APPENDIX ‘A’

GEOTECHNICAL REPORT

Environment

City of Winnipeg

Riverbank Greenways Program
Bunn's Creek Pathway Refurbishment
Geotechnical Investigation Report

Prepared by:

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Project Number:

60321375 (403)

Date:

November 2014

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November 20, 2014

Mr. Ken McKim
Project Management Coordinator
City of Winnipeg
Planning, Property & Development Department
3rd Floor, 65 Garry Street
Winnipeg, Manitoba, R3C 4K4

Dear Mr. McKim:

Project No: **60321375 (403)**

Regarding: **Riverbank Greenways Program**
Bunn's Creek Pathway Refurbishment
Geotechnical Investigation Report

We are pleased to submit our report on the Riverbank Greenways Program: Bunn's Creek Pathway Refurbishment Geotechnical Investigation Report.

Should you have any questions or require clarification, please do not hesitate to contact Faris Khalil directly at (204)928-7437.

Sincerely,
AECOM Canada Ltd.

R. V. Typliski

Ron V. Typliski, P. Eng.
Vice President, Environment
Canada West District

FK/cm
Encl.

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
0	S. Ibrahim	October 31, 2014	Draft
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List of Tables

No table of figures entries found.

Appendices

1. Introduction

The City of Winnipeg (the City) Department of Planning, Property and Development is planning condition improvements for Bunn's Creek Parkway. The proposed improvement aims to refurbish the existing pathway within the limits of the Bunn's Creek Parkway. The City retained AECOM Canada Limited (AECOM) to complete the condition assessment of the pathway, develop conceptual design for an entry/gateway feature and complete the geotechnical investigation and preliminary stability assessment for three selected instability sites (Sites B, C and D) along the banks of Bunn's Creek. These three sites have been identified by the City and are located in the more easterly end of Bunn's Creek Pathway System near Raleigh Street. The approximate locations of the selected instabilities site are presented on Drawing 01 in Appendix A.

The geotechnical components of the work include the following:

- visual inspection of the banks along the Bunn's Creek within the limits of the Bunn's Creek Park.
- drilling three test holes, one at the vicinity of each of the three identified instability sites.
- complete preliminary stability assessment to improve the existing stability of the banks at the three locations.

This report summarizes the findings of the visual inspection and the geotechnical field investigation and discusses the preliminary stability assessment.

2. Visual Inspection

Visual inspection of the banks of the Bunn's Creek was undertaken on June 6th and 9th, 2014. The inspection was completed by AECOM geotechnical staff who walked the both banks for the whole length within the park limits. The objective of the inspection was to look for and document visible signs of potential bank instability. Based on the findings of this inspection, the locations of observed instabilities are presented on Figures 01 to 07 and summarized in tabular format in Appendix A. Data collected during the inspection include digital photos of instabilities along with general views of other features. These photos are included in digital format (on DVD) in Appendix A.

The table provided in Appendix A provides further information with regard to observations at the photo numbers and waypoints (shown on Figures 01 to 07 in Appendix A). Either individual or a range of photos were taken within a general location and are grouped accordingly in the table. Sometimes these photos are directed toward the opposite bank as indicated by the Opposite Bank column. Features related to bank instability and other features are also indicated as being present with marked boxes in the table. The features are described below.

Scarp – Differential elevation in the bank often giving a stepped appearance with an exposed subsurface face. The presence of scarp is indicative of the lower block of the slope moving downslope and potentially with rotation.

Tension Crack – Open crack in the ground without a difference in elevation on either side of the crack. The crack can progress to become a scarp.

Toe Slump – Small localized feature at the slope toe that can be associated with a scarp at the upslope limit.

Bank Inclination – The inclination of the creek bank was estimated at three locations where scarps are present and range from 4H:1V to 5H:1V (horizontal:vertical) with approximate heights of 3.7m to 4.5m.

Toe Erosion – Exposed subsurface face due to erosion that extends above the normal water level surface. Immediately above the water surface and at the edge of the creek, a boundary of tuft grass extends near vertical along most of the reach. Active toe erosion exists where this margin has been undercut or where an exposed subsurface face exists.

Creep Displacement – Slow bank displacements were encountered in the area of Photo 18. Trees located at the upper bank slowly compensated for these bank displacements by continuing to grow vertically as the bank material moved downslope. The result is a pattern of curved tree trunks near the ground surface.

Riffle – Riffles are not aspects of slope instability but were noted during the course of the inspection. Riffles are strategically placed rock weirs that create small water turbulence (rapids) at the riffle location and a small amount of upstream ponding.

Rip Rap Present – This category indicates locations where rock armor has been placed on the river bank face to protect against erosion.

The observed instabilities generally consist of scarps, tension cracks, toe slumps, and erosion. None of these features have engaged the pathway to the point that the pathway is unusable but there are locations where the instabilities have impacted to the point of requiring maintenance (for example, settlement in the area of Photo 012 on Figure 6 of Appendix A, steep scarp immediately adjacent to the path edge in the area of Photo 099 on Figure 2 of Appendix A). At several locations, head scarps are located near the bank crest and indicate that the full bank is engaged (i.e., hummocky slope evident downslope of the crest) while at other locations instabilities are localized to the bank toe. These localized toe instabilities consist of erosion and small slump blocks which can lead to further overall bank instability. Erosion features delineated in Appendix A are those that have created a significantly over-steepened toe, resulting in a lower bank slump block, or caused recession of the shoreline around features such as outfall piping.

3. Geotechnical Investigation

Three test holes (TH14-01 to TH14-03) were drilled on June 3rd, 2014 at the locations shown on Drawing 01 in Appendix A. The test holes were drilled by Maple Leaf Drilling Limited using an Acker MP-5 drill rig equipped with 150 mm diameter hollow stem augers and 125 mm diameter solid stem augers.

In all test holes, the top 4 m was drilled using a combination of hollow stem augers and continuous Shelby tube sampling to obtain full 4 m length samples and assist in examining the retrieved soil samples for visible signs of shear zones, slickensides or other evidence of subsurface displacements, if any. Past the 4 m depth, the drilling was continued using conventional solid stem augers.

TH14-01 is located in the vicinity of instability site D. The test hole was advanced to10.6 m below grade and terminated in clay. TH14-02 is located within instability site B and was advanced into till and terminated at 16.1 m below grade. TH14-03 is located in the vicinity of instability site C and was terminated in clay at 6.1 m below grade. The soil stratigraphy was logged at each test hole and visually classified on site by AECOM personnel. All soil samples were collected for further visual observation at AECOM's soils laboratory in Winnipeg, MB. The coordinates of the test holes were recorded with a hand held GPS unit and are recorded on the test hole logs. Detailed logs have been prepared for each test hole to record the description and relative position of the various soil strata, location of observed slickenside and other pertinent information. The test hole logs are provided in Appendix B.

4. Subsurface Conditions

4.1 Soil Profile

The general soil stratigraphy in descending order from ground surface is as follows:

- Complex Zone – Suspected Fill
- Lacustrine Clay
- Till

Complex Zone - Suspected Fill

A suspected fill zone 1.5 and 2.3 m thick was encountered at ground surface at the locations of TH14-02 and TH14-03, respectively. The zone predominately consists of clay and contains trace amount of organics, trace amount of sand and trace amount of gravel. The clay is mottled black to dark brown, firm and of intermediate plasticity. The soil in this zone lacks the lamination features which is clearly observed in the native clay layer underneath. This zone could be the result of grading work/fill operations in the past associated with the development of the subdivision in the neighborhood or associated with natural or manmade realignment of the stream channel. Photos of the recovered soil samples from the top 4 m are presented in Appendix B which show some of the features of the soil in this zone and the lacustrine clay underneath.

A thin layer about 200 mm thick of sandy gravel fill was encountered on top of the clay fill in TH14-03.

No fill was encountered at the location of TH14-01.

Clay

Brown lacustrine clay was encountered at ground surface or below the fill zone in all test holes. Where the drilling advanced into till in TH14-02, the clay is about 13 m thick. In the other two test holes the clay extends to the exploration depth (i.e. 10.1 and 6.1 m below grade in TH14-01 and TH14-03, respectively). Generally, the clay is firm to stiff and of intermediate to high plasticity. The clay exhibits laminated structure in horizontal bands with lamination colour varying from light to dark brown. Fissures exist predominantly in the horizontal plane but also exist at near-vertical angles. Trace silt and sulphate inclusions (less than 20mm diameter) are observed over the drilled depth. A horizontal silt layer about 75mm thick was encountered at 2.4m below grade in TH14-02. Sulphate inclusions typically were encountered in small horizontal lenses less than 25mm wide and 3 mm thick. Sulphates were also present in a fissure at an angle of 45 degrees in TH14-02.

