ARROYO 2024

SOLUTIONS TO ARIZONA'S WATER CHALLENGES: WHAT CAN WE DO?

Authors: Courtney Lee, Austin Bauer, and Susanna Eden
Layout: John Polle
Executive Publisher: Sharon B. Megdal
Cover Photo: Stephen Cumberworth – Rainfell; Tucson, AZ, WRRC Photo Contest

INTRODUCTION

Water resources in Arizona are under stress from climate change, a two-decade megadrought, and chronic overuse. These combined influences have led to surface water losses, drying streams and wetlands, and groundwater depletion as pumping exceeds replenishment. Communities are facing the possibility that the water sources they rely on now may shrink in the future, or even vanish. Uncertainty regarding Colorado River water — a large component of Arizona's water portfolio and one that is shared with six other US basin states — also raises questions about Arizona's water future. The quality of available water is a concern as well. Where supply is limited, lower quality water and wastewater can be valuable resources, but only if they can be treated to suitable standards. **These concerns beg the question: What can be done?**

That very question was the focus of the Water Resources Research Center's 2023 annual conference, "What Can We Do? Solutions to Arizona's Water Challenges." Panelists and presenters highlighted ongoing efforts to address the state's water challenges, as well as new and innovative solutions currently under development. During the conference, several additional themes emerged, such as the need for better, more accessible data, improved technology, and collaboration.

THE UNIVERSITY OF ARIZONA COOPERATIVE EXTENSION
WATER RESOURCES RESEARCH CENTER

The *Arroyo* is published by the Water Resources Research Center
Cooperative Extension, University of Arizona
350 N. Campbell Ave., Tucson, Arizona 85719; **Phone:** 520-621-9591
Email: wrrc@arizona.edu; **Website:** wrrc.arizona.edu

Drawing from the 2023 annual conference, this *Arroyo* explores themes of water supply and quality, conservation, technological innovation, data, collaboration, funding, and workforce development. It provides an overview of the challenges facing Arizona's water supplies and specific solutions discussed during the conference, including ongoing, new, and emerging ideas, applications, and examples.

Panel discussion at the 2023 WRRC Conference. Source: Clayton B. Lyon

SUMMARY OF CHALLENGES

Arizona relies primarily on four sources for its water needs: groundwater, the Colorado River, in-state rivers and streams, and reclaimed water. According to the Arizona Department of Water Resources (ADWR), a large portion of the water used in Arizona comes from groundwater stored below the earth's surface in aquifers. While percentages have fluctuated over the years, groundwater was estimated to provide around 41% of water used in the state in 2020. The second largest source of water has been the Colorado River, which in the same year made up around 36% of the state's water supply. In-state rivers and reclaimed water constituted another 18% and 5% of the state's water, respectively. Arizona's diverse water portfolio has served it well over the years, but the state now faces significant challenges.

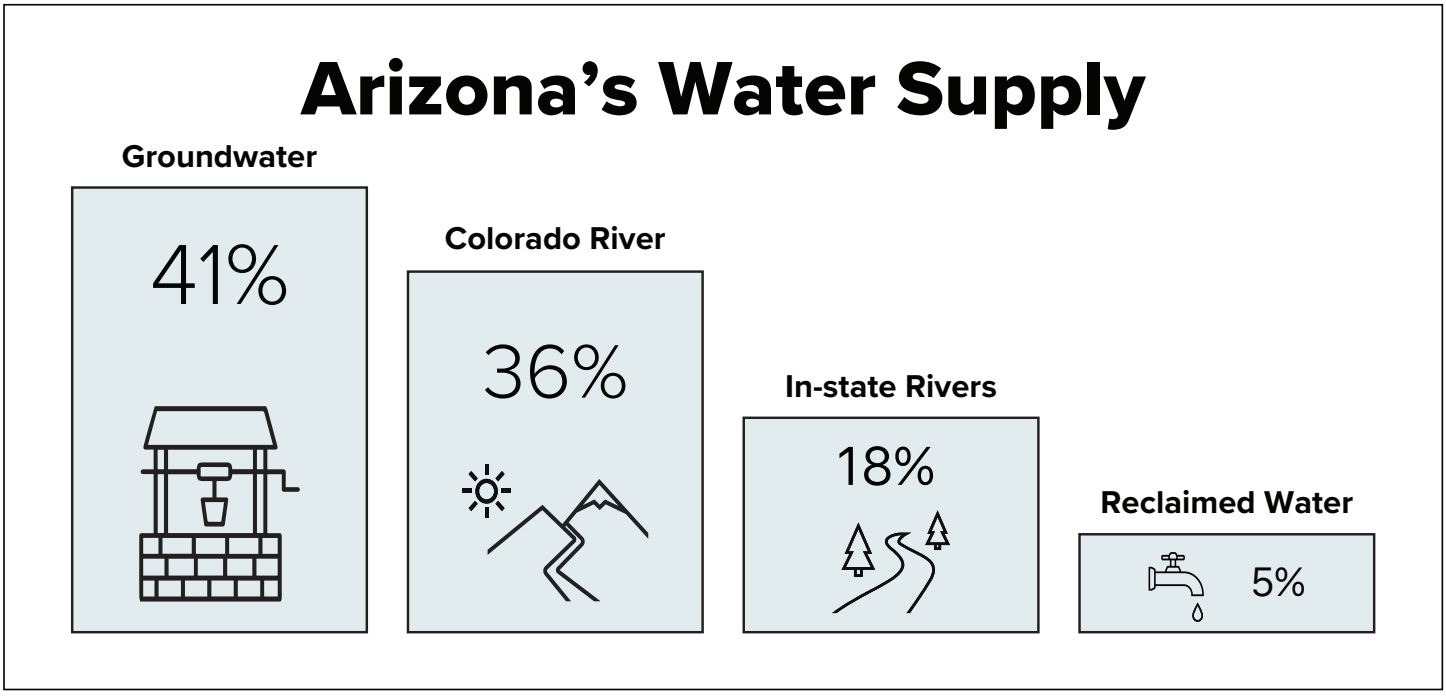
Although groundwater is often seen as a reliable resource, that perception may not hold true in the future. Groundwater pumping has increased over the years in an attempt to keep up with the needs of Arizona's growing population and economy. Since enactment of the 1980 Groundwater Management Act (GMA) and subsequent related water legislation, groundwater management has moderated use in the groundwater-dependent areas of Arizona designated for active management. Active Management Areas (AMAs) contain most of Arizona's population and roughly half of the state's irrigated agricultural land. The GMA also designated several Irrigation Non-Expansion Areas (INAs), where the number of acres of irrigated agriculture is capped.

