Inside Spotlight:

13th Annual Western Regional No-Dig Conference & Exhibition

October 16 & 17, 2017 | Walnut Creek, CA

Early Bird Registration Ends Three Weeks Before the Conference

Featuring
Keynote Speaker
Alexander R. Coate,
General Manager at East Bay Municipal Utility District

The official publication of the North American Society for Trenchless Technology

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Cover photo: Views near Eagle Peak of the Diablo Range in Contra Costa County.
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A Growing Momentum

This year has been a fantastic year for WESTT so far. We’ve had several enthusiastic inquiries from our members about our upcoming Mini No-Dig conference this October and the Member Reception we’re planning for the National No-Dig Show in March 2018. The proactive interest in our events, offers of volunteer assistance with WESTT administration and activities, and ever-increasing membership are a testament to the good work and active outreach of our members, volunteers, and Board of Directors. Trenchless technology can serve to improve our infrastructure assets in a smart way, and WESTT allows exposure to this growing industry through education, networking, and outreach.

“We have newly formed committees tackling the WESTT activities, leadership, and educational opportunities serving to benefit our members.”

WESTT values a diversity of members, ranging from Engineers to Owners, Manufacturers to Vendors and Distributors, and General Contractors to Specialty Inspectors. Our Board of Directors is well rounded with a similar diverse makeup of individuals, allowing well-informed and well-vetted decision making for the success of our society as a whole. And, our WESTT Board of Directors are excited to continue our momentum in growing this important society; we have newly formed committees tackling the WESTT activities, leadership, and educational opportunities serving to benefit our members. These committees include:

- Mini No-Dig Conference Planning Committee – Brian Avon, Chair
- Magazine Committee – Lisa Arroyo, Chair
- No-Dig Conference Coordination Committee – Michelle Beason, Chair
- Nominations and Elections Committee – Tim Taylor, Chair

I would like to personally invite you to reach out to any of our Board members or committee chairs if you want to get involved in WESTT activities. In addition to our website (WESTT.org), we now have an email address (westtchapter.org@gmail.com) and a LinkedIn account (WESTT NASTT) as added methods to reach us and to see what we have on the books for future events. We also welcome feedback on ways to improve our society.

Thank you for your support of WESTT and we hope to see you at an upcoming event!
Services Offered:
HDD (Horizontal Directional Drilling) in dirt and rock
Horizontal Auger Boring (Jack & Bore) in dirt and rock
Pilot Tube (GBM) Horizontal Auger Boring
Pipe Jacking
Pipe Ramming
Hello fellow WESTT Chapter Members! We are well into the year, and I’m excited for the future during my term as Chair of the Board of Directors. NASTT’s 2017 No-Dig Show and ISTT’s 35th International No-Dig in Washington, D.C. were very successful on all accounts. The exhibit hall was a sell-out once again and we experienced excellent attendance. We were thrilled to host delegates from all over the globe! I’d like to thank the 2017 Program Chair and WESTT Chapter Director, Jennifer Glynn of RMC Water & Environment (a Woodard & Curran Company), for all her hard work and dedication in making this year’s Show a true success story!

NASTT exists because of the dedication and support of our volunteers and our 11 regional chapters. There are many WESTT Chapter Members that serve on our No-Dig Show Program Committee and volunteer their time and industry knowledge to peer-review the abstracts. We’re looking forward to the upcoming Show right in our own backyard, in Palm Springs next March. The WESTT’s own Regional Chapter Chair, Cindy Preuss of HydroScience Engineers, is serving as the 2018 Program Vice Chair. Cindy, along with Chair Don Del Nero of Stantec and these 2018 committee members from the WESTT chapter will ensure that the technical presentations are up to the standards we are known for: Sam Ariaratnam, Brian Avon, David Bennett, Glenn Boyce, Sam Branchreau, Craig Camp, Anil Dean, Jennifer Glynn, Rick Hanford, Sarah Johnson, Rachel Maupin, and Matthew Wallin.

The WESTT Chapter is also home to some of our Session Leaders. Session Leaders are Program Committee members who have the added responsibility of managing a session of the technical program and working with the authors and presenters to facilitate excellent presentations. I would like to extend a special thank you to the WESTT Chapter Members who will also serve as Session Leaders in 2018: Anil Dean, Rachel Maupin, and Matthew Wallin.

We are looking for a Regional Ambassador to assist Cindy and Don with grassroots marketing for next year’s conference in Palm Springs. This person will also work closely with the WESTT Chapter and the NASTT Staff. If you’re looking for an opportunity to get involved at the local and national level, let us know!

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 strictly on a volunteer basis. They donate personal time to travel around North America to provide high-quality training on a host of trenchless technologies. The WESTT Chapter may have the largest contingency of volunteer instructors on the NASTT roster! I would like to thank Chapter Members Sam Ariaratnam, Glenn Boyce, Aaron Cohen, Jennifer Glynn, Norm Joyal, Collins Orton, and Matthew Wallin for serving as instructors this year. To learn more about these and all our expert instructors, visit nastt.org/training/instructors.

I’ll hope you’ll not only join us next spring in Palm Springs for the 2018 No-Dig Show, but also this fall at the Western Regional No-Dig Show in Walnut Creek on October 16 and 17. You can read all about the event in the following pages of this magazine.

The North American Society for Trenchless Technology is a society for trenchless professionals. Our goal is to keep our finger on the pulse of our industry and provide beneficial initiatives. To do that, we need the involvement and feedback from our professional peers. 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 and to have your voice heard. Please consider becoming a volunteer – we would love to have you get more involved.

NASTT has a very promising future because of our amazing volunteers. Thank you again for your continued support and dedication to NASTT and the trenchless technology industry.
Go The Distance With CUES
CUES is the world’s leading manufacturer of pipeline inspection and repair equipment. For more than 50 years, CUES has established a reputation as having the most rugged and reliable inspection equipment in the industry. At our Orlando, FL headquarters, we assemble and test all of our products, ensuring they meet the highest standard of functionality, quality, and reliability.

While CCTV systems remain a major portion of our business, CUES has developed a range of advanced products for new, more detailed inspections that provide data previously unavailable. LiDAR, RADAR, and LASER profiling systems provide customers with precision data, allowing an economic approach to infrastructure spending and resource allocation. To reduce downtime, CUES has a large parts inventory, emergency/loaner equipment, and virtually 24-hour on-call service support. CUES also offers full service centers throughout North America, including Ontario, CAN and Vallejo, CA for your convenience.

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CUES SPiDER is the first truly wireless, color, manhole-scanning technology in a lightweight and compact form factor. Using point cloud, SPiDER collects millions of 3D measurements during each manhole inspection to less than 3 mm accuracy. SPiDER calculates its position in the manhole shaft by using its sensor data to measure its incremental motion. This frees inspections from problems associated with inaccurate, poorly calibrated, cable counters and poorly managed cables. SPiDER weighs less than 30 pounds and can be hand-carried to easements or other difficult-to-access sites. This portability is possible because the processing computer and battery supply are integrated into the scanner. Additionally, SPiDER does not require an inspection truck or other piece of equipment (other than the included tablet) for operational use.

Customer sales and support are available through our expert regional sales managers and dealerships. Contact us today to learn more.

Company profiles put your business and your team’s expertise in the spotlight!

To reach trenchless technology professionals through the WESTT Western Regional Trenchless Review and its targeted readership, contact Chad to discuss your company’s promotional plans.

Chad Morrison, Marketing Manager | Phone: 866-985-9788 | Email: chad@kelman.ca
The Western Society for Trenchless Technology (WESTT) is proud to present the 13th Annual Western Regional No-Dig Conference, Exhibition, and Course, Monday and Tuesday, October 16 and 17, 2017 in Walnut Creek, CA.

Register today and enjoy all the benefits of a national conference program in a smaller forum with a personalized touch! Come to sunny Walnut Creek, CA in the San Francisco Bay Area to learn about the latest in trenchless technology from experts in the field. Registration for the first day of the conference includes an informative technical program and product exhibition area.

On the second day of the conference, WESTT is teaming up with the Northern California Pipe User’s Group (NorCal PUG) to offer attendees the choice to attend either NASTT’s Horizontal Directional Drilling (HDD) Good Practices Course or NASTT’s Introduction to Trenchless Installation and Rehabilitation Courses. Attendees may choose to participate in either or both days of the conference (see rates). For more information on course content and instructors, please visit www.NASTT.org/training.

Attendees are responsible for making their own lodging arrangements. A limited block of rooms has been reserved for WESTT at a rate of $189 per night at the Embassy Suites – Walnut Creek. Call (925) 934-2500 and ask for the WESTT group rate. The hotel address is 1345 Treat Boulevard, Walnut Creek, CA 94597. Special room rate is guaranteed until September 15, 2017.

For questions about the program content or registration information, please contact Brian Avon at (925) 956-4800 – Brian_Avon@golder.com or Norm Joyal at (925) 705-4119 – joyal@mcmjac.com.

