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DIST. 6 REGION

W.P. No. 54-82-07

CONT. No.

W. O. No.

STR. SITE No. 24-681

HWY. No. 401

LOCATION HWY 401 EASTBOUND COLLECTOR
RAMP TO 410

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FILE



Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 54-82-07 DIST 6
HWY 401 STR SITE 24-681

Proposed Crossing at Highway 401 Eastbound
Collector and Ramp W-S (403)

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GEOCRES 30M12-222

DATE

NOV 03 1994

FOUNDATION INVESTIGATION REPORT

For

Proposed Crossing at

Highway 401 Eastbound Collector and Ramp W - S (403)

W.P. 54-82-07, Site 24-681

Highway 401, District 6, Toronto

Introduction

This report summarizes the results of a foundation investigation conducted at the Highway 401 Eastbound Collector ramp structure and adjacent retaining walls. The investigation was carried out at the request of Central Region Structural Section. This report applies to the proposed structure and its approaches as well as four retaining walls in the immediate vicinity of the structure.

Site Description

The site is located on the south side of Highway 401, approximately 500 m east of the Kennedy Road flyover structure and adjacent to the Highway 401 W-N ramp to the 410. It is located in the City of Mississauga. The surrounding area is predominantly used for industrial and commercial purposes.

Physiographically, the site is located in the region known as the "Peel Plain". This region is characterized by a level to undulating "till or boulder clay" plain underlain by shale or limestone bedrock.

Investigation Procedures

1) Field

The subsurface investigation for this alignment of the proposed Highway 401 eastbound collector lanes was carried out between 94 06 30 and 94 07 04. It consisted of seven sampled boreholes - E-1, E-2, R-1, R-2, R-3, W-1, and W-2. All borings were advanced using a 5.2(i) track-mounted auger machine. One borehole was advanced by means of hollow stem auger, and the remaining by solid stem augers.

Samples were recovered by means of a 50 mm I.D. split spoon sampler. BQ rock cores were retrieved from boreholes E-1 and W-2.

A subsurface investigation was also conducted at this site in August 1983. It was carried out by L.J. Rak Engineering Ltd. who were retained by the MTO. The previous investigation consisted of 6 sampled boreholes (1 through 6), with rock coring, carried out on 83 08 09, 15 and 25. Since 1983, with the construction of the Highway 410 and Highway 401 interchange, the subsurface conditions appear to have changed. As a result, only the bedrock information from this investigation is being used.

ii) Laboratory

Laboratory testing was carried out on representative samples to identify and determine the physical properties of the overburden and weathered shale including:

- Natural Moisture Content
- Atterburg Limits
- Grain Size Distribution
- Bulk Unit Weight

The results of the laboratory tests are plotted on the Record of Borehole sheets and on Figures 1 and 2.

Subsurface Conditions

General

The borings carried out at the site reveal very shallow overburden, varying in thickness from 1.6 m to 2.6 m from the ground surface. A clayey silt to silty clay fill is the predominant soil deposit in the area. At the western-most boreholes, a thin layer of cohesive glacial till was encountered beneath the fill, ranging in thickness from 0.7 m to 0.8 m. The hard glacial till is composed of a heterogeneous mixture of clayey silt to silty clay, with some gravel, and some sand.

Weathered Shale bedrock was encountered across the site between El. 188.0 at the west end of the site and El. 181.9 at the east end. It is comprised largely of grey shale interbedded with siltstone and limestone, typical of the Georgian Bay Formation. The bedrock dips to the southeast. Queenston Shale was identified at the western-most borehole only, and appears to pinch out between boreholes R-1 and R-2.

Groundwater was encountered in the overburden between El. 182.8 and 183.9.

The subsurface conditions across the area are shown on the Record of Borehole Sheets. The locations and elevations of the borings, together with the stratigraphical sections inferred from the borehole data are shown on Drawing No. 548207-A. Detailed subsurface descriptions follow.

Clayey Silt to Silty Clay (Fill Material)

The surficial and predominant deposit across the site consists of cohesive fill material that is presumed to have been placed during the construction of the large W-N ramp structure to Highway 410. Garbage such as wire, plastic bags and car parts were brought to the surface during augering. For the most part, the fill material is composed of silty clay to clayey silt containing trace to some gravel, some sand, and trace organics. Its thickness varies from 0.9 to 2.4 m.

"N" values obtained from the Standard Penetration Test range from 6 to 85 blows per 28 cm, but more typically from 16 to 37. The material consistency ranges from firm to hard. Results of laboratory testing carried out on representative samples are as follows:

	Range (%)
Natural Moisture Content (w)	10 - 17
Plastic Limit (w_p)	14 - 19
Liquid Limit (w_L)	25 - 38

Refer to Figure 1 for typical grain size distribution curves for this deposit. The Plasticity Chart for this material is provided in Figure 2.

Clayey Silt to Silty Clay (Glacial Till)

At the west end of the site, BH's R-1 and R-2, the fill material was underlain by a clayey silt to silty clay deposit that contains some gravel and some sand. Its heterogeneous nature implies that it is glacial in origin and may contain cobbles and boulders. This stratum was encountered between El. 185.7 and 188.8 and measured 0.7 to 0.8 m in thickness at the borehole locations. Because soil samples were recovered at the upper and lower boundaries, SPT values specific to this deposit are not available. It may be interpolated that the consistency of the deposit is hard. Laboratory tests carried out on a single sample of this material revealed the following properties:

Natural Moisture Content (w)	9%
Plastic Limit (w_p)	19%
Liquid Limit (w_L)	35%

Bedrock

Bedrock was encountered at depths ranging from 1.6m to 2.6m below the present ground surface, i.e. between El. 188.0 and 181.9. It was recovered by means of split spoon sampling and rock coring. The bedrock samples and cores were examined by D.A. Williams, Petrographer with the Soils and Aggregates Section. The bedrock is described as shale interbedded with limestone and siltstone, typical of the Georgian Bay Formation. The recovered cores were light grey in colour and slightly weathered to unweathered. Queenston shale, recovered only in the most westerly borehole R-1, is red in colour and highly weathered.

Detailed Rock Core Descriptions may be referred to in the Appendix of this report.

The borehole information from the investigation carried out in August 1983 is provided in this report solely for its bedrock information. The boreholes are appended and should be referred to only for the bedrock elevations and description.

Groundwater Conditions

Groundwater levels, established by measuring in the open boreholes, varied from El. 182.8 to 183.9. The groundwater elevations recorded at the time of the investigation are tabled below and are plotted on the Record of Borehole sheets and stratigraphical profile.

<i>Borehole</i>	<i>Groundwater Elevation</i>
E-1	182.8
E-2	182.9
R-1	dry
R-2	dry
R-3	183.3
W-1	dry
W-2	183.9

Discussion

It is proposed to construct a single span rigid-frame structure, approximately 13 m wide and 135 m long to carry the eastbound Hwy. 401 collector lanes over Ramp 401 W - 403 S. Four retaining walls are required to accommodate the grade differences between the Highway 401 EB collector lanes and the W-N and the W-S ramps. The retaining walls are numbered 1 to 4 and their proposed locations are shown on the appended Foundation Drawing.

Recommendations

Structure Foundations

Abutments

The abutments to the structure will be founded in bedrock since considerable excavation in bedrock will be required to achieve the profile grade of Ramp W-S. Caisson foundations were considered as an alternative, but it is felt that shallow foundations would be most economical. The West Abutment footing may be founded at or below elevation 182.9 m. The East Abutment footing may be founded at or below elevation 181.9. The recommended design values at the abutments are as per OHBDC 3rd Ed. are as follows:

Factored Bearing Resistance at ULS	1 500 kPa
Bearing Resistance at SLS	will not govern

Retaining Walls

Retaining Wall No. 1

Retaining Wall No. 1 extends from the north end of the East Abutment, between Sta 6 + 810 and 6 + 858 of the EB Collector alignment. It is approximately 48 m in length. The retaining wall footing will be founded partially on/in bedrock, partially on glacial till and partially on fill, and will also require stepping.

Retaining Wall No. 2

Retaining Wall No. 2 extends west from the south corner of the West Abutment, between Sta 6 + 990 and 7 + 095 along the EB Collector alignment. It is approximately 105 m long and decreases in height with an increasing grade to the west. The underlying bedrock follows a similar grade. Hence, a stepped footing arrangement will be required.

Retaining Wall No. 3

Retaining Wall No. 2 extends from the south corner of the East Abutment, between Sta 9 + 920 and 9 + 838 along the Ramp W-S alignment. It is approximately 82 m long and will be founded entirely in bedrock.