Outside of AMAs, groundwater in Arizona is largely unregulated, although many rural areas rely on it as their main source of water. Overreliance and overuse threatens communities where groundwater levels are falling. Already, levels have dropped below the drilled depth of many domestic wells, forcing residents to choose among well deepening, well relocation, hauling water, or relocating. The decline in groundwater levels also negatively impacts Arizona's environment. For instance, water in rivers, streams, and springs can be drawn down until it no longer flows on the surface. The loss of surface flows can harm natural habitats and communities that rely on them for a range of uses.

Groundwater is naturally replenished, or recharged, when water from rain or melting snow sinks below the earth's surface and collects underground. However, natural groundwater recharge takes time and may not be sufficient to offset pumping. Much of the groundwater used today in Arizona was recharged naturally thousands of years ago. To assist and supplement natural recharge, there are artificial or man-made methods for storing water underground. For many years, recharge projects have been storing excess Colorado River water and reclaimed water — highly treated wastewater — in aquifers.

Uncertainty also exists about the future availability of Arizona's other major water resource — the Colorado River.

As climate change and 20 years of drought continue to affect the Southwest, annual flows in the already over-allocated Colorado River have been lower than the long-term average. This impacts not only Arizona but also the six other states and Mexico that share Colorado River water. Declines in the Colorado River's two largest reservoirs—Lakes Mead and Powell—have led to decreases in state water



Water Supply Sources in Arizona. Source data: ADWR, image by Courtney Lee, WRRC

allocations in recent years and have increased the urgency for collective conservation action.

Smaller, non-Colorado River surface water sources, such as rivers and streams, also are threatened. According to The Nature Conservancy of Arizona, many of the state's formerly perennial streams no longer flow year-round due to climate change, human-made diversions, and excessive groundwater pumping. Climate change introduces increased uncertainty. Precipitation is expected to be more variable in terms of storm frequency and intensity. Temperatures are projected to rise, causing water demand, both natural and human, to increase. These changes can have broad, negative impacts on communities and natural environments.

Beyond the reliability of Arizona's water resources, water quality is also a major concern. Federal and state governments have set water quality standards to protect the health and safety of people and the natural environment, although the regulatory safety net has gaps. A range of contaminants, including industrial chemicals, heavy metals, agricultural runoff containing fertilizers and pesticides, and bacteria, currently affect Arizona's water quality and can lead to serious health and environmental impacts. One group of contaminants that is garnering special attention in Arizona and other states is PFAS (per- and polyfluoroalkyl substances). These so-called forever chemicals are man-made chemicals with water-and grease-resistant properties that have been manufactured and used by various industries and added to consumer products since the 1940s. These chemicals persist in surface and groundwater systems due to their strong chemical bonds and continue to pose a significant risk of adverse health effects.

Many of the challenges facing Arizona's water resources often are complicated, interconnected and simultaneous problems all in need of attention. While solutions may exist, developing and implementing them can be hampered by limited funding, manpower, and other supporting resources. Further, data gaps, lack of data, and the inability to share data also can impede efforts to find solutions.

Water is a precious resource, and every drop counts in the arid Southwest. Consequently, numerous projects have been proposed to tackle the complicated array of water-related challenges facing Arizona. Proposed projects address water conservation, availability, and quality, among other solution pathways. Cumulatively, these approaches involve statewide regulations and programs, agricultural and industrial changes, and localized projects guided by municipalities.

ACTIONS BY ARIZONA'S WATER AGENCIES

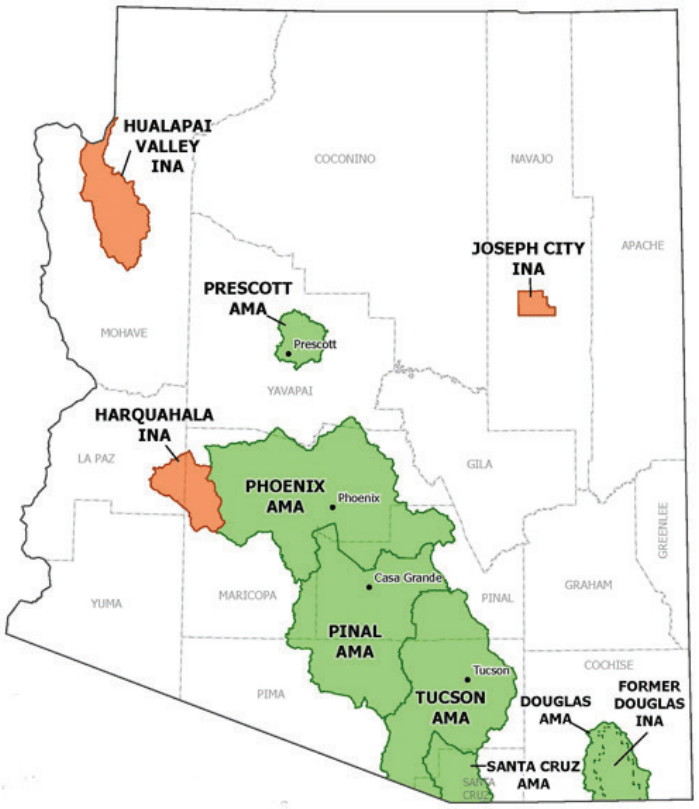
Arizona Department of Water Resources

The keystone department on the frontlines of dealing with the state's water supply challenges is the Arizona Department of Water Resources. This department is tasked with protecting, conserving, and enhancing Arizona's water supplies. ADWR has multiple programs to help achieve these goals, ranging from Colorado River management to drought preparedness.