Agenda

**Technical Program and Product Exhibition**
Monday, October 16, 2017 7:30 am - 5:00 pm (PT)

**Monday Evening Networking Reception**
Monday, October 16, 2017 5:30 pm - 8:00 pm (PT)

**HDD Good Practices Course**
Tuesday, October 17, 2017 7:30 am - 5:00 pm (PT)

**Trenchless Intro Course**
*half-day courses for new installations & rehabilitation*
Tuesday, October 17, 2017 7:30 am - 5:00 pm (PT)

Registration Information

Early Bird Registration will end three weeks before the conference. Member rate for the October 16 technical program is for WESTT members only (does not include PUG).

<table>
<thead>
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<th>Cost</th>
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<tr>
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<td>Non-Member Early Bird</td>
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<tr>
<td>Member Regular</td>
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<tr>
<td>Non-Member Regular</td>
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<td>Municipal Regular</td>
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Day One Sponsorships

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<td>(Table, Program Full-Page, Food Sponsor, up to 4 Representatives)</td>
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<tr>
<td>Gold Sponsor</td>
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<td>Silver Sponsor</td>
<td>$750.00</td>
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Short Course

Member prices for the October 17 courses include both WESTT members and PUG. Courses are HDD and a combination of two half-day classes on new installations and rehabilitation.

<table>
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<td>Non-Member Early Bird</td>
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<tr>
<td>Member Regular</td>
<td>$400.00</td>
</tr>
<tr>
<td>Non-Member Regular</td>
<td>$475.00</td>
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</table>

Online Registration

To register online for this event, go to: www.regonline.com/registration/checkin.aspx?MethodId=0&EventSessionId=8c6e10f674e1a98fa407d96a0&EventId=2022685

If paying by check, please send payable to:
WESTT
Attn: Norm Joyal
1350 Treat Boulevard, Suite 100 • Walnut Creek, CA 94597
Phone: (925) 705-4119 • joyal@mcmjac.com
Alexander Coate became General Manager (GM) of the East Bay Municipal Utility District (EBMUD) in 2011. In his role, he oversees delivery of high-quality drinking water to 1.4 million residents and businesses in 20 cities and 15 unincorporated communities in Alameda and Contra Costa Counties, as well as wastewater treatment for 650,000 of those same customers. As GM, he balances the continued demands of maintaining critical infrastructure and financial stability with innovation in sustainability and long-term water and wastewater planning. Trenchless technologies are an aspect of growing importance for water infrastructure projects, and for helping EBMUD achieve its triple bottom line (social, environmental, and financial responsibilities).

Alexander has a Bachelor of Arts in Neurobiology and a Master’s of Science in Civil/Environmental Engineering, both from UC Berkeley. He lives in Lafayette with his family.

Q&A with Alexander Coate, General Manager of the East Bay Municipal Utility District in California

Keynote speaker at this year’s Western Regional No-Dig Conference in Walnut Creek

Alexander, what will your keynote presentation focus on? My keynote will highlight the growing importance of trenchless technology here at EBMUD. As a water utility, we need to continually invest in a vast underground infrastructure that includes more than 4,000 miles of pipelines. As that infrastructure ages, we’re ramping up our renewal and replacement levels. It’s important to do so with an eye toward high efficiency in order to stretch our ratepayer dollars and speed replacement. We also need to look for ways to minimize environmental and community impacts. Often, a trenchless methodology is the best way for us to address that “triple bottom line.” In my talk, I’ll give some quick examples of interesting projects we’ve been working on over the past few years that really highlight the value of trenchless technologies for addressing our needs.

Tell me about your connection to WESTT and how you came to be involved in this year’s conference. As the western regional branch of NASTT, WESTT is a great forum for EBMUD’s engineers to keep up with the latest technologies as they design underground projects throughout our service area. Over the years they’ve attended several conferences and presented papers, and I believe this involvement has delivered tremendous value to our customers by letting us take advantage of the wealth of knowledge and expertise that comes together at these conferences.

How are trenchless technologies relevant to you and your team at EBMUD? EBMUD provides water to dozens of communities in the East Bay, and we take our responsibilities very seriously. We need to ensure that every time one of our 1.4 million customers turns on their water tap, they get reliable, safe water – and at a reasonable cost. To do that, we are continually proactive in looking for ways to do our work better. Trenchless technologies are part of our design toolbox when we’re planning a project in one of those communities.

There are situations where a trenchless technology can reduce the project cost or duration, reduce traffic impacts and the need to cut and restore pavement. That not only saves money for our ratepayers, but also reduces the impact of our work within the community, and can reduce environmental impacts.

Just last year, EBMUD completed the installation of two 48-inch diameter pipes installed with an open shield tunnel boring machine through an existing reservoir embankment. This effort greatly reduced the excavation volumes and costs compared to open trench. In the same year, EBMUD renewed 2.5 miles of asbestos cement pipe using Cured-In-Place Pipe. And, in 2019, EBMUD plans to install a 24-inch pipeline under the Oakland/Alameda estuary using horizontal directional drilling to connect the pipeline to Alameda Island. In addition to these two projects, EBMUD has experience with installation of casing pipe for freeways and railroad crossings using horizontal auger boring, pipe bursting, and slip-lining.

Is this your first time attending this event? It’s my first time personally attending but EBMUD’s team of engineers has worked with NASTT for many years. I’m really looking forward to sharing information on the trenchless projects we’ve completed and future planned projects where trenchless technology will play a key role in maintaining the triple bottom line in social, environmental, and financial responsibilities.

Alexander Coate became General Manager (GM) of the East Bay Municipal Utility District (EBMUD) in 2011. In his role, he oversees delivery of high-quality drinking water to 1.4 million residents and businesses in 20 cities and 15 unincorporated communities in Alameda and Contra Costa Counties, as well as wastewater treatment for 650,000 of those same customers. As GM, he balances the continued demands of maintaining critical infrastructure and financial stability with innovation in sustainability and long-term water and wastewater planning. Trenchless technologies are an aspect of growing importance for water infrastructure projects, and for helping EBMUD achieve its triple bottom line (social, environmental, and financial responsibilities).

Alexander has a Bachelor of Arts in Neurobiology and a Master’s of Science in Civil/Environmental Engineering, both from UC Berkeley. He lives in Lafayette with his family.

Please join us on Monday, October 16, 2017 for Alexander’s Keynote Address, beginning at 9:00 am.
What are you looking forward to the most this year?
We’re at an exciting time. This year was extremely successful in terms of the miles of pipeline replaced to improve system reliability. EBMUD embarked on a new program called Pipeline Rebuild two years ago with a commitment to increase pipeline renewal from 10 miles per year to (eventually) closer to 40 miles per year. As we study ways to ramp up the renewal rate of our pipeline infrastructure, we’re evaluating every step of project delivery and trying out all kinds of innovative methods. Better ways to plan our work, better ways to design it, to build it. Better ways to share information and collaborate with other utilities and agencies. The Pipeline Rebuild program is looking at all of those things and more, and we’re seeing some tremendous results. We’ve tackled some tough projects by applying some really interesting technologies, everything from structural pipe liners, to new pipe materials, to streamlined design processes. Those new approaches enabled us to increase our pipe renewal to 15 miles, an all-time high for us – and that’s just the beginning. I’m really looking forward to seeing what the team comes up with next.

What connections do you hope to build or develop during your time at the show?
Building relationships is extremely important in our industry. WESTT and NASTT is a great forum for idea sharing – EBMUD can learn much from the participating agencies and industry leaders. What I hope to gain are new relationships that I can call upon to collaborate on trenchless projects – to learn what has worked for others and relate that to what can potentially work for EBMUD. I also hope to learn about new and existing trenchless technologies which I will pass on to our engineers.

Any other last thoughts?
I really appreciate being asked to be the keynote speaker for this year’s WESTT conference and given the opportunity to talk about EBMUD, our challenges and accomplishments, the types of trenchless projects we’ve done and the projects we hope to do in the future. Trenchless technology will continue to be an integral part of our portfolio.
The WESTT Board of Directors would like to recognize the valuable support to the association from the Northern California Pipe Users Group (PUG). Thank you for your support of WESTT and our Regional No-Dig Conference and Exhibition!

The Northern California Pipe Users Group has been a leader in the underground infrastructure industry providing training and education for more than 25 years. PUG members include Public Agencies, Consulting Engineering firms, Contractors, Manufacturers, and Suppliers. PUG’s emphasis has been in sharing new technologies and the latest trends in trenchless and open-cut pipeline construction and repair.

Mission
PUG’s goals are to promote essential education and critical information for those involved in underground sewer and water pipeline installation and rehabilitation. PUG understands that with crucial underground infrastructure aging, communities are at a greater risk of pipeline failure. This situation highlights the importance of PUG’s mission of promoting education, training, and a forum where members find opportunities to gain insight on topics that matter to our industry.

