



California Water 101

Newsha Ajami, PhD
Chief Development Officer for Research
EESA

Nov 1, 2023

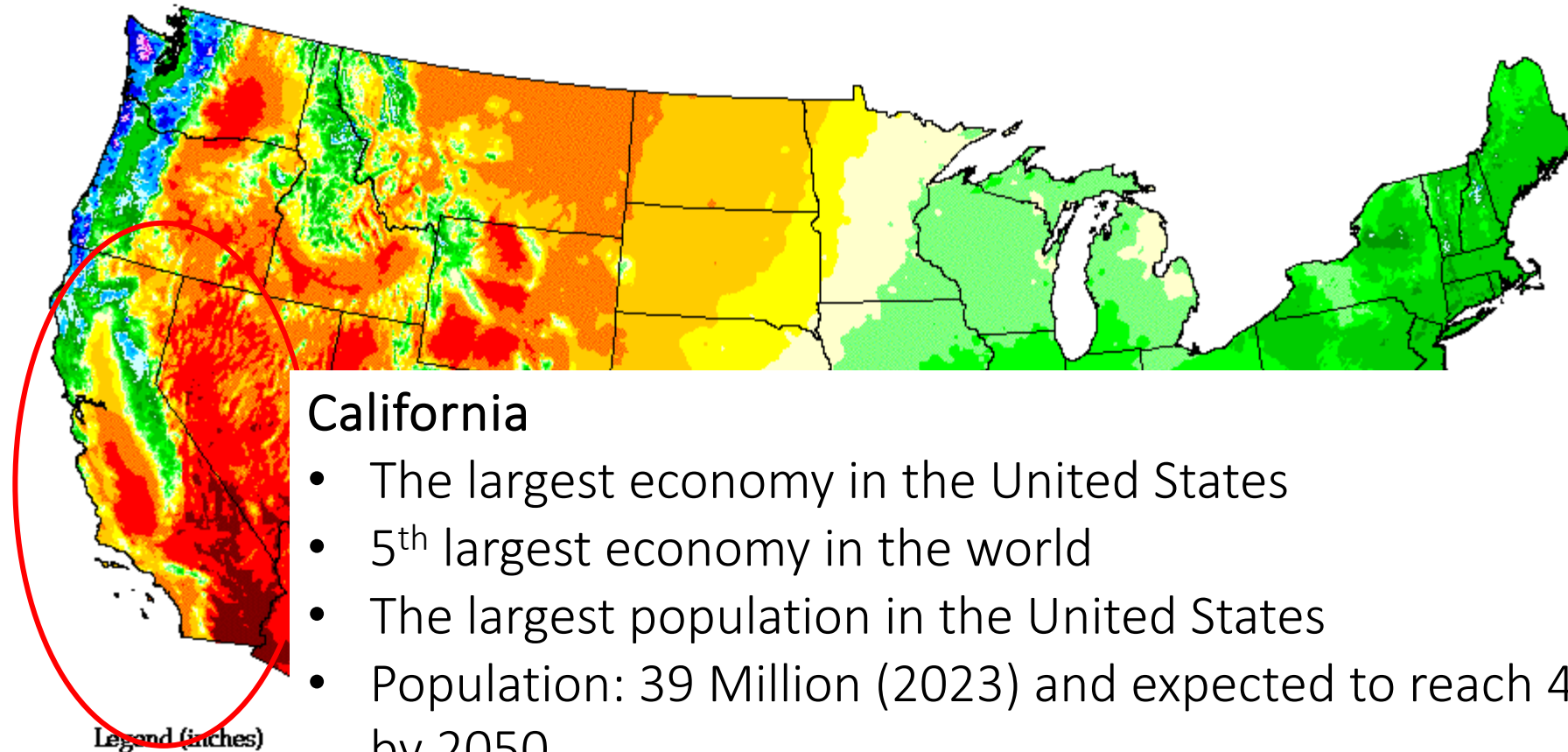


We live in a world defined by 19th century laws/institutions, 20th century infrastructure, and 21st century water needs and challenges.

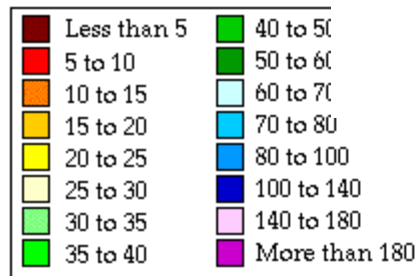


Annual Average Precipitation

United States of America



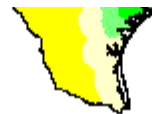
Legend (inches)



Period: 1961-1990

California

- The largest economy in the United States
- 5th largest economy in the world
- The largest population in the United States
- Population: 39 Million (2023) and expected to reach 45-50 Million by 2050



Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.

Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705



Competing Demands for Water in California

Domestic



Wildlife



Agriculture

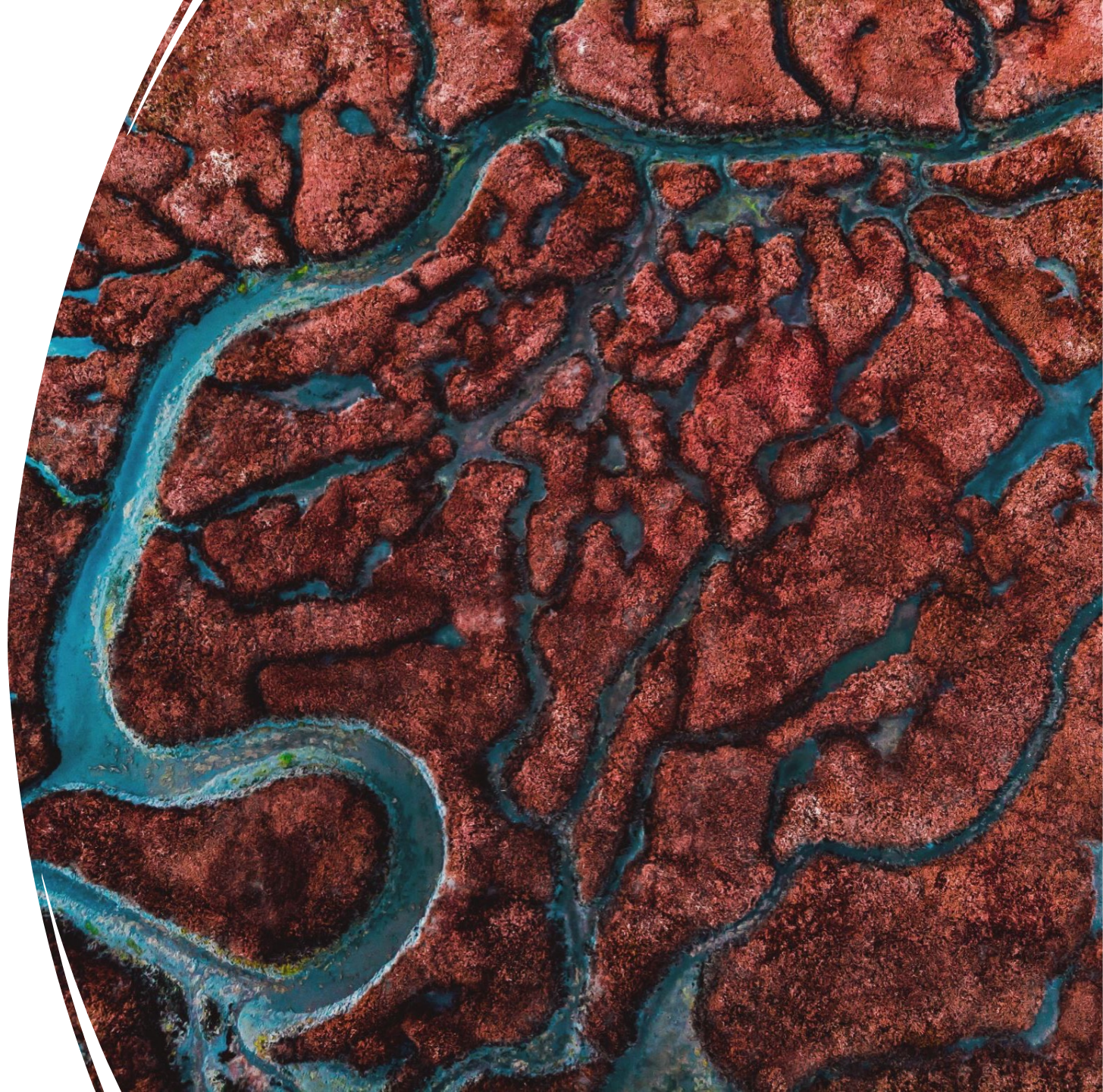


Navigation

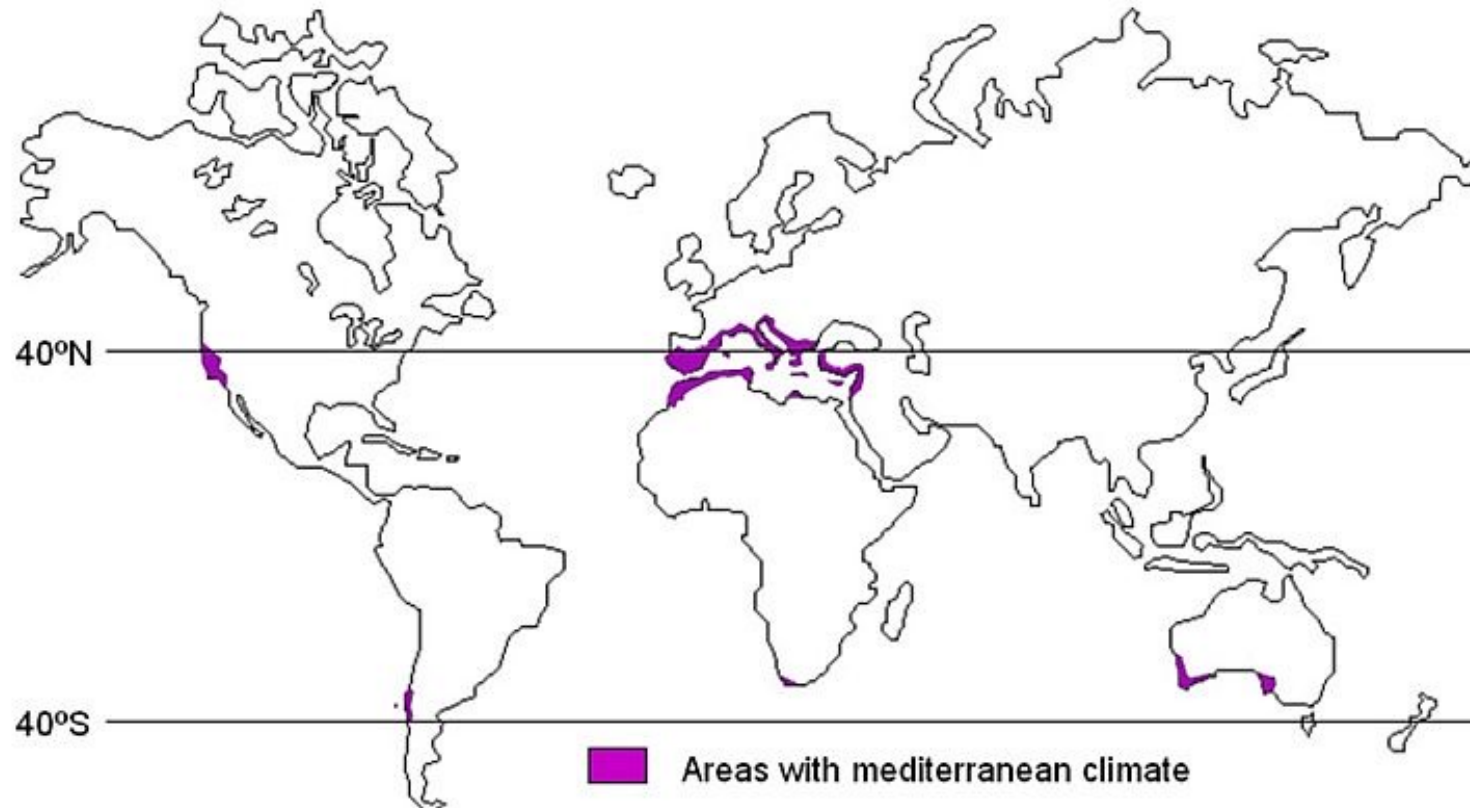


Recreation

Climate and hydrology



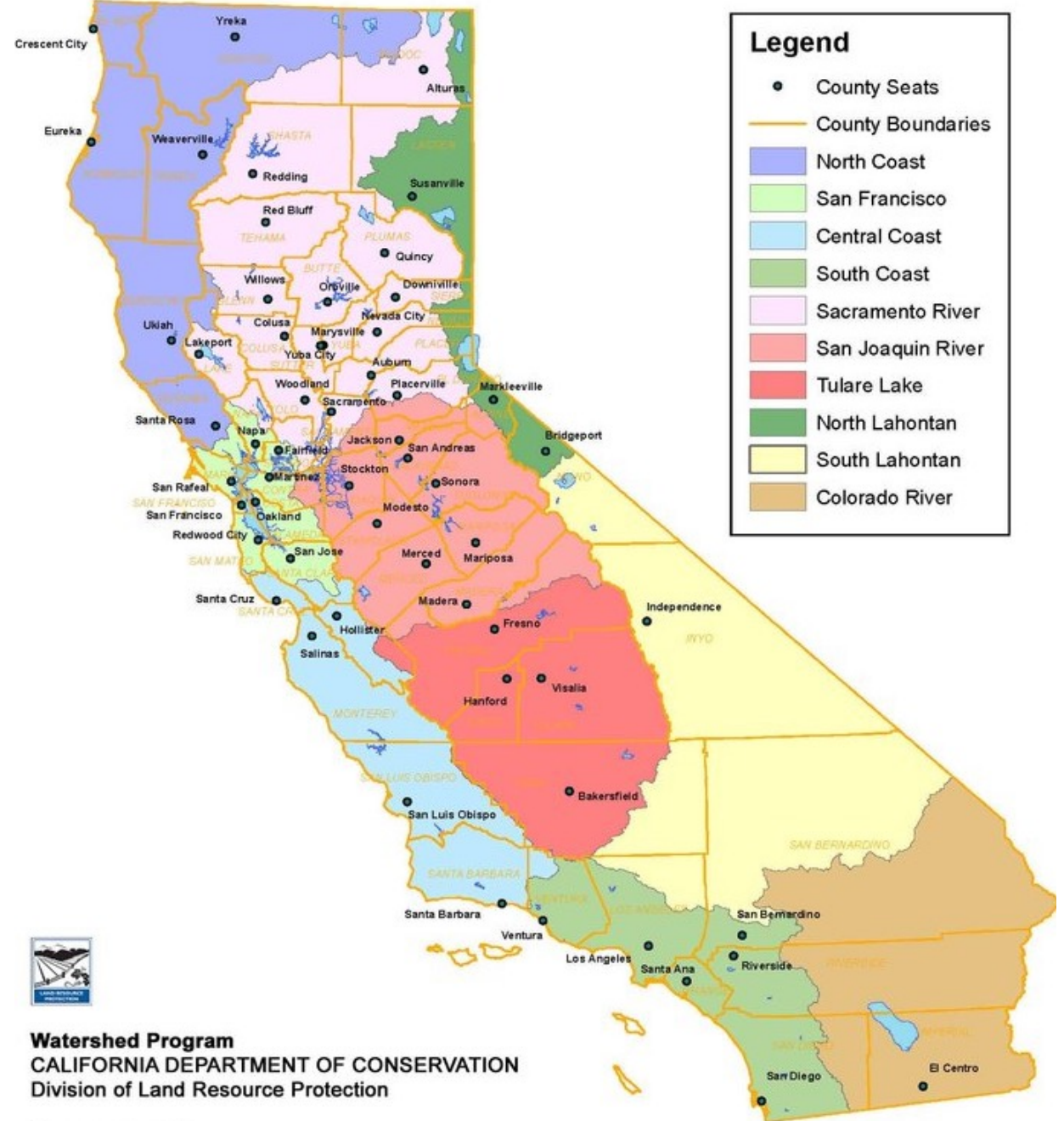
Mediterranean Climates



- Seasonality
- Inter- and intra-annual variability

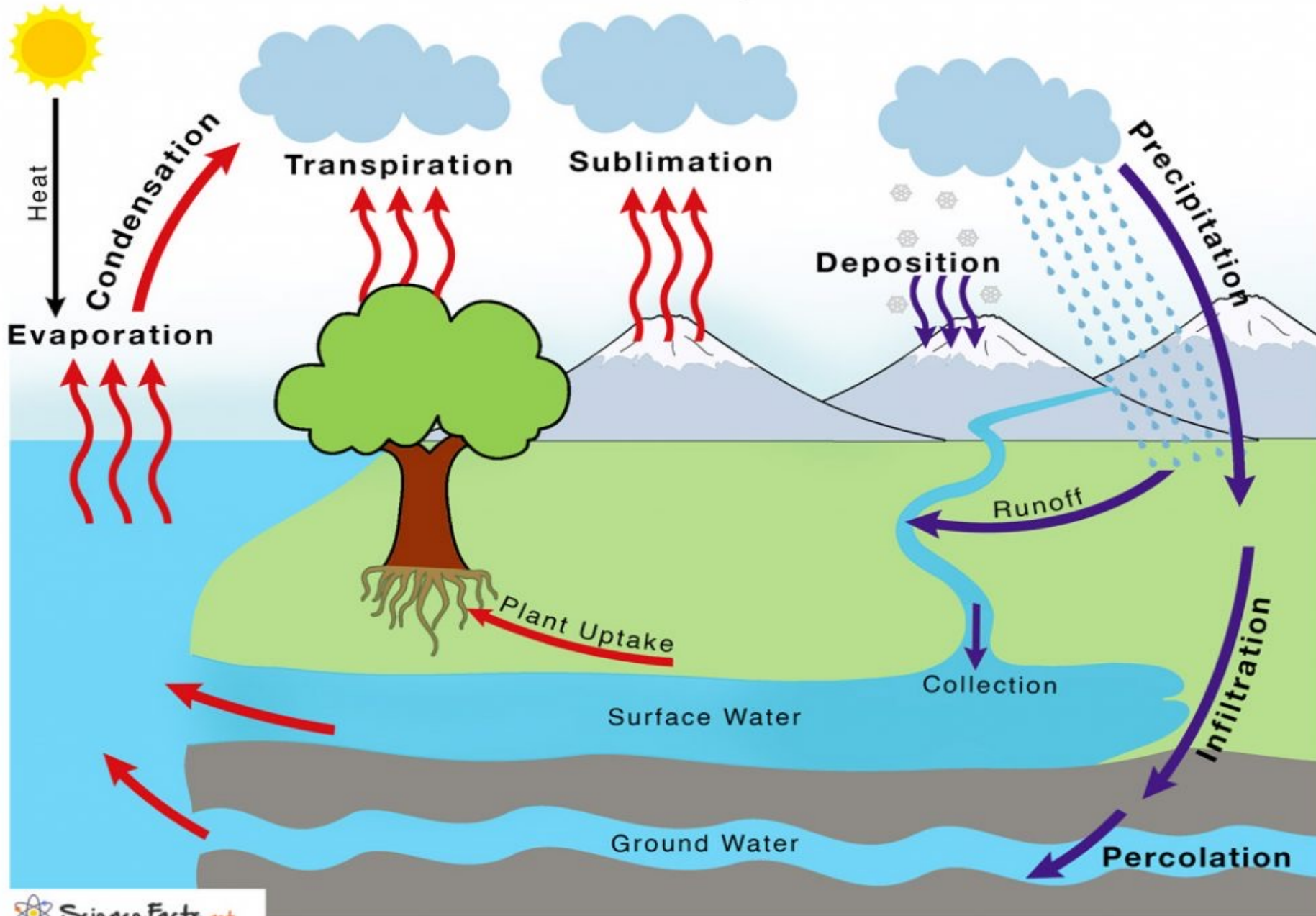
California's Major Watersheds

- **What is a watershed?**
 - It's a land area that **channels rainfall and snowmelt** to creeks, streams, and rivers, and eventually to **outflow points** such as reservoirs, bays, and the ocean.

