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• Asset Assessment, Priorities & Planning
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The presentations were extremely useful especially the topic of Culvert Replacement Utilizing Pneumatic Pipe Ramming. Interesting to see how trenchless pipe ramming is most valuable in situations that require a quick mobilization and surface protection in sensitive locations.

Adam McKnight
Project Manager Engineer
Upper Trinity Regional Water District

One reason I enjoy this show every year is due to the quality time spent networking with contractors and engineers in the Exhibit Hall. I could be talking with someone about their project and end up showing them a way to make their project go smoother, or I might be simply educating new faces in the trenchless technology field. A good way to make lasting relationships in the industry.

Luc Lupien
Director of U.S. Western Region Operations
Sanexen Environmental Services Inc./Aqua-Pipe

See what NASTT’s No-Dig Show can do for you. Plan your experience.
FEATURED...

In Aurora
Engineers at CH2M helped a Colorado city develop a condition assessment system for stormwater pipes

HDPE Liners
Harsh weather, record rainfalls and other adverse conditions were overcome in oil pipeline rehabilitation

Knowledge
When to start with a geotechnical baseline report, and how one could benefit owner and contractor alike

ALSO...

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COVER PHOTO: Ashley Waldron Photography for CH2M

Published by:

PTR COMMUNICATIONS INC.
Unit 1 – 73 Fontaine Crescent
Winnipeg, Manitoba
Canada R2J 2H7

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Printed in Canada 09/16
It is with more than a little nostalgia that I pen my final Chair’s message as part of the Rocky Mountain Chapter of the North American Society for Trenchless Technologies’ (RMNASTT) yearly conference. It has been a labor of love for me, just as it is for the tireless volunteers who make up the Board of Directors, our dedicated group in Utah, and each member of RMNASTT who draws as much as they can from the society across the Rocky Mountain region.

RMNASTT was formed in 2009 to promote the education and implementation of trenchless technology for the public interest throughout the states of Colorado, Utah, Montana, and Wyoming. The mission of the Chapter is to advance the goals of the national NASTT organization: increasing education and awareness of tunneling and trenchless technologies for rehabilitation of existing pipelines and construction of new pipelines and infrastructure within the Rocky Mountain region. Practically speaking, we are providing value for our membership and the utility industry at the local level through promotion of trenchless technology.

This year, the Rocky Mountain Chapter hosted project site visits, the second annual Utah Training Day, and this fall, the first annual RMNASTT conference to take place outside of the Front Range of Colorado. Our annual conference this year will be held in Salt Lake City, Utah, for the first time on October 5th and 6th at the Utah Cultural Celebration Center. “Trenchless Elevated” (www.trenchlessElevated.com) will feature a full day of technical presentations regarding trenchless technology in the Rocky Mountain region and another full day of NASTT-promulgated educational courses. We will hold our Annual General Meeting during the conference to elect new officers and directors, and report on the state of the chapter. And finally, we are looking forward to our first sporting clays event to be held in the Denver area on October 28.

2017 will be filled with more opportunity for RMNASTT. To find out more about RMNASTT activities and to get involved, visit www.rmnastt.org. For more information about NASTT, including membership in the organization, please visit www.nastt.org.

Thank you to all of the volunteers that make this organization hum, I have appreciated working with every one of you. Here is to continued growth and spreading the message of trenchless across the Rocky Mountain region.

Richard (Bo) Botteicher, Chair
NASTT Rocky Mountain Chapter
Greetings, Rocky Mountain Chapter members! NASTT is having another great year, and I’m excited for our future during my term as Chair of the Board of Directors and beyond. As I’m sure you know, NASTT’s 2016 No-Dig Show in Dallas was a huge success as we experienced a sold-out exhibit hall and had excellent attendance. One of the biggest reasons for this success was the leadership provided by the 2016 No-Dig Show Program Chair, Jeff Maier, from this very chapter! I would personally like to thank you, Jeff, for your time and dedication to the conference.

NASTT would never be where we are today without the dedication and support of all of our volunteers and our 11 regional chapters. I would like to thank the following Rocky Mountain Chapter members that served on our No-Dig Show Program Committee and volunteered their time and expertise to peer-review each and every abstract submittal to ensure the technical presentations were up to the standards we are known for: Richard (Bo) Botteicher, Joe Lane, Jeff Maier, Benny Siljenberg and Brenden Tippets. I would also like to extend a special thank-you to Richard (Bo) Botteicher, Joe Lane and Jeff Maier for serving as Session Leaders in addition to serving on the Program Committee.

This year’s 15th Annual Educational Fund Auction was a rockin’ success, due in great part to the Auction Committee Chair, Joe Lane, from your Rocky Mountain Chapter. The Rock ‘n’ Roll-themed event raised over $90,000 for NASTT’s educational initiatives. Beyond that, it was a blast for all the attendees! Thank you, Joe, for your dedication.

In addition to the annual No-Dig Show, NASTT provides many trenchless training courses. We are focused on trenchless education, and our highly experienced instructors are dedicated to trenchless education, providing their expertise on a strictly volunteer basis. They donate personal time to travel around North America to provide high-quality training on a host of trenchless technologies. I would like to thank Rocky Mountain member Jeff Maier for moderating NASTT’s “Trenchless Trends in Atlanta” panel in conjunction with the UCT Show in Atlanta, Georgia, earlier this year.

We are very excited about this year’s Rocky Mountain Regional Chapter event, Trenchless Elevated, in Salt Lake City in October. This event is shaping up to be a fantastic venue for trenchless education and networking in the Rocky Mountains. We hope you will all join us October 5-6 at the Utah Cultural Celebration Center.

During our strategic planning efforts, the Board of Directors identified goals of engaging larger groups of trenchless professionals to participate in the many volunteer opportunities provided by NASTT. These opportunities prove to be very satisfying and rewarding. NASTT has a wide variety of ways to participate that allow involvement at any level. If you are interested in more information, please visit our website at nastt.org/volunteer. There you can view our committees and learn more about these great ways to stay involved with the trenchless community. Please consider becoming a volunteer – we would love to have you get more involved.

NASTT has a very promising future, and the Rocky Mountain Chapter is stronger than ever. Thank you again for your continued support and dedication to NASTT and the trenchless technology industry.

Message from NASTT

Dr. Kimberlie Staheli
Chair, NASTT

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Richard (Bo) Botteicher, PE - Chair

Mr. Botteicher has worked in the water and wastewater industries for the past 16 years. He worked as a consulting engineer for seven years and is a registered professional engineer in Colorado. He served as Senior Product Engineer for Underground Solutions, Inc. for nine years and is now the General Manager, specializing in horizontal directional drilling, slip lining, and pipe bursting trenchless installation methodologies.