Numerous slickenside surfaces were encountered at depths of generally 3.5m to 4.3m in TH14-01 and TH14-03. These polished clay surfaces could represent evidence of past subsurface displacements as the upper block rides over the lower block. The angles of the slickensides range from 45 to 50 degrees from the horizontal. The variety of these angles is indicative of the potential for different mobilizations of upper bank blocks with time. Photos of the recovered samples presented in Appendix B shows the key features discussed above.

4.2 Groundwater Conditions

No seepage nor sloughing was observed during the drilling of the test holes. Groundwater was observed at 6.4 m below grade in TH14-02. TH14-01 and TH14-03 were observed as dry immediately after drilling completion .No piezometers were installed at the site.

It should be noted that groundwater conditions could fluctuate seasonally, annually or due to construction activities.

5. Stability Assessment

5.1 Design Objectives

At the proposal stage and during the project kick off meeting, technical discussions between the City's Riverbank Management Engineer and AECOM's geotechnical engineer emphasized that the primary objective of this project is to allow the improvement in the park with no adverse impact on the current stability and to introduce measures at the three selected sites to improve the stability to a level that:

- provides reasonable protection of the planned investment, and
- addresses the observed surface/bank irregularities to reduce concerns of the pathway users.

It was made clear to AECOM that stabilization measures including stone columns or full depth shear keys are not intended for this site for reasons related to cost and the potential disturbance to the park condition. In this regard, a factor of safety (FS) of 1.3 against slope instability was selected as the design objective for this project under the representative design scenario.

5.2 Stability Analysis

Stability analysis was carried out using Slope/W software. The analysis considers three representative sections, one section for each of the three selected sites. The geometry or the cross section used in the stability analysis is based on recent localized topo survey completed by AECOM on June 20th 2014 for the creek banks and channel bed. The soil stratigraphy encountered during the geotechnical investigation was used to develop the stability model.

AECOM prepared hydraulic profiles for Bunn's Creek Channel for summer and spring events considering a 5-year return period. These hydraulic profiles were used to select design piezometric surface in the banks and design water levels in the channel. The hydraulic profiles are provided in Appendix C.

It is common practice in stability assessment of failed slopes to assign residual or reduced strength parameters to reflect the weak conditions developed at the slip surface(s) and within the displaced mass. Observations from site inspection (e.g. scarp, cracks, toe bulge, etc.), information from geotechnical drilling (e.g., slickenside, extremely wet zone, very soft zone, remolded zone, etc.) and instrumentation monitoring, if available, would provide guidance to infer and identify these zones, within the soil model, to assign the degraded strength parameters. Residual shear strength parameters for soils in the Winnipeg area are well examined in the literature and are generally accepted in the local engineering community to be in the range of Cohesion (c)= 0 to 2 kPa and Friction Angle (ϕ) = 8 to12 degrees.

Back analysis, for fully specified slip surface, was completed for each representative section assuming the design conditions discussed above to obtain an estimate of the operating strength parameters. The slip surface was approximately defined based on the observations from visual inspection and drilling information. The factor of safety was assumed to be close to unity. The estimated soil strength parameters for each section from back analysis are presented in Table 01 and the related analysis results are graphically presented on Stability Figures 01 to 03 in Appendix C. Soil strength parameters for intact clay, till and granular fill, based on published data and knowledge of local conditions, are also presented in Table 01.

Table 01: Soil Strength Parameters for Stability Assessment

Soil Unit	Instability Site	Cohesion, C kPa	Friction Angle, ϕ Degree	Unit Weight kN/m^3	Back Analysis Stability Figure No.
Clay (residual zone) based on back analysis	B	0	12	17	01
	C	1.5	12	17	02
	D	1	10	17	03
Clay (intact zone)		5	14	17	na
Till		0	30	21	
Granular Fill (Granular Toe)		0	40	19	

The assessment was carried forward introducing stabilization effects in the model to attain the design objective FS of 1.3. The stabilization effects were introduced through the following:

- Re-grading and modifications to the existing bank geometry.
- Introducing granular zone within the existing cross section.
- Introducing subdrains to control groundwater condition.

The results of the stability assessment and the corresponding stabilization effects are summarized in Table 02 and graphically presented on Stability Figures 04 to 06 in Appendix C.

Table 02: Summary of Stability Assessment and Stabilization Measures

Instability Site	Design Scenario	Stabilization Measures	FS	Stability Figure No.
B	- GWL 228m in banks - Dry Channel	- Granular toe 1.5m wide, 1m below channel bed on both banks - Grading lower and upper bank. - Install subdrain to control bank GWL at 227m.	1.31	04
C	- GWL 228m in banks - Dry Channel	- Granular toe 1.5m wide, 1m below channel bed. - Grading lower and upper bank. - Install subdrain to control bank GWL at 227m.	1.28	05
D	- GWL 227m in banks - Dry Channel	- Granular toe 1.5m wide, 1m below channel bed on both banks - Grading lower bank. - Install subdrain to control bank GWL at 227m.	1.32	06

The results of the preliminary stability assessment were presented and discussed during a meeting held with the City on September 9th, 2014. A key concern raised in the meeting was the potential that future construction activities at site C may result in further instabilities and could be perceived by private property owner(s) as a contributing factor to future or already occurring instabilities, particularly in the vicinity of the property at 674 McIvor Avenue, where slope instabilities are manifested in forms of multiple slumps, head scarps and disturbance on the bank face. The alternatives discussed were:

- do nothing;
- proceed with construction and accept the associated risk;
- feasibility of pathway protection measures that are less intrusive. Embedded sheet pile wall along the pathway was identified. The wall would retain the pathway and protect against disruption to its elevation or condition in the event bank instability continued and progressed further towards the pathway.
- feasibility of a stabilization measures that address the bank stabilization on both sides of the creek at location C. Stone columns were identified as having been commonly used in riverbank stabilization projects in the Winnipeg area.

The last two alternatives can be designed to attain the corresponding objective. Local contractors are familiar with the construction activities and the related construction equipment is readily available. The City asked AECOM to provide a rough cost estimate for these two alternatives. AECOM has conceptually sized the extent of these measures and developed an estimate of the related construction cost.

- Embedded sheet pile wall to be driven along the edge of the pathway that would retain the pathway in the event slope instabilities continued and result in level difference of up to 1.5m.
- Stone columns stabilization on the west/south bank to address the current large scale bank instability.

6. Closure

The findings and recommendations in this report were based on the results of the field investigations. Soil conditions, by their nature, can be highly variable across a site. If conditions are encountered that appear to be different from those encountered during drilling at this site and described herein, or if the assumptions stated herein are not in keeping with the design, this office should be notified in order that the recommendations can be reviewed and adjusted, if necessary. A contingency should be included in the construction budget to allow for the possibility of variation in soil conditions, which may result in modification of the design and construction procedures.

Appendix A

- Location of Bank Instabilities and Test Holes
- Visual Inspection Findings Figures, Tables and DVD

ANSI B 279.4mm x 431.8mm

Project Management Initials: Designer: Checked: Approved:

