September 2014

Charting New Waters

Navigating to New Shores

Seizing the Future for Sustainable and Resilient U.S. Freshwater Resources

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The Johnson Foundation AT WINGSPREAD

Letter from the Director

A lot can happen in six years. When The Johnson Foundation at Wingspread dipped our institutional oars into the world of water in late 2008, like Lake Michigan in April, it felt a little chilly. In fact, I detected a little ice that needed to be chipped away before we could begin a journey that had no charts or maps and only a vague destination.

But with enough persistence and persuasion, and willing partners, we worked our way into open water and began to explore the challenges facing our nation's water resources. When we packed our bags for this journey, we left behind any preconceived ideas about solutions, bringing with us only a deeply held belief that by convening smart people with shared values but different experiences and perspectives, we could arrive at sensible solutions that can make a difference.

In those early years we heard some common themes. We heard that inexpensive water and water treatment were taken for granted. That water managers were resistant to change, holding on to decades-old solutions even though the world was moving on. That planning for future energy, transportation and food production could plow ahead without worrying about where the water would come from, just as water needs could be mapped out independently of energy demands or resource impacts. And any discussion of climate change was certain to divide.

The majority of Americans now believe that our climate is changing and that we need to do something about it. At the same time, the water sector is rapidly shifting from a culture of stasis to one that values and embraces innovation.

My, how things have changed.

The majority of Americans now believe that our climate is changing and that we need to do something about it. Major portions of the United States have learned what it's like not to be able to take water services for granted. Whether its people in communities hit by hurricane-driven floods that knocked out drinking water or wastewater treatment for weeks at a time; farmers and ranchers dealing with the realities of long-term drought; or citizens left without safe drinking water because their only supply has been contaminated, millions of Americans are realizing that they need to pay attention. At the same time, the water sector itself is rapidly shifting from a culture of stasis to one that values and embraces innovation.

That doesn't mean the work is done – far from it. In the coming years, our country will be investing hundreds of billions of dollars in infrastructure. We can't afford to get this wrong.

And so, with a mixture of hope and impatience, building off of six years of collaborative engagement, we offer these final recommendations. The Johnson Foundation's role is drawing to a close, but with strong partners at the helm, and a brisk wind behind the sails, the shoreline is coming into sight.

Lynn Broaddus
Director, Environment Programs
The Johnson Foundation at Wingspread

Executive Summary

After more than six years of intensive, solution-oriented work on U.S. freshwater issues, The Johnson Foundation at Wingspread is concluding its Charting New Waters initiative. Through convening hundreds of experts representing different sectors and perspectives, we have amplified important ideas and innovations that can make a difference. This executive summary of our final report synthesizes insights from the full arc of Charting New Waters and is meant to provide a platform for our many partners and other leaders as they continue to address water resource and infrastructure challenges.

Without significant changes, existing water systems will soon no longer be able to provide the services that citizens have come to expect. Recent water crises have illustrated that the economic and social consequences of inaction are far too great for this nation and its communities. It is time to accelerate the adoption and implementation of the transformative solutions we know are possible.

Our full report leads with a vision that illustrates what The Johnson Foundation believes is both possible and necessary to achieve if our nation is to successfully navigate our water challenges. It then presents a set of principles, summarized below, to help guide the efforts of leaders in various sectors as they act upon the recommendations we offer. The recommendations themselves, which are also summarized in brief below, fall under the following five key ideas:

1. **Optimize the use of available water supplies**
2. **Transition to next-generation wastewater systems**
3. **Integrate the management of water, energy and food production**
4. **Institutionalize the value of water**
5. **Create integrated utilities**

The Johnson Foundation selected the recommendations presented in the report because of their timeliness and promise for leveraging existing momentum. We hope the recommendations shed light on what is needed to catalyze transformative change and the benefits we can reap as a result. We also hope they will inspire additional action to seize the future for sustainable and resilient U.S. freshwater resources.

Guiding Principles for the Future of U.S. Freshwater Resources

- Forge partnerships and collaborate to solve problems
- Develop integrated solutions
- Incentivize and promote innovation
- Highlight multiple benefits
- Recognize the value of water
- Plan for adaptation to and mitigation of climate change impacts
- Balance human and environmental needs
- Design infrastructure to restore ecosystem function
- Prioritize local water sources
- Redefine "waste" as valuable resources
- Right-size water systems and services
- Tap into sustainable financing streams
- Ensure accountability

Optimize the Use of Available Water Supplies

With water scarcity affecting an increasing number of regions across the United States, one could argue that diminished water supply is the greatest threat to the economic security and social stability of major portions of this country. In addition, we are losing a significant amount of water due to aging, leaky infrastructure; we are not capturing and using readily available sources; and we are using available water inefficiently or unwisely. To counteract these trends, we need to implement a mix of strategies that will optimize the use of available water and increase resilience to acute and chronic water scarcity.

Times have changed, and today's wastewater utilities and municipalities are struggling to cope with everything from rising operating costs to difficulty garnering financing to the effects of climate change.

In the short term, water-supply utilities need to dramatically increase the efficiency of their distribution systems through effective asset management, water audits, pressure management and systematic monitoring. Communities need to establish water rates as well as policies and programs that incentivize conservation and efficiency while maintaining service providers' financial stability. And the agricultural sector should continue to pursue water savings by expanding the adoption of water-wise practices such as high-efficiency irrigation technologies, soil moisture monitoring and cover crops.

To ensure water security over the long term, communities need to build more flexibility and redundancy into their water-supply storage and distribution infrastructure. They can diversify their water supplies by tapping underused water resources, such as rainwater, and by taking greater advantage of natural and engineered ecosystems. Water reuse is arguably the most promising way to extend existing water supplies, and water utilities should more aggressively integrate indirect and direct nonpotable and potable water reuse into their supply portfolios. We also need to shift away from the traditional paradigm of treating all water to the highest public health standards. Using technology that treats water to different quality levels and enables its delivery for safe and appropriate residential, commercial and industrial uses, we can match the right quality water to the right use.

Transition to Next-Generation Wastewater Systems

Most existing wastewater systems in the United States were built with technology developed in the mid-20th century and have served our nation well for many decades. But times have changed, and today's wastewater utilities and municipalities are struggling to cope with everything from rising operating costs to difficulty garnering financing to the effects of climate change. Combined sewer overflows remain a public health hazard in many cities, stringent nutrient standards demand more energy-intensive treatment processes, and large, centralized wastewater systems are vulnerable to single-point failures that can quickly leave entire communities without service. Given these challenges, it is imperative that leaders invest in forward-looking solutions that leverage the surge of innovation in the wastewater sector and bring legacy wastewater systems into the 21st century.

For example, communities can keep stormwater runoff and groundwater out of wastewater systems using a combination of effective asset management, sewer separation and green infrastructure, so that wastewater plants can be reserved for treating water that truly needs treating. To reduce pressure on centralized treatment plants and to bolster resilience, wastewater utilities should consider integrating small-scale distributed systems into their existing infrastructure. Furthermore, the wastewater sector can also use new technologies to transition from minimizing pollution to maximizing the recovery of valuable resources such as nutrients and energy. With biogas produced on-site and other renewable energy technologies, treatment facilities can become net-energy-positive, reducing operating costs and the potential for grid-induced power outages while reducing greenhouse gas emissions.

Integrate the Management of Water, Energy and Food Production

As a nation, we need to be cognizant of the many important intersections between water, energy and food production and establish a comprehensive approach to integrating the management of these essential resources and services. Despite the fundamental links among these sectors and the potential to leverage infrastructure investments, the sectors generally conduct planning and innovate independently. Yet opportunities for coordination are increasing, and great potential exists to integrate the management of all three sectors and collaboratively plan for a sustainable future.

Water and wastewater utilities need to continue to implement energy-efficiency measures and other technological innovations to reduce or eliminate their net energy use and work better with the power grid. As power providers confront climate-driven shifts in water availability and plan for the impending retirement of many fossil fuel plants, they can reduce their dependence on freshwater with low-water cooling technologies or the use of reclaimed water for cooling. Food producers can integrate sustainable nutrient and energy practices borrowed from the water and power sectors, including nutrient recovery and biogas-fueled electricity. In addition, urban and rural water leaders need to collaboratively plan for sustainable rural water supplies. Working together they can implement strategies that eliminate short-sighted municipal and industrial water-supply solutions that transfer water away from farms, ranches and rural communities.

Institutionalize the Value of Water

Historically, capital investments in water infrastructure have been heavily subsidized by federal grants, and water rates have not reflected the externalized costs of water withdrawal, pollutant discharge and other community impacts. This approach to water pricing has conditioned Americans to assume that water delivery and wastewater treatment are and always will be inexpensive services, which in turn has driven utilities to defer maintenance and upgrades so that rates remain low. But with the decline of federal grant funding and the massive water infrastructure investment gap facing our communities, we can no longer afford to maintain the illusion that water and water services are cheap. It is time to rethink how we value water and adopt new strategies and tools that institutionalize its true worth.

Image courtesy of iStock Photo

To repair and revamp water infrastructure, communities and utilities need to tap into new sources of capital and use innovative financing mechanisms such as green bonds and public–private partnerships. Utilities need to institute sustainable pricing for water services so that they are able to recoup operating costs, pay off long-term debt and have funds to invest in innovation. In addition, financial systems need to assign value to the capacity of ecosystems to provide clean water and replenish water supplies, as well as to the human effort that goes into preserving and restoring ecosystem services. Perhaps most importantly, we must instill appreciation for the complexity, importance and benefits of reliable water, wastewater and stormwater management infrastructure so that Americans value water highly and are willing to pay the real costs of water services.

New utility design principles must be established that embrace public values, local control and innovation along with evaluation criteria that center on meeting sustainability and resilience goals.

Image courtesy of iStock Photo

Create Integrated Utilities

The best solutions to our resource management challenges stem from collaboration and integration among the agencies and authorities that oversee water, energy, solid waste, land and air resources. To achieve a sustainable and resilient future for U.S. freshwater, we must push beyond the regulatory and disciplinary silos of the past and reinvent the infrastructure and utility services that Americans depend on. Utilities need to reflect the realities of the physical world and provide integrated services under a common organizational structure that optimizes resource use and minimizes waste. Many of the technological and management characteristics that constitute integrated utilities are captured in the preceding recommendations, but additional elements are necessary to truly transform the management of water and other interdependent resources.

For example, new utility design principles must be established that embrace public values, local control and innovation along with evaluation criteria that center on meeting sustainability and resilience goals. Utilities of the future will go beyond service provision and manage built and natural infrastructure that bridges the urban–rural interface. They will recover nutrients and energy, generate electricity from renewable energy sources and implement distributed systems that ensure redundancy in water-supply and wastewater treatment systems. New business models will foster internal innovation, ensure financial sustainability and generate new revenue streams. Federal and state agencies will need to revisit regulations and policies that hinder integration between traditional service areas and institute mechanisms for flexibility that support new ways of conducting business. Finally, utilities will cultivate partnerships with the communities they serve as well as with well-informed customers who actively participate in how the utility and the resources it relies on are managed.

Overview of Charting New Waters

Charting New Waters was initiated in 2008 following The Johnson Foundation's decision to apply our resources and convening model to a concentrated exploration of U.S. freshwater issues. It evolved through the three phases illustrated in the timeline on the next page.

In phase one, participants in a series of Wingspread conferences examined freshwater challenges associated with climate change, the built infrastructure, agriculture and food production, the water–energy nexus and public health. That phase culminated with the CEO-level Freshwater Summit on June 9, 2010, and with the September 2010 release of *Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges*. The consensus-based *Call to Action* drew from the earlier convenings and detailed potential solutions to the nation's looming water crisis. A diverse group of signatories agreed on the recommendations and made commitments to action.

Driven by those commitments, phase two of Charting New Waters took place between 2011 and 2013 and focused at first on the issue of water infrastructure financing. During the summer of 2011, we hosted two webinars and a conference in partnership with American Rivers and Ceres to examine challenges and emerging options for financing sustainable water infrastructure – an effort that culminated with a report and invited testimony before Congress. This phase also included work with diverse stakeholders in New England, Colorado and the Pacific Northwest to explore how freshwater challenges were playing out in specific regions. Our forums in Denver and Boston generated insights into the kinds of solutions that are viable in two very different parts of the country.

The third and final phase of Charting New Waters focused on catalyzing the widespread adoption of sustainable and resilient water infrastructure systems in the United States. In 2013 and 2014, we hosted discussions about transforming the nation's water infrastructure to adapt to and mitigate climate change; fostering collaboration between water and electric power utilities; ensuring urban water security; improving urban nutrient management; advancing the use of distributed water infrastructure; and developing an action plan for New Jersey's urban water infrastructure.

The entire body of work under Charting New Waters has been built on strong partnerships. More than 600 individuals from approximately 265 organizations participated in one or more meetings, bringing their experience and perspective to the conversations. Some organizations partnered with us to develop and convene meetings, and these collaborations contributed greatly to the outcomes of those conferences. It is this rich history that informs the ideas and recommendations presented in this report.

Charting New Waters

CNW 1.0

2008–2011
Catalyzed new coalitions, new energy and increased visibility around U.S. freshwater challenges

CNW 2.0

2011–2013
Focused on following through on commitments made as part of CNW 1.0

2008 2009 2010 2011

March 17–18, 2009
Impact of Climate Change on Freshwater Resources and Services in the U.S.

May 20–22, 2009
Infrastructure and the Built Environment

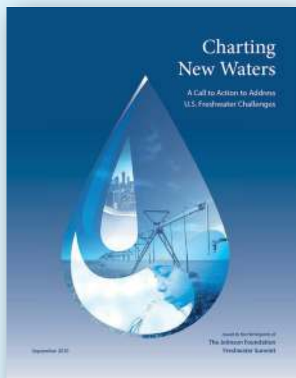
September 1–3, 2009
Agriculture and Food Production

November 16–18, 2009
Reducing Conflicts at the Water–Energy Interface

December 15–16, 2009
Public Health Threats and Solutions

June 9, 2010
Freshwater Summit

September 2010
Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges
Washington, DC



Summer 2011
Financing Sustainable Water Infrastructure

July 26, 2011
Webinar #1: What Is Sustainable Water Infrastructure?

August 10, 2011
Webinar #2: Unpacking the Financing Options

August 16–18, 2011
Financing Sustainable Water Infrastructure Systems

October 18, 2011
Colorado Regional Freshwater Forum
Denver, CO

Charting New Waters

Click on the report covers to view the full reports or visit www.johnsonfdn.org/chartingnewwaters for a list of publications.

NOTE: Unless otherwise noted, all conferences took place at The Johnson Foundation at Wingspread in Racine, Wisconsin.