PUG holds monthly meetings on a variety of topics ranging from trenchless pipeline installation, lateral and manhole repairs, pipe coating, corrosion control, and lessons learned on pipeline installation projects. In general, members walk away equipped with ideas that can be implemented immediately on the job site to maximize productivity. In addition to these dynamic educational monthly presentations, PUG meetings offer outstanding networking opportunities. PUG also sponsors one- or two-day workshops in the month of October. Toward this effort, PUG conducts surveys and requests member input and opinions on topics that might be of interest.

And, in the month of February, PUG holds its annual Sharing Technologies Seminar with a variety of presentation topics for a full day of educational and networking opportunities.

For more information on this group, visit https://norcalpug.com or find us on LinkedIn at https://www.linkedin.com/company/northern-california-pipe-users-group.

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Abstract
In 2016, the City of Yuma, Arizona undertook the replacement of approximately 5,800 L.F. of existing aging and undersized asbestos cement water lines in the vicinity of the downtown core to reduce maintenance and repairs and improve water service levels. The original water lines were installed between 1938 and 1940. Six line segments of existing 2-inch to 6-inch asbestos cement water lines were replaced by 6-inch diameter PVC pipe. To gain a better understanding of the pros and cons of traditional open-cut construction compared to Horizontal Directional Drilling (HDD), the City separated the project into approximately 2,000 L.F. of HDD and 3,800 L.F. of open-cut. Being the same project, it provided an excellent opportunity to study a true head-to-head comparison of the two methods.

Introduction
The City of Yuma, Arizona has a population of just over 93,000 residents and is located in the southwestern corner of the state bordering California. In February 2016, the City started the construction of a Downtown Waterline Replacement project to replace their aging 4-inch (100mm) and 6-inch (150mm) asbestos cement waterlines with 6-inch (150mm) PVC pipes. The existing pipes were installed between 1938 and 1940 and had far exceeded...
data collection included visiting the jobsite over a two-month period between February to March 2016 and collecting real time data on equipment usage and activity characteristics. This involved recording information on all specific equipment used on the project including model year, engine hours, load factor, horsepower, and percent utilization. Emissions are calculated based on specific equipment and respective activities to provide actual emissions and productivities. Equipment information for the open-cut and HDD installations is shown as in the following section.

**Open-Cut Construction Equipment**
The open-cut construction portion of the project that was analyzed in this study involved replacements at three locations: 1) 9th Avenue (April 4-6); 2) 13th Avenue (March 17); and 3) 15th Avenue (March 16). Table 2 presents information on the equipment used on each of the three open-cut sections. The Case 590 Super L excavator used in the project is shown in Figure 2.

<table>
<thead>
<tr>
<th>Name</th>
<th>Model</th>
<th>Power</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavator</td>
<td>2012 Case 590 Super L (4T-390)</td>
<td>95 hp</td>
<td>1. Excavation of trench</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Backfilling of trench</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Lifting of pipe and layout</td>
</tr>
<tr>
<td>Hand Compactor</td>
<td>2014 Lancin 196CC</td>
<td>5.5 hp</td>
<td>Compaction of backfill</td>
</tr>
<tr>
<td>Truck</td>
<td>2015 Dodge Ram 3500</td>
<td>383 hp</td>
<td>Transport</td>
</tr>
<tr>
<td>Truck</td>
<td>2015 Form F350</td>
<td>385 hp</td>
<td>Transport</td>
</tr>
<tr>
<td>Water Truck</td>
<td>2002 Chevrolet C6500</td>
<td>207 hp</td>
<td>Dust control</td>
</tr>
</tbody>
</table>

Table 2. Details of equipment used for open-cut installation.
and 3) 7th Avenue between 2nd and 3rd Streets (February 12). Table 3 presents the information on the equipment used on each of the three sections. The Vermeer D24x40A rig used in the project is shown in Figure 3.

### Environmental Calculation of Airborne Emissions

An emission calculator tool was developed in MS Excel using Visual Basic coding. E-Calc™ estimates emissions [i.e., hydrocarbons (HC); carbon monoxide (CO); nitrogen oxide (NOx); particulate matter (PM); carbon dioxide (CO₂); and sulfur oxide (SOx)] from underground utility projects based on EPA-approved methodology. Required input data can be obtained from daily progress reports or productivity estimates, while equipment-specific information should be acquired from the contractor. Non-road equipment data include: power; model year; engine technology; useful hours and cumulative hours to date; fuel characteristics such as type and sulfur content; and activity characteristics such as representative equipment cycle, power used, and hours of use. The data required to calculate emissions generated from on-road transportation equipment include: model year; gross vehicle weight; mileage; fuel characteristics such as type and sulfur content; and activity characteristics such as altitude of operation, number of trips, one way distance, and return distance.

As with any software tool, the accuracy of output information depends on the accuracy of the input data. The calculator is a tool intended for contractors, engineers, and owners to obtain an estimate of the environmental impact of their proposed underground utility project.

The tool provides a comparison of emissions generated from two possible installation methods with default information available for four typical utility construction methods: 1) horizontal directional drilling; 2) trenchless pipe replacement; 3) trenching; and 4) traditional open-cut. It should be noted that the tool is portable and can be applied to any construction process that incorporates machinery and equipment such as water main replacement technologies studied in this research. This software tool has been used for evaluating numerous trenchless technology options (Ariaratnam and Sihabuddin, 2009; Matthews et al. 2014).

The emission factor is the basic tool for estimating emissions. It is usually

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Table 3. Details of equipment used for HDD installation.

<table>
<thead>
<tr>
<th>Name</th>
<th>Model</th>
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<td>HDD Rig</td>
<td>2000 Vermeer D24x40A</td>
<td>125 hp</td>
<td>1. Pilot bore</td>
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<td></td>
<td></td>
<td></td>
<td>2. Pre-reaming</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3. Pullback and Pipe Installation</td>
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<tr>
<td>Excavator</td>
<td>2012 Case 590 Super L (4T-390)</td>
<td>95 hp</td>
<td>Excavation of entry &amp; exit pits</td>
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<td>Vacuum Truck</td>
<td>Vacmasters System 4000</td>
<td>127 hp</td>
<td>Potholing existing utilities</td>
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<td>Fluid Mixing System</td>
<td>Vermeer 2000 Gallon Mud Mixer</td>
<td>16 hp</td>
<td>Mixing of drilling fluid</td>
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<td>Truck</td>
<td>2008 Ford F650</td>
<td>330 hp</td>
<td>Transport of vacuum equipment</td>
</tr>
<tr>
<td>Truck</td>
<td>1993 Kenworth T800</td>
<td>450 hp</td>
<td>Transport of mixing system</td>
</tr>
<tr>
<td>Water Truck</td>
<td>2002 Chevrolet C6500</td>
<td>207 hp</td>
<td>Dust control</td>
</tr>
<tr>
<td>Truck</td>
<td>Kenworth W900</td>
<td>600 hp</td>
<td>Transport of HDD rig</td>
</tr>
</tbody>
</table>

---

“As with any software tool, the accuracy of output information depends on the accuracy of the input data. The calculator is a tool intended for contractors, engineers, and owners to obtain an estimate of the environmental impact of their proposed underground utility project.”
Table 4. Emission comparison.

<table>
<thead>
<tr>
<th>Installation Method</th>
<th>Installation Length Monitored</th>
<th>HC (lbs)</th>
<th>CO (lbs)</th>
<th>NOx (lbs)</th>
<th>PM (lbs)</th>
<th>CO₂ (S/T)</th>
<th>SOx (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Directional Drilling</td>
<td>1,580 L.F.</td>
<td>1.1</td>
<td>5.3</td>
<td>13.7</td>
<td>0.7</td>
<td>0.98</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td><strong>Emissions/Unit (x10⁻³)</strong></td>
<td><strong>0.7</strong></td>
<td><strong>3.4</strong></td>
<td><strong>8.7</strong></td>
<td><strong>0.4</strong></td>
<td><strong>0.6</strong></td>
<td><strong>0.8</strong></td>
</tr>
<tr>
<td>Open-Cut</td>
<td>945 L.F.</td>
<td>2.1</td>
<td>27.4</td>
<td>18.2</td>
<td>3.7</td>
<td>1.81</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td><strong>Emissions/Unit (x10⁻³)</strong></td>
<td><strong>2.2</strong></td>
<td><strong>29.0</strong></td>
<td><strong>19.3</strong></td>
<td><strong>3.9</strong></td>
<td><strong>1.9</strong></td>
<td><strong>6.0</strong></td>
</tr>
</tbody>
</table>

*Note: 1 S.T. = 2,000 lbs.*
emissions compared to traditional open cut. Overall, the HDD option emitted approximately 23% airborne emissions compared to open-cut.

Traffic Impacts
Numerous researchers have cited reduction in traffic impacts as a major benefit of adopting trenchless technologies such as HDD (Tighe et al. 1999; Gilchrist and Allouche, 2005). Being in a residential neighborhood near the downtown core, it was important to minimize traffic impacts and inconvenience to the local residents. The sections with installations using traditional open-cut construction involved closure of the entire street to traffic as shown in Figure 6. Conversely, only half of the street was closed during the HDD installations as shown in Figure 7, thus enabling traffic flow. This further demonstrates an advantage of utilizing trenchless methods, particularly in urban areas. In this project, the City of Yuma planned on replacing the entire deteriorated pavement. Generally, only minimal sections of pavement at the entry and exit pits require replacement when employing HDD.

