Drought and Climate Change

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Defining Drought -- When Does "Dry" Become "Drought"?

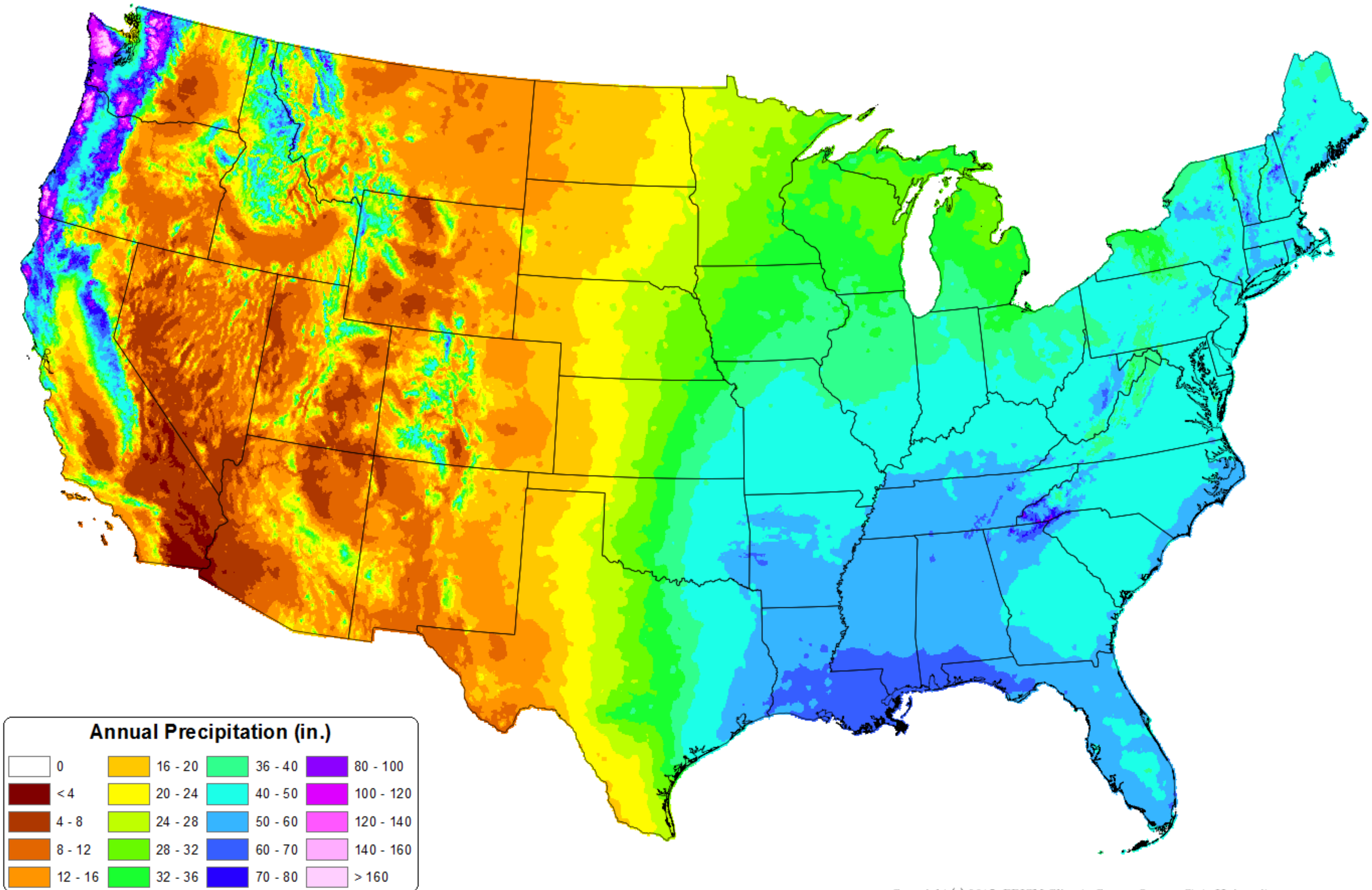
- Meteorological drought
- Hydrological drought
- Regulatory drought
- Drought indices, US Drought Monitor
- Sector-based definitions
- **Drought is a function of impacts (which are typically regional or local)**

When Does “Drought” Become “Drought Emergency”?

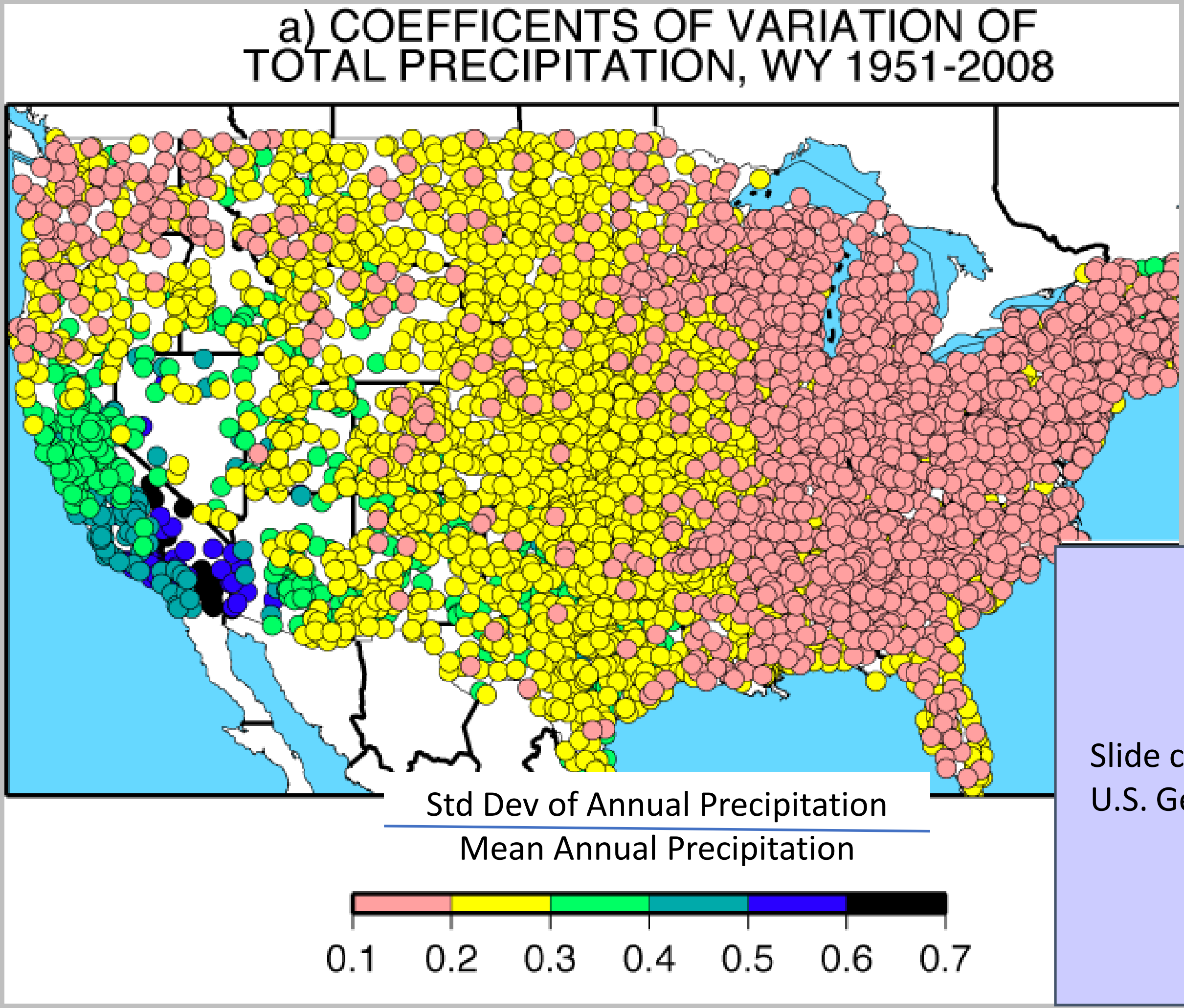
- Depends on impacts, and ability to mitigate impacts
- Drought differs from traditional “emergencies” (flood, fire, etc) in its very slow timescale
- California Emergency Services Act
  - Role of local government (counties)
  - Role of state

