SOUTH CENTRAL CHAPTER

TEXAS & OKLAHOMA

TRENCHLESS REPORT 2024

OFFICIAL PUBLICATION OF THE NASTT SOUTH CENTRAL CHAPTER (NASTT-SC)

2024

- Record-Breaking 36-Inch HDD
- Surface Water Supply Tunnel
- CUIRE/UTA Trenchless Research
- HDD Pull Back Support

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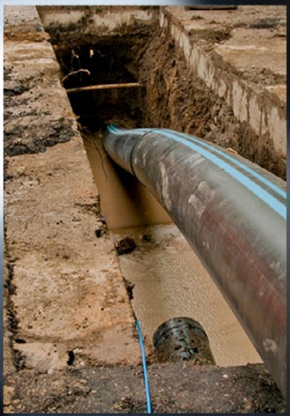

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The No-Dig Show is owned by the North American Society for Trenchless Technology (NASTT), a not-for-profit educational and technical society established in 1990 to promote trenchless technology for the public benefit. For more information about NASTT, visit our website at nastt.org.

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MESSAGE FROM THE NASTT SOUTH CENTRAL CHAIR

Shawn M. Garcia, P.E., NASTT South Central Chair

This journal is a result of the growth of the industry in this region!

Welcome to the 7th publication of the *Texas and Oklahoma Trenchless Report*. Established in 2016, the South Central Chapter of the North American Society for Trenchless Technology (NASTT) is proud to present this journal documenting trenchless projects and technology. This journal is a result of the growth of the industry in this region, and the impressive level of support from our industry colleagues.

The South Central regional chapter of NASTT represents Texas and Oklahoma, two states comprising a geographic area experiencing significant growth in population. As the population grows, so does the need to expand, upgrade and replace existing infrastructure. Now more than ever, the benefits of trenchless technologies are critical to addressing our infrastructure challenges. The *Texas & Oklahoma Trenchless Report* provides an update on the state of trenchless methods and best practices in this region.

The South Central chapter (SCNASTT) was formed in January of 2016, and has since hosted seven chapter events, including in 2016, 2017, 2019, and 2022 at The University of Texas at Arlington (UTA) and at Oklahoma State University (OSU) in 2018. After taking a break in 2020 due to Covid-19, we followed up in 2021 with a conference in Sugar Land, Texas for the first time, and then in an effort to diversify our outreach we held our chapter's first ever event in the City of San Antonio, with our annual conference taking place at the University of Texas San Antonio (UTSA) in 2023. This year we are returning to the DFW Metroplex and will be hosting our 8th annual conference at The University of Texas at Arlington (UTA). These events average roughly 125-150 attendees and include utility owners, consulting engineering firms, municipalities, contractors, and vendors. At these events, attendees learn about trenchless projects in their local region, new trenchless technologies in the industry, and enjoy the professional networking opportunities.

The South Central Chapter is committed to supporting education through scholarships for our members. A total of 10 student scholarships at $1000 each will be awarded at the 8th Annual Chapter Conference on August 13 at UTA in Arlington, Texas for the 2024-2025 school year. The South Central Chapter is excited to continue to support eligible students and members through scholarships, education, and future employment within our industry.

I would like to take this opportunity to thank the members of the South Central Chapter Executive Board, which has been expanded to include more members and better diversify our team. The chapter now has a strong core of 12 dedicated members with professional representation from all industry fields. This publication, the educational conferences we produce, the scholarships and networking opportunities we are able to offer would not be possible without the hard work and support of the executive board members who work to make this chapter what it is. Thank you all for your continued service.

The South Central Chapter has seen exceptional growth over the past several years, and we hope to continue that growth in order to better serve the industry and our communities, and be a resource for the personal and professional growth of our members. I challenge each of you reading this publication to consider joining the South Central Chapter of NASTT and get involved with our organization. We hope you find this publication to be a valuable resource for all things trenchless and we truly appreciate your continued support.

Sincerely,

Shawn M. Garcia

Shawn M. Garcia, P.E.
NASTT South Central Chair

MESSAGE FROM THE NASTT CHAIR

Matthew Wallin, PE, NASTT Chair

ANNUAL SOUTH CENTRAL TRENCHLESS CONFERENCE HEADS TO ARLINGTON!

Hello South Central Regional Chapter Members! As we roll into the second half of the year, I want to share some key updates and upcoming opportunities that are of importance to your chapter and our organization and industry.

I hope you are joining us for the 8th Annual South Central Trenchless Technology & Pipe Conference, August 12-13 at the University of Texas at Arlington. This is an exciting event dedicated to advancing the field of trenchless technology in the region. This year's conference promises to be an exceptional gathering of industry experts, innovators, and professionals, offering a unique opportunity to explore the latest trends, technologies, and best practices in the trenchless sector. Attendees will benefit from insightful presentations and valuable networking sessions. Don't miss this chance to connect with peers, gain fresh perspectives, and contribute to the future of the industry.

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 now 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. The application deadline is November 1, 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 nastt.org /no-dig-show/municipal-scholarships/.

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.

We are also excited for the upcoming No-Dig North conference, scheduled to take place from October 28-30 in 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 in Canada. We encourage all members to attend and take advantage of the technical sessions, exhibits, and networking opportunities. Early bird registration is now open, so be sure to register soon to secure your spot. Visit nodignorth.ca for all the details.

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.

Best regards,

Matthew Wallin

Matthew Wallin, PE
NASTT Board Chair

NEW HEIGHTS. UNDER GROUND.

NASTT SOUTH CENTRAL REGIONAL CHAPTER

SHAWN GARCIA
CHAIR
sgarcia@azuria.com

Shawn Garcia is a licensed Professional Engineer in the State of Texas and currently serves as Regional Manager for Underground Solutions, Inc. (an Azuria Water Solutions Company) for North Texas, Oklahoma, and Arkansas, where he manages and oversees all business development, operations, and activities in these regions. Shawn has gained invaluable experience by working in all sectors of the industry including General Contracting, Public/Municipal, and Private, and has over 22 years of engineering development, engineering design, and construction/management/installation experience specific to Water/Wastewater Utility Infrastructure Rehabilitation and New Construction. He received a Bachelor of Science in Engineering from Texas Tech University. Aside from his role as Chair of SC Chapter of NASTT, he is an active member of AWWA, UCTA North Texas Chapter, and ASCE/UESI.

ASWATHY SIVARAM
VICE CHAIR
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Ash is a licensed Professional Engineer in the state of Texas and currently serves as the Coastal Solutions Leader at Black & Veatch. Her expertise lies in engineering design and construction management, proposal development, preparation of contract documents, and conformance reviews of heavy civil infrastructure projects. Her experience is as broad as it comes – she has worked on all aspects of tunnel projects including pre-positioning with clients, chasing pursuits, technical innovation and value add, and project execution including planning, preliminary and detailed design, and construction contract administration and inspection services. She has successfully delivered dozens of projects adding up to construction contract values of over 1 billion USD. Ash has authored various technical papers and presented in premier industry conferences to a wide variety of audience. Outside of NASTT, Ash is also an active member of Underground Construction Association (UCA).

ALAN SWARTZ
TREASURER
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Alan Swartz is a Principal and Oklahoma Design Team Leader with Plummer Associates, Inc and currently serves as the Treasurer of the Board for the NASTT South Central Chapter. He is responsible for the day-to-day operations of Plummer's Oklahoma City Office which serves clients across the states of Oklahoma and Texas. Alan graduated from Texas Tech University with a bachelor's in mechanical engineering and has over 24 years of experience in the design and rehabilitation of water and wastewater pipelines, lift stations and pump stations and is a licensed Professional Engineer in Oklahoma and Texas. Alan has extensive experience in the design and construction of small and large diameter water transmission and distribution mains utilizing both open cut and trenchless methods including auger boring, tunneling and horizontal directional drilling. Pipeline rehabilitation experience includes sliplining of large diameter sanitary sewer interceptors; pipe bursting and cured-in-place pipe lining for small to medium diameter sanitary sewer lines; and pipe bursting and compressed fit HDPE liners for small to medium diameter water transmission and distribution mains.

PAUL BEARDEN
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Paul is HDR's Trenchless Services Program Leader and has nearly 30 years of experience in the design, project management, and construction of oil, gas, water and utility pipelines utilizing trenchless technologies, specifically horizontal directional drilling (HDD), conventional boring methods, and Direct Pipe®. Paul has special expertise in the construction of complex, large-diameter HDD pipeline installations and extensive on-site experience with major projects around the world. Paul has demonstrable management skills and works effectively with multi-skilled, international teams to complete pipeline projects from front-end engineering design through construction. Paul possesses excellent communication, negotiation, and writing skills and the ability to develop positive working relationships.

BOARD OF DIRECTORS 2024-2025

JUSTIN TAYLOR
PAST CHAIR
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Justin Taylor, P.E. is the VP of Engineering and General Manager for CCI & Associates Inc., an engineering, design, and inspection firm specializing in trenchless technology. Justin holds a B.Sc. in Mechanical Engineering from the University of Alberta. After almost 10 years of various engineering and management roles in the Western Canadian CCI offices, Justin moved to Houston, Texas to head the engineering team in CCI's first stateside offices.

Justin is a licensed P.E. in over 25 states including Texas, Oklahoma, and Louisiana. In his time with CCI, Justin has worked on trenchless crossings for various high profile projects such as Keystone/Keystone XL, Enbridge Line 3, Plains Wink to Webster, and Kinder Morgan TMEP Pipelines, and has been involved in the development of tools for real-time measurement of strain and stress on steel pipe during Horizontal Directional Drill installations. Justin is an active member of NASTT, having authored and co-authored several papers for the organization, and being a member of the NASTT Program Committee.

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TTP-2024
8TH ANNUAL SC-NASTT TEXAS & OKLAHOMA

MONDAY, AUGUST 12, 2024

1:00 – 7:00 PM	**Exhibitor setup (1:00 – 4:00 PM)**	**Welcome Reception with Refreshments (Sports & Social at Texas Live, Arlington) (4:00 – 7:00 PM)**

TUESDAY, AUGUST 13, 2024 • MORNING

7:00 – 9:00 AM	Registration and Refreshments with Exhibitors
	Morning Sessions • 9:00 – 10:30 AM • Room #100
9:00 AM	**Welcome / SCNASTT Board Introduction / SC and National NASTT Updates** Mr. Shawn Garcia - Chair of South Central Chapter of NASTT, Mr. Carl Pitzer - National NASTT Board Member / South Central NASTT Board Member
9:20 AM	**CUIRE Intro / Scholarship Awards** Mr. Shawn Garcia - Chair of South Central Chapter of NASTT, Dr. Mo Najafi - Professor and Director of CUIRE, Shah Rahman - South Central NASTT Board Member
9:30 AM	**UTA Introduction & Welcome** Dr. Mo Najafi - Professor and Director of CUIRE, Dr. Melanie Sattler, Civil Engineering Department Chair, Dr. Peter Crouch, Dean College of Engineering
9:45 AM	**KEYNOTE ADDRESS** Ms. Sarah Standifer – Director Mr. Matt Penk – Assistant Director - Dallas Water Utilities (DWU)
10:15 AM	Coffee Break with Exhibitors

Start of Technical Sessions • 10:30 AM – 12 noon

time / track	**Track A – Room 105** **Rehabilitation** *Moderator: Dr. Madhuri Arjun*	**Track B – Room 100** **New Installations** *Moderator: Paria Hamidzadeh*	**Track C – Room 106** **Trenchless Planning** *Moderator: Salar Bavili Nezhad*
10:30 AM	Investigate-Design-Build approach to apply water pipeline repair technology to a wastewater constructability challenge to save an Interceptor and Interstate highway in downtown Dallas, Mike Larsen, Structural Technologies	Hitting the Mark: Crossing the Guadalupe River with the Second Vertical-Curved Micro tunnel in the United States, Robert Weinert, Plummer	Pullback Lift Considerations for Horizontal Directional Drills, Justin Taylor PE & Gunnar Busch, PE, CCI & Associates Inc.
11:00 AM	Yes, you can bust Water! (Replacing Water Mains via Trenchless Technology), John Newell, President NoDigTec, LLC	Drill Drill Drill!!! A Creative Underground Solution To Very Challenging Surface Conditions, Rami Issa, P.E., Aecom, Rishi Bhattarai, P.E., DWU	Emphasizing the Necessity for Accurate and Detailed As-Built Records for All Underground Installations, David Paul Bearden, HDR
11:30 AM	Large Diameter, No Problems! A Case Study in Large Diameter Condition Assessment and Rehabilitation, Jacob Brumbaugh, P.E., RJN Group, Inc.	City of League City 36-inch Transmission Main HDD, Justin Taylor P.E, Gunnar Busch, P.E CCI and Associates, Damola Ashaye, P.E, Underground Solutions-Azuria	Predictive Models for Assessing the Remaining Useful Life of Sewer Pipes, Shima Zare, Dr. Mo Najafi, Rasoul Adnan Abbas, CUIRE

THE UNIVERSITY OF TEXAS AT ARLINGTON

TRENCHLESS TECHNOLOGY & PIPE CONFERENCE

TUESDAY, AUGUST 13, 2024 • AFTERNOON

12:00 PM	BBQ Buffet Lunch Sponsored by Sunbelt Rentals		
Afternoon Technical Sessions • 1:00 – 4:30 PM			
time / track	**Track A – Room 105 Rehabilitation** *Moderator: Dr. Madhuri Arjun*	**Track B – Room 100 New Installations** *Moderator: Salar Bavili Nezhad*	**Track C – Room 106 Trenchless Planning** *Moderator: Marjan Moradi*
1:00 PM	Building Back ½ a Sanitary Sewer, Justin Mouton & Ted Jones, P.E, Henkel Corporation	Midland North East Sewer, Kyle Krueger, P.E Parkhill and Carl Craigo, P.E, City of Midland	Review of Past Trenchless Cured-in-Place Pipe Air Monitoring Projects, Dr Vinayak Kaushal, University of Texas at Arlington
1:30 PM	Rehabilitation of Sewer Trunk in Lewisville, TX Using CIPP, Nely Rezaei, P.E. City of Lewisville, Timothy Peterie, Insituform-Azuria	Advancing Water Infrastructure: The Surface Water Supply Project in Houston, Chase Juhl, P.E, Corey Evans, P.E, Sergio Flores, P.E., Black & Veatch	Air Quality Monitoring and Emissions Testing Result During the Trenchless Cured-in-Place Pipe Installation, Dr Arpita Bhatt, University of Texas at Arlington
2:00 PM	New installation and replacement of existing pipelines throughout Katy, Cleveland, Sinton, TX., Alan Goodman, Hammer Head Trenchless	Large Diameter HDD Steel Pipe Design and Installation Challenges in Hillsborough County, Florida, Madhab Sharma Bajgain, Brian Glynn, PE, Mears Group, INC. Direct Pipe & HDD DIVISION	Tunneling to Provide Drainage Relief for East Dallas, Milton Brooks, PE, DWU, Todd Woodson, PE, Halff
2:30 PM	Coffee Break with Exhibitors		
	Moderator: Dr. Madhuri Arjun	*Moderator: Salar Bavili Nezhad*	*Moderator: Marjan Moradi*
3:00 PM	Increasing Capacity and Replacing Aging Interceptor Sewers due to Rapid Growth in Irving, TX, Amanda Powers, PE, Brian Glynn, PE, Freese & Nichols Inc Todd Reck, PE , Steve Pettit, PE, Robert Sauceda, PE, City of Irving	Fusible Done Right - Graham, Texas Water Supply Pipeline, Landon Allen, Parkhill, Inc	M-210 Relief Sanitary Sewer Main, Part 5, an enlightening journey in Project Management and Problem Solving in Fort Worth, Texas, Chris Brooks, P.E., RJN Group, Inc.
3:30 PM	From Dust to Gold: Pipe Reaming Renaissance in El Dorado, Kansas, Diego Medrano, & Michael Salinas, PE, Garver	Dallas Water Utilities Seeks Competitive Sealed Proposal Approach Delivery for Cost Savings, Simplified Construction on 96-inch Harry Hines Boulevard Wastewater Interceptor Tunneling Project, Tracey Long, P.E., Rishi Bhattarai, P.E., Neepa Shah, P.E., DWU	
4:00 PM	Condition Assessment and Rehabilitation of a 54-inch PCCP Sanitary Force Main, Timothy Palmer, Wade Trim, Dallas	Friendswood's 24-inch Water Line Chronicles: The Epic Trenchless Trio Showdown! Karina Diaz, EIT, Michael Salinas, PE, Maureen Carlin, Garver	

Distribution of Certificates
(8 PDHs, 0.8 CEUs)

All Hands on Deck for the Record-Breaking 36-inch FPVC HDD

By: Gunnar Busch, P.E., CCI & Associates, Inc.
Damola Ashaye, P.E., Underground Solutions

As one of the fastest-growing cities in the United States, League City has consistently expanded its infrastructure to meet the demands of its burgeoning population and thriving economy. Over the decades, the city has evolved into a vibrant residential and commercial hub, attracting families, businesses, and tourists alike with its excellent schools, recreational amenities, and proximity to major metropolitan areas. As of the latest census data, League City boasts a diverse population of over 100,000 residents, making it one of the largest cities in the Greater Houston area.

Among its recent infrastructure projects, the League City 36-inch Water Transmission Main from State Highway 3 to South Shore Harbor Booster Pump Station is a testament to the city's commitment to sustainable development and resilient infrastructure. The key players involved in the successful installation of the waterline are as follows:

OWNER:
League City
ENGINEER OF RECORD:
CDM Smith
TRENCHLESS SME:
CCI & Associates, Inc.
PRIME CONTRACTOR:
Reytec Construction Resources, Inc.
HDD CONTRACTOR:
TCH Underground
MATERIAL PROVIDER:
Underground Solutions

The League City 36-inch water transmission main consists of approximately 17,470 feet of 36-inch pipe. As part of the 36-inch Water Transmission Main project, approximately 9,600 feet was installed via three (3) separate HDDs. Fusible PVC pipe was selected as the pipe material because

Figure 1: Tight Workspaces at the Entry

of superior mechanical properties and high tensile strength which makes it well suited for long and deep HDD installations. This article focuses on design and construction considerations for the 4,567-LF drill (HDD 2) which is the longest 36-inch FPVC installation of its kind completed in the world to date. Prior to this project, the longest HDD for 36-inch FPVC was a 3,800 LF HDD in Ocean City, MD. For FPVC pipe sizes 30 inches and above, there have been four HDDs that have exceeded 3,000 LF. This project adds two HDDs to that list. The longest HDD FPVC pipe was a 7,658 LF 24-inch DR 18 HDD in Cape Coral, Florida.

HDD 2 measured roughly 4,554 feet in horizontal length and was drilled in a northeast-to-southwest drill direction. The HDD was installed at a depth of approximately 60 feet below Robinson Bayou and utilized entry and exit angles of 12.5 degrees and a vertical curve radius of 2,400 feet.

The entry point was located directly south of a nearby residential property line near the west side of Davis Road, while the exit point was located near the Dr. Ned and Fay Dudney Clear Creek Nature Center parking lot . The entry location was located directly west of Davis Road where the back end of the rig abutting the road. The contractor was able to stage all of the necessary equipment

Figure 2. Entry point near residential property line

within a tight workspace to accommodate HRE 750 HDD rig. The exit point was staged within the park area where all pits and any other supporting equipment was setup to minimize disturbance and impact to the park and its facilities.

