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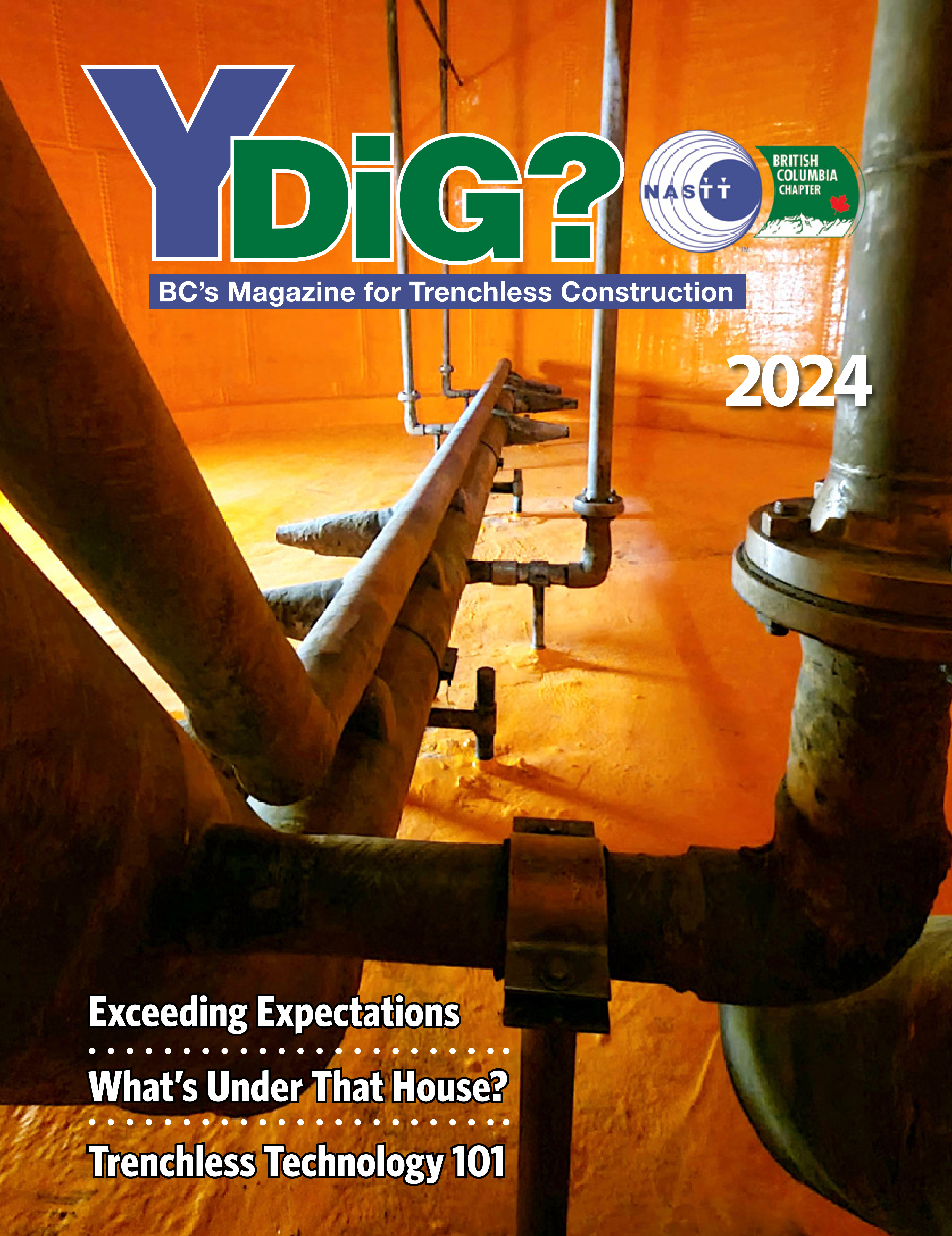
BC's Magazine for Trenchless Construction

NASTT British Columbia Chapter

2024



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Trenchless Technology 101

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MESSAGE FROM THE NASTT-BC CHAIR

Robert Epp, NASTT-BC Chair

Hello Friends:

The British Columbia Chapter is excited to share the incredible momentum building for the 2025 No-Dig North & ISTT International No-Dig North Show. We are proud to be partnering with them to bring together delegates and members from around the globe. With participants expected from more than two dozen international chapters, this event will truly represent a global exchange of ideas, expertise, and innovation in trenchless technology.

Against the stunning backdrop of Vancouver's North Shore Mountains, the 2025 No-Dig North Show will offer a world-class platform to explore the future of trenchless methods. As the industry evolves, this gathering will allow us to learn from each other's successes and challenges, enriching our best practices and driving innovation in every facet of trenchless infrastructure.

NASTT-BC is also taking a proactive approach in expanding our reach across the construction community. We are committed to bringing in new voices from all corners of the industry, ensuring our membership includes not only manufacturers, consultants, and contractors, but also municipal operators, designers, inspectors, and installers. This diversity is key to reflecting the full spectrum of talent that makes the trenchless technology sector thrive.

> *Safety remains our number-one goal.*

> *The 2025 No-Dig North & ISTT International No-Dig Show is a catalyst for progress.*

One of our exciting new initiatives is to establish deeper ties with Safety Professionals, particularly those with an interest in trenchless work.

Safety remains our number-one goal, and the addition of these subject matter experts will allow us to raise the bar even higher, ensuring that we continue to lead in both innovation and safety.

In addition, we are doubling down on efforts to engage the next generation of trenchless professionals through Student Chapters, which are now being formed. Students can join NASTT for free, gaining access to a vast range of training and development resources. This initiative is an investment in the future of our industry, ensuring that young professionals are equipped with the knowledge and networks they need to succeed. We're also continuing to offer scholarships to support students and municipal operators attending best practices offerings and trade show events, because we believe in making these opportunities accessible to everyone.

As we expand our outreach, we're not just looking to grow in numbers, but also to welcome new perspectives and ideas that will fuel innovation. By engaging young professionals, municipal leaders, and safety experts, we're positioning NASTT-BC as a hub for collaboration, where fresh insights can shape the future of trenchless technology.

Please join us on the road ahead. We see the 2025 No-Dig North & ISTT International No-Dig Show as more than just an event—it's a catalyst for progress. As the trenchless community comes together, we will not only celebrate past achievements but also look forward to the exciting possibilities ahead. Whether through technical sessions, demonstrations, or networking opportunities, this event will provide a wealth of knowledge and inspiration for every attendee.

I sincerely hope to see you all there!

Best Regards,

Robert Epp

Robert Epp
CHAIR, NASTT-BC

MESSAGE FROM NASTT CHAIR

Matthew Wallin, PE, NASTT Chair

Hello BC Trenchless Champions!

Fall is here and I want to share some key updates and upcoming opportunities that are of importance to your chapter and our organization and industry.

We are excited to welcome everyone to the upcoming No-Dig North conference, October 28-30 in picturesque Niagara Falls, ON, Canada. This event is a premier opportunity for professionals in our field to learn about the latest innovations and best practices in trenchless technology throughout Canada. We encourage all members to attend and take advantage of the technical sessions, exhibits, and networking opportunities. Visit **www.nodignorth.ca** for all the details.

I'd like to offer a big thank you to everyone who participated in this year's 2024 No-Dig Show held in Providence, RI. Your engagement and contributions made it a resounding success! The presentations were insightful, and the networking opportunities were invaluable. We are currently in the thick of 2025 planning and we hope you will mark your calendars for March 30-April 4 in Denver, CO! If you have any feedback or suggestions for future events, please do not hesitate to reach out to us at **info@nastt.org**.

We are still accepting applications for our municipal scholarship program for the 2025 conference. The NASTT No-Dig Show Municipal & Public Utility Scholarship awards employees of North American municipalities, government agencies and utility owners who have limited or no training funds with a Full Conference and Exhibition registration to the NASTT No-Dig Show. Hotel accommodations are provided for selected applicants. Recipients have full access to all exhibits and technical paper sessions. Applications received after November 1 will be added to the waitlist, so please spread the word to any eligible candidates who may benefit from this opportunity. Detailed information about the scholarship program and the application process can be found on our website at **https://nastt.org/no-dig-show/municipal-scholarships/**.

Together, we are driving the future of trenchless technology forward.

We are excited that the fifth edition of the Horizontal Directional Drilling (HDD) Good Practices Guidelines book has been released. And by popular demand, the book is now available in a digital format you can access online from any device, as well as a print-on-demand version coming soon! The fifth edition includes updated content reflecting the latest advancements and techniques in HDD. Alongside the book, we have also updated our HDD training course to align with the new edition. These courses are designed to provide both new and experienced professionals with the knowledge and skills needed to excel in their roles. Please check our website for more details on how to purchase the book and enroll in the courses.

NEW HEIGHTS. UNDER GROUND.

Thank you for your continued support and dedication to our Chapter. Together, we are driving the future of trenchless technology forward. If you have any questions or need further information on any of the topics mentioned, please do not hesitate to contact me.

Matthew Wallin

Matthew Wallin, PE
NASTT Board Chair

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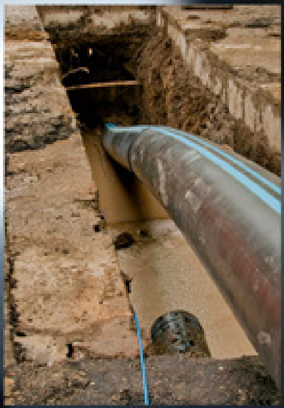

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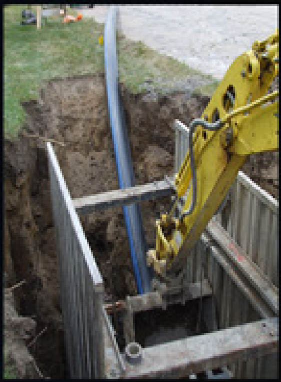

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UNDERGROUND INFRASTRUCTURE SUSTAINABILITY:

NASTT and the Canadian Regional Chapters Host 6th Annual No-Dig North Conference

No-Dig North is the largest trenchless technology conference in Canada where municipalities, contractors, consulting engineers, public utilities, industrial facilities, and damage prevention professionals attend to learn new techniques that will save money and improve infrastructure. This show offers topic tracks over the course of two days with peer-reviewed, non-commercial presentations, including case studies detailing environmentally friendly trenchless solutions and cost-saving opportunities. Additionally, an exhibition hall and networking events are offered throughout the week for opportunities to exchange ideas with colleagues. NASTT's suite of Good Practices Courses is offered on the first day of the conference as well.

No-Dig North held its first conference in 2019 and was an immediate success with over 800 attendees typically in attendance. This year we are expecting to reach the 1,000 + mark as well as welcome over 130 exhibiting organizations.

The No-Dig North 2024 conference will take place October 28-30 in Niagara Falls, ON at the Niagara Falls Convention Centre. Be sure to join us during the conference on Tuesday morning, October 29 for the presentation on the Canadian Projects of the Year. This year awards will be presented for New Installation projects and Rehabilitation projects. Networking events will be held throughout the week including an opening reception in the exhibit hall on Monday evening, Project of the Year and Keynote Breakfast on Tuesday morning and a cocktail reception held at the Niagara Falls Power Station on Tuesday evening.