30-yr Normal Precipitation: Annual

Period: 1981-2010



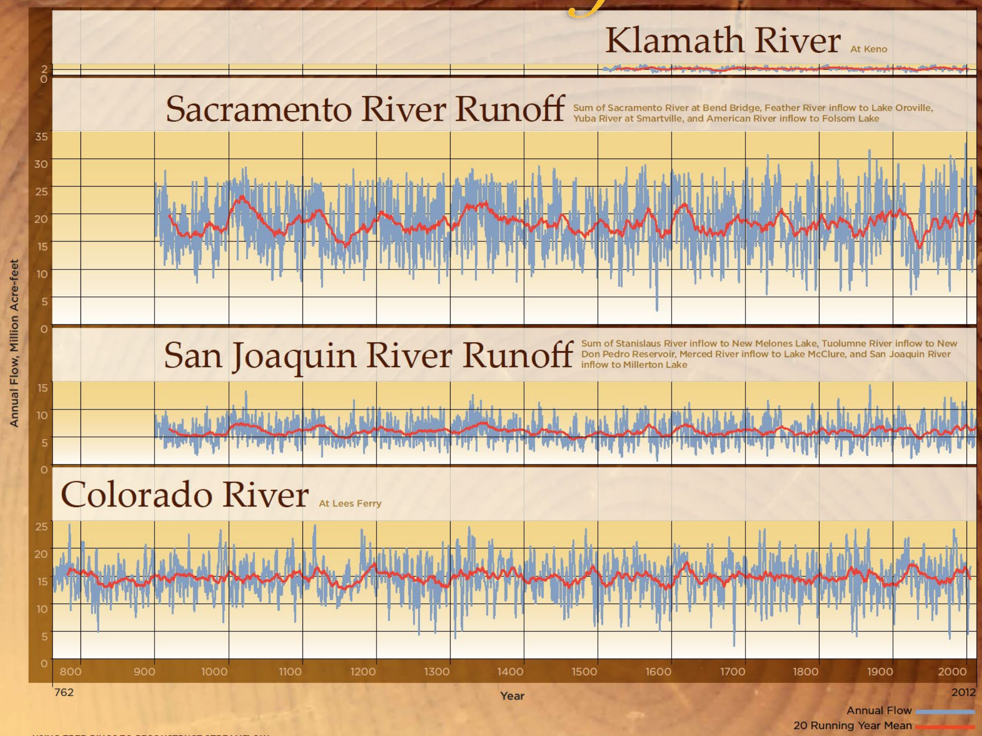
Variability of Western Precipitation



Slide courtesy of Mike Dettinger, U.S. Geological Survey

Dettinger et al, 2011

Reconstructed Streamflows & Drought Periods



USING TREE-RINGS TO RECONSTRUCT STREAMFLOW

A tree-ring reconstruction is a set of tree-ring width data that have been calibrated with an instrumental or gaged record of a hydrologic or climatic variable such as annual streamflow or precipitation. The reconstruction, based on a statistical model that describes the relationship between tree growth and the gage record, extends that record back hundreds of years into the past.

Tree growth in dry climates is limited by water availability. Trees that provide the best information about hydroclimatic variability are those particularly sensitive to variations in moisture. These include species such as blue oak, ponderosa pine, Douglas fir, and western juniper, usually growing at lower elevations in sparse stands on dry and rocky sites where soil moisture storage is minimal.

