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City of Winnipeg

Wellington Crescent Riverbank Assessment – Lamont Boulevard to Academy Road Geotechnical Investigation, Instrument Monitoring and Existing Stability Report

Prepared for:

Mr. Kendall Thiessen, Ph.D., P.Eng.
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Planning, Property, and Development Department
City of Winnipeg
15 – 30 Fort Street
Winnipeg, Manitoba
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Project Number:
0015 017 00

Date:
January 22, 2018

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January 22, 2018 Our File No. 0015 017 00

Mr. Kendall Thiessen, Ph.D., P.Eng
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Planning, Property, and Development Department
City of Winnipeg
15 – 30 Fort Street
Winnipeg, MB R3C 4X5

RE: Wellington Crescent Riverbank Assessment – Lamont Boulevard to Academy Road Geotechnical Investigation, Instrument Monitoring and Stability Report

TREK Geotechnical Inc. is pleased to submit our Final Report for the riverbank assessment for the above noted project.

Please contact the undersigned if you have any questions. Thank you for the opportunity to serve you on this assignment.

Sincerely,

TREK Geotechnical Inc.
Per:

Nelson Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer
Tel: 204.975.9433

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	SGB	January 22, 2018	Final Report

Authorization Signatures

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Shawn Beaudry, B.Sc., EIT
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ENGINEERS GEOSCIENTISTS MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Jan. 22, 2018

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This report summarizes the results of a geotechnical investigation, instrument monitoring and slope stability analysis completed by TREK Geotechnical Inc. (TREK) along the Assiniboine riverbank on Wellington Crescent extending from Lamont Boulevard to Academy Road. The terms of reference are included in our proposal addressed to Mr. Kendall Thiessen (City of Winnipeg Planning, Property and Development Department) dated September 21, 2016 and subsequent scope change authorization dated August 21, 2017.

2.0 Background and Site Conditions

The study area is situated along the south bank of the Assiniboine River within the City of Winnipeg as shown on Figure 01. The site encompasses a relatively straight section of the river to the west transitioning into an outside bend to the east. Wellington Crescent generally runs parallel to the Assiniboine River and is situated in close proximity (as close as 3 m ±) to the top of riverbank within the study area. An asphalt paved active transportation (AT) pathway is also present on the riverside of the roadway and generally follows the top of riverbank with sections of the path transitioning into the mid-bank area west of Grenfell blvd. Evidence of historical riverbank instabilities are present at various locations within the site including historical slump blocks, cracks in the AT pathway, and visible tension cracks.

Three representative riverbank sections (Cross-section A to C) were selected for the study based on a visual assessment performed in September 2016 by Mr. Kendall Thiessen (City of Winnipeg), Mr. Nelson Ferreira (TREK), and Mr. Ken Skaftfeld (TREK). The location of each Cross-section is shown on Figure 01. At the time of the site review, evidence of active riverbank instabilities was present at sections A and C such as ancestral slump blocks and tension cracks, whereas no clear evidence of riverbank instability was visible at Cross-section B. Evidence of riverbank erosion was present at all sections.

The riverbank at Cross-section A is approximately 8.3 m high and is characterized by an ancestral slump block situated downslope of the AT pathway. The upper bank is relatively flat at an elevation of 232.9 m sloping at approximately 3 horizontal to 1 vertical (3H:1V) down to flat mid- and lower bank areas. Below the lower bank area, the riverbank is steeply sloping to the river channel bottom at approximately 1.3H:1V. The riverbank is moderately treed and has moderate vegetative ground cover consisting of native weeds.

The riverbank at Cross-section B is approximately 6 m high. The upper bank is relatively flat at an elevation of 230.6 m and is over-steepened, sloping down into the river channel at approximately 1H:1V. There are few to no trees in the vicinity of the cross-section. The upper-bank is grassed and the bank slope is relatively unvegetated.

The riverbank at Cross-section C is approximately 8 m high with an upper bank elevation (at the road edge) of 232.4 m. Downslope of the road, the bank is sloped at approximately 11H:1V and transitions to a 3H:1V near the river edge at elevation 228.5 m. The AT pathway is situated about mid-slope. The riverbank is moderately treed and has moderate vegetative ground cover consisting of native weeds.

In June 2017, a large slope instability occurred at Cross-section C. The slope instability initiated upslope of the AT pathway and extended into the river channel. The headscarp dropped vertically as much as 1.0 m and numerous tension cracks were observed in close proximity to the headscarp within the zone of riverbank movements. The instability rendered the AT pathway impassable and damaged geotechnical instrumentation that was installed at that Cross-section. It is suspected that the riverbank became saturated due to surface runoff from the roadway through a culvert upslope of the riverbank movement. A supplemental survey and sub-surface investigation was undertaken to further evaluate conditions in and around the riverbank instability.

3.0 Field Program

3.1 Site Survey

A topographic and bathymetric survey was performed at the site between November 2 and 5, 2016. A supplemental topographic survey was performed at Cross-section C on July 24, 2017 following the slope instability. Survey was completed by Wanless Geo-Point Solutions Inc. Riverbank elevations, channel bottom elevations, and relevant site features (*i.e.* AT pathway and road locations, existing tension cracks, test hole locations, etc.) were measured as part of the survey in the vicinity of each of the selected Cross-sections. The surveyed Cross-sections were verified against LIDAR data provided by the City of Winnipeg collected in October 2011 to confirm overall bank geometry. Elevation contours derived from the LIDAR data are shown on Figure 01 to depict general bank geometries across the site. However, ground elevations derived from the surveyed Cross-sections were used in the slope analysis.

3.2 Sub-surface Investigation

A sub-surface investigation was completed between October 17 and 19, 2016 under the supervision of TREK personnel to evaluate sub-surface conditions at each cross-section. The investigation included drilling four deep test holes (TH16-01 to TH16-04) at the locations shown on Figure 01. Test holes were drilled using an Acker SX track mounted rig equipped with 170 mm diameter solid stem augers and a split barrel continuous sampler. All test holes were advanced into till. Power auger refusal (PAR) was encountered at 7.6 (elev. 222.99 m) and 8.4 m (elev. 224.12 m) in TH16-02 and TH16-04, respectively.

Geotechnical instrumentation was installed in all test holes and included slope inclinometers (SIs), standpipe (SP) and vibrating wire (VW) piezometers or combination thereof. The name and location of each instrument is shown on Figure 01. In addition to permanently installed instrumentation, a vibrating wire piezometer (VW-03) was installed inside the casing of standpipe SP-03 to allow continuous monitoring of piezometric levels using a data logger. Data loggers were attached to vibrating wire piezometers in test holes TH16-03 (Cross-section A) and TH16-02 (Cross-section B).

A supplemental sub-surface investigation program was completed by TREK on July 7 and 13, 2017 following the slope movements at Cross-section C. Test holes (HA17-01 to HA17-04) were drilled at the locations shown on Figure 01. Test holes were drilled using a 50 mm diameter hand auger to depths ranging between 2.7 and 4.0 m. A standpipe piezometer was installed in each test hole (SP17-01 to SP17-04).

Sub-surface soils observed during drilling were visually classified based on the Unified Soil Classification System (USCS). Disturbed (split barrel and split spoon) and relatively undisturbed (Shelby tube) samples were collected during drilling. All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba. Laboratory testing consisted of water content determination on all samples, Atterberg limits, bulk unit weight measurements and unconfined compressive strength testing on select samples. Soil laboratory test results are included in Appendix A.

Detailed test hole logs are attached to this report and include a description of the soil units encountered during drilling and other pertinent information such as groundwater conditions, a summary of the laboratory testing results, and instrument installation details.

4.0 Sub-Surface Conditions

4.1 Soil Stratigraphy

A brief summary of the soil units encountered at the test hole locations during drilling is provided below. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole logs.

The soil stratigraphy varies slightly by Cross-section but generally consists of alluvial soils over top of lacustrine clay soils underlain by silt (till). The alluvial soils vary in thickness from a veneer to about 3.8 m. The alluvial soils are predominately clay with interlayers and seams of silt and sand. The extent and detailed characterization of the alluvial was not determined and would required additional test holes and laboratory testing. In this regard, the descriptions below do not distinguish depositional geology.

At Cross-section A (TH16-03 and TH16-04), clay fill was observed at the top of bank extending to a depth of 2.9 m (elev. 229.6 m). The clay fill is brown, damp to moist, stiff to very stiff and is highly plastic. The native silty clay extended to an approximate elevation of 226.3 m. The native clay is brown, damp to moist, very stiff becoming stiff with depth, and intermediate to highly plastic. Interlayers of silt and sand were observed within the silty clay unit ranging in thickness between approximately 0.5 and 0.6 m. A sand layer was encountered near the surface of the silt (till) ranging in thickness between 0.8 and 1.1 m. The silt (till) below is grey, damp to moist, loose becoming dense with depth and low to non-plastic.

At Cross-section B (TH16-02), native silty clay was observed to a depth of 5.8 m (elev. 224.8 m). The silty clay is brown, damp to moist, very stiff becoming firm with depth and of intermediate plasticity.

The underlying silt (till) is grey, damp to moist, loose becoming dense with depth and low to non-plastic.

At Cross-section C (TH16-01 & HA17-01 to HA17-04), native silty clay was observed to a depth of 5.8 m (elev. 223.8 m). The silty clay is brown, moist, very stiff becoming firm with depth, of intermediate plasticity, and contains medium grained sand lenses ranging in diameter between 25 and 75 mm. The underlying silt (till) is light grey, moist to wet, loose becoming dense with depth and low plastic.

4.2 Groundwater Conditions

Groundwater conditions described herein are based on monitoring of piezometers installed at the site. Groundwater levels were recorded either manually or daily using data loggers. It is important to note that the measured piezometric levels are valid at the time they were recorded, and that levels may vary between readings or spatially between piezometers.

Figure 02 shows the monitoring results for piezometers installed in TH16-01 to TH16-04 as well as Assiniboine river levels monitored at the St. James Bridge. Prior to river elevations rising to flood stage at the end of March 2016, piezometric elevations in the clay and silt (till) appeared to be static at Cross-section A and B at elevations of 227.0 and 226.3 m or at 3.7 and 4.3 m below ground surface, respectively. Piezometric elevations in the silt (till) at Cross-section C were comparable to those at A at an approximate elevation of 227.1 m or 3.3 m below ground surface. In general, piezometers in the clay and silt (till) appear to trend relatively closely with rising and falling river levels during the 2016 spring flood. A lag off approximately 4 days was observed between increasing and decreasing clay groundwater levels to river changes. Following flood drawdown, porewater pressure dissipation in both the silt and clay appears to be a slower response when compared to porewater pressure increases recorded due to rising river levels. Piezometric elevations at VW-02 are showing a very slow dissipation and have remained approximately 0.8 m above pre-flood conditions to the end of the current monitoring period.

Note that vibrating wire piezometer VW-01A malfunctioned around March 30, 2017. Also, VW-02A did not work properly following installation based on our interpretation of the readings which appear to be realistic but are likely false based on expected behavior.

Piezometric elevations in the silty clay monitored within SP17-01 to SP17-04 are presented in Table 01. TREK understands that surface run-off from a culvert beneath the road resulted in ponded water upslope of the zone of movement for some time, likely saturating the riverbank prior to the slope movement. The standpipes were installed shortly after the instability occurred and the recorded water levels within SP17-01, SP-02 and SP03 were initially within 1.0 m of ground surface and may have been higher at the time when riverbank movements occurred. Measured groundwater levels lowered with time following remedial works by the City to minimize surface water from entering the area of instability over the summer of 2017.

Piezometric and river elevations used in the stability analysis are discussed in Section 5.1.

Table 01 – Groundwater Monitoring at Cross-Section C Standpipe Piezometers

Standpipe No.	SP17-01		SP17-02		SP17-03		SP17-04	
Ground Elev. (m)	230.08		231.27		230.75		229.11	
Tip Elevation (m)	226.13		227.33		226.97		226.37	
Date	Depth (Below T.O.P.)	Elev. (m)	Depth (Below T.O.P.)	Elev. (m)	Depth (Below T.O.P.)	Elev. (m)	Depth (Below T.O.P.)	Elev. (m)
08-Jul-17	0.82	229.24	1.10	230.15	DRY	-	1.00(1)	228.08
24-Jul-17	1.33	228.73	1.60	229.65	DRY	-	1.16	227.92
02-Aug-17	1.70	228.36	3.26	227.99	DRY	-	1.43	227.65
25-Aug-17	2.16	227.90	3.21	228.04	DRY	-	2.01	227.07
29-Sep-17	2.68	227.38	DRY	-	DRY	-	2.43	226.65

(1) Depth was not measured but was visually estimated to be 1.0 m below the top of pipe.

4.3 Sub-Surface Slope Movement

Two slope inclinometers (SI-01 and SI-02) were installed at Cross-section A to monitor movements within an ancestral slump block. Following the initial baseline measurements, SI-01 and SI-02 have been monitored a total of 4 and 3 times, respectively. Monitoring events spanned between February 2, 2017 and August 25, 2017. Cumulative displacement profiles as well as displacement rate plots for each SI are shown on Figures 03 to 06. Observations for each SI are also provided below.

SI-01 (Mid-Bank) – Cross-section A

A zone of movement has been observed around elevation 227.4 m which is approximately 2.3 m above the silt till contact (Elev. 225.1 m). A total of 11 mm of cumulative displacement has been observed at this elevation. Of this 11 mm, 5 mm appears to have occurred prior to the 2017 spring flood and the additional 6 mm occurred while flood levels were receding. No additional movements were observed following the spring movements to the end of the monitoring period.

SI-02 (Upper-Bank) – Cross-section A

One apparent zone of movement has been observed at elevation 227.2 m which is approximately 0.9 m above the silt till contact (Elev. 226.3 m). 5 mm of total cumulative displacement has been observed at this elevation. Of this 5 mm, 1 mm appears to have occurred prior to the 2017 spring flood and the additional 4 mm occurred following recession of the flood river levels.

5.0 Slope Stability Analysis

Slope stability analysis was competed at all three sections. A back-analysis was completed a Cross-section A to determine conditions and soil properties that could result in riverbank instabilities at the locations where movements were observed in the slope inclinometers. The back analyzed results were then used to predict the level of stability at Cross-sections B and C. The analysis at Cross-section C was modeled to represent conditions at the time riverbank movements occurred. The location of each Cross-section (A to C) is shown in plan on Figure 01.

5.1 Model Development

The stability analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2016 software package (Geo-Slope International Inc.). The slope stability model used the Morgenstern-Price method of slices with a half-sine interslice force function to calculate factors of safety (FS) along various potential slip surfaces. Circular and block shaped slip surfaces were used in the back-analysis for Cross-section A. The circular slip surfaces were determined using a grid and radius slip surface method while the block slip surface was fully specified. Resulting FS between circular and block slip surfaces were comparable for a slip surface through the zones of observed movement. Based on the comparable results between the two types of slips, circular slip surfaces were used for Cross-sections B and C in order to search for critical slip locations.

Groundwater conditions were modeled using a piezometric line defined based on measured groundwater and river levels. Measured piezometric conditions in the clay and till were generally static or demonstrated a slight downward flow gradient. Static groundwater conditions were assumed in the model and is considered a conservative approach. At Cross-section A, the groundwater level in the upper-bank above the piezometers was assumed to be approximately 2.0 m below the ground surface within the silt layer assuming periodic saturation. The river level at Cross-section C was selected based on the approximate date of slope movements estimated to be in June 2017. The groundwater level at Cross-Section C was assumed parallel to the ground surface at about 1 m below ground surface. This groundwater profile is consistent with measured piezometric elevations in standpipe piezometers SP17-01 to SP17-04.

Bank geometries were based on the site-specific survey (bathymetry and topographic survey) conducted as part of this assignment. The soil units used in the models include the silty clay (alluvial or lacustrine), sand till, and silt till units based on sub-surface information. At cross-section A and C, the lacustrine clay was divided into discrete zones in the slope models to reflect varying degrees of soil strengths anticipated due to active ground movements. For Cross-section A, the zone assuming residual clay strengths was situated between the roadway and the river while strengths beyond the road were assigned higher, fully softened strengths. The residual clay zone in Cross-Section C was situated at the approximate location of the head scarp with fully softened strengths upslope of the tension crack. The silty clay at Cross-Section B was assigned alluvial strength properties based on published relationships between Atterberg Limits and friction angles.

