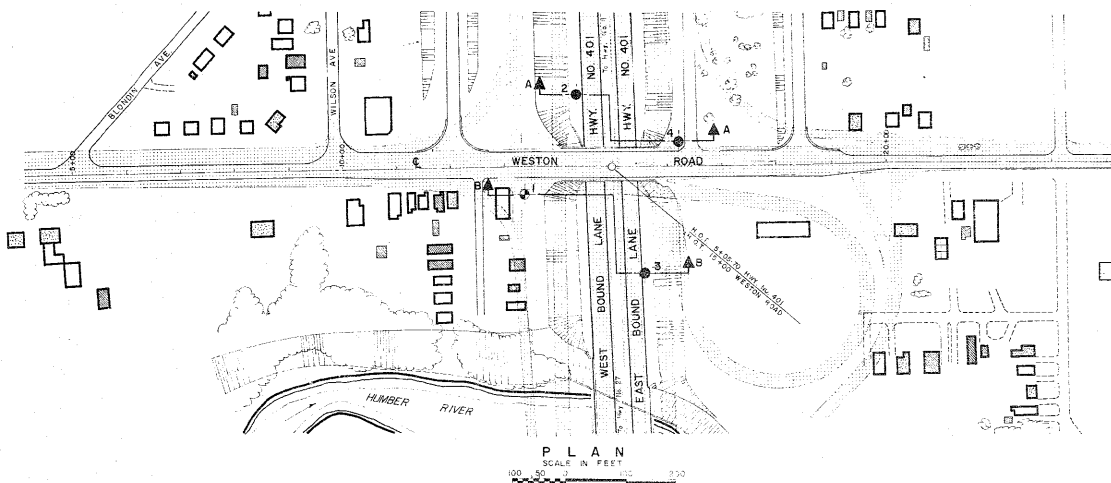
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
								□ QUICK TRIAXIAL	x LAB VANE						
152.7	Ground Level						20 40 60 80 100								
0.0	CLAYEY SILT, with sand, traces of gravel, hard					▽	152								
			1	SS	62		151								
			2	SS	142		150								
			3	SS	182		149								
			4	SS	116		148								
147.2							147								
5.5	SILTY SAND with gravel, occasional boulders, very dense		5	SS	77		146							6 45 48 1	
			6	SS	100		145								
145.1							144								
7.6	CLAYEY SILT with fragments of shale, hard		7	SS	100		143								
143.8							142								
8.8	SHALE BEDROCK, weathered		8	RC											
141.6															
11.1	END OF BOREHOLE AT 11.12 m														

+<sup>3</sup> ×<sup>3</sup> Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

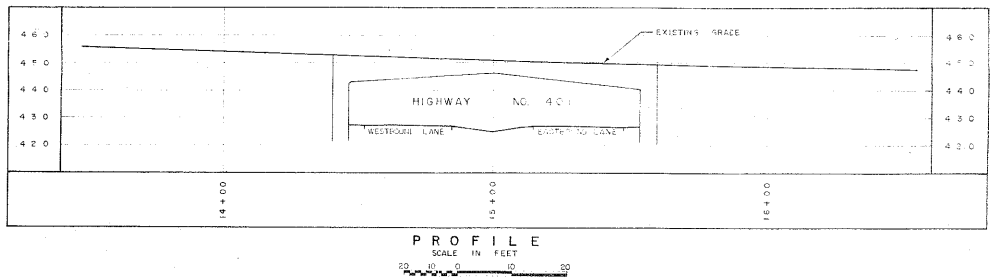
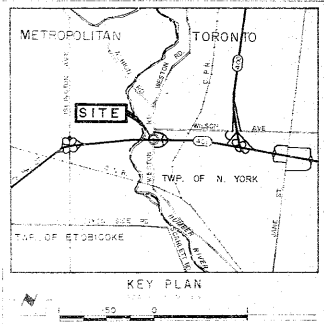
**APPENDIX C**

