ROCKY MOUNTAIN CHAPTER

Trenchless Elevated Journal

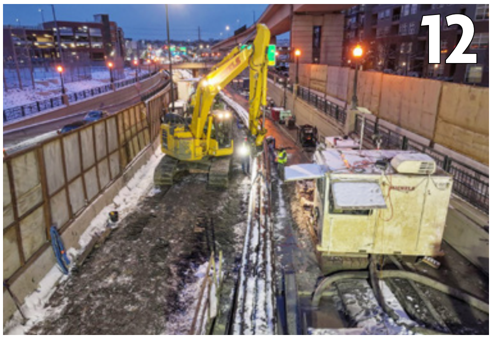
2025

NASTT 2025 NO-DIG SHOW EDITION:

Powering the Future with Trenchless Technology.
Welcome to Denver Colorado Trenchless!
Sterling CO Force Main 19,000LF Slipline.

CONTENTS

Features:



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MESSAGE FROM THE RMNASTT CHAIR

Chris Knott, RMNASTT Chair

An Exciting Time for Our Chapter and the Trenchless Industry.

It is an honor to serve as the Chair of the Rocky Mountain Chapter of NASTT in 2025. This year is shaping up to be an exciting time for our chapter and the trenchless industry. With significant advancements in trenchless technology, growing industry collaboration, and opportunities for education and innovation, we are ready for another impactful year.

One of the highlights of our chapter's success in 2025 so far was the Trenchless Elevated Conference, which took place in February in a new location, Omaha, Nebraska. This event continues to expand, bringing together industry professionals, educators, and innovators to discuss the latest trenchless solutions, best practices, and real-world applications. We are proud of how this conference continues to elevate awareness and technical knowledge across the region.

Looking ahead, we are thrilled to welcome the trenchless community to Denver, Colorado, for the 2025 NASTT No-Dig Show, March 30 – April 3. As this year's Conference Chair, I am excited to help bring together trenchless professionals from across North America for five days of education, networking, and industry advancement. With Denver's vibrant infrastructure scene, the No-Dig Show will provide an exceptional platform to highlight the latest trenchless innovations, share expertise, and strengthen professional connections. We look forward to highlighting the Rocky Mountain region's leadership in trenchless technology.

> The No-Dig Show will provide an exceptional platform.

In addition to these key events, our Rocky Mountain Chapter is committed to expanding our educational outreach in 2025. We plan to:

- Host site visits to active trenchless projects throughout the region, giving industry professionals and students firsthand exposure to innovative technologies and best practices in action.
- Support emerging professionals in our field by providing scholarships and opportunities to engage with industry leaders.

It is also a personal honor to be recognized as the 2025 NASTT Chair Award for Distinguished Service recipient. This recognition reflects not just my work, but the dedication of all who contribute to advancing our industry. I am incredibly grateful to be part of this community and to work alongside so many talented professionals committed to pushing trenchless technology forward.

> We are ready for another impactful year.

I encourage all of you to stay involved, participate in chapter events, and continue sharing your knowledge and expertise. The success of our chapter and the future of trenchless technology rely on the dedication of professionals like you.

I look forward to seeing you all at the 2025 NASTT No-Dig Show in Denver and throughout the year as we continue to elevate trenchless technology together.

Additional information on the chapter and our events and meetings can be found on our website **www.rmnastt.org**

Best regards,

Chris Knott

Chair, Rocky Mountain Chapter of NASTT
2025 NASTT Chair Award for
Distinguished Service Recipient


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MESSAGE FROM THE NASTT CHAIR

Greg Tippett, P.Eng

Dear Rocky Mountain Regional Chapter Members.

I am excited that the NASTT 2025 No-Dig Show is being held in Denver for the first time in 10 years! This premier trenchless technology event, taking place from March 30 through April 3 at the Colorado Convention Center is an incredible opportunity for your region to showcase your leadership in the trenchless industry and engage with professionals from around the country, continent and globe!

As members of the Rocky Mountain Regional Chapter, you have a unique chance to represent your local expertise, network with industry peers, and gain valuable insights into the latest advancements in trenchless technology. Whether you're a seasoned expert or new to the field, the No-Dig Show offers something for everyone – extensive technical sessions, product and equipment demonstrations in an exhibit hall featuring cutting-edge solutions and top-notch networking opportunities all week long.

> Looking forward to seeing you in Denver.

> Highlight the innovation and excellence that defines the Rocky Mountain region.

I encourage each of you to take full advantage of having this world-class event so close to home. Your chapter's participation will not only strengthen your connections within the industry but also highlight the innovation and excellence that defines the Rocky Mountain region.

NEW HEIGHTS. UNDER GROUND.

Thank you for making this a memorable and impactful event for your Regional Chapter and the trenchless community at large!

I am looking forward to seeing you in Denver.

Greg Tippett, P.Eng

Greg Tippett, P.Eng
NASTT Board Chair


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2025-2026 RMNASTT EXECUTIVE COMMITTEE

Chris Knott – *Chair*

For over 30 years, Chris Knott has shaped civil utilities construction, working his way through the ranks of laborer, auger bore crew operator, supervisor, project manager, estimator, and finally director. Chris has been with BT Construction since 2005, overseeing a diversity of trenchless methods and was pivotal in the creation of BTrenchless, Inc., the company's trenchless division. Now, as the Director of Trenchless Estimating, Chris endorses BTrenchless as the premier tunneling contractor, excelling in Pipe Ramming, Auger Boring, Pilot Tube, TBM, Microtunnels, Hand Tunneling and Slip Lining.

Chris advises engineers, owners, and contractors on optimal trenchless methods across varied soil conditions and site restrictions. He has presented at educational institutions including the Colorado School of Mines and the University of Colorado-Boulder.

Chris has also been a lacrosse coach for the last 20 years and brings his championship-level enthusiasm to work. He orchestrated the first Rocky Mountain NASTT No-Dig in 2010 and remains active on the local board. He is also involved at the national level as Director, organizing events such as the Program and Auction Committee for the National show. Chris is invested in growing the trenchless industry and NASTT memberships - channeling his expertise and energy, both in and out of the field.

Stephanie Nix-Thomas, P.E. - *Immediate Past Chair*

Stephanie Nix-Thomas joined the family business in January of 2000. In 2002, she and her brother, Jon Nix purchased the business from their parents and two years later, they completed the first pilot tube microtunneling project in the State of Utah.

In 2005, they made the decision to focus their general contracting company on trenchless methods of construction. In the same year, they won recognition from NASTT for pioneering pilot tube pipe ramming on the commuter rail project in Utah. Over the years they have gained expertise in not only pilot tube microtunneling, but also tunnel bore, auger bore, pipe ramming, pipe bursting and any combination of methods. They have made choosing the 'right horse for the course' a resource for construction projects and for assisting engineers with trenchless designs.

At the inception of the Rocky Mountain Chapter of NASTT, Nix Construction established Utah's first group of participants. Stephanie was involved from the beginning and organized two one-day 'Training Days' in 2015 and 2016. In the fall of 2016, she led the organization of the first regional chapter conference on the west side of the Rockies and has led or helped with conferences in Utah and Colorado since. Currently, Stephanie is the Regional Chair of the Rocky Mountain Chapter and a member of the national board of NASTT.

Stephanie earned her degree in civil and environmental engineering with a business minor from Utah State University in 1984. She worked as a consultant engineer in Salt Lake City for seven years before moving to the State Department of Environmental Quality where she worked in water quality as an environmental engineer. In 1992 she moved to the policy office of DEQ as a liaison with small businesses and Native American tribes.

Rebecca Brock – *Chair Elect*

Becky Brock is the president and owner of Brock Geo-Consulting, which she established in 2019. Becky has over 25 years of experience specializing in geo-engineering, geo-hazards, trenchless and tunneling design, and tunnel inspections. Becky has a BS in Civil Engineering and MS in Geological Engineering and is a registered Professional Engineer in Colorado and California. Her experience includes projects located within complex geological sites affected by collapsible and expansive soils, soft ground, running ground, and mixed face conditions. For trenchless and tunnel projects she provides geological evaluation and design, development of contract drawings and specifications, construction management, assistance with differing site condition claims, and litigation support. Additionally, Becky is an adjunct professor at the Colorado School of Mines in the Geological Engineering Department teaching senior and graduate-level courses. As a member of the RMNASTT Executive Board she is working to grow the Chapter's goal of promoting trenchless technology education in the Rocky Mountain region.

2025-2026 RMNASTT EXECUTIVE COMMITTEE

Kyle Friedman – *Treasurer*

Kyle Friedman is an Associate Project Engineer for Brierley Associates out of the Denver, Colorado office. Kyle has been in the trenchless industry for 8 years and has had an impactful presence within the trenchless community including one award as part of the project team for the 2021 best small project of the year by Engineering News Record for the Empire State Trail Box Tunnel and one award for the 2022 Construction Management Team Member of the year, for the Bismarck Airport. Kyle's true skills come as being a knowledgeable, hands-on field project manager working with owners and contractors.

Kyle has worked on trenchless installations around the country within a variety of ground conditions and installation methods and has witnessed over 15,000 linear feet of trenchless installations. Committed to furthering the use and teachings of trenchless technologies, Kyle has continued to be an active member of the Rocky Mountain Society for Trenchless Technology since 2019.

Matthew Olson – *Secretary*

Matthew Olson is a professional engineer with experience in all stages of the project lifecycle with a myriad of trenchless construction techniques. This experience has been gained through a diverse point of view through instrumentation, monitoring, and analysis of jacking forces as an academic, shoveling sticky clay from an auger boring spoil chute and signaling cranes as a laborer, and back-to-back MS Teams meetings as an engineering consultant. A past partner of Lithos Engineer, Mr. Olson now leads the HDD practice at GEI Consultants, Inc. He is the Secretary for the RMNASTT and leads development of the ***Trenchless Elevated Journal***.

He is the past recipient of two Outstanding Paper awards from the No Dig Show and the 2022 Ralston Young Trenchless Achievement Award. He has volunteered for several NASTT committees since 2012, including student chapter, technical program, and young professional committees.

2025-2026 RMNASTT BOARD OF DIRECTORS

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Trenchless Elevated Networking, Education & Fun!

RMNASTT Chapter hosts a variety of entertaining social and educational events across the Rocky Mountains/Great Plains region

OUR MISSION:

To advance the science and practice of Trenchless Technology for the public benefit by promoting education, training, research, development, information; and to disseminate, through public forums, the improvements and status of Trenchless Technology. Founded in 2008, The Rocky Mountain Chapter of NASTT (RMNASTT) promotes the NASTT mission within our region of Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, Utah and Wyoming.

HERE'S WHAT WE DO!

Recent Events:

5 Feb 2025	Trenchless Elevated 2025 - Omaha, NE
29 Jan 2025	Colorado Holiday Party 2025!
22 Jan 2025	Utah Holiday Party 2025
14 Nov 2024	Trenchless Elevated 2024 - Sandy, UT
13 Nov 2024	RMNASTT Site Visit: 42" GBM-Auger Bore Under I-15
4 Oct 2024	RMNASTT Colorado Clay Shoot
17 Jul 2024	Happy Hour/Networking @ Empower Field at Mile High
30 May 2024	RMNASTT Site Visit: Boulder Sewer Improvement Project
23 Apr 2024	RMNASTT & WEAU Mountain Bike & Hike
25 Jan 2024	Utah Holiday Kick Off Party
24 Jan 2024	RMNASTT Site Visit: Jackson Storm Sewer Drain Project Phase 2
10 Jan 2024	Colorado New Year Happy Hour

Trenchless Elevated 2025

> The RMNASTT Chapter Board of Directors thanks everyone for their participation!

TRENCHLESS ELEVATED ANNUAL CONFERENCE – Attendees enjoy a full day of informative peer-reviewed presentations on a wide range of trenchless technology topics

2025 Trenchless Elevated
RMNASTT 15th Annual Conference
North American Society for Trenchless Technology
Wednesday, Feburary 5th, 2025
A View West Shores Conference Center 110 S 243rd St, Waterloo, NE 68069

	Conference Events Schedule		Time
	Registration and Breakfast		7:30 - 8:30 am
	Introduction and Welcome	Weston Engel, 2025 Trenchless Elevated Chair	8:30 - 8:40 am
	Presentations	Speakers	
Session 1	Moderator: TBD		Time
1.0	Platinum Sponsor Introduction	TBD	8:40 - 8:45
1.1	Jackson St. - Twin 87" TBM's	Sean Weddingfeld (BT Construction)	8:45 - 9:15
1.2	Squeezing The Most Out Of Conpression Fit HDPE Liners	James Lirot (GEI), Benny Siljenberg (GEI), & Cordell Brown (United Pipeline)	9:15 - 9:45
1.3	Guided Boring Using Pilot Tubes; Variations Of The Method and Installations in Omaha Over The Last 15 Years	Jeffrey Boschert P.E. (National Clay Pipe)	9:45 - 10:15
	Break 10:15 - 10:45 in Exhibit Area		
Session 2	Moderator: TBD		Time
	Platinum Sponsor Introduction	TBD	10:45 - 10:50
	...Main: A Multi-Phase Condition Assessment Journey	Chris MacDonald (CPM Pipelines)	10:50 - 11:20
	...Desing, Installation, Lessons Learned	Ben Day P.E. (Olsson)	11:20 - 11:50
	Lunch 11:50 - 1:00 - Presented by Platinum Sponsor TBD		
	Moderator: TBD		Time
	...ntroduction	TBD	1:00 - 1:05
	...Crossing Design Considerations	Sean Bell P.E. & Scott Schmoker P.E. (HDR)	1:05 - 1:35
	...an Solutions for Omaha – Forest Lawn Project	Kyle Friedman P.E. (Brierley Associates) & Glen Wheeler (JW Fowler)	1:35 - 2:05
3.2	Peoia & Colfax Intersection_A Pair of Microtunnels	Jim Kriss P.E. (Carollo Engineering) & Joss Livermore (BT Construction)	2:05 - 2:35
	Break 2:35 - 3:05 in Exhibit Area		
Session 4	Moderator: TBD		Time
4.0	Platinum Sponsor Introduction	TBD	3:05 - 3:10
4.1	Pilot Tubin' In Omaha-Navigating The Waves Of A Tricky lil' Project	Lucas Billesbach P.E. (Embris) & Benny Siljenberg P.E. (GEI)	3:10 - 3:40
4.2	Addition Of Sprayable System to ASTM 1216	Mohamed Gamal PhD, P.E. (Kilduff Underground)	3:40 - 4:10
4.3	Trenchless Sewer Construction with Critical Existing Utility Considerations	Chris Koenig P.E. & Scott Schmoker P.E. (HDR)	4:10 - 4:40
	RM NASTT Conference Wrap Up	Stephanie Nix (RMNASTT Chairman)	4:40 - 4:50
	Social Hour in Exhibit Area Presented by Platinum Sponsor - TBD		4:50 - 6:00