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Drawing: 01

Testhole Locations

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

Issue Status: DRAFT

AECOM

Figure: 1

Geotechnical Investigation

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

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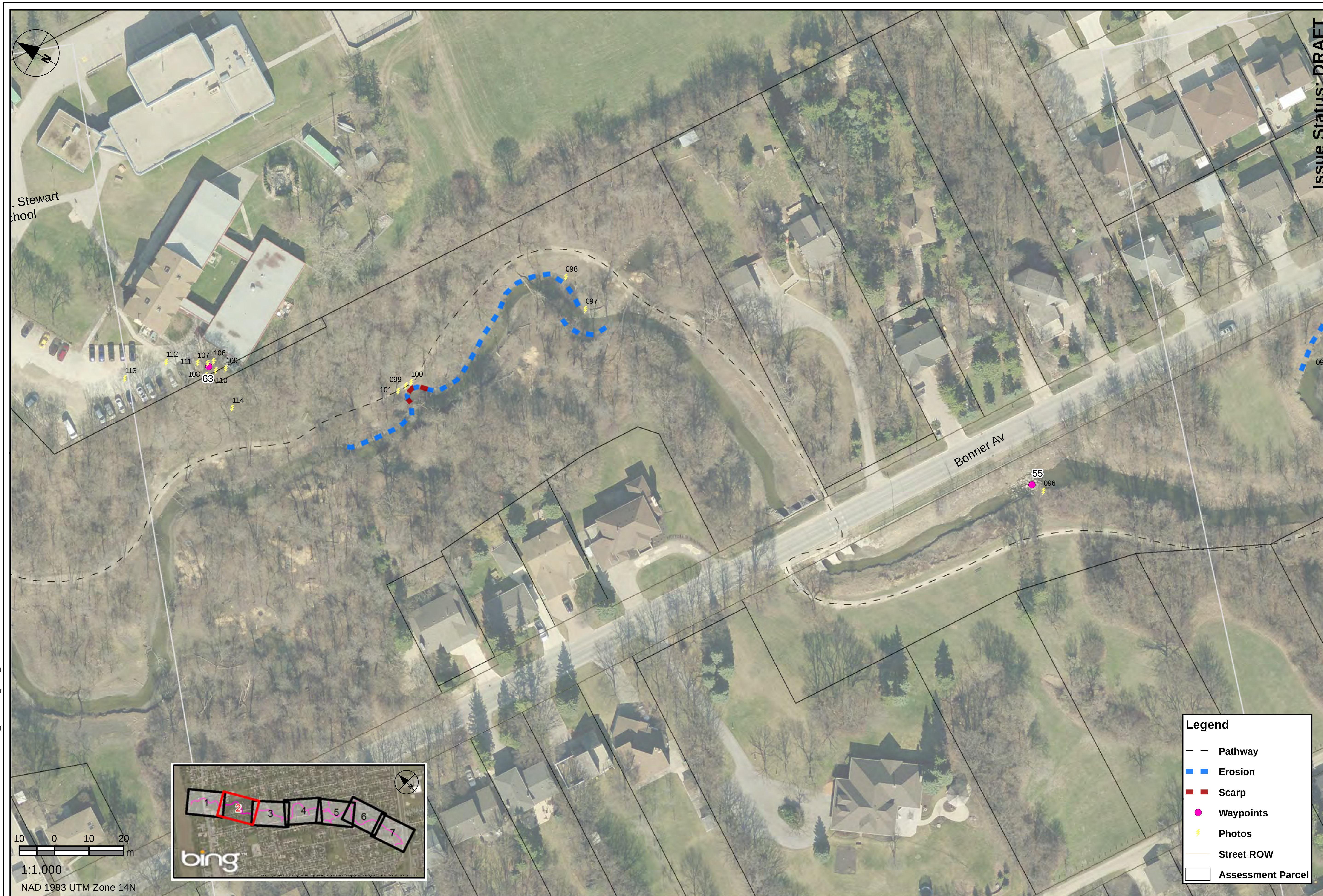

AECOM

Figure: 2

Geotechnical Investigation

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

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ANSI B 279.4mm x 431.8mm

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Figure: 3

Geotechnical Investigation

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

ANSI B 279.4mm x 431.8mm

Approved:

Checked:

Designer:

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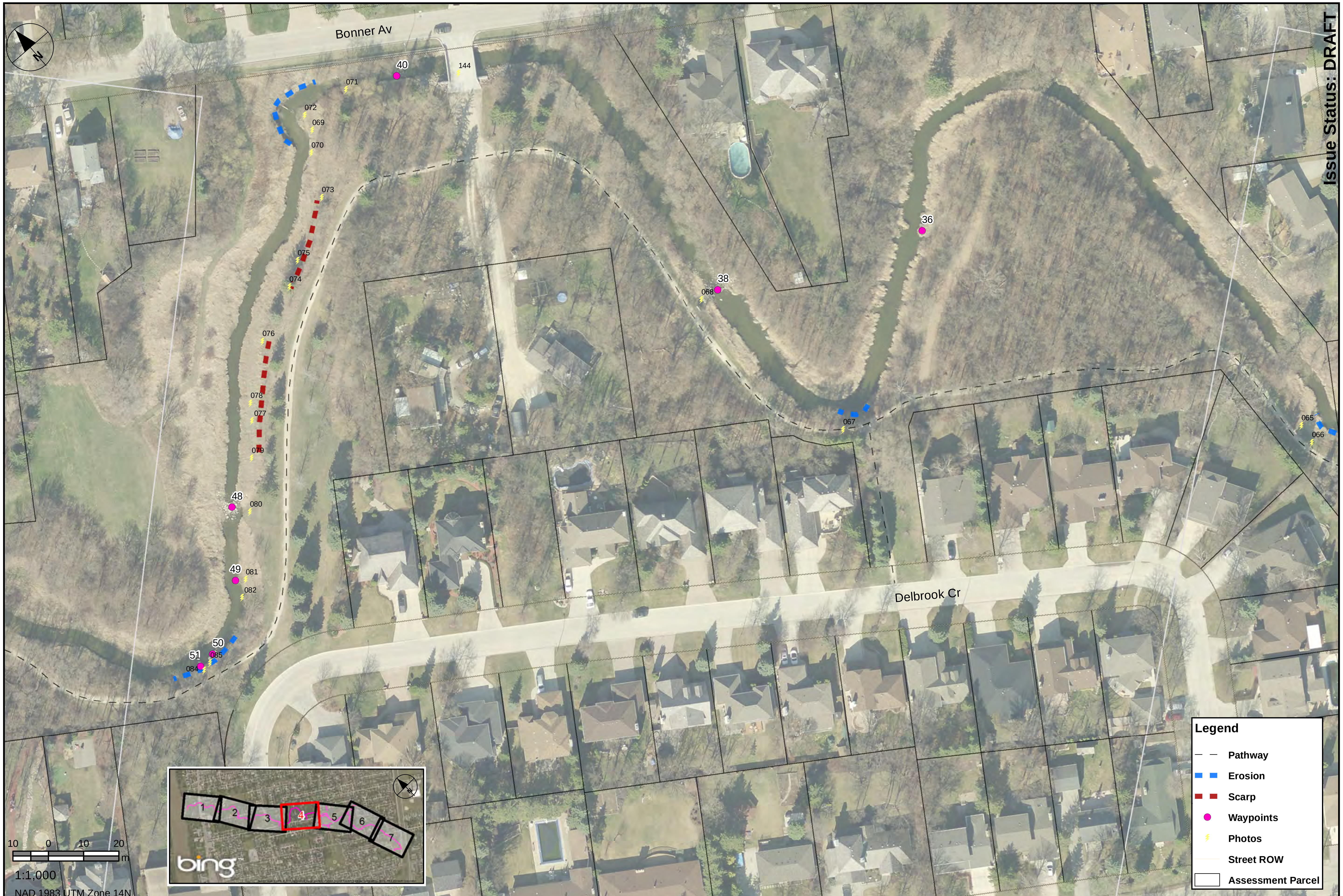
Figure: 4



Geotechnical Investigation

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

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Figure: 5

Geotechnical Investigation

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

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ANSI B 279.4mm x 431.8mm

Bunn's Creek
Pathway Refurbishment
City of Winnipeg

Geotechnical Investigation

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Figure: 6

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Figure: 7

Bunn's Creek Pathway Refurbishment

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BUNN'S CREEK PATHWAY VISUAL INSPECTION

PHOTO FILE NUMBER		WAYPOINT	DIRECTION FACING	OPPOSITE BANK	SCARP	SCARP HEIGHT (mm)	TENSION CRACK	TENSION CRACK WIDTH (mm)	TOE SLUMP	BANK INCLINATION (XH:1V)	TOE EROSION	CREEP DISPLACEMENT	RIFFLE	RIP RAP PRESENT	DESCRIPTION
From	To														
2			Upstream		X										
3		1	Upstream		X					4.1H:1V					
4	5		Upstream/Downstream				X								ON RALEIGH STREET PAVEMENT
6	9		Upstream/Downstream		X										
10			Directly Opposite	X	X										
11	12		Upstream/Downstream		X				X						
13			Downstream	X	X										
14	15		Upstream		X				X						BENT TREE TRUNKS INDICATIVE OF LONG TERM CREEP DISPLACEMENT
16	17		Upstream/Downstream										X		GROUTED STONE
18			Upstream									X			
19			Upstream	X	X				X						
20			Upstream	X					X						
21	23		Upstream/Downstream						X						POTENTIAL LOWER BLOCK PAST INSTABILITY ON INNER BANK
24	25		Upstream/Downstream		X										
26		16	Downstream										X		
27			Upstream												GENERAL VIEW
28	38		Upstream/Downstream		X	410	X	200							
39	46	20	Upstream/Downstream	X	X				X				X		DOWNSTREAM OF CULVERT
47	56		Upstream/Downstream		X	510			X						
57	61		Upstream/Downstream		X	410									
62	64	34	Downstream								X		X		
65	66		Upstream/Downstream								X				
		36													OPENING TO BEAVER DEN, TWO BEAVERS OBSERVED
67			Upstream								X				
68		38	Directly Opposite										X		
		40	Directly Opposite										X		
69	72		Upstream/Downstream	X	X				X		X		X		
73	75		Upstream/Downstream		X										
76	79		Upstream/Downstream		X										
80		48	Directly Opposite										X		
81		49	Directly Opposite												STAND AT CREEK EDGE, POSSIBLY FOR WOOD DUCK BOX
82		51	Downstream								X				OUTFALL CULVERT

