

**PRELIMINARY
FOUNDATION INVESTIGATION REPORT
FREDERICK STREET UNDERPASS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00**

Geocres Number: 40P8-203

Report to

**Ministry of Transportation Ontario
West Region**

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TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION	1
2	SITE DESCRIPTION	2
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Data from previous investigation, 1966 (Reference 1)	3
5.1.1	Topsoil	3
5.1.2	Fill	3
5.1.3	Sand	4
5.1.4	Clayey Silt to Silty Clay	4
5.1.5	Sandy Silt to Silty Sand	6
5.1.6	Groundwater Conditions	7
5.2	Data from the 2012 investigation at Northeast Corner Retaining Wall (Reference 2)	7
6	MISCELLANEOUS	8

Appendices

Appendix A	Record of Borehole Sheets and Laboratory Test Results (Previous Investigation, Geocres No. 40P8-48 – Reference 1)
Appendix B	Record of Borehole Sheets and Laboratory Test Results (Previous Investigation, Geocres No. 40P8-199 – Reference 2)
Appendix C	Site Photographs
Appendix D	Drawing titled “Borehole Locations and Soil Strata”

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents factual information that may be used in the preliminary design of the foundations of a new structure that will carry Frederick Street over the Kitchener-Waterloo Expressway (KWE) in the Regional Municipality of Waterloo. The new structure will incorporate a proposed S-E ramp on the east end. The proposed new underpass structure is part of the Highway 7-New project.

It is understood that an alternate design is being considered for this site and consists of extending the existing structure to the east to carry Frederick Street over the proposed S-E ramp (Bruce St. ramp) of the KWE.

No boreholes were drilled within the footprint of the proposed structure for preparation of this report. This report is based on information on subsurface conditions contained in a previous foundation report prepared in 1966. The title of the report is listed as follows:

- Foundation investigation report for Frederick Street Underpass, Kitchener-Waterloo Expressway, District #4 (Hamilton), W.J. 66-F-53, W.P. 634-64, Geocres No. 40P8-48, prepared by DHO (Department of Highways Ontario), dated July 21, 1966, (Reference 1).
- Foundation investigation and design report for Northeast Corner Retaining Wall, Frederick Street Underpass, Site No. 33-234, G.W.P. 3110-09-00, City of Kitchener, Ontario, prepared by Peto MacCallum Ltd., PML Ref. 10KF079C, Geocres No. 40P8-199, dated May 31, 2012, (Reference 2).

Records of boreholes from the previous report are attached in Appendix A for reference.

A site investigation, field testing and engineering analysis will be required at the detail design stage. The detailed design must be based on site-specific investigation at the foundation elements.

Thurber carried out the investigation for the Ministry of Transportation Ontario, West Region (MTO) under Purchase Order Number 3006-E-0123.

2 SITE DESCRIPTION

The site is located near the eastern limits of the City of Kitchener, approximately 700 m south of the Kitchener-Waterloo Expressway (KWE) and Wellington Street interchange. At this location, an underpass structure carries Frederick Street over the northbound and southbound lanes (NBL and SBL) of the KWE and existing ramps (E-S and S-E). The existing underpass at KWE and Frederick Street is a four-span structure supported on two abutments and three piers.

The site lies within an area of industrial and commercial lands and is generally flat.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows.

The following photographs of the site are included in Appendix E and show the general nature of the surrounding lands:

1. An aerial view of Kitchener-Waterloo Expressway and Frederick Street.
2. A view of the south side of the existing structure at Kitchener-Waterloo Expressway and Frederick Street underpass.

3 SITE INVESTIGATION AND FIELD TESTING

A site investigation and field testing at this site was carried out by DHO from May 26 to June 6, 1966 and consisted of drilling and sampling a total of nine boreholes (numbered 2, 3, 6, 7, 10, 11, 14, 16 and 17) and sixteen dynamic cone penetration tests (DCPTs). Nine DCPTs were conducted adjacent to the boreholes and seven DCPTs were conducted at various locations within the underpass area. Boreholes were terminated at depths ranging from 17.0 m to 25.5 m (elevations 301.4 to 309.0). DCPTs were terminated upon refusal between 3.4 m and 8.2 m depth (elevations 317.1 to 323.1).

An investigation was conducted in 2011 by Peto MacCallum (Reference 2) for the northeast corner retaining wall of the Frederick Street on Highway 7/85 (Kitchener-Waterloo Expressway). This investigation consisted of drilling and sampling four boreholes (numbered RW-1 to RW-4) advanced to depths ranging from 6.4 m to 9.8 m (elevations 309.9 to 316.5).

For description of the subsurface soil conditions, only the boreholes and DCPTs drilled in 1966 near the proposed structure were considered (Boreholes 2, 3, 6, 7, 10, 11 and 14 and DCPTs 1 to 14). A summary is presented for the boreholes drilled in 2012 (RW-1 to RW-4).

The Record of Borehole sheets and DCPTs from the previous investigations are included in Appendices A and B. The approximate locations of the boreholes and DCPTs are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix F.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were subjected to gradation analysis and Atterberg Limits testing. The results of these testing programs are shown on the Record of Borehole sheets in Appendices A and B. Grain size analysis distribution curves and Atterberg Limits results are also included in Appendices A and B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices A and B. Details of the encountered soil stratigraphy along the proposed alignment are presented in this appendix and on the “Borehole Locations and Soil Strata” drawing in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, at the time of the 1966 investigation, the site was underlain by topsoil overlying native layers of loose to very dense sand and sandy silt/silty sand and hard clayey silt/silty clay. The silty clay is underlain by very dense sandy silt to silty sand underlain by hard clay. Fill was encountered in one borehole drilled at the east end of the underpass. It should be recognized that since the deeper boreholes were drilled in 1966, it is possible that the current ground surface elevations may differ and the actual subsurface stratigraphy may have been modified by construction of cuts and addition of fills.

Boreholes drilled in 2011, at the northeast corner retaining wall revealed surficial asphalt and/or generally cohesionless fill overlying layers of native compact sand and stiff to hard silty clay.

5.1 Data from previous investigation, 1966 (Reference 1)

5.1.1 Topsoil

Sandy topsoil was encountered surficially in Boreholes 2, 3, 6, 7, 11, and 14. The thickness of the topsoil ranges from 0.9 m to 2.0 m.

SPT ‘N’ values recorded in the sandy topsoil ranged from 2 to 11 blows for 0.3 m penetration, indicating a very loose to compact relative density.

5.1.2 Fill

A 900-mm thick layer of gravelly sand fill was encountered surficially in Borehole 10, drilled near KWE northbound lane.

5.1.3 Sand

Native sand containing trace to some silt and trace gravel was encountered below the topsoil and fill in Boreholes 2, 3, 6, 7, 10, 11, and 14. The thickness of the native sand ranged from 2.3 m to 11.0 m.

Thin layers (approximately 0.9 m to 1.8 m thick) of silty fine sand, gravelly sand and silty clay were encountered within the sand in Boreholes 3, 11, and 14.

The depth to the base of the sand ranged from 4.3 m to 12.5 m (elevations 312.8 to 321.6).

Most of the SPT 'N' values recorded in the sand ranged from 9 to 36 blows for 0.3 m penetration, indicating a loose to dense relative density. Higher SPT 'N' values ranging from 45 blows for 0.3 m of penetration to 100 blows for less than 0.3 m of penetration, indicating a dense to very dense relative density, were measured near the base of the sand deposit in Boreholes 3, 11, and 14.

Moisture contents measured in Borehole 14 ranged from 12% to 28%.

Grain size distribution results from sand and gravelly sand samples are presented on the Record of Borehole sheets and in Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Sand (%)	Gravelly sand (%)
Gravel	2	47
Sand	80 to 97	46
Silt	1 to 20	7

5.1.4 Clayey Silt to Silty Clay

Native layers of clayey silt to silty clay containing some to trace sand and gravel were encountered in all of the boreholes at the depths and elevations indicated in Table 5.1. In most boreholes a lower layer of clayey silt to silty clay was encountered below a layer of sandy silt to silty sand.

Table 5.1 – Depths and Elevations of Clayey Silt to Silty Clay

Borehole	Depth below existing ground surface (m)	Thickness (m)	Elevation (m)
2	6.1 to 13.4	7.3	320.8 to 313.5
	18.0 to 25.5 (borehole termination depth)	7.5	308.9 to 301.4
3	6.1 to 11.9	5.8	320.6 to 314.8
6	4.3 to 6.1	1.8	321.2 to 319.3
	7.7 to 15.8	8.1	317.8 to 309.6
7	4.3 to 7.0	2.7	321.6 to 318.9
	10.1 to 14.0	3.9	315.8 to 311.8
10	6.1 to 17.2	11.1	319.4 to 308.3
11	4.3 to 7.0	2.7	321.3 to 318.6
	8.8 to 18.0	9.2	316.7 to 307.6
14	12.5 to 15.8	3.3	312.8 to 309.4
	18.6 to 20.3 (borehole termination depth)	1.7	306.7 to 305.0

SPT ‘N’ values measured in the clayey silt to silty clay generally ranged from 16 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a very stiff to hard consistency.

The natural moisture contents generally lay in the range of 9 to 29%.

Grain size distribution results for the clayey silt/silty clay samples tested are presented on the Record of Borehole sheets in Appendix A and in Appendix B. The results of Atterberg Limits tests for the clayey silt/silty clay samples are presented on the Record of Borehole sheets in Appendix A.

The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	7 to 14
Sand	1 to 28
Silt	41 to 80
Clay	15 to 57

Index Property	(%)
Liquid Limit	17 to 56
Plastic Limit	10 to 22

The silty clay ranges in plasticity from low to high.

5.1.5 Sandy Silt to Silty Sand

Native deposits of sandy silt to silty sand were encountered in all of the boreholes at depths and elevations indicated in Table 5.2. In general, an upper layer of sandy silt to silty sand was encountered within the clayey silt/silty clay deposit and a lower layer of sandy silt to silty sand was encountered below the clayey silt/silty clay deposit.