**CCTV2-1: Borehole 4 from  
GEOCRES No. 30M11-121**





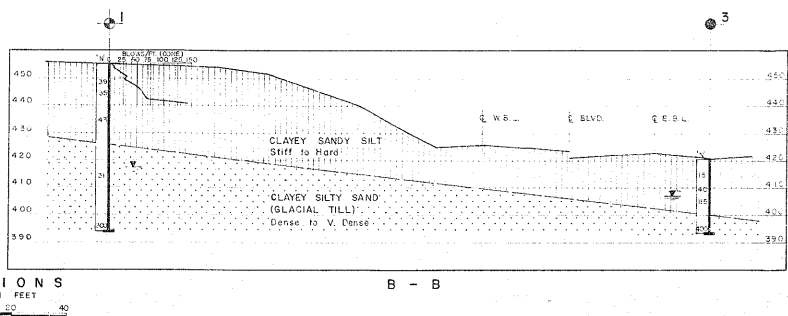
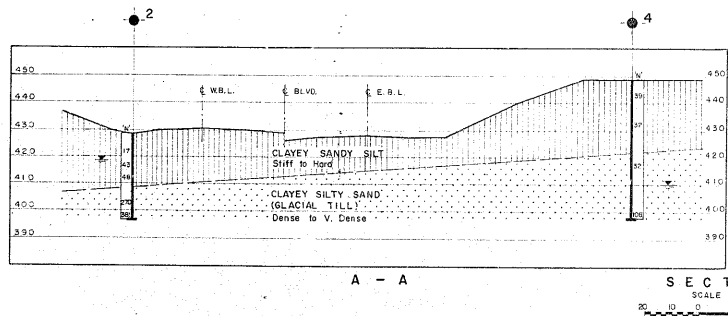
PROPOSED WIDENING & COLLECTOR ROADS OF HWY NO. 401



LEGEND				
	EXISTING GRADE			
	PROPOSED GRADE			
	WATER LEVEL			
	WATER LEVEL AT JUNE 1963			

NO.	ELEVATION	STATION	OFFSET
1	4.55-5	13+40	50' NT
2	4.25-2	14+35	133' LT
3	4.22-2	15+58	195' NT
4	4.49-0	16+20	45' LT

NOTE  
The boundaries between the strata have been established only at the bore hole locations. Between bore holes the boundaries are assumed on the basis of geological evidence and may be subject to considerable error.



DEPARTMENT OF HIGHWAYS - ONTARIO			
WESTON ROAD			
KING'S HIGHWAY NO. 401		DIST. NO. 6	
TWP. NORTH YORK		METROPOLITAN TORONTO	
LOT		CON.	
BORE HOLE LOCATIONS & SOIL STRATA			
BORE HOLE NO. 63-F-70A		BORE DRAWING NO.	
DATE 24 JULY 1963		SITE NO.	
APPROVED		COST NO.	

