CITY OF WINNIPEG

McLeod Creek Drainage Improvements Geotechnical Investigation Report

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PREPARED BY:

Kelly Fordyce, P.Eng.
Geotechnical Engineer

PROVINCE OF MANITOBA
K.D.
FORDYCE
Member
36388
20230505
REGISTERED PROFESSIONAL ENGINEER

APPROVED BY:

Dami Adedapo, Ph.D., P.Eng.
Principal / Geotechnical Department Head

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STATEMENT OF LIMITATIONS AND CONDITIONS

Limitations

This report has been prepared for the City of Winnipeg in accordance with the agreement between KGS Group and the City of Winnipeg (the "Agreement"). This report represents KGS Group's professional judgment and exercising due care consistent with the preparation of similar reports. The information, data, recommendations and conclusions in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

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Geotechnical Investigation Statement of Limitations

The geotechnical investigation findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. The findings and recommendations are based on the results of field and laboratory investigations, combined with an interpolation of soil and groundwater conditions found at and within the depth of the test holes drilled by KGS Group at the site at the time of drilling. If conditions encountered during construction appear to be different from those shown by the test holes drilled by KGS Group or if the assumptions stated herein are not in keeping with the design, KGS Group should be notified in order that the recommendations can be reviewed and modified if necessary.

1.0 INTRODUCTION

1.1 General

KGS Group was retained by the City of Winnipeg Water and Waste Department to perform geotechnical investigations to facilitate the design and construction of the proposed Land Drainage System (LDS) for the McLeod Creek Drainage Improvements project.

It is KGS Group's understanding that LDS pipes ranging in size from 375 to 900 mm will be installed in the project area. The piping system will be installed from Kildonan Drive just north of Hawthorne Avenue and in the surrounding community south of the Bergen Cutoff embankment, and discharge into the existing LDS system north of Essar Avenue.

The purpose of the investigations was to identify the subsurface soil and groundwater conditions along the route of the proposed works. This report contains a description of the geotechnical investigations program performed by KGS Group, our findings and geotechnical design recommendations for the proposed LDS system.

1.2 Purpose of Report and Limitations

This report summarizes the geotechnical condition observed within the alignment of the proposed drainage improvements and provides construction considerations that would form part of the basis of the design for the Work. This report includes:

- Geotechnical data collected at the project site;
- Summary of anticipated subsurface conditions along the pipe alignments; and
- A discussion of design and construction considerations including requirements for excavations, temporary support, groundwater conditions and control, settlement, and trenchless tunnel construction.

The results of the geotechnical investigation carried out at the proposed site are presented in this report. This report presents the geotechnical engineer's best judgement of the subsurface and ground conditions anticipated to be encountered at the project site during construction. The soil stratigraphy has been interpolated between the test holes that were drilled along the alignment. While the actual conditions encountered in the field are expected to be within the range of conditions presented and discussed in this document, the spatial variability of actual subsurface and groundwater conditions that would be encountered at the site may vary from the simplified interpretation presented within this report.

2.0 BACKGROUND INFORMATION

The scope of the project is to replace the portion of the McLeod Creek land drainage system south of Essar Avenue and north of Hawthorne Avenue, through the Bergen Cutoff abandoned railway embankment. The existing land drainage system consists primarily of 750 mm corrugated steel pipe (CSP) installed in the former bed of McLeod Creek. Beneath the Bergen Cutoff embankment lies a concrete arch culvert followed by 550 mm x 900 mm CSP pipe connected to the downstream LDS system. This system eventually discharges into the Red River at the outfall located north of Chief Peguis Trail. The piping south of the Bergen Cutoff was installed in the 1960s and has been known to be in poor condition. The piping was not installed within existing right of ways, rather it was installed in back yards and on private property.

The composition of the Bergen Cutoff embankment is not well understood; therefore, a key aspect of the geotechnical investigation was to identify the soil and groundwater conditions in this area.

2.1 Regional Geologic Setting

Winnipeg geology consists of carbonate sedimentary bedrock overlaying Precambrian era granite and gneiss. The sedimentary rock consists of limestone, dolomite, and shale to a lesser extent. Local geological maps indicate karst topography caused from dissolution of the soluble rock, and a heavily fractured upper bedrock layer. The karst topography is typically infilled with mixtures of silt, sand, and gravel till material.

During the last glacial advance and retreat, Winnipeg's glacial till was laid down by ice masses. Glaciolacustrine deposits suspended in glacial lakes confined by ice masses settled to overlie the tills. Additional information on the regional geology can be found in Geological Engineering Report for Urban Development of Winnipeg, University of Manitoba (Ref. 1).

3.0 SCOPE OF THE 2023 INVESTIGATION PROGRAM

3.1 General

This section provides a summary of the 2023 field investigation program, and laboratory material testing results.

3.2 Test Hole Drilling and Soil Sampling

The test hole drilling and sampling program was completed by KGS Group from March 13 to 17, 2023. The approximate locations of the test holes drilled within the proposed alignment of the McLeod Creek LDS system are shown in Figure 1 and a summary of the locations is presented in Table 1.

Maple Leaf Drilling Enterprises of Winnipeg, Manitoba provided the drilling services using a CME truck mounted drill rig for the test holes drilled from the pavement surface. An Acker MP5 track mounted drill rig was used for the remainder of the test holes. Both drill rigs were equipped with 125 mm solid stem augers. Soil samples were collected directly off the auger flights typically at 1.5 m (5 ft) intervals or at changes in soil strata encountered during drilling. The soil samples were visually inspected for material type and classified according to the Modified Unified Soil Classification System (USCS).

Clay samples were tested with a field Torvane to evaluate consistency and estimate undrained shear strengths. Upon completion of drilling, the test holes were examined for indications of sloughing and seepage, and then backfilled. Detailed test hole log records incorporating all field observations, field test results, and laboratory test results are provided on the test hole log records in Appendix A.

3.3 Groundwater Monitoring

A total of eight (8) vibrating wire piezometers and four (4) standpipe piezometers were installed as part of the investigation program. Two (2) vibrating wire piezometers were installed nested within the clay strata in each of the four (4) instrumented test holes. The standpipe piezometers were installed in the glacial till deposit below the clay. Table 2 summarizes the installation details and the groundwater monitoring to date. The installation details of the piezometers are shown on the borehole log records provided in Appendix A.

3.4 Laboratory Testing

A diagnostic laboratory testing program was performed on representative soil samples to determine the relevant engineering properties of the subsurface soils relative to the trenchless construction method. Diagnostic testing completed included moisture content analyses, Atterberg Limit tests, and grain size analysis. All laboratory testing was completed at a local laboratory accredited by Standards Council of Canada and testing was performed in accordance with ASTM standards. The results of the laboratory testing are shown on the test hole logs in Appendix A and in Appendix B.

FIGURE 1: TEST HOLE LOCATION PLAN

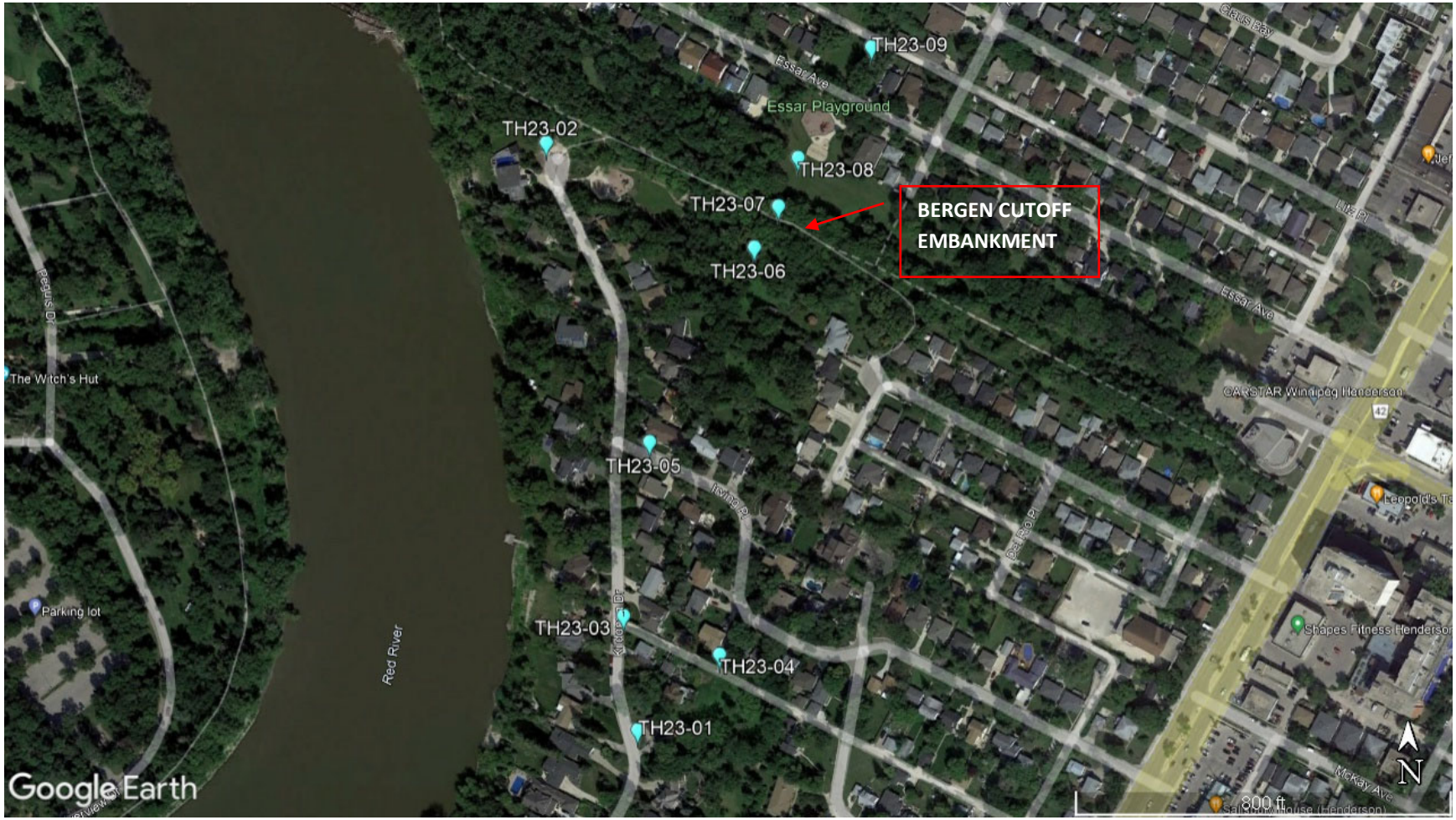


TABLE 1: SUMMARY OF TEST HOLE LOCATIONS

Test Hole ID	Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Approx. Borehole Depth (m)
TH23-01	Kildonan Drive northbound lane in front of 1191 Kildonan Drive	5,533,934.56	636,753.67	228.99	12.19
TH23-02	Turnaround at north end of 1218 Kildonan Drive	5,534,314.28	636,685.35	230.04	20.42
TH23-03	Kildonan Drive northbound lane in front of 1197 Kildonan Drive	5,534,008.66	636,742.67	229.33	20.12
TH23-04	Back lane between Hawthorne Avenue and Irving Place	5,533,985.34	636,806.35	226.61	9.14
TH23-05	Irving Place eastbound lane in front of 1209 Irving Place.	5,534,122.75	636,756.70	229.51	20.42
TH23-06	South toe area of Bergen Cutoff between Kildonan Drive and Corne St.	5,534,250.26	636,822.10	225.63	9.14
TH23-07	Crest of Bergen Cutoff embankment	5,534,276.57	636,837.47	233.26	18.29
TH23-08	North toe area of Bergen Cutoff, south of Essar Park	5,534,309.35	636,848.89	227.56	18.29
TH23-09	Greenspace at 107 Essar Avenue	5,534,381.6	636,895.48	227.24	9.14

TABLE 2: GROUNDWATER MEASUREMENTS

Test Hole		TH23-02			TH23-03			TH23-05			TH23-08		
Ground Elevation:		230.04			229.33			229.51			227.56		
Piezometer No.:		161049	161007	Standpipe	106269	161001	Standpipe	161189	161019	Standpipe	160291	161020	Standpipe
Tip Elevation (m):		223.33	211.75	209.62	222.93	211.96	209.82	224.02	211.22	209.39	222.07	211.71	209.88
Monitoring Zone:		Clay	Clay	Silt Till	Clay	Clay	Silt Till	Clay	Clay	Clay[2]	Clay	Clay	Silt Till
Date:	River Level (m)[1]												
Mar 17, 2023	222.12	Note 3	Note 3	Note 3	Note 3	Note 3	Note 3	226.25	226.57	Note 4	224.65	223.54	217.63
Apr 11, 2023	221.94	224.75	224.21	Note 5	225.39	223.55	Note 5	226.35	223.82	Note 4	224.79	223.61	Note 5
Apr 28, 2023	226.36	224.83	224.93	Note 4	225.50	223.87	Note 6	226.92	223.83	Note 4	225.34	224.50	224.44

Notes:

1) River Level estimated from City of Winnipeg gauge reading at Kildonan Bridge.
2) Standpipe installed at bottom of TH23-05. No till deposit was encountered before refusal.
3) No readings available as flush mount casings were frozen solid with ice.
4) No readings available due to obstruction within 0.5 m depth below top of standpipe.
5) Standpipe readings unavailable due to flush mount casings being full of water.
6) Standpipe readings unavailable due to ice in standpipe.

