



**FEASIBILITY FOUNDATION INVESTIGATION AND DESIGN
REPORT 1 – GEOGRAPHICAL TOWNSHIP OF WATERLOO
for
HIGHWAY 401
FROM 1.0 KM WEST OF HESPELER ROAD EASTERLY TO THE
HALTON REGION BOUNDARY, 25.8 KM
AGREEMENT NUMBER 3007-E-0037
GWP NO. 8-00-00
for
MCCORMICK RANKIN, A MEMBER OF THE MMM GROUP**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email: Toronto@petomaccallum.com

Distribution:

3 cc: MRC for distribution to MTO Project Manager
+ 1 digital copy
1 cc: MRC for distribution to MTO Pavements and
Foundations Section + 1 digital copy
2 cc: MRC + 1 digital copy
1 cc: PML Toronto

PML Ref.: 09TF012-1
Index No.: 018FIDR
Geocres No.: 40P8-206
December 20, 2012



TABLE OF CONTENTS

1. INTRODUCTION	1
2. SITE DESCRIPTION	2
3. INVESTIGATION PROCEDURES	3
4. LITERATURE REVIEW	3
4.1 Inferred Subsurface Conditions	3
4.2 Inferred Structure Foundations.....	5
5. SITE RECONNAISSANCE	6
6. DISCUSSION AND RECOMMENDATIONS	6
6.1 General	6
6.1.1 Structure Foundations.....	8
6.1.2 Embankment Stability	9
6.1.3 Embankment Settlement.....	10
6.1.4 Construction Considerations.....	10
6.1.5 Advantages and Disadvantages of Alternate Configurations.....	10
6.2 Preferred Alternative Considerations	11
6.3 Foundation Investigation Areas For Detail Design	12
7. CLOSURE	13

Table 1-1 – List of Reference Documents

Figure A – Key Plan

Appendix A – Site Photographs 1-1 to 1-19

Photographs 1-1 to 1-10 – Waterloo Regional Road 24 Underpass

Photographs 1-11 to 1-19 – Waterloo Regional Road 36 Underpass

Appendix B – Previous Soil Data and Record of Boreholes

- (1) Foundation Investigation Report for Waterloo Regional Road 24 Underpass
NBL (WP 239-87-01, Site 33-150, Geocres 40P8-94)
- (2) Foundation Investigation Report for Waterloo Regional Road 24 Underpass
(Geocres 58-F-296C)
- (3) Foundation Investigation and Design Report for Waterloo Regional Road 36
Underpass (WP 7-83-09, Site 33-151, Geocres 40P8-104)

**Feasibility Foundation Investigation and Design
Report 1 – Geographical Township of Waterloo**

for

Highway 401

From 1.0 Km West of Hespeler Road Easterly 25.8 km
to the Halton Region Boundary

Agreement Number 3007-E-0037

GWP No. 8-00-00

1. INTRODUCTION

The MTO has undertaken a Class Environmental Assessment and Preliminary Design Study to examine the need and justification for improvements to Highway 401 from 1.0 km west of Hespeler Road easterly to the Wellington / Halton Boundary.

The preferred alternative, as identified by the EA process, is to widen the highway from six lanes to an ultimate ten lane cross-section with provisions to accommodate 2 HOV lanes within the ultimate ten lane cross-section. Initial widening will be from six to eight lanes with the ultimate ten lane cross-section to follow depending on traffic volume growth.

This report presents the results of the foundation feasibility study carried out for the proposed widening of the Highway 401 section through the Geographical Township of Waterloo. The study is being carried out for McCormick Rankin, a member of the MMM Group (MRC) on behalf of the Ministry of Transportation of Ontario (MTO).

Feasibility studies are required for the foundations of the existing and new bridge structures between the study limits. The freeway section traverses two geographical townships and the reporting was separated into two reports designated as follows:

- Report 1 – Geographical Township of Waterloo
- Report 2 – Township of Puslinch

This report concerns the Highway 401 section through the Geographical Township of Waterloo which extends between the west limit of the project and east of the Townline Road in the east for some 4.7 km.

Within the limits of the Geographical Township of Waterloo, there are three interchanges, Hespeler, Franklin and Townline. The Hespeler and Franklin interchanges are described in the



following section. The Townline Road underpass structure is a 2-span bridge and can accommodate a minimum 8 lanes for the initial improvement of Highway 401. Therefore, no foundation work is required at the Townline interchange.

All dimensions in this report are provided in metres except where indicated.

2. SITE DESCRIPTION

The Highway 401 through the Geographical Township of Waterloo is currently a six-lane freeway.

The following table lists the MTO site numbers, stations, locations and structure types along this section of Highway 401.

LIST OF STRUCTURES

Structure Name	Site No.	Station ⁽¹⁾	Type
Waterloo Regional Road 24 Underpass NBL (Hespeler Road)	33-150-N	~19+221	Prestressed Girders (CPCI)
Waterloo Regional Road 24 Underpass SBL (Hespeler Road)	33-150-S	~19+200	Continuous Deck Slab (Rect Void)
Waterloo Regional Road 36 Underpass (Franklin Blvd.)	33-151	~20+706	Continuous Deck Slab (Rect Void)
Waterloo Regional Road 36 S-W Ramp Underpass (Franklin Blvd.)	33-151-N	~20+714	Prestressed Girders (Box)

Note: 1. Stations are approximate from contract drawings.

The topography abutting the highway corridor within the Geographical Township of Waterloo is typically hilly, with local relief with regular slope. In general, the highway grades are considered flat at the underpass structure locations.

The main land use is the typical commercial and residential beyond the highway corridor. Within the Geographical Township of Waterloo, there are some industrial land uses close to properties bordering the Highway 401 corridor near Waterloo Regional Road 36. Treed lands are also present along the highway corridor. The roadside ditches are typically covered with grasses.

The MTO design frost depth for the Geographical Township of Waterloo is 1.2 m.



3. INVESTIGATION PROCEDURES

The foundation feasibility analysis for this report was based primarily on a review of existing data and literature. The data comprised two geological maps, five previous MTO construction contract documents and foundation investigation. Table 1-1 provides a list of the reference documents reviewed for this study.

Chainages are approximate unless clearly provided on the reference documents. Some elevations and dimensions were converted to the metric system from imperial units. All dimensions and elevations provided in this report should be verified during detail design.

Site reconnaissance visits were also carried out at each of the bridge structures. Representative photographs showing relevant natural features and geomorphology are included in Appendix A.

Subsurface field explorations were not carried out for this report. Copies of the previous records of boreholes and associated location plans relevant to the existing structures that were available at the time of the study are included in Appendix B.

4. LITERATURE REVIEW

4.1 Inferred Subsurface Conditions

The reviewed geological and physiographic maps and literature indicated that Highway 401 through the Geographical Township of Waterloo was constructed over sandy soils. These soils consist of sand, silt and some gravel. This section of Highway 401 lies within the physiographic region of the Waterloo Sandhills that comprises shallow water lacustrine, kame and sandy outwash soils.



The bedrock underlying the Highway 401 alignment through the Geographical Township of Waterloo mostly comprises the dolostone of the Guelph Formation. The following table provides a simplified summary of the site conditions that were previously encountered or inferred at the locations of the underpasses and bridge within the Geographical Township of Waterloo.

SUMMARIZED INFERRED SUBSURFACE CONDITIONS

Structure Name	Soil Types/Depths ⁽¹⁾	Bedrock ⁽²⁾		Groundwater ⁽³⁾	
		Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
Waterloo Regional Road 24 Underpass NBL and SBL (Hespeler Road)	Sand, trace/some silt and gravel, to 3.0 to 8.2 m depth (elevation 290.1 to 292.9), compact to very dense. Sand and Gravel, trace silt, dense to very dense. Boulders were encountered below 6.71 m depth (elevation 291.15). Termination depth: 6.2 to 10.1 m (elevation 286.4 to 290.2)	Not reached	Not reached	>6.2 to 10.1	Below 286.4 to 290.2
Waterloo Regional Road 36 Underpass and S-W Ramp Underpass (Franklin Blvd.)	Sandy fill to 2.6 to 8.5 m depth (elevation 316.4 to 320.9), very loose to compact. Underlying this layer, a 0.3 to 0.9 m thick organic silty layer was encountered in most boreholes. Silty sand to sandy silt, extending to bedrock or termination depth of 17.1 to 28.3 m (elevation 291.7 to 302.2), compact to dense. Cobbles and boulders were found occasionally.	29.3 to 36.6	289.1 to 291.7	12.5 to 19.8	305.6 to 307.2

- Notes: 1. From borehole data. Levels indicated are inferred depths and elevations of the bottom of the soil units. Topsoil and fill units were disregarded.
2. From records of boreholes.
3. Groundwater levels were based on records of boreholes.

Depths of topsoil and fill encountered during previous subsurface investigations were disregarded because present conditions are likely to differ from those recorded.



The typical soil stratigraphy encountered in the previous investigations at all of the structure sites comprises cohesionless sandy deposits. These cohesionless soils are typically compact to very dense.

Based on borehole records, the bedrock underlying the Highway 401 site at Franklin Boulevard was encountered at depths ranging between 29.3 and 36.6 m. Groundwater was found at depths ranging from 12.5 to 19.8 m in the boreholes. Based on 5 boreholes drilled in 1987, no groundwater was observed above 10.1 m depth at the site of Waterloo Regional Road 24. The present groundwater conditions may vary from those recorded during the geotechnical investigations.

4.2 Inferred Structure Foundations

Based on the construction drawings reviewed, the foundations of the abutments and piers of the underpass structures were founded on spread footings or piles. The following table summarizes the foundation type and founding levels that were inferred for the foundations on this report section.

BRIDGE STRUCTURE - EXISTING FOUNDATIONS

Structure	Abutments			Piers		
	Type	Elevation ⁽¹⁾		Type	Elevation ⁽¹⁾	
		Top Footing	Bottom Footing		Top Footing	Bottom Footing
Waterloo Regional Road 24 Underpass NBL and SBL. (Hespeler Road)	Spread Footings	296.8	N/A	Spread Footings	292.9	N/A
Waterloo Regional Road 36 Underpass (Franklin Blvd.)	Piles	323.2	~308.0	Piles	318.2	~310.6
Waterloo Regional Road 36 S-W Ramp Underpass (Franklin Blvd.)	Piles	323.2	~308.0	Piles	318.2	~310.6

Note: 1. Elevations were taken from reference contract drawings for top of pile foundations.

N/A Elevation not available for the existing structure foundation.



5. SITE RECONNAISSANCE

The site reconnaissance of the structures within this geographical township was carried out on August 28, 2012. Nineteen relevant photographs of the structure sites are presented in Appendix A for reference. The following notes were compiled:

- The site visit confirmed that the structures are located on generally flat to gently undulating terrain (Photographs 1-2, 1-5, 1-9, 1-12 and 1-15).
- The visual inspection of the underpass structure foundations did not reveal signs of distress such as settlements or other distortions (Photographs 1-4, 1-6, 1-7, 1-14 and 1-18).
- The roadside ditches were typically covered with grass (Photographs 1-10).
- It was judged that the overpass, underpass and bridge approach embankments and interchange ramp embankments are currently stable and without visible settlements. No major signs of distress such as erosion or sliding of the approach embankments were noted (Photographs 1-3, 1-4, 1-5, 1-6, 1-8 to 1-13, 1-17 to 1-19).

6. DISCUSSION AND RECOMMENDATIONS

6.1 General

The MTO is currently planning to initially widen Highway 401 through the Geographical Township of Waterloo from six to eight lanes with the ultimate ten lane cross-section to follow depending on traffic volume growth. The one new lane will be added to the outside of the westbound and eastbound lanes. The widening of Highway 401 will require the replacement of the existing bridges at Waterloo Regional Road 24 and Waterloo Regional Road 36 to accommodate ten lanes. This report pertains to the section through the Geographical Township of Waterloo.



It is understood that the existing 4-span bridges at Waterloo Regional Road 24 and Waterloo Regional Road 36 will be replaced by new 2-span bridge structures. Two piers will be eliminated at each structure. The bridges will be lengthened to accommodate the two new EBL and WBL lanes with provisions for HOV lanes. Due to shift of the alignment or structure change of the new bridges, the existing foundations will not be used by the new structures. Based on the existing geotechnical information, the following foundation alternatives were considered:

1. Spread footing foundations
2. Shallow pile foundations, including steel H-pile and steel tube pile foundations and caissons
3. Deep pile foundations, including steel H-pile and steel tube pile foundations and caissons

It is envisaged that Alternative 2 will require finding a very dense gravel and sand layer or a very dense/hard till layer at pile toes to bear loads from the superstructures of the new bridges.

The following sections of this report provide comments for planning purposes and an overview of the advantages and disadvantages, costs and risks/consequences of each alternate configuration from a foundation perspective.



6.1.1 Structure Foundations

Based on the available data, the following foundation levels and geotechnical resistances for shallow and deep foundations are anticipated.

PRELIMINARY REFERENCE FOUNDING LEVELS AND GEOTECHNICAL RESISTANCES ⁽¹⁾

Structure site	Shallow Foundations ⁽²⁾				Deep Foundations			
	Founding Levels		Geotechnical Resistance		Founding Levels		Geotechnical Resistance	
	Depth (m)	Elev. (m)	ULS (kPa)	SLS (kPa)	Depth (m)	Elev. (m)	ULS (kN)	SLS (kN)
Waterloo Regional Road 24 Underpass ⁽³⁾⁽⁴⁾ (Hespeler Road)	2.3	292.2	1000	400	~20.0	~274.5	2000 ^(5,6) 5500 ⁽⁷⁾	N/A
Waterloo Regional Road 36 Underpass (Franklin Blvd.)	N/A	N/A	N/A	N/A	15.0	305.0	510 ⁽⁸⁾ 2000 ⁽⁹⁾	300 1200
Waterloo Regional Road 36 Underpass (Franklin Blvd.) ⁽¹⁰⁾	N/A	N/A	N/A	N/A	29.3-36.6	289.1-291.7	2000 ^(5,6)	N/A

- Notes: ⁽¹⁾ Geotechnical resistances are to be confirmed during detailed design. Factored resistances at ULS are used on table.
- ⁽²⁾ Abutments founded at 1.2 m depth on engineered fill may be designed for 900 kPa ULS and 350 kPa SLS.
- ⁽³⁾ The spread footings at elevation 292.2 m can be taken as an option of the foundation of the new underpass if the bearing capacity is sufficient.
- ⁽⁴⁾ Driven pile tips assumed to be established on bedrock.
- ⁽⁵⁾ Resistance for HP 310x110 piles when driven to refusal on unyielding bedrock.
- ⁽⁶⁾ Resistance for HSS 324x13 piles when driven to refusal on unyielding bedrock.
- ⁽⁷⁾ Resistance for 0.76 m diameter caissons to be drilled into bedrock with 1.0 m long socket.
- ⁽⁸⁾ The existing pile foundation was established at elevation 305.0 m. Shallow pile foundation can be taken as a foundation option if a low capacity pile (510 kN) is economically feasible.
- ⁽⁹⁾ Resistance for 1.0 m diameter caissons to be drilled to elevation 305.0 m.
- ⁽¹⁰⁾ Pile driven and seated in bedrock can also be taken as another foundation option.
- N/A Shallow spread foundation is not applicable/feasible due to the excessive excavation depth 4 to 6 m to reach competent bearing stratum.

