APPENDIX C – "KING'S PARK RIVERBANK INVESTIGATION MONITORING AND ASSESSMENT" BY KGS GROUP, 2014

Winnipeg

King's Park
Riverbank Investigation Monitoring and Assessment
FINAL

KGS Group 13-0107-008
September 2014

Prepared By

Tony Ng, M.Sc., P. Eng.
Senior Geotechnical Engineer

PROVINCE OF MANITOBA
2014/09/12
T. N.
NG
REGISTERED PROFESSIONAL ENGINEER

Reviewed and Approved By

Rob Kenyon, Ph.D., P. Eng.
Manager, Geotechnical Engineering

KGS Group
Winnipeg, Manitoba

Kontzamanis Graumann Smith MacMillan Inc.

KGS GROUP
CONSULTING ENGINEERS

3rd Floor
865 Waverley Street
Winnipeg,
Manitoba
R3T 5P4
204.896.1209
fax: 204.896.0754
www.kgsgroup.com

September 12, 2014

File No. 13-0107-008

City of Winnipeg
Urban Design Division
Planning, Property and Development Department
Unit 15 - 30 Fort Street
Winnipeg, Manitoba
R3C 4X5

ATTENTION: Mr. Kendall Thiessen, Ph.D., P.Eng.
Riverbank Engineer

RE: Riverbank Investigation, Monitoring and Assessment – King's Park
Final Report

Dear Mr. Thiessen:

Please find enclosed three (3) copies of our final report detailing our geotechnical investigation, monitoring and assessment for King's Park riverbank. The report summarizes the results of the field investigation and monitoring that has been completed to date, and provides KGS Group's interpretation of stratigraphic and groundwater conditions. A preliminary engineering assessment of the riverbank conditions with Class D cost estimate for possible conceptual riverbank improvements is also included in this report.

Please do not hesitate to contact the undersigned at (204) 896-1209 should you have any questions.

Yours truly,

J. Bert Smith, P.Eng. for
Principal

TG/jr
Enclosure

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1.0 INTRODUCTION

KGS Group was authorized by the City of Winnipeg Urban Design Division, Planning, Property and Development – Waterways Branch to investigate, monitor and assess riverbank conditions at King's Park. The study area is a stretch of the Red River, approximately 900 m in length, located as shown on Figure 01. The purpose of this study was to complete a preliminary investigation of the soil stratigraphy along with monitoring of groundwater conditions and slope movements at select locations, and to provide a riverbank stability assessment with budget costs for possible riverbank improvements (if required). The results of the assessment are intended to serve as key background information for the City to prioritize if and when additional engineering and bank remediation works should be undertaken.

The scope of the engineering work for this project included:

- A review of all pertinent background information,
- A geotechnical field investigation,
- A laboratory testing program,
- Topographic and sonar based bathymetric surveys,
- Installation of slope inclinometers and piezometers,
- Monitoring of the instrumentation (minimum of 5 times for one-year period),
- An interim instrumentation monitoring report, and
- A final report of the preliminary engineering assessment of the riverbank conditions with Class D cost estimate for possible conceptual riverbank improvements if recommended.

This report summarizes the findings of the results of the geotechnical field investigation, laboratory testing, topographic and sonar surveys, and the instrumentation monitoring to July 2014. A preliminary engineering assessment of the riverbank conditions with Class D cost estimate for possible conceptual riverbank improvements is also included in this report.

2.0 REVIEW OF BACKGROUND INFORMATION

As part of the KGS Group's riverbank condition assessment, the following background information was reviewed:

- Aerial photographs of 1988, 1992, and 1998 and site photographs.
- Geotechnical Investigation and Riverbank Stability Study at King's Park on Red River, by Independent Test-Lab Limited, February 21, 1989, and
- Existing Logs for Community Rind Dike Project by KGS Group, 2000.

3.0 GEOTECHNICAL INVESTIGATION PROGRAM

The geotechnical investigation program consisted of the topographic and sonar based bathymetric surveys, a geotechnical drilling and sampling investigation with instrumentation installations, some cone penetration testing with pore pressure response (CPTU), and a laboratory index testing program.

3.1 TOPOGRAPHIC AND SONAR SURVEYS

A topographic site survey was performed by KGS Group on July 17, 2013 to evaluate LiDAR data provided by City of Winnipeg in order to confirm the existing riverbank slope geometry. A total of four (4) cross sections were surveyed. In addition a bathymetric sonar survey was conducted on July 17, 2013 for the river channel in the vicinity of the project area. The resulting topographic and bathymetric site plan is shown on Figure 01 and in cross sections on Figures 02 and 03. All surveying was completed in Universal Transverse Mercator (UTM) NAD 83 Zone 14.

3.2 GEOTECHNICAL FIELD INVESTIGATION

The geotechnical field investigation consisted of conventional drilling and Cone Penetration testing with pore water pressure measurements (CPTU), completed between March 19 and 27, 2013 with drilling services provided by Paddock Drilling Ltd. of Brandon, Manitoba. A track mounted Acker SS drill rig under continuous KGS Group supervision was utilized for the field investigation.

Prior to the drilling operation, snow clearance and construction of a ramp for the drill rig to access to the lower bank areas was required. The ramp was constructed down to the shoreline in the vicinity of the outfall areas (Section 2-2), and then snow was cleared along the lower bank areas toward Sections 1-1 and 3-3. However, we were unable to develop access to Section 4-4 due to the very soft ground conditions along that section of the lower shoreline.

A total of five (5) test holes were drilled and four (4) CPTU probes were conducted in three separate areas, the outside bend section (Section 1-1 area), a transition zone from outside to inside bend area (between Sections 2-2 and 3-3 area), and the inside bend (Section 4-4). All test holes were drilled to refusal in till and the CPTU probes were pushed to refusal.

Two test holes (TH13-01 and TH13-08) were drilled and three CPTU (CPT13-01 to CPT13-03) probes were completed along the upper bank. One test hole (TH13-04) was drilled at the mid bank. The other two test holes (TH13-05 and TH13-07) and one CPTU (CPT13-04) probe were completed below the Regulated Summer River Level along the lower bank areas. Other initially proposed test holes of TH13-02, TH13-03 and TH13-06 were not drilled due to inaccessible site conditions or they were replaced with CPTU probes.

Test hole drilling was performed using 200 mm diameter hollow stem augers, with continuous soil sample recovery using a split barrel sampler. Standard Penetration Testing (SPT) was conducted with split spoon sampling in the sandy clay and silt till layers of test holes TH13-05 and TH13-08. Representative samples were typically taken at 1.5 m intervals or change in soil profile. All test holes were drilled to auger refusal in the underlying till. All samples were visually classified in the field according to the Unified Soil Classification System (USCS). Clay samples were tested with a field Torvane to estimate the undrained shear strength. All test holes were outfitted with instrumentation (detailed in the next section) before being backfilled with grout and bentonite chips.

The locations of the test holes and CPTU holes are shown in Figure 01. Results of the CPTU and detailed test hole logs incorporating field observations and subsequent laboratory test data are provided in Appendix A.

3.3 INSTRUMENTAION

A total of nine (9) vibrating wire (VW) Piezometers with data loggers (Data Acquisition System, DAS) were installed. Three VW piezometers were installed in TH13-01 at 4.57 m, 6.09 m and 15.24 m below existing grade respectively. Four VW piezometers were installed in TH13-08 at 6.09 m, 11.27 m, 13.72 m, and 17.67 m below existing grade respectively. The remaining two VW piezometers were installed in TH13-04 and TH13-07 at 8.99 m and 6.09 m below grade. VW piezometers installation details are summarized in Table 1.

In addition, four (4) slope inclinometers (SI) casings were installed in TH13-01, TH13-04, TH13-05 and TH13-08. All casings were anchored in silt till. Installation details are included on the test hole logs in Appendix A.

3.4 LABORATORY TESTING

A diagnostic laboratory testing program was performed on representative soil samples to determine the engineering index characteristics of the subsurface soils. The program included thirty eight (38) moisture content analyses, fourteen (14) Atterberg limit tests and three (3) grain size analyses. The results of the laboratory testing are found on the test hole logs presented in Appendix A.

4.0 PRELIMINARY INVESTIGATION RESULTS

4.1 SITE GEOMETRY

The existing riverbank geometry of the study area is shown in plan on Figure 01 and in section on Figures 02 and 03 (Cross Sections 1, 2, 3 and 4). Section 1-1 shows a typical cross section of the outside bend areas. In Section 1-1, an upper bank area extends from Elev. 230.5 to 230.0 m± and is followed by a 1.0 to 1.5 m± drop, which is interpreted to be probably a headscrap. From there, it slopes down along a broad mid-bank bench at about 7.5H±:1V, again followed by a nearly vertical drop of 2.0 m± to the lower bank areas. The river bottom slopes down at about 10H±:1V. This provides approximately an effective slope of 3.5H±:1V from top of the bank to the Regulated Summer River Level (RSRL).

Section 2-2 shows a typical cross section at the beginning of the transition from outside bend to sharp inside bend. In Section 2-2, the upper bank area (top of bank) begins at Elev. 230.0 m±, slopes down gently at about 10H±:1V, again followed by a 1.0 to 1.5 m± drop to the mid bank area which slopes down at about 6H±:1V to the lower bank areas, and then slopes down to the river at about 6.5H±:1V. This provides approximately an effective slope of 5.8H±:1V from top of the bank to the RSRL. Note that a water retaining pond is located at the upper bank in the vicinity area of Section 2-2.

Section 3-3 shows a typical cross section of the transition to an inside bend. In Section 3-3, the upper bank area (top of bank) extends from Elev. 231.0 m±, begins with a nearly vertical drop of 3.5 to 4.0 m± to the mid bank area, then is more or less flat for approximately 18.0 to 20.0 m before it drops 2.5 to 3.0 m± to the lower bank areas. From there, the channel bottom slopes down at about 10.0H±:1V. This provides approximately an effective slope of 3.2H±:1V from top of the bank to the Regulated Summer River Level.

Section 4-4 shows a typical cross section of the downstream end of the transition to the inside bend areas. Here, the upper bank area (top of bank) elevation ranged from Elev. 230.0 to 230.6m±, followed by a nearly vertical drop of 5.5 to 6.0 m± to the lower bank areas, below which it slopes down at about 7.0H±:1V to the bottom of the channel. This results approximately an effective slope of 1.0H±:1V from top of the bank to the RSRL.

In general, the overall geometry of Sections 1, 2, and 3 is characteristic hummocky of retrogressive, slump block topography where erosion at the river's edge triggers deep seated and retrogressive bank failures. Note that 1989 ITL profile (Section A-A) was superimposed on Section 2 (see Figure 02). The results indicated that there were only minor changes of the upper and mid bank profiles in the last 25 years. However, major changes were detected at the lower bank area. These changes could be due to the remedial work of the existing outfall. The very steep geometry of Section 4 is consistent with an alluvial bank on an inside bend.

Based upon the the bathymetric contours generated from the sonar survey (see Figure 01), the river bottom elevation ranged from Elev. 220.0 m± along the straight section down to Elev. 215.0 m to 216.0 m towards the inside and the outside bends.

4.2 STRATIGRAPHY

In general, the stratigraphy encountered at the site has been interpreted to consist of top soil over silty clay which is underlain by glacial till. The clays were typically of alluvial origin overlying lacustrine origin in four (4) of the five testholes and all the CPTU probes. Alluvial sandy clay was encountered down to glacial till in TH13-08 (Section 4-4).

Top Soil

A top soil layer was encountered at the surface of the test holes locations. The thickness of this layer raged from 0.3 m (TH13-01) to 0.6 m (TH13-08). The material of this layer was mainly organic clay with trace rootlets. It was black in color and was recovered in dry, crumbly and frozen conditions. No top soil was encountered at the TH13-05 location.

Silty Clay (Alluvial Origin)

As indicated in test holes and on the CPTU profiles, an extensive layer of medium to high plasticity silty clay was encountered below the topsoil and was interpreted to be alluvial in origin. This layer extended to approximately Elev. 218 m± (TH13-01) to 221 m± (TH13-04 and TH13-08). The clay was brown to grey in colour, damp to wet, firm in consistency, and contained trace amounts of silt, sand, gravel, organic and oxidation pockets. A 0.3 m± thick layer of medium to coarse grained sand was encountered in TH13-04 at a depth of 7.0 m±, just above the lacustrine clay layer. The sand was brown in color, wet, poorly graded, and contained some clay, gravel and trace silt.

Silty Clay (Lacustrine Origin)

Underneath the alluvial silty clay, high plasticity silty clay of lacustrine origin was encountered in test holes TH13-01, TH13-04 and TH13-07. Slickensides were observed in the clay samples obtained from TH13-01. The lacustrine origin clay was grey in colour, damp to wet, firm in consistency, and contained trace amounts of silt, fine grained sand, gravel, organics and oxidation pockets.

Sandy Clay

A 6 m ± thick layer of sandy clay was encountered under the alluvial origin silty clay in TH13-08 between Elev. 221 m± and 215 m±. The sandy clay was brown in color, of medium to low plasticity, wet, crumbly and contained trace sea shells throughout. The uncorrected SPT blow counts (N) ranged from 4 to 6.

The undrained shear strengths, moisture contents, Atterberg Limits and the soil types as classified by using the Unified Soil Classification System (USCS) of the above noted clays are summarized in Table 2 and shown on the detailed borehole log contained in Appendix A.

Silt Till

Silt till was encountered at approximately Elev. 219.0 m± to 213.7 m±. The till was tan to light grey in colour, wet, compact to very dense and contained some fine to coarse grained sand, and gravel. Moisture contents in this layer ranged from 15% to 22%. The thickness of the till above power auger refusal ranged from 0.3 m± to 2.3 m±.

4.3 PIEZOMETRIC AND SLOPE INCLINOMETER (SI) MONITORING RESULTS

Instrumentation installed included four (4) slope inclinometers, four (4) vibrating wire piezometers installed in the alluvial clay, three (3) installed in the silt till and two (2) installed in the sandy clay.

Vibrating Wire Piezometers

Groundwater elevation data was recorded between April 26, 2013 and July 9, 2014 by using vibrating wire piezometers set up at Section1-1 (TH13-01, TH13-04, and TH13-07) and Section 4-4 (TH13-08). Groundwater elevation data is plotted on Figures 04 and 05 respectively.

As shown on the figures, the bank groundwater levels generally responded directly to the Red River staging during the various seasons. In spring, the groundwater level climbed up sharply during the period of ice break up (end of April to the first week of May); remained high during the spring flood period to the end of May, then declined during June and finally became almost stable during July. After the drawdown of the Red River in October, most of the groundwater levels then remained stable to the end of the end of March 2014 when the river level starts to rise up again. Generally, overall seepage gradients were static to downward during the monitoring period except the piezometric levels of TH14-04 with tip elevation at 219.15 m in till which showed upward gradients of groundwater flow condition. The piezometric levels of TH13-04 in till were generally 4 m to 5 m higher than the piezometric levels of TH13-01 in till.

Slope Inclinometers (SI)

Out of the four (4) slope inclinometers, two (2) were installed in the upper bank of Sections 1-1 (TH13-01) and 4-4 (TH13-08). The other two (2) were installed in the middle to lower bank of Sections 1-1 (TH13-04) and 2-2 (TH13-05). Multiple SI readings were taken between March 26, 2013 (base line reading) and July 9, 2014. Results of the SI readings are included in Appendix A.

No significant slope movement was detected during this period of time of monitoring for the upper bank, but approximately 13 to 14 mm displacements in a period of approximately 1 year (from March 2013 to April 2014) were recorded in the slope inclinometers located in the middle to lower bank. Movements were deep seated shear movements in the lacustrine clay layer immediately over the till.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

- A review of the background information indicated that the riverbank within the study area of approximately 900 meters had been subject to both historic and ongoing shoreline erosion and riverbank movement.

- An investigation program consisting of a total of five (5) test holes and four (4) CPTU was completed within the study area of approximately 900 meters along the riverbank. The stratigraphy for Sections 1, 2 and 3 typically consisted of topsoil over silty clay underlain by glacial till. The upper clays were concluded to be alluvial in origin, overlying clay of lacustrine origin. The alluvial origin clay was an intermediate to high plasticity and extended down to approximately Elev. 218 m± (TH13-01) to 221 m± (TH13-04 and TH13-08). The lacustrine origin clay was of high plasticity and extended down to the top of the till. A 6 m ± thick layer of sandy clay was encountered under the alluvial origin silty clay in TH13-08 between Elev. 221 m± and 215 m±. A deposit of glacial silt till was then encountered below the clay in all test holes and was typically dense to very dense.

- Continuous piezometric monitoring data of over one year indicated that the bank groundwater levels in both clay and till fluctuate in response to changes in the Red River level. There was a downward gradient from the clay to the till except the piezometric levels of TH14-04 with tip elevation at 219.15 m in till which showed an upward gradient of groundwater flow from till to clay. The piezometric levels of TH13-04 in till were generally 4 m to 5 m higher than the piezometric levels of TH13-01 in till.

- The SI monitoring data indicated that the upper bank experienced no significant movement so far, while the middle to lower bank had a measured slope movement of 13 to 14 mm during the approximately one-year monitoring period. Movements were deep seated in lacustrine clays.

- Based on the monitoring, the upper bank had no significant movement and the middle to lower bank had movement at a rate less than 15 mm during the one-year monitoring period at the areas of Sections 1-1 and 2-2. Based on the monitoring results, the site conditions and the past experience on similar projects along the Red River bank, the movement of the middle to lower bank at these areas was primarily caused by ongoing erosion and resulting retrogressive land sliding of the bank.

- The existing geometry of the bank at Section 4-4 was typically near vertical, consistent with alluvial banks. It remains nevertheless susceptible to ongoing shoreline erosion along the bank, particularly with elevated river levels.

- Section 3-3 is considered to be most likely a transition zone between the above two mechanisms.

5.2 RECOMMENDATIONS

Remedial measures such as rockfill columns and/or shear key trenches installed to the till have been proved to be an effective way to reduce the movement of the river bank. In general, shear key trenches could be more cost effective than rockfill columns. The till depth at the lower middle to lower bank areas ranged from 7 to 12 m below the existing grade. This makes the shear key trenches to be constructible and the shear key trenches could be a cost-effective option.

Based on the experience on similar work, remedial measure Option A including shear key trenches combined with a riprap blanket for the erosion protection along the middle to lower bank would cost $6,500,000 (Class D Cost Estimates). Such remedial work is considered to be a complete solution for the bank stability at the site and is recommended if funding permits. If a complete remedial solution is selected, it is highly recommended to perform detailed stability analyses for the design of remedial work and cost estimations.

If budget is a constraint or the City accepts some movements of the riverbank may be tolerated, then remedial work Option B of riprap erosion protection may be considered. Class D Cost Estimates of a riprap blanket for the erosion protection along the middle to lower bank would cost $1,500,000. With this option, it is necessary to have continuously bank movement monitoring. If the monitoring results indicate that the top of the bank movement is on-going after the installation of the riprap erosion protection blanket, the shear keys option should be considered for overall bank stabilization. Again, detailed stability analyses for the above noted design of remedial work and cost estimations are recommended.

Table 3 shows a detailed cost breakdown of the above noted Class D Cost Estimates for Options A and B.

6.0 STATEMENT OF LIMITATIONS AND CONDITIONS

6.1 THIRD PARTY USE OF REPORT

This report has been prepared for the Client to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

6.2 STATEMENT OF LIMITATION

KGS Group prepared the geo-environmental conclusions and recommendations for this report in a professional manner using the degree of skill and care exercised for similar projects under similar conditions by reputable and competent environmental consultants. The information contained in this report is based on the information that was made available to KGS Group during the investigation and upon the services described, which were performed within the time and budgetary requirements of the Client. As the report is based on the available information, some of its conclusions could be different if the information upon which it is based is determined to be false, inaccurate or contradicted by additional information. KGS Group makes no representation concerning the legal significance of its findings or the value of the property investigated.

TABLES

TABLE 1
SUMMARY OF VIBRATING WIRE PIEZOMETERS

Vibrating Wire Piezometers	Section	Piezometers	Depth (m)	Tip Elevation (m)	Soil Types
VW 01a	1-1	TH13-01C	4.6	225.62	Alluvial Clay
VW 01b	1-1	TH13-01B	6.1	224.10	Alluvial Clay
VW 01c	1-1	TH13-01A	15.2	214.95	Silt Till
VW 04a	1-1	TH13-04	9.0	219.15	Silt Till
VW 07a	1-1	TH13-07	6.1	217.41	Alluvial Clay
VW 08a	4-4	TH13-08D	6.1	224.44	Alluvial Clay
VW 08b	4-4	TH13-08C	11.3	219.26	Sandy Clay
VW 08c	4-4	TH13-08B	13.7	216.82	Sandy Clay
VW 08d	4-4	TH13-08A	17.7	212.86	Silt Till

TABLE 2
SUMMARY OF UNDRAINED SHEAR STRENGTH, MOISTURE CONTENTS, ATTERBERG LIMITS AND USCS CLASSIFICATION OF THE CLAYS

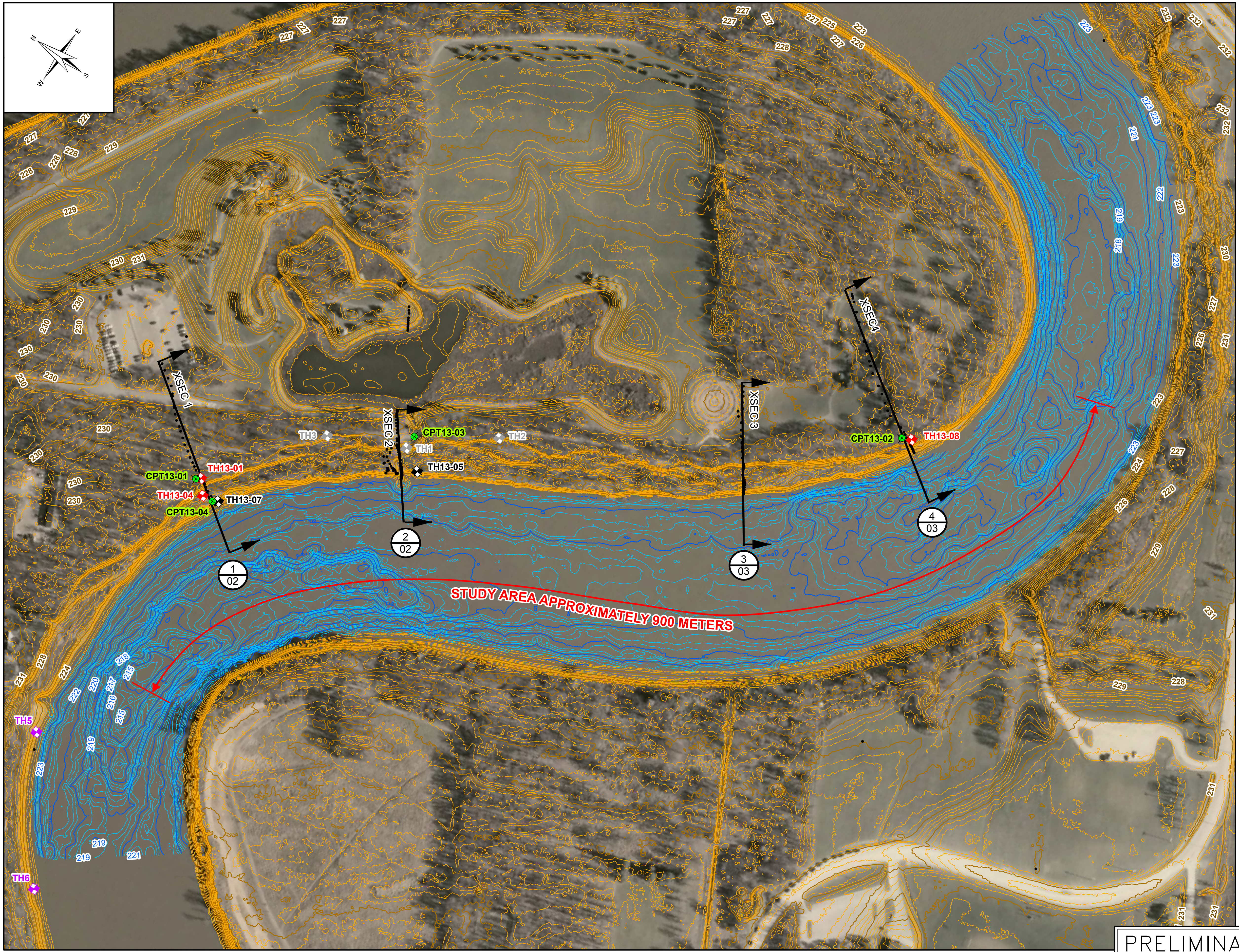
Soil Type	Undrained Shear Strength* (kPa)		Moisture Contents (%)		Atterberg Limits (%)			USCS***
	Range	Average	Range	Average	LL**	PL**	PI**	
Alluvial Clay	30 – 90	65	20 - 53	35	49 - 70	19 - 27	30 - 47	CI-CH
Lacustrine Clay	60 - 90	73	35 - 52	46	76 - 101	23 - 31	53 - 70	CH
Sandy Clay	--	--	26 - 31	29	28 - 52	14 - 16	13 - 38	CI

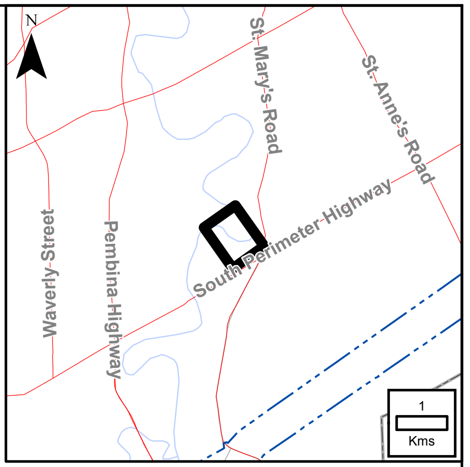
***** Based on field Torvane results.
** LL = Liquid Limit, PL = Plastic Limit, PI = Plasticity Index
*** USCS = Unified Soil Classification System

TABLE 3
CLASS D COST ESTIMATES

Option A: Shear Keys and Erosion Protection Riprap Blanket				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Amount**
Mob & Demob	L.S.	1	$50,000	$50,000
Site Development	L.S.	1	$100,000	$100,000
Rockfill Shear Key (700 m)				
a) Shear Key Excavation	Cu. m	35,000	$25	$ 875,000
b) Shear Key Rockfill	Tonne	58,000	$50	$2,900,000
Rockfill Riprap Blanket	Tonne	22,000	$45	$990,000
Erosion Control Measures	L.S.		$50,000	$50,000
Subtotal Cost (GST Extra)				$4,965,000
15% Engineering Fees (rounded)				$750,000
Contingency at 15 % (rounded)				$750,000
Total Cost (GST Extra)				$6,465,000
ROUND UP TOTAL COST (GST Extra):				**$6,500,000**
Option B: Erosion Protection Riprap Blanket				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Amount**
Mob & Demob	L.S.	1	$40,000	$40,000
Site Development	L.S.	1	$70,000	$70,000
Rockfill Riprap Blanket	Tonne	22,000	$45	$990,000
Erosion Control Measures	L.S.		$40,000	$40,000
Subtotal Cost (GST Extra)				$1,140,000
15% Engineering Fees (rounded)				$175,000
Contingency at 15 % (rounded)				$175,000
Total Cost (GST Extra)				$1,490,00
ROUND UP TOTAL COST (GST Extra):				**$1,500,000**

FIGURES





LEGEND:

- CPTU Location
- Approximate Test Hole Location
- Surveyed Test Hole Location
- Community Ring Dike Project 2000 Test Hole
- ITL 1989 Test Hole
- Survey Point
- Cross Section

Sonar Bathymetry Contours

- 1m Index Contour
- 0.25m Contour

LiDAR Contours

- 1m Index Contour
- 0.25m Contour

NOTES:

1. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, Zone 14. Elevations are in metres above sea level (MSL).
2. Bathymetric surveys were completed by KGS Group on July 17, 2013.
3. Riverbank topography was based on City of Winnipeg LiDAR contours captured in October 2011 and supplemeted by KGS Group survey on July 17, 2013.
4. Imagery from the Manitoba Lands Initiative (MLI), captured 2008–2010.

