



Instrumentation and Monitoring Plan

Proposed Enbridge Gas Main Installation
QEW Crossing from Cliff Road to
Carmen Drive, Mississauga, ON

Project Latitude and Longitude
43.576, -79.592

April 21, 2021



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Introduction
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1.0 INTRODUCTION

Enbridge Gas Inc. (Enbridge) is planning to install approximately 182 m of NPS 6 ST DFBE IP gas pipeline from approximately 74 m north of the Queen Elizabeth Way (QEW) on Cliff Road to approximately 70 m south of the QEW on Carmen Drive, in Mississauga, Ontario. The crossing of the QEW is intended to be undertaken via Horizontal Directional Drilling (HDD).

Stantec Consulting Ltd. (Stantec) was retained by Enbridge to complete a geotechnical investigation and prepare a Foundation Investigation and Design Report (FIDR). The report is required to support a Corridor Encroachment Permit Application with the Ministry of Transportation (MTO) to summarize the subsurface conditions at the crossing location to support the design of the crossing and to provide comment with respect to minimizing potential environmental impacts during installation of the pipe via HDD.

The instrumentation and monitoring plan (IMP) is provided herein. The purpose of the IMP is to identify if the installation of the pipeline could lead to ground disturbance that could potentially affect the highway. It is also a requirement of the MTO Corridor Encroachment Permit Application.

Limitations associated with this report and its contents are provided in the statement included in **Appendix A**.

2.0 BACKGROUND

2.1 SITE LOCATION

The approximate location of the planned crossing under the QEW is shown on the Site Location Plan in Drawing 1 in **Appendix B**. The orientation of the QEW at this location is taken as east-west, and the orientation of the proposed pipeline installation is taken as north-south.

The planned crossing is located on the west side of Cliff Road extending to the west side of Carmen Drive in Mississauga, Ontario. The pipeline will cross under North Service Road, the QEW and South Service Road.

2.2 SITE DESCRIPTION

The north end of the proposed pipeline installation is located on Cliff Road. At the crossing location, Cliff Road is a three lane (one northbound, one right turning southbound and one left turning southbound) paved road. The roadway is approximately 13 m wide, with grass boulevards and sidewalks on either side. Cliff Road intersects with North Service Road at a T-intersection immediately north of the QEW.



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At the crossing location, North Service Road is a two-lane paved road located immediately north of and parallel to the QEW. The roadway is approximately 8.5 m wide, with a grass boulevard and sidewalk on the north side of the road and the QEW noise wall on the south side of the road.

South of North Service Road the pipeline will cross under the QEW. At the crossing location, the QEW is a six lane, divided highway. The highway is approximately 38 m wide (noise wall to noise wall)) at this location, with 3 m wide paved shoulders, guard rails and noise walls on either side. Overhead light posts are located along the center median.

South of the QEW the pipeline will cross under South Service Road. South Service Road is a two-lane paved road located immediately south of and parallel to the QEW. The roadway is approximately 7.8 m wide, with the QEW noise wall located on the north side of the road and a grass boulevard and sidewalk on the south side of the road.

The south end of the proposed pipeline installation is located on Carmen Drive, which intersects South Service Road at a T-intersection immediately south of the QEW. At the crossing location, Carmen Drive is a two-lane unmarked paved local road. The roadway is approximately 7.5 m wide without shoulders or sidewalks.

Land use in the vicinity of the proposed pipeline installation consists of commercial and residential properties. A health club is located to the northeast, an apartment building and auto shop are located to the northwest, a church is located to the southwest, and residential properties are located to the southeast.

The Crossing Plan and Profile drawings were provided to Stantec by Enbridge. The drawing was dated March 30, 2021 and illustrates the preliminary horizontal and vertical alignments of the proposed pipeline at the crossing location, and the locations of some underground infrastructure in the vicinity. The drawing indicates that at the location of the planned crossing:

- The QEW centerline is at an elevation of approximately 100.6 m; and,
- The topography of the surrounding area slopes gently downward from an elevation of approximately 101.2 m at the north end of the alignment on Cliff Road, to an elevation of approximately 100.2 m at the south end of the alignment on Carmen Drive.

2.3 EXISTING UTILITIES AND STRUCTURES

There are noise barrier walls on the north and south sides of the QEW.

Above-ground utilities in the area consist of:

- Overhead powerlines located on the east side of Cliff Road, with wires crossing to the west side of the road at several locations.
- Overhead powerlines located on the north side of North Service Road.
- A guy-wire crossing over the QEW from North Service Road to South Service Road.



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- Overhead powerlines located on the south side of South Service Road; and,
- Overhead powerlines located on the west side of Carmen Drive, with wires crossing to the east side of the road at several locations.

The Plan and Profile drawing provided by Enbridge indicates the following underground utilities and/or services:

- An existing 250 mm storm sewer along Cliff Road, parallel to the pipeline alignment and offset approximately 5 m horizontally (no elevation indicated).
- Existing 150mm and 300 mm watermain along Cliff Road, parallel to the pipeline alignment and offset at least 10 m horizontally (no elevation indicated).
- An existing fibre optic line along the west boulevard of Cliff Road, parallel to the pipeline alignment and offset approximately 2 m horizontally (no elevation indicated).
- An existing 825 mm storm sewer along North Service Road, perpendicular to the pipeline alignment and offset approximately 2 m vertically at an elevation of approximately 97.6 m.
- An existing NPS 6 ST gas main along North Service Road, perpendicular to the pipeline alignment and offset approximately 4.7 m vertically at an elevation of approximately 99.6 m.
- Existing 250 mm and 300 mm watermain along North Service Road, perpendicular to the pipeline alignment and offset approximately 3.7 m vertically at assumed elevations of 98.6 m.
- Several buried telephone cables on Cliff Road and North Service Road, both parallel to and perpendicular to the pipeline alignment and offset approximately 3.5 to 4.5 m vertically, at assumed elevations ranging from 99.2 m to 100.0 m.
- An existing 200 mm watermain across the QEW, parallel to the pipeline alignment and offset approximately 3.7 m vertically at an elevation of approximately 98.6 m.
- Existing 300 mm and 200 mm watermain along South Service Road, perpendicular to the pipeline alignment. The elevation of the 300 mm watermain is indicated to be approximately 98.6 mm (offset from the alignment by approximately 3.7 m), however, the elevation of the 200 mm watermain is not shown.
- An existing NPS 4 PE IP gas main along South Service Road, perpendicular to the pipeline alignment and offset approximately 4.7 m vertically at an elevation of approximately 99.6 m.
- An existing 400 mm corrugated steel pipe (CSP) culvert on the south side of South Service Road at the intersection with Carmen Drive, perpendicular to the pipeline alignment (no elevation indicated).
- An existing 300 mm CSP culvert on the west side of Carmen Drive, crossing the driveway to 1640 Carmen Drive, parallel to the pipeline alignment (no elevation indicated).
- An existing 150 mm watermain along Carmen Drive, parallel to the pipeline alignment and offset approximately 3 m horizontally (no elevation indicated).
- An existing 250 mm sanitary sewer along Carmen Drive, parallel to the pipeline alignment and offset approximately 6 m horizontally (no elevation indicated); and,
- A buried telephone cable along the west boulevard of Carmen Drive, parallel to the pipeline alignment and offset approximately 0.6 m horizontally (no elevation indicated).



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The contractor must identify any/all conflicts with existing utilities and infrastructure including the MTO noise wall foundations, prior to the commencement of construction, as outlined in the report titled "Foundation Investigation and Design Report" dated April 21, 2021 and referred to in the following section.

2.4 SUBSURFACE CONDITIONS

Subsurface conditions are described in detail in the following document:

Foundation Investigation and Design Report
Proposed Enbridge Gas Main Installation
QEW Crossing from Cliff Road to Carmen Drive, Mississauga, Ontario
Project No.: 121623293

A total of four (4) boreholes (BH1 to BH4) were advanced for the investigation. In general, the overburden stratigraphy encountered in the boreholes advanced for the investigation consisted of the following:

- Ground surface cover consisting of asphalt in all boreholes; underlain by,
- Granular fill consisting of silty sand with gravel in all boreholes; underlain by,
- Silty sand in all boreholes; underlain by,
- Silt with sand in boreholes BH3 and BH4; underlain by,
- Sandy clay till to sandy silty clay till in all boreholes; underlain by,
- Possible residual soil consisting of silty, clayey gravel with sand in borehole BH2 and sandy, silty clay to gravelly clay with sand in borehole BH3; underlain by,
- Shale bedrock with limestone interbeds in boreholes BH2 and BH3.

Bedrock of the Georgian Bay formation was encountered underlying the overburden in boreholes BH2 and BH3, at depths of 9.9 m and 9.1 m below grade, or at elevations of 90.7 m and 91.3 m, respectively.

A groundwater monitoring well was installed in borehole BH4 and screened from a depth of 3.0 m to 6.1 m below grade within the sand with silt and sandy clay till. The groundwater level was measured at a depth of approximately 1.9 m below grade (corresponding to an elevation of 98.5 m) on August 7, 2020 approximately three and a half weeks after the well installation.

3.0 HORIZONTAL DIRECTIONAL DRILLING

3.1 OVERVIEW

It is understood that HDD is the preferred method for the pipeline installation at this crossing.



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The HDD process as presented in the literature reference Guidelines for Preventing Underground Facility Damage as a Result of Horizontal Direction Drilling, developed by J.D. Hair and Associates, dated March 2012 is comprised of a three-stage process; pilot hole, pre-reaming, and pullback as described below. For additional reference, a section describing the use of drilling mud is provided.

3.2 PILOT HOLE

The pilot hole begins when the bit enters the ground at the entry point located directly in front of the rig. As the bit is advanced away from the rig, individual joints of drill pipe are added behind it in succession creating a continuous string of drill pipe in the hole.

