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Arizona Policy Responses to Water Shortage: Can They Have an Impact?

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As drought persists in the Colorado River Basin, demand continues to draw down reservoir levels. In 2019, seven Basin States (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming) and the U.S. Bureau of Reclamation (USBR) signed Drought Contingency Plans (DCP) setting guidelines to spread shortfalls across Basin water users. Since that signing, Arizona has faced increasingly stringent cutbacks of Colorado River water, with deliveries falling by 0.7 million acre-feet (MAF) from 2019 to 2023 (USBR, 2019a, 2023a). In May 2023, the Lower Colorado River Basin States (Arizona, California, and Nevada) submitted a plan to the USBR to conserve 1.5 MAF of Colorado River water by the end of 2024 and 3 MAF cumulatively by the end of 2026 (CRBSR, 2023). USBR has accepted this plan as their preferred water management alternative for the basin (USBR, 2023b). The Boulder Canyon Project Act allocates 4.4 MAF to California, 2.8 MAF to Arizona, and 0.3 MAF to Nevada, for a total Lower Basin allocation of 7.5 MAF.

Growers in Central Arizona (who hold the most junior water rights in the basin) have responded to reduced Colorado River deliveries by fallowing cropland. Acreage receiving crop insurance payments for failure of irrigation supply in Pinal and Maricopa Counties averaged fewer than 17,000 acres in 2016–2021 (Figure 1). Acreage receiving payments jumped to 41,278 acres in 2022 and 58,617 acres in 2023. These counties had 404,515 acres of harvested cropland in 2022 (USDA, 2024c).

The Colorado River water cutbacks have triggered policy responses by Arizona state entities related to (i) water supply augmentation, (ii) subsidies for the adoption of efficient irrigation technologies, and (iii) restricting foreign-owned operation of irrigated cropland. These high-profile responses have captured the attention of water policymakers in the state. This article considers how well these policies can address the state's water scarcity issues in a cost-effective, timely, or comprehensive way.

With reductions in Colorado River deliveries, Arizona will be increasingly dependent on groundwater. Since the 1980s, the state has maintained two different groundwater management regimes. In metropolitan counties, there are irrigated acreage limitations, monitoring and reporting requirements for agricultural groundwater use, and pumping regulations. In rural counties, agricultural groundwater use is largely unregulated. Rapid depletion of some rural aquifers has spurred competing legislative proposals for rural groundwater management. Some elements of groundwater management proposals show promise in economic efficiency terms, by, for example, emphasizing use of cost–benefit analysis and on allotments that are tradable across time and between users. Yet, achieving a policy consensus on how to move forward remains elusive.

Water Supply Augmentation

In 2021, the Arizona State Legislature passed nonbinding legislation requesting a congressional feasibility study of a pipeline project to send Mississippi River floodwater to supply Arizona. The USBR (2012) had earlier reviewed water importation schemes to supply the Colorado River Basin. One proposal, which would have shipped water from the Mississippi River, was estimated to cost $2,400 (2012 nominal) per acre-foot and would take 30 years for regulatory approvals and construction.

In 2022, the Arizona State Legislature passed SB 1710, authorizing $1 billion over 3 years for water augmentation projects, earmarking 75% of funds for projects to import water from outside the state with the rest for in-state augmentation. Arizona's Water Infrastructure Finance Authority (WIFA) was designated to approve projects. To date, WIFA's focus has been a desalination plant at Mexico's Gulf of Baja with a pipeline to ship the water to Arizona. Black and Veatch (2020) examined projects that would import water from Baja to

Figure 1. Central Arizona Acres Receiving Crop Insurance Indemnities for Failure of Irrigation Supply

