Turning the Tide: The Digital Future of Water Management

Written by: Dr. Carolina Venegas Martinez, Senior Strategy Manager, Water Industry, Autodesk

"California Water Wars" might sound like a new reality show for 2023, but in fact, this conflict took place more than 100 years ago, when William Mulholland built the California aqueduct and diverted water from the Owens Valley straight to Los Angeles, leaving the eastern region of the state barren. The unscrupulous tactics — which inspired the 1974 film masterpiece Chinatown — shined a harsh light on the ongoing need for better water management. The industry is still grappling with challenges that are forcing water organizations, cities, states, and governments to find new ways to protect and manage the planet's most critical resource.

Every day, billions of gallons of water are wasted. With climate change affecting weather patterns and severity, an exploding population, pollution, and inequitable access to safe water, there is an urgent need for more sustainable water resources management.

What will it take? The practical list is long: new policies, investing in infrastructure, and a digital approach to water management that uses data to guide action. But sustainable water management is also a mindset. The industry can set regulations, but there must be buy-in from the public, which needs to understand the urgency of the situation to create a sustainable future.

What is Water Management?

Water management is the process, planning, oversight, and

evaluation of collecting water from a source; diverting, cleaning, and getting it to an end user; removing the water after it is used; treating it; and disposing of or recycling it. It entails securing the rights to the water, building the infrastructure, and creating the policies that govern water quality and quantity.

Humans use water for three primary purposes:

1. Agriculture, 70%
2. Industrial, 19%
3. Domestic, 11%

Water management includes:

» Providing drinking water from source to tap

» Ensuring water quality is safe and contaminant-free

» Managing the infrastructure involved in water catchment, transport, and cleaning

» Removing wastewater from communities

» Diverting water from sources (lakes, reservoirs, groundwater, and so forth) to reach communities

» Overseeing stormwater management and flood control

Water is a shared resource, but there are 148,000 different public water systems managing it across the United States. And in many areas, different agencies manage the different uses: Stormwater is handled by one entity and drinking water by another. To align the industry on best management practices, the U.S. Water Alliance (USWA) created One Water. This initiative takes a holistic approach to water management, which the USWA laid out in seven steps to coordinate stakeholders across the country:

1. Advance regional collaboration on water management.
2. Accelerate agriculture-utility partnerships to improve water quality.
3. Sustain adequate funding for water infrastructure.
4. Blend public and private expertise and investment to address water infrastructure needs.
5. Redefine affordability for the 21st century.
6. Reduce lead risks and embrace the mission of protecting public health.
7. Accelerate technology adoption to build efficiency and improve water service.

This approach is being adopted by cities small and large, such as New York. It breaks down silos and creates a cohesive voice to reach common goals and create a sustainable future.

What is Water Infrastructure?

Water infrastructure refers to the engineered environment used to capture, transport, treat, and convey water to users, then re-collect and dispose of it. In the case of drinking water, it includes the pipes that carry water from its source and water plants that make it potable. In wastewater, it is the sewer networks and lift stations that bring used water from buildings to treatment plants where a set of physical and chemical processes depollute the water to dispose of it in water bodies.

Water infrastructure includes underground pipes, canals and aqueducts, dikes and dams, drainage systems, reservoirs, levees, catchment basins, water mains, wastewater treatment plants, lift stations, pipes, and storm drains and flood control systems.

Every day, water infrastructure carries 349 billion gallons of water around the United States to different destinations for different uses. But many of the pipes, plants, dams, and sewers were built in the first half of the 20th century and are overdue for an infusion of funding to bring them up to 21st-century standards.

Why is Water Resource Management Important?

From space, it's easy to understand why Earth is called the Blue Planet: 71% of this spinning sphere is made up of water. But as plentiful as it appears, water is a limited resource — only 0.5% of the supply is freshwater that is usable by humans, and access to it is becoming increasingly difficult for millions of people.

The demand for water is growing, and the supply is dwindling. There will be 10 billion people on Earth by 2050, and there are already 2 billion people around the world who live without access to safe drinking water and 3.6 billion without safe sanitation services. Climate change and population growth will widen the gap between who has safe water and who does not, increasing the risk to public health.

Changing weather patterns are increasing the intensity of storms and creating years-long droughts. Infrastructure has long been financially neglected; much of it has reached its expiration date and is failing under the stress of increased water levels.

Policies can protect and conserve water supplies. Governments can incentivize building new infrastructure. Water agencies can equalize water distribution and quality. Water management encompasses all of that — but as the world changes, new strategies and solutions are needed to stay ahead of the challenges and ensure water resilience.