Figure 3: Exit-Side Operations

The HDD crossed beneath Robinson Bayou and several wetland areas on either side of the bayou and near the entry point, however, the entry and exit fell outside any wetland area. The available survey data revealed that the proposed HDD did not cross beneath any buried facilities or pipelines, however, it was parallel to an existing buried Kinder Morgan pipeline and a high voltage powerline through most of the drill path, at a southeasterly offset.

The pipe staging and pullback area was located behind the exit point and was bent to the northwest through an existing park entrance and followed Egret Bay Blvd (Highway 270). In order to stage the pipe in a single continuous section with no mid-fuses, the pipe was laid out along the shoulder and one lane of Hwy 270, which required approximately 3,600 feet of lane closure during pipe string staging, assembly and pullback operations. The pullback alignment incorporated a compound curve as the vertical overbend overlapped with with a horizontal curve which required complex engineering and stress considerations. In order to support the pipe through the overbend and horizontal curve, a total of eight (8) excavators were utilized which required careful coordination. Another (ninth) excavator also supported the tail end of the pipe as it was pulled along. A segment of guardrail was also requried to be removed to facilitate the continuous layout of the pipe as it passed through the park entrance and onto the highway. Another important consideration during the pullback was the manamgent of the ballast water that was used to control pipe bouyancey to reduce the drag in the borehole. The contractor chose to secure several tanks of ballast waster instead of relying of hyrdants as a source of water.

The site conditions and project constraints posed many challenges to the HDD installation for the 36-inch DR21 FPVC pipe. The length, depth, and pipe OD of the HDD installation, when coupled with the challenging geotechnical conditions such as loose sloughing sands and soft swell-prone clays, posed major stress concerns for the pipe installation. For plastic pipe HDD installations (HDPE, MDPE, FPVC, etc.), due to relatively low modulus of elasticity in comparison to steel, selecting an appropriate depth of cover which satisfies factor of safety against hydraulic fracture to the formation while also providing sufficient factor of safety against collapse of the pipe due to external pressures can be a balancing

Figure 4: HDD Pipe Staging along Egret Bay Blvd.

act. The DR 21 FPCV was able to provide sufficient strength and stiffness to withstand the tensile and hoop stresses from the roughly 60-foot deep installation while also meeting the hydraulic capacity requirements for the project (afforded by a lower wall thickness). To further reduce the risk of potential pipe damage during an installation of this scale, the engineering team and contractors teamed up to develop contingency measures and best practices to follow which included maintaining a clean and open bore, utilizing buoyancy control, and monitoring of pull forces and torque during pullback.

A stress analysis was also required for the pipe pullback operations to ensure that the pipe would not become overstressed and that equipment would not be overloaded during lifting and maneuvering. A minimum allowable combined overbend radius was calculated to be 800 feet, therefore a horizontal radius of 1,100 feet and vertical overbend radius of 1,200 feet was chosen which produced a compound radius of 810 feet. The horizontal curve was chosen to be as tight as practical to allow the pipe to be laid out onto the highway while minimizing footprint within the lanes of traffic while the overbend was chosen to minimize above ground supporting requirements.

The longest 36-inch FPVC installation of its kind completed in the world to date.

A hydraulic fracture analysis was completed for the HDD installation to model the downhole pressure during the pilot hole phase of construction and compared with the expected fracture pressure of the geologic formations above the drill path.. The driller used a 2009 HRE 750 drill rig with a 12 ¼-inch jetting assembly and 5 ½-inch drill pipe for the installation of HDD 2. Due to stress restrictions of the 36-inch FPVC pipe, the installation was limited to a maximum of roughly 60 feet deep. Challenging geotechnical conditions such a loose poorly graded sands and soft fat clays provided limited overburden strength at this depth to confine the drilling fluid pressures generated during the pilot hole. However, utilizing the pressure curves generated by the engineering team and following best drilling practices such as limiting pump pressures, maintaining circulation, and controlling drilling fluid properties, the HDD contractor was able to successfully install the pilot hole without impact to any major environmental feature along the drill path during installation.

HDD 2 was successfully installed and pressure tested in November of 2023. The 36-inch League City Horizontal Directional Drilling project achieved remarkable success through meticulous planning and the collaborative efforts of all stakeholders Key to its success was a thorough understanding of site conditions and proactive planning for risks inherent to Horizontal Directional Drilling (HDD). The planning process encompassed comprehensive input from all stakeholders, ensuring a unified approach and effective mitigation strategies. This coordinated effort not only facilitated smooth project execution but also underscored the critical role of strategic planning in complex infrastructure projects.

Figure 5. Minimal footprint along the highway

ABOUT THE AUTHORS:

Gunnar Busch, P.E., is the Trenchless Engineering Lead for CCI & Associates, Inc. Gunnar has managed and designed trenchless engineering projects throughout the United States, Mexico, and South America. Among these projects are a number of high-profile oil & gas, electrical, and municipal pipeline installations and replacements including onshore, offshore, and landfall installations. Gunnar holds a B.S. in Civil Engineering from McNeese State University and is a Licensed Professional Engineer in 15 states.

Damola Ashaye, P.E., is a Regional Manager at Underground Solutions, a subsidiary of Azuria Water Solutions, a pipeline rehabilitation and trenchless solutions provider. He's responsible for Underground Solutions activities in South Texas. He is a licensed professional engineer with over 20 years of experience in Civil Engineering infrastructure projects. He holds a B.S. in Civil Engineering from the University of Oklahoma.

Surface Water Supply Project – Segment B3

Construction of 4.4 mile section of 84-inch and 96-inch steel waterline

By: Sergio Flores, P.E. & Corey Evans, P.E., Black & Veatch

BACKGROUND

Responding to mandated reductions in groundwater extraction in the Houston area, the West Harris County Regional Water Authority (WHCRWA) and the North Fort Bend Water Authority (NFBWA) have collaborated to develop the Surface Water Supply Project (SWSP). The aim of the project is to reduce ground subsidence, which has increased the risk of flooding in certain areas. The SWSP involves the construction of approximately 42 miles of welded steel potable water pipelines, with diameters ranging from 96-inch to 66-inch, and the construction of two large booster pump stations.

An integral part of the SWSP is Segment B. This section of the project involves the construction of nearly 15 miles of 84-inch and 96-inch steel waterlines, predominantly within densely developed urban areas containing single and multi-family residential buildings, light industrial buildings, petroleum pipeline corridors, commercial buildings, and school buildings. In addition to the surface infrastructure and waterways, the alignment crosses extensive underground utility systems, including sewers, natural gas pipelines, petroleum product pipelines, and electric, telecommunication, and fiber optic conduits. One 4.4-mile section of Segment B runs parallel to two distinct petroleum pipeline corridors, this segment is designated as Segment B3.

DESIGN

During the design phase of Segment B3, the WHCRWA and NFBWA opted to conduct a routing and construction methods evaluation study, given the high-risk petroleum pipelines corridors and easement construction limitations. The study revealed that a continuous tunnel was the most cost-effective and feasible construction alternative. This method was chosen because the open-cut method required costly shoring systems, and vibration was not allowed for the shoring installation methods due to the close proximity of the petroleum pipelines.

Tunnel construction allows for continuous working operations, compared to open-cut construction methods, where working hours are typically restricted in urban environments. Other

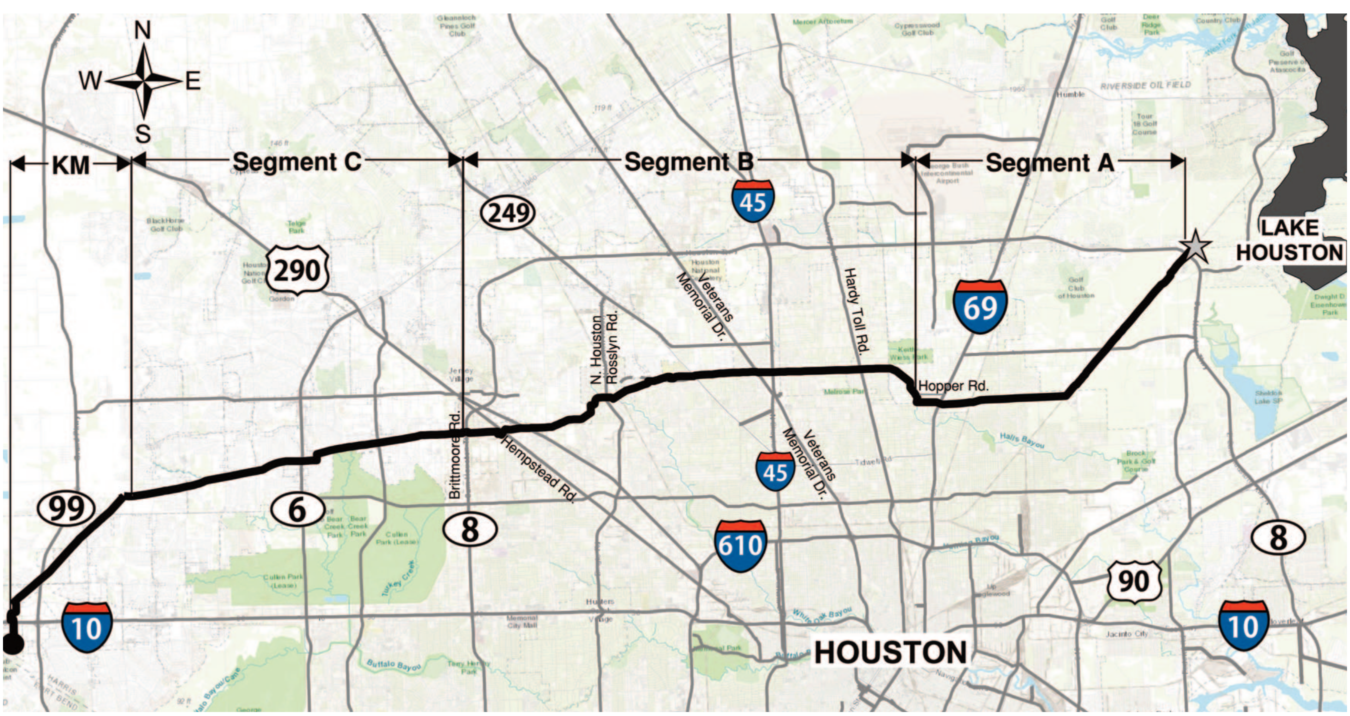

Figure 1. Surface Water Supply Project Alignment Map – approximately 42 miles of welded steel potable water pipelines

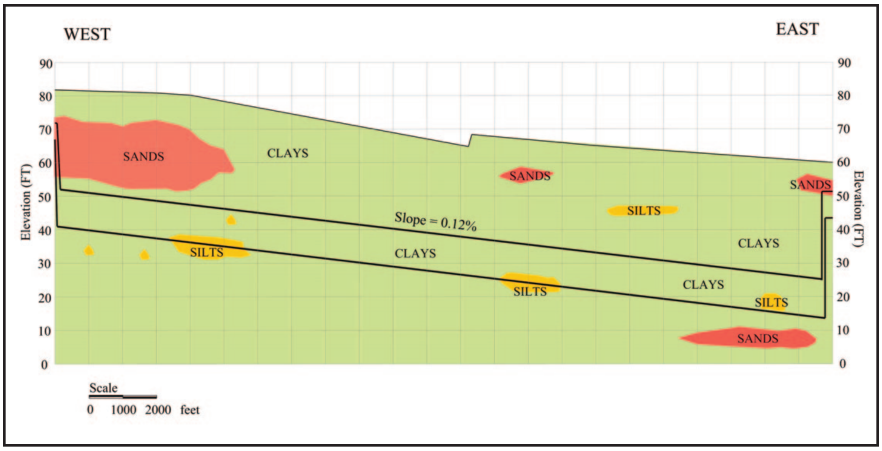

Figure 2. Segment B3 Tunnel horizon ground conditions were predominantly clays, with minor sand and silt lenses

typical open-cut construction restrictions include access, weather, adjacent structures, and utilities. The tunnel alternative allowed for the lowering of the waterline profile, moving the construction away from the sensitive parallel pipelines. The construction costs and the project schedule were the primary alternative decision factors, but other factors were also incorporated into the decision-making process to facilitate the selection of a preferred alternative.

SITE CONDITIONS

The Segment B3 tunnel horizon ground conditions consist mostly of clays, with the presence of minor silt and sand lenses. Some of the silt lenses are challenging and very soft, and some clays are slickensided. The ground water is generally shallow in the Houston area, with the ground water level for Segment B3 averaging 20 feet below ground surface. Tunneling was expected to be under the ground water for the complete alignment, with the ground coverage to the crown of the tunnel ranging from 30 to 40 feet of cover. Since this tunnel was very shallow, surface settlements posed a significant risk factor.

The Segment B3 horizontal alignment is constrained within a relatively narrow 22-foot easement that includes multiple horizontal curves. It is critical that line-and-grade is closely monitored and maintained throughout the entire length of the project. The project began with a long curve 200 feet away from the launch shaft, with the tunnel crossing petroleum gas lines at this first curve. The project was designed with a constant grade, and all the curves were kept to the same radius of 1000 feet, providing consistency to the Contractor, and facilitating the installation of the carrier pipe.

The main tunnel support system for the project is steel ribs and wood lagging. The project specifications required the ribs and lagging/channel to be expanded using a rib expander. Galvanized steel ribs and channel are used for the Interstate 45, Hardy Toll Road, and Union Pacific Railroad (UPRR) crossings because these stakeholders require a steel liner to be utilized. The original design specified galvanized steel liner plates, but the Contractor requested a change to utilize steel ribs and channel so that tunnel excava-

Figure 3. Tunnel support system was steel ribs and wood lagging. Rib expander was utilized

tion operations remained the same throughout the project. This alternative was evaluated and approved. Collaboration between the Engineer and the Contractor helped obtain the approval from TxDOT, Harris County Toll Road Authority, and UPRR.

TUNNEL BORING MACHINE

The Contractor selected a refurbished 1987 M-126 Series 8500 Lovat Tunnel Boring Machine (TBM) with a diameter of 128 inches and the versatility to operate in both Open-mode and Earth Pressure Balance Mode (EPB). The TBM was named Suzzann and had previously been used in

Figure 4. TBM "Suzzann" had versatility to operate in both Open Mode and Earth Pressure Balance Mode

Figure 5. Survey monitors were used for a detailed surface settlement monitoring program

Figure 6. The Contractor's performance was exceptional with settlement well within project specifications

Houston, completing those tunnels successfully. The Contractor had to replace the main bearing for the machine, replaced the motor plate, refurbished the main drives, cylinders, motors, and pumps. The Contractor also installed a PPS automated guidance system. As required per the project specifications, the Contractor added an accumulator to have the flood/face doors close in the event of power loss.

The project specifications required a TBM capable of converting to EPB. The Contractor made the appropriate refurbishment so that the TBM was prepared to convert to Earth Pressure Balance mode if needed. The Contractor was required to have all the parts on-site so that the conversion could be done quickly. The Contractor also prepared a muck-ring, which would allow them to work on a semi-closed/pressurized tunneling mode if they decided to install it. The project included a Geotechnical Baseline Report (GBR) that indicated a baseline length of tunnel that was to be excavated in EPB mode. The location of where the tunnel needed to be excavated in EPB was not specified in the GBR. The Contractor provided positive feedback on not having the location set in the GBR since the Contractor could see more real-time ground conditions during the Construction Phase rather than the Engineer making a determination based on the available geotechnical data at the Design Phase.

CONSTRUCTION

The project construction began in the summer of 2022, with seven construction sites located along the alignment, each having a shaft. Three of the sites were designated by the Contractor to be used for tunnel excavation operations. It was anticipated during design that three or four of the project sites were needed for the tunnel excavation operations and this was worked closely with the Program Manager and the Client to obtain easements with sufficient area to facilitate the tunnel operations.

The shafts were excavated using grouted steel liner plates and steel ribs for the shaft ground support. The excavation was performed in four-foot lifts on average. Three of the shafts required the use of dewatering to allow the excavation of the shafts using steel liner plates. The Contractor selected the shaft sizes based on their means and methods, but the main selection factor was determined by the tunnel muck bucket length and the pipeline segments length. Shaft excavation presented some difficulties at Site 6, which was expected to be excavated through a large sand layer. Even with dewatering, the sands' behavior was categorized as running and slow raveling.

A robust geotechnical instrumentation program to evaluate the Contractor's tunnel excavation performance was required per Contract Specifications. The project drawings included a very detailed surface settlement monitoring program. The Contractor selected a very experienced geotechnical instrumentation and monitoring subcontractor for this project. The monitoring program included a real-time online system that provided data as it was monitored in the field. This allowed for the Contractor, Engineer, and Client to monitor and see the real-time performance of the work. This was done by using survey monitors and automated total station that were mounted on strategic locations determined by the subconsultant.

After the completion of the Site 1 shaft, tunnel excavation began in October of 2022. After a few months of some mechanical and hydraulic issues with the TBM, the Contractor was able to excavate the tunnel with more consistent production rates. The Contractor decided to excavate the first 4,250 feet of the tunnel, which is Reach 1, only on Day Shift. Once complete, the Contractor added a swing shift or night shift to continue excavating the remainder of the tunnel. Over a span of 16 months, the contractor successfully excavated the 4.4-mile-long tunnel, completely in Open-mode, while effectively using the face/flood doors of the cutterhead to regulate face pressure as determined by the TBM Operator. Since the TBM was operated in Open-mode, the TBM Operator was able to see the ground in front of the TBM. If needed, the TBM Operator would open or partially close the face doors to control the face. The Contractor ensured that the tunnel excavation crew performing the work was experienced. The tunneling crew demonstrated that they could undertake this challenge.

The Contractor was able to minimize ground surface settlements by fine-tuning the TBM excavation operations by adjusting parameters like push pressure, advance rate, and face doors opening. The project encountered some very wet silt lenses and some areas with wet sand lenses during tunnel excavation. These were successfully mitigated by excavation with the face/flood doors partially closed. The most challenging area encountered consisted of soils classified as running silts and sands. The project specifications required the use of filter fabric behind the tunnel liner in the areas having silts and sands. The Contractor decided to install the filter fabric even on the clay areas so that they could mitigate any rapid change of ground conditions and also to streamline the tunnel production to have the crews trained for the effective installation of the filter fabric.

Figure 7. Tunnel lining – completion anticipated summer 2025

Tunneling was successfully completed in February of 2024. The Contractor averaged 45 feet of excavation and installation of tunnel liner in 10-hour shifts. The Contractor's performance was exceptional, and there was no settlement that exceeded the project's settlement specifications limits. This was also the case while crossing critical sections like the Hardy Toll Road, the UPRR crossing, and Interstate 45.

COMPLETION

Currently, the Contractor is installing the 96-inch waterline using 25-foot long sections of pipe. The pipeline sections are single-lap welded, completed from inside the pipe. After the completion of the joint welding, it is required that the Contractor inspects each pipe joint weld using Magnetic Particle method by a Certified Welding Inspector. The welds are also visually inspected. The Authorities also have a 3rd party welding inspector to provide Quality Assurance of the welds. This is critical to have a successful hydrostatic pressure testing of the waterline.