BUNN'S CREEK PATHWAY VISUAL INSPECTION

PHOTO FILE NUMBER		WAYPOINT	DIRECTION FACING	OPPOSITE BANK	SCARP	SCARP HEIGHT (mm)	TENSION CRACK	TENSION CRACK WIDTH (mm)	TOE SLUMP	BANK INCLINATION (XH:1V)	TOE EROSION	CREEP DISPLACEMENT	RIFFLE	RIP RAP PRESENT	DESCRIPTION
From	To														
84	85	50	Upstream/Downstream								X				CONCRETE SANDBAG RIP RAP
89	93		Upstream/Downstream								X				
94			Downstream	X							X				
95			Downstream	X							X				
96		55	Downstream										X		
97			Downstream	X							X				
98			Downstream								X				
99	101		Upstream/Downstream		X				X		X				
102		65	Downstream		X					5.1H:1V					
103		64	Upstream							4.1H:1V					
104	105		Upstream/Downstream		X	910									
106	114	63													FILL ABOUT 1m THICK PUSHED OUT ONTO TOP OF BANK
115			Downstream	X										X	SLOPE INCLINOMETER CASING, BANK TOE
117			Downstream	X											VIEW THROUGH BOX CULVERT
118			Upstream	X											SLOPE INCLINOMETER CASING TOP OF BANK
119	127		Upstream/Downstream		X	1520			X		X				
128	134, 143		Upstream/Downstream		X	1220			X		X				
135			Upstream												SLOPE INCLINOMETER CASING TOP OF BANK
136	141		Upstream/Downstream											X	EAST BANK RED RIVER
142			Downstream												VIEW TOWARD RED RIVER
145	158		Upstream/Downstream		X	610			X		X				
161	164		Upstream/Downstream	X	X										
165	169		Upstream/Downstream		X	610			X						

Appendix B

- Test Hole Logs
- Photos of Soil Samples

PROJECT: Bunn's Creek Pathway Refurbishment	CLIENT: City of Winnipeg	TESTHOLE NO: **TH14-01**
LOCATION: Location D, UTM 14U 639536 E /5534440 N		PROJECT NO.: 60321375
CONTRACTOR: Maple Leaf Ltd.	METHOD: B20L - HSA 150 mm/SS 125 mm	ELEVATION (m): 226.77

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

PENETRATION TESTS: Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: Torvane; QU/2; Lab Vane; Pocket Pen.; Field Vane (kPa) 50 100 150 200

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0		CLAY (Lacustrine)- trace silt, - brown, firm, moist - high plasticity - fissures, laminations (light brown and brown) - silt inclusions (<10 mm in dia) - silt laminations , light brown, loose - trace sulphate, trace roots, fissures with (plane - 45 degree)					226
1							225
2		- dark brown to 3.0 m					224
3		- brown below 3.0 m - slickensides from 3.5 m to 4.0 m, plane of 45 degree from horizontal - trace roots					223
4		- slickenside at 4.2 m, plane of 45 degree with horizontal - trace gravel					222
5		- silt inclusion up to 25 mm in dia.					221
6		- grey, soft below 6.0 m					220
7							219
8		- silty below 8.5 m					218
9							217
10							

AECOM	LOGGED BY: Saba Ibrahim	COMPLETION DEPTH: 10.67 m
	REVIEWED BY: Darren Yarechewski	COMPLETION DATE: 6/3/14
	PROJECT ENGINEER: Faris Khalil	

PROJECT: Bunn's Creek Pathway Refurbishment	CLIENT: City of Winnipeg		TESTHOLE NO: **TH14-01**
LOCATION: Location D, UTM 14U 639536 E /5534440 N			PROJECT NO.: 60321375
CONTRACTOR: Maple Leaf Ltd.	METHOD: B20L - HSA 150 mm/SS 125 mm		ELEVATION (m): 226.77

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH: Torvane; QU/2; Lab Vane; Pocket Pen.; Field Vane (kPa) 50 100 150 200	COMMENTS	ELEVATION
10									
		END OF TEST HOLE AT 10.6 m IN CLAY NOTES: 1. No sloughing or seepage observed during drilling. 2. Test hole was dry and remained open to 10.6 m below ground surface immediately upon drilling completion. 3. Test hole backfilled with auger cuttings and sealed with bentonite chips at ground surface.							216
11									
									215
12									
									214
13									
									213
14									
									212
15									
									211
16									
									210
17									
									209
18									
									208
19									
									207
20									

AECOM	LOGGED BY: Saba Ibrahim	COMPLETION DEPTH: 10.67 m
	REVIEWED BY: Darren Yarechewski	COMPLETION DATE: 6/3/14
	PROJECT ENGINEER: Faris Khalil	Page 2 of 2

PROJECT: Bunn's Creek Pathway Refurbishment	CLIENT: City of Winnipeg	TESTHOLE NO: **TH14-02**
LOCATION: Location B, UTM 14U 639589 E /5534187 N		PROJECT NO.: 60321375
CONTRACTOR: Maple Leaf Ltd.	METHOD: Acker MP-5 - HSA 150 mm/SS 125 mm	ELEVATION (m): 228.75

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane +; × QU/2 ×; □ Lab Vane □; △ Pocket Pen. △; Field Vane (kPa) 50 100 150 200

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0		CLAY (Fill)- trace organics, trace sand, trace gravel, trace roots - mottled black to dark brown, firm, moist - intermediate plasticity					
							228
1							
		CLAY (Lacustrine)- trace silt, - brown, firm, moist - high plasticity - fissures, laminations (grey/brown) , - silt inclusions (<6 mm in dia.) - dark brown below 1.9 m - individual layers of sandy silt, light brown (75 mm in thickness) - trace sulphates from 2.3 to 2.6 m					227
2							226
3		- trace oxidation					225
4		- silt inclusions (10 mm in dia.), trace gravel - angular (20 mm in dia.)					224
5		- soft, grey below 5.33 m					223
6		- some silt below 6.7 m - silt inclusions (100 mm in dia.)					222
7							221
8		- varved (silt and clay), 15 mm in thickness from 8.5 to 9.2 m					220
9							219
10							

AECOM

LOGGED BY: Saba Ibrahim	COMPLETION DEPTH: 16.15 m
REVIEWED BY: Darren Yarechewski	COMPLETION DATE: 6/3/14
PROJECT ENGINEER: Faris Khalil	Page 1 of 2

PROJECT: Bunn's Creek Pathway Refurbishment	CLIENT: City of Winnipeg	TESTHOLE NO: **TH14-02**
LOCATION: Location B, UTM 14U 639589 E /5534187 N		PROJECT NO.: 60321375
CONTRACTOR: Maple Leaf Ltd.	METHOD: Acker MP-5 - HSA 150 mm/SS 125 mm	ELEVATION (m): 228.75

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

UNDRAINED SHEAR STRENGTH: + Torvane +; × QU/2 ×; □ Lab Vane □; △ Pocket Pen. △; Field Vane (kPa) 50 100 150 200

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
10							
11		- silty, soft to firm from 11.3 to 11.5 m					218
12							217
13		- silty, some sand, trace to some gravel, firm below 12.8 m					216
14							215
15		SILT (Till)- clayey, some sand ,some gravel, - light grey, firm, wet - intermediate plasticity					214
16		END OF TEST HOLE AT 16.0 m IN TILL NOTES: 1. Soild stem auger refusal at 16.0 m below ground surface. 2. Water level measured at 6.4 m below ground surface immediately after drilling. 3. Test hole remained open to 15.2 m below ground surface immediately upon drilling completion. 4. Test hole backfilled with auger cuttings and sealed with bentonite chips at ground surface.					213
17							212
18							211
19							210
20							209

AECOM

LOGGED BY: Saba Ibrahim	COMPLETION DEPTH: 16.15 m
REVIEWED BY: Darren Yarechewski	COMPLETION DATE: 6/3/14
PROJECT ENGINEER: Faris Khalil	Page 2 of 2

PROJECT: Bunn's Creek Pathway Refurbishment	CLIENT: City of Winnipeg	TESTHOLE NO: **TH14-03**
LOCATION: Location C, UTM 14U 639570 E /5534272 N		PROJECT NO.: 60321375
CONTRACTOR: Maple Leaf Ltd.	METHOD: Acker MP-5 - HSA 150 mm/SS 125 mm	ELEVATION (m): 227.38

