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# ADVANCES in WATER RESEARCH

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# PFAS

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Utility Management

T&O Case Study

Research Strategy

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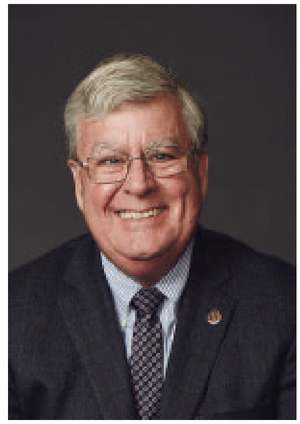
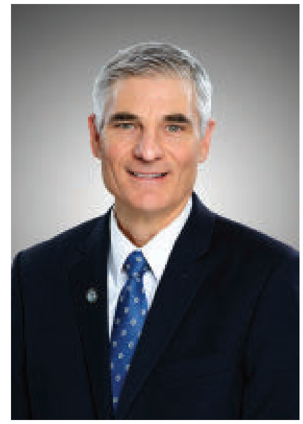
# Communication

**When interacting with customers, the media, project** partners, staff, or other key stakeholders, water utilities understand better than anyone how important it is to communicate effectively and use messaging that resonates with their audience. This is especially important when communicating about potential health concerns, rates, and the many other topics of significant interest to their customers.



Michael Markus



Peter Grevatt

The information water utilities need to convey to their stakeholders is often quite complicated. Rising customer expectations and a rapidly changing and often confusing media environment add to this complexity. On some occasions, customers may receive information about their water services from the media or from other sources far beyond the utility. This can result in a confusing mix of information and can also reduce public trust. Water utilities can no longer work quietly behind the scenes. Instead, they must always strive to be collaborative, transparent partners—constantly working to build positive relationships and convey clear, straightforward messages.

The water sector must be proactive with its communications: staying carefully tuned in to customers' needs, anticipating what questions customers will have, and planning how to respond while keeping customer perceptions of this response in mind. There are both a science and an art to communication, which begin and end with an appreciation of the interests and needs of the audience. Understanding and applying this knowledge can help utilities communicate even more effectively with, and maintain the trust of, their stakeholders. Understanding and addressing stakeholder needs and concerns—and ensuring open, frequent, and timely communication—are critical for the continued success of every water utility.

Research findings from The Water Research Foundation (WRF) can help utilities provide the necessary context and content to successfully navigate their communications with customers on a host of complex topics. From communicating about new projects and rate changes to communicating about health risks and infrastructure failures, WRF has you covered. For example, previous WRF projects address challenges and opportunities related to social media, effective strategies for public communication about emerging contaminants, and more. One of our latest projects, *PFAS One Water Risk Communication Messaging for Water Sector Professionals* (5124), is highlighted in this issue of *Advances in Water Research*. The article provides an overview of this important per- and polyfluoroalkyl substances (PFAS) communication project, which focused on the development of materials that the water sector can use to communicate about PFAS effectively and proactively.

Water utilities are on the front lines of a broad range of challenges and opportunities on a daily basis, and communication is no exception. WRF research provides guidance and best practices that you can deploy as you craft evidence-based messages that resonate with your key audiences.

Michael R. Markus, PE
Chair, Board of Directors

Peter Grevatt, PhD
Chief Executive Officer

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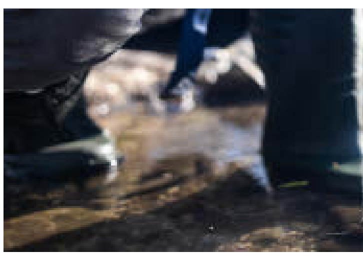
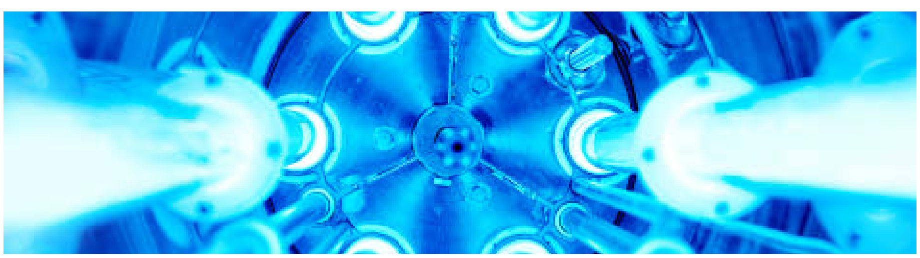
The Water Research Foundation (WRF) is the leading research organization advancing the science of all water to meet the evolving needs of its subscribers and the water sector. WRF is a nonprofit, educational organization that funds, manages, and publishes research on the technology, operation, and management of drinking water, wastewater, reuse, and stormwater systems—all in pursuit of ensuring water quality and improving water services to the public.











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# BY THE NUMBERS

**This installment of By the Numbers provides statistics on per- and polyfluoroalkyl substances (PFAS). For more information on PFAS, see the article, PFAS Communication Guidance.**

**PFAS are certain anthropogenic chemicals with fluorinated carbon chains. PFAS have both past and current uses in industrial processes and consumer products.**

## 1940s

PFAS use in industrial and consumer products begins (EPA 2022)

## 4,730

PFAS identified by the Organisation for Economic Co-operation and Development (OECD 2018).

### Examples of Potential PFAS Sources

| Source | Examples |
|---|---|
| Fire extinguishing foam | Aqueous film-forming foams used to extinguish flammable liquid-based fires; often used at airports, shipyards, military bases, firefighting training facilities, chemical plants, and refineries |
| Household products and dust | Stain- and water-repellent used on carpets, upholstery, clothing, and other fabrics; cleaning products; non-stick cookware; paints, varnishes, and sealants |
| Food packaging | Grease-resistant paper, fast food containers, microwave popcorn bags, pizza boxes, candy wrappers |
| Manufacturing or chemical production facilities that produce or use PFAS | Chrome plating, electronics, and certain textile and paper manufacturers |
| Personal care products | Certain shampoos, dental flosses, and cosmetics |
| Food | Fish caught from water contaminated by PFAS, dairy products from livestock exposed to PFAS |
| Soil and water at or near waste sites | Landfills, disposal sites, and hazardous waste sites |
| Biosolids | Some biosolids from water resource recovery facilities may contain PFAS* |

* Ongoing WRF research projects seek to understand the occurrence and fate of PFAS in water resource recovery facilities and biosolids.

Source: Data from EPA 2022

## >15

WRF projects on PFAS formation, occurrence, analytical methods, treatment, and more. Such as:

- Application of Novel Method to Estimate Total PFAS Content in Water (5102)
- Assessing Per- and Polyfluoroalkyl Substance Release from Finished Biosolids (5042)
- Investigation of Treatment Alternatives for Short-Chain PFAS (4913)

While studies show that conventional treatment at water resource recovery facilities and most drinking water treatment plants is ineffective at removing PFAS from water, there are treatment processes that can remove many PFAS (Dickenson and Higgins 2016).

## PFAS removal by treatment process

| Compound | AER | COAG/DAF | COAG/FLOC/ SED/G- or M-Fil | AIX | GAC | NF | RO | $MnO_4$, $O_3$ $ClO_2$, $Cl_2$, CLM, UV, UV-AOP |
|---|---|---|---|---|---|---|---|---|
| Perfluorobutanoic acid (PFBA) | assumed (Removal <10%) | assumed (Removal <10%) | Removal <10% | Removal <10% | Removal <10% | Removal >90% | Removal >90% | Removal <10% |
| Perfluoropentanoic acid (PFPeA) | Removal <10% | Removal <10% | Removal <10% | Removal <10% | Removal 10–90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorohexanoic acid (PFHxA) | Removal <10% | Removal <10% | Removal <10% | Removal <10% | Removal 10–90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluoroheptanoic acid (PFHpA) | Removal <10% | Removal <10% | Removal <10% | Removal 10–90% | Removal >90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorooctanoic acid (PFOA) | Removal <10% | Removal <10% | Removal <10% | Removal 10–90% | Removal >90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorononanoic acid (PFNA) | Removal <10% | unknown | Removal <10% | assumed (Removal >90%) | assumed (Removal >90%) | Removal >90% | Removal >90% | Removal <10% |
| Perfluorodecanoic acid (PFDA) | Removal <10% | unknown | Removal <10% | assumed (Removal >90%) | assumed (Removal >90%) | Removal >90% | Removal >90% | Removal <10% |
| Perfluorobutane sulfonate (PFBS) | Removal <10% | Removal <10% | Removal <10% | Removal 10–90% | Removal >90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorohexane sulfonate (PFHxS) | Removal <10% | Removal <10% | Removal <10% | Removal >90% | Removal >90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorooctane sulfonate (PFOS) | Removal <10% | Removal 10–90% | Removal <10% | Removal >90% | Removal >90% | Removal >90% | Removal >90% | Removal <10% |
| Perfluorooctane sulfonamide (FOSA) | unknown | unknown | Removal <10% | unknown | assumed (Removal >90%) | unknown | assumed (Removal >90%) | unknown |
| N-methyl perfluorooctane sulfonamidoacetic acid (N-MeFOSAA) | assumed (Removal <10%) | unknown | Removal <10% | assumed (Removal >90%) | assumed (Removal >90%) | assumed (Removal >90%) | Removal >90% | unknown |
| N-ethyl perfluorooctane sulfonamidoacetic acid (N-EtFOSAA) | Removal <10% | unknown | Removal <10% | assumed (Removal >90%) | assumed (Removal >90%) | assumed (Removal >90%) | Removal >90% | unknown[a] |

**Legend:** Removal <10% | Removal 10–90% | Removal >90%

a: <10% removal by $Cl_2$ and $KMnO_4$

"assumed": treatment performance is assumed based on the perfluoroalkyl acid size/charge and/or known removal data of shorter or longer chain homologues

AER : Aeration; AIX: Anion Exchange; CLM: Chloramination; $Cl_2$: Hypocholorous/Hypocholorite; $ClO_2$: Chlorine Dioxide; COAG: Coagulation; DAF: Dissolved Air Flotation; $O_3$: Ozone; FLOC: Flocculation; GAC: Granular Activated Carbon Filtration; G-FIL: Granular Filtration; M-FIL: Microfiltration; $MnO_4$: Permanganate; NF: Nanofiltration; RO: Reverse Osmosis; SED: Sedimentation; UV: UV Photolysis; UV-AOP: UV Photolysis with Advanced Oxidation (Hydrogen Peroxide)

Source: Adapted from Dickenson and Higgins 2016.

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# Interview with Chris Chow and Bryon Wood

## Innovative Technologies

In order to promote innovation, The Water Research Foundation (WRF) developed WRF TechLink, an online platform that facilitates collaboration among water sector stakeholders to accelerate technology commercialization and uptake. Entities with innovative technologies that could benefit the sector are welcome to submit them to WRF TechLink. Once submitted, technologies undergo Technology Scans, reviews conducted by WRF's Volunteer Expert Pool (VEP). VEP reviewers evaluate the value, innovation, technical viability, and state-of-technology related to a technology to determine its suitability for WRF TechLink. WRF spoke with Chris Chow, Professor of Water Science and Engineering at the University of South Australia (UniSA), and Bryon Wood, IT Manager — Enterprise Asset Management Systems at Great Lakes Water Authority (GLWA), to learn more about their expertise and participation on the VEP.

