BAMI-I 2023

Biannual Journal H2 2023, BAMI-I 20th Anniversary

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BURIED ASSET MANAGEMENT INSTITUTE - INTERNATIONAL

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2023

GLOBAL BURIED ASSET MANAGEMENT CONGRESS

&

BAMI-I'S 20TH ANNIVERSARY

SEPTEMBER28-30, CHICAGO, ILLINOIS

TINLEY PAPK CONVENTION CENTER

CONGRATULATIONS !

BAMI-I 2023

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MESSAGE FROM BAMI-I PRESIDENT

Dr. Tom Iseley

Ph.D., P.E., Dist. M. ASCE, PWAM, BAMI-I President

Making Water Asset Management a Priority in Higher Education

In July 2020, Ms. Wei Liao and Mr. Saleh Behbahani transferred from Louisiana Tech University where we worked with Dr. John Matthews at the Trenchless Technology Center to Purdue University in West Lafayette, IN with vision to build a focus area on underground construction, utility engineering and asset management within the Construction Engineering and Management (CEM) program in the College of Engineering. Our efforts have resulted in the formation of the CEM UIT (Underground Infrastructure Team). This UIT has expanded to include the following:

- Dr.Tom Iseley, Professor of Practice , Purdue University/President of BAMI-I-I
- Wei Liao, Lead Research Engineer, Purdue University Executive Director of BAMI-I
- Saleh Behbahani, Phd. Student, Purdue University
- Mahnoush Mohsen, Phd. Student, Purdue University
- Sihan Zhou, Phd. Student, Purdue University
- Dr. Kibum Kim, Visiting Scholar, Purdue University
- Ming Chen, Assistant, BAMI-I

We formed a new student chapter of the UCA (Underground Construction Association) of SME (Society of Mining, Metallurgy & Exploration) and merged it with the existing NASTT (North American Society of Trenchless Technology) student chapter. This provides students with access to a wide range of industry exposure and opportunities. Our mission is to develop the next generation of industry leaders while providing support to current industry professionals. We are accomplishing this through developing a unique and strong academic program, industry workshops for pipe associations, departments of transportations, municipalities, state agencies, industry associations, etc. on an international basis. Our core academic courses consist of the following:

- Asset Management of Underground Infrastructure
- Pipeline Condition Assessment and Integrity Management
- Development of Underground Space

These courses have been developed for the 500 level at Purdue University. They can be taken for graduate or undergraduate credit or for professional development. They are offered as classroom courses for resident students or through PEO (Purdue Engineering Online) for anyone anywhere.

Our Purdue CEM UIT provides administrative and technical support to BAMI-I. BAMI-I provides support for our student chapters and through this partnership we can provide students with opportunities to visit jobsites, attend conferences, the Congress, seminars, workshops, etc. This is all part of developing the next generation of leaders for the underground infrastructure industry.

In previous BAMI-I Journals, I have explained how BAMI-I was an out growth of my commitment to assist Atlanta's Department of Watershed Management Commissioner Jack Ravan with meeting Mayor Shirley Franklin's vision of moving the water program to being first in class. After 20 years, it is wonderful to see how BAMI-I has developed into a full-service industry support organization. This has been accomplished through the contributions of many dedicated water professionals committed to advancing the science and practice of the industry to meet current and future challenges.

Ms. Wei Liao and her team has developed this Journal issue to celebrate the 20-year birthday of BAMI-I and to set the stage for the first Global Buried Asset Management Congress (GBAMC). Asset management leaders from across the glob are assembling to learn from each other to establish what the state-of-practice is, where we need to be by 2030, and what needs to be done to get us there.

The GBAMC will be a major milestone for our industry. It will serve as a turning point from taking about 20 years to establish a support structure with training and certification programs to seeing utilities embrace the commitment to best business practice through the development and implementation of asset management programs.

In summary, I am please to announce that Wei and her team has submitted a concept proposal to the Purdue University administration to establish an Asset Management Center as part of the new Purdue campus in Indianapolis. This will be a joint venture between BAMI-I and the Purdue CEM program. It is anticipated to be funded by federal and state grants, the university, and industry. It is our vision that all of the pipe associations will form the foundation for the industry support. Buried asset is all about pipelines. BAMI-I partners with ASCE UESI for the UIS programs. It is our vision to strengthen this partnering relationship to make sure that we are working together to prepare the next generation of industry leaders while supporting industry professionals.

BAMI-I/UESI 2023 UTILITY INVESTIGATION SCHOOLS

UIS-19th

October 16-20, 2023
Baltimore, Maryland

Early registration ends Feb 3

UIS-20th

December 11-15, 2023
Denver, Colorado

Early Registration ends November 11

8:00 am — 5:00 pm daily

REGISTRATION FEE: **$1,995** EARLY REGISTRATION $1,895 Additional 10% discount for 3 or more attendees from same company.

FOR MORE INFORMATION, CONTACT:

Saleh Behbahani, sbehbaha@purdue.edu or Leonard Ingram, leonard@engconco.com, (334) 872-1012

The 19th UESI/BAMI-I Utility Investigation School (UIS))

OBJECTIVE:

The Buried Asset Management Institute – International (BAMI-I) & the ASCE'S Utility Engineering and Surveying Institute (UESI) have teamed to conduct the 19th ASCE UESI / BAMI-I UIS School in 2023. This short course will give practitioners the knowledge and tools to provide competent utility investigations in accordance with accepted national standards (ASCE 38) and to defend against claims through this knowledge and its documentation. In addition to the classroom lectures, practical sessions will be held where participants will be offered hands-on experience with the GPR, PCL, and etc. This 5-day school will be taught by the foremost experts in the geophysics and subsurface utility engineering field.

This 5-day school has been designed for

- Engineers and surveyors and project managers providing deliverables that include results and depictions of utility investigations.
- Consulting engineers, Employees of utility companies, state DOTs and local highway agencies, regulatory agencies, local governments, etc.
- Design engineers for infrastructure projects with significant expected utility congestion.

Registration Fee

$1,995

$1,895 EARLY REGISTRATION (Ends September 8)

Additional $100 each discount for 3 or more attendees from same company.

At the end of this short course, upon successful completion, students will receive 4 CEUs /40 PDHs and a Certificate of Completion.

Date: October 16-20, 2023

Time: 8:00 am – 5:00 pm Daily

Location: Baltimore, Maryland

Organized by:

Media Partners:

Sponsored by:

Course Director

Tom Iseley, Ph.D., P.E., Dist. M. ASCE, PWAM
Professor of Engineering Practice
Beavers Heavy Construction Distinguished Fellow
Purdue University
Email: diseley@purdue.edu
Phone: (404) 386-5667

Course Developer & Primary Instructor

Jim Anspach, PG(r), Dist. M. ASCE, NAC
ASCE/UESI President 2018
Member-EJCDC, TRB Utility Committee
Chair ASCE -38
A.A. Prof. of Utility Engineering
IOWA State University
Civil, Construction and Environmental Engineering
J.H. Anspach Consulting
Email: jim@jhanspach.com

For more information, contact:

For registration or having additional questions, please email Saleh Behbahani, sbehbaha@purdue.edu or Leonard Ingram, leonard@engconco.com, (334) 872-1012

Register Here

MESSAGE FROM THE JOURNAL EDITOR

Ms. Wei Liao

PWAM

September 6, 2023

When I read the news "127-year-old water main gives way under NYC's Times Square, flooding streets, subways" on August 29th, it immediately brought to mind the complex web of underground utility pipeline beneath the city. This mental image resonated with what I've seen and discussed during the 18th Utility Investigation School hosted by BAMI-I and UESI at New York University. There were two points that caught my attention: "It took DEP crews about an hour to find the source of the leak and shut the water off," and "Breaks happen somewhere in the city almost every day." It's intriguing that in a city as financially robust as New York, which has invested $1.9 billions upgrading aging water and sewer lines over the past three years, a significant disruption like this incident can still occur. Out of over 400 water pipe breaks in a year, this one has captured public attention, and it took an hour to locate and shut off the crucial valve. This underscores the urgency, complexity, and challenges of managing underground asset.

While we may not know the exact extent of the losses caused by this incident, its social impact is undoubtedly widespread. It prompts us to consider what can be done from the perspectives of different stakeholders, such as property owners, users, technology and product suppliers, underground infrastructure professionals, and regulatory authorities. Each of these groups may have entirely different viewpoints.

In my role as an advocate for best practices in asset management within a nonprofit organization, I approach this endeavor with an idealistic perspective, envisioning opportunities for enhancement. Two pivotal aspects stand out: firstly, the capacity to predict and avert such incidents, and secondly, the ability to promptly pinpoint crucial valves in the event of such occurrences. I firmly believe that both of these objectives can be realized through the implementation of robust asset management practices.

In fact, asset management has transcended its role as a mere precautionary measure against accidents. In the current context of increasingly scarce resources and global climate change, the importance of managing underground assets becomes even more pronounced. It has evolved into a broader mission aimed at ensuring that we can plan, maintain, and harness our infrastructure resources more intelligently. This entails not only risk mitigation and emergency response but also a heightened focus on sustainability and resource stewardship to ensure the resilience and growth of our society and environment in an ever-changing world. Consequently, asset management is no longer just a reactive measure but a strategy of higher dimensions, providing critical support and guidance for our future.

The benefits of asset management need no further elaboration. we have reached a point where the focus should be on how to successfully develop and integrate asset management plans into organizational management systems. After a recent roundtable discussion on asset management at the Indiana Rural Water Association Leadership Summit, where Dr. Iseley and I moderated, one utility manager sent their six people to join us as BAMI-I members and expressed the need for more information and resources related to asset management. Their response highlights the importance of the quantity of information available to support asset management decisions. I can very much relate to this need. While this is just one case, it may indicate a growing demand for more information sharing about asset management. We are pleased that Buried Asset Management Institute (BAMI-I), as a representative of underground infrastructure management, is actively working to create a platform for sharing information and fostering communication.

Each specialized componet of underground asset management, such as location and mapping, pipeline condition assessment, maintenance and rehablitation technologies, and financial analysis, etc., has developed to a point where individuals have the enough resources to create comprehensive asset management systems. However, not everyone has easy access to this information. BAMI-I is consolidating and disseminating this knowledge. Our recent initiatives, including active courses , Webinars and the BAMI-I Journal, are all steps in that direction. We are particularly excited about the upcoming Global Buried Asset Management Congress (GBAMC) which will take place on September 28-30, 2023 in Chicago area. It is essential to build a prosperous community that can support the information needed.

BAMI-I journal strives to support the development of the BAMI-I community through our continuous efforts. Readers are the lifeblood of our publication, and in the age of information overload, your attention is precious. We greatly appreciate your choice to read BAMI-I Journal. In this issue, we have reviewed BAMI-I's history, looked ahead to the future of asset management, showcased some of the ongoing courses and programs at BAMI-I, and aimed to provide a comprehensive overview of BAMI-I's resources. Most importantly, we continue to offer crucial information on underground asset management cases and related technologies.

We encourage you to join BAMI-I community, provide your perspectives on this journal, and share your knowledge, research, products, and service information which support managing underground assets.

The field of asset management within the infrastructure sector is relatively young, yet it holds great promise for the future. I consider myself fortunate to have the opportunity to collaborate with numerous knowledgeable individuals in the underground infrastructure industry. Working alongside such talented professionals is always a rewarding experience.

What continues to strike me daily is the vast potential for meaningful work in the realm of asset management. However, I acknowledge that individual capacities have their limits, and successful endeavors require collective effort. Behind the pages of this journal, there exists a dedicated group of people who have invested significant time and effort.

I would like to seize this moment to extend my heartfelt gratitude to the authors, sponsors, and publishers for their unwavering support and encouragement. I also wish to express my special appreciation to Assistant Editor Sihan Zhou for his commitment to this issue of the BAMI-I Journal, as well as to Purdue University's Underground Infrastructure Team (UIT) for their valuable support.

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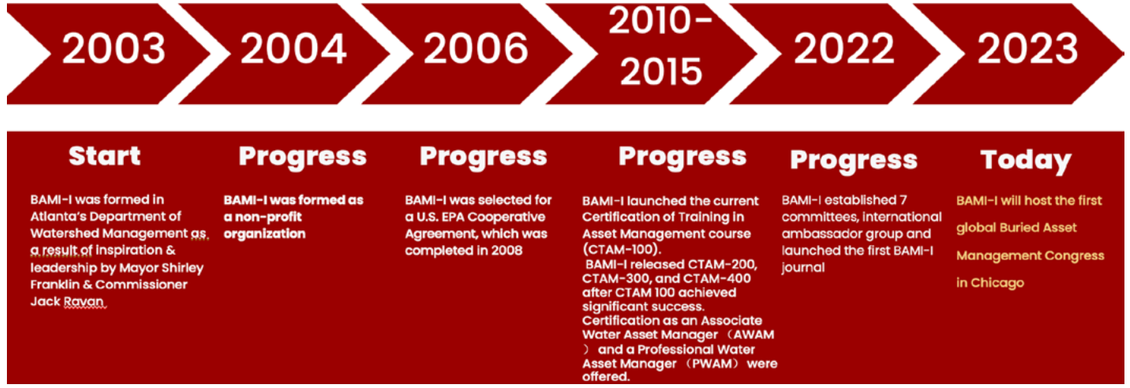
BAMI-I'S JOURNEY OF TWENTY YEARS OF EXCELLENCE IN BURIED ASSET MANAGEMENT

By Wei Liao & Ming Chen



Milestones of BAMI-I

Trenchless Technology Magazine Cover Story: Atlanta's Clean Water Advocates (September, 2003)

In 2003, the Buried Asset Management Institute (BAMI) was established within the Department of Watershed Management (DWM) for the City of Atlanta, driven by the leadership and inspiration of Mayor Shirley Franklin and DWM Commissioner Jack Ravan. Dr. Tom Iseley, the founder of BAMI-I, embarked on this journey in tandem with the City of Atlanta's DWM.

During the period Dr. Tom Iseley was in DWM, Atlanta grappled with the challenges associated with advancing a consent decree program. Mayor Franklin articulated a visionary path: not merely to meet the stipulations of the consent decree, but to ascend as an industry leader deserving of Atlanta's citizens. This vision was effectively communicated. Collaborating with Commissioner Ravan, Dr. Tom Iseley worked ardently to translate this vision into reality. This impelled them to delve deeper into asset management research and comprehension. Evidently, the city's principal obstacle extended beyond surface-level infrastructure; the true challenge lay within the underground infrastructure. Shirley Franklin aptly termed it a "buried treasure," underscoring its significance. Meanwhile, the Environmental Protection Agency (EPA) was engaged in supporting water utilities. Asset management advocate Steve Albee played a pivotal role. Steve Albee's mid-90s gap analysis underscored the importance of asset management, exposing the disparity between investment and demand within the water sector. His role primarily encompassed offering support and gleaning insights from diverse countries, particularly New Zealand and Australia, an experience that left an enduring impression. His global travels provided exposure to various countries' approaches to asset management. Upon returning to the United States, he initiated a series of workshops. Dr. Tom Iseley not only participated in these workshops but also extended an invitation to Steve Albee to assist his team in Atlanta, fortifying the focus on establishing an asset management framework. Through these educational endeavors, Dr. Iseley arrived at the realization that his work at the Trenches Technology Center and his efforts in pipeline condition assessment, while invaluable, would not yield optimal outcomes without integration within a comprehensive, risk-based Asset Management program.

This collaboration embodies the crux of their partnership within DWM. Dr. Iseley's team incorporated academic researchers to not only fathom the problem but also grasp the solution, colloquially referred to as the barrier.

In 2004, BAMI underwent a transition to become Buried Asset management Institute— International (BAMI-I), transforming into a non-profit organization with an independent board of directors. The transformation of BAMI-I in 2004 marked a significant milestone. The purpose and mission at the time of establishment were determined as follows:

BAMI-I's purpose is to educate and assist those who have an interest in applying best-buried asset management practices to extend the life and efficiency of their assets. Although BAMI-I has been mainly focused on water and wastewater systems, the principles of asset management apply to all different types of buried assets including for instance gas distribution pipes, and electric cables.

BAMI-I CTAM Workshop: UCTA-North Texas - Nov 5 — 8, 2018 - Lewisville, TX

BAMI-I's mission is to provide a center of excellence for owners of underground infrastructure to join with industry and researchers, using sound science, to evaluate and / or develop buried asset management protocols for application worldwide to benefit ratepayers and other stakeholders by:

- Protecting public health
- Maximizing asset life-cycle value
- Improving the environment
- Sustaining economic development
- Enhancing the quality of life

This transformation enabled BAMI-I to better address the needs and interests of utility and professional communities and achieve distinctive advancements.

In 2006, BAMI-I was selected for U.S. EPA Cooperative Agreement (CP 83 282901-1), which was completed in 2008. In 2010, BAMI-I launched the current Certification of Training in Asset Management course (CTAM-100). This course provides a comprehensive introduction to asset management principles and concepts — with special emphasis on their application to "buried assets" associated with sewer and water systems. CTAM's success had created awareness of the need to broaden its initial scope and provide more detailed training in an expanded sphere of utility system concerns. To meet this challenge, three additional training courses were being prepared for release at six-month intervals beginning in 2013. These courses have been named CTAM-200, CTAM-300 and CTAM-400.