Back Analysis (Cross-Section A)

The back analysis focused on a slip surface matching the location of observed movement in SI-01 and SI-02. The strength parameters of the lacustrine clay (residual) were adjusted until the FS for a slip surface matching the observed movements was near unity (FS=1.0). Table 02 lists the soil properties used for the soil units in the stability modeling and the back analyzed residual clay strength. The selected material strength properties used in the model are considered consistent with previous observations for soils in the Winnipeg area.

Table 02 Soil Properties used in Stability Modeling

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (deg)
Silty Clay – Lacustrine Fully Softened	17.5	5	17
Silty Clay – Lacustrine Residual (back-analyzed)	17.5	1.5	12
Silty Clay - Alluvial	17.5	3	23
Sand Till	19	10	30
Silt Till	20	10	30

Groundwater and river levels used in the back-analysis were selected based on the most critical condition measured during the monitoring period. Critical conditions were observed following the 2016 spring flood when river levels were receding and measured pore-pressures within the clay and till remained near peak elevations. The critical condition is consistent with when riverbank movements typically occur in Winnipeg. Reduced riverbank stability and slope movements in riverbanks (slope instabilities) are often associated with the annual drawdown of the Red and Assiniboine Rivers in the late fall and an associated time lag before groundwater levels adjust (reduce) to lower river levels.

5.2 Stability Modeling Results

Table 03 summarizes the stability modeling cases and associated factors of safety calculated using the numerical model for each of the cross-sections. Figure 07 to 09 show the stability analysis results for each case, as referenced in Table 03.

Table 03 - Summary of Calculated Factors of Safety

Cross-Section	Geometry Case	River Elevation	Groundwater Level	Slip Surface	Description	FS	Figure No.
A	Existing Geometry	227.2 m	230.5 m Upper Bank 228.1 m Lower Bank	SS1 (Circular)	Critical FS Back Analysis through the zone of observed movement	0.99	07
				SS2 (Block)	Back Analysis through the zone of observed movement	1.02	
				SS3 (Circular)	At the existing edge of roadway	1.02	
B	Existing Geometry	227.2 m	227.7 m Upper Bank	SS1 (Circular)	Critical FS	1.01	08
				SS2 (Circular)	At existing AT pathway edge (corresponds to the closest distance between the top of riverbank and the roadway, 25 m west of Section B)	1.12	
				SS3 (Circular)	At the existing edge of roadway	1.47	
C	Prior to June 2017 Slope Movements	226.4 m	1 m Below Ground Surface	SS1 (Circular)	Critical FS	0.78	09
				SS2 (Circular)	Approximate zone of observed movement	1.04	
				-	At the existing edge of roadway	>1.5	

The calculated minimum FS for all three sections are at or close to unity indicating the riverbanks in this area are unstable (FS ≤ 1.0) or marginally stable (FS ~ 1.10) depending on the groundwater conditions at any given time. The FS at the AT path varies between <1.0 and 1.12 whereas the FS at the road edge varies between 1.02 and >1.5. The level of stability at the AT path edge at all cross-sections and edge of road at cross-sections A and 25m west of B are below typical minimum target values (FS >1.3) for infrastructure under the conditions analyzed.

It should be noted that the application of residual material strengths within the bank at Cross-sections A and C is a simplified approach to evaluating stability in the general areas where movements have occurred. Residual strengths may not exist everywhere in those zones. As such, slip surfaces with an FS less than unity downslope of the instability at Cross-section C may be more stable than depicted in the analysis. The FS for potential slip surfaces in the lower bank area below unity may also be the result of conditions that cannot be accurately incorporated into the model (unsaturated soils, vegetation) and can be considered a limitation of the analysis.

6.0 Future Considerations

Based on the subsurface investigation and stability analysis results, TREK provides the following considerations for future work.

- Ongoing monitoring of instrumentation should be completed to observe trends over a longer duration, assist in identifying critical groundwater and river level conditions, and monitor performance of the bank where slope inclinometers are installed.
- Installation of slope inclinometers at Cross-section B and C would be beneficial to determine if riverbank movements are occurring, where and when they occur, and at what rate to better predict the stability of the riverbank in these areas, especially if stabilization works are being considered. Slope inclinometers may also be beneficial to monitor bank performance if remedial or stabilization works are undertaken.
- Riverbank stabilization works or relocation of infrastructure should be considered at Cross-section A and C given active bank movements that have been observed to date. Riverbank stability is expected to deteriorate as creep movements continue which may lead to retrogression of the slope instabilities that may impact the road or path.
- Remedial repairs of the riverbank in the vicinity of the instability at Cross-section C should be undertaken to minimize the risk of instabilities retrogressing upslope toward the roadway. This should include sealing of tension cracks, re-grading of the riverbank to promote positive drainage, diverting surface runoff, and construction of erosion protection to maintain bank geometries with some improvement to stability. These works may be implemented quickly and with relative ease.

7.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the City of Winnipeg (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

TREK GEOTECHNICAL

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City of Winnipeg

Wellington Crescent Riverbank Assessment - Lamont Blvd. to Academy Rd.

0 25 50 75 100 m

SCALE = 1 : 2 000 (279 mm x 432 mm)

LEGEND:

- TEST HOLE (TREK, OCTOBER 19, 2016)
- HAND AUGER TEST HOLE (TREK, JULY 7 AND 13, 2017)
- APPROXIMATE PROPERTY LINE

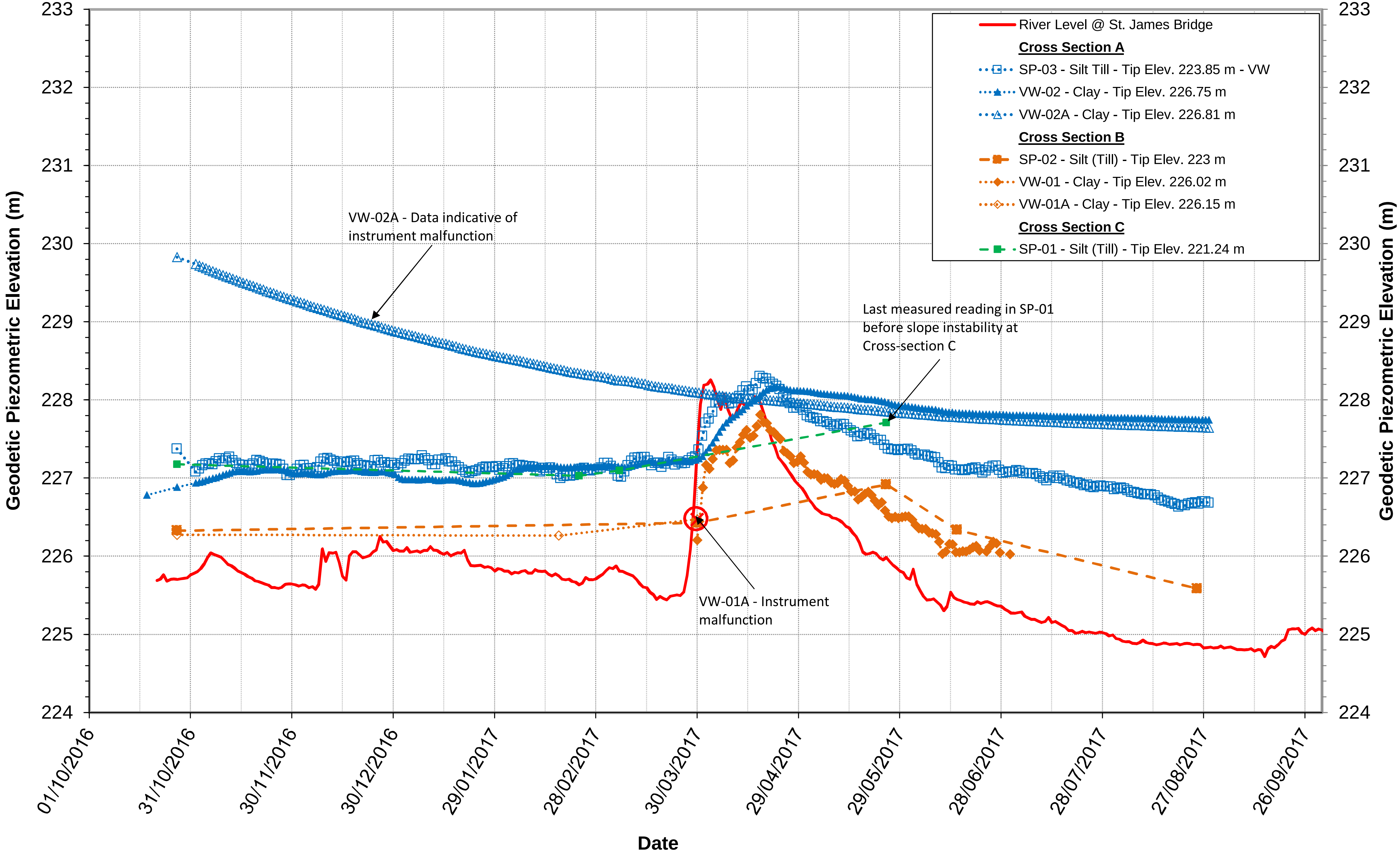
NOTES:

1. AERIAL IMAGE FROM CITY OF WINNIPEG, (FALL 2016)
2. ELEVATION CONTOURS ARE BASED ON CITY OF WINNIPEG LIDAR DATA FROM OCTOBER, 2011.

Figure 01

Test Hole Location and Instrumentation Plan

FIGURE 02
Wellington Crescent Riverbank Assessment – Lamont Boulevard to Academy Road
Piezometer Summary



SLOPE INCLINOMETER WORKSHEET

SI-01

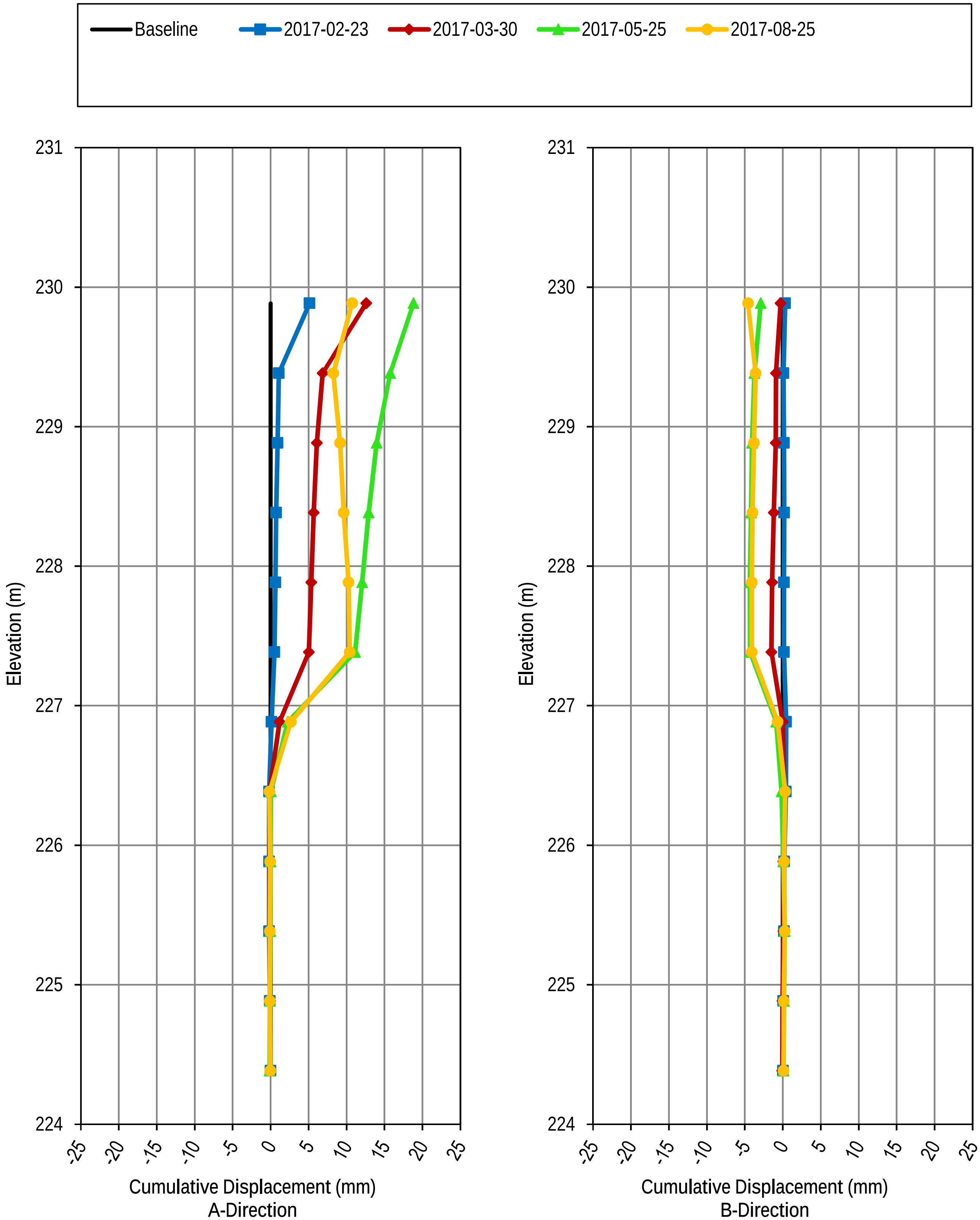
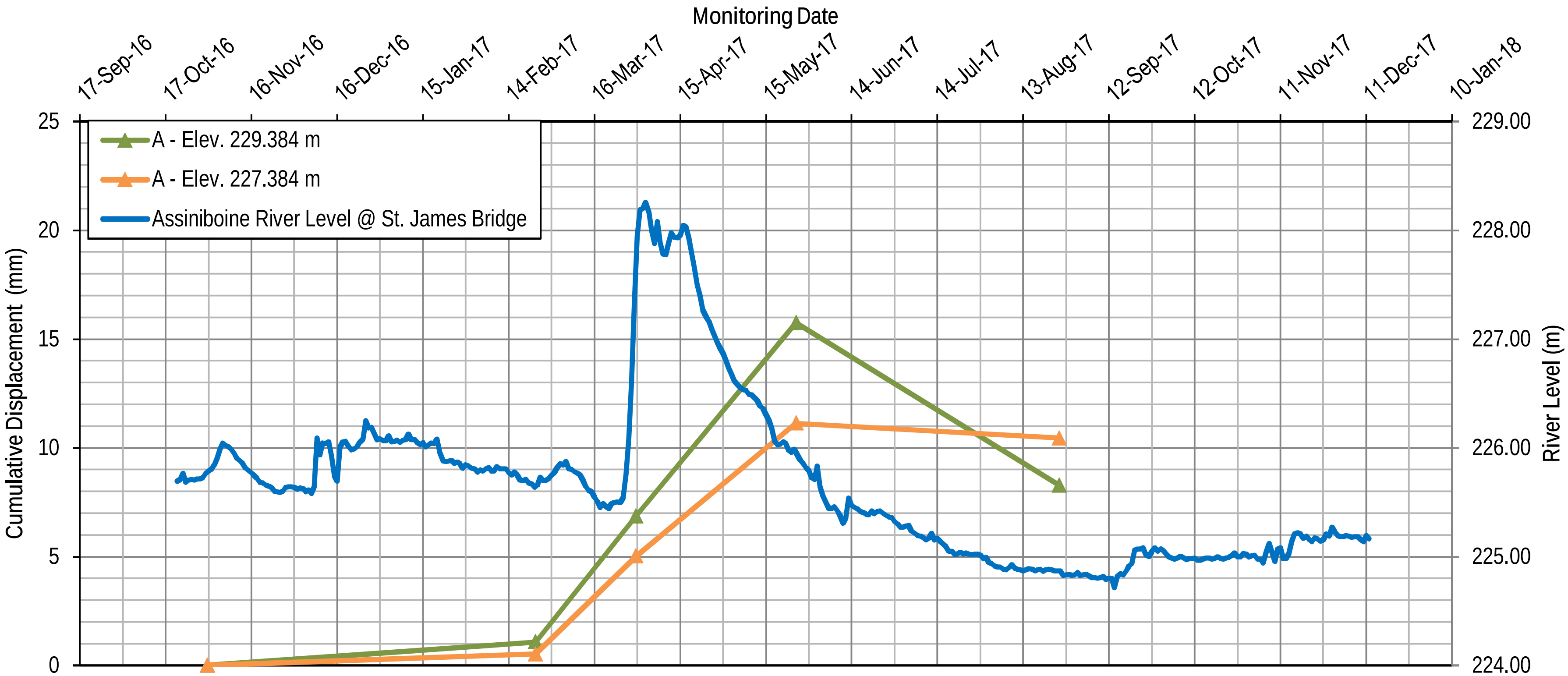