The Contractor has already installed nearly 3 miles of the installation of the pipeline. The annular space between the pipeline and the tunnel is backfilled through grout ports inside the pipeline. The project specifications require the use of 75 PCF cellular grout. This cellular grout density is needed to move any water in the tunnel and to provide corrosion protection since the pipeline section joints don't have a heat-shrink sleeve. The pipeline has a corrosion/cathodic protection system that is an impressed current system.

The Contractor is anticipated to complete the installation of the 96-inch pipeline this fall and have completed all the annular grouting completed by the end of the year. Substantial project completion is anticipated in the summer of 2025.

ABOUT THE AUTHORS:

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Twenty-Two Years of Advancing Research in Underground Infrastructure and Trenchless Technologies: CUIRE's Commitment

By: Kawalpreet Kaur, Ph.D., Diego R. Calderon, P.E., Sanaz Ghalambor, Ph.D, Ehsan Rajaie, Dr. Mo Najafi, P.E. PhD., CUIRE, UTA

22 years have already passed since the Center for Underground Infrastructure Research and Education (CUIRE) was established. In 2006, the first trenchless technology conference was held at the University of Texas at Arlington (UTA). CUIRE is dedicated to advancing research, development, and training in underground infrastructure technologies, particularly focusing on pipelines. Through collaboration with industry, government agencies, and professional associations, CUIRE ensures its programs are both relevant and impactful, addressing the pressing needs of modern infrastructure. CUIRE is involved in groundbreaking research, with over 16 PhD students actively contributing to its projects.

Recent research endeavors include use of trenchless technologies for comprehensive asset management of culverts and drainage structures, real-time monitoring systems for water assets, and development of innovative pipeline renewal methods. In addition, research efforts include development of polymeric spray applied pipe linings (SAPLs) in high-pressure pipe applications; product evaluations for underground stormwater storage, infiltration chambers, and modules under highway truck loading; and leading a nationwide study to assess innovative technologies for monitoring water assets. These projects not only push the boundaries of current knowledge, but also offer practical solutions to infrastructure challenges faced by communities nationwide.

1 APPLICATION OF SAPL IN PRESSURE PIPE APPLICATIONS

Spray applied pipe lining (SAPL) can address pipe deterioration and prevent failures when designed based on the host pipe condition. Due to its minimum access requirements, this technology is one of the most cost-effective and versatile trenchless pipeline renewal methods. Polymeric SAPL is applied inside a pipe for either corrosion prevention or to enhance the load-bearing capacity of the host pipe by creating a new interactive structure. CUIRE is conducting testing for the application of SAPL in pressure pipelines, process pipelines and industrial applications. The researchers at CUIRE are continuously advancing into developing a testing program to better evaluate the use of SAPL material in pressure pipes based on the different AWWA Structural Classifications.

Material Properties Testing

Material properties testing is required to determine the material's mechanical response under various conditions. This can be useful in designing the liner material for different and challenging applications. The properties of polymeric materials are influenced by time, temperature, and loading rate; therefore, we tested these properties at short—and long-term time intervals, as well as at different temperatures and loading rates. These tests show the material's response against tensile straining due to excessive or continuous loading, resistance to bending, impact resistance, ground movement, and temperature changes, and shear impact due to sudden loading for shallow-depth pipes. Figure 1 shows a short-term tensile testing, and Figure 2 presents the short-term flexural testing using a universal testing machine.

To effectively improve the consistency of testing results, a comprehensive approach, considering parameters such as spraying techniques, specimen location,

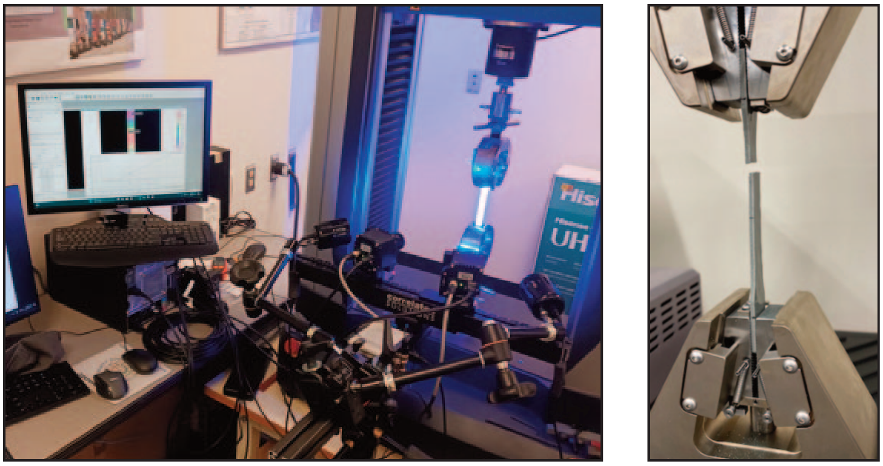


Figure 1: Short-term Tensile Testing Figure

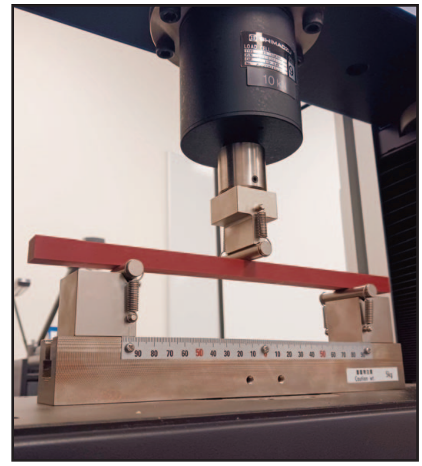


Figure 2: Short-term Flexural Testing

These projects offer practical solutions to infrastructure challenges

and cutting and spraying conditions, was carefully considered while preparing samples. The material properties obtained from the testing results were used to design the full-scale laboratory testing for Class II, Class III, and Class IV as per AWWA Structural Lining Classification System.

Full Scale Laboratory Testing for the Application of SAPL in Pressure Pipes

A short-term hole-spanning testing was performed by researchers at CUIRE for a 30-inch diameter host pipe with hole-spanning sizes of 0.5, 1, 2, 4, and 6 inches. The pipe samples with 0.5, 1 and 2-inch hole spanning sizes were lined with pure polyurea elastomeric material, and the lining system passed 500 psi pressure without failure. The 4 and 6-inch hole-spanning testing is still in progress. The short-term hole spanning test will determine the structural capability of the liner material as per AWWA Class II, which classifies the capacity of the liner material to bridge the corrosion holes in the host pipe under the desired working pressure. Figure 3 shows the pipe sample with a hole and polymeric liner exposed through this hole.

Additionally, evaluating the buckling effects caused by groundwater hydrostatic pressure on polymeric SAPL liners due to water within the annular space between the liner and the host pipe is an important criterion for the Class III structural classification system. Geometric imperfections may exist due to the deteriorated state of the host pipe, inconsistencies in liner installation, or adhesive failure, all of which significantly affect bonding capacity. Non-bonded areas create gaps between the liner and host pipe, through which groundwater may seep, exerting external pressure on the lining system.

Researchers at CUIRE also conducted a short-term external buckling test involving a SAPL liner confined within an 8-inch host pipe. The test evaluated the impact of varying liner thicknesses while maintaining a consistent annular gap. These tests aimed to determine the liner's short-term resistance to hydraulic pressure and its resistance to buckling effects caused by groundwater. The short-term hole spanning and external buckling tests, along with the vacuum pressure test, confirmed the liner's structural properties as per class II and III. Figure 4 shows the external buckling test assembly and the pipe sample with an annular space between the host pipe and pipe sample sealed at both ends.

To evaluate the use of polymeric SAPL per AWWA Class IV, researchers at CUIRE tested the liner material under internal hydrostatic pressure to evaluate its integrity with no support from the host pipe. The testing included 8-inch diameter pipe samples, which were tested at different temperature conditions from 41F to 150F degrees. Figure 5 shows hydrostatic pres-

Figure 3: Hole-Spanning Testing Pipe Sample

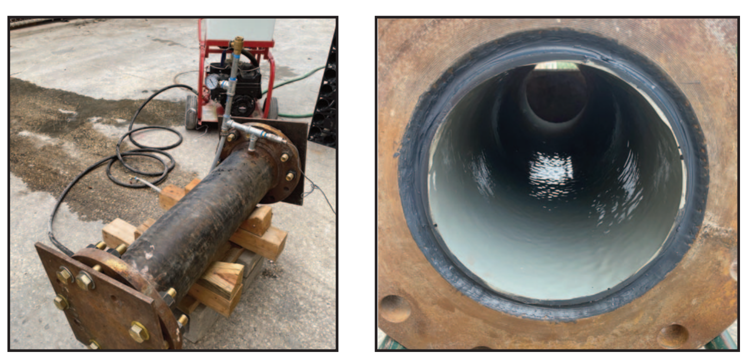


Figure 4: External Buckling Test Assembly (Left) and Inside View of the Pipe Sample Sealed at both Ends (Right)

Figure 5: Hydrostatic Pressure Testing Equipment

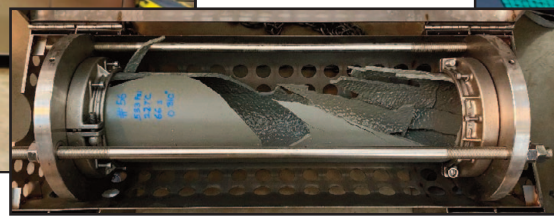


Figure 6: Burst Pipe Sample

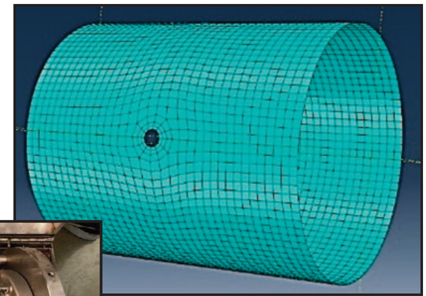


Figure 7: 3D FEM model, meshing of Hole Spanning Pipe Sample

sure testing equipment, and Figure 6 illustrates a picture of a broken test sample.

The test results determined the burst pressure, mode of failure, and hoop stress on the SAPL due to internal pressure. The test results established a relationship between the pipe thickness and pressure at different temperatures, which is required to determine the material's performance under different environmental and loading conditions.

CUIRE is also actively involved in research projects related to the Finite Element Method (FEM). These projects are focused on advancing the understanding and capabilities of structural analysis and numerical modeling for underground infrastructure. Our primary focus is on simulating and developing tests and parametric studies that improve structural methodologies.

One significant project involves conducting 3D Finite Element Method (FEM) analysis on Polymeric Sprayed Applied Pipe Linings (SAPL) in pressure pipes applications. This research evaluates the effects of various parameters, such as pipe diameter, pipe thickness, and running these FEM at different pressure ratings and environmental conditions. By optimizing the thickness of the polymeric material through non-linear FEM analysis, we aim to create a design equation and standard guidelines for SAPL application. Detailed 3D models are developed using ABAQUS® software.

The FEM models have been validated through extensive experimental hole spanning testing, external buckling hydrostatic pressure testing, and pressure integrity testing on full-scale SAPL samples. Figure 7 represents the 3D FEM model with meshing of the hole spanning sample before applying the pressure to the model. The laboratory models tests replicate real-world conditions, ensuring the reliability of our FEM models.

2 FULL-SCALE LIVE LOAD TESTING OF EMBEDDED STORMWATER STORAGE, INFILTRATION CHAMBERS, AND MODULES

CUIRE's wide research capabilities have led them to partner with Xerxes, a leading innovator in composite underground storage solutions products. Together, they are working on creating test procedures and product evaluations for stormwater storage and infiltration chambers, and modules. The test procedures determine how well HydroChain stormwater chambers and modules can withstand vehicular, and soil loads under various real-world scenarios.

The chambers were embedded in a soil box and then backfilled with aggregates. Highway truck loading was simulated

Figure 8: HydroChain S-29B Chambers Assembled in the Soil Box

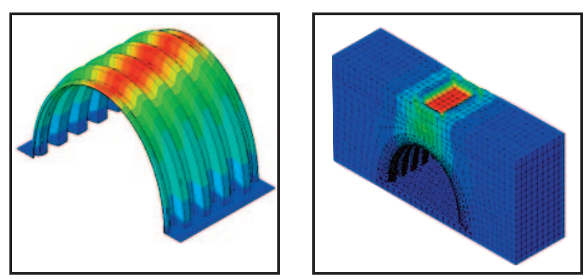


Figure 9: 3D FEM model, meshing and stress analysis of HYDROCHAIN Chamber

with a 330-kip actuator. During the test, different sets of data, such as load applied with the actuator, deflection at the crown of the chambers, strain data and pressure data were collected and analyzed to determine the structural integrity of the chambers.

Additionally, CUIRE researchers performed modeling simulations to predict the structural behavior of the embedded HydroChain chambers under various load conditions, as shown in Figure 9. Studying the impact of different design parameters gives CUIRE data that allows for increased structural performance and durability.

Through such research, CUIRE is helping lead the way in improved efficiency and cost-effectiveness of underground infrastructure systems. Sharing our findings through various publications and conferences contributes to industry knowledge, and helps utilities make informed decisions about infrastructure technology and maintenance.

3 INNOVATIVE TECHNOLOGIES TO IMPROVE MONITORING OF WATER ASSETS

The Water Research Foundation (WRF) project 5191, entitled "Innovative Technologies to Improve Monitoring of Water Assets," is a comprehensive investigation into the use of condition monitoring technologies by water utilities. The project assesses both existing and cutting-edge technologies to enhance the condition monitoring and management of water infrastructure. The research examines the published body of knowledge, surveys utility practices and explores case studies from various water utilities. These sources of knowledge then provide the necessary information to identify gaps and conclusions about condition monitoring approaches.

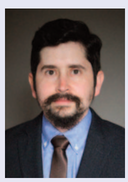
One of the primary objectives is to provide clear, actionable guidelines for water utilities for selecting the most suitable condition monitoring methods for pressure pipelines. This involves a thorough evaluation of technical requirements, and effectiveness of different technologies. The project has engaged multiple stakeholders, including notable utilities throughout North America, ensuring a broad spectrum of input and validation. Figure 10 shows a sample case study for a pump station.

Figure 10: Sample Case Study for a Pump Station (Source: CDM Smith)

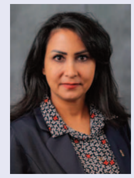
Project aims to drive significant advancements in the condition monitoring of water assets

ABOUT THE AUTHORS:

Kawalpreet Kaur, Ph.D., is a post-doctoral research associate with a research interest in trenchless technology, pipeline rehabilitation, and asset management. Her current research focuses on designing, testing, and evaluating spray-applied pipe linings (SAPL) and underground stormwater storage infrastructure materials. She conducts various experimental tests to assess their suitability for field applications.

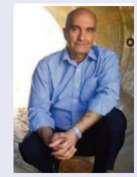


Diego R. Calderon is a licensed professional engineer. His 18 years of experience include roles as university professor, researcher, municipal engineer, project manager, project engineer and field engineer. He is a certified NASSCO trainer, a municipal engineer and a Ph.D. candidate at UTA. His dissertation revolves around innovative technologies for condition monitoring of water assets.



Sanaz Ghalambor, Ph.D., with a Civil and Polymer Engineering background, is working as an Advisory Engineer- Spray-in-place Lining Solutions at Framatome. She has spent two decades in pipeline integrity, corrosion prevention, and rehabilitation. She's had several presentations at different conferences, including UCT, NASTT, and IWA, and has supported many water and wastewater rehabilitation projects.

Ehsan Rajaie is a Ph.D. candidate at UTA and an infrastructure engineering assistant at TRWD. He has 14 years of civil engineering experience, including lecturing, research, design, and construction management. His recent research focuses on pipeline rehabilitation using trenchless technology and developing structural methodology using FEM, presented at conferences like NASTT and UESI.



Dr. Najafi is a Professor and Director of the Center for Underground Infrastructure Research and Education (CUIRE). He is a Board Certified Pipeline Engineer—Water. He has more than 25 years of experience encompassing engineering, education, research, consulting, and management activities. He is the author of four trenchless technology books published by McGraw-Hill (the latest one published in 2022, see Figure 11).

Figure 11: Textbooks Published by Dr. Najafi

Table 1 presents a list of water utilities and organizations supporting this project. Through workshops, surveys, gap analysis, and collaborative efforts, the project aims to drive significant advancements in the condition monitoring of water assets, ultimately contributing to more efficient and reliable practices across the nation.

Table 1- list of water utilities and organizations supporting this project.

Water Utilities and Organizations	City, State
TRWD (Tarrant Regional Water District)	Fort Worth, Texas
WSSC Water	Laurel, Maryland
Underground Infrastructure	Houston, Texas
WaterOne	Lenexa, Kansas
American Water	Camden, New Jersey
Dallas County Public Works	Dallas, Texas
DC Water	Washington, DC
Los Angeles County Sanitation Districts	Los Angeles County, California
Greater Cincinnati Water Works	Cincinnati, Ohio
Orange County Utilities	Orlando, Florida
San Diego County Water Authority	San Diego, CA
Great Lakes Water Authority	Detroit, Michigan
Dallas Water Utilities	Dallas, Texas
Dallas County	Dallas, Texas
CDM Smith	Fairfax, Virginia

Horizontal Directional Drilling - Pullback Support Design for Various Pipe Materials

Ensuring Successful HDD Installations

By: Justin Taylor, PE & Gunnar Busch, PE, CCI & Associates Inc.

Stress measurements conducted on Horizontal Directional Drills (HDDs) have shown that the highest stress imposed on the product pipe during installation in many cases occurs during the lifting of the pipe above ground. HDD pullback lift support design is therefore a critical key component of the overall engineering and design of HDD installations. Lack of detailed lift designs can have severe impacts on the success of the HDD installation, including overstressing of product pipe, pipe damage, schedule delays due to lack of necessary lift equipment on site, high pullback forces and coating damage due to misalignment of the pipe at the exit point, and/or un-safe lifts where lifting equipment may be in danger of overloading and failure. Key to a suitable lift design is a good understanding of the characteristics of different product pipe materials, and the impact the pipe material has on the various considerations that go into it.

The four types of product that could typically be installed by HDD are Carbon Steel, High Density Polyethylene (HDPE), Fusible Polyvinyl Chloride (FPVC), and Ductile Iron pipe. Steel and HDPE pipe are very commonly installed via HDD. FPVC is becoming increasingly prevalent in HDDs in recent years, and ductile iron pipe is relatively uncommon but is sometimes installed via HDD. Steel is primarily used in the Oil & Gas industry with higher operating pressure applications, while FPVC and HDPE are commonly used in both water/sewer and electrical or fibre-optic cable conduit applications, and ductile iron is typically utilized in only water/sewer jobs. Steel pipe joints are welded together while HDPE and FPVC pipes are fused together utilizing heat and pressure to join two joints together with a fusion machine. Ductile iron pipe differs from the others in that it is usually installed in single joint increments, each joint connecting to the previous with a bell and spigot quick-connection before it is pulled downhole. Where steel, HDPE and FPVC pipe elastically bend to adhere to downhole curves, ductile iron pipe does not bend and relies on the deflection at these specially designed bell/spigot joints in order to adhere to any curves. Because of these flexible connections, long strings of ductile iron pipe typically aren't laid out in pre-fabricated strings which are lifted to align with the exit point, as it would be more akin to trying to lift a chain than lift a single solid member. However, if each joint of pipe is supported adequately, long strings of pre-fabricated ductile iron pipe can be utilized.

