envisioning the

DIGITAL UTILITY OF THE FUTURE

JULY 2017

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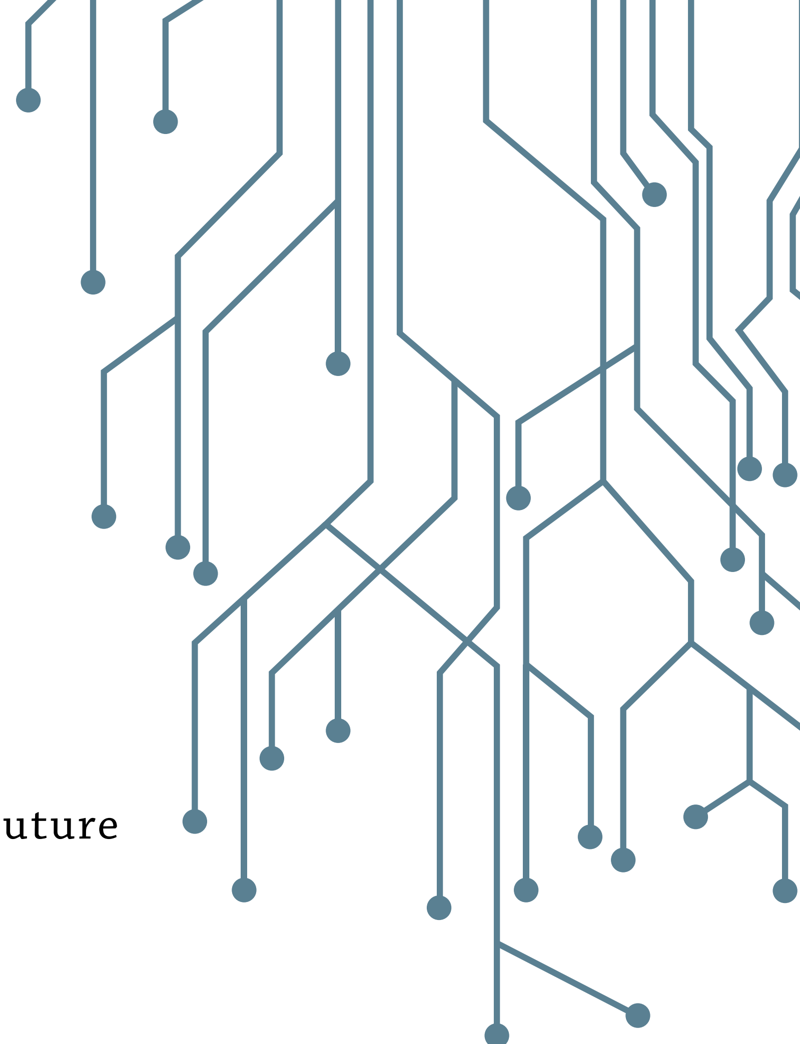

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Introduction

Innovation in the municipal clean water utility sector has been expanding rapidly over the past several years. Not long ago, clean water utilities were content to do their job out of sight and out of mind using traditional operational techniques. But now they seek to be more active participants in ensuring the economic and environmental sustainability of their communities by pursing new business models, advancing creative ideas to challenging problems, and producing valuable products.

This spirit of innovation is what inspired the National Association of Clean Water Agencies (NACWA), the Water Environment Federation (WEF) and the Water Environment & Reuse Foundation (WE&RF) to develop the Water Resources Utility of the Future (UOTF) Blueprint in 2012. At its heart, the UOTF movement is about utilities going beyond just complying with the Clean Water Act (CWA) to embrace innovative approaches and technologies related to energy production, water reuse, green infrastructure, non-traditional partnerships, and more – all to improve environmental performance while lowering costs and increasing revenue.

"IMPROVE ENVIRONMENTAL PERFORMANCE WHILE LOWERING COSTS AND INCREASING REVENUE"

An emerging component of the UOTF arena is the growing reliance on data-driven decision making. The technological advances in cloud computing and communications, coupled with analytic capabilities are enabling clean water utilities to better use the data they already have and to plan and execute new ways of collecting data that are improving the efficiency of their operations. Through these data-driven approaches, the Digital Utility of the Future is reducing costs, mitigating risks, enhancing the customer experience, optimizing performance, and gaining efficiencies, all while improving water quality and the environment more broadly.