Figure 03

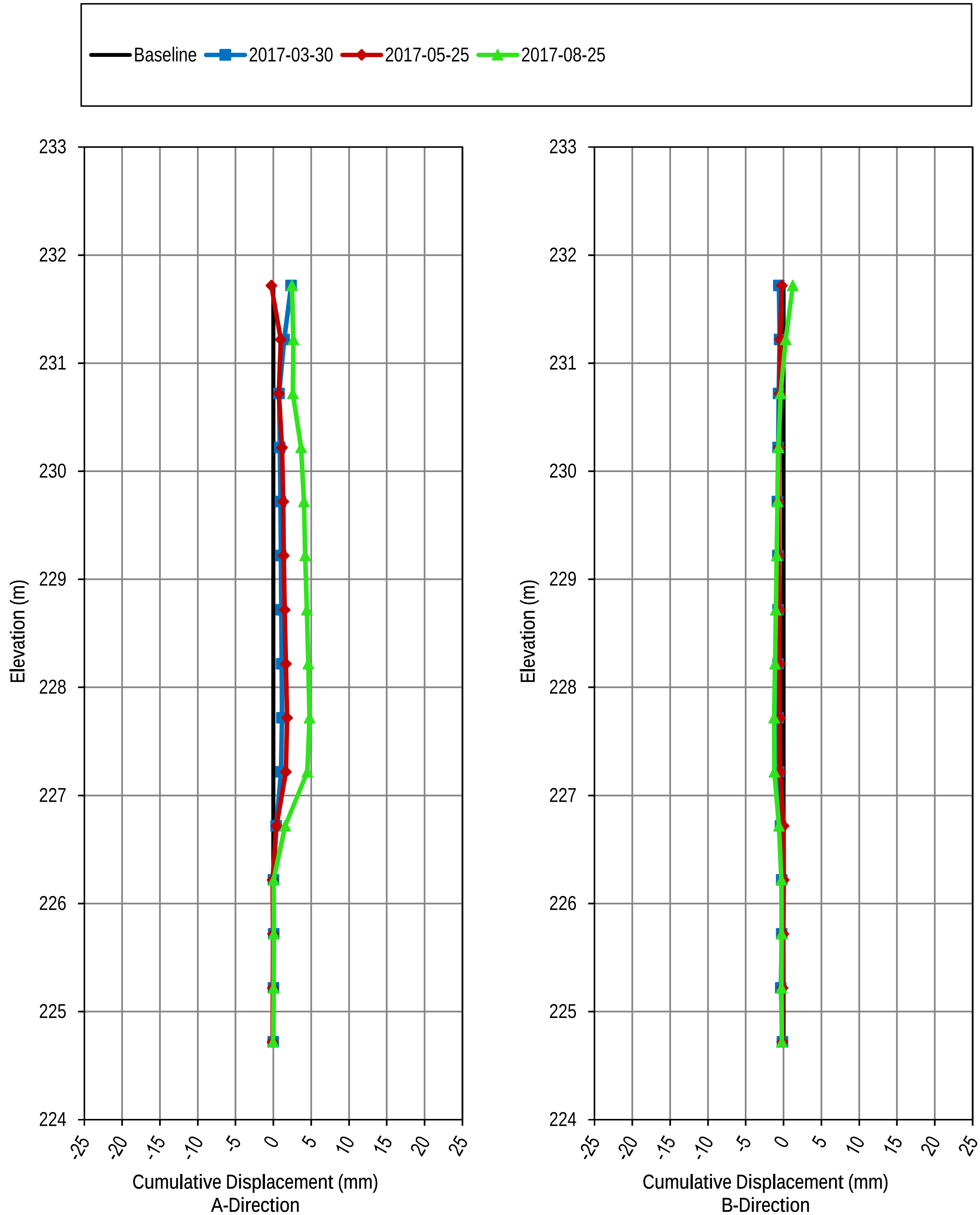
SLOPE INCLINOMETER RATE PLOT

SI-01



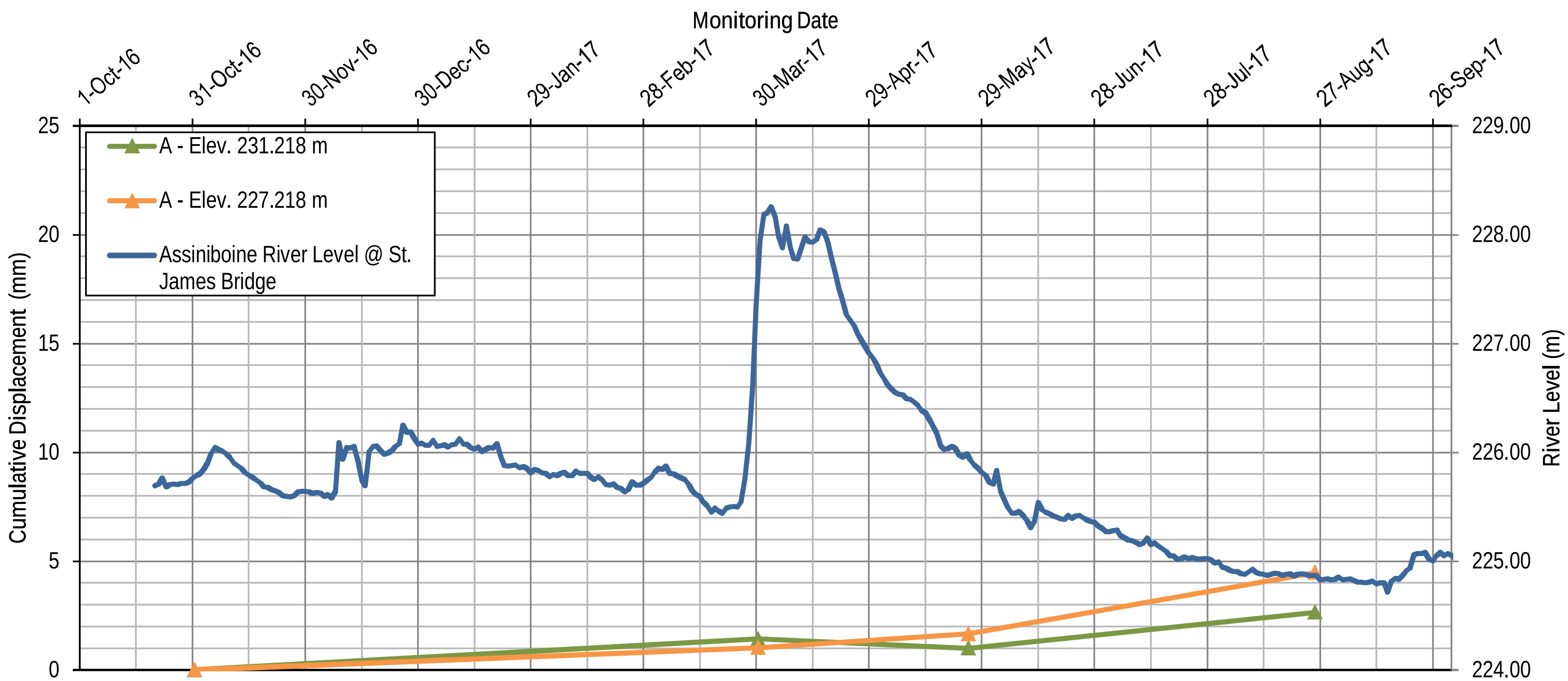
SLOPE INCLINOMETER WORKSHEET

SI-02



SLOPE INCLINOMETER RATE PLOT

SI-02



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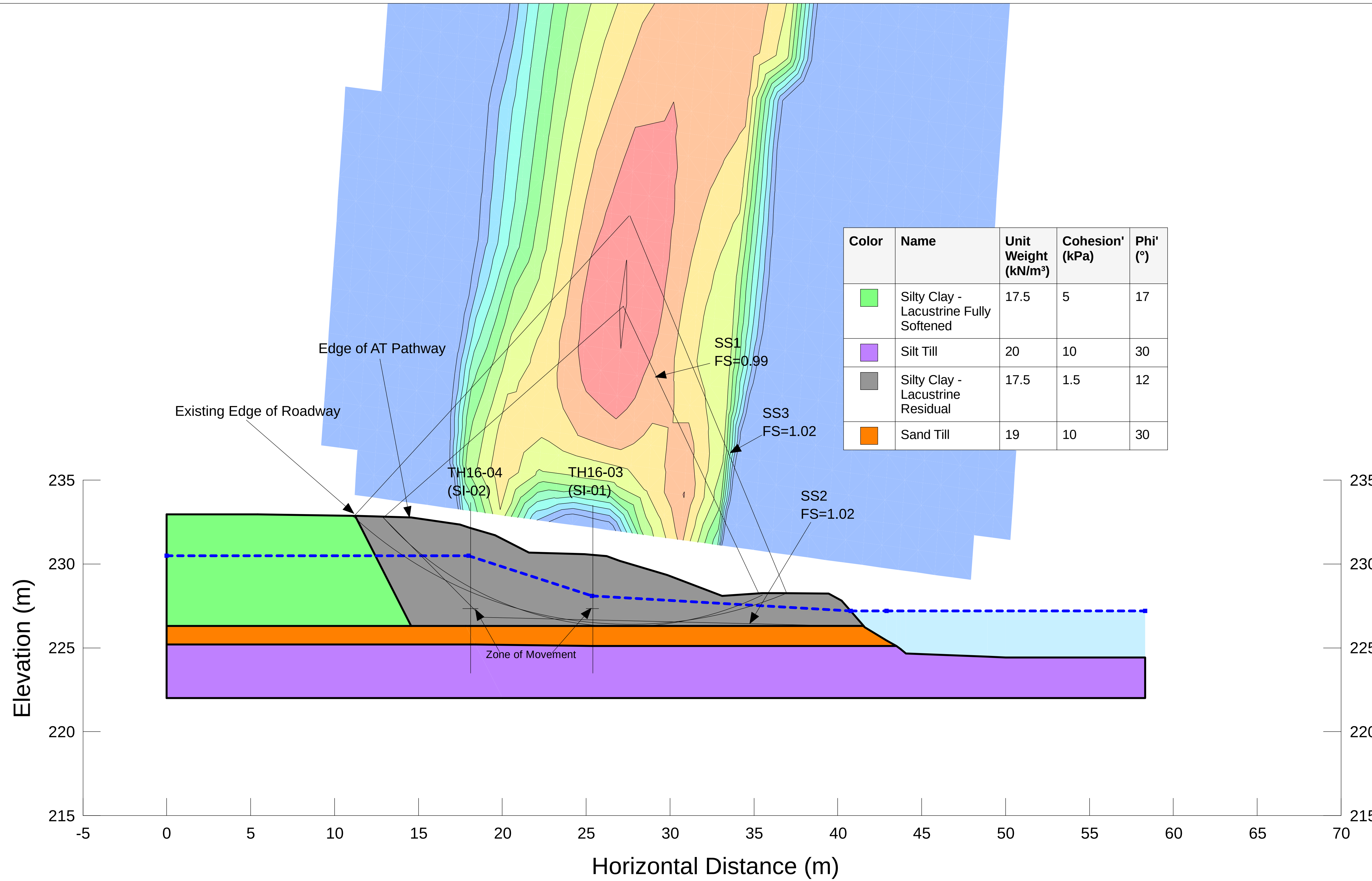
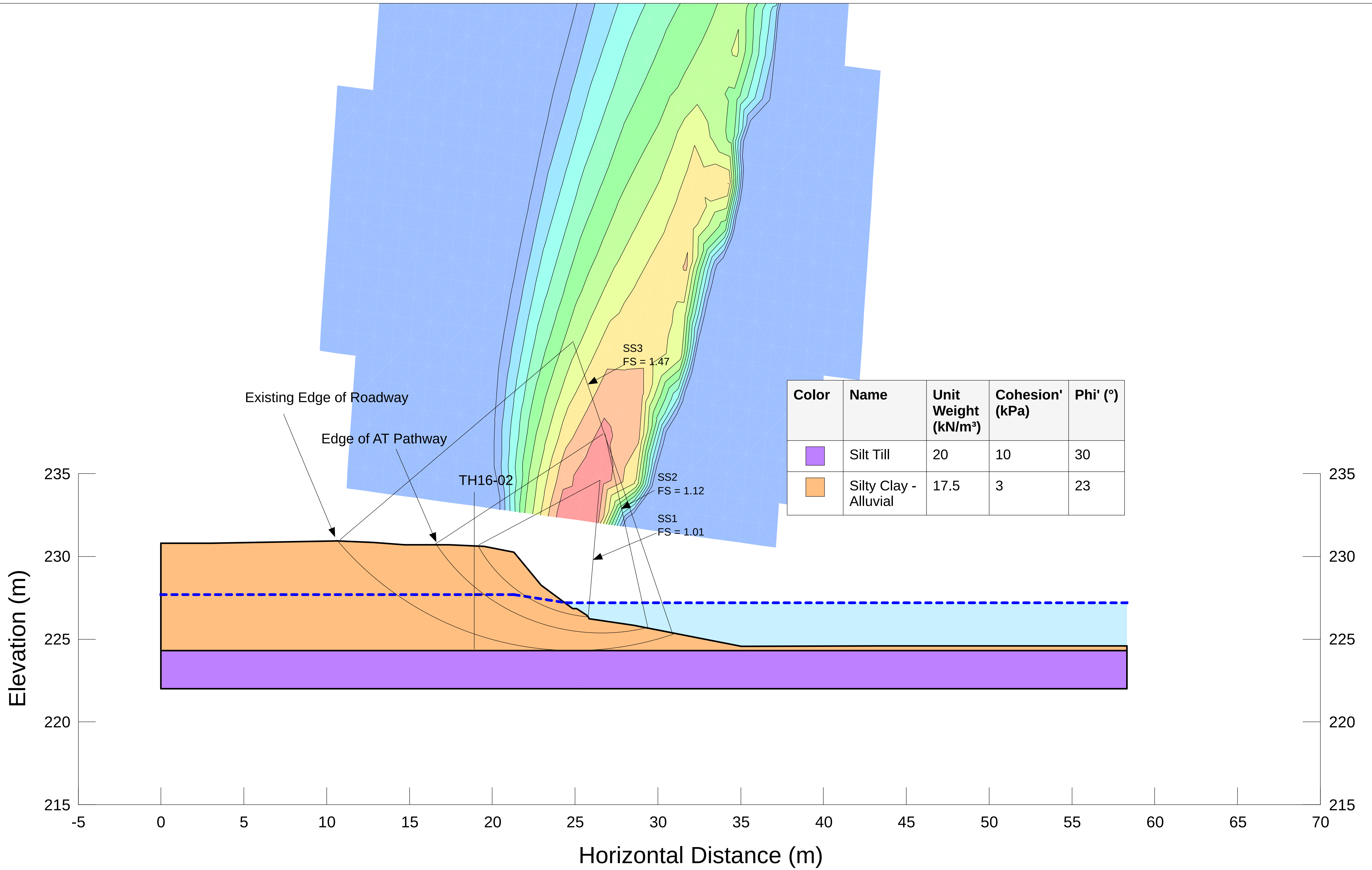


Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silty Clay - Lacustrine Fully Softened	17.5	5	17
	Silt Till	20	10	30
	Silty Clay - Lacustrine Residual	17.5	1.5	12
	Sand Till	19	10	30

SCALE: 1:235 (279mm x 432mm)

Figure 07

Cross Section A - Back Analysis



Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silt Till	20	10	30
	Silty Clay - Alluvial	17.5	3	23

Tabloid (279mm x 432mm)

