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Recent events in **Water and Water Infrastructure** make this *The CIP Report* extremely timely.

GEORGE MASON UNIVERSITY
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First, Michael Arceneaux, Managing Director of the Water Information Sharing and Analysis Center (WaterISAC) explains the work of the WaterISAC and the importance of information sharing in this critical lifeline sector. Next, Erica Brown, Director of Sustainability and Climate Programs with the Association of Metropolitan Water Agencies, discusses the recent Water Resilience Summit and the role of the water sector in climate resilience. Michael Deane, Executive Director of the National Association of Water Companies (NAWC) writes about the organization's work in addressing risk in water systems. Tom Pedersen, of CDM Smith, and Anthony Kane, of the Institute for Sustainable Infrastructure, highlight a new sustainability rating system for horizontal infrastructure projects. Celia Porod, Michael Collins, and Frederic Petit, of the Infrastructure Assurance Center at Argonne National Laboratory, analyze the interdependencies of water and wastewater treatment systems with other critical infrastructure assets. Finally, Stephanie Simpson, Research Participant with the Oak Ridge Institute for Science and Education (ORISE), reviews U.S. Environmental Protection Agency (EPA) efforts to increase water system emergency preparedness.

We would like to take this opportunity to thank this month's contributors. We truly appreciate your valuable insight.

We hope you enjoy this issue of The CIP Report and find it useful and informative. Thank you for your support and feedback.

Mick Kicklighter
Director, CIP/HS
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Information Sharing in the Water and Wastewater Sector

by Michael Arceneaux*

While not the most captivating subject, information sharing is critical as one of the most important strategies in our collective efforts to foster resilient critical infrastructure. Information sharing is essential for analyzing malicious acts; the resulting analyses can be used to detect patterns, identify and fill gaps in preparedness, develop lessons learned and, ultimately, provide advanced warning of potential attacks.

The Water Information Sharing and Analysis Center, better known as WaterISAC, is one of 17 information sharing and analysis centers (three more are in the process of establishing themselves). All of these centers are members of the National Council of ISACs, representing organizations that serve as the operational arm of their respective sectors or subsectors. Most collect and analyze incident reports from members and other sources. Some focus more on cybersecurity than physical security, and vice-versa. Some, like WaterISAC, focus on both.

WaterISAC specifically analyzes security incidents and suspicious activity in the water and wastewater sector. Many incident reports come to WaterISAC directly from its members. Some come from the Department of Homeland Security (DHS), state and local intelligence fusion centers and other information sharing and analysis centers, and open sources. Through its Industrial Control Systems Cyber Emergency Response Team (ICS-CERT), its United States Computer Emergency Readiness Team (US-CERT), and the National Cybersecurity and Communications Integration Center, DHS's Office of Cybersecurity and Communications has been a generous information-sharing partner. DHS cybersecurity program leaders and staff have taken to heart the information sharing provisions in Presidential Policy Directive 21 -Critical Infrastructure Security and Resilience (PPD-21).

Knowledge regarding the incidents water and wastewater systems experience guides WaterISAC in the creation or selection of the mitigation resources it delivers. Recently, when a utility reported that the ransomware Cryptolocker bad encrypted several terabytes of business data and files, WaterISAC shared the "anonymized" details of the incident and mitigation resources with members. In an excellent example of how information sharing begets more information sharing, this alert prompted another utility to report it also had an encounter with ransomware, CryptoWall.

In the last several months, WaterISAC also received reports of brute-force attacks against a weak password mechanism and a distributed denial-of-service attack against a city website by the hacker collective Anonymous. Another utility reported it was the target of a potential social engineering attempt, in which the caller, without success, tried to persuade an employee to divulge sensitive process control system information.

Of course, physical security incidents are not uncommon. Reports from around the country highlight instances of possible tampering, break-ins, and threats by disgruntled employees, among others. In February, unknown individuals illegally disposed of polychlorinated biphenyls (PCBs) in grease traps, contaminating Charlotte-Mecklenburg Utilities' wastewater effluent and critical equipment. Without interrupting service to customers, Charlotte-Mecklenburg captured the contaminated effluent in holding basins for later treatment. Similar events occurred in the Spartanburg, South Carolina area last summer. Both sets of incidents, which are still under investigation, resulted in millions of dollars of cleanup costs.

None of these physical security incidents have been classified as terrorism-related, but reporting these and others like them to WaterISAC is critical for threat awareness. With the information it collects, WaterISAC uncovers trends, identifies emerging threats, and provides warnings to its

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members. WaterISAC frequently reminds its members to report even seemingly uneventful security incidents; what may appear to be common criminal activity could be, in fact, more sinister when an intelligence analyst can see a larger part of the puzzle.

International terrorists may or may not be in the United States targeting critical water and wastewater infrastructure, but their proxies are. The continuing calls by international terrorist groups for U.S.-based extremists, such as the Boston Marathon bombers, to take action at home remains a concern for WaterISAC. Forces closer to home are also a concern. Most water and wastewater systems are government-owned, and government facilities are often targets of anti-government extremists. In February, FBI agents arrested three men in Georgia in connection with a plot to purchase explosives and carry out an attack on water treatment plants, power transfer stations, and federal agencies. The group hoped to "start the fight" with the government by sabotaging infrastructure, inciting mass hysteria, and provoking other militia groups to join the battle.[1]

There is a natural reticence to share examples of security breaches, but WaterISAC provides a safe venue for owners and operators. Members and partners share incidents with WaterISAC on a confidential basis, and the information derived from them is only used with permission from the originator. Reporting also enables WaterISAC's analyst to support the affected utility by pin-pointing the most relevant resources on the WaterISAC portal. The analyst also serves, when requested by the utility, as a liaison to DHS. WaterISAC's relationships, for instance, with ICS-CERT and US-CERT have benefited water and wastewater utilities seeking to resolve risks and vulnerabilities.