Productivity Analysis
Productivity data was collected onsite for both the HDD and open-cut installations. All activities were timed by a stopwatch to gain a better understanding of all tasks associated with both installation methods. Since the installation lengths were not the same, all values were normalized to productivity shown in linear feet per minute (L.F./min). As shown in Table 5, HDD achieved an average productivity of 1.91 L.F./minute compared to traditional open-cut, which achieved an average productivity of 0.43 L.F./minute. This translates to HDD achieving productivity greater than four times that of open-cut. It should be noted that productivity did not consider surface replacement such as paving or other tasks. The City of Yuma decided to repave all of the streets regardless of installation method and thus we did not consider restoration in the analysis. If considered, much more time would have been dedicated to surface restoration with the open-cut method. Productivity was measured as the time from excavation to final installation of the PVC pipe. In the case of open-cut, this included compaction of the backfill material.

Horizontal Directional Drilling was able to achieve more than four times the productivity rate as traditional open-cut. This may be attributed to the ability of HDD to navigate horizontally once the drill rod is inserted into the ground. Furthermore, improved accuracy of the tracking equipment and tooling enables for more accurate installation, thereby reducing the likelihood of striking an existing buried utility. Furthermore, the contractor was required to pothole and confirm the depth of all existing utilities that crossed the path of the PVC pipe installation.

Conclusions
This paper described a field research study to capture and analyze site data comparing differences in environmental impacts, traffic impacts, and productivity between traditional open-cut construction and Horizontal Directional Drilling (HDD) portions of a replacement project of existing asbestos-cement waterline in Yuma, Arizona. The project was unique in that it provided a head-to-head comparison of the two methods in the same local environment. The field study involved assessing the installation of 945 L.F. (288m) of 6-inch (150mm) C900, CL 235 DR18 fully restrained PVC water pipe using traditional open-cut construction and 1,580 L.F. (482m) of 6-inch (150mm) C900, CL 235 DR18 fully restrained FPVC water pipe using HDD.

“As expected, traffic impacts were minimized with the HDD option. The sections with installations using traditional open-cut construction involved closure of the entire street to traffic.”
Field emissions data was collected and inputted into the eCalc™ software. The results found the HDD option to have emitted approximately 23% of airborne emissions compared to open-cut. Furthermore, converting emitted emissions to a normalize value found HDD to have produced less than a third of CO₂ emissions.

As expected, traffic impacts were minimized with the HDD option. The sections with installations using traditional open-cut construction involved closure of the entire street to traffic. Conversely, only half of the street was closed during the HDD installations, thus enabling traffic flow.

Overall productivity was much higher with the HDD option. The analysis found HDD achieved an average productivity of 1.91 L.F./minute compared to traditional open-cut, which achieved an average productivity of 0.43 L.F./minute. This translates to HDD achieving productivity greater than four times that of open-cut. It is worth noting that surface restoration was not included in the analysis because the City of Yuma planned to repave all of the streets regardless of installation method.

### References


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### Table 5. Productivity comparison.

<table>
<thead>
<tr>
<th>Installation Method</th>
<th>Location</th>
<th>Length Monitored</th>
<th>Time for Completion (minutes)</th>
<th>Date</th>
<th>Productivity (L.F./minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Directional Drilling</td>
<td>8th Avenue</td>
<td>520 L.F.</td>
<td>242</td>
<td>Feb. 8-9</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td>7th Avenue</td>
<td>1,060 L.F.</td>
<td>639</td>
<td>Feb. 10-11</td>
<td>1.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average 1.91</td>
</tr>
<tr>
<td>Open-Cut</td>
<td>15th Avenue</td>
<td>70 L.F.</td>
<td>321</td>
<td>March 16</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>13th Avenue</td>
<td>175 L.F.</td>
<td>385</td>
<td>March 17</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>9th Avenue</td>
<td>700 L.F.</td>
<td>1,103</td>
<td>April 4-6</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average 0.43</td>
</tr>
</tbody>
</table>
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- Joint Sealing
- Pipe Bursting
- Pipe Jacking
- Slip-lining
- Swagelining

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New Reclaimed Water Pipeline Expansion Saves Precious Drinking Water

Mike Massaro, Bennett Engineering Services, Roseville, CA
Gayleen Darting, Sacramento Regional County Sanitation District, Sacramento, CA
Sara Maloney, Underground Solutions, Poway, CA

Abstract
In September of 2013, Sacramento Regional County Sanitation District (Regional San) approved the Sacramento Power Authority Cogeneration Recycled Water Recycling Pipeline Project (SPA Project). The first phase will carry approximately 1,000 acre-feet per year (AFY) of tertiary filtered and disinfected recycled water to the Sacramento Power Authority Cogeneration Plant. The second phase will provide an additional 1,700 AFY for landscape irrigation at the Sacramento Regional Wastewater Treatment (SRWTP). This phase will not be completed until 2023, which is when the Sacramento Regional Wastewater Treatment upgrade project, known as EchoWater, will be completed.

A portion of the pipe alignment runs below Regional San’s new Flow Equalization Basin, two levees, and a creek, while also crossing under environmentally sensitive areas. In order to reduce the impact of construction in these areas, horizontal directional drilling was chosen as the major installation method. Two drills were required, one for 3,220-feet of 18-inch pipe for the recycled water pipeline and another for 3,220-feet of 10-inch pipe as part of the EchoWater Project. Approximately 2,470-feet of both 18- and 10-inch pipe were installed using open cut installation methodology.

The focus of this paper will be on Phase 1A of the overall project – the design development, the material choices, and the impact on the project area. It will also look at the benefits of trenchless installation methods when used for discreet pipeline installation.

Introduction
The City of Sacramento has a had a long history as a leading city in California. Often referred to as “River City” due to its location at the confluence of the Sacramento and American Rivers, the settlement was originally established to be an agricultural community.

The city continued to grow as the years passed; it saw its biggest population boom during and after World War II. As California became increasingly important to the South Pacific war effort, Sacramento’s proximity to the new McClellan Air Force Base, the new Army Depot, and the revived Mather Air Force Base meant that thousands of new military men and women were coming through the city on their way to bases and on to San Francisco. It also meant that a large group of laborers who began working at the newly opened bases needed somewhere to raise their families. The increased interest in the area led to an influx of new residents, and thus, a much greater demand for water and wastewater services.

In order to handle this new wastewater demand, a series of wastewater collection systems and treatment plants were established. By the 1970s, there were 20 separate treatment plants servicing the 600,000 people living in the Sacramento area. In an effort to establish a more singular and centralized wastewater treatment facility for the region, the City of Folsom and both the City and County of Sacramento joined forces to create the Sacramento Regional County Sanitation District (Regional San) in 1973. Funding for the new development was provided through a series of federal and state grants. Over the following ten years, a state of the art wastewater treatment facility was built near Elk Grove, CA and a series of interceptor pipelines were installed throughout the region to link each community’s local sewer collection systems to the larger treatment system. The Sacramento Regional Wastewater Treatment Plant (SRWTP) began operations in 1982 – cleaning the region’s wastewater and safely discharging the treated water into the Sacramento River – and has been in service ever since (see Figure 1).

Today, Regional San services 1.4 million residents and business on a daily basis and holds the position as the largest inland wastewater treatment plant west of the Mississippi River. Regional San actively invests in water quality research in order to ensure that the best treatment methods are being used and also advocates and supports scientific research to improve the surrounding natural area. One of the core values of Regional San is its responsibility to environmental stewardship. It has a staff dedicated to monitoring and conserving the surrounding wetlands, renewing woodlands and grasslands, and protecting the valuable “Bufferlands” (see Figure 1).

The Bufferlands is the area surrounding the SRWTP, which Regional San itself owns. Wastewater treatment plants need to be good neighbors to the local community. That’s why in the 1970s, Regional San decided to purchase the property surrounding...
the treatment plant to develop a buffer between treatment plant operations and its nearest neighbors. This 2,150-acre expanse of open space minimizes the potential for odor and other nuisances that could impact the surrounding neighborhoods; however, the Bufferlands provides much more than a nuisance buffer. This important nature area provides hundreds of acres of high quality wildlife habitat, farmland, and open space in a rapidly urbanizing area of California. It has both upland and wetland habitats, which include 230 species of birds and 25 species of native mammals, as well as 20 species of rare plants and animals. Regional San’s natural resources specialists who maintain the Bufferlands operate an extensive outreach program in order to better educate those in the surrounding area about the plants and wildlife that call their neighborhoods home.

