

FOUNDATION INVESTIGATION AND DESIGN REPORT  
FOR  
HIGHWAY 77 UNDERPASS  
G.W.P. 60-00-00, SITE 6-104  
HIGHWAY 401  
COMBER, ONTARIO

Distribution:

4 cc: Ministry of Transportation  
1 cc: PML Hamilton  
1 cc: PML Toronto

PML Ref: 01TF072E  
Geocres No. 40J2-46

September 2002

June 17, 2003

PML Ref.: 01TF072E

Mr. Tony Fediw, P.Eng.  
TPM Agreement Administrator  
Ministry of Transportation  
Southwestern Region  
Structural Section  
659 Exeter Road  
London, Ontario  
N6E 1L3

Dear Mr. Fediw

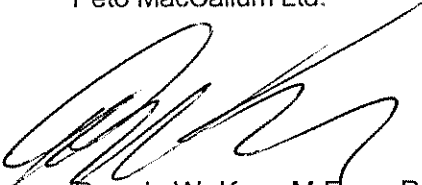
**Foundation Design Report  
Highway 77 Underpass, Site 6-104  
Highway 401 Widening  
G.W.P. 60-00-00  
Windsor, Ontario**

Recommendations regarding foundation design for this structure were provided in our report dated September 2002 (Geocres No. 40J2-46). This letter confirms that the recommendations regarding foundation design at the abutments are applicable to the centre pier location as well.

We trust this brief comment is sufficient and look forward to any further questions you may have.

Sincerely

Peto MacCallum Ltd.

  
Dennis W. Kerr, M.Eng., P.Eng.  
Chief Foundation Engineer



MRA:lad

2 cc: Ministry of Transportation  
1 cc: PML Toronto  
1 cc: PML Hamilton

FOUNDATION DESIGN REPORT  
FOR  
HIGHWAY 77 UNDERPASS  
G.W.P. 60-00-00, SITE 6-104  
HIGHWAY 401  
COMBER, ONTARIO

Distribution:

4 cc: Ministry of Transportation  
1 cc: PML Hamilton  
1 cc: PML Toronto

PML Ref: 01TF072E  
Geocres No. 40J2-46

September 2002

## TABLE OF CONTENTS

INTRODUCTION.....	1
FOUNDATIONS.....	2
Integral Abutments on Piles.....	2
Spread Footings.....	5
Caissons.....	6
ABUTMENT WALLS.....	7
APPROACH EMBANKMENTS.....	9
EXCAVATION AND GROUNDWATER CONTROL.....	9
CLOSURE.....	12

## APPENDICES

TABLE I -- GRADATION SPECIFICATION FOR SAND FILL IN  
PRE-AUGERED HOLES AT INTEGRAL ABUTMENTS

FIGURE 1 -- ABUTMENT ON COMPACTED FILL SHOWING  
GRANULAR "A" CORE

FIGURE 2 -- LATERAL EARTH PRESSURE DISTRIBUTION:  
SINGLY-BRACED CUTS IN COHESIVE SOILS

FIGURE 3 -- LATERAL EARTH PRESSURE DISTRIBUTION:  
MULTI-BRACED CUTS IN COHESIVE SOILS

FIGURE 4 -- GENERAL RECOMMENDATIONS REGARDING  
UNDERPINNING OF FOUNDATIONS/UTILITIES  
LOCATED CLOSE TO EXCAVATION

## FOUNDATION DESIGN REPORT

for  
Highway 77 Underpass  
G.W.P. 60-00-00, Site 6-104  
Highway 401  
Comber, Ontario

---

### INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of foundations, abutments and approaches for replacement of the existing underpass structure at Highway 77 and Highway 401 in Comber (Town of Lakeshore, Township of Tilbury West), Ontario. The investigation was conducted for the Southwestern Region Structural Section of the Ontario Ministry of Transportation.

The proposed underpass will consist of a two-span superstructure of approximately 15 m width, each span being about 25 m in length (ref. drawing 'Proposed Bridge Site at Highway 77 and Highway 401' prepared by the Planning and Design Section of the Ontario Ministry of Transportation's Southwestern Region). Highway 401 will pass under Highway 77 at approximate Station 13+928, Highway 401 chainage.

Road grade on Highway 77 at the underpass location is near elevation 190.5 (interpolated from ground surface elevations at borehole locations and existing grade shown on the drawing referred to above). The existing approaches comprise fill embankments with heights of approximately 7 to 8 m. Details concerning the proposed underpass design, such as foundation loads and founding elevations, were not provided.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial pavement structure over fill underlain by topsoil, silty clay and clay till. Limestone bedrock was contacted below the clay overburden at depths of 41.8 to 41.9 m (elevation 148.5 to 148.6), thereby indicating an insignificant difference in bedrock surface elevation across the site.

Use of conventional construction procedures to construct the structure foundations at this site is considered to be feasible.

## **FOUNDATIONS**

### **Integral Abutments on Piles**

Cognizant of the span length and anticipated foundation loads, as well as the depth of bedrock, construction of integral abutments supported on end-bearing piles founded on competent bedrock is considered to be feasible at this site. A driven pile system consisting of steel H-piles is an appropriate means of supporting the proposed structure. The H-piles should be driven to refusal on bedrock anticipated at depths/elevations shown in the following table:

<b>Location</b>	<b>Depth to Rock (m)</b>	<b>Bedrock Elevation</b>
North Abutment, East Side	41.8	148.5
South Abutment, West Side	41.9	148.6

The recommended factored axial resistance at ultimate limit states (ULS) and serviceability limit states (SLS) for two pile sections is presented below:

<b>H-Pile Section</b>	<b>Factored Axial Resistance at ULS (kN)</b>	<b>Axial Resistance at SLS (kN)</b>
HP 310 x 79	1450	1200
HP 310 x 110	2000	1700

The resistance at SLS allows for 25 mm of compression of the pile and founding medium.

The soil adjacent to the upper portion of the piles is expected to comprise relatively well-compacted approach fill placed on topsoil and deposits of stiff to very stiff silty clay. To accommodate movement of the integral abutment, it is recommended that two concentric CSPs that extend at least 3 m below the bottom of the abutment be placed around the pile to create an annular space. The inner CSP of 600 mm diameter should be filled with sand meeting the gradation requirements of Granular "B" Type I. Alternatively, a single CSP filled with loose uniform sand meeting the requirements shown in Table I may be used. Refer to MTO Report SO-96-01 for further details.

Since the piles will be 40 to 42 m long, the overburden comprises hard to firm clay till, and no evidence of cobbles/boulders was detected during drilling, it is considered, based on our extensive experience with pile driving under similar conditions, that a hammer that **transfers** at least 40 kJ of energy to the pile should be employed to drive the piles. The **rated energy** of the hammer should therefore be 50 to 55 kJ, depending on the type of equipment employed. Since the piles will set on rock, a specific set for this project is not provided.

The piles should be installed and monitored in accordance with the requirements of Special Provision 903S01 (April 2000). This should involve confirmation of the founding elevation, alignment, plumbness, uniformity of set and quality of splices, and should be done on a full-time basis by experienced geotechnical personnel.

Pile caps should be provided with at least 1.2 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

The coefficient of horizontal subgrade reaction,  $k_s$ , for Granular "A" backfill and sand fill as well as the predominant clay overburden present at the site may be computed using the following equations to evaluate the point of contraflexure:

Granular      Embankment fill above the native clay surface at elevation of  $\pm 182.0$

$$k_s = n_h z/b$$

$$\begin{aligned} n_h &= \text{coefficient related to soil density} \\ &= 14.0 \text{ MN/m}^3 \text{ for Granular "A" backfill} \\ &= 2.2 \text{ MN/m}^3 \text{ for loose sand fill} \end{aligned}$$

$$z = \text{depth, m}$$

$$b = \text{pile width, m}$$

Cohesive      Native soil below the granular fill at elevation of  $\pm 182.0$

$$k_s = \frac{67c_u}{b}$$

$$\begin{aligned} c_u &= \text{undrained shear strength of the clay} \\ &= 100 \text{ kPa from ground surface to elevation } 174.0 \\ &= 50 \text{ kPa below elevation } 174.0 \end{aligned}$$

$$b = \text{pile width, m}$$

Resistance to lateral loads may be provided in part by mobilization of passive resistance along the pile below the annular space. The lateral resistance recommended for the pile sections is as follows:

	<u>HP 310 x 79</u>	<u>HP 310 x 110</u>
Factored Lateral Resistance at ULS	130 kN	170 kN
Lateral Resistance at SLS	35 kN	40 kN



## Spread Footings

Supporting the proposed structure on conventional spread footings founded in the native overburden may be considered at the site. The footings should be founded in the stiff to very stiff silty clay at an approximate depth of 8.5 m (elevation 182.0), except in the vicinity of borehole 104-5 where the recommended depth is about 10 m (elevation 180.5). The following resistance values should be used in design of the footings (approximate 2 m wide footings):

Factored Bearing Resistance at ULS = 300 kPa

Bearing Resistance at SLS = 200 kPa

Spread footings could be constructed on structural fill placed in the approaches. Construction of structural fill supporting foundations should include excavation and replacement of the existing approach fill, topsoil and other soft/loose material with engineered fill. The engineered fill should comprise Granular "A" material placed in maximum 200 mm thick lifts, compacted to 100% standard Proctor maximum dry density, and extended laterally to a line originating at least 1 m from the top of footing and inclined outwards at 45° to the horizontal. This scheme is illustrated in Figure 1.

