2023

# TRENCHLESS SANS TRANCHÉE Journal

THE OFFICIAL PUBLICATION OF THE NORTH AMERICAN SOCIETY FOR TRENCHLESS TECHNOLOGY
Great Lakes, St. Lawrence & Atlantic Chapter | Chapitre des Grands-Lacs, du Saint-Laurent et de l'Atlantique

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## Who to contact | Qui contacter:

**By email/Por courriel :**
In Ontario / en Ontario : Kevin Bainbridge
In Atlantic provinces / dans les provinces de l'Atlantic : Brian Moreau

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TRENCHLESS SANS TRANCHÉE
# Journal
2023



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## DEPARTMENTS | CHRONIQUES :



Craig Kelman & Associates
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Managing Editor: Julia Waterer
Marketing Manager: Chad Morrison
Design/Layout: Tracy Toutant
Advertising Coordinator: Stefanie Hagidiakow

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**David Crowder**, *GLSLA Chapter Chair*

# Celebrating a Busy and Fruitful Year for GLSLA

2023 has been a very busy year for all of us in our *Trenchless* community.

Our chapter has had an active and successful year, thanks to the tireless efforts from the GLSLA volunteers that bring a wealth of knowledge and dedication. A special thank you to all our board members who volunteer their time to help us make our initiatives so successful. We are always looking for more volunteers, please get in touch if you are interested in supporting any of our initiatives.

The No-Dig North Show held in Edmonton back in October of this year was a great success, with over 800 in attendance. All three Canadian chapters worked together for the past year to make this show where it is today. Planning for No-Dig North 2024 is well underway and is anticipated to be even bigger: join us October 21–23, 2024 in Niagara Falls.

"Organize a great seminar, and they will come." In May we hosted a technical seminar 'Trends in CIPP' which had over 65 people in attendance, and not just local members: a representative from as far away as Florida participated. A webinar was also well attended back in June for members.

Our end-of-year free luncheon was held with over 40 members and municipal attendees, who heard from the inspiring speaker Dr. Blair Feltmate from the University of Waterloo discussing how we are preparing for climate change in Canada.

GLSLA's Student Engagement Committee was initiated in 2023 to grow stronger connections with the existing NASTT Student Chapters in the GLSLA region, create new Student Chapters and encourage and support Universities to introduce Trenchless Technology at the undergraduate level.

We are looking forward to a busy schedule in 2024, with webinars, an in-person seminar on Inspection Technologies in the spring, No-Dig North in October, NASTT Best Practice Courses (offered in-person in Ontario and Atlantic Canada for 2024), and more networking events.

Please watch out for the call for abstracts for No-Dig North in early January 2024, to get your submission in to share your project experiences with our industry. For more information on the show please visit *www.nodignorth.ca.*

GLSLA Magazine Committee has put together a high-quality publication filled with inspiring projects and industry articles. For more information on GLSLA, our events, magazine, and training sessions please visit our website at *www.glsla.ca.* We look forward to seeing you at a GLSLA event in 2024.



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**David Crowder**, *président de la section GLSLA*

# Projets et succès à célébrer pour la section GLSLA

Quelle année active, pour toute la communauté de la technologie sans tranchée!

Notre section a connu de nombreux succès, grâce aux efforts inlassables, au dévouement et à la compétence des bénévoles. Je remercie particulièrement les membres du conseil d'administration qui donnent de leur temps pour transformer tant d'initiatives en réussites. Nous sommes d'ailleurs toujours à la recherche de bénévoles pour ce genre d'activités gratifiantes. N'hésitez pas à communiquer avec nous.

Plus de 800 personnes ont assisté à ce beau succès qu'a été le No-Dig North Show, à Edmonton, grâce aux efforts déployés pendant un an par les trois sections canadiennes. Déjà, les plans vont bon train pour le No-Dig North de 2024, qui devrait être plus gros encore. Rendez-vous du 21 au 23 octobre 2024 à Niagara Falls!

« Faites-le et ils viendront ». En mai dernier, nous avons proposé un séminaire technique sur l'évolution des techniques de chemisage (« Trends in CIPP ») qui a attiré plus de 65 personnes, dont une est venue de Floride. Rien de moins! Le webinaire de juin a aussi réuni un nombre substantiel de membres.

Plus de 40 membres et représentants de diverses municipalités ont participé au dîner de fin d'année au cours duquel M. Blair Feltmate, de l'Université de Waterloo, a expliqué comment le Canada se prépare aux changements climatiques.

En 2023, la section GLSLA s'est dotée d'un comité chargé de stimuler la participation des étudiants, notamment en resserrant les liens entre les actuelles sections étudiantes de la section GLSLA de la NASTT, en créant de nouvelles sections étudiantes et en aidant les universités à mettre les technologies sans tranchée au programme des études de premier cycle.

Le calendrier de 2024 est très prometteur! Il nous tarde de vous voir aux webinaires, au séminaire du printemps sur les technologies d'inspection, au No-Dig North en octobre, aux cours sur les pratiques modèles de la NASTT (offert en personne en Ontario et dans le Canada atlantique en 2024) et à diverses activités de réseautage.

