

NEWPCC Upgrade: Nutrient Removal Facilities LDS Crossing

CPKC Crossing Geotechnical Report1050 LDS
WSTP

City of Winnipeg

60738849

August 2025

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City of Winnipeg

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CPKC Crossing Geotechnical Report1050 LDS

Quality Information

Prepared by



Colton Wooster, EIT
Geotechnical

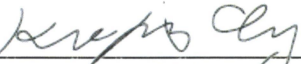
Checked by



German Leal, M.Eng., P.Eng.
Geotechnical Lead



Verified by



Sonny Chang, M.Sc., P.Eng.
Geotechnical Practice Lead

Approved by



Mike Gaudreau, P.Eng.
Municipal Engineer

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CPKC Crossing Geotechnical Report 1050 LDS

Prepared for:

City of Winnipeg
Robert Taylor, P.Eng.
Engineering Services
Water and Waste Department
Unit 110, 1199 Pacific Avenue
Winnipeg, MB R3E 3S8

Prepared by:

Colton Wooster
Geotechnical EIT
T: 204-928-8479
M: 204-583-8797
E: colton.wooster@aecom.com

German Leal, M.Eng., P.Eng.
Discipline Lead, Geotechnical
T: 204-928-8479
M: 431-335-9734
E: german.leal@aecom.com

AECOM Canada ULC
99 Commerce Drive
Winnipeg, MB R3P 0Y7
Canada

T: 204.477.5381
F: 431.800.1210
www.aecom.com

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1. Introduction

AECOM was retained by the City of Winnipeg to design and construct a new land drainage sewer (LDS) system. This system will connect the future developed area on Parcel A LDS System to the Parcel B LDS System which will connect to the John Black outfall within the future Chief Peguis Trail right of way, near the North End Water Pollution Control Center (NEWPCC) site, as part of the NEWPCC Nutrient Removal Facilities (NRF) Project. The proposed LDS will cross under the Canadian Pacific Kansas City (CPKC) railway at Mile 3.78 within the Winnipeg Beach Subdivision.

The proposed LDS qualifies as CPKC's "Process 2 – Intermediate" for the design, excavation, and construction criteria as outlined in their protocol: "CPKC Geotechnical Protocol for Pipeline and Utility Crossing Under Railway Tracks". According to CPKC's protocol, Process 2 is applicable to those crossing(s) applications that do not meet the conditions of Process 1, which depends on the pipe dimensions, depth of pipe, and excavation and construction method. Further details on the general requirements of CPKC's Protocol for Process 2 – Intermediate and proposed design parameters are provided in Section 10.1.

The beginning of this report provides the data collected during the geotechnical investigation completed at NEWPCC, Winnipeg, MB and characterizes the subsurface and groundwater conditions.

This geotechnical report has been prepared for the proposed LDS crossing of the CPKC rail line located at Mile 3.78 within the Winnipeg Beach Subdivision and provides comments and recommendations for consideration in the design and construction of the proposed LDS. German Leal will be the Geotechnical Engineer of Record (GER) for this proposed crossing.

Furthermore, the purpose of this report is to satisfy CPKC's Process 2 – Intermediate application requirements as outlined in the document titled "CPKC Geotechnical Protocol for Pipeline and Utility Crossing Under Railway Tracks", dated May 15, 2024 (Protocol). The settlement monitoring plan presented herein is to monitor the ground movement at the CPKC railway track before, during, and after installation of the proposed LDS. This is to identify if the installation of the LDS results in the ground disturbance that could potentially affect the railway.

2. Proposed Site and Proposed Construction

The site at 2230 Main Street, Winnipeg, MB, is part of the North End Sewage Treatment Plant (NEWPCC). The terrain includes open fields, grass, and sparse trees. Testholes TH24-12 and TH25-01 are located near the future Nutrient Removal Facility (NRF) LDS. This alignment intersects the existing Canadian Pacific Kansas City (CPKC) Ltd. railway. The testholes were drilled on the west and east sides of the CPKC railway, in areas of tall grass.

The proposed LDS consists of a 1067 mm nominal diameter reinforced concrete pipe (RCP); the outside diameter (OD) may be either 1295 mm for a B Wall or 1333 mm for a C Wall. For our analysis the maximum OD of 1333 mm was selected for this report. The crossing profile indicated at the railway crossing location, has an elevation and depth of the following:

- The base of rail (BOR) track is at an elevation of 231.53 m ASL.
- The invert elevation of the 1050 mm RCP ranges from 226.894 m ASL at the jacking pit to 226.950 m ASL at the receiving pit. This results in an invert depth from the BOR of approximately 4.59 m (226.940 m ASL).
- The depth from the BOR to the top of the RCP is 3.54 m (227.99 m ASL).

The dimensions of the jacking and receiving pits are indicated in **Appendix E – Crossing Drawing Sheets**. The drawing indicates that a jacking and receiving pit will be constructed east and west of the crossing. These pits will be outside the CPKC railway right of way (ROW). In addition, the pit locations meet CPKC requirements regarding the zone of potential track loading (ZPTL).

The bottom of the jacking pit and receiving pit is at 226.5 m ASL. With a depth of approximately 5.03 m from the BOR to the bottom of the pits.

3. Geotechnical Subsurface Investigation

3.1 Drilling and Sampling Program

The subsurface drilling program was conducted between 2024 and 2025. TH24-12 was drilled on January 8, 2024, and TH25-01 was drilled between May 20, 2025, and May 21, 2025. The locations of public utility locates were provided by ClickBeforeYouDigMB, while a final complete utility locate was identified and marked by a private locator. Drilling program was completed by Paddock Drilling Ltd. and Maple Leaf Drilling Ltd, under the supervision of AECOM's geotechnical field personnel. The field investigation consisted of drilling two (2) testholes to support the design and construction of the LDS crossing. TH25-01 was drilled east of the CPKC railway (in Parcel A), and TH24-12 was drilled west of the CPKC railway (in Parcel B). TH24-12 was drilled to a depth of 10.7 m BGS where it was terminated in Fat CLAY (CH). TH25-01 was drilled to a depth of 21.4 m BGS where it was terminated due to auger refusal in Sandy Lean Clay (CL) Till.

Subsurface conditions observed during testhole drilling were visually observed and documented by AECOM geotechnical personnel according to the Unified Soil Classification System (USCS). Representative samples were obtained directly from the auger flights at 0.3 m to 1.5 m intervals. The undrained shear strength of cohesive soils was evaluated using a mini torvane. A total of 10 undisturbed samples were retrieved in thin-walled Shelby tubes. Split spoon samples were collected from the underlying Sandy Lean Clay (CL) Till material to obtain Standard Penetration Test (SPT) "N" values. Groundwater, seepage and sloughing conditions were recorded upon completion of drilling. The testholes were backfilled with auger cuttings and bentonite chips. TH25-01 had standpipes installed and was backfilled with filter sand, auger cuttings and bentonite. TH24-12 was backfilled with auger cuttings and bentonite.

The testhole locations drilled during the geotechnical investigation are summarized in **Table 1**.

Table 1: Summary of the Testholes Drilled - Subsurface Investigation

Testhole ID	Location	Coordinates	Ground Elevation (m ASL)	Completion Depth (m BGS)	Termination USCS Soil Type
TH24-12	Parcel B – West of CPKC Railway	5535418.820 m N, 635275.679 m E	230.49	10.7	Fat Clay (CH)
TH25-01	Parcel A – East of CPKC Railway	5535360 m N, 635355 m E	231.27	21.4	Sandy Lean Clay (CL) Till

3.2 Instrumentation

During the geotechnical investigation, two (2) standpipe piezometers (SP) consisting of 50 mm diameter PVC were installed in TH25-01. One standpipe piezometer was installed in the Sandy Lean Clay (CL) Till and had a Casagrande tip with a screen length from 21.3 m BGS to 17.4 m BGS. The second standpipe piezometer was installed in the Fat Clay (CH) and had a Casagrande tip with a screen length from 4.7 m BGS to 0.9 m BGS. The installation details of the standpipe piezometers are shown on the testhole logs in **Appendix B** and summarized in **Table 2**.

Table 2: Standpipe Piezometer Installed for GWL Readings

Testhole ID	SP Depth (m BGS)	Tip Elevation (m ASL)	Slotted Layer USCS Soil Type
TH25-01	21.3	209.97	Sandy Lean Clay (CL) Till/Fat Clay (CH)
TH25-01	4.7	226.57	Fat Clay (CH)/Silt (ML)

4. Laboratory Testing Program

The laboratory testing program was developed to measure the index properties of the different soil types encountered. The laboratory tests consisted of geotechnical testing of disturbed grab and split spoon samples, and of undisturbed Shelby tube samples. The geotechnical tests were conducted at AECOM's Materials Laboratory in Winnipeg, MB. A summary of the tests performed is presented below and detailed laboratory test results are presented in **Appendix C**.

4.1 Geotechnical Testing

Geotechnical laboratory testing was conducted on selected soil samples to evaluate the physical characteristics, assess the engineering properties, and facilitate further characterization of the subsurface. The geotechnical laboratory testing program included determination of moisture content, Atterberg limits, grain size distribution by hydrometer method, and unconfined compressive strength for soils on samples collected during the field investigation. A summary of the geotechnical testing that was completed is provided in **Table 3**.

Table 3: Summary of Laboratory Testing

Laboratory Test	Number of Tests	Testing Standard
Moisture Content	37	ASTM D2216
Grain Size Distribution (Hydrometer Analysis)	4	ASTM D422
Atterberg Limits	4	ATM D4318
Unconfined Compressive Strength	4	ASTM D2850

5. Subsurface Conditions

Subsurface conditions observed during testhole drilling and sample were visually documented by AECOM geotechnical personnel in accordance with the Unified Soil Classification System (USCS). The conditions of the site have been based on the investigation results obtained during the field and laboratory programs. The pertinent results from these investigations are outlined below.

5.1 Subsurface Profile

Soils encountered during the investigation consisted of the following:

- Topsoil
- Silty Clay (CL-ML) Fill
- Silt (ML)
- Fat Clay (CH)
- Sandy Lean Clay (CL) Till

The description of the subsurface soil units encountered at the east and west side of the CPKC crossing is provided in the following subsections. The detailed description of the subsurface conditions are provided in the testhole logs in **Appendix B**, and the laboratory results are provided in **Appendix C**.

5.1.1 Topsoil

Topsoil was encountered at ground surface in TH25-01. The topsoil extended to a depth of 0.15 m BGS. The moisture content was determined to be 26.6%.

5.1.2 Fill: Silty Clay (CL-ML)

Silty Clay (CL-ML) Fill was encountered below the topsoil in TH25-01 and was observed at ground surface in TH24-12. The fill was observed at an elevation ranging from 231.12 m above sea level (m ASL) to 230.49 m ASL and extended to an elevation ranging from 229.90 m ASL to 229.04 m ASL. The undrained shear strength of the fill ranged from 58.84 kPa to 78.45 kPa with an average of 69.87 kPa, classifying the material as firm to stiff. The fill was black in colour, silty with trace gravel and sand. The moisture content of the fill ranged from 32.4% to 40.4% with an average of 36.2%.

5.1.3 Silt (ML)

Silt (ML) was observed in TH24-12 below the Silty Clay (CL-ML) Fill, and in TH25-01 interbedded in the Fat Clay (CH) layer. The Silt (ML) layer was observed at an approximate elevation ranging from 229.14 m ASL to 229.04 m ASL and extended to an approximate elevation range of 228.66 m ASL to 228.22 m ASL. The Silt (ML) was tan in colour, and soft. The moisture content of the Silt (ML) ranged from 22.4% to 23.5% with an average of 23.1%.

5.1.4 Fat Clay (CH)

Fat Clay (CH) was observed in both testholes at an elevation ranging from 229.90 m ASL to 228.66 m ASL and extended to an elevation of approximately 213.59 m ASL. An interbedded Silt (ML) layer was observed within the Fat Clay (CH) in testhole TH25-01. The Fat Clay (CH) was brown initially but switched to grey with depth (at approximately 6.1 m BGS in TH23-01). The Fat Clay (CH) had high plasticity. The undrained shear strength of the Fat Clay (CH) ranged from 19.61 kPa to 49.03 kPa with an average of 33.40 kPa, generally decreasing with depth, classifying the

material as stiff to soft in consistency. The moisture content of the Fat Clay (CH) ranged from 27.9% to 57.9% with an average of 48.8%.

5.1.5 Sandy Lean Clay (CL) Till

Sandy Lean Clay (CL) Till was encountered below the Fat Clay (CH) in TH25-01, at an approximate elevation of 213.59 m ASL, and extended to auger refusal at an elevation of 209.32 m ASL. The Sandy Lean Clay (CL) Till was tan in colour and had low plasticity. SPTs completed within the Sandy Lean Clay (CL) Till show uncorrected “N” values ranging from 26 to >50 blows per 300 mm of penetration, classifying the material as medium dense to very dense, generally increasing with depth. The moisture content of the Sandy Lean Clay (CL) Till ranged from 9.7% to 15.5% with an average of 11.8%. Although not encountered during drilling, cobbles and boulders are commonly found within the Sandy Lean Clay (CL) Till.

6. Groundwater and Sloughing Conditions

Groundwater seepage and sloughing conditions were recorded upon completion of drilling each testhole. Details of the location and nature of the sloughing and seepage conditions, as well as conditions of the groundwater encountered are provided on the testholes logs in **Appendix B** and presented in **Table 4**.

Table 4: Summary of Observed Groundwater Seepage and Sloughing Conditions

Testhole ID	Groundwater Seepage	Observed Depth of Groundwater Seepage (m BGS)	Depth of Groundwater Upon Completion of Drilling (m)	Observed Depth of Soil Sloughing (m BGS)
TH24-12	Not Observed	-	-	-
TH25-01	Minor	2.13	2.29	2.28

Only short-term seepage and sloughing conditions were observed. It should be noted that groundwater levels (GWL) and subsequently the seepage and sloughing depths may change seasonally, annually or as a result of construction activities.

6.1 Standpipe Piezometer Monitoring Result

Two (2) standpipe piezometers were installed in TH25-01, one was slotted within the Sandy Lean Clay (CL) Till and Fat Clay (CH) layer, the other was installed in the Fat Clay (CH) and Silt (ML) layer to monitor and measure the groundwater level in the testhole.

Groundwater depth was measured within the standpipe. The measured groundwater depth and elevation with corresponding dates are provided in **Table 5**.

Table 5: Groundwater Readings

Parameters	TH25-01 (SP1)	TH25-01 (SP2)
Testhole Elevation (m ASL)	231.27	230.83
Tip Depth (m BGS)	21.34	4.62
Tip Elevation (m ASL)	209.93	226.21
USCS Soil Type at Tip Location	Sandy Lean Clay (CL) Till	Fat Clay (CH)
Dates	GWL Depth Below Ground Surface (m ASL)	
May 26, 2025	223.08	229.61
June 9, 2025	223.50	229.42
June 27, 2025	223.33	229.15

The groundwater readings differ between SP1 and SP2 due to the fact SP2 is measuring a perched water table within the Silt layer, while SP1 is measuring the total head in an aquifer within the Sandy Lean Clay (CL) Till layer. Details of the standpipe piezometer installation is provided in the testhole logs provided in **Appendix B**.

Groundwater levels will normally fluctuate during the year and will be dependent on precipitation, surface drainage and regional groundwater regimes. Groundwater seepage and soil sloughing should be expected from the Silt (ML), and Sandy Lean Clay (CL) Till layers.

7. Laboratory Test Results

The results of the laboratory tests are presented in tables within this section, and the laboratory test reports are provided in **Appendix C**.

Table 6: Grain Size Distribution (Hydrometer Analysis) Results

Testhole ID	Sample ID	Sample Depth (m BGS)	Grain Size Distribution (%)			
			Gravel 75 to 4.75 mm	Sand <4.75 to 0.075 mm	Silt <0.075 to 0.002 mm	Clay <0.002 mm
TH25-01	T4	1.52 – 2.13	0.0	0.9	44.7	54.4
TH25-01	T7	3.05 – 3.66	0.2	0.7	26.2	72.9
TH25-01	T14	9.14 – 9.75	0.0	4.7	32.2	63.1
TH25-01	T20	15.24 – 15.85	0.5	9.0	24.1	60.5

Table 7: Atterberg Limit Test Results

Testhole ID	Sample ID	Sample Depth (m BGS)	USCS Soil Type	Liquid Limit	Plastic Limit	Plasticity Index	Activity
TH25-01	T4	1.52 – 2.13	CH	52	17	35	0.64
TH25-01	T7	3.05 – 3.66	CH	89	27	62	0.82
TH25-01	T14	9.14 – 9.75	CH	65	17	48	0.76
TH25-01	T20	15.24 – 15.85	CH	61	18	43	0.71

Table 8: Unconfined Compressive Strength Test Results

Testhole ID	Sample ID	Sample Depth (m BGS)	USCS Soil Type	Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Undrained Shear Strength (kPa)	Unconfined Compressive Strength (kPa)
TH25-01	T4	1.52 – 2.13	CH	16.3	28.5	26.56	53.13
TH25-01	T7	3.05 – 3.66	CH	44.9	17.3	33.73	67.47
TH25-01	T14	9.14 – 9.75	CH	48.0	17.2	35.31	70.62
TH25-01	T20	15.24 – 15.85	CH	46.9	16.7	16.84	33.69

8. Frost

8.1 Seasonal Frost Penetration

The depth of frost penetration has been estimated for a range of annual air freezing indices identified in **Table 9**. The annual average freezing index was inferred from Figure K-4 of the National Building Code of Canada (2020) Commentary document. The ten-year return annual freezing index was calculated using the mean annual freezing index value and recommendations outlined in the Canadian Foundation Engineering Manual (CFEM). The fifty-year return annual freezing index was taken from Figure K-5 of the National Building Code of Canada (2020) Commentary document.

Factors such as snow cover, surface vegetation, soil type, and groundwater conditions can all significantly impact the depth of frost penetration. The predominant soil type on the project site is Fat Clay (CH).

Table 9: Frost Penetration Depth

Parameter	Period		
	Mean	10-Year Return	50-Year Return
Annual Air Freezing Index (°C-days)	1825	1875	2375
Estimated Frost Penetration (Fat Clay Subgrade) – gravel surface, no snow cover (m)	2.1	2.2	2.4
Estimated Frost Penetration (Fat Clay Subgrade) – grass with snow cover (m)	2.0	2.0	2.3

8.2 Frost Susceptibility

The qualitative frost susceptibility of soil is typically assessed using guidelines developed by Casagrande (1932) on the basis of the percentage by weight of the soil finer than 0.02 mm, and the plasticity index. This classification system has been adapted by the U.S. Army Corps of Engineers and the Canadian Foundation Engineering Manual (2023). Soils are classified as F1 through F4 in order of increasing frost susceptibility.

The soils (fat clay and silt) encountered during the geotechnical investigation fall primarily within the frost groups F3 and F4. The F3 group has high to very high susceptibility to frost, and F4 has very high susceptibility. Frost susceptibility has been assigned to the encountered soil type and is summarized in **Table 10**.

Table 10: Project Site Frost Susceptibility

Soil Unit	USCS Soil Type	Frost Group	Percent fine than 0.02 mm, by weight	PI	Frost Susceptibility
Clay	CL, CH	F3	-	>12	High to very high susceptibility
Silt	ML	F4	-	-	Very high susceptibility

Source: Canadian Foundation Engineering Manual (CFEM, 5e), Chapter 14 Frost Action.

9. Seismic Site Classification

AECOM conducted a site seismic classification in accordance with the recommendations provided in the National Building Code of Canada (NBCC) 2020, using subsurface soil and groundwater conditions obtained from the geotechnical investigation. According to Article 4.1.8.4 of NBCC 2020, the resultant Seismic Site Class E has been assessed based on available data, inferred subsurface soil conditions, and more than 3 m of high plasticity clay.

AECOM obtained NBCC 2020 seismic hazard values for the project site from Natural Resources Canada's publicly available seismic hazard calculator. Based on the assessed Seismic Classification, the common 5% damped seismic hazard values, factored for Site Class E, are provided in **Appendix D** for the site under the design seismic conditions.

The seismic hazard values includes spectral accelerations (for periods of 0.05, 0.1, 0.2, 0.3, 0.5, 1.0, 2.0, 5.0, and 10.0 seconds), peak ground acceleration, and peak ground velocity for the site under various design seismic events (2%, 5%, 10% and 40% probability of exceedance in 50 years).

10. LDS Design Criteria

This report aims to provide adequate subsurface information for crossing design, including geotechnical and groundwater information, to support the CPKC crossing application. CPKC's geotechnical or a CPKC-approved services provider will assess the geotechnical information prior to receiving CPKC's approval for each crossing application.

10.1 Design Requirements

Based on the CPKC Protocol Requirements for pipeline crossing under railway tracks with an outside diameter of 300 mm to 1500 mm. The proposed maximum OD for the RCP LDS is 1333 mm which is categorized as "Process 2 – Intermediate". **Table 11** provides the CPKC Protocol Requirements for Process 2 – Intermediate and the proposed trenchless crossing based on the project drawing in **Appendix E**.

Table 11: CPKC Protocol Requirements and Proposed Design Parameters

Criteria	CPKC Protocol Requirements ⁽¹⁾	Proposed Crossing Design
Dimension Criteria		
Outside Pipe Diameter	300 mm to 1500 mm	Reinforced Concrete Pipe: 1333 mm outside diameter (maximum)
Cover Between BOR to top of pipe	Greater than 1.5 m or 2 pipe diameter whichever is greater	3.54 m
Adjacent structures including switches	Within 2.5 times, cover between BOR and top of pipe	None
Depth of Pipes Outside Zone of Potential Track Loading (ZPTL)	Less than 0.91 m burial within ZPTL	Approximate depth of pipe within ZPTL (west) = 2.48 m Approximate depth of pipe within ZPTL (east) = 2.20 m
Excavation Criteria		
Excavation close to CPKC track(s)	Excavation or jacking/access pits within 10 m of the closest track centreline	Centerline of track to edge of Jacking Pit: 20.31 m Centerline of track to edge of Receiving Pit: 20.04 m Outside ZPTL and CPKC's ROW
Crossing Angle	More than 45° off perpendicular to the track	90°
Construction Method		
	Auger Boring	Guided Auger Boring
Other Criteria		
Settlement for Class 2 Track	Level 1 Alert – (Review Threshold): >11 mm Level 2 Critical – (Stop Work): >22 mm	Provided in Section 12.2
Approximate Length of Crossing	None	40.35 m

(1) CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks Criteria for Process 2 – Intermediate.

11. Pipe Installation

11.1 Anticipated Stratigraphy

The proposed 1333 mm OD Reinforced Concrete Pipe invert ranges in elevation from 226.894 m above sea level (ASL) at the west pit (Jacking Pit), to 226.95 m ASL at the east pit (Receiving Pit). The soils encountered in testholes are as follows:

- TH24-12 (West of Rail Line) consisted of Silty Clay (CL-ML) Fill at the surface, underlain by Silt (ML), and Fat Clay (CH). Particularly the Fat Clay (CH) layer was encountered at 228.66 m ASL and extended down to the termination depth of 10.67 m (219.82 m ASL).
- TH25-01 (East of Rail Line) consisted of topsoil at the surface, underlain by Silty Clay (CL-ML) Fill, Fat Clay (CH), Silt (ML), a second Fat Clay (CH) layer, followed by Sandy Lean Clay (CL) Till. Particularly, the second layer of Fat Clay (CH) was encountered at 228.22 m ASL and extended to an elevation of 213.59 m ASL.

Table 12 provides the anticipated soil stratigraphy along the proposed LDS trenchless bore path.

Table 12: Anticipated Soil Stratigraphy along the LDS Trenchless Bore Path

Proposed LDS Bore Path	Approximate Elevation of LDS at BOR (m ASL)	Anticipated Soil Unit at the Jacking Pit	Anticipated Soil Unit at the Receiving Pit	Elevation of Soil Unit (m ASL)
Top of Pipe	227.99	Fat Clay (CH)	Fat Clay (CH)	TH24-12 Fat Clay (CH) below 228.66 m ASL
Bottom of Pipe	226.94	Fat Clay (CH)	Fat Clay (CH)	TH25-01 Fat Clay (CH) between 228.22 m ASL and 213.59 m ASL

As shown in **Table 12**, it is anticipated that the proposed reinforced concrete pipe will be installed within the Fat Clay (CH) layer at the jacking pit and the receiving pits.

The depth of the BOR to the bottom of the jacking pit is 5.03 m at 226.5 m ASL. Based on the bottom depth of the pits, it is anticipated that the topsoil, fill, silt, and fat clay layers will be encountered during excavation of the jacking and receiving pits.

11.2 Tunnelman's Ground Classification

Table 13 is provided for completeness and as general information for the anticipated ground conditions along the crossing alignment. This table provides the framework for Tunnelman's Ground Classification and indicates the respective tunnel working conditions for reference as outlined by Heuer and Virgins (1987) and Brandt (1970) and others. Soft to firm Fat Clay (CH) below the groundwater level is anticipated to exhibit a 'squeezing' behavior.

Table 13: Tunnelman's Ground Classification and Probable Work Conditions

Classification		Representative Soil Types	Tunnel Work Conditions
Hard		Very hard calcareous clay; cemented sand and gravel.	Tunnel heading may be advanced without roof support.
Firm		Loess above water table; hard clay, marl, cement sand and gravel when not highly overstressed.	Tunnel heading can be advanced without initial support, and final lining can be constructed before ground starts to move.
Raveling	Slow Raveling	Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed, due to loosening or to overstress and "brittle" fracture (ground separates or breaks along distinct surfaces, opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes, otherwise the ground is slow raveling.
	Fast Raveling		
Squeezing		Soft or medium-soft clay.	Ground slowly advances into tunnel without fracturing and without perceptible increase of water content in ground surrounding the tunnel (may not be noticed in tunnel but cause surface subsidence).
Swelling		Heavily pre-compressed clays with a plasticity index more than about 30; sedimentary formations containing anhydrite.	Like squeezing ground, moves slowly into tunnel, but movement is associated with a very considerable volume increase in the ground surrounding tunnel.
Running	Cohesive Running	Cohesive running occurs in clean, fine moist sand.	The removal of the lateral support of any surface rising at an angle of more than about 34° to the horizontal is followed by a "run" whereby the material flows like granulated sugar until the slope angle becomes equal to about 34°. If the "run" is preceded by a brief period of raveling, the ground is called cohesive raveling.
	Running	Running occurs in clean, coarse or medium sand above the GWT.	
Very Soft Squeezing		Clay and silts with high plasticity index.	Ground advances rapidly into the tunnel in plastic flow.
Flowing		Below the water table in silt, sand, or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.	Flowing ground moves like a viscous liquid. It can invade the tunnel not only through the roof and the sides but also through the bottom. If the flow is not stopped, it continues until the tunnel is filled.
Bouldery		Boulder glacial till; rip-rap fill; some landslide deposits; some residual soils. The matrix between boulders may be gravel, sand, clay or combination thereof.	Problems occurred in advancing shield or in forepoling; blasting or hard mining ahead of machine possibly necessary.