- CTAM 100 — Overview of Asset Management which was launched in 2010.
- CTAM 200 — Developing an Asset Management Program which was launched in 2012.
- CTAM 300 — Managing an Asset Management Program which was launched in 2015.
- CTAM 400 — Financing an Asset Management Program which was launched in 2015.

In addition, in response to industry demands, BAMI-I established a certification committee and developed two certification levels: Associate Water Asset Manager and Professional Water Asset Manager.

Most of the contributors of CTAM were volunteers who were professionals from industry or academia, including Tom Iseley, Jim Raulston, Kurt Wright, Ronald Thompson, Jim Harris, Gregory Baird, Rick Nelson, Bill Di Tullio, Cameron McHargue, Roderick Lovely, Matt Ray, Bernie Krzys, Jim Rush, Mary Beth Butkovic, Greg Chol, Shadi Eskaf, Leonard Ingram, Matt Klein, Mohammad Najafi, Tod Phinney, Saleh Behbahani, Matt Ray, etc.

Since 2015, Saleh Behbahani has been serving as the manager for the online CTAM courses. Under his coordination and promotional leadership, nearly 1,600 individuals from 16 different countries have participated in these courses. Benjiemin Media Company collaborated in the development of CTAM100 and has been actively promoting the entire online course series.

Notably, organizations like the Environmental Organization in North Carolina Division of Water Infrastructure recognized the growing need for assistance in enhancing utility plans within their state. In response, they awarded the organization a contract with BAMI-I in 2015 to conduct four-day courses, each spanning one day, with the aim of training their personnel and other interested individuals simultaneously. This opportunity has allowed BAMI-I to develop customizable classroom courses, tailored to

UIS on-site demonstration session

UIS Classroom classroom session

specific demands. These significant developments are part of BAMI-I ongoing story, which began to take shape between 2010 and 2015, and continue to evolve. To date, six in-person workshops took place in different States. The upcoming CTAM100-400 workshop which is organized by Back Municipal Consulting will take place from October 30- November 2, 2023 in Cincinnati.

In 2016, Dr. Iseley, in collaboration with James Anspach, a prominent figure in the subsurface utility engineering industry, established the Utility Investigation School (UIS) at Louisiana Tech University. This school offers instruction in accordance with the ASCE 38 standard and initially conducted its classes at Louisiana Tech University. One of the fundamental principles of asset management is understanding what you have and where it's located. This requirement involves precise location and mapping, which prompted BAMI-I to partner with industry experts in the subsurface utility engineering field to address this need. Since the 6th UIS, BAMI-I has successfully conducted this program 13 times in various locations across the country. The upcoming 19th UIS is scheduled to take place in Baltimore, MD from October 16-20, 2023.

In 2022, after two years of preparation, Arlex Toro representing Latin America Society of Trenchless Technology (LAMSTT) and Dr. Iseley representing BAMI-I signed a course collaboration agreement at BAMI-I annual Board of Director meeting to offer the Certificate Course of Mapping and GIS School in the South American region. This is another international event for BAMI-I following the global CTAM online course.

In 2022, under the leadership of Wei Liao, who joined Dr. Iseley's team in 2019, the BAMI-I team began exploring ways to expand the resources related to BAMI-I's core focus. To achieve BAMI-I's mission and realize BAMI-I's vision to a greater extent, it's essential to involve a large number of stakeholders and establish a thriving community. To ensure the realization of BAMI-I's goals, the organization has established seven committees, each with experienced chairpersons. Here are the seven committees along with their inaugural chairpersons:

Trenchless Technology Committee (TT) - Chair: Mark G. Wade.

Pipeline Condition Assessment Committee (PCA) - Chair: Susan Dakak and Jerry Weimer.

Utility Investigation Committee (UI) - Chair: Joseph Murphy.

Financial Management Committee (FM) - Chair: Shah Rahman.

Education & Research Committee (E&R) - Chair: Dr. Andy Chae.

TT-Renewable Energy Infrastructure Committee (TT-REI) - Chair: Kent Weisenberg.

Oil and Gas Committee (O&G) - Chair: Dr. Hongfang Lu.

Each committee has made progress in recruiting members and formulating development strategies during the first year of establishment.

Furthermore, BAMI-I has formed an international ambassador group comprising approximately ten ambassadors, aiming to foster genuine engagement with the global community. This initiative encourages mutual learning, which in turn has a positive influence on the United States. The initial members of this group include Niranian Swarup from India, Baosong Ma from China, Arlex Toro from Columbia, Sriram Ganesan from Singapore, Robert Stein from Germany, Sam Wiffen from New Zealand, Pinky Tso from Hong Kong, Sergio Palazzo from Brazil, Anna Karpińska-Rzepa from Poland, Tom Sangster from Europe and Binu Jayamohan from United Arab Emirates

To establish a channel for providing valuable information and knowledge to both members and the public, BAMI-I announced the launch of the inaugural digital and print BAMI-I Journal. This is a biannual publication. In collaboration with A to B publishing company, BAMI-I released the first issue of BAMI-I Journal. Subsequent issues of BAMI-I Journal, starting with the second issue, are independently published by BAMI-I. Circulated across the US, and internationally, the BAMI-I Journal has raised awareness of the benefits of utilizing best buried asset management practices, demonstrating with case studies and feature articles how best buried asset management practices maximize the life-cycle of underground infrastructure assets, and provide the basis for sound economic decisions regarding these assets.

2022 BAMI-I Annual Board of Director Meeting (July 31st, 2022, Indiana University Purdue University Indianapolis (IUPUI))

BAMI-I Journal

As 2023 approaches, marking BAMI-I's 20th year, a significant stride forward is being taken. The inaugural Global Buried Asset Management Congress is slated to be held in Tinley Park Convention Center, Illinois, from September 28 to 30, 2023. This international event will bring together leaders and experts from the global asset management domain to collectively shape the industry's vision and direction.

The development of BAMI-I from its inception to the present day has been inseparable from the unwavering support and dedication of all the volunteers, BAMI-I Members and partners who have been involved. These enthusiastic individuals have contributed their valuable time and energy, tirelessly striving for BAMI-I's mission and providing continuous momentum to BAMI-I's programs and activities. Their selfless dedication showcases the cohesion and shared pursuit of our community, setting a shining example for BAMI-I's growth and development. And it is through partners support and collaboration that help to expand BAMI-I's reach, enrich BAMI-I's resources, and take firmer steps on the path to fulfilling BAMI-I's mission. Their expertise, resource sharing, and active participation infuse new vitality and creativity into every aspect of BAMI-I's work. Throughout this collective journey, we firmly believe that through the joint efforts of volunteers and partners, BAMI-I will continue to thrive, bringing more value and positive transformation to the industry.

BAMI-I's journey vividly underscores its unwavering dedication to excellence, exemplified by its resolute commitment to education and leadership in the realm of buried asset management. Look into future, the mission and objectives of BAMI-I will keep primarily focusing on the management of underground infrastructure. BAMI-I will consistently strive to promote and advocate for effective practices in asset management, ensuring the long-term reliability, safety, and sustainability of buried assets. Through knowledge sharing and dissemination, formulation of best practices, awareness enhancement, as well as research and innovation support, BAMI-I provides assistance and guidance to professionals and stakeholders in the field of underground infrastructure.

Wei Liao is Lead Research Engineer at Purdue University and Executive Director of BAMI-I. **Ming Chen** is an Assistant at BAMI-I.

Global Buried Asset Management Congress

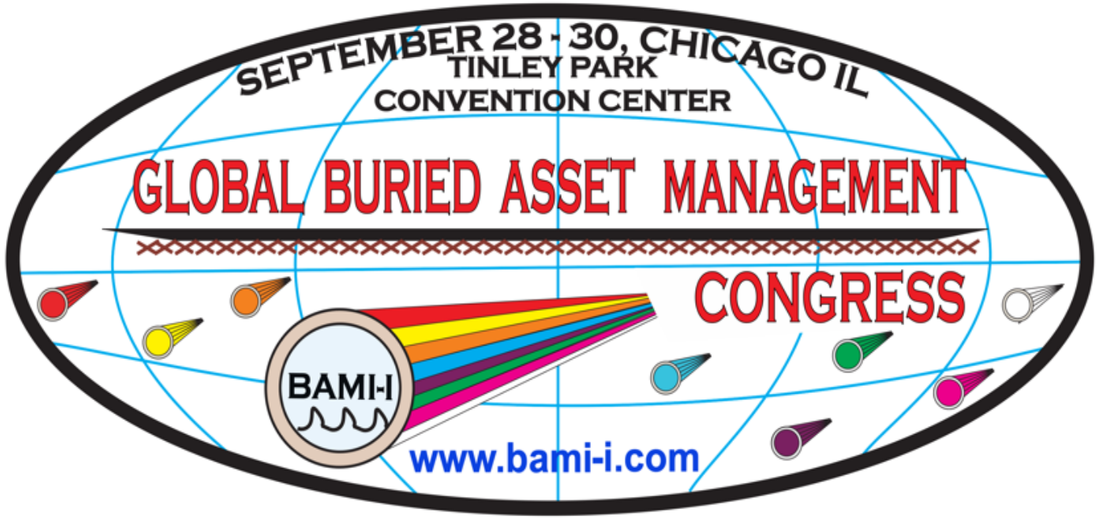
BAMI-I WILL PRESENT THE INAUGURAL GLOBAL BURIED ASSET MANAGEMENT CONGRESS (GBAMC) ON SEPTEMBER 28-30, 2023 IN THE SOUTHERN REGION OF CHICAGO

By Wei Liao

Tinley Park Convention Center

The GBAMC will bring together subject matter experts from around the world to identify the state-of-practice and present strategic future directions in buried asset management. The congress aims to establish a comprehensive set of global directions for the industry, addressing the challenges of managing buried assets and ensuring their longevity and efficiency. Buried infrastructure serves as the lifeline of societies worldwide, requiring effective management to ensure its health, remaining service life, and timely maintenance. GBAMC will focus on advancing the science and practice of asset management under the theme " Buried assets: out of sight but not out of mind through advancing the science and practice of asset management." Key areas of emphasis include implementing best business practices for asset protection, advancing technology and management methods to enhance asset value, ensuring the longevity of buried assets through comprehensive health assessment and management, and ensuring compliance with current and future regulatory requirements.

Stakeholders in the water and wastewater sector and other utility sectors that have underground assets from around the world will participate in this groundbreaking event. This includes,



GBAMC congress's Logo

but is not limited to:

- Senior managers / decision makers
- Asset Managers
- Representatives from government agencies and regulatory bodies
- Representatives from professional associations
- Technical Officers
- Engineers
- Finance Officers
- Strategic Planners
- Industry subject matter experts
- Academic professionals
- Researchers
- Students

Dr. Tom Iseley, President of BAMI-I, expressed his enthusiasm for the upcoming congress, stating, "Our con-

gress is unique, as it is the only asset management congress focused on underground infrastructure. The Congress is proudly co-sponsored by BAMI-I and Purdue University. Under the leadership of Wei Liao, our passionate congress team is fully committed to providing an outstanding experience that surpasses all expectations. We have curated an impressive lineup of world-class speakers who will guide us into the future of buried asset management. We invite you to join us and become our valued partner in shaping the trajectory of this vital industry."

The GBAMC will offer attendees the opportunity to engage with asset management leaders, exchange knowledge and best practices, and gain insights into the latest trends and technologies. Stakeholders in the water and wastewater sector and other utility sectors that have buried assets from around the world will participate in this groundbreaking event.

GBAMC is an excellent opportunity for companies to demonstrate their commitment to Asset Management a, establish themselves as leaders in the field. As an exhibitor or sponsor, companies will not only have a platform to showcase their cutting-edge technologies and services, and network with industry representatives, but you will also have the opportunity to receive ongoing support from BAMI-I and Purdue University, enabling your company to achieve maximum industry influence and stay at the forefront of asset management practices.

The congress program will cover a wide range of topics of asset management, including inventory and mapping, pipeline condition assessment, trenchless technologies, level of service, involvement, risk analysis, life cycle costing, long-term funding plans, research and education, and regulation compliance.

Registration is now open. For more information about the GBAMC, including sponsorship opportunities, registration, and the detailed program, please visit https://bami-igbamc.com/.

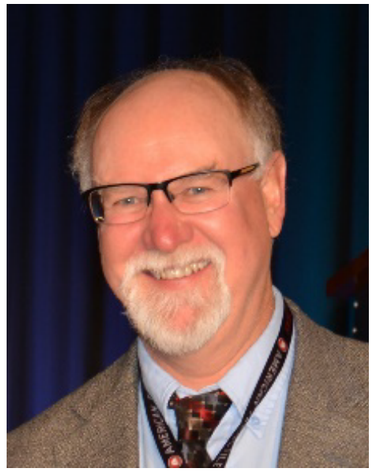
Contact: Wei Liao, liao186@purdue.edu, 3184978288

Wei Liao is Lead Research Engineer at Purdue University and Executive Director of BAMI-I.

TESTIMONIALS OF BAMI-I DEVELOPMENT

JAMES H. ANSPACH

Distinguished Member ASCE, Elected Member National Academy of Construction. A.A. Professor Iowa State University



My journey with BAMI-I started many years ago when Dr. Tom Iseley asked for some assistance with developing course content for a new concept of creating a certification process for water asset managers. I remember a first meeting at IUPUI in 2013, where I joined the BAMI-I Board. We had approximately 20 SMEs in the room, many if not all who are still involved with providing direction and guidance for asset managers. We subsequently developed 4 courses of study, resulting in a Certification of Training in Asset Management (CTAM) program. In 2015, we developed the first UIS (Utility Investigation School) at the Trenchless Technology Center at Louisiana Tech to provide educational opportunities about finding utilities with geophysics in accordance with ASCE 38, with a hands-on component. We switched primary control of this educational event to BAMI-I when we started presenting the class at other universities and locations. We have now presented 18 of these week-long schools, and demand keeps growing. As such, we are growing our reservoir of instructors and continually updating content to keep the course relevant. As testament to its up-to-date value, we have had several people take the course multiple times.

MAZIN AL-BALDAWI

Independent Consultant, Freelance

I am Mazin Faisal Al-Baldawi an Iraqi citizen that I have joined the online CTAM series wonderful informative courses from June 2015 to August 2016. It was a great challenge and great leap on personal qualifications improvement as a value adding content. The four different courses study itself was not easy if I may say. Nevertheless, when I have finished my IEMBA study on Infrastructure asset management subject at PGSM, I have on

search to support this new improvement of my academic achievements by going on a specialized aspect. That was the decision when I have started studying CTAM 100 as it was on a manual before being an electronic edition.

Although there are different related items during the aforementioned period but my main target has been achieved and I have obtained the final certificate of AWAM no. 53 which allowed me to join BAMI-I with the great assistance of a very generous respectful scientific man Dr. Tom Iseley. In matter of fact, Dr. Tom made me a favor by such assistance and opened the door for me to enrich my experience and the academic database by this opportunity.

However, my planning was to introduce BAMI-I in Malaysia when I was there during the time but unfortunately, there was some restrictions to achieve the target. On the other hand, I have succeeded to hold some small groups training on "infrastructure asset management" basis and conceptual planning in order to expand the knowledge base of this industry as its high contribution to any economy over the world.

My continues electronic contact with the BAMI-I through LinkedIn, e-mail newsletters and Mr. Saleh Behbahani direct contact kept me updated and informed about the institute and its expanding role in USA and in China now and hopefully that I can succeed to initiate a new contact to deliver the scientific and rich experience to those who need it in most.

I owe Dr. Tom great thanks for his assistance and kind intention to spread knowledge around the world.

RONALD THOMPSON

Vice President, Waggoner Engineering

I was first introduced to BAMI in 2004 while in Asset management evaluating various technologies that could assist the Atlanta Department of Watershed management to address needed improvements across the system. It was an exciting approach to bring together and evaluate best practice to address regulatory mandates and provide maximum sustainable level of serves to the customers served. Since that time, I have seen the organization obtain EPA funding, develop, and launch Certification of Training in Asset Management, develop CTAM course CTAM100, CTAM200, CTAM300, and CTAM400. These courses set the basis for establishment of Certified Associate Water Asset Manager (AWAM) and Professional Water Asst Manager (PWAM). Since the initiation I have participated in numerous seminars to promote asset management concepts.

There is still much to do in the area of asset management, but the early recognition and focus of the organization has provided a catalyst for drawing focus to the value and need for continued education and innovation. I want to congratulate Tom Iseley for his continued dedication and leadership to move the organization forward.

MARCELLUS T. PITTS

CEO/President
Pitts Fowler Enterprises, Inc.
Board of Directors of BAMI-I
2019 ASCE Civil Engineering Entrepreneur of the Year

At first when I attended a Pipeline Conference in Nashville, Tennessee, I thought that I knew a lot about buried asset management, but I discovered that my exposure was limited. A few years later in meeting Dr. Tom Iseley, my exposure and understanding along with great opportunities exploded. My position, which at the time was heading The Infrastructure Planning Division at Fulton County Department of Public Works was just the beginning of my exposure to this industry. Then my life in the industry elevated, when I became part of a Think Tank Team, at the request of Dr. Tom Iseley, to help evaluate buried asset management technologies that could aid the City of Atlanta Department of Watershed Management in addressing the challenges they were encountering in their water and sewer systems. With that beginning I then became more aware of the opportunities that existed in Buried Asset Management. This also allowed me to be part of the team and process that created the Buried Asset Management Institute-International (BAMI-I). Yes, I have been with this organization since its inception. We were then off to share and expose to the world the possibilities that lie within Buried Asset Management.

