Quality Engineering | Valued Relationships

City of Winnipeg

Erin Street Rail Crossing
Geotechnical Investigation Report (Revision 2)

Prepared for:
Ryan Gama
Contract Administrator
Water and Waste Engineering Division
City of Winnipeg
110-1199 Pacific Ave.
Winnipeg, MB R3E 3S8

Project Number: 0015-041-00

Date: April 27, 2021

Quality Engineering | Valued Relationships

April 27, 2021

Our File No. 0015-041-00

Ryan Gama
Contract Administrator
Water and Waste Engineering Division
City of Winnipeg
110-1199 Pacific Ave.
Winnipeg, MB R3E 3S8

RE: Erin Street Rail Crossing – Geotechnical Investigation Report (Revision 2)

TREK Geotechnical Inc. is pleased to submit our Revised Final Report for the geotechnical investigation for the above noted project. The revisions are related to an updated monitoring plan that includes the BNSF rail crossing, and a modified sending and receiving pit configuration.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

Nelson Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	Steven Harms	February 23, 2021	Final Report
1	Steven Harms	February 26, 2021	Revised Final Report
2	Steven Harms	April 27, 2021	Revised Final Report

Authorization Signatures

Prepared By:

PROVINCE OF MANITOBA
S.M.
HARMS
Member
36160
Apr 27/21
REGISTERED PROFESSIONAL ENGINEER

Steven Harms, M.Sc., P.Eng.
Geotechnical Engineer

Reviewed By:

Nelson Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Apr. 27, 2021

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This report summarizes the results of the geotechnical investigation conducted by TREK Geotechnical Inc. (TREK) for the City of Winnipeg (the City) for the proposed water main (WM) crossing under the Canadian Pacific (CP) and BNSF Railway Company (BNSF) Rail lines in Winnipeg, Manitoba. The crossing is located along Erin Street, approximately 80 to 150 m south of Notre Dame Ave. The terms of reference for the investigation are included in our proposal to the City dated January 12, 2021. The scope of work includes a sub-surface investigation, laboratory testing, and the provision of geotechnical recommendations for the design and construction of the water main installation in compliance with CP Rail requirements. A construction monitoring program to monitor track displacements to determine if movements are within CP Rail's tolerable limits is also included.

TREK contacted BNSF regarding the proposed work and the geotechnical submission requirements they require. Since the encasement pipe is less than 660 mm diameter, BNSF does not require a geotechnical submission for the proposed water main installation. However, BNSF does require that track displacements are monitored during the installation to determine if movements are within BNSF's tolerable limits. Therefore, a construction monitoring program for the BNSF rail line has also been included.

2.0 Background and Site Conditions

The proposed water main consists of a 200 mm outer diameter PVC carrier pipe installed within 407 mm outer diameter steel encasement pipes. The watermain will be installed parallel to Erin Street beneath the south lane approximately 2 m west of the south curb and will cross beneath the CP L-Lead Track at Mile 1.20 and the BNSF rail line at an unknown mileage (BNSF did not provide track subdivision or mileage information for the proposed crossing location). The two rail lines run parallel to each other with the BNSF line situated north of the CP line.

Two steel encasement pipes will be installed: one beneath each rail line. The encasement pipes within the CP and BNSF right of ways will be 32.8 and 32.3 m long, respectively, and will be installed using the horizontal directional drilling (HDD) trenchless installation method. The encasement pipes will be installed in two drill shots from opposite directions, with sending pits south of the CP right of way and north of the BNSF right of way and a central receiving pit between the rail lines. Once the encasement pipes are installed, the carrier pipe will then be fed through the encasement pipes and installed to the design grade. The proposed sending and receiving pit locations along with the encasement pipe alignment are shown on Figure 01. The sending pits will be located outside of the CP and BNSF right of ways, and the central receiving pit will be located outside the BNSF right of way, but will encroach past the north CP property line by approximately 1.5 m. The obvert of the water main encasement pipe will be approximately 3.7 m below the CP and BNSF base of rail (BOR).

<u>CP Rail Requirements</u>

CP Rail requires geotechnical protocols be followed for pipe installations below their right of way in accordance with their stipulated guidelines, *Geotechnical Protocol for Pipeline and Utility Crossing(s) under Railway Tracks*. The guidelines include geotechnical protocols regarding subsurface investigations, recommendations, and construction settlement monitoring. The L-Lead Track is classified as a Class 1 track and the rail settlement thresholds for trenchless pipe installations based on CP requirements are:

- A warning level of 11 mm and;
- A critical level of 22 mm

Track classification and associated settlement tolerances for the rail were provided by CP Rail. Other relevant information regarding CP Rail's geotechnical protocols for trenchless pipe installations are included in Appendix A.

BNSF Requirements

BNSF outlines the installation criteria that trigger a geotechnical study in their *Utility Accommodation Policy*. A geotechnical study is required for a pipe that is greater than 660 mm diameter and within 3.7 m below the top of rail tie. This project, therefore, does not require a geotechnical study, but a surficial track monitoring program is still required during construction. The BNSF settlement/heave threshold for trenchless installations is 6 mm.

2.1 Site Conditions

The construction area for the crossing is grass-covered south of the BNSF line and gravel surfaced / paved north of the BNSF line. The ground surface along the water main alignment crowns between the rail lines to approximately 0.5 m above the rail lines at the central receiving pit, and slopes down to the north and south; the ground surface at the sending pits is approximately 0.2 to 0.4 m lower than the rail lines.

3.0 Sub-surface Investigation

3.1 Drilling Program

A sub-surface investigation was performed on January 27, 2021 under the supervision of TREK personnel to evaluate the sub-surface conditions at the site. Test holes TH21-01 and TH21-02 were drilled and sampled to depths of 6.9 and 5.9 m below ground surface, respectively near the proposed sending pit locations (Figure 01).

Test holes were drilled by Maple Leaf Drilling using a Mobile B40 truck-mounted rig equipped with 125 mm diameter solid stem augers. Sub-surface soils observed during drilling were visually classified based on the Unified Soil Classification System (USCS). Samples retrieved during drilling included disturbed auger cuttings and relatively undisturbed Shelby tubes. All samples retrieved during drilling were transported to TREK's testing laboratory in Winnipeg, Manitoba. Laboratory testing consisted of moisture contents on all samples; bulk unit weight measurements and undrained shear strength tests (Qu, pocket penetrometer and torvane) were performed on select samples. Laboratory testing results are included in Appendix B.

The test hole locations were recorded using a handheld GPS. Test hole elevations were surveyed using a rod and level relative to the CP top of Rail (TOR), which was assigned a temporary benchmark elevation of 100.00 m. This benchmark has a geodetic elevation of 233.1 m based on preliminary drawings provided by the City; TREK's temporary elevations have been adjusted accordingly in this report. The attached test hole logs include a description of the soil units encountered and other pertinent information such as test hole location, elevation (temporary), groundwater and sloughing conditions, and a summary of the laboratory testing results.

3.2 Subsurface Conditions

3.2.1 *Soil Stratigraphy*

Brief descriptions of the soil units encountered at the test hole locations are provided below. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached test hole logs.

In general, the soil stratigraphy at the sending and receiving pits consists of a silty clay to the maximum depth of exploration (6.9 m, El. 226.1 m). A layer of silt was encountered between 1.5 and 1.8 m depth (El. 231.2 and 230.9 m) in TH21-01 and between 1.8 and 2.7 m depth (El. 231.1 and 230.2 m) in TH21-02.

The clay above the silt layer is silty with trace to some sand and trace organics, moist and firm to stiff when thawed, and of high plasticity. The silt layer contains some clay and trace sand, and is soft to very soft and of low to intermediate plasticity. Below the silt layer, the clay is silty, firm to stiff and of high plasticity.

3.2.2 *Power Auger Refusal*

Power auger refusal was not encountered in the test holes.

3.2.3 *Groundwater Conditions*

Groundwater seepage and sloughing were not observed during drilling. The groundwater observations made during drilling are short-term and should not be considered reflective of long-term (static) groundwater levels. Long-term (static) groundwater conditions can only be determined by monitoring over an extended period to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities

4.0 Trenchless Pipe Installation Recommendations

Based on the drawing provided by the City, the steel encasement pipe inverts are to be at El. 229.13at both ends (horizontal). The obverts of the encasement pipes (407 mm diameter) therefore are at El. 229.54 m, which is about 3.7 m below ground surface at the CP and BNSF Rail centerlines. Based on the proposed water main depth, the pipe will likely be within firm to stiff silty clay at the sending pits. The presence of silt pockets or silt layers of variable thickness and extent are common within the upper 3 m of ground surface in the Winnipeg area, and still may be encountered, albeit at likely less frequency at greater depths. The Contractor installing the encasement pipe should be prepared to encounter soft to very soft low plasticity silt during installation.

TREK has not provided recommendations for a specific trenchless installation method for the encasement pipes, but rather outlines a set of recommendations and considerations that applies to any trenchless method. The tender should allow for the Contractors bidding on the work to identify the best trenchless construction methods available and TREK should be contacted to review the Contractor's proposed installation methodology, once established. Regardless of the installation technique, the installation should be halted while trains are moving over the pipe alignment. Table 01 provides a brief overview of some typical trenchless installation methods.

Trenchless installation techniques have varying levels of control over the alignment of the encasement pipe as installation proceeds. The target grade for the carrier pipe should be considered relative to the potential for misalignment of the encasement pipe. Depending on the level of alignment control, measures could be taken that allow for adjustments to be made to the carrier pipe within the encasement pipe to achieve the design grade (e.g. oversized encasement pipe).

The following considerations and recommendations were developed in consultation with local Contractors and TREK's geotechnical assessment of site conditions. The recommendations relate to settlement due to soil collapse, consolidation, and heave.

The considerations and recommendations provided along with the test hole logs are to aid the Contractor in anticipating conditions that may be encountered during the installation and may not be inclusive of all adverse conditions that may arise. For the purpose of design and construction, the water table could be assumed to be at the top of the silt layer (El. 231.2 m).

4.1 Tunnelman's Soil Classification

The Tunnelman's Soil Classification system developed by Terzaghi (1950) and modified by Heuer (1974) defines the general behaviour of an unsupported tunnel face for different soil types (Appendix C). The silty clay present at the proposed encasement pipe elevation is anticipated to behave as a squeezing and swelling material. If silt is encountered, it is anticipated to behave as a flowing material.

4.2 Settlement

4.2.1 Soil Collapse

The trenchless installation may create a larger opening than the outside diameter of the encasement pipe (rough opening) to facilitate installation. The annulus is the space between the rough opening and the outer edge of pipe; settlement can occur due to the collapse of the annulus, so to limit the potential for settlement the size of the annulus should be minimized.

When considering annulus collapse, the maximum theoretical settlement that can occur at ground surface above the encasement pipe results from a shear failure of the column of soil directly above the pipe that is equal to the difference in diameter between the rough opening and the outer edge of the pipe. The maximum settlement that could be realized at the surface from soil collapse above the pipe would equal to be the size of annulus. Based on the proposed depth of the encasement pipe obvert below the rails (approximately 3.7 m) and the nature of the soils at these depths, the potential surficial settlement resulting from annulus collapse may be less than the theoretical maximum due to soil arching around the pipe. Recommendations for rough opening sizes relative to the pipe diameter are provided in section 4.2.4.

For installation methods that involve a cutting head or augers at the leading edge of the encasement pipe, there is a potential for an unsupported length of soil to be exposed in front of the pipe. The unsupported length should be limited to less than 300 mm; to achieve this, the rough opening must be drilled at the same time encasement pipe is being installed to limit unsupported length. Reaming a rough opening prior to encasement pipe installation is not an acceptable installation method.

4.2.1 Over-Excavation

Settlement at or close to the leading edge of the encasement pipe (commonly referred to as ground loss) can occur as a result of excess soil being removed. The magnitude of ground loss varies depending on the installation methodology selected and is also highly dependent on the workmanship of the contractor. Ground losses, expressed as a percentage of the tunnel volume, typically vary from 0.5% for good practice in favourable soil conditions to 4% or more for poor practice with little face control in unfavourable soil conditions (Hung et al. 2009).

The tunnel face at the leading edge of the encasement pipe should be supported to prevent excessive ground loss, particularly in the event flowing silt is encountered. This support can be achieved using fluid pressure, mechanical support, or a combination thereof. The contractor should provide a detailed plan for their proposed installation method outlining how ground loss can be monitored and quantified during installation, and a contingency plan to mitigate excessive ground loss should it be observed.

