



**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT  
for**

**BLOOMINGTON ROAD STRUCTURES  
HIGHWAY 404 HOV LANE EXPANSION  
FROM HIGHWAY 407 TO GREEN LANE  
WO 03-20024  
REGIONAL MUNICIPALITY OF YORK, ONTARIO**

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PML Ref.: 14TF003A-BR  
Index No.: 041FIDR  
Geocres No.: 30M14-418  
May 27, 2015



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**PRELIMINARY FOUNDATION INVESTIGATION REPORT**

for  
Bloomington Road Overpass Structures  
Highway 404 HOV Lane Expansion  
From Highway 407 to Green Lane  
WO 03-20024,  
Regional Municipality of York, Ontario

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**1. INTRODUCTION**

The Foundation Engineering Services required for this project include preparation of a preliminary design level Foundation Investigation and Design Report for the proposed Highway 404 High Occupancy Vehicle (HOV) lanes expansion from Highway 407 to Green Lane, 26 km, in the Regional Municipality of York.

This report addresses the proposed widening into the median of both the existing Highway 404 NBL and SBL Overpasses over Bloomington Road. The report was prepared for the MMM Group Limited on behalf of the Ontario Ministry of Transportation.

The Terms of Reference for this assignment required a Preliminary Foundation Investigation and Design Report in two parts – Preliminary Foundation Investigation Report and Preliminary Foundation Design Report, to be based on existing information only. An excerpt from the RFP defining the scope of services follows:

**Preliminary Foundation Investigation Report**

*For bridges, the Preliminary Foundation Investigation Report shall present a subsurface model under the plan limits of foundation elements, and at the immediate approaches within 20 m of the structure.*

*This portion of the report shall consist of factual information only, with no reference to recommendations or project proposals, and present details of subsurface conditions to justify preliminary recommendations.*



*The Preliminary Foundation Investigation Report shall consist of*

- *Site Description.*
- *Investigation Procedures including site investigation and lab testing procedures.*
- *Description of Subsurface Conditions including soil, rock and groundwater conditions.*

**Preliminary Foundation Design Report**

*The Preliminary Foundation Design Report shall present discussion and recommendations for planning purposes. Recommendations shall be presented in accordance with the requirements of the most recent edition of the Canadian Highway Bridge Design Code in effect for MTO projects. The Service Provider shall analyse field data and test results and make preliminary recommendations, including but not limited to:*

- *Structure foundations design (shallow or deep) including anticipated axial resistances, approximate founding elevations of potential foundation options.*
- *Embankment settlement and stability.*
- *Construction concerns of potential geotechnical problems associated with the site, including the need for shoring, dewatering.*
- *Scope of work required for detail design.*

*The Service Provider shall identify and present a comprehensive overview of the advantages, disadvantages, costs and risks/consequences of viable alternative foundation schemes in tabular format. The Report should conclude a preferred alternative from a foundation technical and cost effectiveness perspective.*

This Preliminary Foundation Investigation Report summarizes the subsurface conditions based on review and compilation of information from available relevant reports for this site and provides preliminary design level recommendations. The report is intended for preliminary design and planning purposes. Detail design level foundation engineering services will be required for the detail design phase of the project.

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



## **2. SOURCES OF INFORMATION**

The following reports, including drawings, were available for the Bloomington Road Overpass Structures. Reference 1 is the original report for the site. The Reference 2 report essentially summarizes the information from the Reference 1 report. Pertinent excerpts from the Reference 2 report are presented in Appendix A. The General Arrangement drawing for Reference 2 is presented in Appendix B.

### **REFERENCE 1:**

- Foundation Investigation Report For Regional Road #40 Extension Interchange, 2.6 Miles North of Regional Road #14, W.P. 160-74-32, Site 37-737, Highway 404, District 6, Toronto by Soil Mechanics Section – Ministry of Transportation and Communications, dated May 10, 1978, GEOCRE 30M14-158.
- Layout and General Notes Drawing, Regional Road 40 Extension Overpass at Highway 404, Drawing 1, Site 37-737, District 6, W.P. No. 160-74-32 by Soil Mechanics Section – Ministry of Transportation and Communications, dated March, 1979.

### **REFERENCE 2:**

- Foundation Investigation and Design Report, Bloomington Road Twin Overpass Bridges, Highway 404 Widening, Bloomington Road to Aurora Road, G.W.P. 433-98-00, Site 37-737/1 and 37-737/2, Regional Municipality of York by Golder Associates Ltd for Delcan Corporation, dated December 1999, GEOCRE 30M14-275.
- General Arrangement Drawing, HWY 404 over Bloomington Road Bridge Widening and Rehabilitation, Site 37-737, Drawing 1, District 6, W.P. No. 433-98-01, CONT NO. 2000-0106 by Delcan Corporation, dated July 2000.

In addition to the above GEOCRE reports, the following documents were also reviewed:

- Ministry of Northern Development and Mines. 1991. Bedrock Geology of Ontario – Southern Sheet, Map 2544, Scale 1:1,000,000.
- Chapman and Putnam. 1984. The Physiography of Southern Ontario, 3<sup>rd</sup> Edition.
- Ontario Geological Survey. 1984. Physiography of Southern Ontario, Map 2715, Scale 1:600,000.



### **3. SITE DESCRIPTION AND GEOLOGY**

The site is located approximately 15.5 km north of Highway 407 and Highway 404 interchange junction and 0.5 km west of the intersection of Woodbine Avenue and Bloomington Road, bordering the Towns of Richmond Hill and Aurora in the Regional Municipality of York. The Canadian National Railway tracks are located about 350 m west of the site location.

Each of the Highway 404 overpass structure carries four lanes of the traffic over the Bloomington Road. The topography of the site area is generally undulating with knob-and-basin features. The surrounding area is mostly cultivated with presence of residential homes east of the site in the vicinity of Preston Lake.

Physiographically, the site is located in a region known as Oak Ridges Moraine, which was formed during the late Wisconsin glaciation period. The subsoils for this region generally transition between deposition layers of glaciofluvial to glaciolacustrine and are comprised of sandy or gravelly materials, which are underlain by glacial till. Bedrock in the area consists of shale of Upper Ordovician Georgian Bay Formation. Based on previous investigations, the bedrock surface was encountered between 180 to 240 m below the ground surface.

### **4. INVESTIGATION PROCEDURES**

This Preliminary Foundation Investigation Report is based on existing subsurface information. No current subsurface investigation was carried out at the site location for this project. Previous MTO GEOCRES reports, listed in Section 2, were reviewed to gather subsoil and groundwater data.

The original foundation investigation field work conducted by the Soil Mechanics Section (Reference 1) was carried out during the period of February 22 and March 6, 1978. A total of six boreholes were put down, each of which was accompanied by a dynamic cone penetration test (DCPT). The borings ranged in depth between 13.7 to 41.1 m (45 to 135 ft.) below the ground surface. At that time, it was proposed to construct an interchange with the twin structures to carry the NBL and SBL of Highway 404 over Bloomington Road Extension. It was anticipated that the



profile grade of Highway 404 will be at elevation 310.6 (1019 ft.) in a fill section up to 2.7 m (9 ft.) and that of Bloomington Road (Regional Road #40) at elevation 303.9 (997 ft.) in a cut section.

The foundation investigation work by Golder Associates Ltd. (Reference 2) was carried out between August 9 and 10, 1999. A total of four boreholes were investigated in the median at the base of the south and north embankments, respectively. The boreholes were drilled to depths between 7.9 and 12.8 m. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Two piezometers were installed to permit monitoring of the groundwater levels at the site. The purpose of the foundation investigation was to determine the subsoil and groundwater conditions for the proposed widening of the twin overpass structures at Highway 404 and Bloomington Road.

## **5. SUMMARIZED SUBSURFACE CONDITIONS**

The subsurface and groundwater conditions encountered are summarized below. The Foundation Investigation Report by Golder Associates Ltd. shows the locations of the borings for both investigations, together with the interpreted stratigraphy profile and sections, in Drawing 1.

### **5.1 General**

Refer to the Record of Borehole (Appendix A) for the details of the subsurface conditions including soil classifications, inferred stratigraphy, and groundwater observations for the median of the Highway 404 NBL and SBL.

The stratigraphy revealed in the boreholes generally comprised 100 to 150 mm thick surficial topsoil underlain by 0.6 to 2.8 m of fill. The fill was underlain by an up to 2.1 m thick deposit of clayey silt, excluding borehole 99-2, which in turn overlaid granular silty/sandy deposit. The granular deposit extended to the full depth of the boreholes except in Borehole 99-3, where a lower deposit of clayey silt was encountered.

### **5.2 Topsoil**

A surficial layer of 100 to 150 mm thick topsoil was present in all boreholes, extending to elevations 303.8 to 310.0.





### **5.3 Fill**

Loose to compact, 0.6 to 1.3 m thick sand to silty sand fill deposits were encountered below the topsoil layer at 0.1 to 0.15 m, elevation 303.8 to 310.0. N values recorded were between 8 and 22. The measured moisture contents of the selected sand to silty sand fill samples ranged between 5 and 10%.

In borehole 99-3 and 99-4, a 1.5 m thick layer of stiff to very stiff clayey silt fill was encountered below the sand fill at 0.7 and 1.5 m, elevation 309.4 and 308.6, respectively, which extended to 2.2 and 3.0 m, elevation 307.9 and 307.1. N values recorded ranged from 12 to 19. One moisture content determination for a selected clayey silt fill sample was measured at 12%.

It is probable that the sand fill was the result of the original highway embankment and roadway construction works and that the clayey silt originated from the native surficial deposit identified in the original foundation investigation (Reference 1), which was reworked and graded to construct the existing embankments.