Chris Chow

Bryon Wood

**What is your professional background?** Chow: My PhD research project at UniSA was supported by SA Water, a local utility providing water and wastewater services to South Australia. After I completed my PhD in 1995, I joined SA Water as a research scientist. I was involved in water quality and treatment research projects, where we also considered the pathway of implementation. In 2013, I was promoted to the Manager of Sensors, Technology and Assets Research where I managed a technology assessment scheme similar to the WRF Technology Scan. After I joined UniSA in 2017, I maintained a connection with the water industry, working on industrial research projects. I am currently the director of a research concentration called Sustainable Infrastructure and Resource Management. In this role, I am facilitating the connection of our research team with the water industry and have expanded from my own personal research focus to cover other areas.

Wood: My career began as a professional engineer at a civil engineering consultant firm, with a focus on planning, design, construction, and asset management of water, wastewater, and stormwater infrastructure. As I progressed in my career, I grew to enjoy utility management services, including master planning, asset management, and technology initiatives, partnering with dozens of utilities across the United States and beyond. After 15 years in the water sector as a consultant, I transitioned to leveraging technology to support people and processes, including geographic information systems (GIS), enterprise asset management (EAM) systems, and business intelligence for one of the largest utilities in the world. In my role as IT Manager — Enterprise Asset Management Systems for GLWA, I lead a skilled and engaged team of data and system analysts in managing over three dozen applications and numerous dashboards supporting operations, maintenance, engineering, finance, and laboratory teams across the utility.

**What is your role on the VEP?** Chow: I started volunteering with WRF in 2015 when I was working for SA Water. I began as an Advisory Committee member for the Intelligent Water Systems research area. I also served as a Project Advisory Committee member for the WRF project *Designing Sensor Networks and Locations on an Urban Sewershed Scale with Big Data Management and Analytics* (4797). At that time, I was managing a technology assessment scheme at SA Water and coordinating with their operations team to see what latest technologies could support their tasks. After joining UniSA, I maintained my volunteerism with WRF and have been serving as a VEP reviewer since 2016.

Wood: I have been involved in the WRF VEP for more than two years. This role considers emerging technologies submitted to WRF and their readiness for use by utilities, like GLWA, in either research or commercial applications. Participation in the VEP for WRF TechLink is only a couple of hours per review and one hour in peer discussion in a web-based meeting, so it is an efficient and valuable use of time for all involved.

**Why did you get involved in the VEP?** Chow: I like to stay up-to-date on the latest technologies and share my research experience. I am involved in industry research projects and I also have water sector experience, particularly with the implementation of research for industry use.

Wood: VEP involvement provides an overview of the types and range of technologies that will become available in the near future. Part of my role as an IT manager involves keeping an eye out for cutting-edge technologies that can meet our diverse challenges and opportunities as a utility. Serving as a VEP reviewer, I gain exposure to innovative technologies and processes that spur ideas for potential solutions for co-workers here at GLWA.

**You've reviewed primarily asset management and sensor technologies. Why are you interested in those specific technology types?** Chow: As the Internet of Things (IoT) and sensors are being used more frequently in the water sector, sensor application has become my primary interest. I picked asset management as well because, in Australia, we have about 100 years of water history and it is time to think about asset replacement. Combining the use of sensors and their signals to inform decisions is beneficial.

Wood: Before joining the IT group at GLWA over three years ago, I was in the EAM group focusing on building our linear system integrity program, including condition assessment methods, sensor technologies, and asset management approaches. Many of the technologies I've reviewed as part of the VEP are related to that area of interest. VEP participation also allows me to continue learning and providing advice to my colleagues. Since I've been in IT, I've started considering other technologies within WRF TechLink that support utility management, data management, water quality, and digital twin initiatives.

**How have you benefitted from your participation in the VEP?** Chow: I am currently conducting research in these areas, particularly focused on implementing research outcomes for industry applications. I haven't yet applied my VEP experience to my work; however, it fits my personal interests and I enjoy contributing to the water sector.

Wood: One of my passions in the water sector is continuing to grow both personally and professionally through continuous learning and application of beneficial technology. The innovation and value proposition aspects related to technology application are exciting to me; however, it must be the right fit for our organization and needs. At GLWA, my IT team and I are problem solvers, applying new or improved technologies where it makes sense. In addition, I've learned a lot from the reviewers from peer utilities, consultants, and research organizations. The expertise they illustrate during the technical review sessions has helped increase my knowledge and understanding for applying similar technologies here at GLWA. I have also developed valuable relationships with other utilities undergoing similar challenges.

**What future technology needs do you see for the water sector?** Chow: I believe both water quality and treatment processes are well managed by the water sector. The latest in water quality monitoring and process control via IoT allows real-time data to be sent back to the server for analysis and overall improvement of the process, prompting better technologies in data analytics and management. We now need to improve overall efficiency by extracting energy from the process and using waste materials—more research and development are needed in these areas. In addition, asset management is becoming a more important topic. Most utilities have good asset management plans and knowledge of how to manage assets with the increasing use of monitoring devices for condition assessment. However, this leads to a need to take the next step of utilising the data in a better way to get a good estimation of the remaining life of an asset; providing more accurate estimations would better inform decisions.

Wood: Making use of all the data we're collecting. We have a lot of data, but we don't always know which data are good or bad (e.g., if a sensor fails). We need something to help us sort, organize, and find anomalies in our data. The digital twin concept, which involves using computer models to mimic system operations so you can test different scenarios, is evolving. This technology will provide additional efficiencies and decision support to relieve ongoing workforce and financial constraints while continuing to deliver high-quality water at affordable rates.

# Utility Analysis and Improvement Methodology

# Managing a water utility is complex, and having a well-defined, structured, and value-based methodology to guide management efforts is imperative to utility success.

By Z. Cello Vitasovic, 9D Analytics; Michael Barnett, HMX.ai; and Scott Haskins, Haskins Strategies LLC

**The Water Research Foundation** (WRF) project 4806, *Utility Analysis and Improvement Methodology* (UAIM; Vitasovic et al. 2022), provides water sector utilities with an improvement methodology they can use to address their unique needs. UAIM efforts have provided participating utilities with practical and actionable steps that add value by executing well-defined business processes while using appropriate technology and leading and managing the workforce to make a positive impact on their customers, the community, employees, and the environment. Additionally, the project applies a systems thinking approach to management of water sector utilities.

The mission of UAIM is to address the issues, challenges, and opportunities that are specific to water sector utilities. Although some of the concepts included in the project are generic and might be applicable to other industries, UAIM is focused primarily on the specific conditions, challenges, and solutions that are common and unique to utilities in the water sector.

A key aspect of UAIM is the application of systems thinking to the analysis of complex issues. Specifically, UAIM considers management of water sector utilities to be a complex system because of the many interactions that occur between different elements that impact the generation of value (e.g., processes, governance, organizational culture, and technology). The analytical approach introduced by UAIM includes the development of different types of system models that help us understand and explain how each component works (e.g., business process models are used to analyze and improve processes).

A conceptual framework to describe how value is created in a water sector utility was originally proposed by Vitasovic et al. (2015). This model was the foundation for the UAIM framework, which combined two familiar concepts:

- People are enabled by processes and technology to drive business improvement.
- Strategic, tactical, and operational levels of utility management are based on the time horizon for business processes and on decisions ranging from real-time at the operational level to months or years at the strategic level.

By combining these concepts, the UAIM framework introduced a holistic view of value creation within an organization, as shown in Figure 1.

The framework provides a conceptual road map and system models that help us understand "how a utility works." This knowledge is useful; however, to leverage that knowledge and achieve tangible improvements in utility management, we need a methodology that also builds on that knowledge. We need an improvement methodology (the "IM" in UAIM) that will achieve our business goals (Figure 2).

UAIM is rooted in systems thinking, and therefore the terms "system" and "model" are used often in UAIM documents. Definitions for these terms are:

- **System:** "A system is a group of interacting or interrelated elements that act according to a set of rules to form a unified whole. A system, surrounded and influenced by its environment, is described by its boundaries, structure, and purpose, and expressed in its functioning. Systems are the subjects of the study of systems theory." (Wikipedia 2022).
- **Model:** A description of a system that represents the important characteristics of that system.

Improvement methodology is envisioned as a cycle of continuous improvement steps that leverage the use of models. This includes maturity models to define how well a system could work; assessment models that tell us how well a specific system does work; and business process models that describe how different elements of value creation (people, processes, and technology) interact with each other.

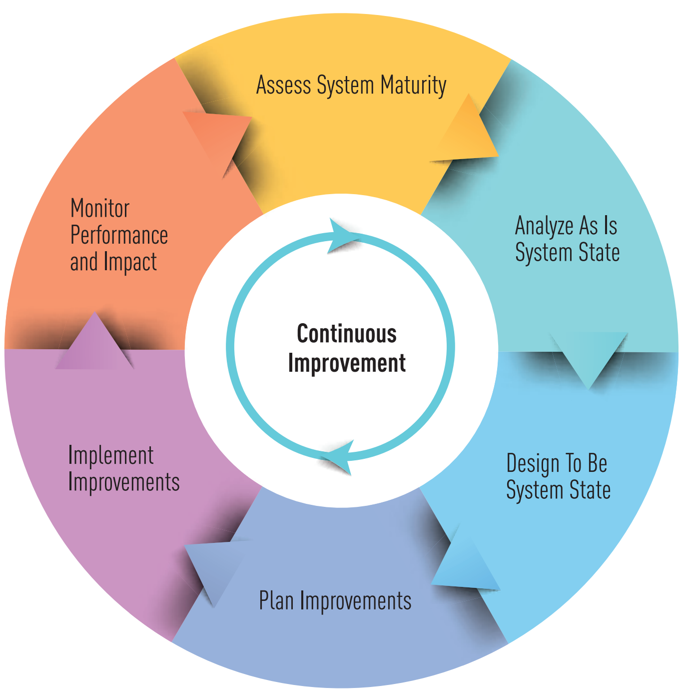
The steps in the improvement methodology can be applied to different areas of focus. We can use these steps to improve processes, technology applications, or management of the workforce. The focus of our improvement efforts (i.e., process, people, technology) becomes the "system," and these steps are used to analyze and improve it. The continuous improvement steps are defined as follows:

1. **Assess system characteristics or maturity:** This step is usually performed on the current/existing (As Is) system. Defining maturity of capabilities and assessing system maturity require:
   a. A maturity model that defines a generic range of possible capabilities on development levels for an area of focus (i.e., system). The maturity model describes how well a system *could* perform. For each of the areas (process, technology, and people), the UAIM project team and utility partners drew from different sources to collaboratively define maturity models that are the best fit for water sector utilities.
   b. An assessment method that we can apply to evaluate how mature a specific system in our organization is (e.g., the level of maturity or capability of our processes, technologies, workforce, or organizational culture.)

| | People | Process | Technology |
|---|---|---|---|
| Strategic | Senior / executive management and officials | Long-range planning and design | Financial and predictive models |
| Tactical | Maintenance and inspection staff | Asset management, work orders, etc. | Computerized maintenance management systems |
| Operational | Operational staff | Operational planning and control | Computerized control systems and sensors |

Source: Vitasovic et al. 2015

**Figure 1. The UAIM framework for value creation in an organization**




Source: Vitasovic et al. 2022

**Figure 2. Improvement methodology cycle**

2. **Analyze:** To examine an area of focus within a specific organization, we start by analyzing the current (As Is) state of the system. This analysis goes beyond assigning a level of capability; it includes a detailed examination of the specifics. Using a maturity model and maturity assessment enables us to get a general sense for the level of capabilities on a standard scale, and it shows where improvements may be needed. To perform a thorough analysis of a specific system, we start by describing the details of how the system currently works or performs by developing specific system models. The UAIM project produced many examples of this. During the first three years of the project, the focus was on business processes and utility partners that developed several As Is system models in the form of business process models that were included in the Water Sector Value Model (a curated compendium of all models produced in the UAIM project).
3. **Design:** Design the desired (To Be) system by defining improvements in business processes, management of workforce, creating a healthy organizational culture, or defining the requirements for technology that can enable improvements. For processes, the same system modeling notation that was used to develop the As Is model is used to design the improved (To Be) system. The recommended standard for analysis and design for both As Is and To Be models was Business Process Model and Notation (BPMN 2020).