The new bridge at Waterloo Regional Road 24 (Hespeler Road) will be partially shifted to east and the new bridge at Waterloo Regional Road 36 (Franklin Boulevard) will be constructed on the existing alignment. Due to shift of the alignments or structure change of the new bridges, the existing foundations will not be used by the new structures. For the Waterloo Regional Road 24



underpass structure, the spread footings or pile foundation can be selected and will depend on foundation loading conditions. For the Waterloo Regional Road 36 underpass structure, the pile foundations to elevation 305.0 m or to bedrock can also be selected. At the feasibility study stage, the foundation loads are not available. Therefore, the foundation options are provided in the above table for potential application.

6.1.2 Embankment Stability

At Waterloo Regional Road 24 (Hespeler Road), the new underpass structure partially built to the east of the existing alignment will require widening of the existing embankments to the east side of the existing embankment. The widened embankment will be about 6 to 7 m high fills at the abutments. It is envisaged that these embankments, if required, would comprise compact silty sand/sandy silt, or/and earth.

At Waterloo Regional Road 36 (Franklin Boulevard), the new underpass structure will be constructed on the existing alignment. The new abutments will be set back. Only the existing embankment cutting is needed.

No signs of distress such as erosion, major sloughing or sliding were noted on the existing underpass structure approach embankments. Based on the condition of these existing earth embankments, it is considered that the earth slopes will be stable at the standard earth slope configurations of 2H:1V.

During construction of the new abutments, the existing embankments will be cut or/and widened. The construction activities for the new abutments, such as excavation and pile driving, may affect the stability of the existing embankments at the new cut surfaces. Adequate temporary shoring, such as sheet pile or soldier pile and lagging shoring, will be required to ensure the stability of the existing approach embankments.

In general, it is considered that the existing native soils are capable of withstanding the additional loading of the new earth embankments or embankment widening, if required. The short and



long-term slope stability of approach embankments on each site should be investigated during detail design.

6.1.3 Embankment Settlement

The settlements of the new embankments constructed separately from the existing fills are expected to be in the order of 50 mm at the location of the highest fills behind the abutments. The settlements will occur immediately once the new embankments are constructed because the native soils under the embankments are cohesionless soils.

Where the embankments are widened, the estimated magnitude of settlements is about half of that indicated for separate embankments and the settlements will occur immediately.

6.1.4 Construction Considerations

The new bridge at Waterloo Regional Road 24 will be partially located to the east side of the existing bridge. The new bridge will overlay some 12.0 m with the footprint of the existing bridge. The new bridge at Waterloo Regional Road 36 will be located on the existing alignment. Due to the shift of bridge location at Waterloo Regional Road 24, a widening of approach embankment will be constructed. During construction, the traffic lanes at Waterloo Regional Road 24 will be reduced and Waterloo Regional Road 36 will be closed to permit construction of the new structure.

Excavations for the installation of new pile caps or spread footings for piers and abutments on native soils will not likely require control of the perched groundwater at Waterloo Regional Road 24 and Waterloo Regional Road 36, where the groundwater was not measured above 10.1 m depth.

6.1.5 Advantages and Disadvantages of Alternate Configurations

In view of the foregoing considerations, the advantages and disadvantages and inferred risks/consequences of each of the alternate configurations from a foundation perspective are summarized as follows. This preliminary analysis is based on the currently planned widening of



Highway 401 from six to eight lanes with the ultimate ten lane cross-section to follow depending on traffic volume growth.

ADVANTAGES AND DISADVANTAGES – BRIDGE STRUCTURES

Structure site	Foundation Option 1		Foundation Option 2		Foundation Option 3	
	Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages
Waterloo Regional Road 24 Underpass (Hespeler Road)	<u>Spread Footing</u> -Easy construction -Low cost	<u>Spread Footing</u> -Large footing foundation will be required to support high load from long span structure	<u>Pile Foundation</u> -High resistance -Integral abutment feasible for H-piles	<u>Pile Foundation</u> -Inducing vibration -High cost -Integral abutment not feasible for tube piles	<u>Caisson Foundation</u> ⁽¹⁾ -High resistance	<u>Caisson Foundation</u> -Difficult construction due to probable groundwater and boulders
Waterloo Regional Road 36 Underpass (Franklin Blvd.)	<u>Shallow Pile Foundation</u> ⁽²⁾ -Lower cost	<u>Shallow Pile Foundation</u> -Large foundation required due to high number of low capacity piles	<u>Deep Pile Foundation</u> ⁽³⁾ -High resistance -Integral abutment feasible for H-piles	<u>Deep Pile Foundation</u> -Inducing vibration -High cost -Integral abutment not feasible for tube piles	<u>Caisson Foundation</u> ⁽⁴⁾ -High resistance	<u>Caisson Foundation</u> -Difficult construction due to probable groundwater and boulders

Notes: ⁽¹⁾ Drilled caissons into bedrock with 1.0 m long socket.

⁽²⁾ Driven pile tips assumed at elevation 305.0 m

⁽³⁾ Driven pile tips assumed to be established on the bedrock.

⁽⁴⁾ Drilled caissons assumed at elevation 305.0 m.

6.2 Preferred Alternative Considerations

Highway 401 within the Geographical Township of Waterloo will be widened from six to eight lanes with the ultimate ten lane cross-section to follow depending on traffic volume growth. It is understood that the existing 4-span bridges at Waterloo Regional Road 24 and Waterloo Regional Road 36 will be replaced by the new 2-span bridge structures. The loads on the foundations will be increased. The foundation types should be selected based on structural analysis and future needs. At the feasibility stage, the loads are not available. The following suggestions are made based on the available information.

At the site of Waterloo Regional Road 24, a layer of very dense sand with gravel was encountered at about 2.3 m. A high bearing resistance (400 kPa at SLS) is available for the spread footing



foundation design. A deep H-pile foundation is practical for the preferred alternative and will permit the use of integral abutments. A 20.0 m depth to bedrock is assumed based on the available bedrock mapping from well records.

At the site of Waterloo Regional Road 36, only pile foundations can be used. However, there are three alternatives: shallow pile foundations and caisson foundations at elevation 305.0 m and deep pile foundation to bedrock. Due to the uncertainty of the founding depth of shallow low capacity piles, deep H-pile foundation supported on bedrock is the preferred alternative.

6.3 Foundation Investigation Areas For Detail Design

Highway 401 is to be initially widened from six to eight lanes with the ultimate ten lane cross-section to follow depending on traffic volume growth. The widening of Highway 401 will require foundation investigations at the new underpass structures through the Geographical Township of Waterloo. Foundation investigations will be required for bridges at Waterloo Regional Road 24, Waterloo Regional Road 36. For the new underpass structures, the following foundation investigations are suggested.

FOUNDATION INVESTIGATION AREAS – BRIDGE STRUCTURES

Stations ⁽¹⁾	Proposed Works	Proposed Investigation ⁽²⁾
19+223	Waterloo Regional Road 24 Underpass (Hespeler Road)	6 boreholes to 20.0 m depth ⁽³⁾⁽⁴⁾ , 4 boreholes to depths from 8.0 to 16.0 m
20+706	Waterloo Regional Road 36 Underpass (Franklin Blvd.)	6 boreholes to depths from 29.3 to 40.0 m ⁽³⁾⁽⁵⁾

- Notes:
1. Stations are approximate from contract drawings.
 2. Relevant data from previous foundation investigation reports.
 3. Six boreholes should be drilled to bedrock. The bedrock should be proved by core drilling.
 4. Depth to bedrock estimated from Bedrock Topography Map No 2030.
 5. Depth to bedrock estimated from existing Geocres Repot 40P8-104.



7. CLOSURE

This report was prepared by Mr. B. Rao, P. Eng. and reviewed by Mr. G. Degil, P. Eng. Mr. B. R. Gray, M. Eng., P. Eng, MTO Designated Contact, conducted an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



Bin Rao, P.Eng.
Project Engineer



Grigory Degil, P. Eng.
Senior Project Engineer



Brian R. Gray, MEng, P.Eng.
MTO Designated Contact

BR/GD/BRG:br-sq



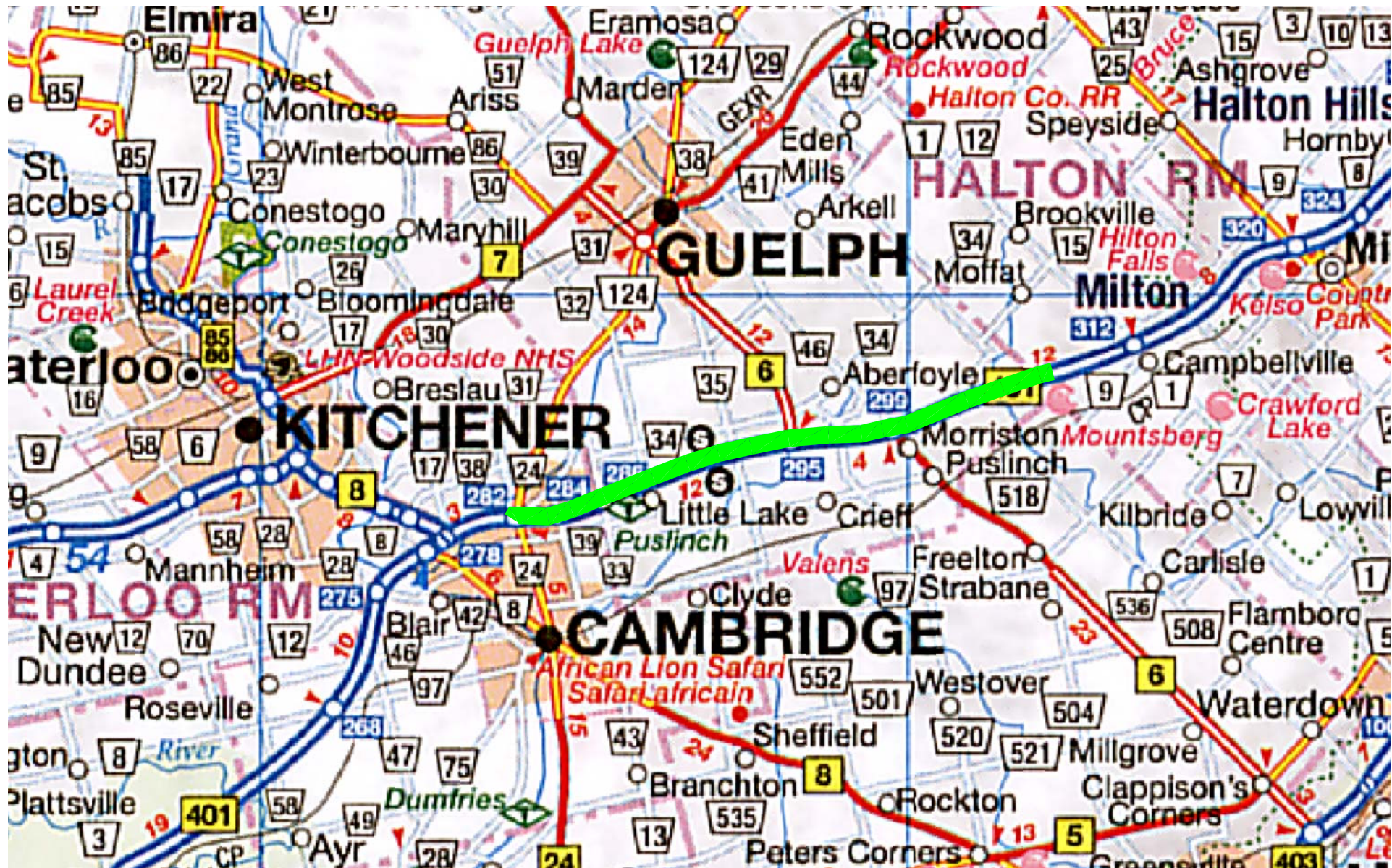
TABLE 1-1
LIST OF REFERENCE DOCUMENTS
(GEOGRAPHICAL TOWNSHIP OF WATERLOO)

A. Geological Maps

- Quaternary Geology of Ontario, Southern Sheet, Map 2556 from Ontario Ministry of Northern Development and Mines, Compiled 1991. Scale 1:1,000,000.
- Bedrock Geology of Ontario, Southern Sheet, Map 2544 from Ontario Ministry of Northern Development and Mines, Compiled 1991. Scale 1:1,000,000.