### **5.4 Clayey Silt**

A 1.5 to 2.1 m thick very stiff to hard clayey silt was encountered below the fill in boreholes 99-1, 99-3 and 99-4 at 1.3 to 3.0 m, elevation 302.6 to 307.9. The layer extended to 2.7 to 4.5 m, elevation 301.1 to 305.9. A lower hard clayey silt deposit was encountered in borehole 99-3 at 7.2 m, elevation 303.0 and extended to the borehole 99-3 termination depth of 7.9 m, elevation 302.2. N values measured ranged between 22 to greater than 50 blows per 300 mm of penetration.

The Atterberg liquid limits for two selected samples were 24 and 22 with corresponding plastic limits of 13 and 14, with a plasticity index of 11 and 8, respectively, indicating low plasticity. The measured moisture contents ranged between 10 and 16%.



## **5.5 Sand**

A 2.9 m thick dense to very dense sand deposit was encountered in borehole 99-3 in between clayey silt layers at 4.3 and 7.2 m, elevation 305.9 and 303.0. Two N values recorded were 45 and 78. Two moisture content determinations were about 2.0%.

## **5.6 Silt and Sand to Silty Sand**

A compact to very dense cohesionless silt and sand to silty sand deposit was encountered in boreholes 99-1, 99-2 and 99-4 below the clayey silt. Occasional silt layers of up to 1.5 m in thickness were encountered within the silt and sand to silty sand deposit. In borehole 99-4, a silt interlayer was encountered which was at least 3.4 m thick. The layer was not fully penetrated. The boreholes 99-1, 99-2 and 99-4 were terminated at 7.9 to 12.8 m, elevation 291.1 to 302.2. N values recorded within the sands and silts were 14 to greater than 50 blows per 300 mm penetration. The moisture contents measured for the samples ranged from 15 to 23%, generally decreased with depth.

## **5.7 Groundwater**

Groundwater levels were noted in the open boreholes during and upon completion of augering. The water levels measured in the open boreholes 99-1 and 99-2 upon completion of augering were 3.4 m, elevation 300.5 and 3.05 m, elevation 300.8, respectively. Boreholes 99-3 and 99-4 were found dry in the open boreholes upon completion of augering.

Two piezometers were installed in boreholes 99-1 and 99-3 for subsequent groundwater measuring. No groundwater was encountered in the piezometer installed in borehole 99-3. The measured depth of the water level in borehole 99-1 piezometer installed was 4.4 m, elevation 299.5, in August 18, 24 and October 19, 1999.

Groundwater levels are subjected to fluctuations due to seasonal and rainfall patterns.



## 6. MISCELLANEOUS

The Preliminary Foundation Investigation portion of this report was prepared by Mr. N. Rahman, P.Eng., and reviewed by Mr. D. Dundas, P.Eng. The report was independently reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact.

Yours very truly,

Peto MacCallum Ltd.



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**PRELIMINARY FOUNDATION DESIGN REPORT**

for  
Bloomington Road Structures  
Highway 404 HOV Lane Expansion  
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WO 03-20024,  
Regional Municipality of York, Ontario

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**7. ENGINEERING RECOMMENDATIONS**

**7.1 General**

This portion of the report provides the preliminary foundation design recommendations for the proposed widening of the existing Bloomington Road Overpass structures, associated with the proposed widening of Highway 404 in the Regional Municipality of York. The recommendations are intended for preliminary design and planning purposes only and are based on the factual subsurface and groundwater conditions obtained from previous investigations. Further foundation engineering services will be required to provide detail design level recommendations.

It is anticipated that the widening will be achieved by adding one lane to the inside of the Highway 404 NBL and SBL lanes. It is envisaged that this may require filling of the median ditch and construction of a barrier along the centreline of the median.

Refer to the General Arrangement Drawing (Appendix B) for illustration of the original structure. It is understood that previous widening of the Bloomington Road Overpass structures was achieved by additional one lane in each direction in the median area. The additional lanes were built to coincide with the Highway 404 grade of elevation 311 at the site. A 1.0 to 1.5 m fill material was anticipated to be placed on the embankments to provide the appropriate grade at the bridge structures.

**7.2 Foundation Options**

The existing abutments are founded on spread footings at about elevation 302.1. The soil stratigraphy at that elevation corresponds to compact to very dense silt and sand to silty sand deposit, interstratified with silt layers. The groundwater level was measured in a piezometer at elevation 299.5.



The following table summarizes the foundation types considered, their advantages and disadvantages as well as relative cost and risks/consequences are tabulated below:

Foundation Type	Advantages	Disadvantages	Relative Cost	Risks/Consequences
Spread Footings (placed on native soils or structural fill)	Ease of installation. Existing foundation type. No vibration concerns from pile driving.	Groundwater level at the site may require dewatering and shoring. May require construction of a fill pad, which would require wider area. Possible differential settlement between the existing and proposed structures.	Low	Differential settlement between widened and existing portions of structure.  May require excavation below the groundwater level.
Driven H-Piles	Driven H-piles cause small soil displacement and less risk to disturbing existing foundations.	Vibration induced during driving may require preaugering for approximately 3m.  Possible presence of cobbles and boulders in the glacial till soils.	Moderate	Pile driving induced vibrations could cause disturbance to ground supporting existing foundations and subsequent settlement of existing structure.
Caissons	Larger bearing capacity than for other options	Challenging installation due to the presence of noncohesive soil and high groundwater table, which could require liners, mud drilling techniques and tremie concreting methods.  Construction difficulties due to possible presence of cobbles and boulders in the glacial till soils.	High	Loss of ground during installation that could cause settlement of existing foundations.  Flowing soils under along shaft and base could cause necking of concrete in caisson and subsequent reduction in resistance of caisson foundation.

The proposed widening of the structures could be supported on spread footings or piles, depending on risk tolerance, relative costs and in consideration of past performance of spread footings. The issue for consideration is differential settlement between the existing structures and proposed widened portions. Driven H-piles would provide the least risk solution to minimize differential settlements, but would cost more and would introduce requirements to monitor and control vibrations during pile driving and would probably require preaugering to minimize those vibrations. Spread footings were effective for the original structure and if they provided acceptable performance for previous structure widening, they could be considered as the simplest and least costly foundation solution.



### 7.2.1 Spread Footings

The preliminary factored geotechnical resistance at ultimate limit states (ULS) and geotechnical reaction at serviceability limit states (SLS) for spread footings founded on native soil at about elevation 302.0 are as follows:

FOUNDATION ALTERNATIVE	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL REACTION AT SLS (kPa)
Spread Footing on native soil	525	350

A footing width of 4.0 m and groundwater at about elevation 299.5 were considered for the bearing resistance computation for footings on native soils. The geotechnical resistance at SLS normally allows for 25 mm of total compression of the founding medium. In this case, it is expected that the settlement could be in the order of 15 mm or less. A construction joint with dowels could be incorporated between the new and existing footings to accommodate differential settlements.

The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and native soil. An unfactored friction factor of 0.50 is recommended for footings placed on native soils.

Footings should be provided with 1.2 m of earth cover or equivalent thermal insulation.

### 7.2.2 Driven H-piles

Alternatively, the widening structures could also be supported on pile foundations. Based on the original investigation (Reference 1), the pile lengths could be greater than 38.0 m in length and possibly driven down to lower than elevation 271. Additional boreholes to depths greater than 38.0 m would be needed to determine the end-bearing stratum and resistance values.

Settlement monitoring of the existing foundations would be required during pile driving operations. The issue would have to be addressed during detailed design.





Vibration and noise would also have to be monitored in order to confirm that all the MTO and other by-law requirements are applicable to this site. This issue would have to be addressed during detailed design.

The approach embankment fill as well as any fill placed below grade to deal with unsuitable/compressible soils within the limits of the pile foundation should comprise Granular A or Granular B Type II with a maximum nominal size of 75 mm to enable driving of the piles and minimise the potential for damage during pile installation.

A 1.2 m thickness of soil cover or the equivalent thermal insulation should be provided for frost protection to the pile caps.

Resistance to lateral loads may be provided in part by mobilization of passive resistance along the pile. It is recommended that the design value used for lateral pile resistance should not exceed 150 kN for Factored Resistance at ULS and 100 kN for SLS. If greater lateral resistance is required, it can be provided by the horizontal component of battered piles.

The abutment and wing walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. Recommendations for earth pressures should be provided in the detail design phase.

### **7.3 Approach Embankments**

Based on the available general arrangement drawing, the existing earth embankment side and front slopes are constructed at 2H:1V slope. The heights of the embankments are expected to be in the order of 6 to 8 m.

It is anticipated that the embankment slopes after pile construction will be at set at 2H:1V from the toe to the crest. However, if 2H:1V slope cannot be realized from the toe to the crest of the embankment slopes, then retaining toe walls would be required at the toe of the slopes. The retaining toe walls locations and height should be such to permit a 2H:1V slope geometry above



the retaining wall. Further, where the height of the embankment is greater than 8 m for earth fill, a 2.0 m wide mid-height bench will be required in accordance with OPSD 202.010.

The embankment height will remain the same as existing. Based on observation of acceptable performance of existing embankments, no slope stability issues will occur.

Due to the anticipated inside widening of the Highway 404 by adding one HOV lane in each direction, the median width will be reduced from the existing 20.0 m. It is assumed that the median will be reduced by 6.0 m from each side resulting in median width reduced to 8.0 m.

The existing materials within the 20 m backfill zone of the abutments should be excavated prior to placement of the backfill. Benching of the existing embankment front slopes (at the abutments) should be carried out to key in the new fill. The new fill should be keyed into the existing fill as per MTO standards.

In view of the widening within the existing median, negligible settlement is anticipated at the approach embankments.

## **7.4 Construction Considerations**

### **7.4.1 Excavation**

All excavation at the structure foundation sites should be carried out in accordance with the Occupational Health and Safety Act (OHSA), local and MTO regulations.

According to OHSA criteria, very loose to loose and soft soils are classified as Type 4 soils, compact non-cohesive and stiff to firm cohesive soils are classified as Type 3 soils. The very stiff cohesive and dense non-cohesive soils are considered as Type 2 soils. The hard cohesive soil is classified as Type 1 soil. Since open cut procedures are governed by soils with the highest soil type number, temporary cut slopes over the full depth of excavation inclined at 3 horizontal to 1 vertical should be provided assuming adequate drainage measures are in place. Flatter slopes may



be required at locations where water seepage affects stability of an excavation. If steeper geometries are required, shoring will be necessary.