Improvement methodology is envisioned as a cycle of continuous improvement steps that leverage the use of models.

4. **Plan Improvements:** This phase includes the development of a project management plan and a change management plan to address the "people issues."
5. **Execute Improvements:** In this phase, the project management and change management plans are executed.
6. **Monitor Performance:** This step includes monitoring all aspects of performance and identifying opportunities for further improvement. Changes in business processes, technology, or workforce are sustained as new systems but can be continually improved.

The UAIM project was conducted over four years and included the following phases:

1. **Phase 1:** The focus of this initial phase was to introduce the methods, tools, and standards for documenting business processes. Utility partners selected different business processes that they were most interested in improving, and each utility independently developed business process models for its As Is processes. This phase also produced the first version of the UAIM Guidelines for Business Process Modeling that included an introduction to Business Process Model and Notation (BPMN 2020).
2. **Phase 2:** The focus of the second phase was on using business process models to analyze the As Is processes and to design improvements, resulting in business process models that described the desired To Be processes.
3. **Phase 3:** Utility partners continued to independently develop business process models for the selected processes, just like in Phases 1 and 2. Additionally, utility partners worked collaboratively to develop and share their separate practices, artifacts, and business processes, and worked together on common models of interest.
4. **Phase 4:** In addition to continuing the work on both independent and collaborative business process modeling, analysis, and improvement, the scope was expanded to include a collaborative effort focused on the People aspect of the UAIM framework depicted in Figure 1.

A critical element throughout this project was the active participation of 22 utilities and over 150 participants. Supported by a consultant project team, with oversight by a steering committee, this effort prospered because it was driven by peer utilities that generated value for participants and their organizations. Utility leaders stewarded topic area teams, helped assure that utility interests were represented, and influenced the research to make it relevant and fit for application. This was accomplished through regular team meetings, individual utility work, a shared platform, training, and workshops that advanced the agenda and produced meaningful products. UAIM utility partners who actively participated in this research project include:

- Baltimore Department of Public Works (MD)
- Charlotte Water (NC)
- City of Avon Lake (OH)
- City of Grand Rapids (MI)
- Clean Water Services (OR)
- DC Water (DC)
- Environment Agency, Team 2100 (UK)
- Great Lakes Water Authority (MI)
- Gwinnett County (GA)
- Kansas City Water (MO)
- King County Wastewater Division (WA)
- Loudoun Water (VA)
- Louisville Metropolitan Sewer District (KY)
- Metro Vancouver (CAN)
- Metropolitan Council Environmental Services (MN)
- Orange County (FL)
- Portland Bureau of Environmental Services (OR)
- Portland Water Bureau (OR)
- San Francisco Public Utilities Commission (CA)
- Tacoma Water (WA)
- Toho Water Authority (FL)
- VandCenter Syd (DEN)
- Washington Suburban Sanitary Commission (MD)

Utility partners developed the following business process models and case studies:

- Orange County developed models for outage notification and pump repair or replacements, along with a case study on the latter.
- Washington Suburban Sanitary Commission developed a business process model and case study for managing pipeline construction, including preconstruction meetings, managing change orders, managing construction safety, and performing daily inspections.
- Metro Vancouver developed a business process model for work scheduling for operations and maintenance trades.
- Toho Water Authority developed a process model and case study for maintaining business continuity after regional storm events, with a focus on lift stations. They also developed models and a case study on implementing a project management office approach to addressing collection system deficiencies.
- The City of Grand Rapids submitted a detailed model and case study using business process simulation for their Cross-Media Electronic Reporting Rule process.
- Metropolitan Council Environmental Services created models for industrial sampling, analysis, and monitoring.
- Louisville Metropolitan Sewer District submitted a process model and case study for their One Water shared services program implementation.
- Clean Water Services developed a fleet acquisition, maintenance, and repair process model.
- A group of utility partners and consulting organizations developed a generic, five-level model for managing vision and strategy processes for utilities.
- VandCenter Syd submitted models for procurement and asset management related to catchment area evaluation and investment plans. They also developed models and a case study on optimization of sample analysis in support of their digital SCADA operations.
- DC Water, in collaboration with their engineering consultant, developed a business process and case study for a lead pipe replacement program.
- San Francisco Public Utilities Commission developed process models and a case study for collection system condition assessment/inspection and replacement/repair.

In summary, the UAIM project produced several key deliverables:

1. A holistic, unified framework for value-based analysis of utility management.
2. A structured improvement methodology that can be applied to any aspect of value creation (people, process, and technology).
3. Learning and application of a sophisticated standard methodology to document business processes so that they can be analyzed and improved.
4. A mechanism for utility partners to share business process models with other utility partners via the Water Sector Value Model knowledge base.
5. A platform for utility partners to share artifacts such as asset management plans, risk matrices, capital improvement program methods, and improvement case studies.

Important benefits of the UAIM project included extensive peer-to-peer collaboration of management

This effort prospered because it was driven by peer utilities that generated value.

and staff representatives from utilities across the water sector and the joint development of business process models, maturity models, assessment methods, and best practices for specific areas of utility management.

After successful completion as a WRF research project, this effort has transitioned to the Water Environment Federation (WEF) and continues under the WEF Water Intrapreneurs for Successful Enterprises (WISE) program (WEF, n.d.).

The goals of the WISE program are to bring the benefits of the UAIM project to a broader group of practitioners and to continue to implement improvements in workforce, organization, business processes, and technology.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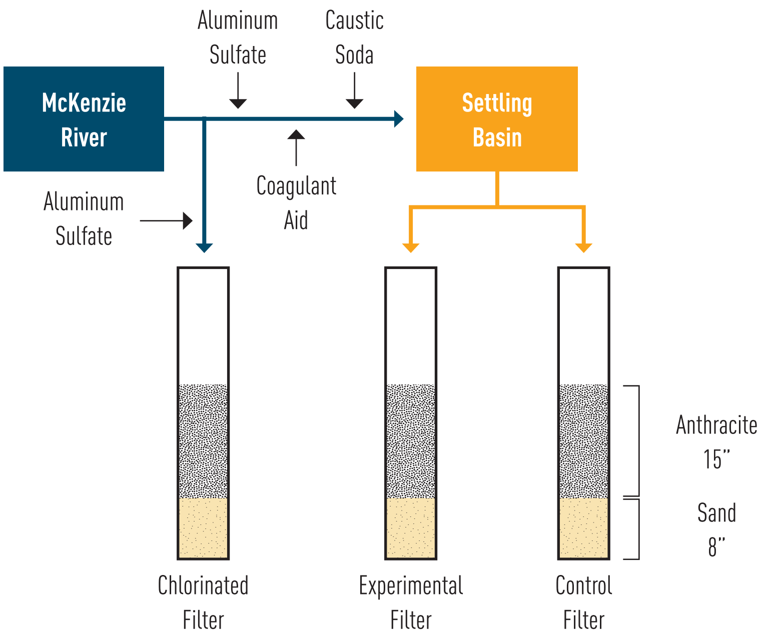
# **Biofilter Performance** (4984)

*Impact of Intermittent Operation on Biofilter Performance* evaluated the transition to biological filtration, determined optimal filter shutdown duration (at pilot-scale), and subsequently identified appropriate operating parameters for full-scale trials. The results of this study will be used to characterize the impact of biofilter shutdown on biomass characteristics and identify an operating strategy that will improve treated water quality while reducing overall treatment costs. This research provides insight regarding the operation of biologically active filters, as well as operating information for future increases in demand.




**Pilot-scale filtration schematic**

# Emerging Technologies

Emerging technology developers face huge hurdles to success, from maintaining the momentum of new ideas to communicating their value to the right audience. It is difficult in the water sector to create a sustainable business model among a shifting landscape. Many developers are working on solutions to improve the performance, efficiency, accuracy, and reliability of utility operations, and their success translates into industry advancement.

The Water Research Foundation (WRF) gives technology developers constructive feedback that enables them to tailor their solutions to meet industry needs. WRF's online innovation resources contain a wealth of information about technology trends, feasibility, piloting needs, utility drivers, and start-up dynamics. When technology providers participate in the WRF Technology Scan program (Figure 1), they receive tailored feedback from the WRF innovation staff and an independent review panel comprised of utility representatives, academic researchers, and industry consultants, including the reviewers highlighted in the Q&A in this issue of *Advances in Water Research*. WRF strives for success in technology development for the water sector but does not endorse any particular organization or technology.

In the water start-up ecosystem, WRF is an advocate on behalf of utility clients. Thus, WRF works with technology financers, accelerators, incubators, pioneers, and communicators to ensure that start-up energies are aligned with actual sector needs. Another way WRF seeks to support early stage technology developers is through sponsorship and mentoring of water innovation competitions. This year, WRF co-sponsored the Massachusetts Institute of Technology (MIT) Water Innovation Prize. This student-run competition awards up to $50,000 annually in grants to teams from across the globe. Several winning teams have gone on to become established water technology providers.

WRF's Chief Innovation Officer, Christobel Ferguson, and Innovation Program Manager, Erin Partlan, served as mentors to teams competing for the MIT Water Innovation Prize. Mentors reviewed the business plans, value propositions, and pitch presentations for the teams. They also provided feedback on product offerings and key markets, as well as presentation tips to give the teams the best chance of success. Technology contenders addressed a broad range of challenges including affordable distribution system monitoring for leak detection, water collection systems for refugee camps, irrigation optimization through machine learning, decentralized and sustainable desalination, and improved energy efficiency for water condensation.

