

**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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**November 13, 2012  
File: 15-64-17**

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**PRELIMINARY  
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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**

<b>Borehole</b>	<b>Depth below existing ground surface (m)</b>	<b>Thickness (m)</b>	<b>Elevation (m)</b>
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:

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

<b>Index Property</b>	<b>(%)</b>
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**

<b>Borehole</b>	<b>Depth below existing ground surface (m)</b>	<b>Thickness (m)</b>	<b>Elevation (m)</b>
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	1.6	319.3 to 317.8
	15.9 to 17.2 (borehole termination depth)	1.3	309.6 to 308.3
7	7.0 to 10.1	3.1	318.9 to 315.8
	14.0 to 17.0 (borehole termination depth)	3.0	311.8 to 308.8
10	4.3 to 6.1	1.8	321.2 to 319.4
	17.2 to 17.5 (borehole termination depth)	0.3	308.3 to 308.0
11	7.0 to 8.8	1.8	318.6 to 316.7
	18.0 to 18.6 (borehole termination depth)	0.6	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:

<b>Soil Particles</b>	<b>(%)</b>
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*

Lindsey Blaine, E.I.T  
Project Manager

Rocío Palomeque Reyna, P.Eng.  
Geotechnical Engineer



P.K. Chatterji, P.Eng.,  
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

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	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
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

### GENERAL

$\pi$	= 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
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	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
$\beta$	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.					WATER CONTENT %			
1072.7 0.0	Groundlevel														
1058.8 13.9	End of borehole.														





DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

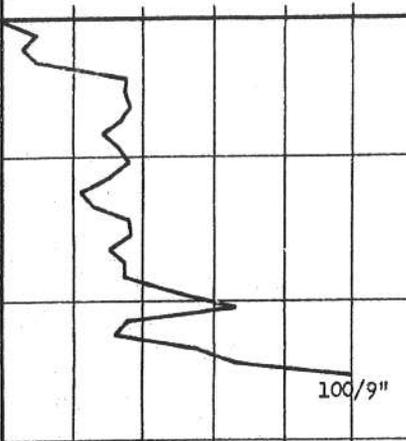
FOUNDATION SECTION

JOB 66-F-53  
 W.P. 634-64  
 DATUM Geodetic

LOCATION N 200,890.443, E 210,747.672  
 BORING DATE May 30, 1966.  
 BOREHOLE TYPE Dynamic Cone Penetration.

ORIGINATED BY D.W.  
 COMPILED BY D.W.  
 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	20	40	60	80	100	WP	W		
1069.3 0.0	Groundlevel														
1044.5 24.8	End of borehole.														



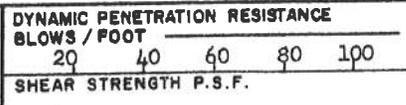
DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 66-F-53 LOCATION N 200.821.407, E210.811.176 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. *[Signature]*

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	ELEV. SCALE	20	40	60	80	100	WP	W		
1069.8 0.0	Groundlevel														
1049.8 20.0	End of borehole.														



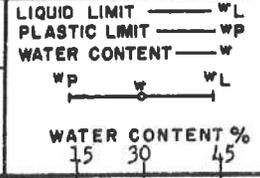
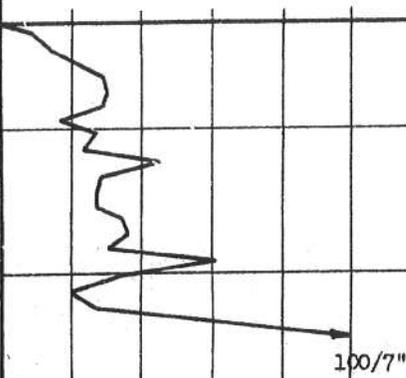
DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION  
 JOB 66-F-53  
 W.P. 634-64  
 DATUM Geodetic

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

LOCATION N 200,919.964, E 210,802.832 ORIGINATED BY D.W.  
 BORING DATE May 30, 1966. COMPILED BY D.W.  
 BOREHOLE TYPE Penetration & Washboring. CHECKED BY K.G.S. *[Signature]*

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
			NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	PLASTIC LIMIT — WP	WATER CONTENT — W	WATER CONTENT %		
1067.7	Groundlevel											
0.0	Sand (Topsoil)											
1064.7	Loose											
3.0	Sand with trace of silt. Compact.		1	SS	24	1060						GWL El. $\nabla$ 1059.2 Gr 2% Sa 90% Si 8%  Sa 42% Si 58%
			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.											









DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

JOB 66-F-53  
 W.P. 634-64  
 DATUM Geodetic

LOCATION N 200,955.200, E 210,895.815  
 BORING DATE June 3, 1966.  
 BOREHOLE TYPE Penetration & Washboring

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

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — wp WATER CONTENT — w			BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	wp	w		
1067.9	Groundlevel															
0.0	Fill gravelly sand.															
1064.9																
3.0	Sand with trace of silt. Loose to compact.		1	SS	9	1060										Sa 90% S1 10%
			2	SS	29											
1053.9																
14.0	Fine sandy silt. Dense		3	SS	34	1050										
1047.9			4	SS	29											
20.0	Clayey silt with some sand & gravel. Hard.		5	SS	54											
1044.9			6	SS	99											
23.0			7	SS	77	9"1040										
	Clayey silt to silty clay. Hard. Brownish grey.		8	SS	64											
			9	SS	73	1030										
			10	SS	41											
			11	SS	45	1020										
1011.4	Fine sandy silt.		12	SS	70											
1010.6	Very dense.		13	SS	123	6"1010										
57.5	End of borehole.															Sa 5% S1 95%

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 66-F-53  
 W.P. 634-64  
 DATUM Geodetic

LOCATION N 200,883.088, E 210,947.710  
 BORING DATE May 31, 1966.  
 BOREHOLE TYPE Penetration & Washboring

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

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W	BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.			
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						
14.0	Clayey silt with some sand and gravel.		6	SS	41	1050					
1045.2	Hard.		7	SS	57						Sa 25% Si 75%
23.0	Fine sandy silt		8	SS	70						
1039.2	Very dense		9	SS	100/3 1/2	1040					
29.0			10	SS	132						Sa 1% Si 54% Cl 45%
	Silty clay.		11	SS	131	1030					
	Hard.		12	SS	62						
	Brownish grey.		13	SS	64	1020					
			14	SS	59						
1009.2						1010					
1007.2	Fine sandy silt. Very dense.		15	SS	62/5						Sa 26% Si 74%
61.0	End of borehole.					1000					

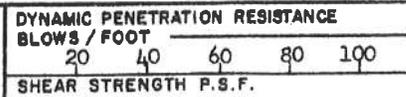
DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

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 Geodetic BOREHOLE TYPE Dynamic Cone Penetration. CHECKED BY K.G.S. *AK*

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	BLOWS / FOOT	BLOWS / FOOT	PLASTIC LIMIT ——— WP	WATER CONTENT ——— W	WATER CONTENT %		
1067.6 0.0	Groundlevel													
1041.6 26.0	End of borehole.													



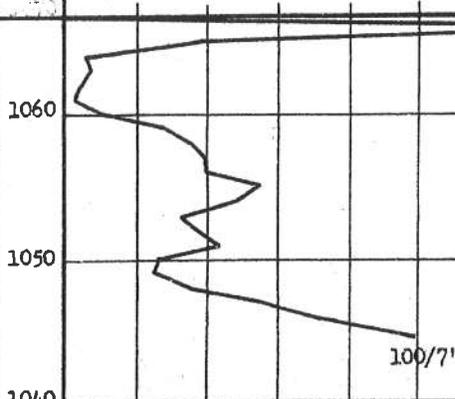
DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 66-F-53 LOCATION N 200,914,762, E 211,000,220 ORIGINATED BY D.W.  
 W.P. 634-64 BORING DATE June 2, 1966 COMPILED BY D.W.  
 DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration 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	ELEV. SCALE	BLOWS / FOOT	20	40	60	80	100	WP			W
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 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 PLASTIC LIMIT — WP			BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT 20 40 60 80 100				WATER CONTENT — W WP W WL				
1067.2	Groundlevel														
0.0	Sand (Topsoil)														
1062.2	Compact		1	SS	11										
5.0	Sand with trace of silt.  Compact.		2	SS	14										
			4	SS	18										
			4	SS	15										
			5	SS	15										
			6	SS	17										
			7	SS	20										
			8	SS	28										
			8	SS	28										
1041.2	Silty clay with trace of sand. Hard.		9	SS	130										
1038.2			10	SS	100/9"										
29.0	Sand with some silt.  Very dense.		11	SS	62										
1026.2			12	SS	93										
41.0	Silty clay.  Hard.		13	SS	47										
1015.2			14	SS	109										
52.0	Fine sandy silt.  Very dense.		14	SS	109										
1006.2			15	SS	120										
61.0	Silty clay Hard		15	SS	120										
1000.7	Brownish grey		15	SS	120										
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