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

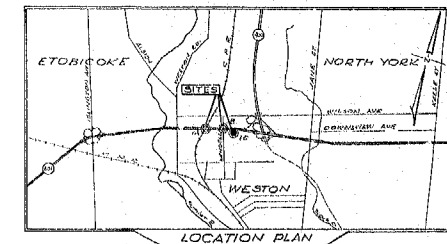
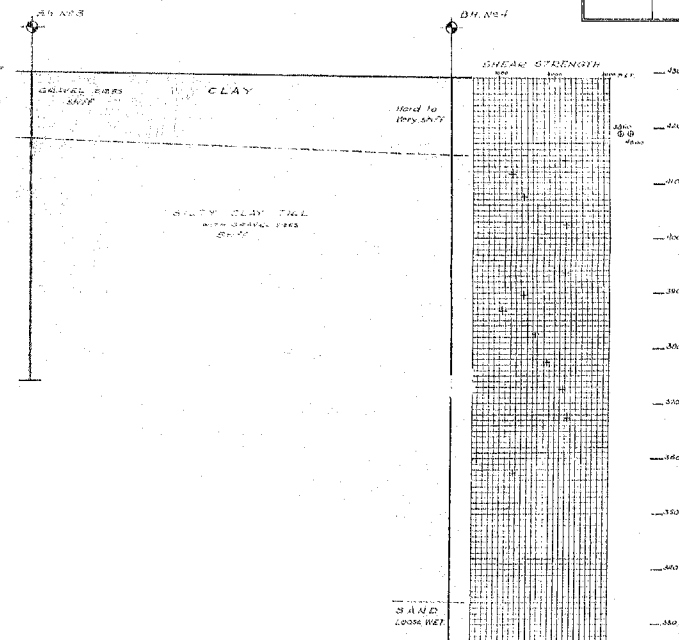
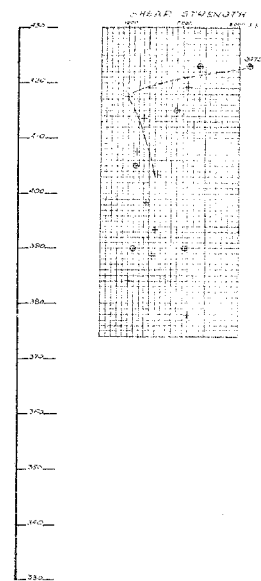
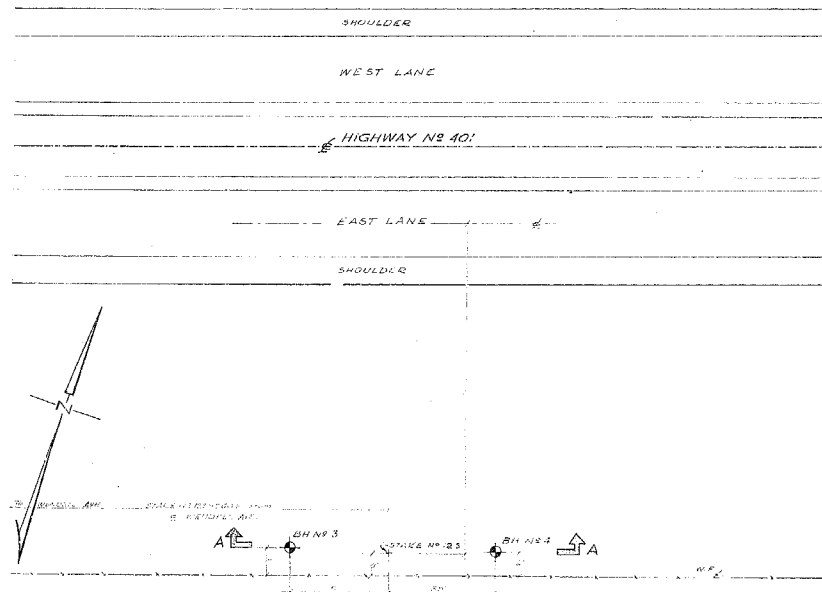
JOB 63-F-70 LOCATION Hwy. #401 and Weston Rd. Ch. 16/20 - 45'-0" Lt. ORIGINATED BY W.W.K.  
 W.P. 236-60 BORING DATE June 24, 1963. COMPILED BY W.W.K.  
 DATUM 449.0 BOREHOLE TYPE Pennndrill - Auger Hole CHECKED BY H.S.

SOIL PROFILE			SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		SHEAR STRENGTH P.S.F.			WP	W	WL		
449.0	Ground Elevation				450								
0.0	Sand & gravel Hwy fill												
446.0													
3.0	Clayey sandy silt. Stiff to Hard.		1	SS	39								
					440								
			2	SS	32								
					430								
422.0													
27.0	Clayey silty sand. (Glacial Till) Dense to very dense.		3	SS	32								
					420								
					410								
					400								
397.5			4	SS	108								
51.5	End of borehole.				390								

W.L.  
Elev.  
= 410.0  
Observed in  
Auger Hole.

**APPENDIX D**

**CCTV2-2: Borehole 4 from  
GEOCRES No. 30M11-124**



SECTION A-A  
Scale 1"=20'

W.A.TROW & ASSOC. LTD.  
FOUNDATION INVESTIGATION  
EXIT STRUCTURE I25 HWY. 401.  
PROJECT N81940 WR N81940-60 DATE 04.1962 DWG. I.C.