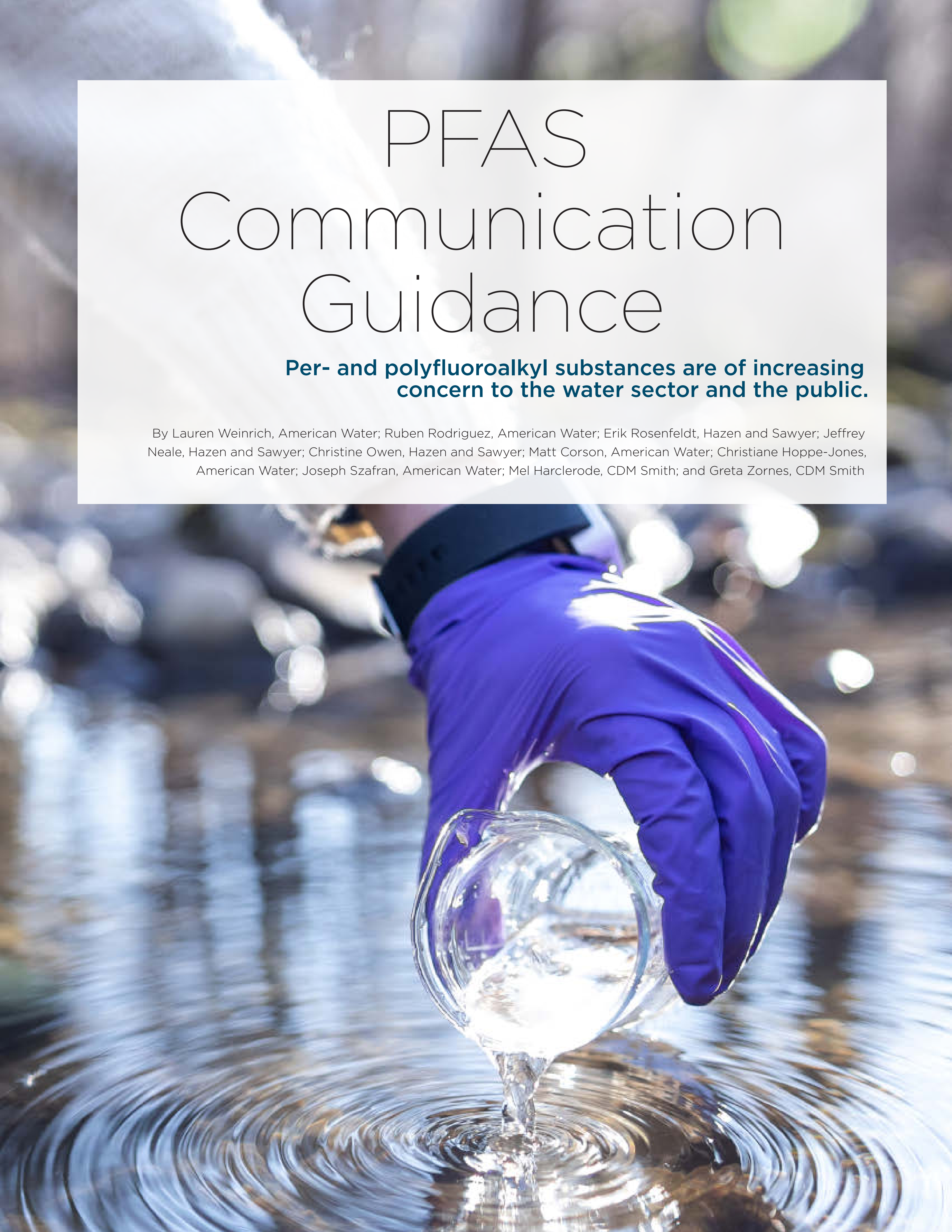
The MIT Water Innovation Prize is just one of many programs designed to help accelerate water innovation by providing student-founders with mentor support and funding. WRF is pleased to support those goals and the future of the water sector.


**Figure 1. WRF Technology Scan process**

# PFAS Communication Guidance

**Per- and polyfluoroalkyl substances are of increasing concern to the water sector and the public.**

By Lauren Weinrich, American Water; Ruben Rodriguez, American Water; Erik Rosenfeldt, Hazen and Sawyer; Jeffrey Neale, Hazen and Sawyer; Christine Owen, Hazen and Sawyer; Matt Corson, American Water; Christiane Hoppe-Jones, American Water; Joseph Szafran, American Water; Mel Harclerode, CDM Smith; and Greta Zornes, CDM Smith



**Water sector professionals need to be able to communicate with their customers clearly, concisely, and consistently about per- and polyfluoroalkyl substances (PFAS). This may include information on what PFAS are, where they come from, why the water system is monitoring them, what levels were detected, and what the monitoring results mean.**

The Water Research Foundation (WRF) commissioned the project *PFAS One Water Risk Communication Messaging for Water Sector Professionals* (Weinrich et al. 2022) in 2021 to develop effective PFAS communication materials for the water sector. The project was funded through WRF and the American Water Works Association, and the research team was comprised of communications and technical experts from American Water, Hazen and Sawyer, and CDM Smith who have experience with communicating risks to a variety of stakeholders. The project provides helpful resources and guidance for water utilities to use as they navigate a rapidly evolving environment.

## Development of PFAS Communication Materials

AS SCIENCE ADVANCES OUR understanding of the environmental and public health impacts of PFAS, it is critical that water systems establish themselves as the customer's trusted source of information for PFAS. Enforceable limits (i.e., maximum contaminant levels) and non-enforceable levels (i.e., health advisory and health guidance levels, etc.) differ by state and at the federal level for PFAS chemicals. This may lead to confusion about the risks that PFAS pose. Water professionals can prepare by having PFAS communication materials to help clear up the confusion.

A series of workshops, stakeholder engagement, and message testing resulted in simple, effective, accurate, and timely PFAS communication resources for the sector. These communication resources support proactive and direct outreach to customers and the ability to respond to inquiries that water systems may receive. The goals are to identify and support the water system as the trusted source of information for customers and to help ensure that water system staff members are prepared with fact-based information and effective ways to share it.

The first objective of the project was to develop guidance and tiered communication tools about PFAS results from sampling related to the U.S. Environmental Protection Agency's (EPA's) Fifth Unregulated Contaminant Monitoring Rule (UCMR5; EPA 2022). This guidance targeted water system customers and media outlets dedicated to promoting responsible coverage of environmental issues. The second objective was to develop One Water-focused messaging about minimizing exposure and targeting customers, state and federal health and regulatory agencies, water sector associations, and politicians involved in PFAS legislative agendas.

## Why it Is Needed Now

PUBLIC AWARENESS ABOUT PFAS continues to expand, and water systems need to be prepared to communicate about the amounts of PFAS detected in their drinking water. Under UCMR5, 29 PFAS will be monitored to improve the EPA's understanding of PFAS levels in drinking water systems. Since monitoring will transition from voluntary to mandatory for a considerable number of systems, the need for effective communication resources is expected to increase. Monitoring data collected under UCMR5 will help the EPA administrator decide if the agency needs to regulate additional PFAS chemicals to protect public health (EPA has already committed to setting maximum contaminant levels for perfluorooctanoic acid [PFOA] and perfluorooctane sulfonate [PFOS]). This project aimed to address these challenges in a timely manner so that utilities have the communication guidance that they need.

Furthermore, utilities with assets outside of drinking water (i.e., wastewater, reuse, and biosolids) will likely feel additional effects of this monitoring as the public, regulators, and politicians become more aware and ask questions such as, "where did PFAS come from?" Based on the One Water concept, utilities and the public can work toward a shared understanding of the connectivity between the hydrologic cycle and human interventions. Since PFAS are present in products used in our daily lives, making informed decisions about what products we use is important, and

Public awareness about PFAS continues to expand, and water systems need to be prepared to communicate about the amounts of PFAS detected in their drinking water.

customers are interested in learning what actions they can take. Materials have been developed to describe how customers can help improve water quality and steps they can take to reduce PFAS around them.

## The Project Approach

THE PROJECT TEAM LISTENED TO the perspectives of our customers and the needs of industry stakeholders, which was an instrumental aspect of our approach. Given the complexity of the regulatory framework at the state and federal levels, the team collected input from customers, water sector professionals, and technical and communication experts throughout the United States. These stakeholders provided important input addressing varied levels of concern, different perspectives from states with or without PFAS limits, voluntary or required sampling efforts, and local media attention. The key aspects of the approach are described below:

1. **Customer Focus Groups:** Customer volunteers from 11 states provided input on their reactions and responses to drinking water contaminants, PFAS messages, and images.
2. **Utility and Industry Representative Workshops:** Representatives from over two dozen utilities openly discussed their PFAS communication challenges and provided input for developing messaging. They shared perspectives from different geographies and varying roles that included directors, water quality managers, public affairs representatives, and compliance leads.
3. **Ready-to-Use Materials:** Based on the above two efforts, communication experts and technical leaders developed messaging and materials for communicating PFAS findings, safety, and regulations. These materials are flexible to the rapidly evolving and variable information and regulations for PFAS chemicals. The experts and leaders extensively cross-checked the messaging materials for readability and accuracy.

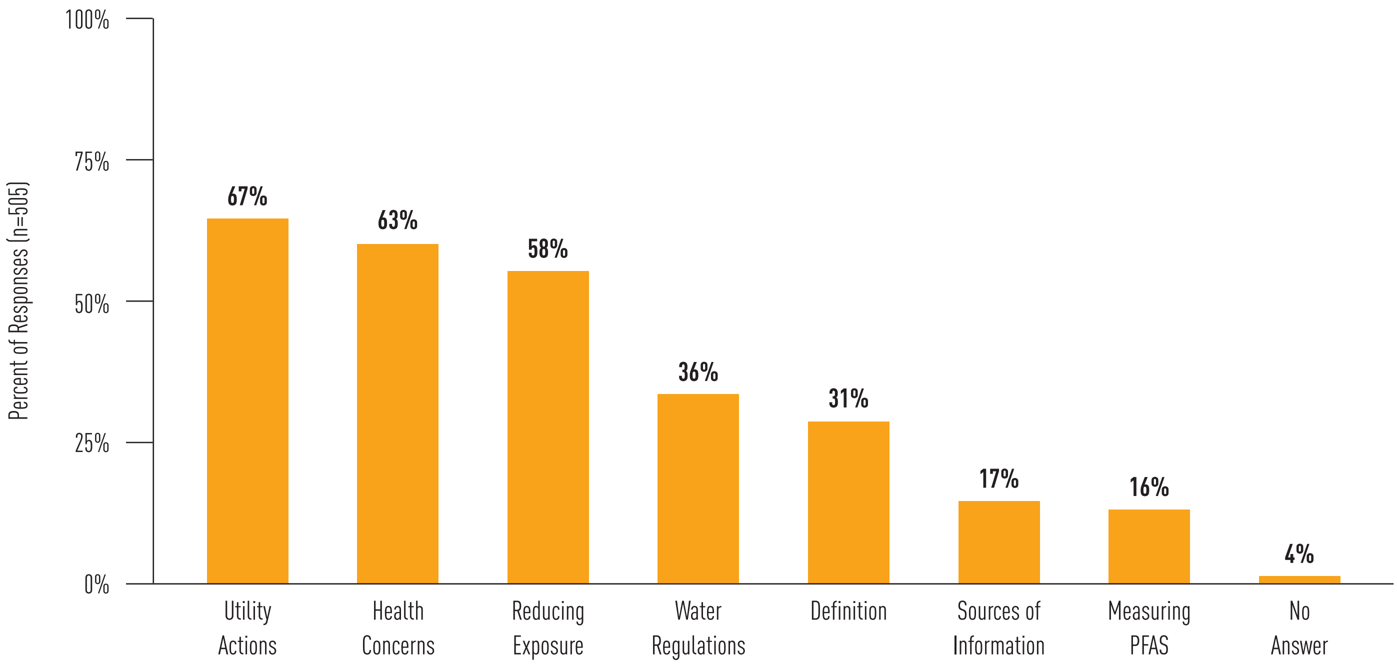
### *Customer Focus Groups*

QUESTIONS WERE SENT TO AN online focus group of drinking water customers. The feedback that was gathered helped inform the project team of what information the customer is interested in. Participants were asked about how often they drink tap water, how safe they feel it is to drink tap water, and their level of concern with drinking water contamination. The answers to these and other questions provided important context to the customer's overall perspective, sentiment for the safety of their drinking water, and their knowledge about water quality. Customers were specifically asked about their familiarity with PFAS and PFOA. The project team chose to present the question of familiarity with "PFAS/PFOA" since these are often the most common acronyms seen in the media. Because of the myriad of different approaches the team used to ask this question about PFAS, the team gained valuable insight into the customer experience. Customers were also given a free text option to provide a specific question, information needs, and/or optional topics that were relevant to them.