The bearing resistance for a minimum 2.5 m wide footing constructed on a minimum 4.0 m thick pad of structural fill is:

Factored Bearing Resistance at ULS = 900 kPa

Bearing resistance at SLS = 350 kPa

The recommended resistance at SLS allows for 25 mm of total settlement; differential settlement is expected to be less than 75% of this value. A footing embedment depth of 1.2 m was assumed for computation of the ULS resistance.

Sliding would be resisted in part by the friction force developed between the underside of the footing and the silty clay or granular fill. Unfactored friction factors of 0.35 and 0.45 are recommended for footings on silty clay and granular fill, respectively.

All footings subject to frost action should be provided with the normal 1.2 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

Prior to placement of structural concrete, all foundation excavations should be examined by qualified geotechnical personnel to verify the competency of the founding surface.

### Caissons

Supporting the structure on augered caissons is not recommended considering the significant depth to bedrock, the potential for squeeze of the clay along the caisson shaft and the possibility of encountering pressurized gas/water in the bedrock.

## ABUTMENT WALLS

The abutment walls should be designed to resist the unbalanced horizontal earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure,  $p$ , may be computed using the equivalent fluid pressures presented in Section 6-7.4 of the Ontario Highway Bridge Design Code (OHBDC, 3rd Edition, 1991) or employing the following equation, assuming a triangular pressure distribution:

$$p = K (\gamma h + q)$$

where

$K$  = lateral earth pressure coefficient

$\gamma$  = unit weight of free-draining granular material (kN/m<sup>3</sup>)

$h$  = depth below final grade (m)

$q$  = surcharge load (kPa) if present

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction, degrees	35	32
Unit weight, kN/m <sup>3</sup>	22.8	21.2
Coefficient of Active Earth Pressure $K_a$	0.27	0.31
Coefficient of Earth Pressure At Rest $K_o$	0.43	0.47
Coefficient of Passive Earth Pressure $K_p$	3.69	3.25

Refer to MTO Report SO-96-01 for procedures to determine the earth pressure coefficient to be employed in design of integral abutments. The coefficient of earth pressure at rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system and/or weep holes should be installed to minimise the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

A retained soil system (RSS) could also be employed. The founding material is expected to comprise granular engineered fill created after excavation of the existing fill to expose the native material or silty clay. The following parameters should be used in design of the system foundation:

	<u>Granular "A"</u>	<u>Granular "B"</u>	<u>Silty Clay</u>
Friction Angle, degrees	35	32	0
Cohesion, kPa	0	0	100
Unit weight, kN/m <sup>3</sup>	22.8	21.2	20.4

The bearing resistance values previously indicated for abutment/pier footing design should be employed for design of the RSS wall.

The supplier of the RSS should be responsible for design of the structure (backfill, reinforcement, internal and external stability) and provide drawings to show pertinent information such as location, length, height, elevations, performance level, appearance etc.

## **APPROACH EMBANKMENTS**

Backfilling adjacent to the structure should be carried out in conformance with Ontario Provincial Standards specifications for granular backfill (OPSD 3501.00).

The embankment fill should be constructed in accordance with OPSD 200.01, 202.01 and 208.01. The side slopes of approach fills should be inclined no steeper than 2 horizontal to 1 vertical. For erosion control and slope maintenance purposes, provide a 2 m wide mid-height berm so that no uninterrupted slope is greater than 8 m high.

No settlement or bearing capacity problems due to placing fill on the inorganic native overburden are anticipated. Topsoil and other deleterious material should be stripped prior to placement of the approach fill.

## **EXCAVATION AND GROUNDWATER CONTROL**

The depth of excavation required to construct the foundations will be dictated in part by the type of foundation unit selected and could range from 3 to 5 m for the centre pier and 2 to 10 m for the abutments.

Excavation for construction of footings or pile caps is expected to be relatively straightforward and carried out primarily within the existing fill. The fill and sandy/clayey material present at the site are classified as Type 3 soils according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Temporary cut slopes inclined at 45° to the horizontal should generally be stable. Flatter side slopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered locally. A 2 m wide mid-height berm should be incorporated for cut depths exceeding 6 m, in accordance with MTO policy.

Shoring will be required to support the walls of the excavation and adjacent traffic lanes during construction of the centre pier foundation.

The magnitude and distribution of the lateral earth pressures acting on a braced excavation wall is dependent upon the support system used, the number of supports, the allowable movements and the construction sequence. The recommended design earth pressure distribution for singly and multi-braced walls, for the conditions that exist at the site, are presented in Figures 2 and 3 respectively. Recommendations concerning design and construction of the braced excavation support systems are provided in the figures.

A soldier pile and lagging system may be considered. Provided the spacing between soldier piles is at least five pile diameters, the unfactored lateral passive resistance developed on the face of the soldier pile below the base of the excavation may be taken as the passive earth pressure developed over an equivalent wall area of width three times the pile diameter and depth of six times the pile diameter. A passive earth pressure coefficient  $K_p$  of 3.0 is recommended for this computation.

Additional lateral resistance could be provided by installing tiebacks anchored in the stiff to hard clay till. The factored pull-out resistance at ULS of soil anchors in the clay till may be computed as follows:

$$R = 0.45c_u A_s L_s$$

where

$c_u$  = average undrained shear strength over the anchor length

= 100 kPa for stiff to hard clay till

$A_s$  = effective unit surface area of the anchor ( $m^2$ )

$L_s$  = effective embedment length of the anchor (m)

The ground surface adjacent to the excavation is expected to experience some inward movement and vertical settlement. The magnitude of movements adjacent to a braced cut can be limited by selection of an appropriate lateral earth pressure coefficient (see Figures 2 and 3) provided good quality workmanship and construction practice is employed. The anticipated magnitude of movements is as follows:

	<u>Movement (% of Excavation Depth)</u>
Lateral Movement	
Braced Excavation	0.2
Anchored Wall	0.1
Vertical Movement	0.05

Construction procedures should be specifically suited to limit any consequent settlement of the pavement subgrade behind the excavation face.

Foundations of heavily loaded/settlement sensitive structures and/or utilities located within close proximity to the excavation may require underpinning to preserve the integrity of these structures. Further comments and general recommendations in this regard are provided in Figure 4.

Groundwater was not observed in the boreholes drilled at this site during the field investigation. Based on visual examination of the samples retrieved during drilling and water level observations/measurements during the field investigations conducted for other structures throughout the study corridor, it is expected that the stabilized water level at this site is near elevation 179.5, about 2.5 m below the original ground surface elevation.

Considering the low permeability characteristics of the overburden, groundwater seepage or surface water that enters the excavation should be readily handled by conventional sump pumping techniques.

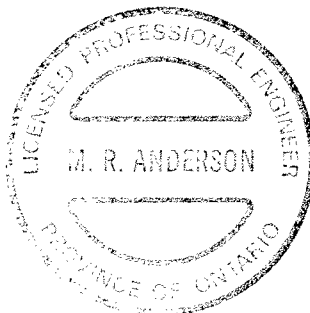
All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

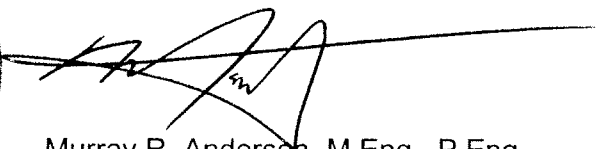
**CLOSURE**

The report was prepared by Mr. G.O. Degil, Ph.D., Senior Project Supervisor, and Mr. M.R. Anderson, M.Eng., P.Eng. It was reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng., P.Eng. carried out an independent review of the report.