Since we are expecting Fat Clay (CH), it is anticipated that the Tunnelman's ground classification may experience squeezing to very soft squeezing.

11.3 Reinforced Concrete Pipe (RCP)

The RCP sizing for the LDS has a maximum 1333 mm outside diameter (OD), as proposed by others. For a comprehensive settlement estimate, a 25.4 mm overcut is considered.

The following table summarizes the details regarding the RCP size, its description, and the corresponding elevations at the east and west pits:

Table 14: Invert Elevations for the RCP

RCP Size (OD)	Description	Invert Elevations (East Pit)	Invert Elevations (West Pit)
1333 mm ⁽¹⁾	Concrete	226.950	226.894

(1) Per the crossing drawing provided in **Appendix E**, nominal diameter of the RCP is 1067 mm, OD is either a 1295 mm B wall or a 1333 mm C Wall.

It is the contractor's responsibility to determine the appropriate method for RCP installation. CPKC will be informed of any method of installation that differs from the one described in this report.

11.4 Recommended Installation Options

The method of RCP installation considered includes the installation of a temporary steel casing, with matching OD installed via Guided Auger Boring (with soil plug). Upon installation of the temporary steel casing, the RCP will be jacked behind the temporary steel casing, displacing the temporary steel casing for removal from the receiving pit. AECOM has experience with pipes with similar diameter and installation method. In 2017, for a CN Rail crossing on Waverly Avenue; AECOM designed and recommended a guided auger bore for a steel casing pipe with an inside diameter (ID) of 1511 mm. The pipe was successfully installed approximately 3.14 m BGS.

The temporary steel casing pipe should be installed with a guided pilot tube when auger methods are used. The Guided Auger Boring method should utilize a guided pilot tube as a technique to accurately install a pipe to line and grade. The pilot tube installation serves as the initial step in guided boring technology.

It is recommended that a soil plug be maintained during the guided auger installation of the temporary steel casing. The soil plug provides face stability at the tunnel head, reducing the risk of collapse. To limit soil settlement due to volume loss a soil plug within the casing pipe with a length of 3 pipe diameters is recommended.

These methods have been considered based upon the known availability of resources, equipment, and expertise within the Manitoba market. Other factors for consideration including the geotechnical/geological constraints are discussed in Section 11.5.6. The contractor shall submit a trenchless installation work plan for the GER to review. A copy of the reviewed trenchless installation work plan will then be provided to CPKC.

11.4.1 Guided Auger Boring

The guided auger boring method involves installation of a temporary steel casing during the auger boring process and is followed by pipe jacking of the RCP displacing the temporary steel casing.

First, excavate the pit to create the jacking and receiving areas. Next, pilot tubes are installed to control line and grade. The pilot tube is connected to a single stage weld-on reaming head, which is welded to a section of casing. The single-stage weld-on reaming head is attached to the casing to enlarge the tunnel to the final diameter; the Contractor may choose to enlarge the tunnel to an intermediate diameter prior and repeating the operation until the final diameter is achieved.

The temporary steel casing is expected to have approximately the same OD as the RCP to allow the jacking of the RCP without the need for additional soil removal. The leading face of the auger cutting head is recessed within the steel casing to maintain a soil plug to provide face stability. The auger is used inside the steel casing to bore through the soil, with cuttings removed towards the launching/jacking pit. Throughout this process, the soil plug is maintained for continuous face stability and reduce the potential for ground subsidence.

Once the section of steel casing has been jacked to its limit, another section of casing is added, and jacking continues until the crossing is completed.

Upon full installation of the temporary steel casing, a section of RCP is connected to the steel casing with a collar and the RCP is jacked into place. When the section of RCP has reached its limit, another section of RCP is added, while a section of temporary steel casing is removed from the receiving pit. This process continues until the RCP has reached the required length, and the entire steel casing has been completely removed.

11.5 Trenchless Construction Risks

Each trenchless option for the CPKC rail crossing has been evaluated against the following risks:

Table 15: Evaluation of Trenchless Construction Risks

Trenchless Method	Perceived Risk
Guided Auger Boring	Ground settlement and heave
	Buried Obstructions
	Groundwater
	Pipe alignment/grade control
	Dense/very stiff soil conditions

11.5.1 Ground Settlement and Heave

The major advantage of guided auger boring method is the reduced ground disturbance during installation. However, ground settlement and heave can still occur during installation of the RCP.

Minor groundwater seepage was observed in TH25-01 at a depth of 2.13 m (229.14 m ASL), while no seepage was observed in TH24-12. The source of the seepage was observed from the Silt (ML) layer. Soil sloughing was observed in TH25-01 in the Fat Clay (CH) at a depth of 2.29 m (228.98 m ASL), while no sloughing was observed in TH24-12 during or upon completion of drilling.

It should be noted that soil sloughing may be encountered in soils with:

- Moisture content closer to its liquid limit – indicating that the soil is behaving like a liquid.
- High silt content – silts are fine soils.
- Undrained shear strength less than 25 kPa i.e., soft soils.

Although soil sloughing was not observed from the Silt (ML) layer during or after drilling, soil sloughing may still be encountered during construction as noted above.

Surface heave can occur during installation using guided auger boring if the pipe is advanced through the Fat Clay (CH) soil too quickly without allowing time for the auger to remove the displaced soils. Settlement can also occur if flowing soils enter the pipe.

For auger boring, the management and control of support pressures at the leading face of the tunnel is largely dependent upon the plug of soil formed in front of the auger and temporary steel casing. The soil plug should only be

developed within the steel casing ahead of the cutting head and not advance at a rate that could cause heave ahead of the soil plug. It is the responsibility of the contractor to limit the development of a soil plug in front of the steel casing and to keep the amount of heave to a minimum.

11.5.2 Buried Obstructions

No buried obstructions were encountered during AECOM's geotechnical investigation in 2024 and 2025. However, buried obstructions such as abandoned rail ties, abandoned pipe or cobbles and boulders may be encountered during trenchless methods. Encountering buried obstructions can prevent or slow down the progress of a trenchless method. Particularly, guided auger boring can have difficulty cutting and moving obstructions, potentially creating misalignment. An installation technique should be selected that can accommodate removal of potential obstructions without having to remove or expose the leading edge of the RCP. Prior to construction, any utilities and/or fiber optics within the ROW should be located by the contractor.

11.5.3 Groundwater

Groundwater seepage and sloughing conditions were recorded upon completions of drilling each testhole. As mentioned in Section 6, minor groundwater seepage was observed in TH25-01 at a depth of 2.13 m ASL, and no groundwater seepage was observed in TH24-12 during or upon completion of drilling. The source of seepage was observed from the Silt (ML) layer.

Two standpipe piezometers (SP) were installed in TH25-01. The first standpipe was slotted in the Sandy Lean Clay (CL) Till, the second standpipe was slotted between the Silty Clay (CL-ML) Fill, Silt (ML) and Fat Clay (CH) layers. The standpipe piezometers were used to monitor and measure the groundwater levels in the testhole. Groundwater level was monitored on May 26, 2026, June 9, 2025, and June 27, 2025. The depths to groundwater in the deep standpipe piezometer (installed in till) were recorded as 8.19 m BGS (223.077 m ASL), 7.77 m BGS (223.497 m ASL) and 7.94 m BGS (223.327 m ASL). The depths to groundwater in the shallow standpipe piezometer (installed in varying clay layers) were recorded as 1.22 m BGS (229.607 m ASL), 1.41 m BGS (229.422 m ASL) and 1.68 m BGS (229.15 m ASL). The installation of the RCP LDS (top of pipe 227.99 m ASL) is below the groundwater elevation recorded by the shallow standpipe piezometer and that was recorded upon completion of drilling. The groundwater recorded is equivalent to approximately 3.11 m of total head within the jacking and receiving pits. The contractor should be prepared to deal with groundwater during installation and during excavation of the jacking and receiving pits. The contractor should have adequate pumping to maintain safe excavations.

Given potential for seasonal fluctuation of the groundwater table, it is recommended that the groundwater level in the SP's be measured again prior to construction to confirm any change arising from seasonal variation or changed conditions since the time of previous monitoring events.

Groundwater will require careful management and control throughout the RCP installation process regardless of which trenchless method is adopted. Groundwater can promote instability at the face of the RCP and may result in higher ground deformations (settlement/heave) at ground surface unless adequate solutions are implemented. The contractor will have to develop a method to mitigate this risk. Groundwater management is the responsibility of the contractor and requires careful consideration during implementation. Groundwater management for excavations (especially for long periods of time) can result in settlement. Silt soils, being fine grained, can undergo consolidation when the water is removed. Meaning the soil particles are pressed closer together, reducing the volume of soil. Groundwater management also results in a reduction of pore water pressure, lowering the water table reduces the pore water pressure in silt soils. This can lead to a decrease in soil volume and settlement. The contractor's groundwater management should be developed to allow for safe construction, while ensuring the settlement observed beneath the crossing is within the tolerable limits.

11.5.4 Pipe Alignment and Grade Control

Pipe alignment and grade control are critical during the initial stages of installation and require careful management to achieve adequate design inverts along the drive length. In difficult ground conditions where potential obstructions maybe present (i.e., abandoned rail ties, abandoned pipes, or cobbles and boulders), encountering an obstruction may result in the reduction of alignment and grade control accuracy. It is the responsibility of the contractor to ensure adequate alignment and grade control are maintained.

11.5.5 Void Development

As mentioned in Section 11.1, the proposed LDS (i.e., RCP LDS) is anticipated to be within the Fat Clay (CH) layer encountered in TH24-12 and TH25-01. Voids between the pipe and the bore may develop as the RCP advances along its drive length. Void development is more prevalent in cohesive soils (i.e., firm to very stiff clays) which generally may provide the ability to support an open excavation without collapsing immediately under pressure from the above soil. Over time, this void may reduce due to settlement, swelling or softening of the exposed soils leading to collapse. Circumference grouting outside the carrier may be required if these ground conditions are encountered. The contractor should install the entry and exit seal on the break-in and break-out point of the trenchless crossing, respectively to prevent slurry loss prior to grouting.

11.5.6 Horizontal Stresses due to Pipe Jacking on the RCP

In general, the jacking force required to propel the pipe sections forward must overcome forces associated with face pressures, plus friction on the shield and pipeline. The frictional forces develop between the surrounding soil and the exposed outer surface of the shield and installed pipe sections. The face pressure component relates to the depth of burial and can be estimated based on the soil and groundwater conditions at the site. The face pressure component of the jacking force remains theoretically constant if the depth of soil cover over the pipeline is constant. However, the frictional force increases as the drive length increases. As a result, longer drives require greater jacking forces. The design team should review the expected stress on the RCP to ensure the RCP can handle the exerted forces developed during the jacking process. Other construction issues such as pipe alignment due to obstructions and jacking stoppage can also affect the required jacking force.

11.5.7 Face Stability

Based on the results of the 2024/2025 AECOM geotechnical investigations and the proposed LDS profile, the proposed RCP will be installed within a Fat Clay (CH) layer. Excavation in front of the leading pipe length will cause stress relief unless support is provided to retain the exposed face. As discussed in Section 11.5.1 of this report, mitigation measures should be put in place to limit the ground loss at the face of the RCP.

It is anticipated that installation of the RCP will take place below the groundwater table; therefore, reduced face stability is considered likely along the LDS drive length.

Two extreme cases of failure may occur due to the poor management of face support pressure: the formation of chimneys or the development of blow-outs in the ground above the tunnel face. The minimum pressure to avoid face instability is affected by various factors, such as cohesion, friction angle and permeability of the ground, type of the machine, advance rate, unit weight of slurry or conditioned soil, tunnel diameter, cover depth, and depth of the groundwater table.

12. Geotechnical Assessment

12.1 Jacking Pit and Receiving Pit

According to CPKC Geotechnical Protocol for Pipeline and Utility Installations within Railway Right of Way, the location of the jacking and receiving pits shall not extend into the “Zone of Potential Track Loading (ZPTL)”. The ZPTL is considered the area under the track and within a 1.0V:1.5H soil zone extending down from a point at the level of the BOR and 2.0 m from the centerline of the track. The face of east pit is 20.04 m from the centerline of the track and the face of the west pit is 20.31 m from the centerline of the track. In this case, the excavations required to construct the pits (i.e., jacking and receiving pits) will not extend into the ZPTL and will be located outside CPKC’s ROW. Further details about the locations of the jacking and receiving pits are indicated on Drawing No.1 in **Appendix E**.

According to the CPKC Geotechnical requirements for excavation close to CPKC track(s), when the excavation of jacking/receiving pits are within 10 m of the closest track centerline, the excavation criteria fall under Process 2 – Intermediate. In our case, the excavation of the jacking and receiving pit will not be within 10 m of the closest track centerline.

As mentioned in previous sections, the depth from the BOR to the bottom of the jacking and receiving pits are 5.03 m at an elevation of 226.5 m ASL. The soils encountered in TH24-12 and TH25-01 consisted of topsoil, Silty Clay (CL-ML) Fill, Silt (ML), Fat Clay (CH), and Sandy Lean Clay (CL) Till. It is anticipated that during the excavation of the pits that the topsoil, fill, silt, lean and fat clay will be encountered.

As mentioned in previous sections, sloughing may occur during the excavation of pits in soils with moisture content close to their liquid limit (i.e., behaving like a liquid), high silt content, and soft soils such as soft fat clay. There is high likelihood that sloughing will be observed within the Silt (ML) layer. The Silt (ML) layer is likely to have groundwater perched within the layer; therefore, the contractor should implement groundwater management such as managing groundwater flows using sump pumps during excavation of the jacking and receiving pits. Based on the results of the geotechnical investigation, the undrained shear strength of the Fat Clay (CH) ranged from 16.84 kPa to 49.03 kPa, generally decreasing with depth, classifying the material as soft to firm in consistency. As the excavation of the pits gets deeper into the Fat Clay (CH), the material becomes progressively softer, which may cause sloughing.

Due to potential variations in in-situ soil conditions between testholes, caution should be exercised during construction. It is advisable to consider the use of large excavating equipment to achieve the intended excavation depth safely and efficiently.

Based on the depth of the jacking and receiving pits, it is anticipated that temporary shoring will be used to facilitate excavation of the jacking and receiving pits. The pits need to be appropriately shored (in accordance with applicable regulations) since the side walls are normally cut vertically into the soil to conserve space. The pits should be large enough to accommodate the backstop, jacking equipment, spacer, muck removal equipment, lubricant pumps, lines, pneumatic hammers, and augers, etc. Additionally, the pits should also have walking room on each side of the jack/pneumatic equipment. All equipment is normally centered along the centerline of the pipe.

12.1.1 Excavation

Guided auger bore operations require the excavation of a suitable jacking and receiving pit. AECOM should be contacted to observe the materials excavated from the jacking and receiving pits and confirm soil conditions match to those encountered during the field drilling program. The method of excavation and support of excavation sidewalls are the responsibility of the contractor and must comply with the appropriate regulations under the Manitoba

Workplace Safety and Health Act. The information provided below is for use by the owner and engineer and should not be interpreted to mean that AECOM is assuming responsibility for contractor's actions or site safety.

Contractors should acknowledge these concerns and develop a Safe Excavation Plan accordingly. Side slopes for temporary open-cut excavations must conform to the Manitoba Guide for Excavation Work. According to Manitoba's Guide for Excavation Work, the minimum excavation side slope is 1H:1V from the base of the excavation. Services of a professional engineer is required to design support structures where the work is required to enter any open excavation that exceeds 1.5 m in depth.

As mentioned from previous sections, groundwater seepage was observed in the Silt (ML), and Sandy Lean Clay (CL) Till layer during AECOM's drilling program. During excavation (i.e., short term duration), groundwater seepage may occur from the Silt (ML) layer. The seepage from these layers is due to seasonal fluctuation. When the excavation is left open for a long period of time (i.e., long term duration), groundwater may rise. Thus, the contractor should be prepared to deal with groundwater during excavation of the jacking and receiving pits. The stability of the excavation slopes should be monitored regularly by knowledgeable geotechnical personnel. Shoring related to temporary work is the responsibility of the contractor, and all necessary measures should be undertaken to protect against adverse detrimental impacts.

The contractor is responsible for the implementation of any required groundwater management to facilitate safe and stable excavations. The groundwater management system would need to address the extent of groundwater management required, the depth of the intended excavations, and the soil and groundwater conditions that prevail at the time of excavation.

The contractor is solely responsible for the design and implementation of any required groundwater management, including requirements for withdrawal, handling, treatment, and discharge in accordance with the Province of Manitoba requirements. For this project, it is anticipated that water seepage into the excavations could be sufficiently controlled using a perimeter ditch and sump. The contractor should include in the work plan required groundwater management system to AECOM for the GER to review.

12.1.2 Temporary Shoring

As mentioned in Section 12.1, it is anticipated that temporary shoring will be used to facilitate excavation of the jacking and receiving pits. Comments regarding the design and temporary shoring system are therefore provided as follows.

The design of the temporary shoring system should be carried out by a professional engineer (hired by the contractor) specialized in shoring design. The shoring system should also be designed in accordance with the methods described in the Canadian Foundation Engineering Manual.

In consideration of the information provided in the preceding sections, it is anticipated that maximum depth of the jacking and receiving pits will be in the order of 5.03 m (226.5 m ASL) for the maximum OD 1333 mm RCP LDS below the BOR. In consideration of the conditions encountered in the testholes, it is recommended that the design of a shoring system consider the parameters provided in **Table 16**. **Table 16** provides the recommended earth pressure coefficients, effective cohesion, angle of internal friction and bulk unit weight of the Silty Clay (CL-ML) Fill, Silt (ML), and Fat Clay (CH) for use in the calculation of the lateral earth pressures. The bulk unit weight of the Fat Clay (CH) was taken from the average bulk unit weight obtained from AECOM's lab test results. The effective cohesion and friction angles provided in the table have been assumed based on the soil conditions encountered in the testholes and consideration of literature references for similar soils.

Table 16: Lateral Earth Pressure Design Parameters

USCS Soil Type	Soil Unit Weight (kN/m ³)	Effective Cohesion (c')	Angle of Internal Friction (°)	At Rest Lateral Earth Pressure Coefficient (K _o)	Active Lateral Earth Pressure Coefficient (K _a)	Passive Lateral Earth Pressure Coefficient (K _p)
Fill (Silty Clay)	17	5	25	0.58	0.41	2.46
Silt	16	0	28	0.53	0.36	2.77
Fat Clay	17	3	25	0.58	0.41	2.46

For the purposes of design of the shoring system, it is recommended that the groundwater elevation be taken as 229.607 m ASL as being the highest elevation of the groundwater recorded in the SP installed in TH25-01.

Given that the water table is observed at 229.607 m ASL. It should be noted that groundwater levels observed may not be representative of stable groundwater conditions. Seasonal fluctuations due to precipitation, snow melting, drainage conditions on site and other factors may influence the groundwater levels recorded over time. Therefore, groundwater conditions at the time of construction may vary from the recorded groundwater depths above. Construction groundwater management should be expected to isolate the work zone and facilitate construction in dry conditions; therefore, provisions for groundwater management should be accounted for in the project schedule and cost.

A perimeter ditch and associated pumping and an appropriated groundwater management system should be provided to intercept surface runoff and groundwater from entering the excavation. To avoid the possibility of piping within the excavation, groundwater management should be performed. The contractor should submit a safe excavation plan, including groundwater management measures, for review by the GER.

Monitoring must be carried out during installation/construction process and following installation/construction to confirm the movements of the temporary shoring system are within a pre-determined acceptable range.

12.1.3 Excavation Base Stability

According to the Canadian Foundation Engineering Manual (CFEM 5e), deep excavations in soft-to-firm clays are susceptible to base heave or squeezing failures due to soil overstressing in shear. For this project, braced excavations are planned for pipe installation at the jacking and receiving pits at a depth of approximately 5.03 m BGS (226.5 m ASL) for the maximum 1333 mm OD RCP LDS. If the soil below the excavation base is soft and normally consolidated, heaving may occur. Since the soil below the excavation base is soft to firm and normally consolidated, heaving could be a concern if the pits reach a soft clay layer. The soil above the base acts as a surcharge on the soil below, potentially exceeding its bearing capacity and causing heaving.

The Factor of Safety (FS) against base heave associated with soil squeezing or shear failure is calculated using the following equation:

$$(FS)_b = \left(\frac{N_b s_u}{\sigma_z + q} \right) = \left(\frac{N_b s_u}{\gamma H + q} \right)$$

Where:

- $(FS)_b$ = factor of safety against base heave associated with soil squeezing or shear failure.

- N_b = stability factor dependent upon geometry of the excavation from Fig. 20.21 of CFEM. N_b depends on H/B and L/B (H is the bottom of the excavation, B is the width of the excavation and L is the length of the excavation).
- s_u = average undrained shear strength of soil below the base, corrected for plasticity, test method, and anisotropy as appropriate (kPa).
- σ_z = total overburden pressure at the bottom of the excavation:
 - γ = unit weight of Fat Clay (CH). In this calculation 17 kN/m³ was used.
 - H = bottom of the excavation.
- q = surcharge on the surface. It has been assumed that no surcharge will be on the surface. Thus, $q = 0$ kPa.

Basal heave is deemed satisfactory if $(FS)_b$ is greater than 1.5. Using an average surface elevation of 230.5 m ASL (for the Jacking Pit) and 231.25 m ASL (for the Receiving Pit) and a maximum excavation elevation of 226.5 m ASL, we estimate the FS of 1.5 to be satisfactory. This FS assumes an excavation length of 12.1 m, width of 5.16 m, and depth of 4 m for the Jacking Pit, and an excavation length of 5.03 m, width of 5.16 m and depth of 4.75 m for the Receiving Pit. The contractor is responsible for confirming the excavation details suited for their means and methods of installation, and to engage a professional engineer specialized in shoring design for the design of the temporary shoring system.

12.1.4 Buoyancy Uplift from Excess Groundwater Pressure Beneath an Impermeable Stratum

According to the Canadian Foundation Engineering Manual (CFEM 5e), when an excavation is dug into a clay deposit underlain by a pervious stratum under artesian pressure, pressure and seepage may result. Leading to instability of the excavation. An analysis has been prepared for the design of the temporary excavation, excavation depth and piezometric condition within the underlying Fat Clay (CH).

The basal heave analysis is based on the ratio of total stresses and uplift pore water pressure.

For this approach, the FS is expressed using the following equation:

$$FS = \frac{H_c \gamma_c}{H_w \gamma_w}$$

Where:

- γ_c = unit weight of Fat Clay (CH) = 17 kN/m³.
- H_c = thickness of the Fat Clay (CH) between the bottom of the excavation to the top of the till = 12.9 m.
- γ_w = unit weight of water = 9.81 kN/m³.
- H_w = the total head in the glacial till layer = 16.00 m.

According to the CFEM, heave due to artesian pressure is satisfactory if the Factor of Safety (FS) is greater than 1.1 (Fran, 2025). Using an average surface elevation of 230.83 m ASL and a maximum excavation elevation of 226.50 m ASL, we estimate the FS of 1.1 to be satisfactory. The Contractor is responsible for confirming their excavation details to suite their means and methods and engage a professional engineer who specialized in braced excavation design prior to beginning construction.

12.2 Settlement Estimation

Like other tunnelling methods, auger bore will result in a change in the state of stress in the ground with corresponding settlements. Ground subsidence can be caused by several factors such as ground loss at the tunnel face, behind the tail of the shield and through the tunnel support or linings. Based on cohesive soils tending toward the stable tunneling

face, the only significant contribution to ground loss is the closure of the over-cut. The overcut is the annular space between the tunnel boring walls and the installed pipe. Some degree of ground subsidence can be expected from tunneling although in many instances its effects, from a practical perspective, are negligible with proper technique.

12.2.1 Empirical Method

A method for prediction of settlement that may develop due to trenchless installation is the method outlined by Schmidt (1969) and later by Thomson (1993). A ground surface deformation induced by trenchless construction is estimated using a reverse gaussian curve based on the anticipated ground loss.

The empirical method is characterized as a simplified method and an upper bound solution as the method does not consider the potential for arching effects in the overlying soil mass above the borehole obvert, nor the does the method consider soil layering, groundwater conditions or the shape of the void.

This method assumes that the total ground loss (V_t) (or over-drill) that occurs over the pipe leads to settlement at the ground surface in the shape of a reverse gaussian curve (normal probability distribution). The maximum settlement δ_{max} occurs at the ground surface above the tunnel centerline and is estimated from the following equation:

$$\delta_{max} = \frac{V_t}{2.5i}$$

Where “i” is the point inflexion for the normal distribution, and “ V_t ” represented the volume of ground loss during tunnel excavation multiplied by the cross-sectional area of the drilled shaft. The method suggests the following correlation between “i”, depth of the tunnel centerline (Z) and settlement trough parameter (K, function of soil type) for cohesive soil.

$$i = Kz$$

Based on the conditions encountered in the testholes soil stratigraphy, the proposed auger boring path is anticipated to consist of soft to firm Fat Clay (CH). The track subgrade is likely comprised of ballast material. However, the empirical method does not address multi-layered systems. The method suggests K values ranging from 0.4 to 0.7 for very soft to stiff clay soils, 0.5 for normally consolidated soils, and a K value of 0.25 for cohesionless soils. The smaller the K value is taken the larger the settlement estimate will be. It is anticipated that the proposed LDS will be within the Fat Clay (CH) layer. Given the conditions in the testholes within the Fat Clay (CH) layer (over consolidated clay), a K value of 0.4 is considered for this estimation.

It is typical to assume contribution of 10% to 15% of the annular space to the ground surface deformation given the potential benefit from ground arching effects and localized ground loosening (i.e., volume change). In addition to the annular space, we can consider a ground loss of approximately 1% to 1.5% of the borehole volume to occur at bore face for boring in soft to stiff cohesive soils (i.e., fat clay). In this respect, a combination of over-drilling (V_1) and soil raveling at the bore face (V_2) is considered to contribute to ground loss (V_t).

Figure 1 shows the settlement estimation for a permanent RCP with a maximum 1333 mm OD. The graph below presents the results of settlement analysis based on the following:

- Scenario 1: 10% annular space collapse with 1% soil loss.
- Scenario 2: 15% annular space collapse with 1.5% soil loss.

