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Issue Brief

Water for Nature and People: Trends in California, 1960–2022

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Water is essential for California, providing for the household needs of nearly 40 million people, supporting one of the world's most productive agricultural regions, sustaining the health and viability of a global biodiversity hotspot, and underpinning the world's fourth-largest economy. Yet, across the state, rivers, streams, and aquifers are stressed from overuse. Climate change and continued growth are increasing pressure on the state's water resources, including water supply, demand, and quality. To address these challenges and inform policy and planning, we must understand water use patterns and trends across the state.

In this brief, we examine urban and agricultural water use in California using the most recent statewide data and publicly available information. We find that California's population and economy have grown dramatically since the 1960s, while total urban and agricultural water use has increased only modestly, reflecting a dramatic decoupling of water use from growth. This is due to several factors, including improvements in urban and agricultural efficiency, denser urban developments with less outdoor space, and shifts to higher-value crops and less water-intensive economic activities. California's total water use peaked at 46.5 million acre-feet (MAF) in 2007 and declined steadily to 39.1 MAF by 2022, a 16% reduction from the peak.

Water dedicated to or protected within the environment is a critical part of the state's overall water system, but important questions remain about how it should be categorized and accounted for. For example, how should we distinguish between legally protected instream flows and water that may flow in the same stream in excess of that legal requirement? To what category should we ascribe agricultural or urban return flows that also help sustain downstream wetlands? While the Department of Water Resources (DWR) characterizes "environmental water" as a user of the state's water supply, it is more accurately the source of the water itself. Water that remains in natural systems, referred to in this brief as "environmental flows," supports human uses and provides essential ecosystem services. Yet determining how much water is truly dedicated to environmental purposes is difficult, largely due to limited direct measurement, a heavy reliance on assumptions, and inconsistent or unclear definitions.

Through this brief, we aim to provide a clear understanding of how water is allocated and used statewide. We offer this analysis to equip researchers, policymakers, advocates, and other stakeholders with the information they need to drive meaningful policy and implementation change. In the face of increasing pressures on the state's water resources and systems, we urge state policymakers and decisionmakers to invest in staff and resources to strengthen measurement and reporting systems.

Understanding Water Data

This brief relies on "applied water use" estimates developed by DWR, which are published in the California Water Plan and made available through the California Open Data Portal.[1] For this brief, we use data from a series of data releases from DWR, from 1964 through 2022.[2] The term "applied water" describes the water delivered to the intake of a water supplier's system, a factory, or a farm headgate; it is the water withdrawn from a water source, usually surface or groundwater, minus any seepage or evaporation from reservoirs and canals (i.e., conveyance losses) prior to delivery to the intake.[3] For the purposes of this brief, we use the term "water use" to refer to "applied water" in urban and agricultural settings.

Together, water used by the agricultural and urban sectors constitutes the developed water supply. California's agricultural water use is not directly measured; rather, it is modeled by DWR based on several factors, including crop type and irrigated acreage, crop coefficients, weather conditions, and assumed irrigation efficiencies. Crop acreage is estimated from remote sensing land use surveys, which are then verified and validated. Estimates of agricultural water use represent the quantity of water delivered to a farm headgate for crop evapotranspiration, leaching salts, frost protection, and pre-irrigation, as well as applied water for conveyance and groundwater recharge.

In the simplest terms, urban water use refers to non-agricultural water use. DWR develops estimates of urban water use based on information submitted by public water system operators to the State Water Resources Control Board through the electronic Annual Reports (eAR). These estimates represent the amount of water at the intake of the water supplier's system that is put into the water delivery system. They exclude water losses upstream of the water supplier's system (i.e., conveyance losses) but include water losses that occur within the delivery system, as well as water intentionally put into an aquifer for storage. The eAR dataset does not collect self-supplied water use (typically by manufacturing industries, golf courses, and rural residents). DWR develops estimates of self-supplied water based on per capita use

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[1] DWR publishes these data in the *California Water Plan* and posts them on the California Open Data Portal at https://data.ca.gov/.

[2] California Department of Water Resources (DWR). 1964. *California Water Plan Update, Bulletin 160-64*. Sacramento, Calif.: Department of Water Resources; California Department of Water Resources (DWR). 1970. *California Water Plan Update, Bulletin 160-70*. Sacramento, Calif: Department of Water Resources. http://wdl.water.ca.gov/waterdatalibrary/docs/historic/Bulletins/Bulletin_160/Bulletin_160-70__1970.pdf; California Department of Water Resources (DWR). 2018. *Historical Trend in Statewide Water Data, 1972–2015*. Provided via email by Francisco Guzman on December 18, 2019; California Department of Water Resources (DWR). 2019. Statewide Water Balances, 1998–2015. Provided via email by Francisco Guzman on December 18, 2019; For years 2016 through 2022: California Department of Water Resources (DWR). *Statewide Water Balances, 2016–2022*. https://data.cnra.ca.gov/dataset/water-plan-water-balance-data.