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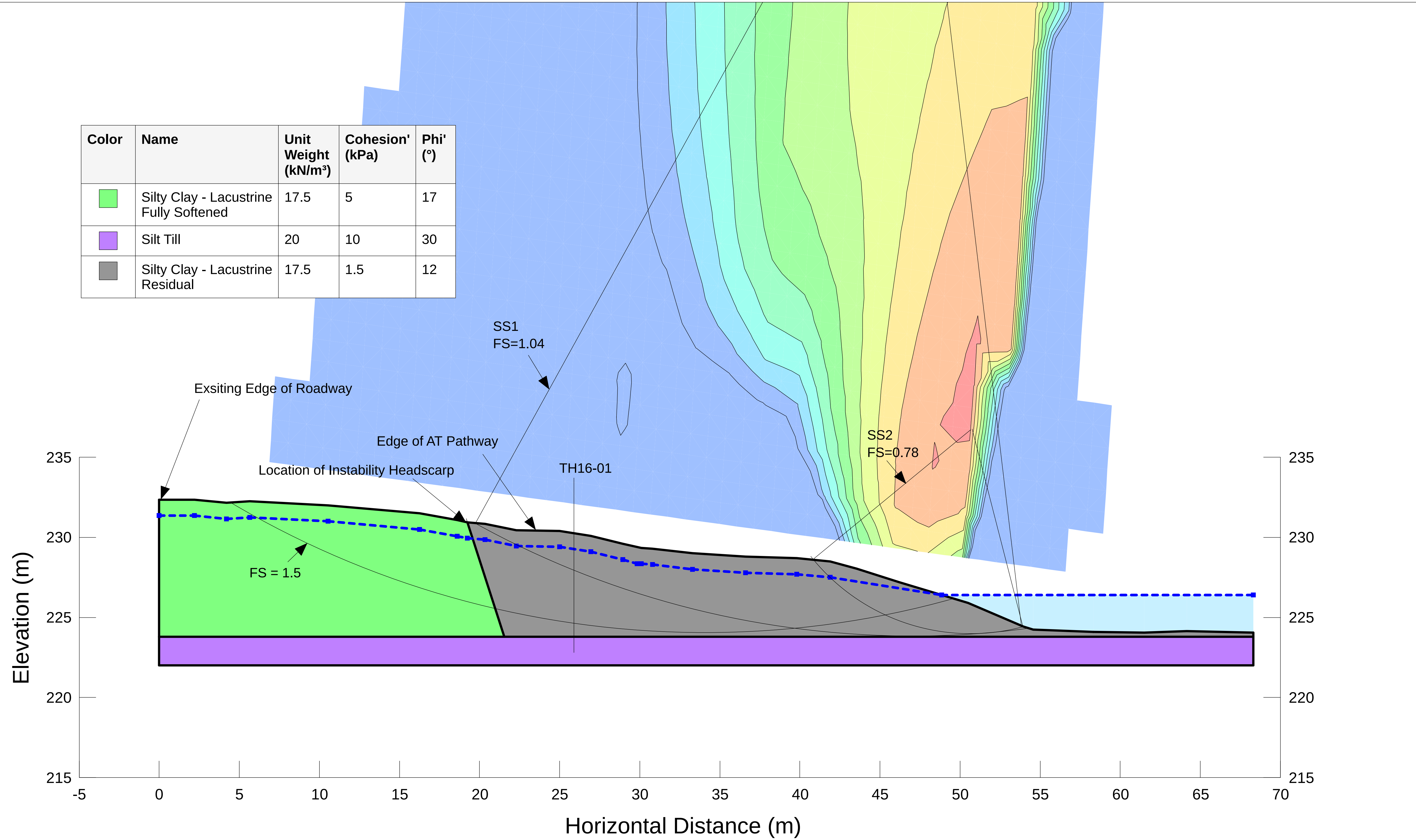


Color	Name	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Silty Clay - Lacustrine Fully Softened	17.5	5	17
	Silt Till	20	10	30
	Silty Clay - Lacustrine Residual	17.5	1.5	12

SCALE: 1:235 (279mm x 432mm)

Figure 09
Cross Section C

Test Hole Logs

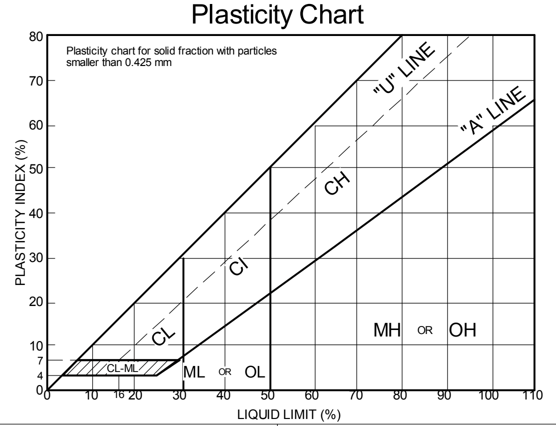
EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent....... GW, GP, SW, SP; More than 12 percent....... GM, GC, SM, SC; 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP		Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM		Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC		Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP		Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM		Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart		
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt		Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Plasticity Chart



Material		Particle Size: mm	Particle Size: ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

	Asphalt		Bedrock (undifferentiated)		Cobbles
	Concrete		Limestone Bedrock		Boulders and Cobbles
	Fill		Cemented Shale		Silt Till
			Non-Cemented Shale		Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

▼ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

TREK GEOTECHNICAL

Sub-Surface Log

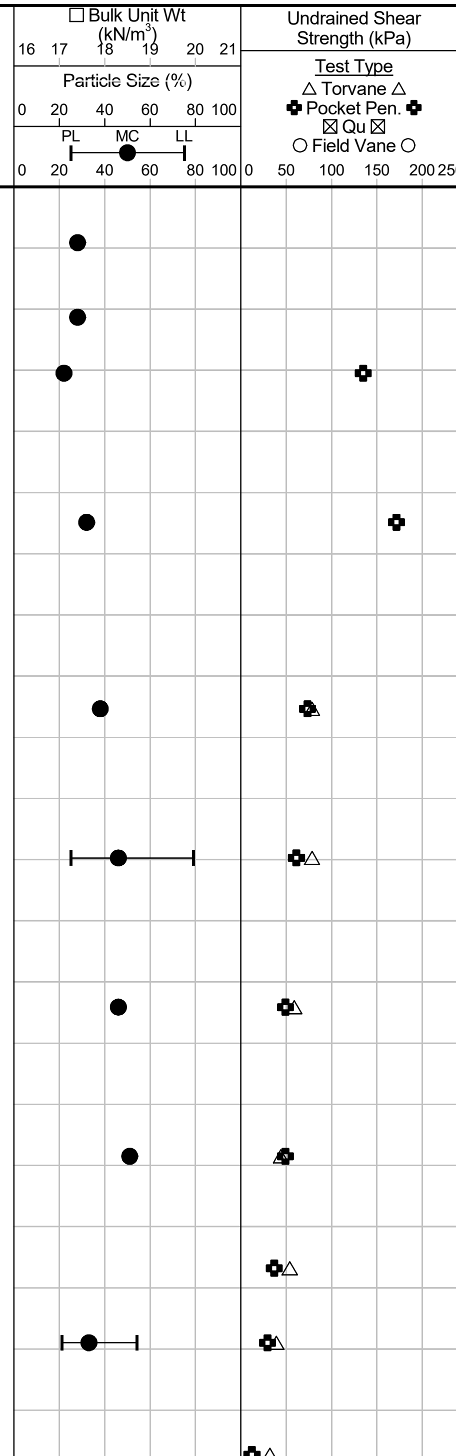
Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526088.156, E-628157.89
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	230.38 m Existing Ground
Method:	170 mm Hollow Stem Auger, Acker SX Track Mount	**Date Drilled:**	October 19, 2016

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
		CLAY (TOPSOIL) - silty, some rootlets, trace sand - black, moist - intermediate to high plasticity, blocky/friable	G	G50	
230.1		CLAY - silty, trace sand - brown - moist, stiff to very stiff - intermediate to high plasticity - blocky/friable	G	G51	
	0.5		SB	SB52	
	1.0		SB	SB53	
	1.5	- sand lens (~ 30 mm diam.) - trace silt, brown, dry, poorly graded, medium grained at 1.8 m - trace silt inclusions (<20 mm diam.), moist, high plasticity, varved below 1.91 m	SB	SB54	
	2.0 – 2.5		SB	SB55	
	3.0 – 3.5		SB	SB56	
	3.5 – 4.0	- sand lens (~ 70 mm diam.) - trace silt, brown, dry to damp, poorly graded, medium grained at 3.7 m - trace to some silt inclusions (<20 mm diam.), trace gravel below 3.7 m - firm below 4.0 m	SB	SB57	
	4.5	- sand lens (~ 25 mm diam.) - trace silt, brown, dry, poorly graded, medium grained at 4.3 m	SB	SB58	
	5.0	- sand lens (~ 50 mm diam.) - trace silt, brown, dry, poorly graded, medium grained at 4.9 m	SB	SB59	



Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Sub-Surface Log

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	SPT (N)
	5.5	- grey, soft to firm below 5.5 m	SB60	
223.8	6.6	SILT (TILL) - some sand, trace to some gravel, trace clay, light grey, wet, loose, low plasticity - some gravel below 6.7 m	SB61	
	7.2	- moist to wet, loose to compact below 7.2 m		
	7.3	- some to with sand, some gravel, wet, loose below 7.3 m		
	7.5	- trace sand, trace gravel, moist, dense below 7.5 m	SB62	
	8.0		SS63	21
221.2	9.1			

Column headings: Elevation (m); Depth (m); Soil Symbol; Standpipe; MATERIAL DESCRIPTION; Sample Type; Sample Number; SPT (N); ☐ Bulk Unit Wt (kN/m³) 16 17 18 19 20 21; Particle Size (%) 0 20 40 60 80 100; PL MC LL 0 20 40 60 80 100; Undrained Shear Strength (kPa) 0 50 100 150 200 250 — Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○

END OF TEST HOLE AT 9.1 m IN SILT (TILL)

Notes:

1. Seepage and sloughing conditions were not observed due to drilling method.
2. Standpipe piezometer SP-01 installed in TH16-01.
3. Test hole backfilled with sand to 8.4 m, bentonite from 8.4 m to 6.1 m , and auger cuttings to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

TREK GEOTECHNICAL

Sub-Surface Log

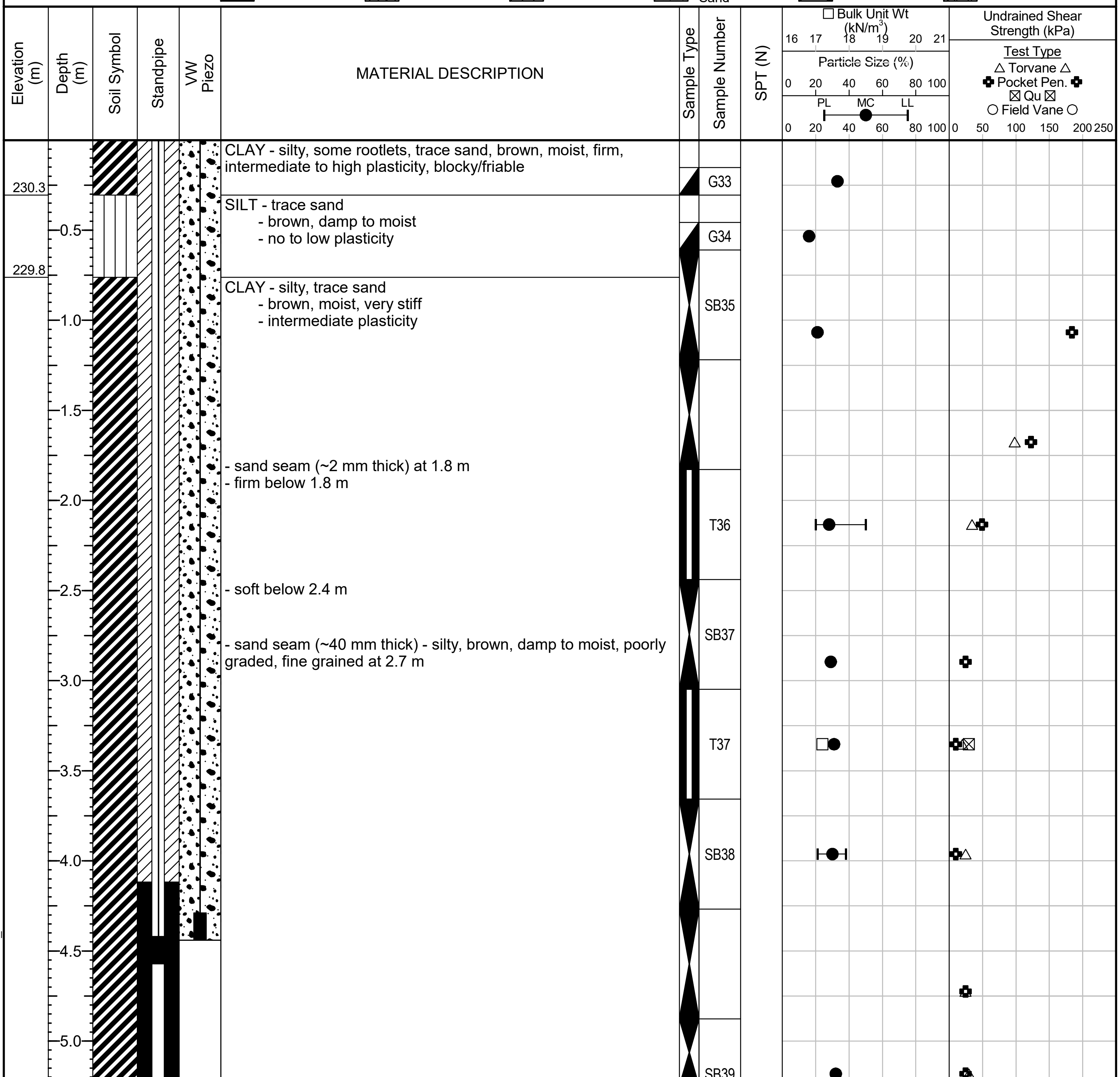
Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526110.587, E-628462.296
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	230.59 m Existing Ground
Method:	170 mm Hollow Stem Auger, Acker SX Track Mount	**Date Drilled:**	October 18, 2016

Sample Type: Grab (G), Shelby Tube (T), Split Spoon (SS), Split Barrel (SB), Core (C)

Particle Size Legend: Fines, Clay, Silt, Sand, Gravel, Cobbles, Boulders

Backfill Legend: Bentonite, Cement, Drill Cuttings, Filter Pack Sand, Grout, Slough

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
230.3	0.0–0.3	CLAY - silty, some rootlets, trace sand, brown, moist, firm, intermediate to high plasticity, blocky/friable	Grab	G33
229.8	0.3–0.8	SILT - trace sand - brown, damp to moist - no to low plasticity	Grab	G34
	0.8–	CLAY - silty, trace sand - brown, moist, very stiff - intermediate plasticity - sand seam (~2 mm thick) at 1.8 m - firm below 1.8 m - soft below 2.4 m - sand seam (~40 mm thick) - silty, brown, damp to moist, poorly graded, fine grained at 2.7 m	SB, T, SB, T, SB, SB	SB35, T36, SB37, T37, SB38, SB39



Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

TREK GEOTECHNICAL

Sub-Surface Log

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	VW Piezo	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ 0 50 100 150 200 250
	5.5				- 25 mm thick piece of wood encountered at 5.5 m					
224.8					SILT - trace sand, grey, wet, loose		SB40			
	6.0				- sand seam (~75 mm thick) - some silt, grey, wet, poorly graded, fine grained at 5.9 m					
224.3					- sand and gravel seam (~280 mm thick) - silty, grey, wet, poorly graded, fine grained sand, medium to coarse grained gravel at 6.0 m		SB41			
	6.5				SILT (TILL) - some to with sand, trace gravel (<25 mm diam.) - grey, moist to wet, loose, low to non plastic					
	7.0				- some sand, dry to moist, dense below 6.7 m			32		
223.0	7.5						SS42	5 / 101mm		

END OF TEST HOLE AT 7.6 m IN SILT (TILL)

Notes:

1. Power auger refusal encountered at 7.6 m in silt (till).
2. Seepage and sloughing conditions were not observed due to drilling method.
3. Standpipe piezometer SP-02 and vibrating wire piezometer VW-01 (tip elevation 226.02 m) installed in TH16-02. VW-01 installed on the exterior side of the standpipe casing.
4. Test hole backfilled with sand to 6.7 m, bentonite from 6.7 m to 4.1 m, and auger cuttings to surface.
5. Vibrating wire piezometer VW-01A (tip elevation 226.15 m) installed in separate test hole (TH16-02A) 0.76 m east of TH16-02 and backfilled with cement-bentonite grout.