Ne manquez pas l'appel à communications pour le No-Dig North qui sera diffusé en janvier 2024. Nous attendons avec intérêt votre proposition détaillée. Pour en savoir plus, rendez-vous à *www.nodignorth.ca.*

Le comité responsable du magazine de la section GLSLA a préparé une publication de grande qualité, qui regorge de projets inspirants et d'articles sur l'industrie. Vous trouverez aussi une foule d'informations sur notre section, nos activités, le magazine et les formations sur le site *www.glsla.* À bientôt au cours d'une activité de section, en 2024.

**Matthew Wallin, PE,** *NASTT Chair*

# No-Dig North 2023: A Successful Canadian Event

Hello GLSLA Chapter Members and Associates! Earlier this year we held the NASTT 2023 No-Dig Show in Portland, Oregon, which was a great success and a wonderful opportunity to see our industry friends and colleagues while we celebrated all things trenchless. And then we switched gears and headed to Edmonton for the 2023 No-Dig North conference last month. No-Dig North is hosted by the Canadian Chapters of NASTT, and your GLSLA Chapter is a big part of why the trenchless community in this area is thriving. No-Dig North offered three full days of training, education, and networking. It was a must-attend event for everyone in Canada and nearby portions of the US. Next year the conference heads to Niagara Falls, right here in our Region. Please visit *nodignorth.ca* for details!

This fall sees many additional events planned to bring the underground infrastructure community together. Our ever-popular NASTT Good Practices Courses are being held both virtually and in-person throughout the year. Visit *nastt.org/training/events* to find a course that fits your schedule.

We are also already planning for the 2024 No-Dig Show which meets in Providence, Rhode Island next April. Providence is a great central location within the heavily populated northeast corridor, just a short drive or train ride from Boston, and within reasonable drive from Philadelphia, New York City, Hartford, and many other cities in between. Our Show motto is *Green Above, Green Below* as it is important that our industry is a steward of our precious natural resources, so we welcome the opportunity to provide a forum for learning about the latest in innovative trenchless products and services that help us all accomplish that lofty goal. Learn more about all the No-Dig Show has to offer at *nodigshow.com.*

If you have attended an NASTT event (national or regional) you probably left feeling excited and eager to get more involved. I ask that you consider getting engaged in one of the many NASTT committees that focus on a wide variety of topics. Some of our committees that are always looking for fresh ideas and new members are the Training and Publications Committee, the individual topic Good Practices Course Sub-Committees, the Educational Fund Auction Committee, the No-Dig Show and No-Dig North Planning Committees and Technical Program Committees. There are many opportunities for you to consider where your professional expertise can be put to use through networking with other motivated volunteers. With education as our goal and a strong drive to provide valuable, accessible learning tools to our community, we are proud of our continued growth as both an organization and as an industry. Our volunteers and committee members are what keep us moving in the right direction.

For more information on our organization, committees, and member benefits, visit our website at *nastt.org* and please feel free to contact us at *info@nastt.org.*

We look forward to seeing you at a regional or national conference or training event soon! And we hope you are planning to join us in Providence, RI next Spring.

**Matthew Wallin, PE,** *président, NASTT*

# No-Dig North 2023 : une belle réussite au Canada

Bonjour aux membres et membres associés de la section GLSLA!

Plus tôt cette année a eu lieu le No-Dig Show de la NASTT à Portland, en Oregon. Un beau succès et de formidables occasions de renouer avec des amis et collègues de l'industrie et de valoriser tout ce qui concerne les technologies sans tranchée. Puis changement de direction, en octobre, vers le NoDig North de 2023 à Edmonton, qui a été organisé par les sections canadiennes de la NASTT et a permis cette fois encore de constater à quel point la communauté des technologies sans tranchée est florissante. Au programme de No-Dig North : trois pleines journées de formation, d'éducation et de réseautage. C'est un incontournable pour tous les membres des sections canadiennes et des régions frontalières des États-Unis. L'an prochain, l'activité aura lieu à Niagara Falls. À nos portes! Détails sur le site *nodignorth.ca*.

Beaucoup d'autres activités attendent cet automne la communauté de l'infrastructure souterraine. Les cours sur les pratiques modèles de la NASTT, toujours populaires, sont offerts l'année durant en mode virtuel et en personne. Vous trouverez la plage horaire qui vous convient à la page *nastt.org/training/events.*

Nous préparons déjà le No-Dig Show de 2024, qui se déroulera à Providence, dans le Rhode Island. Soyez des nôtres en avril prochain dans ce lieu extraordinaire, au cœur du bouillonnement de l'axe nord-est, à faible distance de Boston en voiture ou en train, et à distance raisonnable de Philadelphie, New York, Hartford et tant d'autres. Le thème? *Green Above, Green Below* (vert au-dessus et en dessous). Nous avons tous à cœur de préserver nos précieuses ressources naturelles, d'où l'importance de cette tribune d'information sur les produits et les services les plus innovants de l'industrie, qui nous aideront à atteindre cet objectif des plus respectables. Pour en savoir davantage sur le No-Dig Show, voyez le site *nodigshow.com.*

Si vous avez participé à l'une des activités de la NASTT (à l'échelle nationale ou régionale), votre enthousiasme vous incite sans doute à faire plus. Pourquoi ne pas vous joindre à un comité de la NASTT? Les champs d'action sont très variés, et tous ont besoin d'idées nouvelles et de nouveaux membres : formations et publications, cours sur les pratiques modèles, enchères du fonds éducatif, planification du No-Dig Show et de No-Dig North... Les occasions ne manquent pas de mettre votre expertise au service de la communauté et de nouer des liens avec d'autres bénévoles motivés. Nous sommes fiers de la croissance de notre organisation et de notre industrie, et l'éducation nous tient à cœur. C'est pourquoi nous tenons à offrir des formations utiles et accessibles et c'est pourquoi nous avons besoin de bénévoles et de comités qui nous aident à garder le cap.