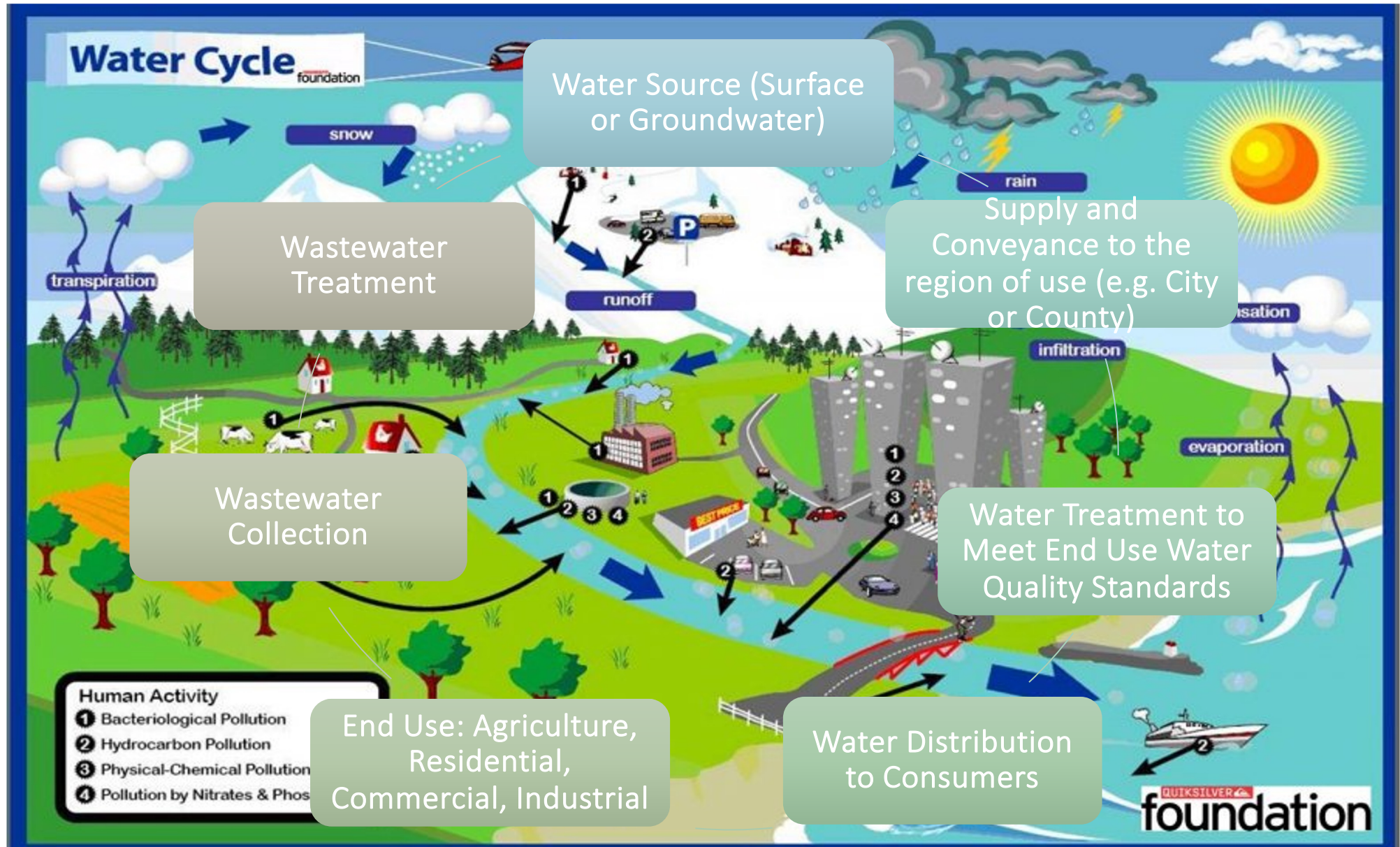


Map courtesy of
California Department of Water Resources

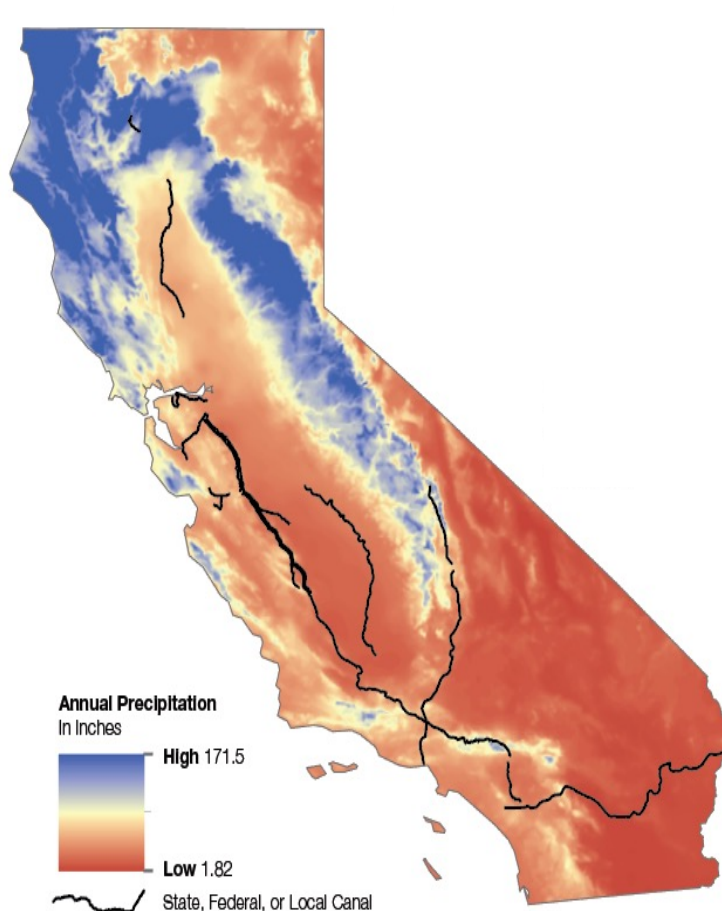
Water Cycle



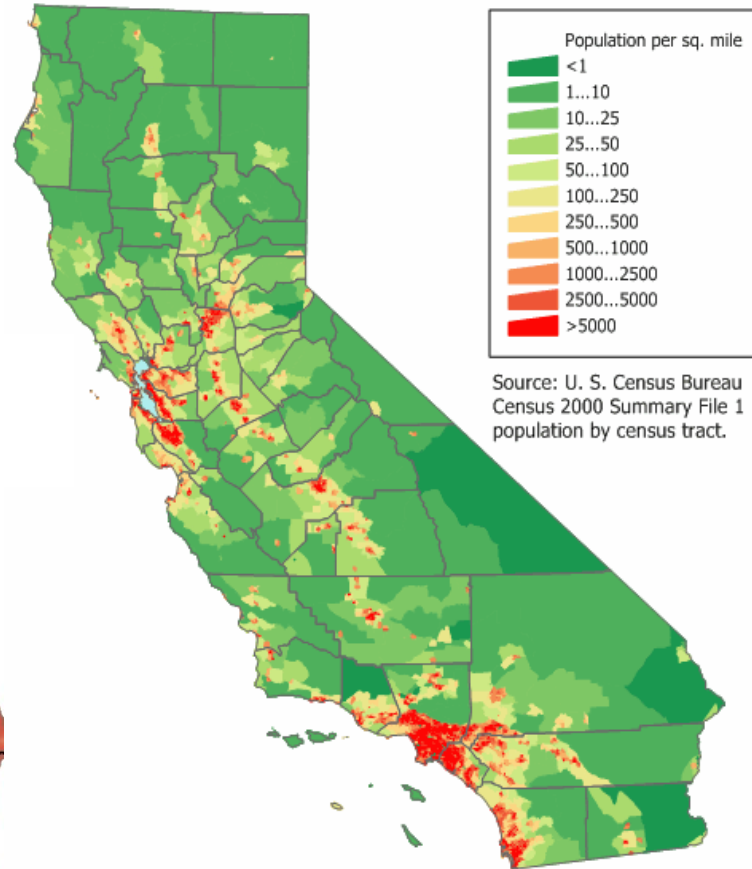
The Water Use Cycle



California: Water Resources, Population, and Infrastructure



Map created by California Department of Water Resources using PRISM (prism.oregonstate.edu).



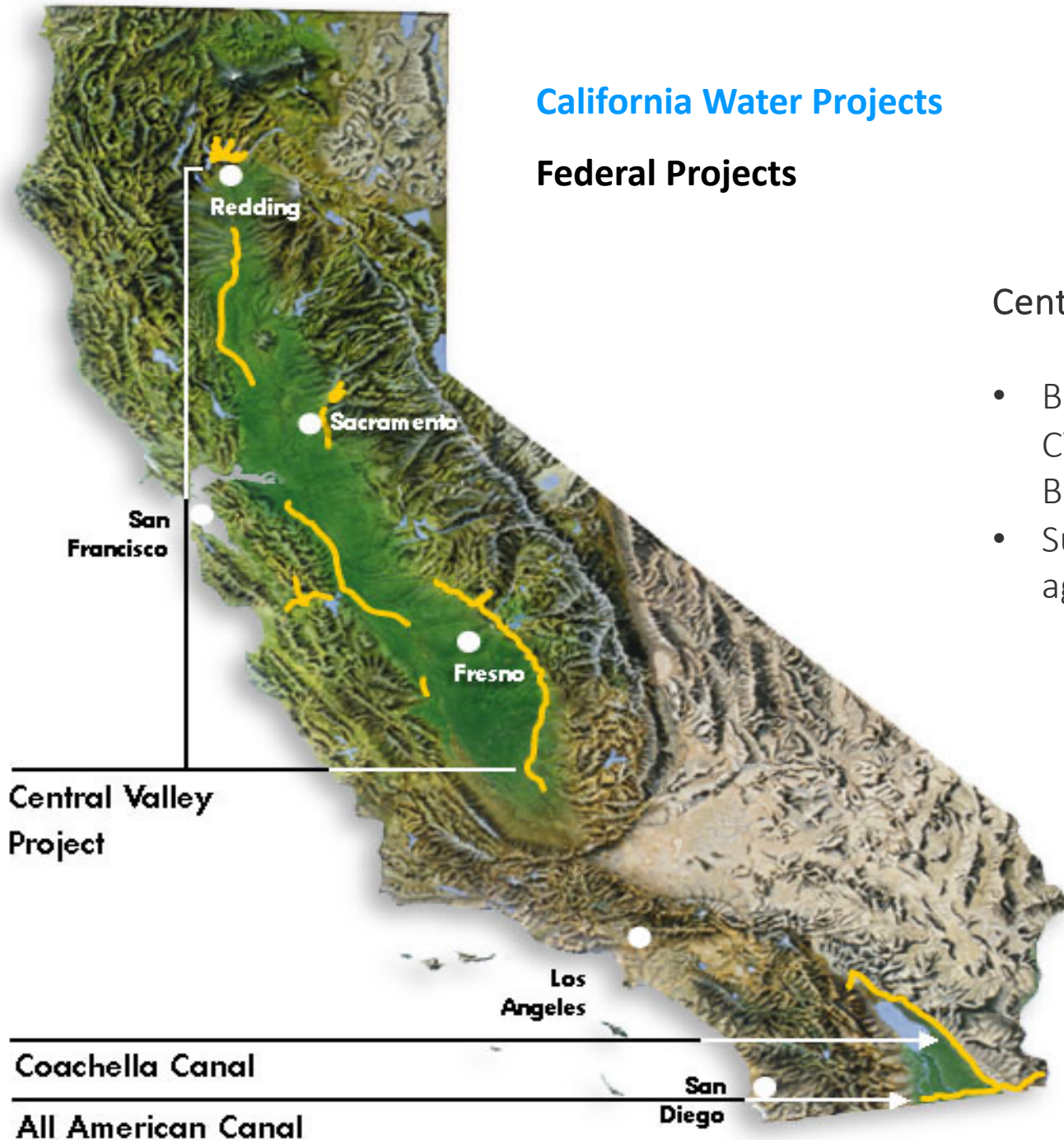
[map from CDWR 2002]

California Water Projects

Federal Projects

Central Valley Project

- Built in the 1930s by the U.S. Bureau of Reclamation, the CVP transports water from Lake Shasta in the north to Bakersfield in the southern San Joaquin Valley.
- Support the arid but fertile Central Valley and its agricultural economy.



California Water Projects

State Projects

State Water Project:

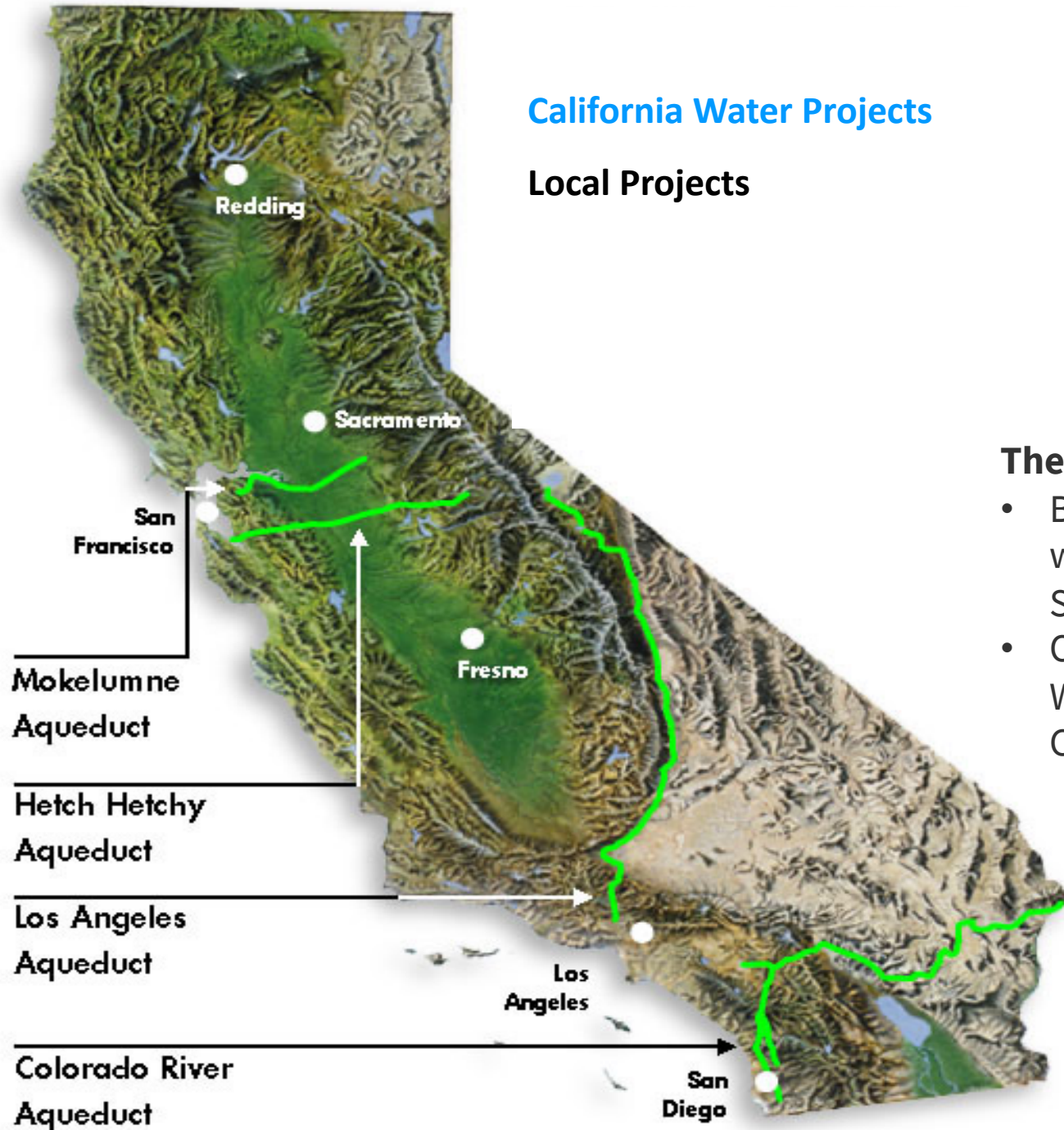
- Was constructed in the 1960s and 1970s to supply water to more than 27 million people and 750,000 acres of farmland
- Planned, constructed, and operated by DWR
- Lift 1926 ft over the Tehachapi mountains



[map from CDWR 2002]