Ken Matthews - Vice-Chair

Mr. Matthews is the Water Practice Leader for Merrick and Company. Ken has been contributing to the analysis, design, and construction of sound municipal wastewater infrastructure for nearly 30 years. He specializes in evaluation and rehabilitation of municipal buried infrastructure. He is actively involved in the NASTT and has authored numerous papers and presentations addressing system-wide combined sewer management, regulatory changes, the basics on abatement of rainfall-induced infiltration and inflow, and individual trenchless technology projects.

Joseph Lane - Treasurer

Mr. Lane is the president of HEBNA Corporation, a global pipeline rehabilitation company headquartered in Aurora, Colorado. He holds a bachelor’s degree in biology from the University of Northern Colorado and is a graduate of the University Of Michigan School Of Business Management and the Leadership Program of the Rockies. Prior to joining HEBNA in 2014, Joe spent over 23 years with SAK and Insituform Technologies. He is a regular speaker and instructor at numerous industry and educational associations such as the Water Environment Federation, American Public Works Association and NASTT.

Christopher Larson - Secretary

Mr. Larson is a vice president of C&L Water Solutions, Inc. out of Littleton, Colorado. He has been immersed in the trenchless field with particular focuses in slip lining, pipe bursting, UV CIPP, lateral rehabilitation, and manhole rehabilitation. He contributes to the advancement of quality-focused applications of trenchless technologies for unique and challenging project applications.
Welcome to Trenchless Elevated

Stephanie Nix-Wille, PE
Conference Chair

Our company has been working with trenchless technologies for almost 20 years. As a contractor, the ability to have more options, or tools in your tool box, is a huge benefit. The challenge in researching these options is finding resources that provide the information necessary to properly validate new ideas in method, equipment and products. Questions such as how equipment will perform, or what products are available, or whether anyone has experienced a similar situation, are often critical to project success.

As an engineer, knowing what needs to be considered in the design of a trenchless project or why a city might want a trenchless option is also helpful. When it comes to trenchless design, will it cost more tax dollars, or will it be more efficient? Will it be money well spent?

These are important questions. However, it is often difficult to find and consider the answers in a format that is not self-serving – one that seeks to be purely educational.

All of my interactions with the North American Society for Trenchless Technologies (NASTT) have been just that – purely educational. Every NASTT event that I have attended, the resources online and printed information, like this Rocky Mountain Trenchless Journal, have always left me feeling like it was time and money well spent.

On behalf of the Rocky Mountain Chapter Board of Directors and the Conference Planning Committee, I welcome you to the Rocky Mountain Chapter of NASTT’s sixth annual conference. My hope is that you will learn something new, find an idea to try, meet someone who can answer a question for you or debate an issue, and enjoy the conference and the proceedings in this publication. I am confident that you will find, much like I have, that these resources truly are ‘purely educational.’

I look forward to seeing you in Utah.
Aurora Water recognized the need to develop baseline condition assessment information for their stormwater system with the goal of developing a proactive approach to maintaining the system. This project included field condition data collection for approximately 10 percent of the RCP stormwater pipelines and associated structures. While the tools used to collect and record the condition data, physical inspection and CCTV were not unique in application, the methodology used to track the inspection teams provided transparency and the approach used to prioritize the assets and associated projects provided for consistency across multiple data collection methods.

This technical paper is presented in three primary sections: 1) the methodology for tracking and recording field data, 2) the standardized framework for risk-based project prioritization, and 3) the capital planning for annual maintenance and proactive renewal of the stormwater system.

Methodology for Tracking & Recording Field Data

The methodology for tracking and recording field data for this project included the use of available technology to improve the safety, consistency, and efficiency of recording field inspection data for structures and pipes. The use of pole-mounted camera systems and tablet-based data entry for assessment of structures provided thorough and efficient inspections without requiring manned entry. The use of CCTV for pipeline inspection with National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) coding and export of a PACP-compliant database allow for consistent database management. The application of ArcGIS to support field inspection activities provided real-time reporting of status and the use of GIS to field-locate structures and pipes.

CH2M conducted topside inspections of

Figure 1: Field Assessment Information Flow
the structures using a pole-mounted QuickView camera inspection system. The QuickView technology allowed for thorough assessment of the structure without manned entry and also pre-inspection of the pipes to determine if cleaning was required before CCTV inspection of the pipes. The condition of the structures was recorded with templates developed by CH2M for consistency in inspection results. Photos of observed defects were taken in addition to standard photos for each structure.

The stormwater pipe and culvert field inspection was completed with CCTV utilizing a video camera (with transporter) and recording the information with PACP-compliant software and coding. The use of the QuickView camera system for pipes less than 40 feet in length with no significant defects reduced the number of CCTV videos required for inspection of the stormwater system, creating time and cost efficiencies.

The use of an ArcGIS Server to support field inspection activities provided significant project benefit with transparency of the field inspection status, real-time reporting of cleaning requirements, and use of the GIS data to field-locate pipes and structures. To supplement the ArcGIS information, Aurora Water maintained a database of assets identified as needing attention to track the status of cleaning and maintenance activities, reviewed during weekly progress meetings. To provide security of the information, the GIS data provided was maintained behind a firewall requiring secure password authentication to access it. Figure 1 shows the information flow for field assessment utilizing the ArcGIS Server and field data collection applications.

To enable the field team’s tabular and spatial editing of the project features, CH2M configured an Adobe Flex viewer to allow team members to locate and update assets through their mobile tablets. Accommodating real-time field modification of the spatial database to reflect the in-field observed configuration and location of structures and pipes improved the quality of the spatial database.

To support Aurora Water’s ability to actively monitor the project, ESRI’s ArcGIS Online (AGOL) configured to support project team login for security. The intent of the AGOL account was to enable sharing of where the field teams had been, where they were going to be working next, and what they had found through a simple status legend that documented where features required cleaning, had been inspected, were submerged, could not be located, or had not yet been inspected. This allowed Aurora Water to know where the CH2M field crews were at all times, helping Aurora Water to quickly respond to any public inquiries regarding field crews and/or field trucks. In addition, links to the digital photos and QuickView videos collected in the field were made accessible through the features after completion of
Figure 2: Aurora Pipe Inspection Field Data (Screen Capture)

Figure 3: ArcGIS Online Simple Status Map

Figure 4: Links to Available Digital Media File
each inspection’s quality review.