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Metres

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REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Winnipeg

KING'S PARK RIVERBANK ASSESSMENT STUDY

SITE PLAN WITH TEST HOLE AND CPT LOCATIONS

SEPTEMBER 2014 | FIGURE 01 | REV: 0

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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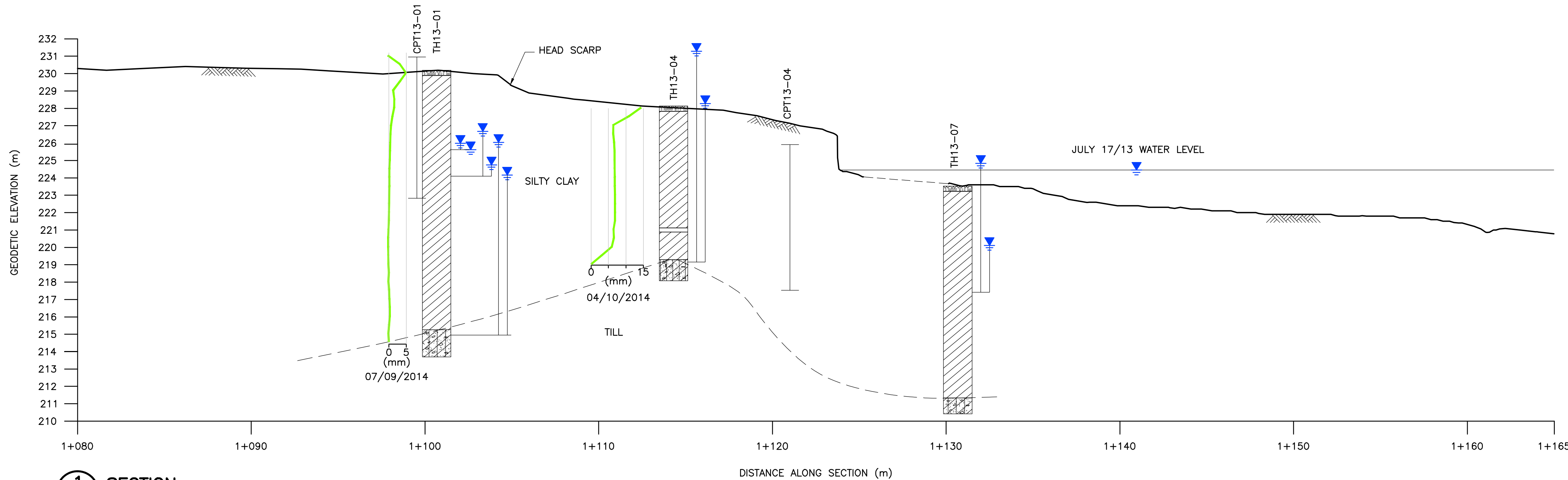

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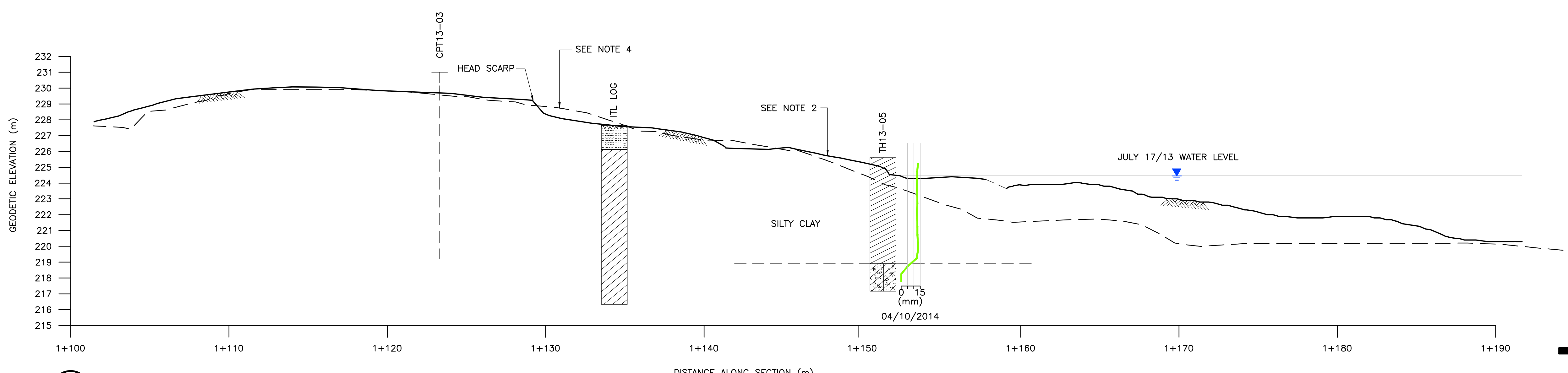

2 SECTION 01
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LEGEND:

- TOPSOIL
- SILTY CLAY
- SAND
- SANDY CLAY
- TILL
- SLOPE M,EASUREMENT ALONG AXIS A ACUMULATIVE DISPLACEMENT AND MEASUREMENT DATE
- MAX / MIN / TIP — VIBRATING WIRE PIEZOMETER LEVELS

NOTES:

1. CPT RESULTS – REFER TO APPENDIX A.
2. GROUND SURFACE BASED ON TOPOGRAPHY SHOWN IN FIGURE 01.
3. STRATIGRAPHY BASED ON KGS GROUP TEST HOLES AND CPTU-PROFILES COMPLETED IN JULY 2013.
4. THE 1989 ITL GROUND PROFILES ARE APPROXIMATE AND FOR INFORMATION ONLY.

10 0 10 20m
SCALE: 1:300 METRIC 24"x36"
1:600 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
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REVISIONS / ISSUE

KGS GROUP CONSULTING ENGINEERS

Winnipeg *Embrace the Spirit*

KING'S PARK RIVERBANK ASSESSMENT STUDY

CROSS SECTIONS 1 AND 2

SEPTEMBER 2014 | FIGURE 02 | REV: 0

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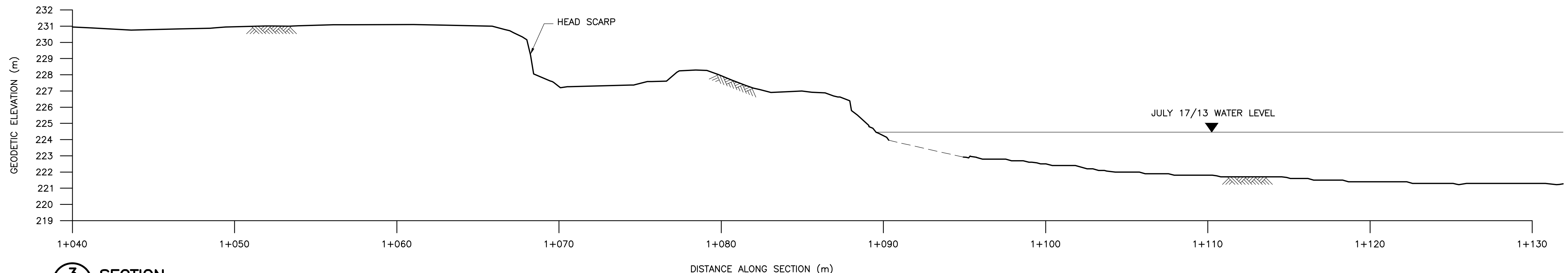

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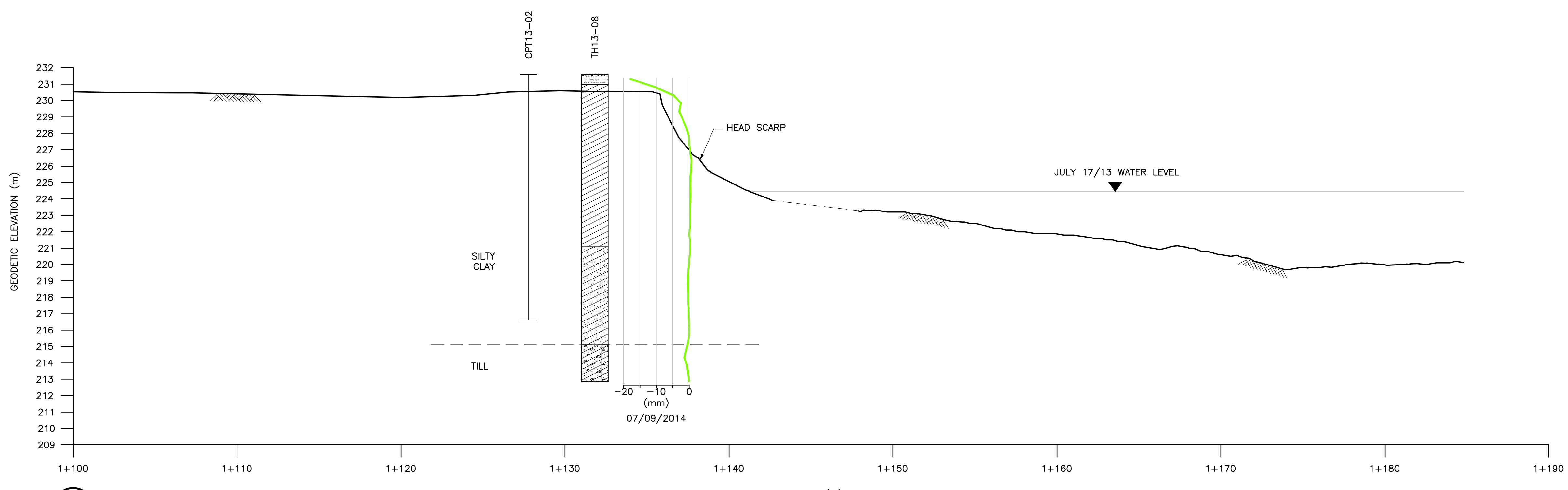

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SCALE: 1:300

LEGEND:

- TOPSOIL
- SILTY CLAY
- SAND
- SANDY CLAY
- TILL
- SLOPE M,EASUREMENT ALONG AXIS A CUMULATIVE DISPLACEMENT AND MEASUREMENT DATE

NOTES:

1. CPT RESULTS – REFER TO APPENDIX A.
2. GROUND SURFACE BASED ON TOPOGRAPHY SHOWN IN FIGURE 01.
3. STRATIGRAPHY BASED ON KGS GROUP TEST HOLES AND CPTU-PROFILES COMPLETED IN JULY 2013.
4. THE 1989 ITL GROUND PROFILES ARE APPROXIMATE AND FOR INFORMATION ONLY.

5 0 5 10m
SCALE: 1:300 METRIC

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/09/09	ISSUED WITH FINAL REPORT	TNN

REVISIONS / ISSUE

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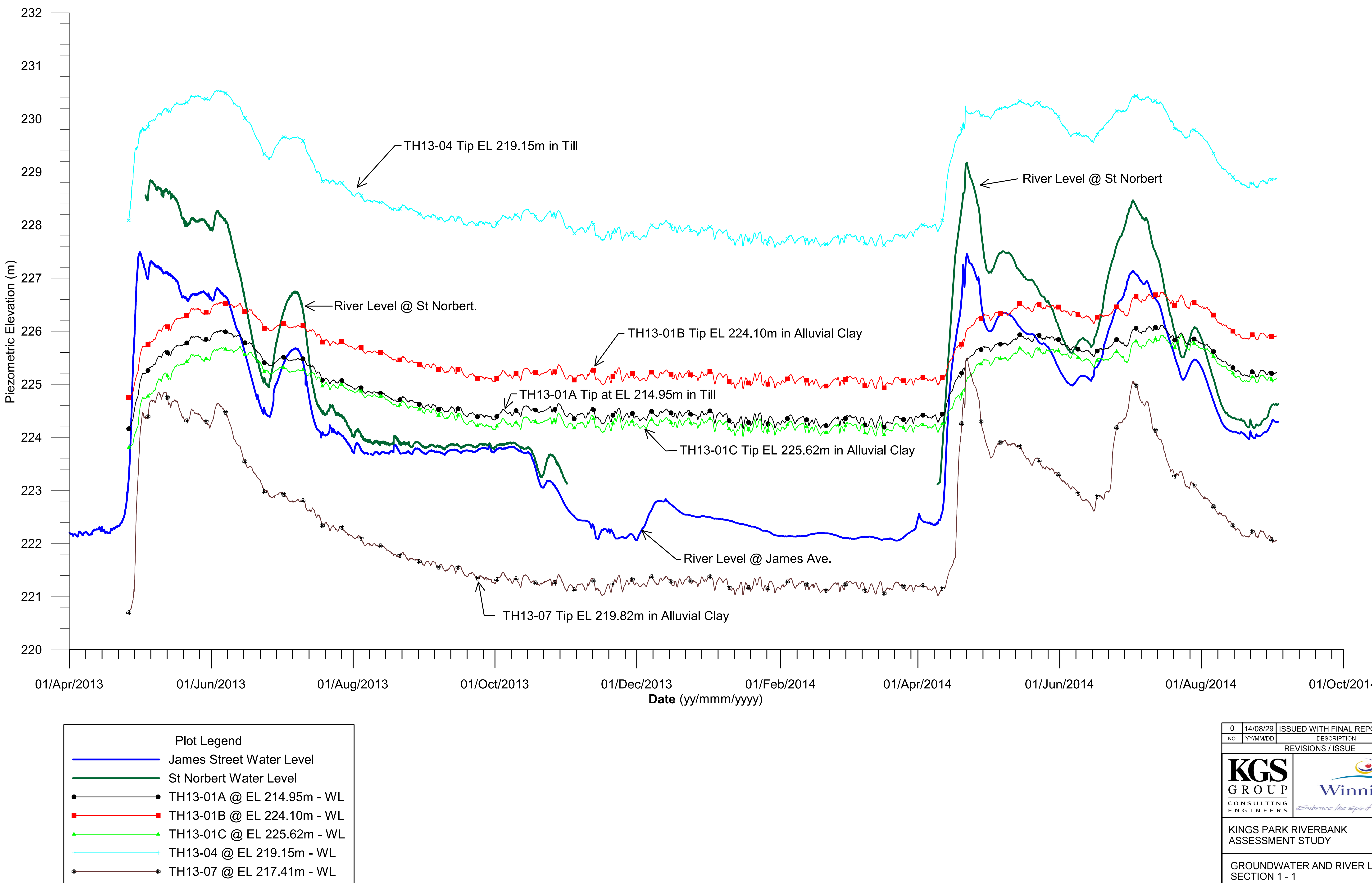
Winnipeg Embrace the Spirit

KING'S PARK RIVERBANK ASSESSMENT STUDY

CROSS SECTIONS 3 AND 4

SEPTEMBER 2014 | FIGURE 03 | REV: 0



NO.	YY/MM/DD	DESCRIPTION	BY
0	14/08/29	ISSUED WITH FINAL REPORT	TNN

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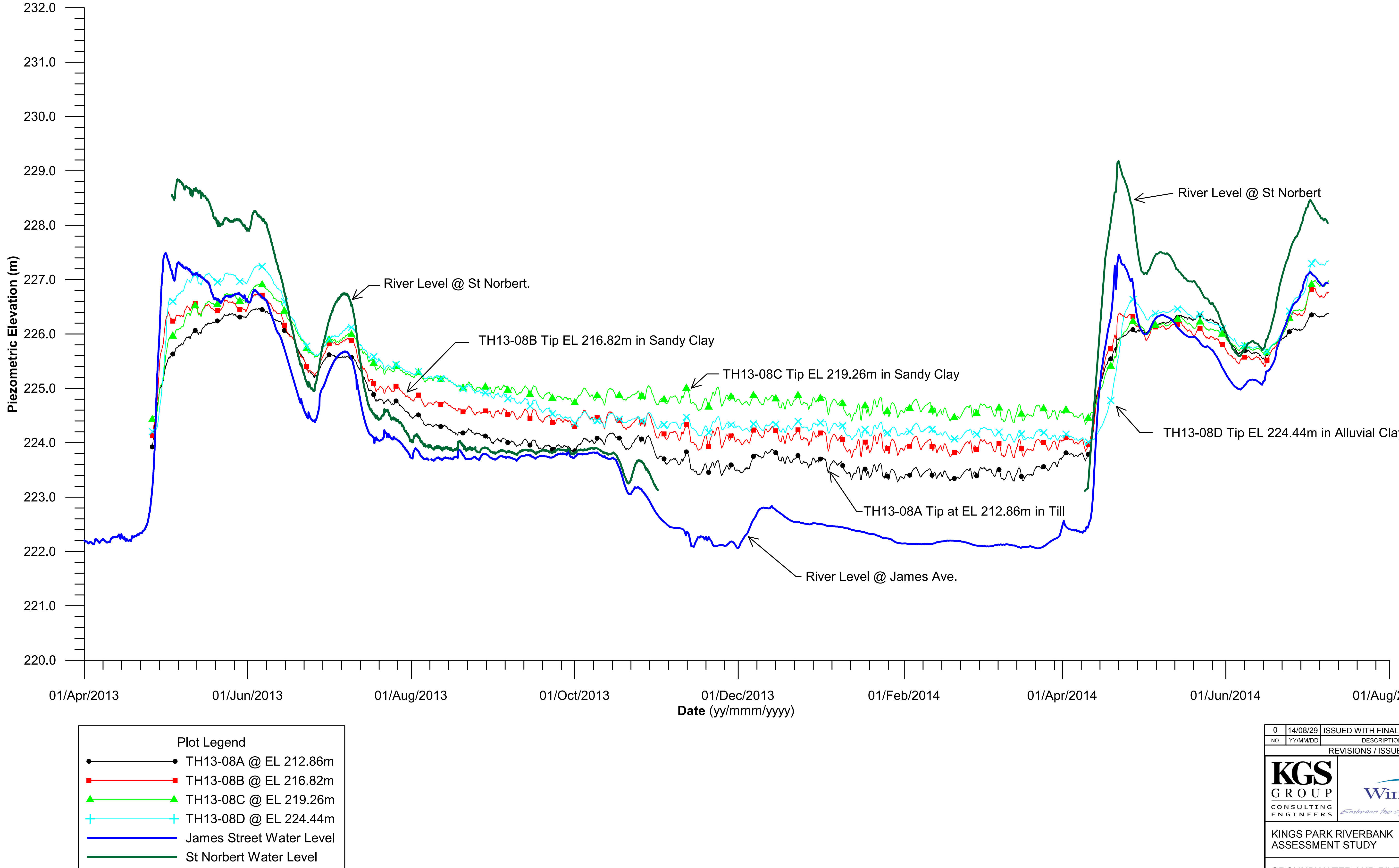
KINGS PARK RIVERBANK
ASSESSMENT STUDY

GROUNDWATER AND RIVER LEVELS
SECTION 1 - 1

August 2014 | FIGURE - 4 | REV. 0



NO.	YY/MM/DD	DESCRIPTION	BY
0	14/08/29	ISSUED WITH FINAL REPORT	TNN

REVISIONS / ISSUE

KGS GROUP
CONSULTING ENGINEERS

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KINGS PARK RIVERBANK
ASSESSMENT STUDY

GROUNDWATER AND RIVER LEVELS
SECTION 4 - 4

August 2014 | FIGURE - 5 | REV. 0

APPENDICES

APPENDIX A

SOIL LOGS, CPTU, LAB TESTING AND SI RESULTS

APPENDIX A-01

SOIL LOGS

KGS GROUP — **SUMMARY LOG**

REFERENCE NO.

HOLE NO. **TH13-01**

CLIENT	CITY OF WINNIPEG- WATERWAYS	JOB NO.	13-0107-08
PROJECT	KING'S PARK RIVERBANK ASSESSMENT	GROUND ELEV.	230.19 m
		TOP OF PVC ELEV.	
SITE	KING'S PARK RIVERBANK ASSESSMENT	WATER ELEV.	
LOCATION	UPPER BANK	DATE DRILLED	25/03/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,517,859 E 634,895

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE NUMBER
229.9	0	**TOPSOIL**- Black, dry, crumbly, trace rootlets, trace organics, frozen.		0.3	S1
		SILTY CLAY (CH)- Brown, dry, firm, high plasticity, trace silt pockets, alluvial in origin.			S2
		- Some organics at 1.82 m.			S3
		- With silt inclusions below 2.13 m.			S4
		- Dry to damp, trace silt inclusions below 3.04 m.			S5
		- Trace oxidation below 3.81 m.		4.3	S6
			VW	4.6	
		- Damp below 4.57 m.			S7
				5.8	S8
			VW	6.1	
		- Firm to stiff below 6.40 m.			S9
		- Trace oxidation pockets below 7.01 m.			S10
		- Grey clay below 7.62 m.			S11
					S12
					S13
					S14
					S15
216.8		**SILTY CLAY (CH)**- Grey, stiff, high plasticity, lacustrine in origin.			S16
		- Slickensided at 13.41 m.			
		- Trace organics below 13.56 m.			S17
		- Possible slickensided at 14.17 m.			
		- Trace silt pockets below 14.47 m.			S18
215.3				14.9	

Column headings: GRAPHICS; SAMPLE TYPE; RECOVERY %; SPT (N) blows/0.15 m ▲; DYNAMIC CONE (N) blows/ft △ (20, 40, 60); Cu POCKET PEN (kPa) ★; Cu TORVANE (kPa) ◆ (20, 40, 60, 80); PL MC LL % (20, 40, 60, 80)

SAMPLE TYPE: Continuous

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J.WILCOX	T. Ng	9/9/14

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-01**

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE	NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	Cu POCKET PEN (kPa) ★ / Cu TORVANE (kPa) ◆ / PL MC LL %
215		50		**SILT TILL** - Tan, wet, very soft, some coarse grained gravel.	VW	15.2	Continuous	S19			
213.8	16			END OF HOLE at 16.38 m		16.4					

Notes:
1. Auger refusal at 15.24 m.
2. Casing advancer used from 15.24 to 16.38 m.
3. Installed V.W. (SN 24758) at 15.24 m below ground surface.
4. Installed V.W. (SN 24757) at 6.10 m below ground surface.
5. Installed V.W. (SN 24751) at 4.57 m below ground surface.
6. Installed Slope Indicator (SI) at 16.38 m below ground surface.
7. Backfilled TH13-01 with grout from 15.24 m to 0.3 m and bentonite chips from 0.3 m to surface.

SAMPLE TYPE: Continuous

CONTRACTOR: Paddock Drilling Ltd.

INSPECTOR: J.WILCOX

APPROVED: T. Ng

DATE: 9/9/14

KGS GROUP — SUMMARY LOG

REFERENCE NO.

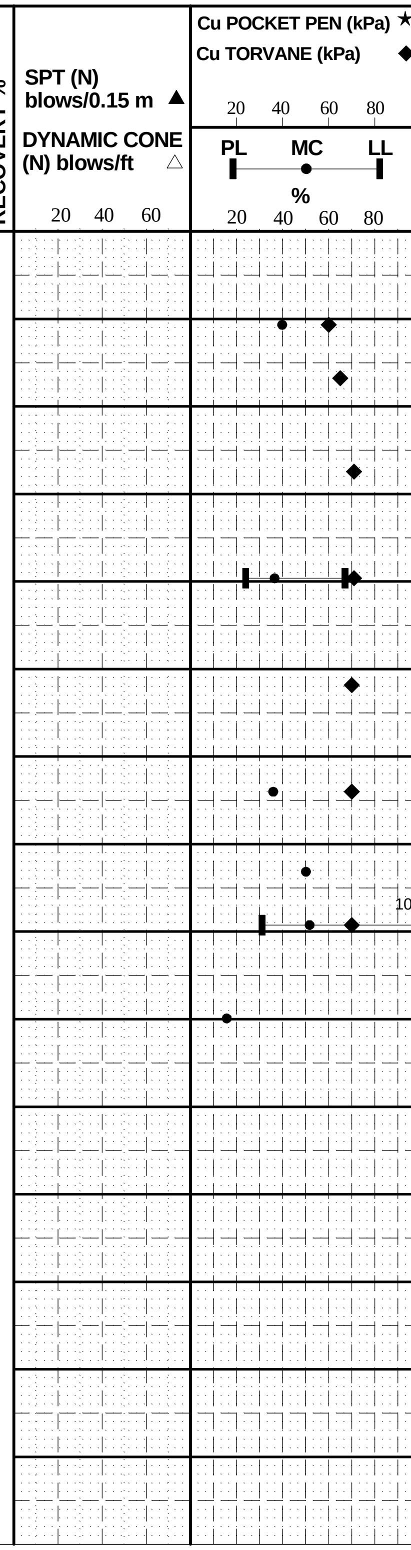
HOLE NO. **TH13-04**

CLIENT CITY OF WINNIPEG- WATERWAYS
PROJECT KING'S PARK RIVERBANK ASSESSMENT
SITE KING'S PARK RIVERBANK ASSESSMENT
LOCATION MID BANK
DRILLING METHOD 200 mm ø Hollow Stem Auger, ACKER SS Drill Rig

JOB NO. 13-0107-08
GROUND ELEV. 228.14 m
TOP OF PVC ELEV.
WATER ELEV.
DATE DRILLED 19/03/2013
UTM (m) N 5,517,849 E 634,884

Elevation (m)	Depth (m)	Description and Classification	Piez. Depth (m)	Sample No.
228 / 227.8	0	**TOPSOIL**- Black, dry, crumbly, trace rootlets, trace organics, frozen.		S1
227.8	0.3	**SILTY CLAY (CH)**- Brown to grey, damp to moist, firm, high plasticity, trace oxidation pockets, trace silt pockets, alluvial in origin.		S2
		- Some oxidation below 1.52 m.		S3
		- Trace oxidation, grey clay, some organic pockets below 2.13 m.		S4
		- Trace silt inclusions below 3.35 m.		S5, S6, S7
221.1	7.0	**SILTY SAND WITH GRAVEL (SP)**- Brown, wet, medium to coarse grained sand, poorly graded. - Grain Size Distribution: Gravel (25.1%), Sand (29.4%), Silt (9.6%) & Clay (35.9%) at 7.0 m.		S8
220.9	7.2	**SILTY CLAY (CH)**- Grey, moist, firm, high plasticity, trace oxidation pockets, trace silt pockets, lacustrine in origin.	8.7	S9
219.3	8.8	**SILT TILL** - Tan, wet, some coarse grained gravel, fine to medium grained sand. - Grain Size Distribution: Gravel (0.0%), Sand (4.0%), Silt (85.9%) & Clay (10.1%) at 8.8 m.	9.0 (VW)	S10
218.1	10.06	**END OF HOLE AT 10.06 m**	10.1	

Notes:
1. Auger refusal at 9.14 m.
2. Used casing advancer from 9.14 m to 10.06 m.
3. Installed V.W. (SN 024756) at 8.99 m below ground surface.
4. Installed Slope Indicator (SI) at 10.06 m below ground surface.
5. Backfilled TH13-04 with grout from 9.14 m to surface.



SAMPLE TYPE: Continuous

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J.WILCOX	T. Ng	9/9/14

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2013\13-0107-008\DESIGN\GEO\LOGS\KINGS PARK DRILLING INVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

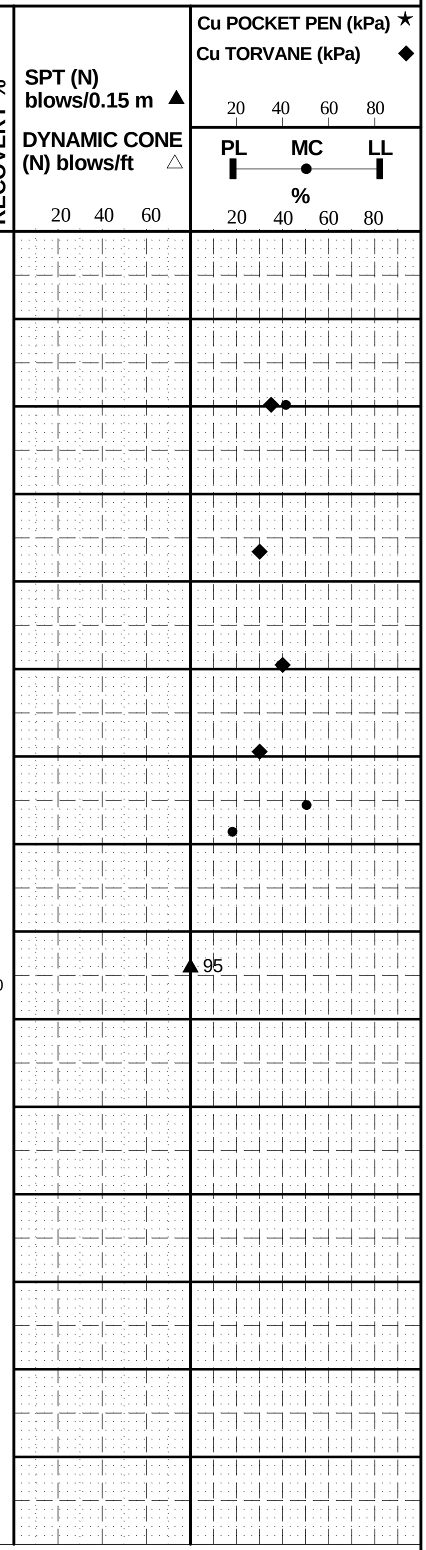
REFERENCE NO.

HOLE NO. **TH13-05**

CLIENT	CITY OF WINNIPEG- WATERWAYS	JOB NO.	13-0107-08
PROJECT	KING'S PARK RIVERBANK ASSESSMENT	GROUND ELEV.	225.61 m
		TOP OF PVC ELEV.	
SITE	KING'S PARK RIVERBANK ASSESSMENT	WATER ELEV.	
LOCATION	LOWER BANK	DATE DRILLED	26/03/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,517,720 E 635,000

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	DEPTH (m)	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m
225.61	0	**SILTY CLAY (CI-CH)**- Brown to grey, moist, firm, intermediate to high plasticity, trace silt pockets.		S1, S2		
		- Grey below 3.04 m.		S3		
		- Trace fine grained sand, trace rootlets below 4.57 m.				
		- Possible slickensided at 4.87 m.		S4		
		- Grey below 5.79 m.		S5		
		- Some silt pockets below 6.24 m.		S6		
218.9		**TILL** - Tan to light grey, wet, very dense, with fine grained sand, trace fine grained gravel.		S7		
217.2		**AUGER REFUSAL at 8.38 m**	8.4	S8	10	95

Notes:
1. Installed Slope Indicator (SI) at 8.38 m below ground surface.
2. Backfilled TH13-05 with grout from 8.38 m to surface.



SAMPLE TYPE: Continuous, Split Spoon

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J.WILCOX	T. Ng	9/9/14

KGS GROUP

SUMMARY LOG

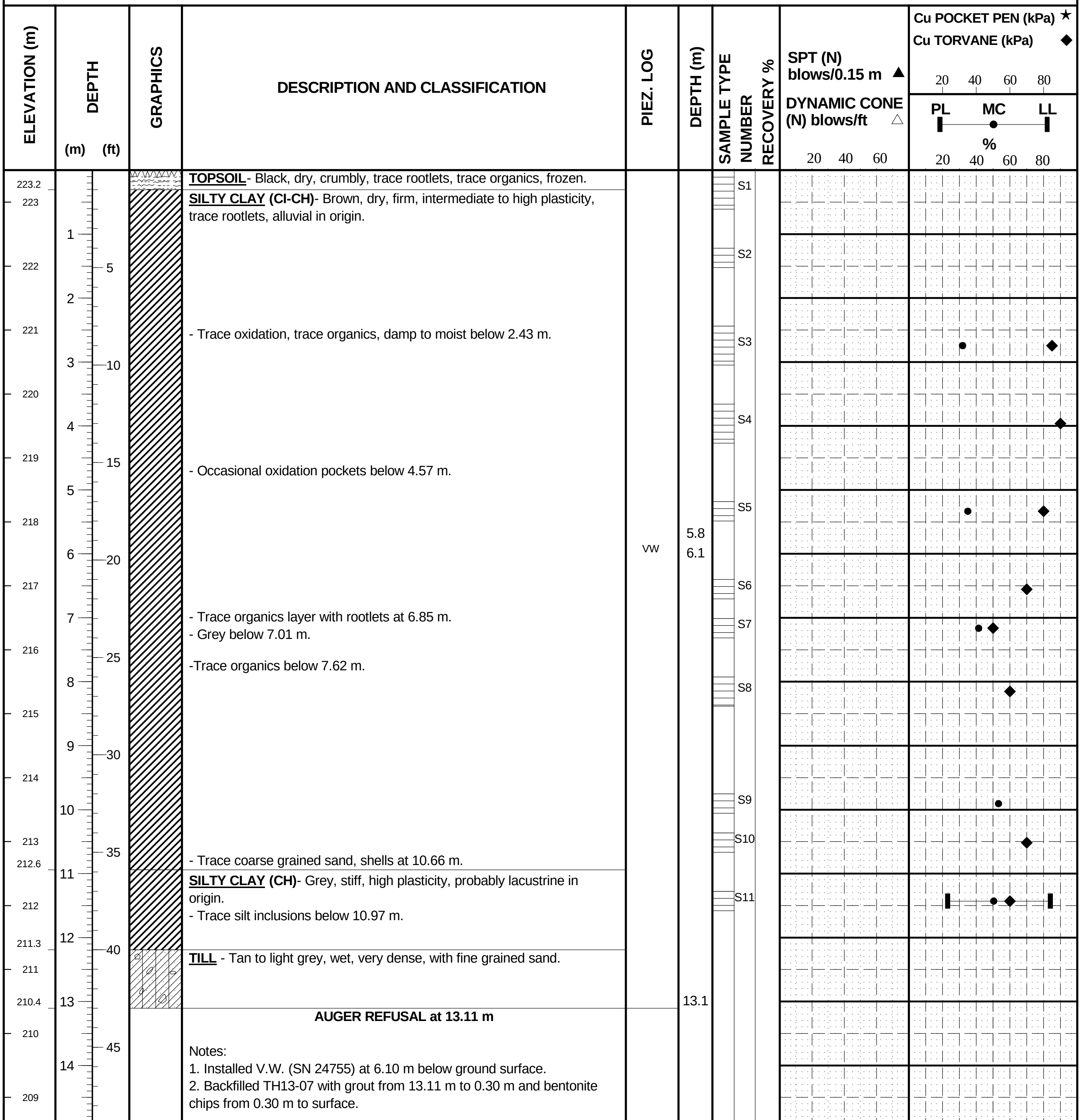
REFERENCE NO.