On the surface, information sharing may seem like a natural process requiring little intervention to be effectively facilitated. Real world situations and exercises, however, have revealed how ineffective communications have put operations at peril and entire communities at risk. Any entity that possesses potentially sensitive information, be it a government agency or a critical infrastructure owner or operator, has understandable reasons for being hesitant about sharing their data. They might withhold data, worrying it might be shared inappropriately, placing facilities and reputations at risk.

Understanding the need to share important data information with its partners while exercising the greatest responsibility in doing so, WaterISAC has established itself at the nexus of information sharing and analysis activities for the water and wastewater sector. In this way, WaterISAC has helped satisfy the value propositions for both the government and the industry for participating in the robust and controlled exchange of information. The result is better informed partners who are optimally positioned to address the security challenges of today and tomorrow. ❖

Michael Arceneaux is WaterISAC's managing director and the deputy director of the Association of Metropolitan Water Agencies. He previously served in the U.S Navy and as a U.S. Senate legislative aide.

[1] Kate Brumback, "FBI: Men Tried To Buy Bombs For Government Attack", *Associated Press*, February 21, 2014, http://bigstory.ap.org/article/fbi-men-tried-buy-bombs-government-attack-0.

Water Sector Identifies Keys to Climate Resilience

by Erica Brown*

Climate resilience is a key component of President Obama's climate change policy. Executive Order 13653, *Preparing the United States for the Impacts of Climate Change*, released in November 2013, directs federal agencies to take steps to support communities in increasing their preparedness to climate change and resilience to extreme weather events. The order also established a State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience to provide recommendations for how the government can modernize its programs and support climate resilient investment to help communities become more resilient to climate change while continuing to protect public health and the environment.

Climate resilience is also on the minds of water utility managers. Resilience challenges attributable specifically to extreme weather events and climate change include too much water, too little water, sea level rise, and falling water tables. Building a resilient water utility goes beyond preparing for the uncertainty of climate change impacts on drinking water, wastewater, or storm water utility operations. Water sector agencies must also plan for other uncertainties, such as declining use of water, declining water availability, employee turnover, tax changes, facility security issues, and population growth.

Recognizing that addressing climate resilience is a necessary component of the efforts of water and wastewater utilities to continue to provide their services, the Association of Metropolitan Water Agencies (AMWA) and the National Association of Clean Water Agencies (NACWA), in collaboration with the U.S. Environmental Protection Agency, hosted the Water Resilience Summit in April 2014 in Washington, D.C.

AMWA is an organization of the largest publicly owned drinking water systems in the United States. NACWA represents more than 300 publicly owned wastewater treatment agencies. Drinking water and wastewater utility directors from coast to coast participated in the Summit, which was led by U.S. EPA Administrator Gina McCarthy, and included representatives from the EPA, the Army Corps of Engineers, the Department of the Interior, the Department of Energy, the White House Council on Environmental Quality, the U.S. Geological Survey, and the Federal Emergency Management Agency. Also joining these participants were financial and insurance experts.

Administrator McCarthy set the theme for the Summit in her keynote address: "From historic droughts that threaten water supplies to super storms that overwhelm sewer systems, the impacts of climate change are felt at the local level where we treat and manage our water."

Noting how these threats affect, or will soon affect, their ability to deliver adequate water supplies and protect water quality, utility directors identified several challenges affecting their ability to build infrastructure and make improvements that will meet the demands of managing water resources in a changing climate.

In their post-Summit report, W*ater Resilience Summit: Summary & Next Steps*, AMWA and NACWA detailed the difficulty in funding critical infrastructure projects that would boost resilience as well as the slow and cumbersome process to secure federal and state permit approval. Utility managers also noted a lack of public understanding regarding the potential risks of climate change to water and wastewater systems. They also expressed concern about the lack of cross-sector and cross-agency dialog on climate and water resilience, noting that there are at least 20 federal agencies with a role in managing or regulating water.

With these challenges in mind, Summit participants discussed a number of potential solutions

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and opportunities:

Planning, Funding and Financing

Federal agencies and local utilities should work together to identify means to fund resilience planning and implementation. With limited federal funds available, utilities suggested that AMWA and NACWA could work to advocate for leveraging existing funds from agencies with programs that benefit drinking water and clean water utilities for projects that advance resilience goals.

In addition, water utilities stressed the desirability of a federal framework for funding infrastructure that incorporates resilience before it is needed rather than post-disaster rebuilding. Equally important is ensuring consideration of how federal investment projects contribute to overall system resilience. Finally, federal agencies and utilities can leverage existing partnerships with the private investment sector to broaden the incorporation of technologies that create more resilient water and wastewater systems.

As explained previously, a resilient utility must consider many uncertainties in order to be sustainable and resilient into the future. Utilities should plan for and fund resilience as a component of all system services, not as a stand-alone activity. Incorporating climate resilience should be one of many components considered in effective utility management.

Permitting and Regulatory Flexibility

Federal and state agencies and utilities must look more holistically at regulations to ensure flexibility for climate resilience and to leverage opportunities that capitalize on multiple benefits for innovation. These opportunities for innovation often exist across communities and across sectors. Given the high priority of water needs, permitting agencies should speed up project review and expedite permit approvals, which in some cases can take several years.