GIS support activities included quality control reviews, field team coordination, planning, weekly summaries, change log reviews, and general mapping. Figures 2, 3 and 4 show screenshots demonstrating the use of the tool in the field, the availability of field-reported data to the office, and the linkage of inspection photos, videos, and forms.

**Standardized Framework For Risk-Based Prioritization**

CH2M and Aurora Water project staff worked collaboratively to develop a prioritization and capital planning approach that could serve as a future standard for similar condition assessment work, whether performed by other consultants or by Aurora Water in-house.

The strategy developed for this project allows for the input of structural and maintenance likelihood of failure (LOF) grades and consequence of failure (COF) grades for assets and the use of a standard risk matrix for combining the scores to develop a combined “risk grade” for each asset. The LOF grade is developed from the field condition information. COF grades are developed by evaluating the expected severity of a failure of each asset as scored against a set of criteria developed by CH2M and Aurora Water. The selected COF criteria are shown in Table 1.

This Phase 1 Project used a proprietary software package developed by CH2M called SCREAM which allowed CH2M to more efficiently evaluate the condition information and develop prioritized recommendations for maintenance and rehabilitation of the inspected assets using the agreed-upon risk-based prioritization approach. However, SCREAM’s output and the end deliverable and prioritization results were designed to be compatible with alternative techniques that others may use in future phases. This approach does not require specialized tools for understanding and using the information. Alternative methodologies could be used in the future as long as the end result of those methodologies provides both LOF and COF grades that can be used in a risk-based prioritization.

The final step in the risk-based prioritization of inspected assets is to utilize the LOF and COF grades to develop an overall risk score and associated recommendation for maintenance and structural actions. The combined risk grade is an ordered pair in the form of “Structural LOF, COF.” For example, an asset that yielded a structural LOF grade of 5 and a COF grade of 3 would have a combined risk grade of “(5,3).” A recommended Priority Level or Next Step action is associated with each ordered-pair combination, as shown in Figure 5.

The top three priority levels are indicated: “Priority 1,” “Priority 2,” and “Priority 3.” All three levels are associated with structural LOF grades of 5. Recommended next-step actions for assets are the repair/rehabilitation/replacement of assets within six months, 12...
Table 1: Consequence of Failure Scoring Matrix with Category Weights

<table>
<thead>
<tr>
<th>Category</th>
<th>Norm Wt*</th>
<th>Insignificant = 1</th>
<th>Minor = 2</th>
<th>Moderate = 3</th>
<th>Major = 4</th>
<th>Catastrophic = 5</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Diameter</td>
<td>8.5%</td>
<td>18&quot; or less</td>
<td>&gt;18&quot; to 36&quot;</td>
<td>&gt;36&quot; to 60&quot;</td>
<td>Greater than 60&quot;</td>
<td>Box Culvert</td>
<td>Field Recorded Information</td>
</tr>
<tr>
<td>Pipe Depth</td>
<td>14.1%</td>
<td>0 to 3 ft</td>
<td>&gt;3 ft to 6 ft</td>
<td>&gt;6 ft to 8 ft</td>
<td>Greater than 12 ft</td>
<td>Greater than 12 ft</td>
<td>Field Recorded Information</td>
</tr>
<tr>
<td>Surface Improvement / Roadway Classification</td>
<td>13.6%</td>
<td>Grass / Easement</td>
<td>Sidewalk / Bike Trail</td>
<td>Road Class 4 and 5</td>
<td>Road Class 2 and 3</td>
<td>Road Class 1 and 6</td>
<td>Combination of Field Data and City of Aurora GIS Classification Codes (1-6)</td>
</tr>
<tr>
<td>Intersection</td>
<td>18.7%</td>
<td>No Intersection</td>
<td>Intersection Road Class 5</td>
<td>Intersection Road Class 4</td>
<td>Intersection Road Classes 2 and 3</td>
<td>Intersection Road Classes 1 and 6</td>
<td>Manipulation of City of Aurora GIS</td>
</tr>
<tr>
<td>Location - Zoning</td>
<td>10.9%</td>
<td>Residential</td>
<td>Minor Industrial</td>
<td>Minor Commercial</td>
<td>Major Industrial</td>
<td>Major Commercial</td>
<td>Utilize City of Aurora GIS zoning information to classify</td>
</tr>
<tr>
<td>Connected Structure Types (Stream Order)</td>
<td>9.3%</td>
<td>Lateral (inlet to manhole)</td>
<td>Main (manhole to manhole, or inlet to inlet)</td>
<td>Box Culvert (large channel to large channel)</td>
<td>Utilize GIS and collected field data to assign categories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity to Public Resources, Historical HBS</td>
<td>19.4%</td>
<td>No Proximity to Resources</td>
<td>Adjacent to Cultural Resources (Library, etc.)</td>
<td>Adjacent to Hospital/School</td>
<td>Utilize GIS and Parcel/property information to determine proximity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table: Consequence of Failure Scoring Matrix with Category Weights

- Assets with structural LOF grades of 4 or less are not recommended for improvement action. However, they have next-step actions consisting of future re-inspection, or monitoring, through visual assessment (structures) or CCTV (pipes). Depending on the combined risk grade, the recommended time for re-inspection is between 18 months and 10 years.

Capital Planning for Annual Maintenance and Renewal

The ultimate goal of condition assessment is to develop an understanding of the existing system condition and remaining life in order to plan and budget for a path forward that maintains and renews the inspected system in a cost-efficient manner. While Phase 1 of the project inspected less than 10 percent of Aurora Water's RCP stormwater system, the Phase 1 effort can provide some initial insight towards understanding of the system condition and serve as a basis for projecting system-wide maintenance and capital requirements.

Towards that end, the detailed condition information obtained during Phase 1 inspection was converted into average annual costs to maintain and renew assets. This annual investment towards a proactive asset management and renewal program can then be compared to infrastructure replacement costs associated with a "run-to-failure" approach. Simply put, run-to-failure is the default approach in the absence of proactive asset management. The comparison is important because responsible expenditure of utility funding should result in whichever approach provides the highest value, whether that is a proactive approach or the default run-to-failure approach.

The cumulative costs of a proactive asset management approach versus running to failure are shown in Figure 6. The annual maintenance investment represents annual inspection of about 10 percent of the system.
Figure 6. Annual Investment for Maintenance and Proactive Renewal versus Run-to-Failure
and cleaning of about 11 percent of the assets inspected, based on the
results on the 2015 inspection. The annual rehabilitation cost assumes
that proactive rehabilitation occurs five years in advance of end of life
(in accordance with the progression to LOF grade 5).

