NATIONAL WATER REUSE
ACTION PLAN
DRAFT

SEPTEMBER 2019

Disclaimer

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On the Cover

Clockwise from top left:

- A farm in Idaho applies treated, reclaimed wastewater to a potato field.
- Monterey One Water in California treats and reclaims approximately 4 billion gallons of wastewater annually for crop irrigation, supplying water to 12,000 acres of edible food crops.
- The City of Columbia, Missouri, incorporated constructed wetlands into its wastewater treatment process, increasing plant capacity from 13 MGD to 20 MGD. The treated effluent is a consistent water source to the Eagle Bluffs Conservation Area, which provides habitat for resident and migratory waterfowl.
- Vegetation along a stream at the Brooklyn Botanic Garden in New York filters water collected on the garden grounds as part of their treatment and recirculation infrastructure, reducing the garden's freshwater consumption.
- The Don van Rasfeldt Power Plant in Santa Clara, California, takes high-salt water (750 mg/L total dissolved solids) and runs it through reverse osmosis. The resulting reclaimed water is fed into the power plant boilers.
- The Prairie Water Project in Aurora, Colorado, supplements groundwater supplies using South Platte River water purified through Riverbank Filtration and Aquifer Recharge and Recovery. The water is then treated at a 50 MGD purification facility for potable use.

Acknowledgements

Two relevant definitions of the word "collaborate"[1] are: (1) to work jointly with others or together, especially in an intellectual endeavor; and (2) to cooperate with an agency or instrumentality with which one is not immediately connected. Development of this draft National Water Reuse Action Plan has truly been a collaborative effort. When development of the draft Action Plan was announced on February 27, 2019, the U.S. Environmental Protection Agency (EPA) began with a clear objective: to facilitate discussions among the federal, state, tribal, and water sector stakeholders and form new partnerships to develop and deploy the plan. David Ross, the EPA's Assistant Administrator for Water, emphasized the following approach and intent on development of the draft Action Plan (press release April 18, 2019):

> *"Working with our federal partners, we are looking to tap the expertise of our nation's farmers, utilities, industry, [non-governmental organizations] NGOs, scientists and others to craft a Water Reuse Action Plan that helps our country better prepare for current and future water challenges and meet the water needs of generations to come."*
>
> — David Ross, EPA

It is difficult to fully and accurately acknowledge all contributors thus far. Particular gratitude is extended to:

- The research and water reuse pioneers of the last 50 years who have built the strong foundation of science, technology, and policy on water reuse. An extent of their work is captured in the literature review that helped underpin the development of this draft Action Plan.
- The federal agency partners who helped lead this collaborative effort across the water sector.
- Our state and tribal partners, who most often have the lead role in implementing water resource management programs. Special thanks to the Association of Clean Water Administrators (ACWA) and the Association of State Drinking Water Administrators (ASDWA) for providing integrated feedback from the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) perspectives.
- The water utility sector and associations (e.g., WateReuse Association, National Association of Clean Water Agencies [NACWA], Association of Metropolitan Water Agencies [AMWA], Water Research Foundation [WRF], American Water Works Association [AWWA], Water Environment Federation [WEF]) for the extensive process of collecting, discussing, and compiling feedback from a diverse set of experts and input from the agricultural, industrial, and academic sectors, as well as other non-governmental organizations that shared significant inputs, expertise, and perspectives in this water-sector-led process.
- International partners that excelled in reusing their water resources and providing a frame of reference for what is possible (e.g., Australia, Israel, Namibia, Singapore, South Africa).
- SUEZ and the Wharton School (Initiative for Global Environmental Leadership, University of Pennsylvania) for hosting the February 2019 Water Reuse Conference, which served as the forum for announcing that this draft Action Plan would be developed.
- The WateReuse Association for hosting the Symposium on September 8–11, 2019, which provided the forum for introducing and discussing the draft Action Plan.
- The stakeholders who provided input on the Discussion Framework, lent their expertise during outreach, helped facilitate our outreach efforts to ensure our comprehensive understanding of stakeholder views—or, in some cases, all of the above.
- Support from PG Environmental and Eastern Research Group, Inc. under EPA Contract No. EP-C-17-041 and ICF International, Inc. under EPA Contract No. EP-C-16-011.

CALL TO ACTION

Seeking Commitments to Actions that Enhance Consideration of Water Reuse to Support Water Resilience, Security, and Sustainability

Safe and reliable water supplies for human consumption, agriculture, business, industry, recreation, and healthy ecosystems are critical to our nation's communities and economy. Due to various pressures, 80 percent of U.S. states anticipate water shortages in some parts of their states in the next decade.[2] Communities, agriculture, and businesses are looking to diversify their supply portfolios to meet current and future needs. Water reuse (also commonly known as water recycling or water reclamation) represents a major opportunity to assure the quality of and supplement existing water supplies from sources such as industrial process water, agricultural return flows, municipal wastewater,[3] oil and gas produced water, and stormwater.

Over the past several decades, agriculture, industry, and communities have demonstrated the value of reusing water, largely in response to various forms of water crises such as drought or source water contamination. Water reuse can increase water security, sustainability, and resilience, especially when considered at broader scales (e.g., watershed, basin, regional) through integrated and collaborative water resource planning approaches.[4]

To accelerate the consideration of water reuse approaches and build on existing science, research, policy, technology, and both national and international experiences, we have engaged stakeholders across the water sector to develop this ***draft National Water Reuse Action Plan***.

This draft Action Plan identifies proposed actions across a spectrum of needs (e.g., policy coordination, technology development, outreach and communication, workforce development). The formal public comment period for the draft Action Plan will seek to:

- Identify the most important actions to be taken in the near term.
- Identify and describe the specific attributes and characteristics of the actions that will achieve success.
- Secure specific commitments to lead/partner/collaborate on implementation of actions.

Our goal is to issue a final Action Plan that includes clear commitments for actions that will further water reuse and help assure the sustainability, security, and resilience of the nation's water resources. Water quantity, supply, and quality decision-makers have historically worked through independent management regimes. Addressing future water resource challenges will require more holistic thinking that embraces the "convergence of water" through more integrated action.

Please join us in this challenge. On behalf of our federal partners,

DRoss

David Ross
Assistant Administrator, Office of Water
U.S. Environmental Protection Agency

Table of Contents

Disclaimer **i**

Acknowledgements **ii**

Call to Action—Seeking Commitments to Actions that Enhance Consideration of Water Reuse to Support Water Resilience, Security, and Sustainability **iii**

Section 1. The Business Case for a National Water Reuse Action Plan **2**

1.1 Drivers, Opportunities, and Challenges for Water Reuse 3

1.2 Sources of Water and Potential Applications for Water Reuse 5

1.3 Guiding Principles for the National Water Reuse Action Plan 7

1.4 Building the Draft National Water Reuse Action Plan 8

Section 2. Proposed Actions to Support Consideration and Implementation of Water Reuse **14**

2.1 Enable Consideration of Water Reuse with Integrated and Collaborative Action at the Watershed Scale 15

2.2 Coordinate and Integrate Federal, State, Tribal, and Local Water Reuse Programs and Policies 17

2.3 Compile and Refine Fit-for-Purpose Specifications 23

2.4 Promote Technology Development, Deployment, and Validation 25

2.5 Improve Availability of Water Information 28

2.6 Facilitate Financial Support for Water Reuse 30

2.7 Integrate and Coordinate Research on Water Reuse 32

2.8 Improve Outreach and Communication on Water Reuse 34

2.9 Support a Talented and Dynamic Workforce 36

2.10 Develop Water Reuse Metrics That Support Goals and Measure Progress 38

Section 3. Next Steps **40**

3.1 Formal Public Comment and Feedback 40

3.2 Facilitating Implementation of the Actions 41

3.3 Building an Enduring Legacy of Watershed-Based Action 41

Section 4. Notes and References **42**

Appendices (Available Online)

Appendix A: Discussion Framework A-1

Appendix B: Federal Partner Profiles B-1

Appendix C: Compilation of Ideas/Actions from the Literature and List of Literature Sources C-1

Appendix D: Compilation of Ideas/Actions from Outreach D-1

Appendix E: Compilation of Public Comments from the Docket and List of Commenters E-1

Appendix F: WateReuse Association Convening Report F-1

Appendix G: Selected International Profiles G-1

Appendix H: Selected Water Reuse Case Studies H-1

Appendix I: Methodology I-1

SECTION 1

THE BUSINESS CASE
FOR A NATIONAL WATER REUSE ACTION PLAN

Water is critical to our nation's health, strength, security, and resilience, but the solutions available to manage water and its availability are often complex. Water reuse can be a valuable tool to enhance the availability and effective use of water resources.

> *"Water is a vital resource, and its management requires a comprehensive approach."*
>
> — American Society of Civil Engineers

There are various names for integrated and collaborative water management approaches (e.g., "One Water" and "Total Water Solutions"). Regardless of the terminology, the concept aims to replace the traditional, fragmented, siloed approach often applied to water resources management with broader, more comprehensive solutions and strategies to meet diverse water quality and quantity needs. Because the points for consideration related to implementing water reuse often cut across federal, state, and regional water programs and may involve multiple local jurisdictions, the decision to recycle water often requires some degree of integrated planning. Thus, the draft Action Plan seeks to encourage consideration of water reuse as a part of integrated water resource management efforts at the watershed or basin scale.

Water reuse can provide alternatives to existing water supplies and be used to enhance water security, sustainability, and resilience. These terms are described in Insets 1 and 2.

Inset 1. Water Reuse Defined

Discussions of **water reuse** commonly include terms such as "recycled water," "reclaimed water," "purified water," "alternative water supplies," "improved water reliability," and "water resource recovery."

Sources of water for potential reuse can include municipal wastewater, industry process and cooling water, stormwater, agriculture runoff and return flows, and oil and gas produced water.

These source waters can be reused after they are assessed for their fit for purpose for a new use and treated to meet specifications for the chosen use application.

Examples of **reuse applications** include agriculture and irrigation, potable water supplies, groundwater storage and recharge, industrial processes, onsite non-potable use, saltwater intrusion barriers, and environmental restoration.

Seawater desalination and atmospheric water generation technologies are not included in the draft Action Plan.

The Carrabassett Valley Sanitary District (ME) provides treated wastewater to Sugarloaf Mountain Ski Resort to generate snow.

1.1 Drivers, Opportunities, and Challenges for Water Reuse

Within the next 10 years, 40 out of 50 state water managers expect to face freshwater shortages in their states.[2] In certain situations, water conservation and efficiency measures may not be enough to meet anticipated increases in demand. Water managers and users are increasingly evaluating reuse options to help diversify and extend their supplies. This issue also drives water management at the global scale (see Inset 3): two of the United Nations' Sustainable Development Goals identify water reuse as key to a more sustainable future. Example federal efforts to recognize the importance of water include the National Drought Resilience Partnership (see Inset 4) and the U.S. Department of Energy's (DOE's) Water Security Grand Challenge (see Inset 5).

Motivations and actions for consideration of water reuse vary by location and can include:

- Creating alternative water sources in response to prolonged and severe droughts (see Inset 4) and reducing reliance on imported water.
- Accommodating population growth and urbanization.
- Providing an alternative approach to managing stormwater runoff.
- Substituting non-potable water for applications that do not require drinking-quality water.
- Protecting aquatic ecosystems through targeted restoration and reduced withdrawals/diversions.
- Addressing groundwater overdrafts and related impacts (i.e., land subsidence and saltwater intrusion).
- Lowering energy costs for treatment and transportation of water.
- Responding to changing economic landscapes that may involve higher costs for water, energy, or other factors.
- Enhancing water security through portfolio diversification to enable long-term economic and environmental sustainability.
- Augmenting existing water sources to protect public health.

> *"Water security is of strategic importance to assure the present and future water demands to cover the basic needs of our population, maintain our food security and sustain economic growth. Reuse of treated wastewater to its full potential is imperative to achieve water security."*
>
> — The Puerto Rico Chapter of the Inter American Association of Sanitary and Environmental Engineering

Inset 2. Water Reuse Objectives

Water security: The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development.[5]

Water sustainability: Ensuring an adequate and continual supply of clean water for human uses and ecosystems.

Water resilience: The ability of a community water system or an asset of a community water system to adapt to or withstand the effects of rapid hydrologic change or a natural disaster.[6]

Inset 3. An International Perspective

Israel reuses approximately 87 percent of its treated wastewater,[7] and Singapore uses reclaimed water to meet 30 percent of its total water demand.[8] In terms of percentage of total water resources, both countries are leaders in water reuse.

Gillette Stadium (MA), which serves 69,000 people on game day, performs onsite reuse of wastewater for toilet flushing and groundwater recharge.

Water reuse is not without significant challenges, particularly related to protection of public health, the environment, and protection of end use quality and needs (e.g., food safety, groundwater/aquifer protection). Inset 6 summarizes examples of these challenges and barriers to water reuse. Recycled water may not be an optimal source in all situations and local decision makers are encouraged to assess the advantages and disadvantages of reuse for their communities.

Though water reuse is a well-established practice in some areas of the United States and internationally, substantial opportunities exist to expand its consideration and application for many different purposes and benefits.

Inset 4. National Drought Resilience Partnership

The National Drought Resilience Partnership (NDRP) supports state, tribal, and local efforts to enhance their drought resilience capacity at regional and basin scales through financial and technical assistance. In July 2019, the NDRP released a priority actions document that NDRP member agencies have identified will strengthen our nation's drought resilience. The National Water Reuse Action Plan is an NDRP priority action, which showcases the importance of water reuse in building long-term drought resilience and collaboration between federal, state, and tribal, governments; local communities; and other stakeholders.