[3] DWR notes that "applied water" is greater than "consumptive use" because it includes consumptive use, reuse, and some outflows, though "applied water" does not account for conveyance losses or reservoir evaporation. In some areas (such as the Upper Colorado River basin), net reservoir evaporative losses are allocated proportionately to water users. DWR previously estimated total California reservoir evaporation at about 2.4 MAF per year, about 8% of total agricultural and urban consumptive use. More than half of this reservoir evaporation occurs in the Sacramento and San Joaquin hydrologic regions. Due to staffing reductions, DWR now estimates and aggregates reservoir evaporation into a larger residual term. See Department of Water Resources. 2024. *California Water Plan Update 2023 Water Balances Supporting Document*, August 2024.

rates in neighboring communities with similar geographic and demographic characteristics.

DWR labels some of the state's water resources not categorized as agricultural or urban use as "environmental water" and separates this into four categories: managed wetlands, Sacramento–San Joaquin Delta (Delta) outflow, instream flow requirements, and flow volumes for designated Wild and Scenic rivers. These volumes are estimated through a combination of flow gauge measurements, extrapolations, and DWR's Cal-SIMETAW model.[4] However, this categorization ignores important distinctions. "Environmental water" has two conceptually separate categories: (1) flows that are actively controlled and released for environmental purposes, and (2) undiverted flows that remain in streams, contributing to minimum flow thresholds or Wild and Scenic rivers, but without active management. Combining these distinct types of water under a single category ("environmental water") blurs a key difference about what counts as intentional, dedicated environmental use.

In addition, "applied water" includes both consumptive uses (water that is evaporated, transpired, or incorporated into a crop or product) and non-consumptive uses (water that returns to rivers, groundwater, or other parts of the system). Because applied water does not distinguish between these types of use, estimates of agricultural and urban use may overstate the volume of water permanently removed from the system. This can affect estimates of the volume of water remaining in the environment, since return flows may continue to support downstream ecosystems and instream conditions.

While DWR's estimates represent the most comprehensive statewide accounting currently available, they have important limitations. Much of the data is not directly measured but instead estimated using models and assumptions. This is especially true of agricultural water use, the largest portion of developed water supply. Small changes in assumptions about irrigation efficiency or crop needs can impact estimates at regional and statewide scales. Total developed supply comprises urban and agricultural use, so any over- or underestimation in those categories directly affects the volume of water that remains in the environment. As a result, findings presented here should be interpreted as estimates subject to data quality, rather than as precise, measured quantities.

Decoupling of Water Use and Growth

Previous studies have documented a clear decoupling between water use and economic and population growth.[5] More recent data confirm these findings. Between 1967 and 2022, California's population more than doubled, and the state's gross

[4] "California Simulation of Evapotranspiration of Applied Water (Cal-SIMETAW) was designed to estimate daily soil-water balance to determine ETc and ETaw for California Water Plan updates. This model requires weather data, soils, crop coefficients, rooting depths, seepage, etc., that influence crop-water balance." (DWR)

[5] Cohen, Michael J. 2011. *Municipal Deliveries of Colorado River Basin Water*. With Jenifer C Martin. Pacific Institute. https://pacinst.org/wp-content/uploads/2011/06/crb_water_8_21_2011.pdf. Cooley, Heather. 2020. *Urban and Agricultural Water Use in California, 1960–2015*. Pacific Institute. https://pacinst.org/wp-content/uploads/2020/06/PI_Water_Use_Trends_June_2020.pdf. Richter, Brian D. 2023. "Decoupling Urban Water Use from Population Growth in the Colorado River Basin." *Journal of Water Resources Planning and Management* 149 (2): 04022082. https://doi.org/10.1061/JWRMD5.WRENG-5887.

domestic product increased sixfold. Over that same period, the state's urban and agricultural water use, which together represent the developed water supply, increased by less than 20% (Figure 1). This decoupling reflects several factors, including improvements in urban and agricultural efficiency, denser urban development with less outdoor space, and shifts to higher-value crops and less water-intensive economic activities.