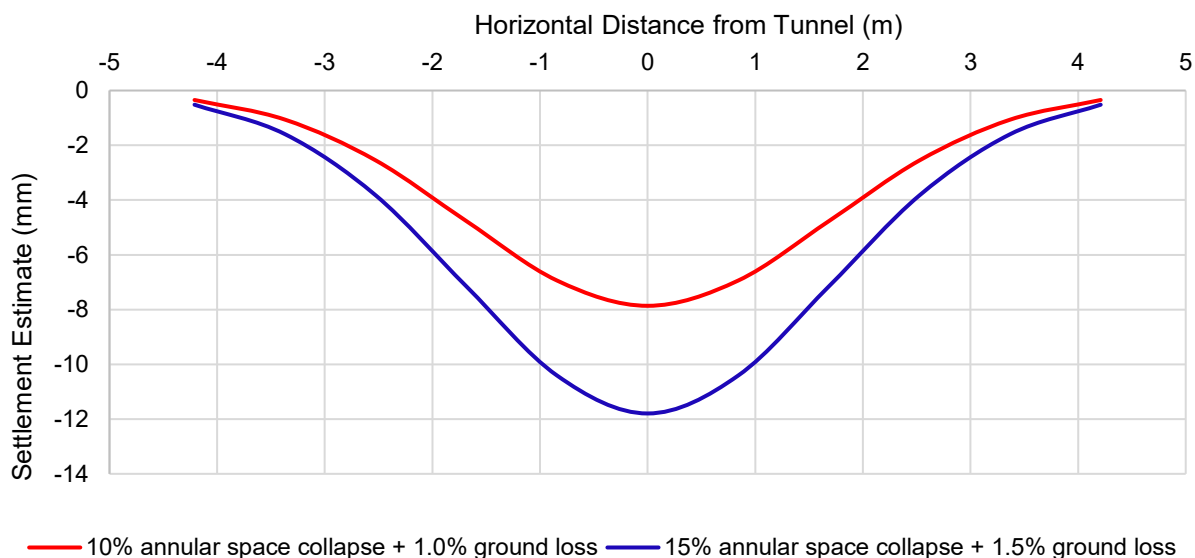


Figure 1: 10% Annular Collapse + 1% Ground Loss and 15% Annular Collapse + 1.5% Ground Loss

As shown in **Figure 1**, the estimated settlement for a maximum 1333 mm RCP OD and a 10% annular space collapse with 1.0% ground loss is 7.9 mm, which is below the Level 1 “Alert – (Review Threshold, 11 mm)” and Level 2 “Critical – (Stop Work, 22 mm)” settlement limits for the CPKC Class 2 Track. While the estimated settlement for 15% annular space collapse with 1.5% ground loss, is 11.8 mm, which is above the Level 1 “Alert – (Review Threshold, 11 mm)” and below the level 2 “Critical – (Stop Work, 22 mm)” settlement limits for the CPKC Class 2 track.

It is the contractor’s responsibility to maintain the required annular space collapse and ground loss to adhere to the settlement limits for the CPKC Class 2 Track. It is the contractor’s responsibility to determine the means and methods for the RCP installation. Based on AECOM’s local experience, the clays remold shortly after installation, reducing annular space/voids. If excessive settlements are observed over time, post-annular grouting or other mitigation measures should be implemented. The maximum radial undercut (25.4 mm) shall be communicated to the contractor in the technical specifications for the RCP installation.

The potential for ground surface movement depends on the contractor’s work methods, equipment, and techniques (e.g., soil plug, guided auger). A settlement monitoring plan will be implemented to monitor settlement during installation (pre- and post-construction) and adjust the methodology as needed before reaching the crossing location. Section 13 further discusses the settlement monitoring plan in accordance with CPKC Geotechnical Protocol for Pipeline Crossings Under Railway Tracks.

Section 13.4 discusses the settlement monitoring program in accordance with CPKC Geotechnical Protocol for Pipeline and Utility Crossings Under Railway Tracks.

13. Track Settlement Monitoring Plan

CPKC provides the requirements for settlement monitoring on “Geotechnical Protocol for Pipeline and Utility Crossing(s) Under Railway Tracks” document dated May 15, 2024. A copy of this document is included in **Appendix G** for reference. This document includes the minimum monitoring frequency requirements for preconstruction, during construction and post-construction. It also identifies two alarm levels to be implemented during the settlement monitoring.

13.1 Monitoring Point Layout

The location of the settlement monitoring points is illustrated in the drawing provided in **Appendix F**.

The installation of the monitoring points shall be as follows:

- As per Section 9.2.2 of the CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks, first set of sub-surface monitoring points to be placed on either side of the outside rail at 2 m distance off track centerline measured from outside of the rails. Additional subsurface points to be placed at the toe of the slope and at end points/toes of the ZPTL. Signal and fibre locates to be completed before installing any settlement monitoring equipment in the railway ROW.
- Surface (rail) monitoring points will be installed along each side of the BOR (east and west). These points will be placed directly at the base of both rails, spaced 9.45 m apart, over the projected settlement trough. This setup will monitor the differential transversal elevation between the rails. AECOM recommends a total of 22 surface monitoring points, centered on each RCP alignment.
- The subsurface monitoring points will be installed 1 m above the crown of the RCP. These points will be installed at an elevation of 228.99 m ASL. CPKC requires 6 subsurface monitoring points. Per CPKC’s *Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks*, the first set of subsurface monitoring points is to be placed on either side of the outside rail at a 2 m distance off track centerline measured from outside of the rails. The additional subsurface monitoring points are to be placed at the toe of the slope and at the endpoints/toes of the ZPTL. The upper portion of the iron bar used for the subsurface monitoring points are to be encased in PVC piping and backfilled with bentonite to prevent water infiltration, and the lower portion will be filled with sand. The installation will include a cover at the ground surface to protect against disturbance (typically a flush-mount or stick-up well casing).

The typical installation and decommissioning details for the surface and subsurface in-ground settlement monitoring points are shown on pages 36 and 37 of the CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) Under Railway Tracks as shown in **Appendix G**.

13.2 Settlement Monitoring Frequency

Track Movement Monitoring Guidelines for Trenchless Pipe Installation of the CPKC Geotechnical Protocol describes the minimum required frequency of the settlement monitoring points at various times. The subsurface settlement points will be monitored simultaneously with the surface settlement points which act as a precursor to potential surface movement during pipe installation. All monitoring points will be surveyed to the typical industry standard accuracy of ± 2 mm. In accordance with CPKC’s monitoring guidelines, a monitoring program of all points is to be conducted once the installation is complete. The instructions listed are to be followed:

- To avoid real time monitoring, the contractor shall complete the crossing under the ZPTL in one day. If the crossing is not completed under the ZPTL in one day, the contractor may be requested to provide real time monitoring overnight due to CPKC not being able to provide flagging services overnight.

- **Pre-Construction:** Monitoring will start before the excavation of the pits and pipe installation begins and readings should be taken twice per day for no less than two days. This is required to establish a reliable methodology and demonstrate the accuracy to be achieved. The collection of the baseline readings will be done by surveyors. An AECOM surveyor will collect two (2) baseline readings daily on two (2) consecutive days. A memo will be prepared summarizing the baseline readings.
- **During Construction:** Monitoring will proceed through the construction period and will be completed twice (2) daily (for branch lines/line with low traffic - Class 1-2 Track). This will be in coordination with the site surveyor. Daily reports will be prepared to include all settlement monitoring data, along with pertinent photos.
- **Post Construction:** Monitoring will continue three (3) days after completion of the construction. A memo will be prepared summarizing the monitoring points.
- If there is any loss of ground during pipe installation, any reason to believe settlement may be delayed or any settlement is identified during the installation of pipe or subsequent monitoring period, the monitoring will be continued until AECOM's Geotechnical Engineer of Record (GER) deems it is safe to discontinue such monitoring.

In accordance with CPKC Protocol, the GER, German Leal, M.Eng., P.Eng., will provide a sealed and stamped final report to CPKC approved service provider with a copy to CPKC Public Works – Utilities supervisor confirming that the work has been completed in accordance with the approved plans and procedures. In addition, the GER will collaborate with an AECOM geotechnical engineer (experienced with CPKC crossings), Sonny Chang, M.Sc., P.Eng., to provide additional support for the surface and subsurface settlement monitoring program.

13.3 Ground Movement Alarm Level

AECOM adopts the following criteria for the settlement monitoring. This criterion is applicable to both the surface and subsurface monitoring points and is based upon a Class 2 Track. According to the *Track Movement Monitoring Guidelines for Trenchless Pipe Installation* from **Appendix G** of the CPKC Geotechnical Protocol, there are two alarm levels for ground movement. The two alarm levels are as follows:

- Level 1: "Alert – (Review Threshold)": maximum value of 11 mm.
- Level 2: "Critical – (Stop Work)": a value ≥ 22 mm.

13.4 Settlement Monitoring Program

CPKC requires carrying out track settlement monitoring (i.e., surface and subsurface settlement points) before, during and after construction. The intent of subsurface settlement points is to measure soil settlement, if any, above the pipe during construction in order to predict the potential movement of the tracks above.

13.4.1 Pre-Construction Tasks

Prior to commencement of construction AECOM will complete the following tasks:

- Submit the scope of the proposed settlement monitoring program to City of Winnipeg to include in the permit submission to CPKC.
- Review and incorporate any comments received from CPKC into the scope of the proposed settlement monitoring program.

On receipt of the CPKC permit from the City of Winnipeg, AECOM will:

- Prior to construction, locate any utilities and/or fiber optics within the ROW. This will be the contractor's responsibility.
- Prepare the monitoring installation such as underground clearance and ClickBeforeYouDigMB. It is understood that utility locates will be the contractor's responsibility. The subsurface monitoring points will be

installed by the contractor under the supervision of AECOM geotechnical personnel. The utility locates program will be as follows:

- Public utility locates for the area of the proposed monitoring points;
- Submit to CPKC to obtain utility locates specific to CPKC railway operations; and
- Retain private utility locate company to identify and mark services and/or utilities in accordance with AECOM's standard ground disturbance protocol.
- Identify if any utilities/services are within 3 m of the intended locations of the monitoring points and if so, said utilities/services will require positive identification (hand or hydro-vac exposure in the field). Where positive exposure is not practical, the locations of the proposed monitoring point will be adjusted accordingly. This will be the contractor's responsibility.
- Develop an emergency contact list that identifies representatives from AECOM, City of Winnipeg, CPKC, the pipe installation contractor, and additional parties as may be identified at that time. The emergency contact list will be distributed to all parties to be used in the event that the settlement Alert – (Review Threshold) Limit range is exceeded.
 - An emergency contact list of CPKC personnel will be prepared by AECOM and distributed to all applicable parties once the CPKC crossing permit has been obtained by the City of Winnipeg.
 - The purpose of the emergency contact list is to notify CPKC representatives of excessive or unexpected settlement during construction. Coordinate with the project surveyor to layout the proposed alignment of the installation between jacking and receiving locations and to layout the locations of the planned surface and subsurface monitoring points.
- Contact the railway operator to request a Protective Person (flag person) and coordinate access to enter the ROW for the described work. This will be the contractor's responsibility. The contractor shall provide CPKC with the intended contract working hours when submitting for CPKC crossing agreement and flagging application. This is to allow CPKC to conduct their internal approvals if overtime for flaggers is required.

On the completion of the preceding tasks and receipt of approval from CPKC to proceed, AECOM will:

- Arrange a pre-construction meeting with all stakeholders to discuss the project and construction details including work description, construction methods and schedule, restrictions, safety, work duration, daily reporting, and other CPKC requirements.
- Submit to the railway for Protective Person (flag person) to be onsite and to coordinate access to enter the ROW. This will be contractor's responsibility.
- Oversee the installation of the monitoring points as outlined in the proposed settlement monitoring program with adjustments as required for the presence of utilities/services. There will be six (6) subsurface points installed. A drill rig will be used to install the subsurface monitoring points.
- AECOM surveyor will collect two (2) baseline readings daily on two (2) consecutive days.
- Collection of baseline readings on all monitoring points will be within 1-2 weeks of the commencement of construction. This timeline can be revised at the discretion of the geotechnical consultant subject to the prevailing subsurface conditions, activity in the area (construction or otherwise), and climate/weather conditions during the period prior to and leading up to the commencement of construction.
- A memo will be prepared summarizing the baseline readings. The memo will be submitted within 5 days upon completion of the baseline readings.

13.4.2 Construction Tasks

Monitoring will proceed through the construction period and will be completed twice (2) daily (for branch lines/line with low traffic Class 1-2 Track). This will be in coordination with the site surveyor. Daily reports will be prepared to include all settlement monitoring data, along with pertinent photos. Per CPKC's *Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks*, a mid-day report should be submitted by 1:00 pm local time each day until installation clears the railway right of way and no further movement is occurring due to the installation activities. This requirement can be reviewed and waived if agreed upon by all parties during the preconstruction meeting. The

GER (German Leal) will conduct a site visit once per week to oversee the surface and subsurface settlement monitoring program. The GER will communicate with the AECOM geotechnical engineer to provide updates on the settlement monitoring.

If the results of the survey are above the level 1: “Alert – (Review Threshold)” and Level 2: “Critical – (Stop Work)”, the following will be implemented:

13.4.2.1 Level 1: “ALERT – (REVIEW THRESHOLD)”

If the measured subsurface and/or surface settlement points are above the Alert – (Review Threshold) Level (i.e., more than 11 mm):

- Notify all parties on the emergency contact list within 24 hours that the results of the monitoring are within the Alert – (Review Threshold) Level.
- A survey of the surface point will be carried out and work will be authorized to continue if no movement of the subsurface point has been measured from the previous reading. In this case, request that the Project Surveyor undertake an additional survey to confirm the results obtained and provide a verbal report of the results to the geotechnical consultant within 1-hour of completion of the survey and a written report of the results to the geotechnical consultant within 24 hours.
- Notify all parties on the emergency contact list within 24 hours of the results of the additional monitoring.

13.4.2.2 Level 2: “CRITICAL – (STOP WORK)”

If the measured subsurface and/or surface settlement points are within a Critical – (Stop Work) Level (i.e., more than 22 mm):

- Mobilize geotechnical staff to the site within 12 hours to identify if there are any obvious visual indications of movement of the rail tracks, rail ballast, rail embankment or similar and/or if there is any indication of the development of ground subsidence, sink holes or slope instability.
- Notify all parties on the emergency contact list, including CPKC, immediately that the monitoring results are above the Critical – (Stop Work) Level.
- Communicate with project team, who shall advise the contractor to cease the drilling operations immediately until an assessment of the observed settlement is conducted by a geotechnical engineer and a conference call/meeting is convened between CPKC, City of Winnipeg, the contractor and the geotechnical consultant to discuss the results of the assessment.
- A survey of the surface points will be carried out and work will be authorized to continue if no movement is measured for at least two (2) readings taken 12 hours apart. In this case, request that the project surveyor undertake an additional survey to confirm the results obtained and provide verbal report of the results to the Geotechnical Consultant immediately on completion of the survey and a written report of the results to the Geotechnical Consultant within 24 hours.
- Notify all parties on the emergency contact list within 24 hours of the results of the additional monitoring and the results of the visual observations of the current conditions.

13.4.3 Post Construction Task

Decommissioning of the monitoring points will begin once post-construction monitoring has been completed (twice daily for three (3) consecutive days), and all parties have reviewed the monitoring data and are satisfied that, if any movement was detected during the monitoring period (if any) have stopped.

For the subsurface monitoring points, the protective covers will be removed, the iron bars will be removed from CPKC ROW. The subsurface monitoring points will be backfilled with bentonite pellets. All backfill material from the installation of the monitoring points will be removed from CPKC right of way as well.

The site shall be restored to its original condition within the CPKC ROW which includes decommissioning of surface and subsurface monitoring points.

A final memo and as-built drawings will be submitted at the end of the project. The memo will summarize the settlement monitoring that was performed for the LDS crossing installation and confirms that the work was completed in general accordance with the submitted plans and procedures. The final memo and the as-built drawings will be sealed and stamped by the GER, German Leal, M.Eng., P.Eng.

14. Conclusion

In general, and based on the available information, it is recommended that the proposed LDS be installed using trenchless methodologies. A guided auger boring trenchless system should be adopted. This method is deemed appropriate given the required installation parameters and based upon the subsurface ground and groundwater conditions. It is the trenchless contractor's responsibility to select a suitable trenchless method based on their means and methods, local experience and trenchless equipment.

Given the possibility that installation will occur within the Fat Clay (CH) layer, the contractor should be prepared to mitigate against instability at the face of the bore path as described in this report. The contractor should submit a construction methodology, including mitigation techniques for adverse track settlement, to the engineer for approval prior to installation. The contractor shall submit a recovery plan, outlining the steps to be implemented in the event of failure (e.g., excessive ground loss or settlement/collapse, heaving, etc.) to the GER. A reviewed copy of this plan shall then be provided to CPKC prior to construction. Throughout the pipe installation process, surface monitoring should be undertaken to evaluate the impact of guided auger bore beneath the CPKC tracks. Should observed surface settlement and heave values exceed the maximum anticipated values, the contractor should implement the noted action plan to correct the unwanted settlement.

Appendix **A**

Testhole Location Plan

Appendix **B**

Testhole Logs

LOG OF TEST HOLE 60705950 - TESTHOLE LOGS - NEWPCC LDS TH PROGRAM - 2025-05-02 GPJ UMA WINN.GDT 25-7-3

PROJECT: NEWPCC Biosolids LDS System						CLIENT: WSTP						TESTHOLE NO: TH24-12					
LOCATION: NEWPCC, Winnipeg, MB UTM Zone 14U: 5535418.820 m N, 635275.679 m E						PROJECT NO.: 60705950											
CONTRACTOR: Paddock Drilling						METHOD: Solid Stem Auger						ELEVATION (m): 230.49					
SAMPLE TYPE		☒ GRAB		☐ SHELBY TUBE		☒ SPLIT SPOON		☒ BULK		☒ NO RECOVERY		☐ CORE					
DEPTH (m) USC SOIL SYMBOL SOIL DESCRIPTION SAMPLE TYPE SAMPLE # SPT (N) PENETRATION TESTS ✱ Becker ✱ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100 UNDRAINED SHEAR STRENGTH + Torvane + × QU/2 × □ Lab Vane □ △ Pocket Pen. △ ● Field Vane ● (kPa) 50 100 150 200 COMMENTS ELEVATION																	
0			FILL: black, silty clay (CL-ML)		G1								230				
1	FILL		- trace gravel, trace sand		G2												
2	ML		Soft tan silt (ML)		G3								229				
			Firm brown fat CLAY (CH)		G4												
3					G5								228				
4					G6								227				
5					G7								226				
6	CH				G8								225				
7					G9								224				
8					G10								223				
9													222				
10													221				
11			END OF TESTHOLE										220				
12			- Testhole terminated at a depth of 10.7 m in fat CLAY										219				
13			- No groundwater seepage or soil sloughing was observed										218				
14			during or upon completion of drilling.										217				
15			- Testhole backfilled with soil cuttings and bentonite to										216				
16			ground surface.										215				
17													214				
18													213				
19													212				
20													211				
21													210				
22													209				
23													208				
24													207				
25													206				

AECOM

LOGGED BY: GA

REVIEWED BY: GL

PROJECT ENGINEER: German Leal

COMPLETION DEPTH: 10.67 m

COMPLETION DATE: 24-1-8

Page 1 of 1

LOG OF TEST HOLE XXXXXXXX - TESTHOLE LOGS - NEWPCC NRF LDS CP CROSSING - 2025-06-18.GPJ UMA WINN.GDT 25-7-3

PROJECT: NEWPCC NRF LDS CP Crossing					CLIENT: WSTP					TESTHOLE NO: TH25-01																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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Appendix **C**

Laboratory Test Results

Memorandum

To	Gene Acurin	Page	1
CC			
Subject	NEWPCC – Biosolids Early Works		
From	German Leal		
Date	October 29, 2024	Project Number	60705950

Please find attached the following material test result(s) on sample(s) submitted to the Winnipeg Geotechnical Laboratory:

- One Hundred eighty-eight (188) Moisture Content Determination Test.
- Twenty-eight (28) Atterberg Limits (3 Points) Test.
- Twenty-eight (28) Grain Size Distribution (Hydrometer method) Test.
- Thirty-three (33) Unconfined Compressive Strength Tests.
- Two (2) Hydraulic Conductivity Tests.

If you have any questions, please contact the undersigned.

Prepared by:

Reviewed by:

**Boughton,
Lee**
Digitally signed by Boughton, Lee
DN: cn=Boughton, Lee,
ou=CAWPG1,
email=Lee.Boughton@aecom.com
Date: 2024.10.29 11:04:00 -05'00'

Lee Boughton
Laboratory Manager

**Leal,
German**
Digitally signed by Leal, German
DN: cn=Leal, German,
ou=CAWPG1,
email=German.Leal@aecom.com
Date: 2024.12.12 12:31:05 -06'00'

German Leal, M.Eng., P.Eng.
Discipline Lead, Geotechnical

Att.



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive
Winnipeg, Manitoba
R3P 0Y7
Phone: 204 477 5381 Fax: 204 284 2040

Project Name: NEWPCC Biosolids Early Works
Project Number: 60705950
Client: WSTP
Sample Location: Winnipeg, Manitoba
Sample Depth: Varies
Sample Number: Varies

Supplier: AECOM
Field Technician: ABonifacio
Sample Date: January 12, 2024
Lab Technician: LBoughton
Date Tested: January 15, 2024

Moisture Content (ASTM D2216-10)

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Location	Sample	Depth (m)	Moisture Content (%)
TH24-09	G1	0.30 m	44.9%
	G2	0.76 m	33.5%
	G3	1.52 m	21.1%
	G4	1.98 m	24.2%
	G5	3.05 m	43.6%
	G6	4.57 m	38.2%
	G7	6.10 m	55.8%
	G8	7.62 m	45.2%
	G9	9.14 m	42.9%
	G10	10.67 m	45.1%
TH24-10	G1	0.30 m	40.3%
	G2	0.76 m	26.7%
	G3	1.52 m	26.2%
	G4	3.05 m	55.4%
	G5	4.57 m	51.7%
	G6	6.10 m	60.0%
	G8	7.62 m	48.0%
	G9	9.14 m	47.7%
	G11	10.67 m	47.4%
	G12	12.19 m	57.2%
TH24-11	G13	13.72 m	51.8%
	G14	15.24 m	62.3%
	G15	16.31 m	10.7%
	G1	0.30 m	52.2%
	G2	0.76 m	40.6%
	G3	1.52 m	26.6%
	G4	1.98 m	23.2%
	G5	3.05 m	37.4%
	G7	4.57 m	36.4%
	G8	6.10 m	50.2%
TH24-12	G9	7.62 m	46.5%
	G10	9.14 m	41.2%
	G11	10.67 m	26.7%
	G12	12.19 m	51.2%
	G13	13.72 m	43.8%
	G14	15.24 m	49.5%
	G15	18.29 m	25.6%
	G16	19.96 m	17.5%

Location	Sample	Depth (m)	Moisture Content (%)
TH24-12	G1	0.30 m	40.4%
	G2	0.76 m	36.7%
	G3	1.52 m	37.6%
	G4	1.98 m	22.4%
	G5	3.05 m	52.5%
	G6	4.57 m	52.2%
	G7	6.10 m	53.8%
	G8	7.62 m	46.2%
	G9	9.14 m	41.6%
	G10	10.67 m	46.9%
TH24-13	G1	0.30 m	44.3%
	G2	0.76 m	31.7%
	G3	1.52 m	15.3%
	G4	2.90 m	25.9%
	G6	4.57 m	50.8%
	G7	6.10 m	53.2%
	G12	20.27 m	10.7%
	G1	0.30 m	48.4%
	G2	0.76 m	42.4%
	G3	1.52 m	35.2%
TH24-14	G4	1.68 m	35.3%
	G5	3.05 m	24.1%
	G7	4.57 m	51.0%
	G9	6.10 m	44.3%
	G11	7.62 m	50.7%
	G12	9.14 m	54.5%
	G1	0.30 m	36.0%
	G2	0.76 m	35.3%
	G3	1.98 m	37.3%
	G4	3.05 m	22.2%
TH24-15	G5	3.20 m	46.4%
	G6	4.57 m	54.9%
	G7	6.10 m	58.0%
	G9	7.62 m	57.2%
	G11	9.14 m	46.7%
	G1	0.30 m	29.7%
	G2	0.76 m	17.8%
	G3	1.52 m	34.2%

Memorandum

To	Colton Wooster	Page	1
CC			
Subject	NEWPCC NRF Procurement Phase - Test Results		
From	German Leal		
Date	June 26, 2025	Project Number	60738849

Please find attached the following material test result(s) on sample(s) submitted to the Winnipeg Geotechnical Laboratory:

- Thirty-two (32) Moisture Content Determination Tests.
- Four (4) Atterberg Limits (3 Points) Tests.
- Four (4) Particle Size Analysis (Hydrometer method) Tests.
- Four (4) Unconfined Compressive Strength Tests.

If you have any questions, please contact the undersigned.

Prepared by:

**Boughton,
Lee**
Digitally signed by Boughton, Lee
DN: cn=Boughton, Lee,
ou=CAWPG1,
email=Lee.Boughton@aecom.com
Date: 2025.07.03 13:20:21 -05'00'

Lee Boughton
Laboratory Manager

Att.