Yours very truly

**Peto MacCallum Ltd.**

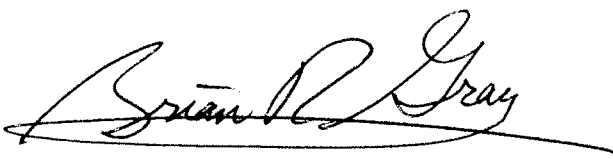


  
Murray R. Anderson, M.Eng., P.Eng.  
Senior Geotechnical Engineer



  
Dennis W. Kerr, M.Eng., P.Eng.  
Chief Foundation Engineer



  
Brian R. Gray, M.Eng., P.Eng.  
President

GD:lad



## **APPENDICES**

TABLE I – GRADATION SPECIFICATION FOR SAND FILL IN  
PRE-AUGERED HOLES AT INTEGRAL ABUTMENTS

FIGURE 1 – ABUTMENT ON COMPACTED FILL SHOWING  
GRANULAR "A" CORE

FIGURE 2 – LATERAL EARTH PRESSURE DISTRIBUTION:  
SINGLY-BRACED CUTS IN COHESIVE SOILS

FIGURE 3 – LATERAL EARTH PRESSURE DISTRIBUTION:  
MULTI-BRACED CUTS IN COHESIVE SOILS

FIGURE 4 – GENERAL RECOMMENDATIONS REGARDING  
UNDERPINNING OF FOUNDATIONS/UTILITIES  
LOCATED CLOSE TO EXCAVATION

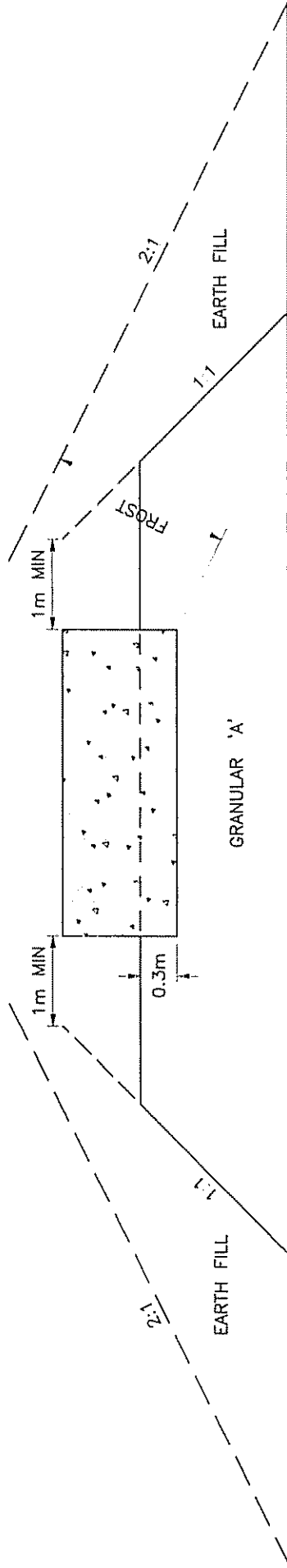
TABLE I

**Gradation Specification for Sand Fill in  
Pre-Augered Holes at Integral Abutments**

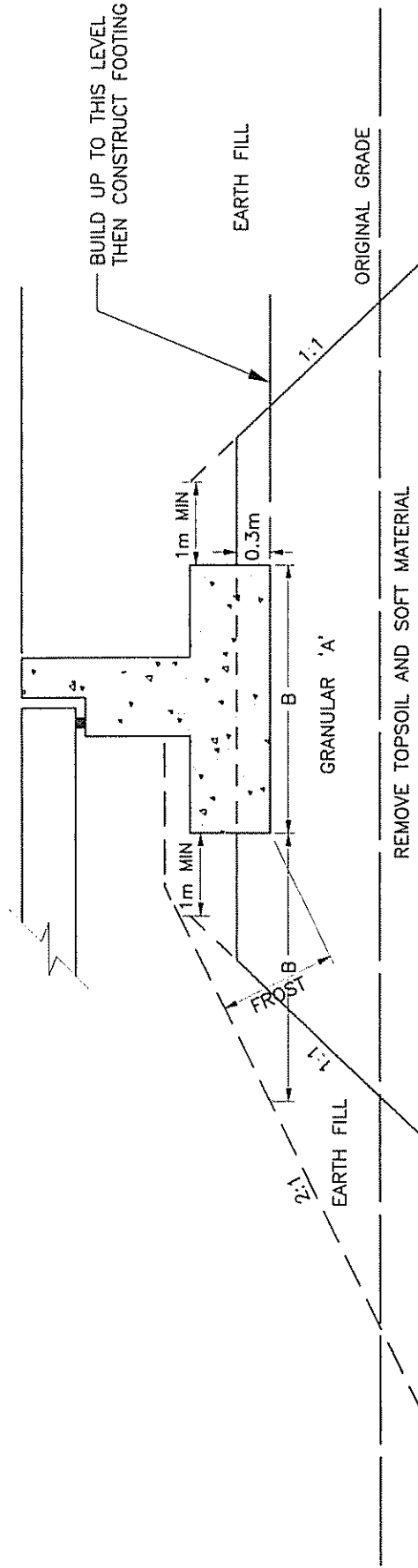
MTO Sieve Designation		Percentage Passing by Mass
2 mm	#10	100
600 $\mu$ m	#30	80 – 100
425 $\mu$ m	#40	40 – 80
250 $\mu$ m	#60	5 – 25
150 $\mu$ m	#100	0 – 6

From MTO Report S0-96-01, Revision 1 – July, 1996.

# ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



**CROSS SECTION**



**LONGITUDINAL SECTION**

## NOTES

1. REMOVE TOPSOIL AND/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.O. STANDARDS.
3. CONSTRUCT CONCRETE FOOTING
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED
5. REFER TO TEXT OF REPORT FOR FROST DEPTH

**Peto MacCallum Ltd.**  
CONSULTING ENGINEERS

45 BURFORD ROAD, HAMILTON, ONTARIO L8E 3C6  
Tel: (905) 561-2231 Fax: (905) 561-6363

DATE	SCALE	JOB NO.	FIGURE NO.
MAR. 2002	NTS	01TF072E	1

### EARTH PRESSURE DIAGRAM

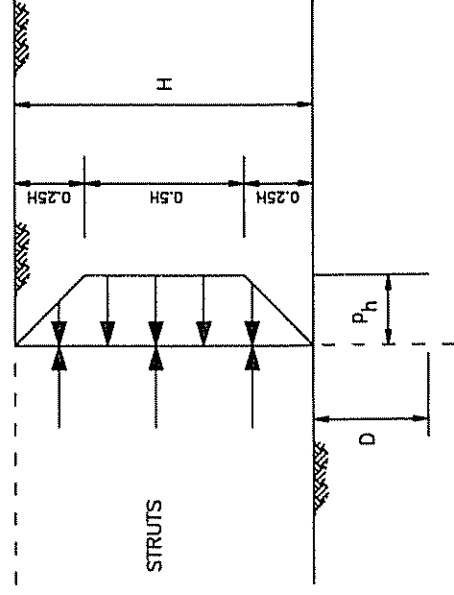


- D = depth of embedment of soldier piles (if used).

K = 0.35 (movement of retained soil acceptable)  
= 0.50 (movement of adjacent structures/facilities unacceptable)

**NOTES**

1. The actual magnitude and distribution of the horizontal earth pressures which will act on the bracing system are dependent upon the permissible lateral/vertical movements adjacent to the excavation, the soil type, groundwater conditions, drainage provisions, temporary/permanent surcharge loads, the type of bracing system adopted, weather conditions, quality of workmanship and length of time the excavation will be supported. Hence, the recommended pressure diagram and design parameters should be reviewed when construction details, schedule and type of support system are established.
2. Stability of base of excavation must be confirmed when bracing system design, excavation geometry and surcharge loads are established.
3. Earth pressure diagram is applicable to maximum depth of cut of 12m (40 ft.).
4. Structural components of bracing system should be confirmed adequate for each level of excavation.
5. If sheeting will not permit drainage, bracing system must be designed to resist water pressure.
6. Surcharge loads such as street/construction traffic, supported utilities, adjacent foundations, temporary stockpiles and other loads carried by bracing system are not included in earth pressure diagram.
7. Temporary surcharge loading should not be closer to the face of the excavation than half the depth of excavation unless accounted for in bracing design.
8. If settlement sensitive structures are located near the excavation, special measures should be undertaken to control settlements. A condition survey should be conducted prior to construction and appropriate monitoring (surface and insitu) carried out during construction.
9. Earth pressure diagram is applicable for relatively short construction periods. If excavation is to be open for long periods, monitoring of deformation is essential, the earth pressure diagram must be reviewed, and remedial works may be required.
10. Earth pressure diagram does not account for extended periods of exposure of the excavation to freezing temperatures.
11. Bracing system should be regularly examined for signs of distress.
12. All work should be carried out in accordance with the Occupational Health and Safety Act and local regulations. Good quality workmanship and construction practices are to be employed.
13. This sheet should be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.

**EARTH PRESSURE DIAGRAM**

$P_h$  = design lateral earth pressure  
 $= 0.4 \gamma H$

where

$\gamma$  = unit weight of soil

$H$  = depth of excavation

$D$  = depth of embedment of soldier piles (if used).

**RECOMMENDED DESIGN PARAMETERS**

$\gamma = 20.4 \text{ kN/m}^3$

**NOTES**

1. The need to underpin existing footings/utilities is dependent upon soil type, proximity of the existing facility to the face of the excavation, loads imposed on the foundation and permissible movements.

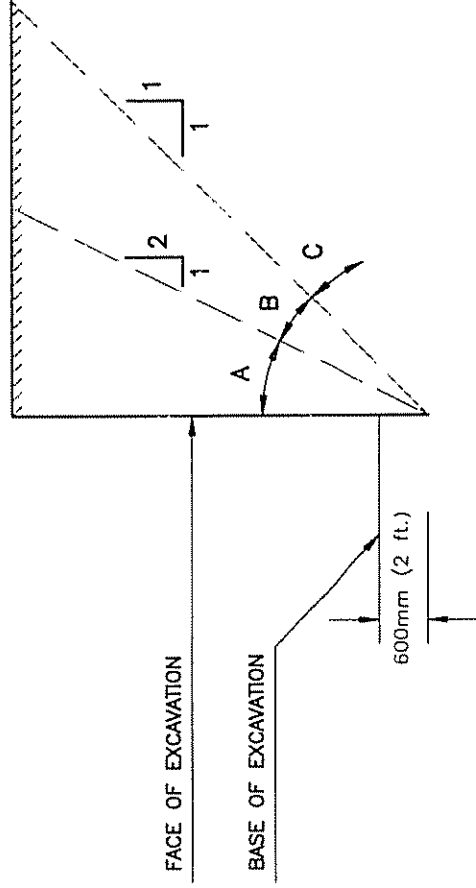
**ZONE A:**  
Foundations of relatively heavy and/or settlement sensitive structures/utilities located in Zone A generally require underpinning.

**ZONE B:**  
Foundations of structures located within Zone B generally do not require underpinning. Consideration should be given to underpinning of settlement sensitive utilities or heavy foundation units located in this zone.

**ZONE C:**  
Utilities and foundations located within Zone C do not normally require underpinning.

Underpinning of foundations located in Zones A and B should extend at least into Zone C.

2. As an alternative to underpinning, it may be possible to control movement of existing utilities and foundations by supporting the face of the excavation with bracing/tiebacks or a rigid (caisson) wall. Horizontal and vertical earth pressures imposed on the excavation wall by non-underpinned foundations must be considered in the design of the support system.
3. A condition survey should be conducted prior to construction and appropriate monitoring (surface and insitu) carried out during construction to monitor any movement which may occur.
4. All work should be carried out in accordance with the Occupational Health and Safety Act and local regulations. Good quality workmanship and construction practices are to be employed.
5. This sheet is to be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.