TABLE 3: SUMMARY OF LABORATORY TESTING RESULTS

Test Hole ID	Sample	Sample Depth (m)	Description	Moisture Content (%)	Grain Size Analysis (%)						Atterberg Limit		
					Gravel (>4.75 mm)	Coarse Sand (2-4.75 mm)	Medium Sand (0.425-2 mm)	Fine Sand (0.075-0.425 mm)	Silt (0.002-0.075 mm)	Clay (<0.002 mm)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)
TH23-01	S01	2.4 – 2.7	Silt	22.2									
	S02	4.0 – 4.3	Clay	52.8									
	S04	5.5 – 5.8	Clay	47.8									
	S07	11.0 – 11.3	Clay	49.7									
TH23-02	S02	4.0 – 4.3	Clay	47.6									
	S04	6.7 – 7.0	Clay	47.7							110	28	81
	S06	9.8 – 10.1	Clay	50.4									
	S08	13.4 – 13.7	Clay	53.2									
	S13	19.8 – 20.1	Silt Till	24.3									
TH23-03	S01	2.6 – 2.7	Silt	22.4							23	18	5
	S02	3.7 – 4.0	Clay	49.1									
	S03	5.3 – 5.6	Clay	49.4	0.0	0.0	0.2	0.5	29.2	70.1			
	S07	11.3 – 11.6	Clay	39.8									
	S09	14.3 – 14.6	Clay	48.3									
TH23-04	S01	2.3 – 2.4	Clay Fill	32.6									
	S02	3.7 – 4.0	Clay	50.6									
	S03	5.6 – 5.8	Clay	48.9									
	S05	8.2 – 8.4	Clay	45.6									
TH23-05	S03	5.3 – 5.5	Clay	53.3									
	S05	8.2 – 8.4	Clay	47.7									
	S07	11.6 – 11.7	Clay	41.1									
	S10	16.2 – 16.3	Clay	58.9									
	S12	19.8 – 20.0	Clay	56.6									
TH23-06	S02	2.7 – 2.9	Clay	41.2									
	S03	4.0 – 4.1	Clay	45.2							88	26	61
	S04	5.5 – 5.6	Clay	41.9									
	S05	7.3 – 7.5	Clay	42.7									

Test Hole ID	Sample	Sample Depth (m)	Description	Moisture Content (%)	Grain Size Analysis (%)						Atterberg Limit		
					Gravel (>4.75 mm)	Coarse Sand (2-4.75 mm)	Medium Sand (0.425-2 mm)	Fine Sand (0.075-0.425 mm)	Silt (0.002-0.075 mm)	Clay (<0.002 mm)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)
TH23-07	S02	2.1 – 2.7	Sand & Gravel	7.5									
	S06	8.2 – 8.5	Sand & Gravel	5.8	36.1	14.2	22.3	8.4	13.4	5.6			
	S07	9.8 – 10.1	Sand & Gravel	9.6	25.8	5.7	31.1	10.9	18.8	7.7			
	S09	11.7 – 11.9	Clay	47.0									
	S10	12.8 – 13.1	Clay	45.9	0.3	0.8	3.0	1.8	22.7	71.4	88	25	63
	S12	16.2 – 16.3	Clay	60.4									
TH23-08	S03	3.4 – 3.7	Clay	53.2									
	S04	5.5 – 5.6	Clay	44.5									
	S06	8.5 – 8.7	Clay	47.8							88	24	64
	S10	14.6 – 14.9	Clay	65.7									
	S12	17.4 – 17.7	Silt Till	22.3	10.2	6.1	10.2	14.1	32.9	26.5			
TH23-09	S02	3.4 – 3.5	Clay Fill	48.3									
	S03	4.3 – 4.4	Clay	39.3									
	S04	5.2 – 5.5	Clay	52.8									
	S05	7.3 – 7.5	Clay	45.0									

4.0 SITE STRATIGRAPHY

The stratigraphy at the site consists of pavement with granular fill overlaying clay with thin silt to clayey silt deposit at shallow depths. Beneath the silt deposit is an extensive layer of high plasticity clay overlying glacial silt till. Clay fill was encountered beneath the pavement structure in some test holes as well as within the alignment of the former McLeod Creek in test holes TH23-04, TH23-08, and TH23-09. Sand with gravel fill was encountered throughout the full depth of the Bergen Cutoff embankment in test hole TH23-07.

The overburden stratigraphy has been divided into five (5) layers, as follows:

- Pavement structure;
- Fill;
- Silt;
- Clay; and
- Glacial till

The division of the soil layers is based on visual classification in the field and laboratory testing.

4.1 Pavement Structure

Pavement structure was encountered in test holes TH23-01, TH23-03, and TH23-05. The pavement structure at the site generally consisted of asphalt overlying concrete and a thin layer of granular base material. The typical thickness of the asphalt and concrete was 0.2 m. The granular base material ranged in thickness from 0.3 to 0.6 m. A thin layer of granular base was also encountered from grade in test holes TH23-02 and TH23-04 with a thickness of 0.1 m and 0.6 m, respectively.

4.2 Bergen Cutoff Abandoned Railway Embankment

Test hole TH23-07 was drilled from the crest of the Bergen Cutoff embankment. The embankment fill consists of silty sand with gravel fill. The sand fill was light brown in colour, damp to moist, compact, well graded, with gravel, and contained some silt, and trace clay. The moisture content of the sand with gravel fill ranges from 6% to 10%. This material is water bearing and may be problematic to deal with during construction as it is anticipated to be encountered during trenchless construction beneath the Bergen Cutoff embankment. Contractors should select a pipe installation method that is suitable for this type of granular material.

Water bearing fine to coarse grained gravel were encountered between approximately El. 215.66 m and El. 224.16 m. Poor recovery on the solid stem augers was also observed between approximately El. 227.76 m to El. 225.66 m.

4.3 Clay Fill

A layer of clay fill was encountered in test holes TH23-01, TH23-02, TH23-04, TH23-08, and TH23-09. The clay fill material ranged in thickness from 0.4 to 3.6 m. In general, the clay fill thickness is greater along the historic alignment of McLeod Creek (TH23-04, TH23-08, and TH23-09). The clay fill ranged from black and

grey to brown in colour, moist, firm to stiff in consistency, of intermediate to high plasticity, and contained organics, trace silt, trace sand, and trace gravel.

In test hole TH23-04, silty clay fill was encountered above the native clay deposit at El. 224.0 m, and free water was observed on the drilling augers below the interface of these two materials.

In test hole TH23-08, a thin 0.3 m thick layer of well graded sand with gravel fill was encountered within the clay fill.

4.4 Silt (ML)

A silt to clayey silt layer approximately 0.3 to 1.1 m thick was encountered in test holes TH23-01, TH23-02, TH23-03, TH23-05, and TH23-06 between approximate elevations El. 223.0 m and 228.5 m. The silt to clayey silt layer was brown in colour, moist, soft to firm, non-plastic, and contained trace clay. Seepage is commonly observed within this silt layer. There may be a perched groundwater table within the silt layer. The moisture content from two tests was approximately 22%. The Atterberg Limits of the silt deposit from one test indicated a Liquid Limit of 23%, Plastic Limit of 18%, and Plasticity Index of 5%.

4.5 Clay

Underlying the fill and silt is a glaciolacustrine clay deposit. In test holes TH23-07, TH23-08, and TH23-09, the glaciolacustrine clay was typically observed below a thin layer of dark grey to black organic clay situated below the fill materials.

In decreasing occurrence, typically the predominant mineral composition of the lacustrine clay consists of montmorillonite (a member of the smectite family), illite, kaolinite, and some mica (Graham and Shield, 1985). An extensive layer of high plasticity clay was encountered between approximate elevations El. 222.0 m and 227.0 m. The thickness of the high plasticity clay varied from 14.3 m to 16.3 m (for test holes advanced to refusal). This deposit will be encountered during the excavation for the shafts and along the proposed pipe alignment and during excavation. The upper layer was brown to mottled brown in colour and extended to approximate elevations ranging between El. 218.6 m and 224.4 m. The upper clay deposit was moist, stiff in consistency, and of high plasticity. The upper clay is highly fissured with the frequency of fissure decreasing with depth. The lower clay deposit was grey, moist to wet with increasing depth, of high plasticity, and firm to stiff in consistency, generally becoming softer with depth.

The clay deposit contained trace to some silt inclusions, trace gypsum inclusions, and trace fine to coarse grained sand and fine grained gravel. These non-plastic, non-clay materials generally occur throughout the clay deposit as varves, veins, seams, inclusions or pockets that are typically less than a centimeter in diameter. The tendency for horizontal orientation of the varves, veins, and seams introduce a visible macrostructure to the clay and are a contributing cause for the observed anisotropy in horizontal permeability and strength in the deposit. Quigley (1968) offers the explanation that frozen silt lumps were rafted into glacial Lake Agassiz by icebergs and dropped into the clays as frozen lumps. Baracos (1977) provided a more likely explanation, considering the sharply defined boundaries of the inclusions, that they were deposited not frozen, but as cemented or lithified material which subsequently disintegrated into silt.

The moisture content in the clay ranged from 39% to 66%. Atterberg Limit test within the brown and grey clay has shown the brown clay is typically more plastic than the underlying grey clay. Liquid Limits in the brown clay ranged from 88% to 110%, and the Plasticity Index from 63% to 110%. The Liquid Limits from one sample in the grey clay was 88%, and the Plasticity Index was 61%.

Undrained shear strengths are generally higher within the upper clay zone with strengths decreasing approximately uniformly with increasing depth below 4 to 5 m. The higher undrained shear strength within the upper brown clay and lower shear strengths at depths near the glacial till is caused by weathering near the ground surface and decreasing over consolidation ratios to approximately normally consolidated conditions near the bottom of the deposit. The undrained shear strength, as estimated from the field Torvane, in the upper clay varied from 40 to 90 kPa with an average of 60 kPa. In the lower clay, the undrained shear strength varied from 10 to 85 kPa with an average of 45 kPa. Figure 2 shows variation of undrained shear strength in the clay deposit with elevation.

4.6 Glacial Till

Silt till deposit was encountered below the clay deposit at elevations ranging between approximate elevations El. 210.2 m and 211.1 m. Test holes TH23-02, TH23-03, and TH23-08 were advanced through the silt till to power auger refusal. Test hole TH23-05 was also advanced to refusal; however, the silt till deposit was not observed. The silt till was brown to grey in colour, moist to wet, compact, and contained some to with fine to coarse grained sand, trace to some fine to coarse grained gravel, and some to with clay. Boulders and cobbles are commonly found within the till layer and should be anticipated within the deposit at the project site. The moisture content from two tests ranged from 22% to 24%.

4.7 Seepage, Sloughing and Ground Water Observations

Water infiltration was observed in six (6) of the test hole after drilling. The elevation of the water immediately after drilling ranged from 217.14 (TH23-03) to 224.94 (TH23-05). Some sloughing and squeezing was observed during the drilling program. Sloughing was encountered around El. 224.81 m in test hole TH23-05. Test holes TH23-07 and TH23-08 caved in to approximate El. 224.16 m and El. 212.06 m, respectively.

As mentioned above, a total of eight (8) vibrating wire piezometers and four (4) standpipe piezometers were installed. The piezometric levels are summarized in Table 2. It should be noted that groundwater levels will fluctuate seasonally and following precipitation events.

In general, a downward gradient from the clay into the silt till was observed from the groundwater readings. The groundwater readings in the upper clay ranged from El. 224.75 to 226.92 m, and the lower clay immediately above the silt till ranged from El. 223.55 to 224.93 m. The groundwater reading within the silt till ranged from El. 217.63 to 224.44 m (TH23-08). Note that the piezometric pressures in the till was at El. 224.44 m in late April 2023 when the Red River level was high (El. 226.36 m).

Details of the piezometer installations are included on the borehole logs in Appendix A.

5.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

5.1 Trenchless Pipe Construction Methods

It is our understanding that a portion of the work will be installed using trenchless methods with pipe diameters ranging from 375 to 900 mm. The most viable trenchless pipe methods suitable for the proposed work and readily available locally for installing the land drainage sewer pipe are the Atkins method, Auger/Thrust Boring, Pipe Ramming, Horizontal Directional Drilling (HDD), and Microtunneling.

5.1.1 CONSIDERATIONS FOR ATKINS METHOD

The Atkins pipe jacking method is a variation of Atkins traditional coring method. This method requires a shaft at both ends of the pipe length to be installed. Three steel rods are driven through from shaft to shaft along the centre of the proposed pipe alignment. A push-pull earth coring knife is attached to the center rod and the front cutting and shielding rim is attached to the two outer rods. The first pipe section is placed so that it abuts to the front cutting and shielding rim securely. A pulling and holding rim connected to the outer rods and secured against the back of the pipe section is used to advance the pipe forward. The rods are pulled, or jacked, towards the opposite shaft to move the whole assembly through the soil. The spoil is removed from the coring knife as necessary by pushing the knife outward. Once a pipe section is installed, additional sections are added, and the installation process continues.

This method can be utilized to install the proposed land drainage system pipe sizes; however, the drive length between shafts is limited to 25 to 35 m. The Atkins boring knife or cutting head configuration at the boring face offers limited protection against face instability in cohesionless soils and below the water table.

5.1.2 CONSIDERATIONS FOR AUGER/THRUST BORING

Auger boring is ideal for installing pipe in relatively soft stable ground conditions such as clay located above the water table. The soil within the pipe is retained during auger boring to reduce the likelihood of ground settlement from excavation, making auger boring a popular installation method for installing utilities under highways, railways, and levies where potential settlement is a concern.

The auger boring process uses an auger boring machine to rotate an auger placed within the pipe and fitted to a cutter head at the front of the pipe. The rotating cutter head, which is slightly larger in diameter than the pipe, excavated the soil in front of the pipe. The soil is transported back to the launching where it is removed by hand or machine. The auger boring machine advances along a track, which is aligned to drive the casing pipe on the designed grade. Once the machine reaches the end of the track arrangement, the auger chain is disconnected from the machine and the machine is moved back to the original starting point on the track where a new casing pipe segment and auger chain is connected to the machine and to the existing chain/cutter head. The excavation and thrust process is repeated until the project is completed. The auger chain is then withdrawn from the casing pipe and the pipe is cleaned of all remaining soil and ready to use.

5.1.3 CONSIDERATIONS FOR PIPE RAMMING

Pipe ramming is a non-steerable trenchless installation technique executed by driving an open-ended casing (mainly steel) from a launch pit to a receiving pit using percussive blows from a horizontal pneumatic

hammer. Similar to auger boring, the pipe and hammer advance along the track arrangement, which is aligned to drive the casing pipe on the designed grade. Once the hammer reaches the end of the track arrangement, it is moved back to the original starting point on the track where a new casing pipe segment is welded to the previous segment, and the hammer is connected to the tail end of the new segment. The ramming process is repeated until the project is completed. The pipe ramming process can be coupled to a pilot tube system to improve the accuracy of line and grade.

The soil remains in the casing until the installation drive is completed and then may be removed by water, augering, jet-cutting, or compressed air. Only the soil equivalent to the thickness of the pipe is displaced around the pipe during the process. Pipe ramming is popular for the installation of conduits beneath highway and railway embankments as the method requires minimal annular overcut and retains the embankment soil inside the pipe until the installation is complete, resulting in a reduced likelihood of ground loss and settlements. Pipe ramming is a viable installation method for variable ground conditions both above and below the water table provided the diameter of the pipe is large enough to accept larger obstructions (i.e. boulders). This method is considered suitable for the pipe crossing beneath Bergen Cutoff embankment.

5.1.4 CONSIDERATIONS FOR HDD METHOD

HDD is a technique used for installing pipes and utility lines below the ground surface that uses a surface-mounted drill rig that launches a drill string at an essentially horizontal or shallow angle relative to the ground surface and has tracking and steering capabilities achieved by controlling the orientation of the drill head. The procedure uses either fluid jet, mechanical cutting, or both, with a controlled volume of drilling fluid to help stabilize the borehole, remove cuttings, provide lubricant for the drilling string and pipe, and cools the drill head. The drill string creates a pilot bore hole which is incrementally reamed during subsequent drilling passes, The pipe or utility is then pulled back through the borehole once the desired diameter is achieved. HDD is a viable installation method for variable ground conditions and below the water table.

5.1.5 CONSIDERATIONS FOR MICROTUNNELING

Microtunneling is a remote-controlled, guided, pipe-jacking operation that provides continuous support to the excavation face is a key feature of microtunneling, distinguishing it from traditional open-shield pipe-jacking. Microtunnel Boring Machines (MTBMs) have been used extensively and successfully to install gravity flow sewer lines requiring precise line and grade in weak clay soil deposits.

Microtunneling installation technique requires a jacking shaft from which the pipe installation starts and a reception shaft at the opposite end of the pipeline to retrieve the MTBM which would be used to excavate underground along the pipe alignment. The MTBM is pushed into the earth by hydraulic jacks mounted and aligned in the jacking shaft. The jacks are then retracted, and the slurry lines and control cables are disconnected. The pipe or casing to be installed is lowered into the shaft and inserted between the jacking frame and the MTBM or previously jacked pipe. Slurry lines and power and control cable connections are made, and the pipe and MTBM are advanced another drive stroke. This process is repeated until the MTBM reaches the reception shaft. Upon drive completion, the MTBM and trailing equipment are retrieved, and all equipment removed from the pipeline.