The Digital Utility is described here by its characteristics and what it can achieve now and into the future. As with any innovation, the extent of adoption in the water sector is at varying levels across a spectrum. As observed with the broader UOTF effort, further adoption will proceed along a continuum and will depend on a number of factors. Our hope is that this document can illustrate for utility executives the benefits of continued adoption of these technologies and practices.

Ultimately, the Water Resources Utility of the Future will no doubt be committed to data-driven management. Data management already is reshaping the industry, helping utilities order, in real time, robust streams of raw information from disparate systems into coherent and actionable intelligence. The Digital Utility will be best equipped to meet the ultimate goal of the sector – the delivery of reliable, safe and affordable water services.

Becoming a Digital Utility of the Future

OVERVIEW

What do data and information mean to utility management? Today it varies depending on the utility, but for the Digital Utility of the Future, gathering of all forms of data and creating meaning and value from it will become a foundational element. Generated, looped and analyzed in endlessly flowing and seamlessly connected systems, data will be the lifeblood of the utility.

Facts are power and digital data are especially powerful because of recent advances. The latest technology – miniature sensors, handheld devices, cloud storage, software programs – gives organizations the ability to gather and see, in the blink of an eye, information integrated from all points across the utility enterprise. Extraordinary insights are delivered that can inform effective, cost-saving decision-making in real time.

Without this integrated understanding of system performance, clean water utilities will be constrained in their ability to respond to the operational challenges they will face in the future. As other industries have learned, business as usual approaches are coming under increasing pressure from customers who are wary of increasing costs and who have come to expect information to be available at the touch of screen. Clean water utilities are facing unique pressures, including mounting regulatory costs and assets and infrastructure that have aged well beyond their planned lives. This is threatening water sustainability and reliability and is raising growing concerns about the affordability of water services into the future.

"KNOWLEDGE MINED FROM INTEGRATED DATA CAN SUPPORT PREDICTIVE MANAGEMENT OF A UTILITY'S RISKS."

As a data-driven operation, the Digital Utility of the Future makes relative performance improvements through analytics and collective industry advancement from insights gleaned from analytics and benchmarking. It also leverages limited resources to do more, proactively identifying issues before they become serious problems, and driving efficiencies that can free up funding for improvements and repairs. Data analytics can be used to stretch every dollar, driving down operational costs, making processes more efficient, and maximizing the use of existing systems. This can help the utility keep its total annual expenses to a practical minimum. Knowledge mined from integrated data can support predictive management of a utility's risks. It can help a utility identify and resolve issues before they escalate into costly, five-alarm events.

Digital Utilities can also be more effective in planning capital, operational and maintenance priorities. They can better manage their energy and water resources through conservation, recovery and reuse while meeting quality requirements. And they can more effectively track and understand interconnections within and across the utility's systems, make informed decisions from this comprehensive vantage point, and keep focus on organization-wide goals.

While the technologies and approaches described below are currently being used by water utilities to some extent in the United States, this document is intended to provide an aspirational vision of how Digital Utilities will increasingly leverage data, analytics and integrated systems to:

1. Reduce Operational Costs
2. Manage and Mitigate Risks
3. Enhance the Customer Experience
4. Improve Financial Execution
5. Optimize Asset Performance and Uncover Hidden Value
6. Leverage Existing Communications and Computing Platforms
7. Maximize the Engagement and Efficiency of Employees; and
8. Integrate Water Quality, Policy, and Performance.

NACWA intends to update this document as advances are made in data-driven decision making and to build a collection of case studies illustrating how clean water utilities continue to embrace these practices.

1. REDUCING OPERATIONAL COSTS

If energy consumption, maintenance activities, chemical usage, etc. can be tracked, then a utility can effectively benchmark performance and move to drive cost savings into their organization. Data, sensors, robust asset management systems and financial tracking tools can determine operational costs and drive more efficiency into processes. This will benefit the utility by doing more with less and drive down the costs of services to stakeholders. A win-win for all involved.

