

San Diego County Water Authority

CASE STUDY

NOVEMBER 2025

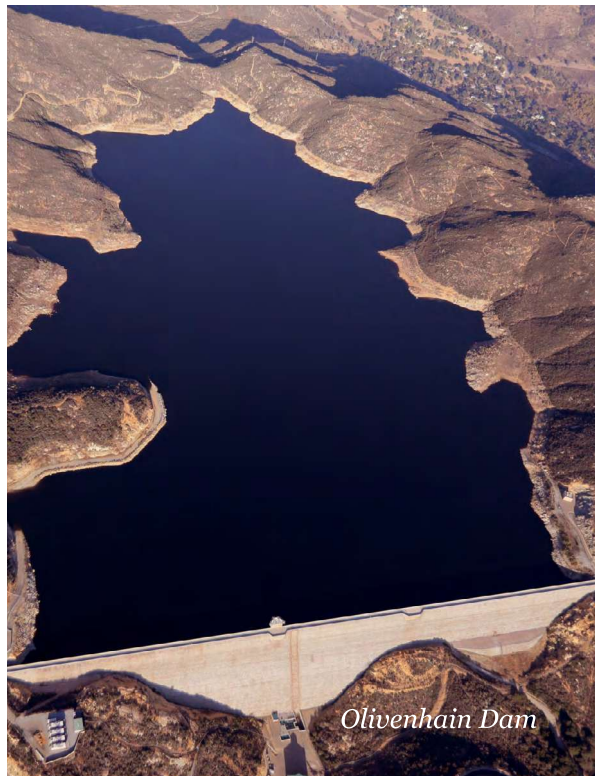
Every five years, a state-mandated planning cycle (Urban Water Management Plan) prompts **San Diego County Water Authority** (SDCWA) to update its long-range water demand forecasts. The 2025 update presented an opportunity to revisit the potential impacts of climate change on demand, using new (CMIP6) climate model data in a time-tested approach. These updated demand forecasts will also inform the agency’s broader scenario planning approach for its decadal Water Facilities Master Plan. Recent unusually wet years demonstrated that drought is not the only climate vulnerability SDCWA needs to prepare for.



**San Diego County
Water Authority**



WUCA
Water Utility Climate Alliance



Olivenhain Dam

LESSONS LEARNED

Forecasting demand under climate change involves many confounding factors

Climate change projections that look 25 years out may prove useful much sooner

As a water portfolio changes, new climate vulnerabilities may emerge

Learn more about these lessons on [page 12](#)

SUMMARY

Utility	San Diego County Water Authority (SDCWA)
Contact	Jeremy Crutchfield, jcrutchfield@sdcwa.org
Project name	SDCWA Water Demand Forecast Update
Project timeline	2025 – Summer 2026
Geographic scope	SDCWA service area, 1,325 sq. mi.
Utility business functions affected	<ul style="list-style-type: none"> • Water supply
Objective	<ul style="list-style-type: none"> • Produce updated demand forecasts for 2030–2050 • Understand how climate change could impact system water demand in 2050
Potential decisions or actions to be informed	<ul style="list-style-type: none"> • Informing capital improvement projects and system optimization needs to meet demands • Supporting financial planning through the Long-Range Financing Plan • Optimizing monthly to annual operations
Variables, thresholds, and/or events of interest	<ul style="list-style-type: none"> • Monthly average daily maximum temperature (T_{max}) • Monthly precipitation • Monthly irrigation requirement (ETc)
Climate data used	CMIP6* LOCA2-Hybrid, under 3 SSPs (emissions scenarios)
Why those data were selected	<ul style="list-style-type: none"> • LOCA2-Hybrid data are optimized for California • Data developed by local researchers (Scripps Institution of Oceanography)
Impact modeling performed	<ul style="list-style-type: none"> • Econometric water demand modeling
Key attributes of this case study	<ul style="list-style-type: none"> • Well-established approach, updated with new climate model data • Five climate scenarios were used to capture the range of potential future climate changes across the climate models and emissions scenarios • Climate change is acknowledged as just one of several highly uncertain influences on future water demand

* For definitions of CMIP6 and other climate modeling terminology, see [this glossary](#).

