California Water Plan Update 2023 Water Balances Supporting Document

August 2024

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Acronyms and Abbreviations

CalSIMETAW	California Simulation of Evapotranspiration of Applied Water
CNRA	California Natural Resources Agency
DAU	detailed analysis unit
DAUCO	detailed analysis unit by county
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
GIS	geographic information system
HR	hydrologic region
maf	million acre-feet
PA	planning area
PRISM	Parameter-elevation Relationships on Independent Slopes Model
QA/QC	quality assurance/quality control
SWP	State Water Project
Update 2018	California Water Plan Update 2018
Update 2023	California Water Plan Update 2023
WaDE	Water Data Exchange
Water Plan	California Water Plan
WY	Water Year

Introduction — Why and What is a water balance?

Why?

As part of each California Water Plan Update, current water conditions data and information are required by Water Code Section 10004.6. Major categories of data include basin hydrology, groundwater supplies, land use patterns, environmental water, population, evapotranspiration rates for major crop types, recycling and reuse, and water use. Water use categories include:

- Residential water uses.
- Commercial water use.
- Industrial water use.
- Parks and open space water use.
- Agriculture water use.

See Draft Assumptions and Estimates for California Water Plan Update 2023 for additional information.

What is a Water Balance?

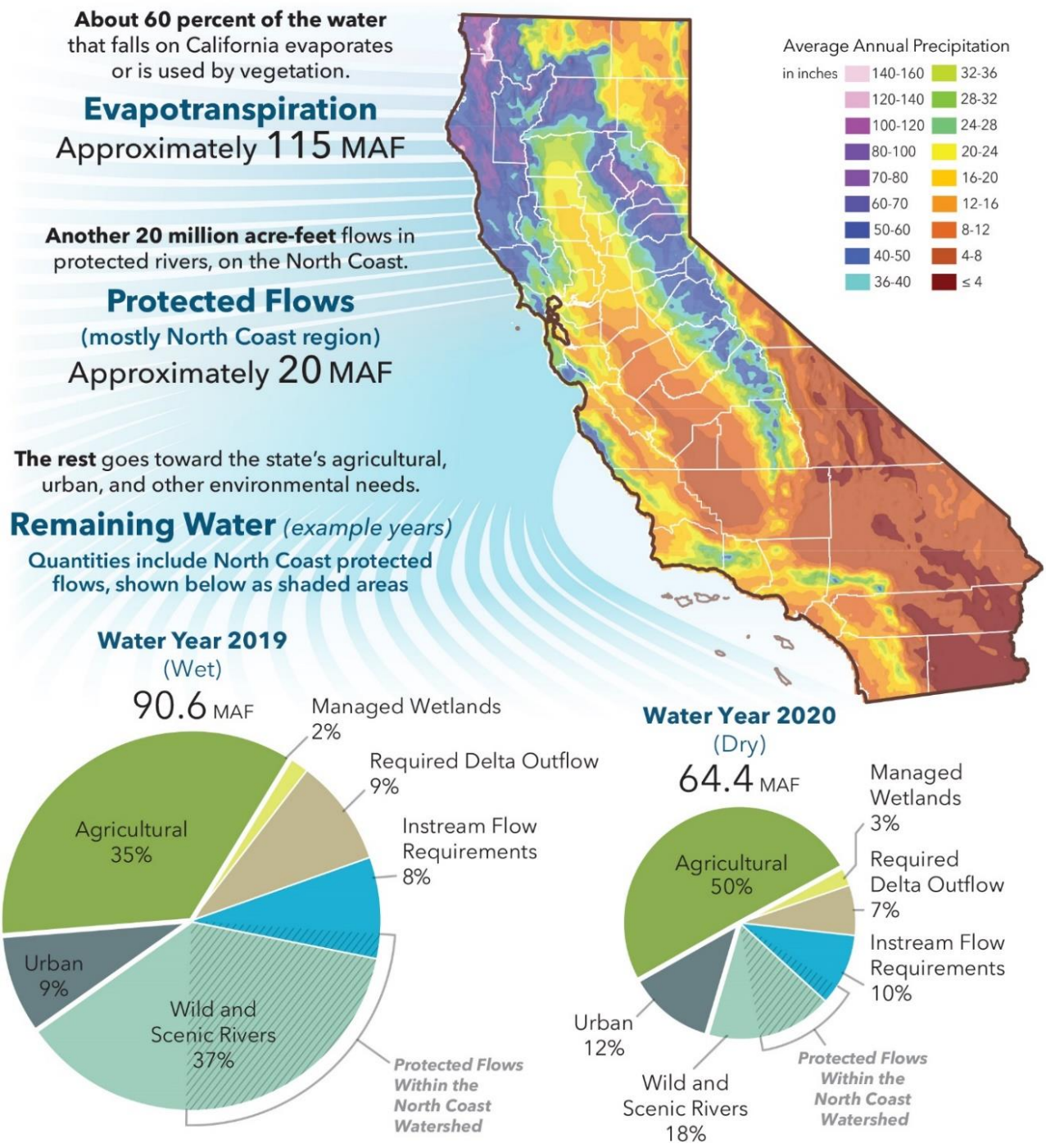
California water balances are simplified water budgets that include inflows and outflows from the land surface to the root zone. Water balances are a quantification of where and how water was used and the corresponding supply sources for a given water year. Water uses include accountings of agriculture, urban, environmental, and system uses. Developed water supply categories include surface water delivery projects, groundwater, and reused water. Dedicated water supplies include instream environmental flow volumes for Wild & Scenic Rivers, Required Delta Outflow, and Minimum Instream flow requirements.