Networking and close personal access to industry expertise is a central feature of the annual No-Dig North show

Delegates have easy access to industry experts and trenchless technology exhibits featuring innovative new technologies

For agenda and an overview of technical please visit:

https://www.nodignorth.ca/program/

BEFORE

infraStruct Products & Services Exceeds Expectations

Extending the Life of a WWTP Digester with Installation of Revolutionary High-Shear Tank Liner

A Case History from Aquatera Grande Prairie

By: Stormy Shafer, Creative Raven

INTRODUCTION

Aquatera Utilities Inc. manages water and wastewater operations for multiple communities in northwest Alberta, Canada. It operates on behalf of four major shareholders: the City of Grande Prairie, County of Grande Prairie, Town of Sexsmith, and the Town of Wembley.

Due to ongoing population growth in its service territory over the past decades, the company has created a water treatment plant capacity upgrade plan, to keep up with processing needs.

Recently, the utility realized the need for interim measures to maintain treatment capacity at its Grande Prairie Wastewater Treatment Plant (WWTP), until a masterplan is complete and identifies a future upgrade path. Currently a biological nutrient removal (BNR) treatment facility that processes roughly 21 million liters (about 5,548,000 gallons) of sanitary waste per day, the plant uses an Autothermal Thermophilic Aerobic Digestion system, or ATADs, to handle sludge removal.

PROBLEM: PLANT CAPACITY LIMITED BY DETERIORATING INFRASTRUCTURE

Standing in the way of the plant's ability to reliably maintain capacity was the fact that a key piece of infrastructure was no longer able to pull its processing weight, due to decreasing wall thickness.

The culprit was a digester tank, originally designed to help create Class A biosolids, but currently used as sludge storage prior to a centrifuge system.

"This usage created different conditions than the tank was designed for," recalls Aquatera Engineering Manager, Shane Kutin, P.Eng. Shortly after the plant had removed the heating component circa 2015 and converted the ATADs to operate as a storage tank, the utility ended up having to replace the roof of the epoxy-coated carbon steel tank. "We started replacing the roof with stainless steel, but another eight years later, the tank walls were starting to show signs of localized corrosion at liquid levels."

The tank was in fairly good shape below the liquid level, but above it, plant technicians began seeing a lot of serious pitting. Soon, they were actually starting to see holes forming all the way through the walls.

Kutin believes the conversion of the tank from its original function as digester to storage unit likely accelerated some of the localized corrosion issues, though it had previously been apparent that the tank wasn't lasting as long as it had originally been specified for.

Management recognized that extending the life of this sludge tank – by repairing these voids in the inner and outer walls, then relining

> *The system actually extends significant redundancy, ensuring bridging and hull load-bearing capacity.*
>
> - Jordon Bergen, infraStruct

Tanks walls were corroded with serious pitting the interior – would buy them a few years of needed functionality to reach the point where the WWTP would get its own system-wide capacity upgrade plan. But they didn't want to have to commit serious dollars to an asset which may or may not survive a near-future upgrade.

"We will be moving to, I believe, a Mesophilic Anaerobic Digestion (MAD) process," says Kutin. "Hopefully we get a new system, but that's to be decided. I think we could potentially incorporate (the tank) with our next system, at least in a short – five, maybe ten-year – term, then put in another. In essence, it could become strictly a holding tank for a new system.

"We need this tank. It really helps operationally, so we don't have to centrifuge as we go. The sludge that comes out of our process goes through a centrifuge that dries it out, so we can haul it, then the rest of the liquids go back to be reprocessed. If we don't have this tank (available), it's just got to run 24/7; whereas right now, we just hold it for a couple hours, maybe a couple days, and just centrifuge as we need to."

SOLUTION: APPLY ANTI-CORROSION HIGH SHEAR CAPACITY POLYMER LINER TECHNOLOGY

Plant management has performed other such asset lining, but for this badly deteriorated tank, would have had to replace panels, or done quite a bit of patchwork repair, due to the complete perforation of the walls. This would have meant a lot of prep to get the surface ready for welding, then re-prep before lining; quite a bit of work for a temporary fix.

They considered the option of foregoing repair work completely, by simply replacing the previous digester with a brand new tank, which would ultimately be designed into the new MAD treatment process. But cost estimates were five to seven times as much as even the most expensive lining solution.

"It wouldn't be wasted money, since we'll use it in the next-gen MAD system," says Kutin, "but that cost probably doesn't even include everything such as site prep for the berms, spill containment, things like that.

"We didn't want to sink a whole bunch of money into tearing the tank apart, or new sections of tank, so we looked around for products that could help line it. There were a lot of lining products out there, but when I talked to infraStruct, they had this three-layer liner system that provided load-bearing capacity, as well as corrosion protection redundancy.

"That just made everybody feel a lot better. When you start having holes in your tank, to put a structural layer on, versus having to do spot repairs and some coating. So now we have not just a coating, but an extra bit of structure on this tank. It gives us peace of mind, that we had a lot of localized damage in one area, but now we have some extra support there."

Another major factor in Aquatera's decision was infraStruct's assurance that, by using its three-layer structural liner, the plant would be able to extend the tank's life by several years beyond their intended replacement date, allowing breathing room to accommodate budgets and design. This would give the asset owner substantial latitude in how the tank would fit into any future plans.

Sandblasting prepared surface for polyurea application

Spray application done with stringent safety protocols including live air

> *Our treatment and ops team dealt with infraStruct, they loved working with them, said they were one of the most communicative contractors we've had in a while.*
>
> - Shane Kutin, P.Eng, Engineering Manager, Aquatera

CREATING A SOLID INTERIM PLAN

infraStruct approached this application using a methodology they created, called the "Diagnose, Advise and Treat (D.A.T.)" approach to solving complex problems. infraStruct's Senior Project Manager, Robert Epp, explains:

"We assembled a group with diverse expertise to diagnose the problem, understanding the behavior we are trying to resolve. Advise: Do we repair, renovate or replace? Treat: Select the right technology to complete the project safely, on time, on budget, and resolve the problem."

A solution of this magnitude requires an independent peer review process regulated by APEGA (the Association of Professional Engineers and Geoscientists of Alberta). It must be reviewed, stamped and sealed by a registered professional engineer in Alberta.

Through the D.A.T. process, infraStruct established that the OBIC Multi-Layer System addressed the behaviors needing resolution, to protect the tank from both corrosion and the hydraulic fluid loading force placed on the existing wall, currently and in the future.

THE TEAM

infraStruct retained Victoria, B.C.-based Colquitz Engineering Ltd. (practicing in B.C. and A.B.) to design the rehabilitation process. Chris Lee, P.Eng. led the design process and brought on Hillard, Ohio-based Rehabilitation Resources Solutions LLC (RRS), to provide design consultation for the rehabilitation design of the liner. RRS's Ed Kampbell, P.E., is one of the most experienced rehabilitation expert engineers in North America in designing high shear capacity liners for structural applications, as well as providing national specifications for design and construction of these liners.

Kampbell has been mentoring Lee in a few rehabilitation projects, within areas of B.C.'s Mainland. Lee's keen interest in working with trenchless repair and rehabilitation technologies made him an ideal mentee. "As engineers, we are continuously learning and furthering our education, and RRS provided valuable expertise to support our team," says Lee.

IDENTIFIED BEHAVIORS TO RESOLVE

The liner system application characteristics (constructability) were critical to the success of this project, detailing how the liner

Pre-existing pipe remained uncoated

The OBIC system utilizes a structural version of spray foam insulation as a middle layer

The system provides a structural liner with insulating properties

Detail of coating termination against the uncoated utilities

system was to be applied in specific areas, to bridge wall pit holes, manway, piping and other intrusions, including areas in and around the sludge drainage system and appropriate application on a high-temperature circulation pipe.

"Bridging the gap is a significant problem for single-layer lining products," explains Jordon Bergen of infraStruct. "OBIC's polyurea coatings can be an effective solution for bridging pit holes in metal surfaces. Formulated from a two-component system that rapidly reacts upon mixing, polyurea coatings offer exceptional adhesion and flexibility. OBIC's Armour alone can seamlessly fill and bridge pit holes. In combination with two additional layers, the system actually extends significant redundancy, ensuring bridging and hull load-bearing capacity."

HEATED SEWAGE SYSTEM CHALLENGE

Above-ground storage of wastewater sludge requires continuous heating in the winter months, as Grande Prairie can experience temperatures well below -30 degrees C for periods of time. Heated sewage systems can often exacerbate the issue of hydrogen sulfide (H2S) production, due to increased temperatures facilitating the growth of sulfate-reducing bacteria. These bacteria thrive in warm environments, and produce H2S gas as a byproduct of their metabolic processes, leading to accelerated corrosion of the steel tank.

The selected liner had to have extensive ability to withstand a highly corrosive environment, while sustaining elevated temperature fluctuation. S.W.A.T. testing results of the OBIC Muti-Layer Technology demonstrated its ability to protect the steel from acids produced by sewage gases. However, it was not suitable for substrate lining of a wall exceeding 90 degrees C in temperature.

Explains Lee, "Within certain high-temperature areas in the sludge tank, the OBIC three-layer liner system was not suitable – specifically, a one-foot diameter surrounding the pipe penetration of the heating element – so a high-temperature performance epoxy was selected to bridge this gap. Often, in complex design engineering, we need to marry technologies to accommodate unique behaviors."

The choice of OBIC's three-layer solution also fit well with Aquatera's organizational mission statement of providing "high-quality, environmentally sustainable utility services and optimizing value to customers and shareholders." The OBIC system utilizes a structural version of spray foam insulation as a middle layer, similar to commercial roofing design. The use of this system within a heated tank provides insulation, increasing the tank's effectiveness in maintaining heat with less energy consumption.

ENGINEERING EVOLUTION

"We were able to confirm that the standard OBIC liner system thickness was sufficient for the design loads," recalls Lee. "The OBIC system provides a redundant liner; in essence, it has a fail-safe system provided by two polyurea layers, not foam."

"That really separated us from anyone else in the industry today, having that load-bearing capacity liner," says Epp. "It's much more than just a painted-on coating for corrosion protection. It's an engineered, dimensional liner, designed to handle the hydraulic load placed on it from the internal fluids."

The design took a few months to engineer, and Colquitz/RRS were able to satisfy Aquatera's many concerns, explains Kutin, about how the liner system would address the needs of their infrastructure:

"A tank is not simply a cylindrical vessel in itself. It consists of pipe penetrations, internal aeration systems, man entry hatches, protruding bolts, sensors." Placement of a liner needs to acknowledge and overcome these details. infraStruct's ability to combine the skills and talents of the team delivered a detailed design package, illustrating how the OBIC system would address the anomalies.

Lee explains, "Working with infraStruct was a very interesting and collaborative process. The project served to advance all parties' understanding of polyurea lining materials," especially interesting to Lee and his engineering colleagues. Teaming up with Kampbell gave Colquitz the opportunity to grow their understanding of the application of OBIC liners in this somewhat unique environment, advancing their knowledge of this innovative technology.

Project completed on time and on budget – things are looking up

RESULT: RESTORED TANK FUNCTIONALITY, BOTH IMMEDIATE AND LONG TERM

"Our treatment and ops team dealt with infraStruct, and I didn't hear anything (during the liner installation), because it all went well," recalls Kutin. "They loved working with them, said they were one of the most communicative contractors we've had in a while.

"Jordon Bergen, specifically, was always in contact with our ops teams on site. There was a lot of coordination they did together about scaffolding, clean-up, obtaining fuel, and helping watch the site at night. The ops team said it was one of the one of the best experiences they've had with a contractor in recent history."

infraStruct brought the project in on time and on budget, allowing Aquatera the breathing room they needed, without breaking the bank.

"We have a lot of big capital improvement projects coming up, so it's nice that we don't have to spend a lot more on this in the next few years; that we can hold off and get many more years out of this tank, and allocate budget to other critical items," says Kutin.