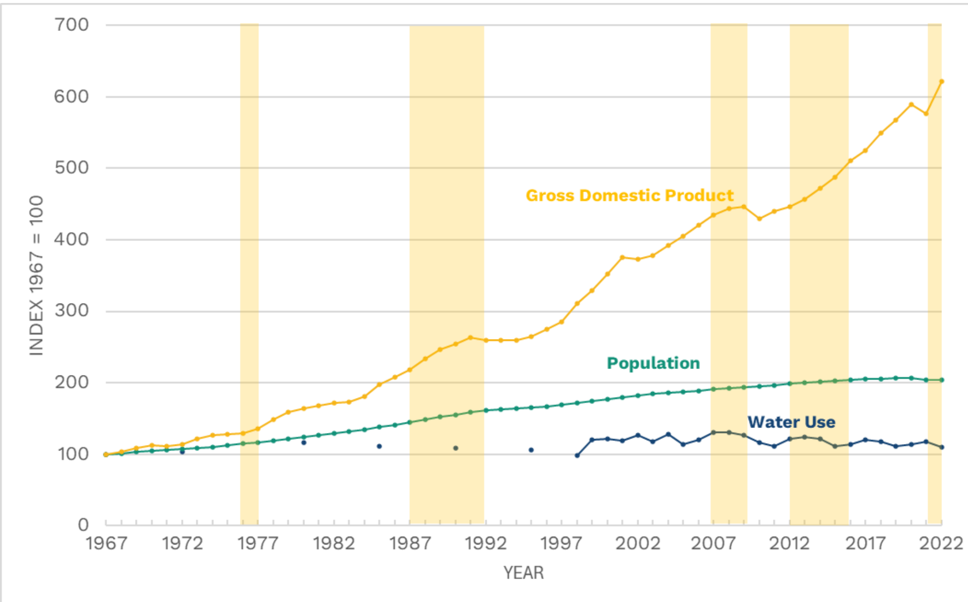

Figure 1. California Water Use, Population, and Gross State Product Indices, 1967–2022.
Note: All values are indexed to their 1967 values to allow for comparison. Shaded areas represent statewide droughts.
Sources: Water use data from DWR. Population data from California Department of Finance. Gross state product from U.S. Bureau of Economic Analysis.

Total urban and agricultural water use peaked in 2007 at 46.5 MAF and has declined over the past 20 years (Figure 2). Between 2018 and 2022, the most recent five-year period for which data are available, total developed water use in California averaged 40.6 MAF per year. Of that amount, agriculture accounted for 80%, or 32.6 MAF per year, while homes and businesses in urban areas accounted for the remaining 20%, or 8 MAF per year.

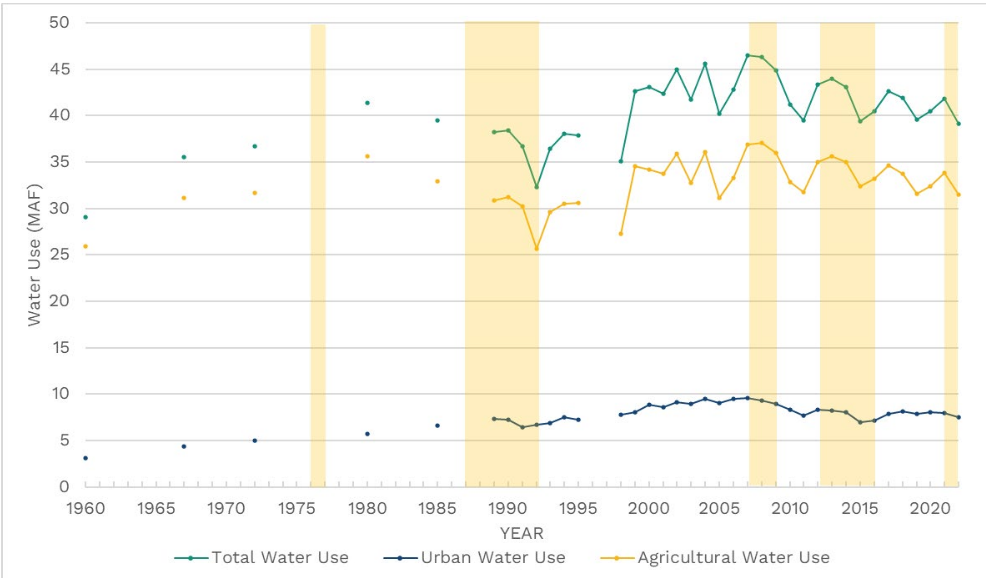

Figure 2. Total, Urban, and Agricultural Water Use in California, 1960–2022.
Note: Shaded areas represent periods of statewide drought.
Source: DWR.

Trends in Agricultural Water Use

Water plays a substantial and vital role in California's rich agricultural production. Agricultural water use is highly variable from year to year, ranging from a low of about 25.7 MAF in 1992 to a high of 37.0 MAF in 2008, a difference of roughly 44% (Figure 3). Weather, irrigated acreage, and crop type are key drivers of this variability. Cooler, wetter conditions and less irrigated acreage tend to reduce agricultural water use, while hotter, drier conditions and more irrigated acreage increase water use, although differing assumptions about use rates also affect these annual estimates.

Total irrigated crop acreage is also a factor, but as shown in Figure 4, it has varied only modestly since the early 1970s. Irrigated acreage peaked in 1981 at about 9.8 million acres and generally ranged between 8.8 and 9.8 million acres between 1972 and 2020. This indicates relatively small changes in irrigated area compared with the larger variation in total agricultural water use over time.