In soft soils, progress is typically achieved using a high-velocity stream of drilling mud to erode the soil ahead of the bit. This is referred to as jetting. In harder soils and rock, mechanical cutting action is required. This is provided by a hydraulically driven mud motor which allows for continuous rotation of the bit.

As the pilot hole is drilled, its actual path is monitored using either a transmitter or a steering tool positioned as close as possible to the bit. Directional control is achieved using a non-rotating drill string with an asymmetrical leading edge. The asymmetry of the leading edge creates a steering bias while the non-rotating aspect of the drill string allows the steering bias to be held in a specific position while drilling. If a change in direction is required, the drill string is rolled so the direction of bias is the same as the desired change in direction. The drill string may also be continuously rotated where directional control is not required. On large rig installations, leading edge asymmetry is typically accomplished with a bent sub or a bent motor housing located directly behind the bit. Leading edge asymmetry on small rig installations is typically accomplished using a slant-faced bit.

Pilot-hole drilling continues until the bit punches out at the exit point on the opposite end of the crossing, at which point the pilot hole is complete.

3.3 PRE-REAMING

Enlargement of the pilot hole is typically accomplished by conducting one or more pre-reaming passes until the desired hole size has been achieved. The number of passes that are required is dependent upon the diameter of the pipeline being installed and the properties of the subsurface materials along the drilled path.

For a typical pre-reaming pass, a reaming tool is attached to the drill string at the exit point and is rotated and drawn back to the drill rig, thus enlarging the hole. This process has the benefit of maintaining tension on the reamer throughout the reaming operations. Drill pipe is typically added behind the reamer as it progresses toward the rig so that a full string of pipe is maintained in the hole throughout the process.



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It is also possible to ream away from the drilling rig. This is referred to as “push reaming” whereby the reamer is fitted into the drill string and rotated and advanced away from the drill rig using only the drill rig’s thrust. However, push reaming is generally considered to be poor practice as it increases the potential for a drill pipe failure.

3.4 DRILLING MUD

Typically, a drilling mud is injected into the bore during the cutting and reaming process to stabilize the hole and remove soil/rock cuttings.

The drilling mud typically consists of a clay or polymer material; the most common clay used is a sodium montmorillonite (referred to as bentonite). The drilling mud must have sufficient gel strength to keep the cuttings suspended for transport, to form a filter cake on the boring wall that contains the water within the drilling mud, and to provide lubrication between the pipe and the boring wall on pullback.

The drilling mud used are often described as thixotropic and thus thicken when left undisturbed after pullback. However, unless cementitious agents are added, the thickened mud provides little to no side-support for the pipe.

3.5 PULLBACK

Prior to commencing pullback operations, the pipeline to be installed is typically assembled to its full length on the side of the crossing opposite the drilling rig. This prefabricated segment is referred to as the pull section. Once the hole has been enlarged to its final diameter, the pipeline is installed in the reamed hole by attaching the pull section behind a reaming assembly at the exit point, then pulling both the reaming assembly and pull section through the hole to the drilling rig.

A swivel is placed between the pull section and the reaming assembly to minimize the amount of torsion that is transmitted to the pipeline being installed.

The pull section is typically supported as it proceeds into the hole using some combination of roller stands and pipe handling equipment to minimize the tensile load and prevent damage to the pipeline.

4.0 MTO INSTRUMENTATION AND MONITORING PLAN

4.1 OVERVIEW

The IMP outlined in the following sections has been developed with consideration for the MTO’s Guidelines for Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application Settlement Monitoring Guidelines - Tunneling, Stantec’s project history on previous undertakings for the MTO, Stantec’s experience on projects having similar requirements, and good engineering practice.



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It is noted that the ownership of the monitoring points will ultimately reside with Enbridge. It is typical that the owner of the points will undertake to have the monitoring points decommissioned at the end of the monitoring period.

The IMP is based on the Contractor working a 10 to 12 hour daylight shift per 24 hour period. If working hours are extended, the monitoring frequency should be reviewed and revised as necessary.

4.2 APPLICABLE STANDARDS

The IMP described herein is intended to meet the requirements of the following documents:

- Guidelines for Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application, issued by the Ontario Ministry of Transportation, Pavement and Foundation Section (Last updated: March 28, 2018); and,
- Non-Standard Special Provision (NSSP) Pipe Installation by Trenchless Method (July, 2020) provided by the MTO.

A copy of the NSSP Pipe Installation by Trenchless Technology document is provided in **Appendix C** for reference. The attached is the standard, unedited version of the document. It is noted that the document may require edit and revision in consideration of the specific approach, design and construction methodology adopted.

It is noted that the instrumentation and monitoring plan discussed and described herein was developed with specific reference to the HDD method of installation as currently proposed. Changes to the trenchless technology methodology could warrant changes to this plan.

4.3 CONDITION SURVEY

Prior to commencement of the construction/installation of the pipeline, Stantec will undertake a pavement condition survey in the immediate area of the crossing for the purpose of establishing the pavement conditions prior to construction/installation of the pipeline. The intent of this survey is to document the pavement conditions prior to construction should restoration or repairs be warranted at a later date.

The survey will be based on the MTO Manual for Condition Rating of Flexible Pavements, Distress Manifestation, SP-024. During the condition survey, visible defects such as cracks, distortions and deviations, observations of heaved pavement or depressed pavement will be documented.

Stantec will repeat the condition survey in accordance with the following:

- If movement is identified during or immediately following construction/installation; at such time as all parties are in agreement that said movement has stopped; and,
- If no movement is identified during or immediately following construction/installation; approximately two weeks after the construction/installation is completed.



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4.4 DISPLACEMENT MONITORING POINT INSTALLATION AND LAYOUT

The locations of the displacement monitoring points are illustrated on Drawing No. 1 in **Appendix B**.

The layout has been adapted from the instrumentation monitoring requirements stated in the NSSP document to be consistent with displacement monitoring point arrangements used for similar projects completed for the MTO.

The installation of the monitoring points shall be as follows:

- Surface monitoring points shall be identified/marked on the pavement. This methodology eliminates the need to install surface marker pins in the asphalt. Previous use of this methodology on similar projects has proven that this method is simpler and more efficient to implement than installing marker pins without compromising the integrity of the monitoring results.
- Target monitoring points consisting of small, fluorescent target stickers affixed to the noise walls on either side of the QEW; and,
- In-ground monitoring points will be installed using a drill rig or hydro excavation truck, depending on site conditions, topography and available access. The deep points will consist of a reinforcing steel bar sleeved in a PVC pipe, installed to a depth of 1.5 m below grade. The base of the deep monitoring points will be grouted in place. The upper portion of the installation will be backfilled with sand. The installations will include a cover at the ground surface to protect against disturbance (typically a flush-mount or stick-up well cap).

Due to the location of existing guard rails and limited spacing on the shoulder and vegetated boulevard, one only row of in-ground monitoring points is being proposed on each side of the QEW shoulder.

Typical details of surface and in-ground monitoring points are presented in Drawing 2 in **Appendix B**.

4.5 DISPLACEMENT MONITORING FREQUENCY

The NSSP document describes the required frequency of monitoring of the points. Based on the MTO Guidelines for Foundation Engineering – Tunneling Specialty for Corridor Encroachment Permit Application, the frequency of monitoring was adjusted from that described in the NSSP document to the following schedule:

- **Prior to construction:** two (2) times daily for two days at least one week prior to commencement of work
- **During construction:** two (2) times per day during permitted shoulder closure timeframe (i.e. after rush hours)
- **During work stoppage** (i.e. non-operation period or weekends/ holidays): two (2) times per day
- **After completion of construction:** once per week for the greater of the following:
 - A period of one (1) month; or
 - Until such time at which all parties agree that any observed/recorded movement has stopped.



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It is noted that as the monitoring readings will require a shoulder closure, the frequency of baseline and construction readings has been reduced from three (3) times per day to two (2) per day during permitted shoulder closure timeframe to reduce traffic disruption. This reduction has been approved by the MTO, as the diameter of the bore will not exceed 300 mm.

If the work is to be conducted over a longer period (i.e. 24 hour shift), the monitoring times during construction will be shifted to include a reading taken at night. In this case, the Contractor will be required to provide lighting to allow the Project Surveyor to obtain the readings.

4.6 DISPLACEMENT LIMITS

The following limits and ranges have been adopted for displacement monitoring for MTO Highway crossings:

- **Review Level**
A maximum value of 10 mm
- **Alert Level**
A maximum value of 15 mm

The criteria stated are based on cumulative displacement with reference to the respective baseline reading. The baseline reading is calculated as the average of the readings obtained in advance of commencement of construction.

The limits stated were developed with consideration for the typical industry standard accuracy for the survey which is in the order of +/- 2 mm.

For reference, positive displacement denotes heave of the monitoring point and negative displacement denotes settlement of the monitoring point.

4.7 PRE-CONSTRUCTION TASKS

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

- Submit the scope of the proposed IMP to Enbridge to include in any permit submissions to the MTO; and,
- Review and incorporate any comments received from the MTO into the scope of the proposed IMP.

On receipt of the MTO permit from Enbridge, Stantec will:

- Develop an emergency contact list that identifies representatives from Stantec, Enbridge, the MTO, the pipe installation contractor, and additional parties as may be identified at that time. The emergency contact list will be distributed to all parties to be used should the displacement Review Limit range be exceeded.
- Conduct the following verification utility locates program:



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- Obtain public utility locates for the area of the proposed monitoring points.
- Submit to the MTO to obtain utility locates.
- Retain a private utility locate company to identify and mark services and/or utilities in accordance with Stantec's standard ground disturbance protocol.
- Compare the results of Stantec's Verification Utility Locates with the Enbridge Primary Locates.
- Identify if any utilities/services are within 3 m of the intended locations of the deep (in-ground) monitoring points and if so said utilities/services will require positive identification (hand or hydro-vac exposure in the field). Where positive exposure is not practical, the locations of the proposed monitoring points will be adjusted accordingly; and,
- Coordinate with the MTO to enter the ROW for the described work.