Reviewed by:

**Leal,
German**
Digitally signed by Leal, German
DN: cn=Leal, German,
ou=CAWPG1,
email=German.Leal@aecom.com
Date: 2025.07.03 15:49:09 -05'00'

German Leal, M.Eng., P.Eng.
Discipline Lead, Geotechnical



Supplier/Location:	AECOM
Field Technician:	GAcurin
Sample Date:	21-Mar-25
Lab Technician:	LBoughton
Date Tested:	22-Mar-25

Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

[illegible]



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Client: City of Winnipeg

Sample Location: TH25-01

Sample Depth: 1.52 - 2.13 m

Sample Number: T4

Supplier/Location: Winnipeg, MB

Field Technician: AECOM

Sample Date: May 21, 2025

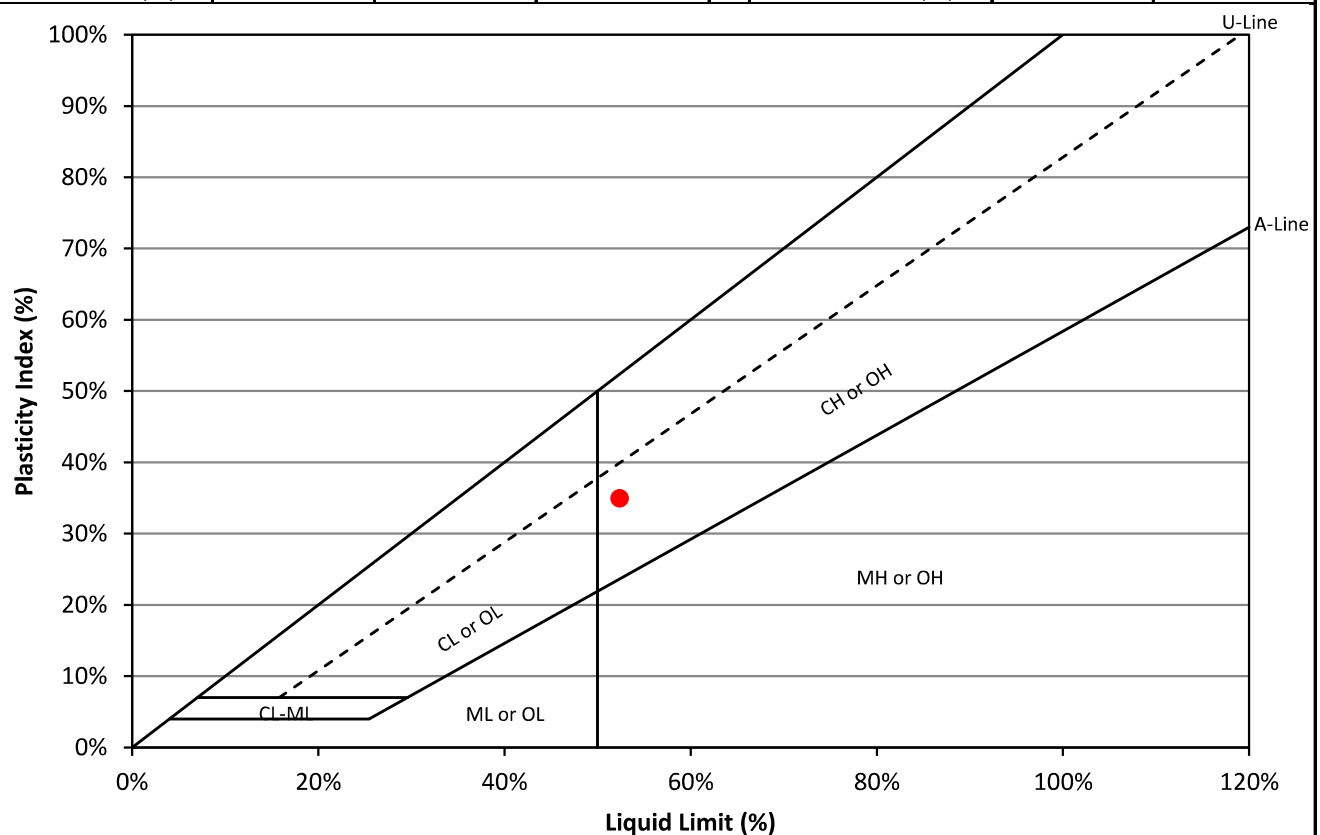
Lab Technician: FNovilla

Date Tested: June 9, 2025

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit				Plastic Limit		
Blows	30	27	23	Trial	1	2
Wet Sample (g)	7.0	6.8	6.2	Wet Sample (g)	6.0	6.9
Dry Sample (g)	4.6	4.5	4.0	Dry Sample (g)	5.1	5.9
Water Content (%)	50.6%	52.0%	53.0%	Water Content (%)	17.8%	17.1%



Liquid Limit:

52

Plastic Limit:

17

Plasticity Index:

35

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Client: City of Winnipeg

Sample Location: TH25-01

Sample Depth: 3.05 - 3.66 m

Sample Number: T7

Supplier/Location: Winnipeg, MB

Field Technician: AECOM

Sample Date: May 21, 2025

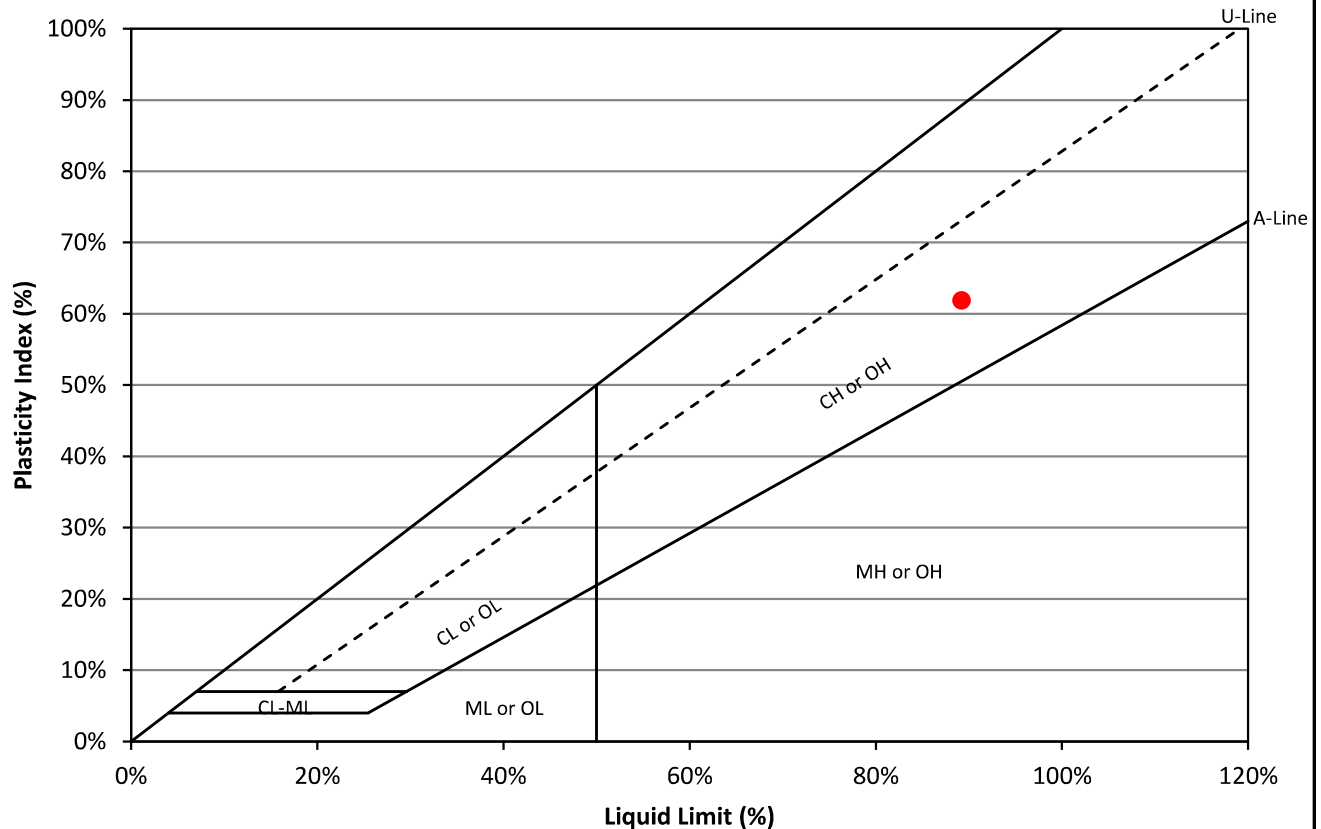
Lab Technician: FNovilla

Date Tested: June 9, 2025

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit				Plastic Limit		
Blows	31	21	18	Trial	1	2
Wet Sample (g)	7.2	6.9	6.4	Wet Sample (g)	6.1	6.7
Dry Sample (g)	3.8	3.6	3.4	Dry Sample (g)	4.8	5.3
Water Content (%)	88.1%	90.3%	90.8%	Water Content (%)	27.6%	27.1%



Liquid Limit:

89

Plastic Limit:

27

Plasticity Index:

62

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Client: City of Winnipeg

Sample Location: TH25-01

Sample Depth: 9.14 - 9.75 m

Sample Number: T14

Supplier/Location: Winnipeg, MB

Field Technician: AECOM

Sample Date: May 21, 2025

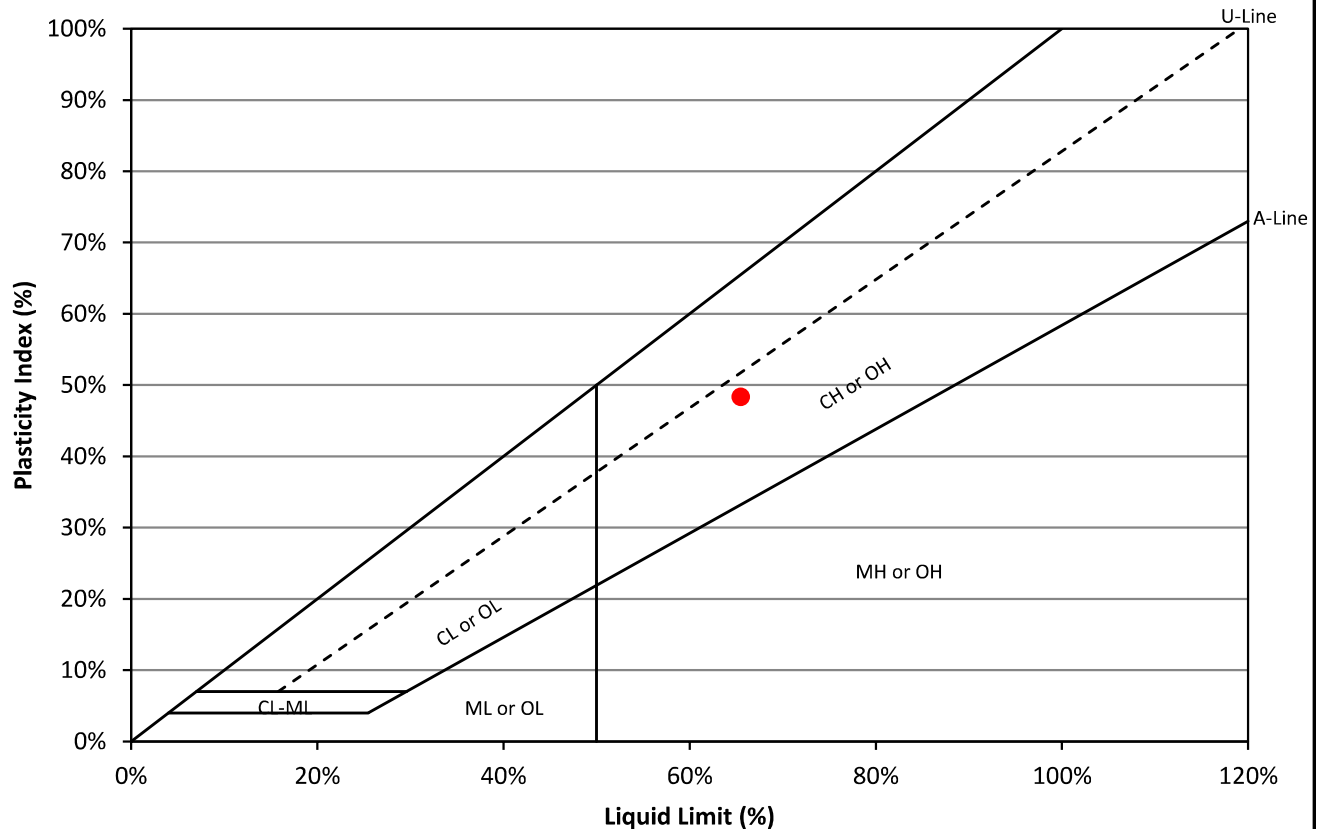
Lab Technician: FNovilla

Date Tested: June 9, 2025

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit				Plastic Limit		
Blows	32	27	16	Trial	1	2
Wet Sample (g)	6.3	6.4	6.3	Wet Sample (g)	6.1	6.0
Dry Sample (g)	3.8	3.9	3.8	Dry Sample (g)	5.2	5.1
Water Content (%)	64.4%	65.2%	67.3%	Water Content (%)	16.7%	17.5%



Liquid Limit:

65

Plastic Limit:

17

Plasticity Index:

48

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Client: City of Winnipeg

Sample Location: TH25-01

Sample Depth: 15.24 - 15.85 m

Sample Number: T20

Supplier/Location: Winnipeg, MB

Field Technician: AECOM

Sample Date: May 21, 2025

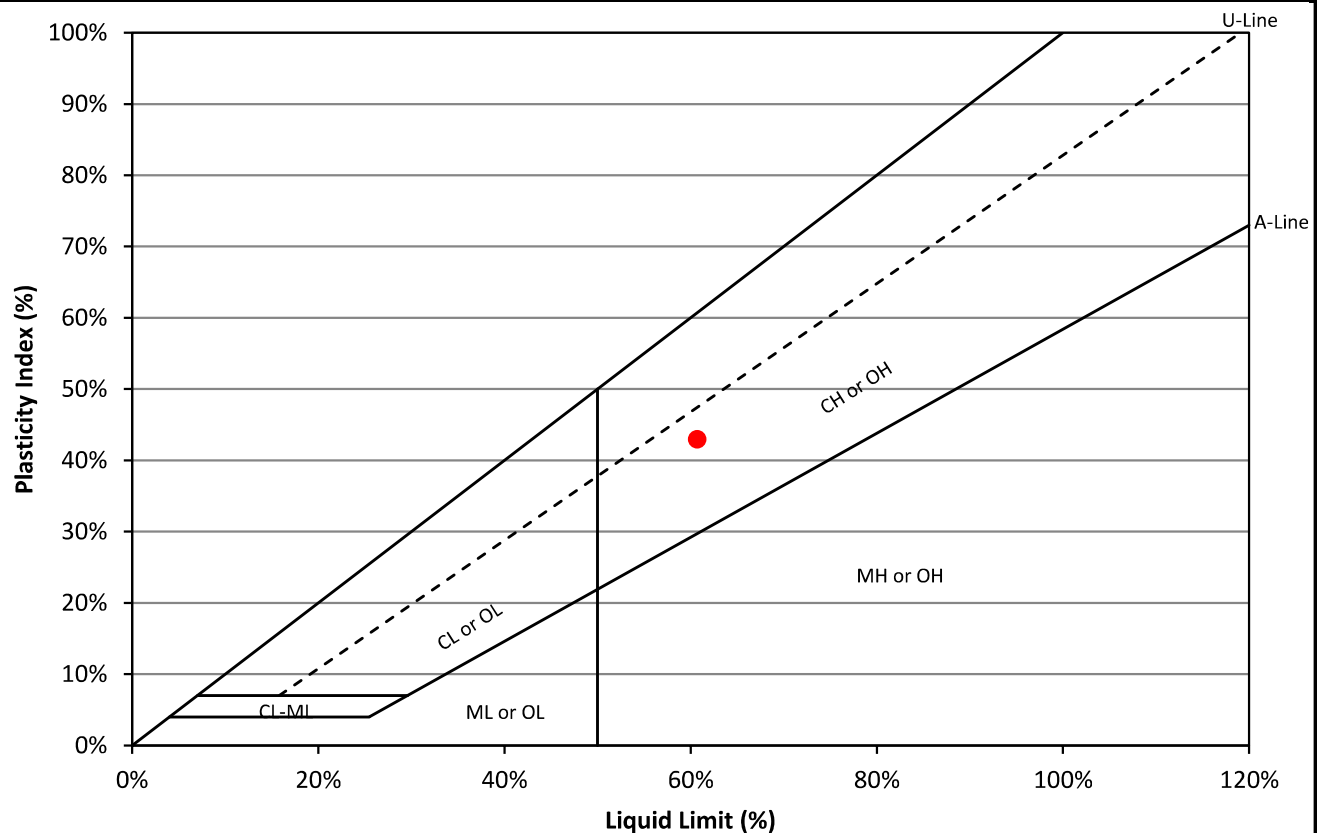
Lab Technician: FNovilla

Date Tested: June 9, 2025

Atterberg Limits (ASTM D4318)

Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

Liquid Limit				Plastic Limit		
Blows	35	23	18	Trial	1	2
Wet Sample (g)	6.7	6.6	6.2	Wet Sample (g)	6.2	6.2
Dry Sample (g)	4.2	4.1	3.8	Dry Sample (g)	5.2	5.3
Water Content (%)	58.4%	61.2%	63.0%	Water Content (%)	17.8%	17.7%



Liquid Limit:

61

Plastic Limit:

18

Plasticity Index:

43

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Supplier/Location: Winnipeg, MB

Client: City of Winnipeg

Field Technician: GAcurin

Sample Location: TH25-01

Sample Date: 21-May-25

Sample Depth : 1.52 - 2.13 m

Lab Technician: FNovilla

Sample Number: T4

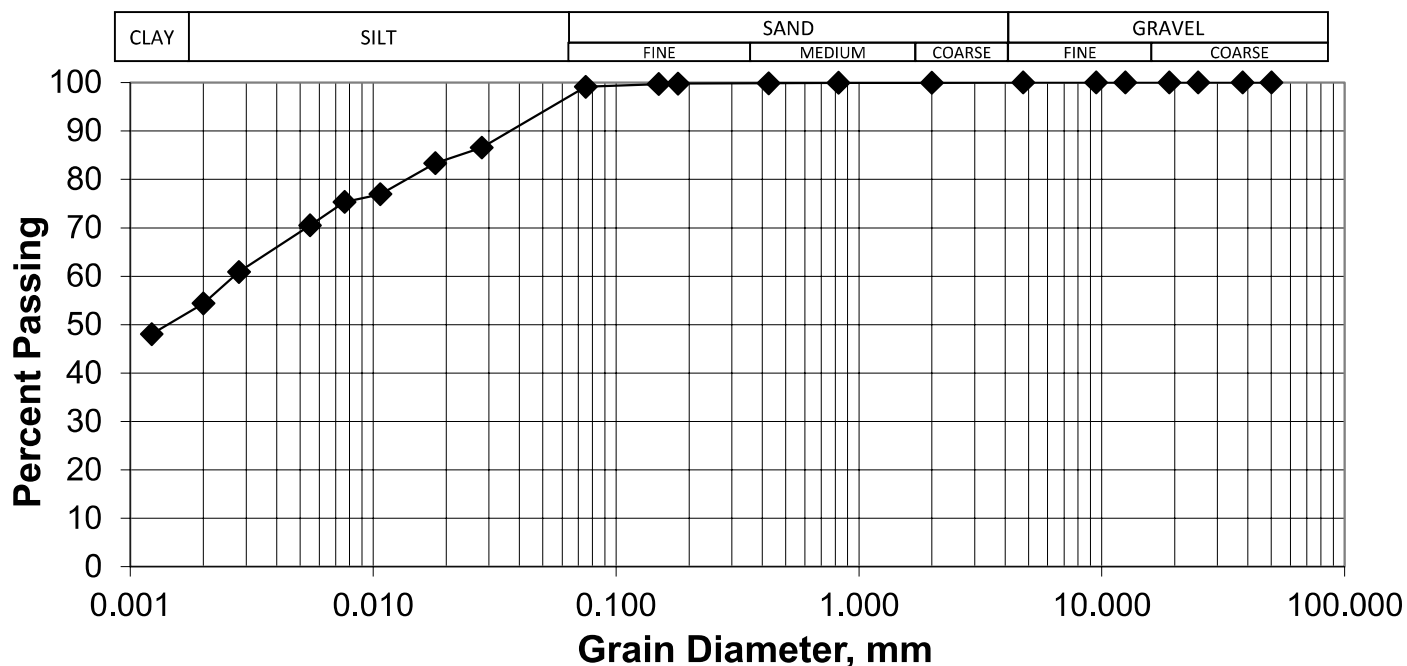
Date Tested: 9-Jun-25

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	100.0	0.0750	99.1
38.0	100.0	2.00	100.0	0.0280	86.6
25.0	100.0	0.825	99.9	0.0180	83.4
19.0	100.0	0.425	99.8	0.0107	77.0
12.5	100.0	0.18	99.8	0.0076	75.3
9.5	100.0	0.15	99.7	0.0055	70.5
4.75	100.0	0.075	99.1	0.0028	60.9
				0.0020	54.4
				0.0012	48.0

GRAIN SIZE DISTRIBUTION CURVE



Gravel	0.0%	Silt	44.7%
Sand	0.9%	Clay	54.4%

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Supplier/Location: Winnipeg, MB

Client: City of Winnipeg

Field Technician: GAcurin

Sample Location: TH25-01

Sample Date: 21-May-25

Sample Depth : 3.05 - 3.66 m

Lab Technician: FNovilla

Sample Number: T7

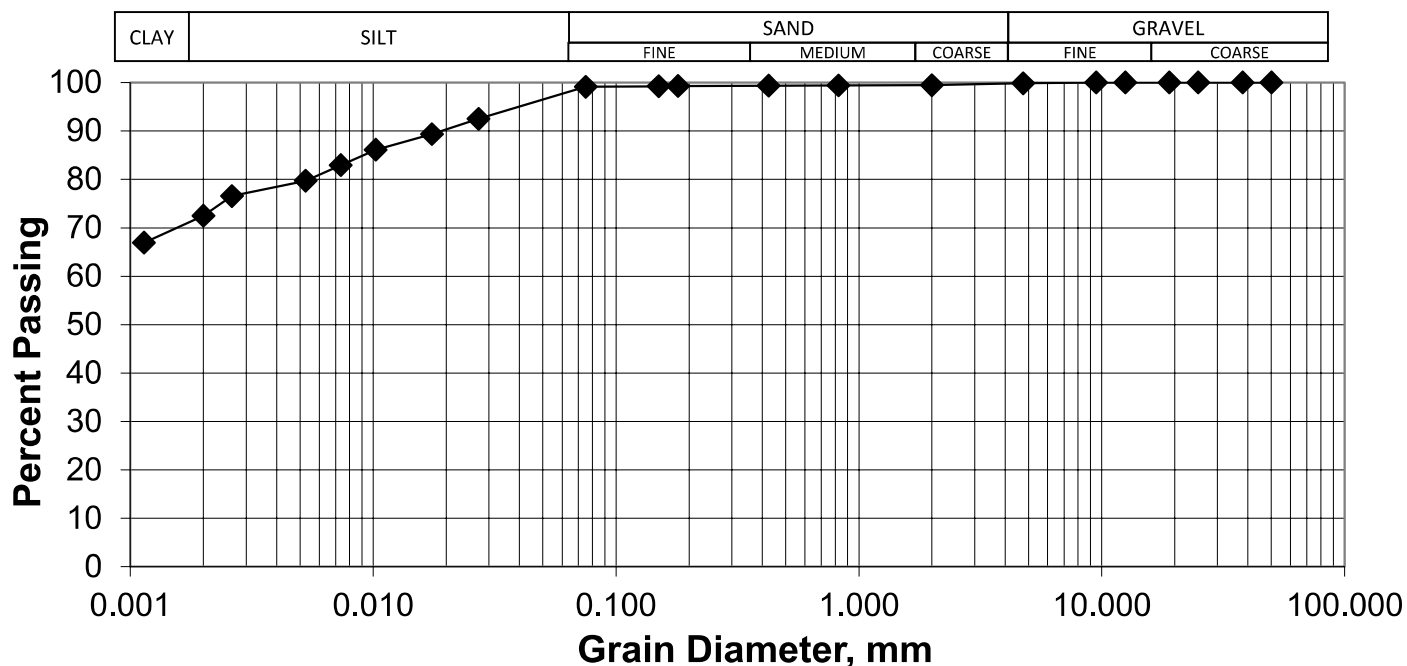
Date Tested: 9-Jun-25

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	99.8	0.0750	99.1
38.0	100.0	2.00	99.4	0.0271	93.0
25.0	100.0	0.825	99.4	0.0175	89.8
19.0	100.0	0.425	99.3	0.0102	86.6
12.5	100.0	0.18	99.2	0.0073	83.4
9.5	100.0	0.15	99.2	0.0053	80.2
4.75	99.8	0.075	99.1	0.0026	77.0
				0.0020	72.9
				0.0011	67.3

GRAIN SIZE DISTRIBUTION CURVE



Gravel	0.2%	Silt	26.2%
Sand	0.7%	Clay	72.9%

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Supplier/Location: Winnipeg, MB

Client: City of Winnipeg

Field Technician: GAcurin

Sample Location: TH25-01

Sample Date: 21-May-25

Sample Depth : 9.14 - 9.75 m

Lab Technician: FNovilla

Sample Number: T14

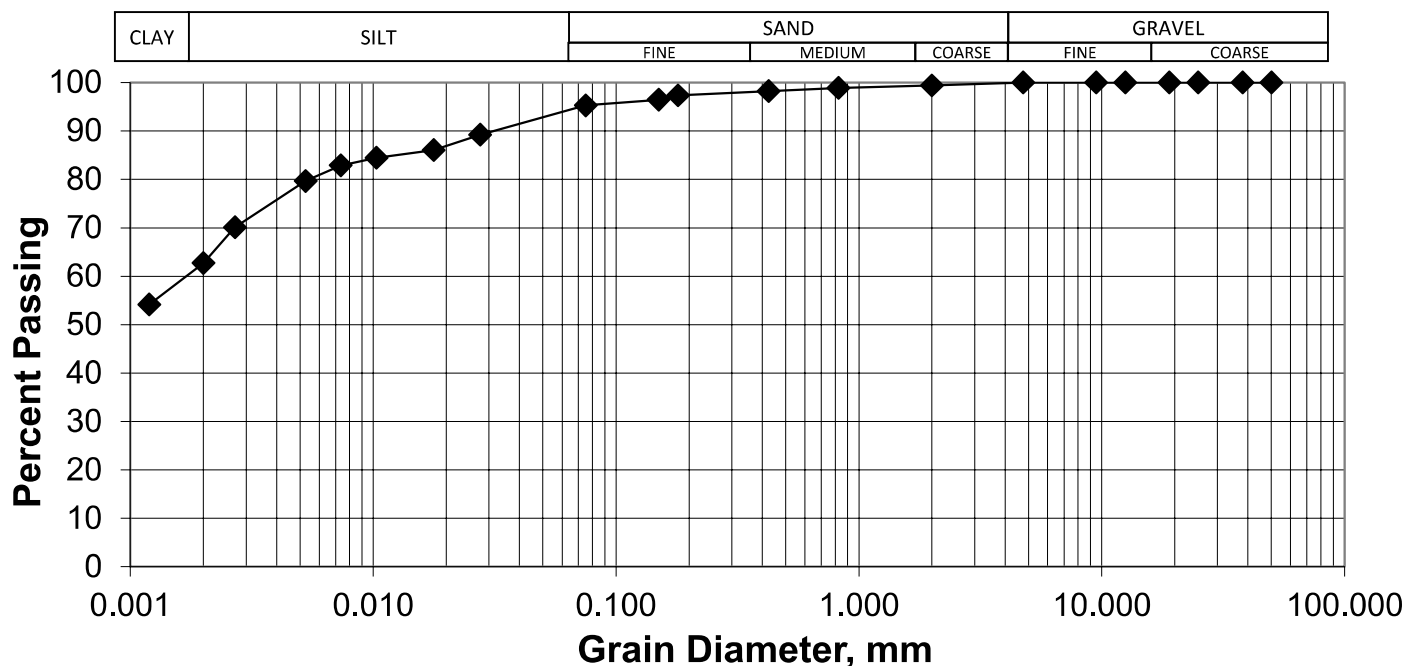
Date Tested: 9-Jun-25

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	100.0	0.0750	95.3
38.0	100.0	2.00	99.4	0.0276	89.8
25.0	100.0	0.825	98.9	0.0177	86.6
19.0	100.0	0.425	98.2	0.0103	85.0
12.5	100.0	0.18	97.3	0.0073	83.4
9.5	100.0	0.15	96.4	0.0053	80.2
4.75	100.0	0.075	95.3	0.0027	70.5
				0.0020	63.1
				0.0012	54.5