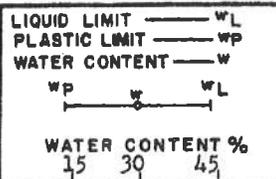
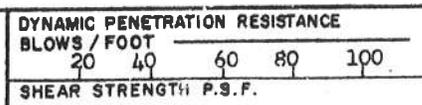
FOUNDATION SECTION

JOB 66-F-53  
W.P. 634-64  
DATUM Geodetic

LOCATION N 201,116.543, E 210,741.917  
BORING DATE June 3, 1966  
BOREHOLE TYPE Penetration & Washboring

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

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY	REMARKS
E. EV. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W		
1065.0	Groundlevel										
0.0	Sand										
	Compact	1	SS	17	1060						
1056.0		2	SS	26							
9.0	Clayey silt to silty clay with some sand and gravel.	3	SS	62	1050						
	Very stiff to hard	4	SS	111							
	Brownish grey.	5	SS	126	1040						
		6	SS	87							
1036.0		7	SS	85							
29.0	Silty clay	8	SS	83	1030						
	Hard	9	SS	39							
	Brownish grey.										
1024.0		10	SS	105							
41.0	Silty fine sand.	11	SS	93/6	1020						
	Very dense										
1008.5		12	SS	116	1010						
56.5	End of borehole.				1000						



Gr 7%  
Sa 28%  
Si 46%  
Cl 19%  
  
Sa 2%  
Si 41%  
Cl 57%

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

RECORD OF BOREHOLE NO. 17

FOUNDATION SECTION

LOCATION N 200,754.293, E 210,935.966 ORIGINATED BY D.W.  
 BORING DATE June 2, 1966 COMPILED BY D.W.  
 BOREHOLE TYPE Penetration & Washboring CHECKED BY K.G.S.

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20	40	60	80	100	WP	WL		
1069.6	Groundlevel															
0.0	Sand Loose to v. dense	[Dotted pattern]	1	SS	9											
			2	SS	70	1060										
			3	SS	28											
1054.6	Clayey silt Very stiff to hard.	[Horizontal lines]	4	SS	34											
1049.1	Fine sandy silt, v. dense	[Vertical lines]	5	SS	22	1050										
1046.8			6	SS	27											
23.0	Clayey silt to silty clay. Hard. Brownish grey.	[Diagonal lines]	7	SS	53											
			8	SS	150/7"	1040										
			9	SS	60/6"											
			10	SS	88											
			11	SS	75	1030										
1025.0	Fine sandy silt. Very dense	[Vertical lines]	12	SS	68/6"											
			13	SS	50/3"	1020										
1013.8	End of borehole.					1010										

Sa 91%  
 Si 9%  
 GWL  
 El. 1057.8

Sa 1%  
 Si 80%  
 Cl 19%

Sa 28%  
 Si 72%

100/7"

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

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

Coarse

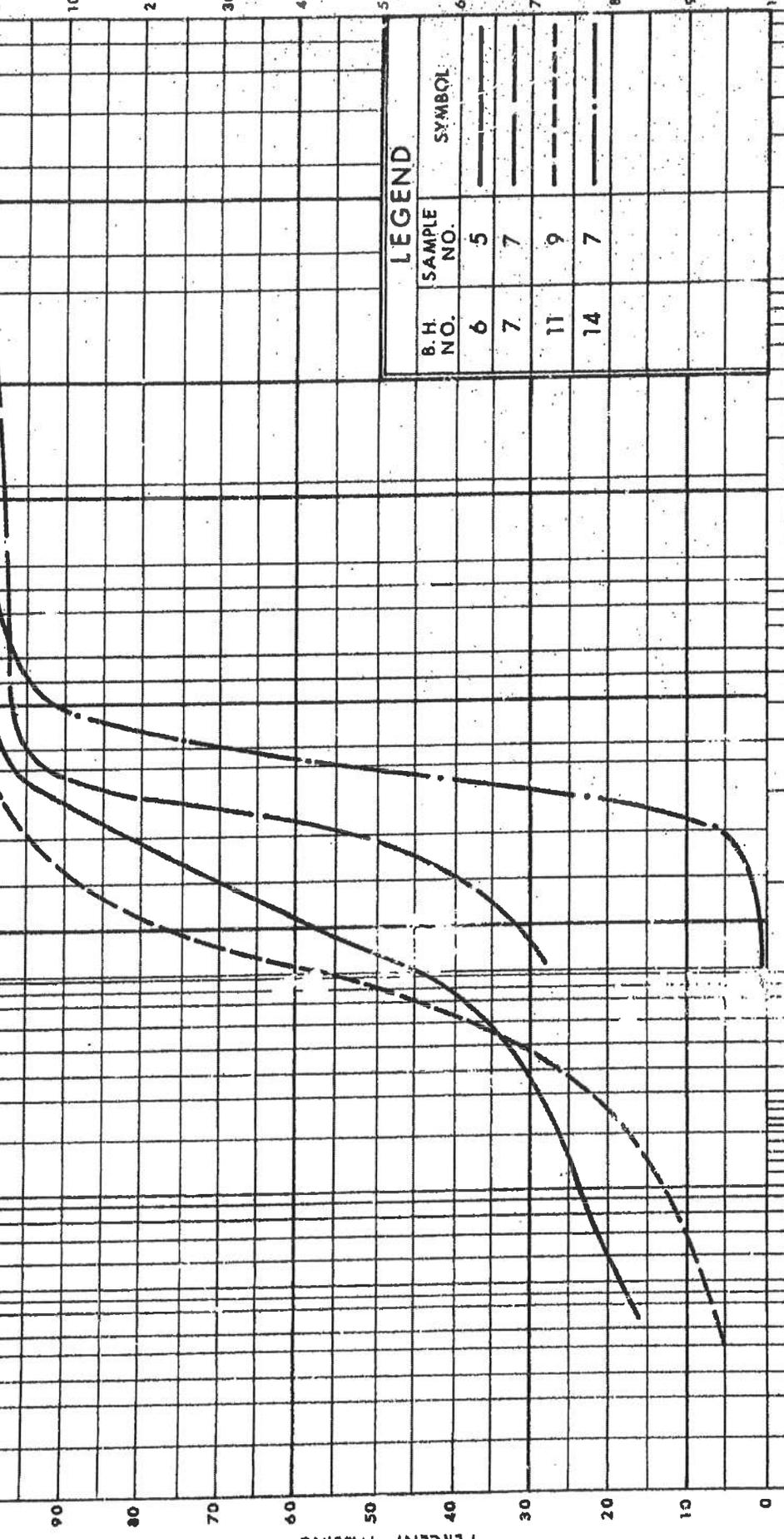
Medium

Fine

Coarse

DEPARTMENT SIEVE DESIGNATION

100 90 80 70 60 50 40 30 20 10 0



PERCENT PASSING

PERCENT RETAINED

GRAIN SIZE IN MILLIMETERS

LEGEND

B.H. NO.	SAMPLE NO.	SYMBOL
6	5	—
7	7	—
11	9	- - -
14	7	· · ·

DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION



ONTARIO

GRAIN SIZE DISTRIBUTION

W.P. No. 634-64

JOB No. 66-F-53

## **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 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 BODS. 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	10-30	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	F M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	l	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	l	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

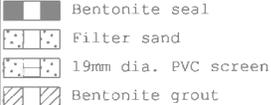
$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	l	COMPRESSION INDEX
$C_s$	l	SWELLING INDEX
$C_{\alpha}$	l	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	l	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_r$	l	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$n$	l, %	POROSITY	$e_{max}$	l, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$w$	l, %	WATER CONTENT	$e_{min}$	l, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	l	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	$D$	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	l	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	l	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	l	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	$i$	l	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTPL		WETTER THAN PLASTIC LIMIT	$j$	kN/m <sup>3</sup>	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 LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20					
319.7	Ground Surface												
0.0	Asphalt over sand some silt, some gravel Very loose Brown Wet		1	AS	-								
	(FILL)		2	SS	3								
318.3	Silty clay, trace sand Very stiff Brown Moist		3	SS	17								
1.4	sand layers to 4.9m Hard to Greyish very stiff brown		4	SS	34								
			5	SS	25								
			6	SS	28								
	Hard		7	SS	37								
			8	SS	31								
			9	SS	33								
			10	SS	39								
309.9	End of borehole												
9.8	* Borehole dry (**) Base of footing -El.318.2 Note: Borehole cave-in at 8.5m  C.F.H.S.A. denotes Continuous Flight Hollow Stem Augers  <u>Water Level Readings:</u> Date            Depth    Elev. Apr. 08, '11    2.9      316.8  <u>Piezometer Legend:</u> 												