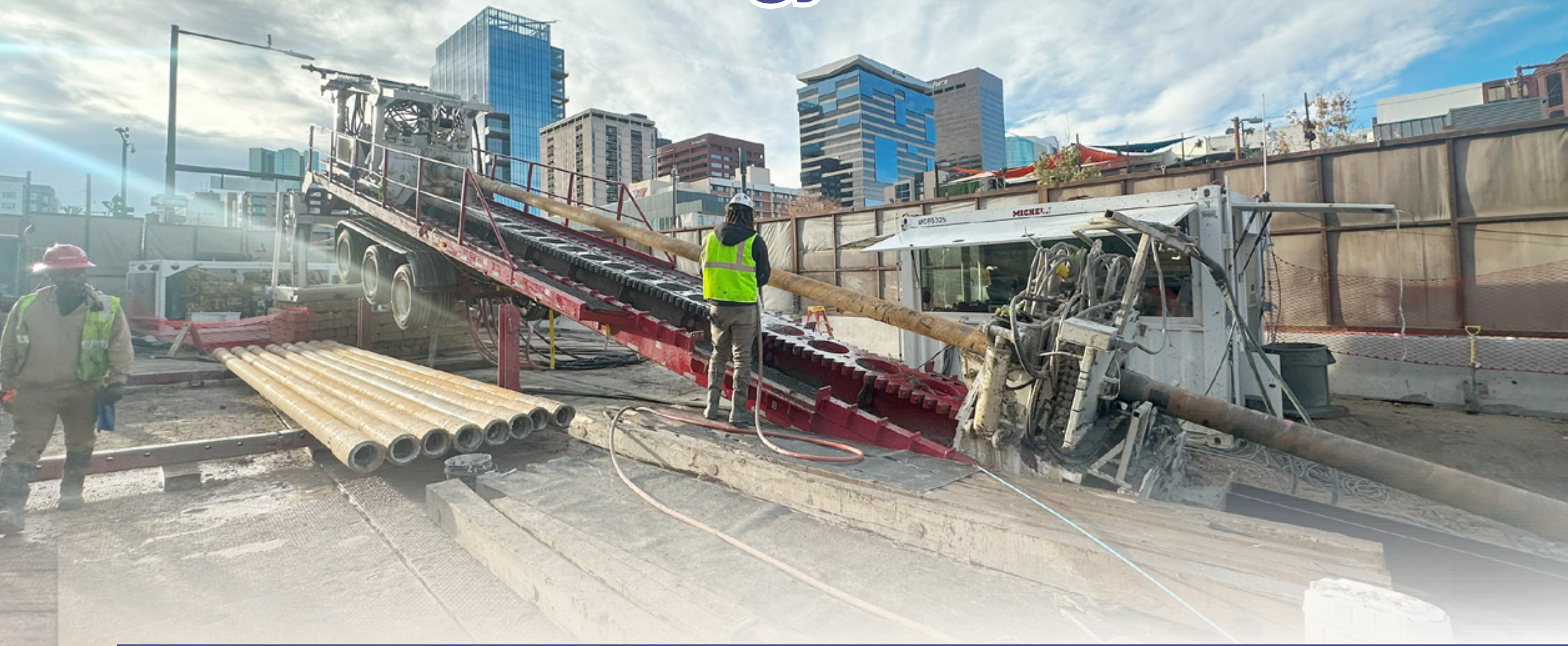
SITE VISITS – Opportunities for up close access to industry expertise

HAPPY HOUR SOCIALIZING – Networking and Fun

For information dates and locations of future RMNASTT Networking & Educational Events, visit:

www.rmnastt.org

Powering the Future with Trenchless Technology



By: Kyle Friedman, Brierley Associates;
Adam Smith, Power Engineers;
Jim Williams, Brierley Associates;
Mehana Ho'opi'i, Xcel Energy

The Denver metropolitan area has experienced unprecedented growth in recent years, leading to increased demand for reliable electricity. As the demand for electricity increases, substations reach their capacity and become unable to supply enough low-voltage electricity to meet customer needs.

Xcel Energy's Lacombe to Barker Underground Transmission Project includes the installation of parallel 230-kilovolt underground electrical transmission lines underneath 20th street from Lacombe Substation west of Chestnut Place to the alley between Blake and Market Streets, and along the alley between 20th Street and the Barker Substation located in the historic district of Lower Downtown and Ballpark neighborhood.

The system in this area does not currently have the capability to reliably serve future customer electric needs. Building additional, or upgrading and interconnecting existing substations, like the Barker Substation, enables Xcel Energy to continue to provide safe reliable electric service in the future, while enhancing system resiliency.

The Lacombe to Barker Design and Construction team, comprised of Power Engineers, Brierley Associates, and Michels Corporation, completed the construction of two 2,100-foot, 14-HDPE pipe duct bundle transmission lines under 20th Street in Lower Downtown Denver by using a horizontal directional drill (HDD). A horizontal directional drill is a trenchless construction technique that allows for installation of underground utilities by drilling a curved path beneath the surface to reach a desired exit point.

> "Stakeholders played a significant role in the project.

Logistical Challenges

With the project in the heart of downtown Denver, stakeholders played a significant role in the project.

The City and County of Denver (CCD) typically does not allow closures of public Right-of-Way (ROW) including street, alley, sidewalk, and parking lane closures from Thanksgiving Day to New Year's Day in the Downtown Business Area. This area includes 20th Street between I-25 and

Site plan – located within the heart of lower Downtown

Market Street, and the alley between 20th Street and the proposed Barker Substation. This Holiday Moratorium would result in a 1.5 month stoppage of work for duct bank construction outside of Lacombe Substation. However, POWER worked with the CCD Department of Transportation and Infrastructure (DOTI) to have them better understand the construction process, which resulted in construction being allowed to continue through the Holiday Moratorium as long as the permits were in place prior to the start of the Holiday Moratorium.

Also, CCD restricts construction activities and closures of travel lanes, parking lanes, and sidewalks in the ROW on Game Day during Colorado Rockies' baseball season, which typically extends from April 1st to October 1st. The boundaries of the moratorium include 20th Street between I-25 and Market Street, and the alley between 20th Street and the proposed Barker Substation. This restriction created tight construction windows dependent upon the success of the Rockies season, which could be prolonged if the team was successful in the playoffs. Lastly, work within 20th Street between Blake Street and Market Street was also restricted on St. Patrick's Day each year due to the work areas proximity to the St. Patrick's Day parade route.

> "Trenchless technologies were going to play a large role in this project.

For an HDD option, the conduit bundle strings would be assembled at the entry point. However, due to the close proximity to I-25, the entire 2,100-foot pipe string could not be assembled, and an intermediate fusion point was required. Additionally, the pipe string layout alternative faced challenges from the need to keep Little Raven Street accessible to I-25 for residents. This required the pipe bundle to either be trenched below Little Raven Street through a temporary chase or being suspended in the air for the pull back.

Geology Encountered

The alignment for the underground transmission lines is located in an older part of downtown Denver where old building debris was utilized as fill. For this project, a total of 5 borings were drilled along the trenchless alignment along 20th street ranging in depth from 64 feet to 102 feet. All borings were drilled with a 6-inch diameter sonic rig, where drilling/coring is performed using high-frequency vibrations to obtain continuous sampling. Standard geotechnical sampling techniques were used at 5 feet on center intervals.

Urban fill was encountered in in all borings along the alignment from the below the pavement to approximately 12 feet below the ground surface. The urban fill consisted of multiple soil types with traces of bricks, asphalt, and rebar. This material was determined to be unstable. Native alluvial soils were encountered below the urban fill on the western half of the project near the South Platte River, ranging in depth from 14 feet to 24 feet

Pipe string layout required an intermediate fusion point

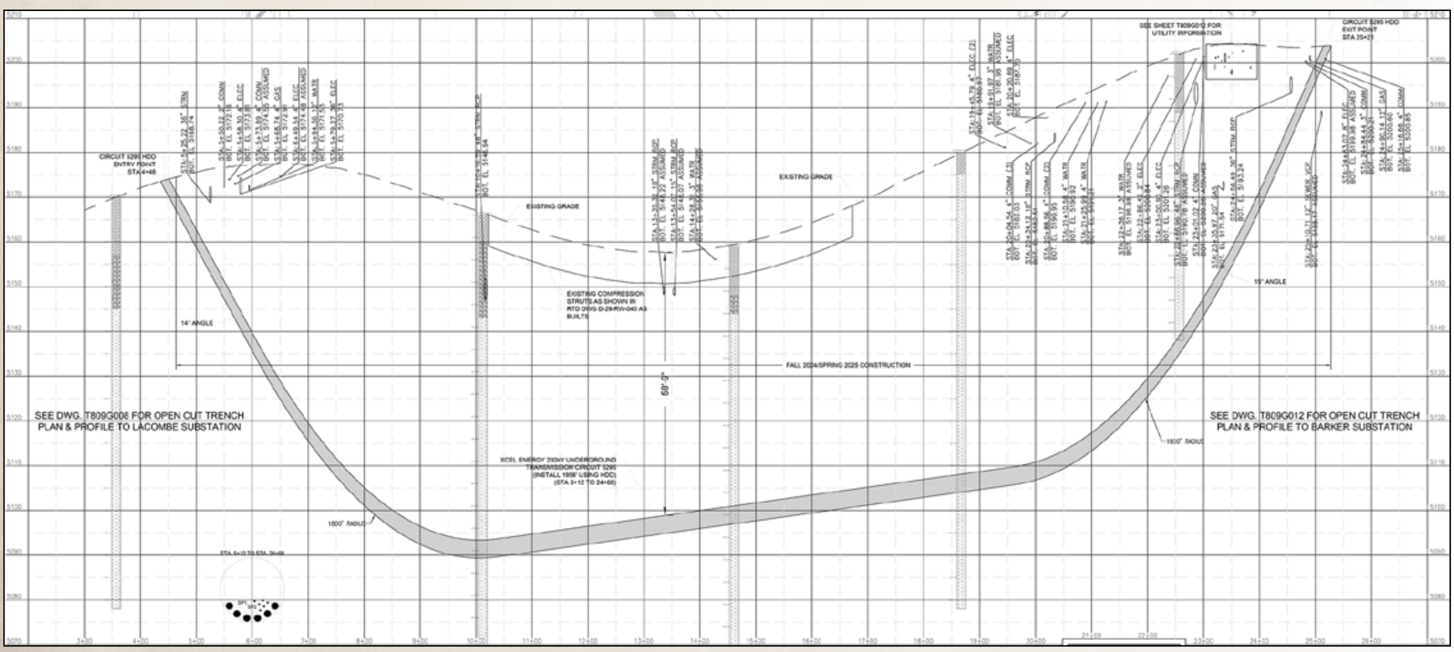
below the ground surface. The alluvial soils consisted of poorly graded sand with gravel with blow counts ranging from 16 to 34.

Further below the urban fill and the native soils was bedrock consisting of Denver Formation Claystone. The claystone ranged in blow count from 50/12 inches to 50/1 inches. Some sandstone stringers were found within the claystone at depths greater than 91 feet.

Trenchless Design

During the first phase of design, it became apparent that trenchless technologies were going to play a large role in this project. The underground transmission lines needed to be installed beneath 20th Street, a major thoroughfare into and out of the downtown area. The street has a below grade area with large retaining walls that support the RTD and Amtrak bridge to Union station. The retaining walls are supported by concrete 3 feet wide and 4 feet tall compression struts spanning 20th street just below grade, and are located approximately every 15 feet for 650 feet.

To keep 20th Street open to traffic during construction, a short trenchless crossing design was not possible to span the compression strut section below 20th street. The team worked with CCD to determine where entry and



Fill material was encountered down to 14 feet, with alluvial soils below then bedrock at 30 – 40 feet depth

> HDD was the most feasible method for installing the underground transmission lines.

exit locations would be for a trenchless crossing with minimal traffic impacts.

The teams identified two areas for the ends of the trenchless crossing, which consisted of a section of 20th street between Blake Street and Market Street, and the area of 20th street just west of the intersection with Chestnut place. This created two parallel trenchless crossings that needed to be approximately 2,100 feet in length and a diameter of 48 inches with 50 feet elevation difference between the highest point and lowest point along the alignment.

Brierley Associates worked with Power Engineers to determine feasible trenchless options for a crossing of this length and magnitude, while meeting the ampacity requirements for the cable. The duct bundle required the installation of eight (8) 8-inch ducts and six (6) 4-inch ducts for each installation creating a bundle diameter of approximately 32 inches.

First, a microtunneling concept was created. This concept would either require the crossing to be constructed as a single crossing or be split up. If it was constructed as a single crossing, a larger diameter machine would have been required to reach the lengths needed, and it would also require deep shafts that would range from 55 feet to 80 feet in depth. If the crossing was split into two drives to alleviate the grade changes along the alignment, a 1,440 foot crossing and a 500-foot crossing would be required. Again, due to the crossing length, a larger machine would have been required, and shafts would have varied from 55 feet to 65 feet in depth. Ultimately, the microtunneling option was determined to be impractical for this project due to the lengths, diameter, and depths required for this installation within a downtown street.

Brierley determined that a HDD was the most feasible method for installing the underground transmission lines. This concept would require the final ream pass for the installation to be approximately 48 inches in order to fit the 32-inch duct bundle. Determining the geometry of the HDD and balancing the stresses on the duct bundle and the HDD tooling was critical to this installation. Brierley worked with Michels to understand the installation needs, and with Power to determine the maximum depth the HDD could reach due to ampacity concerns within the electrical cables, and worked backwards from there. The radiuses for the crossings would need to be on the order of 1,800 feet minimum in order to minimize the stresses on the HDPE pipe, drill steel, and the tooling during installation.

The radiuses and bottom tangent inclination were all designed to reduce the total depth of the underground transmission lines while the entry and exit angles were increased, gaining depth as quickly as possible at both sites to reduce the length of the conductor casing required due to the urban fill that would be encountered.