MTBMs have a rotating cutting head to excavate the ground material; the spoil is transported through conveyor or piping system back to the jacking/launching shaft. The cutting head is turned by a hydraulic or electric motor while a pressurized slurry mixing chamber behind the cutter head maintains face stability. MTBMs are capable of independently counter-balancing earth and hydrostatic pressures. Earth pressure is counter-balanced by careful control of advance rates and excavation rates of spoil materials. Groundwater pressure is counterbalanced by using pressurized slurry in the soil-mixing chamber of the MTBM.

5.2 Launching and Receiving Shafts

For trenchless installation of the pipe launching and receiving shafts are required. The shafts will be constructed primarily within the clay deposit and may extend into the underlying till. General design and construction considerations are outlined below:

- The shaft locations will be used to launch and/or receive the TBM and provide space for construction activities;
- The shaft will be excavated through the clay. Shoring may penetrate into the glacial till depending on the shaft depth;
- The Contractor is responsible for the design of the shoring and temporary support systems at the shaft locations;
- The temporary support systems must be designed to resist lateral earth pressures, lateral hydrostatic pressures, surcharge of equipment/material stockpiled adjacent to the shaft and control ground movements;
- Groundwater monitoring data is included on Table 2. A base slab capable of resisting buoyancy and basal heave is required at the shaft locations unless the Contractor can demonstrate that heave is not a concern and that pressures can be relieved in a controlled manner.
- The design of the shaft complied with Manitoba Workplace Safety and Health Act and Regulation. The Contractor shall be required to submit design details and drawings for their shafts to the City of Winnipeg for approval; and
- All seepage water pumped from the shaft locations will be discharged according to City of Winnipeg requirements.

5.2.1 BASE HEAVE

The base of excavation and shoring should be designed to achieve a minimum factor of safety of 1.5 with respect to basal heave. Installation of groundwater monitoring instrumentation may be required at shaft locations to measure the piezometric elevation in the vicinity of the shaft during construction. Depending on the groundwater conditions at the time of construction, groundwater dewatering and/or depressurization may be required to achieve the specified factor of safety against basal heave.

5.2.2 CARE AND CONTROL OF WATER

In order to maintain safe working conditions in the excavation and to protect against instability of the excavation base, water will not be allowed to accumulate anywhere within the excavations. Effective drainage and sump pump systems will be required below the base of excavation to maintain a firm, dry working surface. The Contractor shall design the internal drainage system to efficiently collect groundwater

seepage and all water inflow draining into the excavation shall be pumped out and treated or use a watertight concrete slab designed to resist uplift. The Contractor will be responsible to prevent surface runoff from entering the excavation.

5.3 Tunneling

Trenchless pipe installation will be required for a portion of the work. General design and construction considerations for tunneling are outlined below:

- The Contractor must pick suitable equipment to properly handle the excavated material and groundwater conditions;
- The tunnel will generally be installed within the clay layer up to 5.0 m below grade. At the Bergen Cutoff embankment, the tunnel will be installed through the sand with gravel fill up to 10 m below the crest of the embankment;
- The clay layer has a very high swelling potential, and mitigation measures such as increasing the size of the overcut may be required depending on the trenchless pipe installation method selected by the Contractor. Furthermore, any activity that may result in a drastic change in the moisture content of the clay (drying or wetting) may aggravate the potential for swelling and should be avoided; and
- The Contractor is required to collect and discharge groundwater flows according to City of Winnipeg requirements.

5.3.1 STICKINESS POTENTIAL AND CLOGGING RISKS

The clay deposit present at the site has a tendency to develop sticky behaviour (adhesion of clay material to each other or to a metal surface). This stickiness may result in the clogging and blockage of the cutterhead, tooling, work chamber, screw conveyors, muck carts, conveyors, slurry lines, or prevent the shield advancement due to excessive friction.

The potential for clogging while tunneling through the clay formation was evaluated using the chart suggested by Hollmann and Thewes (2013). Atterberg limits (Liquid limit, Plastic limit, and natural moisture content) of clay samples tested in the Laboratory and their Plasticity Indices were plotted on Figure 3 to determine the corresponding clogging potential of the clay. It should be noted that the Hollman and Thewes chart (Figure 3) was developed from data collected from fluid supported shield drives, but are assumed to be applicable to other tunneling methods. Based on the Hollmann and Thewes chart the clay deposit at the site has high stickiness and strong clogging potential.

The additional effort that will be required for cleaning clogged components may lead to significant reduction in productivity and increased cost. Therefore, the tunneling system and separation plant (for a slurry supported shield drive) used for this project should be designed to mitigate this potential clogging problem. Thewes and Burger (2004) suggested the following upgrades to the design of the TBM to mitigate the risk of clogging:

- Enlarge passages and other obstructions in the transport of clay chips from the tunnel face to the slurry line;
- Increase the ratio of suspension flow rate to the volume of excavated soil to prevent accumulation of clay in the chamber (circuit and flushing concepts);

- Avoid clay agglomeration by increasing agitation in areas prone to material settlement; and
- Avoid closed-type cutting wheels.

Other mitigating measures include optimizing the cutting tools' penetration to get a favourable clay chip size, the use of chemical additives and provision of high-pressure water jets in the cutter head chamber.

5.3.2 POTENTIAL DIFFICULT GROUND AND GROUNDWATER CONDITIONS BELOW THE BERGEN CUTOFF

The sand with gravel fill comprising the Bergen Cutoff embankment was encountered within the approximate elevations of the proposed LDS pipe alignment. Sloughing during drilling and cave-in of the test hole upon completion of drilling were observed in TH23-07 within the approximate proposed pipe elevations. Groundwater monitoring data is summarized on Table 2 and indicates that the sand with gravel fill within the elevation of the pipe is water bearing based on the readings from TH23-08. The Contractor should select a pipe installation method that is suitable for this type of granular material. The Contractor should assume that dewatering of the cohesionless soils will be required for the trenchless installation and shafts excavation through the Bergen Cutoff embankment.

Cobbles and boulders up to 1.2 m in diameter were observed to be exposed at ground surface along the south slope and toe areas of the Bergen cutoff embankment in the vicinity of the proposed pipe alignment as shown in Photos 1 to 3. The Contractor should select an appropriate installation method to handle the boulder-sized material below grade.

PHOTO 1: BOULDERS OBSERVED EAST OF EXISTING CONCRETE ARCH CULVERT

PHOTO 2: BOULDERS OBSERVED NEAR APPROXIMATE PIPE ALIGNMENT

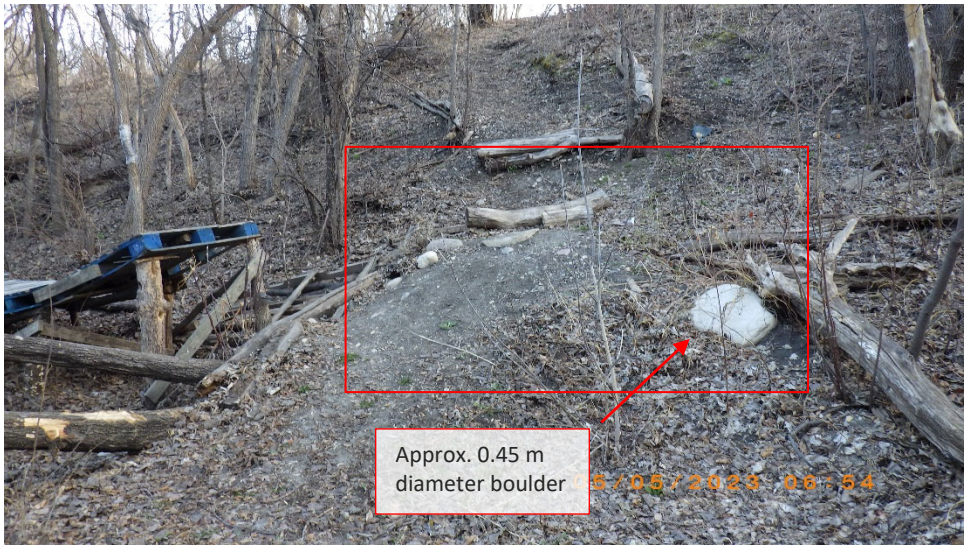


PHOTO 3: BOULDERS OBSERVED WEST OF PROPOSED PIPE ALIGNMENT

5.4 Excavations

Temporary excavations will be required to facilitate the construction of the proposed LDS pipe sewer. All excavation work is required to be performed in accordance with the Workplace Safety and Health Act and Part 26 of the Manitoba Workplace Safety and Health Regulation, M.R. 217/2006.

Excavations performed adjacent to the existing roadway or infrastructure require temporary shoring or bracing. Excavations deeper than 1.5 m are required to be designed and approved prior to construction by an experienced professional engineer with an expertise in geotechnical engineering. The shoring design should

account for all applicable surcharge loads. Opening and voids behind shoring lagging or sheet piles will be backfilled with cement grout.

The silt layers are known to be water bearing and are susceptible to strength loss when subjected to mechanical disturbance and sloughing from wetting. All open excavation side slopes will be covered with waterproof material to prevent saturation of the soil and all surface runoffs will be directed away from the excavations. The Contractor will maintain all surcharge loads such as stockpiled soil, equipment, etc. a minimum of 10 m away from the edge of excavations.

During the site investigations water infiltration was observed in some of the test holes as discussed in Section 4.7. Temporary pumping may be required as well as potential shoring. The design of the above measures depends on the size, depth, and extent of the excavation.

5.4.1 IMPACT ON EXISTING STRUCTURE

Excavation support systems will be designed by the Contractor to control ground movement/subsidence around the perimeter of the excavation. Potential settlement of the ground surface adjacent to temporary shoring system should be recognized and accounted for in the design. Any resulting movement/settlement around the perimeter of the excavation and of utilities, roadways, and buildings must be kept with acceptable limits.

The excavation and shoring system will be designed by a professional engineer with extensive relevant experience and the works must be inspected and certified by the same professional engineer to verify that the temporary structure has been installed according to the design.

5.4.2 BASE HEAVE

The stability of the bottom of the excavation could be compromised if the high plastic clay is overstressed and allowed to shear. The base of excavation and shoring should be designed to achieve a minimum factor of safety of 1.5 with respect to basal heave.

5.4.3 CARE AND CONTROL OF WATER

The base of the excavations may be below the groundwater level during construction. In order to maintain safe working conditions in the excavation and to protect against instability of the excavation base, the water should not be allowed to accumulate anywhere within the excavations or to within 0.5 m below the lowest point within the excavation. Therefore, it will be important to have an effective drainage and sump pump system below the base of excavation, and to maintain a firm, dry working surface. The drainage system should be designed to efficiently collect groundwater seepage and surface water drainage within the excavation so it can be pumped out and treated. Surface run-off resulting from rainfall should be controlled and prevented from entering into the excavation.

5.5 Lateral Earth Pressures

For design purposes the soils may be assigned active, at-rest, and passive lateral earth pressure coefficients as shown in Table 4.

TABLE 4: LATERAL EARTH PRESSURE COEFFICIENTS

Backfill Material	ϕ'	K_a	K_o	K_p
Till	25°	0.41	0.58	2.46
Native Clay	18°	0.53	0.69	1.89
Well Graded Compacted Granular	35°	0.27	0.43	3.69

5.6 Groundwater Management and Spoil Disposal

The Contractor is expected to be familiar with and follow all local spoil disposal regulations including all monitoring, analysis, permits, and treatment required by the City of Winnipeg. Transportation and disposal of spoil material is required to comply with all applicable laws and regulations. The Contract will be required to obtain all necessary permits/approvals for the discharge of groundwater. Routine monitoring of groundwater discharge quality by the Contractor will be required during construction.

5.7 Frost Penetration

The expected depth of frost penetration has been estimated assuming a design freezing index of 2680°C days, taken as the coldest winter over a ten (10) year period. The estimated maximum depth of frost penetration is 2.5 m assuming no insulation cover.

5.8 Corrosion Potential

The degree of exposure of concrete in contact with soils to sulphate attack is classified in CAN/CSAA23.1-M94 (Concrete Materials and Methods of Concrete Construction) as moderate (S-3), severe (S-2) or very severe (S-1). All concrete utilized in foundation elements should have a minimum specified 28-day compressive strength of 35 MPa and class of exposure of S-1, corresponding to very severe sulphate attack. A maximum water to cement ratio of 0.40 should be specified in accordance with Table 2, CSA A23.1-09 for concrete with very severe sulphate exposure (S-1). Concrete which may be exposed to freezing and thawing should be adequately air entrained to improve freeze-thaw durability in accordance with Table 4, CSA A23.1-09.

6.0 CLOSURE

The geotechnical investigation conducted by KGS Group describes the underlying soil and groundwater conditions at the test hole locations along the proposed alignment for the McLeod Creek Drainage Improvements project. This report presents the geotechnical engineer's best judgement of the subsurface and ground conditions anticipated to be encountered at the project site during construction. In order to develop the design, it was necessary to interpolate between the test holes that were at the site. While the actual conditions encountered in the field are expected to be within the range of conditions discussed in this document, the spatial variability of subsurface and groundwater conditions that would be encountered at the site may be more complex than the simplified interpretation presented in this report.

