



# How Have Water Resource Challenges and Solutions Evolved Over the Past 20 Years?

*A Special Retrospective Report for Water Professionals Working on Real-World Problems*

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# Executive Summary

In the water industry, we face countless challenges. There are legal and regulatory challenges; water quality, quantity, and social justice challenges; and, technical, infrastructure, and funding challenges, just to name a few. All of these must be addressed and overcome in the context of changing politics and climate. By reflecting on how water challenges have evolved, stagnated, or been resolved over time, we can better understand why we are where we are today and what may be in store for the future.

Trying to solve these massive, complex, and often interconnected challenges through the actions of one individual or organization is impossible. But at the end of the day, water professionals must decide how to address the problems that directly impact their communities, ideally in a way that avoids any negative externalities and is politically well received.

*This is an enormous undertaking.*

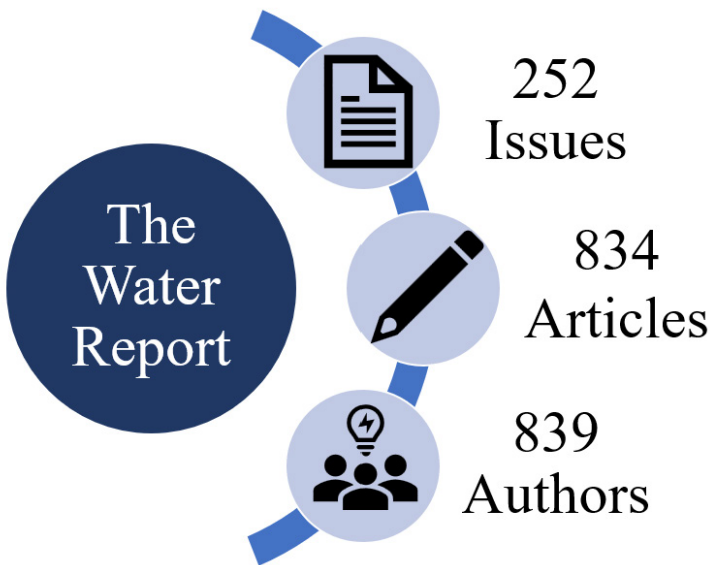
Luckily, water challenges are quite common and cyclical in nature; they appear, disappear, and reappear over time. For a particular challenge, it is likely that someone—in one water sector or another—has faced something similar and found a pathway forward.

As a premier long-format water periodical, *The Water Report* has been tracking water challenges and solutions for over 20 years. To create this retrospective report, we used data—collected from 252 published issues, containing 834 in-depth articles, written by 839 industry thought leaders—to examine how water challenges and the solutions developed to meet them have evolved over the past two decades. This 20-year retrospective is intended to take the cumulative wisdom of these authors and discern key trends and recommendations.

Cleanly separating challenges and solutions and extracting them from articles is nearly impossible. Because we encourage in-depth analysis (our articles average 3,500-5,000 words), articles will often focus on one topic that addresses multiple challenges and/or solutions. For example, a community building a new recharge project to address climate change impacts may still be

considering water quality concerns from agricultural runoff. Thus, like most things in water, the results of this analysis are complicated. While the results of *The Water Report (TWR)* analysis may be oversimplified out of necessity, it is interesting to see how hot water topics have come and gone over time.

We hope the key findings and takeaways discussed below are of use to the water community and can aid in informed and impactful action.



## TRENDS IN WATER CHALLENGES OVER TIME

Current water challenges do not differ significantly from those existing 20 years ago. We identified 7 categories of prevalent and critical water challenges. They are listed in order—highest to lowest—based on total number of *TWR* articles covering the topic.

1. Changing federal standards (194 articles)
2. Legal water rights (193 articles)
3. Water quality (159 articles)
4. Tribal water rights (120 articles)
5. Transboundary water management (119 articles)
6. Aging infrastructure (103 articles)
7. Climate change (99 articles)

One significant finding in our analysis is that over the past 20 years discussions about climate change have evolved from being warnings based on theoretical projections to being discourse about real-world impacts. As climate change is being realized, consideration for continued climatic change is being incorporated into nearly every aspect of water resource management and planning. Other findings about these water challenges are discussed in the **Nagging Water Resource Challenges** section below.