GRAIN SIZE DISTRIBUTION CURVE



Gravel	0.0%	Silt	32.2%
Sand	4.7%	Clay	63.1%

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC NRF Procurement Phase

Project Number: 60738849

Supplier/Location: Winnipeg, MB

Client: City of Winnipeg

Field Technician: GAcurin

Sample Location: TH25-01

Sample Date: 21-May-25

Sample Depth : 15.24 - 15.85 m

Lab Technician: FNovilla

Sample Number: T20

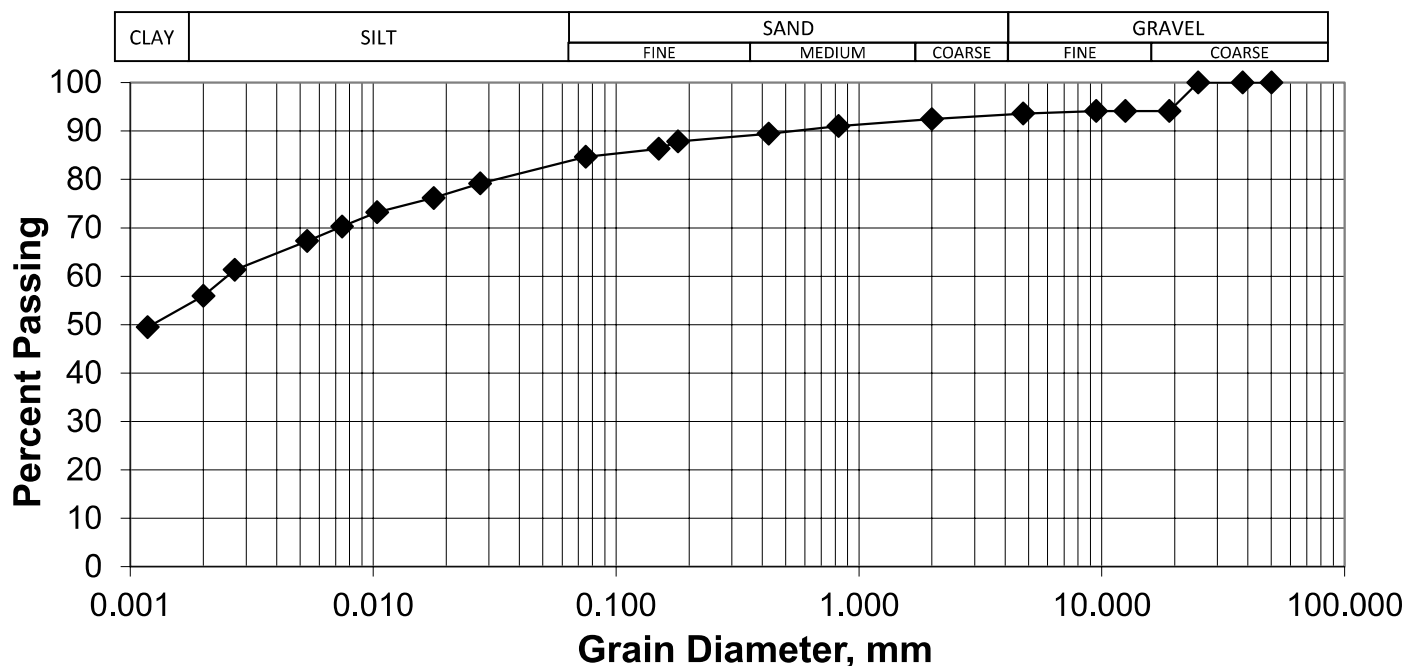
Date Tested: 9-Jun-25

Hydrometer (AASHTO T88)

Standard Test Methods for Particle Size Analysis of Soils

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	4.75	93.6	0.0750	84.6
38.0	100.0	2.00	92.4	0.0276	85.6
25.0	100.0	0.825	91.0	0.0177	82.4
19.0	94.1	0.425	89.4	0.0104	79.2
12.5	94.1	0.18	87.8	0.0074	76.0
9.5	94.1	0.15	86.3	0.0053	72.8
4.75	93.6	0.075	84.6	0.0027	66.4
				0.0020	60.5
				0.0012	53.5

GRAIN SIZE DISTRIBUTION CURVE



Gravel	0.5%	Silt	24.1%
Sand	9.0%	Clay	60.5%

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC LDS Crossing
Project Number: 60738849
Client: City of Winnipeg
Supplier/Location: Winnipeg, MB
Sample Depth (m): 1.52 - 2.13 m
Sample Location: TH25-01
Sample Number: T4

Date Sampled: May 21, 2025
Sampled By: Gacurin
Date Received: May 21, 2025
Submitted By: Gacurin
Date Tested: June 6, 2025
Tested By: LBoughton

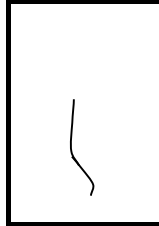
Unconfined Compressive Strength (ASTM D2166)

Standard Test Method for Unconfined Compressive Strength of Cohesive Soil, using strain-controlled application of the axial load.

Soil Description: CLAY - brown, stiff, moist, silty, high plasticity, blocky

Average Diameter (cm):	7.21
Average Length (cm):	14.79
Length/Diameter Ratio:	2.05
Moisture content (%):	16.3
Bulk Density (g/cm ³):	2.906
Bulk Unit Weight (kN/m ³):	28.5
Bulk Unit Weight (pcf):	181.4
Dry Unit Weight (kN/m ³):	24.51

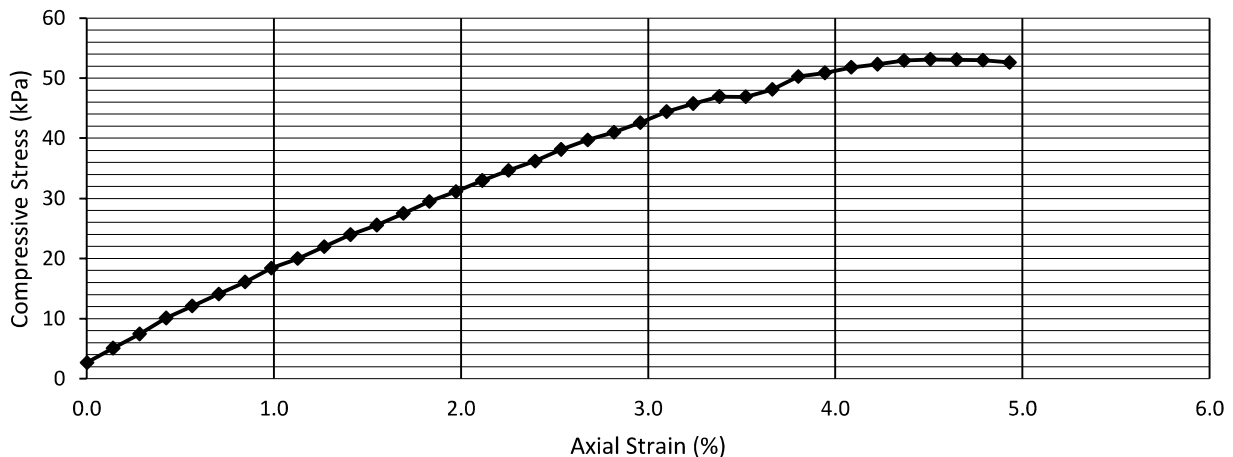
FAILURE SKETCH



Torvane	Undrained Shear Strength (kPa)	47.1
Pocket Pen.	Undrained Shear Strength (kPa)	70.2

UCS	Unconfined compressive strength (kPa)	53.13	Undrained Shear Strength (kPa)	26.56
	Unconfined compressive strength (ksf)	1.110	Undrained Shear Strength (ksf)	0.555
	Avg. Rate of Strain to Failure (%/min):	0.85	Strain at Failure (%):	4.51

Unconfined Compressive Strength



Comments:

Lower undrained shear strength (kPa) for unconfined compressive test due to the structure being blocky.

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC LDS Crossing
Project Number: 60738849
Client: City of Winnipeg
Supplier/Location: Winnipeg, MB
Sample Depth (m): 3.05 - 3.66 m
Sample Location: TH25-01
Sample Number: T7

Date Sampled: May 21, 2025
Sampled By: Gacurin
Date Received: May 21, 2025
Submitted By: Gacurin
Date Tested: June 6, 2025
Tested By: LBoughton

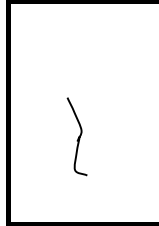
Unconfined Compressive Strength (ASTM D2166)

Standard Test Method for Unconfined Compressive Strength of Cohesive Soil, using strain-controlled application of the axial load.

Soil Description: CLAY - brown, stiff, moist, silty, high plasticity, blocky

Average Diameter (cm):	7.19
Average Length (cm):	14.91
Length/Diameter Ratio:	2.07
Moisture content (%):	44.9
Bulk Density (g/cm ³):	1.763
Bulk Unit Weight (kN/m ³):	17.3
Bulk Unit Weight (pcf):	110.1
Dry Unit Weight (kN/m ³):	11.93

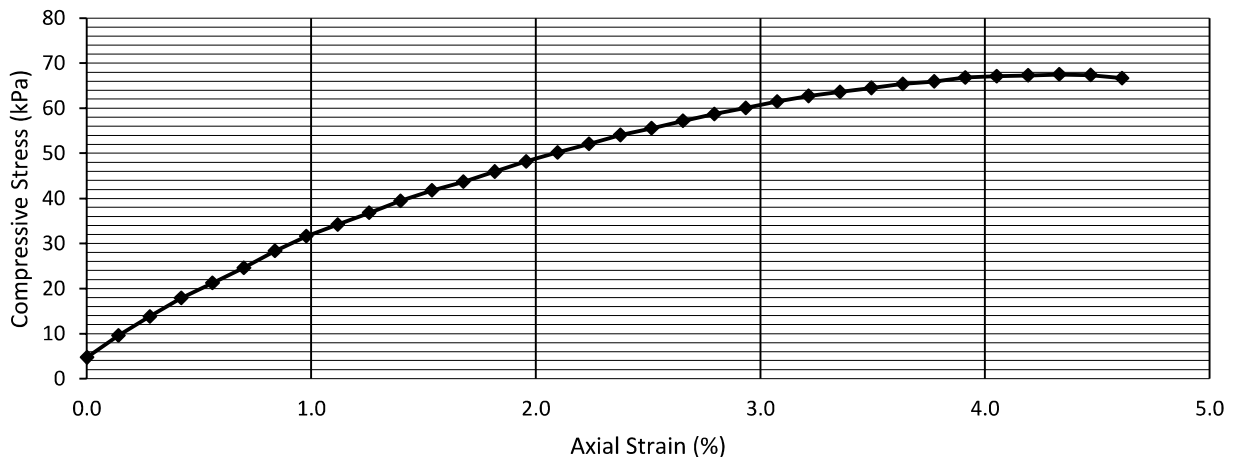
FAILURE SKETCH



Torvane	Undrained Shear Strength (kPa)	24.5
Pocket Pen.	Undrained Shear Strength (kPa)	92.6

UCS	Unconfined compressive strength (kPa)	67.47	Undrained Shear Strength (kPa)	33.73
	Unconfined compressive strength (ksf)	1.409	Undrained Shear Strength (ksf)	0.705
	Avg. Rate of Strain to Failure (%/min):	0.84	Strain at Failure (%):	4.33

Unconfined Compressive Strength



Comments:

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC LDS Crossing
Project Number: 60738849
Client: City of Winnipeg
Supplier/Location: Winnipeg, MB
Sample Depth (m): 9.14 - 9.75 m
Sample Location: TH25-01
Sample Number: T14

Date Sampled: May 21, 2025
Sampled By: Gacurin
Date Received: May 21, 2025
Submitted By: Gacurin
Date Tested: June 6, 2025
Tested By: LBoughton

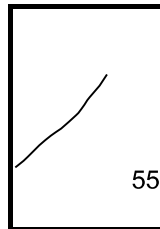
Unconfined Compressive Strength (ASTM D2166)

Standard Test Method for Unconfined Compressive Strength of Cohesive Soil, using strain-controlled application of the axial load.

Soil Description: CLAY - grey, firm, moist, silty, high plasticity, slickensided

Average Diameter (cm):	7.20
Average Length (cm):	14.76
Length/Diameter Ratio:	2.05
Moisture content (%):	48.0
Bulk Density (g/cm ³):	1.752
Bulk Unit Weight (kN/m ³):	17.2
Bulk Unit Weight (pcf):	109.4
Dry Unit Weight (kN/m ³):	11.61

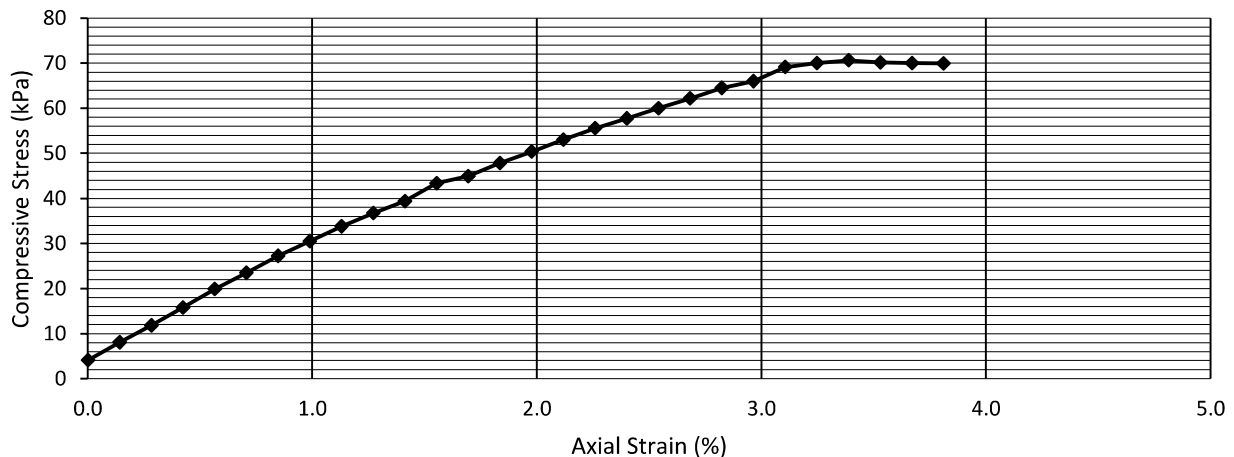
FAILURE SKETCH



Torvane	Undrained Shear Strength (kPa)	51.0
Pocket Pen.	Undrained Shear Strength (kPa)	36.7

UCS	Unconfined compressive strength (kPa)	70.62	Undrained Shear Strength (kPa)	35.31
	Unconfined compressive strength (ksf)	1.475	Undrained Shear Strength (ksf)	0.737
	Avg. Rate of Strain to Failure (%/min):	0.85	Strain at Failure (%):	3.39

Unconfined Compressive Strength



Comments:

Lower undrained shear strength (kPa) for unconfined compressive test due to the structure being slickensided.

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead



AECOM Canada Ltd.
Winnipeg Geotechnical Laboratory
99 Commerce Drive, Winnipeg, MB R3P 0Y7
Phone: 204 477 5381

Project Name: NEWPCC LDS Crossing
Project Number: 60738849
Client: City of Winnipeg
Supplier/Location: Winnipeg, MB
Sample Depth (m): 15.24 - 15.85 m
Sample Location: TH25-01
Sample Number: T20

Date Sampled: May 21, 2025
Sampled By: Gacurin
Date Received: May 21, 2025
Submitted By: Gacurin
Date Tested: June 6, 2025
Tested By: LBoughton

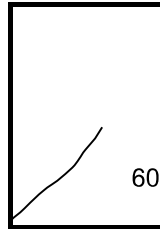
Unconfined Compressive Strength (ASTM D2166)

Standard Test Method for Unconfined Compressive Strength of Cohesive Soil, using strain-controlled application of the axial load.

Soil Description: CLAY - grey, firm, moist, silty, trace gravell, trace sand, high plasticity, slickensided

Average Diameter (cm):	7.26
Average Length (cm):	14.92
Length/Diameter Ratio:	2.06
Moisture content (%):	46.9
Bulk Density (g/cm ³):	1.706
Bulk Unit Weight (kN/m ³):	16.7
Bulk Unit Weight (pcf):	106.5
Dry Unit Weight (kN/m ³):	11.39

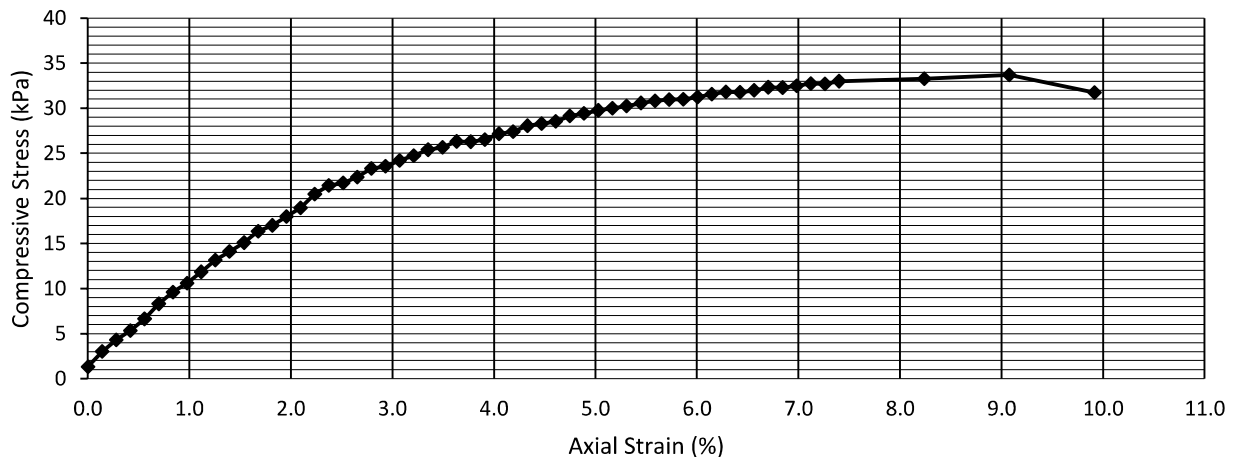
FAILURE SKETCH



Torvane	Undrained Shear Strength (kPa)	30.4
Pocket Pen.	Undrained Shear Strength (kPa)	27.9

UCS	Unconfined compressive strength (kPa)	33.69	Undrained Shear Strength (kPa)	16.84
	Unconfined compressive strength (ksf)	0.704	Undrained Shear Strength (ksf)	0.352
	Avg. Rate of Strain to Failure (%/min):	0.84	Strain at Failure (%):	9.08

Unconfined Compressive Strength



Comments:

Lower undrained shear strength (kPa) for unconfined compressive test due to the structure being slickensided.

Reviewed by: Lee Boughton
Laboratory Manager

Approved by: German Leal, M.Eng., P.Eng.
Geotechnical Discipline Lead

Appendix **D**

Seismic Hazard Calculation





Government
of Canada

Gouvernement
du Canada

Canada.ca › [Natural Resources Canada](#) › [Earthquakes Canada](#)

2020 National Building Code of Canada Seismic Hazard Tool

i This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_s	X_E
Latitude (°)	49.952
Longitude (°)	-97.107

Please select one of the tabs below.

NBC 2020

Additional Values

Plots

API

Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration ($PGA(X)$) values are given in units of acceleration due to gravity (g , 9.81 m/s^2). Peak

ground velocity. (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_E)$	$S_a(0.5, X_E)$	$S_a(1.0, X_E)$	$S_a(2.0, X_E)$	$S_a(5.0, X_E)$	$S_a(10.0, X_E)$	PGA(X_E)	PGV(X_E)
0.113	0.107	0.055	0.0216	0.00434	0.00126	0.0679	0.0544

The log-log interpolated 2%/50 year $S_a(4.0, X_E)$ value is : **0.0064**

▼ Tables for 5% and 10% in 50 year values

NBC 2020 - 5%/50 years (0.001 per annum) probability

$S_a(0.2, X_E)$	$S_a(0.5, X_E)$	$S_a(1.0, X_E)$	$S_a(2.0, X_E)$	$S_a(5.0, X_E)$	$S_a(10.0, X_E)$	PGA(X_E)	PGV(X_E)
0.0591	0.0565	0.028	0.0104	0.00193	0.000552	0.0339	0.027

The log-log interpolated 5%/50 year $S_a(4.0, X_E)$ value is : **0.0029**

NBC 2020 - 10%/50 years (0.0021 per annum) probability

$S_a(0.2, X_E)$	$S_a(0.5, X_E)$	$S_a(1.0, X_E)$	$S_a(2.0, X_E)$	$S_a(5.0, X_E)$	$S_a(10.0, X_E)$	PGA(X_E)	PGV(X_E)
-----------------	-----------------	-----------------	-----------------	-----------------	------------------	--------------	--------------

$S_a(0.2, X_E)$	$S_a(0.5, X_E)$	$S_a(1.0, X_E)$	$S_a(2.0, X_E)$	$S_a(5.0, X_E)$	$S_a(10.0, X_E)$	PGA(X_E)	PGV(X_E)
0.0334	0.0317	0.0149	0.00517	0.000881	0.000242	0.0184	0.0142

The log-log interpolated 10%/50 year $S_a(4.0, X_E)$ value is : **0.0014**

Download CSV

← Go back to the [seismic hazard calculator form](#)

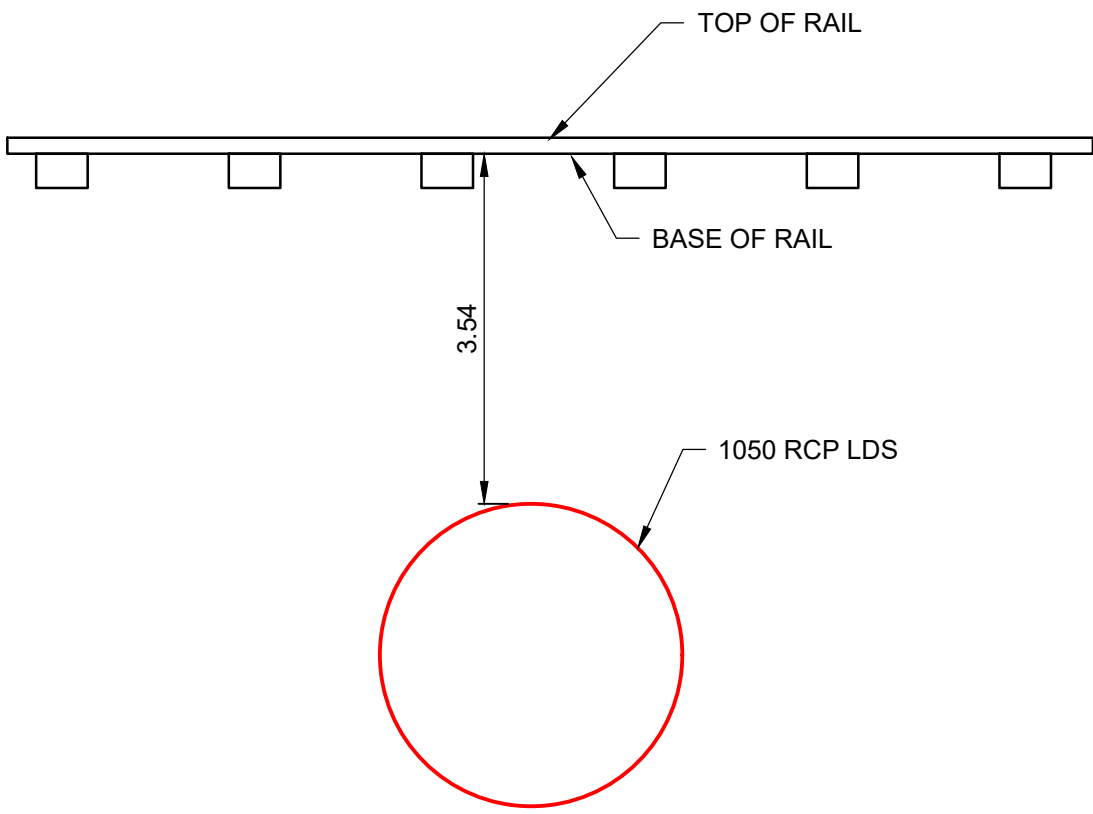
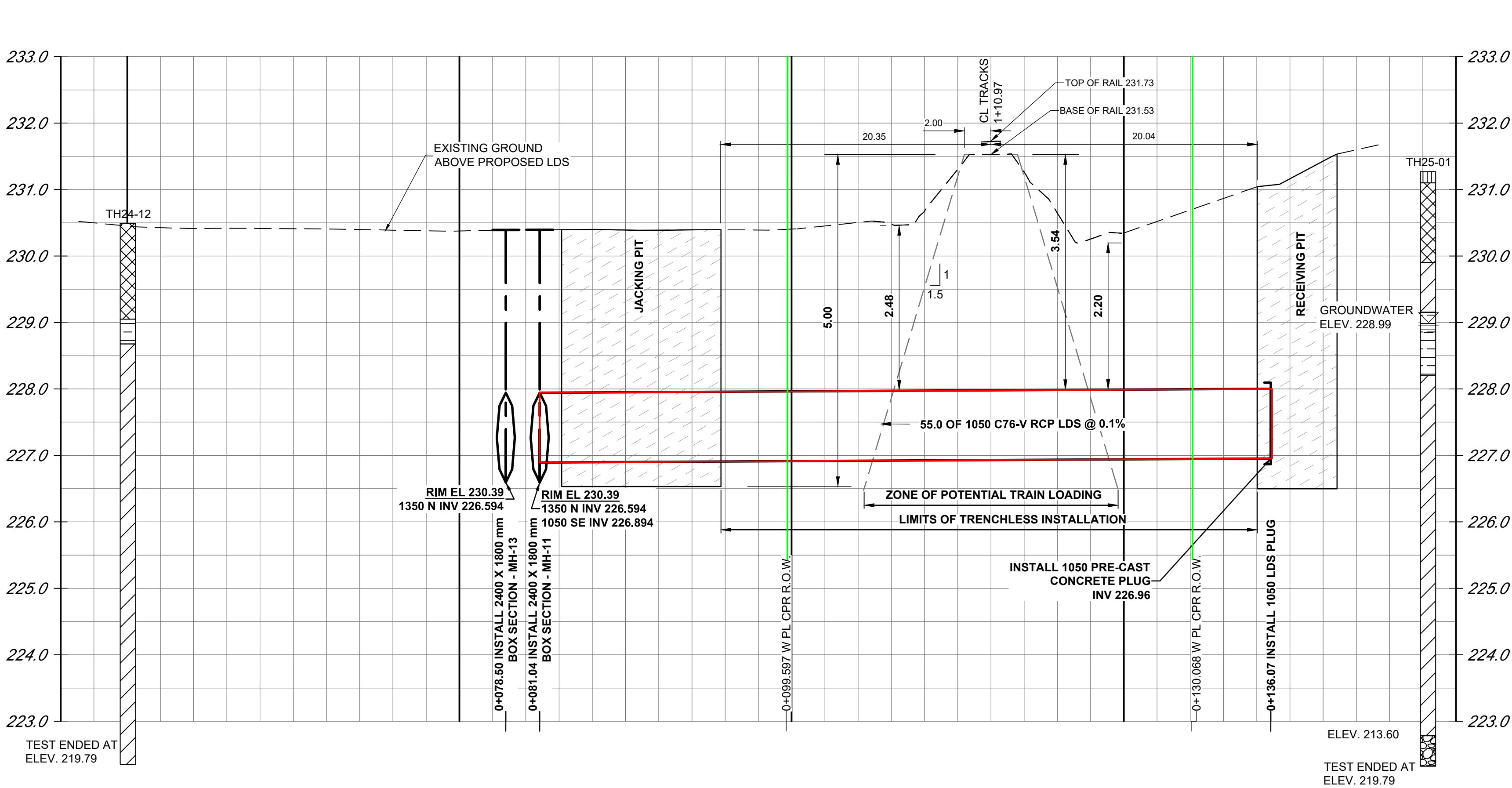
Date modified: 2021-04-06