Retaining Wall No. 4

Retaining Wall No. 4 is proposed along the north side of the EB Collector alignment between Sta 6 + 753 and Sta 6 + 808. The collector lanes will cut into the toe of the existing embankment supporting the Ramp W - N from Hwy 401 to NB Hwy 410. The retaining wall footing will be placed on fill.

Conventional Retaining Walls

For footings on shale bedrock, the design values provided for the abutment footings may be used.

For footings founded on the cohesive glacial till or cohesive fill, it is recommended that a granular pad with minimum thickness of 0.3 m be placed a minimum of 1.2 m below the final ground elevation.

Where the addition of fill is required, the surficial material containing organics should be removed for the area of the footing and replaced with compacted granular to the base of the footing elevation. For footings on a granular pad the following design values are recommended:

Factored Bearing Resistance at ULS	375 kPa
Bearing Resistance at SLS	250 kPa

Granular fill should be compacted to a minimum 95% SPDD.

For calculation of resistance to sliding, the following unfactored friction coefficients may be assumed:

Between concrete and shale bedrock	$\phi = 22^\circ$
Between concrete and granular fill	$\phi = 30^\circ$

Retained Soil System Walls

Proprietary walls may be considered for all three retaining walls. Space permitting, 1H:1V reinforced slopes may be considered. If retained soil systems are used, the proposal should be forwarded to the MTO RSS Committee c/o George Al-Bazi, Structural Office.

Design considerations for construction excavations and dewatering are the responsibility of the proprietary RSS company and shall be in accordance with the requirements of the Occupational Health and Safety Act. Fully detailed proposals should be submitted to the Foundation Design Section for review a minimum of 10 working days prior to construction.

General Recommendations for Spread Footings

No dewatering concerns are anticipated for the footing excavations. It is expected that any seepage into the excavation can be relieved by sump pumping techniques.

Due to the rapid disintegration of shale bedrock when exposed, it is recommended that a 150 mm thick working slab of concrete be poured within 8 hours of the completion of footing excavation. In addition, shale bedrock exposed on the sides of excavations should be protected with tarpaulins.

It is preferable to provide a minimum of 1.2 m of earth cover for the footings founded on shale bedrock because of the friable nature of the weathered shale.

The sliding resistance between the base of the footing and the weathered shale may be computed using an unfactored friction coefficient of $\tan 22^\circ$.

Lateral Earth Pressure

Backfill to the abutments should consist of granular material in accordance with MTO Standard Special Provision 109F03. Computation of earth pressures should be carried out as per Section 6-7.4.2 of the OHBDC, 3rd Ed.. Design parameters of the acceptable granular backfill are as follows.

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m^3)	22.8	21.2

An at-rest condition may be assumed to apply for the rigid frame structure.

For conventional retaining walls in bedrock, it is recommended that the rock face be cut at an angle approximately 60° to the horizontal and granular backfill placed between the rock and the retaining wall to minimize possible lateral pressures applied by the rock.

Construction Considerations

Temporary excavations within the overburden may be carried out at 1.5H:1V slopes or flatter. Temporary excavations in the shale bedrock may be as steep as 1H:3V to a maximum depth of 6.0 m before incorporating a 2.0 m wide mid-height berm. Sides of excavations exposing shale bedrock should be protected with a tarpaulin to minimize disintegration of the shale.

To avoid acquisition of a temporary limited interest agreement, a vertical cut at approximate Sta 9+865 of the Ramp W-S for Retaining Wall S/E is being considered. The vertical cut would extend approximately 8 m in length and for a height of 7 m+/-, 5 m of which would be shale bedrock. A vertical cut is possible with the following requirements:

1. A drainage pipe should be placed a distance of 1.5 m to 2.0 m away from the face of the excavation (south side) and embedded in the ground at a depth just below the top of bedrock (approx. 2m deep). The pipe should be perforated, wrapped in geotextile and buried in HL8 granular. It is intended that the pipe will intersect the groundwater table and prevent the seepage of water over the face of the exposed shale bedrock. The pipe

- should extend for a distance downslope to ensure water flow away from the excavation.
2. The vertical face of the shale should be protected with a tarpaulin or shotcrete.
 3. At this location, the overburden may be cut at a 1H:1V slope, provided that this scheme complies with Occupational Health and Safety regulations.

Across the site, cohesive glacial till overlies shale bedrock. The Contractor should be made aware that cobbles/boulders may be encountered during excavation and during placement of foundations.

Slope Stability

The proposed slopes will be stable at 2H:1V. Where embankments exceed 6.0 m in height, a 2.0 m wide mid-height bench should be incorporated. The bench is recommended for cut and fill slopes.

Note that in the vicinity of the proposed Retaining Wall No. 4, the existing W-N ramp embankment reaches a height of 10 m +/- without any berms apparent on the slope. Cross sections reveal that the south slope of this embankment is inclined at slightly flatter than 2H:1V. Because reconstructing the slope to include a berm would require a more extensive retaining wall, it is recommended that more aggressive surficial treatment, such as the application of a geosynthetic mat, be applied on the slope to encourage vegetative growth and minimize surficial instabilities. With such treatment, consideration may also be given to grading back the existing slope to 2H:1V, thereby eliminating the need for a retaining wall. This recommendation applies only at this location. All other slopes should comply with standard recommended geometries.

Bedrock elevations are high and may be exposed at the proposed grade elevations. Due to the rapid decomposition of the shale upon exposure, it is recommended that the cut slopes in bedrock be covered as soon as possible with an adequate cover of topsoil and sodded. This item will require consultation with the Landscape Architecture Section.

Miscellaneous

The fieldwork for this investigation was carried out by L. O'Malley, Engineering Student, under the supervision of B. Bennett, Foundation Engineer, utilizing drilling equipment owned and operated by Canadian Soil Drilling Inc..

The report was prepared by B. Bennett and reviewed and approved by D. Dundas, Sr. Foundation Engineer.



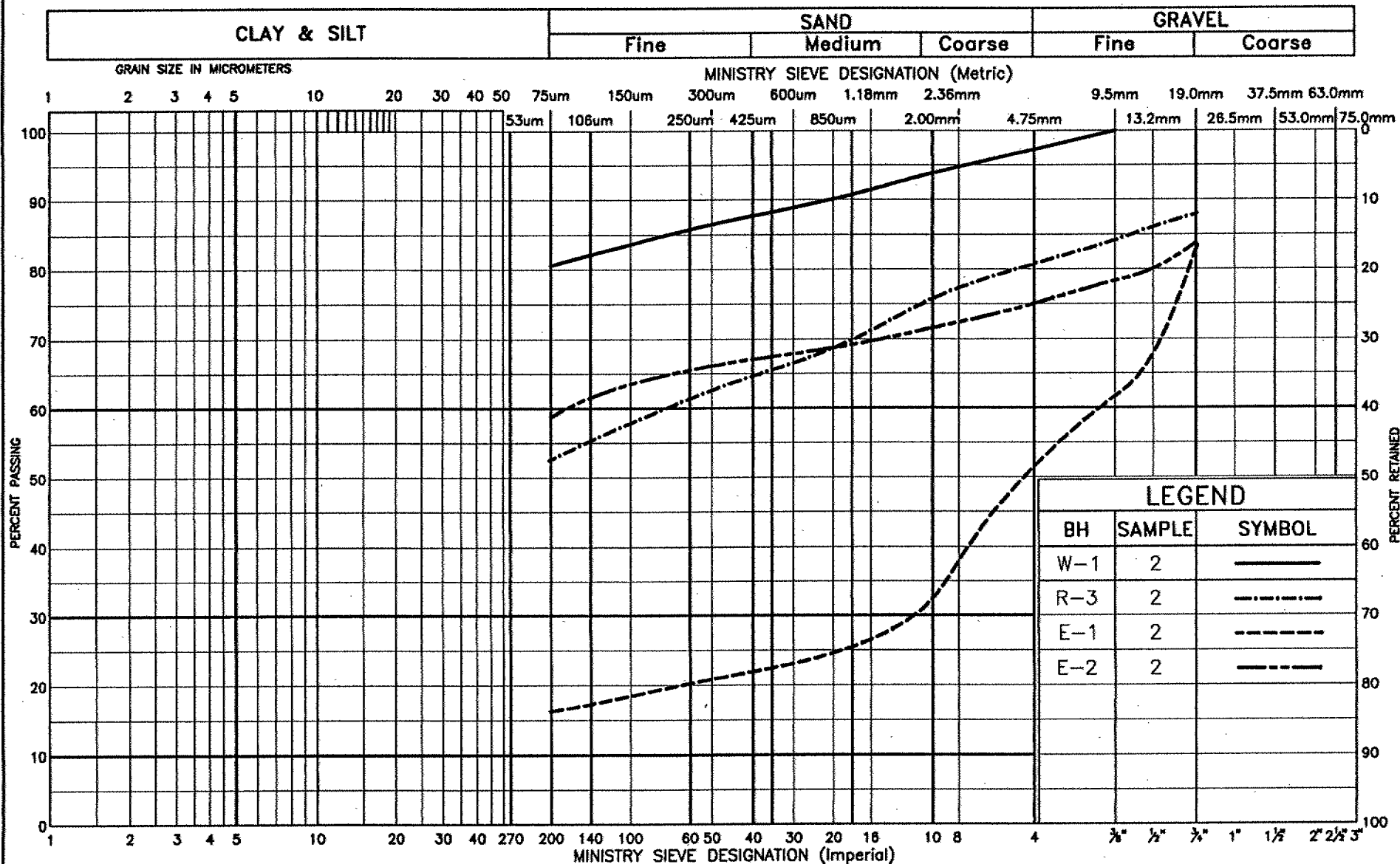
B. Bennett
Betty Bennett, P.Eng.
Foundation Engineer