## TRENDS IN WATER SOLUTIONS OVER TIME

While the terminology used and the priority for employing water solutions has changed slightly over the past two decades, the categories of solutions have remained relatively consistent. We identified 4 categories of water solutions, listed in order—highest to lowest—based on total number of *TWR* articles covering the topic.

1. Nature-Based Solutions, Low-Impact Design (LID), & Green Infrastructure (182 articles)
2. Water Reuse and Conservation (106 articles)
3. Water Markets and Transfers (94 articles)
4. Data and Technology (63 articles)

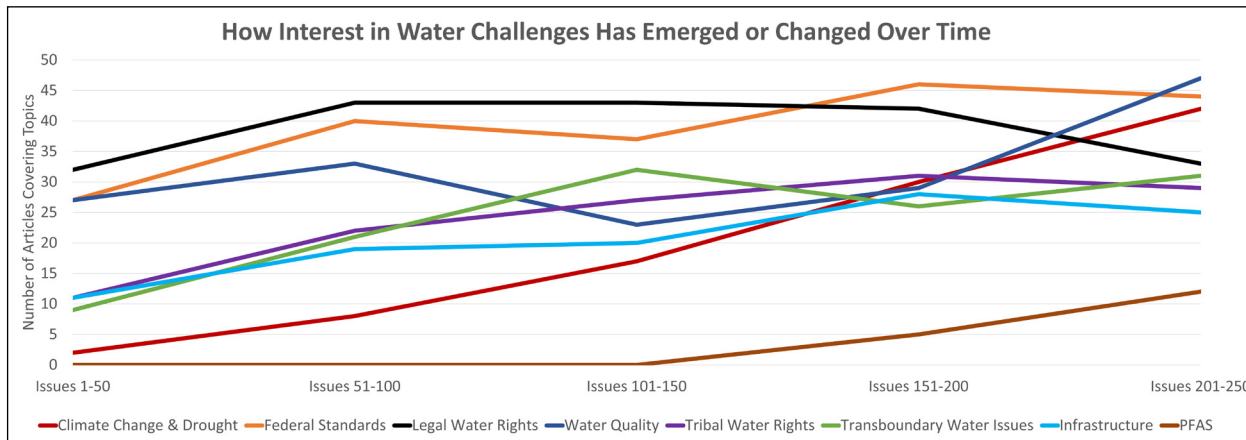
Our analysis showed a transition from a traditional focus on large-scale infrastructure projects to address water challenges towards a more holistic nature-based approach. There was also an increase in the number of articles demonstrating the need for and describing the execution of interdisciplinary collaboration. Other findings about these water solutions are discussed in the **Existing Solutions and Difficulties** section below.

## KEY TAKEAWAYS

- Increasing prominence of climate change (drought, fires, and floods) as a driving factor in water challenges and management.
- Shift from a focus on the establishment of water rights through adjudications to a focus on sustainable management and adaptation.
- Growing importance of California and the Colorado River Basin in the Western water narrative.
- Emergence of new challenges, such as PFAS contamination, that require innovative solutions.
- The importance of quantifying and supporting Tribal water rights.

# Nagging Water Resource Challenges

The water challenges identified in this report are neither novel or surprising. In many cases they are ongoing challenges, that are frequently covered in the news (albeit often described at only a high level). Figure 1 provides a fascinating record of how *TWR* coverage of water challenges has changed throughout the years. The following sections explore, one-by-one, the 7 categories of challenges we identified above. Each section will also identify the first time a ‘nagging challenge’ was reported on and the most recent *TWR* discussion.



**Figure 1 Prevalence of Water Challenges Over Time**  
 Note: Issues 1-50 (Mar 2004-Apr 2008); Issues 51-100 (May 2008-Jun 2012); Issues 101-150 (Jul 2012-Aug 2016); Issues 151-200 (Sep 2016-Oct 2020); Issue 201-250 (Nov 2020-Dec 2024)

## 1. CHANGING FEDERAL STANDARDS: ESA, CWA, AND NEPA

There are numerous local, state, and federal laws and policies that govern water use, and they often contradict each other. At the federal level, regulations remain in flux as laws and acts—such as the Clean Water Act (CWA), Endangered Species Act (ESA), and National Environmental Protection Act (NEPA)—are often revised to suit political changes and new administrations.

Despite the changing political climate, the need to balance the use of water by humans with that required to sustain the environment (e.g., aquatic ecosystems and endangered species) remains essential to preserve the life and health of every living thing. Many *TWR* articles in this category cover the interplay between federal rules and local water management, habitat restoration, and instream flow protections.