One of the department's chief responsibilities discussed during the 2023 conference was the regulation of Active Management Areas and Irrigation Non-Expansion Areas. Created by the Groundwater Management Act of 1980 in response to groundwater overdraft, these areas are the focus of requirements and regulations intended to protect the groundwater supply in areas of the state where overdraft was most problematic. The original AMAs included 90% of the state's population and excluded most of rural Arizona.

In INAs, the development of new irrigated land is prohibited, and groundwater withdrawal levels must be reported to ADWR annually. The AMA's are the most highly regulated areas in the state and are guided by an area-specific management goal. The management goal of three of the six AMAs is safe-yield, a condition in which groundwater withdrawals are balanced by groundwater recharge on an annual basis. In addition, according to the Assured Water Supply Program, within AMAs anyone planning to develop property by building and selling six or more new homes must demonstrate the availability of enough water to support the development for 100 years.

The Groundwater Management Act of 1980 initially created four AMAs and two INAs, but those numbers have slowly increased. The Harquahala INA was created in 1981, and in 1994, the Santa Cruz AMA was split out of the Tucson AMA. In December 2022, the Douglas INA became an AMA, and the Hualapai Valley INA was established. The 2022 changes mark the first time since the early 1980s that regulated areas expanded in the state, signaling growing concern over rural groundwater supplies.



Arizona's Active Management Areas and Irrigation Non-Expansion Areas.
Source: ADWR

The Groundwater Management Act is often lauded by water policy experts as a far-reaching and innovative way to regulate the state's groundwater. In the 40-plus years since it passed, however, conditions have changed, revealing flaws in the original legislation and new challenges.

In January 2023, Arizona Gov. Katie Hobbs created the Governor's Water Policy Council through executive order. The council was tasked with providing recommendations to update, revise, and improve Arizona's water management framework, including the GMA. In November 2023, the council provided a set of recommendations to Hobbs, including suggestions on how to improve the Assured Water Supply Program and a framework for establishing rural groundwater management areas.

Arizona Department of Environmental Quality

The Arizona Department of Environmental Quality (ADEQ) is tasked with protecting and enhancing public health and the environment within the state. The department's responsibilities are informed by both state and federal environmental regulations, including guidance from the federal Environmental

Protection Agency (EPA). Water quality is a key component of ADEQ's oversight responsibilities.

One of ADEQ's water-related functions discussed during the 2023 conference was ensuring the quality of water reaching Arizona residents through public water utilities. The state's Monitoring Assistance Program (MAP) helps small drinking water systems collect, analyze, and report on regulated contaminants such as nitrate, nitrite, asbestos, and inorganic contaminants, assisting in compliance with the federal Safe Drinking Water Act. Public water utilities (except those that are state or federally owned) serving fewer than 10,000 people are required to participate in MAP, while larger systems may opt in.

Combating unregulated contaminants is also an ADEQ priority. PFAS, mentioned previously, are one group of contaminants under scrutiny. They are environmentally durable chemicals that have become widespread in surface waters and groundwater. Some studies in humans have shown that certain PFAS may interfere with the body's natural hormones and increase the risk of cancer, among other potential health effects. The EPA requires public water systems serving 3,300 or more customers to test for PFAS under its Unregulated Contaminant Monitoring Rule. In March 2023, the agency announced its proposed National Primary Drinking Water Regulation, which would regulate six PFAS compounds in drinking water. Complying with any new PFAS drinking water regulations will be a challenge for smaller water utilities, and MAP may help. Meanwhile, many of Arizona's 1,500 public water systems have far fewer than 3,300 customers and fall outside EPA's unregulated contaminant monitoring rule. Helping to close this gap in PFAS testing, ADEQ has been using $3 million in federal Safe Drinking Water Act funds to test for PFAS in smaller systems at no cost to them. A link to the map detailing PFAS testing information in Arizona can be found in the additional resources section at the end of this *Arroyo*.

ADEQ is also supporting efforts to bolster Arizona's drinking water portfolio through safe water reuse. Tested and verified advanced water purification (AWP) practices are essential to ensure the safety of potable (safe to drink) reuse. AWP is a combination of treatment methods that removes contaminants from wastewater to produce potable water. In 2023, ADEQ completed a rulemaking process to define AWP requirements and establish a framework for AWP permitting. Once implemented, the new rules will assist communities looking to use reclaimed water as an additional source of clean drinking water.

In addition to its drinking water protection responsibilities, ADEQ is responsible for protecting the quality of surface water and groundwater. For surface water, ADEQ implements programs to comply with the federal Clean Water Act. This federal legislation protects surface water quality across the US for bodies of water considered to be "waters of the United States" (WOTUS). A final definition of WOTUS remains elusive, however, as definitions have been proposed, challenged, and revised over successive federal administrations. Litigation over this issue likely will continue for years to come, making it difficult for states to know how to comply with the Clean Water Act. Nevertheless, Arizona has taken steps to protect the state's surface water quality. In 2021, Arizona lawmakers passed legislation allowing ADEQ to create a state Surface Water Protection Program. The new law gives ADEQ the authority to decide which waters it will protect, regardless of how WOTUS is defined.

The federal Clean Water Act does not regulate groundwater. With that in mind, shortly after its establishment in 1986, ADEQ created the aquifer protection program to ensure that groundwater quality would meet aquifer water quality standards. As part of this program, an aquifer protection permit is required for any facility, such as a mining operation or a sewage treatment plant, that discharges pollutants to an aquifer. A permit is also required if pollutants are discharged onto a land surface where it's probable that the pollutant will reach an aquifer.