Overview of the utility

SDCWA is the wholesale water supplier in San Diego County. SDCWA serves water to 22 member agencies representing large-scale metropolitan areas, agricultural regions, and a large federal military base, with a total population of approximately 3.3 million. While the footprint of agriculture in the service area has decreased over time, crop irrigation still represents 6% of total water use. The impacts of drought on water supply and use are buffered by local storage reserves secured by SDCWA and its member agencies, currently totaling over 250,000 acre-feet.

SDCWA and its member agencies have an increasingly diverse water portfolio, consisting of both local and trans-basin sources, and including surface water, groundwater, desalinated seawater, supplemental water transfer, and recycled water. The next increment of local supply includes several potable reuse projects under

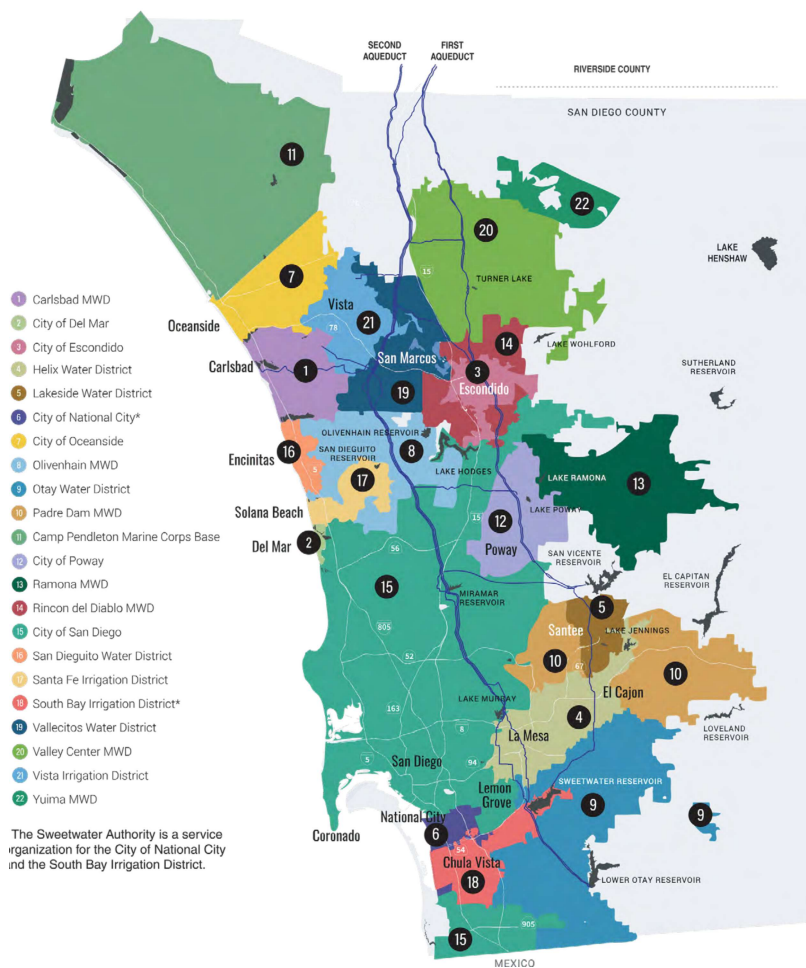


FIGURE 1.

Map of the San Diego County Water Authority (SDCWA) service area, its 22 member agencies, and key infrastructure. The First and Second Aqueducts each can convey both State Water Project and Colorado River water. (Source: SDCWA.)

development. SDCWA's trend toward diversification over the last 25 years has greatly reduced its reliance on water purchased from Metropolitan Water District of Southern California that is sourced from the State Water Project and the Colorado River. This water is subject to large swings in availability and cost due to drought impacts and other factors. SDCWA acquired highly reliable Colorado River supplies through a long-term Quantification Settlement Agreement (QSA) consisting of conserved water transfer from the Imperial Irrigation District and the concrete lining of sections of the All-American and Coachella canals. These Colorado River supplies accounted for over 60% of SDCWA's total portfolio over the last seven years.