About 60% of the precipitation that falls on California is either used by native vegetation or evaporates (Figure 1). Generally, the remaining precipitation includes developed and dedicated water supplies provided for actual uses. Figure 1 shows the variability of water use for a recent wet year (2019) compared with a dry year (2020). For the 1998–2020 time series, water use ranged from 64 million acre-feet (maf) in 2015, a critical dry water year, to 108 maf in 2006, a wet water year.

Water year hydrologic classifications

The water year hydrologic classifications in California are Wet, Above Normal, Below Normal, Dry, and Critical. These classifications are determined by two 4-river indices, one for the Sacramento Valley and one for the San Joaquin Valley, based on the unimpaired runoff from the two systems. Link:
https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

Figure 1 Water Use Distribution



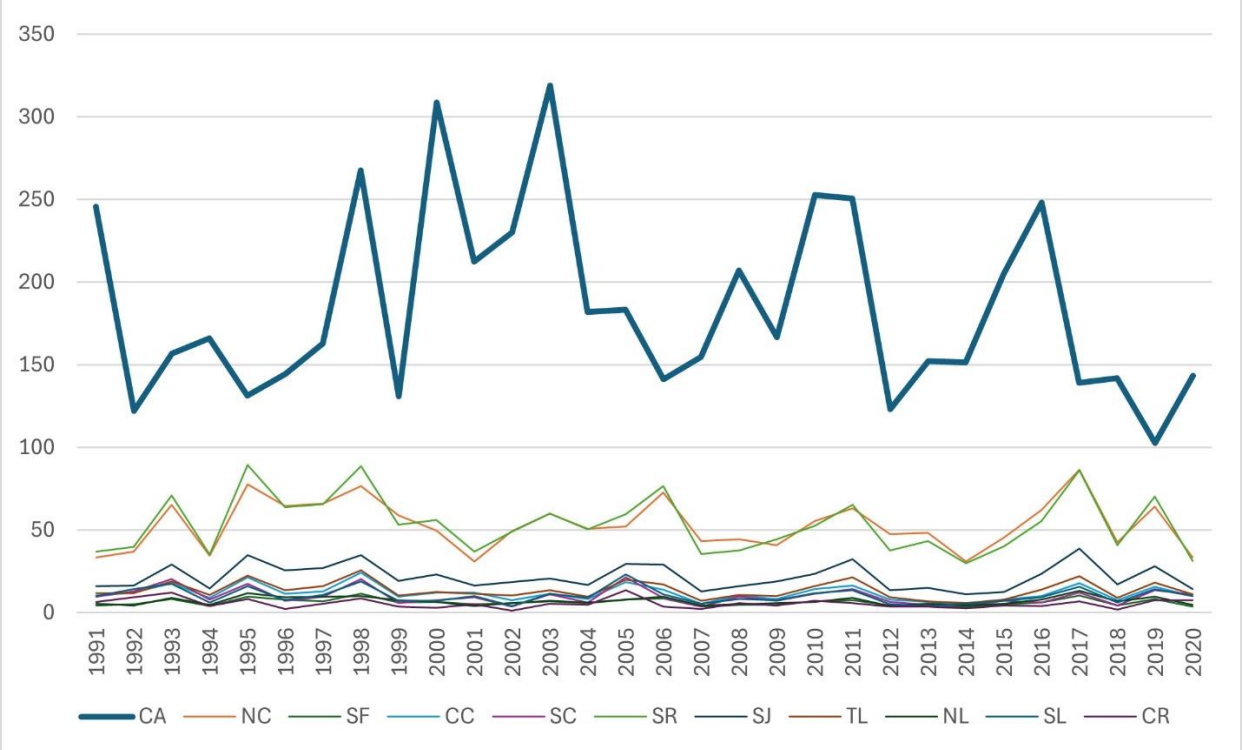
Precipitation

Precipitation differs dramatically throughout California. Average conditions are not useful for regional or local planning but do give a general picture of the entire state. Table 1 gives 30-year averages for precipitation in the state for three time-periods. Figure 1 shows the distribution of average annual precipitation in the state. Precipitation is calculated for various boundaries by application of yearly Parameter-elevation Relationships on Independent Slopes Model (PRISM) data at a 4-kilometer scale. The 30-year average for 1991–2020 is about 192 maf. Figure 2 shows both the entire state's and the individual hydrologic regions' precipitation for water years 1991–2020 in million-acre feet.

Table 1 30-Year Averages of Annual Precipitation

Years	Precipitation (in.)	Precipitation (maf)
1981–2010	23.4	197.5
1986–2015	21.9	184.7
1991–2020	22.5	191.8

Figure 2 State and Hydrologic Regions Precipitation (MAF)



