Civil infrastructure systems support social and economic development by providing essential services that enhance the quality of life. However, sustaining the performance of these systems is challenging due to a number of factors: resource constraints, political bureaucracy, population growth and urbanization, aging infrastructure, and ecological degradation, to name a few.

Civil infrastructure systems built 50 or more years ago are nearing the end of their economic and functional service lives and will require extensive capital funding, as well as innovative condition assessment and rehabilitation techniques, to be fully restored. This challenge will be compounded if it is tackled individually by the multitude of utilities in the United States.

Water is a lifeline sector because its functions are essential to the core operations of other critical sectors, such as food and agriculture, healthcare and public health, and manufacturing. But the reality is that some of the water systems in the U.S. were constructed more than a century ago, with a surge of infrastructure investment following World War II. Aging and degraded assets are to blame for an estimated 240,000 water pipe breaks each year in the U.S., a number that is likely to increase over the next 30 years if aggressive programs are not in place. Inadequate wastewater system capacity results in as many as 75,000 sanitary sewer overflows each year; the discharge of 3–10 billion gallons of untreated wastewater into rivers, lakes and other water bodies; and some 5,500 illnesses.

In 2001, the American Water Works Association (AWWA) announced the “dawn of the replacement era” and called for steadily increasing investments to replace worn-out water pipes and other assets. However, water infrastructure investment is not keeping pace with the escalating need, creating an investment gap that is expected to reach $84.4 billion by 2020 and increase over the coming decades. Even as recently as 2016, AWWA’s “State of the Water Industry Report” listed the renewal and replacement of aging water and sewer infrastructure as a top concern for the more than 800 utility respondents.

So, what can be done to improve our chances of surviving this impending infrastructure crisis? This paper demonstrates how implementing an integrated asset management program and collaborating with industry-leading resources can help utilities, and the cities and communities they serve, improve water resiliency, efficiency and quality for a sustainable water future.

THE EVOLUTION OF ASSET MANAGEMENT

Recent floods, droughts, fires, tsunamis, earthquakes and catastrophic infrastructure failures remind us that natural, technological and human-caused hazards take a high toll on cities and communities—their people, their natural and built assets, and their economic strength. How a country operates, retrofits and expands its water infrastructure systems will help determine its competitiveness in the global economy and define its quality of life for future generations. If the U.S. is to meet important challenges of the 21st century, policy makers, agencies, utilities, academia, private industry, consultants and technology providers must come together to confront the problems of water infrastructure and deconstruct the cost and technological barriers hindering the renewal of existing water infrastructure systems and the expansion of new water infrastructure.
Enter asset management.

In its essence, asset management is about streamlining processes, improving business performance, and creating a line of sight between a company’s strategy and the activities carried out across the organization. For asset management programs to successfully address the challenges posed by aging water buried infrastructure, they must present a strong business case that quantifies expected benefits, such as savings, risk reductions and efficiency gains.

Programs that already exist, such as those launched by the City of Columbus Department of Public Utilities (OH) and the Washington Sanitary Sewer Commission (MD), focus on taking advantage of opportunities that evolve the utility to the next level and increase returned value. However, a 2015 survey of asset management practices conducted by AWWA indicates that the majority of utilities still struggle with implementing asset management programs due to a lack of organizational understanding and available resources, and an inability to demonstrate the cost benefits to stakeholders to gain investment. This suggests that building a strong business case for an asset management program is more nuanced and challenging than previously believed, and that those directly responsible for managing water systems and their infrastructure may need help rethinking their approach to asset management. So what’s the answer?

The answer is twofold.

Whether utilities have a mature asset management program or are just getting started, the solution to creating a sustainable water future should consider:

1. Reframing how you approach asset management.
2. Engaging resources that can help.

REFRAMING HOW YOU APPROACH ASSET MANAGEMENT

Well-managed assets can realize huge value, but using outdated approaches can result in underperformance and loss. Effective asset management is crucial to ensuring long-term performance and unlocking value. Both public and private organizations will have to effectively plan and optimize their assets to remain competitive, and the magnitude of the prize for those who succeed is vast.