ABOUT THE AUTHOR:

Stormy Shafer *is Director of Content Development and Public Relations for Creative Raven, a utility infrastructure boutique marketing agency, and has written for trade publications in the potable water, stormwater and wastewater management industry since 2002.*

What's Under That House?

What's Under That Graveyard?

By: Tonia Jurbin, PEng

Like something out of a Charles Dickens novel, the City of Victoria (the City), has about 10kms of large brick storm sewers that were built between the late 1800s and the 1930s. These large brick sewers were built in a variety of shapes including tear drop, egg, arch and even a few circles that range in sizes of up to 2,100mm wide and up to 1,200mm tall depending on the shape and application. Many of the brick sewers were built when filling in historical creeks and streams. Today all of these sewers are all used for storm water though historically some of them were used as sanitary sewers. The City only awards trenchless rehabilitation work on the brick sewers to prequalified contractors.

Sometime in the mid 2000s the City started investigating the brick conduits using camera inspections and assigning ratings from 1 to 5. To date they are almost half way through the program having completed almost 4kms and all of the sewers that were rated a '5'. As the program continues new technology is constantly being reviewed. In some cases, full segment lining or rehabilitation may not be necessary. Where the consequences of failure are lower a cementitious or geopolymer spray might be the rehabilitation method of choice. Where the consequences of failure are high, especially for the larger pipes, CIPP or sliplining using the Glass Reinforced Pipe (GRP) is being used.

The deterioration is not just a matter of failing mortar, some of the worst pipes have significant, even alarming, deformation and are close to collapse. Differential loading and cracking failures longitudinally along the crown have the highest priority for rehabilitation as there are houses sitting above some of these big old pipes. In some cases, the pipes are so badly deformed it's impossible to line them with anything close to the original size. There are also a few unique sections where the pipe goes through or near rock and there is no brick where the rock becomes a part of the conduit.

Main service pit was relocated due to utility conflicts with site access was very tight in this predominantly residential neighbourhood

Victoria's brick sewers were built in a variety of shapes

Condition of the crown put this section high on the City's rehab priority list

The GRP liners supplied by Channeline International–GRP Structural Lining Systems have a smooth 1.5mm thick corrosion resistant inner lining on their approximately 25mm walls that significantly increases the flow when compared with the turbulent flow through a very rough and aged surface that also has considerable sediment and debris deposits. The outside of the GRP liner is treated with a bonded graded aggregate to enhance adhesion to the annular grout required after the liner installation is complete.

Consultant for the City Eric Leydon, P. Eng. with Aecom Canada Limited elaborates, "In some cases the liner is much smaller than the host pipe, for example we did one in 2018 where the host pipe was 1006mm tall by 1600mm wide but it was so deformed the GRP liner we used was 760mm tall by 1500mm wide. With such a reduced flow area there is often a

Brick pipes cleaned out using high pressure water, and debris removed by hydrovac

Correctly sized pipe segments were delivered to the site from Dubai

> *"There was no open cut option to carry out this work because of the existing properties above."*

capacity reduction however the intent of this particular program is structural rehabilitation. In this specific example an earlier diversion was installed to manage the majority of the flow that previously went through this stretch of pipe."

In parts of Victora just outside of the downtown core there are homes in older neighbourhoods that are directly above some of the brick conduits. The initial camera inspection in the neighbourhood under discussion revealed enough dips and cracks in the crown of the pipe for the City to put this section high on the priority rehab list and was rated as a '4'. The big concern at this site was because of the additional loading of the single family dwellings over the alignment, and another five properties that were at risk of developing sink holes.

There are few trenchless rehabilitation contractors in the Capital Regional District (CRD). PW Trenchless of Surrey BC easily prequalified for this work as they have been growing their experience with GRP liners for storm sewer applications and most recently completed a first in BC, having rehabilitated a 1500mm sanitary conduit live – that is without building a bypass or interrupting the flow.

With their growing experience of using this product they were awarded the contract to line a 120m section of a 1930s 1070mm high by 1860mm wide brick storm sewer. The GRP

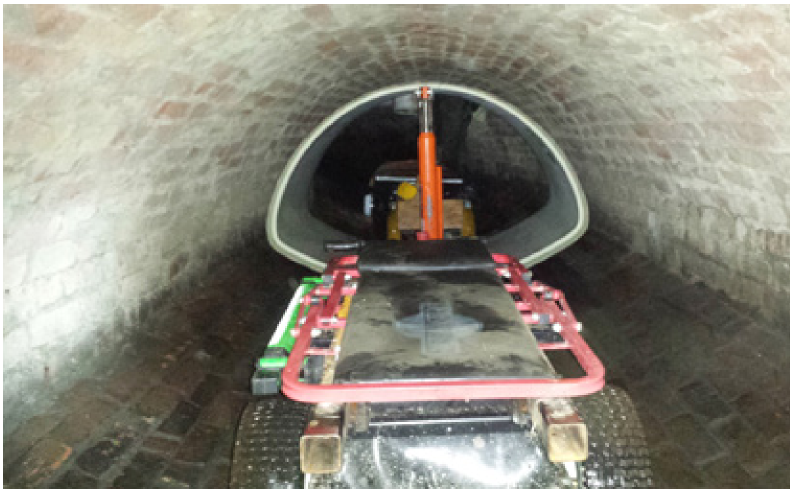

GRP liners conform to the unique shape of the existing pipe

used for this project was 1020mm high by 1770mm wide using one service pit on the street outside a home. The liner was pushed 100m in one direction directly under three houses and other properties to an existing manhole, and then another 20m in roughly the opposite direction to another existing manhole.

Each 2.4m segment of GRP was carefully pushed together for a watertight joint

Once a contract for rehabilitation using GRP is awarded the pipe that needs to be rehabilitated must be properly surveyed so that the correct size of pipe can be ordered from the manufacturer in Dubai. The waiting period is up to 10 weeks. The pipes were cleaned out using high pressure water, the debris removed by hydrovac.

After the pipes are cleaned out a custom-built mandrill was used to determine the internal diameter of the pipes – after which time the GRP liners were ordered. Towards the end of the waiting period the equipment is mobilized, the bypass set up, service pits might be excavated and other preparatory tasks are managed. An above ground 200mm bypass had to be installed which took about five days. Because this is a storm sewer there is an overall lower risk as small leaks would not be catastrophic but flooding is still a risk so the bypass must be installed with care.



Each GRP segment was maneuvered into place using an electronic motorized cart

Each seam had internal gasket and external seal

GRP segments are treated with bonded graded aggregate material to enhance adhesion to the annular grout

Man entry was necessary prior to grouting

> *"The big concern at this site was because of the additional loading of the single family dwellings."*

The soil fortunately could take a vertical cut in dry weather so shoring cages worked well at this site. Once the excavation was set up a 3m access hole was cut into the crown of the brick pipe long enough to accept the 2.4m GRP segments.

Utility conflicts made it necessary to relocate the main service pit. The original location was too close to the sanitary, gas and water. Like so many trenchless projects contractors have to be nimble since you just don't know what you have until there's a shovel in the ground.

Annular grouting completed the construction process

Intent of the sliplining program is a fully structural rehabilitation

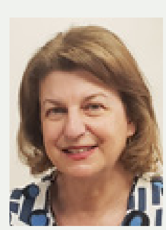
Laterals were located and cut

There is growing experience with using GRP liners for storm sewer applications, with an ability to be installed through major vertical and horizontal bends in the host pipe

Project was successfully completed with minimal disruption

The GRP was dropped into the service pit and then 'chauffeured' into place by the crew lead using an electronic motorized cart. The next pipe was fitted with a gasket then lined up and carefully pushed together for a watertight joint. This description is a little vague as the contractor has some trade secrets to protect. The whole process took about 7 weeks including the bypass, set up, installation, grouting and final testing. There was no open cut option to carry out this work because of the existing properties. All property owners were notified and kept well informed so the project was successfully completed with minimal disruption.

ABOUT THE AUTHOR:



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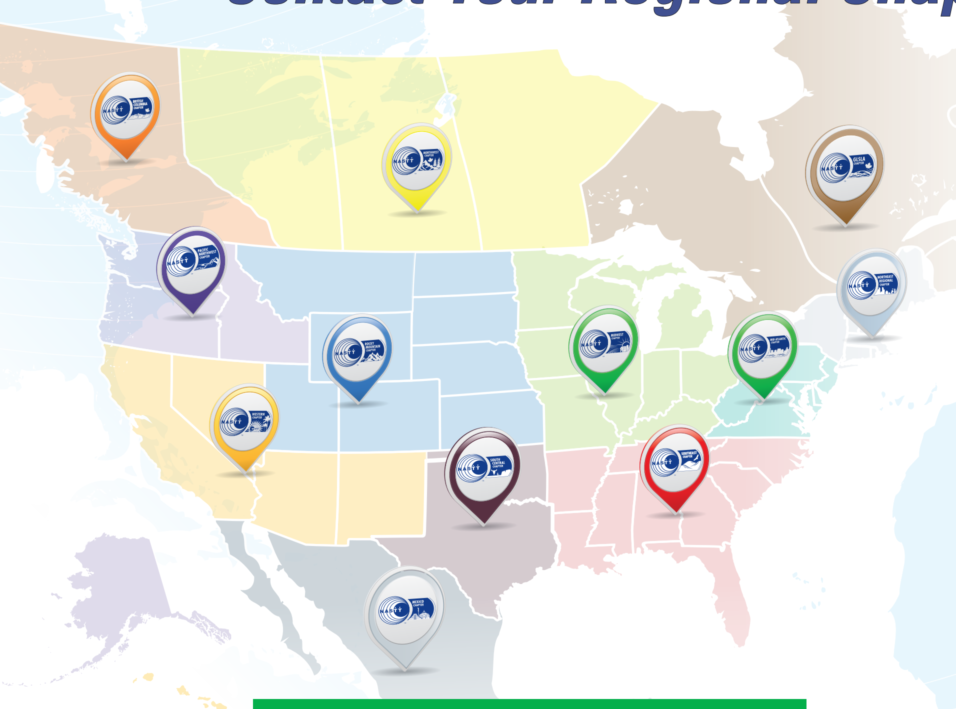

The grassroots of NASTT is a network of 12 Regional Chapters throughout the United States, Canada and Mexico. Regional Chapters network at the local level, share infrastructure challenges and develop new ideas. Regional Chapters hold various events throughout the year, and like NASTT, are dedicated to the advancement of trenchless technologies for the benefit of the public and the environment.

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Canadian Underground Infrastructure Innovation Centre (CUIIC):

Innovating Underground: CUIIC's Groundbreaking Achievements and Future Plans

By: Alyscia Sutch, CUIIC

The Canadian Underground Infrastructure Innovation Centre (CUIIC), based at the University of Alberta in Edmonton, has made remarkable progress in its mission to advance the underground infrastructure sector in Canada. Established to address the challenges and opportunities in this diverse field, CUIIC unites 80 member organizations, including utilities, municipalities, contractors, consultants, manufacturers, suppliers, and non-profit agencies. By spanning various sectors – such as water, stormwater, wastewater, telecommunications, power, energy, and transportation – CUIIC facilitates collaboration and innovation across the underground spectrum.

CUIIC Academy Workshop "Geotechnical Risks & Considerations for Underground Construction" May 30, University of Alberta, Edmonton. Meghan Squires, BMI (left), Alyscia Sutch, CUIIC (right)

The mission of CUIIC is three-fold:

(1) Target current and future needs for underground infrastructure and push innovation;

(2) Facilitate research and collaboration among stakeholders from across Canada and beyond, and;

(3) Promote excellence in education and foster engagement among young professionals.