A total of 194 articles relate to federal standards, thus demonstrating the importance and impact of these changes, even on a local level. There has been a slight increase in the frequency of discussions around changing federal standards, likely due to the more extreme swings in political ideology seen over the past decade.

**First issue focusing on Federal Standards:** Issue #2 (4/15/2004) featured an article discussing a Supreme Court case impacting waterway-to-waterway transfers, dams, and the National Pollution Discharge Elimination System (NPDES) under the CWA.

**Most recent issue on Federal Standards:** Issue #237 (11/15/2023) featured an article comparing the 2023 EPA regulation for the CWA section 401 water quality certification program to the previous 2020 rule.

## 2. LEGAL WATER RIGHTS: ADJUDICATION AND LITIGATION

Water law is the foundation on which water management, planning, and regulations are built. In the Western US, prior appropriation is the precedent—the principal of “first in time, first in right.” *TWR* focuses primarily on water challenges and solutions in the West that stem from this common legal framework, its contentious nature, and its surprising flexibility. This challenge category captures such topics as water adjudication, state compact disputes, and Supreme Court cases.

Coverage of water-related litigation and its impact on policy remains a high-priority. In the past 20 years, a total of 193 articles in *TWR* have been written about water law.

**First issue focusing on Water Law:** Issue #1 (3/15/2004) featured the first article on adjudication for the Edwards Aquifer. The first article on litigation was in Issue #6 (8/15/2004). It discussed the ‘takings’ clause under the fifth amendment and implications for the water industry.

**Most recent issue on Water Law:** Issue #244 (6/15/2024) featured the most recent article on adjudication for the Nooksack River. The most recent article about water litigation was in Issue #246 (8/15/2024). It described the implications of the *Chevron* Supreme Court decision for the water industry. Another article in that issue shared an update on *Texas v. New Mexico and Colorado*.

## 3. WATER QUALITY: NUTRIENTS, PFAS, AND EMERGING CONTAMINANTS OF CONCERN

Pollution from various sources (agricultural runoff, urban stormwater, industrial discharges, legacy contamination) poses a significant threat to water quality. To address risks to public health, the federal government set up national standards for discharging water. In addition, many states have established their own regulations to reduce the risks associated with poor water quality. Articles under this umbrella category of Water Quality cover a wide range of pollutants, including nutrients (nitrogen and phosphorus), sediments, pesticides, heavy metals, emerging contaminants (e.g., PFAS, PPD-Q, pharmaceuticals, microplastics), and the impacts of temperature.

Awareness about PFAS—a category of contaminants that have vast negative health implications—has emerged in the last decade. Chemicals under the PFAS umbrella are ubiquitous, difficult to break down chemically, and are notoriously expensive to eliminate. We included PFAS as a separate category in the water challenges graph (see Figure 1) to show how quickly interest in PFAS has developed. It is also included in the water quality category which may account, in part, for the drastic increase in interest over the past 7 years. Of the total 159 articles written on the topic of water quality, 17 have focused on PFAS.

**First issue focusing on Water Quality and PFAS:** Issue #2 (4/15/2004) was the first to discuss water quality. It featured an article on Oregon's EPA-approved standards for temperature, inter-gravel dissolved oxygen, and antidegradation. Issue #177 (11/15/2018) documented Congressional Hearings on PFAS, sharing excerpts from US House of Representatives and Senate Committees about the concerns regarding these ubiquitous "forever chemicals."

**Most recent issue on Water Quality and PFAS:** The most recent discussion of water quality was an article in Issue #247 (9/15/2024) discussing nitrate contamination and management in the state of Nebraska. Issue #248 (10/15/2024) featured an article about the regulatory and legal landscape surrounding PFAS in biosolids. It described the steps publicly owned treatment works can take to mitigate risk and potential liability.

## 4. TRIBAL WATER RIGHTS

Tribal water rights are a fundamental component of the US water landscape but they have often been unfairly overlooked in water management discussions and plans despite such rights frequently being senior to other water rights under prior appropriation.

Articles in this category cover topics including tribal water rights settlements, litigation, the federal government's trust responsibility, and the role of tribes in water management.