Inset 5. The U.S. Department of Energy's Water Security Grand Challenge

The Water Security Grand Challenge is a White House initiated, DOE led framework to advance transformational technology and innovation to meet the global need for safe, secure, and affordable water. Using a coordinated suite of prizes, competitions, early-stage research and development, and other programs, the Grand Challenge has set five goals for the United States to reach by 2030. Each goal has a nexus with water reuse.

- **Goal 1:** Launch desalination technologies that deliver cost-competitive clean water.
- **Goal 2:** Transform the energy sector's produced water from a waste to a resource.
- **Goal 3:** Achieve near-zero water impact for new thermoelectric power plants, and significantly lower freshwater use intensity within the existing fleet.
- **Goal 4:** Double resource recovery from municipal wastewater.
- **Goal 5:** Develop small, modular energy-water systems for urban, rural, tribal, national security, and disaster response settings.

Some actions in this draft Action Plan, such as Action 2.4.3, will specifically leverage the Water Security Grand Challenge. Learn more about the Water Security Grand Challenge at: https://www.energy.gov/eere/water-security-grand-challenge.

Inset 6. Example Challenges and Barriers Associated with Reuse

Challenges related to water reuse commonly cited in the literature and outreach include:

- **Public health protection** from known and unknown constituents.
- **Cost** of infrastructure upgrades, including system assessment, installation, and operation.
- **Safety risk** from inadequate levels of treatment, in situ reactions, or inadequate monitoring.
- **Consumer concerns** about contamination and safety.
- **Inadequate technologies** or validating technology performance.
- **Inadequate monitoring** including lack of real-time information.
- **Unintended downstream impacts** from reduced flows.
- **Unclear, inconsistent, or conflicting regulations** governing the applications of water reuse.

The City and County of San Francisco (CA) adopted the Onsite Water Reuse for Commercial Multi-Family, and Mixed Use Development Ordinance for collection, treatment, and use of alternative water sources for non-potable applications.

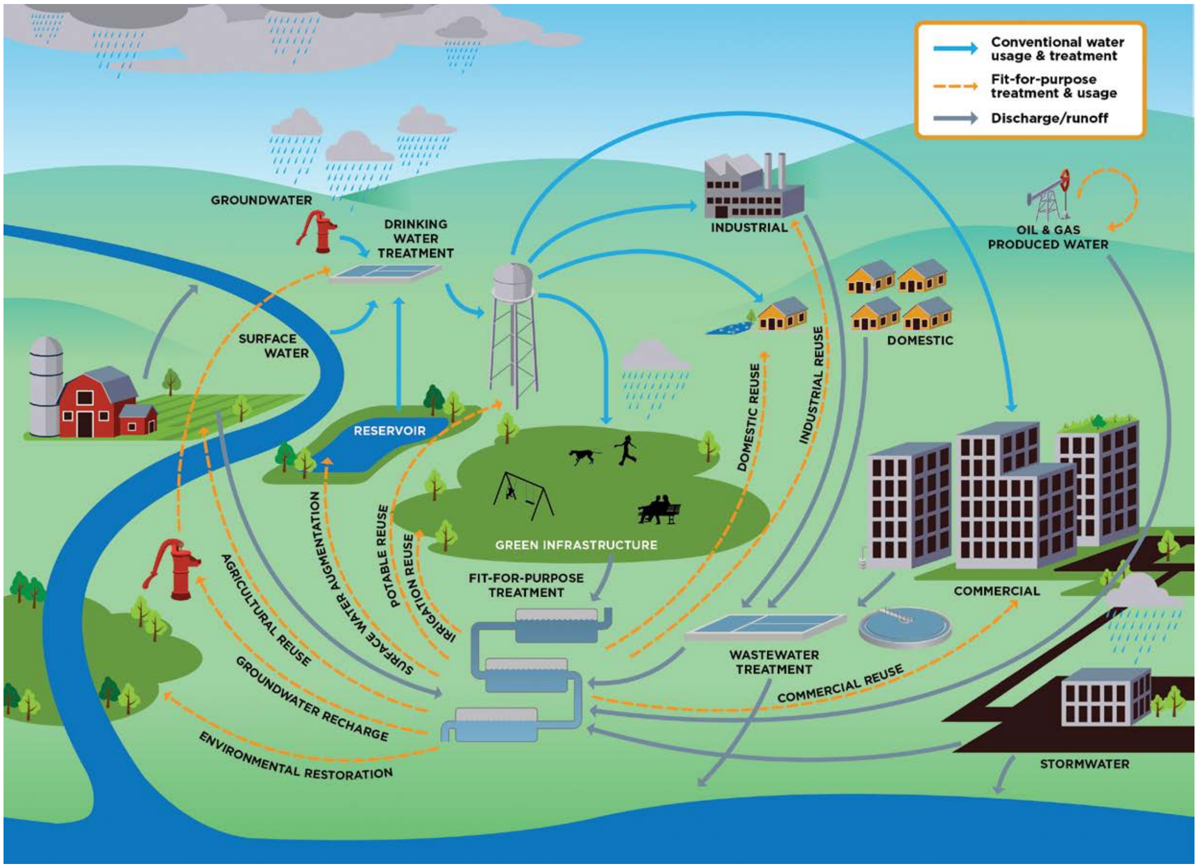
1.2 Sources of Water and Potential Applications for Water Reuse

The major sources of water for potential reuse include: (1) municipal wastewater, (2) industry process water and cooling water, (3) agriculture runoff and return flows, (4) oil and gas produced water,[9] and (5) stormwater.[10] The use of the reclaimed water may be different than the source (e.g., agricultural use of a municipal or industrial source).

Fit-for-purpose treatment specifications are the treatment requirements to bring water from a particular source to the quality needed for the intended use. When considered together, the water source and the use application determine the extent and nature of treatment required. Example use applications are described in the Discussion Framework for Development of a Draft Water Reuse Action Plan (Appendix A). Figure 1 attempts to characterize various sources of water and the potential use applications.

National daily volumes (e.g., discharge, withdrawal, use, or needs) from the various available source waters demonstrate significant reuse potential. However, water generated as discharge from these sectors is largely an untapped resource. For example, municipal wastewater facilities collectively treat a total estimated 33 billion gallons per day (BGD), most of which is returned to the environment as treated effluent. Only an estimated 2.2 BGD (6.6 percent) is recovered for reuse.[11]

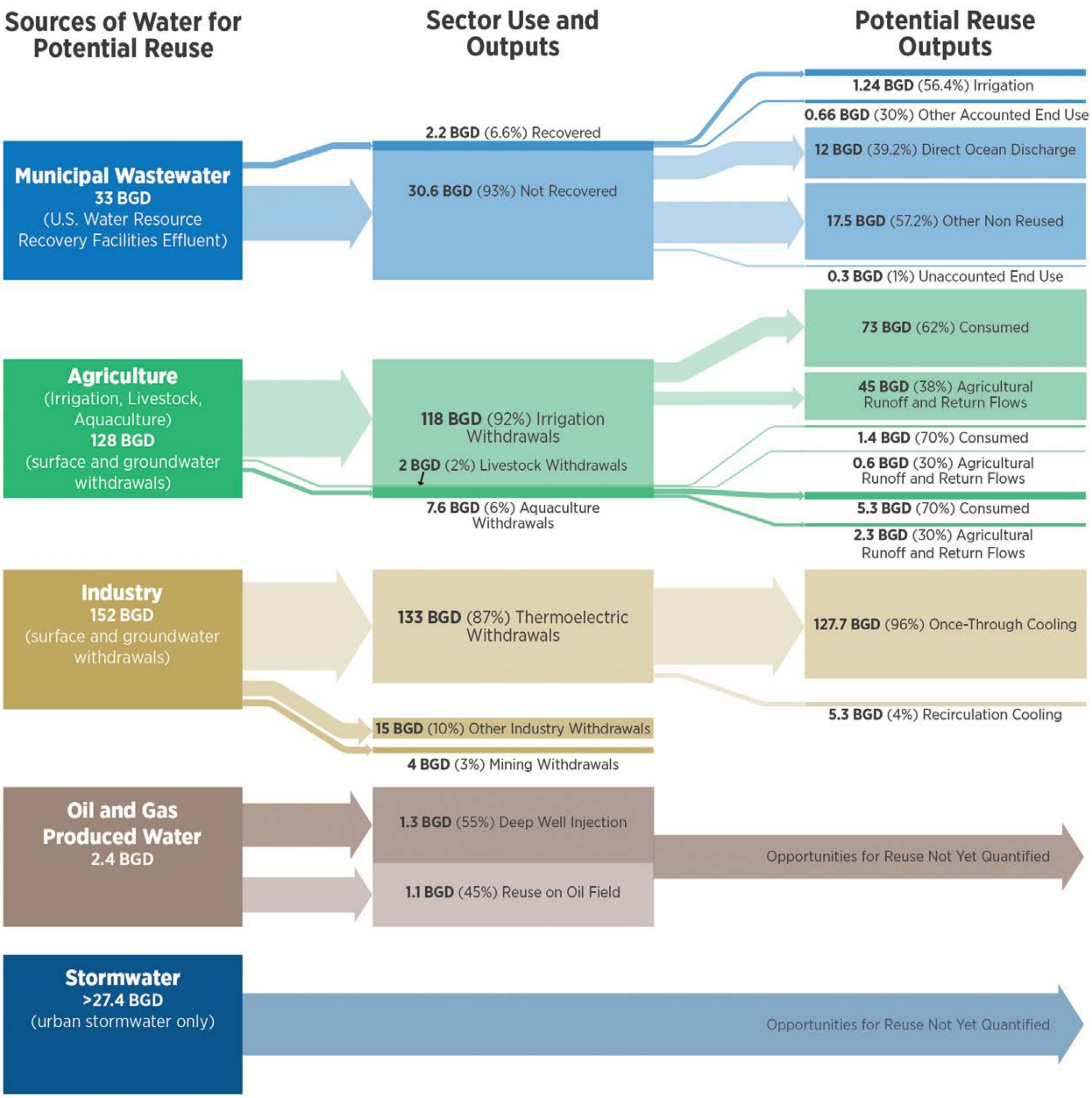
Figure 1. Examples of water sources and use applications.



UTC Aerospace Systems (CT) installed a closed loop system to recycle 80 percent of its wastewater as deionized water for reuse in its industrial processes, such as metal finishing.

Figure 2 illustrates, for five different source categories (from left to right): (1) the estimated daily water discharge volumes; (2) estimated withdrawal percentages; and (3) estimates of how the water is currently used, which together offers an estimated percent of reuse in the United States. The intent of this graphic is simply to illustrate the clear potential to reclaim considerably more of our nation's water resources than currently practiced.

Figure 2. Estimated daily volumes (e.g., discharges, needs, withdrawals, consumptive uses) and current uses of sources of water in the United States.



Note that not all flows and associated percentages in Figure 2 add up to 100 percent.

Figure 2 Sources:

- Rauch-Williams, T; Marshall, MR; Davis, DJ. (2018). Baseline data to establish the current amount of resource recovery from WRRFs. Water Environment Federation. https://www.wef.org/globalassets/assets-wef/direct-download-library/public/03---resources/WSEC-2018-TR-003.
- U.S. Geological Survey. (2015). Estimated use of water in the United States in 2015. Retrieved from https://pubs.er.usgs.gov/publication/cir1441.
- U.S. Department of Energy. (2014). The water-energy nexus: Challenges and opportunities. https://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf.
- Veil, J. (2015). U.S. produced water volumes and management practices in 2012. Prepared for the Ground Water Protection Council. http://www.gwpc.org/sites/default/files/Produced%20Water%20Report%202014-GWPC_0.pdf.
- U.S. Environmental Protection Agency. (2004). Report to Congress: Impacts and control of CSOs and SSOs. https://www.epa.gov/sites/production/files/2015-10/documents/csossortc2004_full.pdf.

1.3 Guiding Principles for the National Water Reuse Action Plan

The development of the draft Action Plan was guided by the following key principles:

- **Protect public health.** The paramount need to protect public health, given the array of chemical and pathogenic contaminants that may exist in sources of water for potential reuse applications. Protection of public health is central to virtually all the potential uses.
- **Protect the environment and ecosystems.** Recognize water reuse can have both positive (e.g., ecosystem restoration) and negative (e.g., diminished in-stream flows) impacts on aquatic ecosystems.
- **Promote action based on leadership, partnership, and collaboration.** Rely on the expertise and leadership at all levels of a diverse range of water partners to ultimately lead and support the actions.
- **Build on past progress and experience.** Rely and build upon the decades of existing research, policy, technology, practice, and experience as the foundation of the draft Action Plan.
- **Identify the most impactful actions.** Identify the actions that will have the greatest value and impact on consideration of water reuse.
- **Recognize distinct challenges posed by water reuse.** Recognize that water reuse demands new levels of technology, monitoring, and workforce expertise given the characteristics and variability of sources of water for potential reuse.
- **Consider water reuse in an integrated water resources management framework.** Water reuse must not be considered in isolation or as a unique outcome; rather, it should be considered as part of an integrated planning framework perhaps best accomplished at the watershed scale. Inset 7 illustrates one example of integrated planning for water reuse.
- **Recognize and address state and local considerations.** Many important factors are beyond the scope of this draft Action Plan but should be identified at the national, state, or local scale when evaluating water reuse scenarios. These include affordability, water rights, and environmental justice.

This draft Action Plan (and ultimately the final Action Plan) will contribute to a growing community of practice and national, state, and local efforts to consider applications of water reuse. It will seek to identify the critical technology, policy, and programmatic issues we must address as a nation to enhance the sustainability, security, and resilience of our water resources.