B. MTO Reports and Drawings

- (1) Foundation Investigation Report for Waterloo Regional Road 24 Underpass NBL (WP 239-87-01, Site 33-150, Geocres 40P8-94)
- (2) Foundation Investigation Report for Waterloo Regional Road 24 Underpass (Geocres 58-F-296C)
- (3) Foundation Investigation and Design Report for Waterloo Regional Road 36 Underpass (WP 7-83-09, Site 3-151, Geocres 40P8-104)



GEOCRE NO. : 40P-206

KEY MAP
HIGHWAY 401

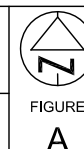
FROM 1.0 KM WEST OF HESPELER ROAD EASTERLY
TO THE HALTON REGION BOUNDARY, 25.8 KM

METRIC



Peto MacCallum Ltd.
CONSULTING ENGINEERS

HIGHWAY 401
G.W.P. 8-00-00





APPENDIX A

Site Photographs 1-1 to 1-19

- Photographs 1-1 to 1-10 – Waterloo Regional Road 24 Underpass
- Photographs 1-11 to 1-19 – Waterloo Regional Road 36 Underpass



PHOTOGRAPH 1-1: Waterloo Regional Road 24 Bridge and Hwy 401 WBL.
(August 28, 2012)



PHOTOGRAPH 1-2: Residential buildings at the SW corner of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-3: Side slope and front slope at the north abutment of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-4: Front slope at the north abutment of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-5: Commercial buildings at the NE corner of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-6: Front slope at the south abutment of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-7: Girders and continuous deck slab of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-8: Side slope at the south abutment of Waterloo Regional Road 24 Bridge. (August 28, 2012)



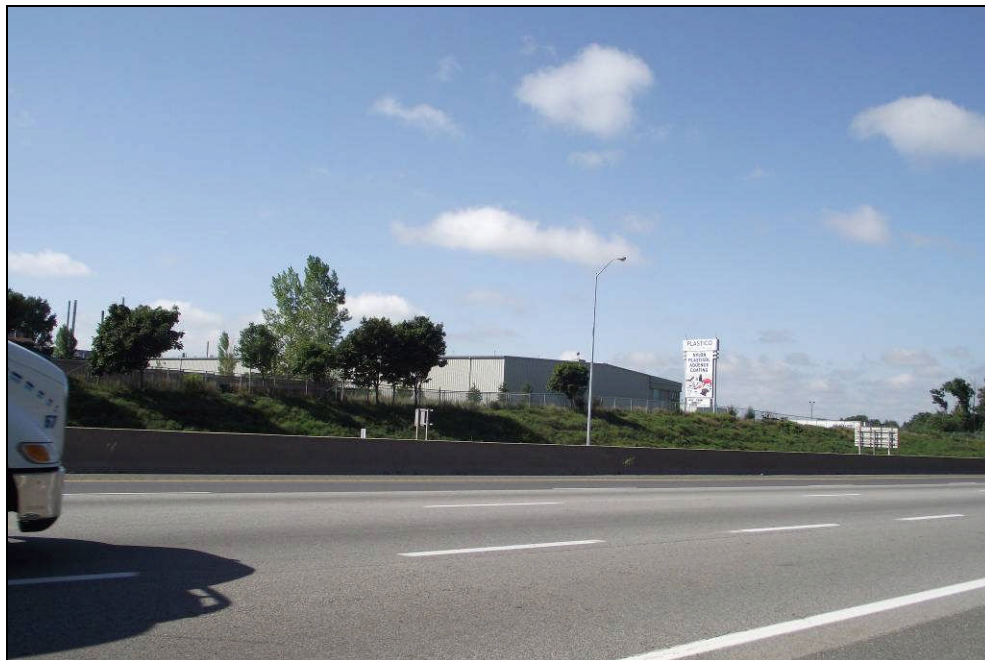
PHOTOGRAPH 1-9: Residential house at the NW corner of Waterloo Regional Road 24 Bridge. (August 28, 2012)



PHOTOGRAPH 1-10: South side ditch of Hwy 401 at Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-11: Waterloo Regional Road 36 Bridge and Hwy 401 WBL.
(August 28, 2012)



PHOTOGRAPH 1-12: Industrial building at the SW corner of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-13: Side slope at the south abutment of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-14: Continuous deck slab and Girders of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-15: Residential and commercial buildings at the NE corner of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-16: Flat terrain at the SE corner of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-17: Side slope and front slope at the south abutment of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-18: Front slope at the south abutment of Waterloo Regional Road 36 Bridge. (August 28, 2012)



PHOTOGRAPH 1-19: Side slope of approach embankment at the south abutment of Waterloo Regional Road 36 Bridge. (August 28, 2012)



APPENDIX B

Previous Soil Data, Records of Boreholes and Contract Drawings

- (1) Foundation Investigation Report for Waterloo Regional Road 24 Underpass
NBL (WP 239-87-01, Site 33-150, Geocres 40P8-94)
- (2) Foundation Investigation Report for Waterloo Regional Road 24 Underpass
(Geocres 58-F-296C)
- (3) Foundation Investigation and Design Report for Waterloo Regional Road 36
Underpass (WP 7-83-09, Site 33-151, Geocres 40P8-104)

(1) Foundation Investigation Report for Waterloo Regional Road #24 Underpass NBL
(WP 239-87-01, Site 33-150)

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 239-87-01

DIST 3

HWY 401

STR SITE 33-150

Hwy. #24N Underpass (N.B.L.)

CONT 89-20

DISTRIBUTION

A. Ho (2) ✓
C.M. Bond
R.E. Thompson
D.A. Waller (2)
K. Bassi (2)
J.H. Peer
T. Yakutchuk
G. Szekreny
A. Crowly (Cover Only)
M. MacLean (Cover Only)
File

FOUNDATION INVESTIGATION REPORT

For

Hwy. #24N Underpass (N.B.L.)
Hwy. #401; City of Cambridge
W.P. 239-87-01; Site 33-150
District #3, Stratford

INTRODUCTION

This report contains the information obtained from a Foundation Investigation carried out at the above-mentioned site, together with recommendations for design and construction of a new bridge and approaches.

The fieldwork for this project was carried out during the period from 87 09 08 to 87 09 23 utilizing a Bombardier Mounted Type III Augering Machine equipped with hollow or solid stem augers and BX size casing.

The investigation consisted of 5 sampled boreholes accompanied with Dynamic Cone Penetration Tests.

SITE DESCRIPTION

The site is located in the City of Cambridge where Hwy. #24 crosses Hwy. #401 by means of an underpass structure.

The topography of the site with the exception of the existing interchange complex (cuts and fills) is relatively flat and landscaped terrain. Physiographically, the area is located in the Region known as the 'Guelph Drumlin Field' and consists of granular type materials.

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site is predominantly gravel and sand containing small amounts of fines. For classification purposes it can be divided into two different zones:

- a) Sand, Trace/Some Gravel and
Trace/Some Silt
- b) Sand and Gravel
Trace/Some Silt

The drilling procedure was extremely difficult and required augering with solid and hollow stem augers and/or driving or drilling BX size casings combined with rotary washboring techniques. The boundaries of the deposits at the boring locations together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. A stratigraphical profile is shown on Drawing No. 2398701-A. This drawing also shows the locations and elevations of the borings. A description of the different strata encountered is given below.

Sand

This stratum was encountered in all boreholes immediately below ground level for a maximum thickness of 8.2 m (B.H. #2). The material consists mainly of sand. Trace/Some Gravel and Trace/Some Silt was also observed to be present in all of the samples obtained on the field. The results of the grain-size distribution tests are shown on Figure #1 in an envelope form. The natural moisture content ranges from 2 to 8%. The standard penetration tests 'N' values (12 to over 100 blow per 30 cm) indicate that the denseness ranges from compact to very dense.

Sand and Gravel

Below the sand stratum a sand and gravel deposit containing traces of silt was intersected for a minimum thickness of 1.9 m in the borings. The lower boundary was not determined since the borings were terminated within this zone between El. 286.4 and El. 290.2. The grain-size distribution test results are plotted in an envelope form on Figure No. 2 of the Appendix. The natural moisture content ranges from 1 to 12%. The denseness may be described as dense to very dense.

Groundwater Conditions

No groundwater was observed in the borings within the depth of penetration. Even the water which was pumped into the borings has disappeared in a short period of time indicating a groundwater level below El. 286.4.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to construct a new, four span underpass structure (11379-21031-21031-11379) at this location to carry the future north-bound lanes of Hwy. #24 over Hwy. #401. The existing bridge, built some 28 years ago will serve as the south-bound structure. The proposed profile grade is set at El. 301.4± some 6.8 m over the \mathcal{C} (median) of Hwy. #401.

Structure Foundations

In view of the encountered subsurface conditions it is recommended that the new structure be supported on spread footing type foundations (piers and abutments) placed at levels not deeper than the existing structure footings. A safe design load of 385 kPa (4TSF) is recommended for the abutments and 285 kPa (3TSF) for the piers. The footing levels and design values in the terms of the O.H.B.D.C. are as follows:

<u>Footing</u>	<u>Level</u>	<u>U.L.S.</u> (kPa)	<u>S.L.S. Type II</u> (kPa)
North Abut.	El. 297.0	1500	385
North Pier	El. 292.7	1300	285
Centre Pier	El. 292.2	1300	285
South Pier	El. 292.5	1300	285
South Abut.	El. 296.1	1500	385

Earth Pressures should be computed as per Subsection 6.6.1.2.2 of the code. A yielding foundation condition may be assumed. The Granular 'A' or 'B' backfill should be in accordance with Special Provision No. 121 (dated October, 1983). The following parameters are recommended for the granular type backfill:

	<u>Gran. 'A'</u>	<u>Gran. 'B'</u>
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight (kN/m ³)	$\gamma = 22.8$	$\phi = 21.2$

The coefficient of friction value may be taken as 0.50.

Approach Embankments

Since Highway #401 is located in an approximate 3 m deep cut, the required fill height is only about 3.8 m. No stability problems are anticipated for the approach embankments constructed with 2:1 forward and side slopes. The fill material should consist of well compacted acceptable material.

Other Considerations

The frost protection requirement in this area is a minimum of 1.2 m of earth cover. The concrete for the footings should be placed in the dry. No dewatering problems are anticipated.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. I. Robertson and Mr. D. Morch, Co-op Students. The equipment used was owned and operated by Dominion Soil Investigation Inc. This report was prepared by Mr. P. Payer and reviewed by Mr. K.G. Selby.



P. Payer
P. Payer, P. Eng.
Sr. Foundation Engineer

K.G. Selby
K.G. Selby, P. Eng.
Chief Foundation Engineer
(West)

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

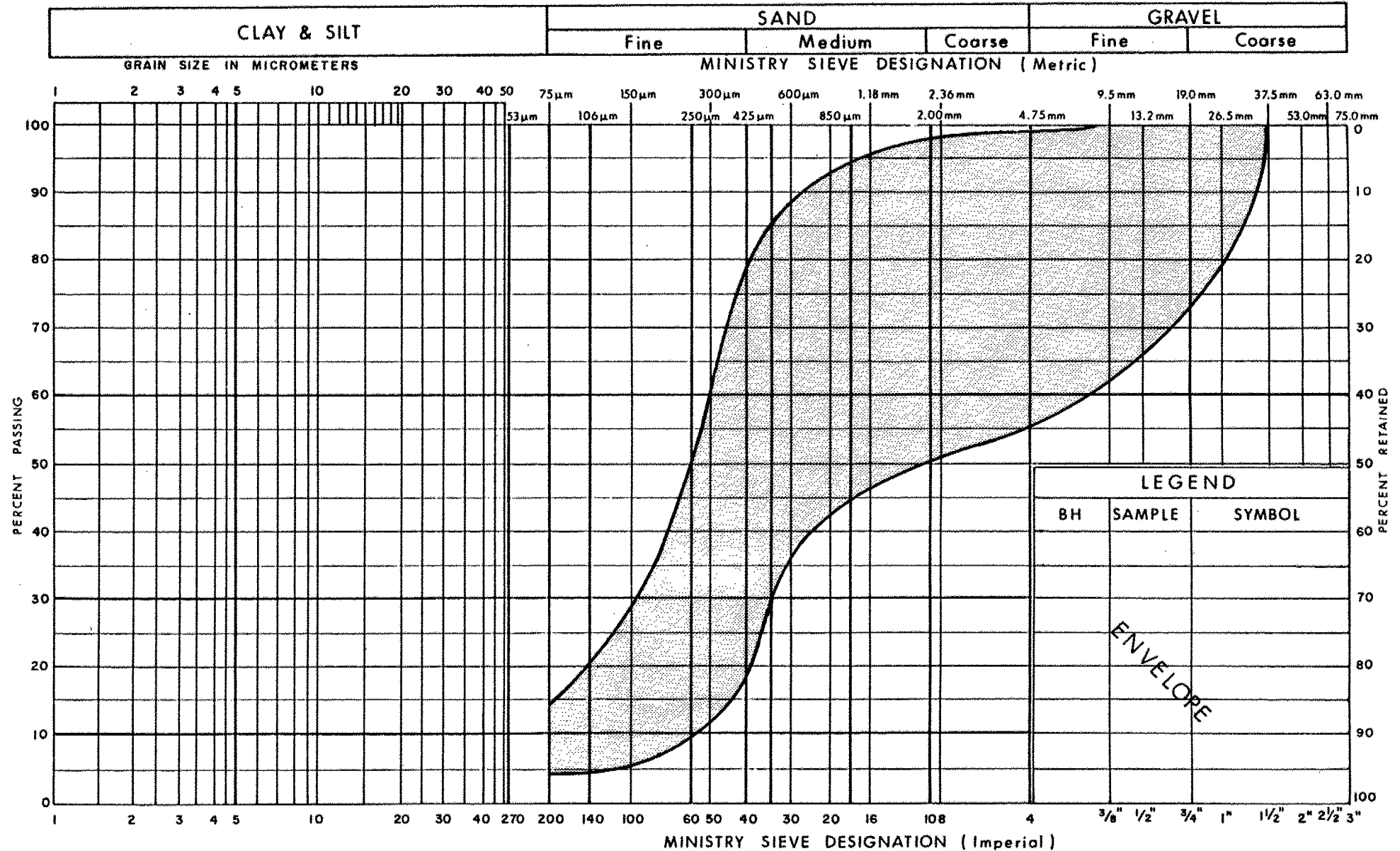
MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