Pour en savoir davantage sur notre organisation, nos comités et les avantages de l'adhésion, visitez le site *nastt.org.* N'hésitez pas à communiquer avec nous, à l'adresse *info@nastt.org.*

À bientôt, au congrès régional ou national, à une activité de formation, et à Providence, RI, au printemps prochain.

MEMBERSHIP

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# NO-DIG NORTH WRAP UP FROM EDMONTON

No Dig North continues to demonstrate the success of a Canadian based trenchless conference, building on the record attendance of No Dig North 2022 with another record attendance. The 2023 edition was held in October this year in Edmonton, Alberta and in addition to record attendance, the event also sold out the exhibit hall months in advance.




# AWWA ACE COMES TO TORONTO

The GLSLA Chapter was well represented at the AWWA's Annual Conference and Expo (ACE) conference which was held this year in Toronto, Ontario in June. The ACE23 conference, hosted by the Ontario Water Works Association chapter of AWWA, brought some 10,000 water professionals and more than 900 exhibitors from around the world to the Enercare Centre Exhibition Place on the Toronto waterfront. The 126 educational sessions provided attendees with invaluable information on the theme of ACE23 – the future of water.

The conference recognized Ranin Nseir from the Regional Municipality of York, who received the Innovation Award, the City of Guelph's Waterwork Engine House/Pumping station, and Hamilton's First Waterworks as Water Landmarks. The Region of Peel took the the top spot in the Women's category of Hydrant



Hysteria, the competition which measures how fast a team can assemble a hydrant, with the City of Toronto's team finishing in third place.

MEMBERSHIP

# Connect • Learn
# Achieve • Influence

## Join to be part of an elite community of trenchless professionals!

### Career Advancement Doors Opened!

"Because of NASTT, I have a pretty stacked tool belt that helps me bring innovative approaches to infrastructure concerns. My experiences with trenchless technologies gives me a 'leg-up' over others."

*~ Eric Schuler, PE, Onondaga County Department Water Environment Protection*

### Education Second to None

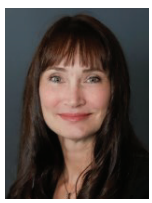
"NASTT is far and away the leading educator and networking pool in the trenchless industry. If your company plays a part in the trenchless industry, you will benefit from NASTT membership much more than you realize."

*~ Joe Lane, Aegion Corp.*

### Tops at Staying on Top of the Industry

"I first joined NASTT to stay current on technological developments, best practices and market trends. Participating in NASTT committees and events and accessing its expert mentors and professionals is essential to the success of almost any project."

*~ Marya Jetten, Jacobs Engineering Group*



### Amazing Network

"NASTT has been the most significant vehicle relative to the industry-specific connections I've made and cultivated throughout my career."

*~ Cindy Preuss, PE, CDM Smith*

### Membership Helps Me Strut My Stuff

"I would not be doing what I love to do without the presence and impact of NASTT. I wanted the industry to know about a record HDD project and NASTT gave me the access and opportunity to tell to the industry."

*~ Jim Murphy, UniversalPegasus International*

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# Queen's Student Chapter Visit to Peel Region's Arthur P. Kennedy (APK) Water Treatment Plant

Earlier this spring, several students from Queen's University visited Peel Region's Arthur P. Kennedy Water Treatment Plant. Accompanied by staff from Peel's Water and Wastewater Division, the group spent the afternoon touring one of the world's largest water treatment facilities. It has the treatment capacity to produce 1200 million litres of clean water every day for residents in the eastern part of Mississauga and Brampton, and the community of Bolton and York Region. Its state-of-the-art treatment facility provides multiple levels of treatment to clean your water. It was a great way for the group to maximize their visit to the Greater Toronto Area ahead of attending the NASTT GLSLA's 'Trends in CIPP' seminar in Mississauga the next day.

# Trends in CIPP – GLSLA Technical Training

On May 24, 2023 the GLSLA chapter of NASTT held a full day session of technical presentations titled Trends in CIPP. Experts and users of CIPP from around North America gathered in Mississauga, Ontario to share valuable insights on this rapidly changing area of rehabilitation technologies. The well attended event included sessions covering the basics of CIPP technology, standards and specifications, procurement models, the health risks of CIPP and inspection and testing requirements. Attendees included engineering professionals who were looking to begin or expand their use of CIPP to rehabilitate sanitary and storm water collection systems as well as water transmission and distribution systems. The GLSLA Training committee is planning webinars and seminars for 2024 so watch for upcoming events.