D. Dundas
D.H. Dundas, P.Eng.
Sr. Foundation Engineer

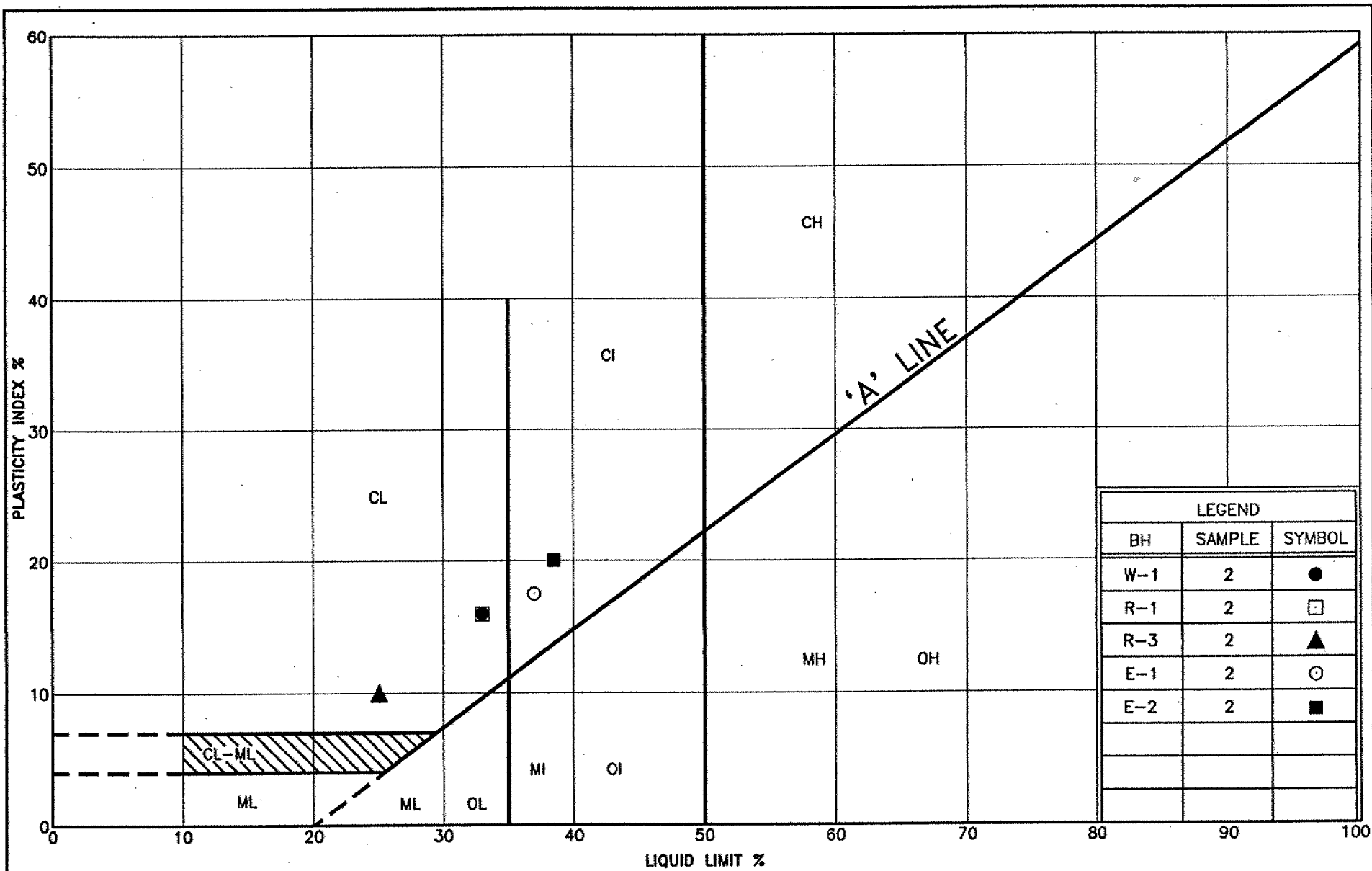
APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION
CLAYEY SILT TO SILTY CLAY (FILL MATERIAL)

FIG No 1
WP 54-82-07



RECORD OF BOREHOLE No E-1

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 771, E 291 576 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger, BW Casing, BQ Rock Core COMPILED BY L.O.
 DATUM Geodetic DATE 1994 07 04 CHECKED BY B.B.

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					
183.9	Ground Surface																
0.0	CLAYEY SILT TO SILTY CLAY Trace to Some Gravel Some Sand Trace Organics Firm to Very Stiff (Fill Material)		1	SS	6												
181.9			2	SS	53		182										61 22 (17)
2.0	BEDROCK Shale Interbedded with Siltstone / Limestone Highly Weathered Slightly Weathered		3	SS	85	/8cm											
	Georgian Bay Formation		4	RC	REC 63%		180										RQD 14%
179.4																	
4.5	End of Borehole																

RECORD OF BOREHOLE No E-2

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 757, E 291 579 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 07 04 CHECKED BY B.B.




SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)							
						20	40	60	80	100	20	40	60	80	100	10	20	30		
184.3	Ground Surface																			
0.0	CLAYEY SILT TO SILTY CLAY Trace to Some Gravel Some Sand Trace Organics Stiff to Very Stiff (Fill Material)		1	SS	14															
			2	SS	85	/28cm														
181.9			3	SS	75	/15cm														
2.4	BEDROCK Shale interbedded with Siltstone/Limestone		4	SS	85	/5cm														
181.2	Georgian Bay Formation																			
3.1	End of Borehole																			

RECORD OF BOREHOLE No R-1

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 679, E 291 357 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 06 30 CHECKED BY B.B.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							WATER CONTENT (%) 10 20 30			
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
190.6	Ground Surface																	
0.0	CLAYEY SILT TO SILTY CLAY Some Gravel and Sand Trace Organics Very Stiff (Fill Material)					DRY *	190							0 1 (99)				
			1	SS	16													
188.8			2	SS	37													
1.8	CLAYEY SILT TO SILTY CLAY Some Gravel, Some Sand Hard																	
188.0	(Glacial Till)		3	SS	64			188										
2.8	BEDROCK Queenston Shale Highly Weathered																	
			4	SS	97	/28cm												
186.8			5	SS	85	/13cm												
3.8	End of Borehole																	

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No R-2

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 701, E 291 407 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 06 30 CHECKED BY B.B.

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					
186.6	Ground Surface																
0.0	CLAYEY SILT TO SILTY CLAY Stiff					DRY *											
185.7	(Fill Material)						186										
0.9	CLAYEY SILT TO SILTY CLAY Hard		1	SS	51												
185.0	(Glacial Till)		2	SS	90	/5cm											
184.8	** Bedrock																
1.8	End of Borehole																
	** Shale interbedded with siltstone / limestone Georgian Bay Formation																

RECORD OF BOREHOLE No R-3

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 798, E 291 617 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 07 04 CHECKED BY B.B.

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					
185.0	Ground Surface																
0.0	CLAYEY SILT TO SILTY CLAY Some Sand Trace to Some Gravel Trace Organics Very Stiff to Hard (Fill Material)		1	SS	19		184										
			2	SS	37												
182.7			3	SS	85	/3cm											
2.3	BEDROCK Shale interbedded with Siltstone / Limestone		4	SS	85	/10cm	182										
181.6	Georgian Bay Formation		5	SS	80	/3cm											
3.4	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No W-1

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 735, E 291 448 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 07 04 CHECKED BY B.B.