The selection of the method of excavation is the responsibility of the Contractor and a provision must be made for the handling of pavement materials, potential obstructions in the fill, and potential presence of cobbles and boulders.

Excavations should not extend below the base elevation of existing footings unless they are outside of a plane defining stable geometry that can be taken as 1H:1V from a point 1 metre beyond the base of the existing footing to the base of the excavation for excavations above the groundwater level. Where steeper excavation geometries are required, shoring will be required.

#### 7.4.2 Roadway Protection

Temporary roadway protection will probably be required to permit excavation between the existing highway lanes and the proposed widenings. A minimum performance level of 2, according to OPSS 539 is recommended. The contractor is responsible for selection, preparation of a detailed design and performance for the roadway protection system. Several protection scheme alternatives such as sheet piling, sheeting supported by rakers or bracing, cantilever or anchored soldier piles and lagging may be considered.

#### 7.4.3 Groundwater Control

No major groundwater problems are anticipated at the abutments during the time of construction. Subject to the groundwater level at the time of construction, it is considered feasible to employ sump pumps to control groundwater seepage into the excavations during construction.



## **8. SCOPE OF ADDITIONAL FOUNDATION INVESTIGATION**

The recommendations in this report are preliminary. Detailed foundation engineering services will be required during the Detail Design phase of the project.

The extent of further investigations at this site may be limited to 1 borehole in the Highway 404 median at each of the north and south abutments extending to depth sufficient to provide information for shoring and dewatering plus 1 additional borehole in the median at each of the north and south structure approaches within 20 m of the abutments to determine the extent of compressible material to be removed for the widened highway lanes. If H-piles are selected to support the widenings, 1 deep borehole will be required between each existing abutment. Further, it is recommended to install piezometers at the proposed abutment and approach embankment borehole locations to monitor and establish a stabilized groundwater level at the site location during the detailed design of the widening structures.

Detail design recommendations would be required for all aspects including slope stability, settlement, axial and lateral spread footing or pile resistance, seismic design, temporary roadway protection, dewatering, construction specifications and liaison with the design team.



## 9. CLOSURE

The Preliminary Foundation Design part of this report was prepared by Mr. N. Rahman, P.Eng., and reviewed by Mr. D. Dundas, P.Eng. The report was independently reviewed by Mr. B. R. Gray, MEng, P.Eng., MTO Designated Principal Contact.

Yours very truly,

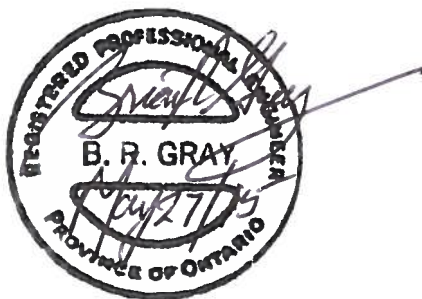
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## **APPENDIX A**

Previous Foundation Investigation Report

December 1999

991-8024A

**PART A - FIELD INVESTIGATION  
BLOOMINGTON ROAD TWIN OVERPASS BRIDGES  
HIGHWAY 404 WIDENING  
BLOOMINGTON ROAD TO AURORA ROAD  
G.W.P. 433-98-00, SITE 37-737 / 1 AND 37-737 / 2  
REGIONAL MUNICIPALITY OF YORK**

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## 1.0 INTRODUCTION

Golder Associates Ltd. has been retained by Delcan Corporation (Delcan) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation at the site of the proposed widening of the twin overpass structures at Highway 404 and Bloomington Road in the Region of York, Ontario. The project consists of the widening of Highway 404 from south of Bloomington Road to Aurora Road, and the widening of the twin overpass structures at Bloomington Road and the CNR tracks within the project limits. This report addresses the proposed widening of the Highway 404 twin overpass structures at Bloomington Road and their approaches within 20 m of the structures.

The purpose of the foundation investigation is to determine the subsurface conditions at the site of the proposed additions to the bridge structures by drilling boreholes, and carrying out in-situ tests and laboratory tests on selected samples. Based on our interpretation of the data obtained, recommendations on the foundation aspects of design of the proposed works are provided. Comments are also provided on anticipated construction problems where they may affect the design of the proposed bridges and approach embankments.

The terms of reference for the scope of work are outlined in our proposal letter P91-1113, dated March 26, 1999. The work was carried out in accordance with our Quality Control Plan for Foundation Design Services, dated June 1999.

## 2.0 SITE DESCRIPTION

The site is located approximately 4.2 km north of the intersection of Stouffville Road and Highway 404 and 0.5 km west of the intersection of Woodbine Avenue and Bloomington Road, bordering the Towns of Aurora and Richmond Hill, in the Regional Municipality of York.

The topography of the general site area is undulating. The ground surface generally slopes down to the south towards Lake Ontario, but varies locally from about Elevation 303 m to Elevation 310 m. Based on available existing site information, it appears that Bloomington Road was constructed in cut at the location of Highway 404. A review of existing contract documents and the provided plan indicates the approximate grades of Highway 404 and Bloomington Road at the site are at about Elevation 310.6 m and Elevation 303.9 m, respectively.

The vegetation cover within the median and along the embankment slopes consists of grass. The existing median embankment slopes are at 2 horizontal to 1 vertical (2H:1V). At the time of site investigation, there was no evidence of surficial instabilities on the median embankment slopes.

The original MTO foundation report for the existing structures at the site is referenced as:

- GEOCRETS 30M14-158, titled "Regional Road #40 Extension Interchange, 2.6 Miles North of Regional Road #14", W.P. 160-74-32, Highway 404, District 6, Site 37-737, Toronto, dated May 1978.

### 3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out on August 9 and 10, 1999. At this time four boreholes were put down at the site. Two boreholes, 99-1 and 99-2, were put down in the median at the base of the south and north embankments, respectively. Boreholes 99-3 and 99-4 were drilled in the median at the crest of the south and north approach embankments, respectively.

The investigation was carried out using a truck-mounted D-90 drill rig supplied and operated by Master Soil Investigation of North York. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. The boreholes were extended to depths of between 7.9 m and 12.8 m below the existing ground surface. Groundwater conditions in the open boreholes were observed throughout the drilling operations. Piezometers were installed in two boreholes to permit monitoring of the groundwater levels at the site.

The field work was supervised on a full-time basis by a member of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labeled containers and transported back to our laboratory in Mississauga for further examination. Index and classification tests were carried out on selected samples. The results of the testing are shown on the attached Record of Borehole sheets and on Figures 1 to 5.

A plan view for the twin bridge structures at Bloomington Road and Highway 404 was provided to us in digital format by J.D. Barnes Limited, professional land surveyors. J.D. Barnes Limited surveyed and staked in the field the Highway 404 median at 50 m chainage intervals within the project limits.

The boreholes were surveyed by J.D. Barnes Limited upon completion of the drilling operation. It is understood that the northing and easting co-ordinates of the borehole locations are given in UTM, and the borehole elevations are referenced to the Geodetic Datum. The co-ordinates of the boreholes are indicated on the Record of Borehole sheets and the locations of the boreholes are shown on Drawing 1.

## **4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY**

### **4.1 Site Geology**

The site is located in the physiographic region known as the Oak Ridges Moraine, which was formed between two opposing movements of ice during the late Wisconsinan period of glaciation (Chapman and Putnam, "The Physiography of Southern Ontario", 3<sup>rd</sup> Edition, 1984). The topography of the Oak Ridges Moraine is hilly, with knob and basin relief that is typical for an end moraine. The subsoils for this region are generally comprised of sandy or gravelly materials, which are underlain by glacial till. Interbeds of fine sand, silt, and clay are also common. Bedrock is generally deep below the ground surface in this region; a previous investigation carried out by others in the region found the top of bedrock varied between 180 m to 240 m below the ground surface.

### **4.2 Site Stratigraphy**

The detailed subsurface soil and groundwater conditions encountered in the boreholes, together with the results of the laboratory tests carried out on selected soil samples, are given on the attached Record of Borehole sheets following the text of this report. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

Relevant information on subsurface conditions was obtained from Boreholes 99-1 to 99-4. The subsurface information obtained from the current investigation was supplemented by the borehole information from the original foundation report for the existing bridge structures. Copies of the boreholes put down as part of the original site investigation are found in Appendix A of this report.

In summary, the subsoils at the site consist of surficial topsoil underlain by about 0.6 m to 2.8 m of sand and / or clayey silt fill. The fills are underlain by a deposit of clayey silt up to 2.1 m in thickness encountered in all boreholes, except Borehole 99-2, which in turn is underlain by a granular deposit. The granular deposit consists of sand within the area of the south embankment (Borehole 99-3) and silt and sand to silty sand with occasional silt interlayers at the other areas of investigation. The silt / sand deposit extends to the full depth of the boreholes except in

Borehole 99-3, where a lower deposit of clayey silt was encountered. The lower clayey silt was not fully penetrated but proved to a thickness of at least 0.8 m.

Locations and elevations of the borings for the current and original investigations, together with the interpreted stratigraphical profile and sections, are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided in the following sections.

#### **4.2.1 Topsoil**

A surficial layer of topsoil was encountered at the location of all boreholes for this investigation. The topsoil thickness varies between 100 mm and 150 mm in the boreholes.

#### **4.2.2 Fills**

Below the topsoil is a 0.6 m to 1.3 m thick layer of sand fill, which varies from sand with some silt in Boreholes 99-1 and 99-2 to silty sand in Boreholes 99-3 and 99-4. Standard Penetration testing (SPT) carried out within the sand fill gave "N" values ranging from 8 blows to 22 blows per 0.3 m of penetration, indicating a loose to compact state of packing. The measured water contents for selected samples of the sand fill range from 5 percent to 10 percent.

