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Sustainability and Resiliency Planning for Water Utilities

Introduction

During a significant weather event, a water utility's level of preparedness can mean the difference between temporary inconveniences and serious health and environmental consequences. Since many Americans rely on water utilities to provide drinking water and sanitation, water utility preparedness can greatly impact how quickly communities can recover from an emergency.

A utility's ability to draw, treat and provide water to customers is directly affected by the variation and intensity of rainfall and can be impacted by both flood and drought. Changes to historical patterns of water availability and quality affect how much water the company can expect to access, whether they can meet expected demand, where treatment plants are located, and the water treatment technologies that are used.

Water and wastewater systems are built for resiliency and sustainability of operations during weather events or other circumstances that could potentially interrupt service. Water utility customers generally do not lose service during storm events because systems are designed to provide continuous service under a wide range of events. Distribution system water storage tanks are built to act as buffers, as are standby energy sources that ensure critical facilities keep running should the utility lose power.

Within a short time frame, the Mid-Atlantic states have experienced multiple significant weather events including the Christmas Blizzard in 2010 that shut down NYC and coastal N.J. for five days, Hurricane Irene, the 2011 Tropical Storm Lee, the October Northwest snowstorm in 2011, and the Mid-Atlantic/Midwest Derecho and Hurricane Sandy in 2012.

The experience of these events has created a renewed focus on business continuity planning and emergency response for water utilities. When events that were historically considered to be "100-year" events happen more and more frequently, utilities must prepare for a new "normal."

Water Availability

The recently released Report on Freshwater Supply from the Government Office of Accountability states that according to state water managers, experts, and literature GAO reviewed, freshwater shortages are expected to continue into the future. In particular, 40 of 50 state water managers expected shortages in some portion of their states under average conditions in the next 10 years.

Most of the southwest, parts of California and the southern and central Great Plains will be the most vulnerable areas in the U.S. to water shortages during the next 60 years, according to a U.S. Forest Service Report.[1] The report also stated that, according to some scenarios, precipitation for the U.S. is expected to decline by more than 30 percent of current levels by 2080. Drought may leave customers dry and stoke competition among stakeholders for water resources. In some particularly vulnerable regions of the U.S., important reservoirs will be left with little or no water. [2]

1 "Vulnerability of US Water Supply to Shortage: A Technical Document Supporting the Forest Service 2010 RPA Assessment"
2 "Vulnerability of US Water Supply to Shortage: A Technical Document Supporting the Forest Service 2010 RPA Assessment"

Salt water intrusion into groundwater, which often happens when groundwater levels are low, can also affect the quality of available water supply. Salinity levels that exceed U.S. drinking water standards could require development of new, more expensive water sources (surface water treatment) or the installation of advanced water treatment solutions such as brackish water desalination, which is more energy-intensive to operate than conventional treatment systems.

With water treatment plants located very close to water sources, having too much water can be just as much a problem for operations as having too little. Storms and floods may overwhelm systems and interrupt operations.

Climate Change

Climate change is affecting weather patterns and the world's ecosystem and, in particular, posing serious challenges to the world's water supply. Climate change is having a profound effect on how communities can reliably access clean water, causing poor water quality and scarcity and putting significant stress on the water infrastructure. In 2011 and 2012 alone, there were 25 climate-related extreme-weather events that each caused about $1 billion in economic damages.[3]

For U.S. water providers, addressing the impact of climate change will require: finding solutions to maintain adequate levels of water supply to communities; ensuring high standards of water quality in the face of droughts or flooding; and balancing the need for infrastructure improvements while keeping this vital resource as affordable as possible.

The water utility industry is both a contributor to climate change as well as a voice for initiating, planning and building resilience, since they experience climate and weather variability firsthand. Water and wastewater utilities contribute substantially to greenhouse gas (GHG) emissions, largely through the electricity used to treat and pump water. Water is very heavy to deliver – a family using 240 gallons of water per day is literally using a *ton of water every day*.

The industry uses an average four percent of U.S. electricity, seven percent of global electricity, and nearly 20 percent of the electricity in some regions like California. A water utility's energy needs can account for as much as 30 percent of its operating budget.[4]

Nearly 93 percent of American Water's GHG emissions come from electricity use, used largely for pumping water,[5] from a combination of natural gas (for buildings and treatment facilities) and gasoline and diesel fuel (for vehicles and generators) use.[6]

Other Factors

The impact of climate can also be amplified by "man-made" factors such as urbanization and population growth. The creation of impervious surfaces—parking lots, roads, roofs—associated with urbanization accelerates the impact of climate changes: flooding, for example, is accelerated by faster rain collection and run-off into streams than has been experienced in the past. Continued population growth is expected in the West and Southwest United States, exacerbating the region's limited groundwater and surface water supplies. The water-stressed Southeast is also rapidly increasing in population, especially in coastal areas vulnerable to storms and salt-water intrusion.