Public Education and Community Outreach

Water infrastructure is often invisible until it fails. Federal agencies and utilities should work together to better inform the public and communities about the need for resilience in water systems. Raising awareness of local elected officials and ratepayers on the value of this infrastructure is important today and will continue to be important in the future as the cost of maintenance and upgrades to address climate resilience continue to increase. Similarly, as the public often sees utility leaders as the face of water in their community, utility leaders should make use of this unique relationship to more effectively communicate the importance of investment in utility resilience.

Partnerships and Coordination at All Levels of Government

Numerous federal agencies share responsibilities for water and climate resilience. Understanding these connections and the number of existing partnerships involving federal agencies, local utilities, and communities will help identify redundancies and raise awareness for local utility managers.

Federal agencies should more effectively coordinate among themselves and with the private sector to ensure the ability to optimally manage water resources. In addition to federal agencies, utilities should build more partnerships with NGOs and the public, to move from confrontation to collaboration for holistic water resource management.

Concluding Observations

More cross-sector and cross-agency solutions are needed that can consider environmental protection, health, energy, transportation, and communications in a comprehensive resilience implementation package. This requires coordination across agencies at all levels of government and with the private sector. AMWA and NACWA must work to understand how federal agencies are currently working to support water utility climate resilience and should continue discussions with federal agencies and within their memberships to work collaboratively to address these challenges.

AMWA and NACWA's *Water Resilience Summit: Summary & Next Steps* is available at www.amwa.net/2014summit. ❖

**Erica Brown is the Director of Sustainability and Climate Programs at the Association of Metropolitan Water Agencies.*

Addressing Risk in the Water and Wastewater Systems Sector

By Michael Deane*

The National Association of Water Companies (NAWC) is voice of the private water industry and exclusively represents private water system providers—both the regulated utilities and public-private partners—who efficiently and reliably deliver drinking and wastewater services to communities around the country, drive innovation in water system delivery, and who are responsible partners with the public drinking and waste water sector. We are an association characterized by our members' collaborative efforts to leverage our strengths to more effectively address the opportunities and challenges facing our nation's drinking water and wastewater needs.

Every day, private water service companies help provide essential water and wastewater services to nearly 73 million people in the United States, almost one quarter of the nation's population. NAWC serves as a credible resource for this industry sector, engaging with municipal leaders, as well as educators, legislators, regulators, and other water industry experts to help shed light on water-related issues, including those that often go unseen by the general public, such as prevalent risks to the water sector's critical infrastructure security.

Over the past decade, the scope, scale, and meaning of "security" have evolved and our members have adapted to maximize protection and safety. Following 9/11, water system owners and operators overwhelmingly viewed security through the lens of hardening their physical assets. This "guns, guards, and gates" mentality led facilities to make significant investments in order to physically protect and defend their plants and areas of operation within a given geographic fence-line. However, while the resources they poured into installing and instituting closed-circuit cameras, Jersey barriers, checkpoints, biometric sensors, and countless other physical-based improvements helped enhance their onsite security programs, they were typically instituted to prevent terrorism and did little to address natural threats.

Following Hurricane Katrina, owners and operators expanded their security horizons to include all-hazards risks. Balancing the high financial barriers associated with expanding from a terrorism-based focus to an all-hazards approach to security required the development of significant amounts of training and resources that had never existed prior to that time. However, members of the water sector have gone above and beyond in their investments and commitment to these matters, making preparedness and resilience against manmade and natural risks part of their daily operations.

Over time, risks change. And yet, operating within largely voluntary frameworks, private water service companies continue to generate successful, innovative, and forward-thinking approaches to protecting the communities they serve. Where regulatory requirements exist, the sector meets them with high rates of efficiency despite the often costly and burdensome practices associated with them.

Today, while well poised to tackle physical and natural risks, the sector continues to evolve and adapt as it faces new challenges, such as cybersecurity.

As more and more water systems automate their systems, the sector's vulnerability to cyber-attacks has increased exponentially. Recognizing this and eager to mitigate the problem, drinking water and wastewater owners and operators have worked tirelessly to address this critical issue.

Over the past several years in particular, the private and public sector have come together to shore up its cybersecurity posture by working in collaboration to develop and achieve the following:

- Creation of the 2008 "Roadmap to Secure Control Systems in the Water Sector"

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- Formulation of the 2013 "Roadmap to a Secure and Resilient Water Sector"

- Having the Water Information Sharing and Analysis Center develop a partnership with the Department of Homeland Security's ICS-CERT team to facilitate the transfer of real-time threat data across the sector

- Leveraging the Water Sector Coordinating Council to institute a new Water Sector Cybersecurity Strategy Workgroup, which began meeting in June

- Actively participating in the development of the NIST Cyber Framework

- Promoting the American Water Works Association Process Control System Security Guidance

- Collaborating with public municipal drinking and wastewater providers

Once thought to be an issue that only affected information-technology-based sectors, the water sector is making tremendous strides to protect itself from cybersecurity-related risks.

Water companies recognize that, even though we operate within a largely voluntary framework when it comes to security, the important role of legislators cannot be understated.

We appreciate the hard work of those in Congress striving to champion the importance of better information sharing, development of best practices, and the institution of funding mechanisms that foster greater opportunities for public-private partnership, as all these efforts serve to further preparedness and resilience. Our nation needs legislators to address these issues in order to continue the advancement of preparedness and resilience.