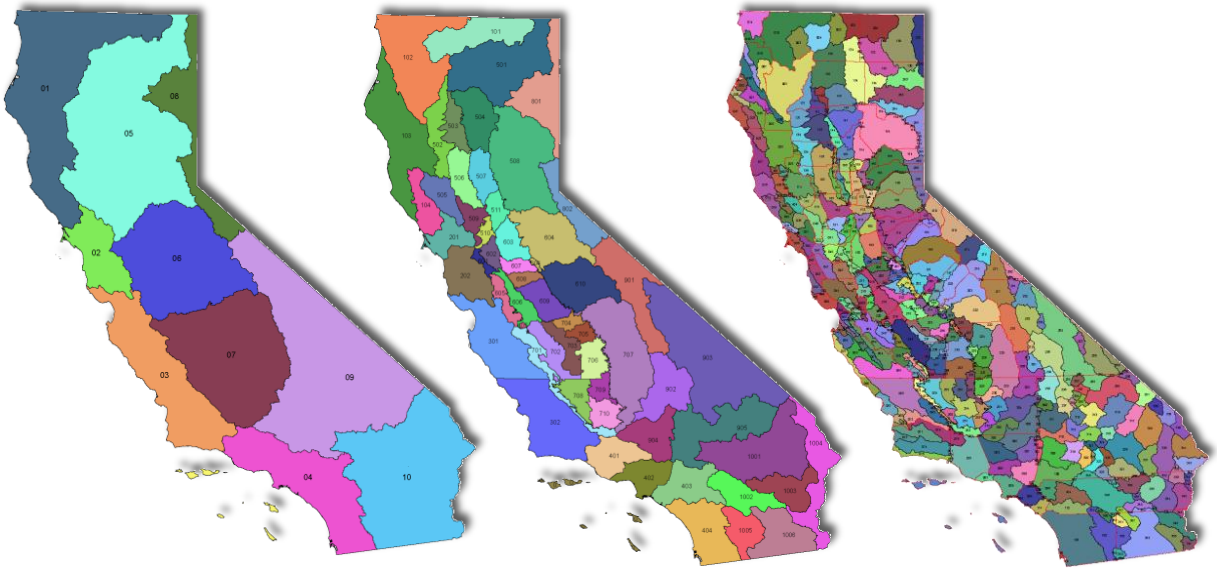
Study Areas

The California Department of Water Resources (DWR) subdivides California into specific geographical study areas for planning purposes, data collection and analysis, and reporting. Besides the entire state, the largest study areas are the 10 hydrologic regions (HRs) that correspond to the state's major drainage basins. Using drainage basins as planning boundaries allows logical tracking of water runoff and accounting of supplies. Water Plan study areas are shown in Figure 3. Boundaries can also be viewed on DWR's Water Management Boundary Tool (https://gis.water.ca.gov/app/boundaries/).

The Water Plan subdivides HRs into 56 planning areas (PAs) that are composed of 278 detailed analysis units (DAUs). The DAUs are split by county, so the smallest study area reported in the water balance is DAU by county (DAUCO). These 487 study areas are a mix of hydrologic and political boundaries. This means that when counties change their boundaries, even slightly, the DAUCO boundaries change. In some cases, a river is a boundary to a study area. When a river veers, it causes a change to a boundary area as well. Many planning studies begin at the DAUCO or PA level depending on available data. The results are aggregated to county or hydrologic region for presentation, reporting, and sharing.

The DAUCO spatial data set is now a static data set, as it is no longer being updated by DWR's GIS Committee. It is available for download on the California Natural Resources Agency (CNRA) Open Data Platform (https://data.cnra.ca.gov/dataset/i03-dau-county-cnty2018).

Figure 3 Hydrologic Regions, Planning Areas, and Detailed Analysis Units



California is 158,542 square miles with a population of about 40 million people. California's largest urban and agricultural areas are misaligned with the timing, quantity, and location of precipitation. California's surface water projects were designed and continue to be managed to mitigate these misalignments. Surface reservoir storage capacity is about 42 maf. Regional inflow and outflow Figures 4 and 5 provide a geographic overview of California and surface water inflows and outflows with adjoining states, between hydrologic regions, and to the Pacific Ocean, for a recent wet year and dry year. Summaries of California's Hydrologic Regions describing conditions and vulnerabilities in each of the 10 hydrologic regions and two overlay areas are found in *California Water Plan Update 2023 — Chapter 3, Natural and Built Backbone Water Infrastructure and Regional Summaries*.