Appendix **E**

Crossing Drawing Sheet



A1 SIZE - 594mm x 841mm
 LAST SAVE: 2025/07/01 14:42 AM
 PATH: C:\Users\mroberts\OneDrive\Documents\AECOM\City of Winnipeg - NEWPCC Upgrade\2021 Project Files\500 Design Collaboration\6709590 Boreholes, Earthworks & Paved C_ EarlyWorks_LDS\CC111.dwg



SECTION ALONG TRACK

Scale NTS

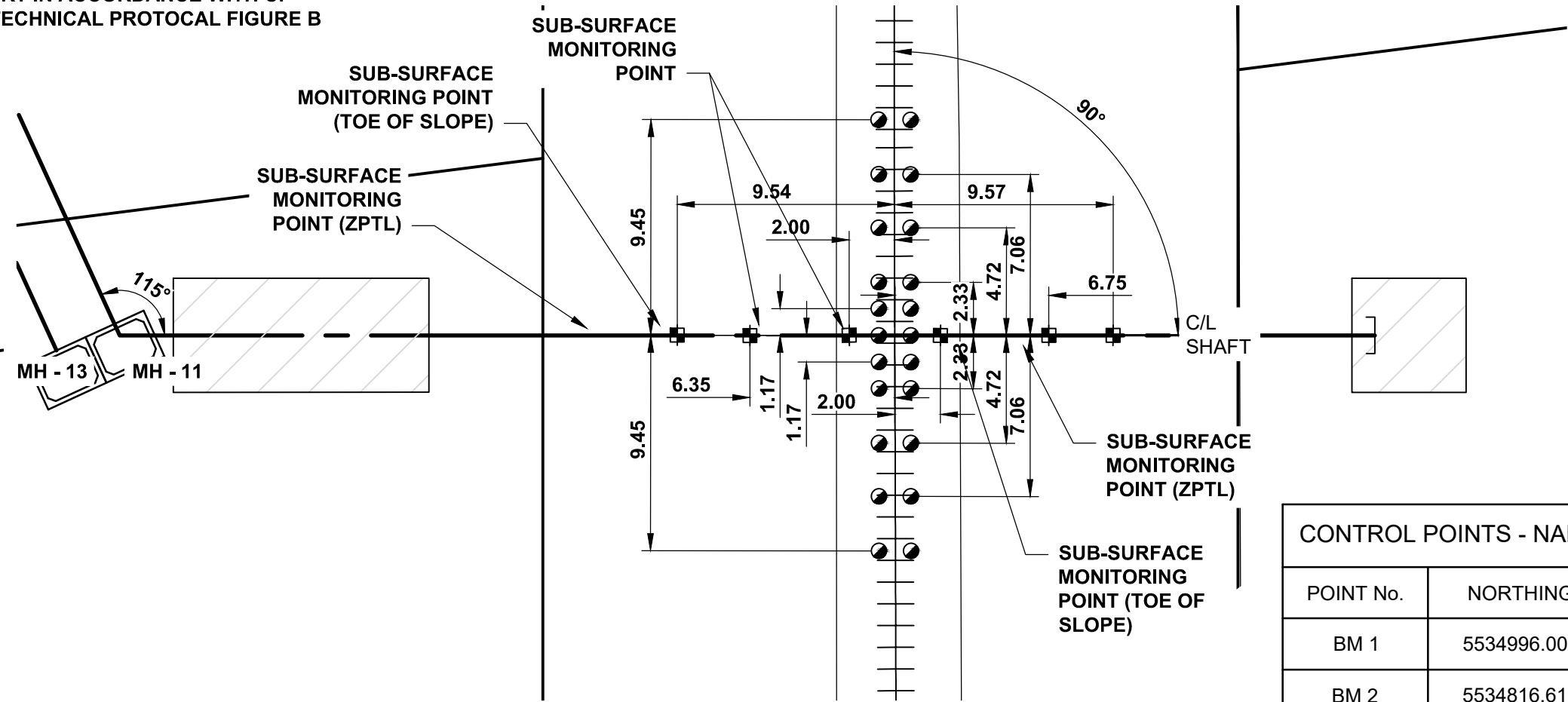
REFER TO GEOTECH REPORT FOR GROUNDWATER ELEVATIONS.

BOREHOLE LEGEND:	
	TOPSOIL
	FILL
	LEAN CLAY
	FAT CLAY
	SILT
	TILL

RAIL CROSSING NOTES:		
RAILWAY MILEAGE AND SUBDIVISION : MILE 3.78, CP WINNIPEG BEACH SUBDIVISION		
MUNICIPAL DESCRIPTION OF ADJACENT PROPERTIES: NORTH END POLLUTION CONTROL CENTRE		
NAME OF PIPELINE OWNER: CITY OF WINNIPEG, WATER AND WASTE DEPARTMENT 204-986-2626		
CONTENTS TO BE HANDLED:		LAND DRAINAGE
MAXIMUM OPERATING PRESSURE:		N/A
MAXIMUM SURGE AND TEST PRESSURE:		N/A
MAXIMUM OPERATING TEMPERATURE:		- °C
MINIMUM OPERATING TEMPERATURE:		- °C
PIPING MATERIALS:		CARRIER
NOMINAL DIAMETER:		1067 mm
OUTSIDE DIAMETER:		1295 mm B WALL or 1333 mm C WALL
MATERIAL:		CONCRETE
SPECIFICATION AND GRADE:		ASTM C76 CL. V
WALL THICKNESS:		114 mm B WALL or 133 mm C WALL
TYPE OF JOINT:		RUBBER GASGET
COATING:		N/A
LOCATION OF SHUT OFF VALVES:		N/A
METHOD OF INSTALLATION TRENCHLESS - GUIDED AUGER BORE WITH NO SOIL REMOVAL AHEAD OF PIPE		
VENTS: N/A		
NUMBER: N/A		
HEIGHT ABOVE GROUND: N/A		
SEALS: N/A		
BOTH ENDS TYPE: NO		
BURY: BASE OF RAIL TO TOP OF PIPE		CONC. PLUG FOR FUTURE CONNECTIONS
NOT BENEATH TRACKS		CONC. MANHOLE FOR FUTURE CONNECTION (N)
ROADWAY DITCHES		3.54 m
BASE OF RAIL TO BOTTOM OF JACKING/RECEIVING PITS		2.20 m
EXTENT OF CASING MEASURED PERPENDICULAR TO CENTERLINE OF TRACK		5.00 m (S) 5.00 m (N)
ANGLE OF PIPE / TRACK CROSSING 90°		
DIRECTION OF FLOW BI-DIRECTIONAL		
CENTERLINE OF TRACK TO FACE OF JACKING/RECEIVING PITS		20.04 m (S) 20.31 m (N)
TYPE, SIZE, AND SPACING OF INSULATORS OR SUPPORTS		N/A
CATHODIC PROTECTION		N/A
GEOTECHNICAL BOREHOLES		REFER TO SOILS REPORT
SOIL TYPE		REFER TO SOILS REPORT
BASE OF RAIL TO GROUND WATER		REFER TO SOILS REPORT
INSTALLATION AND MAINTENANCE SHALL BE IN ACCORDANCE WITH TC-E10 AND THE LATEST EDITION OF APPLICABLE CSA STANDARD Z662		

GEOTECHNICAL ENGINEER EVALUATION HAS BEEN COMPLETED AND THE GEOTECHNICAL ENGINEER HAS DETERMINED THAT BASED ON THE SOIL CONDITIONS, THERE WILL BE NO ADVERSE EFFECTS TO CPR OPERATION AND PROPERTY.

SUB-SURFACE MONITORING POINTS (2) TO BE INSTALLED TO 1m ABOVE CASING OBVERT IN ACCORDANCE WITH CP GEOTECHNICAL PROTOCOL FIGURE B



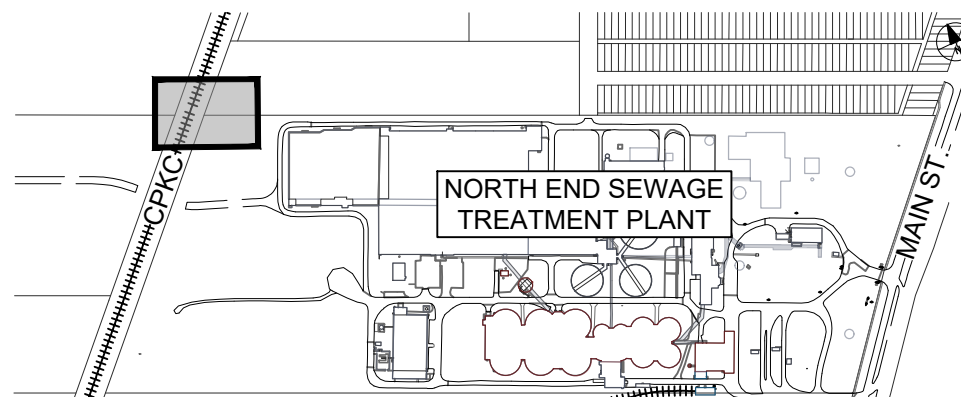
SUB-SURFACE/TRACK MONITORING PLAN

Scale 1:250

TRACK MONITORING

- MONITOR RAIL TRACK IN ACCORDANCE WITH TRACK MONITORING PLAN. SEE SPECIFICATIONS.
- REPORT MONITORING THRESHOLDS: CRITICAL / REVIEW THRESHOLD: ≥22mm
ALERT / WARNING THRESHOLD: >11mm
- SETTLEMENT MONITORING OF THE RAIL TRACK SHALL COMMENCE A MINIMUM OF 2 DAYS PRIOR TO CONSTRUCTION/EXCAVATION IN ORDER TO ESTABLISH BASELINE COORDINATES AND ELEVATIONS.
- MONITORING POINTS SHOULD BE SURVEYED AT LEAST TWICE PER DAY DURING THE DURATION OF CONSTRUCTION AND AT LEAST 3 DAYS AFTER THE COMPLETION OF CONSTRUCTION.
- SURVEY RESULTS SHALL BE SUBMITTED DAILY TO GEOTECHNICAL ENGINEER FOR REVIEW.

CONTROL POINTS - NAD83 UTM ZONE 14 - JUNE 90 (LBIS)			
POINT No.	NORTHING	EASTING	ELEVATION
BM 1	5534996.006	636000.318	231.073
BM 2	5534816.615	635804.484	230.670
BM 3	5535144.163	635145.506	232.293
BM 4	5535479.063	635036.233	231.014



KEY PLAN

TENDER NO. 116-2025

150 WM	WATERMAIN	150 WM	150 WM	CURB STOP	230.850	GRADE	231.000
	HYDRANT		VALVE		230.50	CONTOUR ELEVATION	
	LAND DRAINAGE SEWER		COUPLING			SWALE	
	WASTE WATER SEWER		MTS				
	MANHOLE		GRAVEL				
	CATCH BASIN		LIP CURB				
	CURB INLET		RAMP CURB				
	SUBDRAIN		LEGEND - PLAN				
	COMMUNITY MAILBOX		LEGEND - PLAN				
	SURVEY BAR		LEGEND - PLAN				
	EXISTING		NEW				

SITE PLAN

1:250

WARNING

IF POWER EQUIPMENT OR EXPLOSIVES ARE TO BE USED FOR EXCAVATION ON THIS PROJECT THE CONTRACTOR MUST:

- NOTIFY THE GAS COMPANY OF THE PROPOSED LOCATION OF EXCAVATION.
- TAKE PRECAUTION TO AVOID DAMAGE TO GAS COMPANY INSTALLATIONS.

SEE PROVINCIAL REGULATION 210/72 FOR DETAILS

0 6.25 12.5 m	
1:250	
METRIC	
WHOLE NUMBERS INDICATE MILLIMETRES DECIMALIZED NUMBERS INDICATE METRES	
Certificate of Authorization	
AECOM Canada ULC	
No. 4671	

DESIGNED BY: NJD		CHECKED BY: MPG	
DRAWN BY: LMB		APPROVED BY: KWF	
SCALE: AS NOTED		RELEASED FOR CONSTRUCTION BY:	
DATE: 2025-02-21		DATE:	
CONSULTANT NO.: C111			
A ISSUED FOR REVIEW		2025-06-12	
NO. REVISIONS		DATE DESIGN CHECK	

ENGINEER'S SEAL			
NEWPCC LAND DRAINAGE SYSTEM			
CIVIL			
LDS - CPKC CROSSING			
WINNIPEG BEACH SUBDIVISION - MILE 3.78			
CITY DRAWING NUMBER		SHEET	REV. SIZE
		001	01 A1

Appendix **F**

Survey Monitoring Detail

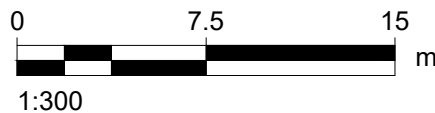
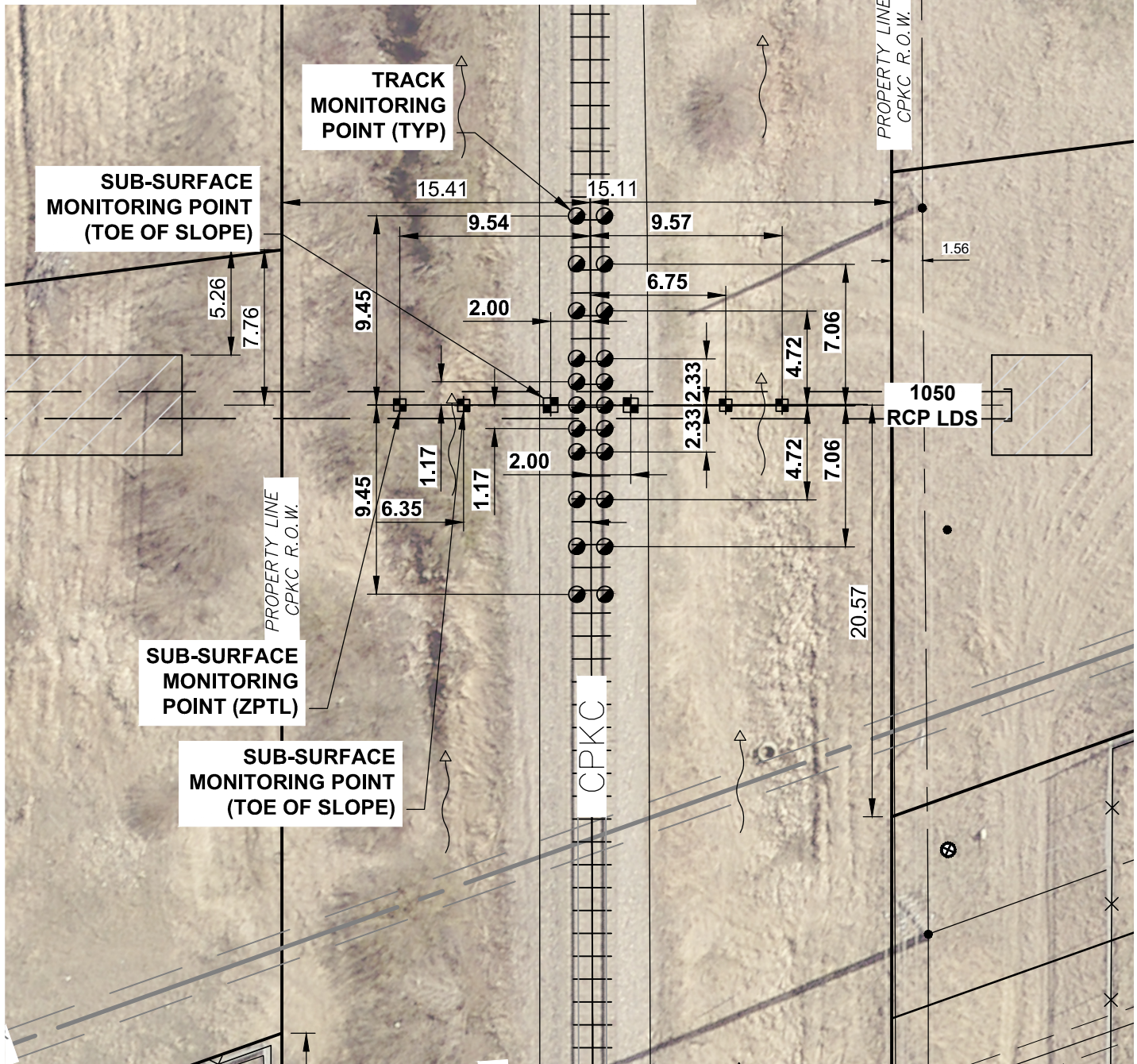


LEGEND:

-  SUB-SURFACE MONITORING POINTS
-  SURFICIAL MONITORING POINT

NOTES:

THE SUBSURFACE MONITORING POINTS TO BE INSTALLED 1.0m ABOVE CASING PIPE OBVERT (BOTTOM ELEV. 228.99m)



Appendix **G**

CPKC Geotechnical Protocol for Pipeline and Utility Installations within Railway Right-of-Way



**GEOTECHNICAL PROTOCOL
FOR
PIPELINE AND UTILITY CROSSING(S) UNDER
RAILWAY TRACKS**

**Engineering
Geotechnical and Utilities Department
Last Updated: May 15, 2024**

4	May 15, 2024	DJW /JC / GD	7.1.1 added: retainer fee is Canada only 7.2 added: clarity on excavation pit placement 7.3, 7.3.1, 7.3.2 removed reference to Appendix A 9.2.2 added: clarity for 2m offset and end points of ZPTL 9.2.4 added: reference to Class 3/4/5 tracks for remote monitoring
3	March 12, 2024	DJW /JC / GD	Multiple sections highlighted throughout
2	May 16, 2022	DJW	Fig C – Pg 39
1	Feb 25, 2020	MR	Level 2 criteria – Pg 36
No	Date	By	Revision



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Last Updated: March 12, 2024

Engineering
Geotechnical & Utilities

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CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Last Updated: March 12, 2024

Engineering
Geotechnical & Utilities

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Appendices

Appendix A – Sample Daily Report and Settlement Report

Appendix B – Track Movement Guideline for Trenchless Pipe Installation

Appendix C – Additional Notes & Installation Requirements



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Last Updated: March 12, 2024

Engineering
Geotechnical & Utilities

1.0 *Limitations of the Document*

The following protocol is independent of the requirements for assessing the structural components of the pipeline and pipeline crossing. The structural requirements for all pipeline crossings are included in SP-TS-2.39 - Pipeline and Cable Installations within Railway Right of Way. An agreement or permit from Canadian Pacific Kansas City Railway's Utilities Department is required before commencing with any work within the railway corridor. **Proposals for pipelines and utilities parallel to the track(s) are not covered under this protocol.**

In addition, this document does not cover review on any of the engineering design aspects of the proposed pipelines and utility crossings. Suitable engineering design is the sole responsibility of the applicant. Geotechnical approval of a proposed pipeline crossing by Canadian Pacific Kansas City (CPKC) in no way warrants the suitability of construction methods/techniques for anticipated ground conditions, nor does it warrant the suitability of existing ground and site conditions for the use proposed by the applicant of the crossing. CPKC does not take any responsibility for the suitability of the construction method or warrant the ground and/or site conditions. CPKC geotechnical approval of a pipeline and utility installation application merely indicates that based on the provided and available information, the proposed construction and design addresses CPKC's needs at the time of review and approval. CPKC does not provide engineering recommendations, directions or minimum standards to the applicant or their contractor(s) for design and execution of their work within CPKC Right-of-Way (ROW).

Due to third party work on CPKC ROW, CPKC will not be liable for any damages or delays to the applicant and/or CPKC assets and operation because of its approval of an application. In addition, any damages incurred to CPKC due to third party pipeline and utility crossing(s) will be the responsibility of the applicant.

CPKC requires that the applicant provide adequate documentation as outlined in this protocol; clearly identify the responsible Professional Engineer of Record and the components of the project for which they are responsible.

2.0 *General Terminology*

Base of Rail (BOR): is the bottom surface of the rail and is frequently used as a local datum from which vertical measurements are referenced. If an external datum is utilized the elevation of the BOR will be identified.

Geotechnical Engineer of Record's onsite designate/representative: A geotechnical trained and competent person assigned by the Geotechnical Engineer of Record to act as site inspector



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who will be present onsite during the full duration of the construction and installation within railway operating corridor, unless, otherwise directed by CPKC Utilities Supervisor. The site inspector must have the required training, experience and understanding of the site conditions, proposed design, and construction methodology to make sound engineering judgement and decisions, and reports during the course of the work.

Service Provider(s): include professional engineering firm(s) or individual(s) representing relevant or applicable engineering disciplines, to be retained on behalf of CPKC for engineering related review and/or oversight of fieldwork and track settlement monitoring results, for which the compensation will be paid by the applicant.

Zone of Potential Track Loading (ZPTL): is considered as the area under the track and within a 1V to 1.5H soil zone extending down from a point at the level of the BOR and 2 m (6.6 ft.) from The centerline of track as shown in Figure 3.

FRA: Federal Railroad Administration.

TC: Transport Canada.

3.0 Introduction

The purpose of this document is to ensure efficient application process and ensure safety and uninterrupted operation of Canadian Pacific Kansas City (CPKC) Railway's operations during the execution of proposed third party pipeline and utility crossing(s) within CPKC ROW. This document is intended to guide the applicant of the minimum application requirements, review and approval process for proposed pipeline and utility crossing(s) as completed by CPKC Utilities and Geotechnical groups. The goal of this protocol is to:

- 3.1 Provide safe track(s) conditions during and after the installation of proposed pipeline and utility crossing(s);
- 3.2 Establish requirements and procedures to be followed by the applicant(s) to minimize difficulties and risks to CPKC's operations and its assets during the installation and operation of pipeline and utility crossing(s) under CPKC's tracks and within its ROW;
- 3.3 Specify minimum criteria to be met for CPKC's review;



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- 3.4 Ensure adequate subsurface information including geotechnical and groundwater information is available and an assessment by CPKC's geotechnical group or a CPKC approved service provider has been completed prior to providing approval; and
- 3.5 Allow timely processing of application for pipeline and utility crossing(s) approvals.

4.0 Emergencies

In the event of any occurrence due to construction/contractor activities that does or could pose a hazard, immediately contact CPKC Police at [1-800-716-9132](tel:1-800-716-9132).

5.0 Winter Work Restriction within CPKC ROW

No construction and installation of pipeline and utility crossing(s) that fall under the Geotechnical Protocol will take place between **December 15th and March 31st**. This restriction is particularly critical to areas where frost penetrates the ground and may make it difficult to observe surface settlement and loss of soil from underneath the track substructure due to misperception of a levelled frozen surface. Such conditions pose a risk to the stability of CPKC's track and its substructure during thawing season and are not acceptable.

In areas where the applicant does not consider frost as a potential risk, the applicant is required to assure and demonstrate to CPKC as to why winter work restriction is not applicable to their proposed work. Exceptions to winter work restriction will be evaluated on case by case basis.

6.0 Application Process Identification

To identify the applicable process, complete appropriate level of assessment and allow timely processing of a pipeline and utility crossing(s) proposal, the requirement criteria have been divided into three levels as identified in Table 1, i.e. Minimum, Intermediate and Detailed. These processes are categorized based on the size, cover, location and proximity of pipeline from tracks and other structures, and construction methodology of the proposed pipeline and utility crossing(s).

Applicant is expected to consult Table 1 to identify the level of effort and detail of submission required to meet CPKC review requirements for review. Details of each process are discussed in the following sections.



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Table 1 – Process Identification

		Process Levels		
		1. Minimum ¹	2. Intermediate	3. Detailed
Dimension Criteria	Outside diameter of pipe	Less than 300 mm (12 in.)	300 mm (12 inches) to 1500 mm (59 in.)	Greater than 1500 mm (59 in.)
	Cover between BOR and top of pipe	Greater than 1.5 m (5 ft.) or three pipe diameters whichever is greater.	Greater than 1.5 m (5 ft.) or two (2) pipe diameters whichever is greater.	Less than 1.5 m (5 ft.) or two (2) pipe diameters.
	Adjacent structures including switches and signals	Greater than 10 m (32.8 ft.) from centerline	Within 2.5 times, cover between BOR and top of pipe.	
	Depth of pipes outside ZPTL	Refer to SP-TS 2.39 All pipes will be at least 0.91 m (3 ft.) below ground (below sub-ballast layer) where pipes are not below the ZPTL.	Less than 0.91 m (3 ft.) burial within ZPTL.	
Excavation Criteria	Excavation close to CPKC track(s)	Jacking/access pits shall be more than 10 m (32.8 ft.) from the closest track centerline and shall not encroach on the ZPTL.	Excavations or jacking/access pits within 10 m (32.8 ft.) of the closest track centerline.	
	Crossing angle	Less than 45 degrees off perpendicular to the track.	More than 45 degrees off perpendicular to the track.	



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	Process Levels		
	1. Minimum ¹	2. Intermediate	3. Detailed
Construction Method	Trenchless method ²		All methods considered.
	Pipe bursting will only be considered where the predicted heave is less than 10% of the movement that would result in a change of the FRA or TC track class.		
Approval Process	Utility group to approve with no geotechnical submission.	Full review of design, geotechnical and construction method Applicant to pay for the review cost of CPKC approved service provider.	

¹ Move to next class if one or more criteria are not met.

² Trenchless methods include Auger Boring (AB), Pipe Jacking, Pipe Ramming (PR), Horizontal Directional Drilling (HDD) except high pressure fluid jetting method, Microtunnelling (MT) but exclude any type of mining techniques where any stand up time is required before the tunnel support is placed.

7.0 Minimum Information Requirements

7.1 All proposals for pipeline and utility crossing(s) approvals will be under the signature and seal of a locally registered professional Geotechnical Engineer referred to as Geotechnical Engineer of Record (GER). The objective is to ensure that a registered professional from applicant's design firm or organization is given the opportunity and responsibility to assess the site and subsurface conditions and demonstrates due diligence to assure CPKC that the proposal is appropriate for such conditions. This, however, depending on the complexity of design and proposal, may be in addition to the requirements of meeting industry standards or current regulatory requirements for structural integrity of the pipeline/utility. Such design will also require signature and seal by a professional geotechnical and/or structural engineer.

7.1.1 All applications to which the CPKC Geotechnical Protocol applies must include a separate retainer fee to cover costs incurred to the railway due to the project's activities, (such as but not limited to) resurfacing work, survey to obtain as-built drawings, site cleanup, and removal of settlement monitoring equipment. Retainer fee (or a portion thereof) is refundable if final stamped geotechnical



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construction summary report and stamped as-built drawing(s) are provided within six (6) months of completion of construction and post-construction monitoring. Retainer fee only applies to applications in Canada.