MAKING EVERY DROP COUNT: MUNICIPAL AND AGRICULTURAL CONSERVATION

Soil, Irrigation, and Grazing Management for Water Efficiency

Agriculture is by far the largest consumer of Arizona's water resources. Agricultural use accounts for approximately 70% of the state's available water supply, although this estimate fluctuates from year

Flood irrigation in Safford.
Source: Rachael Lewis, WRRC Photo Contest 2017

to year. Because of the sector's outsized impact on water consumption, agriculture is one area where even modest boosts in water conservation could result in meaningful water savings.

Over the years, various investments in more efficient irrigation infrastructure; new land and soil management and grazing strategies; smarter and enhanced technologies; and crop research have improved water conservation, and advanced innovative solutions. Irrigation with systems like center pivot, micro sprinklers, and drip use less water than older irrigation methods such as flood irrigation, although flood irrigation may be optimal for specific purposes, such as managing soil salinity. Research continues on these alternative irrigation methods to see how effective they can be and how much water can be saved while maintaining or even improving crop yields.

The traditional practices of some of Arizona's Native American Tribes can offer an alternative to standard irrigation. Ak Chin (translated to mean mouth of the wash) farming is a form of dryland farming based on capturing rainwater for irrigation. Essentially, this method uses a series of raised ridges, sunken plant beds, slopes, and/or ditches to capture rainwater then deliver it to crops. This practice can also be used to capture a large amount of rain that falls in a short amount of time, such as during Arizona's monsoon. In the right locations, Ak Chin farming can be used when communities lack access to wells and other irrigation infrastructure. The Ajo Center for Sustainable Agriculture, a Native American governed non-profit that provides agricultural education, practices Ak Chin farming.

Changes in grazing management can improve soil health, and the management of soil health can save water. Conventional grazing, which involves keeping a herd dispersed over large plots of land for an extended time, often damages soil structures and reduces the soil's ability to hold water. New research on alternative grazing management strategies indicates that keeping grazing animals in a smaller area for shorter time periods can protect or even improve soil health. Research on this grazing system in Cochise County, part of a Cochise Conservation Recharge Network and WEST Technologies Inc. collaboration, shows reduced compaction and increased soil organic matter

Cattle quenching their thirst in Rimrock.
Source: David Shafer, WRRC Photo Contest 2017

both of which improve soil water absorption and holding capacity. This grazing system also reduces water pooling on the land surface and consequent evaporation, enhancing water recharge.

Municipal Water Supply Strategies and Conservation

Municipal water use (including residential, commercial, and institutional uses) accounts for about 20% to 24% of Arizona's water demand. The key responsibility for municipal water providers is service reliability. Drought and Colorado River uncertainties are prompting cities to reexamine their water supply strategies. To ensure demands can be met, municipalities are improving plans for coping with drought and shortage, while implementing new conservation efforts. The 2023 conference highlighted efforts of the following municipalities in portfolio planning and conservation initiatives.

Cave Creek wastewater treatment plant site for planned Advanced Water Purification plant. Source: Phoenix Water Services

City of Phoenix Water Services is the largest potable water provider in Arizona with around 1.7 million customers. Phoenix's water service is planning for Advanced Water Purification and has proposed four possible locations in its service area. Two facilities considered for advanced treatment are the Cave Creek Water Reclamation Plant and the 91st Avenue Wastewater Treatment plant.

At the Cave Creek plant, Phoenix Water Services plans to upgrade treatment to produce water that meets or exceeds drinking standards. In early 2026, the utility plans to use the treated water for indirect potable reuse; that is, treat the water to potable standards and store it in a reservoir or aquifer for later use. Treated water from the Cave Creek facility will be recharged. After two years of operation, the utility plans to convert to direct potable reuse with permits from ADEQ. By that time, ADEQ's AWP rules should be in place.

Phoenix has supported ADEQ's proposed AWP Roadmap. The roadmap serves as a resource for stakeholders to gain understanding and anticipate what will be required for AWP permits. ADEQ anticipates implementing the permitting process by the end of 2024. The 91st Avenue treatment plant, offers a larger-scale opportunity. Treating an average of 140 million gallons of wastewater per day, the 91st Avenue facility is one of the largest wastewater treatment plants in the Southwest. It is co-owned by Phoenix, Scottsdale, Mesa, Tempe, and Glendale and is operated by Phoenix Water Services. The interconnected piping to and from this plant could allow for regional participation in an AWP project. The 91st Avenue facility treats enough water to develop a new potable supply, while continuing to supply reclaimed water to the Palo Verde Generating Station, a nuclear power plant located near Tonopah, Arizona.

Scottsdale Water already employs AWP technology. The city worked intensively with ADEQ to obtain the necessary permits, and as of the beginning of 2024, was the only facility in the state permitted for potable water reuse. The system recharges AWP water into the local aquifer before delivery and is used for demonstration purposes. Since 2006, Scottsdale Water has withdrawn less water from the ground than it has recharged. While projections suggest the city will be using more groundwater in the future, the incorporation of reclaimed water into its potable water portfolio has effectively eased pressure on the resource by reducing the city's reliance on groundwater.

Tucson, Arizona's second largest city, also has revisited its supply strategy in the wake of Colorado River uncertainties. In October 2023, the Tucson City Council officially adopted the Tucson One Water 2100 Plan. This plan will guide Tucson's water infrastructure and conservation policies for the next 77 years. Goals described in the plan include reducing the city's reliance on Colorado River water, continuing groundwater recharge and long-term storage, and, uniquely, expanding rain and stormwater harvesting.