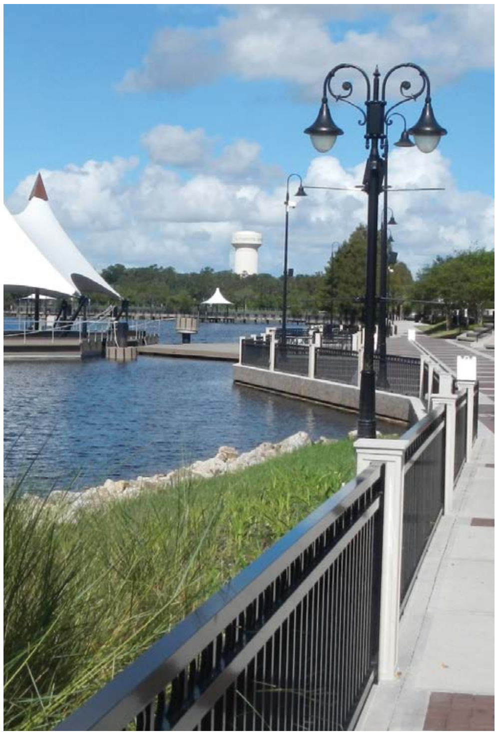
The City of San Jose, California, uses reclaimed water for city offices and a public fountain.

Inset 7. Planning and Implementation of Recycled Water Benefits Farmers in California

The Eastern Municipal Water District (EMWD) in southern California is converting wastewater into water that can be reused (currently 35 percent of the EMWD's water supply portfolio), regularly repurposing and selling 100 percent of its recycled water for use in agricultural, irrigation, landscaping, and industrial applications. The EMWD uses treatment facilities and storage ponds to ensure year-round water availability, drought-proofing, and setting up the community for future urban development. The EMWD is also exploring future uses of recycled water, including recharging local groundwater supplies that could then be extracted for drinking water. More info: https://www.emwd.org/recycled-water-service.

The Western Pennsylvania Conservancy implements water reuse at the famed Fallingwater, designed by Frank Lloyd Wright, to recycle 100 percent of wastewater produced by 140,000 annual visitors for toilet flushing and irrigation.

1.4 Building the Draft National Water Reuse Action Plan



Runoff from a Florida interstate and adjacent drainage basins flows into a regional stormwater facility that delivers reclaimed water to the city of Altamonte Springs for lawn, landscape, and other non-drinking purposes.

An extensive foundation of research, practice, and experience in water reuse exists, both here in the United States and abroad. Development of the draft Action Plan has attempted to build on this progress and experience by including significant outreach, engagement, and collaboration with individuals and organizations across the water sector and federal, state, and tribal partners.

Key sources of information, ideas, and inputs informing the draft Action Plan include:

- **Current federal agency roles.** Several of the federal partners have summarized and documented their efforts and explicit roles related to water reuse (Appendix B).
- **Analysis and summary of the water reuse literature** (over 155 sources) (Appendix C). Four particular sources of water reuse information stand out and are summarized (see Insets 8, 9, 10, and 11) because of their pertinent scope and thoroughness regarding categories of sources of water for potential reuse:
  - The National Research Council's *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater*.[12]
  - The Ground Water Protection Council's *Produced Water Report: Regulations, Current Practices and Research Needs*.[13]
  - The Water Research Foundation's *Agricultural Reuse of Recycled Water: Impediments and Incentives*.[14]
  - Bluefield Research's *U.S. Municipal Water Reuse: Opportunities, Outlook and Competitive Landscape 2017–2027*.[15]
- **Outreach and dialogue** through more than 20 forums with an estimated 2,300 participants (Appendix D).
- **Public input** submitted to the docket by 55 commenters (Appendix E). Examples of relevant statements from some of the public input are included in italics in the draft Action Plan.
- **WateReuse Association expert convening report** (spring 2019) (Appendix F). We include this as a distinct appendix to the draft Action Plan given the significance of the two national convenings that were held and the broad representation among the participants. We recognize that the WateReuse Association final report may not reflect the views of all convening participants.
- **Review of international experiences** (Israel, Singapore, Australia, South Africa, Namibia) (Appendix G).
- **Consideration of reuse case studies** provided on facilities in the United States (Appendix H). In addition, examples of water reuse applications are included at the bottom of the pages of the draft Action Plan.

The methodology for development of the draft Action Plan is discussed in more detail in Appendix I.

The National Security Agency (MD) uses reclaimed wastewater from Howard County as industrial cooling water for critical IT infrastructure at its East Campus, addressing all first phase cooling needs.

Inset 8. Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater

The National Research Council of the National Academies of Sciences, Engineering, and Medicine completed a comprehensive study of reuse of municipal wastewater in 2012. The following are selected conclusions and recommendations from the study:

- Municipal wastewater reuse offers the potential to significantly increase the nation's total available water resources. Approximately 12 billion gallons of municipal wastewater effluent is discharged each day to an ocean or estuary out of the 32 billion gallons a day discharged nationwide.
- The de facto reuse of wastewater effluent as a water supply is common in many of the nation's water systems, with some drinking water treatment plants using waters from which a large fraction originated as wastewater effluent from upstream communities.
- A portfolio of treatment options, including engineered and managed natural treatment processes, exists to mitigate microbial and chemical contaminants in reclaimed water, facilitating a multitude of process combinations that can be tailored to meet specific water quality objectives.
- Natural systems are employed in most potable water reuse systems to provide an environmental buffer. However, it cannot be demonstrated that such "natural" barriers provide any public health protection that is not also available by other engineered processes.
- Reclamation facilities should develop monitoring and operational plans to respond to variability, equipment malfunctions, and operator error to ensure that reclaimed water meets the appropriate quality standards for its use.... Reuse systems should be designed with treatment trains that include reliability and robustness.
- Improved coordination among federal and nonfederal entities is important for addressing the long-term research needs related to water reuse.
- When assessing risks associated with reclaimed water, the potential for unintended or inappropriate uses should be assessed and mitigated.
- Guidance and user-friendly risk assessment tools would improve the understanding and application of these risk assessment methods.

Source: National Research Council. (2012). Water reuse: Potential for expanding the nation's water supply through reuse of municipal wastewater. Washington, DC: National Academies Press. https://www.nap.edu/catalog/13303/water-reuse-potential-for-expanding-the-nations-water-supply-through

The F. Wayne Hill Water Resources Center in Gwinnett County, Georgia, treats up to 60 MGD of wastewater effluent for surface water recharge to Lake Lanier, while also recovering phosphorus and methane gas.

The King County (WA) regional water plant produces nearly 77 million gallons of reclaimed water each year for park irrigation, street and sewer cleaning, and wetland recharge as well as 669 million gallons of reclaimed water each year for in-plant processes.

Inset 9. Produced Water Report: Regulations, Current Practices, and Research Needs

In June 2019, the Ground Water Protection Council (GWPC) completed a comprehensive report on oil and gas produced water. The report engaged geologists, engineers, lawyers, toxicologists, soil experts, public health experts, the petroleum industry, and regulators. From this group, the GWPC sought ideas and advice on the report's content and conclusions. Relevant highlights considered in development of the draft Action Plan are excerpted below.

- Produced water varies widely in quality. Most produced water is highly saline and may contain a mix of mineral salts; organic compounds; hydrocarbons, organic acids, waxes, and oils; inorganic metals and other inorganic constituents; naturally-occurring radioactive material; chemical additives; and other constituents and byproducts....The physical and chemical properties of produced water vary considerably depending on the geographic location of the field, the geologic formation, and the type of hydrocarbon product being produced.
- Based on the best available data from 2012, the nearly 1 million producing oil and gas wells in the United States produce approximately...2.4 billion gallons/day, or 2.7 million acre-feet/year.
- In a 2015 GWPC report, which analyzed 2012 data, about 45 percent of produced water was used within conventional oil and gas enhanced recovery operations, leaving about 55 percent to be disposed of in permitted underground injection control (UIC) wells with a small percentage managed in other ways including evaporation and discharge.
- The multi-stage hydraulic fracturing of a single horizontal well can use an average of about 12 million gallons of water. Growth in volumes of sourced and produced water required in hydraulic fracturing operations has raised sustainability concerns in unconventional regions, prompting greater emphasis on long-term water planning.
- While produced water is currently being used in applications both within and outside of oil and gas operations, many potential applications remain. Further research will be needed to assure that these potential applications are both suitable and safe.
- Although some states require volume reporting, widespread available data on produced water volumes is currently limited. Limited data on produced water volumes and current management strategies also limits the ability to identify pressure points on existing disposal options in advance or to identify volumes that may need other management options, such as reuse.
- Most research needs identified...pertain to produced water treatment and reuse outside the oil and gas industry.... Produced water is complex, and in most cases further research and analysis is needed to better understand and define the "fit for purpose" quality goals for treatment and permitting programs.
- Managing potential risks with such applications requires improved understanding of the composition of a specific produced water source and identification of the health and environmental risks of reuse or release.
- As water becomes scarcer, the increasing benefits of reusing produced water in some regions may outweigh the costs of managing, treating, storing, and transporting it if health and environmental risks can be understood and appropriately managed.

Source: Ground Water Protection Council. (2019). Produced water report: Regulations, current practices, and research needs. http://www.gwpc.org/sites/default/files/files/Produced%20Water%20Full%20Report%20-%20Digital%20Use.pdf

Apache Corporation, an oil and gas company, recycles produced water, reducing its freshwater withdrawals to only 1 to 2 percent. Pictured here is an Apache Corporation facility in Texas.

Emerald Coast Utilities Authority (FL) recycles 100 percent of the wastewater from its Central Water Reclamation Facility, providing it to Gulf Power and International Paper.

Inset 10. Agricultural Use of Recycled Water: Impediments and Incentives

The Water Research Foundation completed this comprehensive study in 2019, based on literature reviews, stakeholder interviews, case studies, and data analysis; relevant highlights are below. The researchers developed recommendations (provided in an appendix to the report) for wastewater and water supply utilities, agricultural operations, regulators, journalists, community members, and elected officials to address potential impediments to agricultural water reuse. Following are excerpts of selected findings:

- In aggregate and under idealized conditions, existing effluent could supply an average of about 17% of the irrigation water needed in the west and more than 75% of demand in the eastern states.
- The extent to which existing discharges of effluent to surface waters represent a viable opportunity for increasing agricultural reuse depends largely on existing water rights.
- Impediments to the use of recycled water in agriculture vary substantially from one location to another....Some of the identified impediments in one region acted as drivers under certain conditions in other regions.
- Many commonly cited impediments and incentives to water reuse (broadly) are not relevant or differently relevant when considering only agricultural water reuse.
- Regulatory constraints vary greatly from one area to another: there are no global or national (U.S.) standards for water reuse.
- Water quantity (scarcity, drought, climate-change, overdraft) was one of the most frequently cited impediments and/or drivers across all stakeholder groups.... Another impediment is seasonality of recycled water demand for irrigation.
- Water quality issues are both impediments and incentives to agricultural reuse.
- Capital investments needed to upgrade treatment facilities and/or construct recycled water distribution networks to agricultural customers are some of the most commonly cited impediments for utilities.
- Policy changes are needed in some areas to allow for recycled water to be transported in existing infrastructure.
- Increasing agricultural water reuse may require incentives at multiple points along the produce supply chain.
- Increasing [the Clean Water Act's (CWA) National Pollutant Discharge Elimination System] NPDES limits on nutrient loads and/or effluent temperature were commonly cited as motivation for agricultural water reuse.
- Policy innovations are needed to create appropriate incentives to capture the nutrient benefit of agricultural application of recycled water.
- Creative combinations of financing, collaborative management agreements, and outreach can (and have helped) overcome many common impediments to agricultural reuse projects.

Source: Water Research Foundation. (2019). Agricultural use of recycled water: Impediments and incentives. https://www.waterrf.org/research/projects/agricultural-reuse-impediments-and-incentives

This study was funded by The Water Research Foundation, California State Water Resources Control Board, and Pentair.

A farm in Idaho applies treated, reclaimed wastewater to a potato field.

The Walla Walla Water Reclamation Plant (WA) produces 7.2 MGD reclaimed water for agricultural use and to satisfy Mill Creek water rights.

Inset 11. U.S. Municipal Water Reuse: Opportunities, Outlook, and Competitive Landscape 2017-2027

Bluefield Research, LLC completed a market assessment in 2017 of water reuse in the United States over a ten-year period. The Bluefield "Outlook" offers an analysis of the rapidly changing U.S. municipal water reuse landscape, examining regulatory changes, technology trends, and company strategies influencing the deployment of water reuse as a water resource management strategy. Selected highlights are provided below.

- Bluefield Research forecasts the municipal wastewater reuse segment to total an aggregate US$21.5 billion from 2017 to 2027, demonstrating significant opportunity for deployment of innovative technologies and solutions in a mature U.S. utility market.
- Water managers are increasingly looking at long-term strategies, including reuse, in order to secure water supplies in the face of increased future demand and uncertain water availability.
- Power plants, oil refineries, and fracking operations are the biggest opportunities for expansion of municipal reclaimed water use for industrial users.
- Potable reuse is an increasingly important application for reclaimed water as it avoids issues of finding willing off-takers and can reduce costs by avoiding the installation of segregated reclaimed water distribution systems.
- With an infrastructure investment gap of more than US$500 billion for drinking water and wastewater treatment over the next twenty years, wastewater reuse is expected to be a key part of the water supply solution.
- Population growth, largely in urban areas, is driving an increase in water demand, precipitating an increase in potable, commercial and industrial reuse applications.
- Climate change will greatly increase the risk that water supplies will not be able to keep pace with demand, necessitating the need to develop new, drought proof supplies.
- Thirty-nine out of 50 states currently have reuse regulations or guidelines in place, with three more in the process of adopting regulations, a key development for the growth of the water reuse industry.
- The growing water demand from the fracking sector is forcing energy services players to look to municipal reclaimed water in order to secure supplies for operations. At least five midstream operators have already signed purchase agreements with local municipalities in Texas and Oklahoma.
- In 2014, Pioneer Natural Resources began to address its water challenges with a 10-year take-or-pay contract with the City of Odessa, Texas and its Bob Derrington Water Reclamation Plant. The deal is expected to deliver up to five million gallons per year at a declining rate for US$6.33 to US$6.00 per thousand gallons based volume.
- In 2014, Apache signed a contract to purchase up to 3 million gallons per day from the city of College Station's WWTP over a two-year period. The contract is expected to net the city US$5 million.
- Alpha Reclaim Technology, owned by BNN Energy, purchases municipal reclaimed effluent from Karnes City and other municipalities in the area and resells it to oilfield operators. Since 2011, Alpha Reclaim Technology has contracted with over 120 cities in Texas to purchase their treated wastewater.