4.2.1 Soil Consolidation

Vibrations due to encasement pipe installation can cause consolidation or even liquefaction of the soil surrounding the encasement pipe, depending on the nature of the soil and groundwater conditions. The magnitude of vibrations will vary depending on the installation technique.

Soil settlements due to vibrations during installation are difficult to predict. However, the foundation soils at the site have been subjected to vibrations associated with regular train traffic which would have consolidated the soils encountered during the sub-surface investigation and any vibration-induced settlement likely will have already occurred. While the frequency and amplitude of pipe vibrations will likely be different than that of train loading and the reaction of the soils may differ, this uncertainty will be addressed through surficial and sub-surface monitoring during installation.

Table 01. Typical Trenchless Installation Methods

Method	Typical Installation*		Compatible Soil Type*	Limitations	Notes
	Length (m)	Diameter (mm)			
Auger Boring (Jack and Bore)	12-150	200-1500	Firm to hard cohesive, compact to dense cohesionless	• Soft/loose soil conditions, especially below water table, can result in excessive ground loss	• No annulus unless wing cutters are used, which reduces the potential for settlement, but may increase the potential for heave • Steerable in some cases • Continuous flight augers within pipe during installation excavate soil as installation proceeds • No face support, so not recommended for flowing soil conditions. If soft/loose soil conditions are encountered, particularly below water table, care must be taken to avoid over-excavation and ground loss • Cobbles/boulders larger than 1/3 of pipe diameter could result in obstruction*
Horizontal Directional Drilling (HDD)	12-1800	50-1370	Firm to hard cohesive, compact to dense cohesionless	• Drill fluid pressure can result in hydro fracturing and heave, particularly in shallow installations • High permeability materials can result in drill fluid infiltration. Fluid mix must be selected carefully to maintain pressure to support annulus.	• Reamers typically come in 50 mm diameter increments, so minimum 25 mm annulus created • Steerable • Drill fluid (bentonite slurry) used to lubricate installation, support annulus and remove cuttings. • Experienced operator required to select appropriate drill fluid mix, pressure and installation speed • Cobbles/boulders could hinder or prevent successful installation*
Pipe Ramming	12-60	100-1070	Soft to stiff cohesive, loose cohesionless	• Not steerable, so unable to correct deviations from design grade during installation • Hard/stiff soil conditions can significantly slow or halt the rate of pipe advancement	• No annulus unless external cutting shoe used • Not steerable, and can deflect toward soft/loose material in non-uniform conditions • Vertical face not created during installation, preventing ground loss. • If soil plug forms, soil displacement can result in heave. • Installation vibrations can induce settlement of surrounding soil • Can accommodate cobbles/boulders up to 90% of the pipe diameter, provided they are centered on the pipe alignment.*
Microtunneling	25-225+	250-3000	All	• Typically high cost, but costs have been coming down and becoming more competitive • Annulus needs to be grouted after installation	• Annulus size varies. Drill fluid (bentonite slurry) used to lubricate installation and support annulus • Steerable • Cuttings removed by slurry or augers • Tunnel face supported either mechanically or by drill fluid pressure, provided an Earth Pressure Balance (EPB) microtunneling machine is used. • Cobbles/boulders larger than 1/3 of pipe diameter could result in obstruction*
Tunnel Boring Machine (TBM)	25-500+	1060-3050	Firm to hard cohesive, compact to dense cohesionless	• Typically higher cost • Specialized contractor • Annulus needs to be grouted after installation	• Annulus size varies. Drill fluid (bentonite slurry) used to lubricate installation and support annulus • Steerable • Cuttings removed by cart, conveyor, slurry, auger, or vacuum • Tunnel face may supported if an EPB TBM is used • Cobbles/boulders up to 95% of the pipe diameter may be accommodated. However, if boulders are manually removed, additional ground loss should be expected*

(Iseley & Gokhale, 1997)

4.2.2 Settlement Estimate

Considering the potential for soil collapse, over-excavation and soil consolidation, and in the absence of more rigorous analysis of the soil-pipe interaction, TREK recommends the encasement pipe be installed using methods that limit the rough opening diameter to be 50 mm larger than the encasement pipe diameter (ie. a 25 mm annulus). This is expected to limit rail settlement to be less than 6 mm. If a larger opening relative to the encasement pipe diameter is being considered, TREK should be notified to re-assess the potential for settlement at the tracks.

4.3 Heave

Surface heave and can occur during installation using either drilling or jacking methods. Heave can be a result of the installation technique such as pumping too much drill fluid after a circulation loss, inappropriate drill fluid viscosity, insufficient cover for the tooling used, or pulling/pushing the tooling or encasement pipe through too quickly. The excessive installation pressures associated with heave can also result in drill fluid blow-out, which is an uncontrolled hydraulic connection that develops through cracking between the tunnel and the ground surface. Blow-out has the potential to compromise surficial infrastructure (e.g. rail lines). The Contractor should select the appropriate installation method and modify their approach to suit site conditions.

Heave can also occur if the soil within the encasement pipe forms a soil plug during installation causing the soil in front of the pipe to displace as the encasement pipe continues to move forward. The potential for soil plugging varies depending on the installation technique and is more likely to occur for methods that involve ramming or jacking without continuous, balanced cutting removal.

4.4 Construction Monitoring Program

CP rail and BNSF have different requirements for monitoring during construction, which are summarized below.

It should be noted that short-term natural movement (mostly horizontal) of the rails, in particular due to thermal changes, can exceed the tolerances outlined by CP and BNSF in the absence of any construction activities. In this regard, TREK recommends surficial monitoring points using survey nails be located on the top of the rail tie beside the rail and not on the rail itself to minimize these effects.

4.4.1 CP Rail

CP Rail requires sub-surface and surficial points be monitored prior to, during and after construction to measure any ground movements (settlement and heave) associated with any trenchless pipe installations. Surficial monitoring points will be in pairs at the base of each rail. In total, TREK recommends an array of 2 sub-surface and 22 surficial monitoring points centred on the encasement pipe alignment to satisfy CP Rail's requirements. The sub-surface and surface monitoring point locations are shown in plan on Figure 02. Sub-surface monitoring points will consist of sleeved rods anchored in the soil 1 m above the encasement pipe obvert elevation as shown on Figures 02 and 03; the sleeve is required to isolate the rod from the surrounding soil and provide an accurate reading of ground movement at the anchor depth. TREK can assist in the design of the sub-surface anchors, if requested.

All monitoring points should be surveyed to an accuracy of +/- 2 mm (or better) every 12 hours beginning a minimum of 2 days before the excavation of the pits and finishing a minimum of three days after construction is complete. A higher monitoring frequency may be required while the encasement pipe is being installed within the zone of potential train loading at TREK or CP Rail's discretion. As per CP Rail requirements, there will be two ground movement thresholds (Warning and Critical) that will trigger response measures. The following is a brief summary of CP Rail's monitoring requirements as summarized in their January 24, 2020 document entitled *"Track Movement Monitoring Guidelines for Trenchless Pipe Installation"*, which is included in Appendix A.

Level 1: Warning

The warning level of ground movement for the CP L-Lead Track at Mile 1.20 is 11 mm. If the threshold of ground movement for Level 1 is measured at the sub-surface monitoring points, the surficial survey points must be immediately measured:

- If the surficial monitoring points have not settled or heaved since the previous monitoring event construction can continue;
- If settlement or heave has been observed at the surficial monitoring points, construction must be put on hold until the movement at both the sub-surface and surficial monitoring locations stops. TREK recommends construction can continue when two consecutive monitoring point surveys taken 30 minutes apart indicate no additional ground movement has occurred.

Level 2: Critical

The critical level of ground movement for the CP L-Lead Track at Mile 1.20 is 22 mm. If the threshold of ground movement is measured at the sub-surface monitoring points, construction must be halted, and the surficial survey points must be immediately measured.

- If the surficial monitoring points have not settled or heaved since the previous monitoring event, construction must remain on hold for a minimum of 12 hours to confirm no surficial ground movement is occurring.
- If settlement or heave has been observed at the surficial monitoring points, monitoring of both sub-surface and surficial monitoring points must continue every 12 hours until movement has stopped. In addition, the installation procedure must be modified to mitigate ground movement and approved by CP Rail before construction can continue.

4.4.2 BNSF

BNSF requires surficial points be monitored prior to and during construction to measure any ground movements (settlement and heave) associated with trenchless pipe installations. Surficial monitoring points will be in pairs at the base of each rail. In total, TREK recommends an array of 22 surficial monitoring points centred on the encasement pipe alignment to satisfy BNSF requirements. The surface monitoring point locations are shown in plan on Figure 03.

All monitoring points should be surveyed to an accuracy of +/- 2 mm (or better) twice per day beginning a minimum of 2 days before the encasement pipe installation to establish a baseline and continuing throughout construction. A higher monitoring frequency may be required while the encasement pipe is being installed within the zone of potential train loading at TREK or BNSF's discretion. As per BNSF requirements, a ground movement threshold of 6 mm will trigger specific actions. This is identified as the Warning level, to which TREK has added a Critical threshold as described below.

Level 1: Warning

The warning level of ground movement for BNSF rail lines is 6 mm. If the threshold of ground movement for Level 1 is measured, construction will be paused, and BNSF will be notified and provided the opportunity to conduct an in-person inspection of the track. Following a warning level measurement, TREK recommends additional surveys be taken at 30-minute intervals while construction is paused to identify whether ground movements have stopped. If ground movements have stopped, construction may continue with BNSF approval.

Level 2: Critical

TREK proposes a critical level of ground movement for the BNSF rail line consistent with the CP L-Lead track of 22 mm. If the critical threshold is reached, construction must be halted and BNSF will be notified and provided the opportunity to conduct an in-person inspection of the track. Following a critical level measurement, construction must remain on hold for a minimum of 12 hours to confirm ground movements have stopped. In addition, the installation procedure must be modified to mitigate ground movement and approved by BNSF before construction can continue.

5.0 Temporary Excavations and Shoring

Excavations must be carried out in compliance with the appropriate regulations under the Manitoba Workplace Safety and Health Act. Any open-cut excavation greater than 3 m deep must be designed and sealed by a professional engineer and reviewed by the geotechnical engineer of record (TREK). If space is limited or the stability of adjacent structures or infrastructure may be endangered by an excavation, a shoring system may be required to prevent damage to, or movement of, any part of adjacent structures, and the creation of a hazard to workers and the public. Hydraulic jacking pits and pipe jacking reaction systems should be designed by a qualified structural engineer to support anticipated jacking forces based on the soil conditions at the site.

Excavation stability is the responsibility of the Contractor for the duration of construction. Excavations should be monitored regularly and flattened as necessary to maintain stability recognizing that excavation stability is time and weather dependent. Excavated slopes should be covered with polyethylene sheets to prevent wetting and drying.

Stockpiles of excavated material and heavy equipment should be kept away from the edge of any excavation by a distance equal to or greater than the depth of excavation. Dewatering measures may be required to maintain a dry excavation and permit proper completion of the work. If seepage is encountered, it should be collected and pumped out of the excavation. If saturated silts or sands are encountered, shoring or slope flattening may be required. To prevent wet silts and sands from entering the excavation, gravel buttressing could be used in conjunction with sump pits for dewatering. Surface water should be diverted away from the excavation and the excavation should be backfilled as soon as possible following construction.

Cantilevered (un-braced or braced) walls will be required for deep excavations or physically constrained areas where temporary shoring is necessary. Table 02 provides the recommended earth pressure coefficients and bulk unit weights of silty clay and silt for use in the calculation of lateral earth pressures. Surcharge loads and hydrostatic water pressure should be incorporated into the design of retaining walls and shoring, as well as an adequate factor of safety against instability.