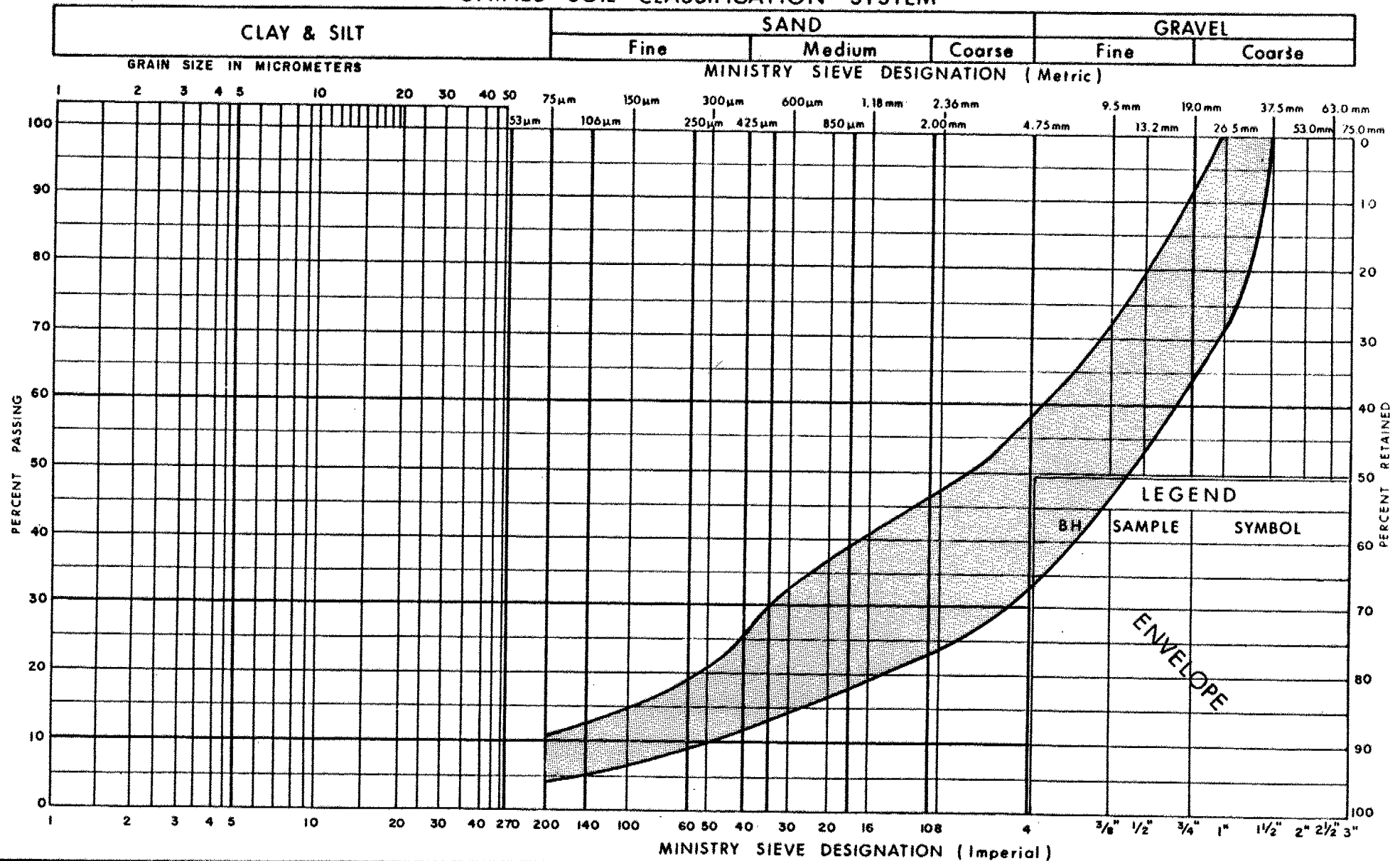
GRAIN SIZE DISTRIBUTION

SAND TRACE / SOME SILT, TRACE SOME GRAVEL

FIG No 1

W P 239-87-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION

SAND & GRAVEL TRACE OF SILT

FIG No 2

W P 239-87-01



RECORD OF BOREHOLE No 1

METRIC

W P 239-87-01 LOCATION STA: 10 + 025.2; O/S 17m LT (Q New Hwy #24) ORIGINATED BY IR
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 08 to 87 08 11 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
294.6	Ground Level																GR SA SI CL
0.0	Sand		1	SS	14	*	294										9 86 (5)
	Trace of Silt		2	SS	12		292										5 90 (5)
	Trace of Gravel		3	SS	23												
290.5	Compact		4	SS	23												4 87 (7)
4.1			5	SS	153/	23cm											
	Sand and Gravel		6	SS	82/	5cm	290										
	Trace of Silt		8	SS	51/	2cm											53 37 (10)
			9	SS	50/	5cm											
			10	SS	120/	10cm	288										42 54 (4)
286.9	Very Dense		12	SS	90/	29cm											
7.7	END OF BOREHOLE																
	*Note: Groundwater was not observed.																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 239-87-01 LOCATION STA: 10 + 036.6; O/S 7.9m LT(C New Hwy #24) ORIGINATED BY DM
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 11 to 87 09 15 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
298.4	Ground Level										
0.0											
	Sand		1	SS	--		298				
	Trace/some Silt		3	SS	42						
			4	SS	68		296		120	23cm	35 51 (14)
	Some Gravel		5	SS	112						
			6	SS	134/	18cm					44 49 (7)
			7	SS	47		294				
	Compact		8	SS	38						
	to		9	SS	29		292				9 86 (5)
	Very dense		10	SS	41						1 94 (5)
290.2			11	SS	32/	28cm					1 91 (8)
8.2	Sand & Gravel		12	SS	91	8cm	290				
	Trace of Silt		13	SS	86	14cm					
203.3	Very Dense										
10.1	Refusal END OF BOREHOLE										
	*Note: Groundwater was not observed.										



RECORD OF BOREHOLE No 3

METRIC

W P 239-87-01 LOCATION STA: 9 + 965; O/S 9.3m LT (Q New Hwy #24) ORIGINATED BY IR
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (S.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 15 to 87 09 17 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
297.2	Ground Level												
0.0	Sand		1	SS	13	*	296						28 57 (15)
	Traces/some Silt		2	SS	24								
	Some Gravel		3	SS	85								
	Compact to		4	SS	99		294						33 56 (11)
292.9	Very Dense		5	SS	90								
4.3	Sand & Gravel		8	SS	34		292						65 28 (6)
	Trace of Silt		10	SS	112								49 44 (7)
	Dense to		11	SS	30								
290.2	Very Dense		12	SS	103								
7.0	END OF BOREHOLE												
	*Note: Groundwater was not observed.												

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 4

METRIC

W P 239-87-01 LOCATION STA: 9 + 975; O/S 2m LT (C New Hwy.#24) ORIGINATED BY DM
DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
DATUM Geodetic DATE 87 09 17 to 87 09 21 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
295.2	Ground Level										
0.0	Sand		1	SS	24		294				
	Trace of Silt		2	SS	17						
	Some Gravel		3	SS	39						
292.2	Compact to Dense		4	SS	95	15cm	292				
3.0	Sand & Gravel		5	SS	120	6cm					
	Trace of Silt		6	SS	52	8cm					
289.0	Very Dense		7	SS	120	28cm	290				
6.2	END OF BOREHOLE		8	SS	43	3cm					
	* Note: Groundwater was not observed.										

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 5

METRIC

W P 239-87-01 LOCATION STA: 9 + 998.8; O/S 7.1 m LT (C New Hwy #24) ORIGINATED BY IR
 DIST 3 HWY 401 BOREHOLE TYPE Cont. Flight Auger (H.S.) & Bx Casing COMPILED BY PP
 DATUM Geodetic DATE 87 09 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
294.5	Ground Level																GR SA SI CL
0.0	Sand					*	294										32 54 (14)
	Trace/some Silt		1	SS	66								○				
	Trace/some Gravel		2	SS	29								○				9 85 (6)
	Compact		3	SS	26		292						○				
	to		4	SS	14								○				
290.1	Very Dense		5	SS	84								○				34 58 (8)
4.4	Sand & Gravel		6	SS	65	10cm	290										
	Trace of Silt		7	SS	55	8cm							○				53 40 (7)
			8	SS	114		288						○				
	Very Dense		9	SS	67								○				52 36 (12)
286.4			10	SS	82								○				
8.1	END OF BOREHOLE																
	*Note: Groundwater was not observed.																

+3, x5: Numbers refer to
Sensitivity

20
15
10
5
0
5 (%) STRAIN AT FAILURE

METRIC

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

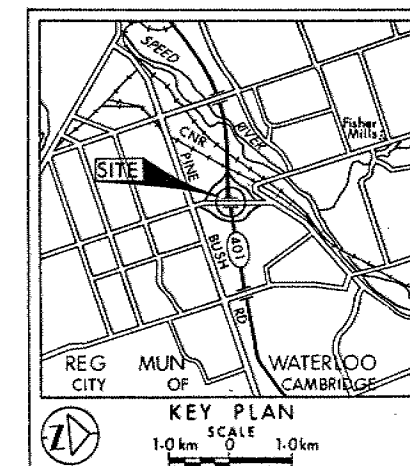
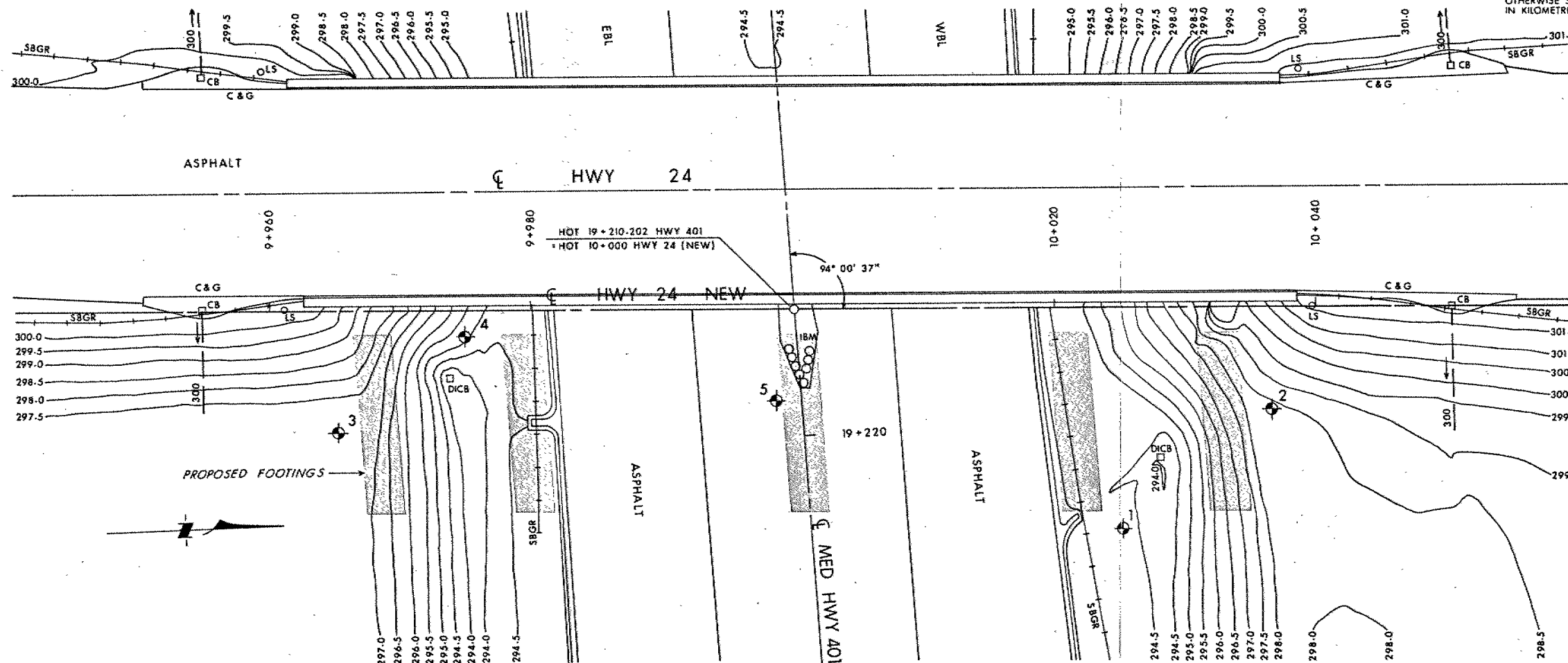
CONT No
WP No 239-87-01



HWY 24 NEW U'PASS (NBL)

SHEET

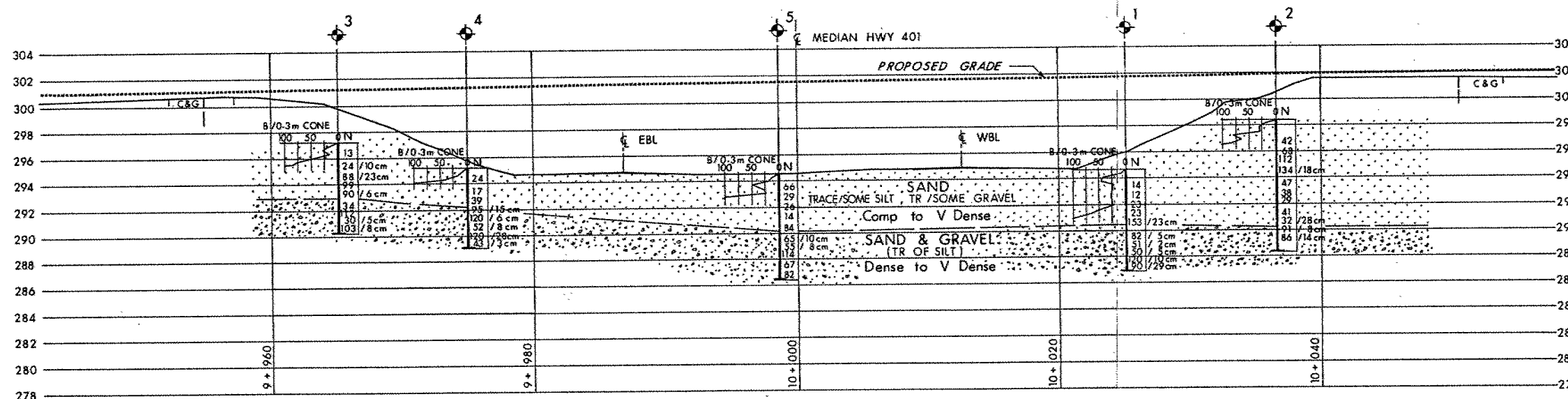
BORE HOLE LOCATIONS & SOIL STRATA



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & 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
- W L not observed in bore holes 1 to 5

No	ELEVATION	STATION	OFFSET
1	294.6	10+025.2	17.0m Lt
2	298.4	10+036.6	7.9m Lt
3	297.2	9+965.0	9.3m Lt
4	295.2	9+975.0	2.0m Lt
5	294.5	9+998.8	7.1m Lt



PROFILE HWY 24 NEW

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 40PB-94

HWY No 401	DIST 3
SUBMD PP CHECKED	DATE 8710 02
DRAWN DT CHECKED	APPROVED
	OWG 2398701-A

(2) Foundation Investigation Report for Waterloo Regional Road #24 Underpass

58-F-296C

Hwy. # 24

Hwy. 401 OVERPASS

BH799

TROW, SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS
AND
SOIL MECHANICS CONSULTATION

W. A. TROW, M.A.S.C., M.E.I.C., P.ENG.
L. G. SODERMAN, B.S.C., D.I.C., P.ENG.

884 WILSON AVE.,
DOWNSVIEW, ONT.
ST. 8-5921

Project: C108/J263

Sept. 17, 1958.

Mr. A. M. Toye,
Bridge Engineer,
Dept. of Highways of Ontario,
280 Davenport Road,
Toronto, Ont.

Attention: Mr. J. McAllister

58-F-296C

Foundation Investigation
Hwy. #24 Overpass of Highway #401
West of Hespeler, Ontario

Dear Sirs:

Enclosed herewith is our report on the soil conditions underlying the proposed intersection of Hwy. 24 and Hwy. 401.

No foundation problem exists at this location and abutments can be founded at or below a depth of 3 feet from present ground surface. A safe bearing stress of 4 tons per square foot is quite permissible. The ground water table is 23 feet below the surface, in dense gravel.

We hope that the contents of this report assist you in the design of this structure. Please do not hesitate to call if clarification of any matter is required.

Yours very truly,

WATrow

WAT/lt
Encls.

William A. Trow (P. Eng.)

DEPARTMENT OF HIGHWAYS OF ONTARIO
280 DAVENPORT ROAD,
TORONTO, ONTARIO.

FOUNDATION INVESTIGATION
HWY. #24 OVERPASS OF HIGHWAY #401
WEST OF HESPELER, ONTARIO

C108/J263

Trow Soderman & Associates

Sept.17 1958

TABLE OF CONTENTS

Description of Site	P. 1
Field Investigation Methods	1
Description of Soil Types	2
Foundation Considerations and Conclusions	2

ENCLOSURES

Borehole Location Plan	Dwg. 1
Borehole Profiles	2 - 5

FOUNDATION INVESTIGATION
HWY. #24 OVERPASS HWY. #401
WEST OF HESPELER, ONTARIO

This report contains the results of an investigation consisting of 4 borings performed recently at the above noted highway crossing. Comments concerning foundation requirements have been given.