SUB-SURFACE LOG 0015 017 00_REV1.GPJ TREK GEOTECHNICAL.GDT 1-22-18

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526085.253, E-628689.36
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	230.69 m Existing Ground
Method:	170 mm Hollow Stem Auger, Acker SX Track Mount	**Date Drilled:**	October 19, 2016

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

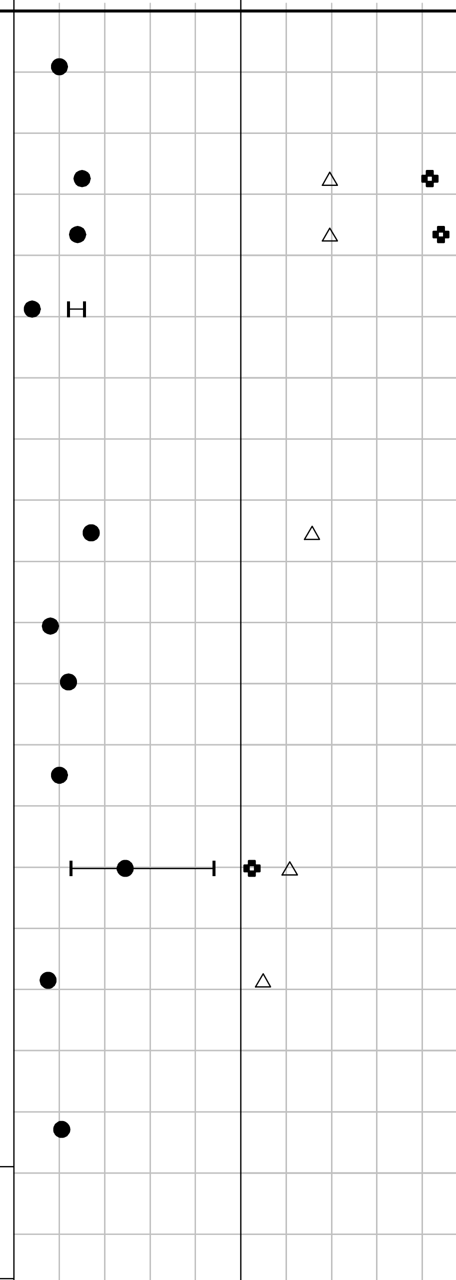
Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Column headings: Elevation (m) | Depth (m) | Soil Symbol | Slope Inclinometer | Standpipe | VW Piezo | MATERIAL DESCRIPTION | Sample Type | Sample Number | SPT (N) | Bulk Unit Wt (kN/m³): 16, 17, 18, 19, 20, 21; Particle Size (%): 0, 20, 40, 60, 80, 100; PL, MC, LL: 0, 20, 40, 60, 80, 100 | Undrained Shear Strength (kPa): Test Type: △ Torvane △, ✽ Pocket Pen. ✽, ⊠ Qu ⊠, ○ Field Vane ○; 0, 50, 100, 150, 200, 250

Elevation (m)	MATERIAL DESCRIPTION
	CLAY (TOPSOIL) - silty, trace to some sand, trace to some rootlets, trace gravel, black, moist, intermediate plasticity, blocky/friable
230.4	CLAY - silty, trace rootlets - brown, moist, very stiff - intermediate to high plasticity - trace sand, trace gravel (<20 mm diam.) below 0.8 m
229.6	SILT - trace sand, trace clay - light brown, damp - low plasticity
229.0	CLAY - silty, trace sand, trace rootlets - brown, moist, stiff - intermediate to high plasticity - some sand, some gravel, poorly graded, fine sand to fine gravel below 2.1 m
227.9	SAND - trace to some silt, trace gravel - brown, damp to moist - poorly graded, fine to coarse grained
227.5	CLAY - silty, trace to some silt inclusions (<15 mm diam.), trace sand, trace gravel - brown mottled grey, moist, stiff - high plasticity
226.9	Transition from clay to till below 3.8 m - some sand, grey, moist to wet, soft, low to intermediate plasticity.
226.3	SAND (TILL) - silty - light brown - wet, loose - poorly graded, fine to medium grained

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0

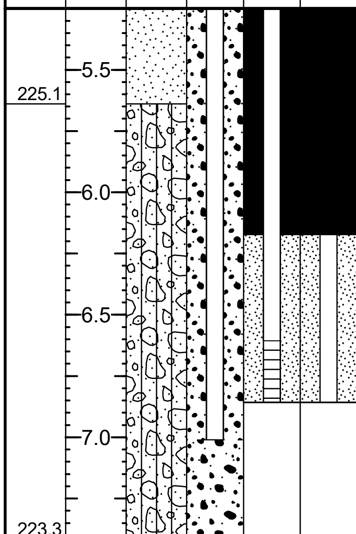
Sample Number	SPT (N)
G01	
G02	
SB03	
SB04	
SB05	
SB06	
SB07	
SB08	
SB09	
SB10	
SB11	
SS12	8



Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Sub-Surface Log

TREK GEOTECHNICAL



Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
225.1	5.4	SILT (TILL) - trace to some sand, trace gravel, trace clay - grey - damp to moist - compact to dense - low plasticity		SB13	
				SS14	45
223.3	7.4			SS15	58 / 253mm

Bulk Unit Wt (kN/m³): 16 17 18 19 20 21
Particle Size (%): 0 20 40 60 80 100
PL MC LL: 0 20 40 60 80 100
Undrained Shear Strength (kPa) — Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○: 0 50 100 150 200 250

END OF TEST HOLE AT 7.4 m IN SILT (TILL)

Notes:

1. Seepage and sloughing conditions were not observed due to drilling method.
2. Slope inclinometer SI-01 installed in TH16-03.
3. Test hole backfilled with cement-bentonite grout to surface.
4. Standpipe piezometer SP-03 (tip elevation 223.85 m) and vibrating wire piezometer VW-02 (tip elevation 226.75 m) were installed in a seperate test hole (TH16-03A) located 2.1 m east of TH16-03. Test hole backfilled with sand to 6.2 m, bentonite from 6.2 m to 3.7 m, and cuttings to surface.
5. Vibrating wire piezometer VW-02A (tip elevation 226.81 m) was installed in a separate test hole (TH16-03B) located 3.3 m east of TH16-03. Refer to summary log TH16-03B for installation details.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526086.339, E-628692.492
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	230.77 m Existing Ground
Method:	170 mm Hollow Stem Auger, Acker SX Track Mount	**Date Drilled:**	October 19, 2016

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	Soil Symbol	VW Piezo	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ 0 50 100 150 200 250
	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0			Notes: 1. Refer to TH16-03 for the material description. 2. Vibrating wire piezometer VW-02A (tip elevation 226.81 m) installed in TH16-03B. 3. Test hole backfilled with cement-bentonite grout to surface.					

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

TREK GEOTECHNICAL

Sub-Surface Log

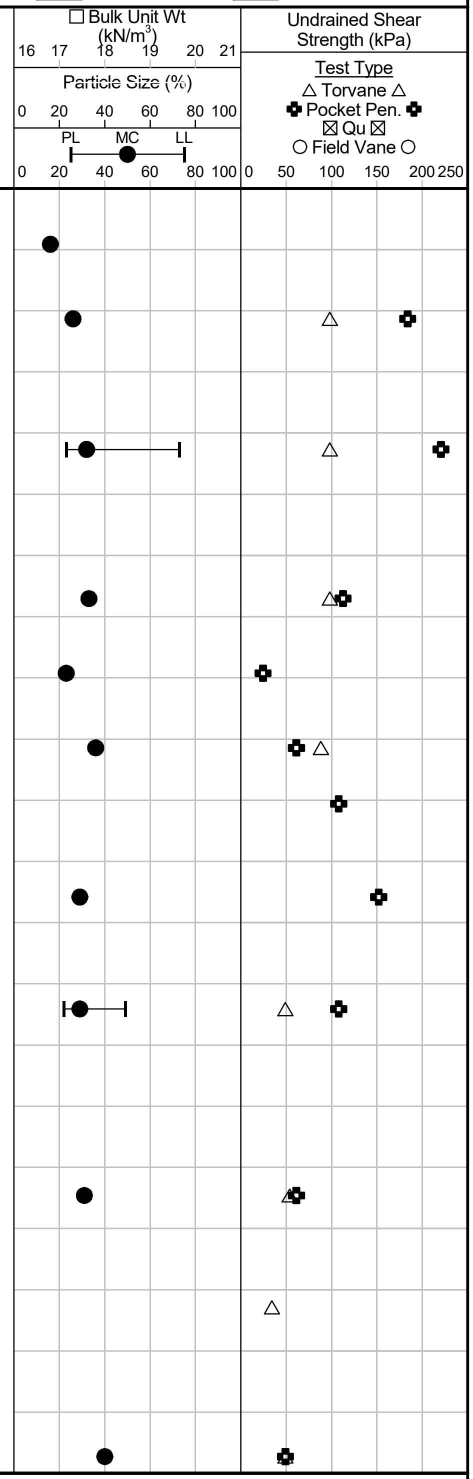
Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526075.783, E-628684.625
Contractor:	Paddock Drilling Ltd.	**Ground Elevation:**	232.52 m Existing Ground
Method:	170 mm Hollow Stem Auger, Acker SX Track Mount	**Date Drilled:**	October 18, 2016

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

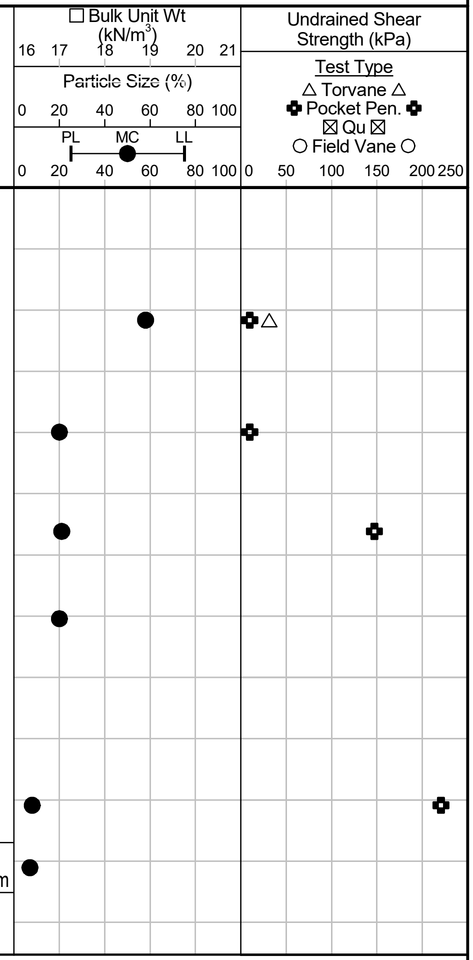
Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
		CLAY (TOPSOIL) - trace to some rootlets, trace sand, trace gravel, brown, moist, low to intermediate plasticity, blocky/friable	Grab	G16	
232.2		CLAY (FILL) - silty, trace rootlets to 0.6 m, trace sand - brown, moist, very stiff - high plasticity	Grab	G17	
	1.0		Split Barrel	SB18	
	1.5		Split Barrel	SB19	
	2.0	- silt lens (~100 mm thick) - light brown, moist at 1.9 m - trace silt inclusions (<20 mm diam.), stiff below 2.0 m	Split Barrel	SB20	
			Split Barrel	SB21	
	2.5	- 200 mm thick layer of sand mixed with ceramic fragments and degraded black rock at 2.5 m	Split Barrel	SB22	
229.6			Split Barrel	SB23	
	3.0	CLAY - silty - brown, damp to moist, stiff - intermediate to high plasticity			
	3.5		Split Barrel	SB24	
	4.0		Split Barrel	SB25	
	4.5				
	5.0		Split Barrel	SB26	



Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Sub-Surface Log

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	SPT (N)
227.0	5.5	Transition from clay to till below 5.5 m - trace silt inclusions, trace sand, trace gravel (<10 mm diam.), moist to wet, soft to firm.	SB27	
226.3		SILT (TILL) - trace to some sand, trace gravel (<20 mm diam.), trace clay, grey, moist to wet, loose, low plasticity	SB28	
226.0	6.5	SAND (TILL)- silty - brown - wet, loose to compact - poorly graded, fine to medium grained	SB29 SB30	
225.2		SILT (TILL) - trace to some sand, trace gravel (<65 mm diam.) - grey, wet, loose - moist, dense below 7.6 m - very dense below 7.9 m	SB31 SS32	 26 / 52mm
224.1				



END OF TEST HOLE AT 8.4 m IN SILT (TILL)
Notes:
1. Power auger refusal encountered at 8.4 m in silt (till).
2. Seepage and sloughing conditions were not observed due to drilling method.
3. Slope inclinometer SI-02 installed in TH16-04.
4. Test hole backfilled with cement-bentonite grout to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Sub-Surface Log

TREK GEOTECHNICAL

Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526094.171, E-628172.552
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	230.08 m Existing Ground
Method:	50 mm Hand Auger	**Date Drilled:**	July 7, 2017

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △ ✚ Pocket Pen. ✚ ⊠ Qu ⊠ ○ Field Vane ○ 0 50 100 150 200 250
	0.0		Bentonite	CLAY - silty, trace sand, trace gravel (<20 mm diam.), trace rootlets to 0.3 m, brown, damp, firm to stiff, intermediate to high plasticity, blocky, friable					
	0.3			- moist below 0.3 m					
	0.5				G	G01			
	1.0			- moist to wet below 1.0 m					
	1.8			- moist below 1.8 m					
	2.0				G	G02			
	3.0		Filter Pack Sand						
	3.5				G	G03			
226.1	4.0								

END OF TEST HOLE AT 4.0 m IN CLAY

Notes:

1) Seepage observed below 1.1 m during drillig.
2) No sloughing observed.
3) Test hole open to 4.0 m 15 minutes after drilling.
4) Water level at 0.8 m 15 minutes after drilling.
5) Standpipe SP17-01 installed in HA17-01.
6) Test hole backfilled with sand to 3.0 m, and bentonite to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

GEOTECHNICAL

Sub-Surface Log

Client: City of Winnipeg
Project Number: 0015 017 00
Project Name: Wellington Crescent (Lamont Blvd. to Academy Rd.)
Location: UTM N-5526094.876, E-628194.785
Contractor: TREK Geotechnical Inc.
Ground Elevation: 231.27 m Existing Ground
Method: 50 mm Hand Auger
Date Drilled: July 13, 2017

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ 0 50 100 150 200 250
				CLAY - silty, trace rootlets to 0.3 m, brownish black, damp to moist, high plasticity					
				- brown, intermediate to high plasticity below 0.3 m					
	0.5								
					G	G04			
	1.0								
	1.5								
	2.0				G	G05			
	2.5			- trace silt inclusions (<5 mm diam.) below 2.5 m					
	3.0				G	G06			
	3.5			- grey, moist, firm, high plasticity below 3.5 m	G	G07			
227.3									

END OF TEST HOLE AT 3.9 m IN CLAY
Notes:
1) Seepage observed below 1.5 m during drillig.
2) No sloughing observed.
3) Test hole open to 3.9 m 10 minutes after drilling.
4) Water level at 1.1 m 10 minutes after drilling.
5) Standpipe SP17-02 installed in HA17-02.
6) Test hole backfilled with sand to 3.4 m, and bentonite to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Test Hole HA17-03

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526085.321, E-628145.87
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	230.75 m Existing Ground
Method:	50 mm Hand Auger	**Date Drilled:**	July 13, 2017

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)	Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○ 0 50 100 150 200 250
	0.0–1.1		Bentonite	CLAY - silty, trace sand, trace gravel (<10 mm diam.), trace rootlets to 0.3 m - brown - moist - intermediate to high plasticity					
	1.1			- trace to some silt inclusions (<15 mm diam.) below 1.1 m	G	G08			
					G	G09			
	3.0		Filter Pack Sand		G	G10			
	3.3			- moist, firm to stiff below 3.3 m	G	G11			
227.0	3.8								

END OF TEST HOLE AT 3.8 m IN CLAY

Notes:

1) No seepage or sloughing observed.
2) Test hole open to 3.8 m 10 minutes after drilling.
3) Water level not observed following drilling.
4) Standpipe SP17-03 installed in HA17-03.
5) Test hole backfilled with sand to 3.0 m, and bentonite to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015 017 00
Project Name:	Wellington Crescent (Lamont Blvd. to Academy Rd.)	**Location:**	UTM N-5526100.925, E-628161.311
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	229.11 m Existing Ground
Method:	50 mm Hand Auger	**Date Drilled:**	July 13, 2017

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Backfill Legend: Bentonite | Cement | Drill Cuttings | Filter Pack Sand | Grout | Slough

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	SPT (N)
	0.0–0.75	CLAY - silty, trace rootlets - brown - moist - high plasticity	Grab	G12	
228.3	0.75–1.8	SILT - clayey - light brown - wet, loose - low plasticity	Grab	G13	
227.3	1.8–2.7	CLAY - silty - brown - wet, soft - intermediate plasticity	Grab	G14	
226.4					

Chart headings: Bulk Unit Wt (kN/m³) 16 17 18 19 20 21; Particle Size (%) 0 20 40 60 80 100; PL MC LL 0 20 40 60 80 100; Undrained Shear Strength (kPa), Test Type: △ Torvane △, ✚ Pocket Pen. ✚, ⊠ Qu ⊠, ○ Field Vane ○; 0 50 100 150 200 250

END OF TEST HOLE AT 2.7 m IN CLAY
Notes:
1) Seepage observed below 1.3 m during drillig.
2) Sloughing observed in silt layer from 0.75 to 1.8 m during drilling.
3) Test hole open to 1.4 m 10 minutes after drilling.
4) Water level at approximately 1.0 m immediately after drilling.
5) Standpipe SP17-04 installed in HA17-04.
6) Test hole backfilled with sand to 1.8 m, and bentonite to surface.