**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 <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
319.7	Ground Surface													
0.0	Asphalt over sand and crushed gravel, trace silt Compact Brown Moist (FILL)		1	AS	-									
318.3			2	SS	11									
1.4	Silty clay, trace gravel sand layers Stiff Dark Brown Moist sand layers to 3.7m Hard Greyish brown		3	SS	9				225					(**)
			4	SS	31				225					
			5	SS	23				225					0 2 45 53
			6	SS	44				225					
			7	SS	43				225					0 0 32 68
			8	SS	35				225					
			9	SS	29				225					
309.9	End of borehole													

\* 2011 04 08

Water level measured after drilling

(\*\*) Base of footing -E1.318.2

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 <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
						20	40	60	80	100	20	40	60	GR SA SI CL
322.3	Ground Surface													
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													23 39 27 11
320.0	Compact Brown Damp clayey silt layers		3	SS	20									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									(H*) 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	End of borehole		9	SS	70/15cm									
6.4	Sample 9: Sampler bouncing													
	* 2011 07 19													
	▽ Water level observed during drilling													
	(**) Base of footing -El.318.2													
	<u>Water Level Readings:</u>													
	Date      Depth      Elev.													
	July 19, '11      Dry      ----													
	Sept. 23, '11      3.3      319.0													
	Oct. 08, '11      3.3      319.0													
	<u>Piezometer Legend:</u>													
	Bentonite seal													
	Filter sand													
	30mm dia. PVC screen													
	Filter bed													

**RECORD OF BOREHOLE No RW-4**

1 of 1

**METRIC**

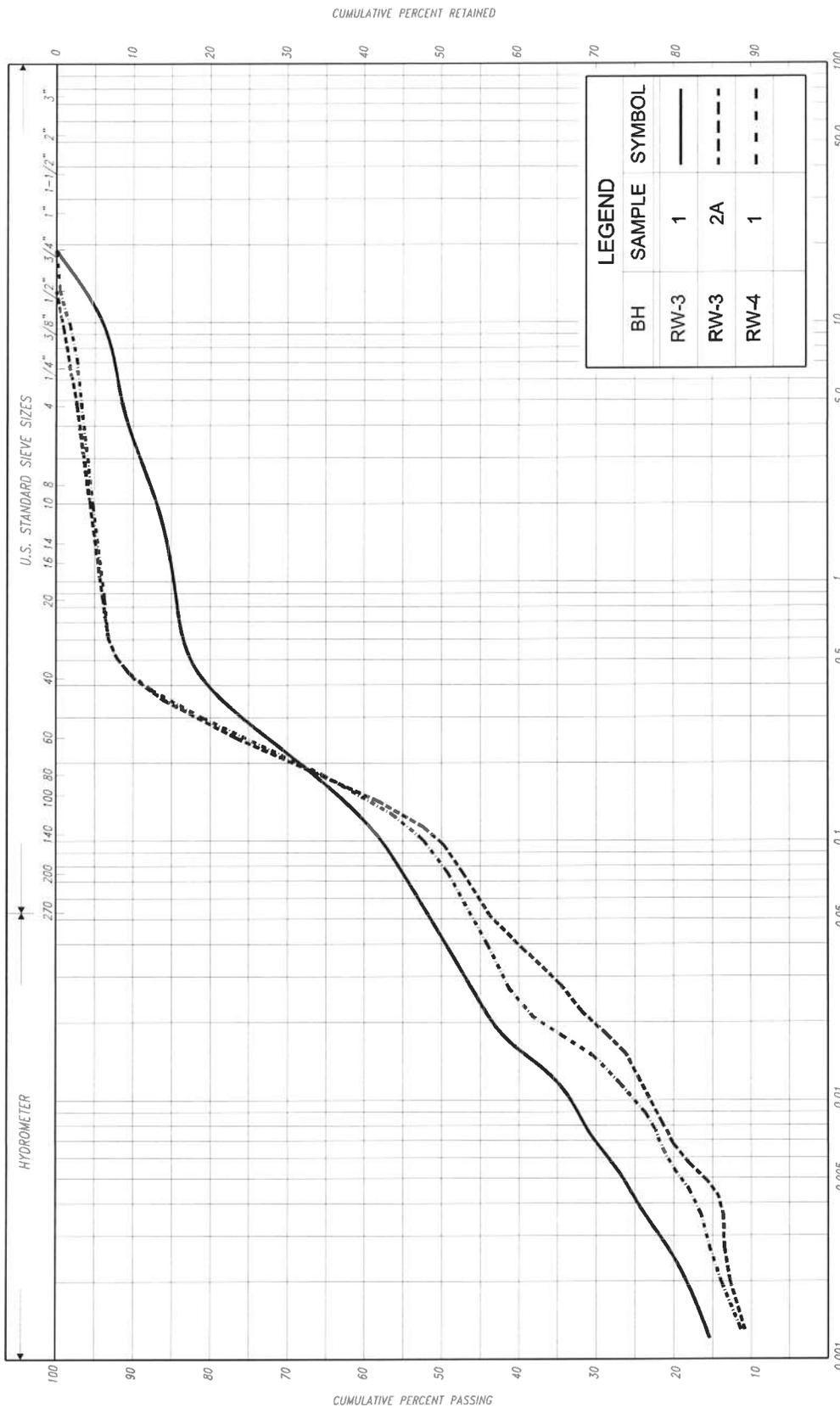
**G.W.P.** 3110-09-00      **LOCATION** Coords: 4 813 705.4 N; 226 228.2 E      **ORIGINATED BY** A.L.  
**DIST** London      **HWY** 7/ 85      **BOREHOLE TYPE** Dynamic Ram Sounder      **COMPILED BY** N.S.B.  
**DATUM** Geodetic      **DATE** July 20, 2011      **CHECKED BY** B.R.G.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE		"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	w			W <sub>L</sub>	GR	SA
323.5	Ground Surface																	
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 4
	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 (8)
	Sand trace to some gravel trace to some silt trace clay		5	SS	13													11 73 12 4
	Compact Brown Moist to wet																	
	Gravelly to with gravel		6	SS	13													38 43 13 6
			7	SS	9													2.6 68 3 3
			8	SS	14													(**)
317.6	Silty clay, trace gravel cobbles		9	SS	49													
5.9	Stiff to hard Grey Moist		10	SS	52/15cm													
316.5	End of borehole		11	SS	50/13cm													
7.0	End of borehole																	