**First issue focusing on Tribal Water:** Issue #14 (4/15/2005) featured an article discussing disputes in New Mexico between the State and Tribal sovereigns regarding the quantification, nature, and administration of Tribal water rights.

**Most recent issue on Tribal Water:** Issue #235 (9/15/2023) featured an article about the *Arizona v. Navajo Nation* decision and implications for the Tribe.

## 5. TRANSBOUNDARY WATER MANAGEMENT

Water does not recognize legal boundaries. The fact that most watersheds and groundwater basins cross multiple jurisdictional boundaries (local, state, and federal) makes managing water use exceptionally difficult. For this reason, river and groundwater basins are a common topic in **TWR**. We estimate that approximately 40 Western river basins or sub-basins and 20 specific groundwater basins have been discussed in articles over the years.

Competition for water resources across state boundaries is particularly prevalent, as demonstrated by frequent disputes and litigation in the Colorado, the Rio Grande, the Columbia, and the Snake River basins. There has been a total of 119 **TWR** articles written on this subject.

**First issue focusing on Transboundary Water Management:** Issue #13 (3/15/2005) featured an article on the Rio Grande River and its watershed. It discussed large infrastructure projects (e.g., the Rio Grande project), the Texas adjudication process which impacted total water deliveries, and conjunctive management of water within the river system.

**Most recent issue on Transboundary Water Management:** Issue #243 (5/15/2024) offered a deep dive into water management in the Middle Rio Grande in New Mexico (agricultural use, environmental concerns, and Tribal rights) and the Rio Grande Compact between Colorado, New Mexico, and Texas.

## 6. AGING WATER INFRASTRUCTURE

The American Society of Civil Engineers creates a yearly report card to rate the health of American infrastructure. As of 2024, the US was awarded a “C minus”, due to in part to the frequency of water main breaks and the poor condition of levees across the country. Many water systems in the West rely on aging infrastructure that is in need of repair or replacement. The challenges of funding infrastructure upgrades, building new infrastructure to meet growing demands, and adapting existing infrastructure to adapt to climate change impacts are topics regularly covered in *TWR*.

As infrastructure has aged, interest in and coverage of this topic has increased. A total of 103 articles have been about US water infrastructure.

**First issue focusing on Aging Infrastructure:** Issue #37 (3/15/2007) had an article about aging dams and the concept of leveraging mitigation credits to make decisions regarding dams that are both environmentally and economically beneficial.

**Most recent issue on Aging Infrastructure:** Issue #250 (12/15/2024) had an article describing a new modeling approach to help utilities with limited resources classify lead pipes present in their systems.

## 7. CLIMATE CHANGE: DROUGHTS, FIRES, AND FLOODS

The term ‘climate change’ captures a wide range of water-related issues, including altered precipitation patterns (e.g., more intense storms, and longer droughts), reduced snowpack, earlier snowmelt, increased evapotranspiration, sea level rise, and increased frequency and intensity of extreme weather events (e.g., floods and wildfires).

Articles in *TWR* classified under this category consistently highlight the need for adaptive management strategies, resilient infrastructure, and the incorporation of climate projections into water planning. Discussion of climate change has grown dramatically over the 20-year period, indicating an increasing awareness of its importance. A total of 99 articles were written specifically about climate change, although countless other articles addressing water challenges also refer to the impacts of climate change.