Figure 4 Water Year 2019 Regional Inflows and Outflows

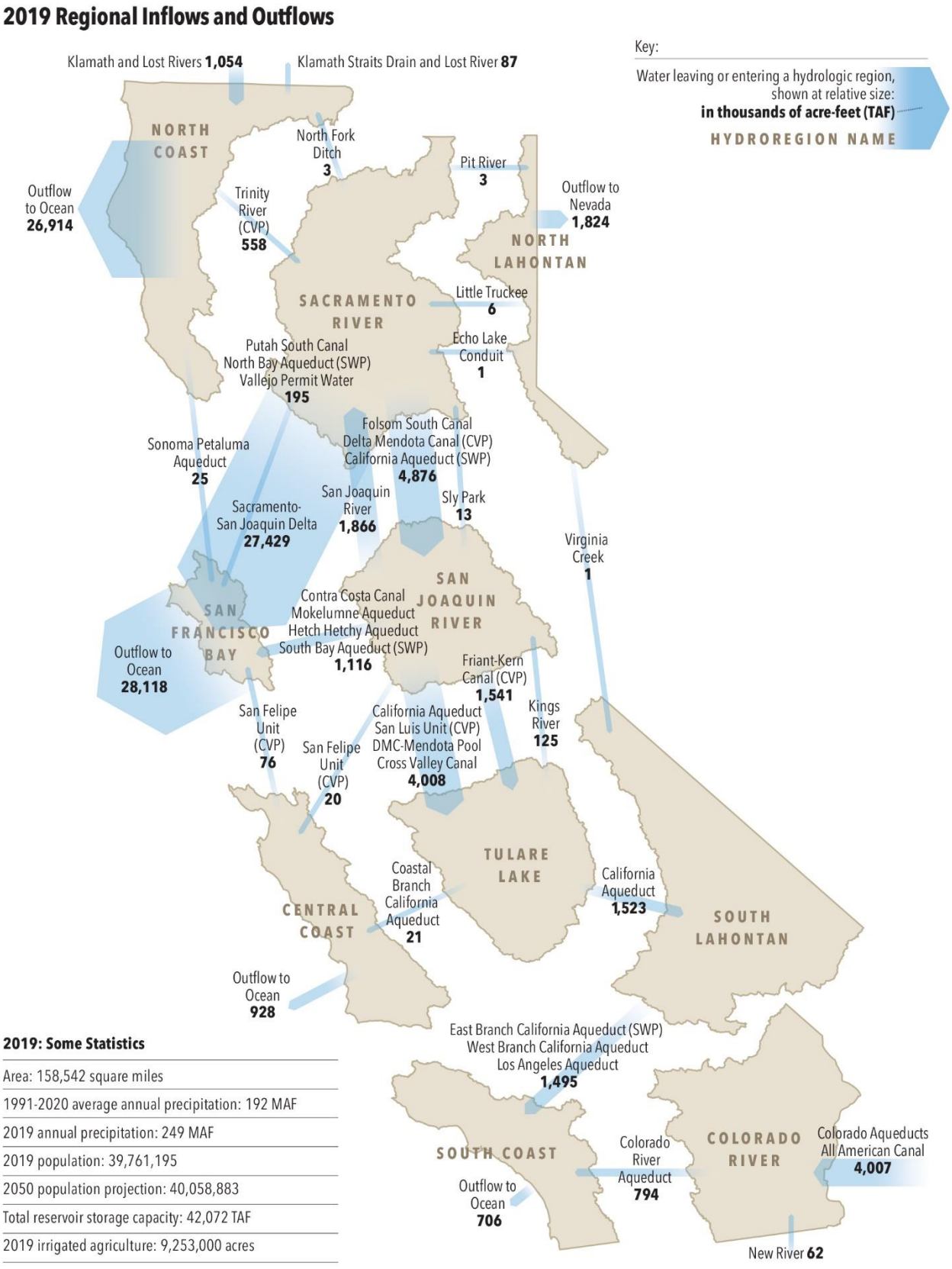
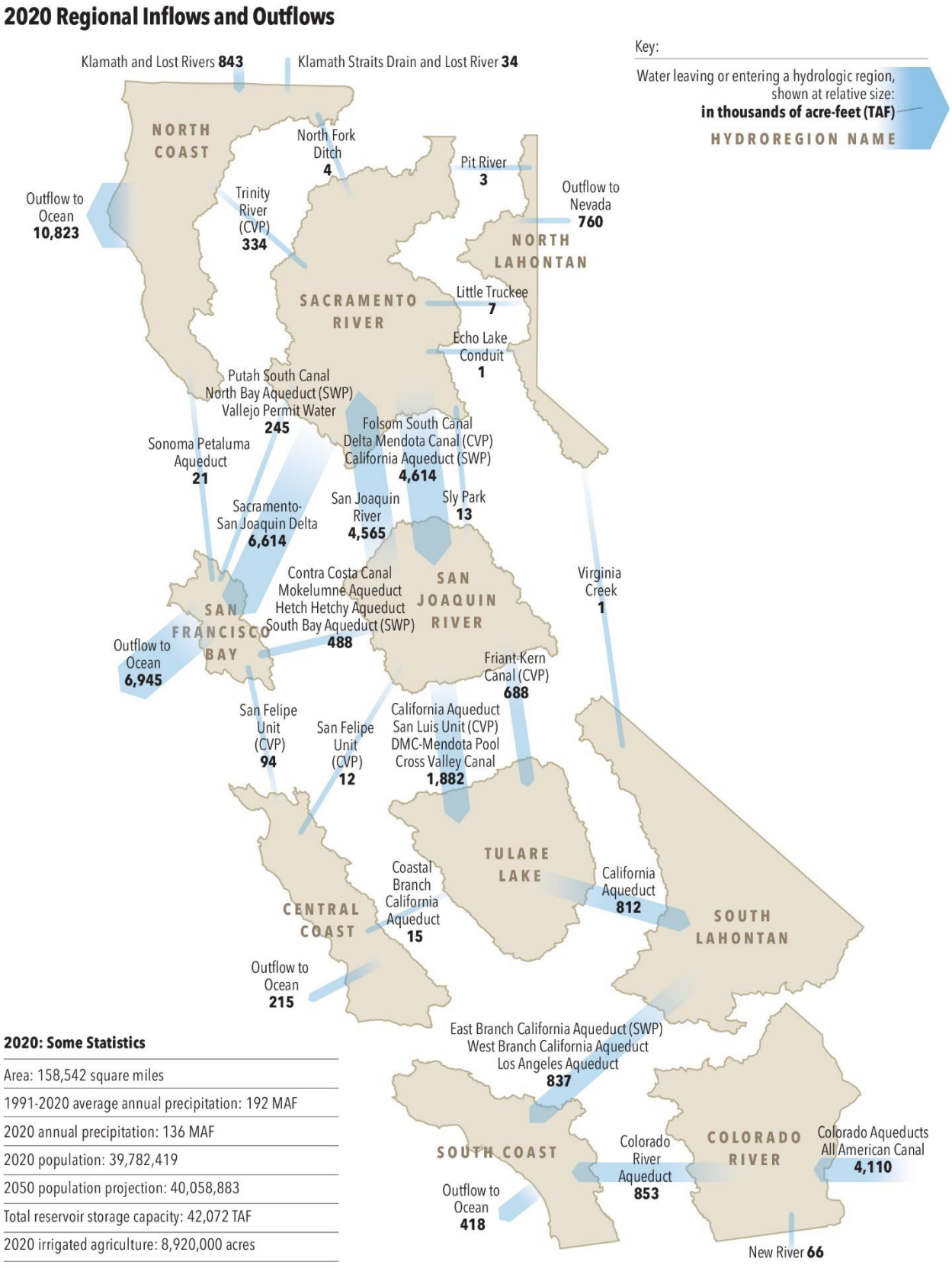