One of the benefits of the new digital age is the ability to track, compile, and analyze vast amounts of operational data in real time – data about energy use, chemical application, maintenance activities, and system performance (e.g., high-rate treatment, disinfection effectiveness, pump efficiency, flows in collection systems). Baselines and trends can be derived and managed over time to make sure that a system is performing in an optimal and cost-effective manner.

There are many examples of this concept in practice, both at the treatment plant and in the collection system.

WASTEWATER TREATMENT

Wastewater pumping and blower systems are typically the largest consumers of energy at a wastewater treatment plant. If their energy uses and performance are tracked, inefficiencies can be spotted and corrected so that money spent goes toward creating greater utility value. In addition, the amount of chemicals and/or energy used in process and disinfection systems can be tracked and benchmarked. Deviations from the long-term averages can indicate issues and prompt maintenance staff to make targeted and focused improvements.

One of the newer project delivery mechanisms is focused on this exact concept. Performance contracting can take energy and cost data that have been collected, look for inefficiencies, and fund new and higher efficiency solutions through the money recovered from the inefficient processes. Wherever data can be collected, monitored and benchmarked, the ability to drive efficiencies and cost savings exists.

COLLECTION SYSTEMS

Collection systems must be operated and maintained to convey sewage to the wastewater treatment plant, prevent overflows and environmental impacts, and accommodate a community's growth and development goals. Programs designed to control inflow and infiltration (I/I) and reduce the discharge of fats, oils and grease are important to keeping collection systems operational and efficient.

Managing digital data with flow meters, level sensors and pump station flow rates can further enhance a utility's ability to focus and make operational decisions. For example, a utility that deploys flow meters and level sensors as a part of its overflow mitigation program can track trends to see if water levels are slowly increasing due to a buildup of a potential blockage. Knowing this information can help to prioritize maintenance and cleaning crews and prevent overflows. Instead of these resources going into the field based on random patterns and historical visits, they can proactively move from identified issue to issue, focusing their time, money and expertise.

WATER TREATMENT AND DISTRIBUTION SYSTEMS

Similar to wastewater treatment, water supply requires significant energy and money to treat and move water to consumers. Data collected can be used to look for inefficiencies in pumps, manage pressure zones more dynamically so energy is not wasted, and "market-time" the use of high-energy intensive pumps and systems to avoid their use during peak hours – all of which drive cost savings to the utility.

In addition, utilities now have access to Advanced Metering Infrastructure (AMI) that allows two-way and real-time communication between consumers in a distribution system and the utility. AMI systems can be used for many purposes, but one major operational challenge they can definitely address is quantifying water loss. Water loss can be a significant source of lost revenue for a utility, so being able to quantify the water loss, institute asset management programs to resolve water losses, and show the return on investment can be a win-win for both the utility and consumers.

By levering digital data and analytic platforms, utilities have the ability to track and benchmark their performance. Efficiencies can be improved, and operational costs and expended resources minimized.

2. MANAGING AND MITIGATING RISKS

Risk management is critical in proactively determining and mitigating issues. Mitigating risks in a planned manner is less expensive than reacting to a major system failure. Predictive risk management using state-of-the-art asset management systems, such as pipe, pump, and process sensors, can help a utility spot a problem and plan accordingly before it becomes a catastrophe. Instead of wait-and-react utility management, Digital Utilities proactively plan capital, operational and maintenance activities while smoothing out rate impacts to customers.

Photo Credit: SmartCover Systems - Sensors like this can provide early warning of potential problems, allowing utility maintenance crews time to respond before an overflow occurs.

Utility risk management is paramount to maintaining product integrity, public safety, and stakeholder trust. You do not have to look far in today's news to find examples of where risks were not appropriately managed and mitigated, resulting in public health emergencies.