> *"CUIIC unites eighty member organizations spanning various sectors."*

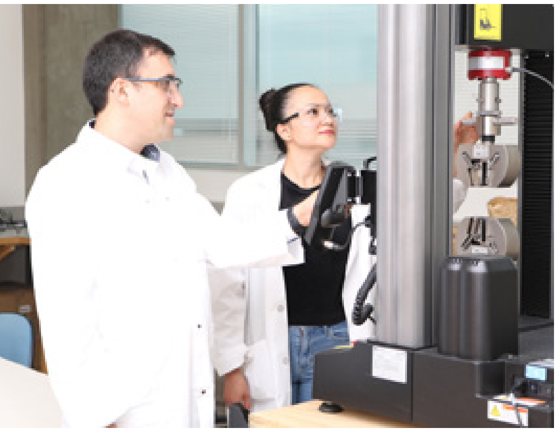
RECENT EDUCATIONAL ACHIEVEMENTS AND INITIATIVES

CUIIC's vibrant membership has been crucial in driving forward our initiatives. This collaborative community has driven significant growth in both research and educational activities. CUIIC Academy is an Accredited CEU Provider through the Engineering Institute of Canada (EIC). The Academy, in partnership with Benjamin Media, has hosted 25 live webinars, attracting over 4,000 attendees. These sessions, free to the public, feature expert speakers and cover a wide range of topics. Recorded webinars are available on CUIIC's YouTube channel for ongoing access.

In addition to webinars, CUIIC Academy has organized six educational events across Ontario, Alberta, and BC, featuring 40 experts from industry and academia and drawing more than 500 attendees. Supported by over 20 sponsoring companies, these events have also awarded 15 student scholarships, demonstrating our commitment to fostering a diverse professional community.

Recent events included the Geotechnical Risks and Considerations for Underground Construction Workshop at the University of Alberta in May and the CUIIC Advanced HDD School held in April in Calgary. These events were well-received and offered valuable insights and networking opportunities. Both events will be returning in Spring 2025.

The second annual Pipeline Rehabilitation Academy held on March 13-14, 2024, at the Fairmont Hotel Vancouver, was a highlight of the year. This two-day course provided attendees with an unmatched learning opportunity focused on asset management, condition assessment, maintenance, and rehabilitation of underground pipelines. Participants earned CEUs from the Engineering Institute of Canada while networking, engaging with experts and discovering the latest advancements and technologies. The Pipeline Rehab Academy returns to Mississauga March 5 - 6, 2025. An opportunity not to be missed!



CUIIC fosters innovation and research in underground construction

> *CUIIC Academy has organized six educational events across Ontario, Alberta, and BC, featuring 40 experts from industry.*

ONGOING RESEARCH AND FUTURE ENDEAVORS

CUIIC is excited to have been awarded a Natural Science and Engineering Research Council (NSERC) Alliance Grant for the groundbreaking project titled "Greenhouse Gas Emission Reduction in Design, Construction, Repair, and Maintenance of Underground Infrastructure." This project, supported by NSERC and 21 industry partners – including the NASTT-NW Chapter – has received a total of three million dollars in funding and in-kind contributions over five years. The research will provide training opportunities for ten graduate and undergraduate students, offering them hands-on experience and interaction with industry professionals in the field of underground infrastructure.

LOOKING AHEAD

The challenges facing the underground infrastructure industry are considerable and wide-ranging, from aging infrastructure and labour shortages to awareness and climate change unpredictability. However, CUIIC's efforts to foster collaboration and innovation are already achieving strong, positive results. With a focus on research, education, and innovation, CUIIC is well-positioned to support the sector in collaboratively addressing future challenges.

Join us at No-Dig North 2024, where CUIIC will be exhibiting from October 28-30, 2024, at the Niagara Falls Convention Centre in Booth #521. This event will provide an opportunity to explore how CUIIC continues to support stakeholders across the underground infrastructure industry through unmatched research and training opportunities.

To learn more about CUIIC and how to get involved visit **www.cuiic.ca**.

ABOUT THE AUTHOR:

Alyscia Sutch *is the Research Marketing and Communications Coordinator at the Canadian Underground Infrastructure Innovation Centre (CUIIC) located at the University of Alberta. She has over 15 years of experience working in the underground construction industry.*

CUIIC events offer valuable insights and networking opportunities

Trenchless 101:

PART ONE – Rehabilitation Methods

By: Tonia Jurbin, PEng (for: PW Trenchless Construction Inc.)

Acknowledgement

Much of the content for this study comes from a presentation 'Trenchless Tapas – An Introduction to Trenchless' delivered by Mr. David O'Sullivan, President of PW Trenchless Inc. of Surrey BC. David is a longtime advocate, educator and tireless crusader on trenchless technologies.

In 2007 the world-leading medical journal, *The Lancet,* asked more than 11,000 readers to vote on a list of 15 milestones going back to 1840 when the BMJ was first published. Clean water and sewage disposal or 'the sanitary revolution' topped the pole followed by the discovery of antibiotics and development of anesthesia.

It's been about 200 years since Edwin Chadwick - originally a lawyer, later a planner and by all accounts of his activities today's equivalent of a social activist, reintroduced the development of underground piping to supply clean water, and sewers to remove waste. Of course the Romans and other ancient cultures had solved this issue, however those solutions were lost and had to be re-pioneered by Chadwick and his contemporaries.

Let's reflect for a moment on how the widespread adoption of the humble underground water and sewer systems have impacted human civilization. Sanitation is credited with adding about 35 years to the life spans of most people in first world countries. Without modern sanitation it is estimated the lifespans in the developed world might drop to the mid-40's as is evidenced by the life spans of many in the developing or third world countries where effective sanitation is largely unavailable. While other countless medical advancements exist, and more are continually being discovered, people largely make it past mid-life because of sanitation.

The Greater Vancouver Regional District (GVRD) with a population of about 2.5 million operates an estimated $20 - $30 billion worth of public water, sewer and stormwater infrastructure. There are also an estimated 25,000 corrugated steel pipe (CSP) culverts under the GVRD's streets and highways. A target replacement rate for these aging systems is about 1 percent a year at an estimated cost of about $200 million, an aggressive target which is not being met. Given the importance of, and the investment in sanitation to human civilization there is a duty to maintain the utilities in the least disruptive, least expensive way that will also generate the lowest carbon emissions possible.

Trenchless methods are becoming widely accepted as rehabilitation tools for numerous reasons including:

✓ **minimal excavations** resulting in greatly reduced volumes of removal, transport, disposal and importing of fill. In an open cut installation or repair to reach the pipe, an excavation of at least 1.5 metres wide by the depth of the installation over the length of the project – well, that's a considerable volume of material that has to be managed. Safety requirements for shoring, caging, or sloping the excavation walls to a safe angle for anything deeper than 4 feet is an added cost. So too does the cost increase if special waste is detected in the fill.

- ✓ **significantly less damage to all existing road surfaces**. Once an asphalt surface is cut the lifespan of that surface is reduced by 15 to 20 percent depending on the traffic loading.
- ✓ **significantly less GHG emissions** due to less removal, transport and import of fill.
- ✓ **significantly less GHG emissions due to traffic disruptions**. Assume that 1,000 cars worth about $40/hour to society are held up for 20 minutes in the morning and afternoon rush, that is a cost of $26,000 per day to society for two 20-minute delays in one location. Anyone who has driven around any large city can appreciate that there are many such disruptions costing society millions of dollars a year and generating considerable GHG emissions.

WHAT IS THE ROLE OF A PIPE?

Containment - A pipe is a tube-shaped vessel that carries either liquids or gas. The functionality of the pipe has to be designed for the fluid it is carrying. If the pipe is carrying natural gas or petroleum products it has to be a robust system, the contents must be 100 percent contained. Pipes carrying storm water do not require the same degree of rigor, water pipes not so surprisingly leak, however, in some cities 30 percent to even 50 percent of treated water is lost through leakage. Sewers in some cities like Vancouver with its famously wet autumns and winters can experience high volumes of inflow and infiltration (INI) that increases the volume of material running through these pipes. During extreme wet weather a gravity sewer can develop 'head' and act like a pipe under pressure.

Function – Are the pipes big enough to keep up with urban densification? Pipes installed 50 or even 100 years ago that are still in service cannot keep up with the increasing volumes resulting from the massive development in many Canadian cities. These pipes, even if they are still serviceable may eventually have to be twinned, replaced or upsized.

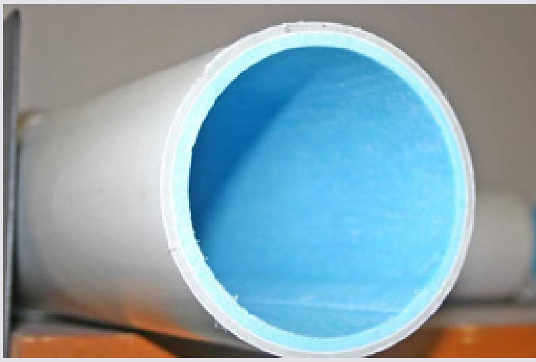
Structure – Is the structure of the pipe or the tunnel still sound? For example, is the pipe still round? Does it still have structural integrity? Most smaller diameter pipes will not likely collapse but larger pipes, especially large brick or concrete sewers and CSP culverts do deform and can collapse.

Trenchless methods can support resolving the losses caused by any one or all of these issues and result in an additional 50 to 75 possibly even up to 100 years of extended service – without digging up entire roads, parks or neighbourhoods. Some excavations usually entry, exit and service pits may be necessary depending on the rehabilitation method chosen.

Many of these older systems lie under occupied private buildings so the benefits of using trenchless rehabilitation methods cannot be overstated.

REHABILITATION METHODS

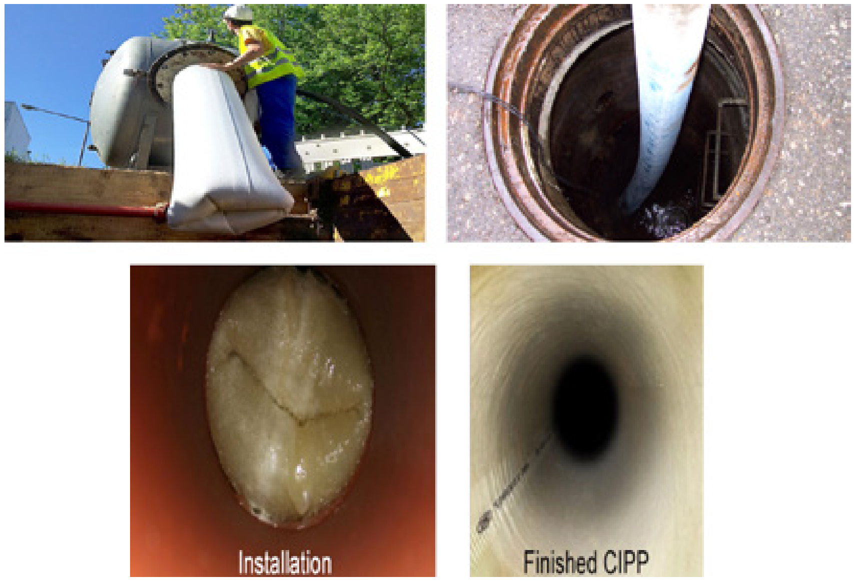
CIPP – Cast in Place Pipe - was the first method of rehabilitation introduced in the early 1970s in the UK and is still one of the most widely used rehabilitation methods. CIPP is a close fit liner, typically a resin impregnated felt or fiberglass liner is fed into the host pipe then expanded using water or air pressure and the resins cured using hot water, steam or UV light. In doing so the resin impregnated liner gets pushed into the damaged host pipe filling the cracks, spanning holes and taking the shape of the host pipe.