The sand fill is likely the result of the original highway embankment and road construction works.

At the location of Borehole 99-3 and 99-4 a layer of clayey silt fill was encountered, which immediately underlies the sand fill. The clayey silt fill contains trace to some sand, trace gravel, and occasional organics. The clayey silt fill is stiff to very stiff in consistency. Standard Penetration testing carried out within this layer gave "N" values of 12 blows to 19 blows per 0.3 m of penetration. The natural water content for a selected sample of this layer was measured at 12 percent.

The clayey silt fill likely originates from the native surficial clayey silt deposit identified in the original foundation investigation, which was probably reworked and graded to construct the existing embankments.

#### 4.2.3 Clayey Silt

A 1.5 m to 2.1 m thick deposit of clayey silt to silty clay was encountered below the fill in Boreholes 99-1, 99-3 and 99-4. The clayey silt contains trace to some sand and trace gravel. A grain size distribution curve for a selected sample of clayey silt is shown on Figure 1. The clayey silt is very stiff to hard in consistency. Standard Penetration testing carried out within this deposit gave "N" values of between 22 blows to greater than 50 blows per 0.3 m of penetration. Atterberg limits testing carried out on two selected samples of the clayey silt to silty clay gave a liquid limit of 24 percent and 22 percent, and a plasticity index of 11 percent and 8 percent, respectively; this indicates the clay is of low plasticity. A plasticity chart, which includes the results of the Atterberg limits tests, is shown on Figure 2. The water contents measured for selected samples of the clayey silt range from 10 percent to 16 percent, and were generally near or below the plastic limit.

#### 4.2.4 Sand

Below the clayey silt in Borehole 99-3 a deposit of sand was encountered. The sand deposit contains trace gravel and silt. A grain size distribution curve for the sand is shown on Figure 3. Standard Penetration testing carried out within the sand gave "N" values of 45 blows to greater than 50 blows per 0.3 m of penetration, indicating a dense to very dense state of packing. The natural water contents for two selected samples of this deposit were measured at about 2 percent.

#### 4.2.5 Silt and Sand to Silty Sand

Immediately below the clayey silt deposit in Boreholes 99-1, 99-2 and 99-4 exists a deposit of silts and sands. In general, the deposit is comprised of silt and sand to silty sand with occasional layers of silt of up to about 1.5 m in thickness. Grain size distribution curves for three selected samples of silt and sand to silty sand deposit are shown on Figure 4. At the location of Borehole 99-4 a silt interlayer that was encountered was not fully penetrated, but proved to be at least 3.4 m in thickness. Grain size distribution curves for selected samples of the silt interlayers are shown on Figure 5.

Standard Penetration Testing carried out within the sands and silts gave "N" values of 14 blows to greater than 50 blows per 0.3 m of penetration, indicating a compact to very dense state of packing. The natural water content for selected samples of this deposit range from 15 percent to 23 percent, and generally decrease with depth.

The sands and silts extend to the full depth of all the borings, except in Borehole 99-3 where a lower deposit of hard clayey silt with some sand and trace gravel was encountered at the base of the borehole. The lower clayey silt deposit was not fully penetrated, but proved to a thickness of at least 0.8 m.

#### 4.2.6 Groundwater Conditions

Groundwater levels were noted in the open boreholes during and upon completion of the drilling operation; the noted levels are shown on the attached record of Borehole sheets. Piezometers were sealed in Borehole 99-1 and 99-3 to permit the monitoring of the stabilized groundwater conditions at the site. Details of the piezometer installations and water level measurements are shown on the attached Record of Borehole sheets. A summary of the monitoring results are provided in the following table.

<i>Borehole</i>	<i>August 18, 1999</i>		<i>August 24, 1999</i>		<i>October 19, 1999</i>	
	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>	<i>Depth (m)</i>	<i>Elevation (m)</i>
99-1	4.4	299.5	4.4	299.5	4.4	299.5
99-3	dry	-	dry	-	dry	-

Groundwater levels are expected to fluctuate seasonally and are expected to be higher during wet periods of the year.

**GOLDER ASSOCIATES LTD.**

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DKB/AJW/MSD/FJH/clg  
WORD S/FINAL.DAT/1100991-8024/8024ALR1



## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### II PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

#### Dynamic Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### III SOIL DESCRIPTION

#### (a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or 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	$c_u, s_u$ kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (L.V.-laboratory vane test)
$\gamma$	unit weight

Note:

1. Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. GENERAL

$\pi$	= 3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10} x$ or $\log x$ ,	logarithm of x to base 10
$g$	acceleration due to gravity
$t$	time
$F$	factor of safety
$V$	volume
$W$	weight

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
$u$	porewater pressure
$E$	modulus of deformation
$G$	shear modulus of deformation
$K$	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
$e$	void ratio
$n$	porosity
$S$	degree of saturation
*	Density symbol is $\rho$ . Unit weight symbol is $\gamma$ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

#### (a) Index Properties (con't.)

$w$	water content
$w_L$	liquid limit
$w_p$	plastic limit
$I_p$	plasticity Index = $(w_L - w_p)$
$w_s$	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
$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (c) Hydraulic Properties

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

#### (d) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (overconsolidated range)
$C_s$	swelling index
$C_\alpha$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation
$T_v$	time factor (vertical direction)
$U$	degree of consolidation
$\sigma'_p$	pre-consolidation pressure
OCR	Overconsolidation ratio = $\sigma'_p / \sigma'_{vo}$

#### (e) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction = $\tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
$p$	mean total stress $(\sigma_1 + \sigma_3) / 2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
$q$	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
$S_t$	sensitivity

Notes: 1.  $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

PROJECT 991-8024			RECORD OF BOREHOLE No 99-1			1 OF 2		METRIC															
W.P. 433-98-00			LOCATION N 4870628.02; E 313378.93			ORIGINATED BY DKB																	
DIST 6 HWY 404			BOREHOLE TYPE 114mm SOLID STEM AUGERS			COMPILED BY DKB																	
DATUM GEODETIC			DATE 9.8.99			CHECKED BY AJW																	
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	γ	GR	SA	SI	CL						
303.88 0.96 0.10	Topsoil Sand, some silt, trace gravel Compact Brown Moist (Fill)		1	50 DO	18																		
302.61			2	50 DO	22		303																
1.27	Clayey Silt, trace gravel and sand Hard Brown Moist		3	50 DO	41		302							3	9	88							
			4	50 DO	70		301																
301.14 2.74	Silt and Sand to Silty Sand, occ. layers of silt Compact to Dense Brown Moist to wet		5	50 DO	38		300																
300.13 3.75			6	50 DO	34		299							0	35	65							
299.38 4.50	Silt		7	50 DO	20		298																
			8	50 DO	24		297																
			9	50 DO	20		296																
			10	50 DO	17		295																
			11	50 DO	23		294																
			12	50 DO	24		293							1	40	59							
291.08 12.80	END OF BOREHOLE						292																

ON MOT 991-8024 GPJ ON MOT GDT 24/1/99

Continued Next Page

+ 3 . X 3 . Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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

ON MOT 991-8024.GPJ ON MOT.GDT 24/11/99

PROJECT 991-8024

# RECORD OF BOREHOLE No 99-2

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870653.58; E 313376.02

ORIGINATED BY DKB

DIST 6 HWY 404

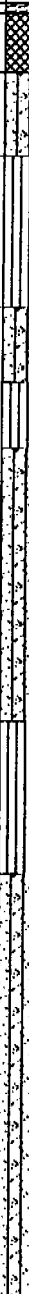
BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 9.8.99

CHECKED BY AJW

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										
								20	40	60	80	100						
303.87	Topsoil		1	50 DO	8	303												
0.98	Sand, some silt, trace gravel																	
303.18	Loose Brown Moist (Fill)		2	50 DO	24													
0.69	Silt and Sand to Silty Sand, occasional layers of silt																	
302.37	Compact to very dense Brown Moist to wet		3	50 DO	32													
1.50																		
300.87	Silt		4	50 DO	36													
3.00																		
300.12				5	50 DO		50											
3.75																		
299.47	Silt		6	50 DO	70													
4.40																		
			7	50 DO	62													
			8	50 DO	26													
298.77																		
7.10																		
	Silt	9	50 DO	28														
295.27			10	50 DO	26													
8.60																		
			11	50 DO	14													
			12	50 DO	24													
291.07																		
12.80	END OF BOREHOLE																	
	Note: Water level measured in open borehole at 3.05m depth (Elev. 300.82) upon completion of drilling.																	

ON MOT 991-8024.GPJ ON MOT.GDT 28/9/99

PROJECT 991-8024

# RECORD OF BOREHOLE No 99-3

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870610.30; E 313384.54

ORIGINATED BY DKB

DIST 6 HWY 404

BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 10.8.99

CHECKED BY AJW

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
310.14								20 40 60 80 100						
0.00	Topsoil													
0.15	Silty Sand, trace gravel		1	50 DO	19									
309.44	Compact Brown Moist (Fill)													
0.70	Clayey Silt, trace to some sand, trace gravel, occ. silty sand seams/pockets, occ. organics		2	50 DO	12									
	Stiff to very stiff Brown Moist (Fill)		3	50 DO	16									
307.93	Clayey Silt, trace to some sand, trace gravel													
2.21	Very stiff to hard Brown Moist		4	50 DO	39									
	Sand layer noted at 2.97m-3.35m depth.		5	50 DO	24									
305.87	Sand, trace silt, trace gravel		6	50 DO	39									
4.27	Dense to very dense Brown Dry to moist		7	50 DO	45									
			8	50 DO	78									
302.97	Clayey Silt, some sand, trace gravel													
7.17	Hard Brown Moist		9	50 DO	50/15									
302.22														
7.92	END OF BOREHOLE													
	Note: 1. Open borehole dry upon completion of drilling. 2. Piezometer dry on August 18/99. 3. Piezometer dry on August 24/99.													