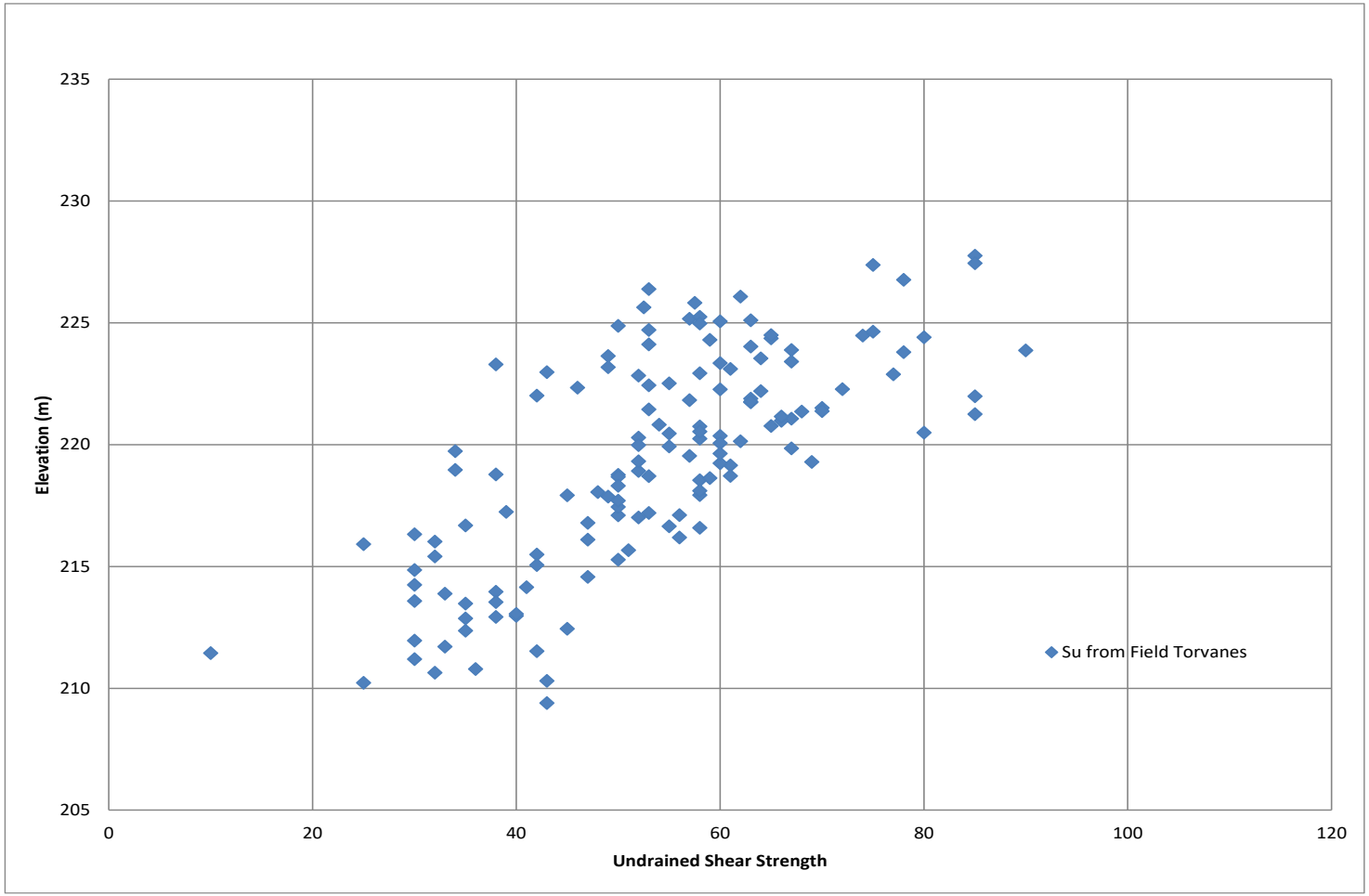
To facilitate project design, certain assumptions were made with respect to the construction methods and on the level of workmanship that can reasonably be expected for the construction of a land drainage sewer project. It should be noted that the Contractor's selected equipment, means, methods, and workmanship will influence the behaviour and performance of the subsurface soils encountered at the site.

Full-time inspection by qualified geotechnical personnel is recommended during construction to ensure that design intent is achieved and address any issue that may arise due to variability in soils condition.

7.0 REFERENCES

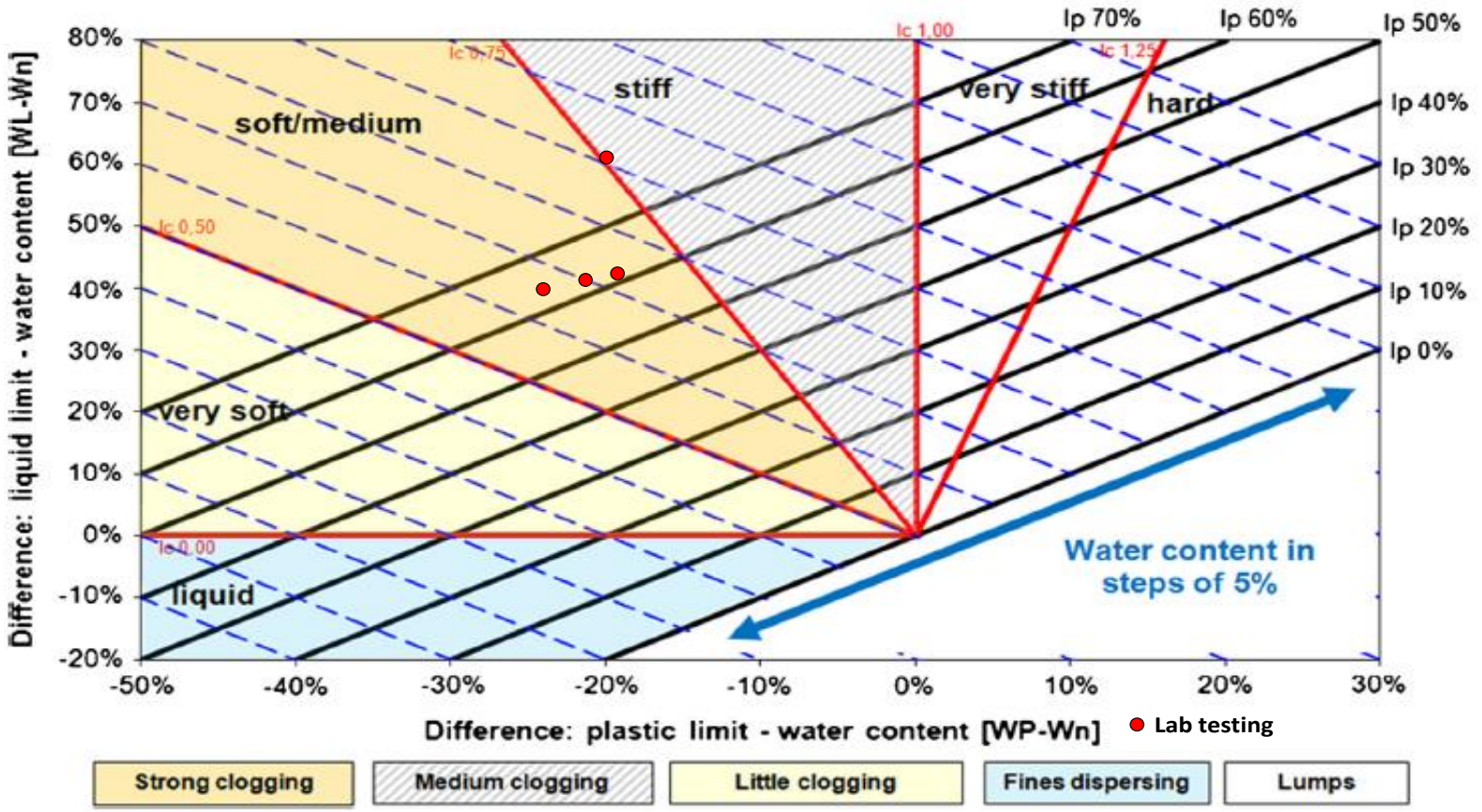
1. Department of Geological Engineering, the University of Manitoba, (1983). Geological Engineering Report for Urban Development of Winnipeg.

FIGURES



NOTES:

KGS GROUP	Winnipeg
McLeod Creek Drainage Improvements	
Geotechnical Factual Report	
Undrained Shear Strength of Clay Deposit	
April 2023	Figure 2
0 Rev	



NOTES:

KGS GROUP	Winnipeg
McLeod Creek Drainage Improvements	
Geotechnical Factual Report	
Clogging Potential of the Clay Deposit	
April 2023	Figure 3 — 0 Rev

APPENDIX A

2023 Test Hole Logs

KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-01

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	228.99 m
LOCATION	Winnipeg, Manitoba	**START DATE**	3-13-2023
DESCRIPTION	Kildonan Dr. northbound lane in front of 1191 Kildonan Dr.	**UTM (m)**	N 5,533,934.56
DRILL RIG / HAMMER	CME-75 Truck Mounted Drill with Auto-Hammer		E 636,753.67 Zone 14
METHOD(S)	0.0 m to 12.2 m: 125 mm ø SSA		

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	SAMPLE TYPE	NUMBER
				ASPHALT - Black.	228.9			
				CONCRETE - White.	228.8			
				SAND & GRAVEL FILL - Light brown, frozen.	228.2			
228	1.0			**CLAY FILL** - Dark brown, intermediate to high plasticity, frozen, trace silt inclusions.				
	1.5	5						
227	2.0			- Moist, firm below 1.8 m.	226.9			
	2.5			**SILT** - Brown, moist, firm, low plasticity, some to with clay.				S1
226	3.0	10			225.9			
	3.5			**CLAY** - Brown, moist, stiff, high plasticity, trace silt inclusions, trace gypsum inclusions.				
225	4.0							S2
	4.5	15						
224	5.0							
	5.5							S3
223	6.0	20						
	6.5			- Grey below 6.4 m.				
222	7.0							S4
	7.5	25						
221	8.0			- Trace to some silt inclusions below 7.9 m.				
	8.5							S5
220	9.0	30						
	9.5							
219	10.0			- Trace fine grained gravel below 9.9 m.				
	10.5	35						S6
				- Some silt inclusions, trace coarse grained sand below 10.7 m.				
218	11.0							S7
	11.5							
217	12.0	40			216.8			
	12.5			Notes:				
216	13.0			1. End of test hole at 12.19 m.				
	13.5	45		2. Test hole remained open to 12.19 m upon completion of drilling/digging.				
215	14.0			3. Test hole backfilled with auger cuttings.				
	14.5			4. Asphalt cold patch at surface.				
214	15.0							

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** on 3-13-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**
INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE
DATE 4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-02

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	230.04 m
LOCATION	Winnipeg, Manitoba	**TOC STICK-UP / ELEV.**	-0.03 m / 230.01 m (Standpipe)
DESCRIPTION	Turnaround at north end of 1218 Kildonan Dr.	**START DATE**	3-13-2023
DRILL RIG / HAMMER	CME-75 Truck Mounted Drill with Auto-Hammer	**UTM (m)**	N 5,534,314.28
METHOD(S)	0.0 m to 20.4 m: 125 mm ø SSA		E 636,685.35 Zone 14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	LOG OF INSTALLS: DIAGRAM	LOG OF INSTALLS: DEPTH (m)	SAMPLE TYPE	NUMBER
230	0.0	0		**SAND & GRAVEL FILL** - Light brown, frozen.	230.0					
	0.5			**CLAY FILL** - Grey and black, stiff, intermediate plasticity, frozen, some silt, trace sand.						
229	1.0									
	1.5	5			228.5					
				SILT - Brown, moist, soft, non-plastic.	228.1					
228	2.0			**CLAY** - Brown, moist, stiff, intermediate plasticity, some silt.						
	2.5			- Silt pocket from 2.4 m to 2.6 m.						
227	3.0	10			227.0				S1	S1
	3.5			**CLAY** - Brown, moist, stiff, high plasticity, trace silt inclusions, trace gypsum inclusions.						
226	4.0								S2	S2
	4.5	15								
225	5.0									
	5.5								S3	S3
224	6.0	20		- Oxidized silt inclusion at 5.6 m.						
	6.5						Vibrating Wire 161049	6.7		
223	7.0			- LL=110, PL=28, PI=82 at 6.7 m.					S4	S4
	7.5	25								
222	8.0									
	8.5			- Grey below 8.4 m.		▼			S5	S5
221	9.0	30		- Moist to wet, trace to some silt inclusions below 9.1 m.						
	9.5									
220	10.0								S6	S6
	10.5	35		- Trace coarse grained sand, trace fine grained gravel below 10.4 m.						
219	11.0								S7	S7
	11.5			- Firm below 11.3 m.						
218	12.0	40								
	12.5			- Wet, decreasing stiffness below 12.2 m.						
217	13.0									
	13.5	45							S8	S8
216	14.0			- Firm to soft below 13.7 m.						
	14.5								S9	S9
215	15.0									

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 8.53 m on 3-13-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-02

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	LOG OF INSTALLS DIAGRAM	LOG OF INSTALLS DEPTH (m)	SAMPLE TYPE	NUMBER
			- Silt till inclusion, trace fine grained sand at 16.3 m.					S10	
			- Soft below 18.3 m.			Vibrating Wire 161007	18.3	S11	
			SILT TILL - Grey, wet, compact, low plasticity, trace to some medium to coarse grained sand, trace fine grained gravel, trace clay.	211.1			18.9	S12	
				209.6			19.8	S13	
							20.4		

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

Notes:
1. End of test hole at 20.42 m.
2. Refusal encountered in silt till at a depth of 20.42 m.
3. Test hole remained open to 20.42 m upon completion of drilling/digging.
4. Casagrande tip installed from 19.8 m to 20.4 m. Vibrating wire piezometer VW161049 installed at 6.7 m. VW 161007 installed at 18.3 m.
5. Test hole backfilled with silica sand from 20.4 to 19.8 m, bentonite chips from 19.8 to 18.9 m, and grout from 18.9 m to grade.
6. Flush mount well cover installed at grade.

WATER LEVELS ▼ **Upon Completion** 8.53 m on 3-13-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**
INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE
DATE 4-28-2023

KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-03

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	229.33 m
LOCATION	Winnipeg, Manitoba	**TOC STICK-UP / ELEV.**	-0.07 m / 229.26 m (Standpipe)
DESCRIPTION	Kildonan Dr. northbound land in front of 1197 Kildonan Dr.	**START DATE**	3-14-2023
DRILL RIG / HAMMER	CME-75 Truck Mounted Drill with Auto-Hammer	**UTM (m)**	N 5,534,008.66
METHOD(S)	0.0 m to 20.1 m: 125 mm ø SSA		E 636,742.67 Zone 14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	LOG OF INSTALLS: DIAGRAM	LOG OF INSTALLS: DEPTH (m)	SAMPLE TYPE	NUMBER
229	0.5			**ASPHALT** - Black.	229.3					
				CONCRETE - White.	229.2					
				SAND & GRAVEL FILL - Light brown, frozen.	228.9					
228	1.0			**CLAY** - Brown, high plasticity, frozen, trace sand, some silt inclusions.				0.9		
	1.5	5								
	2.0				227.2					
227	2.5			**SILT** - Light brown, moist, soft, low plasticity, trace clay.						
	3.0	10		- LL=23, PL=18, PI=5 at 2.6 m.	226.3				S	S1
226	3.5			**CLAY** - Brown, moist, stiff, high plasticity, trace silt inclusions.					S	S2
	4.0									
225	4.5	15								
	5.0			- Grey below 4.9 m.						
224	5.5			- PSA: 0% gravel, 1% sand, 29% silt, 70% clay at 5.3 m.					S	S3
	6.0	20								
223	6.5						Vibrating Wire 160269	6.4		
	7.0								S	S4
222	7.5	25		- Trace to some silt inclusions below 7.6 m.						
	8.0									
221	8.5									
	9.0	30							S	S5
220	9.5									
	10.0			- Firm below 9.8 m.					S	S6
219	10.5	35		- Some silt inclusions, trace fine grained gravel below 10.7 m.						
	11.0									
218	11.5								S	S7
	12.0	40				▼				
217	12.5									
	13.0			- Silt till inclusion from 12.8 m to 13.1 m.						
216	13.5	45							S	S8
	14.0			- Trace fine grained gravel at 13.7 m.						
215	14.5								S	S9
	15.0									

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 12.19 m on 3-14-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**
INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE
DATE 4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-03

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)
			SILT TILL - Light grey, wet, compact, some fine to coarse grained sand, some fine grained gravel.	210.7
			- Grey, moist, very stiff, high plasticity, and clay, some fine to coarse grained sand below 19.8 m.	209.2

Notes:
1. End of test hole at 20.12 m.
2. Refusal encountered on suspected bedrock at a depth of 20.12 m.
3. Test hole caved to 19.81 m upon completion of drilling/digging.
4. Casagrande tip installed from 19.5 m to 18.9 m. Vibrating wire piezometer VW160269 installed at 6.4 m. VW 161001 installed at 17.4 m.
5. Test hole backfilled with silica sand from 19.8 to 18.6 m, bentonite chips from 18.6 to 18.0 m, and grout from 18.0 to 0.9 m, and bentonite chips from 0.9 m to grade.
6. Flush mount well cover installed at grade.