## LEGEND

BOREHOLE NO. 4  
PROJECT Proposed Expansion of Hwy. 401. W.P. 233-60  
LOCATION C.P.R. West of Wandell Avenue  
HOLE LOCATION See Dwg. 1.  
HOLE ELEVATION 429.0 ft.  
DATUM See Hole 1.

## PENETRATION RESISTANCE

2" O.D. SPLIT TUBE   
2" I.D. SHELBY TUBE   
2" DIA. CONE   
SHEAR STRENGTH  
UNDRAINED TRIAXIAL AT OVERBURDEN PRESSURE   
UNCONFINED COMPRESSION   
VANE TEST AND SENSITIVITY (S)

## NATURAL MOISTURE CONTENT AND LIQUIDITY INDEX

## ATTERBERG LIMITS

LIQUID LIMIT

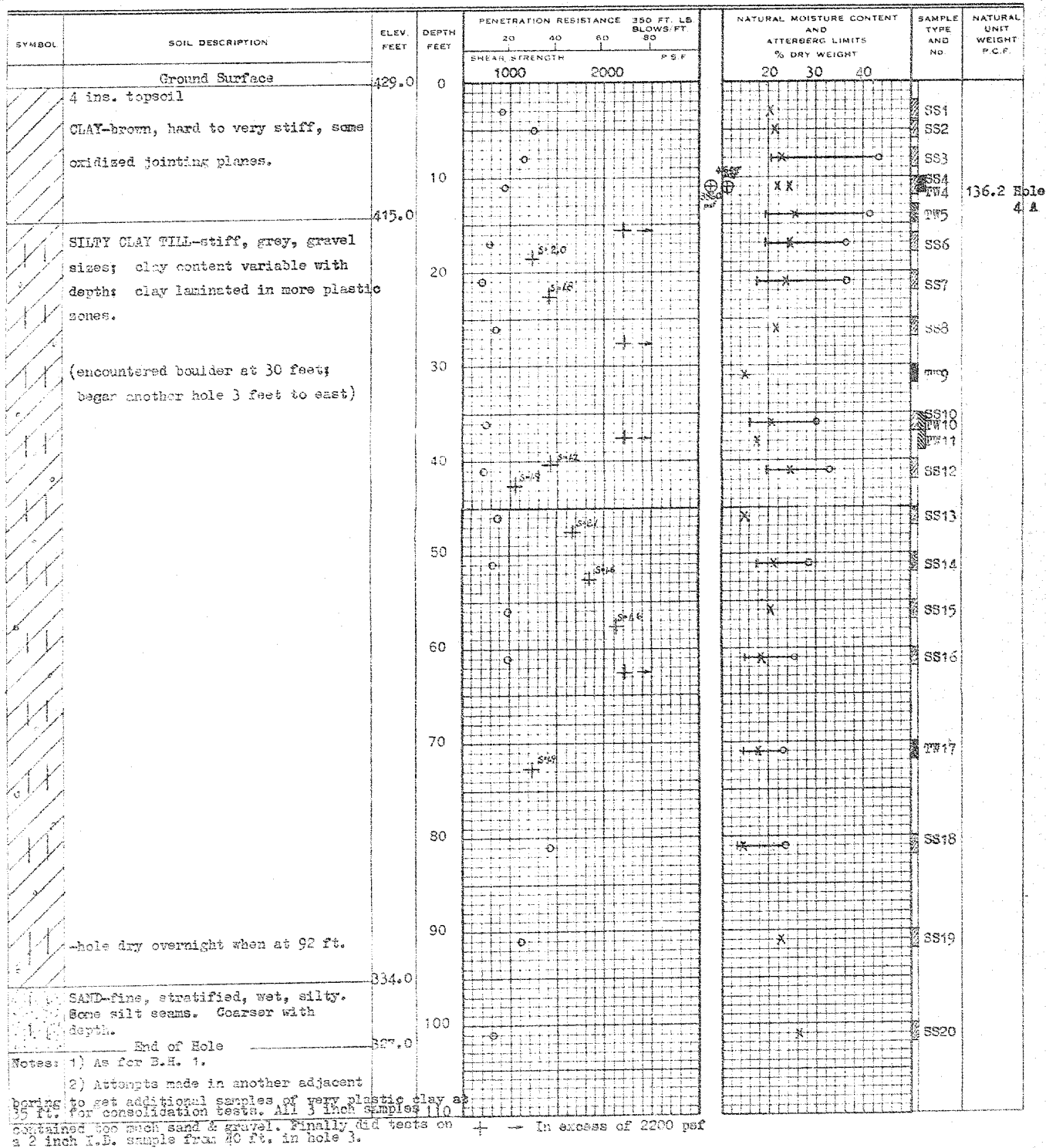
PLASTIC LIMIT

## SAMPLE TYPE

2" O.D. SPLIT TUBE

2" I.D. SHELBY TUBE

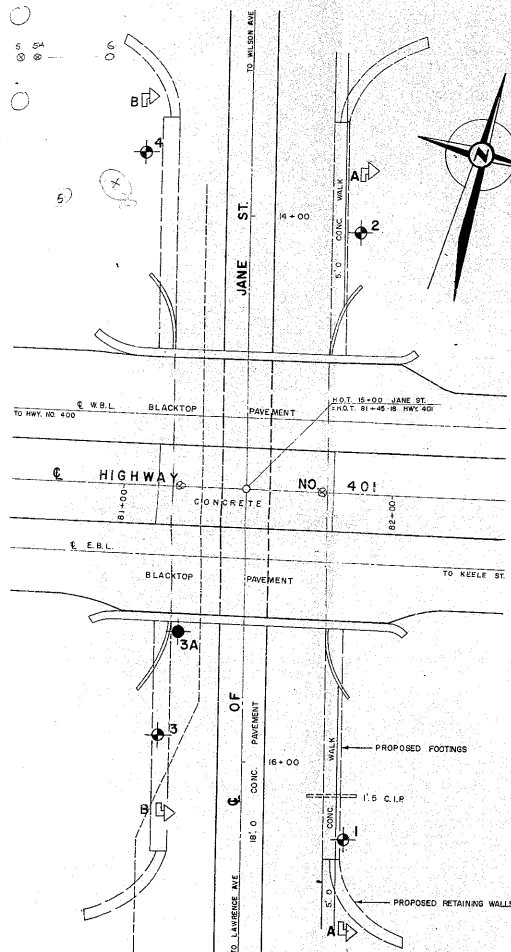
3" O.D. SHELBY TUBE



**APPENDIX E**

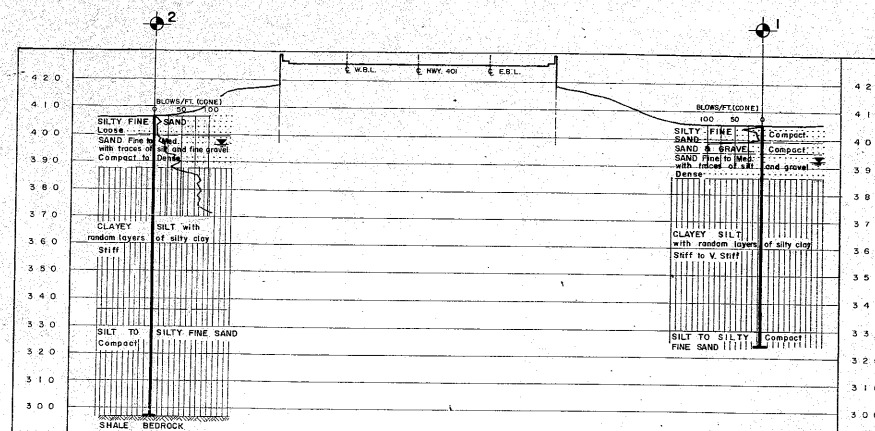
**CCTV2-3: Borehole 3 from  
GEOCRES No. 30M11-135**