A total of 505 responses was received to the focus group questions. The relevant topics shown in Figure 1 are derived from feedback from the following questions that were presented to the customers and the number (n) of responses reported from each.

- What is my water utility doing to manage and reduce PFAS in drinking water? (n=339)
- What are the health concerns or risks associated with PFAS exposure? (n=317)
- What can I do to protect myself and my family from PFAS exposure? (n=292)
- What regulations are in place regarding PFAS in drinking water? (n=183)
- What are PFAS/PFOA? (n=158)
- Where can I find detailed information regarding PFAS in my state? (n=79)

These themes guided the development of the messaging materials




Source: Data from Weinrich et al. 2022

**Figure 1. Survey results from drinking water customers about the PFAS topics that are most relevant to them**

that utilities can use when discussing PFAS sampling, UCMR5 results, and the broader One Water context. This input shifted the narrative away from the complicated regulatory and risk assessment discussions, or extensive descriptions of the individual PFAS chemicals and expanded method development. Rather, the messaging focused on what customers should know, providing flexibility for utilities to discuss their efforts, with language that is understandable for the audience.

### *Utility and Industry Representative Workshops*

THE PROJECT TEAM ENGAGED A range of industry representatives to further refine messaging. Workshops were held in November and December 2021 with participation from approximately two dozen utilities, many with multiple representatives (e.g., operations, compliance and water quality, public affairs, and research). Two workshops, one focused on UCMR5 messaging and the other on One Water messaging, produced invaluable guidance from the tremendous engagement and input from the participants. Workshops were conducted in a modified format from The World Café using a virtual breakout group platform. Attendees convened in opening and closing plenary sessions. Each group had a facilitator who guided the discussion with a series of questions and a scribe who summarized the conversations. Facilitators fostered open dialogue and knowledge transfer between participants. This approach allowed the project team to leverage small groups to solicit input on the questions and topics in an efficient and collegial manner.

The questions and discussion points that were posed to participants are included below. Based on the strong engagement from approximately 50 participants in each workshop, the messaging toolkits incorporated the major themes and needs of utilities and communities. The questions may also be helpful for utilities that want to further develop their communication programs through internal discussions and engagement with stakeholders; using these probing questions and subsequent discussion points can aid them in ascertaining their needs as the field develops.

- **Workshop 1:** UCMR5 messaging for drinking water utilities
  - What is the best information to share, and how can we best communicate PFAS results from UCMR5 with customers?
  - What are your thoughts on training on PFAS for internal employees?
  - How can we best communicate PFAS results from UCMR5 with decision makers?
  - What questions do you anticipate needing to be able to answer about PFAS in drinking water once you share UCMR5 results?

  - Is there value to communicating about PFAS prior to UCMR5 sampling?
- **Workshop 2:** One Water messaging needs of the broader industry
  - Tell us about One Water and your community
  - What are your big picture concerns with PFAS?
  - How do PFAS fit into the One Water discussion?
  - Does the uncertainty of the PFAS regulatory landscape affect your agency? (Do you want to discuss the regulatory landscape with your stakeholders? Is it important to describe the variability of PFAS regulations with customers [given the federal timing in developing regulations, and state-by-state actions]?)
  - Is a discussion of PFAS risk critical or important to your stakeholders?

When considering the best information to share and how to best communicate it, there was consensus around keeping the messaging simple, consistent, and relatable, acknowledging that Consumer Confidence Reports have limitations given the changing regulatory environment. Despite being challenged with regulatory uncertainties and ambiguity around additional PFAS health risks, the breadth and depth of experience contributed by the workshop attendees, technical experts, and the skilled moderators was invaluable in bringing our industry voices together and creating a united path forward.

## *Ready-to-Use Materials*

AFTER ENGAGING VOLUNTEER customer focus groups, industry partners, public affairs teams, and external relations teams, the project team created two PFAS messaging toolkits for use by utilities as part of their communication plan. The toolkits include one for UCMR5 and sampling related communications and one for broader PFAS implications in a One Water context. The materials in these toolkits are customizable by the utility and encompass the breadth of customer and stakeholder outreach types.

### *UCMR5 Toolkit*

Each water system faces unique circumstances related to PFAS management and regulatory requirements. Included in the UCMR5 toolkit is a "how to" manual that allows individual water systems to design their own frequently asked questions (FAQ) document(s) to share with customers and stakeholders and to post on their websites. The FAQ document can also be used as the basis for other communication materials, including talking points for different speakers such as frontline employees, public information officers/spokespersons, employees handling customer questions, and utility leaders.

Water sector professionals should use the "how to" manual to refine their messaging and tell their own stories by weaving their specific information into the template provided. Below are the questions that the water systems should consider ultimately including in their FAQs to best inform their customers.

- What are PFAS?
- Why should I care about PFAS?
- What steps have the state's regulator taken?
- Are PFAS in my drinking water? Is my water safe?
- What have you done/are you doing/will you be doing about PFAS in drinking water?
- How will I know what is going on?
- What do I need to do? What can I do?

Guidance is designed for different scenarios that utilities will be able to identify with when creating their messaging. For example, one scenario addresses a water system that is reporting PFAS and whose state regulatory authority has established enforceable limits for PFAS chemicals. The manual also provides examples and considerations for systems in other scenarios, including ones in states that have established Health Advisory Levels (or similar) and systems in states that have not acted on PFAS.

History has shown that PFAS is a topic that is readily covered by local and national news outlets. Unfortunately, this coverage is often lacking

This array of materials will allow utilities to bolster their communications with messaging that is consistent across the sector.

context and accurate information, which leads to the public's confusion and distrust about the risks that PFAS may pose. To highlight the water system as the trusted source, the toolkit also includes materials that can be accessed by, or distributed to, media outlets as press releases.

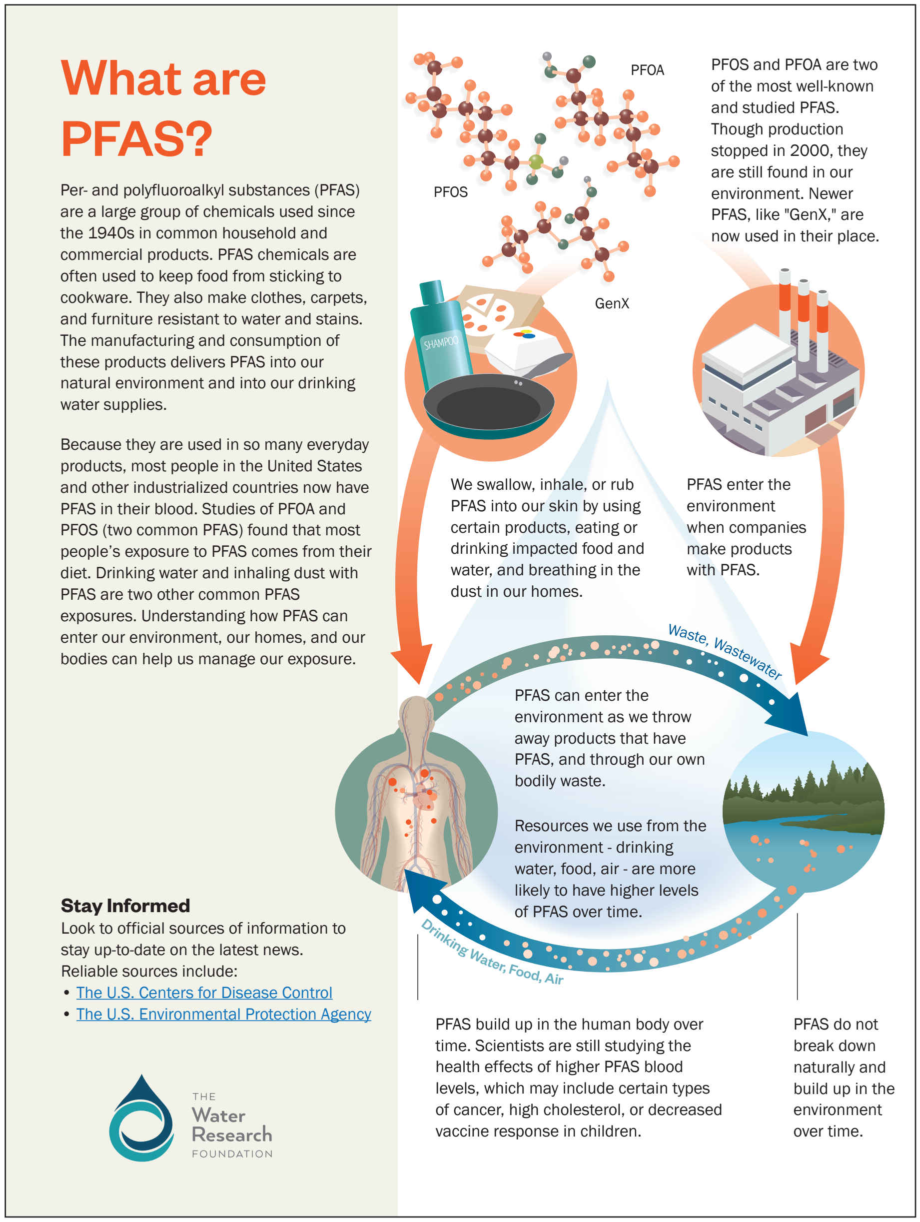
### *One Water Toolkit*

The materials developed for the One Water toolkit present information tailored to describe where PFAS come from and how they enter the environment and drinking water systems. They also present the public with an opportunity to understand additional PFAS exposure routes in their daily lives and recognize how their choices in materials and products purchased, used, and disposed of can ultimately be beneficial. Content was developed in anticipation that utilities may want to dedicate a single webpage or multiple webpages to PFAS content and that utilities' ability and desire to use associated images would vary. Recommended text for PFAS web content is provided in a format that is easy to copy from Word and post to a utility's website content management system. Each page contains a box that identifies suggested images that could be associated with the content and captions for each image. These recommendations, as well as information on risks and exposure from PFAS in the environment, are also included as a brochure that can be sent to customers and the public (Figure 2).