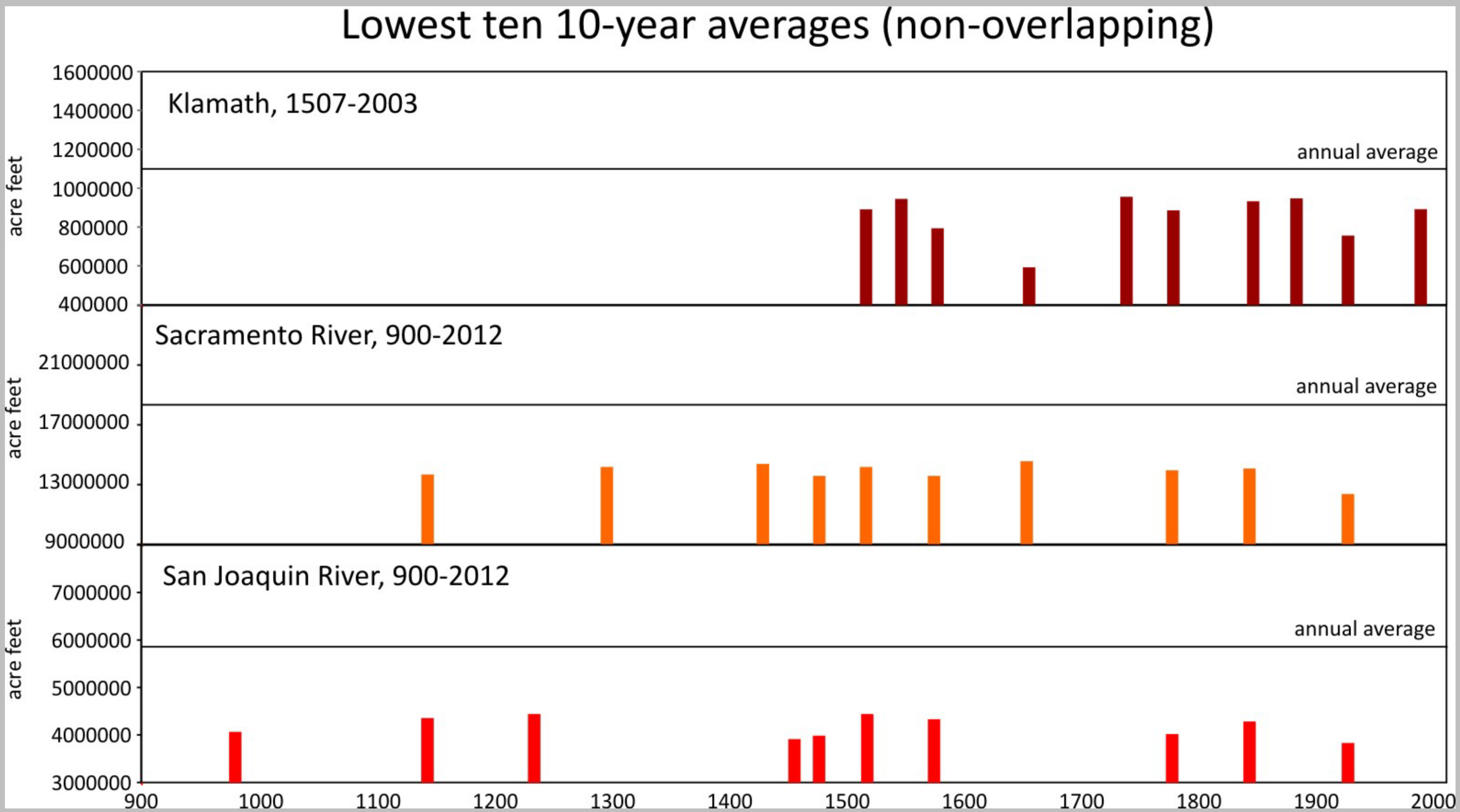
Tree-ring reconstructions of hydroclimatic variables are developed from tree-ring chronologies. A tree-ring chronology is a time-series of annual values derived from the ring-width measurements of 10 or more trees of the same species at a single site. To create a tree-ring chronology, cores from the sampled trees at each site are cross-dated (i.e., patterns of narrow and wide rings are matched from tree to tree) to account for missing or false rings, so that every annual ring is absolutely dated to the correct year. Then all rings are measured to the nearest thousandth of a millimeter using a computer-assisted measuring device. After growth-related trends unrelated to climate are statistically removed, the ring width values from all sampled trees for each year are averaged to create a time series of annual ring width indices. The complete series of ring width indices from a site is called a tree-ring chronology.

Once a gaged record of interest is selected for reconstruction, a set of tree-ring chronologies from the region near the gage is calibrated with the gage record to form a reconstruction model. A statistical technique called multiple linear regression is commonly used. The reconstruction is evaluated by comparing the observed gage values with the reconstructed values by assessing the amount of variance in the gage record that is explained by the reconstruction.

DROUGHTS PRIOR TO THE HISTORICAL RECORD

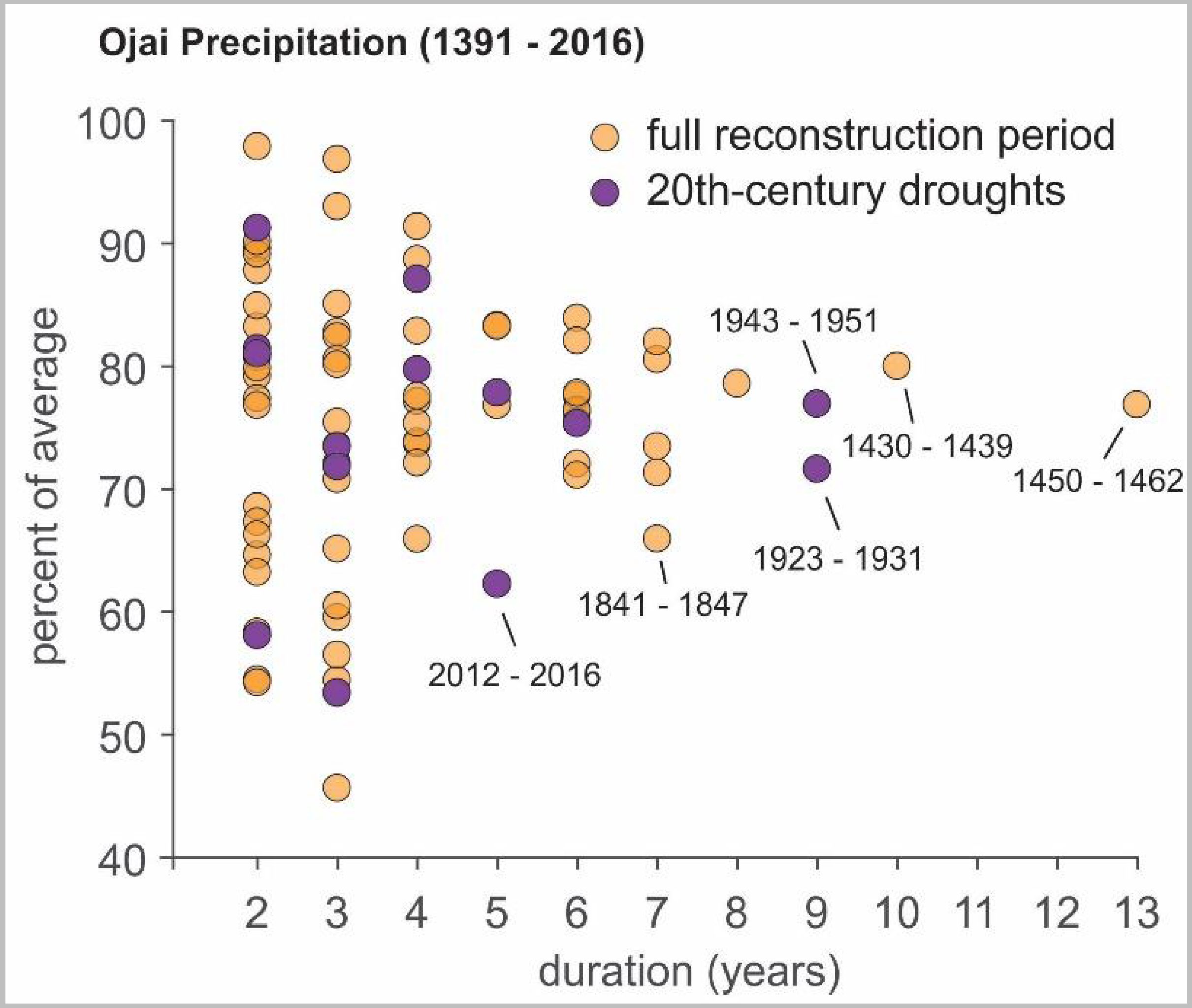
The period of reliably measured streamflows for rivers throughout the West seldom reaches beyond 100 years, which represents only a fraction of climatologically modern time. As these streamflow reconstructions show, there have been droughts prior to the historical period that were more severe – particularly in duration – than those in the measured record. The reconstructed record captures a broader range of hydrologic variability than does the historical record, making reconstructions useful for drought preparedness planning. Of particular interest from a scientific perspective is the Medieval Climate Anomaly, a time during which sustained severe drought gripped much of the western United States, as exemplified illustrated in the Sacramento, San Joaquin, and Colorado River reconstructions.