The growth of the suburbs over the past 50 years has also increased the presence of mature shade trees that are directly in the alignment of above ground power distribution and communications lines that are critical to the reliability of electric utility service. The requirement of local Shade Tree Commissions often inhibits the ability of power utilities to remove or trim these trees and thus the impact and recovery from

[3] Center for American Progress: Infrastructure and Resilience: Forging a National Strategy for Reconstruction and Growth. April 18, 2013.
[4] Julia Pyper, "Limited Budgets a Major Concern for Health of U.S. Water Sector—Survey," *E&E Climatewire*, June 12, 2012, available at http://www.nwra.org/content/articles/limited-budgets-a-major-concern-for-health-of-us-w/.
[5] American Water, "Innovation & Environmental Stewardship: Review of Significant Water Industry Trends," http://www.amwater.com/files/I&ES%202009%20Review%20of%20Water%20Industry%20Trends.pdf.
[6] American Water, *Corporate Responsibility Report 2010*, available at http://amwater.com/files/AMER0838_CR%20Report%202010_8_23.pdf.

severe storm events is increased. Newer communities have installed these utilities underground but the cost to relocate these utilities underground for older communities is significant and thus has not yet occurred.

Infrastructure

One of the major challenges facing the water and wastewater industry in the United States is the age of its infrastructure. Much of the vast network of aging treatment plants, pumping stations, storage facilities, and nearly 700,000 miles of main and collection pipe is in need of replacement or repair. The U.S. EPA estimates that $633 billion is needed for capital improvements to drinking water and sewage infrastructure just to maintain current levels of service over the next two decades.[7] In addition, by some estimates it will cost utilities between $448 billion and $944 billion to address climate change issues through 2050.[8]

Across the country, water systems – and their customers – are enduring the ramifications of underinvestment and, consequently, poor maintenance. Aging infrastructure, main breaks, climate change and weather is impacting the way we live. It is estimated that every two minutes a significant water line ruptures somewhere in the U.S,[9] leading not only to trillions of gallons of water wasted annually, but severe economic losses as well. In the summer of 2011, for instance, the rupture of a century-old water main in The Bronx disrupted the morning commute, damaged two gas mains, shut down electrical service to 500 customers for several days,[10] and put as many as 60 local businesses at risk of permanently closing.[11]

Water main breaks have stranded drivers on washed-out roads, impacted businesses and ruined roads around the nation. They caused a mudslide in California, flooded school libraries in Minnesota and Texas and snarled traffic and flooded homes in Philadelphia. A break in Niagara Falls, N.Y., spewed some 11 million gallons of water. In 2009, just after Gov. David A. Paterson attended the opening of a new subway station in Lower Manhattan, service to the subway line was suspended when a water main that was installed in 1870 burst, flooding the tracks.

Severe droughts in the Midwest in 2010 caused the ground to shrink and crack, leading to an increased number of water main breaks nationally. Additionally in 2012, low rainfall and extreme heat led to crisis drought conditions in many states, with the Midwest hit hardest again. According to the National Weather Service, 2012 was the fourth hottest summer on record in St. Louis County, Mo., with 21 days of triple-digit temperatures. County facilities pumped 368 million gallons of water on June 30—a new record for the system with a 400 million-gallon-per-day capacity. Iowa City saw a record number of water main breaks in 2012, primarily due to low soil moisture which caused the ground to shift and water mains to be displaced.

Maintaining Operations

In water / wastewater system terms, resilience is the ability of an asset or system to withstand an attack or natural hazard without interruption of performing its function or, if the function is interrupted, to restore the function rapidly.

Like all large users dependent on electricity from the grid, water utilities must plan for power outages and develop plans for maintaining continuity of operations when such outages occur. Nonetheless, recent weather patterns combined with the issue of aging infrastructure are causing utilities to review traditional

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[7] Brett Walton, "America's Water Infrastructure Shows Its Age," Circle of Blue, http://www.circleofblue.org/waternews/2012/world/americas-water-infrastructure-shows-its-age-the-national-debate-about-how-to-pay-for-repairs/. See also American Water Works Association, *Buried No Longer: Confronting America's Water infrastructure Challenge*, February 2012, http://www.circleofblue.org/waternews/wp-content/uploads/2012/02/AWWA_BuriedNoLonger.pdf.