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# Efficient Watermain Installation Through Horizontal Directional Drilling: A TRENCHLESS APPROACH

By Osama Alfalahi, P.Eng. Program Manager, Transportation-Design and Construction for the Region of Peel, Public Works Transportation Division

## PROJECT OVERVIEW

The Region of Peel owns, operates and maintains assets that make it possible for the Region of Peel to provide high quality and affordable municipal services to the community.

Keeping existing assets in a state of good repair and building new infrastructure are both critical to the short and long–term success of the Region of Peel.

As part of the comprehensive State of Good Repair program, the Region identified several watermain assets that required replacement. The specific project outlined in this document is one of numerous watermain replacement initiatives, focusing on the retirement of substandard gray thin-walled PVC watermains and their replacement with a superior and robust water conveyance system.

This project entailed the replacement of approximately one kilometer of 150mm diameter gray thin-walled PVC watermain, a critical measure aimed at enhancing water quality and bolstering the reliability of the overall system. The operations and maintenance team had consistently reported multiple watermain breaks associated with the existing thin-walled PVC watermain in recent years.

## INTRODUCTION

The watermain infrastructure spanning Granite Stones Drive, situated between Mountainview Road and The Grange Sideroad within the Town of Caledon, is instrumental in supplying potable water to the local residents, providing fire protection, and supporting various functions at a nearby pumping station, local park, and storm pond. An overview of the watermain along Granite Stones Drive is presented in **Figure 1**.

This watermain faced recurring challenges, characterized by multiple watermain breaks and operational disruptions, prompting its inclusion in the state of good repair program for replacement. However, the project faced a unique challenge: the watermain


**Figure 1.** Overview of Granite Stones Drive Watermain Replacement in the Town of Caledon

> “Following an in-depth feasibility analysis, the project was meticulously designed to employ Horizontal Directional Drilling (HDD) for the construction of a High-Density Polyethylene (HDPE) Watermain.

replacement couldn't follow conventional open cut methods due to various factors. These included potential damage to recently paved roadways by the lower tier municipality, limited right-of-way, and the intricate topography of the region, making boulevard open cutting extremely challenging. Additionally, environmental concerns associated with open cut methods necessitated exploring new technologies and innovative solutions beyond conventional approaches.

In response, trenchless technologies emerged as a viable alternative; however, they brought their own set of challenges. The Region had limited prior experience implementing a comprehensive water distribution system through trenchless methods, presenting a significant learning curve and risk assessment requirement. Following an in-depth feasibility analysis, the project was meticulously designed to employ Horizontal Directional Drilling (HDD) for the construction of a High-Density Polyethylene (HDPE) Watermain. The proposed HDPE watermain was to be exclusively constructed using HDD and Fusion Bonding Techniques, at depths ranging from approximately 2.1 to 5.5 metres below the ground surface. The substratum was anticipated to consist of compact to very dense native silt sand, sandy silt, and sand deposits, potentially housing cobbles and boulders. Certain areas featured silty sand deposits in a very loose to loose state.

The Project included two working HDD shafts and as many connection shafts as was deemed necessary by the contractor. All shafts for mainline and water services had to be constructed in the boulevard outside the driven portion of the road to avoid any damage to the existing asphalt recently laid on Granite Stones Drive by the local municipality. The project also included all watermain appurtenances such as mainline gate valves, butt-fused elbows, electro-fused fittings, anchor-tee valves, hydrants, water-services, sampling station, couplings, small sections of PVC pipes, plugs and several fittings.

## HDD DESIGN

The HDD design process commenced with the advancement of ten boreholes along the designated watermain alignment on Granite Stones Drive. The borehole investigation offered insights into the soil composition, ranging from compact to very dense silt sand, sandy silt, and sand, potentially containing cobbles or boulders. Notably, the monitoring wells did not encounter groundwater, and the majority of boulders in cohesionless deposits were less than 1 m in diameter.

In the geotechnical design phase, it was anticipated that 99% of the boulders would not exceed a 1m maximum dimension, while 1% could range from 1 to 3 m. These boulders and cobbles were expected to exhibit rounded characteristics and possess an unconfined compressive strength of up to 250 MPa. Soil categorization in the drilling zone varied from ‘bouldery’ or ‘running’ for compact to very dense silt sand, sandy silt, and sand, to ‘slow ravelling’ for very loose to loose sandy silt, based on Terzaghi's ground classification system from 1950.

The HDD operation was projected to face uniform to mixed face conditions, presenting a challenge due to the transition in soil texture from silt to sand and the potential presence of boulders/cobbles within the cohesionless deposit. The Horizontal Directional Drilling (HDD) methodology encompassed pilot boring, back reaming, and pipe pulling.

In shaping the design of the High-Density Polyethylene (HDPE) watermain, foundational principles from the Plastic Pipe Institute Handbook of Polyethylene Pipe were adhered to. Various design parameters were tailored for different scenarios, drawing upon assumed values from ASTM F1962. The BoreAid tool, a development of the Plastic Pipe Institute, proved instrumental in validating design calculations and exploring alternative approaches. HDPE-PE4710 (DIPS) emerged as the chosen pipe type, aligning predominantly with operational requirements, and the allowable pullback force was meticulously calculated to reach approximately 14,969 kg.