Source: Bluefield Research. (2017). U.S. municipal water reuse: Opportunities, outlook, and competitive landscape 2017–2027.

The Upper Occoquan Sewage Authority in Virginia treats wastewater for recharge to the Occoquan Reservoir. Currently about 50 MGD of treated wastewater is recycled, which, depending on hydrologic conditions, is 10 to 90 percent of the drinking water reservoir inflow.

Cary, North Carolina, operates two water reclamation facilities providing a total of nearly 25 MGD of treated wastewater for non-potable reuse including irrigation, cooling, and industrial processes.

The Tres Rios Environmental Restoration Project in Arizona pumps treated wastewater effluent through 700 acres of Salt River wetlands, creating wildlife habitat and reducing flood risk.

SECTION 2

PROPOSED ACTIONS

TO SUPPORT CONSIDERATION AND IMPLEMENTATION OF WATER REUSE

This draft Action Plan identifies 46 proposed actions organized around 10 strategic objectives (e.g., policy coordination, technology development and validation, research coordination, communications, workforce, metrics).

During the formal public comment period, we will engage in a process to: (1) narrow the actions to the most important and impactful while ensuring the inclusion of key actions that may not be included in this draft; (2) identify the key attributes and characteristics that are needed to ensure success; (3) identify the leaders, partners, and collaborators whose contributions are needed for success; (4) and outline key milestones and accountability to ensure successful action execution. We anticipate that this process may result in a smaller set of actions than what is proposed in this draft Action Plan. Example attributes of the ideal actions in the final Action Plan include:

- Address key opportunities and barriers to consideration of water reuse.
- Lead to answers about key science, risk, and technology problems and solutions.
- Optimize the expertise of many water interests.
- Achieve greater efficacy and efficiency of delivery of policy, science, research, and technology.
- Recognize the different needs of geography, capability, and community size.
- Support the role of states and tribes.
- Encourage watershed-scale action.
- Achieve substantial progress in the near term.
- Create momentum for future actions and success.

The Denver Zoo in Colorado, in partnership with Denver Water, has reduced its water consumption by 42 percent, using reclaimed water for irrigation, enclosure washdown, and animal swimming pools. Overall, 35 percent of the zoo's water comes from Denver Water's Recycling Plant.

The San Ysidro Land Port of Entry (CA) features a membrane bio-reactor blackwater onsite treatment system, producing non-potable treated graywater that is combined with rainwater for flushing toilets, irrigation, and cooling towers.

The formal comment period following release of the draft Action Plan will help identify the priority actions; articulate the attributes and implementation steps; and seek leaders, partners, and collaborators for each action in the final Action Plan. Key questions to consider include:

- Of the proposed actions, which are the most important and would have the greatest positive impact at the local, regional, and national level?
- What are the attributes, characteristics, and steps necessary for success?
- What are the key implementation steps and milestones necessary to successfully implement these actions?
- Is your organization willing to lead the action and collaborate with others to implement the actions?
- Is your organization willing to contribute to implementation as a partner or collaborator?
- Do you have additional information or recommendations to inform these or other proposed actions?

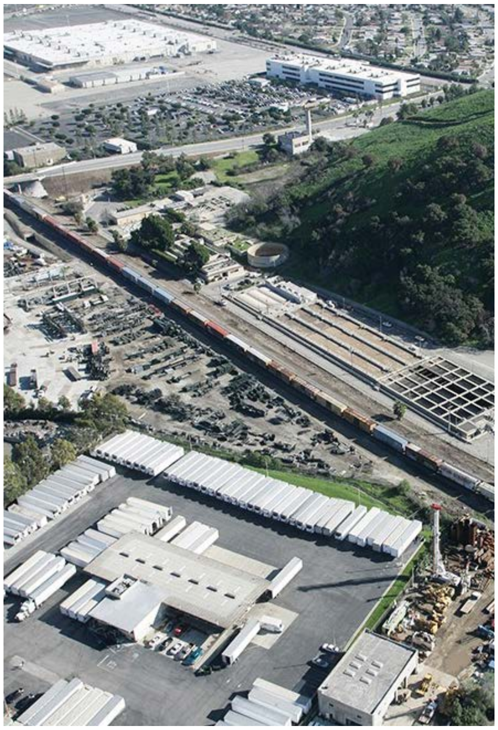
2.1 Enable Consideration of Water Reuse with Integrated and Collaborative Action at the Watershed Scale

Water management, and water reuse as a water management tool, is most successful when viewed as part of the entire water portfolio at the watershed scale.

Successful comprehensive water reuse projects, such as Orange County's early Water Factory 21 (commissioned in 1975) and northern Virginia's Upper Occoquan Sewerage Authority (UOSA) (constructed in 1978), have shared many attributes that are hallmark traits of effective integrated water resources management:

- Gathering and sharing information about current water needs and resources.
- Critical thinking about long-term water availability, security, and sustainability for both quantity and quality.
- Integrated planning and implementation that addresses multiple needs and objectives.
- Effective water sector and public health outreach to gain acceptance and confidence.

> *"A key lesson from the ongoing [Orange County, CA] [groundwater replenishment system] GWRS experience is that water reuse is complex and regional in nature, and local agencies that utilize an integrated stakeholder-engaged planning strategy are better positioned to provide sustainable water supplies that are safe, reliable, cost-effective, and environmentally responsible."*
>
> — Orange County Sanitation District, California



The City of Pomona Water Reclamation Plant in California now recycles approximately 8 MGD of water for landscape irrigation, dust control, and industrial use.

The Orange County Water District (CA) recycles water through its Groundwater Replenishment System (100 MGD), Green Acres Project for irrigation, and Water Factory 21 to combat saltwater intrusion.

Integrated water resource planning is a well-established framework supported by states, basin-level planning entities, and local communities. Academic institutions can also play a role in facilitating integrated planning (see Inset 12).

Inset 12. Bay Area One Water Network

A coalition of state and local water management agencies and districts in the San Francisco Bay region, facilitated by Stanford University and University of California, Berkeley, are developing a regional network to encourage integrated water resource planning and management and water reuse.

The network will help align planning of water resources projects, improve coordination among currently single-purpose water management districts, and serve as a forum to promote wastewater recycling, stormwater capture and use, and onsite/distributed water reuse systems, demonstrating the utility of regional-scale planning.

"The Action Plan will be a critical step toward advancement of Integrated Planning across regulatory boundaries and for promoting more resilient water management across the United States."

— New York City Department of Environmental Protection

Proposed Actions

ACTION 2.1.1 Develop a Federal Policy Statement to Support and Encourage Consideration of Water Reuse in a Watershed-Scale Planning Context

To support and encourage water managers to engage in planning efforts at watershed scales and to fully evaluate approaches such as water reuse, federal partners could develop a common policy statement supporting protective watershed-scale integrated water resources management planning approaches to enhance water resilience, security, and sustainability through a diverse water portfolio.

ACTION 2.1.2 Prepare Case Studies of Successful Applications of Water Reuse Within an Integrated Water Resources Management Framework

Compile, prepare, and disseminate case studies and programs where water reuse was considered and implemented as part of successful integrated water resources management programs. One such program is the Regional Conservation Partnership Program (RCPP) administered by the Natural Resources Conservation Service (NRCS) at the U.S. Department of Agriculture (USDA), which facilitates watershed scale planning through projects involving the NRCS, conservation partners, and agricultural producers.[16]

ACTION 2.1.3 Incorporate Water Reuse and Capture Concepts into Integrated Planning Efforts at the Local Level

Explicitly recognize the importance of wastewater reuse, stormwater capture, and drinking water supply in the design of integrated water management plans and policies. This should include consideration of financial capacity to implement integrated solutions addressing combined sewer system, wastewater, stormwater, and drinking water management needs.

Microsoft teamed with the City of Quincy (WA) to build a water treatment plant, which provides reclaimed water for cooling at data centers and injection into the local aquifer.

2.2 Coordinate and Integrate Federal, State, Tribal, and Local Water Reuse Programs and Policies

Federal, state, tribal, and local programs and policies can be aligned and coordinated to encourage consideration of water reuse.

Laws, regulations, and policies can have a substantial bearing on the consideration, application, and implementation of water reuse. The Safe Drinking Water Act (SDWA) and CWA, for example, provide the framework and baseline requirements—e.g., the SDWA's Maximum Contaminant Levels, the CWA's NPDES and Effluent Limitations Guidelines (ELGs), water quality standards, and source water protection—to ensure drinking water and surface waters are protective of public health and the environment.

> *"Going forward, perhaps the most important action EPA can undertake is to maintain its stature as an honest broker for water reuse policy. As our nation's lead regulator for water policy, the Agency is in a unique position, one that if maintained allows the Agency to backstop sound local and state decision making."*
>
> — AWWA

In most cases, states have the primary role to implement these requirements and programs (i.e., cooperative federalism).

Beyond the CWA and SDWA, there are other federal, state, tribal, and local regulations, statutes, programs, and policies that can support water reuse as part of a watershed-scale integrated water resources management approach.

Several states have established regulations, policies, and programs specifically tailored to encouraging, managing, and/or regulating water reuse activities.[17, 18] Inset 13 describes examples of state-wide initiatives and policies intended to address water resource challenges. Some states have also established state-wide legislation and initiatives to encourage, foster, and/or require water reuse. States can benefit from sharing their successes and the challenges they face both facilitating and regulating the use of recycled water. The spectrum of experience and practice with water reuse at the state level is diverse across the country. Maryland and New Mexico are examples of states with very different interests and needs (see Insets 14 and 15).

The water sector has also played an important role in advocating water reuse, including, for example, the Water Environment Federation *Water Reuse Roadmap* (2018) and the recent *California WateReuse Action Plan*[19] released by WateReuse California earlier this year.

Inset 13. Example State Actions Relating to Water Reuse

California: California's Recycled Water Policy from 2013 establishes a mandate to increase the use of recycled water by 200,000 acre-feet per year (afy) by 2020 and by an additional 300,000 afy by 2030.

Florida: Florida's state budget for fiscal year 2019–2020 appropriates $40 million toward advancing alternative water supplies.

Hawaii: The Fresh Water Advisory Council of the Hawaii Fresh Water Initiative developed a 2015 Blueprint for Action to make up the fresh water deficit facing the state by 2030. The blueprint identifies a strategic target of more than doubling the amount of wastewater reused to 50 million gallons per day.

New Mexico: New Mexico enacted a new law in 2019 (HB 546), effective July 1, for the protection of water quality by encouraging the oil and natural gas industry to favor reuse, recycling and treatment options over reliance on New Mexico's limited fresh water resources.

Texas: Texas' 2017 State Water Plan (one in a series published every five years) called for 4.5 million cubic meters per day of additional reuse capacity over a 50-year period with 85 projects specified.

Alaska: In 2013, Alaska issued the Alaska Water and Sewer Challenge, focused on decentralized water and wastewater treatment, recycling, and water minimization. Reuse approaches have high potential for use in the 3,300 homes currently lacking running water and flush toilets.

The City of St. Petersburg's (FL) reclamation system provides 37 MGD of reclaimed water for non-potable uses including 300 fire hydrants.

On May 15, 2019, the EPA released a draft of its *Study of Oil and Gas Extraction Wastewater Management Under the Clean Water Act*. The draft study describes input from states, tribes, and stakeholders on available approaches to manage produced water from onshore oil and gas extraction facilities and input on whether potential revisions to federal regulations that may allow for broader discharge of treated produced water to surface waters are supported.

Inset 15. New Mexico's Management of Produced Water

Reuse, recycle, and treatment of water produced during oil and gas extraction can help provide a more sustainable fresh water supply for the State of New Mexico. As of 2018, the State of New Mexico is the third largest producer of oil in the country. For every barrel of oil, four to seven barrels of produced water may be generated, which totaled more than one billion barrels of produced water generated in 2018 alone. In 2019, the New Mexico Legislature passed the Fluid Oil & Gas Waste Act, clarifying jurisdiction of state agencies to regulate produced water. The law facilitates recycling and treatment of produced water, while providing regulatory oversight and conserving existing freshwater. It also authorizes development of regulations for use of treated produced water outside of oil fields, including in irrigation, road construction, and industrial applications.

Inset 14. State Leadership: Maryland Develops State Water Reuse Strategy

The Maryland Department of the Environment (MDE) is currently adopting regulations for generating and using Class IV quality wastewater effluent (water with high potential for human contact) and is developing regulations to enable residential graywater reuse for outdoor irrigation, indoor toilet flushing, and fire suppression. The MDE is working with several jurisdictions on pilot projects to address local water and wastewater challenges to guide future reuse projects and help establish appropriate regulatory frameworks. The MDE will continue to provide outreach and tools via its Water Reuse Center.