[8] National Association of Clean Water Agencies and Association of the Metropolitan Water Agencies, *Climate Change: An early analysis of Water and Wastewater adaptation Costs*, October 2009, http://www.amwa.net/galleries/climate-change/ConfrontingClimateChangeOct09.pdf.

9 Duhigg, Charles. "Saving U.S. Water and Sewer Systems Would be Costly," The New York Times. 14 March 2010. http://www.nytimes.com/2010/03/15/us/15water.html

10 Ember, Sydney, "Flooding in Bronx After Water Main Breaks," The New York Times. 27 July 2007. http://cityroom.blogs.nytimes.com/2011/07/27/jerome-ave-becomes-river-after-a-water-main-bursts/

11 Paddock, Bary. "Owners of 60 Bronx Businesses Face Going Broke in Wake of Water Main Break," New York Daily News. 29 July 2011. http://articles.nydailynews.com/2011-07-29/local/29844261_1_flood-zone-business-owners-giant-water

planning and design criteria. The design standards for supplies, treatment plants, pump stations and tanks are taken together to achieve a level of zero service outages. The so-called new normal has led experts to look beyond traditional reliability and emergency planning into a world that needs the speed of recovery and resiliency for much more widespread events.

Updating event response planning and procedures to keep up with the increase in extreme weather is just as important as preparing for long-term changes in climate. In the past few years, American Water has found that its planning standard of 50 percent of an average day demand for standby power is no longer adequate for maintaining service for extended time periods after an extreme event. As a result, it has systematically added additional standby power capacity, in addition to using a more diverse and reliable mix of emergency fuel supply.

The company operates or has operated facilities in hurricane-prone regions, including a customer call center in Pensacola, Fla., and a wastewater plant in Jefferson Parish, La., that was affected by flooding from Hurricane Katrina in 2005. Storms and hurricanes may not only inundate facilities, they can also interrupt the electricity needed to operate treatment plants and communication systems needed to quickly restore service. After Hurricanes Floyd and Irene in 1999 and 2011, respectively, widespread power outages and floods in the Northeast disrupted service in the company's New Jersey and Pennsylvania systems.

Preparing to quickly restore service also requires the right skills and personnel to respond to emergency conditions. After the 1993 Mississippi River flood, American Water was able to bring in personnel from around the country to dry pumps, airlift them to the manufacturer to be rapidly retrofitted, and then re-installed. American Water's plant was running again in five days, while a neighboring plant was out of water for 30 days. In 2011 when an intense tornado leveled parts of Joplin, MO., American Water mobilized crews within the state to be on-site within hours to bring the system back into service.

In June 2012, West Virginia American Water responded as a 600-mile super storm devastated the state and presented the company with the biggest test of its disaster preparedness and emergency response in 126 years of existence. Approximately half of the company's system's 550 electricity-dependent remote sites lost power – sites that either physically pump water throughout the distribution system or monitor tank levels and pressures and communicate the data to central control rooms through SCADA systems. Within twelve days after the initial storm, all West Virginia American Water systems were fully operational, no customers were experiencing storm-related outages, and no customers were under a precautionary boil water advisory. But like every crisis situation, the company used this event as an opportunity to learn from the experience and improve operations for future responses.

Most recently in October 2012, Hurricane Sandy was one of the largest storms to hit the northeast U.S. in recorded history, killing 159, knocking out power to millions, and causing $70 billion in damage in eight states. Sandy severely damaged numerous treatment plants and pumping stations, and damage to a number of wastewater treatment plants kept largely untreated sewage flowing into local waterways for weeks, and in some cases, even months after the storm.

Hurricane Sandy caused water and wastewater utilities to rely completely on emergency power generation to provide service. New Jersey American provides water service to approximately 30 percent of the state's population and as a result of Hurricane Sandy experienced widespread power interruptions in its service territories. Through the use of both stationary and portable emergency power generation, it was able to provide uninterrupted service to the vast majority of its customers. The company is also building redundancies into its telecommunications systems—something it has never had to do before. And, the company is using Geographic Information System maps and global positioning system technologies in some areas to better position valves and meter boxes out of harm's way.