Note a few of the following moments in time:

2004 BAMI-I Development

Buried Asset Management Institute, BAMI, was established in 2003, however because of a high level of interest from other domestic and international municipalities of all sizes (including product, service providers, academic, and research institutions) Buried Asset Management Institute-International, BAMI-I, was formed in 2004 as a non-profit organization.

2005 South African Trip

Traveled to South Africa to further discuss and introduce Trenchless Technologies to cities in South Africa, such as Johannesburg, Mogale City, Pretoria to name a few. The trip was fruitful for all involved. This trip exposed and educated many in South Africa to more excellent possibilities of addressing underground infrastructure issues.

2006 Japan

The expansion of a Trenchless product called "SSPRA Spiral Wound Technologies" into the US market and opening an office, in the Metro Atlanta area. This deeper dive into this area of the industry opened my eyes to the industry as it relates to product development.

2007 NCBM- National Conference of Black Mayors, Baton Rouge, LA

With the developing of a partnership with the National Conference of Black Mayors, BAMI-I worked with NCBM to build opportunities for their membership to help their constituency live better lives through the supplying of better water and sewer services. At this conference BAMI-I coordinated a show case of Trenchless Technologies and Trenchless Companies. Also, provided and hosted The Managing Buried Treasures Reception. All of which were greatly received.

2008 ASCE Pipeline Conference

In cooperation with ASCE, the Pipeline Division Conference was hosted in Atlanta, Georgia. At this conference, there was great information shared about the underground infrastructure industry. One of the things that helped move the needle of understanding further was the exposure for industry personnel, politicians, students, and many others, to Buried Asset Management

2012 GCBM — Georgia Conference of Black Mayors

Created a working relationship with the Georgia Conference of Black Mayors. Offered Technical and Training Assistance to GCBM. BAMI-I participated in the GCBM Annual Spring Conference with the theme of "Job Creation".

Note that the timeline shared in no way truly represents what my association with Dr. Tom Iseley and BAMI-I has been and meant. This relationship has sent me into a trajectory that I never imagined or envisioned. I want to thank Dr. Tom Iseley for his dedication to Buried Asset Management, BAMI-I, and engineers like me who have been blessed by this man's vision.

CORI CRISS

President, ITpipes

I'm honored to work with Tom (Iseley) and serve as a Director for the BAMI-I - Buried Asset Management Institute International - since 2019.

I was introduced to Tom in 2012, through a dearly missed mutual friend, Jim Raulston. Jim was regularly sharing Tom's concepts and thoughts with me, of course, enhanced with Jim's own input and contributions! Jim worked with us on a Seattle Public Utilities (SPU) project and simultaneously was working with Tom on the RWELLS project - an innovative project that established a living lab to transform low-income risk neighborhoods into enterprise neighborhoods. The SPU project brought together sewer system condition assessment information to build a foundation with one high-quality, authoritative repository that was linked to GIS and met CMOM guidelines - a new concept for sewers at that time. These parallel projects both involved asset management planning overall and highlighted a core interest between our careers. With both of these industry stalwarts encouraging me, I was ecstatic and honored to become involved with BAMI-I.

My ITpipes team and I began actively working with BAMI-I to provide education sessions within the Trenchless Technology and Asset Management (TT&AM) classes. From there the relationship has grown. We've been involved with developing content for CTAM at different levels, providing content and case studies for Purdue's Underground Infrastructure Asset Management classes, and producing various case studies and marketing efforts. Tom's collaboration has shaped ITpipes' partnering with Purdue University to allow for real-world pipe inspection data and buried infrastructure scenarios to help future Asset Managers gain practical experience.

I'm excited to attend the Global Congress 2023 in Chicago and continue working with BAMI-I to shape and educate our industry.

RICHARD NICHOLS

Technical Director, Uni-Bell PVC Pipe Association

Uni-Bell has been a proud supporter of BAMI-I over the years. Initially involved with BAMI-I while at Louisiana Tech, Uni-Bell has always seen the benefit that BAMI-I offers to asset managers and utility operators across the world. BAMI-I stated purpose to educate and assist those who have an interest in applying best-buried asset management practices to extend the life and efficiency of their assets closely aligns with Uni-Bell's goal to educate and assist those users and operators of buried, gasketed PVC pipe. Uni-Bell believes that a better understanding of buried asset management goes hand-in-hand with a better understanding of those various piping materials; learning about one helps with learning about the other.

Uni-Bell staff have been involved with BAMI-I in several different ways. Most recently, I have had the pleasure of working with BAMI-I staff to develop a PVC pipe educational seminar that will teach and assist those asset managers who do use the pipe material. Previously, I have attended several educational seminars. Having had the benefit of being both an attendee as well as an instructor provides a unique perspective that has shown me the true value of bringing asset management knowledge to the forefront of the industry.

SHAURAV ALAM

Associate Professor, Louisiana Tech university

I learned about BAMI-I when Dr. Iseley resumed at Tech back in 2014-15 and assumed the directorship position at the TTC. Since then, I have been interested in BAMI's activities for managing buried infrastructure, the life-support systems for societies worldwide, which aligned with my research interest.

Dr. Shaurav Alam is presently serving as one of the Directors on the Board of the Buried Asset Management Institute — International (BAMI-I); thanks to Dr. Tom Iseley for making the recommendation. Dr. Alam is currently employed as an Associate Professor at the Department of Civil Engineering and Construction Engineering Technology and an Associate Director of Research position at the Trenchless Technology Center (TTC), Louisiana Tech University. His involvement in research with Drs. Iseley, Sterling, and Matthews brought several international and national level recognitions — ISTT 2012 and 2022 - Annual Award Academic Research, NASTT 2012 Best Technical Paper award on Rehab Category, and NASTT 2011 student poster competition.

KURT D. WRIGHT

President of SDG Engineering, Inc.

My connection with BAMI-I began with CTAM 100 in January 2012. At that time, SDG Engineering, Inc. was writing its first Asset Management Plan (AMP) for a small municipality. I was tasked with writing the AMP and needed to broaden my understanding of Asset Management. I decided to take the CTAM 100 course after reading about it in a magazine published by Benjamin Media Inc. I do not remember exactly which one now. As a result of taking CTAM 100, I met Dr. Tom Iseley, P.E., who was monitoring the CTAM 100 course. Through CTAM 100, Dr. Iseley and I began to correspond via email. We have been close associates ever since. The AMP mentioned above, developed by SDG Engineering, was submitted to the regulatory agency and highly acclaimed by them. Dr. Iseley invited me to join BAMI-I. Upon joining, I became involved in the development of CTAM 200. Subsequently, I was involved in developing both CTAM 300 and 400. When the CTAM series began to be taught in classroom settings in various locations in the U.S., I was invited to become part of the team of instructors. Although I have contributed numerous hours to BAMI-I in developing CTAM, I have gained much more in return. I attribute my skill set in Asset Management largely to Dr. Iseley and the BAMI-I organization, my colleagues, and my friends. I currently serve on the Board of Directors for BAMI-I.

ARLEX TORO

Executive director, Latin America Society of Trenchless Technology

On March 31, 2015, before the general assembly of members of ICTIS/CISTT (Colombian Association of Trenchless Technologies), Dr. Tom Iseley presented the CTAM 100-200 program in the city of Bogotá, Colombia. At that moment we started the path towards

the implementation of management of buried assets.

In 2016, Dr. Tom Iseley presented a master class in the city of Cartagena, Colombia to socialize the topic of Buried Asset Management before the Colombian water and sewage authorities.

In 2017, Dr. Tom Iseley presented the importance of having a certification program for network mapping at the Trenchless World Congress held in Medellín, Colombia.

In 2018, we attended the CTAM course in Lewisville, Texas to learn about the content and importance of the CTAM program.

In 2019, Dr. Tom Iseley presents the content of the 16-hour, short course mapping course for asset management in Spanish. To develop the management of buried assets, two fundamental tools are required that we must implement first: mapping and inspection of pipes and manholes. We implemented the mapping with the support of BAMI-I and the inspections with the support of NASSCO INC.

In the year 2020, we affiliated as CISTT to BAMI-I and attended the first assembly in Texas. There, we began to prepare the logistics for the mapping course that we already have on the web today. We define the quality of instructors. The 40-hour course that BAMI-I does with UESI was required. Before pandemic!

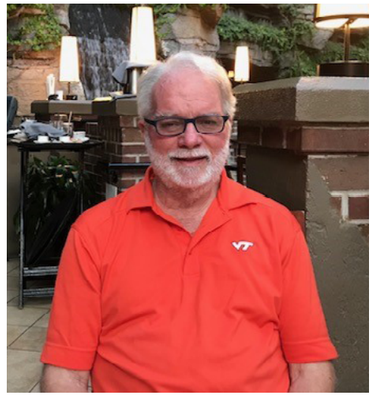
In 2021, we prepared the manual for the 16-hour short course of mapping with chalk, during the pandemic. Dr. Tom Iseley presented in the largest aqueduct and sewerage company in Colombia (12 million users) through a conference by Dr. Tom Iseley because government authorities have demanded the presentation of the 5, 10 and 15-year program with indicators such as the unbilled water losses.

In the year 2022, we did the first virtual course of 16 hours-short course of mapping with GIS. The course consists of 4 modules. Each module has a theoretical exam and there are two practical workshops with an exam to opt for certification. We had 12 attendees. We attended the general assembly at Purdue University in Indianapolis and delivered the manual in Spanish.

In 2023, the second mapping course and the first face-to-face course were held at the 4th Latin American Congress of Trenchless Technologies with the presence of Dr. Tom Iseley to promote the BAMI-I GLOBAL CONGRESS 2023 in Chicago.

RICHARD THOMASSON

Acadis U.S., Inc. (Retired)



I was working with Parsons Brinckerhoff and was the project manager for a sewer separation project we had with the City of Atlanta. Tom Iseley and I knew each other since we were founding directors of NASTT. He asked Parsons Brinckerhoff to come to the formation meeting of BAMI-I. I recommended to by boss, Bill Gray that we become a founding member of BAMI-I and he agreed. We joined as a founding member and assisted with various things with the City of Atlanta. In 2008 I left Parsons Brinckerhoff and went to work for Malcolm Pirnie who was also a founding member of BAMI-I. I have participated in the development of the CTAM program and am the chair of the AWAM and PWAM certification group. I have been the Vice Chair of BAMI-I for many years. Tom's vision for BAMI-I has always been to promote education and assist utilities in their asset management programs. It is very rewarding to know that all we do in BAMI-I will enhance the quality of life for public. It is also very rewarding to network with like-minded individuals who seek to serve the public and ensure their utility systems will be resilient and sustainable. BAMI-I has been successful in carrying out the vision Tom set for BAMI-I.

JIM HARRIS

Civil Discipline Specialist, Jacobs Engineering Group Inc.

My entire career has been involved Asset Management, but we did not call it this at the time. We used terms such as Sewer System Evaluation Survey and Cost-Effective Priority Analysis.

In the early 2000s, Rod Thornhill introduced me to NASSCO PACP becoming both an analyst and trainer. While, I never was employed in a CCTV truck, I coded hundreds of thousands linear feet of legacy CCTV data and have conducted numerous PACP certification courses.

During this time, I became reacquainted with a colleague of mine — Jim Raulston. He had become involved in the early stages of BAMI-I. He introduced me to Dr. Tom Iseley. Shortly after, Dr. Iseley invited me to join the Board where I have served for more than a decade.

Dr. Iseley approached me about getting involved in their CTAM (Certification of Training in Asset Management) program. This is a 4-level course that introduces asset management principles (CTAM-100), describes what an asset management program is (CTAM-200) , guides in the management of asset management (CTAM-300), and considers how an asset management program may be funded (CTAM-400). I was assigned the task of chairing a committee to write CTAM-300 "Managing an Asset Management Program." I have had the privilege of teaching this live on several occasions.

Through my current work as an Asset Management-Asset Assessment Engineer at Jacobs Engineering Group Inc., I have had numerous opportunities to incorporate the asset management principles BAMI-I has emphasized. We still must determine what assets we have, where they are, what their condition is, what the asset is worth, what rehabilitation or maintenance it needs, the priority of this action, what it will cost, and how it will be paid? These are the same things I have been doing for 40 years, but now, with significantly more system.

REVOLUTIONIZING THE UTILITY INDUSTRY: THE IMPACT AND GROWTH OF THE UTILITY INVESTIGATION SCHOOL (UIS)

By Wei Liao & Ming Chen

In the USA, there are more than 50 million miles of underground utilities, varying in depth, soil conditions, materials, size, and access points. Accurate location of these utilities is crucial for construction projects. Recent data shows that over 70% of projects face delays and budget overruns due to utility conflicts. In 2018, the Common Ground Alliance reported a 16% increase in damages from 439,000 incidents in 2017 to 509,000 in 2018. Inaccurate utility information increases the risk of incidents, and delays in utility relocation threaten public safety, with utility line strikes occurring every minute in the country.

In order to have an industry paradigm shift to reverse this trend. Louisiana Tech University Trenchless Technology Center (TTC) has responded to this crisis by partnering with ASCE Utility Engineering and Surveying Institute (UESI) to offer the 5-day Utility Investigation School (UIS). TTC was established by Dr.Tom Iseley over 30 years ago as an Industry/University/Government Cooperative Research Center to advance the science and practice of trenchless technology (TT) through research, education and technology transfer. TTC hosted its first Utility Investigations School (UIS) developed with ASCE/UESI in August, 2016. Dr. Tom Iseley, who held the position of TTC director at that time, played a pivotal role in collaboration with Jim Anspach, representing UESI. The foundation of UIS is rooted in ASCE38, as illustrated in Figure 1. The concept for establishing the school arose when Dr. Iseley and Jim Anspach observed a deficiency in awareness regarding ASCE 38 within both the engineering community and among property owners.

The class was intended to address the two performance goals of ASCE 38: how can a project be designed so as to have minimal utility issues during project development, and how can the professionals protect themselves against utility-related claims. UIS provided attendees the knowledge and tools to provide competent utility investigations in accordance with accepted national standards.

Jim Anspach, Chair ASCE 38 and 2018 UESI President developed the school curriculum. The course covered geophysics, utility systems construction and configuration, ASCE 38 risk-based presentations and professional liability issues. In addition to the classroom lectures, a practical session was held where participants were offered hands-on experience with mutipule technology such as the Ground Penetrating Radar (GPR), Pipe and Cable Locator (PCL), etc.

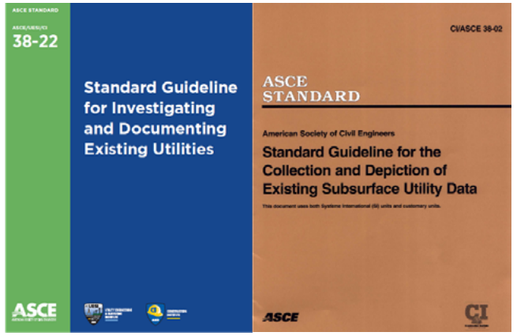


Figure 1: ASCE 38- 02 and ASCE 38-22

As commonly recognized, one of the asset management fundamentals is knowing what you've got and where it is. This delves into the aspect of location and mapping, and it served as the primary motivation for Buried Asset Management Institude(BAMI-I)to collaborate with companies operating in the subsurface utility engineering sector, with the aim of becoming a part of it. Since 6th UIS, BAMI-I has conducted this program 13 times across various locations in the country.

The 13th UIS and 14th UIS had a distinct character. The California Department of Transportation (Caltrans) displayed substantial interest and dedication to the subject matter. They made requests for two distinct schools, one in San Diego and one in Sacramento, exclusively intended for Caltrans personnel. In the end, a group of 40 participants was successfully assembled. These initiatives have achieved considerable success, and it is gratifying to observe the active involvement of the Department of Transportation (DOT). It is believed that DOT, as one of the key stakeholders, plays a critical role in the mission.

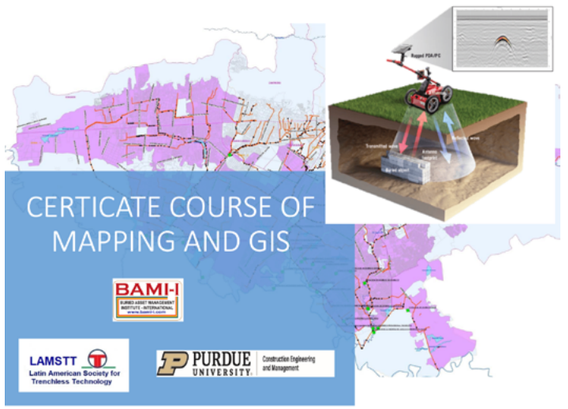
BAMI-I has organized three UIS in the Denver area: two at the Colorado School


The 13th BAMI-I/UESI Utility Investigation School September 19-23, 2022 San Diego, CA.