> *"ACWA members are interested in updating current Effluent Limitation Guidelines (ELGs) for oil and gas extraction wastewater management. Water scarce states would benefit from more cost-effective treatment so that they can utilize produced water."*
>
> — ACWA and ASDWA

Inset 16. Aquifer Recharge Terminology

Aquifer recharge: The replenishment of water in aquifers, either by natural or artificial (surface spreading, infiltration basins, or injection wells) processes.[20]

Managed aquifer recharge (MAR): The recharge of an aquifer using either surface or underground recharge techniques.[21] Synonyms include **enhanced aquifer recharge** (EAR),[22] **artificial recharge**,[23] **planned recharge**,[23] and **water banking**.[21]

Aquifer storage and recovery (ASR): The storage of water in an aquifer for later withdrawal and beneficial use.[24]

Managed underground storage (MUS): Encompasses a number of approaches that purposefully add water into (recharge) an aquifer system for later recovery and use.[25]

Loudoun Water's Broad Run Water Reclamation Facility (VA) reclaims 1 MGD of its water (treated to drinking water quality) for irrigation, industrial cooling for data centers, and other non-potable uses.

Proposed Actions

ACTION 2.2.1 Compile State Policies and Approaches to Implement Water Reuse Programs

Compile existing state-level statutes, regulations, policies, programs, frameworks, and/or approaches that are currently in place for water reuse. This would also include a compilation and description of water-reuse-related terms and opportunities for greater alignment. For example, Inset 16 provides examples of various terms used to describe aquifer recharge and recovery. Assembling this information will enable sharing across states. This could build on prior efforts, such as the State Water Policy and Program Database managed by Western Resource Advocates and state-based resources managed by the WateReuse Association.

ACTION 2.2.2 Enhance State Collaboration on Water Reuse

The states, principally led by the ACWA, the ASDWA, and the Environmental Council of the States, will create ongoing forums for states to share and discuss experiences and attributes of their water reuse programs. The first such opportunity to engage a spectrum of states is expected to be initiated in September 2019.

ACTION 2.2.3 Complete the EPA Study of Oil and Gas Extraction Wastewater Management

The EPA is continuing to review public input received on the May 15, 2019, draft *Study of Oil and Gas Extraction Wastewater Management Under the Clean Water Act* and anticipates finalizing the study in 2019. The final study will inform the EPA's consideration of potential regulatory and nonregulatory approaches for management of produced water under the CWA, including the potential for greater reuse opportunities. See https://www.epa.gov/eg/study-oil-and-gas-extraction-wastewater-management for more information.

ACTION 2.2.4 Enhance Wastewater Source Control through Local Pretreatment Programs to Support Water Reuse Opportunities for Municipal Wastewater

Develop best practices describing how local pretreatment programs can mitigate and reduce problematic pollutants discharged into publicly owned treatment works and enhance reuse opportunities for reclaimed wastewater. For example, this might involve convening pretreatment program coordinators to compile, share, and advance approaches and strategies for wastewater source control to support water reuse.

ACTION 2.2.5 Compile and Develop Protection Strategies for Different Sources of Waters for Potential Reuse

Pollution prevention concepts and best practices can be applied to sources of waters for potential reuse (e.g., industry process water, oil and gas produced water, agricultural return water, stormwater). Protecting various source waters from problematic contaminants can reduce treatment costs and expand opportunities to reclaim water. Compile and develop best practices for pollution prevention to reduce contamination and enhance opportunities for reclaimed water. For example, lessons learned from the drinking water source water protection program could be summarized and disseminated to local water managers.

Scottsdale Water Campus (AZ) reuses up to 1.7 billion gallons of treated wastewater annually through aquifer recharge.

ACTION **2.2.6**

Develop Informational Materials to Better Enable Water Reuse in CWA NPDES Permits

Develop informational materials describing how NPDES permits can enable reuse associated with municipal and industrial wastewater recycling and stormwater capture projects. This suite of materials (e.g., training programs) could be actively distributed to existing permit writers and inspectors to help foster better understanding of the potential for water reuse.

ACTION **2.2.7**

Convene a Federal Multi-Agency Working Group to Serve as a Forum for Coordinated Engagement on Water Reuse

Convene a working group (or groups) to serve as a forum for discussion of water reuse, including in federal installations and buildings. This would include working with all federal agencies that have designated responsibilities related to practices enabling water reuse. See Insets 17 and 18 as examples of federal leadership.

Inset 17. Executive Order 13834, "Efficient Federal Operations"

Section 2 of EO 13834 establishes eight goals, one of which concerns water management. Federal agencies are directed to reduce potable and non-potable water consumption and comply with stormwater management requirements at federal facilities. Specifically, the Implementing Instructions issued by the Council on Environmental Quality in April 2019 recommend that agencies identify and implement measures to replace use of freshwater with **alternative water**, where feasible, and consider life cycle cost-effective measures,[26] consistent with state and local laws, to achieve performance toward the water management goal outlined in Section 2(c) of EO 13834.

The Implementing Instructions of EO 13834 define **alternative water** as water from non-freshwater sources, such as onsite harvested rainwater and stormwater, harvested sump pump/foundation water, gray water, air-cooling condensate, reject water from water purification systems, reclaimed wastewater, or water derived from other water reuse strategies.

Inset 18.Reuse at U.S. Embassies

As a matter of standard practice, the State Department recycles water for irrigation in most new embassies and consulate projects undertaken through the Capital Security Construction Program. Modeled on existing requirements from California and Arizona, new onsite wastewater treatment plants treat effluent for drip or spray irrigation. Example projects include U.S. embassy buildings in Dakar, Senegal; Paramaribo, Suriname; Islamabad, Pakistan; and Tegucigalpa, Honduras. In water-scarce regions, the State Department considers further additional reuse design features. For example, the new embassy campus in Mexico City, currently under construction, will take reclaimed water from the city, treat it to a higher standard, and use it for evaporative cooling and sewage conveyance.

ACTION **2.2.8**

Advance Alternative Water Use in Federal Operations through the Federal Energy Management Program

The Implementing Instructions for Executive Order (EO) 13834, "Efficient Federal Operations" (see Inset 17) describe how the DOE's Federal Energy Management Program (FEMP) will consolidate previously issued guidance and technical materials into an integrated web resource and issue a plan on developing an updated federal water management resource guide that provides direction on how to design and optimize water use at federal facilities, track and report water use, expand use of alternative water, use water balance methodologies, and implement water conservation measures that promote energy efficiency in accordance with 42 U.S.C. § 6834(a)(3). In developing the updated federal water management resource guide, FEMP should consider the objectives in this draft Action Plan and opportunities to expand the use of alternative water sources, including reclaimed water, within federal facilities and operations.

The Hart-Dole-Inouye Federal Center (MI) sends rainwater to a 125,000-gallon cistern, treats and filters the water, and uses it onsite for cooling tower make-up water and irrigation.

ACTION **2.2.9**

Revise Guidance on "Disposal of Unused Medicines" to Better Reflect Source Control Benefits that Support Water Reuse and Recycling

Modify and align existing guidance to discourage any flushing of unused and/or expired medicines to sanitary sewers or septic systems. The guidance would describe alternative means for disposing of medicines (e.g., take-back programs) to provide further source control for difficult-to-treat compounds.

ACTION **2.2.10**

Incorporate Water Reuse Considerations in the Development of Civil Works Projects through the U.S. Army Corps of Engineers Civil Works Program

The Civil Works Program of the U.S. Army Corps of Engineers focuses on responsible development, protection, and restoration of the Nation's water and related land resources. Civil Works projects are developed, implemented, and operated with non-federal sponsors for flood risk management, commercial navigation, ecosystem restoration, recreation, and environmental stewardship. Clarification on how the civil works project development process can directly include water reuse considerations could enable better incorporation of such reuse features in projects authorized by Congress.

ACTION **2.2.11**

Incorporate Stormwater Capture Considerations in Assessment of Stormwater Finance Needs and Opportunities

Through the Environmental Financial Advisory Board's Stormwater Infrastructure Funding Workgroup/Task Force, evaluate costs and funding options regarding stormwater capture as part of overall assessments of stormwater program funding needs and opportunities.

ACTION **2.2.12**

Leverage U.S. Department of Agriculture Programs to Encourage Consideration and Integration of Agricultural Reuse

Key agencies at USDA, such as NRCS and Rural Development, are uniquely positioned to promote the consideration and integration of agricultural reuse through financing and grants, technical assistance, and conservation initiatives. Additional considerations may include:

1. Promotion and further development of environmental exchange partnerships at the local and state levels to facilitate "services exchanges" whereby entities can pay farmers to provide certain services;
2. Development of a pilot project to demonstrate cost-effective management of systems for monitoring, control, and automation of agricultural water reuse systems, including a decision support framework to help farmers integrate information; and
3. Inclusion of agricultural water capture and reuse practices in state nutrient reduction strategies.

ACTION **2.2.13**

Enhance Combined Sewer Overflow/Sanitary Sewer Overflow Abatement Strategies

Provide examples where water reuse strategies can support local efforts to achieve local wet weather management goals, such as combined sewer overflows and sanitary sewer overflows.

The City of Columbia (MO) constructed wetlands in 1994 and 2001 as part of its wastewater treatment process. These deliver treated water into the Eagle Bluffs managed wetlands, providing managed habitat for migratory waterfowl and saving electrical costs.

ACTION
2.2.14

Promote Water Reuse through the Federal Emergency Management Agency's Hazard Mitigation Programs

Promote the consideration and inclusion of water reuse and stormwater capture and reuse through the Federal Emergency Management Agency's Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program projects to reduce long-term risk from natural hazards, as appropriate.

ACTION
2.2.15

Work with Tribes to Support Water Reuse Solutions to Drought Challenges

Partner with the National Tribal Water Council, National and Regional Tribal Operations Committees, and the NDRP to identify strategies to support consideration of water reuse in tribal water supply and drought management planning.

> *"States are at various stages of water reuse development ranging from mature, multi-decade programs to very limited or no program. Additionally, it will be important for EPA to recognize the drivers for reuse and the type of water being reused will vary from state to state based on state and local conditions."*
>
> — Oklahoma Department of Environmental Quality

Constructed wetlands in Orlando, Florida, provide advanced treatment for reclaimed water.

***Wichita's Aquifer Storage & Recovery project* (KS) diverts Little Arkansas River water above a minimum flow threshold, treats it to drinking water standards, and then injects it into the Equus Beds aquifer to meet water demand and ensure drought preparedness.**

2.3 Compile and Refine Fit-for-Purpose Specifications

A compilation of existing fit-for-purpose treatment specifications, and focused effort to develop new specifications, for all potential end uses of reclaimed water would facilitate a better understanding and consideration of potential sources and use applications.

A thorough understanding of the nature and quality of sources of water for potential reuse and end user needs can help inform the decision-making process for a reuse strategy that considers public and environmental health. Inset 19 provides examples of pathogens that may be found in sources of water for potential reuse.

Fit-for-purpose specifications (see Inset 20) describe the level of treatment needed to protect public health, the environment, or other needed end points for a given use application of reclaimed water. While it is not possible to eliminate all risks, treatment technologies are available to generate high-quality water designed for specific use applications that do not pose significant risks.

"Compiling thresholds for fit for purpose can be a resource intensive roadblock for many States. States could benefit from a compilation of evidence-based information so that States can match use and source."

— ACWA and ASDWA

Development of future fit-for-purpose specifications can be informed by human health and ecological risk assessments designed to address specific exposure scenarios and risk management questions. See Inset 21 for example specifications for direct potable reuse. The principles of hazard identification, dose-response, exposure assessment, and risk characterization are used to inform risk evaluations. For example, risk assessments can influence engineering design and treatment facility monitoring to ensure protection of end user health and the environment.

Inset 19. Example Microbial Constituents of Concern Related to Reclaimed Water[27]

Bacteria: Vegetative cells can be inactivated by most common disinfectants (ultraviolet radiation, chlorination, ozonation, or chlorine dioxide); spore-forming bacteria are more resistant to treatment; concerns about regrowth (*Legionella*[28]). Examples: *Salmonella, Campylobacter, E. coli*.

Viruses: Important to reuse applications because of their small size (0.02–0.03 microns) and resistance to disinfection; can cause infection at low doses. Examples: norovirus, adenovirus, enterovirus, hepatitis A.

Protozoa: Oocysts highly resistant to environmental stressors and chlorine disinfection; can cause infection at low doses. Examples: *Cryptosporidium* and *Giardia*.

Inset 20. Fit-for-Purpose Treatment Specifications

Fit-for-purpose treatment specifications describe and quantify the water quality characteristics necessary to meet end use needs, including public health protection.

Inset 21. Example Fit-for-Purpose Specifications for Acute Microbial Risks for Potable Reuse Applications

California's "12/10/10 Rule" for indirect potable reuse: Requires 12 $\log_{10}$ reductions of enteric viruses and 10 $\log_{10}$ reductions of *Cryptosporidium* oocysts and *Giardia* cysts, based on a risk benchmark of 1 infection per 10,000 people per year.[29]

World Health Organization for potable reuse: recommends 9.5 $\log_{10}$ reduction of viruses and 8.5 $\log_{10}$ of enteric bacteria and protozoa, based on a disability-adjusted life year risk approach.[30]

Hampton Roads Sanitation District (VA) performs advanced treatment on wastewater effluent and injects the drinking quality water into the Potomac Aquifer, a primary source of drinking water for eastern Virginia.