On completion of the tasks described above Stantec will contact the Project Surveyor and advise of the project-specific requirements and format for the data processing and reporting. A sample report is included in **Appendix D** for general reference.

Prior to commencement of the monitoring program the Project Surveyor will undertake the following tasks:

- Coordinate to have appropriate traffic control and protective measures in place for baseline readings; and,
- Layout the proposed alignment of the Track Bore between entry and exit locations and layout the locations of the planned surface and deep monitoring points.

On completion of the preceding tasks and receipt of approval from the MTO to proceed Stantec will:

- Coordinate to have appropriate traffic control and protective measures in place for installation of the displacement monitoring points.
- Obtain a Ground Disturbance Permit from Enbridge.
- Obtain a Safe Work Permit from Enbridge; and,
- Oversee the installation of the surface monitoring points and the deep monitoring points as outlined in the proposed IMP with adjustments as required for the presence of utilities/services.

4.8 BASELINE READINGS

Prior to commencement of construction, baseline readings for all monitoring points will be obtained in accordance with the following:

- The project surveyor will:
 - Provide notification to MTO (if required) and coordinate to have appropriate traffic control and protective measures in place during monitoring activities. It should be noted that due to the presence of MTO noise walls on both side of the QEW, additional efforts on traffic control and coordination with MTO may be required (i.e. shoulder closure, the use of crush truck, etc.).
 - Collect baseline readings on all monitoring points within 1 – 2 weeks of the commencement of construction. This timeline can be revised at the discretion of the geotechnical consultant subject



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- to the prevailing subsurface conditions, activity in the area (construction or otherwise), and climate/weather conditions during the period prior to and leading up to the commencement of construction.
- Collect the baseline readings on two (2) separate days.
 - Conduct the survey using a survey methodology and equipment capable of obtaining vertical displacement accuracy of +/- 2 mm.
 - Forward the baseline readings to the geotechnical consultant following collection and collation.
- The geotechnical consultant will:
 - Review the baseline survey data; and,
 - Forward the baseline readings to Enbridge and the MTO.

4.9 CONSTRUCTION MONITORING

During the installation of the pipeline the following is intended:

- The project surveyor will:
 - Provide notification to MTO (if required) and coordinate to have appropriate traffic control and protective measures in place during monitoring activities; and,
 - Conduct displacement monitoring of all points at the frequency described previously.

If the results of the survey are within the accuracy of the survey, in reasonable accordance with the established database and below the Review Limit:

- The Project Surveyor will:
 - Process the data and submit the results to the geotechnical consultant within 48 hours of conducting the survey.
- The geotechnical consultant will:
 - Review the available data; and,
 - Notify Enbridge via email with a weekly summary report to be submitted mid-week of the week following obtaining the results. It is understood that Enbridge will notify the MTO.

If the results of the survey are beyond the accuracy of the survey and/or if the results are above the Review Level, but below the Alert Level:

- The Project Surveyor will:
 - Verbally advise the geotechnical consultant of the results within 1 hour of conducting the survey.
- The geotechnical consultant will:
 - Implement the contingency measures as described below.

If the results of the survey are beyond the accuracy of the survey and/or if the results exceed the Alert Limit range:

- The Project Surveyor will:



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- o Verbally advise the geotechnical consultant of the results within 1 hour of conducting the survey.
- The geotechnical consultant will:
 - o Implement the contingency measures described below.

4.10 POST-CONSTRUCTION MONITORING

On completion of the installation of the pipeline the following tasks will be undertaken:

- The Project Surveyor will:
 - o Provide notification to MTO (if required) and coordinate to have appropriate traffic control and protective measures in place during monitoring activities; and,
 - o Conduct displacement monitoring of all points at the frequency described previously.

If the results of the survey are within the accuracy of the survey, in reasonable accordance with the established database and below the Review Limit:

- The Project Surveyor will:
 - o Process the data and submit the results to the geotechnical consultant within 48 hours of conducting the survey.
- The geotechnical consultant will:
 - o Review the available data; and,
 - o Notify Enbridge via email with a weekly summary report to be submitted mid-week of the week following obtaining the results. It is understood that Enbridge will notify the MTO.

If the results of the survey are beyond the accuracy of the survey and/or if the results are above the Review Level, but below the Alert Level:

- The Project Surveyor will:
 - o Verbally advise the geotechnical consultant of the results within 1 hour of conducting the survey.
- The geotechnical consultant will:
 - o Implement the contingency measures as described below.

If the results of the survey are beyond the accuracy of the survey and/or if the results exceed the Alert Level:

- The Project Surveyor will:
 - o Verbally advise the geotechnical consultant of the results within 1 hour of conducting the survey.
- The geotechnical consultant will:
 - o Implement the contingency measures described below.



PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO CARMEN DRIVE, MISSISSAUGA, ON

Contingency Measures
April 21, 2021

4.11 REPORTING

The results of the IMP will be provided to Enbridge via email consistent with the schedule(s) noted in the preceding sections. The final monitoring report will also be provided to Enbridge.

A report attachment will be included with the email summarizing the results of the monitoring. A sample report is included in **Appendix D** for general reference.

5.0 CONTINGENCY MEASURES

5.1 OVERVIEW

The following sections summarize the required responses and actions to be undertaken by Stantec for monitoring results that are below the Review Level, above the Review Level, but below the Alert Level, and exceed the Alert Level. The contractor is solely responsible for the execution of the HDD and accordingly for the protection of existing infrastructure and the general public. The contractor must prepare a Response Action Plan to be submitted to Enbridge in advance of commencement of construction. The Response Action Plan must clearly identify the actions to be taken should the monitoring data be in the review limit range or exceed the Alert limit.

5.2 BELOW REVIEW LEVEL

Readings less than 10 mm are below the Review Limit.

If monitoring results are below the Review Limit, Stantec will:

- Review the available data; and,
- Notify Enbridge and the MTO via email with a weekly summary report to be submitted mid-week of the week following obtaining the results.

5.3 ABOVE REVIEW LEVEL, BELOW ALERT LEVEL

Readings of 10 mm to less than 15 mm are above the Review Level, but below the Alert Level.

If monitoring results are above the Review Level but below the Alert Level Stantec will:

- Notify all parties on the emergency contact list within 24 hours that the results of the monitoring are within the Review Limit.
- Request that the project surveyor undertake an additional survey to confirm the results obtained and provide a verbal report of the results to the geotechnical consultant within 1 hour of completion of the survey and a written report of the results to the geotechnical consultant within 24 hours; and,



PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO CARMEN DRIVE, MISSISSAUGA, ON

Contingency Measures
April 21, 2021

- Notify all parties on the emergency contact list within 24 hours of the results of the additional monitoring.

5.4 BEYOND ALERT LEVEL

Readings of 15 mm or greater exceed the Alert level.

If monitoring results are beyond the Alert level the Contractor shall cease construction operations and execute pre-planned measures. In this event, Stantec will:

- Notify all parties on the emergency contact list within 2 hours that the monitoring results have exceeded the Alert Level.
- Request that the project surveyor undertake an additional survey to confirm the results obtained and provide verbal report of the results to the geotechnical consultant within 1 hour of completion of the survey and a written report of the results to the geotechnical consultant within 24 hours.
- Communicate with Enbridge and if requested by the MTO, Enbridge to advise the Contractor to cease HDD operations until an assessment of the observed displacement is conducted by a geotechnical engineer and a conference call/meeting is convened between the MTO, Enbridge, the Contractor and Stantec to discuss the results of the assessment.
- Mobilize geotechnical staff to the Site within 12 hours to identify if there are any obvious visual indications of movement of the road surface, road embankment or similar and/or if there is any indication of the development of ground subsidence, sink holes or slope instability. The geotechnical staff will also require a response from the Contractor, within 6 hours, to identify if: there has been a stoppage in the boring process and the timing of the stoppage, if there has been an increase or decrease in the mud pressure beyond the normal operating range; and/or, if there has been any indication of possible collapse of the bore.
- Notify all parties on the emergency contact list within 24 hours of the results of the additional monitoring and the results of the visual observations of the current conditions.
- The monitoring frequency may be adjusted and/or increased at the discretion of the geotechnical consultant; and,
- On the recommendation and direction of Enbridge, Stantec may retain a geophysics sub-contractor to conduct a field survey to assess the potential development and/or presence of subsidence, voids, or similar deformation. On the recommendation and direction of Enbridge, Stantec may retain a drill rig to conduct subsurface investigation of any observed ground surface or subsurface anomalies that are identified via the geophysics sub-consultant and/or via visual observations.



PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO CARMEN DRIVE, MISSISSAUGA, ON

Roles and Responsibilities
April 21, 2021

6.0 ROLES AND RESPONSIBILITIES

For purposes of the implementation of this instrumentation and monitoring plan, it has been assumed that Enbridge will obtain the required MTO encroachment permit and maintain said permit in good standing from the time of initial commencement of installation of the instrumentation through to the time of decommissioning of the instrumentation.

Stantec and its designated sub-contractors and/or sub-consultants will provide the following services as components of the Instrumentation and Monitoring Plan:

- Install the deep (in-ground) monitoring points and locate/mark the surface monitoring points prior to commencement of construction.
- Assess the monitoring data and report the results to the MTO (and other parties as may be designated); and,
- Undertake to have the deep (in-ground) monitoring points decommissioned at the completion of the work and at the request of Enbridge.