To deal with an ever-changing risk landscape, operators have to ensure they can respond and recover in a safe, efficient, and effective manner from acts of physical terrorism, natural disasters, cyber incidents, or any other event (foreseen or unforeseen). Accordingly, the sector has invested hundreds of millions of dollars on mitigation strategies, training programs, exercises, vulnerability assessments, and emergency response plans. However, one risk to security that often goes unnoticed is a lack of federal resources to support our industry's efforts.

As grant programs, federal partnership opportunities, and reimbursements continue to erode, a water company's ability to single-handedly shoulder the ever-present costs of security similarly erodes.

In order to perform well during times of crisis (e.g. Hurricane Sandy), mechanisms to fund the sector's vital activities must be put in place and protected. Whether through tax cuts/credits, lifting the cap on private activity bonds, or via other means and methods, water companies need greater access to federal resources to maintain strong security-related postures.

Another threat to sector security comes from efforts at the national level to remove the current decision-making authority of local utility experts to determine the safest and most effective way to treat their water supplies. Efforts to transfer authority away from local utility experts, particularly on critical operational decisions such as whether or not to implement so-called "inherently safer technologies," could be potentially harmful, costly, and cumbersome for the water industry and could negatively impact the sector's ability to continue providing safe, reliable, and high-quality water services to the nation's communities.

For these reasons, we favor the continued coordination between lawmakers, the Administration, and water companies as legislative proposals concerning this area are considered before Congress.

The water sector has and continues to operate at an accelerated level of commitment to secure its operations. As a whole, security is seen by those in the sector as a critical aspect in maintaining and promoting public health and safety.

As our industry moves forward in this important endeavor, the nation can be assured that NAWC, along with our public sector partners will continue to collaborate and lead the charge. ❖

**Micheal Deane is the Executive Director of the National Association of Water Companies.*

Envision Resilient Infrastructure

by Tom Pedersen* and Anthony Kane**

Introduction

The LEED™ green building rating system has been instrumental in "transforming the way buildings and communities are designed, built and operated."[1] Since its introduction in 2000 by the U.S. Green Building Council (USGBC), projects using the LEED rating system have resulted in building sustainability improvement. Yet LEED does not address the horizontal infrastructure — such as roads, bridges, landfills, drinking water and sewer systems, and wastewater treatment plants — that is integral to every community in this country. The most recent Report Card for America's Infrastructure, released by the American Society of Civil Engineers (ASCE) in 2013, assigns an overall grade of "D+" to our country's infrastructure and indicates that $3.6 trillion is needed to address infrastructure needs by 2020.[2]

Consideration of the social and economic dimensions of sustainability is crucial for any infrastructure project; it is also increasingly important to consider the environmental impacts and benefits over the full life cycle of an infrastructure project, not just those resulting during the construction phase. LEED was used by some to guide the design of infrastructure projects, but the framework does not address the unique issues posed by horizontal infrastructure.

The American Public Works Association (APWA), the American Council of Engineering Companies (ACEC), and ASCE, seeing the need for a unified approach to address the issue of infrastructure sustainability, founded the Institute for Sustainable Infrastructure (ISI) in 2011. ISI's mission is to transform tomorrow's infrastructure through the application of a sustainability rating system for civil infrastructure that fosters the efficient delivery of infrastructure in an environmentally and socially responsible way. Early in 2012, ISI, in collaboration with the Zofnass Program for Sustainable Infrastructure at Harvard University, released the Envision™ sustainable infrastructure rating system.

The online Envision rating system guides users in assessing the sustainability of their project in five major categories: quality of life, leadership, resource allocation, natural world, and climate and risk. Much like how LEED provides certification of building projects, this tool allows for project rating. Owners can then apply to ISI for recognition of their projects. Envision, and its associated tools, serves as an industry resource to promote sustainability in infrastructure development and re-development and supports the best economic choice in the long term.

The demand for a sustainability rating system that can be uniformly applied across all horizontal infrastructure continues to gain momentum as evidenced by increases in the numbers of ISI accredited Envision Sustainability Professionals (ENV SP); the number of professional organizations becoming members of ISI, including the American Society for Landscape Architects (ASLA) and the American Water Works Association (AWWA); and the adoption of the framework by the engineering community and municipal sector.

Over 2,200 individuals have been accredited by ISI as ENV SPs; Envision is being used on over 200 projects including three that have received Envision Awards to date: the William Jack Hernandez Sport Fish Hatchery in Anchorage, Alaska; the Placer County Snow Creek Restoration Project in North Lake Tahoe, California; and the South Los Angeles Wetland Park in Los Angeles, California.

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[1] United States Green Building Council, About the USBGC, http://www.usgbc.org/About.
[2] American Society of Civil Engineers, Report Card for America's Infrastructure, http://www.infrastructurereportcard.org.

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William Jack Hernandez Sport Fish Hatchery - Anchorage, Alaska

The William Jack Hernandez Sport Fish Hatchery in Anchorage, Alaska was the first project completed using the Envision sustainable infrastructure rating system. The project, designed by HDR, Inc., received an Envision Gold award.

The 141,000-square foot hatchery facility is the largest indoor sport fish hatchery in North America, and contains many sustainable features including sophisticated recirculation technology that reduces, by ninety-five percent, the water and energy normally used by conventional hatcheries. Several aspects of the fish hatchery garnered high-level ratings in sustainability, including cleaning of the brownfield site, savings on water and energy, maintaining Ship Creek, and building public education into its design.