Finished CIPP liner inside PVC pipe

CIPP decreases the cross-sectional area of the host pipe however the flow may not decrease significantly and under the right circumstances could increase slightly as the roughness of the existing pipe surface is smoothed out thereby decreasing the coefficient of roughness Mannings "n", resulting in a higher flow rate. The major advantages of CIPP are:

- low-cost trenchless solution
- is suitable for horizontal and vertical rehabilitation



CIPP offers a long term (50 years+) structural repair

Glass Reinforced Plastic (GRP) segments are becoming more widely used for sliplining

- provides an effective seal against infiltration and exfiltration
- offers an enduring (50 years or more) structural repair to the host pipe
- the liners are highly resistant to oils, caustic chemicals and high temperatures
- suitable for most pipe materials
- has been widely accepted around the world
- can be completed in the same day (with a boil water advisory for up to 4 days)

Spray on Centrifuge Products – Also a close fit solution, spray on Spray-In-Place Liner (SIPL) products can be used to augment the strength of pipes and of course stop leaks, depending on the structural condition of the host pipe. This can also be done in a day, also with a boil water advisory for up to 4 days. SIPL can add up to 50 years of service to a pipe.

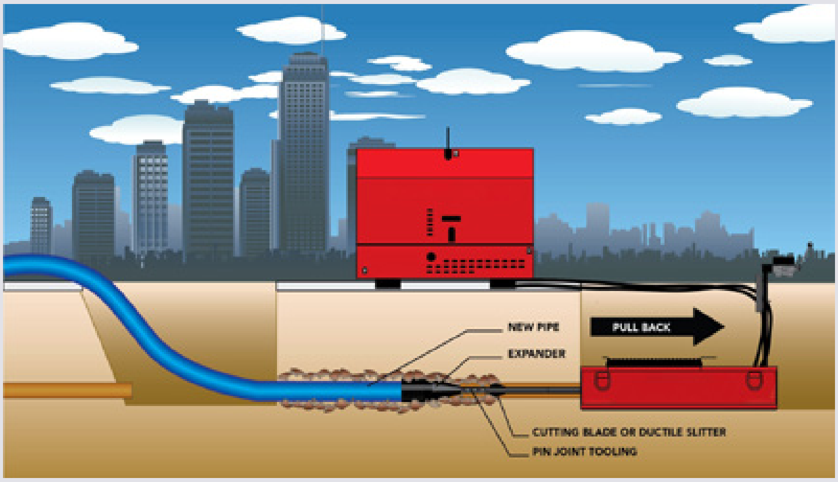
Sliplining – is a method in which a manufactured liner is slipped into an existing host. This is not a close fit solution and in sliplining there is a loss of the inside diameter, or the cross-sectional area of the pipe. The pipes being rehabilitated could be wood stave or old brick sewer tunnels that might be deformed but not yet failed structures and the liner size will be limited to a little smaller than the smallest constriction within the host pipe. The annulus between the host and the manufactured liner is usually grouted. A pipe can be sliplined with a variety of material, typically PVC, HDPE and Glass Reinforced Plastic (GRP) is becoming more widely used.

The GRP liners that are manufactured in Dubai have a durable core of fiberglass with a 1.5mm thick smooth corrosion resistant inner lining, and a typical wall thickness of 25 to 35mm. A bonded graded aggregate is applied to the GRP liner exterior to enhance adhesion to the annual grout. Like all sliplining projects, the result is a smaller diameter pipe with improved hydraulics and enough structural integrity to give a host pipe at least 50 more years of service.

During a large diameter sanitary sewer rehabilitation project the biggest cost is often the bypass, up to 75 percent of the project and there is always some environmental risk. However live flow sliplining offers a cheaper solution as sliplining can be done on a live system without a bypass if it is well planned and additional health and safety measures are taken to protect the crew and the environment.

Pipe Bursting – is used when the pipe that needs to be rehabilitated also needs to be upsized. Typically, a pipe can be upsized by 2 or 3 sizes, possibly more depending on a number of factors including the density or confinement of

SIPL is versatile and can add structural strength of pipes



Pipe bursting has a unique ability to upsize pipe capacity

Typical pipe bursting setup

the soil around the existing pipe. During pipe bursting, a bursting head is put into the existing pipe at an entry pit and has a new conduit pipe attached to it that is pulled through the space that the bursting head creates. Care must be taken with metal pipes in that the pipe being split can retain some of its spring or 'memory' and revert to its original state Pipe bursting has successfully burst many kilometers of pipes in BC in the last 25 years for rehabilitation and upsizing sewer mainlines.

Large CSP culverts are worth a special mention because they are so numerous and can be very large - ranging from about 300mm to large enough for 2 lanes of traffic to travel through, and culverts generally daylight at both ends. They have some unique challenges with concentrated abrasive bed loads, large deposits of sediment which in some cases completely

> *"CIPP was the first method of rehabilitation introduced in the early 1970s."*

Pipe bursting has wide application - from residential services to mainlines

Large CSP Culverts have unique challenges and are rehabilitated in a number of ways

> *Sanitation is credited with adding about 35 years to the spans.*

block the culvert that can threaten nearby infrastructure, and erosion of the structural fill around the culvert. Culverts are most of the time also considered to be fish bearing so environmental constraints have to be managed in the rehabilitation design.

Culverts are rehabilitated in a number of ways depending on where the corrosion is concentrated or where more support for the total structure is needed. Spray on products for large culverts might be applied directly to the culvert, or if the host pipe needs reinforcement, re-bar can be installed and shotcrete applied, concrete floors can be installed where the bottom of the culvert is corroded. Any number of different products can be used in different combinations. The methods and products chosen will be unique to every situation. When restoring CSP pipes it is likely the bedding or supporting material will also need attention.

DIRECT COST COMPARISON

For most projects the costs of trenchless verses open cut are competitive, especially so as the depth of the pipe gets deeper, or, the ground above the service requires special consideration as in the case of pipes installed in now environmentally or culturally sensitive areas, or where older services are under occupied buildings.

The City of Langley, BC uses comparison bidding, trenchless methods are resulting in about 25 percent less cost than open cut. The City of Nanaimo has been adopting new technologies ranging in everything from trenchless methods to Artificial Intelligence for years. Their position is that trenchless will always be considered where it makes sense to do so and they have realized about 40 percent savings on many projects where the bids were open to both trenchless and open cut contracts.

It's advisable to always invite tenders using both methods. Asset owners typically realize savings averaging 30 percent. Pipe bursting tenders come in about 25 percent lower, CIPP about 40 percent lower, and Horizontal Directional Drilling (not described in this piece) about 40 percent lower than open cut.

The best pearl of wisdom offered by senior management at PW Trenchless Inc. out of Surrey BC is to invite an experienced trenchless contractor to have a high-level look at your project. The final decision on rehabilitation method(s) is going to be unique for every project depending on many variables. Owners must have a good understanding of what the desired outcomes are. Are you simply trying to contain the fluid by plugging up a few leaks and cracks, or do you need to transport more product by upsizing your pipes? Is your pipe severely corroded, deformed or missing large chunks of material and in great need of restoring structural integrity, or all of the above? The project owner needs to fully understand and identify what their system needs in terms of flow, velocity, capacity, reliability, tolerance for failure etc.

CIPP was the first method of rehabilitation introduced in the early 1970s.

Once the goal of the project is understood the project constraints need careful identification and consideration. Examining the variables with a specialist contractor will help point to the best rehabilitation method. The technologies described above are only a high-level look at the many variations of trenchless rehabilitation, each has variations and adjustments that can be carried out to meet a specific challenge.

Key points the project designer must consider: are there multiple services, bends or differing diameters of pipe? Can you afford to lose some cross-sectional area? Is the pipe to be rehabilitated eventually going to be twinned to increase capacity overall and therefore some loss of capacity in the existing host is allowable? Are there environmental constraints? Are there temperature constraints for the product or for the method being proposed? What are the access and lay down requirements for the methods under consideration? Is there adequate on-site storage? Can the work be done without costly, risky and time-consuming bypass work. Are the pipes in a congested utility corridor with multiple nearby conflicts with other infrastructure that cannot be disturbed by undermining, vibration or contact? Is the nearby public supportive or protesting the project and why? Are there first nations or archeological issues? How will these issues be managed?

Always start with what your system is and what it is that you are trying to rehabilitate or improve and let your trenchless contractor provide input to support you while you develop a solution that will likely be less expensive, less disruptive to the public and generate less GHG emissions.

Pipe Bursting is used when the pipe that needs to be rehabilitated also needs to be upsized.

ABOUT THE AUTHOR:

PW Trenchless Construction Inc. *is an experienced General Contractor established in January 2000, specializing in both trenchless and traditional open cut utility construction methodologies. The company has pioneered trenchless technologies in BC throughout its history and stands apart from other trenchless contractors in the local marketplace by completing all civil works for trenchless projects in-house, using own equipment and forces.*

PART TWO – NEW INSTALLATION METHODS** will be published in the **NASTT-BC Y-DIG 2025** edition, circulated to all delegates at the joint **NASTT/ISTT NO-DIG NORTH SHOW** October 27 – 30 Vancouver Convention Centre, Vancouver BC

Critical Aspects and Construction Challenges for Use of Direct Steerable Pipe Thrusting (DSPT)

By: James P Murphy, P.Eng, UPI Projects Inc., Calgary, AB
Manjiri Khare, P.Eng, UPI Projects Inc., Calgary, AB
Trevor Miles, P.Eng, UPI Projects Inc., Calgary, AB
Biju Kochatt, P.Eng, Trans Mountain Pipeline, Calgary, AB

1. INTRODUCTION

The Trans Mountain Expansion Project (TMEP) pipeline spans the two western provinces of Canada. The pipeline extends from Edmonton, Alberta to Burnaby, B.C., carrying dilbit (diluted bitumen) to the Westridge Terminal in Burrard Inlet in Burnaby. The route largely follows the existing Trans Mountain Pipeline (TMPL) route, deviating only in areas of environmental or constructability challenges. Figure 1 shows the location of the Trans Mountain Expansion Project (TMEP) pipeline route relative to North America.

The Trans Mountain Pipeline Expansion Project included the following installations:

- 988 km of NPS 36 and NPS 42 Pipeline
- 347 km in Alberta and 640 km in British Columbia
- 190 km of reactivation pipeline
- 11 Pump stations
- 3 Maritime Berths
- 19 Petroleum storage tanks
- Current projected cost – 34 Billion CAN$
- Trenchless pipeline crossings:
  - o Horizontal Directional Drills (HDDs) - 51
  - o Direct Pipe Installations - 15
  - o Engineered HD Bores - 23
  - o TBM Tunnel – 1
  - o Drill and Blast tunnel - 3
  - o MTBM microtunnels – Numerous
  - o Misc bore methods (Auger Bore, Pipe Ram, Down the Hole Hammer)

Construction of the original Trans Mountain Pipeline (TMPL) was completed in 1953, connecting the Edmonton refineries and terminal to the offload point at Kamloops B.C., Sumas B.C. and the Westridge Terminal in Burrard Inlet, a total of 1181 kilometres (km). This pipeline was constructed as an NPS 24 line to carry approximately 300,000 barrels per day (bpd). Details about the original project are as follows:

- Originally conceived by the Trans Mountain Pipeline Company in 1951
- Original (Line 1) constructed in 1953 (NPS 24) with short sections looped (NPS 36) in subsequent years (now the Reactivation sections of TMEP)
- Originates at the Edmonton, Alberta Tank Farm and ends at the Westridge Terminal, British Columbia for a total of 1181 km
- Expands the capacity and markets for shipping oil offshore

The TMEP Line 2 Project will result in the looping (or twinning) of the existing 1,147 km TMPL system between Edmonton and Burnaby terminals with about 987 km of new buried pipeline. The previously constructed pipeline segments are shown in yellow in Figure 1. These NPS 36 segments were constructed in previous years and the original NPS 24 pipe was deactivated with plans to reactivate when the new Line 2 was constructed.