With the latest technologies, utility risks can be much more actively managed and minimized. Monitoring of treatment processes and effluent has the ability to alert operators well before permit violations occur. Active monitoring of waterbodies and watersheds, such as recreational waters and drinking water supplies can now include real-time environmental measurements (in-situ sensors or analyzers) as early warning for contaminants and treatment process risks. Depending on the water source, quality monitoring closer to the treatment process may include bioassay organisms, using fish in tanks with image intelligence systems or clams/mussels with shell-closing sensors to indicate possible contaminants. Within water distribution networks, in-situ probes or analyzers provide water quality parameters for software (e.g., EPA CANARY) to detect contamination events and better protect public health. Similar technologies are now available to monitor collection system outfalls and actively notify utility mangers about overflows and potential environmental contamination. Digital Utilities harness the power of real-time data from all sources and together with the capability of computing systems to model and simulate physical conditions digitally, gain insights into enhanced risk mitigation strategies. In the long-term, integration of watershed scale climate models and receiving stream models will significantly enhance infrastructure planning and operating strategies.

3. ENHANCING THE CUSTOMER EXPERIENCE

Utilities of the Future are increasingly viewing themselves as enterprises where efficiency and consumer outcomes are paramount. They look to integrate clean water, energy recovery and generation, waste-to-product systems, high quality recycled water (to supplement regional water supplies), environmental compliance, and streamlined billing and professional services, all while delivering high customer satisfaction. The Digital Utility is best positioned to achieve all of these objectives.

Utilities are under increasing pressure to show customers value for rates paid and to enhance customer engagement and participation in various programs. Digital Utilities seek to produce a fully functional, integrated system of operations that fully optimizes meter services, including meter reading, billing, customer service, collections, and fiscal reporting. In some respects, there are two types of customers, utilities themselves and their individual retail customers, both with different needs and expectations.

Digital Utilities seek to monitor and record anything that will help them better understand their system, make better decisions, or improve efficiency. All data sets and information will be stored until needed, and analytics will be built to analyze this data. This level of storage and analysis is still in its relative infancy within the water industry and most analysis is relatively rudimentary. But advances are taking place every day and expanding this arena to provide actionable intelligence through more active use of existing datasets.

The utility's customers are much more focused on their immediate needs. Most of the customer experience is directed toward near real-time management, centered on customer metering data. How much did I use? Am I using too much, or do I have a leak? More active and automated customer data can provide retail customers with the information they desire. If presented properly, this reduces the burden on the utility's customer service department to record, monitor and explain anomalies. The use of social media to actively engage the customer and the use of real time data to communicate water quality and availability will soon become the norm for our sector.

Advanced metering and the movement to hourly meter reads from monthly (or bi-monthly, or quarterly) reads can enhance data volume, but more data collection needs to be paired with visual tools that are easy to use and understand. As with anything, Digital Utilities will need to be careful not to go too far without a plan for what to do with the data. Otherwise, the utility will just have a lot more data creating confusion.

4. IMPROVING FINANCIAL EXECUTION

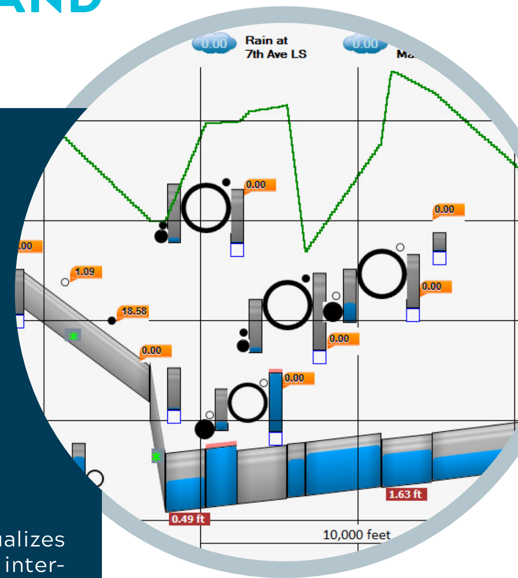
Pressures on utilities are ever-mounting. Water quality standards are increasingly stringent, aging infrastructure is in need of repair or replacement, and communities are starting to reach their limits of affordability for water services. Utilities are looking to stretch every dollar. Digital Utility systems and approaches provide more opportunities to improve efficiency and financial performance.

Photo Credit: DC Water - This image features screens from DC Water's new Customer Information System (CIS).