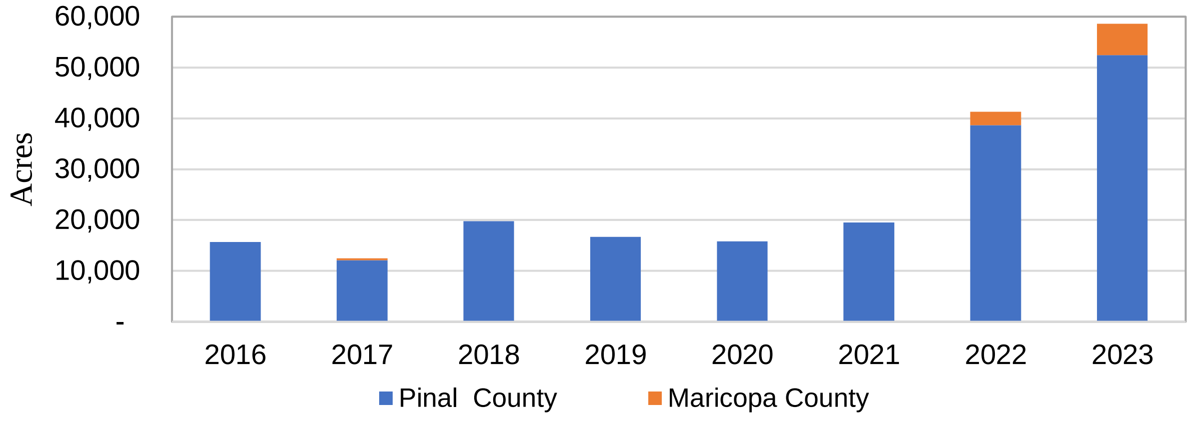

Figure 1. Central Arizona Acres Receiving Crop Insurance Indemnities for Failure of Irrigation Supply
Source: USDA (2024a).

Arizona. Comparing different technology options that could deliver 200,000 AF of water annually, they estimated costs between $2,050 and $2,280 per acre-foot. WIFA considered a subsequent plan by the Israeli firm IDE costing $2,500/AF (Mumme and Lyde, 2023). The USBR (2012) estimated that a Gulf of Baja desalination project would require 20 years for feasibility studies, permitting, and implementation. To date, no large-scale water importation projects have been approved. WIFA received only half of its first-year funding of $333 million. In the newly approved state budget, Governor Hobbs and the state legislature agreed not to provide WIFA with its authorized allocation of $333 million for water supply augmentation in FY 2025 (Sanchez 2024).

Four smaller brackish groundwater desalination projects have been proposed throughout the state. Combined, these could provide 126,000 AF/year and cost $600–$1,200 per acre-foot (2017 nominal) (Kyle Center, 2024). Proposed in 2017, these projects have yet to be developed. None have been funded, and none have been formally proposed to WIFA.

Subsidies for Improving Irrigation Efficiency

Improving irrigation efficiency is seen by many as a key component of Western water conservation. This is shown by federal funding for improved efficiency through the USDA EQIP program, USBR projects, and new programs under the Inflation Reduction Act (IRA) (USBR, 2021; Stern, Sheikh, and Hite, 2023; USDA, 2024b). Improved irrigation efficiency has also received financial or technical support from the North American Development Bank and from environmental groups such as Environmental Defense and The Nature Conservancy (NADBank, 2004; Carter, Seelke, and Shedd, 2015; The Nature Conservancy, 2018; USBR, 2021).

Arizona instituted two programs in 2022 to subsidize adoption of more efficient irrigation technology: the Water Conservation Grant Fund (WCGF) (WIFA, 2023) and the Water Irrigation Efficiency Program (WIEP) (University of Arizona, 2024). The WCGF, administered by WIFA, was established via $200 million from the federal American Rescue Plan Act. Funds must be obligated by June 2024 and spent by December 2026. At least one-third of funds must address Colorado River water shortages, while another third must encourage groundwater replenishment. The program has spent $113 million to date (WIFA, 2023). While agricultural system upgrades (reducing conveyance losses and switches from flood to pressurized irrigation) account for 22% of funding, they are credited with achieving 93% of the program's water savings. WIFA claims savings from one-time system upgrades of 2.6–3.9 MAF over 50 years. The reported cost is an astonishingly low $6–$10 per acre-foot conserved. Ironically, WIFA is arguing publicly with Governor Hobbs about insufficient funds for importation projects (Podolak, 2024) that would cost $2,500/AF, while simultaneously claiming to achieve water savings at a cost of $6–$10 per acre-foot via irrigation efficiency improvements (WIFA, 2023).