PROJECT 991-8024

# RECORD OF BOREHOLE No 99-4

1 OF 1

METRIC

W.P. 433-98-00

LOCATION N 4870872.81, E 313371.74

ORIGINATED BY DKB

DIST 6 HWY 404

BOREHOLE TYPE 114mm SOLID STEM AUGERS

COMPILED BY DKB

DATUM GEODETIC

DATE 10.8.99

CHECKED BY AJW

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 (%) GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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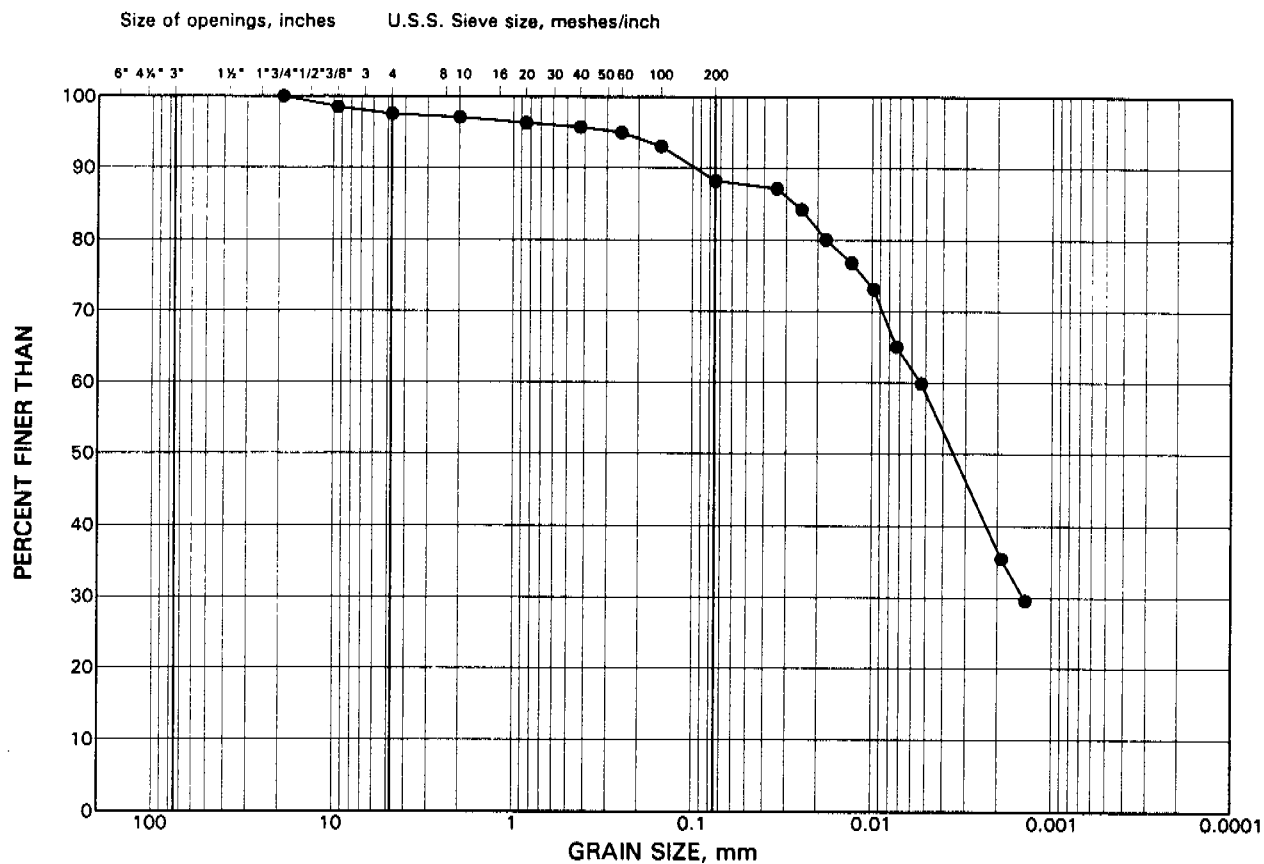
Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