Data source: Work performed by the University of Arizona under contract to the California Department of Water Resources. CDWR Agreements 4600003882 (David Meko, 2006) and 4600008850 (David Meko, Connie Woodhouse, Ramzi Touchan, 2014)



Courtesy of Connie Woodhouse

Drought Risk for Local Supplies

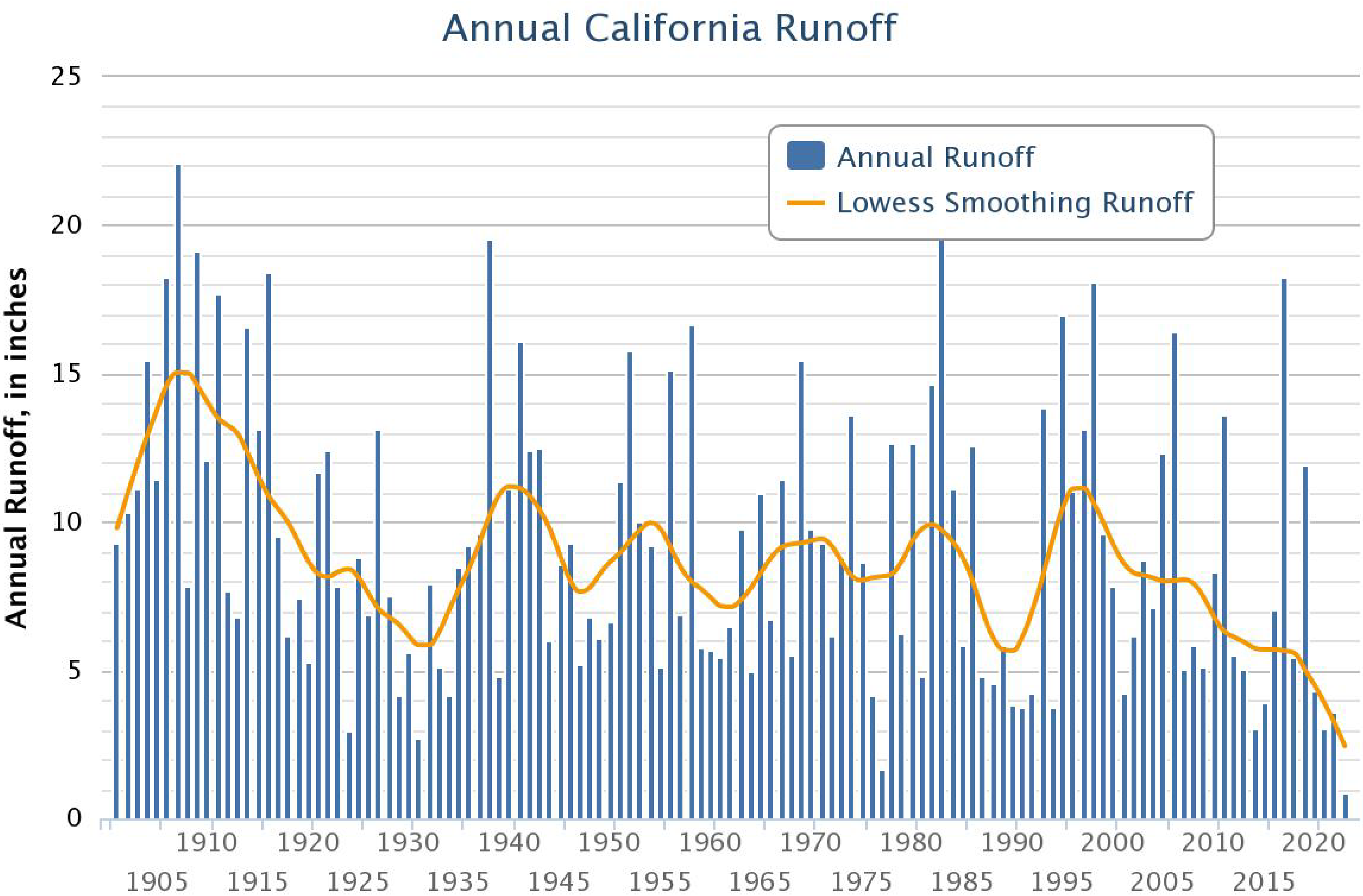


Courtesy of University of Arizona

California's 20th & 21st Century Statewide Droughts
(consecutive dry years)

- 1918-20
- 1922-24
- 1929-34
- 1947-50
- 1959-61
- 1976-77
- 1987-92
- 2007-09
- 2012-2016
- 2020- ??

USGS Calculated Statewide Runoff



Things Are Heating Up

These Aren't Our Grandparents' Droughts

Things Are Changing

Old

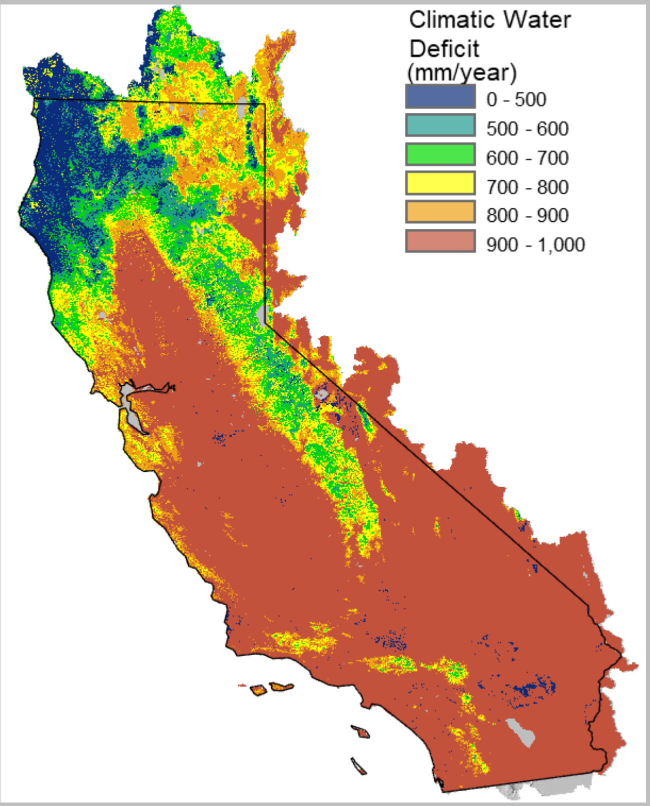
- Multi-year drought normal in reconstructed paleo & historical records
- Severely reduced CVP & SWP allocations
- Groundwater overdraft & land subsidence
- Impacts in San Joaquin Valley