The storm surge, wind and wave energy from Sandy also resulted in significant property and underground infrastructure destruction for a large coastal region. Underground infrastructure is generally felt to be less vulnerable during extreme weather events but the effects of Sandy and other recent extreme weather events has changed that thinking. Utilities have experienced the destruction of buried water mains as trees are uprooted during high winds.

Managing Risks

Managing water and climate risk is not new to the water industry as the climate is always changing. But there is greater climate variability than in the past. American Water is mitigating these risks in a number of ways:

Risk Assessment: Engineering Planning Studies

A systematic approach to assessing vulnerability of water supply to climate variability is embedded into American Water's engineering planning studies. The engineering and operations team examines every facility and regional water availability to develop a capital plan—how much investment is needed, based on a five-year planning cycle, to meet future infrastructure needs—as well as a 15-year outlook that incorporates estimates of population growth, urbanization rates, and other factors. Business continuity and emergency response plans are also developed or updated to increase preparedness to address climate related scenarios. Climate change factors may not be explicitly included in the capital plan if there is not sufficient detail for physical climate change impacts in particular geographic zones and within its 15-year planning horizon. The company will however conduct sensitivity analyses of its historic water variability record with future predictions and safety factors that can consider accelerated impacts such as, for example, a 100-year flood occurring every 20 years or a 20-year flood occurring every five years. The engineering planning studies drive American Water's capital needs assessments, business planning, and financial forecasting.

Planning studies include, for example:

- Historic water variability records;
- Regional urbanization trends;
- Expectations about population growth;
- Local and regional per capita use of water;
- Regional availability of water supply; and
- Current and future regulations impacting the quantity and quality of water supplies.

American Water's in-house engineering team relies on extensive historic records of its water systems' supply withdrawals and customer water usage patterns, as well as government databases (such as those from the U.S. Geological Survey) that track quality and quantity of groundwater and surface water supplies. The team also factors in trends in water use and conservation that indicate over 1 percent decline in U.S. per capita water use per year across the past ten years—a trend that the company expects will continue.[12] The U.S. EPA's Climate Ready Water Utilities Working Group[13] was also a very helpful forum for sharing lessons among utilities. The water supply "safety factors" are a judgment call that balance project costs with operational reliability and dependability. The company's 15-year planning horizon allows for incremental improvements using the most up-to-date available data over the 50 to 80 year lifetime of an asset.

The engineering planning studies also have the added benefit of providing a strong foundation for communicating with state utility regulators and local government officials about the impacts of climate change and other factors on the integrity of water supplies and infrastructure, and the need for a more integrated approach to water resource management. The studies have proved to be a valuable tool for making the business case to state regulators, who assess costs and rates based on historic records, for system investments needed to meet customer demands now and in the future.

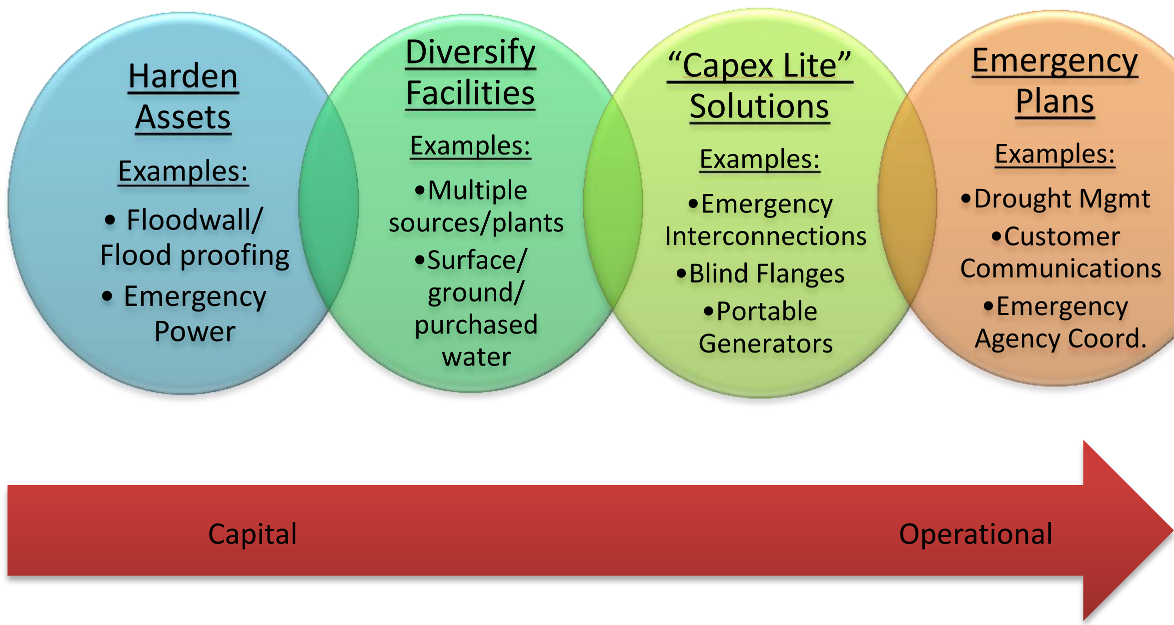
American Water emphasizes, however, the conclusions from its risk assessment models and planning studies do not always result in a decision to build additional infrastructure. Often, an operational solution or well-scoped emergency plan could be a more effective solution to a particular scenario. In many cases, a combination of solutions, ranging from capital to operational, provide the best resiliency against extreme events (see Figure 1).