Green stormwater infrastructure in Tucson. Source: Tucson Water

Tucson Water has developed a Green Stormwater Infrastructure (GSI) program called Storm to Shade. GSI consists of landscaped areas in urban environments that encourage rainwater to move towards plants rather than collecting and evaporating on paved areas. Vegetation in these landscaped areas helps reduce urban heat island effects without increasing irrigation demands for potable or reclaimed water. Storm to Shade is funded by $0.13 on customer's Tucson Water utility bill. To determine where GSI resources should be directed, Storm to Shade uses a tool called the Tree Equity Score, which overlays existing tree cover data with socioeconomic factors within all of Tucson's wards. GSI high-priority areas have low tree cover and high socioeconomic vulnerability.

Gilbert has identified specific mitigation strategies for different time scales based on anticipated impacts of Colorado River shortages. The time scales include near-term plans for 0-3 years, short-term plans for 3-10 years, and long-term plans for 10+ years. In their near-term plan, the town hopes to work with partners to exchange water. An existing partnership allows Gilbert to recharge reclaimed water from the Town of Queen Creek, for which the latter earns water storage credits each year. Storage credits are useful to Queen Creek for complying with Assured Water Supply requirements, while Gilbert temporarily augments its supplies in the summer to meet reclaimed distribution system peak demands. Gilbert is seeking other exchanges to augment its potable system in peak demand season. In the short-term plans, Gilbert will drill additional wells; beyond 10 years, it plans to have secured additional supplies. Throughout all time scales, Gilbert will use strategies to reduce demand by promoting and expanding conservation programs available to customers.

Arizona Water Company, a private water utility that operates in many small- to medium-sized Arizona cities and towns and a number of unincorporated areas, focuses on internal water management but also has developed programs for community education that promote efficient water use. Serving 250,000 customers across eight counties and four incorporated areas, Arizona Water Company helps the communities it serves achieve their sustainability goals through conservation projects that engage the public in youth education programs, water audits, and facility tours. In the past two years, this utility's new water conservation programs have engaged just under 64% of customers in Casa Grande, Superior, Apache Junction, and other served communities.

DATA: FILLING GAPS AND IMPROVING ACCESSIBILITY

Having the right information is important to improve water management. The 2023 conference highlighted a few notable tools among the many under development that are designed to help fill data gaps and increase data accessibility. The following online resources can help fill the need for more and better-quality data. These resources can be accessed via a smartphone by scanning the QR codes presented in each subsection below.

Water Quality Portal

https://www.waterqualitydata.us/

Various groups and organizations collect water quality data, but not all of them format the data in the same way. Groups trying to use another organization's data may run into roadblocks and be forced to spend time and energy on reformatting. One resource working to reduce this problem is the online Water Quality Portal hosted by the National Water Quality Monitoring Council. This one-stop shop for publicly available water quality data pools information from the US Geological Survey (USGS), EPA, and more than 400 state, federal, tribal, and local agencies. By providing a large amount of data in the same format, the Water Quality Portal can help water resource managers use data quickly and efficiently.

Arizona's Water Quality Assessment Dashboard

https://azdeq.shinyapps.io/assessment_dashboard_2026_Prod/

One application already making use of data from the Water Quality Portal is Arizona's Water Quality Assessment Dashboard. The dashboard gives the public current information regarding the water quality of Arizona's lakes and streams. Automation has drastically cut the time it takes for the department to make these assessments; what previously took nine months now takes

roughly 15 minutes. Beyond helping ADEQ make decisions about the health of Arizona's water, the application includes a data gap map, indicating areas where additional data is needed to improve and complete assessments. This information in particular can be used by those outside of ADEQ who are interested in helping improve the quality of Arizona's water. The department encourages people to submit water quality data through its Arizona Water Watch Volunteer program. The Arizona Water Watch Volunteer Toolkit, located in the Additional Resources section at the end of this *Arroyo*, provides information about ADEQ volunteer training on water sampling and credible data collection.

Arizona's TMDL Priority Application

https://azdeq.shinyapps.io/tmdl_priority/

Dozens of surface waters across Arizona do not meet Clean Water Act water quality standards and are considered impaired. With limited time, funding, and resources, ADEQ must prioritize these problems. Arizona's TMDL Priority Application helps ADEQ determine which waters to focus on. The application is publicly accessible and used by other individuals and organizations. This interactive online platform ranks impaired waters based on 12 weighted factors, including years the water has been impaired, number of impairments, probability that contaminant standards will be exceeded, and environmental justice considerations, among others. The platform also allows the user to adjust the weights of these metrics to better align with their own priorities and objectives. It will then provide a list of priority waters based on those weighted metrics. This customization makes the application useful to anyone who is interested in watershed restoration.

OpenET

https://openetdata.org/

While gathering data can be expensive, tedious, and time-consuming, the information it produces is important to have when making decisions about water usage. For instance, evapotranspiration (ET) is the water that returns to the atmosphere as water vapor from the land surface and from plants. In arid places such as the Southwest US, ET is a major component of the water cycle. Gathering ET data is difficult, often requiring satellites or measurement stations. OpenET is an online repository of ET data that can be used for irrigation scheduling, groundwater management, and drought mitigation. OpenET uses a satellite-based approach to gathering ET data, which farmers and others across the western US can use instead of having to make their own ET measurements.

Water Adaptation Techniques Atlas

https://webapps.jornada.nmsu.edu/wata/

As water resource managers look for solutions to address and manage water scarcity and climate change impacts, they can learn from others' successes. The Water Adaptation Techniques Atlas (WATA) provides a collection of examples. With a wide range of case studies, WATA maps where actual management interventions have occurred throughout the Southwest, such as crop rotation, irrigation changes, the use of Indigenous techniques, and more. The atlas also features a number of filters that can be used to find relevant information.

Navajo WaterGIS 2.0

https://unmcop.unm.edu/metals/

It is important for communities to know the quality of the water they are using. Water that is unsuitable for human consumption, for example, might be acceptable for other uses in and around the household. Navajo WaterGIS 2.0 is an interactive map that provides access to a water quality database for unregulated water sources on and around the Navajo Nation. Designed for use by people on the Nation, it makes recommendations for the safe use of water from these sources and indicates the level of confidence these recommendations warrant. Recommendations about sites that have been sampled often can be made more confidently than recommendations for sites that have not been sampled.