Pullback design is key to ensuring the validity, feasibility, efficiency, and safety of HDD Construction

The type of material being installed by HDD will affect many considerations within the pullback and lift design. One of the first major differences in pipe materials is weight. Steel pipe and ductile iron pipe of similar OD may have relatively similar weights, depending on wall thickness. An HDPE pipe of a similar OD may be lighter by 40 percent or more in comparison to these pipes, and an FPVC pipe of the same OD would be even lighter since FPVC typically has lower wall thicknesses than similarly sized HDPE. The differences in weights could equate to differences in required lift support spacing in order to ensure the lifting equipment is not overloaded.

Workspace limitations are one of the primary concerns that pullback lift plans have to deal with. Preferably, any HDD would have a section of straight open space past the exit point, at least as long as the HDD, so that a single straight pipe section can be prepared for pullback. This would allow the contractor to install the product in one continuous pull, without having to stop for completion of an intermediate weld or fusion. Depending on the size of pipe, a weld, coating and inspection of a steel pipe could add up to a full day of stoppage on the pullback operations, which in many cases could add unacceptable risk of the product pipe becoming stuck and resulting in an unsuccessful pullback. For an intermediate fusion on PVC and HDPE pipes, the stoppage time can be significantly less than steel, but still can cause undue delays that add unwanted risk. Additionally, there are other impacts such as internal de-beading of the fuses that can be difficult or impossible when fusing two long

Figure 1. Steel, HDPE and FPVC pipe all elastically bend to adhere to above-ground curvture

sections of plastic pipe together. Proper quality control during the welding, fusion, and coating (where applicable) processes are key, as cutting out a bad fusion or re-coating pipe during pullback is not tolerable from a risk standpoint.

Having straight open workspace to accommodate a single pull section is, unfortunately, not always the case. In fact, in densely populated areas it is almost never possible. Sometimes the designer may need to get creative in trying to utilize available workspace and minimize intermediate welds and fuses while also minimizing impact to the public and ensuring worker safety. In general, steel pipe can afford the least amount of horizontal bending or "roping" in order to go around obstacles or stay within available open workspace, whereas PVC and especially HDPE can be curved at much tighter radii which can allow single pullback sections in some relatively tight locations. On average, FPVC pipe can be bent to approximately 50 percent of the radius steel pipe can, while HDPE can be bent down to approximately 10 percent of the radius that similarly sized steel pipe can be bent to due to their relative flexibilities. An analysis should be completed to determine that the pipe will not be over-stressed when roping around obstacles and that the equipment intended to support the pipe through these changes in direction above ground are properly sized to ensure they can safely support it.

Where the limiting workspace constraint for a straight pullback is a road,

Figure 2. HDPE can turn a much tighter corner than other pipe materials

rail, or watercourse, there may be ways to accommodate crossing these obstacles with the pull section without significantly impacting them or blocking them off. For roads and rails, support of the pull-section above the road/railway such that traffic can continue below the pipe section can be completed. If this is to be

Figure 3. If a road can't be closed, why not go under it? Having straight open workspace to accommodate a single pull section is increasingly rare

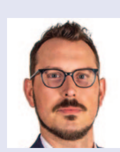
done, careful planning, permitting, and engineering design of redundant supports above the lane of travel are key to achieving this successfully and safely. Another alternative may be the completion of a pre-installed large diameter casing or culvert below the road/railway. This can allow threading the pipe pull section through the casing/culvert under the obstacle, therefore avoiding any impact to flow of travel.

One of the major differences in pipe materials is weight

Where watercourses intersect a pullback alignment, sometimes if it is small enough the contractor may be able to provide lifting supports on either side in order to span the pipe across the water without causing overstressing of the pipe. Where a wider watercourse is crossed, it may be worthwhile constructing temporary bridging above the watercourse to allow for pipe and support equipment travel above it.

Buoyancy Control is another consideration that can impact many HDD pullback lifting plans. Buoyancy control entails filling the product pipe up with water as it is pulled below surface to reduce the buoyant weight of the pipe and reducing overall pull force. Buoyancy control is typically recommended for steel pipe installations of 24-inch OD or larger and would be considered necessary for most sizes of plastic pipe. The pullback alignment and laydown area should be selected with consideration of the buoyancy control plan, as the ballasting of the pipe will require a considerable amount of water, pumps, as well as ballast

ABOUT THE AUTHORS:



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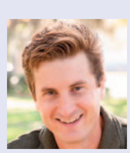

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lines. Additionally, the ballast line and water flowing through it within the pipe being installed will add weight to supports holding the pipe in place which should be accounted for when sizing the equipment.

CONCLUSION:

Different product pipe/conduit materials have differing physical properties and each needs to be treated accordingly. Industry guidelines and codes, as well as manufacturer specifications need to be referenced when developing pullback designs, and detailed calculations on allowable bending, equipment loading and required lift heights should be completed, whether these be hand calculation models, software-based analysis models, or a combination of both. Additional impacts of horizontal curves, buoyancy control, sloped grades, and roller friction force contribution to vertical support loading all need to be considered within these calculations. Completing such analysis is a critical key in ensuring the validity, feasibility, efficiency, and safety of a full HDD design.

Figure 4. Pullback towering over a road

Hitting the Mark

Crossing the Guadalupe River with the Second Vertical-Curved Microtunnel in the United States

By: Robert Weinert, P.E., M.ASCE, Plummer Associates, Inc.;
Jesse Guerra, P.E., Plummer Associates, Inc.;
Ashley Heckman, P.E., Aldea Services., Inc.

INTRODUCTION

New Braunfels, Texas has experienced extraordinary growth over the past two decades, nearly tripling in size to a 2023 estimated population of over 105,000. This growth has come with challenges for New Braunfels Utilities (NBU), which provides the City of New Braunfels ("City") with electricity, water, and sewer infrastructure. NBU updated its Water Resources Plan in 2018 to prepare for the city's projected growth, with $600+ million in water and sewer capital improvement projects planned over the next five-year period.

This plan included the expansion of NBU's Surface Water Treatment Plant (SWTP) from an 8 million gallons per day (MGD) capacity to a 16 MGD capacity. NBU retained Plummer Associates, Inc. ("Plummer") to design the SWTP Discharge Water Line Project (shown in Figure 1) and Plummer retained Aldea Services, Inc., as its tunneling engineering subconsultant. The Project increases the SWTP's treated water transmission capacity using a waterline connecting the SWTP to NBU's FM 306 Pump Station and Ground Storage Tank, in anticipation of the future plant expansion.

PROJECT OVERVIEW AND ALIGNMENT

Plummer performed a desktop alignment study to determine the optimal pipeline route, which is shown in Figure 1. Plummer chose this route because it was the lowest cost option, was the only route that avoided conflict with future City drainage and pavement projects, and was the only route that did not require easement acquisition on privately-owned land, limiting potential delays and real estate cost uncertainty. However, the route did require the crossing of the Guadalupe River on a tight tolerance, which presented risks and challenges for the design team.

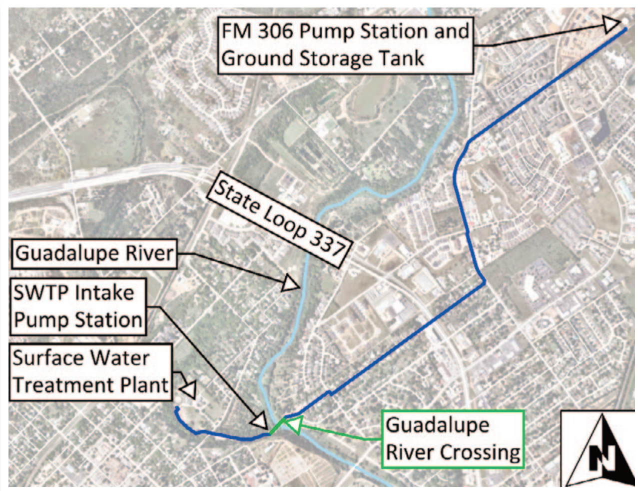


Figure 1. SWTP Discharge Water Line alignment and location of related improvements

Based on the water modeling and alignment study, Plummer designed a pipeline consisting of approximately 10,000 linear feet (LF) of 30-inch diameter pipeline (with 413 LF at the Guadalupe River crossing, discussed below) and 2,785 LF of 24-inch diameter pipeline.

GUADALUPE RIVER CROSSING ALIGNMENT AND GENERAL CHALLENGES

General Challenges

The chosen alignment was selected because it was the lowest cost option and limited private easement acquisition. However, the Guadalupe River crossing (shown in Figure 2) presented several design challenges:

Ultimately, vertical-curved microtunneling was utilized for the crossing

1. The southwest side of the river had very tight clearance between the SWTP Raw Water Intake Pump Station (which had to remain in service throughout construction and could not be affected) and a 20-feet+ steep embankment.
2. The river crossing required a permit from the Texas General Land Office, which NBU indicated requires either a cased installation or that the pipeline be shut down annually to conduct leak testing. Because this project is vital to NBU's water supply, Plummer strongly preferred a cased installation.
3. The existing ground at the crossing location had a 20-foot surface elevation difference at the installation shaft locations, such that a horizontal installation could have required a shaft up to 60-feet deep adjacent to the pump station.

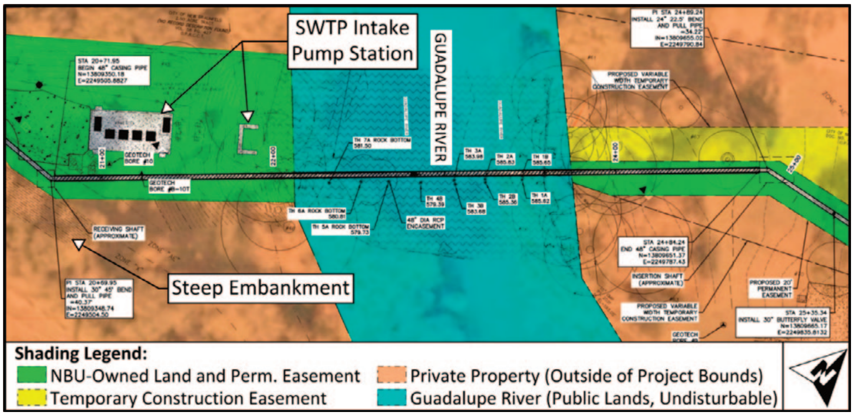


Figure 2. SWTP Discharge Water Line Guadalupe River crossing alignment

TRENCHLESS METHODS CONSIDERED

Three trenchless methods were considered for the river crossing:

1. Horizontal Auger Boring (HAB)
2. Horizontal Directional Drilling (HDD)
3. Vertical-Curved Microtunneling (MT).

Ultimately, vertical-curved microtunneling was utilized for the crossing.

Horizontal Auger Boring (HAB)

HAB employs an auger boring machine to jack steel casing segments forward while removing the spoils through a rotating auger chain positioned within the casing pipe and fitted to a cutter head at the front of the casing. The rotating cutter head excavates the soil in front of the casing, which is then transported back to the jacking pit where the soil is removed by hand or machine. HAB had several drawbacks that eliminated it as an option:

1. It is not generally steerable and therefore line and grade are set during initial set up.
2. It is typically limited to stable soils above the water table or soils that can be actively dewatered.
3. It can have issues in harder rock without specialized attachments.
4. Because HAB is linear, the shafts would be 25 feet deeper than with curved installations, which would increase costs, pump station damage risks, risks for line and grade issues, and risks of encountering difficult-to-excavate rock.

Horizontal Directional Drilling (HDD)

HDD is a steerable method that uses a surface-launched drilling rig to install the pipeline in three stages:

1. Pilot Drilling: A small diameter pilot hole is drilled along the drill path, with directional control achieved using a steerable drilling bit or assembly.
2. Pre-Reaming: The pilot hole is enlarged to the required diameter by pre-reaming using at least one pass with a reamer tool/attachment.
3. Pullback: The pipeline is pulled back through the enlarged and clear bore hole.

HDD allows for over 3000 feet between entry and exit pits, minimal surface disturbance and adjacent land impacts, smaller shafts/pits than some other technologies, and as minimized excavation, dewatering, and shoring efforts. It is also possible to steer away from encountered obstacles. However, because HDD requires extensive longitudinal laydown area for pipe layout, has few options for the installation of large-diameter pipe, and does not have positive tunnel support during the potential several passes that may be required during Pre-Reaming, it was removed as an option.

Vertical-Curved Microtunneling (MT)

In a vertical-curved microtunnel, a slurry microtunnel boring machine (MTBM) is used to trenchlessly install pipelines. During construction, the MTBM excavates the ground material and is simultaneously jacked into the ground. The jacks are then retracted, and the slurry lines and control cables are disconnected so that a joint of carrier or casing pipe can be lowered into the shaft and inserted in the jacking frame. Lines and hoses are then reconnected and the pipe/MTBM are advanced another drive stroke. This process is repeated until the MTBM reaches the reception shaft.

During microtunneling, the excavated envelope was lubricated using bentonite injected via grout ports in the microtunnel pipe during pipeline installation to fill the annular space between the outside of

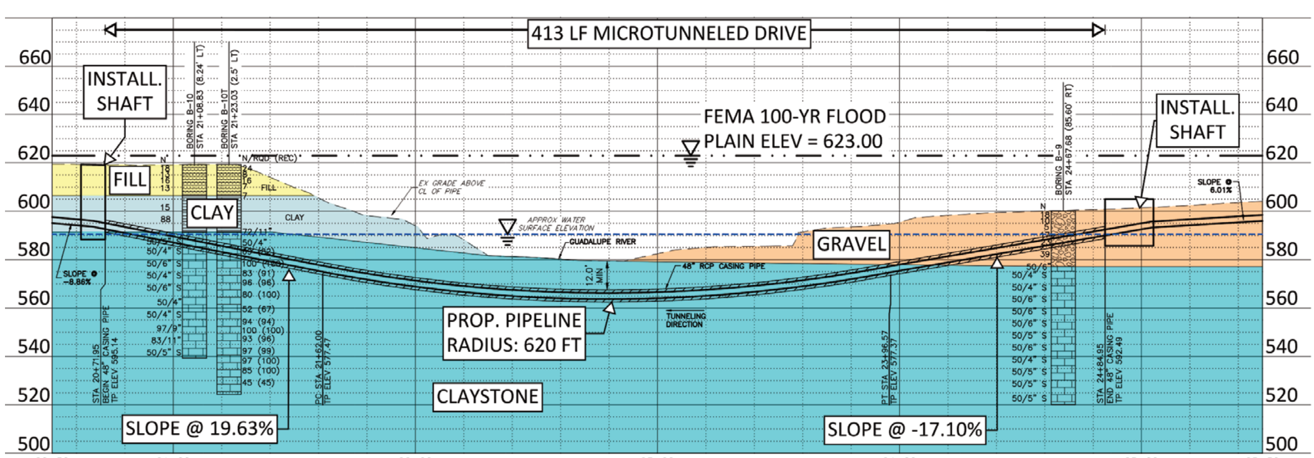


Figure 3. Guadalupe River crossing profile (1H:1V scale) with ground conditions shown (southwest bank is on left)

the pipe and the excavated surface. Upon completion of the microtunnel drive, the space between the jacked pipe and the surrounding soil was grouted.

However, the MTBM provides positive tunnel support, is highly accurate, and can be installed in the mixed soil conditions found in this crossing; additionally, the curved alignment minimized shaft depths. Therefore, the design team opted to utilize a vertical-curved microtunneling installation for the crossing of the Guadalupe River.

The curved alignment design required special consideration of eccentric/non-uniform jacking forces, minimum allowable radius, maximum allowable pipe length, minimum required overcut, and maximum allowable joint deflection on curve to maintain water tightness. As shown in the pipeline crossing profile in Figure 3 (at a 1:1 horizontal-to-vertical scale), the tunnel was installed on a 19.73 percent downslope, through a tight 620-foot radius curve and recovered on a 17.10 percent upslope.

GUADALUPE RIVER CROSSING ANTICIPATED (BASELINE) GROUND CONDITIONS AND CHALLENGES

Geotechnical Baseline Report

The design team anticipated that the Guadalupe River crossing would have geotechnical risks, and thus created a Geotechnical Baseline Report (GBR), which is a contract document that establishes a statement of the baseline subsurface conditions the Contractor can expect to encounter during construction. The GBR was this project's sole document for geotechnical interpretation, reflecting the design team's interpolation between geotechnical borehole data, engineering judgment, past construction experience, and the Owner's attitude towards risk. The GBR baselines are used to judge the merits of any differing site condition claims, regardless of how the Contractor bid the work.

Anticipated Ground Conditions

In general, the tunnel was constructed through stratigraphy consisting of clay, claystone, and gravel (shown in Figure 3). On the northeast bank of the river, gravel alluvium with potential cobbles was the anticipated ground for the entirety of the shaft and for the last 100 LF of the tunnel. On the southwest bank of the river, fill underlain by clay was the anticipated ground for the shaft with the initial launch made into approximately 15 feet of clay followed by a transition into bedrock.

The Pecan Gap Chalk, described as a bluish gray, weak to very weak calcareous Claystone, was the predominant bedrock formation encountered during construction of the Project with the upper 5-10 feet of the rock expected to be weathered. Approximately 300 feet of the tunnel was anticipated to be entirely within the Pecan Gap Chalk, including the apex of the vertical curve.

GEOTECHNICAL CHALLENGES

Many potential geotechnical challenges were anticipated during construction. These challenges included:

CURVE GEOTECHNICAL CONDITIONS: One of the biggest considerations for a vertical-curved microtunnel is ensuring that the tunneling medium is conducive to excavating a curve. At the curve apex, the geotechnical conditions require subsurface material that is strong enough for the MTBM to "bite into" and make the curve, but not too hard to prohibit the curve itself. Additionally, if the tunnel is to be excavated through more than one tunneling medium, it is important that the material strengths do not have a large differential. However, the Pecan Gap Chalk found near the Guadalupe River proved the ideal curve material.

MIXED GROUND CONDITIONS DURING TUNNELING (CLAY TO CLAYSTONE TO GRAVEL): Mixed ground types encountered during construction can be problematic during tunneling. The microtunnel profile (Figure 3) passed through ground types with different properties and behavioral characteristics. During microtunneling, with the Claystone in the invert and gravel encountered above, the machine will likely advance slowly while cutting the claystone as it continues to draw in the less stable soil above; this can lead to over-excavation and settlement at the ground surface or voids which can create potential long-term instability problems.