In terms of its material ownership, Regional San owns and maintains the following:

- 169 miles of 36-inch to 144-inch gravity interceptors throughout Sacramento and Yolo Counties
- 46 miles of 16-inch to 66-inch force mains
- 11 wastewater pumping facilities that each pump between 10 and 264 million gallons per day (MGD)

Regional San provides wastewater conveyance and treatment services to residential, industrial, and commercial customers throughout unincorporated Sacramento County; the cities of Citrus Heights, Elk Grove, Folsom, Rancho Cordova, Sacramento, and West Sacramento, as well as the communities of Courtland and Walnut Grove.

Each day, an average of 127 MGD of wastewater is treated and then safely discharged by Regional San to the Sacramento River.

**Project Background**

In 2003, Regional San completed its Water Reclamation Facility (WRF). This small-scale water recycling plant was initially designed to provide up to 5 MGD of Title 22 disinfected tertiary recycled water. Title 22 is a California regulation set forth by the California Department of Health (now known as the Division of Drinking Water) in regards to the quality of water that is to be used for specific purposes. For example, in order for water to be used for public park irrigation, residential landscape irrigation, agricultural irrigation, and industrial cooling towers, the water must reach a level of disinfection that is nearing that of potable water. By using recycled water, the demand on potable water is lessened, which is crucial given the current drought-stricken status of California.

In 2007, Regional San completed the Water Recycling Opportunities Study (WROS). This study took a county-wide look at a variety of potential recycled water projects. The WROS concluded that water recycling projects near the vicinity of the SRWTP were the most promising projects for implementation, since they were the closest to a recycled water supply from the WRF. The City of Sacramento, in collaboration with Regional San and other stakeholders, initiated the process of updating its Water Supply Master Plan (WSMP) in 2009. The feasibility of using recycled water within the City’s service area was evaluated and it was found that the most promising recycled water opportunities were located in the southwest portion of Sacramento. In particular, the SPA Cogeneration Plant, located in unincorporated Sacramento County and currently using potable water to supply its cooling tower water needs (approximately 1 MGD), could be converted to recycled water without significant changes to its operation.

Regional San completed the SPA/ City of Sacramento Recycled Water Feasibility Study in 2013, which concluded that a phased project should be initiated to first provide recycled water to the Sacramento Power Authority (SPA) Cogeneration Plant and then to expand service to other users in the area. This phased approach would allow for other non-potable uses, such as irrigation to parks, schools, and golf courses, as Regional San expanded its supply of recycled water.

While the feasibility of the SPA project was being studied, a new National Pollutant Discharge Elimination System (NPDES) permit was issued to Regional San by the state in December 2010. In order to maintain its discharge permit, Regional San would need to implement a greater degree of treatment for discharged wastewater. This level of treatment included increased ammonia and nitrate removal as well as enhanced filtration and disinfection. Importantly, this would allow virtually all the treatment plant’s effluent to meet the requirements for Title 22 disinfected tertiary recycled water or equivalent effluent.

In order to meet the new 2010 permit requirements, Regional San has undertaken the largest public works project in the county’s history. This project has been named the EchoWater Project. The EchoWater Project will provide ammonia and nitrate removal, filtration, and...
enhanced disinfection treatment required to meet the standards for tertiary recycled water. The EchoWater Project is estimated to cost between $1.5 and $2.1 billion overall and must be completed by 2023. The new treatment processes are expected to provide up to a 95% reduction in the ammonia discharge of treated water. Regional San was approved to receive approximately $1.6 billion in financing through the California State Clean Water State Revolving Fund. This low-interest financing will save rate-payers nearly half a billion dollars in interest while the project itself negates the need to expand the WRF to provide the recycled water capacity for the Sacramento Power Authority Cogeneration Recycled Water Project (SPA Project). Prior to the SPA Project, the WRF produced 2.2 MGD of recycled water seasonally for landscape irrigation in the Elk Grove area, south of the SRWTP. The WRF was ultimately designed to be expanded to a 10 MGD facility.

Project Design
The SPA Project was divided into two phases. The initial phase (subdivided to Phases 1A and 1B) provides a recycled water transmission line from the SRWTP to the SPA Cogeneration Plant (see Figure 2 for Phase 1A). The pipe itself is sized to convey up to 4.2 MGD for possible future expansion, as well as local irrigation use. Phase 2 will supply irrigation water to parks, schools, and golf courses near the Phase 1 alignment. The recycled water supply for Phase 2 will be available once the EchoWater Project is complete in 2023.

As a service to the City, and at its request, the Phase 1 pipeline will also include stub outs for recycled water fill stations. These can be used by residents and commercial users to obtain recycled water to irrigate their property or for other allowed uses. These additional uses from the fill stations will not markedly increase the overall draw on the recycled water supply, benefitting all at a near negligible cost. The sum of these uses will also assist the region in meeting water recycling goals set from a local level all the way up to a federal level.

At the beginning of design, Phase 1 was estimated to cost $15.2 million. Funding was provided by a number of grants through California Propositions 1, 50, and 84, totaling approximately $8 million. An additional $8 million low-interest loan was awarded through the State Revolving Fund Loan Program. The pipeline was designed to be six miles long and involved a levee crossing, a future street expansion, and an alignment along 24th Street and 47th Avenue to the Cogeneration Plant. The alignment crosses an existing urbanized area and a new mixed-use development for residential, commercial, and industrial customers called Delta Shores. The design had to coordinate with the future extension of 24th Street and take future utilities in Delta Shores into account, altering the depth required for pipe installation.

The Phase 1 design and construction was further split into three pipeline segments in order to maximize funding opportunities and minimize local impacts while also taking advantage of available land use rights (see Figure 2). Phase 1A includes two segments on land that is owned by the Regional San, so once permitting was completed, work could begin. Phase 1B, the third segment, is designed to be constructed on publicly and privately owned land through the City of Sacramento. The alignment crosses two private properties, which required the acceptance of easements on the land.

Regional San issued a request for proposals in 2013 and selected MWH, now part of Stantec, to design the SPA Project. In total, the project consisted of 5,690-feet of pipe for both the SPA recycled water transmission main and
the EchoWater’s Nitrified Sidestream Effluent (SSE) pipeline. The SSE pipe’s purpose is to connect a pipeline, set to be installed at a later portion of the project, to the Lower Northwest Interceptor sewer force mains in order to carry nitrate-rich effluent water into the sewer collection system. This effluent provides odor control while the sewer flows to the SRWTP. The pipeline was to run parallel to the SPA Project, which provided significant opportunity for savings by constructing both at the same time.

During the design process, a few concerns arose about the project’s alignment as it would be crossing utilities that already existed as well as through areas that were actively under construction for the EchoWater Project. Regional San and MWH worked diligently to ensure that all aspects of both the projects would remain stable during both installation and operation of the pipelines.

In order to coordinate better with the EchoWater Project, the first segment (which overlapped the EchoWater Project’s Site Prep Project construction area) was handed over in 2014 to the Site Prep Project designer, Kennedy-Jenks, and contractor, Overaa Construction.

Among the most important aspects of the project for the Regional San was to commit to its core value of environmental stewardship in the area. Regional San maintains an environmental stewardship statement which is one of the defining aspects of its business. It was paramount to Regional San that the local, sensitive habitats, such as those of the Burrowing Owls and Swainson’s Hawks (see Figure 3) remain as untouched as possible.

It became apparent that splitting the project into two separate installation methods was really less of a choice and more of a necessity. The United States Army Corps of Engineers (Corps) maintains a 200-year levee protection area around the SRWTP that could not be breached, effectively eliminating the option of open cut installation from the area. Trying to use an open cut method through the creeks and wildlife sanctuary would have required significantly more permitting, which would have delayed the contract by two years and increased costs by a large margin.

A trenchless method would be best for crossing the environmentally sensitive areas. Horizontal Directional Drilling (HDD) was chosen as the best option for the project because it allowed an installation depth that would pose no harm to the ground level plant life, would not disrupt the creek beds, and would not conflict with existing utilities and ongoing EchoWater construction. It was to be used to cross below Morrison Creek, two levees, wetlands, and the EchoWater project’s Flow Equalization basins that were already under construction.

In order to cross below the levee, the installation had to begin a minimum of 300 feet away from the edge of the levee and cross at least 30 feet below it. During the design process, it was discovered that the new EchoWater Project’s flow equalization basins were going to be de-watered and excavated to a deeper level in the same time frame that the pipeline was due to be installed. Though it presented a challenge at that time, it ultimately resulted in a positive change because it meant the depth of the pipelines would be well below what was required for crossing below the creeks and levee.

Overall, ground conditions were favorable, mostly consisting of soil with sands and silts. There had been some gravels identified in the geotechnical work, but it was the clay layers that raised the most concerns. The HDD contractors were worried about the efficiency of slurry separation and bentonite reclamation after similar projects involving HDD recorded a higher volume of off-haul than anticipated due to separation challenges with the bentonite slurry.

The existing levee toe relief wells posed another problem in the alignment. There are between 30 and 50 wells in operation north of the north Morrison Creek levee, operated by the Sacramento City Department of Utilities. In order to ensure that the pipe passing between two of the wells had caused no damage to the wells, Regional San agreed to pay for the cleaning and pump testing of the wells both before and after the HDD installation process. The utility department agreed and received two free well cleanings. The Sacramento Area Flood Control Agency’s (SAFCA) levee relief wells were not affected by the HDD installation of the two pipelines.