Placer County Snow Creek Restoration Project - North Lake Tahoe, California

The Snow Creek Stream Environment Zone restoration project was the first to earn the Envision Platinum award—the highest level attainable. CDM Smith provided planning and design services to Placer County Department of Public Works for the project which is located about one and a half miles from Lake Tahoe's north shore in the community of Tahoe Vista.

The project restored a U.S. Environmental Protection Agency brownfield, removed approximately 10,000 cubic yards of fill, and constructed a Low Impact Development (LID) storm water treatment and conveyance to Snow Creek meadow. The project also constructed a Class 1 bicycle trail, which connects to other multi-modal sites and recreation areas on one end, and existing mountain biking trails on the other. The project provides for public education and stewardship opportunities in restoration, LID storm water infrastructure, and the value of conserving wetlands and meadows to preserve water quality.

South Los Angeles Wetland Park - Los Angeles, California

The South Los Angeles Wetland Park in Los Angeles, California, planned and designed for the City of Los Angeles Department of Public Works Bureau of Engineering by Psomas, earned the Envision Platinum award.

The wetland park is located in a historically undeveloped area of Los Angeles County, formerly known as South Central Los Angeles. The project is a result of Proposition O, a program supported by a series of general obligation bonds valued at $500 million, whose projects were conceived to protect public health by removing pollution from the City's watercourses, beaches, and the ocean to meet Federal Clean Water Act requirements.

Conclusion

As sustainability rating systems continue to proliferate, those that provide added value to users, such as LEED, will find a place in the increasingly crowded marketplace. The Envision rating system provides the means for infrastructure project owners, planners, designers, and stakeholders to collaborate in decision making not only about "doing the project right" but about "doing the right project." Envision is a rating system that will help improve the sustainability of infrastructure and help make our communities more resilient. ❖

** Tom Pedersen, CDM Smith Senior Vice President and Director of Sustainability, has over 36 years of environmental consulting experience with a focus on sustainability. Pedersen is an accredited Envision™ Sustainability Professional (ENV SP) and an Institute for Sustainable Infrastructure (ISI) qualified instructor. He is also an American Academy of Environmental Engineers and Scientists (AAEES) Board Certified Environmental Scientist (BCES) by eminence in Sustainability Science.*

*** Anthony Kane is Vice President of Research & Development at the Institute for Sustainable Infrastructure in Washington, DC. Kane, an ENV SP and LEED™ Accredited Professional, oversees and directs the research and further development of Envision. Kane is a research director and instructor most recently with the Zofnass Program for Sustainable Infrastructure at Harvard University's Graduate School of Design in Cambridge, MA and The Boston Architectural College in Boston, MA.*

Water Treatment Dependencies

by Celia Porod, Michael Collins, and Frederic Petit*

Introduction

As one of the lifeline sectors in the 16 U.S. critical infrastructure sectors, water and wastewater systems are essential for public health and crucial for most critical infrastructure to maintain its operability. As such, it is essential to ensure both the protection and resilience of these systems in order for the successful treatment of water and wastewater to occur. To achieve the required levels of protection and resilience, the interactions of water and wastewater systems with other critical infrastructure assets must be considered. This paper presents an overview of water treatment systems and their interconnections with other critical infrastructure sectors and highlights the criticality of these systems in order to promote understanding of upstream and downstream dependencies they share with other critical infrastructure.

Water Treatment Systems Overview

Public drinking water systems (PWSs) provide potable water for human consumption by treating raw water and delivering treated water through pipes or other structures.[1] There are approximately 160,000 publicly and privately owned PWSs with 2.3 million miles of distribution system piping in the United States. These systems, regulated by the U.S. Environmental Protection Agency (EPA) and delegated States and tribes, provide potable water to about 84% of the U.S. population.[2] The potable water produced and provided by PWSs has several uses. For example, it is used for drinking and sanitary purposes, safety-related activities (firefighting, fire suppression, deluge systems, etc.), and production processes (diluting concentrate materials, dissolving product ingredients, commercial irrigation, etc.). The loss or disruption of a PWS could lead to degraded water quality, decreased pressure in the distribution system, and a reduced amount of water produced.

Water distribution systems are interconnected, and in large cities, several water treatment plants (WTPs) are used to produce the volume of water required. One WTP can usually compensate for a malfunction in another for a short period of time. The number of WTPs in a region depends upon the number of customers served. A very small system (population served < 501) will require only one WTP while a very large system (population served > 100,000) may require more than nine WTPs. Consequences of a malfunction vary according to the characteristics of the system, the criticality of the component degraded (e.g., WTP, pipe, aqueduct, water tower), the season, and the water usage.

Consequences of Water Treatment Degradation

Americans use large quantities of water inside their homes. The average family of four can use 400 gallons of water every day.[3] Water is also required for local business and industry. Industrial water use includes fabrication, processing, cleaning, and cooling. Industries may use treated water produced by a PWS or raw water directly from the environment. In 2000, the United States' water withdrawals for industries were estimated at 19,700 millions of gallons per day (Mgal/day).[4] The average production of PWSs is highly variable, driven

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[1] U.S. Environmental Protection Agency, *Public Drinking Water Systems Programs* (last updated Jan. 17, 2013), http://water.epa.gov/infrastructure/drinkingwater/pws/index.cfm.

[2] U.S. Department of Homeland Security, *Water and Wastewater Systems Sector* (last published June 12, 2014), http://www.dhs.gov/water-and-wastewater-systems-sector; U.S. Environmental Protection Agency, *Understanding Water Sector Interdependencies*, (Aug. 2010), http://water.epa.gov/infrastructure/watersecurity/communities/upload/CBWRGeneralInterdependenciesFactSheet.pdf.