In addition to the new pipeline, all existing facilities, including the existing Westridge Terminal will be enlarged to accommodate the new capacity.

The Project will increase the capacity of the existing TMPL system from 47,690 m^3/d (300,000 bbl/d) to 141,500 m^3/d (890,000 bbl/d) of crude petroleum and refined products.

2. HISTORY OF DIRECT PIPE ON TMEP

Direct Pipe® was invented by the Herrenknecht company in Germany with the design of the Herrenknecht "thruster". From the inception to the completion of the TMEP project, Direct Pipe (or Direct Steerable Pipe Thrusting, as it is referred to now,) has gone from an unknown new trenchless technology to a well-accepted trenchless methodology with about 200 installations to date including the 48-inch Wastewater pipeline in New Zealand with a length of just over 2,000 m.

According to Herrenknecht, at the start of 2012 there were only 15 Direct Pipe installations completed around the world. Of these 15, only 3 had been constructed in the United States and the first one in Canada was not completed until 2013. However, the technology was proven and discussions were underway with Dr. Gerhard Lang (Herrenknecht) in early 2013 to see if this technology would have some benefit for the TMEP project. The first installation considered was the crossing of the Fraser River, which consisted of a crossing of about 1,000m. At the time, only a single DP crossing had been completed with a length over 1,000 m which was a crossing

Figure 1. Location of the Trans Mountain Expansion Project

completed in the Netherlands at Lochem with a distance of 1,400 m and a diameter of 48 inches. TMEP's product pipe was much smaller at 36-inch diameter, which required more specialized construction. This is due to 36-inch Direct Pipe installations being limited to under 1000 m due to the size of the pumps available to deliver fluids to the cutter head.

This started the discussion of installing a casing first and then extracting the casing while installing the product pipe using a reducer to connect to the smaller diameter. However, the final crossing alignment was moved to another location due to conflicts with new and proposed infrastructure, and the concept of using Direct Pipe was set aside. The Fraser River was ultimately crossed using HDD with a length of 1400 m, but the groundwork for the Two-Pass Direct Pipe method had been laid.

TMEP's trenchless construction needs had parameters that aligned to propose the use of the Herrenknecht Direct Pipe technology. When the project was initiated for design in 2011, the concept of Direct Pipe had not reached North America.

By the end of construction in 2024 the technology had become a widely accepted solution to complex projects.

Over the course of the pipeline design and execution, Jim Murphy (UPI) remained in communication with Gerhard Lang as the methodology became used more frequently and for increasingly complex crossings. By the project's completion, a total of 15 Direct Pipes were attempted with 14 being successful. Two experienced issues near the reception location, but were successfully recovered using large diameter rescue casing, and the installations completed.

The first one Jim discussed with Gerhard in 2013 never came to pass as the location changed and the trenchless method changed. However, this effort led to significant investigation of the technology which gave UPI the ability and confidence to utilize the technique during the Trans Mountain Expansion design phase on at least 2 crossings.

Table 1. Direct Pipe History During the TMEP detailed design and construction.

2007	First DP constructed in Germany (464 m)
2010	First DP constructed in USA # 5 (224 m)
2011	TMEP Routing & Design begins
2013	First DP constructed in Canada #34 (344 m)
2013	First DP 'discussed' for TMEP's Fraser River (1000 m length)
2017	Initial Construction Package for TMEP, contains only 2 DPs
2020	First TMPL DP constructed – TMPL Sumas River 1 #168 (311 m)
2021	First TMEP DP constructed – TMEP Sumas River 2 (259 m)
2023	Total of 14 DPs designed and constructed by mid-2023 on TMEP

Ultimately the use of the Direct Pipe methodology was introduced to the project by way of a replacement crossing for the NPS 24. The concept of the use of a temporary casing was also introduced on this crossing.

The method of installing an oversized casing first via Direct Pipe and then subsequently installing the product pipe became known as the Two-Pass method. The advantage of the technique is twofold. Maximum lengths of DP installations are usually limited by the pipe and MTBM diameter, so a larger MTBM thrust by temporary casing can install over greater distances than a size-for-size DP using the product pipe. Additionally, the method allowed for much more reliable installation of fiber-optic leak detection conduits, which was a design feature of TMEP.

The Line 1 NPS 24 pipe was inserted via a small HDD rig inside a 42-inch casing that had been installed using Direct Pipe. The casing was subsequently extracted by the Direct Pipe thruster and the void filled with a bentonite grout. According to Herrenknecht, this was world installation number 168, completed in early July 2021. This installation went so well that the NPS 36 pipeline construction was constructed using DP just a year later only metres away from the NPS 24. This installation was carried out by the same contractor, IPC (now Bothar) and the same 42-inch MTBM and two-pass system was utilized.

As the pipeline design developed and construction continued, multiple other locations were identified as feasible DP locations, typically in response to construction challenges. In the end, 6 Direct Pipe installations of the NPS 36 product pipe were accomplished using a size-for-size MTBM, with the remaining 9 locations being Direct Pipe installations of an oversized casing with the product pipe pulled in after casing installation. In most cases the casing was extracted successfully afterwards.

Michels utilized the DP technology to construct the adjacent Highway No 1 (the Trans Canada Highway) undercrossing just a few hundred meters to the south of the Sumas Direct Pipes. This crossing was constructed successfully about 2 years after the Sumas 'double' cross, in 2023.

The TMEP and its associated DP crossings

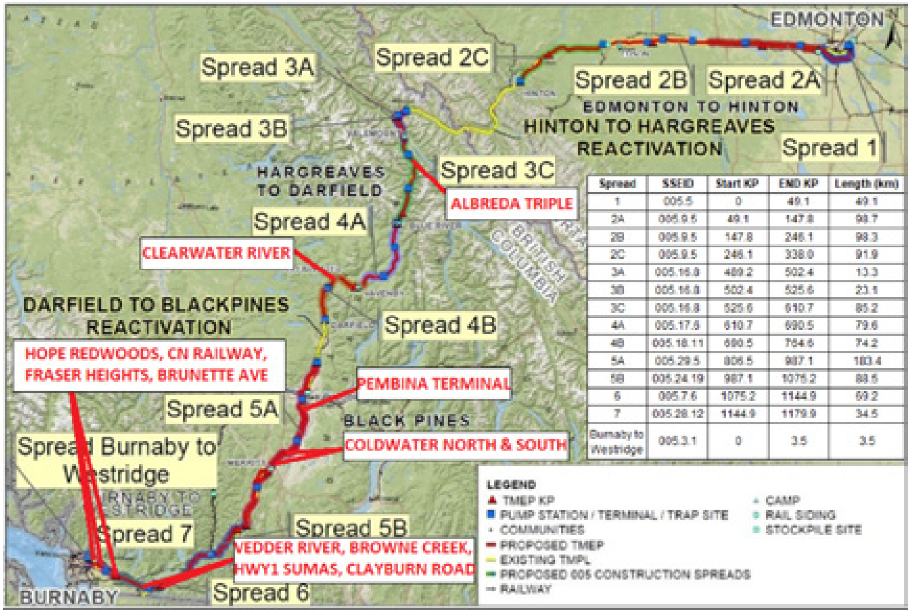


Figure 2. Locations of the Direct Pipe Crossings on Trans Mountain Pipeline

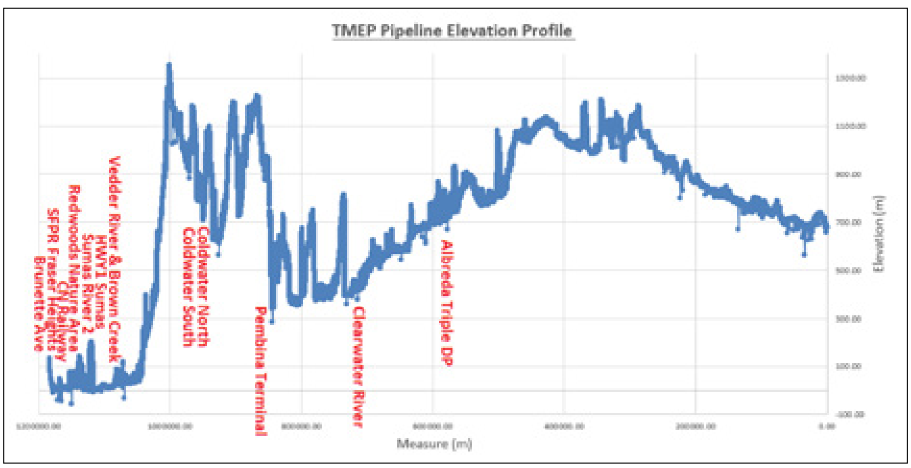


Figure 3. Trans Mountain Pipeline Elevation Profile Showing the Direct Pipe Crossings

certainly experienced weather extremes; the first DP crossing was performed in the middle of the July 2020 heat wave when temperatures reached over 100 degrees F, a rare occurrence for this area. It was virtually impossible to go inside the pipe as the temperature was too hot. In 2021 an atmospheric river led to the Pacific Northwest Floods, putting large portions of the project underwater for a significant amount of time. Construction on the project in the area was halted for many months. Once restarted, construction of the Sumas River 2 Direct Pipe 42-inch casing went very well.

The TMEP pipeline elevation profile is shown in Figure 3 in a very condensed format. Starting out at an elevation of 680 m at KP 0.0 (Baseline Road HDD) in Edmonton, the pipeline rises to an elevation of 1229 m at KP 350 (near Hinton AB and the Hardisty Creek Geohazard HDD) before dropping to the central plateau with an elevation of approximately 400 m at KP 840 (Kamloops BC and the Thompson River HDD) and then rising again to a peak elevation of 1360 m at about KP 1000 (the Dry Gulch HDD) then finally dropping off to sea level at the Westridge terminal at the termination of the Burnaby Pipeline Tunnel. This geography has presented numerous challenges which have been solved in some cases with the use of trenchless construction methodologies. Figure 4 demonstrates the versatility of the methodology with rivers, dykes, railway, highway, pipelines, commercial private

CROSSING	CROSSING METHOD	DP TYPE	CROSSING TYPE	WT (mm)	Crossing Length (m)	SPREAD	AREA
Albreda River, CN and Hwy 97	DP (2P)	2-Pass	River/Road/Rail	22.2	401.1	SPREAD 3	BC
Clearwater River Crossing	DP (2P)	2-Pass	River	19.0	399.1	SPREAD 4B	BC
Pembina Terminal	DP (2P)	2-Pass	Buried Pipelines	19.0	344.3	SPREAD 5A	BC
Coldwater North	DP	1-Pass	River	19.0	210.7	SPREAD 5A	BC
Coldwater South	DP	1-Pass	River	19.0	252.7	SPREAD 5A	BC
Vedder River DP Crossing	DP (2P)	2-Pass	River, Dykes	19.0	468.5	SPREAD 6	BC
Browne Creek and South Vedder Dyke	DP	1-Pass	Creek, Dyke	19.0	280.9	SPREAD 6	BC
HWY1 Sumas	DP	1-Pass	Road	19.0	268.6	SPREAD 6	BC
Sumas River 1 DP Crossing (NPS24)	DP (2P)	2-Pass	River	12.7	311	SPREAD 6	BC
Sumas River 2 DP Crossing	DP (2P)	2-Pass	River	19.0	258.6	SPREAD 6	BC
Clayburn Road Nursery DP Crossing	DP (2P)	2-Pass	Road, Property	19.0	497	SPREAD 6	BC
Salmon River DP	DP (2P)	2-Pass	River	19.0	732.4	SPREAD 7	BC
Hope Redwoods Nature Area DP Crossing	DP	1-Pass	Nature Area	19.0	252.5	SPREAD 7	BC
CN Railway Crossing (CWP 38)	DP	1-Pass	Rail	19.0	347.7	SPREAD 7	BC
SFPR Fraser Heights Crossing	DP (2P)	2-Pass	Property	19.0	722.9	SPREAD 7	BC
Brunette Ave DP Crossing	DP (2P)	2-Pass	Road	19.0	416.2	SPREAD 7	BC