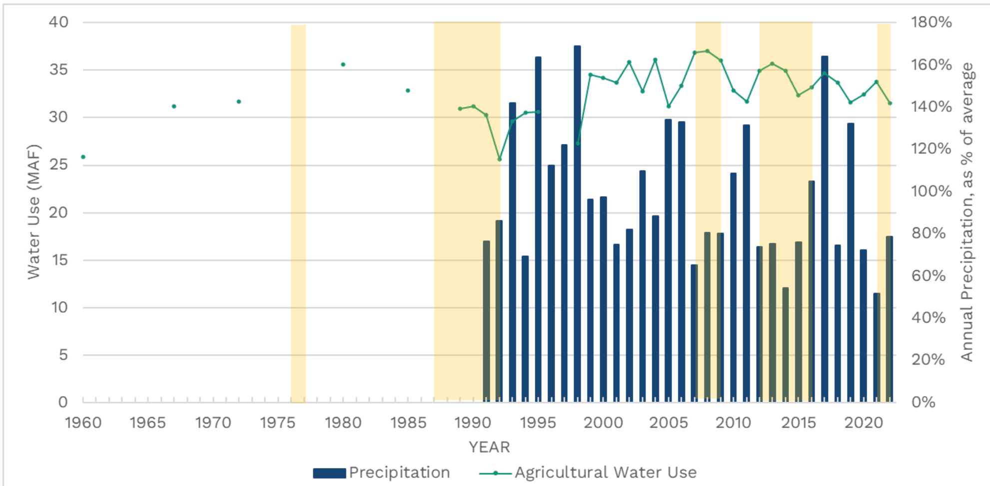

Figure 3. Agricultural Water Use and Annual Precipitation for California, 1960–2022.
Note: Shaded areas represent statewide droughts.
Source: DWR.

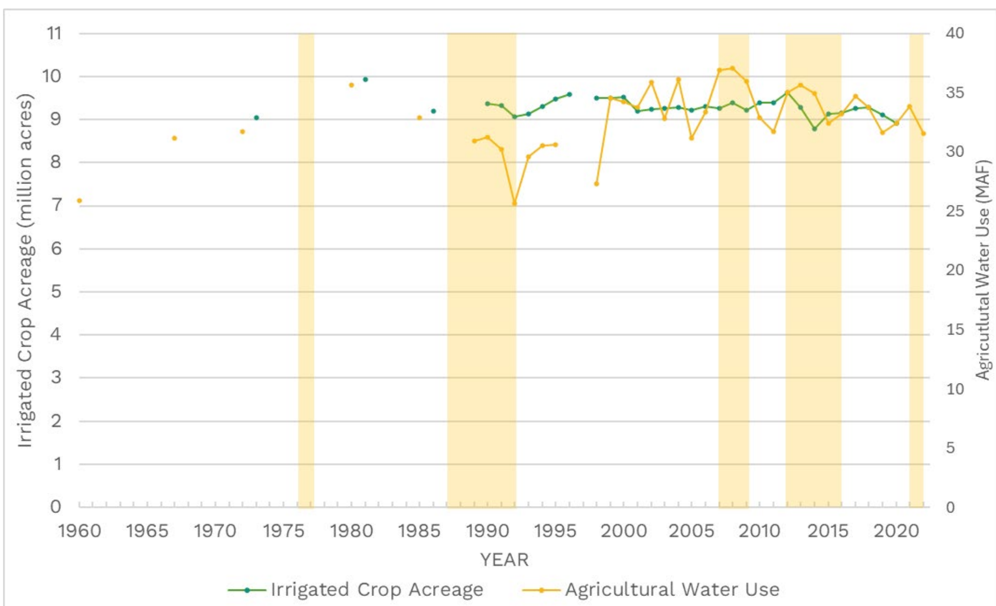

Figure 4. Irrigated Crop Acreage and Water Use for Agriculture, California, 1960–2022.
Note: Actual irrigated acreage is lower, due to double cropping. Shaded areas represent statewide droughts.
Source: DWR.

Agricultural water use accounts for 80% of the developed water supply. While statewide summaries provide a useful overview, regional information helps identify where changes may be most impactful. California has 10 hydrologic regions, corresponding to the state's major drainage basins (Figure 10). However, only four of these regions account for 90% of the state's agricultural water use: Tulare Lake (30%), Sacramento River (25%), San Joaquin River (23%), and Colorado River (12%). Water management strategies in these regions play a critical role in shaping statewide water demand.

Trends in Urban Water Use

Urban water use is comprised of various subsectors, including residential, commercial, and industrial uses. These data show that most water delivered to urban areas is used in and around homes, with residential use accounting for 61% of total urban water use between 2018 and 2022, the most recent five-year period for which data are available (Figure 5). Together, institutions (such as schools, prisons, and hospitals) and commercial businesses (such as hotels, restaurants, and office buildings, including large landscapes) accounted for 24% of urban water use. Industry used an additional 4% to manufacture a wide range of products, from chemicals and electronics to food and beverages. The smallest urban subsectors are groundwater replenishment (5%), conveyance losses (4%), and energy production (1%).