**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
		5	3.3 / 316.3	19	35	17	18
		7	6.3 / 313.4	21	45	23	22



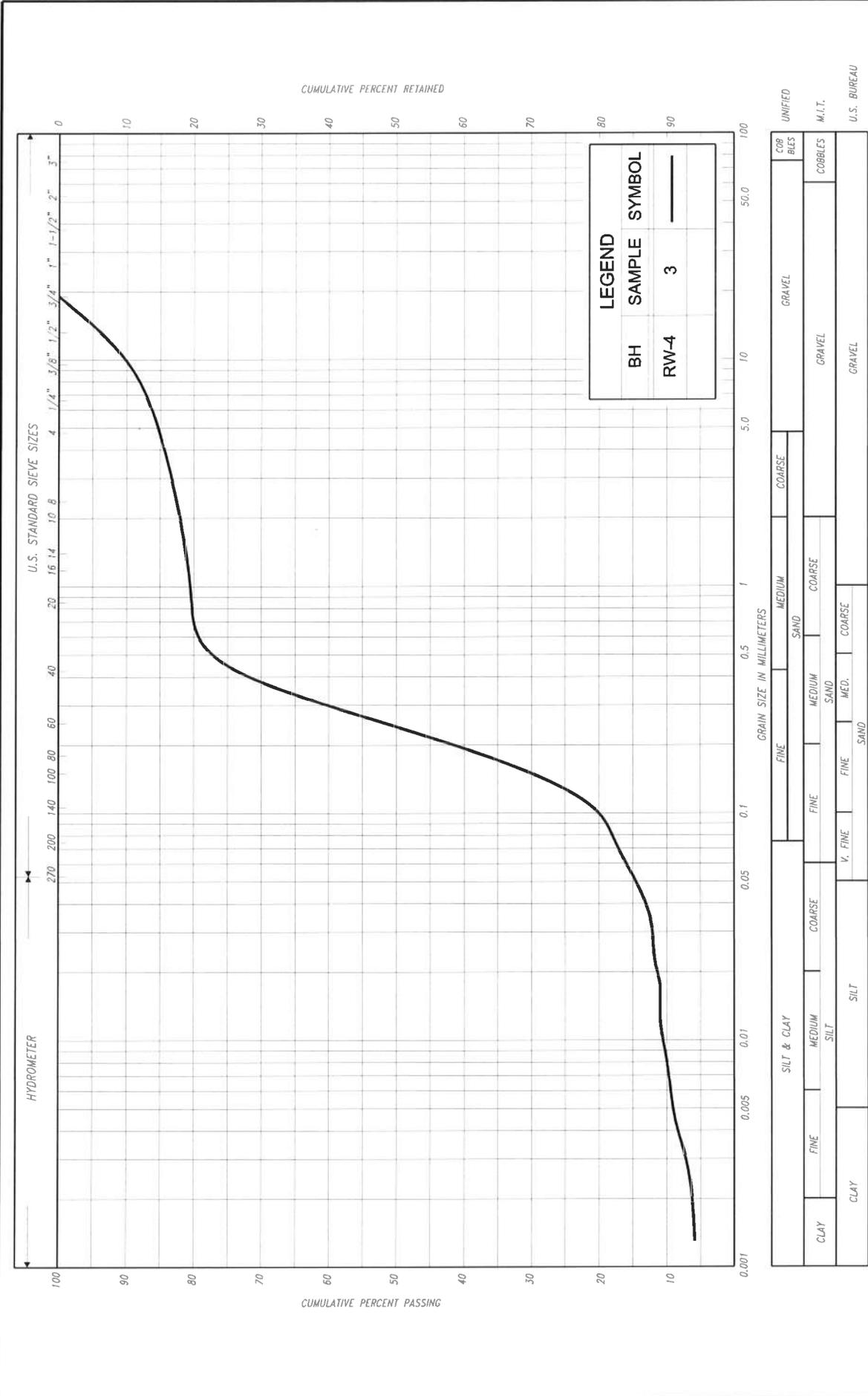
CLAY		SILT & CLAY		FINE SAND		MEDIUM SAND		COARSE SAND		GRAVEL		UNIFIED	
CLAY	FINE	MEDIUM SILT	MEDIUM SILT	FINE	FINE	FINE	COARSE	COARSE	COARSE	GRAVEL	GRAVEL	COBBLES	M.I.T.
			SILT	V. FINE	FINE	FINE	COARSE						U.S. BUREAU