- 7.2 The application package must include a construction plan that specifies the terms and conditions for the execution of the proposed work, including assignment of responsibility. The applicant of the crossing(s) is responsible to ensure that the work is executed in accordance with the terms of the agreement with CPKC. The drill path and installation of the jacking and receiving pits should be planned to have the least impact to railway operations. The jacking and receiving pits should be placed outside CPKC property and not be planned or excavated within the (ZPTL) - zone of potential track loading. The access pits can be closer to the tracks if the grades and soil conditions call for it and if it also reduces the chances of voids or track settlement, but will require review of the specific site. Any exceptions to the placement of the pits will require additional reviews at the applicant's expense
- 7.3 **Engineering Drawings:** All pipeline and utility crossing(s) application packages will be accompanied by following documents, at minimum, showing features on drawings in true scale.
- 7.3.1 Plan of the proposed pipe and utility crossing(s) under the track. This drawing will show the following features:
- 7.3.1.1 Location of the crossing(s), referencing identifiable landmarks including Mileage and Subdivision of the proposed crossing(s) as per CPKC Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CPKC Utilities group; The title of the plan will include the subdivision name and mileage of the location.
 - 7.3.1.2 Pipe centerline, diameter, length, size, limits, thickness and material;
 - 7.3.1.3 Location of any adjacent structures including but not limited to signals, switches, culverts, other existing underground/buried services including Fibre Optics Transmission Systems (FOTS) and relevant distances from the centerline of the track(s);
 - 7.3.1.4 Location of the ditch line and any breaks in slope;
 - 7.3.1.5 Location of drilled boreholes or test pits from geotechnical investigation;



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- 7.3.1.6 Location of all tracks and distances from track centerline to the proposed work area location; and
- 7.3.1.7 Location of all access pits, size, depth and details of support of excavation, if applicable.
- 7.3.2 Profile of the track and proposed pipeline and utility crossing(s) along the centerline of the track. The profile will show the following features:
 - 7.3.2.1 Location of the crossing(s), referencing identifiable landmarks including Mileage and Subdivision of the proposed crossing(s) as per CPKC Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CPKC Utilities Group;
 - 7.3.2.2 Pipe centerline, diameter, length, size, limits, thickness and material;
 - 7.3.2.3 Location of any adjacent structures including but not limited to signals, switches, culverts, other existing underground/buried services including Fibre Optics Transmission Systems (FOTS) and vertical distance from BOR;
 - 7.3.2.4 Elevation of surface water in ditches, elevation of the ground water table in all boreholes and the date it was measured;
 - 7.3.2.5 Test pit/borehole locations along with the stratigraphic profile as determined through the geotechnical investigation;
 - 7.3.2.6 Depth of top of pipe to the BOR; and
 - 7.3.2.7 Location of all jacking/access pits, size, depth and details of support of excavation, if applicable.
- 7.3.3 Section of the track along the centerline of the proposed pipeline and utility crossing(s). This drawing will show the following features:
 - 7.3.3.1 Location of the crossing(s), referencing identifiable landmarks including Mileage and Subdivision of the proposed crossing(s) as per CPKC Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CPKC Utilities group;



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- 7.3.3.2 Pipe centerline, diameter, length, size, limits, thickness and material;
 - 7.3.3.3 Any adjacent structures including but not limited to signals, switches, culverts, other existing underground/buried services including FOTS and vertical distance from BOR;
 - 7.3.3.4 Elevation of surface water in ditches, elevation of the ground water table in all boreholes and the date they were measured;
 - 7.3.3.5 Test pit/borehole locations along with the stratigraphic profile as determined through the geotechnical investigation;
 - 7.3.3.6 Location of jacking or access pits and proposed cut slope angles;
 - 7.3.3.7 Location of the centerline of all tracks;
 - 7.3.3.8 Depth of the top of pipe to the BOR; and
 - 7.3.3.9 Any excavations that encroach on the ZPTL; Indicate ZPTL and distance from ground to the top of pipe.
 - 7.3.3.10 Cross-Sections of perpendicular to the track shall be displayed as viewing in the direction of increasing CPKC mileage; left and right-hand being so determined.
- 7.4 Geotechnical Investigation Report must be signed and sealed by a locally registered professional Geotechnical Engineer;
- 7.5 Settlement Monitoring Plan indicating layout and types of settlement monitors to be installed, frequency of measurements, alarm thresholds i.e. "Alert" and "Critical" thresholds, reporting protocol, and immediate actions to take when required. General track movement monitoring guidelines are provided in Appendix C.
- 7.6 Other Information: This includes information related to additional design and requirements based on the ground conditions and proposed construction. This may include excavation support/shoring, dewatering requirements etc. If required, complete design and relevant drawings will be required.
- 7.7 Applicant is expected to restore the site to its original condition.
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- 7.8 Proposals for open cut is not a preferred method of installation. This, however, will be assessed on a case by case basis, and prior written approval from CPKC is required for any exceptions.
- 7.9 Installations using high pressure fluid jetting will not be considered.
- 7.10 The cost of remediation incurred to CPKC as a result of pipeline and utility crossing(s) construction and installation and related activities will be borne by the crossing(s) applicant. Some of the issues include settlement or soil heave induced by the crossing(s) installation during and after the construction and may be partially offset by the geotechnical retainer fee.
- 7.11 All pipelines and utilities installed below the highest ground water level predicted will be sealed during construction.
- 7.12 All pipelines that will or could carry water shall be:
- 7.12.1 Installed with even bearing throughout its length to limit local settlement; and
 - 7.12.2 Sloped to one end and prevent standing water. Special exemptions will be considered for inverted siphons or other applications requiring level pipes.

8.0 Process 1 – Minimum

8.1 Criteria

The general requirements included in Table 1 in conjunction with the following requirements must be met to obtain approval for a pipeline and utility crossing(s) that qualifies as a Process 1 crossing(s).

Table 2: Process 1 – Minimum

Dimension Criteria	
Outside pipe diameter	Less than 300 mm (12 in.)
Cover between BOR and top of pipe	Greater than 1.5 m (5 ft.) or three pipe diameters whichever is greater.



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Adjacent structures including switches and signals	Greater than 10 m (32.8 ft.) centerline.
Depth of pipes outside ZPTL	Refer to SP-TS 2.39 All pipes will be at least 0.91 m (3 ft.) below ground where pipes are not below the ZPTL.
Excavation Criteria	
Excavation close to CPKC track(s)	Jacking/access pits shall be more than 10 m (33 ft.) from the closest track centerline and not encroach on the ZPTL.
Crossing angle	Less than 45 degrees off perpendicular to the track.
Construction Method	
1. Trenchless method ¹ 2. Pipe bursting will only be considered where the predicted soil heave is less than 10% of the movement that would result in a change of the FRA or TC track class.	

¹ Trenchless methods include Auger Boring (AB), Pipe Jacking, Pipe Ramming (PR), Horizontal Directional Drilling (HDD) except high pressure fluid jetting method, Microtunnelling (MT) but exclude any type of mining techniques where any stand up time is required before the tunnel support is placed.

8.2 Application Requirements

- 8.2.1 The applicant will provide documents and drawings containing the information identified in Section 7.0.
- 8.2.2 Generally, an installation that falls under the minimum review detail level does not require a geotechnical investigation. However, in areas with poor subsurface soil conditions or where failures have occurred with similar pipe crossings, CPKC reserves the right to request a Geotechnical investigation to be conducted in order to proceed with the proposed pipe installation. In situations where a pipe is below the 300mm OD threshold, but the borehole size is 300mm or larger, a Geotechnical investigation is required. Voids between the bore and outside casing are to be filled with non-shrinkable material.



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- 8.2.3 Even if not required by CPKC, a geotechnical investigation may be completed at the discretion of the applicant.

8.3 Application Review and Approval Process

- 8.3.1 Applicant submits engineering documents to CPKC Utilities.
- 8.3.2 CPKC Utilities reviews documents to ensure applicable and complete engineering documents are provided.
- 8.3.3 An assessment is completed by CPKC Utilities to provide decision/approval documentation.

9.0 Process 2 – Intermediate

The Intermediate process pertains to those proposed pipeline/track crossing(s) that exceed the minimum criteria but do not exceed the maximum criteria. The applicant will be required to submit information for review and approval by CPKC Utilities Department or a CPKC approved service provider but may be subjected to additional engineering, monitoring, and construction requirements.

9.1 Criteria

The general requirements included in Table 1 in conjunction with the following requirements must be met to obtain approval for a pipeline and utility crossing(s) that qualifies as a Process 2 crossing(s).

Table 3: Process 2 – Intermediate

Dimension Criteria	
Outside pipe diameter	300 mm (12 in.) to 1500 mm (59 in.)
Cover between BOR and top of pipe	Greater than 1.5 m (5 ft.) or two (2) pipe diameters whichever is greater.



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Adjacent structures including switches and signals	Within 2.5 times, cover between BOR and top of pipe.
Depth of pipes outside ZPTL	Less than 0.91 m (3 ft.) burial within ZPTL.
Excavation Criteria	
Excavation close to CPKC track(s)	Excavations or jacking/access pits within 10 m (32.8 ft.) of the closest track centerline.
Crossing angle	More than 45 degrees off perpendicular to the track.
Construction Method	
	1. Trenchless method¹ 2. Pipe bursting will only be considered where the predicted soil heave is less than 10% of the movement that would result in a change of the FRA or TC track class.

¹ Trenchless methods include Auger Boring (AB), Pipe Jacking, Pipe Ramming (PR), Horizontal Directional Drilling (HDD) except high pressure fluid jetting method, Microtunnelling (MT) but exclude any type of mining techniques where any stand up time is required before the tunnel support is placed.

9.2 Application Requirements

- 9.2.1 Identification of the Geotechnical Engineer of Record (GER). The GER will be responsible for the proposed works on CPKC's ROW from project start up to project closeout including submission of construction summary report and as-built drawing.
- 9.2.2 Description of the subsurface soil and ground water conditions within and adjacent to CPKC embankment along the proposed pipe/track crossing alignment and to a depth no less than 1.5 times the invert depth below the BOR.



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This will consider the impact of silt, fine sand or sand soil, and their relation to the water table and pipe depth. First set of deep monitoring points to be placed on either side of the outside rail at 2m distance off track centerline measured from outside of the rails. Additional deep monitoring points to be placed at the toe of slope and at end points/toes of ZPTL. Signal and fibre locates to be completed before installing any settlement monitoring equipment in the railway right of way.

- 9.2.3 An estimate of the expected extent and magnitude of ground movement over time based on the proposed pipe installation method will be provided.
- 9.2.4 A program of ground surface and subsurface (settlement plates) movement monitoring will be implemented. The program must be capable of detecting movement of no less than 50 percent of the movement that would result in a change of the track class as determined by the FRA or TC track safety rules. A real-time remote settlement monitoring system should be used, aiding in reduction of requirements for overnight railway flagging protection when work is paused, but within the ZPTL. Remote settlement monitoring is recommended for all Class 3, 4, and 5 tracks. Manual methods of gathering settlement monitoring readings (such as rod and level) will only be entertained with prior approval.
- 9.2.4.1 A GIMP (Geotechnical Instrumentation and Monitoring Plan) system will be required if installation is occurring within the zone of potential loading of rail bridge supporting piers or abutments. The instrumentation installed is intended to monitor short and long term embankment performance, along with settlement and stability due to the subsurface site conditions and the nature of the proposed construction activities.
- 9.2.5 A procedure for notification of the appropriate CPKC personnel in the event that excessive or unexpected settlement occurs. A complete 24 Hour CPKC Emergency contact list, including local personnel and OC will be compiled and in place before any work proceeds within the railway right of way.
- 9.2.6 A recovery plan will be provided outlining the steps to be implemented in the event of failure (excessive ground loss or settlement / collapse, heaving etc).
- 9.2.7 Design of de-watering control measures where applicable for the proposed construction method.
- 9.2.8 Temporary track support system will be required if any of the excavation is closer than 6 m (19.7 feet) from the centre of track and encroaches on the zone of



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potential track loading. The length of the excavation and an estimated stand-up time of the proposed cut within these limits must be provided and demonstrated to be safe.

- 9.2.9 A complete description of the proposed construction method.
- 9.2.10 Confirmation that the proposed construction/installation technique is suited to the site conditions and performance criteria. An assessment of the influence of construction on the track structure including estimated settlement/heave and assessment of risk associated with uncontrolled loss of ground or heaving.
- 9.2.11 Based on CPKC's review of the conditions, CPKC Geotechnical group may elevate a proposed crossing to Process 3 if deemed necessary.
- 9.2.12 A qualified independent CPKC approved engineer is required to provide periodic or continuous (at the discretion of CPKC) on-site supervision and document conditions during construction.

9.3 Application Review and Approval Process

- 9.3.1 Applicant submits engineering documents and **utility crossing application** to the CPKC Utilities Department.
- 9.3.2 CPKC Utilities Department reviews documents to check if appropriate **and accurate** engineering documents have been provided.
- 9.3.3 CPKC approved **Geotechnical** service provider to review initially & sign off on behalf of CPKC at applicant's expense. CPKC Geotechnical to provide final geotechnical approval.
- 9.3.4 CPKC Structural Engineering Group may have to provide structural approval, if required.
- 9.3.5 CPKC Utilities Department – To provide final decision or approvals.

10.0 Process 3 – Detailed

Process 3 will be applicable to those crossing(s) applications that do not meet the conditions of Process 2. In this case, expert engineering submissions are required, along with additional work such as dewatering as well as monitoring by on site engineering consultants during construction.



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10.1 Criteria

The general requirements included in Table 1 in conjunction with the following requirements must be met to obtain approval for a pipeline crossing(s) that qualifies as a Process 3 crossing.

Table 4: Process 3 – Detailed

Dimension Criteria	
Outside pipe diameter	Greater than 1500 mm (59 in.)
Cover between BOR and top of pipe	Less than 1.5 m (5 ft.) or two (2) pipe diameters.
Adjacent structures, switches and signals	Within 2.5 times, cover between BOR and top of pipe.
Depth of pipes outside ZPTL	Less than 0.91 m (3 ft.) burial within ZPTL.
Excavation close to CPKC track(s)	Excavations or jacking/access pits within 10 m (33 ft.) of the closest track centerline.
Excavation Criteria	
Excavation close to CPKC track(s)	Excavations or jacking/access pits within 10 m (30 ft) of the closest track centerline.
Crossing angle	More than 45 degrees off perpendicular to the track.
Construction Method	



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All methods considered

Ground conditions, complex installation method, and/or the complexity of the project warrant that specialist-engineering personnel review the design and or construction of the pipe/track crossing(s).

10.2 Application Requirements

10.2.1 The applicant will meet the requirement outlined in Process 2 - Section 9.2.

10.2.2 The applicant will provide resources for CPKC to retain CPKC approved service provider(s) or experts(s) to assess and review the application and advise CPKC on the impact of the applicant's proposal on CPKC ROW.

10.3 Application Process and Approval Process

10.3.1 Applicant submits engineering documents to CPKC Utilities. All applications will be processed as per the procedure outlined in Section 9.3.

11.0 Pre-Construction Meeting Requirement

Prior to commencement of any work within CPKC property/ROW, the Geotechnical Engineer of Record (GER) or their designate shall arrange a pre-construction meeting at least thirty days before with all stakeholders to discuss project and construction details including work description, construction methods and schedule, restrictions, safety, hours/days of work, start time, Daily Reporting & other CPKC requirements and agreed upon Protocols governing Extreme Weather/Rainfall Warning Alerts issued from Local/National weather offices. This may mean that drilling operations ceases until these Alerts are no longer in effect. It is the responsibility of the GER or their designate to ensure that flagging protection has been arranged for the duration of the project, all construction oversight and track settlement monitoring review has been arranged with CPKC approved service provider and that the expectations have been clearly communicated before construction commences.

12.0 Daily Inspection & Reporting during Construction

This section is applicable to Process Levels 2 and 3 application proposals. The agreement holder or applicant will identify a Geotechnical Engineer of Record (GER) responsible for the complete work and installation of proposed crossing/excavation within CPKC ROW from start to finish. The Geotechnical Engineer of Record may assign a competent/trained person to act as Site



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Inspector/Engineer who will be present onsite during the full duration of the bore or any other ground disturbance activity within railway operating corridor, unless, otherwise directed by CPKC Utilities Supervisor. Depending on the complexity of the installation and or field issues encountered during the installation that may adversely impact CPKC Infrastructure, CPKC may, at their discretion, assign a full time Geotech Monitor, of their choice, to be on site, at the Applicant's expense.

CPKC flagger or assigned representative must be present at all times when working or drilling within CPKC property or rail operating corridor. **No movement of pipe within the ROW or ZPTL is permitted without the presence of a CPKC flagger unless prior written approval from CPKC for an exemption has been provided.** The Site Inspector/Engineer must have the required training, experience and understanding of the site conditions, proposed design, and construction methodology to make sound engineering judgement and decisions, and reports during the course of the work.

The Site Inspector/Engineer must ensure that the work is being carried out in accordance with the approved designs, permits and procedures, and/or relevant specifications. The Site Inspector/Engineer must immediately report any issues encountered during construction work and could have an impact on CPKC assets and its operations. Some examples include instability or potential of instability of the embankment or potential ground settlements either future or immediate.

Any concerns about the imminent stability of the grade shall immediately be escalated to CPKC Flagger or representative in order to protect against train operations. In addition, refer to CPKC 24 Hour Emergency Contact list to use in case of emergency. The concerns shall also be escalated to the GER and CPKC Utilities supervisor so immediate remediation plans can be implemented.

The Site Inspector/Engineer will provide a daily report to CPKC approved service provider, copying CPKC Utilities supervisor, CPKC's Director Geotechnical Engineering and the GER, outlining the progress during the day, any deviations from the original plans, any unexpected ground conditions, or any issues that were encountered during the construction. The report shall also contain relevant information that assures CPKC that the field activities are being monitored and documented to ensure that the installation is proceeding in accordance with approved plans and no unexpected conditions/issues are expected. Some examples of relevant information examples include some of the following information:

- A quantitative estimation of amount of material removed versus theoretical material;
- Auger location - Location of both, the leading edge of the pipe and the location of the leading edge of the auger should be documented;



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- A description of the progress and any observations or issues encountered during the pipe installation including geologic conditions, change in material composition, characteristics, etc.

The daily report will also include all settlement monitoring data, along with any pertinent photos. If applicable, this report will also make notes and highlight any measures taken for “out of compliance” practice or when conditions requiring attention are expected or encountered. See Appendix B for a Sample Report.

A mid-day report should also be submitted by 13:00 local time each day until installation clears the railway right of way and no further movement is occurring due to the installation activities. This requirement can be reviewed and waived if agreed upon by all parties during the preconstruction meeting.

Upon completion of the construction and installation of pipeline and utility crossing(s), the GER will provide a final sealed and stamped letter/construction report to CPKC approved service provider with a copy to CPKC Utilities supervisor confirming that the work has been completed in accordance with the approved plans and procedures. If there are any deviations from the approved plans/procedures, these must be noted in the final letter/report. As-built stamped drawings are to be submitted to the CPKC Utilities Department along with final settlement data collected and correspondence.

All costs associated with above mentioned i.e. complete geotechnical review, track settlement monitoring, flagging and construction oversight provided CPKC approved service provider will be borne by the applicant.

A contract between CPKC approved service provider(s) and the applicant must be place before proceeding with this work proposal.

13.0 Review Steps

The following is a checklist of steps that will be completed to ensure that the appropriate level of care has been taken for Process 2 and 3 pipe crossings below the track.

Table 5 – Review Steps

No.	Step	Action/Review by
-----	------	------------------



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Last Updated: March 12, 2024

Engineering
Geotechnical & Utilities

No.	Step	Action/Review by
13.1	Submission of crossing(s) proposal by applicant including details of the crossing(s) specification and potential construction method(s) to CPKC Utilities.	Applicant
13.2	Review of the proposal as per this protocol to determine what level of geotechnical engineering and review is required.	CPKC Utilities
13.3	Designation of review i.e. CPKC approved service provider. (ASP)	CPKC Utilities
13.4	Identification of the Applicant's Geotechnical Engineer of Record.	CPKC Geotech Engineering/ASP
13.5	Assessment of adequacy of the geotechnical investigation and other required information.	CPKC Geotech Engineering/ASP
13.6	Applicant's geotechnical engineer determines that the proposed construction/installation method will not cause settlement of the CPKC track or structures.	CPKC Geotech Engineering/ASP
13.7	Settlement monitoring program, if required and developed by the applicant's geotechnical engineer.	CPKC Geotech Engineering/ASP
13.8	Once a contractor has been selected, the Geotechnical Engineer of Record (GER) will review the shop drawings submitted by the contractor or the sub-contractor(s) to determine if the tunnelling and dewatering (if required) method proposed could cause track settlement.	CPKC Geotech Engineering/ASP
13.9	Applicant will provide CPKC with written documentation of who will be completing the onsite review of the contractor's construction practice and the specifics of the assignment.	CPKC Geotech Engineering/ASP
13.10	Applicant will enlist the services of a Geotechnical Engineer of Record (GER) with the responsibility for inspection of the tunnelling contractor's work. They will also assure that adequate measures are in place to minimize the potential for track settlement. The intention is to assign an appropriate group with the task of assuring that actions undertaken by the contractor do not endanger the track structure because of ground loss during tunneling which may affect CPKC Train operations.	CPKC Geotech Engineering/ASP
13.11	An emergency response will be developed and posted on site and will reside with key personnel.	CPKC Geotech Engineering/ASP
13.12	A contingency plan will be prepared and submitted by Tunneling contractor prior to start of construction, identifying tasks/activities that can be completed within hours to get track back in service, if	CPKC Geotech Engineering/ASP



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Last Updated: March 12, 2024

Engineering
Geotechnical & Utilities

No.	Step	Action/Review by
	significant track settlement is experienced.	
13.13	24 Hour Emergency Contact List to be provided prior to commencement of construction.	CPKC Utilities

14.0 Abandoned Pipe/Track Crossing(s)

In the event that an existing installation is abandoned or a proposed crossing(s) is abandoned during construction, all potential hazards to CPKC property must be removed or abated. This may be achieved by removal of any buried pipes and the backfill and compaction of any excavations. Alternately, upon approval of the CPKC Geotechnical group any voids within ground may be backfilled with non-shrinkable fill, or pressured grout sufficient to prevent future sloughing or track settlement. Any buried material (wood or metal) that could increase or decrease volume over time due to chemical reaction (oxidation) or decomposition must be removed or stabilized to the satisfaction of CPKC.



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Appendix A

SAMPLE DAILY REPORT AND SETTLEMENT REPORT

SAMPLE DAILY REPORT

PROJECT INFORMATION

Project Name: _____ Date: July 11, 2019

Location: _____ Contractor: _____

Client: _____ Site Rep: _____

DAILY SUMMARY

Excavation Details:

[i.e., depth, sideslopes, trench boxes, sloughing, etc.]

No additional casing installed today. No sloughing of CPR embankment noted. See attached sketch.

Construction Summary:

[i.e., soil type, issues, etc.]

Contractor attaching shoes (wedges) to the casing exterior near the casing head behind the gravel plug (approx. station 0+031). One shoe on track west side of casing approx. 250 mm X 300 mm X 50 mm (deep outside of casing). One shoe on bottom of casing approx. 275 mm X 300 mm X 25 mm (deep outside of casing).

Cumulative Settlement Movement (mm):

☒ Minimal Movement (<8) ☐ Level 1 – Warning (≥8 to <16) ☐ Level 2 – Critical (≥16)

Compliance with Design:

☐ Yes ☒ No If No, discuss below

Issues with Installation:

☒ Yes ☐ No If Yes, discuss below

Other Notes, if any:

Casing was out of alignment by approximately 40 mm track west and 25 mm lower than designed location at about station 0+031. Contractor attaching shoes (wedges) to the casing exterior near the casing head behind the gravel plug (approx. station 0+031) for alignment correction.