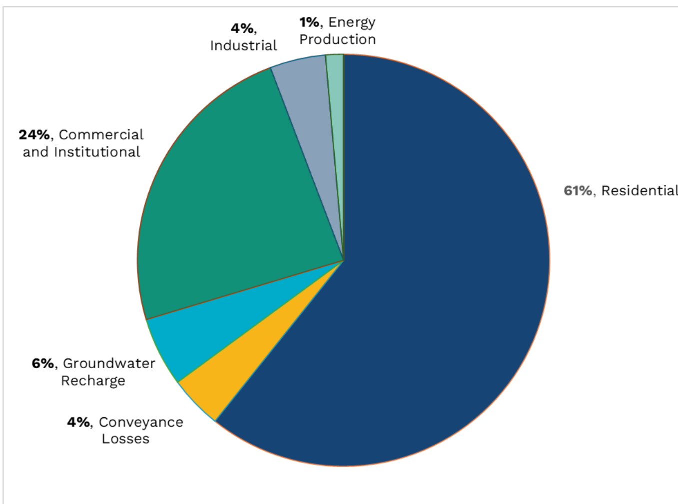

Figure 5. Breakdown of Average Urban Water Use, California, 2018–2022.
Source: DWR.

Urban water use has changed dramatically over the past 62 years. In 1960, total urban water use was 3.1 MAF, or 177 gallons per capita per day (GPCD).[6] Both total and per capita water use increased over the subsequent three decades, before declining sharply during the 1987–1992 drought. After that drought ended, total and per capita urban use resumed an upward trend, although both remained below pre-drought levels for nearly a decade (Figure 6). Since 2007, both total and per capita use have declined markedly. Across the full period of record, 2015 and 2016 represent historic lows, driven by severe drought and mandatory statewide restrictions. Water use rebounded slightly after the

[6] We calculate GPCD here simply as total urban water use divided by population. This includes residential, commercial, and industrial uses, as well as groundwater recharge, energy production, and conveyance losses.

drought, though total use remains comparable to levels last observed in the late 1980s, and per capita use remains well below levels observed since at least 1960.

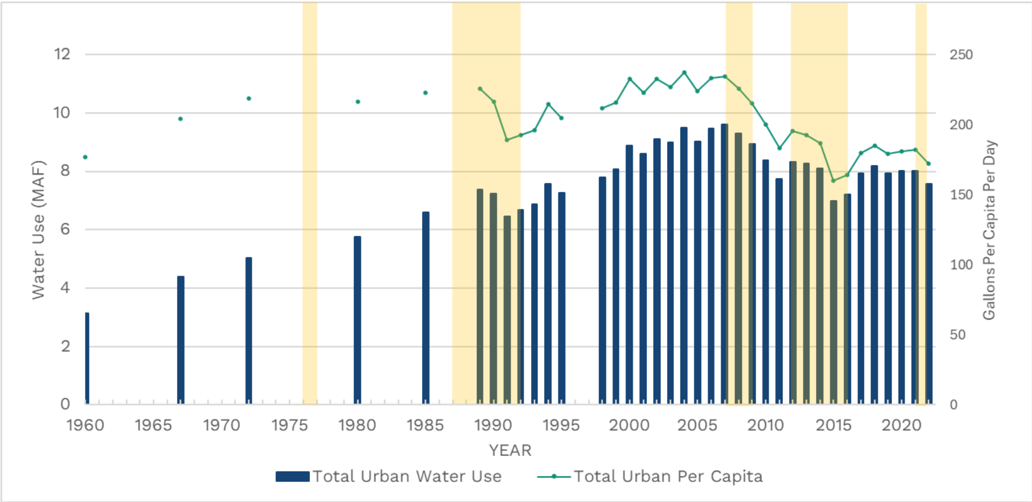

Figure 6. Total and Per Capita Urban Water Use, California, 1960–2022.
Note: Prior to 1998, DWR published urban water use data every five years as part of its semi-decadal water plans, with some gaps. Shaded areas represent statewide droughts.
Source: DWR.

Statewide urban water use declined by 11% between the early 2000s and 2022. All 10 hydrologic regions experienced declines in urban water use during this same period, although the magnitude of these changes varied across regions (Figure 7). Coastal regions have historically had lower per capita use, while hotter inland areas have maintained higher levels. Population growth has been concentrated in warmer areas of the state, where outdoor water demands are higher. This shift has offset some regional efficiency gains and lessened the overall decline in statewide per capita use.

The San Francisco Bay hydrologic region had the lowest per capita use among regions in the early 2000s. Per capita use declined from 162 GPCD in the early 2000s to 130 GPCD in 2022, a 20% reduction. Although the region experienced notable declines during drought years, its long-term reductions were lower in percentage terms. The South Coast hydrologic region followed a similar pattern, declining by 19% over the same period, with per capita use reaching 158 GPCD in 2022. These regions include dense urban centers and help drive statewide trends.

In contrast, the Colorado River hydrologic region had the highest baseline per capita use, at 963 GPCD in the early 2000s. The region experienced a dramatic decline, reaching 454 GPCD in 2022, a 53% reduction. Despite this decrease, per capita use in the region remains far higher than anywhere else in the state, reflecting the combined effects of high temperatures, intensive irrigation, and extensive landscaping and golf courses.