Figure 4. Specifics of the Direct Pipe Crossings

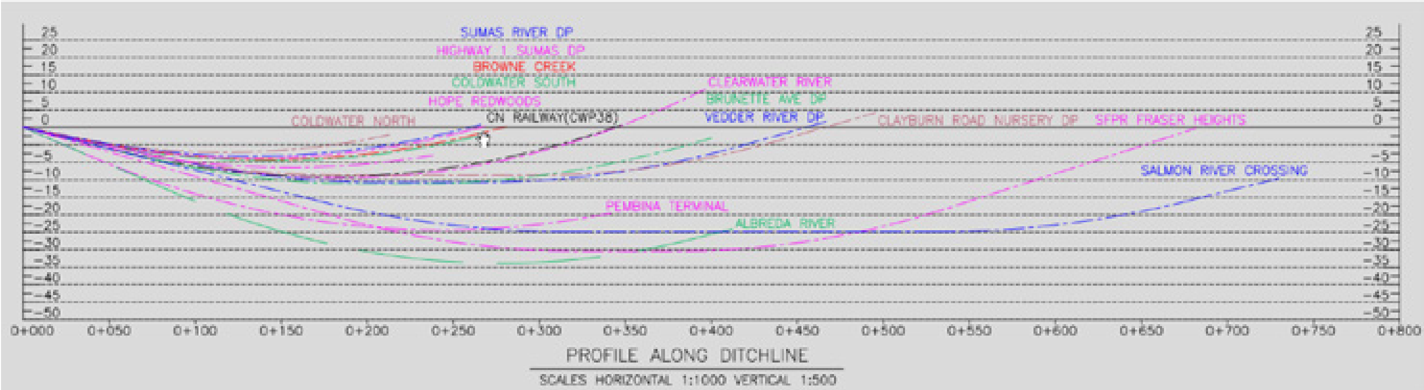


Figure 5. Comparison of TMEP Direct Pipe Profiles

property and nature reserves being crossed. Note that while only 2 Direct Pipe crossings were designed at the time of the original regulatory filings, ultimately 15 successful crossings were performed including the Sumas River NPS 24 replacement. This also demonstrates that, as the geographical challenges increased from Spread 3 to Spread 7, standard HDDs and bored crossings no longer were sufficient. The Direct Pipe crossings were utilized in areas where other crossing methods might not or could not work. A good example is the Clearwater River Direct Pipe; the mainline contractor told us that he didn't understand why Direct Pipe was chosen until he looked at all other options and then agreed that it was the only technology that would work in that location. This Direct Pipe crossed the river, but unfortunately a large boulder lodged in the cutting head doors and stalled the advancement.

This required the first use of a large diameter Rescue Casing that was driven over the MTBM, essentially swallowing the machine. The product pipe was then pulled through once the MTBM was removed.

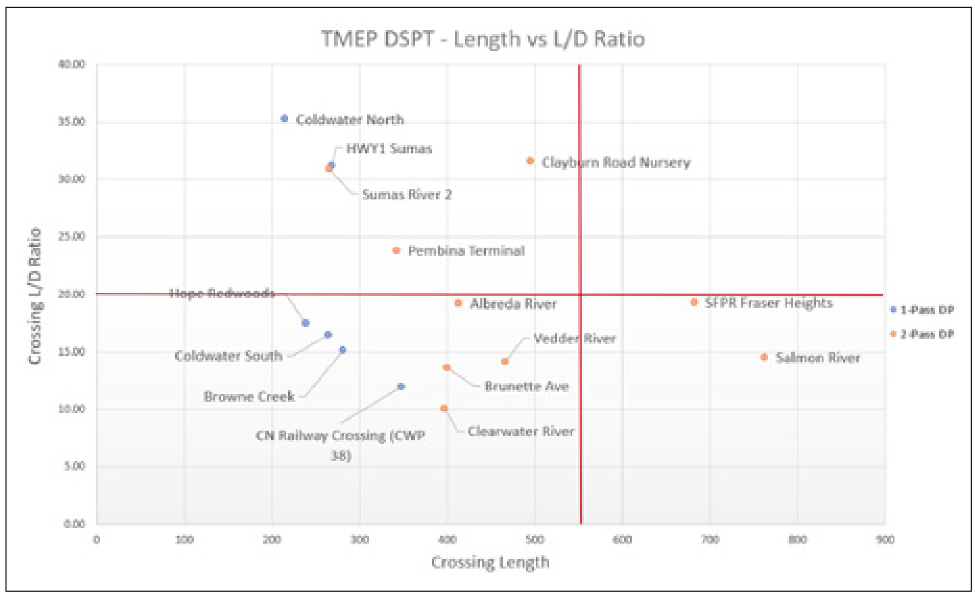


Figure 6. Trans Mountain Direct Pipe Length vs L/D Ratio

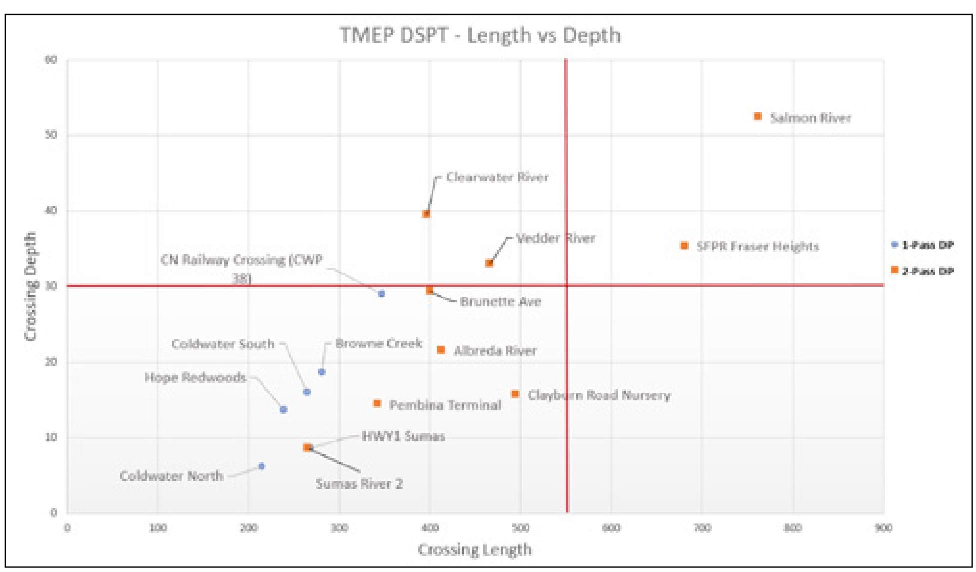


Figure 7. Trans Mountain Direct Pipe Crossings Length vs Depth

3. PROJECT FINDINGS AND CROSSINGS COMPARISON

After construction of 15 Direct Pipes, with just a single unsuccessful attempt, and two that had significant challenges that required rescue casing installations, two of these seemed to have some similarities in their geometry. Seeing the similarities, Figure 5 was developed to show a relationship between the crossing profiles of successful

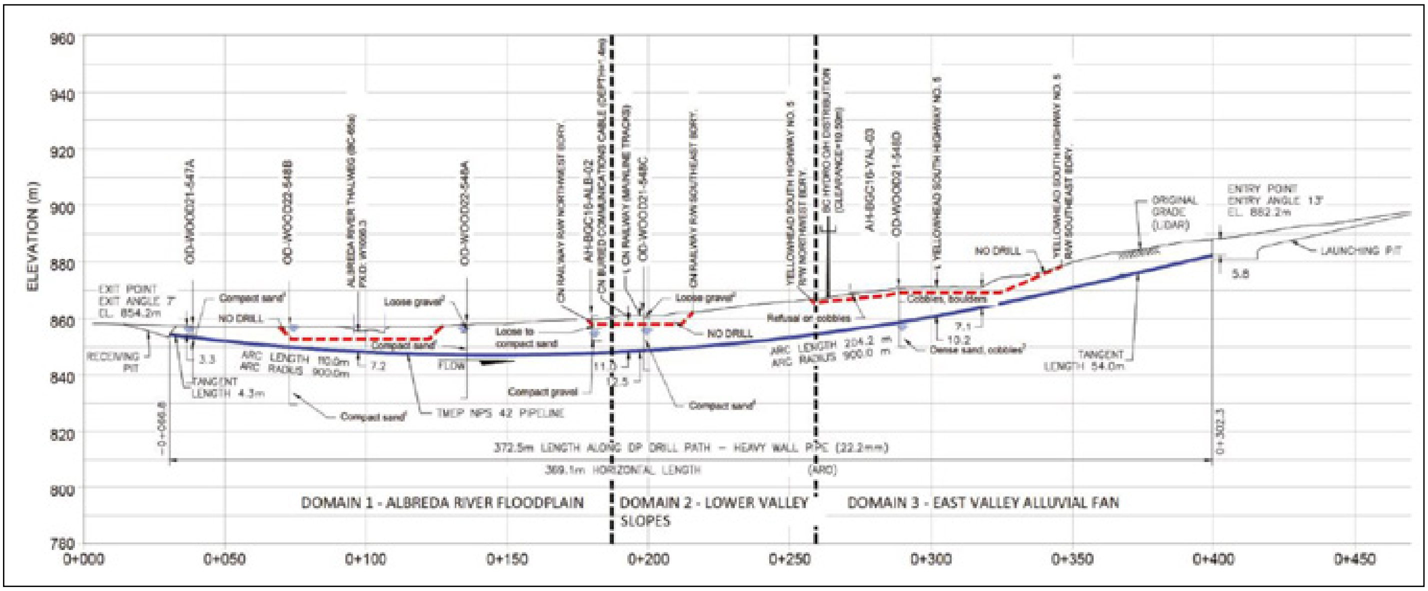


Figure 8. Albreda NPS 42 Triple Crossing of River/Highway/Railway

and challenged crossings. Fraser Heights and Salmon River both seemed to be longer and deeper than the other crossings. These crossings failed due to the required thrust force to proceed either exceeding the available thrust capacity of the 750 Tonne thrusters, or of the casing pipe. The Clearwater crossing was much shorter and was stalled for geotechnical reasons. There were two other crossings that when plotted, had similar depths, Pembina Terminal and the Albreda River (triple crossing). However the lengths were significantly less and they were both tunneled from high to low which offset the potential for the high thrust forces.

Figures 6 & 7 summarize the crossings with regards to Length/Depth vs Length and then Length vs Depth. The two Direct Pipes, Fraser Heights and Salmon River seemed to share similar locations on both graphs. The results seem to imply that these Direct Pipe installations with Length › 550 m and the L/D ‹ 20 were challenging, even with an oversized MTBM. Therefore, where the DP length is › 550 m and the depth is greater than 30 m, the DP installation may have challenges that might not be immediately obvious. With this geometry, one should consider the soil conditions and the use of the two-pass system where it is possible to have preinstalled bentonite injection points at regular intervals not unlike a microtunnel installation.