Challenges Facing the Water Industry

Some people can turn on the tap and have immediate access to clean water. Many others must travel for miles to reach the nearest water source. But supply, though the most urgent issue, is just one challenge the water industry contends with today.

Water Supply Availability

For water management, the main challenge is water scarcity, which is when the demand for water is greater than the supply. Although many people don't realize it, there is not an endless amount of water: The supply is depleting.

Here's what the future looks like:

» Two-thirds of the world's population will face a water shortage by 2025 if consumption keeps up at the current pace.

» One in every four children will live in a place experiencing an extreme water shortage by 2040.

» Agricultural production currently uses 70% of the water supply. Feeding the global population in 2050, which is expected to reach 10 billion, will require a 50% increase in agricultural growth and 15% higher water usage.

» Water demand may exceed supply by 40% by 2030.

Governments are setting strict limits in an effort to conserve this limited supply, but there is simply not enough to provide more people with water the way it is managed now. Every single drop of water that is captured, transported, consumed, and treated needs to be protected.

Severe Weather Events

Water and climate change are inextricably linked. As the United Nations reports: "Climate change is primarily a water crisis. We feel its impacts through worsening floods, rising sea levels, shrinking ice fields, wildfires, and droughts." Between 2001 and 2018, three quarters of natural disasters were related to water. Places such as California are experiencing massive droughts and devastating fires while Europe is experiencing severe flooding. But those patterns can be unpredictable: In 2023, California went from the driest three years on record to the wettest winter in 70 years.

Communities around the world are unprepared for these changing water cycles. Food production is disrupted and crops are destroyed, hurting livelihoods and economies. Increased surface-water runoff is picking up more chemicals and debris and polluting waterways. The water industry is starting to make changes to prepare for what's to come.

Aging Infrastructure

Much of the water infrastructure in place today comprised feats of engineering when they were first constructed. But fast-forward to today, and the vast networks of water systems are reaching their life expectancy. Climate change is only hastening the aging process.

» There are 2.2 million miles of drinking-water pipes in the United States. Every two minutes, a water main bursts and 6 billion gallons of ready-to-use, treated water is lost.

» There are 16,000 wastewater treatment plants in the U.S., and they are operating at just 81% of their maximum capacity while the demand on them is increasing.

» There are more than 92,000 dams across the country that were built an average of 61 years ago, and 85% of them are past their life expectancy.

Water infrastructure is past its expiration date and under extreme stress from frequent superstorms. In 2017, the Oroville spillway was on the brink of a catastrophic disaster during severe rain, forcing thousands in the water's path to evacuate as the water level quickly rose. Massive failures risk lives, cost billions of dollars, and impact the quality of the water.

In Jackson, Miss, 100-year-old pipes and a 110-year-old water plant have been plagued with leaks for years, leaving residents without water for weeks at a time. In 2022, the system reached a breaking point when a storm forced the river to flood, overwhelming the plant and rendering it unable to treat the water. It left residents of the capital city under boil-water mandates while the city remained without the financing to make needed repairs. It's just one example of a bigger national problem.

Financing

Financing has been a longstanding issue for the water

industry: Not enough money is invested into management and infrastructure. With decentralized water systems, funding is hard to come by for overhauling the patchwork of pipes and infrastructure. Federal expenditures are scarce, leaving it up to states, municipalities, and the people they serve to pay for desperately needed improvements and upgrades.

Water Pollution

Increasingly, stormwater runoff is picking up chemicals, garbage, agricultural pollutants, and bacteria and carrying it all back into the water supply. In Los Angeles alone, 100 million gallons of polluted water move through the storm drains each day. In less-developed regions of the world, inadequate management resources and lack of infrastructure can lead to cross-contamination of sewage and drinking supplies. Every year, millions of people die from health issues related to unsafe water.

Labor Shortage

Like other industries, water management is also facing a workforce shortage. Seasoned operators, 30% of the industry's 1.7 million workers, will reach retirement age within the next 10 years. But the next generation is not entering this line of work, instead choosing careers in industries that incorporate more data and technology.

Three Ways Technology is Changing Water Management

Every drop of water carries data throughout its journey. But the industry needs the software, solutions, and the cloud infrastructure to convert that data into insights so operators can make better decisions. And while the industry is starting on its journey, it is primed for a full digital transformation.

The water industry has long understood the benefits that data can bring. It's used sensors and supervisory control and data acquisition (SCADA) systems to see underground assets and monitor the function of pipes and treatment plants for some time. But without a connected ecosystem, that technology is disconnected and siloed, and the industry has been slow to advance to a fully digital operation.