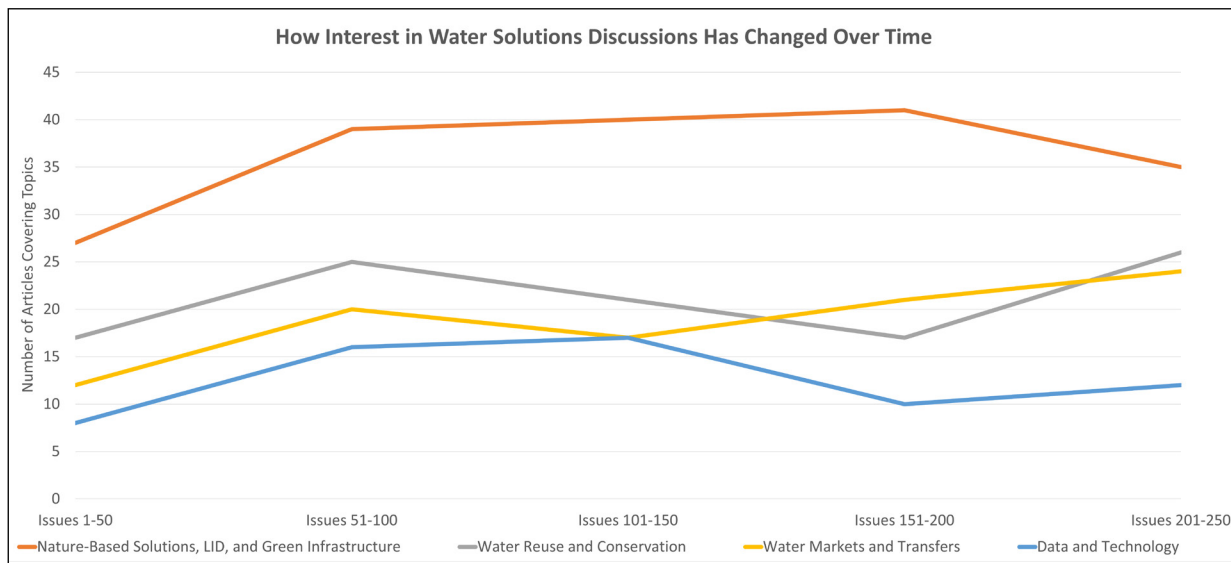
**First issue focusing on Climate Change:** Issue #56 (10/15/2008) featured an article discussing a technical paper written by the Intergovernmental Panel on Climate Change (IPCC) that warned water users in the Western US to prepare for changes due to decreased water availability.

**Most recent issue on Climate Change:** Issue #248 (10/15/2024) summarized a technical paper written by the Northwest Climate Resilience Collaborative’s Tribal Coastal Resilience Portfolio describing the needs of Tribes and the barriers they faced when trying to adapt to a changing climate.

# Existing Solutions and Difficulties

Water professionals work hard every day to address water challenges. Solutions that arise from these efforts are often region-specific and frequently employ multiple tactics simultaneously to address complex problems. Our analysis has shown that there has been increasing efforts to find holistic solutions that have multiple system benefits and incorporate environmental values. We have combined three different approaches into one category to account for this trend: nature-based solutions, low-impact design, and green infrastructure. There has been consistent coverage of this solution over the years. One solution category that has increased in coverage is water reuse and conservation (see Figure 2). We also found that solutions coalesced into articles discussing two other key topics: water markets and transfers; and, data and technology. An in-depth assessment of trends for these 4 solution categories is shared below.

While solutions continue to emerge and evolve, they often share two similar difficulties: finding funding and getting public/political buy-in. Educating the public has a large role to play in implementing water solutions, because a well-designed solution will still fail if it is not publicly or politically accepted.



**Figure 2 Prevalence of Water Solutions Over Time**

Note: Issues 1-50 (Mar 2004-Apr 2008); Issues 51-100 (May 2008-Jun 2012); Issues 101-150 (Jul 2012-Aug 2016); Issues 151-200 (Sep 2016-Oct 2020); Issue 201-250 (Nov 2020-Dec 2024)

## 1. NATURE-BASED SOLUTIONS, LOW IMPACT DESIGN, AND GREEN INFRASTRUCTURE

Nature-based solutions are actions that protect, restore, or manage natural ecosystems to address societal challenges. Low-impact design (LID) techniques include green infrastructure, permeable pavements, rain gardens, and bioswales. Green infrastructure uses natural systems to improve the environment and reduce the impact of stormwater runoff. These are broad-brush definitions used for purposes of this retrospective analysis and many more nuances exist for each of these three categories of solutions.

Overall, using natural systems and processes to address water management challenges is an impactful way to make positive change. Some techniques include restoring wetlands, forests, and floodplains to improve water quality, reduce flood risk, enhance groundwater recharge, and provide habitat. There has been steady coverage of these holistic water solutions (*see* Figure 2). **TWR** has published a total of 182 articles on topics that fall under this category.

**First issue focusing on Nature-Based Solutions:** Issue #48 (2/15/2008) featured an article outlining opportunities for action in an era of growth and climate change. Recommendations included, integrated water planning, enhancing streamflow programs, and promoting watershed-scale efforts.

**Most recent issue on Nature-Based Solutions:** Issue #244 (6/15/2024) featured an article explaining how a carbon market funding mechanism could support water utilities executing large watershed and source water protection projects.