Since 2000 there has been an equally dramatic trend in SDCWA's water use, spurred by its aggressive conservation and efficiency measures, along with the lasting impacts of drought restrictions. Total per capita potable water use declined from about 216 gallons per day (gpd) in Fiscal Year (FY) 2000 to 113 gpd in FY 2024. Systemwide use of potable water (excluding use of recycled water) declined over that same period by about 40% to about 414,000 acre-feet, despite a 16% increase in the service area's population. Inflation, the cost of water, climate change, reduced water demand, and other factors continue to put upward pressure on water rates in San Diego County and across the state.



SDCWA desalination pumps and pipes



Project background

Like other California municipal providers, SDCWA is required by the state’s Urban Water Management Act to update its Urban Water Management Plan (UWMP) every five years, with the 2025 plan coming due in July 2026. At minimum, a UWMP must assess the reliability of water sources given expected demand over a 20-year future time frame, under “normal” weather conditions, in a dry year (“single dry”), and over five consecutive dry years (“multi-dry”). A UWMP must consider the effects of climate change on supply and demand, but these effects are not required to be quantitatively incorporated into the reliability assessment. For both the 2020 and 2025 UWMPs, SDCWA modeled the effects of climate change on demand, though these effects were not included in the formal reliability assessment. According to Seevani Bista, Principal Water Resources Specialist with SDCWA, while the California Water Code “does not prescribe that we have to do quantitative climate-change-related projections,” SDCWA does produce “a separate forecast based on climate change scenarios.”

For the 2025 UWMP update, SDCWA is revising its full suite of long-range demand forecasts (Water Demand Forecast Update). As with the demand forecasts developed to inform the 2020 UWMP, much of the work is being carried out by consultant Hazen and Sawyer (Hazen), led by Jack Kiefer, Hazen’s practice lead for water demand forecasting. SDCWA and its member agencies are collecting and confirming the historical demand information and historical weather data. Hazen is updating the econometric model, processing the input data and revisiting the explanatory variables and trends therein, and recalibrating the regression equations used to forecast demand for different sectors. Hazen is also developing climate model inputs to update those demand scenarios that do incorporate climate change, following a similar approach to previous climate-informed demand forecasts.

The contract with Hazen for the 2025 update includes training for SDCWA staff on understanding and using econometric model output for scenario analysis, including the climate-impacted demand scenarios. In the longer term, following a broader trend among Water Utility Climate Alliance (WUCA) member utilities,¹ SDCWA is considering coordinating with its member agencies to develop a long-range demand forecast for future UWMPs rather than developing a sophisticated model using outside consulting services.

¹ WUCA Summary Report: Representing Climate Change Impacts in Water Demand Modeling. (October 2022).



Twin Oaks Valley Water Treatment Plant

USE OF DEMAND FORECASTS BEYOND THE UWMP

The long-range demand forecasts and overall water supply assessment produced for the UWMP are also critical inputs for SDCWA's Water Facilities Master Plan (Master Plan). The Master Plan identifies and prioritizes capital improvement projects (CIPs) needed to meet future demands while emphasizing operational flexibility, system resilience, and climate and earthquake preparedness. In the most recent (2024) update of the Master Plan, supply and demand forecasts developed for the 2020 UWMP—assuming continuation of the historical climate—were used as a reference scenario (1A/1B), or baseline. This baseline was used to compare several other future scenarios as part of a scenario-planning approach:

- **Scenario 2A/2B** - Capture the range in uncertainty in the scale and timing of local water supply development
- **Scenario 3A/3B** - Climate change impacts to demand only (3A) and to both demand and supply (3B)
- **Scenario 4** - Reduction in demands due to additional conservation efforts to reduce indoor and outdoor water use