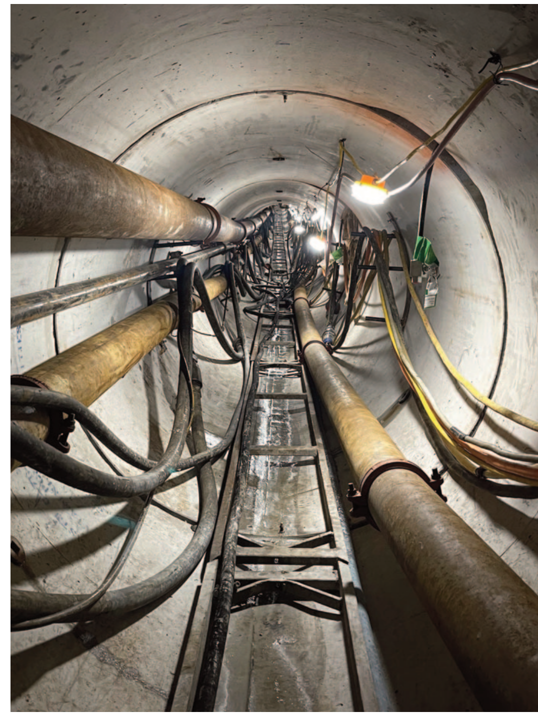


Figure 4. View of the downslope of the tunnel approaching the apex of the curve

Figure 6. Jacking frame and casing pipe wihin installation shaft

Figure 5. RCP hydraulic joint configuration

CONSTRUCTION

The Guadalupe River crossing was constructed on the following schedule:

Launch Shaft Installation:	08/01/22 – 08/26/22
Receiving Pit Installation:	10/10/22 – 10/14/22
Pre-Construction Conference:	10/13/22
Microtunnel Launch and Installation:	10/15/22 – 12/13/22
Carrier Pipe Installation:	12/14/22 – 12/16/22
Water Line in Service:	03/07/23
Substantial Completion:	04/18/23

STICKY CLAY: The microtunnel was advanced through both the Pecan Gap chalk and the Clay above the chalk, both of which are composed of high plasticity calcareous clay with medium to high stickiness potential; this can cause clogging of equipment, impede spoils removal from the MTBM cutter head, and create other complications that slow or stop construction progress. In such cases, additives can be used to limit the reactions that cause stickiness and clogging.

UNKNOWN TOP OF ROCK (TOR) ELEVATION AT THE RIVER: During design, the two available borings were on either side of the river. To determine how deep the tunnel needed to be to avoid the risk of river water infiltration, a probing investigation was conducted across the river. For this effort, a surveying team manually drove rods into the river bottom at regular intervals and took survey shots and pictures to obtain the TOR elevation. Once the TOR was confirmed, the clear cover above the tunnel crown could be defined and used to guide the design.

TIGHT CURVE RADIUS: There was very little flexibility in locating the shafts, and therefore, the curve radius of 620 feet was both necessary and a very tight curve to complete for 48-inch diameter pipe. Consequently, regular technical conversations with the hydraulic joint manufacturer were scheduled to ensure the curve radius was feasible. The extremity of the curve can be seen in Figure 4.

VERTICAL-CURVED MICROTUNNEL CONSIDERATIONS AND DECISIONS

Carrier Pipe Material

Ductile iron pipe (DIP) is the carrier pipe material for the rest of the project and was also originally planned the river crossing. However, discussions with DIP manufacturers revealed that while DIP can be deflected at each pipeline joint during open cut installation and in certain curved trenchless installations, given this project's severe vertical curve and pipe diameter, they did not feel comfortable rating it for use in this trenchless application. Therefore, Plummer instead utilized high-density polyethylene (HDPE), which allowed for installation on a sharp curve.

Casing Pipe Material

To achieve the curve, it was necessary to use precast reinforced concrete pipe (RCP) with hydraulic joints for the casing/jacking pipe. Hydraulic joints are composed of a mechanically fixed hydraulic joint attached to the pipe joint wall (see the black ring in Figure 4). Hydraulic joints utilize a pressure transmission ring that enables the jacked pipes to pass through curved alignments with no reduction in allowable jacking force or pipe length and provides real time monitoring to ensure pipes are not overloaded during jacking. The only significant design modification from standard MT jacking pipe is the inclusion of a cavity in the pipe's bell. This cavity ensures that the steel fittings (shown at top left of the joint in Figure 5) at the ends of the hydraulic hose are not clamped between the pipe joints.

Optimization of the Curve Radius

The alignment radius proved to be a challenge for the project as the launch and receiving locations were limited. Developing the curve radius was a balance of alignment length, carrier pipe diameter, casing pipe diameter, maintaining the adequate cover between the base of the river and the top of the casing pipe and the minimum curve radius capacity of the

Figure 7. Site constraints limited launch and receiving pit locations

Figure 8. Installation was generally smooth except for sticky clays

hydraulic joints. Changing any of those elements resulted in additional capacity and clearance checks of the other elements.

Project was successful because of proactive steps taken to ensure that risks were properly considered

Tunneling Pre-Construction Conference

Because a vertical-curved microtunnel is novel within the United States, a separate pre-construction conference was held specifically for the river crossing. This meeting allowed impacted parties to discuss the crossing and ensured that parties were on the same page before installation. Further, it opened dialogue that allowed the tunneling subcontractor to feel informed and supported throughout construction. Ultimately, this was particularly valuable prior to the highest-risk portion of the project.

No major issues were encountered during construction; at times, swelling clay slowed the advancement of the MTBM, but the Contractor countered that by using additives to overcome the stickiness of the clay. Otherwise, installation was a generally smooth process.

CONCLUSION

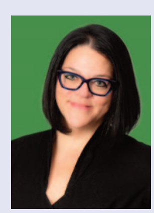
A vertical-curved microtunnel was used on the Guadalupe River crossing, which allowed for the cased installation of a water main on line and grade. This installation method minimized project risk and the curved installation reduced shaft installation costs. However, the higher design effort and overall construction costs means this method is not optimal for most trenchless installations but is preferred under the right circumstances.

Ultimately, the project was successful because of the proactive steps taken to ensure that risks were properly considered and addressed. This was aided by close communication between the owner, engineers, contractors, and construction manager; this started between the client and consultants during design and continued between the client, consultants, and contractors during pipeline construction.

ABOUT THE AUTHORS:

Robert Weinert, P.E., has nine years of engineering experience on water and wastewater pipelines from 6-inch to 72-inch diameter, as well as pump and lift stations. He is currently the president of the Oklahoma City branch of the American Society of Civil Engineers, has a B.S. in Mechanical Engineering from Baylor University, and is a licensed professional engineer in Oklahoma and Texas.

Jesse Guerra, P.E., has 32 years of experience, 26 of which includes working for a major utility (with several of those years directly responsible for construction of the utility's $400M CIP). His projects include water distribution, wastewater collection, production, wastewater treatment, recycled water facilities, lift stations, water booster stations, and large diameter wastewater outfall mains.



Ashley Heckman, P.E., is a geologist and tunnel engineer with nearly 25 years of experience in performing geologic characterization, tunnel lining analysis and design, site inspection, condition assessment and construction management. Her tunneling experience includes microtunneling (MT), horizontal directional drilling (HDD), horizontal auger boring (HAB), NATM, EPBM, Rock TBM, tunnel inspection, and tunnel rehabilitation.

Aging Water Distribution Systems Need Help

Pipe Bursting is the Solution!

By: John Newell, NO-DIGTEC

Minimal excavation/restoration. The pipe bursting method reduces digging requirements are reduced as much as 90 percent compared to an open cut "dig and replace" method. The only excavation required is for the pulling machine, insertion pit and accesses to service connections

CHALLENGES CLOSE TO HOME

Headlines are alarming: Houston, a major metropolis in a drought-prone region, is hemorrhaging treated drinking water. This isn't a science fiction scenario – a recent Houston Chronicle article revealed a staggering loss of 30 billion gallons of treated water in 2022 due to failing infrastructure. The situation has only worsened in 2024, with an additional 9 billion gallons lost between January and April. This translates to over $150 million worth of precious water vanishing into the ground – enough to supply a city of hundreds of thousands for months.

This crisis isn't unique to Houston. Aging water infrastructure plagues communities across the nation, with an estimated 3.3 billion feet of asbestos cement (AC) pipe nearing the end of its lifespan. However, Houston's situation is particularly concerning. The city is experiencing rapid population growth, coupled with a booming industrial sector. These factors place a tremendous strain on an already overburdened water distribution system.

These huge water line losses are happening at the same time, communities across Texas and Oklahoma are experiencing rapid economic and population growth, necessitating a greater water supply and distribution capacity. The population of Texas just surpassed 30 million and there are large industrial developments cropping up everywhere like the semiconductor plants going into the City of Sherman. The predominantly Cast Iron (CI) and asbestos cement (AC) water main networks are aging out and lack sufficient capacity to meet projected future demand, and minimum standards for fire protection.

With over 2,100 towns and cities across both states, there is a need for secure dependable water supply. Immediate action and focused attention on longer-term cost effective solutions, rather than expensive short-term repairs are necessary to avoid a dire future of repeated water shortages. As the Houston Chronicle reports, Houston replaced only 10 miles of its 7000 miles of aging water pipe inventory in 2022. Just to keep pace with a 50-year replacement cycle would require a minimum 140 miles of pipe replacement annually. It is important to keep in mind that Houston is just one city out of many communities, one example among many.

Unlike failures in sewer lines, clean water leaking into the environment poses little risk itself to public health or safety. Municipalities are highly motivated to prevent and immediately clean up leaks and repair failures in the sewer system, responding as rapidly as possible to mitigate environmental hazards, health risks and negative social impact. By comparison, waterline replacement projects are left aside until they inevitably become urgent, prompting unscheduled repair jobs, which redirects time and money earmarked for other longer-term projects. This reactive "whack-a-mole" approach to fixing leaks only when they become urgent is costly, disrupts planning and public works schedules, while at the same time diverting crucial funding away from proactive long term replacement programs.

We can no longer keep kicking this can down the road. The very definition of a "false economy" is to force ratepayers to keep paying for short-term fixes to leaks and line breaks in these aging water systems when effective long-term options do exist that can efficiently, and cost effectively fix the entire water distribution system. It is no longer possible to meet current waterline replacement needs by continuing as usual, bidding out piecemeal replacement projects as large-scale "dig-and-extract" jobs. A planned proactive approach involves using appropriate technologies to replace the aging CI and AC waterlines with newer larger diameter water pipes, thereby properly managing this precious resource and accommodating increased demand well into the future.

Using proven well-established trenchless technology methods such as pipe bursting to install new longer lasting pipe materials has the added benefits of dramatically reducing impacts on traffic

Joint fusing and pipe staging area. Sticks of PVC are joined to full run length prior to the day of the burst, stored conveniently out of the way near the insertion point

flow, businesses and residences, decreasing carbon emissions due to a much smaller construction footprint, and greatly reducing the costs associated with excavation and surface restoration. By greatly decreasing these restoration costs, more "bang for the buck" can be achieved so that substantially more AC and CI pipe can be replaced using the same funding already in place.

There is great value on the ability of a contractor to increase the water main from a 4-inch to a 6-inch or 8-inch main while allowing traffic to continue, with minimal community impact

COST EFFECTIVE TRENCHLESS SOLUTION

Pipe bursting technology first originated in Europe in the 1970s as a trenchless solution for gas pipeline replacement that involves fracturing the existing host pipe into the surrounding soil while simultaneously pulling in a new pipe. First introduced to North America in the late 1980s, the pipe bursting method has since gained wide acceptance as a reliable, long-term, low-cost solution for replacing aging sewer system piping. Despite many advantages, pipe bursting remains grossly underutilized in potable water replacement applications.

In fact, some municipal wastewater collection and water department officials simply do not realize that the technique they already endorse for use in their sewer replacement program is equally viable for potable waterline replacement. Even within the state of Texas, one of the world's largest pipe bursting markets, it is still possible to find city engineers and utility directors who admit they did not know pipe bursting is also well suited for waterline rehabilitation.

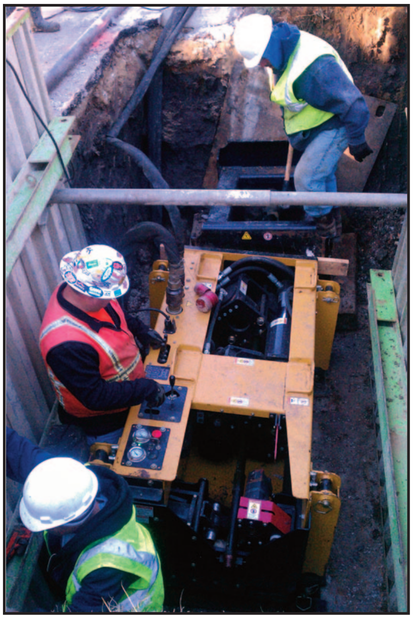
However, increasing efforts to educate infrastructure decision makers on the applicability and benefits of waterline pipe bursting are beginning to yield results, and many municipalities are now looking at pipe bursting technology as the preferred method to replace and upgrade their existing potable water pipe systems. Because of the cost, environmental and social advantages over the traditional open-cut method, municipalities are now much more open to exploring the use of innovative pipe-bursting technology in their water line replacement programs.

With its unique ability and the only trenchless technology on the market capable of upsizing and increasing capacity while replacing a water line, pipe bursting is rapidly gaining great acceptance. Experience using the method has also demonstrated conclusively that complaints from local residents and business are reduced enormously when pipe bursting is used. Overall, this accumulated experience demonstrates the advantages of pipe bursting as a cost-effective method for replacement and upsizing of existing water lines and service laterals without any need for open-cut digging.

PIPE BURSTING METHOD

Waterline pipe bursting is like other static (drawn by hydraulic cable or rod pulling machines) pipe bursting applications, in which the existing pipe is opened and forced outward by a bursting tool. The tooling fractures and pushes the existing pipe into the surrounding ground. At the same time, the new pipe is pulled into place as the bursting head assembly progresses. New product pipe follows behind the pipe bursting tools, which usually consist of a pulling rig, pipe bursting head and expander. A powerful hydraulic pulling machine at the far end of the pipe path pulls the bursting head and expander through the existing AC, CI, Ductile Iron, or PVC pipe. As the expansion head is pulled through the existing pipe, it pushes that pipe radially outward into the soil until it breaks apart, creating a space for the new pipe. The bursting device also pulls the new pipeline behind it, immediately filling the void created by the old, burst pipe with the new pipe.

Various types of expander heads can be used on the bursting tooling to expand the existing pipeline. Static heads, which have no moving internal parts, ex-



Machine pit dimensions need to be only big enough to accommodate a 4-foot by 12-foot shore box, at a depth not much deeper than the lay of pipe being replaced

pand the existing pipe through only the pulling action of the bursting tool. The condition of the existing host pipe being replaced does not affect the ability to perform pipe bursting, as long as the rods can be inserted through the existing pipe.

Although the most common replacement scenario is a size-for-size replacement, replacement with a pipe of larger diameter is also achieved with the pipe-bursting method. The amount of up-sizing possible depends largely on soil conditions, depth of the existing host pipe, existing adjacent utilities, and other factors. Larger upsizing requires more force to pull the expander through because there is more ground being moved while bursting through the existing pipe. These factors must be taken into consideration when determining the feasibility of a large up-sizing of existing pipe.

PIPE BURSTING ADVANTAGES

Because of this ability to upsize diameters along an existing pipe path, pipe-bursting harbors great future promise as a method for cost effectively increasing water distribution capacity. In fact, pipe bursting is the perfect solution for any municipality looking to increase the capacity of its water distribution system pipes, while securing existing supply. Even better, this is accomplished without extensive excavation and the usual costs associated with extensive surface restoration after construction. In fact, pipe bursting is the best method for replacing old water pipes in congested urban areas where disruption to surrounding utilities, local residences, businesses and the environment are important considerations.

Municipal water department directors generally assume that out of any funding they are allotted for their urgent asbestos concrete (AC) pipe and cast iron (CI) pipe replacement plans, at least half must be set aside to pay for restoration costs, patching or replacing pavement and repairing surface construction. In some jurisdictions, project restoration costs can exceed two thirds of total project spending. Pipe bursting significantly reduces these restoration costs by 85 to 90 percent because working from small access pits without trenching eliminates a vast majority of this excavation work while minimizing disruption to adjacent buildings, roadways, parking lots and landscaping. Overall construction impacts to the community are minimized while achieving the larger diameter pipe replacement sufficient to meet demand. Lateral pipe-bursting rehabilitation offers a portable, quick and cost effective method for replacing 1/2 – 6-inch laterals when used in conjunction with an overall replacement program.

For more than 70 years, AC and CI pipes have played an important part in waterline distribution across the US. Decades of construction and additional buried services now often crowd the easement they share with them, some lying parallel to the aging water lines and others crossing over it. Unless the pipeline must be relocated or has greatly offset joints, the pipeline can be fully replaced and even upsized using this technique exactly as it lays in situ, following in the same path as the existing pipe. The method greatly reduces the risk of damage or harm to property, shared utilities and personnel during the pipe replacement process. For this reason, the method is often viable when some other trenchless methods, such as horizontal directional drilling (HDD), are not.

There is great value in the ability of a contractor to increase the water main from a four inch up to a six or eight-inch main while still allowing traffic to flow, with minimal community impact from construction. There is simply no other better method to increase waterline capacity along the same pipe path.

CONSTRUCTION PROCESS

A waterline pipe bursting job reduces excavation requirements significantly compared to open cut replacement. Each bursting run requires only a pulling pit (machine pit) at one end, an insertion pit for the replacement pipe at the other end,

Great value in a contractor being able to upsize a water main while still allowing traffic to flow

and small access pits as necessary at each service connection along the run. The machine pit dimensions generally need to be only big enough to accommodate a 4-foot by 12-foot shore box, at a depth not much deeper than the lay of pipe being replaced. The insertion pit need only be wide enough to accommodate the replacement pipe. Length of the insertion pit depends on the depth of the pipe, along with the length and stiffness of the new pipe. The insertion pit needs to be long enough to ensure the new pipe can flex sufficiently without damage during its transition from the surface to point of insertion, as it gets pulled through.

The new water pipe is staged and fused into a pipe string of the necessary length on the surface prior to the bursting run. This can be done in a separate staging area off to the side to limit any disruption to traffic, businesses, and residents before the installation. Installation rates typically average 3 to 7 feet a minute, with a whole run generally not taking more than a few hours depending on length of run, site conditions and the equipment used.

Even though the pipe bursting operation takes place within a short span of time, creating a temporary waterline bypass ensures customers are not without water during installation. The temporary bypass offers two valuable advantages during construction. First, the contractor has the ease of converting over the newly installed main to the services run to the home or business. Secondly, the bypass affords the operator the ability and time to address any obstacle that may arise during the bursting process, such as unknown repair clamps the crew must stop to access and cut through, encountering a concrete encasement, directional changes, etc. Customers are thereby not inconvenienced in case any unexpected delays arise during the construction process.