The geotechnical borings encountered fill material at all borings to a maximum depth of 14 feet with alluvial soils below the fill layer. The bedrock formation in this area is the Denver Formation and is encountered at a depth of about 30 to 40 feet below ground surface. Temporary steel conductor casings were installed from grade through the fill and alluvium layers into the bedrock layer at the HDD entry points. The conductor casing was utilized to provide borehole stability within the soft soils, which also added risk mitigation against the potential inadvertent release of drilling fluid to the ground surface and the potential for settling issues under the intersections near the entry and exits. Since a pilot hole intersect is planned, casings will be installed on the exit side as well for each of the HDDs to protect the existing utilities in Blake Street.

HDD Construction

> Radiuses for the crossings would need to be on the order of 1,800 feet minimum in order to minimize the stresses.

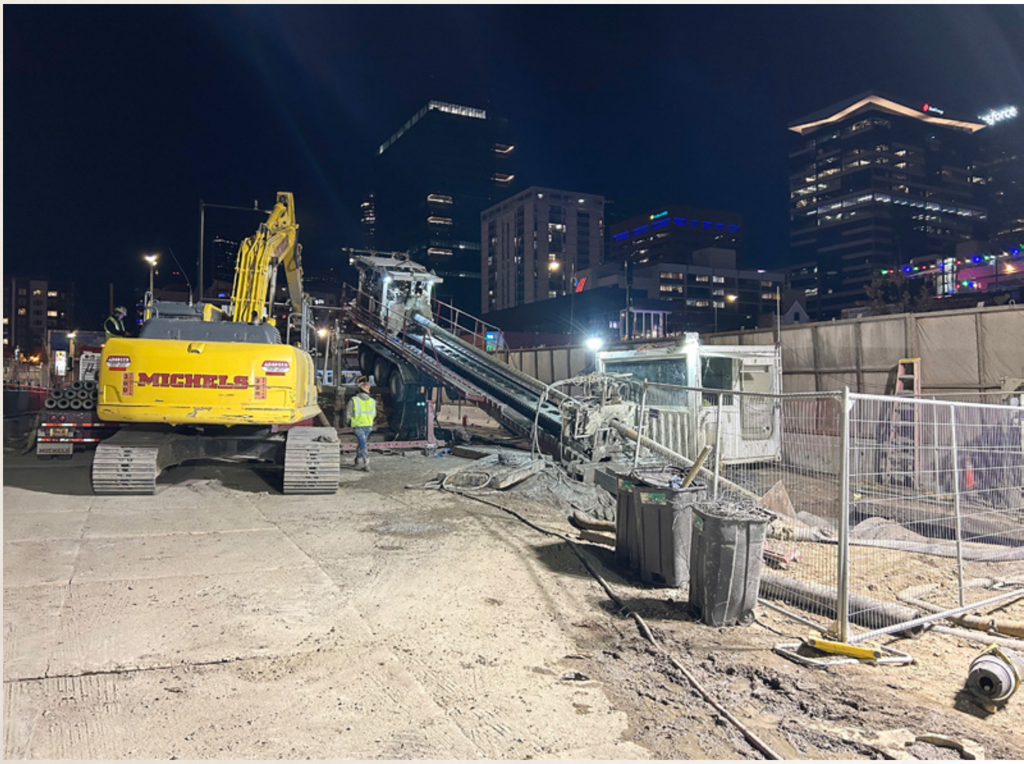
Construction for the Lacombe to Barker project has been stretched into multiple baseball off seasons due to the project's proximity to Coors Field. The installation of the HDDs occurred after the Rockies 2024 regular season ended and continued through March 2025 before the start of the 2025 regular season.

For the start of the HDD construction, Michels worked to install the conductor casing through the overburden and down to bedrock for both circuits at both sides of the crossings. The conductor casings consisted of 54-inch diameter, 1.00-inch wall steel pipe and was installed with a 24-inch TT Technologies Taurus pneumatic hammer. At the Lacombe and Barker ends, the conductor casings were installed to a length of 155 feet and 50 feet respectively.

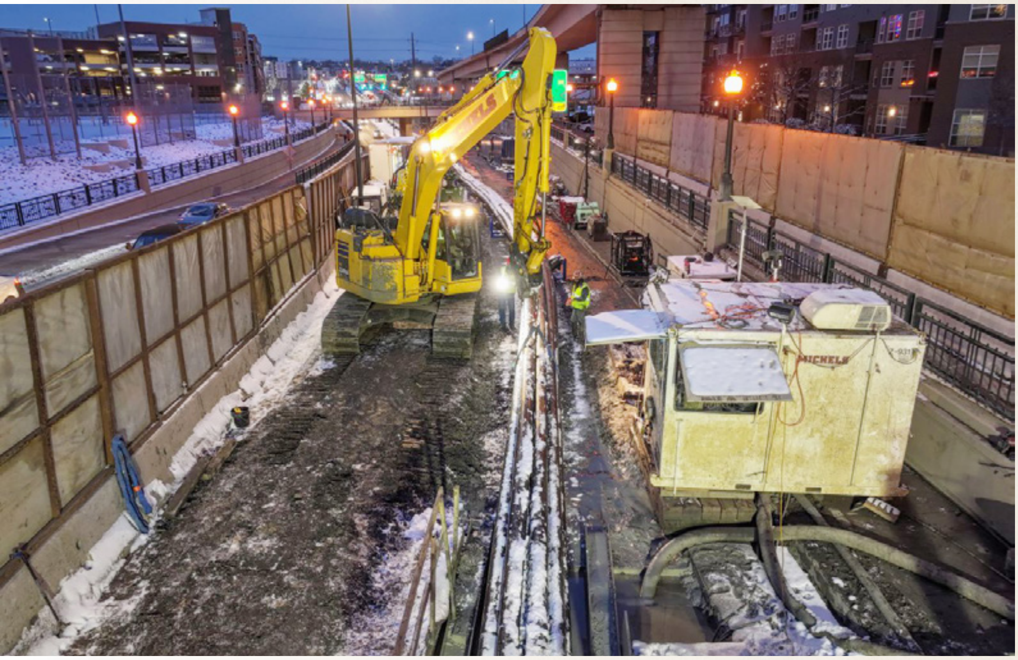
Once the Conductor casings were installed, Michels could begin the setup for the Pilot bore operations. On the Lacombe side, all equipment had to sit within the two west bound lanes of 20th street and a sidewalk. The Lacombe side was an extremely tight work area which required almost all pieces of equipment necessary for an HDD to be touching. The Barker side is where a majority of the HDD operations occurred, using not only the west bound lanes of 20th street but also a parking lot located next to the entry location. Michels began the pilot bore operations from both the Lacome and Barker sites using their custom built Atlas 840 drill rig, with a minimum pullback of 840-thousand pounds and 180-thousand foot-pounds of torque. Michels engaged Brownline USA for steering assistance so Michels could perform an intersect drill within the claystone formation. Brownline monitored pressures during the pilot hole to prevent drill fluid migration to 20th street above and mapped the installation of the pilot bores.

During the drilling and reaming process, Michels fused 50-foot sections of the (8) 8-inch DR9 HDPE and (6) 4-inch DR9 HDPE duct bundle along 20th street west of the Lacombe site up onto the overpass of Interstate 25. The length for the pipe layout was not long enough for the entire bundle, which required a 300-foot section to be mid-fused during pullback operations. Internal de-beading of the ducts occurred during the fusing process.

Extremely tight work area on the Lacombe side



More room on the Barker side where a majority of HDD operations were launched



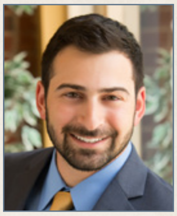
Duct bundle pullback completed during late spring snowstorms

Pullback completed in only two shifts

The duct bundle pullback for each installation was completed over the course of 2 shifts using only 120,000 pounds and 135,000 pounds of pull force for Circuit 5295 and Circuit 5297, respectively. Pullback occurred with Michels 840-thousand pound rig positioned on the Barker side of the crossing.

Battling multiple early season snow storms, the installation of each HDD crossings were successfully completed before the start of the Rockies 2025 regular season. Work will continue on the Lacombe to Barker project through 2027 to complete construction on the substations and install electrical distribution lines.

ABOUT THE AUTHORS:



Kyle Friedman *is an Associate Project Engineer for Brierley Associates out of the Denver, Colorado office. He has worked on trenchless installations around the country within a variety of ground conditions and installation methods and has witnessed over 15,000 linear feet of trenchless installations. Committed to furthering the use and teachings of trenchless technologies, Kyle has been an active member of the NASTT Rocky Mountain Chapter since 2019.*

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Welcome to Denver Trenchless!

By: Ryan Marsters, GEI Consultants

The Front Range and Colorado

Upon arriving beneath the white-pinnacled caps of the Denver International Airport, you might have noticed, besides Denver being unfortunately far from the actual mountains, the booming metropolitan area sprawling north and south as far as the eye can see along the mountain front. Cities have developed where the rivers crash down from the mountains and enter the plain, providing historic pathways to the mining communities at higher elevation. Towns have developed at the smaller tributary creeks. Urban sprawl has caused these towns to creep like a vine along the waterbodies, and the cities to overflow across the plains, with condominiums gradually replacing farmland. This area is commonly referred to as the Front Range, and it is among the fastest growing communities in the country. Likewise, the mountain communities themselves have transitioned from dotted seasonal homes for the affluent to thriving year-round communities beset by big town troubles.

Ribs and lagging behind a TBM and beneath Denver International Airport's main runway

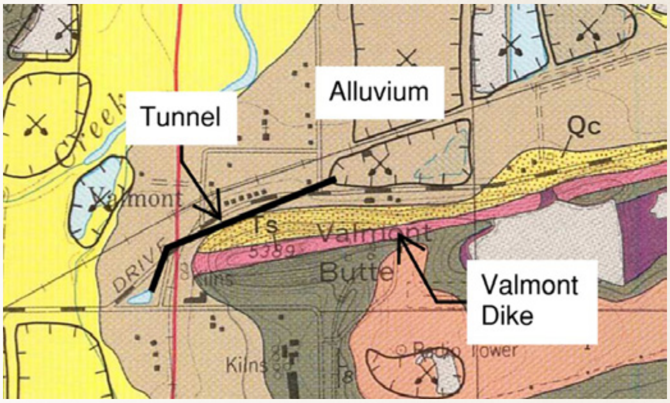
Need for Trenchless

The population boom requires infrastructure to support it. Historic tunneling has improved the flow of raw water across geographic divides, and the transportation networks for rail and commuting. The tunneling scene of the 20th century was primarily driven by geographic barriers: mountains, ridgelines, and hills. The large-scale tunneling projects are few and far between, but smaller scale trenchless projects are implemented daily. First, water rules the west and Denver is no exception. Urban growth drives creativity and innovation in sourcing raw water, traditionally from the mountains, and now from deep well fields within scattered aquifers. The sprawling communities need water and gas to come in, and flood waters and sewage to get out. The trenchless scene today is driven by end user need, with the utility network crisscrossing canals, highways, railroads, and more from all geographic points.

The Builders

Unlike many urban communities, the talent pool to enact the infrastructure modernization does not lag behind the need. The Rocky Mountain region is privileged to be in a central location influenced by engineers, suppliers, manufacturers, and contractors nationwide. That collective knowledge has translated to the thriving trenchless practice centered around the Front Range communities.

The state of the engineering practice in Denver has always been relatively advanced thanks to an existing core of underground engineers and geologists serving the mining industry, large scale civil works including dam construction, trans-divide water diversions, and rail transit from approximately the late 19th century through modern times. The area saw a further infusion of talented engineers from the coasts carrying significant transit design and construction experience, yet seeking lifestyle changes. While we are a few generations removed from these early efforts, most of the region's engineers have either branched off directly from them, or are benefiting from their groundwork in educating owners on the state of practice. Modern trenchless risk management systems such as Geotechnical Baseline Reports (see pgs 38-44) have been in use for decades. The Colorado School of Mines, University of Colorado, Boulder, and other schools have contributed to education and research for understanding the underground environment and our influence on it. Key



Tunnel alignment amidst geologic complexities such as volcanic dikes, shallow bedrock, and cobbles and boulders with shallow groundwater


Microtunnel boring machine being lowered into a secant pile shaft

> The trenchless scene today is driven by end user need.

industry partners such as geotechnical drillers and geophysicists are abundantly capable of supporting data acquisition and underground understanding. Premier civil and construction management programs from Colorado State University and other programs have positioned relationships between owners, engineers, and contractors in an amenable state.

As with the engineers, the contractor pool has always been well developed. Civil construction firms have adopted mining talent for the heart of trenchless: hand excavation. Slowly, the process of putting a hole in the ground has replaced manual labor with hydraulic power and machines, but labor is still needed for when the going gets tough and for moving muck from Point A to Point B, even though the locations for those points in the process have changed over the years. Still, Denver Metro is privileged to have multiple premier trenchless construction firms offering a variety of equipment from auger bores, pipe rams, directional drilling, and tunnel boring machines. Recently, the region has seen an influx of "steerable" auger bores more resembling TBMs with internal augers, and horizontal down the hole hammers. Both of these newer systems are proving adept at Colorado's unique subsurface conditions.

The Ground

Colorado has a unique geologic environment with extreme topographic relief. Along with relief comes geomorphology: the evolution of landforms. Understanding geomorphology is key to understanding trenchless techniques. The famous Rocky Mountains cross much of the state, with towering granitic and meta-volcanic peaks thrusting through inclined sedimentary bedrock layers. These upwellings of land are the ultimate source of many of our problematic ground: 25,000 psi granitic boulders, collapsible evaporites, and large sandstone ridges. Ancient glaciers have carved gouges in these peaks, depositing boulders and debris along the valleys and over-steepening slopes. Mass wasting, gravity, and water have eroded these landforms, and transported materials far from their source along valleys and riverbanks. As the materials travel further from the source, mechanical action breaks the materials down into smaller and smaller grain sizes until small enough for winds to redistribute materials further across the plains.

> Smaller scale trenchless projects are implemented daily.

In short, with respect to geology, Colorado has it all, though most of urban development and trenchless need is focused along the rivers and plains. Close to the rivers, trenchless techniques must consider cobbles and boulders and their ability to be excavated and expelled from a machine. Further from rivers, soft collapsible soils present challenge for steering and alignment, requiring innovations in guidance. Shallow bedrock is prevalent most everywhere, requiring considerations for mixed face excavation.

> Denver Metro is privileged to have multiple premier trenchless construction firms.