Website content recommendations include:

- What are PFAS?
- How do PFAS enter the environment and how are humans exposed?
- How do PFAS affect me?
- How do PFAS affect your water?
- How can we reduce exposure to PFAS?
- What can I do?
- Make your voice heard
- Reliable sources of information to link to

A sample letter is also provided as a guide for customers to write to their local representatives. It includes key messages from a joint letter sent to Congress by the American Water Works Association, the Association of Metropolitan Water Agencies, the National Association of Water Companies, and the National Rural Water Association asking for legislation to address PFAS. Text for bill inserts and social media assets are also provided to empower customers with the information that they need.




Source: Weinrich et al. 2022

**Figure 2. PFAS brochure**

### Conclusion

THIS ARRAY OF MATERIALS WILL allow utilities to support their communication needs with messaging that is consistent across the sector. These materials reinforce the utility/customer relationship, and utilities will be able to leverage the materials developed in this project to enhance their roles as trusted sources of accurate information and as environmental stewards for the communities they serve.

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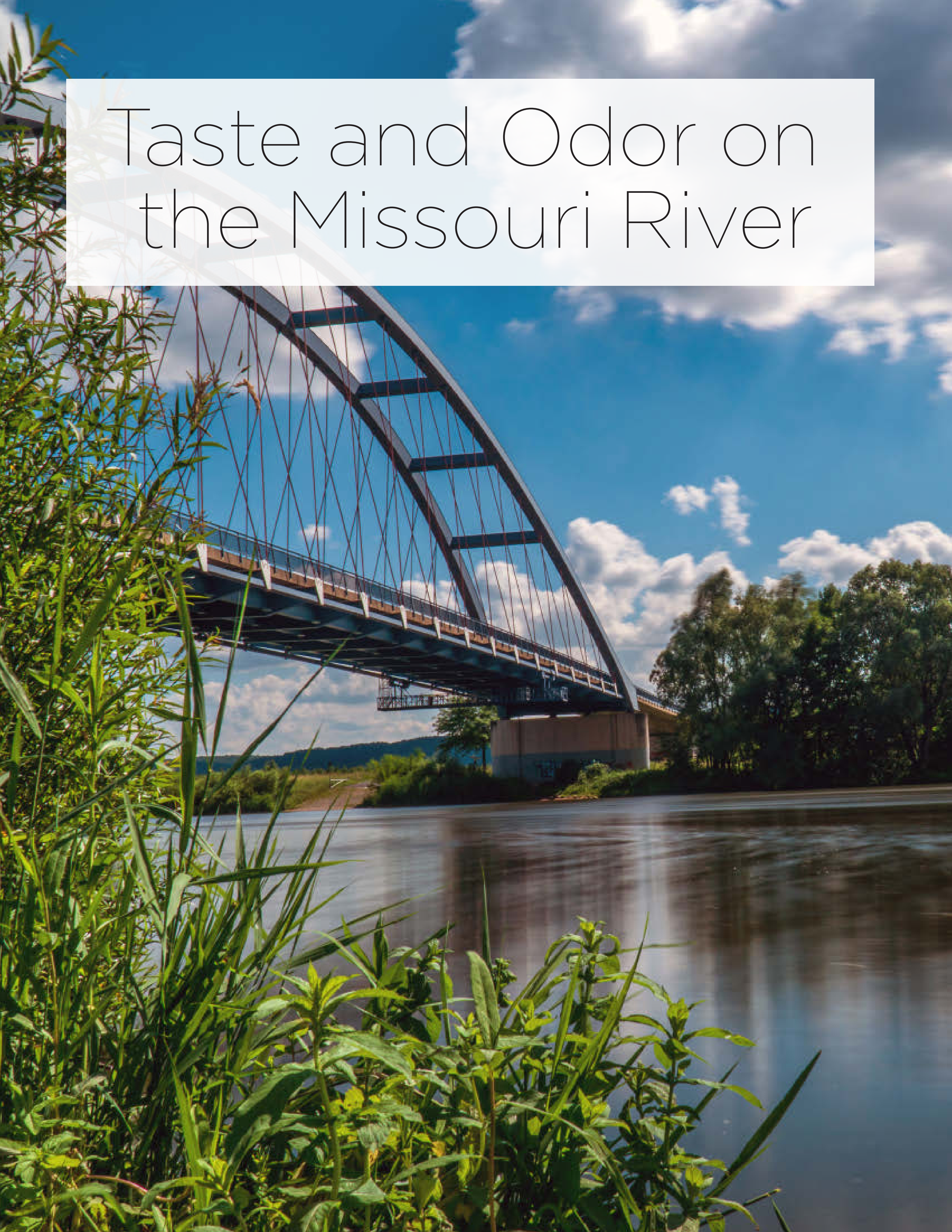
WEINRICH, L., R. Rodriguez, E. Rosenfeldt, J. Neale, C. Owen, M. Corson, C. Hoppe-Jones, J. Szafran, M. Harclerode, and G. Zornes. 2022. *PFAS One Water Risk Communication Messaging for Water Sector Professionals*. Project 5124. Denver, CO: The Water Research Foundation.

# Detecting SARS-CoV-2 (5093)

Wastewater surveillance of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a promising complement to clinical testing as a means of assessing COVID-19 trends within a community. The objective of *Understanding the Factors That Affect the Detection and Variability of SARS-CoV-2 in Wastewater* was to understand how wastewater sampling designs impact the quantifiable SARS-CoV-2 genome in both centralized and decentralized wastewater collection and treatment systems. SARS-CoV-2 genome concentrations were analyzed in primary clarifier sewage influents and primary sludge samples from centralized water resource recovery facilities (WRRFs). Study of decentralized wastewater collection and treatment systems for SARS-CoV-2 genome detection was carried out in septic systems that serve public restrooms. The results showed that 24-hour composite samples best represent the trends of SARS-CoV-2 concentrations in centralized WRRFs. The primary sludge samples had nearly 10 times higher concentrations of the viral genome, suggesting that sludge testing could provide greater sensitivity for SARS-CoV-2 detection. Decentralized wastewater management systems also have the potential to be used as access points for wastewater surveillance.

**Images of a sampling event at the lift station influent (left) and effluent (right)**

# Taste and Odor on the Missouri River



## Most customer complaints that drinking water utilities receive are related to the aesthetic qualities of water, such as taste and odor.

By Megan Karklins, The Water Research Foundation;
and Curt Skouby, City of St. Louis

**Public perception of water quality** is driven by taste and odor (T&O) and other aesthetic characteristics. Between February and March 2014, an intense and prolonged T&O event occurred over a stretch of 400 miles in the lower Missouri River. This event was atypical and extraordinary in multiple ways. Most T&O events occur in the summer and fall, but this one took place in late winter/early spring. The intensity of the event was also abnormal, with recorded raw water threshold odor numbers (TONs) as high as 25 and a longer-than-usual duration (almost 4 weeks).

In the aftermath, four WRF subscribing utilities (Saint Louis Water Division, Missouri American Water, Kansas City Water Services Department, and Water District #1 of Johnson County) came together, raised funds, and approached WRF to conduct the Tailored Collaboration study, *Sources and Fate of Taste and Odor Causing Compounds in the Missouri River* (Ghosh et al. 2019). Under WRF's Tailored Collaboration (TC) Program, a WRF subscriber or group of subscribers can obtain matching funds of up to $150,000 for a research idea that they have developed.

In order to improve preparation for future T&O events, Ghosh et al. (2019) described an approach for developing, implementing, and maintaining early warning systems (EWS) for source water challenges related to T&O compounds. The research resulted in near- and long-term recommendations for utilities located along the lower Missouri River, and general recommendations for utilities that experience T&O challenges in source waters.

### Sampling and Monitoring

BASED ON THE REPORT'S recommendations, utilities aiming to implement robust T&O EWS should revisit their sampling and monitoring plans, and consider their monitoring parameters, sampling locations, and sampling frequencies. Monitoring plans should be detailed enough to include sampling parameters based on seasonal, baseline, and T&O conditions.

In the three years following the 2014 T&O event, based on initial findings from this project, all of the participating utilities increased their monitoring protocols to include the following water quality parameters: 2-methylisoborneol (MIB), geosmin, TON, atrazine, nitrogen species (ammonia, nitrate, nitrite), and total phosphorus. Some of the participating utilities further monitored fluorescent dissolved organic matter, chlorophyll *a*, fluorescent chlorophyll, and fluorescent phycocyanin.

Table 1 summarizes the recommended water quality parameter monitoring frequencies during baseline conditions at various times of the year (i.e., summer versus winter). Note that for parameters recommended for online monitoring, there may be some additional considerations, such as seasonal effects, that need to be addressed during implementation. For example, during cold weather freeze scenarios, a procedure should be in place to protect and maintain the instruments.

## Data Collection and Storage

WHEN THE EVENT OCCURRED, some of the affected utilities did not have historical sampling and monitoring data that they could compare their readings to. A key recommendation from Ghosh et al. (2019) was for utilities to establish robust databases for collection, analysis, and inventory of data and information. Ideally, utilities that share water sources would further pursue an integrated, GIS-based platform. Such platforms allow both spatial and temporal analyses of collected data, as well as development of trends, correlations, and statistical summaries of data. Several GIS-based data management platforms are available commercially that also have the capability to send out alerts or messages to key stakeholders if a water quality issue is identified.

Utilities aiming to implement robust T&O EWS should revisit their sampling and monitoring plans.

continued on page 24

**Table 1. EWS water quality parameter monitoring frequencies during baseline conditions**

| WATER QUALITY PARAMETERS | Summer Conditions (March 1 – November 30) | | Winter Conditions (December 1 – February 28) | |
|---|---|---|---|---|
| | Water Treatment Plant (WTP) Intakes | River Locations | WTP Intakes | River Locations |
| Temperature | Online | | Online | |
| pH | Online | | Online | |
| Alkalinity | 1/ day | 1/ 2 weeks | 1/ day | 1/ 4 weeks |
| Turbidity | Online | | Online | |
| Conductivity | Online | | Online | |
| Total Organic Carbon (TOC) | 1/ week | 1/ 2 weeks | 1/ week | 1/ 4 weeks |
| $UV_{254}$ | 1/ week | 1/ 2 weeks | 1/ week | 1/ 4 weeks |
| Dissolved Oxygen | Online | | Online | |
| Phycocyanin | Online | | Online | |
| Chlorophyll *a* | Online | | Online | |
| MIB | 1/ week | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks |
| Geosmin | 1/ week | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks |
| Algae Identification | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks | 1/ 4 weeks |
| Algae Enumeration | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks | 1/ 4 weeks |
| Sensory Analysis — TON | 1/ day | 1/ 2 weeks | 1/ day | 1/ 4 weeks |
| Sensory Analysis — Smell Test | 1/ week | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks |
| Total Nitrogen | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks | 1/ 4 weeks |
| Nitrogen Speciation (Nitrate/Nitrite/Ammonia) | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks | 1/ 4 weeks |
| Total Phosphorus | 1/ 2 weeks | 1/ 2 weeks | 1/ 4 weeks | 1/ 4 weeks |

Source: Ghosh et al. 2019

"Many past T&O studies have focused on reservoirs or lakes and not so much on rivers. Flowing rivers are subject to continuous change, depending on rainfall or precipitation that could come into the river system from any number of locations, any of which could possibly contribute to a T&O event. That's why we approached WRF to get this study done.