Pipe-bursting is versatile and can easily accommodate installing various pipe materials

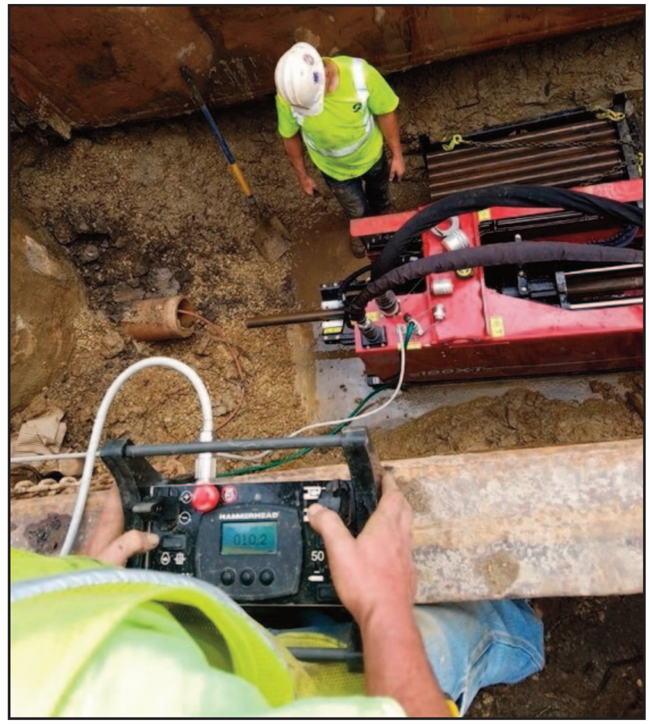
Once the line and services are reconnected, restoration consists of simply backfilling the pits and patching any pavement or landscaping removed during the installation. Because the replaced pipe remains in the ground, there are no costs associated with disposal. In the case of AC pipe that is replaced there are similarly no costs associated with hazardous material mitigation as the shards of the burst AC pipe stay safely in the soil. Effectively, the project is complete.

PIPE BURSTING MATERIALS

Pipe bursting is used mostly to replace pipe made of fracturable materials, mainly AC, CI, Ductile Iron, and PVC waterline pipes, and can be used to replace pipe in diameters ranging from 2 to 24 inches. Pipe Bursting can and has been successfully performed up to 36", but these size bursts are case by case and considered comprehensive. The pipe bursting method is used not only for size-on-size replacement but to upsize pipe where increased capacity is desired.

Fortunately, pipe-bursting is versatile and can easily accommodate installing various pipe materials. Historically, the majority of aged gravity sewer lines replaced via pipe-bursting are with HDPE, but the technology can accommodate other pipe types including Fusible PVC (FPVC), restrained-joint PVC, and restrained-joint ductile iron. It is most common for a fused piping system to be utilized for pipe bursting due to its low profile and ability to decrease expansion needed during the burst. Since the early 2000's, Fusible PVC (FPVC) has become much more prevalent for water pipe bursting, for several reasons. While HDPE is readily familiar in other pipe bursting applications, Fusible PVC and its PVC material is a long-established, widely used material in the municipal potable water distribution market. It therefore enables water department crews to use connec-

The majority of the insertion pit does not need to be much wider than the pipe itself



Enhanced safety. Some modern pulling machine designs free the operator from the pit, offering a superior view of the operation and of worksite surroundings during an installation

tions and fittings they already have on hand and are familiar with for short-term and long-term maintenance needs, therefore maintaining uniformity of product type and service technique throughout their delivery system.

Regardless of what the existing pipe material is, as well as the type of new pipe material being installed, pipe-bursting offers a cost-effective environmentally friendly way of replacing and upsizing aging water mains while minimizing overall impact and disruption to the community.

CONCLUSION

The North American water supply industry urgently needs an effective, fast, environmentally safe and economical means of replacing over 3 billion feet of AC waterline, as well as millions of feet of CI waterline now past its rated useful life. Pipe bursting is a viable, proven yet underutilized replacement method that meets all these requirements.

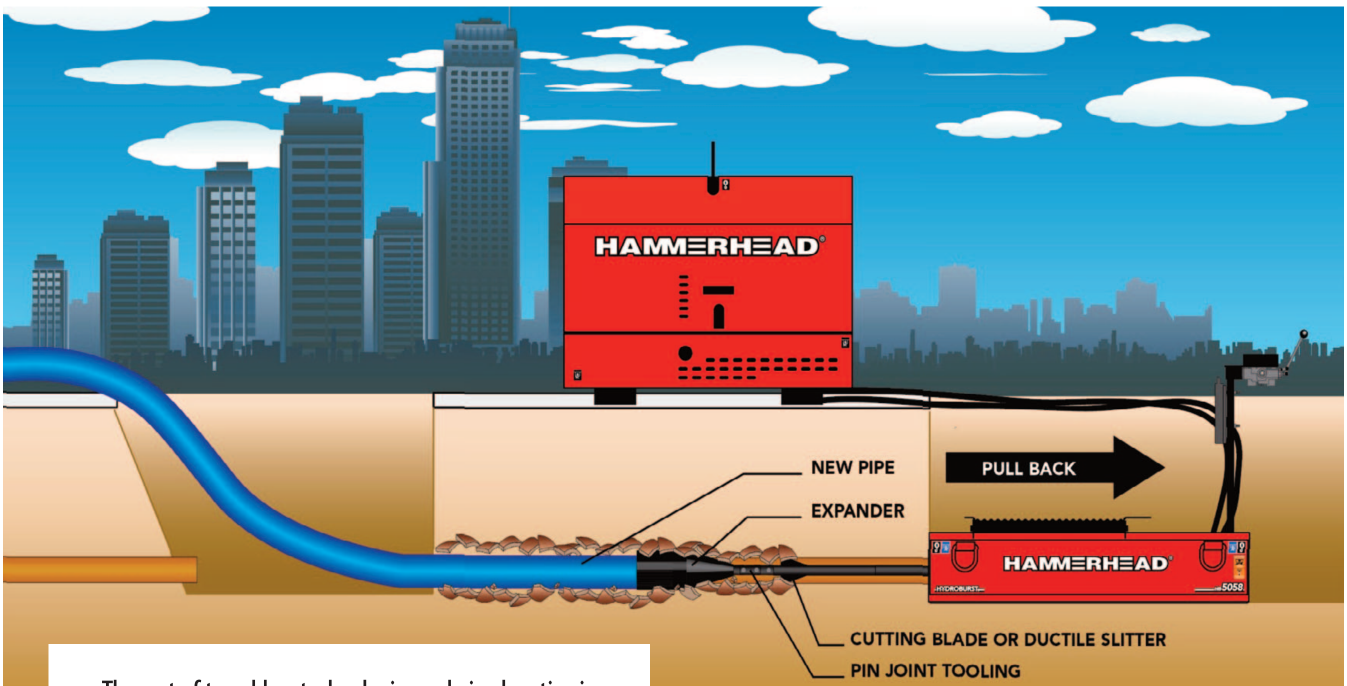
Pipe bursting narrows the surface footprint, minimizing project work impact on daily traffic, commerce and social routines around the construction zone. Few if any passersby realize a significant project is underway, which in many cases is completed in a few days. The result is a renewed waterline projected to last a century and will likely last much longer.

Waterline pipe bursting is a powerful tool whose time has come. As the population continues to grow rapidly and the demand for water increases, public infrastructure decision-makers urgently need to address a looming crisis in waterline delivery/distribution systems in Texas and Oklahoma. Pipe bursting offers a viable cost-effective solution to these challenges, and the best way forward to secure our critical water supply.

ABOUT THE AUTHOR:

John Newell is founder and President of NO-DIGTEC LLC, based in Ferris Texas, the largest Pipe Bursting contractor in North Texas and a pioneer and advocate of this trenchless method over the past 24 years. With nearly 50 years total experience in underground utility construction, John shares his extensive knowledge by serving as guest lecturer on various trenchless pipe replacement techniques at the Center for Underground Infrastructure Research and Education (CUIRE), University of Texas. He is a highly motivated energetic proponent of the pipe bursting method, and a longtime member of NASTT, UCTA, AWWA and NUCA.

The Advantages of Pipe Bursting



The cost of trenchless technologies and pipe bursting is DECREASING in North America. Contrary to that, the cost of open cut construction is becoming more expensive due to the increased cost of fuel, concrete, equipment, environmental, and social impacts.

OPEN CUT COSTS ↑ CONSTRUCTION COSTS ↓ PIPE BURSTING COSTS

Pipe bursting is a cost-effective method of pipe replacement.

What are ALL the costs?

- Contract value (Direct Costs) = X
- Social value = Y
- Environmental value = Z

X + Y + Z = Total Project Impact

- **Permanently solving the problem by spending less money and time with lower project risk and inconvenience to everyone while providing less disruption.**
- **Surface restoration costs reduced by 90%**
- **Funding used for more actual pipe replacement, instead of excavation/ restoration**
- **Reduced project time and costs**
- **Greatly decreased carbon emissions due to smaller construction footprint**
- **No need for additional easement, ROW**
- **Minimal impact on adjacent utilities**
- **Minimal traffic disruption**
- **Minimal impact on businesses/residences**
- **Minimal impact on environment, trees, landscape**
- **Safe effective "disposal" of legacy AC pipe**
- **Ability to upsize and increase waterline capacity**

Overcoming Challenges in Graham, Texas

Fusible PVC HDD Waterline Installation with Minimal Environmental Impact

By: Landon Allen PE & Ryan Kennerly PE, Parkhill

PIPELINE DETAILS & PROJECT SUMMARY

PROJECT
City of Graham Water Supply Line Replacement

LOCATION
Graham, TX

LENGTH & PIPE SIZE
5200 LF ; 20- in AWWA Fusible C900 PVC Pressure pipe (DR 18)

INSTALLATION METHOD
Open Trench & Horizontal Directional Drilling

OWNER
The City of Graham

ENGINEER
Parkhill

CONTRACTOR
TIMCO Blasting & Coatings, Inc.

SUBCONTRACTOR
Lovelady Directional Drilling

EXECUTIVE SUMMARY

The City of Graham, Texas, faced an urgent need to replace its aging water transmission line, a critical lifeline for residents and businesses. The pipeline's alignment beneath a major highway, delicate wetlands, and a river crossing ruled out traditional open-cut construction.

Parkhill, the engineering consultant partnering with the City of Graham, proposed Horizontal Directional Drilling (HDD), a trenchless technology that installs pipelines underground with minimal surface disruption, and selecting TIMCO as the General Contractor for the project. This approach addressed the site's unique constraints while minimizing environmental impact to areas where open cut excavation was non-optimal.

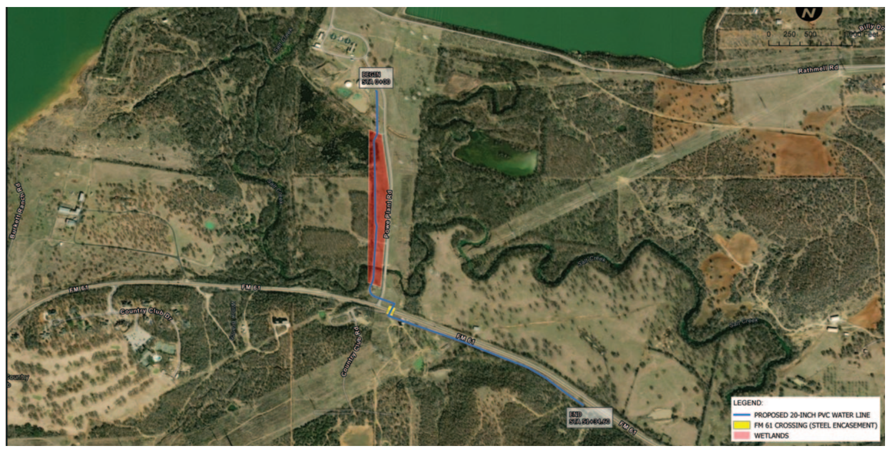


Figure 1. Project Location

The project encompassed the installation of approximately 5,200 feet of 20-inch diameter fusible PVC waterline, navigating diverse soil conditions and unexpected geological formations. Through meticulous planning, geotechnical investigation, and adaptive engineering, the project was completed on time and within budget. The successful outcome demonstrates HDD's effectiveness in tackling complex infrastructure challenges while protecting the environment.

PROJECT BACKGROUND

The City of Graham relies on a single transmission line from the water treatment facility near Lake Graham for its water supply. The aging pipeline posed a significant risk to the community's water security. The alignment beneath Farm to Market Road 61 (TxDOT), wetlands, and a river crossing further complicated the situation, precluding traditional open-cut replacement methods that would have caused disruptions and environmental damage.

TECHNICAL APPROACH

Horizontal Directional Drilling (HDD): HDD is a trenchless method for installing pipelines underground. It involves drilling a pilot hole along a predetermined path, enlarging the hole, and then pulling the pipeline through. This approach minimizes surface disturbance, making it ideal for environmentally sensitive areas and locations with existing infrastructure.

Geotechnical Investigation: Thorough soil borings along the proposed bore path revealed varying soil conditions, including loose sands, sandy clays, and hard sandstone. Shallow groundwater, with some areas exhibiting artesian pressure, was also identified at depths of 5 to 18 feet. This data informed the bore path design, drilling fluid program, and pipe selection.

Bore Path Design: The bore path was aligned to closely follow the existing waterline, minimizing disturbance to undisturbed areas. The profile was adjusted to maintain adequate cover above the water table, preventing inadvertent returns and ensuring borehole stability.

Figure 2. Wetlands

HDD Rig and Equipment Selection: The project's drilling subcontractor, Lovelady Drilling, deployed a Vermeer D100x140 HDD rig, chosen for its capacity to handle the challenges of the diverse soil conditions and the significant portion of 5,200-foot waterline to be bored. The rig's 100,000 lbs. of pullback force and 14,000 lbs. of rotational torque provided the necessary power to pull the 20-inch diameter PVC pipe through the site's geological formations.

Navigation and Steering: Precise navigation and steering were critical, especially during the highway crossing and in proximity to existing utilities. The DigiTrak Falcon F5+ guidance system, primarily utilizing a 15-inch transmitter, offered real-time tracking and steering capabilities. However, when working parallel to overhead power lines, electrical interference necessitated a switch to a larger 19-inch transmitter to maintain accurate tracking and avoid potential conflicts.

Drilling Fluid Recycling: To maintain efficient drilling operations and minimize environmental impact, Lovelady Drilling employed a Tulsa Rig Iron MDS 355 cleaning system, augmented by a 3,200-gallon buffer tank. This system allowed for continuous reclamation and reuse of drilling fluids, reducing the need for fresh water and minimizing waste disposal.

Figure 3. Geotechnical boring rig (left) and Directional boring rig (right)

Drilling Fluids and Mud Program: The success of HDD operations heavily relies on a well-designed drilling fluid program. In this project, the specific soil conditions, particularly the presence of sandstone and shale formations, required a customized approach. DCS bentonite, a commonly used drilling fluid base, was enhanced with various additives to address specific challenges:

Flopac and Vismax: These additives were incorporated to improve the viscosity and filtration properties of the drilling fluid, enhancing borehole stability in the loose, sandy soils encountered along the bore path.

Claybreaker and Ballbuster: These additives played a crucial role in preventing the formation of sticky balls of clay and shale, which can clog the borehole and impede drilling progress. By effectively breaking down these formations, the additives ensured smooth and efficient drilling operations.

Figure 4. 20-inch fusible PVC pipe

Successful outcome demonstrates HDD's effectiveness in tackling complex infrastructure challenges while protecting the environment

Liquid Polymer: During the pipe pull-back stage, a liquid polymer from DCS was introduced to the drilling fluid. This polymer acted as a lubricant, reducing friction between the pipe and the bore-hole walls, thereby facilitating the smooth and controlled installation of the waterline.

Pipe and Casing Installation: North American Pipe Corporation's AWWA C900 PVC pressure pipe (DR 18) was chosen for its high-pressure rating, corrosion resistance, and leak-free joints. Steel casing with high-density polyethylene spacers was used during the highway crossing to protect the carrier pipe and ensure smooth installation.

CONSTRUCTION AND CHALLENGES

The construction phase, spanning from

Figure 5. Boring pit showing a high groundwater level

Figure 6. Location of HDD showing minimal environmental disruption

September 2023 to February 2024, encountered the following challenges:

Groundwater Infiltration: The presence of shallow groundwater, particularly in areas with artesian pressure, required continuous adjustments to the drilling fluid program to maintain borehole pressure and prevent fluid loss.

Highway Crossing: This required meticulous planning, permitting with local authorities, and the use of steel casing with spacers to protect the carrier pipe during installation.

Environmental Considerations: Erosion control measures were implemented to protect the wetlands, adhering to best practices for HDD in sensitive areas.

CONCLUSION: PROJECT OUTCOMES AND LESSONS LEARNED

The Graham waterline replacement project demonstrates the successful application of HDD in a challenging environment. The new pipeline ensures a reliable water supply for the City of Graham while minimizing environmental impact and community disruption.

Key lessons learned include the importance of thorough geotechnical investigation, the need for adaptive engineering to address unforeseen challenges, and the value of collaboration and communication between stakeholders.

This project serves as a model for future infrastructure projects, showcasing the potential of HDD to deliver sustainable solutions that benefit both communities and the environment.

ABOUT THE AUTHORS:

Landon Allen, PE is a Civil Engineer who specializes in Water Resources Engineering at Parkhill. He is an Associate at Parkhill who is an active member of TSPE, and has 10+ years of experience in the design, installation and replacement of buried water and wastewater pipelines. He was the Project Manager for this Graham Water Supply Pipeline project and graduated with a Bachelor's in Civil Engineering from Texas Tech University.

Ryan Kennerly, PE, DBIA has 15+ years of experience in the Civil Engineering industry. As a Principal within Parkhill's Water Resources Sector, his knowledge in the dynamic realms of fast-track Design-Build and CMAR industries enables him to effectively cater to the region's extensive water supply projects. He remains actively engaged with the local branches of ASCE, TSPE, TWUA, and DBIA, further enhancing his professional network and contributions to the industry.

SAWS W-6 UPPER SEGMENT: CONSTRUCTION FOR SAN ANTONIO'S FUTURE GENERATIONS

A Critical Project for Reducing SSOs

By: Henry Leighton, P.E., CAS;
Jason Swartz, P.E., Black & Veatch;
Gerardo Gomez, P.E., San Antonio Water System

ABSTRACT

San Antonio has experienced sustained growth for decades, putting increased pressure on existing wastewater infrastructure. In June 2013, San Antonio Water System (SAWS) reached a Consent Decree agreement that requires significant improvements to the wastewater system over a 10-year period to reduce Sanitary Sewer Overflows. One of the critical projects was the W-6 Upper Segment Tunnel project to reduce sanitary sewer overflows on an existing sewer main running through Lackland Airforce Base. The replacement project consisted of a new tunnel nearly 29,000 LF of primarily 104-inch FRP. The project also includes nine shafts and multiple trenchless crossings to make near surface connections to the new works.

PROJECT OVERVIEW

The San Antonio Metropolitan area has experienced sustained growth for decades, putting increased pressure on existing wastewater infrastructure. In June 2013, San Antonio Water System (SAWS) entered into a Consent Decree (CD) with the United States Environmental Protection Agency (EPA), which requires certain actions by SAWS to rehabilitate the wastewater collection system and reduce sanitary sewer overflows (SSOs). This work includes the targeted replacement and rehabilitation of an aging infrastructure system that consists of over 5,200 miles of sewer pipe throughout their system.