Based on a 100-year projection, annual investment on the order of
$2.0 million per year (2015 dollars) is indicated for the first 45 years,
with a significant increase in the last 55 years to approximately $7.0
million per year (2015 dollars) as the system ages and more assets
need rehabilitation each year. The shift from $2 million to $7 million
is due to the generally observed good condition of the assets in the
Phase 1 inspection area. The majority of these assets are judged to
have a remaining useful life in excess of 50 years and so renewal costs
for the next 50 years are comparatively low. However, these assets will
age over time, and the likelihood of failure is expected to increase as
their remaining useful life decreases.

The annualized cost of a run-to-failure scenario projects to be $2.5
million per year (2015 dollars) for the next 50 years. This would be the
average annual cost for emergency replacement of assets expected to fail
based on their remaining useful life, as projected by SCREAM, assum-
ing that Phase 1 is representative of the entire RCP system. After 50
years, the average annual cost increases to $17.5 million (2015 dollars) to
replace the system in larger amounts as the system ages.

The result of the Phase 1 analysis, projected over the entirety of the
Aurora RCP stormwater system, is that proactive renewal and mainte-
nance in the early years saves significant costs in the later years under
a run-to-failure scenario. As future condition assessment phases are
performed, a more informed picture of the overall condition of the
RCP stormwater system will develop. The more informed picture will
allow for refinement of the annual costs needed for an effective proac-
tive management approach and further insight into the cost efficien-
cies of the approach.

Conclusion
This process developed by Aurora Water and CH2M resulted in a
standardized approach for prioritization of assets on a risk basis. This
approach of a standardized framework allows for the ongoing use of
multiple contractors and the most current inspection tools and
methodologies for interpreting field data to generate a consistent and
uniform assessment output.

The application of innovative methodologies to standardize condi-
tion assessment and analysis provides Aurora Water with flexibility in
implementing their proactive maintenance and renewal program. The
approach provides a standardized methodology to compare the results
of individual inspection projects and consolidate the information into
a single program to annually inspect, maintain, and renew their
stormwater system.
Since 2004, hazardous liquid, gas gathering, transmission and distribution pipelines in the United States have been regulated by the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) Office of Pipeline Safety (OPS). Created to ensure that our nation's pipelines are safe, reliable and environmentally sound, PHMSA regulates pipeline construction, maintenance and operation. In the decade since the agency was formed, these regulations have grown increasingly stringent.

Most of today's pipeline regulations did not exist in the 1940s, when the eight-inch-diameter crude oil pipeline that runs from 55 miles north of Oklahoma City to just east of the city's downtown was first installed. By the time the pipeline celebrated its 70th birthday, however, it was subject to regulations which called for periodic inspections to test the integrity of the pipeline.

Pipeline integrity refers to a system that is in sound, unimpaired condition that can safely carry out its function under the conditions and parameters for which it was designed. An integrity management program is a documented set of policies, processes, and procedures that are implemented to ensure the integrity of a pipeline, and these plans are required within the federal regulations for natural gas distribution and transmission pipelines, as well as for hazardous liquids pipelines.

Technically speaking: In accordance with pipeline safety regulations for oil pipelines (49CFR 195.452), an operator's integrity management program must include, at a minimum, the following elements:

- a process for determining which pipeline segments could affect a High Consequence Area (HCA);
- a Baseline Assessment Plan;
- a process for continual integrity assessment and evaluation;
- an analytical process that integrates all available information about pipeline integrity and the consequences of a failure;
- repair criteria to address issues identified by the integrity assessment method and data analysis (the rule provides minimum repair criteria for certain higher-risk features identified through internal inspection);
- a process to identify and evaluate preventive and mitigative measures to protect HCAs;
- methods to measure the integrity management program’s effectiveness; and
- a process for review of integrity assessment results and data analysis by a qualified individual.

A 2013 assessment confirmed that the 55-mile-long segment of pipeline operating at 500 psi was experiencing internal corrosion. In recent years, the pipeline had been temporarily put out of service and repaired due to minor failures. Following the 2013 assessment, regulators determined that it would need to be replaced or brought back into compliance before it could be returned to service.

As the oil and gas company that owned the pipeline planned its future, they considered several alternatives. The first option considered was to permanently retire the pipeline and have the crude oil it carried transported by truck instead—an option that was both economically inefficient and more dangerous.

The second option was total replacement of the pipeline. However, the owner knew that new construction would be expensive due to the development that had taken place along the pipeline’s route in the decades following its original construction. It could take years to obtain the necessary permits, negotiate with homeowners, and tunnel under roads and highways before the first foot of new pipe could be laid.

The owner also explored a third option, the possibility of applying liquid epoxy coatings to the interior wall of the existing pipe, but feared the solution would not provide the desired longevity and safety factor sought by the company.

The fourth option was to install a compressive-fit HDPE liner inside the existing pipe. The corrosion-resistant barrier provided by an advanced polyethylene liner would...
extend the pipeline’s life by 50 or more years, as well as provide dual containment, helping to improve pipeline environmental safety. Notwithstanding HDPE-lined pipelines’ safety advantages and vastly improved longevity, this option was the best value as the entire rehabilitation could be accomplished for less than half the cost of pipeline replacement.

Nevertheless, HDPE liners had not been widely used as a method of achieving PHMSA compliance. Owners were concerned that regulations requiring periodic tests to measure wall thickness, a process that required tools to be send through the pipeline, were not practical with an HDPE liner. The oil and gas company decided to work with regulators to find an alternative approach to bring the pipeline back into compliance. In doing so, the company’s project team was successful in convincing regulators of the effectiveness of existing methods to test and assess HDPE-lined pipelines, and that the dual containment provided by the system would both be a viable solution for extending pipeline life and meet PHMSA requirements/objectives.

Design Challenges
Finding an effective way to conduct pipeline assessments with an HDPE liner in place was just one of the challenges the oil and gas company and its project team would need to overcome on this project. Other major challenges included:

• A long and winding route – During installation, the liner would need to negotiate over 400 separate bends along the pipeline’s nearly 56-mile route, many of which were particularly tight, short-radius 45- to 90-degree bends.