California Water Projects

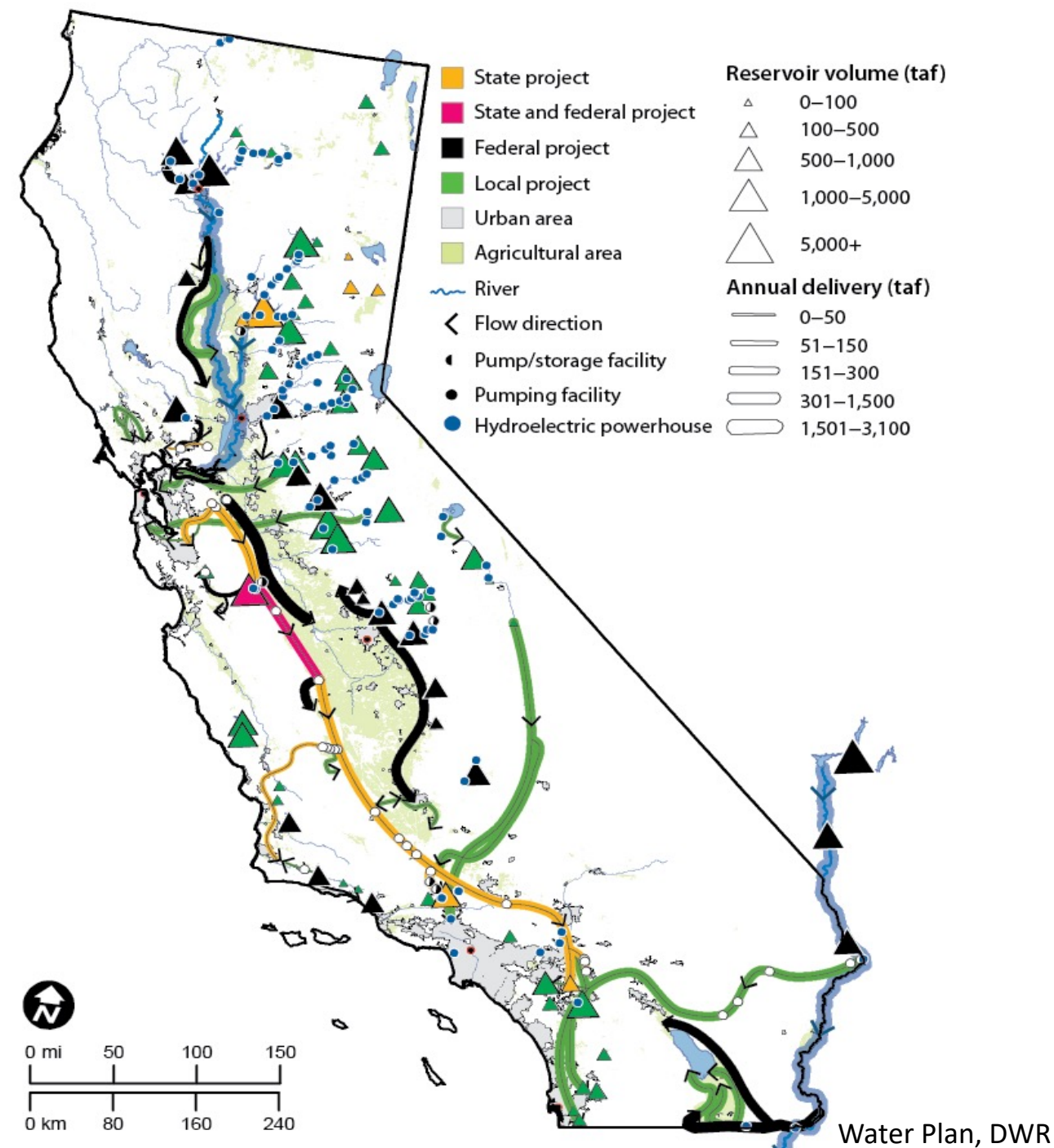
Local Projects



The Colorado River Aqueduct

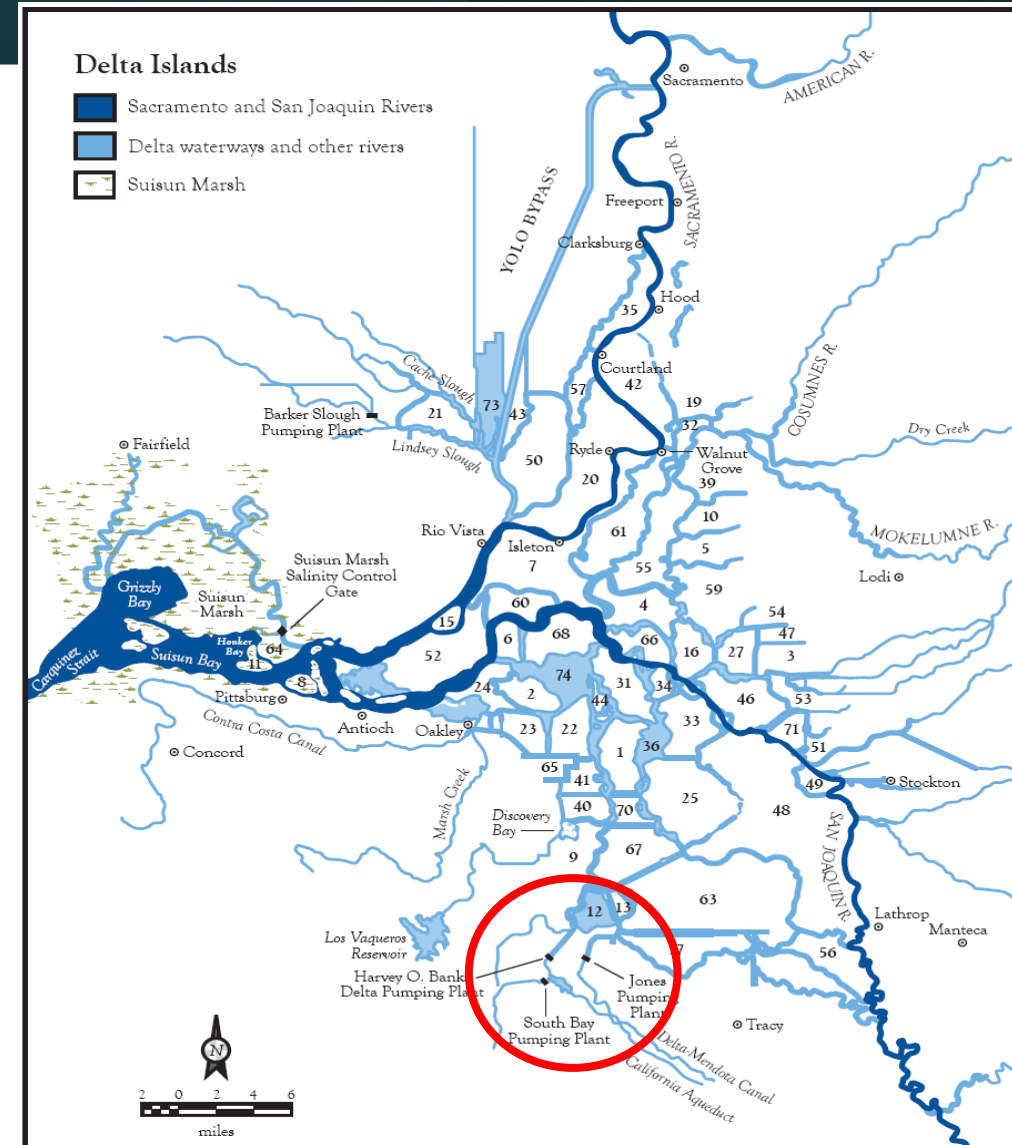
- Built in the 1930s, transports water from the Colorado River to Southern California
- Operated by the Metropolitan Water District of Southern California

An Elaborate Network of Conveyance and Storage Infrastructure



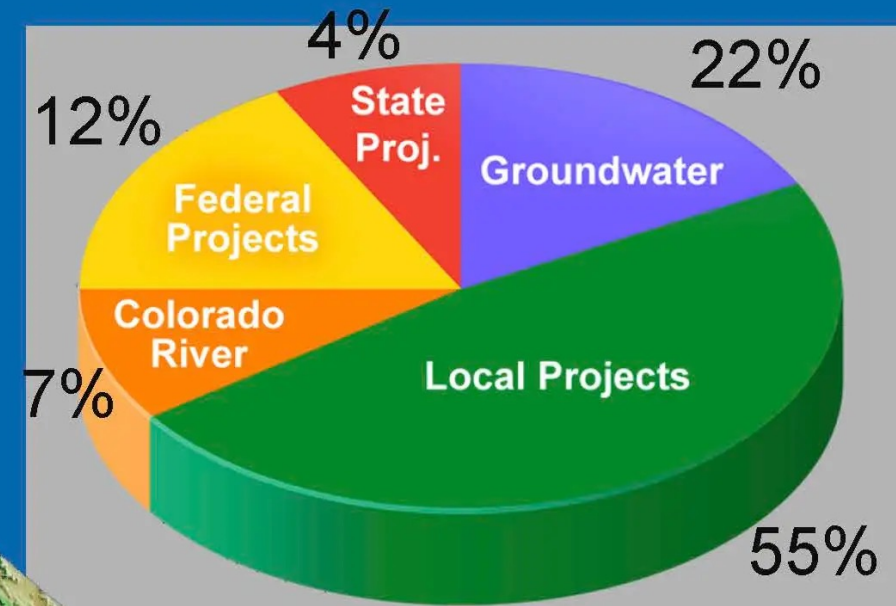
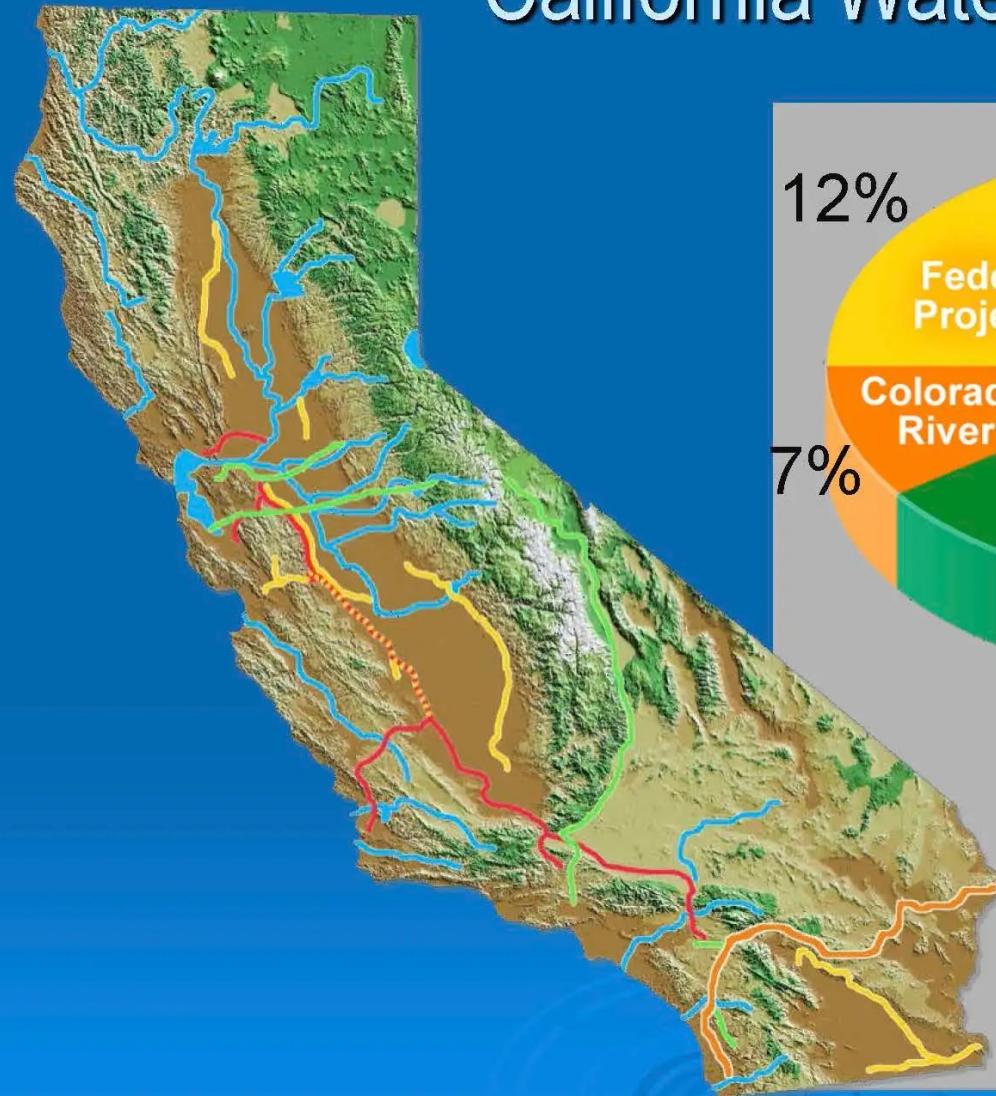
Heart of California's Water System: Sacramento-San Joaquin Delta

- Historically – a very rich inland aquatic ecosystem.
- It is the center of California's water distribution system: from North/Sierra to South/Coastal.
- Ecosystems are collapsing all across California especially in the Delta
- Many recent laws and court rulings have been trying to remedy



California Water Supply Systems in Numbers

California Water Supply Systems



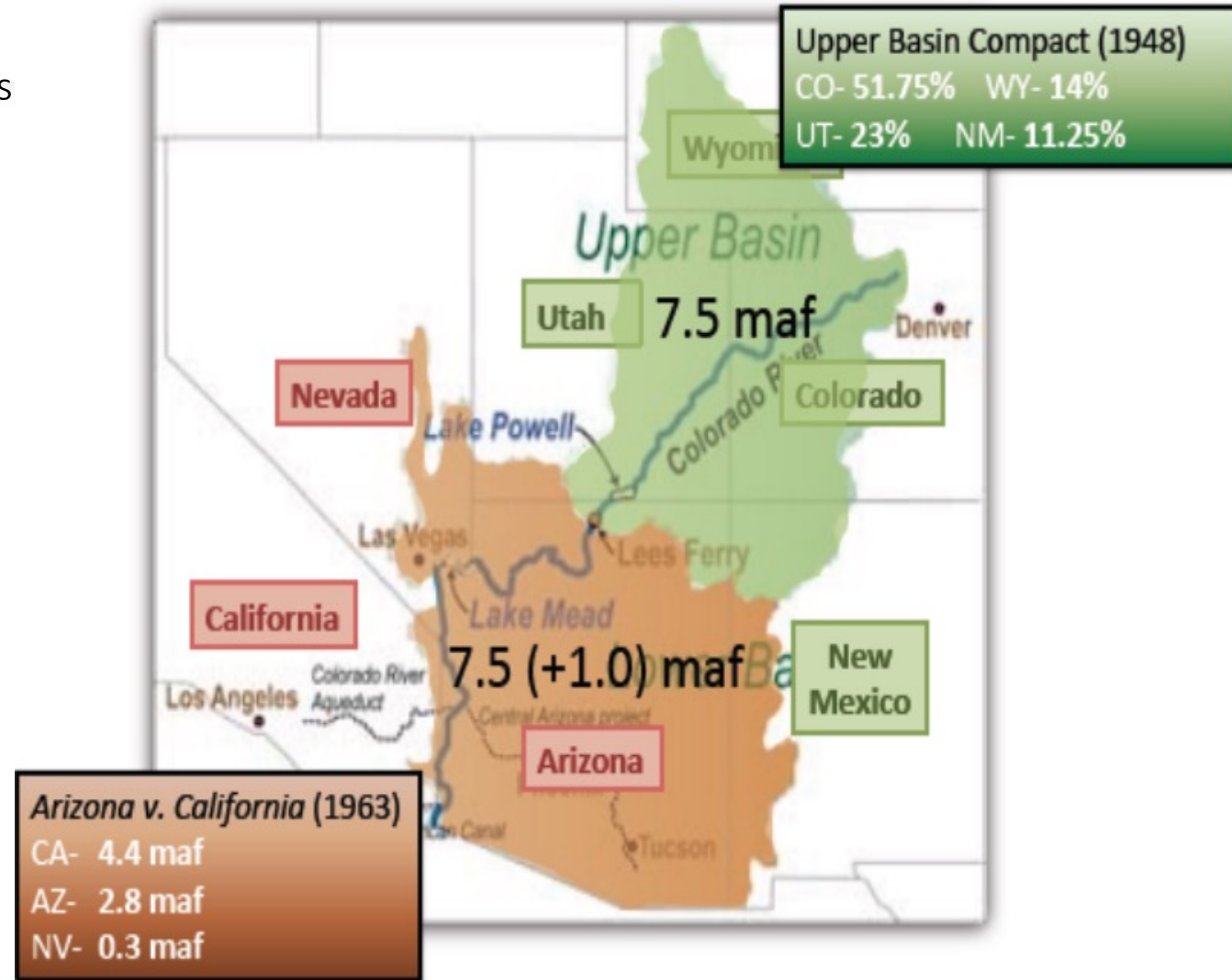
	Local	--	38.3 maf
	Colorado	--	4.8 maf
	Federal	--	8.1 maf
	State	--	2.9 maf
	Groundwater	--	15.0 maf

1998-2005 average... Does not include reuse or recycling. Quantities vary by year.

Courtesy of Kamyar Givchchi

Colorado River

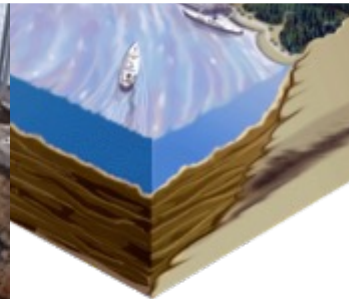
- California derives up to 15% of its surface water supplies from the Colorado River.
- Right to 4,308,000 acre-feet or enough water to supply more than 20 million people annually
- California holds senior water rights due to the "Law of the River:" a group of agreements dating back more than a hundred years
- It is thus entitled to one-third the flow of the river, meaning it can continue to draw water from the Colorado even if Lake Mead reaches dead pool.
- The reality is water rights claims exceeded the amount of available water by a great degree.