HOLE NO. **TH13-07**

SHEET 1 of 1

CLIENT	CITY OF WINNIPEG- WATERWAYS	JOB NO.	13-0107-08
PROJECT	KING'S PARK RIVERBANK ASSESSMENT	GROUND ELEV.	223.50 m
		TOP OF PVC ELEV.	
SITE	KING'S PARK RIVERBANK ASSESSMENT	WATER ELEV.	
LOCATION	LOWER BANK	DATE DRILLED	27/03/2013
DRILLING METHOD	200 mm ø Hollow Stem Auger, ACKER SS Drill Rig	UTM (m)	N 5,517,837 E 634,887

ELEVATION (m)	DEPTH (m)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE NUMBER
223.2		**TOPSOIL**- Black, dry, crumbly, trace rootlets, trace organics, frozen.			
		SILTY CLAY (CI-CH)- Brown, dry, firm, intermediate to high plasticity, trace rootlets, alluvial in origin.			S1
					S2
		- Trace oxidation, trace organics, damp to moist below 2.43 m.			S3
					S4
		- Occasional oxidation pockets below 4.57 m.			S5
			VW	5.8 6.1	
					S6
		- Trace organics layer with rootlets at 6.85 m. - Grey below 7.01 m.			S7
		-Trace organics below 7.62 m.			S8
					S9
					S10
		- Trace coarse grained sand, shells at 10.66 m.			
212.6		**SILTY CLAY (CH)**- Grey, stiff, high plasticity, probably lacustrine in origin. - Trace silt inclusions below 10.97 m.			S11
211.3		**TILL** - Tan to light grey, wet, very dense, with fine grained sand.			
210.4		**AUGER REFUSAL at 13.11 m**		13.1	



Notes:
1. Installed V.W. (SN 24755) at 6.10 m below ground surface.
2. Backfilled TH13-07 with grout from 13.11 m to 0.30 m and bentonite chips from 0.30 m to surface.

SAMPLE TYPE Continuous

CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J.WILCOX	T. Ng	9/9/14

GEOTECHNICAL-SOIL LOG P:\PROJECTS\2013\13-0107-008\DESIGN\GEOLOGS\KINGS PARK DRILLING INVESTIGATION.GPJ

KGS GROUP

SUMMARY LOG

REFERENCE NO.

HOLE NO. **TH13-08**

CLIENT: CITY OF WINNIPEG- WATERWAYS
PROJECT: KING'S PARK RIVERBANK ASSESSMENT
SITE: KING'S PARK RIVERBANK ASSESSMENT
LOCATION: UPPER BANK
DRILLING METHOD: 200 mm ø Hollow Stem Auger, ACKER SS Drill Rig

JOB NO.: 13-0107-08
GROUND ELEV.: 230.54 m
TOP OF PVC ELEV.:
WATER ELEV.:
DATE DRILLED: 21/03/2013
UTM (m): N 5,517,410 E 635,250

Elevation (m)	Depth (m)	Description and Classification	Piez. Depth (m)	Sample Number
230.0	0.0–0.5	**TOPSOIL**- Black, dry, crumbly, trace rootlets, trace organics, frozen.	0.3	S1
	0.5–10.5	**SILTY CLAY (CI)**- Brown, dry, firm, intermediate plasticity, trace silt pockets, trace organics, crumbly, trace rootlets, alluvium in origin.		S2
		- Some silt inclusions below 1.82 m.		S3
		- Trace oxidation below 3.04 m. - Damp below 3.35 m.		S4
		- Firm below 4.52 m. - Grey below 4.87 m. - Damp, some oxidation below 5.18 m.	5.8 / 6.1 (VW)	S5, S6
		- Trace silt inclusions, no oxidation below 6.40 m.		S7
		- Some organics below 7.01 m.		S8, S9, S10
		- High plasticity, trace fine grained sand below 9.44 m.		S11, S12
220.0	10.5–15.0	**SANDY CLAY (CL-CI)**- Brown, wet, very loose, intermediate plasticity, crumbly, trace sea shells, alluvium in origin.	11.0 / 11.3 (VW)	S13, S14 (Split Spoon, 100% recovery, SPT 2, 2, 2), S15
		- Low plasticity below 13.72 m.	13.4 / 13.7 (VW)	S16, S17 (Split Spoon, 100% recovery, SPT 1, 1, 2), S18
215.6				

Column headings: Elevation (m); Depth (m) (ft); Graphics; Description and Classification; Piez. Log; Depth (m); Sample Type; Number; Recovery %; SPT (N) blows/0.15 m ▲; Dynamic Cone (N) blows/ft △ (20, 40, 60); Cu Pocket Pen (kPa) ★; Cu Torvane (kPa) ◆ (20, 40, 60, 80); PL, MC, LL % (20, 40, 60, 80)

SAMPLE TYPE: Continuous; Split Spoon

CONTRACTOR: Paddock Drilling Ltd.
INSPECTOR: J.WILCOX
APPROVED: T. Ng
DATE: 9/9/14

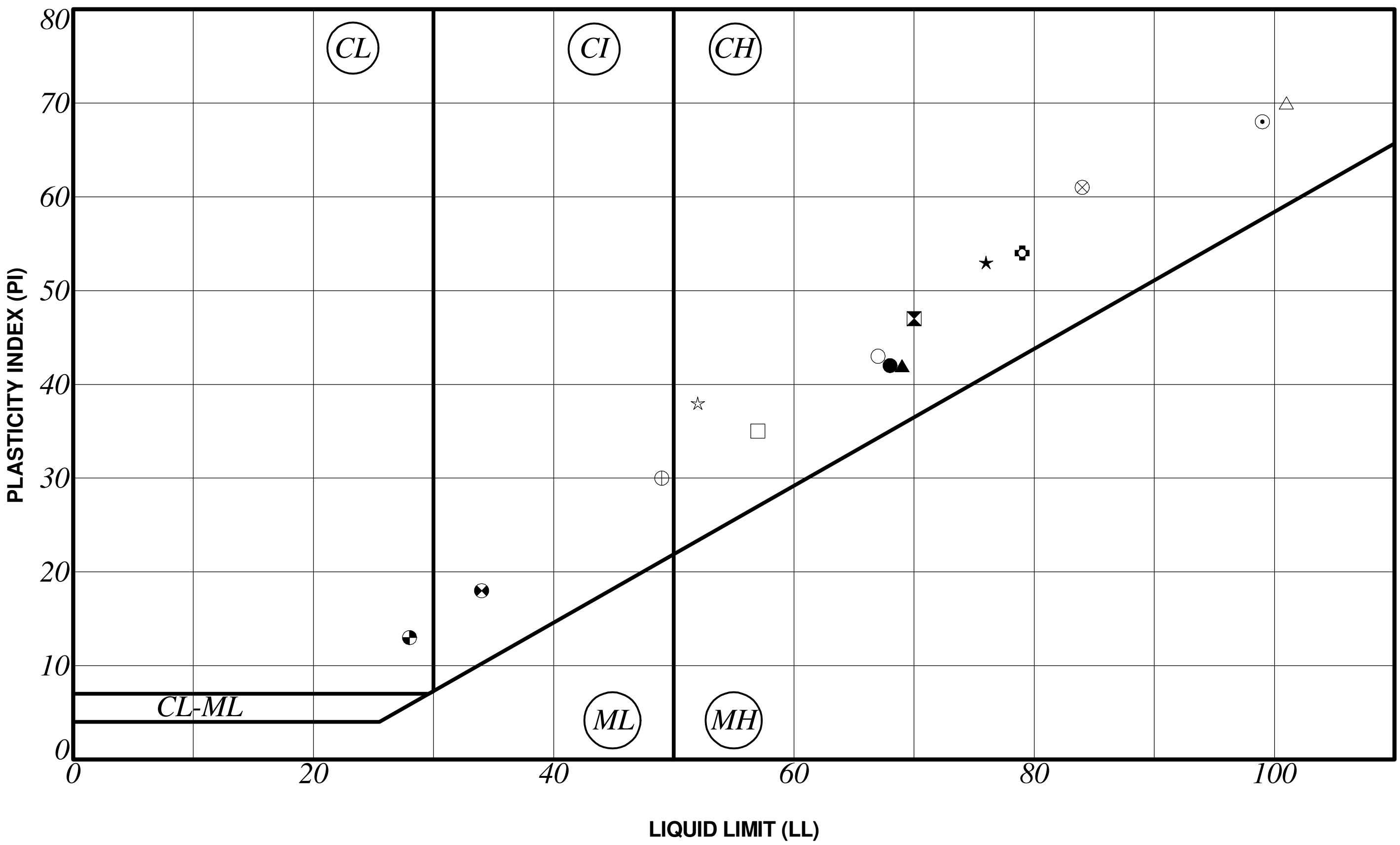
ELEVATION (m)	DEPTH (m)	DEPTH (ft)	DESCRIPTION AND CLASSIFICATION	PIEZ. LOG	DEPTH (m)	SAMPLE TYPE / NUMBER	RECOVERY %	SPT (N) blows/0.15 m ▲ / DYNAMIC CONE (N) blows/ft △	PL / MC / LL %
		50	**SILTY CLAY (CH)**- Grey, high plasticity, lacustrine in origin.			S19			
214.1			**SILT TILL** - Tan to light grey, wet, very dense, with fine to medium grained sand, some coarse grained gravel. - Grain Size Distribution: Gravel (2.2%), Sand (2.1%), Silt (80.6%) & Clay (15.1%) at 16.8 m.			S20, S20			
					17.4	S21	100	7, 19, 20	
				VW	17.7				
211.8			**AUGER REFUSAL at 18.75 m**		18.7				

Notes:
1. Installed V.W. (SN 24759) at 17.68 m below ground surface.
2. Installed V.W. (SN 24752) at 13.72 m below ground surface.
3. Installed V.W. (SN 24753) at 11.28 m below ground surface.
4. Installed V.W. (SN 24754) at 6.10 m below ground surface.
5. Installed Slope Indicator (SI) at 18.75 m below ground surface.
6. Backfilled TH13-08 with grout from 18.75 m to 0.3 m and bentonite chips from 0.3 m to surface.

Cu POCKET PEN (kPa) ★ ; Cu TORVANE (kPa) ◆

SAMPLE TYPE: Continuous; Split Spoon

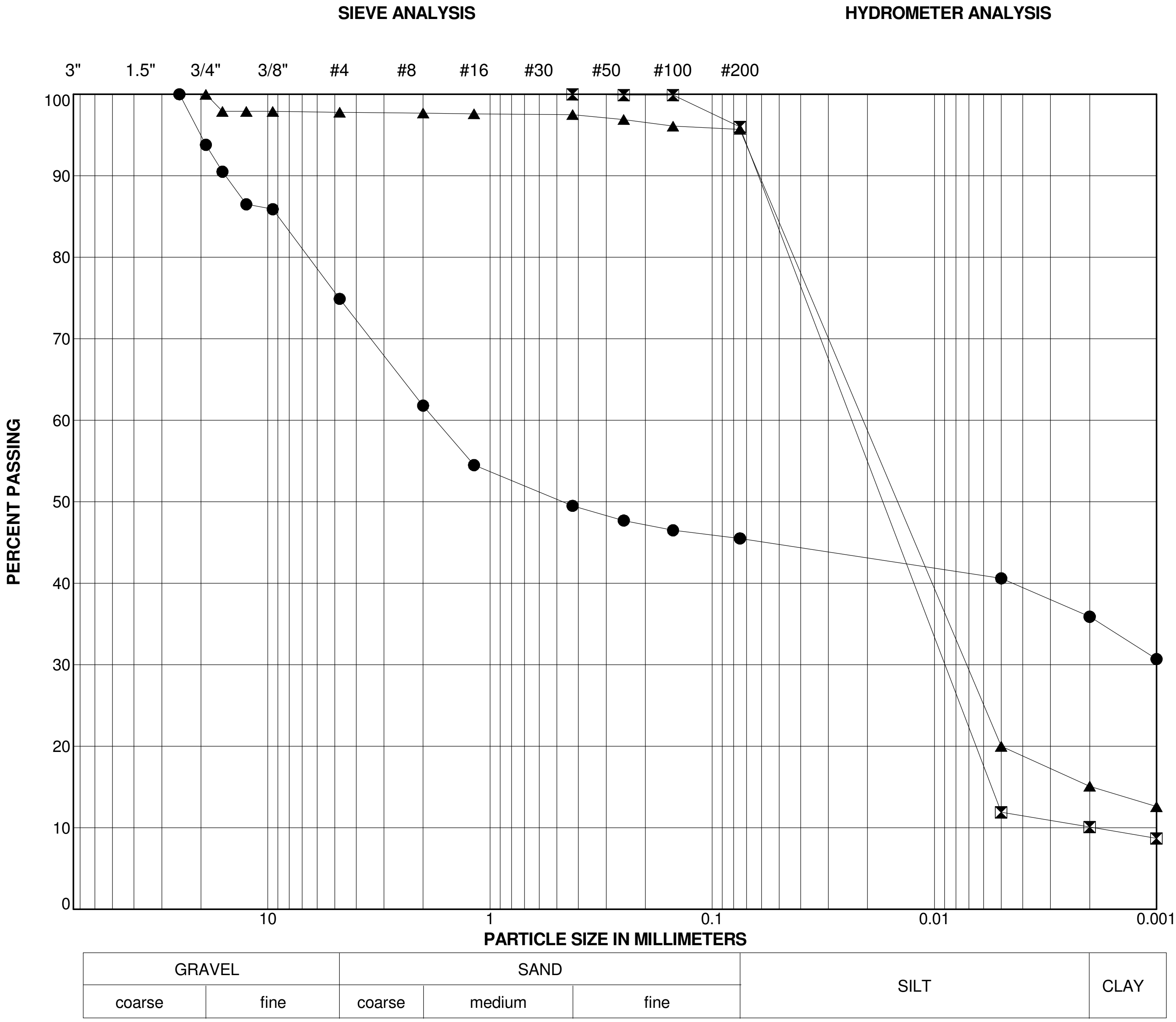
CONTRACTOR	INSPECTOR	APPROVED	DATE
Paddock Drilling Ltd.	J.WILCOX	T. Ng	9/9/14



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	% SAND	% SILT	% CLAY	% MC	CLASSIFICATION
●	TH13-01	4.0	S6	68	26	42				39.0	CH
⧗	TH13-01	7.6	S11	70	23	47				33.1	CH
▲	TH13-01	11.6	S14	69	27	42				35.4	CH
★	TH13-01	13.4	S16	76	23	53				35.0	CH
⊙	TH13-01	14.0	S17	99	31	68				46.0	CH
✿	TH13-01	14.5	S18	79	25	54				41.3	CH
○	TH13-04	3.7	S5	67	24	43				36.5	CH
△	TH13-04	7.6	S9	101	31	70				51.7	CH
⊗	TH13-07	11.3	S11	84	23	61				50.4	CH
⊕	TH13-08	3.7	S4	49	19	30				19.6	CI
□	TH13-08	9.4	S11	57	22	35				37.9	CH
◉	TH13-08	12.2	S14	34	16	18				36.8	CI
◕	TH13-08	13.7	S17	28	15	13				31.1	CL
☆	TH13-08	14.9	S19	52	14	38				26.4	CH

Notes:
ML - Low Plasticity Silt
MH - High Plasticity Silt
CL-ML - Silty Clay
CL - Low Plasticity Clay
CI - Intermediate Plasticity Clay
CH - High Plasticity Clay
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
MC - Moisture Content
NP - Non-Plastic

KGS GROUP	CITY OF WINNIPEG - WATERWAYS	
KING'S PARK RIVERBANK ASSESSMENT		
A-LINE PLOT		
July 2014	**Figure A1**	**Page 1 of 1**



SYMBOL	HOLE	DEPTH (m)	SAMPLE #	% GRAVEL	% SAND	% SILT	% CLAY	% SILT & CLAY	Cu	Cc	CLASSIFICATION
●	*TH13-04*	*7.0*	*S8*	*25.1*	*29.4*	*9.6*	*35.9*	*45.5*			
⧗	*TH13-04*	*8.8*	*S10*	*0.0*	*4.0*	*85.9*	*10.1*	*96.0*	*12.4*	*1.8*	
▲	*TH13-08*	*16.8*	*S21*	*2.2*	*2.1*	*80.6*	*15.1*	*95.7*			

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KGS GROUP

CITY OF WINNIPEG - WATERWAYS

KING'S PARK RIVERBANK ASSESSMENT

GRAIN SIZE ANALYSES

July 2014	Figure A2	Page 1 of 1

APPENDIX A-02

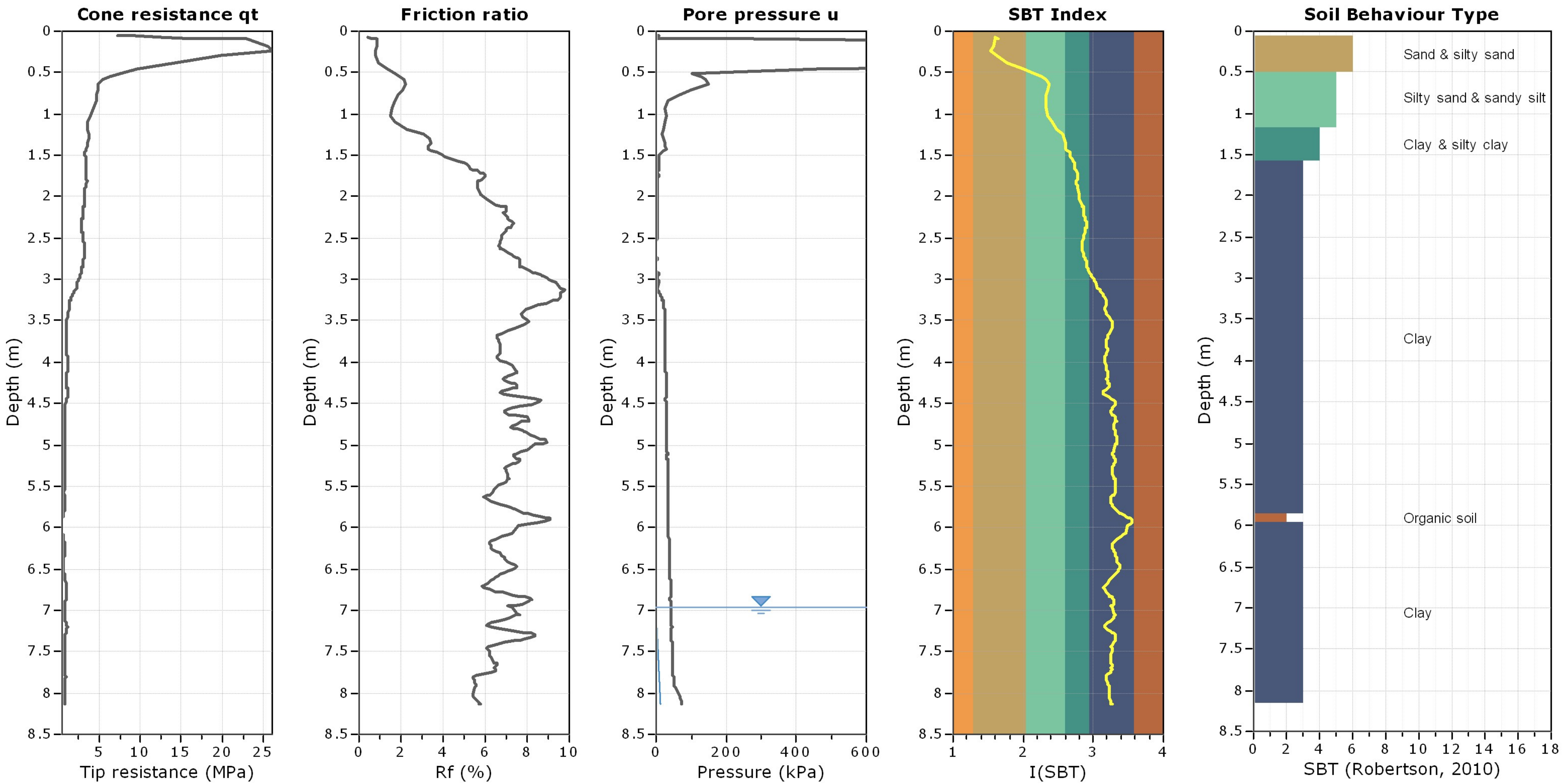
CPT RESULTS

KGS GROUP CONSULTING ENGINEERS

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

Project: 13-0107-008 - City of Winnipeg
Location: Kings Park

CPT: CPT13-01
Total depth: 8.13 m, Date: 3/19/2013
Surface Elevation: 230.96 m
Coords: X:634897.00, Y:5517860.50
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox

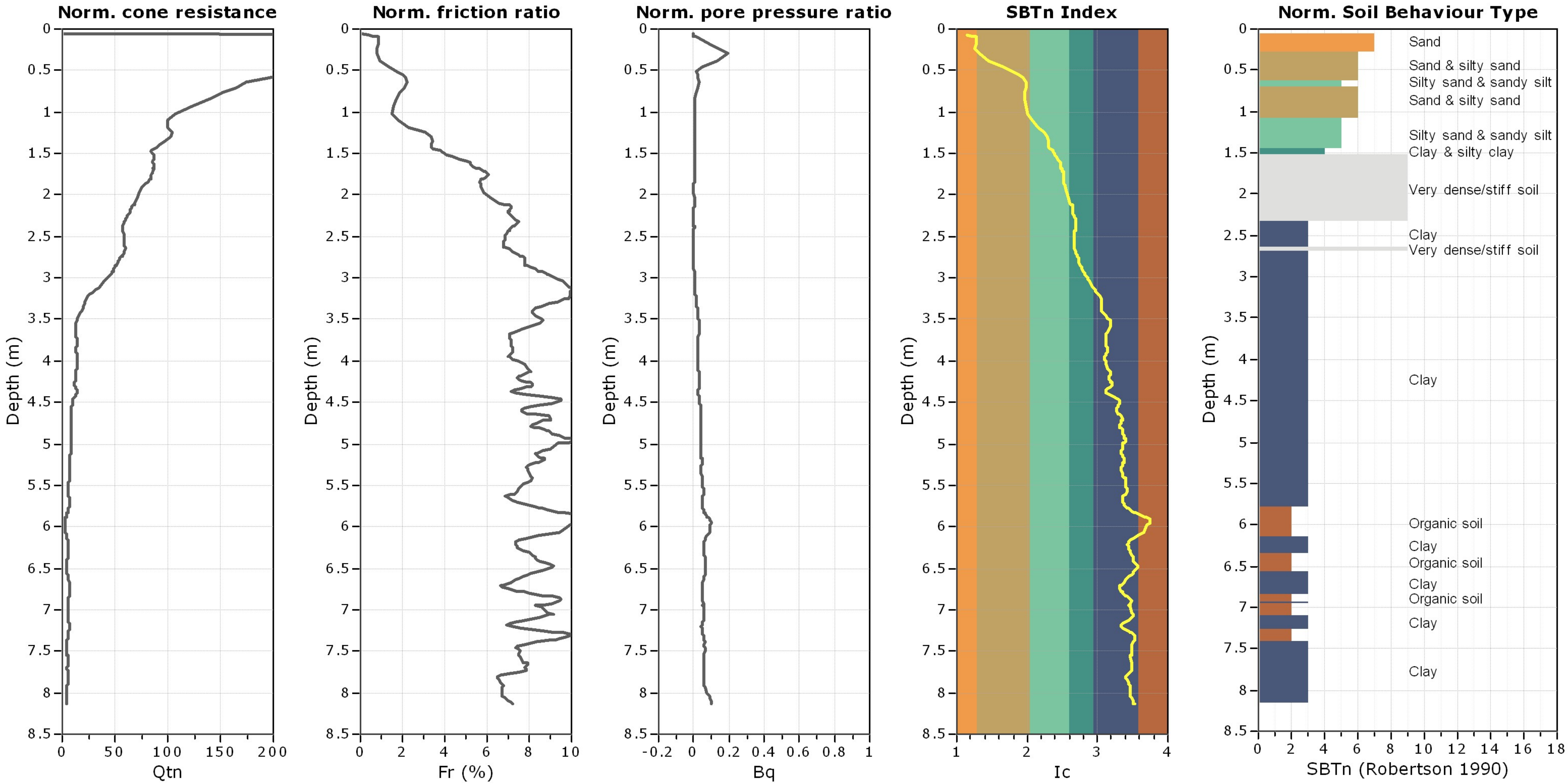


SBT legend
- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

Project: **13-0107-008 - City of Winnipeg**
Location: **Kings Park**

CPT: CPT13-01
Total depth: 8.13 m, Date: 3/19/2013
Surface Elevation: 230.96 m
Coords: X:634897.00, Y:5517860.50
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox



SBTn legend

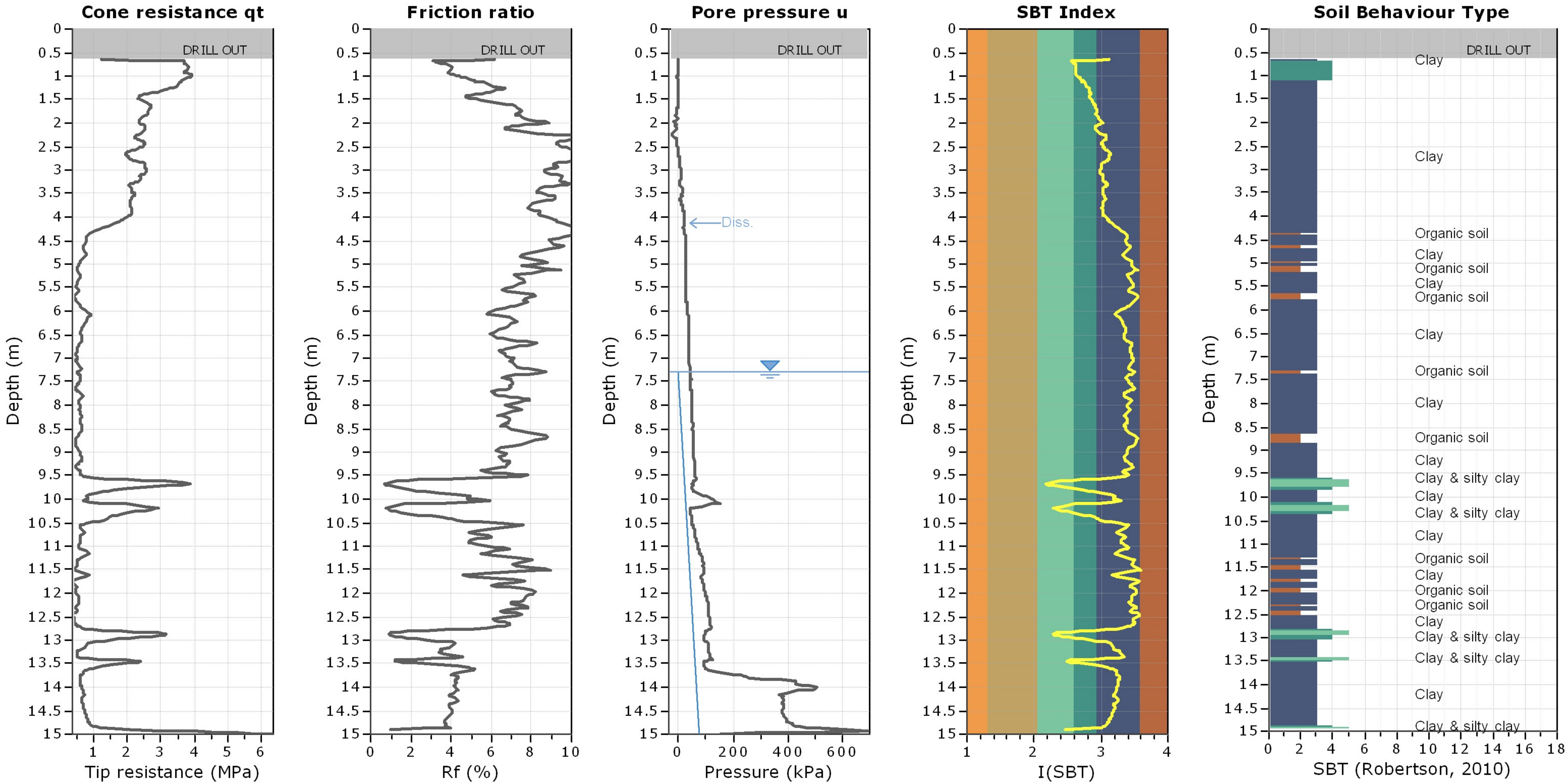
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

KGS GROUP
CONSULTING ENGINEERS

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

CPT: CPT13-02
Total depth: 14.99 m, Date: 3/22/2013
Surface Elevation: 231.60 m
Coords: X:635252.00, Y:5517412.00
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox