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	UNDRAINED SHEAR STRENGTH: + Torvane +; × QU/2 ×; □ Lab Vane □; △ Pocket Pen. △; Field Vane (kPa) 50 100 150 200	COMMENTS	ELEVATION
0		GRAVEL (FILL) - sandy							
		CLAY (FILL) - trace sand, trace gravel, trace roots - mottled black to dark brown, firm, moist - intermediate plasticity							227
1									226
2									
		CLAY (Lacustrine)- trace sand , trace gravel, - dark brown, firm, moist - high plasticity - fissures - trace sulphates, silt inclusions							225
3		- slickenside at 3.4 m - plane of 50 degree from horizontal							224
4									223
5									222
6		END OF TEST HOLE AT 6.0 m IN CLAY NOTES: 1. No sloughing or seepage observed during drilling. 2. Test hole was dry and remained open to 6 m below ground surface immediately upon drilling completion. 3. Test hole backfilled with auger cuttings and sealed with bentonite chips at ground surface.							221
7									220
8									219
9									218
10									

AECOM	LOGGED BY: Saba Ibrahim	COMPLETION DEPTH: 6.10 m
	REVIEWED BY: Darren Yarechewski	COMPLETION DATE: 6/3/14
	PROJECT ENGINEER: Faris Khalil	Page 1 of 1

(TH14-01)–From 0.0 to 2.5 feet below ground surface

(TH14-01)–From 2.5 to 5 feet below ground surface

(TH14-01)–From 5 to 9 feet below ground surface

(TH14-01)–From 9 to 11 feet below ground surface

(TH14-01)–From 11 to 13.5 feet below ground surface

(TH14-01)–From 13.5 to 15 feet below ground surface

(TH14-02) –From 0.0 to 2.5 feet below ground surface

(TH14-02) –From 2.5 to 5.0 feet below ground surface

(TH14-02) –From 5.0 to 7.5 feet below ground surface

(TH14-02) –From 7.5 to 10 feet below ground surface

(TH14-02) –From 10 to 12.5 feet below ground surface

(TH14-02) –From 12.5 to 15 feet below ground surface

(TH14-03) –From 0.0 to 5 feet below ground surface

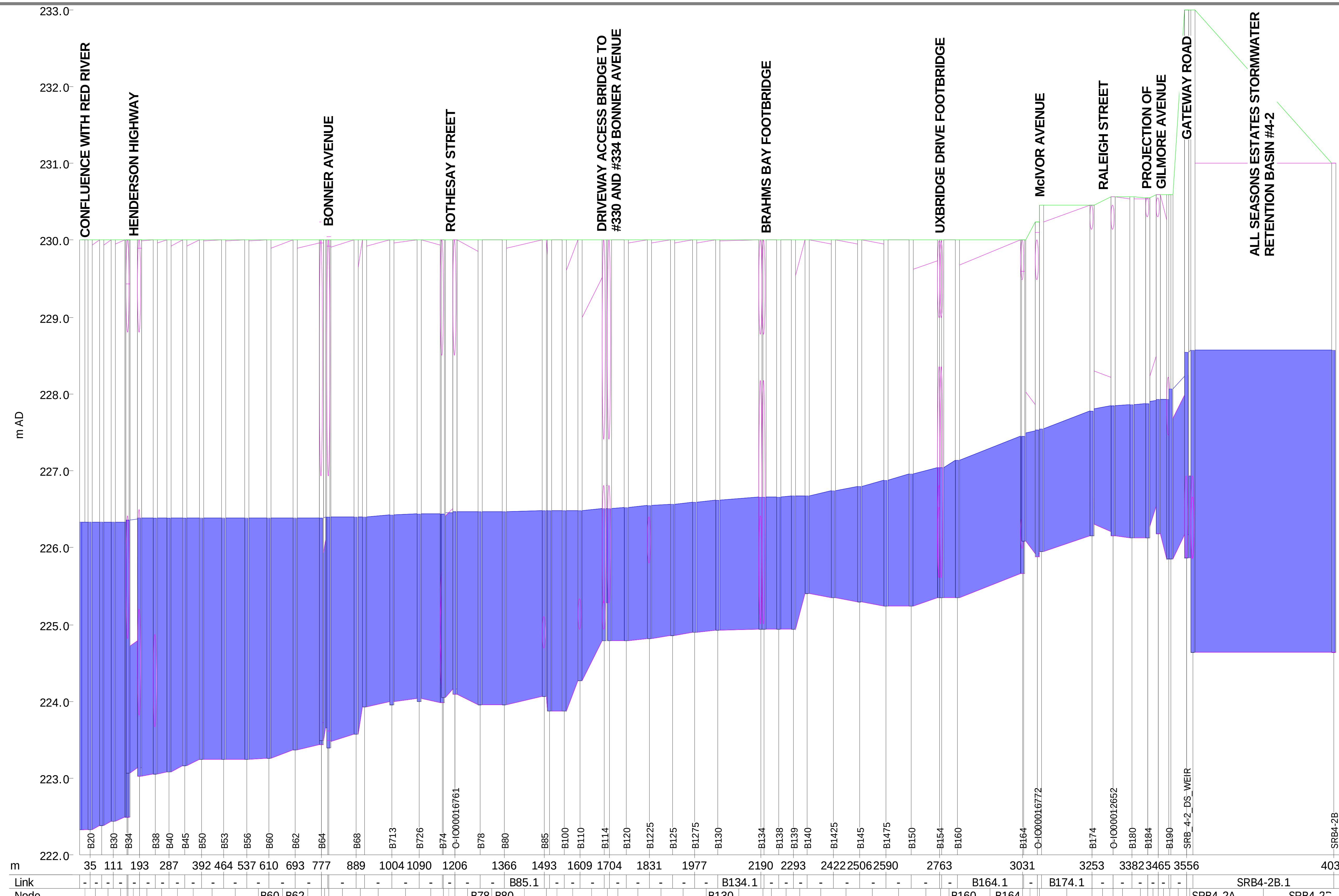
(TH14-03)–From 5 to 9 feet below ground surface

