York Region mining project's geotechnical and hydrogeological challenges overcome through the project design

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ABSTRACT
The existing regional 900 mm sewage forcemain was built about 30 years ago. Through the Environmental Assessment (EA) completed in 2013 the new forcemain will twin the existing sewer and to minimize an overall impact to the community and environment will be placed within the previously disturbed corridor parallel to the existing forcemain. The EA selected alignment has identified a number of constraints, such as: numerous crossings and proximity to the East Holland River, to railways with their bridges, to existing forcemain and to heritage buildings, construction through the public parks and areas of high public use. Most of these constraints were eliminated during Detailed Design, where the micro-tunneling construction method to minimize any disturbance to the surface has being selected. This selection was possible due to the lower the project's vertical alignment (10-12 mbgs vs 3-5 m for an open cut and HDD at the EA design) which, in turn, has reduced potential frac-outs to the surface and into the streams. The Project was issued for Tender in January, 2019 and awarded in April, 2019. Construction will commence in June with anticipated substantial completion by the end of 2021. Region has to implement an extent construction monitoring and reporting to the Ontario Ministry of Environment, Conservation and Parks (MECP) through the entire construction.

RÉSUMÉ
La conduite de refoulement pour les eaux usées régionale de 900 mm existante a été construite il y a environ 30 ans. Dans le cadre de l'évaluation environnementale achevée en 2013, la nouvelle conduite de refoulement sera jumelée à l'égout existant et, afin de minimiser les répercussions globales sur la communauté, l'environnement sera placé dans le corridor précédemment perturbé, parallèle à la conduite de refoulement existante. L'alignement choisi par l'équipe d'évaluation a identifié uncertain nombre de contraintes, telles que: de nombreux passages à niveau et la proximité de la rivière East Holland, des chemins de fer avec leurs ponts, des conduites existantes et des édifices à valeur patrimoniale, de la construction dans les parcs publics et des zones très fréquentées. La plupart de ces contraintes ont été éliminées lors de la conception détaillée, dans laquelle la méthode de construction par micro-tunneling visant à minimiser toute perturbation de la surface a été sélectionnée. Cette sélection a été rendue possible par l'alignement vertical réduit du projet (10-12 mbgs contre 3-5 m pour une tranchée à ciel ouvert et un disque dur lors de la conception de l'EA), ce qui a permis de réduire les fissures potentielles à la surface et dans le fond. ruisseaux. Le projet a été lancé pour appel d'offres en janvier 2019 et adjugé en avril 2019. Les travaux de construction débuteront en juin et devraient s'achever d'ici la fin de 2021. La région doit mettre en œuvre une surveillance de la construction et en rendre compte au ministère de l'Environnement de l'Ontario, Conservation et parcs (MECP) tout au long de la construction.

1 INTRODUCTION

The Regional Municipality of York (York Region), directly north of the City of Toronto (Figure 1) stretches to Lake Simcoe across the area of 1,776 square kilometers (686 square miles). York Region is an upper tier municipality that includes 9 lower tier municipalities: local Towns, Cities and Townships. With the population over 1 million residents, York Region is the sixth-largest municipality in Canada.

Ranked as Canada's fastest-growing, large municipality, York Region will continue to expand rapidly over the coming decades. York Region is forecasted to reach 1,790,000 residents and 900,000 jobs by 2041.

Figure 1. Map of York Region including Greater Toronto Area

1.1 York Durham Sewage System

The York Durham Sewage System (Figure 2) conveys sanitary sewage flows from two Regional municipalities: York Region and Durham Region to the Duffins Creek Water Pollution Control Plant at Lake Ontario. This system was largely built in the 1970s by the Province of Ontario and was then in the 1990s passed to York and Durham Regions for operation and further maintenance.

Wastewater servicing in the Town of Newmarket, one of the lower tier north municipalities is currently provided through local sewers connecting to the existing York Durham Sewage System (YDSS) as shown on Figure 2.

The Newmarket and Bogart Creek Sewage Pumping Station systems are critical components of the YDSS within the Town of Newmarket. The Newmarket Sewage Pumping Station services the majority of the existing and future population in Newmarket, approximately 65,000 people to date. They were initially constructed by the Province of Ontario in the early 1980s and transferred to the Region in 1997.