Project: 13-0107-008 - City of Winnipeg
Location: Kings Park



SBT legend

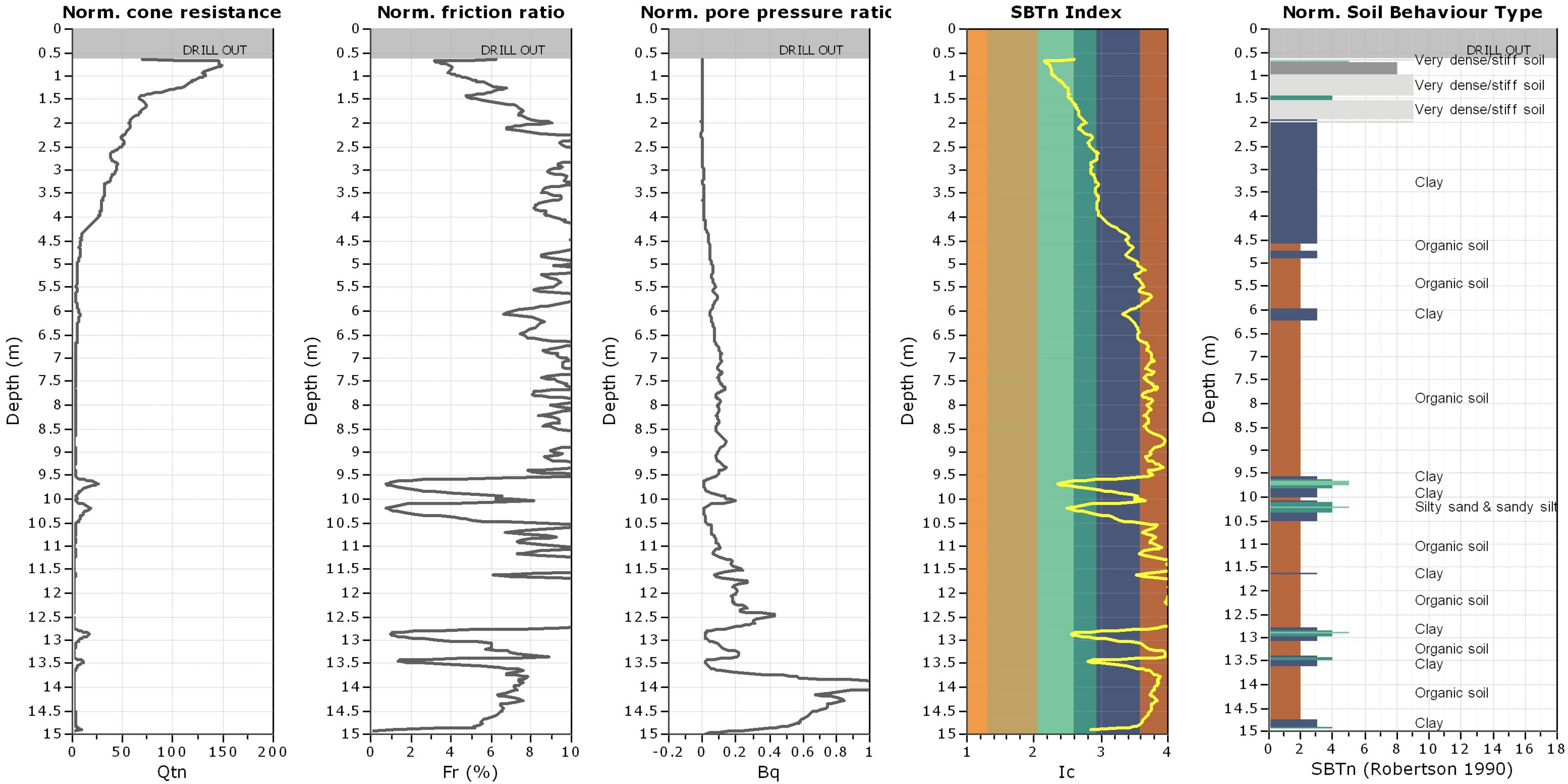
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

CPeT-IT v.1.7.6.42 - CPTU data presentation & interpretation software - Report created on: 9/9/2014, 1:04:09 PM
Project file: P:\Projects\2013\13-0107-008\Design\Geo\Cone-Processed-Final\CPet_IT-pdf\CPT-1 to CPT-4.cpt

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

CPT: CPT13-02
Total depth: 14.99 m, Date: 3/22/2013
Surface Elevation: 231.60 m
Coords: X:635252.00, Y:5517412.00
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox

Project: 13-0107-008 - City of Winnipeg
Location: Kings Park

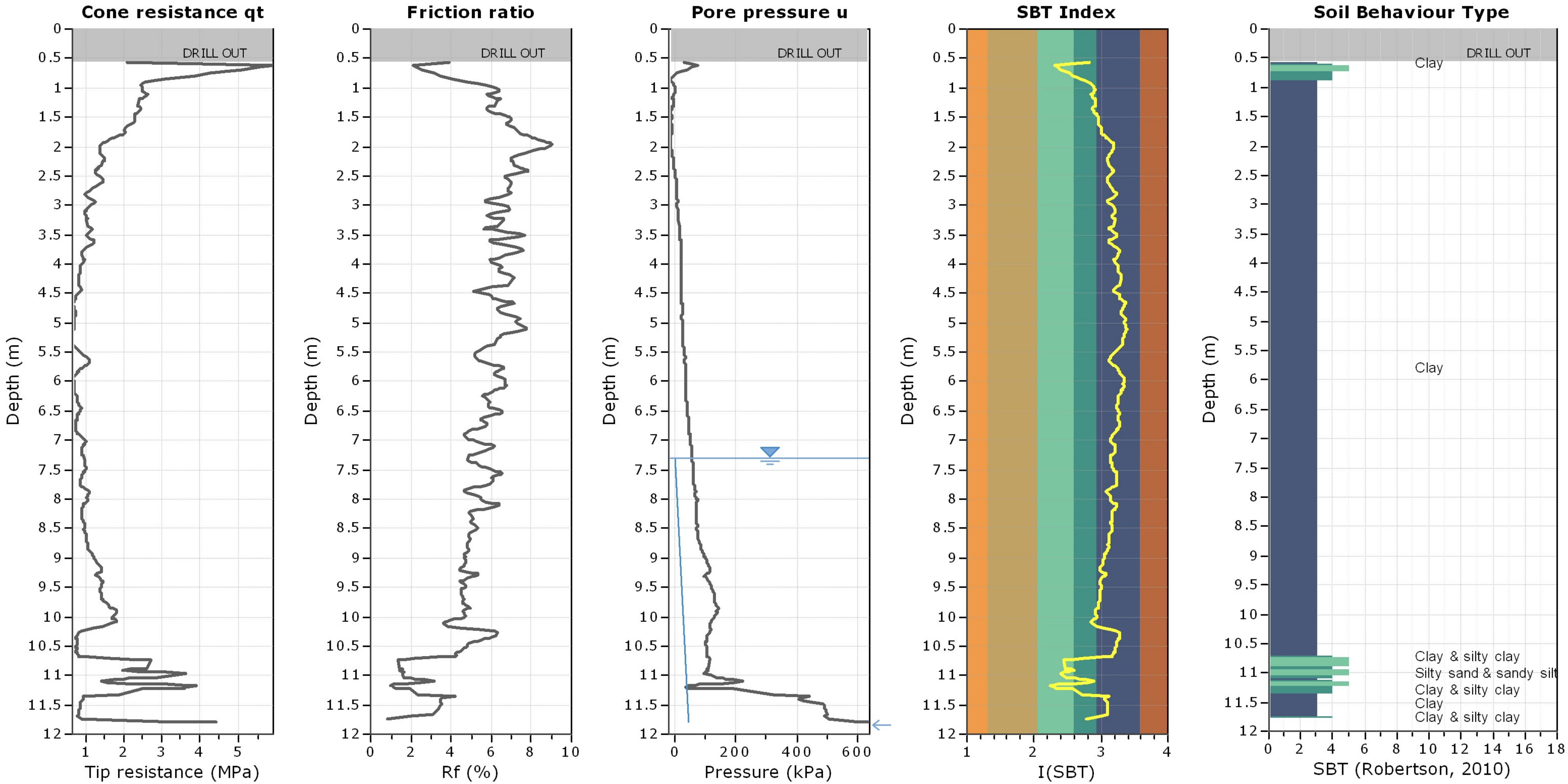


SBTn legend
1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

CPT: CPT13-03
Total depth: 11.80 m, Date: 3/22/2013
Surface Elevation: 231.00 m
Coords: X:635033.00, Y:5517731.00
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox

Project: **13-0107-008 - City of Winnipeg**
Location: **Kings Park**



SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

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CPT: CPT13-03
Total depth: 11.80 m, Date: 3/22/2013
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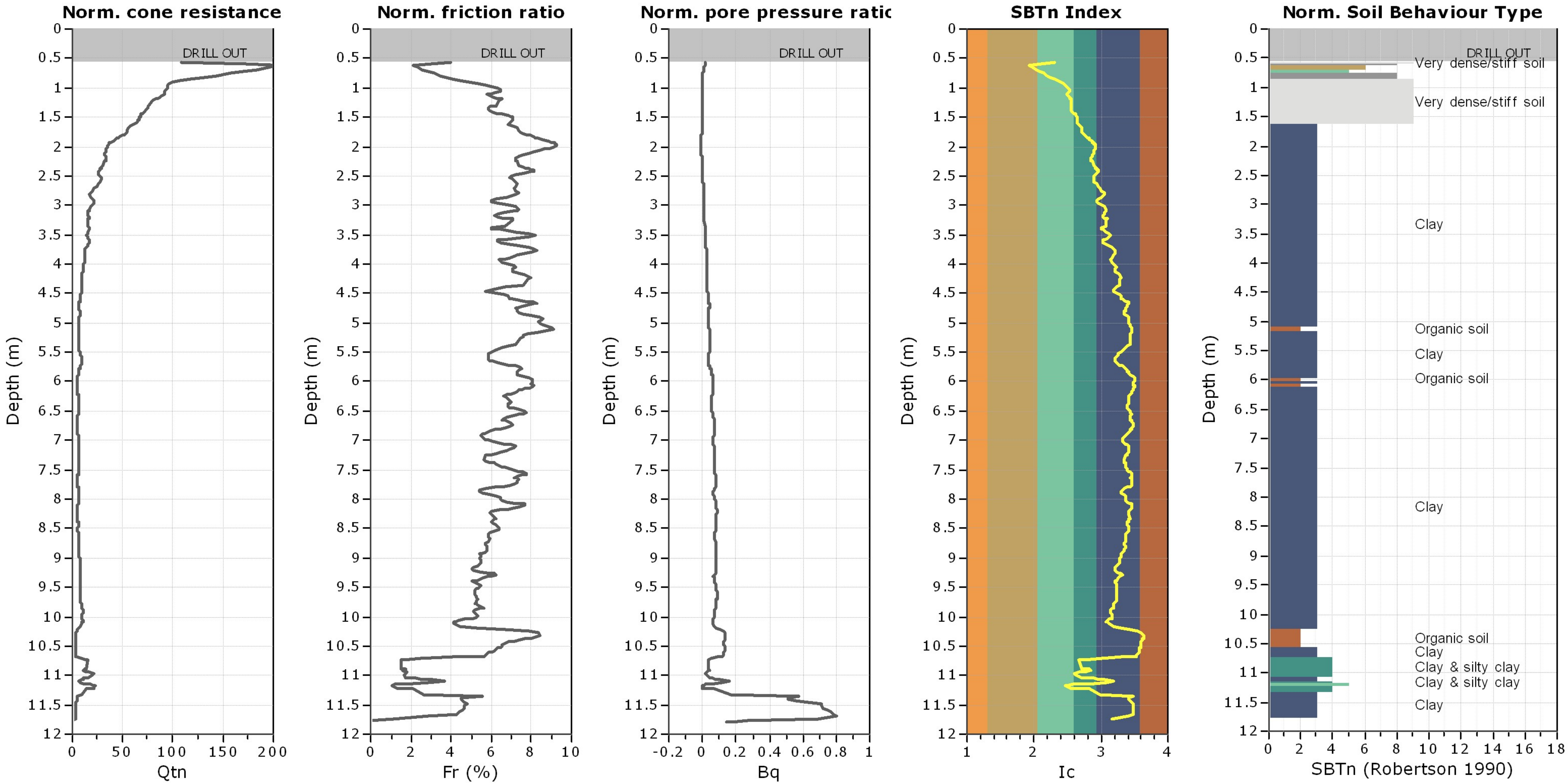
Project: **13-0107-008 - City of Winnipeg**
Location: **Kings Park**



SBTn legend

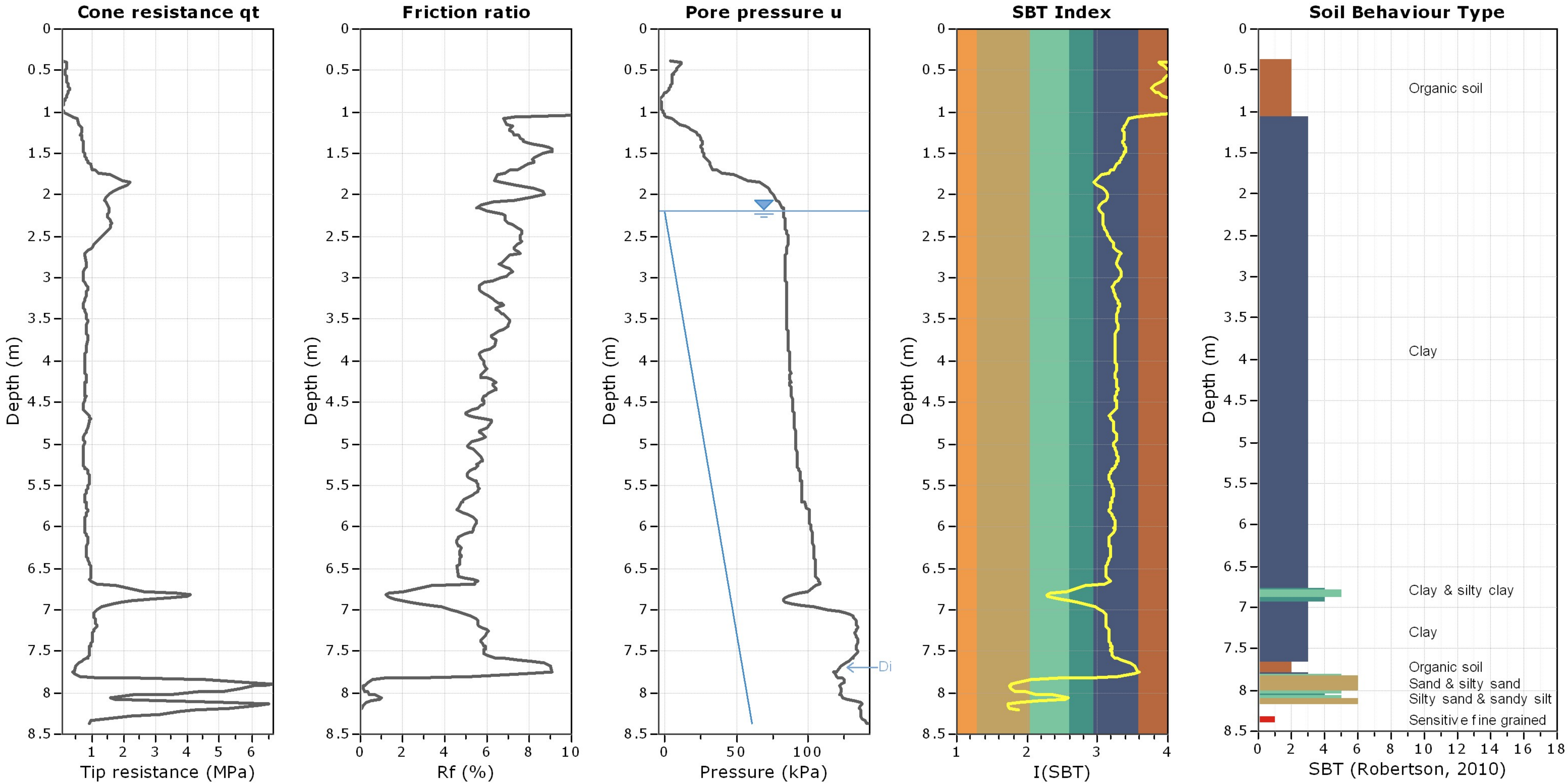
- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

KGS GROUP CONSULTING ENGINEERS

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

CPT: CPT13-04
Total depth: 8.37 m, Date: 3/26/2013
Surface Elevation: 225.90 m
Coords: X:634889.00, Y:5517835.00
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox

Project: **13-0107-008 - City of Winnipeg**
Location: **Kings Park**



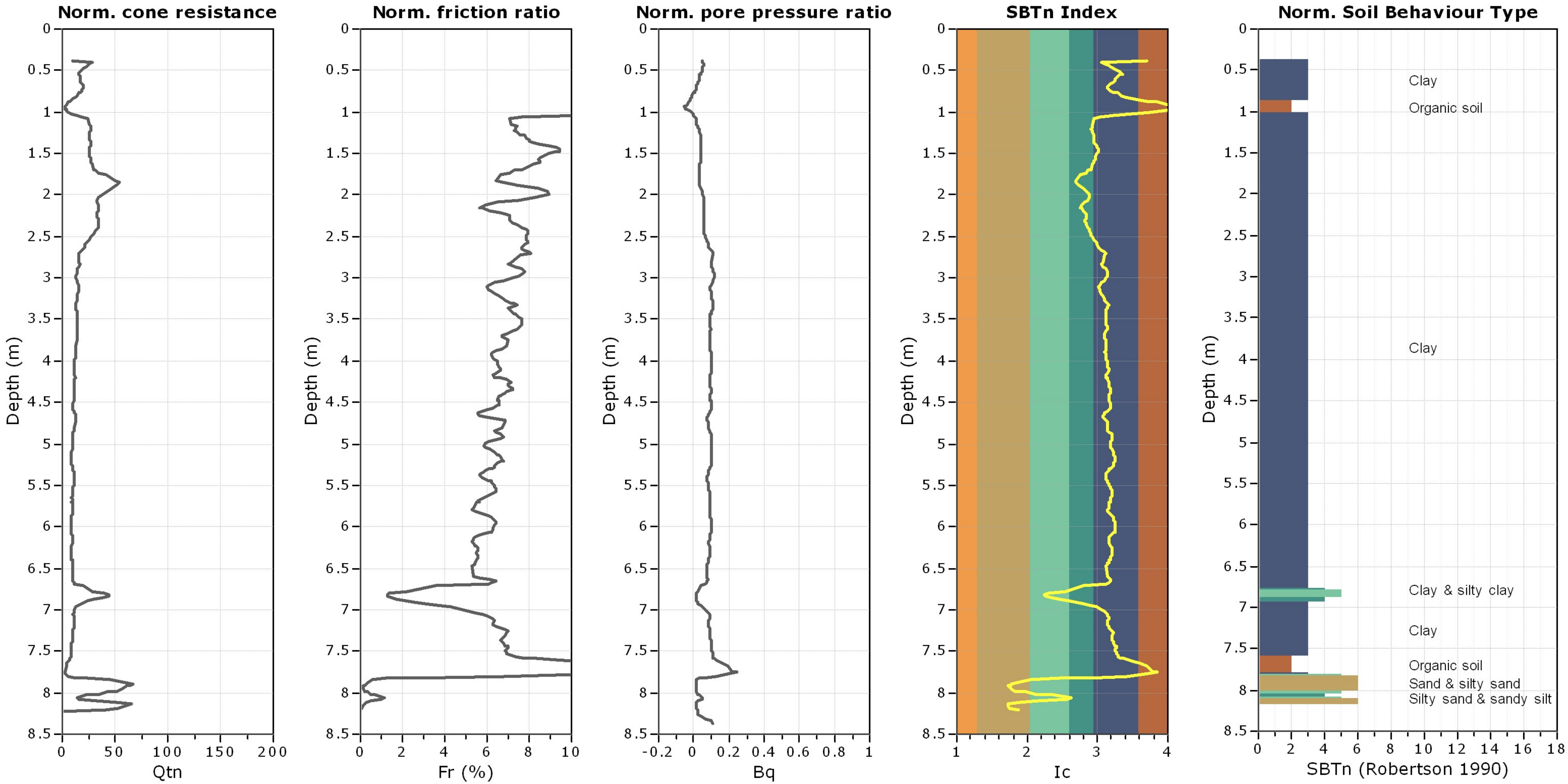
SBT legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty clay
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to clayey sand
- 9. Very stiff fine grained

KGS Group
300 - 865 Waverley Street
Winnipeg, Manitoba
Phone 204-896-1209 Website www.kgsgroup.com

Project: **13-0107-008 - City of Winnipeg**
Location: **Kings Park**

CPT: CPT13-04
Total depth: 8.37 m, Date: 3/26/2013
Surface Elevation: 225.90 m
Coords: X:634889.00, Y:5517835.00
Cone Type: Vertek
Cone Operator: H. Dahl & J. Wilcox



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

APPENDIX A-03

LABORATORY TEST RESULTS

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

199 Henlow Bay
Winnipeg, MB R3Y 1G4
Phone (204) 488-6999
Fax (204) 488-6947
Email info@nationaltestlabs.com
www.nationaltestlabs.com

CELEBRATING 90 Years 1923 - 2013

KGS Group Inc.
3rd Floor-865 Waverly Street
Winnipeg, Manitoba
R3T 5P4

Attention: Jen Wilcox

April 30, 2013

Project: King's Park Drilling
(13-0107-08)

Soil samples were submitted to our laboratory on April 23, 2013. The following tests were conducted on selected soil samples:

- Water content (ASTM D2216)
- Particle-Size Analysis (ASTM D422)
- Liquid limit (one-point), plastic limit, and plasticity index (ASTM D4318)

The test results are summarized in the attached tables and particle size analysis and Atterberg limits reports.

We appreciate the opportunity to assist you in this project. Please call if you have any questions regarding this report.

Farouk Fourar-laidi, B.Sc., EIT
Geotechnical Engineering

TABLE 1
WATER CONTENT TEST DATA
KING’S PARK DRILLING (13-0107-08)

Testhole	Sample ID	Water Content (%)	Testhole	Sample ID	Water Content (%)
TH13-01	S2	23.4	TH13-05	S2	41.4
TH13-01	S4	25.4	TH13-05	S4	39.2
TH13-01	S6	39.0	TH13-05	S6	50.4
TH13-01	S8	33.7	TH13-05	S7	18.2
TH13-01	S11	33.1	TH13-07	S3	31.9
TH13-01	S12	35.5	TH13-07	S5	35.0
TH13-01	S13	40.8	TH13-07	S7	41.4
TH13-01	S14	35.4	TH13-07	S9	53.2
TH13-01	S15	35.3	TH13-07	S11	50.4
TH13-01	S16	35.0	TH13-08	S2	19.8
TH13-01	S17	46.0	TH13-08	S4	19.6
TH13-01	S18	41.3	TH13-08	S6	35.0
TH13-01	S19	17.4	TH13-08	S8	39.0
TH13-04	S2	39.8	TH13-08	S11	37.9
TH13-04	S7	35.9	TH13-08	S12	30.4
TH13-04	S8	50.1	TH13-08	S14	36.8
TH13-04	S9	51.7	TH13-08	S17	31.1
TH13-04	S10	15.7	TH13-08	S19	26.4
TH13-04	S5	36.5	TH13-08	S21	22.0

TABLE 2
PARTICLE SIZE AND ATTERBERG LIMITS TEST DATA
KING'S PARK DRILLING (13-0107-08)

Testhole	Sample ID	Particle Size Analysis					Atterberg Limits		
		Gravel (%) 75 to 4.75 mm	Sand (%) <4.75 to 0.075 mm	Silt (%) <0.075 to 0.002 mm	Clay (%) <0.002 mm	Colloids (%) <0.001 mm	Liquid Limit	Plastic Limit	Plasticity Index
TH13-01	S6	NT					68	26	42
TH13-01	S11	NT					70	23	47
TH13-01	S14	NT					69	27	42
TH13-01	S16	NT					76	23	53
TH13-01	S17	NT					99	31	68
TH13-01	S18	NT					79	25	54
TH13-04	S5	NT					67	24	43
TH13-04	S8	25.1	29.4	9.6	35.9	30.7	NT		
TH13-04	S9	NT					101	31	70
TH13-04	S10	0.0	4.0	85.9	10.1	8.7	NT		
TH13-07	S11	NT					84	23	61
TH13-08	S4	NT					49	19	30
TH13-08	S11	NT					57	22	35
TH13-08	S14	NT					34	16	18
TH13-08	S17	NT					28	15	13
TH13-08	S19	NT					52	14	38
TH13-08	S21	2.2	2.1	80.6	15.1	12.6	NT		

Notes:
1. A high speed stirring device was used for 1 minute to disperse the test samples for particle size analysis
2. Atterberg limits conducted in accordance with ASTM D4318 Method B (one-point liquid limit)
3. The soil samples were air-dried during sample preparation for Atterberg limits and particle size analysis
4. NT denote not tested

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

PARTICLE SIZE ANALYSIS
ASTM D422

KGS Group Inc.
3rd Floor- 865 Waverley Street
Winnipeg, Manitoba
R3T 5P4

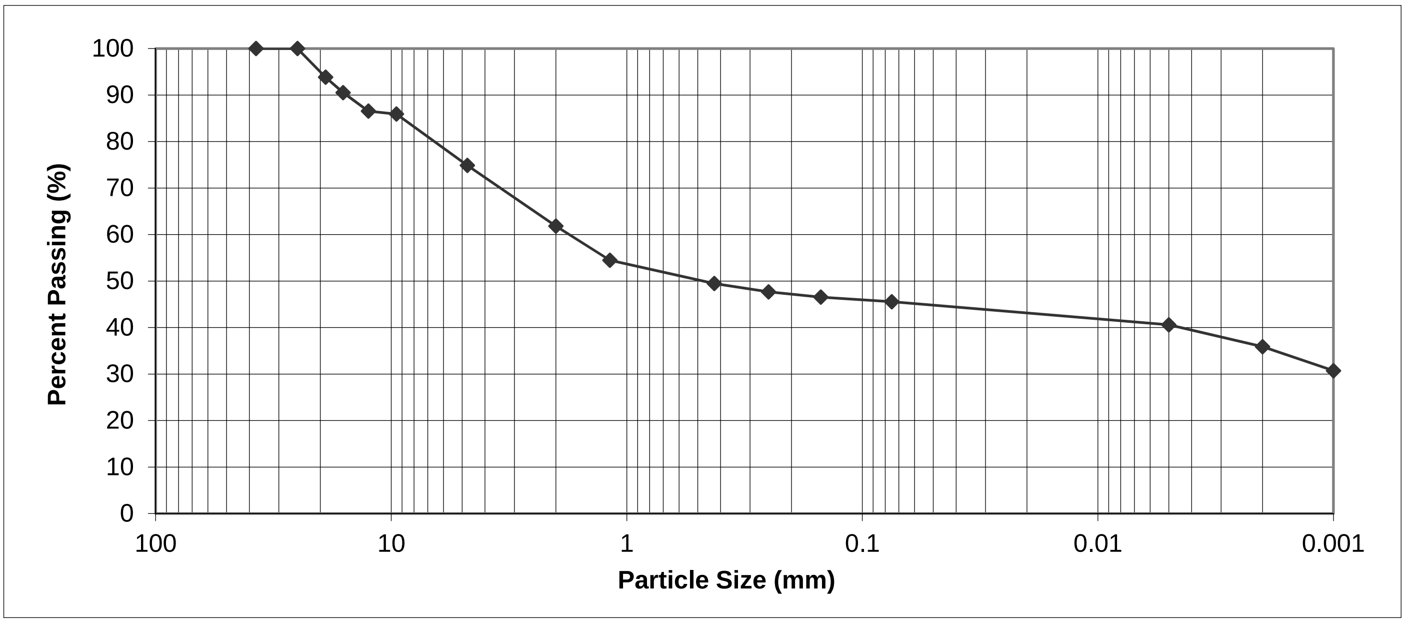
PROJECT: King's Park Drilling (13-0107-08)

Attention: Jen Wilcox

PROJECT NO.: KGS-1310

SAMPLED BY: Client
SAMPLE ID: TH13-04-S8

DATE RECEIVED: April 23, 2013
TESTED BY: Nestor Abarca



PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	54.5
25.00 mm	100.0	0.425 mm	49.5
19.00 mm	93.8	0.250 mm	47.7
16.00 mm	90.5	0.150 mm	46.5
12.50 mm	86.5	0.075 mm	45.5
9.50 mm	85.9	0.005 mm	40.6
4.75 mm	74.9	0.002 mm	35.9
2.00 mm	61.8	0.001 mm	30.7

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.002 mm	Clay, % <0.002 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
25.1	13.1	12.3	4.0	9.6	35.9	30.7

April 30, 2013

REVIEWED BY: Farouk Fourar-Laidi, B.Sc., EIT

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

PARTICLE SIZE ANALYSIS
ASTM D422

KGS Group Inc.
3rd Floor- 865 Waverley Street
Winnipeg, Manitoba
R3T 5P4

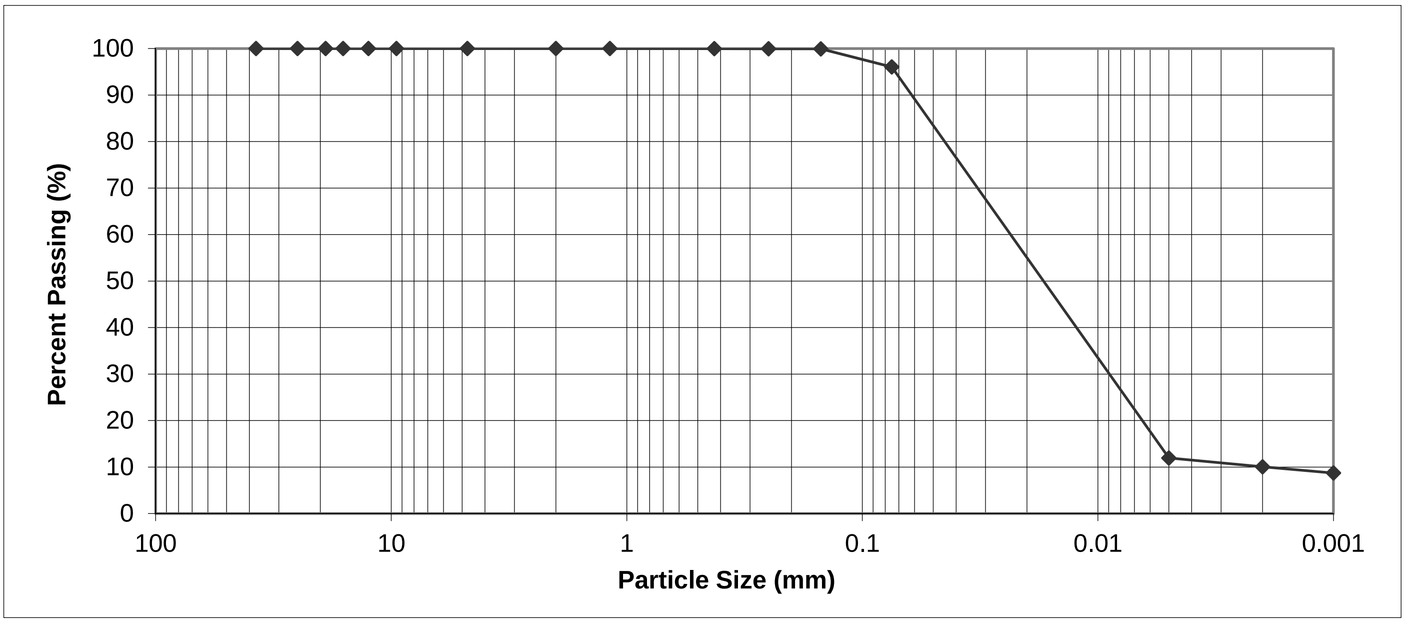
PROJECT: King's Park Drilling (13-0107-08)