Table 02. Recommended Design Parameters for Retaining Walls and Shoring

Design Parameter	Material	
	Silty Clay	Silt
Active Earth Pressure Coefficient (Ka)	0.5	0.5
At-rest Earth Pressure Coefficient (Ko)	0.7	0.6
Passive Earth Pressure Coefficient(Kp)	1.9	2.2
Bulk Unit Weight, Υ (kN/m³)	18	18

6.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If subsurface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the City of Winnipeg (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

7.0 References

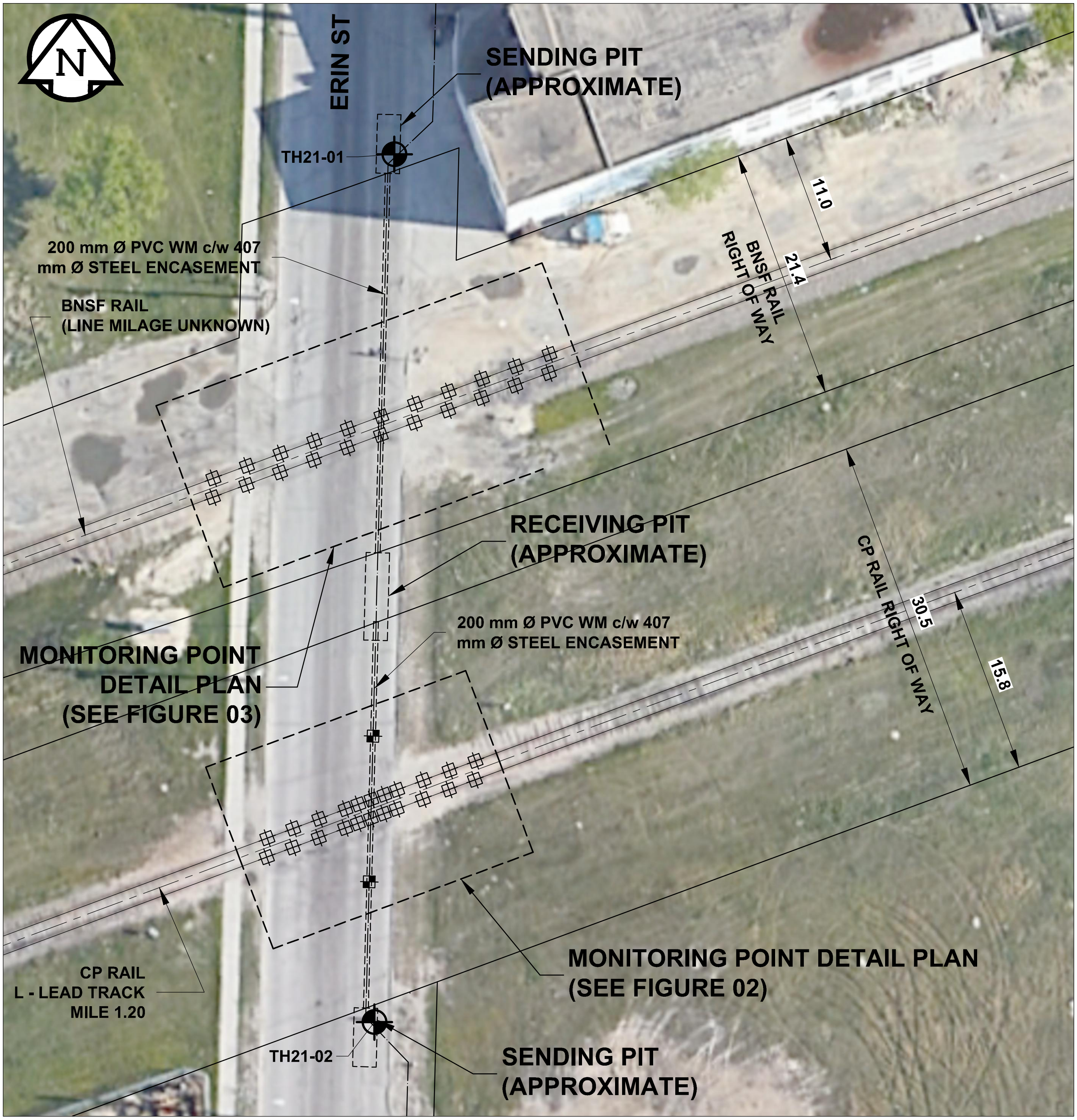
Heuer, R. E. (1974). Important ground parameters in soft ground tunnelling. *Proceedings of Specialty Conference on Subsurface Exploration for Underground Excavation and Heavy Construction*.

Hung, J., Monsees, J., Munfah, N., & Wisniewski, J. (2009). *Bridges & Structures Technical Manual for Design and Construction of Road Tunnels - Civil Elements* (Issue FWHA-NHI-09-010).

Iseley, T., & Gokhale, S. B. (1997). Trenchless Installation of Conduits Beneath Roadways. In *NCHRP Synthesis 242*. Transportation Research Board. http://libraryarchives.metro.net/DPGTL/studies/1997-nchrp-242-trenchless-conduit-installation.pdf

Terzaghi, K. (1950). Geologic aspects of soft ground tunnelling. In Applied Sedimentation. John Wiley & Sons, Inc. .

Figures



NOTES:

1. AERIAL IMAGE FROM GOOGLE EARTH (2020)
2. DIMENSIONS IN METERS.
3. SUB-SURFACE MONITORING POINTS TO BE INSTALLED 1 m ABOVE ENCASEMENT PIPE OBVERT.
4. TOP OF RAIL CAN BE SURVEYED IF BASE OF RAIL NOT ACCESSIBLE.

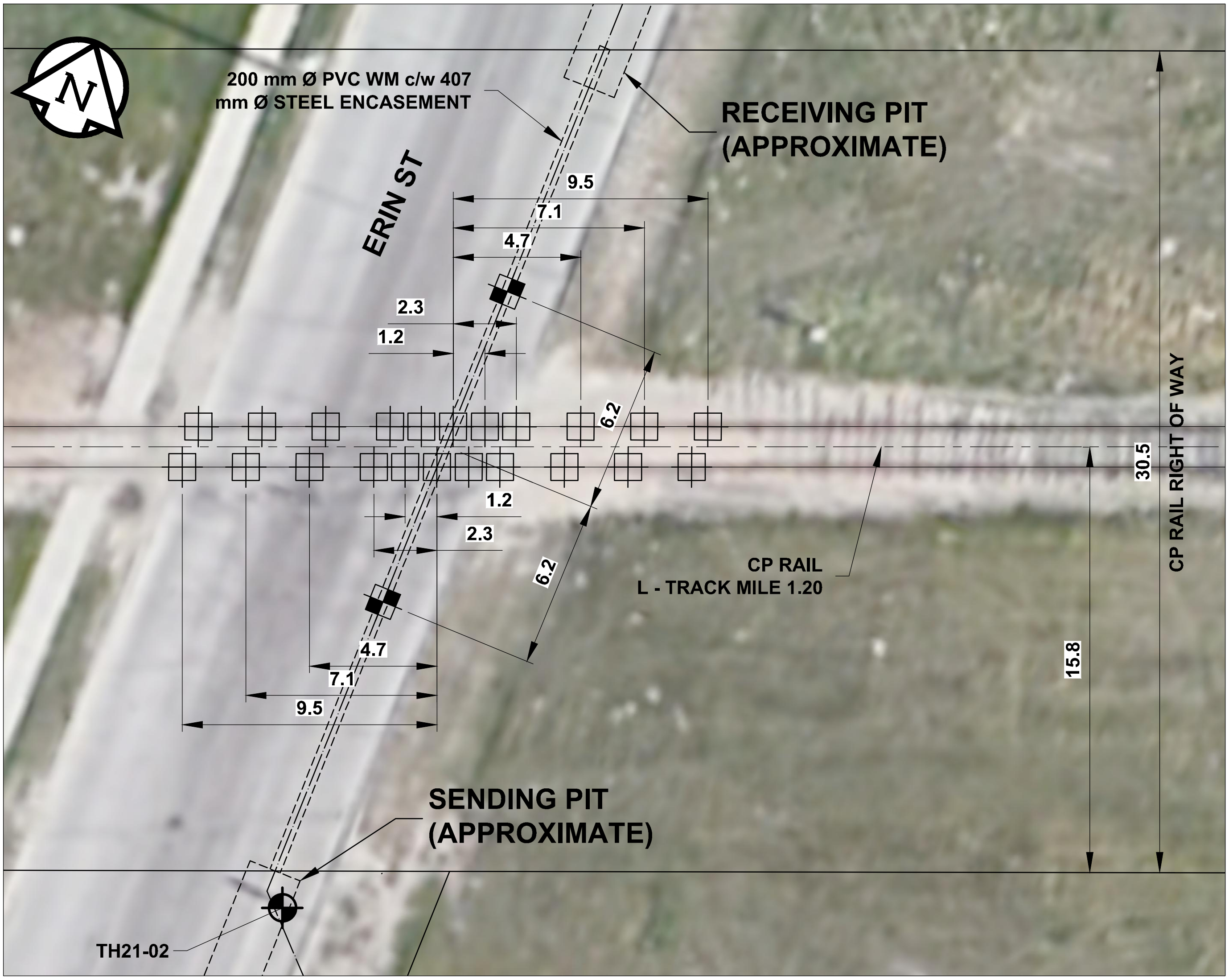
LEGEND:

- TEST HOLE (TREK)
- SURFICIAL MONITORING POINT (BASE OF RAIL)
- SUB-SURFACE MONITORING POINT (FIGURE 03)

0 5 10 15 20 25 m
SCALE = 1 : 500 (219 mm x 279 mm)

Figure 01
Monitoring Point Location Plan

Z:\Projects\0015 City of Winnipeg\0015 041 00 Erin St Rail Crossing\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\0015 041 00_Erin Xing_A_CJH.dwg, 2021-04-21 3:26:24 PM
ANSI full bleed A (8.50 x 11.00 Inches)



NOTES:

1. AERIAL IMAGE FROM GOOGLE EARTH (2020)
2. DIMENSIONS IN METERS.
3. SUB-SURFACE MONITORING POINTS TO BE INSTALLED 1 m ABOVE ENCASEMENT PIPE OBVERT.
4. TOP OF RAIL CAN BE SURVEYED IF BASE OF RAIL NOT ACCESSIBLE.

LEGEND:

- TEST HOLE (TREK)
- SURFICIAL MONITORING POINT (BASE OF RAIL)
- SUB-SURFACE MONITORING POINT (FIGURE 04)

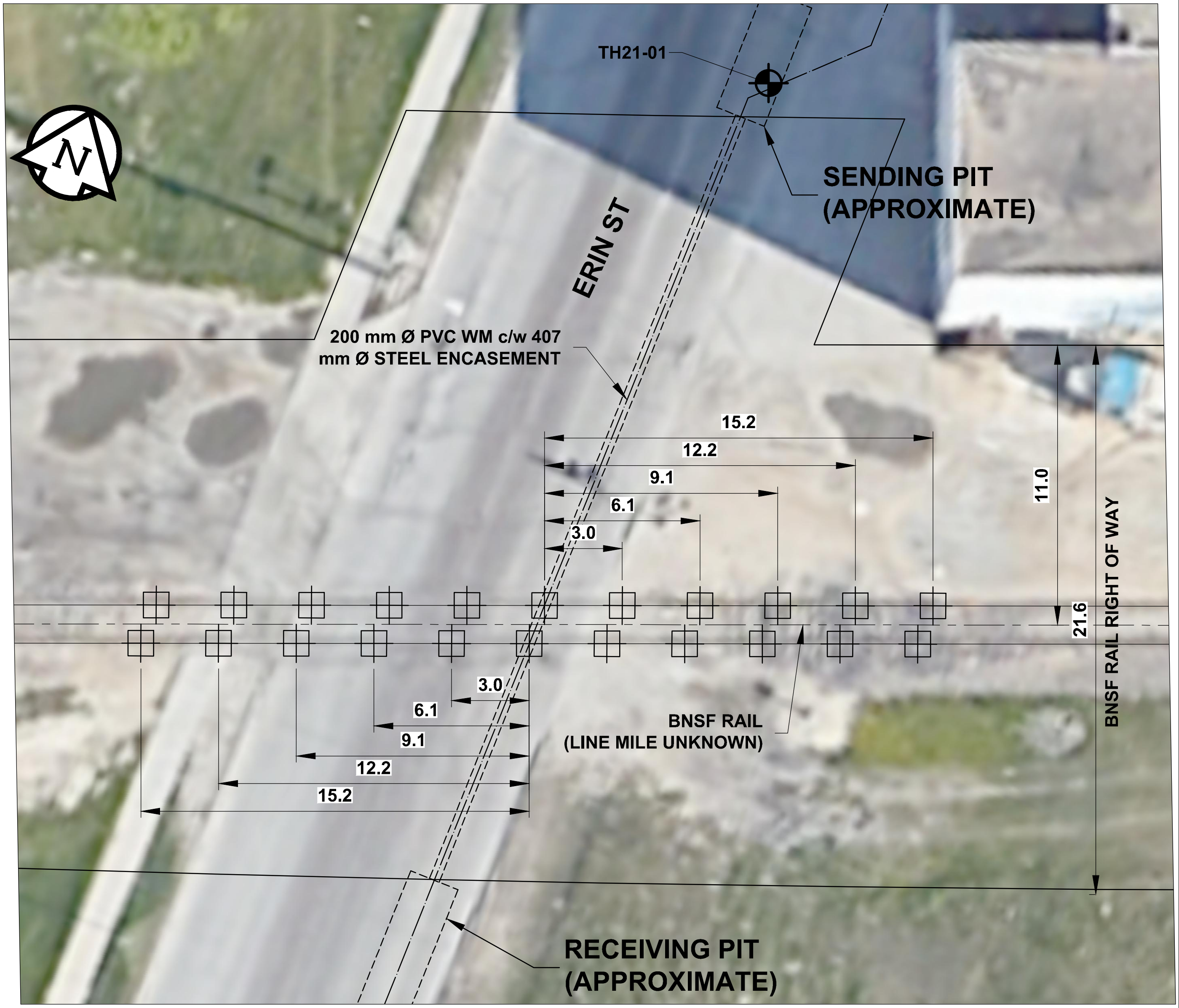
0 2.5 5 7.5 10 12.5 m

SCALE = 1 : 250 (219 mm x 279 mm)

Figure 02

Monitoring Point Detail Plan on CP RAIL Track

0015 041 00
City of Winnipeg
Erin Street Rail Crossing



NOTES:

1. AERIAL IMAGE FROM GOOGLE EARTH (2020)
2. DIMENSIONS IN METERS.
3. SUB-SURFACE MONITORING POINTS TO BE INSTALLED 1 m ABOVE ENCASEMENT PIPE OBVERT.
4. TOP OF RAIL CAN BE SURVEYED IF BASE OF RAIL NOT ACCESSIBLE.