### Challenges Encountered

The project encountered challenges rooted in the curvature and topography of the roadway, as depicted in **Figure 2.** The designed watermain alignment had to consider relatively small horizontal radii, dropping as low as 95 metres in specific areas. While this posed no hindrance for the flexible HDPE pipe, capable of accommodating tighter curves, the limitation arose from the drill rods and their bending capacity.

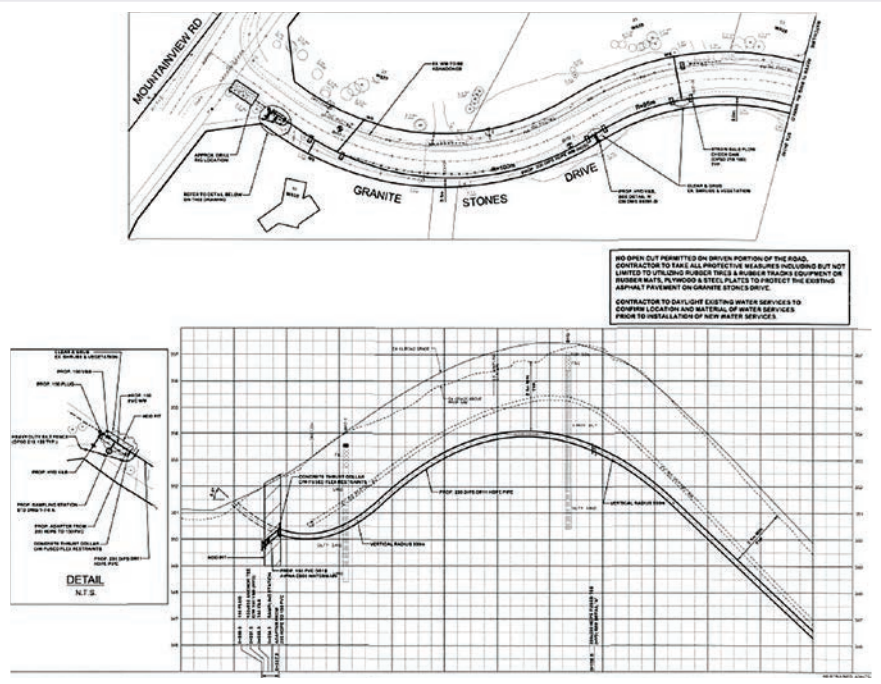


**Figure 2.** Plan & Profile View of the Watermain Northern Section

The selection of an appropriate drilling rig size demanded careful consideration. Striking a balance between pulling force capacity and rod flexibility was crucial. An ideal drilling rig needed to possess adequate pulling capacity (minimum of 18,000 kgs) while ensuring the drill rods maintained a diameter conducive to navigating the curvature of the drilling path. Balancing these factors determined the optimal drilling rig size for the project, essential for its successful execution.

### Operational Concerns

One of the primary considerations in this project revolved around the operation and maintenance of the novel High-Density Polyethylene (HDPE) watermain, a construction unprecedented in the Region for a full-scale water distribution system. Within the region, watermains predominantly consisted of ductile iron and PVC DR 18, covering sizes up to 400 mm in diameter. Consequently, the operations and maintenance teams were well-versed in repairing and maintaining PVC and ductile iron mains. However, when confronted with HDPE, they faced a lack of readily available stock fittings and equipment for repair works. The project's design had to meticulously account for this constraint to ensure that the new HDPE watermain remains repairable in the future when necessary.

In the HDPE industry, Iron Pipe Size (IPS) is the prevalent standard, likely influenced by the widespread use of Iron Pipes for watermains in the United States and other parts of the world. However, the scenario differs in Canada, particularly in Ontario. Historically, Ductile Iron Pipes held predominance, leading to the adoption of Ductile Iron Pipe Size (DIPS) for new PVC pipes replacing the old ductile iron pipes. The key distinction between IPS and DIPS lies in the pipe's outside diameter dimension, consequently affecting the fittings and mechanical joints used.

As a result, the operations and maintenance teams are equipped with DIPS fittings and mechanical joints that are readily accessible. Consequently, for this project, the HDPE pipe had to be designed following the DIPS standard. However, this presented a challenge due to longer production lead times compared to the standard IPS HDPE pipe production lead times.

**Figure 3.** Different Fittings Electrofused to the HDPE Watermain

## CONSTRUCTION

The chosen contractor opted for the deployment of four drilling sequences, referred to as 'shots.' The process initiated with the creation of a small-diameter pilot bore along a pre-established alignment, employing flexible drill rods equipped with a remote-controlled steering system. Throughout the pilot hole operation, all HDD sections were meticulously executed under the constant vigilance of a walk-over locating system (Digitrak F5), ensuring accurate recording of the pilot bore location and alignment at minimum 10 metre intervals.

Following the pilot boring phase, a back reamer was introduced and driven back through the pilot hole to achieve the required diameter for pipe installation. A typical reamer diameter-to-pipe diameter ratio of 1.5 was maintained. The utilization of drilling fluid served the dual purpose of averting borehole collapse and facilitating lubrication and flushing during the drilling process. The selection of the appropriate reamer and drilling fluid was contingent upon the prevailing ground conditions.