(TH14-03)–From 9 to 12.5 feet below ground surface

(TH14-03)–From 12.5 to 15 feet below ground surface

Appendix C

- Bunn’s Creek Hydraulic Profiles
- Stability Analysis: Figures 01 to 06

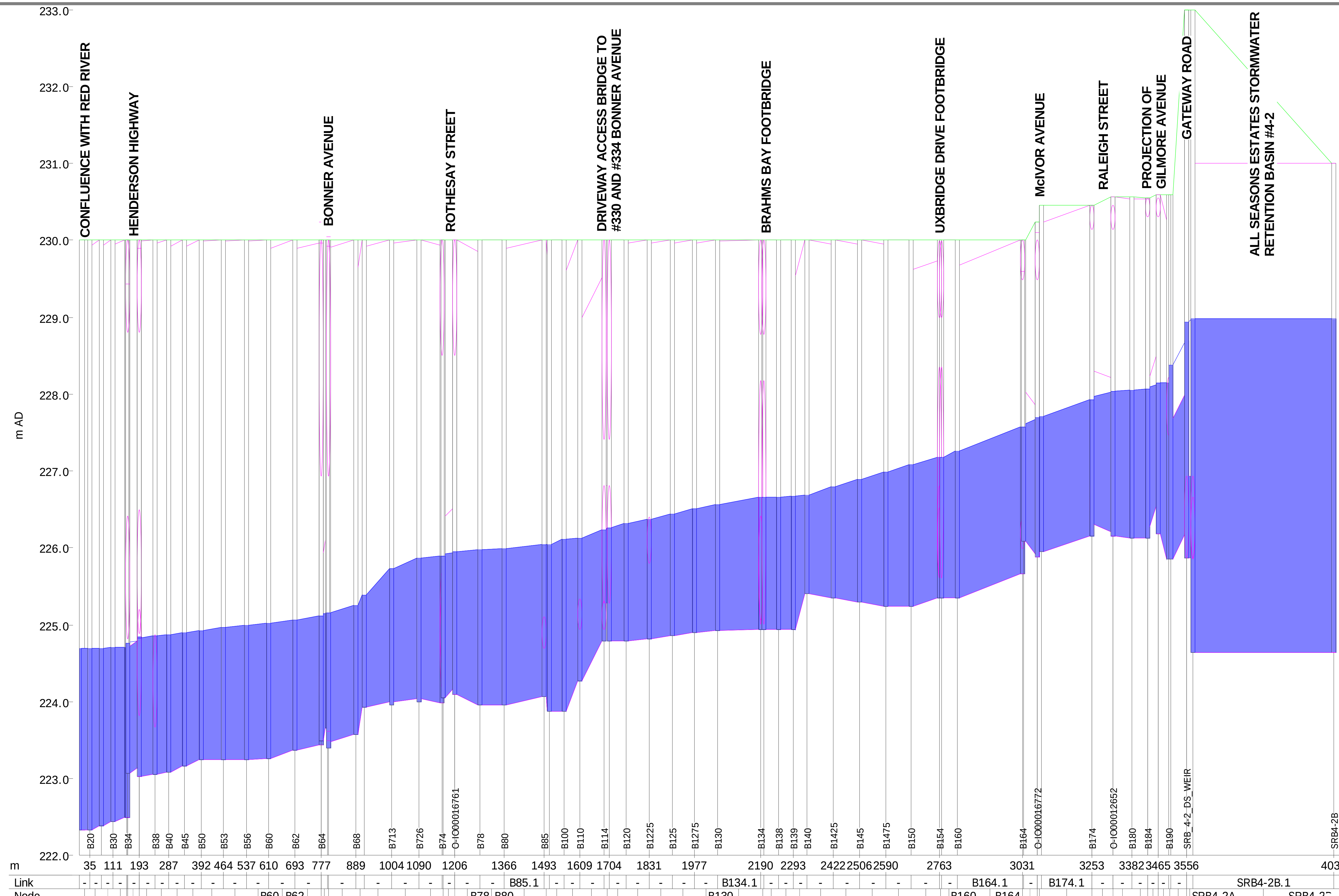


CITY OF WINNIPEG

BUNN'S CREEK PATHWAY REFURBISHMENT

SPRING EVENT HYDRAULIC PROFILE

Figure 1

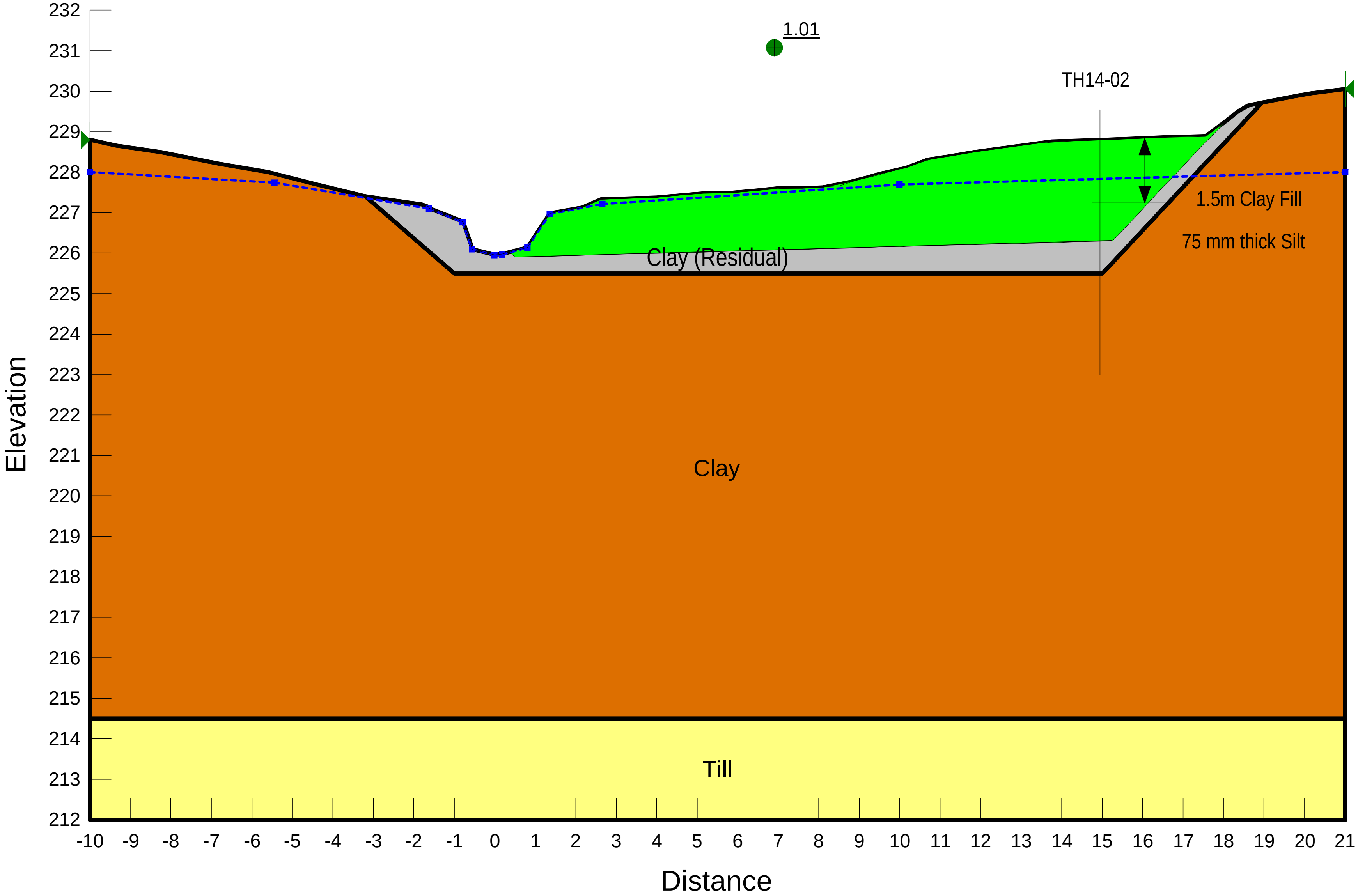


AECOM

CITY OF WINNIPEG
BUNN'S CREEK PATHWAY REFURBISHMENT
SUMMER EVENT
HYDRAULIC PROFILE
Figure 2

File Name: Site B- 001 back analysis- 1.gszDirectory: P:\60321375\400-Technical\402 Geotechnical\Modelling

Stability Figure 01
Bunn's Creek Pathway
Site B
Back Analysis

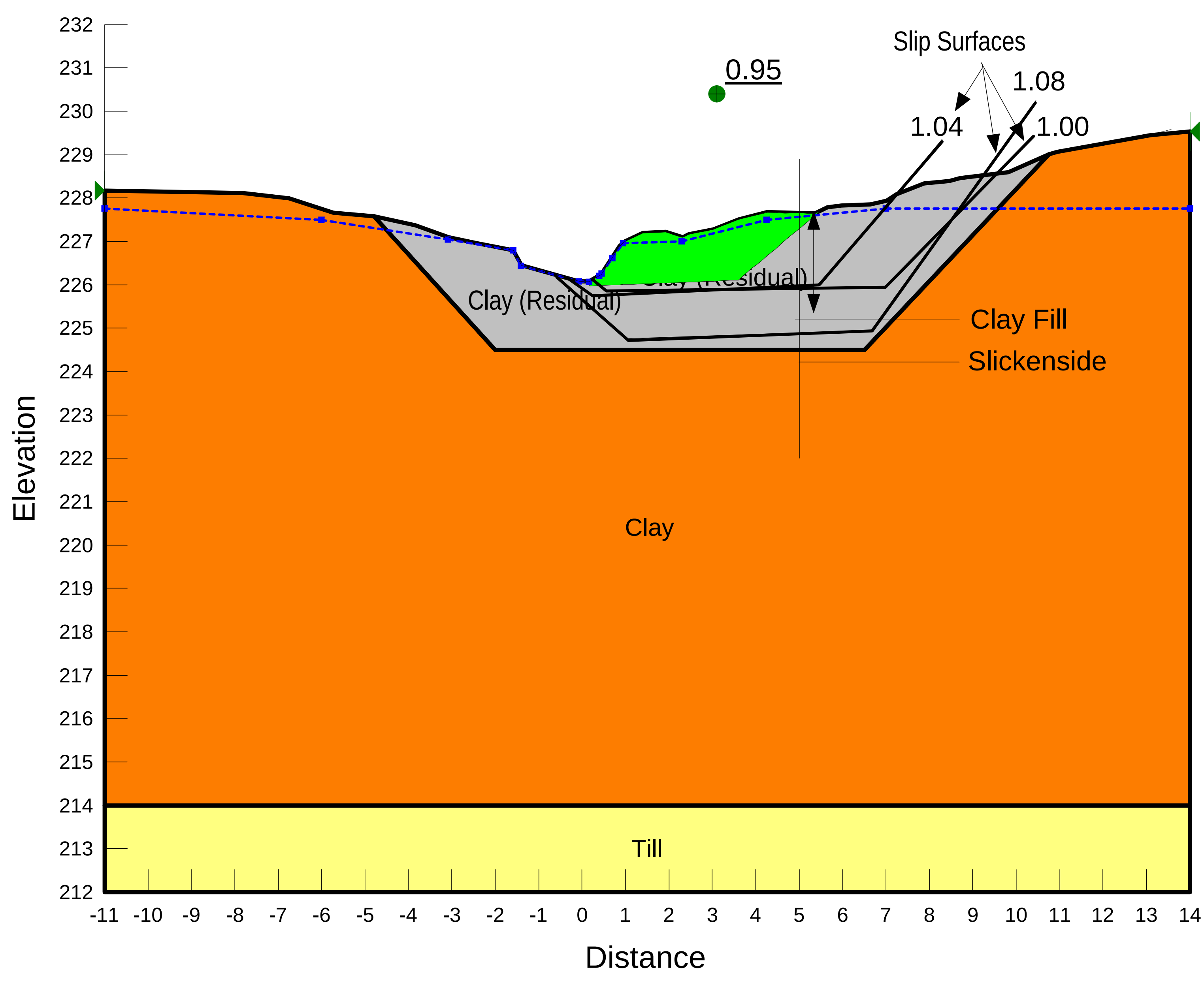


Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 12 °

File Name: Site C- 001 back analysis- 1.gszDirectory: P:\60321375\400-Technical\402 Geotechnical\Modelling\