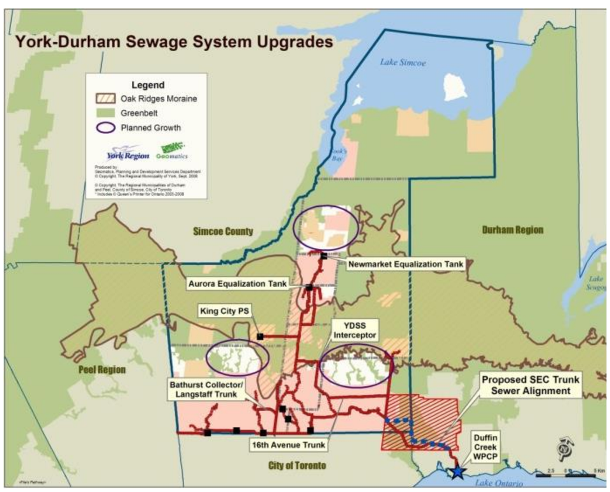

Figure 2. York Durham Sewage System map

The Newmarket and Bogart Creek Sewage Pumping Stations currently have 'single' forcemains. The Newmarket forcemain is approximately 5 km long and connects to a gravity sewer that discharges into the Aurora Sewage Pumping Station. The existing 900 mm Newmarket sewage forcemain was constructed through the heart of the Town of Newmarket The existing 450 mm Bogart Creek forcemain is approximately 500 m long and discharges into the existing Newmarket forcemain.

1.2 Master Planning

Given to constant population growth and attraction to the new businesses, York Region has to extend and enhance the existing infrastructure. Such process commences from strong planning conducted via the 10 year Master Planning process. Each Master Plan (wastewater, water. transportation) is developed in stages and is formed on the extensive consultation with the public, approving agencies, municipal partners and Regional Council.

The 2009 Wastewater Master Plan identified twinning these forcemains to ensure redundancy in the existing regional wastewater system. The work will improve the reliability of the sewage system and allow for future maintenance on the existing forcemain.

2. ENVIRONMENTAL ASSESSMENT DESIGN CONSIDERATIONS

2.1 Project Approval

The Municipal Class Environmental Assessment (EA) for this project was completed as part of a larger concept for York Region's north growth (Upper York Sewage Solutions) project and was filed with the Province in July, 2013.

Through the EA process, several alignments were identified and evaluated. The preferred new twinning forcemain alignment (Figure 3) identified through the EA process was generally parallel to the existing forcemain pipe. This alignment was selected to minimize the overall impacts to the natural and social environment by placing the new infrastructure within the previously disturbed corridor.

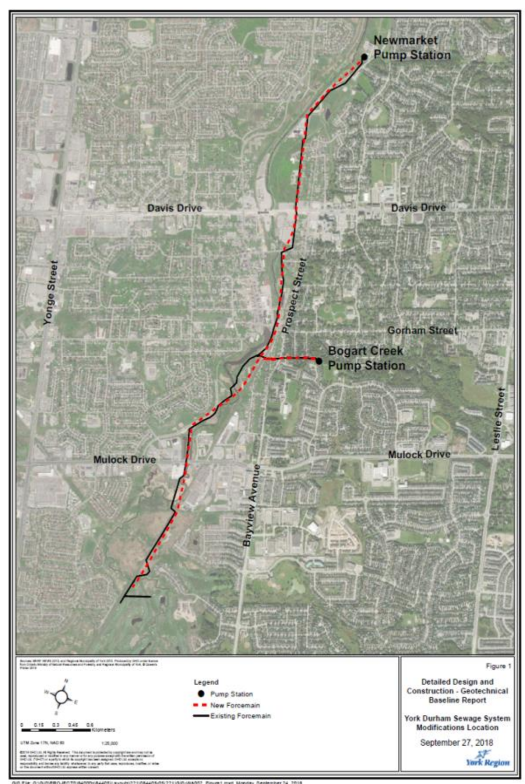

Figure 3. Project alignment

This alignment was also based on the existing property easement, where the Region wanted to utilize the existing property rights to avoid the need for new properties. Property acquisition is one of the major constraints for infrastructure development within the York Region.

Given the desperate need for rehabilitation of the aging regional infrastructure (twinning of the existing pipe), the Ministry issued a Declaration Order on March 7, 2018 to allow the project to proceed for implementation.

The full scope of the project also includes connections to the existing pumping stations and to the existing gravity pipe in the south. This article focuses only on the linear portion of the project.