LEGEND:

TEST HOLE (TREK)

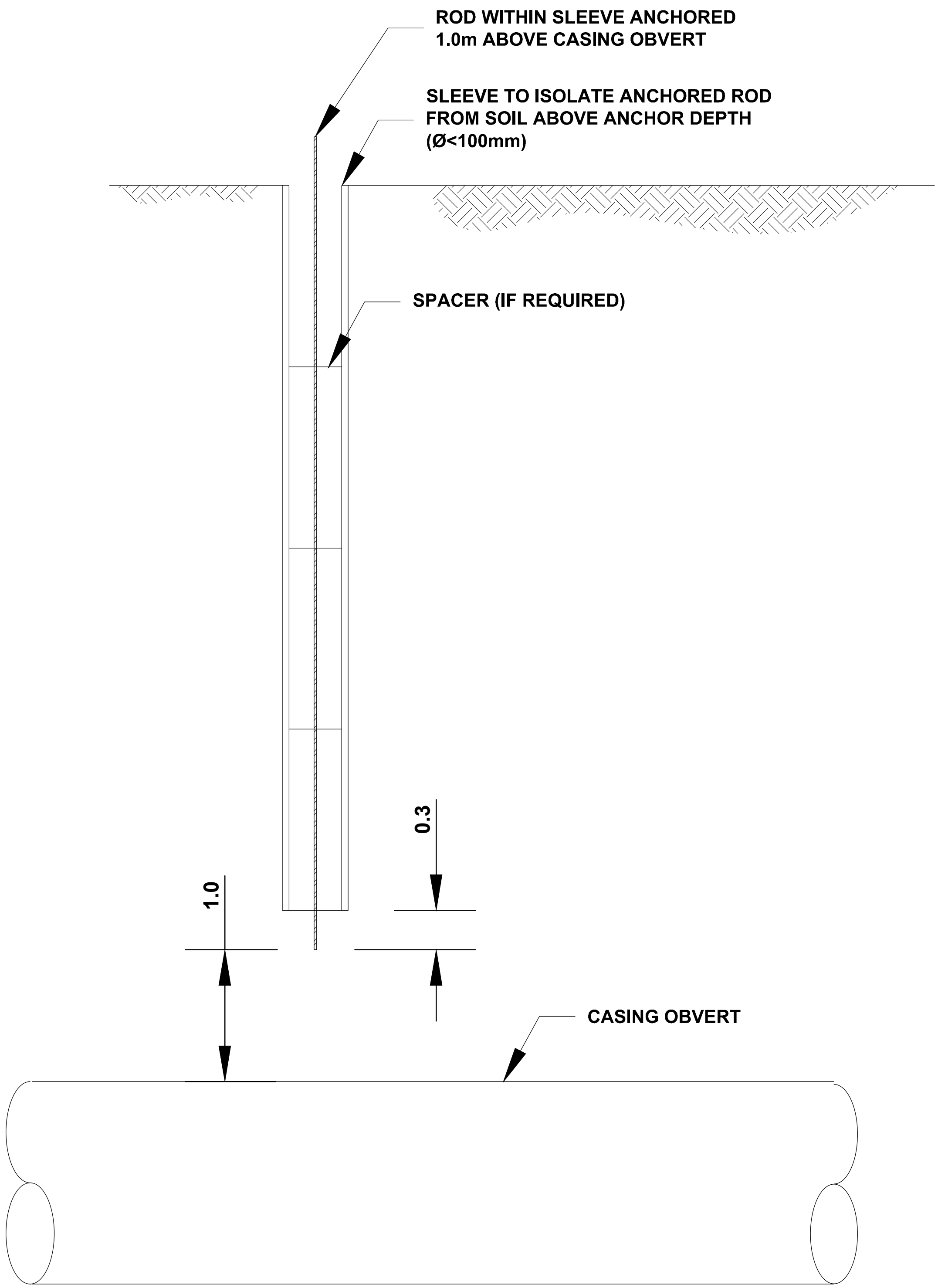
SURFICIAL MONITORING POINT (BASE OF RAIL)

0 2.5 5 7.5 10 12.5 m

SCALE = 1 : 250 (219 mm x 279 mm)

Figure 03
Monitoring Point Detail Plan on BNSF RAIL Track

Z:\Projects\0015 City of Winnipeg\0015 041 00 Erin St Rail Crossing\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\0015 041 00_Erin Xing_A_CJH.dwg, 2021-04-21 3:27:40 PM
ANSI full bleed A (8.50 x 11.00 Inches)



NOTES:

1. MONITORING POINT TO BE PROTECTED AT SURFACE AS REQUIRED, AND FLAGGED.
2. BASE OF ROD SHOULD BE DESIGNED TO PREVENT SETTLEMENT UNDER IT'S OWN WEIGHT.

SCALE: NTS

Figure 04
Sub-Surface Monitoring Point Concept

Test Hole Logs

EXPLANATION OF FIELD AND LABORATORY TESTING

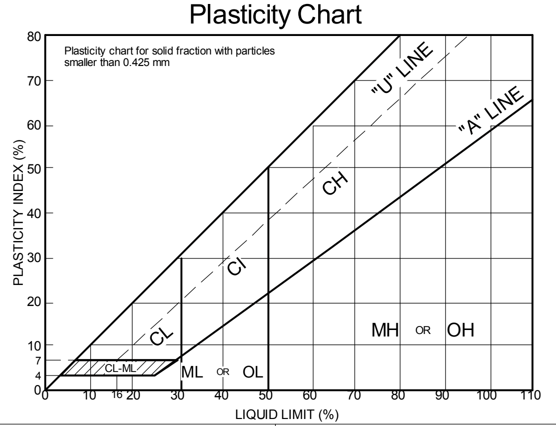
TREK GEOTECHNICAL

GENERAL NOTES

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

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria	
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent....... GW, GP, SW, SP; More than 12 percent....... GM, GC, SM, SC; 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			GP		Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW
		Gravel with fines (Appreciable amount of fines)	GM		Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 / Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC		Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3
			SP		Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW
		Sands with fines (Appreciable amount of fines)	SM		Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4 / Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart	
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL		Organic silts and organic silty clays of low plasticity		
	Silts and Clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts		
			CH		Inorganic clays of high plasticity, fat clays		
			OH		Organic clays of medium to high plasticity, organic silts		
	Highly Organic Soils		Pt		Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture

Plasticity Chart



Material		Particle Size mm	ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

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

Other Symbol Types

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

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL	-	Liquid Limit (%)
PL	-	Plastic Limit (%)
PI	-	Plasticity Index (%)
MC	-	Moisture Content (%)
SPT	-	Standard Penetration Test
RQD	-	Rock Quality Designation
Qu	-	Unconfined Compression
Su	-	Undrained Shear Strength
VW	-	Vibrating Wire Piezometer
SI	-	Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

▼ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

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

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

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

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

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

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

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

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

TREK GEOTECHNICAL

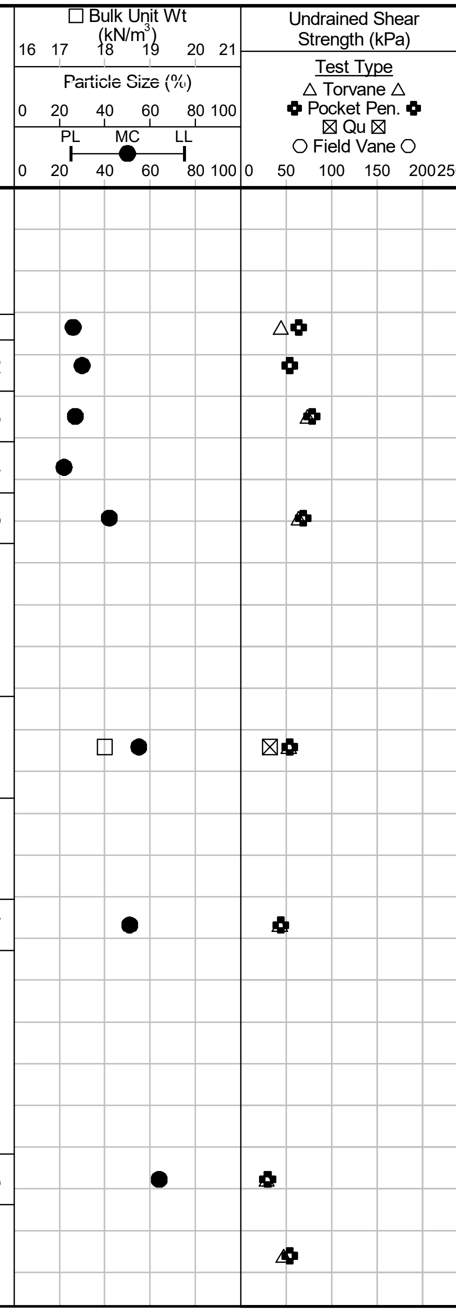
Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015-041-00
Project Name:	Erin Street Rail Crossing	**Location:**	UTM N-5530014, E-630447
Contractor:	Maple Leaf Drilling Ltd.	**Ground Elevation:**	99.67 m (local datum)
Method:	125mm Solid Stem Auger, B40 Mobile Truck Mount	**Date Drilled:**	January 27, 2021

Sample Type: Grab (G) · Shelby Tube (T) · Split Spoon (SS) · Split Barrel (SB) · Core (C)

Particle Size Legend: Fines · Clay · Silt · Sand · Gravel · Cobbles · Boulders

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
99.4	0.0–0.25	ASPHALT - 250 mm thick		
98.9	0.25–0.8	SAND AND GRAVEL (FILL) - trace to some silt, light brown, frozen, dry to moist and compact when thawed, fine sand to coarse gravel, sub-rounded to sub-angular		
98.1	0.8–1.55	CLAY - silty, dark grey, frozen, moist and firm to stiff when thawed, high plasticity - trace organics, black below 0.9 m - dark grey, stiff below 1.2 m	Grab Grab Grab	G01 G02 G03
97.8	1.55–1.85	SILT AND CLAY - trace sand, light brown, moist, soft to very soft, low to intermediate plasticity	Grab	G04
93.0	1.85–6.9	CLAY - silty - dark grey - moist, firm to stiff - high plasticity	Grab Shelby Tube Grab Grab Shelby Tube	G05 T06 G07 G08 T09



END OF TEST HOLE AT 6.9 m IN CLAY
1) No seepage or sloughing observed.
2) Test hole open to 6.9 m immediately after drilling.
3) Test hole backfilled with auger cuttings, granular fill and cold patch asphalt.
4) Test hole elevation surveyed relative to top of rail at Mile 1.20 of the CP L-Lead Track Top of rail assigned benchmark elevation of 100.00 m.