Table 5.2 – Depths and Elevations of Native Sandy Silt to Silty Sand

Borehole	Depth below existing ground surface (m)	Thickness (m)	Elevation (m)
2	13.4 to 18.0	4.6	313.5 to 308.9
3	11.9 to 18.1 (borehole termination depth)	6.2	314.8 to 308.6
6	6.1 to 7.7 15.9 to 17.2 (borehole termination depth)	1.6 1.3	319.3 to 317.8 309.6 to 308.3
7	7.0 to 10.1 14.0 to 17.0 (borehole termination depth)	3.1 3.0	318.9 to 315.8 311.8 to 308.8
10	4.3 to 6.1 17.2 to 17.5 (borehole termination depth)	1.8 0.3	321.2 to 319.4 308.3 to 308.0
11	7.0 to 8.8 18.0 to 18.6 (borehole termination depth)	1.8 0.6	318.6 to 316.7 307.6 to 307
14	15.8 to 18.6	2.8	309.4 to 306.7

SPT ‘N’ values measured in the sandy silt to silty sand ranged from 29 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a compact to very dense relative density.

The natural moisture contents generally lay in the range of 10% to 18%.

Grain size distribution results for the sandy silt to silty sand samples tested are presented on the Record of Borehole sheets Appendix A. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Sand	5 to 67
Silt	32 to 95

5.1.6 Groundwater Conditions

In 1966, water levels were observed during drilling operations at depths ranging from 2.6 m to 4.0 m below ground surface (elevations 321.3 to 322.9). These water levels may have been affected by subsequent construction of the underpass. The depth to water level at this site should be confirmed during additional field investigation required for the detailed design.

Seasonal fluctuations of the groundwater level are to be expected, in particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

5.2 Data from the 2012 investigation at Northeast Corner Retaining Wall (Reference 2)

Boreholes RW-1 to RW-4 were drilled at the northeast corner retaining wall at this site. The 2011 boreholes were advanced through the embankment fill and into the underlying native materials. The subsurface conditions encountered were as follows:

- Asphalt was encountered surficially in Boreholes RW-1 and RW-2 drilled on the existing Highway 7 speed change lane in front of the retaining wall.
- Fill was contacted below the asphalt in Boreholes RW-1 and RW-2 and surficially in Boreholes RW-3 and RW-4. The fill consisted of various soils: very loose sand with some silt and some gravel, compact sand and crushed gravel, compact silty sand and silt and very stiff clayey silt. The thickness of the fill ranged from 1.4 m to 2.3 m, with a base elevation of 318.3 to 321.2.
- Native brown sand containing trace to some gravel to gravelly, trace to some silty and trace clay was contacted below the fill at 2.3 m depth (elevations 320.0 and 321.2) in Boreholes RW-3 and RW-4. The sand was compact in density. The thickness of the sand layer was 2.1 and 3.6 m in Boreholes RW-3 and RW-4, respectively.
- Stiff to hard dark brown to grey silty clay containing trace sand and trace gravel was contacted below the fill in Boreholes RW-1 and RW-2 at 1.4 m depth (elevations 318.3) and below the sand in Boreholes RW-3 and RW-4 at 4.4 m and 5.9 depth (elevations 317.9 and 317.6). Layers of silty sand and gravelly sand were encountered within the silty clay in Borehole RW-3. Cobbles were noted in the silty clay in Boreholes RW-3 and RW-4. The silty clay is low to medium plastic. The boreholes were terminated within the silty clay at depths ranging from 6.4 m to 9.8 m (elevations 309.9 to 316.5).
- Water levels measured during, upon completion of drilling and in the piezometers are indicated in Table 5.3.

Table 5.3 – Water Level Measurements

Borehole	Date	Water Level (m)		Comments
		Depth	Elevation	
RW-1	April 8, 2011	2.9	316.8	In piezometer
RW-2	April 8, 2011	7.3	312.4	Upon completion of drilling
RW-3	April 8, 2011	3.0	319.3	During drilling
	July 19, 2011	Dry	-	In piezometer
	September 23, 2011	3.3	319.0	In piezometer
	October 8, 2011	3.3	319.0	In piezometer
RW-4	April 8, 2011	4.2	319.3	During drilling

Cave-in was observed in Boreholes RW-1, RW-2 and RW-4 at 5.0 m to 8.7 m depth (elevations 311.0 to 318.5).

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

Interpretation of the 1966 borehole data and preparation of the report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. R. Palomeque Reyna, P.Eng.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd

L. Blaine
Nov. 13/12

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Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets and Laboratory Test Results (Previous Investigation, Geocres No. 40P8-48 – Reference 1)

Foundation investigation report for Frederick Street Underpass, Kitchener-Waterloo Expressway, District #4 (Hamilton), W.J. 66-F-53, W.P. 634-64, Geocres No. 40P8-48, prepared by DHO (Department of Highways Ontario), dated July 21, 1966.

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

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

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

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

SOIL TESTS

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

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d , DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_i	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 66-P-53 LOCATION N 200,786.159, E210,719.093 ORIGINATED BY D.W.
W.P. 634-64 BORING DATE May 31, 1966. COMPILED BY D.W.
DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration CHECKED BY K.G.S.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WP	WL		
1072.7 0.0	Groundlevel										
					1070						
					1060						
1058.8 13.9	End of borehole.										
					1050						

103/11"

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-53

LOCATION N 200,803.248, E 210,761.731

ORIGINATED BY D.W.

W.P. 634-64

BORING DATE May 31, 1966.

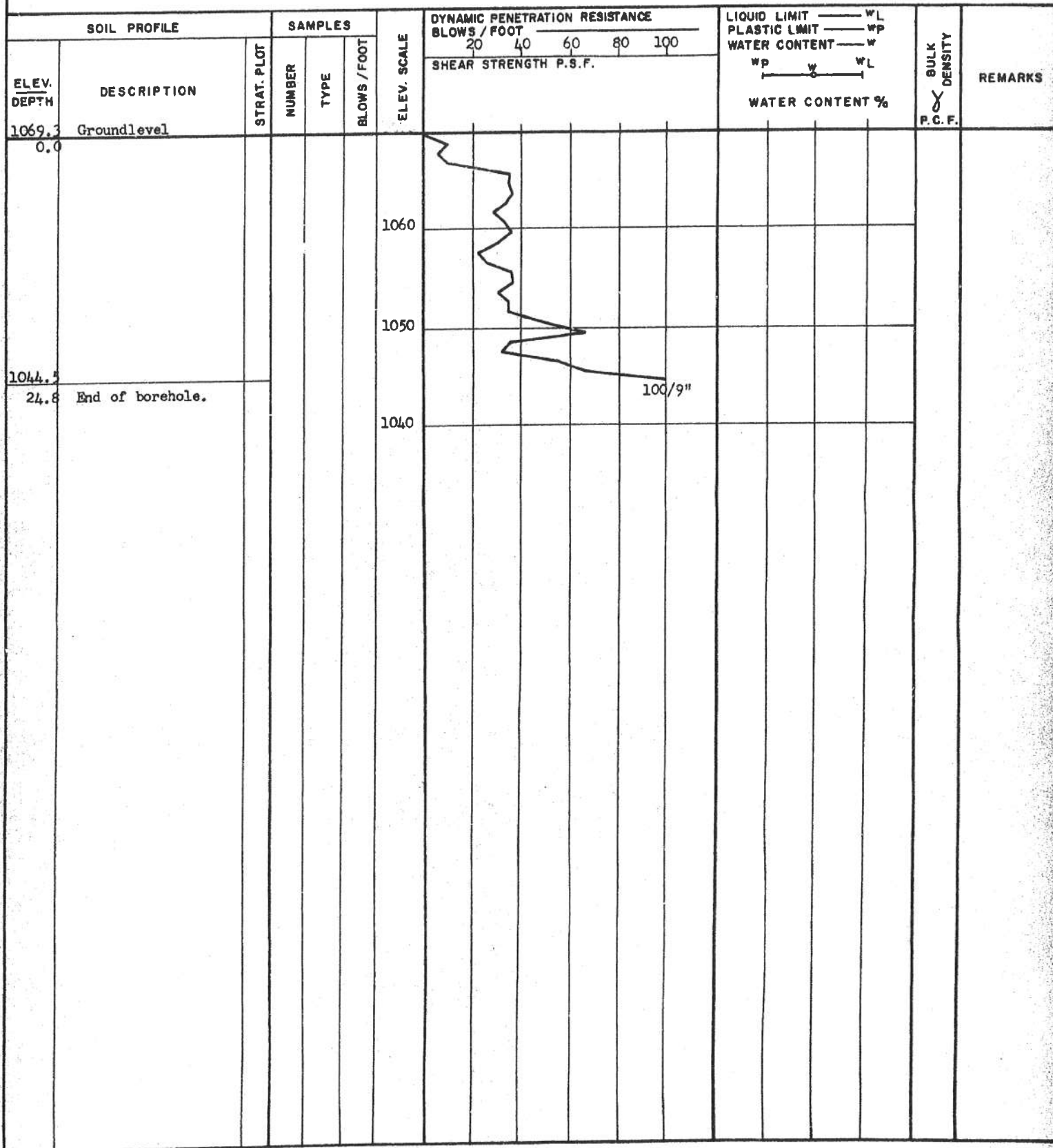
COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring.

CHECKED BY K.G.S.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		20 40 60 80 100	SHEAR STRENGTH P.S.F.	WP WL	WATER CONTENT % 15 30 45		
1071.9	Groundlevel										
0.0	Sand (Topsoil)				1070						Sa 92% Si 8%
1067.9	Loose	1	SS	2							
4.0	Sand	2	SS	10							
	Compact to dense.	3	SS	36							
1060.9	Silty fine sand	4	SS	22	1060						
1057.9	Compact										
14.0	Gravelly sand	5	SS	45							
	Dense to very dense	6	SS	62							
1051.9	Clayey silt	7	SS	27	1050						
20.0	Hard	8	SS	31							
1045.9	Grey	9	SS	49							
26.0	Silty clay	10	SS	108	1040						
	Hard	11	SS	60							
	Brownish grey										
1032.9		12	SS	99	1030						
39.0		13	SS	158							
	Silty fine sand to fine sandy silt.	14	SS	877/8"	1020						
	Very dense.										
1012.4		15	SS	507/8"							
59.5	End of borehole.				1010						



DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-53

LOCATION N 200,919.964, E 210,802.832

ORIGINATED BY D.W.