The survey data obtained from the monitoring of the surface monitoring points and the deep (in-ground) monitoring points will be certified by a registered Ontario Land Surveyor. It is understood that the Surveyor will be contracted by Enbridge separately.

The data will be reviewed by Gwangha Roh. P. Eng., Ph.D., who is registered in MTO RAQS for Tunneling.



**PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO
CARMEN DRIVE, MISSISSAUGA, ON**

Appendix A
April 21, 2021

Appendix A

A.1 STATEMENT OF GENERAL CONDITIONS



STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or subsurface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

**PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO
CARMEN DRIVE, MISSISSAUGA, ON**




Appendix B
April 21, 2021

Appendix B

B.1 DRAWINGS



LEGEND

-  SURFACE MONITORING POINT
-  DEEP (IN-GROUND) MONITORING POINT WITH FLUSH MOUNT
-  TARGET POINT

NOTES

1. COORDINATE SYSTEM: NAD 1983, MTM ZONE 10.
2. BASEPLAN PROVIDED ENBRIDGE GAS INC.
FILENAME: 23515074_D_V1.DGN.dgn DATED 2020-08-24.
3. ALL DIMENSIONS IN METERS.
4. TEMPORARY BENCHMARK LOCATIONS TO BE
ESTABLISHED BY SURVEYORS PRIOR TO
COMMENCEMENT OF MONITORING.
5. THE LOCATION OF THE SURFACE MONITORING POINTS
AND IN-GROUND MONITORING POINTS MAY NEED TO
BE ADJUSTED FROM THAT SHOWN IN CONSIDERATION
OF ACCESS AND VISIBILITY FOR SURVEY. IN ADDITION, IT
IS ANTICIPATED THAT THE LOCATIONS OF THE
IN-GROUND MONITORING POINTS MAY REQUIRE
ADJUSTMENT FROM THAT SHOWN SUBJECT TO THE
PUBLIC AND PRIVATE UTILITY LOCATES AND THE
SPECIFIC REQUIREMENTS OF THE MUNICIPAL AND
REGULATORY AUTHORITIES, AND PRIVATE
PROPERTY/INFRASTRUCTURE OWNERS.

Client/Project

ENBRIDGE GAS INC.

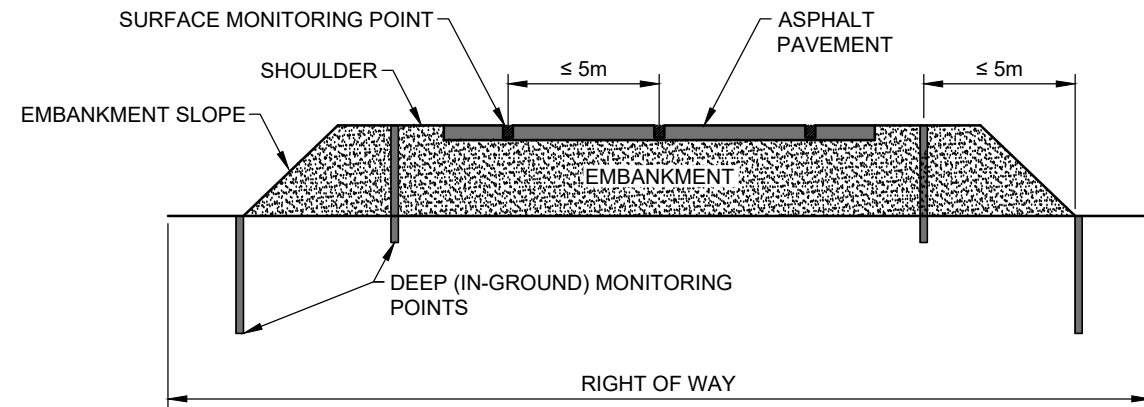
QEW CROSSING FROM CLIFF ROAD TO CARMEN DRIVE
MISSISSAUGA, ONTARIO

Drawing No.

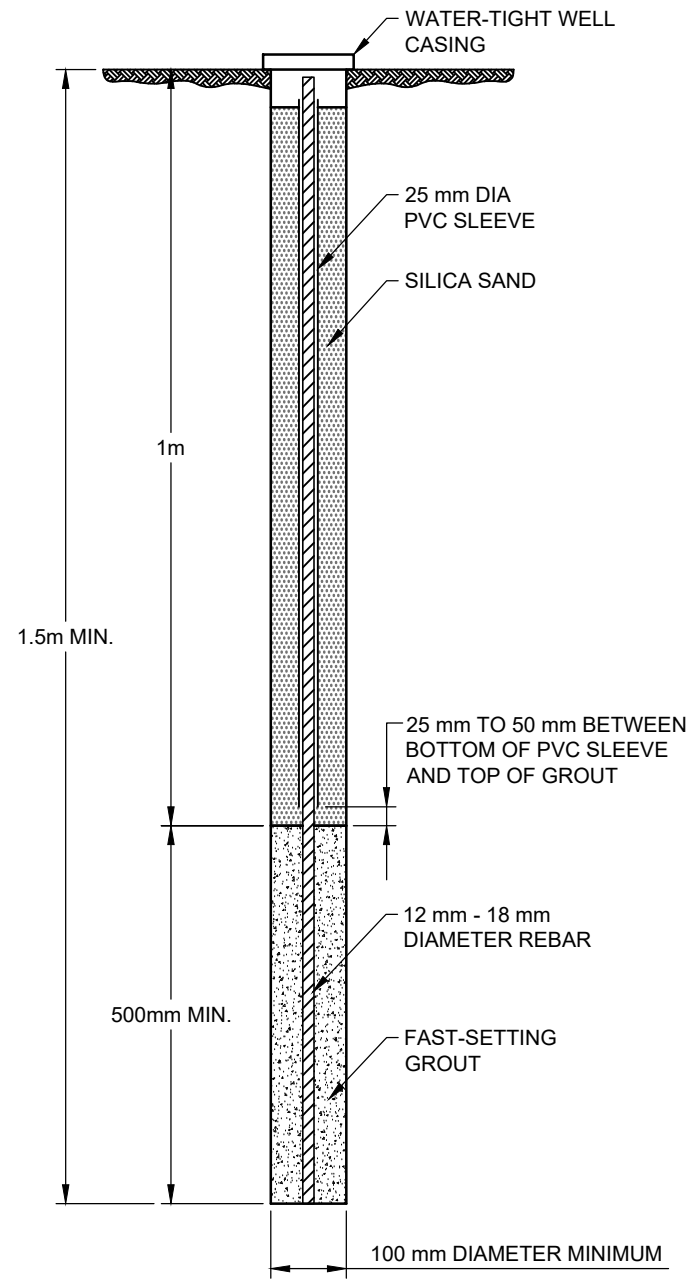
Title

PROPOSED MONITORING POINT LAYOUT

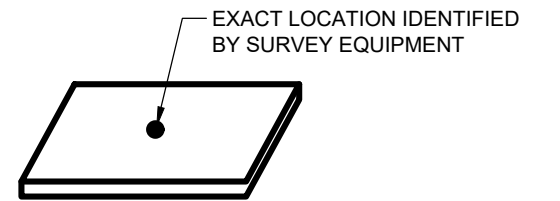
C:\CAD Drawings\Acad2019 Drawings\2020\121623240\121623240_Innisfil_PMP.dwg
2020/08/04 3:57 PM By: Briones, Gilceia



TYPICAL CONFIGURATION OF INSTRUMENTATION
ALONG THE PIPELINE ALIGNMENT

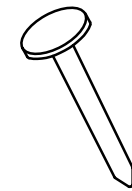


DEEP (IN-GROUND) MONITORING POINT



SURFACE MEASUREMENTS TAKEN DIRECTLY FROM SURFACE MARKER LOCATION ON PAVEMENT.

OPTION 1
(preferred)



OPTION 2

SURFACE MONITORING POINTS

NOTES

1. DRAWING IS NOT TO SCALE.



400 - 1331 CLYDE AVENUE
OTTAWA, ON, CANADA K2C 3G4
www.stantec.com

Client/Project
ENBRIDGE GAS INC.
PROPOSED GAS MAIN INSTALLATION
QEW AND CLIFF ROAD, MISSISSAUGA, ONTARIO

Drawing No.

2

Title

TYPICAL DETAILS
SURFACE AND IN-GROUND MONITORING
POINTS

AUGUST 2020 PROJECT
No. 121623183

**PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO
CARMEN DRIVE, MISSISSAUGA, ON**

Appendix C
April 21, 2021

Appendix C

C.1 NSSP (FOR INFORMATION ONLY)



PIPE INSTALLATION BY TRENCHLESS METHOD – Item No.

Special Provision

July 2020

CONSTRUCTION SPECIFICATION FOR THE INSTALLATION OF PIPES BY TRENCHLESS METHODS

TABLE OF CONTENTS

1.0	SCOPE
2.0	REFERENCES
3.0	DEFINITIONS
4.0	DESIGN AND SUBMISSION REQUIREMENTS
5.0	MATERIALS
6.0	EQUIPMENT
7.0	CONSTRUCTION
8.0	QUALITY ASSURANCE- Not Used
9.0	MEASUREMENT FOR PAYMENT
10.0	BASIS OF PAYMENT
1.0	SCOPE

This specification covers the requirements for the installation of pipe by a selected trenchless method.