Most financial decisions in water and wastewater utilities are made using spreadsheet models that are relatively static. This method does allow some degree of repeatability, but it is relatively cumbersome and labor-intensive. The programs also are not usually built to manage more than total system information even though data, down to the individual customer and asset in some cases, is available.

As sensors, metering and Customer Information Systems (CIS) become more advanced, processes can become more active. They also can be updated automatically. Utilities already have large datasets that can be of value to their financial systems, but in many cases they are not being utilized. CIS is almost exclusively used for billing and to respond to customer interaction. But there is much more possibility in these datasets. For example, with usage data down to the customer level, a utility can better understand its financial commitments and impacts down to that level. Use of granular customer classifications and economic forecasts will further enable long range financial planning updates, affording tighter rate projections and financial planning. As affordability challenges become more acute, having more granular, actionable information on financial impacts will be extremely valuable for the Digital Utility.

5. OPTIMIZING ASSET PERFORMANCE AND UNCOVERING HIDDEN VALUE



Given the extent of the existing infrastructure challenge, it is imperative to optimize existing assets so that every bit of performance can be distilled prior to replacement. Robust and predictive asset management programs, employing data-driven approaches, can create a systematic methodology for rehabilitating and repairing aging assets in a manner that the utility can plan for, more easily pay for, and flatten out potential rate increases to ease the burden on rate payers.

Photo Credit: Emnet - This image is from a profile dashboard at a client installation that visualizes field data in real time so operators can clearly see precipitation, hydraulic conditions in the interceptor system and at combined sewer overflow gates, operation modes of all critical assets, as well as grit deposition levels in problem areas. It provides real time conditions and can play back previous wet weather events for forensic study, showing how conditions change and allowing the utility to maximize use of its existing assets.

The impacts of our aging infrastructure are in the news more and more these days. Assets need rehabilitation, repair or replacement. However, many older communities struggle to find the necessary resources to make needed infrastructure investments. Predictive and prognostic data analytics coupled with decision optimization tools are already emerging as powerful ways to maximize the benefit of available capital and limited financial resources.

In addition to monitoring assets such as pumps, blowers, collection and distribution systems, significant value can be extracted through analysis of those assets. If old pumps/blowers and other energy intensive systems are shown, through data benchmarking, to be operating less efficiently than state-of-the-art products, the utility can capitalize by replacing old and inefficient systems. Operating funds can be saved and reinvested into the utility.

In the future, integration and analysis of multi-variable datasets combined with the analytics to provide actionable intelligence will allow optimization, even for the individual asset and in some cases components of that asset. For example, vibration can already be monitored in all types of rotary applications, from helicopter blades to pumps to turbines. This information can be used to determine when the rotor is likely to fail and so can determine the needs and timing of preventative maintenance. It can also be used to better understand the required capital investment for these components and their life expectancy. This optimizes asset performance and financial performance at the same time.

As utilities look to benefit from other assets, including the resources that can be recovered from wastewater such as minerals, nutrients, and energy, understanding the composition of the influent waste streams will help determine whether resource recovery approaches can be economically viable. If resource recovery and marketability can be predicted and monetized, performance contracts can be established to pay for the recovery project through the newly created revenue stream. Coupling digital data with a detailed understanding of operations can create significant value for the utility.

6. LEVERAGING EXISTING COMMUNICATION AND COMPUTING PLATFORMS

Digital data approaches enable a better understanding of the complex dynamics throughout a utility's interdependent systems, predict outcomes, and improve decision making. Handheld devices, cloud computing, sensors, and analytics allow monitoring of highly complex and dynamic systems so utilities can create cause-and-effect correlations to guide them in making quick and data-informed decisions. With the ability to synthesize millions of inputs and leverage existing data and computing platforms, utilities can make sense out of the "chaos," turning disconnected streams of raw data into actionable intelligence and better results.

Currently, utilities use various data management and analytical tools, depending on their primary business applications. Most business functions are supported by commercial off-the-shelf software. Examples include LIMS for laboratory management, and systems for asset management, industrial pretreatment, tactical decision support at treatment plants, mapping assets and field data collection among others.