W.P. 634-64

BORING DATE May 30, 1966.

COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring.

CHECKED BY K.G.S. *KL*

SOIL PROFILE		STRAT. PLOT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT	20 40 60 80 100	WATER CONTENT % 15 30 45		
1067.7	Groundlevel										
0.0	Sand (Topsoil)										
1064.7	Loose										
3.0	Sand with trace of silt. Compact.		1	SS	24	1060					
			2	SS	28						
1053.7	Clayey silt. Very stiff		3	SS	26	1050					
1047.7	Grey		4	SS	28						
20.0	Fine sandy silt. Very dense		5	SS	157	11"					
1042.5			6	SS	67						
25.2	Silty clay with trace of sand and gravel. Hard.		7	SS	34	1040					
			8	SS	38						
			9	SS	60						
1032.7			10	SS	85	1030					
35.0	Silty clay Hard Brownish grey		11	SS	43						
			12	SS	60	1020					
1015.7											
52.0	Silty fine sand Very dense		13	SS	131	9"					
1011.4						1010					
56.3	End of borehole.										

GWL EL.
1059.2Gr 2%
Sa 90%
Si 8%Sa 42%
Si 58%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 66-F-53 LOCATION N 200,844.706, E 210,861.156

ORIGINATED BY D.W.

W.P. 634-64 BORING DATE May 31, 1966.

COMPILED BY D.W.

DATUM Geodetic BOREHOLE TYPE Penetration & Washboring.

CHECKED BY K.G.S.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W		
1069.1	Groundlevel										
0.0	Sand (Topsoil) Loose										Sa 88% Si 12%
1062.6		1	SS	6							
6.5	Sand with trace of silt. Compact.	2	SS	20	1060						GWL El. 1058.6
1055.1											
14.0	Clayey silt with trace of sand and gravel. Very stiff to hard.	3	SS	19							
1046.1		4	SS	16	1050						
23.0	Grey	5	SS	34							Sa 67% Si 32%
		6	SS	100/11"							
	Silty fine sand. Very dense.	7	SS	100/9"	1040						
1036.1		8	SS	52/3"							
33.0											
	Silty clay. Hard. Brownish grey.	9	SS	80	1030						
		10	SS	61							
1023.1		11	SS	97							
46.0					1020						
	Fine sandy silt. Very dense.										Sa 28% Si 72%
1013.2		12	SS	110/5"							
55.9	End of borehole.				1010						

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION
JOB 66-F-53
W.P. 634-64
DATUM Geodetic

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 66-F-53 LOCATION N 200.939.749, E 210.847.402 ORIGINATED BY D.W.
 W. P. 634-64 BORING DATE June 6, 1966. COMPILED BY D.W.
 DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration. CHECKED BY K.G.S. *AK*

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 66-F-53 LOCATION N 200,873.400, E 210,912.942 ORIGINATED BY D.W.
W.P. 634-64 BORING DATE June 2, 1966 COMPILED BY D.W.
DATUM Geodetic BOREHOLE TYPE Dynacore Cone Penetration. CHECKED BY K.G.S. *KGS*

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION
JOB 66-F-53
W. P. 634-64
DATUM Geodetic

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

LOCATION N 200,955.200, E 210,895.815

ORIGINATED BY D.W.

W. P. 634-64

BORING DATE June 3, 1966.

COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring

CHECKED BY K.G.S.O.

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 66-F-53

LOCATION N 200,883.088, E 210,947.710

ORIGINATED BY D.W.

W.P. 634-64

BORING DATE May 31, 1966.

COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring

CHECKED BY K.G.S. *AK*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT %	WATER CONTENT %		
1068.2	Groundlevel											
0.0	Sand (Topsoil)											
1063.2	Loose		1	SS	6							
5.0	Sand with trace of silt.		2	SS	13	1060						Sa 83% Si 17%
1057.2	Compact.		3	SS	23							GWL El. 1055.7
11.0	Silty fine sand.		4	SS	47							
1054.2	Dense		5	SS	32	1050						
14.0	Clayey silt with some sand and gravel.		6	SS	41							
1045.2	Hard.		7	SS	57							
23.0	Fine sandy silt		8	SS	70							Sa 25% Si 75%
1039.2	Very dense		9	SS	100/3 1/2"	1040						
29.0			10	SS	132							
			11	SS	131	1030						
	Silty clay.		12	SS	62							
	Hard.		13	SS	64	1020						
	Brownish grey.		14	SS	59							
1009.2			15	SS	62/5"	1010						
1007.2	Fine sandy silt. Very dense.											Sa 26% Si 74%
61.0	End of borehole.					1000						

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 12

FOUNDATION SECTION

JOB 66-F-53

LOCATION N 200,967.693, E 210,949.158

ORIGINATED BY D.W.

W. P. 634-64

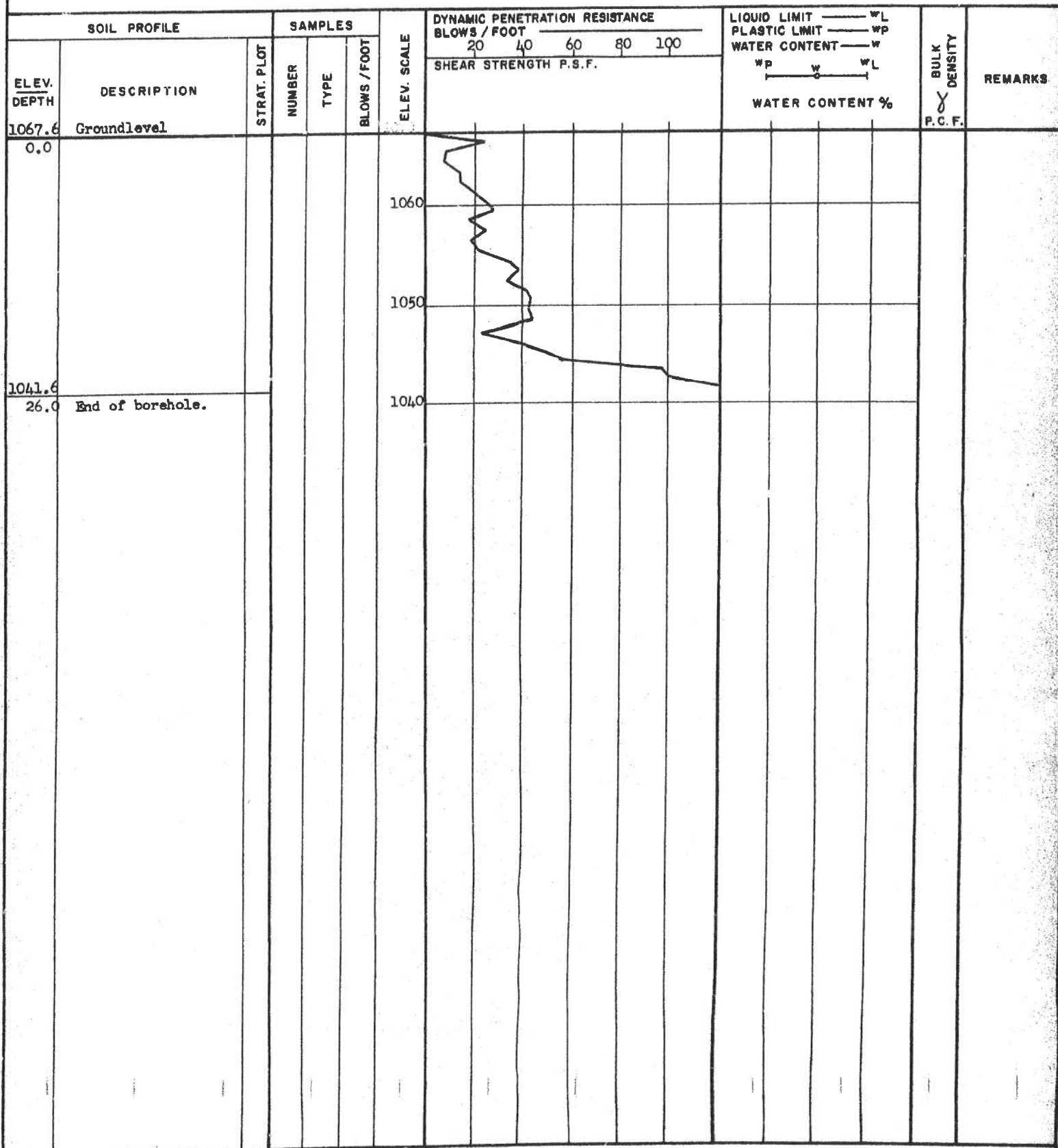
BORING DATE June 6, 1966

COMPILED BY D.W.

DATUM Goodetic

BOREHOLE TYPE Dynamic Cone Penetration.

CHECKED BY K.G.S.



DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-53LOCATION N 200,914,762, E 211,000,220ORIGINATED BY D.W.W.P. 634-64BORING DATE June 2, 1966COMPILED BY D.W.DATUM GeodeticBOREHOLE TYPE Dynamic Cone PenetrationCHECKED BY K.G.S.

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT 20 40 60 80 100	WATER CONTENT % WP — W — WL			
1067.0	Groundlevel										
0.0											
1044.4											
22.6	End of borehole.										

DEPARTMENT OF HIGHWAYS - ONTARIO
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 14

FOUNDATION SECTION

 JOB 66-F-53 LOCATION N 200,997.938, E 210,999.324
 W.P. 634-64 BORING DATE June 2, 1966
 DATUM Geodetic BOREHOLE TYPE Penetration & Washboring.

 ORIGINATED BY D.W.
 COMPILED BY D.W.
 CHECKED BY K.G.S.