FOUNDATION INVESTIGATION REPORT  
FOR  
HIGHWAY 77 UNDERPASS  
G.W.P. 60-00-00, SITE 6-104  
HIGHWAY 401  
COMBER, ONTARIO

Distribution:

4 cc: Ministry of Transportation  
1 cc: PML Hamilton  
1 cc: PML Toronto

PML Ref: 01TF072E  
Geocres No. 40J2-46

September 2002

## TABLE OF CONTENTS

INTRODUCTION .....	1
SITE DESCRIPTION .....	1
INVESTIGATION PROCEDURES .....	2
SUMMARIZED SUBSURFACE CONDITIONS.....	3
Pavement Structure.....	4
Fill .....	4
Topsoil .....	5
Silty Clay .....	5
Clay Till .....	5
Bedrock.....	6
Groundwater .....	6
CLOSURE .....	7

## APPENDICES

### APPENDIX A

- TABLE 1           – ROCK CORE DESCRIPTION
- FIGURE 1        – PLASTICITY CHART
- FIGURES 2 and 3 – GRAIN SIZE DISTRIBUTION CHARTS

### APPENDIX B

- RECORD OF BOREHOLE SHEETS
- DRAWINGS 1 and 2



## FOUNDATION INVESTIGATION REPORT

for  
Highway 77 Underpass  
G.W.P. 60-00-00, Site 6-104  
Highway 401  
Comber, Ontario

---

### INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the proposed replacement of the existing underpass structure at Highway 77 and Highway 401 in Comber, Ontario. The investigation was conducted for the Southwestern Region Structural Section of the Ontario Ministry of Transportation.

Highway 401 will pass under Highway 77 at approximate Station 13+928, Highway 401 chainage, in the Town of Lakeshore (Township of Tilbury West).

The report pertains to the proposed underpass structure and approaches within about 20 m of the abutments.

### SITE DESCRIPTION

The site is situated at the intersection of the existing Highways 77 and 401. The proposed structure will carry Highway 77 traffic over Highway 401. At the location of the structure, Highway 401 runs in the east-west direction. The existing approaches comprise fill embankments with heights of approximately 7 to 8 m.

The site is located in the Town of Lakeshore in Essex County (Southwestern Ontario), east of Windsor along Highway 401. The surrounding lands are mainly level and used for agricultural purposes.

The area is part of the Essex Clay Plain physiographic sub-region. It is essentially a till plain smoothed by deposits of lacustrine clay which settled in the depressions while the knolls were being lowered by wave action. In general, the overburden in the sub-region consists of silty clays and/or clayey silts. The bedrock belonging to the Dundee Formation and anticipated at a depth of about 40 m is largely composed of Middle Devonian limestone, dolostone and shale.

### **INVESTIGATION PROCEDURES**

The field work was carried out during the period January 20 to 25, 2002 and comprised six boreholes advanced to depths of 5.0 to 44.8 m, as summarized in the following table, at the locations indicated on Drawing 1 (Appendix B).

Location	Borehole No.	Depth (m)		
		Auger	Rock Core <sup>(1)</sup>	Total
North Approach	104-1	5.0	-	5.0
North Abutment, West Side	104-2	12.6	-	12.6
North Abutment, East Side	104-3	41.8	3.0	44.8
South Abutment, West Side	104-4	41.9	2.2	44.1
South Abutment, East Side	104-5	14.2	-	14.2
South Approach	104-6	5.0	-	5.0

(1) NXL diamond rock coring equipment

The coring in borehole 104-4 was terminated before the programmed 3.0 m of core was recovered to avoid further difficulties as pressurized natural gas was encountered in the bedrock at this location.

The locations of and ground surface elevations at the boreholes were established in the field by Peto MacCallum Ltd. The following benchmark (BM) was used for vertical reference:

**BM 207:**      Cut cross on southeast corner of  
                     concrete footing for handrail  
                     28.2 RT 13+919.1  
                     Elevation 190.663 (geodetic)

The boreholes were advanced using continuous flight solid and hollow stem augers, powered by a truck-mounted CME-75 drill rig, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Representative samples of the overburden were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. In situ vane shear and pocket penetrometer tests were also performed to further assess the shear strength of the cohesive soils.

NW casing was extended to the bedrock surface and NXL diamond rock coring equipment used to recover two rock cores from each of the deep holes – boreholes 104-3 and 104-4.

The groundwater conditions in the boreholes were closely monitored during the course of the field work. Upon completion of augering, boreholes 104-1, 104-2, 104-5 and 104-6 were backfilled with auger cuttings to the ground surface. Boreholes 104-3 and 104-4 were grouted upon completion of rock coring.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. Atterberg Limits tests and grain size distribution analyses were carried out on selected samples, their results being presented in Figures 1 to 3 (Appendix A) and on the Record of Borehole sheets (Appendix B).

### **SUMMARIZED SUBSURFACE CONDITIONS**

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard penetration and in situ vane shear/pocket penetrometer test results, rock core descriptions, groundwater observations, the results of laboratory grain size distribution analyses, Atterberg Limits tests and moisture content determinations. Samples submitted for laboratory testing are also shown on the borehole logs.

The borehole locations and stratigraphic profiles prepared from the borehole data are presented on Drawings 1 and 2.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial pavement structure over fill underlain by topsoil, silty clay and clay till. Limestone bedrock was contacted below the clay overburden at an approximate depth of 41.8 m (elevation 148.6). The strata encountered are summarized below.

#### Pavement Structure

A pavement structure of 750 mm in thickness (910 mm in borehole 104-3) was present surficially in all the boreholes. It consisted of 210 to 280 mm of asphaltic concrete and 470 to 660 mm of sand and gravel.

#### Fill

The fill below the surficial pavement structure was represented by silty clay in the approach boreholes and fine to coarse sand over silty clay in boreholes 104-2 to 104-5. The sand was very loose to compact and 1.5 to 5.5 m thick, its moisture content ranging from 5 to 8%, locally 23% (at 6.2 m depth in borehole 104-5).

The silty clay was encountered at depths of 0.8 to 6.3 m (elevation 184.3 to 189.6). The confirmed thickness of this layer varied between 1.7 and 4.7 m. The clay was typically stiff to very stiff with a localized firm zone in borehole 104-5 and had a moisture content of 16 to 22%.

The fill was not penetrated in boreholes 104-1 and 104-6 which were terminated at 5 m depth (elevation 184.8 and 185.3 respectively).

### Topsoil

Consisting of silty clay, the topsoil was revealed at depths of 7.1 to 7.9 m (elevation 182.6 to 183.2). Assessed at one location as being very stiff, this unit was 300 to 700 mm thick and had a moisture content of 23 to 27%.

### Silty Clay

Directly beneath the topsoil at elevation 182.3 to 182.5 was a 0.8 to 1.9 m thick layer of silty clay. This unit was not identified in borehole 104-5. The silty clay was stiff to very stiff in consistency, its moisture content being about 25%. Pocket penetrometer testing conducted within the unit gave the values of unconfined strength in a range of 70 to 125 kPa.

### Clay Till

The silty clay till was encountered at depths of 8.6 to 10.1 m (elevation 180.4 to 182.0). Its consistency was stiff to hard in the upper portion of the unit, becoming firm with depth. The results of vane shear testing carried out in this stratum at 22 m depth indicate that the undisturbed and remolded shear strength values are 85 and 70 kPa respectively (soil sensitivity is 1.2). A number of pocket penetrometer tests conducted within the unit gave the values of unconfined strength varying broadly between 40 and 250 kPa, typically decreasing with depth. The moisture content of the clay till ranged from 18 to 23% in the upper portion of the unit, reaching 21 to 29% at depth.

The deposit was 31.7 to 32.8 m in thickness, in borehole 104-4 containing an approximately 6 m thick layer of loose to dense silt and sand till that was revealed at 32.2 m depth (elevation 158.3). The clay till was not penetrated in boreholes 104-2 and 104-5 which were terminated at respective depths of 12.6 and 14.2 m (elevation 177.5 and 176.4).

The results of the Atterberg Limits tests are presented in Figure 1 (Appendix A). The clay till plots as a silty clay of medium plasticity. The results of particle size distribution analyses conducted on the clay till and local silt/sand deposit are presented in Figures 2 and 3 (Appendix A).

## Bedrock

Limestone bedrock, confirmed by rock coring, was contacted below the clay till overburden at the following depths and elevations:

Location	Depth to Rock (m)	Bedrock Elevation
North Abutment, East Side	41.8	148.5
South Abutment, West Side	41.9	148.6

Rock core description is provided in Table I (Appendix A). The measured core recovery varied between 90 and 100%. The RQD determined from the rock cores was in a range of 80 to 93%, indicating a good to excellent quality rock. Loss of drill water circulation was experienced shortly after the start of coring – at depths of 43.2 m (elevation 147.1) in borehole 104-3 and 42.0 m (elevation 148.5) in borehole 104-4. A small void was detected in the core in borehole 104.3 about 1.4 m below the rock surface. It is worth noting that a natural gas deposit with trace of oil under pressure was discovered in the latter borehole at 42.5 m depth (elevation 148.0).

The unconfined compressive strength of the rock determined on two representative samples corresponding to depths of 41.9 and 44.4 m (elevation 148.4 and 145.9 respectively) was about 90 MPa.

## Groundwater

No water was observed in any of the boreholes during or upon completion of drilling in the overburden.