CNW 3.0

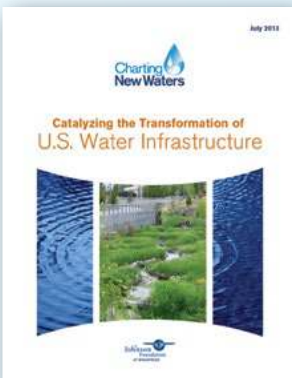
2013–2014

Focused on catalyzing the widespread adoption of more sustainable and resilient water infrastructure systems in the United States

2012 2013 2014

May 30–31, 2012
New England Regional Freshwater Forum
Boston, MA

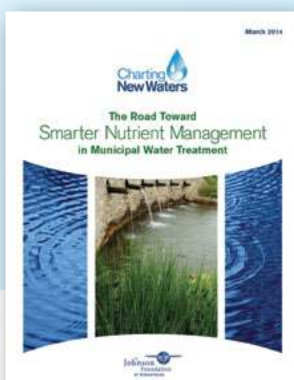
April 17–19, 2013
Catalyzing the Transformation of U.S. Water Infrastructure



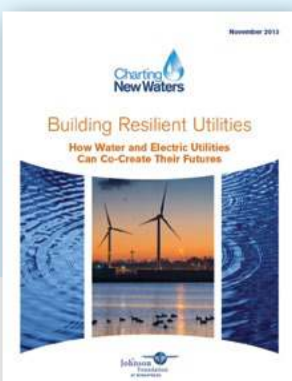
Winter and Fall 2013
The Road Toward Smarter Nutrient Management in Municipal Water Treatment

February 13–15, 2013
Part 1

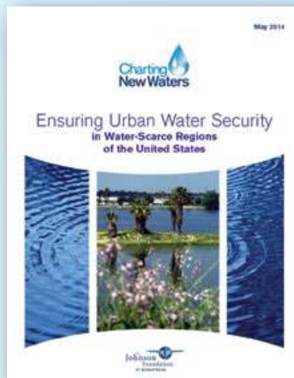
October 28–29, 2013
Part 2
Warrenton, VA



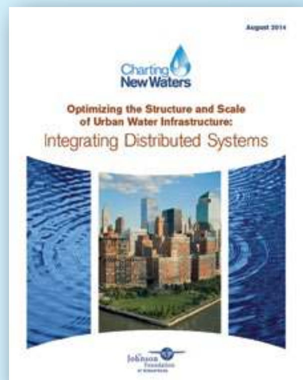
August 21–23, 2013
Building Resilient Utilities: How Water and Electric Utilites Can Co-Create Their Futures



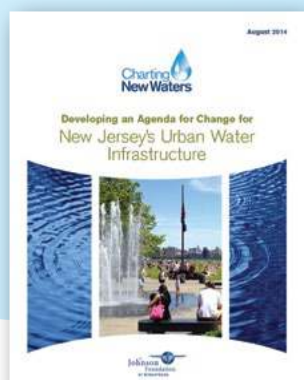
December 11–13, 2013
Ensuring Urban Water Security in Water-Scarce Regions of the United States



March 19–21, 2014
Optimizing the Structure and Scale of Urban Water Infrastructure: Integrating Distributed Systems



May 20–21, 2014
Developing an Agenda for Change for New Jersey's Urban Water Infrastructure
Jersey City, NJ



Introduction

This report marks the conclusion of The Johnson Foundation at Wingspread's Charting New Waters initiative, which has examined freshwater issues in the United States. Since our work began in 2008, more than 600 experts from many different sectors have participated in Charting New Waters, collaborating to identify potential solutions to a remarkable range of water resource challenges facing this great nation. With this final report, The Johnson Foundation aims to distill and deliver the most powerful messages and timely recommendations generated during these six years of work.

> *By convening innovators, early adopters and thought leaders to discuss the most promising water infrastructure and management solutions, The Johnson Foundation aimed to amplify important ideas, promote innovation and articulate useful recommendations.*

Charting New Waters has focused on identifying solutions that recognize the gravity of the challenges we face and hold promise for overcoming them. As we wrote this report, we had several recent water crises in mind: the severe, multi-year drought in California; the three-day drinking water ban in Toledo, Ohio, sparked by a nutrient-fueled cyanobacteria bloom in Lake Erie; the shutdown of the water supply in Charleston, West Virginia, due to a chemical spill into the Elk River; the dramatic impact of Hurricane Sandy on water infrastructure in New York and New Jersey; and the historically low level of Lake Mead, source of water for 40 million Americans. Also, we developed this report with an eye on the most critical trends and challenges of our time, including climate change, which is expected to affect all aspects of the human experience; population growth; increasing urbanization; the degradation of natural systems; and growing global economic competition.[1]

In its final phase, Charting New Waters explored what it will take to transform the country's vulnerable and failing 19^{th}- and 20^{th}-century water infrastructure into systems that will sustain our environment, economy and society for future generations and be resilient to a variety of threats – both acute, episodic events (natural or human-made) as well as slow, chronic trends (e.g., population growth or decline, drought). We define *water infrastructure* broadly to encompass built gray and green infrastructure as well as natural and engineered systems that provide services that benefit humans and other living organisms. Working from the premise that many of our nation's freshwater challenges stem from chronic underinvestment in water infrastructure or misguided investment in outmoded solutions, this final report emphasizes the need to invest in proven innovations that will optimize, upgrade and ultimately transform our water infrastructure.

By convening innovators, early adopters and thought leaders to discuss the most promising water infrastructure and management solutions in the United States, The Johnson Foundation has aimed to amplify important ideas, promote innovation and articulate useful recommendations for actions that can make a difference. We deliver this report in the spirit of synthesizing information and insights we have gathered from the deliberations we have hosted over the past several years. As the Foundation steps away from the work of Charting New Waters, we have tried to craft this report so that it provides a platform that will help advance the work of our partners and other leaders as they continue striving to ensure that Americans will enjoy sustainable and resilient water resources in the 21^{st} century and beyond.

The report leads with a vision of opportunity that illustrates what The Johnson Foundation believes is both possible and necessary to achieve if we are to successfully navigate our water challenges. We present a set of principles to help guide the efforts of federal, state and local government agencies, utilities, advocates, businesses and community leaders as they seek to act upon the recommendations that follow. Finally, we offer targeted recommendations intended to catalyze change in U.S. freshwater management.

We can no longer afford to dawdle on the waves while storm clouds build overhead. It is clear that existing systems will soon no longer be able to provide the water services that citizens have come to expect. Recent water crises have illustrated that the economic and social consequences of inaction are far too great for this nation and its communities. Now is the time to put the paddle in the water and accelerate toward shore, implementing the transformative solutions we know are possible.

A Vision of Opportunity

The ethos of Charting New Waters is and always has been grounded in a recognition of real-world challenges and motivated by optimism about our nation's ability to solve those challenges. In September 2010, leaders representing business, nongovernmental organizations, agriculture, academia, government, foundations and communities issued *Charting New Waters: A Call to Action to Address U.S Freshwater Challenges*, a consensus report that urged action and laid out a vision for sustainable and resilient U.S. freshwater resources (see inset). The subsequent work of Charting New Waters has continued to reinforce the opportunity expressed in that vision, while observing an ever-increasing urgency for action.

Innovation is happening in every aspect of water resources management and in all regions of the United States. Implementation of the most effective and promising solutions is spreading, and momentum

A Vision for Sustainable and Resilient U.S. Freshwater Resources, from *Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges,* 2010

[We] see many opportunities to establish a more promising future for U.S. freshwater resources – a future that is sustainable and resilient. We see a future in which leaders in all sectors have the courage and tools to chart a new course that ensures access to clean freshwater for all Americans. We have a vision of institutions, organizations, communities and individuals who recognize that the health and safety of our natural and built freshwater systems warrant dedicated attention, investment and action. Streamlined and effective regulation and enforcement, collaborative problem solving, innovative local and regional strategies, technological innovation, integrated policy and management solutions, and co-beneficial strategies and outcomes are the hallmarks of the new course we see for freshwater management and resources in the United States.

is building for widespread adoption. Cutting-edge technologies, management techniques and financing strategies are available, and success stories are unfolding in communities large and small.

However, change is still occurring piecemeal, driven either by crises or bold leaders, or (more likely) both. In many cases, efforts to bring about change are being hampered by outdated regulatory frameworks, uncertainties about the performance of new technologies or management practices and a lack of communication among the many entities responsible for aspects of freshwater management. The Johnson Foundation's work is intended to help create a pathway for change that will set widespread transformations in motion and shape a future in which sustainable and resilient water management is the norm.

The Johnson Foundation sees myriad opportunities to leverage success stories and take water-sector innovation to the next level. We see a future in which water infrastructure is no longer "out of sight, out

Principles for Action from *Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges,* 2010

When we act, we need to…

Take bold steps and make intentional investments to transform our current trajectory toward freshwater crisis into one toward sustainable and resilient freshwater resources.

Support and empower visionary leaders at all scales of society who champion freshwater and facilitate collaboration across jurisdictions, disciplines and sectors to implement durable freshwater solutions.

Design context-sensitive freshwater solutions that account for communities' sociopolitical, economic and environmental dynamics and leverage people's sense of place, while adhering to relevant federal and state laws and policies.

Consider the potential impacts of freshwater resource solutions on all people and places, including minority and low-income urban and rural communities, and avoid solutions that benefit one group or place at the undue expense of another, including future generations.

Seek robust co-beneficial solutions and triple-bottom-line outcomes that address environmental, economic and social equity challenges simultaneously in a cost-efficient manner.

Generate sound science that accounts for the dynamic nature of freshwater systems and our emerging understanding of climate change impacts on water that can be shared in real-time to inform mitigation and adaptive management strategies.

Employ inclusive, fair and transparent public participation processes, including respectful government-to-government consultation with indigenous peoples.

Target performance-based incentives and standards toward different freshwater users and innovators to drive solution-oriented behavioral and technological change.

Identify, share, replicate and scale up the best freshwater solutions from across the nation.

of mind." Instead it is a top priority of Americans nationwide who revere the value it delivers to their lives and are willing to make the political and financial investments necessary to take care of it. We envision communities served by utilities that integrate water delivery, wastewater treatment and stormwater management with power generation and solid waste management under a common umbrella. A future in which the infrastructure and service areas of these utilities are no longer designed based upon political boundaries, but according to an entirely new set of design principles and performance standards. And where evaluation criteria center on the ability of the utility to deliver a desired level of service that meets specific sustainability and resilience goals.

The Future of U.S. Freshwater Resources: Guiding Principles

As we seek to catalyze transformational changes that will lead to a sustainable and resilient future, our efforts should be guided by and evaluated against a clear set of principles. We believe that the Principles for Action presented in the 2010 *Call to Action* remain wholly relevant and can continue to serve as a touchstone (see inset on p. 10). Inspired by the leadership and innovation we have seen take off since 2010, we developed an updated set of principles, listed on this and the following page, to complement and bring further specificity to those from the *Call to Action*. The Johnson Foundation believes that by adhering to this suite of guiding principles developed through Charting New Waters, leaders across the United States can accelerate the widespread adoption of truly transformative water infrastructure and management solutions that enable the creation of sustainable and resilient communities with highly efficient and cost-effective infrastructure, healthy environments, vibrant economies and an excellent quality of life.

Forge Partnerships and Collaborate to Solve Problems: Forge partnerships between leaders and new allies who share common interests in solving water problems, strive to overcome differences respectfully and work collaboratively to achieve mutually beneficial outcomes.

Develop Integrated Solutions: Employ long-term, systems thinking to develop integrated water management solutions that cut across traditional siloes within the water sector (e.g., water supply, wastewater treatment, stormwater management); beyond the water sector (e.g., energy, transportation); and across conventional boundaries (e.g., political jurisdictions, urban–rural interface).

Incentivize and Promote Innovation: Create incentives and mechanisms for regulatory flexibility that foster and accelerate innovation. Promote successful technological and management innovations by working with researchers and entrepreneurs to create demonstration projects that tangibly illustrate their benefits and allay concerns about risk and uncertainty.

Highlight Multiple Benefits: Account for (quantitatively or qualitatively) and highlight the compounding environmental (e.g., improved water quality, reduced flooding), economic (e.g., cost savings, job creation) and social (e.g., better quality of life) benefits that stem from investment in innovative water infrastructure and management solutions.

Recognize the Value of Water: Provide education and transparency to cultivate understanding and awareness among ratepayers, decision makers and other water users so that: they have a thorough understanding of the systems and costs involved in delivering the water services they depend on; they value those services accordingly; and they make informed decisions about how they use water and interdependent resources such as energy.

Plan for Adaptation to and Mitigation of Climate Change Impacts: Given projections of future climate variability (e.g., dry regions getting drier, wet regions becoming wetter, more frequent and intense storms), develop long-term water resources management plans for climate readiness, to adapt to and mitigate further climate change.

Balance Human and Environmental Needs: Conduct water management and infrastructure planning in a watershed context, to create functional, performing landscapes that provide for human needs, while maintaining the water resources needed to support other living organisms and systems.

Design Infrastructure to Restore Ecosystem Function: Recognize the role that natural systems play in managing and protecting our water resources, and systematically implement green infrastructure and low-impact development solutions that mimic, integrate or restore natural hydrologic processes and ecosystem functions.

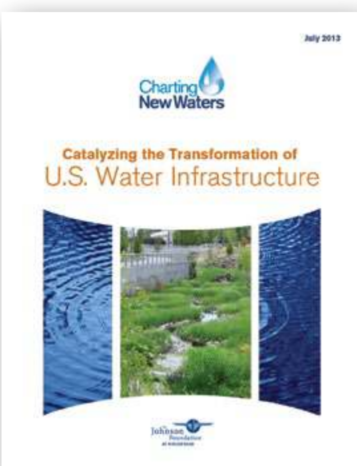
Prioritize Local Water Sources: Invest in reducing the water footprint of communities and securing urban and rural water supply from local sources, to minimize the energy necessary for long-distance water transport and to balance water withdrawals and returns within watersheds, so that adequate water is available over the long term to meet municipal, agricultural and ecosystem needs.

Redefine "Waste" as Valuable Resources: To the greatest extent possible, reclaim, recover and reuse valuable resources from residential, commercial and industrial wastewater and agricultural processes.

Right-Size Water Systems and Services: Implement distributed water infrastructure systems where possible to complement existing centralized systems and better align the structure and size of water infrastructure and services with needs at different spatial scales.

Tap into Sustainable Financing Streams: Pursue a range of capital sources and establish adequate revenue streams that will enable and sustain improved rural and urban water infrastructure and services designed for the next 50 to 100 years, while ensuring affordable rates over time for ratepayers.

Ensure Accountability: Establish transparent systems and processes to ensure that water management decisions are better understood by those they impact and that decision makers are accountable to community members.



The July 2013 Charting New Waters report ***Catalyzing the Transformation of U.S. Water Infrastructure*** provides a discussion of the challenges and opportunities climate change and adaptation pose for U.S. water infrastructure.

Click here to view the full report or visit www.johnsonfdn.org/chartingnewwaters.

Navigating to New Shores: Recommendations to Catalyze Change

Time and again, we have heard that water challenges vary with local circumstances and that solutions must be tailored accordingly. Therefore, we need a range of options to enhance sustainability and resilience at the local level. Scaled up successfully, local-level solutions can collectively improve the resilience of regions and the nation as a whole. While we acknowledge that there is no definitive set of solutions for any particular situation, and that problem solving is not a static endeavor, innovation and models of success abound in the water sector today that can be adapted and applied to different contexts.

In this section, we offer a suite of recommendations that reflect a continuum of change derived from our infrastructure-focused work, but which we believe can be applied to any aspect of the water sector. The Framework for Change presented on p. 14 is based on the premise that – regardless of the age or current condition of a drinking water, wastewater, storm sewer or irrigation system; its geographic location; or the inertia surrounding legal or regulatory frameworks, policies or management practices – there are steps utilities, agricultural producers and other water managers can take to advance communities toward the water infrastructure and management strategies of the future.

The phases described in the Framework offer a conceptual pathway for leaders in all sectors to keep in mind as they work to revamp infrastructure, apply cutting-edge management practices or revise policies and regulations that inhibit innovation and progress. The Framework is meant to reflect the reality that incremental change is the easiest to achieve in the near term, while recognizing that the challenges we face demand bold, transformational action. It also recognizes that change doesn't necessarily occur in a linear fashion. Given the right leadership and forums for communication, it is possible to leapfrog over the optimization and/or transitional phases and achieve transformation. Regardless of where one falls on the continuum today, or the chosen path ahead, the goal is ultimately the same – to radically change the way we use and manage our freshwater resources.

The conventions of writing and reporting have required us to parse out the recommendations below into standalone sections, even though they are interrelated and intertwined pieces of an extremely complex puzzle. Informed by the full arc of Charting New Waters, and in consultation with our partners, The Johnson Foundation selected the following recommendations because of their timeliness and promise for leveraging existing momentum. Collectively, we hope they set a beacon on the horizon and shed light on the route necessary to catalyze change and seize the future envisioned above. The recommendations fall under the following five key ideas:

1. **Optimize the use of available water supplies**
2. **Transition to next-generation wastewater systems**
3. **Integrate the management of water, energy and food production**
4. **Institutionalize the value of water**
5. **Create integrated utilities**

Framework for Change

Optimize

Leaders in all sectors can take immediate steps to optimize the efficiency of existing water systems. System optimization involves implementing basic but critical measures to operate and maintain systems more efficiently and produces benefits such as reduced water and energy use, lower operating costs, increased revenues and improved environmental quality.

Transition

Water, wastewater and electric power utilities and other water managers can push beyond the traditional limits of their operations by integrating proven innovations into existing systems. Technologies and management solutions are available that increase the capacity of systems to: meet current demand; generate value from resources that are typically wasted; and adapt to and mitigate climate change.