The 14th BAMI-I/UESI Utility Investigation School, November 14-18, 2022 Sacramento, CA.


The 9th BAMI-I/UESI Utility Investigation School, August 9-13, 2021 in Southfield, MI.


6th UIS Colorado School of Mines



The 18th BAMI-I/UESI Utility Investigation School, NYU Tandon School of Engineering — May 15-19, 2023

of Mines and one near the airport. BAMI-I will return there in December 11-15, 2023 to conduct the 20th UIS. These UIS have been highly successful, particularly because Colorado has enacted a law mandating the use of ASCE 38 for designers working on projects involving a specified amount of excavation.

BAMI-I has been requested to assist other countries, particularly Colombia, South America, in developing their educational programs for stakeholders. In 2022, after two years of preparation, Arlex Toro representing Latin America Society of Trenchless Technology (LAMSTT) and Dr. Iseley representing BAMI-I signed a course collaboration agreement at BAMI-I annual Board of Director meeting to offer the Certificate Course of Mapping and GIS School in the South American region. This course is two-day program with plans to expand it into a five-day program in the near future. BAMI-I has been actively involved in this effort, with recent visits and the successful organization of multiple schools in collaboration with them.

In May 2023, BAMI-I hosted the 18th Utility Investigation School (UIS) in collaboration with New York University. New York University has entered into a contract with the city to evaluate the fesability tackling the challenging task of mapping the entire underground infrastructure of New York, a highly complex endeavor. In this context, BAMI-I was engaged to organize a comprehensive five-day school, offering valuable insights and expertise in the field.

The 19th UIS is scheduled to occur in Baltimore, MD from October 16-20, 2023.

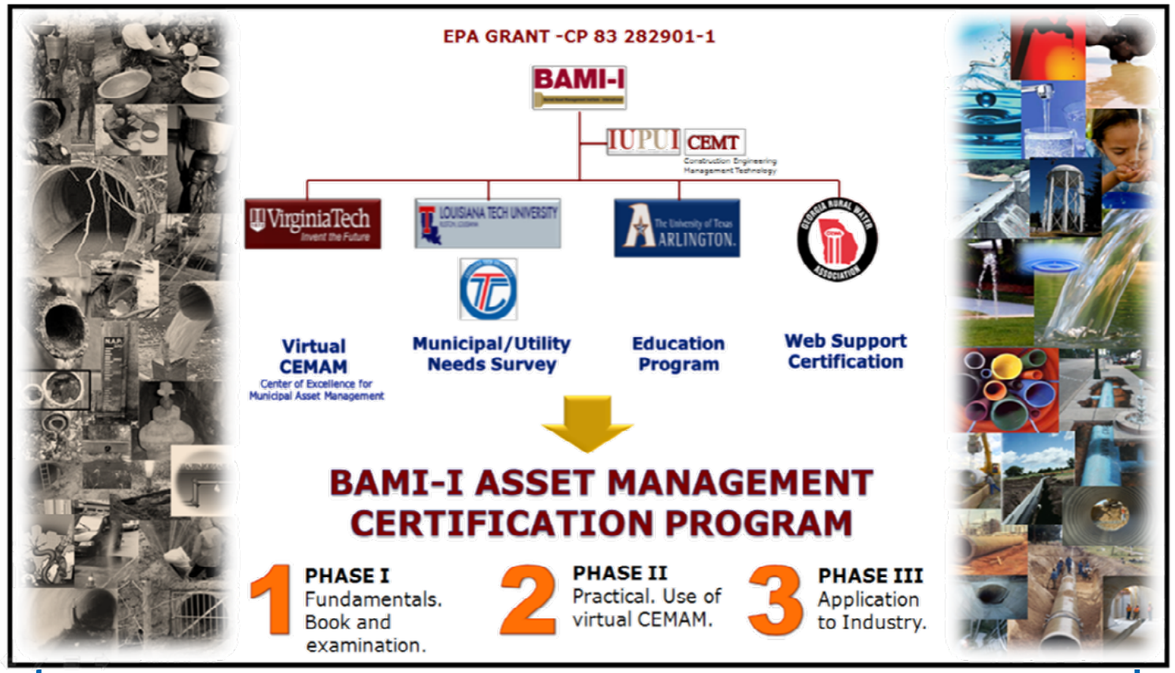
So far, more than 400 students have enrolled in this course, which serves as a Body of Knowledge course for test preparation related to UESI Utility Engineering certifications. It has been gratifying to witness the engagement and sustained enthusiasm among learners interested in Subsurface Utility Engineering (SUE) and the ASCE 38 Standard. BAMI-I has consistently prioritized ongoing education and the promotion of best practices in SUE.

Wei Liao is the Lead Research Engineer at Purdue University and Executive Director of BAMI-I. **Ming Chen** is an Assistant at BAMI-I.

Online Asset Management Training for Water Utility Professionals

Exclusive Four-Part Series in Asset Management Certification

1. CTAM-100 – Overview of Asset Management
2. CTAM-200 – Developing an Asset Management Program
3. CTAM-300 – Managing an Asset Management Program
4. CTAM-400 – Financing an Asset Management Program



The CTAM program was developed by BAMI-I (Buried Asset Management Institute International) in conjunction with the Trenchless Technology Center at Louisiana Tech and Indiana University-Purdue University at Indianapolis, in partnership with UIM: Water Utility Infrastructure Management, and is hosted by the Construction Engineering and Management Department at Purdue University.

Visit Website: www.bami-i.com for more information, contact:

Saleh Behbahani
sbehbaha@purdue.edu

BAMI-I'S CERTIFICATION OF TRAINING IN ASSET MANAGEMENT PROGRAM REPORT

By Wei Liao & Ming Chen

In 2006, BAMI-I was selected for a U.S. EPA Cooperative Agreement (CP 83 282901-1). Its role involved surveying utilities of various sizes across the nation to identify genuine requirements. The primary objective was to educate these utilities comprehensively about asset management, covering everything from plan and project development to implementation and reaping benefits. To fulfill this mission, BAMI-I assembled a team of researchers from Virginia Tech, the Trenchless Technology Center at Louisiana Tech, and the University of Texas at Arlington. Notably, they engaged the Georgia Rural Water Association to oversee their efforts, ensuring a utility-focused approach. By 2008, the project had been successfully completed, and the report was presented that same year. This accomplishment paved the way for them to explore the creation of an online training program.

In 2010, BAMI-I introduced the current Certification of Training in Asset Management course (CTAM-100). This course offers a comprehensive introduction to asset management principles and concepts, with particular emphasis on their application to underground assets related to water and sewer systems. The success of CTAM has highlighted the necessity to expand its initial scope and offer more intricate training across a broader spectrum of utility system concerns. To address this challenge, three additional training courses are in the works for release at six-month intervals starting in 2013. These courses are named as below:

CTAM-200: Developing Buried Asset Management Programs

focuses upon a utility's buried assets such as pipes, manholes and valves that are "out-of-sight and out-of-mind." The course introduces the internationally accepted "Total Asset Management Plan" concept and terminology and then focuses on modifications to address current North American priorities, such as developing a basic Buried Asset Management Program for water and wastewater infrastructure. In this effort, the course provides guidance for program design and implementation; long-range planning; selecting data collection methods; data storage and access; database management; and asset condition assessment.

CTAM-200 provides in-depth examination of asset "Condition Assessment" and introduces sub-topics to review available assessment methodologies and their application in the effort to define "The Current State of My Assets."

CTAM-300: Implementing Buried Asset Management Programs

This course sequentially follows CTAM-200 and provides in-depth review of pertinent government regulations, customer expectations and performance measurements associated with Buried Asset Management Programs. The course goal is to clarify regulations that are currently implemented as part of compliancy in asset management requirements and measuring performance. Registrants will also gain an understanding of the risk assessment process, prioritization methods, evaluation technologies, asset life estimation methods and different depreciation models. All of these will lead to answering the question of performance sustainability. The module concludes with information on capital improvement planning (CIP) methods, operations and maintenance (O&M) estimation, government regulations (i.e., CMOM and GASB 34), and repair-renewal technologies that are currently promoted and practiced in the water and wastewater industry.

CTAM-400: Financing Buried Asset Management Programs

Funding is one of the most critical issues that require attention in the effort to successfully implement a Buried Asset Management Program. This course will delve into topics such as economic analysis; planning concepts for project screening; planning for uncertainty and risk; financial analysis with respect to time value of money concepts; economic analysis applications of environmental and social impact assessment; public environment, legal and institutional aspects; and, last but not least, different funding methods currently available (e.g., bonds, partnerships, taxation, utility rates, etc.).

By completing these three courses, participants should acquire a working knowledge of how to initiate the Buried Asset Management Program develop- ment process and launch the program with long-term views and commitment.

In response to industry demands, BAMI-I established a certification committee and developed two certification levels: Associate Water Asset Manager and Professional Water Asset Manager.

Around 1600 People from 16 different countries have participated in the online courses. Notably, organizations like the Environmental Organization in North Carolina Division of Water Infrastructure recognized the growing need for assistance in enhancing utility plans within their state. In response, they awarded BAMI-I a contract with BAMI-I in 2015 to conduct four-day courses, each spanning one day, with the aim of training their personnel and other interested individuals simultaneously. Table 1 shows the CTAM workshop series which was conducted by BAMI-I in the past few years:

Table 1 CTAM workshop series

No.	COURSE SERIES	Organizer	Location	Date	Attendees
1	CTAM 100-400	North Carolina Division of Water Infrastructure	Raleigh, NC	August 17 — 20, 2015	24
2	CTAM 100-400	Rural Community Association Partnership (RCAP)	Columbus, OH	May 16 — 19, 2017	34
3	CTAM 100-400	UCTA-North Texas	Lewisville, TX	Nov 5 — 8, 2018	47
4	CTAM 100	NJWEA Annual Conference	Atlantic City, NJ	May 6, 2019	43
5	CTAM 100-400	City of Atlanta (COA) DWM	Atlanta, GA	September 9-12, 2019	33
6	CTAM 200	NJWEA Annual Conference	Atlantic City, NJ	May 8, 2023	20

CTAM Workshop #: Raleigh, NC August 17 — 20, 2015

CTAM Workshop #2: Columbus, OH, May 16 — 19, 2017

CTAM Workshop #3: UCTA-North Texas - Lewisville, Nov 5 — 8, 2018.

CTAM Workshop #4: Atlantic City - May 6, 2019

CTAM Workshop #5: City of Atlanta (COA) Department of Watershed Management (DWM). September 9-12, 2019

CTAM workshop #6: CTAM 200 - Atlantic City — May 8, 2023

In 2023, BAMI-I, Back Municipal Consulting and MSD of greater Cincinnati are offering The CTAM workshop. This workshop will take place in Metropolitan Sewer District of Greater Cincinnati (MSDGC) Room 106, 1600 Gest St. Cincinnati, OH 45204.

The CTAM series currently serves as the primary instructional material at Purdue University's Asset Management of Underground Infrastructure (AMUI) course. The AMUI course is conducted in a traditional classroom format for on-campus students and are also offered through PEO (Purdue Engineering Online) for remote learners seeking university credit or professional development credits. CTAM has already accumulated over a decade of experience and has achieved considerable success. However, BAMI-I is not content with its current achievements. In order to stay abreast of the evolving times and technological advancements, BAMI-I team is in the process of undertaking a comprehensive upgrade and modernization of the CTAM series, with the aim of achieving even greater success in the future.

SWITZ CITY ASSET MANAGEMENT PLAN PROGRAM UPDATE

By Wei Liao & Ming Chen

In January 2023, Ziptility, BFU & BAMI-I agreed to work together to develop an Asset Management Plan (AMP) for the Town of Switz City, IN on a pro bono basis to aid in developing a team with experience in developing AMPs utilizing the IFA guidelines. The intent was for this AMP to be used as a model/template for future small utilities on a fee basis. The Town Council approved this project.

August 2, 2023. Representatives from Switz City, BAMI-I, Bynum Fanyo Utilities, Purdue University, and Utiliz gathered for the fourth meeting in The Town of Switz City. The purpose of this meeting was for team leaders and participants to meet to discuss progress to date and to develop a strategy for completion. The first three meeting, conversation and

Tom Iseley led discussions explaining various aspects related to the importance of AMPs. He briefly explained what is required in an AMP to comply with the IFA guidelines published in 2019. He emphasized that the AMP needed to be a living document that the Town could utilize to ensure that their water and wastewater system is being management efficiently with the proper investment. He described that the AMP requires data for determining the remaining life of each asset and being able to project the rates of deterioration for a 20 forecast to examine the following 3 scenarios:

- What happens if the Town does not invest in their water infrastructure,
- What happens if the Town increases rates to permit only investing to keep the level of deterioration at the current status, and
- What happens if the Town has a rate increase structure which allows moving from being reactive to proactive to ensure that the status of the assets are improving and there exists sufficient funds for unexpecting events.

He ended by providing an example of what happened with Spindale, NC when they developed an AMP in 2013 and how they have used it for 10 years even with changes related to personnel and how it has assisted with getting external funding.

During the meeting, Tom Iseley introduced Jackson Bolek from Utiliz, who provided an overview of Utiliz's background and expressed a willingness to contribute to the project as a team member, with a specific focus on Loss of Functionality (LoF) and Cost of Failure (CoF) aspects, as well as establishing criticality assessments.

Mahnoush Moshen then presented an overview of the data and information.

Carla Porter supplied the AM development team with relevant record documents during the meeting.

Throughout the discussion, various topics were covered, including utility system diagrams, data management, and energy consumption. Jeff Farmer actively participated, sharing his valuable insights and ideas, contributing to lively and insightful discussions aimed at enhancing the project. Representatives emphasized the significance of efficient resource management and offered numerous suggestions related to environmental stewardship, sustainability, and community involvement.

Subsequently, participants were divided into smaller groups to engage in more in-depth discussions about project details. This approach facilitated a clearer understanding of individual roles and allowed for collaborative problem-solving.

Following the meeting, a visit to the wastewater treatment plant was organized, where Adam Hershberger guided the attendees through the practical aspects of water asset management.

The meeting proved to be both positive and highly productive for all participants. It fostered extensive discussions and the exchange of valuable ideas. Consequently, it has injected new energy and a revitalized sense of dedication into the Asset Management Plan program, reaffirming BAMI-I's commitment to safeguarding Switz City's water assets.

LEVERAGING ASSET MANAGEMENT TO INFORM RATE SETTING AND CAPITAL PLANNING IN WATER AND WASTEWATER UTILITIES

By Dan Hilyer, P.E.

Water and wastewater utilities serve a critical role in ensuring the delivery of safe and reliable services to their communities. However, they often face significant infrastructure challenges due to aging assets and the need for costly repairs and replacements. Historically, funding for first-generation infrastructure development was primarily in the form of home mortgages and business loans which paid the initial infrastructure cost with limited and relatively low one-time connection fees. This approach provided limited to no involvement from ratepayers. The long-term financial demands of water and wastewater utilities have proven this approach insufficient. In this article we will investigate the merits of utilizing asset management to better inform rate setting and capital planning.

Evolution of Infrastructure Funding

First-generation water and wastewater infrastructure relied heavily on funding through home mortgages and business loans which covered the initial infrastructure development cost. This approach removed infrastructure investment from rates paid by utility customers. Consequently, ratepayers were not required to shoulder the burden of funding the initial infrastructure installations. While this model is still in widespread use today, it presents many challenges and limitations for the utility. A key limitation is the absence of dedicated revenue streams for long-term infrastructure maintenance and replacement. This limitation impedes the utilities' ability to adequately plan for future funding requirements and may result in deferred maintenance and higher costs for future generations.

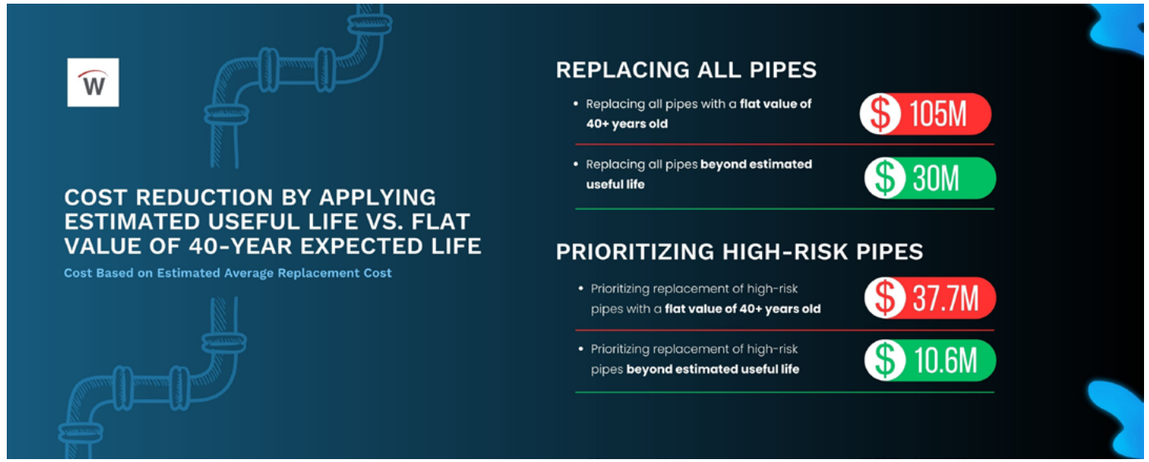
Depreciation has been a commonly used method for funding infrastructure replacement. However, relying solely on depreciation has its limitations. Many systems fail to fully fund depreciation resulting in a shortfall of funds required to adequately address infrastructure needs. Even when fully funded, depreciation rarely provides needed funding levels to support the infrastructure replacement demands. Depreciation calculations are typically limited to the original costs of assets, disregarding the impact of inflation over time. This omission leads to a significant disparity between the actual cost of replacement and the available funds set aside through asset depreciation. To address this issue, utilities must adjust depreciation annually to account for inflation and ensure adequate funds are allocated for future capital needs. Failure to account for inflation will result in deferred maintenance and continued infrastructure deterioration, resulting in increased future costs that will land on the shoulders of the ratepayers. Unfortunately, general accounting standards do not allow for the possibility of adjusting depreciation for inflation.