Microtunnel break into the receiving shaft at the Boulder MSI project

The Projects

A handful of projects are provided below, showcasing the unique geologic environment and diversity of Colorado's trenchless practice:

Boulder Main Sewer Improvements

The City of Boulder is a growing community right at the base of the mountains, with famous outdoor access and a thriving technical community to drive growth. To service this growth, upgrades to its wastewater conveyance system were planned, including the design and construction of a new 2.5-mile wastewater conveyance interceptor to serve the City's wastewater treatment facility. The project also included rehabilitation of its existing 2.5-mile-long main interceptor.

Sewer overflows observed in Boulder's stressed system

To understand the geology adjacent to the mountain foothills, a geotechnical investigation was performed including borehole drilling and sampling to assess general materials and test pits to characterize cobbles and boulders adjacent to the streams. Primary materials encountered during the subsurface investigation included clay, sand, and gravel within stream-deposited alluvium overlying shallow weak shale bedrock. Cobbles, boulders, and shallow groundwater were observed throughout the area. The shale bedrock contained areas of contact metamorphism attributed to the proximity to the Valmont Dike, a volcanic intrusion. Contact metamorphism between the shale and the volcanic intrusion resulted in the formation of hornfels, or partially metamorphosed shale, which could be worrisome for tunneling excavation and groundwater control.

To combat construction issues associated with wet, mixed face conditions including alluvium over bedrock, the trenchless alignment was lowered to be completely within bedrock and split into two tunnels by an intermediate shaft. One tunnel drive was approximately 1,500 feet long and the other was 400 feet long. Both tunnels cross below multiple utilities and roadways. A 42-inch-diameter fiberglass reinforced plastic carrier pipe was installed within a minimum 60-inch-diameter steel casing pipe for both tunnels.

BTrenchless of Henderson, Colorado, built both tunnels using a microtunnel boring machine (MTBM) manufactured by Akkerman and launched from a central secant pile shaft.

Mesa Verde Waterline Replacement

The population boom has increased tourism across the state's many parks as the Front Range community seeks to explore natural recreational opportunities every weekend and holiday, leading to infamous "red light" traffic jams Friday and Sunday evenings along the highways connecting the Front Range to the mountains.

The Mesa Verde Waterline Replacement project serviced one of Colorado's four national parks seeing an increase in tourism and planning infrastructure upgrades to accommodate the influx. Mesa Verde National Park is known for 7th century AD ancestral Puebloan cliff dwellings exhibiting native American culture and archaeological preservation. The waterline project involved 40 miles of 6- to 8-inch HDPE to be replaced by primarily open cut trenching. To minimize open trenching along hillsides, a visual detractor for tourists seeking an outdoor reprieve, three Horizontal Directional Drills were planned, ranging in length from 1,300 to 4,800 LF with elevation differentials up to 1,000 feet.

The geology was known to include sandy clay and gravity-deposited colluvium overlying interbedded sandstone, shale, and mudstone tilted at an angle by nearby mountain uplift. To better explore geologic conditions

> Urban sprawl has caused these towns to creep like a vine along the waterbodies.

Landscapes within Mesa Verde National Park. HDD was chosen to maintain the visual appeal of the park which has seen an increase in visitation from the Front Range

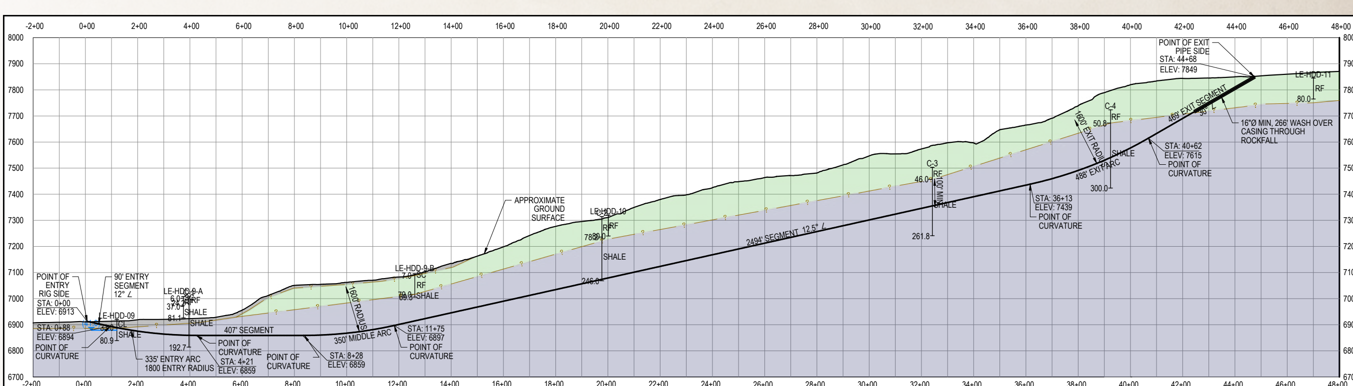
Mancos Shale bedrock analyzed for fractures that could lead to inadvertent returns

and assess for trenchless risks such as settlement, heave, failure to advance, and inadvertent returns ("frac outs"), boreholes were drilled along the alignment to obtain lithology and rock core samples. Due to the extreme elevation differential between entry and exit locations creating a dry hole condition, boreholes instability and collapse risks were significant concerns mitigated by locating the HDD profiles completely within bedrock. A robust geophysical program with the ability to detect the colluvium/bedrock interface to depths of several hundred feet below grade was utilized to evaluate the bedrock surface at key intervals along the alignment.

With the aid of geological insight, the design was progressed for an HDD alignment to be constructed in late 2025.

West Gates DIW Project

With both population growth and a central United States location, Denver International Airport (DEN) has become the third busiest airport in the United States. The airport is anticipated to expand with 100 million passengers expected annually by 2027 and 120 million passengers by 2045. To accommodate this growth, DEN has announced the construction of four new concourses with 100 new gates. The combination of growth and the winter weather conditions in Denver from approximately September through May means that airport deicing operations and infrastructure also need to be expanded. The $70M West Gates DIW Pond Expansion project aims to improve and expand the current deicing industrial wastewater (DIW) infrastructure to accommodate both the current deficit and future capacity, while



HDD alignment within Mesa Verde National Park

Erected liner plate for a 60-inch TBM-excavated tunnel at Denver International Airport

Carrier pipe installation inside a steel casing pipe to support growth at Denver International Airport

maintaining environmental compliance by preventing DIW discharge from entering receiving waters. The full project includes detention ponds, glycol supply piping, DIW outfalls, pump facilities, and auxiliary structures in addition to the tunnels.

DEN was originally built on expansive open land far from current population centers as there was room to grow. Various communities have followed suit and grown towards the airport as one of the largest employers in the state, driving need for utilities to and from the airport and surrounding communities. The land was also subject to poor geologic conditions: soft and collapsible wind-deposited silts overlying swelling claystone. Fossils were present within the claystone, acting as large block-in-matrix type obstructions that threatened many closed face trenchless techniques. During original construction, deep overexcavations up to 40 feet removed problematic ground and replaced it after mixing it with additives to serve as suitable foundations. During earlier trenchless projects, the swelling soils in native soils reacted to a MTBM's bentonite slurry and locked up the casing pipe.

To minimize impacts to DEN flights, six tunnels were planned, ranging from 2 – 11-foot diameter with lengths from 300 LF to 2,050 LF beneath active runways and taxiways. Excavation techniques used open faced techniques to overcome the block in matrix type obstructions: steerable-head auger boring, tunnel boring machines, and shielded hand mining. Support techniques within the soft yet firm claystone used steel casing, direct install Fiberglass Reinforced Mortar, and erected support including steel ribs and lagging, and liner plate.

Southland Contracting based in Texas began project construction in April 2023 and all tunnels are complete as of February 2025. Southland Contracting built three tunnels between 5- and 11-foot diameter using home-built TBMs while subcontracting Underground Infrastructure Technologies of Lakewood, Colorado, to build three tunnels less than 5-foot diameter with a combination of hand mining and the McLaughlin On-Target System.

Second Creek Interceptor

The Second Creek Interceptor is an approximately 17.5-mile-long pipeline intended to alleviate capacity constraints and aging pump station and pipeline infrastructure in the system. The system

MTBM outfitted with disc cutters and scrapers for mixed face conditions

Jacking system within a sheet pile shaft for a microtunneling operation in challenging mixed ground

is meant to support infrastructure and population growth on the east side of Denver Metro, which has seen rapid expansion thanks to both the airport, and the highway transportation network. The interceptor collects wastewater flows from this region and conveys it to wastewater facilities. In all, the project had 20 tunnel crossings of major roadways, rail tracks, and water ways.

The geotechnical investigation at each of the tunnels included borings and test pits to characterize the ground conditions, primarily consisting of wind-blown silts and sand and gravel alluvium. Though far from the mountains, larger diameter cobbles and boulders were transported by the South Platte River. Similar to the West Gates project, sandstone, calcite, and fossils were observed in the weak claystone matrix, serving as potential obstructions to excavation. Mixed face conditions were also present with shallow claystone and sandstone bedrock, and localized areas of higher groundwater.

Bradshaw Construction of Maryland constructed several tunnels using microtunneling to overcome the challenging mixed face conditions, while UIT constructed additional tunnels using McLaughlin On Target System, and shielded mining within bedrock.

Summary

Colorado's central United States position, along with extensive urban growth in the Front Range community, has positioned the local industry well with respect to talented engineers, educated owners, and qualified contractors. The infrastructure need and geologic complexity have allowed for a showcase of wide ranging trenchless technologies, with auger bore s, pipe rams, and all types of tunnel boring machines in use daily. With a broad array of techniques and talent available, the Front Range can continue to support knowledge and growth in trenchless technologies.

ABOUT THE AUTHOR:

Ryan Marsters *is a tunnel engineer and geologist practicing out of Golden, Colorado, where he obtained degrees from the Colorado School of Mines. He supports tunnel engineering projects nation-wide for GEI Consultants and manages the local team. He has had the privilege of working under renowned tunnel experts transplanted to Denver for the mountain lifestyle.*

Sterling Wastewater System Improvements - Force Main Slipline

By: Michael Perez, Underground Solutions, Inc.

1.0 ABSTRACT

The City of Sterling, Colorado was dependent upon a four-mile-long and 50-year-old 20-inch ductile iron force main to move the City's sewage to its wastewater treatment plant. Over time, the pipeline had been heavily corroded by hydrogen sulfide (H_2S) gas. Faced with the need for a new pipeline and the desire for a redundant pipeline, the City asked Mott MacDonald to suggest the best plan to achieve their goals. Mott MacDonald analyzed the system and determined that constructing dual 16-inch PVC pipelines would provide both redundancy and more than enough capacity. The first pipeline was constructed primarily with traditional open-cut construction methods. For the second pipeline, instead of abandoning the existing 20-inch force main, the City elected to rehabilitate the existing pipe and slipline it with a new 16-inch Fusible PVC piping (FPVCP).

By utilizing 16-inch FPVCP, the replacement portion of the project was greatly simplified by sliplining the fusible pipe into the existing 20-inch ductile iron pipe. Additionally, 4,000 feet of the existing force main was lying in an environmentally sensitive area. Sliplining through this section of the existing force main minimized construction impacts within the sensitive area. Finally, but certainly not the least important problem averted by sliplining, was the abundant presence of groundwater in certain portions of the project alignment. Limiting excavation to slipline pull-pits and FPVCP-strung tail ditches greatly reduced de-watering requirements.

> "Utilizing the sliplining method resulted in a notable reduction in equipment and construction time.

2.0 INTRODUCTION

The City of Sterling is a municipality and the county seat of Logan County, Colorado, located in the North-Eastern section of the state. From humble beginnings in 1882 when it was founded by homesteaders along the South Platte River, to its immense growth in the sugar beet industry, the City has become an economic and commercial hub. With more plans to grow in population and technology, updates to infrastructure were necessary.

Installed back in 1980, the City relied upon a 20-inch existing ductile iron pipe (DIP) force main to convey flows from their headworks lift station to their wastewater treatment facility. The existing force main was over four miles in length and deteriorated. Also, due to its age and the debris/buildup inside, high amounts of energy were required to meet flow demands.

Additionally, the City experienced high rates of inflow and infiltration (I&I) during significant rain events, which increased the amount of wastewater flows to their headworks and the lift station. As a result, it was not only important to improve the reliability of the force main, but also critical to increase its capacity. Providing a redundant pipeline would help resolve this capacity issue.

Rehabilitation by sliplining the existing system with new pipe would be the most cost effective and quickest way to improve the system as opposed

Dia	Length	Volume		Retention Time at:		Velocity				Pigging Required (if v < 2.5 fps)
			Total	1.7 MGD	Operation of FM Alternating Days	1.7 MGD	2.25 MGD	4 MGD	8 MGD	
(in)	(ft)	(gal/ft)	(gal)	(hr)	(hr)	(fps)	(fps)	(fps)	(fps)	
16	24,000	10.4	249,600	3.5	27.5	1.9	2.5	4.4	N/A	NO
20	24,000	16.3	391,200	5.5	29.5	1.2	1.6	2.8	5.7	YES
24	24,000	23.5	564,000	8.0	32.0	0.8	1.1	2	3.9	YES

Figure 1. Options for force main sizes. Note: From "Sterling Wastewater System Improvements Project Engineering Report," by Mott Macdonald

to digging up the whole system to replace the pipeline. The benefits for this installation and choosing FPVCP were evaluated during the design process.

3.0 DESIGN

The City hired Mott MacDonald to identify the problems and review solutions. Mott MacDonald performed an inspection in 2016 and assessed all of the current conditions and systems. Mott MacDonald's evaluation was documented in a letter to the City and identified that the improvements involved a redundant force main and rehabilitation of the existing pipeline via sliplining with new pipe. These solutions would prove to be easier to construct and be efficient for long term maintenance. Having dual force mains provided more system reliability in the event that one of the pipes would need future maintenance or repair.

Mott MacDonald calculated the velocity for the new force main installations. Ideally, 2.5 fps would prevent the settling of solids and loss of capacity. Keeping the same size force main could not maintain this velocity when aiming for the minimum 3.0 MGD flow rate from their study. As a result, the calculations showed that a 16-inch force main would be ideal per figure 1 from Mott MacDonald's Engineering Report.