Digital Utilities will continue to improve integration and interoperability of these systems to support improved decision-making. Existing systems may be supplied and configured by different vendors to meet disparate ends, and often do not share common technology or communication formats. However, this is changing and systems are increasingly being integrated, with the goal of having a unified information infrastructure that consistently connects all of a utility's data and analytical platforms. This infrastructure will allow for new decision support capabilities. Simple data analytics reveal basic insights. As more sophisticated analytics are applied to data from external and enterprise sources that have been integrated, utilities will be able to unearth deeper insights that will help to optimize performance and enhance communication to stakeholders.

An effective communication network and leveraging cloud computing capabilities are foundational for a digital utility. The emerging smart devices, enabled with local computing capabilities, will serve as the base layer feeding data to the cloud through the communication network. The value creation will happen when utilities leverage these foundational elements to involve people, business processes, and data analytics. As more innovative utilities leverage digital capabilities, the opportunities for collaborative platforms for peer-to-peer utility engagement will also increase

Digital Utilities will benefit from this integration in a number of ways:

- Reduced reliance on IT developers,
- Easily constructed models using data from various sources (CMMS GIS, SCADA, project management, financial and customer information systems),
- Eliminating the extensive costs and need for complex and disparate system integration, and
- Quicker, more meaningful visual displays of information across integrated utility systems.

7. MAXIMIZING THE ENGAGEMENT AND EFFICIENCY OF EMPLOYEES

Utilities manage a range of complex systems: SCADA, collection system flow meters, water quality sensors, and so on. All are meant to collect, analyze, and manage energy use, waste recovery, financial systems, etc. Yet far too often these systems are seen as distinct and are disconnected from one another. This leaves utility professionals operating ineffectively in silos. By collecting, analyzing, and displaying information through intuitive heads-up displays, and keeping information in central repositories that are easily accessible, the time and energy of operators and managers can be focused on running the utility as a whole. Seeing the utility as an interconnected system, they can make truly informed decisions. Resource productivity is therefore maximized and focused on the primary outcomes and products of the utility.

In the future, employees will still play a central role in managing, operating and maintaining utilities. But what will that role entail?

The Digital Utility provides tools, such as mobile devices like smart phones, tablets and headsets using mixed reality, for employees to make jobs faster and easier while increasing the quality and accuracy of data collected in doing the work. Facilitating work in the plant or in the field, these devices are configured to meet end-user needs for ease of interaction and avoidance of unnecessary navigation to get the job done. Customer interactions via websites, social media, or phones provide customer service agents with an immediate connection to customers, including all account information, near real-time metering data, and the latest information related to customer location, such as water quality, sewer back-ups, and maintenance or construction activity. These technology enablers not only increase the efficiency of the "digital employee" but also increase customer satisfaction and effectiveness of business processes and programs.

The Digital Utility also enables more extensive employee engagement to ensure the success of the technology solutions. Involvement of employees begins with problem-solving and designing solutions where technology supports efficiency, quality and effectiveness in new/redesigned work processes. This employee engagement creates the mindset for change going forward. Involvement of employees through various teams, workshops, surveys or interviews builds the commitment, trust and ownership for successful systems.

Appropriate training must accompany all new technology to gain the intended benefits. In the Digital Utility, training is tailored to roles based on intended use of the technology and includes many forms for efficient and effective results in technology adoption. Classroom and on-the-job training employs "adult learning" methods to fit the aptitude of the employees, including remedial training if needed. The utility assesses use of the technology in place and targets training where needed to gain efficiencies and improvements. Ongoing training to leverage additional capability of the technology can yield substantial improvements. Over time, workers become more proficient and can utilize more software or system capabilities to gain added benefits.

Well-educated employees create the foundation for the Digital Utility and the deployment of these types of systems will enhance recruitment and selection of employees with the interest and aptitude to be "Digital Employees of the Future."

8. INTEGRATING WATER QUALITY, POLICY, AND PERFORMANCE

Utilities exist to achieve reliable, affordable and sustainable outcomes. Whether it is high quality effluent, sophisticated treatment to create recycled water, collecting and conveying flows or minimizing sewer overflows, utilities must ensure their operations protect human health and the environment. The Digital Utility is uniquely positioned to achieve this most important objective while also optimizing its operations and minimizing cost.

