

CITY OF WINNIPEG

Armstrong Detailed Design and Contract
Administration
CPKC Mile 2.93 Winnipeg Beach Spur
Crossing
Geotechnical Report

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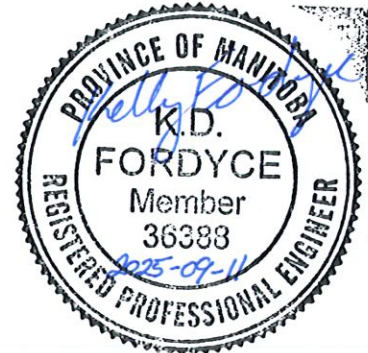
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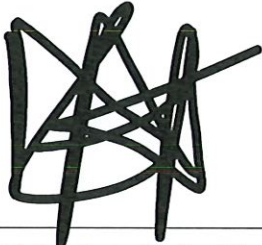
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Certificate of Authorization

KGS Group

No. 245

TABLE OF CONTENTS

1.0 INTRODUCTION	1
2.0 BACKGROUND INFORMATION	2
2.1 Project Understanding	2
2.2 Previous Investigations	2
2.2.1 2022 Geotechnical Investigation.....	2
2.2.2 2024 Geotechnical Investigation.....	4
3.0 2025 GEOTECHNICAL INVESTIGATION PROGRAM	6
3.1 Borehole Drilling and Soil Sampling	6
3.2 Instrumentation	7
3.3 Geotechnical Laboratory Testing	7
4.0 INVESTIGATION RESULTS	8
4.1 Stratigraphy.....	8
4.1.1 Fill and Upper Clay Deposit	8
4.1.2 Clay (CL).....	8
4.1.3 Clay (CH).....	8
4.1.4 Glacial Till	9
4.2 Groundwater Conditions and Monitoring Results.....	9
5.0 FORCE MAIN DESIGN CRITERIA	11
6.0 DESIGN AND CONSTRUCTION CONSIDERATIONS.....	12
6.1 Considerations for Pipe Installation at CPKC Rail Crossing	12
6.2 Trenchless Pipe Installation Method	12
6.2.1 Considerations for Auger Boring Method	12
6.2.2 Considerations for Pipe Ramming Method.....	13
6.2.3 Settlement Analysis.....	13
6.2.4 Settlement and Construction Monitoring.....	15
6.2.5 Geotechnical Personnel	16
6.2.6 Emergency Response and Contingency Plan	17

6.2.7 Construction and Post Installation Reporting..... 18

6.3 Temporary Excavations..... 19

6.3.1 Ground movement..... 19

6.4 Basal Heave 19

6.5 Care and Control of Water 20

6.6 Lateral Earth Pressures 20

6.7 Groundwater Management and Spoil Disposal 20

6.8 Frost Penetration 20

7.0 CLOSURE 21

8.0 REFERENCES 22

List of Tables

Table 2-1: 2022/2023 Boreholes in Project Area

Table 2-2: 2022/2023 Groundwater Monitoring Data

Table 2-3: 2024 Boreholes in Project Area

Table 4-1: Atterberg and Particle Size Analyses – High Plastic Clay

Table 4-2: Groundwater Monitoring Results

Table 5-1: CPKC Geotechnical Protocol Requirement and Proposed Design Parameters

Table 6-1: Emergency Response Contact List

Table 6-2: Lateral Earth Pressure Coefficients

List of Figures

Figure 3-1: Test Hole Location Plan

Figure 6-1: Estimated Surface Settlement for Casing Pipe

List of Appendices

Appendix A: Detailed Design Drawings

Appendix B: 2022/2024 Trek Geotechnical Borehole Logs

Appendix C: 2025 KGS Group Borehole Logs

Appendix D: 2025 Select Drilling Photos

Appendix E: 2022 to 2025 Geotechnical Laboratory Testing Results

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 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.

This report is based on information made available to KGS Group by City of Winnipeg. Unless stated otherwise, KGS Group has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith. KGS Group shall not be responsible for conditions/issues it was not authorized or able to investigate or which were beyond the scope of its work. The information and conclusions provided in this report apply only as they existed at the time of KGS Group’s work.

Third Party Use of Report

Any use a third party makes of this report or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

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

The Armstrong Combined Sewer (CS) district is a mix of combined sewers and storm relief sewers, located in the West Kildonan neighbourhood of Winnipeg, Manitoba. This project includes the installation of a new land drainage and wastewater sewer network to separate from the existing CS network. The separation work will be staged over eight (8) contracts, with the first constructed length to be Contract 1, currently scheduled to be tendered in October 2025. The work includes the design and construction of the proposed sewer main pipeline beneath the Canadian Pacific Kansas City (CPKC) railway at Mile 2.93 Winnipeg Beach Spur in Winnipeg. The subject CPKC railway line is a Class 2 track which runs north-south at the project site, crossing Leila Ave.

A geotechnical field investigation program was completed in 2025, along the proposed alignment of the new sewer main pipeline to close data gaps with respect to the geotechnical and groundwater conditions.

2.0 BACKGROUND INFORMATION

2.1 Project Understanding

The proposed gravity wastewater sewer (WWS) is being constructed as part of the Armstrong Combined Sewer Relief project for the City of Winnipeg. The proposed WWS is planned to be installed beneath the CPKC tracks using trenchless construction methods. The new carrier pipe and required casing pipe specifications are summarized on the detailed design drawings in Appendix A. All carrier pipes were designed to meet flow capacity requirements determined by hydraulic modelling analysis previously completed by KGS Group.

The proposed WWS consists of 600mm nominal diameter PVC carrier pipe installed within a 900mm nominal diameter steel casing. The approximate length of casing pipe across the CPKC right-of-way (ROW) is 45.4 m.

The crossing profile indicates the elevation of the following at the railway crossing location:

- The approximate Base of Rail (BOR) is at elevation Elev. 231.86 m. ***Please note that BOR data will be confirmed during construction and updated on the as-built drawing.***
- The invert elevation of the 600mm PVC carrier pipe across the CPKC ROW is Elev. 221.66 m and 221.56 m at the west and east extents of the casing respectively.
- The invert elevation of the 900mm steel casing pipe across the CPKC ROW is Elev. 221.52 m and 221.42 m at the west and east extents of the casing respectively.
- Depth from the approximate BOR to the top of the pipe casing is approximately 9.39 m (i.e., obvert Elev. 222.37 m).

Assumed dimensions of the launch and receiving pits are indicated on the detailed design drawings in Appendix A; the sizing of the working pits and actual dimensions will be the responsibility of the Contractor based on their means and methods and excavation support structure design. The launch pit is anticipated to be constructed on the east side of the crossing and the receiving pit is anticipated to be constructed on the west side of the crossing. The footprints of these working pits will be outside of the CPKC ROW.

Notwithstanding, KGS Group will review the excavation plan and shoring details for the pits to ensure that it does not adversely impact the rail line.

2.2 Previous Investigations

A review of relevant geotechnical information pertinent to the project area is presented in this report, including geotechnical investigations completed by Trek Geotechnical in 2022 and 2024 to support the preliminary design phases of this project. Select boreholes from the previous investigations were considered and incorporated in the development of the site stratigraphy and the associated figures. The results of these geotechnical investigations are summarized in this section.

2.2.1 2022 GEOTECHNICAL INVESTIGATION

In 2022, Trek Geotechnical conducted a geotechnical investigation for Jacobs Canada Inc. and the City of Winnipeg within the Armstrong CS district as part of the preliminary design phase of this project. The geotechnical investigation was carried out in two phases: in September 2022, and in January 2023. The

geotechnical investigation was completed to assess the subsurface stratigraphy and groundwater conditions within the project area.

A total of one (1) borehole (TH22-13) was drilled within the vicinity of the pipeline crossing location at Mile 2.93 Winnipeg Beach Spur. The borehole was drilled to power auger refusal within the glacial till deposit.

Soil samples collected during drilling were visually classified using the Unified Soil Classification System (USCS). Disturbed grab samples were collected at regular intervals and submitted to the lab for additional material testing. In non-cohesive and till deposits, Standard Penetration Tests (SPTs) were performed, and split spoon samples were retrieved. Shelby tube samples were extracted at unique depths within the clay overburden deposit. Laboratory analyses included moisture content determination, Atterberg Limits, particle size analysis, unconfined compressive strength, and bulk unit weight of select samples.

The borehole in Table 2-1 was drilled within the CPKC Crossing area and was used to develop the soil profiles.

TABLE 2-1: 2022/2023 BOREHOLES IN PROJECT AREA

Borehole ID	Northing (m)	Easting (m)	Approx. Ground Surface Elevation (m)	Approx. Borehole Depth (m)	Approx. Silt Till Contact Elevation (m)
TH22-13	5,534,433	6,34,312.5	231.15	16.50	215.90

The 2022 borehole log is included in Appendix B. The location of the boreholes within the project area is shown on Figure 3-1. Laboratory testing results from the 2022/2023 boreholes are included in Appendix E.

A total of two (2) standpipe piezometers were installed within borehole TH22-13. One (1) standpipe was installed within the glacial till deposit and one (1) standpipe was installed within the silt overburden. The installation details of the piezometers are shown on the borehole logs in Appendix B. Groundwater monitoring data for the 2022 instrumentation is summarized in Table 2-2.

TABLE 2-2: 2022/2023 GROUNDWATER MONITORING DATA

Borehole ID		
TH22-13		
Ground Elevation (m)	231.15	231.15
Piezometer No.	SP22-13A	SP22-13B
Tip Elevation (m)	214.65	228.65
Monitoring Zone	Silt Till	Silt
Groundwater Elevation Monitoring Data		
Date:		
2022-10-13	222.82	228.71
2022-11-20	225.82	228.71
2023-01-19	-	-
2023-02-02	225.36	228.77
2023-03-30	-	-
2023-04-27	Frozen to 228.79	Frozen to 230.35
2023-06-08	226.28	229.14

Notes:

- 1) The field instrumentation installed during the 2022 investigation program was deemed to be unusable in 2025.

2.2.2 2024 GEOTECHNICAL INVESTIGATION

In February 2024, Trek Geotechnical carried out a geotechnical investigation adjacent to the Canadian Pacific Kansas City (CPKC) Winnipeg Beach Spur right-of-way at the intersection of the rail line with Leila Ave. within the project area. The objective of the investigation was to assess the subsurface stratigraphy and groundwater conditions in support of the new pipeline crossing beneath the CPKC right-of-way as part of the Armstrong CS preliminary design phase.

A total of two (2) boreholes were drilled with one (1) being located on either side of the CPKC right-of-way at the crossing location. The boreholes were drilled to depths ranging from 16.2 to 16.8 m until power auger refusal was encountered in the glacial till deposit.

Soil samples collected during drilling were visually classified in accordance with the Unified Soil Classification System (USCS). The sampling program included both disturbed samples (auger cuttings) and relatively undisturbed samples (Shelby tubes). Laboratory testing included determination of moisture content, measurement of bulk unit weight, Atterberg Limits, particle size analysis of select samples, and estimation of the undrained shear strength on Shelby tube samples using unconfined compression strength tests, pocket penetrometer, and torvane.

The boreholes in Table 2-3 were drilled within the CPKC Crossing area and were used to develop the soil profiles.

TABLE 2-3: 2024 BOREHOLES IN PROJECT AREA

Borehole ID	Northing (m)	Easting (m)	Approx. Ground Surface Elevation (m)	Approx. Borehole Depth (m)	Approx. Silt Till Contact Elevation (m)
TH24-01	5,534,390	634,384	231.45	16.80	216.25
TH24-04	5,534,419	634,320	231.51	16.20	215.72

The 2024 borehole logs are included in Appendix B. The location of the boreholes within the project area is shown on Figure 3-1. Laboratory testing results from the 2024 boreholes are included in Appendix E.

3.0 2025 GEOTECHNICAL INVESTIGATION PROGRAM

3.1 Borehole Drilling and Soil Sampling

A drilling and sampling investigation program consisting of one (1) borehole (TH25-04) was completed on May 29, 2025. TH25-04 was advanced east of the Mile 2.93 Winnipeg Beach Spur crossing, outside the CPKC ROW, as shown in Figure 3-1. Drilling services were provided by Maple Leaf Drilling Ltd. of Winnipeg, Manitoba under KGS Group's supervision. The investigation was completed using a track mounted drill rig with 125 mm and 150 mm diameter solid stem continuous flight augers. The borehole was advanced to power auger refusal, which was achieved in the till at 17.5 m (El. 214. m) below grade. It is KGS Group's opinion that the 2025 geotechnical investigation, along with the results of the 2022 and 2024 geotechnical investigations, is adequate to support the pipe crossing design.

FIGURE 3-1: BOREHOLE LOCATION PLAN



The location of boreholes and associated stratigraphy are also shown on the detailed design drawings in Appendix A (except for TH22-13 which is located outside the viewport on the drawings).

Representative disturbed soil samples were obtained from each borehole at 1.5 m (5 ft) intervals, at any change in soil strata, or at the discretion of KGS Group personnel. Soil samples were collected either directly off auger flights or from a driven split spoon sampler. Collected samples were visually classified in the field in general accordance with the modified Unified Soil Classification System (USCS) and placed in resealable plastic bags. Standard Penetration Tests (SPT) were advanced at each split spoon sample depth (typically within the glacial till) to evaluate relative material density, and pocket penetrometer tests were performed on select sample to estimate unconfined compressive strength. Cohesive clay samples were tested with a field Torvane to estimate undrained shear strength.

Upon completion of drilling, the borehole was examined for indication of sloughing and seepage and subsequently backfilled to grade. The borehole was backfilled with auger cuttings and bentonite chips. The location of the borehole was captured using survey-grade GPS.

The borehole log containing all field observations is provided in Appendix C. Select photos of the 2025 drilling are provided in Appendix D.

3.2 Instrumentation

Two (2) vibrating wire (VW) piezometers were installed in TH25-04 as part of the geotechnical investigation program. One (1) VW piezometer was installed 14.27 m (El. 217.62 m) below grade in the overburden clay, and one (1) was installed 17.3 m (El. 214.47 m) below grade in the glacial till. The borehole was grouted to the ground surface using tremie methods. A protective well cover was installed at the ground surface.

3.3 Geotechnical Laboratory Testing

Geotechnical laboratory testing was completed on select representative samples to determine relevant geotechnical engineering index properties. Laboratory testing included:

- Ten (10) moisture content tests;
- Two (2) Atterberg limit tests;
- Two (2) particle size analyses;

All laboratory testing was completed at a Canadian Council of Independent Laboratories (CCIL) certified soil testing laboratory in Winnipeg, Manitoba. Testing was completed in general accordance with American Society for Testing and Materials (ASTM) standards. A summary of the 2025 laboratory testing has been provided in Appendix E and on the borehole log records in Appendix C.

4.0 INVESTIGATION RESULTS

4.1 Stratigraphy

In general, the stratigraphy at the site was interpreted by KGS Group to consist of topsoil and clay deposits overlying glacial silt till. The stratigraphy description provided below is based on observations from the relevant Trek Geotechnical 2022 and 2024 boreholes, and the KGS Group 2025 borehole.

4.1.1 FILL AND UPPER CLAY DEPOSIT

Two (2) boreholes were advanced within the roadway along Leila Ave. The pavement structure consisted of asphalt and concrete overlying a layer of granular fill, extending to elevations ranging from El. 230.5 to 230.8 m. The granular layer consisted of sand and gravel fill that was brown in colour, moist, poorly graded to well graded, and contained trace amounts of silt and clay.

Two (2) boreholes were advanced in the roadway median where a topsoil layer was encountered, extending from El. 231.4 to 231.7 m. The organic topsoil was dark brown to black, dry to moist, low to intermediate plasticity, and contained some clay, trace sand, and trace gravel.

An upper clay deposit was encountered underlying the pavement structure and topsoil layer in boreholes TH22-13, TH24-01, and TH25-04. In borehole TH24-01, the clay layer underlying the topsoil was denoted as clay fill, however, it is comprised of similar characteristics as the upper clay deposit. The upper clay and clay fill extended to elevations ranging from El. 229.0 to 229.9 m. The upper clay and clay fill deposits varied in colour from black to brown to grey, was dry to moist, of intermediate to high plasticity, very stiff, and contained varying amounts of silt, trace sand, trace to some gravel, and trace rootlets. Nine (9) moisture content tests completed on the upper clay deposit and clay fill ranged from 7% to 36%.

4.1.2 CLAY (CL)

Below the fill and upper clay deposits, low plasticity clay deposit with varying silt content was encountered in TH25-04, TH24-01, and TH22-13, extending to elevations ranging from El. 228.1 to 229.0 m. The clay was light brown in colour, damp to moist, soft, of low plasticity, and contained varying amounts of silt, trace fine sand, and trace rootlets.

The moisture content of the low plasticity clay deposit ranged from 20% to 25% based on seven (7) moisture content tests. One (1) Atterberg limit test was conducted on a soil sample from TH22-13 at an elevation of El. 228.8 m. The Atterberg Limit test measured a liquid limit of 29%, a plastic limit of 18%, and plasticity index of 11%, classifying the soil as low plasticity clay (CL). It should be noted that boreholes TH22-13 and TH24-01 denote this layer as silt; however, the index testing results in a classification of CL.

4.1.3 CLAY (CH)

High plasticity clay was encountered underlying the fill, upper clay, and low plasticity clay deposits. The high plasticity clay extended to elevations from El. 216.2 to 215.3 m. The clay was brown to grey in colour and often mottled, damp to moist, soft to stiff, of high plasticity, and contained trace to some silt inclusions, trace

gypsum, trace sand, trace gravel, and varying amounts of silt and oxidation staining. Trace cobbles were encountered in TH22-13 below an elevation of El. 221.3 m.

A pocket Torvane was used to estimate the undrained shear strength of the high plasticity clay which ranged from 10 to 83 kPa, resulting in a soil description as very soft to stiff.

The moisture content of the high plasticity clay layer ranged from 24% to 61% based on thirty-six (36) moisture content tests. Three (3) Atterberg limit tests were conducted on select soil samples at elevations ranging from El. 217.8 to 220.4 m. The Atterberg limit tests measured liquid limits of 71 to 94%, plastic limits of 23 to 31%, and plasticity indices of 48 to 63%, classifying the soil as high plasticity clay (CH). Three (3) particle size analyses were completed on select soil samples at elevations ranging from El. 217.75 to 220.44 m, which measured 44% to 75% clay; 23% to 40% silt; 1% to 15% sand; and 0% to 2% gravel.

Index testing results for the high plastic clay deposits are summarized in Table 4-1.

TABLE 4-1: ATTERBERG AND PARTICLE SIZE ANALYSES – HIGH PLASTIC CLAY

Borehole ID	Sample Elevation	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	%Gravel	%Sand	%Silt	%Clay
TH22-13	217.8 m	94	31	63	1	1	23	75
TH24-01	221.0 m	71	23	48	2	8	30	61
TH25-04	220.4 m	76	28	48	0.3	15	41	44

4.1.4 GLACIAL TILL

Glacial till was encountered underlying the high plasticity clay deposit at elevations ranging from El. 214.0 to 216.25 m and extended to the end of borehole depths explored. The till deposit was light brown to greyish brown in colour, moist, compact to dense, of no to low plasticity, and contained varying amounts of silt, clay, sand, gravel, and trace cobbles.

A Standard Penetration Test in TH22-13 at elevation El. 215.65 within the glacial till resulted in an uncorrected blow count of 41; resulting in a relative density description of dense.

The moisture content of the glacial till layer ranged from 8% to 30% based on five (5) moisture content tests. One (1) particle size analysis completed on a soil sample in TH25-04, at an elevation of El. 215.2 m, measured 15% clay; 50% silt; 30% sand; and 5% gravel.

4.2 Groundwater Conditions and Monitoring Results

Two (2) VW piezometers were installed to monitor the local groundwater conditions. The installation details and piezometer monitoring completed to date are summarized in Table 4-2 and detailed on the borehole log provided in Appendix C.

The water level in TH25-04 was observed to be 12.8 m below grade upon completion of drilling. Groundwater level readings were collected four (4) times between May 2025 to September 2025 and are summarized in Table 4-1. As fluctuations can occur in response to seasonal conditions and following heavy precipitation or spring snow melt events, current groundwater levels may differ from those provided in this report. As such, water levels should be monitored both prior to and during construction activities.

TABLE 4-2: GROUNDWATER MONITORING RESULTS

Borehole ID TH25-04		
Ground Elevation (m)	231.79	231.79
Piezometer No.	VW202425	VW202480
Tip Elevation (m)	217.62	214.47
Monitoring Zone	Clay	Silt Till
Groundwater Elevation Monitoring Data		
Date:		
2025-06-16	227.01	225.94
2025-06-25	226.97	225.95
2025-07-30	225.98	225.49
2025-08-28	225.90	225.42

5.0 FORCE MAIN DESIGN CRITERIA

Table 5-1 provides the general requirements for CPKC Geotechnical Protocol Requirement for Process 2 – Intermediate and the proposed design parameters based on the detailed design drawing in Appendix A.

TABLE 5-1: CPKC GEOTECHNICAL PROTOCOL REQUIREMENT AND PROPOSED DESIGN PARAMETERS

Parameter/Criteria	CPKC Protocol Requirement	Proposed Design
Dimension Criteria		
Outside Pipe Diameter	300 mm to 1500 mm	914 mm
Cover between BOR and top of pipe (Note 2): measurements are from estimated BOR and BOR data will be collected during construction to update on the as-built drawings)	Greater than 1.5 m or 2 pipe diameters, whichever is greater	9.39 m (greater than 1.5 m and greater than 2 * 914 mm)
Adjacent structures, including switches and signals	Within 2.5 times, cover between BOR and top of pipe	One signal standard within 3 m of horizontal pipe alignment
Depth of pipes outside Zone of Potential Track Loading (ZPTL)	Less than 0.91 m burial within ZPTL	Approx min. depth of pipe outside ZPTL (East) = 9.3 m Approx min depth of pipe outside ZPTL (West) = 9.4 m
Excavation Criteria		
Excavation close to CPKC track(s)	Excavation or jacking/access pits within 10 m of the closest track centreline	Centreline of track to face of shaft (East) = 21.2 m Centreline of track to face of shaft (West) = 21.8 m
Crossing Angle	More than 45 degrees off perpendicular to the track	109.6 degrees
Construction Method Criteria		
	Trenchless method – Auger Boring, Pipe Jacking, Pipe Ramming, HDD	Pilot Tube Auger Boring Pilot Tube Pipe Ramming
Other Criteria		
Settlement for Class 2 track	Level 1 Warning/Alert: >11 mm Level 2 Critical/Review: >22 mm	See Section 6.2.4

Notes:

- 1) CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks Criteria for Process 2 – Intermediate.
- 2) Cover measurements are from the estimated Base of Rail (BOR) data. BOR data will be collected during construction to update on the as-built drawings for consistency with CPKC documentation.

6.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

6.1 Considerations for Pipe Installation at CPKC Rail Crossing

Construction of the pipeline that will be installed beneath the existing CPKC railway at Mile 2.93 Winnipeg Beach Spur will be completed using pilot tube auger boring or pilot tube pipe ramming methods as described in Section 6.2 and will comply with the following specifications and standards.

- CPKC document “CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks” May 2024.
- Transport Canada document “Standards Respecting Pipeline Crossings Under Railways TC E-10 (June 21, 2000)”.

6.2 Trenchless Pipe Installation Method

KGS Group has presented two (2) trenchless pipe installation methods that may potentially be utilized for the installation of the pipeline including pilot tube auger boring and pilot tube pipe ramming. Based on the available borehole data, the crossing horizon will be set deep within the firm to stiff, high plastic clay layer, and the identified methods are suitable for the installation. The specifications for the casing pipes are provided in Section 5.0. Each proposed method is further described in the subsequent sections.

6.2.1 CONSIDERATIONS FOR AUGER BORING METHOD

KGS Group considers pilot tube auger boring to be a viable installation option for the 900 mm diameter casing pipeline.

Auger boring is a technique ideal for installing pipe in soft to firm stable ground conditions such as the clay at this site. 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 railways, highways, and levies where potential settlement is a concern.

The auger boring process uses an auger boring machine to rotate an auger within the pipe that may be connected to a cutter head at the lead end. A small overcut is produced at the lead end to reduce skin friction along the pipe. The auger conveyance system can be situated further away from the pipe lead end to maintain a soil plug at the front of the bore. The soil is transported through the pipe to the launching area where it is removed by hand or machine. The auger boring machine advances along a track that 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 starting point on the track where a new casing pipe segment and auger chain are connected to both the machine and existing chain / cutter head. The excavation and thrust process is then repeated until the alignment is complete. The auger chain is then withdrawn from the casing pipe, and the pipe is cleaned of all remaining soil prior to use. The pilot tube version of this methodology includes the initial installation of small diameter pilot rods to achieve the desired line and grade between the launch and reception shafts. An adapter head is typically

welded onto the last pilot rod and the first casing. As the auger boring machine advances the casing pipe, the pilot rods are pushed through and removed at the reception shaft.

6.2.2 CONSIDERATIONS FOR PIPE RAMMING METHOD

KGS Group considers pilot tube pipe ramming to be a viable installation option for the 900 mm diameter casing pipeline.

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 accuracy of line and grade. As described above, an adapter head is typically welded onto the last pilot rod and the first casing. As the hammer advances the casing pipe, the pilot rods are pushed through and removed at the reception shaft.

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 or a small overcut can be added. Pipe ramming is suitable 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).

6.2.3 SETTLEMENT ANALYSIS

KGS Group conducted settlement analysis using O'Reilly and New (1982) to estimate the potential surface settlement during installation of each proposed pipeline crossing group based on the assumed volume of ground loss using auger boring installation methods for the casing pipe (the settlement estimate from the pipe ramming process is anticipated to be less). The settlements for a single tunnel installation can be estimated from the formula as shown below,

$$S_{(y,z)} = S_{(max,y,z)} e^{-y^2/2i^2} = \frac{V_s}{i\sqrt{2\pi}} e^{-y^2/2(i)^2}$$

where

$S_{(y,z)}$ = vertical displacement at a transverse distance y and a vertical distance z (m)

V_s = volume of settlement trough per unit length of tunnel (m³)

i = trough width parameter, taken as $0.43 z + 1.1$ (m) for cohesive soils

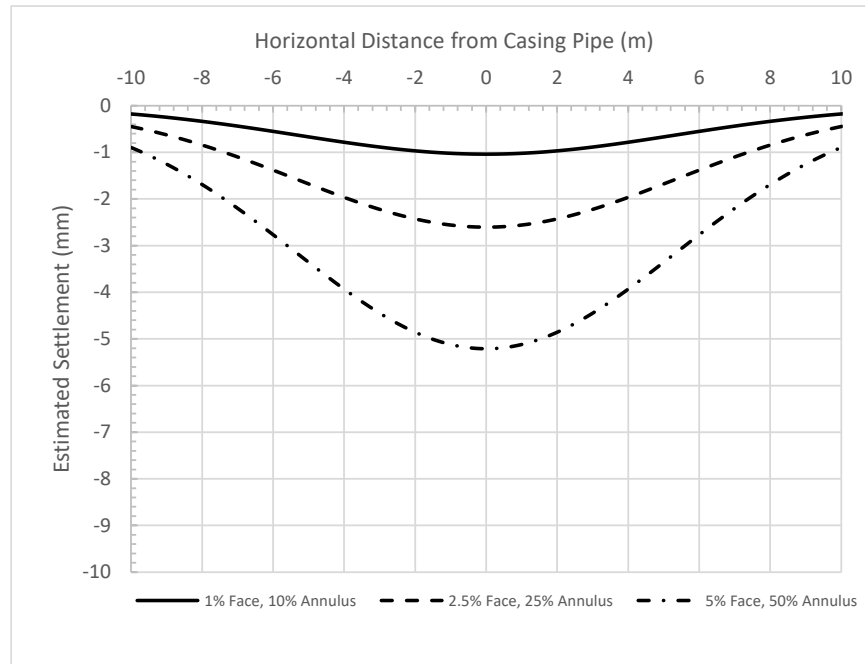
z = depth of the tunnel center (m)

The maximum surface settlement, S_{max} , can be estimated when $y = 0$ (along the bore axis), which is a function of vertical distance z . For a single bore, the settlement obtained below was based on the depth below the base of rail to the crown of the steel casing pipe as shown on the drawings in Appendix A.

For the pipes to be installed by auger boring (or pipe ramming), it is typical to assume 1% to 2.5% of ground loss at the bore face during installation. The overcut that is created around the pipe to reduce friction forces during installation can also squeeze and collapse, and it is typical to assume that 10% to 25% of the annular space will contribute to the total ground loss. As such, the total ground loss is calculated from a combination of soil raveling at the bore face and squeezing of the annular overcut. An extreme settlement case of 5% ground loss at the bore face and 50% ground loss in the annulus was also evaluated. A maximum radial overcut of 25 mm was used in the analysis and will be specified in the construction technical specifications.

The estimated settlement profile over the alignment of the casing pipe within the CPKC right-of-way is shown in Figure 6-1.

FIGURE 6-1: ESTIMATED SURFACE SETTLEMENT FOR CASING PIPE



The CPKC rail line for this project is defined as a Branch Line/Line with Low Traffic. Settlement thresholds of 11 mm (Warning) and 22 mm (Critical) are required in accordance with CPKC's Geotechnical Protocol.