Logged By: Shawn Beaudry **Reviewed By:** Nelson Ferreira **Project Engineer:** Shawn Beaudry

Appendix A
Soil Laboratory Test Results

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Moisture Content Report
ASTM D2216-98

Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent

Sample Date 02-Nov-16
Test Date 05-Nov-16
Technician LI

Test Pit	TH16-03	TH16-03	TH16-03	TH16-03	TH16-03	TH16-03
Depth (m)	0.2 - 0.3	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	2.1 - 2.3	2.5 - 2.7
Sample #	G01	G02	G03	G04	G05	G06
Tare ID	AB16	AB28	AB40	AB98	AB67	AB91
Mass of tare	6.7	6.7	6.8	6.7	6.7	6.6
Mass wet + tare	284.8	286.6	273.1	169.5	301.0	178.7
Mass dry + tare	238.5	222.9	215.2	157.2	225.7	154.5
Mass water	46.3	63.7	57.9	12.3	75.3	24.2
Mass dry soil	231.8	216.2	208.4	150.5	219.0	147.9
Moisture %	20.0%	29.5%	27.8%	8.2%	34.4%	16.4%

Test Pit	TH16-03	TH16-03	TH16-03	TH16-03	TH16-03	TH16-03
Depth (m)	2.7 - 2.9	3.1 - 3.3	3.5 - 3.7	4.0 - 4.1	4.6 - 4.7	5.3 - 5.4
Sample #	G07	G08	G09	G10	G11	G12
Tare ID	AB21	AC28	AB96	AB20	AB14	AB86
Mass of tare	6.6	6.6	6.7	6.6	6.6	6.6
Mass wet + tare	249.8	319.8	332.5	375.4	335.1	332.7
Mass dry + tare	202.8	267.5	224.9	328.5	279.2	280.9
Mass water	47.0	52.3	107.6	46.9	55.9	51.8
Mass dry soil	196.2	260.9	218.2	321.9	272.6	274.3
Moisture %	24.0%	20.0%	49.3%	14.6%	20.5%	18.9%

Test Pit	TH16-03	TH16-03	TH16-03	TH16-04	TH16-04	TH16-04
Depth (m)	6.1 - 6.2	6.6 - 7.0	7.0 - 7.4	0.2 - 0.3	0.5 - 0.6	1.1 - 1.2
Sample #	G13	SS14	SS15	G16	G17	G18
Tare ID	AB64	AB63	N43	F20	E37	K26
Mass of tare	6.6	6.8	8.5	8.4	8.2	8.5
Mass wet + tare	448.9	380.6	344.0	215.6	311.9	293.6
Mass dry + tare	412.4	354.7	321.1	186.8	249.8	224.9
Mass water	36.5	25.9	22.9	28.8	62.1	68.7
Mass dry soil	405.8	347.9	312.6	178.4	241.6	216.4
Moisture %	9.0%	7.4%	7.3%	16.1%	25.7%	31.7%

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Moisture Content Report
ASTM D2216-98

Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent

Sample Date 02-Nov-16
Test Date 05-Nov-16
Technician LI

Test Pit	TH16-04	TH16-04	TH16-04	TH16-04	TH16-04	TH16-04
Depth (m)	1.7 - 1.8	2.0 - 2.0	2.3 - 2.4	2.9 - 3.0	3.4 - 3.5	4.1 - 4.3
Sample #	G19	G20	G21	G23	G24	G25
Tare ID	D26	D37	E123	A103	E6	F76
Mass of tare	8.8	8.2	8.4	8.5	8.2	8.7
Mass wet + tare	346.2	253.4	287.7	245.6	333.6	329.9
Mass dry + tare	263.4	208.0	213.4	192.9	260.6	253.1
Mass water	82.8	45.4	74.3	52.7	73.0	76.8
Mass dry soil	254.6	199.8	205.0	184.4	252.4	244.4
Moisture %	32.5%	22.7%	36.2%	28.6%	28.9%	31.4%

Test Pit	TH16-04	TH16-04	TH16-04	TH16-04	TH16-04	TH16-04
Depth (m)	5.2 - 5.3	5.8 - 5.9	6.2 - 6.4	6.6 - 6.7	7.0 - 7.3	7.8 - 7.9
Sample #	G26	G27	G28	G29	G30	G31
Tare ID	AB65	F91	F103	W18	F83	E35
Mass of tare	6.8	8.4	8.9	8.5	8.5	8.5
Mass wet + tare	358.6	301.4	369.4	384.9	369.3	449.3
Mass dry + tare	258.6	193.5	309.9	320.6	310.3	418.7
Mass water	100.0	107.9	59.5	64.3	59.0	30.6
Mass dry soil	251.8	185.1	301.0	312.1	301.8	410.2
Moisture %	39.7%	58.3%	19.8%	20.6%	19.5%	7.5%

Test Pit	TH16-04	TH16-02	TH16-02	TH16-02	TH16-02	TH16-02
Depth (m)	7.9 - 8.1	0.2 - 0.3	0.5 - 0.6	1.1 - 1.2	2.9 - 3.0	4.0 - 4.3
Sample #	G32	G33	G34	G35	G37	G38
Tare ID	E128	Z64	AB82	F42	Z138	F109
Mass of tare	8.4	8.3	6.6	8.3	8.6	8.7
Mass wet + tare	327.0	280.5	206.4	318.3	345.3	421.9
Mass dry + tare	306.4	213.8	178.4	265.3	270.2	326.9
Mass water	20.6	66.7	28.0	53.0	75.1	95.0
Mass dry soil	298.0	205.5	171.8	257.0	261.6	318.2
Moisture %	6.9%	32.5%	16.3%	20.6%	28.7%	29.9%

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Moisture Content Report
ASTM D2216-98

Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent

Sample Date 02-Nov-16
Test Date 05-Nov-16
Technician LI

Test Pit	TH16-02	TH16-02	TH16-02	TH16-02	TH16-01	TH16-01
Depth (m)	5.2 - 5.5	5.8 - 5.9	6.2 - 6.4	7.3 - 7.4	0.2 - 0.3	0.5 - 0.6
Sample #	G39	G40	G41	G42	G50	G51
Tare ID	F72	K24	AC27	AB02	N77	D40
Mass of tare	8.5	8.6	6.6	6.6	8.4	8.2
Mass wet + tare	361.5	337.2	461.3	195.6	215.3	174.5
Mass dry + tare	275.5	263.5	423.3	180.4	169.6	138.3
Mass water	86.0	73.7	38.0	15.2	45.7	36.2
Mass dry soil	267.0	254.9	416.7	173.8	161.2	130.1
Moisture %	32.2%	28.9%	9.1%	8.7%	28.3%	27.8%

Test Pit	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01
Depth (m)	0.8 - 0.9	1.4 - 1.5	2.1 - 2.3	2.7 - 2.9	3.4 - 3.5	4.0 - 4.1
Sample #	G52	G53	G54	G55	G56	G57
Tare ID	F102	N93	H38	F89	E102	N52
Mass of tare	8.8	8.5	8.4	8.4	8.7	8.4
Mass wet + tare	377.9	313.0	366.8	326.6	357.5	334.2
Mass dry + tare	311.6	240.1	268.2	226.3	248.3	224.8
Mass water	66.3	72.9	98.6	100.3	109.2	109.4
Mass dry soil	302.8	231.6	259.8	217.9	239.6	216.4
Moisture %	21.9%	31.5%	38.0%	46.0%	45.6%	50.6%

Test Pit	TH16-01	TH16-01	TH16-01	TH16-01	TH16-01	
Depth (m)	4.7 - 4.9	5.3 - 5.5	5.9 - 6.1	7.0 - 7.2	7.9 - 8.4	
Sample #	G58	G59	G60	G61	SS63	
Tare ID	W42	F5	H54	Z04	E130	
Mass of tare	8.3	8.4	8.3	8.4	8.2	
Mass wet + tare	332.8	313.5	342.8	390.5	401.8	
Mass dry + tare	251.8	204.3	237.3	253.4	371.2	
Mass water	81.0	109.2	105.5	137.1	30.6	
Mass dry soil	243.5	195.9	229.0	245.0	363.0	
Moisture %	33.3%	55.7%	46.1%	56.0%	8.4%	

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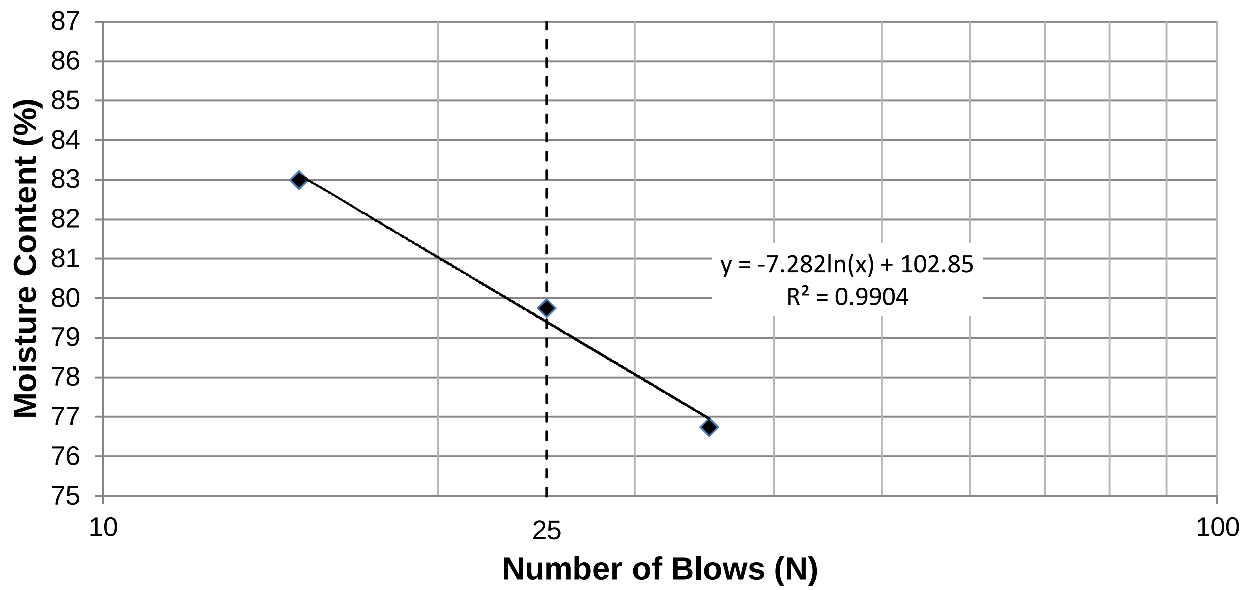
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-01
Sample #	G54
Depth (m)	2.13 - 2.29
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	79
Plastic Limit	25
Plasticity Index	55

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	15	25	35		
Mass Wet Soil + Tare (g)	20.154	22.113	21.533		
Mass Dry Soil + Tare (g)	17.403	18.571	18.332		
Mass Tare (g)	14.088	14.130	14.161		
Mass Water (g)	2.751	3.542	3.201		
Mass Dry Soil (g)	3.315	4.441	4.171		
Moisture Content (%)	82.986	79.757	76.744		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	22.072	23.875			
Mass Dry Soil + Tare (g)	20.453	21.945			
Mass Tare (g)	13.968	14.138			
Mass Water (g)	1.619	1.930			
Mass Dry Soil (g)	6.485	7.807			
Moisture Content (%)	24.965	24.721			

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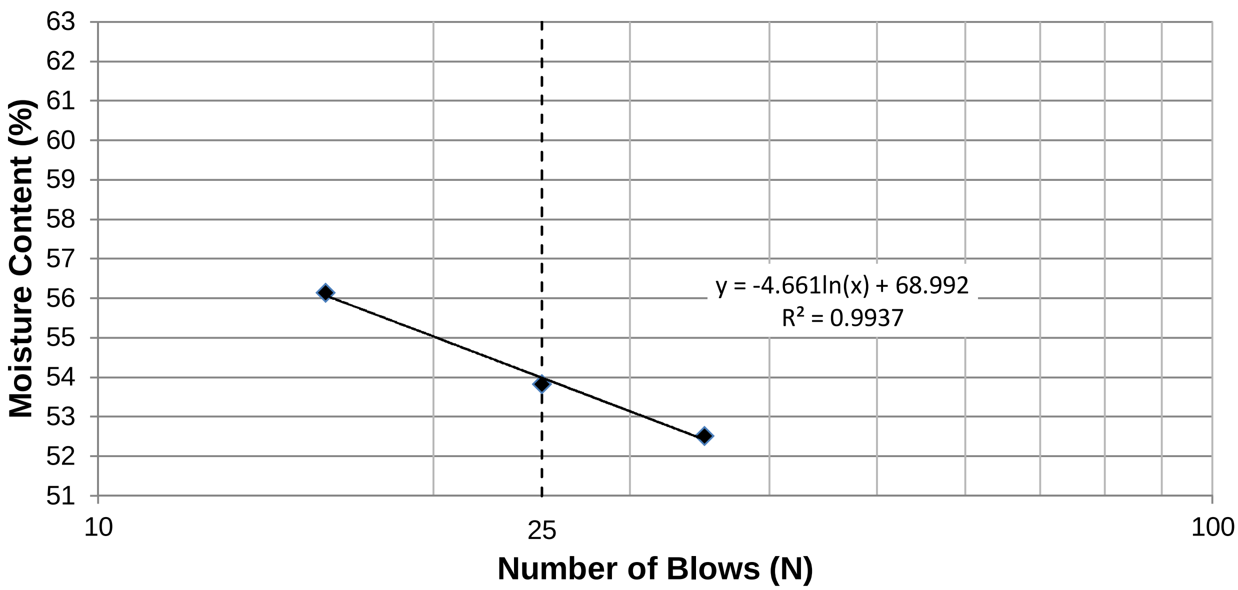
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-01
Sample #	G58
Depth (m)	4.72 - 4.88
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	54
Plastic Limit	21
Plasticity Index	33

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	16	25	35		
Mass Wet Soil + Tare (g)	23.274	21.641	20.779		
Mass Dry Soil + Tare (g)	20.052	19.029	18.526		
Mass Tare (g)	14.313	14.176	14.236		
Mass Water (g)	3.222	2.612	2.253		
Mass Dry Soil (g)	5.739	4.853	4.290		
Moisture Content (%)	56.142	53.822	52.517		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.206	20.582			
Mass Dry Soil + Tare (g)	19.106	19.494			
Mass Tare (g)	14.030	14.319			
Mass Water (g)	1.100	1.088			
Mass Dry Soil (g)	5.076	5.175			
Moisture Content (%)	21.671	21.024			