2.2 EA Design Issues and Risk Assessment

Based on the EA selected alignment almost parallel to the existing forcemain, the project's study area became restricted within the existing easement majorly following the East Holland River by crossing this stream and also smaller tributaries up to 17 times.

The new forcemain's diameter of 900 mm triggered the EA design concept focusing on relatively shallow vertical profile about 4-5 metre below ground surface predominantly built as an open cut with few sections of horizontal directional drilling. The direction drilling sections were proposed for the most sensitive crossings including the East Holland River, railways, bridges and the existing forcemain pipe.

The existing forcemain pipe was built via an open cut with the fill placed on the top and around the pipe. The new forcemain alignment would cross the existing forcemain at multiple locations, which triggered the risk of possible damages to the existing pipe during construction.

Open cut construction in the exact proximity to the existing stormwater ponds, heritage buildings, public parks and areas of high public use has required further analyses to be addressed during detailed design in order to mitigate and avoid all potential risks.

All of the EA's design challenges listed in the above (not limited) were compiled in a Risk Assessment Matrix. The completed Risk Assessment identified a need for extended field investigations to ensure the project team's access to all missing and insufficient details to progress with the detail design.

3. DETAILED DESIGN

Detailed Design commenced after the EA file was submitted with the Ministry in July 2013, and it was ongoing parallel with the EA's review by the Ministry. This fact by itself was a major challenge on the project. It also involved significant risk to the Region to proceed with design without assurance that the project would be approved by the Ministry in general.

The proposed work for the YDSS Forcemain Twinning project included a new second approximately 900 diameter Newmarket forcemain of about 5 km in length, and a new second 450 mm Bogart Creek forcemain approximately 630 m in length.

The project is located in an urbanized setting, along existing road rights-of-ways, through industrial, commercial, and residential properties as well as parklands and wetlands. A significant portion of the forcemain alignment crosses lands regulated by the Lake Simcoe Region Conservation Authority (LRSCA). The new forcemain crosses Metrolinx rail tracks in three different locations, local watercourses in 17 locations, existing streets and utilities.

Upon completion of the EA report and based on the completed risk assessment (mentioned in the previous section), the Design team has focused its effort on further mitigation of all potential issues and reduction of all possible impacts to natural, social, cultural and economic environment.

Also, the local municipality (Town of Newmarket) and the Lake Simcoe Region Conservation Authority (LSRCA) identified significant concerns associated with the EA design's directional drilling (HDD) and open cut,through the certain areas along the project's alignment.

The Town requested that the Region minimize impacts to the community as much as possible with respect to urban traffic movements, noise and vibration. LSRCA identified that the open excavations and HDD construction in the vicinity of the Holland River would require special attention and protective measures. In addressing these concerns, the Region extended the scope of trenchless construction for the majority of the forcemain alignment to offset the potential impacts due to open cut construction.

A forcemain sewage pipe to sustain sewage flows under high pressure could not be directly built by tunneling, where tunneling pipes only suitable for construction of gravity flow pipes due to segmental joints not capable to sustain high pressures. As such, it was decided that the new forcemain pipe will be constructed as a double pass system, with the first pass for installation by tunneling of the reinforced concrete casing and the second pass for installation of the actual carrier forcemain pipe.

3.1 Selection of tunneling method

Various tunneling construction techniques including earth pressure boring machine EPBM, and micro-tunneling were analyzed in detail to select the preferred trenchless construction method. An evaluation of trenchless construction methodologies was conducted. The evaluation included (i) long and curved microtunnel drives (ii) short and straight microtunnel drives (iii) combination of above two approaches, and (iv) Tunnel Boring Machine (TBM).

The TBM option was ruled out due to its very high cost. Microtunnelling was selected as the preferred approach using a combination of both long and curved, and short and straight drives, which was determined as the optimized alignment.

The use of Hobas pipe material as a single pass microtunnelling system has been ruled out because it is not well suitable for drive lengths beyond 375-400 meters in mixed face variable density ground conditions. The use of HDPE pipe material as an internal forcemain was ruled out because its risk of collapse due to the heat of hydration when grouting between external jacking pipe and forcemain.

The change in construction methodology from an open-cut and HDD to microtunnelling has increased the estimated capital cost by approximately 50 percent. However, it was determined to proceed due to the social and environmental benefits to the community.