Attention: Jen Wilcox

PROJECT NO.: KGS-1310

SAMPLED BY: Client
SAMPLE ID: TH13-04-S10

DATE RECEIVED: April 23, 2013
TESTED BY: Nestor Abarca



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	100.0
2.00 mm	100.0

PARTICLE SIZE	PERCENT PASSING
1.18 mm	100.0
0.425 mm	100.0
0.250 mm	99.9
0.150 mm	99.9
0.075 mm	96.0
0.005 mm	11.9
0.002 mm	10.1
0.001 mm	8.7

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.002 mm	Clay, % <0.002 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.0	0.0	0.0	4.0	85.9	10.1	8.7

April 30, 2013

REVIEWED BY: Farouk Fourar-Laidi, B.Sc., EIT

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

PARTICLE SIZE ANALYSIS
ASTM D422

KGS Group Inc.
3rd Floor- 865 Waverley Street
Winnipeg, Manitoba
R3T 5P4

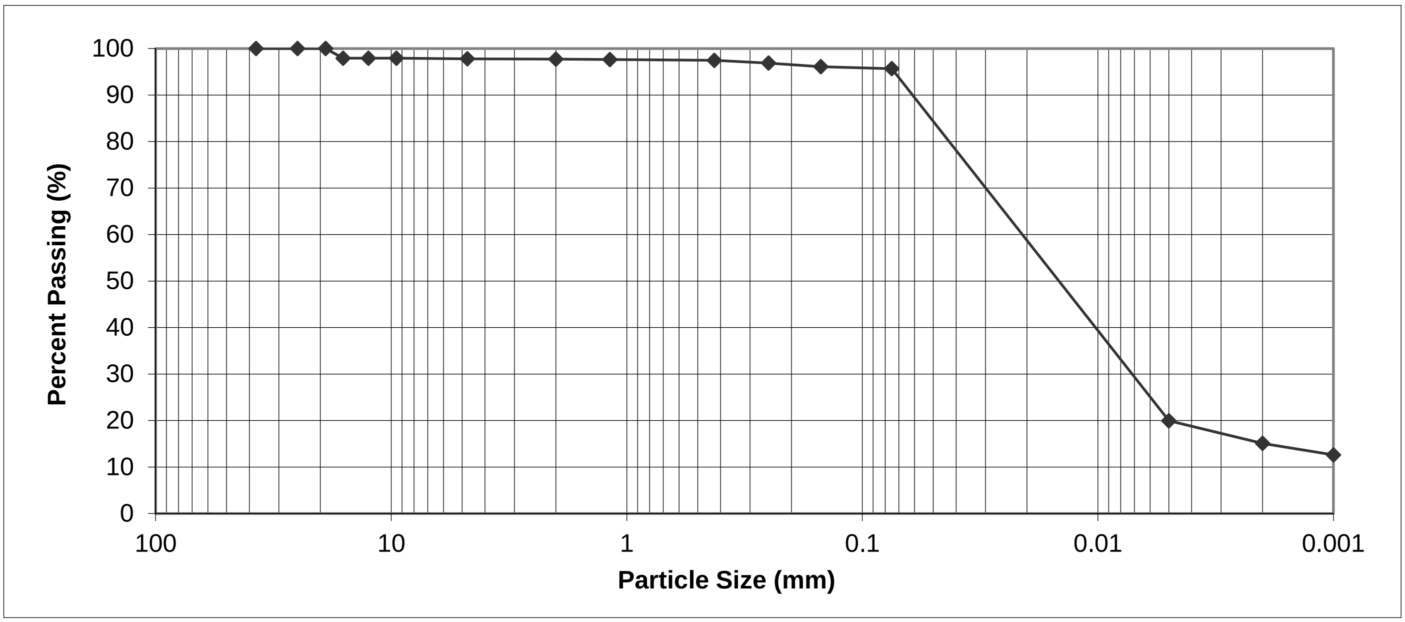
PROJECT: King's Park Drilling (13-0107-08)

Attention: Jen Wilcox

PROJECT NO.: KGS-1310

SAMPLED BY: Client
SAMPLE ID: TH13-08-S21

DATE RECEIVED: April 23, 2013
TESTED BY: Nestor Abarca



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	97.9
12.50 mm	97.9
9.50 mm	97.9
4.75 mm	97.8
2.00 mm	97.7

PARTICLE SIZE	PERCENT PASSING
1.18 mm	97.6
0.425 mm	97.5
0.250 mm	96.9
0.150 mm	96.1
0.075 mm	95.7
0.005 mm	20.0
0.002 mm	15.1
0.001 mm	12.6

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.002 mm	Clay, % <0.002 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
2.2	0.1	0.2	1.8	80.6	15.1	12.6

April 30, 2013

REVIEWED BY: Farouk Fourar-Laidi, B.Sc., EIT

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS ASTM 4318

KGS Group Inc.
3rd Floor- 865 Waverley Street
Winnipeg, Manitoba
R3T 5P4

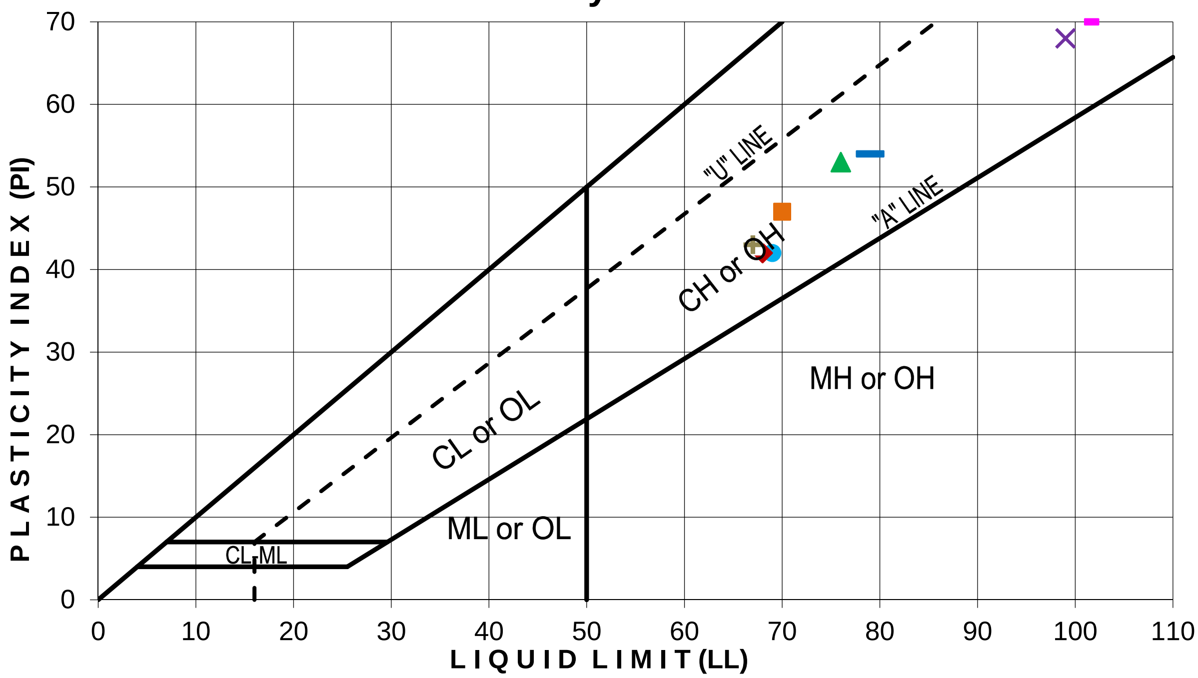
PROJECT: King's Park Drilling (13-0101-08)

Attention: Jen Wilcox

PROJECT NO.: KGS-1310

Symbol	Testhole No.	Sample ID	Liquid Limit	Plastic Limit	Plasticity Index	USCS
u	TH13-01	S6	68	26	42	CH
<	TH13-01	S11	70	23	47	CH
=	TH13-01	S14	69	27	42	CH
p	TH13-01	S16	76	23	53	CH
×	TH13-01	S17	99	31	68	CH
—	TH13-01	S18	79	25	54	CH
+	TH13-04	S5	67	24	43	CH
-	TH13-04	S9	101	31	70	CH

Plasticity Chart



April 30, 2013

Reviewed by: Farouk Fourar-Laidi, B.Sc., EIT

THE NATIONAL TESTING LABORATORIES LIMITED
Established in 1923

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS ASTM 4318

KGS Group Inc.
3rd Floor- 865 Waverley Street
Winnipeg, Manitoba
R3T 5P4

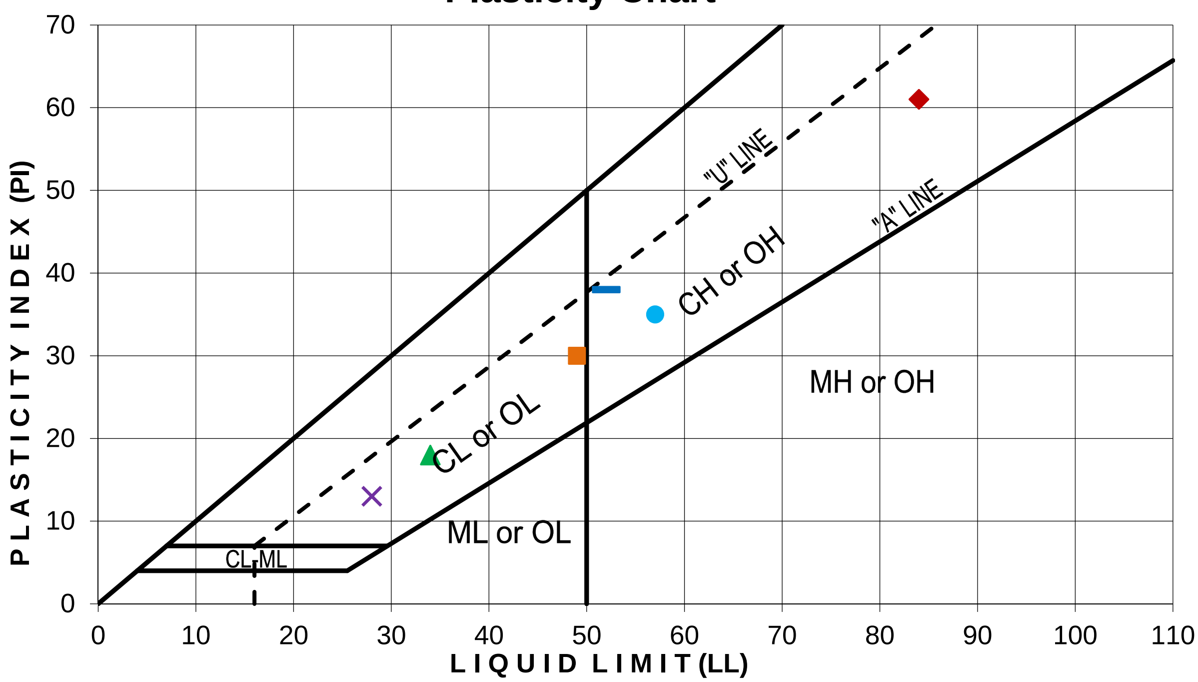
PROJECT: King's Park Drilling
(13-0101-08)

Attention: Jen Wilcox

PROJECT NO.: KGS-1310

Symbol	Testhole No.	Sample ID	Liquid Limit	Plastic Limit	Plasticity Index	USCS
u	TH13-07	S11	84	23	61	CH
<	TH13-08	S4	49	19	30	CL
=	TH13-08	S11	57	22	35	CH
p	TH13-08	S14	34	16	18	CL
×	TH13-08	S17	28	15	13	CL
—	TH13-08	S19	52	14	38	CH