New

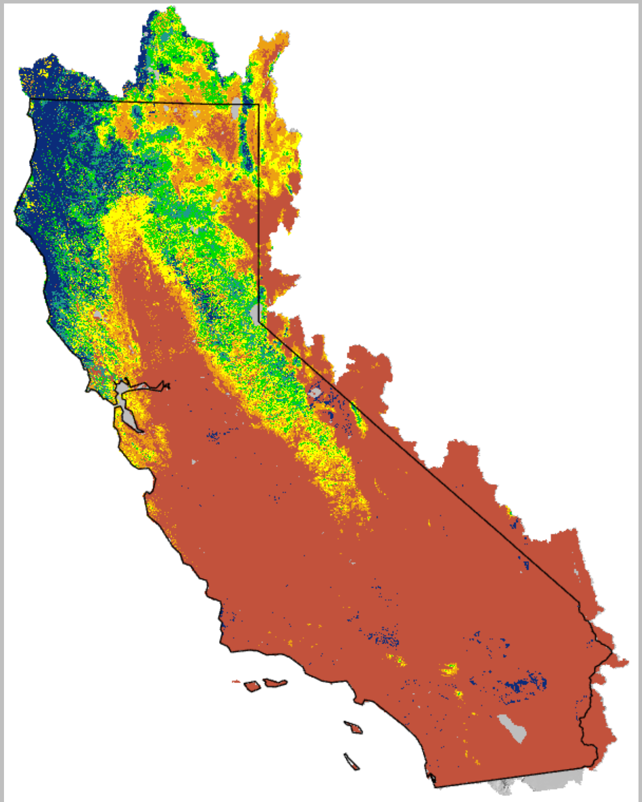
- Droughts occur in warming climate, exacerbates impacts
- First Lower Colorado River Basin shortage declared, SWP & CVP health & safety allocations
- Early stages of SGMA implementation
- Impacts in Sac Valley