Description of Site

The above-noted intersection of Highways 24 and 401 lies in a gently sloping field approximately one mile south-west of Hespeler, Ont. About 1000 feet to the west, along Hwy. 401 centre line, is the excavated face of a gravel pit operated by the Preston Sand and Gravel Co. Examination of the pit face shows dense deposits of rounded gravel up to 6 inches in size with some thin layers of sand. The gravel particles are essentially in contact and the sand matrix which fills the pore spaces is less predominant. The present approximately 25 feet depth of the pit has been determined by the ground water table. Workmen advise that future plans call for the depression of this ground water to permit the removal of gravel at greater depths. Another gravel pit lies about one-half mile to the south along a side road to Preston, Ont.

Swampy ground comprising the valley of the Speed River begins some 1000 feet to the north of the Preston Sand and Gravel Pit. The bed of this river contains large gravel.

Field Investigation Methods

The investigation at this site was performed in its entirety using continuous flight auger equipment. Because of the permeable gravelly nature of the subsoil, it was feared that the use of conventional boring methods would be very slow and would provide no more information than was obtainable by augering. In addition, the inspection of the adjacent gravel pit to the west left little doubt concerning the foundation materials to be encountered.

Because the uncased borings tended to cave in this coarse gravel, the performance of standard penetration tests and disturbed sampling was generally restricted to a depth of 15 to 20 feet. However, the difficulty in augering to greater depths definitely confirmed that similar dense material extended below these limits. Three of the four borings were limited to a depth of 20 to 25 feet at which level stresses from surface abutment footings would be quite dissipated.

In order to confirm the gravel to greater depths and hence to ensure that embankment stability and deep seated settlement would be of no concern, efforts were made to auger deeper in hole No. 3. Unfortunately however, refusal to the augers was met in boulders at 31 feet. Since a cone penetration test was impossible in this gravel,

attempts were made to drive a 1-5/8 inch A rod to greater depths. This was accomplished with extreme difficulty to a depth of 42 feet at which level the boring was terminated. Forty-two feet of dense gravel cover appeared sufficient to carry the bridge crossing and approach abutments safely.

Observations of the augers and drill rods indicated that the water table in this boring lay at a depth of 23 feet or at elevation 952 feet. This level coincided approximately with the ground water in the adjacent gravel pit.

As in the other investigations in this area all boreholes were backfilled at the completion of work.

Description of Soil Types

The soil underlying this site can be described very briefly. The predominant soil type is a very dense mixture of gravel and sand which extends from a depth of 3 feet to at least 42 feet below ground surface. Above this material is a thin veneer of fine brown sand overlain by about one foot of sandy topsoil.

Foundation Consideration and Conclusions

Because of the uniformity and extreme density of the gravel deposit at this site, a discussion of foundation conditions can be very brief.

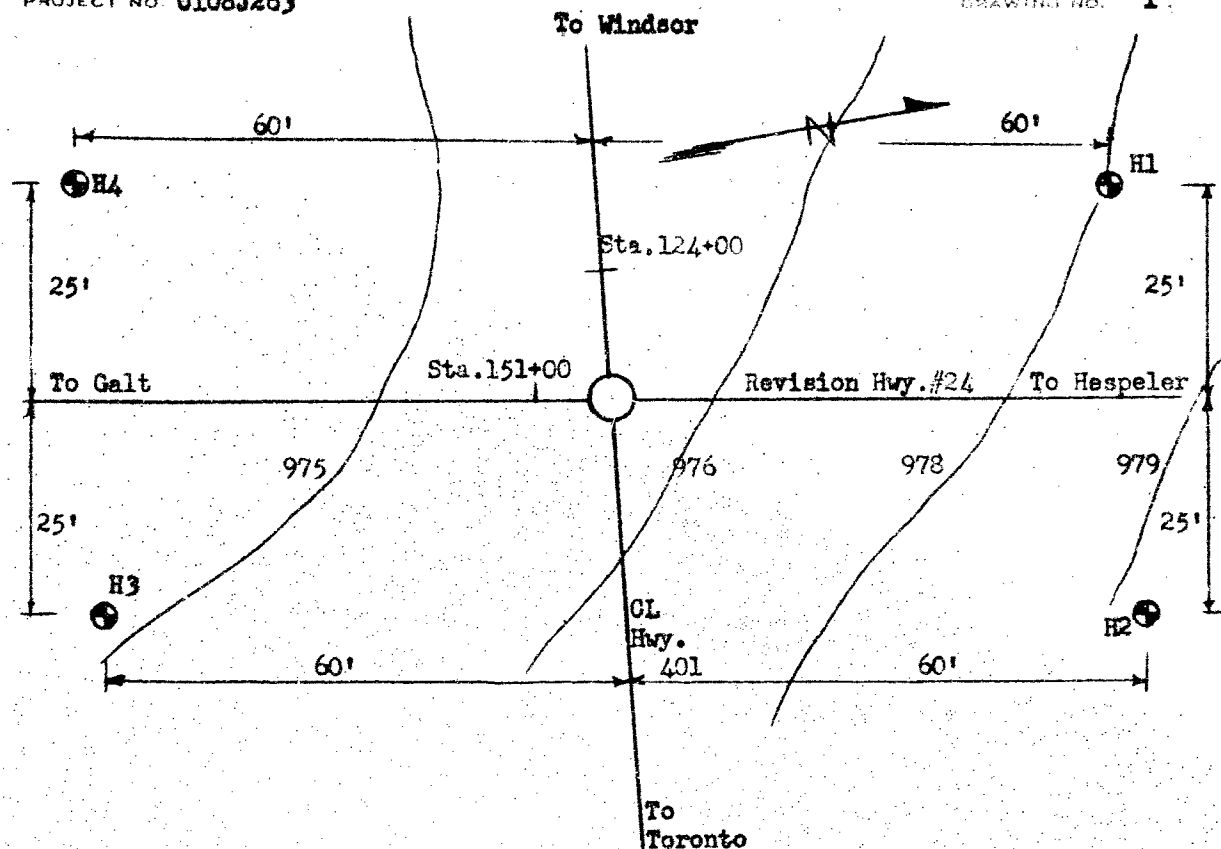
It is apparent that abutment footings can be carried at any level below 3 feet from the present ground surface. The safe bearing value in the gravel and sand below this shallow depth is at least equal to 4 tons per square foot. The coefficient of friction between the gravel and the abutment footing bases is at least equal to 0.8 and hence the force helping to resist the abutment fill thrust is almost equal to the abutment reactions.

No stability problem exists for the 25 foot embankments at this site and sufficient gravel is available for use as embankment fill. The existence of gravel and the dense soil below a depth of 42 feet is extremely likely. However, even if soft clay were to underlie this level, any resulting settlement would be widespread and should not induce differential movement in the bridge structure.

WAT/lt
Sept. 17, 1958
C108/J263

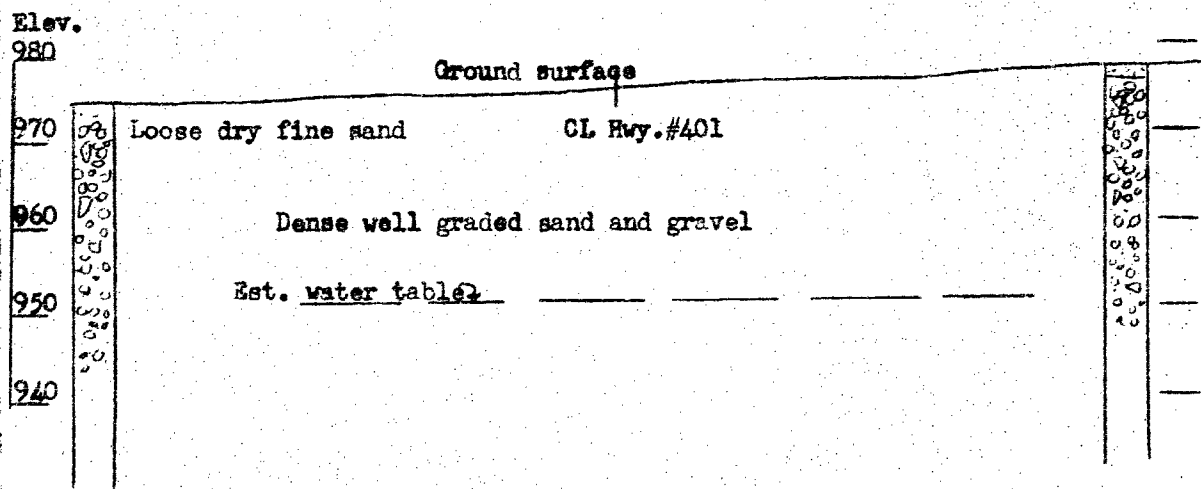


W. Trow
William A. Trow (P. Eng.)



SKETCH OF PROPOSED OVERPASS CROSSING SHOWING BORING LOCATIONS

Overlay of DHO Dwg. E 2958-1 Scale 1" = 20'

PROFILE ALONG CENTRE LINE OF HWY. 24 REVISION SHOWING
SUBSOIL STRATIGRAPHY

PROJECT NO C108J263

DRAWING NO. 2

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Hwy. #24 Overpass of Hwy. 401

BOREHOLE NO. 1

LOCATION Waterloo Township - 1 mi. west of Hespeler

FIELD SUPERVISOR

WAT

HOLE LOCATION See Dwg. 1

DRILLER

PV

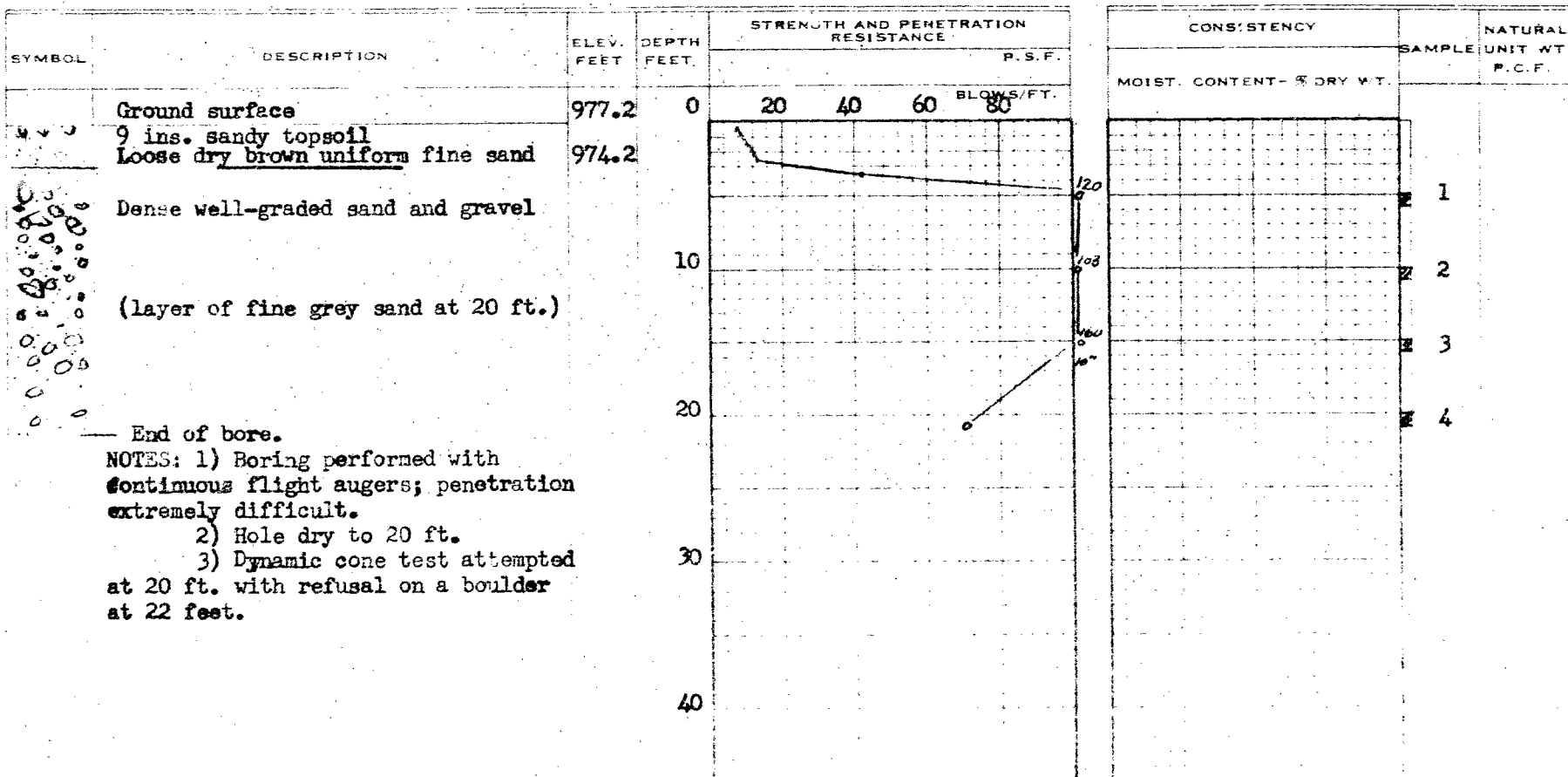
HOLE ELEVATION AND DATUM 977.2

PREP.

WT

LEGEND

2" DIA. SPLIT TUBE
 2" SHELBY TUBE
 2" SPLIT TUBE
 2" DIA. CONE
 CASING
 2" SHELBY
 1/2 UNCONFINED COMPRESSION (QU)
 VANE TEST (C) AND SENSITIVITY (S)
 NATURAL MOISTURE AND
 LIQUIDITY INDEX
 LIQUID LIMIT
 PLASTIC LIMIT



PROJECT NO. C108J263

DRAWING NO. 3

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Hwy. #24 Overpass of Hwy. 401

LOCATION Waterloo Township-1 mi. west of Hespeler

HOLE LOCATION See Dwg.1

HOLE ELEVATION AND DATUM 978.1

BOREHOLE NO. 2

FIELD SUPERVISOR

DRILLER

PREP.

WI

PV

WT

LEGEND

- 2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
CASING
2" SHELBY
1/2 UNCONFINED COMPRESSION (QU)
VANE TEST (C) AND SENSITIVITY (S)
NATURAL MOISTURE AND
LIQUIDITY INDEX.
LIQUID LIMIT
PLASTIC LIMIT

[illegible][illegible]

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Hwy. #24 Overpass of Hwy. 401

LOCATION Waterloo Township-1 mi. west of Hespeler

HOLE LOCATION See Dwg.1

HOLE ELEVATION AND DATE 974.9

BOREHOLE NO. 3

FIELD SUPERVISOR

DRILLER

PREP.