Maximizing the utility of risk assessment to inform decision-making requires thorough and accurate information. Certain source waters for potential reuse can contain a variety of chemicals and pathogenic microbes that can result in adverse human, animal, and/or environmental health effects. In addition, contaminants and health risks can result from interactions between reclaimed water and receiving water (e.g., an aquifer). Chemical risk assessments are useful to evaluate known chemicals and contaminants of emerging concern, such as endocrine disruptors, pharmaceuticals, and other contaminants including per- and polyfluoroalkyl substances (PFAS). Microbial risk assessments evaluate pathogen exposure, which may be infectious at low doses, resulting in acute adverse health effects within hours or days of exposure. Microbial risk assessments are important to safely manage water in all scenarios, but are particularly relevant when ingestion of the reclaimed water is possible. Inset 22 describes an effort to assess microbial characteristics of stormwater.

"The academic and professional communities in the United States are embracing a 'One Water' approach that recognizes that water sources that were once thought to be unfit for consumption (e.g., treated wastewater, urban runoff, agricultural runoff) can now potentially be made safe for human consumption with appropriate treatment technologies."

— National Science Foundation's (NSF's) Engineering Research Center for Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)

Inset 22. Minnesota Studies Microbial Quality of Captured Stormwater

The State of Minnesota, EPA Region 5, and the EPA Office of Research and Development are investigating storm-water quality and required treatment for non-potable application in urban areas. The effort will identify and rank appropriate treatment technologies and conduct treatability studies at selected water reuse sites. It will involve data collection and analysis regarding microbial quality of captured stormwater to help identify the appropriate level(s) of treatment for captured stormwater in specific use applications.

Proposed Actions

ACTION 2.3.1 Compile Existing Fit-for-Purpose Specifications

Compile existing fit-for-purpose specifications (e.g., chemical and microbial) for different sources of water for potential reuse and end use applications to inform water reuse best practices and facilitate broader implementation of reuse projects.

ACTION 2.3.2 Develop Frameworks for Public and Environmental Health Risk-Based Targets

Develop a quantitative risk framework to inform public and environmental health risk-based targets for microbial and chemical hazards of concern. The framework would inform water reuse best practices across use applications, aid states in decision-making on treatment technologies (i.e., multi-barrier needs) and permitting, and/or assist in the creation of state-level reuse recommendations for potable and non-potable applications.

ACTION 2.3.3 Convene Experts to Address Challenges Related to Stormwater Capture and Reuse

Convene experts to identify critical institutional, legal, and technical barriers to stormwater capture and use and recommend key actions to address these challenges.

***El Paso Water* (TX) provides nearly 6 MGD of reclaimed water to golf courses, city parks, schools, apartments, construction, and industrial sites, and to recharge the Hueco Bolson. The company is pursuing an advanced water treatment purification facility to treat wastewater for potable use by 2024.**

2.4 Promote Technology Development, Deployment, and Validation

Advances in treatment technologies and corresponding information on technology performance can accelerate water reuse opportunities.

The provision of safe and reliable water reuse systems relies heavily on technologies that are demonstrated to be responsive and resilient to the dynamics of diverse sources of water for potential reuse and needs of various use applications. Reuse technologies fall into four broad categories: (1) collection and distribution, (2) monitoring, (3) treatment, and (4) operation and maintenance. The ability to effectively operate and maintain these systems and keep pace with innovation relies on efficient data management, dependable communications, real-time control, and strategic asset management.

> *"Establishing a national framework for reuse water quality, dictated by the source and end use, would promote reuse technology development and provide a greater economy of scale for manufacturers of equipment and engineered solutions."*
>
> — The U.S. Chamber of Commerce Business Task Force on Water Policy

The water utility sector is a champion for transforming the nation's "Municipal Wastewater Treatment Plants" to "Water Resource Recovery Facilities," where technologies and operators now emphasize recovery of energy, nutrients, water, and other products (see Figure 3).

The collection and sharing of technology performance information can support the deployment of future water reuse systems. Currently, a wide range of academic, private, public, and non-government organizations are leading such efforts, both in the United States and abroad. For example, the Water Research Foundation's Leaders Innovation Forum for Technology (LIFT) Program established a test bed network that aggregates data analysis from many water technology categories.

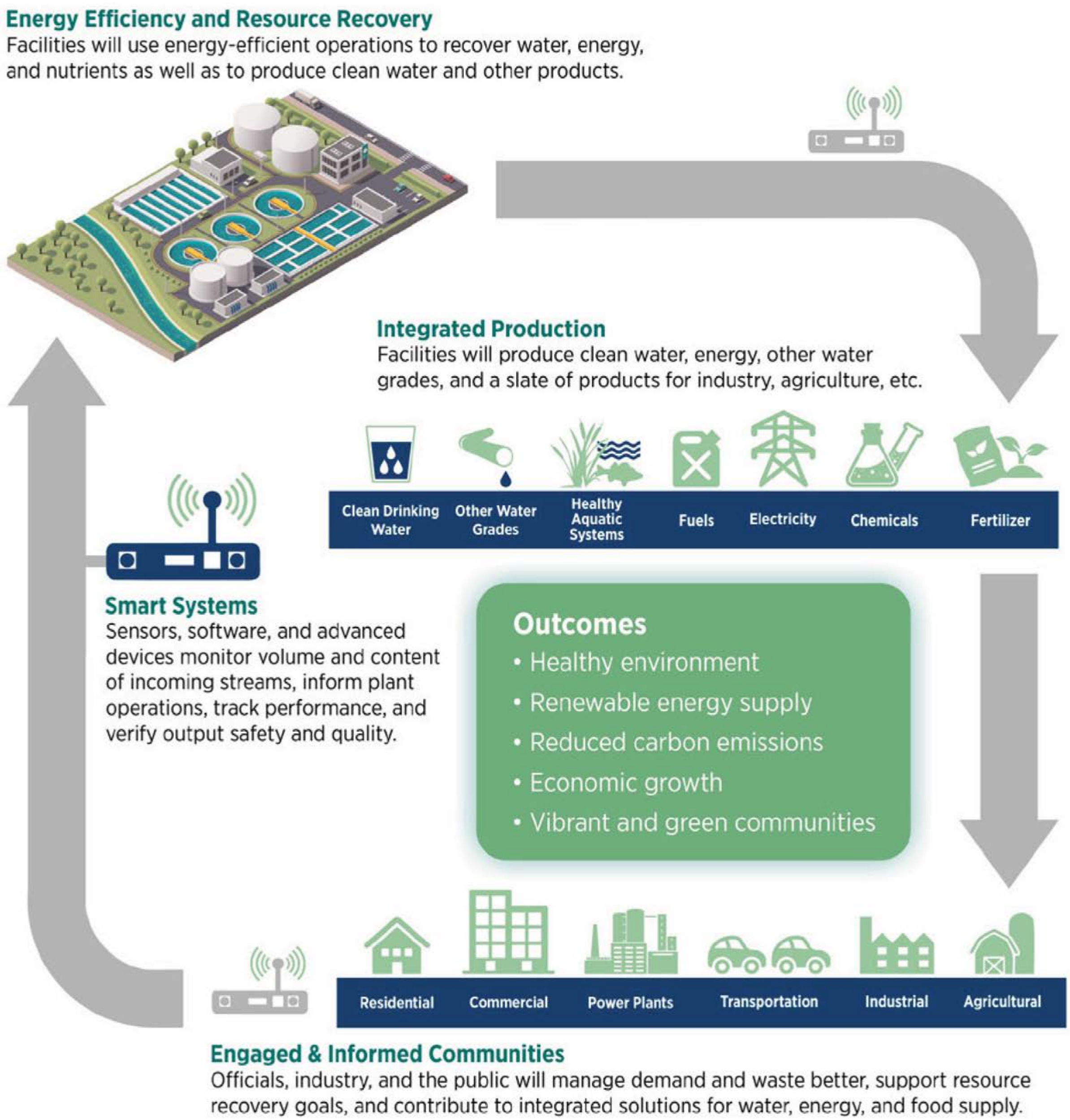
One of the greatest needs for technology development, deployment, and validation is for small and rural communities, building-scale applications, disaster response, and other small and remote systems.

> *"Onsite systems are cost-effective, and scaling investment in these decentralized solutions is an important way for communities to meet their resilience and sustainability goals."*
>
> — WaterNow Alliance

UMass Amherst in Massachusetts offsets its water consumption by using reclaimed water from the Amherst Wastewater Treatment Plant for non-potable applications such as steam and hot water, cooling water, and irrigation.

***Alliant Energy* (IA), in partnership with Clear Lake Sanitary District, uses tertiary treated water that is further disinfected and blended with groundwater for power plant cooling processes.**

Figure 3. Model of water resource recovery facility of the future.



The water resource recovery facility approach to water management involves the incorporation of operational efficiencies with the recovery of valuable resources, including reclaimed water. Operating advanced systems like these relies on deploying technologies that are enabled by performance validation.

Figure 3 Source:

- NSF, U.S. DOE, and U.S. EPA. (2015). Energy-positive water resource recovery workshop report. https://www.energy.gov/sites/prod/files/2016/01/f28/epwrr_workshop_report.pdf

Fort Carson Army Base (CO) conserves up to 300 million gallons of potable water annually through wastewater reuse for irrigation and a closed-loop vehicle wash facility.

Proposed Actions

ACTION 2.4.1 Integrate, Coordinate, and Enhance Technology Demonstration and Validation Programs to Provide Reliable Performance Information to Support Water Reuse

For entities to evaluate the adoption of water reuse, reliable and actionable technology performance and cost data should be generated and shared. This action will build on technology evaluation programs (e.g., LIFT, Isle Utilities, Smart Water Networks Forum [SWAN], Transitions to the Urban Water Systems of Tomorrow [TRUST]) in the water sector to focus and enhance their support of water reuse systems. Through active collaboration and coordination, reuse-oriented information will be collected/generated and delivered to those considering and implementing water reuse systems.

ACTION 2.4.2 Identify and Fill Science and Technology Gaps and Needs Inhibiting Greater Consideration of Off-Field Use of Treated Produced Water

The State of New Mexico, in partnership with the EPA, the DOE, and local universities, will build on existing research efforts to better understand the science and technology gaps and needs associated with consideration of off-field use of treated produced water that protects public health and the environment. This would include assessment of the feasibility and efficiency of existing or future technologies to treat produced water to fit-for-purpose specifications and the availability of reliable analytical methods to test treated produced water for all constituents of concern.

ACTION 2.4.3 Leverage the U.S. Department of Energy's Water Security Grand Challenge

Use the DOE's Water Security Grand Challenge to develop challenges that promote specific technological advancements in support of water reuse, including:

1. A modular reuse challenge focused on the design of a "plug and play" system to be employed in rural communities, during emergency response, or at a building interested in implementing onsite reuse.
2. A multi-phase challenge for the development and testing of sensor technology that promotes the implementation of water reuse, to include prototype testing and complete International Organization for Standardization certification.
3. Innovative brine management (e.g., reclamation) approaches and treatment technologies that do not require a discharge.

ACTION 2.4.4 Provide Case Examples and Identify Candidates for Water Reuse System Implementation in Federally Owned Facilities

Review the portfolio of federally owned facilities to identify candidates for water reuse systems and compile examples where federal facilities have been champions of water reuse. For example, the federal supercomputer facilities may be able to consider using reclaimed water for cooling.

***Allianz Field* (MN) soccer stadium in Saint Paul recycles more than 2 million gallons of rainwater every year for irrigation of trees and grass using a smart hub to clean the water and adjust its levels.**

2.5 Improve Availability of Water Information

Data and information on the quality and quantity of available water can improve opportunities for water reuse.

> *"Sharing information in a sector-specific context can help build awareness of the benefits of reuse and encourage stakeholders not yet engaged in reuse to consider options for implementation."*
>
> — WateReuse Association Convening Report

Enhancing the availability of water data can create opportunities to make more informed water resource management decisions. Water data owners span all levels of government, utilities, industry and agriculture, non-governmental organizations, academia, and citizen scientists. Sharing information on quality and quantity of potential sources of water for reuse and reclaimed water users can highlight the potential for and eventually enable more reuse (see Insets 23, 24, and 25).

Improvements in availability of water information may contribute to:

- Opportunities for water trading to meet regional/watershed user needs.
- A more effective use of water resources and alternate water supplies, including groundwater recharge.
- Public reassurance about "what is in the water."
- Quicker identification of public health threats.
- Improved system reliability to ensure systems perform as designed.
- Near-real-time understanding of water quantity and quality to satisfy fit-for-purpose user needs.
- Improved understanding of downstream impacts (i.e., freshwater stream flow).

Inset 23. Data to Confirm Designer Water Quality from West Basin Water District

The West Basin Municipal Water District's Edward C. Little (ECL) Water Recycling Facility in El Segundo, California, was built in 1995 and is the only water recycling facility in the world that produces five types of "designer" recycled waters tailored for irrigation, commercial and industrial applications, and potable groundwater augmentation. The ECL facility, which recently celebrated 200 billion gallons of recycled water produced, treats approximately 40,000 acre feet of water annually and conducts more than 2,000 tests per month using near-real-time monitoring to deliver accurate data. West Basin's water recycling efforts are the cornerstone of its "Water for Tomorrow" program.

Inset 24. National Water Census

The U.S. Geological Survey's National Water Census is designed to systematically provide information that will allow resource managers to assess the supply, use, and availability of the nation's water. The census's goal is to provide nationally consistent base layers of well-documented data that account for water availability and use nationally.

The West Basin Municipal Water District's (CA) supplies reclaimed water, which is treated using reverse osmosis, for low- and high-pressure boiler feed water for three major refineries.

The quality of water information can be improved through several approaches: (1) strengthening data sharing networks and partnerships at the watershed scale; (2) improving data sharing practices for more user confidence (e.g., by standardizing units of measurements, using industry best practices for constituents and surrogates, and identifying water collection methods); (3) deploying advanced monitoring technologies for near-real-time data (e.g., sensors and remote sensing capabilities); and (4) advancing near-real-time detection methods for microbiological constituents.