One of the biggest applications of this research is that it has informed how we conduct our daily operations as far as tastes and odors are concerned, including how we train our personnel. Based on the recommendations of the project, we've adjusted how we monitor the water every day—the standardized panel that evaluates the water coming into the plant, and then the finished water that we are producing. This has allowed us to build a history of what is typical for our source water and our finished water.

The utilities that participated in the project now have their own databases to store this data. So far, we have not pursued an integrated joint database. Even without it, this research resulted in better communication between utilities in our region. If another major T&O event occurs, we will be in a much better position to capture samples, identify and quantify the problem, and respond more effectively. We have spent time building relationships and making arrangements with laboratories in our area, and we know exactly where we want to send our samples to be analyzed. Much of the lab equipment used to analyze these samples is research grade and not something that utilities necessarily have on site.

I would definitely recommend WRF's TC Program to any utility that hasn't applied before. I thought it was worthwhile. I liked that we were able to involve other utilities who were in our same situation. The TC Program is a way to address issues that are more focused on your utility's circumstances. Oftentimes, a study might be focused on somebody else—their situation is different. With the TC Program, you can eliminate that factor by investigating your specific circumstances."

—CURT SKOUBY, DIRECTOR OF PUBLIC UTILITIES, CITY OF ST. LOUIS

Another benefit of collecting robust data in an integrated database is that it can be used in conjunction with predictive models. The research team considered several modeling tools for the participating utilities, and ultimately recommended that they use the Incident Command Tool for Drinking Water Protection (ICWater). This is a GIS-based model that can provide real-time assessments of the travel and dispersion of contaminants in streams and rivers. ICWater can be used both in upstream and downstream analysis modes to predict fate and transport of contaminants, as well as perform retrospective analyses of potential sources of T&O during or after an event. If a hydraulic modeler is already available at an EWS lead agency, they should be designated to acquire and run the model. If such a person is not available, someone should be designated to complete this task and provided appropriate training so they can run the model using various scenarios, during both baseline conditions and T&O events. The ICWater tool is only available to public utilities; however, other similar tools exist that could be utilized by private utilities.

The effectiveness of PAC treatment varies among different T&O compounds.

### Treatment Optimization

ANOTHER KEY OUTCOME OF THE project included recommendations for how the participating utilities could optimize their treatment trains, specifically their use of powdered activated carbon (PAC). PAC treatment is used at all of the participating utilities' water treatment plants (WTPs) and is the primary mitigation strategy for both T&O and atrazine control. The effectiveness of PAC treatment varies among different T&O compounds. It is possible that a different PAC product (than the one currently used at the WTP), a higher dose, or a different application location will yield higher treatment effectiveness of PAC towards the control of the less common T&O compounds.

Four separate rounds of treatability studies for T&O compounds with the application of PAC and ozone were performed as part of this project. Several emerging T&O compounds (not MIB or geosmin) that may be responsible for T&O events in the Missouri River were identified. Treatability studies were performed to develop standard sampling, preservation, and analytical techniques for the accurate identification and quantification of these compounds, as well as treatment effectiveness for the removal of these compounds with the application of PAC and ozone. Further in-depth treatability studies should be conducted with various PAC types and doses to determine the optimal control strategy for the T&O compounds.

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# Water Quality Linkages Research (5038)

**In order to identify and prioritize** research needs in the area of linkages among point and nonpoint source effluents, receiving water quality, and ecosystem outcomes, *Roadmap Workshop on Prioritizing Permitting and Linkages Research in Water Quality* characterized the state of knowledge from a range of stakeholder perspectives. A research roadmap was developed that identifies existing data gaps and research needs. This project represents a fresh look at the One Water continuum and focuses on how to address the gaps between the sources of impairments within a watershed, the impacts of those impairments on the ecosystem, and the regulatory and permitting impacts for effective and efficient management of water quality.

# Research Driven by You

**A recent research planning summit resulted in over 50 prioritized project concepts that will be considered for funding through 2023.**

By Megan Karklins, The Water Research Foundation

**Since fall 2020, The Water** Research Foundation (WRF) has been reimagining our Research Priority Program (RPP). The RPP is WRF's flagship program, receiving 60% of our yearly research funding. The main goal of reassessing the RPP is to reduce the time it takes to bring a research concept from idea to published results. We are keen to deliver targeted solutions to pressing water sector problems as quickly as possible, thereby increasing subscriber value. While speeding up the process, it is vital for WRF to strike a balance where the integrity of the process can be maintained and the ability for experts to weigh in throughout is preserved.

We last provided an RPP update in the final 2021 issue of *Advances in Water Research* (WRF 2021), where we shared five new themes that research projects would be grouped under starting in 2022. The themes were chosen based on the results of WRF's 2021 Upstream Strategies gathering (WRF 2022); conversations with WRF subscribers, partners, volunteers, and other stakeholders; water sector surveys; and water sector reports.

In October 2021, WRF's Research Advisory Council (RAC) approved the five recommended themes and their aspirational goals with minor adjustments. In turn, the WRF Board of Directors approved the themes and goals at their December 2021 meeting. The finalized themes and goals are shown in Figure 1.

Once the themes and aspirational goals were finalized and approved, the next step was to consider subtopics under each theme. The subtopics were chosen via a WRF staff summit held in February 2022. In the deliberations, staff considered several inputs, including data from a research prioritization survey (deployed to WRF subscribers in December 2021), innovation trends, and WRF analytics data (e.g., what topics and deliverables are most viewed on our website or clicked on in our e-newsletters). In the end, WRF staff recommended 16 subtopics. In March 2022, the subtopic recommendations were approved by the RAC, with minor modifications. As shown

Through this effort, the interconnectedness of the water cycle became even more clear.

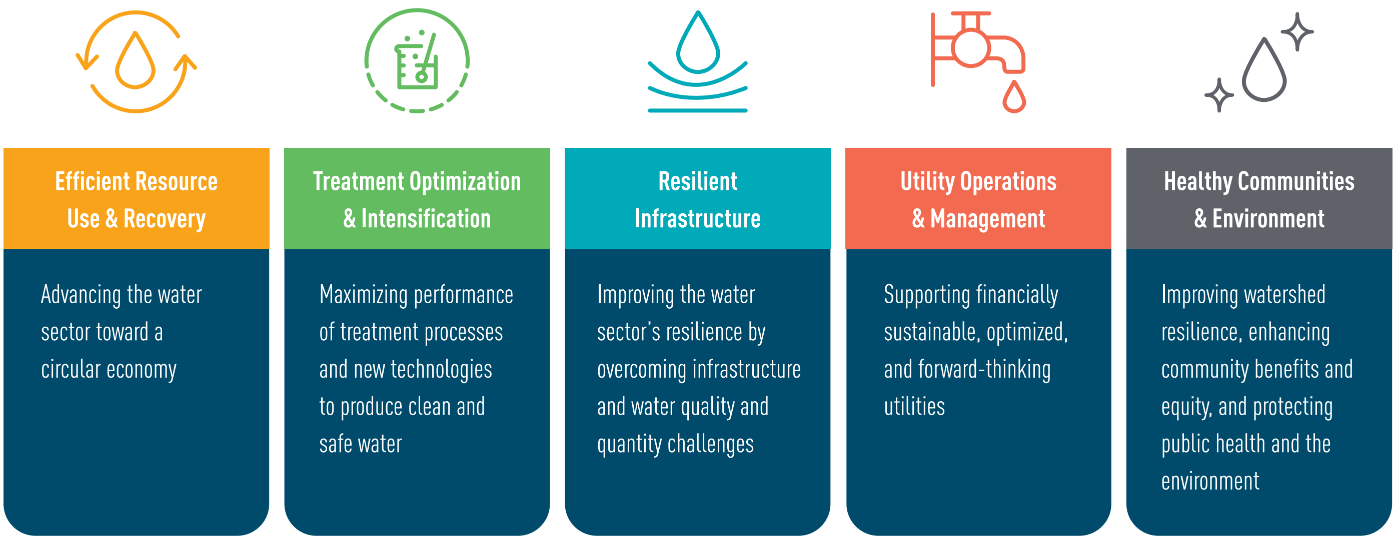


**Figure 1. Research Priority Program themes**

in Figure 2, the RAC recognized that certain overarching topics are cross-cutting and should be considered in all of WRF's RPP research projects: climate risk assessment and adaptation, communication, and environmental justice.

With the themes and subtopics chosen, the next step was to brainstorm high-priority project concepts to be funded in 2022 and 2023. In April 2022, WRF hosted a virtual research planning summit to gather expert input on high-priority research project concepts under each subtopic. Around 250 water professionals, utility representatives, researchers, and regulators participated in three two-hour sessions during which project concepts were brainstormed, refined, and prioritized. Through this effort, the interconnectedness of the water cycle became even more clear. As subtopic groups brainstormed project concepts, many came up with ideas that overlapped with or complemented another subtopic's ideas. WRF staff worked diligently to share these project concepts across subtopic groups and discuss how best to push these ideas forward. In the end, there were over 30 cross-cutting project concepts identified. This experience reinforces the importance of WRF's dedication to fund research on all types of water—drinking water, wastewater, stormwater, and recycled water.

In the end, a list of 51 high-priority project concepts spread across the 16 subtopics was developed. The final list of project concepts was brought to the RAC on May 25, 2022. The RAC selected 22 projects to be funded for 2022, totaling over $4,000,000 in funding. Table 1 shows a few of the concepts the RAC approved from the 51 presented to them.

After the final list of projects was approved by the RAC, WRF

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# Thanks to Yvonne Forrest, Outgoing RAC Chair

**WRF would like to thank Yvonne Forrest, Director at the City** of Houston, for her service as Chair of the Research Advisory Council (RAC). The Chair of the RAC is charged with leading a group of 18 volunteers, primarily water sector leaders, to evaluate research topics and projects based on importance, broad relevance, feasibility, and suitability.

During her three-year term as Chair, Yvonne has pushed our staff and the RAC to think outside the box and consider innovative approaches to streamline and improve our flagship research program. It is her vision and strategic direction that led to WRF's 2022 research planning summit.