Transform

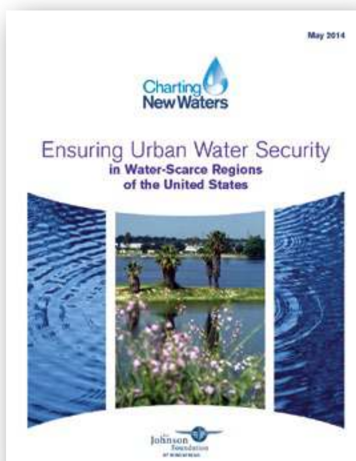
Ultimately, all sectors need to embrace innovation and reinvent how water systems are designed, managed and financed and how water services are delivered. With visionary leadership and cross-sector collaboration, it is possible to establish water systems and governance structures that: integrate water, energy and food production; value water appropriately; and enable the creation of integrated utilities.

1. Optimize the Use of Available Water Supplies

One could easily argue that diminished water supply is the greatest threat to the economic security and social stability of major portions of the United States. For a variety of reasons, water scarcity is affecting an increasing number of regions across the country, including some of our fastest-growing urban areas. In the arid West, long-term drought driven by meager rainfall, low snowpack and earlier snowmelt is becoming a more regular phenomenon. States across the American West are looking at futures with even more severe drought and depleted groundwater supplies. As of August 2014, the entire state of California was in exceptional or severe drought. But water-supply problems are not limited to arid regions. Certain areas of the eastern United States, which generally have ample rainfall, are struggling to meet the water demands of growing populations. In New England, homeowners have over-pumped groundwater wells to the point that rivers are drying up.[2] In Florida's Tampa Bay region, saltwater intrusion into aquifers due to groundwater over-pumping and rising sea levels is limiting access to freshwater.[3]

Meanwhile, we are losing a significant amount of water due to aging, leaky infrastructure; we are not capturing and using readily available sources; and we are using available water inefficiently or unwisely. The U.S. Geological Survey estimated that, nationally, the United States loses as much as 6 billion gallons of water per day to leakage, poor accounting and other unbilled consumption.[4] In New Jersey alone, the annual statewide loss of treated drinking water is estimated at 20–22 percent, with some distribution systems losing as much as 45 percent of treated water to leaks.[5] The impact of even some of the most successful residential conservation programs across the nation have leveled off because deeply held values regarding personal liberty and aesthetics continue to compel people to use substantial volumes of water for discretionary purposes such as lawn watering. These dynamics highlight the need for additional measures to enhance urban water conservation and efficiency. There also remain opportunities to increase water efficiency in the agricultural sector, which accounts for approximately 80 percent of consumptive water use nationally.[6]

We must accelerate the adoption of proven practices and technologies, as well as regulations and policies that support the optimal use of available water supplies. Facing a future in which freshwater will become increasingly scarce, we can no longer afford to wait for severe drought to spark conservation and efficiency initiatives. Instead, we need to implement a mix of strategies that will increase resilience to water scarcity – acute or chronic – by extending and diversifying our water supplies. As we make decisions about how to optimize the use of water and ensure urban and rural water security, we must balance human and environmental needs and consider potential unintended consequences.



The May 2014 Charting New Waters report ***Ensuring Urban Water Security in Water-Scare Regions of the United States*** provides a comprehensive exploration of ways to optimize the use of available water supplies.

Click here to view the full report or visit [www.johnsonfdn.org/chartingnewwaters.](http://www.johnsonfdn.org/chartingnewwaters)

Increase the Efficiency of Water Distribution Systems

In the short term, water-supply utilities need to dramatically increase the efficiency of their distribution systems through effective asset management, water audits, pressure management and systematic monitoring.[7, 8] Water-loss audits, in combination with information communications technology or "smart" sensors for leak detection and repair, can significantly reduce nonrevenue water loss from water systems.[9, 10, 11] Reducing nonrevenue water loss bolsters water supply and improves a utility's fiscal health. System repairs and improvements help utilities to avoid future capital costs related to emergency repairs, which translates into a greater return on investment in the short term. Utilities should also examine pressure management as a cost-effective and efficient strategy for controlling water losses from distribution systems.[13] Diligently replacing aging infrastructure is another critical task, as it helps to ensure that new leaks in deteriorating parts of the system do not negate efficiencies gained in other areas. Reducing the loss of treated water from water distribution and delivery systems can effectively produce "new" water and increase the security of existing supplies, while also bringing down operating costs and producing savings that can be passed on to ratepayers.

Establish Water Rates and Other Fees that Drive Conservation and Efficiency

Traditionally, water utilities have had a clear disincentive to promote conservation and efficiency, because declining water use results in a corresponding decrease in revenues. It is possible, however, using proper rate-making principles, for utilities to incentivize water conservation and efficiency while not threatening their fiscal sustainability. A variety of methods and models are available for setting conservation- and efficiency-oriented rates.[14] A 2013 water rates survey, for instance, found that 65 percent of utilities in California were using inclining tier block rate structures, in which the cost per unit of water increases as the customer uses more water. Three percent were using water-budget-based structures, which have punitive tiers when customers exceed their allotted budget. Water budget rate structures are growing in popularity because of their effectiveness in motivating ratepayers to be water efficient.[15, 16] Another approach is to adjust rates seasonally, or at times of peak demand, so that the utility passes on the often-higher costs of the water supplied during those times. For example, rates might go up during times of peak demand when the utility has to draw on higher-cost water sources.

The electricity sector also offers models that could be adapted to the water sector. Some investor-owned water utilities have piloted decoupling

Tools for Behavioral Water Efficiency

The emerging concept of behavioral water efficiency leverages smart metering technologies and social norms to drive conservation and efficiency. Various technologies can alert customers about their water usage, providing comparisons with their previous bills *and* with average household water use in the neighborhood. In 2014, the East Bay Municipal Utility District (EBMUD) in Oakland, California, implemented a pilot program using WaterSmart Software, which resulted in a 5 percent reduction in residential water use.[12] Customers were notified of water use via mail or email in the EBMUD pilot, but other technologies exist that can provide real-time information via smartphone or tablet apps. Badger Meter, for instance, allows customers to track their water consumption and provides alerts to potential leaks and high water use relative to household and neighborhood averages. Instead of focusing on household use, the EveryDrop app allows individuals to report leaks or overuse observed in the community.

Image courtesy of WaterSmart Software

strategies adapted from the power sector so that revenues are no longer generated based solely on the volume of water sold. This method could be implemented more broadly, given the right economic conditions.[17] Water utilities could also adapt the concept of a public goods charge from the power sector, whereby they would apply a nominal fee to water bills, the proceeds from which could be dedicated to funding water conservation and efficiency projects.[18]

In terms of regulatory drivers, state-level energy-efficiency rules could be adapted to spur water utilities to invest in conservation and efficiency. For example, the state Public Service Commission of Wisconsin requires investor-owned electric and natural gas utilities to spend 1.2 percent of their annual gross revenues on energy-efficiency and renewable resource programs, and requires municipal and retail electric cooperative utilities to collect an average of eight dollars per meter to fund energy-efficiency programs.[19] Similar rules could be instituted by bodies regulating water utilities.

Regardless of the specific approach, utilities and decision makers need to carefully consider revenue stability when setting conservation-oriented rates, including using modeling and scenario planning to examine what might happen should ratepayers respond better than expected to pricing signals.[20]

Implement Policies and Programs to Stimulate Efficient Water Use

In addition to setting rates carefully, utilities and local government agencies (e.g., planning and land use departments) need to establish systems, policies and regulations that drive conservation and efficiency among residential, commercial and industrial users. DC Water in Washington, DC, for instance, implemented a state-of-the-art High Usage Notification Application (HUNA), which uses Automatic Meter Reading technology as a demand management method as well as an optimization measure. HUNA allows the utility to monitor water use in real time and notify customers by phone, text message and/or email when the system detects a spike in usage. Such a spike may be due simply to high use, or it may stem from a leak, which can then be addressed rapidly.[21]

Municipal agencies, particularly planning departments, in both water-scarce regions and those perceived to be water rich, need to continually press for stronger efficiency standards and plumbing codes that require high-efficiency appliances and fixtures for new residential and commercial development. These agencies must also take steps to drive behavioral change among citizens. Communities such as Santa Fe, New Mexico, have enacted water ordinances that require new developments to offset their water use through conservation credits, water rights transfers or

Image courtesy of the city of Westminster, Colorado

Water Conservation Can Limit Rate Increases

A report from the Alliance for Water Efficiency shows that conservation measures implemented by the city of Westminster, Colorado, saved the city a great deal in water and infrastructure costs between 1980 and 2010 and also significantly limited rate increases during that time. Analyses conducted by the city demonstrated that the avoided infrastructure costs saved residents and businesses 80 percent in tap fees and 91 percent in rates compared to what they would have paid without conservation. In addition, the city achieved a 21 percent reduction in per capita water demand, which helped to buffer potential demand increases due to population growth that would have otherwise required capital investment to meet.[22]

a combination of the two. In this manner the overall water use in the community stays the same, while still allowing for economic growth.[23] States such as Florida, with its Water Star[SM] program, and utilities such as the Southern Nevada Water Authority, with its Water Smart Home program, encourage builders to construct highly water-efficient housing.[24] In addition, incentives such as rebates can be used to stimulate owners of existing homes and businesses to replace inefficient appliances and fixtures, thereby accelerating the process of retrofitting, which would otherwise occur passively over a longer timeframe.

Enhancing water conservation and efficiency can generate economic benefits for farmers by increasing crop yields and quality and saving energy, while also reducing withdrawals from surface water and groundwater sources and improving water quality.

The use of drought-tolerant landscaping that does not require irrigation, the replacement of inefficient irrigation equipment with higher-efficiency technology, and the employment of low-water landscaping practices can also have rapid and dramatic effects on water demand and result in significant water savings. Water agencies and municipalities should implement programs that create an atmosphere in which efficient outdoor water use is an attractive choice and a cultural norm. Water utilities should develop a range of education, outreach and incentive programs that provide community members with a menu of low-water landscaping options – from low-irrigation lawns to complete xeriscapes with no lawn. Utilities can also promote smart irrigation controllers to reduce unnecessary water use; such controllers act like thermostats for sprinkler systems, using local weather and landscape conditions to tailor watering schedules to actual site conditions.[25]

Through its SoCal Water$mart program, the Metropolitan Water District of Southern California (MWDSC) offers residential customers two dollars for every square foot of grass they replace with drought-tolerant landscaping, as well as rebates on water-efficient irrigation systems.[26] To cope with the deepening drought in the state, one of the MWDSC's member agencies, the Western Municipal Water District in Riverside, raised that incentive in August 2014 to five dollars per square foot.[27] In extreme situations, a municipality might consider banning lawn watering or lawns entirely. The Lake Arrowhead Community Services District in California, for instance, banned the planting of new turf grass to help cope with local water shortages, and during drought stages the district limits landscape watering to three days a week or less (down to none at all) depending upon the severity of the shortage.[28]

Expand Adoption of Water-Wise Agricultural Practices

While agricultural irrigation systems and management practices have become more water-efficient in recent decades, there remains untapped potential for the agricultural sector to bolster water supplies and ecosystem health by adopting water-wise practices more broadly.[29] Using technology similar to that noted above for outdoor residential use, weather-based irrigation scheduling can process data about local weather conditions to determine how much water a crop needs. Sprinkler and drip irrigation systems tend to distribute water more uniformly and be more water-efficient than traditional flood or gravity irrigation systems, with drip irrigation precisely applying water and fertilizer to crops by slowing releasing them from plastic tubing placed near the root zone.[30] In addition, evidence is mounting that practices such as soil moisture monitoring, cover crops, prairie strips, bioreactors, crop rotation, two-stage ditches for tile drains, and low- or no-till farming are cost-effective ways to reduce agricultural water demand, improve nutrient retention on agricultural fields and return clean water to ecosystems.[31, 32]

Enhancing water conservation and efficiency can generate economic benefits for farmers by increasing crop yields and quality and saving energy, while also reducing withdrawals from surface water and groundwater sources and improving water quality. To catalyze the wider adoption of water-wise agricultural practices, we need to build capacity through farmer networks and institutional relationships and facilitate the development of more demonstration farms. There is also a need for additional incentives and funding to support implementation. The U.S. Department of Agriculture, for example, could realign Farm Bill funding to make targeted investments in programs that conserve water and protect water quality. This could be achieved by using the Regional Conservation Partnership Program to create a revolving loan program for irrigation technology and management upgrades and/or reducing commodity support payments for low-value, water-intensive crops. In addition, realizing the full suite of potential benefits from more-efficient irrigation technologies and innovative agricultural practices will require proper management and maintenance on the part of producers on the ground.

Diversify Supply Portfolios with Underused Water Sources

To ensure water security over the long term, communities need to build more flexibility and redundancy into their water-supply storage and distribution infrastructure. A variety of technologies and infrastructure options exist that allow access to water not typically considered for water supply. For example, rainwater can be captured at the site level and used in building-scale systems, while larger quantities of stormwater or urban runoff can be captured, stored and managed to gradually recharge urban aquifers via large infiltration basins.[33]

In terms of water supply, centralized capture and recharge facilities are more cost-effective and easier to manage than distributed approaches, especially in arid climates where much of the rain falls in large storms.[34] Increasing the permeability of urban landscapes with low-impact development and green infrastructure is a more dispersed approach to capturing stormwater and can contribute to recharging aquifers and bolstering in-stream river flows. To effectively use urban stormwater runoff as water supply, city planners will have to reimagine how to design and build cityscapes, treating them as water infrastructure to capture, infiltrate and manage runoff at a variety of scales.

Distributed Systems in Action: Building-Scale Nonpotable Reuse

Through the Nonpotable Water Program of the San Francisco Public Utilities Commission (SFPUC), new developments have an efficient process for incorporating nonpotable uses into their development designs. Established in 2012 to help reduce pressure on the utility's potable water supply and combined sewer system, the program provides guidelines and water-quality regulations for collection and treatment systems at the building and district scale, including systems that use alternative water sources such as graywater, blackwater, rainwater, stormwater and foundation drainage. As of 2013, the program also included a process for sharing water between buildings. In addition to helping expedite the permitting process, the SFPUC offers grant assistance for large alternative water source projects, providing up to $250,000 for an individual building and up to $500,000 for multiple buildings implementing on-site nonpotable water reuse.[35]

Image courtesy of iStock Photo

Untapped opportunities also exist for water utilities to integrate and leverage the services provided by both natural and engineered ecosystems to enhance water security. Urban utilities should adopt a broader concept of urban water infrastructure that encompasses conjunctive use of surface water and groundwater, managed aquifer recharge and the natural filtration offered by forests and wetlands. A January 2014 study, for instance, recommended that the state of Massachusetts adopt a land use planning scenario that labels forests "living infrastructure" that provides a range of benefits, including improved source water quality and flood control.[36] In Colorado, Denver Water has partnered with the U.S. Forest Service to invest in forest conservation and watershed management activities that reduce soil erosion and wildfire risks and mitigate the potential impacts of sedimentation on water sources and infrastructure.[37] The passage of water through soil or engineered wetlands can also provide passive water treatment that can remove nutrients, pathogens and chemical contaminants, while using very little energy, sequestering carbon and providing wildlife habitat and recreational opportunities.[38]

Untapped opportunities exist for water utilities to integrate and leverage the services provided by both natural and engineered ecosystems to enhance water security.

Reclaim and Reuse Water from Wastewater

Negative perceptions of both nonpotable and potable water reuse are beginning to shift, opening up greater opportunities to supplement public water supplies with reclaimed and reused water.[39] With reuse being arguably the most promising way to extend existing water supplies, water utilities planning for long-term water security should more aggressively integrate indirect and direct nonpotable and potable water reuse into their supply portfolios.[40] While large-scale reuse of nonpotable water has become common for irrigating parks and golf courses in arid regions of the country, distributed systems can produce nonpotable water supply at smaller scales, which keeps water local and further reduces demand on potable water supplies. To date, the implementation of building-scale water reuse systems has primarily been driven by private developers and has occurred opportunistically, with the buildings of Battery Park City in Lower Manhattan being a marquee example.[41] However, utilities can create mechanisms to facilitate the broader implementation of distributed systems for nonpotable water reuse. The Nonpotable Water Program of the San Francisco Public Utilities Commission, for example, offers a model that utilities elsewhere may be able to adopt (see inset on p. 19).