FIG No. RW-GS-1  
 HWY: 7 / 85  
 G.W.P. No. 3110-09-00

**GRAIN SIZE DISTRIBUTION**  
 SILTY SAND, some clay, trace gravel  
 (FILL)







**FIG No. RW-GS-3**

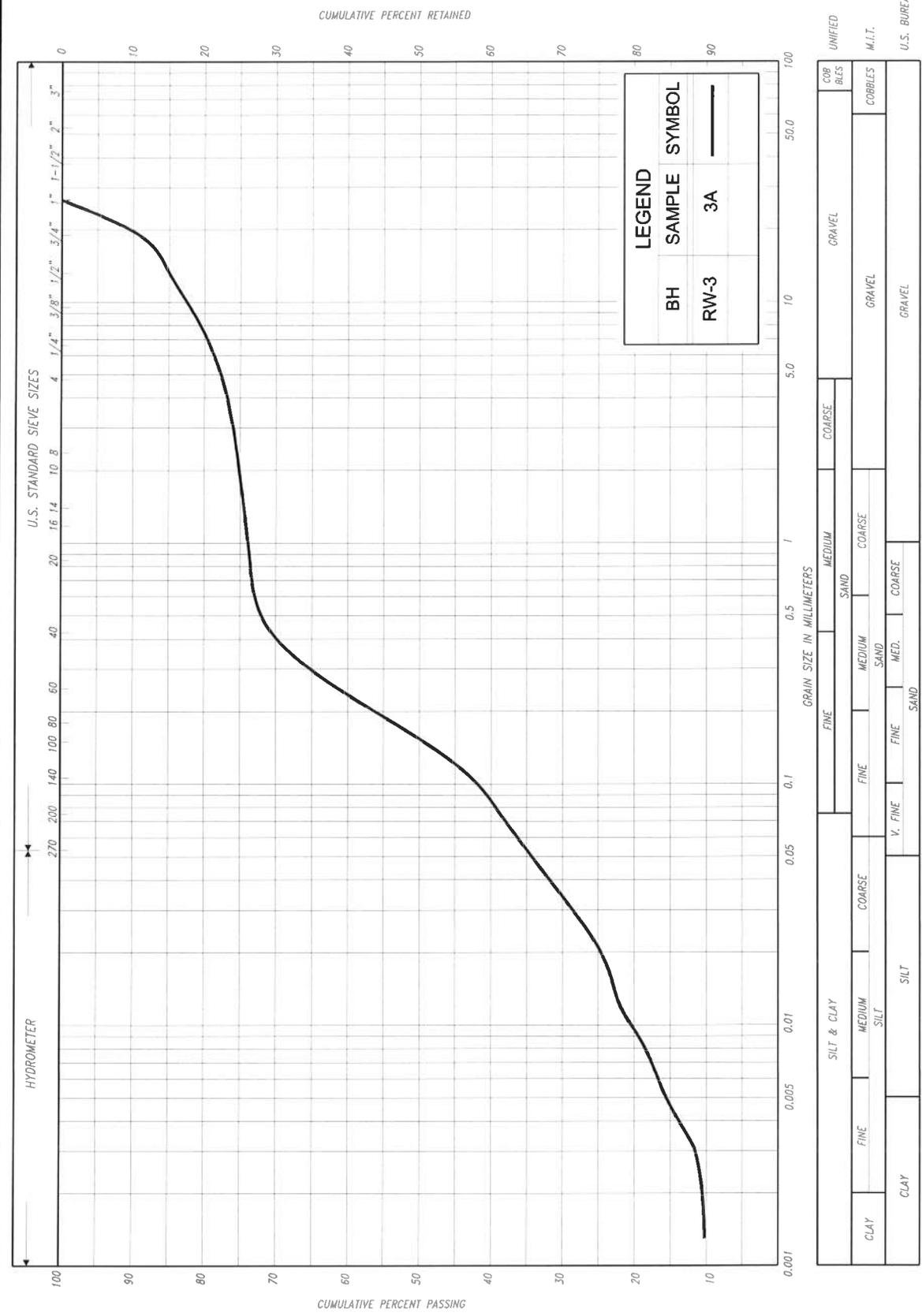
**HWY: 7 / 85**

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

**GRAIN SIZE DISTRIBUTION**

**SAND, some silt, some gravel, trace clay (FILL)**

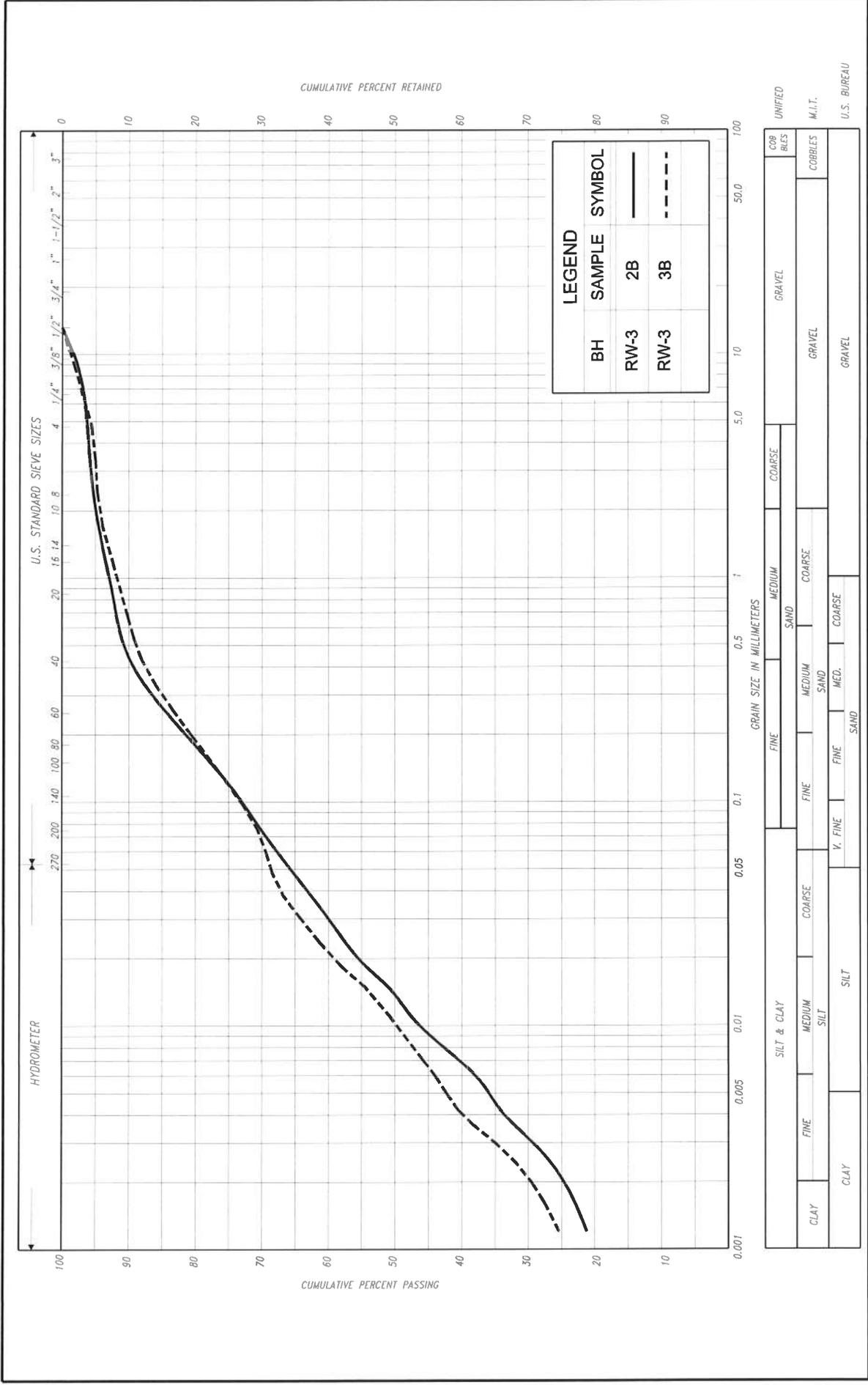




**FIG No. RW-GS-4**  
**HWY: 7 / 85**  
**G.W.P. No. 3110-09-00**

**GRAIN SIZE DISTRIBUTION**  
**GRAVELLY SAND, with silt, some clay**  
**(FILL)**





**GRAIN SIZE DISTRIBUTION**

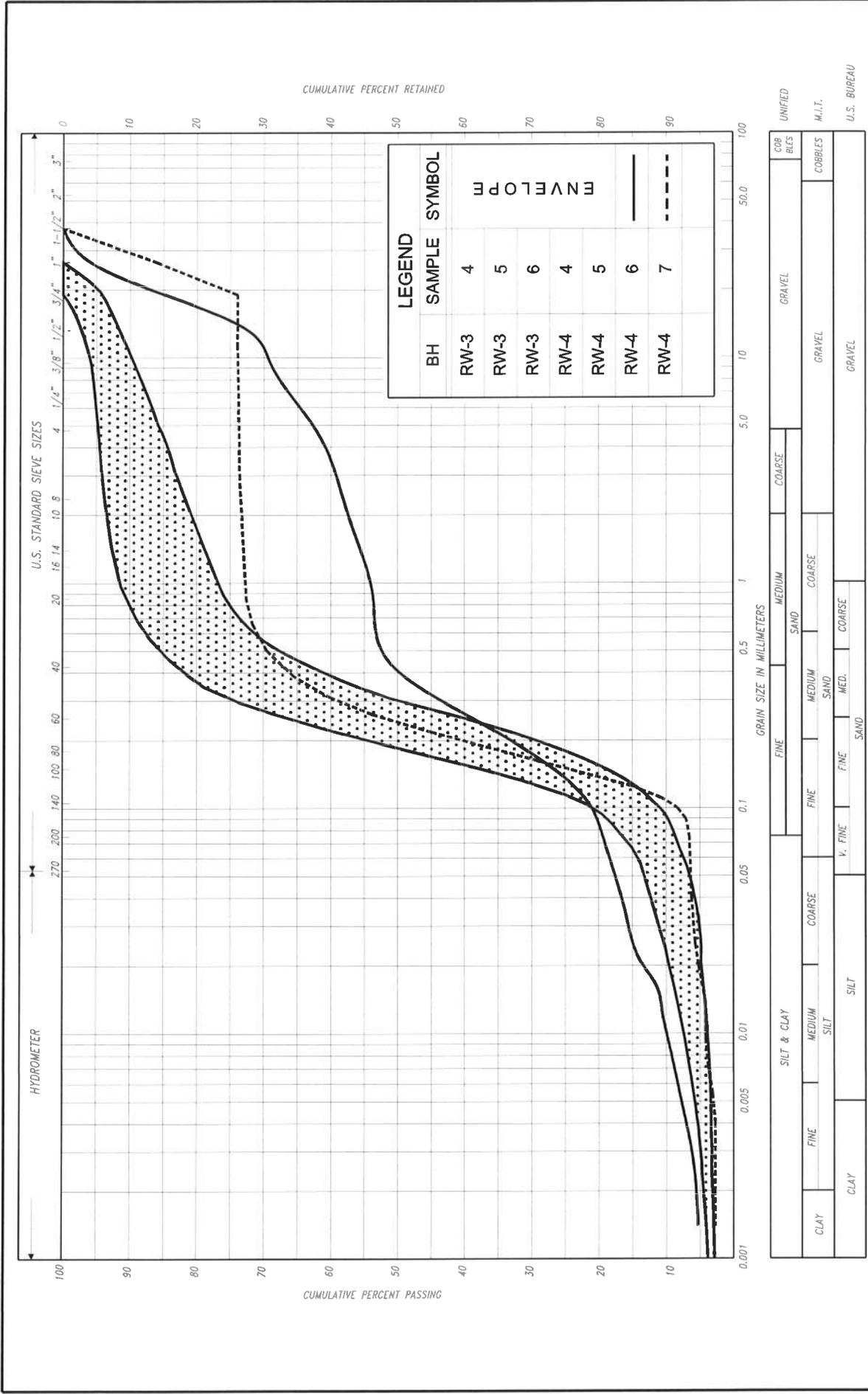
**CLAYEY SILT, with sand, trace gravel (CI)**  
(FILL)

FIG No. **RW-GS-5**

HWY: **7 / 85**

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





**GRAIN SIZE DISTRIBUTION**

FIG No. RW-GS-6

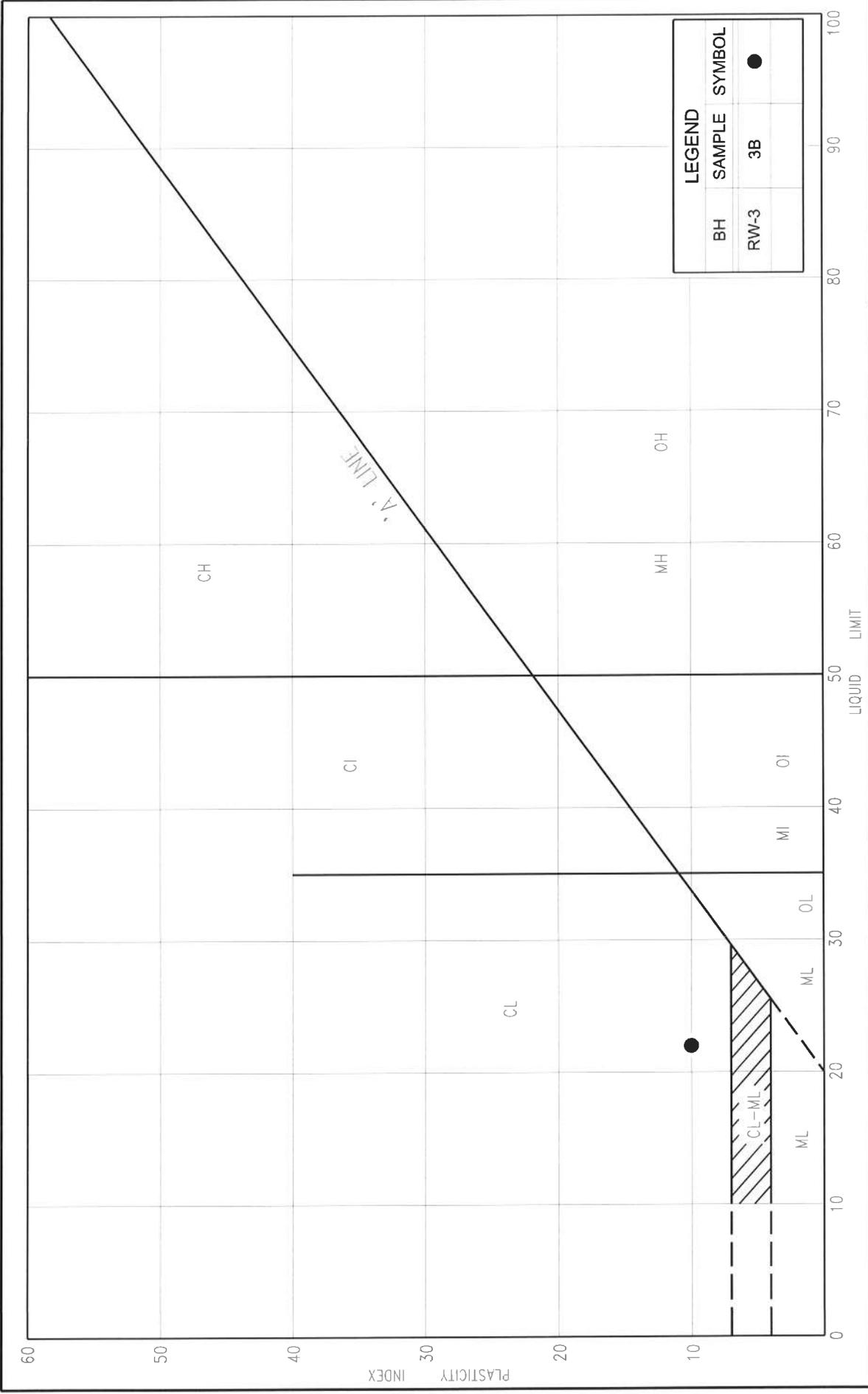
SAND, trace gravel to gravelly, trace to some silt, trace clay