Understandably, this means the role of asset management is changing. We are in the midst of an asset management revolution that is fundamentally expanding in scope. No longer solely a technical discipline, primarily driven by the need to better forecast capital investment, today’s business-driven mindset considers the entire asset life cycle, inherently transforming the way organizations, including utilities, operate. This transformation is further fueled by the need to meet future demands with limited resources. Regardless of how optimal existing practices might be, stand-alone budgeting exercises or isolated maintenance procedures are not enough. Utilities must break their functional silos and optimize asset performance throughout the asset life cycle.

Like all major organizational changes, asset management programs take time, and benefits are not realized overnight. It is recommended that utilities identify the elements of the program that can jumpstart the desired changes while recognizing that the data required to fully realize the benefits may not be available right away. The Recommendation Snapshot that follows highlights six critical elements of a successful asset management program as well as their application to utilities.

“Ineffective management of water assets can lead to public safety risks, high repair and emergency costs, poor customer service, and negative impacts to quality of life.”
- Celine Hyer, Conveyance Lead, Arcadis North America
## Six critical elements of a successful asset management program.

### RECOMMENDATION SNAPSHOT

<table>
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<tr>
<th>Recommendations for a successful asset management program</th>
<th>Greatest challenge utilities face when embarking on this recommendation</th>
<th>Tips for overcoming this challenge</th>
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<td>Truly understand and communicate the goals of the asset management program, ensure strong leadership and engage stakeholders to win support.</td>
<td>Establishing concise goals that are tied to your overall strategic objectives and will resonate with your internal and external stakeholders.</td>
<td>Network with utilities that have comprehensive, long-term asset management programs to gain perspective and lessons learned that can increase your chances of implementing a program that is successful and delivers sustainable outcomes.</td>
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<td>Recognize the organizational implications of an asset management program to ensure long-term success.</td>
<td>Identifying the necessary roles and responsibilities that touch all levels of asset management within your utility, (i.e., IT, engineering, operations and maintenance, and finance) and understanding that it may require implementing a change in management strategy.</td>
<td>Perform an organizational assessment specific to asset management implementation to gain a thorough understanding of your workforce and their roles, responsibilities, capabilities and expertise. Map where each person brings value to the program and where there may be talent gaps that inhibit long-term program success. Network with other utilities regarding their asset management staffing and change management strategies to learn how they set up their programs for success and why they did so, and what’s working and what’s not, to help accelerate the implementation of your program.</td>
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<td>Implement a framework that integrates all asset-related functions, activities and financials to achieve true ownership across all levels of the organization.</td>
<td>Deciding how to begin and which framework to adopt and roll out to the organization.</td>
<td>Adopt industry standards and utilize proven gap analysis tools (e.g., ISO 55000 or the Water Environment &amp; Reuse Foundation’s Strategic Asset Management Research Area) to define the elements of your framework and learn where you stand today. Stay up to date on the most innovative, research-based asset management trends, strategies and applications by participating in training and continuing education opportunities that will give you the perspective, knowledge and tools to implement and manage your program with clarity and confidence.</td>
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<td>Strike the right balance between financial performance, risk management and operational performance.</td>
<td>Defining effective service levels and key performance measures to target capital and maintenance decisions.</td>
<td>Leverage existing performance measures, such as those published in the AWWA’s “Benchmarking Performance Indicators for Water and Wastewater Utilities: 2013 Survey Data and Analyses Report”, to develop measurements that deliver financial returns, manage risk and enhance operational performance.</td>
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<tr>
<td>Leverage IT to enable organizational change, optimize business processes and support informed decision making.</td>
<td>Determining where to start, what products to use and how to effectively tie existing systems together.</td>
<td>Conduct a review of your existing systems relative to asset management best practices.</td>
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To learn more about the future of asset management and how you can unlock the full value of your assets, visit [http://arcad.is/AssetMgmt-na](http://arcad.is/AssetMgmt-na) and download your copy of the paper “On the road to an asset management revolution.”
ENGAGING RESOURCES THAT CAN HELP

To address the aging water and wastewater buried infrastructure challenge, utilities, agencies, academia, consultants and technology providers must come together and share their knowledge, experience and ongoing research from within and outside the U.S. Doing so will provide utilities with information they need to build an asset management program rooted in research, innovation and practicality, and with access to a network of professionals who can relate and help.

Enter the Virginia Tech Sustainable Water Infrastructure Management (SWIM) Center.