2.0 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, General

OPSS 180 Management of Disposal of Excess Material

Ontario Provincial Standard Specifications, Construction

OPSS 401	Trenching, Backfilling, and Compacting
OPSS 402	Excavating, Backfilling, and Compacting for Maintenance Holes, Catch Basins, Ditch Inlets and Valve Chambers
OPSS 403	Rock Excavation for Pipelines, Utilities, and Associated Structures in Open Cut
OPSS 404	Support Systems
OPSS 409	Closed-Circuit Television (CCTV) Inspection of Pipelines

OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 492	Site Restoration Following Installation of Pipelines, Utilities and Associated Structures
OPSS 517	Dewatering
OPSS 539	Temporary Protection Systems

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe
OPSS 1820	Circular and Elliptical Concrete Pipe
OPSS 1840	Non-Pressure Polyethylene (PE) Plastic Pipe Products

CSA Standards

B182.6	Profile polyethylene (PE) sewer pipe and fittings for leak-proof sewer applications
A3000	Cementitious Materials Compendium
W59	Welded Steel Construction (Metal Arc Welding)

American Society for Testing and Materials (ASTM) International Standards

A 252	Standard Specification for Welded and Seamless Steel Pipe Piles
D 2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
D6910	Standard Specification for Marsh Funnel Viscosity of Clay Construction Slurries
F 894	Standard Specification for Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)

17025	General Requirements for the Competence of the Testing and Calibration Laboratories
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3.0 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Auger Jack & Bore means a method of forming a horizontal bore in the subsurface by simultaneously or alternately jacking into the ground a casing pipe and rotating a cutter head at the lead end of an auger flight with removal of material from inside the casing by using continuous-flight augers.

Backreamer or Reamer means a cutting head suitably designed for the subsurface conditions that is attached to drilling equipment and used to enlarge the bore

Bore Path means a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer means the Engineer retained by the Contractor who produces the design and working drawings and other engineering documents required of the Contractor.

Design Checking Engineer means the Engineer retained by the Contractor who checks the original design and

working drawings.

Digger Shield/Hand Mining means a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking a casing pipe, with or without a protective shield at the lead end, into the ground while tunnelling and removal of earth and rock is completed using manually-operated tools (e.g., pneumatic spades, rams, shovels, breaker bars, etc.) or a “digger” type shield with a hydraulic excavator arm or “road-header” rock cutting machine to remove materials from inside the shield and liner pipe.

Horizontal Directional Drilling (HDD) means horizontal directional boring or guided boring.

Drilling Fluids means a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

Drilling Fluid Hydraulic Fracture or “Frac Out” means a condition where the drilling fluid’s pressure in the bore is sufficient to fracture the soil and/or rock materials and allow the drilling fluids to migrate to the surface at an unplanned location.

Earth Pressure Balance (EPB) means a tunnelling system that provides support to the excavated face of the ground and resistance to groundwater inflow through the pressure of mixed earth, rock and any drilling fluids or additives (spoil) as maintained by and in a chamber behind the cutting face of a tunnel boring machine through which spoil can pass only by manner of controlled-load relieving gates or an internal screw-conveyor that is separate from subsequent spoil conveyance systems (e.g., flight augers, belt conveyor, spoil bucket rail cars, etc.). Trenchless systems that apply pressure to the excavated face of the ground only through mechanical and jacking forces on metal parts of the machinery (e.g., steel parts of cutting tools, adjustable gates or doors at cutting face, etc.) will not be considered equivalent to EPB systems.

Excavation means all materials encountered regardless of type and extent and shall include removal of natural soil, boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

Environmentally Sensitive Area (ESA) means areas specified in the Contract Documents that are prohibited from entry or use.

Fill means man-made mixture of previously placed or handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

Guidance System means an electronic system capable of indicating the position, depth and orientation of the drill head during the directional drilling process.

Hand Mining means a method of forming a horizontal bore in the subsurface by simultaneously jacking ahead while tunnelling advances using hand-mining (man-entry operation or “Jack and Mine”) or a “digger” type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Inadvertent Returns means the unexpected flow of fluids, saturated materials (or flowing soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

Loss of Circulation means the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

Microtunnelling means an underground method of constructing a passage by using a microtunnel boring

machine (MTBM) or hand mining using a shield to support the opening.

Pilot Bore means the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

Pipe Jacking means a method for installing steel casing, concrete pipe or other acceptable material in the subsurface utilizing hydraulically operated jacks of adequate number and capacity for the smooth and uniform advancement of the casing or pipe.

Pipe means pipe culverts, pipe storm and sanitary sewers, watermain pipe, conduits and ducts.

Pipe Ramming means a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

Pullback means that part of the HDD method in which the drilling equipment is pulled back through the bore path to the entry point.

Reaming means a process for enlarging the bore path

Rock means natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a volume of 0.5 m³ or greater.

Shaft means an excavation used as entry and/or exit points, alternatively called entry/exit pits, from which the trenchless method is initiated for the installation of the pipe product.

Slurry Pressure Balance (SPB) means a tunnelling system that provides support to the excavated face of the ground and resistance to groundwater inflow through the pressure of slurry as maintained by and in a chamber behind the cutting face of a TBM or MTBM through which spoil can pass only by manner of controlled-pressure and controlled flow slurry pumping systems.

Strike Alert means a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

Slurry means a mixture of soil and/or rock cuttings, and drilling fluid.

Soil means all soils except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials.

Spoil means mix of earth cuttings, rock cuttings, water (groundwater or added water), bentonite, polymers and/or other additives that is discharged from the trenchless construction systems.

TBM means a tunnel boring machine.

Trenchless Installation means an underground method of constructing a passage open at both ends that involves installing a pipe product by auger jack & boring, pipe ramming, horizontal directional drilling, or tunnelling.

Tunnelling means an underground method of constructing a passage using a tunnel boring machine (TBM) operated by personnel within the tunnel, a microtunnel boring machine (MTBM) operated by personnel at a

remote control station or excavation using a shield to support the opening and protect workers.

Zone of Influence means a zone defined by lines projected outward and upward at 45 degrees from horizontal to the ground surface from the vertical and horizontal alignment of the pipe constructed using trenchless/tunnel methods.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Design

4.01.01 General

The Contractor shall determine the most appropriate method of trenchless installation for each pipe crossing for each location within the terms of this specification.

The trenchless installation method selected for each pipe crossing shall be designed for the subsurface conditions in accordance with the Contract Documents.

The detailed design of the installation method selected to carry out the work as specified in the Contract Documents shall be completed.

* The HDD installation method shall be used for pipeline installation at the MTO infrastructure crossing as specified in the Foundation Investigation and Design Report (FIDR).

4.02 Submission Requirements

4.02.01 Working Drawings

Three (3) sets of Working Drawings for each trenchless installation method selected, and a Request to Proceed shall be submitted to the Contract Administrator two (2) weeks prior to the commencement of the trenchless installation operation work.

The trenchless installation operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

All Working Drawings shall bear the seal and signature of the design Engineer and design check Engineer. A copy of the Working Drawings shall be kept at the site during construction.

Information and details shown on the Working Drawings shall include, but not be limited to:

a) Plans and Details:

- i. Plans and profiles defining all horizontal and vertical alignment positions and positions of all utilities and other infrastructure within the zone of influence of the work;
- ii. A work plan outlining the materials, procedures, methods and schedule to be used to execute the work.
- iii. A list of personnel, including backup personnel, and their qualifications and experience.
- iv. A safety plan including the company safety manual and emergency procedures.
- v. The work area layout.
- vi. An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail.

- vii. A contingency plan with specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner.
- viii. A drilling fluid management plan, if applicable, that addresses control of frac-out pressures, any potential environmental impacts and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails.
- ix. Lighting, ventilation and fire safety details as may be required by applicable occupational health and safety regulations.
- x. Excavated materials disposal plan.
- xi. Locations of protection systems.

b) Designs

- i. Primary liner design (e.g., steel liner plates, steel ribs and wood lagging, steel casing pipe, etc.).
- ii. Design assumption and material data when materials other than those specified are proposed for use.
- iii. Drill path design, details of alignment and alignment control, maximum curvature and reaming stages.

c) Materials:

- i. Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer's product specification and that the materials supplied are suitable for the application.
- ii. Manufacturer data sheets for all drilling fluids and additives for use in Earth Pressure Balance, Slurry Pressure Balance
- iii. Manufacturer data sheets for drilling systems.
- iv. Mix designs, target rheology criteria (e.g., viscosity, density, shear strength, gel time, pressure-filtration – fluid losses under pressure, etc.) and additive dosage rates for all slurries and EPB TBM and MTBM operations.
- v. The proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces.
- vi. Compressive strength of concrete pipe products.
- vii. Pipe class for all steel pipe products.
- viii. Steel for Permanent Casings
 - One copy of a mill test certificate certifying that the steel meets the requirements for the appropriate standards for permanent casings shall be submitted to the Contract Administrator at the time of delivery.
 - Where mill test certificates originate from a mill outside Canada or the United States of America, the information on the mill certificates shall be verified by testing by a Canadian laboratory. The laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate.
 - The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date (i.e., yyyy-mm-dd), and the signature of an authorized officer of the Canadian testing laboratory
- ix. Slurry, drilling fluids, and tunnelling fluids
 - type, source, and physical and chemical properties of bentonite, polymer or other additives;
 - source of water;
 - method of mixing;

- the water to solids ratio and the mass and volumes of the constituent parts, including any chemical admixtures or physical treatment employed to achieve required physical properties; details of procedure to be used for monitoring physical properties of slurry, drilling fluids and tunnelling fluids or EPB spoil; and method of disposal of the slurry, drilling fluids and associated spoil

d) Upstream/Downstream Portal Installation Procedure:

- i. Access shaft or entry/exit pit details, as applicable.
- ii. Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

- i. Excavation and pipe installation procedures, including methods to handle obstructions and prevent soil cave-in.
- ii. Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