The pullback phase was executed as a continuous operation, minimizing or altogether eliminating delays during the backreaming process for each of the four designated shot sections. Throughout the pullback operation, monitoring of downhole pull pressure was systematically conducted and recorded to ensure compliance with the manufacturer's designated safe allowable pull tension. In cases where pull tensile pressure neared or exceeded the allowable safe pull calculation, relief pits were to be installed along the trench alignment through hydrovac procedures until pull tension levels reached acceptable parameters. A comprehensive frac-out monitoring program was rigorously implemented throughout all reaming and pullback operations, encompassing both downhole pressure monitoring and walk-over patrols.

Following the completion of the pullback procedure, the HDPE pipe, measuring 200 mm (8") in diameter and conforming to SDR11 standards, was stored on-site in proximity to the fusion operation location. The pipe fusing process was carried out and documented by a fully certified technician utilizing the McElroy 412 (10 cm – 30 cm) fusion machine. Pipe strings were strategically stored at designated receiving pit areas along the right of way, ensuring no disruption to public vehicular or pedestrian traffic flow.

Lastly, all connections and electrofusions were carried out (see **Figure 3**), The watermain underwent pressure testing and commissioning procedures, culminating in the final integration of connections into the distribution system. The project was substantially completed in November 2020.

## CONCLUSIONS

Embracing trenchless technologies was a pivotal decision, driven by the necessity to overcome challenges posed by the unique characteristics of the project site and the restriction imposed by conventional open-cut methods. Horizontal Directional Drilling (HDD) emerged as a promising solution, albeit with its own set of complexities due to its novel application within the Region.

The geotechnical and operational considerations were meticulous and thorough. Geotechnical analysis provided critical insights into the soil composition, boulders, and ground classification, guiding the HDD design and execution. The innovative use of High-Density Polyethylene (HDPE) pipes through HDD method necessitated careful design and operational planning, ensuring the project's success.

Despite challenges such as the curvature of the roadway and operational concerns, the construction phase was executed with precision and efficiency. The careful selection of drilling rig size and continuous monitoring during the drilling process were instrumental in navigating complex terrains.

Operational concerns, particularly in maintenance and repair, were addressed by adhering to Ductile Iron Pipe Size (DIPS) standards, considering the existing infrastructure landscape and regional practices.

The successful implementation of this trenchless HDD project not only replaced the aging watermain but also set a precedent for future water distribution system projects within the Region. It showcased the effectiveness of trenchless technologies in overcoming unique challenges, ultimately contributing to the Region's commitment to providing efficient and sustainable municipal services.

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ASTM F1962-20 - Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings

# Building Better Communities

Congratulations to the team from Associated Engineering, Thurber, Delve Underground, Whissell, and Ward and Burke Microtunnelling, who worked on the Northwest Inner-City Upper Plateau Separation project for the City of Calgary. The team was honoured with the Project of the Year Award at the No-Dig North conference. The project, which carries storm flows from the Upper Plateau under the Sunnyside neighbourhood to alleviate flooding risk, is the largest diameter microtunnel constructed in North America.

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# INVESTIGATIONS FROM THE UNDERGROUND:
## Predicting CIPP Liner Capacity at Queen's Geo-Engineering Lab

Robert Cichocki, PhD

Driven by a passion for sustainable engineered infrastructure solutions, research students under the guidance of Dr. Ian Moore at Queen's University have set out to uncover the structural mechanics of deteriorating and rehabilitated pipes that carry potable water, wastewater and storm water. Over time, all structures deteriorate and will require either rehabilitation or replacement. With the latter option of replacement often incurring larger costs and undesirable disruptions to society and the natural environment, rehabilitation of these structures could be preferred over replacement. As water and wastewater infrastructure within Ontario nears the end of its service life, the City of Toronto has set aside over seven billion dollars for state-of-good repair projects, between the years 2022 and 2031, to ensure the replacement or rehabilitation of aging watermains and sewers and investment in the aging water and wastewater facilities.

*"Rehabilitation versus replacement is a critical decision in infrastructure and asset management, and when making the decision, certainty, and confidence in the quality of the rehabilitation as well as longevity of the rehabilitation is critical."* – 2022 Program Summary Toronto Water.

Dr. Ian Moore's research group directly focuses its attention here by measuring, understanding, and detailing the load-resistance mechanisms associated with deteriorating and rehabilitated water infrastructure to ensure these rehabilitated systems perform for their intended design life.

Often these water conveying assets experience various types of structural distress due to deterioration such as corrosion, abrasion, construction installation issues, soil erosion, and differential ground movements. Throughout the decades, many rehabilitation technologies, such as slip-lining, sprayed-in-place-pipe (SIPP), and cured-in-place pipe (CIPP), have emerged to address the need of extending our water infrastructure's serviceable design life. At Queen's University, within the Geo-Engineering Laboratory, pictured below in **Figure 1**, a battery of full-scale prototype tests accompanied by numerical modelling have been and are being undertaken to study these technologies, as well as intact and deteriorating pipes with state-of-the-art tools, knowledge, and understanding.