The primary purpose of the SWIM Center is to serve as a focal point for multi-investigator, interdisciplinary initiatives related to sustainable water infrastructure systems. The SWIM Center interacts with national laboratories, industry professionals and utilities to provide a centralized outreach resource on topics related to distribution and collection systems.

The SWIM Center’s core activities include the following:

- Creating and sharing water infrastructure data, analytical tools and techniques, best practices, case studies and synthesis reports
- Fostering multidisciplinary collaboration among water experts to advance and shape the water infrastructure industry
- Advancing science and technology through leading-edge innovative research and interdisciplinary education
- Articulating priorities for global water infrastructure systems and promoting interactions among diverse water utilities
- Developing and delivering the most comprehensive source of water infrastructure asset management information and innovative research available through the WATERID and PIPEiD national databases, conferences, workshops, training courses, publications and reports and SWIMeD online certification programs
- Pioneering outreach programs that are renowned for addressing local, state, national and international water infrastructure asset management challenges

Knowledge centers, such as the SWIM Center, have been proven to advance the state of asset management in other countries. For example, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia has been involved in buried infrastructure research, studies and publications for more than 20 years and has prompted new techniques for the condition assessment of pipelines and supporting data for replacement planning. The work of the CSIRO has greatly contributed to making Australia a leader in asset management, helping the country thrive through difficult challenges such as drought. The National Research Council Canada is another example of an established knowledge center that had similar impact for more than 15 years, supporting the development of condition assessment technologies that are currently applied to asset management programs in the U.S.
Implementing asset management programs is nuanced and challenging, but, when done right, can result in an evolved and inspired program that can produce sustainable outcomes that improve quality of life in utilities and the cities and communities they serve. Joining the SWIM Center is a simple and easy step utilities can take immediately to help ensure the long-term success of our country’s water systems.

**SWIM Center Case Study: City of San Diego**

In partnership with Arcadis, the City of San Diego was able to develop a cost-effective and prioritized replacement program to replace aging asbestos cement water lines. This case study has been published by the SWIM Center.

The City of San Diego currently maintains approximately 2,100 miles of asbestos cement (AC) pipe as part of a water distribution system that is aging and beginning to cause service disruptions to its customers. Limited data on the actual condition of the pipe exist today, and the cost to perform condition assessment on the entire length of pipe is too expensive to consider. Therefore, to be proactive and maintain its excellent level of service, the city decided to create a master plan for pipe replacement.

To develop the master plan for replacement of the AC pipe, Arcadis created a unique approach that applied asset management best practices and state-of-the-art desktop and field condition assessment tools to generate a risk-based prioritized plan within GIS. A risk score was calculated for each pipe by identifying the consequence and likelihood of failure. The consequence of failure was based on evaluating “triple bottom line” impacts, including financial, social and environmental criteria. This analysis was completed within GIS using pipe attributes, adjacency factors and hydraulic modeling information. The likelihood of failure was calculated by analyzing 10 years of existing break data through descriptive statistics and applying the Linear Extended Yule Process (LEYP) model for failure forecasting. This desktop model predicted a likelihood of failure score for each pipe based on its age, past break history and risk factors such as soils, pressures and traffic densities. Where no break data existed for certain groups of pipe, non-invasive acoustic leak detection and wall integrity testing was performed in the field to provide the remaining wall thickness percentage over an average of 300 feet. Based on the percentages, likelihood of failure scores were assigned to each pipe. Additional acoustic field testing was conducted to validate the highest-priority projects selected for replacement.

**Lessons learned and benefits:**

- By using a combination of modeling and field condition assessment, the city only needed to assess 6 percent of pipes to determine the expected condition of each pipe, which saved the city more than $15 million.
- The failure of AC pipe is driven not only by age but also by other factors, including soils, installation, pressures, the type of AC material and manufacturer.
- The failure forecasting model and GIS tools were easily transferred to the city so that it can continue to update the program as future data on failures and condition become available.
- This initial risk-based plan provides a sound basis for obtaining the funding and approval necessary for the AC replacement program to move forward.
- Addressing the AC pipes based on risk enables the city to maintain its excellent service levels with the least amount of capital cost. Original funding needs were reduced by $40 million each year through this process.

**NEXT STEPS**

To learn more about how Arcadis and the Virginia Tech SWIM Center are partnering to help utilities better understand, manage and maintain their buried assets, contact Celine Hyer or Dr. Sunil Sinha.

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