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.					WATER CONTENT %				
1067.2	Groundlevel														
0.0	Sand (Topsoil)														
1062.2	Compact		1	SS	11										
5.0			2	SS	14	1060									
	Sand with trace of silt.		3	SS	18										
			4	SS	15										
	Compact.		5	SS	15	1050									
			6	SS	17										
			7	SS	20										
			8	SS	28										
1041.2	Silty clay with trace of sand. Hard.		9	SS	130	1040									
1038.2			10	SS	100/9"										
29.0	Sand with some silt. Very dense.		11	SS	62	1030									
			12	SS	93										
1026.2															
41.0	Silty clay. Hard.		13	SS	47	1020									
1015.2	Fine sandy silt. Very dense.		14	SS	109	1010									
1006.2															
61.0	Silty clay Hard														
1000.7	Brownish grey		15	SS	120	1000									
66.5	End of borehole.														

 Sa 89%
 Si 11%
 GWL EL.
 1054.2
 Sa 93%
 Si 7%
 Gr 2%
 Sa 97%
 Si 1%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 16

FOUNDATION SECTION

JOB 66-F-53

LOCATION N 201,116.543, E 210,741.917

ORIGINATED BY D.W.

W.P. 634-64

BORING DATE June 3, 1966

COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring

CHECKED BY K.G.S.

SOIL PROFILE			SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100 SHEAR STRENGTH P.S.F.	LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W WP — W — WL WATER CONTENT % 15 30 45	BULK DENSITY P.C.F.	REMARKS
E. EV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE					
1065.0	Groundlevel								
0.0	Sand								
	Compact		1	SS	17				
1056.0			2	SS	26				
9.0	Clayey silt to silty clay with some sand and gravel.		3	SS	62				
	Very stiff to hard		4	SS	111				
	Brownish grey.		5	SS	126				
			6	SS	87				
1036.0			7	SS	85				
29.0	Silty clay		8	SS	83				
	Hard		9	SS	39				
	Brownish grey.		10	SS	105				
1024.0			11	SS	93/6				
41.0	Silty fine sand.								
	Very dense								
1008.5			12	SS	116				
56.5	End of borehole.								

100/8"

Gr 7%
Sa 28%
Si 46%
Cl 19%

Sa 2%
Si 41%
Cl 57%

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 17

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-53

LOCATION N 200,754.293, E 210,935.966

ORIGINATED BY D.W.

W.P. 634-64

BORING DATE June 2, 1966

COMPILED BY D.W.

DATUM Geodetic

BOREHOLE TYPE Penetration & Washboring

CHECKED BY K.G.S.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W		
1069.6	Groundlevel											
0.0	Sand											
	Loose to v. dense		1	SS	9							
			2	SS	70	1060						
			3	SS	28							
1054.6	Clayey silt		4	SS	34							
15.0	Very stiff to hard.		5	SS	22	1050						
1049.1	Fine sandy silt, v. dense		6	SS	27							
20.5			7	SS	53							
1046.6	Clayey silt to silty clay.		8	SS	150/7"	1040						
23.0	Hard.		9	SS	60/6"							
	Brownish grey.		10	SS	88							
			11	SS	75	1030						
1025.4	Fine sandy silt.		12	SS	68/6"							
44.0	Very dense					1020						
1013.8			13	SS	50/3"							
55.8	End of borehole.					1010						

Sa 91%
 Si 9%
 GWL
 El. 1057.8
 Sa 1%
 Si 80%
 Cl 19%
 Sa 28%
 Si 72%

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

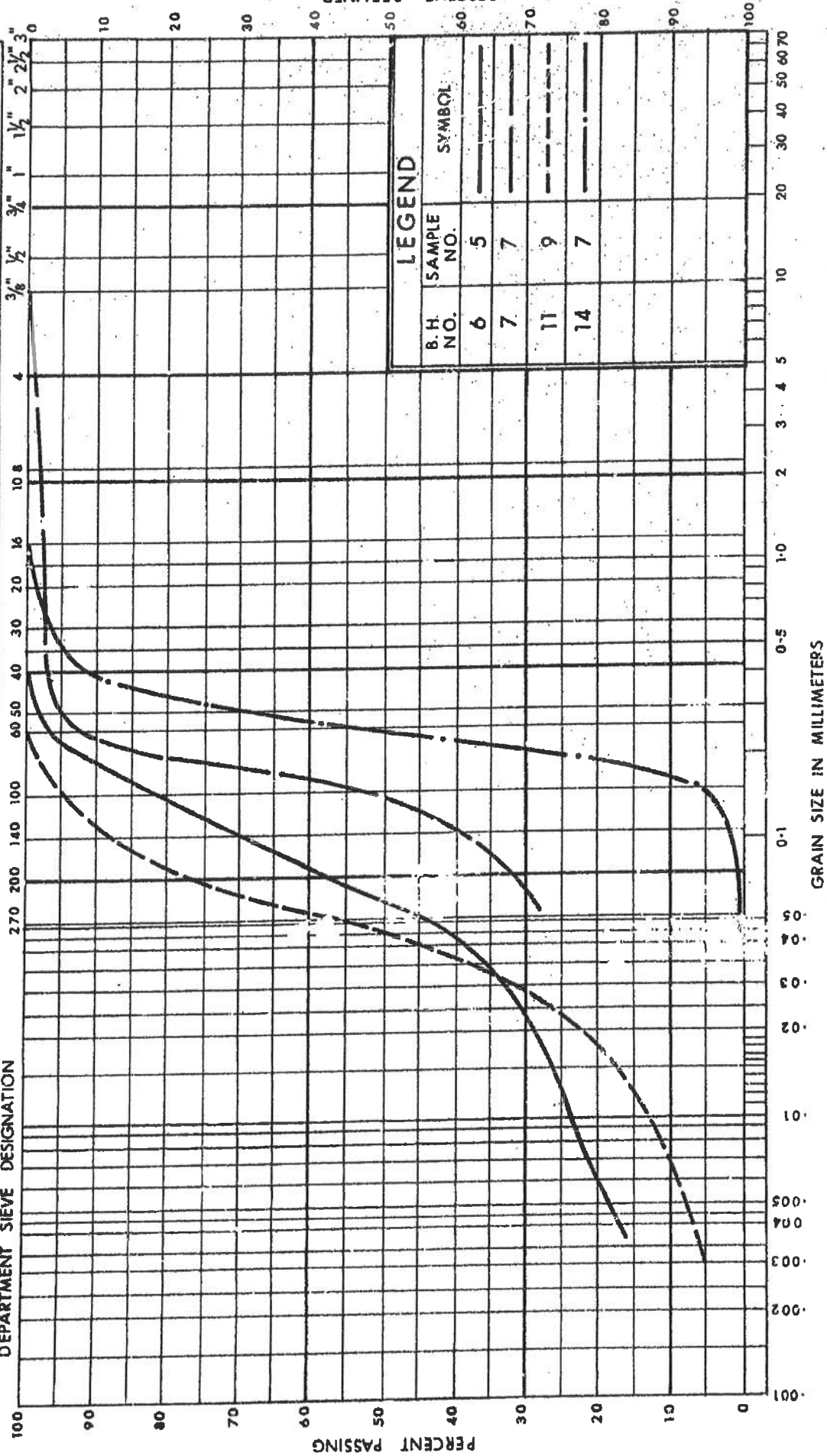
Fine 3/8" 1/2" 3/4" 1" 1 1/2" 2 1/2" 3"

Coarse 4 10.8

Medium 16 20 30 40 60 50 100 140 200 270

Fine

DEPARTMENT SIEVE DESIGNATION



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION

W.P. No. 634-64

JOB No. 66-F-53



ONTARIO

Appendix B

Record of Borehole Sheets and Laboratory Test Results (Previous Investigation, Geocres No. 40P8-199 – Reference 2)

Foundation investigation and design report for Northeast Corner Retaining Wall, Frederick Street Underpass, Site No. 33-234, G.W.P. 3110-09-00, City of Kitchener, Ontario, prepared by Peto MacCallum Ltd., PML Ref. 10KF079C, Geocres No. 40P8-199, dated May 31, 2012.

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 31mm 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 (31mm 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.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

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 - 20	20 - 30	> 30
	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	FM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE
FV FIELD VANE	

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u_v	l	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	l	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	l	COMPRESSION INDEX
C_s	l	SWELLING INDEX
C_{α}	l	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	l	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_r	l	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No RW-1

1 of 1

METRIC

G.W.P. 3110-09-00 LOCATION Coords: 4 813 701.9 N; 226 222.6 E ORIGINATED BY R.P.
DIST London HWY 7/ 85 BOREHOLE TYPE C.F.H.S.A. and Dynamic Cone Penetration Test COMPILED BY N.S.B.
DATUM Geodetic DATE April 08, 2011 CHECKED BY B.R.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		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		W _p	W			W _L
319.7	Ground Surface							20 40 60 80 100						
0.0	Asphalt over sand some silt, some gravel Very loose Brown Wet (FILL)		1	AS	-			20 40 60 80 100						
318.3			2	SS	3			20 40 60 80 100						
1.4	Silty clay, trace sand Very stiff Brown Moist sand layers to 4.9m Hard to Greyish very stiff brown Hard		3	SS	17			20 40 60 80 100	225				(**)	
			4	SS	34			20 40 60 80 100	225					
			5	SS	25			20 40 60 80 100	225					
			6	SS	28			20 40 60 80 100	225					
			7	SS	37			20 40 60 80 100	225					
			8	SS	31			20 40 60 80 100	225					
			9	SS	33			20 40 60 80 100	225					
			10	SS	39			20 40 60 80 100	225					
309.9	End of borehole							20 40 60 80 100						
9.8	<div>* Borehole dry</div> <div>(**) Base of footing -El.318.2</div> <div>Note: Borehole cave-in at 8.5m</div> <div>C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers</div> <div>Water Level Readings:</div> <div>Date Depth Elev. Apr. 08,'11 2.9 316.8</div> <div>Piezometer Legend:</div> <div><div>Bentonite seal</div><div>Filter sand</div><div>19mm dia.PVC screen</div><div>Bentonite grout</div></div>													

ON_MTO_VER3 NEW LOGO 10KF079 RW LOGS.GPJ ON_MOT.GDT 5/30/2012 12:54:22 PM

Numbers refer to
Sensitivity 20 15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RW-2
1 of 1
METRIC

G.W.P. 3110-09-00 **LOCATION** Coords: 4 813 710.4 N; 226 223.0 E **ORIGINATED BY** R.B.
DIST London **HWY** 7/ 85 **BOREHOLE TYPE** Continuous Flight Hollow Stem Augers **COMPILED BY** N.S.B.
DATUM Geodetic **DATE** April 08, 2011 **CHECKED BY** B.R.G.