# GRAIN SIZE DISTRIBUTION

Silty Clay, some sand, trace gravel

FIGURE 1



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

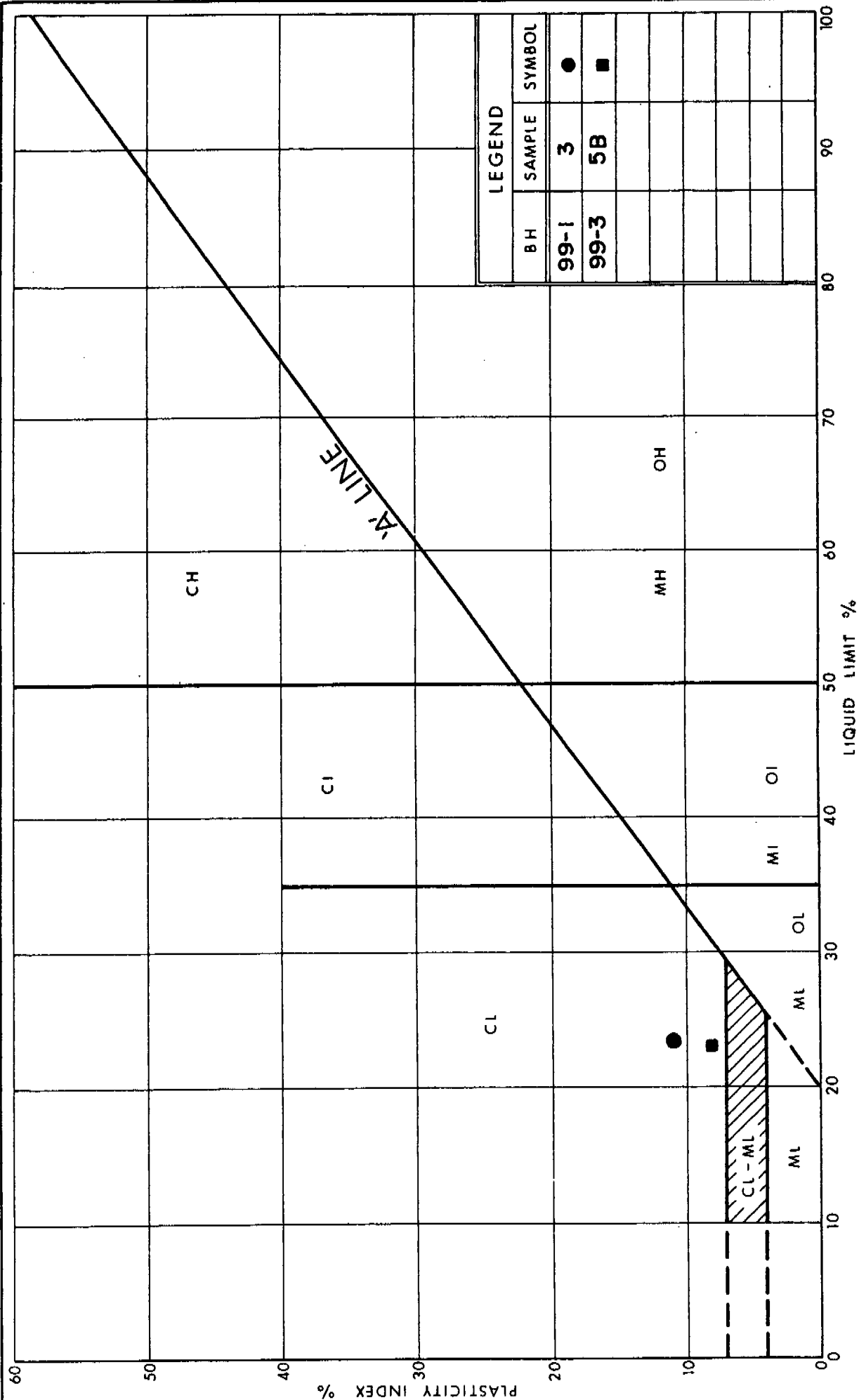
## LEGEND

SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

•      99-1      3      301.8



Oct 75, FF-S-21



# PLASTICITY CHART

CLAYEY SILT

FIG No 2

W P 433-98-00

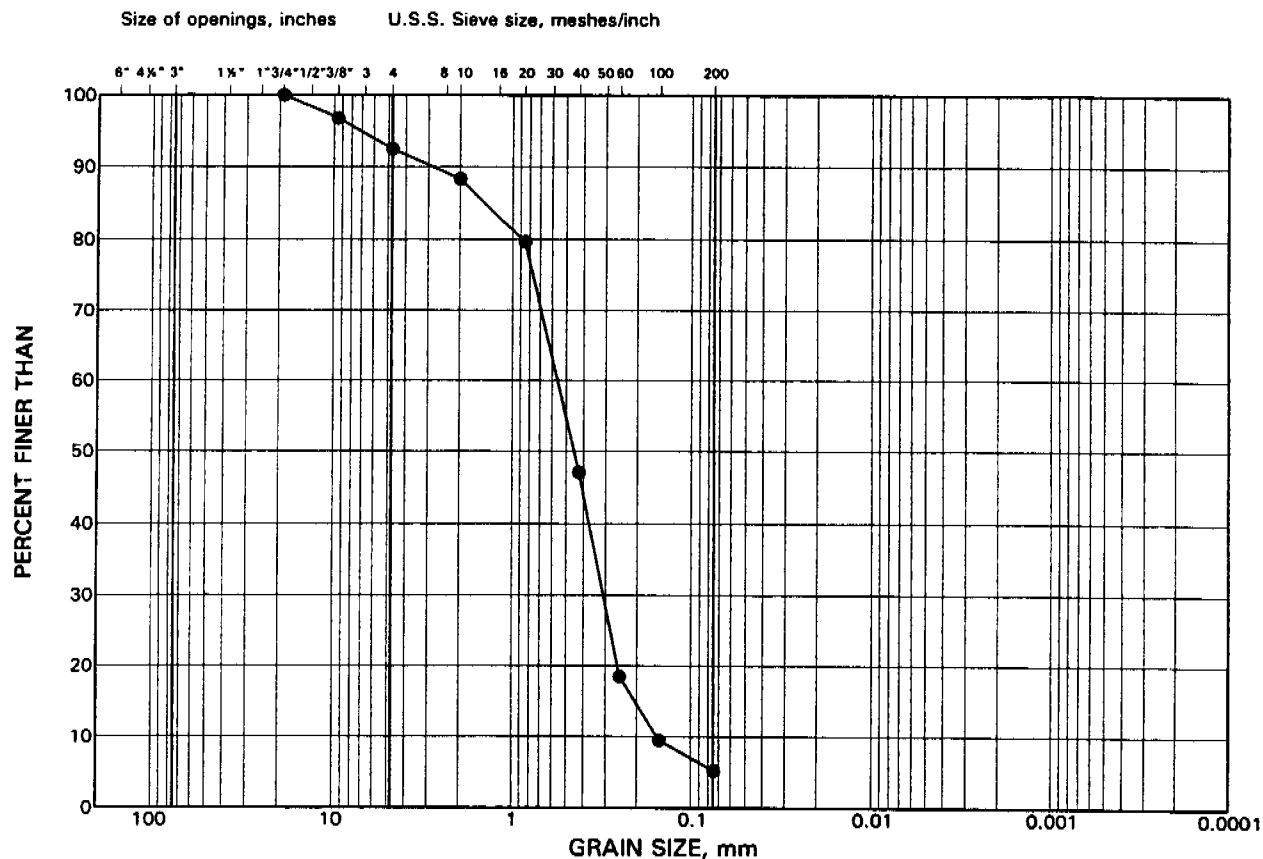
Ministry of  
Transportation



# GRAIN SIZE DISTRIBUTION

Sand, trace to some gravel, trace silt

FIGURE 3



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

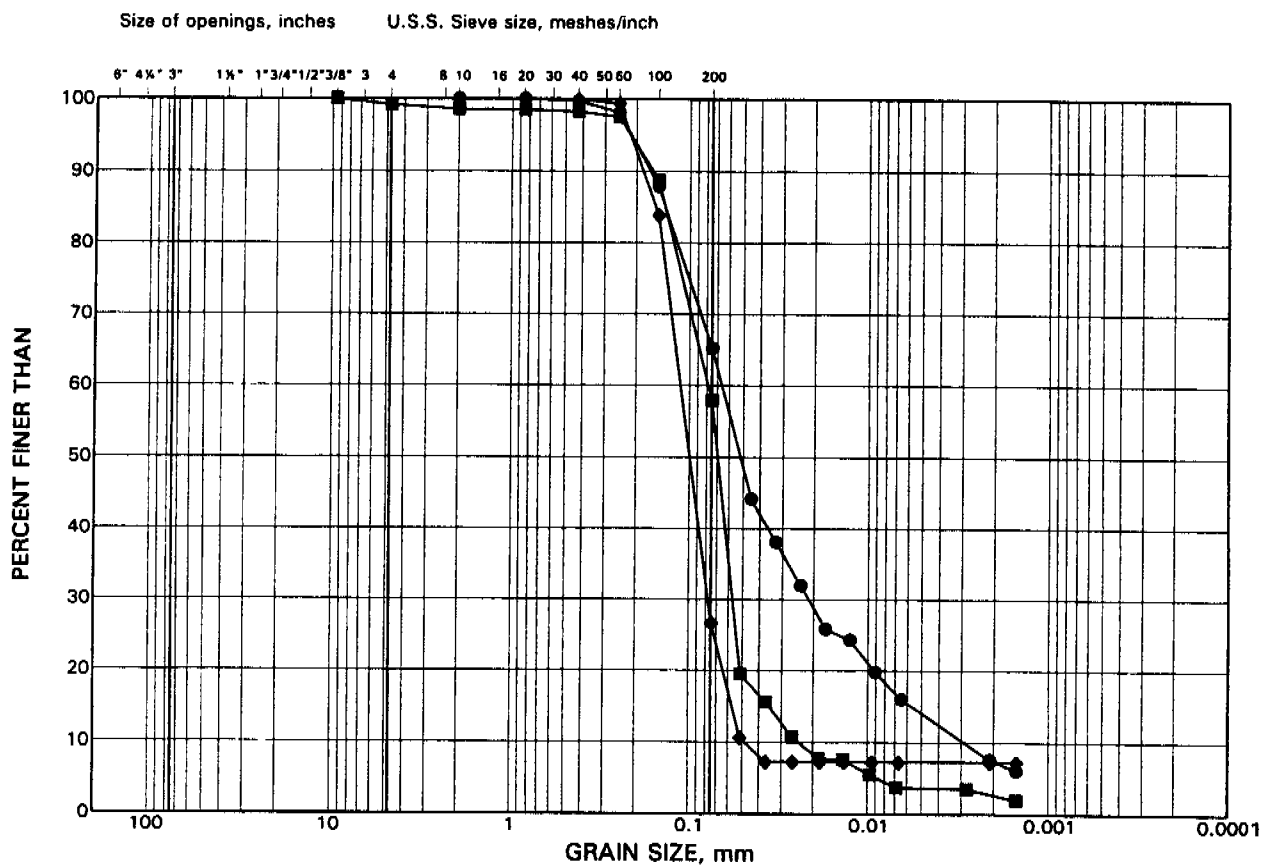
## LEGEND

SYMBOL	BOREHOLE	SAMPLE ELEVATION(m)
•	99-3	7      304.9

# GRAIN SIZE DISTRIBUTION

## Silt and Sand to Silty Sand

FIGURE 4



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

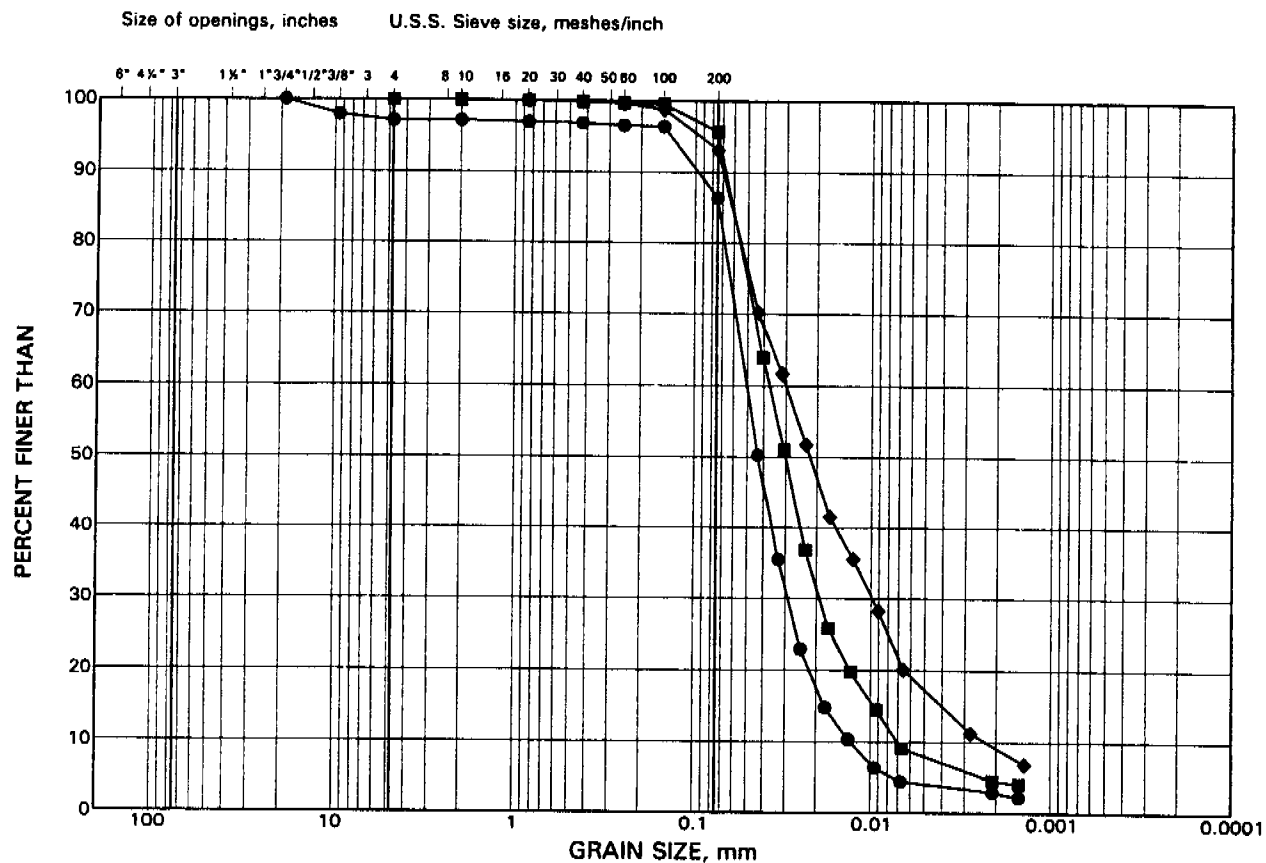
### LEGEND

SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

●	99-1	7	298.7
■	99-1	11	292.6
◆	99-2	11	292.6

# GRAIN SIZE DISTRIBUTION Silt

FIGURE 5



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

## LEGEND

SYMBOL      BOREHOLE      SAMPLE ELEVATION(m)

●	99-2	3	301.7
■	99-2	6	299.6
◆	99-4	8	303.4

**APPENDIX A**

**EXISTING BOREHOLE LOGS  
GEOCRE 30M15-158**

**"REGIONAL ROAD #40 EXTENSION INTERCHANGE,  
2.6 MILES NORTH OF REGIONAL ROAD #14",  
W.P. 160-74-32, HIGHWAY 404,  
DISTRICT 6, SITE 37-737, TORONTO,  
MAY 1978**



RECORD OF BOREHOLE No 1 cont.