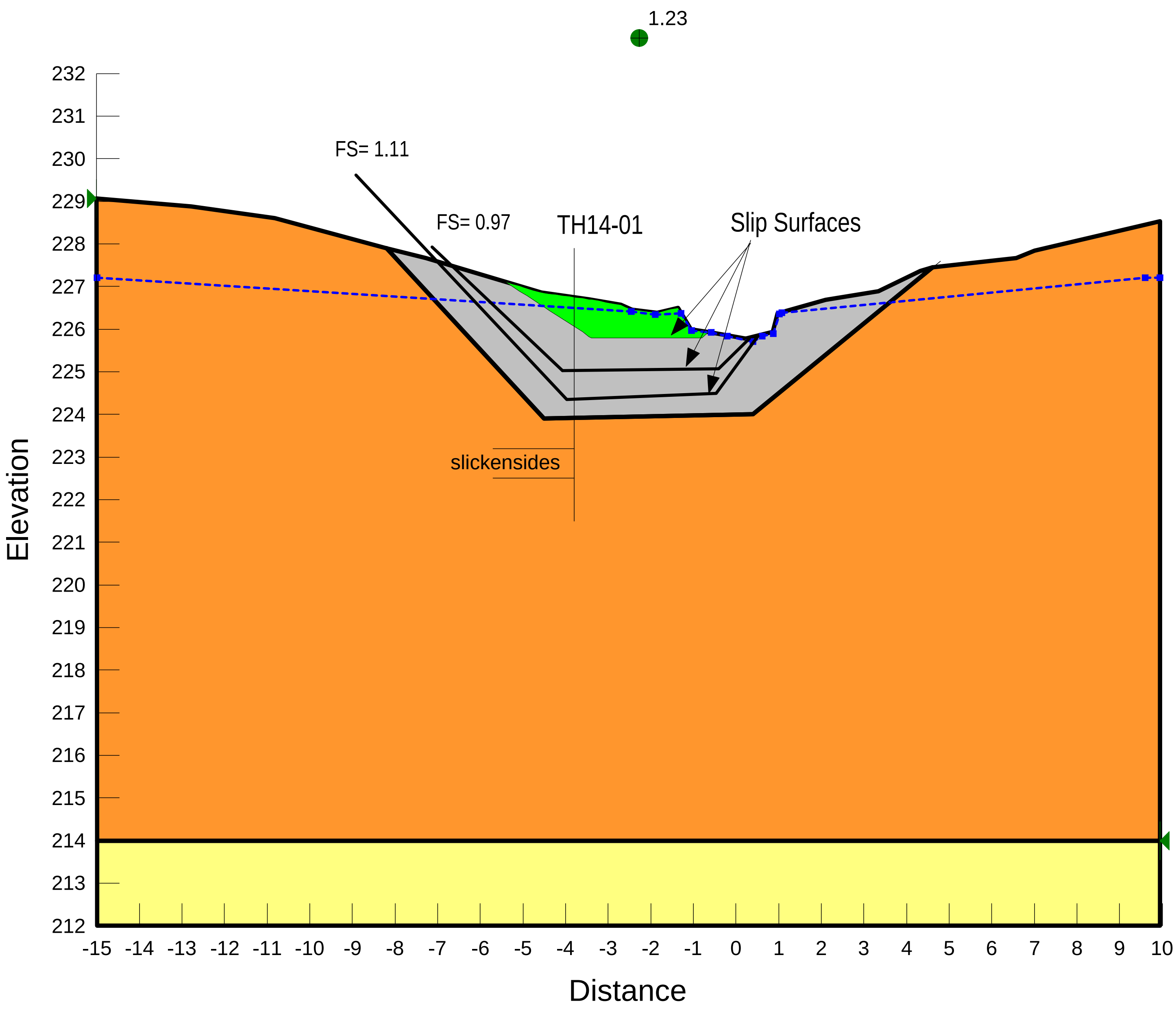


Stability Figure 02
Bunn's Creek Pathway
Site C
Back Analysis

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1.5 kPa
Phi: 12 °



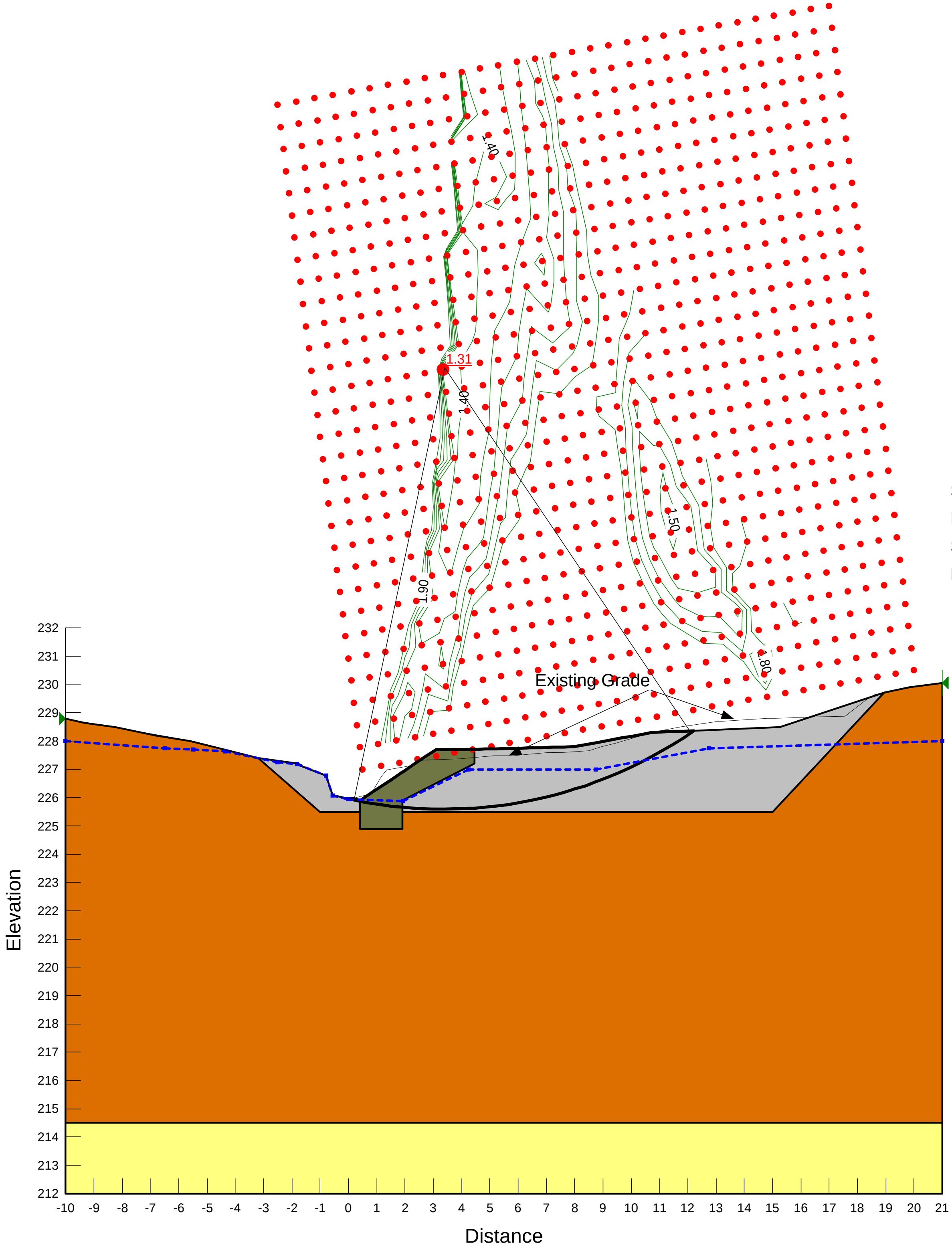
Stability Figure 03
Bunn's Creek Pathway
Site D
Back Analysis

Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °
Piezometric Line: 1

Name: Clay (Lacustrine-Fully Softened)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °
Piezometric Line: 1