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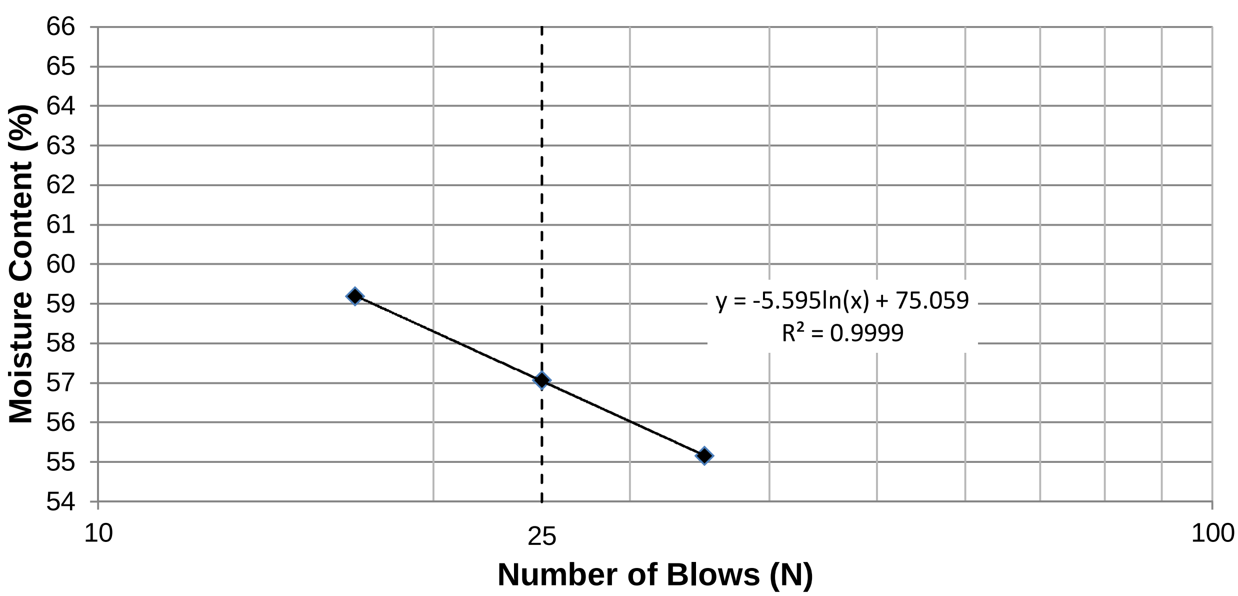
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-01
Sample #	G60
Depth (m)	5.94 - 6.1
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	57
Plastic Limit	24
Plasticity Index	33

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	17	25	35		
Mass Wet Soil + Tare (g)	22.403	20.874	21.272		
Mass Dry Soil + Tare (g)	19.371	18.442	18.725		
Mass Tare (g)	14.249	14.181	14.107		
Mass Water (g)	3.032	2.432	2.547		
Mass Dry Soil (g)	5.122	4.261	4.618		
Moisture Content (%)	59.196	57.076	55.154		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	21.452	22.453			
Mass Dry Soil + Tare (g)	20.083	20.874			
Mass Tare (g)	14.252	14.198			
Mass Water (g)	1.369	1.579			
Mass Dry Soil (g)	5.831	6.676			
Moisture Content (%)	23.478	23.652			

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Atterberg Limits
ASTM D4318-10e1

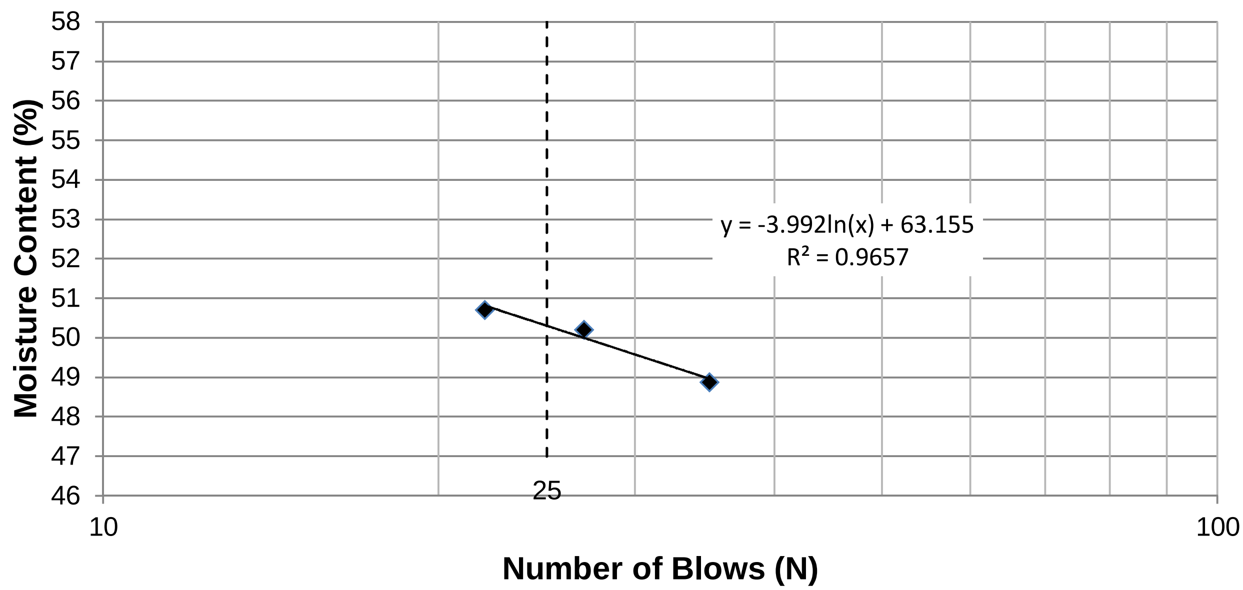
Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent

Test Hole TH16-02
Sample # T36
Depth (m) 1.83 - 2.44
Sample Date 20-Oct-16
Test Date 17-Nov-16
Technician SB

Liquid Limit	50
Plastic Limit	20
Plasticity Index	30

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	22	27	35		
Mass Wet Soil + Tare (g)	33.667	33.761	21.464		
Mass Dry Soil + Tare (g)	27.108	27.123	19.012		
Mass Tare (g)	14.172	13.900	13.995		
Mass Water (g)	6.559	6.638	2.452		
Mass Dry Soil (g)	12.936	13.223	5.017		
Moisture Content (%)	50.703	50.200	48.874		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	27.593	26.973			
Mass Dry Soil + Tare (g)	25.363	24.754			
Mass Tare (g)	14.220	14.030			
Mass Water (g)	2.230	2.219			
Mass Dry Soil (g)	11.143	10.724			
Moisture Content (%)	20.013	20.692			

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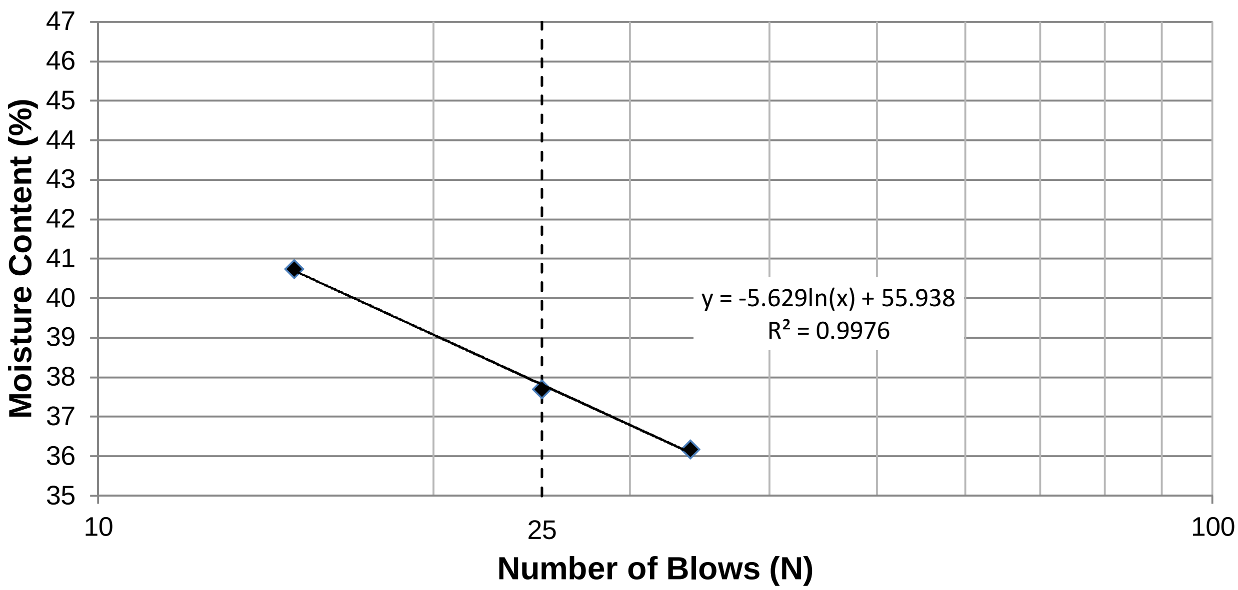
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-02
Sample #	G38
Depth (m)	3.96 - 4.27
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	38
Plastic Limit	21
Plasticity Index	16

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	15	25	34		
Mass Wet Soil + Tare (g)	22.282	21.938	22.192		
Mass Dry Soil + Tare (g)	19.947	19.786	20.024		
Mass Tare (g)	14.216	14.076	14.030		
Mass Water (g)	2.335	2.152	2.168		
Mass Dry Soil (g)	5.731	5.710	5.994		
Moisture Content (%)	40.743	37.688	36.170		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	21.454	21.678			
Mass Dry Soil + Tare (g)	20.143	20.340			
Mass Tare (g)	13.968	14.154			
Mass Water (g)	1.311	1.338			
Mass Dry Soil (g)	6.175	6.186			
Moisture Content (%)	21.231	21.629			

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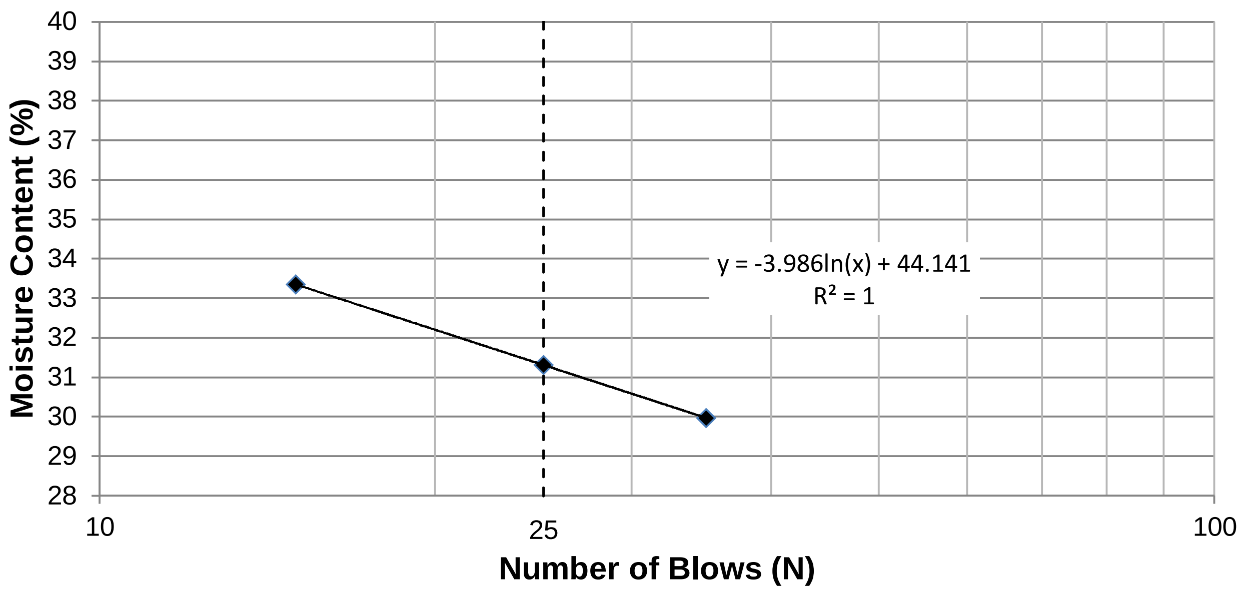
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-03
Sample #	G04
Depth (m)	1.22 - 1.37
Sample Date	18-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	31
Plastic Limit	24
Plasticity Index	7

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	15	25	35		
Mass Wet Soil + Tare (g)	21.252	20.926	20.829		
Mass Dry Soil + Tare (g)	19.474	19.294	19.253		
Mass Tare (g)	14.142	14.083	13.994		
Mass Water (g)	1.778	1.632	1.576		
Mass Dry Soil (g)	5.332	5.211	5.259		
Moisture Content (%)	33.346	31.318	29.968		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	22.871	23.200			
Mass Dry Soil + Tare (g)	21.137	21.476			
Mass Tare (g)	14.024	14.315			
Mass Water (g)	1.734	1.724			
Mass Dry Soil (g)	7.113	7.161			
Moisture Content (%)	24.378	24.075			

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Atterberg Limits
ASTM D4318-10e1

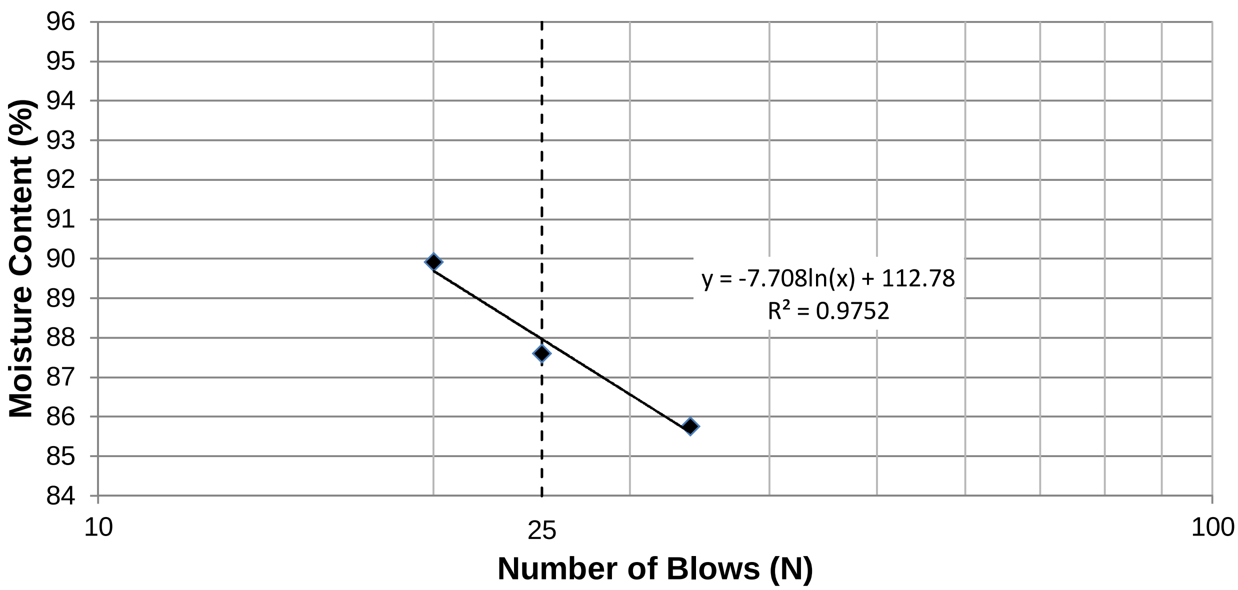
Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent

Test Hole TH16-03
Sample # G09
Depth (m) 3.51 - 3.66
Sample Date 18-Oct-16
Test Date 14-Nov-16
Technician JW

Liquid Limit	88
Plastic Limit	25
Plasticity Index	63

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	20	25	34		
Mass Wet Soil + Tare (g)	21.252	20.926	20.829		
Mass Dry Soil + Tare (g)	17.937	17.713	17.667		
Mass Tare (g)	14.250	14.045	13.980		
Mass Water (g)	3.315	3.213	3.162		
Mass Dry Soil (g)	3.687	3.668	3.687		
Moisture Content (%)	89.910	87.595	85.761		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	20.140	20.230			
Mass Dry Soil + Tare (g)	18.937	18.984			
Mass Tare (g)	14.178	14.066			
Mass Water (g)	1.203	1.246			
Mass Dry Soil (g)	4.759	4.918			
Moisture Content (%)	25.278	25.336			