Based on the results as outlined in Figure 6-1, the estimated maximum settlement over the alignment of the steel casing pipe assuming a 25 mm radial overcut is less than the allowable Alert threshold prescribed by CPKC for the lower bound (1% and 10%), upper bound (2.5% and 25%), and the extreme (5% and 50%) volume loss assumptions for soil raveling at the face and annular squeezing for the anticipated ground conditions at this site.

Lowering the water table may not be required since the recommended trenchless construction methods are capable of managing groundwater flows, particularly in cohesive soils anticipated for this installation and

when an adequate soil plug is maintained at the lead end of the bore in the case of auger boring. A minimum soil plug will be prescribed to the contractor in the technical specifications. Based on groundwater observations during the drilling investigation, groundwater will be encountered at the tunnel horizon. Groundwater levels are prone to fluctuations depending on the amount of precipitation and the time of year of the construction.

It is KGS Group's opinion that the surface settlements associated with the casing pipe installation will mostly occur within two (2) weeks of completing the installation and are unlikely to impact the railway operation, provided good construction practices are followed. It is recommended to monitor ground movements during the casing installation and up to two weeks afterwards to confirm the permissible settlement thresholds are not exceeded.

6.2.4 SETTLEMENT AND CONSTRUCTION MONITORING

Installation of the proposed pipeline and associated infrastructure using the trenchless construction methods outlined above should not result in any adverse effects to CPKC operations or property. Since the proposed pipeline is greater than 300 mm (12 inches) OD, the installation falls under CPKC Process 2 – Intermediate, and a KGS Group engineer will be on-site for the entirety of the installation process to monitor construction. The ground surface above the trenchless pipe installation alignment will be monitored for movement / settlement during the installation and afterwards via the following.

- Track monitoring points installed at approximate spacings of 1.18 m, 2.34 m, 4.72 m, 7.08 m, and 9.45 m extending in both directions along the track from the intersection point of the pipe alignment and railway track centerline. The layout and details of the settlement monitoring program are shown on the sealed drawings in Appendix A.
- Surface monitoring points will consist of prism or placard-type devices attached directly to the web of the rails using high-strength epoxy. The surface monitoring setup is intended to allow for remote survey monitoring from outside the CPKC right-of-way during non-working hours, if required. Due to the proximity of the proposed crossing to Leila Avenue, approximately four (4) surface monitoring points will be located within the at-grade crossing on the roadway. Measurements for these four (4) points will either be collected directly from the surface of the rails or from survey nails installed directly in the adjacent pavement structure. Regardless, monitoring of these four (4) points would require direct occupation of the point by a surveyor and would only be able to be monitored during working hours when a CPKC flag person is present. If track monitoring is required during non-working hours, these four (4) points would not be monitored, and it is KGS Group's opinion that this would still satisfy the intent of the CPKC protocol as critical monitoring points located directly above the proposed pipe alignment would still be monitored.
- Four (4) sub-surface monitoring points are recommended to be installed along the alignment near the CPKC track, including two (2) on either side of the track offset approx. 2.5 m from the respective outside rail; and two (2) on either side of the track at the projected intersection of the ZPTL with the pipeline. The subsurface monitoring points are shown on the detailed design drawings in Appendix A and are consistent with the example provided in the CPKC Geotechnical Protocol. The offset of the first pair of sub-surface monitoring points is a deviation from Section 9.2.2 of the CPKC Geotechnical Protocol, and

the additional offset is requested to facilitate installation of the instruments using a drill rig, to ensure the equipment does not foul the track. A third pair of subsurface monitoring points at the toe of the railway embankment as prescribed in Section 9.2.2 of the CPKC Geotechnical Protocol is not required for this crossing since there is no embankment raising the track above the adjacent prairie level at this crossing location. The tip of the sub-surface settlement points will be installed to a minimum of 1 m above the pipe obvert. The proposed monitoring locations meet the intended purpose of the CPKC Geotechnical Protocol despite the requested deviations to the offsets from the tracks.

- A baseline survey of all survey points conducted and submitted to CPKC prior to the installation of the pipeline infrastructure. All monitoring surveys will be conducted by means of a 1-arc total station with 2 mm accuracy and capable of detecting movements that would result in a change of the track class as determined by the Federal Railway Administration and Transport Canada track safety rules. KGS Group intends to set up the monitoring program so that no or minimal access to the CPKC right-of-way is required to conduct monitoring surveys during construction.
- Daily surveying of all monitoring locations will be completed with submission of values to CPKC for review. The required frequency of survey monitoring and reporting will be confirmed by CPKC in writing; however, based on the Class 2 track classification, we anticipate the following in accordance with CPKC's "Track Movement Monitoring Guidelines for Trenchless Pipe Installation" (March 2024):
 - **Pre-construction:** Baseline survey monitoring will occur a minimum of two (2) days prior to the trenchless construction operations for both surface and subsurface monitoring points twice per day to establish reliable methodology and demonstrate accuracy.
 - **During Construction:** Daily monitoring will proceed during the duration of construction in which survey monitoring will be captured a minimum of twice per day, and before and after each train passage during the contractor's working shift.
 - **Post Construction:** At a minimum, an additional three (3) days of monitoring (readings collected twice per day) will be conducted after completion of the installation. If delayed settlements are anticipated based on observations during construction, KGS Group may perform daily monitoring surveys up to two (2) weeks following completion of the installation.

Based on the underground utility drawings and upon KGS Group field observations of the proposed pipeline alignment option, there is no major building / infrastructure identified in the vicinity of the pipeline alignment. Upon receipt of the crossing permit, KGS Group will request CPKC buried utility locates to determine the presence of utilities within the railway corridor (e.g. fiber optic cables). The risk of potential conflicts with subsurface facilities for the pipeline installation is anticipated to be very low; however, the location of the sub-surface settlement points may be adjusted to avoid any conflicts. Should the selected trenchless installation methods encounter any obstructions or premature refusal of any kind, work should stop immediately for reassessment, and CPKC will be notified.

6.2.5 GEOTECHNICAL PERSONNEL

Mr. Kelly Fordyce, P.Eng., will be the Geotechnical Engineer of Record for this project. He will be responsible for reviewing the shop drawings and work plans submitted by the pipeline contractor to determine if the proposed installation method (and dewatering method, if required) could cause any adverse impact to the

CPKC infrastructure. He will also be responsible for day-to-day review and inspection of the work to ensure that the geotechnical requirements are satisfied during construction.

Mr. Dami Adedapo, Ph.D, P.Eng., will act as the senior geotechnical and trenchless technical advisor on behalf of KGS Group for the proposed utility crossing.

6.2.6 EMERGENCY RESPONSE AND CONTINGENCY PLAN

The railway tracks at this crossing fall under Track Class 2. Two (2) alarm levels (Level 1 Warning/Alert and Level 2 Critical/Review) have been established for the installation of the pipe under the tracks.

Level 1 Warning/Alert

Warning/Alert level indicates a measurement of 11 mm of settlement or heave has been measured at a surface/subsurface monitoring point. If the results of the monitoring are within the Warning/Alert Level, KGS Group will contact CPKC and their geotechnical service provider within 6 hours of the recorded exceedance and will record this information in the daily report. The contractor's work method will be reviewed at this stage and necessary adjustments will be made to mitigate any additional movements. A survey of the monitoring points will be completed prior to commencing further work and work will only proceed if the magnitude of movement has stabilized from the previous readings. If movement is observed, work will be discontinued until movement is stopped at which point the pipe installation will be authorized to proceed. The results of the additional monitoring will be provided to CPKC and their geotechnical service provider within 6 hours of the additional monitoring.

Level 2 Critical/Review

Critical/Review level indicates a measurement of 22 mm of settlement or heave has been measured at a surface/subsurface monitoring point. If the results of the monitoring trigger the Critical level, KGS Group will direct the work to stop immediately, and contact CPKC and their geotechnical service provider as soon as possible (within 1 hour of the exceedance) and will record this information in the daily report. The Geotechnical Engineer of Record will also mobilize to site to identify if there are any visual indications of movement or subsidence of the rail tracks, ballast, rail embankment, and surrounding area. A survey of the monitoring points will be conducted, and work will only be authorized to proceed if there is no movement between at least two readings taken 12 hours apart. If movement is recorded, survey monitoring will continue until movement has stopped and a new pipe procedure has been submitted. In all cases, CPKC will have the right to carry out maintenance of the track upon completion of the works and during any agreed warranty period to restore the track at the expense of the City of Winnipeg's contractor to the same or better condition as was established in the baseline survey. The results of the additional monitoring will be provided to CPKC and their geotechnical service provider as soon as possible from completion of the additional monitoring.

If a critical defect is detected, an on-site meeting or conference call would be held between all parties including the Contractor, Geotechnical Engineer of Record, City of Winnipeg, and CPKC representative to determine the cause of the defect and remedial action based on the contingency plan. A contingency plan will be developed prior to the start of construction including potential local sources of ballast rock and fill materials to aid in an emergency. The contingency plan may also include pressure injected grout to fill any

potential voids to prevent further settlement. As aforementioned, the risk that such a problem will occur with the proposed installation methodology is unlikely.

The contingency plan will be reviewed and approved by the Geotechnical Engineer of Record prior to construction and a copy will be provided to CPKC. A copy of the contingency plan will be posted on site and will reside with key personnel including the on-site geotechnical representative. An example emergency response contact list is presented in Table 6-1 below.

TABLE 6-1: EMERGENCY RESPONSE CONTACT LIST

Department / Title	Name	Email	Phone Number
Project Manager – Overseeing Utility Installation	Duane Baker	DuaneBaker@winnipeg.ca	c. 204-770-6745
Geotechnical Engineer of Record for Utility Owner	Kelly Fordyce, P.Eng	kfordyce@kgsgroup.com	c. 204-803-1312
CPKC Geotechnical Engineer or Service Provider	TBD by CPKC		
CPKC Roadmaster	Darryl Packulak	Darryl.packulak@cpkcr.com	c. 204-761-8771
CPKC Signal & Communication Supervisor	Warren Nistico	Warren.nistico@cpkcr.com	c. 204-771-4257
CPKC Director Geotechnical Engineering	Danny Wong	Dannyj_Wong@cpkcr.com	c. 403-826-3313
CPKC Utilities Supervisor – ON, MB	Jack Carello	Jack_Carello@cpkcr.com	c. 416-992-2676
CPKC Call Before You Dig - Canada	Main Desk	call_b4udig@cpkcr.com	1-800-387-1833
CPKC 24HR Utility Owner Emergency Response			204-986-2511

Notes:

- 1) A complete list of emergency contacts will be provided to CPKC at least 2 weeks prior to construction.

6.2.7 CONSTRUCTION AND POST INSTALLATION REPORTING

The Geotechnical Engineer of Record or their on-site representative will prepare daily construction inspection/monitoring reports in accordance with Section 12.0 of the CPKC's Geotechnical Protocol document. The daily reports are expected to be issued within a few hours of the end of a work shift. Please note that this proposed installation will include day shifts only, and extended work hours may be requested by the Contractor to reduce the construction duration.

The Geotechnical Engineer of Record will compile a final memorandum to summarize the daily construction and monitoring activities and provide results of the survey monitoring data. The final memo and survey monitoring data will be submitted to CPKC. In addition, the Geotechnical Engineer of Record shall provide confirmation in writing that the work was conducted in accordance with the detailed plan reviewed and accepted by CPKC. The report shall include as-constructed drawings sealed by the Engineer of Record, and should confirm that there are no expected issues of the railway track due to the installation.

6.3 Temporary Excavations

Excavations for the trenchless installation pits will be required to facilitate installation of the pipeline at the entry and exit locations. This may require temporary shoring or bracing to allow safe entry by workers and minimize adverse effects to any adjacent infrastructure.

All excavations must be located outside the ZPTL which is defined as the area under the track and within a 1V:1.5H soil zone extending down from a point at the level of the Base of Rail and 2 m (6.6 ft) from the centerline of the track. It is also recommended to locate excavations outside of the CPKC right-of-way entirely. All excavation work should be performed in accordance with the latest version of the Manitoba Workplace Safety and Health Regulation.

Suitable options include steel piling and timber lagging or driven steel sheet piling. All excavations deeper than 1.5 m should be reviewed and designed prior to construction by an experienced professional engineer with an expertise in geotechnical engineering. Openings and voids behind shoring lagging or sheet piles should be backfilled with free draining granular material.

All open excavation side slopes should be covered to prevent saturation and raveling of the soil, and all surface runoffs should be directed away from excavations. All surcharge loads such as stockpiled soil, equipment, etc. should be kept a minimum horizontal distance of 10 m away from the edge of excavations.

There may be the potential of localized groundwater inflows into the excavations from the cohesionless overburden layers as well as below the water table, which may require temporary pumping as well as potential shoring. Additionally, groundwater levels will fluctuate seasonally and following precipitation events and should be monitored regularly prior to, and during construction. Design of the above measures depends on the size, depth, and extent of excavation during construction. Should dewatering systems be required, KGS Group will review the contractor's dewatering plan to confirm that there would not be adverse impacts to CPKC's infrastructure. A copy of the dewatering plan will be provided to CPKC prior to construction.

6.3.1 GROUND MOVEMENT

Excavation support systems should be designed to control ground movement / subsidence around the perimeter of the excavation. The magnitude of ground movement could be affected by the procedure and workmanship applied during construction. Potential settlement of the ground surface adjacent to temporary shoring systems should be recognized and accounted for. Any resulting movement / settlement around the perimeter of the excavation must be kept within acceptable limits as specified in the contract document.

The excavation and shoring system should 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. KGS Group will review all excavation and shoring plans to confirm that there will not be adverse impacts to the rail line and CPKC property.

6.4 Basal Heave

The base of excavation and shoring is recommended to be designed to achieve a minimum factor of safety of 1.3 with respect to basal heave.

6.5 Care and Control of Water

To maintain safe working conditions in excavations/shafts and to protect against instability of the excavation base, water should not be allowed to accumulate anywhere within excavations or to within 0.5 m below the lowest point within the excavation. 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 potential groundwater seepage and surface water drainage within the excavation so it can be pumped out and treated before being released into the environment. Surface run-off resulting from rainfall should be controlled and prevented from entering the excavation.

6.6 Lateral Earth Pressures

For design purposes, the soils may be assigned active, passive and at-rest lateral earth pressure coefficients as shown in Table 6-2.

TABLE 6-2: LATERAL EARTH PRESSURE COEFFICIENTS

Material	Bulk Unit Weight	Φ'	K_a	K_p	K_o
Well-Graded Granular Fill	20 kN/m ³	35°	0.27	3.69	0.43
Clay (CL)	18 kN/m ³	20°	0.49	2.04	0.66
Clay (CH)	18 kN/m ³	17°	0.55	1.83	0.71
Glacial Till	22 kN/m ³	23°	0.44	2.28	0.61

6.7 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 the spoil material is required to comply with all applicable laws and regulations. The Contractor will be required to obtain any and all necessary permits/approvals for the discharge of groundwater. Routine monitoring of groundwater discharge quality by the Contractor may be required during construction.

6.8 Frost Penetration

The depth of frost penetration will vary depending on air temperature, ground cover, the type of fill material used during development and other factors. 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 bare ground and no insulation cover.

7.0 CLOSURE

The geotechnical investigation conducted by KGS Group describes the underlying soil and groundwater conditions along the proposed alignment of the feeder main pipeline beneath the CPKC railway tracks at Mile 2.93 Winnipeg Beach Spur. 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. To develop this report, it was necessary to interpolate between the boreholes that were drilled 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 method and on the level of workmanship that can be reasonably expected for the installation of the pipelines. It should be noted that the Contractor's selected equipment, means and methods, and workmanship will influence the behaviour and performance of the subsurface soils encountered at the site. KGS Group will review the contractor's construction work plan including shoring design, dewatering plan, and emergency response/contingency plans, and ensure that there is no adverse impact to the rail line and CPKC's infrastructure.

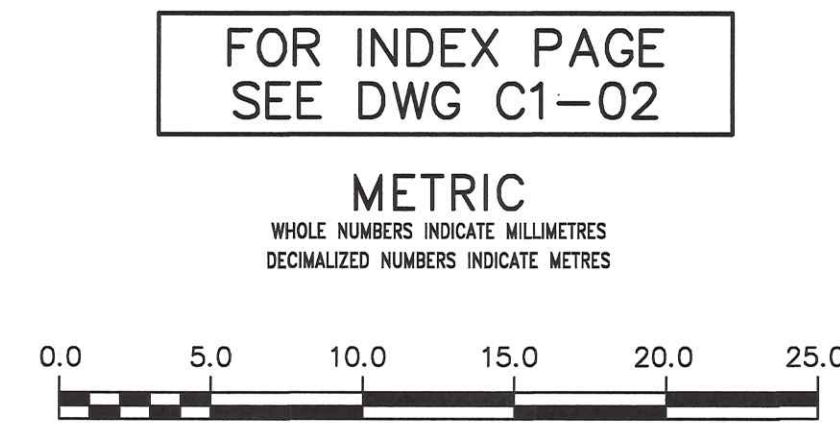
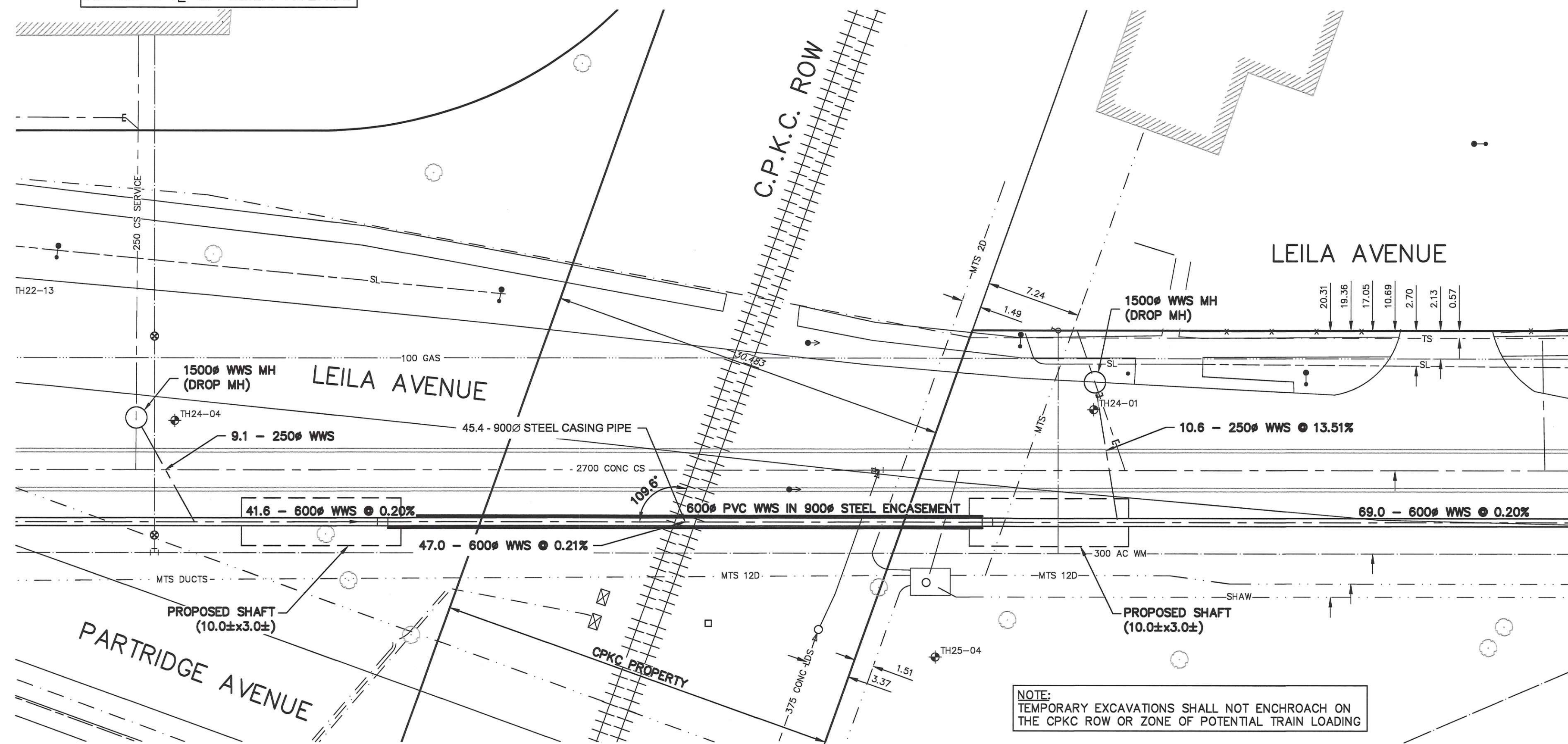
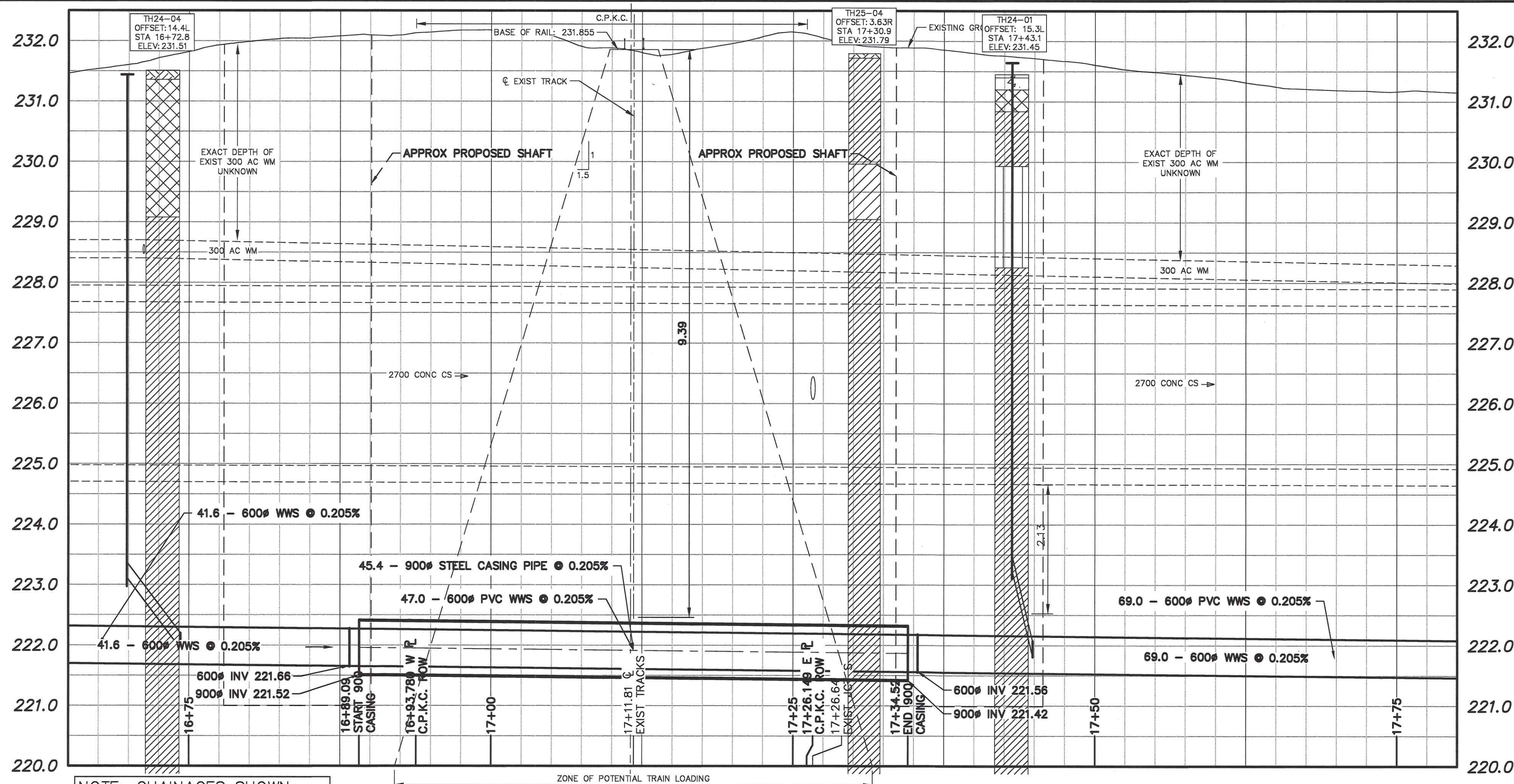
In accordance with CPKC's Geotechnical Protocol, full time inspection by qualified geotechnical personnel is required during construction to ensure that design intent is achieved, and to address any issues that may arise due to variability in soil conditions.

8.0 REFERENCES

1. Trek Geotechnical (2024). CP Rail Pipe Crossing Mile 2.93 Winnipeg Beach Subdivision – Geotechnical Investigation Report – Final Rev 1. July 2024.
2. Trek Geotechnical (2023). Armstrong Combined Sewer Preliminary Design – Geotechnical Investigation Report – Final Rev 3. October 2023.
3. KGS Group, September 2025. Armstrong Combined Sewer Relief Project – Geotechnical Data Report – Draft Rev A.
4. Department of Geological Engineering, the University of Manitoba, (1983). Geological Engineering Report for Urban Development of Winnipeg.
5. Transport Canada, 2000. Standards Respecting Pipeline Crossings Under Railways TC E-10, June 21, 2000
6. Canadian Pacific Kansas City Railway, 2024. Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks. May 15, 2024.
7. O'Reilly, M.P., & New, B.M. (1982). Settlements above tunnels in the United Kingdom -their magnitude and prediction. In: Tunnelling 82. Proceedings of the 3rd international symposium (pp. 173-181), Brighton 7-11 June 1982.

APPENDIX A

Detailed Design Drawings



WARNING
IF POWER EQUIPMENT OR EXPLOSIVES ARE TO BE USED FOR EXCAVATION ON THIS PROJECT THE CONTRACTOR MUST:
1) NOTIFY THE GAS COMPANY OF THE PROPOSED LOCATION OF EXCAVATION.
2) TAKE PRECAUTION TO AVOID DAMAGE TO GAS COMPANY INSTALLATIONS.
SEE PROVINCIAL REGULATION 210/72 FOR DETAILS

LOCATION APPROVED UNDERGROUND STRUCTURES
SUPV. U/O STRUCTURES COMMITTEE
DATE
NOTE:
LOCATION OF UNDERGROUND STRUCTURES AS SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE BUT NO GUARANTEE IS GIVEN THAT ALL EXISTING UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL UTILITIES MUST BE OBTAINED FROM THE INDIVIDUAL UTILITIES BEFORE PROCEEDING WITH CONSTRUCTION.