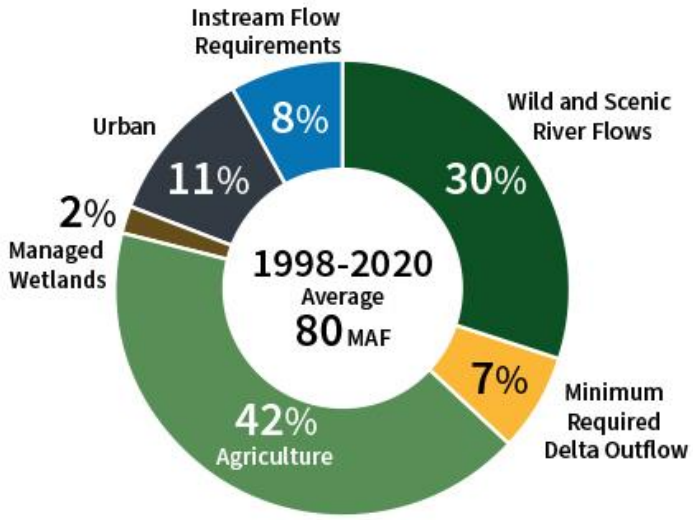
Figure 5 Water Year 2020 Regional Inflows and Outflows



Water Use

On average, about 80 maf goes to our state's agriculture, urban, and required environmental and system needs (see Figure 6). The Water Plan's water balances include water used for urban and agricultural sectors and water dedicated to the environment.

Figure 6 Average Applied Water Use



Urban and Agricultural Use

Urban water use includes water for interior and exterior residential, commercial, industrial, and large landscape uses. Urban applied water use is the quantity of water delivered to the intake of a water supplier's system. It equals the amount of water delivered to customers plus water used for conveyance and/or groundwater recharge. Urban water data in the water balances is analyzed on a per capita basis using public water system statistics data or Electronic Annual Reports (eAR) and population data. Statewide urban water uses for WYs 2016–2020 ranged from 7.2–8.2 million acre-feet (maf), as shown in Figure 7.

Agricultural water use is calculated from annual irrigated crop acres, precipitation, crop evapotranspiration coefficients, and other factors using the California Simulation of Evapotranspiration of Applied Water (CalSIMETAW) model. Crop acres are estimated from remote sensing land use surveys combined with ground truthing. Total applied water used in the agricultural sector is the quantity of water delivered to a farm headgate and

includes applied water for crop production, conveyance applied water, and applied water for groundwater recharge. It includes adjustments for irrigation efficiencies and the amount of water required for farming practices such as frost protection, the ponding of water in rice fields, or the application of extra water to leach accumulated salts from the soil. Agriculture applied water use had a range of 31.6–33.7 during water years 2016–2020 (Figure 7) for a range of 8.9–9.3 million irrigated crop acres.

Additional information about urban and agricultural water use can be found on the DWR Land and Water Use web page: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use. Land use data, information, and documentation can be accessed on California Department of Water Resources Land Use Gallery (arcgis.com). Population information can be found on DWR Demographics web page: https://water.ca.gov/Library/Modeling-and-Analysis/Statewide-models-and-tools/Economic-Modeling-and-Analysis-Tools.

Environmental Water

Environmental water includes water used for managed wetlands and water dedicated to the environment for minimum required Sacramento-San Joaquin Delta (Delta) outflow, minimum instream flow requirements, and flow volumes for designated Wild and Scenic rivers and river reaches.

Managed wetlands include impounded freshwater and nontidal brackish water wetlands. Managed wetlands water use is calculated for different habitat types. Habitat types include cropland; permanent, semi-permanent, and seasonal wetlands areas; upland forage and upland irrigated habitats; managed nesting areas; groundwater recharge areas; reverse cycle wetlands; and alkali sink scrub areas. Cropland water use is calculated using the CalSIMETAW model. Water uses for other habitat types are estimated using evapotranspiration data, habitat type coefficients, and precipitation data.

Delta outflow volumes are compiled by using daily data for total outflow (Dayflow). Minimum required outflow relies on DWR operational data for the amount required by law to maintain flow and water quality standards to protect the beneficial uses within the Delta. While it is acknowledged that this water benefits all water uses, it is grouped here for convenience.

Annual volumes for instream flow requirements consist of actual flows released by project operators or within their natural watercourse as specified in a water rights permit, court decision, agreement, or Federal Energy Regulatory Commission license to support natural ecosystems or create habitat for plants and animals. Instream flow requirements generally vary by water year type. Volumes are collected from project operators and/or stream gauges.

Wild and Scenic Rivers are federally and/or State-designated river systems under federal and State Wild and Scenic Rivers Acts. More than 2,000 miles of rivers and river reaches are designated as wild, scenic, or recreational in California. Unimpaired natural flow volumes are collected or calculated for designated rivers and river reaches. Wild and Scenic volumes depend on how much precipitation falls on a watershed and becomes unimpaired runoff; the volumes ranged from 11.4 maf to 33.4 maf during Water Years 2016–2020 (Figure 7). This excludes data for WY 2017, an extremely wet year, which is likely the actual high end of the range.

Locations of designated Wild and Scenic rivers can be seen on DWR's Water Boundary Management Tool as an interactive layer.