12 North America Residential Water Usage Trends Since 1992

13 Climate Ready Water Utilities, Final Report of the National Drinking Water *Advisory Council*, December 9, 2010, available at http://water.epa.gov/drink/ndwac/climatechange/upload/CRWU-NDWAC-Final-Report-12-09-10-2.pdf.

Thus, consideration is given to other factors in determining the need for upgrades, such as equipment age, condition and historic performance, opportunities to improve efficiency through better technologies, and ability to meet future regulations and growth projections. It is more often a combination of these primary drivers that triggers infrastructure upgrades, and climate change impacts can be an added consideration in the decision-making process.

FIGURE 1



Risk Management: Integrated Resource Management

As part of its business continuity and investment planning, the company has made a number of decisions over the years to modify operations, harden systems, and even move plant locations. Between 2007 and 2010, American Water invested $800 million to $1 billion annually in system improvements.[14] In a few cases, investment decisions have been augmented by concerns caused by extreme weather.

- After 1993's Mississippi River flood, American Water decided to move its Alton, Ill., plant to higher ground. Given the plant's age, limited opportunity for future expansion, and company expectations about the likelihood and consequence of future floods, the plant was decommissioned and a new one built at a higher elevation.
- After Hurricane Floyd in 1999, the company installed a floodwall at a major plant in N.J. Twelve years later, that investment decision proved to be invaluable when flooding from Hurricane Irene came within an inch of the top of the floodwall but protected a critical water supply facility serving a large population. In Iowa, the company last year received approval to increase floodwall protections—a 2,000-foot earth levee surrounding the plant—at its Davenport facility along the Mississippi River. Construction on this is expected to be complete in 2013.
- Engineering guidelines for new buildings in flood zones require that facilities be built high enough that system electronics installed are protected from potential floods.
- In the drought-prone Midwest United States, the company has replaced turf grass with natural prairie grass at a number of locations that, in addition to supporting local wildlife, needs much less water to maintain.
- To help resolve periodic severe water scarcity challenges in Kentucky, which may further intensify with climate change, the company constructed a $164 million water treatment plant to help

[14] American Water, Corporate Responsibility Report 2010.

ensure adequate water supply to the region, which has been severely challenged by drought and increased demand.

- The company is working toward replacing older, inefficient water treatment plant pumps through 2017. This effort is timed seasonally in order to maintain adequate customer service as well as meet operational requirements for pumps available for back-up needs. This phase-out will both reduce energy use and help minimize risk of disruptions in electricity supply.
- Availability and use of alternative or distributed water supplies, for example, re-use, groundwater recharge, storm water retention and treatment, and non-potable supplies, and technologies that enhance these opportunities;
- Integrated analysis of engineering, economic, societal, and environmental costs;
- Identifying and managing risk and uncertainty, including considering emerging guidance on relevant issues such as the potential impacts of climate change; and
- Encouraging coordination of planning between water and wastewater utilities, environmental agencies, nongovernmental organizations, land use planners, transportation planning, and others in specific regions.[15]

Support from state and federal regulators[16] is critical for the company to achieve these water risk management objectives. For many state regulators, especially in water-stressed states like Texas, California, and Arizona, water conservation is a way of life. Regulators in California, for example, have implemented water "conservation pricing" that decouples the price of water from the amount of water that people use. Regulators in Pennsylvania, New Jersey, Indiana, and Illinois are beginning to explore the costs and benefits of water conservation tariffs. For American Water, these policies help achieve its water risk management objectives and help the company communicate with customers about the interaction between conservation measures and water prices.