WATER LEVEL

LOG OF INSTALLS

DIAGRAM: Vibrating Wire 161001

DEPTH (m): 17.4, 18.0, 18.6, 18.9, 19.5, 19.8

SAMPLE TYPE / NUMBER: S10

PL MC LL

Cu TORVANE (kPa) ◆

qu POCKET PEN (kPa) ★

SPT (N) BLOWS/0.30 m ▲

20 40 60 80

WATER LEVELS ▼ **Upon Completion** 12.19 m on 3-14-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-04

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	226.61 m
LOCATION	Winnipeg, Manitoba	**START DATE**	3-14-2023
DESCRIPTION	Back lane between Hawthorne Ave and Irving Pl.	**UTM (m)**	N 5,533,985.34
DRILL RIG / HAMMER	CME-75 Truck Mounted Drill with Auto-Hammer		E 636,806.35 Zone 14
METHOD(S)	0.0 m to 9.1 m: 125 mm ø SSA		

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	WATER LEVEL	SAMPLE TYPE	NUMBER
226	0.5			**SAND & GRAVEL FILL** - Light brown, frozen, well graded.	226.0				
	1.0			**CLAY FILL** - Black, stiff, high plasticity, frozen, with organics.	225.4				
225	1.5	5		**SILTY CLAY FILL** - Grey, moist, stiff, intermediate to high plasticity, some silt. - Trace sand, trace organics below 1.5 m.					
	2.5				224.0				S1
224	3.0	10		**CLAY** - Brown, moist, stiff, high plasticity, trace silt inclusions, trace gypsum inclusions.		- free water observed on exterior of augers below 3.0 m.			
223	3.5								S2
	4.0								
222	4.5	15							
	5.0								
221	5.5								S3
	6.0	20							
220	6.5								
	7.0								S4
219	7.5	25		- Grey, some silt inclusions below 7.6 m.			▼		
	8.0								
218	8.5								S5
	9.0	30		- Firm below 8.8 m.	217.5				
217	9.5			Notes: 1. End of test hole at 9.14 m. 2. Test hole remained open to 9.14 m upon completion of drilling/digging. 3. Test hole backfilled with auger cuttings. 4. Asphalt cold patch at surface.					
	10.0								
216	10.5	35							
	11.0								
215	11.5								
	12.0	40							
214	12.5								
	13.0								
213	13.5	45							
	14.0								
212	14.5								
	15.0								

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 7.62 m on 3-14-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**
INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE
DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-05

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	229.51 m
LOCATION	Winnipeg, Manitoba	**TOC STICK-UP / ELEV.**	-0.08 m / 229.43 m (Standpipe)
DESCRIPTION	Irving Pl. eastbound lane in front of 1209 Irving Pl.	**START DATE**	3-15-2023
DRILL RIG / HAMMER	Acker MP5 Truck Mounted Drill Rig with Auto-Hammer	**UTM (m)**	N 5,534,122.75
METHOD(S)	0.0 m to 20.4 m: 125 mm ø SSA		E 636,756.7 Zone 14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	WATER LEVEL	LOG OF INSTALLS: DIAGRAM	LOG OF INSTALLS: DEPTH (m)	SAMPLE TYPE	NUMBER
229	0.5			**ASPHALT** - Black.	229.4						
				CONCRETE - White.	229.3						
	1.0			**SAND & GRAVEL FILL** - Light brown, frozen.	229.1				0.9		
228	1.5	5		**CLAY** - Brown, stiff, high plasticity, frozen, trace silt inclusions.							
	2.0			- Moist below 2.1 m.							
227	2.5									S	S1
	3.0	10			226.5						
226	3.5			**SILT** - Brown, moist, soft, non-plastic.							
	4.0				225.4						
225	4.5	15		**CLAY** - Brown, moist, stiff, high plasticity, trace to some silt inclusions.		- Sloughing and squeezing around 4.7 m during drilling.	▼			S	S2
	5.0			- Trace gypsum inclusion at 5.0 m.				Vibrating Wire 161189	5.5	S	S3
224	5.5										
	6.0	20									
223	6.5			- Grey below 6.4 m.							
	7.0									S	S4
222	7.5	25									
	8.0									S	S5
221	8.5										
	9.0	30									
220	9.5									S	S6
	10.0			- Some silt inclusions below 10.1 m.							
219	10.5	35		- Trace fine grained gravel at 10.7 m.							
	11.0										
218	11.5									S	S7
	12.0	40									
217	12.5										
	13.0			- Trace coarse sand, trace fine grained gravel from 12.8 m to 13.4 m.							
216	13.5	45								S	S8
	14.0										
215	14.5										
	15.0									S	S9

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 4.57 m on 3-15-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-05

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	WATER LEVEL	LOG OF INSTALLS: DIAGRAM	LOG OF INSTALLS: DEPTH (m)	SAMPLE TYPE	NUMBER	PL MC LL; Cu TORVANE (kPa) ◆; qu POCKET PEN (kPa) ★; SPT (N) BLOWS/0.30 m ▲ 20 40 60 80
214	15.5		- Trace silt inclusions below 15.2 m.								
	16.0										
213	16.5								S10	S10	
	17.0										
212	17.5										
	18.0						Vibrating Wire 161019	18.3	S11	S11	
211	18.5							18.6			
	19.0		- Trace silt inclusions, trace fine to coarse grained gravel from 18.9 m to 20.4 m.					18.9			
210	19.5							19.5			
	20.0			209.1				20.1	S12	S12	
209	20.5		Notes: 1. End of test hole at 20.42 m. 2. Refusal encountered on boulder or bedrock at a depth of 20.42 m. 3. Casagrande tip installed from 20.1 m to 19.5 m. Vibrating wire piezometer VW161189 installed at 5.5 m. VW 161019 installed at 18.3 m. 4. Test hole backfilled with silica sand from 20.1 to 18.9 m, bentonite chips from 18.9 to 18.6 m, and grout from 18.6 to 0.9 m, and bentonite chips from 0.9 m to grade. 5. Flush mount well cover installed at grade.							
	21.0										
208	21.5										
	22.0										
207	22.5										
	23.0										
206	23.5										
	24.0										
205	24.5										
	25.0										
204	25.5										
	26.0										
203	26.5										
	27.0										
202	27.5										
	28.0										
201	28.5										
	29.0										
200	29.5										
	30.0										
199	30.5										
	31.0										
198	31.5										
	32.0										
197	32.5										
	33.0										

WATER LEVELS ▼ **Upon Completion** 4.57 m on 3-15-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-06

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	225.63 m
LOCATION	Winnipeg, Manitoba	**START DATE**	3-15-2023
DESCRIPTION	South toe area of Bergen Cutoff between Kildonan Dr. / Corne St.	**UTM (m)**	N 5,534,250.26
DRILL RIG / HAMMER	Acker MP5 Truck Mounted Drill Rig with Auto-Hammer		E 636,822.1 Zone 14
METHOD(S)	0.0 m to 9.1 m: 125 mm ø SSA		

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	SAMPLE TYPE	NUMBER
225	0.5			**CLAY** - Brown, stiff, high plasticity, frozen, trace silt inclusions.				
	1.0			- Moist below 1.1 m.				S1
224	1.5	5						
	2.0				223.3			
223	2.5			**SILT** - Brown, moist, soft, non-plastic, trace clay.	223.0			
	3.0	10		**CLAY** - Brown, moist, stiff, high plasticity, trace silt inclusions.				S2
222	3.5			- Grey below 3.0 m.				
	4.0			- LL=88, PL=26, PI=62 at 4.0 m.				S3
221	4.5	15						
	5.0			- Trace gypsum inclusions around 4.9 m.				
220	5.5							S4
	6.0	20		- Trace coarse grained sand, trace fine grained gravel below 6.1 m.		▼		
219	6.5							
	7.0							
218	7.5	25						S5
	8.0			- Firm below 7.6 m.				
217	8.5							S6
	9.0	30			216.5			
216	9.5			Notes: 1. End of test hole at 9.14 m. 2. Test hole backfilled with auger cuttings.				
	10.0							
215	10.5	35						
	11.0							
214	11.5							
	12.0	40						
213	12.5							
	13.0							
212	13.5	45						
	14.0							
211	14.5							
	15.0							

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 6.10 m on 3-15-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**	INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE	DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-07

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	233.26 m
LOCATION	Winnipeg, Manitoba	**START DATE**	3-16-2023
DESCRIPTION	Crest of Bergen Cutoff embankment	**UTM (m)**	N 5,534,276.57
DRILL RIG / HAMMER	Acker MP5 Truck Mounted Drill Rig with Auto-Hammer		E 636,837.47 Zone 14
METHOD(S)	0.0 m to 18.3 m: 125 mm ø SSA		

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	SAMPLE TYPE	NUMBER
233	0.5			**SAND WITH GRAVEL FILL (SW-SM)** - Light brown, compact, fine to coarse, frozen, well graded, some silt, trace clay.				
				- Some organics from 0.0 m to 0.1 m.				
	1.0			- Damp to moist below 0.9 m.				
232	1.5	5						S1
	2.0							
231	2.5							S2
	3.0	10		- Some clay around 3.0 m.				
230	3.5							
	4.0							S3
229	4.5	15						
	5.0							S4
228	5.5					- Poor recovery on augers from 5.5 m to 7.0 m.		
	6.0	20						
227	6.5							
	7.0					- Approx. 50% recovery on augers from 7.0 m to 7.6 m.		S5
226	7.5	25		- Pockets of fine to coarse grained gravel from 7.6 m to 9.1 m.		- Difficult drilling from 7.6 m to 9.1 m.		
	8.0							
225	8.5			- PSA: 36% gravel, 45% sand, 13% silt, 6% clay at 8.2 m.				S6
	9.0	30						
224	9.5			- Trace to some clay from 9.1 m to 11.0 m.		- Sloughing around 9.1 m.		
	10.0			- PSA: 26% gravel, 47% sand, 19% silt, 8% clay at 9.8 m.				S7
223	10.5	35						
	11.0				222.3			
222				**ORGANIC SOIL** - Black, moist, compact, non-plastic.	222.0			S8
	11.5			**CLAY** - Brown, moist, stiff, high plasticity, minor oxidation, trace silt inclusions, trace gypsum inclusions.				S9
	12.0	40						
221	12.5			- Brown, trace oxidation from 12.2 m to 14.0 m.				
	13.0			- LL=88, PL=25, PI=63 at 12.8 m.				S10
220				- PSA: 0% gravel, 6% sand, 23% silt, 71% clay at 12.8 m.				
	13.5	45						
	14.0			- Grey below 14.0 m.				
219	14.5							S11
	15.0							

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS

CONTRACTOR **Maple Leaf Drilling Ltd.**
INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE
DATE 4-28-2023

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TEST HOLE LOG

HOLE NO.
TH23-07

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	SAMPLE TYPE	NUMBER
217	16.5	55		- Trace fine to coarse grained sand below 16.2 m.				S12
216	17.5							S13
215	18.0	60			215.0			

PL MC LL

Cu TORVANE (kPa) ◆

qu POCKET PEN (kPa) ★

SPT (N) BLOWS/0.30 m ▲

20 40 60 80

Notes:
1. End of test hole at 18.29 m.
2. Test hole caved to 9.14 m upon completion of drilling/digging.
3. Test hole backfilled with auger cuttings.

WATER LEVELS

CONTRACTOR
Maple Leaf Drilling Ltd.

INSPECTOR
A. SEKKAT

APPROVED
K. FORDYCE

DATE
4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-08

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	227.56 m
LOCATION	Winnipeg, Manitoba	**TOC STICK-UP / ELEV.**	-0.07 m / 227.49 m (Standpipe)
DESCRIPTION	North toe area of Bergen Cutoff, south of Essar Park	**START DATE**	3-16-2023
DRILL RIG / HAMMER	Acker MP5 Truck Mounted Drill Rig with Auto-Hammer	**UTM (m)**	N 5,534,309.35
METHOD(S)	0.0 m to 18.3 m: 125 mm ø SSA		E 636,848.89 Zone 14

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	WATER LEVEL	LOG OF INSTALLS DIAGRAM	LOG OF INSTALLS DEPTH (m)	SAMPLE TYPE	NUMBER
227	0.5			**CLAY FILL** - Dark brown, low to intermediate plasticity, some to with organics, with roots, mild odour, frozen.							
	1.0				226.5				0.9		S1
				SAND WITH GRAVEL FILL - Brown, compact, well graded, frozen.	226.2						
226	1.5	5		**CLAY FILL** - Brown, stiff, high plasticity, frozen, trace silt inclusions, trace gypsum inclusions.							
	2.0			- Moist below 1.5 m.							
225	2.5										S2
	3.0	10			224.5						
				CLAY (CH) - Black, moist, stiff, intermediate to high plasticity, with organics.							S3
224	3.5										
	4.0			- Brown mottled grey, high plasticity, trace silt inclusions below 3.8 m.							
223	4.5	15		- Firm below 4.3 m.			▼				
				- Stiff below 4.6 m.							
	5.0										
222	5.5			- minor oxidation, trace gypsum around 5.5 m.				Vibrating Wire 160291	5.5		S4
	6.0	20									
221	6.5										
	7.0										S5
220	7.5	25									
	8.0										
219	8.5			- LL=88, PL=24, PI=64 at 8.5 m.							S6
	9.0	30		- Grey below 9.1 m.							
218	9.5										
	10.0										S7
217	10.5	35									
	11.0										
216	11.5										S8
	12.0	40									
215	12.5			- Firm, trace coarse grained gravel, trace fine grained gravel below 12.2 m.							
	13.0										
214	13.5	45									S9
	14.0			- Moist to wet below 13.7 m.							
213	14.5								14.6		S10
	15.0										

PL MC LL
Cu TORVANE (kPa) ◆
qu POCKET PEN (kPa) ★
SPT (N) BLOWS/0.30 m ▲
20 40 60 80

WATER LEVELS ▼ **Upon Completion** 4.57 m on 3-16-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-08

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	DRILLING/ DIGGING REMARKS	WATER LEVEL	LOG OF INSTALLS: DIAGRAM	LOG OF INSTALLS: DEPTH (m)	SAMPLE TYPE	NUMBER	PL MC LL; Cu TORVANE (kPa) ◆; qu POCKET PEN (kPa) ★; SPT (N) BLOWS/0.30 m ▲ (20 40 60 80)
212	15.5				- Sloughing and squeezing around 15.5 m during drilling.		Vibrating Wire 161020	15.5 15.8			
211	16.5								S11		
	17.0		- Grey to Brown, moist to wet, soft to firm, intermediate plasticity, with silt, some fine to coarse grained sand, trace fine grained gravel. below 16.9 m.	210.2				17.1			
210	17.5		**SILT TILL** - Brown, moist to wet, compact, low plasticity, with clay, with fine to coarse grained sand, trace fine to coarse grained gravel. - PSA: 10% gravel, 30% sand, 33% silt, 27% clay at 17.4 m.	209.3				17.7	S12		
209	18.5										
208	19.5		Notes: 1. End of test hole at 18.29 m. 2. Refusal encountered on suspected bedrock at a depth of 18.29 m. 3. Test hole caved to 15.54 m upon completion of drilling/digging. 4. Casagrande tip installed from 17.7 m to 17.1 m. Vibrating wire piezometer VW160291 installed at 5.5 m. VW 161020 installed at 15.8 m. 5. Test hole sloughed 17.7 to 15.5 m, backfilled with bentonite chips from 15.5 to 14.6 m, grout from 14.6 to 0.9 m, and bentonite chips from 0.9 m to grade. 6. Flush mount well cover installed at grade.							
207	21.0										
206	22.0										
205	23.0										
204	24.0										
203	25.0										
202	26.0										
201	27.0										
200	28.0										
199	29.0										
198	30.0										
197	31.0										
196	32.0										
195	33.0										