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
185.1	Ground Surface															
0.0	CLAYEY SILT TO SILTY CLAY Trace to Some Gravel Some Sand Trace Organics Very Stiff to Hard (Fill Material)	X	1	SS	28	DRY *										
		X	2	SS	80											
183.0		X	3	SS	85	/10cm										
2.1	BEDROCK Grey Shale Interbedded with Siltstone / Limestone	X	4	SS	85	/10cm										
182.0		X														
3.1	End of Borehole															

RECORD OF BOREHOLE No W-2

1 OF 1

METRIC

W.P. 54-82-07 LOCATION Coords.: N 4 832 722, E 291 452 ORIGINATED BY L.O.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY L.O.
 DATUM Geodetic DATE 1994 06 30 CHECKED BY B.B.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L		
185.0	Ground Surface															
0.0	CLAYEY SILT TO SILTY CLAY Trace to Some Gravel Some Sand Trace Organics Stiff to Very Stiff (Fill Material)		1	SS	10											
			2	SS	29											
182.9																
2.1	BEDROCK Shale Interbedded with Siltstone / Limestone Highly Weathered Slightly Weathered Georgian Bay Formation		3	SS	100	/25cm									23.1	33 12 38 17
			4	SS	85	/8cm										
			5	RC	REC 94%											ROD 37%
180.5																
4.5	End of Borehole															



RECORD OF BOREHOLE No 1

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,744 N; 291,525 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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 Y KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N ^o VALUES			20	40	60	80	100					
185.49	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel.		1	AS	—	*	185									21.4	
184.73	Loose Brown																
0.76	Silty clay, low plast. some sand, trace of gravel.		2	SS	55		184						o			20.1	
	Hard Grey-brown to grey		3	SS	23								o				
			4	SS	75/	50mm	183						o				
182.48	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered.																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,753 N; 291,559 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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					
184.05	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown		1	AS	—	*	184										
183.44																	
0.61	Silty clay, low plast. some sand, tr. of gravel Hard Grey-brown		2	AS	—		183										
182.68																	
1.37	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered.																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

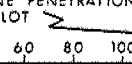
20
15-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 3

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,775 N; 291,597 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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					
183.70	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown		1	AS	—	*											
183.00							183										
0.70	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered.																

+3, x5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 4

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,768 N; 291,617 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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					
184.15	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel.		1	AS	—	*	184										
183.54	Loose Brown																
0.61	Silty clay, low plast.																
182.78	some sand, tr. of gravel Hard Grey-brown						183										
1.37	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered.																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



RECORD OF BOREHOLE No 5

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,787 N; 291,644 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 19 and 25, 1983 CHECKED BY AP

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
								SHEAR STRENGTH								WATER CONTENT (%)	
184.85	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel.					*											
184.24	Loose Brown																
0.61	Silty clay, low plast., some sand, trace of gravel.		1	SS	31												
	Hard Grey-brown		2	SS	44									22.0			
			3	SS	28												
182.42			4	SS	25/	50mm											
2.43	Bedrock, shale with limestone bands.																
			5	RC BXL	95% RQD 32%												
			6	RC BXL	50% RQD 0%												
			7	RC BXL	93% RQD 49%												
			8	RC BXL	97% RQD 50%												
			9	RC BXL	97% RQD 80%												
175.25																	
9.60	End of borehole																
	* Groundwater at elev. 182.03 on August 27, 1983.																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 6

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,795 N; 291,681 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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					
183.91	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel.		1	AS	—	*											
183.30	Loose Brown																
0.61	Silty clay, low plast., some sand, trace of gravel.		2	AS	—		183										
182.39	Hard Grey-brown																
1.52	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered																

OFFICE REPORT ON SOIL EXPLORATION

ROCK CORE DESCRIPTION **WP 54-82-07**

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
E-1 (S)	4	2.87-4.47	63	14	2.87-4.47	SILTSTONE (calcareous) and LIMESTONE (containing brachiopods), medium grey, with interbeds up to 7 cm thick of medium dark grey to dark grey SHALE ; medium to very fine grained; medium strong to weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat, planar to undulating, smooth.
W-2 (S)	5	2.95-4.55	94	37	2.95-4.55	SILTSTONE (calcareous) and LIMESTONE (containing corals), medium grey, with interbeds up to 7 cm thick of medium dark grey to dark grey SHALE ; medium to very fine grained; medium strong to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat, planar to undulating, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%

Logged by: DAW, Soils and Aggregates Section

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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

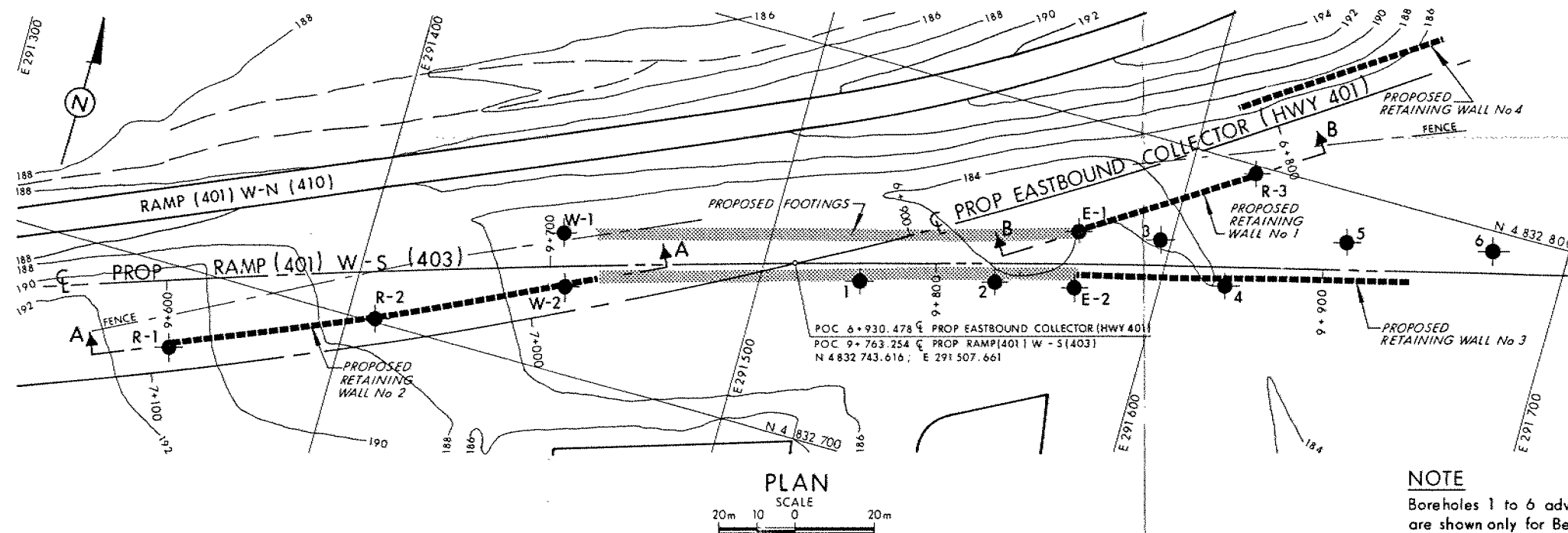
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	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'_{v0}	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_f	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						



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

CONT No
WP No 54-82-07

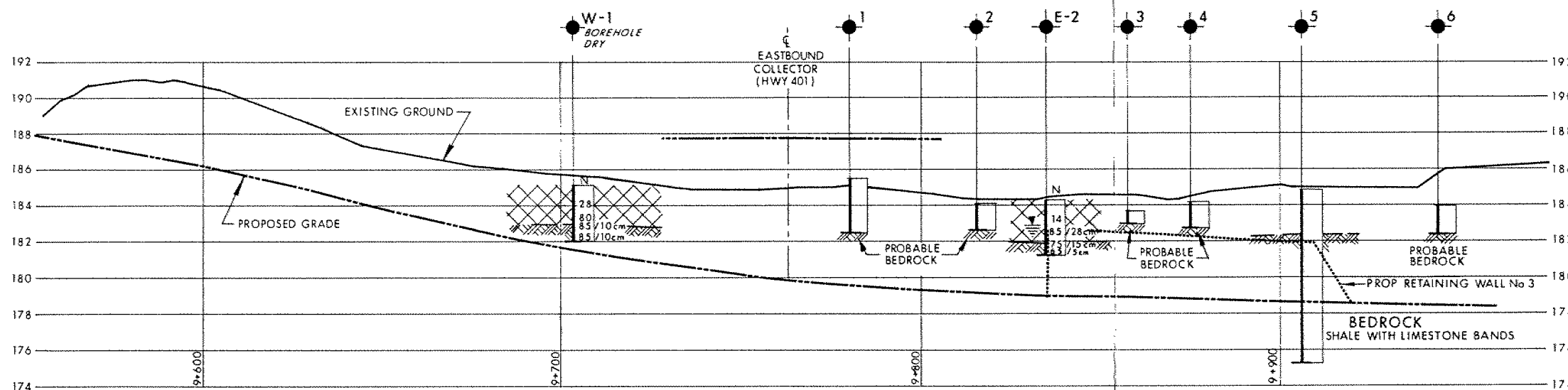
E.B. COLLECTOR (HWY 401) &
RAMP (401) W-S (403)
BORE HOLE LOCATIONS & SOIL STRATA