3.2 Further Changes to the Design

Microtunnelling method provided the opportunity to install a larger diameter forcemain, which has several operational and maintenance advantages. Those advantages included better access for future inspection, cleaning and potential future in situ pipe rehabilitation with insertion of liners without affecting the conveyance design capacity. As such, it was decided to increase the size of the forcemain carrier pipe from 900 mm diameter to 1050 mm.

Based on the evaluation, construction of the new forcemains would involve both open cut and trenchless construction methods. The primary construction methodology for the new Newmarket forcemain will be to microtunnel the majority of the alignment with the exception of the service connections at each end and the Bogart forcemain. The optimized Newmarket tunnel alignment included a total of nine (9) tunnel shafts with an average spacing of approximately 650 meters (m).

The primary construction methodology for the new Bogart Creek forcemain will be to open-cut the majority of the alignment with the exception of microtunnelling for the crossing of the Metrolinx Rail, approximately 60 m.

One of the risks associated with the optimized alignment was that it required two long angles crossings across the Metrolinx railway tracks. The ultimate design was conditional on whether or not Metrolinx would allow long angled microtunnelling crossing(s).

The change in construction methodology required significant changes to the design. Microtunneling could only be possible by lowering the pipe's profile, which in turn required more field investigations.

The final decision on selection of certain techniques and construction methods were made between 30 to 60 percent Design after all field investigations including constructability workshops and risk re-assessments were completed.

3.3 Geotechnical and Hydrogeological Field Investigations

Geotechnical and hydrogeological field investigations were based on the existing data collected as part of the EA field investigations (2011-2012) and conducted into two phases: Phase 1 in 2015-2016 and the Phase 2 in 2017-2018. Phased approach allowed all existing data being analyzed in detail and then refined in the field by zooming in and filling-up the data gaps. Also, the Phase 2 boreholes and monitoring wells were delayed due to some property issues, where certain properties were not accessible until later on the project's stage.

There were total of almost 178 boreholes drilled as part of all phases. Where some boreholes were initially drilled to a shallow depth of about 5-7 metre below ground surface (mbgs) as part of the EA Design's concept and then were over-drilled farther down of about 10-15 mbgs as part of the Design's two phases geotechnical investigations. The spacing between boreholes in general was in the range from 50 to 150 m.

The geotechnical boreholes were advanced using hollow stem augers to a depth of approximately 5 m and then advanced using tri-coning to termination depth. For shallower boreholes where soil conditions permitted, hollow stem augers were used to termination depth. Samples of the soil encountered were obtained altogether with the Standard Penetration Test (SPT). In-situ vane shear testing, thin Shelby Tube Samples and potential indicators for cobbles or boulders were logged over drilling. Soils samples were identified, placed in labelled containers and transported to a certified geotechnical laboratory for further examination and testing.

Majority of the boreholes (125) were completed as monitoring wells, which were monitored over four years. Monitoring wells were typically instrumented with 51 mm diameter polyvinyl chloride (PVC) riser pipe and a Number 10 slot screen with length ranging from 1.5 to 3 m.

Following completion all monitoring wells were developed to ensure representative water levels information and then were completed with in-situ single well response test (SWRT). This testing was undertaken to determine hydraulic properties (transmissivity, hydraulic conductivity) of the hydro stratigraphic units to be intersected during construction.

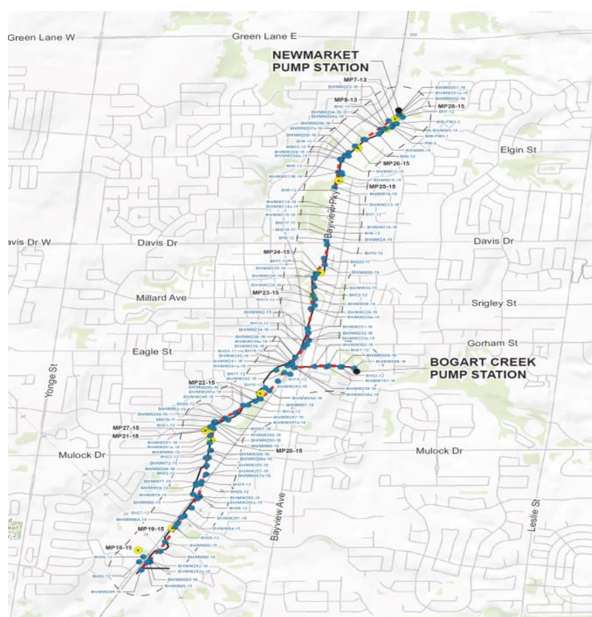

Figure 4. Boreholes and Monitoring Wells locations

All geotechnical and hydrogeological field data collected over the investigation and during the entire monitoring period including the EA stage have being analyzed and compiled into the Geotechnical Baseline Report (GBR) and the Hydrogeological Report. Both Reports helped the project team to completely understand the underlying soils including their properties and move forward with the Design and selection of the tunneling technique.