Reclaimed water can also be used for indirect potable uses such as replenishing drinking water sources and managing aquifer levels. And, direct potable reuse may be a viable option assuming appropriate treatment and public health safeguards. The U.S. Environmental Protection Agency (EPA) has provided extensive guidelines for nonpotable water reuse, but more robust guidance is needed for potable reuse. Federal public health standards for both practices are also needed.[42] In the absence of federal standards, states such as California and Texas are developing rules for potable reuse using existing drinking water standards, which might serve as models for other states interested in forging ahead.[43] Overall, water-sector leaders and policymakers need to go beyond the current piecemeal approach to water reuse and identify higher-order policy, regulatory and market adjustments that would enable communities to supplement their water supplies using these practices.

In many coastal regions of the country, wastewater plants discharge treated effluent directly into coastal waters, transferring large quantities of freshwater from surface waters and groundwater aquifers into saltwater, permanently depleting terrestrial freshwater sources as a result.[44] Utilities in areas where this practice is standard need to rethink and redesign their systems to capture and reuse this viable water source for appropriate purposes. Ramping up the capture and reuse of water previously lost to oceans can produce "new" water supply, potentially relieving pressure on existing sources and the need to secure additional supply.

Match the Right Quality Water to the Right Use

Nationally, we need to shift away from the traditional paradigm of treating all water to the highest public health standards. The vast majority of municipal water in the United States is filtered, purified and disinfected to drinking water quality regardless of its intended use. This full-scale treatment, however, with its energy- and chemical-intensive steps, is only necessary for about 30 percent of all indoor household uses (e.g., faucets and showers).[45, 46] Less-intensive treatment is adequate for toilet flushing, outdoor irrigation, cooling and a variety of commercial and industrial purposes.

We need to begin implementing more fit-for-purpose or tailored water systems, where technically and economically feasible and in compliance with applicable public health standards. Such systems treat water to different quality levels and enable its delivery for safe and appropriate residential, commercial and industrial uses. Currently, this approach is achieved most cost effectively with centralized infrastructure. The West Basin Municipal District's Edward C. Little Water Recycling Facility in El Segundo, California, for example, is a large plant that produces 30 million gallons of recycled, custom-made water to five different quality levels daily to meet different nonpotable water needs. The only facility of its kind in the United States, it conserves enough drinking water to meet the needs of 60,000 households for a year and has the flexibility to increase or decrease production of each type of water depending on demand (see inset).[47]

Distributed technologies for tailored water are under development and may eventually be able to produce potable water if fitted with appropriate membranes or combined with other small point-of-use treatment systems that produce clean drinking water at the tap.[48, 49] In addition to conserving potable water supplies, fit-for-purpose systems can increase the efficiency of nonpotable water use, reduce energy consumption for wastewater treatment, reduce discharges of treated effluent and provide water to recharge groundwater aquifers.

Delivering Tailored Water

The West Basin Municipal Water District's Edward C. Little Water Recycling Facility (ELWRF) in El Segundo, California, is the largest water recycling facility of its kind in the United States and was recognized by the National Water Research Institute in 2002 as one of only six National Centers for Water Treatment Technologies. The ELWRF is the only treatment facility in the country that produces five different qualities of "designer" or custom-made recycled water that meet the unique needs of the West Basin's municipal, commercial and industrial customers.[50] The five types of designer water include:

1. Tertiary Water (Title 22), for a wide variety of industrial and irrigation uses;
2. Nitrified Water, for industrial cooling towers;
3. Softened Reverse Osmosis Water, which is secondary treated wastewater purified by micro-filtration, followed by reverse osmosis and disinfection, for groundwater recharge;
4. Pure Reverse Osmosis Water, for refinery low-pressure boiler feed water; and
5. Ultra-Pure Reverse Osmosis Water, for refinery high-pressure boiler feed water.

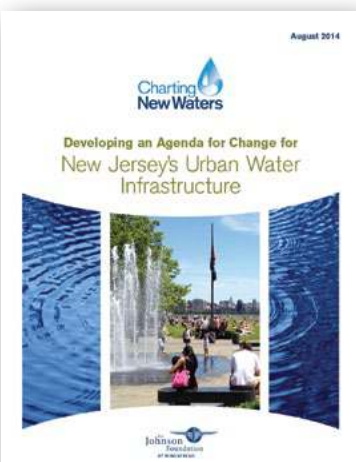
Image courtesy of West Basin Municipal Water District

2. Transition to Next-Generation Wastewater Systems

Most existing wastewater systems in the United States were built with technology developed in the mid-20th century and served our nation well during times of abundant water, inexpensive energy and ample federal grant funding.[51] But those times have passed. Water is increasingly scarce nationwide, energy and other materials are more expensive and financing is more difficult to garner. In addition, climate change and other extreme events (e.g., natural and manmade disasters, terrorist attacks) pose risks for which many wastewater utilities and municipalities are struggling to prepare.

One of the foremost challenges is controlling combined sewer overflows (CSOs), which remain a significant source of water pollution and a public health hazard in many older U.S. cities and are becoming harder to mitigate in some places because of more intense rainstorms.[52] Combined and separate sanitary sewer systems that suffer from leaks and degraded pipes can also adversely affect groundwater resources, exfiltrating (leaking) raw sewage when pipes fill up and sometimes absorbing groundwater during dry periods. Also, as nutrient standards and discharge permits have become more stringent, the energy intensity and cost of wastewater treatment has increased significantly. Large, centralized wastewater systems are also vulnerable to single-point failures that can quickly leave entire communities without sanitary sewer service, a resilience shortfall highlighted during Hurricane Sandy. Disruptions to the power grid, supply chains for essential materials, sewer pipes, or transportation infrastructure can also lead to the failure of centralized facilities.

Meanwhile, a surge of innovation in the wastewater sector offers numerous opportunities to bring legacy wastewater systems into the 21st century. With concerted leadership, local governments and utilities can convert today's systems into the pollution-prevention and resource-recovery systems of the future and generate a variety of environmental, economic and social benefits. They can reduce pressure on sewer systems and treatment plants, while enhancing local water security and creating healthier and more vibrant communities. They can produce "new" water and enhance the security of local water supplies. And, utilities can extract and repurpose byproducts from the wastewater treatment process (e.g., nutrients, biosolids, biogas, waste heat) and convert them into commodities (e.g., water, fertilizer, electricity) while meeting regulatory obligations, eliminating odors and improving water quality. We know that sewer and wastewater systems in the United States are in serious need of renovation, and that billions of dollars will have to be spent to upgrade infrastructure and maintain service. Decision makers must invest in solving tomorrow's challenges and seizing key opportunities rather than fixing today's problems with yesterday's solutions.



The August 2014 Charting New Waters report ***Developing an Agenda for Change for New Jersey's Urban Water Infrastructure*** provides a place-based discussion of the opportunities associated with innovative approaches to CSO control and green infrastructure implementation.

Click here to view the full report or visit www.johnsonfdn.org/chartingnewwaters.

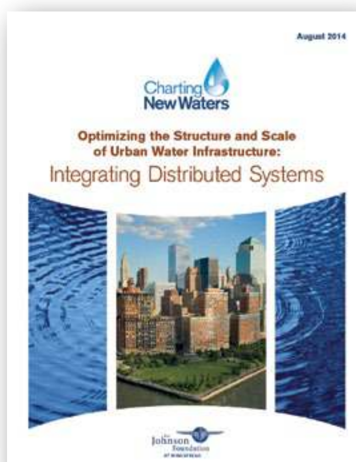
Prevent Clear Water from Entering Sewer Systems

Stormwater runoff and groundwater must be kept out of wastewater conveyance systems wherever possible so that wastewater utilities can focus on treating water that truly needs treating. Utilities need robust asset management programs that document the volume of non-sewage water entering the system and include normalized measures of leakage that allow for tracking and comparison independent of the size of the system or weather variability. Effective asset management enables utilities to prioritize the work needed to fix leaks and proactively address components near the end of their useful lives.[53] That said, separating combined sewer systems into sanitary and storm systems is the only foolproof solution for eliminating stormwater from combined sewer systems and preventing CSOs. Wastewater utilities responsible for CSO control need to devise plans and financing strategies to separate parts of their combined sewer systems where it is technically feasible and cost-effective.

Green infrastructure, if implemented systematically and at scale, can also treat stormwater runoff while keeping a substantial amount of it out of sewer systems; this approach has become widely accepted by cities, utilities and regulators as an integral component of CSO control.[54] Shown to provide a wide array of ancillary benefits, green infrastructure solutions should be promoted, incentivized and permitted to support long-term CSO control and municipal stormwater management.[55] As communities undertake sewer separation or green infrastructure projects (or some combination thereof), they can save on costs by coordinating construction with other projects such as housing developments, roadwork or other repairs being performed in the public right-of-way. Together or individually, effective asset management, combined sewer separation and green infrastructure can dramatically lower the amount of water that wastewater plants must treat, bring down operating costs and reduce both pollution and greenhouse gas emissions.

Complement Centralized Wastewater Infrastructure with Distributed Systems

Distributed wastewater treatment systems can be more efficient, effective and resilient than conventional centralized systems, and as such they are becoming an attractive alternative. They can service a range of scales, from individual homes to communities; function independently or remain connected to a centralized system; and be located remotely or within city boundaries. Wastewater utilities seeking to reduce the volumes handled by centralized wastewater treatment plants should consider integrating distributed systems into their existing infrastructure.



The August 2014 Charting New Waters report ***Optimizing the Structure and Scale of Urban Water Infrastructure: Integrating Distributed Systems*** provides detailed examination of the opportunities and implementation challenges associated with distributed water infrastructure.

Click here to view the full report or visit www.johnsonfdn.org/chartingnewwaters.

Distributed systems that are linked with existing centralized systems can be described as "distributed–networked" or "distributed–integrated," and can provide redundancy that bolsters a utility's level of service. Technologies for small-scale, on-site water treatment and reuse offer flexibility for utilities in how they deliver services and for communities in how they develop over time. Utilities should consider distributed options in their long-term planning, particularly when deciding how to serve new development that would otherwise require extending existing, centralized systems. Building out water infrastructure on an "as-needed" basis to accommodate new customers can be far more cost-effective and help minimize pressure on existing systems.

Distributed Systems Provide Low-Cost Alternative for New Development

Faced with rapid population growth, Piperton, Tennessee, a rural community outside of Memphis, had to determine an infrastructure solution to provide wastewater services for new development. The city considered three options: building its own centralized wastewater treatment plant; connecting to a plant in the adjacent city; or implementing distributed treatment systems to provide service when and where it was needed. With a small tax base and the neighboring town reluctant to allow the city to connect with their plant, Piperton decided to work with private developers to implement cluster-scale distributed systems to serve new neighborhoods. The city negotiated agreements for developers to install the systems, with the city taking responsibility for operations and maintenance once the systems were installed. Maintenance personnel monitor performance remotely using an internet-based system. This approach allowed Piperton flexibility and adaptability in construction and financing; minimized capital and operational costs and impacts on ratepayers; and enabled the city to preserve its open space and floodplain. In addition, development continued following the installation of four initial clustered systems, further enhancing the economic potential of the area.[56]

Image courtesy of Water Environment Research Foundation

The system redundancy enabled by distributed treatment systems also increases resilience to extreme weather events, natural disasters and other disruptions. Distributed systems can be more resilient than centralized systems because they are smaller and easier to locate in less flood-prone areas, and they can usually be kept online using backup generators, as opposed to relying on the power grid.[57] During Hurricane Sandy, for example, more than 80 distributed wastewater treatment systems in the New York/New Jersey region remained operational, while many centralized systems suffered severe damage and operational failures.[58] The Charles River Watershed Association is creating an example of how to approach the implementation of distributed–networked wastewater infrastructure through pilot projects in the Boston area that integrate energy capture and groundwater restoration.[59]

The acceptance and adoption of small-scale distributed systems among regulators, the public and utilities remains inhibited by concerns about performance and public health. Therefore, more research and development into such systems is needed, as are demonstration projects that address uncertainty about health risks. In addition, local, state and federal environmental and public health regulators need to reexamine – and revise, as needed – laws and policies that inhibit the implementation of small-scale treatment systems.

Maximize Resource Removal and Recovery from Wastewater

Wastewater utilities traditionally have focused on limiting the pollution they contribute to local surface waters. With the use of new technologies, however, utilities have a significant opportunity to transition from minimizing pollution to maximizing the recovery of valuable resources from wastewater – especially nutrients (discussed here) and energy (discussed in the next section).

Given adequate concentration of nutrients in wastewater, available technologies can remove much of the load from discharges and convert it into useful commodities. As an example, more wastewater treatment facilities are adopting struvite recovery technologies that capture phosphorus for direct reuse as a high-quality fertilizer while also eliminating problematic struvite buildup inside of conveyance pipes. There is a need for greater incentives to adopt these technologies and develop viable markets for the resulting products.

Wastewater utilities should seek out nitrogen-removal technologies that minimize energy use and greenhouse gas emissions. In this regard, anaerobic ammonium oxidation (known as anammox) is an innovation that should be evaluated and scaled up aggressively where viable. Rather than using conventional, energy-intensive processes to remove ammonia and denitrify wastewater, this process harnesses the power of special bacteria to convert ammonia into harmless nitrogen gas at drastically lowered energy costs.

Pilot Projects Test Energy-Saving Nutrient Removal Processes

DC Water and the Hampton Roads Sanitation District (HRSD) have been collaborating to resolve fundamental scientific and technical engineering challenges associated with integrating partial nitritation with anammox bacteria (commonly termed *deammonification*) into the activated sludge wastewater treatment process at scale. Driven by stringent nutrient-control targets stipulated as part of the Chesapeake Bay Total Maximum Daily Load, the two utilities are forging a path for sustainable wastewater treatment nationally and globally. Through their "public–public partnership," DC Water and the HRSD seek to create a model sustainable wastewater utility that achieves permit compliance while minimizing impacts on ratepayers, communities and the environment. DC Water is testing sidestream and mainstream deammonification at its Blue Plains Advanced Wastewater Treatment Plant, and the HRSD is piloting mainstream deammonification processes and operating the first two, full-scale sidestream deammonification processes in North America at their York River and James River treatment plants.[60]

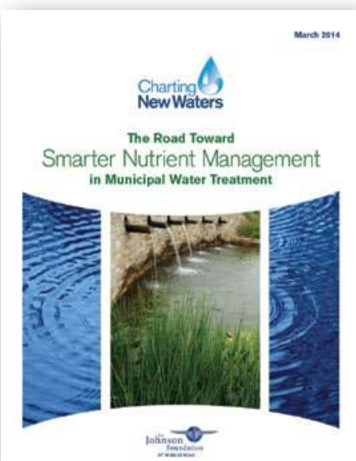
Image courtesy of HRSD and Backus Aerial Photography, Inc.

In California, chemists at the Delta Diablo Sanitation District in Antioch are working with researchers at Stanford University to develop methods for converting nitrogen into nitrous oxide, which could produce a new alternative energy source for the district. The project – called Coupled Aerobic-anoxic Nitrous Decomposition Operation, or CANDO – is the first to test the process outside of a laboratory. The goal is to prove that the process can be implemented cost-effectively and can enable energy-positive wastewater treatment operations.[61]

Opportunities also exist to take advantage of and help manage organic waste streams while enhancing the efficiency and productivity of these systems. Scaling up existing resource removal and recovery technologies has the potential to transform how we treat wastewater, while dramatically reducing nutrient concentrations in treated effluent as well as energy use at treatment plants.

Develop Energy-Positive Wastewater Treatment Facilities

The water sector as a whole is responsible for roughly 12.6 percent of our country's primary energy use, and a substantial portion of that is attributable to wastewater treatment.[62] Energy is a major expense for most wastewater treatment facilities. However, it is possible for such facilities to recover enough chemical, kinetic and thermal energy from municipal wastewater itself to generate more than enough energy to run the treatment process.[63] With this in mind, the Water Environment Federation released a 2013 report that outlines tools for reducing the amount of energy used in wastewater treatment as well as increasing the energy-generation capabilities of utilities, leading to net-zero or near-net-zero energy footprints.[64]



The March 2014 Charting New Waters report ***The Road Toward Smarter Nutrient Management in Municipal Water Treatment*** provides a discussion of utility strategies for meeting regulatory obligations while managing energy and operational costs more effectively.