HUMAN RESOURCES, EDUCATION, AND TRAINING

As water challenges gain urgency and more possible solutions arise, the water industry finds itself in need of human resources. The Groundwater Management Act brought a hiring spike to the water industry in Arizona. Now, more than 40 years later, many executives and leaders in the industry are retiring, the result of a demographic shift called the Silver Tsunami. **How is the water industry coping with the loss of experience and expertise?**

Water quality sampling at groundwater monitoring well.
Source: Michael McCasland, WRRC Photo Contest 2017

Filling those positions is difficult because few technical training programs are available to the next generation wanting to join Arizona's water industry. In addition, skill requirements are changing. For example, water conservation positions have been staffed largely with public relations professionals, but now these positions may require economic analysis, knowledge of environmental systems, and data collection and monitoring skills. Filling workforce gaps will take a multi-pronged solution that includes improving technical education programs, tapping out-of-state expertise for appropriate remote work, and improving information sharing across Arizona about effective approaches to solving common problems. Collectively, these efforts can help ensure that jobs in the water sector are seen as career choices.

In the training context, some people have observed a hiring bias that favors college-educated applicants. For many positions in the water industry, a four-year degree may be desirable but is not required. Reevaluating positions that required a bachelor's degree in the past can identify opportunities for individuals from community college or alternative technical educational programs.

Additionally, greater investment in technical education programs for high school and non-degree seeking post-secondary students can be modeled on existing vocational programs and expose students to water-related careers and relevant training. When potential employers participate in such programs, they can benefit from higher retention rates and lower internal training costs.

An example of a water training-for-hire program is the Central Arizona Project (CAP) Apprenticeship Program. With cohorts of up to 10 trainees, the program is designed to fill around 20% of the trade force for CAP. Training includes electronics, mechanics, and heavy equipment operations. Lessons from this successful program highlight the importance of mentorship in the water industry and value of internal knowledge sharing.

INNOVATIVE WATER RELATED TECHNOLOGIES

Arizona requires technological innovation to improve water quality, source new water supplies, manage water, and improve industrial and agricultural conservation efforts. The WRRC's 2023 conference highlighted a few of the fresh technologies that have been proposed as tools for the state's water solutions toolbox.

Agricultural Technology

Weather modification is not generally considered a technological tool for agriculture because agricultural fields in Arizona rely almost entirely on irrigation water. In general, weather modification is synonymous with cloud seeding. Clouds are "seeded" with silver iodide crystals, dropped into clouds from airplanes or propelled from ground-based systems. Silver iodide encourages water droplets to form, increasing precipitation in the region. This practice has not yet been used in Arizona, but cloud seeding projects are underway in the upper basin states, funded in part by CAP. Multiple studies suggest cloud seeding can increase precipitation from storm clouds by 5% to 15%, thus potentially increasing water supplies for all

Agrivoltaics test site at the University of Arizona Biosphere 2. Source: Bob Demers/UANews

Colorado River users. To prevent dangerous storm events, cloud seeding operations are suspended based on predicted precipitation in these areas.

The Pinal County Water Augmentation Authority has expressed interest in cloud seeding to increase local rainfall. Research model results indicate that weather modification could potentially increase rainfall on Pinal County agricultural fields by enough to offset more than 160,000-acre feet of irrigation water. Actual benefits of weather modification are still disputed, as are the practice's potential unintended adverse consequences.

Other technologies proposed to solve water challenges related to irrigated agriculture involve changes to conventional farming practices. For example, methods that increase soil organic matter have been shown to reduce irrigation requirements by increasing the soil's water-holding capacity. Microbial inoculation, the application of a microbe mixture to farm fields, may not only increase soil organic matter but also sequester carbon.

Another technology showcased at the conference was controlled environment agriculture (CEA). The limited land and water footprint of CEA makes it an attractive way to reduce the use of these resources. BKW Farms recently transformed an old shipping container into a controlled indoor agriculture facility to grow oyster mushrooms. The facility uses solar energy for power and recycles its water.

Agrivoltaics, a new technology in the agriculture industry, involves placing a solar panel structure above a crop field. The solar panels can provide shade for the plants below, limiting exposure to high-intensity sun. The shaded plants tend to require less water, and the water transpired by plants cools the solar panels, promoting more efficient energy production.

Water Treatment Technology

Nanofiltration technologies show promise for low-cost water treatment applications as research focuses on optimizing energy inputs and contaminant removal. Nanofiltration is a technology that uses membranes to filter out microscopic contaminates and salts. An innovative application of nanofiltration involves the Star School, a public charter school in northern Arizona serving mostly Navajo students. In this project, Apex Applied Technologies (AATech) collaborated with the Star School to retrofit an old school bus with nanofiltration technology. The "Water Bus" teaches native students about water quality and treatment technologies. Through USDA Rural Development grants, AATech/the Star School installed small-scale nanofiltration demonstration systems on the Navajo Nation, Hopi, and San Carlos Apache tribal lands. Using 100% solar energy, each system can produce up to 1,000 gallons/day of purified water. The off-grid, on-site water treatment systems provide safe drinking water to dispersed populations, such as those on Navajo and Hopi

Decentralized nanofiltration display in the Apex Applied Technology "Water Bus." Image: Apex Applied Technology, Inc.

lands, where about 30-50% of people live without access to drinking water systems and commercial power.

Desalination, the removal of salts from saline or brackish water, provides potable water in many water-scarce regions worldwide. Yet high cost and energy usage have limited its adoption. Witten Technologies Inc. is developing a biofilm that can desalinate water with less energy input than current methods. The biofilm comes from lung surfactant lipids. Passing brackish water through discs coated in the biofilm reduced salt content by 30-35%. Further research is needed to enable the full-scale application of low-energy desalination such as biofilm membranes, but substantially reducing energy use could propel sustainable desalination in the Southwest.