In areas that were not particularly sensitive, such as farmland and other land that was regularly disturbed, open-cut was chosen as the best option. It was more cost effective, and in one area, there was already an open trench for another portion of the project so less work was required. A portion of the open cut did travel through an area that had been leased by the Regional San to a farmer, but due to the dryness of the season, that tract of land was not to be in use during construction. The contractor was directed to stockpile the topsoil and return it to the area to ensure that the farmer would be able to use the field again.

At the beginning of the design process, the project was designed around the use of high density polyethylene (HDPE) and ductile iron pipe because that was what had traditionally

Figure 3. (On left) Burrowing Owl (Brian E. Small); (right) Swainson’s Hawk (Jack Binch, 2009).
been used by Regional San. Once the project had been advertised, however, a potential bidder submitted a request for information, requesting that fusible polyvinylchloride pipe (FPVCP) be allowed as an alternative.

Regional San contacted agencies who had completed similar projects using FPVCP to study whether it was a viable option. After hearing from a number of different agencies that they had had good experiences with the material, it was decided to allow an FPVCP option into the bid in Amendment 2. This also alleviated some concern held by Regional San about the ability of the HDPE pipe to successfully complete the longer crossings based on the maximum pull strength of the material.

With the option to use FPVCP available on six separate bid items, all bidding contractors chose to bid with the FPVCP option over HDPE or ductile iron, as it provided the greatest cost efficiency overall. Though the material itself may be slightly more expensive, the smaller outer diameter of the pipe for a comparable inner diameter (see Figure 4) meant that smaller boreholes would be required, which lowers equipment, material, and labor costs.

The cost of Phase 1A at the end of design was estimated by the engineer to be approximately $3 million.

Bidding & Construction
At the time of bidding, Garney Construction (Garney) was determined to be the lowest responsible bidder on the project. They would function as the general contractor for the overall project. In order to complete the HDD portion of the project, Garney chose to bring in The HDD Company. The HDD Company in turn subcontracted the drilling of the smaller SSE line to J-C General Engineering (J-C). The general contractor was not involved in the majority of the work completed on site during the HDD portion of the project’s execution. Instead, each driller was responsible for their own bores; The HDD Company for the 18-inch line and J-C for the 10-inch.

Permitting
In order to begin construction, Regional San needed to work through a large amount of permitting from a number of different agencies. Once it was determined that the project would cross below the levee, the Army Corps of Engineers (Corps) had to be contacted. The Corps is the responsible agency for levees passing through populated areas (see Figure 5), though the levees themselves may be owned by the city or county, and as such has final approval on any alterations. Due to the depth of the drill passing below the levee, the Corps found no issue with the project and approved construction in the area.

As another regulatory body that deals with the levees of the region, the Central Valley Flood Protection Board (CVFPB) also approved construction. The CVFPB is responsible for making sure that the flood control system of California’s Central Valley is protected through the enforcement of standards. They issue the encroachment permits needed to begin construction and work with other agencies to continuously improve the Central Valley’s flood management system.

The Sacramento Area Flood Control Agency (SAFCA) was also involved in approving the construction project. Due to Sacramento’s delicate position at the meeting of two major rivers, there is the potential for catastrophic flooding throughout the city. SAFCA’s purpose is to increase flood protection along both the American and Sacramento Rivers. Their involvement with the project was limited to approving the installation’s alignment to ensure that it would not cause additional flood risks to the surrounding areas.

Another benefit of the use of HDD in construction projects is how much permitting can be avoided under the right conditions. The California Department of Fish and Wildlife was able to write a letter of no interference for the project because the proposed drill would pass far enough below the wetlands to cause no alterations to the creek floors.

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As another regulatory body that deals with the levees of the region, the Central Valley Flood Protection Board (CVFPB) also approved construction. The CVFPB is responsible for making sure that the flood control system of California’s Central Valley is protected through the enforcement of standards. They issue the encroachment permits needed to begin construction and work with other agencies to continuously improve the Central Valley’s flood management system.

The Sacramento Area Flood Control Agency (SAFCA) was also involved in approving the construction project. Due to Sacramento’s delicate position at the meeting of two major rivers, there is the potential for catastrophic flooding throughout the city. SAFCA’s purpose is to increase flood protection along both the American and Sacramento Rivers. Their involvement with the project was limited to approving the installation’s alignment to ensure that it would not cause additional flood risks to the surrounding areas.

Another benefit of the use of HDD in construction projects is how much permitting can be avoided under the right conditions. The California Department of Fish and Wildlife was able to write a letter of no interference for the project because the proposed drill would pass far enough below the wetlands to cause no alterations to the creek floors.

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Both HDD drills were completed within the same time frame. At the start, two rigs were used. The HDD Company used a “Rig 3” 900 k-lb. drill rig to install the larger 18-inch pipe while J-C General Engineering used an “American Augers” 200 k-lb. drill rig for the 10-inch pipe. J-C General Engineering had the misfortune of intersecting the first local area of cobbles discovered by drill, geotechnical report, or survey in 50 years. They were alerted to the problem when, while drilling, they lost 100 gallons of drilling fluid. There were no detrimental effects to the surrounding area or the equipment; the fluid seeped into the space between the cobbles. In an effort to reduce the downhole fluid pressures generated by the drill, another rig, an “American Augers” 60 k-lb. drill rig was set up at the north side of the drill to meet in the middle. This allowed the drill mud to better circulate, reducing the threat of a frac-out.

One additional issue arose during the drilling of the SPA line; there was a small frac-out that took place 100 feet to the side of the drill alignment while in the farmer’s field. Upon inspection, it was discovered that there was a vein of gravel running into the drill hole that allowed the drilling fluid to escape. There were no resulting issues from this occurrence. Most of the mud was vacuumed up at no detriment to the project or farm.

Each of the drilled portions of the project were 3,220-feet long. The SPA recycled water line consisted of a single pull back of 18-inch FPVCP and the EchoWater SSE Project pipeline consisted of a single pull of 10-inch FPVC. Both lines were installed using a pull head of comparable size to the pipe itself. Pull back for the SPA line was completed in approximately 14 hours while the SSE line only took about eight hours.

The open-cut portions of the project went equally as smoothly. Both lines consisted of 2,470 feet of pipe, the same diameter sizes as the drilled portions (see Figure 6). Once both lines had been installed, the trenches were filled and the remaining aggregate soil was left on site for the farmer to till into his fields.

Also near the open-cut area of the project was an access road that is used by many different utilities in the area, such as gas lines, county streams and creek maintenance, raw water maintenance, and levee maintenance.

A fair amount of coordination amongst the utilities had to take place to ensure that all parties had appropriate access to their holdings when needed, without disrupting the progress of the project.

There was a hard deadline set for the drillers to have their installations completed and to have vacated the premises by February 26, 2016 in order to clear the way for additional work on the EchoWater Project. The 10-inch SSE line was pulled into place on December 22, 2015 with the 18-inch line following on December 29 (see Figure 6). Since the open-cut installation went equally as smoothly, the lines were quickly connected. Final pressure testing on both lines was completed on February 12, 2016.

**Conclusion**

Due to the efficiency of the drillers and contractor, the Phase 1A project was completed well ahead of schedule. In addition, only one change order was needed for the entire project; when J-C General Engineering located the buried cobbles, it set their schedule back one day which was deemed acceptable because of the unexpectedness of the geology discovered. The project was bid under the engineer’s estimate and finished only $3,000 over the bid budget, keeping both the anticipated and executed budget at $3,195,762, which was still about $100,000 under budget.

**References**


Sacramento Regional Sanitation District (2015) – Aerial overview of SRWTP.


Sacramento Regional Sanitation District – Bufferlands Map.

County of Sacramento (2015) – Bid Opening Results 4289 SPA Project.

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ABSTRACT
For more than 25 years, Central Contra Costa Sanitary District (Central San) has identified and replaced problematic sewers through the use of trenchless technologies. The M1 CIPP Lining Phase 1 project was part of Central San’s capital improvement plan, and it addressed the rehabilitation of trunk sewers that were identified as moderately to severely deteriorated pipe in a previous corrosion study. The project scope included the in-house planning, design, and construction management services for the rehabilitation of 3,100 linear feet of 42-inch tar-lined reinforced concrete (RCTL) pipe and the rehabilitation of corroded manholes.

The design of the project proved challenging due to the unique bypass systems required to divert the flows during lining. The project took place at Central San’s treatment plant, so cooperation and coordination from the Operations Department was necessary to divert flows while lining in different areas of the treatment plant. Portions of the project were between different TP processes requiring substantial coordination. The contractor used both off-site and over-the-hole wet-out methods, and water curing was used to complete the work. Lining distances achieved ranged from 1,250 LF to 150 LF, with the latter ending in the treatment plant’s influent structure. This paper will discuss the challenges faced during design, the methods and equipment used to perform the lining, the coordination between parties to build a successful bypass system, difficulties encountered during construction, and lessons learned from the project.