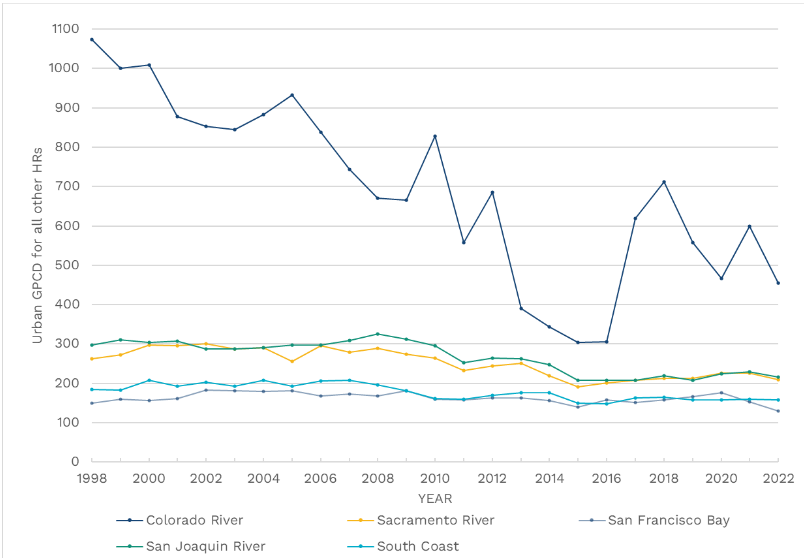

Figure 7. Urban Per Capita Water Use for Five Selected Hydrologic Regions, 1998–2022.
Note: Due to limited data availability, 2021 and 2022 values are calculated using 2020 population data for each hydrologic region.
Source: DWR.

Water Use and the Environment

Freshwater habitats such as streams and wetlands support very high biodiversity and are critical to the lifecycles of many California plants and animals. Such habitats also provide many critical ecosystem services, such as dampening flood flows and improving water quality. While freshwater species in California have adapted to periodic droughts and floods, human alterations to freshwater ecosystems, combined with the de-prioritization of water for these ecosystems, especially during droughts, reduce species' ability to withstand them. Human-caused changes to rivers and riparian corridors have significantly altered and degraded much of California's 190,000 miles of rivers and streams, threatening native plants and animals with extinction. During droughts in California, freshwater ecosystems experience low water flows, reduced peak flows, higher temperatures, and reduced water quality.

The Brisbane Declaration of 2018 defines "environmental flows" as "the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems which, in turn, support human cultures, economies, sustainable livelihoods, and well-being."[7] As noted in the Brisbane Declaration, environmental flows sustain human uses as well, providing invaluable ecosystem services such as filtration. Similarly, diversions for human uses can support critical ecosystem functions. Many agricultural lands sustain rich biodiversity, as can some municipal landscapes at finer scales. Water released to satisfy instream flow requirements is often diverted and applied for agriculture and cities farther downstream. Agricultural and urban return flows, in turn,

[7] Anderson et al. 2019. "Understanding rivers and their social relations: a critical step to advance environmental water management." *WIREs Water*, 6 (6). https://doi.org/10.1002/wat2.1381.

often sustain wetlands and other aquatic ecosystems. Categorizing and accounting for these multiple uses and benefits challenges efforts to describe water use in California by category or end user, especially within the categories of applied water and dedicated environmental flows.

DWR reports four categories of environmental water. Calculated as a percentage of the statewide average for 2018–2022, these are: managed wetlands (5.6%), minimum required Delta outflow (16.7%), minimum instream flow requirements (22.9%), and Wild and Scenic rivers (54.9%). DWR notes that Delta outflows reflect a legal obligation "to maintain flow and water quality standards to protect the beneficial uses within the Delta."[8] Delta outflows maintain a hydraulic barrier to protect water quality at pumping plants from saltwater intrusion; the timing of such releases does not necessarily match species or ecosystem needs.[9] "While it is acknowledged that this water benefits *all* water uses, it is grouped here [*as an environmental flow*] for convenience."[10] The accounting decision to include Delta outflows as environmental water, rather than allocate them proportionately across all sectors or classify them separately, reflects a broader taxonomy challenge.

A key question is how to account for environmental flows. There is a clear difference between water that is actively managed for environmental purposes, such as reservoir releases timed to support ecosystems, and water that remains in a river because it is not diverted. The former reflects deliberate allocation, similar to urban or agricultural water use. The latter may include runoff that cannot be diverted or water that has not been diverted from the system. It is important to note that legally protected minimum flows are not diverted from the river due to regulatory requirements and reflect deliberate "allocation." In addition, grouping together consumptive uses (water that is lost to evaporation) and non-consumptive uses (flows that meet temperature or minimum flow requirements) can overstate the amount of water actively dedicated to environmental purposes. Recognizing and accounting for this difference could clarify the volume of water explicitly managed for environmental purposes.