WATER LEVELS ▼ **Upon Completion** 4.57 m on 3-16-2023

CONTRACTOR **Maple Leaf Drilling Ltd.**

INSPECTOR **A. SEKKAT**

APPROVED K. FORDYCE

DATE 4-28-2023

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KGS GROUP

TEST HOLE LOG

HOLE NO.
TH23-09

CLIENT	**CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT**	**PROJECT NO.**	22-0107-024
PROJECT	**McLeod Creek Drainage Improvements**	**SURFACE ELEV.**	227.24 m
LOCATION	Winnipeg, Manitoba	**START DATE**	3-17-2023
DESCRIPTION	Greenspace at 107 Essar Ave.	**UTM (m)**	N 5,534,381.6
DRILL RIG / HAMMER	Acker MP5 Truck Mounted Drill Rig with Auto-Hammer		E 636,895.48 Zone 14
METHOD(S)	0.0 m to 9.1 m: 125 mm ø SSA		

ELEVATION (m)	DEPTH (m)	DEPTH (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	ELEV (m)	WATER LEVEL	SAMPLE TYPE	NUMBER
227	0.0			**TOPSOIL** - Brown, compact, non-plastic, frozen, with organics and roots.	227.2			
	0.5			**CLAY FILL** - Brown, firm, high plasticity, frozen, trace of silt inclusions, trace fine to coarse grained sand, trace fine to medium grained gravel.				
226	1.0							
	1.5	5						
	2.0							
225	2.5			- Brown, moist, stiff, high plasticity, trace silt inclusions.				S1
	3.0	10						
224	3.5			- Light brown, intermediate to high plasticity, some silt below 3.2 m.	223.6			S2
	4.0			**CLAY** - Dark grey, moist, stiff, intermediate to high plasticity, some organics, some roots.				
223	4.5	15						S3
	5.0			- Grey, high plasticity, trace fine grained gravel below 4.6 m. - Brown, moist, minor oxidation, trace silt inclusions, trace gypsum inclusions below 4.9 m.				
222	5.5							S4
	6.0	20						
221	6.5							
	7.0			- Grey below 6.9 m.				
220	7.5	25						S5
	8.0			- Silty clay pocket at 7.6 m.				
219	8.5							S6
	9.0	30			218.1			
218	9.5			Notes: 1. End of test hole at 9.14 m. 2. Test hole caved to 8.53 m upon completion of drilling/digging. 3. Test hole backfilled with auger cuttings.				
	10.0							
217	10.5	35						
	11.0							
216	11.5							
	12.0	40						
215	12.5							
	13.0							
214	13.5	45						
	14.0							
213	14.5							
	15.0							

PL MC LL

Cu TORVANE (kPa) ◆

qu POCKET PEN (kPa) ★

SPT (N) BLOWS/0.30 m ▲

20 40 60 80

WATER LEVELS ▼ **Upon Completion** on 3-17-2023 Dry

CONTRACTOR **Maple Leaf Drilling Ltd.**	INSPECTOR **A. SEKKAT**
APPROVED K. FORDYCE	DATE 4-28-2023

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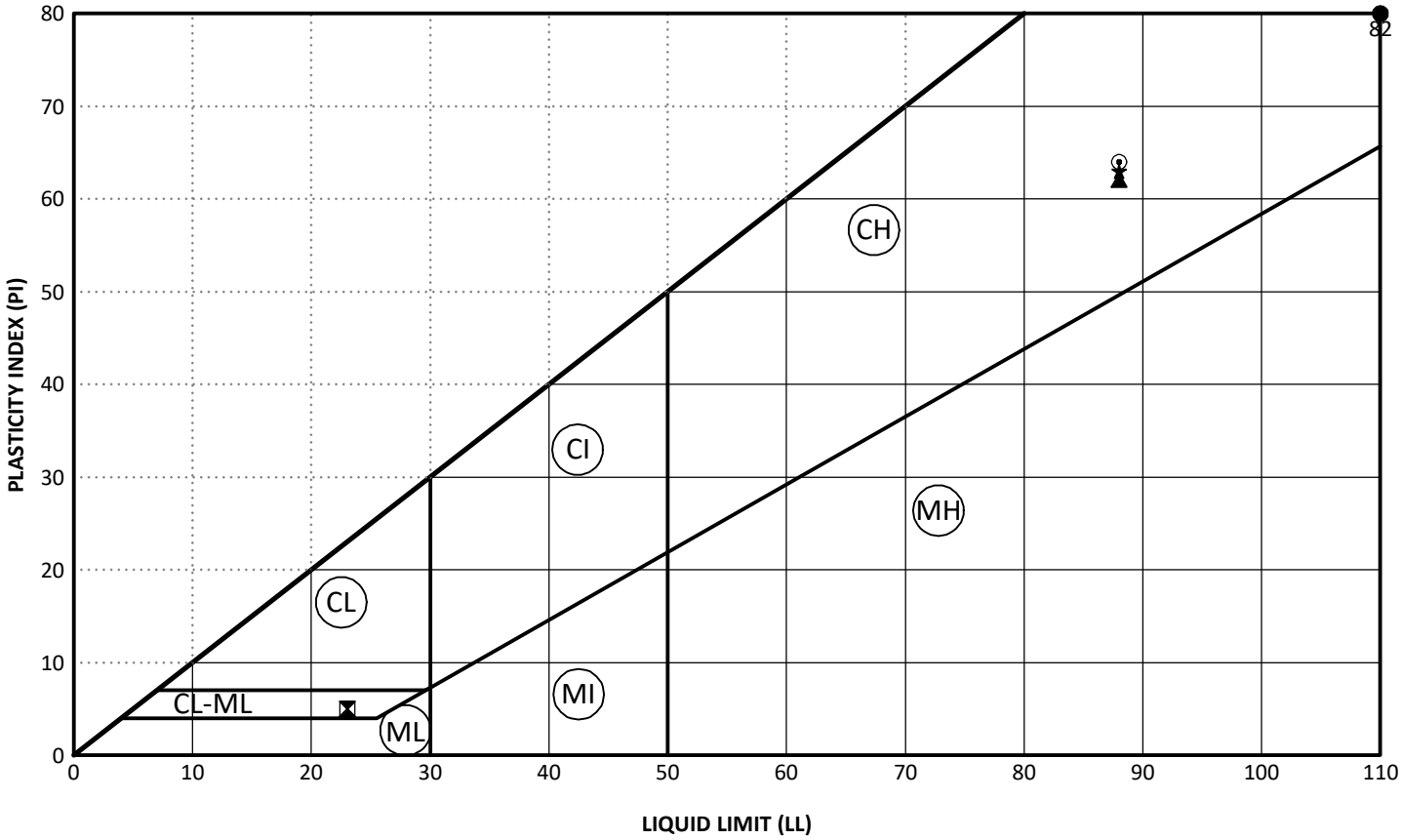
ATTERBERG LIMITS

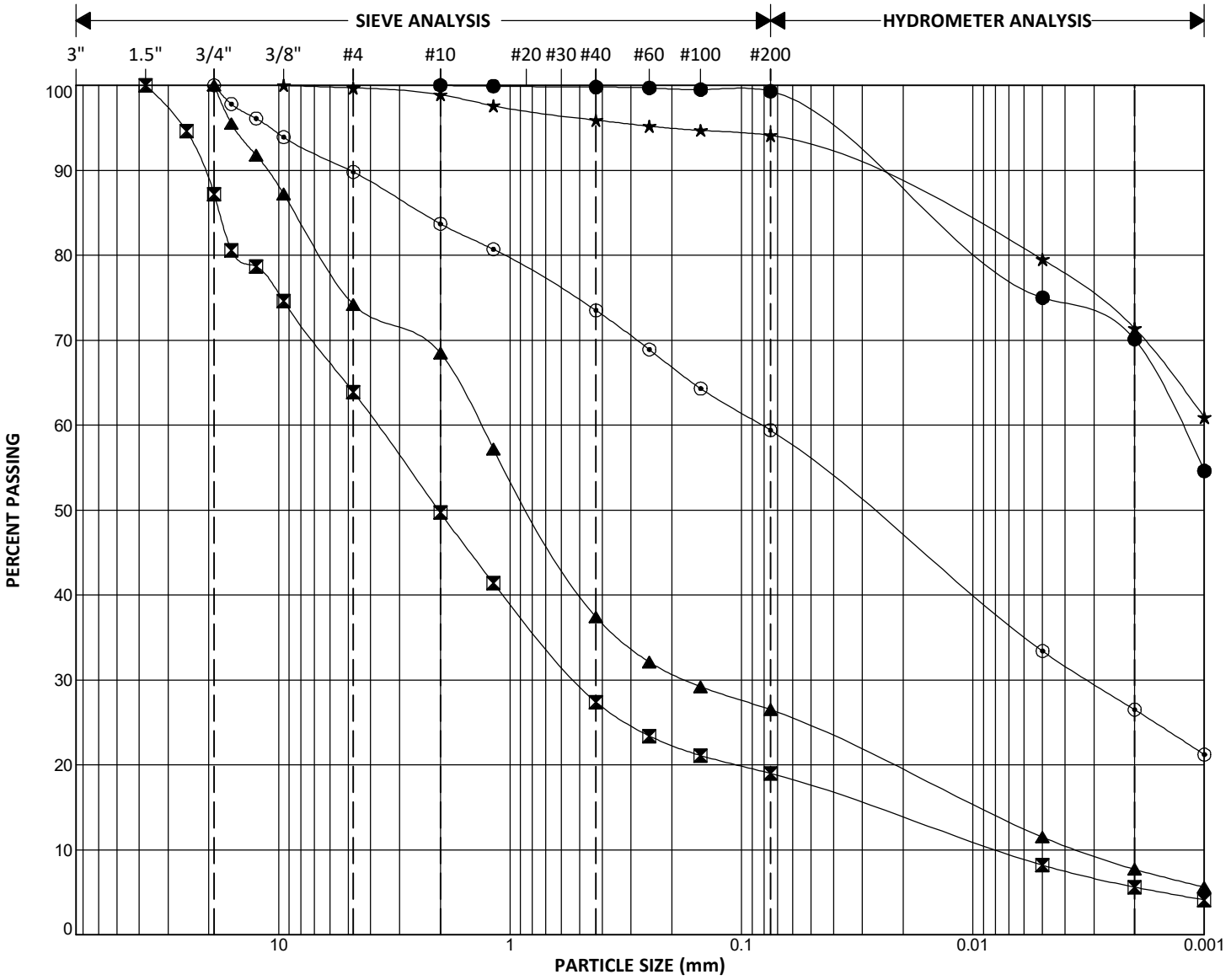


	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	SAND (%)	SILT (%)	CLAY (%)	SILT & CLAY (%)	MC (%)	CLASSIFICATION
●	TH23-02	6.7	S04	110	28	82					48	CH
⊠	TH23-03	2.6	S01	23	18	5					22	CL-ML
▲	TH23-06	4.0	S03	88	26	62					45	CH
★	TH23-07	12.8	S10	88	25	63	6	23	71	94	46	CH
⊙	TH23-08	8.5	S06	88	24	64					48	CH

KGS GROUP

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT NAME McLeod Creek Drainage Improvements
TESTED BY Stantec
PROJECT NO. 22-0107-024
LOCATION Winnipeg, Manitoba

GRAIN SIZE DISTRIBUTION



GRAVEL		SAND			SILT	CLAY
coarse	fine	coarse	medium	fine		

	HOLE	DEPTH (m)	SAMPLE #	GRAVEL (%)	SAND (%)	SILT (%)	CLAY (%)	SILT & CLAY (%)	Cu	Cc	CLASSIFICATION
●	TH23-03	5.3	S03	0	1	29	70	99			CH
⊠	TH23-07	8.2	S06	36	45	13	6	19	477.02	8.97	SM
▲	TH23-07	9.8	S07	26	47	19	8	27	386.17	6.37	SM
★	TH23-07	12.8	S10	0	6	23	71	94			CH
⊙	TH23-08	17.4	S12	10	31	33	27	59			

KGS GROUP

CLIENT CITY OF WINNIPEG - WATER AND WASTE DEPARTMENT
PROJECT NAME McLeod Creek Drainage Improvements
TESTED BY Stantec
PROJECT NO. 22-0107-024
LOCATION Winnipeg, Manitoba

SIEVE ANALYSIS C:\USERS\KFORDYCE\DESKTOP\FMS\22-0107-024\22-0107-024 GINT LOGS.GPJ

APPENDIX B

Laboratory Material Testing Results

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D2216 - LABORATORY DETERMINATION OF WATER (MOISTURE) CONTENT OF SOIL AND ROCK BY MASS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 1

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.24
TESTED BY: Jemal Ibrahim

TESTHOLE	SAMPLE	MC %
TH23-01	S01	22.2
	S02	52.8
	S04	47.8
	S07	49.7
TH23-02	S02	47.6
	S04	47.7
	S06	50.4
	S08	53.2
	S13	24.3
TH23-03	S01	22.4
	S02	49.1
	S03	49.4
	S07	39.8
	S09	48.3
TH23-04	S01	32.6
	S02	50.6
	S03	48.9
	S05	45.6
TH23-05	S03	53.3
	S05	47.7
	S07	41.1
	S10	58.9
	S12	56.6

TESTHOLE	SAMPLE	MC %
TH23-06	S02	41.2
	S03	45.2
	S04	41.9
	S05	42.7
TH23-07	S02	7.5
	S06	5.8
	S07	9.6
	S09	47.0
	S10	45.9
	S12	60.4
TH23-08	S03	53.2
	S04	44.5
	S06	47.8
	S10	65.7
	S12	22.3
TH23-09	S02	48.3
	S03	39.3
	S04	52.8
	S05	45.0

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D4318 - LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (LL METHOD A - MULTIPOINT)

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 1

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.28
TESTED BY: Larry Presado