Federal and state funding programs have been presented as the future of infrastructure replacement. While grants, appropriations, state revolving funds, and other government programs can provide short-term funding solutions and address new regulatory requirements, they have limitations when it comes to long-term sustainability. Although these programs can offer immediate financial relief, they are simply not generationally sustainable. There is no guarantee of the continued availability of these funds and access to these programs is not assured in the long term. Reliance on grants and similar programs can create uncertainty and instability in funding, forcing utilities to constantly seek alternative sources. This approach of "kicking the can down the road" burdens future generations with the responsibility of addressing infrastructure replacement needs without a reliable financial support mechanism.

Water & Wastewater Rates

The key to the long-term sustainability of water and wastewater utilities is the ability and willingness to develop rates that adequately address current and future infrastructure repair and replacement needs. Historically, utilities have developed rates that rely heavily on consumption-based charges. While these forms of rates are equitable across the customer base, they are based on assumptions that are entirely out of the control of the utility. Consumption-based rates depend on predicting on an annual basis the usage habits of the customer base being served while also considering forecasted weather patterns that can have a significant impact on how much water each customer uses. Additionally, consumption-based rates depend on continued economic growth and do not account for any unexpected shrinkage caused by an economic downturn that forces commercial and industrial customers to close or reduce their water usage based on demand downturns. These assumptions make it a gamble to accurately project revenue. To overcome this challenge, rates need to capture capital funding requirements through a base rate structure. This approach removes the guesswork associated with consumption-based rates and provides a stable and predictable revenue stream.

Rates must also be sustainable and equitable, ensuring the burden of infrastructure funding is fairly distributed across the customer base. To achieve this, rates should be based on a well-defined Capital Improvement Plan that aligns funding needs with the anticipated infrastructure replacement requirements. By developing rates that address infrastructure funding, utilities can secure the financial resources required to maintain and upgrade their systems, ensuring sustainable service for future generations.



Need for Asset Management

Water and wastewater utilities must embrace asset management to address the limitations of traditional funding models. Asset management encompasses the systematic and strategic management of assets throughout their life cycle and provides utilities with valuable insights into asset data and condition assessments. By incorporating asset management data into the capital planning and rate-setting process, utilities can make informed decisions and accurately estimate the revenue required to fund infrastructure investments over time, ensuring that rates are equitable, sustainable, and reflect the true cost of providing reliable water and wastewater services.

Asset management plans rely on accurate

asset data and comprehensive condition assessments to inform decision-making. Utilities gain a holistic view of their infrastructure by gathering and organizing detailed information about assets, such as location, age, condition, and maintenance history. This information allows for prioritizing investments based on risk and criticality. It helps identify assets that necessitate immediate attention, ensuring that resources are allocated efficiently to address potential failures or service disruptions.

Asset management plays a crucial role in strategic and capital planning. Utilities can proactively develop long-term plans to address infrastructure needs by analyzing asset information and condition assessments. These plans consider factors such as asset life expectancy, regulatory requirements, technological advancements, and economic development. With this data, utilities can prioritize investments and allocate funds appropriately, ensuring that infrastructure replacement aligns with the utility's long-term goals and financial capabilities.

Asset management contributes to enhanced customer confidence and satisfaction. By prioritizing investments in critical assets, utilities can prevent unexpected

service disruptions, minimizing the inconvenience to customers. Reliable service promotes trust and satisfaction among ratepayers and enhances their confidence in the utility's ability to meet their water and wastewater needs. Asset management also enables utilities to communicate transparently with their customers about infrastructure investments, emphasizing the importance of rate structures that reflect the true cost of service.

Implementing an asset management plan provides utilities with defensible funding requirements. By analyzing asset data, condition assessments, risks, and criticality, utilities can articulate their long-term funding needs based on objective criteria, not subjective opinions. This transparency ensures accountability to stakeholders, including ratepayers, policymakers, regulatory agencies, and lending institutions. Defensible funding priorities assist utilities in securing required financial resources and help build trust with stakeholders who rely on the utility's services.

Focusing on infrastructure needs, including first and second-generation assets, plays a vital role in the utility's long-term sustainability. Asset management helps utilities maintain this focus. By continuously monitoring asset conditions and assessing their performance, utilities can proactively plan for future capital expenditures. This proactive approach limits the risk of deferring critical maintenance which will result in costly repairs and premature asset failures. Furthermore, asset management removes personal and recency bias from the decision-making process, ensuring investments are made on objective data and risk analysis.

Asset Management at Work

To illustrate the effectiveness of an asset management program, let's consider an example involving the Environmental Protection Agency's (EPA) life cycle standards. EPA applies as a basis for replacing assets their age only and does not consider other factors such as criticality and risk that play crucial roles in determining replacement priority. Using EPA's standards for infrastructure life expectancy, a utility in the southeastern United States identified a $105 million, 25-year infrastructure problem. Utilizing asset age as the only criterion created an unreasonable and unsurmountable problem. By implementing an asset management approach, which uses asset condition, consequence of failure, and probability of failure, assets that present unacceptable risk can be prioritized for replacement. Using this approach, the utility was able to significantly reduce the problem to a $10 million, 10-year issue. The $105 million problem did not simply disappear — the reduction was achieved by refocusing attention and resources on critical and high-risk assets identified by using the asset management approach and applying estimated useful life metrics versus a flat, 40-year expected life. This approach allowed the utility to develop a plan with manageable steps to address their funding needs.

The utility's asset management plan provided the required data and insights to prioritize investments, resulting in more efficient use of resources and improved long-term financial sustainability. In the three years since its inception, the asset management plan has played a pivotal role in providing valuable direction for infrastructure investment. This strategic approach allowed the utility to embark on the monumental task of addressing the critical needs of the system, resulting in a positive impact on the utility's ability to develop a sustainable and well-funded capital improvement program for the long term. By incorporating the insights and guidance provided by the asset management plan, the utility has been able to confidently allocate resources, prioritize investments, and ensure the ongoing reliability and efficiency of its water infrastructure.

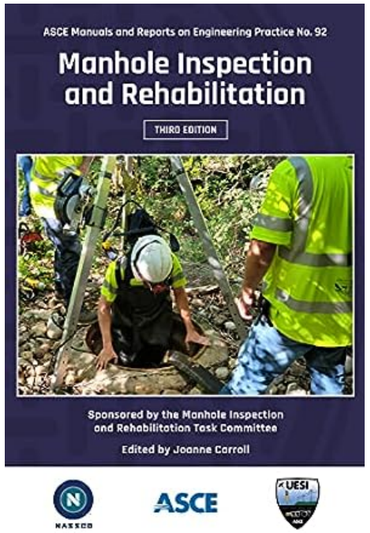
Conclusion

Incorporating asset management in water and wastewater utilities is crucial for informed capital planning and rate development. Asset management provides utilities with defensible funding requirements and ensures transparency and accountability to stakeholders, including ratepayers, policymakers, regulatory agencies, and lending institutions. It enables utilities to maintain focus on infrastructure needs, including first and second-generation infrastructure. Leveraging asset management can help utilities develop a comprehensive rate roadmap that removes guesswork and bias, directing available funds where they are most needed. Ultimately, this approach ensures the long-term sustainability and resilience of water and wastewater infrastructure, benefiting the utilities and the communities they serve.

Dan Hilyer is the Utility Management & Operations Discipline Manager at Waggoner.

MANHOLE INSPECTION AND REHABILITATION, ASCE MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 92 (MOP 92), 3RD EDITION

By Mark G. Wade, P.E.



1.ABSTRACT

The American Society of Civil Engineers (ASCE) published its first manual of practice in 1992 to help the utility industry improve their manhole inventory. Since then, MOP 92 has been updated twice. The most current update is particularly helpful to anyone engaged or involved in manhole inspection, design, rehabilitation, renewal, or (and in particular) asset management. The most recent edition, which was recently available in its final published format (available on ASCE on-line Book Store for $80.00), is much more robust and detailed (and helpful) than prior editions. This article provides an overview of the updates included in this 3rd edition This article will also be helpful to anyone engaged or involved day-to-day operations, maintenance, and management of manhole structures in the following areas:

- Non-entry Manhole Inspection
- Condition Assessment
- Management
- Rehabilitation and Renewal
- Asset Management.

2.KEY WORDS

Manhole, rehabilitation methods, repair technology, ASCE, MOP, I/I, asset management, trenchless, cost, budget, NASSCO, Third Edition

3.INTRODUCTION

The idea for MOP 92 began in 1991 during the annual ASCE Pipeline Infrastructure (PINS) meeting as part of the Water Environment Federation Conference (WEFTEC) in Washington, DC. At that time, there was broad consensus and agreement that an MOP dedicated to the inspection, rehabilitation, and management of manhole structures were needed. A subcommittee was formed and over the course of then next four years MOP 92 was ready for publication which happened in 1997. This overall effort was accomplished through a partnership with the ASCE Committee on Manhole Rehabilitation of the Pipeline Division of ASCE and NASSCO's Manhole Rehabilitation Committee. A second edition followed. These two prior editions of MOP-92 addressed issues associated with inspection, scoring and prioritizing manhole structures. Finally, the recent release of MOP 3rd Edition on December 21, 2022 has significantly expanded the two previous editions.

Specifically, under this new edition, there is much more emphasis on Chapter 5 "Manhole Rehabilitation Methods". By way of summary, there are a total of nine chapters in this current release:

Chapter 1 - Introduction
Chapter 2 - Worker Safety
Chapter 3 - Inspection
Chapter 4 - Quantification of Infiltration, Inflow, and Structural Condition
Chapter 5 - Manhole Rehabilitation Methods
Chapter 6 - Examining Cost-Effectiveness of Manhole Rehabilitation
Chapter 7 - Wall Thickness Design for Full-Depth Manhole Rehabilitation
Chapter 8 - Quality Management
Chapter 9 - Summary
Glossary
Index

This article along with its numerous photos and figures will focus primarily on the particulars of what is included in **Chapter 5** so that there's time and space to do a deep dive into the content and important highlights of the specific technologies featured in this chapter. In particular, this will include nearly all technologies and products that are currently available to both private and public utilities when considering cost-effective approaches to renewing aging manholes structures. Areas of rehabilitation that are covered include (a) manhole covers and frames, (b) chimney seals, (c) wall joint seals, (d) injection grouting, and (e) coatings and liners. As part of this discussion, this article and companion tables and exhibits will be wrapped up with a high-level consideration of some asset management strategies (and particularly a condition assessment matrix that is featured in MOP 92), along with the impact that these new approaches will be added to the NASSCO codes for both PACP and MACP.

Table 5-1. Manhole Rehabilitation Options

Manhole Component/Renewal Methods	O&M	I/I	STRUC	COR	Comments and Limitations
Lid Seals and Dishes	■	■			None
Chimney, Frame and Joint Seals	■	■	■		Rehabilitate adjustment section for structural repair
Chemical Grouts	■	■			
Cementitious Liner (Portland Based)	■	■	■		pH >3
Cementitious Liner: Calcium Aluminate		■	■	■	pH >2
Cementitious Liner: Polymer or Additive Modified		■	■	■	Corrosion protection varies by material
Polymer Liner: Rigid		■	■	■	May be installed as composite system with cementitious basecoat for cost savings
Polymer Coating: Flexible		■		■	Installed as composite system w/ cementitious or rigid polymer coating for structural repair
Cured-in-Place Liner		■	■	■	
Thermoplastic Liner Composite			■	■	Uses cementitious or polymer basecoat to install and effect structural repair

4.JUMPING DIRECTLY INTO CHAPTER 5 OF MOP 92 — MANHOLE REHABILITATION METHODS

Once information is gathered through the inspection process, the recorded data are reviewed to prioritize repairs and select rehabilitation materials and methodology. Material and technology choices for rehabilitation are dependent upon the specific reasons for the implementation of the project (Table 5-1) including the correction of structural deficiencies, addressing maintenance requirements, elimination of I&I, and prevention of future corrosion.

There are many products available that may fulfill the need to satisfy maintenance requirements and control inflow that require minimal training and little or no specialized equipment. This type of work includes specialty products such as:

- Cover or lid replacement or vent hole plugs
- Cover or lid seals (gaskets) and inserts (dishes)
- Chimney seals (mechanical seals and applied sealants)

Defects in manhole covers, frames and chimneys present multiple opportunities for surface water (inflow) to enter the manhole through holes in the cover and through the space between the cover and the frame. These sources of inflow may account for a significant amount of leakage in manholes contributing to sanitary sewer overflows and costly treatment of non-wastewater flow.

Manhole Covers and Frames

Leaking manhole covers can be sealed by plugging vent or pick holes or through replacement with new watertight covers (see Figure 1). Installation of a bitumastic sealant when the seal is missing or damaged, or replacement of rubber gaskets when the frame and cover are grooved specifically for a gasket can also create a seal. The use of manhole dishes or inserts under the cover is also common to capture residual water, especially in flood prone areas.

Chimney and Wall Joint Seals

Ground movement, thermal expansion and contraction of the surrounding pavement, frost heave, and traffic loadings can cause the seal between the frame and chimney to deteriorate or break allowing surface water to enter the manhole. This water, entering the manhole after running along pavement subgrades, washes subgrade material in with it resulting in settlement of the pavement around the manhole. Concentric surface cracks may be evidence of subgrade washout.

The frame-chimney joint area can be sealed internally without excavation when frame alignment and chimney conditions permit. When excavation is required to replace the frame or to reconstruct the chimney and/or cone, the frame-chimney joint can be sealed internally and/or externally. Methods for sealing this frame-chimney joint area include mechanical frame-chimney seals, flexible epoxy and urethane applied sealants, mastic and rubber adhesive

Figure 1 . Example of Manohle Cover Replacements and Inserts

Figure 2 . Example Methods of Chimney and Wall Joint Renewal

laminates and cured-in-place liners.

Ground movement and/or worn, failing, or improperly installed joint gasket material may allow infiltration to occur through the wall joint. These leaks add to the overall daily dry weather flows and unnecessary treatment processes and cost. One method for sealing the wall joint is using mechanical joint seals. These seals are a non-structural repair manufactured from the same materials used in the mechanical frame-chimney seal. Flexible epoxy and urethane applied sealants may also be used but only after active leaks have been stopped. The following methods can be used to repair manholes requiring more comprehensive rehabilitation: injection grouting, spot repairs, coatings and liners.

Examples of Rehabilitation methods for this upper area of typical manhole structures are shown in Figure 2.

Injection Grouting

Injection grouting is typically used in manholes for infiltration control and void stabilization. It is also commonly used in conjunction with coating and lining technologies to stop infiltration prior to their installation. Manhole grouting does require training and equipment for proper installation and effectiveness. The success of grouts in reducing infiltration is largely dependent upon the following factors:

- Soil conditions
- Moisture conditions and groundwater table elevation
- Injection patterns
- Gel time and grout mixture
- Containment of excessive grout migration
- Selection of the proper type of grout
- Experience of the grouting crew
- Project quality control

The wide range of grouts on the market for pressure injection fall into these categories: Acrylic resins, urethane gels, hydrophobic urethane foam, and hydrophilic urethane foam.

Acrylic Gels: Thinnest of the acrylic family of resins (acrylamide, acrylic and acrylate) on the market; all with controllable set times and little or no expansion. Acrylic gels are often specified for curtain grouting to create an impermeable gel/soil matrix and positive seal outside the structure, thereby stopping infiltration and future erosion.

Urethane Gels: A prepolymer which activates and cures upon reaction with water. Urethane gels have excellent permeation properties to create an effective water barrier while providing soil stabilization.

Hydrophobic Urethane Foams: Generally injected as a single component that requires little water to activate. These grouts withstand wet/dry cycles, and with high expansion rates make them ideal for filling voids and stabilizing soil outside the structure.

Hydrophilic Urethane Foams: Single component and moisture activated with 1:1 up to 1:12 water-to-resin ratios. These chemical grouts are available with various viscosities and are well-suited to seal cracks, joints and pipe penetrations. Where the following conditions are observed, pressure grouting within manholes can be used:

- Brick manholes with somewhat tight joints
- Active infiltration
- Structurally sound manholes
- Cohesive soils with high moisture content
- Manholes with voids or unstable surrounding soil

The most common grouting techniques used within manholes include curtain grouting, expanded gasket placement technique, horizontal joint, and vertical crack injection.