- i. Equipment and methods for control, handling, treatment, and disposal of groundwater and water or fluids introduced by the Contractor.
- ii. Equipment and methods for maintaining control of ground inflow at the excavation face during excavation.
- iii. Equipment and methods for removal of cobbles and boulders.
- iv. Manufacturer data sheets for each TBM, shield, tunnelling system or drilling system noting all intermediate and final cut dimensions, and methods and equipment for controlling and measuring drilling fluid, SPB and EPB pressures;
- v. Methods for measuring excavated volumes or weights of earth and rock materials cut from ground on a per meter or per pipe basis up to a maximum of 3 m long intervals per measurement;
- vi. Target operating pressures (minimum and maximum) and range of expected pressure variation for slurry or EPB spoil at excavated face or drilling fluids at lead end of drilling equipment and in annular gap between maximum excavated dimensions and outside dimensions of tunnelling equipment, drilling equipment and primary liner systems;
- vii. Basis for setting target operating conditions (pressures, flow rates, advance rates) and the relationship of target operating conditions to ground conditions;
- viii. Basis for selection of excavation tools (e.g., bits, TBM face tools, MTBM face tools, excavator fittings, etc.) as related to expected ground conditions;
- ix. Jacking forces for installation of pipe, for driving of trenchless equipment forward and, in the case of Auger Jack & Bore, for advancing the lead end of the casing ahead of the lead end of the auger cutting tools.

g) Monitoring Method:

Methods, equipment, frequency and repeatability (accuracy and precision) of data collection to be employed for measuring and monitoring shall be submitted for:

- i. Maintaining the alignment of the installation;
- ii. EPB, SPB and drilling fluid pressures at the leading edge of excavation (face), flow rates and volume or weights of spoil;
- iii. Jacking forces on pipes, linings and cutting tools;

- iv. Torque, total revolutions and revolution rates on rotating equipment such as TBM or MTBM heads, auger flights, drill bits, etc.
- v. Grout injection pressures and volumes;
- vi. Longitudinal position of all casings and excavation cutting tools (auger flight heads, TBM face, drill bit position, etc.);
- vii. Ground displacements (heave and settlement); and noise and ground vibrations induced by trenchless construction

4.02.03 As-Built Drawings

As-built drawings shall be submitted to the Contract Administrator in a reproducible format prior to Contract Completion.

The as-built drawings shall be dated and bear the seal and signature of the design Engineer and design checking Engineer.

5.0 MATERIALS

5.01 Pipe

5.01.01 General

The product shall be concrete pipe, steel pipe or high density polyethylene pipe as specified.

All joints shall be suitable for jacking operations as specified in the Working Drawings.

Fittings shall be suitable and compatible with the class and type of pipe with which they will be used.

All fittings shall be designed to be watertight.

5.01.02 Steel Pipe

Steel pipe shall be according to ASTM A252.

All steel casing pipe shall be square cut.

Steel casing pipe shall meet a straightness tolerance of 1.5 mm/m. When placed anywhere on the pipe parallel to the pipe axis, there shall not be a gap more than 1.5 mm between a 1 m long straightedge and the pipe.

5.01.03 HDPE Pipe

High density polyethylene (HDPE) pipe according to OPSS 1840 shall be used in accordance with ASTM D3350.

Fittings shall be according to CAN/CSA-B182.6 or ASTM F894 and suitable for the class and type of pipe with which they will be used.

Jointing of HDPE piping shall be completed according to the manufacturer's recommended procedures and ASTM D2657. Where conflicts exist between the manufacturer's instructions and ASTM D2657, the manufacturer's instructions are to be followed.

Jointing of HDPE piping to other piping materials or appurtenances shall be completed using flanged connections.

5.01.04 Concrete Pipe

Concrete pipe shall be according to OPSS 1820.

5.02 Concrete

Concrete shall be according to OPSS 1350. The concrete strength shall be as specified on the Working Drawings.

5.03 Steel Reinforcement

Steel reinforcement for concrete work shall be according to OPSS 1440.

5.04 Wood

Wood shall be according to OPSS 1601.

5.05 Drilling Fluids

Drilling fluid shall be mixed according to the Working Drawings.

Selection of drilling fluid type shall be based on the soils encountered in the subsurface investigation.

The drilling fluids shall be mixed according to the manufacturer's recommendations.

Slurry shall be mixed according to the submitted slurry design and be appropriate for the anticipated subsurface conditions. The viscosity of slurry used for SPB tunnelling shall be no less than 40 seconds Marsh Funnel viscosity, as defined by ASTM D6910, measured prior to introduction of groundwater and spoil and as required to ensure:

- a) development of appropriate filter cake at excavation face to provide slurry support pressures exceeding ground and groundwater pressures at excavation face;
- b) lubricate installation of primary liners as required;
- c) transport spoil through pipe systems;

5.06 Grout

Purging grout shall conform to the requirements of OPSS 1004 wetted with only sufficient water to make the mixture plastic

6.0 EQUIPMENT

6.01 Auger Jack & Bore

Except in the case of dewatering to at least 1 m below the tunnel/bore invert for the full length of the pipe alignment, Auger Jack & Bore shall not be used and will not be permitted where subsurface conditions indicate

that saturated gravel, sand and silt soils may be encountered at pipe level or within one pipe diameter above or below outside pipe dimensions.

Pipe auger jack & bore equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the equipment with which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

The lead end of the auger shall be maintained at least one pipe diameter inside the lead end of the casing. The auger cutting tools shall not extend to or beyond the lead end of the casing at any time unless specific exception is provided by the Ministry prior to construction. Submittals shall identify anticipated jacking forces for advancing casing ahead of leading edge of auger cutting tools in addition to friction forces that are to be overcome by jacking systems

6.02 Pipe Ramming

Pipe ramming equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

The pipe ramming hammer(s) shall be capable of driving the pipe casing from the entry pit to the exit pit through the existing subsurface conditions at the site without removal of soil from within the casing until the lead end of the pipe is outside the zone of influence for any overlying infrastructure.

Specific details of the equipment with which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the pipe shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.03 Horizontal Directional Drilling

6.03.01 General

The Horizontal Directional Drilling equipment shall consist of a directional drilling rig and a drilling fluid mixing and delivery system to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

6.03.02 Drilling Rig

The horizontal directional drilling rig shall:

- a) Consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head.
- b) Have drill rod that is suitable for both the drill and the product pipe installation.
- c) Contain a drill head that is steerable, equipped with the necessary cutting surfaces and fluid jets, and be suitable for the anticipated ground conditions.
- d) Have adequate reamers and down-bore tooling equipped with the necessary cutting surfaces and fluid jets to facilitate the product installation and be suitable for the anticipated ground conditions.

- e) Contain a guidance system to accurately guide boring operations.
- f) Be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation.
- g) Be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

6.03.03 Drill Head

The drill head shall be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions,

6.03.04 Guidance System

The guidance system shall be setup, installed, and operated by trained and experienced personnel. The operator shall be aware of any magnetic or electromagnetic anomalies and shall consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

6.03.05 Drilling Fluid Mixing System

The drilling fluid mixing system shall be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

6.03.06 Drilling Fluid Delivery System

The delivery system shall have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe shall be leak-free.

6.04 Tunnelling

Tunnelling equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein. Specific details of tunnelling equipment included in the submission shall be provided for:

- a) rock or boulder breaking and removal;
- b) equipment used within shields for spilling, fore-poling, face drainage, breasting boards/plates and for otherwise maintaining support of the tunnel crown and face under all anticipated conditions;
- c) jacking systems;
- d) alignment control systems;

Use of rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use. Use of explosives is prohibited without specific application and acceptance by the Ministry prior to construction.

6.05 Microtunnelling Equipment

The Contractor shall be responsible for selecting microtunnelling equipment which, based on past experience, has proven to be satisfactory for excavation of the soils that will be encountered.

The Contractor shall employ microtunnelling equipment that will be capable of handling the various anticipated ground conditions.

The MTBM shall also be capable of controlling loss of soil ahead of and around the machine and shall provide continuous pressurized support of the excavated face.

a) Remote Control System – The Contractor shall provide a MTBM that includes a remote control system with the following features:

- i. Allows for operation of the system without the need for personnel to enter the microtunnel. Has a display available to the operator, at a remote operation console, showing the position of the shield in relation to a design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force cutter head torque, rate of advance and installed length.
- ii. Integrates the system of excavation and removal of spoil and its simultaneous replacement by Product Pipe. As each pipe section is jacked forward, the control system shall synchronize all of the operational functions of the system.
- iii. The system shall be capable of adjusting the face pressure to maintain face stability for the particular soil condition encountered.
- iv. The system shall monitor and continuously balance the soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow.
- v. The pressure at the excavation face shall be managed by controlling the volume of spoil removal with respect to the advance rate.
- vi. The system shall include a separation process designed to provide adequate separation of the spoil from the slurry so that slurry with a sediment content within the limits required for successful microtunnelling, can be returned to the cutting face for reuse. Appropriately contain spoil at the site prior to disposal.
- vii. The type of separation process shall be suited to the size of microtunnel being constructed, the soil type being excavated, and the work space available at each work area.
- viii. The system shall allow the composition of the slurry to be monitored to maintain the slurry weight and viscosity limits required.

b) Active Direction Control - Provide an MTBM that includes an active direction control system with the following features:

- i. Controls line and grade by a guidance system that relates the actual position of the MTBM to a design reference Provides active steering information that shall be monitored and transmitted to the operating console and recorded.
- ii. Provides positioning and operation information to the operator on the control console.

6.05.01 Pipe Jacking Equipment

Provide a pipe jacking system with the following features:

- a) Has the main jacks mounted in a jacking frame located in the launch shaft.
- b) Has a jacking frame that successively pushes towards a receiving shaft, a string of Product Pipe that follows the microtunnelling excavation equipment.
- c) Has sufficient jacking capacity to push the microtunnelling excavation equipment and the string of pipe through the ground.