Groundwater was not observed in the boreholes drilled at this site during the field investigation. Based on visual examination of the samples retrieved during drilling and water level observations/measurements during the field investigations conducted for other structures throughout the study corridor, it is expected that the stabilized water level at this site is near elevation 179.5, 2.5 m below the original ground surface elevation.

## CLOSURE

The field work was carried out under the supervision of Mr. M. Rapsey and direction of Mr. M.R. Anderson, P.Eng., Senior Geotechnical Engineer. The equipment was supplied by Elite Drilling.

The report was prepared by Mr. G.O. Degil, Ph.D., Senior Project Supervisor, and Mr. M.R. Anderson, M. Eng., P.Eng. It was reviewed by Mr. D.W. Kerr, M. Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M. Eng., P.Eng., carried out an independent review of the report.



Yours very truly

**Peto MacCallum Ltd.**

A handwritten signature of Murray R. Anderson in black ink.

Murray R. Anderson, M.Eng., P.Eng  
Senior Geotechnical Engineer

A handwritten signature of Dennis W. Kerr in black ink.

Dennis W. Kerr, M.Eng., P.Eng  
Chief Foundation Engineer

A handwritten signature of Brian R. Gray in black ink.

Brian R. Gray, M.Eng., P.Eng  
President

GD:lad

## **APPENDIX A**

TABLE I	–	ROCK CORE DESCRIPTION
FIGURE 1	–	PLASTICITY CHART
FIGURES 2 and 3	–	PARTICLE SIZE DISTRIBUTION CHARTS



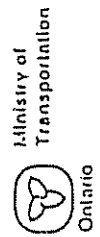
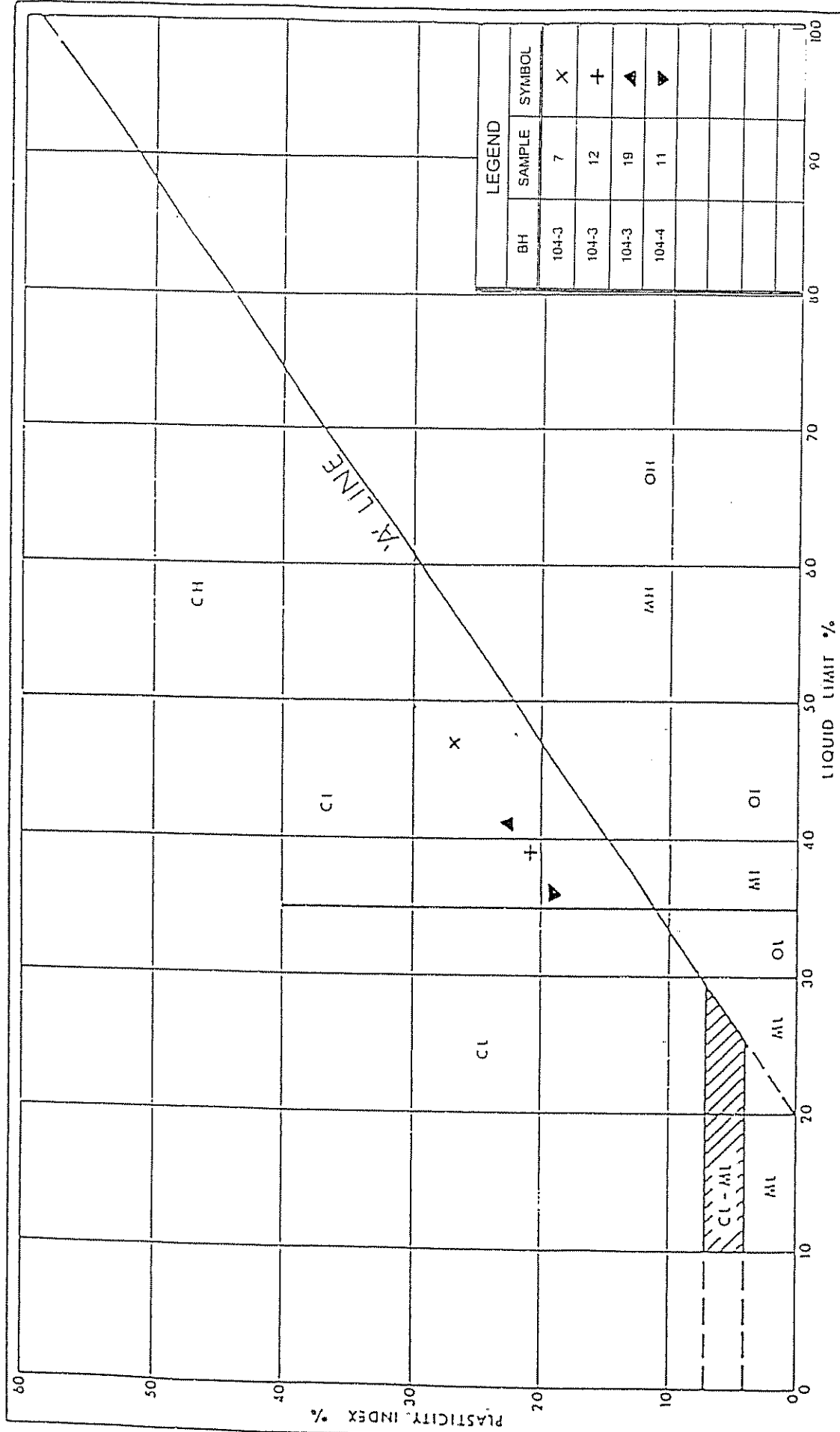
TABLE I

ROCK CORE DESCRIPTION  
HIGHWAY 77 UNDERPASS  
G.W.P. 60-00-00, SITE 6-104  
HIGHWAY 401  
WINDSOR, ONTARIO

CORE RECOVERY						CORE DESCRIPTION	
HOLE NO.	RUN NO.	DEPTH (m)	RECOVERY %	RQD %	DEPTH (m)	DESCRIPTION	
104-3	20	41.75 – 43.30	100	85	41.75 – 44.80	LIMESTONE: grey, fine grained, occ. white mottling, occ. stylitic partings; medium to high strength; unweathered; closely to moderately spaced discontinuities; fracture index 3; good quality (Dundee Formation)	
	21	43.30 – 44.80	100	93			
104-4	21	41.90 – 42.50	100	90	41.90 – 44.05	LIMESTONE: buff to grey, fine grained, with irregular shaley parting at 42.50 m (gas); medium to high strength; unweathered; closely to moderately spaced discontinuities; fracture index 4; good quality (Dundee Formation)	
	22	42.50 – 44.05	90	80			

Logged by J.F. Wright using the Provincial Highways "A Guide to the Description of Rock for Engineering Purposes"  
Dated October, 1982.

RQD = Rock Quality Designation



Ministry of  
Transportation

# PLASTICITY CHART

SILTY CLAY, some sand, trace of gravel (CI)