The term "environmental water" is inherently imprecise and can obscure these important distinctions. Because a single volume of water can simultaneously support multiple purposes, clearer terminology is needed to distinguish between actively managed environmental allocations and ambient river flows. Here, we use "environmental flows" to capture the "fluid" nature of water for and from the environment, referring to three of the four categories in DWR's environmental water data: managed wetlands, minimum instream flow requirements, and Wild and Scenic rivers. In the following, we exclude Delta outflows from environmental water totals because such flows benefit all users.

Environmental flow trends closely mirror precipitation patterns over the period analyzed, with pronounced declines during drought years (Figure 8). In 2014 and again

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[8] DWR, 2024, *California Water Plan Update 2023 Water Balances Supporting Document*, p. 10.

[9] Reis et al. 2019. "Clarifying Effects of Environmental Protections on Freshwater Flows to—and Water Exports from—the San Francisco Bay Estuary." *San Francisco Estuary and Watershed Science* 17 (1). https://doi.org/10.15447/sfews.2019v17iss1art1.

[10] DWR, 2024,. *California Water Plan Update 2023 Water Balances Supporting Document*, p. 10.

in 2021, both dry years, environmental water reached its lowest levels, at roughly 21.5 MAF per year. In contrast, 2017 — one of the wettest years on record — saw one of the highest volumes in the period analyzed, at 64.6 MAF. These shifts show significant interannual variability in environmental water, with volumes in some years more than doubling relative to prior years, highlighting that environmental flows are more climate-dependent than a product of management decisions.

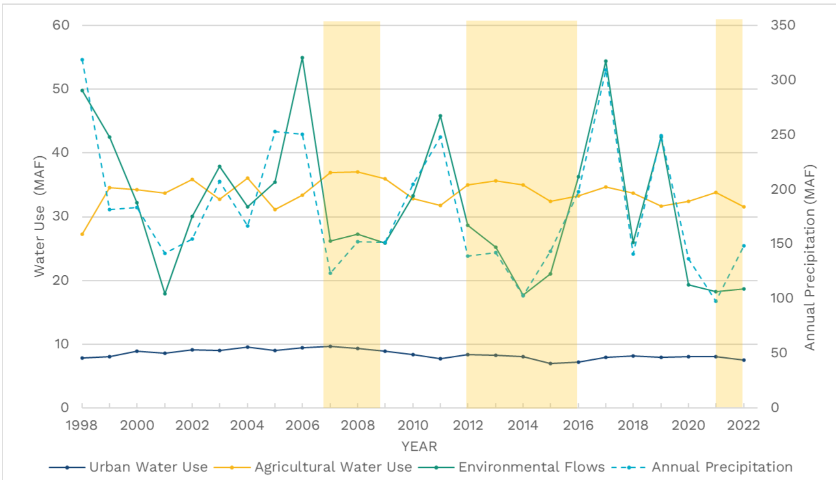

Figure 8. Agricultural and Urban Water Use, Environmental Flows, and Annual Precipitation, California, 1998–2022.
Note: Shaded areas represent statewide droughts.
Source: DWR.

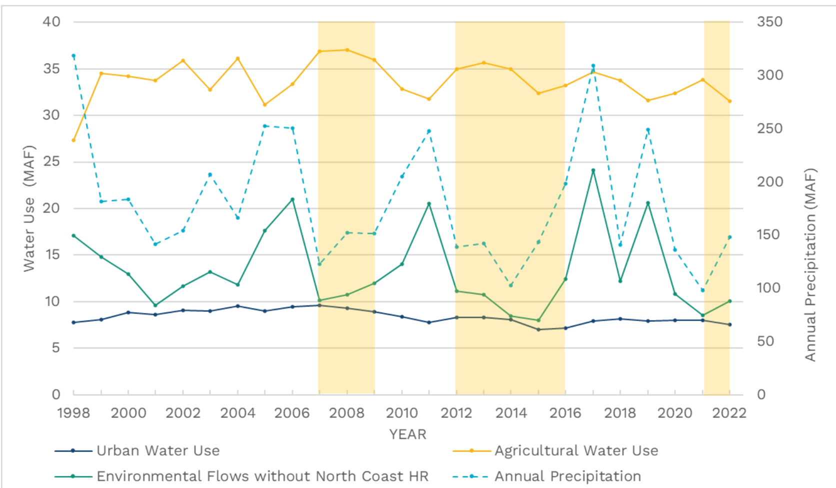

Figure 9. Environmental Flows for California Excluding the North Coast Hydrologic Region, seen with Agricultural and Urban Water Use and Annual Precipitation for California, 1998–2022.
Note: Shaded areas represent statewide droughts.
Source: DWR.

Geographic and temporal differences across California further complicate our understanding of the fate of the state's waters. For the period of record (1998–2022), 58% of the state's environmental flows occurred in the North Coast region, which covers 12% of the state's area and is home to only 2% of its population. Figure 9 shows the drop in environmental flows across the state when the North Coast hydrologic region is excluded; on the other hand, agricultural and urban use in the North Coast region average only about 2% of statewide water use. Figure 10 normalizes the average annual volume of dedicated environmental flows by hydrologic region by adjusting the relative size of the region to reflect flows per unit area, showing that the preponderance of such flows occurs in the North Coast and Central Valley hydrologic regions, while a negligible percentage occurs in the rest of the state.