Logged By: Asad Dustmamatov **Reviewed By:** Nelson Ferreira **Project Engineer:** Steven Harms

TREK GEOTECHNICAL

Sub-Surface Log

Client:	City of Winnipeg	**Project Number:**	0015-041-00
Project Name:	Erin Street Rail Crossing	**Location:**	UTM N-5529940, E-630446
Contractor:	Maple Leaf Drilling Ltd.	**Ground Elevation:**	99.83 m (local datum)
Method:	125mm Solid Stem Auger, B40 Mobile Truck Mount	**Date Drilled:**	January 27, 2021

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) | Split Barrel (SB) | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Columns: Elevation (m) | Depth (m) | Soil Symbol | MATERIAL DESCRIPTION | Sample Type | Sample Number | Bulk Unit Wt (kN/m³) 16 17 18 19 20 21 / Particle Size (%) 0 20 40 60 80 100 / PL MC LL 0 20 40 60 80 100 | Undrained Shear Strength (kPa) Test Type △ Torvane △ ✤ Pocket Pen. ✤ ⊠ Qu ⊠ ○ Field Vane ○ 0 50 100 150 200 250

Elevation (m)	MATERIAL DESCRIPTION
99.8	ASPHALT - 75 mm thick
99.5	CONCRETE - 230 mm thick
99.2	SAND AND GRAVEL (FILL) - trace silt, trace clay, light brown, frozen, dry to moist and compact when thawed, fine sand to coarse gravel, sub-rounded to sub-angular
98.0	CLAY - silty, trace organics, trace to some sand - black - frozen, moist and firm to stiff when thawed, high plasticity - dark grey below 1.2 m
97.1	SILT AND CLAY - trace sand - light brown - moist, soft to very soft - low to intermediate plasticity
93.9	CLAY - silty - light brown - moist, firm to stiff - high plasticity

Sample Type	Sample Number
Grab	G10
Grab	G11
Grab	G12
Grab	G13
Grab	G14
Shelby Tube	T15
Grab	G16

END OF TEST HOLE AT 5.9 m IN CLAY
1) No seepage or sloughing observed.
2) Test hole open to 5.9 m immediately after drilling.
3) Test hole backfilled with auger cuttings, granular fill and cold patch asphalt.
4) Test hole elevation surveyed relative to top of rail at Mile 1.20 of the CP L-Lead Track Top of rail assigned benchmark elevation of 100.00 m.

Logged By: Asad Dustmamatov **Reviewed By:** Nelson Ferreira **Project Engineer:** Steven Harms

Appendix A

CP Rail Geotechnical Protocols

GEOTECHNICAL PROTOCOL

FOR

PIPELINE AND UTILITY CROSSING(S) UNDER

RAILWAY TRACKS

Engineering

Geotechnical and Public Works – Utilities

Last Updated: February 25, 2020

Table of Contents

Appendices

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 CP – SP-TS-2.39- Pipeline and Cable Installations within Railway Right of Way. An agreement or permit from Canadian Pacific Railway's Public Works - Utilities 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 (CP) 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. CP does not take any responsibility for the suitability of the construction method or warrantee the ground and/or site conditions. CP 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 CP's needs at the time of review and approval. CP does not provide engineering recommendations, directions or minimum standards to the applicant or their contractor(s) for design and execution of their work within CP Right-of-Way (ROW).

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

CP 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 who will be present onsite during the full duration of the construction and installation within railway operating corridor, unless, otherwise directed by CP Public Works - 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 CP 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 (CP) Railway's operations during the execution of proposed third party pipeline and utility crossing(s) within CP 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 CP Public Works - 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 CP's operations and its assets during the installation and operation of pipeline and utility crossing(s) under CP's tracks and within its ROW;

3.3 Specify minimum criteria to be met for CP's review;

3.4 Ensure adequate subsurface information including geotechnical and groundwater information is available and an assessment by CP's geotechnical group or a CP 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 CP at **1-800-716-9132**.

5.0 Winter Work Restriction within CP ROW

No construction and installation of pipeline and utility crossing(s) will take place from January 1st to 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 CP'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 CP 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 CP review requirements for review. Details of each process are discussed in the following sections.

Table 1 – Process Identification

		Process Levels		
		1. Minimum[1]	**2. Intermediate**	**3. Detailed**
Dimension	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.)

		Process Levels		
		1. Minimum[1]	**2. Intermediate**	**3. Detailed**
	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 CP 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.	
Construction Method		Trenchless method[2]		All methods considered.

	Process Levels		
	1. Minimum[1]	**2. Intermediate**	**3. Detailed**
	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	Public Works - Utility group to approve with no geotechnical submission.	Full review of design, geotechnical and construction method Applicant to pay for the review cost of CP 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 CP 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.

7.2 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 CP.

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 (Appendix A, Figure 1). 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 CP Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CP Public Works - Utilities group;

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;

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 (Appendix A, Figure 2). 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 CP Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CP Public Works - 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) (Appendix A, Figure 3). 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 CP Subdivision naming and Mileage convention. Applicant can obtain the Mileage and Subdivision information from CP Public Works - Utilities group;

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.

7.4 Geotechnical Investigation Report (if applicable) 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. “Warning” 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.

7.8 Proposals for open cut will only be considered at sites where conditions make other installation techniques impractical or where rail traffic is low. This, however, will be assessed on case by case basis.

7.9 Installations using high pressure fluid jetting will not be considered.

7.10 The cost of remediation incurred to CP 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.

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.
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 CP 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,a geotechnical investigation is not required. However, in areas or conditions where problems have arisen with similar pipe crossings CP reserves the right to require a geotechnical investigation to be completed and submitted with the application.

8.2.3 Even if not required by CP, 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 CP Public Works - Utilities.

8.3.2 CP Public Works – Utilities reviews documents to ensure applicable and complete engineering documents are provided.

8.3.3 An assessment is completed by CP Public Works – 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 CP Geotechnical group, Public Works – Utilities or a CP approved service provider but may not 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.
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 CP 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 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.

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 CP's ROW.

9.2.2 Description of the subsurface soil and ground water conditions within and adjacent to CP embankment along the proposed pipe/track crossing alignment and to a depth no less that 1.5 times the invert depth below the BOR. This will consider the impact of silt, fine sand or sand soil, and their relation to the water table and pipe depth.

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.

9.2.5 A procedure for notification of the appropriate CP personnel in the event that excessive or unexpected settlement occurs. A complete 24HR CP 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 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 CP's review of the conditions, CP Geotechnical group may elevate a proposed crossing to Process 3 if deemed necessary.

9.2.12 A qualified independent CP approved engineer is required to provide periodic or continuous (at the discretion of CP) on-site supervision and document conditions during construction.

9.3 Application Review and Approval Process

9.3.1 Applicant submits engineering documents and applications to CP Public Works – Utilities.

9.3.2 CP Public Works – Utilities reviews documents to check if appropriate engineering documents have been provided.

9.3.3 CP approved service provider to review initially & sign off on behalf of CP at applicant's expense. CP Geotechnical to provide final geotechnical approval.

9.3.4 CP Structural Engineering Group may have to provide structural approval, if required.

9.3.5 CP Public Works – Utilities to provide final decision or permits.

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.

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 CP track(s)	Excavations or jacking/access pits within 10 m (33 ft.) of the closest track centerline.
Excavation Criteria	
Excavation close to CP 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	
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 CP to retain CP approved service provider(s) or experts(s) to assess and review the application and advise CP on the impact of the applicant's proposal on CP ROW.

10.3 Application Process and Approval Process

10.3.1 Applicant submits engineering documents to CP Public Works – 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 CP property/ROW, the Geotechnical Engineer of Record (GER) or their designate shall arrange a pre-construction meeting with all stakeholders to discuss project and construction details including work description, construction methods, restrictions, safety, and CP requirements and agreed upon protocol. 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 has been arranged with CP approved service provider and that the expectations have been clearly communicated.

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 responsible for the complete work and installation of proposed crossing/excavation within CP ROW. The Geotechnical Engineer of Record may assign a competent/trained person to act as site inspector 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 CP Public Works - Utilities Supervisor.

CP flagger or assigned representative must be present at all times when working or drilling within CP property or rail operating corridor. 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.

The site inspector 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 must immediately report any issues encountered during construction work and could have an impact on CP 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 CP Flagger or representative in order to protect against train operations. In addition, refer to CP 24HR Emergency Contact list to use in case of emergency. The concerns shall also be escalated to the GER and CP Public Work - Utilities supervisor so immediate remediation plans can be implemented.

The site supervisor will provide a daily report to CP approved service provider, copying CP Public Works – Utilities supervisor, CP'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 CP 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;
- 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.

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 CP approved service provider with a copy to CP Public Works – 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 CP Public Works – Utilities 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 CP approved service provider will be borne by the applicant.
A contract between CP approved service provider(s) and the applicant must be place before proceeding with this 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
13.1	Submission of crossing(s) proposal by applicant including details of the crossing(s) specification and potential construction method(s) to CP Public Works - Utilities.	Applicant
13.2	Review of the proposal as per this protocol to determine what level of geotechnical engineering and review is required.	CP Public Works - Utilities
13.3	Designation of review i.e. CP approved service provider.	CP Public Works - Utilities
13.4	Identification of the Geotechnical Engineer of Record.	CP Geotechnical Engineering
13.5	Assessment of adequacy of the geotechnical investigation and other required information.	CP Geotechnical Engineering
13.6	Applicant's geotechnical engineer determines that the proposed construction/installation method will not cause settlement of the CP track or structures.	CP Geotechnical Engineering
13.7	Settlement monitoring program, if required and developed by the applicant's geotechnical engineer.	CP Geotechnical Engineering
13.8	Once a contractor has been selected, the Geotechnical Engineer of Record will review the shop drawings submitted by the contractor or the sub-contractor(s) to determine if the tunnel and dewatering (if required) method proposed could cause track settlement.	CP Geotechnical Engineering
13.9	Applicant will provide CP with written documentation of who will be completing the onsite review of the contractor's construction practice and the specifics of the assignment.	CP Geotechnical Engineering

No.	Step	Action/Review by
13.10	Applicant will enlist the services of a geotechnical engineer of record with the responsibility for inspection of the tunnel contractor's work. They will also assure that adequate measures are in place to minimize the potential for track settlement. The intention is to ensure that 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.	CP Geotechnical Engineering
13.11	An emergency response will be developed and posted on site and will reside with key personnel.	CP Geotechnical Engineering
13.12	A contingency plan will be identified that can be completed within hours if settlement is experienced.	CP Geotechnical Engineering
13.13	24 Hour Emergency Contact List to be provided prior to commencement of construction.	CP Public Works - 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 CP 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 CP 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 CP.