[3] U.S. Environmental Protection Agency, *Indoor Water Use in the United States* (last updated July 24, 2014), http://www.epa.gov/watersense/pubs/indoor.html.

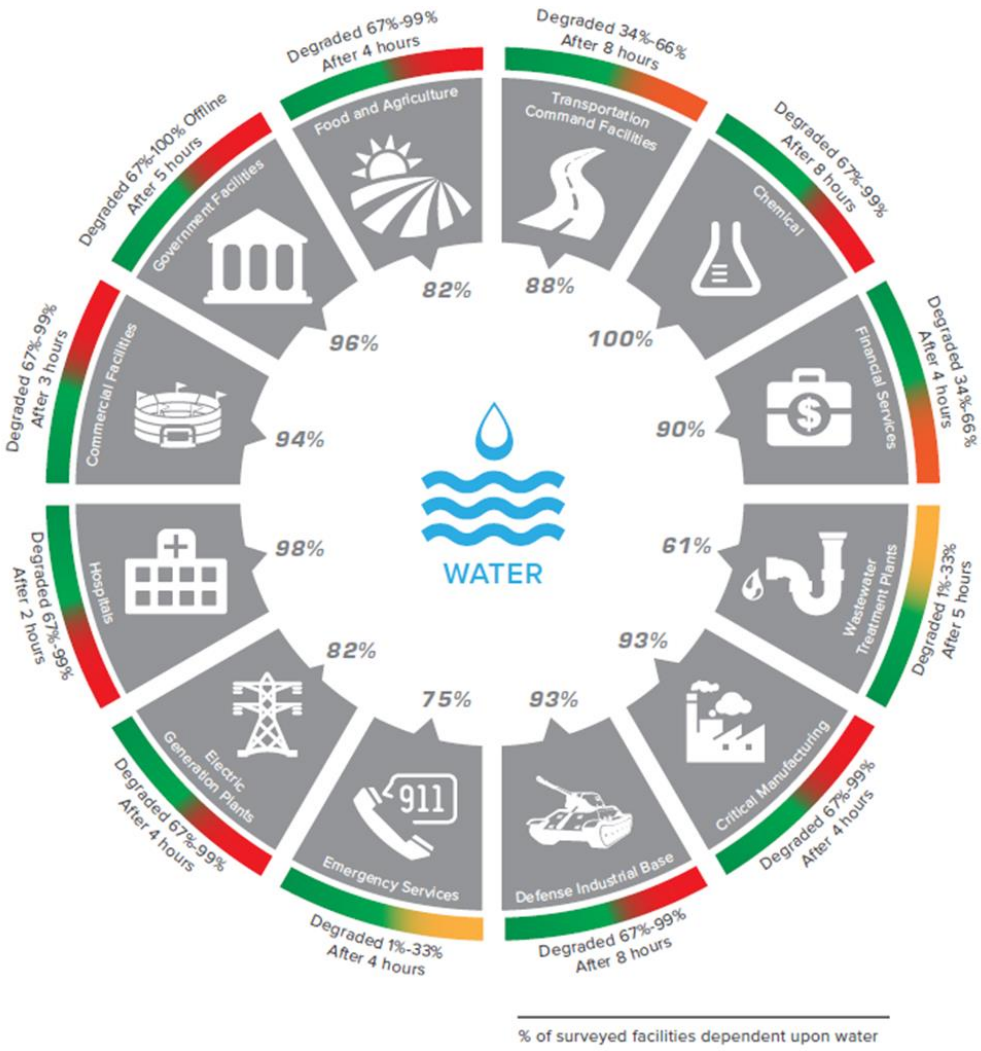

Figure 1 - Critical Infrastructure Assets Dependent on Water and Potential Functional Degradation Following a Loss of Water Services[7]

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in part by the size of the system. Small systems have an average daily production of around 21,000 gallons while larger systems can have an average daily production around 33,000,000 gallons.[5]

Degradation of water treatment and distribution infrastructures can manifest in several different ways, including loss of pressure, water quality, and water volume. All these characteristics of treated water are related. A decrease in volume produced affects the pressure in pipes and can cause chlorine residual to fade, thus allowing development of biofilm in the network and possible water contamination. Changes to hydraulic conditions can also cause sedimentation that protects microorganisms from disinfection.[6] Most, if not all, of the population served by the PWS could be potentially impacted by water contamination or a diminution of pressure in the distribution system (which can cause water quality concerns). The total impact, however, would be determined by the location of the degradation (e.g. at the WTP vs. in a distribution pipe). An event at a central WTP or a primary distribution pipe would cause effects over a large portion of the population served, while effects could be more localized if an event occurs in a smaller end user pipe. All these criteria (vol-

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[4] U.S. Geological Survey, *USGS Circular 1268: Estimated Use of Water in the United States in 2000* (last revised Feb. 2005), http://pubs.usgs.gov/circ/2004/circ1268/.

[5] U.S. Environmental Protection Agency, *2006 Community Water System Survey* (Feb. 2009), http://water.epa.gov/infrastructure/drinkingwater/pws/upload/cwssreportvolumeI2006.pdf.

[6] Z. Michael Lahlou, *A National Drinking Water Clearinghouse Fact Sheet: Water Quality in Distribution Systems, TECH BRIEF* (2002), http://www.nesc.wvu.edu/ndwc/pdf/ot/tb/ot_tb%20_f02.pdf.