Climatic Water Deficit, USGS Basin Model

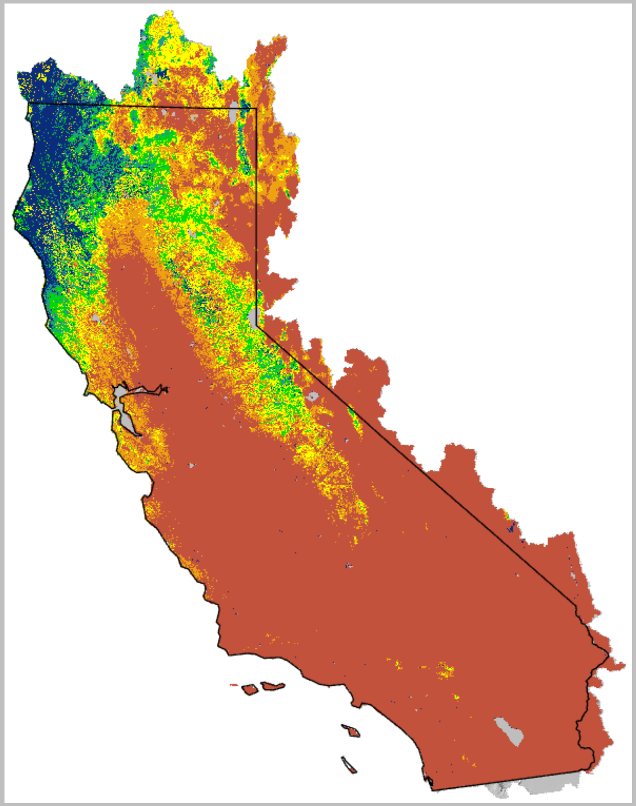
1977
a year with no water



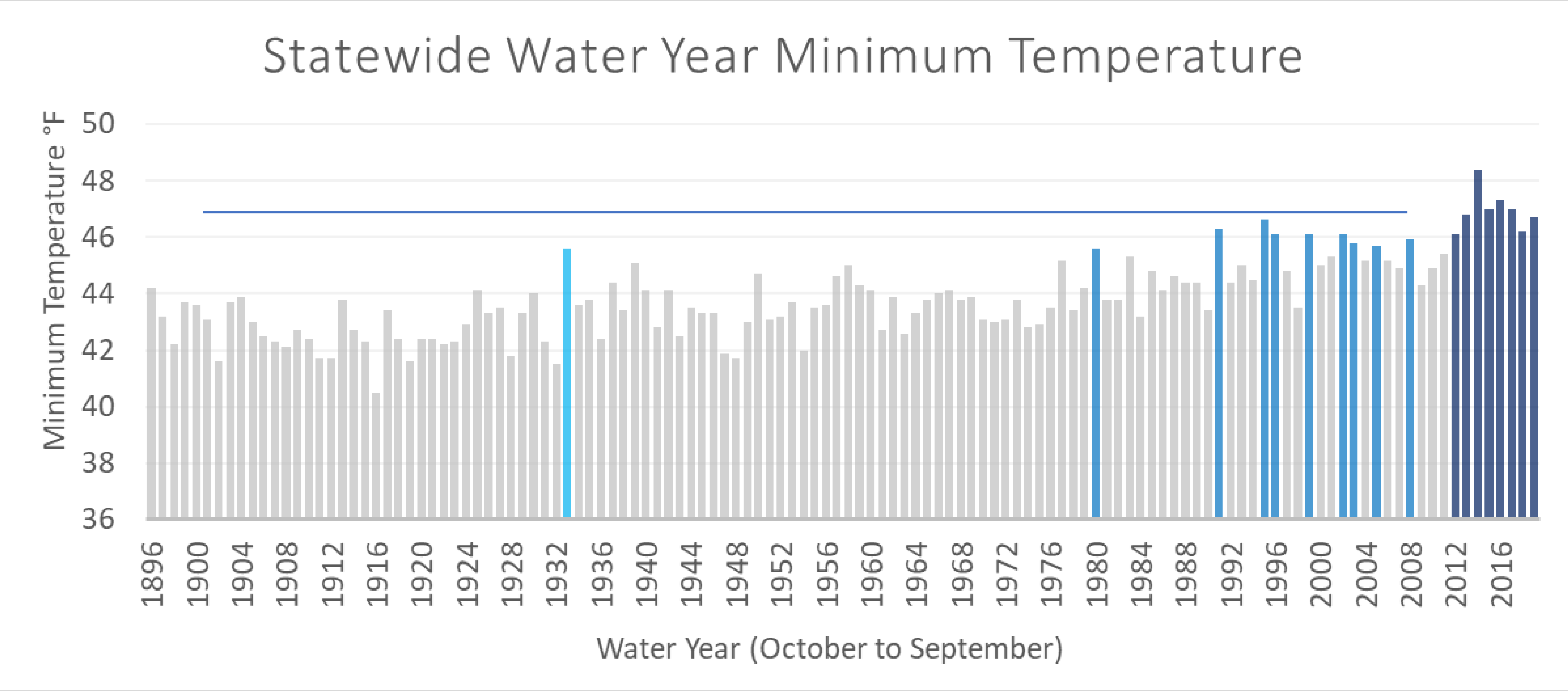
2014
a hot year with no water



2021
a hotter year with no water



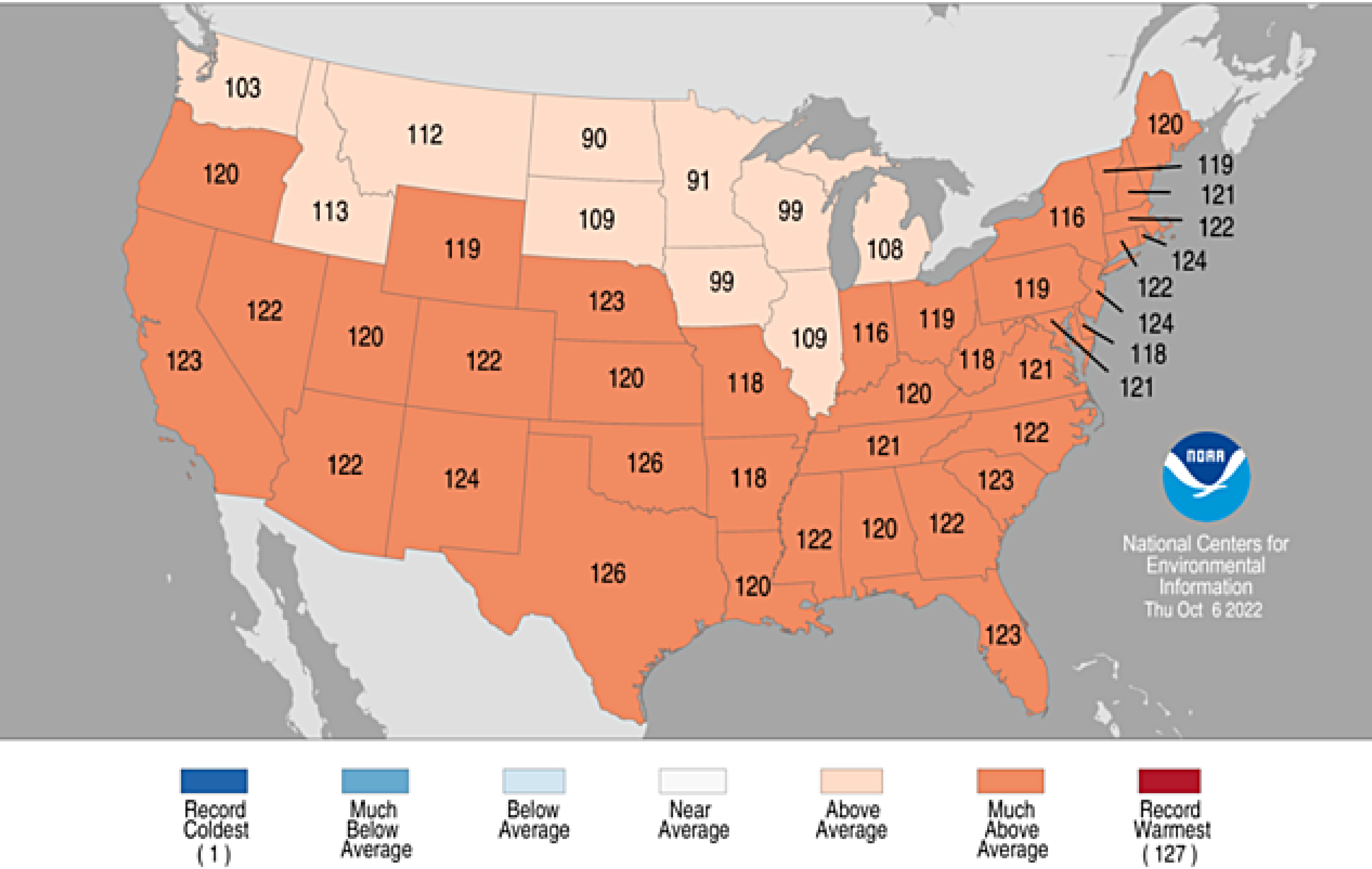
Change Is Happening



Statewide Average Temperature Ranks

October 2021 – September 2022

Period: 1895–2022



September 2022 Heatwave

- 134 Death Valley
- 125 Needles
- 124 Blythe
- 123 Palm Springs
- 121 Chico, Red Bluff
- 120 El Centro, Lake Cachuma, Lake Henshaw, Whiskeytown
- 119 Ojai, Redding
- 118 Calistoga, Elsinore, Ontario, Palmdale, Riverside
- 117 Chico, Healdsburg, Paso Robles, San Luis Obispo, Ukiah
- 116 Fullerton, Gilroy, Merced, Oroville, Sacramento
- 115 Bakersfield, Escondido, Madera, Pasadena
- 114 Fairfield, Fresno
- 113 Los Angeles
- 111 Long Beach, San Diego
- 110 San Rafael, Santa Cruz

Catastrophic Wildfire Risk

- 1991 Oakland Hills fire (25 lives lost)
- October – November 2003 Southern California wildfires (22 lives lost)
- October 2007 Southern California wildfires (1 million people evacuated)
- 2017 Tubbs Fire, 2018 Camp Fire, 2021 Dixie Fire (urban water distribution system destruction)
- All but 2 of the state's 20 largest & 20 most damaging fires have occurred from 2000 onward

And Wildfire Damage to Water Infrastructure

2012-16 Drought

- Included warmest years on record, record low statewide snowpack
- State response actions not seen since 1976-77
- First-ever zero CVP ag contractor allocations
- About 500,000 acres fallowed
- First-ever state emergency response for areas of dry private residential wells