- **Scenario 5A/5B** – Abrupt disruption scenarios: seismic events (5A) and wildfires (5B)
- **Scenario 6** – Member agencies transition from untreated SDCWA water to treated SDCWA water, impacting delivery rates
- **Scenario 7** – Temporary interruptions in local potable reuse supplies and increased reliance on SDCWA

These scenarios illustrate the wide range of events and impacts that utilities consider in their planning; climate change (3A/3B) is one of many. The 3B scenario incorporated climate change impacts on demand and supply more extreme than those developed for the UWMP, by incorporating a multi-year drought worsened by climate change.² According to Anjuli Corcovelos, Senior Water Resources Specialist with SDCWA, “We want to be prepared for potential deviations or scenario changes even beyond what’s in [the UWMP]. And we have the flexibility to do that in [the Master Plan].” Because the Master Plan is updated on a decadal cycle, the supply and demand forecasts for the 2030 UWMP, as well as the 2025 UWMP update, will be available to inform the next Master Plan in the mid-2030s. Recognizing that much can change over 10 years—new science, new facts on the ground, changes to the system—SDCWA is developing a tool that can be used to explore and test customized “what if” scenarios in periods between the Master Plan efforts.



Project methods and data selection

TIME HORIZONS AND ASSUMPTIONS ABOUT THE FUTURE

While the state standard for UWMPs requires a minimum 20-year horizon, SDCWA uses a 25-year horizon (through 2050) for the demand forecasts and supply reliability assessment in the 2025 UWMP. For the main demand analysis, the demands are forecasted at five-year increments from 2030 to 2050, assuming the historical baseline climate at each time step. For the climate change demand forecast scenarios, the climate projections are analyzed over two different future periods: mid-century (2045–2065) and late century (2080–2100).³

² The climate change portion of the 3B scenario is taken from the “hot-dry” mid-century scenario in the [San Diego Watershed Basin Study, Task 2.2 technical memo](#) (2016).

³ Since the other demand drivers (e.g., population) are only projected out to 2050, as described below, the late-century (2080–2100) climate change demand forecast scenarios effectively pair a late-century climate condition with the mid-century conditions for the other drivers.

SELECTING AND PROCESSING CLIMATE MODEL DATA

For the 2020 update of the demand forecasts, Hazen used CMIP5 LOCA projections, under both the RCP4.5 and RCP8.5 scenarios, to derive the climate change demand forecast scenarios. Going into the 2025 update, new LOCA projections based on CMIP6 (LOCA2) had become available in two versions: the “standard” North America-wide dataset (6-km resolution) and a special “hybrid”⁴ higher-resolution (3-km) dataset covering only California, based on a subset of 15 CMIP6 models shown to simulate well the historical climate patterns for California. Kiefer said that for Hazen, the fact that the LOCA2-Hybrid projections were optimized for California was the key factor in selecting them for the 2025 UWMP demand forecasts. Also, the LOCA2 developers are based locally in San Diego, at the Scripps Institution of Oceanography, and SDCWA has a history of working with Scripps researchers to obtain data and guidance for utility analyses.

The full LOCA2-Hybrid dataset includes 129 future projections in all: 15 models run from 1 to 10 times under one, two, or all three of the SSPs (emissions scenarios): SSP2-4.5, SSP3-7.0, SSP5-8.5). Based on informal guidance from the LOCA2 developers, Hazen started the approach with all 129 runs to encompass the full breadth of the available data and their inherent uncertainties.