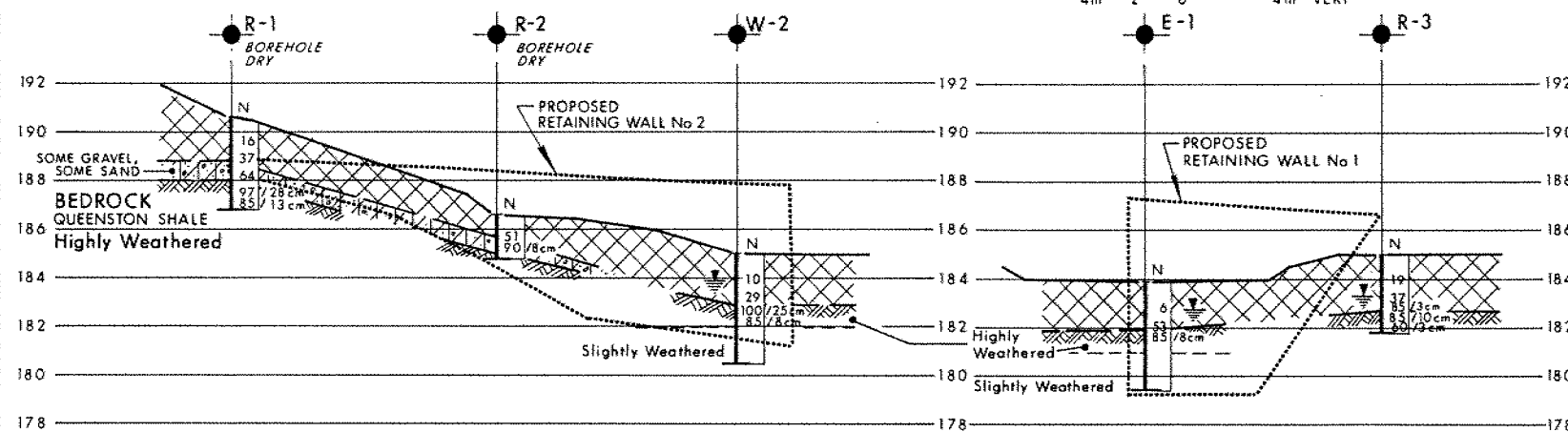
SHEET



NOTE
Boreholes 1 to 6 advanced in 1983 08,
are shown only for Bedrock information.



PROFILE PROP RAMP (401) W-S (403)



SECTION A-A

SECTION B-B

SOIL STRATIGRAPHY LEGEND

CLAYEY SILT TO SILTY CLAY
TRACE TO SOME GRAVEL,
SOME SAND, TRACE ORGANICS
(FILL MATERIAL) Firm to Hard

CLAYEY SILT TO SILTY CLAY
(Glacial Till) Hard

BEDROCK
SHALE INTERBEDDED WITH
SILTSTONE / LIMESTONE

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)
- WL at time of investigation
1994 06 and 07

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	185.5	4 832 744	291 525
2	184.1	4 832 753	291 559
3	183.7	4 832 775	291 597
4	184.2	4 832 768	291 617
5	184.9	4 832 787	291 644
6	183.9	4 832 795	291 681
E-1	183.9	4 832 771	291 576
E-2	184.3	4 832 757	291 579
R-1	190.6	4 832 679	291 357
R-2	186.6	4 832 701	291 407
R-3	185.0	4 832 798	291 617
W-1	185.1	4 832 735	291 448
W-2	185.0	4 832 722	291 452

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 GC 2.01 of OPS Gen Cond

REV DATE BY DESCRIPTION

Geocres No 30M12-222

HWY No 401
SUBM'D B.B. CHECKED DATE 1994 10 24 SITE 24-681
DRAWN R.S. CHECKED APPROVED DWG 548207-A



MEMORANDUM



To: V. Boehnke, P.Eng.
Head, Structural Section
Central Region

Date: June 15, 1994

Attn: N. Potak, P.Eng
Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Tel: (416) 235-3731
Fax: (416) 235-5240

Re: Preliminary Foundation Recommendations for
Hwy 401 EB Collector Ramp to Hwy 410
Hwy 401 Widening betw'n Hwys 401/403 and First Line West
W.P. 54-82-07, Site 24-681, District 6

A foundation investigation has been completed at the above-mentioned location. This memo outlines the general subsurface conditions encountered at the site and the preliminary foundation recommendations for the proposed rigid frame ramp structure and adjoining retaining walls.

General Site and Subsurface Conditions

The fieldwork was carried out on the south side of Highway 401, approximately 500 m east of the Kennedy Road flyover structure and adjacent to the ramp to Highway 410. The site is located in the City of Mississauga. Physiographically, it is located in the Peel Plain that is characterized by glacial overburden overlying bedrock.

The borings carried out at the site revealed a very shallow overburden varying in thickness from 1.6 m to 2.7m from the ground surface. Weathered shale bedrock was encountered across the site and is comprised largely of grey shale interbedded with siltstone/limestone of the Dundas-Meaford Formation. The bedrock dips gently to the south-east. Queenston shale was identified at the west-most borehole only and appears to pinch out between BH's R-1 and R-2.

Discussion and Recommendations

It is proposed to construct a single span rigid-frame structure, approximately 13 m wide and 135 m long. Three retaining walls are required to accommodate the grade differences between the Highway 401 EB collector lanes and the W-N and the W-S ramps. The retaining walls will be identified as shown on the E-Plan, i.e. S/W Retaining Wall extends west from the south corner of the West Abutment, N/E Retaining Wall extends from the north end of the East Abutment, and S/E Retaining Wall extends from the south corner of the East Abutment.

Structure Foundations

Abutments

The abutments to the structure will be founded in bedrock since considerable excavation in bedrock will be required to achieve the profile grade of Ramp W-S. At this site, shallow foundations would be most economical. The West Abutment footing may be founded at or below elevation 182.9 m. The East Abutment footing may be founded at or below elevation 181.9. The recommended design values at the abutments are as per OHBDC 3rd Ed. are as follows:

Factored Bearing Resistance at ULS	1 500 kPa
Bearing Resistance at SLS	will not govern

Retaining Walls

Retaining Wall S/W

Retaining Wall S/W is approximately 104 m long and decreases in height with an increasing grade to the west. The underlying bedrock follows a similar grade. Hence, a stepped footing arrangement will be required.

Retaining Wall N/E

Retaining Wall N/E is approximately 50 m in length. The retaining wall footing will be founded partially on/in bedrock, partially on glacial till and partially on fill, and will also require stepping.

Retaining Wall S/E

Retaining Wall S/E is approximately 86 m long and will be founded entirely in bedrock.

Conventional Retaining Walls

For footings on shale bedrock, the design values provided for the abutment footings may be used.

For footings on the clayey silt glacial till, it is recommended that a granular pad with minimum thickness of 0.3 m be placed a minimum of 1.2 m below the final ground elevation.

Where fill is required, the surficial material containing organics should be removed for the area of the footing and replaced with compacted granular to the base of the footing elevation. For footings on a granular pad the following design values are recommended:

Factored Bearing Resistance at ULS	375 kPa
Bearing Resistance at SLS	250 kPa

Granular fill should be compacted to a minimum 95% SPDD.

For calculation of resistance to sliding, the following unfactored friction coefficients may be assumed:

Between concrete and shale bedrock	$\phi = 22^\circ$
Between concrete and granular fill	$\phi = 30^\circ$

Retained Soil System Walls

Proprietary walls may be considered for all three retaining walls. If retained soil systems are used, the proposal should be forwarded to the MTO RSS Committee c/o George Al-Bazi, Structural Office.

Design considerations for construction excavations and dewatering are the responsibility of the proprietary RSS company and shall be in accordance with the requirements of the Occupational Health and Safety Act. Fully detailed proposals should be submitted to the Foundation Design Section for review a minimum of 10 working days prior to construction.