Name: Clay (Lacustrine-Residual Strength)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1 kPa
Phi: 10 °
Piezometric Line: 1

File Name: Site B- 004 design section-3.gszDirectory: P:\60321375\400-Technical\402 Geotechnical\Modelling



Stability Figure 04

Bunn's Creek Pathway

Site B

Preliminary Design Section

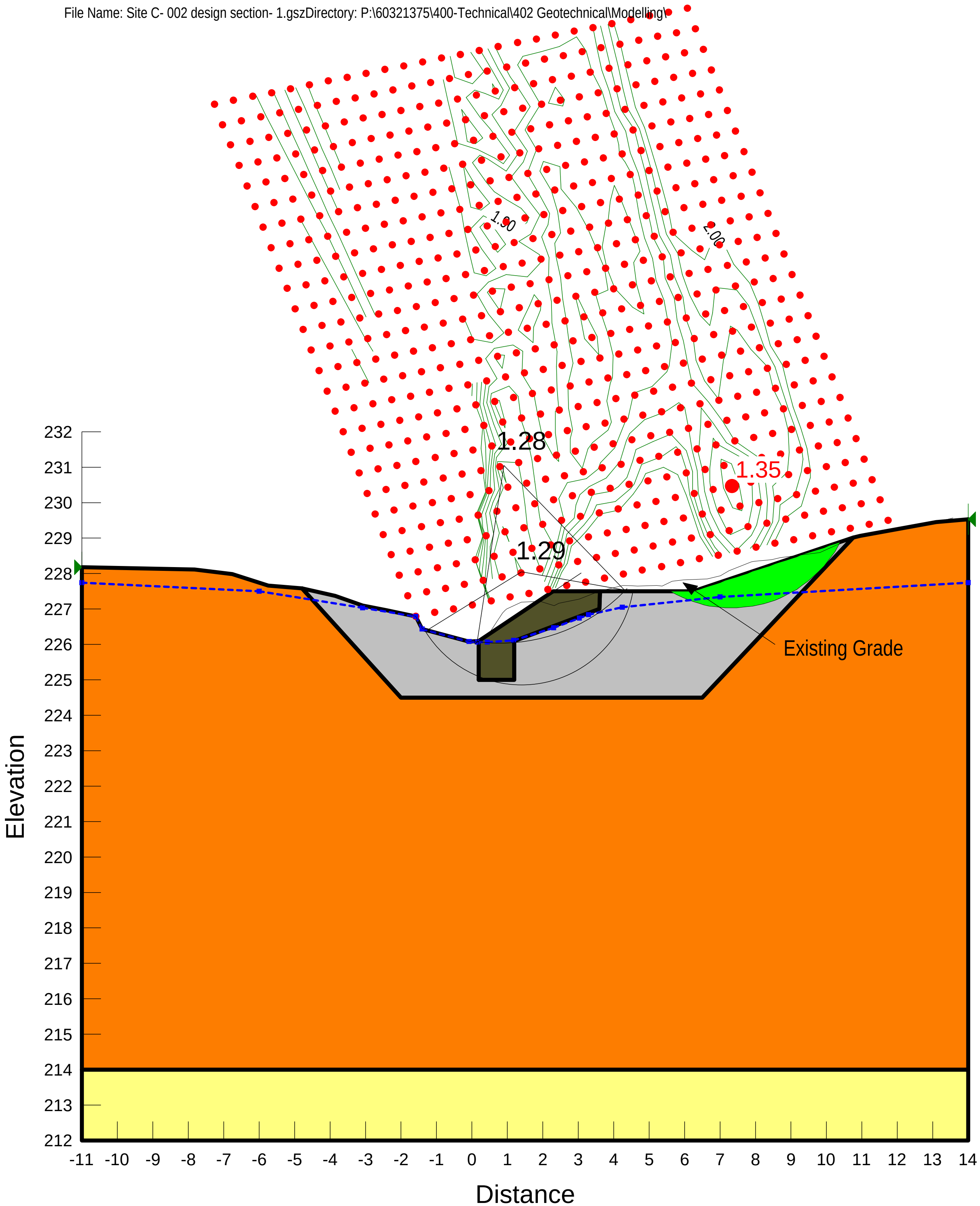
Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 12 °

Name: Granular Fill
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 40 °

File Name: Site C- 002 design section- 1.gszDirectory: P:\60321375\400-Technical\402 Geotechnical\Modelling\



Stability Figure 05

Bunn's Creek Pathway

Site C

Design Section

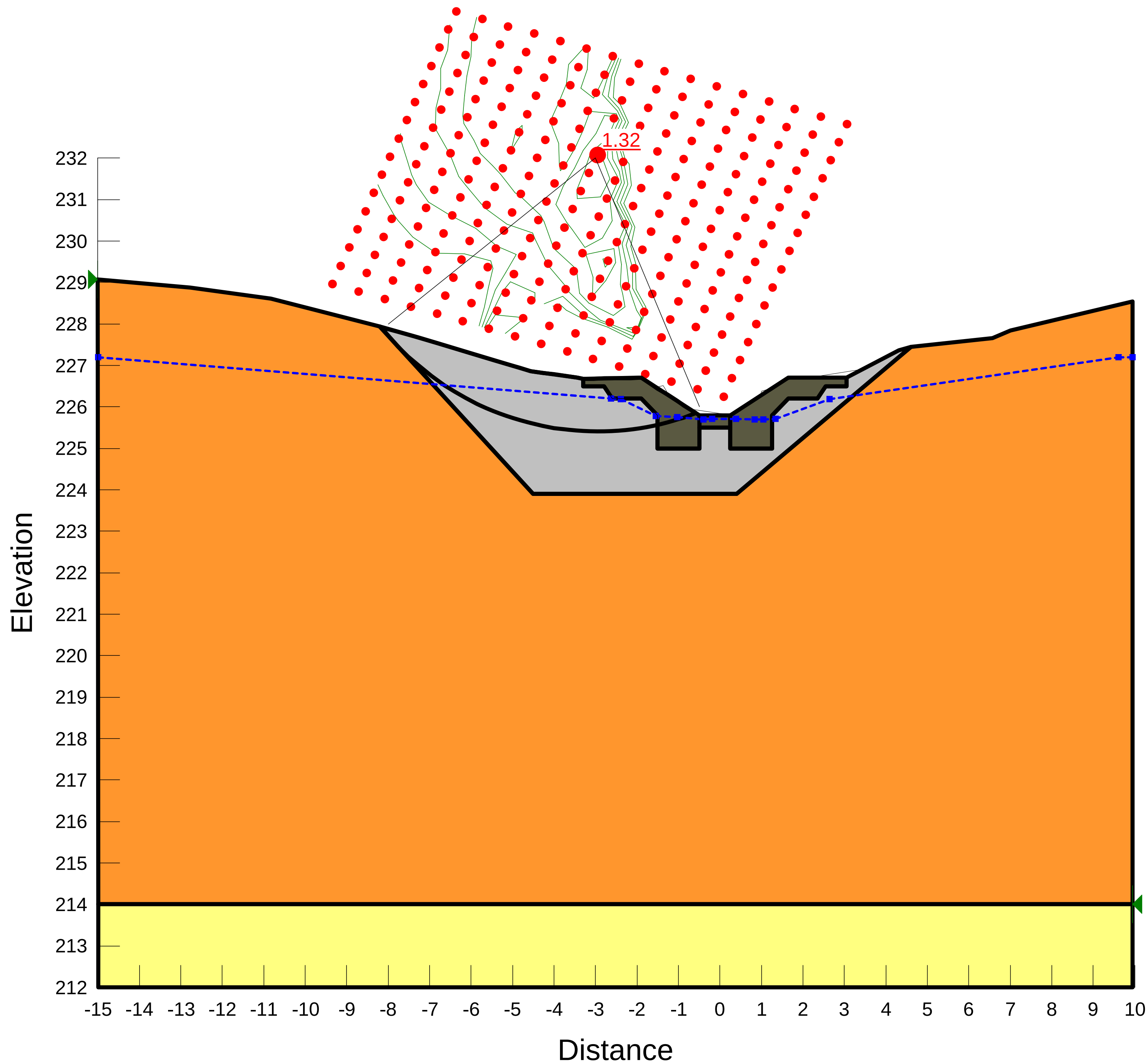
Name: Clay
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1.5 kPa
Phi: 12 °

Name: Granular Fill
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 40 °

File Name: Site D- 002 design section- 1.gszDirectory: P:\60321375\400-Technical\402 Geotechnical\Modelling\



Stability Figure 06
Bunn's Creek pathway
Site D
Design Section

Name: Till
Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Clay
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 5 kPa
Phi: 14 °

Name: Clay (Residual)
Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Cohesion: 1 kPa
Phi: 10 °

Name: Granular Fill
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 40 °