## 2. WATER REUSE AND CONSERVATION

Reducing water demand through improved efficiency in all sectors (municipal, agricultural, industrial) is a critical and cost-effective solution. This includes using technologies such as efficient irrigation systems and leak detection, as well as changing public behavior and installing water-wise landscaping.

Another approach to better utilize existing resources is treating wastewater to a high standard and using it for non-potable (and increasingly potable) purposes is a way to augment water supplies, particularly in water-scarce regions.

There has been an increase in coverage of both of these techniques as communities seek ways to better leverage limited water resources. More recently, the concept of using advance purified wastewater—also known as direct potable reuse—as a new drinking water source has become more popular. There continues to be a tension between those who want to see water used more efficiently and those who advocate for new water sources and water augmentation. In the end, there are merits for both approaches despite differences in cost. **TWR** has published 106 articles written on these topics.

**First issue focusing on Water Reuse and Conservation:** Issue #4 (6/15/2004) featured an article about lessons learned from recycling water in California. Lessons included the importance of garnering support from elected officials, communicating clearly and effectively with communities, and identifying potential partners.

**Most recent issue on Water Reuse and Conservation:** Issue #236 (10/15/2023) had an article that discussed best practices and considerations for communicating potable reuse efforts to the public.

### 3. WATER MARKETS AND TRANSFERS

Water markets have long been explored as mechanisms to more accurately value water by allowing it move to where it is most highly valued. Creating frameworks for voluntary water transfers, either permanent or temporary, can address scarcity and help reallocate water to higher-value uses. The term 'water market' can refer water banks, leasing arrangements, and other creative market-based transactions.

This topic has been growing in interest and coverage in the past decade as more communities put theory into practice. *TWR* has published 94 articles on this topic.

**First issue focusing on Water Markets:** Issue #4 (6/15/2004) contained two articles on water markets, one on Texas water markets and transfers and a second on a groundwater transfer tool used in the Snake River basin.

**Most recent issue on Water Markets:** Issue #249 (11/15/2024) featured an article about a new market framework being utilized in southeastern Colorado that supported transactions benefiting both agricultural users and the environment.

### 4. DATA AND TECHNOLOGY

Technology is often viewed as the ultimate solution to our challenges. While it is not a panacea for the water industry, data gathered through new technologies is often very useful in supporting a variety of solutions. Collecting, aggregating, and analyzing water data has huge potential to improve water management, thus, it is an ongoing endeavor. Topics in this category include remote sensing, real-time monitoring, data platforms, modeling, and decision-support tools.

There has more recently been an uptick in coverage of this topic, likely due to technology advancing faster than ever before. Besides ongoing advancement in water treatment technologies, as AI improves, there will likely be accelerated benefits for the water industry. We continue to track these new developments. There have been 63 articles written about data and technology in *TWR*.

**First issue focusing on Data and Technology:** Issue #9 (11/15/2004) shared an article about a regional data exchange network called the Pacific Northwest Water Quality Data Exchange, established by the EPA. The goal was to share data using the internet to improve understanding of water resources across the region.

**Most recent issue on Data and Technology:** Issue #250 (12/15/2024) had an article discussing a new wastewater treatment technology that used algae to address nutrient pollution.

# Recommended Solution

Because they are so complex, water challenges cannot be solved in isolation. For example, community-level water issues resulting from drought, poor water quality, groundwater depletion, risk to endangered species, and the need for new infrastructure are all connected and cannot be addressed by solving just one problem (i.e., only building a new well). Employing a framework that gathers support from multiple stakeholders and integrates multiple approaches can result in holistic, water cycle-scale improvements that benefit different water uses and users. Collaboration among diverse stakeholders (e.g., government agencies, tribes, water users, environmental groups, the public) is essential to find these solutions and ensure that they are both effective and equitable.

Based on this retrospective analysis we recommend that the most effective solution will always be improving collaboration and communication. Many articles in *TWR* have been written by multiple authors because the topics covered have required multiple perspectives. Mountains are moved when water professionals from different backgrounds work together. Check out a few case studies of success below.