• Diverse urban, suburban and city landscapes – The pipeline segment began in the countryside 55 miles outside of Oklahoma City in a region that was dominated by dirt roads and farm fields at the time of its original construction 70-plus years ago. In the decades since the pipeline’s original construction, major developments have been constructed along the route, including towns, subdivisions and a golf course, busy highways and river crossings, and significant urban development around the pipelines termination near downtown Oklahoma City. Some segments of the line were buried as much as 20 feet beneath the surface. The construction team was challenged to work within the owner’s existing easement, minimizing disruption under this wide range of environmental conditions.

• Record rainfall – The project was completed over an eight-month period between October 2014 and June 2015, which included one of the wettest springs in Oklahoma history. Record rainfall in May was accompanied by frequent tornadic activity. The excessive mud at many project sites, in combination with the heavy equipment involved in excavation and construction, resulted in deep mud and water-filled excavation sites, both of
which slowed construction and limited the lining contractor’s access to the sites.

**Liner Installation**

The installation of the liner was completed in three phases, each of which included between 15 and 20 miles of pipeline. Before the lining process could begin, the line was first tested for strength and leaks using hydrostatic testing, a process that regulators agreed could replace the more typical approach to measuring wall thickness.

Each phase was further broken down into a series of installations ranging from just 25 feet to more than 3,000 feet in length. Working in coordination with the owner’s steel and excavation contractor, the HDPE-lining contractor arranged for entry and termination sites to be excavated at the beginning and end of each installation.

In each case, the polyethylene pipe was delivered to site and fused together along the right of way. The fusion procedure involved setting two pieces of polyethylene pipe into a fusion machine in a straight line. After each piece was cleaned of any dust, dirt or other material, the two ends were trimmed and carefully aligned to...
allow for an exact flushness. The ends were then trimmed one more time before being brought together against a heating plate that had been inserted in the machine.

The ends remained under pressure until a visible bead formed completely around the pipe edges. At that point, the pressure is released, the fusion machine is opened and the heater plate is quickly removed. The two ends are then brought together and fused using pressure. After the fused pipe cools naturally, it is removed, the bead is trimmed and examined for any visible flaws.

Using compressed air, a blow-down pig with a sizing plate was then inserted the entire length of the steel pipeline section to be lined. This allows the contractor to determine the presence of any abnormalities, such as pipe heavy wall changes, mitered welds, deep weld penetrations, ovalities and dents.

Fused sections of HDPE liner were then passed through a reduction roller box, temporarily reducing the size of the liner. The reduced liner was then pulled through the host pipe until the pull-head emerged at the other end. A wireline truck was used to measure tension and distance, allowing for a tight fit. After the sections were pulled in, time was allowed for the liner to "relax" and revert to near its original size.

When each of the three phases were complete, each segment again underwent hydrostatic testing before it could be returned to service.

**Construction Challenges**

Crews had to adjust to a variety of conditions and environments during the eight-month construction period. In rural areas, they had to be careful to keep cattle from escaping through gates that were opened to gain access to installation sites. Later, when construction passed directly through a golf course where a tournament was underway, crew members were careful to use site entry and exit points in the areas that were non-disruptive to the activities underway.

Similarly, when the pipeline traveled beneath a restaurant, car dealerships and residential neighborhoods and streets, the lining contractor chose pipe entry and exit points that were as far away from the structures and commercial activity as possible.

The pipeline also passed beneath railroad tracks and several major highways leading to downtown Oklahoma City. At river crossings, the pipeline varied from bury depths of four to 25-plus feet. In other areas, excavations up to 20 feet deep were needed to reach the buried pipe.

The lining process itself was not always sequential. Because actual pipe construction sometimes deviated from the original plans, the project team had also to be prepared to address changes in wall thickness, pipeline abnormalities unexpected bends and other "surprises" along the way. In some cases, the
pipe wasn’t constructed according to the original specifications, or contained an unmarked bend. Point repairs were also frequently needed. But the team persevered, never leaving the site until all three segments were complete. When a problem area emerged, the project team moved to a different section of the pipe while a solution for the problem area was developed. Crews typically installed multiple segments of pipe in a day. At the project highpoint, crews installed 90,000 feet of pipe in 30 days, completing two to three pulls a day.

Results, Lessons Learned

In all, crews constructed and installed nearly 56 miles of eight-inch-diameter internal HDPE pipe using the Compression Fit Liner system. Following completion, hydrostatic testing demonstrated that the new pipe was strong and leak-free, enabling it to be returned to service. Despite record rainfalls, harsh weather and muddy job sites that slowed construction and posed safety risks, the project was completed successfully in a high-quality manner to the satisfaction of both the pipeline owner and PHMSA.

With minimal disruption to traffic, businesses and homeowners, the oil and gas company received a renewed, reliable and durable pipeline internally protected against corrosion and abrasion, extending the existing asset’s life by 50 years or more. The new pipe-within-a-pipe also provides the oil company with a dual containment system for the oil it transports near farmlands, residences and businesses, offering peace of mind to the homeowners and others whose backyards and property the line passes.

Just as importantly, the project demonstrates to other owners of regulated pipelines that it is possible to meet PHMSA requirements by lining an aging pipeline with HDPE, with periodic inspections of wall thickness successfully accomplished using hydrostatic pressure testing.
Geotechnical Baseline Reports: Understanding Them and How They Can Be Used Successfully on Trenchless Projects

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The Geotechnical Baseline Report (GBR) is an interpretive report typically used in tunnel construction projects that establishes a contractual understanding of the subsurface site conditions. The GBR is an effective tool to manage risks and control costs by providing risk sharing between the Owner and Contractor. Risk sharing can lead to lower project construction costs and minimize the time and effort required to resolve differing site conditions (DSC) claims. GBR guidelines have historically been written for conventional tunneling methods. This paper explores their use and applicability in trenchless construction projects.

Why Use a GBR?

Subsurface conditions have an enormous impact on underground construction and heavily influence the means, methods, and construction costs. Since the entirety of the work is completed underground, unanticipated subsurface conditions can have an adverse impact on the project and thus cause delays, add cost, and in some cases warrant changing trenchless installation methods or result in abandonment of the installation. Adding to the risk associated with unknown subsurface conditions, trenchless projects are often linear, increasing the likelihood that subsurface conditions may vary significantly along the alignment. GBRs can be used to manage the risk associated with underground surprises.

Allocating risk is understood to be the most important reason for writing a GBR. Through the GBR, risk can be allocated to the Contractor for a specified range of anticipated ground conditions. The GBR defines contractual “baselines” of anticipated subsurface conditions and ground behavior, upon which the contractor will base his/her bid. The GBR tells the Contractor what to expect and establishes a clear basis for DSC claims, and claims evaluation. The Contractor carries the risk for conditions within the established baselines, and the Owner carries the risk for conditions beyond the established baselines. If ground conditions are materially different than baselined, the DSC clause takes effect and compensation for additional costs due to changed conditions can be negotiated.