SAMPLE ID: TH23-02, S04

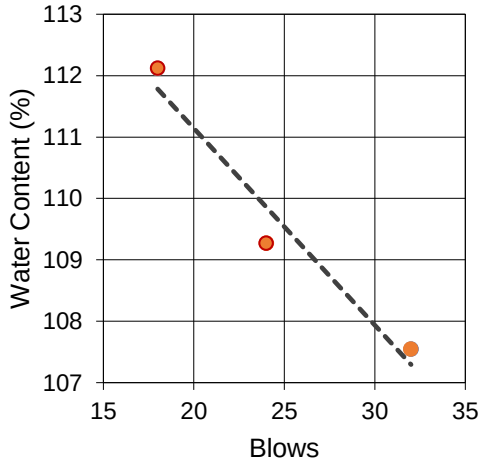
LIQUID LIMIT

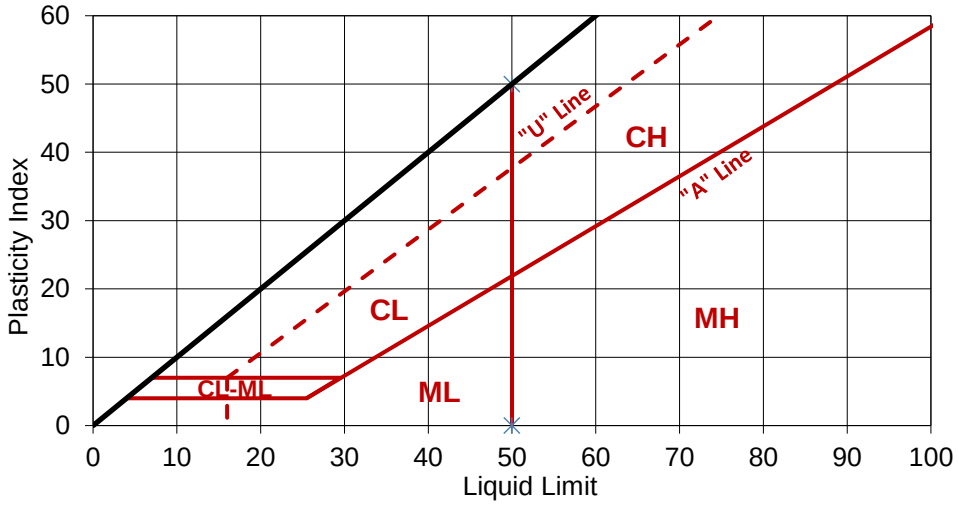
TRIAL	1	2	3
BLOWS	32	24	18
MC (%)	108	109	112

PLASTIC LIMIT

TRIAL	1	2
MC (%)	28	28

LIQUID LIMIT, LL	110
PLASTIC LIMIT, PL	28
PLASTICITY INDEX, PI	81
AS REC'D MC (%)	47.7





COMMENTS:

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D4318 - LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (LL METHOD A - MULTIPOINT)

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 2

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.28
TESTED BY: Larry Presado

SAMPLE ID: TH23-03, S01

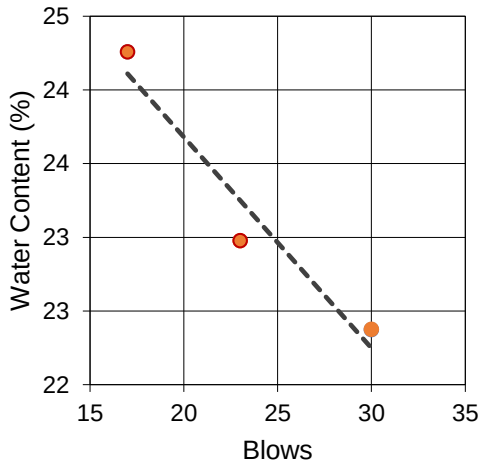
LIQUID LIMIT

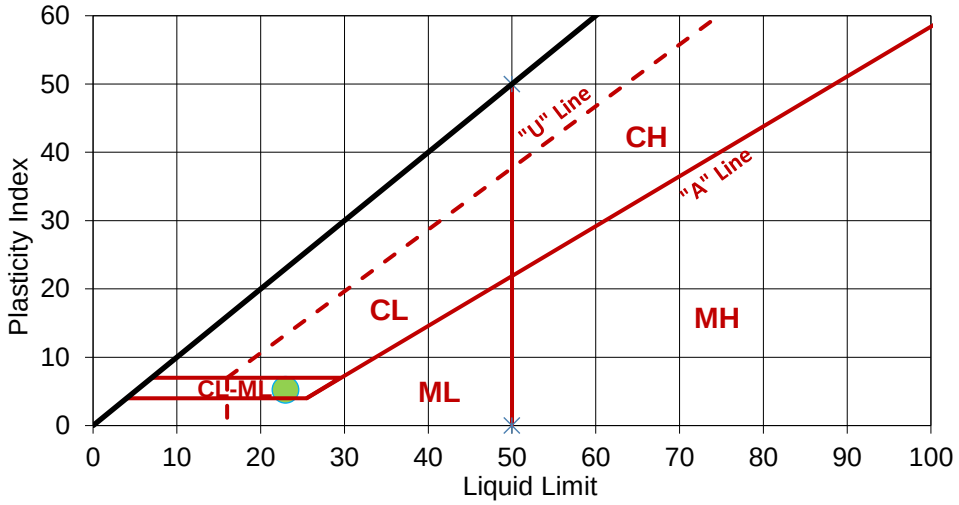
TRIAL	1	2	3
BLOWS	30	23	17
MC (%)	22	23	24

PLASTIC LIMIT

TRIAL	1	2
MC (%)	18	18

LIQUID LIMIT, LL	23
PLASTIC LIMIT, PL	18
PLASTICITY INDEX, PI	5
AS REC'D MC (%)	22.4





COMMENTS:

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D4318 - LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (LL METHOD A - MULTIPOINT)

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 3

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.28
TESTED BY: Madison Murphy

SAMPLE ID: TH23-06, S03

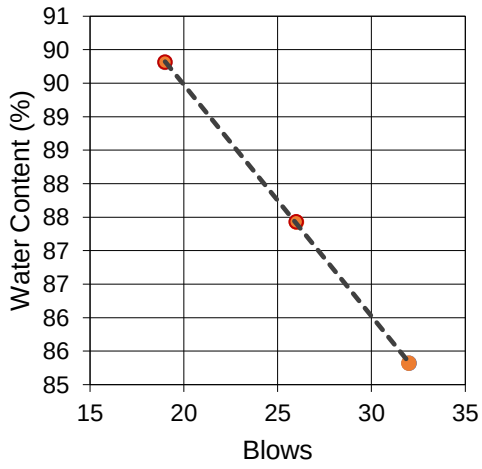
LIQUID LIMIT

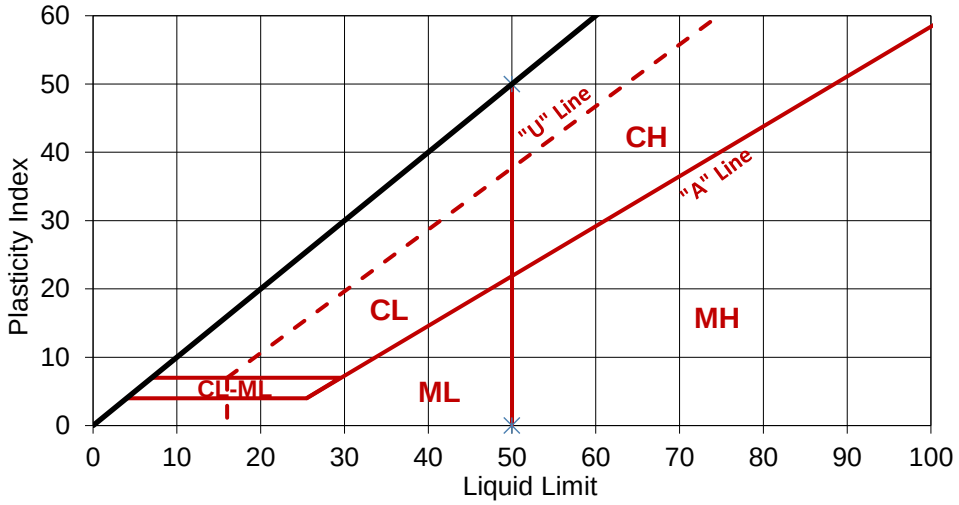
TRIAL	1	2	3
BLOWS	32	26	19
MC (%)	85	87	90

PLASTIC LIMIT

TRIAL	1	2
MC (%)	26	26

LIQUID LIMIT, LL	88
PLASTIC LIMIT, PL	26
PLASTICITY INDEX, PI	61
AS REC'D MC (%)	45.2





COMMENTS:

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D4318 - LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (LL METHOD A - MULTIPOINT)

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 4

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.28
TESTED BY: Madison Murphy

SAMPLE ID: TH23-07, S10

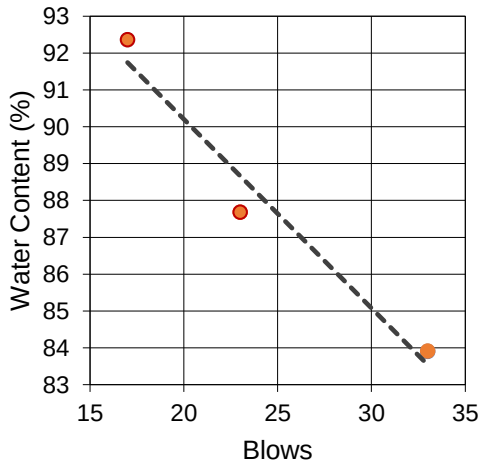
LIQUID LIMIT

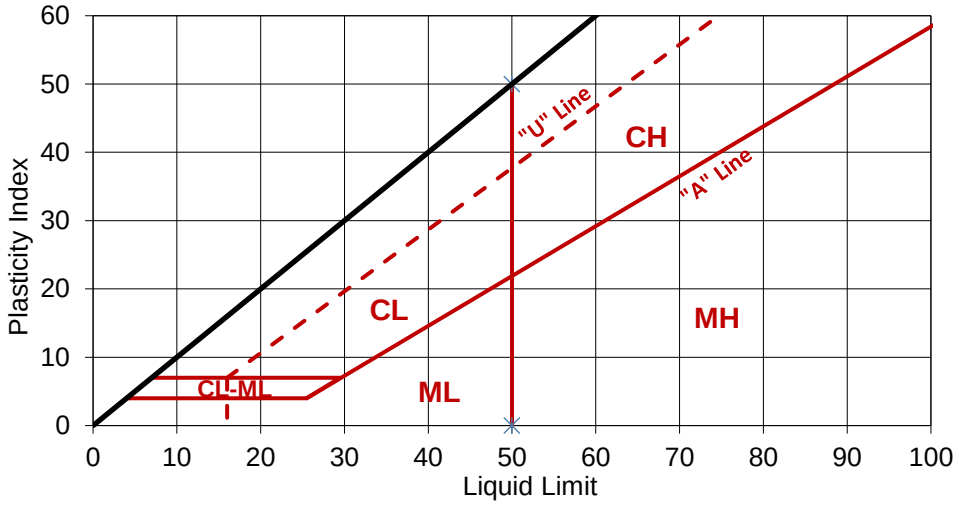
TRIAL	1	2	3
BLOWS	33	23	17
MC (%)	84	88	92

PLASTIC LIMIT

TRIAL	1	2
MC (%)	25	25

LIQUID LIMIT, LL	88
PLASTIC LIMIT, PL	25
PLASTICITY INDEX, PI	63
AS REC'D MC (%)	45.9





COMMENTS:

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

ASTM D4318 - LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS (LL METHOD A - MULTIPOINT)

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

PROJECT NO. 123316442

REPORT NO. 5

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.28
TESTED BY: Madison Murphy

SAMPLE ID: TH23-08, S06

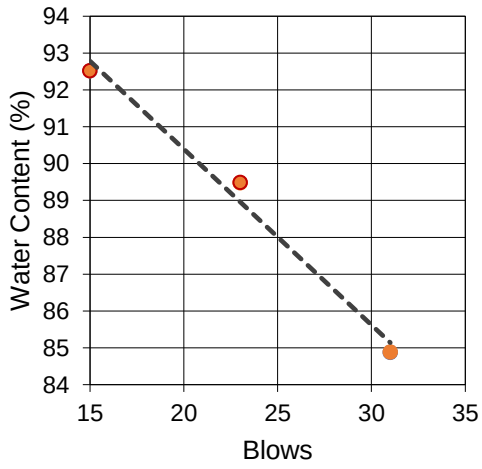
LIQUID LIMIT

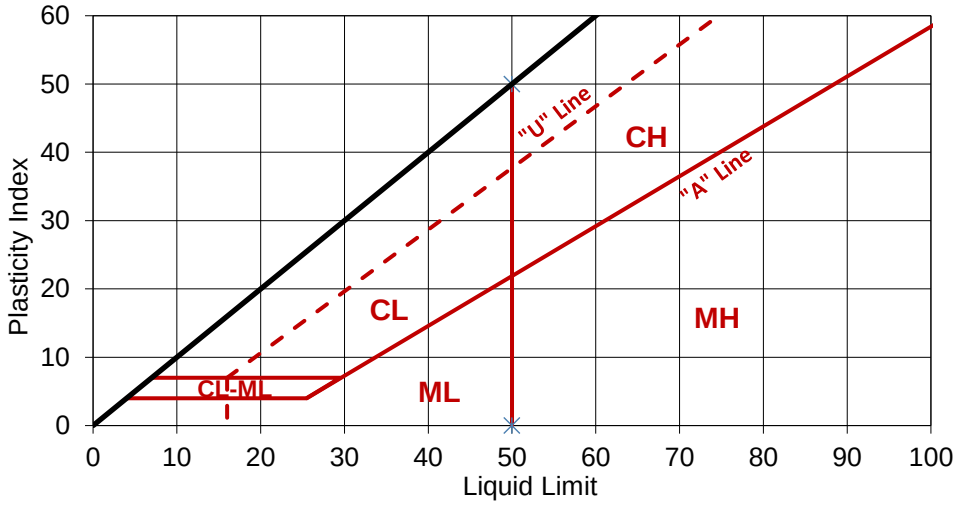
TRIAL	1	2	3
BLOWS	31	23	15
MC (%)	85	89	93

PLASTIC LIMIT

TRIAL	1	2
MC (%)	24	24

LIQUID LIMIT, LL	88
PLASTIC LIMIT, PL	24
PLASTICITY INDEX, PI	64
AS REC'D MC (%)	47.8





COMMENTS:

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

AASHTO T88 (ASTM D422) - PARTICLE-SIZE ANALYSIS OF SOILS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

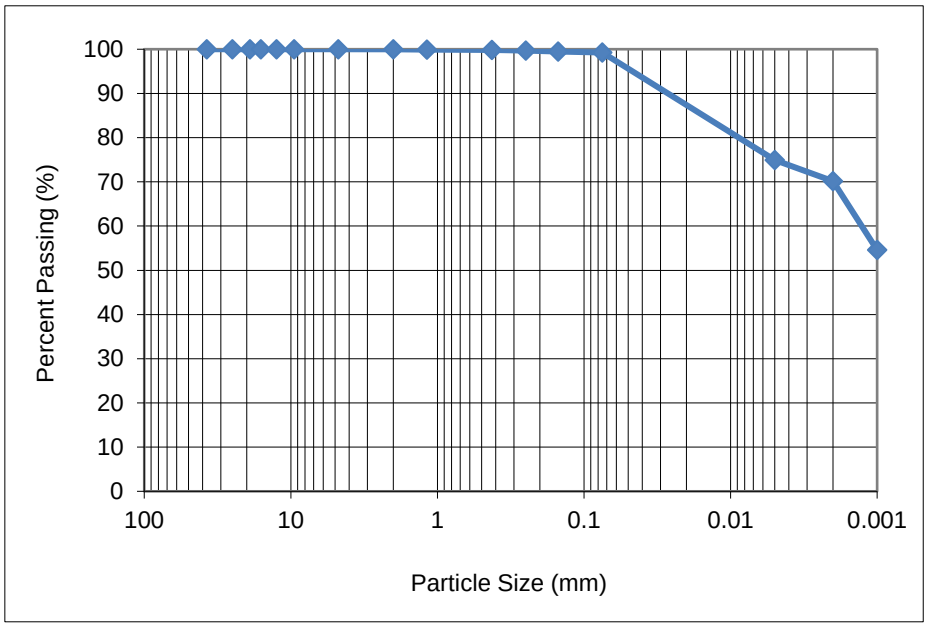
PROJECT NO. 123316442

REPORT NO. 1

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.27
TESTED BY: Larry Presado



SIEVE SIZE (mm)	% PASSING
37.5	100.0
25.0	100.0
19.0	100.0
16.0	100.0
12.5	100.0
9.5	100.0
4.75	100.0
2.00	100.0
1.18	99.9
0.425	99.8
0.250	99.7
0.150	99.5
0.075	99.3
0.005	75.0
0.002	70.1
0.001	54.6

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
0.0	0.0	0.2	0.5	29.2	70.1	54.6

COMMENTS:
Material tested was identified as TH23-03, S03.