Plasticity Chart

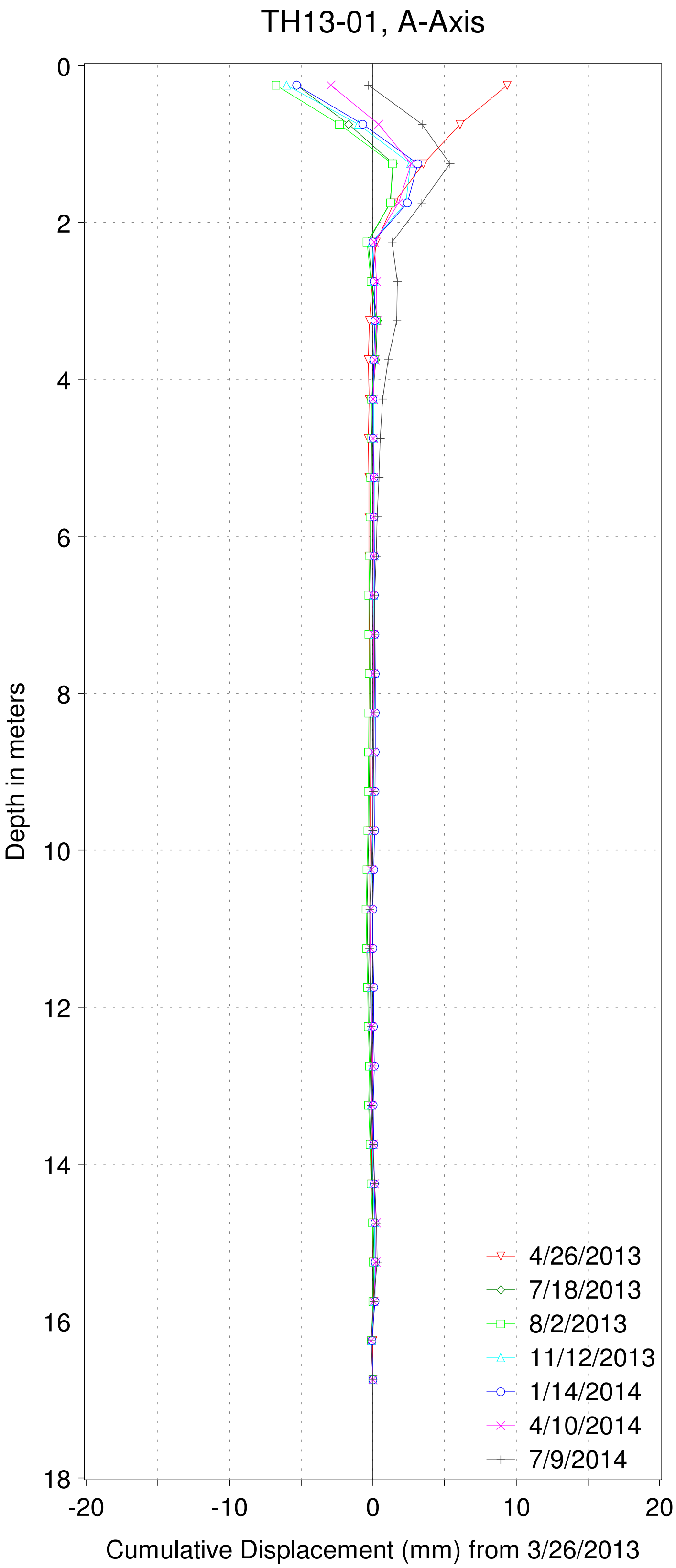


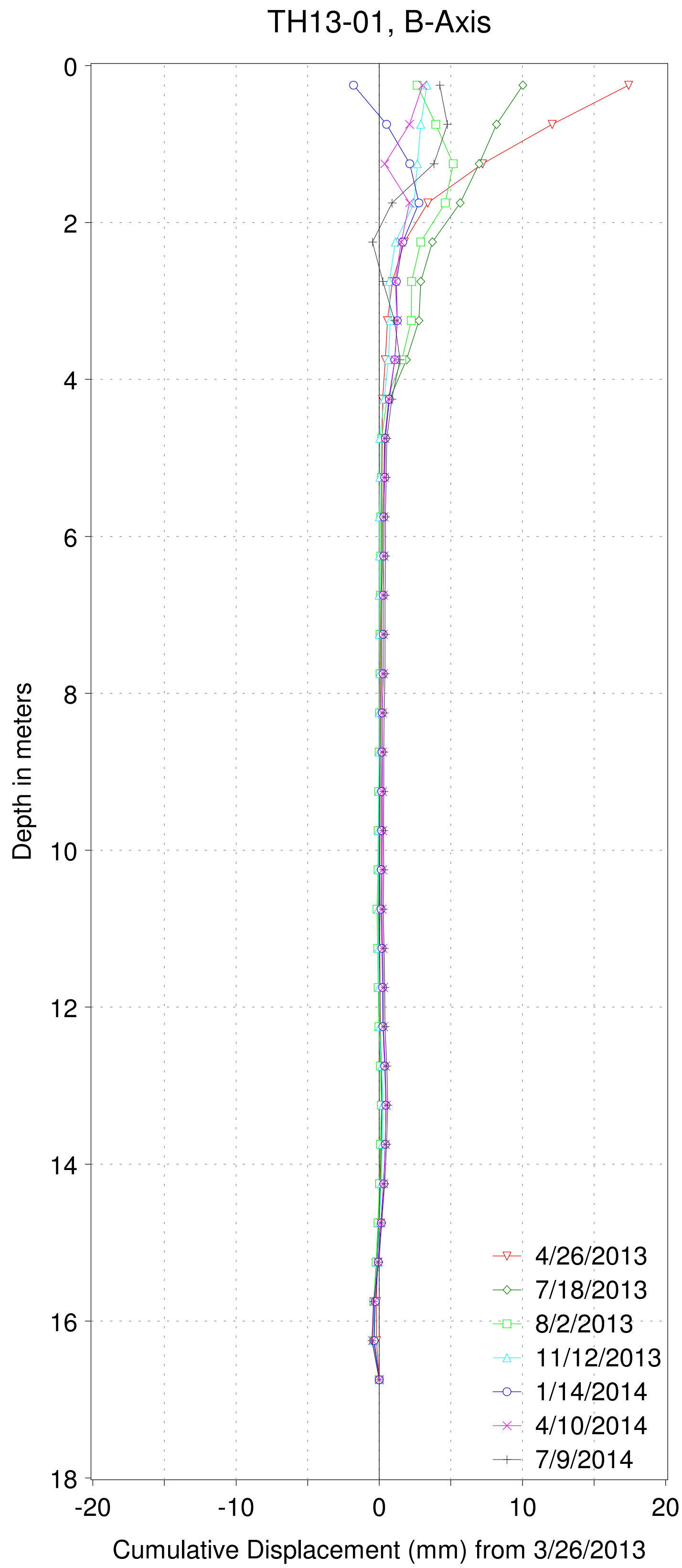
April 30, 2013

Reviewed by: Farouk Fourar-Laidi, B.Sc., EIT

APPENDIX A-04

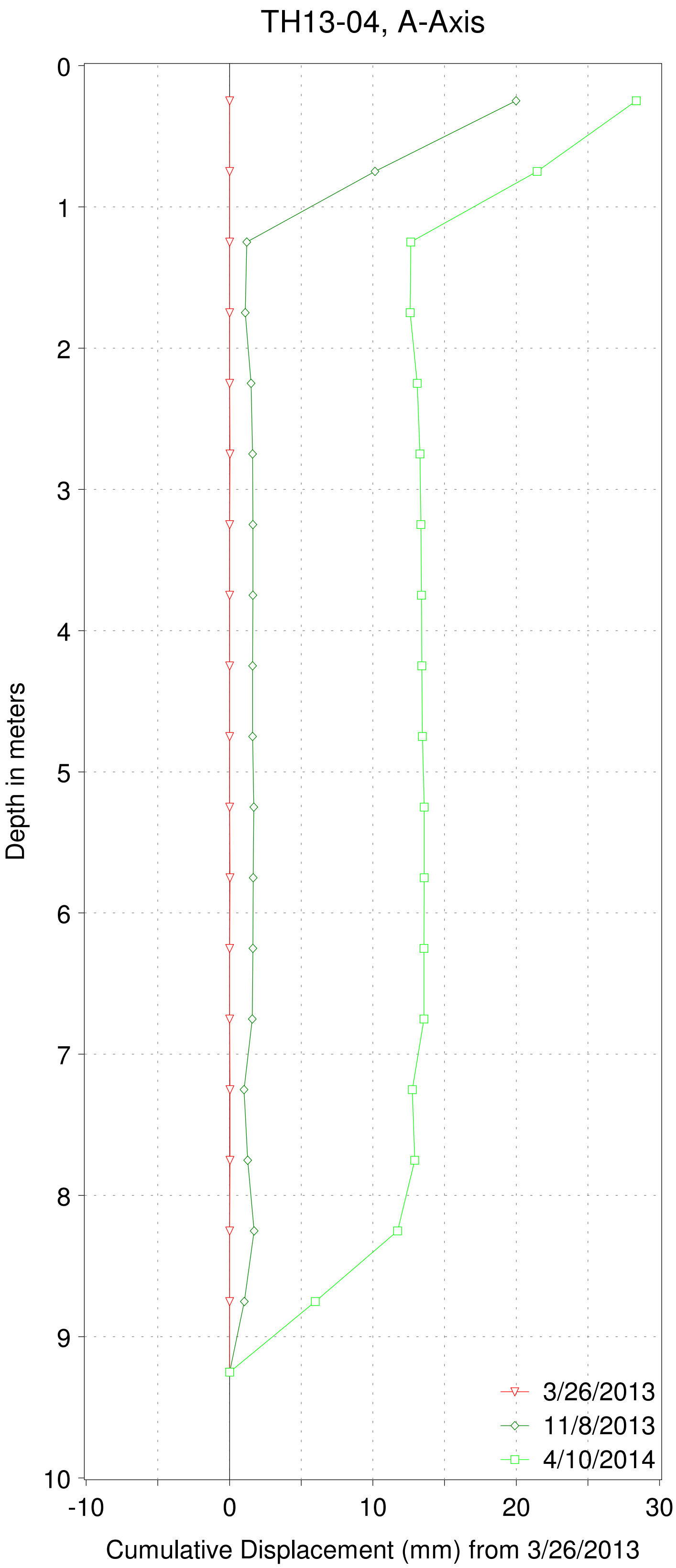
SI RESULTS

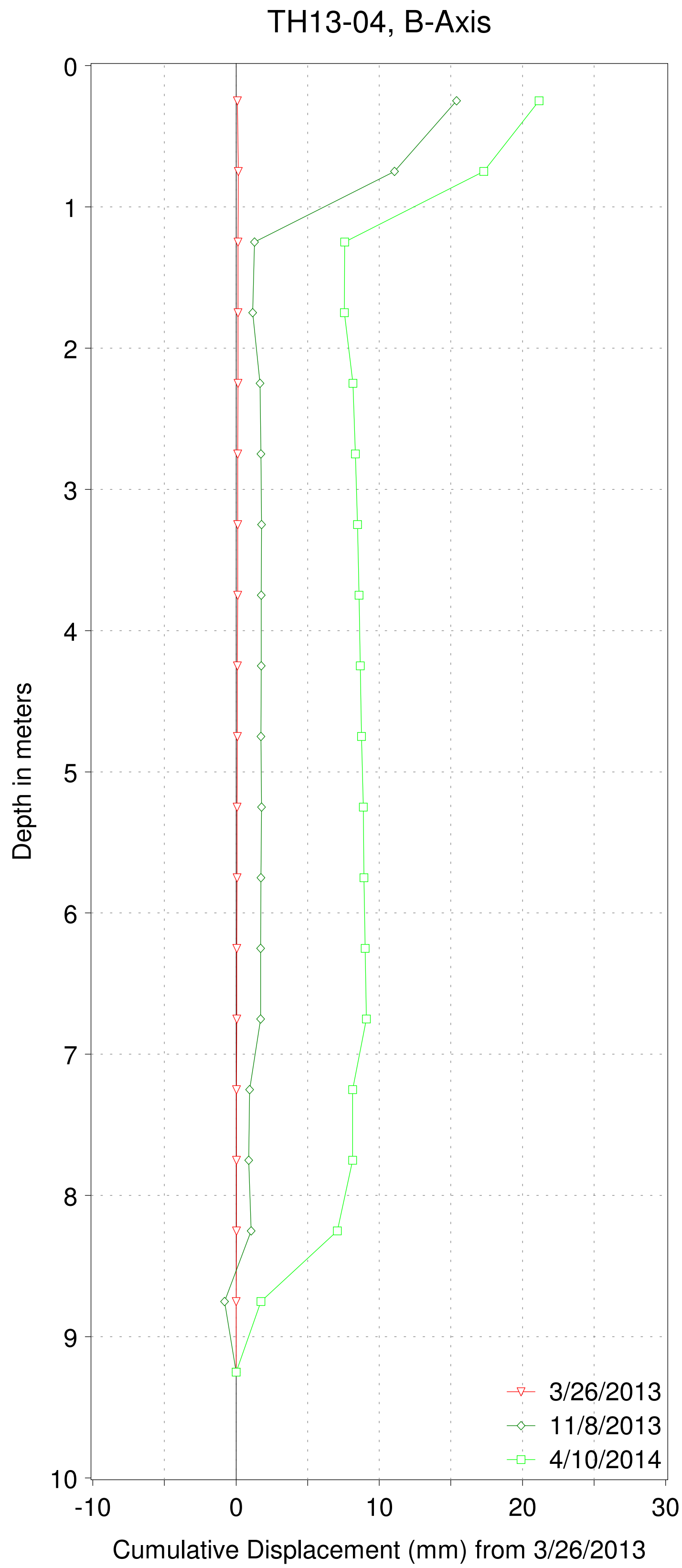




KGS GROUP

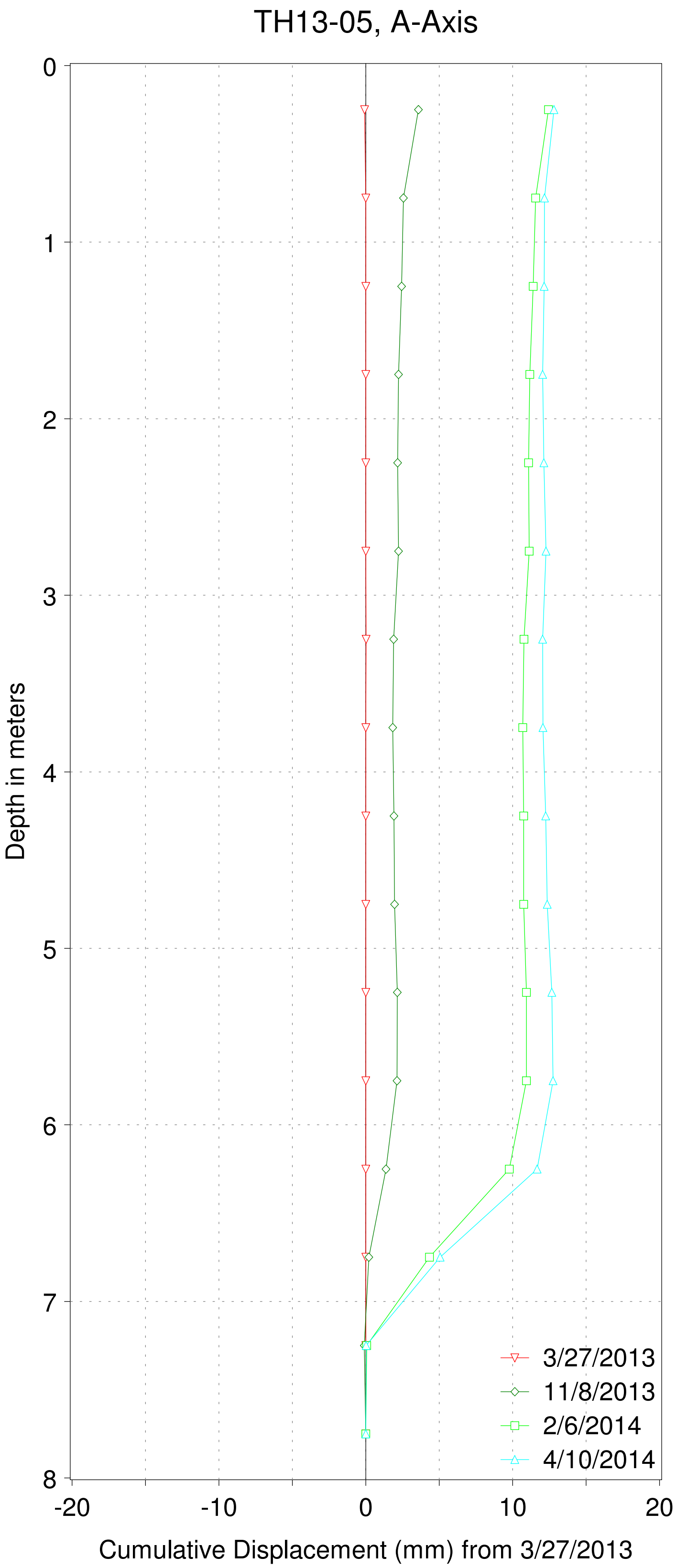
13-0107-008
Kings Park
TH13-01

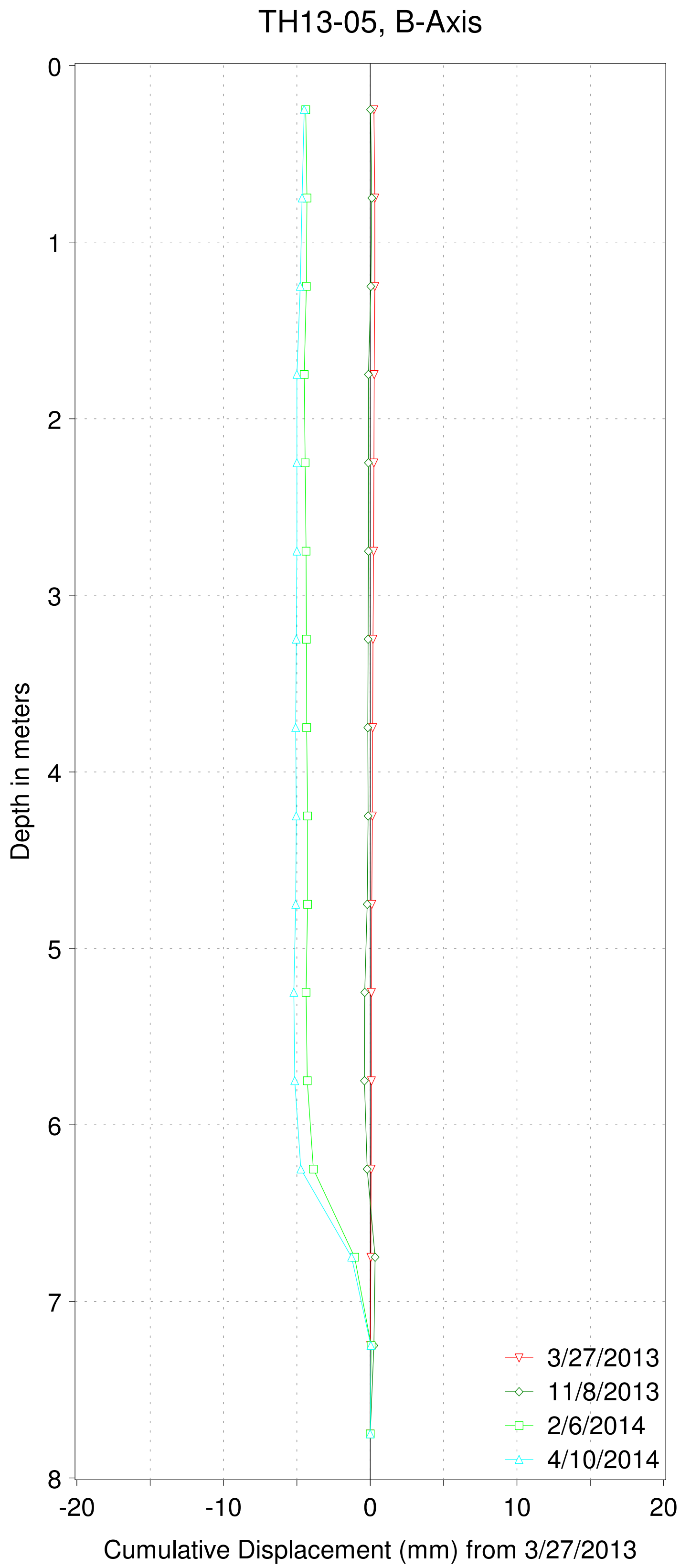




KGS GROUP

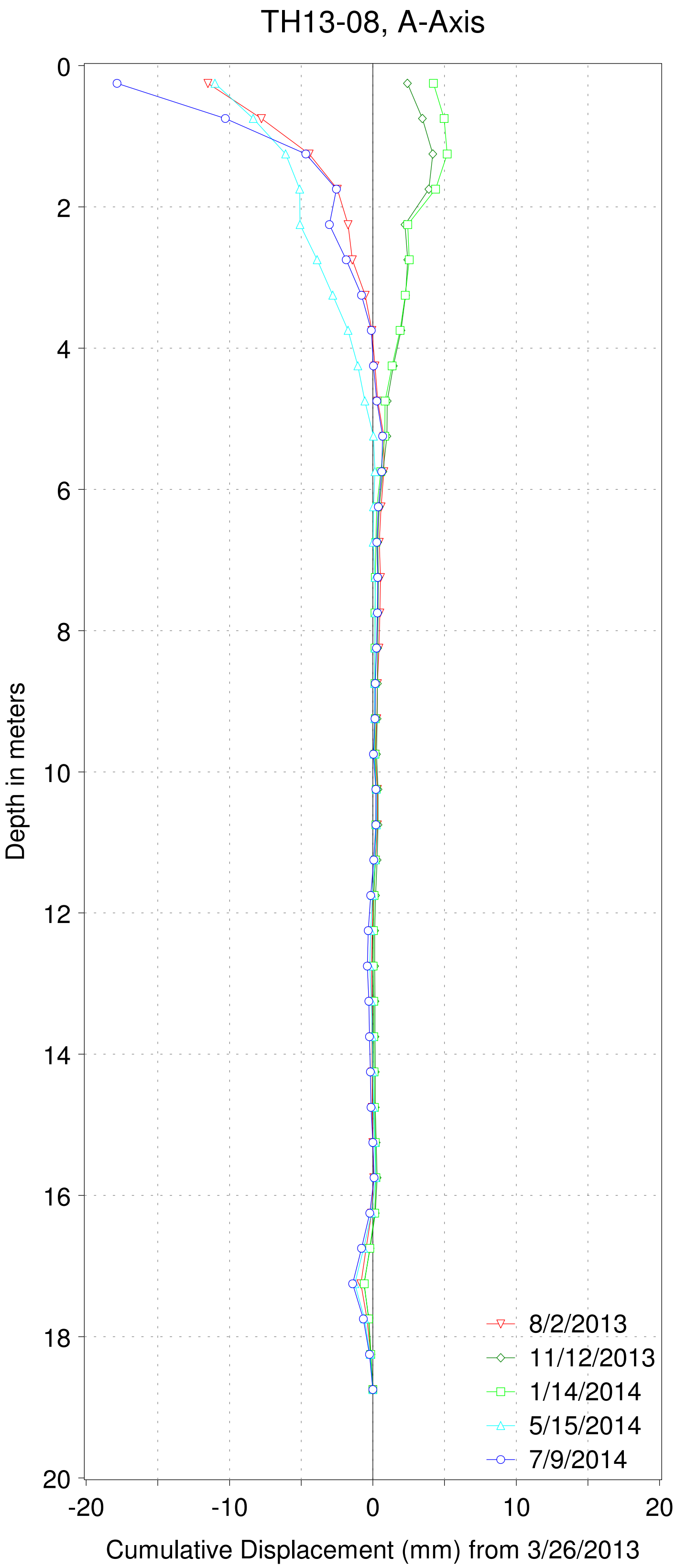
13-0107-008
Kings Park
TH13-04

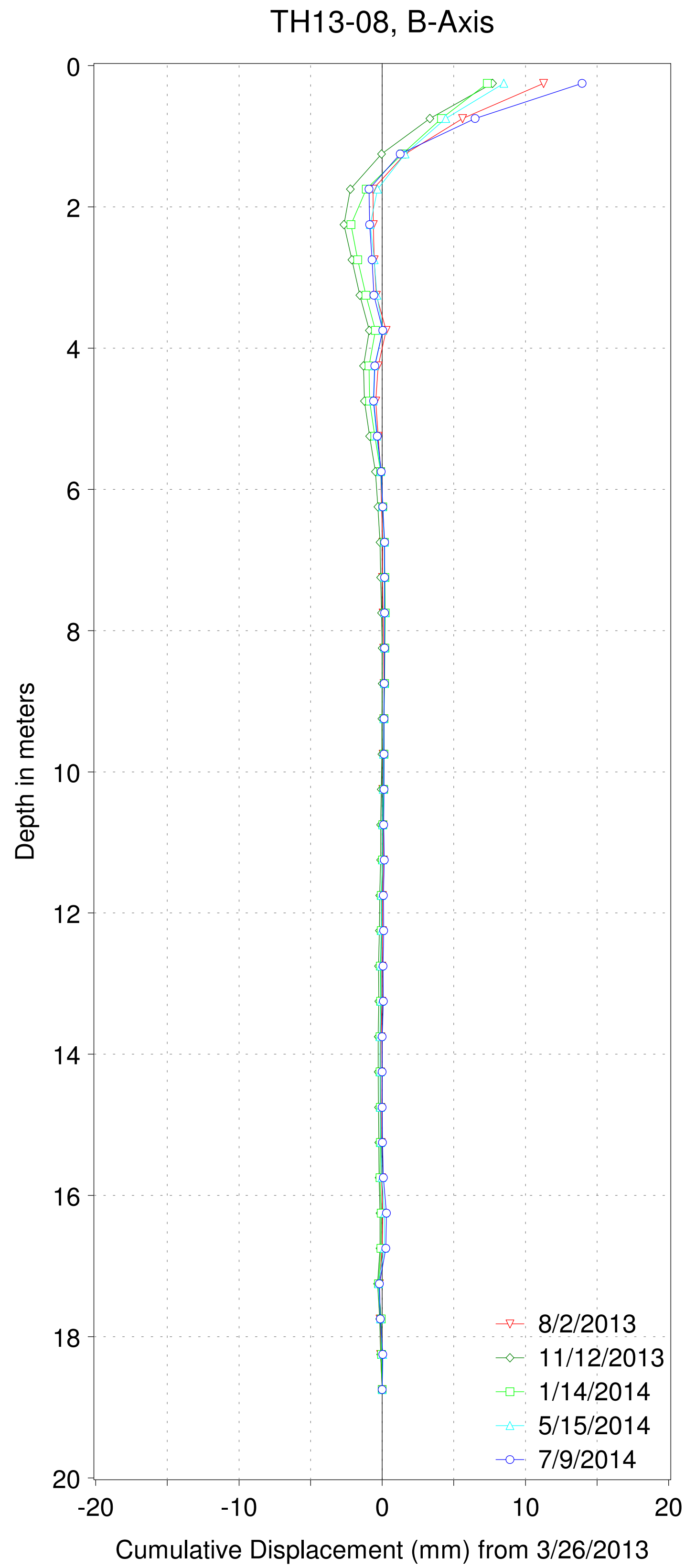




KGS GROUP

13-0107-008
Kings Park
TH13-05





KGS GROUP

13-0107-008
Kings Park
TH13-08

APPENDIX B

EXISTING LOGS AND REPORT

APPENDIX B-01

EXISTING LOGS OF COMMUNITY RING DIKE PROJECT BY KGS GROUP 2000

KGS GROUP

SUMMARY LOG

HOLE NO. **TH5**

SHEET 1 of 1

CLIENT	CANADA, MANITOBA, CITY OF WINNIPEG	JOB NO.	99-107-05
PROJECT	COMMUNITY RING DIKE PROJECT	GROUND ELEV.	(not surveyed)
SITE	KILKENNY DRIVE		
LOCATION	Lower Bank @ #600 Kilkenny Drive, See Dwg. 99-107-05 39	WATER ELEV.	(See Note 1)
DRILLING METHOD	180 mm Hollow Stem Auger	DATE DRILLED	07/02/00

DEPTH (m)	DESCRIPTION AND CLASSIFICATION	SAMPLE NUMBER	RECOVERY %
0	**ALLUVIAL SILTY CLAY (CI)** - Brown, moist, soft to firm, intermediate plasticity, trace silt inclusions, trace organic matter, trace oxidation.		
1		1	46
		2	58
2	-mottled grey and brown, firm to stiff between 1.83 and 3.65 m -(CH) high plasticity below 1.83 m -trace fine grained sand between 1.83 and 3.05 m	3	83
		4	63
3	-Grain Size Distribution: 41.7% silt, 58.3% clay at 3.4 m	5	100
4	-dark grey between 3.65 and 4.25 m -stiff, trace fine grained sand below 3.65 m	6	100
		7	88
5	-mottled grey and brown, trace fine grained sand, trace organic matter, blocky structure between 4.88 and 5.79 m	8	100
6	-silty sand seam (1 mm thick), grey, moist, loose, fine to medium grained, trace coarse grained, trace fine to coarse grained gravel at 5.79 m -most of sample washed out, left chunks of wood, grey silty sand, fine to coarse grained, trace fine to coarse grained gravel from 6.1 to 6.63 m	9	100
	-dark grey, trace silt inclusions (<2 mm ø) below 6.63 m	10	13
7		11	21
	SILTY SAND (SM) - Tan, wet, loose, fine grained, some water infiltration.	12	67
8		13	100
	AUGER REFUSAL @ 8.23 m Note: 1. Water level measured at end of drilling and may not be static.		
9			

Columns: ELEV. (m) | DEPTH (m) | GRAPHICS | DESCRIPTION AND CLASSIFICATION | SAMPLE: TYPE, NUMBER, RECOVERY %

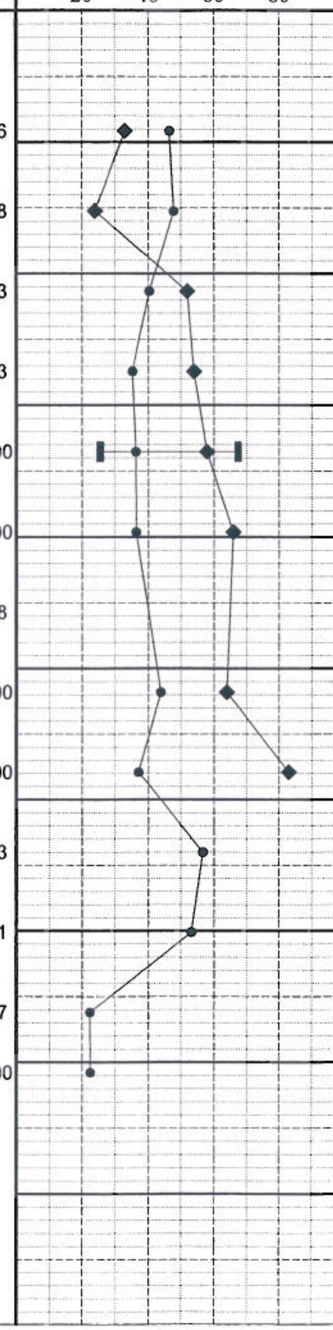
Cu from Unconfined Comp. Test (kPa) ◇

Cu TORVANE (kPa) ◆

PL MC LL

% - kPa

20 40 60 80



SAMPLE TYPE: SPLIT BARREL, SHELBY

CONTRACTOR: Paddock Drilling Ltd.

INSPECTOR: A. PROSKIN

APPROVED

DATE 28/11/00

GENERAL_FT_M 9910705.GPJ

KGS GROUP

SUMMARY LOG

HOLE NO. **TH6**

CLIENT	CANADA, MANITOBA, CITY OF WINNIPEG	JOB NO.	99-107-05
PROJECT	COMMUNITY RING DIKE PROJECT	GROUND ELEV.	(not surveyed)
SITE	KILKENNY DRIVE		
LOCATION	Lower Bank @ #620 Kilkenny Drive, See Dwg. 99-107-05 39	WATER ELEV.	(See Note 1)
DRILLING METHOD	180 mm Hollow Stem Auger	DATE DRILLED	07/02/00

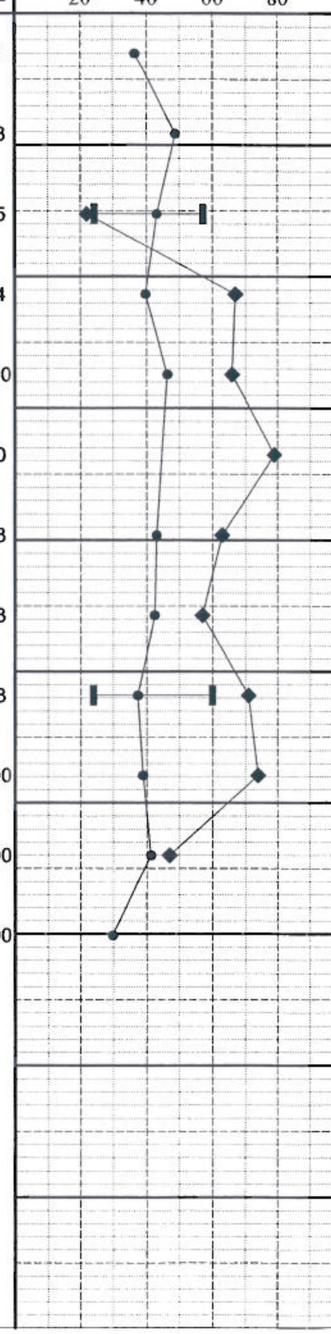
ELEV. (m)	DEPTH (m)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY %
			ALLUVIAL SILTY CLAY (CI) - Brown, moist, soft to firm, intermediate plasticity, trace fine grained sand. -frozen to 0.15 m depth		1	8
	1		-grey to brown between 0.6 and 2.44 m -soft between 0.6 and 1.83 m -trace fine to medium grained sand between 0.6 and 1.22 m		2	13
			-(CH) high plasticity, trace organic matter, trace fine grained sand, trace oxidation below 1.22 m -Grain Size Distribution: 3% sand, 52.4% silt, 44.6% clay at 1.5 m		3	75
	2		-stiff between 1.83 and 2.44 m		4	54
			-mottled brown and grey, firm, trace organics and rootlets between 2.44 and 4.9 m -nuggety, blocky structure below 2.44 m		5	100
	3			Shelby	6	50
	4				7	88
					8	88
	5		-grey, stiff, and silt, blocky structure, trace organics and fine grained sand, trace silt inclusions (<5 mm ø) below 4.88 m -Grain Size Distribution: 5% sand, 48.9% silt, 46.1% clay at 5.2 m		9	88
	6		**LACUSTRINE SILTY CLAY (CH)** - Grey, moist, firm to stiff, high plasticity, trace fine to coarse grained sand, trace silt inclusions (1-20 mm ø). -trace fine grained gravel below 6.1 m		10	100
					11	100
	7		-layer (3 mm thick) of light grey silty clay, soft to firm, low plasticity, trace fine grained sand at 6.63 m		12	100
	8		**CLAYEY SILT TILL** - Light grey, wet, soft, low plasticity, trace fine to coarse grained sand. -water infiltration in test hole below 7.1 m			
	9		**AUGER REFUSAL @ 8.23 m** Notes: 1. Water level measured at end of drilling and may not be static. 2. Test hole backfilled with auger cuttings and 0.5 bag bentonite at clay-till interface.			

Cu from Unconfined Comp. Test (kPa) ◇

Cu TORVANE (kPa) ◆

PL — MC — LL

% - kPa



SAMPLE TYPE: SPLIT BARREL, SHELBY

CONTRACTOR Paddock Drilling Ltd.	INSPECTOR A. PROSKIN	APPROVED	DATE 28/11/00

GENERAL_FT_M 9910705

APPENDIX B-02

PREVIOUS GEOTECHNICAL REPORT
BY INDEPENENT TEST-LAB LIMITED 1989

THE CITY OF WINNIPE(
PARKS AND RECREATION DEPARTMENT

D.J. (JIM) PATERSON, M.A.L.A., C.S.L.A.
DESIGN AND PROJECT CO-ORDINATOR
PLANNING AND DEVELOPMENT DIVISION

2799 ROBLIN BOULEVARD
WINNIPEG, MANITOBA R3R 0B8
PHONE: (204)

GEOTECHNICAL INVESTIGATION AND RIVERBANK STABILITY STUDY AT KING'S PARK ON THE RED RIVER

Prepared for:

The City of Winnipeg
Parks and Recreation Department

Prepared by:

Independent Test-Lab Limited

PROVINCE OF MANITOBA
K. V. LEW
890221
REGISTERED ENGINEER

February 21, 1989
Job No. 35-804

INDEPENDENT TEST-LAB LIMITED
Geotechnical Engineering and Materials Testing

905 Waverley Street
Winnipeg, Manitoba R3T 5P4
(204) 489-6777 Telex: 07-587870 Fax: (204) 453-9012

ITL

A Division of — The I.D. Group Inc.
Edmonton, Lloydminster and Winnipeg

TABLE OF CONTENTS

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation and riverbank stability study at King's Park on the Red River in The City of Winnipeg. Authorization to proceed with the study (File: SG-11-1) was given by Mr. E.W.J. Clarke, P. Eng., Director of Streets and Transportation, The City of Winnipeg.

The purpose of the study is to investigate a minimum 200 m length of unstable riverbank in the vicinity of the existing outfall on the west side of the park (Drawing 028-406). The study was carried out in accordance with our letter proposal of September 21, 1987 to Mr. G. Knoll, P. Eng.

2.0 FIELD WORK

2.1 Subsurface Investigation

On November 23, 1987 a subsurface investigation consisting of drilling and sampling of three (3) test holes was conducted at the site. The test holes were located as shown on Drawing 028-406.

All test holes were drilled using a Williams drilling machine equipped with a 400 mm diameter auger, owned and operated by Pile Foundation Ltd. of Winnipeg. The test holes were extended to maximum depths of 11.3 - 14.6 m. Power auger refusal was encountered within the glacial till deposit at the 14.6 m depth. Field supervision, logging and sampling was carried out by Mr. D. Yaremko, C.E.T. of Independent Test-Lab Limited. All field work was conducted under the direction of Mr. K. V. Lew, P. Eng., Manager of Geotechnical Engineering from ITL.

Undisturbed shelby tube samples and remoulded samples from auger cuttings were obtained and returned to the firm's laboratory for visual examination and testing. Test Hole 1 was continuously logged and sampled with shelby tubes in an attempt to locate the actual slip plane in the failed bank. During and following completion of the test drilling, the test holes were inspected for signs of groundwater inflow and instability of test hole walls. All information was recorded on the appended Soil Log Sheets. The test holes were then backfilled with native material to ensure against public hazard.

A detailed log of each test hole as determined in the field is shown on the Soil Log Sheets appended.

2.2 Site Surveys

Detailed surveys were carried out to obtain information of the existing topography, riverbank profiles, and the locations of test holes, failure scarps and cracks. A total of nine (9) riverbank cross-sections was surveyed. Riverbottom soundings were also conducted at three (3) selected sections. The survey information was plotted on Drawings 028-406, 029-406 and 030-406. Elevations are referenced to Geodetic elevation and all dimensions as noted on the drawings are in metric Units.

The existing riverbank cross sections were used in slope stability analysis discussed in Section 5.0.

3.0 SITE CONDITIONS

Numerous inspections of the study area were made prior to and during the study period by Mr. K. V. Lew, P. Eng. for the purpose of visually examining the site conditions and assessing the existing stability

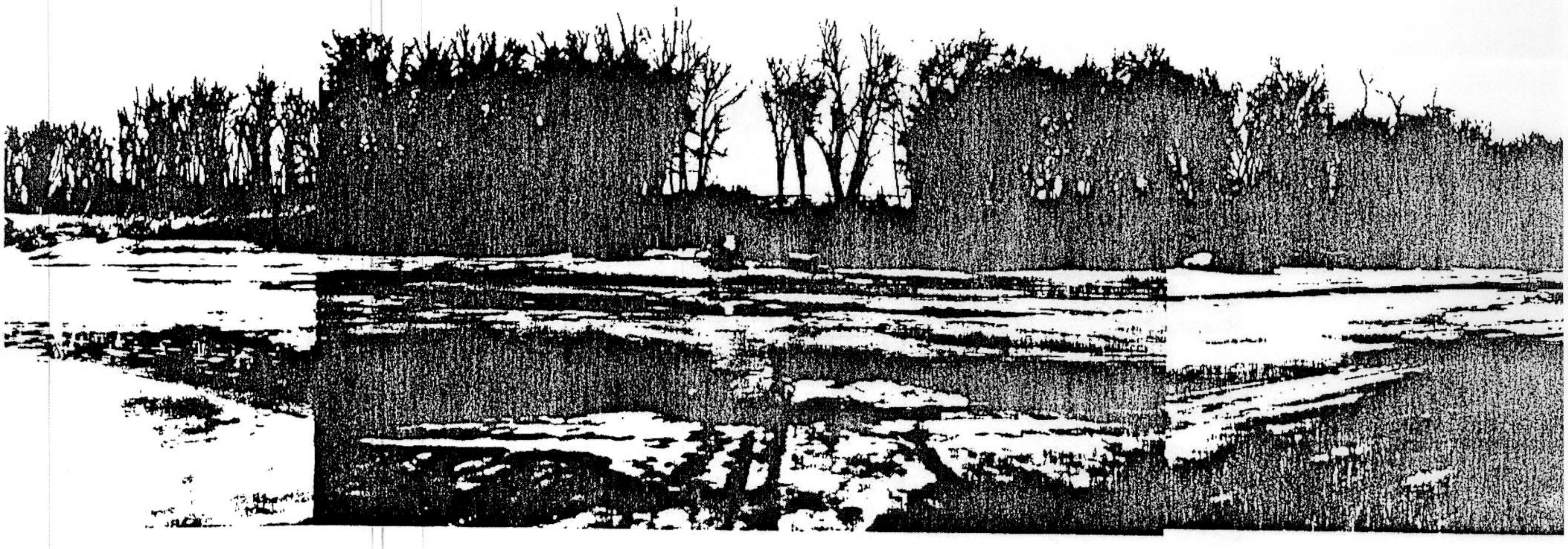


PHOTO 1: King's Park Riverbank Study Area.
Note dense tree cover on the riverbank and severe shoreline erosion. (February 27, 1988).

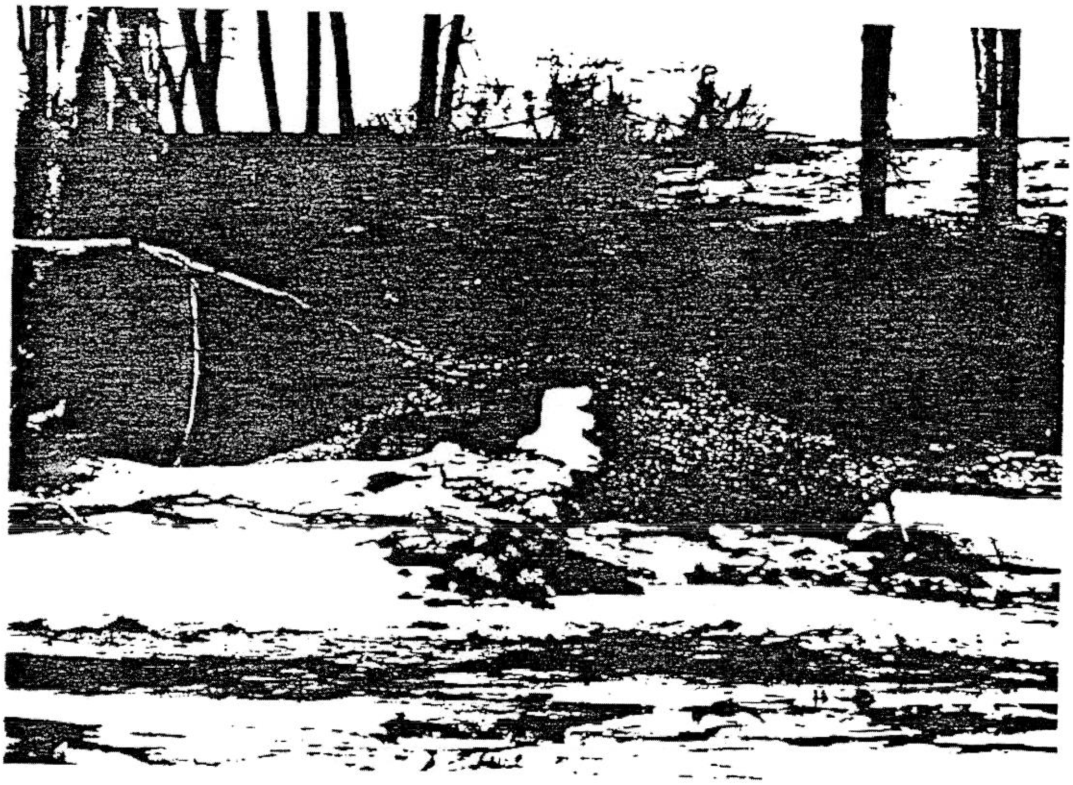


PHOTO 2: Condition of the existing riverbank at the outfall location. Note severe shoreline erosion and head failure scarp in Background (February 27, 1988).

PHOTO 3: Condition of the existing riverbank upstream of the outfall. Note regraded bank with trees removed and location of failure scarp (February 27, 1983).

PHOTO 4: Condition of the existing riverbank downstream of the outfall. Note regraded bank with trees removed and location of failure scarp (February 27, 1983).

condition of the riverbank. The following observations were made during these inspections.

The site is located on the outside bend of the Red River (Drawing 028-406). The bank is 8 - 10 m in height and has very irregular bank profile with heavy tree and bush cover. Review of aerial photographs indicated that the riverbank (in excess of 500 m) in this area has a long history of instability. Severe shoreline erosion is occurring at the summer water's edge (Photo 1). Photo 2 shows the existing bank condition at the outfall location with most of the trees removed. Based upon the site inspections and test drilling, it appears that fill has been placed at the outfall location and bank regraded. Photos 3 and 4 show the location of failure scarps and evidence of ongoing bank movements. The head failure scarp generally runs close to and parallel to the asphalt pathway located at the top of the bank. Long term downslope creep movements are evident and the continual bank movements have already affected the asphalt pathway pavement at a number of locations.

The riverbank movements are retrogressive in nature. A head failure scarp up to 2 m high is evident both upstream and downstream of the existing outfall (Photos 3 and 4). At the outfall location, a failure scarp up to 0.3 m high is noted.

4.0 SOIL CONDITION

4.1 Soil Profile

Based upon the soils investigation, the soil profile at this site essentially consists of brown and grey silty clays overlying the glacial till deposit, typical of the Winnipeg area. At the outfall location, a layer of silty clay fill of 1.2 m thick was encountered in Test Hole 1. A detailed log of each test hole is given in the Appendix.

The brown and grey silty clays encountered are medium to highly plastic, contains oxide pockets and silt inclusions throughout, and varve with occasional thin layers of silt and sand. Traces of black organics, decayed wood fibres and sea shells were encountered at approximately 10 m depth in Test Hole 2. The brown silty clay generally blends into the grey silty clay at approximately the 6 m depth. The silty clays have firm to stiff consistency at the top and generally become softer with increased depth. Occasional soft zones within the grey silty clay strata were encountered. The silty clay and glacial till interface was encountered at elevation approximately 216 - 217 m. The glacial till at this location is soft, wet and 'putty' like. The major components of the glacial till are silt, sand, gravel and stones.

Water inflow was encountered in all test holes within the silty clay strata at different depths during test drilling. Caving-in of test hole walls were also encountered in all test hole during and upon completion of test drilling. At completion of test drilling, the groundwater levels were measured at elevation 220 m in the Test Hole 1 and at elevation 224 m in Test Holes 2 and 3 on November 23, 1987.

4.2 Locations and Probable Shape of Slip Surface

Visual inspections of the extruded continuous Shelby tube samples from Test Hole 1 revealed zones of well developed slip planes (or slickensided surfaces). The locations of these slip planes are summarized as follows:

Slip Planes Elevation (m)	Approximate Angle To Horizontal	Remarks
221.6	30°	Tube Sample 1T12
218.8	5°	Tube Sample 1T19
217.6	0°	Tube Sample 1T22

Based on the slope geometry and the soil profile, the bank failure appears to be deep-seated and in the shape of multiple sliding block. A non-circular slip surface sliding on the clay-till interface is consistent with the pattern of the failure scarp observed and the slip planes identified from the continuous tube samples. The most probable slip surfaces are presented in Drawing No. 030-406.

4.3 Laboratory Testing

Samples obtained from the above investigation were tested in the firm's Winnipeg laboratory. The laboratory testing consisted of visual classification, moisture content determination, grain-size analysis, Atterberg Limits and a direct shear test. All testing conformed to ASTM procedures as required under the Unified Soil Classification System. The results of the laboratory testing are summarized and presented on the appended Soil Property Summary Sheets.

Tube sample 1T22 are subjected to direct shear in an effort to achieve a measure of the stress-strain relationship for the silty clay encountered at this site. Specimen for the direct shear test was trimmed from the immediate vicinity of the observed slip zone in tube sample 1T22. The rate of strain in the test was maintained at 0.0085 mm/min. The residual shear strength parameters (the effective angle of the shearing resistance and the cohesion intercept) for the silty clay as determined through the test are $\phi'_r = 10° - 13°$ and $C'_r = 0 - 3.5$ kPa (See Drawing 1).