General Recommendations for Spread Footings

No dewatering concerns are anticipated for the footing excavations. It is expected that any seepage into the excavation can be relieved by sump pumping techniques.

Due to the rapid disintegration of shale bedrock when exposed, it is recommended that a 150 mm thick working slab of concrete be poured within 8 hours of the completion of footing excavation. In addition, shale bedrock exposed on the sides of excavations should be protected with tarpaulins.

It is preferable to provide a minimum of 1.2 m of earth cover for the footings founded on shale bedrock because of the friable nature of the weathered shale.

The sliding resistance between the base of the footing and the weathered shale may be computed using an unfactored friction coefficient of $\tan 22^\circ$.

Lateral Earth Pressure

Backfill to the abutments should consist of granular material in accordance with MTO Standard Special Provision 109F03. Computation of earth pressures should be carried out as per Section 6-7.4.2 of the OHBDC, 3rd Ed.. Design parameters of the acceptable granular backfill are as follows.

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m^3)	22.8	21.2

An at-rest condition may be assumed to apply for the rigid frame structure.

For conventional retaining walls in bedrock, it is recommended that the rock face be cut at an angle approximately 60° to the horizontal and granular backfill placed between the rock and the retaining wall to minimize possible lateral pressures applied by the rock.

Construction Considerations

Temporary excavations within the overburden may be carried out at 1.5H:1V slopes or flatter. Temporary excavations in the shale bedrock may be as steep as 1H:3V to a maximum depth of 6.0 m before incorporating a 2.0m wide mid-height berm. Sides of excavations exposing shale bedrock should be protected with a tarpaulin to minimize disintegration of the shale.

To avoid acquisition of a temporary limited interest agreement, a vertical cut at approximate Sta 9+865 of the Ramp W-S for Retaining Wall S/E is being considered. The vertical cut would extend approximately 8 m in length and for a height of 7 m+/-, 5 m of which would be shale bedrock. A vertical cut is possible with the following requirements:

1. A drainage pipe should be placed a distance of 1.5 m to 2.0 m away from the face of the excavation (south side) and embedded in the ground at a depth just below the top of bedrock (approx. 2m deep). The pipe should be perforated, wrapped in geotextile and buried in HL8 granular. It is intended that the pipe will intersect the groundwater table and prevent the seepage of water over the face of the exposed shale bedrock. The pipe should extend for a distance downslope to ensure water flow away from the excavation.
2. The vertical face of the shale should be protected with a tarpaulin or shotcrete.
3. At this location, the overburden may be cut at a 1H:1V slope, provided that this scheme complies with Occupational Health and Safety regulations.

Across the site, cohesive glacial till overlies shale bedrock. The Contractor should be made aware that cobbles/boulders may be encountered during excavation and during placement of foundations.

Slope Stability

The proposed slopes will be stable at 2H:1V. Where embankments exceed 6.0 m in height, a 2.0 m wide mid-height bench should be incorporated. The bench is recommended for cut and fill slopes.

Bedrock elevations are high and may be exposed at the proposed grade elevations. Due to the rapid decomposition of the shale upon exposure, it is recommended that the cut slopes in bedrock be covered as soon as possible with an adequate cover of topsoil and sodded. This item will require consultation with the Landscape Architecture Section.

If there any questions or comments regarding these recommendations, please advise. The complete report will be distributed once drafting is completed.



Betty Bennett, P.Eng.
Sr. Foundation Eng. (Acting)

memorandum

235-3696



To: D. Dundas
Chief Foundation Engineer (Acting)
Foundation Design Section
Central Building, Room 315

Date: 94 07 19

Attn: B. Bennett

From: Soils and Aggregates Section
Engineering Materials Office
Central Building, Room 311

File No: 3162-2-4-113

Re: **Borehole Core Description**
Highway 401/Highway 410-Highway 10, Mississauga
W.P. 54-82-01

As requested by you, core from five (5) boreholes was logged. A description is appended. Bedrock is **SILTSTONE** and **LIMESTONE** (with interbeds of **SHALE**) of the Georgian Bay Formation and **SHALE** and interbedded **SILTSTONE** of the Queenston Formation. Depth to bedrock and depth to unweathered to slightly weathered bedrock in each borehole are tabulated below:

Borehole number	Depth to bedrock in metres below ground surface (*based on split spoon samples)	Depth to unweathered to slightly weathered bedrock in metres below ground surface
W-1 (SOUTH)	2.3* 7.242'	2.9 9.514'
W-2 (SOUTH)	2.3* 7.540'	3.0 9.843'
P-2 (NORTH)	3.1* 10.171'	4.1 13.451'
W-1 (NORTH)	8.4* 27.559'	9.9 32.430'
E-1 (NORTH)	2.3* 7.546'	4.7 10.420'

If you have any questions, please contact me.

D. A. Williams

David A. Williams,
Petrographer.



DAW/jlp
Attachment

ROCK CORE DESCRIPTION **WP 54-82-01**

Page 1 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
E-1 (S)	4	2.87-4.47	63	14	2.87-4.47	SILTSTONE (calcareous) and LIMESTONE (containing brachiopods), medium grey, with interbeds up to 7 cm thick of medium dark grey to dark grey SHALE ; medium to very fine grained; medium strong to weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat, planar to undulating, smooth.
W-2 (S)	5	2.95-4.55	94	37	2.95-4.55	SILTSTONE (calcareous) and LIMESTONE (containing corals), medium grey, with interbeds up to 7 cm thick of medium dark grey to dark grey SHALE ; medium to very fine grained; medium strong to weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat, planar to undulating, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%
 Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION **WP 54-82-01**

Page 2 of 2

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
P-2 (N)	5	4.14-5.74	59	0	4.14-7.34	SHALE, greyish red, with interbedded greenish grey SILTSTONE (17%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures extremely close to close spaced, flat to near vertical, planar to undulating, smooth.
	6	5.74-7.34	95	13		
W-1 (N)	14	9.91-11.51	70	0	9.91-11.51	SHALE, greyish red, with interbedded greenish grey SILTSTONE (5%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures extremely close to close spaced, flat to near vertical, planar to undulating, smooth.
E-1 (N)	6	4.70-6.30	79	0	4.70-6.30	SHALE, greyish red, with interbedded greenish grey SILTSTONE (15%); very fine grained; very weak to weak; unweathered to slightly weathered; fractures extremely close to close spaced, flat to near vertical, planar to undulating, smooth.

*CR = CORE RECOVERY

*RQD = ROCK QUALITY DESIGNATION

Note: Depths are approximated where core recovery is less than 100%
 Logged by: DAW, Soils and Aggregates Section

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M12-182
30M12-222

DIST. 6 REGION

W.P. No. 54-82-06

CONT. No.

W. O. No.

STR. SITE No. 24-681

HWY. No. 401

LOCATION HWY 401 WESTBOUND COLLECTOR
EB Collector over W-S Ramp
Bridge 66

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



FOUNDATION INVESTIGATION REPORT
HIGHWAY 401
E.B. COLLECTOR OVER W-S RAMP TO HWY 403
CITY OF MISSISSAUGA

W.P. 54-82-07
DISTRICT 6
C274

SITE 24-483
STRUCTURE No. 66
AUGUST 1983

DISTRIBUTION:

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PREPARED BY:

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TABLE OF CONTENTS

	PAGE NUMBER
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
3.0 FIELD WORK	1 - 2
4.0 SOIL CONDITIONS	2 - 4
4.1 Sandy Silt	2 - 3
4.2 Silty Clay	3
4.3 Bedrock	3 - 4
5.0 GROUNDWATER	4
6.0 DISCUSSIONS AND RECOMMENDATIONS	4 - 7
6.1 General	4
6.2 General Design Considerations	5
6.3 Foundations	5
6.4 Stability	6
6.5 Lateral Pressures	6
6.6 Construction	7
6.7 Fills and Cuts	7
7.0 MISCELLANEOUS	7

1.0 INTRODUCTION

L.J. Rak Engineering Limited has been retained by the Ministry of Transportation and Communications to carry out a foundation investigation for a proposed underpass structure designated as Highway 401 E.B. Collector over W-S Ramp to Highway 403.

2.0 SITE DESCRIPTION AND GEOLOGY

The area under investigation is located on the south side of Highway 401 about 500 m east of Kennedy Road (First Line East) in the City of Mississauga. It is part of the physiographic region known as the "Peel Plain". The characteristic deposit in the area of investigation consists of cohesive glacial till of variable thickness. The overburden is underlain by grey shale bedrock of the Meaford - Dundas formation, Ordovician Period.