Without a contract document establishing the anticipated ground conditions, unknown ground conditions translate into increased commercial risk for Contractors. As such, Contractors are likely to incorporate a contingency into their bid price to cover unexpected conditions. Experience suggests that use of a GBR tends to result in comparable Contractor bids. With a GBR, bid contingencies are often reduced, lowering overall project cost. With this model, the Owner pays only when adverse conditions beyond the established baselines are encountered.

Preparing a GBR requires careful consideration about how the interpreted ground conditions, the proposed trenchless method, and the project layout will interact. GBR preparation should be completed by personnel familiar with the intended trenchless...
process. Anticipated ground behaviors and necessary ground control measures influence which construction methods are appropriate to meet the project design criteria while minimizing impacts to third parties. By identifying these risks during the design phase, the Owner has the opportunity to mitigate these risks in advance of construction. Not only does the GBR prescribe the anticipated ground conditions which may be the source of the risk, it discusses mitigation measures and how they have been incorporated to reduce those potentially negative and costly impacts. Risk mitigation measures included in the contract documents may present themselves in many different forms and should be specific to the project; however, some examples may include the use of pre-excavation ground improvement or specifying the allowable trenchless excavation techniques.

While development of a GBR adds additional cost to the project, it should be considered an investment intended to reduce risk, improve efficiency, and control costs.

When to use a GBR

Development of a GBR adds additional cost to the project, and may extend the duration of the design stage. In many cases, such as for short, small-diameter installations where the risk and impact of differing ground conditions is judged to be low, development of a full GBR may not be warranted. An example might include a 50-foot-long, 36-inch-diameter auger bore installation in stiff clay, above the water table, at a depth where surface heave or settlement is unlikely. In such cases a suitable alternative to a GBR may be a trenchless method performance specification containing a succinct summary of ground conditions that the Contractor should anticipate.

Conversely, there are situations where use of a GBR is a very worthwhile investment. These are cases where changes in ground conditions or behavior may have a profound impact on performance of the specified trenchless method and overall project success.

We recommend the use of a GBR on trenchless projects that involve one or more of the following:

- Obstructions are present which could hinder or halt the installation;
- The cost of trenchless tool replacement or loss may exceed the cost of the installation;
- The project schedule is sensitive, whereby the owner is required to enforce penalties associated with liquidated damages;
- Surface settlement or ground movement poses significant risk to overlying or adjacent facilities (e.g., roadways, utilities, buildings);
- An erratic bedrock surface, or mixed-face conditions may be present within the trenchless horizon, which could adversely impact line and grade (beyond acceptable tolerances), or require retooling.
- Groundwater conditions could adversely impact the stability of unsupported ground;
- Different soil conditions could result in inadvertent drill fluid or slurry loss to ground surface, possibly resulting in environmental fines.

In general, the benefits of a GBR increase as the size of the project increases. They become especially useful when the Contractors are large national or international firms who are unfamiliar with local subsurface conditions.

In many cases, determining if a GBR is a worthwhile investment may require development of a risk register. This is an exercise whereby the designer and Owner prepare a succinct list of potential risk sources, possible impacts should they arise, and potential risk mitigation measures (which may include the GBR).

Applications on Trenchless Projects

GBRs are often used on microtunneling projects, as this is a logical extension of the concept developed for larger tunnels. Relative to other trenchless installations, microtunneling projects tend to be more expensive, and the ramifications of machine loss are significant. Therefore, the cost of the project and equipment at risk often justify the use of a GBR.

Currently, for other trenchless technologies, including horizontal directional drilling (HDD), auger boring, pipe jacking, pilot
tube, pipe ramming, and pipe bursting, the use of GBRs is not common. One reason for this is the type of contractors who generally complete these projects. For example, smaller trenchless contractors tend to focus on local projects, have completed many similar installations in familiar ground, and tend to rely on their past experience to develop their bids and select the tools to get the job done correctly. Due to their familiarity with the local site conditions, these contractors are not necessarily looking for a comprehensive geotechnical document describing the subsurface conditions. Instead, they manage their risk, or the size of their bid contingency, based on their past local experience.

Additionally, GBRs require a significant effort to produce and the cost of the project often doesn’t justify a GBR in the mind of the Owner. On small projects (i.e., short drive, small budget), Owners, even if they are familiar with the GBR, will often gamble and not use them.

In summary, if the bidding contractors are anticipated to be local and therefore familiar with the ground conditions, the ground conditions are considered to be straightforward, and the project is tight on time and money, the decision to not use a GBR may be appropriate. However, when small jobs utilizing local contractors are anticipated to encounter challenging excavation conditions as the result of complex ground conditions, a GBR can benefit all parties involved. In addition to managing risk, GBRs present key information about the anticipated ground conditions and the challenges associated with construction, helping Contractors to prepare more accurate cost estimates during the bidding process.

**Preparing GBRs**

The primary reference for preparing GBRs is the ASCE publication Geotechnical Baseline Reports for Construction: Suggested Guidelines (2007). The report should describe the anticipated subsurface conditions and how those conditions have influenced the design and will influence construction.

For GBRs to be successful, baselines should provide the Contractor with the information needed to build the job and are primarily divided into two categories: physical conditions and ground behavior. Baselines should be verifiable and measured during construction. Physical condition baselines are typically quantitative and include the types of geology that will be encountered in the shafts and along the trenchless alignment. These may include rock and soil characteristics, mixed face conditions, groundwater levels, and frequency of obstructions. In comparison, behavioral baselines tend to be qualitative and describe how the ground will respond to the excavation. When developing behavioral baselines, it is recommended that industry standard accepted definitions such as the Tunnelman’s Ground Classification for Soils (Heuer, 1974) or Terzaghi Rock Mass Descriptions (Terzaghi, 1946) be used where appropriate. This helps to limit variable interpretations from the different parties involved in the project and may help to avoid misunderstandings related to ground behavior should differing ground conditions be encountered.

Ground behavior will be influenced by the installation method. The behavioral baselines must be specific to the installation method, and should consider any applicable or required dewatering or ground improvement. If dewatering is required along the alignment, ground behavior during trenchless construction may be anticipated to be consistent with behavior above the groundwater table as opposed to its in-situ condition below the groundwater table. Similarly, if pre-excavation grouting is required, the anticipated ground behavior will reflect the improved (grouted) condition, rather than the original untreated ground. Because behavior is dependent on construction...
methodology, baselines are typically written to include statements regarding the construction assumptions.