In-field water quality monitoring of reclaimed water is conducted at a Florida water reuse facility to ensure fit-for-purpose specifications are being met.

Inset 25. Water Quality Portal

The Water Quality Portal is a cooperative service sponsored by the U.S. Geological Survey, the EPA, and the National Water Quality Monitoring Council. It provides data collected by over 400 state, federal, tribal, and local agencies.

Proposed Actions

ACTION 2.5.1 Foster Watershed-Scale Pilot Projects to Share Water Information to Support Water Reuse Actions

Seek opportunities and support existing case studies and databases that share information about water quality and quantity at the watershed scale, which facilitates and enables consideration of water reuse. Sharing information and experiences can help identify and pilot best practices toward data sharing for water budgets and local, market-based solutions for water trading.

ACTION 2.5.2 Identify Monitoring Best Practices for Various Sources of Water and Reuse Applications

Develop guidance or best practices relating to sampling and monitoring techniques based on the source water type and use application of reclaimed water.

ACTION 2.5.3 Use National Oceanic and Atmospheric Administration/U.S. Geological Survey Water Forecast and Prediction Network to Target Watersheds with Reuse Potential

The National Oceanic and Atmospheric Administration, the U.S. Geological Survey, the National Aeronautics and Space Administration, the U.S. Bureau of Reclamation, and others can integrate and apply real-time water quality and quantity observing and forecasting tools to support local understanding of current and predicted water issues that can directly inform consideration of and opportunities for water reuse as alternative water supplies.

The Long Island Water Reuse Initiative (NY) created an interactive permitting roadmap displaying reuse opportunities for golf courses.

2.6 Facilitate Financial Support for Water Reuse

Improved understanding of water reuse finance options can enable water reuse projects.

Assembling adequate project funding is crucial to the success of water reuse projects, and many reuse proponents have found access to funding to be a significant challenge. Several sources of federal funding are available to supplement state, local, and private investment in water reuse, including Clean Water and Drinking Water State Revolving Funds (SRFs); the Water Infrastructure Finance and Innovation Act (WIFIA); the Bureau of Reclamation's WaterSMART Title XVI Program, WaterSMART Drought Response Program, and Desalination and Water Purification Research Program; and Rural Development (USDA). Inset 26 summarizes one example of combining funding sources for a large-scale reuse project. Improving community access to information about existing federal and non-federal financing programs could enable the consideration of more reuse projects in the future, as the varied landscape for financing infrastructure can be challenging for communities relying on funding and administrative approval from many sources. Wastewater utility managers view expanding funding opportunities, specifically "additional grants, loans or other sources of funding for pilot projects," as having high potential for technology innovation.[31]

> *"EPA should clarify that water reuse projects are eligible expenses for State Revolving Funds (SRF) and which SRF, clean water or drinking water, should fund which pieces of a project"*
>
> — ACWA and ASDWA

In addition, existing and future financing programs could clarify and emphasize water reuse project eligibility. At times, funding mechanisms lack an official policy on, or do not permit, funding for water reuse projects. The lack of consistency in the procurement and eligibility of funding could be daunting to smaller systems exploring water reuse for the first time. In Fiscal Year 2019, WIFIA funding specifically identifies water reuse as a priority area for the $60 million allocated by Congress (see Inset 27). EPA estimates that this new appropriation will provide approximately $6 billion in direct credit assistance, and, when combined with other funding sources, will result in approximately $12 billion in water infrastructure investment.

To help with navigating the funding landscape, clearinghouses like the Water Infrastructure and Resiliency Finance Center seek to aggregate and organize financial information into useful sources for decision makers.

In addition to public funding options, water trading, market-based financing, and public-private partnership approaches can support reuse and capture projects and enable more cost-effective financing solutions. Clarifying how these innovative financing approaches can be applied to water reuse projects will help build capacity to finance reuse and capture projects. An example of state funding to support agriculture enhanced water management practices is shown in Inset 28.

Inset 26. Monterey One Water Financing Approach

By the mid-2010s, Monterey County, California, was facing a water crisis. State-ordered restrictions to local drinking water supplies spurred the public agency for wastewater treatment into action. Monterey One Water developed a coalition of stakeholders to commit to their involvement, develop a collective plan, and secure funding from disparate mechanisms. All told, with agreements in hand, Monterey was able to secure $103 million in SRF funding, plus another $30 million in various federal, state, and local grants. Together, the coalition built a novel wastewater treatment facility that treats to drinking water standards and promotes groundwater replenishment.

Inset 27. WIFIA Funds Focus on Water Reuse in 2019

When the EPA issued its Notice of Funding Availability for the WIFIA program on April 5, 2019, the notice highlighted water reuse as a key priority for project selection:

> "The EPA is highlighting water reuse and recycling as a new or innovative approach. The EPA recognizes that reuse and recycling of water can play a critical role in helping states, tribes, and communities meet their future drinking water needs with a diversified portfolio of water sources."

The Santa Rosa Regional Water Reuse System (CA) pumps tertiary treated wastewater 40 miles uphill to steam fields where it generates electricity for 100,000 households as part of the Geysers Recharge Project.

Inset 28. Kentucky On Farm Water Management

The On Farm Water Management Program is a collaboration between the Kentucky Agricultural Development Board and the Energy and Environment Cabinet's Water Resources Board, which provides 50/50 cost share monies to support agriculture producers to promote innovative water management and improve farm resiliency to drought, including through stormwater capture and reuse.

Proposed Actions

ACTION 2.6.1 Compile Existing Federal Funding Sources for Water Reuse

Identify, compile, and publicize programs that fund the planning, construction, and maintenance of water reuse projects and explore opportunities to better coordinate and highlight funding programs.

ACTION 2.6.2 Promote Eligibility of Existing SRF and WIFIA Funding for Water Reuse

Work with states to promote water reuse projects' eligibility as expenses under SRFs and clarify which SRFs, clean water or drinking water, apply to various elements of a project. The EPA plans to continue to support the use of WIFIA funds for water reuse projects as was explicitly called out in the 2019 WIFIA Notice of Funding Availability (see Inset 27).

ACTION 2.6.3 Compile Resources Concerning Non-Traditional Funding Mechanisms

Identify and compile information about the design and use of non-traditional reuse project funding and financing approaches, including credit trading programs, collaborative funding models, public-private partnerships, pay-for-performance procurement approaches, and innovative local fee-financing options.

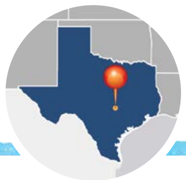
ACTION 2.6.4 Compile and Promote Existing U.S. Department of Agriculture Funding and Resources for Rural Communities

Identify, compile, and promote USDA funding opportunities for water and wastewater infrastructure projects that can advance reuse and conservation, such as the Rural Development's Water and Waste Disposal Loan and Grant Program and NRCS' Conservation Innovation Grant. Provide information and technical assistance to both rural communities and farmers on assessing opportunities for water reuse.

ACTION 2.6.5 Support Development of Tools to Assist Effective Integration of Onsite Water Reuse Systems in Communities

Develop planning approaches, financial models, and decision support tools to assist appropriate implementation of onsite non-potable reuse projects while maintaining viability of centralized community water systems.

The Austin Water Forward Plan (TX) provides community-scale onsite reuse for up to one-third of Austin's water, creating a diversified water portfolio.



2.7 Integrate and Coordinate Research on Water Reuse

Enhanced coordination of past and future water reuse research can optimize its value, better identify critical gaps, and speed delivery to users.

While innovative examples of water reuse are increasing, research can help expand its scope and effectiveness. For example, the range of potential fit-for-purpose reuse options calls for a quantitative assessment of a variety of risks, emphasizing the need for new analytical capabilities, a more comprehensive understanding of technology performance, and a deeper knowledge of potential health effects. Improving the energy efficiency and reliability of treatment systems will increase applications and reduce impacts but may also require fundamental advancements in process engineering.

> *"Federal leadership is sorely needed to help ensure that, as we go forward with utilizing this critically important resource, we make sound, scientifically based decisions that work to prepare our country for the successful utilization of all alternate water sources."*
>
> — Plumbing Industry Leadership Coalition

Relevant research areas cut across scientific disciplines, including technological advancements in membrane technologies and nanomaterials, public health assessments of existing and emerging contaminants, and the sociology of both acceptance and response to reuse. Development and implementation of a coordinated research action plan can help to effectively address the broad range of topics related to water reuse.

There is a need to collate the breadth of existing and rapidly developing research, synthesize this information to prioritize targets for future research, and clearly coordinate the research activities of many federal agencies and multiple nonfederal entities currently conducting or supporting research related to water reuse. Translational research—in which research or user communities stay in early, frequent contact to define research questions, review results, and define next steps—should be emphasized in future actions (see Inset 29 for a successful example of ongoing water reuse research coordination and collaboration).

Inset 29. Partnership in Action: National Blue Ribbon Commission for Onsite Non-Potable Water Reuse Systems

The National Blue Ribbon Commission was originally established as a partnership between the U.S. Water Alliance and the Water Research Foundation, and is now supported by the WateReuse Association. It is composed of representatives from municipalities, public health agencies, water utilities, and national organizations leading the industry in onsite non-potable water systems. To date, the Commission has undertaken the following initiatives:

- Served as a forum for collaboration and knowledge exchange.
- Conducted research that has led to transformational human health risk-based water quality thresholds.
- Crafted guidance and frameworks for nationally consistent state regulations for onsite non-potable water reuse systems.
- Developed resources for water utilities based on best practices and lessons learned in the design, development, integration, and operation of onsite non-potable water reuse systems.
- Identified additional research needs in the field.

This group's efforts are an excellent example of translational research. Close linkage between the users and researchers allowed for definition of a priority knowledge gap (i.e., specific guidance on treatment requirements), completion of needed peer-reviewed science on risk-based treatment, development of a framework for guidance, and passage of state legislation to occur within four years. Similar workgroups could advance key, science-related implementation in other priority areas (e.g., stormwater, produced water).

As part of its Water Independence Now (WIN) initiative, the Water Replenishment District of Southern California operates spreading grounds and coastal injection wells to recharge aquifers and prevent saltwater intrusion. A stormwater capture system also recharges aquifers with rainwater that would otherwise flow into the ocean.

Proposed Actions

ACTION 2.7.1 Develop and Maintain a Comprehensive, Accessible, and Searchable Inventory of Water Reuse Research

Water reuse research is conducted by many entities (e.g., federal, state, academics, utilities, industry). Several entities stated that better integration and synthesis of research findings and results could provide critical access to research and benefit existing and potential water reuse initiatives. These data and research results could be housed in a data clearinghouse, along with case studies, with a robust search function.

ACTION 2.7.2 Develop a Coordinated National Research Strategy on Water Reuse

In order to best leverage water reuse research efforts, a coordinated water reuse research strategy based on research gaps identified in Action 2.7.1 should be developed. The strategy would include a prioritized list of research needs across various water reuse applications and sources of water for potential reuse, including those specified through public input.

ACTION 2.7.3 Coordinate Federal Water Reuse Research to Address Action Plan Priorities

Federal agencies with relevant internal research programs could define specific actions in the near term relating back to the National Water Reuse Action Plan. For example, the agencies could develop grant requests for applications focusing on research needs and gaps identified during development of the National Water Reuse Action Plan. This could leverage existing federal efforts to ensure immediate progress before finalization of a national research strategy on water reuse.

ACTION 2.7.4 Coordinate Research and Compile Best Practices for Enhanced Aquifer Recharge

Aquifer recharge seems to be a growing practice, yet (as Inset 16 indicates) there are apparent differences in how it is described and implemented. Senate Report 114-281 and House of Representatives Report 115-765 identify partnerships among federal agencies, institutes, foundations, and universities that could leverage scientific expertise in the field of enhanced aquifer recharge to establish a best practices approach.

Idaho's private Hidden Springs sewage treatment facility provides treated wastewater for irrigation on public land and small-scale crops.

The Murfreesboro Water Resources Department (TN) provides drinking-water-quality reclaimed water to the West Fork Stones River, supporting downstream users, aquatic life, and agricultural irrigation.

2.8 Improve Outreach and Communication on Water Reuse

A critical aspect of implementing a successful water reuse program across applications is public acceptance and user confidence.

Successful international and U.S. water reuse programs included effective outreach with early public engagement and education, namely to clarify how treatment processes and regulatory requirements (e.g., monitoring, performance standards) provide safe water. Broad and transparent engagement with stakeholders (including academia, non-governmental organizations, public health specialists, industry, and the public) and leveraging various media and community engagement efforts were key to their success. Inset 30 describes how utilities and others are using the novel approach of brewing beer from reclaimed water as a community engagement technique.

> *"More messaging on a national level of the benefits and successes [of water reuse] in tandem with discussion of the public health and environmental protection safeguards and benefits is necessary."*
>
> — NACWA

In the United States, water reuse practitioners have articulated the need for a new and specific level of engagement with users and the public.

While different uses of reclaimed water will likely require a tailored outreach and communications approach, common public (domestic and international) concerns related to water reuse, specifically potable reuse, reoccur across four main themes:[32]

- **Water quality and safety.** Outreach to address public health concerns and ensuring the water is clean and safe for its intended use is key.
- **Education.** Potable water reuse is a new concept in many communities. Early stakeholder engagement and public understanding and support are cited as factors in the success of Singapore's NEWater program. (NEWater is the treated wastewater that makes up about 30 percent of Singapore's water needs.) El Paso, Texas, educates the public, including school children, using several effective strategies (see Inset 31).
- **Emotional response.** This is best characterized as the visceral aversion to drinking highly treated reused water, based on emotional reactions rather than on facts. A message that has been used to counter this aversion: "Judge water by its quality, not by its history."[33]
- **Trust.** Trust in water authorities shapes public opinion on water reuse, including the perception of water safety and treatment system reliability. The City of Ventura, CA understood the need for public outreach to ensure the success of

Inset 30. Homebrew Made with High-Quality Reclaimed Water

As a novel approach to raising awareness about water reuse, a group of utilities, brewers, engineering firms, and technology companies involved in brewing beer from high-quality reclaimed water formed the Pure Water Brewing Alliance. Their beer, Pure Water Brew, is produced in nine states nationwide with reclaimed water.