FUNDING SOLUTIONS

Whether large- or small-scale, all of Arizona's water solutions require funding. **New funding initiatives by the federal and state governments and support from private organizations have directed money towards implementing water solutions.**

In 2023, the Biden-Harris Administration announced that about $585 million from the Bipartisan Infrastructure Law will support water infrastructure. Around $28 million will be going to aging infrastructure projects in Arizona on the Colorado River levee system, Laguna Dam, and pipe replacement in Yuma.

Significant state funding also is available for communities to implement water solutions. The Water Infrastructure Finance Authority (WIFA) is a state agency that allocates public funds in the form of grants and low-interest loans for projects that aim to improve water quality, conservation, and long-term planning in Arizona. WIFA operates on the premise that the best water solutions come from the communities that need those solutions. When possible, WIFA supports those projects through low-cost financing and grant programs for water infrastructure. Projects that have been and can be supported by WIFA range from installing drip irrigation on agricultural fields to improving municipal resilience by installing smart meters.

WIFA currently has five available funds for making water infrastructure loans and grants. Two funds that have been in place for decades use EPA-funded state revolving funds (SRF) to help communities with drinking water and wastewater management. Those funds are the Clean Water SRF and the Drinking Water SRF. Recently, WIFA saw three new funds added to its menu of resources. These include the Water Conservation Grant Fund, the Water Supply Development Revolving Fund, and the Long-Term Water Augmentation Fund. The goal of these additional programs is to implement a "both-and" approach to water solutions, displacing the notion that tackling water challenges requires choosing between projects that conserve water and projects that augment water supply. This allows WIFA to take a holistic approach to meeting Arizona's water supply needs.

As of May 2024, WIFA had awarded the full $200 million that was budgeted for the Water Conservation Grant Fund. The 189 projects selected are estimated to save between 3.3 and 5.6 million acre-feet of water. Funds have been awarded in every Arizona county, with Maricopa and Pima receiving the most funding.

Applicants for these funds must be water providers or nongovernmental agencies partnered with a water

provider and must be able to provide matching funds for at least 25% of the cost. Eligible activities include water education and research programs, municipal infrastructure upgrades, groundwater recharge, ecosystem management, irrigation upgrades, and more.

BUILDING PARTNERSHIPS AND COLLABORATION

A frequent theme to emerge during the conference was the need for collaboration within Arizona's water industry. International policy, tribal participation, and interagency cooperation provide examples of successful collaborations as well as areas for improvement.

Wise management of transboundary aquifers — bodies of groundwater shared by adjacent jurisdictions, requires cooperation. The US-Mexico Transboundary Aquifer Assessment Program (TAAP) was established in 2009, following the enactment of U.S. Public Law 109-448 in 2006. TAAP's goal is to improve the knowledge base on aquifers shared by the Mexican states of Chihuahua and Sonora and the three US states of Texas, New Mexico, and Arizona. Major partners in the project include the WRRC, USGS, the National Water Commission in Mexico (CONAGUA), and the University of Sonora (Universidad de Sonora), with the International Boundary and Water Commission (IBWC) serving as the coordinating agency. The program has produced multiple publications in English and Spanish on transboundary aquifer characterizations, climate change assessments, water balance modeling tools, as well as outreach at regional, national, and international levels. TAAP has achieved a remarkable level of cross-border cooperation on protocols, data, and maps, serving as a model of collaboration for other efforts around managing transboundary waters.

While interest in transboundary aquifers is relatively new, the need for cooperation on transboundary rivers is not. In the US, collaborative agreements on the use of shared rivers date back generations. Tribal nations, however, typically have been excluded from most past collaborative processes. In the Colorado River Basin, tribes had no place at the negotiating table as recently as 2007, with the adoption of interim guidelines for shortage sharing. Negotiations involving tribal water rights and access have taken place through separate water settlement processes. Federal and state policy makers have only recently recognized the essential role of tribal participation in achieving water conservation goals. There are 30 federally recognized tribes in the Colorado River Basin, which comprises seven states. Twenty-two of those tribes are located in Arizona. During the 2023 WRRC conference, the governor of the Gila River Indian Community stated that collaborative processes convened by federal and state agencies should continue to improve the amount of tribal participation. Improvements to facilitate tribal participation in US government consultation processes are needed, especially with respect to ongoing discussions about new shortage sharing guidelines that will replace the interim guidelines expiring in 2027.

Shortage risks inspired Phoenix, Tucson, and other municipalities, to collaborate with ERA Economics, an economic analysis firm, to build the Central Arizona Water Clearinghouse Project. Its goal was to reduce water shortage risk by increasing shared water supplies through increased municipal collaboration. The collaborators envisioned a digital tool that would assess capabilities of existing infrastructure and pair up potential utility collaborators. Unforeseen challenges to establishing the platform for matching utilities led to a new focus on policy collaboration. Challenges encountered included the lack of publicly available data, which prevented the computer algorithm from modeling existing infrastructure. In addition, stakeholders were wary of depending on an electronic tool for decision making. This developing discomfort caused the project to pivot from an optimization tool to one that provides information to stakeholders who develop their own partnerships. A key lesson of this project was that working on water transactions is more about building relationships than devising technological fixes.

Forums for collaboration and tools to support collaborative processes will increase the probability of finding solutions to shared water challenges. Arizona State University recently launched the Arizona Water Innovation Initiative. This collaborative project aims to put ASU's assets at the service of water management. The initiative comprises four pillars: the Global Center for Water Technology, the Advanced Water Observatory and Decision Support Team, Impact Water — Arizona, and Arizona Water for All. Partners include state

agencies and universities, cities, nongovernmental organizations, and others.