NOTE:
TEMPORARY EXCAVATIONS SHALL NOT ENCHROACH ON THE CPKC ROW OR ZONE OF POTENTIAL TRAIN LOADING

VERTICAL DATUM: CGVD28 (HT2.0 Geoid)	
HORIZONTAL DATUM: NAD83 (June 1990), Zone 14	
0	ISSUED FOR CONSTRUCTION
1	REVISIONS
2	DATE (YYYY/MM/DD)
3	BY

KGS GROUP	
DESIGNED BY: KF	CHECKED BY: TE
DRAWN BY: GEL	APPROVED BY: TE
SCALE: HORIZONTAL 1:250 VERTICAL 1:50	RELEASED FOR CONSTRUCTION
DATE	DATE

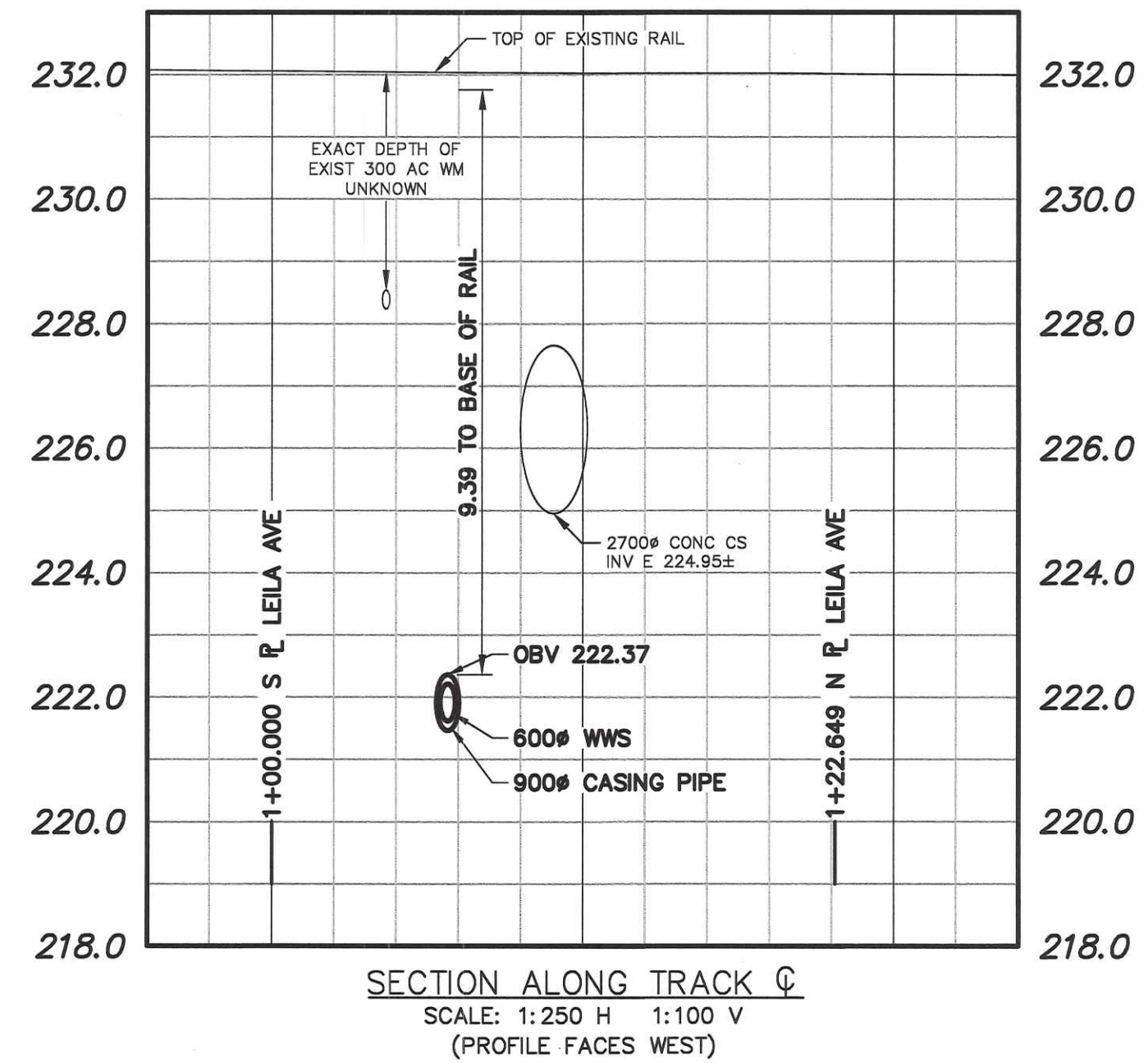
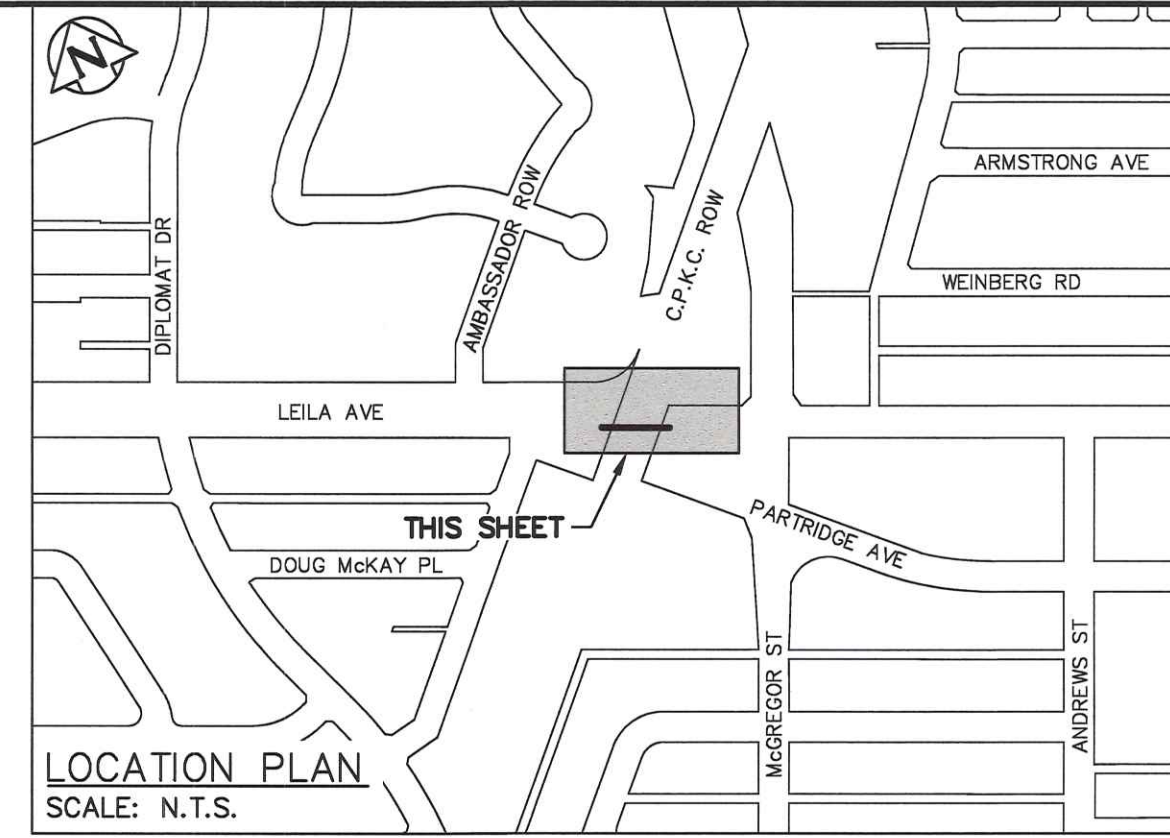
ENGINEER'S SEAL
CONSULTANT DRAWING NUMBER
13640

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT
ENGINEERING SERVICES DIVISION

ARMSTRONG SEWER RELIEF WORKS
CONTRACT 1
LEILA AVENUE
CPKC RAILWAY MILE 2.93
WINNIPEG BEACH SPUR CROSSING DESIGN

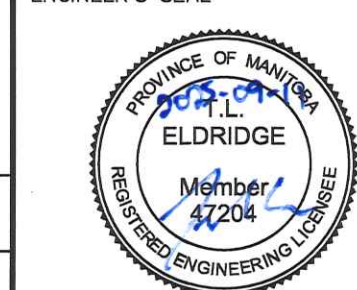
SHEET **32** OF **33**
CITY DRAWING NUMBER
13640

- LITHOLOGY GRAPHICS**
- ASPHALT/CONCRETE
 - TOPSOIL
 - SILT
 - SILT AND CLAY
 - GRANULAR/CLAY FILL
 - CLAY (CL)
 - CLAY (CH)
 - SILT TILL
 - LIMESTONE



- GENERAL NOTES:**
- ALL UTILITIES SHOWN ARE APPROXIMATE ONLY. LOCATIONS OF ALL UTILITIES TO BE CONFIRMED IN FIELD BY THE CONTRACTOR, INCLUDING ANY UTILITIES IN THE RAILWAY CORRIDOR (E.G. FIBER OPTIC TRANSMISSION SYSTEMS).
 - THIS DRAWING DEPICTS THE DESIGN OF THE CASED CROSSING, WASTEWATER SEWER DESIGN ELEMENTS ARE SHOWN FOR INFORMATION ONLY.
 - RAILWAY MILEAGE AND SUBDIVISION: MILE 2.93 WINNIPEG BEACH SPUR.
 - GEOTECHNICAL REPORT: ARMSTRONG DETAILED DESIGN AND CONTRACT ADMINISTRATION CPKC MILE 2.93 WINNIPEG BEACH SPUR CROSSING GEOTECHNICAL REPORT (KGS GROUP AUGUST 2025).
 - CONTRACTOR TO CONFIRM BASE OF RAIL ELEVATION UPON LAYOUT OF THE WORKS.
- TRENCHLESS NOTES:**
- CASING WALL THICKNESS DESIGN BASED ON COOPER E80 TRACK LOADING.
 - CARRIER PIPE TO BE SUPPORTED BY MANUFACTURED CASING SPACERS. CASING ENDS TO BE SEALED WITH MANUFACTURED NEOPRENE RUBBER END SEALS.
 - CROSSING TO BE CONSTRUCTED, MAINTAINED AND OPERATED IN ACCORDANCE WITH TRANSPORT CANADA STANDARD TC E-10 AND THE LATEST EDITION OF CSA STANDARD Z662.
 - WORKING PIT DIMENSIONS ARE APPROXIMATE. SUPPORT STRUCTURE DESIGNS ARE THE CONTRACTOR'S RESPONSIBILITY.
 - SUPPORT STRUCTURES SHALL BE DESIGNED AND CERTIFIED BY A PROFESSIONAL ENGINEER LICENSED TO PRACTICE IN THE PROVINCE OF MANITOBA.
 - SUPPORT STRUCTURES SHALL BE DESIGNED BASED ON THE SITE CONDITIONS, ANTICIPATED GROUND AND GROUNDWATER CONDITIONS, TRENCHLESS INSTALLATION EQUIPMENT AND THE RECOMMENDATIONS IN THE GEOTECHNICAL REPORT.
- ENCASEMENT PIPE SPECIFICATION:**
- OUTSIDE DIAMETER: 914mm
 - PIPE MATERIAL: STEEL
 - SPECIFICATION AND GRADE: ASTM A252 GR2 (241 MPa SMYS)
 - WALL THICKNESS: 13.5mm
 - PROTECTION: N/A
 - JOINT: WELDED (CJP GROOVE WELDS)
 - INSTALLATION METHOD: PILOT TUBE, AUGER BORING OR PIPE RAMMING
- CARRIER PIPE SPECIFICATION:**
- CONTENTS: WASTE WATER
 - NOMINAL DIAMETER: 600mm
 - PIPE MATERIAL: PVC
 - SPECIFICATION: AWWA C900
 - DIMENSION RATIO: SDR 35
 - OPERATING PRESSURE: N/A
 - SURGE/TEST PRESSURE: N/A
 - JOINT: RESTRAINED (EXTERNAL BELL HARNESS)

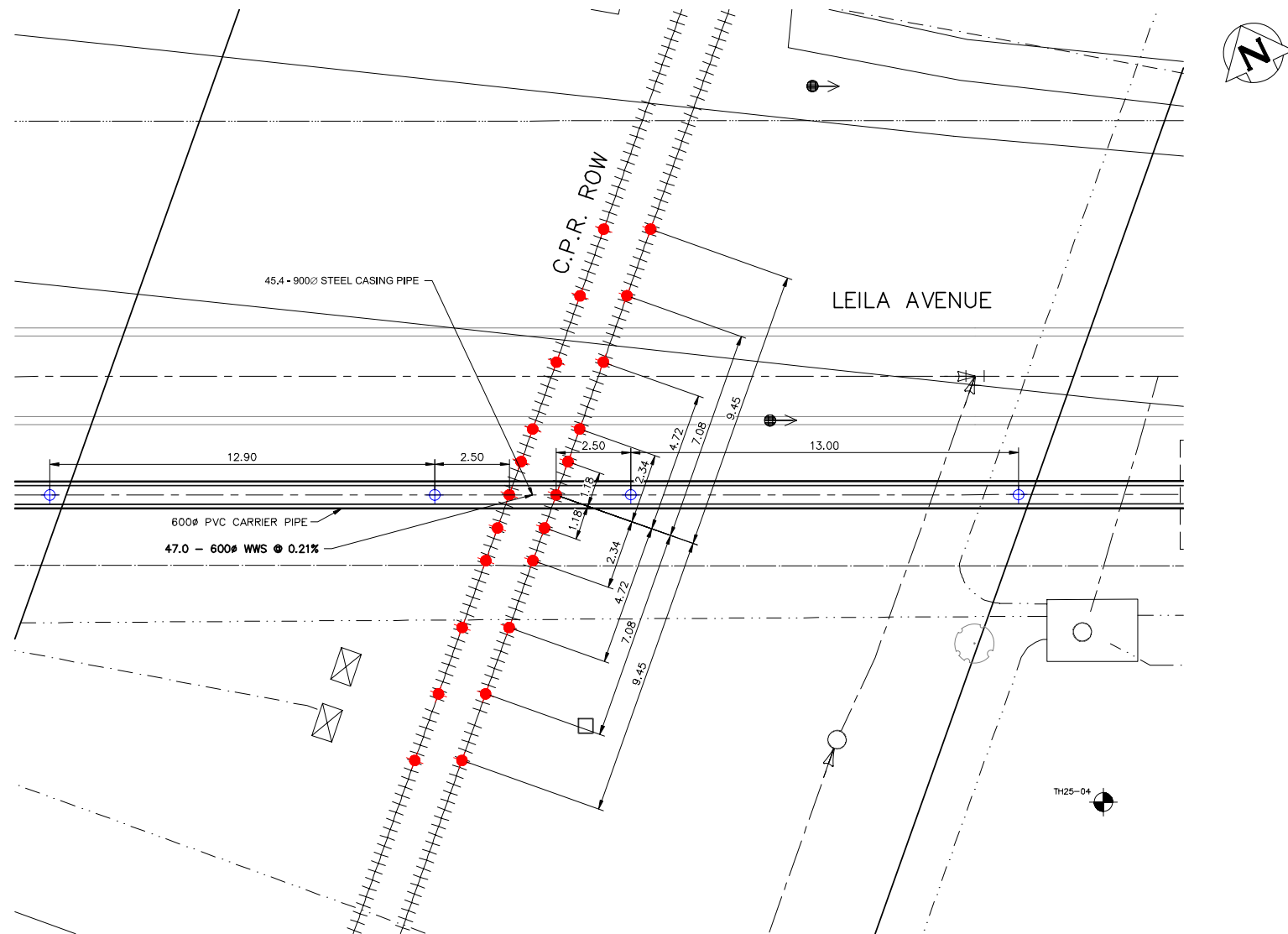
ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
KGS Group
No. 245



BID OPP: ###-20##
CONTRACT NUMBER: #

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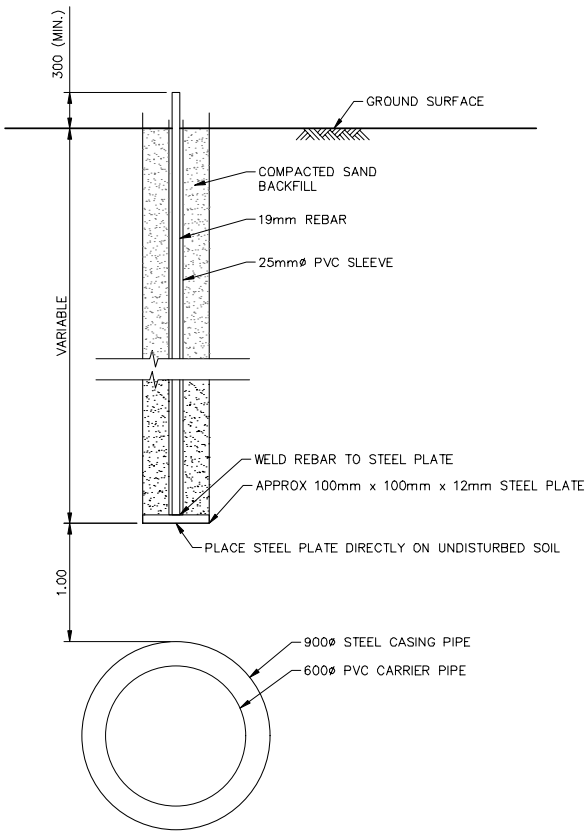
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TRACK MONITORING PLAN
SCALE = 1:100

- LEGEND:**
- SURFACE MONITORING LOCATION
 - SUB-SURFACE MONITORING LOCATION

- NOTES:**
- SUB-SURFACE MONITORING POINTS TO BE INSTALLED TO 1.0m ABOVE CASING OBVERT.
 - EXACT LOCATION OF SUB-SURFACE MONITORING POINT TO BE DETERMINED FOLLOWING LOCATION OF UTILITIES WITHIN THE RAILWAY CORRIDOR.



SUB-SURFACE MONITORING POINT INSTALLATION DETAIL
SCALE = NTS

- TRACK MONITORING:**
- MONITOR RAIL TRACK IN ACCORDANCE WITH TRACK MONITORING PLAN, SEE TECHNICAL SPECIFICATIONS AND KGS GROUP GEOTECHNICAL CROSSING REPORT.
 - SETTLEMENT MONITORING THRESHOLDS:
 - CRITICAL/REVIEW THRESHOLD: >22 mm
 - ALERT/WARNING THRESHOLD: >11 mm
 - SURVEY RESULTS SHALL BE SUBMITTED DAILY TO GEOTECHNICAL ENGINEER AND CPKC FOR REVIEW.



FOR INDEX PAGE
SEE DWG C1-02

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES



WARNING IF POWER EQUIPMENT OR EXPLOSIVES ARE TO BE USED FOR EXCAVATION ON THIS PROJECT THE CONTRACTOR MUST: 1) NOTIFY THE GAS COMPANY OF THE PROPOSED LOCATION OF EXCAVATION. 2) TAKE PRECAUTION TO AVOID DAMAGE TO GAS COMPANY INSTALLATIONS. SEE PROVINCIAL REGULATION 210/72 FOR DETAILS	LOCATION APPROVED UNDERGROUND STRUCTURES SUPV. U/G STRUCTURES COMMITTEE _____ DATE _____ NOTE: LOCATION OF UNDERGROUND STRUCTURES AS SHOWN ARE BASED ON THE BEST INFORMATION AVAILABLE BUT NO GUARANTEE IS GIVEN THAT ALL EXISTING UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL SERVICES MUST BE OBTAINED FROM THE INDIVIDUAL UTILITIES BEFORE PROCEEDING WITH CONSTRUCTION.	VERTICAL DATUM: CGVD28 (HT2.0 Geoid) HORIZONTAL DATUM: NAD83 (June 1990), Zone 14 <table><tr><td>DESIGNED BY</td><td>KF</td><td>CHECKED BY</td><td>TE</td></tr><tr><td>DRAWN BY</td><td>GEL</td><td>APPROVED BY</td><td>TE</td></tr><tr><td>SCALE:</td><td></td><td>RELEASED FOR CONSTRUCTION</td><td></td></tr><tr><td>HORIZONTAL</td><td>1:100</td><td></td><td></td></tr><tr><td>VERTICAL</td><td>—</td><td></td><td></td></tr><tr><td>DATE</td><td></td><td>DATE</td><td></td></tr></table>	DESIGNED BY	KF	CHECKED BY	TE	DRAWN BY	GEL	APPROVED BY	TE	SCALE:		RELEASED FOR CONSTRUCTION		HORIZONTAL	1:100			VERTICAL	—			DATE		DATE		KGS GROUP ENGINEER'S SEAL CONSULTANT DRAWING NUMBER 13641	THE CITY OF WINNIPEG WATER AND WASTE DEPARTMENT ENGINEERING SERVICES DIVISION ARMSTRONG SEWER RELIEF WORKS CONTRACT 1 LEILA AVENUE CPKC RAILWAY MILE 2.93 WINNIPEG BEACH SPUR SETTLEMENT MONITORING	SHEET 33 OF 33 CITY DRAWING NUMBER 13641
DESIGNED BY	KF	CHECKED BY	TE																										
DRAWN BY	GEL	APPROVED BY	TE																										
SCALE:		RELEASED FOR CONSTRUCTION																											
HORIZONTAL	1:100																												
VERTICAL	—																												
DATE		DATE																											

APPENDIX B

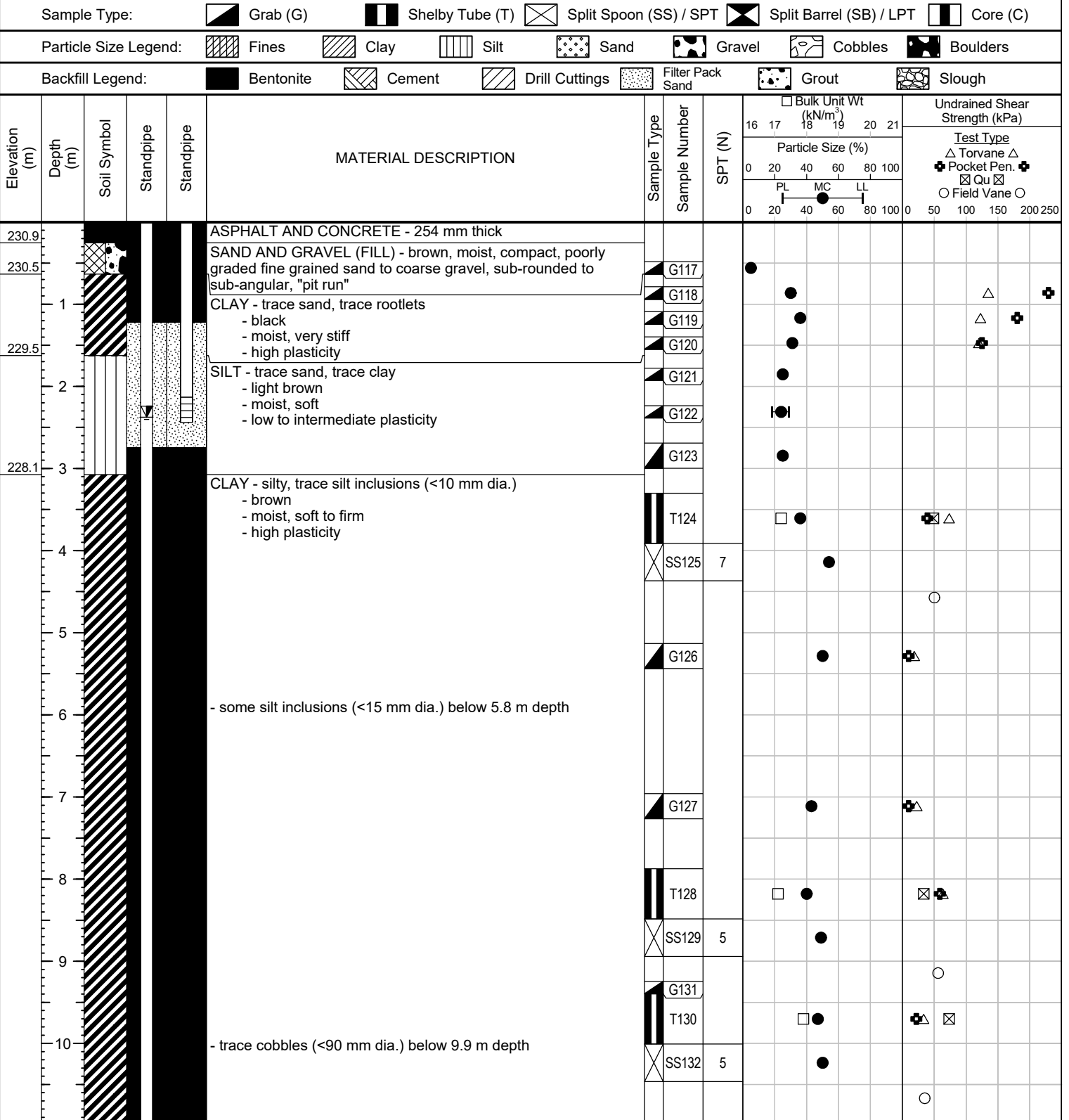
2022/2024 Trek Geotechnical Borehole Logs

Sub-Surface Log

Test Hole TH22-13

1 of 2

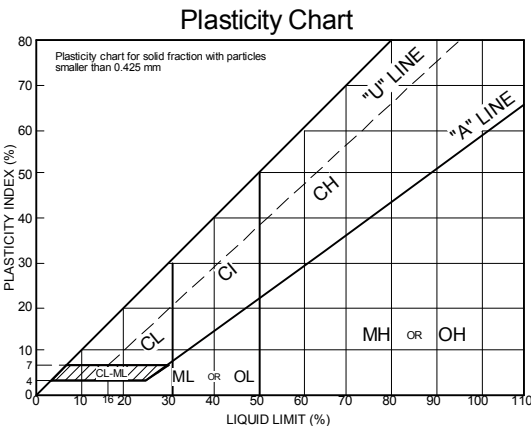
Client: Jacobs Canada Inc. **Project Number:** 0336-003-00
Project Name: Armstrong Combined Sewer **Location:** UTM N-5534432.9, E-634312.5
Contractor: Paddock Drilling Ltd. **Ground Elevation:** 231.15 m Top of Pavement
Method: 150mm Solid Stem Auger, Acker MP8 Truck Mount **Date Drilled:** September 21, 2022



Logged By: Tyler Chapko **Reviewed By:** Kent Bannister **Project Engineer:** Nelson Ferreira












GENERAL NOTES

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

Major Divisions		USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		Particle Size		Material							
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	<div>Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent..... GW, GP, SW, SP More than 12 percent..... GM, GC, SM, SC 6 to 12 percent..... Borderline cases requiring dual symbols*</div>	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	mm	ASTM Sieve sizes							
			GP		Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW									
			GM		Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4			Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols						
			GC		Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7									
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3									
			SP		Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW									
			SM		Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4			Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols						
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7									
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)	ML		Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity		Particle Size		mm	ASTM Sieve Sizes							
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		mm	> 300									
		OL		Organic silts and organic silty clays of low plasticity						75 to 300	3 in. to 12 in.					
	Silts and Clays (Liquid limit greater than 50)	MH		Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts		19 to 75	3/4 in. to 3 in.									
		CH		Inorganic clays of high plasticity, fat clays						4.75 to 19	#4 to 3/4 in.					
		OH		Organic clays of medium to high plasticity, organic silts												
	Highly Organic Soils	Pt		Peat and other highly organic soils		Von Post Classification Limit	Strong colour or odour, and often fibrous texture			Material	Boulders	Cobbles	Gravel	Coarse	Fine	

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

Other Symbol Types

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

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)	VW - Vibrating Wire Piezometer
PL - Plastic Limit (%)	SI - Slope Inclinator
PI - Plasticity Index (%)	▽ Water Level at Time of Drilling
MC - Moisture Content (%)	▼ Water Level at End of Drilling
SPT - Standard Penetration Test	▽ Water Level After Drilling as Indicated on Test Hole Logs
RQD- Rock Quality Designation	
Qu - Unconfined Compression	
Su - Undrained Shear Strength	

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

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

* Used when the material is classified based on behaviour as a cohesive material

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

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

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

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

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

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

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



Sub-Surface Log

Test Hole TH24-01

1 of 2

Client: Jacobs Canada Inc.

Project Number: 0336-003-00

Project Name: Armstrong Combined Sewer - Rail Crossings

Location: UTM N-5534390, E-634384

Contractor: Paddock Drilling Ltd.

Ground Elevation: 231.45 m (geodetic)

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Date Drilled: February 1, 2024

Sample Type:

☒ Grab (G)

☐ Shelby Tube (T)

☐ Split Spoon (SS) / SPT

☐ Split Barrel (SB) / LPT

☐ Core (C)

Particle Size Legend:

☒ Fines

☒ Clay

☐ Silt

☐ Sand

☐ Gravel

☐ Cobbles

☐ Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m³)		Particle Size (%)		Undrained Shear Strength (kPa)		Test Type
						16	17	18	19	20	21	
231.4			ASPHALT - 50 mm thick									
231.2			CONCRETE - 200 mm thick									
230.8			SAND and GRAVEL (FILL) - trace clay, trace silt, trace organics, brown, frozen, moist when thawed, well graded, sub-rounded to sub angular	G01								
	1		CLAY - silty, trace sand, trace gravel, brownish grey, frozen to 1.2 m, moist and firm when thawed, high plasticity	G02								
229.9			SILT - trace clay, trace sand	G03								
	2		- light brown									
			- moist, soft	G04								
			- low plasticity									
			- wet below 2.4 m depth	G05								
228.2	3		CLAY - silty, trace sand, trace precipitates (< 5mm dia.)									
	4		- grey	G06								
			- moist, firm									
			- high plasticity									
	5			T07								
	6											
	7											
	8			G08								
	9											
	10			G09								
				G10								
				T11								
				G12								



Sub-Surface Log

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m ³)					Undrained Shear Strength (kPa)				
						Particle Size (%)					Test Type				
						0 20 40 60 80 100					△ Torvane △ ✦ Pocket Pen. ✦ ⊠ Qu ⊠				
						0 20 40 60 80 100					○ Field Vane ○				
	12				G13										
	13														
	14				G14										
	15				G15										
216.2			SILT (TILL) - some sand, trace gravel, trace clay - light brown - moist, compact - no to low plasticity		G16										
	16														
214.7															

END OF TEST HOLE AT 16.8 m IN SILT (TILL)

Notes:

- 1) Power auger refusal at 16.8 m depth.
- 2) Seepage and sloughing observed between 2.4 to 3.2 m depth in SILT.
- 3) Test hole open to 14.2 m depth immediately after drilling.
- 4) Water level at 14.1 m depth immediately after drilling.
- 5) Test hole backfilled with auger cuttings, bentonite, sand, and asphalt cold patch to surface.
- 6) Test hole elevation measured relative to a Temporary Benchmark (BM-2) established by Jacobs as 231.95 m on the top of rail at UTM 14U, N-5534409, E-634361.



Sub-Surface Log

Test Hole TH24-04

1 of 2

Client: Jacobs Canada Inc.

Project Number: 0336-003-00

Project Name: Armstrong Combined Sewer - Rail Crossings

Location: UTM N-5534419, E-634320

Contractor: Paddock Drilling Ltd.