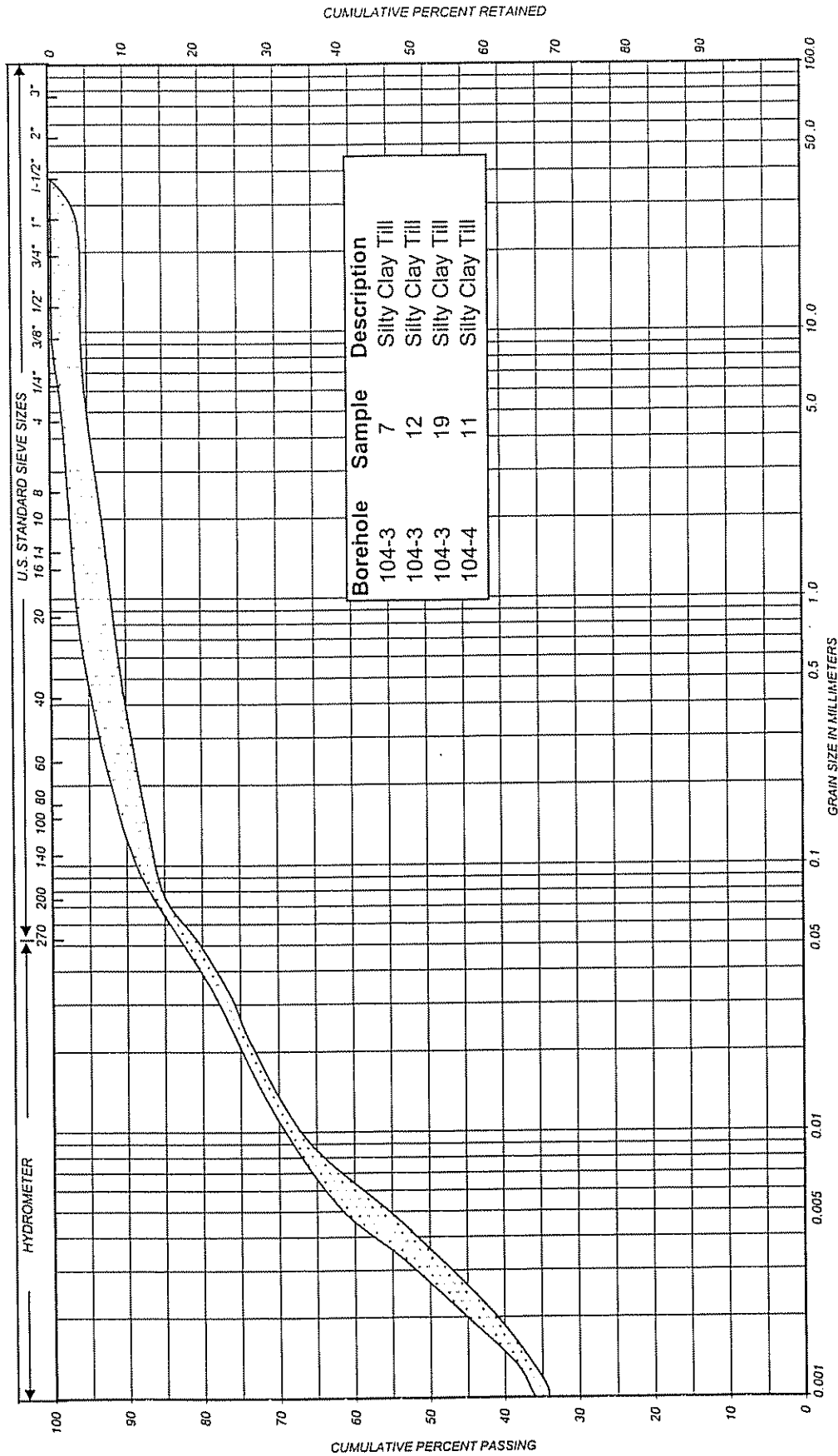
FIG No 1

HIGHWAY 401

G.W.P. No. 60-00-00

PML REF 01TF072E  
REPORT NO. 1  
FIGURE 2

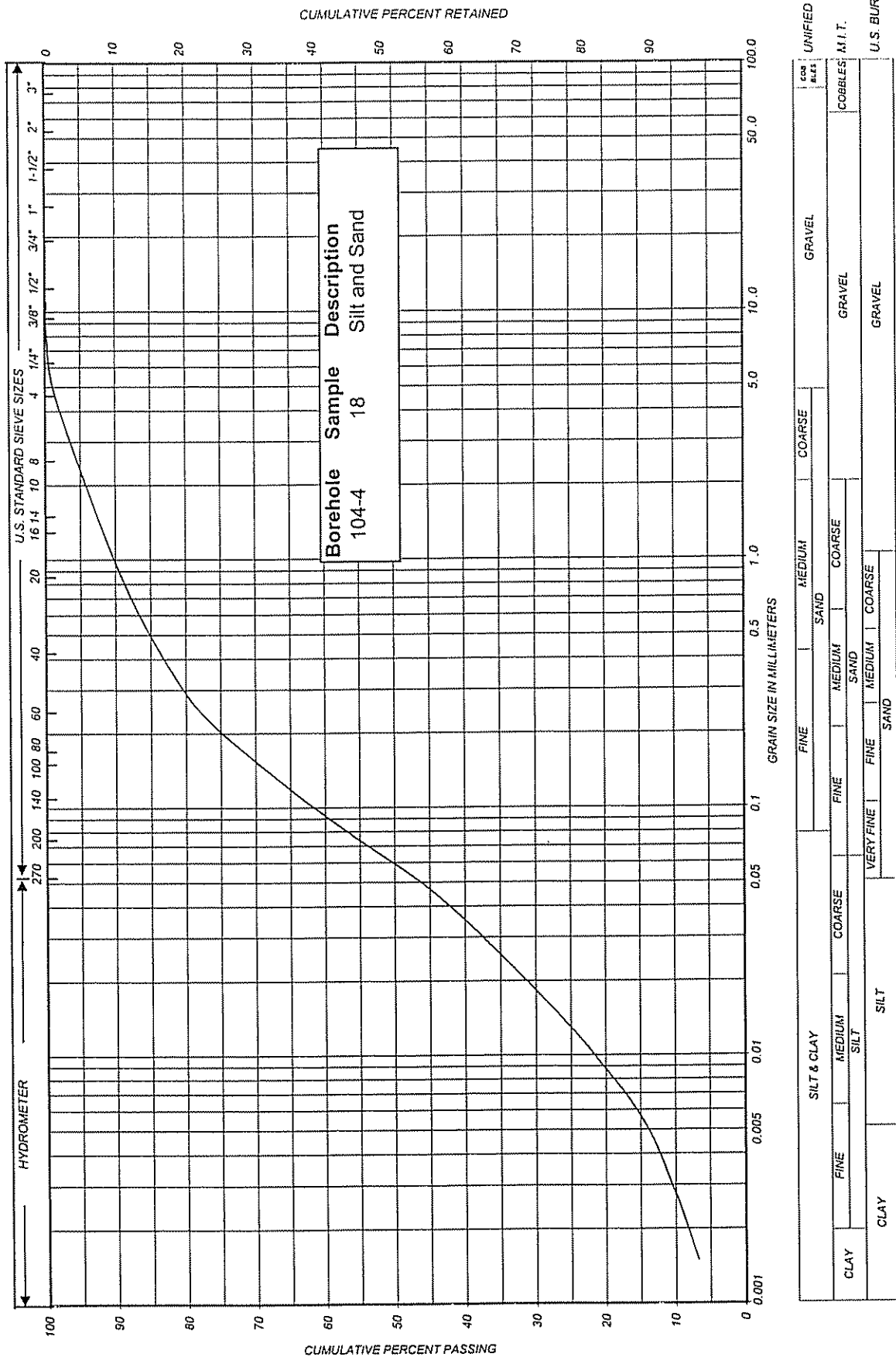
PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY										GRAVEL		UNIFIED			
CLAY	FINE		MEDIUM		SILT		COARSE		SAND		COARSE		COBBLES	M.I.T.	
	FINE		MEDIUM		SILT		COARSE		SAND		COARSE				
CLAY	FINE		MEDIUM		SILT		COARSE		SAND		COARSE		COBBLES	M.I.T.	
	FINE		MEDIUM		SILT		COARSE		SAND		COARSE				
CLAY										SILT		GRAVEL		U.S. BUREAU	

REMARKS SILTY CLAY TILL

# PARTICLE SIZE DISTRIBUTION CHART



REMARKS SILT AND SAND

## **APPENDIX B**

RECORD OF BOREHOLE SHEETS

DRAWINGS 1 AND 2

## LIST OF ABBREVIATIONS

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N'. - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 0.3 m INTO THE SUBSOIL. DRIVEN BY MEANS OF A 63.5 kg HAMMER FALLING FREELY A DISTANCE OF 0.76 m

DYNAMIC PENETRATION RESISTANCE: - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 51 mm. 60 DEGREE CONE. FITTED TO THE END OF DRILL RODS 0.3 m INTO THE SUBSOIL. THE DRIVING ENERGY BEING 475 J PER BLOW

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:

<u>CONSISTENCY</u>	<u>'N' BLOWS/0.3 m</u>	<u>c kPa</u>	<u>DENSENESS</u>	<u>'N' BLOWS/0.3 m</u>
VERY SOFT	0 – 2	0 – 12	VERY LOOSE	0 – 4
SOFT	2 – 4	12 – 25	LOOSE	4 – 10
FIRM	4 – 8	25 – 50	COMPACT	10 – 30
STIFF	8 – 15	50 – 100	DENSE	30 – 50
VERY STIFF	15 – 30	100 – 200	VERY DENSE	> 50
HARD	> 30	> 200		
W.T.P.L. WETTER THAN PLASTIC LIMIT			D.T.P.L. DRIER THAN PLASTIC LIMIT	
A.P.L. ABOUT PLASTIC LIMIT				

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL		

▲, Δ - UNDISTURBED AND REMOULDED SHEAR STRENGTH DETERMINED FROM IN SITU VANE TEST

■ - UNDRAINED SHEAR STRENGTH DETERMINED FROM POCKET PENETROMETER TEST.

RECORD OF BOREHOLE No 104-1

1 of 1 METRIC

G W P. 60-00-00 LOCATION Co-ords. 4 678 144 N; 300 508 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY MRA  
DATUM Geodetic DATE January 24, 2002 CHECKED BY DWK

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	"N" VALUES			SHEAR STRENGTH kPa								
189.86 0.00	Ground Surface						20	40	60	80	100					
189.11 0.75	Pavement, 280mm asphaltic concrete over 470mm sand and gravel															
	Silty clay, trace of sand Stiff to Very Stiff		1	SS	13	189										
	Brown (Fill)		2	SS	12	188										
	occ. small pockets of dark brown silty clay topsoil		3	SS	17	187										
			4	SS	18	186										
184.81 5.05	End of Borehole		5	SS	20	185										
	2002-01-24 Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 104-2

1 of 1 METRIC

G W P: 60-00-00 LOCATION Co-ords. 4 678 125 N; 300 496 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY MRA  
DATUM Geodetic DATE January 24, 2002 CHECKED BY DWK

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	"N" VALUES			20	40	60	80	100					
190.19 0.00	Ground Surface						190										
189.44 0.75	Pavement, 230mm asphaltic concrete over 530mm sand and gravel						189										
	Sand, fine to coarse, some silt, some gravel		1	AS	-												
	Loose Brown Moist (Fill)		2	SS	6												
187.69 2.50	Silty clay, trace of sand Stiff to Very Stiff Brown (Fill)		3	SS	11		187										
			4	SS	18		186										
			5	SS	23		185										
183.09 7.10	Topsoil, silty clay, trace of sand		6	SS	28		183										
182.39 7.80	Dark Brown Silty clay, trace of sand Very Stiff		7	SS	46		182										
181.59 8.60	Brown Silty clay, trace of sand and gravel, with blueish grey fissures (Till) Hard Brown Grey		8	SS	36		181										
			9	SS	30		180										
177.54 12.65	End of Borehole  2002-01-24 Borehole dry on completion of drilling						179										
							178										



RECORD OF BOREHOLE No 104-3


1 of 4 METRIC

G.W.P. 60-00-00 LOCATION Co-ords. 4 678 124 N; 300 509 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE C.F.H.S.A. & NXL Rock Coring COMPILED BY MPA  
DATUM Geodetic DATE January 20, 2002 CHECKED BY DWK