W

पु

WT

L F , E N D

2 DIA. SPLIT TUBE

2. SHELBY TUBE

SPLIT TUBE

2¹¹ DIA. CONE

CASING

2" SHELBY

1/2 UNCONFINED COMPRESSION $1Q_u$

VANE TEST (C) AND SENSITIVITY (S)

NATURAL MOISTURE AND

LIQUIDITY INDEX

LIQUID LIMIT

PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE		CONSISTENCY		SAMPLE	NATURAL UNIT WT. P.G.F.
				P.S.F.		MOIST. CONTENT- % DRY WT.			
	Ground surface	974.9	0	BLOWS/FT.					
	Approx. 9 ins. sandy topsoil and then fine brown sand								
	Dense well-graded mixture of sand and gravel. (thin layers of sand between 5 and 10 feet depth)								
	Auger ahead through gravel to refusal on boulder at 31 feet.								
		W.T. 952							
NOTES: 1) Boring performed using continuous flight auger equipment, Penetration extremely difficult. 2) Drove a 1-5/8 inch OD A rod from 31 ft. to 42 ft. with great difficulty, required 2 men with wrenches to supplement the normal 350 ft.lb. of energy per blow. Gravel extends at least to 42 feet or El.933 ft.									

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT Hwy. #24 Overpass of Hwy. 401
 LOCATION Waterloo Township - 1 mi. west Hespeler
 HOLE LOCATION See Dwg. 1
 HOLE ELEVATION AND DATUM 974.5

BOREHOLE NO. 4
 FIELD SUPERVISOR WT
 DRILLER PV
 PREP. WT

LEGEND

2" DIA. SPLIT TUBE
 2" SHELBY TUBE
 2" SPLIT TUBE
 2" DIA. CONE
 CASING
 2" SHELBY
 1.2 UNCONFINED COMPRESSION (QU)
 VANE TEST (C) AND SENSITIVITY (S)
 NATURAL MOISTURE AND
 LIQUIDITY INDEX
 LIQUID LIMIT
 PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE			
				P.S.F.			
	Ground surface	974.5	0	20	40	60	80
	Approx. 1 ft. topsoil then dry fine sand to 3 feet.						
	Dense well-graded mixture of sand and gravel.		10				
	(Augered to refusal in a boulder at 22 ft.)		20				
	NOTES: 1) Boring performed with continuous flight augers, penetration difficult at all depths. 2) Sampling not possible below 15 ft. 3) Boring dry to 22 ft.						

CONSISTENCY		SAMPLE	NATURAL
MOIST. CONTENT - % DRY WT.			UNIT WT
			P.C.F.
		1	
		2	
		3	

(3) Foundation Investigation and Design Report for Waterloo Regional Road #36 Underpass
(WP 7-83-09, Site 33-151)



Ministry of
Transportation and
Communications

FILE COPY

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

R

CONT 91-12
ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 7-83-09 DIST 3

HWY 401 STR SITE 33-151

Regional Road #36 Proposed Crossing
Hwy. #401, City of Cambridge

DISTRIBUTION

A. Ho (2)
C.M. Bond
A.E. Irving
D.A. Waller (2)
K.G. Bassi
S.J. Dunham
G. Szekreny
D. Fusee (Cover Only)
M. MacLean (Cover Only)
File ✓

FOUNDATION INVESTIGATION REPORT
For
Regional Road #36 Proposed Crossing
Hwy. #401, City of Cambridge
W.P. 7-83-09, Site 33-151
District #3, Stratford

INTRODUCTION

This report contains the results of a site investigation carried out at the above mentioned site to provide information for the design and construction of the bridge, retaining wall and approaches.

The field work for this project was carried out between 89 10 02 and 89 10 26, and comprised of ten sampled boreholes accompanied with Dynamic Cone Penetration Tests and coring of rock.

The boreholes were advanced to a maximum depth of 39.2 m below the existing ground level (El. 286.6) using continuous flight hollow stem auger and BX size diamond bit.

SITE DESCRIPTION

The proposed site is located at the crossing of Hwy. 401 and Regional Road #36 in the City of Cambridge.

The topography of the site with the exception of the existing interchange (fills) is relatively flat and landscaped terrain. Physiographically the area is located in the region known as the "Guelph Drumlin Field" and consist of granular type materials.

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site consists of granular (Granular 'A' or Granular 'B') fill underlain by natural soil predominantly composed of sand and silt, with virtually no gravel content. Despite the geological history of this area, glacial till was not encountered, except near terminal depth

in boreholes 8, 9 & 10. The natural soil is underlain by dolostone bedrock of the Guelph formation. For classification purposes, the soils encountered at this site can be divided into two different zones:

- a) Sand some silt and Gravel (Granular Fill)
- b) Layered Sand and Silt

The soils encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Boreholes sheets contained in the Appendix of this report. Three stratigraphical profiles are shown on Drawing No. 78309-A. This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

Granular Fill

This fill which was placed to raise the finished grade of Hwy. 401 and the Regional Road #36 was encountered in all the boreholes, immediately below the existing ground level. The gradation tests carried out on representative samples are shown on Figure #1 in an envelope form. The gradation analyses indicate that this fill is predominantly composed of sand with varying proportions of silt and gravel sized particles. The natural moisture content of this fill varies from 3% to 16% with an average value of 9%. The Standard Penetration Test results indicate that this granular fill is in very loose to compact state of compaction (N-values 2 to 31 blows/30 cm). The thickness of this fill varies from 2.7 m to 8.5 m and extends to elevation 317.0±. In majority of the boreholes, a 0.3 m to 0.9 m thick organic silty layer was observed to separate the fill and the natural soil.

Layered Sand and Silt

The organic silty layer is underlain by this deposit. The gradation tests carried out on representative soil samples are shown on Figure #2 in an envelope form. The gradation analyses indicate that this deposit is

predominantly composed of sand and silt, with virtually no gravel content. The natural moisture content of this deposit varies over a wide range (3% to 32%) depending on the sand and silt contents. The Standard Penetration Test results indicate that this stratum is in compact to very dense state of compaction (N-values 11 blows/30 cm to 84 blows/30 cm). In boreholes 2, 6 & 8, occasional boulders and cobbles were encountered near terminal depth (El. 292.0± to 299.0±).

Bedrock

Boreholes 8, 9 & 10 were taken into the bedrock and rock cores were obtained using BX-size diamond bits. The rock cores were examined by Mr. S.A. Senior, Geological Engineer and his description is included in the Appendix of this report.

The project area is underlain by dolostone bedrock of the Guelph Formation. The presence of boulders and cobbles immediately above the bedrock made the identification of weathered rock very difficult. However, in borehole 8, the thickness of weathered rock was observed to be about 1.83 m. The elevation of the unweathered rock is as follows:

<u>Borehole No.</u>	<u>Elevation</u>
8	289.8
9	289.1
10	290.7

The RQD values measured from BX size cores (0% to 7%) indicate that the bedrock up to the depth of drilling may be classified as very poor quality rock. However, in borehole 8, the rock quality was observed to improve (RQD = 68%) near terminal depth (El. 288.1).

Ground Water Conditions

The ground water level was encountered in all the boreholes with the exception of borehole 7, and was observed between 12.5 m and 19.6 m (El.

306.0± to 307.0±) below the existing ground level. The ground water elevation at each borehole location is as follows:

<u>Borehole No.</u>	<u>Elevation Metre</u>
1	307.2
2	307.0
3	305.6
4	306.0
5	306.3
6	306.5
8	307.2
9	305.9
10	306.3

The groundwater elevations indicated above are based on the observations made during drilling operations and the stabilized water level could not be established in a short period of time. In our opinion, the water table may be expected to rise above the elevations indicated.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to widen the existing bridge along the Regional Road #36 at the Hwy. 401 crossing to provide exit from Hwy. 401 as well as entry facility to Hwy. 401. These facilities will require construction of a retaining wall in front of the north abutment, and piers and abutments for the bridge widening.

The piers and abutments of the existing bridge are supported on approximately 7.6 m long HP 310 x 79 driven piles founded at about elevation 309.0±.

Structure Foundation

Considering the type of soils encountered at this site, shallow foundation may not be feasible. In addition, if displacement type driven piles such as closed end pipe are used, the vibrations created by the pile driving may cause some disturbance to the existing foundation. However, low displacement piles such as steel H-piles may be used to support the piers and abutments. If steel H-piles are selected, it should be driven at least 3 times the flange width away from the existing piles. The following bearing capacity values are recommended for the steel H-piles.

	<u>Pile Tip Elevation</u>	
	<u>309 m</u>	<u>305 m</u>
Factored Capacity at U.L.S.	230 kns.	510 kns.
Capacity at S.L.S. Type II	200 kns.	300 kns.

Alternatively, the proposed structures may (piers and abutments) be supported on caissons founded at about elevation 309.0±. The following bearing capacity values are recommended for the design of the caissons.

<u>Centre Pier</u>	<u>Pile Diameter in Metre</u>	
	0.76	1.00
Factored Capacity at U.L.S.	1160 kN	2000 kN
Capacity at S.L.S. Type II	700 kN	1200 kN

<u>North and South Piers and Abutments</u>	<u>Pile Diameter in Metre</u>	
	0.76	1.00
Factored Capacity at U.L.S.	1520 kN	2640 kN
Capacity at S.L.S. Type II	900 kN	1550 kN

If caisson size in between 0.76 m and 1.0 m is selected, the bearing capacity values may be interpolated from the above recommendations.

If caissons are constructed below ground water level, loosening of the founding soil could be anticipated. The soil is highly susceptible to conditions of unbalanced hydrostatic head and seepage forces and is likely to 'boil' and become unstable under such conditions. The Contractor shall maintain the stability of the soil in the sides and bases of the holes for the caissons at all times from commencement of their construction to the placing of concrete.

Some differential settlement is expected to take place between the new and the existing structures. In view of this, it is advisable to provide either a 'slip' or 'isolation' joint between the existing and the new structures.

If caissons are selected to support the piers and abutments, the construction of pile-cap may be eliminated by taking the caissons to the underside of the bridge deck.

Retaining Wall

Considering the removal and backfilling of large volume of fill material and construction difficulties, tangent piles (drilled-in-place concrete piles) with anchors may be used instead of concrete retaining wall. We

understand that there are machineries available in the construction industry to construct large diameter drilled-in-place concrete piles under limited head-room facility. With this in view, the option of tangent pile wall with soil anchors is recommended.

The presence of granular fill and the silty sandy soil encountered at this site will require liner for the construction of tangent pile wall. Considering the limited space the liner will have to be lowered in short lengths.

The soil anchors may be constructed using hollow-stem auger or cased hole and grout injected under pressure while the hollow-stem auger or casing is withdrawn.

If the cement grout is injected under pressure, a maximum bond stress value of 75 kPa is recommended for the design of the soil anchors.

For aesthetic purposes, the wall may be covered with concrete pannels.

Alternatively, the retaining wall may be constructed using the following construction sequence.

- 1) Close Regional Road #36 for traffic during construction.
- 2) Remove embankment fill on both side of the north abutment simultaneously to elevation 317±, and on the south side of the south abutment to about elevation 324±.
- 3) After excavation, wire brush clean the exposed piling of all dirt and loose scale, inspect for damage and apply sufficient coat of coal tar paint to avoid transfer of any down-drag load during compaction of backfill.
- 4) Construct caissons using drilled-in-place concreting.

5) Construct pile cap and retaining wall.

6) Compact the backfill on both side of the abutment simultaneously.

Earth pressure should be computed as per 6.1.2.2 of the code. In the case of retaining wall and abutments, an unyielding foundation condition may be assumed for the earth pressure computations. The Granular 'A' or 'B' backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	<u>Granular 'A'</u>	<u>Granular 'B'</u>
Angle of Internal Friction	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

Approach Embankment

A maximum fill height of about 7 m may be expected at this crossing. The subsoil conditions at this site is not expected to create any stability problems for the approach embankments constructed with 2 horizontal to 1 vertical slopes. The fill material should consist of well compacted acceptable material. The topsoil as well as any spongy or soft areas observed within the base width of the embankment, should be removed before placing the fill.

Other Considerations

The pile caps should have a minimum of 1.2 m earth cover for frost protection. Ground water problems are not anticipated within the proposed founding level of the caisson.

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. M. Hopper. The equipment used was owned and operated by Marathon

Drilling Company Limited. This report was prepared by Mr. M. Vasavithasan and reviewed by Mr. P. Payer, Senior Foundation Engineer.



M. Vasavithasan, P.Eng.
Foundation Engineer

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N}

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O D 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

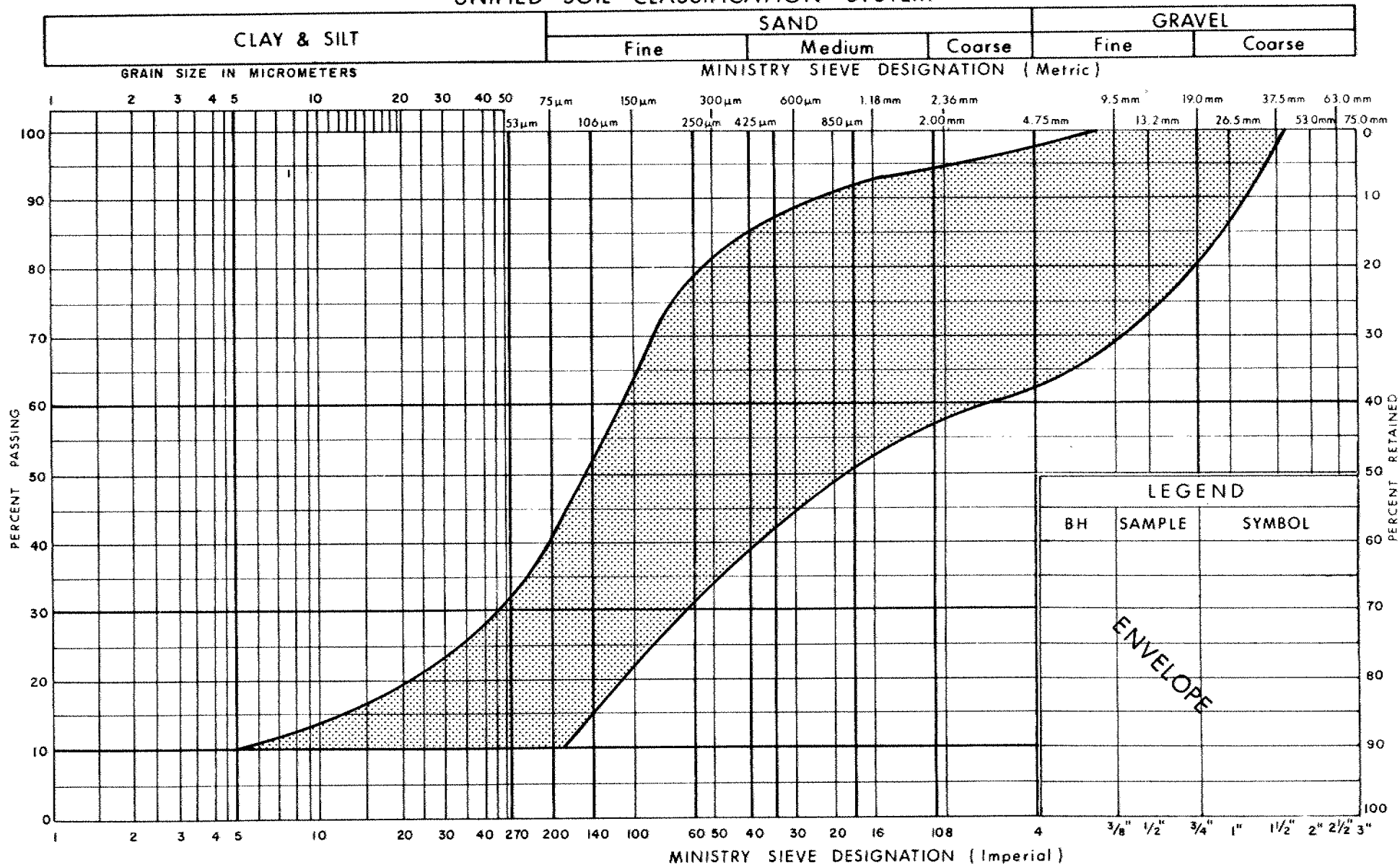
STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