Click here to view the full report or visit www.johnsonfdn.org/chartingnewwaters.

Energy-generation technologies already in use at treatment plants include solar arrays, wind turbines and biogas systems. In addition, facilities can capture waste heat from different aspects of their operations to sustain the anaerobic digestion process, and then use the methane from the digesters to fuel biogas-fired turbines. With adequately fueled digesters and right-sized power generation systems, treatment facilities can indeed produce more than enough electricity on-site to power their own operations. In 2012, the wastewater treatment plant operated by EBMUD in Oakland, California, which uses biogas to power low-emission gas turbines, became the first net-positive, energy-generating wastewater plant in the United States.[65] Other utilities are now following suit.

In addition, although it doesn't directly offset the energy demand of wastewater treatment plants, extracting thermal energy from sewer lines via heat exchange can help to heat nearby buildings (see inset on p. 27). Wastewater utilities may also be able to install hydropower turbines in sewer lines, a retrofit that water-supply utilities are also beginning to install in water distribution lines.

Wastewater treatment facilities that generate their own renewable power are more resilient, as they are better able to maintain service when the power grid is disrupted. They also have more stable energy costs, and they may even be able to create new revenue streams by selling excess electricity back to the power grid. Moreover, reducing reliance on fossil fuels will bring down the wastewater sector's greenhouse gas emissions and help to mitigate climate change.

3. Integrate the Management of Water, Energy and Food Production

As a nation, we need to be cognizant of the many important intersections between water, energy and food production. We need to establish a comprehensive approach to integrating the management of these essential resources and services, maximizing the synergies while minimizing any negative tradeoffs. We need adequate water supplies to keep power plants functioning and agricultural fields producing.[66, 67] And we need substantial amounts of electricity to deliver water and treat wastewater. Despite the fundamental links among these sectors and the potential to leverage infrastructure investments, they generally plan and innovate independently.[68] Meanwhile, the impacts of climate change and drought, as well as changing economic conditions, bring increased urgency to the need to conserve natural and financial resources while continuing to meet the country's energy and food needs.[69]

Fortunately, opportunities for coordination and collaboration among the water, energy and agricultural sectors are increasing. With climate change projected to bring greater environmental extremes to every region of the country, water and electric power utilities are seeking ways to strengthen their resilience to future disruptions and to mitigate climate change by reducing greenhouse gas emissions.[70] Farmers and ranchers are striving to produce more food and biofuels with less water and lower environmental impact. The use of hydraulic fracturing for oil and gas production has surged in recent years, and the process uses and contaminates large quantities of (typically rural) water. But companies involved in the activity are developing water treatment and reuse technologies that reduce the need to tap into municipal and agricultural supplies. To avoid putting public health, economic growth and national security at risk, leaders within each of these sectors, along with federal decision makers, must take proactive steps to collaboratively plan for the future and integrate the management of water, energy and food production for a sustainable future.

Improve Energy Management at Water and Wastewater Utilities

As significant energy consumers, water and wastewater utilities need to continue to implement energy-efficiency measures and other technological innovations to significantly reduce or eliminate their net energy use, bring down operating costs and work better with the power grid. An initial step is for water utilities to conduct energy-intensive activities – such as treating and pumping water – during periods when electricity is most available. Coordinating water operations with electricity demand in this way would

Mining Sewers for District-Scale Electricity: The Village on False Creek

The Neighbourhood Energy Utility (NEU) serving the Southeast False Creek community in Vancouver, British Columbia, was the first utility in North America to recover waste heat from untreated urban wastewater. Sewage heat recovery meets approximately 70 percent of the utility's annual energy demand, with solar panels on buildings in the neighborhood providing the balance of the supply. The NEU has reduced greenhouse gas emissions by more than 50 percent compared to conventional energy sources; stabilized energy costs for customers, compared to more volatile fossil fuel prices; and, as a self-funded utility, provided a return on investment to taxpayers.[71]

Image courtesy of Ausenco Sandwell

allow water-sector utilities to take advantage of lower-cost electricity and relieve stress on the power grid during peak demand, the point at which it is at the greatest risk of failure.

In cases where power cannot be generated with assets controlled by water or wastewater utilities, communities should leverage the purchasing power of these utilities to reduce the water-related impacts of their power choices by purchasing low-water and low-greenhouse-gas electricity. For example, the Sonoma County Water Agency in northern California purchases a large portion of its electricity from a nearby landfill-to-gas operation as part of its Carbon-Free Water by 2015 initiative.[73] Local governments and utilities can also help to reduce the energy footprint of water through water-conservation and -efficiency programs, and by developing local water sources to limit energy-intensive water transfers.

Energy and Water in a Warming World: The EW3 Initiative

The Energy and Water in a Warming World Initiative (EW3) of the Union of Concerned Scientists (UCS) is researching ways the U.S. power sector can address its water and carbon footprints simultaneously. This multi-year partnership between the UCS and dozens of independent experts – which was launched during a 2009 meeting at The Johnson Foundation at Wingspread – is analyzing the current and projected impacts of electricity production on freshwater availability and regional vulnerability and risks, and recommending low-water energy solutions. In 2011, EW3 issued the first systematic assessment of both the effects of power plant cooling on U.S. water resources and the quality of information available to help the public and private sectors make water-smart energy choices. A 2013 follow-up report offered recommendations for achieving up to a 97 percent reduction in water use in the power sector through the adoption of "no regrets" energy-efficiency technologies and renewable energy technologies such as wind power and solar photovoltaics that require no water and emit little carbon.[72]

Image courtesy of iStock Photo

Prioritize Water-Smart Electric Power

Like the water sector, the electric power sector is experiencing challenges tied to climate change, greenhouse gas regulations and shifts in water availability.[74] This is especially true in water-scarce parts of the country, where power providers are looking for ways to reduce their reliance on freshwater to avoid the risk of curtailed operations and temporary shutdowns at thermoelectric plants that require water for cooling.[75] With the retirement of American coal-fired power plants projected to increase in coming years, utilities have an opportunity to make long-term investments that minimize their dependence on water.[76] To ensure the reliability of electricity supply, regulatory bodies, planners and elected officials should evaluate the water intensity of power generation operations and prioritize low-water technologies or identify alternative cooling water sources. Toward that end, a 2013 resolution of the National Association of Regulatory Utility Commissioners urged states and federal authorities to take a variety of steps to recognize the role of water in the U.S. power supply and reduce electricity-related water risks, including reducing the water-intensity of power generation.[77] The water-quality impacts (e.g., temperature) of power plant effluent should also be mitigated using conservation-based water cooling strategies (i.e., riparian habitat restoration) adapted from the wastewater sector.[78]

Electric utilities should be required to retrofit facilities with low-water cooling technologies or obtain cooling water from alternative sources such as water recovered from wastewater plants. As of 2011, only about 67 electric utilities in the United States were using reclaimed water for cooling at power generation facilities, yet there are opportunities to vastly expand this number.[79] A 2009 U.S. Department of Energy study found that nearly 50 percent of existing coal-fired power plants in the United States have sufficient reclaimed water available within a 10-mile radius to meet their water needs, and 75 percent have adequate reclaimed water within a 25-mile radius.[80] Shifting the electric power sector toward low-water renewable energy and other technologies, and expanding the use of reclaimed water for remaining cooling needs, will help reduce the sector's impact on freshwater supplies, reduce stress on ecosystems and increase energy and water security.[81]

Recover Nutrients and Energy from Agriculture

Food producers across the nation should integrate key innovations from the water and power sectors into their operations. Most wastewater treatment facilities already have relationships with local farmers who use biosolids as a source of fertilizer. These existing relationships could be leveraged to facilitate technology transfer between the sectors. For instance, anaerobic digesters and biogas capture technologies, which enable more effective nutrient management and energy capture at wastewater treatment facilities, can also be implemented on-farm to better manage animal and plant "waste." Anaerobic digesters can be used to manage manure from livestock operations and/or plant material produced on farms or at food processing operations; these digesters can generate biogas-powered electricity on-farm as well as compressed natural gas, which can fuel equipment or heat buildings. Anaerobic digestion also produces rich compost material that can be recycled and applied to farm fields in a form that is less likely to impact water quality than fresh manure. Applying these technologies and processes on farms and ranches across the country could significantly reduce nutrient-related water-quality impacts from agriculture such as groundwater contamination, eutrophication of surface waters and fish kills.[82]

The smaller-scale, biogas-producing anaerobic digesters appropriate for on-farm use are just entering the marketplace in the United States, but they remain relatively expensive. Research and development need to be accelerated and incentives need to be provided to catalyze the adoption of this technology on farms and at food processing facilities.

Wind Energy Saves Billions of Gallons of Water

Wind energy, a small but growing piece of the nation's electricity portfolio, offers a no-water, no-carbon alternative for electricity generation, saving enough water nationwide to meet the annual domestic water needs of more than 1 million Americans while also displacing carbon-dioxide emissions and other air pollution. The state of Texas, well-versed in water-supply challenges, is saving 8.6 billion gallons of water annually and avoiding 19.3 million metric tons of carbon-dioxide emissions annually through investment in wind power. These water savings equate to the annual domestic water-supply needs of more than 172,000 Texas residents. States such as California and Colorado are also expanding wind energy production and reaping the benefits of approximately 2.7 billion and 1.4 billion gallons of annual water savings, respectively.[83]

Image courtesy of iStock Photo

Furthermore, urban wastewater operators can and should look for opportunities to share their knowledge about anaerobic digestion and methane capture with food producers so that both sectors are taking advantage of the latest technological and operational advancements.[84] Some wastewater service providers may even be able to expand their service models to incorporate capital and/or operations support for distributed rural treatment facilities.

Resource Recovery Technology Links Water, Energy and Food Production

A variety of entrepreneurs are advancing technological innovations that foster integration between the wastewater and agricultural sectors. A company called Ostara, based in Vancouver, has proprietary technology that recovers phosphorus, nitrogen and magnesium from municipal and industrial wastewater and transforms them into environmentally friendly, slow-release fertilizer. The process helps achieve compliance with nutrient-discharge regulations, produces a new source of revenue for wastewater utilities and offers farmers an efficient, cost-effective fertilizer, all while eliminating the buildup of pipe-clogging struvite.[85]

Image courtesy of Forest County Potawatomi Community

Wisconsin-based BIOFerm Energy Systems offers an array of on-farm anaerobic digestion systems that turn crop and animal waste into methane, helping farmers save on both waste disposal and power costs and enabling them to earn carbon-reduction and renewable energy credits that can be used to meet compliance standards.[86]

In Milwaukee, Wisconsin, a waste-to-energy facility owned by Forest County Potawatomi Community Renewable Generation, LLC, converts liquid and solid waste from the food and beverage industry into biogas. In turn, the biogas fuels two 1.0 megawatt generators that produce electricity that is sold to a local electrical utility. The electricity provided by the facility helps the power utility fulfill its renewable energy portfolio requirements.[87]

Like their counterparts in the water and wastewater sectors, farmers and ranchers are looking for ways to capture the energy embedded in water moving through their property. With the 2013 passage of two key federal laws that make it easier to implement low-head hydropower turbines in existing infrastructure, rural property owners can now harness energy from water moving through irrigation canals and other conveyance conduits that they manage.[88] Accelerated knowledge transfer between the water and agriculture sectors could stimulate the adoption of technologies and practices that benefit both.

Plan for Sustainable Rural Water Supplies

The long-term sustainability of the water supplies that underpin the production of food, fiber and fuels is essential to the economic vitality of the nation. Particularly in rapidly growing areas of the water-scarce West, urban and rural water leaders need to collaboratively develop strategies to eliminate short-sighted "buy-and-dry" municipal and industrial water-supply solutions that transfer water away from farms, ranches and rural communities. Leaders need to forge partnerships to devise mutually beneficial water management solutions that balance municipal, agricultural, industrial and ecosystem water needs. Durable water-sharing solutions can be achieved by coordinating demand management and supply enhancement strategies that cut across the urban–rural interface and involve tradeoffs deemed acceptable by the affected water users.

Strategies that require further pilot testing and refinement to facilitate broad adoption include leasing and fallowing agreements with agricultural producers and regulated deficit irrigation programs, which enable the sharing of saved water.[89] In Colorado, for example, the Arkansas Valley Super Ditch project is planning a pilot water-sharing program under a 2013 state law encouraging water sharing as an alternative to the permanent dewatering of farm land.[90] Farmers can also prioritize crops that are able to adapt to local or regional changes in temperature and precipitation, and implement soil management practices that maintain moisture and soil health to support greater drought resilience.[91] In addition, urban water utilities and rural water agencies should implement more sustainable supply management approaches, such as conjunctive use of groundwater and surface water, which can help replenish groundwater supplies diminished by over-pumping.

The energy production sector must also help to sustain rural water supplies, as escalating water demand for domestic production of biofuels (i.e., corn-based ethanol) and impacts from oil and natural gas development (i.e., hydraulic fracturing) are contributing to water stress in many regions of the country.[92, 93] As discussed previously, government agencies need to continue to incentivize agricultural water conservation and efficiency, including among cellulosic ethanol producers.[94]

One of the most promising water management innovations in the hydraulic fracturing arena is the reclamation and recycling of flowback water and produced water that return to the surface, which can be treated and reused for fracturing other wells and may be appropriate for use as irrigation water. Some companies are also applying inland desalination to treat brine-laden groundwater to a quality appropriate for hydraulic fracturing.[95] State regulatory agencies, researchers, private companies and investors should continue to advance research and development of water recycling technologies (e.g., distributed treatment, inland desalination) for oil and gas operations as well as rules and policies that stimulate their use.[96] As the nation continues to take advantage of domestic energy sources in the interest of energy independence and strengthening national security, we must carefully consider and manage impacts on our water resources.

4. Institutionalize the Value of Water

Historically, a substantial portion of utilities' capital investments in water infrastructure was heavily subsidized by federal grants, which allowed utilities to provide service without passing on the cost of capital to ratepayers. In addition, water rates have not traditionally reflected the externalized costs of water withdrawal, pollutant discharge and other community impacts. This approach to water pricing has conditioned the vast majority of Americans to assume water delivery and wastewater treatment are and always will be inexpensive services. To avoid rate increases, many utilities have chosen for years (if not decades) to defer maintenance, delay capital investments and forgo improving their systems' environmental performance. However, with the decline of federal grant funding and the massive and growing water infrastructure investment gap facing communities, we can no longer afford to maintain the illusion that water and water services are cheap.[97] In addition, more stringent water-quality requirements, long-term debt obligations and declining water and wastewater volume sales mean that utilities are faced with the unsettling prospect of costs rising more quickly than revenues, requiring significant and frequent water rate increases.

It is time to rethink how we value water and adopt new strategies and tools that institutionalize its true worth. Utilities need to get creative and tap into new sources of capital to repair and revamp their water infrastructure. They must be more forward thinking about pricing water and related services so that they can recoup operating costs and pay off long-term debt, as well as have funds available to

It is time to rethink how we value water and adopt new strategies and tools that institutionalize its true worth. Utilities need to get creative and tap into new sources of capital to repair and revamp their water infrastructure.

invest in innovation in the short term. They need to charge for water services in a way that provides more resilient revenues, and more effectively leverage the power of markets to account for previously unnoted costs and benefits. Perhaps most importantly, all who care about this issue must find more cohesive, compelling and visible ways to raise awareness about the value of water and instill an appreciation among the public and policymakers for water infrastructure and resources commensurate with the essential role water plays in the daily lives of Americans.