The 20th Century Centralized Water Infrastructure Model: Supply-side focused



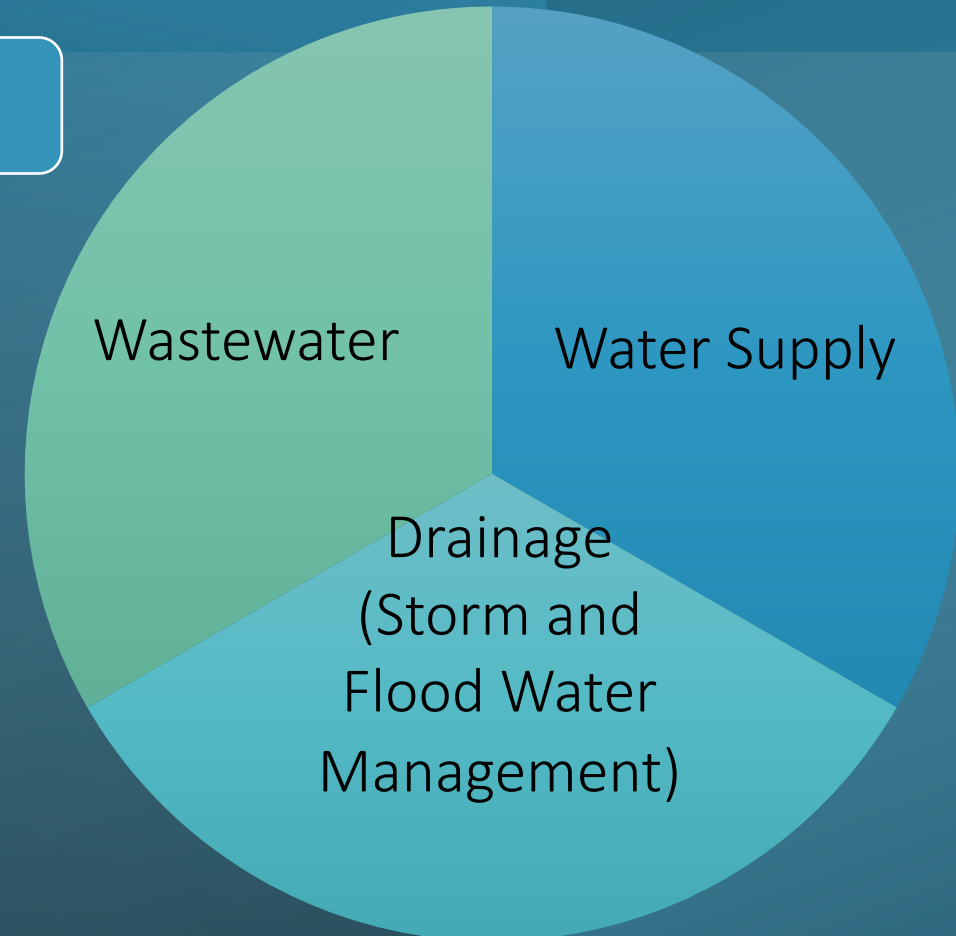
- Once through systems
- Based on
 - water abundance
 - hydrologic stationarity
 - steady and perpetual demand growth
 - Disregard for the environment and tribal water rights



Early 20th Century Water Use Cycle

Principles of Water Use Cycle:

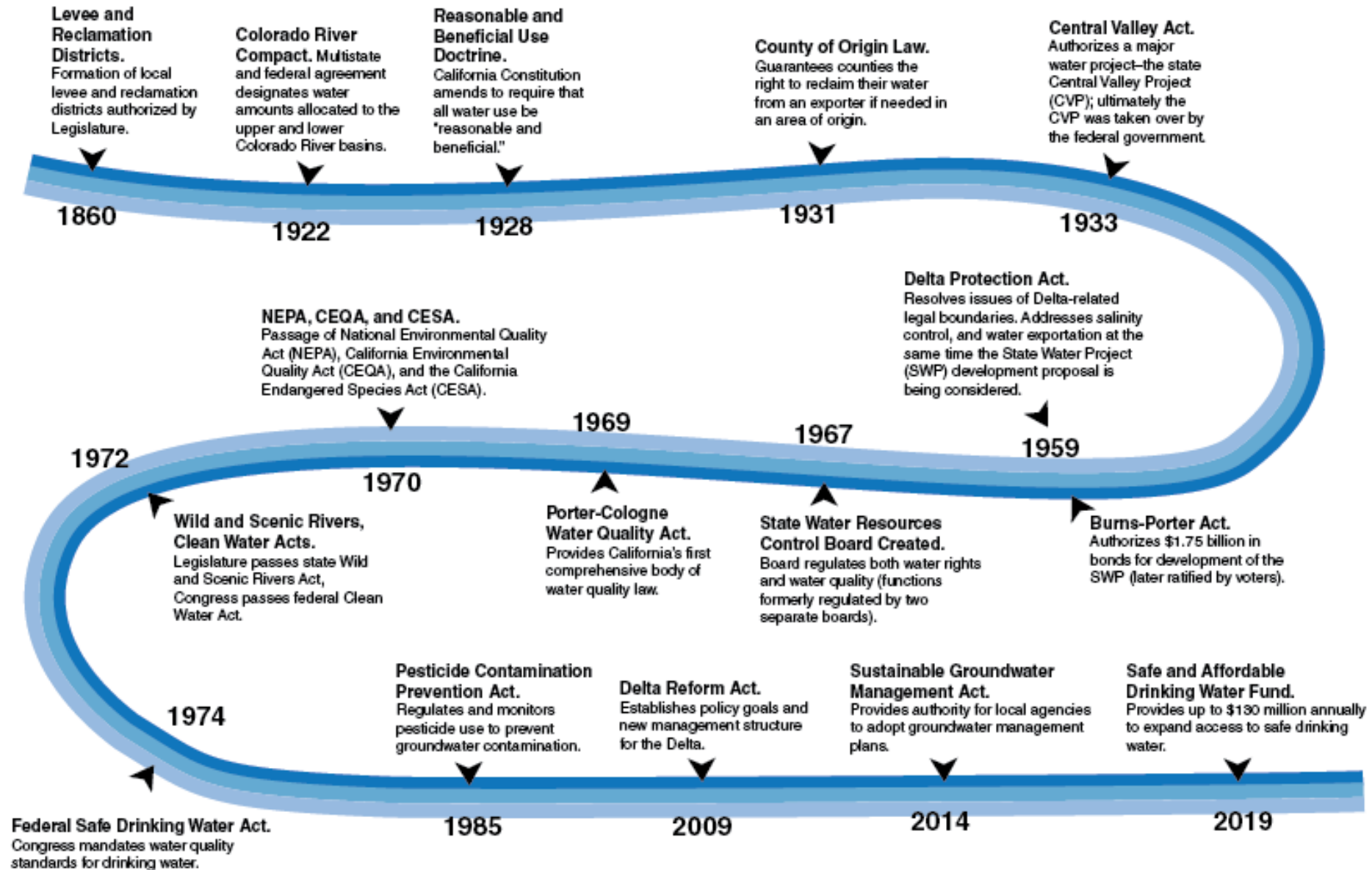
- Enable growth and economic development
- Build large scale centralized assets
- Design a once through system
- Deliver clean potable water
- Manage Wastewater
- Drain stormwater and floodwater
- Develop a top-down governance structure





Evolution of the State Water Policy and Governance

Selected Events in State Water Policy History—Timeline



California Water Rights System Dictates Water Allocation

The State of California owns all of the water in the state, and rights pertain to the use of water, not ownership.

- Riparian rights: Based on ownership of land bordering a waterway
- The doctrine of prior appropriation: “First in time, first in right”
- The California Doctrine or Dual Rights: Refers to the blending of Appropriative and Riparian Rights
- Pueblo rights: Under Spanish and Mexican law, some missions attained status as a municipality to use adjacent sources of water
- Federal Reserved rights: Reserved water rights to support public domain land for national parks and forests
- Groundwater rights: Landowners have overlying rights to use groundwater beneath their parcel

Many Entities Are Involved in Water Management

	Responsibilities		
	Water Supply	Water Quality	Flood Control
State Agencies			
Department of Water Resources	X		X
State Water Resources Control Board	X	X	
California Public Utilities Commission	X	X	
Colorado River Board	X		
Delta Stewardship Council	X	X	X
Department of Pesticide Regulation		X	
Department of Toxic Substances Control		X	
Department of Conservation		X	
Office of Environmental Health Hazard Assessment		X	
Federal Agencies			
Bureau of Reclamation	X		X
Army Corps of Engineers	X		X
Environmental Protection Agency		X	
Geological Survey	X	X	
Other Entities			
Cities and counties	X	X	X
Special districts	X	X	X
Tribal governments	X	X	X
Private water companies	X		

Climate Change

Increased frequency & severity of extreme events



Image: California Department of Water Resources

Image: George Herald



Aging Infrastructure
\$1 trillion to update US drinking water systems

Urbanization

68% urban population in 2050



Image: Getty Images

Image: The Atlantic



Competing Environmental Needs
Stricter regulations

Environmental Justice
water access and affordability



A close-up photograph of a small, vibrant green seedling with two leaves emerging from a crack in parched, greyish-brown soil. The soil is heavily cracked and fragmented, suggesting extreme dryness. The background is a blurred expanse of similar cracked earth, creating a sense of vastness and isolation. The lighting is soft, highlighting the texture of the soil and the freshness of the plant.

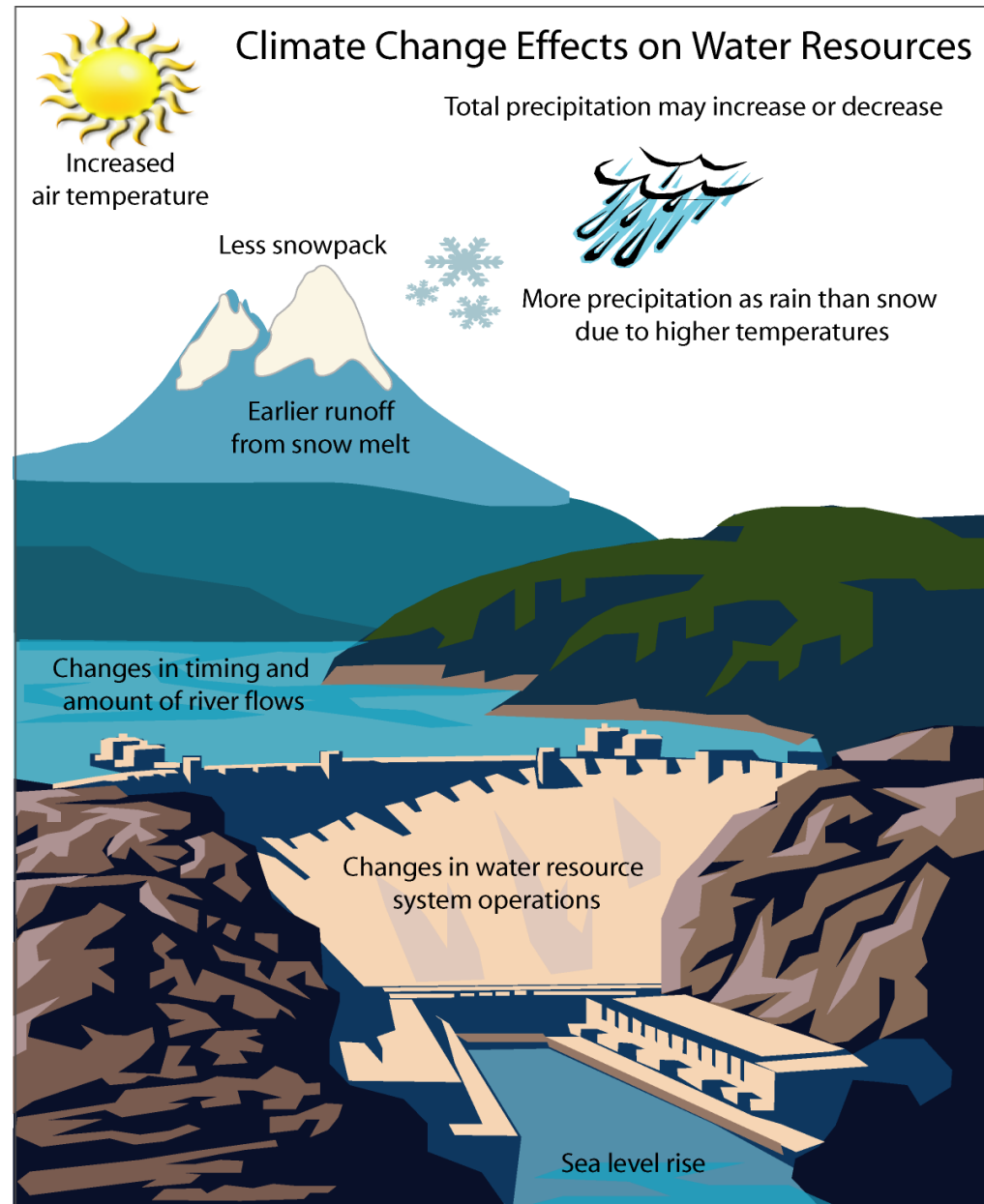
Climate change

If climate
change is a
shark, water is
its teeth:

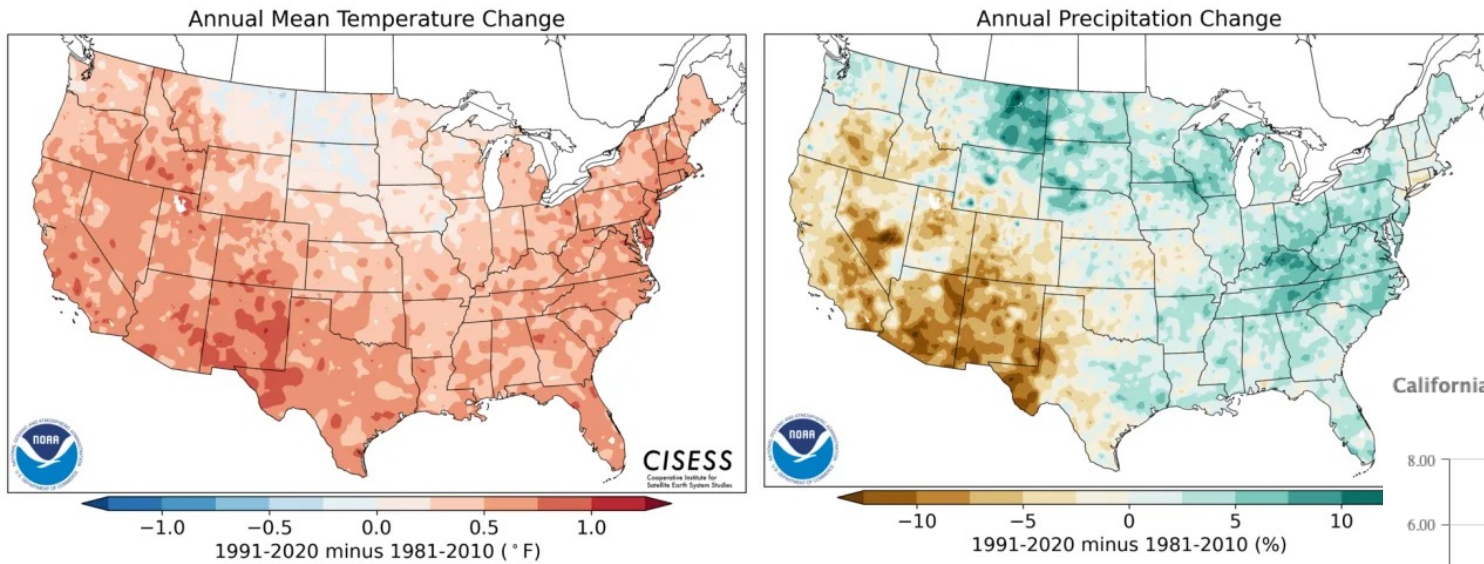
According to the UN Environmental Programme (UNEP):

- “The vast majority of natural disasters (over 90 percent) are water related, including drought, flood and tropical storms, with significant impact on societies and the economy.”

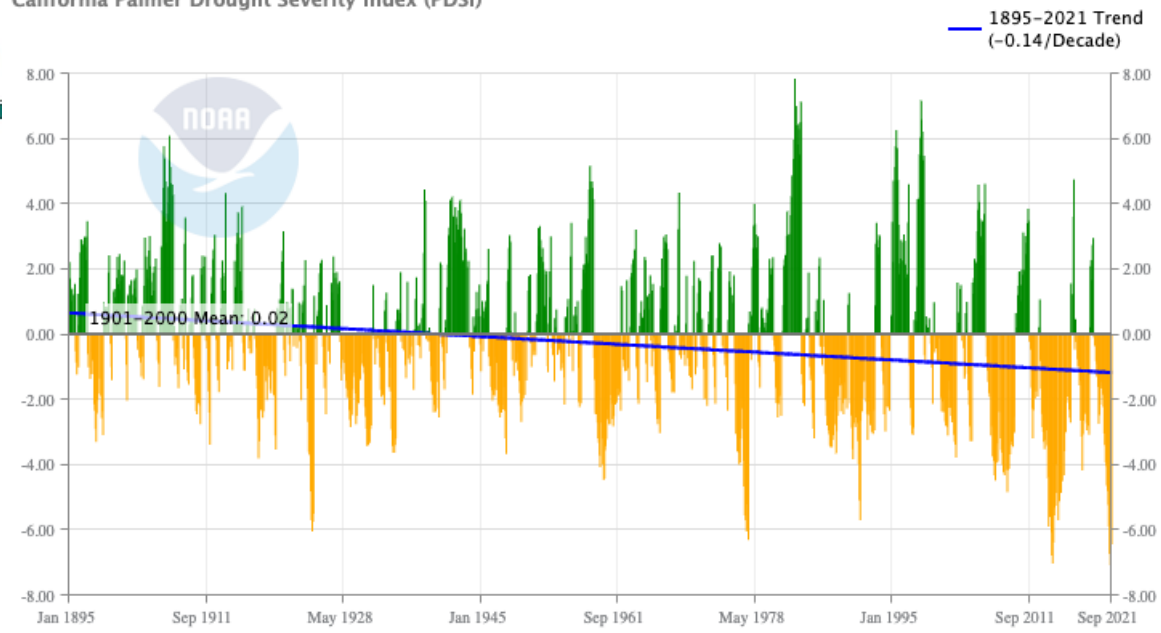
Climate Change and Water Resources



Changing Climatic Patterns



California Palmer Drought Severity Index (PDSI)



Water Availability

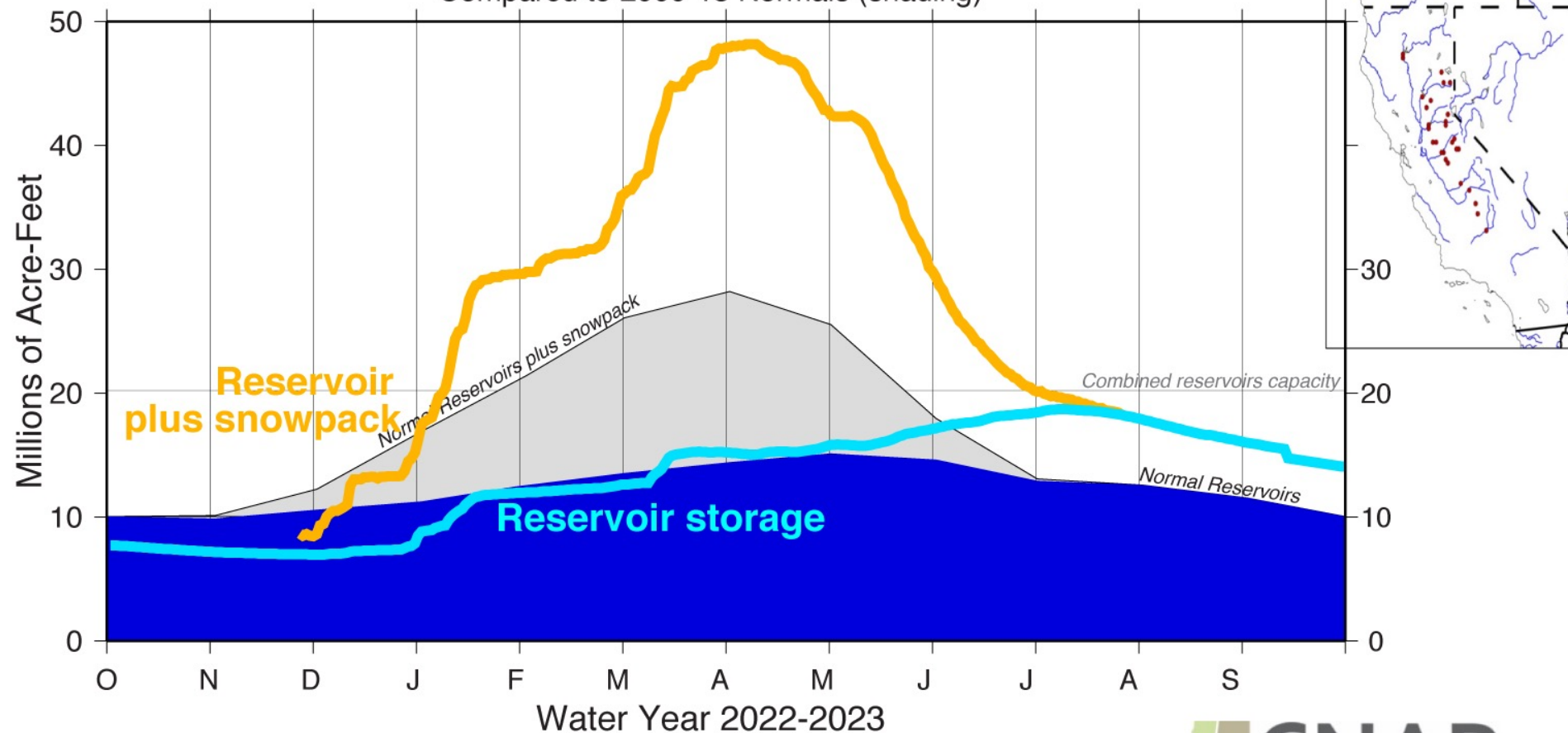
- Change in evaporation and transpiration rates means an altered water cycle.
- Changes in the type and intensity of precipitation mean changes in availability.
- Changes in snowfall and snowmelt dynamics and runoff timing will affect management.
- Reduced runoff from snowmelt due to sublimation and infiltration
- Uncertain impacts on extreme events, through both floods and droughts may be more of a problem.