## STORIES OF SUCCESS

### Collaboration on Legislation: The Creation, Passing, and Implementation of New Stream Restoration Legislation in Colorado

Before 2023, Colorado's water laws did not sufficiently accommodate the ecological and public benefits of stream restoration. The state's strict prior appropriation system, which grants water rights based on seniority, raised questions about restoration efforts aiming to restore natural stream functions. Colorado's Department of Natural Resources, the Colorado General Assembly, conservation organizations, restoration practitioners, and the water community took on the challenge of considering the balance between stream restoration's large-scale benefits relative to the potentially small impacts to water rights. The result was bipartisan Senate Bill 23-270 titled *Projects To Restore Natural Stream System* (SB2-270). SB23-270 created an exemption to obtaining a water right for certain types of stream restoration projects that was added to the many other statutorily created exemptions under Colorado Revised Statute (CRS) 37-92-602(9). To support the bill, a training program was developed to educate stakeholders about changes in SB23-270 and empower them to leverage it for their own projects. Stream restoration projects are now underway.

## Collaboration for River Management: The Water Management Community in the Middle Rio Grande

The “Middle Rio Grande Valley” is the stretch of river through the central part of the state from the ancient Native American community of Cochiti, where the Rio Grande emerges from the canyons to the north, to the century-old Elephant Butte Reservoir in the south, one of the nation’s first Bureau of Reclamation (Reclamation) dams. The Middle Rio Grande’s governance structure is “polycentric,” with interlocking government agencies responsible for various aspects of water management but often lacking centralized authority over the entire system. Adaptation—the strategies, actions, and initiatives undertaken by various stakeholders—in the Middle Rio Grande takes many forms from innovative water management practices and collaborative governance approaches to targeted conservation programs and infrastructure improvements. By proactively adapting to the challenges posed by climate change, population growth, and competing water demands, the region’s water managers, farmers, municipalities, and other stakeholders are working together to build a more resilient future for the Middle Rio Grande’s unique and precious agricultural-urban-ecosystem. One example is a pilot conservation program for the agricultural sector with the goal to reduce irrigated acreage through compensated temporary fallowing, shifting the conserved water strategically to habitat in the Rio Grande’s main channel. The program, which began in 2019, is a partnership with Reclamation and the National Fish and Wildlife Foundation.

## Collaboration for Watershed-Scale Funding: Delivering Results at Scale

Technology is now available to identify, target, and implement conservation actions at the scale necessary to secure resilient watersheds. The challenge has become how to quickly organize and deploy available funding to produce the best outcomes. The potential to use multiple programs to reinforce funding is often splintered, with each program focused on a sliver of the problem. One solution is to reassemble these currently disparate efforts into a collective watershed-wide investment approach. With watershed analytics, both water agencies and water users can effectively quantify the “outcomes” of projects using measurements such as: gallons of water saved; tons of carbon sequestered; or pounds of excess nutrients avoided. One example is how funding from the Inflation Reduction Act (IRA) was added to US Department of Agriculture (USDA) conservation programs. “Climate-smart” projects that directly improve soil carbon, reduce nitrogen losses, or sequester carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), or nitrous oxide (N<sub>2</sub>O) emissions (collectively greenhouse gases, or GHGs) were included, after lobbying, into the USDA Natural Resources Conservation Service’s (NRCS) Climate-Smart Agriculture and Forestry Mitigation Activities List. Adding irrigation modernization practices benefited rural communities’ long-term water resilience, enhanced domestic food supply, and supported a healthy environment for the future.

# About The Water Report

Each issue of The Water Report features 2-4 in-depth articles written by subject-matter experts on specific water challenges and/or solutions. **TWR** is the only publication of its kind offering news and knowledge across every water sector: law, policy, environment, climate change, markets, infrastructure, energy, agriculture, reuse and more. We believe that sharing insights across these often-siloed sectors accelerates solutions.

## WHO WOULD BENEFIT FROM READING THE WATER REPORT?

- **Engineers:** Interested in discussions about infrastructure needs, innovative technologies (desalination, water reuse, ASR), and nature-based solutions.
- **Scientists:** Interested in the coverage of climate change impacts, water quality issues, emerging contaminants, and the role of data and technology.
- **Lawyers:** Interested in the analysis of key legislation (SGMA, Farm Bills, IIJA), the WOTUS debates, ESA litigation, tribal water rights, and interstate water compacts.
- **Policymakers:** Interested in the overall trends in water management, the challenges facing different regions, and the potential solutions being explored.
- **Planners:** Interested in integrated water resources management, land use planning, and climate change adaptation.
- **Tribal Professionals:** Interested in the consistent coverage of tribal water rights, settlements, and the federal trust responsibility.

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