Figure 7 California Applied Water Balances, WYs 2011–2020

WATER YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
percent of average rainfall	134%	75%	77%	56%	78%	103%	161%	73%	130%	71%
APPLIED WATER USE										
Wild & Scenic River	36.5	20.2	17.1	10.5	14.2	28.6	no data ↓	18.2	33.4	11.4
Instream Flow	7.9	6.8	6.6	5.6	5.3	6.3		6.5	7.7	6.4
Required Delta Outflow	7.4	5.3	4.5	4.0	3.7	4.8		5.3	8.4	4.4
Managed Wetlands	1.5	1.6	1.6	1.6	1.5	1.5		1.6	1.5	1.7
Irrigated Agriculture	31.7	35.0	35.7	35.0	32.4	33.2		33.7	31.6	32.4
Urban	7.7	8.3	8.3	8.1	7.0	7.2		8.2	7.9	8.0
DEDICATED AND DEVELOPED WATER SUPPLY										
Colorado Project	4.2	4.7	5.3	5.8	5.0	4.7		4.4	4.0	4.1
Federal Projects	7.1	6.4	5.7	3.9	3.3	7.0		8.7	8.9	7.8
State Project	2.9	2.8	2.0	1.3	0.9	1.8		2.5	2.4	1.9
Local Imports	1.0	0.8	0.7	0.5	0.4	0.6		0.7	0.9	0.9
Local Projects	10.3	8.2	6.8	6.3	4.9	5.4		6.9	8.3	6.5
Groundwater	12.1	18.1	20.8	23.0	22.9	17.9		16.2	12.2	16.4
Reused and Recycled Water	23.6	14.4	14.2	11.4	10.4	15.9		15.7	23.5	14.5
Instream Environmental	31.3	21.6	18.0	12.4	16.2	28.1		18.2	30.3	12.0
SWP allocation on April 1	80%	65%	35%	5%	20%	60%	85%	35%	75%	20%

Water Supplies

Water balances include data for developed and dedicated water that supplied water uses for a given water year. Dedicated and developed supplies include

surface water, groundwater, reused water, and recycled water. Supplies are grouped into categories for summary tables and graphics (Figure 7). Supply categories include Colorado River; federal, State, local and local imported deliveries; groundwater; reused and recycled water; and instream environmental supply. Applied water balances include water that is used multiple times for multiple benefits. Dedicated and developed water supply statewide averages 40–50% of annual precipitation, but in extremely wet or critical years can be 29% (1998-wet) or 63% (2014-critical) respectively.

On average, approximately two-thirds of precipitation is depleted through evapotranspiration by trees and other native vegetation, evaporates to the atmosphere, or is stored as effective precipitation. Approximately one-third of California's precipitation stays in the system as runoff, including runoff used for consumptive use and storage changes in the region. About 30 percent of that one-third is depleted as non-designated (though often beneficial) outflow to the Pacific Ocean, other salt sinks, and/or other states. This additional runoff is significantly reduced in dry years and as low as 0 percent in critical years and drought sequences.

Figure 8 charts the general disposition of precipitation for a 22-year average. Table 2 is a hydrologic summary table for California, showing data for WYs 2016–2020. Hydrologic summary tables itemize water entering the region, water leaving the region, and storage changes in the region. Supporting documentation includes the hydrologic summary tables for 10 hydrologic regions and the entire state for WYs 1998–2020. The disposition of precipitation and runoff varies dramatically throughout regions in the state by water year type and by different hydrologic conditions. California's variability makes standardization of water management nearly impossible.

Figure 8 Disposition of Average Precipitation and Inflow for WYs 1998–2020

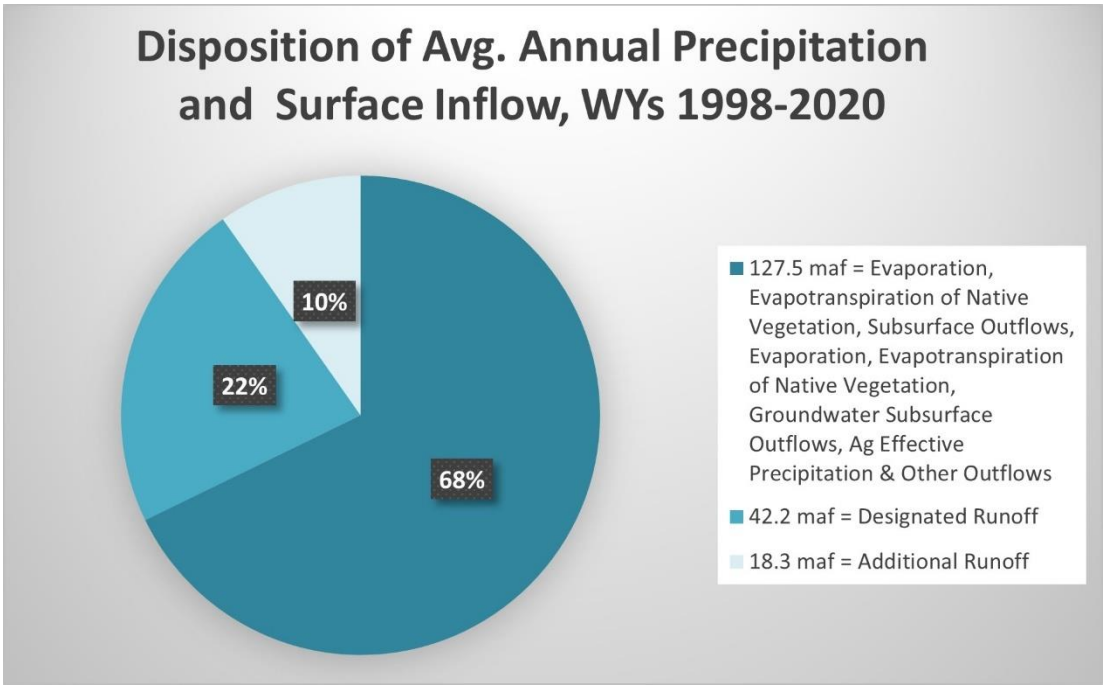


Table 2 California Hydrologic Summary WYs 2016–2020 (maf)