UNIFIED SOIL CLASSIFICATION SYSTEM



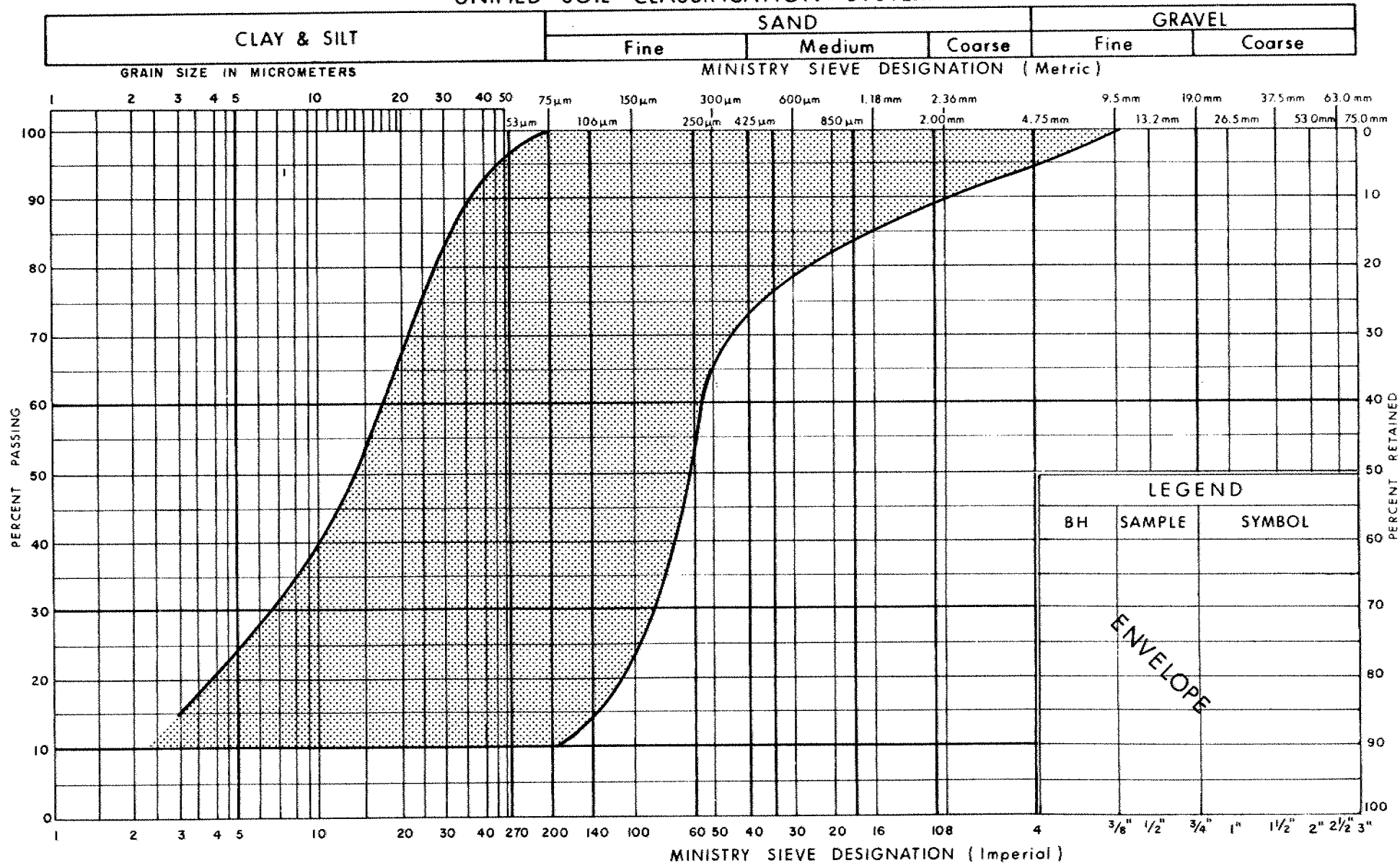
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND & GRAVEL SOME SILT (FILL)

FIG No 1

W P 7-83-09

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

FIG No 2

W P 7-83-09

ROCK CORE DESCRIPTION **WP 7-83-09**

Page 1 of 1.

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
8	39	35.48-35.53	100	0	35.48-39.22	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; slightly weathered to unweathered; close to extremely close spaced fractures.
	41	35.53-35.79	95	0		
	42	35.70-36.27	50	0		
	43	36.27-36.53	100	0		
	44	36.53-36.70	86	0		
	45	36.70-37.74	95	0		
	46	37.74-39.22	100	68		
9	32	34.90-35.20	-	-	34.90-36.58	OVERBURDEN , boulders, cobbles
	33	35.20-36.25	-	-	36.58-37.16	DOLOSTONE , very light grey; medium to fine grained, vuggy; medium strong rock; moderately to slightly weathered; very close spaced fractures.
	34	36.25-37.16	42	0		
10	19	27.61-29.13	40	-	27.61-29.26	OVERBURDEN , boulders, cobbles
	20	29.13-30.66	93	7	29.26-30.66	DOLOSTONE , light grey; medium grained, vuggy; medium strong rock; slightly weathered to unweathered; very close spaced fractures.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated in zones of poor core recovery)

Logged by: SAS, Soils and Aggregates Section.



RECORD OF BOREHOLE No 1

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 433.9, E 239 242.2 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 02 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
319.7	Ground Level																
0.0	Silty Sand to Sandy Silt Very Loose to Compact (Fill)		1	SS	24												8 56 (36)
			2	SS	13												
			3	SS	5												
			4	SS	4												
			5	SS	8												
			6	SS	2												
317.1	Sandy Silt to Silty Sand Compact to Very Dense		7	SS	12												
2.6			8	SS	18												
			9	SS	28												0 29 (71)
			10	SS	28												
			11	SS	22												
			12	SS	26												0 66 (34)
			13	SS	21												
			14	SS	24												
			15	SS	22												
			16	SS	22												0 89 (11)
			17	SS	45												
			18	SS	53												0 31 (69)
			19	SS	18												
			20	SS	29												0 61 (39)
			21	SS	17												
301.1	End of Borehole		22	SS	32												0 16 (84)
18.6																	



RECORD OF BOREHOLE No 2

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 427.5, E 239 234.8 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.): BW Casing COMPILED BY PM
DATUM Geodetic DATE 89 10 02 to 89 10 03 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
319.6	Ground Level										
0.0	Silty Sand to Sandy Silt, Trace of Gravel, Very Loose to Compact		1	SS	3						8 65 24 3
			2	SS	7						
			3	SS	15						
			4	SS	6						
			5	SS	3						
			6	SS	2						1 48 (51)
316.4	(Fill)		7	SS	8						
3.2			8	SS	15						
			9	SS	20						
			10	SS	26						
			11	SS	31						
			12	SS	31						
			13	SS	30						
			14	SS	23						
	Sandy Silt to Silty Sand, Compact to Dense		15	SS	24						
			16	SS	30						
			17	SS	58						0 8 (92)
			18	SS	27						
			19	SS	39						
			20	SS	16						
			21	SS	50						
	Occasional Boulders		22	RC							
			23	SS	58						
295.1			24	SS	62						0 91 (9)
24.5	End of Borehole										



RECORD OF BOREHOLE No 3

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 426.4, E 239 209.1 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 03 to 89 10 04 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
319.3	Ground Level		1	SS	7									
0.0	Topsoil		2	SS	5									
	Sand, Some		3	SS	10									
	Silt, Trace of		4	SS	12									
	Gravel, Loose to		5	SS	19									
	Compact		6	SS	17									
316.6	(Fill)		7	SS	6									
2.7	Organic Silt, Loose		8	SS	8									
			9	SS	31									
			10	SS	29									
			11	SS	22									
			12	SS	29									
			14	SS	34									
			15	SS	31									
	Silty Sand		16	SS	35									
	to Sandy		17	SS	29									
	Silt, Compact		18	SS	30									
	to Dense		19	SS	26									
			20	SS	36									
			21	SS	45									
			22	SS	84									
			23	SS	29									
			24	SS	17									
302.2			25	SS	24									
17.1	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 426.0, E 239 218.8 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 04 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT			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	PLASTIC LIMIT W _p	LIQUID LIMIT W _L	WATER CONTENT (%)	W _p		
320.0	Ground Level													
0.0	Sand, Some Silt and Gravel, Loose to Compact		1	SS	6									
			2	SS	16									
			3	SS	11									
			4	SS	11									
	(Fill)		5	SS	26									
317.2	Organic Silt, Some Sand, V. Loose to Loose		6	SS	67									
2.7			7	SS	5									
316.7			8	SS	2									
3.6			9	SS	3									
			10	SS	29									
			11	SS	29									
			12	SS	24									
			13	SS	30									
	Silty Sand to Sandy Silt, Compact to Dense		14	SS	21									
			15	SS	32									
			16	SS	40									
			17	SS	51									
			18	SS	23									
			19	SS	17									
	Occasional Cobbles		20	SS	27									
			RC	REC										
298.4			21	SS	07									
21.6	End of Borehole		22	SS	44									

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 388.2, E 239 244.8 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 05 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
320.0	Ground Level										
318.5	Topsoil		1	SS	4						
0.5	Sand, Some Silt and Gravel, Very Loose to Compact (Fill)		2	SS	9						
			3	SS	7						
			4	SS	14						
			5	SS	21						
317.3			6	SS	13						
2.7	Clayey Silt, Very Soft		7	SS	1						
	Sand, Some Silt and Gravel Compact to Dense		8	SS	13						
315.6			9	SS	55						
			10	SS	19						
4.4			11	SS	21						
	Silty Sand to Sandy Silt, Compact to Dense		12	SS	33						
			13	SS	36						
			14	SS	27						
			15	SS	25						
			16	SS	23						
			17	SS	20						
			18	SS	32						
			19	SS	36						
			20	SS	49						
			21	SS	41						
			22	SS	42						
			23	SS	11						
			24	SS	41						
			25	SS	55						
209.4	End of Borehole										
21.6											

OFFICE REPORT ON SOIL EXPLORATION



METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.4, E 239 242.9 ORIGINATED BY NH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 05 to 89 10 06 CHECKED BY _____

[illegible]

+3, x5: Numbers refer to 10^{20} (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 7

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 454.4, E 239 216.1 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.) COMPILED BY PM
DATUM Geodetic DATE 89 10 10 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
325.6	Shoulder Level		1	SS	75								
0.0	Asphalt		2	SS	23								
	Sand With Silt, Some Gravel, Compact to Dense (Fill)		3	SS	16								
			4	SS	15								
			5	SS	28								
			6	SS	27								
			7	SS	27								
			8	SS	20								
			9	SS	21								
			10	SS	12								
			11	SS	5								
			12	SS	14								
			13	SS	30								
			14	SS	37								
			15	SS	43								
			16	SS	32								
			17	SS	21								
			18	SS	38								
			19	SS	26								
316.9													
8.7	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 7-83-09

LOCATION Co-ords: N4 808 448.6, E 239 227.6

ORIGINATED BY MH

DIST 3 HWY 401

BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing

COMPILED BY PM

DATUM Geodetic

DATE 89 10 11

CHECKED BY _____

[illegible]

Continued

+3, x5: Numbers refer to

20
15-20.5 (%) STRAIN AT FAILURE

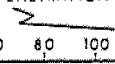
Continued



RECORD OF BOREHOLE No 8

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 448.6, E 239 227.6 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
DATUM Geodetic DATE 89 10 11 to 89 10 12 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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																														
295.6	Continued																																														
30.2	Silty Sand to Sandy Silt, Dense to Very Dense		33	SS	103/28cm																																										
	Occasional Boulders		34	RC	40%																																										
			35	SS	71																																										
291.7																																															
34.1	Weathered Unweathered		36	RC BXL	25																																										
	Dolostone Bedrock																																														
			45	RC BXL	86%																																										
			46	RC BX	97%																																										
286.6																																															
39.2	End of Borehole																																														
<div>* Note Sample</div> <table border="1"><thead><tr><th>No.</th><th>Type</th><th>Rec.</th><th>RQD</th></tr></thead><tbody><tr><td>37</td><td>RC</td><td>40%</td><td>0</td></tr><tr><td>38</td><td>RC</td><td>80%</td><td>0</td></tr><tr><td>39</td><td>RC</td><td>100%</td><td>0</td></tr><tr><td>41</td><td>RC</td><td>95%</td><td>0</td></tr><tr><td>42</td><td>RC</td><td>50%</td><td>0</td></tr><tr><td>43</td><td>RC</td><td>100%</td><td>0</td></tr><tr><td>44</td><td>RC</td><td>86%</td><td>0</td></tr></tbody></table>																No.	Type	Rec.	RQD	37	RC	40%	0	38	RC	80%	0	39	RC	100%	0	41	RC	95%	0	42	RC	50%	0	43	RC	100%	0	44	RC	86%	0
No.	Type	Rec.	RQD																																												
37	RC	40%	0																																												
38	RC	80%	0																																												
39	RC	100%	0																																												
41	RC	95%	0																																												
42	RC	50%	0																																												
43	RC	100%	0																																												
44	RC	86%	0																																												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 9

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 366.4, E 239 245.6 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), Casing NX COMPILED BY PM
DATUM Geodetic DATE 89 10 17 to 89 10 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
325.7	Ground Level																
0.0			1	SS	7												
			2	SS	13												33 53 (14)
			3	SS	10												
			4	SS	12												
			5	SS	17												
			6	SS	15												28 44 (28)
			7	SS	12												
			8	SS	8												
			9	SS	10												19 48 (33)
			10	SS	10												
			11	SS	6												
			12	SS	26												
			13	SS	29												
			14	SS	28												
			15	SS	24												37 49 (14)
			16	SS	26												
317.2	Organic Silt		17	SS	10												
8.5			18	SS	54												
			19	SS	80												
			20	SS	47												
			21	SS	25												
			22	SS	25												0 81 (19)
			23	SS	20												
			24	SS	24												
			25	SS	40												
			26	SS	97												1 29 (70)
			27	SS	23												
			28	SS	24												0 1 88 11
			29	SS	109												
295.5																	
30.2																	