The WIEP provided an initial $30 million in state funding. The program, administered by Arizona Cooperative Extension, pays growers $1,500 per acre up to $1 million per farm to switch from flood to drip or sprinkler irrigation. WIEP has distributed $23.1 million of $30 million to date with legislative plans to spend $15.2 million in the coming year. The program requires matching funds, with farmers paying $16 million. WIEP reports water savings to date of 38,000 AF with a public program cost of $631 / AF (Orr, 2024). Savings over the next three years are estimated to exceed 109,000 AF.

It has been an article of faith among many water conservation advocates that improving irrigation efficiency will conserve water. Yet, a large body of scientific evidence shows that improving efficiency, by itself, often does not conserve water, and, in most cases, actually increases water consumption (Huffaker and Whittlesey, 2003; Golden and Peterson, 2006; Jensen, 2007; Upendram and Peterson, 2007; Ward and Pulido-Velazquez, 2008; Lecina et al., 2010; Contor and Taylor, 2013; Gómez and Pérez-Blanco, 2014; Pfeiffer and Lin, 2014; Scheierling and Treguer, 2016; Grafton et al., 2018; Sears et al., 2018; Persons and Morris, 2019; Pérez-Blanco, Hrast-Essenfelder, and Perry, 2020; Pérez-Blanco et al., 2021). Summarizing the findings of 230 studies, Pérez-Blanco et al. (2021, p. 1) stated, "A zombie idea is one that has been repeatedly refuted by analysis and evidence, and should have died, but clings to life… The perception that investments in modern irrigation systems automatically save water constitutes a zombie idea."

What accounts for this disconnect between policy preference and scientific evidence? One reason is that water is not like other inputs. Withdrawn water, not taken up by the crop, can flow back to rivers or aquifers. This residual water can then be available to others. Irrigation efficiency measures the share of applied water consumed by the crop. Improving efficiency, by definition, reduces the share of unused water that could go back to rivers or aquifers. At the field level, improved efficiency means that the irrigator does not need to withdraw as much water to get the same level of output. At a system level, improving efficiency can reduce water available to others. A number of studies provide figures illustrating this process (Huffaker and Whittlesey, 2003; Jensen, 2007; Scheierling and Treguer, 2016). The effect depends on whether water leaving fields is recoverable or "lost to the system" (Jensen, 2007). If return flows cannot be recovered, then increased consumptive use from increased efficiency does not reduce water availability to others. How common are such cases? Not very. In their comprehensive review, Pérez-Blanco, Hrast-Essenfelder, and Perry (2020) found this occurring in just 7% of cases. They also found that improved efficiency increased water consumption in 70% of cases and consumption did not change or results were ambiguous in 19% of cases.

Pérez-Blanco, Hrast-Essenfelder, and Perry (2020) found reduced water consumption following improved efficiency in 11% of their case studies. But in every one of these, improved efficiency was combined with institutional constraints (such as charges or quotas) being imposed. Here, the institutional constraints are what achieved reductions in consumptive use. Improved efficiency can make constraints less costly to irrigators. Increased irrigation efficiency, by itself, may not conserve water. But it could be combined with institutional constraints to make those constraints less economically onerous and more politically feasible.

A problem with both WIFA's WCGF and the WIEP is that they measure water conservation based on potential reductions in withdrawals, not reductions in water consumption. Their "water savings" are the estimated reductions in withdrawals required to maintain production at a constant level. There are two problems here: First, withdrawals are not the same as consumption. Improved efficiency can lower withdrawals without lowering consumption; Huffaker and Whittlesey (2003), Jensen (2007), and Scheierling and Treguer (2016) provide graphical examples. Second, why would irrigators necessarily maintain their output at a constant level? Improved efficiency reduces the effective price of water (Caswell and Zilberman, 1986). Why would output remain fixed with a reduction in an input cost? Irrigators have incentives for "water deepening" (Scheierling and Treguer, 2016). If they have rights to withdraw a certain volume of water, they can keep that volume constant but apply water to more acres, increasing output, profits, and consumptive use.

Might there be cases where these programs can achieve true system-level water conservation? Two come to mind. First, as Pérez-Blanco et al. (2021) have found, programs that combine improved irrigation efficiency with institutional constraints have successfully reduced water consumption. The WIEP allows for payments to irrigators to "piggyback" on federal conservation agreements under the Inflation Reduction Act. For example, Arizona irrigators can receive federal payments for not taking water deliveries and keeping water in Lake Mead. Combining subsidies for efficient irrigation systems with required curtailments could be both economically attractive and actually conserve water.