The SAWS W-6 Upper Segment: Highway 90 to W Military Drive Sewer Main project was the largest and one of the most critical projects included in the CD. It involved a new sanitary sewer tunnel on the southwest side of San Antonio, TX that replaced nearly 19,000 linear feet of 54-inch sewer pipeline running through the heart of Lackland Air Force Base. The existing sanitary sewer was severely deteriorated and lacked additional capacity needed for the projected growth of the area. Replacement of critical sanitary infrastructure through the middle of Lackland Air Force Base would have been full of challenges including known soil contamination within the base. As a result, the alignment of the W-6 project extended approximately 29,190 linear feet around the permitter of the military facility deep underground via tunneling construction methods. The alignment extends along portions of Highway 90 and W Military Drive and consisted of primarily 104-inch gravity sewer with shorter segments of 60-inch and 78-inch (See Figure 1). Of the total 29,190 linear feet, the project included 485 linear feet of pipe installed through open trenching, 943 linear feet by means of hand tunneling, and 27,762 linear feet installed in a deep tunnel utilizing Tunnel Boring Machine (TBM) excavation methods. The project also included two 36-inch microtunneling drives each approximately 375 feet and 167 feet of 24-inch sliplining. A total of nine (9) shafts were located along the alignment. This project ties into the W-1 Lower Segment Sewer located at the north end of the project and to the W-6 Middle Segment Sewer located at the southern end of the project.

IDENTIFYING THE TEAM

In 2019 SAWS selected Kimley-Horn and their subconsultants for design of the project. Due to the CD, an aggressive design schedule was implemented. Mid-way through design, the Construction Management (CM) Team of CAS with Black & Veatch was brought onto the project. This allowed the CM Team to provide constructability reviews and input into the design documents prior to bidding for construction. It also allowed the CM Team to be fully integrated into the project before construction began allowing for a smooth and rapid transition between design and construction.

Due to the size and complexity of the project, SAWS advertised the project as a Competitive Sealed Bid. This meant that the construction contract was awarded based on both a technical score and cost score. SAWS received a total of six (6) proposals and they were scored according to the terms defined in the contract documents. Negotiations and interviews were conducted with the two highest scoring teams. Ultimately, SAK Construction (SAK) was awarded the contract and given a Notice to Proceed (NTP) on July 13, 2020.

PROJECT CONSIDERATIONS

Most of the tunnel was excavated within a local formation referred to as the Navarro formation formed by marine clays and claystone deposited under anaerobic conditions. As a result, the tunnel was classified as potentially gassy due to the potential release of hydrogen sulfide and

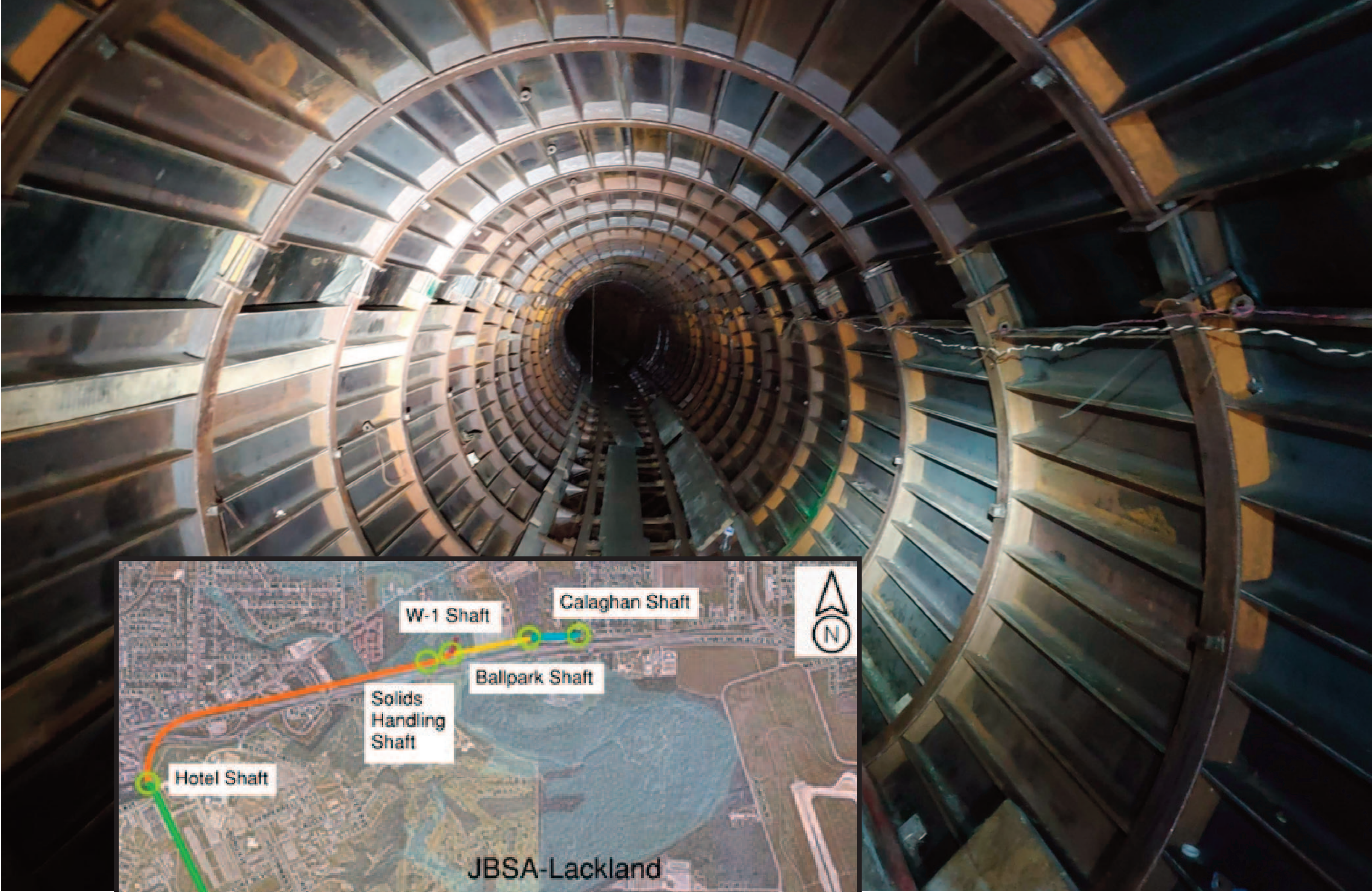


Figure 2. Gasketed Steel Channels Following Excavation

Figure 1. SAWS W-6 Upper Segment Tunnel Alignment

methane gases as the material was excavation and broken down. Naturally occurring hydrocarbons were also identified in some sections of the alignment. Although most of the tunnel required a soft ground TBM, the ground conditions had sufficient strength and stand-up time to allow an open mode TBM with steel ribs and wooden lagging as initial support. However, two sections of the alignment did cross under or adjacent to Leon Creek. These sections specified the use of an Earth Pressure Balance TBM with the ability to operate in closed mode with liner plates to provide a watertight initial support. SAK elected to utilize two Dual Mode Lovat TBMs that could operate in both open mode for higher efficiencies when allowed and closed mode in pressurized operation (with minor field adjustments such as replacing the open conveyor with a screw conveyor) when crossing under or near Leon Creek if needed.

For the first section requiring pressurized mode, SAK elected to utilize gasketed steel channels in lieu of liner plate and operate in open mode until the observed ground conditions warranted switching to closed mode. This was submitted as a change request and was ultimately accepted following several negotiations and discussions. This allowed the TBM to continue to mine seamlessly and push off the ribs without modifications to a liner plate arrangement. (See Figure 2.) Ground conditions remained stable, even under Leon Creek and the entire reach was able to be constructed in open mode.

Figures 3 & 4. Photo the left is showing the end of the tail tunnel around the end of its excavation on December 01, 2020 and the photo on the right is showing the same section several months later on March 26, 2021

Another factor that had to be taken into consideration was the potential for the ground to swell and distribute the resulting forces onto the initial support. The GBR identified the swell potential, particularly in areas known to contain bentonite seams. The documents provided a baseline swell value of 5 ksf to be used in the initial support design and a baseline value of 10 ksf within the sections known to contain bentonite seams. SAK came up with an initial support design involving collapsible dutchman to mitigate the impacts from swelling ground. The approach was to allow the dutchman to compress as loads increased to avoid over stressing the rest of the initial support.

By the time tunneling commenced, the tail tunnel had been excavated for a couple months. The end of the tail tunnel was left exposed for monitoring of the ground behavior with a number of strain gauges on the initial support. Very little swell stresses were identified. In fact, the continuously forced ventilation and exposure to the dry Texas air resulted in the ground slightly shrinking as it dried out (see figures 3 & 4). The collapsible dutchmen proved more difficult to install than traditional dutchmen and tended to fall out easier if not loaded due to the lack of swelling ground. Consequently, SAK Construction submitted a cost proposal to eliminate the collapsible dutchmen and use a standard dutchman. Multiple discussions and negotiations were held between the design engineer, CM Team, and contractor. Ultimately the proposal was accepted. SAK assumed the risk for any future swell and additional strain gauges were installed throughout the tunnel for monitoring. No impacts from swelling ground were identified during construction except for an approximately 500-foot section late in the project. This one section that did experience some swell following a period of heavier rain events. Most of the stress concentrations were on the wooden lagging and not the steel ribs. A few sections of lagging had to removed or braced which the contractor was able to resolve without issue.

No project that spans over multiple years is without some unexpected challenges.

CORROSION PROTECTION EFFORTS

A project of this scale is no simple undertaking. The design and construction of the project was built to last one hundred years or more. A lot has been learned over the last 50 years or more in terms of how the corrosive environment inherent to wastewater affects construction materials. Technology has also grown leaps and bounds with engineering solutions continuing to be developed.

A key component of this project was to implement materials that were chemically inert to the corrosive affects associated with wastewater. The pipe material utilized was a Fiberglass Reinforced Pipe (FRP) (see Figure 5) that was constructed of resin, fiberglass, and sand. This composite material has revolutionized the wastewater industry. The hydrogen sulfide which produces sulfuric acid easily corrodes steel and concrete but has no im-

Figure 5. Hotel Shaft Site and FRP Pipe Ready to be Installed

pact on the FRP pipe. Two different FRP joints were used (Hobas's FWC Coupling and their Flush Mounted Joint). The two different types of joints were used as each had a specified deflection angle that could be achieved following connection. The FWC Couplings were used for most of the joints but some of the tighter curves utilized the more expensive Flush Mounted Joint that had a slightly higher deflection angle. This allowed the pipe to be installed without complex fittings in the curves while controlling costs and maximizing constructability.

Once the FRP pipe was installed and blocked in the tunnel it was grouted in place with a low-density cellular concrete (LDCC). The wastewater never comes in contact with the grout, allowing the LDCC to be utilized without the risk of corroding. Air entrainment within the LDCC nearly doubles its yield resulting in less overall material used. Once the void of the annular space was filled, the pipe was locked into place.

The flush mounted joints allowed for pipe installation without complex fittings in the curves while controlling costs and maximizing constructability

The shaft structures also utilized an inert resin material with the polymer concrete structures. These structures are produced similar to concrete structures; however, the binding agent is a specially formulated resin in place of the traditional Portland Cement. This makes the shaft structures completely corrosion resistant throughout the structure. It does not depend on a liner or coating that could fail over time. Since it is uniform throughout, a chip or ding in the polymer concrete structure has no impact on its ability to resist corrosion.

The quality control for the polymer concrete structures with the associated equipment and permitting typically requires these structures to be precast in a factory. The shafts were designed with an internal diameter of sixteen feet (the largest polymer concrete structures that could be reasonably transported to site). A big challenge of these shafts were the bottom sections due to the troughing and shaping pieces needed for a smooth flowline. The troughing pieces were constructed separately in 3-4 pieces so they could be shipped to site within a reason-

Figures 6 & 7. Polymer Concrete Structure Field Assembly

The W-6 project was the first major tunnel project in the country to bid during COVID-19.

able size and weight. These pieces were then fitted together (like a Lego set) and field applied resin locked the pieces together. This is the first time structures of this scale have been constructed in this manner to the author's knowledge (see Figures 6 & 7). A significant learning curve was required for these structures. There were a number of challenges that had to be overcome for the pieces to fit correctly while also allowing for some construction tolerances and constructability issues. Although many of the structures required minor field adjustments once onsite, the result was a completely seamless and uniform structure that was completely safeguarded from the wastewater's corrosion. The entire system was protected.

COVID-19

During the last couple of months of the design of the project, the world was shaken by the COVID-19 pandemic. The CD did not allow SAWS to take their focus off the schedule of the project. The project team had to rapidly adapt as the project was deemed critical infrastructure. Following the closure of Government offices, ongoing progress meetings were rapidly transitioned from in-person meetings to virtual meetings. To the author's best knowledge, the W-6 project was the first major tunnel project to bid during COVID-19 (March/April 2020) in the country. Although there was still a lot of uncertainty associated with the long-term impacts of COVID-19, contractors were successful in putting together teams and proposals. This was due, in part, to the extensive contractor outreach prior to the pandemic and contractor awareness of the project.

Once construction started, careful considerations were given to avoid mixing day and night shifts as much as possible. In addition, the team was mindful not to introduce outside visitors unless necessary for the work. Other measures included limiting the number of people confined closely together (for example, limiting the number of people in the man-basket) at the height of the pandemic. The majority of the weekly progress meetings held between the contractor, design team, CM Team and Owner were conducted on an outside porch constructed at the start of the project for such meetings. Opportunities were also provided for members to call into virtually if needed to further reduce the team members in physical attendance.

Although multiple team members contracted COVID-19 throughout the project, the project Team was effective in preventing any severe COVID-19 outbreaks. Those infected were quickly isolated and sent home until their recovery was complete. No significant disruptions occurred among the project teams and most cases of COVID-19 were isolated instances.

CHALLENGES OVERCAME

No project that spans over multiple years is without some unexpected challenges. In addition to the COVID-19 outbreak discussed, the project experienced one of the worst winter storms in the state's recorded history on February 14, 2021. The winter storm named Uri is considered a "Once in a Lifetime" event by many. The storm dumped up to eight inches across a region that had virtually no equipment to handle such situations. The storm knocked out nearly 50 percent of the power generation across the state, leaving the entire City susceptible to rolling blackouts. Every major bridge or overpass in the City was closed (most for several days). Furthermore, the closures prevented critical supplies from getting into the City. Fuel shortages were at the top of the list. The few gas stations that had power were completely empty of fuel and those potentially with fuel were without power. In total, the immediate effects of the storm lasted the better part of an entire week but the "ripple impacts" around the Region lasted several months if not longer. One industry that was hard hit was the production of resin. A lot of resin is either manufactured in Texas or utilizes by-products produced in the Region. As discussed, resin was a necessary material for both the FRP pipe and polymer concrete shaft structures. This had an impact on the overall project and required the pipe and shaft structures manufacturers to re-sequence their work.

Two tunnel hole throughs in one day at the same site is unprecedented – and that occurred on this project!

On July 6, 2021, a few months following Winter Storm Uri, the project experienced another extreme weather event. An intense rain event situated directly over the Leon Creek watershed resulted in water levels in the creek increasing over eighteen feet in a matter of a couple hours. This flooded one of the shaft sites that was within the 100-year floodplain. Luckily, SAK was able to move most of their equipment to higher ground, but they were unable to install their flood protection doors they had fabricated as part of their flood contingency plan. Fortunately, SAK also sequenced their work in such a way to minimize potential flooding impacts as a secondary precaution. Their tunnel excavation sequence isolated the TBMs and other tunnel segments from any flooding risk by mining to the shafts located in the floodplain and not connecting the remaining tunnel segments until the very end. In fact, during this event tunneling never stopped on the project except for a short lightning delay. The TBM was safely isolated and working in areas not susceptible to the flood risks. SAK simply had to dewater the tunnel and clean any debris in that tunnel segment before installing the pipe.

ONCE IN A LIFETIME EVENT

Although the W-6 project saw its share of unique challenges, it also had some unique accomplishments. The sequencing of this project resulted in a total of five tunnel hole throughs. A tunnel hole through is a momentous milestone on any tunnel project, however, having two tunnel hole throughs in one day at the same site is unprecedented which occurred on this project! As previously noted, the W-6 project required two TBMs due to the aggressive construction schedule. Both TBMs were dual mode Lovat TBMs that had been refurbished by SAK Construction prior to the start of the project. Due to the sequencing of the excavation, both TBMs were launched toward the Solids Handling/W-1 Shaft sites from opposite sections of the alignment. Finishing at the same time was not planned nor anticipated as the two TBMS were launched. A combination of multiple factors resulted in the TBMs reaching the retrieval shafts on the same day within hours of each other. Having two tunnel hole throughs on the same day and at the same site was unprecedented, likely another "Once in a Lifetime" event. Typically removing the cutting

Figure 8. Dual Tunnel TBM Hole Throughs on Adjacent Shafts - Same Day (Image courtesy of SAK. Used with permission)

head and first couple section of the TBM requires a larger crane to manage the weight. Having both TBMs removed together certainly helped SAK by only having one major crane mobilization to this site (see Figure 8).

WORKING AS A TEAM

The key to any successful project is active communication throughout the project. No one party can break this process and expect a positive outcome. Challenges and unexpected events can quickly derail a project without active communication. Active communication does not mean that all parties will agree. Differences can and will occur at times throughout the project. The W-6 Team included representatives from the owner, designer, CM Team, and contractor. Each individual party had different project drivers and differences of opinion with slightly different risk profiles they were trying to manage. It was imperative that everyone worked together to achieve the common goals of completing the Project successfully while satisfying the CD requirements. The contract documents provided the basic milestones and project requirements so each team member could be fully utilized within their area of expertise.

The W-6 project was fortunate to have a very qualified tunnel contractor in SAK with a strong workforce that worked well together. They were very skilled in working in similar ground conditions. Both TBMs used by the contractor were refurbished at SAK's headquarters in St. Louis by the same professionals that would later operate and run the machines. This resulted in the crew being intimately familiar with the operation and fabrication of the TBM. As much prep work as could be accomplished in the shop was completed prior to shipment to the site. The TBMs would arrive onsite and almost instantly be underground. The turnaround time and teamwork was amazing. Production mining was achieved in only a matter of days. In addition, because many of the crew members operating the TBM were involved in the refurbishment, maintenance activities and repairs could be accomplished very quickly. The crew knew all the ins and outs of the machine.

All the upfront efforts in working together combined with a very skilled and knowledgeable contractor resulted in the tunnel excavation being completed approximately 6 months ahead of schedule. This is a feat that few other projects in this era of post COVID-19 can boast. The affects of the resin shortage due to Winter Storm Uri also resulted in SAK eliminating a second tunneling shift on the last excavation segment to allow the pipe manufacturer to catch up on pipe deliveries. Without this disruption it is possible the tunnel excavation could have been completed an extra month or two earlier in addition to the 6 months already achieved. In addition to substantially completing the project ahead of an already aggressive schedule, the project was completed under budget with a number of additional scope of work items added to the project.

CLOSING

This project will serve the residents of San Antonio for generations to come and paves the way for continued growth while maintaining the quality of life for the stakeholders and environment. The authors would like to thank SAWS and the project team for a tremendous opportunity to be involved in one of the most critical projects for the Region. Few will understand the years of planning, construction efforts and challenges faced along the way. Furthermore, most of the local stakeholders and general public will not understand the vast construction feat that was literally accomplished under their feet, but then that is why many communities are turning toward tunneling alternatives. As an industry, we measure our success, in part, by people not being aware of all the challenging work that is involved. People have become accustomed to being able to flush their toilets or turn on the faucet for water without ever having to think about it. Most of us have entered this industry with the mindset of improving the life within our communities while minimizing impacts to the stakeholders, the public and the environment. Tunnelled solutions are here to stay. We cannot wait to build upon the lessons learned from this project and see what new opportunities the future holds for the underground industry.