Both Reports were included in the Contract package, where GBR became part of a Contract and the Hydrogeological Report was provided as an Appendix to disclose all available information and provide additional references.

3.4 Local Geology and Topography

Regional Geological mapping suggests that the quaternary geology of the study area and its general surroundings are dominated by the glacio-lacustrine deposits of silt, sand and clay in unconsolidated condition. The sediment succession was formed by various glacial, fluvial and lacustrine processes including their erosions. As such, the lateral continuity and consistency of soils across the study area is affected and generally does not exist.

The study area is underlain by limestones, dolostones, shale, sandstone bedrocks of Middle Ordovician Lindsay Formation (Simcoe Group), which can be expected at depth greater than 40 mbgs. The project's vertical alignment (tunneling depth) is about 10 to 15 mbgs, and therefore, the bedrock geology was not studies in more detail as part of this project.

The topography of the project's alignment is generally flat and ranges from 240 m above sea level (masl) in the south end to 230 masl in the north end. The entire study area is located on the north side of the Oak Ridges Moraine, major watershed divider between two lakes: Lake Ontario and Lake Simcoe. The project alignment is almost parallel to the East Holland River and crosses this stream and its tributaries 17 times. The study area drains to the East Holland River, which takes its flow to Lake Simcoe.

3.5 Geotechnical Baseline Report

GBR was prepared by Consultants via few steps: preliminary geotechnical consideration including Geotechnical Design Recommendations and Parameters, Geotechnical Data Report, which then formed the Geotechnical Baseline Report.

After the GBR was drafted, Region completed the peer review process, where all recommendations and best management practices were used to finalize the GBR. GBR was written based on Geotechnical Baseline Report for Construction Guidelines prepared by Randall J and Essex P.E 2015 updated version.

GBR sets the rules to potentially minimize the Contractor's issues on change of soil condition that are pretty common practice during any tunneling contract. The completed GBR provides all needed baseline soils data that in turn supports the final design including the tunneling technique selected previously.

3.6 Project Completed Design

The new Newmarket forcemain alignment of about 5040 metres was selected for microtunnelling at the depth of about 10 to 15 mbgs. The primary construction method for the new Bogart Creek is open-cut with some microtunnelling for the crossing of the Metrolinx corridor and a possible trenchless for the crossing of a major arterial road.

Microtunnelling construction techniques selected as cost efficient for installation of a pipe at such depth also minimize a potential for frac-out to the surface including East Holland River. The lowered vertical alignment provides the separation depth between the river's bed and tunnel obvert in average of 8 metre with minimum of 4 metre at one crossing. The entire alignment will be built majorly through silty soils relatively tight and limited with the water content.

Groundwater dewatering is generally not anticipated, although the provision of a contingency dewatering in case of any unforeseen situation is analyzed and included as part of the Hydrogeological Report to support the Permit to Take Water (PTTW) Application.

The microtunnelling work will be constructed in nine tunnel drives ranging from 60 m to 815 m in length with straight and curved drives (smallest curve is 500 m radius).

Construction of the casing pipe (Figure 5) via microtunelling will require installation of the ten shafts, four sending shafts and six receiving shafts. Shafts vary in depth from approximately 10 to 16 mbgs. These shafts will be constructed using sealed shaft technology, which was specified in detail in the Contract package. Sending and receiving shafts are designed based on the geological and geotechnical/hydrogeological soils characteristics at each location, although their construction will be verified in the field by a Contractor.