HWY: 7 / 85

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







**PLASTICITY CHART**  
**CLAYEY SILT, with sand, trace gravel (CL)**  
**(FILL)**

FIG No. RW-PC-1

HWY: 7 / 85

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



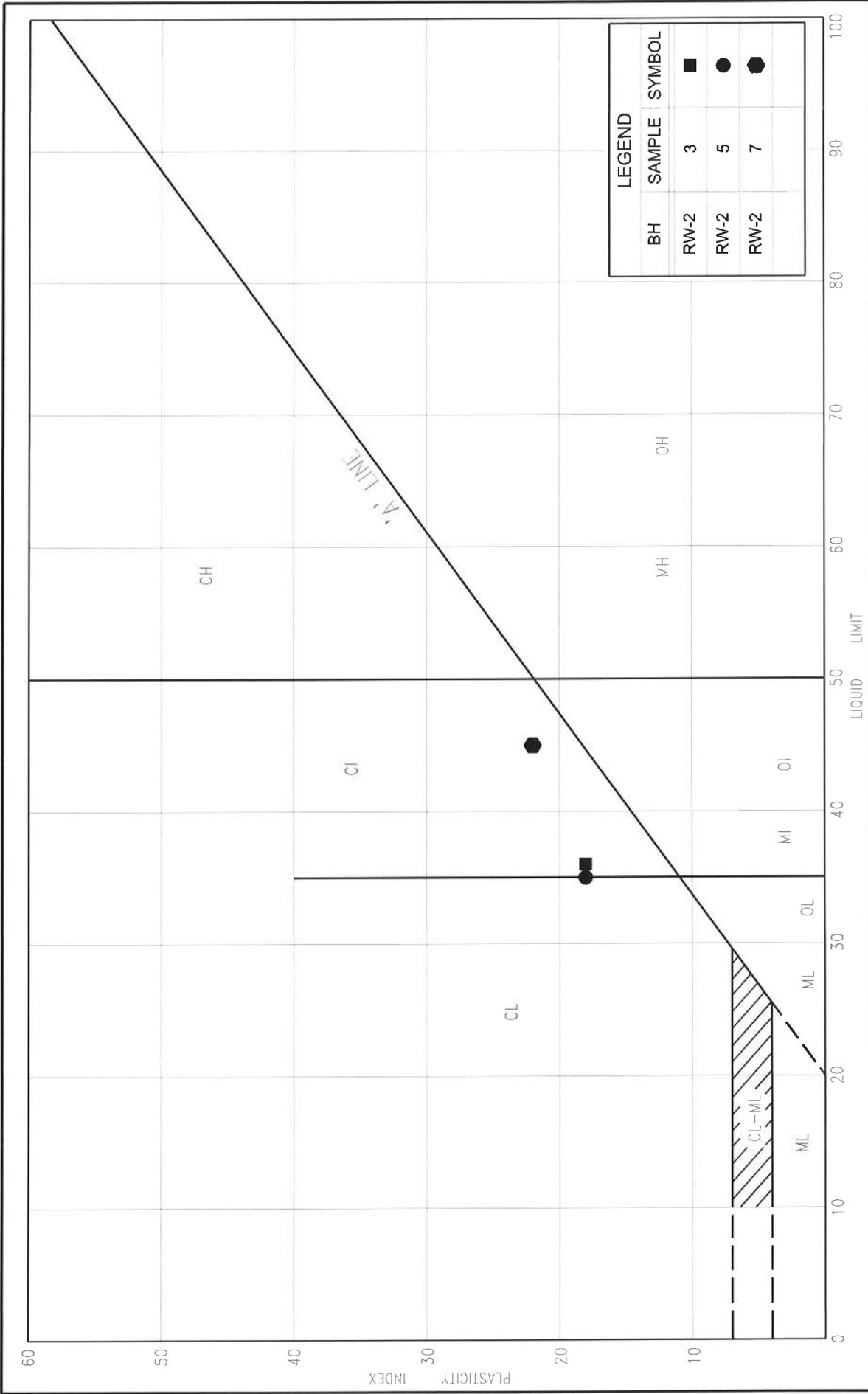


FIG No. RW-PC-2  
 HWY: 7 / 85  
 G.W.P. No. 3110-09-00

**PLASTICITY CHART**  
 SILTY CLAY, trace to with sand, trace gravel (CI)



**Appendix C**

**Site Photographs**

Frederick Street Underpass  
Highway 7-New, Kitchener to Guelph



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
	

  
**THURBER ENGINEERING LTD.**



**KEYPLAN  
LEGEND**

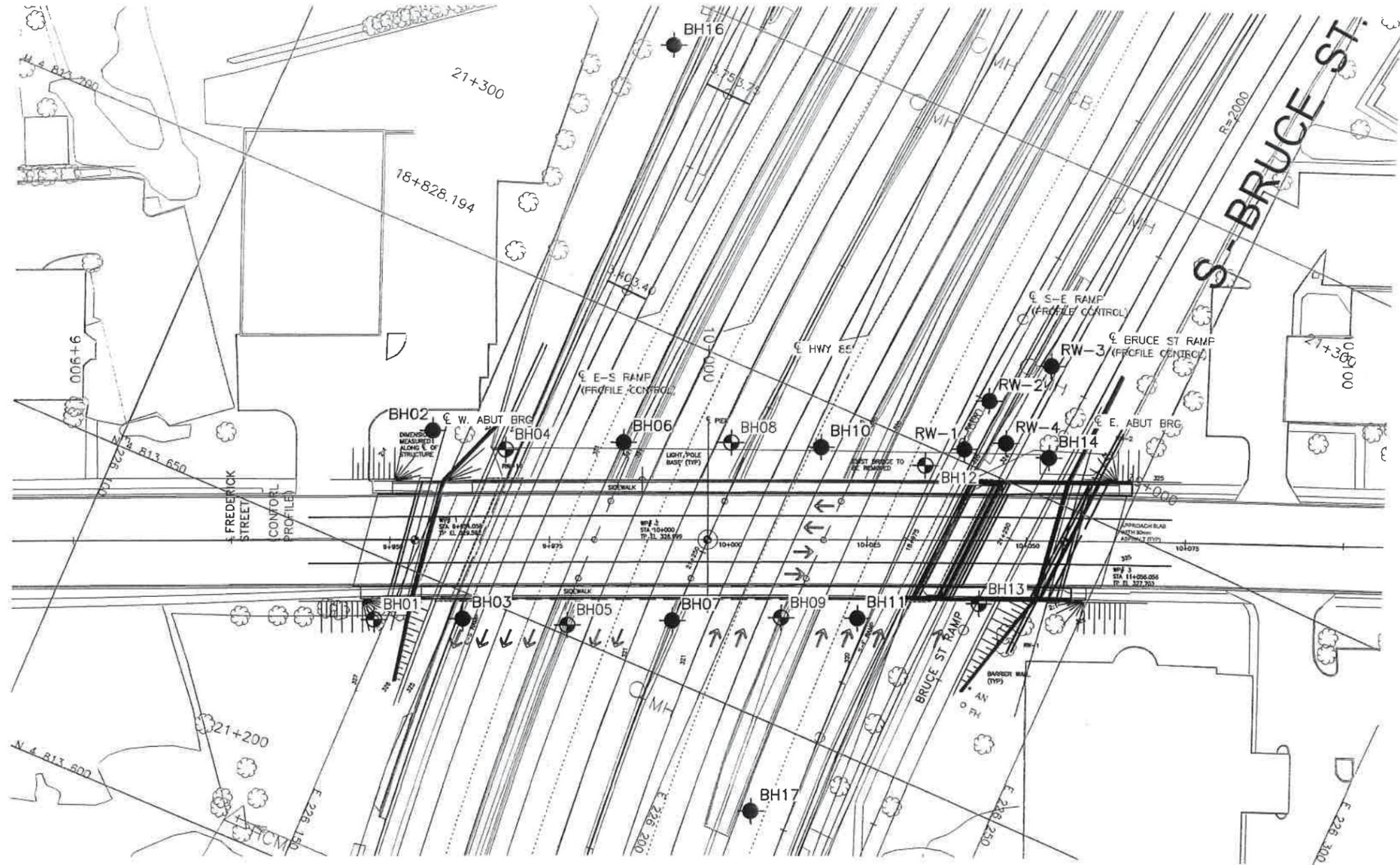
-  Borehole & Cone (Previous Investigation)
-  Cone Penetration Hole (Previous Investigation)
-  Blows /0.3m (Std Pen Test, 475J/blow)
-  Pressure, Hydraulic
-  Water Level
-  Head Artesian Water
-  Piezometer
-  90% Rock Quality Designation (RQD)
-  A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RW-1	319.7	4 813 701.9	226 222.6
RW-2	319.7	4 813 710.4	225 223.0
RW-3	322.3	4 813 719.3	225 229.5
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		
BH10	325.5		
BH11	325.6		
BH12	325.4		
BH13	325.2		
BH14	325.3		
BH15	-		
BH16	324.6		
BH17	326.0		