--*END OF TEXT*--

APPENDIX A

SAMPLE FIGURES 1 TO 3

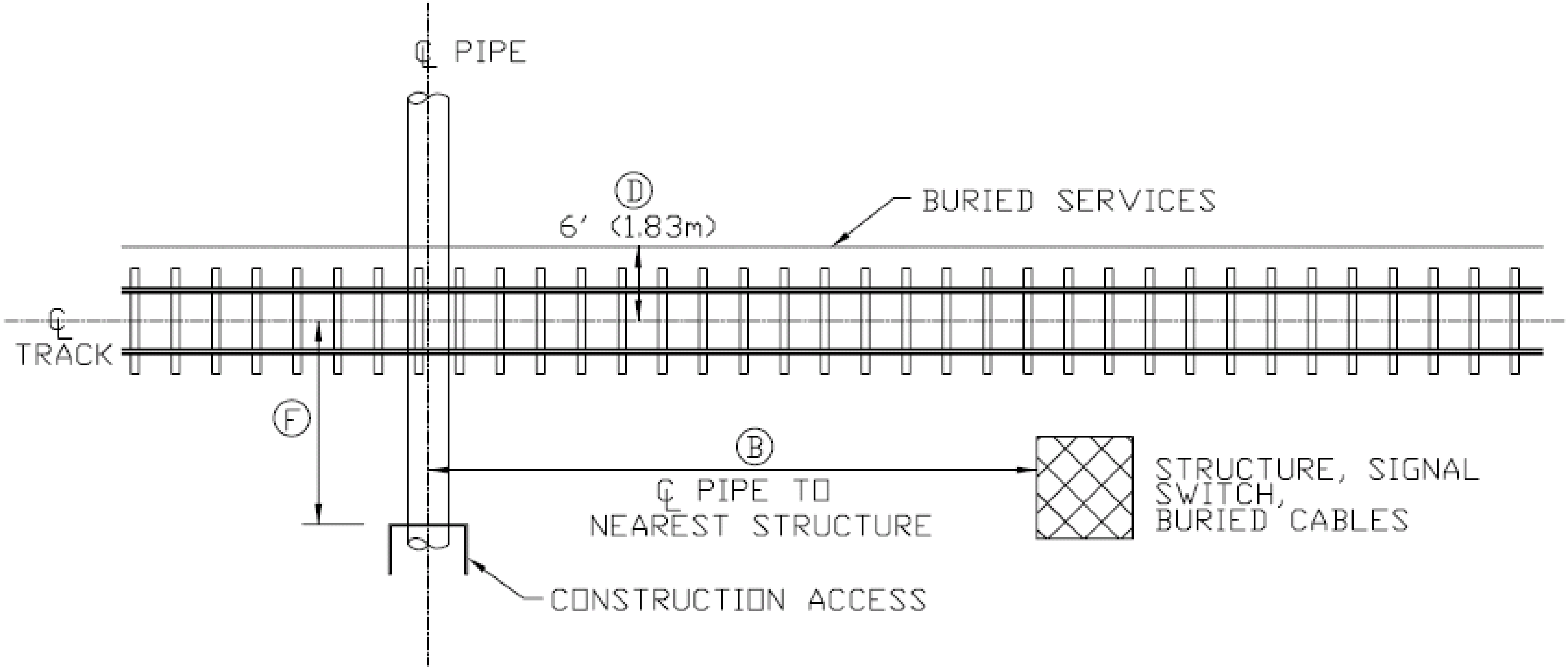


Figure 1 – Plan of the proposed pipe crossing

SAMPLE

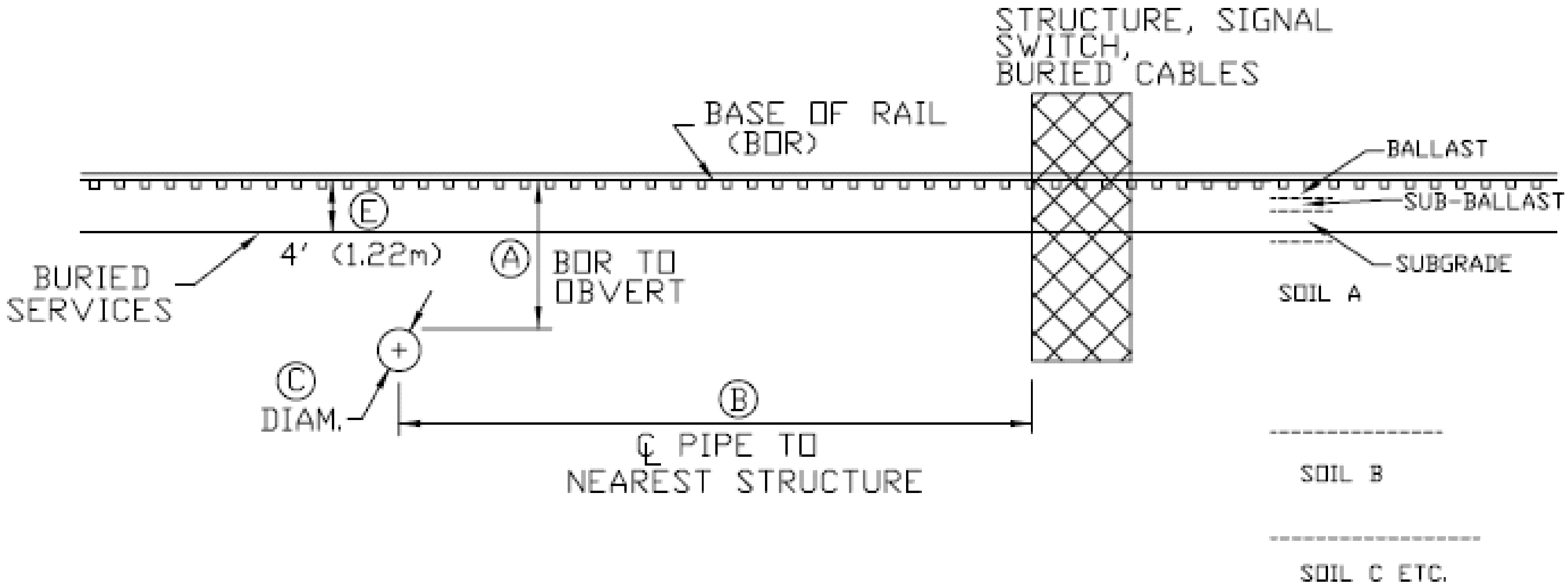
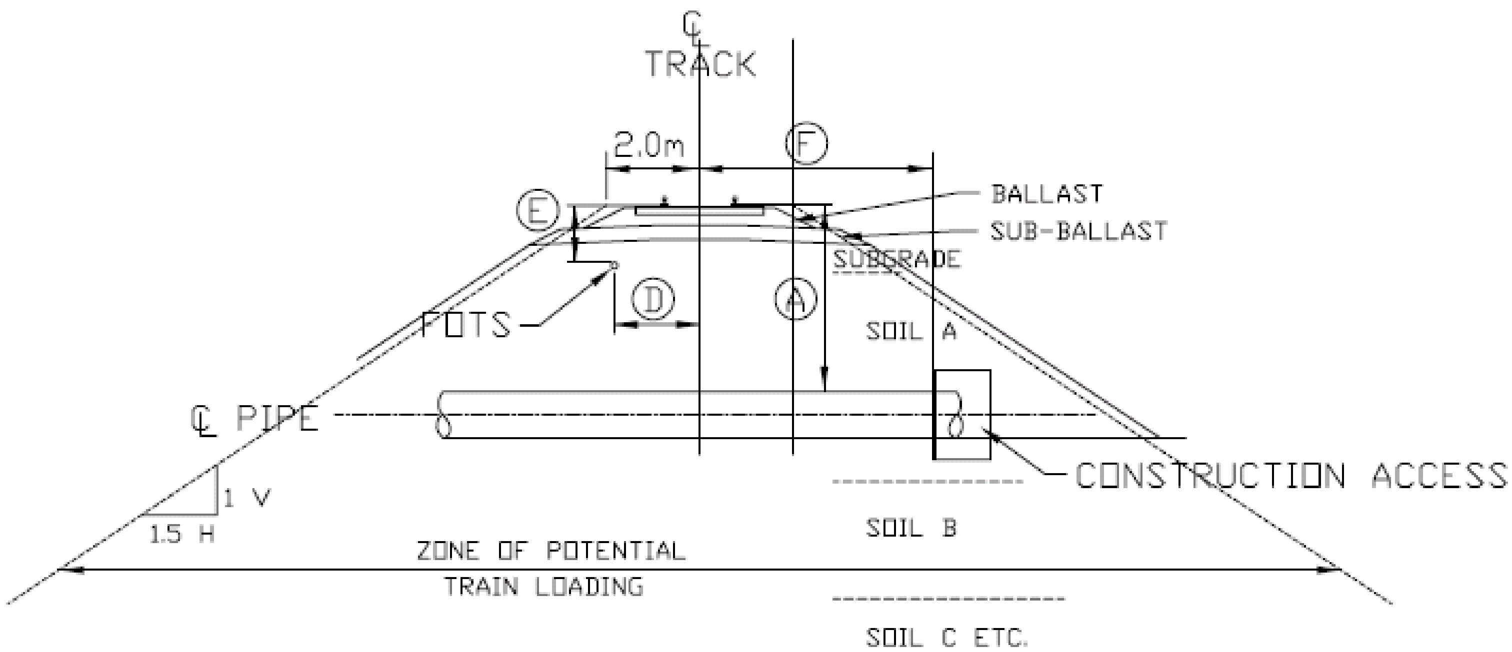


Figure 2 – Profile of the track and proposed pipe crossing along the centerline of track

SAMPLE



FOTS = FIBRE OPTICS TRANSMISSIONS SYSTEM

Figure 3 – Section of Track along centerline of proposed pipe

SAMPLE

Appendix B

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:

SAMPLE

SAMPLE DAILY SETTLEMENT MONITORING REPORT

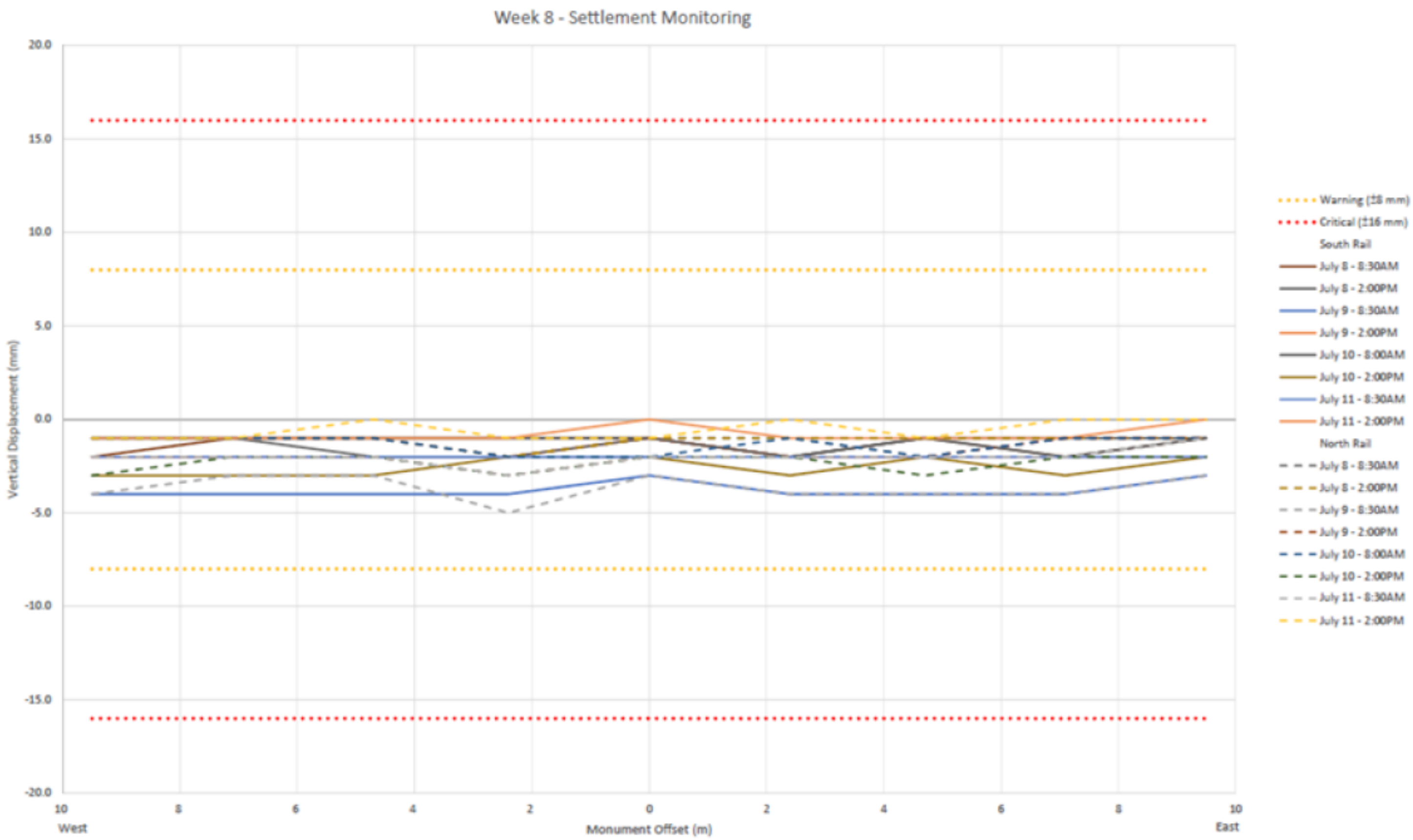
SETTLEMENT MONITORING

Surveyor:		Date:	July 11, 2019	CP Flagger	
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

SAMPLE



Week 8 - Settlement Monitoring
Vertical Displacement (mm)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
10
West
8
6
4
2
0
2
4
6
8
10
East
Monument Offset (m)
Warning (±8 mm)
Critical (±16 mm)
South Rail
July 8 - 8:30AM
July 8 - 2:00PM
July 9 - 8:30AM
July 9 - 2:00PM
July 10 - 8:00AM
July 10 - 2:00PM
July 11 - 8:30AM
July 11 - 2:00PM
North Rail
July 8 - 8:30AM
July 8 - 2:00PM
July 9 - 8:30AM
July 9 - 2:00PM
July 10 - 8:00AM
July 10 - 2:00PM
July 11 - 8:30AM
July 11 - 2:00PM