Statewide (million acre-feet)	Water Year (Percent of Normal Precipitation)	Water Year (Percent of Normal Precipitation)	Water Year (Percent of Normal Precipitation)	Water Year (Percent of Normal Precipitation)
	2016 (103%)	2018 (73%)	2019 (130%)	2020 (71%)
Water Entering the Region				
Precipitation	198.1	140.6	249.2	136.3
Inflow from Oregon/Mexico	1.1	1.0	1.1	0.9
Inflow from Colorado River	4.7	4.4	4.0	4.1
Imports from Other Regions	NA	NA	NA	NA
Total	**204.0**	**145.9**	**254.3**	**141.3**
Water Leaving the Region				
Consumptive Use of Applied Water * (Ag, M&I, Wetlands)	28.9	28.9	26.6	28.0
Outflow to Oregon/Nevada/Mexico	1.1	1.5	2.1	1.0
Exports to Other Regions	NA	NA	NA	NA
Statutory Required Outflow to Salt Sink	28.4	18.9	30.1	12.8
Additional Outflow to Salt Sink	13.5	9.3	28.0	7.1
Evaporation, Evapotranspiration of Native Vegetation, Groundwater Subsurface Outflows, Natural and Incidental Runoff, Ag Effective Precipitation & Other Outflows	139.9	103.0	168.6	111.2
Total	**211.9**	**161.7**	**255.3**	**160.1**
Storage Changes in the Region				
[+] Water added to storage				
[–] Water removed from storage				
Change in Supply - Surface Reservoir	6.0	-4.7	5.7	-7.0
Change in Supply - Groundwater Storage	-13.9	-11.0	-6.7	-11.7
Total	**-7.9**	**-15.7**	**-1.0**	**-18.7**
Applied Water * (compare with Consumptive Use for Ag, M&I, and Managed Wetlands only.)	41.9	43.5	41.1	42.1
* Definition - Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.				

Water Balances

Each area's water needs are unique. The amount of water required to meet an area's needs depends on several factors, including water uses in an area, opportunities to reapply water, and the types of resource management strategies that have been implemented. The Water Plan provides applied, net, and depletion water balances for the entire state and the individual hydrologic regions, planning areas, and DAUCOs. These water balances are analyses of developed and dedicated water supplies, water uses, water reuses, and operational characteristics for an area. Water balance analyses show the amount of water applied to actual uses. In this way, use equals supply. Water uses are calculated and then compared and matched with supply data collected by the Water Supply and Balance Team.

An applied water balance provides an upper boundary on the amount of water used because it includes consumptive use, reuse, and outflows. *Applied water* refers to the total amount of water diverted from any source to meet uses without adjusting for water that is used up, returned to the developed supply, or irrecoverable (losses).

- Net water supply and net water use amounts are smaller than applied water amounts because net water use consists of water that is consumed in the system, irrecoverable water, and outflow.

- Applied water includes reuse of surface and groundwater supplies while net water does not.

- Water depletion is net water use minus water that can be later recovered, such as deep percolation to groundwater or return flow to a developed supply.

- Applied water methodology is easier for local water agencies to evaluate because applied water use information is closer in concept to agency water-system-delivery data.

Instream environmental water "use" includes:

- Water that is required to remain in a stream because of an instream flow requirement.
- Any flow given a Wild and Scenic River designation or is required Delta outflow (this water is not applied in the traditional sense of being diverted and applied).

The designated water supply, also called *instream environmental*, is the water that is required by law, code, or agreement to remain in a stream and is often reused for multiple purposes.

Detailed water balance parameters, equations, diagrams, and technical definitions can be found in the Update 2023 Standard Operating Procedures for Water Balance Automation. Applied, net, and depletion water balances by PA, HR, and the State for WYs 1998–2020 can be found in the Supporting Document Files section, folder /3-Summaryfiles/. Detailed DAUCO results are in folder /0-Level0-DAUCO-Data_Entry/. Hydrologic region water balances by water year for 1998 to 2020 are on a Tableau Data Viewer for

Water Balances, Workbook: Water_Balance (ca.gov). Water balance data for WYs 2002–2020 is published on Water Plan Water Balance Data - Dataset - California Natural Resources Agency Open Data.

Looking Forward

Water balances are a simplified water budget that includes the land surface to the root zone. A full water budget includes every hydrologic cycle component. Water balances must integrate with a full water budget, creating a total water accounting system to manage and develop water resources for sustainability and resilience for the people of California. A roadmap is currently being developed for statewide water accounting.