**-NOTES-**

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

**GEOGRES No. 40P8-203**



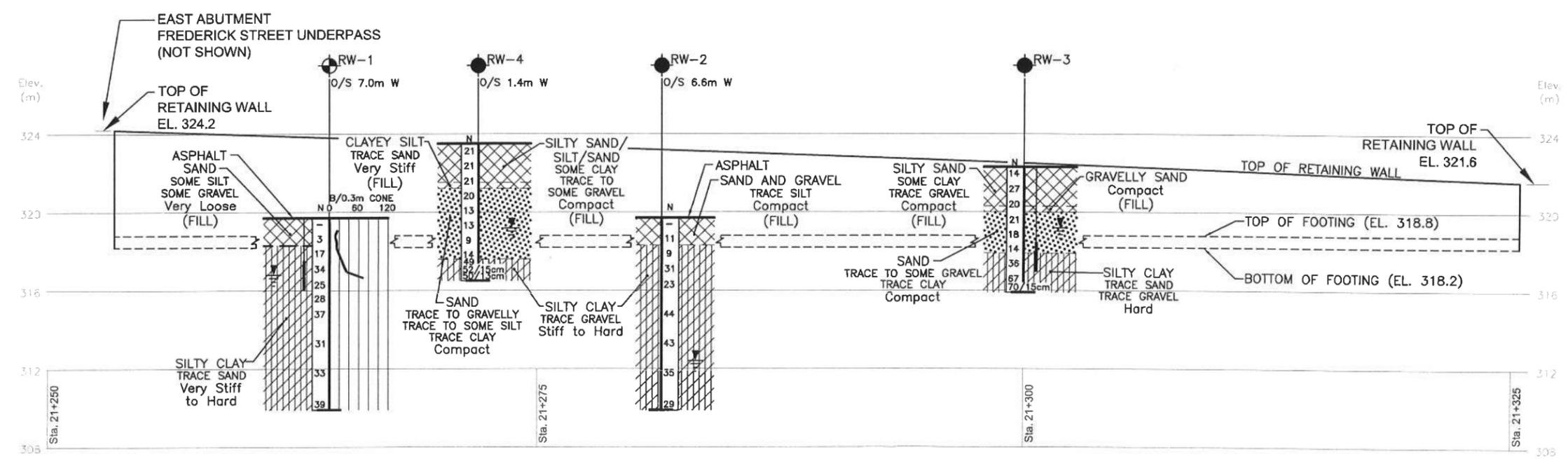
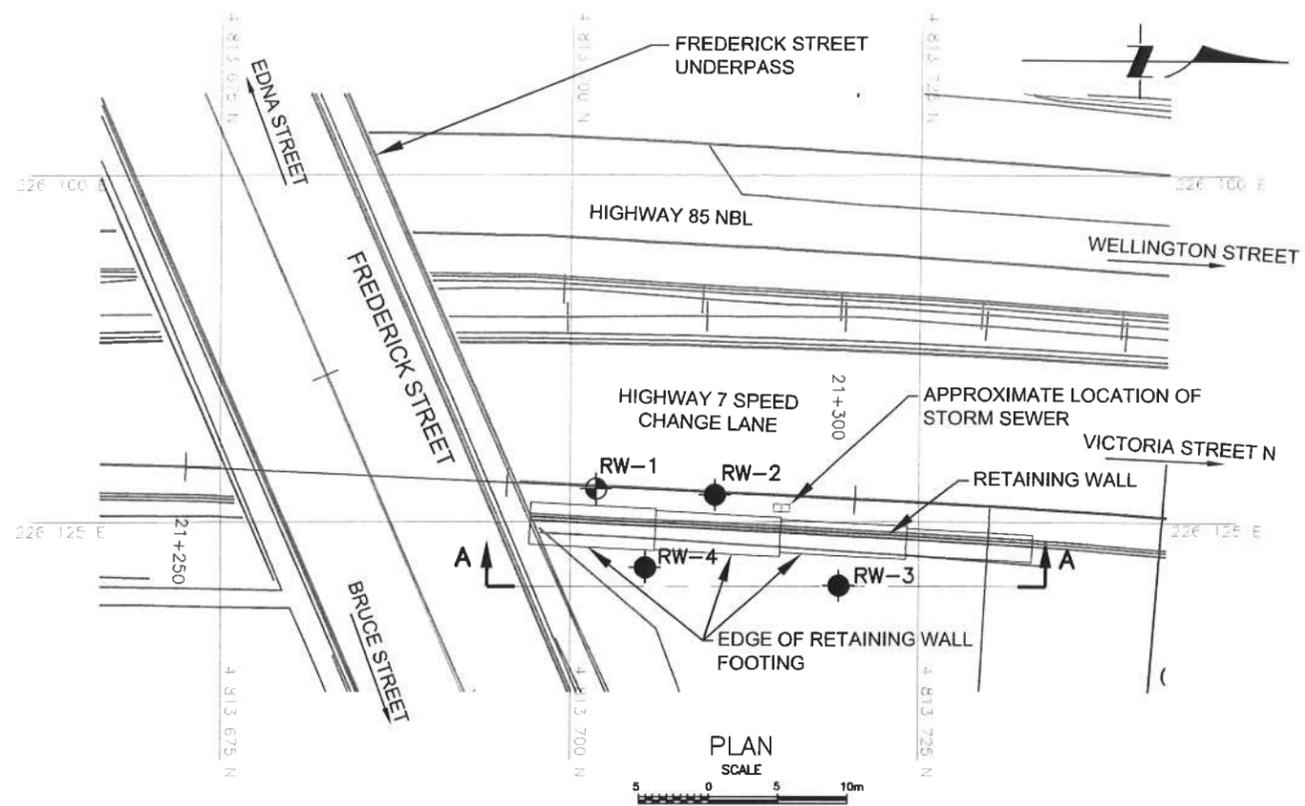
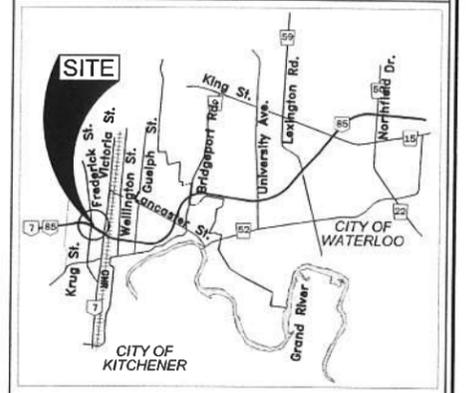
**LICENSED PROFESSIONAL ENGINEER**  
*R. Palomeque Reyna*  
R. Palomeque Reyna  
100083209  
No 13/2012  
PROVINCE OF ONTARIO



**LICENSED PROFESSIONAL ENGINEER**  
*P.K. Chatterji*  
P. K. CHATTERJI  
No 13/12  
PROVINCE OF ONTARIO

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	CODE	LOAD	DATE	NOV, 2012
DRAWN	AN	CHK	SITE	STRUCT	DWG	1	

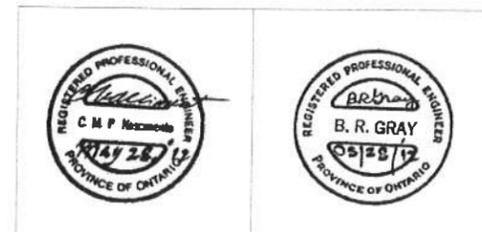
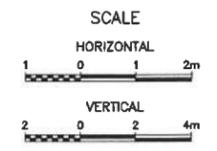