The Fraser Heights two-pass crossing essentially maxed out the available thrust near the halfway point but was successfully retracted. The second attempt, which had bentonite injection points added along the length of the casing, almost made it to the reception point before thrust forces were maxed out. Unfortunately, with all the DP internals inside the casing already present, it was not possible to install injection points in the most advantageous locations. If the injection points could have been installed at more regular intervals and specifically in the invert locations, the Direct Pipe would likely have made it to the reception point unassisted.

Unfortunately, the two-pass Salmon River Direct Pipe was unsuccessful. It had been

Figure 9. Albreda Triple Crossing Looking down from Launch to Reception

decided that in this case it would be prudent to use a 48-inch MTBM for the 42-inch casing and fill the additional void with the bentonite slurry. The thrust forces maxed out at roughly the halfway point of the crossing, buckling the casing pipe, and the decision was made to extract the casing and MTBM. Unfortunately, the larger diameter MTBM did not survive the attempt. During extraction, there was an indication that the MTBM had separated, likely at the interface of the cutter head. With the machine now open and flooded with groundwater and slurry, it was decided to abandon the attempt and the recovery. An HDD was initiated and was successful in completing the crossing.

The Albreda Triple crossing was unique in both scope and execution. Originally envisioned as three semi-contiguous auger bores of a highway, railway, and river that run parallel in proximity, it was determined during construction that the terrain features and environmental challenges made conventional boring unfeasible. The Project turned to Direct Pipe as the solution, but the constraints meant that all three crossings needed to be completed with a single DP installation. After careful alignment selection and an extensive geotechnical program, the Albreda Triple DP was declared feasible if performed as a two-pass installation. Unlike other crossings on the project, the Albreda crossing existed in a section of the project that used an NPS 42 product pipe, so a 48-inch MTBM and casing were utilized instead of the standard 42-inch/NPS 36 arrangement. Due to availability of workspace for the thrust sections, the DP was executed from the high elevation to low with three thrust sections. Installation forces for the crossing were noted as being somewhat higher than expected, likely due to mixed ground conditions along the DP path. Once underway, installation thrust forces were, on average, around 2000 kN. Once the product pipe was installed, it was found that the temporary 48-inch had become stuck and the DP thruster was incapable of getting it moving. A 24-inch pneumatic hammer was employed to free up the casing, and the crossing was successfully completed.

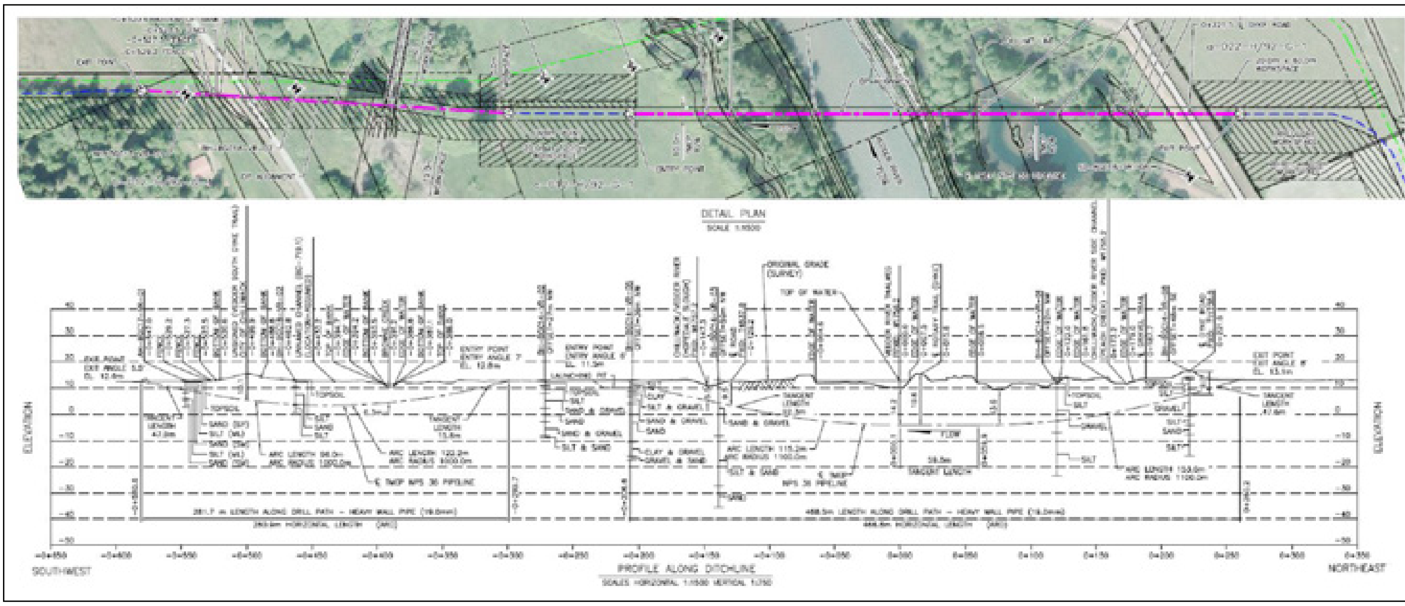


Figure 10. Back to back Direct Pipe Crossings

In two locations, two Direct Pipe crossings were in very close proximity. The Vedder River and Browne Creek Crossings were essentially back-to-back with Vedder constructed first then Browne Creek. Vedder River was a two-pass crossing, while the shorter Browne Creek crossing was completed with a size-for-size DP. They crossed multiple dykes which required extensive settlement monitoring. Settlement at the dykes was essentially negligible, similar to the Sumas Crossings. The Vedder River crossing was quite long at 469 m, necessitating the two-pass method to be successful. The river had overflowed during the extensive British Columbia flooding in 2021, so extreme care had to be taken to maintain the integrity of the four dykes running parallel to the river, of which the Vedder DP crossed three.

The installation of the Vedder River crossing went quite smoothly; thrust forces were largely as expected and well within the limits of the equipment, while casing extraction after product pipe installation was performed entirely by the DP thruster without any hammer assistance required. The annular space was filled with viscous bentonite slurry, and the dyke settlement monitoring results were well within the acceptable range (max of 31mm) three months after construction.

4. LESSONS LEARNED

The following bullets identify some of the lessons learned from the aforementioned DP crossings:

- The Two-Pass DP system was highly effective in pursuit of extended crossing length and leak detection conduit installation.
- Plan on some casings not being able to be extracted – even with hammer assistance, some casings may become too cemented-in to be broken free and a contingency plan should be on hand.
- On deep long crossings, bentonite injection points may be required and should be designed into the casing system for the two-pass DP system.
- Plan for multiple confined space entries for survey and/or repairs. Hydraulic, mechanical, electrical, and instrumentation problems led to scores of casing entries across the DP installations.
- Steep inclinations causing strain in the internal assembly connections. Ensure that internal connections are strong and fully seated, as an internal connection is a messy and time- consuming issue.
- Extreme cold weather can have effects on the externals & internals above ground – contractors should be familiar with working in the Canadian climate and ready to hoard and heat when needed.
- Steep inclination increases control survey time and effort (internal piping moving once the bore enters into flatter tunnelling.)
- Gas detection monitors need to have models that read specific gases that could be encountered set up in the TBM and relayed to the Operator. Redundancy on gas monitoring is also beneficial; a faulty gas monitor led to significant delays on one DP crossing as erroneous readings prevented the team from performing a standard confined space entry into the casing.
- Establish connection points to the supplied air so if entries must be performed in gaseous conditions, SCBAs/hoses don't have to be dragged in the entire length by the entrants.
- Specifying a larger design radius early on allows for flexibility during the project. Reducing the design radii can still be done where circumstances demand, but starting with a larger radius gives more headroom for steering deviations. Several crossings had to undergo extensive analysis of the as-built data to approve the as-installed radii.
- Thruster foundation design and construction in weak soils and in rock and boulders can be challenging – geotechnical investigation at entry locations can inform designers and contractors alike of potentially weak

or difficult soils that may lead to challenges in designing/constructing a foundation capable of handing the thruster's maximum output.

- Guidance issues may be present in small diameter installations, where the pipe size makes it impossible to enter for control surveys on longer crossings. Albreda was longer than the length that surveyors were permitted to enter.
- MTBM Head nozzle selection: consider all soils in the tunnel path in sizing nozzles and select appropriately. (The MTBM used for the Albreda crossing needed to be pulled back just after launching to replace the nozzles.)

5. CONCLUSION

The Trans Mountain Expansion Project clearly demonstrates the versatility of the Direct Pipe technology. The major takeaway is that there is possibly a point where the L/D ratio may prove challenging and that a two-pass system with bentonite injection points may solve the problems that may occur.

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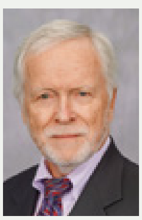

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Going Further for Transmountain

Tunneling Company uses Horizontal Hammer Boring for success in B.C.

By: Richard Revolinsky, Geonex Inc, (GEO)

The culture of The Tunneling Company (TTC) of Kamloops B.C., a subsidiary of The Crossing Group is engrained with a commitment to expand their expertise and capabilities. That culture manifests a desire to embrace and evaluate emerging technologies to go further for their clients.

The Transmountain Pipeline project included a variety of trenchless construction methods of which TTC was already well versed, including HDD, Micro-Tunneling, Auger Boring and Pipe Ramming. However, when evaluating the ground conditions for the project, a relatively new method, Horizontal Hammer Boring (HHB), offered a great opportunity for success.

Horizontal Hammer Boring utilizes a pneumatic hammer located within the first section of pipe to be installed. The hammer and cutting face pulverize the subgrade instead of cutting it like traditional methods. Compressed air is released with each stroke of the hammer, conveying the fragmented rock cuttings back into the casing where they are carried by auger back to the launch pit. The next strike of the hammer propels the cutting head forward which simultaneously advances the casing.

GEONEX Inc., a leading manufacturer of complete Horizontal Hammer Boring systems worked extensively with the TTC team to evaluate anticipated conditions to determine the feasibility of deploying the equipment. With over 10,000 completed installations in similar conditions in Europe, GEONEX was confident in their HZR1200 drill machine with 42-inch tooling to perform. Having experience in smaller diameters with the GEONEX Equipment, TTC invested heavily the technology, expanding their capabilities and their experience.

Engrained with a commitment to expand expertise and capabilities

Initially The Tunneling Company was contracted to perform several crossings with alternate/conventional methods. However TTC was successful in petitioning Transmountain to allow the use of Horizontal Hammer Boring as an alternate. Upon successful completion of the first installations, TTC was contracted to perform more crossings with Horizontal Hammer Boring, which included

Pulverized rock cuttings from auger

"Horizontal Hammer Boring (HHB), offered a great opportunity for success"

Project included a variety of roadway and sensitive area crossings

roadway and sensitive area crossings on the project, some of which had been previously unsuccessful when attempted with other methods.

By the end of the project, The Tunneling company completed more than 1,200 Meters of Installation among 16+ crossings on the project, proving their ability to go further for their client and aid in the ultimate completion of the Transmountain Pipeline project. To date, including the work on Transmountain Pipeline, TTC can boast of more than 100 successfully completed projects utilizing their fleet of GEONEX Horizontal Hammer Boring equipment in sizes from 139.7mm to 1220mm in diameter and up to 120 meters in length.

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