Likewise, the percentage of environmental flows relative to urban and agricultural applied water also varies dramatically between regions. In the North Coast, environmental flows make up 95% of total water, compared with just 3% in the San Francisco Bay hydrologic region, 2% in the South Coast, and 1% in the Colorado River hydrologic region.

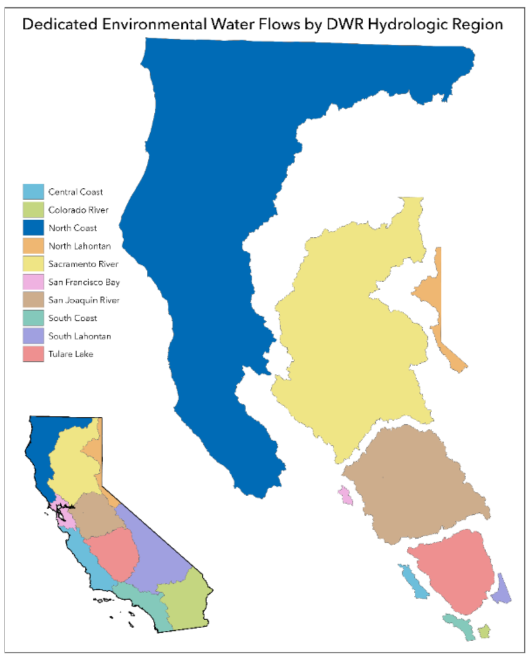

Figure 10. Environmental Flows (Excluding Delta Outflow) by Hydrologic Region.
Note: This image resizes hydrologic regions based on DWR's reported average annual dedicated environmental flows (excluding required Delta outflows) per unit area of each hydrologic region; see inset map for relative locations and unadjusted sizes of each hydrologic region.

While almost 60% of the state's dedicated Wild and Scenic river flows occur in the North Coast region, more than 60% of its instream flow requirements (defined as the lesser of actual releases or required releases[11]) occur in the Sacramento River region — about 4.3 MAF per year. The San Joaquin River region averaged 1.5 MAF per year of

[11] DWR reports about 6.8 MAF per year of dedicated environmental water to satisfy minimum instream flow requirements. While information on the satisfaction of individual instream flow requirements can be obtained from various regulatory agencies, California does not compile or generate a comprehensive annual report on such flows.

required instream flows for the years 1998–2001, but that rate has fallen to 0.6 MAF per year since then. As noted above, the classification of environmental flows can be challenging. In the case of minimum instream flow requirements, water can be counted more than once if it passes through multiple regulatory measurement locations, and especially if it is subsequently diverted and applied for offstream uses. For example, water delivered to satisfy the Sacramento River instream flow requirement below Keswick Dam (above Redding) may be diverted downstream for irrigation in the Sacramento Valley, some of which may then return to the system and be pumped through the Delta to cities in coastal southern California and counted in each category.

Ultimately, understanding the significance of these values requires an understanding of environmental flow needs and the minimum threshold volumes established for rivers and streams, among others. Without this context, it is difficult to assess the extent to which ecological and regulatory requirements are being met.

Conclusion

California has made notable strides in decoupling water use from population and economic growth. Since the 1960s, total applied water has increased only modestly, even as both population and the economy have grown significantly. Total urban and agricultural water use peaked at 46.5 MAF in 2007 and declined over the next 15 years, falling to 39.1 MAF by 2022, a 16% decline.

Agricultural water use continues to dominate the state's developed supply, accounting for roughly 80% of total applied water, and is relatively stable despite variation in weather. Urban water use has steadily declined since its peak in 2007, reflecting efficiency gains, denser urban development, and shifts toward less water-intensive economic activities.

Water allocated for the environment is a critically important component of the state's overall water portfolio, yet limited data and inconsistent measurement make it difficult to fully assess. Geographic disparities further complicate the picture, with most dedicated environmental flows concentrated in the North Coast region, while more heavily populated regions dedicate a negligible fraction, creating confusion and misunderstanding in discussions around management of water for the environment.

These findings highlight the need for more accurate data, consistent definitions, and expanded monitoring of water use and environmental flows across the state. Much of the current statewide information relies on modeled estimates rather than direct measurement, particularly in the agricultural sector, which accounts for the largest share of the developed water supply. Improving the terminology and classification of environmental water would provide a clearer picture of how water supports both ecosystems and human uses. In addition, more comprehensive and transparent reporting on legally protected minimum flows would make it easier to evaluate whether environmental water needs are being met in practice. Strengthening measurement and reporting systems will require additional investment in state staff and resources and would give decisionmakers the information they need to make more informed decisions in the face of increasing pressure on the state's water resources.