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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
319.7	Ground Surface														
0.0	Asphalt over sand and crushed gravel, trace silt Compact Brown Moist (FILL)		1	AS	-		319								
318.3			2	SS	11										
1.4	Silty clay, trace gravel sand layers Stiff Dark Moist brown sand layers to 3.7m Hard Greyish brown		3	SS	9		318	225						(**)	
			4	SS	31		317	225							
			5	SS	23		316	225						0 2 45 53	
			6	SS	44		315	225							
			7	SS	43		313	225						0 0 32 68	
			8	SS	35		312	225							
			9	SS	29		310	225							
309.9	End of borehole														
9.8															
	* 2011 04 08 ▼ Water level measured after drilling (**) Base of footing -El.318.2 Note: Borehole cave-in at 8.7m														

* 2011 04 08





▼ Water level measured
after drilling

(**) Base of footing
-El.318.2

Note: Borehole cave-in at
8.7m

RECORD OF BOREHOLE No RW-3
1 of 1
METRIC

G.W.P. 3110-09-00 LOCATION Coords: 4 813 719.3 N; 226 229.5 E ORIGINATED BY F.P.
 DIST London HWY 7/ 85 BOREHOLE TYPE Dynamic Ram Sounder COMPILED BY N.S.B.
 DATUM Geodetic DATE July 19, 2011 CHECKED BY B.R.G.

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa												
						○ UNCONFINED			● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	WATER CONTENT (%)						
322.3	Ground Surface					20	40	60	80	100								GR SA SI CL
0.0	Silty sand some clay, trace gravel organic inclusions		1	SS	14													8 37 37 18
	Compact Grey Moist (FILL)		2	SS	27													3 50 34 13
	clayey silt layers																	4 26 45 25
	gravelly sand		3	SS	20													23 39 27 11
320.0	Compact Brown Damp clayey silt layers																	4 25 42 29
2.3	Sand trace to some gravel trace clay		4	SS	21													15 76 6 3
	Compact Brown Moist to wet		5	SS	18													10 76 10 4
			6	SS	14													(*) 73 12 4
317.9	Silty clay trace sand, trace gravel silty sand and gravelly sand layers, cobbles		7	SS	36													3 23 50 24
4.4	Hard Grey Moist		8	SS	67													
315.9			9	SS	70/15cm													
6.4	End of borehole																	
	Sample 9: Sampler bouncing																	
	 * 2011 07 19																	
	▽ Water level observed during drilling																	
	(**) Base of footing -El.318.2																	
	 Water Level Readings:																	
	Date Depth Elev. (m)																	
	July 19, '11 Dry ----																	
	Sept. 23, '11 3.3 319.0																	
	Oct. 08, '11 3.3 319.0																	
	 Piezometer Legend:																	
	 Bentonite seal																	
	 Filter sand																	
	 30mm dia. PVC screen																	
	 Filter bed																	

RECORD OF BOREHOLE No RW-4

1 of 1

METRIC

G.W.P. 3110-09-00 LOCATION Cords: 4 813 705.4 N; 226 228.2 E ORIGINATED BY A.L.

DIST London HWY 7/ 85 BOREHOLE TYPE Dynamic Ram Sounder COMPILED BY N.S.B

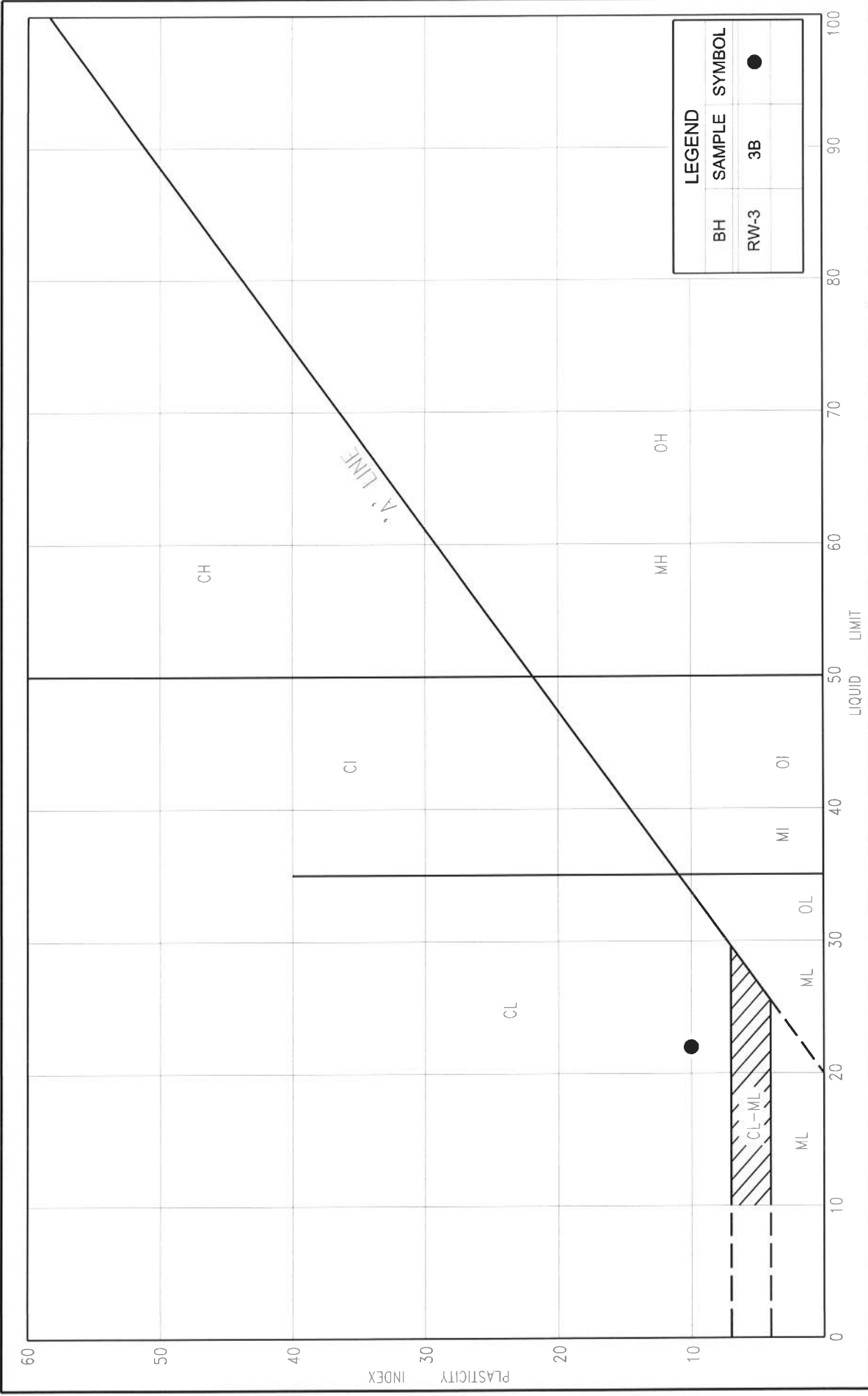
DATUM Geodetic DATE July 20, 2011 CHECKED BY B.R.G.

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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
323.5	Ground Surface						20	40	60	80	100						
0.0	Silty sand, some clay trace gravel, rootlets		1	SS	21											4 47 35 14	
	Compact Brown Moist (FILL)																
	Silt with sand, trace gravel		2	SS	21											22 20 54	
	Compact Grey Sand, some silt some gravel, trace clay		3	SS	21											15 68 11 6	
321.2	Compact Brown Clayey silt, trace sand											125					
2.3	Very stiff Grey		4	SS	20											9 83 (B)	
	Sand trace to some gravel trace to some silt trace clay																
	Compact Brown Moist to wet		5	SS	13											11 73 12 4	
	Gravelly to with gravel		6	SS	13											38 43 13 6	
			7	SS	9											26 68 3 3	
																(**)	
317.6			8	SS	14												
5.9	Silty clay, trace gravel cobbles		9	SS	49							175					
	Stiff to Grey Moist hard		10	SS	52/15cm												
316.5			11	SS	50/13cm												
7.0	End of borehole																
	Samples 10 and 11: Sampler bouncing																
	* 2011 07 20																
	▽ Water level observed during drilling																
	(**) Base of footing -El.318.2																
	Note: Borehole cave-in at 5.0m																