Dual 16-inch force mains also proved to be more cost effective when compared to the dual 20-inch and 24-inch options,

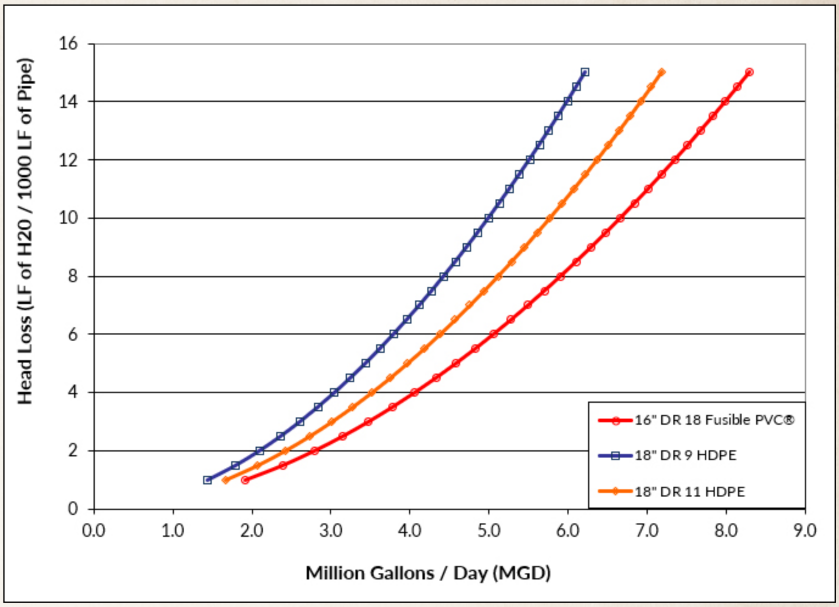


Figure 2. Head loss of FPVCP compared to two HDPE pipes using the Hazen-Williams formula

Figure 3. The 16-inch pipes were fused together and laid out alongside County Road 370

largely because one of the 16-inch force mains could be sliplined inside of the existing 20-inch force main. Utilizing sliplining eliminated the need to fully remove and replace the existing 20-inch force main. The City of Sterling operators and staff agreed that dual 16-inch force mains were the best alternative.

When choosing pipe materials, the City of Sterling selected PVC and FPVCP. FPVCP provided a superior flow compared to other pipe solutions for the slipline replacement. HDPE piping was considered as well, but the thicker wall required for the HDPE piping resulted in a decreased inside diameter based upon the maximum allowable outside diameter that would fit inside the existing 20-inch DIP force main. For a given flow rate, FPVCP yielded less head loss per MGD than HDPE piping as shown in the graph in Figure 2.

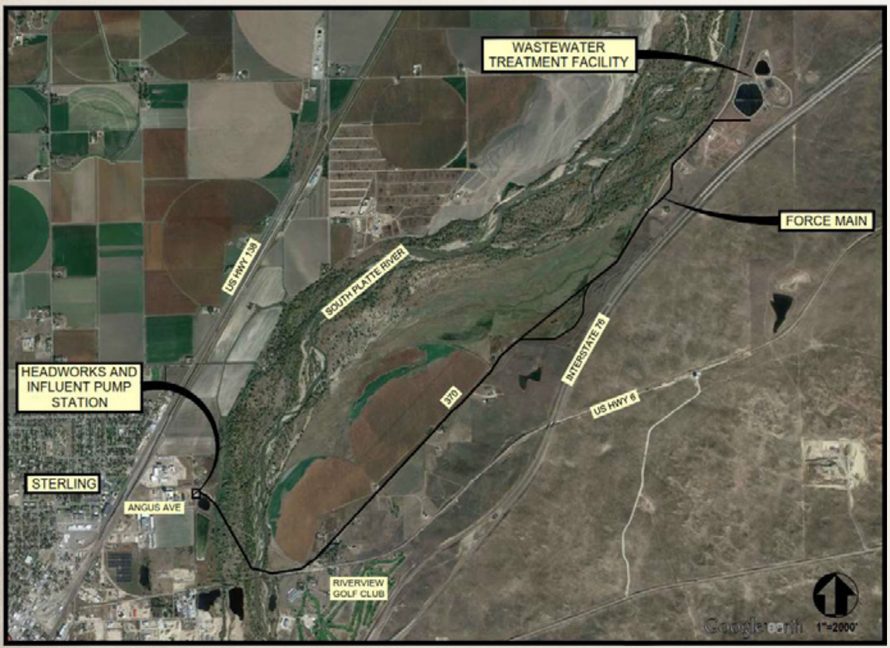


Figure 4. Aerial view for scope of project

The dual 16-inch force mains would be installed by constructing the first 24,000 feet near the existing 20-in DIP using traditional open trench methods, then rehabilitating the existing DIP by sliplining it with 16-inch FPVCP. Interconnections would be installed as well, as shown in Figure 3. Through the use of both force mains, the City was able to meet the force main capacity requirements determined by Mott MacDonald.

4.0 BIDDING

Timing for the project bid could not have been worse. When the design was completed and the bid package prepared, the world was battling the unprecedented COVID-19 pandemic and the construction market was extremely volatile. The City received several competitive bids in February of 2021. Unfortunately, both the apparent low bidder and the second apparent low bidder were unable to follow through with their initial bids and the City was forced to re-bid. Further exacerbating the situation, disruptions in the supply chain for construction materials and labor shortages started to inflate prices and lead times to numbers never seen before. The City quickly identified the issue and worked with suppliers to pre-procure materials instead of waiting until the project re-bid, which saved the City hundreds of thousands of dollars in material costs. The re-bid went out in June of 2021 and the winning bid was SMH West Construction of Castle Rock (SMH West).

5.0 CONSTRUCTION

The City was given a deadline to finish construction by 2027. Ellingson Trenchless from West Concord, MN was selected by the general contractor, SMH West, to handle the sliplining portion of the project. The 16-inch pipes were fused together and laid out alongside County Road 370, (Figures 3 and 4). Short trenches were dug to remove sections of the old pipe at the pipe entry locations, allowing the FPVCP to be pulled down the insertion ramps and into the existing pipe. The engineer located and designed the pit dimensions to minimally disturb

Figure 5. Insertion of new 16-inch FPVCP into existing 20-inch DIP

the environment and reduce the overall costs for excavation. These calculations are found in Figure 5. The insertion pit is shown in Figure 6, as well as the relatively short sections of the host pipe that were cut out and put to the side to accommodate the sliplining operations. The photo clearly shows the significant degradation of the existing pipe. Utilizing the sliplining method prevented the need of having to remove all the existing piping, which resulted in a notable reduction in equipment and construction time. Additionally, the portion of the project located near the headworks lift station had high groundwater, so using the sliplining process to minimize the amount of excavation in that area was important in limiting costs to manage the groundwater.

Before sliplining each section, Ellingson Trenchless proofed the existing pipe to ensure that it was clear of any debris, major joint deflections, or other obstructions that would prevent the existing pipe from being sliplined. The tooling used to the proof the pipe was a custom-sized reamer that Ellingson fabricated and attached in front of the pipe string (Figure 7). For pulling the pipe, a Ditch Witch JT 100 horizontal directional drilling (HDD) rig (Figure 8) was used. A custom-made pull head from Quick Connect was made for efficiently handling the pulls (Figure 9).

> Sliplining provided a cost effective and efficient method.

The sliplined portion of the project was broken into 21 separate segments with a variety of different pull lengths. The shortest pull length was 177 feet and the longest was 2,659 feet through an environmentally sensitive wetlands

Figure 6. (Left) Insertion pit. (Right) Deteriorated old force main segments extracted at access pit locations

area. Avoiding disruption to this area was a key factor in the design and selection of the slipline construction method. Many of the pull lengths were in the range of 800 to 1,500 feet. Conventional mechanical joint fittings were then used to tie all of the separate runs together at the pit locations. Throughout the entire project, Ellingson mobilized to the jobsite three separate times and successfully sliplined over 19,000 feet of 16-inch FPVCP inside the existing 20-inch ductile piping.

Figure 7. Custom-made proofing reamer

Figure 8. HDD rig for pulling pipe

6.0 CONCLUSION

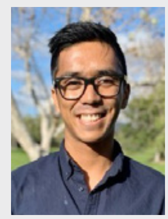
The Sterling Wastewater Improvement Project resulted in successful improvements to a portion of the City's infrastructure that was reaching the end of its useful life. The recommendations for the improved force main and its ultimate construction were a joint effort between the City, their engineer, the low bid contractor, and the material suppliers. The alignment of the existing force main required a solution that would minimize disruption to the environment while also utilizing the existing infrastructure to minimize the overall project costs. The use of sliplining provided a cost effective and efficient method to install a redundant force main that will yield a dramatic improvement in the reliability of the City's infrastructure.

Figure 9. (Left) FPVCP pipe sliplined with custom-made pull head. (Right) Pipe being pulled to get into position to for connection

7.0 REFERENCES

Mott Macdonald, (2020). *Sterling Wastewater System Improvements Project Engineering Report.*

ABOUT THE AUTHOR:



Michael Perez *is an Applications Engineer for Underground Solutions®, Inc where he provides technical engineering support for trenchless construction projects. He holds a Bachelor of Science in Chemical Engineering from the University of California San Diego.*

Right the First Time

Claude H. Nix Core Values Lead to Purchase of GEONEX System

By: Richard Revolinsky, Geonex Inc, (GEO)

In November 2024, after successful completion of their first GEONEX™ project in Boise ID, Utah based contractor Claude H. Nix (C.H.Nix) took the next step in expanding their trenchless capabilities with the purchase of a complete GEONEX™ Horizontal Hammer Boring system (HHB), making them the western-most U.S. based contractor to do so.

C.H.Nix is not new to trenchless construction. For the past 50 years since Claude and Barbara Nix opened their doors in 1974, the company has built a reputation for reliability, professionalism, and a commitment to offering the right solutions for the project. Barbara and Claude believed in doing it right the first time, a core value that lives on today under the leadership of sibling team Stephanie Nix-Thomas and Jon Nix who purchased C.H.Nix in 2002.

C.H.Nix owns and operates a fleet of trenchless equipment for both new installations and rehabilitation that continues to evolve alongside the technological improvements of the trenchless industry. Whether using their GBM equipment, Auger Boring systems, steerable heads, or pipe-rammers, C.H.Nix is willing to invest in the right tools to get the job done right the first time.

> There's just so much tough ground that the system is perfect for.
>
> - Jon Nix, Vice President/COO, C.H.Nix

Jon Nix recalls when pipe ramming, first came along. "We rented one for the first project and I thought wow, this can really help in some of the areas we get into. We bought one, learned how to use it well, then bought the second, then the third. Adding these tools to our tool box and getting-in on the ground floor allowed us to use the technology to our advantage, getting more work and completing it faster. Where other methods struggled, we were able to be successful. Now there's a lot of pipe ramming

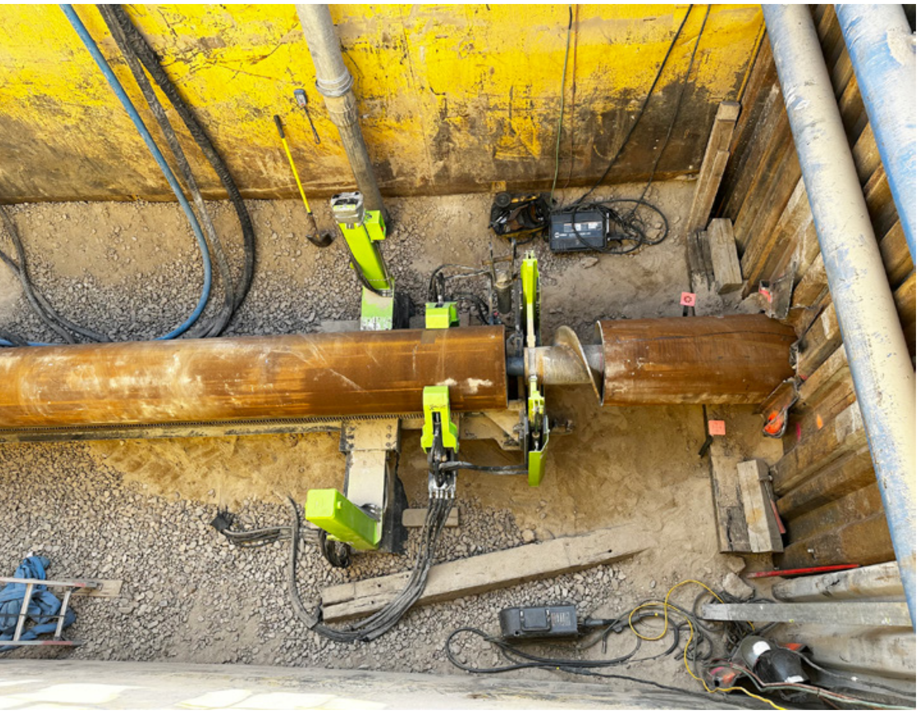

Only C.H. Nix offered an alternative solution to what was attempted previously

Horizontal Down-Hole Hammer Boring is a trenchless method for new installations

> Because of the risk using water we had to find a different solution.
>
> - Stephanie Nix-Thomas, P.E., President/CEO, C.H.Nix

contractors out there, and we believe the same thing will happen with GEONEX™. There's just so much tough ground that the system is perfect for, instead of fighting it we'll be confident we can get through like we did in Boise."

The Boise project Jon referred to was their first GEONEX™ installation, a 300-foot installation of 24-inch casing under parallel railway and roadway which would ultimately be used for electrical conductors for a new solar project. After previous and unsuccessful attempts by a different contractor, the electrical subcontractor contacted C.H. Nix and other trenchless contractors to investigate what they thought would be the best approach. Only C.H. Nix offered an alternative solution to what was attempted previously. "The ground was a hard, compact silty clay that was almost like rock, but if you add water it would quickly lose any form," explained Stephanie Nix-Thomas. "Because of the risk using water would add to possible failure of the railroad, or roadway we had to find a different solution. Pipe-ramming was prohibited and probably wouldn't make the 300-foot length. Auger boring had failed before so they didn't want to try it again, so we thought 'what about GEONEX™ ?'."