When the COVID-19 pandemic hit, many water systems experienced disruption to their daily operations. Water professionals had to connect to each other and needed more robust systems to manage their operations. It was a catalyst for change. Now, the industry is on a digital journey and harnessing digital tools to improve operations. Fifty-five percent of water industry companies say their main goal in using technology is to monitor their assets and analyze data, which will drive the industry's future toward sustainable water management.

Here are three ways technology is changing the way water is managed and creating water resilience.

1. Digital Twins

Digital twins have become commonplace in the manufacturing and construction industries. Now, the water industry is starting to discover how digital twins allow it to visualize entire underground systems and monitor performance. For water management, digital twins are virtual replicas of physical assets (water infrastructure networks) pulsing with live data. It amasses all the information from SCADA, Internet of Things (IoT) sensors, and meters, as well as information like when a pipe was installed and the material it's made from. The model can track historical data and real-time function to deliver forecasts of system functions.

With sensors alerting operators to pressure fluctuations or a change in conditions, digital twins can quickly identify a leak or failure. They can reveal water capacity and pH levels in tanks. Customers can be notified right away of a leak, limiting disruption of their service. Operators can easily access their model to monitor current performance. Digital twins also facilitate continuous improvement of water systems, detecting weak areas and resolving problems before they become catastrophic failures.

Digital twins are becoming the solution for modern water management. Even in the Jackson example, where leaks plagued the system for years, engineers have digitally mapped the city's 100 square miles of water infrastructure and created a virtual model with live data to monitor flow and pressure, provide uninterrupted water service, and improve water quality for the city's 150,000 residents.

2. Cloud Collaboration

The digital journey is more than buying a piece of software or upgrading a single system. It's about connecting the right tools, teams, and workers to make that transition and unlock the value of technology. And that requires working in a cloud-based environment.

The benefits of the cloud are well-known. By 2025, 95% of work will happen in the cloud. Water professionals have yet to maximize the full potential of this open ecosystem, but it is starting to gain traction. Water distribution networks are complex systems. The cloud centralizes everything and everyone, enabling real-time collaboration. Digital twins with all that valuable data will be built in the cloud, and the data will live in one central place. That means the right people at the right time can get the information they need for planning, designing, operating, and maintaining, eliminating the silos of traditional water management.

The full visibility of a cloud environment eliminates redundancy and reduces rework. Data is interoperable in the cloud, enabling faster simulations, which will be a huge advantage for improving water operations and management.

3. Artificial Intelligence

Artificial intelligence (AI) is showing up everywhere, and water is no different. Before technology, leaks were detected when water appeared above ground. With AI, the system can predict failure before it happens and drastically reduce the amount of water wasted throughout its lifecycle. AI and machine learning will allow organizations to simulate scenarios, a revolutionary tool for a world that is regularly experiencing unprecedented weather events.

AI can remedy the inefficiencies of traditional water resources management. For example, agriculture uses 70% of the world's water, but up to 60% of it may be wasted. AI-powered "smart farms" use sensors for light and irrigation data, satellite imagery, and forecasts to determine "as-needed" watering.

AI in water management can:

» Monitor levels and predict peak water flows to adjust capacity.

» Inform predictive maintenance to reduce unplanned downtimes and disruptions.

» Identify patterns and recognize past trends to continually refine risk assessments to determine when an event or disruption may happen.

» Optimize chemical treatments to water as needed.

» Use machine learning to optimize asset and infrastructure performance.

» Adjust operating periods for pumps for energy efficiency.

AI will be a powerful tool in the future of water management, supporting conservation and sustainability efforts.

Five Benefits of Technology in Water Management and Planning

Water operations have long been mired in traditional workflows as other industries rocket through digital transformations. But technology can revolutionize water management, attaching data-powered tools to create more sustainable water cycles and more efficient operations. Here are some of the top benefits of digital water.

1. Simulation and Modeling for Better Preparedness

With hydraulic modeling, engineers can ingest all relevant information about a water system to create a digital version of either a new project in the design stage or an existing network of pipes. This work used to be done on spreadsheets, which were static, hard to share, and inefficient. Visually modeling a water system allows simulations showing how that system will respond to different scenarios, revealing weak spots and letting engineers know where and when to make infrastructure improvements before failures happen. It also helps in the planning and design stage, identifying flaws before construction begins. This creates a level of preparedness that can save communities from flooding and destruction.