OFFICE REPORT ON SOIL EXPLORATION

Continued

*3, x5: Numbers refer to
penetration

20
15 & 5 (%) STRAIN AT FAILURE

Continued



RECORD OF BOREHOLE No 9

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 366.4, E 239 245.6 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), Casing NX COMPILED BY PM
DATUM Geodetic DATE 89 10 17 to 89 10 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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					
295.5	Continued		30	SS	32												
30.2																	
	Occasional Boulders		31	SS	64												
			32	RC	50%												
			33	RC	12%												
289.1																	
288.5	Dolostone Bedrock		34	RC BX	REC 43%											RQD = 0	
37.3	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 10

METRIC

W P 7-83-09 LOCATION Co-ords: N4 808 407.8, E 239 219.4 ORIGINATED BY MH
DIST 3 HWY 401 BOREHOLE TYPE Continuous Flight Auger (H.S.), BX Casing COMPILED BY PM
DATUM Geodetic DATE 89 10 24 to 89 10 25 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W _n LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
320.0 0.0	Ground Level										
	Silty Sand to Sandy Silt, Compact to Dense		1	SS	15						
			2	SS	45						
			3	SS	15						
			4	SS	26						
			5	SS	4						
			6	SS	12						
			7	SS	19						
			8	SS	32						
			9	SS	21						
			10	SS	14						
			11	SS	26						
			12	SS	34						
			13	SS	17						
			14	SS	21						
			15	SS	45						
			16	SS	14						
			17	SS	28						
		18	SS	86/							
	Occasional Boulders		19	BX	REC 42%						
290.7 29.3	Dolostone Bedrock		20	BX	REC 96%						
289.3 30.7	End of Borehole										

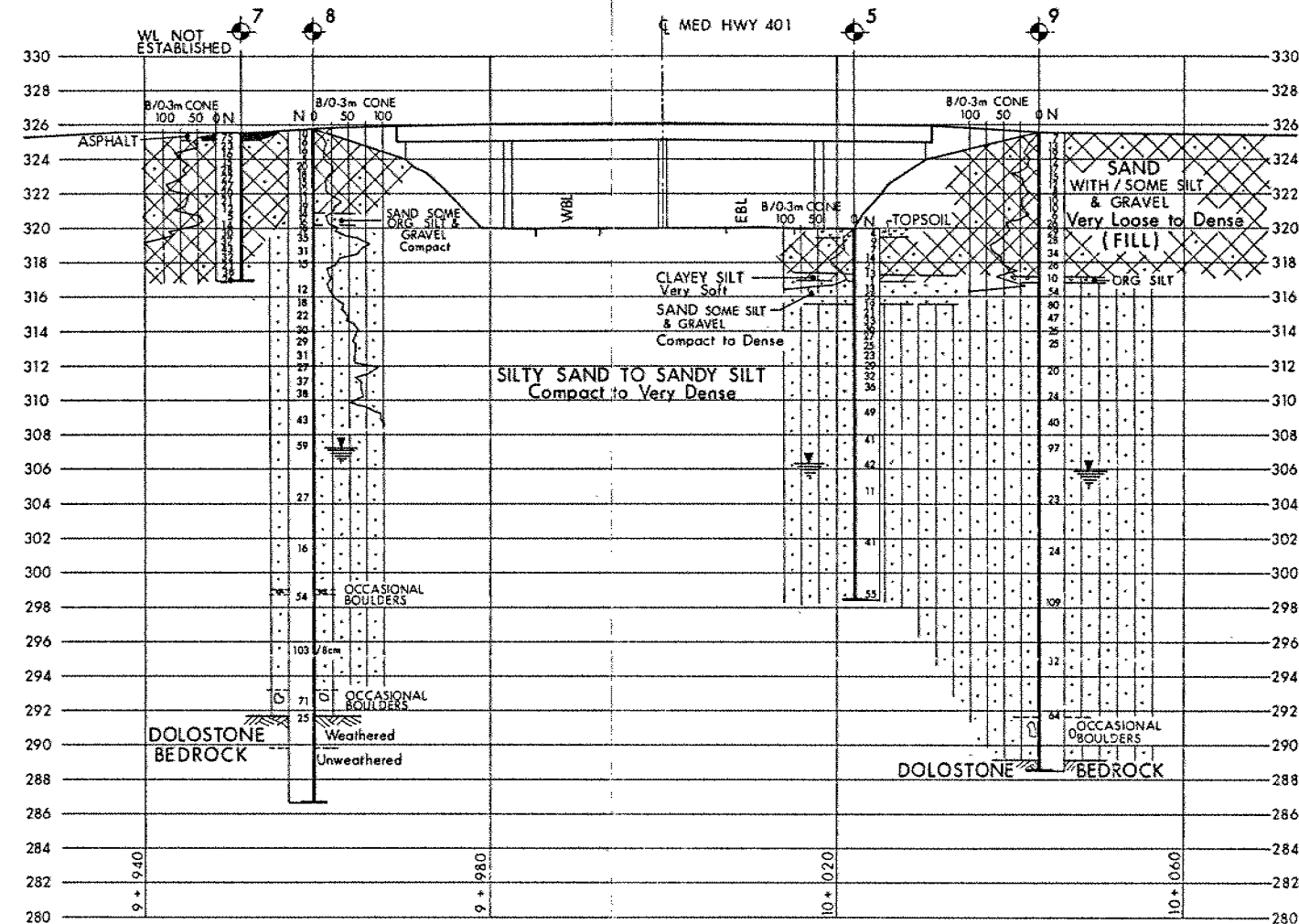
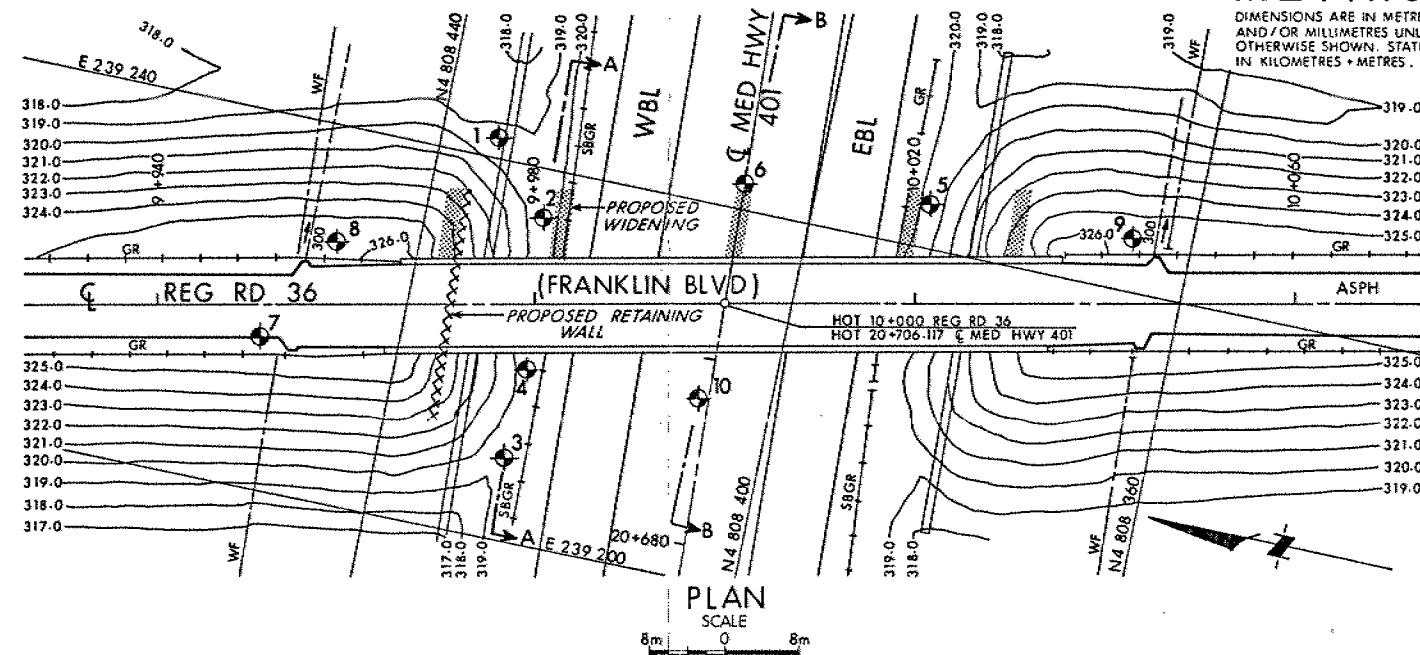
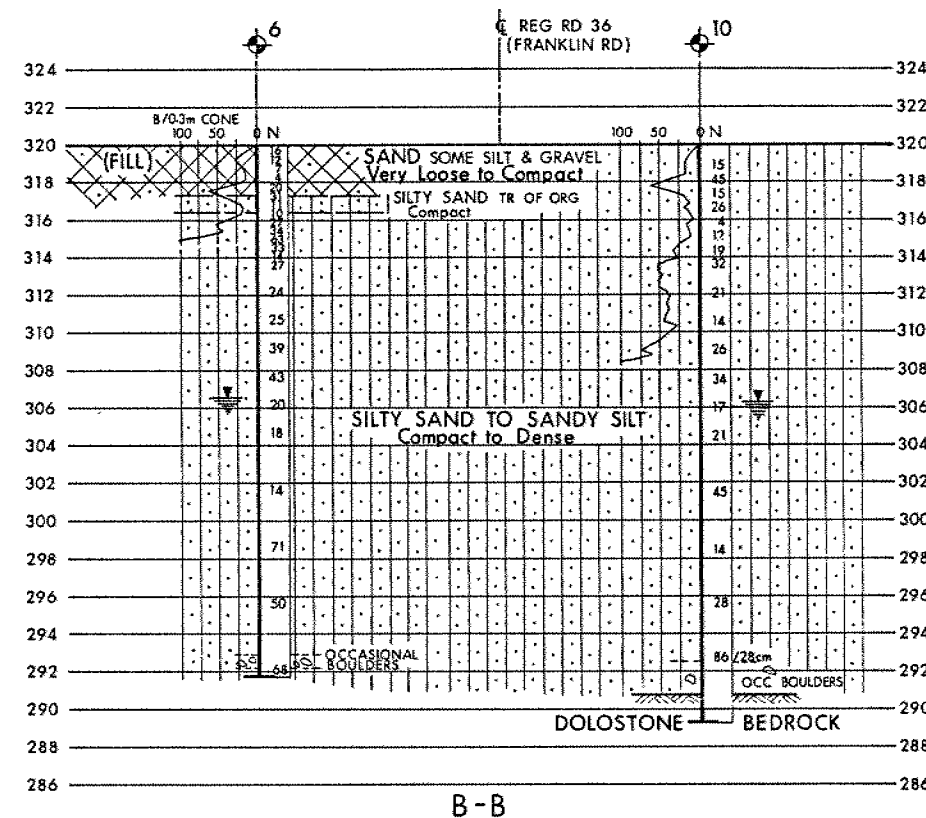
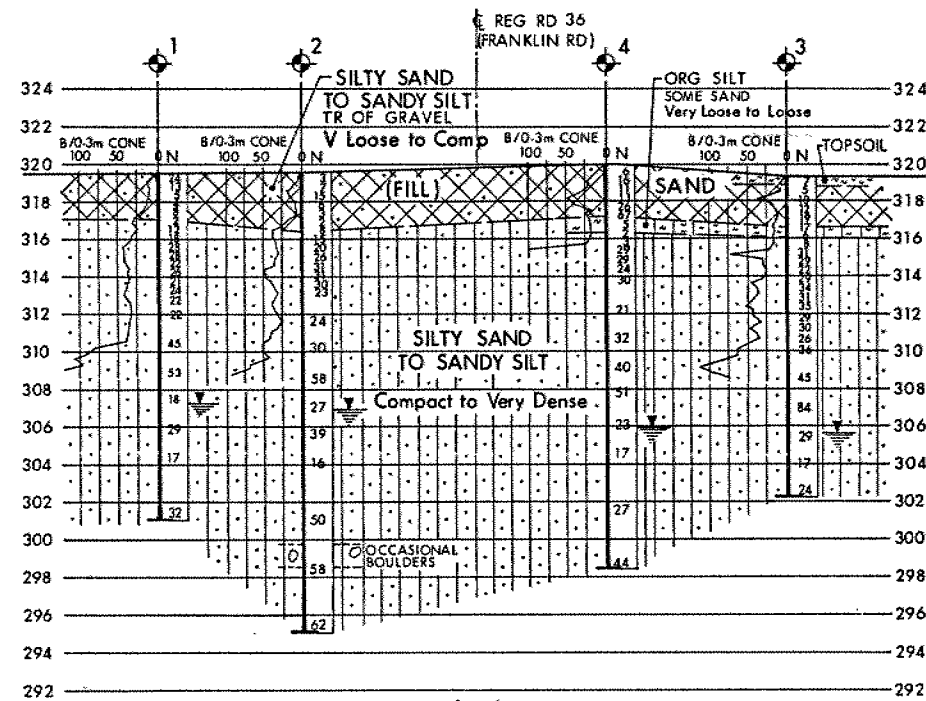
318
316
314
312
310
308
306
304
302
300
298
296
294
292

104/30cm

28cm Bouncing

RQD = 7%

OFFICE REPORT ON SOIL EXPLORATION



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

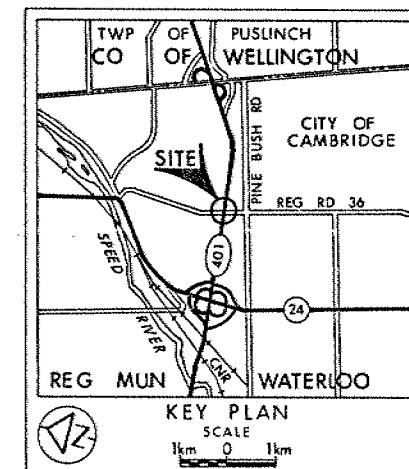
CONT No
WP No 7-83-09

REG RD 36 (FRANKLIN BLVD)

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & 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 89 10

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	319.7	4 808 433.9	239 242.2
2	319.6	4 808 427.5	239 234.8
3	319.3	4 808 426.4	239 209.1
4	320.0	4 808 426.0	239 218.8
5	320.0	4 808 388.2	239 244.8
6	320.0	4 808 407.4	239 242.9
7	325.6	4 808 454.4	239 216.1
8	325.8	4 808 448.6	239 227.6
9	325.7	4 808 366.4	239 245.6
10	320.0	4 808 407.8	239 219.4

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 40P8-104

HWY No 401		DIST 3	
SUBMD MV	CHECKED	DATE 90 01 17	SITE 33-151
DRAWN DT	CHECKED	APPROVED	DWG 78309-A