INTRODUCTION
Central San is a Special District in Contra Costa County, California, that collects and treats approximately 42 MGD of wastewater for 462,000 residents in a 146-square mile service area. Year to year, Central San is faced with problematic sewers that are reaching the end of their service life and threaten to create a health hazard via sanitary sewer overflows. Within the collection system, there are a variety of materials, as shown on Figure 1, Central San is constantly faced with maintenance-related issues [2]. Corrosion, roots, grease buildup, and structural defects are all contributing factors to the deteriorating collection system. These problems create the need for renovation projects throughout Central San’s service area. The replacement of pipeline in the collection system is a collaborative effort among Central San forces. Maintenance crews serve on the front line of the collection system and offer instrumental insight to the identification of problematic sewers. Central San’s maintenance crews are responsible for cleaning, maintaining, and inspecting approximately 1,500 miles of pipeline ranging in size from 4 inches to 102 inches in diameter. Central San’s Capital Projects Division uses information gathered by
Early in the design phase of the project, staff determined that replacing M1 with a new sewer line would have been very expensive, and lining was our best option to renovate this sewer line at a reasonable cost.

Central San manages a yearly capital budget utilized for the replacement of its aging infrastructure. Approximately 23,000 linear feet of sanitary sewer is renovated each year. The M1 pipeline is a 42-inch reinforced concrete pipe in length located within Central San’s treatment plant property. It is the last gravity line in a series of gravity and force mains that transmit wastewater from the City of Martinez six miles to Central San’s treatment plant. The M1 pipeline is critical because it carries wastewater from approximately 21,000 residents and businesses and has no redundancy. During the dry season, it transports 1.2 MGD of sewage, and, during wet weather, 3.2 MGD. The M1 pipeline also serves as the waste line for Central San’s recycled water filter plant, as well as a drain for numerous buildings and other processes on the treatment plant site. Central San’s M1 line was identified by both engineering and maintenance staff as a line in need of replacement due to structural and risk assessments. In 2015, Central San staff decided to move forward on a renovation project that would address the issues in this pipeline.

PLANNING AND DESIGN

In 2003, Central San conducted a Large-Diameter Reinforced Concrete Pipe Corrosion Evaluation, which identified corrosion issues and recommended further investigation. The following year, Central San hired Brown and Caldwell to perform the Martinez Transmission Line Corrosion Study, which included M1 and provided a more accurate condition assessment of the pipeline. Both corrosion studies recommended near-term and future renovations based on its corrosion findings. In 2010, Central San televised M1 and recommended that the pipeline be renovated due to corrosion deficiencies, such as exposed rebar, corroded joints, and a general lack of interior coating protection.

Early in the design phase of the project, staff determined that replacing M1 with a new sewer line would have been very expensive, and lining was our best option to renovate this sewer line at a reasonable cost. Cured-in-Place Pipe (CIPP) would structurally repair the line with minimal to no capacity loss; the construction would be much quicker with less disruption of the regular operation of the plant; and there would be no need to locate and protect the numerous buried utility lines running throughout the treatment plant, for which there are few reliable record drawings. After selecting CIPP, the project team proceeded to identify critical elements for the design and construction that would require further investigation, including bypassing mainline and treatment plant process flows, locating buried utilities near potential manhole cone excavations, construction equipment staging areas and access, water availability for curing, and safety requirements.

The project team identified several operational issues that would need to be taken into consideration to ensure a seamless operation of the treatment plant during construction. Several examples of the operational hurdles included routing the bypass line to maintain access routes for ash hauling, continual production of recycled water for summer-time demand from recycled water customers, maintaining adequate pressure levels in the plant’s utility water system for various processes (while using utility water for curing), and maintaining minimum elevations of the water surface elevation in the influent structure. Working with Operations staff, the project team evaluated alternatives and practices that would best work for each of these constraints. Based on our findings, the project team developed working conditions and included them in the project documents for the contractor to understand the complex nature and requirements of the work to be undertaken.

BYPASS PLAN

The bypass is a critical part of lining because the CIPP process requires that there be no flow in the line. An unreliable bypass could cause an overflow or irreparably damage the liner during insertion or curing. The key component of the project’s bypass plan was to identify all the various processes discharging to the M1 line and create a reliable bypass for each. Due to the critical nature of the bypass line handling active treatment plant processes, as well as being a single path for the Martinez flows, the project team required redundant pumps at all bypass locations. The contractor provided two 6-inch pumps to meet the mainline flowrates specified in the project documents, and provided two more of the same size pumps as a standby. Similar setups were used at the process discharge locations with appropriately sized primary and backup pumps. The bypass line involved 10-inch fused HDPE pipe that spanned almost 3,900 feet. This bypass started at a force main access structure, finished at the treatment plant’s junction structure just upstream of the headworks facility, and took 20 days to build.

As stated before, prior to bypass design, it was critical to outline all the inflows to the M1 pipeline. Record drawings and as-builts often offered little information as to where the pipes drained. CCTV of the M1 line and manhole inspections revealed laterals connected to the line for which the source was not known. The project team worked with key operations staff who had a long history at the treatment plant to discover sources of flow. We meticulously tested every source of flow, knowing that half of the treatment plant drained into the M1 line. It was critical to find every toilet, process pipe, and drain that had a possibility of contributing to the M1 line. We discovered that we had inflows from the filter plant, solids conditioning building, area drains, storm drains, basins, and sump pumps. After gathering this information, we needed to make a decision to...
divert, bypass, or shut off the inflows to the M1 line. Table 1 displays the information provided to the contractor for each of the flows, and Figure 2 shows the bypass layout.

After identifying flows, the project team needed to determine how the upstream and downstream connections would work, and how the bypass line would be routed through the plant site. Further complicating the bypass is that a force main discharges into the M1 line rather than a standard gravity line. However, conveniently for the project, about 20-feet upstream from the force main discharge structure was an access structure with a prefabricated tee. The bypass line was connected to this tee and a plug was inserted into the end of the force main. This meant that the pumps at Central San’s upstream pumping station would need to provide additional pumping capacity into the contractor’s bypass setup.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Description</th>
<th>Flow (MGD)</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>20” FM</td>
<td>Martinez Flows</td>
<td>1</td>
<td>Contractor to bypass</td>
</tr>
<tr>
<td>12”</td>
<td>Sewer from Building</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>10”</td>
<td>Sump from Clearwell Liner Leaks</td>
<td></td>
<td>Contractor to plug. Monitor MH noted on plans. Bypass from MH to drainage ditch as necessary.</td>
</tr>
<tr>
<td>6”</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>4”</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>30”</td>
<td>Filter Backwash Flows. 15,000 GPM for 20 minutes once per day</td>
<td>0.3</td>
<td>Contractor to plug. Central San to close valve at 9000 structure. Waste backwash flows to accumulate in backwash tank. Contractor to provide bypass pumping from backwash tank to empty forebay. Possible passive bypass from connections on west side of waste backwash tank. Max 10 days. Contractor to bypass to Basin B Diversion channel from forebay if time limit is exceeded and/or as necessary.</td>
</tr>
<tr>
<td>30”</td>
<td>RS from Gunite channel</td>
<td>0</td>
<td>Contractor to plug. Central San to close any applicable valves.</td>
</tr>
<tr>
<td>4”</td>
<td>RS from Gunite channel</td>
<td>0</td>
<td>Contractor to plug. Central San to close any applicable valves.</td>
</tr>
<tr>
<td>42”</td>
<td>RS from Gunite channel</td>
<td>0</td>
<td>Contractor to plug and/or bypass as necessary. Central San to close drain-back valve for Gunite channel.</td>
</tr>
<tr>
<td>4”</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>12”</td>
<td>SD from Basin</td>
<td>0</td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>12”?</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>24”?</td>
<td>Unknown</td>
<td>0</td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>24”?</td>
<td>Scrubber Water</td>
<td>500 gpm</td>
<td>POD to valve off flows during duration of project. Contractor to provide bypass from adjacent manhole as necessary.</td>
</tr>
<tr>
<td>18”?</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>4”?</td>
<td>Unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>4”</td>
<td>Bio filter drainage</td>
<td>5 gpm</td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>6”</td>
<td>Bio filter drainage</td>
<td>5 gpm</td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>30”</td>
<td>Storm drain: Condenser cooling water, odor control</td>
<td>100 gpm</td>
<td>Contractor to plug at adjacent manhole and bypass.</td>
</tr>
<tr>
<td>12”</td>
<td>DAF Underflow, DAF Tank 3 Drain</td>
<td>200 gpm</td>
<td>Contractor to plug and/or bypass as necessary. POD to operate on two DAF tanks and send underflow to primary effluent as possible.</td>
</tr>
<tr>
<td>10”</td>
<td>Sanitary sewer, storm drain</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>12”</td>
<td>SCB Drainage</td>
<td>300 gpm</td>
<td>Contractor to plug at manhole and bypass from cleanout on south side of SCB.</td>
</tr>
<tr>
<td>18”</td>
<td>DAF Tanks 1 &amp; 2 Drain</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary. Central San to close valve; minor valve leaks may need bypassing.</td>
</tr>
<tr>
<td>4”</td>
<td>unknown</td>
<td></td>
<td>Contractor to plug and/or bypass as necessary.</td>
</tr>
<tr>
<td>NA</td>
<td></td>
<td></td>
<td>POD to lower WSE set point to 93 or lower.</td>
</tr>
</tbody>
</table>

Table 1: Flows entering M1.
The project team evaluated the additional dynamic head placed on Central San’s pumps and found the extra amount negligible and well within their operating capacity. The bypass line was plumbed from the tee into a manifold that connected to a 21,000-gallon, open-top Baker tank and the primary and standby bypass pumps. The tank was used to accommodate fluctuations in flow and variations in flowrates between Central San’s pumping station pump and the contractor’s bypass pumps. The contractor provided an attendant to monitor the tank level at all times when the bypass was in use.