SAMPLE

SAMPLE TRENCHLESS INSTALLATION MONITORING REPORT

TRENCHLESS INSTALLATION MONITORING

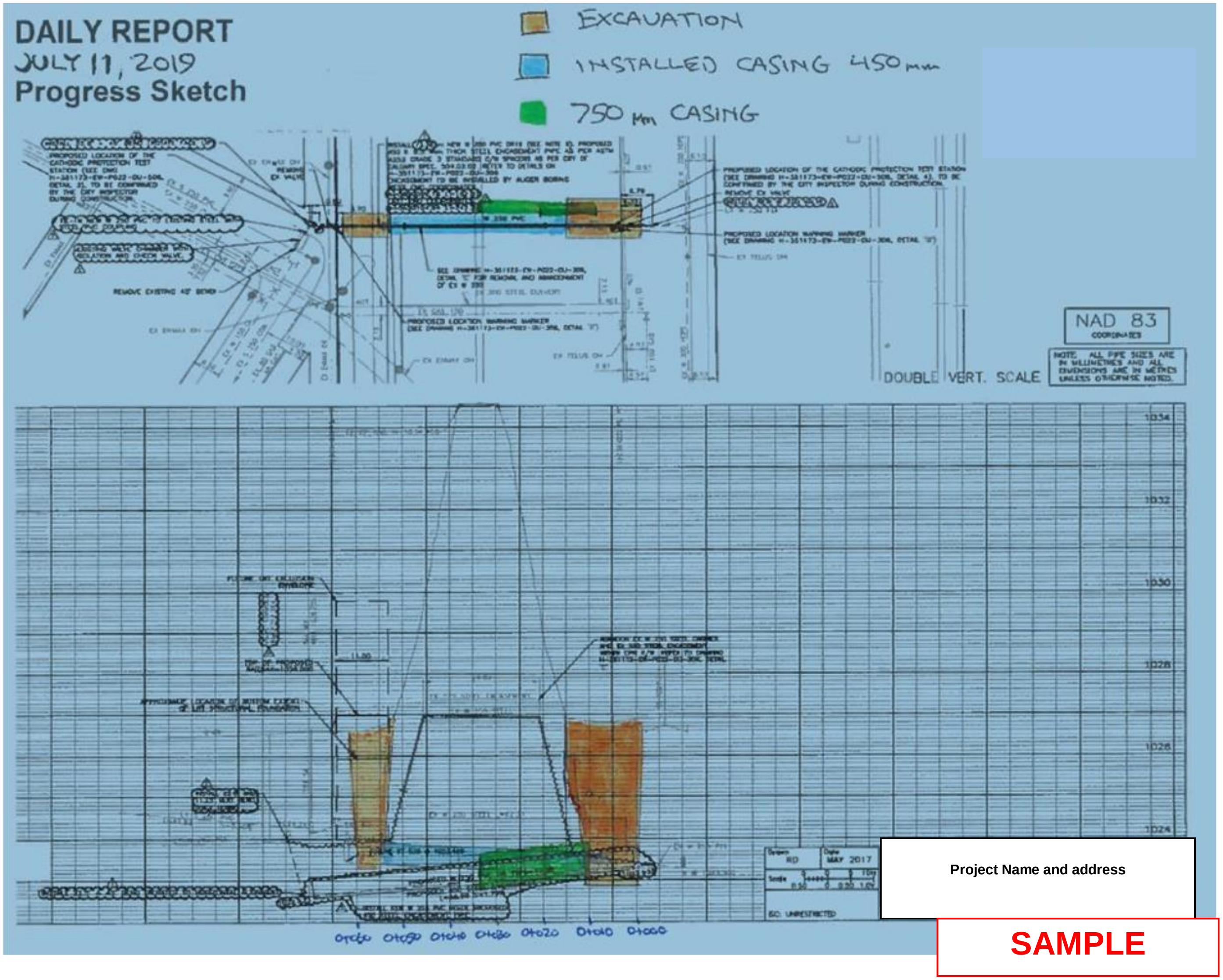
Equipment:	Air Hammer	**Operator:**	
Casing Pipe Diameter:	750 mm	16 mm overcut on casing head	
Date:	July 11, 2019	2m plug at casing head during installation	

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

SAMPLE


N1
N2
N3
N4
N5
N6
N7
N8
N9
S1
S2
S3
S4
S5
S6
S7
S8
S9
9.45 m
7.08 m
4.72 m
2.36 m
UPDATED CL OF WATERMAIN
CL OF 450 WATERMAIN (ORIGINAL)
26A STREET SE
LEGEND
SURFACE SETTLEMENT MONITORING POINT (PREVIOUS)
UPDATED SURFACE SETTLEMENT MONITORING POINT (JUNE 12)
0
20m
LOCATION OF
SETTLEMENT MONITORING MONUMENTS

SAMPLE


DAILY REPORT
JULY 11, 2019
Progress Sketch
EXCAVATION
INSTALLED CASING 450mm
750 mm CASING
NAD 83
DOUBLE VERT. SCALE
Project Name and address
SAMPLE

Appendix C

TRACK MOVEMENT MONITORING GUIDELINES FOR TRENCHLESS PIPE INSTALLATION

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

(Last updated – Feb. 25, 2020)

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 CP 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 CP 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 CP 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 or lines with low traffic - At least twice daily.

   2) For main lines and heavy traffic lines - Every 2 hours or after each train, whichever provides the most number of readings while the boring operation is within the ZPTL (Zone of Potential Train Loading).

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 CP Geotechnical Engineering group or CP 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 CP property) and without the requirement of a CP Flagger or representative presence on site.

Two alarm levels are proposed:-

Level 1:

"WARNING" will be indicated on the field memo/report when a settlement of **50 percent (%)** 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.

Level 2:

"CRITICAL" will 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 CP Geotechnical Engineering group or CP 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 CP Roadmaster or their designate, 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 how much 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 construction and monitoring and should be directed to local CP

Roadmaster, CP approved service provider, Supervisor – CP Public Works – Utilities and Director of Geotechnical Engineering.

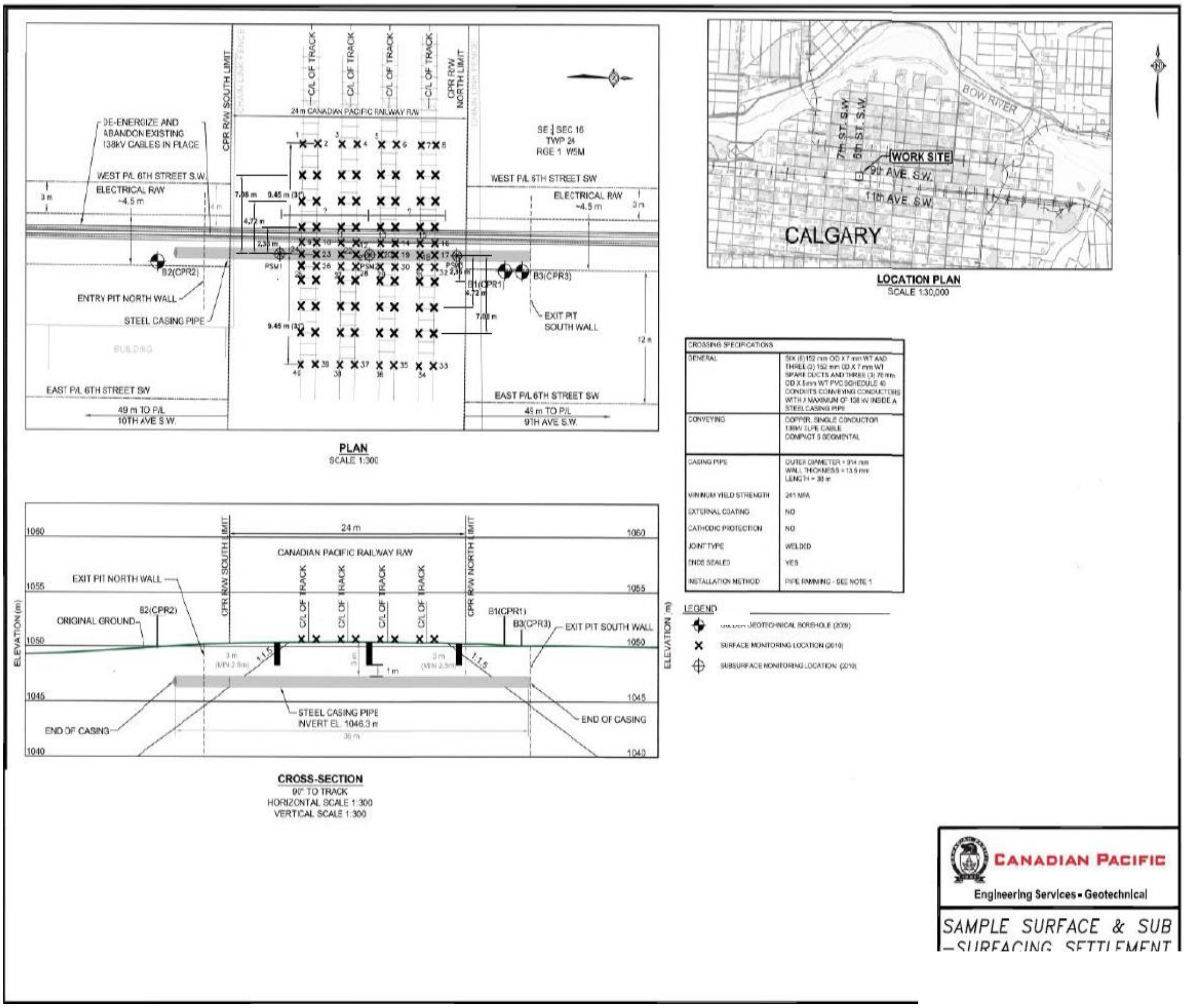


Figure A - Sample Surface and Subsurface Settlement Monitoring Layout

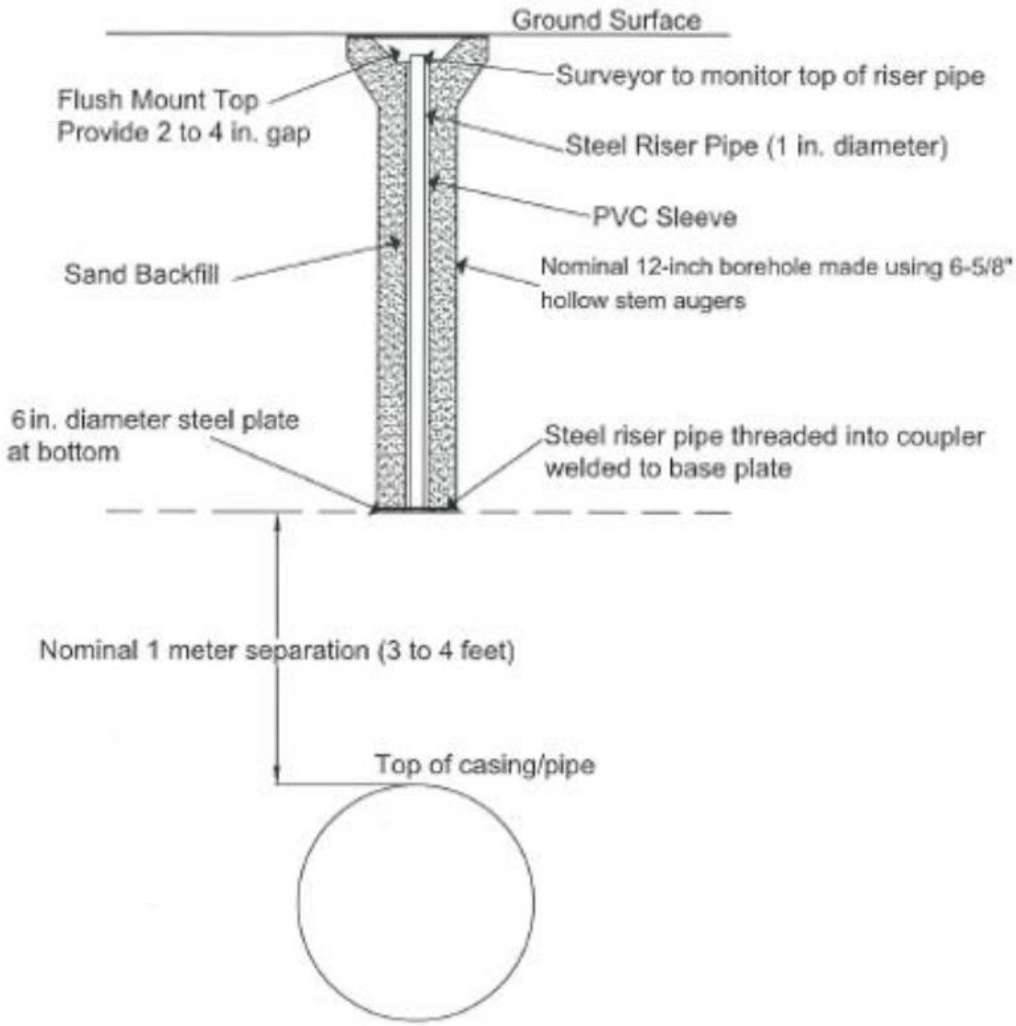


Figure B - Typical Subsurface Settlement Point Detail

Track Settlement Monitoring Review and Alert Thresholds

Class	Alert Threshold	Review Threshold
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