Supporting Document Files (Water Balance | Powered by Box)

0. /0-Level0-DAUCO-Data_Entry/ (https://cadwr.box.com/s/44jkzuk84qli5tatwjghfpsvgj9c37wm)
    - 2016_Data_Entry_final-update-nw
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    - 2019_Data_Entry_final
    - 2020_Data_Entry_final
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        - /2016/
        - /2018/
        - /2019/
        - /2020/
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    - Master-OWIA WaterBalance-2016-DataTables-Verification.pdf
    - Master-OWIA WaterBalance-2018-DataTables-Verification.pdf
    - Master-OWIA WaterBalance-2019-DataTables-Verification.pdf
    - Master-OWIA WaterBalance-2020-DataTables-Verification.pdf
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    - /2018_CA_Level01_final.zip/

- /2019_CA_Level01_final.zip/
- /2020_CA_Level01_final.zip/

2. /2-Level2-published/ (https://cadwr.box.com/s/397h2ao35k6wodlpda22rdylzxzcn63u)
3. /3-Summaryfiles/ (https://cadwr.box.com/s/khk29gjw7m3zmlc121plfzhjggqx3zva)
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    - Table200-AppliedNetDepletionWaterBalances-PA_22_WY-1998-2020-balances_avgs.xlsx
    - County_totals_1999and2002-2020_20-year_2023-July.xlsx
    - HistoricalTrend-1972-2020_statewide_water_data.xlsx
    - HydrologicSummary_CAandRegions_1998-2020.xlsx
    - /Graphics/
4. /4-EnvrWater/ (https://cadwr.box.com/s/53wu19ovp95z6v8n1kh44l76cpti4v1c)
    - 1998-2020-DeltaOutflow(7_7_2021)-Total_MinReqd.xlsx
    - FOR-RegionalOffices-State-Level-Environmental-Data-wys2011-2020.xlsx
    - Instream_Flow_Requirements_2010-2020_FG_Mar2023.xlsx
    - Wild_and_Scenic_River_Data_WY2010-2020_Mar2023.xlsx
    - Wild_Scenic_legal-descriptions.xlsx
5. /5-LandandWaterUse/ (https://cadwr.box.com/s/iuvdqq5g3s8ppwl3hcq9b8f29kwz8opw)
    - 2019AgDataStatewideByDauCo_ByUnitValueRevisedFeb1_23.xlsx
    - 2019AgDataStatewideByDauCo_ByVolumeVer1RevisedFeb1_23.xlsx
    - 2020Statewwide_AgDataDauCo_UnitValuesWorkingFile_Jul12_23.xlsx
    - 2020Statewwide_AgDataDauCo_VolumeWorkingFile_Jul12_23.xlsx

- RevisedStatewide_2018AgDataByDauCO_ByUnitValueOct12_22.xlsx
- RevisedStatewide_2018AgWaterDataByDauCO_ByVolumeOct12_22.xls
- Statewide_2016AgWaterUseDataByDAUCO_UnitValue_Jun23_20.xlsx
- Statewide_2016AgWaterUseDataByDAUCO_Volume_Jun23_20.xlsx

6. /6-Precipitation/ (https://cadwr.box.com/s/058cvfim7d3ina7tnsbivi7xg2f7lr5i)
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    - /AnnPcpState_WY2016-2020/
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    - 30-YrAvgPcp_CC.csv
    - 30-YrAvgPcp_CR.csv
    - 30-YrAvgPcp_NC.csv
    - 30--YrAvgPcp_NL.csv
    - 30--YrAvgPcp_SC.csv
    - 30-YrAvgPcp_SF Bay.csv
    - 30-YrAvgPcp_SJR.csv
    - 30-YrAvgPcp_SL.csv
    - 30-YrAvgPcp_SR.csv
    - 30-YrAvgPcp_TL.csv
7. /7-Population/ (https://cadwr.box.com/s/6xqrd6vhkqa8b60h048vf85v7sppjs0e)
    - DAU_CO_Pop_Trends_2000-2020-withDAUCOcodes.xlsx
    - HR_PA_County_Pop_Current_Trend_Updated w DOF Census 2020.xlsx
    - Jan 1998-Jan 202.xlsx
    - Population1990-2019.xlsx

8. /8-Text/ (https://cadwr.box.com/s/7cct8mxrizd3o0gktp9rawgm4s67e90m)
    - Update 2023 Water Balances Supporting Document.pdf
    - Update 2023 Standard Operating Procedures for Water Balance Automation.pdf

URLs:

California water year hydrologic classification: https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST

California Natural Resources Agency (CNRA) Open Data Platform DAUCO dataset: https://data.cnra.ca.gov/dataset/i03-dau-county-cnty2018

CNRA Open Data Platform Water Plan Water Balance Data: https://data.cnra.ca.gov/dataset/water-plan-water-balance-data

DWR California Water Plan Update 2023: https://water.ca.gov/Programs/California-Water-Plan/Update-2023

DWR California Water Plan Update 2023 Draft Assumptions and Estimates Report: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2023/PrePRD/CWP-Draft-AE-2023.pdf

DWR California Water Plan Water Balances: https://water.ca.gov/Programs/California-Water-Plan/Data-and-Tools

DWR Demographics web page: https://water.ca.gov/Library/Modeling-and-Analysis/Statewide-models-and-tools/Economic-Modeling-and-Analysis-Tools

DWR Draft Handbook for Water Budget Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Water-Budget-Handbook.pdf

DWR Land and Water Use web page: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use

DWR Land Use Gallery: California Department of Water Resources Land Use Gallery (arcgis.com)
https://storymaps.arcgis.com/collections/dd14ceff7d754e85ab9c7ec84fb8790a

DWR Tableau water balances data viewer:
https://tableau.cnra.ca.gov/t/DWR_Planning/views/Water_Balance/HRButterflyChart?iframeSizedToWindow=true&%3Aembed=y&%3AshowAppBanner=false&%3Adisplay_count=no&%3AshowVizHome=no

DWR Water Management Boundary Tool:
https://gis.water.ca.gov/app/boundaries/

eAR:
https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/ear.html

Spatial Patterns of Water Supply and Use in California:
https://doi.org/10.15447/sfews.2024v22iss2art2

Update 2023 Standard Operating Procedures for Water Balance Automation:
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2023/Supporting-Documents/Update-2023-Water-Balances-Automation-SOP.pdf