The Global Center for Water Technology fosters technologies to improve water quality and develop new renewable water sources. The Advanced Water Observatory and Decision Support Team will focus on collecting data and improving modeling and predictions to support informed decision making. Impact Water — Arizona will focus on making water information more accessible to the public, especially young people. Plans include engaging communities through media projects such as water games, a water-related Q&A chatbot, and 30-day challenges. The goal of Arizona Water for All is to eliminate water insecurity in the state. To this end, it will employ machine learning to develop a better understanding of the relationships between sociodemographic vulnerability and limited water access.

CONCLUSION

There is no denying the challenges facing Arizona's water resources; however, realistic solutions exist, are developing, and can be imagined.

Improved data collection and accessibility help water resource managers and policymakers understand Arizona's water supplies and make informed decisions. New and more efficient technologies promise to conserve water and energy. But as more information and more efficient technologies become available, they reveal the need for strategic investments to turn proposals into real-life results. Funding is available through organizations like WIFA for projects that aim to improve water quality, conservation, and long-term planning in Arizona.

The water workforce also requires investments in training to recruit and retain people with the skills needed to lead the state's water industry into the future. Initiatives like the CAP Apprenticeship Program and others are starting to address this need.

Arizona's water challenges are large and complex. They require, by their very nature, that leaders at various levels of the water world — local, state, tribal, federal, and private — cooperate and collaborate. Combined efforts can help make the most of limited resources through efficiency gains; augment the resource base through treatment of saline, impaired, and wastewater; and expand access to all, including the historically disadvantaged.

In the end, no single solution will solve the complicated challenges facing Arizona and the region. Taken together, proposals like those highlighted in this *Arroyo* encourage optimism about our potential for creating a water-secure future.

Additional Resources

- **ADEQ PFAS Interactive Data Map**
  https://experience.arcgis.com/experience/9a4b9734d7134b5e8e4820a996eb3191?views=Interact-with-the-Map2
- **Ak Chin Farming Downloadable Document from Ajo Center**
  https://www.ajocsa.com/_files/ugd/0f77a8_c0d85bd35e104aed91c62b286669a83c.pdf
- **Arizona's Water Quality Assessment Dashboard**
  https://azdeq.shinyapps.io/assessment_dashboard_2026_Prod/
- **Arizona Water Watch Volunteer Toolkit**
  https://azdeq.gov/node/4497
- **Navajo WaterGIS 2.0**
  https://unmcop.unm.edu/metals/
- **OpenET Data**
  https://openetdata.org/
- **TMDL Priority Application**
  https://azdeq.shinyapps.io/tmdl_priority/
- **WATA (Water Application Technique Atlas)**
  https://webapps.jornada.nmsu.edu/wata/
- **Water Quality Portal**
  https://www.waterqualitydata.us

Arroyos Cover Water Issues Critical to Arizona

The WRRC's *Arroyo* is produced each year to look in depth at a single water topic of timely importance to Arizona. Intended for the lay public, it reaches educators, water managers, decision makers, students, and other interested individuals and has been used to inform policy discussions. Published regularly since 2007, topics have ranged widely. In recent years, the *Arroyo* has been linked with the WRRC Annual Conference topic to capture and expand on the themes and lessons of the conference. Prepublication reviews by experts ensure accuracy and comprehensibility. Copies of the *Arroyo*, from its earliest issue to the present, are available online: **https://wrrc.arizona.edu/arroyo**.

For more information from the 2023 and 2024 conferences, including videos and presentations, visit our past conferences page: **https://wrrc.arizona.edu/news-events/past-conferences**

Image: Clayton B. Lyon

WEEKLY WAVE

Be Informed

Keep up with our news and events with a subscription to the *Weekly Wave*.

wrrc.arizona.edu/subscribe

THE UNIVERSITY OF ARIZONA
COOPERATIVE EXTENSION
WATER RESOURCES
RESEARCH CENTER

Water Resources Research Center
The University of Arizona
Cooperative Extension
P.O. Box 210437
Tucson, AZ 85721-0437

Address Service Requested

NON-PROFIT ORG.
US POSTAGE
PAID
TUCSON, ARIZONA
PERMIT NO.190

Land Acknowledgement

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

About the Authors

Courtney Lee and Austin Bauer are AmeriCorps service members serving with the WRRC for the 2023-2024 academic year. Courtney Lee graduated in 2023 from the Department of Environmental Science at the University of Arizona and is beyond excited to apply her degree towards improving environmental conditions. Austin Bauer is a communications specialist and independent publisher with degrees from Missouri Western State University. Since 1988, Susanna Eden has held various positions at the university's Water Resources Research Center, including 10 years as assistant director. She holds a Ph.D. from the UArizona Department of Hydrology and Water Resources (now Hydrology and Atmospheric Sciences).

Acknowledgements

Production of this *Arroyo* was funded in part by Southern Arizona Water Users Association and Stantec, and by the Technology and Research Initiative Fund/Water, Environment and Energy Solutions Initiative administered by the University of Arizona Office for Research, Innovation and Impact, funded under Proposition TRIF Initiative 301, the Arizona Sales Tax for Education Act, in 2000. Funding from the Water Resources Research Act section 104(b) Program, administered through the U.S. Geological Survey, supported *Arroyo* printing.

The authors thank the following reviewers for their comments and suggestions on this *Arroyo*. Any errors or misstatements are the authors' and cannot be attributed to these conscientious reviewers: Xochitl Coronado-Vargas, Jennifer Davidson, Jeff Inwood, Jason Jones, Jing Luo, Raluca Mihalcescu, Chuck Podolak, David Proctor, Jeffrey Silvertooth, Elia Tapia, David Wegner, and Grant Weinkam.

Suggested citation: Lee, Courtney, Austin Bauer, and Susanna Eden. "Solutions to Arizona's Water Challenges: What Can We Do?" *Arroyo*. Tucson, AZ: University of Arizona Water Resources Research Center, 2024.
https://wrrc.arizona.edu/publication/arroyo-2024