American Water has implemented an emergency response process in accordance with the National Incident Management System framework that was established by the United States Department of Homeland Security. Not only is it comprehensive but it facilitates better role alignment and coordination with Federal, State and local emergency management agencies. Another lesson from these events is the dual purposing of resources during storms. Support personnel in non-operational roles are pre-assigned to specific duties during emergencies to augment the operational staff.

Technology Innovation

Developing new technologies is as important as improved decision-making for making the water industry more effective and efficient.

American Water has taken a proactive approach to leverage the company's position and expertise to validate innovations using the company's large and geographically diverse footprint, ultimately becoming an early-adopter of new technologies for industry use. This unique program is called the Innovation Development Process (IDP). This program fills a vital need to seek innovative, cost effective, and sustainable solutions that can benefit all water utilities. It combines research and development, technical expertise, and infrastructure assets with innovations from both within American Water and from external business partners to create greater efficiencies in the areas of drinking water and wastewater. *See American Water White Paper: Bridging the Water Innovation Gap*.

The company believes that two of the most important technological solutions for better water availability risk management are water reuse and desalination. American Water currently operates recycled water systems that process and reuse wastewater for flush water, HVAC systems, and landscape irrigation—greatly reducing demand for freshwater resources. The company's zero-discharge water recycling plant

[15] Excerpted from American Water, Corporate Responsibility Report 2010.
[16] Water quality and service rates are subject to extensive oversight by state utility commissions and all operations are subject to water quality regulations by federal, state and local governments.

developed through a public-private partnership with the city of Fillmore, Calif., provides one million gallons of treated water per day for irrigation and groundwater recharge. In Tampa Bay, Fla., American Water operates the United States' largest desalinization plant, providing 25 million gallons of water per day through a reverse osmosis process.

Also an active Research & Development area is an energy-efficient wastewater treatment technology called NPXpress. Most of the energy used for treating wastewater occurs during aeration, to remove nitrogen and phosphorous. NPXpress uses 50 percent less oxygen (and therefore less energy) for aeration, and fewer chemicals for treatment. The technology enhances energy and operational efficiency, and reduces costs, making water re-use a more economical and promising way to expand overall water supplies. It is also more effective at reducing nitrogen and phosphorous emissions from plants, which are coming under more stringent government regulation, as well as nitrous oxide (N_2O) emissions—a very powerful greenhouse gas.[17] American Water is piloting the technology at eight water systems in its service territory, and expects that N_2O emissions from wastewater plants will become an increasingly important business risk within the next five to ten years.

American Water is exploring new technologies and applications even from outside of its industry to enhance efficiency and build flexibility and resilience into its electricity service. One such example is its partnership with Canadian firm ENBALA, an energy technology developer that had never before worked with water utilities in the United States. The ENBALA Power Network is the first smart grid[18] partnership between water and electric utilities in the United States.

American Water initiated the relationship with ENBALA to pilot, validate, and build a business model for the smart grid system. The partnership is currently rolling the system out and expects to have four major systems in place by the end of 2013. Pilot projects are taking place on the PJM power grid where American Water has a large concentration of customers, and the company has also reached out to grid system operators in California and Illinois.

Conclusion

Sustainable water infrastructure is vital to providing the American public with clean and safe water and helping to ensure the environmental, economic, and social health of the nation's communities. As the practice of planning for sustainability evolves, more effective practices will emerge.[19]

A water utility's goals are to protect public health and ensure service continuity. Service reliability has been and will always continue to be a key parameter in the planning and design of all water and wastewater systems. The bottom line is, the better prepared you are, the better the outcome.

[17] When wastewater companies take steps to reduce nitrogen emissions, they can inadvertently create nitrous oxide (N_2O). NPXpress eliminates N_2O emissions by treating nitrogen through a different metabolic pathway than traditional treatments.

[18] The "smart grid" refers to the application of digital technology to the electric power sector to improve reliability, reduce cost, increase efficiency, and enable new components and applications. See discussion at C2ES, "Climate Techbook: Smart Grid," http://www.c2es.org/technology/factsheet/SmartGrid.

19 U.S Environmental Protection Agency: "Planning for Sustainability: A handbook for water and wastewater utilities."