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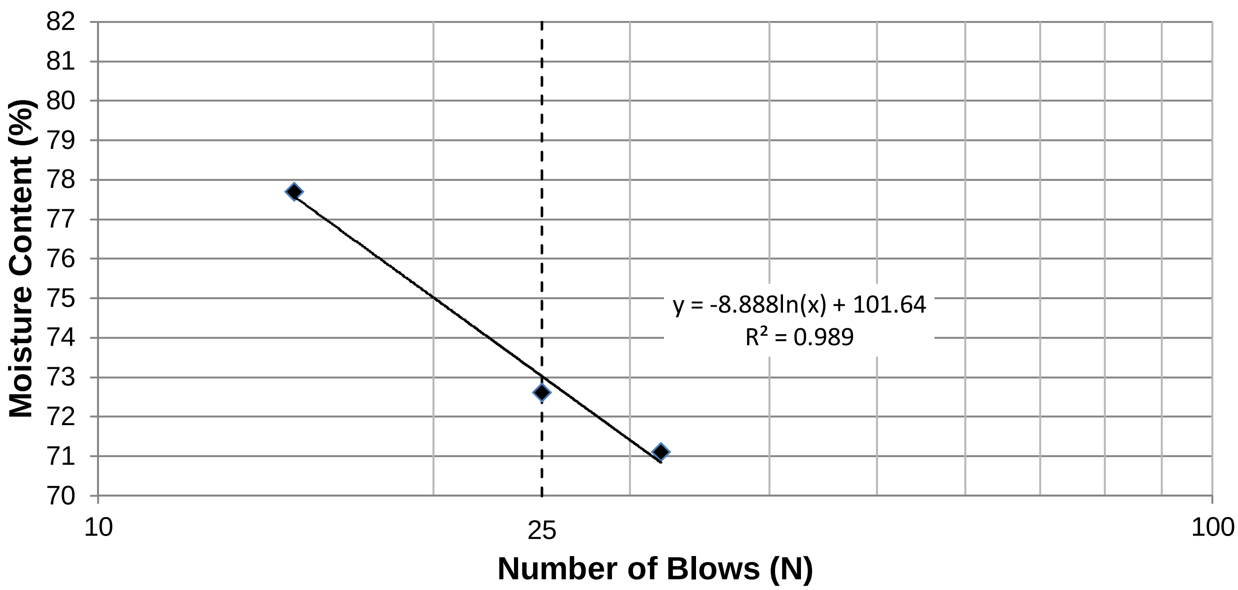
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-04
Sample #	G19
Depth (m)	1.67 - 1.83
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	73
Plastic Limit	23
Plasticity Index	50

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	15	25	32		
Mass Wet Soil + Tare (g)	24.441	21.834	22.353		
Mass Dry Soil + Tare (g)	19.910	18.590	18.894		
Mass Tare (g)	14.079	14.123	14.030		
Mass Water (g)	4.531	3.244	3.459		
Mass Dry Soil (g)	5.831	4.467	4.864		
Moisture Content (%)	77.705	72.621	71.114		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	23.973	21.819			
Mass Dry Soil + Tare (g)	22.145	20.340			
Mass Tare (g)	14.268	14.034			
Mass Water (g)	1.828	1.479			
Mass Dry Soil (g)	7.877	6.306			
Moisture Content (%)	23.207	23.454			

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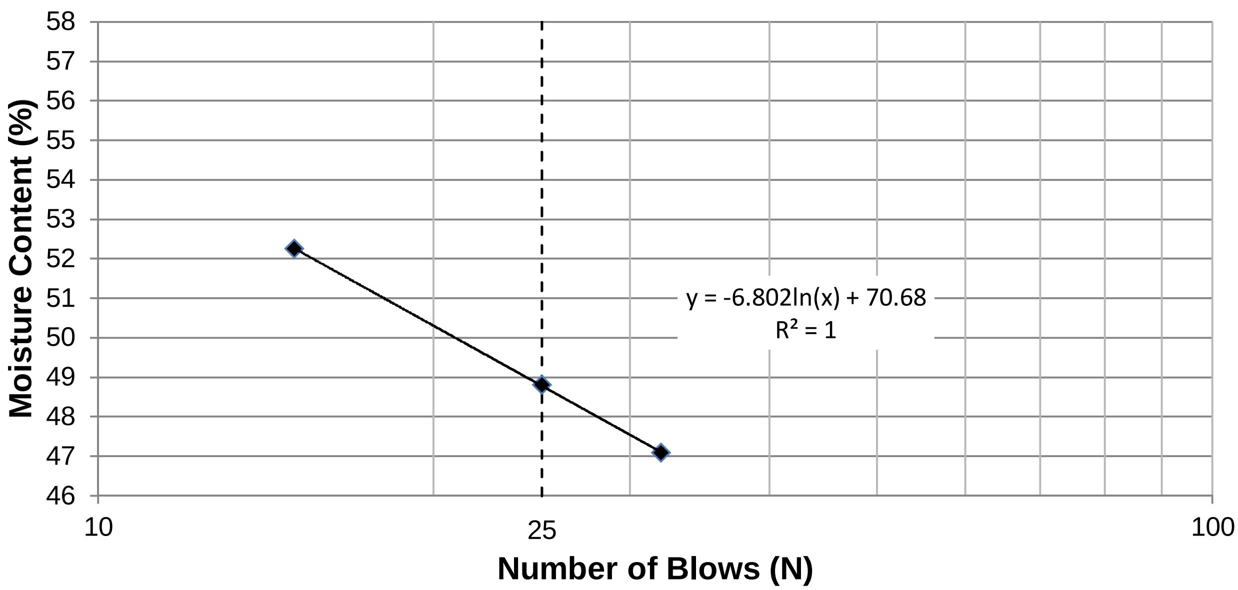
Atterberg Limits
ASTM D4318-10e1

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent
Test Hole	TH16-04
Sample #	G24
Depth (m)	3.35 - 3.50
Sample Date	20-Oct-16
Test Date	14-Nov-16
Technician	JW

Liquid Limit	49
Plastic Limit	22
Plasticity Index	26

Liquid Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Number of Blows (N)	15	25	32		
Mass Wet Soil + Tare (g)	20.691	19.780	21.000		
Mass Dry Soil + Tare (g)	18.407	17.800	18.813		
Mass Tare (g)	14.036	13.743	14.169		
Mass Water (g)	2.284	1.980	2.187		
Mass Dry Soil (g)	4.371	4.057	4.644		
Moisture Content (%)	52.253	48.805	47.093		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Wet Soil + Tare (g)	21.458	22.045			
Mass Dry Soil + Tare (g)	20.135	20.610			
Mass Tare (g)	14.176	14.248			
Mass Water (g)	1.323	1.435			
Mass Dry Soil (g)	5.959	6.362			
Moisture Content (%)	22.202	22.556			

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Shelby Tube Visual

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent (Lamont Blvd. to Academy)

Test Hole	Th16-02
Sample #	T36
Depth (m)	1.8 - 2.1
Sample Date	18-Oct-16
Test Date	15-Nov-16
Technician	JW

Tube Extraction

Recovery (mm) 260

Bottom - 2.1 m | **Top - 1.8 m**

160 mm	100 mm
MC Visual PP, TV	Due to silt laminations, sample broke into short pieces, too short for Qu or bulk weight

Visual Classification

Material	CLAY
Composition	silty
trace rootlets	
trace oxidation	
Color	brown
Moisture	moist
Consistency	firm
Plasticity	intermediate plasticity
Structure	blocky, silt laminations
Gradation	-

Torvane

Reading	0.40
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	39.2

Pocket Penetrometer

Reading	1	2.00
	2	2.00
	3	2.00
	Average	2.00
Undrained Shear Strength (kPa)		98.1

Moisture Content

Tare ID	H35
Mass tare (g)	8.3
Mass wet + tare (g)	398.2
Mass dry + tare (g)	313
Moisture %	28.0%

Unit Weight

Bulk Weight (g)		
Length (mm)	1	
	2	
	3	
	4	
Average Length (m)		
Diam. (mm)	1	
	2	
	3	
	4	
Average Diameter (m)		
Volume (m^3)		
Bulk Unit Weight (kN/m^3)		
Bulk Unit Weight (pcf)		
Dry Unit Weight (kN/m^3)		
Dry Unit Weight (pcf)		

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Shelby Tube Visual

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent (Lamont Blvd. to Academy)
Test Hole	TH16-02
Sample #	T37
Depth (m)	3-3.4
Sample Date	18-Oct-16
Test Date	15-Nov-16
Technician	JW

Tube Extraction

Recovery (mm) 380

Bottom - 3.4 m		Top - 3 m
MC Visual PP, TV	Qu Bulk Weight	
150 mm	150 mm	

Visual Classification

Material	CLAY
Composition	silty
Color	brown
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	blocky
Gradation	-

Torvane

Reading	0.28
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	27.5

Pocket Penetrometer

Reading	**1**	0.60
	2	0.60
	3	0.50
	Average	0.57
Undrained Shear Strength (kPa)		27.8

Moisture Content

Tare ID	H25
Mass tare (g)	8.3
Mass wet + tare (g)	430
Mass dry + tare (g)	331.4
Moisture %	30.5%

Unit Weight

Bulk Weight (g)			1030.5
Length (mm)	**1**		141.65
	2		142.03
	3		142.05
	4		141.98
Average Length (m)			0.142
Diam. (mm)	**1**		72.72
	2		72.58
	3		72.83
	4		72.64
Average Diameter (m)		0.000	0.073
Volume (m^3)			5.89E-04
Bulk Unit Weight (kN/m^3)			17.2
Bulk Unit Weight (pcf)			109.2
Dry Unit Weight (kN/m^3)			13.1
Dry Unit Weight (pcf)			83.7

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Unconfined Compressive Strength

ASTM D2166

Project No.	0015-017-00
Client	City of Winnipeg
Project	Wellington Crescent (Lamont Blvd. to Academy)

Test Hole	TH16-02
Sample #	T37
Depth (m)	3-3.4
Sample Date	18-Oct-16
Test Date	15-Nov-16
Technician	JW

Unconfined Strength

	kPa	ksf
Max q_u	58.7	1.2
Max S_u	29.3	0.6

Specimen Data

Description CLAY - silty, , brown, moist, firm, high plasticity, blocky

Length	141.9	(mm)	**Moisture %**	31%	
Diameter	72.7	(mm)	**Bulk Unit Wt.**	17.2	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	13.1	(kN/m^3)
Initial Area	0.00415	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.28	27.5	0.57
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	0.60	29.4	0.61
	0.60	29.4	0.61
	0.50	24.5	0.51
Average	**0.57**	**27.8**	**0.58**

Failure Geometry

Sketch:

Photo:

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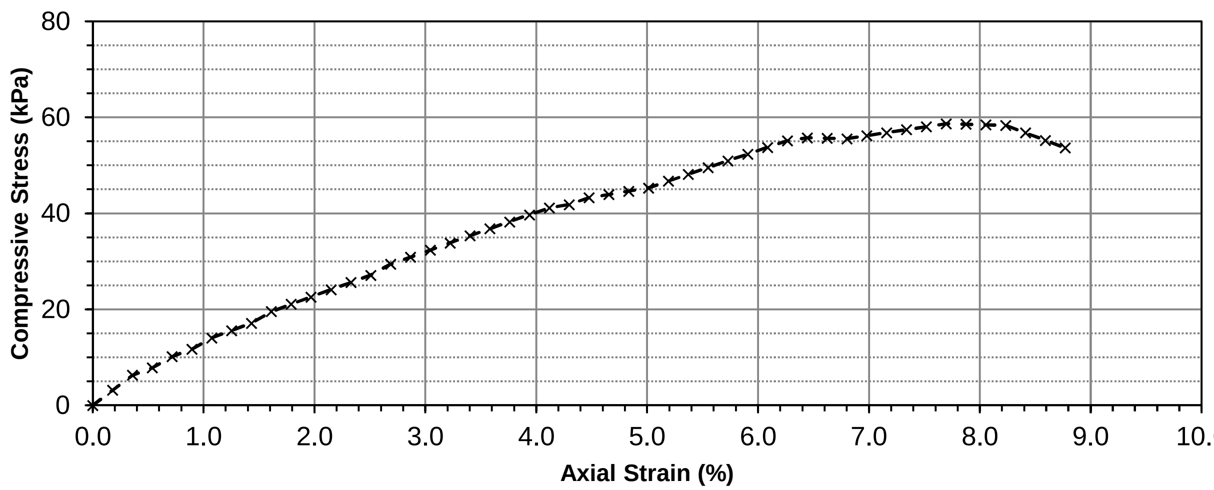
Unconfined Compressive Strength
ASTM D2166

Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent (Lamont Blvd. to Academy)

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004150	0.0	0.00	0.00
10	4	0.2540	0.18	0.004158	13.1	3.14	1.57
20	8	0.5080	0.36	0.004165	26.2	6.28	3.14
30	10	0.7620	0.54	0.004173	32.7	7.84	3.92
40	13	1.0160	0.72	0.004180	42.5	10.18	5.09
50	15	1.2700	0.89	0.004188	49.1	11.72	5.86
60	18	1.5240	1.07	0.004195	58.9	14.05	7.02
70	20	1.7780	1.25	0.004203	65.5	15.58	7.79
80	22	2.0320	1.43	0.004210	72.1	17.12	8.56
90	25	2.2860	1.61	0.004218	82.4	19.54	9.77
100	27	2.5400	1.79	0.004226	89.0	21.06	10.53
110	29	2.7940	1.97	0.004234	95.6	22.58	11.29
120	31	3.0480	2.15	0.004241	102.2	24.10	12.05
130	33	3.3020	2.33	0.004249	108.8	25.61	12.80
140	35	3.5560	2.51	0.004257	115.4	27.11	13.55
150	38	3.8100	2.68	0.004265	125.3	29.38	14.69
160	40	4.0640	2.86	0.004273	131.9	30.87	15.43
170	42	4.3180	3.04	0.004280	138.5	32.35	16.18
180	44	4.5720	3.22	0.004288	145.1	33.83	16.91
190	46	4.8260	3.40	0.004296	151.7	35.31	17.65
200	48	5.0800	3.58	0.004304	158.3	36.77	18.38
210	50	5.3340	3.76	0.004312	164.9	38.23	19.11
220	52	5.5880	3.94	0.004320	171.4	39.68	19.84
230	54	5.8420	4.12	0.004328	178.0	41.13	20.56

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Unconfined Compressive Strength
ASTM D2166

Project No. 0015-017-00
Client City of Winnipeg
Project Wellington Crescent (Lamont Blvd. to Academy)

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	55	6.0960	4.2952	0.004336	181.4	41.82	20.91
250	57	6.3500	4.47	0.004345	187.9	43.26	21.63
260	58	6.6040	4.65	0.004353	191.2	43.93	21.97
270	59	6.8580	4.83	0.004361	194.5	44.61	22.30
280	60	7.1120	5.01	0.004369	197.8	45.27	22.64
290	62	7.3660	5.19	0.004377	204.4	46.69	23.35
300	64	7.6200	5.37	0.004386	211.0	48.12	24.06
310	66	7.8740	5.55	0.004394	217.6	49.52	24.76
320	68	8.1280	5.73	0.004402	224.2	50.93	25.46
330	70	8.3820	5.91	0.004411	230.8	52.32	26.16
340	72	8.6360	6.08	0.004419	237.4	53.72	26.86
350	74	8.8900	6.26	0.004428	244.0	55.11	27.55
360	75	9.1440	6.44	0.004436	247.3	55.74	27.87
370	75	9.3980	6.62	0.004445	247.3	55.64	27.82
380	75	9.6520	6.80	0.004453	247.3	55.53	27.76
390	76	9.9060	6.98	0.004462	250.6	56.16	28.08
400	77	10.1600	7.16	0.004470	253.9	56.79	28.39
410	78	10.4140	7.34	0.004479	257.2	57.41	28.71
420	79	10.6680	7.52	0.004488	260.4	58.04	29.02
430	80	10.9220	7.70	0.004496	263.8	58.67	29.33
440	80	11.1760	7.87	0.004505	263.8	58.55	29.28
450	80	11.4300	8.05	0.004514	263.8	58.44	29.22
460	80	11.6840	8.23	0.004523	263.8	58.33	29.16
470	78	11.9380	8.41	0.004531	257.2	56.75	28.37
480	76	12.1920	8.59	0.004540	250.6	55.19	27.59
490	74	12.4460	8.77	0.004549	244.0	53.63	26.82