Second, if water tables are low enough, then return flows may not reach the water table and be usable by others. In such cases, improved efficiency can reduce groundwater depletion (Peterson and Ding, 2005). Do such cases exist in Arizona? Perhaps. They are unlikely along the Colorado River mainstem, where the water table is extremely shallow. However, Clemmens et al. (2000, p. 96) argued that in one Central Arizona irrigation district, "It is unclear whether… water actually reaches the groundwater (transit times are on the order of decades) … All water delivered is assumed lost to the system." Arizona Department of Water Resources (ADWR) planning models assume that, because of slow seepage and deep water tables, it can take 10–20 years in some subbasins for percolating water to be usable (ADWR, 2009, 2020). So, flows are nonrecoverable in the short run but not in the longer run.

The default assumption among state programs is that improving irrigation efficiency will necessarily conserve water. While such cases are uncommon, they might exist in some of Arizona's groundwater subbasins. If the state programs (i) assessed whether areas targeted for efficiency improvements had hydrological features favoring conservation and (ii) measured water savings correctly in terms of changes in water consumption instead of potential reductions in withdrawals, holding production constant, then they would be more likely to achieve true system-wide water conservation.

Restricting Foreign-Owned Company Operation of Irrigated Cropland

Fondomonte, a subsidiary of a Saudi Arabian-based corporation, has been leasing Arizona State Trust Lands since 2014, growing alfalfa for export to Saudi Arabia. Fondomonte held four leases totaling 3,520 acres in Butler Valley and a 3,088-acre lease in the Ranegras Plain Basin, both in La Paz County. This made Fondomonte the second largest lessee of Arizona State Trust agricultural lands. The Butler Valley leases became contentious for several reasons. Fondomonte's pumping was leading to rapid groundwater depletion. There were objections to a foreign-held company "exporting" the water through alfalfa exports. The area was seen as a future source of water for the Phoenix metro area. Fondomonte was not required to report its groundwater use nor pay fees for groundwater pumped (although Fondomonte paid the energy costs for pumping). Finally, Fondomonte's lease rate was below market rates for similar cropland.

In reality, Fondomonte's lease arrangements were no different than other State Trust Land lessees. An Arizona Auditor General report determined that lease rates paid by Fondomonte were below market rates, but this was also true for other State Trust Land agricultural leases (Perry, 2024). While the State Land Department has authority to charge lessees fees for groundwater pumping, it does not do so for any lessees (Perry, 2024). Agricultural water users outside the state's regulated Active Management Areas (AMAs) or Irrigation Non-Expansion Areas (INAs), in general, are not required to report their groundwater use.

In 2022, the federal Domestic Water Protection Act was introduced, calling for a 300% excise tax "on the sale and export of any water-intensive crop by any foreign company or foreign government in areas experiencing prolonged drought." In 2023, Arizona Attorney General Kris Mayes and Governor Hobbs announced that the Butler Valley leases would not be renewed. Fondomonte accounted for virtually all of the groundwater use in Butler Valley. These leases accounted for 18% of Arizona's alfalfa exports but 2% of total alfalfa production. The lease cancellations are a solution to a localized groundwater problem, but they do not address broader issues of groundwater depletion in the state.

Groundwater Management

Since passage of the state's Groundwater Management Act in 1980, there have been two distinct groundwater management regimes in Arizona. In more urban counties with 80% of the population, five AMAs (Prescott, Phoenix, Pinal, Tucson, and Santa Cruz) were established along with two INAs (ADWR, 2024d; McGreal and Eden, 2021). Both AMAs and INAs require reporting of groundwater use and limit expansion of irrigated acreage. Outside the AMAs and INAs, in rural areas, groundwater is largely unregulated. These unregulated areas account for 47% of Arizona's entire groundwater pumping capacity (James, 2020). These two areas—inside versus outside the AMAs/INAs—differ in the paths of their water use and groundwater supplies and face distinct groundwater management challenges.

In the AMAs, irrigated acreage cannot expand beyond 1970 levels. However, this period was the historic peak of agricultural acreage and so is not a binding constraint (Frisvold, Wilson, and Needham, 2010). Wells pumping more than 35 gallons per minute (nonexempt wells) must use approved measuring devices and report their annual groundwater withdrawals to the ADWR. New real estate developments must demonstrate that they have 100 years of assured water supplies. INAs do not have this restriction but do limit the expansion of irrigated acreage. Those with nonexempt wells must also monitor and report groundwater use if irrigating 10 or more contiguous acres.