5.0 SLOPE STABILITY ANALYSIS

A stability back analysis of the existing slope was made to examine the current site of riverbank stability and to establish the appropriate shear strength parameters for analysis and design of remedial measures. The analysis was performed in terms of effective stresses and using Morgenstein - Price Method (1965) of analysis for non-circular slip surfaces. The analysis was carried out with the low river level after drawdown and assumed pore-pressure conditions as indicated on Drawings 030-406. Baracos (1978) showed that, when the effects of river level, groundwater and other seasonal changes on the riverbank in Winnipeg have been taken into account, the conditions of stability can be related to theory using residual strength parameters for the clays.

Based upon the bank profile and riverbottom sounding surveys, cross-section A-A along the centerline of the outfall pipe, as shown on Drawing 030-406, was selected for analysis as it is most subject to sliding in view of the existing slope and soil conditions encountered. Knowing that the riverbank has failed and from a theoretical standpoint, a proper stability analysis of an existing failure should give a computed factor of safety against sliding of 1.0. The stability back analysis was therefore performed to compute the shear strength values (ϕ' and c') for the clay required to be mobilized along a potential slip surface for a factor a safety of unity when considering various different potential slip surfaces (See Drawing 030-406). The results of the stability back analysis are summarized as follows:

(A) Pore-Pressure Condition I

Slip Surface	Factor of Safety: c' = 3 kPa, Ø' = 13°	c' = 4.5 kPa, Ø' = 10°	c' = 5.2 kPa, Ø' = 10°
1	1.06	1.01	1.08
2*	1.02	0.98	1.05
3	1.03	0.98	1.05
4	1.05	0.98	1.05
5*	1.00	0.94	1.00
6	1.15	1.16	>1.2
7	1.26	1.29	>1.3

(B) Pore-Pressure Condition II

Slip Surface	Factor of Safety: c' = 2.65 kPa, Ø' = 13°	c' = 3 kPa, Ø' = 10°	c' = 4.5 kPa, Ø' = 10°
1	1.11	1.14	1.07
2*	1.00	1.03	0.99
3	1.12	1.15	1.07
4	1.21	1.24	1.12
5	1.14	1.16	1.07
6*	<0.88	0.88	0.96
7*	<0.87	0.87	0.99

(C) Pore-Pressure Condition III

Slip Surface	Factor of Safety: c' = 0.5 kPa, Ø' = 13°	c' = 3 kPa, Ø' = 13°	c' = 3.0 kPa, Ø' = 10°	c' = 4.5 kPa, Ø' = 10°
1	1.11	1.34	1.09	1.23
2*	0.99	1.22	1.00	1.14
3	1.11	1.33	1.08	1.21
4	1.18	1.39	1.12	1.24
5*	1.11	1.31	1.06	1.18
6*	0.79	1.11	0.94	1.13
7*	0.75	1.12	0.96	1.18

* Most Probable Slip Surface

The analysis shows that the computed shear strength values required for the clay for a factor of safety of unity are comparable to the residual strength parameters derived through the direct shear tests. Residual strength parameters for the clay have proven to be applicable to riverbank analysis (Baracos 1978, Baracos and Graham 1981, Lew and Graham 1988).

5.1 Discussions

Field evidence and site conditions suggest that the riverbanks at the King's Park area are sliding and the bank movements are retrogressive in nature. Based upon the slope geometry and soil conditions, the bank failure appears to be deep-seated and the most probable slip surface appears to be non-circular (or composite) in shape sliding just above the clay-till interface. A non-circular slip surface tangent to the clay-till interface is consistent with the pattern of failure scarps and cracks observed in the field. The results of the stability back analysis presented in Section 5.0 reflects the existing stability condition of the riverbanks at the King's Park area which is unstable to marginally stable. The stability conditions vary seasonally depending on river level and the actual pore-pressure conditions in the bank. The stability analyses suggest that the periods of minimum stability occur in the fall (after the drawdown) and spring (before the spring flood) from the simultaneous effects of rain and/or snow melt on the bank, low river level and rising of piezometric level in the bedrock aquifer during the winter months due to low demand of well water (Render 1970). The unusual artesian condition reported by Baracos (1978), such as pore-pressure condition II and III, could develop near the toe of the riverbank as a result of rising piezometric level in the bedrock aquifer. The artesian condition is especially detrimental to the stability of the lower bank which in turn will affect the stability of the overall bank.

The above-mentioned factors do not fully explain why the riverbank is continuously sliding into the river channel, while the head failure scarp continues to more retrogressively away from the river. In general, this process of bank movement should create a more stable bank configuration against further movement of the slope. However, the stability calculations indicate that the riverbank at the King's Park area remains unstable to marginally stable, with a factor of safety close to 1.0. The recently completed study at the Minnetonka outfall site concluded that the mechanism of riverbank instability is complex and appears to be closely related to river morphology and riverbed degradation due to the tractive forces exerted by the flowing water. After a bank failure, the slope configuration is less than the original surface gradient and is generally more stable. The toe of the failed mass acts as a new buttress against further movements. However, if this buttress is removed by stream erosion, the force equilibrium of the slope may be upset. The slope continues to move in order to stabilize itself. This phenomenon may be used to explain the continual movements of the riverbank at the King's Park area (in Winnipeg in general) and why stability condition of the existing riverbank (post failure condition) remains marginal. The riverbank would continue to slide if there is continuing erosion at the lower bank in the river channel. The frequency of bank movement depends on the frequency and magnitude of spring floods, and rate of drawdown.

6.0 REMEDIAL MEASURES

There are a variety of remedial schemes for riverbank stabilization depending on the specific site condition. Various alternative remedial measures, such as slope regrading, rock toe berm, riprap protection, granular key trench, rock gabion, stone column, compacted sand-fill trench drain and structure wall, etc., have been examined and investigated. Based upon our past experience, such solutions would cost upwards of $300,000 to $500,000. To stabilize the riverbank at King's

Park using any one or combination of these solutions would therefore require high capital cost and/or extensive alteration of existing park setting including terrain, vegetation and asphalt pathway, etc. In our opinion, such extensive stabilization measures are not warranted at this time, given that the existing condition of the bank (although marginally stable) does not jeopardize the integrity of the park setting other than the outfall pipe and certain sections of the asphalt pathway. Therefore, we suggest that the riverbank be left as it is, but that maintenance be carried out to repair or, if necessary, relocate affected portions of the asphalt pathway. We estimate an average construction cost of $1,500 to $2,000 per year to repair/maintain the asphalt pathway. Because the riverbank is expected to continue to move, it is anticipated that the asphalt pathway would have to be relocated within the next 10-15 years. Therefore, consideration should be given to relocate the asphalt pathway sooner. We estimate the construction cost of relocating 350 m of asphalt pathway at $20,000. We further recommend that the conditions of the riverbank, asphalt pathway and outfall pipe be monitored on a year-to-year basis.

We believe that the outfall pipe is still in good operating condition. However, it is our view that the outfall pipe would eventually be damaged by the continual bank movements and will have to be repaired at that time. Construction cost of such repair is estimated at $25,000.

7.0 REFERENCES

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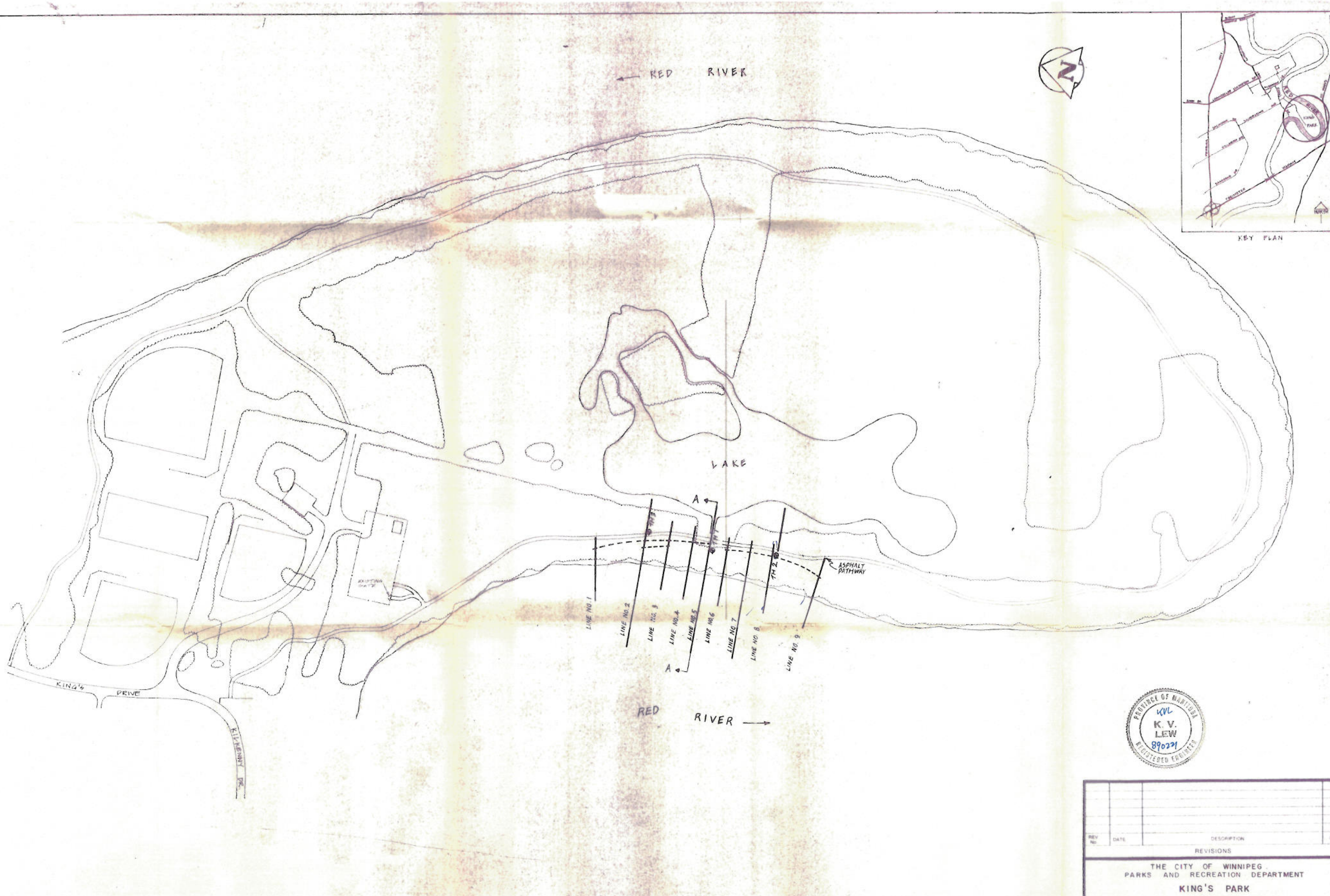
APPENDIX



LEGEND

---- FAILURE SCARP OR CRACK

PROVINCE OF MANITOBA
K.V. LEW
890221
REGISTERED ENGINEER

REV No.	DATE	DESCRIPTION	BY

REVISIONS

THE CITY OF WINNIPEG
PARKS AND RECREATION DEPARTMENT

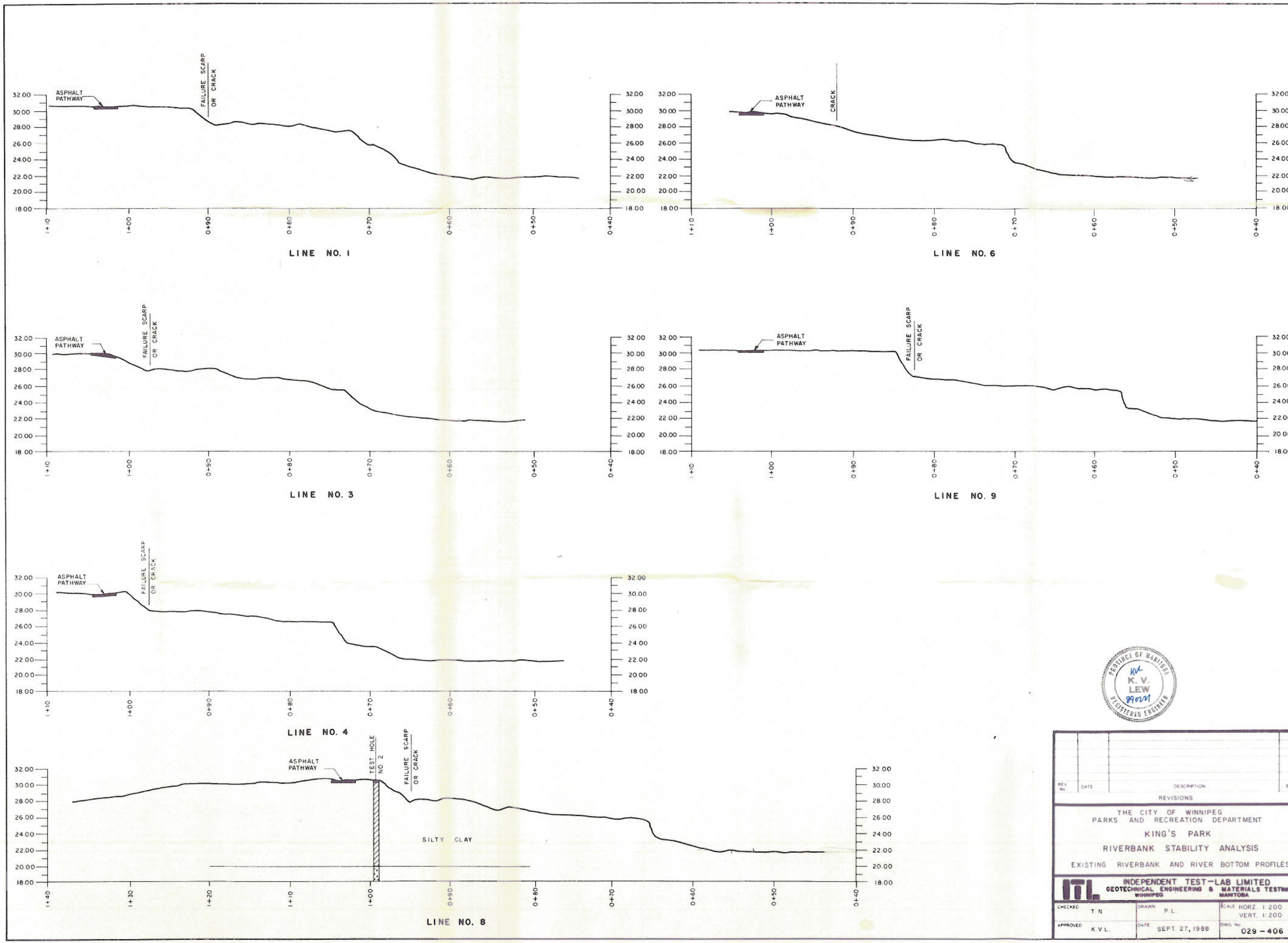
KING'S PARK

RIVERBANK STABILITY ANALYSIS

LOCATION PLAN

ITL INDEPENDENT TEST-LAB LIMITED
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
WINNIPEG MANITOBA

CHECKED	DRAWN	SCALE
T.N.	P.L.	1:1500
APPROVED K.V.L.	DATE SEPT 27, 1988	DWG No. 028 - 406



REV. No.	DATE	DESCRIPTION	BY

REVISIONS

THE CITY OF WINNIPEG
PARKS AND RECREATION DEPARTMENT

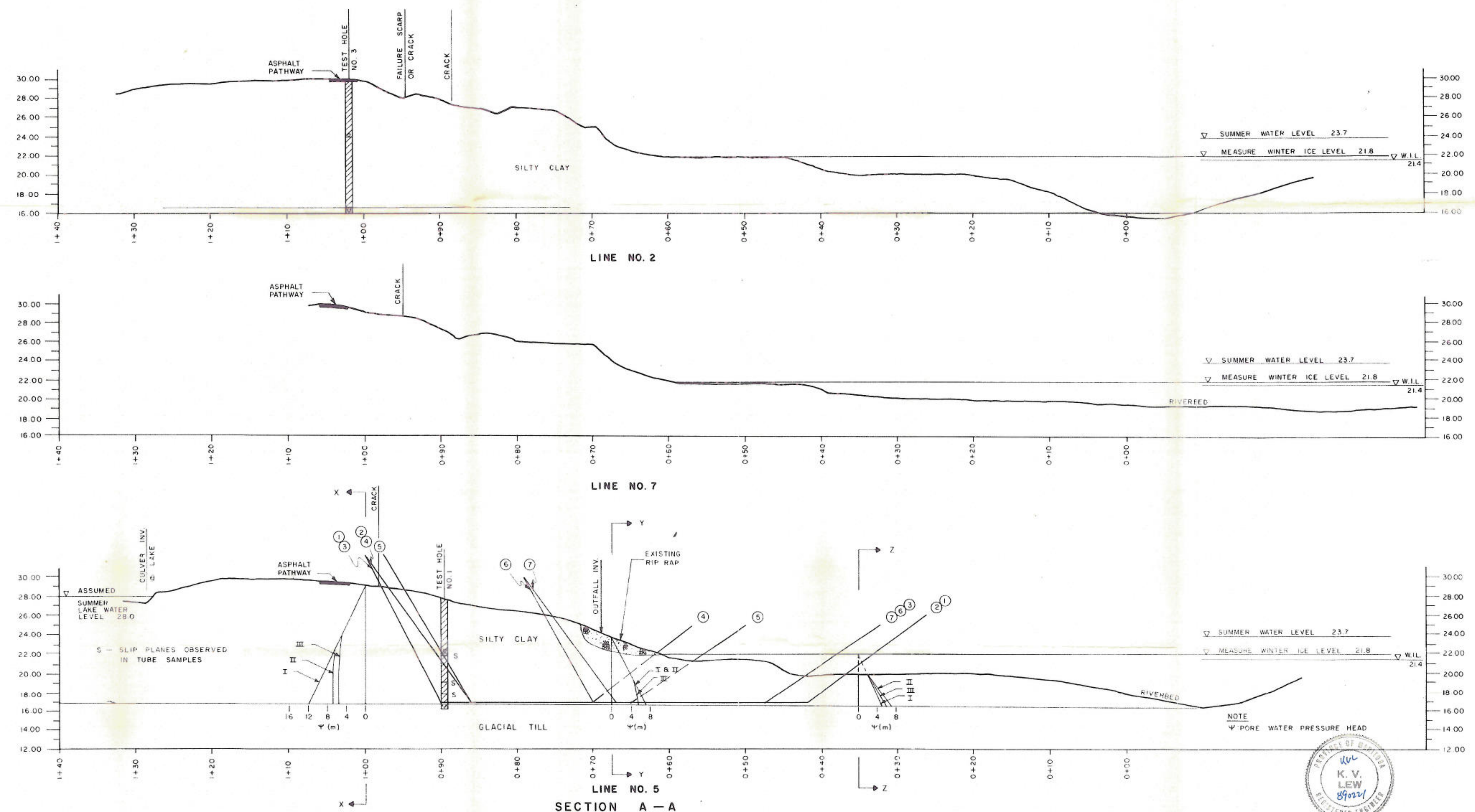
KING'S PARK

RIVERBANK STABILITY ANALYSIS

EXISTING RIVERBANK AND RIVER BOTTOM PROFILES

ITL INDEPENDENT TEST-LAB LIMITED
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
WINNIPEG MANITOBA

CHECKED: T.N.	DRAWN: P.L.	SCALE: HORZ. 1:200 VERT. 1:200	
APPROVED: K.V.L.	DATE: SEPT. 27, 1988	DWG. No.: 029 - 406	



ASSUMED PORE WATER PRESSURE CONDITIONS	SECTION X–X	SECTION Y–Y	SECTION Z–Z	HYDRAULIC HEAD REMARK @ CLAY / TILL INTERFACE
CASE I	HYDROSTATIC	HYDROSTATIC	HYDROSTATIC	221.8 m (WINTER ICE LEVEL)
CASE II	(DOWNWARD GRADIENT)	HYDROSTATIC	(UPWARD GRADIENT)	223.7 m (SUMMER WATER LEVEL)
CASE III	(DOWNWARD GRADIENT)	(DOWNWARD GRADIENT)	(UPWARD GRADIENT)	222.5 m

K.V. LEW 890221 — PROVINCE OF MANITOBA REGISTERED ENGINEER

REV No	DATE	DESCRIPTION	BY

REVISIONS

THE CITY OF WINNIPEG
PARKS AND RECREATION DEPARTMENT
KING'S PARK
RIVERBANK STABILITY ANALYSIS
EXISTING RIVERBANK PROFILES AND REMEDIAL MEASURES

ITL INDEPENDENT TEST-LAB LIMITED
GEOTECHNICAL ENGINEERING & MATERIALS TESTING
WINNIPEG MANITOBA

CHECKED T.N.	DRAWN P.L.	SCALE HORZ 1:250 VERT 1:200
APPROVED K.V.L.	DATE SEPT. 27, 1988	DWG No 030 – 406

INDEPENDENT TEST-LAB LIMITED
Geotechnical Engineering and Materials Testing

EXPLANATION OF SOIL LOG SHEET

The soil profile and some laboratory test results for each borehole are summarized on one or more soil log sheets located elsewhere in this report. Soil types are interpreted according to a modified version of the Unified Classification System which is accepted by most geotechnical organizations in western Canada. It is the purpose of the appendix to explain both this system of classification and other terms used in the soil log sheets.

Starting at the left margin the first and second columns give the key depths and denotes the vertical scale to which the log has been drawn. The first column gives the depth in the Imperial measure (feet) and the second column is the metric equivalent in meters.

The third column is entitled Elevation and Water. The elevations of major occurrences, such as the surface deposit changes, and seepages, are usually written in abbreviated form -- e.g. 16.1 could refer to 716.1 with respect to the geodetic datum. Unless otherwise defined elsewhere in the report, all elevations refer to the geodetic datúm.

A special set of symbols is used to denote water occurrences. For example:

- 4 gpm → seepage into borehole (at a rate of 4 Imperial gallons per minute);
- ← a loss of mud or water circulation (in bedrock, usually);
- ▽ water level in borehole at the time of completion;
- ▼ (4/VII) ground water table (determined on July 4th).

In the fourth and fifth columns the soil letter symbol and graphical symbol are plotted for each soil type and sub-division. These symbols conform to the modified Unified Classification System explained on the sheet at the end of this appendix.

The sixth column contains a detailed verbal description of each soil type. Solid lines across this column and those following divide the soil types into bands. At the top of each band the first lines describe the elementary compositon of the soil, eg. silty **CLAY**. The principal component, which is underlined, is established in acordance with the Unified Classification. Thus, a soil having 30% clay-sized particles and 70% silt-sized particles but with a high plasticity would be a silty clay; in this case the disproportionate content of silt would be indicated by describing the soil as very silty **CLAY**.

Following the description of the composition of the soil band, the other characteristics are stated. They are:

Colour
plasticity (if any)
compressibility or gradation
consistency or relative density
bedding or structure (if any observed)
and inclusions that may be found.

The soil types can be subdivided according to these characteristics; these subdivisions would be denoted by broken lines crossing the fourth and ensuing columns.

The columns at the right hand edge of the page illustrate the sampling that was performed.

In the column entitled "Type", the type of sample is indicated by the following symbols:

- routine Undisturbed (ASTM D1587)
- any kind of sample with No Recovery
- Semi Disturbed (not conforming to a specification)
- representative disturbed or Remoulded sample of the indicated depth range
- Disturbed or spoon of standard penetration test
- rotary Coring

The column entitled "Sample Number" gives the sample designation. The following abbreviations are used:

T..............................Thin-walled tubes (either 2" or 3" in diameter)
R..............................Remoulded specimens other than the penetration tests
S..............................Spoons driven during penetration tests
E,A,B, and N,..................Core Sizes (ASTM, D2113)
W..............................Washed cuttings

The number after the designation indicates the sequence of sampling in each hole.

In the next column the blows per foot for either the standard penetration test (ASTM D1586 or local equivalent) or a 2" o.d. cone are recorded for such field tests. For tube samples the estimated recovery in per cent or the fraction of inches recovered over inches sampled (i.e. 15/20, instead of 75%) is reported in the same column.

The final column describes other tests which are the most part performed in the laboratory. The following code applies:

CODE OF OTHER TESTS

C*	Consolidation test
e	Void ratio, (vol. of voids/vol. of solids)
F	Portion by weight passing # 200 sieve
G	Specific gravity at 68°F.
HYDROM*	Hydrometer test (ASTM D422)
k	Coefficient of Permeability in cm./sec
MA*	Mechanical analysis using sieve and hydrometer
pp	Pocket penetrometer value (average) in tsf
Q	Strength tests in laboratory
Qc	Confined compression strength in ksf or kPa
Qr	Compressive strength on remoulded specimen in ksf or kPa
Qt*	Triaxial compression strength test
Qu	Unconfined compression strength in ksf or kPa
Qv	Vane shear strength in psi or kPa
Sr	Degree of saturation
St	Sensitivity (undisturbed strength/remoulded strength)
SO_4	Concentration of soluble sulphates in % of dry weight
SIEVE*	Washed sieve test
V	Vane shear strength in situ in psi
ε	Unit strain at failure
Y	Unit weight of soil (bulk density) in pcf or kg/m^3
Yd	Dry unit weight of soil in pcf or kg/m^3

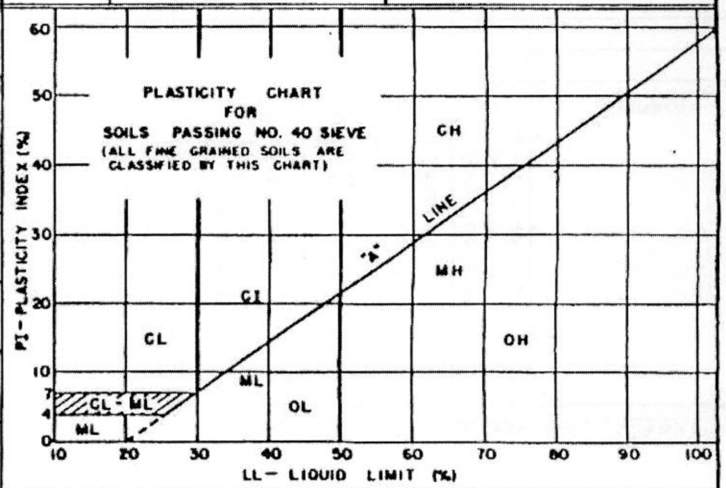
The asterisk indicates that a separate summary sheet is enclosed elsewhere in the report.

The following sheet summarizes the main features of the Modified Unified Classification System used in this report. A number of special symbols for describing commonly occuring types of rock are also included.

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF OF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	—	RED	WELL GRADED GRAVELS, LITTLE OR NO FINES.	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ TO } 3$	
			GP	—	RED	POORLY GRADED GRAVELS & GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM	—	YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE & PI LESS THAN 4
			GC	—	YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES.		ATTERBERG LIMITS ABOVE "A" LINE & PI MORE THAN 7
	SANDS MORE THAN HALF OF COARSE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW	—	RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ TO } 3$	
			SP	—	RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM	—	YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE PI LESS THAN 4
			SC	—	YELLOW	CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE PI MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	LL < 50%	ML	—	GREEN	INORGANIC SILTS & VERY FINE SANDS ROCK FLOUR, SILTY SANDS OF LOW PLASTICITY & LOW COMPRESSIBILITY.		
		LL > 50%	MH	—	BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS OF HIGH COMPRESSIBILITY.		
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART, NEGLIGIBLE ORGANIC CONTENT	LL < 30%	CL	—	GREEN	INORGANIC CLAYS OF LOW COMPRESSIBILTY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS		
		30% < LL < 50%	CI	—	GREEN BLUE	INORGANIC CLAYS OF INTERMEDIATE COMPRESSIBILITY, SILTY CLAYS, VERY SILTY CLAYS.		
		LL > 50%	CH	—	BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS OF HIGH COMPRESSIBILITY.		
	ORGANIC SILTS & CLAYS BELOW "A" LINE ORGANIC CONTENT	LL < 50%	OL	—	GREEN	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY & LOW COMPRESSIBILITY.		
		LL > 50%	OH	—	BLUE	ORGANIC CLAYS OF HIGH COMPRESSIBILITY.		
HIGHLY ORGANIC SOILS			Pt	—	ORANGE	PEAT & OTHER HIGHLY ORGANIC SOILS.	STRONG COLOR OR ODOR & OFTEN FIBROUS TEXTURE.	