2. Real-Time Insights for More Efficient Operations

Digital twins are brought to life with IoT sensors that deliver real-time data about the conditions and functions of a water system. They can track factors such as water quality, capacity, pressure, and performance. Traditionally, discovering a leak and finding the source required visually locating where the water was erupting from the ground. By the time it was found, service

had been disrupted and water wasted — sometimes millions of gallons. With real-time data, operators can quickly identify and resolve issues and optimize performance.

3. Increased Asset Visibility

Most of the managed water cycle happens underground, in pipes and tanks. Detecting a problem often happens when water arrives (or doesn't) at its destination. Water management professionals can use live models to see the exact function of each asset, and use GIS-equipped sensors to pinpoint the exact location of issues. This helps teams better understand performance measures and plan for future improvements. They can create accurate budgets and request funding to improve systems backed by the data to justify those capital improvements.

4. Support for Existing Infrastructure

Replacing all existing pipes, plants, and water systems with modern, digitally powered systems would be unrealistic. To capture real conditions, operators often send cameras into pipes. But cloud-powered hydraulic models can be created using existing systems and deliver real-time data to optimize operations. Once a model with GIS and sensors exists, operators can reference a layout of their entire system and start collecting data, even in small circuits, to capture what's happening. Creating a digital replica can prioritize areas needing repairs and upgrades. Although it's cost-prohibitive to equip a whole system with sensors, having them in the right place can get the right information.

5. Sustainability and Smart Water Management

Water and sustainability are intrinsically linked. From water consumption to flood management to wastewater management, technology will make its biggest imprint on delivering sustainable outcomes. Water and wastewater management account for 2% of all energy used in the United States and emit 45 million tons of greenhouse gases each year. Smart water management with digital models reduces the power used in heating, treating, pumping, and moving water — and optimizes power levels based on need – for more sustainable water resources management. In New Zealand, Wellington Water worked with global firm Stantec, which used Autodesk Info360 Insight to track pump performance and adjust pump run times as needed. This digital approach saved 20% in electricity costs and extended the life of the assets.

Five Examples of Digital Water Management

The water industry is beginning to accelerate digital transformation to improve water management practices. Here are some examples of digital water management and the benefits sustainable water resources management delivers.

1. Toledo's Water System Gets a Rapid Overhaul

When a harmful algae bloom grew in Lake Erie in August 2014, half a million residents of Toledo, Ohio, were forced to stop using their water for days. The 80-year-old water treatment plant was overwhelmed and unable to handle the contaminated supply.

The city hired engineering firm Arcadis to upgrade the existing infrastructure and build two new treatment basins. Using 3D scans of the existing site, it created a digital model of the system. Arcadis had remote teams in multiple disciplines (architectural, HVAC, electrical, structural, mechanical) all working on BIM models in the cloud, saving roughly 1,000 design hours by reducing file-transfer lag time by 80%. And as the project wraps up, Arcadis will hand over the BIM model to Toledo's water operations team, helping it detect issues early for continued resilience.

2. From Ancient Trade Routes to Smart Canals

Built in 1790, Glasgow's Forth and Clyde Canal was once a well-traveled trade route. By the 1960s, the canals were abandoned and dilapidated. Scottish Canals, the government agency in charge of these waterways, sought to revitalize them in the early 2000s — but with climate change and an increasing amount of rainfall, the canals easily flooded.

The team began by modernizing their management approach. They created a digital twin of the canal, allowing access to real-time data through sensors, as well as the ability to analyze impending rainfall and open and close gates to adjust the canal's capacity. Today, with better management, the canal has become a haven for wildlife and a recreational destination visited by kayakers and paddleboarders floating on the waterway.

3. Renaissance Period for Water Management

Florence, Italy, is steeped in history and culture. But in 1966, a devastating flood and 600,000 tons of mud, debris, and sewage inundated the city, claimed 100 lives, and ruined many antiquities.

More than half-century later, hydraulic engineer Paolo Tamagnone created a model that mapped the Arno River from its source to the city, assessing areas prone to flooding. He modeled water and wastewater systems, as well as the city's buildings, and ran simulations to predict what happens above and below ground in various flooding scenarios. Detailed maps revealed the most vulnerable areas and enabled the creation of an effective emergency response plan.

4. Digital Models for Faster Response Times

In January 2018, a master meter failed in Livonia, Mich., causing multiple water-main breaks. Officials issued a boil-water advisory and closed a major highway due to flooding. Livonia has 485 miles of water mains built in the 1920s. Its water-management processes were paper-based, and documentation lived in binders. The city hired OHM Advisors, an architecture, engineering, and planning firm, to create GIS-based hydraulic models to simulate more than 40 scenarios for planned and unplanned disruptions. All information is now stored in an interactive digital dashboard that all stakeholders can access. Abandoning archaic processes led to the creation of an emergency response plan based on digital workflows.