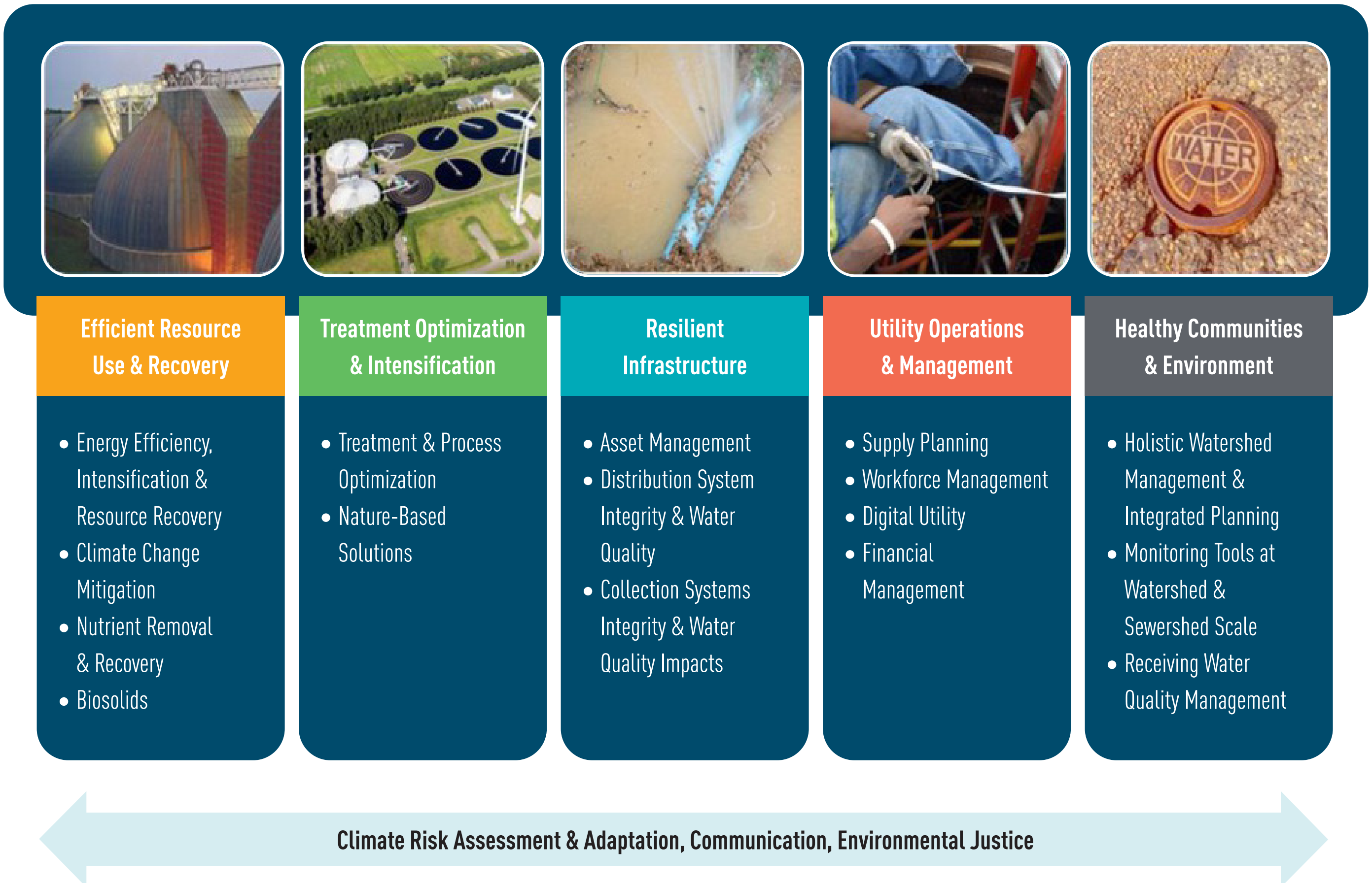


Figure 2. New subtopics under the five Research Priority Program themes

Table 1. Examples of approved project concepts

| Project Concept Title | Objectives | Funding Amount |
|---|---|---|
| DE&I Best Practices for the Water Sector Workforce | Identify and define an inclusive work environment, best practices, methods, metrics, etc.; identify partnerships that have been successful in accelerating diversity, equity, and inclusion objectives; and identify utilities that have been successful. | $125,000 |
| Developing Sustainable Technologies and Assessing Innovative Treatment Options for Biosolids | Identify and evaluate technologies and approaches for solids management, including PFAS destruction. | $175,000 |
| Feasibility of Full-Scale Implementation of LED UV Disinfection | Evaluate the effectiveness of UV LED light for microbial inactivation, and assess the feasibility of using UV LED light at treatment plants. | $250,000 |
| Innovative Technologies to Improve Monitoring of Assets | Assess possibilities of new and emerging technologies to increase utility resilience, and conduct case studies of demonstrated applications of new and emerging technologies with quantified costs and benefits. | $150,000 |
| Navigating One Water Planning through Municipal Water Programs: Meeting Multiple Objectives and Regulatory Challenges | Apply One Water planning principles and approaches in multiple municipal programs and holistic watershed management that need to meet both environmental objectives and inter-connected regulatory requirements, create a decision framework that can help describe a roadmap of inter-connected projects and initiatives at utilities, and facilitate engagement with regulatory agencies to proactively identify the priorities and the benefits of relative actions. | $200,000 |

staff shifted gears to begin writing Requests for Proposals (RFPs) for the funded projects. RFPs will be released around September 2022, with proposals due around November 2022. Any projects from the prioritized list that were considered by the RAC but not chosen for funding in 2022 will be reconsidered for funding in 2023.

Through this process, WRF has benefited greatly from the input and expertise of subscribers, volunteers, partners, and subject matter experts throughout the water sector. It has also become even more clear how many water issues are cross-cutting, requiring collaboration between diverse stakeholders. WRF will continue to lead the way, bringing the water sector together to fund the most crucial research.

### References

WRF (The Water Research Foundation). 2021. "Reimagining WRF's Flagship Research Program." *Advances in Water Research*, 31 (4): 25-27.

——— 2022. "Upstream Strategies." Accessed May 20, 2022. https://www.waterrf.org/upstream-strategies.

# Biogas from Co-digestion (4892)

**There is much potential to extract** energy from organic wastes. In the past few decades, the addition of organic high-strength wastes (HSWs) such as food waste to anaerobic digesters for co-digestion with wastewater solids has been identified as an additional source of biogas production. However, there is limited information available on the characterization of biogas produced from co-digestion of different feed stocks with wastewater sludge. *Quality of Biogas Derived from Wastewater Solids and Co-Digested Organic Wastes: A Characterization Study* evaluated the impact of HSW addition on the quality of biogas from anaerobic digestion. The research results discuss potential biogas quality changes due to organic waste addition and identify parameters for analysis in sludge and organic waste samples to evaluate potential impacts on regulatory compliance and treatment requirements.

**Details of participating utilities**

| Treatment Facility | Location | Treatment Capacity | Digester Operation | Co-waste |
|---|---|---|---|---|
| City of Petaluma | Petaluma, CA | 6.7 MGD | Secondary treatment by oxidation ditch followed by mesophilic digestion | Poultry, creamery |
| Gloversville Johnstown Joint Water Treatment Facility | Johnstown, NY | 13.8 MGD | Mesophilic digestion with recuperative thickening | Greek yogurt and feta, cheese whey |
| Central Marin Sanitation Agency | San Rafael, CA | 7.5 MGD | Mesophilic digestion | Fats, oils and grease (FOG) and food waste |
| Clean Water Services | Tigard, OR | 22 MGD | Mesophilic digestion | FOG |
| Encina Wastewater Authority | Carlsbad, CA | 44 MGD | Mesophilic digestion | Winery waste |
| Los Angeles County Sanitation Districts | Carson, CA | 330 MGD | Mesophilic digestion | Food waste |

**October 2–4, 2022**
**Southwest Section AWWA Annual Conference and Exposition**
Rogers, AR
swawwa.org

**October 2–5, 2022**
**Atlantic Canada Water & Wastewater Association Annual Conference**
Hilton Saint John, NB
acwwa.ca/index.php

**October 4–6, 2022**
**WaterSmart Innovations Conference & Exposition**
Las Vegas, NV
watersmartinnovations.com

**October 8–12, 2022**
**WEFTEC**
New Orleans, LA
weftec.org/about/about-weftec

**October 16–19, 2022**
**ASDWA Annual Conference**
Scottsdale, AZ
asdwa.org/event/23649

**October 23–26, 2022**
**CA-NV AWWA Annual Fall Conference**
Sacramento, CA
ca-nv-awwa.org/canv/CNS/Events_Classes/Future_Events/Annual_Fall_Conference_2022/CNS/EventsandClasses/conf/AFC22/AFC2022.aspx?hkey=a00fe607-d755-433c-9dd1-eca3815cddb6

**October 30–November 2, 2022**
**AMWA Executive Management Conference**
Savannah, GA
amwa.net/conference/2022-executive-management-conference

**November 13–17, 2022**
**AWWA Water Quality Technology Conference**
Cincinnati, OH
awwa.org/Events-Education/Water-Quality-Technology

**November 15–17, 2022**
**American Water Summit**
Los Angeles, CA
americanwatersummit.com

**November 27–November 30, 2022**
**Florida Section AWWA Annual Fall Conference**
Orlando, FL
fsawwa.org/page/ConferenceOveview

**November 29–December 1, 2022**
**ACWA Fall Conference & Exhibition**
Indian Wells, CA
acwa.com/events/2022-fall-conference-exhibition

**December 4–7, 2022**
**NC One Water Annual Conference**
Charlotte, NC
nconewater.org/events/EventDetails.aspx?id=1610018&group=

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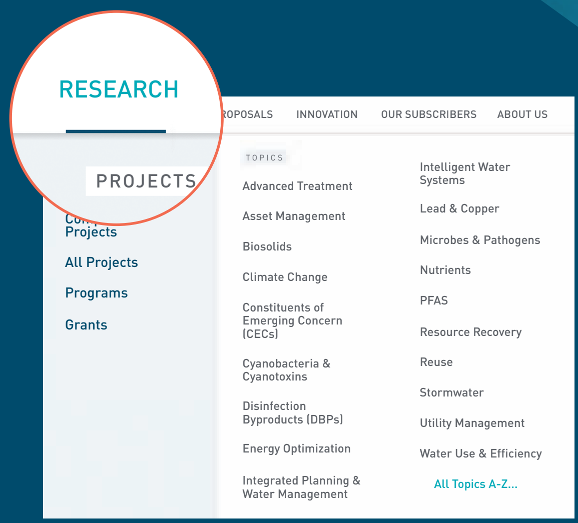


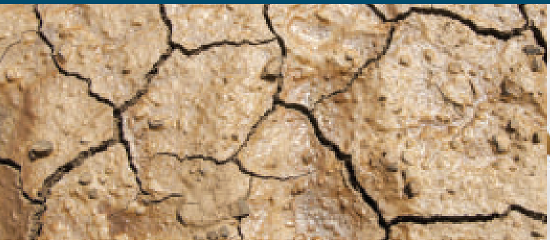

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