Curtain Grouting: Curtain Grouting is a technique used to encapsulate a structure by drilling through the manhole walls in a pattern that begins from the bottom of the structure and rotates (serpentine or coil) towards the top of the structure. Specially designed mechanical packers are then inserted into the drilled holes and the grout is pumped to the outside of the structure to encapsulate and seal the structure preventing infiltration. Curtain grouting may be performed with acrylic gels, urethane gels or low viscosity highly expansive foam grouts. The primary uses for curtain grouting are to control infiltration and stabilize voids outside the structure. The equipment necessary to perform this task is composed of a drill and drill bits, a dual or single component pump, injection gun and packers, chemical grout and safety equipment.

The Expanded Gasket Placement (EGP) Technique: Figure 3 shows the insertion of a resin-soaked foam backer rod or dry oakum into a joint. This resin (absorbed into the oakum or backer rod) reacts with the incoming groundwater to expand and isolate the joint or pipe connections to the manhole creating a flexible, watertight gasket. This technique can also be used around the invert and pipe penetrations.

Horizontal Joint Injection: This technology targets actively leaking joints and/or the

Figure 3 . Example of Injection Methodologies for Manhole Cone/Corbel and Wall Sections

seams between precast concrete sections. Many times, the original seals were improperly installed or have eroded, allowing groundwater to leak into the manhole. The leaks are generally sealed using flexible hydrophobic or hydrophilic urethane grouts. The EGP technique may be used if the joints are separated, or holes may be drilled below the seam where the sections are joined. A mechanical injection packer is inserted into the hole and grout is injected into the crack to create an impermeable barrier to infiltration.

Vertical Crack Injection: This is a method of injecting grout into a crack, filling any defects, and bonding to the structure. The new seal in the crack will be flexible and able to handle minor movement. A low viscosity grout is recommended for thin cracks, with higher viscosity grout used for wide cracks. When using this technique all loose, friable and porous debris is removed from the leaking crack before creating injection points. Holes are drilled and grout is injected from the bottom of the crack. The drilled holes should be flushed with clean water before installing the mechanical injection packers. Upon completion of grouting, cured grout is removed even with the surface prior to application of other rehabilitation products.

A few examples of various types and methods of grouting the cone/corbel and wall portions of typical manhole structures are shown in Figure 3.

Coatings and Liners

For the purposes of defining coating and liner terminology as used in this manual, coatings provide a barrier preventing surface and groundwater from entering the manhole and to protect against future corrosion. Coatings include polymeric spray or trowel applied materials including epoxy, polyurethane and polyurea systems. Liners are used to restore manhole surfaces and renew structural integrity. Liners used in manhole rehabilitation include rigid polymers, cementitious, geopolymer, and cured-in-place manhole liners (CIPM). Composite systems, which utilize more than one of the technologies to rehabilitate the manhole, are typically comprised of a cementitious underlayment with an epoxy topcoat or embedded thermoplastic protective sheet liner.

Correcting structural deficiencies, elimination of infiltration and prevention of corrosion may require the use of a monolithic full depth coating or liner in the manhole. Knowledge of the following project criteria and manhole condition is essential to making the proper selection of material and rehabilitation technology:

- Accessibility
- Downtime available for rehabilitation process
- Presence of corrosion
- Structural deterioration
- Infiltration

In addition, an understanding of the characteristics of available products is necessary for matching needs to rehabilitation technology. The selection of rehabilitation product(s) is complicated by the sheer number of available technologies.

Preparation for installation of coatings is essentially the same for all product types. Good coating practices have been standardized through NACE and ASTM standards; the basic steps include:

- Cleaning, decontaminating, and creating adequate profile of the host substrate
- Eliminating infiltration, diverting and bypassing flows
- Repairing and/or resurfacing concrete and masonry surfaces
- Installation of the coating or liner
- Inspection and testing

Cleaning and profiling of concrete and masonry substrates includes the removal of oils, grease, waxes, form release and curing compounds, laitance, sealers, salts, existing coatings or other contaminants which may adversely affect the adhesion of the coating or liner to the substrate. Concrete and/or mortar damaged by corrosion, chemical attack or other means of degradation are also removed. The preparation process chosen should also remove all laitance and weak concrete to expose a sound surface. There are several methods available to accomplish proper surface preparation. The most common methods are low-pressure water cleaning or pressure washing (3,500 — 5,000 psi), high-pressure water cleaning (5,000 — 10,000 psi), water jetting (>10,000 psi), and dry or wet abrasive blast. The objective of surface preparation is to prepare a uniform, sound, clean, neutralized surface to meet requirements of the specified coating or liner.

Active infiltration can be stopped by use of hydraulic cements and injection grouting prior to installation of coatings or liners which rely upon adhesion for performance or where the active leaks can result in detrimental wash-out of resin or liner material.

Repair or patching products are used to fill voids, honeycombs, bug holes, spalls,

Figure 4 . Example Rehablitation Metods Using Cementitious Technologies

cracks and other surface imperfections which would adversely affect the installation or performance of the coating or liner. This process is less intensive when utilizing cementitious liners, as the same materials are generally used for the repair/patching as the liner itself. However, it is also common to utilize cementitious coatings to resurface masonry or severely corroded concrete manholes to repair, smooth or rebuild surfaces to receive polymer coatings or thermoplastic liners. Refer to Chapter 7 for design guidelines including applied thickness when resurfacing materials are used in a composite system.

The basic types of coatings and liners include: 1) cementitious liners (Portland cement, calcium aluminate, geopolymer) and poured-in-place concrete with or without thermoplastic protective sheet liners, 2) polymer liners (epoxy, polyurethane), 3) protective coatings (epoxy, polyurea, polyurethane and hybrids), and 4) CIPM.

Cementitious Liners: Cementitious liners can provide an effective solution for infiltration, full depth structural rehabilitation and corrosion protection. Corrosion protection can be provided through the use of specialty cements, antimicrobial additives, the topcoat application of a polymer coating or thermoplastic sheet liners. Since corrosion is common to sanitary sewers as a result of MIC, any method that prevents development of acid or provides an acid resistant barrier between the acid and the substrate can provide protection. Manholes exposed directly to acids from industrial effluent require an engineered evaluation prior to selection. Cementitious materials may be applied by trowel, spray or spin cast. All systems require specialized training, and some systems require specialized equipment for installation. Example applications for cementitious liners are shown in Figure 4.

Formed-in-Place Concrete: The formed-in-place (FIP) method provides a new concrete interior wall conforming to the dimension and shape of the existing manhole. When a corrosive environment may occur, a thermoplastic sheet liner can be placed around the exterior of the inside forms prior to pouring the concrete to provide a protective barrier that is permanently anchored to the new concrete wall. Alternatively, specialty cements or antimicrobial additives may be used. Generally, the new concrete wall is about 3 inches thick. The placed concrete fills all voids or missing bricks in the existing wall making it a complexly independent, new concrete manhole. Typically, excavation is not required with this trenchless replacement method. Examples are shown in Figure 5.

Polymer Coatings and Liners: Polymers can provide effective solutions for structural rehabilitation, elimination of inflow and infiltration, and protection against future corrosion. There are many types of polymers being used in manhole rehabilitation including epoxies, polyurethanes and polyureas. These single or multi-component products can be applied by trowel, brush, spray or spin cast, curing within minutes or hours depending on the type and formulation.

- Epoxies used in manhole rehabilitation are generally formulated for moisture and surface tolerance to achieve the best bond as compared to properly prepared buried substrates. Epoxy liners are rigid, structurally enhancing formulations with excellent corrosion resistance. Flexible epoxy coatings are also used as non-structural chimney and joint sealants.
- Polyurethanes can be formulated with elastomeric properties to tolerate some movement within the structure, or rigid with structural enhancement capabilities. Although polyurethanes are less tolerant of moisture than epoxies, they typically set-up (become hard to the touch) within seconds or minutes.
- Polyureas are typically formulated to offer the most elongation and flexibility of the polymer systems. However, polyureas are highly sensitive to moisture requiring a dry substrate for adhesion.
- Hybrid Systems may be formulated from one or more of the above polymers to provide a variety of characteristics which can be evaluated for specific applications.

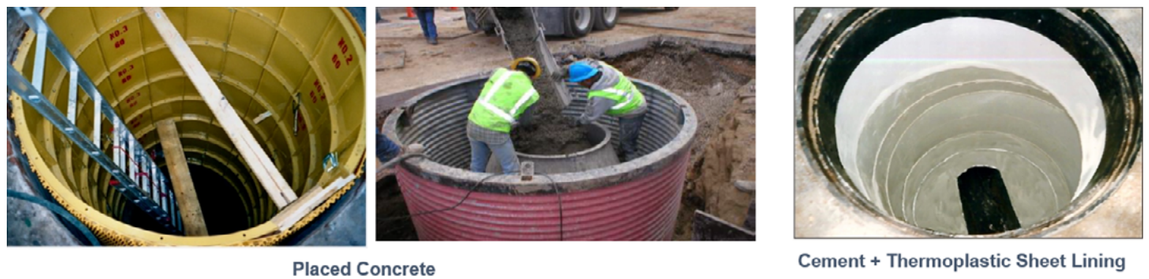


Figure 5 . Example Applications of Manhole Rehablitation using FIP Methods

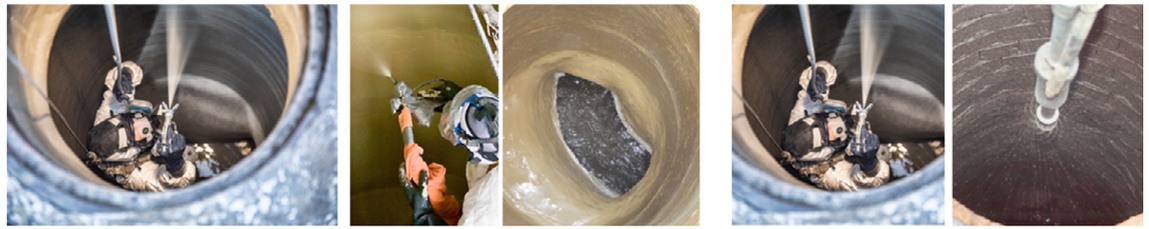


Figure 6 . Manhole Rehabilitation Using Polymer Coatings (Epoxies, Polyyureethanes, Polyureas)

See Figure 6 for examples. Polymer coatings should be applied at a thickness that will ensure proper wetting of the substrate to attain a good mechanical bond and adequate thickness to create a monolithic impermeable barrier against corrosive elements. A minimum of 80 mils (0.080 inch) is accepted as industry standard for application to relatively smooth surfaces. Specification at 125 mils (0.125 inch) is most common for rough surfaces such as patched or resurfaced concrete and brick manholes. Structural design may require greater thickness depending upon depth, shape, condition, traffic loading and groundwater pressure (see Chapter 7 for design guidelines). Because polymers are generally applied relatively thin (125 mils or less) and perform based upon the composite system formed by adhesion to the host structure, surface preparation is critical. Only 100% solids, solvent-free products should be considered due to safety and performance advantages. Polymer application requires specialized equipment and training.

Cured-in-Place Manhole

Cured-in-place manhole liners (CIPM) used for manhole rehabilitation generally consist of a polyester needle punched felt or fiberglass reinforced “bag” saturated with a thermoset resin. CIPM systems are most often used for structural rehabilitation where replacement is difficult or impossible. The manhole is pre-measured and each bag is custom made at the factory. Resin is impregnated into the bag at the job site and installed into the manhole. Steam pressure is used to expand and cure the CIPM. The invert and pipe inlets are cut open and sealed with trowel application of epoxy grouts before returning to service. Surface preparation is critical for adhesion of the liner to the existing manhole and should include filling recessed voids to eliminate potential problems including infiltration that may migrate along the annular space between the liner and the host manhole. A similar cured-in-place method has an expandable range that precludes prefabrication to a specific dimension. The object is to provide a tightly adhered liner that provides structural value and leak protection. Alternatively, fiberglass mat is hand applied in resin-saturated sections which overlap similar in concept to papier mâché. These processes require specialized equipment and training and are shown in Figure 7.

Composite Systems

The combination of coating and liner material results in a composite system which serves multiple purposes within the manhole structure. Most common is the use of a cementitious product for resurfacing or rebuilding deteriorated and structurally deficient manholes, and the application of a polymer coating for corrosion protection. The installation of a thermoplastic sheet liner embedded into a cementitious material or polymer mastic may be used to achieve structural renewal and corrosion protection as well. Another composite system includes an epoxy prime coat followed by a thick polyurea foam which then receives a thin polymer topcoat to complete the rehabilitation.

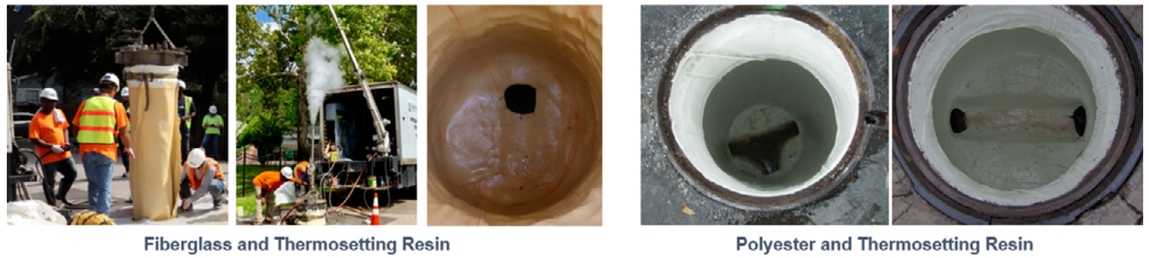


Figure 7 . Exmple Cured-in-Place (CIP) Technologies for Manhole Rehablitation

Before Relining System | After Cement Base is Applied | After Epoxy Topcoat is Applied

Figure 8 . Exmple Manhole Renewal Method using a Composite System (cement base + Epoxy)

5.SUMMARY

The decision making becomes easier once an understanding of the need is identified clearly. The advantages and limitations of the many rehabilitation options allow specifiers to custom design each project to meet both immediate and long-term needs. Table 5-2 provides an example decision matrix based upon a pre-designed condition rating for defects and available solutions for rehabilitating manholes.

Mark G. Wade, P.E. is the president of BlueWater Solutions Group, Inc.

TABLE 5-2. MANHOLE REHABILITATION DECISION MATRIX

DEFECT RATING/SCALE		
Low	**Moderate**	**Severe**
Leaks and spot defects in structurally sound manholes	Low classified defects + leaks in w/in structural defects	Moderate class defects + broad structural issues
Isolated Leaks	>15% of area leaking >5 gal/min during a rain event	Portions of wall missing
Inflow problems (a) around cover or (b) under frame	Some missing bricks	More than 1" of precast wall corroded
Misaligned or broken casting	Repairable small void pockets	Exposed rebar
No evidence of corrosion	More than 40 years old	Subjected to heavy traffic loading
Unsafe steps	Evidence of corrosion	MH in critical area w/sewer system w/major rehab a low risk
Minor damage to bench and/or leaking in channel	Unusable or missing bench	
Dry or low groundwater present	Leaking channel + high ground water present	
CORRECTIVE ACTION		
Stop leaks using hydraulic cement or chemical grouting	Stop leaks using hydraulic cement or chemical grouting	Remove and replace manhole structure
Install manhole dish or insert	Fill voids w/ high-strength cement in prep for new liner	Resurface with high-strength cement or polymer to prepare for liner installation
Install frame and chimney seal	Reinforce and seal w/ cementitious or polymer liner, composite system with corrosion protection, or CIP liner	Reinforce and seal with full-depth rehabilitation using cementitious or polymer liner, composite system with corrosion protection, or CIP liner
Repair bench or channel	Install corrosion-resistant barrier w/polymer or plastic liner combined w/non-resistant cementitious base liner	Install corrosion-resistant barrier w/polymer or plastic liner combined w/non-resistant cementitious base liner

THE EPIDEMIC MAKES THE SUSTAINABILITY OF SEWAGE PIPES MORE URGENT

Hongfang Lu *, Houming Ni

a China-Pakistan Belt and Road Joint Laboratory on Smart Disaster Prevention of Major Infrastructures, Southeast University, Nanjing 210096, China
b Asoe Hose Manufacturing Inc., Taizhou 225319, China
*Corresponding author: luhongfang_sci@126.com (H. Lu)

Abstract: Problems such as aging and leakage of sewers became more acute during the COVID-19 outbreak than before. In this paper, we first introduce the two most serious problems (leakage and blockage) of sewage pipeline during the epidemic, and their harm to environment and health. Secondly, we describe the countermeasures of relevant departments from two aspects (during and after the outbreak). During the outbreak, some of China's experience can be learned and acted upon from now on. Some inspection, monitoring, and repair technologies may set off a boom after the outbreak and promote the sustainability of sewage pipes. Finally, we put forward the development direction of the sewage pipeline in the future, and the related computer technology has great application potential. The purpose of this article is to call on relevant industries and departments to carry out the sustainable development of sewage pipes as soon as possible.