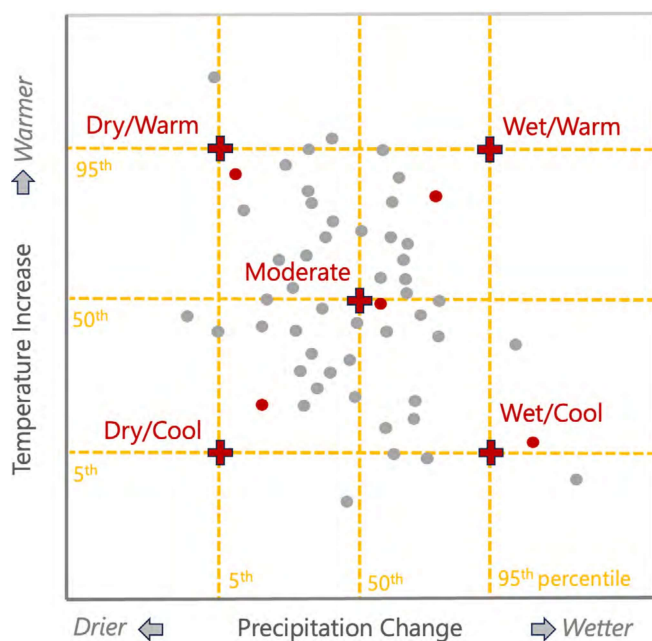


FIGURE 2.

Conceptual schematic showing the method for generating the five climate scenarios. All of the climate model runs (gray and red dots) are plotted according to the future precipitation change and future temperature change indicated by each run. Those model runs (red dots) that are plotted closest to each of the five ideal scenarios (red crosses) are selected to represent those scenarios. See the text for more details.

4 The term “hybrid” refers to the dataset being a hybrid of statistical downscaling (e.g., “regular” LOCA and LOCA2) and dynamical downscaling (i.e., using regional climate models). In LOCA2-Hybrid, future simulations with a regional climate model are used as the source of weather patterns (the *localized constructed analogs*, or LOCA) to statistically downscale the raw, coarser global climate model output. See [this webpage](#) for additional details.

Following a method first used for the 2015 UWMP, Hazen then calculated the change in annual average maximum daily temperature (T_{max}) and the change in annual precipitation across the grid cells covering the SDCWA service area. This calculation was performed for the 129 projections for each of the future periods relative to the historical baseline. Then, Hazen calculated the 5th, 50th (median), and 95th percentiles of T_{max} change and precipitation change across the projections (Figure 2). When the percentiles are plotted as lines, their crossing points demarcate five scenarios covering most of the range of the potential climate futures, in terms of T_{max} change and precipitation change:⁵

- 95th percentile T_{max} , 95th percentile precipitation (“Warm/Wet”)
- 95th percentile T_{max} , 5th percentile precipitation (“Warm/Dry”)
- 5th percentile T_{max} , 95th percentile precipitation (“Cool/Wet”)
- 5th percentile T_{max} , 5th percentile precipitation (“Cool/Dry”)
- 50th percentile T_{max} , 50th percentile precipitation (“Moderate”)

To populate the details of these scenarios, of the 129 sets of projected changes in T_{max} and precipitation (i.e., individual model runs), the one that plots nearest to each scenario is selected, resulting in five model runs that represent the five scenarios.

IMPACT MODELING

The demand modeling involves separate econometric equations, or models, for each of four use sectors:

- Single-family residential
- Multi-family residential
- Non-residential (i.e., businesses, manufacturing)
- Agricultural

The models, calibrated using a regression procedure, relate changes in average rates of water use—per household, per employee, or per acre—to the climatic, socioeconomic, and land-use factors that influence water use within and among the water-using sectors. Additional model terms are used to capture variation specific to each member agency in SDCWA. The climatic or weather factors include monthly departure from normal T_{max} and monthly departure from normal precipitation, with lagged terms to represent delayed responses to weather. For the agricultural model only, the factor is monthly crop irrigation requirement (ETc), which is calculated from

⁵ This specific projection-selection methodology was first described in Water Research Foundation Project 4263 (2013). *Changes in Water Use Under Regional Climate Change Scenarios*.

temperature and precipitation and weighted by assumed acreage by crop.

After the models are calibrated, trends and other analytical tools (e.g., demographic models) are used to estimate the values of the non-weather factors at five-year increments from 2030 to 2050. The baseline demand modeling runs do not incorporate climate change; instead, one of two “weather scenarios” is input to the models along with each set of non-weather factors (for 2030, 2035, 2040, etc.):

- “Normal weather” – Based on the averages over a 30-year period
- “Single dry” – Based on the most stressful (hot-dry) recent year; for the 2020 and 2025 UWMPs, the year 2014 was chosen

To quantify the “multi-dry” scenario (five consecutive dry years), the demand that is calculated for the “single dry” year is followed by four years for which scaling factors are used to increase demand.