A wide-angle photograph of a snowy landscape. The foreground is filled with soft, undulating snowdrifts. In the middle ground, a large, smooth snow-covered hill rises, its peak slightly hazy. The sky above is a pale, hazy blue with some wispy clouds. The overall tone is serene and quiet.

Snowpack as a natural storage is
disappearing!

Water Stored in 28 Western Sierra Reservoirs plus Snowpack

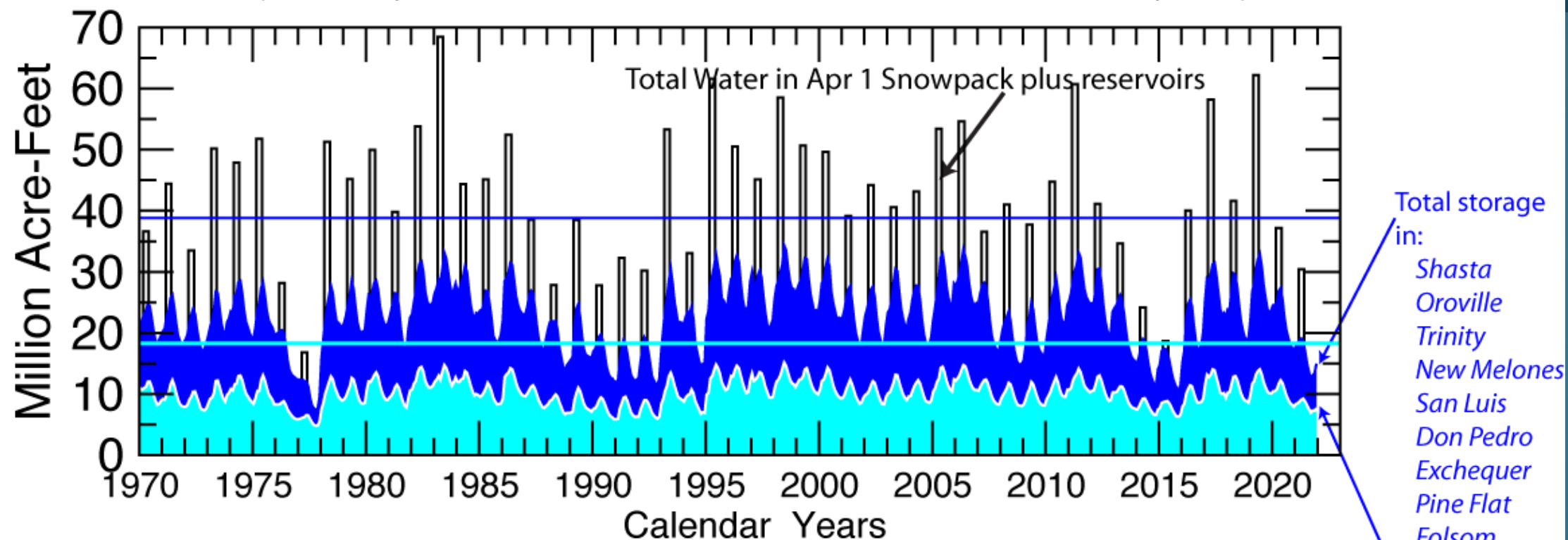
Compared to 2000-15 Normals (shading)



SOURCES: SWE dailies from <https://cdec.water.ca.gov/querySWC.html>
 SWE volume conversion factor based on Margulis et al, JHM 2016, SWE reanalysis
 Reservoir storage from <https://cdec.water.ca.gov/queryDaily.html>
 Reservoirs: SHA, KES, ORO, ANT, FRD, DAV, BUL, ENG, FOL, UNV, LON, ICH, NAT, CMN, PAR, DON, BRD, TUL, NML, DNP, HTH, CHV, EXC, MIL, PNF, TRM, SCC, ISB

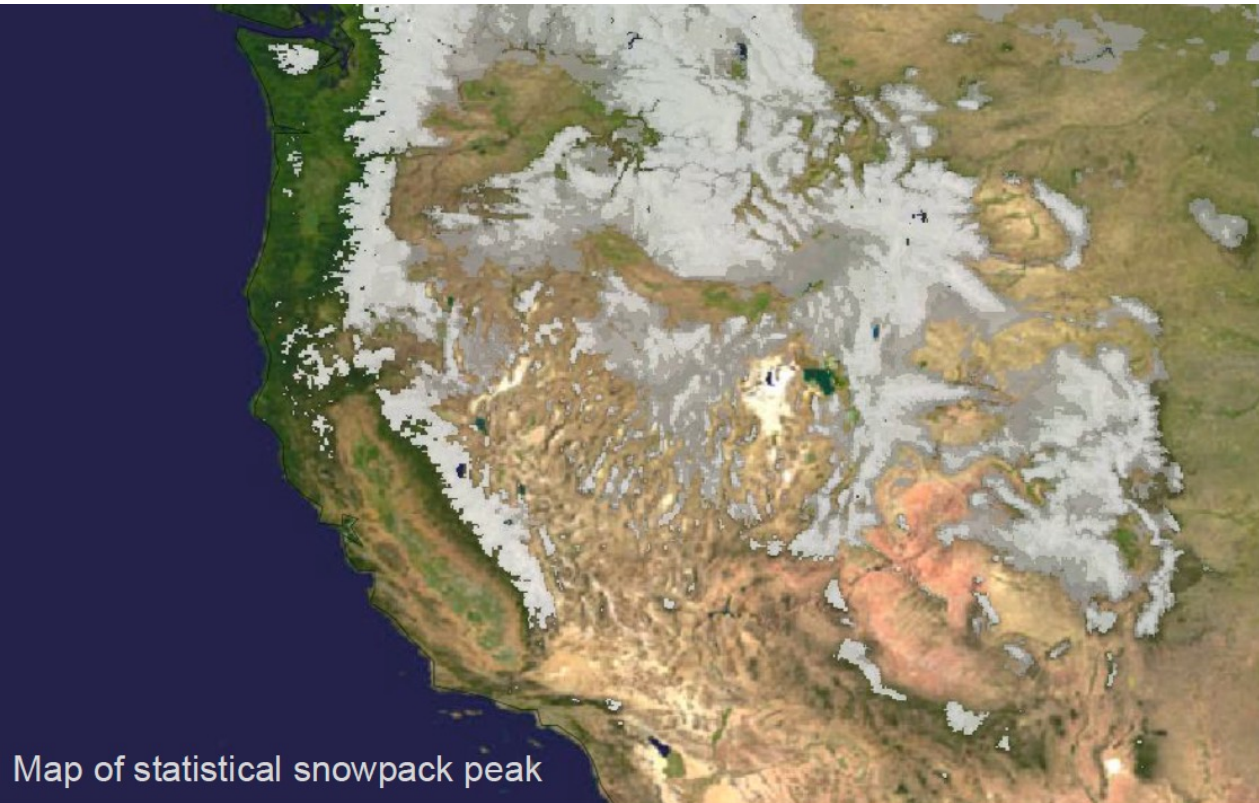
For info: mddettinger@gmail.com
https://cnap.ucsd.edu/storage_in_sierra_ucrb/

TOTAL WATER STORED *(monthly)* in **12 major** & **152 other** California Reservoirs with Statewide April 1 Snow-water contents *(stacked atop each other; horizontal dashed lines=combined current reservoir capacities)*

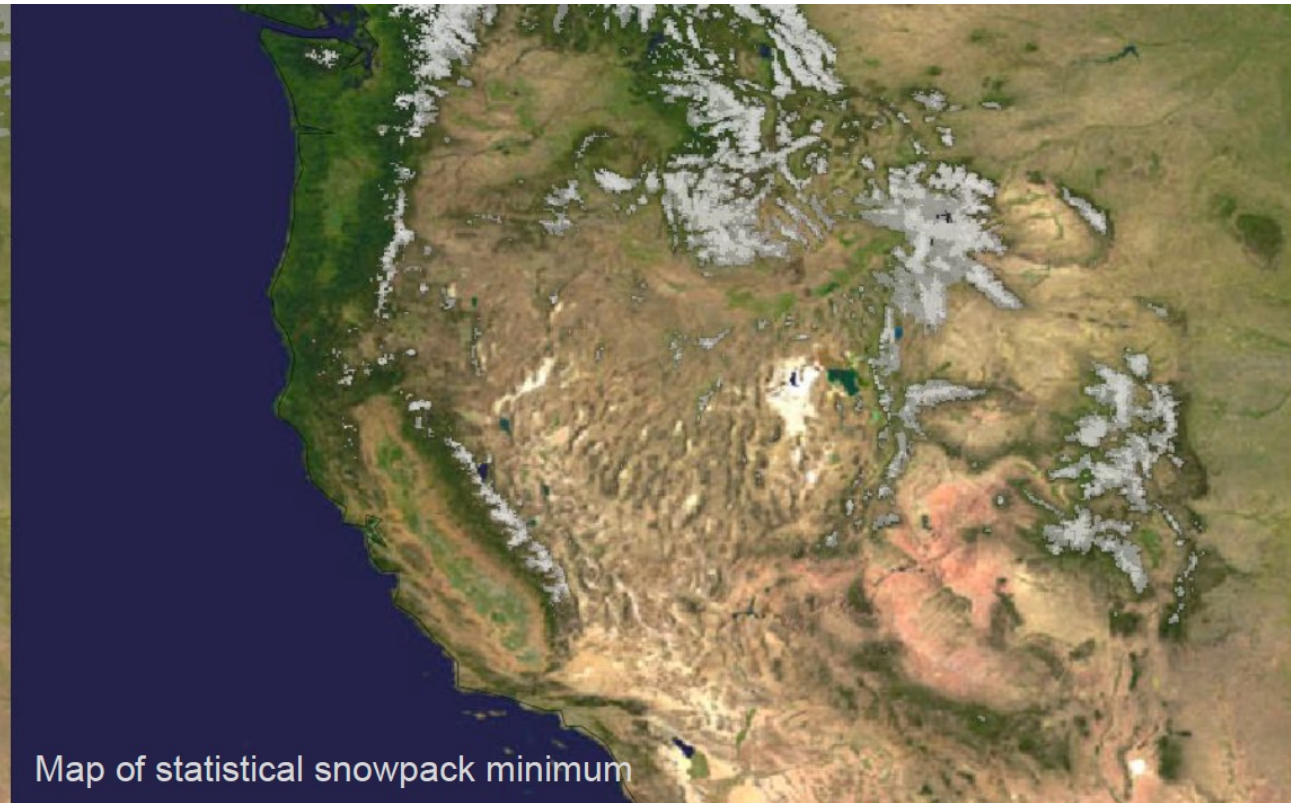


A Low-to-No Snow Future for California

- We are expected to lose about 70% of our snowpack by the end of this century.
- Snowpack naturally store water for us and accounts for about 70% of our total storage (not accounting for groundwater)



Map of statistical snowpack peak



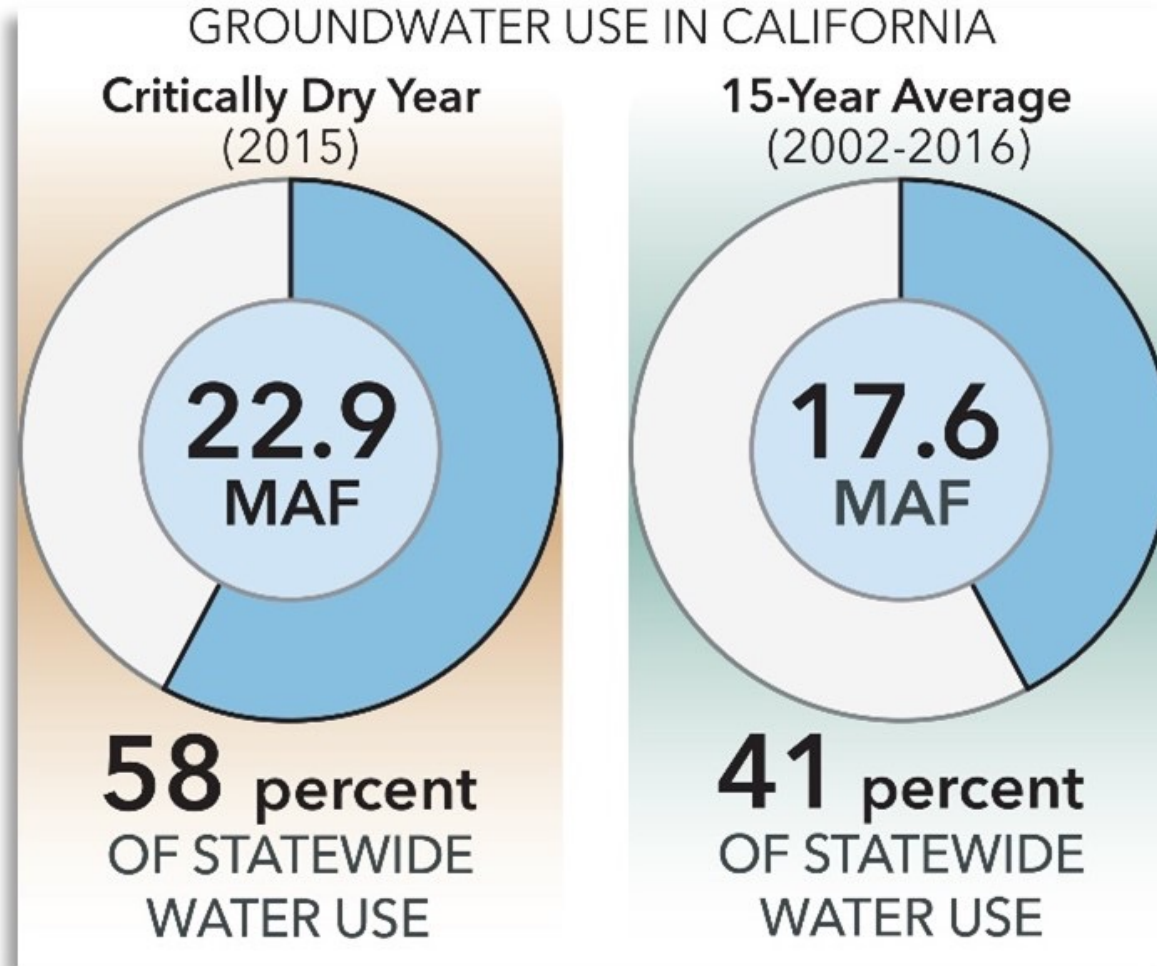
Map of statistical snowpack minimum

Siirila-Woodburn, Rhoades, et al., 2021



Groundwater

Groundwater use in California



Source: Draft California's Groundwater Update 2020 (DWR).

Severe Groundwater Depletion

California's groundwater (our second natural storage) is also disappearing.