W P 160-74-32 LOCATION Coords. N 15 979 708, E 1 028 052 ORIGINATED BY OL. J.  
DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casting and Cone Test COMPILED BY OL. J.  
DATUM Geodetic DATE February 27, 1978 CHECKED BY *[Signature]*

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
951.5							920										
61.5	Silty Fine Sand Very Dense		17	SS	151		910										
			18	SS	188/	10"	900										
			19	SS	90		890										
			20	SS	142/	9"	880										
878.5																	
134.5	End of Borehole																

# RECORD OF BOREHOLE No 2

WP 160-74-32

LOCATION Coords. N 15 979 737, E 1 028 145

ORIGINATED BY OL. J.

DIST 6 HWY 404

**BOREHOLE TYPE** Hollow-Stem Auger and Cone Test

COMPILED BY OL. J.

DATUM Geodetic

DATE February 22, 1978

CHECKED BY                     

[illegible]



## RECORD OF BOREHOLE No 3

160-74-32 LOCATION Coords. N 15 979 772, E 1 028 251 ORIGINATED BY OI. J.  
 HWY 404 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY OI. J.  
 DATUM Geodetic DATE February 28, 1978 CHECKED BY VJ.

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
DEPTH ELEVATION	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
1023.7	Ground Level												
1020.0	Silty Top Soil												
1019.7	Clayey Silt, with Sand		1	SS	6								0 49 33 18
	Firm to stiff		2	SS	21								
1009.7			3	SS	66								
1009.7	Sand trace to some gravel		4	SS	79								8.88 (4)
	very dense		5	SS	103								
995.7			6	SS	54								
28.0	Silty fine sand with occasional layers of silt		7	SS	100								
	boulder		8	SS	83								2 13 81 4
	very dense		9	SS	149								
977.2													
46.5	End of borehole												

3, x 5 : Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

W P 160-74-32 LOCATION Coords. N 15 979 808 E 1 028 035 ORIGINATED BY OL. J  
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL. J  
 DATUM Gauderic DATE May 7, 1978 CHECKED BY *u.f.*

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1005.9	Ground Level																
0	Silty Top Soil																
2.0	Clayey/Silt with Sand		1	SS	14												
	Stiff to very Stiff		2	SS	38												0 10 84 6
993.9																	
12.0	Silty fine sand with occasional layers of silt. Compact to very dense.		3	SS	43												
			4	SS	37												
	----- silt		5	SS	51												0 13 71 16
	Generally		6	SS	27												
	Dense to very dense		7	SS	28												0 49 49 2
			8	SS	22												
			9	SS	4												
			10	SS	32												
			11	SS	56												
944.6																	
61.5	End of borehole																

# RECORD OF BOREHOLE No 5

W P 160-74-32 LOCATION Coords. N 15 979 847 N 1 028 150 ORIGINATED BY 01. J  
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY 01. J  
 DATUM Geodetic DATE March 3 & 7 1978 CHECKED BY *WJ*

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20	40	60	80	100				
1047.9	Ground Level															
2.0	Silty Top Soil															
	Clayey Silt with Sand		1	SS	18											
	Stiff to very stiff		2	SS	25											
1003.9																
14.0	Sand. Traces of gravel		3	SS	47											0 89 (11)
4.7	very dense															
997.9			4	SS	89											0 15 68 17
20.4	Silt															
6.1	Traces of Clay and Sand		5	SS	134											0 11 83 6
			6	SS	103											
	Silty fine Sand		7	SS	80											
	with occasional layers of silt		8	SS	37											
	Compact to very Dense		9	SS	41											
			10	SS	116											
	Generally dense to very dense		11	SS	53											
			12	SS	71											
			13	SS	9											0 77 (23)
			14	SS	26											
916.4																
101.5																

# RECORD OF BOREHOLE No 5 cont

W.P. 160-74-32 LOCATION Coords. N 15 979 847 E 1 028 150 ORIGINATED BY 01. J.  
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY 01. J.  
 DATUM Geodetic DATE March 7, 1978 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
916.4 101.5	Cont.																
			15	SS	154	11"	810										2 31 62 5
891.4 126.5	End of borehole		16	SS	75		900										

## RECORD OF BOREHOLE 'No 6

160-74-32 LOCATION Coords. N 15 979 872 E 1 028 230 ORIGINATED BY OL. J.  
 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL. J.  
 Geodetic DATE March 1 & 2 1978 CHECKED BY *OL. J.*

ELEV DEPTH IN FOOT	SOIL PROFILE DESCRIPTION	STRAT PLOT	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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
1013.3	Ground Level																
7.0	Silty Top Soil																
	Clayey silt with sand and a trace of gravel		1	SS	9												3 25 52 20
	firm to very stiff		2	SS	32												
14.0	Sand		3	SS	92												0 96 (4)
995.3	Trace of gravel		4	SS	30												
22.0	Dense to very dense																
	Silty Fine Sand		5	SS	44												0 12 69 19
	with																
	----- silt		6	SS	33												
	Occasional layers of Silt		7	SS	36												
	Low plasticity.		8	SS	19												
	Generally		9	SS	39												
	Dense to very dense		10	SS	75												
			11	SS	69												
			12	SS	106												
			13	SS	99												
925.8			14	SS	35												
91.5																	