OVERVIEW OF THE ANALYTICAL APPROACH

The overall use of the climate models follows a “period-change” approach; the difference or change between a modeled baseline period and a modeled future period is used to adjust a historical climate condition or climate record (Figure 3). First, the five individual model runs are selected for each of the two climate projection periods (2045–2065; 2080–2100) as described earlier. Then, the resulting 10 sets of projected changes in average maximum daily temperature (T_{max} ; degrees F) and annual precipitation (%) are used to adjust the “normal weather” scenario, which is the historical (1991–2020) average T_{max} and annual precipitation as calculated from several local weather stations, and validated with the PRISM gridded climate dataset. This baseline for the “normal weather” scenario is calculated separately for the locations of each of the 22 member agencies, to reflect the climatological variation across the SDCWA service area, especially the temperature gradient from the coast to inland locations.

Next, the four sector demand models described above are re-run with the 10 sets of climate-change adjusted values of T_{max} and annual precipitation substituted for the original “normal weather” values. All the other inputs to the demand models are the ones previously estimated for 2050. This results in new demand numbers whose increase or decrease over the demand that was previously calculated for 2050 (i.e., without climate change) reflects only the additional influence of climate change.

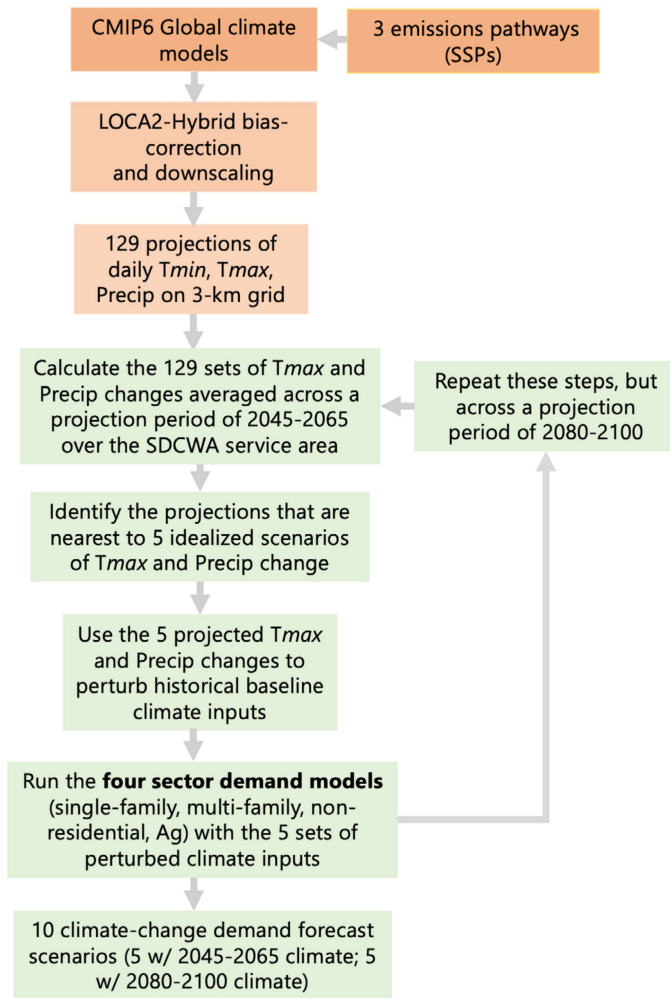


FIGURE 3.

Schematic of the approach to develop the climate change demand forecasts for the SDCWA Water Demand Forecast Update. Orange shading indicates data and processing completed by others prior to the analysis. Green shading denotes the steps performed by SDCWA with Hazen.