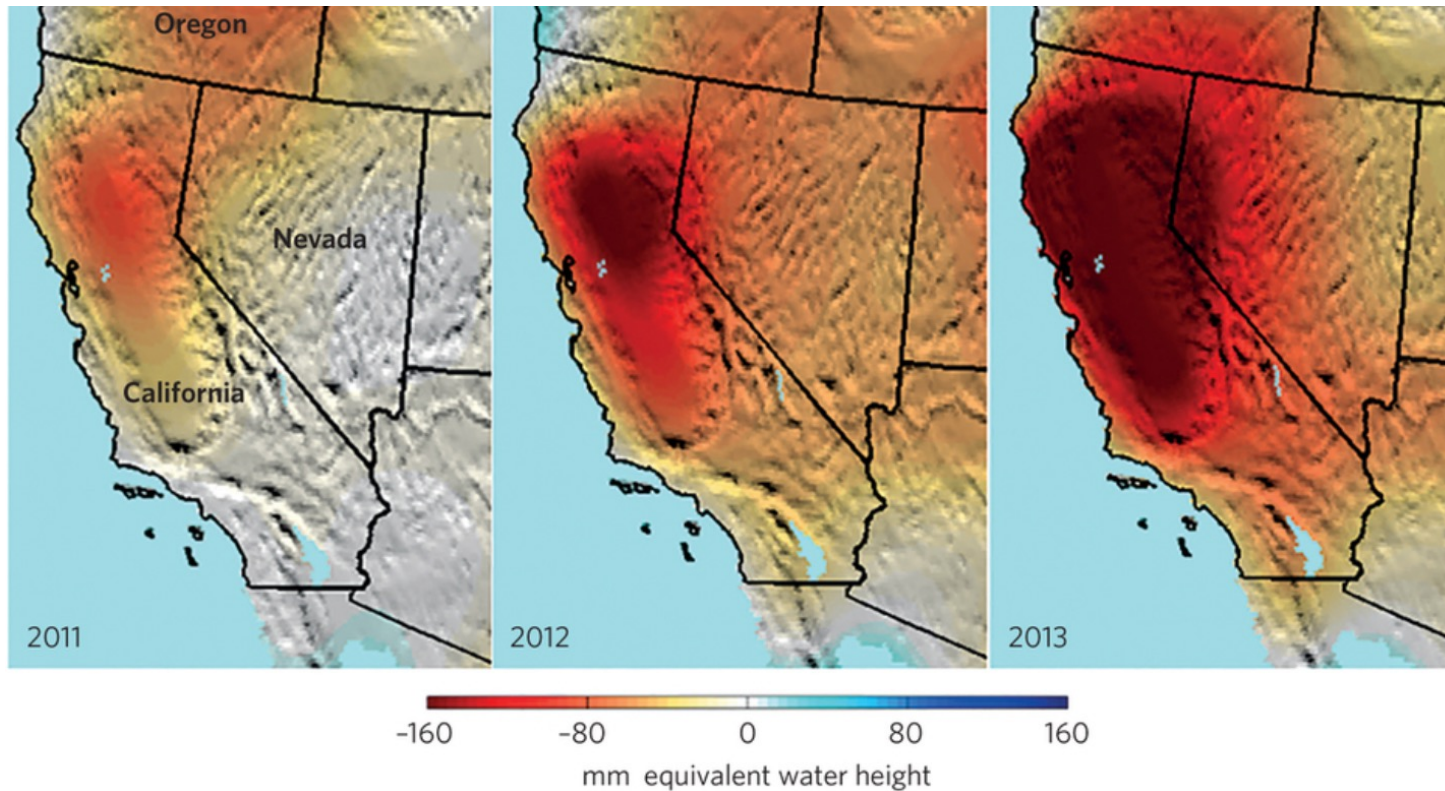
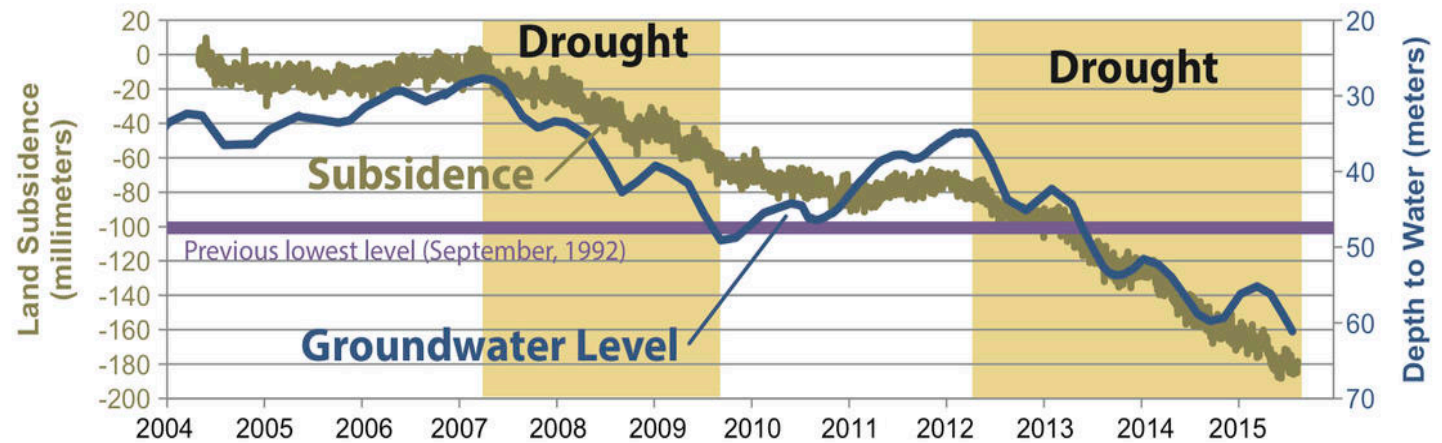
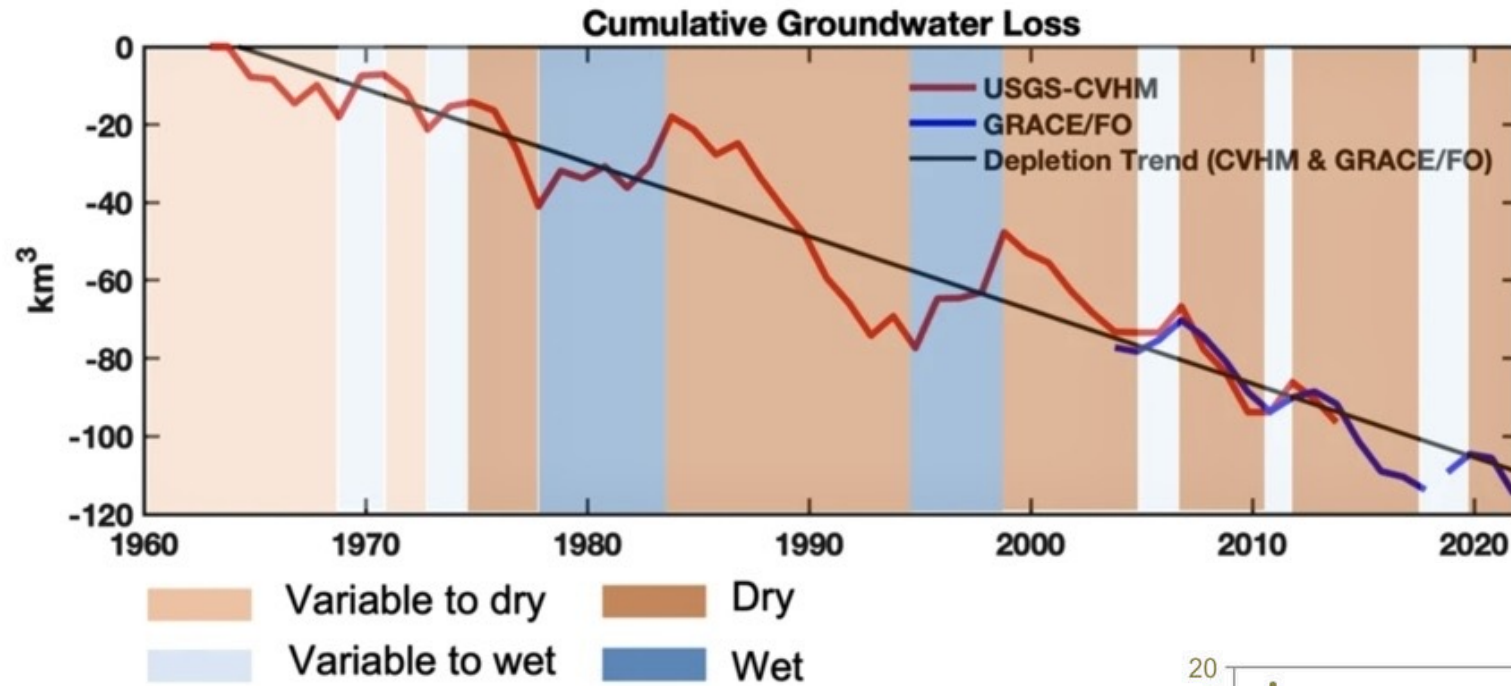


Image by Felix Landerer, NASA Jet Propulsion Laboratory.

Groundwater



Groundwater mining and subsidence



Measures of land Subsidence in San Joaquin Valley. Credit: USGS

Implementation Timeline for Major Sustainable Groundwater Management Act (SGMA) Requirements



January 2015

DWR released initial basin prioritization. High and medium priority basins are subject to SGMA requirements.

January 2016

DWR identified final list of basins subject to critical conditions of overdraft. These basins face some expedited compliance deadlines.

June 30, 2017

Local agencies must establish groundwater sustainability agencies (GSAs). SWRCB may designate probationary basins subject to intervention for areas that fail to comply.

January 31, 2020

GSAs from basins in critical overdraft must adopt and begin to implement groundwater sustainability plans (GSPs). DWR will review plans for adequacy after adoption.

January 31, 2022

GSAs from basins not in critical overdraft must adopt and begin to implement GSPs. DWR will review plans for adequacy after adoption.

January 31, 2040

GSAs from basins in critical overdraft must achieve sustainability goals.

January 31, 2042

GSAs from basins not in critical overdraft must achieve sustainability goals.

Climate Whiplash

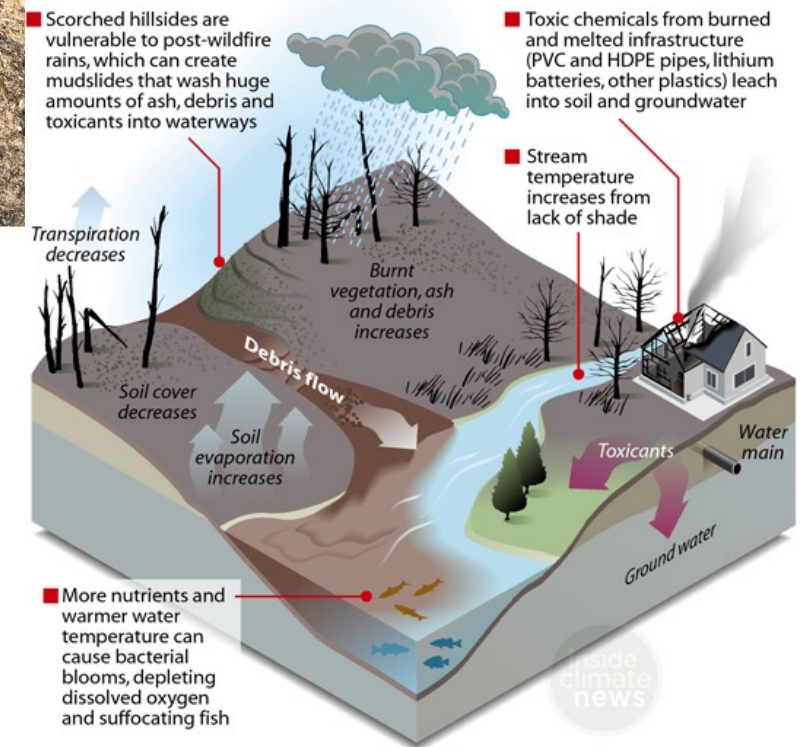
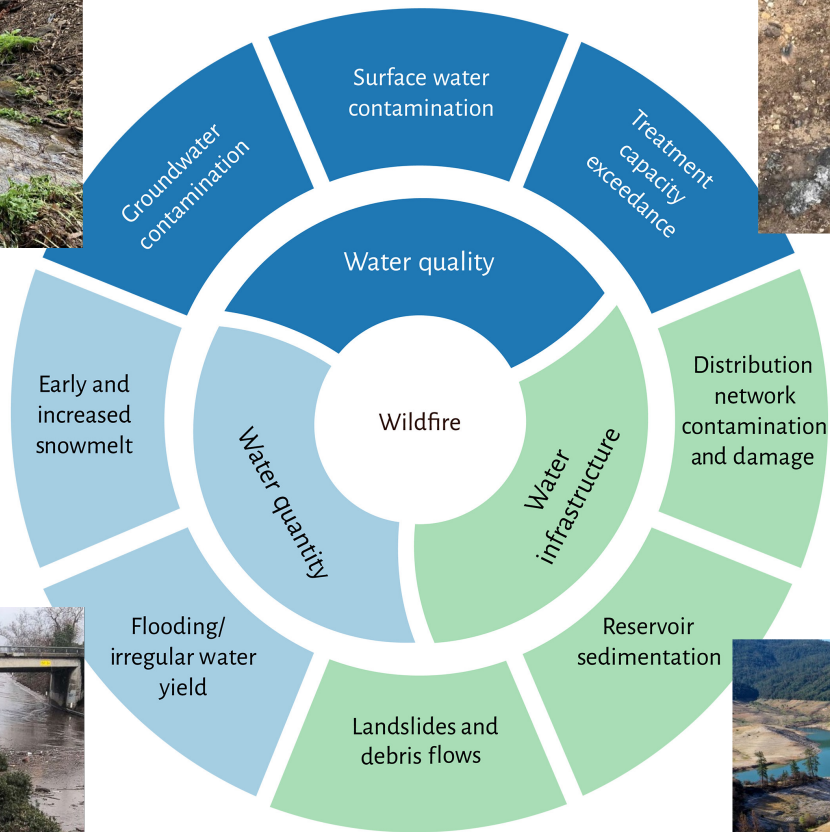


Lake Oroville, seen here in September 2021



A Flooded Neighborhood in California, 2021

Wildfires



SOURCES: Water Quality Australia; Purdue University

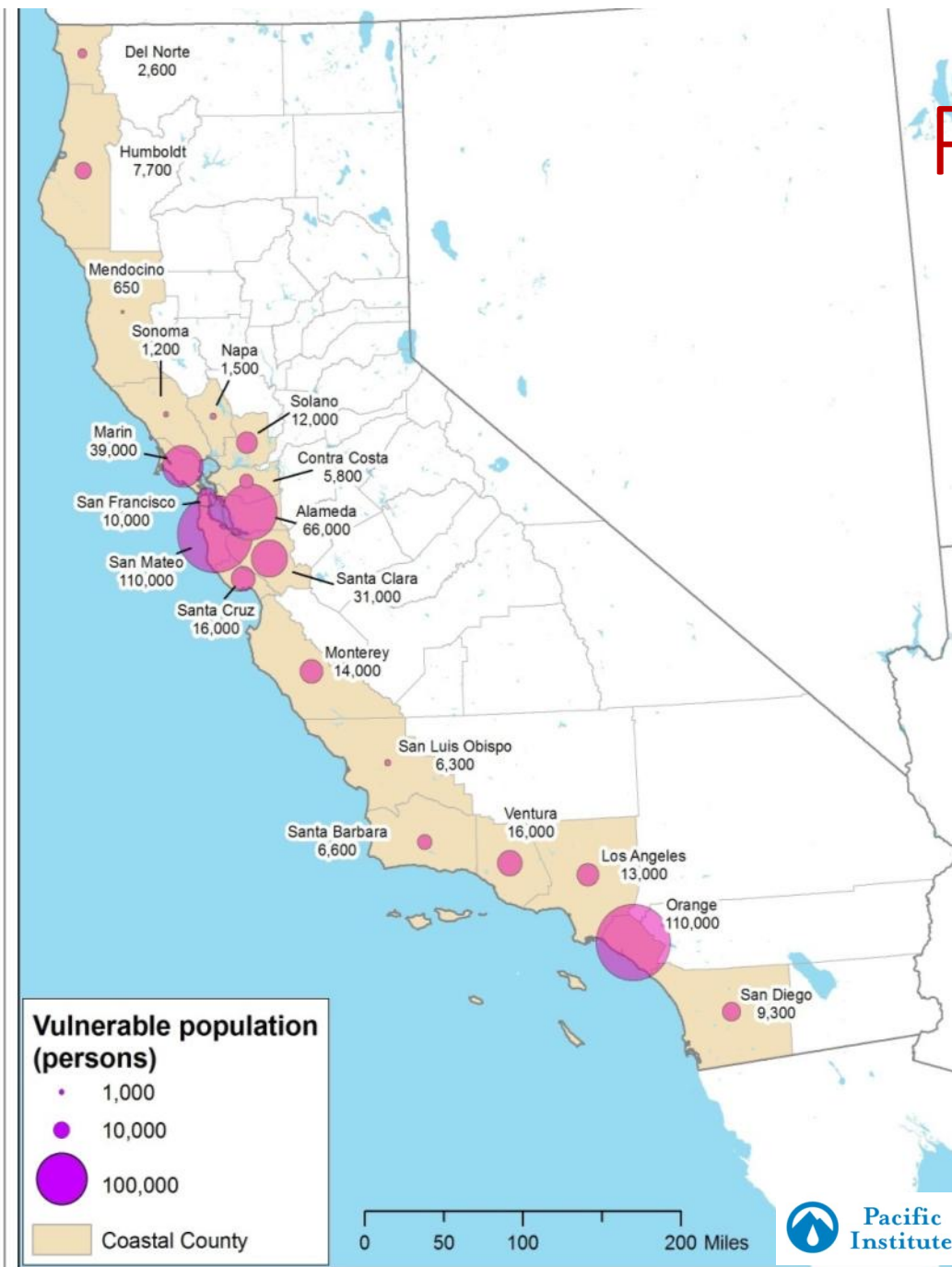
PAUL HORN / InsideClimate News

Sea Level Rise and Water Infrastructure

- Alter groundwater quality in coastal regions: saline water intrusions.
- Poses risk to
 - Coastal population
 - Wastewater treatment plants
 - Wetlands

Population at Risk

- 480,000 people
- 300,000 workers
- Large numbers of low-income people and communities of color who depend on depleting groundwater