In the Phoenix, Pinal, and Tucson AMAs, many irrigators are served by the Central Arizona Project (CAP), which delivers Colorado River water. Irrigators have been given incentives to use CAP water in lieu of groundwater. Managed aquifer recharge (MAR) projects were also implemented, storing unused portions of Arizona's CAP allocations underground (Megdal, Dillon, and Seasholes, 2014; Scanlon et al., 2016). The MAR projects have raised water tables in Central Arizona at rates that are among the fastest in the world (Jasechko et al., 2024). The combination of substituting CAP water for groundwater and the MARs has significantly bolstered groundwater supplies in the Phoenix and Tucson AMAs.

Moving forward, as Arizona's CAP allocations are curtailed, there will be less water available for MAR. But this could also make these facilities more valuable. The city of Tucson in 2003 entered into a water-sharing agreement with the cities of Scottsdale, Peoria, and Gilbert, which will store some of their CAP water at Tucson's Southern Avra Valley Storage and Recovery Project facility when supplies are more plentiful and withdraw them under shortages. The cities make use of Tucson's storage infrastructure and will pay Tucson $75/AF of water stored (City of Tucson, 2023).

Prior to the construction of the CAP, Central Arizona faced substantial groundwater overdraft problems. Many irrigators plan to switch back to groundwater pumping in response to reduced CAP supplies. It remains to be seen whether this leads to a return of rapid groundwater depletion.

Groundwater depletion has been more rapid in certain rural areas outside the AMAs and INAs. Over the past

20 years, the Gila Bend Aquifer had the third-fastest rate of depletion among all aquifers in the United States (Jasechko et al., 2024). Depletion has also been rapid in the Willcox–Douglas Basin (Jasechko et al., 2024). Rural residents throughout the state have had to deepen or drill new wells to continue accessing groundwater.

Concerns over groundwater have spawned state and local responses. Locally, voters approved the establishment of an INA in Hualapai Valley (ADWR 2024b) and the conversion of the Douglas INA to an AMA (Federico, 2022; ADWR, 2024a). In the Willcox area, voters rejected a referendum to create an AMA (Federico, 2022). Governor Hobbs has discussed the possibility of having the ADWR establish an AMA in the Gila Bend area (Davis, 2024). Attorney General Mayes is also exploring the use of lawsuits under Arizona nuisance laws to limit groundwater use where local landowners have documented damages from depletion (Loomis, 2024).

Alternative bills for rural groundwater management have been introduced in the state legislature. Senate Bill SB 1221 (Arizona Senate, 2024), favored by agricultural interest groups, passed out of the Senate but is not supported by the governor. House Bill HB 2857 (Arizona House of Representatives, 2024) has yet to be passed out of committee. These bills have some similarities but also major differences in approaches. SB 1221 requires that cost-benefit analyses be conducted for management areas limiting groundwater use. Both bills allow groundwater use certificates that are transferable between users. SB 1221 allows rights to be transferable across time so that withdrawals can be deferred but “banked” for later use. While HB 2857 requires the use of water ADWR-approved metering devices, SB 1221 prohibits metering requirements. Under SB 1221, plans cannot be implemented without the unanimous vote of a local council. Under HB 2857, if the local council does not develop a management plan within 2 years, then the ADWR director can implement one. SB 1221 also sets an upper limit on groundwater use reductions.

A 2022 state statute requires the ADWR to issue Supply and Demand Reports (SDRs) for the state’s 51 groundwater basins, beginning in 2023 and issuing at least six basin reports per year. The ADWR completed seven SDRs in 2023 (ADWR, 2024e). Five basins had agricultural water use: Douglas AMA, McMullen Valley, Harquahala INA, Willcox Basin, and Butler Valley (ADWR, 2024f). Fondomonte’s canceled leases account for virtually all of Butler Valley’s agricultural water use. We focus on the remaining basins (Table 1).