DATA HANDLING

The CMIP6 LOCA2-Hybrid data were obtained by Hazen as netCDF files from Cal-Adapt’s Amazon Web Services bucket: <https://cadcat.s3.amazonaws.com/index.html#loca2/aaa-ca-hybrid/>. Most of Hazen’s processing of the LOCA2 data was done using Python, with the output further processed and summarized in Excel. These spreadsheets were then loaded into SAS, Eviews, and/or PowerBI for the demand model calculations.



Lessons learned

FORECASTING DEMAND UNDER CLIMATE CHANGE INVOLVES MANY CONFOUNDING FACTORS

Kiefer highlighted that estimating the weather-response relationships that are then used to calculate climate change effects on demand is based on analysis of historical water use data and weather, in which many other confounding factors are present: water pricing, water shortage response, conservation, socioeconomic indices, and land use. Going forward, changes in these other factors may dampen or amplify the sensitivity of demand to each increment of temperature and precipitation, and so the historical correlations between water use and weather may not hold in the future. The uncertainties across all of the factors, including climate change, support the use of scenario planning or other approaches that consider multiple possible trajectories for future demand.

CLIMATE CHANGE PROJECTIONS THAT LOOK 25 YEARS OUT MAY PROVE USEFUL MUCH SOONER

In water year 2023, several potent atmospheric rivers hit southern California, and San Diego County experienced very wet and cool conditions overall; it was the coolest year since 1999. As a result, SDCWA's potable water use in 2023 dipped to a record low for the 21st century. In the winter season of 2023-2024, more atmospheric rivers heralded a second consecutive wet year, and SDCWA's "conventional" demand projections as mandated for the UWMP ("normal," "dry-year," "multi-dry") were not capturing the use pattern that was occurring. However, says Bista, the demand forecast for the "cool-wet" climate change scenario for 2045, developed for the 2020 forecast update, did provide useful guidance as to what would happen in a second wet year, and SDCWA was able to anticipate a slightly larger drop in water use in 2024.

AS A WATER PORTFOLIO CHANGES, NEW CLIMATE VULNERABILITIES MAY EMERGE

Historically, the main climate vulnerability that SDCWA has prepared for is drought and water shortages. The primacy of drought as the key vulnerability across all of California's urban water systems is reflected in the state-mandated UWMP reliability assessments. The investments made by SDCWA over the last 20-plus years shielded the region from cutbacks during the recent droughts. But as SDCWA reshaped its

water portfolio after 2000 to reduce drought vulnerability, among other motivations, it became more vulnerable to the financial impacts of demand reductions—and resulting “oversupply”—during wet years. After large infrastructure investments in desalination, and given long-term agreements to purchase fixed amounts of water annually through the QSA, the back-to-back wet years of 2023 and 2024 brought unexpected disruption to both system operations and financial planning. SDCWA has realized that these periodic wet/cool conditions need to be part of its scenario planning, alongside overall warmer and drier futures, and is currently exploring options to provide water to other water agencies through intrastate and interstate exchanges.



Further reading

OTHER INFORMATION ABOUT THE PROJECT

- [SDCWA 2020 Water Demand Forecast Update](#). (July 2021). (The methodology used for the 2020 update is very similar to that used for the 2025 update.)

RESEARCH OUTPUTS ABOUT THE METHODOLOGY/DATASET(S)

- [Krantz et al. \(2021\)](#). Memorandum on Evaluating Global Climate Models for Studying Regional Climate Change in California. (Describes the selection of 15 climate models for the LOCA2-Hybrid dataset.)

OTHER RELEVANT LITERATURE/WEBPAGES

- [WUCA Summary Report: Representing Climate Change Impacts in Water Demand Modeling](#). (October 2022).

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This case study was developed by Jeff Lukas (Lukas Climate Research and Consulting and AGCI) and Julie Vano (AGCI) based on conversations with staff from the San Diego County Water Authority. Additional guidance and input came from WUCA project managers Keely Brooks (Southern Nevada Water Authority) and Nolie Templeton (Central Arizona Project), and from WUCA's Climate Modeling Work Group.

We thank all who provided their insights!