DETAILS ON COARSE GRAINED SOILS

- THIS SYSTEM GOVERNS THAT PORTION OF SOIL SMALLER THAN 3 INCHES
- CLEAN SANDS & GRAVELS CONTAIN LESS THAN 5% BY WEIGHT PASSING #200 SIEVE, DIRTY SANDS & GRAVELS CONTAIN MORE THAN 12% BY WEIGHT PASSING #200 SIEVE.
- BORDERLINE CATEGORIES BETWEEN 5% & 12% ARE GIVEN DUAL DESIGNATIONS EG GW-GM WOULD BE A WELL GRADED GRAVEL WITH SOME SILT BINDER
- ALL SIEVE SIZES MENTIONED ARE US STANDARD SIZES DEFINED BY ASTM DESIGNATION E-11
- WHENEVER THE NATURE OF FINES HAS NOT BEEN DETERMINED DEFINITELY THEY ARE IDENTIFIED BY "F" EG SF IS DIRTY SAND EITHER SILTY OR CLAYEY
- PARENTHESES DENOTE VISUAL OR DOUBTFUL CLASSIFICATIONS THAT HAVE NOT BEEN VERIFIED BY LABORATORY TESTING



SPECIAL SYMBOLS

UNSPECIFIED OVERBURDEN · GRANITE · SANDSTONE · CLAYEY OR SANDY SILT TILL

UNSPECIFIED BEDROCK · LIMESTONE · SHALE · CLAY FILL

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

INDEPENDENT TEST-LAB LIMITED
Geotechnical Engineering and Materials Testing

INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL PROPERTY SUMMARY SHEET

CLIENT: CITY OF WINNIPEG

PROJECT: KING'S PARK OUTFALL RIVERBANK STABILITY

BORING NO.	SAMPLE DATA: No.	SAMPLE DATA: Type	SAMPLE DATA: Depth Range (m)	Unified Classification	Natural Water Content w %	Specific Gravity Gs	Bulk Density γ kN/m³	PHYSICAL PROPERTIES – CONSISTENCY LIMITS: Liquid Limit L.L. %	Plastic Limit P.L. %	Plasticity Index P.I. %	MECHANICAL ANALYSIS: Clay %	Silt %	Sand %	Gravel %	Uniformity Coefficient Cu	UNCONFINED COMPRESSIVE STRENGTH: Strength as Received qu	Remolded Strength qu'	Vertical Strain at Peak Strength εv %	Sensitivity St	MISCELLANEOUS: Void Ratio e	Degree of Saturation S %	Water Soluable Sulphates (as SO4) %	Remarks
1	R1	BAG	0.8	CI-CH	32																		
	T2	TUBE	1.8	"	33.2																		
	T3	TUBE	2.1		32.6																		
	T4	TUBE	2.3	"	33.6																		
	T5	TUBE	2.9		29.5																		
	T6	TUBE	3.1	"	33.9																		
	T7	TUBE	3.8	"	31.0																		
	T8	TUBE	4.3		33.6																		
	T9	TUBE	4.6		36.9																		
	T10	TUBE	5.3	"	37.1																		
	T11	TUBE	5.6	"	38.8																		
	T12	TUBE	6.2	"	46.0																		
	T13	TUBE	6.7	CH	37.5																		
	T14	TUBE	7.0	"	39.1																		
	T15	TUBE	7.9	"	40.4																		
	T16	TUBE	8.0	"	32.9																		
	T17	TUBE	8.5	"	37.8																		
	T18	TUBE	8.7	"	40.3																		
	T19	TUBE	9.0	"	41.1																		
	"	"	9.1	"	58.8																		
	T20	TUBE	9.4	"	38.0																		
	T21	TUBE	10.1	"	39.9																		
	T22	TUBE	10.4	CH	47.3			64	22	42	88	12	0	0									
	R23	BAG	10.8	"	21.9																		
	R24	BAG	11.3	"	43.7																		

INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL PROPERTY SUMMARY SHEET

CLIENT: CITY OF WINNIPEG

PROJECT: KING'S PARK OUTFALL RIVERBANK STABILITY

BORING NO.	SAMPLE DATA No.	Type	Depth Range	Unified Classification	Natural Water Content w %	Specific Gravity Gs	Bulk Density γ	Consistency Limits: Liquid Limit L.L. %	Plastic Limit P.L. %	Plasticity Index P.I. %	Mechanical Analysis: Clay %	Silt %	Sand %	Gravel %	Uniformity Coefficient Cu	Unconfined Compressive Strength: Strength as Received qu	Remolded Strength qu'	Vertical Strain at Peak Strength ϵ_v %	Sensitivity St	Miscellaneous: Void Ratio e	Degree of Saturation S %	Water Soluable Sulphates (as SO_4) %	Remarks
2	R1	BAG	0.9	CI	26.0																		
	R2	BAG	1.5	"	19.8																		
	R3	BAG	2.3	"	29.7																		
	R5	BAG	3.4	"	30.7																		
	R7	BAG	5.0	-	33.3																		
	R9	BAG	6.9	-	34.3																		
	R11	BAG	8.6	CH	40.4																		
	R13	BAG	9.9	CH	41.3																		
	R15	BAG	10.8	CH	43.4																		
	R16	BAG	12.1	GC	19.2																		

INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL PROPERTY SUMMARY SHEET

CLIENT: CITY OF WINNIPEG

PROJECT: KING'S PARK OUTFALL RIVERBANK STABILITY

BORING NO.	SAMPLE DATA No.	Type	Depth Range	Unified Classification	Natural Water Content w %	Specific Gravity Gs	Bulk Density γ	Liquid Limit L.L. %	Plastic Limit P.L. %	Plasticity Index P.I. %	Clay %	Silt %	Sand %	Gravel %	Uniformity Coefficient Cu	Strength as Received q_u	Remolded Strength q_u'	Vertical Strain at Peak Strength ϵ_v %	Sensitivity St	Void Ratio e	Degree of Saturation S %	Water Soluable Sulphates (as SO_4) %	Remarks
3	R1	BAG	0.6	CI	23.4																		
	R2	BAG	1.2	CI	29.3																		
	R4	BAG	2.1	CI	27.2																		
	R6	BAG	3.7	CI	32.8																		
	R8	BAG	5.5	CI-CH	36.9																		
	R10	BAG	6.7	CH	37.5																		
	R12	BAG	8.7	CH	43.1																		
	R14	BAG	9.9	CH	34.8																		
	R16	BAG	11.4	CH	37.8																		
	R18	BAG	13.2	CH	51.9																		
	R19	BAG	13.7		19.8																		

INDEPENDENT TEST-LAB LIMITED

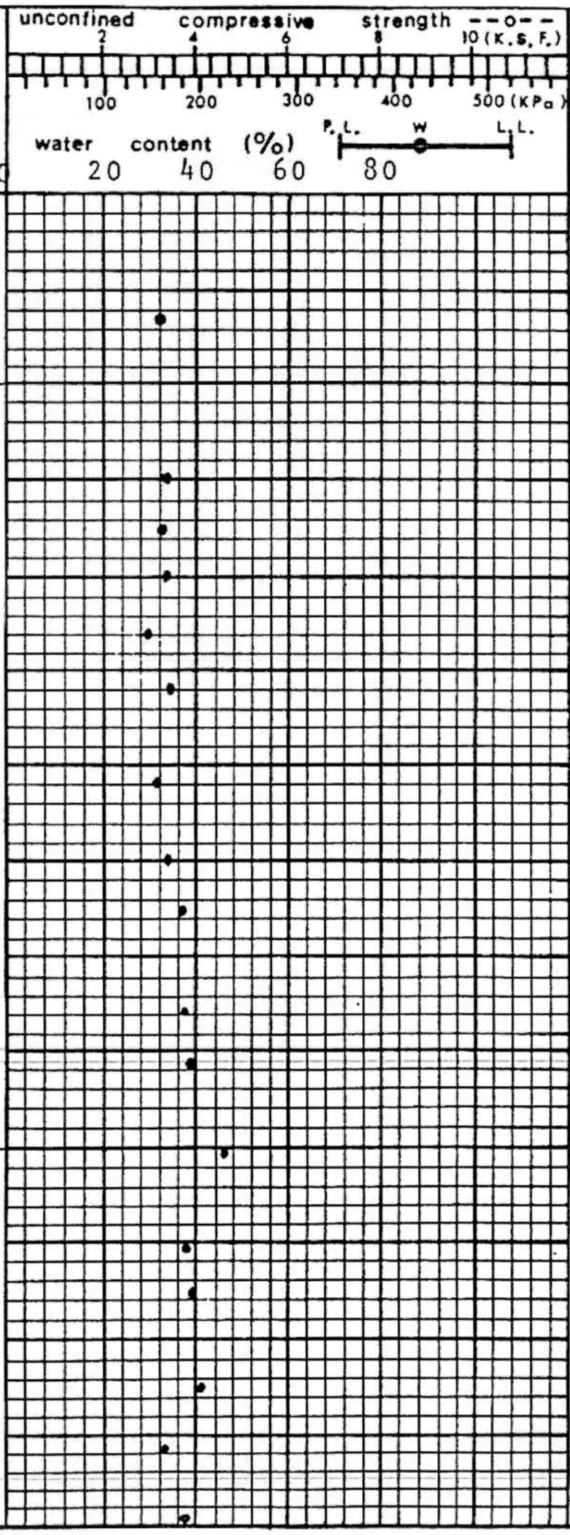
Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

HOLE NO. 1

CLIENT	CITY OF WINNIPEG
PROJECT	RIVERBANK STABILITY STUDY
SITE OR SECTION	KING'S PARK (AT OUTFALL LOCATION)
LOCATION	REFER TO SITE PLAN
CONTRACTOR	PILE FOUNDATIONS LTD.
RIG	LDH-80
JOB NO.	35-804
SHEET	1 OF 2
DATE DRILLED	NOV. 23/87
LOGGED BY	DDY
ENGINEER	KVL
HOLE SIZE	400mm Ø

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL DESCRIPTION	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
				SURFACE –				
2–4	1			**SILTY CLAY-FILL** - dark brown - firm to stiff - medium to high plasticity - trace of brown organics - roots, rubber debris		1R1		
4–20	2–6		(CI-CH)	**SILTY CLAY** - medium brown - firm - medium to high plasticity		T2		
				- gypsum deposits		T3, T4		
				- beige silt inclusions - nuggety		T5, T6		
						T7		
				- trace of mottled grey clay		T8, T9, T10, T11		
		→		- free water in test hole at 5.8m - SOFT, SILTY @ 6.10–6.20m		T12		
20–28	6–8		(CH)	**SILTY CLAY** - grey - firm to stiff - high plasticity - trace of medium brown organic streaks - free water in Testhole		T13, T14, T15, T16, T17		



INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

HOLE NO. 1

CLIENT: CITY OF WINNIPEG

PROJECT: RIVERBANK STABILITY STUDY - KING'S PARK

JOB NO. 35-804

SHEET 2 OF 2

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL PROFILE	SOIL DESCRIPTION	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
30	9		(CH)		SILTY CLAY - grey - firm - high plasticity - SOFT ZONE 8.97 - 9.12m		T18, T19		
32					- trace of sand from 9.3m to 9.7m		T20		
34	10				- thin light grey silt lenses, siltstone fragments - SOFT FROM 10.21 - 10.31m - 150mm SILT layer at 10.6m, light beige, moist		T21, T22, R23		
36	11				- TESTHOLE CAVING-IN AT 7.9m		R24		
38					- TESTHOLE DISCONTINUED AT 11.3m (37.0 ft) - TESTHOLE CAVED-IN TO 5.5m - CAVITY IN TESTHOLE WALLS FROM 2.7 to 4.0m				
40	12								
42	13								
44									
46	14								
48									
50	15								
52	16								
54									
56	17								

unconfined compressive strength --o-- 2 4 6 8 10 (K.S.F.) / 100 200 300 400 500 (KPa)

water content (%) P.L. W L.L. 0 20 40 60 80

INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

HOLE NO. 2

JOB NO. 35-804

CLIENT: CITY OF WINNIPEG

PROJECT: RIVERBANK STABILITY STUDY

SITE OR SECTION: KING'S PARK

LOCATION:

CONTRACTOR: PILE FOUNDATIONS LTD. RIG: LDH-80

SHEET 1 OF 2

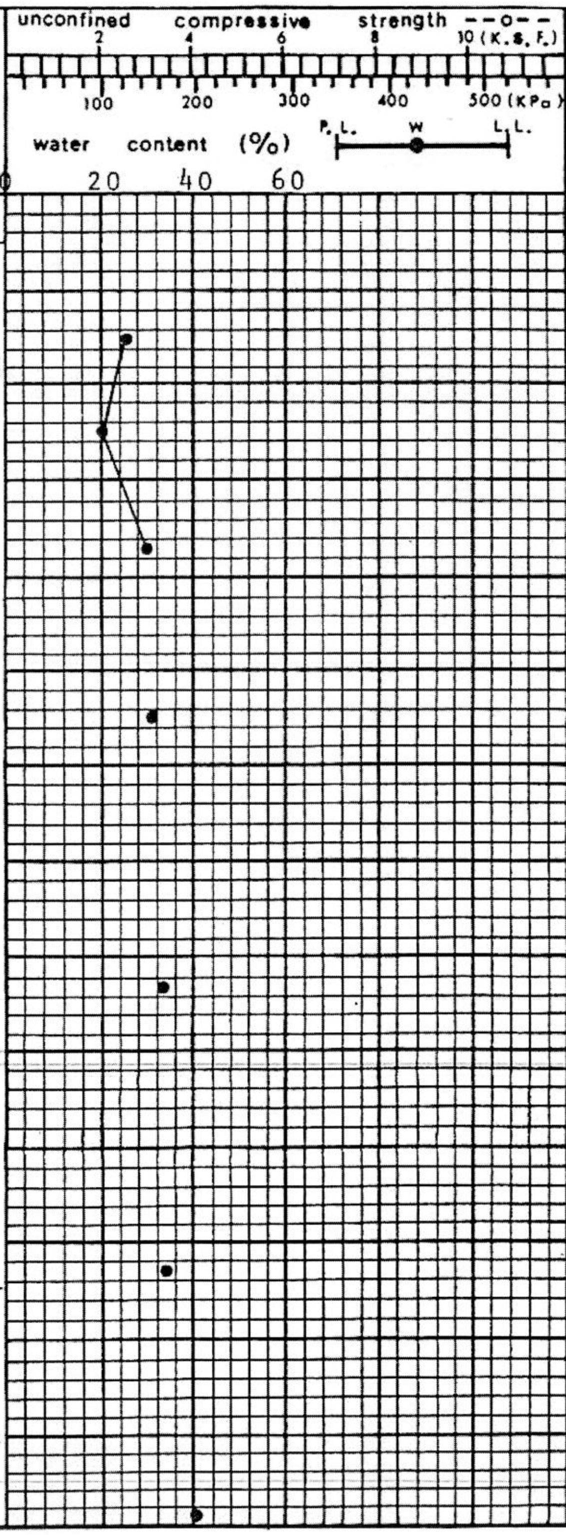
DATE DRILLED: NOV.23/87

LOGGED BY: DDY

ENGINEER: KVL

HOLE SIZE: 400mm Ø

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL DESCRIPTION	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
			Pt	SURFACE – TOPSOIL – dark brown – organic				
2				SILTY CLAY – medium brown – firm to stiff – medium plasticity – mottled with gypsum deposits				
4	1					R1		
				– siltier – mottled with beige silt		R2		
6	2							
8						R3		
10	3					T4		
12			(CI)	– mottled with grey clay		R5		
14	4					T6		
16	5					R7		
18				– FREE WATER IN TESTHOLE				
20	6	▽				T8		
22				– greyish-brown		R9		
24	7			SILTY CLAY – grey – soft to firm – high plasticity – trace of oxides – some dark brown organic streaks		T10		
26	8		(CH)					
28						R11		



INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

CLIENT: CITY OF WINNIPEG

PROJECT: RIVERBANK STABILITY STUDY-KING'S PARK

JOB NO.: 35-804

HOLE NO.: 2

SHEET 2 OF 2

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL PROFILE	SOIL DESCRIPTION	unconfined compressive strength (K.S.F. / KPa); water content (%) P.L. W L.L. — 20 40 60	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
30–38	9–11		(CH)		SILTY CLAY – grey – firm – high plasticity – trace of black organics – trace of seashells – trace of decayed wood fibres – WATER IN TESTHOLE AT 7.6m DURING DRILLING			T12, R13, T14, R15		
					– TESTHOLE SLOUGHED TO 9.8 m DURING DRILLING					
38–48	12–14		(GC) SP		GRAVEL WITH SILTY CLAY - grey - angular gravel particles – AUGER DROPPED APPROX. 1.2m DURING DRILLING AT 12m			R16		
48–56	15–17				– TESTHOLE AUGERED TO REFUSAL AT 14.6m (48.0ft) – SLOUGH AT 8.2m UPON COMPLETION – WATER LEVEL AT 6.4m UPON COMPLETION					

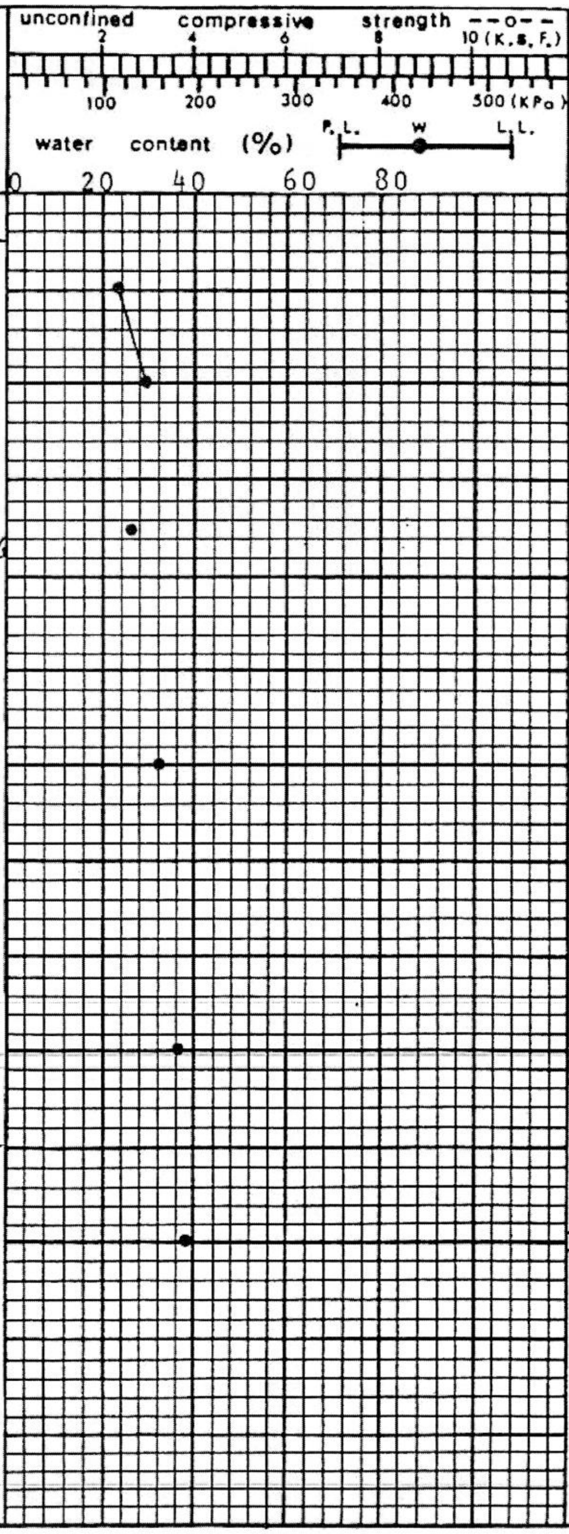
INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

CLIENT	CITY OF WINNIPEG
PROJECT	RIVERBANK STABILITY STUDY
SITE OR SECTION	KING'S PARK
LOCATION	REFER TO SITE PLAN
CONTRACTOR	PILE FOUNDATIONS LTD.
RIG	LDH-80
JOB NO.	35-804
HOLE NO.	3
SHEET	1 OF 2
DATE DRILLED	NOV.23/87
LOGGED BY	DDY
ENGINEER	KVL
HOLE SIZE	400mm Ø

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL PROFILE	SOIL DESCRIPTION	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
					SURFACE –				
			(OL)		CLAYEY SILT – dark brown, organic				
2					SILT CLAY – medium brown – stiff to firm, – medium plasticity		R1		
4	1				– greyish-brown		R2		
6			(CI)		– mottled with gypsum deposits – oxides – nuggety		T3		
8	2				– medium to dark brown – mottled with beige silt bands – occassional black organic streaks		R4		
10	3						T5		
12					– medium, brown – mottled with grey clay – trace of rootlets		R6		
14	4		(CI-CH)		– medium to high plasticity				
16	5				– FREE WATER PRESENT IN TESTHOLE AT 4.6m DURING DRILLING		T7		
18							R8		
20	6	▽							
22					SILTY CLAY – grey – firm – high plasticity		T9		
							R10		
24	7		(CH)						
26	8						T11		
28									



INDEPENDENT TEST-LAB LIMITED

Geotechnical Engineering and Materials Testing

SOIL LOG SHEET

HOLE NO. 3

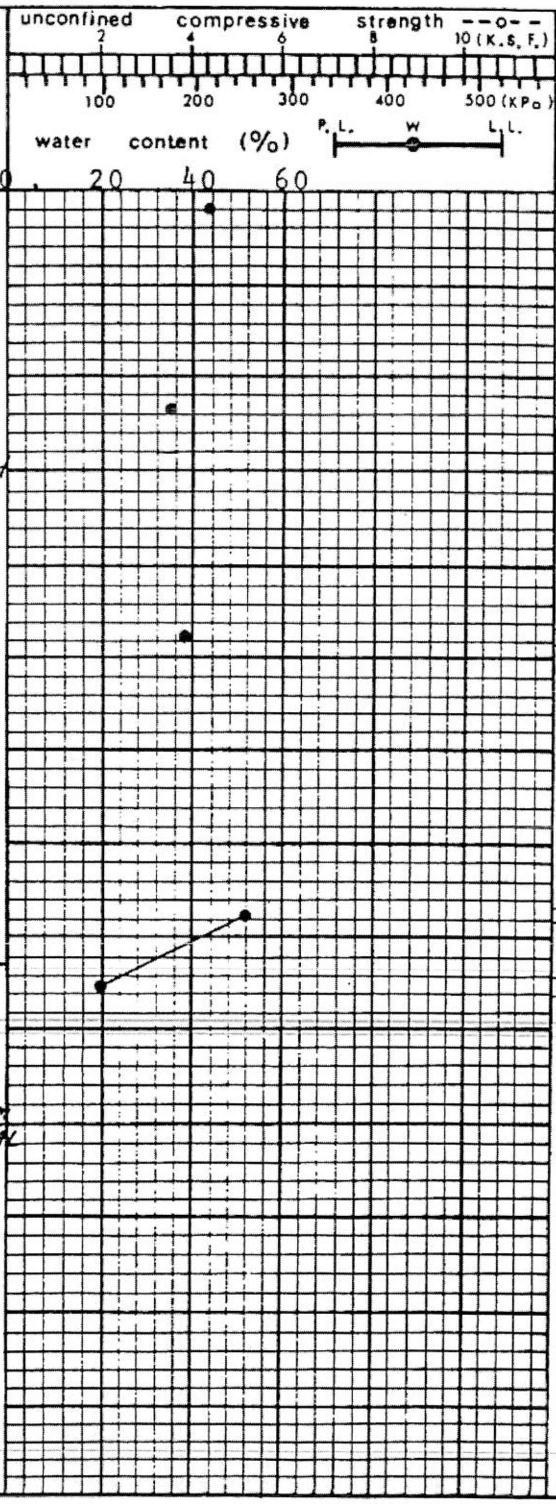
CLIENT: CITY OF WINNIPEG

PROJECT: RIVERBANK STABILITY STUDY-KING'S PARK

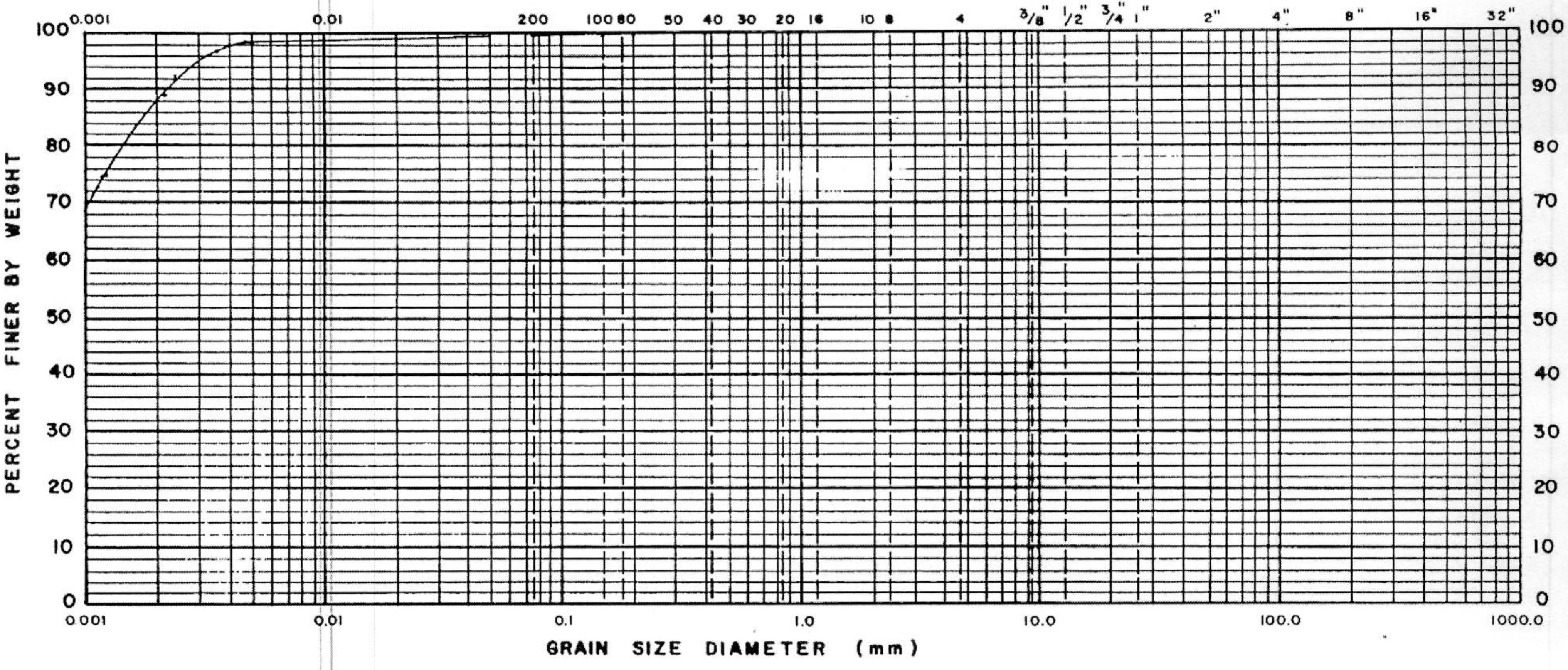
JOB NO. 35-804

SHEET 2 OF 2

DEPTH (FT)	DEPTH (m)	ELEV. & WATER	UNIFIED SYSTEM	SOIL PROFILE	SOIL DESCRIPTION	TYPE	SAMPLE NO.	BLOWS/FT(0.3m) OR RECOVERY	OTHER TESTS (SEE CODE)
			(CH)		SILTY CLAY		R12		
30	9				- grey - firm - high plasticity		T13		
32					- FREE WATER IN TESTHOLE AT 9.1m - Trace of Coarse Sand at 9.4m				
34	10				- Some dark brown decayed Wood fibres		R14		
36	11						T15		
38							R16		
40	12								
42	13						T17		
44					- Occassional light brown Silt Specks		R18		
46	14				SILT TILL - TRANSITION - beige - Soft - NO SAMPLE RECOVERY AFTER 13.7m - SOIL WASHING OFF AUGER, TRACE OF GRAVEL AT 14.3m		R19		
48					- TESTHOLE AUGERED TO REFUSAL AT 14.6m (48.0ft) - SLOUGH AT 13.3m UPON COMPLETION - WATER LEVEL AT 6.1m UPON COMPLETION				
50	15								
52	16								
54									
56	17								



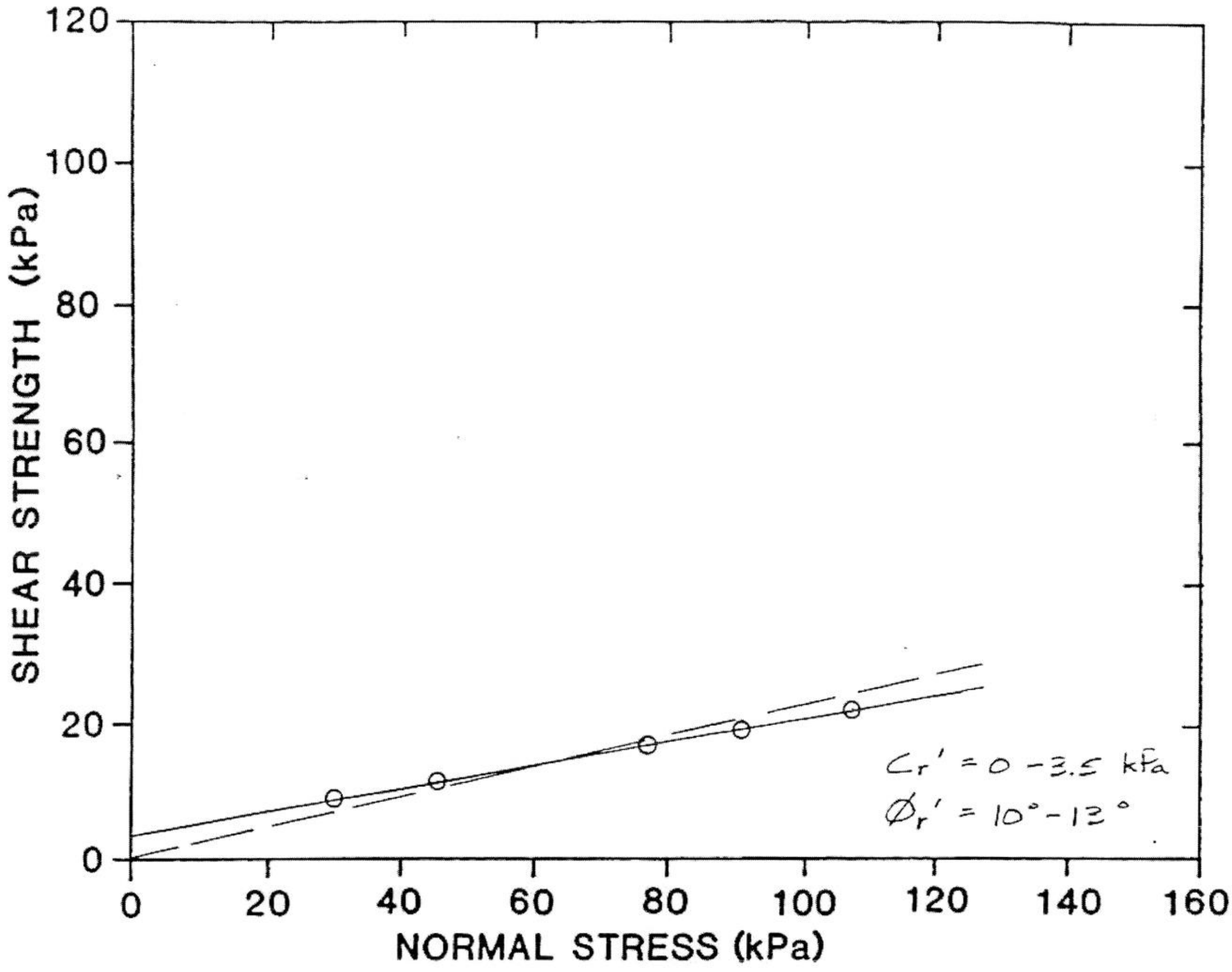
GRAIN SIZE DISTRIBUTION



CLAY	SILT	SAND			GRAVEL		COBBLES & BOULDERS
		FINE	MEDIUM	COARSE	FINE	COARSE	

UNIFIED GRAIN SIZE CLASSIFICATION

PROJECT: KING'S PARK RIVERBANK STABILITY STUDY				THE CITY OF WINNIPEG.
BORING NO: 1	GRAIN SIZE DISTRIBUTION			ITL INDEPENDENT TEST-LAB LIMITED Geotechnical Engineering and Materials Testing
SAMPLE NO: 1T22	% GRAVEL 0	% SAND 0	% SILT 12	
DEPTH: 10.2 - 10.6 m	% CLAY 88	% SILT & CLAY 100		DATE: DEC, 1988 / PLAN NO.



SAMPLE IT22

DEPTH 10.2 - 10.6 m

INDEPENDENT TEST-LAB LIMITED Geotechnical Engineering and Materials Testing	KING'S PARK RIVERBANK STABILITY STUDY SHEAR STRENGTH PARAMETERS

Date: DEC/1988	Scale: AS SHOWN	App'd: KVL	Dwg. No. 1