[7] U.S. Department of Homeland Security, Office of Cyber and Infrastructure Analysis, *Sector Resilience Report: Water and Wastewater Systems* (July 22, 2014), http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB8QFjAA&url=http%3A%2F%2Fwww.amwa.net%2Fsites%2Fdefault%2Ffiles%2FOCIA_SRR_Water_and_Wastewater_Systems_JULY2014.pdf&ei=3iThU6zTF8jeoATXmoD4CA&usg=AFQjCNHanSIih9ekAQW_pQEsflCpXFO5gQ&sig2=Yipg-f3tTX-6q8SRQyqIdg&bvm=bv.72197243,d.cGU&cad=rja.

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ume, pressure, and quality) must be considered in the development and implementation of contingency and emergency plans to overcome a possible lack of production and transportation of potable water.

The U.S. Department of Homeland Security (DHS) conducts assessments of national critical infrastructure across the 16 sectors. Approximately 75% of facilities that have received a DHS assessment require potable water, provided by PWSs, for their core operations.[8] Figure 1 illustrates potential degradation that could be generated for various critical infrastructure sectors and subsectors in case of loss of potable water supply, as well as the timeframe before that degradation would significantly impact core operations. The impact data for each asset is based on the median percentage of degradation and time to impact for the facility type.[9]

For example, most hospitals (98% of them) receive water from an external provider. In case of loss of service, 67% to 99% of their operations would be impacted after four hours. Such information on downstream dependencies allows prioritization of water service restoration based on the needs of water users. As can be seen in Figure 1, most of the sectors would be severely degraded upon the loss of water, which could impede their ability to provide their primary functions and/or services, potentially generating cascading failures.

Beyond direct physical dependency impacts (contamination or loss of pressure), the population and critical infrastructure assets surrounding the WTPs could also be impacted by water pipe breaks or the release of chemicals stored or used at the WTPs.

Water Treatment Dependencies

In general, PWS daily operations depend on external resources provided by other critical infrastructure sectors (upstream dependencies):

- Chemical—PWSs depend on a variety of chemicals (e.g., chlorine, alum) for ensuring potable water supplies
- Communications—PWSs depend on communications services to control operations, communicate with additional personnel and facilities, and contact emergency response personnel if necessary
- Dams—Some water assets and facilities depend on dams for water retention, regulation of water flow, and potentially even electric power generation
- Energy—PWSs depend on the Energy Sector to provide electricity for operations, natural gas for heating purposes, and fuel for pumps and generators
- Information Technology (IT)—PWS operational control systems and communication processes are typically highly dependent on IT systems and services
- Transportation Systems—PWSs depend on multiple methods of transportation for delivering critical products, transporting personnel, and providing access to repair or response crews

During emergencies, PWSs also heavily depend on the Emergency Services Sector for response and recovery operations.

In order to ensure that WTPs remain operational during an incident, or to ensure quick response and restoration following a disruption, resiliency measures should mitigate any negative internal and external impacts of water treatment upstream dependencies:

- Establish regular communications with critical utility and critical product suppliers to ensure a quick response to any service disruption
- Provide adequate physical security around utility connections and product delivery points
- Where practical, establish redundant or alternate resource capabilities for both utilities and critical products through backup generation, onsite storage, or alternate suppliers
- If possible, establish priority restoration agreements with resource suppliers
- Plan for potential outages by ensuring that business continuity plans include contingencies for utility and critical product disruptions

Conclusion

The Water and Wastewater Systems Sector in general, and PWSs in particular, are vital for public health and the well-functioning of other critical infrastructure assets. This sector (with its PWSs) is strongly interconnected with other critical infrastructure and is dependent

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[8] Ibid.
[9] Ibid.

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upon many other systems to support its core operations (i.e., chemical, communications, dams, energy, IT, and transportation systems). Furthermore, 75% of the critical infrastructure facilities assessed by DHS could be directly impacted if the potable water supply is lost, thereby generating cascading failures. The strong upstream and downstream dependencies between water treatment systems and other critical infrastructure assets emphasize the importance of ensuring the protection and resilience of PWSs.

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Reaching Utilities Large and Small: EPA's Efforts to Increase Water System Emergency Preparedness

By Stefanie Simpson*

Water and wastewater systems play a critical role in communities. However, water services can be taken for granted, often with little thought of how safe water is delivered and where it goes when we are done with it. Despite being vital for the health of our communities and the environment, water and wastewater services often fail to be included in conversations about emergency planning efforts.

Water systems face many threats, including accidental or intentional contamination, loss of power, and damage to infrastructure. Storm events are increasing in intensity and frequency, yet many utilities, faced with limited resources, do not know how to prepare. Although large water systems serve most of the U.S. population, the number of small and rural systems is far greater. These smaller systems face just as much risk of experiencing a water emergency while operating with significantly limited staff and budget resources.

The President has designated the U.S. Environmental Protection Agency (EPA) as the sector-specific agency for water and wastewater infrastructure protection activities. In this role, the EPA works with water sector associations and emergency response partners to develop and promote free tools and resources for water systems to use in preparing for, responding to, and recovering from all types of hazards, from natural disasters to contamination incidents.

Utilities impacted by previous storms like Super Storm Sandy have experienced firsthand the effects of storm surge, flooding, loss of power and damage to infrastructure on their ability to provide reliable service to their community. Utilities can better prepare by creating or updating emergency response plans, securing facilities and assets, reaching out to local emergency management officials, and implementing mitigation measures, such as raising the height of electrical systems and maintaining access to generators and fuel storage. The EPA's tools and resources assist water and wastewater utilities to accomplish these preparedness tasks.