Class of Track

TRACK CLASSES		
Class	**Freight Train Speed**	**Passenger Train Speed**
1	10 MPH	15 MPH
2	25 MPH	30 MPH
3	40 MPH	60 MPH
4	60 MPH	80 MPH
5	80 MPH	95 MPH❶ 90 MPH❷

❶ *For LRC Trains, 100 MPH*

❷ *Applies to US only*

Figure 5-1

Appendix B

Laboratory Testing Results

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

Moisture Content Report
ASTM D2216-10

Project No.	0015-041-00
Client	City of Winnipeg
Project	Erin Street Rail Crossing
Sample Date	27-Jan-21
Test Date	1-Feb-21
Technician	AD

Test Hole	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01	TH21-01
Depth (m)	0.8 - 0.9	0.9 - 1.2	1.2 - 1.5	1.5 - 1.8	1.8 - 2.1	4.3 - 4.6
Sample #	G01	G02	G03	G04	G05	G07
Tare ID	AA27	A23	AC26	AB14	AA01	W22
Mass of tare	8.6	8.7	6.8	6.7	6.7	8.5
Mass wet + tare	316.9	192.6	342.6	328.0	243.7	270.6
Mass dry + tare	253.8	150.2	271.7	269.5	173.6	181.7
Mass water	63.1	42.4	70.9	58.5	70.1	88.9
Mass dry soil	245.2	141.5	264.9	262.8	166.9	173.2
Moisture %	25.7%	30.0%	26.8%	22.3%	42.0%	51.3%

Test Hole	TH21-01	TH20-02	TH20-02	TH20-02	TH20-02	TH20-02
Depth (m)	5.8 - 6.1	0.8 - 0.9	1.2 - 1.5	1.8 - 2.1	2.7 - 3.0	4.3 - 4.6
Sample #	G08	G10	G11	G12	G13	G14
Tare ID	W111	H53	AB58	AB53	H67	N75
Mass of tare	8.5	8.5	6.8	7.0	8.6	8.8
Mass wet + tare	215.5	298.1	305.1	392.6	271.1	239.2
Mass dry + tare	134.5	225.7	237.9	317.7	197.8	162.8
Mass water	81.0	72.4	67.2	74.9	73.3	76.4
Mass dry soil	126.0	217.2	231.1	310.7	189.2	154.0
Moisture %	64.3%	33.3%	29.1%	24.1%	38.7%	49.6%

Test Hole	TH20-02					
Depth (m)	5.8 - 5.9					
Sample #	G16					
Tare ID	D12					
Mass of tare	8.3					
Mass wet + tare	283.7					
Mass dry + tare	176.7					
Mass water	107.0					
Mass dry soil	168.4					
Moisture %	63.5%					

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

Shelby Tube Visual

Project No.	0015-041-00
Client	City of Winnipeg
Project	Erin Street Rail Crossing

Test Hole	TH21-01
Sample #	T06
Depth (m)	3.0 - 3.7
Sample Date	27-Jan-21
Test Date	1-Feb-21
Technician	AD

Tube Extraction

Recovery (mm) 540

Bottom - 3.6 m	3.47 m	3.30 m	3.13 m / Top - 3 m
Moisture Content PP/TV Visual	Qu Bulk	Keep	Toss
120 mm	170 mm	170 mm	80 mm

Visual Classification

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

Torvane

Reading	0.56
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	54.9

Pocket Penetrometer

Reading	**1**	1.20
	2	1.30
	3	1.10
	Average	1.20
Undrained Shear Strength (kPa)		58.8

Moisture Content

Tare ID	W47
Mass tare (g)	8.5
Mass wet + tare (g)	283.5
Mass dry + tare (g)	185.6
Moisture %	55.3%

Unit Weight

Bulk Weight (g)		1056.7
Length (mm)	**1**	150.82
	2	150.57
	3	150.61
	4	150.53
Average Length (m)		0.151
Diam. (mm)	**1**	72.47
	2	72.48
	3	72.08
	4	72.42
Average Diameter (m)		0.072
Volume (m^3)		6.19E-04
Bulk Unit Weight (kN/m^3)		16.7
Bulk Unit Weight (pcf)		106.5
Dry Unit Weight (kN/m^3)		10.8
Dry Unit Weight (pcf)		68.6

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

Unconfined Compressive Strength

ASTM D2166

Project No.	0015-041-00
Client	City of Winnipeg
Project	Erin Street Rail Crossing

Test Hole	TH21-01
Sample #	T06
Depth (m)	3.0 - 3.7
Sample Date	27-Jan-21
Test Date	1-Feb-21
Technician	AD

Unconfined Strength

	kPa	**ksf**
Max q_u	63.2	1.3
Max S_u	31.6	0.7

Specimen Data

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

Length	150.6	(mm)	**Moisture %**	55%	
Diameter	72.4	(mm)	**Bulk Unit Wt.**	16.7	(kN/m^3)
L/D Ratio	2.1		**Dry Unit Wt.**	10.8	(kN/m^3)
Initial Area	0.00411	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.56	54.9	1.15
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	1.20	58.9	1.23
	1.30	63.8	1.33
	1.10	54.0	1.13
Average	**1.20**	**58.9**	**1.23**

Failure Geometry

Sketch:

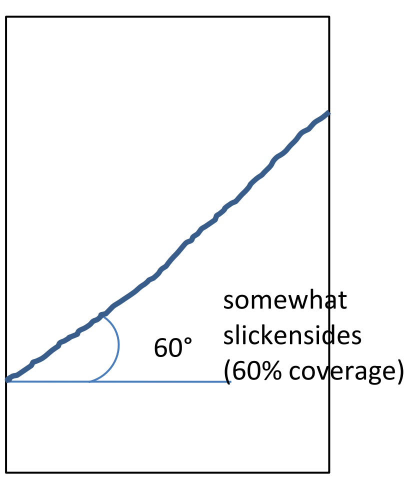
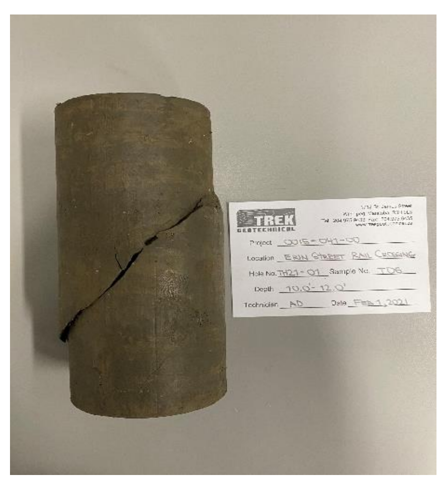


Photo:

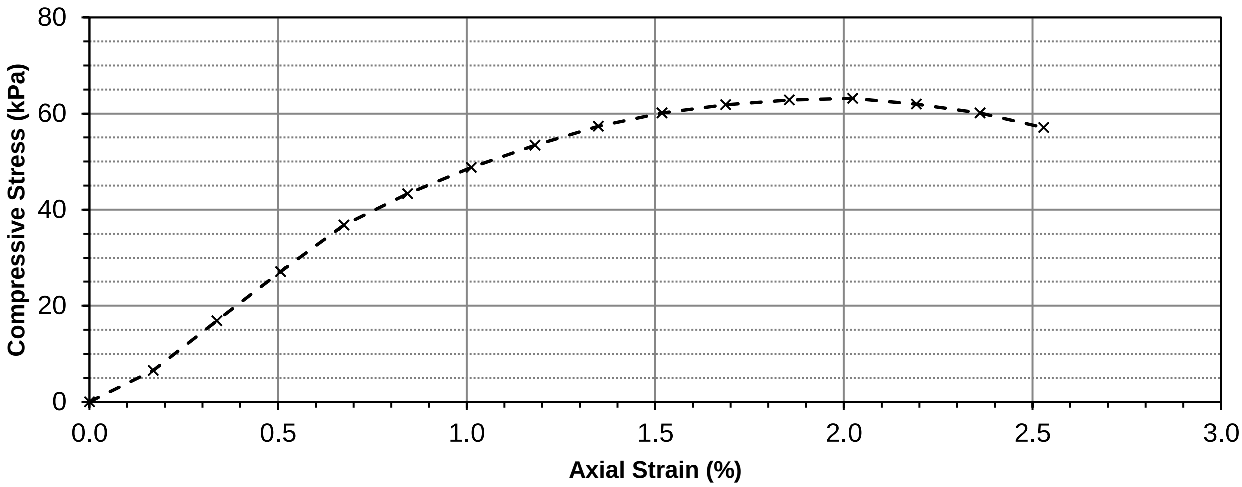


www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Unconfined Compressive Strength
ASTM D2166

Project No. 0015-041-00
Client City of Winnipeg
Project Erin Street Rail Crossing

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	-0.10	0.0000	0.00	0.004113	0.0	0.00	0.00
10	0.43	0.2540	0.17	0.004120	26.7	6.48	3.24
20	1.28	0.5080	0.34	0.004127	69.6	16.86	8.43
30	2.12	0.7620	0.51	0.004134	111.9	27.07	13.54
40	2.92	1.0160	0.67	0.004141	152.2	36.76	18.38
50	3.46	1.2700	0.84	0.004148	179.4	43.26	21.63
60	3.92	1.5240	1.01	0.004155	202.6	48.77	24.38
70	4.31	1.7780	1.18	0.004162	222.3	53.41	26.70
80	4.64	2.0320	1.35	0.004169	238.9	57.31	28.65
90	4.88	2.2860	1.52	0.004176	251.0	60.11	30.05
100	5.03	2.5400	1.69	0.004183	258.6	61.81	30.91
110	5.12	2.7940	1.85	0.004190	263.1	62.79	31.39
120	5.16	3.0480	2.02	0.004198	265.1	63.16	31.58
130	5.07	3.3020	2.19	0.004205	260.6	61.97	30.99
140	4.92	3.5560	2.36	0.004212	253.0	60.07	30.04
150	4.68	3.8100	2.53	0.004219	240.9	57.10	28.55

Appendix C

Tunnelman's Ground Classification System

Tunnelman's Ground Classification for Soils

Classification	Behaviour	Typical Soil Types
Firm	Heading can be advanced without initial support, and final lining can be constructed before ground starts to move	Loess above water table, hard clay, marl, cemented sand and gravel when not highly overstressed.
Raveling (Slow or Fast)	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 over-stress 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.	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 the degree of overstress.
Squeezing	Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination of raveling at excavation surface and squeezing at depth behind surface.
Running (including cohesive-running)	Granular materials without cohesion are unstable at a slope greater than their angle of repose (approx. 30 to 35 degrees). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean, dry granular materials. Apparent conhesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of raveling before it breaks down and runs. Such behaviour is cohesive-running.
Flowing	A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown and walls, and can flow for great distances, completely filling the tunnel in some cases.	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 a material is disturbed.
Swelling	Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly preconsolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

**Modified by Heuer (1974) from Terzaghi (1950)*

Heuer, R. E. (1974). Important ground parameters in soft ground tunnelling. *Proceedings of Specialty Conference on Subsurface Exploration for Underground Excavation and Heavy Construction*.

Terzaghi, K. (1950). Geologic aspects of soft ground tunnelling. In *Applied Sedimentation*. John Wiley & Sons, Inc.