Construction considerations are also baseline and may include a description of which trenchless methods are applicable and why, and also which methods are not applicable and perhaps not allowed.

It is important to remember that baselines are contractual assumptions and are not necessarily limited to the extent of the available geotechnical data. They should also be based on reasonable engineering and geologic judgment, and local experience. Cases where this may apply are when there are limited borings and lab testing available, there is uncertainty between the borings, there is local knowledge about the ground as the result of previous project experience in the area, or when the owner wants to allocate risk for specific conditions. For example, boulders may be baselined even if they are not detected in the soil boring program but are generally known to exist based on the regional geology or experience from previous construction in the area. Another example includes adverse rock mass or groundwater conditions that are known to occur within faulted zones but are not well documented in the boring logs. It is recommended that interpretations and extrapolations from the available geotechnical data be reasonable, and be explained if the resulting baselines deviate from the available data.

**Presenting the GBR**

While the concept and purpose of the GBR is familiar to most microtunneling contractors, it remains unfamiliar to many other trenchless groups. In particular, use of GBRS is still rather uncommon on HDD projects. When a GBR is planned for a trenchless installation, we recommend considering the following measures to ensure the contractor is fully aware of the purpose, and the content of the document:

- Plan a pre-bid meeting, and require attendance by the General Contractor and any trenchless subcontractors (as applicable). At this time the Owner or Owner’s representative should make the bidders aware of the GBR and provide a brief overview of the document.
- Require that the General Contractor and all trenchless subcontractors submit a form along with their bid attesting that they have reviewed the GBR.
- Following project award, schedule a pre-construction meeting. At this time the measures required for monitoring subsurface conditions and quantifying the baselines should be discussed.

**Construction Observation**

When GBRS are included on a trenchless project, construction observation by qualified personnel is essential. Documentation of the contractor’s means and methods, the subsurface conditions encountered, and the ground
behavior observed is required to quantify the accuracy of the baselines. This information becomes critical if a differing site condition is encountered.

For some methods, including auger boring and pipe jacking, the nature of the materials encountered may be readily determined though observation of the cuttings, and in some cases (where face access is achievable), through direct observation of the heading.

For other trenchless methods, including HDD and microtunneling, where cuttings generated at the face are removed by slurry or drill fluid, it may be difficult to verify the conditions encountered. In the case of microtunneling, the tunneling machine will crush cobbles and boulders into smaller rock fragments to transport the excavated material in a slurry, resulting in very little recognizable material. Figure 1 depicts an example of observable excavated material produced by a microtunneling slurry separation plant.

Likewise, cobbles and boulders encountered by HDD may be pushed aside, or similarly reduced to smaller particles before transport to the ground surface within the drill fluid. With these methods, careful examination may be required to distinguish cuttings produced from cobbles and boulders, and bedrock. Because there is typically no face access with these trenchless methods, identification of particle size and formation nature may be challenging, and the frequency and distribution of cobbles and boulders cannot be easily identified. This can make it difficult to verify baselines and requires experienced personnel in the field monitoring cuttings, penetration rate, equipment behavior, and instruments.

**Conclusion**

GBRs can be an effective risk allocation tool for underground projects and, depending on project risk and complexity, can be a valuable tool for trenchless projects. Writing a
successful GBR requires experience and critical evaluation. The GBR must be compatible with other contract documents. The Contractor (and trenchless subcontractors) must be made aware of the document, and in some instances the Owner’s representative should consider educating bidders on its content and purpose. GBRs are recommended for use on some trenchless projects; however, the GBR should be specific to the intended trenchless method, and the ASCE suggested guidelines may need to be adapted to suit the project.

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The North Davis Sewer District Pipeline Rehabilitation Program

A Look into One of the Largest UV-Cured CIPP Lining Projects in North America

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Brown and Caldwell (Presented at NASTT’s 2016 No-Dig Show – Dallas, Texas)

The North Davis Sewer District (NDSD), a municipal entity located north of Salt Lake City, Utah, is in the midst of a multi-year pipeline rehabilitation program that has been proactively addressing corrosion and infiltration concerns throughout its wastewater interceptor system. Through a multi-phased approach that started in 2012, the NDSD program has quickly become one of the largest UV-cured CIPP lining installations in the United States and is a true trenchless rehabilitation success story.

Serving more than 200,000 people, NDSD provides wastewater conveyance and treatment services for nine northern Utah cities. With an aging system that consists primarily of reinforced concrete pipe (RCP), the District’s pipelines are not immune to the typical microbial-induced corrosion and water infiltration issues that plague the rest of the country. What is different, however, is how NDSD has approached their problem.

Prior to the current program, the District performed projects with alternative lining products to address corrosion and infiltration issues that failed to meet some of the primary objectives such as stopping inflow of groundwater. In order to find a rehabilitation solution that would effectively address the problems in their system, NDSD, together with their engineering consultant, re-evaluated their approach and started conducting their own research. Through this research process, it was determined that UV-cured CIPP lining provided the most effective, best-value solution that would become the foundation for NDSD’s rehabilitation projects moving forward.

CIPP Lining Program

Given the challenging combination of corrosion and significant infiltration issues within their system, along with a desire for a high-quality pipeline rehabilitation solution, NDSD developed a comprehensive five-year CIPP pipeline rehabilitation program to aggressively address the priority trunk lines within their system that centered around using UV-cured CIPP lining.

The District’s program began in 2012 with CIPP Project 1, the Gordon Avenue Project, which involved rehabilitation of over 25,000 linear feet of pipe ranging from 12 to 36 inches in diameter using UV-cured CIPP lining. The project had the challenges of being on residential roadways where all of the connections tied into relatively shal-
The scope of work involved lining the interceptor pipelines in their entirety, sealing all of the laterals, bypassing nearly 8 MGD (million gallons per day) of sewer flows (with 150% redundancy), removal and replacement of select pipe segments to include polymer manhole installations and re-alignments, all while maintaining water and wastewater service to the residents and maintaining access and two-way traffic along the roadways in the area. The District put this first project out to bid in late 2012 and the contract was awarded to C&L Water Solutions for an eventual final construction cost of approximately $5.8 million. Work began in April 2013 and was completed in early 2014. Despite the logistical challenges, the Gordon Avenue Project was highly successful and set the standard and expectations for the subsequent years of CIPP work for the District.