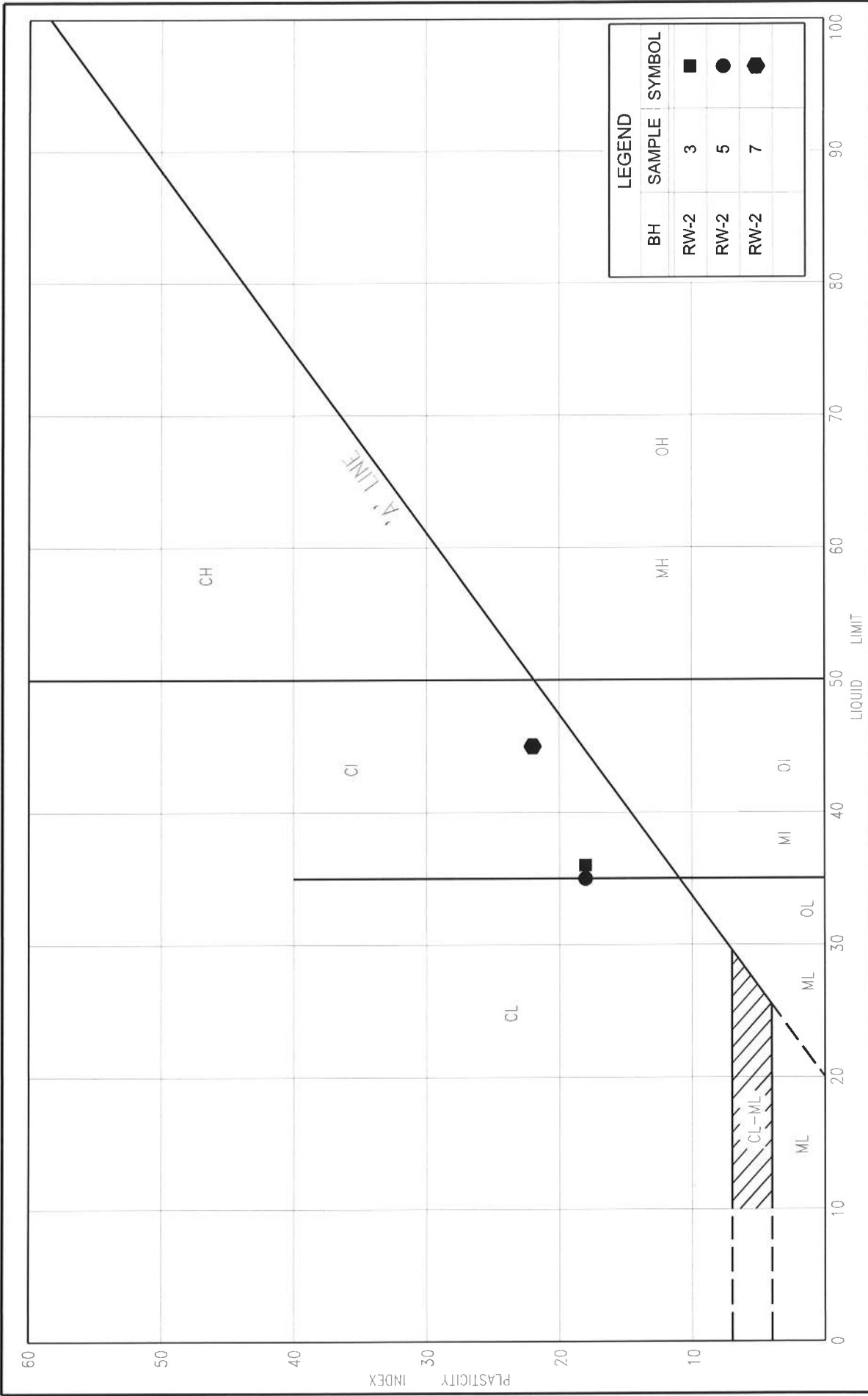



TABLE A-1
LIST OF ATTERBERG LIMITS RESULTS

SOIL TYPE	BOREHOLE NO.	SAMPLE NO.	DEPTH / ELEVATION (m)	MOISTURE CONTENT (W %)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)
Clayey Silt Fill	RW-3	3B	2.1 / 320.2	-	22	12	10
Silty Clay	RW-2	3	1.9 / 317.8	19	36	18	18
	RW-2	5	3.3 / 316.3	19	35	17	18
	RW-2	7	6.3 / 313.4	21	45	23	22



	PLASTICITY CHART		FIG No.	RW-PC-1
	CLAYEY SILT, with sand, trace gravel (CL)		HWY:	7 / 85
	(FILL)		G.W.P. No.	3110-09-00



**Ontario**

PLASTICITY CHART

SILTY CLAY, trace to with sand, trace gravel (CI)

FIG No. RW-PC-2

HWY: 7 / 85

G.W.P. No. 3110-09-00

Appendix C

Site Photographs

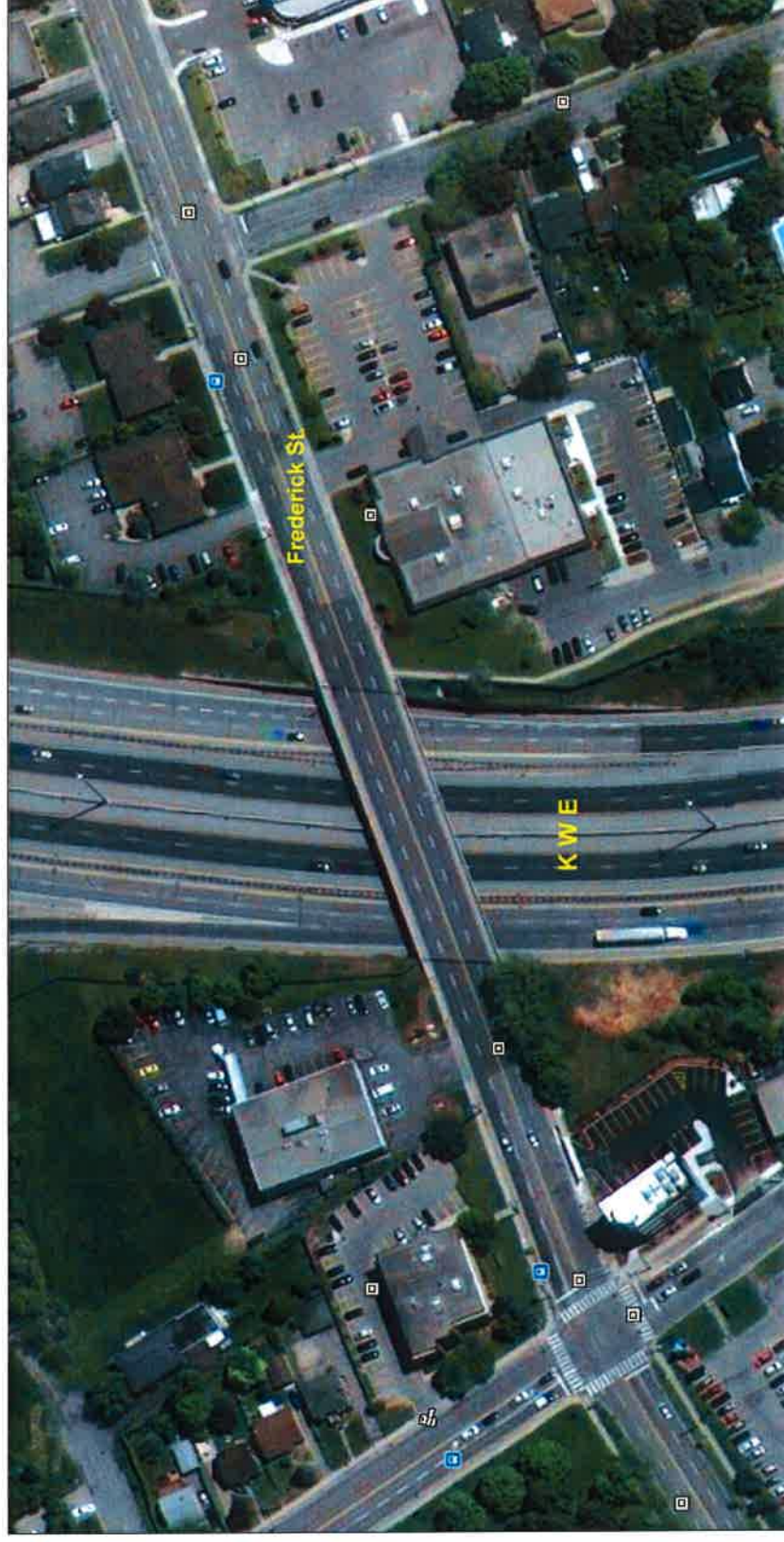


Photo 1. Aerial view of Kitchener-Waterloo Expressway and Frederick Street

Frederick Street Underpass
Highway 7-New, Kitchener to Guelph



Photo 2. Existing Frederick Street Underpass at Kitchener-Waterloo Expressway (south v

Appendix D

Drawing titled “Borehole Locations and Soil Strata”

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

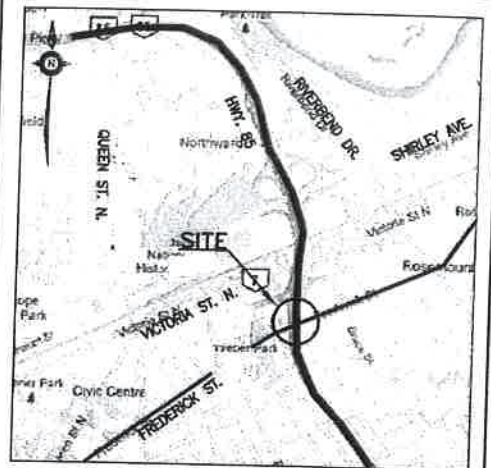
CONT No
WP No 408-88-00

FREDERICK STREET
UNDERPASS
BOREHOLE LOCATIONS PLAN

SHEET

Ontario

THURBER ENGINEERING LTD.