Ground Elevation: 231.51 m (geodetic)

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Date Drilled: February 2, 2024

Sample Type:

Grab (G) Shelby Tube (T) Split Spoon (SS) / SPT Split Barrel (SB) / LPT Core (C)

Particle Size Legend:

Fines Clay Silt Sand Gravel Cobbles Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m³)		Particle Size (%)		Undrained Shear Strength (kPa)									
						16	17	18	19	20	21	Test Type							
												0	20	40	60	80	100		
												0	20	40	60	80	100		
231.4			ORGANIC CLAY (TOPSOIL) - some silt, trace sand, trace gravel, trace rootlets, dark grey to black, frozen, moist and stiff when thawed, low to intermediate plasticity																
	1		CLAY (FILL) - silty, trace sand, trace gravel - grey - frozen to 1.2 m, moist and stiff when thawed and below - intermediate to high plasticity		G29														
					G30														
	2				G31														
229.1			CLAY - silty, trace sand, trace precipitates (< 5mm dia.) - grey - moist, firm - high plasticity		G32														
	3				G33														
	4				G34														
	5																		
	6				T35														
	7																		
					G36														
	8																		
					G37														
	9																		
	10																		
					T38														
	11																		

Logged By: Enrico Manimbao

Reviewed By: Matt Klymochko

Project Engineer: Nelson Ferreira

SUB-SURFACE LOG LOGS 2024-02-06 ARMSTRONG RAIL CROSSINGS 0_A_TC 0336 003 00.GPJ TREK GDT 5/10/24



Sub-Surface Log

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	Bulk Unit Wt (kN/m ³)		Particle Size (%)		Undrained Shear Strength (kPa)	
						16	17	18	19	20	21
						0 20 40 60 80 100					
						0 20 40 60 80 100					
215.7	12				G39						
215.4	16										

SILT (TILL) - some sand, trace gravel, trace clay, light brown, moist, compact, no to low plasticity









END OF TEST HOLE AT 16.2 m IN SILT (TILL)
Notes:
1) Power auger refusal at 16.2 m depth.
2) Seepage and sloughing not observed.
3) Test hole open and dry to 14.0 m depth immediately after drilling.
4) Test hole backfilled with auger cuttings and bentonite to surface.
5) Test hole elevation measured relative to a Temporary Benchmark (BM-2) established by Jacobs as 231.95 m on the top of rail at UTM 14U, N-5534409, E-634361.

APPENDIX C




2025 KGS Group Borehole Logs

KEY TO SYMBOLS




LITHOLOGIC SYMBOLS

	Asphalt
	Clay (CH, high plasticity)
	Clay (CL, low plasticity)
	Concrete
	Fill
	Limestone
	Till (mix of gravel, sand, clay and silt)
	Topsoil

SAMPLER SYMBOLS

	Auger Grab
	Core Barrel
	SPT Split Spoon

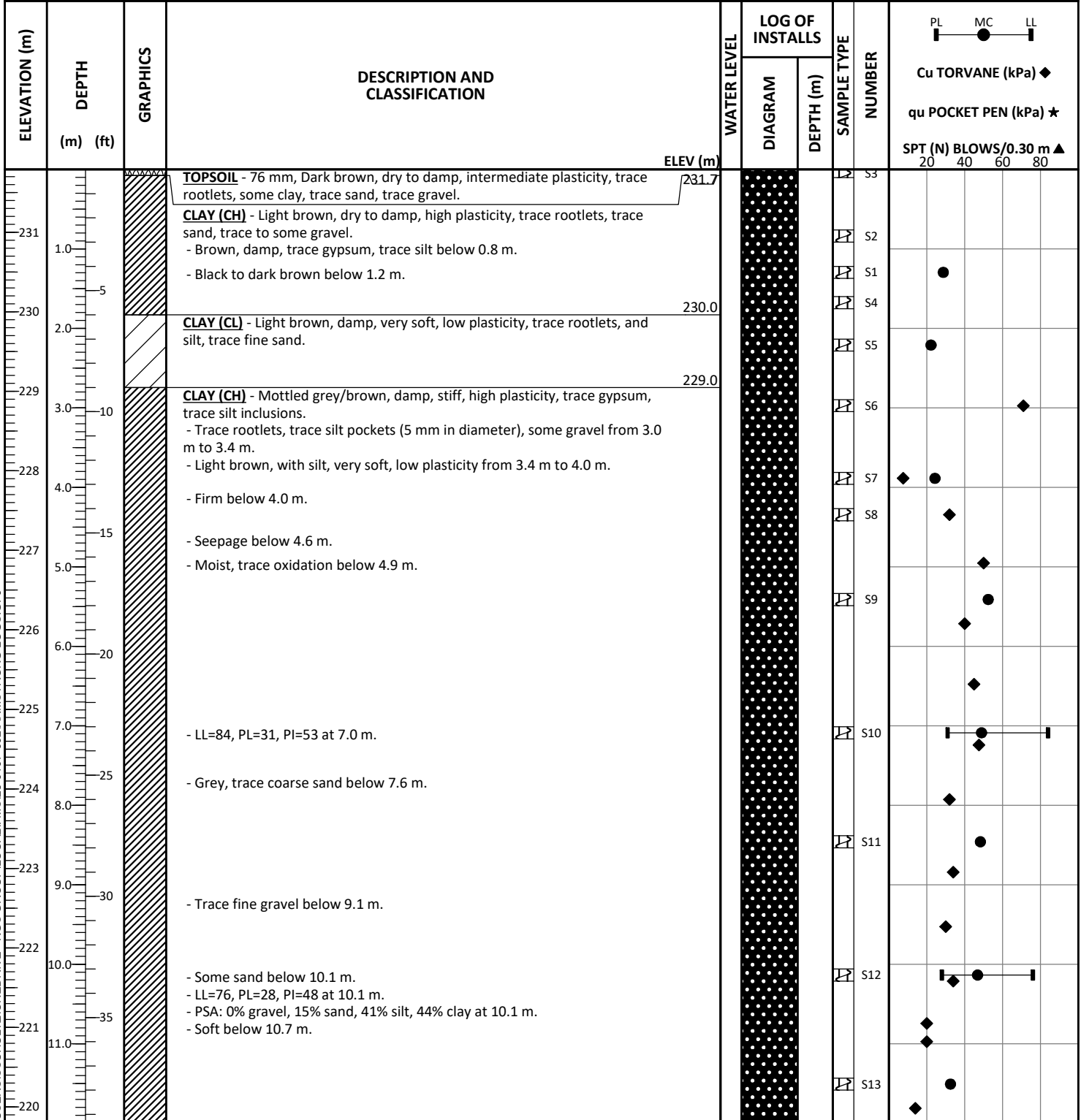
WELL CONSTRUCTION SYMBOLS

	Piezometer (bentonite backfill)
	Piezometer (grout backfill)
	Piezometer (sand backfill)

ABBREVIATIONS

LL	- Liquid Limit	PN	- Pneumatic Piezometer
PL	- Plastic Limit	VW	- Vibrating Wire Piezometer
PI	- Plastic Index	PID	- Photoionization Detector
MC	- Moisture Content	ppm	- Parts Per Million
DD	- Dry Density		Water Level During Drilling
NP	- Non-Plastic		Water Level Upon Completion of Drilling
-200	- Percent Passing No. 200 Sieve		Water Level Remeasured/Static
TV	- Torvane (kPa)		
PP	- Pocket Penetrometer (kPa)		
PSA	- Particle Size Analysis		
TOC	- Top Of Casing		

CLIENT	CITY OF WINNIPEG, WATER AND WASTE DEPARTMENT	PROJECT NO.	25-0107-002
PROJECT	Armstrong Detailed Design and CA/CI	SURFACE ELEV.	231.79 m
LOCATION	Winnipeg, Manitoba	START DATE	5-26-2025
DESCRIPTION	In the median southeast of the Leila Ave	UTM (m)	N 5,534,378
DRILL RIG / HAMMER	Mobile B54X Track Mounted Drill Rig with Auto-Hammer		E 634,365 Zone 14
METHOD(S)	0.0 m to 17.5 m: 125 mm ø SSA		



WATER LEVELS ▼ Upon Completion

12.80 m on 5-26-2025

CONTRACTOR
Maple Leaf Drilling Ltd.

INSPECTOR
S. SCHULTZ

APPROVED
DRAFT

DATE

ELEVATION (m)	DEPTH (m) (ft)	GRAPHICS	DESCRIPTION AND CLASSIFICATION	WATER LEVEL	LOG OF INSTALLS		SAMPLE TYPE	NUMBER	<div> <div>PL</div> <div>MC</div> <div>LL</div> </div> <div>Cu TORVANE (kPa) ◆</div> <div>qu POCKET PEN (kPa) ★</div> <div>SPT (N) BLOWS/0.30 m ▲</div> <div>20 40 60 80</div>		
					DIAGRAM	DEPTH (m)					
219	13.0		- Very soft below 14.2 m.			14.17		S14			
218	14.0										
217	15.0										
216	16.0										
215.3	55		SILT TILL - Light brown, moist, compact, low plasticity, with sand, some clay, trace gravel. - PSA: 5% gravel, 30% sand, 50% silt, 15% clay at 16.6 m.			17.32		S17			
214.3	17.0										
214	18.0		Notes: 1. End of test hole at 17.5 m. 2. Refusal encountered in silt till at a depth of 17.5 m. 3. Test hole caved to 14.9 m upon completion of drilling/digging. 4. Test hole backfilled with grout. 5. Grout mix consisted of 3 part cement, 1 part bentonite, 1 part water. 6. Flush mount well cover installed at surface.			17.53		S18			
213	19.0										
212	20.0										
211	21.0										
210	22.0										
209	23.0										
208	24.0										
207	25.0										
206	26.0										
205	27.0										

WATER LEVELS ▼ Upon Completion

12.80 m on 5-26-2025

CONTRACTOR
Maple Leaf Drilling Ltd.

INSPECTOR
S. SCHULTZ

APPROVED
DRAFT

DATE

SUMMARY OF INDEX TESTS

Sheet 1 of 2

Test Hole ID	Sample No.	Depth (m)	Classification	Gravel (%)	Sand (%)	Silt/Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	Moisture Content (%)	Dry Density (kN/m3)	Specific Gravity	Saturation (%)	Void Ratio
TH25-01	S2	2.1	CH							42				
TH25-01	S3	3.7	CH							52				
TH25-01	S4	5.3	CH	0	1	99	85	28	57	53				
TH25-01	S5	6.9	CH							52				
TH25-01	S6	8.6	CH							48				
TH25-01	S7	9.3	CH							46				
TH25-01	S8	10.4	CH							23				
TH25-01	S9	11.7	CH				59	19	40	46				
TH25-01	S10	13.1	CH							27				
TH25-01	S11	14.4	TILL	2	44	54				9				
TH25-02	S2	1.3	CL							21				
TH25-02	S3	2.1	CH							49				
TH25-02	S4	3.7	CH							50				
TH25-02	S5	5.3	CH							45				
TH25-02	S6	7.1	CH							43				
TH25-02	S7	8.5	CH				83	26	57	48				
TH25-02	S9	10.2	CH							25				
TH25-02	S10	11.6	CH							14				
TH25-02	S13	13.1	TILL	6	31	63	19	12	7	12				
TH25-02	S17	16.2	TILL	4	33	63				11				
TH25-03	S2	1.9	CL							24				
TH25-03	S3	2.6	CH							47				
TH25-03	S5	5.2	CH				93	28	65	53				
TH25-03	S6	6.9	CH							52				
TH25-03	S7	8.3	CH							52				
TH25-03	S8	9.8	CH	0	5	95	88	35	53	48				
TH25-03	S9	11.4	CH							51				
TH25-03	S10	13.1	CH							68				
TH25-03	S13	16.2	TILL	18	29	53				8				
TH25-04	S1	1.2	CH							29				
TH25-04	S5	2.1	CL							22				
TH25-04	S7	3.8	CL							24				
TH25-04	S9	5.3	CH							52				
TH25-04	S10	7.0	CH				84	31	53	49				
TH25-04	S11	8.4	CH							48				
TH25-04	S12	10.1	CH	0	15	85	76	28	48	47				
TH25-04	S13	11.4	CH							33				
TH25-04	S14	13.0	CH							57				
TH25-04	S15	14.5	CH							57				
TH25-04	S17	16.6	TILL	5	30	65				12				
TH25-05	S2	1.2	CL							24				
TH25-05	S5	2.7	CH							37				

* Moisture conditioned and remolded sample.
 ** Assumed specific gravity.



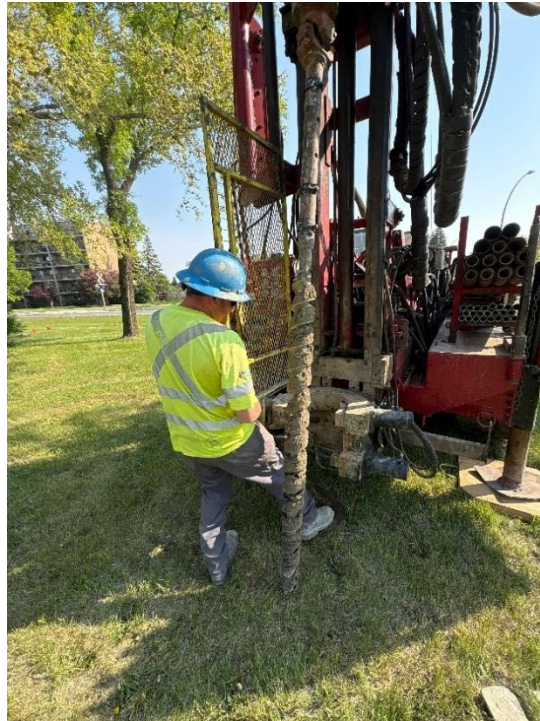
CLIENT
PROJECT NAME

CITY OF WINNIPEG, WATER AND WASTE DEPARTMENT
Armstrong Detailed Design and CA/CI

PROJECT NO. 25-0107-002
LOCATION Winnipeg, Manitoba

APPENDIX D

2025 Select Drilling Photos



TH25-04 Photo 1: 0 to 1.5 m (0 to 5 ft)



TH25-04 Photo 2: 1.5 to 3.0 m (5 to 10 ft)



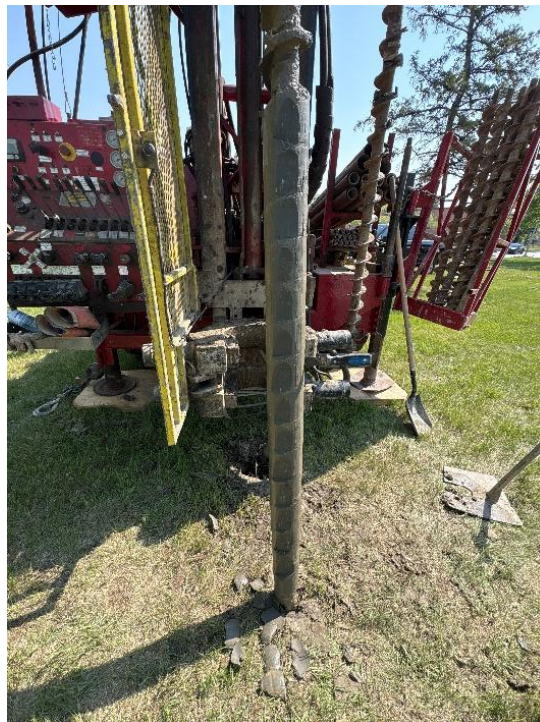
TH25-04 Photo 3: 3.0 to 4.5 m (10 to 15 ft)



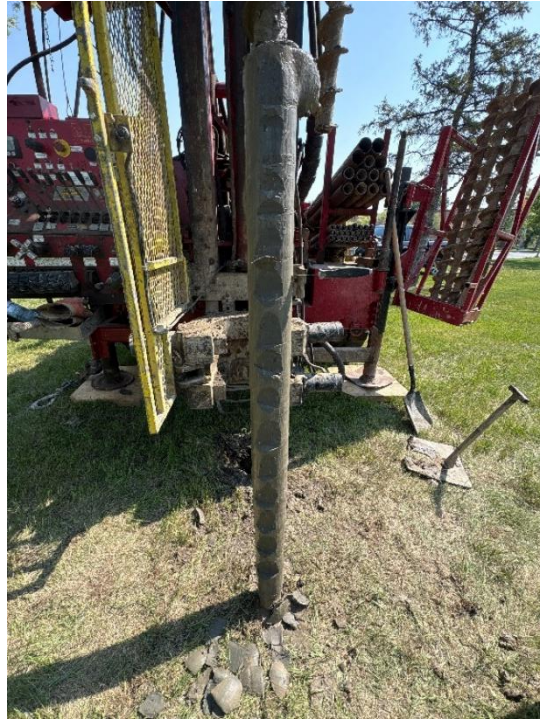
TH25-04 Photo 4: 4.5 to 6.0 m (15 to 20 ft)



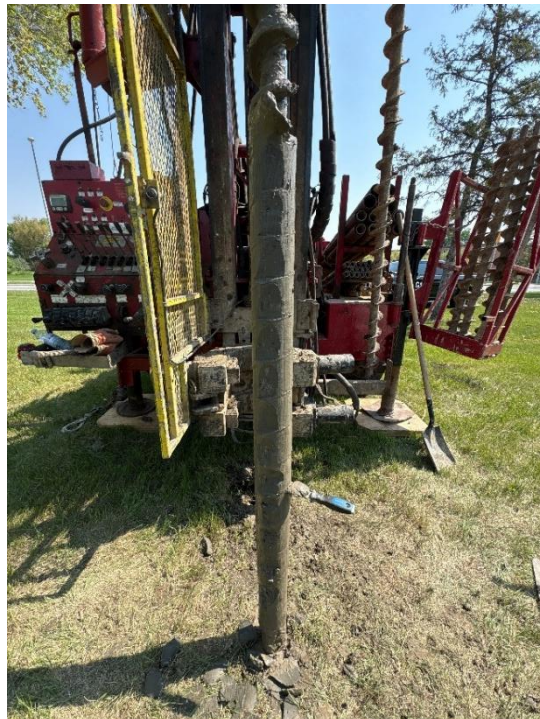
TH25-04 Photo 5: 6.0 to 7.5 m (20 to 25 ft)



TH25-04 Photo 6: 7.5 to 9.0 m (25 to 30 ft)



TH25-04 Photo 7: 9.0 to 10.5 m (30 to 35 ft)



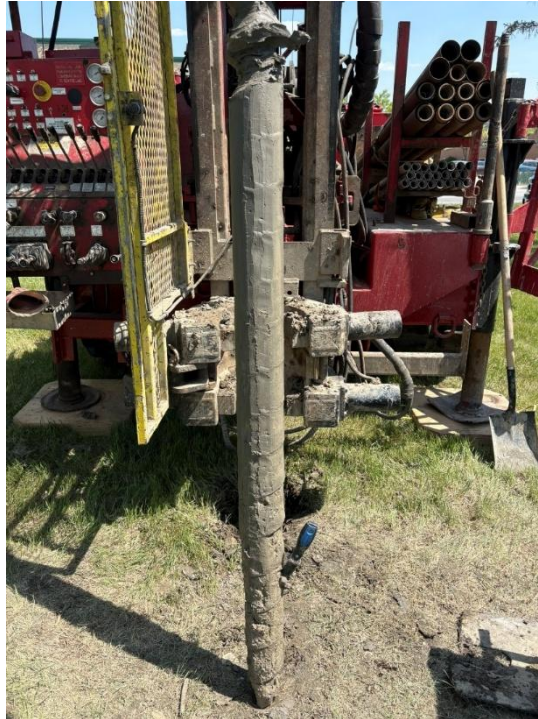
TH25-04 Photo 8: 10.5 to 12 m (35 to 40 ft)



TH25-04 Photo 9: 12 to 13.5 m (40 to 45 ft)



TH25-04 Photo 10: 13.5 to 15 m (45 to 50 ft)



TH25-04 Photo 11: 15 to 16.5 m (50 to 55 ft)

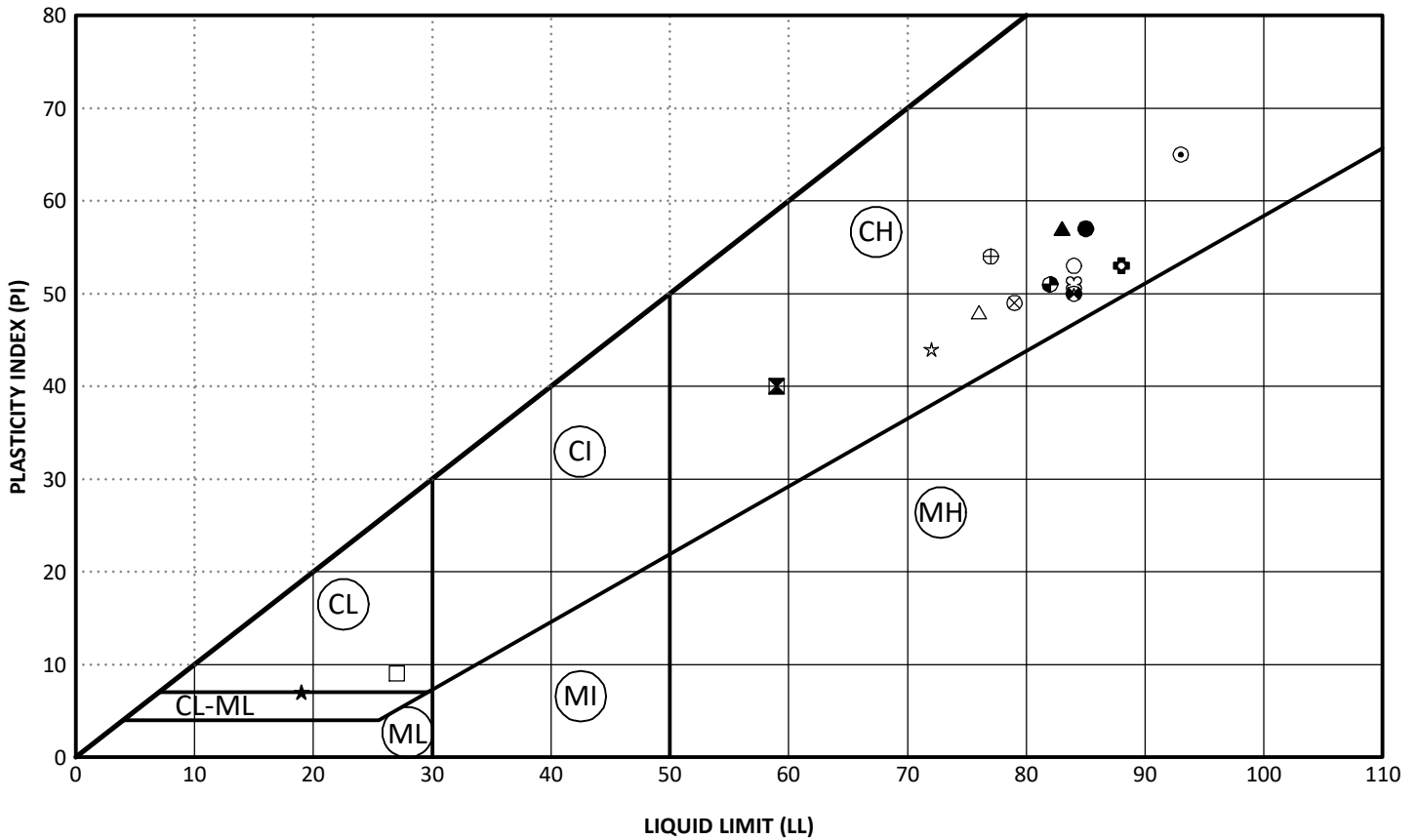


TH25-04 Photo 12: 16.5 to 18 m (55 to 57.5 ft)

APPENDIX E

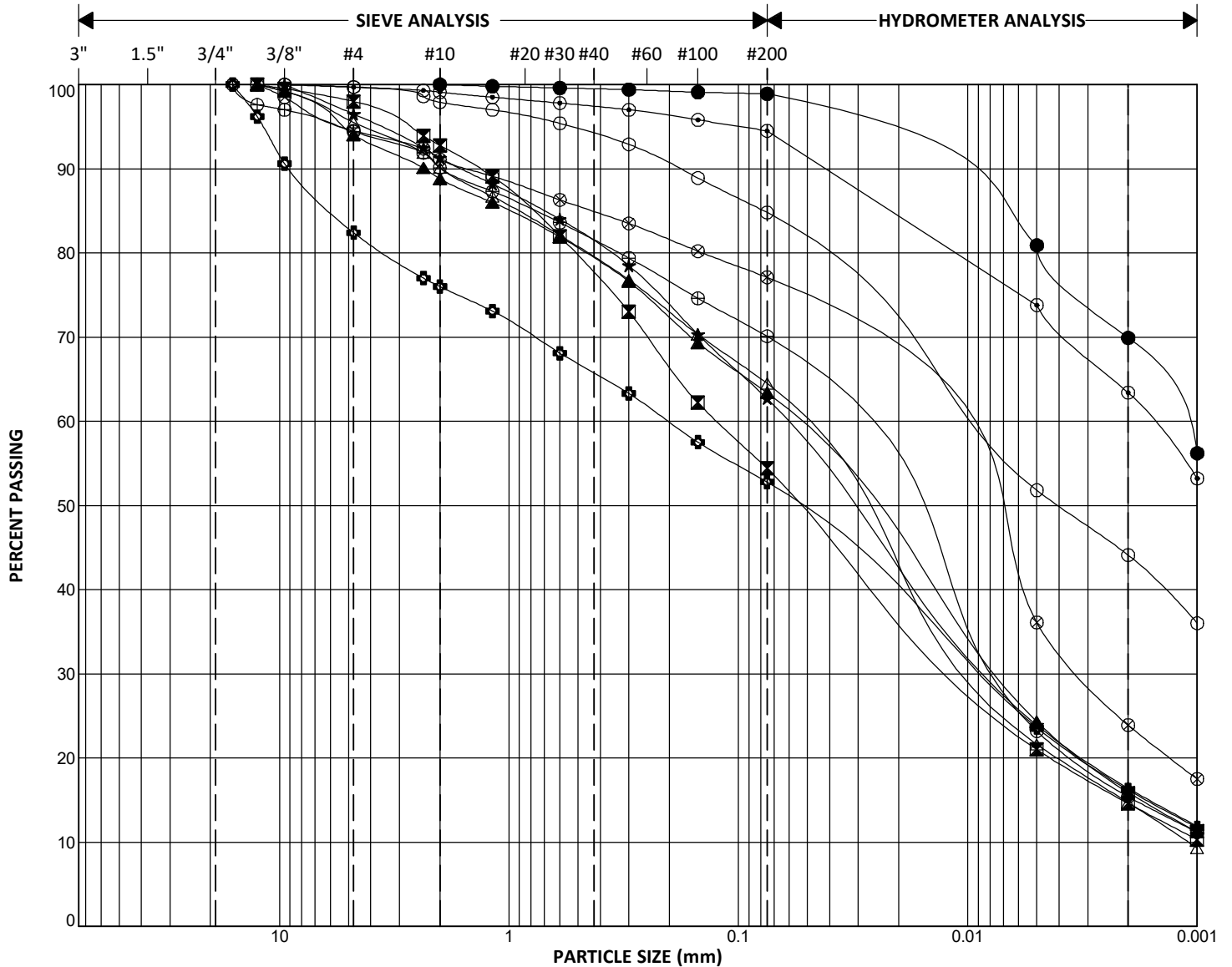
2022 to 2025 Geotechnical Laboratory Testing
Results

ATTERBERG LIMITS



	HOLE	DEPTH (m)	SAMPLE #	LL	PL	PI	SAND (%)	SILT (%)	CLAY (%)	SILT & CLAY (%)	MC (%)	CLASSIFICATION
●	TH25-01	5.3	S4	85	28	57	1	29	70	99	53	CH
☒	TH25-01	11.7	S9	59	19	40					46	CH
▲	TH25-02	8.5	S7	83	26	57					48	CH
★	TH25-02	13.1	S13	19	12	7	31	48	16	63	12	CL-ML
⊕	TH25-03	5.2	S5	93	28	65					53	CH
⊕	TH25-03	9.8	S8	88	35	53	5	31	63	95	48	CH
○	TH25-04	7.0	S10	84	31	53					49	CH
△	TH25-04	10.1	S12	76	28	48	15	41	44	85	47	CH
⊗	TH25-05	8.4	S9	79	30	49					47	CH
⊕	TH25-05	11.4	S11	77	23	54					47	CH
□	TH25-06	2.3	S4	27	18	9					24	CL
⊕	TH25-06	8.2	S9	84	34	50					53	CH
⊕	TH25-07	8.2	S8	82	31	51					52	CH
★	TH25-07	10.8	S10	72	28	44					51	CH
☒	TH25-08	8.5	S8	84	33	51					51	CH

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
●	TH25-01	5.3	S4	0	1	29	70	99			CH
⊠	TH25-01	14.4	S11	2	44	40	15	54			
▲	TH25-02	13.1	S13	6	31	48	16	63			CL-ML
★	TH25-02	16.2	S17	4	33	46	16	63			
⊙	TH25-03	9.8	S8	0	5	31	63	95			CH
⊕	TH25-03	16.2	S13	18	29	37	16	53			
○	TH25-04	10.1	S12	0	15	41	44	85			CH
△	TH25-04	16.6	S17	5	30	50	15	65	51.60	1.17	
⊗	TH25-05	17.5	S16	6	17	53	24	77			
⊕	TH25-07	19.6	S17	6	24	55	15	70			



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

PROJECT Armstrong CA/CI (25-0107-002)

PROJECT NO. 123317744

ATTN Suzanne Schultz

REPORT NO. 1

DATE SAMPLED: Not Provided
SAMPLED BY: KGS Group Inc.