- d) The main jack station may be complemented with the use of intermediate jacking stations as required.
- e) Has a capacity at least 20 percent greater than the calculated maximum jacking load.
- f) Develops a uniform distribution of jacking forces on the end of the casing pipe.
- g) Provides and maintains a pipe lubrication system at all times to lower the friction developed on the surface of the pipe during jacking.
- h) Jack Thrust Blocking shall adequately support the jacking pressure developed by the main jacking system.
- i) Special care shall be taken when setting the pipe guide rails in the jacking shaft to ensure correctness of the alignment, grade, and stability.

6.05.02 Spoil Separation System

The Contractor shall determine the type of spoil separation equipment needed for each drive based on the geotechnical information available and other project constraints.

6.05.03 Electrical Equipment, Fixtures and Systems

Electrical equipment shall be suitably insulated for noise reduction. Noise produced by electrical equipment must comply with local municipal noise by-laws.

Electrical systems shall conform to requirements of the Canadian Electrical Code – CSA C22.1.

7. CONSTRUCTION

7.01 General

The Contractor shall notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation to be used by the Contractor shall be subject to the limitations presented in the following subsections.

The Contractor's Engineer shall supervise the work at all times.

A Request to Proceed shall be submitted to the Contract Administrator upon completion of each of the following operations and prior to commencement of each subsequent operation and no less than 2 weeks prior to the commencement of the trenchless installation.

- a) Site Surveying (see Clause 4.02)
- b) Excavation for pits including dewatering of excavations
- c) Jacking / Ramming / Directional Drilling of Casing / Liner
- d) Installation of the Product
- e) Grouting Operations

Operations a) to e) shall not proceed until the Contract Administrator has issued a Notice to Proceed for each proceeding operation.

7.01.01 Layout, Alignment and Depth Control

The location of the installation shall be established from the lines, elevations and tolerances specified in the Contract Documents. The pipe installation shall be to the horizontal and vertical alignments specified in the

Contract Drawings. Deviations from location, alignment, grades and/or invert levels shall be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the pipe installation and appurtenances shall be laid out.

The Contractor shall calibrate tracking and locating equipment at the beginning of each work day, and shall monitor and record the alignment and depth readings provided by the tracking system every 2 m.

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

The Contractor shall submit records of the alignment and depth of the installation to the Contract Administrator at the completion of the installation.

7.01.02 Construction Shafts

Construction shafts shall be specified in the Contractor's submission. The boundaries and protection of these shall be as required to contain all disturbances to areas outside of the ESA limits.

Shafts shall be maintained in a drained condition.

A minimum 2.4 m high secure fence shall be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence shall be removed on completion of the work.

7.01.03 Protection Systems

The construction of all protection systems shall be according to OPSS539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA's may be impaired due to the method of operation, protection shall be provided. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

7.01.04 Settlement or Heave

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation shall be immediately corrected by the Contractor, at no additional cost to the Ministry.

7.01.05 Stability of Excavation

The construction methods, plant, procedures, and precautions employed shall ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, procedures, and materials employed shall prevent the migration of soil and/or rock material into the excavation from adjacent ground.

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

Minimum horizontal and vertical clearances to existing facilities as specified in the Contract Documents shall be maintained. Clearances shall be measured from the nearest edge of the largest cut diameter required to the nearest edge of the facility being paralleled or crossed.

Existing underground facilities shall be exposed to verify its horizontal and vertical locations when the outlet pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities shall be exposed by non-destructive methods. The number of exposures required to monitor work progress shall be as specified in the Contract Documents.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path shall be according to OPSS 401.

7.01.09 Support Systems

Support systems shall be according to OPSS 404.

If any open excavation will encroach into the highway embankment the protection system shall satisfy the requirements for Performance Level 2 as specified in OPSS 539.

7.01.10 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor shall review the foundation investigation report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor shall control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor shall maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor shall take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering shall be according to OPSS 517.

7.01.11 Removal of Cobbles and Boulders

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor shall address the removal of cobbles and boulders in the proposed method of construction. Removal of cobbles shall be expected to be routine and will not be considered cause for obstruction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered.

** The native till deposits along the proposed pipe crossing alignment may contain cobbles and boulders. Removal of cobbles and boulders is not typically applicable to the HDD construction. However, the HDD Contractor must be equipped to handle those conditions. Boulder Volume Ratio (BVR) and Boulder Number Ratio (BNR) were not accessed for this project and shall not be considered as a baseline for payment.

7.01.12 Removal of Obstructions

The Contractor is alerted that obstructions such as, but not limited to wood debris, roots, and construction debris consisting of (broken asphalt, concrete etc.) are expected within the trenchless alignment as identified in the Contract Documents. Accordingly, the Contractor shall address methods for the removal of obstructions in the proposed method of construction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered and the Contractor's expected method of and schedule for removal.

*** Removal of obstructions is not typically applicable to the HDD construction. However, the HDD design and construction should consider the potential presence of obstructions in the overburden and interface between overburden and bedrock as referenced in the FIDR.

7.01.13 Management of Excess Material

Management of excess material shall be according to OPSS 180. Satisfactory re-usable excavated material required for backfill shall be separated from unsuitable excavated material.

7.01.14 Site Restoration

Site restoration shall be according to OPSS 492.

7.02 Auger Jack & Bore Installation

7.02.01 Method of Installation Procedure

The installation procedure to be used shall be subject to the following limitations:

- a) Hydraulically operated jacks of adequate number and capacity shall be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- b) A suitably padded jacking head or collar shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- c) The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
- d) Selection of the excavation method and jacking equipment shall take into consideration the conditions at each pipe crossing.

7.02.02 Pipe Installation

Concrete pipe joints shall be watertight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavated volume (e.g., maximum cut diameter) shall be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavated volume shall be filled with grout or slurry with gel strength properties

demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground.

The annular space between the liner and the product shall be fully grouted with a water tight, expandable and stable grout.

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe shall be used. Butt welding of pipe joints shall conform to CAS W59.

Ramming equipment of adequate capacity shall be provided to ensure smooth and uniform advancement between the shafts/pits without overstressing of the pipe. Delays shall be avoided between ramming operations.

A ramming head shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills shall be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe shall be installed to the line and grade specified.

Removal of materials from within the pipe shall not be undertaken until the lead end of the pipe has passed fully through and beyond the zone of influence of any overlying infrastructure.

Following installation of the liner pipe, all material shall be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall shall be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product shall be fully grouted with a water tight, expandable and stable grout.

7.04 Horizontal Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they shall be activated during drilling and maintained at all times.

For horizontal directional drilling, the contractor shall ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” shall be 2.5 degrees per 9 m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location shall be within 0.5m of the target location.

7.04.02 Site Preparation

The work site shall be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for HDD operations are to be made. All activities shall be confined to designated work areas.

7.04.03 Pilot Bore

The pilot bore shall be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor’s submitted drilling plan to ensure that the product is installed to the line and grade

shown on the Contract Drawings. The Contractor's methods shall take into consideration the conditions at each crossing within the pipe alignment and shall be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contract Administrator shall be notified. The Contract Administrator may require the Contractor to pullback, fill and abandon the hole and re-drill from the location along the bore path before the deviation.

If a drill hole beneath highways, roads, watercourses or other infrastructure must be abandoned, the hole shall be backfilled with grout or bentonite to prevent future subsidence and subsurface water conveyance.

The Contractor shall maintain drilling fluid pressure and circulation throughout the HDD process, including during the initial pilot bore and during the reaming process.

The Contractor shall at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

7.04.04 Drilling Fluid Losses to Surface ("Frac-Out")

To reduce the potential for hydraulic fracturing of the hole during horizontal directional drilling, a minimum depth of cover of 5 m shall be maintained between the top of pipe and the surface of any pavements or beds of water courses. Sections of the pipe close to the entry and exit pit with less than 5 m cover shall be cased. The Contractor shall ensure that drilling fluid pressures are properly set and controlled for the full length of the bore to prevent frac-out for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Once a fluid loss or frac-out event is detected, the Contractor shall halt operations immediately and conduct a detailed examination of the drill path and implement measures to collect all fluids discharged to surface, mitigate and prevent additional fluid loss.

7.04.05 Reaming

The bore shall be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

7.04.06 Product Installation

7.04.06.0 General

The product shall be jointed according to manufacturer's recommendations. The length of the product to be pulled shall be jointed as one length before commencement of the continuous pulling operation.

The product shall be protected from damage during the pullback operation.

The minimum allowable bending radius for the product shall not be contravened.

Product shall be allowed to recover to static conditions from thermal and installation stresses before connections to new or existing facility are made. Product recovery time shall be according to manufacturer's recommendations.

7.04.06.02 Pullback and Grouting

After successfully reaming the bore to the required diameter, the product pipe shall be pulled through the bore path. Once the pullback operation has commenced, it shall continue without interruption until the product pipe is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel shall be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. A weak link or breakaway connector shall be used to prevent excess pulling force from damaging the product.

The product pipe shall be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted shall be rectified to the satisfaction of the Contract Administrator.

The pull back and reaming operations shall not exceed the fluid circulation rate capabilities. Reaming and back pulling operations shall be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the walls of the excavated volume shall be filled with grout or slurry with gel strength properties demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground.

7.05 Tunnelling Installation

7.05.01 General

Excavation of native soil and fill shall be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel shall be capable of fully supporting the face and shall accommodate the removal of boulders and other oversize objects from the face. Continuous ground support shall be maintained during excavation.

As the excavation progresses, the Contractor shall continuously monitor (every 2 m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor shall provide ventilation and lighting in accordance with OSHA requirements for the entire length of the tunnel installed as tunneling progresses.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times in tunnels.

If excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor shall cease excavation and make the excavation face secure. The Contractor shall then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor shall maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

7.05.01 Tunnelling Method

The tunnelling method shall be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil conditions at each pipe crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

7.05.02 Primary Liner (Support System)

Primary support systems shall prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system shall be designed and installed to achieve the intended performance requirements.