The ADWR estimated annual groundwater withdrawals (demand), recharge (including incidental recharge from farms), and net impacts on groundwater depletion and supplies. Available water storage was measured as “groundwater reasonably accessible at the average depth of the wells in the basin.” Groundwater below average well depth in the Willcox Basin was reported as a negative value. To access this water, “well owners will have to deepen wells or drill new wells at a significant financial cost” (ADWR, 2024f). In the Willcox Basin, the cumulative drawdown of groundwater from supplies below accessible levels from 2023 to 2049 is 4.6 million AF (ADWR, 2024f).

The ADWR examined groundwater depletion paths under various scenarios (ADWR, 2024c,f). A status quo scenario was based on water use and practices as of 2022. A technology scenario assumed cotton and alfalfa acres using flood irrigation would switch to gravity micro-irrigation, reducing water demand 33%. Improvements to sprinkler and center pivot systems would reduce water withdrawals by 5%. A 2% annual growth rate in adoption was assumed. The ADWR assumed that electricity power plants would switch to dry or hybrid cooling. A conservation scenario assumed allotment-based quantity restrictions resembling the program in the ADWR’s 5th Management Plans.

While improved irrigation technology lowers agricultural water demand (Table 1), it also reduces incidental recharge of aquifers, which reduces groundwater supplies (ADWR, 2024f). By 2049, improved technology reduced annual overdraft by less than 1.5% in the Harquahala Valley and Willcox Basin, while it minutely increased overdraft in the McMullen Valley and Douglas AMAs. By 2049, improved technology had a minimal positive impact on available groundwater in one basin and minimal negative impacts in the other three. The allotment-based Conservation scenario significantly increased groundwater available in storage in two of the basins but had a negligible effect in the other two. For these basins, the ADWR’s simulations are consistent with the findings of Pérez-Blanco, Hrast-Essenfelder, and Perry (2020) that, under most actually observed hydrological settings, improved irrigation efficiency does not contribute significantly to basin-wide water conservation.

Conclusions

If one assesses Arizona’s highest-profile policies to address water scarcity, water augmentation comes up short in terms of cost-effectiveness and timeliness, while irrigation restrictions on foreign firms fail to have large state-wide impacts. State programs to conserve water via improved irrigation efficiency will more likely succeed if they are combined with institutional constraints (or incentives), measure water conservation properly (which they currently do not), and determine whether hydrological conditions favor conservation beforehand (which they currently do not). Competing legislative bills for rural groundwater management have stalled. These groundwater management proposals have, however, encouraging elements from an economist’s perspective. These proposal elements include quantity limits that are transferable across users, over time, or both, and an emphasis on cost-benefit analyses.

Table 1. Projected Groundwater Demand, Supply, and Depletion by 2049 in Selected Arizona Basins under Status Quo, Technology, and Conservation Scenarios

	Douglas	McMullen	Harquahala	Willcox
Agricultural demand				
Status quo	60,975	53,168	131,224	190,140
Technology	59,373	52,987	116,673	185,297
Conservation	58,907	51,330	121,017	189,885
Total demand				
Status quo	67,984	53,658	135,696	214,060
Technology	66,381	53,478	118,381	207,048
Conservation	65,383	51,755	125,482	212,904
Supply				
Status quo	19,722	9,128	40,794	66,760
Technology	17,999	8,933	24,838	61,554
Conservation	19,689	10,915	33,304	67,572
Balance (total demand – supply)				
Status quo	-48,262	-44,530	-94,902	-147,300
Technology	-48,382	-44,545	-93,543	-145,494
Conservation	-45,694	-40,873	-92,183	-145,332
Percentage difference in groundwater overdraft from status quo				
Technology	0.2%	0.03%	-1.4%	-1.2%
Conservation	-5%	-8%	-3%	-1%
Water available in storage				
Status quo	6,451,700	116,200	2,235,900	-4,608,800
Technology	6,450,000	116,000	2,245,600	-4,582,500
Conservation	6,516,600	214,600	3,309,400	-4,559,000
Percentage difference in water available in storage from status quo				
Technology	-0.03%	-0.2%	0.4%	-0.6%
Conservation	1.0%	84.7%	48.0%	-1.1%

Note: The technology scenario assumes diffusion over time of improved irrigation systems and water-efficiency improvements in power generation. The conservation scenario assumes allotment-based water conservation

Source: ADWR (2024f).

For More Information

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