DATE RECEIVED: 2025.Jun.12
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2025.Jun.13
TESTED BY: Larry Presado

TESTHOLE	SAMPLE	MC %
TH25-01	S2	42.1
	S3	52.2
	S4	52.6
	S5	52.4
	S6	47.6
	S7	45.5
	S8	22.9
	S9	45.7
	S10	27.4
	S11	8.6
TH25-02	S2	21.4
	S3	48.9
	S4	50.1
	S5	44.8
	S6	42.6
	S7	48.2
	S9	25.4
	S10	14.4
	S13	12.0
TH25-03	S2	24.3
	S3	47.4
	S5	52.9
	S6	51.8
	S7	51.8
	S8	47.5
	S9	51.2
	S10	67.5
	S13	7.7
TH25-04	S1	28.7

TESTHOLE	SAMPLE	MC %
TH25-04	S5	22.2
	S7	24.3
	S9	52.4
	S10	48.9
	S11	48.3
	S12	46.8
	S13	32.5
	S14	57.3
	S15	57.4
	S17	11.6
TH25-05	S2	23.5
	S5	37.1
	S7	54.0
	S9	47.2
	S10	48.8
	S11	47.1
	S12	51.7
	S14	48.6
	S16	13.1
TH25-06	S2	31.0
	S4	24.4
	S5	27.7
	S7	58.5
	S9	52.5
	S10	53.3
	S11	50.8
	S13	50.5
	S14	49.5
TH25-07	S18	10.6
	S4	24.6

REPORT DATE 2025.Jun.24

PAGE 1 OF 2

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the test results is provided on written request. The data presented is for sole use of client stipulated above. Stantec is not responsible, nor can be held liable, for the use of this report by any other party, with or without the knowledge of Stantec.

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

PROJECT Armstrong CA/CI (25-0107-002)

PROJECT NO. 123317744

ATTN Suzanne Schultz

REPORT NO. 7

DATE SAMPLED: Not Provided

DATE RECEIVED: 2025.Jun.12

DATE TESTED: 2025.Jun.23

SAMPLED BY: KGS Group Inc.

SUBMITTED BY: KGS Group Inc.

TESTED BY: Rimanshi Gorasiya

MATERIAL IDENTIFICATION

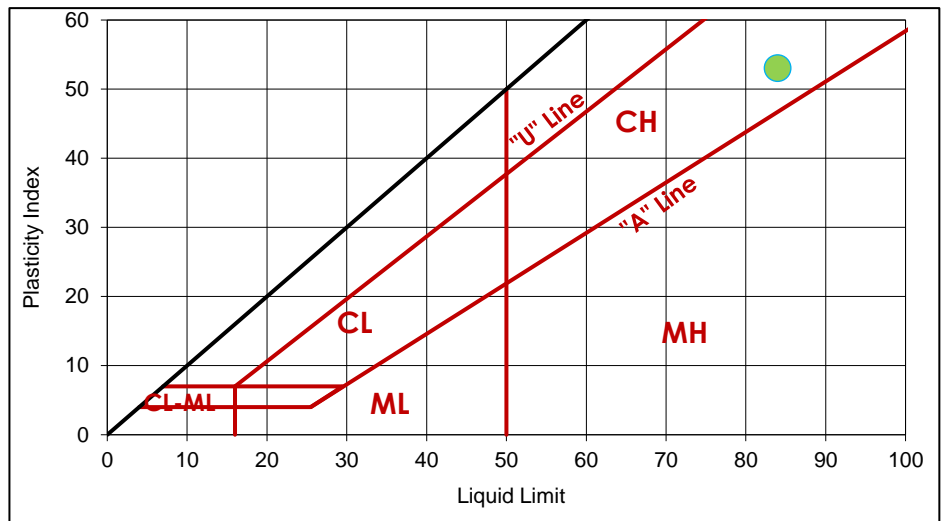
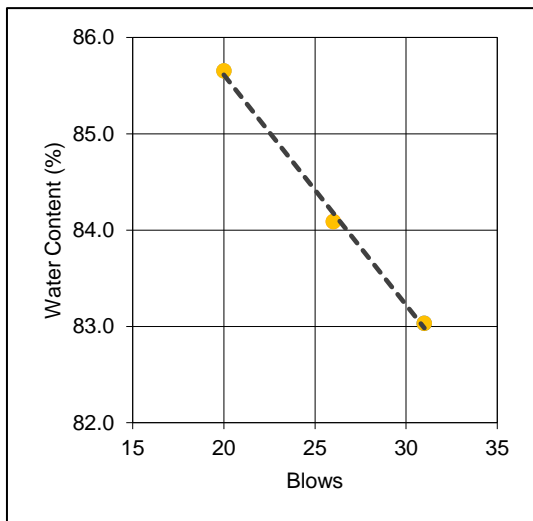
CLIENT FIELD ID TH25-04, S10

STANTEC SAMPLE NO. 1157

	LIQUID LIMIT		
TRIAL	1	2	3
BLOWS	31	26	20
MC (%)	83	84	86

	PLASTIC LIMIT	
TRIAL	1	2
MC (%)	31	31


LIQUID LIMIT, LL	84
PLASTIC LIMIT, PL	31
PLASTICITY INDEX, PI	53
AS REC'D MC (%)	48.9



COMMENTS

No comments.

REPORT DATE 2025.Jun.24

REVIEWED BY 
Guillaume Beauce, P.Eng.
Geotechnical Engineer - Materials Testing Services

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

PROJECT Armstrong CA/CI (25-0107-002)

PROJECT NO. 123317744

ATTN Suzanne Schultz

REPORT NO. 8

DATE SAMPLED: Not Provided

DATE RECEIVED: 2025.Jun.12

DATE TESTED: 2025.Jun.20

SAMPLED BY: KGS Group Inc.

SUBMITTED BY: KGS Group Inc.

TESTED BY: Rimanshi Gorasiya

MATERIAL IDENTIFICATION

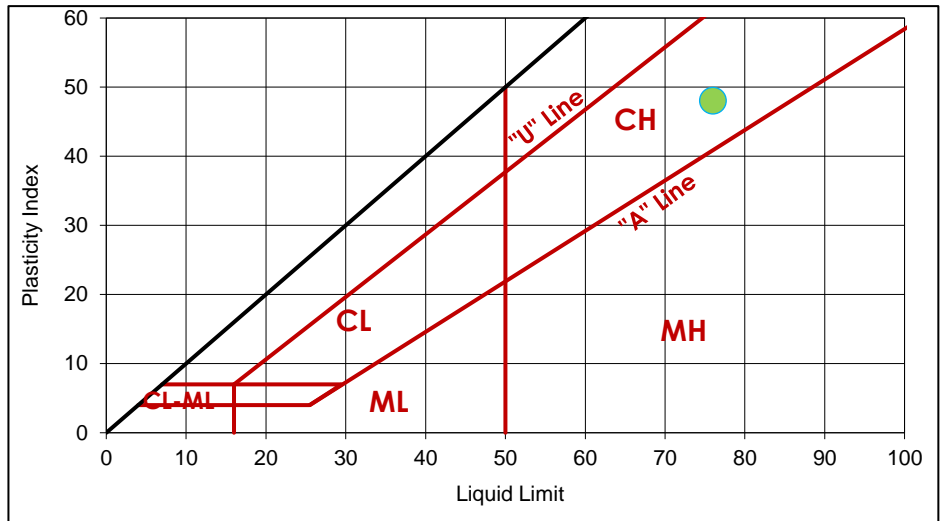
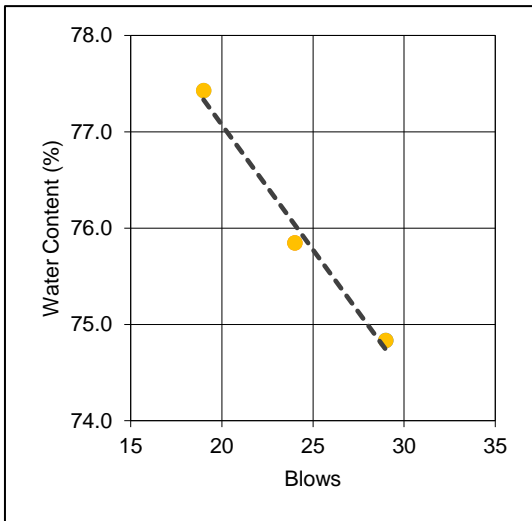
CLIENT FIELD ID TH25-04, S12

STANTEC SAMPLE NO. 1158

	LIQUID LIMIT		
TRIAL	1	2	3
BLOWS	29	24	19
MC (%)	75	76	77

	PLASTIC LIMIT	
TRIAL	1	2
MC (%)	28	28


LIQUID LIMIT, LL	76
PLASTIC LIMIT, PL	28
PLASTICITY INDEX, PI	48
AS REC'D MC (%)	46.8

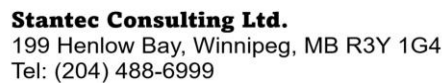


COMMENTS

No comments.

REPORT DATE 2025.Jun.24

REVIEWED BY 
Guillaume Beauce, P.Eng.
Geotechnical Engineer - Materials Testing Services



ASTM D7928 - PARTICLE-SIZE DISTRIBUTION OF FINE-GRAINED SOILS USING THE SEDIMENTATION ANALYSIS

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

PROJECT Armstrong CA/CI (25-0107-002)

PROJECT NO. 123317744

ATTN Suzanne Schultz

REPORT NO. 7

DATE SAMPLED: Not Provided
SAMPLED BY: KGS Group Inc.

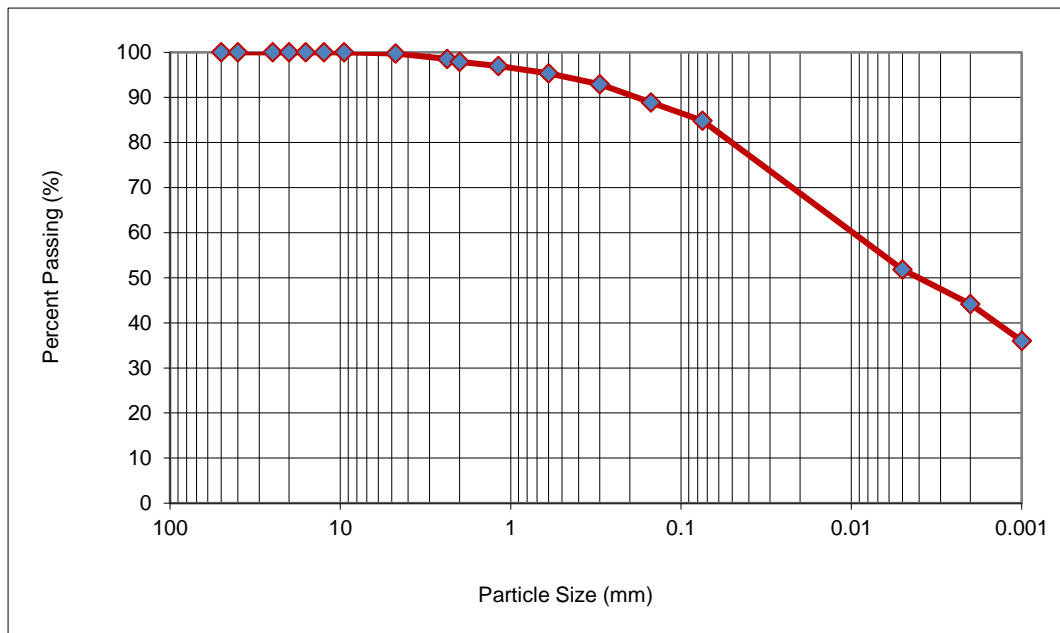
DATE RECEIVED: 2025.Jun.12
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2025.Jun.17
TESTED BY: Rimanshi Gorasiya

MATERIAL IDENTIFICATION

CLIENT FIELD ID TH25-04, S12

STANTEC SAMPLE NO. 1158



Sieve Size (mm)	% Passing
50.0	100.0
40.0	100.0
25.0	100.0
20.0	100.0
16.0	100.0
12.5	100.0
9.5	100.0
4.75	99.7
2.36	98.6
2.00	97.9
1.18	97.0
0.600	95.4
0.300	92.9
0.150	88.9
0.075	84.8
0.005	51.8
0.002	44.1
0.001	36.0

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
0.3	1.8	4.0	9.1	40.7	44.1	36.0

COMMENTS

No comments.

REPORT DATE 2025.Jun.24

REVIEWED BY Guillaume Beauce, P.Eng.
Geotechnical Engineer - Materials Testing Services

ASTM D7928 - PARTICLE-SIZE DISTRIBUTION OF FINE-GRAINED SOILS USING THE SEDIMENTATION ANALYSIS

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

PROJECT Armstrong CA/CI (25-0107-002)

PROJECT NO. 123317744

ATTN Suzanne Schultz

REPORT NO. 8

DATE SAMPLED: Not Provided
SAMPLED BY: KGS Group Inc.

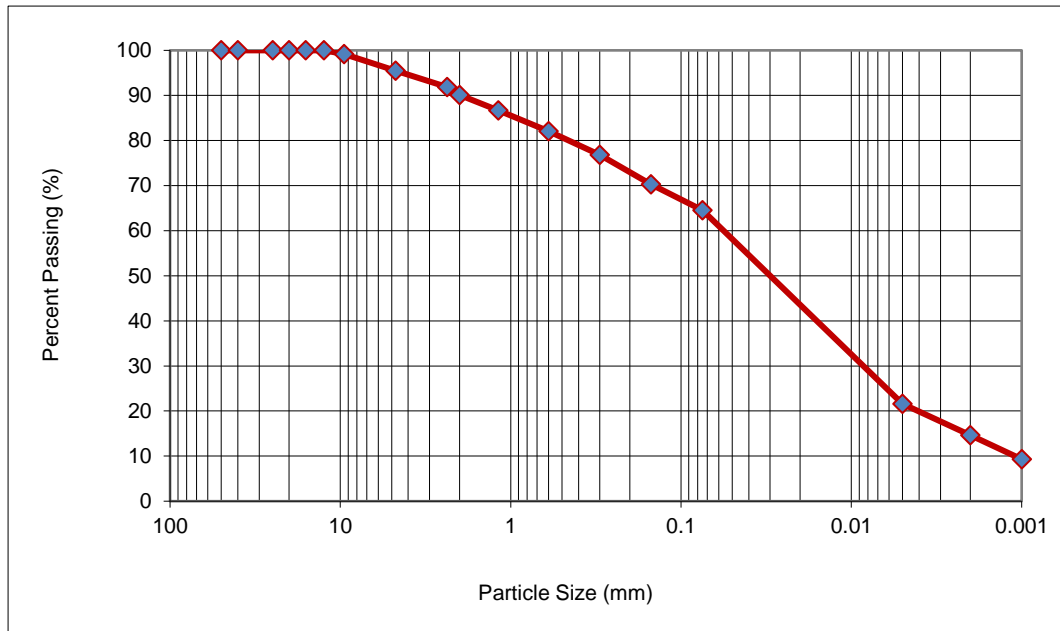
DATE RECEIVED: 2025.Jun.12
SUBMITTED BY: KGS Group Inc.

DATE TESTED: 2025.Jun.17
TESTED BY: Rimanshi Gorasiya

MATERIAL IDENTIFICATION

CLIENT FIELD ID TH25-04, S17

STANTEC SAMPLE NO. 1159



Sieve Size (mm)	% Passing
50.0	100.0
40.0	100.0
25.0	100.0
20.0	100.0
16.0	100.0
12.5	100.0
9.5	99.2
4.75	95.5
2.36	91.9
2.00	90.1
1.18	86.7
0.600	82.1
0.300	76.8
0.150	70.3
0.075	64.5
0.005	21.6
0.002	14.7
0.001	9.3

Gravel	Sand			Silt	Clay	Colloids
	Coarse	Medium	Fine			
4.5	5.4	11.1	14.5	49.8	14.7	9.3

COMMENTS
No comments.



REPORT DATE 2025.Jun.24

REVIEWED BY Guillaume Beauce, P.Eng.
Geotechnical Engineer - Materials Testing Services



www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report ASTM D2216-98

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong combined Sewer - Rail Crossings

Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Test Hole	TH24-01	TH24-01	TH24-01	TH24-01	TH24-01	TH24-01
Depth (m)	0.6 - 0.9	0.9 - 1.2	1.5 - 1.8	2.3 - 2.4	2.6 - 2.7	3.8 - 4.0
Sample #	G01	G02	G03	G04	G05	G06
Tare ID	C6	N48	F91	F152	H29	K9
Mass of tare	8.6	8.4	8.4	8.4	8.4	8.6
Mass wet + tare	260.6	153.8	195.6	240.0	178.6	194.0
Mass dry + tare	225.6	126.6	164.6	197.9	145.2	131.6
Mass water	35.0	27.2	31.0	42.1	33.4	62.4
Mass dry soil	217.0	118.2	156.2	189.5	136.8	123.0
Moisture %	16.1%	23.0%	19.8%	22.2%	24.4%	50.7%

Test Hole	TH24-01	TH24-01	TH24-01	TH24-01	TH24-01	TH24-01
Depth (m)	6.1 - 6.4	8.5 - 8.8	10.5 - 10.7	12.0 - 12.2	13.6 - 13.7	15.1 - 15.2
Sample #	G08	G10	G12	G13	G14	G15
Tare ID	Z21	Z118	Z66	E135	H74	C19
Mass of tare	8.6	8.4	8.4	8.6	8.6	8.6
Mass wet + tare	151.2	135.9	438.2	166.2	158.8	148.4
Mass dry + tare	101.6	94.4	301.6	115.4	111.6	95.8
Mass water	49.6	41.5	136.6	50.8	47.2	52.6
Mass dry soil	93.0	86.0	293.2	106.8	103.0	87.2
Moisture %	53.3%	48.3%	46.6%	47.6%	45.8%	60.3%

Test Hole	TH24-01	TH24-02	TH24-02	TH24-02	TH24-02	TH24-03
Depth (m)	15.8 - 16.2	1.4 - 1.5	2.9 - 3.0	5.9 - 6.1	7.5 - 7.6	1.4 - 1.5
Sample #	G16	G17	G18	G20	G21	G23
Tare ID	W50	K7	Z32	J74	W73	M14
Mass of tare	9.0	8.6	8.8	7.0	8.6	7.0
Mass wet + tare	300.8	218.8	262.0	170.4	226.4	193.2
Mass dry + tare	268.4	171.0	215.0	112.6	154.0	152.8
Mass water	32.4	47.8	47.0	57.8	72.4	40.4
Mass dry soil	259.4	162.4	206.2	105.6	145.4	145.8
Moisture %	12.5%	29.4%	22.8%	54.7%	49.8%	27.7%



www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report ASTM D2216-98

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong combined Sewer - Rail Crossings

Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Test Hole	TH24-03	TH24-03	TH24-03	TH24-03	TH24-04	TH24-04
Depth (m)	2.9 - 3.0	4.6 - 4.7	7.5 - 7.6	9.0 - 9.1	0.6 - 0.9	0.9 - 1.2
Sample #	G24	G25	G27	G28	G29	G30
Tare ID	N43	N53	Z85	W76	W106	N71
Mass of tare	8.4	8.6	8.3	8.6	8.4	8.6
Mass wet + tare	227.2	412.6	153.4	201.8	225.4	202.2
Mass dry + tare	182.6	275.4	110.4	142.2	210.4	178.2
Mass water	44.6	137.2	43.0	59.6	15.0	24.0
Mass dry soil	174.2	266.8	102.1	133.6	202.0	169.6
Moisture %	25.6%	51.4%	42.1%	44.6%	7.4%	14.2%

Test Hole	TH24-04	TH24-04	TH24-04	TH24-04	TH24-04	TH24-04
Depth (m)	1.5 - 1.8	2.3 - 2.4	2.6 - 2.7	4.3 - 4.6	7.6 - 7.9	9.1 - 9.4
Sample #	G31	G32	G33	G34	G36	G37
Tare ID	W15	W45	A100	D20	W20	AC02
Mass of tare	8.4	8.4	8.4	8.8	8.4	6.8
Mass wet + tare	213.0	219.4	174.0	187.8	148.8	161.6
Mass dry + tare	173.2	173.4	128.2	134.4	103.2	109.6
Mass water	39.8	46.0	45.8	53.4	45.6	52.0
Mass dry soil	164.8	165.0	119.8	125.6	94.8	102.8
Moisture %	24.2%	27.9%	38.2%	42.5%	48.1%	50.6%

Test Hole	TH24-04	TH24-04	TH24-04	TH24-04		
Depth (m)	12.2 - 12.5	13.7 - 14.0	15.2 - 15.5	15.8 - 16.2		
Sample #	G39	G40	G41	G42		
Tare ID	Q69	J94	F18	E56		
Mass of tare	6.8	7.0	6.8	6.8		
Mass wet + tare	143.0	147.6	217.6	169.2		
Mass dry + tare	100.8	109.0	144.6	148.8		
Mass water	42.2	38.6	73.0	20.4		
Mass dry soil	94.0	102.0	137.8	142.0		
Moisture %	44.9%	37.8%	53.0%	14.4%		

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer

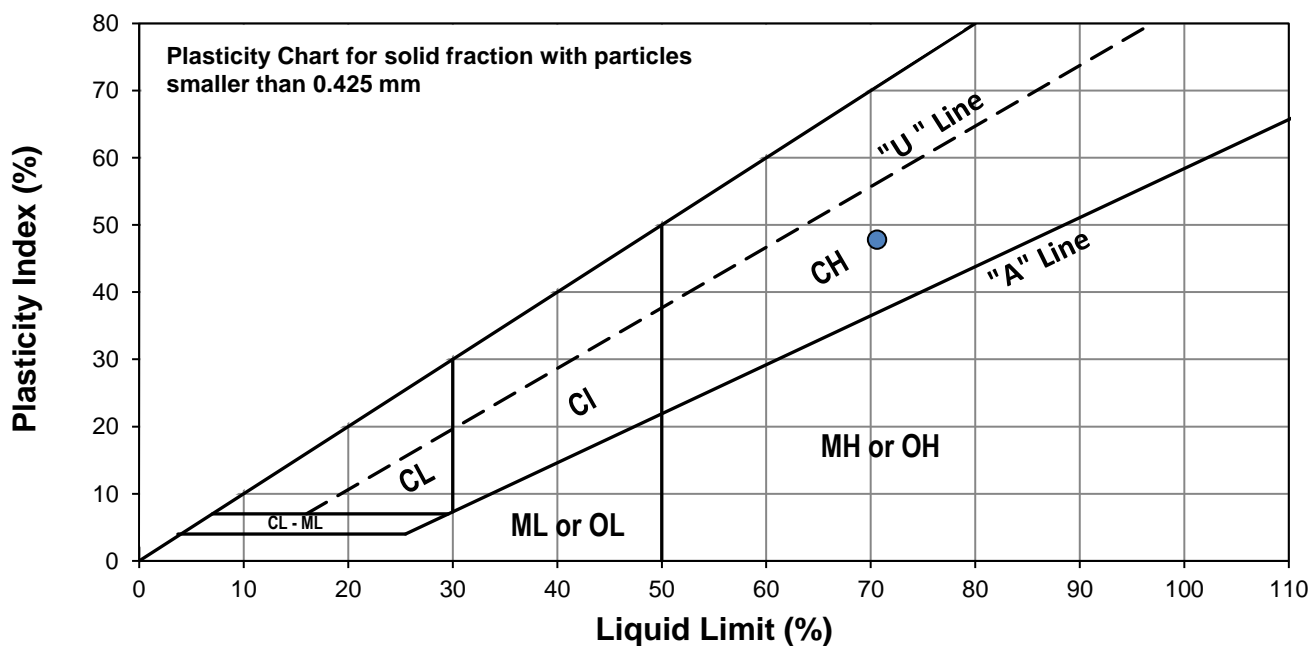
Test Hole TH24-01
Sample # G12
Depth (m) 10.5 - 10.7
Sample Date 01-Feb-24
Test Date 16-Feb-24
Technician KF



Liquid Limit 71
Plastic Limit 23
Plasticity Index 48

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	17	22	26		
Mass Tare (g)	14.141	13.988	14.182		
Mass Wet Soil + Tare (g)	23.264	23.749	23.213		
Mass Dry Soil + Tare (g)	19.419	19.687	19.482		
Mass Water (g)	3.845	4.062	3.731		
Mass Dry Soil (g)	5.278	5.699	5.300		
Moisture Content (%)	72.850	71.276	70.396		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.087	14.226			
Mass Wet Soil + Tare (g)	25.216	26.170			
Mass Dry Soil + Tare (g)	23.154	23.953			
Mass Water (g)	2.062	2.217			
Mass Dry Soil (g)	9.067	9.727			
Moisture Content (%)	22.742	22.792			

Note: Additional information recorded/measured for this test is available upon request.

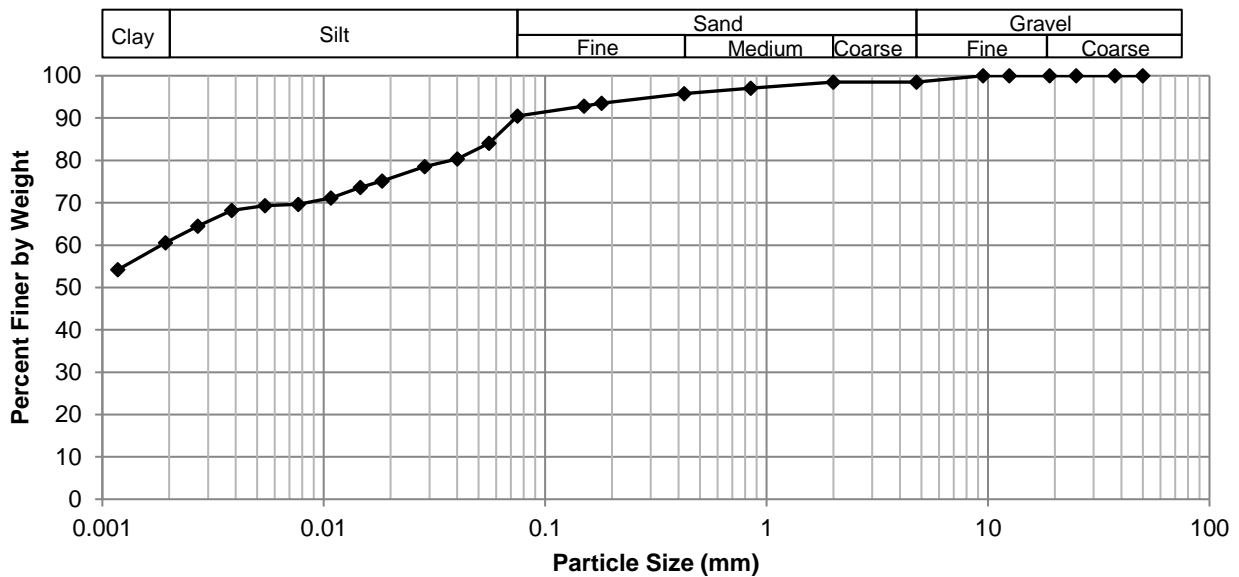
Project No. 0336-003-00
Client Jacobs Canada
Project Armstrong Combined Sewer



Test Hole TH24-01
Sample # G12
Depth (m) 10.5 - 10.7
Sample Date 1-Feb-24
Test Date 20-Feb-24
Technician DS

Gravel	1.5%
Sand	8.0%
Silt	29.6%
Clay	60.9%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing
50.0	100.00	4.75	98.48	0.0750	90.51
37.5	100.00	2.00	98.47	0.0558	84.09
25.0	100.00	0.850	97.09	0.0401	80.40
19.0	100.00	0.425	95.76	0.0286	78.55
12.5	100.00	0.180	93.51	0.0184	75.16
9.50	100.00	0.150	92.85	0.0146	73.62
4.75	98.48	0.075	90.51	0.0108	71.16
				0.0077	69.62
				0.0054	69.35
				0.0038	68.18
				0.0027	64.52
				0.0019	60.58
				0.0012	54.23

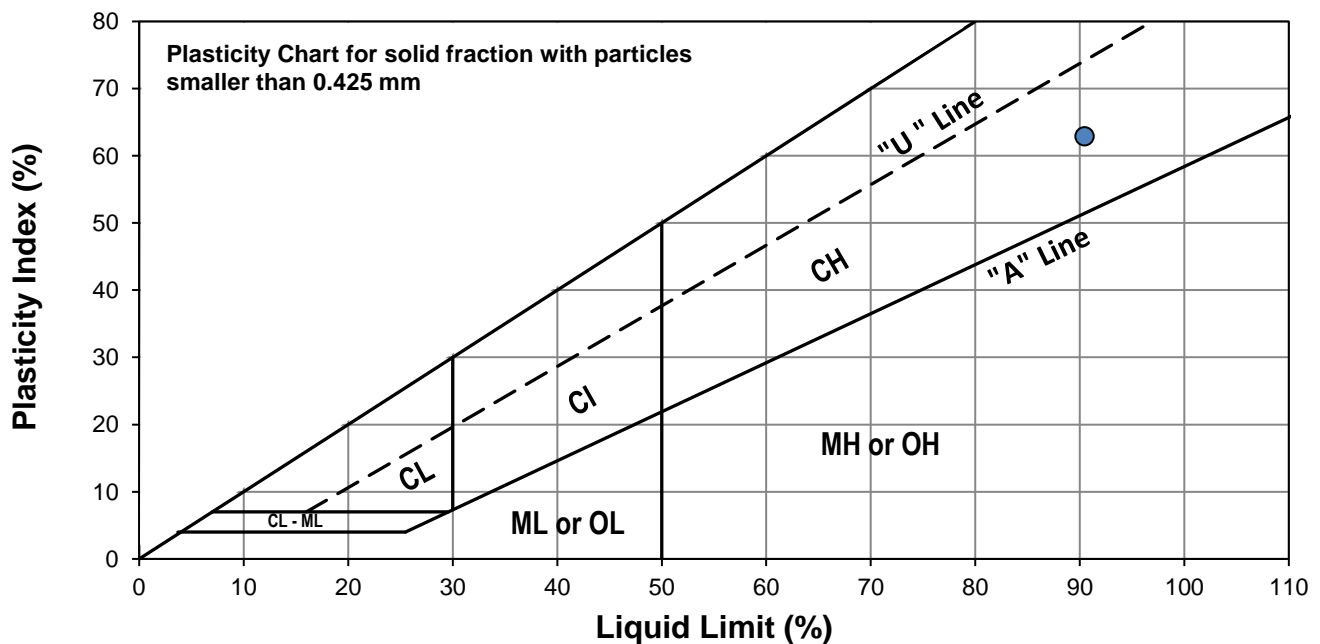
Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer
Test Hole TH24-03
Sample # G25
Depth (m) 4.6 - 4.7
Sample Date 01-Feb-24
Test Date 16-Feb-24
Technician DS



Liquid Limit 90
Plastic Limit 28
Plasticity Index 63

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	19	22	34		
Mass Tare (g)	14.041	14.153	14.119		
Mass Wet Soil + Tare (g)	23.298	22.857	23.700		
Mass Dry Soil + Tare (g)	18.832	18.693	19.233		
Mass Water (g)	4.466	4.164	4.467		
Mass Dry Soil (g)	4.791	4.540	5.114		
Moisture Content (%)	93.216	91.718	87.348		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.071	14.061			
Mass Wet Soil + Tare (g)	21.493	21.524			
Mass Dry Soil + Tare (g)	19.897	19.904			
Mass Water (g)	1.596	1.620			
Mass Dry Soil (g)	5.826	5.843			
Moisture Content (%)	27.394	27.725			

Note: Additional information recorded/measured for this test is available upon request.