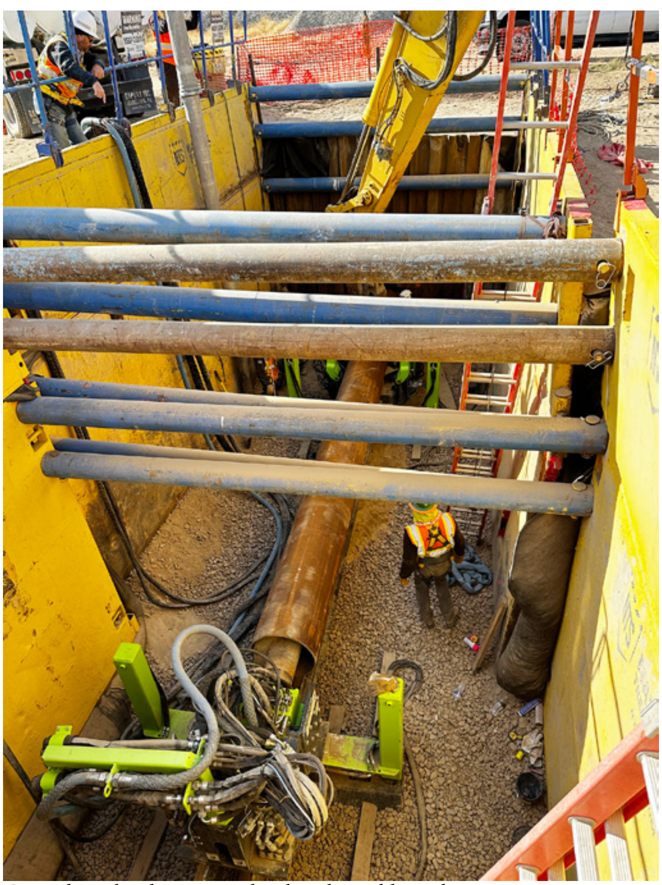
Project installed 300 feet of 24-inch casing for electrical conductors under parallel road and railway

C.H. Nix is looking at other projects to identify where horizontal hammer boring is best suited

> "We wind up doing a lot of projects after first attempts with other technologies fail.
>
> - Tuomas Lassheikki, Vice President, GEONEX Inc

C.H.Nix reached out to Geonex who evaluated the potential for success and risk on the project and began preparing documents for C.H.Nix to present to their client. Within a few short weeks C.H.Nix got the green light to proceed.

"It's become a pretty common scenario for us," explained Tuomas Lassheikki, Vice President of GEONEX Inc. "We wind up doing a lot of projects after first attempts with other technologies fail. Projects run into problems with cobbles, hard rock, or something and we get the call asking if our equipment can get through it. We'll look at the installation and situation and discuss the pros and cons, then typically recommend they call one of our clients to do the work." In 2023 GEONEX clients accounted for 10 Units in North America, two years later there are 16. "Not every contractor has the ability to jump across the country to perform an installation when someone needs help, so in 2023 we started to offer a rental. This allows us to help in these situations and also showcase to the industry how HHB can be beneficial."



Ground was hard compact silty clay almost like rock

Pounding the way to success, the installation in Boise was completed to the satisfaction of the General Contractor, the project owner, and to the C.H.Nix team. Having become more familiar with the GEONEX™ system and trusting in the feedback from their field crews, Jon and Stephanie started looking at some of their other projects and identifying where they felt horizontal hammer boring would be better suited. "We have work on the books that we think there's a greater opportunity for success by using the GEONEX system, and we've had jobs over the past few years that were just too risky that we passed on. It made a lot of sense to buy our own GEONEX system now," said Jon.

C.H.Nix received their GEONEX HZR610 Drill Machine capable of installations of steel casing up to 30-inch diameter in late February 2024. "Our first project is scheduled for April this year," explained Stephanie, "and we have a few more lined up after that in 2025 as well."

ABOUT THE AUTHOR:

***Richard Revolinsky** is the North American Operations Manager for Geonex Inc. He is committed to furthering the Trenchless Construction industry with viable innovative solutions.*

Getting the Flow to Go – Twin 84-inch TBM Installation with HDD Support

By: Sean Weddingfeld, BTrenchless
John Beckos, P.E., Btrenchless
Cody Telgheder, P.E., Nicholson Construction

Project Background and Overview

The City and County of Denver has experienced persistent flooding issues in the Upper Montclair Basin for decades. This is due to a significant portion of the existing stormwater infrastructure being installed in the 1930s; a system that is now undersized and aging.

The continual population growth along the Denver front range poses challenges to this aging infrastructure and necessitates the development of new infrastructure to meet the rising demands. The Upper Montclair Basin is the largest drainage basin in Denver that does not have an open waterway. This includes the neighborhoods of Bellevue-Hale, Congress Park, Crestmoor, Hilltop, Mayfair, Montclair, & South City Park. These areas have consistently flooded, damaging homes, businesses, infrastructure, and vehicles over the years.

In 2017 Denver Public Works began a study to evaluate the area and how they could identify and better manage the basin through green infrastructure, better land use, & updated infrastructure to improve storm drainage volume and enhance system reliability. This undertaking encompassed the creation of the Jackson Street Storm project which was divided into three different phases for installation of 110-inch fiberglass Reinforced Polymer Mortar Pipe (RPMP). Phase 1 was for approximately 683 feet, phase 2 had over 1,000 feet, and phase 3 is yet to be finalized. Phase 2 also includes our twin 140-foot-long tunneled sections of 84-inch (RPMP).

The 84-inch pipes were designed to traverse underneath Colorado Boulevard with an invert max depth of approximately 24 feet. The groundwater table elevation that was encountered during the subsurface investigation was approximately the same depth as invert of the 84-inch pipes. The soil conditions for the trenchless drilling primarily consisted of sandstone with a portion of alluvium above and the bottom couple of feet being claystone.

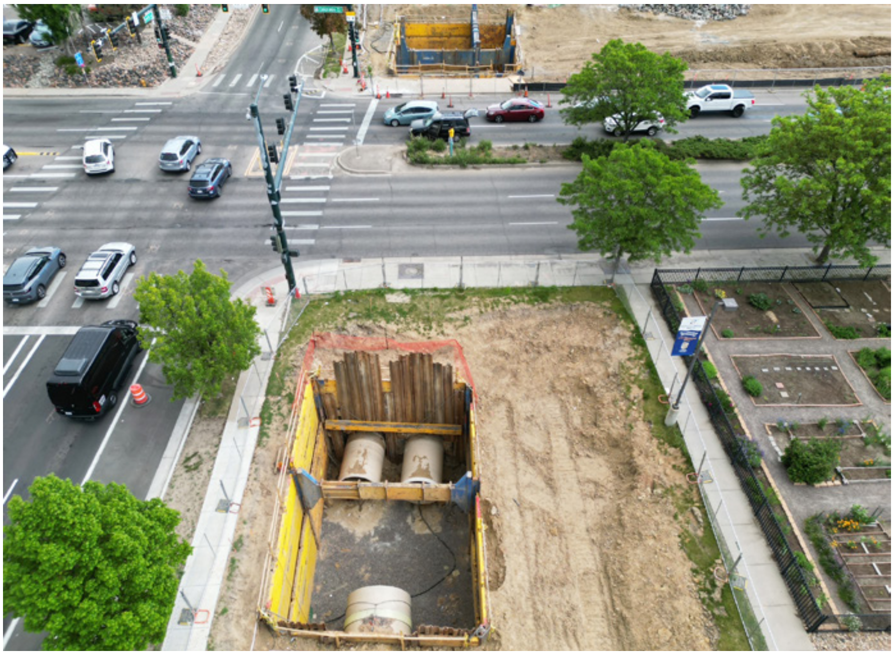


Figure 1. Bore traversing under Colorado Boulevard

Soils, Groundwater, and Soil Treatment

A geotechnical baseline report (GBR) was prepared for this project by Lithos Engineering, now GEI Consultants. This report outlined the expected soil conditions within the construction shafts and the tunneling profile. For the shafts and the tunneling profile the anticipated soil makeup was comprised of fill, alluvium, sandstone, and claystone. The invert of the tunnels was expected to be above ground water levels. However, the general contractor, Iron Woman Construction (IWC) would be installing dewatering pumps in their excavation pits to eliminate any potential water issues.

Perhaps the largest concern during the bidding phase was how to eliminate the potential for any roadway settlement during the tunneling operations. With this being one of the most traveled areas of the

Figure 2. Project location map in relation to Downtown Denver, City Park, & the Denver Zoo

Figure 3. Jackson Street Project Map for Phases 1, 2, & 3

Front Range, no chances could be taken in possibly shutting down the road for settlement issues. To solve this problem, conversations were held during the bidding phase between IWC, BTrenchless, and Nicholson Construction. It was assumed the closures of lanes of Colorado Boulevard would be allowed during the daytime to perform the permeation grouting. However, approximately one week prior to the bid date, the City & County of Denver (CCD) decided that daytime closures would not be allowed and that only nighttime closures would be allowed. This might have been an acceptable solution if this work was to take place during the summer months, but this work was going to need to be completed during the winter months.

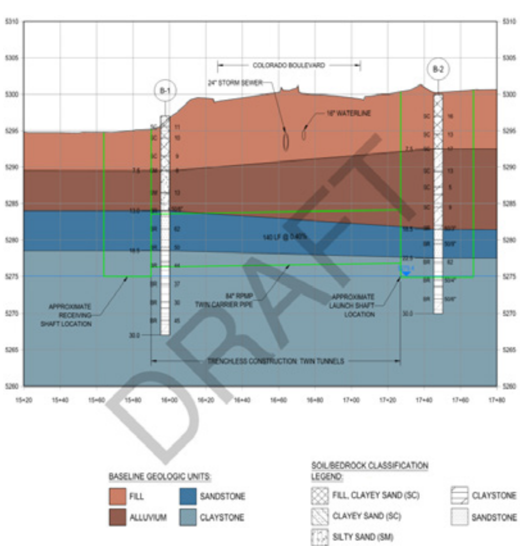


Figure 4. Geologic Profile

Horizontal Directional Drilling to the Rescue!

Traditionally, this method of permeation grouting would be accomplished with vertical drilling. However, due to the traffic restrictions, a different methodology was needed. Nicholson proposed a plan to perform horizontal directional drilling (HDD) to inject chemical grout between the launch and receive pits. They've used HDD techniques on many projects over the past decade including under historical buildings, airport runways, and even nuclear facilities.

Nicholson quickly recognized that acrylamide chemical grouting was the most effective solution for constructing the tunnels in the high fines content soils as seen on this project with up to 31 percent. The permeation grouting profile shows the anticipated areas of fill, silty-sand alluvium, and underlying sandstone rock on the project in relation to the tunneling areas.

Permeation grouting was proposed to create a treatment zone that would mitigate the risk of unraveling the alluvium above the tunneling which could cause settling or possible sink holes. The grouting was planned for a depth of 13 feet to 18 feet below the driving surface of Colorado Boulevard. This would also put the grouting layer at the top of the tunneling profile. The width of the zone was 24 feet by approximately 5 feet in height, which was sufficient to cover the tunnels.

Nicholson performed this horizontal drilling by setting up their operation in the lot on the East side of Colorado Boulevard. Two rows of drilled holes then angled to 13 to 16 feet below grade, then straightened across the entire 140-foot length of the planned tunnels, before angling back up on the West side. Due to the angling down and up, the overall length of these holes ranged from 380 to 420 feet. There were 9 primary and 8 secondary locations for a total of 17 holes. The drilling was completed with multi-port sleeve pipes for the grout injection. This allowed specific volumes of grout to be pumped in at exact locations. The drilling and grouting process allowed for a stable canopy to be installed prior to any excavation or tunneling activities taking place.

Excavation & Tunneling Method Selection

The excavation of the pits was challenging for several reasons. The first reason is that both pits needed to be large enough to accommodate the room needed

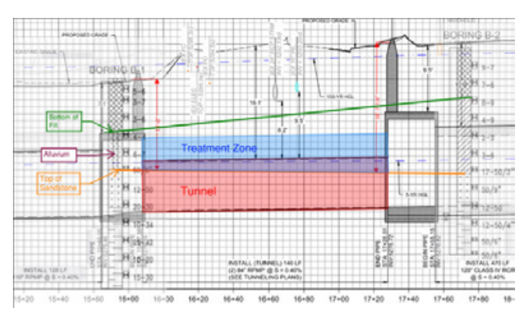


Figure 5. Permeation Grouting Profile

> Perhaps the largest concern was how to eliminate the potential for roadway settlement during tunneling.

for the tunneling equipment. During the bidding phase, it was determined to go with a Tunnel Boring Machine (TBM) option for the tunnel. Other options considered were a hand tunnel and a micro tunnel. Due to the length, material, and size of the pipe to be installed, a closed face TBM was the consensus. The launch pit was determined to be optimally located on the southeast corner of the intersection and the receive pit being on the southwest corner.

A concern during the bidding process for BTrenchless was the general contractor needed to know how large the excavation pits needed to be. Both pits would need to be large enough for the follow-on construction of the concrete vault diversion structures, but the east pit also needed to be able to accommodate the TBM setup. This included the drill head, power pack, and skids. For the East side the excavation pit would need to be 40 feet long by 25 feet wide at a depth of 26 feet. For the West side there only needed to be enough room to pull the drill head out so this pit was only 30 by 25 feet and a depth of 22 feet. Due to these sizes, traditional trench boxes were not considered, and a slide rail system was installed.

Primarily due to the over abundance of caution in any potential roadway settlement, and even with the grouting canopy from Nicholson, BTrenchless planned to use a closed face TBM. This would allow greater cutting face control to better track how much material was being removed as the TBM face advanced. A closed-face TBM has a shield that entirely covers the excavation face and is typically used in unstable ground to prevent any additional material from being excavated other than what is desired. However, from multiple site visits during the installation process of the slide rail system it became apparent that there was no concern of the material sloughing off and creating void spaces. In fact, the material was so strong and competent, there was additional time and effort expended by IWC just to get the material removed to allow for the full depth installation of the slide rail system. Seeing this, the decision was made to switch to an open-faced system. This decision was made approximately 1 week from BTrenchless mobilizing to the site. Going to an open-faced system would also allow for increased production rates.

BTrenchless used the Akkerman 5200 Series Pump Unit along with the 5000 Series Skid. This equipment is paired with a thrust yoke that is appropriately sized for the pipe that is to be installed. The thrust yoke transfers the thrust from the pump unit to the drill face. Sitting just on the inside of the drill face are the steering mechanisms and a seat where that operator monitors the drilling activity. As the TBM face cuts into the material, those shavings are then collected and deposited onto a conveyor belt which transfers the material to a soil cuttings bucket. Once that bucket is filled, it is then pulled back along the rails within the previously installed pipe, until it sits outside the last piece of pipe placed on the tracks. The excavator (CAT 390 on this project) that is sitting outside the top of the slide rail system, then grabs the bucket, and empties its contents into the spoil pile, before returning it back to the tracks to go back to the front of the tunnel. This process works great but, does have its limitations. Primarily due to the distance of the tunnel being excavated. On shorter tunnels like this one, the amount of time lost for the bucket to travel from the TBM face to the excavation pit and back, is minimal. However, on longer runs the amount of time that the crew will be sitting idle, and no drilling happens, while the bucket is in transit can devastate production time. Once that becomes more of a factor, a micro tunnel might be a more cost-effective solution. Micro tunnels do come with a very large upfront cost though.