KEYPLAN LEGEND

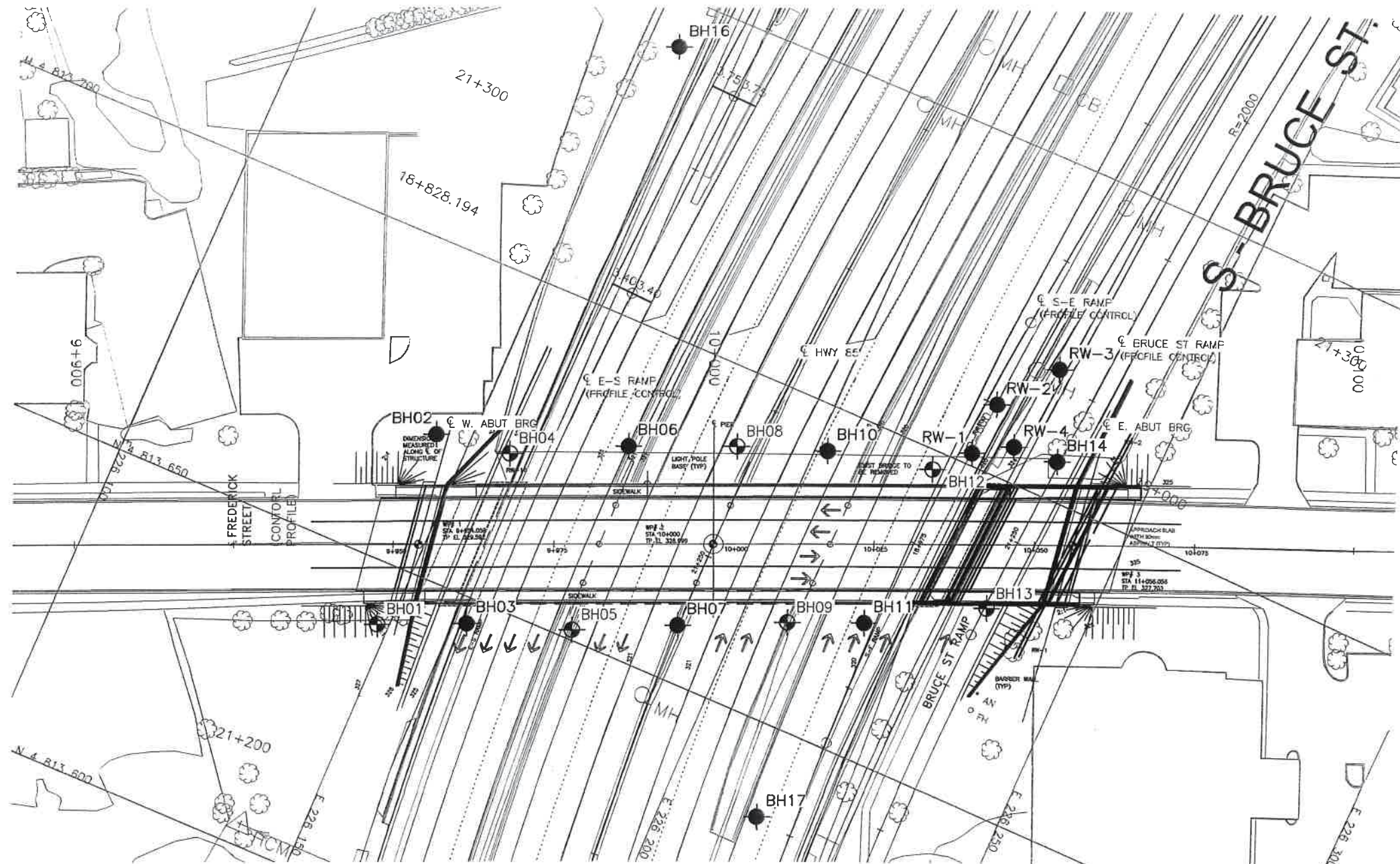
- ◆ Borehole & Cone (Previous Investigation)
- ◆ Cone Penetration Hole (Previous Investigation)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- P Piezometer
- 90° Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RW-1	319.7	4 813 701.9	226 222.6
RW-2	319.7	4 813 710.4	226 223.0
RW-3	322.3	4 813 719.3	226 229.5
RW-4	323.5	4 813 705.4	226 228.2
BH01	327.0		
BH02	326.9		
BH03	326.7		
BH04	325.9		
BH05	326.1		
BH06	325.4		
BH07	325.9		
BH08	325.6		
BH09	325.8		

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 40P8-203



BH10	325.5		
BH11	325.6		
BH12	325.4		
BH13	325.2		
BH14	325.3		
BH15	-		
BH16	324.6		
BH17	326.0		

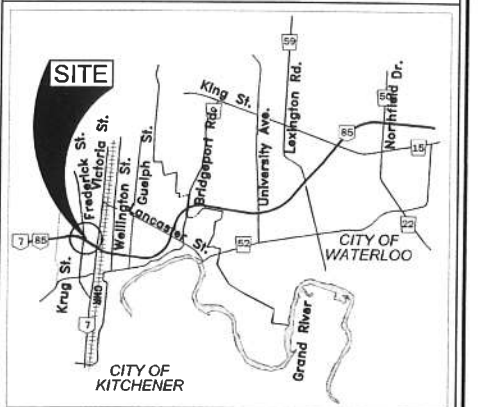
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK	LRB
DRAWN	AN	CHK	SITE
			STRUCT
			DWG 1
			DATE NOV. 2012

CONT No
GWP No 3110-09-00



FREDERICK STREET UNDERPASS
RETAINING WALL
HIGHWAY 7/85
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



LEGEND

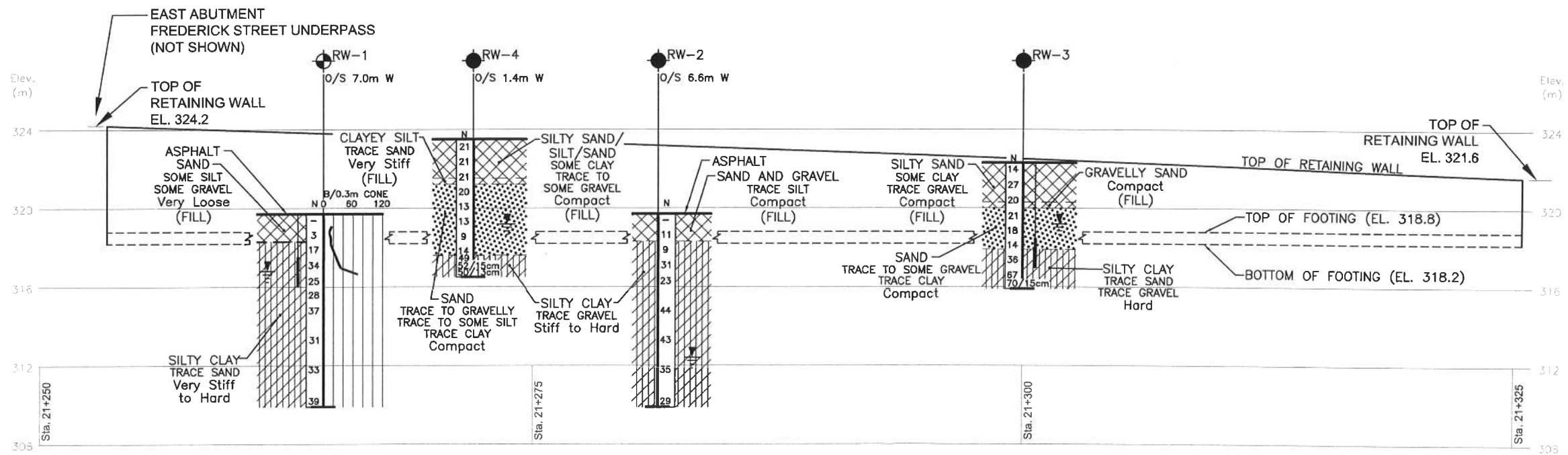
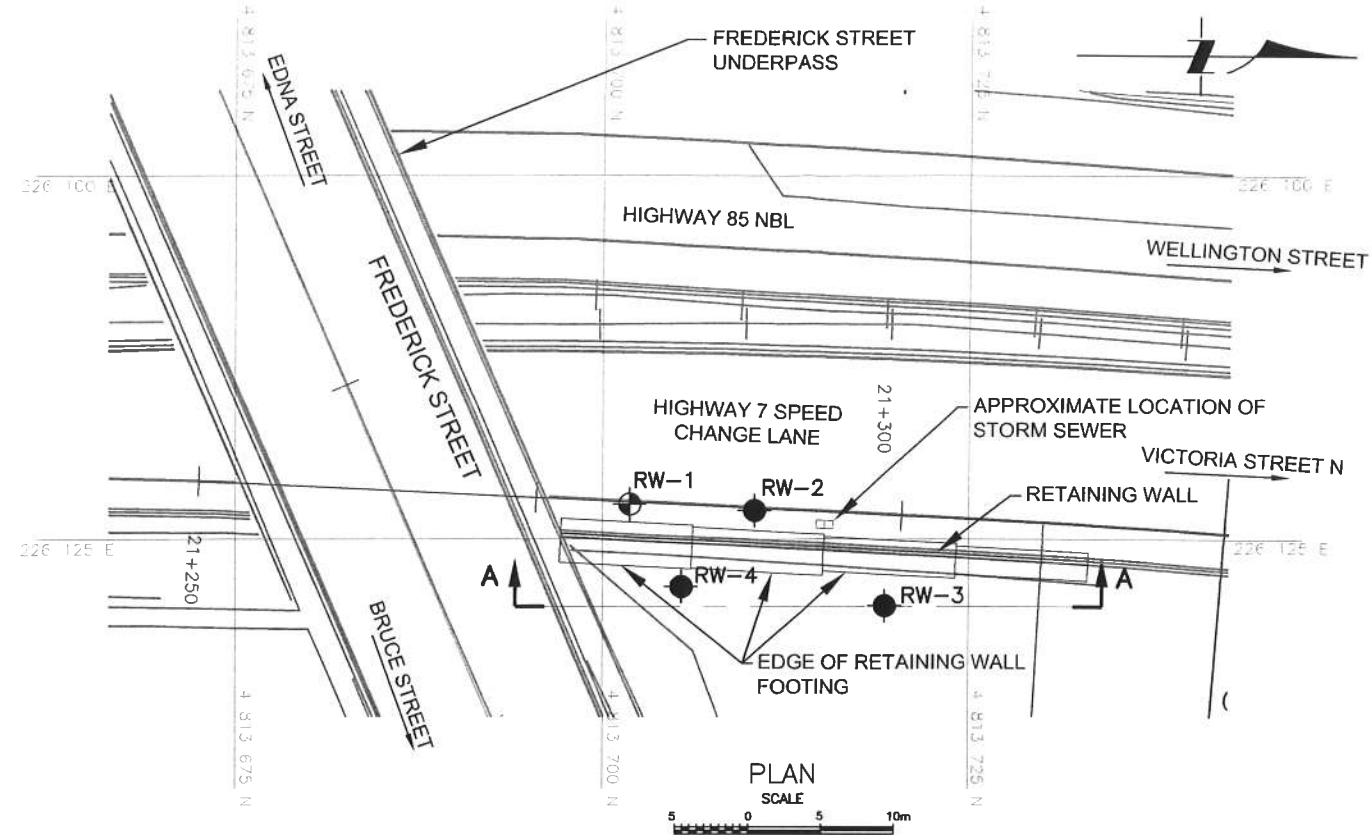
- Borehole
- Dynamic Cone Penetration Test (Cone)
- Borehole & Cone
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation April and July 2011
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
RW-1	319.7	4 813 701.9	226 222.6
RW-2	319.7	4 813 710.4	226 223.0
RW-3	322.3	4 813 719.3	226 229.5
RW-4	323.5	4 813 705.4	226 228.2