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Grain Size Analysis (Hydrometer Method) AASHTO T 88

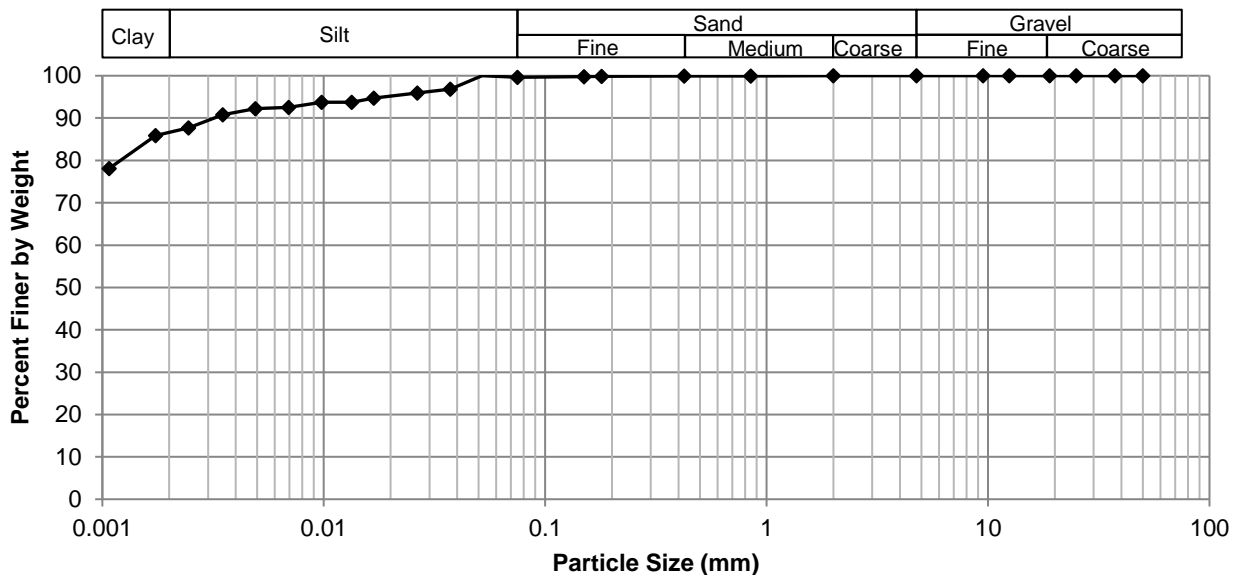
Project No. 0336-003-00
Client Jacobs Canada
Project Armstrong Combined Sewer



Test Hole TH24-03
Sample # G25
Depth (m) 4.6 - 4.7
Sample Date 1-Feb-24
Test Date 20-Feb-24
Technician DS

Gravel	0.0%
Sand	0.3%
Silt	13.1%
Clay	86.5%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing
50.0	100.00	4.75	100.00	0.0750	99.65
37.5	100.00	2.00	100.00	0.0518	100.00
25.0	100.00	0.850	99.95	0.0373	96.87
19.0	100.00	0.425	99.90	0.0265	95.94
12.5	100.00	0.180	99.84	0.0169	94.69
9.50	100.00	0.150	99.82	0.0134	93.75
4.75	100.00	0.075	99.65	0.0098	93.75
				0.0070	92.50
				0.0049	92.23
				0.0035	90.76
				0.0025	87.68
				0.0017	85.90
				0.0011	78.11



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-01
Sample # T07
Depth (m) 4.6 - 5.2
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	500			
Bottom				Top
5.07 m	4.97 m	4.80 m	4.63 m	4.57 m
Moisture Content PP/TV Visual	Bulk Qu	Keep	Toss	
100 mm	170 mm	170 mm	60 mm	

Visual Classification

Material	CLAY
Composition	silty
trace precipitates (sulphates, seams, <15mm thick)	
trace precipitates (sulphates, inclusions, <5mm diam.)	
trace oxidation	
Color	grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	stratified (black and grey clay, <8mm thick)
Gradation	-

Torvane

Reading	0.75
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	73.6

Pocket Penetrometer

Reading	1	1.80
	2	1.80
	3	2.00
	Average	1.87
Undrained Shear Strength (kPa)		91.5

Moisture Content

Tare ID	E13
Mass tare (g)	6.8
Mass wet + tare (g)	318.0
Mass dry + tare (g)	212.6
Moisture %	51.2%

Unit Weight

Bulk Weight (g)		1089.8
Length (mm)	1	150.78
	2	150.91
	3	151.23
	4	151.00
Average Length (m)		0.151
Diam. (mm)	1	72.88
	2	73.21
	3	72.98
	4	72.90
Average Diameter (m)		0.073

Volume (m³)	6.32E-04
Bulk Unit Weight (kN/m³)	16.9
Bulk Unit Weight (pcf)	107.7
Dry Unit Weight (kN/m³)	11.2
Dry Unit Weight (pcf)	71.2

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-01
Sample # T07
Depth (m) 4.6 - 5.2
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	97.6	2.0
Max S_u	48.8	1.0

Specimen Data

Description CLAY - silty, trace precipitates (sulphates, seams, <15mm thick), trace precipitates (sulphates, inclusions, <5mm diam.), trace oxidation, grey, moist, stiff, high plasticity, stratified (black and grey clay, <8mm thick)

Length 151.0 (mm)
Diameter 73.0 (mm)
L/D Ratio 2.1
Initial Area 0.00418 (m²)
Load Rate 1.00 (%/min)

Moisture % 51%
Bulk Unit Wt. 16.9 (kN/m³)
Dry Unit Wt. 11.2 (kN/m³)
Liquid Limit -
Plastic Limit -
Plasticity Index -

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.75	73.6	1.54
Vane Size		
m	91.5	1.91

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.80	88.3	1.84
1.80	88.3	1.84
2.00	98.1	2.05
Average	1.87	91.6
		1.91

Failure Geometry

Sketch:

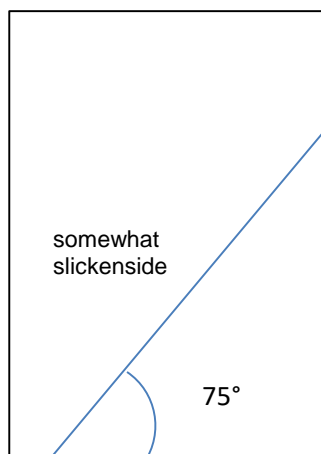
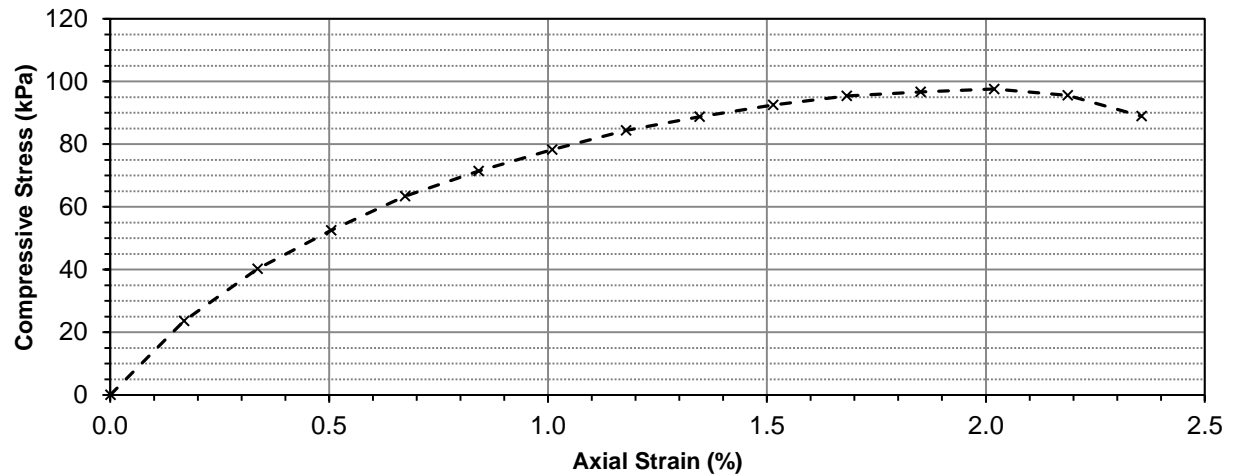


Photo:



Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.74	0.0000	0.00	0.004185	0.0	0.00	0.00
10	2.70	0.2540	0.17	0.004192	98.8	23.57	11.78
20	4.09	0.5080	0.34	0.004199	168.9	40.22	20.11
30	5.12	0.7620	0.50	0.004206	220.8	52.49	26.25
40	6.04	1.0160	0.67	0.004213	267.1	63.41	31.70
50	6.72	1.2700	0.84	0.004220	301.4	71.42	35.71
60	7.30	1.5240	1.01	0.004227	330.6	78.22	39.11
70	7.83	1.7780	1.18	0.004234	357.4	84.39	42.20
80	8.21	2.0320	1.35	0.004242	376.5	88.77	44.38
90	8.54	2.2860	1.51	0.004249	393.1	92.53	46.26
100	8.79	2.5400	1.68	0.004256	405.7	95.33	47.67
110	8.92	2.7940	1.85	0.004263	412.3	96.71	48.35
120	9.01	3.0480	2.02	0.004271	416.8	97.60	48.80
130	8.85	3.3020	2.19	0.004278	408.8	95.55	47.77
140	8.30	3.5560	2.36	0.004285	381.0	88.92	44.46



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-01
Sample # T11
Depth (m) 9.1 - 9.8
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	490			
Bottom				Top
9.63 m	9.54 m	9.37 m	9.20 m	9.14 m
Moisture Content PP/TV Visual	Bulk Qu	Keep	Toss	
90 mm	170 mm	170 mm	60 mm	

Visual Classification

Material	CLAY
Composition	silty
trace gravel (<10mm diam.)	
trace silt inclusions (<5mm diam.)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.50
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	49.0

Pocket Penetrometer

Reading	1	1.20
	2	1.20
	3	1.20
	Average	1.20
Undrained Shear Strength (kPa)		58.8

Moisture Content

Tare ID	J68
Mass tare (g)	7.0
Mass wet + tare (g)	279.6
Mass dry + tare (g)	195.2
Moisture %	44.8%

Unit Weight

Bulk Weight (g)		1102.2
Length (mm)	1	150.04
	2	149.91
	3	149.83
	4	149.56
Average Length (m)		0.150
Diam. (mm)	1	73.01
	2	72.60
	3	72.24
	4	72.35
Average Diameter (m)		0.073

Volume (m³)	6.19E-04
Bulk Unit Weight (kN/m³)	17.5
Bulk Unit Weight (pcf)	111.1
Dry Unit Weight (kN/m³)	12.0
Dry Unit Weight (pcf)	76.7

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-01
Sample # T11
Depth (m) 9.1 - 9.8
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	151.8	3.2
Max S_u	75.9	1.6

Specimen Data

Description CLAY - silty, trace gravel (<10mm diam.), trace silt inclusions (<5mm diam.), grey, moist, firm to stiff, high plasticity

Length	149.8	(mm)	Moisture %	45%
Diameter	72.6	(mm)	Bulk Unit Wt.	17.5 (kN/m ³)
L/D Ratio	2.1		Dry Unit Wt.	12.0 (kN/m ³)
Initial Area	0.00413	(m ²)	Liquid Limit	-
Load Rate	1.00	(%/min)	Plastic Limit	-
			Plasticity Index	-

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.50	49.0	1.02
Vane Size		
m	58.8	1.23

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.20	58.9	1.23
1.20	58.9	1.23
1.20	58.9	1.23
Average	1.20	58.9
		1.23

Failure Geometry

Sketch:

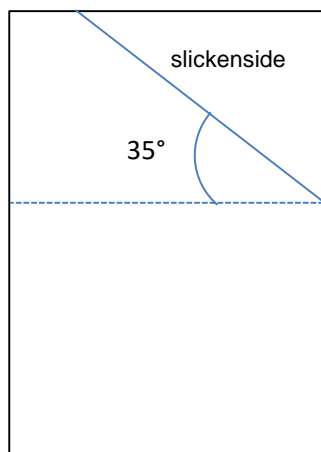
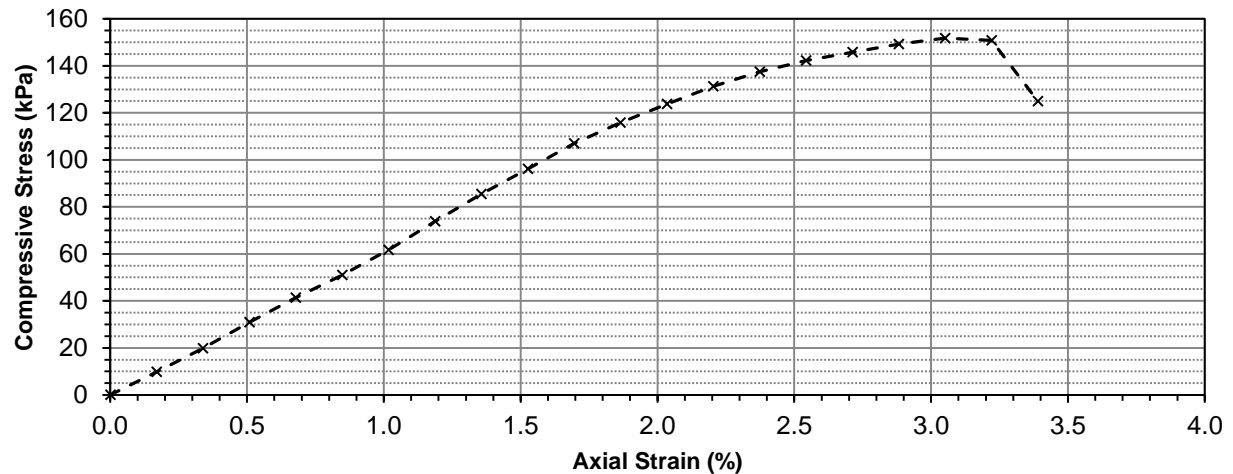


Photo:



Project No. 0336-003-00
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Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.77	0.0000	0.00	0.004134	0.0	0.00	0.00
10	1.57	0.2540	0.17	0.004141	40.3	9.74	4.87
20	2.40	0.5080	0.34	0.004148	82.2	19.81	9.90
30	3.32	0.7620	0.51	0.004155	128.5	30.93	15.47
40	4.19	1.0160	0.68	0.004162	172.4	41.42	20.71
50	4.99	1.2700	0.85	0.004169	212.7	51.02	25.51
60	5.88	1.5240	1.02	0.004176	257.6	61.67	30.83
70	6.90	1.7780	1.19	0.004184	309.0	73.85	36.93
80	7.87	2.0320	1.36	0.004191	357.9	85.39	42.70
90	8.78	2.2860	1.53	0.004198	403.7	96.17	48.09
100	9.69	2.5400	1.70	0.004205	449.6	106.91	53.46
110	10.45	2.7940	1.86	0.004212	487.9	115.82	57.91
120	11.13	3.0480	2.03	0.004220	522.2	123.74	61.87
130	11.78	3.3020	2.20	0.004227	554.9	131.28	65.64
140	12.32	3.5560	2.37	0.004234	582.2	137.48	68.74
150	12.74	3.8100	2.54	0.004242	603.3	142.23	71.12
160	13.06	4.0640	2.71	0.004249	619.5	145.78	72.89
170	13.37	4.3180	2.88	0.004257	635.1	149.20	74.60
180	13.61	4.5720	3.05	0.004264	647.2	151.77	75.89
190	13.55	4.8260	3.22	0.004272	644.2	150.80	75.40
200	11.37	5.0800	3.39	0.004279	534.3	124.86	62.43



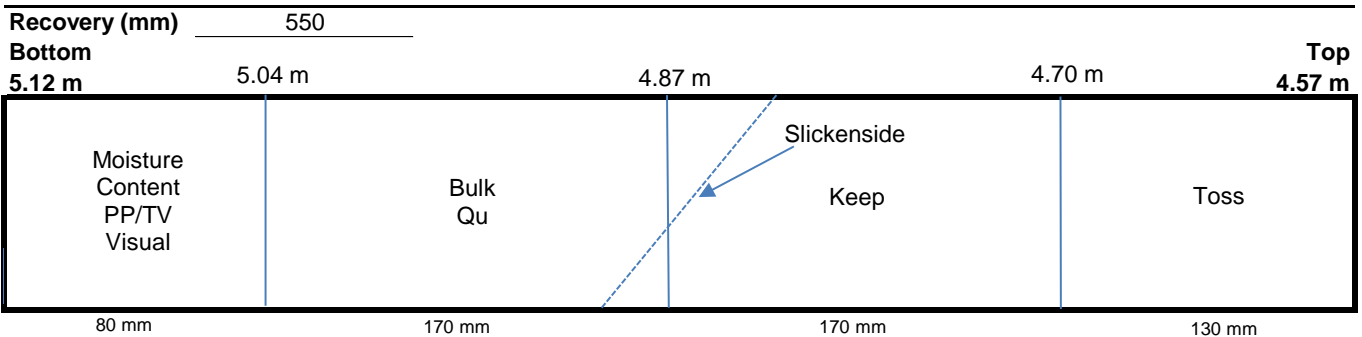
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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-02
Sample # T19
Depth (m) 4.6 - 5.2
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Tube Extraction



Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<5mm diam.)	
trace precipitates (sulphates, <5 mm diam.)	
Color	grey
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	slickenside, laminated (grey and lt.brown clay, <5mm thick)
Gradation	-

Torvane

Reading	0.65
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	63.8

Pocket Penetrometer

Reading	1	1.30
	2	1.20
	3	1.30
	Average	1.27
Undrained Shear Strength (kPa)		62.1

Moisture Content

Tare ID	M85
Mass tare (g)	6.6
Mass wet + tare (g)	256.0
Mass dry + tare (g)	167.0
Moisture %	55.5%

Unit Weight

Bulk Weight (g)		1041.6
Length (mm)	1	148.05
	2	148.03
	3	148.05
n thick)	4	148.15
Average Length (m)		0.148
Diam. (mm)	1	72.57
	2	73.09
	3	72.99
	4	72.55
Average Diameter (m)		0.073

Volume (m³)	6.16E-04
Bulk Unit Weight (kN/m³)	16.6
Bulk Unit Weight (pcf)	105.5
Dry Unit Weight (kN/m³)	10.7
Dry Unit Weight (pcf)	67.9

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-02
Sample # T19
Depth (m) 4.6 - 5.2
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	90.1	1.9
Max S_u	45.0	0.9

Specimen Data

Description CLAY - silty, trace silt inclusions (<5mm diam.), trace precipitates (sulphates, <5 mm diam.), grey, moist, stiff, high plasticity, slickenside, laminated (grey and lt.brown clay, <5mm thick)

Length 148.1 (mm)
Diameter 72.8 (mm)
L/D Ratio 2.0
Initial Area 0.00416 (m²)
Load Rate 1.00 (%/min)

Moisture % 55%
Bulk Unit Wt. 16.6 (kN/m³)
Dry Unit Wt. 10.7 (kN/m³)
Liquid Limit -
Plastic Limit -
Plasticity Index -

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.65	63.8	1.33
Vane Size		
m	62.1	1.30

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.30	63.8	1.33
1.20	58.9	1.23
1.30	63.8	1.33
Average	1.27	62.1
		1.30

Failure Geometry

Sketch:

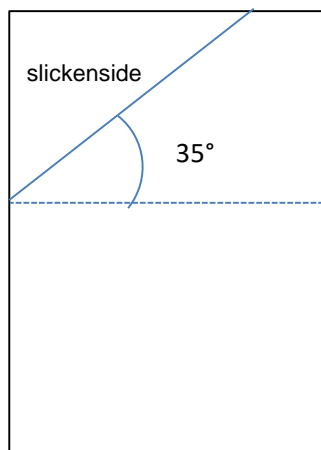
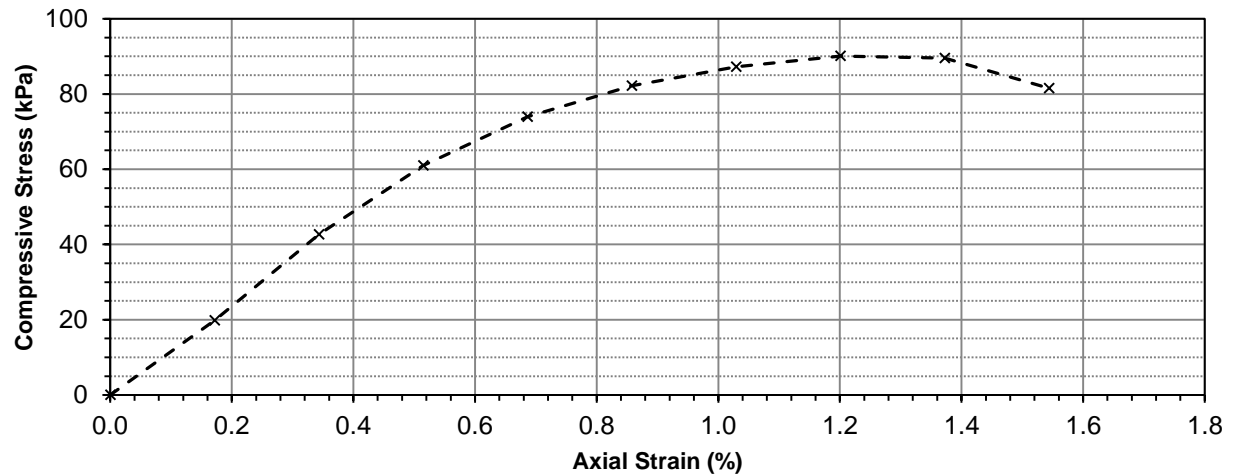


Photo:



Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.82	0.0000	0.00	0.004162	0.0	0.00	0.00
10	2.46	0.2540	0.17	0.004170	82.7	19.82	9.91
20	4.36	0.5080	0.34	0.004177	178.4	42.72	21.36
30	5.88	0.7620	0.51	0.004184	255.0	60.96	30.48
40	6.97	1.0160	0.69	0.004191	310.0	73.96	36.98
50	7.67	1.2700	0.86	0.004198	345.3	82.23	41.12
60	8.10	1.5240	1.03	0.004206	366.9	87.25	43.62
70	8.35	1.7780	1.20	0.004213	379.5	90.08	45.04
80	8.32	2.0320	1.37	0.004220	378.0	89.57	44.79
90	7.66	2.2860	1.54	0.004228	344.8	81.55	40.77



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-02
Sample # T22
Depth (m) 9.1 - 9.8
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	500			
Bottom				Top
9.64 m	9.56 m	9.39 m	9.22 m	9.14 m
Moisture Content PP/TV Visual	Bulk Qu	Keep	Toss	
80 mm	170 mm	170 mm	80 mm	

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<5mm diam.)	
Color	grey
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.50
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	49.0

Pocket Penetrometer

Reading	1	1.00
	2	0.90
	3	1.10
	Average	1.00
Undrained Shear Strength (kPa)		49.0

Moisture Content

Tare ID	M09
Mass tare (g)	5.8
Mass wet + tare (g)	274.2
Mass dry + tare (g)	184.8
Moisture %	49.9%

Unit Weight

Bulk Weight (g)		1072.2
Length (mm)	1	148.15
	2	148.28
	3	148.41
	4	148.18
Average Length (m)		0.148
Diam. (mm)	1	72.39
	2	72.87
	3	71.80
	4	72.82
Average Diameter (m)		0.072

Volume (m³)	6.12E-04
Bulk Unit Weight (kN/m³)	17.2
Bulk Unit Weight (pcf)	109.5
Dry Unit Weight (kN/m³)	11.5
Dry Unit Weight (pcf)	73.0

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-02
Sample # T22
Depth (m) 9.1 - 9.8
Sample Date 01-Feb-24
Test Date 14-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	108.6	2.3
Max S_u	54.3	1.1

Specimen Data

Description CLAY - silty, trace silt inclusions (<5mm diam.), grey, moist, firm, high plasticity

Length	148.3	(mm)	Moisture %	50%
Diameter	72.5	(mm)	Bulk Unit Wt.	17.2 (kN/m ³)
L/D Ratio	2.0		Dry Unit Wt.	11.5 (kN/m ³)
Initial Area	0.00412	(m ²)	Liquid Limit	-
Load Rate	1.00	(%/min)	Plastic Limit	-
			Plasticity Index	-

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.50	49.0	1.02
Vane Size		
m	49.0	1.02

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.00	49.1	1.02
0.90	44.1	0.92
1.10	54.0	1.13
Average	1.00	49.1
		1.02

Failure Geometry

Sketch:

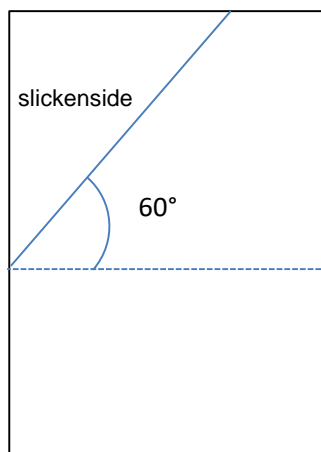
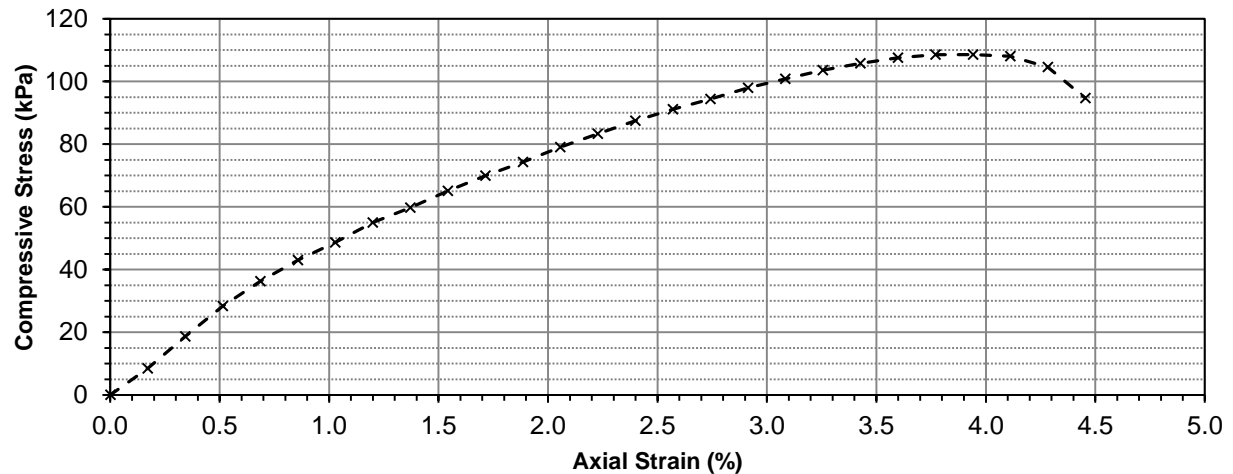


Photo:



Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.77	0.0000	0.00	0.004125	0.0	0.00	0.00
10	1.46	0.2540	0.17	0.004132	34.8	8.42	4.21
20	2.30	0.5080	0.34	0.004139	77.1	18.63	9.32
30	3.10	0.7620	0.51	0.004146	117.4	28.32	14.16
40	3.76	1.0160	0.69	0.004153	150.7	36.29	18.14
50	4.32	1.2700	0.86	0.004160	178.9	43.01	21.50
60	4.79	1.5240	1.03	0.004168	202.6	48.62	24.31
70	5.32	1.7780	1.20	0.004175	229.3	54.93	27.47
80	5.73	2.0320	1.37	0.004182	250.0	59.78	29.89
90	6.18	2.2860	1.54	0.004189	272.7	65.09	32.54
100	6.59	2.5400	1.71	0.004197	293.3	69.90	34.95
110	6.97	2.7940	1.88	0.004204	312.5	74.33	37.17
120	7.37	3.0480	2.06	0.004211	332.7	78.99	39.50
130	7.74	3.3020	2.23	0.004219	351.3	83.27	41.64
140	8.10	3.5560	2.40	0.004226	369.5	87.42	43.71
150	8.42	3.8100	2.57	0.004234	385.6	91.08	45.54
160	8.71	4.0640	2.74	0.004241	400.2	94.36	47.18
170	9.03	4.3180	2.91	0.004249	416.3	97.99	49.00
180	9.28	4.5720	3.08	0.004256	428.9	100.78	50.39
190	9.53	4.8260	3.26	0.004264	441.5	103.56	51.78
200	9.73	5.0800	3.43	0.004271	451.6	105.73	52.87
210	9.90	5.3340	3.60	0.004279	460.2	107.55	53.77
220	10.00	5.5880	3.77	0.004286	465.2	108.53	54.27
230	10.02	5.8420	3.94	0.004294	466.2	108.58	54.29



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Unconfined Compressive Strength ASTM D2166

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	9.99	6.0960	4.11	0.004302	464.7	108.03	54.02
250	9.71	6.3500	4.28	0.004309	450.6	104.56	52.28
260	8.88	6.6040	4.45	0.004317	408.8	94.68	47.34



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-03
Sample # T26
Depth (m) 6.1 - 6.7
Sample Date 01-Feb-24
Test Date 16-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	650				
Bottom	6.70 m	6.21 m	6.15 m		Top
6.75 m					6.10 m
Toss	Bulk Qu	Keep	Keep	Moisture Content PP/TV Visual	Toss
50 mm	170 mm	170 mm	150 mm	60 mm	50 mm

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<5mm diam.)	
trace sand	
trace rootlets	

Color	grey
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.35
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	34.3

Pocket Penetrometer

Reading	1	0.80
	2	0.80
	3	0.80
	Average	0.80
Undrained Shear Strength (kPa)		39.2

Moisture Content

Tare ID	N40
Mass tare (g)	9.0
Mass wet + tare (g)	309.2
Mass dry + tare (g)	204.5
Moisture %	53.6%

Unit Weight

Bulk Weight (g)	1018.6
------------------------	--------

Length (mm)	1	144.17
	2	144.42
	3	144.36
	4	144.11

Average Length (m)	0.144
---------------------------	-------

Diam. (mm)	1	72.16
	2	72.33
	3	72.29
	4	71.91

Average Diameter (m)	0.072
-----------------------------	-------

Volume (m³)	5.90E-04
Bulk Unit Weight (kN/m³)	16.9
Bulk Unit Weight (pcf)	107.7
Dry Unit Weight (kN/m³)	11.0
Dry Unit Weight (pcf)	70.2

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-03
Sample # T26
Depth (m) 6.1 - 6.7
Sample Date 01-Feb-24
Test Date 16-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	109.3	2.3
Max S_u	54.7	1.1

Specimen Data

Description CLAY - silty, trace silt inclusions (<5mm diam.), trace sand, trace rootlets, grey, moist, firm, high plasticity

Length 144.3 (mm)
Diameter 72.2 (mm)
L/D Ratio 2.0
Initial Area 0.00409 (m²)
Load Rate 1.00 (%/min)

Moisture % 54%
Bulk Unit Wt. 16.9 (kN/m³)
Dry Unit Wt. 11.0 (kN/m³)
Liquid Limit -
Plastic Limit -
Plasticity Index -

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.35	34.3	0.72
Vane Size		
m	39.2	0.82

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.80	39.2	0.82
0.80	39.2	0.82
0.80	39.2	0.82
Average	0.80	0.82

Failure Geometry

Sketch:

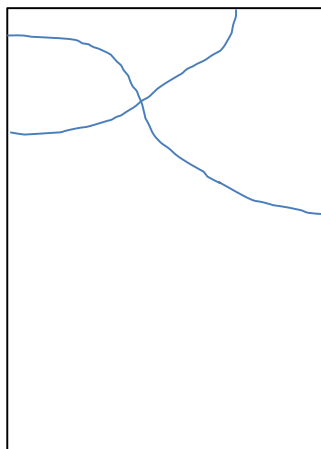
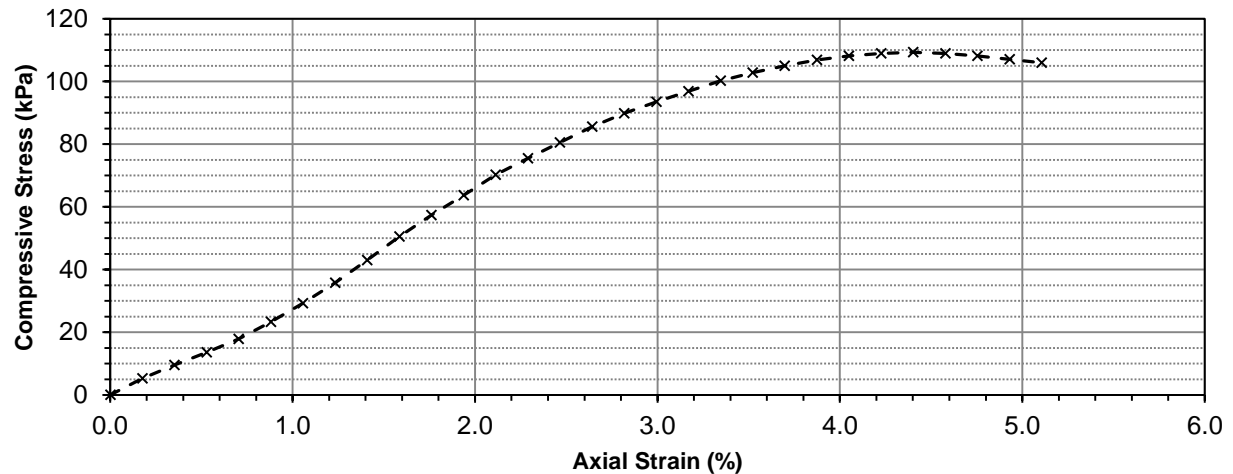


Photo:



Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.72	0.0000	0.00	0.004091	0.0	0.00	0.00
10	1.15	0.2540	0.18	0.004098	21.7	5.29	2.64
20	1.50	0.5080	0.35	0.004105	39.3	9.58	4.79
30	1.83	0.7620	0.53	0.004113	55.9	13.60	6.80
40	2.18	1.0160	0.70	0.004120	73.6	17.86	8.93
50	2.63	1.2700	0.88	0.004127	96.3	23.32	11.66
60	3.12	1.5240	1.06	0.004135	121.0	29.26	14.63
70	3.66	1.7780	1.23	0.004142	148.2	35.78	17.89
80	4.26	2.0320	1.41	0.004149	178.4	43.00	21.50
90	4.89	2.2860	1.58	0.004157	210.2	50.56	25.28
100	5.46	2.5400	1.76	0.004164	238.9	57.37	28.69
110	5.99	2.7940	1.94	0.004172	265.6	63.67	31.84
120	6.54	3.0480	2.11	0.004179	293.3	70.19	35.09
130	6.99	3.3020	2.29	0.004187	316.0	75.48	37.74
140	7.42	3.5560	2.46	0.004194	337.7	80.51	40.26
150	7.85	3.8100	2.64	0.004202	359.4	85.52	42.76
160	8.22	4.0640	2.82	0.004210	378.0	89.80	44.90
170	8.54	4.3180	2.99	0.004217	394.2	93.46	46.73
180	8.84	4.5720	3.17	0.004225	409.3	96.87	48.44
190	9.14	4.8260	3.35	0.004233	424.4	100.27	50.13
200	9.37	5.0800	3.52	0.004240	436.0	102.82	51.41
210	9.57	5.3340	3.70	0.004248	446.1	105.00	52.50
220	9.74	5.5880	3.87	0.004256	454.6	106.83	53.41
230	9.87	5.8420	4.05	0.004264	461.2	108.17	54.08



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Unconfined Compressive Strength ASTM D2166

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	9.95	6.0960	4.23	0.004272	465.2	108.91	54.46
250	10.00	6.3500	4.40	0.004279	467.7	109.30	54.65
260	9.99	6.6040	4.58	0.004287	467.2	108.98	54.49
270	9.94	6.8580	4.75	0.004295	464.7	108.19	54.10
280	9.86	7.1120	4.93	0.004303	460.7	107.06	53.53
290	9.78	7.3660	5.11	0.004311	456.7	105.92	52.96



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-04
Sample # T35
Depth (m) 6.1 - 6.7
Sample Date 02-Feb-24
Test Date 16-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	450					
Bottom	6.15 m Top					
6.55 m	6.49 m	6.32 m			6.10 m	
Moisture Content PP/TV Visual	Bulk	Sand Seam	Keep	Sand Seam	Toss	
60 mm	170 mm	170 mm			50 mm	

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<5mm diam.)	
trace to some sand seams (20mm thick)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	blocky
Gradation	-

Torvane

Reading	0.55
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	53.9

Pocket Penetrometer

Reading	1	1.70
	2	1.80
	3	1.70
	Average	1.73
Undrained Shear Strength (kPa)		85.0

Moisture Content

Tare ID	E85
Mass tare (g)	6.8
Mass wet + tare (g)	313.0
Mass dry + tare (g)	204.8
Moisture %	54.6%

Unit Weight

Bulk Weight (g)		913.9
Length (mm)	1	128.93
	2	129.41
	3	128.97
	4	128.83
Average Length (m)		0.129
Diam. (mm)	1	72.72
	2	72.83
	3	72.70
	4	72.89
Average Diameter (m)		0.073

Volume (m³)	5.37E-04
Bulk Unit Weight (kN/m³)	16.7
Bulk Unit Weight (pcf)	106.3
Dry Unit Weight (kN/m³)	10.8
Dry Unit Weight (pcf)	68.7



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-04
Sample # T38
Depth (m) 10.7 - 11.3
Sample Date 02-Feb-24
Test Date 16-Feb-24
Technician AD

Tube Extraction

Recovery (mm)	380		
Bottom	10.97 m	10.80 m	Top
11.05 m			10.67 m
Moisture Content PP/TV Visual	Bulk Qu	Toss Slough	
80 mm	170 mm	130 mm	

Visual Classification

Material	CLAY
Composition	silty
trace silt inclusions (<10mm diam.)	
trace gravel (<10mm diam.)	
Color	grey
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

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

Pocket Penetrometer

Reading	1	1.00
	2	1.00
	3	1.00
	Average	1.00
Undrained Shear Strength (kPa)		49.0

Moisture Content

Tare ID	H4
Mass tare (g)	8.6
Mass wet + tare (g)	296.8
Mass dry + tare (g)	202.7
Moisture %	48.5%

Unit Weight

Bulk Weight (g)		1061.4
Length (mm)	1	150.20
	2	149.99
	3	149.80
	4	149.80
Average Length (m)		0.150
Diam. (mm)	1	72.59
	2	72.97
	3	71.10
	4	71.09
Average Diameter (m)		0.072

Volume (m³)	6.09E-04
Bulk Unit Weight (kN/m³)	17.1
Bulk Unit Weight (pcf)	108.7
Dry Unit Weight (kN/m³)	11.5
Dry Unit Weight (pcf)	73.2

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Test Hole TH24-04
Sample # T11
Depth (m) 10.7 - 11.3
Sample Date 02-Feb-24
Test Date 16-Feb-24
Technician AD

Unconfined Strength

	kPa	ksf
Max q_u	42.7	0.9
Max S_u	21.3	0.4

Specimen Data

Description CLAY - silty, trace silt inclusions (<10mm diam.), trace gravel (<10mm diam.), grey, moist, firm, high plasticity

Length	149.9	(mm)	Moisture %	48%
Diameter	71.9	(mm)	Bulk Unit Wt.	17.1 (kN/m ³)
L/D Ratio	2.1		Dry Unit Wt.	11.5 (kN/m ³)
Initial Area	0.00406	(m ²)	Liquid Limit	-
Load Rate	1.00	(%/min)	Plastic Limit	-
			Plasticity Index	-

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.40	39.2	0.82
Vane Size		
m	49.0	1.02

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.00	49.1	1.02
1.00	49.1	1.02
1.00	49.1	1.02
Average	1.00	49.1
		1.02

Failure Geometry

Sketch:

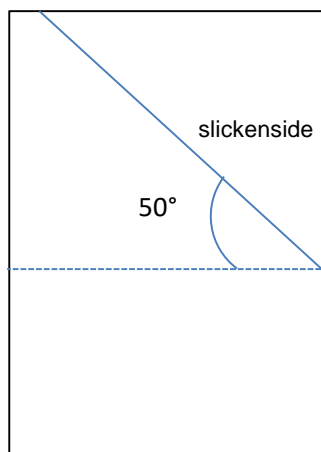
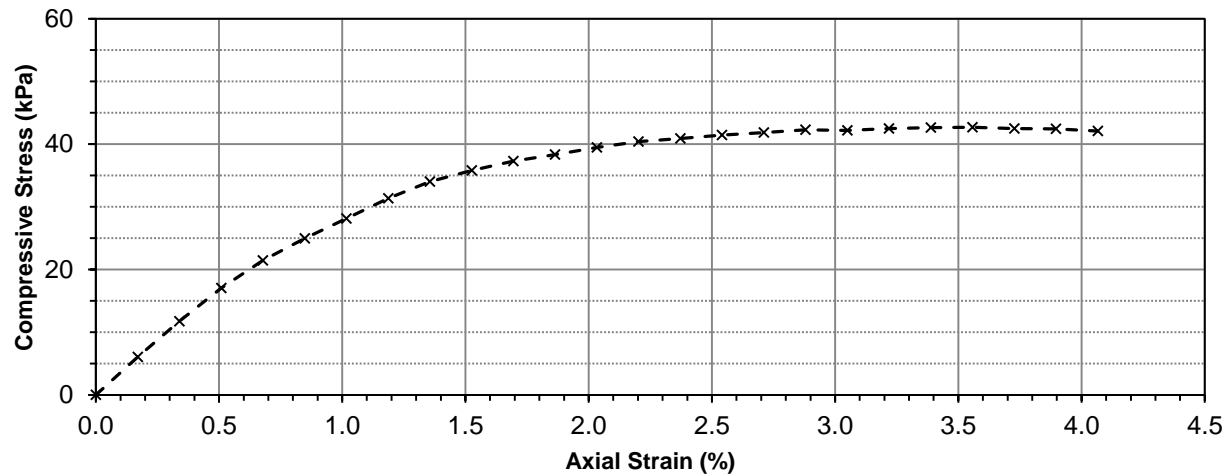


Photo:



Project No. 0336-003-00
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Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.80	0.0000	0.00	0.004064	0.0	0.00	0.00
10	1.29	0.2540	0.17	0.004071	24.7	6.07	3.03
20	1.75	0.5080	0.34	0.004078	47.9	11.74	5.87
30	2.18	0.7620	0.51	0.004085	69.6	17.03	8.51
40	2.54	1.0160	0.68	0.004092	87.7	21.43	10.72
50	2.83	1.2700	0.85	0.004099	102.3	24.96	12.48
60	3.09	1.5240	1.02	0.004106	115.4	28.11	14.05
70	3.36	1.7780	1.19	0.004113	129.0	31.37	15.69
80	3.58	2.0320	1.36	0.004120	140.1	34.01	17.00
90	3.73	2.2860	1.52	0.004127	147.7	35.78	17.89
100	3.86	2.5400	1.69	0.004134	154.2	37.30	18.65
110	3.95	2.7940	1.86	0.004142	158.8	38.34	19.17
120	4.05	3.0480	2.03	0.004149	163.8	39.48	19.74
130	4.13	3.3020	2.20	0.004156	167.8	40.39	20.19
140	4.18	3.5560	2.37	0.004163	170.4	40.92	20.46
150	4.23	3.8100	2.54	0.004170	172.9	41.45	20.73
160	4.27	4.0640	2.71	0.004178	174.9	41.87	20.93
170	4.31	4.3180	2.88	0.004185	176.9	42.27	21.14
180	4.31	4.5720	3.05	0.004192	176.9	42.20	21.10
190	4.34	4.8260	3.22	0.004200	178.4	42.49	21.24
200	4.36	5.0800	3.39	0.004207	179.4	42.65	21.33
210	4.37	5.3340	3.56	0.004214	179.9	42.70	21.35
220	4.36	5.5880	3.73	0.004222	179.4	42.50	21.25
230	4.36	5.8420	3.90	0.004229	179.4	42.43	21.21



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Unconfined Compressive Strength ASTM D2166

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer - Rail Crossings

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	4.34	6.0960	4.07	0.004237	178.4	42.11	21.06

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer

Sample Date 28-Sep-22
Test Date 10-Nov-22
Technician JC

Test Hole	TH22-12	TH22-12	TH22-12	TH22-12	TH22-12	TH22-12
Depth (m)	13.7 - 14.0	15.2 - 15.5	15.5 - 16.1	16.4 - 16.7	17.0 - 17.5	59.8 - 17.9
Sample #	G180	G181	SS182	G183	SS184	G185
Tare ID	C7	F89	AA14	A109	C4	AA21
Mass of tare	8.6	8.6	6.9	9	8.5	6.9
Mass wet + tare	253.6	282.2	248.8	227	242.2	211.1
Mass dry + tare	206.9	253	227.3	199.6	221.4	193.2
Mass water	46.7	29.2	21.5	27.4	20.8	17.9
Mass dry soil	198.3	244.4	220.4	190.6	212.9	186.3
Moisture %	23.6%	11.9%	9.8%	14.4%	9.8%	9.6%

Test Hole	TH22-12	TH22-13	TH22-13	TH22-13	TH22-13	TH22-13
Depth (m)	18.5 - 19.0	0.5 - 0.6	0.8 - 0.9	1.1 - 1.2	1.4 - 1.6	1.8 - 1.9
Sample #	SS186	G117	G118	G119	G120	G121
Tare ID	AB12	F17	P06	P85	N32	Z99
Mass of tare	7	8.6	8.7	8.6	8.5	8.6
Mass wet + tare	238.7	249.8	251.9	227.4	223.4	224.9
Mass dry + tare	214.3	238.2	196.5	170	172.2	181.8
Mass water	24.4	11.6	55.4	57.4	51.2	43.1
Mass dry soil	207.3	229.6	187.8	161.4	163.7	173.2
Moisture %	11.8%	5.1%	29.5%	35.6%	31.3%	24.9%

Test Hole	TH22-13	TH22-13	TH22-13	TH22-13	TH22-13	TH22-13
Depth (m)	2.2 - 2.4	2.7 - 3.0	3.9 - 4.4	5.1 - 5.4	6.9 - 7.3	8.5 - 8.9
Sample #	G122	G123	SS125	G126	G127	SS129
Tare ID	F131	N84	F66	F50	AB95	N16
Mass of tare	8.4	8.6	8.6	8.6	6.7	8.9
Mass wet + tare	358.3	242.5	229.3	221.5	262.4	244.8
Mass dry + tare	291.8	196.2	152.1	150.3	185	167.1
Mass water	66.5	46.3	77.2	71.2	77.4	77.7
Mass dry soil	283.4	187.6	143.5	141.7	178.3	158.2
Moisture %	23.5%	24.7%	53.8%	50.2%	43.4%	49.1%

Project No. 0336-003-00
Client Jacobs Canada Inc.
Project Armstrong Combined Sewer

Sample Date 28-Sep-22
Test Date 10-Nov-22
Technician JC

Test Hole	TH22-13	TH22-13	TH22-13	TH22-13	TH22-13	TH22-14
Depth (m)	10.0 - 10.5	11.5 - 11.8	13.4 - 13.7	15.2 - 15.5	15.5 - 15.9	0.5 - 0.8
Sample #	SS132	G133	G134	G135	SS136	G109
Tare ID	F105	D34	AC28	N41	H80	Z15
Mass of tare	8.5	8.8	6.3	8.6	8.9	8.5
Mass wet + tare	205.7	284.2	406.3	210.5	236	262.6
Mass dry + tare	140	209.8	255.3	188.3	218.6	205.9
Mass water	65.7	74.4	151.0	22.2	17.4	56.7
Mass dry soil	131.5	201.0	249.0	179.7	209.7	197.4
Moisture %	50.0%	37.0%	60.6%	12.4%	8.3%	28.7%

Test Hole	TH22-14	TH22-14	TH22-14	TH22-14	TH22-14	TH22-14
Depth (m)	0.8 - 1.1	1.7 - 2.0	2.4 - 2.6	2.9 - 3.2	4.1 - 4.5	6.0 - 6.3
Sample #	G110	G111	G112	G113	G114	G116
Tare ID	C26	AC27	H48	H35	F75	F61
Mass of tare	8.5	6.9	8.5	8.5	8.7	8.6
Mass wet + tare	287.1	301.2	262.8	251.2	239	270.4
Mass dry + tare	215.2	246.5	208.5	171.6	154.5	183.6
Mass water	71.9	54.7	54.3	79.6	84.5	86.8
Mass dry soil	206.7	239.6	200.0	163.1	145.8	175.0
Moisture %	34.8%	22.8%	27.2%	48.8%	58.0%	49.6%

Test Hole	TH22-15	TH22-15	TH22-15	TH22-15	TH22-15	TH22-15
Depth (m)	0.5 - 0.6	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5	1.8 - 1.9	2.2 - 2.4
Sample #	G250	G251	G252	G253	G254	G255
Tare ID	D20	W90	AC17	H56	E136	A6
Mass of tare	8.7	8.6	6.7	8.5	8.4	8.2
Mass wet + tare	281.7	323.5	351.1	299.5	312	260.3
Mass dry + tare	234.9	259.6	264.7	224.3	252.7	184.9
Mass water	46.8	63.9	86.4	75.2	59.3	75.4
Mass dry soil	226.2	251.0	258.0	215.8	244.3	176.7
Moisture %	20.7%	25.5%	33.5%	34.8%	24.3%	42.7%

Project No. 0336-003-00
Client Jacobs Canada Inc
Project Armstrong Combined Sewer

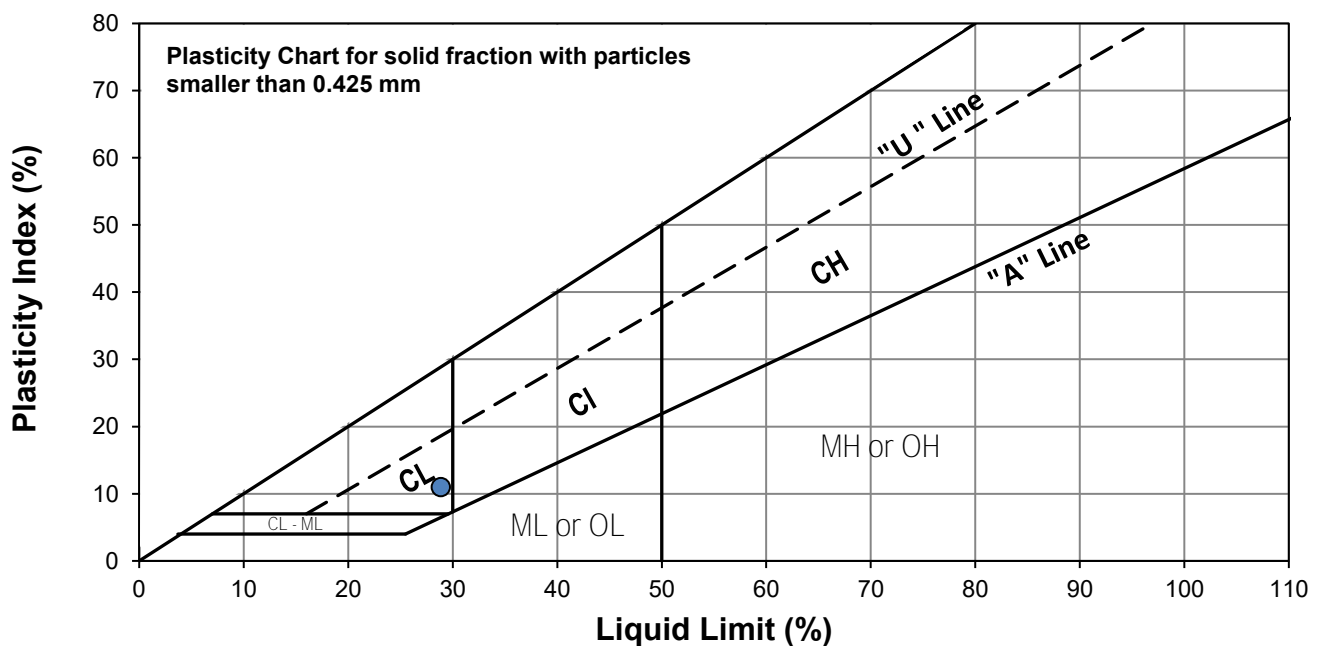
Test Hole TH22-13
Sample # G122
Depth (m) 2.3 - 2.4
Sample Date 2022-
Test Date 02-Nov-22
Technician TN



Liquid Limit 29
Plastic Limit 18
Plasticity Index 11

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	18	30	35		
Mass Tare (g)	13.802	13.889	13.928		
Mass Wet Soil + Tare (g)	24.791	23.133	24.731		
Mass Dry Soil + Tare (g)	22.268	21.099	22.364		
Mass Water (g)	2.523	2.034	2.367		
Mass Dry Soil (g)	8.466	7.210	8.436		
Moisture Content (%)	29.802	28.211	28.058		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.025	13.962			
Mass Wet Soil + Tare (g)	25.755	26.428			
Mass Dry Soil + Tare (g)	23.976	24.534			
Mass Water (g)	1.779	1.894			
Mass Dry Soil (g)	9.951	10.572			
Moisture Content (%)	17.878	17.915			

Note: Additional information recorded/measured for this test is available upon request.

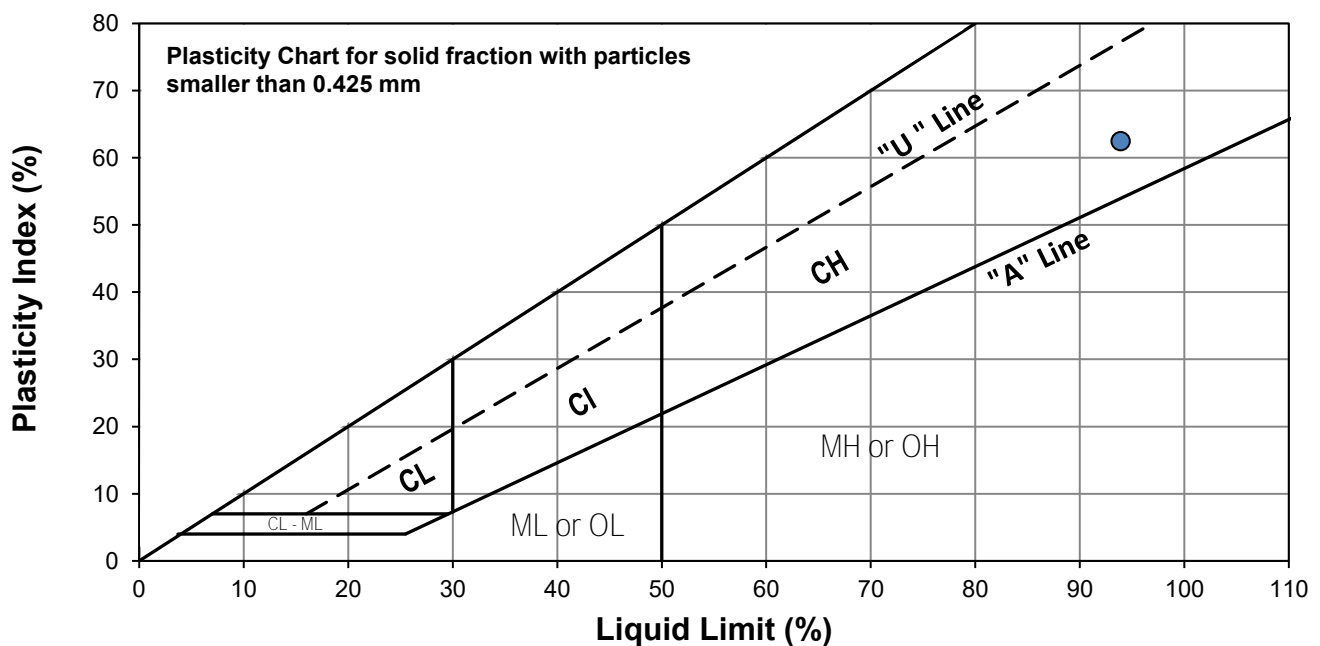
Project No. 0336-003-00
Client Jacobs Canada Inc
Project Armstrong Combined Sewer
Test Hole TH22-13
Sample # G134
Depth (m) 2.0 - 2.3
Sample Date 2022-
Test Date 02-Nov-22
Technician TN



Liquid Limit 94
Plastic Limit 31
Plasticity Index 62

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	18	28	34		
Mass Tare (g)	14.115	14.201	14.160		
Mass Wet Soil + Tare (g)	23.826	21.613	22.501		
Mass Dry Soil + Tare (g)	19.035	18.047	18.535		
Mass Water (g)	4.791	3.566	3.966		
Mass Dry Soil (g)	4.920	3.846	4.375		
Moisture Content (%)	97.378	92.720	90.651		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	13.935	14.052			
Mass Wet Soil + Tare (g)	23.920	22.195			
Mass Dry Soil + Tare (g)	21.524	20.255			
Mass Water (g)	2.396	1.940			
Mass Dry Soil (g)	7.589	6.203			
Moisture Content (%)	31.572	31.275			

Note: Additional information recorded/measured for this test is available upon request.