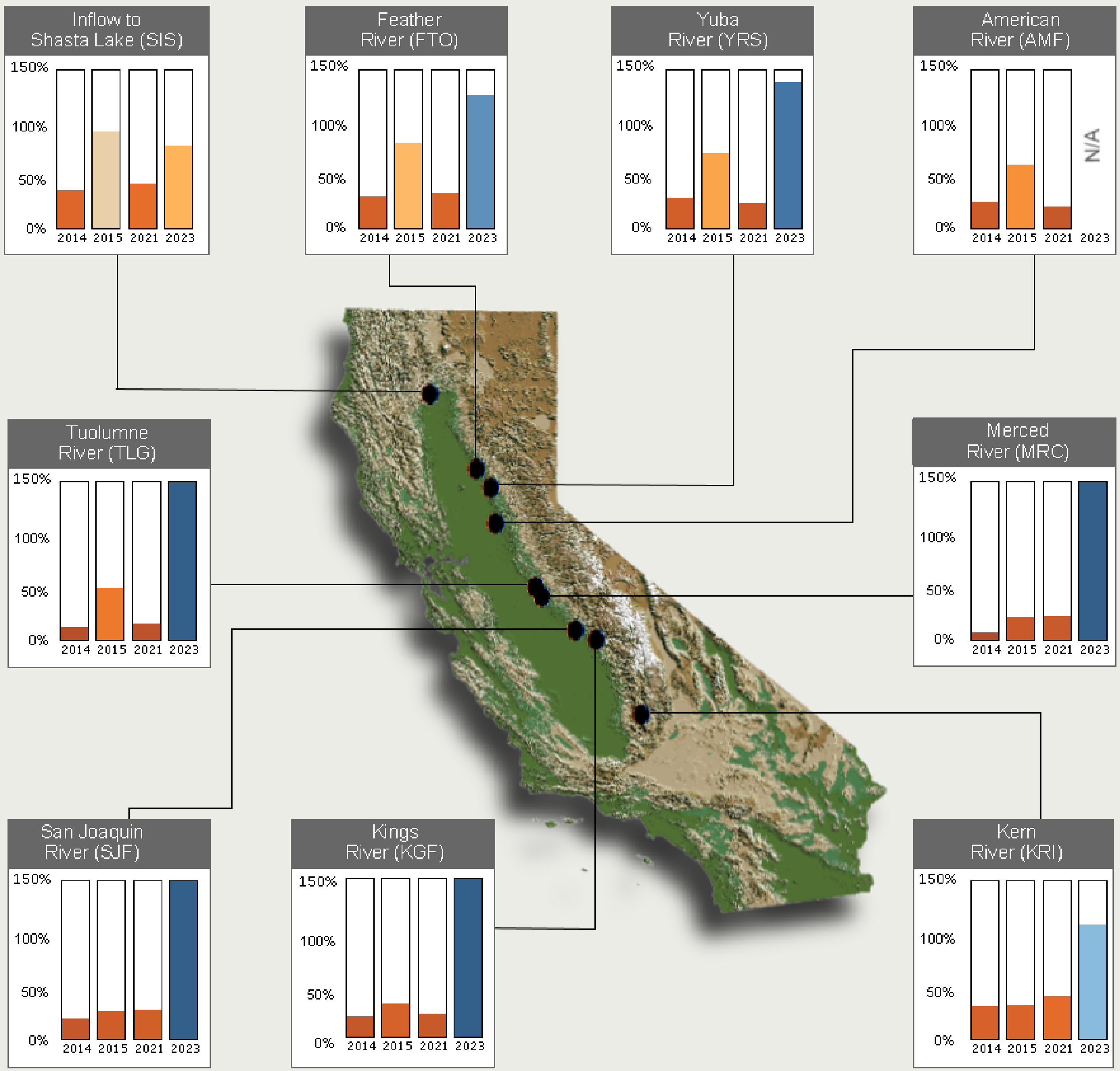
California's Present Drought

- Zero allocation to most CVP ag contractors in WY 2021 and 2022, CVP M&I health & safety allocation in WY 2022, 5% SWP allocation
- Pending 2022 large-scale urban water use restrictions in Southern California due to infrastructure limitations
- First Lower Colorado River Basin shortage pursuant to the Interim Guidelines
- Record low Lake Oroville elevation in 2021, Hyatt PP unable to generate
- 70% statewide snowpack in WY 2021, yet runoff comparable to 2014-2015
- Groundwater impacts similar to San Joaquin Valley in 2012-16 now seen in parts of Sacramento Valley