Keywords: COVID-19; sustainability; sewage pipe; inspection; repair

1. Introduction

Sewage pipe is an indispensable project in people's livelihood, and it is also a key component of modern cities and economic prosperity. Its function is to transport the polluted water of each household to the main pipeline and finally flow into the sewage treatment plant. Among the 17 sustainable development goals established by the United Nations, goals 6 (clean water and sanitation), 9 (industry, innovation and infrastructure), and 11 (sustainable cities and communities) are all related to the sustainable development of sewage pipes[1]. The status of sewage pipes in many countries is not optimistic, even the United States, one of the most developed countries in the world. According to the wastewater infrastructure condition for the United States in 2017 (see Fig.1(a)) evaluated by American Society of Civil Engineers (ASCE), although the data for some states are not available, it is not difficult to see that the condition of wastewater infrastructure in most states is C (mediocre, requires attention) or D (poor, at risk)[2]. In 2017, the overall rating of wastewater facilities in the United States is D+, looking back at the rating of C in 1988[3], it shows that the condition of the infrastructures has declined dramatically in about 30 years. Thus, ASCE also estimated the investment needed for each state's wastewater facilities over the next 20 years based on the condition and scale. Fig.1(b) reveals that the required investment is high in densely populated and economically developed areas, such as New York, California, and New Jersey.

The outbreak of COVID-19 in early 2020 has severely affected everyone in the world, and the current situation in the United States is still not optimistic. According to the COVID-19 statistics system of Johns Hopkins University, as of June 18, more than 2.17 million people have been infected in the United States. In this context, the wastewater pipes in the United States are facing new challenges. Therefore, although the sustainable development of sewage pipes has been put on the agenda in the past few years, COVID-19 may make this demand even more urgent. Globally, some existing and developing technologies are valuable in improving the sustainability of sewage pipes.

2. New challenges for sewage pipes during the epidemic

Leakage and blockage of sewage pipes are two common problems, and these two problems have brought new challenges to public health during the pandemic.

Leakage. The leakage of sewage pipes during the epidemic will threaten public health and increase the probability of residents becoming infected. Studies have shown that leaks in sewage pipes can prevent residents' sewer systems from stopping airborne diseases. Moreover, once the sewage pipeline leaks, it will also seriously affect groundwater, soil, and the surrounding environment, especially hospital sewage during the epidemic[4]. Similar conclusions have been drawn from the 2003 SARS outbreak. On the other hand, some research groups have confirmed that the number of infected people in the community can be estimated by detecting the amount of virus in the sewage[5]. It can be used as an early warning method for the virus to make a comeback. Apparently, the leakage of sewage pipes will affect the detection results and lead to misjudgment.

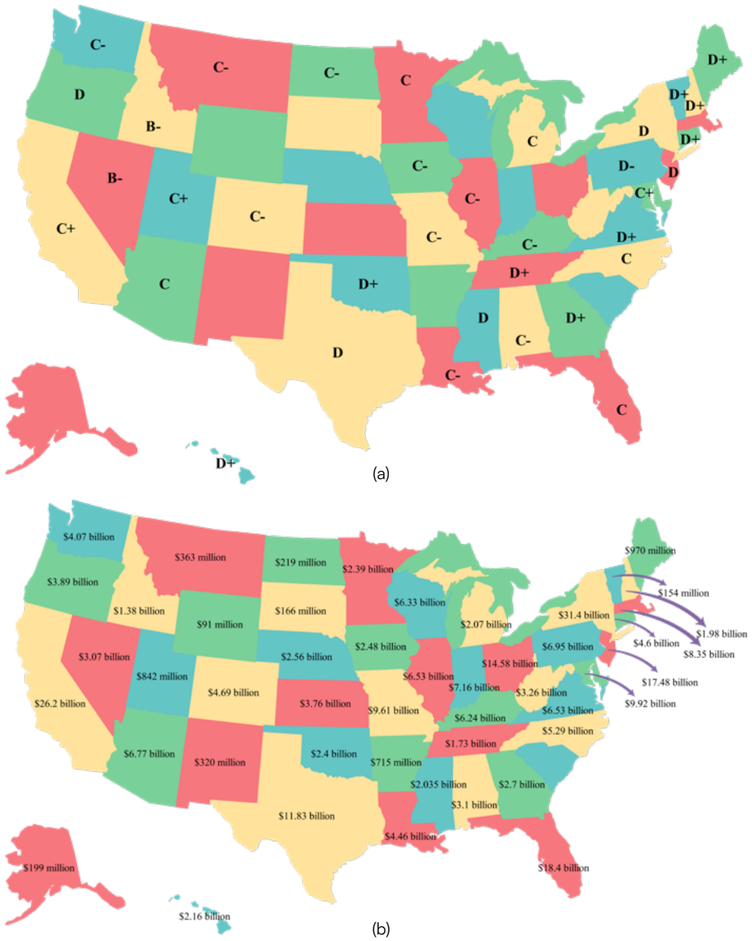


Fig. 1. Conditions and investments needed for wastewater infrastructure in the United States. **(a)** Wastewater infrastructure conditions for different states (data for ten states are not available). **(b)** Investment required for wastewater infrastructure in the next 20 years (data for South Carolina is not available). Source: ASCE Infrastructure Report Card.

Blockage. The blockage caused by the accumulation of residues in the sewage pipe often occurs. It will not only overflow the upstream sewage to pollute the soil and groundwater, but also corrode the pipe or cause leakage at the connections, and even lead to the backflow of sewage[6]. Especially during the epidemic period, if the sewage pipe is blocked, it will seriously pollute people's living environment and increase the risk of infection when there are few maintenance personnel available.

3. What to do now?

Due to the lockdown, the available staff is very limited. Therefore, it is challenging to start the sustainable development of sewage pipes now. However, there are still some feasible actions. China is the country with the earliest outbreak and the first country to respond[7]. Some experience has been proved to be effective and can provide some reference for other countries. Although these actions cannot fundamentally solve the problem of sewage pipe, they can reduce the impact of the hidden health problems caused by the sewage pipe defects to a certain extent.

Water quality monitoring. Strengthen the frequency and intensity of water quality monitoring, and accurately judge whether there is an infection in the area. Strictly ensure that the discharge of medical sewage and domestic sewage meets the standards.

Put disinfectant. Strengthen the use of disinfectants, ozone, and other agents, to control the spread of the virus.

Strengthen classified management. Act according to circumstances. Accurately classify medical sewage and non-medical sewage, or sewage in the infected area and sewage in the uninfected area, and then formulate different countermeasures.

Strengthen the protection of drinking water sources. Strengthen the protection and monitoring of drinking water sources, and strengthen sewage management in critical places such as farmers markets, supermarkets, and airports, investigate and deal with illegal sewage discharge in accordance with the law, and strictly prevent pollution accidents.

4. Sewage pipe inspection, monitoring, and repair in post-pandemic

COVID-19 reminded the entire wastewater industry to promote the sustainable development of the pipe as soon as possible. To meet this demand, some inspection, monitoring, and repair technologies can be more widely used.

Inspection. Sewage pipe inspection is to put the device into the pipe and collect data to determine whether there is defect, blockage, or damage. Some mature or emerging technologies have been successfully applied to sewage pipes[8]. For example, closed circuit television (CCTV), a visual technique, can clearly see the actual situation in the pipeline (see Fig.2(a)). Some sensor-based techniques with different shapes can move and collect data in the pipe, and later signal analysis can be used to determine defects that are difficult to identify with the naked eye (see Figs.2(b)-(c)). The detector based on sonar technology can also carry out online detection when the pipe is filled with liquid (see Fig.2(d)). By increasing the frequency and scope of inspections, managers can assess the condition of the pipe and decide whether replacement and maintenance are required.

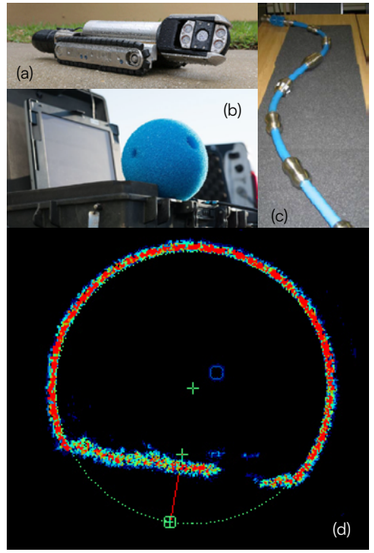


Fig.2. Some inspection methods suitable for sewage pipes. **(a)** CCTV. **(b)** SmartBall. **(c)** See Snake tool. **(d)** Sonar inspection tool.

Monitoring. The monitoring technology is mainly realized by sensors, which can monitor the leakage or rupture of the pipe in real-time[9]. When an abnormal signal is collected at the far end, it means that the pipeline is not operating normally. Monitoring technology can be used as an early warning or emergency alarm measures in management, which can avoid or reduce the failure probability of pipes.

Repair. When the sewage pipe is defective or has been damaged, it needs to be replaced or repaired[10]. In recent years, managers are more willing to adopt the repair scheme to save investment, especially in European and American countries. Trenchless technology is widely considered to be able to repair pipes more rapidly with low carbon in densely populated areas. Some techniques, such as curved in place pipe (CIPP), sliplining, and inserted hose method (see Fig.3), have been proved to significantly improve the corrosion resistance of the pipe and increase the service life of the pipeline for up to 50 years.

5. Outlook for interdisciplinary applications

With the rapid development of digital technologies such as artificial intelligence, big data, and virtual reality in recent years, traditional fields will also benefit from them. In the sustainable development of sewage pipeline, some scholars have applied big data and deep learning for intelligent pipe inspection[11] and pipe remaining life prediction[12]. Moreover, a technique named "digital twin"[13] in the "Industry 4.0" system may be able to monitor more intelligently in the future. It can not only capture data to realize the sewage pipe monitoring, but also predict and analyze the pipe status. Although these applications are still in their infancy or just an idea, there is no doubt that some interdisciplinary applications will be more widely used soon.

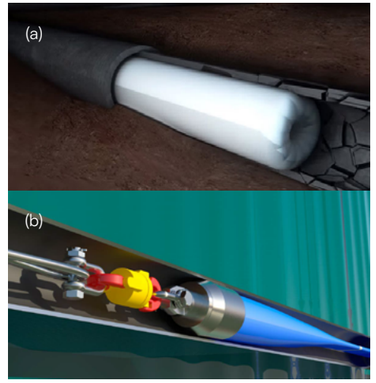


Fig.3. Some trenchless repair methods suitable for sewage pipes. **(a)** CIPP. **(b)** Inserted hose method.

References

1. Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., ... & Noble, I. (2013). Sustainable development goals for people and planet. Nature, 495(7441), 305-307.
2. ASCE. (2017). 2017 infrastructure report card. Reston, VA: ASCE.
3. ASCE. (1988). 1988 infrastructure report card. Reston, VA: ASCE.
4. Xu, Z., Xu, J., Yin, H., Jin, W., Li, H., & He, Z. (2019). Urban river pollution control in developing countries. Nature Sustainability, 2(3), 158-160.
5. Mallapaty, S. (2020). How sewage could reveal true scale of coronavirus outbreak. Nature, 580(7802), 176-177.
6. DeSilva, D., Marlow, D., Beale, D., & Marney, D. (2011). Sewer blockage management: Australian perspective. Journal of Pipeline Systems Engineering and Practice, 2(4), 139-145.
7. The Central People's Government of the People's Republic of China. http://www.gov.cn/zhengce/zhengceku/2020-02/02/content_5473898.htm
8. Datta, S., & Sarkar, S. (2016). A review on different pipeline fault detection methods. Journal of Loss Prevention in the Process Industries, 41, 97-106.
9. Liu, Z., Kleiner, Y., Rajani, B., Wang, L., & Condit, W. (2012). Condition assessment technologies for water transmission and distribution systems. United States Environmental Protection Agency (EPA), 108.
10. Pacheco-Torgal, F., Abdollahnejad, Z., Miraldo, S., Baklouti, S., & Ding, Y. (2012). An overview on the potential of geopolymers for concrete infrastructure rehabilitation. Construction and Building Materials, 36, 1053-1058.
11. Cheng, J. C., & Wang, M. (2018). Automated detection of sewer pipe defects in closed-circuit television images using deep learning techniques. Automation in Construction, 95, 155-171.
12. Zhou, J., Sun, J., Wang, Y., & Chen, F. (2017). Wrapping practical problems into a machine learning framework: using water pipe failure prediction as a case study. International Journal of Intelligent Systems Technologies and Applications, 16(3), 191-207.
13. Tao, F., Cheng, J., Qi, Q., Zhang, M., Zhang, H., & Sui, F. (2018). Digital twin-driven product design, manufacturing and service with big data. The International Journal of Advanced Manufacturing Technology, 94(9-12), 3563-3576.

ENABLING TECHNOLOGICAL ADVANCEMENTS IN ARLINGTON'S INFRASTRUCTURE REHABILITATION

By Mark Grabowski

A distinguished hub for both community and tourism, Arlington, located a mere five miles from the nation's capital, stands as the smallest self-governing county in the United States, encompassing an area of nearly 26 square miles. Boasting a remarkable array of crucial American governmental, educational, and technological infrastructures, Arlington serves as home to prominent landmarks like the Pentagon, Reagan National Airport, Arlington Cemetery, and esteemed academic institutions such as Marymount University, as well as satellite campuses of Virginia Tech and the University of Virginia. Furthermore, it proudly hosts industrial giants Boeing and Raytheon, along with Amazon's upcoming secondary headquarters.

As a leading proponent of the "Smart Growth" movement, Arlington has embraced sustainable practices and transit-oriented development, catering to its population of 233,000 residents. Ensuring the longevity of its aging sanitary sewer infrastructure without causing significant disruptions remains a paramount objective for the County. Employing advanced trenchless technologies like cured-in-place rehabilitation (CIPP) instead of traditional dig-and-replace methods, Arlington effectively curtails traffic congestion, safeguards historical landscapes, and maintains exceptional walkability, all in alignment with the goals of "Smart Growth" cities.

Handling the vast network of sewer assets, extending over 465 miles of pipeline, and carrying out annual relining of approximately 14-17 miles, necessitates a well-orchestrated approach. The County's dedicated workforce invests substantial hours in exhaustive investigations and generates vast terabytes of Closed-Circuit Television (CCTV) condition assessments well before the CIPP boiler trucks arrive. To accomplish their weekly lining target of 2,000 feet, a benchmark that exceeds many other agencies' annual rehabilitation efforts, Arlington relies on an efficient software trio comprising Esri, Cartegraph, and ITpipes.

For an ongoing project of this magnitude to succeed, flawless coordination of numerous moving parts is essential. With a full-time in-house CIPP contractor, AM-Liner, dedicated solely to the County, and an additional two full-time in-house CCTV inspection crews, alongside an external CCTV contractor, maximizing productivity stands as a critical imperative. The prudent allocation of the annual $3M budget necessitates careful deliberation in the selection of asset management, pipe inspection, and rehabilitation methods. A seamless integration of software is pivotal to this process.

In 2018, Arlington employed Esri ArcGIS and Cartegraph Asset Management System. Seeking pipe inspection software that would seamlessly integrate with their existing infrastructure, the County discovered ITpipes. Built on Esri's latest technologies and featuring Esri's Web Maps, ITpipes seamlessly integrates with Cartegraph through automated bi-directional data synchronization. Any data input into ITpipes automatically transfers to Cartegraph and vice versa, streamlining Arlington's workflow to remarkable efficiency.

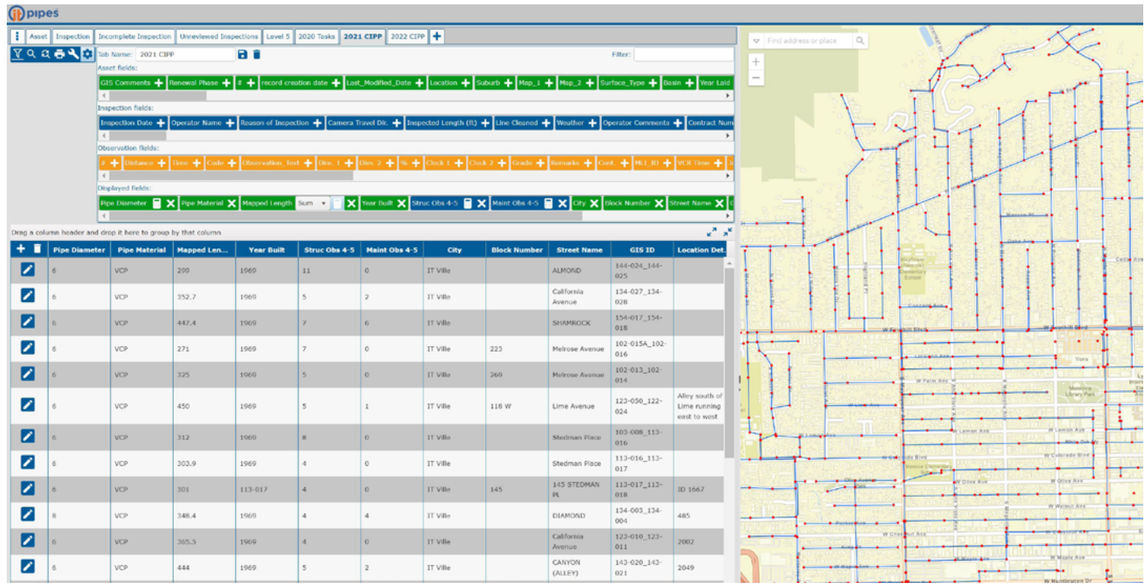
Here's a glimpse into a typical workflow session: Jeremy Hassan, PE, Chief Operating Engineer of Sewers & Streets, utilizes the Esri ArcGIS map within Cartegraph to select an area in the County and initiate work orders for the assets within that designated area. These work orders are instantly transmitted to the CCTV inspection vehicle's ITpipes Mobile software. Operators are then provided with a comprehensive view of the assigned pipes, along with their locations on the map, with relevant asset information already populated from GIS and Cartegraph. Following completion, the inspection data is uploaded from the vehicle via hotspot, accessible to all relevant stakeholders on ITpipes Web, and the Cartegraph work order is marked as complete. The ITpipes Web's SmartTabs further facilitate efficient filtering and selection of pipe inspections that meet Arlington's specific criteria, creating a separate list for review.