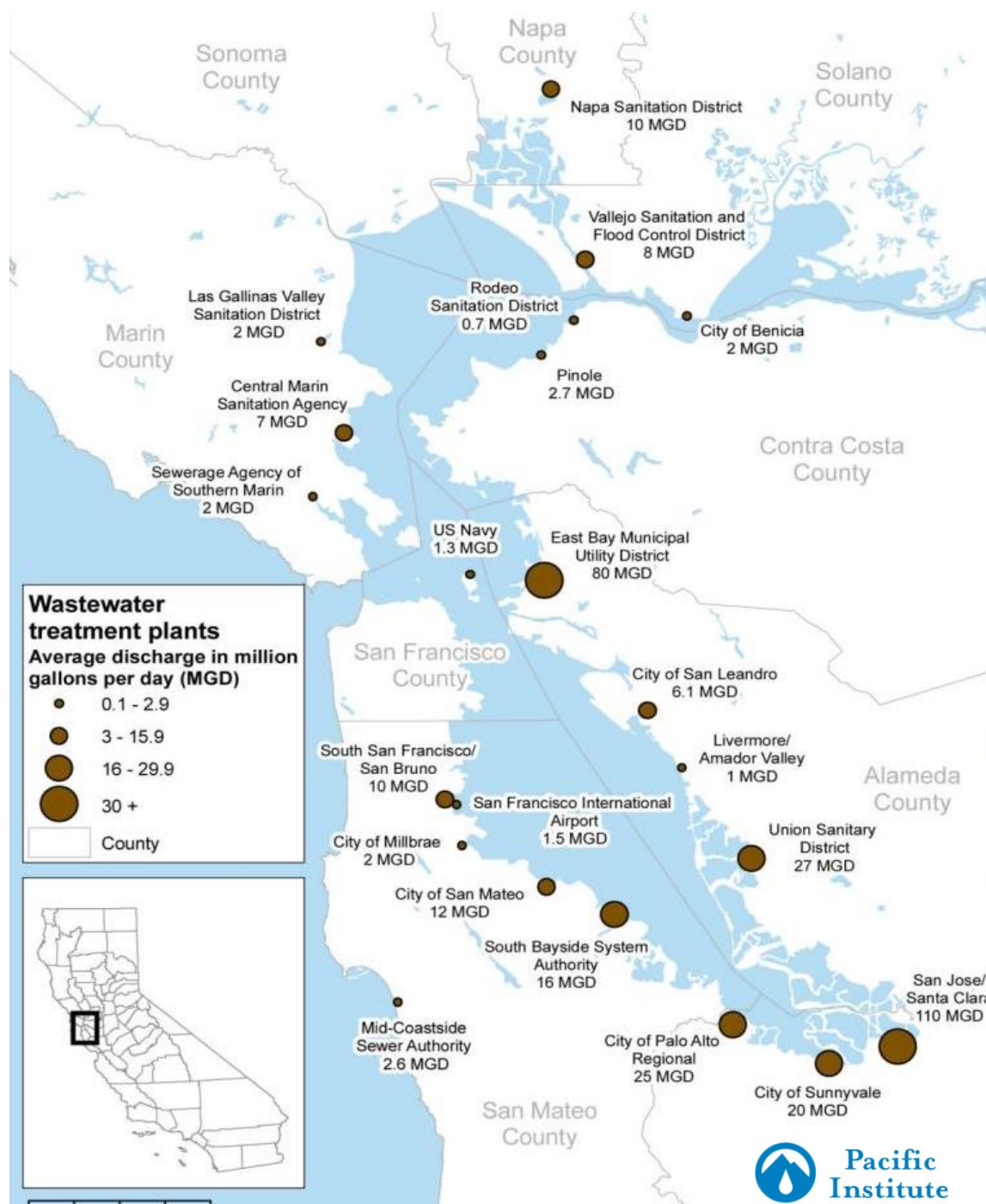


Power Plants at Risk

- 30 coastal power plants
- Generating capacity of 10,000 MW



Wastewater Treatment Plants at Risk



- 22 wastewater treatment plants
- Capacity of 325 million gallons per day

Wetlands and Sea Level Rise

- Some wetlands may become permanently inundated if sea levels rise faster than they can respond
- California has already lost 96% of its wetlands, at a great cost to the state
- Wetlands are vital for:
 - flood protection
 - water quality improvement
 - wildlife habitat
 - recreation
 - carbon sequestration





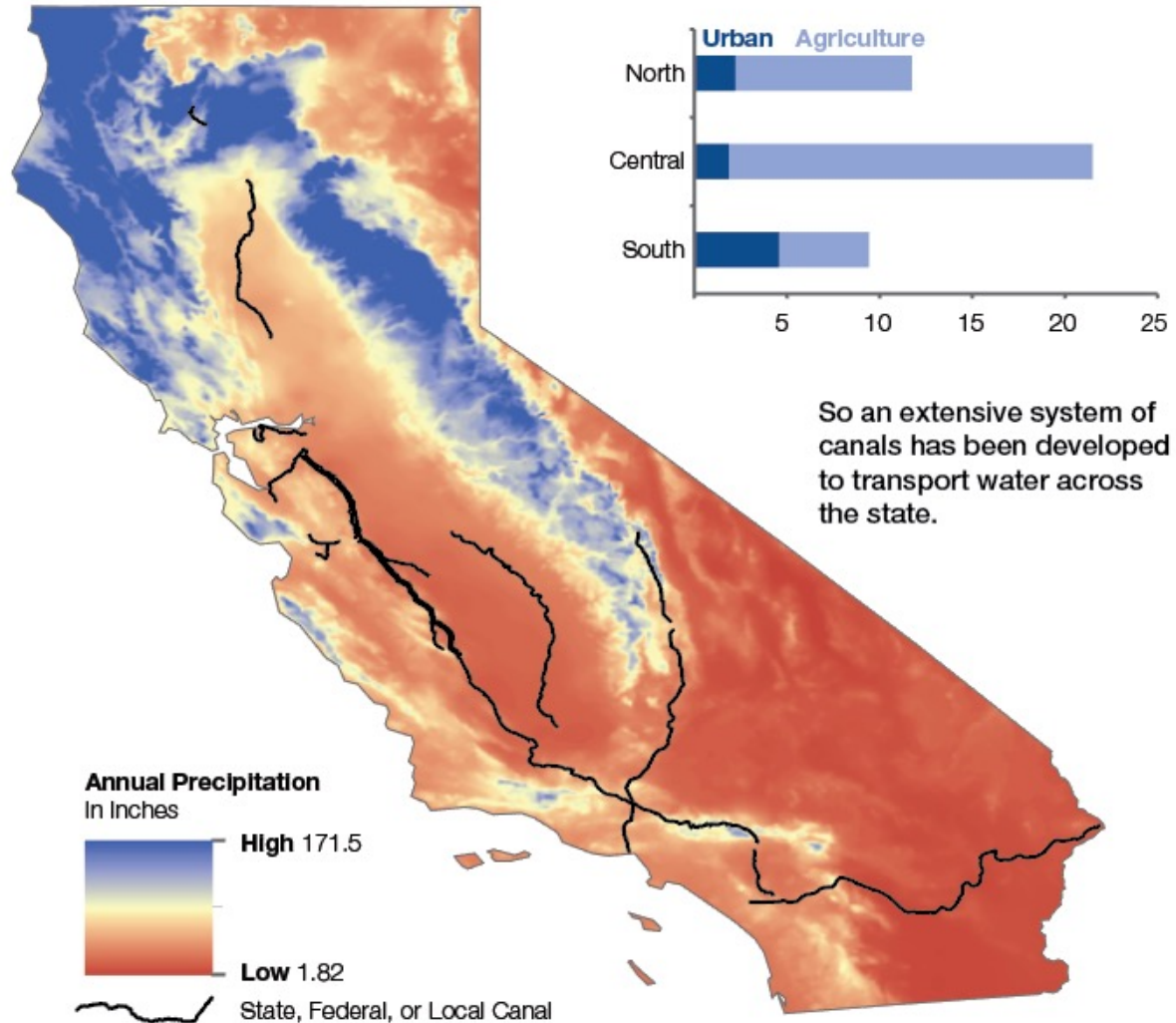
Water Demand

Water Supply Versus Demand

Most Precipitation Falls in Northern California

But Much of People's Water Use Occurs in Southern and Central California

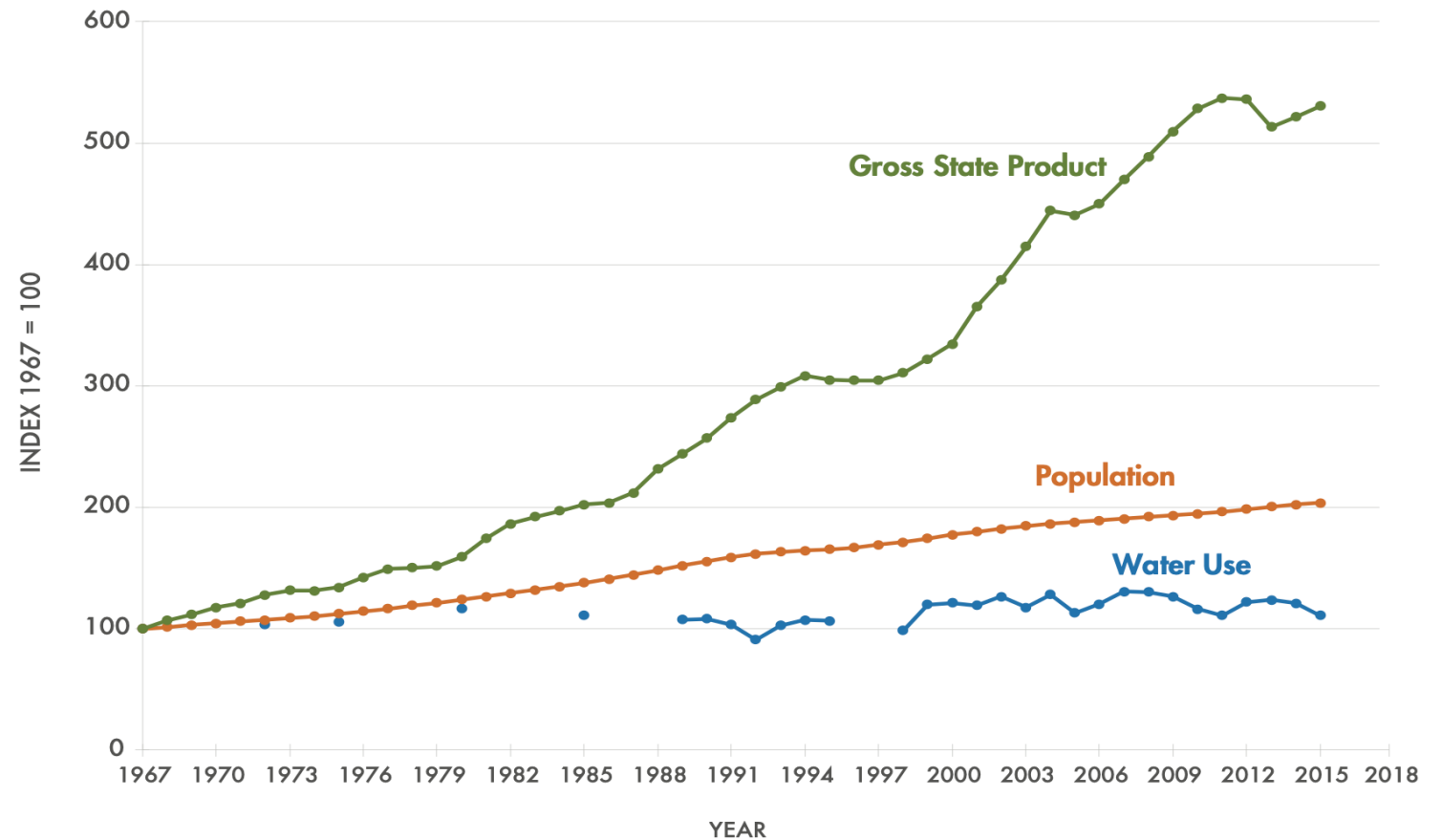
Water Use in Millions of Acre Feet



Map created by California Department of Water Resources using PRISM (prism.oregonstate.edu).

Water Demand in California has decoupled from population and economic growth!

Figure 1. California Population, Gross State Product, and Water Use Indices, 1967-2016



Note: All values are indexed to their 1967 values to allow for comparison. Statewide water use data are not yet available for 2017 through the present.

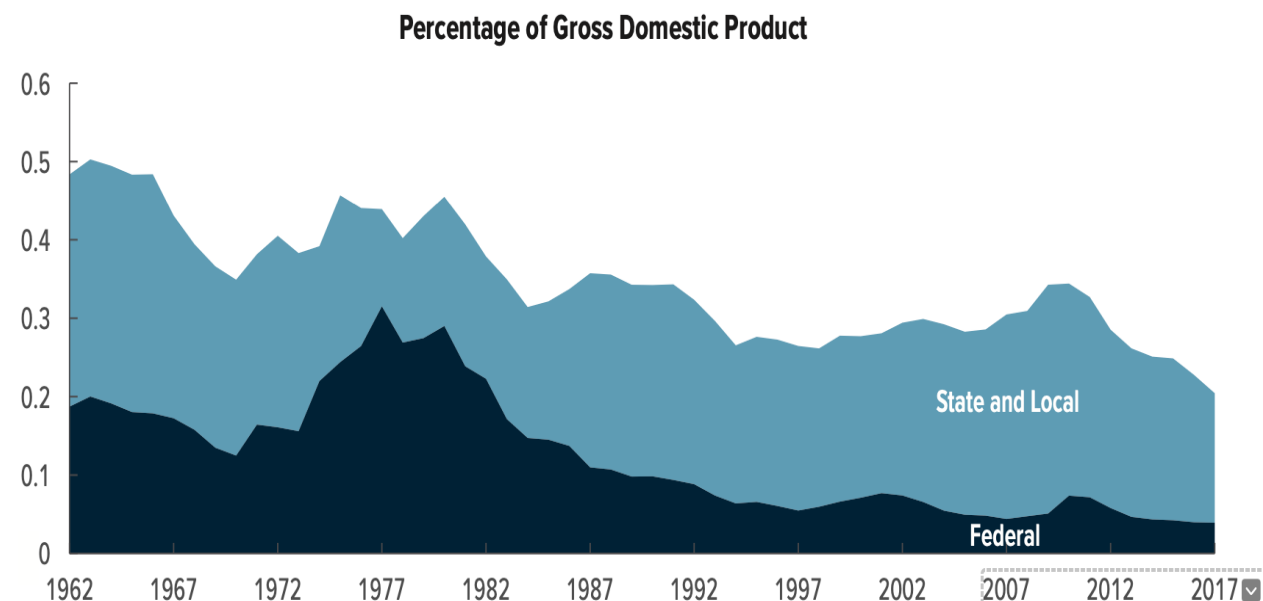
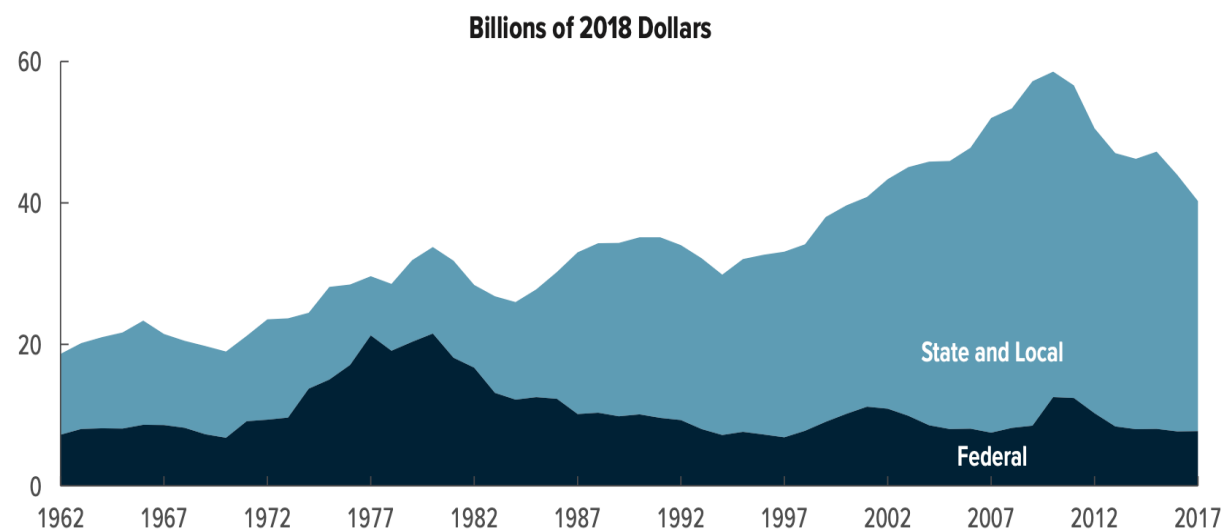
Data sources: Water use data from California Department of Water Resources (DWR) 1964; 1970; 2018a; 2019b. Population data from California Department of Finance 2018. Gross state product from United States Bureau of Economic Analysis 2019.



Funding Water Resilience

The Federal, State and Local Governments' Spending on Water

Water Infrastructure: Sources of Nondefense Investment, 1962 to 2017

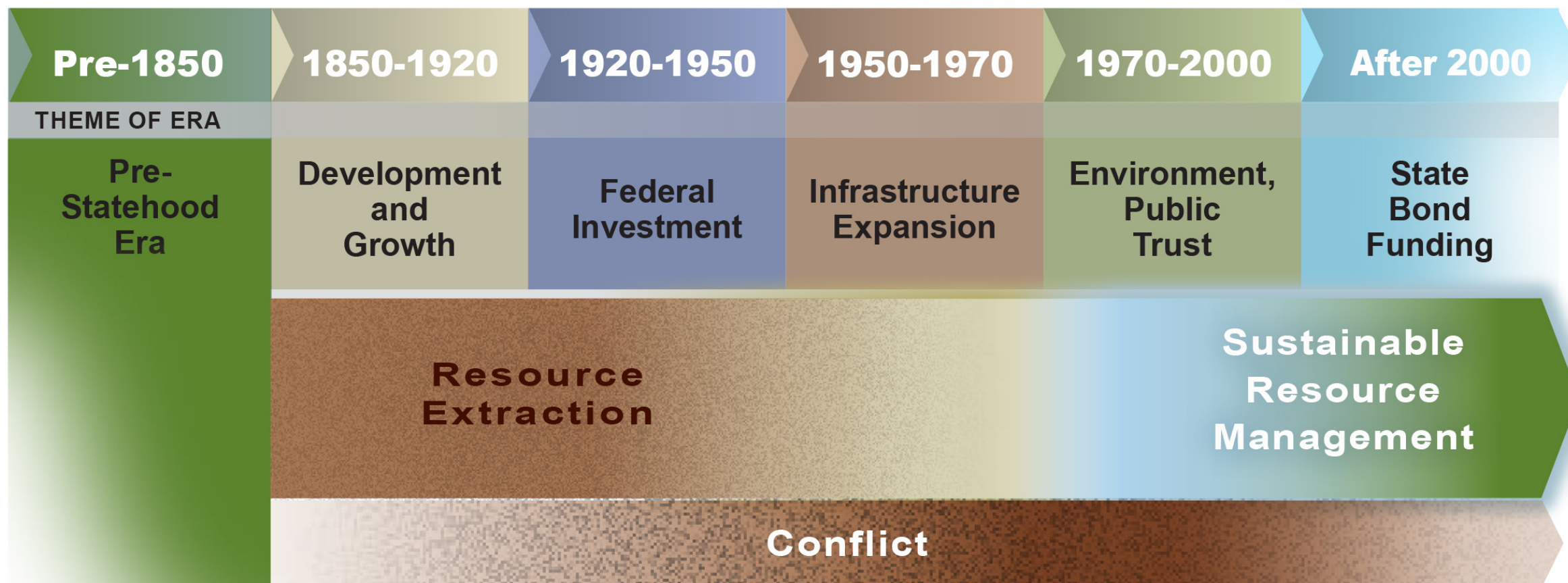


Source: Congressional Budget Office, using data from the Office of Management and Budget and the Bureau of the Census.

a. Includes water supply and wastewater treatment facilities.

b. Includes water containment systems (dams, levees, reservoirs, and watersheds) and sources of freshwater (lakes and rivers).