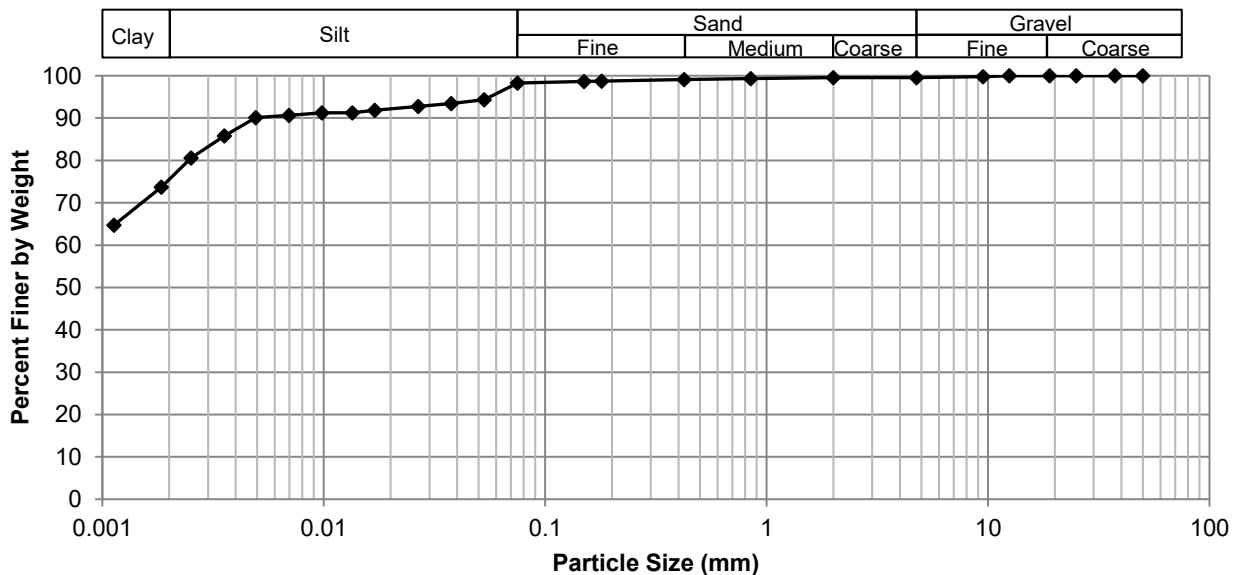
Project No. 0336-003-00
Client Jacobs Canada
Project Armstrong Combined Sewer



Test Hole TH22-13
Sample # G134
Depth (m) 13.4 - 13.7
Sample Date 19-Sep-22
Test Date 2-Nov-22
Technician AFK

Gravel	0.5%
Sand	1.2%
Silt	23.0%
Clay	75.3%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing	Particle Size (mm)	Percent Passing
50.0	100.00	4.75	99.53	0.0750	98.29
37.5	100.00	2.00	99.53	0.0530	94.34
25.0	100.00	0.850	99.31	0.0377	93.41
19.0	100.00	0.425	99.13	0.0267	92.78
12.5	100.00	0.180	98.74	0.0170	91.85
9.50	99.80	0.150	98.63	0.0135	91.23
4.75	99.53	0.075	98.29	0.0098	91.23
				0.0070	90.65
				0.0049	90.07
				0.0036	85.77
				0.0025	80.61
				0.0018	73.68
				0.0011	64.73



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Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T124
Depth (m) 3.3 - 3.9
Sample Date 20-Sep-22
Test Date 11-Nov-22
Technician DS

Tube Extraction

Recovery (mm) 430

3.56 m

3.40 m

Bottom - 3.9 m

Top - 3.5 m

Keep	Qu Bulk	Moisture Content PP/TV Visual
160 mm	160 mm	110 mm

Visual Classification

Material	CLAY
Composition	silty
trace sand	
trace gravel (<10mm diam.)	
trace silt inclusions (<30mm diam)	
trace oxidation	
Color	brown
Moisture	moist
Consistency	stiff
Plasticity	high plasticity
Structure	grey clay lenses (<15mm thick)
Gradation	-

Torvane

Reading	0.85
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	83.4

Pocket Penetrometer

Reading	1	1.70
	2	1.70
	3	1.80
	Average	1.73
Undrained Shear Strength (kPa)		85.0

Moisture Content

Tare ID	H31
Mass tare (g)	8.6
Mass wet + tare (g)	303
Mass dry + tare (g)	224.4
Moisture %	36.4%

Unit Weight

Bulk Weight (g)		1047.6
Length (mm)	1	146.43
	2	146.76
	3	147.18
	4	146.41
Average Length (m)		0.147
Diam. (mm)	1	72.61
	2	72.07
	3	72.14
	4	71.04
Average Diameter (m)		0.072

Volume (m³)	5.97E-04
Bulk Unit Weight (kN/m³)	17.2
Bulk Unit Weight (pcf)	109.6
Dry Unit Weight (kN/m³)	12.6
Dry Unit Weight (pcf)	80.3

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T124
Depth (m) 3.3 - 3.9
Sample Date 20-Sep-22
Test Date 11-Nov-22
Technician DS

Unconfined Strength

	kPa	ksf
Max q_u	97.5	2.0
Max S_u	48.8	1.0

Specimen Data

Description CLAY - silty, trace sand, trace gravel (<10mm diam.), trace silt inclusions (<30mm diam), trace oxidation, brown, moist, stiff, high plasticity, grey clay lenses (<15mm thick)

Length	146.7	(mm)	Moisture %	36%
Diameter	72.0	(mm)	Bulk Unit Wt.	17.2 (kN/m ³)
L/D Ratio	2.0		Dry Unit Wt.	12.6 (kN/m ³)
Initial Area	0.00407	(m ²)	Liquid Limit	-
Load Rate	1.00	(%/min)	Plastic Limit	-
			Plasticity Index	-

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength	
tsf	kPa	ksf
0.85	83.4	1.74
Vane Size		
m		

Pocket Penetrometer

Reading	Undrained Shear Strength	
tsf	kPa	ksf
1.70	83.4	1.74
1.70	83.4	1.74
1.80	88.3	1.84
Average	1.73	85.0

Failure Geometry

Sketch:

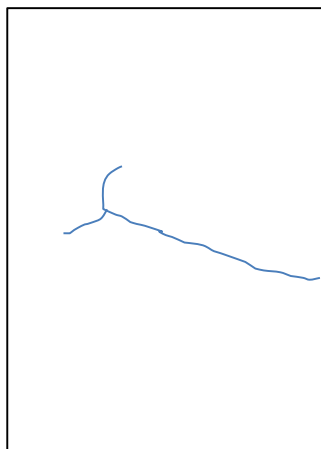
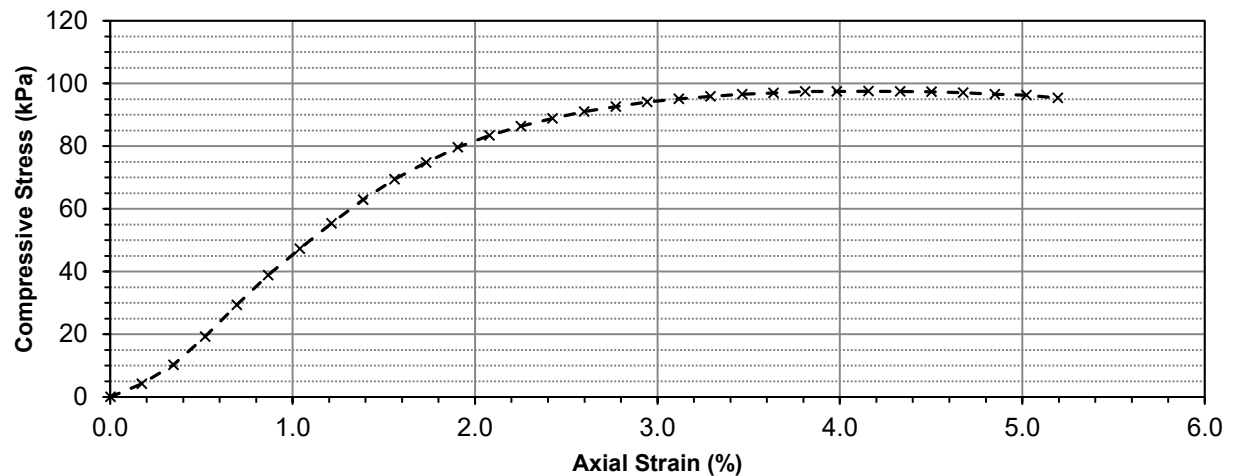


Photo:



Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.35	0.0000	0.00	0.004068	0.0	0.00	0.00
10	0.69	0.2540	0.17	0.004075	17.1	4.21	2.10
20	1.18	0.5080	0.35	0.004082	41.8	10.25	5.12
30	1.91	0.7620	0.52	0.004089	78.6	19.23	9.62
40	2.73	1.0160	0.69	0.004096	120.0	29.29	14.64
50	3.51	1.2700	0.87	0.004103	159.3	38.82	19.41
60	4.20	1.5240	1.04	0.004110	194.1	47.21	23.61
70	4.87	1.7780	1.21	0.004117	227.8	55.33	27.67
80	5.50	2.0320	1.39	0.004125	259.6	62.93	31.47
90	6.04	2.2860	1.56	0.004132	286.8	69.41	34.70
100	6.49	2.5400	1.73	0.004139	309.5	74.77	37.38
110	6.90	2.7940	1.90	0.004147	330.1	79.62	39.81
120	7.22	3.0480	2.08	0.004154	346.3	83.36	41.68
130	7.48	3.3020	2.25	0.004161	359.4	86.36	43.18
140	7.70	3.5560	2.42	0.004169	370.5	88.87	44.43
150	7.89	3.8100	2.60	0.004176	380.0	91.01	45.50
160	8.04	4.0640	2.77	0.004183	387.6	92.65	46.33
170	8.17	4.3180	2.94	0.004191	394.2	94.05	47.02
180	8.27	4.5720	3.12	0.004198	399.2	95.08	47.54
190	8.35	4.8260	3.29	0.004206	403.2	95.87	47.94
200	8.42	5.0800	3.46	0.004213	406.8	96.54	48.27
210	8.47	5.3340	3.64	0.004221	409.3	96.96	48.48
220	8.53	5.5880	3.81	0.004229	412.3	97.50	48.75
230	8.54	5.8420	3.98	0.004236	412.8	97.44	48.72

Unconfined Compression Test Data (cont'd)



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Unconfined Compressive Strength ASTM D2166

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q _u (kPa)	Shear Stress, S _u (kPa)
240	8.56	6.0960	4.16	0.004244	413.8	97.51	48.75
250	8.57	6.3500	4.33	0.004252	414.3	97.45	48.72
260	8.58	6.6040	4.50	0.004259	414.8	97.39	48.70
270	8.57	6.8580	4.68	0.004267	414.3	97.10	48.55
280	8.54	7.1120	4.85	0.004275	412.8	96.57	48.28
290	8.53	7.3660	5.02	0.004283	412.3	96.27	48.14
300	8.47	7.6200	5.19	0.004290	409.3	95.39	47.70

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T128
Depth (m) 9.4 - 10.0
Sample Date 22-Sep-22
Test Date 07-Nov-22
Technician JC

Tube Extraction

Recovery (mm)	400			
	9.77 m	9.61 m	9.46 m	
Bottom - 10 m				Top - 9.6 m
Toss	Qu Bulk	Keep	Moisture Content PP/TV Visual	
20 mm	160 mm	150 mm	70 mm	

Visual Classification

Material	CLAY
Composition	silty
trace sand	
trace gravel (<10mm diam.)	
trace silt inclusions (<10mm diam.)	
trace precipitates (gypsum, <5mm diam.)	
Color	grey
Moisture	moist
Consistency	frim
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.48
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	47.1

Pocket Penetrometer

Reading	1	1.00
	2	0.80
	3	0.90
Average		0.90
Undrained Shear Strength (kPa)		44.1

Moisture Content

Tare ID	E2
Mass tare (g)	8.6
Mass wet + tare (g)	315.8
Mass dry + tare (g)	227.6
Moisture %	40.3%

Unit Weight

Bulk Weight (g)		1071.5
Length (mm)	1	149.34
	2	149.44
	3	149.12
	4	149.69
Average Length (m)		0.149
Diam. (mm)	1	72.08
	2	72.41
	3	73.06
	4	72.00
Average Diameter (m)		0.072

Volume (m³)	6.15E-04
Bulk Unit Weight (kN/m³)	17.1
Bulk Unit Weight (pcf)	108.8
Dry Unit Weight (kN/m³)	12.2
Dry Unit Weight (pcf)	77.6

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T128
Depth (m) 9.4 - 10.0
Sample Date 22-Sep-22
Test Date 7-Nov-22
Technician JC

Unconfined Strength

	kPa	ksf
Max q_u	67.1	1.4
Max S_u	33.6	0.7

Specimen Data

Description CLAY - silty, trace sand, trace gravel (<10mm diam.), trace silt inclusions (<10mm diam.), trace precipitates (gypsum, <5mm diam.), grey, moist, firm, high plasticity

Length 149.4 (mm)
Diameter 72.4 (mm)
L/D Ratio 2.1
Initial Area 0.00412 (m²)
Load Rate 1.00 (%/min)

Moisture % 40%
Bulk Unit Wt. 17.1 (kN/m³)
Dry Unit Wt. 12.2 (kN/m³)
Liquid Limit -
Plastic Limit -
Plasticity Index -

Undrained Shear Strength Tests

Torvane

Reading	Undrained Shear Strength
tsf	kPa ksf
0.48	47.1 0.98
trace precipitates (gypsum, <5mm diam.)	
m	

Average

Pocket Penetrometer

Reading	Undrained Shear Strength
tsf	kPa ksf
1.00	49.1 1.02
0.80	39.2 0.82
0.90	44.1 0.92
0.90	44.1 0.92

Failure Geometry

Sketch:

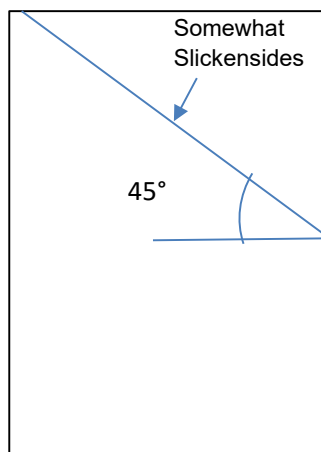
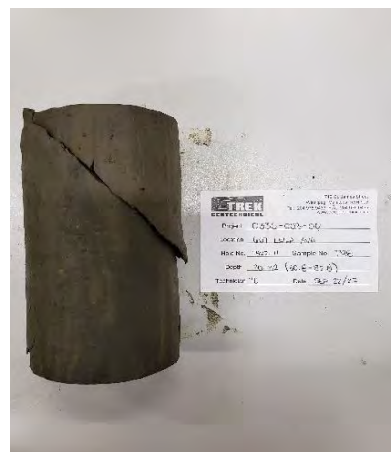
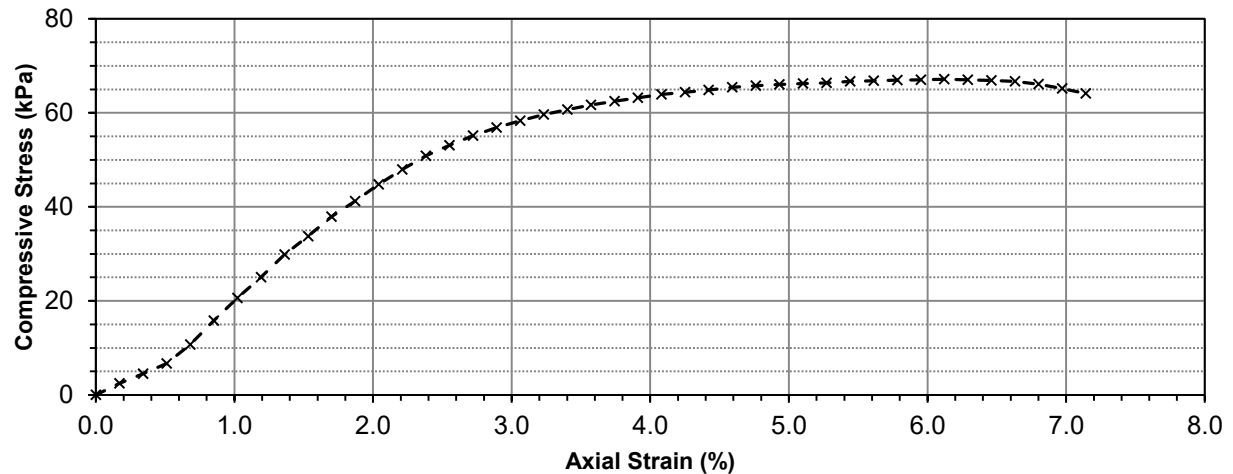


Photo:



Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.32	0.0000	0.00	0.004115	0.0	0.00	0.00
10	0.52	0.2540	0.17	0.004122	10.1	2.45	1.22
20	0.69	0.5080	0.34	0.004129	18.6	4.52	2.26
30	0.87	0.7620	0.51	0.004137	27.7	6.70	3.35
40	1.20	1.0160	0.68	0.004144	44.4	10.70	5.35
50	1.62	1.2700	0.85	0.004151	65.5	15.79	7.89
60	2.02	1.5240	1.02	0.004158	85.7	20.61	10.30
70	2.39	1.7780	1.19	0.004165	104.3	25.05	12.53
80	2.79	2.0320	1.36	0.004172	124.5	29.84	14.92
90	3.12	2.2860	1.53	0.004179	141.1	33.77	16.88
100	3.47	2.5400	1.70	0.004187	158.8	37.92	18.96
110	3.75	2.7940	1.87	0.004194	172.9	41.22	20.61
120	4.05	3.0480	2.04	0.004201	188.0	44.75	22.38
130	4.32	3.3020	2.21	0.004208	201.6	47.91	23.95
140	4.57	3.5560	2.38	0.004216	214.2	50.81	25.41
150	4.77	3.8100	2.55	0.004223	224.3	53.11	26.56
160	4.95	4.0640	2.72	0.004231	233.4	55.16	27.58
170	5.10	4.3180	2.89	0.004238	240.9	56.85	28.42
180	5.23	4.5720	3.06	0.004245	247.5	58.29	29.15
190	5.35	4.8260	3.23	0.004253	253.5	59.61	29.81
200	5.45	5.0800	3.40	0.004260	258.6	60.69	30.35
210	5.54	5.3340	3.57	0.004268	263.1	61.65	30.82
220	5.62	5.5880	3.74	0.004275	267.1	62.48	31.24
230	5.69	5.8420	3.91	0.004283	270.7	63.20	31.60

Unconfined Compression Test Data (cont'd)

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q _u (kPa)	Shear Stress, S _u (kPa)
240	5.76	6.0960	4.08	0.004291	274.2	63.91	31.95
250	5.81	6.3500	4.25	0.004298	276.7	64.38	32.19
260	5.86	6.6040	4.42	0.004306	279.2	64.85	32.43
270	5.92	6.8580	4.59	0.004313	282.3	65.44	32.72
280	5.96	7.1120	4.76	0.004321	284.3	65.79	32.89
290	5.99	7.3660	4.93	0.004329	285.8	66.02	33.01
300	6.02	7.6200	5.10	0.004337	287.3	66.25	33.12
310	6.04	7.8740	5.27	0.004344	288.3	66.36	33.18
320	6.08	8.1280	5.44	0.004352	290.3	66.71	33.35
330	6.10	8.3820	5.61	0.004360	291.3	66.82	33.41
340	6.12	8.6360	5.78	0.004368	292.3	66.93	33.46
350	6.14	8.8900	5.95	0.004376	293.3	67.04	33.52
360	6.16	9.1440	6.12	0.004384	294.4	67.15	33.57
370	6.16	9.3980	6.29	0.004392	294.4	67.02	33.51
380	6.16	9.6520	6.46	0.004400	294.4	66.90	33.45
390	6.15	9.9060	6.63	0.004408	293.8	66.67	33.33
400	6.11	10.1600	6.80	0.004416	291.8	66.09	33.04
410	6.04	10.4140	6.97	0.004424	288.3	65.17	32.59
420	5.96	10.6680	7.14	0.004432	284.3	64.14	32.07



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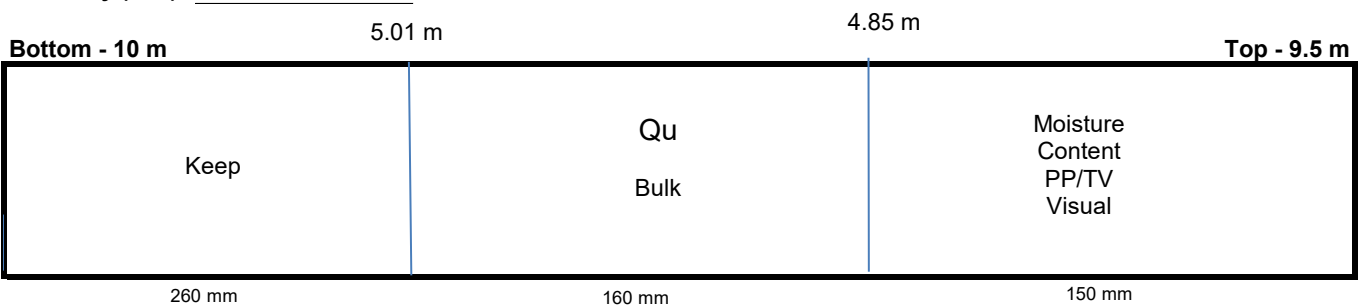
Shelby Tube Visual

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T130
Depth (m) 9.4 - 10.0
Sample Date 19-Sep-22
Test Date 09-Nov-22
Technician DS

Tube Extraction

Recovery (mm) 525



Visual Classification

Material	CLAY
Composition	silty
trace sand	
trace gravel (<10mm diam.)	
trace silt inclusions (<20mm diam.)	

Color	dark brown
Moisture	moist
Consistency	firm
Plasticity	high plasticity
Structure	stratified (clay and silt, <10mm thick)
Gradation	-

Torvane

Reading	0.60
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	58.8

Pocket Penetrometer

Reading	1	1.20
	2	1.30
	3	1.30
Average		1.27
Undrained Shear Strength (kPa)		62.1

Moisture Content

Tare ID	N19
Mass tare (g)	8.8
Mass wet + tare (g)	238.4
Mass dry + tare (g)	165.4
Moisture %	46.6%

Unit Weight

Bulk Weight (g)	1137.6
------------------------	--------

Length (mm)	1	153.65
	2	153.47
	3	153.47
	4	153.38

Average Length (m)	0.153
---------------------------	-------

Diam. (mm)	1	72.03
	2	72.22
	3	71.86
	4	71.76

Average Diameter (m)	0.072
-----------------------------	-------

Volume (m³)	6.24E-04
Bulk Unit Weight (kN/m³)	17.9
Bulk Unit Weight (pcf)	113.7
Dry Unit Weight (kN/m³)	12.2
Dry Unit Weight (pcf)	77.6

Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Test Hole TH22-13
Sample # T130
Depth (m) 9.4 - 10.0
Sample Date 19-Sep-22
Test Date 9-Nov-22
Technician DS

Unconfined Strength

	kPa	ksf
Max q_u	147.1	3.1
Max S_u	73.5	1.5

Specimen Data

Description CLAY - silty, trace sand, trace gravel (<10mm diam.), trace silt inclusions (<20mm diam.), dark brown, moist, firm, high plasticity, stratified (clay and silt, <10mm thick)

Length 153.5 (mm)
Diameter 72.0 (mm)
L/D Ratio 2.1
Initial Area 0.00407 (m²)
Load Rate 1.00 (%/min)

Moisture % 47%
Bulk Unit Wt. 17.9 (kN/m³)
Dry Unit Wt. 12.2 (kN/m³)
Liquid Limit -
Plastic Limit -
Plasticity Index -

Undrained Shear Strength Tests

Torvane

Reading
tsf
0.60
Vane Size
m

Undrained Shear Strength
kPa
58.8
ksf
1.23

Pocket Penetrometer

Reading
tsf
1.20
1.30
1.30
Average 1.27

Undrained Shear Strength
kPa
58.9
63.8
63.8
62.1
ksf
1.23
1.33
1.33
1.30

Failure Geometry

Sketch:

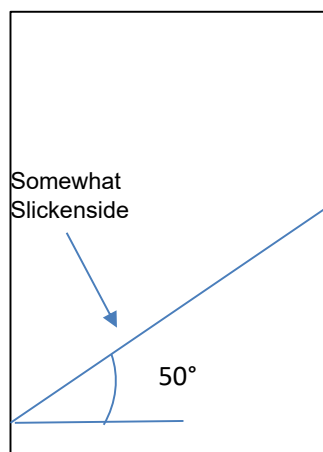
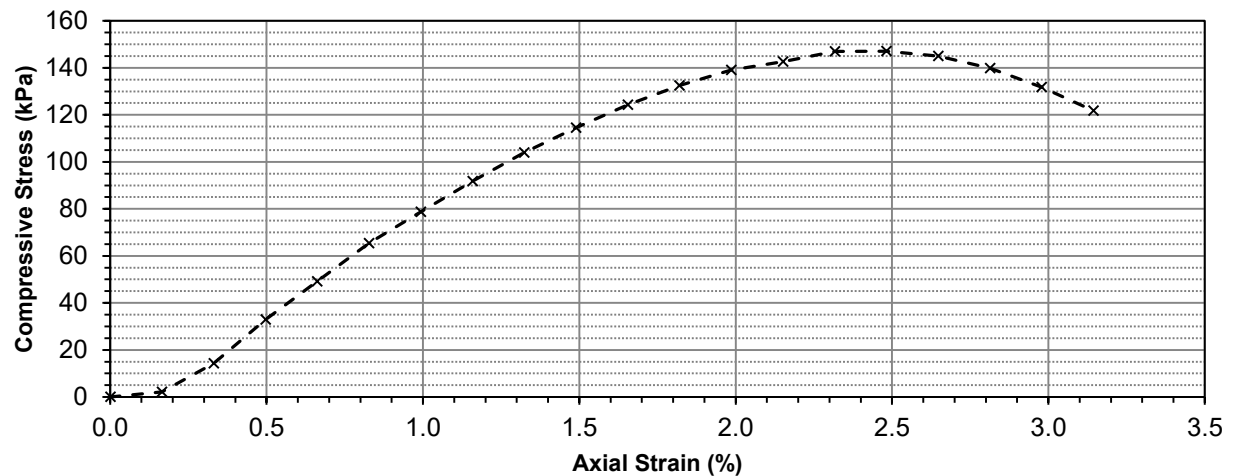


Photo:



Project No. 0336-003-00
Client Jacobs Canda Inc.
Project Armstrong Combined Sewer

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m ²)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0.33	0.0000	0.00	0.004068	0.0	0.00	0.00
10	0.50	0.2540	0.17	0.004075	8.6	2.10	1.05
20	1.49	0.5080	0.33	0.004081	58.5	14.33	7.16
30	3.00	0.7620	0.50	0.004088	134.6	32.92	16.46
40	4.32	1.0160	0.66	0.004095	201.1	49.11	24.56
50	5.65	1.2700	0.83	0.004102	268.1	65.37	32.69
60	6.75	1.5240	0.99	0.004109	323.6	78.76	39.38
70	7.82	1.7780	1.16	0.004116	377.5	91.73	45.87
80	8.83	2.0320	1.32	0.004122	428.4	103.93	51.96
90	9.71	2.2860	1.49	0.004129	472.8	114.49	57.25
100	10.53	2.5400	1.65	0.004136	514.1	124.29	62.15
110	11.22	2.7940	1.82	0.004143	548.9	132.48	66.24
120	11.78	3.0480	1.99	0.004150	577.1	139.06	69.53
130	12.09	3.3020	2.15	0.004157	592.7	142.58	71.29
140	12.47	3.5560	2.32	0.004164	611.9	146.94	73.47
150	12.50	3.8100	2.48	0.004171	613.4	147.05	73.53
160	12.35	4.0640	2.65	0.004178	605.8	144.99	72.50
170	11.94	4.3180	2.81	0.004186	585.2	139.81	69.90
180	11.29	4.5720	2.98	0.004193	552.4	131.76	65.88
190	10.48	4.8260	3.14	0.004200	511.6	121.81	60.91



Experience in Action