Tap New Sources of Capital and Use Innovative Financing Mechanisms for Infrastructure Upgrades

In today's financial atmosphere, communities and utilities need to start tapping into new sources of capital and using new financing mechanisms to pay for major system improvements. While federal and state government funding remains a key source of capital, it is not adequate to meet water infrastructure needs. The traditional municipal bond market also remains a critical source, but forward-looking water and wastewater utilities should consider new opportunities as well. "Green bonds," for example, are an emerging debt vehicle targeted at a growing group of investors interested in supporting projects and enterprises that enhance sustainability and resilience. In July 2014, DC Water was the first water utility in the country to issue green century bonds, which match financing terms with the projected life of the new assets being developed so that the debt obligation is spread over the generations of people who will benefit from the investments.[98]

> *Communities and utilities need to tap into new sources of capital and use new financing mechanisms to pay for major system improvements.*

Financially strapped municipal utilities can form public–private partnerships (P3s) with investor-owned water utilities or private water services companies; these P3s can include agreements for the private entity to invest a designated amount of capital in infrastructure improvements over a set period of time. For example, the Bayonne (New Jersey) Municipal Utilities Authority (BMUA) and United Water (with financial participation by private investor KKR) forged a P3 in 2012, through which the BMUA will continue to own its water and wastewater assets, while United Water operates the system under a rate schedule established in the contract. Over the life of the 40-year agreement, $130 million of BMUA debt will be retired, and United Water will invest $107 million into upgrading aging infrastructure.[99]

When possible, water utilities should coordinate with other local departments (e.g., transportation, parks and recreation) to leverage funding for joint projects, using diligent accounting methods to ensure the integrity of separate enterprise and governmental funds. Municipalities should also encourage private investment in green infrastructure by establishing state or local performance standards for new development and redevelopment and by establishing financial incentives (e.g., state tax exemptions or credits, reduced monthly utility fees, grants) for developers to manage stormwater on-site. The Philadelphia Water Department, for instance, launched the Green Acre Retrofit Program, which provides grant funding to companies and contractors to construct stormwater projects on private property in the city's combined sewer area. The program is specifically targeted at large-scale stormwater management projects.[100] Crowdfunding initiatives are another emerging source of private capital that cities and utilities ought to consider using to fund smaller infrastructure projects. This strategy has been particularly successful to date when applied to civic projects focused on greening neighborhoods.[101]

Institute Sustainable Pricing for Water Services

To ensure sufficient cash flow, water utilities need to set rates so that they recover all relevant costs associated with regular operations, maintenance and existing debt service while also achieving efficiency and conservation goals. With the majority of water systems across the nation in need of repair or upgrades, however, utilities must also consider rate-setting measures that will generate revenue to cover future capital improvements. Elected officials, utility leaders and advocacy groups need to work together to gain ratepayer trust, reset expectations and institute pricing that allows for long-term operational sustainability. When pricing water, decision makers must ensure fairness across their ratepayer base and consider the implications of the rates for the community, including economic development and customer affordability. To provide financial assistance to customers that need it, the federal government and rate-setting entities can look to the energy sector for model affordability programs, such as the Low-Income Home Energy Assistance Program. Such programs could be adapted and adopted nationally by the water sector to accelerate the transition to sustainable pricing at the local level.[102] Taking steps like these to ensure affordability will only become more important as "human right to water" laws such as those in Pennsylvania, Massachusetts and California become more common.

Public–Private Partnership Funds Urban Stormwater Retrofits

Image courtesy of U.S. EPA

The Urban Stormwater Retrofit Public–Private Partnership Demonstration Pilot in Prince George's County, Maryland, will leverage private equity to finance green infrastructure projects designed to control stormwater runoff and help meet regulatory obligations under Chesapeake Bay Total Maximum Daily Load (TMDL) requirements. By applying a typical public–private partnership (P3) model to urban stormwater retrofits, the county aims to meet its TMDL targets by retrofitting approximately 8,000 acres of impervious surfaces. Selected bidders provide a minimum of 40 percent of the program costs up front, and the county uses impervious surface stormwater fees to repay the costs over time, as long as agreed-upon performance standards are met. This P3 arrangement accelerates project implementation, provides a sustainable financing strategy for the county to meet its regulatory obligations and will reduce pollution in local waterways and the Chesapeake Bay while creating local jobs. This approach – the first P3 in the nation aimed at funding urban green infrastructure retrofits – could serve as a model for other municipalities across the country.[103]

Leverage Market Mechanisms to Account for the Value of Ecosystem Services

We need financial systems that explicitly recognize and assign value to the capacity of ecosystems to provide clean water and replenish water supplies at a fraction of the cost of built infrastructure. Such market-based schemes must also assign value to the human effort that goes into preserving and restoring ecosystem services. Streams, wetlands, lakes, green spaces and other natural systems should be considered assets on par with dams, treatment plants, pipes and pumps. The value these natural infrastructure assets provide should be reflected in standard accounting procedures, as should the fact that they also require capital investment and maintenance. Doing so could bolster utilities' credit-worthiness, expand their debt capacity and enhance their ability to garner financing for critical capital improvements.

To establish validated approaches to ecosystem services valuation, triple-bottom-line accounting must be further developed and standardized. In addition, regional markets for ecosystem services payments should be explored, to sustain and increase their value over time. Opportunities exist to build upon the work to date by communities that are pioneering ecosystem services markets, such as the Willamette Partnership in Oregon.[105] Paying for upstream ecosystem services that protect source waters typically costs far less than developing treatment plants or alternative water supplies. In this sense, avoided costs equate to revenues.

Network Aims to Shape Water-Quality Trading Markets

The World Resources Institute, the Freshwater Trust and the Willamette Partnership of Portland, Oregon, have led the creation of a National Network on Water Quality Trading. The Network is a community of water-quality trading (WQT) practitioners dedicated to developing accountable, scientifically sound WQT programs that are supported by diverse stakeholders. WQT offers Clean Water Act permittees alternatives for meeting regulatory obligations in a cost-effective manner and gives other stakeholders a role in meeting clean water goals. Through facilitated dialogues and stakeholder collaboration among the agricultural sector, permitted point sources, state water-quality agencies, environmental groups and other practitioners, the Network plans to issue clear guidance regarding options and considerations for building or operating WQT programs, as well as principles and best practices for successful programs. Ultimately, the Network hopes to spur markets that link land and water managers who have direct impacts on the conservation and restoration of ecosystem services with those willing to pay for the water-quality outcomes of those activities.[104]

Image courtesy of iStock Photo

Create a Culture in Which Water Services Are Highly Valued

Utilities, water-sector associations and advocates need to work in concert to deliver information and messaging that cultivates awareness and understanding among U.S. citizens about the costs involved in delivering the water services on which they depend. Efforts should focus on creating a culture that recognizes the benefits of reliable water, wastewater and stormwater management infrastructure. We need to raise the visibility of these issues through the amplification of efforts such as the U.S. Water Alliance, Growing Blue, and the Value of Water Coalition – all collaborative initiatives formed in recent years to raise awareness about the importance of clean, safe and reliable water and to provide leadership on water solutions.[106]

Local utilities and advocates can do more to carry similar messages into their communities to help people understand where their water comes from, the infrastructure and operations that manage it and its fundamental importance to society. Instilling more robust understanding and appreciation of the complexity and importance of our water systems will create citizens who value water highly and are therefore willing to pay for the real costs of enjoying the innumerable benefits of reliable water services, including life itself.

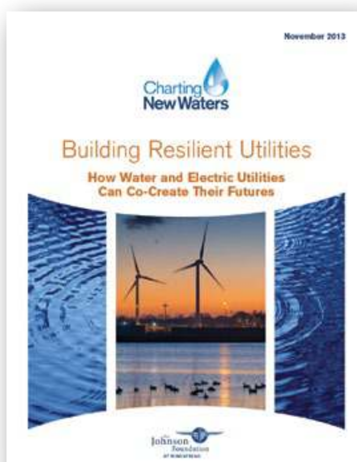
5. Create Integrated Utilities

To achieve a future in which the vision and principles presented at the outset of this report are operationalized, we must push beyond the regulatory and disciplinary silos of the past and reinvent the infrastructure and utility services on which Americans depend. Water, energy, solid waste, land and air resources are highly interdependent, although typically regulated separately. We have repeatedly heard from the experts we've assembled that the best solutions stem from collaboration and integration among the agencies and authorities that oversee these resources. Utilities of the future need to reflect the realities of the physical world and provide integrated services under a common organizational structure that optimizes resource use and minimizes waste.[107] Even where institutional integration is not attainable, managers need to build working relationships with colleagues in complementary service areas and find ways to reduce overall resource consumption while increasing community and regional resilience.

Many of the technological and management characteristics that constitute an integrated utility of the future are captured in the recommendations discussed previously. We include the following additional recommendations to paint a more complete picture of how these elements can be woven together to truly transform the management of water and other interdependent resources. The Johnson Foundation recognizes that the way these recommendations will play out will vary across the country due to regional geographic and ecological differences. Nonetheless, we urge those who have responsibility and authority for managing water, waste and electric power in our communities to create organizational cultures that prioritize multiple-benefit innovation and to pursue implementation of the ideas herein. In so doing, they can ultimately create integrated utilities.

Create New Design Principles and Evaluation Criteria

To create integrated utilities, new design principles must be established that embrace public values and local control and that advance the innovations available today. Principles guiding the integration of services would allow for both more centralized plants as well as small-scale, distributed facilities. For example, facilities and operations should be right-sized according to the customer base and resource availability within the watershed or region, while



The November 2013 Charting New Waters report ***Building Resilient Utilities: How Water and Electric Utilities Can Co-Create Their Futures*** provides an in-depth exploration of how water utilities and electric utilities can help each other reduce costs, stretch resources and respond to climate change.

Click here to view the full report or visit www.johnsonfdn.org/chartingnewwaters.

allowing for future flexibility to respond to changing conditions. Such an approach would stimulate the optimal use of distributed systems. In addition, climate change projections and associated risks need to be considered in long-term planning and capital improvement decisions. Systems thinking and triple-bottom-line analyses ought to be applied to all management decisions, including those relating to design, construction, operations and maintenance.

In the future, utilities will not simply provide services, but will take into consideration the long-term sustainability and resilience of communities and regions.

New criteria for evaluating success must also be developed. Evaluations should consider the ability of the utility to deliver a desired level of service and meet sustainability and resilience goals associated with water security, ecosystem health, energy management, greenhouse gas emissions, waste minimization, financial security and community livability.

Transform Utilities from Service Providers into Resource Managers

In the future, utilities will not simply provide services, but will take into consideration the long-term sustainability and resilience of communities and regions. They will manage built and natural infrastructure that bridges the urban–rural interface, relying on smart technologies and collaborative relationships with other resource managers in the service area. Systems will be designed and operated to go beyond permit compliance, closing the loop on resource use so that outputs from one process become fodder for another. Valuable resources embedded in waste streams will be recovered and reused or converted into commodities.[108] For instance, utilities of the future will capture and supply treated water for a variety of residential, commercial and industrial uses, and will recover biosolids from anaerobic digesters to produce marketable byproducts such as fertilizer, soil amendments, compost, livestock bedding and renewable energy sources.

In terms of electric power, integrated utilities will be able to produce electricity using biogas, combined heat and power, low-head and in-line hydropower, solar and wind to power operations on-site and feed electricity back into the grid. As part of their power generation role, utilities could consider operating a truck fleet that collects food and agricultural waste to feed into anaerobic digesters that also process human waste and produce biogas. The biogas derived from the digestion process, if not used for electricity, can be compressed and used to fuel vehicles. Furthermore, utilities will commonly implement and maintain distributed water reclamation and reuse systems, linking them to centralized infrastructure where appropriate to ensure redundancy and resilience in the water-supply and wastewater treatment system.

Develop New Business Models and Regulatory Schemes

In addition to integrating historically independent services, utilities will need to develop new business models that foster internal innovation, ensure financial sustainability and generate new revenue streams. They can create organizational cultures in which innovation is encouraged and rewarded through elements such as substantial budgets for research and development, partnerships with research institutions and private industry, and mechanisms for patenting and disseminating new technologies and products. Integrated utilities will bill based on new services, in addition to volume of water or energy used, which can help stabilize billing revenue and opens the possibility for new means and methods of service provision.[109]

Potential new, revenue-generating services include water-quality testing; maintenance agreements on customer service lines; household water-efficiency audits; automated billing services for smaller utilities; processing and interpreting automatic metering data for other utilities; and maintaining industrial water systems or private distributed treatment systems. Utilities can also create fee-based parks on open space maintained for watershed management, and even host profitable community events, such as outdoor concerts, on such land. In this way, utilities can go beyond providing essential services and move into enhancing the overall quality of life in their communities.

As business models evolve and the range of services expands, tomorrow's utilities will have to become adept at assembling complex funding and management agreements between entities. Such utilities are likely to be a hybrid of public and private providers that operate and maintain systems with centralized and distributed elements, which will require the delineation of clear contractual relationships. Federal and state agencies will need to revisit regulations and policies that hinder integration between traditional service areas and institute mechanisms for flexibility that support new ways of conducting business. One potential scheme to explore is to bring all public and private water, wastewater and electric utilities under a common regulatory umbrella at the state level. For instance, if public utilities commissions regulated all utilities, they could create common systems and frameworks, including policies regarding the provision of public goods.

Cultivate Resource Management Partners and Customers of the Future

As a key player in watersheds, communities and regions, future utilities will foster sustainable and resilient practices among customers through active community engagement, transparent communication and standardized metrics that support rational consumer choices aligned with the utility's larger goals. Inter-agency and cross-sector partnerships and joint planning with stakeholders who depend on or impact the same water resources will be key aspects of normal operations. Potential partners include transportation and public works departments and agricultural producers.

Perhaps one of the most profound benefits of integrated utilities will be the cultivation of "customers of the future" who are well-informed about resource management and who help the utilities meet their sustainability and resilience goals. Sophisticated outreach and education programs, transparent billing, open operations and management, and real-time information will help customers of the future understand the sources of their water and electricity and how to use both efficiently. Customers

Cost-Effective, Building-Scale Rainwater Harvesting and Reuse

Aquanomix, a private North Carolina-based company, is pushing the boundaries of building-scale water reclamation and nonpotable reuse and related services. It develops customized rainwater, stormwater and graywater harvesting and purification systems that provide water for evaporative cooling, toilets and urinals, and irrigation. The systems drastically reduce stormwater runoff and are able to supply up to 80 percent of a building's nonpotable water needs. The company also provides management technologies such as programmable touchscreens and remote access capability that are compatible with existing building systems and result in the efficient use of harvested water. Aquanomix is also pioneering the use of predictive modeling and real-time weather forecasting to take a proactive approach to stormwater control. Systems like these are of great interest in communities with impervious-surface-based stormwater fees or standards for on-site stormwater management, and can contribute toward green building certification under the U.S. Green Building Council's LEED program. Most projects result in a return on investment realized in less than five years.[110]

Image courtesy of Aquanomix

will also support utilities' efforts to recover resources and maximize the value of operational assets (e.g., biosolids, digester capacity, sewer heat). Ongoing interaction with the utilities will stimulate behavioral adjustments so that customers contribute to utility risk management through their personal choices.[111] As a result, customers of the future will be more conscientious about conservation and efficiency and be active stewards of water and energy resources. These measures will bolster utilities' financial bottom lines by optimizing resource use and service delivery, while enhancing quality of life in the communities they serve.

Conclusion: Seizing the Future for U.S. Freshwater Resources

As The Johnson Foundation concludes Charting New Waters, we chose to focus on what is possible for the future of U.S. freshwater resources, because we know that solutions to our water challenges are available and working today. All of our convenings have examined impediments to change and ways to overcome them, and those ideas are captured in our other reports. We hope that, by focusing this report on opportunities, we will fuel the optimism we have observed among the many thoughtful experts and extraordinary leaders we have had the pleasure to call partners in this endeavor. We also hope this focus will help others to see the opportunities and inspire them to join in the important work ahead.

The transformation of the water sector has already begun, but completing it will require visionary and collaborative leadership across sectors and scales. Across the nation, we are poised to adopt and scale up the most innovative technologies, management practices, policy incentives and financing strategies. Public and private utility managers need to step forward and become more visible and active leaders in their communities. Researchers and advocates need to keep advancing the cutting edge of innovation and demonstrating best-available options. Government policymakers and regulators must continue to create mechanisms that allow flexibility and enable innovation. Local, state and national elected leaders need to be bold and steadfast about making investments in water infrastructure commensurate with the value of water and its fundamental importance to our economy, the environment and life itself. Finally, citizens need to demand the best solutions and actively support the changes ahead. Working in concert, we can achieve transformational change to seize the future for sustainable and resilient U.S. freshwater resources.

The transformation of the water sector has already begun, but completing it will require visionary and collaborative leadership across sectors and scales. Across the nation, we are poised to adopt and scale up the most innovative technologies, management practices, policy incentives and financing strategies.