The following year, C&L completed its second project for the District, CIPP Project 2 – the Antelope Drive Project – at an eventual construction cost of approximately $4.6 million. This project involved approximately 25,000 linear feet of UV-cured CIPP lining, and included manhole removal and replacement work as well as lateral seal installation. The Antelope Drive Project had a different set of complexities as it involved construction through one of the busiest state roads in Layton, the eight-lanes-wide Antelope Drive. Working in the UDOT right of way involved significant time restrictions due to roadway work that was scheduled to immediately follow the CIPP project, as well as night work and significant lane restrictions. Using a resourceful flow management approach, C&L was able to find two key diversion locations that allowed flows to be diverted, removing over half of the 4.5 MGD flow from the bypass system. Creatively utilizing these diversions eliminated most of the bypass pumping for the first and most complex portion of the project and kept flows in the ground, reducing risk and saving time and money. The second portion of the project involved a self-performed bypass system that exceeded 7,000 linear feet in length and included a railroad crossing. The project finished successfully in late 2014.

For 2015, the District’s long-term rehabilitation plan continued to move forward with CIPP Project 3. C&L Water Solutions was once again the low bidder and awarded this project. As opposed to the prior two years, this year’s project involved four primary locations with pipe sizes ranging from 12 to 30 inches and approximately 20,000 linear feet of CIPP lining. Like the prior two projects, however, the scope remained the same with isolated polymer manhole replacements and lateral services to be sealed. Much of the project’s bypass requirements were mitigated through a network of diversions. The final construction cost for CIPP Project 3 was approximately $4.9 million.

At the time this paper was written, C&L Water Solutions was the low bidder for CIPP Project 4 and will be awarded this project in early 2016. The project is scheduled to commence during the first quarter of 2016. Project 4 will include over 18,000 LF of eight-inch-to 21-inch-diameter pipeline rehabilitation along with lateral rehabilitation work that will utilize the LMK T-Liner system. Once again, unique bypass pumping requirements will play a role in this project, with a significant challenge being the bypass set up in and around the intersection of Antelope Drive and Hill Field Road, located near Hill Air Force Base.

The Difference Maker

The invention of CIPP lining in 1971 marked the beginning of the trenchless pipeline rehabilitation revolution. The product provided a method to repair and essentially provide a new pipe within a pipe, in-place, without the costs, time, inconvenience, and challenges of open-cut excavation and replacement. Since then, many innovations and improvements to the process have expanded CIPP into one of the most widely used pipeline rehabilitation technologies for wastewater applications. Specifically, UV-cured CIPP is perhaps the best example of how the CIPP lining process has improved and is continuing to evolve.

The development of UV-cured CIPP lining has ushered in a wave
of benefits, providing owners with a high-quality product that addresses specific needs such as infiltration control, strict QA/QC requirements, higher structural requirements, as well as sustainable and responsible environmental design. In Germany, for example, where high quality is consistently preferred over quantity or low price, UV-cured lining systems are the predominant CIPP lining technologies and account for more than 75% of market share. As the technology becomes more readily available throughout North America, an increasing number of utility owners are taking notice. Over the past decade, UV-cured CIPP production and installation has more than doubled in the North American market, with significant growth projected to continue.

UV-cured CIPP offers a higher strength, fiberglass reinforced lining system that is cured using UV light rather than using steam or boiling water. It features an impermeable outer membrane that serves to both contain the styrenated resins and prevent outside groundwater from adversely affecting the curing process. Another advantage is that the shelf life of UV liners is typically several months, while felt liners need to be installed within a few days after wet-out, which provides significant flexibility in installation scheduling.

For installation, UV-CIPP lining tubes are winched into place within a pipe, rather than relying on the inversion methods commonly employed by traditional felt CIPP lining. It is also important to note that UV CIPP utilizes ASTM F1216, the same design methodology as traditional felt lining. When the UV-CIPP liner is positioned within the pipe, the liner is inflated using air pressure and a train apparatus carrying the UV light system is inserted. Prior to curing, a pre-inspection video is taken to ensure that the liner is positioned properly and that there are no issues, which is a distinct quality-control advantage compared to other lining methods. Once started, curing of the UV-CIPP lining typically takes a fraction of the time of steam- and water-cured lining methods and provides a highly accurate and consistent final lining product that is documented throughout the process. Because of these advantages, UV-cured CIPP lining was selected as the lining method of choice for the North Davis Sewer District projects.

The North Davis Sewer District pipeline rehabilitation program has become one of the largest UV-cured CIPP lining-specific projects in North America with over 70,000 LF of pipe successfully lined to date, making it a true trenchless rehabilitation success story. Due to the significant infiltration issues coupled with the severe corrosion problems that the District was experiencing throughout their system, UV-cured CIPP lining was selected as the go-to rehabilitation method because of its superior material performance in wet conditions, increased strength, and high degree of quality control throughout the installation process.

At this time, one additional phase (CIPP Project 5) is slated for 2017, which will complete the five-year rehabilitation program. Due to the overwhelming success of the current program, the North Davis Sewer District has continued plans for additional pipeline and manhole rehabilitation work in 2018 and beyond.

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NASTT Calendar of Events

October 5-6, 2016
Trenchless Elevated 2016
Utah Cultural Celebration Center
Salt Lake City, Utah
Information: trenchlesselevated.com

October 17-18, 2016
Western No-Dig Conference & Exhibition
South Point Hotel
Las Vegas, Nevada
Information: westt.org

October 18, 2016
NASTT’s Pipe Bursting Good Practices Course
South Point Hotel
Las Vegas, Nevada
Information: nastt.org/calendar

October 18, 2016
NASTT’s New Installations Good Practices Course
South Point Hotel
Las Vegas, Nevada
Information: nastt.org/calendar

November 9, 2016
NASTT’s Gas Good Practices Course
Fantasyland Hotel
Edmonton, Canada
Information: nastt.org/calendar

November 9-10, 2016
NASTT Northwest Trenchless Conference & Tradeshow
Fantasyland Hotel
Edmonton, Canada
Information: nastt-nw.com

November 17, 2016
NASTT Northeast Trenchless Conference
UMASS Lowell Inn & Conference Center
Lowell, Massachusetts
Information: nastt-ne.org

January 11-12, 2017
NASTT Pacific Northwest Trenchless Symposium
Cedarbrook Lodge
SeaTac, Washington
Information: pnwnastt.org

April 9-13, 2017
NASTT’s 2017 No-Dig Show & ISTT’s 35th International No-Dig
Gaylord National Hotel & Convention Center
National Harbor, Maryland
Information: nodigshow.com
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