Materials and Modifications

The GBR indicated drilling would be through two primary materials. The majority would be a sandstone layer on top of a layer of claystone. The sandstone layer was labeled at 250 PSI (pounds per square inch) and the claystone was at 200 PSI. Once

Figure 6. TBM arrives safely

the TBM equipment was set up and drilling commenced, it was noticed very soon by our team that the material seemed to be significantly harder. Within a couple of days this was needing to be confirmed by testing. A core drill company was arranged to come out to the site and take samples. During the project, this company was asked to come out two more times as the material would seem to get a bit soft and then other areas were very hard. This harder material had a significant impact on the drilling as the wiper bars were bending and breaking off. Other modifications had to be made to the drill face as well. Once the testing results came back, they ranged from 264 to 513 PSI. This area seemed to have varying layers within short distances. The two bore logs that were done had one directly in the receive pit and the other one was approximately 60 feet South of the launch pit at the tunnel face. There was no bore taken directly in the middle, in the tunnel profile due to the complexity of obtaining one in the middle of Colorado Blvd.

Solutions and Lessons Learned

Three key takeaways emerged from this project:

1) While geotechnical reports provide valuable insights, firsthand knowledge is invaluable. When feasible, increasing the number of borings is advantageous in preparation of the Geotechnical Baseline Report (GBR). However, challenges arise when surface obstructions limit access for data collection. Collaborating with stakeholders and maximizing available information is crucial in such situations.

2) Update Maintenance Schedules Based on Experience: During the installation of the second tunnel an electrical breaker met its maker and had to be replaced. There was none in the Denver area and a new one had to be overnighted from out of state. Drawing from project experience, it is essential to update maintenance schedules for tunneling equipment. Proactively replacing parts approaching the end of their service life and maintaining a stock of spare parts can mitigate unexpected delays.

3) Preplanning and Early Coordination of Partners is Critical: There was a lot of communication that needed to happen on this project even prior to bidding. Then with the change of traffic closures just prior to bidding, a new solution was needed. This was something that all three parties (IWC, Nicholson, BTrenchless) needed to agree on. This allows partners to define and evaluate risks throughout a project's lifecycle.

ABOUT THE AUTHORS:

Sean Weddingfeld *is a Project Manager with BT Construction in Henderson CO. After graduating from Colorado State University, Sean gained experience in commercial, soil stabilization, heavy highway, and bridges as both Project Manager and Estimator. Since joining BT, he has been the PM on a variety of projects. From traditional bid/build projects with HDD, auger bores, and TBM, to a CMGC with a bore under 5 railroad lines and 3 different owners, and for the Xcel Energy Steam Line Distribution system in downtown Denver.*

John Beckos, P.E.*, is a Senior Project Manager and Estimator for BTrenchless. Since becoming a part of BT in 2013, he has been involved in a wide range of trenchless underground projects, encompassing various aspects of the work, including: Auger Bores, Guided Bores, Hand Tunnels, Pipe Ramming, McLaughlin Boring, Microtunneling, TBM's, Pipe Bursting, Slip Lining, and Horizontal Directional Drilling.*

Cody Telgheder, P.E.*, is the Operations Manager for the Rocky Mountain Region of Nicholson Construction Company, the US subsidiary of Paris-based Soletanche Bachy, one of the world's premier geotechnical general contractors. Cody has been involved in the construction industry since 2010 and within the geotechnical construction industry since 2014. He has worked on a wide variety of projects covering deep foundation, earth retention and ground treatment applications, with specific expertise focusing on Micropiles, Soil Nail Walls, Anchors, Permeation Grouting, and High/Low Mobility Grouting.*

GBRs on Trenchless Projects - Are they working?

By: Kimberlie Staheli, Ph.D, P.E. Staheli Trenchless Consultants Inc.

1.0 ABSTRACT

Geotechnical Baseline Reports (GBRs) were developed to be a risk sharing mechanism between the Owner and the Contractor and introduced to the trenchless sector over 20 years ago. Complex trenchless projects often have a GBR that is intended to define the conditions that constitute a differing site condition, allowing the Contractor to be eligible for payment under the contract's Differing Site Condition (DSC) clause. However, GBRs have often been used by Owners and Engineers as a risk-shedding document instead of a risk-sharing document. This paper details case histories where GBRs were included in the contract documents but were not effective in defining a DSC, leading to disputes over the validity of a differing site condition claims. The case histories focus on how the GBRs were executed during construction and the impacts of GBR statements on claims and disputes. It details a number of DSC claims were filed, the execution of the GBR and whether it was an effective tool when determining the existence of a DSC, and whether the GBR met the goal of sharing risk between the Owner and Contractor.

> Each trenchless method offers a unique risk profile.

2.0 INTRODUCTION

One of the critical elements of any design for a new pipeline installed with trenchless construction is the identification of construction risks. Inherently, trenchless construction carries more risk than open-cut construction. Therefore, quantification of trenchless risk is a critical portion of the design. Most trenchless risks are geotechnical in nature and rely on the site-specific geotechnical information and experience of the Engineer and the Geotechnical Engineer of Record (EOR). A trenchless risk register is used to identify and compare the risks associated with different trenchless techniques.

The trenchless EOR must be familiar with the intricacies of the trenchless method under consideration to identify a comprehensive list of risks. Significant risk elements with high impacts can be overlooked when choosing a trenchless method if the designer does not have design and construction experience. To select the most appropriate trenchless method, the EOR must understand what can go wrong during construction and what is necessary to overcome specific risk elements. Each trenchless method offers a unique risk profile that is specific to the capabilities of the technology and the challenges of the geotechnical conditions.

> Inherently, trenchless construction carries more risk than open-cut construction.

An example would be the selection of the appropriate trenchless method for a pipeline installation where the geotechnical conditions are known to have cobbles and boulders. If microtunneling, auger boring and pipe ramming were all considered feasible for a project, it would be necessary to evaluate all three methods with the consideration of the impacts of cobbles and boulders. In this example, the probability of encountering cobbles and boulders is the same for all three trenchless alternatives; however, if cobbles and boulders were to be encountered on the project, the impacts to the project would be significantly different:

1. Microtunneling. Encountering cobbles and boulders may result in a microtunneling machine getting stuck. There are a number of mitigation measures that can be considered including digging up the machine or a compressed air intervention, both of which are extremely expensive. In addition, there have been projects on which microtunneling machines have been abandoned because machine recovery was not possible. (Staheli, 2007)
2. Auger Boring: Encountering cobbles and boulders may result in the inability to move the auger boring machine forward. Cobbles and boulders can also lock the auger flights. The mitigation for such a risk typically involves pulling the augers from the casing and sending personnel to the face to remove the offending rock from the auger flights, both of which are relatively inexpensive.
3. Pipe Ramming: cobbles and boulders are typically considered low impact items because pipe ramming is uniquely suited to installing pipelines in boulder and cobble environments without getting stuck.(Staheli, et. al, 2018). However, even if the pipe ram were stuck, there is no equipment at the face of the tunnel that gets "lost down hole."

This comparison illustrates the importance of evaluating different trenchless methods for a pipeline installation to ensure that the method selected has a risk profile that is in concert with the Owner's risk tolerance.

3.0 MANAGING RISK

On any pipeline project that includes open cut and trenchless installations, the trenchless installations are much higher risk than the open cut portions of the project. Risk analyses are of critical importance to successful trenchless design and construction. As the industry has evolved, Owners and Engineers have used geotechnical baselines reports (GBRs) to manage trenchless risk.

Evolving forms of the GBR have been used on construction projects since the early 1990s (Essex, R. ed., 2022). GBRs were traditionally used on conventional tunneling projects to ensure that all bidders were using the same basis to prepare their bid, including the amount of risk that was included in the up-front cost of the project. This approach allows the Owner to decide if they want to pay for risk recovery in the base bid cost or whether they prefer to negotiate a change order if the risk event occurs. As the trenchless industry has evolved, GBRs have been incorporated into contract documents, largely guided by the ASCE publications that provided guidance on the development of the GBR.

The first ASCE guidance publication was entitled "Geotechnical Baseline Reports for Underground Construction – Guidelines and Practices" and was published in 1997 (Ed. Essex. R. 1997). The publication has been updated twice providing additional guidance for effective ways to prepare baseline reports. The latest version is entitled, "ASCE Manuals and Reports on Engineering Practice No. 154. Geotechnical Baseline Reports suggested Guidelines" was published in 2022 (Essex, R. ed., 2002). The 2022 is the first edition to reference trenchless technologies. No specific guidance is provided for trenchless applications; however, the document states:

> *"For the purposes of this book, tunnels include jacked pipe, microtunneling, and horizontal directional drilling applications."*

Microtunneling is the most common trenchless technique on which GBRs have been included in the contract documents. However, the GBR has proven to be a largely ineffective way to share risk on many microtunneling projects. Their ineffectiveness is largely because of the difficulty in determining whether the geotechnical conditions encountered reflect the presence of a differing site condition. The closed excavation face on a microtunneling machine does not allow observation or measurement of the material at the face, leading to man disputes over whether the baselined condition was actually encountered.

4.0 ADDRESSING TRENCHLESS RISK

The GBR is intended to be a risk sharing mechanism where the Owner decides specific risk items that they want to share with the Contractor. The Owner/Engineer identifies specific risk elements in the project to include in the GBR if they want to share the risk cost allocation with the Contractor. If the Owner has a risk tolerance that allows risk sharing, the specific risks are addressed in the GBR, and the terms of the risk sharing are identified accordingly. If the Owner is risk averse, they may elect to put all construction risk on the Contractor, negating the purpose of the GBR. Risk sharing should result in a lower bid price; however, if specific risks (constituting a differing site condition) are realized during construction the Owner should expect to compensate the contractor in a fair manner for the costs associated with the risk event. Additional payment for recovery from the risk event is executed according to the differing site condition (DSC) clause, typically included in the general conditions of the specification.

Theoretically, this approach allows the Owner to dictate the risk costs that are carried in the Contractor's bid price. However, in a low-bid environment, if the contractor includes the cost of risks apportioned to them as detailed in the GBR, they likely won't be the low bidder. As such, many contractors do not include the risk costs that were outlined in the GBR in their bid. Instead, if a risk is realized, a claim will likely be provided to the Owner for additional project costs or schedule, regardless of any GBR statements. These claims are often focused on the interpretation of the baseline statements, and whether any condition at the site was different than the baselined parameter, regardless of whether the baselined parameter was the primary cause of the damages.

If the contractor does not price the risk in their work, a differing site condition dispute arises, whether or not the DSC relates to the GBR. If the dispute raises to the level of litigation, the contractor then argues about the interpretation of the baseline statement rather than the conditions that were encountered and how they impacted construction. The GBR must be concise with specific quantified baseline. If a histogram of parameters is included in the baseline, the baseline value must be clear. The histogram helps the Owner understand the probability of encountering the baseline condition; however, it is not a baseline as it would allow the contractor to make a reasonable interpretation of the data in the histogram. The Contractor's interpretation of the histogram could be completely different than the interpretation of the Owner. For the GBR to effectively provide risk sharing between the Owner and the Contractor, it must include a specific baseline value.

Often the GBR statements are not clearly written, making it very difficult to determine if a DSC exists. If a GBR is written such that a DSC can't be determined, either because the GBR is ambiguous or it is not possible to observe the conditions at the face of the excavation, the dispute then changes focus and is evaluated by what a reasonable contractor should have expected given the information provided in Geotechnical Data Report (GDR). When this occurs, the GBR does not fulfill the primary purpose of allowing determination of a differing site condition. In fact, the poorly-written GBR can be very disadvantageous to the Owner during dispute resolutions, especially in the courts, and the Owners attempt to risk share is negated (Parnass, 2013). Many Owners that have included a poorly-written GBR in the project document have negative experiences, even after they have invested a considerable amount to get site-specific geotechnical information and the development of the GBR, to find out it does not serve the intended purpose.

5.0 THE MISSING PIECE

The ASCE GBR guidance (Essex, R. ed., 2022) provides a section of the purpose of a GBR:

*"the principal purpose of the GBR is to set realistic, **measurable, and observable** baselines that represent the best estimate of the subsurface conditions that will be encountered during construction. In doing so, the bidders are provided with a single contractual interpretation that can be relied on in preparing their bids and in the **administration of the DSC clause in the contract**." (Essex, R., ed., 2022; highlights added).*

There are key words in the defined purpose of the GBR that need to be considered carefully by the Owner, Engineer and Geotech before deciding if a GBR is appropriate on trenchless projects:

5.1 Measurable and Observable Baselines

It is crucial that the author of the GBR considers whether the Baseline is both measurable and observable. However, on many trenchless installation techniques do not allow observation of the excavated material or a way to measure the quantity of a specific geotechnical parameter to determine if the material encountered during installation is more averse than the baseline.

For example, in horizontal directional drilling (HDD) applications the in-situ soils are not available for examination as the borehole is supported by drilling mud. Any excavated material is pulverized by the drill bit, dramatically altering them from their in-situ conditions, and making it very difficult to determine whether the conditions encountered on the project were materially different from the conditions represented in the contract, let alone determining if a baselined parameters were exceeded.

This is also true of microtunneling where the soil at the face of the microtunnel machine enter the machine by way of a rotating cutter and advance into the soil mass. The material is then crushed to a particle size of approximately one to two inches (depending on the machine manufacturer). That material enters a slurry chamber where it is mixed with slurry and transported from the machine to the ground surface using pumps. The maximum size of particle is often dictated by the size of particle that can move through the slurry pumps. In turn, the size of the slurry pump is often dictated by the size of the machine, which simply may not have sufficient space to use larger pumps.

When the slurry containing the excavated material is pumped to the ground surface, it typically passes through a slurry separation plant that separates the particles by size. Figure 1 shows a portion of a typical slurry separation plant used on microtunneling projects. This photo shows the "coarse screen" on the plant that retains the larges particles that are within the slurry.