Charting New Waters Key Staff

Charting New Waters has been a project of The Johnson Foundation at Wingspread (www.johnsonfdn.org), a nonprofit operating foundation based in Racine, Wisconsin, and supported in part through SC Johnson Giving, Inc. In addition to our internal staff, this work has been co-led by the skilled staff of Meridian Institute, collaborative problem-solving and facilitation experts (www.merid.org), and Outreach Strategies, a mission-driven communications and public affairs firm (www.outreachstrategies.com). Staff members from these three organizations have worked seamlessly together, across many time zones, providing the first-string team that gave us confidence every time we stepped up to the plate.

The Johnson Foundation at Wingspread

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Wendy S. Butler, Meetings and Special Events Manager

Roger Dower, President

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Participating Organizations

Charting New Waters has by definition been a collaborative effort, and it would not have been possible without the willing partnership of the hundreds of experts who have shared their time, experience, smarts, networks and encouragement over the past six years. The following is a list of organizations that have shared their staff and leaders with us either through attendance at meetings, or commitments to carrying out the principles in the 2010 *Call to Action*, or both. Each of these organizations' names represent real people who have become our friends and colleagues through this process. It is their leadership that has inspired us over the years and instilled the optimism we have for the possibilities ahead.

Alliance Environmental, LLC

Alliance for Water Efficiency

American Farmland Trust

American Public Power Association

American Rivers

American Water, Inc.

American Water Works Association

Amy S Conklin LLC

Aqua-Tex Scientific Consulting, Inc.

Arizona Public Service Company

Aurora Water

Austin Water Utility

Bayern LB

Bioengineering Group

Biohabitats, Inc.

Black & Veatch

Brown University, Center for Environmental Studies

Built Environment Coalition

The Cadmus Group, Inc.

California Association of Sanitation Agencies

California Energy Commission

California Public Utilities Commission

California Stormwater Quality Association

Camden County Municipal Utilities Authority

Cape Cod Commission

Cape Cod Water Protection Collaborative

Cascade Water Alliance

Cascadia Green Building Council

CDM Smith

Center for Neighborhood Technologies

Center for Resilient Cities

Central Colorado Water Conservancy District

Ceres

CH2M Hill

Charles River Watershed Association

City of Austin, Texas

City of Boulder, Colorado

City of College Park, Maryland

City of Hoboken, New Jersey

City of Jersey City, New Jersey

City of Milwaukee, Wisconsin

City of Newark, New Jersey

City of Philadelphia, Pennsylvania

City of Racine, Wisconsin

City of Stevens Point, Wisconsin

City of Vancouver, Washington

The City Project

Clean Air–Cool Planet

Clean Water Action

Clean Water Fund

Clean Water Services

The Coca-Cola Company

Collins Woerman

Colorado Attorney General's Office

Colorado Bureau of Reclamation

Colorado Department of Natural Resources

Colorado Foundation for Water Education

Colorado House of Representatives

Colorado Inter-Basin Compact Committee

Colorado School of Mines

Colorado Springs Utilities

Colorado State University

Colorado Water Congress

Colorado Water Conservation Board

Colorado Water Institute

Colorado Watershed Assembly

Columbia University, Earth and Environmental Engineering

Connecticut Fund for the Environment and Save the Sound

Conservation Law Foundation

ConservationStrategy, LLC

Cooper's Ferry Partnership

DC Water

Delta County Farm Bureau

Denver Water

Diversey, Inc.

Douglas County Conservation District

Downers Grove Sanitary District

The Downstream Neighbor

Ducks Unlimited, Inc.

Duke University, Nicholas Institute for Environmental Policy Solutions

e.Republic, Inc.

East Bay Municipal Utility District

Eastern Research Group, Inc.

EcoDistricts

Edgewood Properties

El Paso Water Utilities

Electric Power Research Institute

Environmental Defense Fund

Environmental Justice and Climate Change Initiative

The Environmental Working Group

The Fertilizer Institute

Fitch Ratings

Florio Perrucci Steinhardt & Fader, LLC

F. M. Kirby Foundation

Forston Labs

Funders' Network for Smart Growth & Livable Communities

The Fund for New Jersey

The Future 500 Group

Gates Family Foundation

GE Water & Process Technologies

Geraldine R. Dodge Foundation

Great Lakes Protection Fund

Green For All

Gunnison Basin Roundtable

Hampton Roads Sanitation District

HDR, Inc.

Honeywell International Inc.

Hudson River Foundation

HYDROLYSIS

IBM

Inland Empire Utilities Agency

Institute for Agriculture and Trade Policy

Institute of Medicine, The National Academies

Iowa Soybean Association

Jasculca/Terman and Associates, Inc.

JEA

John Deere Water Technologies

The Johnson Foundation at Wingspread

Johnson Outdoors Inc.

The Joyce Foundation

Kansas Department of Health and Environment

Kohler Co.

The Kresge Foundation

Laborers' International Union of North America,

LimnoTech, Inc.

Los Angeles Department of Water and Power

Madrona Venture Group

Manchester Water Works

Manhattan College

Mars, Incorporated

Massachusetts Institute of Technology

The McKnight Foundation

Metro Wastewater Reclamation District, Denver, Colorado

Metropolitan Water District of Southern California

Michigan State University

Middlesex Water Company

MITHUN

Mystic River Watershed Association

National Association of Clean Water Agencies

National Association of Water Companies

National Corn Growers Association

National Heritage Institute

National Institutes of Health

National Renewable Energy Laboratory

National Sustainable Agriculture Coalition

National Water Research Institute

Natural Resources Defense Council

Natural Systems Utilities, LLC

The Nature Conservancy

New England Interstate Water Pollution Control Commission

New Jersey Alliance for Action

New Jersey Board of Public Utilities

New Jersey Community Development Corporation

New Jersey Conservation Foundation

New Jersey Department of Environmental Protection, Division of Water Quality

New Jersey Environmental Infrastructure Trust

New Jersey Future

New Jersey Senate Majority Office

New Jersey Utilities Association

New York City Department of Environmental Protection

North Carolina State University

Northbridge Environmental

Northeastern University

Northern Water

NY/NJ Baykeeper

NY-NJ Harbor & Estuary Program

Oak Ridge Strategy Group

The Ocean County Utilities Authority

Office of U.S. Senator Cory Booker

Office of U.S. Senator Mark Udall

Pacific Institute

Passaic Valley Sewerage Commission

Paul Redvers Brown Inc.

Philadelphia Water Department

Phyllis Thomas Consulting

Piper Jaffray & Co.

PNM Resources

Puget Sound Partnership

Rampart Realty, Inc.

Rettig Farms

Rio Tinto

River Network

Rocky Mountain PBS

The Russell Family Foundation

Rutgers University

S.C. Johnson & Son, Inc.

San Antonio Water System

San Diego County Water Authority

San Francisco Public Utilities Commission

Sand Dollar Research

Sandia National Laboratories

Save the Bay, Narragansett Bay

Seattle Public Utilities

Siemens Water Technologies LLC

Snow Goose Farms/Glenn Colusa Irrigation District

Southern California Water Committee

Southern Research Institute

Spartanburg Water

St. Vrain and Left Hand Water Conservancy District

Stanford University

Stine-Haskell Research Center

StopWaste

Stratus Consulting

Synchrony Advisors, LLC

Tampa Bay Water

Texas Water Development Board

Timberland, LLC

Town of Durham, New Hampshire

Town of Silverthorne, Colorado

Town of Yarmouth, Massachusetts

Trout, Raley, Montaño, Witwer & Freeman P.C.

TurningPoint Capital Partners, LLC

UNC Environmental Finance Center

Union of Concerned Scientists

United States Department of Agriculture

United States Department of Interior

United States Environmental Protection Agency

United States Environmental Protection Agency, Office of Water

United States Environmental Protection Agency, Region 1

United Water

University of California, Berkeley

University of California, Santa Barbara

University of Colorado at Boulder

University of Colorado, School of Law

University of Connecticut

University of Georgia, Odum School of Ecology

University of South Florida, Patel College of Global Sustainability

University of Texas

University of Texas at Austin

University of Wisconsin–Extension

University of Wisconsin–Madison, Center for Sustainability and the Global Environment

University of Wyoming

U.S. Water Alliance

Veolia Water North America

Vermont Department of Environmental Conservation

Vranesh and Raisch

Waggonner & Ball Architects

Walton Family Foundation

Water Alliance

Water Asset Management, LLC

Water Energy Innovations

Water Environment Federation

Water Environment Research Foundation

Water Research Foundation

Water Stewardship, Inc.

Water Utility Climate Alliance

WateReuse Foundation

WaterJamin Legal & Policy Consulting

Waterkeeper Alliance

Watermark Initiative, LLC

West Atlanta Watershed Alliance

Western Governors' Association

Western Grid Group

Western Resource Advocates

Western Water Assessment

White House Council on Environmental Quality

Whitman Strategy Group

William Penn Foundation

Wisconsin Department of Natural Resources

World Resources Institute

World Wildlife Fund

Xcel Energy

Xylem

Endnotes

[1] Intergovernmental Panel on Climate Change, *Climate Change 2014: Impacts, Adaptation and Vulnerability*, Working Group II Contribution to AR5, 2014. Available online at: http://www.ipcc.ch/report/ar5/wg2/.

[2] See http://www.climatehotmap.org/global-warming-locations/ipswich-river-ma-usa.html for a profile of the Ipswich River in Massachusetts, which has run dry repeatedly since 1995.

[3] See http://www.circleofblue.org/waternews/2010/world/north-america/overdraft-saltwater-intrusion-strain-the-floridan-aquifer/ for a discussion about saltwater intrusion in the Floridan aquifer.

[4] W.B. Solley, et al., *Estimated Use of Water in the United States 1995,* United States Geological Survey, Circular 1200, 1998. Available online at: http://pubs.usgs.gov/circ/1998/1200/report.pdf.

[5] Council of New Jersey Grantmakers, *Facing Our Future: Infrastructure Investments Necessary for Economic Success,* 2013, p. 33. Available online at: http://www.cnjg.org/sites/default/files/resources/2013%20Facing%20Our%20Future%20Report%20-%20Infrastructure%20Investments%20Necessary%20for%20Economic%20Success.pdf.

[6] U.S. Department of Agriculture Economic Research Service, "Irrigation & Water Use," 2013. Available online at: http://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use.aspx.

[7] See http://water.epa.gov/infrastructure/sustain/asset_management.cfm for more information about asset management for sustainable water infrastructure.

[8] See http://www.awwa.org/store/productdetail.aspx?productid=6725 for guidance on how to conduct water audits and implement loss-control programs.

[9] M. Farley, et al., *The Manager's Non-Revenue Water Handbook: A Guide to Understanding Water Losses*, 2008. Available online at: http://www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=2624.

[10] See http://growingblue.com/case-studies/leakages-in-water-distribution-systems/ for a discussion of water loss from water distribution systems.

[11] See http://www.awwa.org/Portals/0/files/resources/water%20knowledge/water%20loss%20control/iwa-awwa-method-awwa.pdf for a discussion of the American Water Works Association/International Water Association water audit method.

[12] See http://californiawaterfoundation.org/uploads/1389391749-Watersmart_evaluation_report_FINAL_12-12-13(00238356).pdf for the full report on EBMUD's pilot study.

[13] J.R. Stokes, "Water Loss Control Using Pressure Management: Life-Cycle Energy and Air Emissions Effects," *Environmental Science & Technology*, 2013.

[14] See Alliance for Water Efficiency, *Building Better Water Rates for an Uncertain World: Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability*, August 2014. This handbook provides comprehensive guidance on developing, evaluating and implementing conservation- and efficiency-oriented rate structures. Available online at: http://www.financingsustainablewater.org/tools/building-better-water-rates-uncertain-world.

[15] Raftelis Financial Consultants, Inc., and the California–Nevada Section of the American Water Works Association, *2013 Water Rate Survey*, 2013. Available online at: http://www.sweetwater.org/Modules/ShowDocument.aspx?documentid=5333.

[16] See http://www.allianceforwaterefficiency.org/1Column.aspx?id=712 for a basic overview of conservation-oriented rate structures from the Alliance for Water Efficiency, including definitions of inclining tier block and water-budget-based rate structures.

[17] H. Cooley, et al., *Energizing Water Efficiency in California: Applying Energy Efficiency Strategies to Water*, Pacific Institute, 2013, pp. 26–27. Available online at: http://pacinst.org/publication/energizing-water-efficiency/.

[18] Ibid., p. 29.

[19] See http://www.aceee.org/energy-efficiency-sector/state-policy/wisconsin/220/all/191 for more information about Wisconsin's energy-efficiency programs.

[20] UNC Environmental Finance Center and Ceres, *Measuring & Mitigating Water Revenue Variability: Understanding How Pricing Can Advance Conservation Without Undermining Utilities' Revenue Goals*, 2014. Available online at: http://www.ceres.org/resources/reports/measuring-mitigating-water-revenue-variability-understanding-how-pricing-can-advance-conservation-without-undermining-utilities2019-revenue-goals/view.

[21] See http://www.dcwater.com/highusage/default.cfm for more information about DC Water's High Usage Notification and Automatic Meter Reading system.

[22] See http://www.allianceforwaterefficiency.org/WorkArea/DownloadAsset.aspx?id=8671 for more information on the analysis of water use trends and avoided costs in Westminster and to download the full report.

[23] See Alliance for Water Efficiency, *Net Zero Water Use Literature Search and Case Study Documentation*, 2014, for examples of water demand offset programs and related policies. Also see http://www.santafenm.gov/development_water_budgets for more information about water ordinances for new development in Santa Fe, New Mexico.

[24] See http://floridawaterstar.com for more information on the Florida Water Star[SM] certification program, and http://www.snwa.com/biz/programs_home.html for more information on the Southern Nevada Water Authority's Water Smart Home program.

[25] See http://www.epa.gov/WaterSense/products/controltech.html for more information about smart irrigation controllers.

[26] See http://www.socalwatersmart.com for more information about the Metropolitan Water District of Southern California's water conservation rebate programs.

[27] Western Municipal Water District, "Western Works to Boldly Avert Water Waste," 2014. Available online at: http://www.wmwd.com/CivicAlerts.aspx?AID=149.

[28] See http://www.lakearrowheadcsd.com/Index.aspx?page=60 for more information about landscaping restrictions instituted by the Lake Arrowhead Community Services District.

[29] The following excerpt is from G.D. Schaible and M.P. Aillery, *Water Conservation in Irrigated Agriculture: Trends and Challenges in the Face of Emerging Demands*, EIB 99, U.S. Department of Agriculture Economic Research Service, 2012: "From 1984 to 2008, total irrigated acres across the West increased by 2.1 million acres, while total agricultural water applied declined by nearly 100,000 acre-feet…. While substantial technological innovation has already occurred in western irrigated agriculture, significant room for improvement in farm irrigation efficiency still exists; traditional gravity or less efficient pressure-sprinkler systems still account for over 50 percent of irrigated acres. The historical transitions suggest that, while western irrigated agriculture is on a path toward greater sustainability, further progress will likely be needed as water demand and supply conditions change. Similar conditions exist for irrigated agriculture across the 31 Eastern States. More efficient pressure (sprinkler) and gravity systems account for 52 percent of total farm irrigated acres in the Eastern States. But the remaining 48 percent of eastern irrigated acres are irrigated with traditional, less efficient systems." The full report is available online at: http://www.ers.usda.gov/media/884158/eib99.pdf.

[30] Pacific Institute and Natural Resources Defense Council, *Issue Brief: Agricultural Water Conservation and Efficiency Potential in California*, 2014. Available online at: http://www.nrdc.org/water/files/ca-water-supply-solutions-ag-efficiency-IB.pdf.

[31] See https://engineering.purdue.edu/watersheds/webinars/2StageDitch/JLTank%2011Sept13.pdf for an overview of the effects of two-stage ditches on water quality.

[32] See http://www.nrem.iastate.edu/research/STRIPs/ for a research project on the effects of integrating prairie strips within agricultural landscapes.

[33] The Johnson Foundation recognizes that there are legal constraints on the capture of rainwater in some western states, but firmly believes rainwater is an underused resource that should be leveraged wherever possible.