Within the laboratory, the research group possess the capability to replicate a wide array of burial and trenchless construction


**Figure 1.** Queen's University West Campus Large Scale Geo-Laboratory.



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scenarios. The laboratory is equipped with a spacious overhead crane, facilitating the effortless movement of equipment and materials between five distinct test chambers, each tailored for specific assessments. These test chambers accommodate experiments involving new, deteriorated, and rehabilitated pipes under the influence of deep depths, shallow covers accompanied by vehicle loads, and experiences pertaining to differential ground settlements. Moreover, they are configured to investigate both pull- and push-type trenchless construction techniques. The facilities feature multiple reaction frames designed to apply a diverse range of loads, magnitudes up to 2000 kN at shallow burial and 5 MN for deep burial, complemented by the integration of cutting-edge sensing technologies such as spatially continuous fibre optic strain monitoring, electrical resistance strain monitoring, and digital image correlation to collect invaluable experimental data.

A particular point of interest within the laboratory has been and continues to be CIPP lining. A technique utilized worldwide for over five decades (Sterling et al., 2010) which involves the use of a resin-impregnated, hollow cylindrical sock constructed from conventional polyester and/or reinforcement materials like glass-fiber reinforced polymer and carbon fiber woven into the textile sock (ASTM F2019). In North America, CIPP liners find application in the rehabilitation of pipelines ranging from 51 to 2700 mm in diameter (ASTM F1216). A global comparison of design practices reveals a common focus, as illustrated in **Figure 2**, on ensuring that CIPP liners can endure buckling pressure from:

1) Hydrostatic pressure stemming from groundwater.
2) Combined stressors including hydrostatic pressures, earth pressure, and the load imposed by traffic.

Recent contributions to the development of the use of these CIPP liners within irregular shaped structures under these loading conditions have been made. Specifically, ASCE has published a new Manual of Practice (MOP), ASCE MOP 145, which characterizes a close fit liner's load-resistance against external pressures based upon Thépot's derivations for critical and non-critical shapes while considering irregular geometries and imperfections. These solutions provide more explicit consideration of various elements of the host pipe and liner installation such as gap imperfections and localized geometry which could more accurately capture the load performance of the close-fit liner rehabilitated structure. However, many asset managers are still soliciting CIPP liner design and installation according to the ASTM standards or WRC standards with custom modifications. Having these inconsistent design approaches between three methods could lead to inconsistent liner designs and confusion.

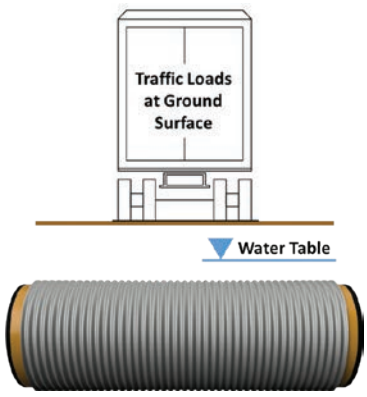


**Figure 2.** Loading on CIPP Liners.

At the No-Dig Show 2023 and within the No-Dig Conference proceedings, Cichocki demonstrated how to model the behavior of an existing close-fit liner under hydrostatic loading, while carefully determining critical input parameters, with the finite element method (FEM) and semi-analytical equations published by Thépot in his latest ASCE publication. The investigation consisted of having a CIPP liner installed within a 1.2 m x 1.6 m corrugated steel ellipse, measuring the exact geometry of the liner with digital image correlation, measuring the liner stiffness from curved (ISO 11296) and rectangular (ISO 178) material test specimens, and