Full Natural Flow at DWR Forecast Points on Selected California Rivers

Shown as a Percent of Average to Date

Data as of Midnight: 15-Feb-2023

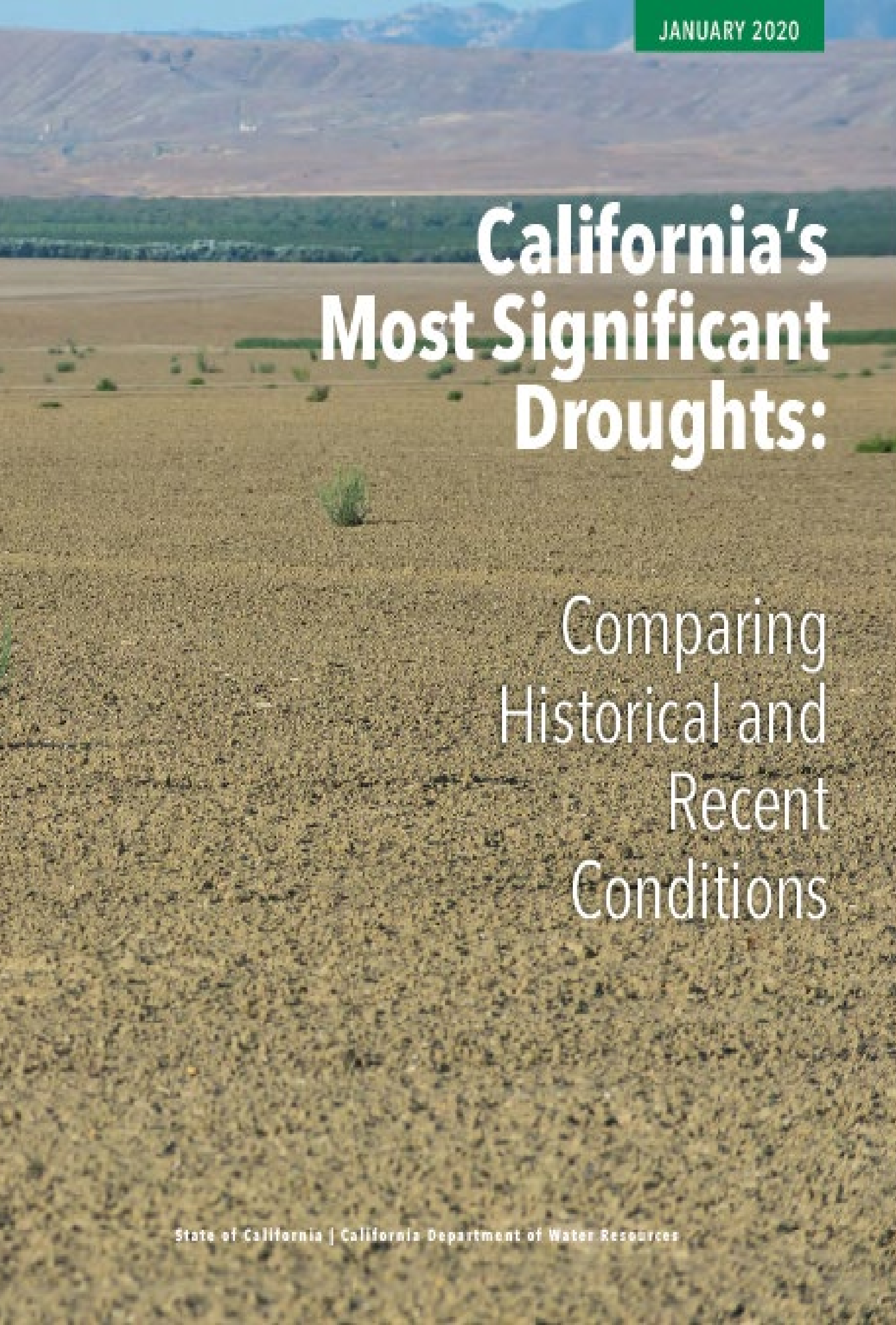
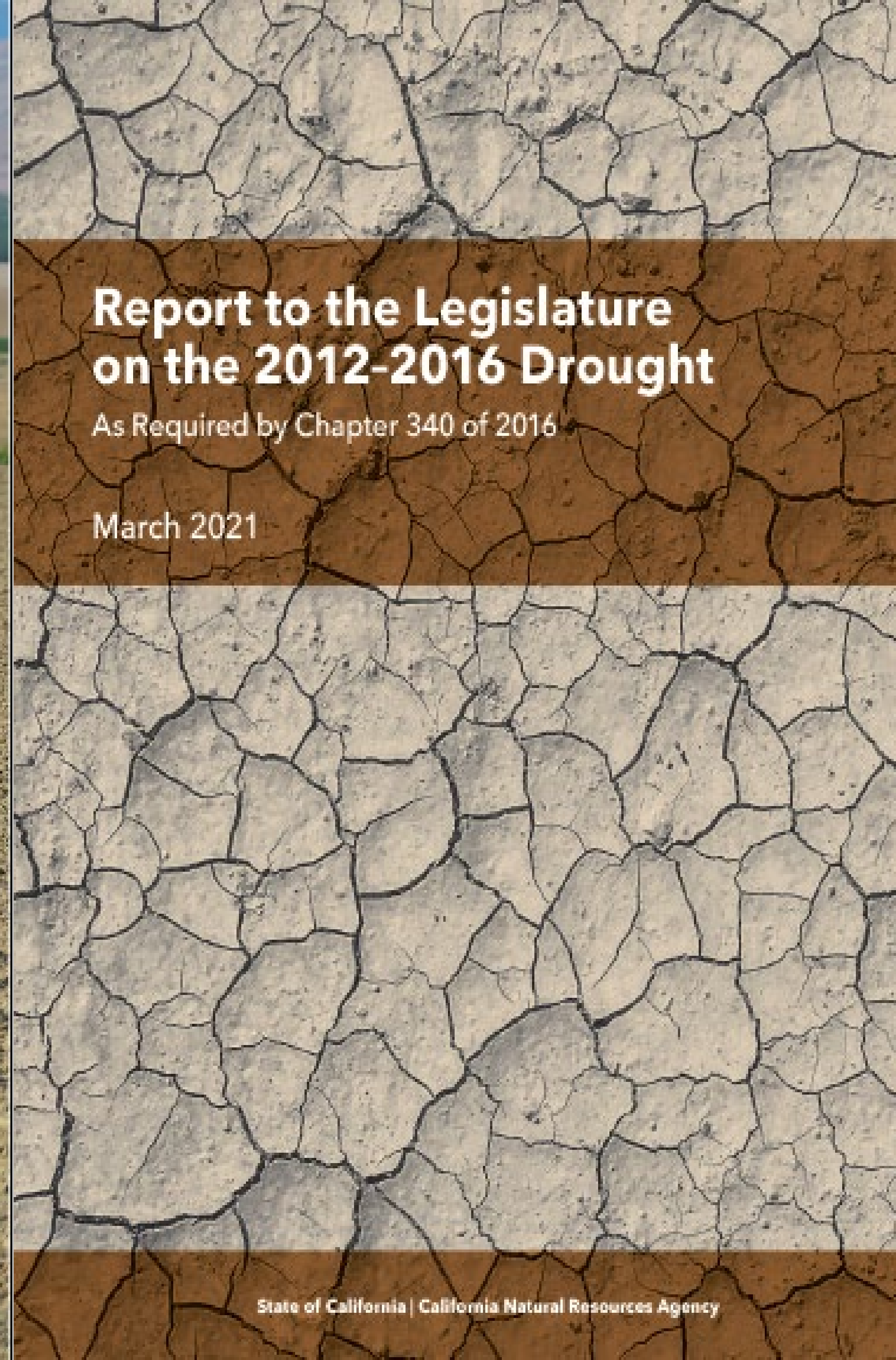


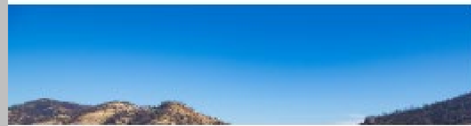
(XYZ) = CDEC Station ID

Date Created: 02/16/2023

Lessons Learned from Recent Droughts

- Act sooner when dry conditions emerge
- Recognize that increased temperatures are creating new or intensified impacts
- Plan for cutbacks in historical irrigation deliveries affecting shallow drinking water wells due to absence of groundwater recharge sources or compensatory construction of deeper irrigation wells
- Plan for wildfire impacts
- Transition from thinking of drought as an occasional emergency to thinking in terms of creating resiliency in a more arid climate

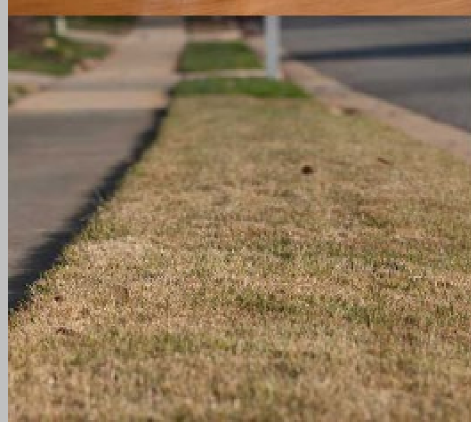

JANUARY 2020
California's Most Significant Droughts:
Comparing Historical and Recent Conditions
State of California | California Department of Water Resources

Report to the Legislature on the 2012-2016 Drought
As Required by Chapter 340 of 2016
March 2021
State of California | California Natural Resources Agency



AUG 2022

CALIFORNIA'S WATER SUPPLY STRATEGY

Adapting to a Hotter, Drier Future



CALIFORNIA NATURAL RESOURCES AGENCY

California Water Boards

CalEPA California Environmental Protection Agency

cdfa