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

AASHTO T88 (ASTM D422) - PARTICLE-SIZE ANALYSIS OF SOILS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

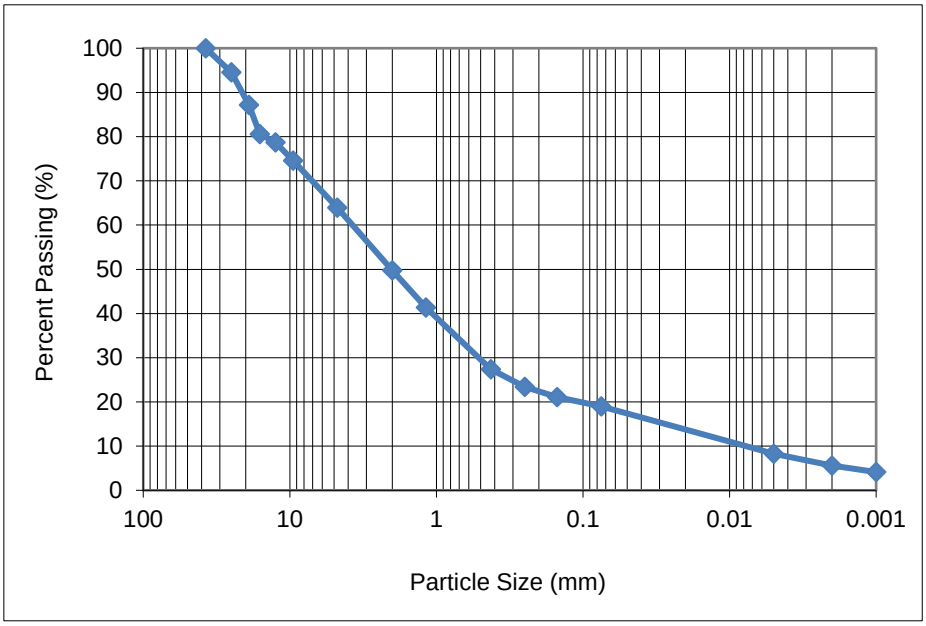
PROJECT NO. 123316442

REPORT NO. 2

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.27
TESTED BY: Larry Presado



SIEVE SIZE (mm)	% PASSING
37.5	100.0
25.0	94.6
19.0	87.2
16.0	80.6
12.5	78.7
9.5	74.6
4.75	63.9
2.00	49.7
1.18	41.4
0.425	27.4
0.250	23.4
0.150	21.1
0.075	19.0
0.005	8.2
0.002	5.6
0.001	4.1

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
36.1	14.2	22.3	8.4	13.4	5.6	4.1

COMMENTS:
Material tested was identified as TH23-07, S06.

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

AASHTO T88 (ASTM D422) - PARTICLE-SIZE ANALYSIS OF SOILS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

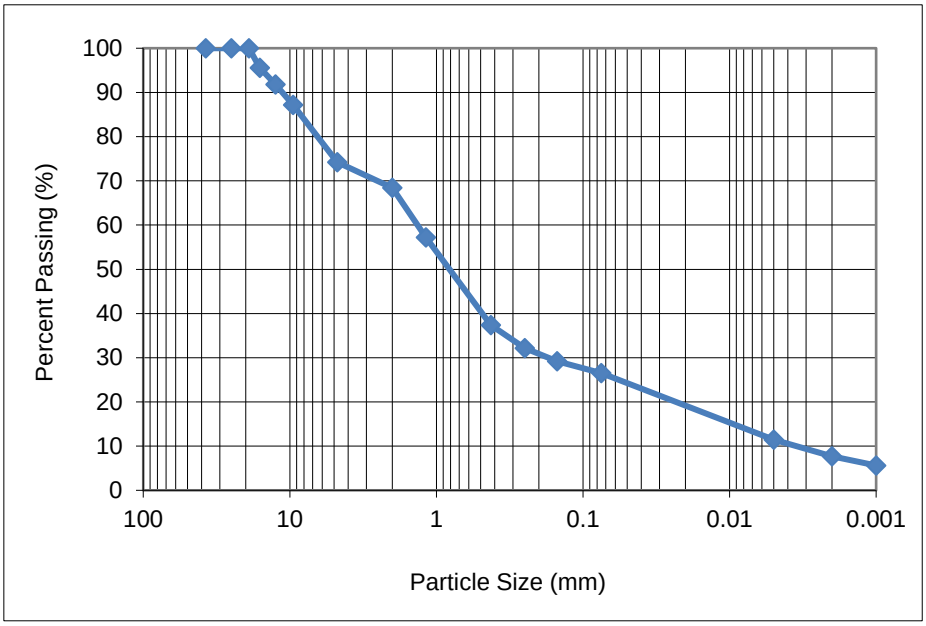
PROJECT NO. 123316442

REPORT NO. 3

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.27
TESTED BY: Larry Presado



SIEVE SIZE (mm)	% PASSING
37.5	100.0
25.0	100.0
19.0	100.0
16.0	95.5
12.5	91.8
9.5	87.2
4.75	74.2
2.00	68.5
1.18	57.2
0.425	37.4
0.250	32.1
0.150	29.2
0.075	26.5
0.005	11.5
0.002	7.7
0.001	5.6

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
25.8	5.7	31.1	10.9	18.8	7.7	5.6

COMMENTS:
Material tested was identified as TH23-07, S07.

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

AASHTO T88 (ASTM D422) - PARTICLE-SIZE ANALYSIS OF SOILS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

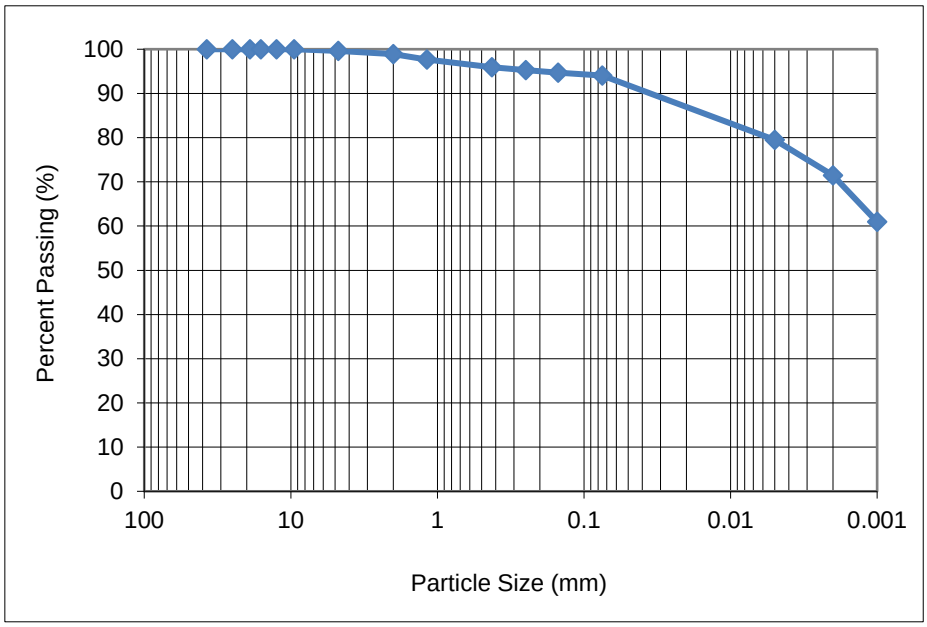
PROJECT NO. 123316442

REPORT NO. 4

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.27
TESTED BY: Larry Presado



SIEVE SIZE (mm)	% PASSING
37.5	100.0
25.0	100.0
19.0	100.0
16.0	100.0
12.5	100.0
9.5	100.0
4.75	99.7
2.00	98.9
1.18	97.6
0.425	95.9
0.250	95.2
0.150	94.7
0.075	94.1
0.005	79.5
0.002	71.4
0.001	60.9

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
0.3	0.8	3.0	1.8	22.7	71.4	60.9

COMMENTS:
Material tested was identified as TH23-07, S10.

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg, MB R3Y 1G4
Tel: (204) 488-6999

AASHTO T88 (ASTM D422) - PARTICLE-SIZE ANALYSIS OF SOILS

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

ATTN: Ali Sekkat

PROJECT McLeod Creek Drainage Improvements (22-0107-024)

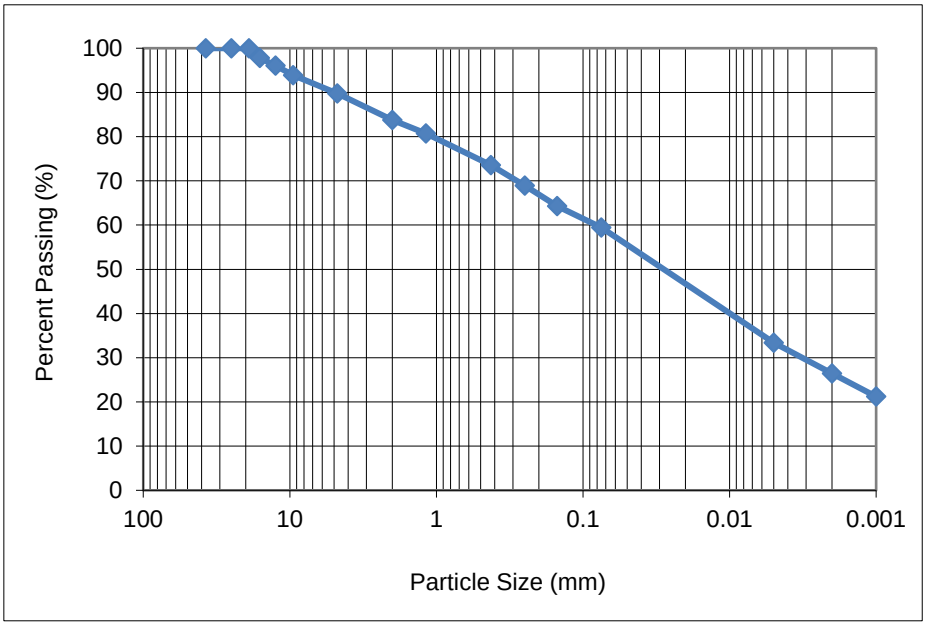
PROJECT NO. 123316442

REPORT NO. 5

DATE SAMPLED: 2023.Mar.16
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2023.Mar.23
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2023.Mar.27
TESTED BY: Larry Presado



SIEVE SIZE (mm)	% PASSING
37.5	100.0
25.0	100.0
19.0	100.0
16.0	97.8
12.5	96.1
9.5	93.9
4.75	89.8
2.00	83.7
1.18	80.7
0.425	73.5
0.250	68.9
0.150	64.3
0.075	59.4
0.005	33.4
0.002	26.5
0.001	21.2

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
10.2	6.1	10.2	14.1	32.9	26.5	21.2

COMMENTS:
Material tested was identified as TH23-08, S12.

REPORT DATE 2023.Mar.30

REVIEWED BY Kevin Hiraoka, C.Tech.
Senior Materials Technician - Lab Supervisor

APPENDIX C

Drilling Photos

TH23-01 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-01 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-01 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-01 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-01 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-01 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-01 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-01 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-02 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-02 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-02 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-02 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-02 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-02 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-02 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-02 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-02 Photo 9: 40 ft to 45 ft (12.19 m to 13.72 m)

TH23-03 Photo 10: 45 ft to 50 ft (13.72 m to 15.24 m)

TH23-02 Photo 11: 50 ft to 55 ft (15.24 m to 16.76 m)

TH23-02 Photo 12: 55 ft to 60 ft (16.76 m to 18.29 m)

TH23-02 Photo 13: 60 ft to 65 ft (18.29 m to 19.81 m)

TH23-02 Photo 14: 65 ft to 67.5 ft (19.81 m to 20.57 m)

TH23-03 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-03 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-03 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-03 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-03 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-03 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-03 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-03 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-03 Photo 9: 40 ft to 45 ft (12.19 m to 13.72 m)

TH23-03 Photo 10: 45 ft to 50 ft (13.72 m to 15.24 m)

TH23-03 Photo 11: 50 ft to 55 ft (15.24 m to 16.76 m)

TH23-03 Photo 12: 55 ft to 60 ft (16.76 m to 18.29 m)

TH23-03 Photo 13: 61 ft to 66 ft (18.60 m to 20.12 m)

TH23-04 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-04 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-04 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-04 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-04 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-04 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-05 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-05 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-05 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-05 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-05 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-05 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-05 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-05 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-05 Photo 9: 40 ft to 45 ft (12.19 m to 13.72 m)

TH23-05 Photo 10: 45 ft to 50 ft (13.72 m to 15.24 m)

TH23-05 Photo 11: 50 ft to 55 ft (15.24 m to 16.76 m)

TH23-05 Photo 12: 55 ft to 60 ft (16.76 m to 18.29 m)

TH23-05 Photo 13: 62 ft to 67 ft (18.89 m to 20.42 m)

TH23-06 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-06 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-06 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-06 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-06 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-06 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-07 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-07 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-07 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-07 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-07 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-07 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-07 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-07 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-07 Photo 9: 40 ft to 45 ft (12.19 m to 13.72 m)

TH23-07 Photo 10: 45 ft to 50 ft (13.72 m to 15.24 m)

TH23-07 Photo 11: 50 ft to 55 ft (15.24 m to 16.76 m)

TH23-07 Photo 12: 55 ft to 60 ft (16.76 m to 18.29 m)

TH23-08 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-08 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-08 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-08 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-08 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-08 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

TH23-08 Photo 7: 30 ft to 35 ft (9.14 m to 10.67 m)

TH23-08 Photo 8: 35 ft to 40 ft (9.14 m to 12.19 m)

TH23-08 Photo 9: 40 ft to 45 ft (12.19 m to 13.72 m)

TH23-08 Photo 10: 45 ft to 50 ft (13.72 m to 15.24 m)

TH23-08 Photo 11: 50 ft to 55 ft (15.24 m to 16.76 m)

TH23-08 Photo 12: 55 ft to 60 ft (16.76 m to 18.29 m)

TH23-09 Photo 1: 0 ft to 5 ft (0 m to 1.52 m)

TH23-09 Photo 2: 5 ft 10 ft (1.52 m to 3.05 m)

TH23-09 Photo 3: 10 ft to 15 ft (3.05 m to 4.57 m)

TH23-09 Photo 4: 15 ft to 20 ft (4.57 m to 6.1 m)

TH23-09 Photo 5: 20 ft to 25 ft (6.1 m to 7.62 m)

TH23-09 Photo 6: 25 ft to 30 ft (7.62 m to 9.14 m)

KGS
GROUP

Experience in Action