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			20	40	60	80	100					
190.26 0.00	Ground Surface						190										
189.35 0.91	Pavement, 250mm asphaltic concrete over 660mm sand and gravel						189										
187.86 2.40	Gravelly sand, fine to coarse with silt Loose Brown Damp (Fill)		1	SS	5		188										
							187										
	Silty clay, trace of sand and gravel Stiff to Very Stiff Brown (Fill)		2	SS	10		186										
							185										
			3	SS	24		184										
							183										
183.16 7.10	Topsoil, silty clay, trace of sand						182										
182.46 7.80	Dark Brown		5	SS	23		181										
	Silty clay, trace of sand Very Stiff to Stiff Brown		6	SS	14		180										
181.26 9.00	Silty clay, some sand, trace of gravel, with blueish grey fissures (Fill)		7	SS	18		179										
	Very Stiff Brown						178										
	Grey		8	SS	32		177										
							176										
			9	SS	22												
			10	SS	15												

Cont'd

## 2 of 4 METRIC

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		W <sub>p</sub>	W		
100.00	Grazed Surface						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)				
							20 40 60 80 100	20	40	60		GR SA SI C

10.26 Ground Surface

Silty clay, some sand,  
trace of gravel, with  
blueish grey fissures  
(Till) (Cont'd)

\_\_\_\_\_

Firm

Unit	SS	Gravel	Gravel
11	SS	17	
12	SS	7	
13	SS	7	
14	SS	5	
15	SS	4	

175  
174  
173  
172  
171  
170  
169  
168  
167  
166  
165  
164  
163  
162  
161

5 10 40 4

Cont'd

RECORD OF BOREHOLE No 104-3

3 of 4 METRIC

G.W.P. 60-00-00 LOCATION Co-ords. 4 678 121 N; 300 508 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE C.F.H.S.A. & NXL Rock Coring COMPILED BY MRA  
DATUM Geodetic DATE January 20, 2002 CHECKED BY DWK




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			20 40 60 80 100	20 40 60 80 100					
190.26	Ground Surface												
	Silty clay, some sand, trace of gravel, with blueish grey fissures (Till) (Cont'd)		16	SS	4								
			17	SS	3								
			18	SS	0								
			19	SS	7								
148.51	Bedrock Unweathered, strong limestone Grey												
41.75													
			20	RC	REC 100%								
			21	RC	REC 100%								
145.46	Cont'd												
44.80													

4 10 41 45

RQD = 85%

RQD = 93%

## 4 of 4 METRIC

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					
100.35	Ground Surface						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	W <sub>p</sub> — W — W <sub>L</sub> 20 40 60	WATER CONTENT (%) 20 40 60		GR SA SI	

[illegible]

2002-01-20  
Borehole dry on  
completion of  
drilling

### ■ Penetrometer Test

RECORD OF BOREHOLE No 104-4

1 of 4 METRIC

G.W.P. 60-00-00 LOCATION Co-ords. 4 678 975 N; 300 496 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE C.F.H.S.A. & MXL Rock Coring COMPILED BY MRA  
DATUM Geodetic DATE January 22 to 24, 2002 CHECKED BY DWK

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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
190.53 0.00	Ground Surface							20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
189.78 0.75	Pavement. 250mm asphaltic concrete over 500mm sand and gravel													
	Sand, fine to coarse, some gravel, trace of silt		1	AS	-									
	Very Loose		2	SS	4									
	Brown													
	Damp													
	(Fill)													
			3	SS	3									
			4	SS	4									
185.03 5.50	Silty clay, trace of sand		5	SS	3									
	Stiff													
	Brown													
	(Fill)													
			6	SS	26									
182.63 7.90	Topsoil, silty clay, trace of sand		7	SS	18									
182.33 8.20	Silty clay, trace of sand and gravel, with blueish grey fissures		8	SS	13									
	Stiff to Very Stiff													
	Brown													
180.38 10.15	Silty clay, some sand, trace of gravel		9	SS	43									
	Hard													
	(Fill)													
	Brown													
	Grey													
	Very Stiff		10	SS	20									
	Stiff													
			11	SS	13									
	Cont'd													

ON\_MOT 01TF072E GPJ ON\_MOT GDT 09/18/2002 11:33:17 AM

+7 X 5: Numbers refer to  
Sensitivity 20  
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 104-4

2 of 4 METRIC

G.W.P. 60-00-00 LOCATION Co-ords. 4 679 075 N; 300 496 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE C.F.H.S.A. 4 NXL Rock Coring COMPILED BY MRA  
DATUM Geodetic DATE January 22 to 24, 2002 CHECKED BY DWK

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	"N" VALUES			20	40						60	80	100	20
190.53	Ground Surface																	
	Silty clay, some sand. trace of gravel (Till) (Cont'd)		12	SS	13		175											
							174											
							173											
	Firm		13	TM	PH		172											
							171											
							170											
			14	SS	4		169											
				FV			168											
							167											
			15	SS	5		166											
							165											
							164											
			16	SS	3		163											
							162											
							161											

Cont'd

ON\_MOT 01TF072E GPJ ON\_MOT GDT 09/18/2002 11:33:18 AM

+7 X 5: Numbers refer to  
Sensitivity 20  
15 5 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 104-4

3 of 4 METRIC

G.W.P. 60-00-00 LOCATION Co-ords. 4 67H 075 N; 300 496 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE C.F.H.S.A. & NXL Rock Coring COMPILED BY MRA  
DATUM Geodetic DATE January 23 to 24, 2002 CHECKED BY DWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
190.53	Ground Surface													
	Silty clay, some sand. trace of gravel (Till) (Cont'd)		17	SS	11		160							
	Sandy						159							
158.33 32.20	Silt and sand, trace of clay and gravel Dense Grey (Till)		18	SS	38		158							
							157							2 42 48 8
							156							
	with zones and lenses of silty clay, some sand loose		19	SS	8		155							
							154							
							153							
152.23 38.30	Silty clay, some sand to sandy, trace of gravel Firm Grey (Till)		20	SS	7		152							
							151							
							150							
							149							
148.63 41.90	Bedrock Unweathered, strong limestone Buff to Grey		21	RC	REC 100%		148							RQD = 90%
			22	RC	REC 90%		147							Natural gas encountered RQD = 80%
146.48 44.05	End of Borehole													
	Cont'd													

ON\_MOT 01T672E.GPJ ON\_MOT GDT 09/18/2002 11:33:19 AM

+7 X<sup>5</sup>: Numbers refer to  
Sensitivity  
20  
15 0 5 (%) STRAIN AT FAILURE  
10

## 4 of 4 METRIC

+7 X5: Numbers refer to Sensitivity



RECORD OF BOREHOLE No 104-5

1 of 2 METRIC

G W P, 60-00-00 LOCATION Co-ords. 4 678 075 N; 300 507 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY MRA  
DATUM Geodetic DATE January 25, 2002 CHECKED BY DWK

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	"N" VALUES			SHEAR STRENGTH kPa									
190.58 0.00	Ground Surface						20	40	60	80	100						
189.83 0.75	Pavement. 255mm asphaltic concrete over 495mm sand and gravel																
	Sand, fine to coarse, some gravel. trace of silt																
	Loose Brown Damp (Fill)		1	SS	6												
			2	SS	5												
	Compact		3	SS	11												
184.33 6.25	Silty clay. trace of sand		4	SS	6												
	Firm Mottled Brown (Fill)																
182.63 7.95	Very Stiff		5	SS	24												
181.98 8.60	Topsoil, silty clay, trace of sand																
	Very Stiff Dark Brown																
	Silty clay, some sand		6	SS	8												
	Stiff																
	Mottled Brown/ Fissured Grey (Fill)																
	Hard		7	SS	52												
	Very Stiff		8	SS	22												
	Grey		9	SS	15												
176.38 14.20	End of Borehole																
	Cont'd																

RECORD OF BOREHOLE No 104-5

2 of 2 METRIC

G W P. 60-00-00 LOCATION Co-ords. 4 679 075 N; 300 507 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY MRA  
DATUM Geodetic DATE January 25, 2002 CHECKED BY DWK

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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
190.58	Ground Surface						20	40	60	80	100	20	40	60			
	2002-01-25 Borehole dry on completion of drilling																
	■ Penetrometer Test																

RECORD OF BOREHOLE No 104-6

1 of 1 METRIC

G W P. 60-00-00 LOCATION Co-ords. 4 678 055 N; 300 507 E. ORIGINATED BY MR  
DIST 31 HWY 401 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY MPA  
DATUM Geodetic DATE January 24, 2002 CHECKED BY DWK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
190.35 0.00	Ground Surface													
189.60 0.75	Pavement. 210mm asphaltic concrete over 540mm sand and gravel													
	Silty clay, trace of sand		1	SS	15									
	Stiff to Very Stiff													
	Brown		2	SS	13									
	(Fill)													
	occ topsoil lenses		3	SS	12									
			4	SS	15									
185.30 5.05	End of Borehole		5	SS	20									
	2002-01-24 Borehole dry on completion of drilling													