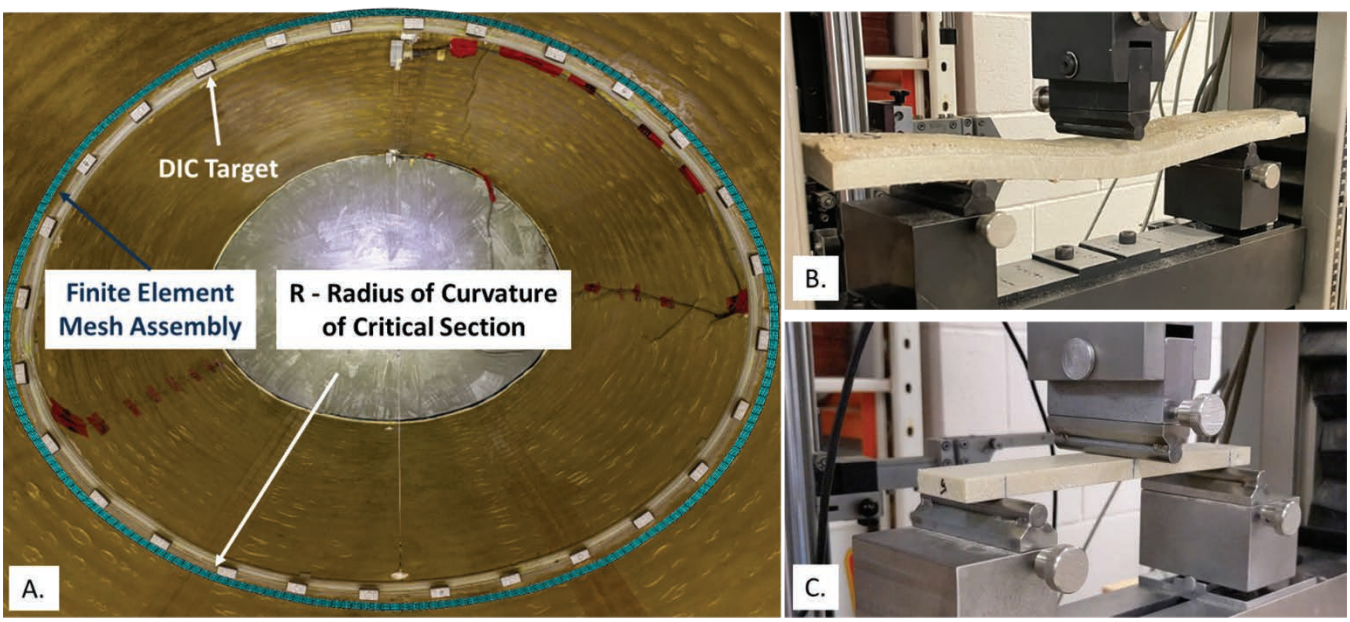


**Figure 3.** Characterization of CIPP Properties A) Geometry – Radius of Curvature, B) Liner Section Stiffness, and C) Material Stiffness.

studying the load-displacement behaviour of the liner using the FEM and Thépot's equations to determine its critical capacity.

When determining the radius of curvature of the critical section for analysis with Thépot's equations, the study suggests that depending on how the radius of curvature is measured, the results for critical buckling pressure can vary up to 17%. Knowing this, a conservative approach could be to use the most critical radius of curvature observed. However, a more accurate approach could be using the average measurement. However, the most realistic and accurate approach could be modelling the exact liner geometry with the FEM.

When predicting the capacity of the liner with the given geometry, with careful determination of the radius of curvature of the critical section, the study shows that similar results can be achieved between Thépot's equations and the FEM, as seen in Figure 4 below. In the study, load-displacement curves and the predicted critical capacity are determined with Thépot's equations and the FEM for comparison under three different configurations:

1) A liner installed within a rigid conduit with no annular gap.
2) A liner installed within a flexible conduit with no annular gap,
3) A liner installed in a flexible conduit with annular gap.

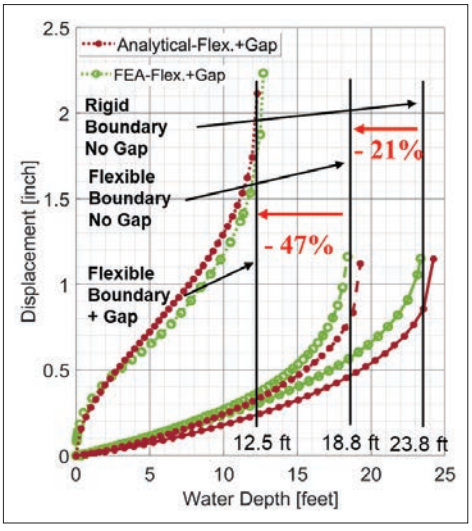


**Figure 4.** Load Displacement Curves of the critical buckling lobe.

The first configuration considers an idealized liner installation where the supporting soil and host structure have enough remaining stiffness to be considered perfectly rigid. However, depending on the host pipe material (e.g., corrugated steel, cracked concrete or clay, or plastic) and the existing state of the surrounding soil, the liner and soil may interact and further oval while deforming under the given load. Configuration two is modeled to analyze the effect of not having a rigid boundary and determine what is the resulting maximum reduction in capacity. To account for the ovaling during deformation, a modification to the input parameters of Thépot's equations is required. Further, within the third configuration, an annular gap between the liner and host pipe is introduced as due to the liner's stiffness, thermal properties, and installation method it is also expected that CIPP liners will experience some small magnitude of shrinkage relative to the host pipe inner diameter.

For the three configurations, similar results between the FEM and the semi-analytical design were achieved. However, to accurately predict the capacity of the liner representative measurements of the radius of curvature are required, and other imperfections may also have a significant on the liner. Within this analysis, ovaling of the liner due to a flexible boundary reduced the capacity of the liner by 21% and adding a gap imperfection (less than 2 mm) reduced the capacity of the liner by an additional 47%. Further work is being undertaken to compare these results to experimental measurements to verify predictions of capacity, load and deflection, and stress resultants. However, with careful selection of input parameters, and appropriate modifications, if required, accurate predictions of close-fit liner capacity could be made using Thépot's semi-analytical equations.

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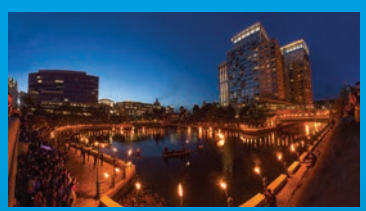


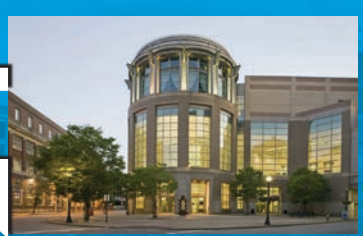

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