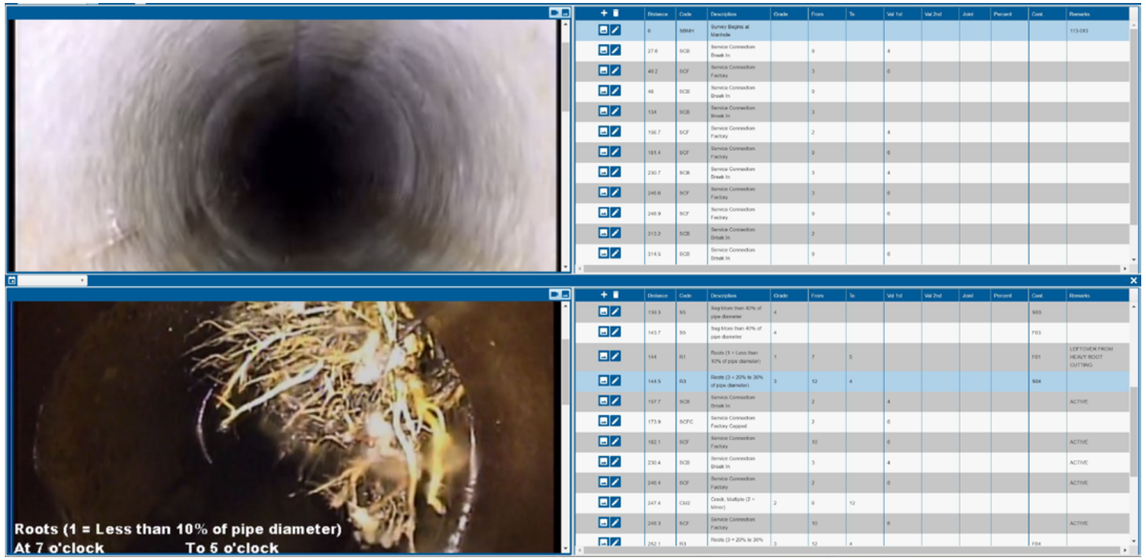
Jeremy Hassan, PE, notes, "We are deeply committed to maintaining our buried assets in Arlington. The new workflow has almost eradicated duplication in inspection efforts and enables us to track pipes requiring follow-up, keeping work orders open until completion. Our previous system lacked cohesion, leading to data collection with no tangible output. Now, once data is collected, it is readily available to all appropriate County personnel, transitioning us from being reactive to becoming predictive."

Efforts to address identified issues are spearheaded by Jon Lawler, Hisham Wahdan, and Carla Alayon, the dedicated team overseeing ongoing sanitary sewer rehabilitation projects within Arlington.

Hisham Wahdan, Construction Manager at Arlington County, shares their approach, stating, "We assess the filtered pipe assets in the ITpipes Web's SmartTab and initiate the decision-making process for rehabilitation. Our evaluations consider not only observed defects from the pipe inspections but also factors like age, location, size, and notes from Cartegraph work orders provided by the jetting crews. Based on this information, we determine whether full-length lining or point repair is the appropriate course of action, updating the corresponding SmartTab accordingly."

Apart from annually rehabilitating 75,000-90,000 feet of 8" - 15" pipes, Arlington embarks on at least one large-diameter lining project each year. In the current year, this undertaking involves a 54" sewer main leading to Arlington National Cemetery, with the section downstream within the Cemetery already having undergone





relining.

Carla Alayon, Maintenance Contracts Supervisor, comments on the rehabilitation approach, stating, “For our sanitary sewer, we primarily employ steam-cured felt CIPP, as it has proven highly effective for us. Our contractor, AM-Liner, consistently delivers exceptional results. However, for stormwater applications, the County is actively exploring UV-cured fiberglass liners, offering diversified rehabilitation options.”

Taking a holistic approach to infrastructure rehabilitation, Arlington addresses manholes as well through a combination of curtain grouting and cementitious and epoxy lining, ensuring comprehensive maintenance.

Jon Lawler, Chief Support Engineer, adds, “Despite our growing population, our plant’s flows are decreasing. While various factors contribute to this trend, our aggressive yet strategic trenchless rehabilitation program significantly contributes to the decline.”

Jeremy Hassan highlights the positive impact on planning and budgeting, stating, “Efficiency in our operations allows us to plan and budget strategically. Data collected in ITpipes and cost estimates from Cartegraph empower us to project financial needs for multiple years. This effective budgeting ensures that rehabilitation remains on schedule and delivers favorable outcomes for our ratepayers.”

Mark Grabowski is the Business Development Manager at ITpipes.

CONSIDERATIONS FOR DESIGNING THE OUTER DIAMETER OF FFRP LINERS IN PIPE REHABILITATION

By Aaron Homing Ni

1. Introduction:

In the field of pipe rehabilitation, Flexible Fabric Reinforced Pipe (FFRP) liners have emerged as a popular solution for restoring the structural integrity and hydraulic performance of aging pipelines. However, determining the appropriate outer diameter (OD) of the FFRP liner is a critical consideration that requires careful attention. This article delves into the significant of selecting the appropriate OD for FFRP liners and the implications it has on pipe rehabilitation projects.

2. Standardization Challenges:

Several standards, including ISO11298-1 and ISO11298-11, have been established with the objective of standardizing the utilization of Lining with inserted hose techniques. However, these standards exhibit a significant gap when it comes to providing explicit guidance to pipeline owners on designing the OD of FFRP liners. This lack of clarity presents challenges for the industry currently facing, as it strives to undertake pipe rehabilitation projects with the highest level of precision and accuracy.

To address the lack of OD design guidelines, companies like ASOE Hose Manufacturing Inc. have stepped up to offer customized solutions. ASOE demonstrates its ability to design and manufacture FFRP liners with different ODs to meet the diverse needs of different pipe sizes to be rehabilitated so as to enhance flexibility in their selection. For instance, when rehabilitating a DN500 water pipes, ASOE offers a variety of OD options, such as 454mm, 470mm, 475mm, 480mm, 485mm, and 490mm, to owners who are looking to rehabilitate DN500 water pipes.

3. The Importance of Close Fit:

The primary objective when selecting an FFRP liner OD is to ensure a close fit between the liner and the host pipe under operating pressure. Achieving a snug fit is crucial as it eliminates the presence of an annual space or gap between the liner and the host pipe to prevent long term effect to the liner, Eg:

- The accumulation of corrosion within the pipe, root growth and subsequent leaks can result in soil infiltration, potentially leading to a reduction in the cross-section of the pipe and compromising its long-bearing capacity.
- Deformations of the host pipe diameter
- Crack formation
- Groundwater contain impurities, contaminants and microorganisms. These impurities can include chemicals, heavy metals, bacteria, viruses and other pathogens. When groundwater infiltrates pipes, it can introduce these impurities into the system.

Firstly, if smaller OD liners, such as 450mm, 454mm, or 460mm, are installed, an annual space is created. This gap becomes an entry point for water, earth, and sand to infiltrate the host pipe through leaking holes. In cases where the water supply is temporarily terminated, vacuum pressure can develop within the pipeline. If the vacuum pressure reaches a significant level, the FFRP liner may collapse temporarily, leading to further sand and earth ingress. Subsequent resumption of water supply causes the water within the annual space to be squeezed out, but the sand and earth remain, accumulating

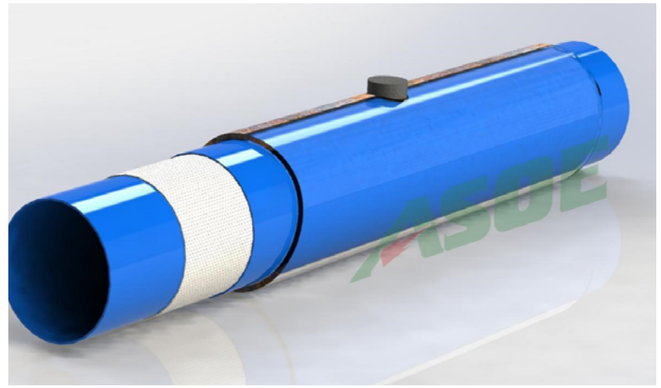


FIGURE 1. CLOESED FIT LINER

over time. Although the liner is expected to be subject to the groundwater pressure practically in all design cases, other loads may be transferred on the liner in some way during the service life of the liner if the host pipe deteriorates further or the surrounding soil weakens.

These accumulations can gradually press against the liner, potentially choking its functionality and necessi-

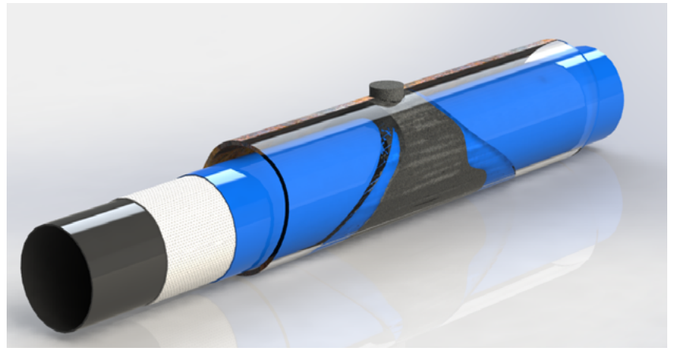


FIGURE 2. NON-CLOSED-FIT LINER

tating pipe rehabilitation once again. Furthermore, a close fit between the FFRP liner and the host pipe minimizes the reduction in the liner's inner diameter, ensuring maximum water flow and hydraulic efficiency.

4. Requirements for OD Selection:

Based on the aforementioned considerations, two key requirements emerge for selecting the OD of FFRP liners in pipe rehabilitation projects.

Requirement One: Close Fit under Operating Pressure

Owners must choose FFRP liners that can closely fit the inner wall of the host pipe when subjected to operating pressure. If owners install FFRP liners with ODs of 450mm, 454mm, or 460mm, it will result in the formation of an annual space. This space provides an entry point for water, earth, and sand to infiltrate the host pipes through leaking holes and fill the gap. In the event of temporary water supply termination, vacuum pressure may occur within the pipeline. When the vacuum pressure reaches a certain level, the FFRP liner could temporarily collapse, allowing more sand and earth to enter the annual space.

Upon resumption of water supply, the water within the annual space can be expelled, but the sand and earth will remain trapped. If water supply disruptions occur repeatedly, the accumulation of sand and earth will progressively increase, exerting infinite pressure on the liner (as shown in the provided image). This accumulation can cause the FFRP liner to become choked, necessitating pipe rehabilitation. Additionally, when the FFRP liner closely fits the inner wall of the host pipes, it minimizes the reduction in the liner's inner diameter (ID), ensuring maximum water flow. This close fit is crucial for maintaining optimal hydraulic performance. The range of OD options provided by companies like ASOE allows owner to make an informed decision that caters to the specific requirements of their pipe rehabilitation projects

Requirement Two: Avoiding OD Exceeding ID

It is essential to ensure that the OD of the FFRP liner does not exceed the ID of the host pipe. If the OD is larger than the ID, the liner will not be able to fully expand within the pipe, leading to a decrease in water flow capacity. This limitation emphasizes the significance of meticulous OD selection to preserve the hydraulic performance of the rehabilitated pipeline.

Requirement Three: Grouting or patch rehabilitation is necessary to close the leaking holes/cracks if annular space between host pipe and liner exist

Without closed-fit, all leaking holes/cracks should be closed by grouting or other patch rehabilitation techniques. Closing leaking holes/cracks is to stop soil infiltration. In fact, in many scenarios it is impossible to close the leaking holes or cracks of the host pipes undr ground or rivers. For example, if water pipes under river contains leaking holes, it is difficult or impossible to stop water and mud infiltration by grouting or patch rehabilitation techniques.

Closed-fit lining is preferred due to its superior structural integrity, leak prevention, improved flow capacity, reduce contamination risk and long term performance benefits.

5. Conclusion:

Determining the suitable OD for FFRP liners in pipe rehabilitation is a crucial factor that profoundly impacts the project's success and durability. Although existing standards may not provide clear directives on this matter, companies like ASOE Hose Manufacturing Inc. specialize in customized solutions to cater to owners' precise needs. By placing emphasis on achieving a tight fit between the liner and the host pipe, it can effectively mitigate the risks associated with the formation of an annual space and ensure the optimal hydraulic performance of the rehabilitated pipeline.

Aaron Homing Ni is the president of Sales at Asoe Hose Manufacturing Inc.

INDIANA INNOVATION DISTRICT FLOURISHES 10 YEARS AFTER BAMI-I TARGETS AREA FOR LIVING LAB PROJECT

By Erik Hromadka

A new innovation district in Indianapolis, Indiana is flourishing with a variety of innovative companies and activities that have developed just northwest of the city's downtown business district in the 10 years since BAMI-I and Global Water Technologies (OTC: GWTR) envisioned a living lab for the location.

In 2013, the organizations outlined a "Smart Water for Indiana" plan that focused on neighborhoods near the combined Indiana University and Purdue University campus in the state's capital city that is home to more than 850,000 people. Anchored by the city's water company headquarters, the area contained a wide range of key infrastructure assets, including a large pumping station, underground water wells, surface water collection from a river and a canal system and a water treatment plant that served the downtown area.

The Riverside Watershed Environmental Living Lab for Sustainability (RWELLS) began with a BAMI-I initiative to map water resources in the area, apply asset management principles and introduce new technologies that improve water efficiency. Working with students from the Purdue School of Engineering and Technology, the effort reviewed a history of water main breaks in the area and analyzed impacts of water scarcity that led to city restrictions in 2012 when drought conditions caused a new record daily consumption of 233 million gallons per day.

BAMI-I and Global Water Technologies presented water utility officials with an innovative multi-parameter sensor that could be used to establish district metered areas and discover hidden leaks in underground water pipes. They also introduced a People + Pipes + Policy approach that recognized adoption of new water technologies must include a combination of customer demand from the people served; infrastructure engineering solutions for the aging pipes; and public policy tools to encourage and enforce best practices.

These lessons were early indications of the impact that water infrastructure problems could cause — something that got national attention a few years later with the problems in Flint, Michigan. The approach initiated in Indianapolis was shared with city leaders who gathered in Flint during a 2015 infrastructure conference that discussed new standards for asset management and lead service line replacement.

In 2016, Global Water Technologies and BAMI-I hosted the first international technology demonstration in the area that featured a new UV-C LED system for disinfecting water and a unique water pipeline cleaning and rehabilitation process developed in Canada. The demonstration was hosted in the new 16 Tech district that was being created to repurpose the old water company headquarters after the utility moved into a new complex. The event was attended by a combination of city and state leaders, US Environmental Protection Agency officials, local business leader, students and even a delegation from China that was brought to the event by Dr. Tom Iseley.

The following year, Global Water Technologies organized a smart city initiative promoting the area with support from the City of Indianapolis and Indiana University Purdue University at Indianapolis (IUPUI). Focusing on water + energy + transportation, the efforts were recognized by the Smart Cities Council readiness grant competition as one of the top five winners from more than 100 cities that applied from across the United States. That resulted in a workshop on smart infrastructure solutions and consideration and testing of wireless technologies like LoRa networks and advanced metering infrastructure.

At the same time, the 16 Tech District kicked off a comprehensive construction project that repurposed the old water company headquarters into a multi-faceted complex that today houses a makerspace for testing designs and building protoypes, a large co-working facility for entrepreneurial companies and a remarkable food and event space in the building that was formerly the water utility's garage. A new office building constructed across the street houses the Indiana Bioscience Research Institute, a collection of statewide industry organizations and medical school facilities. Future plans include a variety of new housing and office spaces and even a hotel on the site.

While some efforts were slowed by the pandemic that resulted in a virtual grand opening and ribbon-cutting in 2021, today there are a growing number of exciting new projects taking shape in the district. From the Indy Autonomous Challenge that brought university teams from around the world to build and race driverless cars at the famed Indianapolis Motor Speedway to a start-up drone company targeting new methods to improve agriculture and a new project by Global Water Technologies to combine UV-C LED disinfection with capacitive deionization, the initial "living lab" concept envisioned a decade ago is alive and well.

Erik Hromadka is the CEO of Global Water Technologie.

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