5. Brazil's Olympic Challenge

Soon after Rio de Janeiro won the bid to host the 2016 Olympics, the city faced a big undertaking: separating the stormwater from the wastewater, which both ran straight to local rivers and oceans via an antiquated system that was built in the 1850s. In Guanabara Bay, 8,200 liters of sewage spilled into the water every second. Engineers started by manually mapping out the underground utility lines. Then, they created a modern model of the centuries-old system with BIM, which reduced clashes; saved $15 million; and paved the way for a safer, cleaner environment for Olympic competitors and the residents of Rio de Janeiro.

The Future of Water Management

Water management is decentralized, but the entire industry is facing the same challenges. Global demands are predicted to increase water usage by 20% – 50% by 2050, further stressing the dwindling resource. As data reveals more about the dire situation the world is facing, it's forcing an alignment across the industry to achieve collective goals and ensure resilient water systems and infrastructure. And these solutions will rely on a digitized future for water management.

Increased Government Investment in Water Infrastructure

The pandemic was a wake-up call for governments to reinvest in water. Suddenly, the water supply was more than an infrastructure or scarcity issue — it was an immediate public health issue.

So far, in the U.S., that renewed commitment is off to a good start.

- The Department of the Interior is poised to spend $580 million to fix water infrastructure across the West.
- In 2021, the Bipartisan Infrastructure Law allocated $50 billion to improve water infrastructure and systems.
- In the past few years, 80 cities across the country have invested $9.5 billion in their local water resources and infrastructure.

Investing in infrastructure doesn't mean rebuilding the same way it's always been done. Water infrastructure needs to be redesigned for a resilient future.

In Richmond, Calif., West County Wastewater (WCW) is upgrading its treatment plant and reducing its carbon footprint in the process. The utility owns and operates 249 miles of sewer pipelines, 17 lift stations, six miles of pressure-force mains, and a water-quality and resource-recovery plant that takes in 12.5 million gallons a day.

When the project, called Clean & Green, is complete, process improvements and upgrades will save $83 million over the new plant's lifetime and reduce greenhouse gas emissions by 93%. Instead of producing sludge that goes to landfills, the plant will produce Class A biosolids used for agriculture.

Finally, the upgrades will produce energy from digested sludge and a new cogeneration system that will power almost 100% of West County Wastewater's operation.

According to Keith Reynolds, Jr., senior project manager for WCW, the Clean & Green project is an ambitious example of a utility's commitment to the environment and its ratepayers. He says the project will prove to be a model of energy efficiency and has allowed WCW to create an internship program to train water professionals of the future.

AI-Powered Water Management

As the demand on water supply continues to increase, more water agencies will turn to smart water technologies to optimize every part of the water cycle and asset management. They are on pace to spend $6.3 billion on AI by 2030. By leveraging AI and machine learning, they can ensure quality, reduce leaks and wasted water, and optimize energy usage. The water industry has learned the impact of not using technology, but the tide has turned. AI will create a data-powered industry that is more sustainable and more efficient.

For example, Anglian Water, located in eastern England, has been using AI-powered technology for the past couple of years as one of the foundations of its smart water strategy. At its Wing Water Treatment Works production facilities, Anglian Water used Autodesk plant operations products to build 30 water-management models that analyze millions of data coming from live asset data feeds. These models continue to learn, predict, and dynamically respond to problems that arise within the system, which helps operational staff monitor and minimize system-wide energy and chemical costs. This project has already helped the company save £150,000 (about $191,300).

A Stronger Workforce

As the water-management industry increasingly embraces technology for the design and operations of its systems, it will also attract top talent. The next generation of workers includes digital natives who want to work with data and technology. And as machines and robots take over more of the manual tasks, the transition will create more opportunities to upskill the current workforce to achieve the level of smart operations for better systems.

Sustainable water management is one of the world's most pressing issues. To better manage this invaluable resource, data will prove to be the solution the industry needs. By setting a collective goal to push the industry toward a digital future, everyone can do their part to ensure water resilience for generations to come.

About the Author

Dr. Carolina Venegas Martinez is the senior strategy manager for the water industry at Autodesk. She has more than 20 years of experience in the environmental engineering, water, wastewater field and has worked for consulting firms, regulatory agencies, and academia in the United States and overseas.

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