The site is part of cultivated land. It undulates gently in the area of Boreholes 1, 2, 3 and 4 and is relatively flat in the area of Boreholes 5 and 6. About 90% of the site area is recently cultivated. The remainder has been formerly cultivated and is covered with grasses.

3.0 FIELD WORK

The field work for this foundation investigation was carried out in the period of August 9 to August 25, 1983 and consisted of six boreholes at the locations shown on Drawing No. 548207-A. The work was carried out using a track-mounted CME-55 drilling machine supplied and operated by Master Soil Investigations Limited.

On August 9, all boreholes were put down to refusal and assumed bedrock at elevations well above the proposed grade of the W-S ramp. Following consultation with the Ministry, it was decided to extend at least one borehole into bedrock, sufficiently deep to define the rock conditions to below the anticipated founding level.

3.0 FIELD WORK (Continued)

The coring of bedrock was commenced on August 19 and, with interruptions due to difficulties with the equipment, one borehole was completed on August 25. Due to budget and time restrictions, it was then decided to terminate the field work at that point.

Soil samples were taken using the Standard Penetration Test method and bedrock was cored with a BXL core barrel. The soil and rock samples will normally be stored for a period of three months following the date of this report and then discarded unless other instructions are received.

The elevations of the ground surface at the borehole locations were determined using a temporary Benchmark (elevation 185.936) described as paint mark on top of bolt on S.E. leg of hydro tower 1 m above ground level 161.7 LT 6 + 496.1 (centre of N-E loop ramp) located about 600 m east of the site.

4.0 SOIL CONDITIONS

The predominant natural overburden at the site consists of silty clay with some sand and a trace of gravel (cohesive glacial till) extending to depths ranging from 0.7 to 3.0 m. It directly overlies bedrock at elevations ranging from 182.4 to 183.0 at the borehole locations.

The soil and rock conditions are shown on the enclosed Record of Borehole Sheets and in an estimated stratigraphical profile on Drawing No. 548207-A. They are briefly described in the following paragraphs.

4.1 Sandy Silt

The site is covered by about 600 to 750 mm of brown sandy silt with a trace of clay and a trace of gravel. All boreholes are located on cultivated land and this surficial layer is the result of previous tilling of the underlying deposit. As a result, this

4.0 SOIL CONDITIONS (Continued)

deposit appears to have lost most of its original clay sizes and the remaining silty material is in a loose state of relative density. Its organic content is low.

4.2 Silty Clay

The sandy silt is underlain by a stratum of grey-brown to grey silty clay of low plasticity, extending to bedrock at depths ranging from about 0.7 to 3.0 m below ground level. The silty clay contains some sand and a trace of gravel and is believed to be of late glacial origin.

Due to the limited depth of the overburden only a small number of Standard Penetration ("N") values were obtained. They ranged from 23 to 55 blows per 300 mm and on that basis, it is considered that the material is generally of hard consistency.

The natural moisture content of the silty clay as determined on a limited number of samples is of the order of 11 percent. The unit weight ranged from 20 to 22 kN/m³.

4.3 Bedrock

Bedrock was encountered or inferred from auger refusals at depths ranging from about 0.7 to 3.0 m below ground level at a corresponding narrow range of elevations between 182.4 and 183.0.

The rock was core drilled in BXL size in Borehole 5 and found to consist of grey shale with horizontal limestone bands. A summary of the core results is given on the following page.

4.0 SOIL CONDITIONS (Continued)

Run (m)	Recovery (%)	RQD (%)	Shale Content (%)	Limestone Content (%)	Range of Length of Limestone Pieces (mm)
3.0 - 4.1	96	32	40	60	60 - 200
4.1 - 5.4	48	0	50	50	10 - 30
5.4 - 6.6	93	49	80	20	40 - 60
6.6 - 8.1	97	50	80	20	90 - 220
8.1 - 9.6	97	80	55	45	30 - 200

Overall core recoveries were generally close to 100 indicating that the bedrock is sound. R.Q.D.'s varied between 32 and 80% with an apparent tendency to increase with depth. The results of Core Run #2, i.e. between depths of 4.1 and 5.4 m, have been ignored in this evaluation, as equipment difficulties were experienced during this run.

5.0 GROUNDWATER

Groundwater was not encountered within the overburden. A water level standpipe equipped with a piezometer tip was installed in Borehole 5. The groundwater in this piezometer was measured to be at elevation 182.03 on August 27, 1983, i.e. two days after completion of the borehole.

6.0 DISCUSSIONS AND RECOMMENDATIONS

6.1 General

The proposed W-S Ramp is understood to be a rigid frame structure with a span of about 9 m, a height of about 7 m and a total length of about 87 m. Retaining walls are to be provided at either end of the structure to confine the fill to be used in the construction of the East-bound Collectors.

6.0 DISCUSSIONS AND RECOMMENDATIONS (Continued)

6.2 General Design Considerations

Based on the results of this investigation and the proposed grade elevations for the W-S Ramp, it is evident that the foundations for the structure and the retaining walls will be wholly in bedrock.

The excavation in bedrock could be cut vertically and the structure and retaining walls could be cast directly against the rock. This method would result in minimum excavation, minimum form work and minimum backfill. However, this method will result in eccentric foundations for the structure, complicated foundations for the retaining walls and, above all, large lateral pressures.

The latter are not predictable but they can become in time very large as they are associated with rock squeeze. They can be reduced or eliminated by placing compressible material between the rock and the walls. However, it is recommended that the rock excavation be cut under an angle of about 60 degrees with the horizontal to allow for standard foundations with granular backfill and standard earth pressure evaluations.

6.3 Foundations

The structure and retaining walls may be founded on footings which should be placed below the depth of frost influence, i.e. about 1500 mm below grade.

It is recommended that the factored bearing capacity at ultimate limit states be taken as 1500 kPa. This is a conservative value and is based on practical experience with bedrock of this type. As far as the bearing capacity at serviceability limit states is concerned, the design of the foundation is not governed by settlement as the loads required to produce detrimental settlement of the structure will be much larger than 1500 kPa.

6.0 DISCUSSIONS AND RECOMMENDATIONS (Continued)

6.4 Stability

The structure and retaining walls are subject to lateral loads and their foundations must be designed to resist them. Reference is made to OHBDC sections 6.7.3.3.5 and C 6.7.3.3.5. Further lateral resistance, if required, may be obtained by the provision of dowels or rock anchors. In addition the design could incorporate the mobilization of passive pressure within rock.

Rock anchors may be designed using a bond stress between rock and good quality grout of 650 kPa. Passive pressure within the rock is essentially a case of horizontal bearing capacity which may be taken as 1000 kPa provided that sufficient rock coverage is provided over the footing. Further restraining effect may be provided by keying the footing into the rock. The frictional resistance along a plane at the bottom of the key(s) may be calculated using a cohesion of 1000 kPa.

6.5 Lateral Pressures

It is assumed that rock cuts will be shaped as recommended and that the backfill to the structure and retaining walls will be free-draining granular material, suitably but not overly compacted. In this case the lateral pressure may be estimated from equivalent fluid pressures as outlined in OHBDC Section 6.6.1.2.2.

The evaluation of lateral pressures may also be obtained from the unit weight of the backfill (20 kN/m^3) together with earth pressure coefficients as determined from Section C 6.6.1.2.2 of the Code, using an internal angle of friction $\phi = 30^\circ$. All estimates of earth pressure should include the evaluation of surcharge loads as outlined in Section 6.6.1.2.4 of the Code. The possibility of hydrostatic pressures acting behind the walls must be eliminated by the provision of positive and permanent drainage.

6.0 DISCUSSIONS AND RECOMMENDATIONS (Continued)

6.6 Construction

Groundwater level readings were only carried out over a limited time period. The overburden does not contain free water although perched water may exist locally at times. There may be a freatic level within the bedrock above the excavation elevations but this is unlikely to cause unusual construction problems.

6.7 Fills and Cuts

The maximum height of embankments in the area covered by this investigation is of the order of 3 to 4 m. The surficial soil at the site is cultivated to a depth of about 600 to 800 mm. This material should be compacted if left in place. The natural soil below the cultivated depth is suitable for the support of embankments with normal side slopes of 1 vertical to 2 horizontal.

Cuts in the silty clay (till) may be sloped at the same angle but should be protected from surface erosion. Cuts in the shale bedrock will stand at near-vertical slopes.

7.0 MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. I.R. Munro, P.Eng. The report was prepared by Mr. A. Prior, P.Eng.