ABOUT THE AUTHORS:

Henry Leighton, P.E. is President of CAS Consulting and Services, Inc. He has 48 years of industry experience, specializing in cradle-to-grave project/program management. His experience covers heavy civil/tunnel and building construction, waste remediation, and D&D; acting as surveyor, inspector, designer, CM/PM, contractor, and owner's representative. He is a registered PE in Colorado, Georgia, and Texas. Over 21 years in Texas, he has provided these services for $2 Billion in capital improvements.

Jason Swartz, P.E. is Black & Veatch's Tunnel Practice Lead with over 24 years of experience. His career focus has been on the design and construction management of all forms of trenchless and underground projects. He has experience throughout North America in varying geology and specializes in projects in heavily urbanized settings.

Gerardo Gomez, P.E. serves as a senior project engineer within the San Antonio Water System Water. Gerardo has over 20 years of experience at different roles within SAWS. Most recent notable work includes the CWIP and the W-6 Upper Project where Gerardo was involved in both the design and construction management oversight for both projects.

Compression Fit HDPE Pipe – Another Proven Pipeline Replacement Method

ASTM Standard Codifies Method for Gravity and Pressure Pipe for Both Water and Force Main Projects

By: Steve Cooper, SCA Communications

"The thicker HDPE pipe provides structural integrity. In this case, the ovality would have no affect during installation and the HDPE pipe would form a tight compression fit within the old ductile iron pipe"

- Harvey Svetlik, P.E.
HDPE Pipe Industry Consultant

It wasn't a typical, normal sliplining job to replace a failing force main line in Sioux Falls SD. The original ductile iron pipe had deformed and had severe ovality. Hydrogen sulfide gas from the sewage flow made sulfuric acid, which collected at the top of the metal pipe and destroyed it. It was thought that pulling through a new pipe wouldn't be possible as it would hang up on the deformed inner wall of the old pipe. Reducing the diameter was not possible — the diameter of the new pipe needed to be as close to the old one to maintain the rate of flow. The solution provided by Murphy Pipeline Contractors (Jacksonville, FL) was to use high-density polyethylene (HDPE) pipe and compress it to fit, knowing that the thermoplastic pipe would naturally reform itself.

"This is one of the inherent attributes of HDPE pipe," stated Camille George Rubeiz, P.E., F. ASCE, co-chair, HDPE Municipal Advisory Board, and senior director of engineering for the Plastics Pipe Institute's (PPI) Municipal & Industrial Division. "As well as being corrosion proof, it is flexible and ductile to go through a special die on the job site that makes it possible to be pulled inside a host pipe even when the pipe is not round. In this case, the ovality would have no affect during installation and the HDPE pipe would form a tight compression fit within the old ductile iron pipe." PPI is the major North American association representing the plastic pipe industry.

More than 8,700 feet of 36-inch ductile iron sewer force main was replaced with HDPE PE 4710, DR 21 pipe using Murphy's CompressionFit™ method, patent pending. The new pipe has a 100-psi operating and a 200-psi surge pressure rating, and is rated as a Class 6 solution in accordance with ASTM F3508. The sewer force main traversed under three city parks, along Covell Lake, through major commercial districts and under state highway SD 115. It was made and provided by WL Plastics (Fort Worth, TX), a member company of PPI.

Opened in 1985, the Sioux Falls system treats some 18 million gallons of wastewater daily. There are 900 miles of pipe in the system that conveys the wastewater to the city's treatment plant. There is a $215 million expansion plan underway that will increase the facility's capacity by 50 percent when completed in 2025.

"One of the questions we were asked was 'Can a 36-inch ductile iron sewer force main with severe ovality be replaced with HDPE pipe using CompressionFit?'", said HDPE pipe industry expert and consultant Harvey Svetlik, P.E. "The answer was an unequivocal 'yes'. Matter of fact, some other recent projects saw 54-inch diameter pipe with a three-inch wall thickness installed using the CompressionFit method. One of the principal things that this technology does is that it preserves the flow rate of the existing host pipeline and seals over holes and leaks, so you have a dual-wall composite pipeline. And the thicker HDPE pipe provides structural integrity."

Svetlik has more than 40 years of experience in the plastic pipe industry, specializing in polyethylene pipes and fittings. He is the inventor of the MJ Adapter, also known as the Harvey Adapter. An active member of PPI for 30 years, he is the author of numerous PPI technical notes, developer of ASTM/AWWA standards, and an inventor who holds 16 patents.

One of the most recent ASTM standards authored by Svetlik is ASTM F3508 for the installation of compressed fit shape memory polymer pipe. "ASTM F3508 codifies the specification of the material to use and deals with the shape memory characteristics of the material such as high-density polyethylene.

"With the CompressionFit technology, instead of elongating a rubber band and letting it recover as is done with Swagelining, they basically do a lot more of radial compression. Instead of stretching it and thinning the wall, they downsize it and radially thicken the wall, such that when it goes into place it enlarges in diameter, and the radial wall thickness stands as it expands out, like rolling out pie dough."

"In this case, the ovality would have no effect during installation and the HDPE pipe would form a tight compression fit within the old ductile iron pipe."

-Camille George Rubeiz, P.E., F. ASCE
Co-chair, HDPE Municipal Advisory Board
Sr. Dir. Engineering, PPI Municipal & Industrial Division

The developer of CompressionFit is Murphy Pipeline Contractors (Jacksonville, FL). "Most cities cannot afford to relocate and replace a 16-inch diameter or larger pipeline within their vast utility network," said Todd Grafenauer, education director for Murphy. "The result of the CompressionFit HDPE pipe lining technology is that a new HDPE pipe will be 'compressive fit' inside the existing host pipe. This lining offers remarkable value over other construction methods such as an increased flow rate over sliplining, we do an average pull distance of 2,000 feet with more than a 90 percent reduction in excavation and there's no new easement documentation needed. Plus, we simply follow the existing pipe path using GIS maps." Murphy is a member of the association's Municipal Advisory Board (MAB).

The new 36-inch HDPE pipe replaces the corroded ductile iron pipe (Photo credit: Murphy Pipeline)

Governed by ASTM F3508, the CompressionFit HDPE pipe lining technology specifies an HDPE pipe with an outside diameter larger in size than the inside of the host pipe to be renewed. After the HDPE is butt fused to correspond to the pull distance, the pipe is pulled through a reduction die immediately before entering the host pipe. This reduces the HDPE pipe temporarily below the inside diameter of the host pipe allowing it to be inserted.

While the towing load keeps the HDPE under tension during the pull, the pipe remains in its reduced size. The HDPE remains fully elastic throughout the reduction and installation process. After installation, the pulling load is removed. The HDPE pipe expands until it is halted by the inside diameter of the host pipe. The effectively natural 'tight' or 'compression fit' is accepted as exchanging an existing failing pipeline with a composite pipe in its place.

"One of the things about the ASTM F3508," Svetlik explained, "is that it can be utilized not only for municipalities for gravity flow, but even more ideally for pressure pipes for water pipeline replacement, or force main replacement."

Additional information can be found at www.plasticpipe.org/mabpubs or www.plasticpipe.org/municipalindustrial

ABOUT PPI:

The Plastics Pipe Institute, Inc. (PPI) is the major North American trade association representing the plastic pipe industry and is dedicated to promoting plastic as the materials of choice for pipe and conduit applications. PPI is the premier technical, engineering and industry knowledge resource publishing data for use in the development and design of plastic pipe and conduit systems. Additionally, PPI collaborates with industry organizations that set standards for manufacturing practices and installation methods.

Replacing the corroded ductile iron pipe that had been eaten away by sulfuric acid caused by sewage, the HDPE pipe is inserted into the destroyed pipe using the CompressionFit method from Murphy Pipeline (Photo credit: Murphy Pipeline)

Trenchless Technology Applied To Major Highway:

WHCRWA Surface Water Supply Project - Segment B1/B2, Beltway 8

By: Julian O'Connell, HB Trenchless

During construction of the Launch Shaft an unconfined aquifer was encountered

The launch of a MTBM is always critical but this launch was even more so

CROSSING BENEATH SAM HOUSTON TOLLWAY – BELTWAY 8

PROJECT BACKGROUND

HB Trenchless is the Subcontractor to its sister company, Harper Bothers Construction for the West Harris County Regional Water Authority (WHCRWA's) Segment B1/B2 (the Project). This project is a part of the overall Surface Water Supply Project. Segment B1 and B2 is total of 10.4 miles of 96-inch surface water supply tunnels in Houston, Texas. The scope of work is for construction of approximately 14,500 linear feet of 84-inch diameter and 40,000 linear feet of 96-inch diameter waterlines with necessary valves and appurtenances, from west of Brittmoore Road to west of I-45. The proposed waterline installation has been primarily installed with Open-Cut construction methods. The tunnels crossed Harris County roads, TxDOT roads, Union Pacific Railroad, BSNF Railroad, Harris County Flood Control District (HCFCD) drainage systems, and private pipelines.

For the 18 tunneling sections of this project, HB Trenchless deployed a Herrenknecht EPB (convertible) machine, Lovat M130RL Series 1000, Akkerman Digger Shield and Open face Shields. The microtunnel sections were four crossings using a Herrenknecht AVN2000AB System with the final one under Sam Houston Tollway – Beltway 8, which this article will elaborate on.

MTBM "Vanessa" lowered into Launch Shaft

Beltway 8, the Sam Houston Parkway, along with the Sam Houston Tollway, is an 88-mile beltway around the city of Houston, Texas. It has four main lanes each way plus a feeder lane on each side which is highly trafficked.

The geological profile for the 745-foot long tunnel was poorly graded sand beneath the water table with a soil cover to the road of approximately 27 feet. Due to the complex tunneling conditions on this tunnel and the other tunnels with similar parameters where the 106-inch outside diameter steel pipe was installed by Microtunneling, a Herrenknecht AVN2000AB Microtunneling Boring Machine (MTBM) was selected by HB Trenchless.

The AVN Machines belong to the cate-

Bulls Eye! MTBM entering Reception Shaft

Final crossing was under Sam Houston Tollway – Beltway 8

gory of closed, full face excavation machines with a hydraulic slurry circuit. The soil is excavated using a cutterhead, in this case a soft ground cutterhead. A cone-shaped crusher inside the excavation chamber crushes stones and other obstructions to a conveyable grain size while tunnelling and advancing. The soil then passes through openings in the crusher chamber and is then removed through the slurry line in suspension. The MTBM uses slurry pressure in conjunction with the jacking force and excavation speed to maintain tunnel face stability and prevent over excavation.

This MTBM was purchased new from Germany for the project. The soft ground wheel was modified as some sandstone seams were found in some of the shafts and encountered on one of the other drives.

Despite the challenging conditions microtunneling was able to make this project a success

HBT's experienced crews worked 24 hours, seven days a week and completed the tunnel safely, accurately and well within the allowable settlement limits which were constantly measured.

The Drive Shaft is where the MTBM is launched from and that houses the shaft seal, slurry pump, main Jacking Frame (2.4 million lbs thrust capacity) and ancillary equipment was constructed with a 36-foot diameter liner plate. Due to high water table the sand was dewatered with deep wells. During construction of the shaft an unconfined aquifer was encountered which necessitated the installation of additional wells within the shaft to enable completion to the depth required for tunneling.

The launch of a MTBM is always critical

but this launch was even more so being adjacent to a major highway with wet running sand outside the zone of the dewatered area. Knowing this, HB Trenchless decided prior to start of the shaft excavation to install circular insitu cast concrete piles in the area of the shaft breakout. The piles acted as support of the tunnel face once the liner plate was removed and additional support for the MTBM.

The Reception Shaft was also constructed with liner plate and deep wells to stabilize the soil. A soft wall was cast inside the headwall and a reception seal was placed. This allowed the MTBM to safely enter into the shaft without ingress of surrounding soil and ground water.

Despite the challenging conditions microtunneling was able to make this project a success. All four Microtunnel were completed safely by April 2024 with the remaining work expected to be completed later this year.

ABOUT THE AUTHOR:

Julian O'Connell is Vice President of HB Trenchless LLC. Julian has over 35 years of experience in the Tunneling Industry. He has vast experience of deep shaft construction and tunnelling by mechanized, compressed air and conventional methods. He has international experience having worked in Europe, South America, Caribbean and North America.

Sewer Bypass Scoping

A How-to Guide

SUNBELT RENTALS | PUMP SOLUTIONS

By: Sunbelt Rentals, Pump Solutions

When a municipality puts out an RFQ for an engineering project and includes the following words — **design a temporary sanitary sewer bypass system as needed to construct improvements** — design engineers need to focus on two tasks: defining the scope and designing the solution. But typically the sewer bypass is just one part of a much larger project, and design engineers may not be trained in sewer bypass design. Fortunately, you can ask for help from bypass subcontractors and rental companies. That way, when your engineering firm helps the municipality take the project out for bid, estimators will be working with solid information that will help ensure reasonable bids.

The goal is to scope and design quickly, accurately, and effectively to avoid expensive mistakes and delays. We've put together a how-to guide to help you get it right.

DEFINE THE SCOPE

Before we list the steps to define the scope, let's define what project scope actually means.

Projects are time-constrained undertakings to produce a product, service, or result. The scope defines the purpose, the ultimate goal, and how you will achieve it. Scope also determines the boundaries – what's included in the project and what's not. If you fail to define scope adequately, your project will likely end up over budget and behind schedule.

According to the Project Management Institute, scope changes are the single biggest reason projects fail. If the scope becomes a moving target, you're increasing the chance for the project and your career to take a nosedive.

HERE ARE SIX STEPS TO HELP YOU THOROUGHLY DEFINE THE PROJECT SCOPE

1. **Provide an overall project description.** The project description should include what the municipality wants to accomplish, the current sewer capacity, equipment in use, location and layout of existing facilities, and duration of the project. You may also want to note challenges, such as existing buildings, roads, and other structures, or areas of environmental concern such as creek crossings.

2. **Explain the driving forces.** Billions of dollars in federal aid have been made available to rehabilitate decaying sewer systems. Many municipalities have taken advantage of the funds to initiate rehabilitation projects, whether for sewer lines, lift stations, or wastewater treatment plants. Or the municipality may be working under a consent decree that mandates specific improvements to a sewer system by a deadline.

3. **Specify the deliverables.** The municipality's requirements may list the details of sewer system improvements. But often the sewer bypass system itself simply directs you to design a system that will allow the improvements to be made without an interruption of service. It's up to you to determine the requirements and provide the specifications.

4. **Determine the boundaries.** Based on the improvements the municipality intends to make, you'll need to determine exactly what the sanitary sewer bypass system should look like to meet the sewer requirements for as long as the project is active. For example, you'll need to determine if the temporary system must operate at all times during construction, if it can be tied into the existing sanitary sewer system overnight, if the existing sanitary sewer system can be returned to normal flow for long periods, and if the flow can be partially diverted or must be fully diverted.

5. **State your assumptions.** Define the conditions you're assuming and their impact on the project. For example, the municipality may claim sandy soil in an area. If it's actually rocky, you'll be less productive while dealing with unexpected soil conditions. That will impact project time and cost, and generate a change order.

6. **List uncertainties and potential impacts.** Uncertainties create risk and cost money. For example, you need to know up front about any time limitations on when work can be performed to complete the project. You also need to be aware of physical obstructions such as rivers and streams, railroad crossings, parks, and public and private property the sewer bypass may need to cross.

TO KEEP YOUR PLANS FOR A SEWER BYPASS ON POINT, WE'VE DEVELOPED A LIST OF THE KEY REQUIREMENTS AND WHERE YOU CAN GET THE INFORMATION TO SPECIFY THEM.

PROJECT DESCRIPTION

Item	Source
Scope of work	Municipality
Residential, commercial, or industrial application	Municipality
Project timeline	Municipality
Project budget	Municipality
Pump operation needed 24/7 or other	Municipality
Redundancies or back-up provisions needed for sewer system operation	Municipality **- or -** Bypass subcontractor/ pump rental company
Suction line on standby in case of pump clogging	Bypass subcontractor/ pump rental company
Maintenance person needed 24/7 or alarm system with auto dialer	Municipality **- or -** Bypass subcontractor/ pump rental company
Clean water and chlorination to flush bypass lines and pumps at end of project	Bypass subcontractor/ pump rental company

ENGINEERING DATA

Item	Source
Fluid being pumped	Municipality **- or -** Bypass subcontractor/ pump rental company for items municipality can't provide
Sewer line intake and discharge	
Sewer line pipe size, material, depth, distance, slope	
Flow velocity, percentage of sewer pipe	
Peak, average, low flow rates for sewer system	
Suction lift for bypass	
Distance between pump and discharge for bypass	
Friction in pipe used for bypass	
Pressure at discharge point	

SITE CONDITIONS

Item	Source
Guide for a site visit and in-depth project knowledge	Municipality
Access and traffic control issues	Municipality
Power source to run pumps	Municipality **- or -** Bypass subcontractor/ pump rental company
Operating speed of pumps	Bypass subcontractor/ pump rental company
Fuel consumption per hour	Bypass subcontractor/ pump rental company
Maintenance person needed to service and refuel pumps	Bypass subcontractor/ pump rental company
Sufficient space for equipment required	Bypass subcontractor/ pump rental company
Noise level allowed	Municipality
Environmental conditions	Municipality **- or -** Bypass subcontractor/ pump rental company

DESIGN THE SOLUTION

Your bypass system design needs to be as detailed as possible, or you risk change orders, higher costs, and a damaged reputation. You may want to rely on a bypass subcontractor and/or rental company to help you specify accurately. In addition, technology continues to evolve, and the design should allow the project to meet the highest standards at the lowest cost in the shortest amount of time.

If you've established a partnership with a company with expertise in designing sewer bypass systems, you're a step ahead. You can provide the known parameters to the bypass subcontractor or pump rental company and receive a sewer bypass design in return. For parameters that the municipality can't provide, your partner can go on site and fill in missing pieces of engineering data to ensure the designed system will operate as intended. A bypass subcontractor will typically provide you with a quote up front, but you normally won't receive the engineering submittal until after you sign a contract. The engineering submittal and drawings should show exactly how they'll perform the project and what assumptions they've used to make calculations. You can take that back to the municipality for confirmation.

CONSULT WITH A PARTNER AT NO COST

We hope this guide will help you better define the scope and design the solution for sewer bypass projects. But you don't have to go it alone. It helps to work with a partner that can not only provide high-quality equipment and accessories, but engineering knowledge and installation expertise. The next time you need to design a sewer bypass system, we invite you to call for a free consultation.

From initial design through final installation, our team provides the equipment and expertise you need to meet your project requirements. Whether it's bypass scoping, water level management, fluid diversion for the repair of existing pipelines, or another type of project entirely, our team is available 24/7 to ensure that your pumping project is a success.

To speak to a Pump Solutions expert, call **866-783-9135** or visit sunbeltrentals.com

AD INDEX:

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