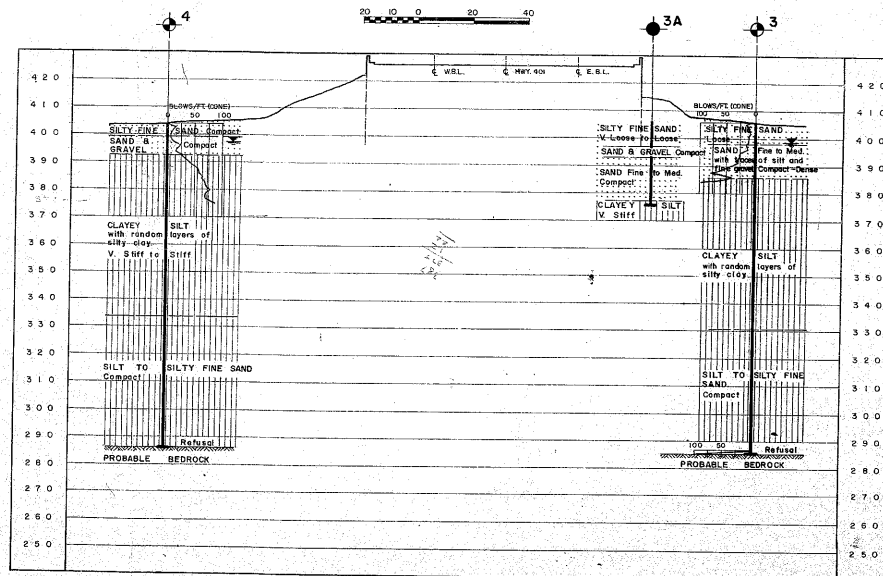
PLAN

Scale in Feet



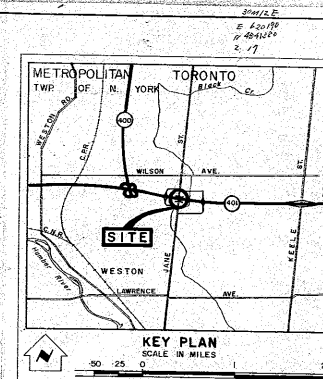
A - A

Scale in Feet



B - B

Scale in Feet



LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation (May 1962)

NO.	ELEVATION	STATION	OFFSET
1	406.0	15+28	38' LT.
2	407.0	14+06	41' LE
3	406.0	15+91	31' RT.
3A	406.0	15+93	24' RT.
4	404.0	13+77	39' RT.

NOTE

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

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH SECTION

JANE STREET  
AND  
HIGHWAY NO. 401

DESIGNED BY	DISTRICT NO. 6	DATE 21 JUNE 1962
CHECKED BY	W.P. NO. 632-60	JOB NO. 62-F-51
APPROVED	CONTRACT NO.	DRAWING NO.

62-F-51A

CHECKED BY I.H.

SOIL PROFILE		SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE	LIQUID LIMIT — WL	BULK DENSITY	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	BLOWS / FOOT			BLOWS / FOOT	PLASTIC LIMIT — WP	WATER CONTENT — W
									20		
					SHEAR STRENGTH P.S.F.	WATER CONTENT %		P.C.F.			
					Quick Triaxial	10 20 30					
					Field Vane						
					500	1000	1500	2000	2500		
406.0	Ground Surface										
0	Silty fine sand		1	SS	7						
	Loose		2	SS	6						
398.5			3	SS	3						
7.5	Sand, fine to med.		4	SS	7						
	with traces of silt		5	SS	23						
	and fine gravel		6	SS	26						
	Compact to dense.		7	SS	30						
386.0			8	SS	37						
20.0			9	TW	PH				130		
			10	TW	28				130		
	Clayey silt with		11	TW	PH				129		
	random layers of silty										
	clay.										
	Hard to stiff.		12	TW	PH				123		
			13	TW	PH				129		
			14	TW	PH				127		
			15	TW	PH				126		
331.0											
75.0			16	TW	PH						
	Silt to silty fine										
	sand.										
	Compact.										
	</										

**APPENDIX F**

# Notice to Contractor - Obstructions

## **OBSTRUCTIONS**

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Notice to Contractor

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The Contractor shall be alerted to the presence of obstructions including shale fragments, cobbles and boulders within the fill and native soils and glacially derived till deposits. Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for drilling, excavating and construction of the CCTV pole foundations.