Primary liner support system shall maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the excavation.

The primary liner shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and shall ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner shall be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems shall be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the wall of the excavated volume shall be filled with cement grout or slurry with gel strength properties demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground. If an unexpanded liner is used, the space outside the liner plates shall be filled at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

The void outside the finished secondary liner shall be filled with cement grout according to the Contractor's submission.

Grout shall not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting shall be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property. Grout mix design shall be chemically and thermally compatible with all pipe systems.

7.06 Microtunnelling

7.06.01 General

Excavation of soil, rock and fill shall be done in a manner to control and prevent groundwater inflow to the tunnel.

The MTBM shall be capable of fully supporting the face and shall accommodate the removal of boulders and other obstructions from the face. Continuous ground support shall be maintained during excavation.

The tunnel is to be kept well drained at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times.

In the event that excavation threatens to endanger personnel, the Work, adjacent property, roadways, railways, waterways, or the public in any way, the Contractor shall cease excavation. The Contractor shall then evaluate the methods of construction and revise as necessary to ensure the safe continuation of the Work.

The Contractor shall maintain the tunnel excavation line and grade to provide for construction of the product within the specified tolerances.

7.06.02 Method of Installation

The installation procedure to be used shall be subject to the following limitations:

- The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment shall take into consideration the subsurface conditions within the tunnel alignment.
- Perform microtunnelling operations in a manner that will minimize the movement of the ground in front of and surrounding the tunnel in conformance with the limits listed in the Contract Documents.
- Prevent damage to structures and utilities above and in the vicinity of the microtunnelling operations.
- Excavated diameter should be the minimum size required to permit pipe installation by jacking.
- Whenever there is a condition encountered which could endanger the microtunnel excavation or adjacent structures if tunnelling operations cease, continue to operate without intermission including 24-hour working days, weekends and holidays, until the condition no longer exists.
- Maintain an envelope of lubricant around the exterior of the pipe during the jacking and excavation operation to reduce the exterior soil/pipe friction and possibility of the pipe seizing in place.
- In the event a section of pipe is damaged during the jacking operation or a joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, the Contractor shall submit for approval his methods for repair or replacement of the pipe.

7.06.03 Casing Installation

Casing must withstand the jacking forces determined by the Contractor.

The space between the Casing and the wall of the excavation shall be kept filled with lubricant during the pipe jacking operation. Upon completion of pipe jacking, the space between the Casing and the wall of the excavation shall be filled with grout that is compatible with the Casing.

The Casing shall act as a support system to maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the Casing.

The Casing shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting.

7.07 Instrumentation and Monitoring

**** Designer Fill-in, See Notes to Designer

7.07.01 General

The Contractor shall furnish, install and monitor Surface Monitoring Points (SMP) and In-Ground Monitoring Points at the locations shown on the contract drawings.

The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within a repeatability (combined accuracy and precision of equipment and methods) ± 2 mm of the actual elevation.

7.07.02 Surface Settlement Monitoring Points

Surface settlement monitoring points shall be installed on the traffic lanes and shoulders to monitor settlement and stability. The surface settlement monitoring points shall be installed centred on the tunnel alignment as arrays of three points at intervals of 5 m or less and off-set a lateral distance of 1.5 m on either side of the tunnel centerline

Surface settlement monitoring points shall be hardened steel markers treated or coated to resist corrosion, with an exposed convex head having a minimum diameter of 12 mm and similar to surveyor's PK nails. Markers shall be rigidly affixed so as not to move relative to the surface to which it is attached. Traffic shall be managed by the contractor using short-term lane closures in accordance with the Ontario Traffic Manual (OTM). Surface markers shall be recessed or otherwise designed for safe passage of vehicles at highway speeds and protected from snow removal equipment in the event that work occurs during snow removal seasons.

7.07.03 In-Ground Settlement Monitoring Points

In-ground settlement monitoring points shall be installed beyond the traffic lanes and shoulders to monitor settlement and stability of the ground surface between the surface settlement monitoring points and the entry and exit portals. In-ground settlement monitoring points shall be located at intervals of 5 m or less along the tunnel alignment.

In-ground settlement monitoring points shall be 12-18 mm rebar encased in a 50-70 mm, SCH40 PVC pipe, set to a depth of 1.5 m below ground surface or below frost penetration depth whichever is greater. The assembly shall be placed in a drill hole, backfilled with uniform sand and provided with protective covers suitable for high vehicular traffic areas.

7.07.04 Installation, Replacement and Abandonment

The Contractor shall install all settlement monitoring points a minimum of two weeks prior to the start of works to permit baseline surveying to be completed. The settlement monitoring points shall be clearly labelled for easy field identification. The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points including station, offset and elevation. Instruments damaged by the Contractor's operations or other causes shall be replaced and surveyed at the time of installation within 24 hours at no additional cost. At the completion of the job, the Contractor shall abandon all instrumentations installed during the course of the Work and restore the surface at

instrument locations.

7.07.05 Monitoring and Reporting Frequency

The Contractor shall survey and otherwise obtain elevations of all settlement monitoring points at the following time intervals:

- a) Three consecutive readings at least one week prior to commencement of the work (Baseline Reading);
- b) Once per shift or once daily during tunnelling operations period whichever results in the more frequent reading intervals; and
- c) Weekly after completion of the work for one month, or until such time at which all parties agree that further movement has stopped.

All readings shall be submitted to the Contract Administrator for information purposes on a weekly basis.

Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

7.07.06 Benchmarks

Two independent benchmarks shall be used for all settlement monitoring surveying and shall be located sufficiently outside the zone of influence such that the benchmarks are not influenced by any trenchless or other construction activity or weather conditions (e.g., frost heave). All surveying shall be reported using the geodetic datum and coordinate system as defined in the Contract Documents.

7.08 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsections 4.02 and 7.07, the following represents trigger levels that define magnitude of movement and corresponding action:

- a) Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor shall review or modify the method, rate or sequence of construction or ground stabilization measures to mitigate further ground displacement. If this Review Level is exceeded, the Contractor shall immediately notify the CA and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.
- b) Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of the public and maintain traffic. No construction related to trenchless operation shall take place until all of the following conditions are satisfied:
 - i. The cause of the settlement has been identified.
 - ii. The Contractor submits a corrective/preventive plan.
 - iii. Any approved corrective and/or preventive measure deemed necessary by the Contractor is implemented.
 - iv. The CA's written approval.

7.09 Certificate of Conformance

A Certificate of Conformance shall be submitted to the Contract Administrator upon completion of the installation of the pipe at each location. In addition, upon completion of the installation of the pipe at each location, the Contractor shall submit to the Contract Administrator a final Quality Control Certificate sealed and signed by the Design and Design Checking Engineer. The Certificate shall state that the pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, sealed Working Drawings and Contract Documents.

8. QUALITY ASSURANCE - NA

9. MEASUREMENT FOR PAYMENT

Measurement shall be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of pipe installed by trenchless methods.

10. BASIS OF PAYMENT

Payment at the contract price shall be full compensation for all labour, equipment and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, , settlement instrumentation and monitoring, site restoration, and all other work necessary to complete the installation as specified.

Payment for the pipe installed inside the pipe liner shall be paid separately under the appropriate tender items.

Where a protection system is made necessary because of the Contractor's operations (e.g., choice of trenchless installation method), the cost shall be included in this item and shall be full compensation for all labour, equipment and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for connecting intercepted drains and service connections shall be made on the following basis:

- (a) Where such drains and service connections are shown on the contract drawings the cost of connections shall be included in the contract price for pipe installation.
- (b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders exceeding Boulder Volume Ratios (BVR) and Boulder Number Ration (BNR) shall be by Time and Material.

NOTES TO DESIGNER:

***4.01 - Design Requirements**

The HDD installation method shall be used for pipeline installation at the MTO infrastructure crossing

as specified in the Foundation Investigation and Design Report (FIDR).

**** 7.01.11 - Removal of Cobbles and Boulders**

Removal of cobbles and boulders is not applicable to the HDD method. However, the HDD design and construction should consider the potential presence of cobbles and boulders in the overburden as referenced in the FIDR.

***** 7.01.12 - Removal of Obstructions**

Removal of obstructions is not applicable to the HDD method. However, the HDD design and construction should consider the potential presence of obstructions in the overburden as referenced in the FIDR.

WARRANT: Always with this specification

**PROPOSED ENBRIDGE GAS MAIN INSTALLATION QEW CROSSING FROM CLIFF ROAD TO
CARMEN DRIVE, MISSISSAUGA, ON**

Appendix D
April 21, 2021

Appendix D

D.1 REPORT TEMPLATE



LOCATION	POINT ID	Rnd 1:	Rnd 2:	Rnd 3:	Rnd 4:	Rnd 5:	Rnd 6:	Rnd 7:	Rnd 8:	Rnd 9:	Rnd 10:	Rnd 11:	Rnd 12:	Rnd 13:	Rnd 14:	Rnd 15:	Rnd 16:	Rnd 17:	Rnd 18:
		dd-mmm			dd-mmm			dd-mmm			dd-mmm			dd-mmm			dd-mmm		
		hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm	hh:mm
HIGHWAY 403 - SHALLOW POINTS	S1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	S18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HIGHWAY 403 - IN GROUND POINTS	D1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

LEGEND	
<div></div>	$\Delta < 5\text{mm}$
<div></div>	$5\text{ mm} < \Delta < 10\text{mm}$
<div></div>	$10\text{mm} < \Delta < 15\text{mm}$
<div></div>	Not recorded due to visual obstruction

**FIGURE 1 - SETTLEMENT / HEAVE MONITORING DATA
CROSSING: QEW and Cliff Road**