Under the Public Health and Bioterrorism Preparedness and Response Act of 2002,[1] water and wastewater utilities serving more than 3,300 people were required to perform a vulnerability assessment (VA) by the middle of 2004. The EPA encourages water systems to keep their VAs updated along with their Emergency Response Plans. The EPA currently provides several free online assessment tools, including the newly updated Vulnerability Self-Assessment Tool (VSAT), to help utilities with this task. VSAT 6.0, which is consistent with the new ANSI/AWWA industry J100-10 standard, helps utilities in assessing their unique vulnerabilities and threats. The 6.0 version of VSAT includes new features that make the tool more user-friendly for small systems and new users.[2] Additionally, the Water Health and Economic Analysis Tool (WHEAT) identifies health and economic consequences that may be caused by a water emergency.[3] Understanding these risks is the

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[1] Pub. L. No. 107-188, § 401.
[2] This system is available at water.epa.gov/infrastructure/watersecurity/techtools/vsat.cfm or www.vsatusers.org/.
[3] The WHEAT system can be accessed at www.epa.gov/wheat.

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first step in improving emergency preparedness and resiliency.

The EPA has also developed a tool to help utilities find funding for mitigation and recovery projects. The Federal Funding for Utilities in Natural Disasters tool (Fed FUNDs) provides information on funding opportunities specifically for water and wastewater systems. Fed FUNDs also provides downloadable forms that utilities can use to document damage and includes mentor contact information to provide assistance during the application process.[4]

The EPA is working to connect water systems with other sectors like transportation, energy, and emergency services. Including water systems in emergency planning and building community relationships prepares utilities and their communities to handle water emergencies. The EPA developed the Community-Based Water Resiliency tool to help utilities with starting these conversations.[5] Bridging the gap between water service providers and other critical sectors, such as the power sector, improves community resilience to natural disasters. The EPA has convened representatives from water utilities, power utilities, and state agencies to better coordinate power restoration efforts and reduce the impact of power outages to water service. Using lessons learned from the workshops along with additional research, the EPA is currently developing a best practices guide for water and wastewater utilities.

Understanding possible threats and knowing where your resources are ahead of time can increase preparedness. To help water systems better prepare for a possible contamination event the EPA provides access to tools like the Water Contaminant Information Tool (WCIT), which is an expanding database of contaminant information including detection and treatment.[6] In addition, the Water Laboratory Alliance, which is part of the larger Environmental Response Laboratory Network, is specifically for the use of water systems. It connects water utilities with laboratories around the country that can respond to accidental or intentional contamination events.

When an incident occurs, county and state Emergency Operations Centers (EOCs) may be activated to handle coordination of information and resources for short-term response and recovery. It is important to include water system representation at local and state EOCs to improve water service restoration, a service vital for human health protection and emergency response activities (i.e. hospitals and fire suppression). All too often, water utilities are not well represented at the local and state EOCs. Therefore,

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[4] www.epa.gov/fedfunds.
[5] www.epa.gov/communitywaterresiliency.
[6] www.epa.gov/wcit.

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the EPA is working with water sector associations to include water systems in local emergency planning.

In order to ensure these tools and resources are meeting the needs of water systems, the EPA often invites stakeholder feedback. Focus groups of water and wastewater utilities and pilot studies are used to ensure that resources are being developed in a usable and practical way. For example, pilot water surveillance and response systems have been deployed at drinking water utilities in Cincinnati, San Francisco, New York City, Philadelphia, and Dallas. These pilot studies help to demonstrate that monitoring and response systems can be practical, effective, and sustainable. The EPA is using the lessons learned from these pilots to develop guidance documents and tools to assist other water utilities to develop similar systems.

Another pilot program involved a small water utility in Maine that was interested in evaluating its flood risk and determining what actions it could take to increase flood resiliency. The lessons learned from this pilot led to the development of a Flood Resiliency Guide targeted for small and medium utilities. This guide will assist water and wastewater utilities to identify asset specific mitigation measures to lessen the impacts of flooding. The guide's expected release date is summer 2014.

The EPA is also working to meet utility needs in addressing climate change impacts.[7] Climate change effects, such as increased drought and flooding, will impact utilities and their ability to provide reliable service. The EPA's Extreme Events Workshop Planner tool helps utilities plan for various scenarios, including drought, floods, wildfire, and reduced snowpack. In addition, the Climate Resilience Evaluation and Awareness Tool (CREAT) assesses a utility's vulnerabilities and risks to climate change impacts for its exact location. Additional scenarios can be found on the EPA's Tabletop Exercise tool, which provides materials for utilities to plan and facilitate their own tabletop exercise focusing on water-related emergencies.[8] The tool includes 15 scenarios addressing natural hazards as well as man-made incidents. Practicing emergency response before an incident happens can help identify gaps and increase overall emergency response preparedness.

Water and wastewater systems will continue to face risks, whether from extreme weather and other threats, but they can take steps to prepare. The EPA will continue to reach out to water and wastewater systems and the communities they serve, so they can better prepare for, respond to, and recover from all types of hazards. Working with the water sector and its partners, the EPA strives to increase community resilience to water emergencies, protecting both human health and the environment.[9] ❖

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[7] www.epa.gov/climatereadyutilities.
[8] http://water.epa.gov/infrastructure/watersecurity/techtools/ttx.cfm.
[9] For more information and access to the tools and resources mentioned, visit http://www.epa.gov.watersecurity or email WSD-Outreach@epa.gov.

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