Submitted by

L.J. RAK ENGINEERING LIMITED



A. Prior, P.Eng.
AP/mr

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_f	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						

RECORD OF BOREHOLE No 1

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,744 N; 291,525 E.
DIST. 6 HWY 401 BOREHOLE TYPE Solid Stem Auger
DATUM Geodetic DATE August 9, 1983

ORIGINATED BY IM
COMPILED BY MR
CHECKED BY AP

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					
185.49	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown		1	AS	—	*	185									21.4	
184.73																	
0.76	Silty clay, low plast. some sand, trace of gravel.		2	SS	55		184									20.1	
	Hard Grey-brown to grey		3	SS	23												
			4	SS	75/	50mm	183										
182.48																	
3.01	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered.																

RECORD OF BOREHOLE No 2										METRIC					
W P 54-82-07		LOCATION Co-ords. 4,832,753 N; 291,559 E.				ORIGINATED BY IN									
DIST 6 HWY 401		BOREHOLE TYPE Solid Stem Auger				COMPILED BY MR									
DATUM Geodetic		DATE August 9, 1983				CHECKED BY AP									
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60					
184.05	Ground Level														
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown		1	AS	—	*									
0.61	Silty clay, low plast. some sand, tr. of gravel Hard Grey-brown		2	AS	—										
1.37	End of borehole Refusal on auger Probable Bedrock														
	* Groundwater not encountered.														

RECORD OF BOREHOLE No 3										METRIC					
W P 54-82-07		LOCATION Co-ords. 4,832,775 N; 291,597 E.				ORIGINATED BY IM									
DIST 6 HWY 401		BOREHOLE TYPE Solid Stem Auger				COMPILED BY MR									
DATUM Geodetic		DATE August 9, 1983				CHECKED BY AP									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)			
183.70	Ground Level		1	AS	—	*									
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown						183								
183.00	End of borehole Refusal on auger Probable Bedrock						182								
0.70															
	* Groundwater not encountered.														

RECORD OF BOREHOLE No 4										METRIC				
W P 54-82-07		LOCATION Co-ords. 4,832,768 N; 291,617 E.				ORIGINATED BY IM								
DIST 6 HWY 401		BOREHOLE TYPE Solid Stem Auger				COMPILED BY MR								
DATUM Geodetic		DATE August 9, 1983				CHECKED BY AF								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)		
184.15	Ground Level													
0.00	Sandy silt, trace of clay, trace of gravel. Loose Brown		1	AS	—	*	184							
183.54														
0.61	Silty clay, low plast. some sand, tr. of gravel. Hard Grey-brown						183							
182.78														
1.37	End of borehole Refusal on auger Probable Bedrock						182							
* Groundwater not encountered.														

RECORD OF BOREHOLE No 5

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,787 N; 291,644 E. ORIGINATED BY IM
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
DATUM Geodetic DATE August 9, 19 and 25, 1983 CHECKED BY AP

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
							SHEAR STRENGTH								
							○ UNCONFINED + FIELD VANE								
							● QUICK TRIAXIAL x LAB VANE								
184.85	Ground Level											10	20	30	GR SA SI CL
0.00	Sandy silt, trace of clay, trace of gravel.														
184.24	Loose Brown														
0.61	Silty clay, low plast., some sand, trace of gravel.		1	SS	31										
			2	SS	44										
	Hard Grey-brown		3	SS	28										
182.42			4	SS	25	50mm									
2.43	Bedrock, shale with limestone bands.														
			5	RC BXL	95% RQD 32%										
			6	RC BXL	50% RQD 0%										
			7	RC BXL	93% RQD 49%										
			8	RC BXL	97% RQD 50%										
			9	RC BXL	97% RQD 80%										
175.25															
9.60	End of borehole														
	* Groundwater at elev. 182.03 on August 27, 1983.														

RECORD OF BOREHOLE No 6

METRIC

W P 54-82-07 LOCATION Co-ords. 4,832,795 N; 291,681 E. ORIGINATED BY IM
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY MR
 DATUM Geodetic DATE August 9, 1983 CHECKED BY AP

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
183.91	Ground Level																
0.00	Sandy silt, trace of clay, trace of gravel.		1	AS	—	*											
183.30	Loose Brown																
0.61	Silty clay, low plast., some sand, trace of gravel.		2	AS	—		183										
182.39	Hard Grey-brown																
1.52	End of borehole Refusal on auger Probable Bedrock						182										
	* Groundwater not encountered																

Caisson Foundations

Again, to reduce the amount of excavation of the existing shale fill, short caissons may be considered.

The following recommendations apply for caissons socketed into the weathered shale:

	<u>West Pier</u>	<u>East Pier</u>
Est. Base of Caisson Elev.	188.7	188.8
Factored Resistance @ U.L.S.	2 200 kPa	2 200 kPa
Axial Resistance @ S.L.S.	will not govern	will not govern

The depth of socketing should be equal to twice the caisson diameter.

It is expected that the caissons can be installed without liners and that any water encountered can be removed from the excavated caisson by pumping prior to the placement of concrete.

Retaining Walls

Retaining Wall S/W

Retaining Wall S/W is approximately 55 m long and decreases in height with an increasing grade to the west. Hence, a stepped footing arrangement should be considered. Its foundation will be located within or above the weathered shale fill.

Retaining Wall N/E

Retaining Wall N/E is approximately 95 m in length. The retaining wall footing will be founded on or above glacial till and will also require stepping.

Conventional Retaining Walls

For footings within the weathered shale fill, on the clayey silt glacial till, or in a fill, it is recommended that a granular pad with minimum thickness of 0.5 m be placed a minimum of 1.2 m below the final ground elevation.

Where fill is required, the surficial material containing organics should be removed for the area of the footing and replaced with compacted granular to the base of the footing elevation. For footings on a granular pad the following design values are recommended:

Factored Bearing Resistance at ULS	375 kPa
Bearing Resistance at SLS	250 kPa

Granular fill should be compacted to a minimum 95% SPDD.

For calculation of resistance to sliding, an unfactored friction coefficient of $\phi = 30^\circ$ may be assumed between concrete and granular fill

Retained Soil System Walls

Proprietary walls may be considered for all three retaining walls. If retained soil systems are used, the proposal should be forwarded to the MTO RSS Committee c/o George Al-Bazi, Structural Office.

Design considerations for construction excavations and dewatering are the responsibility of the proprietary RSS company and shall be in accordance with the requirements of the Occupational Health and Safety Act. Fully detailed proposals should be submitted to the Foundation Design Section for review a minimum of 10 working days prior to construction.

General Recommendations for Spread Footings

No dewatering concerns are anticipated for the footing excavations. It is expected that any seepage into the excavation can be relieved by sump pumping techniques.

Due to the rapid disintegration of shale bedrock when exposed, it is recommended that a 150 mm thick working slab of concrete be poured within 8 hours of the completion of footing excavation. In addition, shale bedrock exposed on the sides of excavations should be protected with tarpaulins.

A 1.2 m earth cover is required for all footings. It is preferable to provide a minimum of 1.2 m of earth cover for the footings founded on shale bedrock because of the friable nature of the weathered shale.

The sliding resistance between the base of the footing and the weathered shale may be computed using an unfactored friction coefficient of $\tan 22^\circ$.

Lateral Earth Pressure

Backfill to the abutments should consist of granular material in accordance with MTO Standard Special Provision 109F03. Computation of earth pressures should be carried out as per Section 6-7.4.5 of the OHBDC, 3rd Ed.. Design parameters of the acceptable granular backfill are as follows.

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2

An active condition may be assumed provided that soil movement behind the wall is permitted.

Construction Considerations

A NSSP for caisson installation, developed by the Foundation Design Section, should be incorporated into the contract package.

Temporary excavations within the weathered shale fill and overburden may be carried out at 1.5H:1V slopes or flatter. Temporary excavations in the shale bedrock may be as steep as 1H:3V to a maximum depth of 6.0 m before incorporating a 2.0m wide mid-height berm. Sides of

excavations exposing shale bedrock should be protected with a tarpaulin to minimize disintegration of the shale.

Across the site, cohesive glacial till overlies shale bedrock. The Contractor should be made aware that cobbles/boulders may be encountered during excavation and during placement of foundations. In addition, it is likely that cobble and boulder sized fragments of weathered shale or siltstone will be encountered during excavations within the weathered shale fill.

Slope Stability

The proposed slopes will be stable at 2H:1V. Where embankments exceed 6.0 m in height, a 2.0 m wide mid-height bench should be incorporated.

If there any questions or comments regarding these recommendations, please advise. The complete report will be distributed once laboratory testing and drafting is completed.



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(Acting)