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 40PB-199	HWY No 7 / 85	DIST London
SUBM'D NA	CHECKED NSB	DATE MAY 28, 2012
DRAWN NA	CHECKED CN	APPROVED BRG
		DWG RW-1



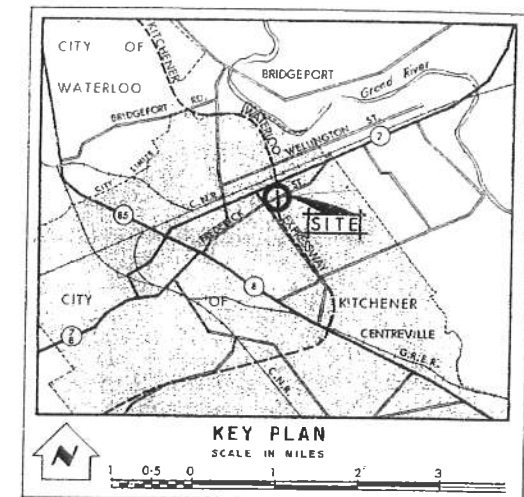
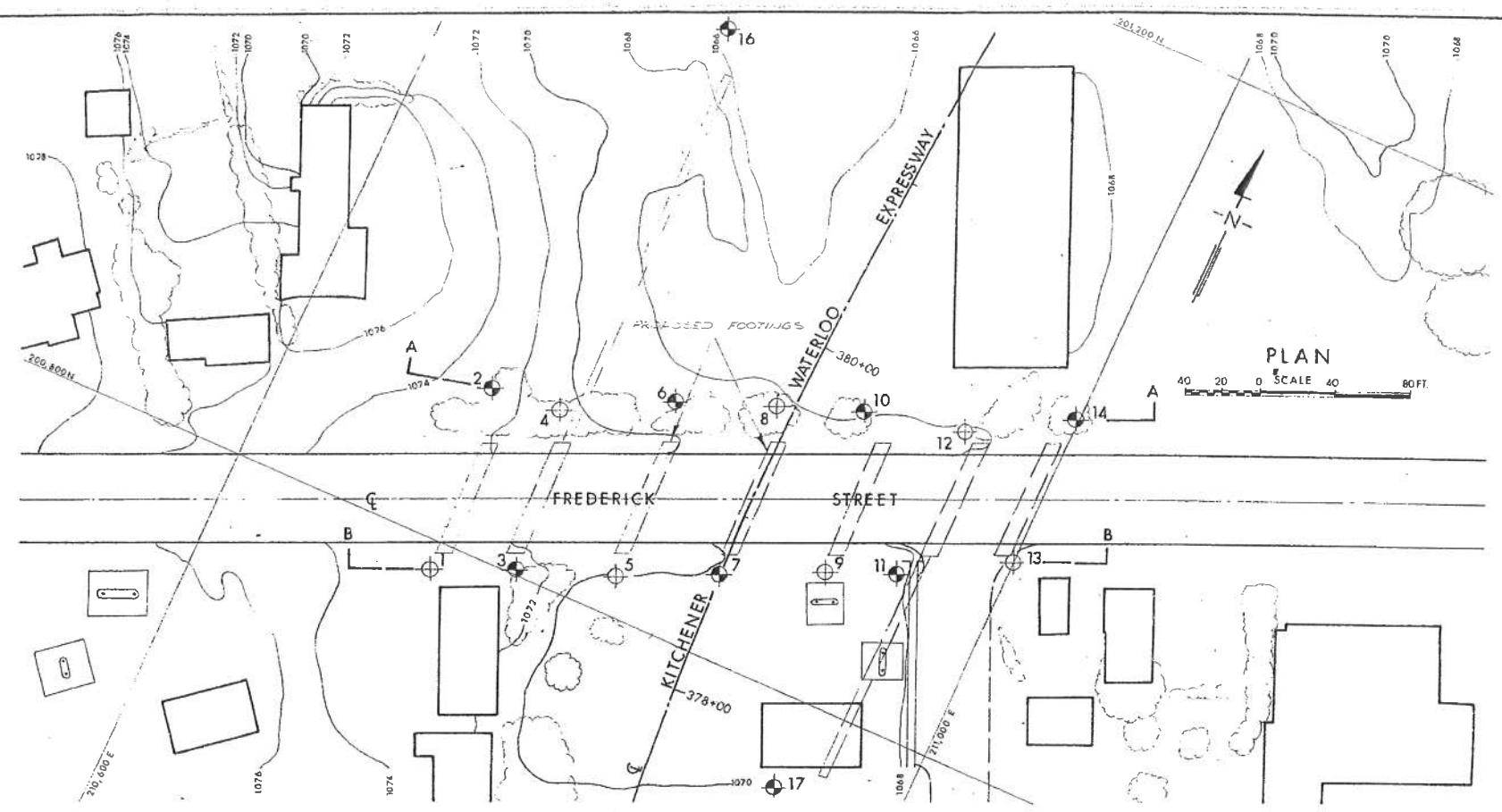
PROFILE A - A

NOTES:

- DRAWING RW-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



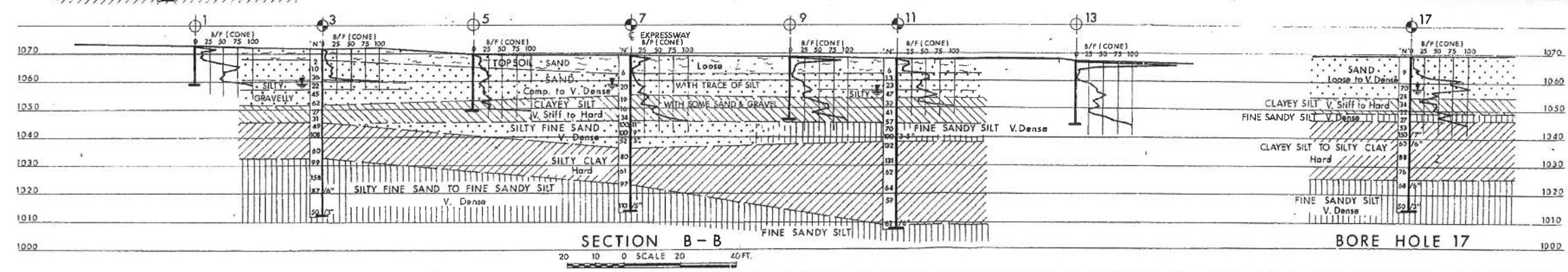
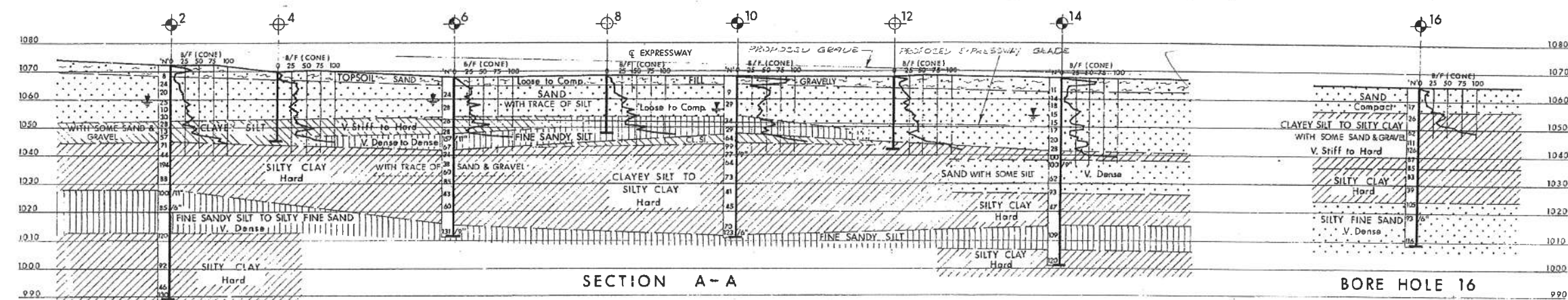
REF MRC Drawing: 2010362_Alignment.dwg; CONTRACT
DRAWINGS - CONTRACT No. 68-62



- LEGEND**
- Bore Hole
 - ⊕ Cons. Penetration Hole
 - ⊗ Bore & Cone Penetration Hole
 - Water Levels established at time of field investigation, MAY & JUNE 1966

NO.	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	1072.7	200,785	210,719
2	1072.4	200,887	210,709
3	1071.9	200,803	210,761
4	1069.3	200,890	210,747
5	1069.8	200,821	210,811
6	1067.7	200,919	210,802
7	1069.1	200,844	210,861
8	1068.1	200,939	210,847
9	1069.0	200,873	210,912
10	1067.9	200,955	210,895
11	1068.2	200,883	210,947
12	1067.6	200,967	210,949
13	1067.0	200,914	211,000
14	1067.2	200,797	210,999
16	1065.0	201,116	210,741
17	1069.6	200,754	210,935

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



PRINT RECORD		
NO.	FOR	DATE

REVISIONS		
NO.	DATE	DESCRIPTION

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

FREDERICK STREET

KING'S HIGHWAY NO. KITCHENER-WATERLOO EXPRY. DIST. NO. 4
CO. WATERLOO CITY OF KITCHENER
TWP. LOT CON.

BORE HOLE LOCATIONS & SOIL STRATA

SUB'D. D.W. CHECKED	W.P. NO. 634-6A	M.B.T. DRAWING NO.
DRAWN S.O. CHECKED	JOB NO. 66-F-53	66-F-53A
DATE 16 AUG. 1966	SITE NO.	BRIDGE DRAWING NO.
APPROVED	CONT. NO.	