The next obstacle for the bypass routing was crossing Imhoff Drive, a busy public road bisecting the treatment plant property. A 48-inch culvert crosses beneath Imhoff Drive, connecting an old Central San storage basin with a concrete channel that is used to send flows to the outer basins during large, wet-weather events. Operations staff permitted us to use the culvert as a sleeve for our bypass line. The bypass line was then routed upward through a floor grate in the gate structure that blocks off flows to the defunct basin. Due to an unrelated operational incident during our project, the bypass pipe was submerged in this area as treatment plant flows were sent through the concrete channel to the outer basins. The last challenging part of the bypass was that we had to cross multiple treatment plant access roads while routing the bypass line. The contractor used 12-inch manifold ramps to cross the treatment plant roads and keep them open for the plant’s daily operations. Finding the correct bypass layout was done with careful consideration and cautious thought. For example, we worked with the contractor to move the bypass away from a fence line that ran along a levee and a creek. In case of a spill, we wanted no chance of the sewage reaching the creek. As a result, we took preliminary steps such as these, and made decisions in order to find the best-suited and safest bypass layout.

The bypass discharged into the influent structure at the downstream end of the M1 pipeline through a grate that was removed from the roof of the structure. After the bypass was constructed, the project specifications called for a 24-hour pressure test, which identified several small leaks in the air relief valves. The leaks were repaired, and another 24-hour pressure test was successful. The last phase of bypass testing included a 24-hour live bypass test, incorporating coordination with our pump station operations for the mainline flows.

**CONSTRUCTION**

Once the bypass was established and running reliably, the contractor was able to begin pre-lining work. The first step was cleaning the lines and performing CCTV inspection. Complete removal of the grit and debris in the line is necessary for successful lining. On a previous project that lined upstream portions of the Martinez pipeline, the grit that was removed during cleaning had been tested and declared hazardous for heavy metals. With this knowledge, the project team decided that complete capture and testing of the long-sitting pipeline grit was preferable rather than flushing the grit into the grit handling facilities in the headworks area of the treatment plant. The project team specifically included a bid item allowance for testing and disposal in the event of hazardous grit. It took the contractor seven days to clean the 3,100 feet of pipe, with
approximately 10 cubic yards of grit being pulled out and put into disposal bins for testing. The grit was tested and found hazardous and had to be transported to an out-of-state dump site.

After the pipe was cleaned, inspected, and declared acceptable for lining by the Central San construction management team, the contractor prepared for lining by removing the cone off the insertion manhole to create enough room for the 42-inch liner to be inserted. The contractor then set up the tower, lining equipment, chemical and boiler trucks, and constructed a large tent over the roller bed to prevent the wet-out (resin-impregnated) liner from curing prior to insertion. To accommodate the distances between manholes and the turns, the contractor lined the 3,100 feet of 42-inch RCP in four separate shots. Overall, it took 11 days to CIPP the entire pipeline. For the first two shots, the contractor decided to set up over a manhole where they could line both upstream and downstream. Due to the long lengths in both directions, they had to wet-out the bag on site because the weight of a prewetted-out bag would exceed the allowable weight limits on roads. During wet-out, a two-part epoxy resin is mixed and injected into the felt liner and then rolled out to a calculated thickness. On this project, the liner was designed for fully deteriorated conditions, with a minimum required thickness of a half-inch. The contractor submitted liner designs for each shot, which met or exceeded Central San requirements. The amount of resin that can be mixed each time is limited by the length of the roller bed; the contractor refers to the liner pumped full of resin as a “slug,” and on this project the maximum slug was approximately 20,000 lbs. of resin. When rolled out to the calculated thickness, each slug of resin on our project allowed for the insertion of approximately 400 feet of liner, after which the process was repeated until the fully impregnated liner was inserted through the entire pipe. The wet-out, over-the-hole process took longer to complete insertion, but it was the only option for the constraints on our project. The first shot was 1,072-feet long beginning at a middle manhole, passing through three other manholes, and ending at the junction structure where the force main discharges. The second shot was inserted through the same manhole, but in the downstream direction, and was 1,290-feet long. The third shot was a shorter distance, at 590 feet, which allowed the contractor to truck in a pre-wetted liner. The final shot was also trucked in, started from the influent structure, and went upstream 150 feet to a manhole.

The contractor used water for insertion and curing on this project. Due to both the long-shot lengths and the large diameter of the host pipe, steam was not a viable option. Central San provided utility (recycled) water for use by the contractor at nearby connections on the treatment plant property. The nearest potable water source large enough to provide the volume of water needed for insertion was too far away, and since the project was conducted during a drought, this solution was preferable to the alternative. The contractor did experience one minor problem with equipment filters clogging, although this was unrelated to the use of utility water. As part of the CIPP curing process, styrene from the heated resin leaches into the cure water as it is circulated through the liner. On a previous Central San project, the discharge of a large volume of unfiltered cure water coincided with a large disruption of the biological process in the secondary treatment. Due to this previous process upset, Central San required carbon filtration of the cure water prior to discharge back into the sewer system. The contractor was required to obtain a special discharge permit from Central San’s Environmental Compliance group, and meet all conditions of the permit during construction. Based on constraints specified by the filter manufacturer and in the permit, the contractor could only discharge the processed cure water at 300 gallons per minute. Multiple water samples were taken during the process as part of the permit requirements to ensure adequate styrene removal. Normally, the filtered process water would be discharged back to the sewer system; however, at the request of our operations group, and in an abundance of caution due to the immediate proximity to our plant, the water was discharged to storage basins where it evaporated over several days.

One challenging part of the final shot was working inside the influent structure. There are several large lines from our collection system other than the M1 that flow into the influent structure, and bypassing them was not an option. The contractor worked with Central San’s Safety Officer to determine a safe plan for working inside the structure. The contractor used forced air, and only worked inside the structure in the early morning hours when incoming flows were reduced and atmospheric conditions would be less volatile. Working inside of the influent structure is also difficult due to limited access into the structure. Prior to the project, we had a separate contractor cut a new access point over the M1 discharge location; however, this access point turned out to be smaller.
than expected and the CIPP contractor struggled to get the 42-inch resin impregnated liner inserted. Eventually, the contractor was able to insert the liner through the 24-inch by 24-inch hole, but it took significantly more time than the other insertions. Another condition while working in the influent structure was the water level within the structure. The water surface elevation within the structure is controlled by influent pumps in the headworks facility. The normal operating water level within the structure is actually about a foot higher than invert of the M1 line, which obviously would not work for lining. The project team had to coordinate with the plant operators to adjust the water elevation setpoint to be lower than the invert while maintaining adequate head over the pumps for them to not lose suction and flood our pipe during the CIPP process.

When all lining work was completed, every manhole on the M1 line was rehabilitated with a coating system that would repair past corrosion damage and protect them from future corrosion. The existing manholes were a mix of bare concrete, epoxy coated, or protected T-Lock liner. The manholes that were not previously coated were prepped and coated with Raven 405. Manholes that already had an epoxy coating had to be prepped and recoated. In those manholes, the old coating was flaking off so it was either sandblasted or chipped off, pressure washed, and finally coated with the Raven coating. After each manhole was completed, the contractor spark tested it for defects. In total, 14 manholes were rehabilitated.

CONCLUSION

In conclusion, the M1 CIPP Rehabilitation Project was completed in 51 days, and presented several challenges during design and construction. Using cured-in-place pipe proved to be a valuable method of construction for rehabilitating long pipe segments in a short amount of time. Maintaining communication with all the invested parties was time well spent. Investigating pipe inflows and planning the bypass layout helped mitigate potential problems that we may have encountered during construction. Problems related to lining long reaches in between manholes were addressed through the process of wetting-out the liner on site. Limited access at insertion and receiving pits multiplied the time it took to complete tasks at those locations. Carbon filtration systems effectively removed concerns our treatment plant staff had in regards to styrene. After construction, a few small wrinkles were found in the pipe, but were easily cut out. Lastly, manholes were coated to prevent corrosion due to H₂S issues.

REFERENCES


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