**LEGEND**

- 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

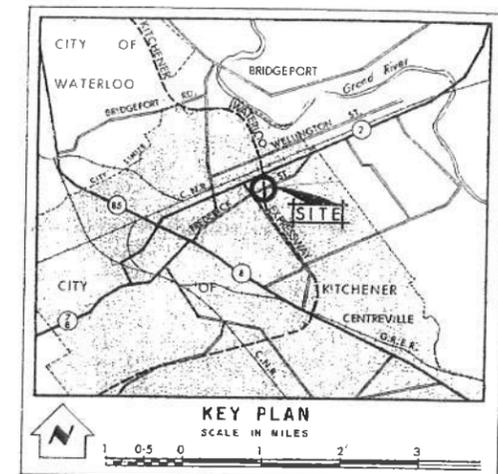
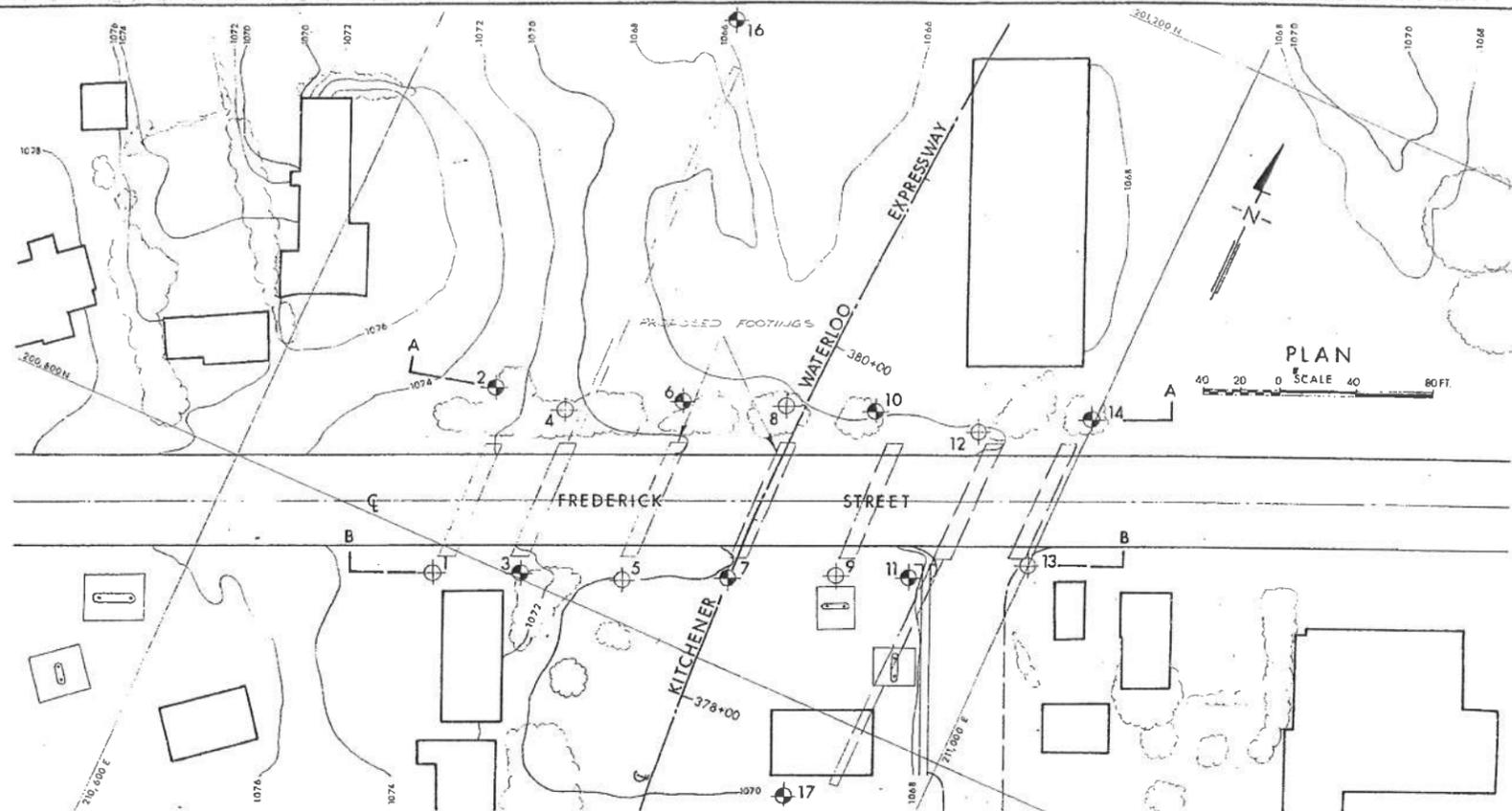
- NOTES:
- DRAWING RW-1 SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND THE RECORD OF LOG OF BOREHOLES.
  - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
  - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.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



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



**LEGEND**

- Bore Hole
- Cone 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	210,647
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	200,997	210,999
16	1065.0	201,116	210,741
17	1069.5	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.

NO.	DATE	BY	DESCRIPTION

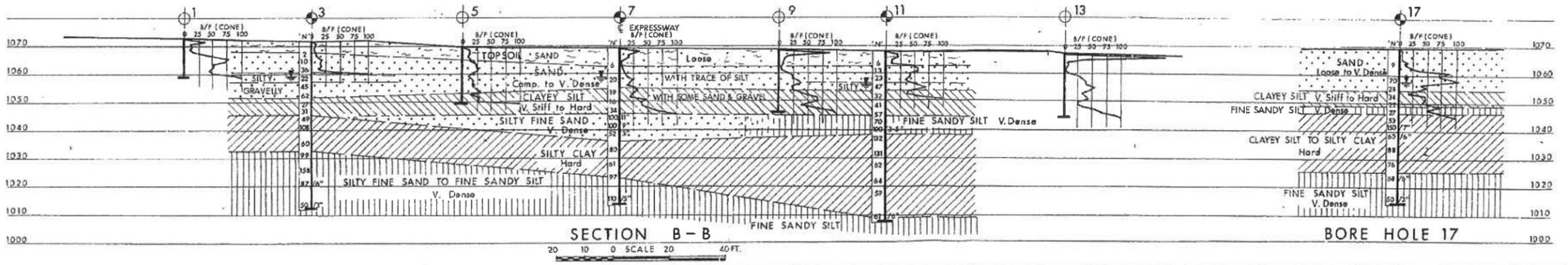
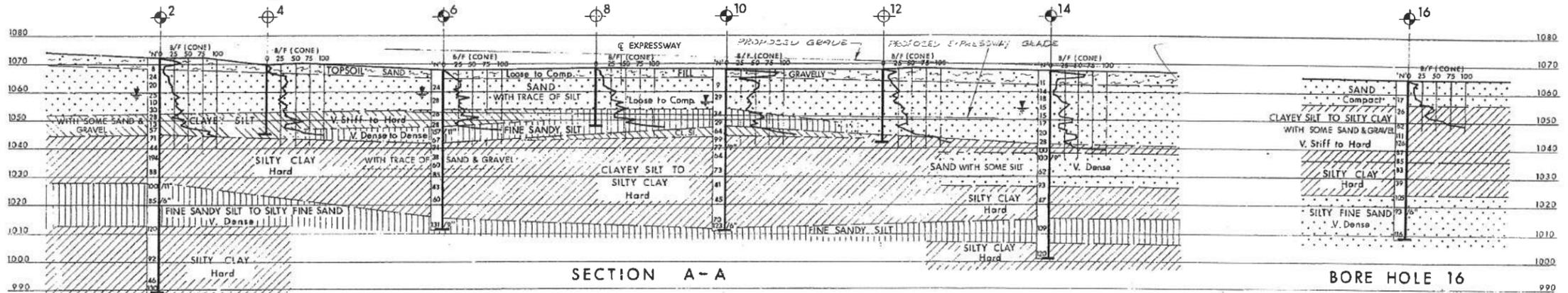
DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

**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.	634-62	M.B.T. DRAWING NO.	66-F-53A
DRAWN S.O.	CHECKED	JOB NO.	66-F-53	BRIDGE DRAWING NO.	
DATE	16 AUG. 1966	SITE NO.			
APPROVED	<i>[Signature]</i>	CONT. NO.			



**PRINT RECORD**

NO.	FOR	DATE