History of Funding for Water in California



A Challenge or An Opportunity

Addressing our 21st century water challenges requires rethinking of current financing mechanisms.

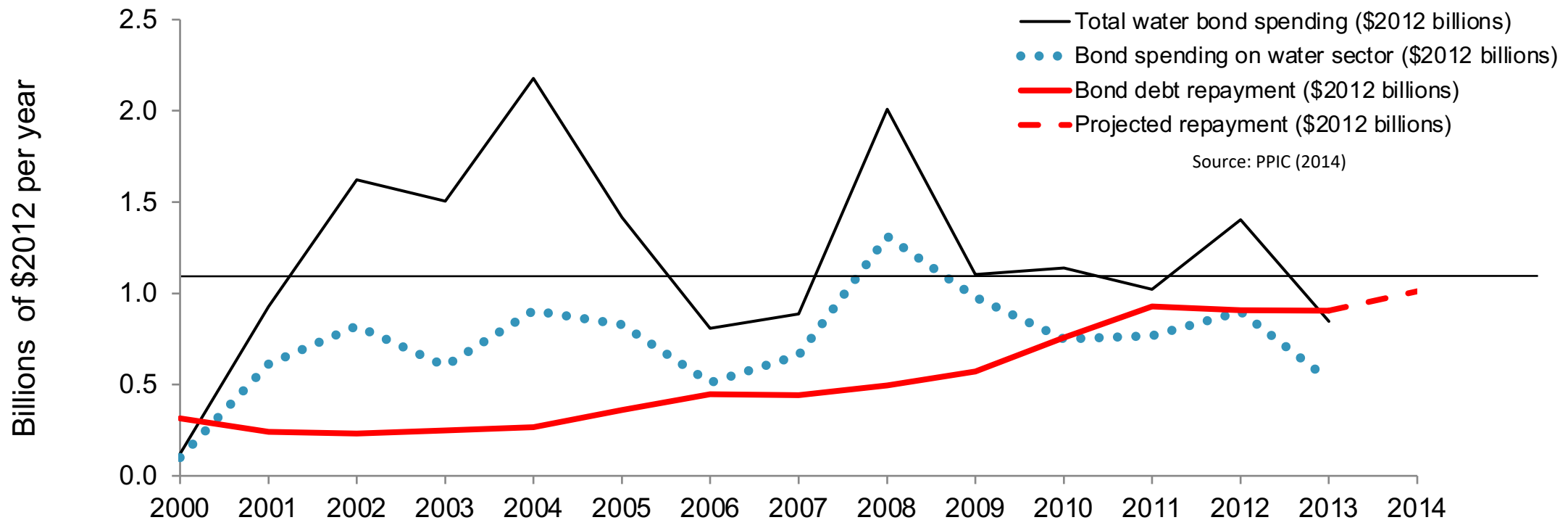
- Some of the financing options include:
 - Municipal bonds
 - State revolving funds
 - Public-Private Partnerships (PPP)
 - Tax initiatives
 - Public benefit funds
- Funding gaps include
 - Conservation and efficiency efforts,
 - Watershed Management
 - Water research and development,
 - Monitoring and data management,
 - Capital investment for innovative water systems
- In California, State General Obligation (GO) bonds, while only 3% of annual water spending, cover about 10% of capital investment in various water projects.



California's Reliance on GO water Bonds

Bond financing is unreliable and expensive:

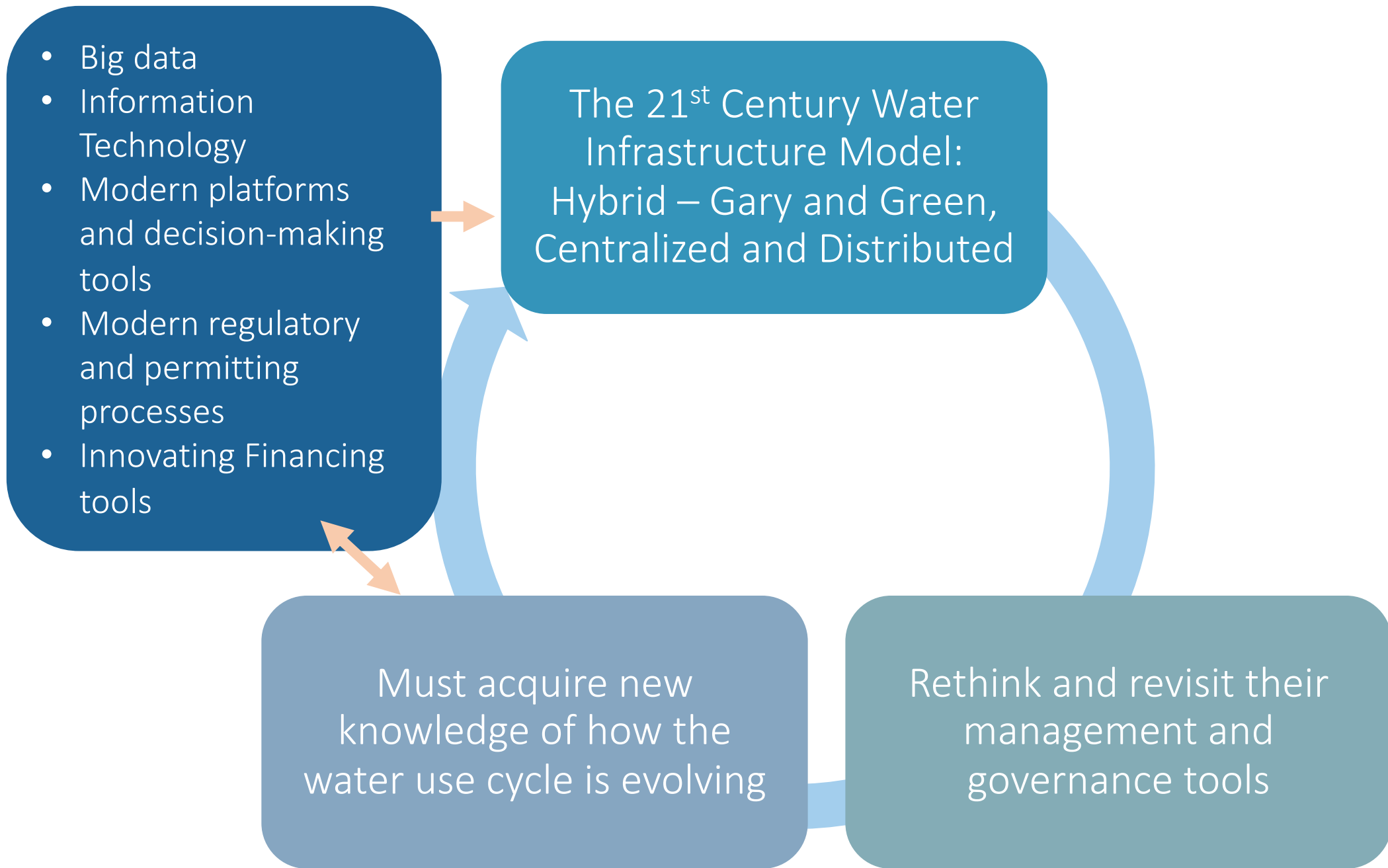
- Californians pay \$120 annually / household to pay back water bonds
- Between 2008-2011, 18% of statewide annual water-related spending in California covered Debt service on GO water bonds



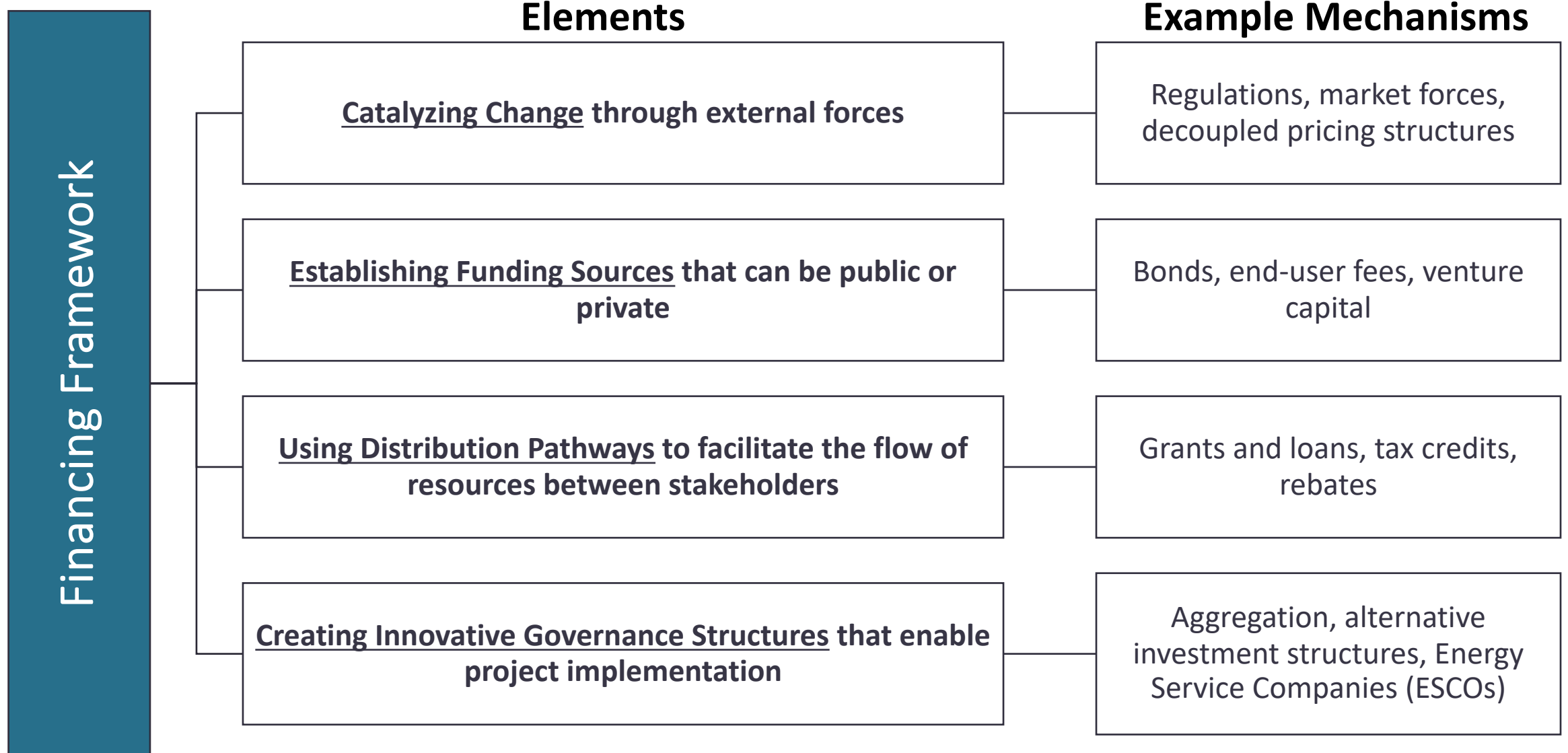
An architectural rendering of a modern waterfront park. The scene features a series of white, curved, tiered walkways and seating areas that curve along a body of water. The park is lush with green grass, various trees, and clusters of yellow wildflowers. In the foreground, the silhouettes of three people are visible as they look out over the park. In the background, a city skyline with several tall buildings is visible across the water under a bright sky. A semi-transparent white box with black text is overlaid in the upper center of the image.

Transitioning to the 21st Century Infrastructure Model Requires Fresh Thinking

Paradigm Shift in the Water Sector



Innovative Financing Framework



The 21st century hybrid urban water infrastructure model: mix of distributed solutions at various scales and centralized ones

- Flexibility
- Resiliency
- Reliability



Behind the Meter

=

Changing Demand Baseline

Front of the Meter

=

Diversifying Supply Portfolio

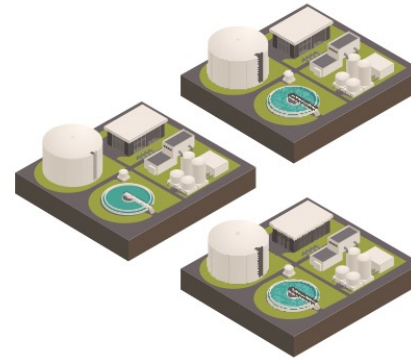
Scales of Water Reuse



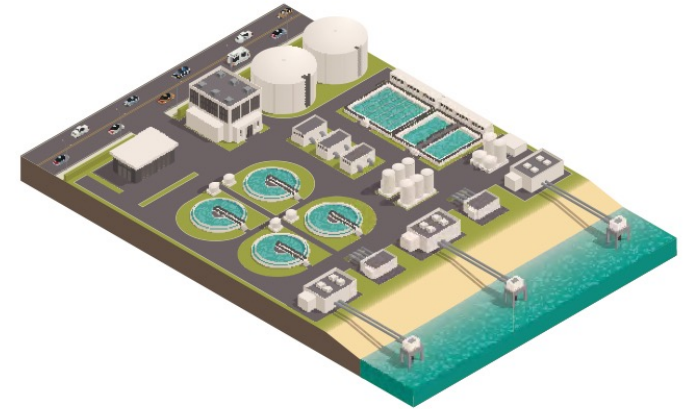
**Building-Scale
Treatment**



**District-Scale
Treatment**



**Small
Treatment Plants**



**Large
Treatment Plant**

Distributed Water Systems



Centralized Water Systems

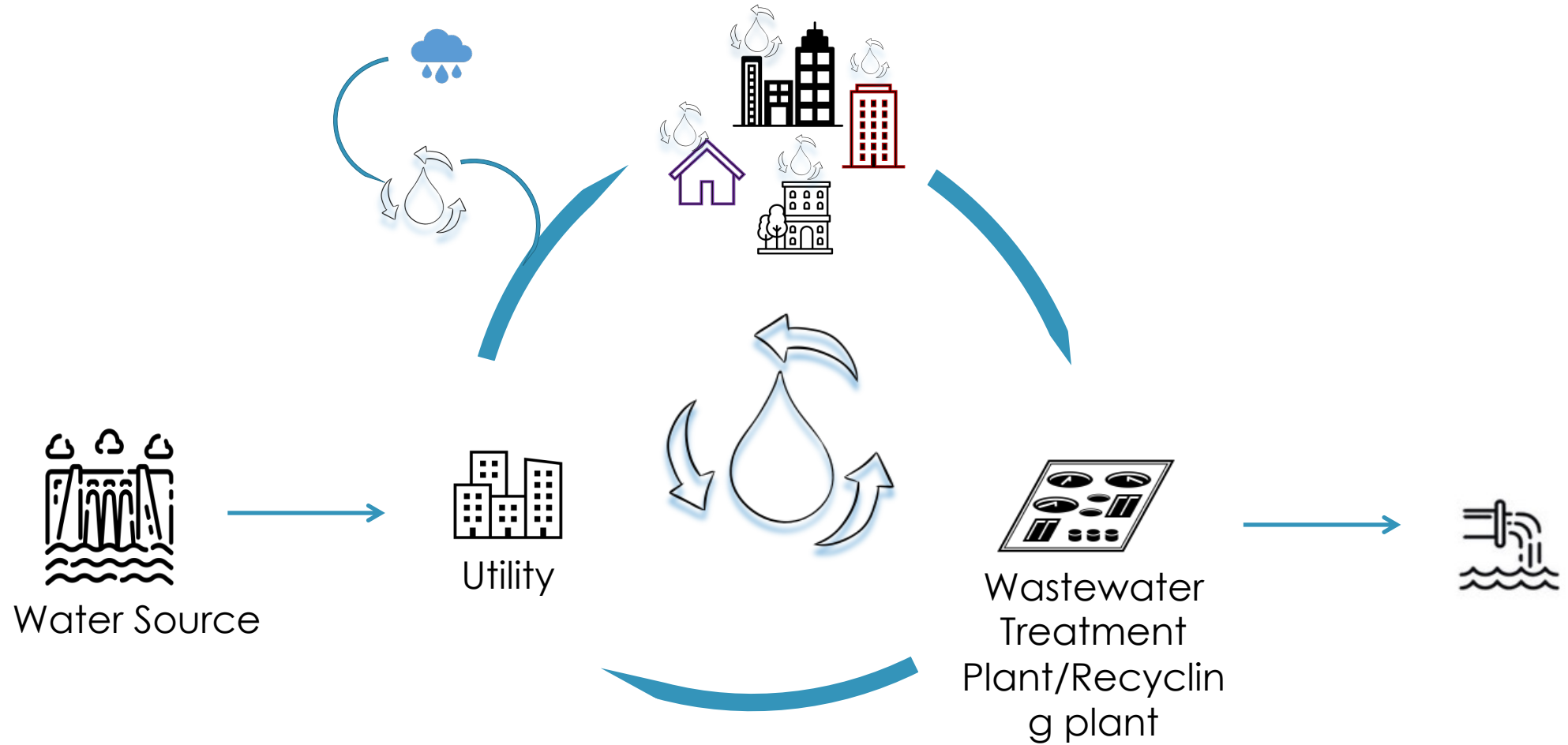


San Francisco's Non-potable Water Program

A Guidebook for Implementing Onsite Water Systems in the City and County of San Francisco



The 21st century hybrid urban water infrastructure model: data-centric, circular, and modular



- Utility is not the only actor
- Customer are also becoming water producers - prosumers
- Data and information is key in managing this system

The 21st century hybrid water infrastructure model

Where, when, and how much? A smart grid that can track distributed production and consumption patterns


What is infrastructure? more than hard/physical infrastructure there is a need for a better set of soft infrastructure data, DSS tools, IT systems, smart meters

What kind of performance measure do we need? Multi benefit and cross-sectoral to enable investment in Nature Based Solutions and Green Infrastructure

What kind of business model? Circular, data-driven, and customer-centric

What kind of policy and governance reforms are needed?

Who is at the table?



Current and emerging water issues/opportunities in California

- Water-energy-land nexus
- Equitable transition
- Transitioning from a snow-driven to a rain-driven water system
- Managed Aquifer Recharge and groundwater governance
- Wildfires-water interlinks
- Green and natural infrastructure
- Climate informed infrastructure management and planning

Thank you!



“We can't solve problems by using the same kind of thinking we used when we created them.” Albert Einstein

email: newsha@lbl.gov



Questions?



The 20th Century Urban Water Infrastructure Model: A Linear/ Once-Through System