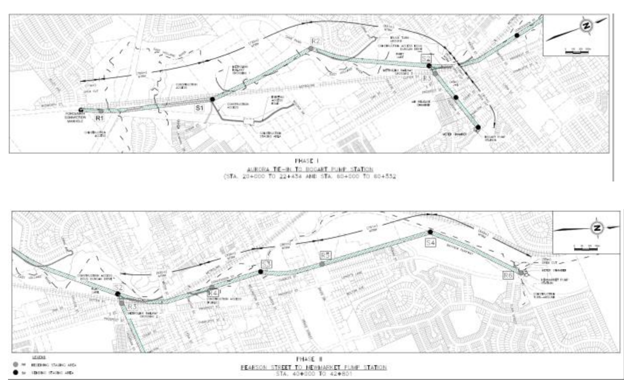

Figure 5. Detailed Design Alignment, Shaft and Tunnel Drive Locations

Each shaft location will require a construction compound, in other words, a staging area. All such areas are now completed with their design including all logistics for both: tunneling and carrier pipe installation, dewatering and discharge, noise and vibration control, and visual protection. Each construction compound and its surroundings will be monitored over entire construction period (estimated two and half years).

3.5 Tender and Contract Package

The work on the Tender package commenced right after the Ministry approved the project via the Declaration Order on March 7, 2018, At that time, the Design was almost complete and just require few refinements including acquisition of all permits and approvals required for construction.

One of the biggest challenges was to obtain the Environmental Certificate of Approval (ECA), which is required under the Ontario Environmental Protection Act to build any new or upgrade, like in our case, the existing wastewater system. The application was submitted to MECP in May with conditional approval issued in October.

Another challenge was to obtain the Permit to Take Water with the Ministry of Environment. The Application was made to MECP in August and the PTTW was obtained in the end of December. Given that all other permits and approval including all required communications, like with Department Fisheries and Oceans, were in place by the end of December, 2018, the Tender was planned for early 2019.

The project team was working with Consultants including regional Legal and Procurement office to ensure the Tender as planned.

In order to provide flexibility to Contractors and encourage local Contractors to bid, the completed design of the casing pipe on the project included a range of 2200 mm and 2500 mm diameter. It shall be reinforced concrete casing pipe. The wastewater carrier pipe, the actual forcemain pipe of 1050 mm diameter concrete pressure pipe (CPP), will be installed inside the casing pipe.

4 PROJECT PROCUREMENT

4.1 Pre-qualification

The Micro-tunnelling drives as per Detailed Design ranged from 60 m to 815 m long. The longer drives are not too common for the microtunnelling industry. Also due to the curved drives and the project taking place through the centre of the Town of Newmarket, the Region decided to prequalify contractors to demonstrate their experience and confidence of dealing with all listed challenges.

As such, in Fall 2018, the Region issued a request for prequalification for the General Contractor, Microtunnelling Sub-Contractor and Open Cut Sub Contractor for the proposed works. As part of the prequalification process, the Contractors needed to demonstrate experience with The Region shortlisted four prequalified Contractors for this project.

There were number of companies interested in pre-qualification process, however only four companies were short-listed to participate in the future Tender.

4.2 Tender

The project was tendered in January 2019 and was open for tender for three weeks, which then was extended twice to approximately two months. The project was awarded to Ward and Burke in April 2019.

The project's construction should commence in early June, 2019 and is estimated over two and half years with substantial completion by the end 2021. Region is currently working with the Contractor to finalize its schedule and complete all required preparation to ensure smooth and timely Contract's implementation. The Scheduling and Risk management workshops are scheduled in the nearest time in order to commence construction.

Region has to fulfill significant environmental monitoring commitments on this project to satisfy MECP's requirements and also to maintain own commitments to the public. Such monitoring will be conducted within construction compounds and outside of the compounds along the tunneling alignment. Pre-construction monitoring outside of construction compounds has commenced in April, 2019.

5 CONCLUSIONS

York Region selected the construction methodology that tends to minimize any impact to the environment (social, natural, economic) by reducing general disturbance through the core of the Town of Newmarket.

Pre-qualification process completed as part of procurement has helped the Region to select a successful bidder as a well-known and experienced Contractor, which should minimize the overall risks during construction.

Region has chosen to change the construction technology even the Environmental Assessment has selected a different preferred alternative method, which demonstrates regional commitment to minimize general impact caused by the project.

The project was recognized by Canadian Ministry of Infrastructure and Communities and received federal funding up to 40 percent of total eligible project's cost under the Disaster Mitigation and Adaption Fund.

York Region demonstrates the leading edge innovative approach for underground infrastructure projects by selecting construction methodology that would limit general disruption and direct surface impacts.

6 REFERENCES

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