Prepared By: _____

Reviewed By: _____



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

SAMPLE DAILY SETTLEMENT MONITORING REPORT

SETTLEMENT MONITORING

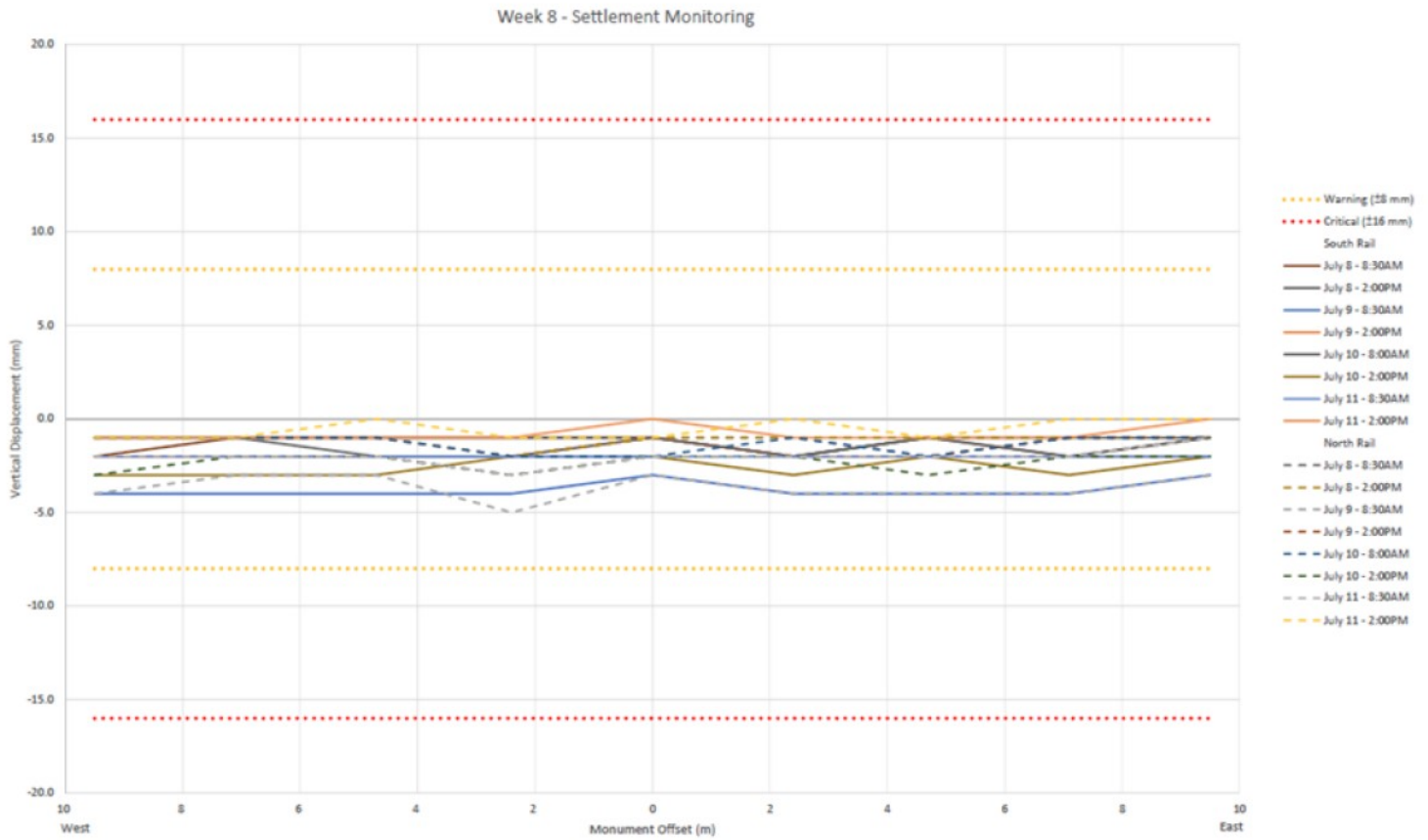
Surveyor: D. Makowsky (Stantec) **Date:** July 11, 2019 **CPR Flagman:** kasnpai jaswai
Weather: Sunny **Temperature:** 16°C at 8:30 am; 27°C at 2:00 pm

*Survey locations along the top of the rails. **Baseline elevation is average of 2 surveys on June 12, 2019. ***Positive numbers correspond to heave and negative numbers correspond to settlement

Rail Location	Location Description and Monument ID*	Baseline Elevation (m)**	Reading 1			Reading 2		
			Time	Elevation (m)	Cumulative Movement (mm)***	Time	Elevation (m)	Cumulative Movement (mm)***
South Rail	9.45 m East (S9)	1034.587	8:30 am	1034.585	-2	2:00 pm	1034.587	0
	7.08 m East (S8)	1034.593		1034.591	-2		1034.592	-1
	4.72 m East (S7)	1034.597		1034.595	-2		1034.596	-1
	2.36 m East (S6)	1034.601		1034.599	-2		1034.600	-1
	Centerline (S5)	1034.605		1034.603	-2		1034.605	0
	2.36 m West (S4)	1034.612		1034.610	-2		1034.611	-1
	4.75 m West (S3)	1034.618		1034.616	-2		1034.617	-1
	7.08 m West (S2)	1034.622		1034.620	-2		1034.621	-1
	9.45 m West (S1)	1034.626		1034.624	-2		1034.625	-1
North Rail	9.45 m West (N1)	1034.624		1034.622	-2		1034.623	-1
	7.08 m West (N2)	1034.621		1034.619	-2		1034.620	-1
	4.75 m West (N3)	1034.617		1034.615	-2		1034.617	0
	2.36 m West (N4)	1034.612		1034.609	-3		1034.611	-1
	Centerline (N5)	1034.604		1034.602	-2		1034.603	-1
	2.36 m East (N6)	1034.599		1034.597	-2		1034.599	0
	4.75 m East (N7)	1034.597		1034.595	-2		1034.596	-1
	7.08 m East (N8)	1034.590		1034.588	-2		1034.590	0
	9.45 m East (N9)	1034.586		1034.585	-1		1034.586	0



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks





CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

SAMPLE TRENCHLESS INSTALLATION MONITORING REPORT

TRENCHLESS INSTALLATION MONITORING

Equipment:	Air Hammer	Operator:	Jorden Calgary Tunneling
Casing Pipe Diameter:	750 mm	16 mm overcut on casing head	
Date:	July 11, 2019	2m plug at casing head during installation	

Date	Segment No.	Segment Length (m)	Station Interval along the Face of Installation	Length of Pipe Installed (m)	Distance of Head to CL Track (S or N) (m)	Soils Condition/Description
July 7, 2019	1	6.0	0+015	6.0	18 m N	Gravel, sandy, some silt, trace clay. Dry
July 8, 2019	2	6.0	0+021	6.0	12 m N	Gravel, sandy, some silt, trace clay. Dry
July 9, 2019	3	6.0	0+027	6.0	6 m N	Gravel, sandy, some silt. Damp
July 9, 2019	4	6.0	0+033	6.0	0 m (CL Track)	Gravel, sandy, some silt. Damp
July 10, 2019 July 11, 2019						No casing installed, contractor attaching shoes (wedges) to casing at station 0+031



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks





CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Appendix B

TRACK MOVEMENT MONITORING GUIDELINES FOR TRENCHLESS PIPE INSTALLATION

Track Movement Monitoring Guidelines for Trenchless Pipe and Utility Crossing(s) Installation under Railway Tracks

The monitoring of track settlement should be carried out by means of surface and subsurface settlement points. The intent of subsurface settlement points is to measure voids created just in the vicinity and above the pipe during construction in order to predict the potential movement of overlying CPKC tracks.

The settlement point essentially consists of a small diameter pipe anchored at the bottom of a vertical borehole and an outer casing to isolate the pipe from down drag forces caused by settlement of soil above the anchor (see Figure B). The subsurface settlement points would be installed to 1 m above the crown of the casing profile. The total number of subsurface settlement points within CPKC Right-of-Way (ROW) along the axis of the proposed pipe crossing(s) would be installed as per the configuration shown in Figure A – Sample Surface and Subsurface Settlement Monitoring Layout.

Surface points installed directly along the base of both rails at a spacing of 9.45 m (31 ft.) over the projected settlement trough would be used to monitor differential transversal elevation between both rails. The total number of surface settlement points within CPKC ROW would be installed as per the configuration shown in Figure A – Sample Surface and Subsurface Settlement Monitoring Layout. These points shall be monitored simultaneously with the subsurface settlement points that would act as a precursor to potential surface movement during pipe installation.

Once the installation is complete, a monitoring program of all points is to be carried out in accordance with the following instructions:

1. Monitoring should start before the excavation of the pits and pipe installation begins and readings should be taken at least twice per day for no less than two days. This is required to establish a reliable methodology and demonstrate the accuracy to be achieved.
2. Monitoring should proceed through the construction period and should be completed:
 - 1) For branch lines/lines with low traffic - (Class 1-2 Track) - At least twice daily.
 - 2) For main lines and heavy traffic lines – (Class 3-5 Track) Every 2 hours and before and after each train, whichever provides the most number of readings while the boring operation is within the ZPTL (Zone of Potential Track Loading).



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

3. Monitoring should continue for at least 3 days after the completion of construction.
4. If there is any loss of ground during pipe installation, any reason to believe settlement may be delayed or any settlement is identified during the installation of pipe or subsequent monitoring period, the monitoring must be continued until the applicant's Geotechnical Engineer of Record deems it is safe to discontinue such monitoring. This must be approved by CPKC Geotechnical Engineering group or CPKC approved service provider reviewing the monitoring results.

Monitoring measurements should be taken with sufficient frequency (as noted above) to capture the unexpected performance at the earliest possible stage and be evaluated in a timely manner. Additional measures will be proposed should this monitoring protocol be considered insufficient based on the ground conditions or installation process. Track survey preference would be for survey shots to be taken remotely (i.e. off CPKC property) and without the requirement of a CPKC Flagger or representative presence on site.

Two alarm levels are proposed:-

Level 1:

ALERT – (Review Threshold) must be indicated on the field memo/report when a settlement of **50 (%)** of the critical monitoring threshold is obtained from the subsurface and/or surface settlement points. A survey of the surface points will then be carried out and work will be authorized to continue if no movement of the subsurface point has been measured from the previous reading. If movement of the rails is recorded, monitoring will be continued until rail movement is stopped. At this point, the drilling work will then be authorized to continue. See Figure C – Track Settlement Monitoring Review and Alert Threshold for Threshold values per Class of Track designation. Please contact CPKC Utilities Supervisor to obtain Class of Track designation pertaining to the proposed Utility Crossing location. CPKC Geotechnical Engineer/Utility Supervisor should be called to discuss these findings in order to discuss next steps.

Level 2:

CRITICAL – (Stop Work) - Installation **must** come to an immediate stop if monitoring points trigger Critical levels.

Above information must be indicated on the field memo/report when a settlement of specified monitoring threshold is obtained from the subsurface settlement point. A survey of the surface points will then be carried out and work will be authorized to continue if no movement is measured for at least two (2) readings taken 12 hours apart. If movement of the rails is recorded, monitoring will be continued until movement is stopped and the applicant has submitted a new pipe installation procedure. This procedure must be reviewed and approved by CPKC Geotechnical Engineering group or CPKC approved service provider reviewing the monitoring results.

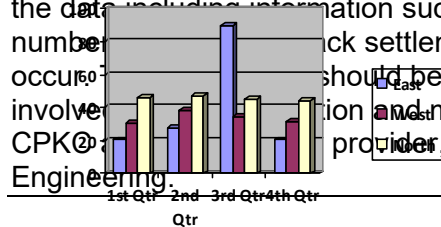
The applicant and their Geotechnical Engineer of Record are responsible for ensuring that track settlement does not occur and for notifying CPKC Roadmaster or their designate, as indicated



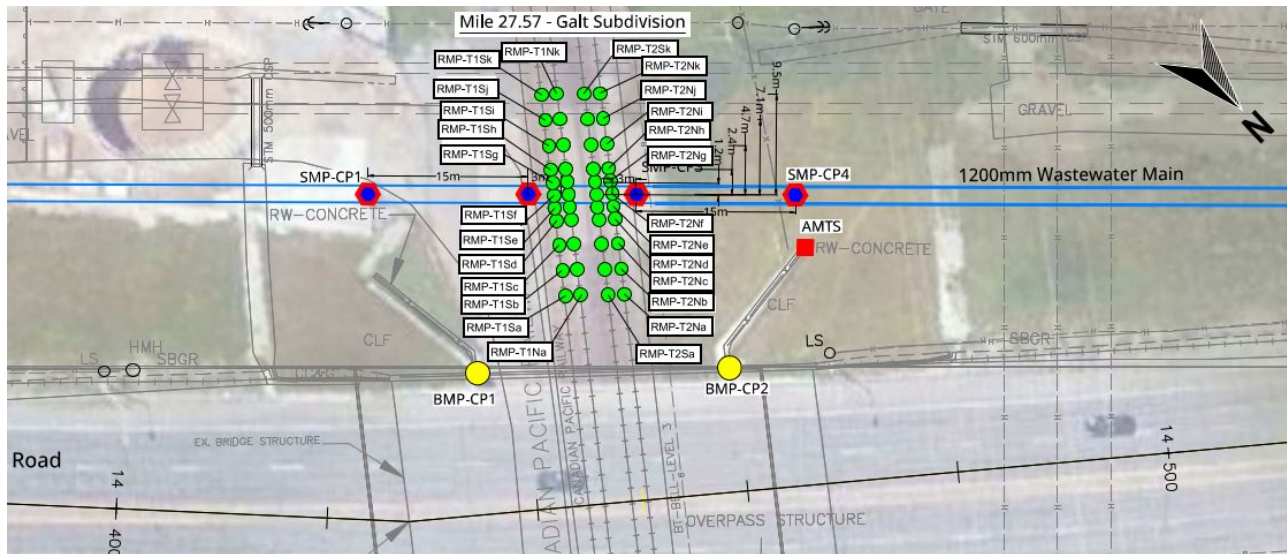
CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

on the 24 Hour Emergency Contact List, should unforeseeable track settlement occur or be expected.

The above guidelines do not relieve the applicant and their engineer(s) of this responsibility. The applicant or their engineer(s) shall provide the settlement information and their interpretation of the data including information such as: no track settlement, deep settlement etc., a quantitative number of times track settlement has occurred, is likely to occur and when it is likely to occur. This information should be provided in easily understandable terms for all parties involved in the project and should be directed to local CPKC Roadmaster, CPKC District Engineer, CPKC Area Supervisor – CPKC Utilities and Director of Geotechnical Engineering.



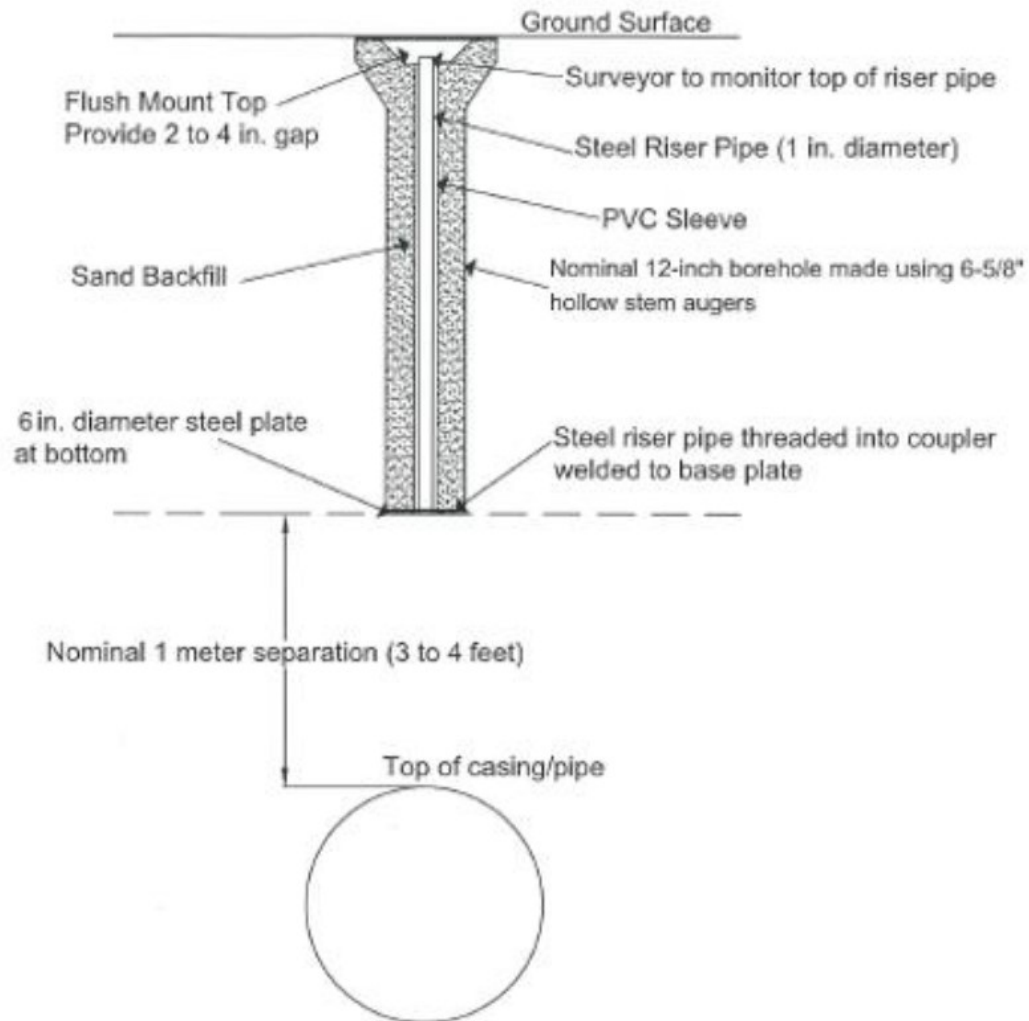
SAMPLE TRACK SETTLEMENT MONITORING DRAWING





CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Figure A - Sample Surface and Subsurface Settlement Monitoring Layout





CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Figure B – Track Settlement Monitoring Critical and Alert Thresholds (Surface and Subsurface)

<u>Class of track</u>	<u>Critical Threshold</u>	<u>Alert Threshold</u>
1	22 mm	11 mm
2	22 mm	11 mm
3	19 mm	10 mm
4	16 mm	8 mm
5	13 mm	6 mm
6	10 mm	5 mm

Note – All above numbers are maximum values

Class of Track

TRACK CLASSES

Class	Freight Train Speed	Passenger Train Speed
1	10 MPH	15MPH
2	25 MPH	30 MPH
3	40 MPH	60 MPH
4	60 MPH	80 MPH
5	80 MPH	95 MPH* 90 MPH **
*Denotes for LRC trains – 100 MPH	** - Applies to US only	Note – Numbers above are maximum values



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

Appendix C

ADDITIONAL NOTES & INSTALLATION REQUIREMENTS

1. Many of CPKC's properties contain buried parallel fibre optic networks. CPKC will supply the appropriate 1-800 numbers to call to ensure the protection of these fibre lines when crossing. The applicant must arrange with the various fibre maintenance providers for the proper hand digging and exposure of the fibre cable prior to commencing construction. No pipelines or cable crossings are to be installed at less than 1 vertical meter above or below the fibre cables, and no buried parallel occupancies, poles or anchors are to be located within 3 horizontal meters of the fibre optic cables.

2. In absolutely no instance is the utility to be installed without receiving prior approval from CPKC and arranging with the Utilities group for track protection. Any contractors entering the property prior to making these arrangements or without the presence of a CPKC representative will be subject to immediate and lengthy work stoppages by the railway.



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

CASING AND INSTALLATION OF LONGITUDINAL PIPES, AND PIPES IN CLOSE PROXIMITY TO BRIDGES AND IMPORTANT STRUCTURES:

The AREMA Specifications address pipeline installation in proximity to railway bridges with the following clauses:

1. Pipelines shall be located, where practicable, to cross tracks at approximately right angles thereto but preferably at not less than 45 degrees and shall not be placed within culverts nor under railway bridges where there is a likelihood of restricting the area required for the purposes for which the bridges or culverts were built, or of endangering the foundations.
2. Pipelines laid longitudinally on railway rights-of-way shall be located as far as practicable from any tracks or other important structures. If located within 25 feet (7.62M) of the centerline of any track or where there is danger of damage from leakage to any bridge, building or other important structure, the carrier pipe shall be encased or of special design as approved by the engineer.

Whereas the AREMA specifications require that longitudinal pipelines, and those in proximity to a bridge or other important structure be encased if within 7.62 M of the track or structure, or of special design as approved by the engineer, should the pipeline be encased;

1. CPKC requires that the length of the casing pipe adjacent to a track shall be for the full length of pipe falling within the 7.62 M distance from the track, and
2. If adjacent to a bridge or structure, the casing pipe must extend to the point where the end of the casing pipe is a minimum of 7.62 M beyond the nearest points of the structure or bridge foundation.

In all cases, the design engineer must be confident that the depth, ground conditions and method of installation used will not in any way interfere with the integrity of the track bed and/or adjacent foundations and they must also provide CPKC with a stamped design plan or report, detailing the installation methodology to be used.



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

The following tables may be used for water, sewer, steam and non-flammable substances, and are Metric versions of the tables contained in the AREMA manual.

Minimum Wall Thickness for Steel Casing Pipe for E80 Loading:

Diameter (mm) less than or equal to	When coated or cathodically protected Nominal Thickness (mm)	When not coated or cathodically protected Nominal Thickness (mm)
324	4.77	4.77
356	4.77	6.35
406	5.59	7.14
457	6.35	7.92
559	7.14	8.74
610	7.92	9.53
660	8.74	10.31
711	9.53	11.13
762	10.31	11.91
813	11.13	12.70
914	11.91	13.49
965	12.70	14.27
1016	13.49	15.09
1067	14.27	15.88
1168	15.09	16.66
1219	15.88	17.48
1270	16.66	18.26
1321	17.48	19.05
1372	18.26	19.84
1473	19.05	20.62
1524	19.84	21.44
1575	20.62	22.23
1626	21.44	23.01
1727	22.23	23.83
1778	23.01	24.61
1829	23.83	25.40

Note: The length of steel casing pipe in this table and the steel carrier pipe in the following table must be as per CPKC Specification 2.39 Appendix A.

The inside diameter of the casing pipe must be at least 50.8 mm larger than the outside diameter of the carrier pipe if the carrier pipe is 152.4 mm or less. For all carrier pipes with outside diameters in excess of 152.4 mm, the inside diameter of the casing pipe must be at least 101.6 mm larger than the outside diameter of the carrier pipe.



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

The following Tables give the minimum thickness for steel carrier pipe for E80 loading.

Note: The length of the steel carrier pipe in these tables must be as per CPKC Specification 2.39 Appendix A. Additionally, all carrier pipes that are not provided with cathodic protection, (impressed current or sacrificial anode) must be a minimum of 1.59 mm thicker than shown in these tables.

Dia. (mm)	Minimum Yield Strength (mPa) > =					Minimum Yield Strength (mPa) > =				
	241	290	358	414	483	241	290	358	414	483
	MAOP < = 689 kPa					MAOP < = 1379 kPa				
<=457.2	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77
508	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
558.8	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74
609.6	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
660.4	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14
711.2	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14
762	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92
812.8	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74
863.6	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74	8.74
914.4	9.53	9.53	9.53	9.53	9.53	10.31	9.53	9.53	9.53	9.53
965.2	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31	10.31
1016	10.31	10.31	10.31	10.31	10.31	11.91	10.31	10.31	10.31	10.31
1066.8	10.31	10.31	10.31	10.31	10.31	12.7	10.31	10.31	10.31	10.31

Dia. (mm)	Minimum Yield Strength (mPa) > =					Minimum Yield Strength (mPa) > =				
	241	290	358	414	483	241	290	358	414	483
	MAOP < = 11721 kPa					MAOP < = 12411 kPa				
<= 101.6	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78
114.3	4.78	4.78	4.78	4.78	4.78	5.16	4.78	4.78	4.78	4.78
141.3	6.55	4.78	4.78	4.78	4.78	6.55	5.56	4.78	4.78	4.78
168.3	7.11	6.35	4.78	4.78	4.78	7.92	6.35	5.56	4.78	4.78
219.1	9.53	7.92	6.35	5.56	4.78	9.53	7.92	6.35	5.56	4.78
273.1	11.13	9.27	7.92	6.5	5.56	11.91	10.31	7.92	7.09	6.35
323.9	13.49	11.13	9.53	7.92	7.14	14.27	11.91	9.53	8.74	7.14
355.6	15.09	12.7	10.31	8.74	7.92	15.88	12.7	10.31	9.53	7.92
406.4	16.66	14.27	11.13	10.31	8.74	17.48	15.09	11.91	10.31	8.74
457.2	19.05	15.88	12.7	11.13	9.53	19.84	16.66	13.49	11.91	10.31
508	20.62	17.48	14.27	12.7	10.31	22.23	18.26	15.09	12.7	11.13
558.8	23.01	19.05	15.88	13.49	11.91	24.61	19.84	16.66	14.27	12.7
609.6	25.4	20.62	16.66	15.09	12.7	26.19	22.23	18.26	15.88	13.49
660.4	26.97	23.01	18.26	15.88	13.49	28.58	23.83	19.05	16.66	14.27
711.2	29.36	24.61	19.84	17.48	15.09	30.96	25.4	20.62	18.26	15.88
1016	36.53	30.96	25.4	22.23	19.05	38.89	32.54	26.97	23.01	19.84
1066.8	38.89	32.54	26.97	23.83	19.84	---	34.14	27.79	24.61	21.44



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

REQUIREMENTS FOR THE DESIGN OF STEEL CULVERTS CARRYING RAILWAY TRAFFIC

1. Design Specifications

AREMA Manual of Recommended Practice, Chapter 1: Part 4: Culverts, latest edition.

2. Type of Construction, Materials, Structural Design and Installation

Culverts may be constructed with corrugated steel pipe (CSP, shop fabricated); structural plate corrugated steel pipe (SPCSP, field fabricated) or steel pipe (bored or jacked).

CSP installations shall be in accordance with CPKC Standard Plans B-1-4950-1 (Canada) or B-1-4950-2 (United States). These standard plans outline material, structural and installation requirements for CSP installations up to 1800 mm (6'-0") in diameter.

SPCSP installations, and installations using materials other than corrugated steel, require specific design and plans relating to material, structural and installation requirements to be prepared by a qualified professional engineer.

Steel pipe installations shall be in accordance with Table 4.9 "Least Nominal Wall Thickness for Steel Casing Pipe in Cased Crossings and Carrier Pipe in Uncased Crossings" in C.S.A. Standard Z662, latest edition, as amended by the Transport Canada "Standards Respecting Pipeline Crossings Under Railways" (originally invoked May 10, 2001); or as otherwise required by the proposed method of installation.

3. Hydraulic Design

Many culverts, based on history of the installation and experience of local officers, are replaced in-kind without need of a hydrological assessment. However, a hydrological assessment is required for new culvert installations, installations where a change in watercourse conditions has occurred, or where required by regulatory authorities. Where a hydrological assessment is performed, culvert requirements shall be determined in accordance with the following hydraulic criteria:

1. Culverts under main line tracks shall be designed for the following, whichever is greatest;

The 50-year flood with culvert pipes flowing no greater than 2/3 full (head to depth ratio less than 0.67); or

The 100-year flood with culvert pipes flowing no greater than full (head to depth ratio less than 1.00), where culvert cover is not less than 1500 mm (5'-0"). Where culvert cover is less than 1500 mm (5'-0") culverts shall be designed for the 100-year flood frequency flow with culvert pipes flowing no greater than 2/3 full (head to depth ratio less than 0.67).

2. Culverts under secondary and branch lines shall be designed for the following, whichever is greatest;

The 50-year flood with culvert pipes flowing no greater than full (head to depth ratio less than 1.00); or

The 100-year flood with culvert pipes flowing with a headwater depth no greater than 50% of the diameter of the pipes above the top of pipe (head to depth ratio less than 1.50). However the headwater depth shall not be less than 1 metre (3 feet) below base-of-rail.



CPKC Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks

The following table lists the minimum requirements for round CMP pipes used as casing pipes for water, sewer, steam and non-flammable materials.

Culvert Size (mm) (Inside Dia.)	Corrugation Profile (mm)	Min. Depth of Cover (base of rail to top of pipe) (mm)	Max. Depth of Cover (m) (base of rail to top of pipe)			
			Specified Wall Thickness (mm)			
			1.6	2	2.8	3.5
300	68 x 13	1100	15.2	15.2		
380	68 x 13	1100	12.2	12.2		
460	68 x 13	1100	9.1	9.1	16.8	
530	68 x 13	1100	7.6	7.6	13.7	
600	68 x 13	1100	7.6	7.6	12.2	13.7
760	68 x 13	1100			9.1	10.7

In all cases where inside diameters exceed 760 mm, CMP casing pipes shall be designed as per CPKC standard plan B-1-4950-1.

Culverts must be zinc or aluminum coated. Additional coatings and couplings shall be provided as per CPKC standard plan B-1-4950-1.

Some supplementary information contained in the AREMA specification, regarding pipeline (not including Gas and Oil pipelines) and casing pipes for wire crossings of the Railway is as follows:

Calculation for Cooper E80 Loading for pipelines in pounds per square foot

T_{E80} = Total E80 Load in pounds per square foot

L_L = Live Load in pounds per square foot

I_P = Impact Loading Percentage

L_D = Dead Load in pounds per square foot

D = Lateral Live Load Distribution Length in feet

H = Depth of cover in Feet

W = Weight of overburden in pounds per cubic foot.

$$T_{E80} = L_L * (1.0 + I_P) + L_D$$

$$L_L = 80000 / (5 * D)$$

$$L_D = W * H + 200 / D$$

$$I_P = (10 - H) * .04 \quad \text{Negative results equate to zero.}$$

$$D = (8.5 + H)$$

Colton Wooster
Geotechnical EIT
T: 204-928-8479
M: 204-583-8797
E: colton.wooster@aecom.com

German Leal, M.Eng., P.Eng.
Discipline Lead, Geotechnical
T: 204-928-8479
M: 431-335-9734
E: german.leal@aecom.com

AECOM Canada ULC
99 Commerce Drive
Winnipeg, MB R3P 0Y7
Canada

T: 204.477.5381
F: 431.800.1210
www.aecom.com