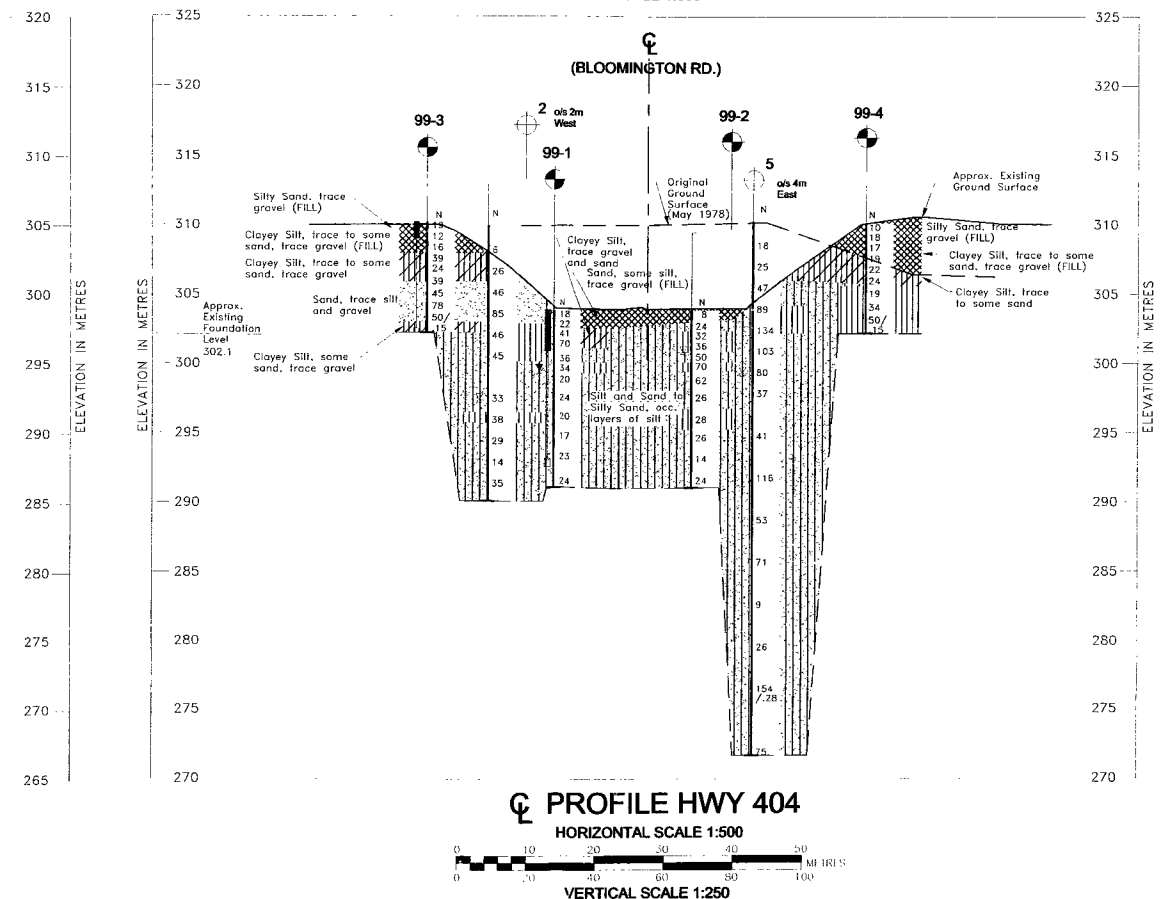
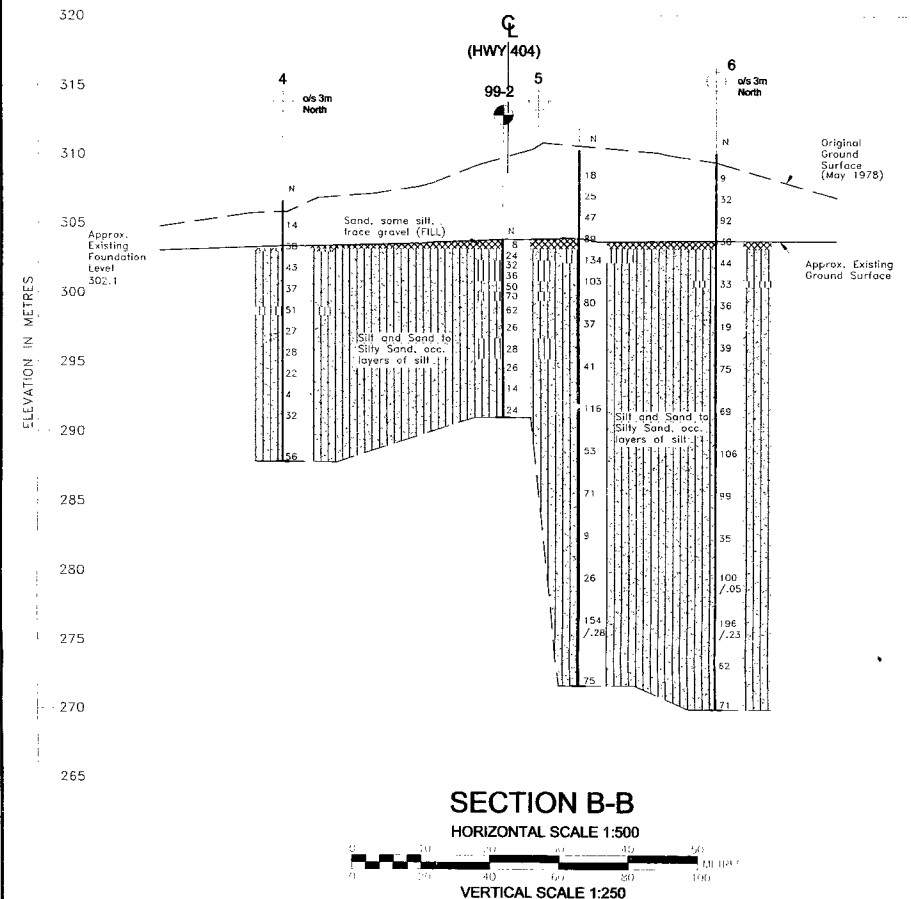
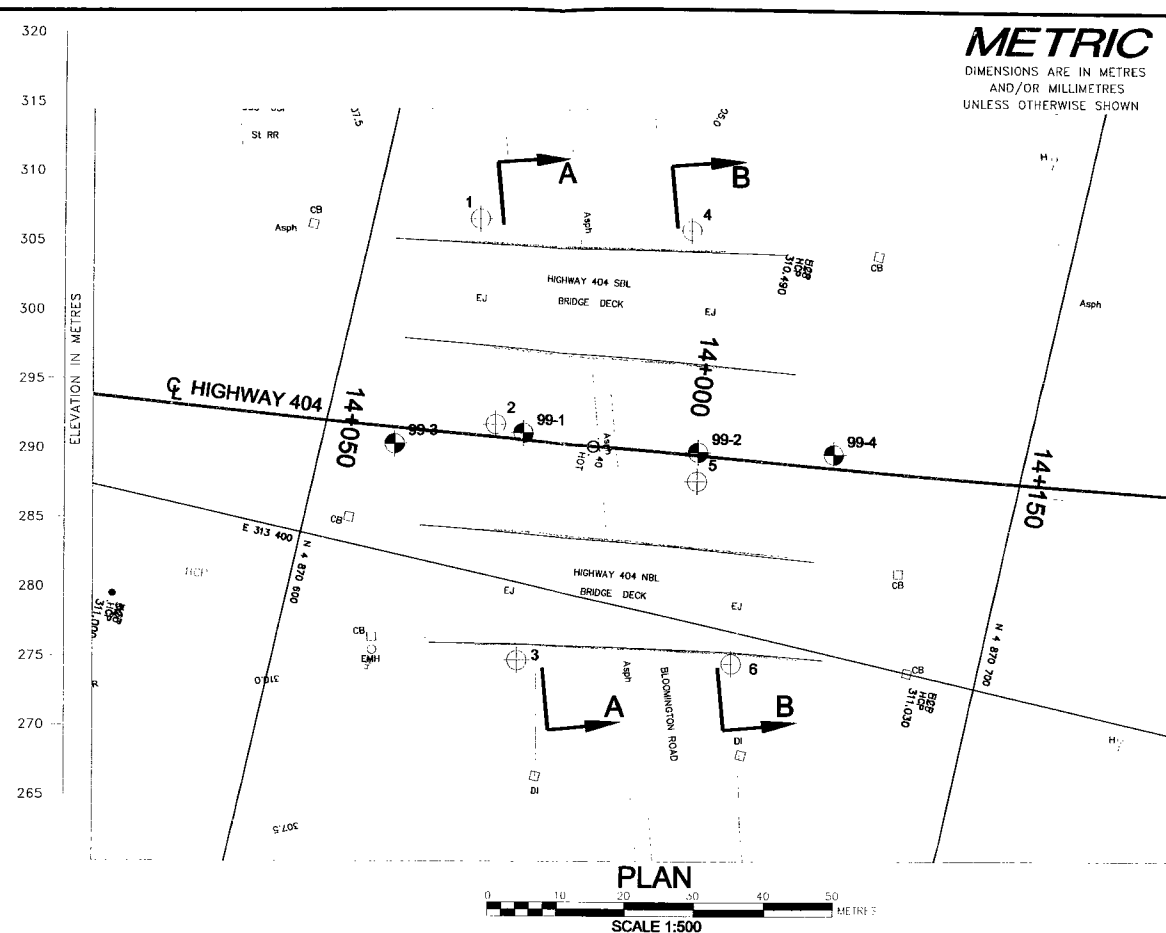
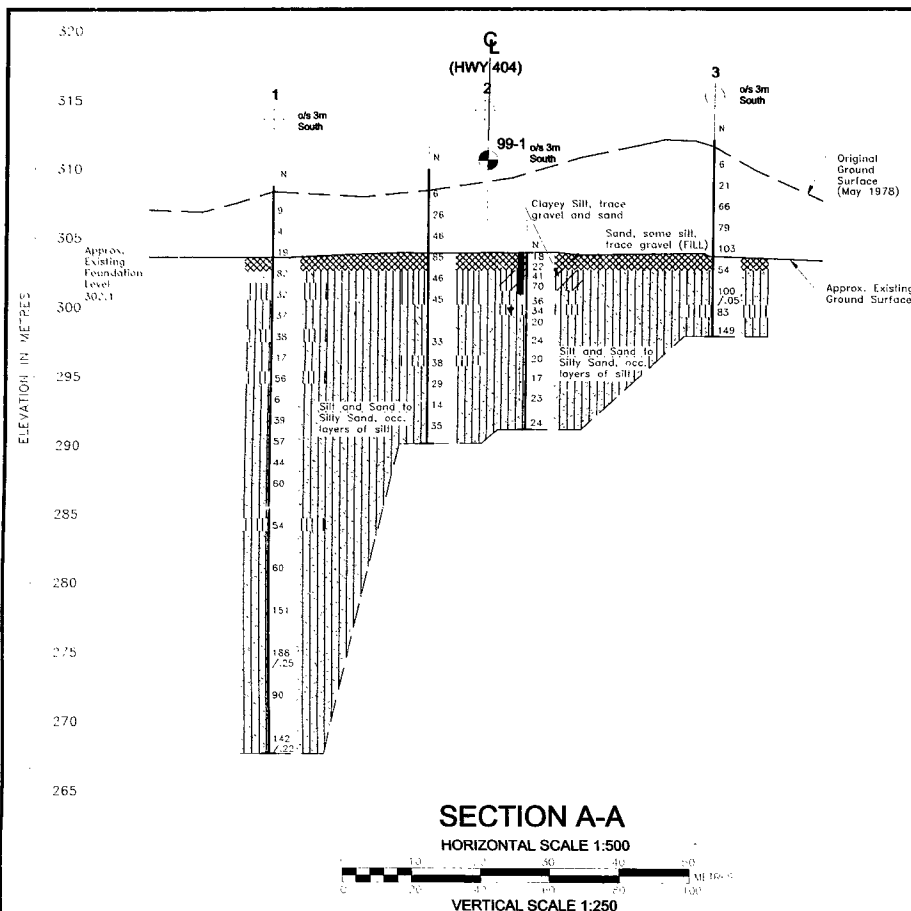
\*3, \*5: Numbers refer to  
Sensitivity

20  
15  $\div$  5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 6 cont

PROJECT 160-74-32 LOCATION Coords. N 15 979 872 E 1 028 230 ORIGINATED BY OL J.  
 DIST 6 HWY 404 BOREHOLE TYPE Hollow Stem Auger BX Casing & Cone Test COMPILED BY OL J.  
 DATUM Geodetic DATE March 3 & 6 1978 CHECKED BY *2/*

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
925.8	Cont.																
91.5																	
			15	SS	100	/2"	920										0 85 (15)
	Silty fine Sand																
	Very dense		16	SS	196	/9"	910										
			17	SS	62		900										
885.8			18	SS	71		890										
131.5	End of Borehole																



**DIST 6 HWY 404**  
**WP No. 433-98-00**

**HIGHWAY 404 & BLOOMINGTON ROAD**  
**BOREHOLE LOCATIONS & SOIL STRATA**

**Golder Associates Ltd.**  
MISSISSAUGA, ONTARIO, CANADA

**SHEET**

**KEY PLAN**

**LEGEND**

- Borehole - Current Golder Associates Ltd. Investigation
- Borehole - Previous MTO Investigation Geocres 30M14-158, dated May 1978
- Seal
- Piezometer
- Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer on October 19, 1999
- WL upon completion of drilling (current and existing boreholes)

No.	ELEVATION	LOCATION	
		NORTHING	EASTING
99-1	303.88	4870628.02	313378.93
99-2	303.87	4870653.58	313376.02
99-3	310.14	4870610.30	313384.54
99-4	310.09	4870672.81	313371.74
1	308.76	4870615.00	313350.25
2	309.89	4870623.84	313378.60
3	312.02	4870634.51	313410.90
4	306.60	4870645.48	313345.07
5	310.26	4870657.37	313380.12
6	310.07	4870664.99	313404.50

**NOTES**

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

No.	DATE	BY	REVISION
2	99 12 02	AJW	FINAL
1	99 09 29	AJW	ISSUED FOR REVIEW

Geocres No. \_\_\_\_\_

HWY. No. 404 PROJECT NO.: 991-8024A DIST. 6

SUBM'D. DKB CHKD: AJW DATE: 1999 09 09

DRAWN: PS CHKD: DKB APPD. \_\_\_\_\_ DWG. 1



## **APPENDIX B**

Previous General Arrangement Drawing