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES

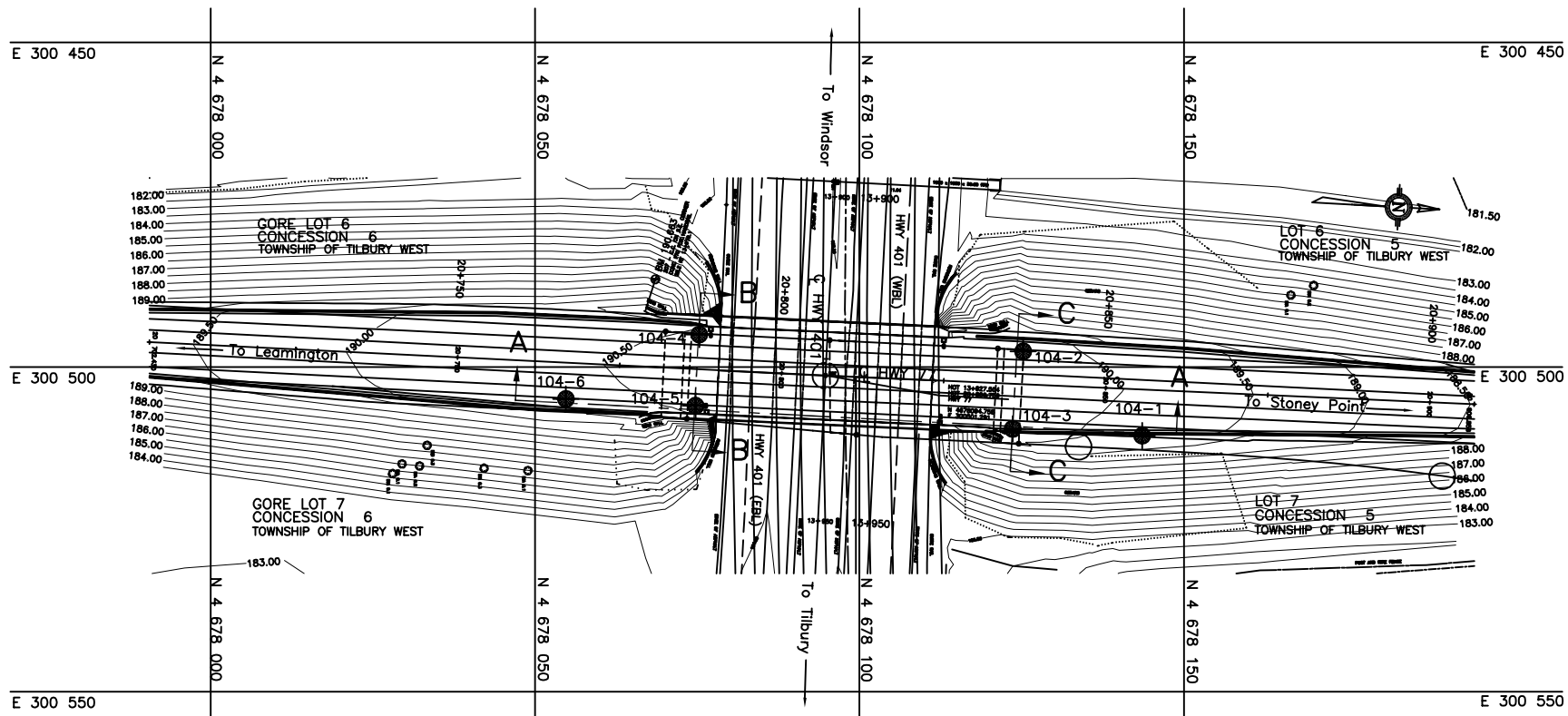
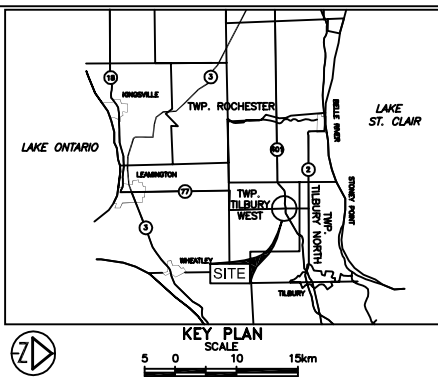
CONT No  
GWP No 60-00-00

HIGHWAY 401  
HIGHWAY 77 UNDERPASS  
BOREHOLE LOCATIONS & SOIL STRATA

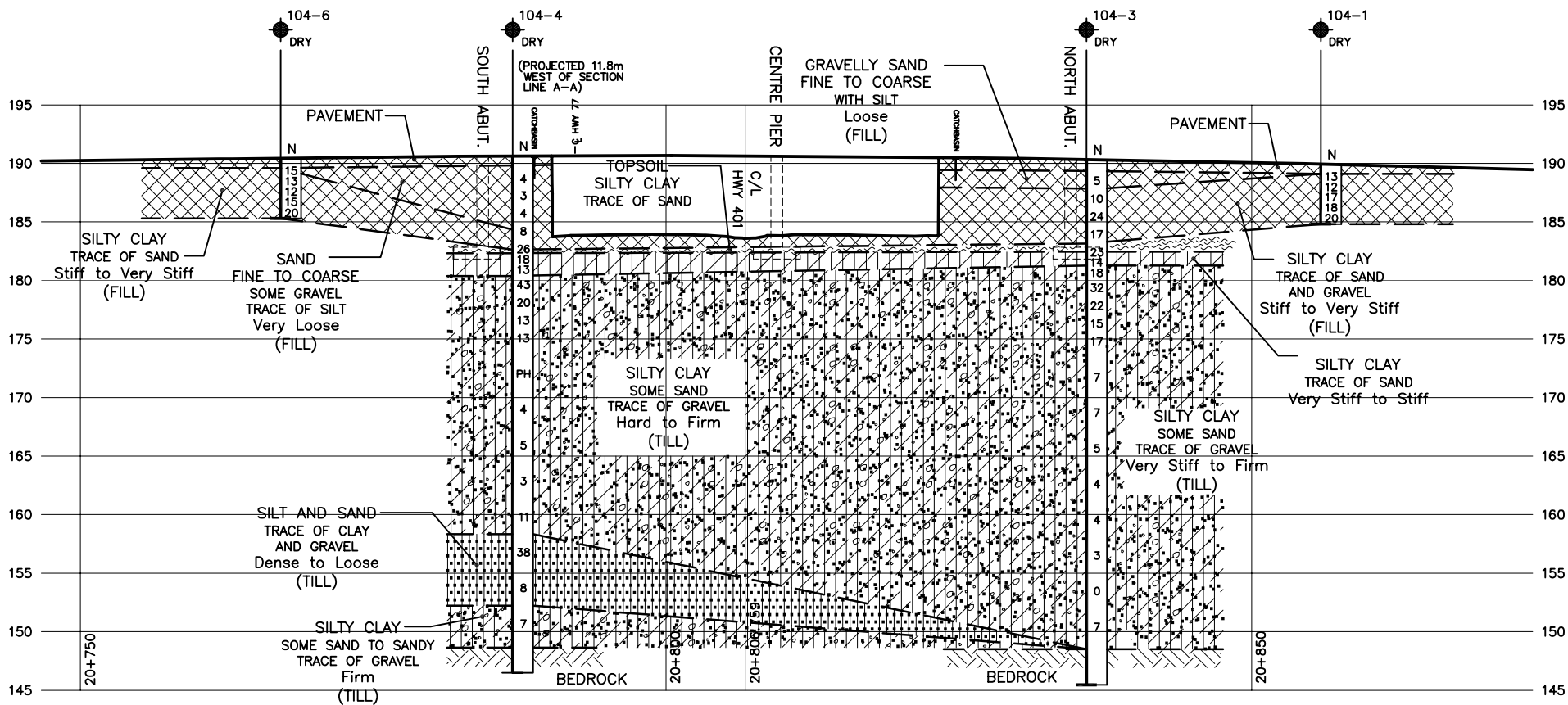


SHEET

Peto MacCallum Ltd.  
CONSULTING ENGINEERS



PLAN  
SCALE



A-A

SCALE



NOTES:

- REFER TO DRAWING 2 FOR SECTIONS B-B AND C-C.
- SECTIONS ARE PROVIDED SOLELY FOR ILLUSTRATIVE PURPOSES. REFER TO RECORD OF BOREHOLES FOR DETAILED DESCRIPTION OF SUBSURFACE CONDITIONS, IN-SITU TEST DATA AND LABORATORY TEST RESULTS.

REF No E-Plan401Hwy 77-StJoachim.dwg; Jan 2002

LEGEND

- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J / blow)
- CONE Blows/0.3m (60° Cone, 475 J / blow)
- W L at time of investigation Jan 2002
- Head
- ARTESIAN WATER Encountered

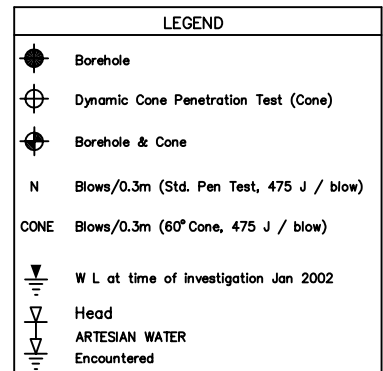
BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
104-1	189.86	4 678 144	300 508
104-2	190.19	4 678 125	300 496
104-3	190.26	4 678 124	300 508
104-4	190.53	4 678 075	300 496
104-5	190.58	4 678 075	300 507
104-6	190.35	4 678 055	300 507

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No.

HWY No 401	DIST 31
SUBM'D GD CHECKED MRA DATE SEP 18, 2002 SITE 6-104	
DRAWN MM/TKI CHECKED BRG APPROVED DWK DWG 1	



BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST

(Refer to drawing 1 for co-ordinates)

REVISIONS			
	DATE	BY	DESCRIPTION

Geocres No.						
HWY No 401				DIST 31		
SUBM'D	GD	CHECKED	MRA	DATE SEP 18, 2002		SITE 6-104
DRAWN	MM/TK	CHECKED	BRG	APPROVED	DWK	DWG 2

REF No E-Plan401Hwy 77-StJoachim.dwg; Jan 2002