On microtunneling projects, baselines for cobbles and boulders are often included in GBRs, providing definitive sizes or numbers of each, alerting the contractor to prepare their bid according to the cobble and boulder baseline. Since neither cobble nor boulder size

Figure 1 Coarse Screen on Microtunneling Slurry Separation Plant

particles can pass through the slurry, it is not possible to determine if cobbles or boulders were encountered during normal microtunnel operations. If the Owner elected to include a baseline in the GBR that indicated two boulders of a specific size would be encountered during microtunneling, it is not possible to ***observe and measure*** the baselined parameter unless the machine is exposed after it has become stuck. However, microtunneling is commonly used to install pipelines beneath a feature such as a river, roadway, railroad, or wetland. It can be difficult to get permission from the permitting agencies to construct a rescue shaft at the location where the microtunnel is stuck, eliminating the opportunity for the material to be *observed and measured*. In addition, microtunneling is commonly used beneath the groundwater making it difficult to observe the actual conditions at the face, even if the machine has to be removed from the ground at the location where it became stuck.


Figure 2. Launch Pit

5.2 Administration of the Contractual DSC Clause

Whether or not a GBR is used for risk sharing in a contract, the mechanism of payment should be the Contract's DSC clause. It is important that the GBR not repeat or redefine conditions of the GBR as there is a risk of negating the DSC language that is typically in the project General Conditions. As such, Courts can find that the direction within the GBR may have been intended to negate some of the provisions of the DSC clause that has historically been the contractual language that provides provisions and mechanisms that must be followed to show entitlement of additional payment by the Owner.

5.3 Dispute Resolution

The ASCE 2022 guidelines include four critical key provisions that are necessary on underground projects from the publication Avoiding and Resolving Disputes During Construction (as cited in Essex, R., ed., 2022):

1. Differing Site Conditions (DSC) clause
2. An interpretive geotechnical report, at the time called a Geotechnical Design Summary Reports (GDSR) – A GDSR was intended to reflect the designer's anticipated subsurface conditions and their impact on design and construction. The title was later changed to Geotechnical Baseline Report (GBR).
3. Escrow Bid Documents (EBDs) – submitted at the time of bidding, preserve the contractor's calculation and the information used in preparing the bid so the information can be reviewed, if required, to assist in the resolution of a dispute.
4. Disputes Review Board (DRB) – A three-person board, mutually selected and agreed on by the Owner and Contractor with knowledge and technical expertise in the type of project to be constructed. The DRB is formed following contract initiation to foster cooperation between the parties to provide for prompt and equitable resolution of disputes.

Of these provisions, the most critical element is the inclusion of the DRB. The DRB, as defined by number 4, is intended to be the body that provides a resolution to a dispute. Further, it is intended to provide a recommendation for resolution without the need to use the legal system. If a DRB is not used, and the Contractor and Owner can't agree on the existence of a DSC claim, the only remedy for the Contractor to obtain additional payment is to file a lawsuit against the Owner. The disadvantage with this approach is that the judge or jury may not have sufficient geotechnical knowledge or knowledge of the trenchless method to make an informed ruling. In addition, a Judge most commonly rules in accordance with standing legal precedent, which may resolve the dispute that is not in accordance with the conditions set by the GBR.

Although GBRs have been used on many trenchless projects, very few trenchless projects use a DRB for dispute resolution. As such, when a dispute arises on a project, claims that are unable to be resolved on the project are adjudicated through the legal system, resulting in tremendous costs to both the Owner and Contractor for legal representation and technical experts.

6.0 CASE HISTORIES AND THE APPLICATION OF GBRS ON TRENCHLESS PROJECTS

Some trenchless methods do allow observation and measurement of parameters that are baselined such as cobbles and boulders. These technologies include open shield pipe jacking, auger boring, or pipe ramming, where there is clear access to the face. These methods are feasible in conditions that are above the groundwater or the groundwater is controlled such that material does not flow into the face of the excavation. The case histories are included to illustrate how GBRs can be ineffective and effective on trenchless methods where face access, visual observations, and measurements of materials encountered are possible. This section presents two Open Shield Pipe Jacking projects on which a GBR was included and illustrates impact of the GBR on resolving disputes.

6.1 Case History #1

This project included several pipeline segments that were specified for installation with open shield pipe jacking as required by the Contract Documents. The geology of the project included glacial till and glacial outwash at the face of the excavation. The Owner elected to use a GBR to reduce the risk of litigation on an unresolved claim. However, this project did not include a DRB.

In the glacial soils, the presence of cobbles and boulders was identified as a risk to the trenchless installation. The Geotechnical Engineer of Record wrote the GBR and recommended baselines to the Owner that were ultimate included in the Contract Documents. The GBR classified the geotechnical conditions by defining Baseline Engineering Soil Units which included 8 different soil units – four of which were defined as Non-Overridden Deposits and four defined as Glacially Overridden Deposits. Baselines for each tunnel drive were defined as the volumetric percentage of the soil unit that would be encountered during the tunneling. Figure 3 shows the baselined ground conditions on two tunnel segments on the project.

There are three important things to note:

1. The baselined conditions for Subreach 1 contained two soil types: one classified as non-overridden deposits and the other as glacially overridden deposits. These baselined definitions for the two soil units were very similar except for density, with the glacially overridden soil that was the denser unit.
2. The upper end percentages add up to more than 100 percent, making the baseline ambiguous; and
3. The baseline is based on a volumetric analysis – also undefined. If the intention of the baseline was to be the total volume of the tunnel, all spoils would have to be saved and the material percentages evaluated after excavation when the in-situ density is unknown. This is very difficult if possible. However, the Contractor argued that they interpreted the volumetric analysis to be measured at the face of the machine at any one time. The actual intent of the GBR was later clarified by the author; however, this was during a DSC dispute that eventually led to a lawsuit.

In addition, the note beneath the baseline states that the contact between the two materials will occur between the crown and the invert of the casing. This baseline was odd as if the tunnel was expected to encounter two different materials, there would have to be a contact that was within the cross section of the tunnel.

Subreach 1: STA 7+65 to STA 11+90

ESU	Percentage
RGD	55 to 65
TLD	35 to 45

Note: the RGD/TLD contact is between the crown and invert of the casing.

Figure 3 Soil Unit Baselines contained in the GBR on Case History #1

Subreach 1: STA 7+65 to STA 11+90

Boulder Size (feet) *	Number
1-3	51
3-5	3
5+	1

Figure 4 Boulder baseline in the GBR for Case History #1

On this project, the Contractor filed a DSC claim. The definitions of the baselines were so vague and subject to multiple interpretations. As such, there was no clear way to evaluate the DSC by the Owner or the Contractor, making the baselines ineffective.

On the same project, the Geotechnical Engineer baselined the incident of boulders on which the contractor should expect (and include in their bid price) as shown in Figure 4.

The project included the installation of a 72-inch casing installed by Open Shield Pipe Jacking. It is unlikely that a boulder of 3-foot diameter could be excavated by the machine and would likely require intervention. According to this baseline, the contractor was to include 51 incidents of removing 3-foot boulders from the face within the bid price. On a drive length of 425 feet, the boulder baseline would have required that the contractor plan for face intervention on a possible 55 occasions prior to exceeding the baseline, four of which would likely require excavation from the surface or extensive work from within the tunnel shield.

The Contractor did not include these costs in the bid. Clearly, the low bid contractor could not include all of the boulders baselined and develop a reasonable bid price. As such, the contractor used geotechnical borings to develop a reasonable interpretation of the numbers of boulders for which he accounted for in the bid price, which is the legal percent. Since there was no DRB on the project, a lawsuit was filed and the parties mediated three times and settled out of court. The mediator recommended settlement to the Owner because he determined that the baselines were not reasonable for the tunneling method specified and the court precedent allows the bidder to make a reasonable interpretation based on the project site-specific borings. The mediator felt that the Contractor could have considered a design defect claim if the DSC dispute was not settled. Both the Contractor and the Owner expended over a million dollars in legal fees and experts by the time the case settled.

The GBR is intended to be a risk sharing mechanism.

The GBR for Case History #1 was represented as written following the ASCE GBR Guidelines when clearly it violated the recommendations contained within the report in many ways. The GBR did not allow the determination of a DSC leading to a protracted dispute. It is unknown whether the Engineer of Record recommended a DRB for the project; however, the Owner should have been informed that a DRB was essential to settle the dispute without litigation. In addition, it was clear that the Owner did not understand that a GBR is not a risk-shedding document but a risk-sharing document. It is difficult to imagine more adverse conditions than were baselined for boulders, which theoretically should have resulted in an extremely high bid price.

6.2 Case History #2

This project included a 60-inch casing to be installed by Open Shield Pipe Jacking by specification. This project also had soil conditions where encountering boulders was a possibility along the tunnel alignment. The Owner decided to include a GBR on the project to share the risk of encountering boulders with the Contractor and ensure that all bidders were making the same assumptions when preparing their bid. This project did not include a DRB.

The GBR included baseline statements regarding the boulders that included the following language:

"For baseline purposes, the Contractor is instructed to assume that boulders up to 14 inches will be encountered along the alignment. All costs of any kind incurred in connection with ingesting and excavating boulders that measure up to 14 inches shall be included in the base bid and are not compensable under the Differing Site Condition clause or otherwise.

The Contractor is instructed to The Contractor is instructed that it is responsible for all costs associated with excavating and removing five (5) boulders measuring from larger than 14 inches to 25 inches, whether such excavation and removal is accomplished with the trenchless equipment or requires additional intervention for removal. All costs of any kind incurred with removing the five (5) boulders at any location ranging from larger than 14 inches to 25 inches (including costs for drilling rocks, breaking rocks, removing broken parts of rocks, jack-hammering, or other necessary tasks including repair to equipment) shall be included in the base bid and are not compensable under the Differing Site Conditions Clause or otherwise.

Additional compensation under the Differing Site Condition Clause will be considered when the number of boulders measuring from larger than 14 inches to 25 inches exceeds five (5) and for boulders measuring over 25 inches. To be considered for additional payment under the Differing Site Condition Clause, such boulder must exceed the quantity or dimension stated herein (more than five (5) boulders measuring larger than 14 inches to 25 inches or boulders greater than 25 inches) and stop forward progress of the open shield pipe jacking machine in spite of diligent efforts by the Contractor to overcome such boulder."

The baselines in the GBR were clear and the baselined item, in this case boulders, was observable and measurable. In addition to the baseline, the supplemental conditions of the contract stated that all additional work would be paid for on a time and materials basis.

During construction, the specialty trenchless inspector collected information on the boulders that were encountered and what means were necessary to remove the boulders and resume tunneling. During tunneling the contractor encountered eight boulders that were between 12 and 25 inches in the longest dimension (note that this is a different definition than used in the United Soil Classification System that defines boulders by the smallest dimension). During the recovery from the first 5 boulders, the inspector tracked the actual time and equipment

Figure 5. Hole Out

necessary to determine the reasonable "value" of excavating the boulders. The three remaining boulders that necessitated intervention at the face were paid on a time and material basis, and the contractor submitted an RCO based on the number of boulders encountered that were above the baseline. The total contractor claim was approximately $50,000. The Owner evaluated the claim documents and paid the Contractor a total sum of $43,000 for the DSC.

In Case History #2, the GBR functioned as intended, even without a DRB; however, the contract was written such that the provisions of the baselines were clear. In addition, the construction documentation collected by the specialty trenchless inspector allowed the Owner to determine if the RCO reflected the actual costs of boulder removal as opposed to other project costs. Figure 4 shows one of the boulders that was removed from the face of the open shield machine and the measurements performed by the inspector.

7.0 CONCLUSIONS

To date, very few GBRs that have been used on trenchless projects have met the full objective of the GBR as presented in the ASCE Guidelines (Essex, R., Ed. 2002). Writing effective, clear baselines is not

Figure 6. Boulder that was recovered from machine face. Note the tape measure is for scale. The largest dimension was measured with calipers that could measure up to 36-inches

a simple task and requires an Engineer with experience writing GBRs, with the construction method that is specified in the Contract, and how disputes are resolved when a GBR is a contract document. Owners should require that the author of the document have significant experience in geotechnical engineering as well as extensive experience authoring and executing GBRs. A poorly worded baseline increases the Owners risk as often the baselines result in a dispute over whether a DSC exists that can't be resolved easily and results in litigation. The effective use of the GBR on a trenchless project will only occur when the baselines are clear, and the conditions can be observed and measured. As such, the GBR is not compatible on projects such as microtunneling or HDD where the material encountered can't be observed and measured in the in-situ state. Other critical items to consider when contemplating a GBR include the following:

- The purpose of the GBR and the required contracting components must be understood by the Owner and the Engineer. All of the necessary components of the GBR need to be included in the contract, including a DSC clause, escrow bid documents, and the use of a DRB for dispute resolution.
- It is incumbent on the Engineer/ Geotechnical Engineer to explain that the GBR is not intended to shed risk and that an overly conservative baseline will end up in a very high contract price. If the Owner is risk averse and is not willing to share the geotechnical risk, the document is not appropriate for inclusion in the contract.
- In a low bid environment, the contractor with the low bid is unlikely to include the costs of the risks that were baselined in the GBR.
- A dispute resolution mechanism, other than legal avenues, must be included in the Contract as GBRs have limited legal precedent. Litigating a GBR can be challenging when legal precedent indicates that the contractor has a right to base the bid on reasonable interpretation of the geotechnical borings.
- The Owner and Geotechnical Engineer must understand that baseline parameters must be observable and measurable if the baseline is going to be an effective means for evaluating a DSC. The Engineer and Owner should discuss how the baseline will be measured and their strategy of verifying the baselined parameter before including the baseline in the GBR.
- The GBR works in concert with the DSC clause of the contract. Serious caution should be used to any GBR statements that define the conditions under which a valid DSC will be eligible for payment. The determination of entitlement and quantum should be determined in accordance with the DSC Clause included in the General Conditions of the contract.

8.0 REFERENCES

Essex, R.J. ed. (1997), Geotechnical Baseline Reports for Underground Construction, Guidelines and Practices, Technical Committee on Geotechincal Reports of the Underground Technology Research Council. (1997).

Essex. R.J. ed. (2022). Geptechnical Baseline Reports, Suggested Guidelines, ASCE Manuals and Reports on Engineering Practice No. 154, 2022.

Parnass, J. and Staheli, K. (2010). The legal impacts of geotechnical baseline reports. Proceedings for the NASTT 2010 No-Dig Show, Chicago, IL (Paper D-5-03). May 2-7, 2010.

Staheli, et. al., 2003. Snohomish River crossing: Bring on the boulders. Success on the second attempt. Proceeds for the NASTT No-dig Show, Las Vegas, NV.

Staheli, et al., 2018. Pipe Ramming: Understanding the Forces that Drive the Industry Forward. Proceedings for the NASTT No-Dig Show, Palm Springs, CA (Paper MA-T4-03) March 25-29, 2018.

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The abstracts must be submitted electronically by June 30, 2025 on the NASTT website:

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