Clean Water Services (Hillsboro, Oregon) is one of the founding members of the alliance; it has one of the largest water reuse programs in Oregon. They launched Pure Water Brew to deliver high-quality reclaimed water to Oregon homebrewers, along with a competition to showcase the homebrews.

Inset 31. El Paso Water Public Outreach[34]

A clear communication strategy is key to the success of reuse projects, especially when the application is direct potable reuse. For example, the award-winning El Paso Water communication strategy around advanced water purification has included a speakers' bureau, third-party expert endorsements, proactive media relations, health community outreach, and tours of a pilot facility. The utility's TecH2O Learning Center hosts thousands of student and public visitors every year for events and tours. Visitors gain an appreciation for water in the desert, the need for reuse, and the treatment processes that makes purified water safe to drink. For El Paso Water, public outreach is essential to building customer trust and acceptance of advanced purified water as a drought-proof, reliable water supply.

The green roof at the U.S. Coast Guard Headquarters (DC) intercepts, stores, and treats stormwater—up to and including water from a 95th percentile storm—and uses it for onsite irrigation and water features.

its VenturaWaterPure demonstration project. The city maintained transparency through frequent and clear communications to stakeholders throughout the project by publishing information on the reuse process, monitoring protocols, and water quality results.[32] Inset 32 describes a framework to increase public support in water management programs through a transparent decision-making process.

"The [Action] Plan is an opportunity to expand education efforts by USEPA and others that reuse water is not characterized as dangerous to human health, but part of an overall strategy to ensure adequate supplies of usable water will continue to be available to everyone in the future."

— Tyson Foods

Inset 32. Framework to Increase Public Support Through Multi-Benefits

In April 2019, the Pacific Institute published *Moving Toward a Multi-Benefit Approach for Water Management*. The report provides a holistic decision-making framework for addressing water challenges. The multi-benefit approach maximizes resources, increases public support, and builds project coalitions by identifying and incorporating costs and benefits of water sustainability alternatives.

Proposed Actions

ACTION 2.8.1 Compile and Develop Water Reuse Program Outreach and Communication Materials

Compile examples of outreach and communication strategies and techniques that have been implemented for successful reuse projects, and develop new materials based on the needs articulated by stakeholders. The materials could address programmatic themes with the overarching goal to educate key audiences, such as the public, decision makers, and key message carriers (e.g., public health professionals). A potential aspect of the framework could be an outreach and communications kit (with contents such as talking points; press materials; public safety announcements; and other utility, state, and tribal enforcement and compliance assistance materials) crafted and tailored for different audiences.

ACTION 2.8.2 Develop a Community of Practice Around Water Reuse

A community of practice can serve as a "network of practitioners with a shared passion who learn how to do something or how to do something better through repeated interactions."[35] A water reuse community of practice would create a peer network of water reuse stakeholders and professionals both face-to-face and virtually. The repeated convenings could bring together examples of lessons learned, implementation challenges, regulatory strategies, recognition and partnership programs, communication approaches, and outcomes to catalyze water reuse projects. Virtually, the community could be a central database of tools or a listserv intended to facilitate open questions, discussions, and requests. This group, or topic-specific subgroups, could be led by sector experts focused on water reuse advancement, technology, and deployment building on existing resources and forums.

ACTION 2.8.3 Pursue a National Branding Campaign for Water Reuse

Initiate a collaborative campaign to assess the public's understanding and acceptance of water reuse. This campaign could be available nationally, while recognizing regional variation in reuse based on local understanding of needs.

Southern Nevada Water Authority reclamation facilities treat water for non-potable use as well as input to Lake Mead and the Las Vegas Wash to supplement drinking water supplies.

2.9 Support a Talented and Dynamic Workforce

Water reuse is driving a new generation of treatment technologies, monitoring, and operations and maintenance needs that, in general, exceeds existing workforce capabilities.

Water sector professionals are vital to protecting public health and the environment through strategic planning, operation and maintenance of treatment technologies, and implementation of water management programs for various use applications. Many professionals undergo significant training and complete certification programs to ensure they can properly operate their respective systems.

In a recent survey of water utility operators and water regulators across the country about innovative water technologies, only 54 percent of respondents indicated they had experience with implementing non-potable reuse, while 73 percent indicated they had no experience with potable reuse.[36]

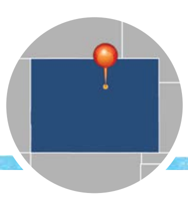
Since many water reuse practices (e.g., potable and non-potable) apply technologies or management approaches that are not widely used, there is a growing need to fill knowledge gaps and ensure the workforce is fully capable of designing, reviewing, and operating complex reuse systems. Meanwhile, thousands of water treatment operators are expected to retire from their positions in coming years.[37] Pursuing new efforts and making targeted investments to build and train an emerging, more diverse generation of water sector professionals will help fill the projected gaps in an aging workforce and create a community of practice around strategies for water reuse.

> *"With increasingly complex systems, particularly in the case of direct potable reuse, there are skills, knowledge and abilities that go beyond traditional operator certification requirements. ACWA and ASDWA recognize and respect the States' autonomy in implementing their operator certification programs, however water reuse represents a unique opportunity for EPA to partner with states to identify key knowledge and skills needed by water system operators who are presiding over these water reuse projects."*
>
> — ACWA and ASDWA

Inset 33. A Partnership for Water-Reuse-Related Operator Certification in California and Nevada

To help fill the void between existing drinking water and wastewater operator certifications, the California Water Environment Association and the California-Nevada Section of AWWA have partnered to develop a voluntary Advanced Water Treatment Operator (AWTO) certification program.

> "The AWTO certification program dovetails with the water sector's move toward the 'One Water' concept, which stresses that all water—wastewater, stormwater and drinking water—has value and should be managed as a resource."[38]



Since 2004, the Xcel Cherokee Station, one of Colorado's largest power plants, combines raw water with reclaimed municipal wastewater for cooling towers, ash silo washdown, and fire protection.

Proposed Actions

ACTION 2.9.1 Support State(s) Development of a Pilot Operator Certification Program for Water Reuse Applications

Foster development and propagation of an operator certification program for water reuse applications, which bridges and complements existing water and wastewater certification programs. The program could address planned potable reuse technologies and be focused on the intersection of wastewater and drinking water programs. It could also include training for designers, operators, and permitting authorities undertaking new reuse projects, such as onsite non-potable water systems. Inset 33 describes an example collaborative effort.

ACTION 2.9.2 Support Opportunities to Promote a Skilled Workforce of Practitioners Across Various Water Reuse Sectors

Promote a skilled workforce through workforce development efforts, including training and transition mechanisms to address an aging workforce and creating opportunities for knowledge transfer and peer-to-peer engagement related to water reuse across various use applications. Encourage and support development and dissemination of training opportunities and materials for operators, technical assistance providers, and regulators related to water reuse. As part of this action, existing training resources and delivery mechanisms (e.g., webinars, workshops, newsletters) could be leveraged to reach a broader audience.

ACTION 2.9.3 Support Water Reuse Training Networks

Seek opportunities to integrate water reuse considerations into the existing networks of national, regional, and state and tribal training forums.

Shakopee Mdewakanton Sioux Community in Minnesota operates a water reclamation facility, using reclaimed water for irrigation and discharge to wetlands for wildlife habitat.

***Frito-Lay in Arizona** recycles up to 75 percent of its process water, reducing its water use by 100 million gallons annually.*

2.10 Develop Water Reuse Metrics That Support Goals and Measure Progress

Setting goals and accountability for implementation of the actions in the Action Plan can help ensure progress and results.

Metrics and benchmarks for overall water usage and reuse are important tools to assess conditions, set targets, and measure progress. Such water metrics are routinely used by international partners who, by many measures, are among the global leaders in water reuse.

Israel and Singapore have achieved notable rates of water reuse. Israel recycles approximately 87 percent of its wastewater, while Singapore relies on recycled water to meet 30 percent of its water needs. These targets were met in part because of longstanding commitments to and needs for diverse water portfolios (see Appendix G).[39, 40]

Overall water usage and reuse metrics are essential components to water system planning, providing managers with feedback to help determine the progress of programmatic goals. Without specified performance goals and metrics, it becomes difficult to evaluate the efficacy of a program or technology objectively.

Generating metrics for water reuse in the United States could begin with improving current baseline estimates for both general water usage and reuse. Currently, national estimates on water information and availability across all water uses are lacking. Exceptions include the Water Environment Federation's methodology and estimates for resource recovery from municipal wastewater, which identified an estimated 33 BGD total volume of treated municipal wastewater. Of that volume, approximately 7 percent is currently reused.[12] In addition, the GWPC produced water report indicates the oil and gas sector reuses 45 percent within oil and gas operations. Water reuse metrics would also help inform the water-reuse-related goals in the DOE's Water Security Grand Challenge.[41]

Bilingual signage about the use of reclaimed water for landscaping is protective of the entire community at one Florida hotel complex.

> *"According to the 2017 Reuse Inventory Report, Florida reused approximately 813 [million gallons per day] MGD of reclaimed water, which was estimated to have offset the use of 442 MGD (over 161 billion gallons per year) of potable quality water while serving to add 252 MGD (approximately 92 billion gallons per year) back to available water supplies."*
>
> — Florida Department of Environmental Protection

The Ephrata WRF (WA) treats municipal wastewater to produce water for groundwater recharge, irrigation, holding in a seasonal fish pond, and equipment cleaning.

Proposed Actions

ACTION 2.10.1

Compile National Estimates of Available Water and Water Needs

Develop one or more approaches or methodologies to explore and clarify the national volumes of current water use and water potentially available for reuse (such as existing ocean discharges). This protocol would also estimate or update the current baseline of water reused from key sources, including:

- Municipal wastewater
- Agricultural drainage[42]
- Industry process and cooling water
- Oil and gas produced water
- Stormwater

ACTION 2.10.2

Establish Goals for Extent and Types of Water Reuse in the United States

Create reuse targets (e.g., percentage goals) for reuse applications (e.g., potable and onsite non-potable) and associated supplies (e.g., rainwater, graywater, ocean discharges), in accordance with state and local laws. These objectives can be rolled up into broader, aggregated goals for reuse among communities nationwide.

ACTION 2.10.3

Ensure Implementation of the National Water Reuse Action Plan

Develop and maintain an online implementation plan that is updated and available that describes the progress to implement each of the actions in the final National Water Reuse Action Plan.

Monterey One Water in California delivers reclaimed water for irrigation of 12,000 acres of edible food crops.

UNC-Chapel Hill (NC) partnered with Orange Water and Sewer Authority to use treated wastewater effluent, in parallel with rainwater captured by cisterns, for irrigation and cooling water.

SECTION 3

NEXT STEPS

This draft National Water Reuse Action Plan is the beginning of a new collaborative effort among federal, state, and tribal partners and across the entire water sector to identify the critical science, technical, policy, communications, and other opportunities and incentives to enhance consideration of water reuse. We hope and expect the draft Action Plan will stimulate continued conversation and the articulation of the ultimate actions to be pursued by the spectrum of water interests.

3.1 Formal Public Comment and Feedback

Following release of the draft Action Plan, a Federal Register Notice will open a formal comment period. An accompanying docket in regulations.gov will open for the submission of comments. During the comment period, any interested stakeholders are encouraged to provide specific feedback on a variety of topics such as:

- The proposed actions identified and other suggested actions that can enhance implementation of water reuse.
- The key attributes, implementation steps, and milestones to successfully implement the proposed actions.
- Potential action leaders to champion the proposed actions.
- Potential contributing organizations to serve as partners/collaborators in implementing the proposed actions.
- Additional information or recommendations to inform these or other proposed actions.

Comments received on the draft Action Plan will be received on the docket website (www.regulations.gov). Due to the action-oriented nature of this plan and the need for commitments to help ensure its execution, ongoing outreach and engagement will continue during the comment period and during finalization of the Action Plan.

The Sterling Creek Water Reclamation Facility (GA) provides 3 MGD of treated effluent to the Elbow Swamp, sustaining a constructed wetland system and providing water for irrigation.

3.2 Facilitating Implementation of the Actions

During the comment period, we will also consider ways to build a framework to help facilitate the implementation of actions in the National Water Reuse Action Plan and provide routine status updates to interested stakeholders.

3.3 Building an Enduring Legacy of Watershed-Based Action

Our hope is to enhance and stimulate watershed-based collaborations where business, finance and policy leaders, communities, nonprofits, and others come together to solve local water resource (quantity and quality) challenges. Water reuse applications provide an opportunity for this level of collaboration and offer the potential to improve water resilience, security, and sustainability.

Thank you for contributing to the security, resilience, and sustainability of our most precious resource...water.

The Heart of the Valley Metropolitan Sewerage District treatment plant (WI) discharges approximately 1.7 MGD treated effluent to a nearby power generating facility for use as cooling water.

SECTION 4

NOTES AND REFERENCES

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[42] 7 U.S.C. §8791 establishes parameters for releasing certain producer information obtained by the U.S. Department of Agriculture to cooperators helping implement its programs.

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The Holmes Harbor Sewer District (WA) facility discharges reclaimed water for golf course irrigation in dry months and stores it in lagoons during wet months.