Today's water utility is expected to deliver regulatory compliance while also making cost-effective investments to maintain infrastructure and ensure reliable operations. Continuing advances in the collection, management, and analysis of data provide new tools to realize these sometimes competing objectives.

In the future, Digital Utilities will increasingly use advanced sensors in real-time to monitor parameters that are reported to demonstrate compliance with permit requirements. Regulatory agencies have recognized that the evolution in the water industry's data capabilities will likely support a more modern, and integrated approach to compliance. The U.S. Environmental Protection Agency (EPA) has in fact established an entire Next Generation Compliance program to embrace the new tools for collecting and reporting environmental data. While this may be concerning to some, the power utilities will wield with this information will enable more flexible regulations and permits. With more information about their discharges and processes, utilities will drive the need for better permitting approaches and more flexibility in effluent limits due to more advance monitoring technology.

Water and wastewater treatment plants have been equipped for years with SCADA systems that deliver near-real time information regarding system performance and effluent quality. However, to address the CWA and improve receiving stream water quality, Digital Utilities will increasing explore more comprehensive and watershed-based approaches that can better account for other sources of pollution such as stormwater runoff from urban and agricultural areas and groundwater flows including septic systems. Armed with this information, utilities will be better equipped to engage with regulators and watershed stakeholders.

The Digital Utility will increasingly be able to contribute to the development of next-generation permits that reflect improved understanding of system hydraulics, watershed hydrology, and effluent and receiving water quality processes. These next-generation permits may allow the utility to optimize treatment plant operations, to take advantage of receiving water assimilative capacity in novel ways that remain protective of designated uses while reducing energy and resource consumption and more.

Next-generation integration of utility data to support improved water quality promises many benefits:

- Better system understanding and system wide management,
- Readily demonstrated regulatory compliance,
- Transparency enhancing ratepayer, regulator and stakeholder satisfaction, and
- Next-generation permits that deliver energy and resource savings benefiting the environment.

Digital Utilities will have access to more and more data and with the right knowledge and technology will be able to leverage that data to more efficiently and effectively address their water quality challenges and meet their CWA obligations.

Putting It Together to Build a Digital Utility of the Future

Examining the work already underway and envisioning what the Digital Utility of the Future will look like, underscores the importance of data-driven and data-informed decisions to drive the greatest efficiency and return on investment. As the father of the Plan-Do-Study-Act quality cycle, W. Edwards Deming, famously said: "Without data, you're just another person with an opinion." No matter the industry, whether it is manufacturing, sports performance, healthcare, education, environmental science, etc., benchmarking and data are key to understanding complex systems and driving better outcomes.

As we create new value from the emerging opportunities of the Digital Utility of the Future, however, we can expect an increase in the resource requirements to plan, execute, train and operate these modified systems. The new value creation opportunities will also present new risks, especially risks related to technology obsolescence and overall security. As a result, establishing a digital plan or roadmap will be an essential step towards ensuring the necessary resources are available and risk management strategies are in place. Such planning will be based on foundational elements like mapping of communication infrastructure along with information technology and control systems. Hiring, training and developing digitally savvy employees will also need to become a core competency.

"WITHOUT DATA, YOU'RE JUST ANOTHER PERSON WITH AN OPINION."

Digital Utilities have proven templates from the manufacturing world to draw upon to become highly efficient enterprises. By collecting data, applying analytics, and implementing continuous process improvement strategies, utilities can streamline procedures and eliminate wasteful processes to enhance efficiency, reduce costs and, ultimately, maximize their return on investment.

While the Digital Utility was described here largely as an aspirational vision, the tools and capabilities that will be used by the Digital Utilities of the Future already exist and are being used effectively by utilities today. Every day they are being further developed and refined. Digital Utilities are already demonstrating the necessary vision, willingness to embrace change and a commitment to the approaches that will change the clean water community.

As this work continues, NACWA will highlight the success stories and look to further enable broader adoption by the clean water sector.

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