[34] See http://www.socalwater.org/issues/stormwater for a range of information about the potential for stormwater capture and groundwater recharge in Southern California.

[35] See http://sfwater.org/np for more about the SFPUC's Nonpotable Water Program.

[36] J. Thompson, et al., *Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape*, Harvard Forest, Harvard University, 2014. Available online at: http://harvardforest.fas.harvard.edu/sites/harvardforest.fas.harvard.edu/files/Changes%20to%20the%20Land%20-%20final%20report%20-%20Jan%202014.pdf.

[37] See http://www.denverwater.org/supplyplanning/watersupply/partnershipuSFS/ for more information on the watershed management partnership between Denver Water and the U.S. Forest Service.

[38] J.T. Jasper, et al., "Unit Process Wetlands for Removal of Trace Organic Contaminants and Pathogens from Municipal Wastewater Effluents," *Environmental Engineering Science*, vol. 30, no. 8 (2013): 421–436. Available online at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3746285/.

39 See http://www.awwa.org/about-us/policy-statements/policy-statement/articleid/211/reclaimed-water-for-public-water-supply-purposes.aspx for the American Water Works Association's policy statement, "Reclaimed Water for Public Water Supply Purposes," revised January 19, 2014.

40 See Committee on the Assessment of Water Reuse as an Approach to Meeting Future Water Supply Needs; Water Science and Technology Board; Division on Earth and Life Studies; National Research Council, *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater*, The National Academies Press, 2012, for an in-depth discussion of options, opportunities and regulatory needs for water reuse. Available online at: http://www.nap.edu/catalog.php?record_id=13303.

41 See http://www.naturalsystemsutilities.com/battery-park-city-water-reuse-system for more information about the Solaire Building water reuse system in Battery Park City.

42 See http://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf for the U.S. EPA's 2012 Guidelines for Water Reuse.

43 Texas Water Development Board, *Water for Texas: Water Reuse*, 2013. Available online at: http://www.twdb.texas.gov/publications/shells/WaterReuse.pdf.

44 L. Konikow, "Contribution of Global Groundwater Depletion Since 1900 to Sea-Level Rise," *Geophysical Research Letters*, vol. 38 (2011). Available online at: http://water.usgs.gov/nrp/proj.bib/Publications/2011/konikow_2011b.pdf.

45 AWWA Research Foundation and American Water Works Association, *Residential End Uses of Water*, 1999. Available online at: http://www.waterrf.org/PublicReportLibrary/RFR90781_1999_241A.pdf.

46 See http://www.epa.gov/watersense/pubs/indoor.html for a discussion of indoor water use and tips for efficiency.

47 See http://www.westbasin.org/water-reliability-2020/recycled-water/water-recycling-facility for more information about the Edward C. Little Water Recycling Facility.

48 D. Sedlak, *Water 4.0: The Past, Present and Future of the World's Most Vital Resource*, Yale University Press, 2014, pp. 254–259.

49 D. Vuono, et al., "Flexible Hybrid Membrane Treatment Systems for Tailored Nutrient Management: A New Paradigm in Urban Wastewater Treatment," *Journal of Membrane Science*, vol. 446 (2013): 34–41. Available online at: http://inside.mines.edu/~tcath/publications/CathPub/27_SBMBR_Tailored_Reuse.pdf.

50 See http://www.westbasin.org/water-reliability-2020/recycled-water/water-recycling-facility for more information about the Edward C. Little Water Recycling Facility.

51 The Johnson Foundation recognizes that industry leaders are moving away from the term *wastewater*, but we used it in this report out of necessity as there is not yet a widely accepted alternative term that encompasses the scope of our recommendations.

52 See http://water.epa.gov/polwaste/npdes/cso/ for more information from the U.S. EPA about combined sewer overflows.

53 See http://water.epa.gov/infrastructure/sustain/asset_management.cfm for a primer from the U.S. EPA about asset management for water infrastructure.

54 U.S. EPA, *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control*, 2014. Available online at: http://water.epa.gov/infrastructure/greeninfrastructure/upload/Greening_CSO_Plans.PDF.

55 Center for Neighborhood Technology and American Rivers, *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits*, 2010. Available online at: http://www.americanrivers.org/wp-content/uploads/2013/09/Value-of-Green-Infrastructure.pdf?422fcb.

56 See https://www.werf.org/c/Decentralizedproject/Piperton.aspx for more information about the systems implemented in Piperton, Tennessee.

57 This is not necessarily aligned with sustainability due to high greenhouse gas emissions.

58 Personal Communication, Ed Clerico, Natural Systems Utilities, LLC, March 20, 2014.

59 See http://www.crwa.org/ for more information about the Charles River Watershed Association.

[60] See http://www.aaees.org/e3competition-winners-2013gp-research.php for more information about the pilot projects being implemented by DC Water and the HRSD.

[61] See http://www.ddsd.org/ for more information on the joint project between Stanford University and Delta Diablo Sanitation District.

[62] K.T. Sanders and M.E. Webber, "Evaluating the Energy Consumed for Water Use in the United States," *Environmental Research Letters*, vol. 7, no. 3 (2012). Available online at: http://iopscience.iop.org/1748-9326/7/3/034034.

[63] G. Tchobanoglous, et al., "Impacts of New Concepts and Technology on the Energy Sustainability of Wastewater Management," presented at the Conference on Climate Change, Sustainable Development and Renewable Resources in Greece, October 17, 2009. Available online at: http://www.researchgate.net/publication/237492728.

[64] Water Environment Federation, *The Energy Roadmap: A Water and Wastewater Utility Guide to More Sustainable Energy Management*, 2013. Available online at: http://www.wefnet.org/ewef/toc/WEF%20The%20Energy%20Roadmap%20TOC.pdf.

[65] See http://www.ebmud.com/sites/default/files/pdfs/energy-fact-sheet-03-12_1.pdf for more information about the East Bay Municipal Utility District's energy program.

[66] U.S. Department of Energy, *Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water*, 2006, pp. 25–26. Available online at: http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf.

[67] See *Water in the West, Water and Energy Nexus: A Literature Review*, 2013, for a comprehensive overview of the water–energy nexus. Available online at: http://waterinthewest.stanford.edu/sites/default/files/Water-Energy_Lit_Review.pdf.

[68] J. Rogers, et al., *Water-Smart Power: Strengthening the U.S. Electricity System in a Warming World,* Union of Concerned Scientists, 2013. Available online at: http://www.ucsusa.org/assets/documents/clean_energy/Water-Smart-Power-Full-Report.pdf.

[69] See D. Shi, et al., *America's Water Risk: Water Stress and Climate Variability*, Columbia Water Center and Veolia Water, 2013, for an examination of the diverse ways in which water scarcity can pose threats to businesses in certain regions of the country and sectors. Available online at: http://growingblue.com/wp-content/uploads/2013/05/GB_CWC_whitepaper_climate-water-stress_final.pdf.

[70] See A. Georgakakos, et al., "Ch. 3: Water Resources," in *Climate Change Impacts in the United States: The Third National Climate Assessment*, Melillo, et al., Eds., U.S. Global Change Research Program, 2014, for a discussion of projected regional climate change impacts. Available online at: http://nca2014.globalchange.gov/report/sectors/water.

[71] See http://vancouver.ca/docs/planning/renewable-energy-neighbourhood-utility-factsheet.pdf for more information about the Neighbourhood Energy Utility at the Village on False Creek.

[72] See www.ucsusa.org/ew3 for more information about the EW3 Initiative.

[73] See http://www.scwa.ca.gov/carbon-free-water/ for more information about the Sonoma County Water Agency's Carbon-Free Water by 2015 initiative.

[74] See http://utilityofthefuturecenter.org/center for more information about drivers of change facing the U.S. electricity sector.

[75] U.S. Department of Energy, *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather*, 2013, p. i. Available online at: http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf.

[76] See http://www.eia.gov/todayinenergy/detail.cfm?id=15491 for more information about projected power plant retirements in the United States.

[77] National Association of Regulatory Utility Commissioners, *Resolution in Support of Water-Smart Energy Choices*, 2013. Available online at: http://www.naruc.org/Resolutions/Resolution%20in%20Support%20of%20Water%20Smart%20Energy%20Choices.pdf.

[78] See http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=4096&section=home&eod=1 for a discussion of the Willamette Ecosystem Marketplace, a water-quality trading scheme that supports riparian habitat restoration as a cost-effective way to cool river water impacted by wastewater effluent discharges.

[79] J. Veil, *Use of Reclaimed Water for Power Plant Cooling*, Argonne National Laboratory Environmental Science Division, 2007, Appendix A. Available online at: http://www.alrc.doe.gov/technologies/coalpower/ewr/pubs/reclaimed%20water.pdf. After additional research using the Energy Information Agency's 2009 EIA-860 data and cross-referencing with monthly EIA updates from 2010 and 2011, the Natural Resources Defense Council (NRDC) identified 14 additional facilities in addition to those listed in Veil's 2007 report. Meanwhile, some plants listed in the original report were proposed but never completed. See NRDC, *Power Plant Cooling and Associated Impacts: The Need to Modernize U.S. Power Plants and Protect Our Water Resources and Aquatic Ecosystems*, 2014. Available online at: http://www.nrdc.org/water/files/power-plant-cooling-IB.pdf.

[80] NRDC, 2014, p. 9.

[81] K. Averyt, et al., *Freshwater Use by U.S. Power Plants: Electricity's Thirst for a Precious Resource*, Union of Concerned Scientists, 2011. Available online at: http://www.ucsusa.org/assets/documents/clean_energy/ew3/ew3-freshwater-use-by-us-power-plants.pdf.

[82] See https://www.extension.org/mediawiki/files/c/ce/L01_sec4.pdf for an overview of water-quality contaminants associated with animal manure.

[83] Schneider, et. al., *Wind Energy for a Cleaner America II: Wind Energy's Growing Benefits for Our Environment and Our Health*, Environment Texas Research and Policy Center, 2013. Available online at: http://environmenttexas.org/sites/environment/files/reports/TX_WindEnergy_scrn.pdf.

[84] See U.S. Water Alliance, *Coming Together to Protect Mississippi River Watersheds: Agriculture & Water Sector Collaboration for Nutrient Progress*, 2014, for a discussion of opportunities for collaboration between agriculture- and water-sector stakeholders. Available online at: http://www.uswateralliance.org/wp-content/uploads/2014/08/USWA-MRND-Report6.pdf.

[85] See http://www.ostara.com/ for more information on Ostara.

[86] See http://www.biofermenergy.com/ for more information on BIOFerm Energy Systems.

[87] See http://renewwisconsin.org/pdf/PotoProfile.pdf for more information on Forest County Potawatomi Community Renewable Generation.

[88] C. Sensiba and M. Pincus, "New Hydropower Laws for Irrigators: New Challenges and Opportunities," *Irrigation Leader*, vol. 4, no. 9 (2013): 26–27. Available online at: http://www.waterandpowerreport.com/newsletters/October%20_2013.pdf.

[89] See H. Cooley, et al., *Sustaining California Agriculture in an Uncertain Future*, Pacific Institute, 2009, for a definition of regulated deficit irrigation. Available online at: http://pacinst.org/wp-content/uploads/sites/21/2014/04/sustaining-california-agriculture-pacinst-full-report.pdf.

[90] See https://coyotegulch.wordpress.com/category/colorado-water/arkansas-valley-super-ditch/ for more information about the Arkansas Valley Super Ditch water-sharing pilot program.

[91] See http://www.farmfoundation.org/Mailings/Soil-Health-Strategic-Plan-Booklet-3_c9c31cac32aa4dfab108a08a77caa11f.pdf for a discussion of the importance of soil health for the future of natural resource systems and food security.

[92] See Ceres, *Water and Climate Risks Facing U.S. Corn Production: How Companies and Investors Can Cultivate Sustainability*, 2014, for statistics on corn production for ethanol. Available online at: http://www.ceres.org/resources/reports/water-and-climate-risks-facing-u.s.-corn-production-how-companies-and-investors-can-cultivate-sustainability/view.

[93] See Ceres, *Hydraulic Fracturing & Water Stress: Water Demand by the Numbers*, 2014, for statistics on the water demands of hydraulic fracturing. Available online at: https://www.ceres.org/issues/water/shale-energy/shale-and-water-maps/hydraulic-fracturing-water-stress-water-demand-by-the-numbers.

[94] Ceres, *Water and Climate Risks Facing U.S. Corn Production*, 2014.

[95] See http://www.thermoenergy.com/produced-water-treatment for examples of available technologies for produced water treatment and other technologies to tap alternative water sources for oil and gas operations.

[96] See http://efdsystems.org/index.php/ for information about the Environmentally Friendly Drilling program, which is devoted to unbiased science and developing solutions to address environmental issues associated with oil and gas development.

[97] The American Society of Civil Engineers estimates that the gap between water infrastructure needs and investment nationally will be approximately $84.4 billion by 2020. See American Society of Civil Engineers, *Failure to Act: The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure*, 2011, for the detailed analysis. Available online at: http://www.asce.org/uploadedFiles/Infrastructure/Failure_to_Act/ASCE%20WATER%20REPORT%20FINAL.pdf.

98 See http://www.dcwater.com/site_archive/news/press_release663.cfm for information about DC Water's green century bonds.

99 See http://www.unitedwater.com/bayonne/company-overview.aspx for more information about the public–private partnership between Bayonne Municipal Utilities Authority and United Water.

100 See http://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/GARPFactSheet.pdf for more information about the Philadelphia Water Department's Green Acre Retrofit Program.

101 R. Davies, *Civic Crowdfunding: Participatory Communities, Entrepreneurs and the Political Economy of Place*, 2014. Available online at: http://ssrn.com/abstract=2434615.

102 See http://www.acf.hhs.gov/programs/ocs/programs/liheap for more information about the Low-Income Home Energy Assistance Program.

103 See http://yosemite.epa.gov/opa/admpress.nsf/0/C73E9DD8611D83AD85257C5C005CBD1B and http://stormwater.wef.org/2013/07/financing-urban-retrofits-via-a-public-private-partnership/ for more information about the Prince George's County Urban Stormwater Retrofit Public–Private Partnership Demonstration Pilot.

104 See http://willamettepartnership.org/NationalNetworkonWQTOverview_2014%2001%2010.pdf for an overview of the National Network on Water Quality Trading.

105 See http://willamettepartnership.org/ for more information about the Willamette Partnership.

106 See http://www.uswateralliance.org for more information about the U.S. Water Alliance; www.growingblue.com for more information about Growing Blue; and http://thevalueofwater.org/ for more information about the Value of Water Coalition.

107 The Johnson Foundation acknowledges that the vision statement and the final recommendation in this report build from previous work on the utility of the future concept led by the National Association of Clean Water Agencies (NACWA), as well as the Cities of the Future program of the International Water Association (IWA). See http://www.nacwa.org/index.php?option=com_content&view=article&id=1604&Itemid=250 for more information on the NACWA Water Resources Utility of the Future concept, and http://www.iwahq.org/3p/themes/cities-of-the-future.html for more information on the IWA Cities of the Future program.

108 National Association of Clean Water Agencies, *Today's Clean Water Utility: Delivering Value to Ratepayers, Communities, & the Nation*, 2014. Available online at: http://www.nacwa.org/images/stories/public/meetings/2014summer-final.report.design.uotf.pdf.

109 See Water Research Foundation, *Expanding Water Utility Services Beyond Water Supply*, 2012, for an exploration of potential supplemental services that water utilities could offer. Available online at: http://www.waterrf.org/Pages/Projects.aspx?PID=4171.

110 See http://www.aquanomix.com/ for more information about Aquanomix Technologies.

111 H. Cooley and K. Donnelly, *Water–Energy Synergies: Coordinating Efficiency Programs in California, Pacific Institute*, 2013. Available online at: http://pacinst.org/wp-content/uploads/sites/21/2013/09/pacinst-water-energy-synergies-full-report.pdf.

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The Johnson Foundation at Wingspread, based in Racine, Wisconsin, is dedicated to serving as a catalyst for change by bringing together leading thinkers and inspiring new solutions on major environmental and regional issues. Over the course of 50 years, The Johnson Foundation at Wingspread has inspired consensus and action on a range of public policy issues. Several organizations have roots at Wingspread, including the National Endowment for the Arts, National Public Radio, the International Criminal Court and the Presidential Climate Action Plan.

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