



UNIVERSITY OF CALIFORNIA  
Agriculture and Natural Resources

Cooperative Extension



# Managing Water for multiple benefits in California

**Dr. Laura Garza**

Area Water Quality, Quantity, and Climate Change Advisor  
UC Cooperative Extension

# Agenda

1

## California Water Setting

- Climate and Hydrology
- Water Challenges and Pressures
- Water monitoring indices

2

## North Coast Case Study

- Water strategies to balance agriculture and biodiversity needs

3

## Water Strategy for irrigation systems

- Water Budget
- Irrigation efficiency methods
- Best practices for improving Water conservation and quality
  - Cover Crops

# Agenda

1

## California Water Setting

- Climate and Hydrology
- Water Challenges and Pressures
- Water monitoring indices



# California

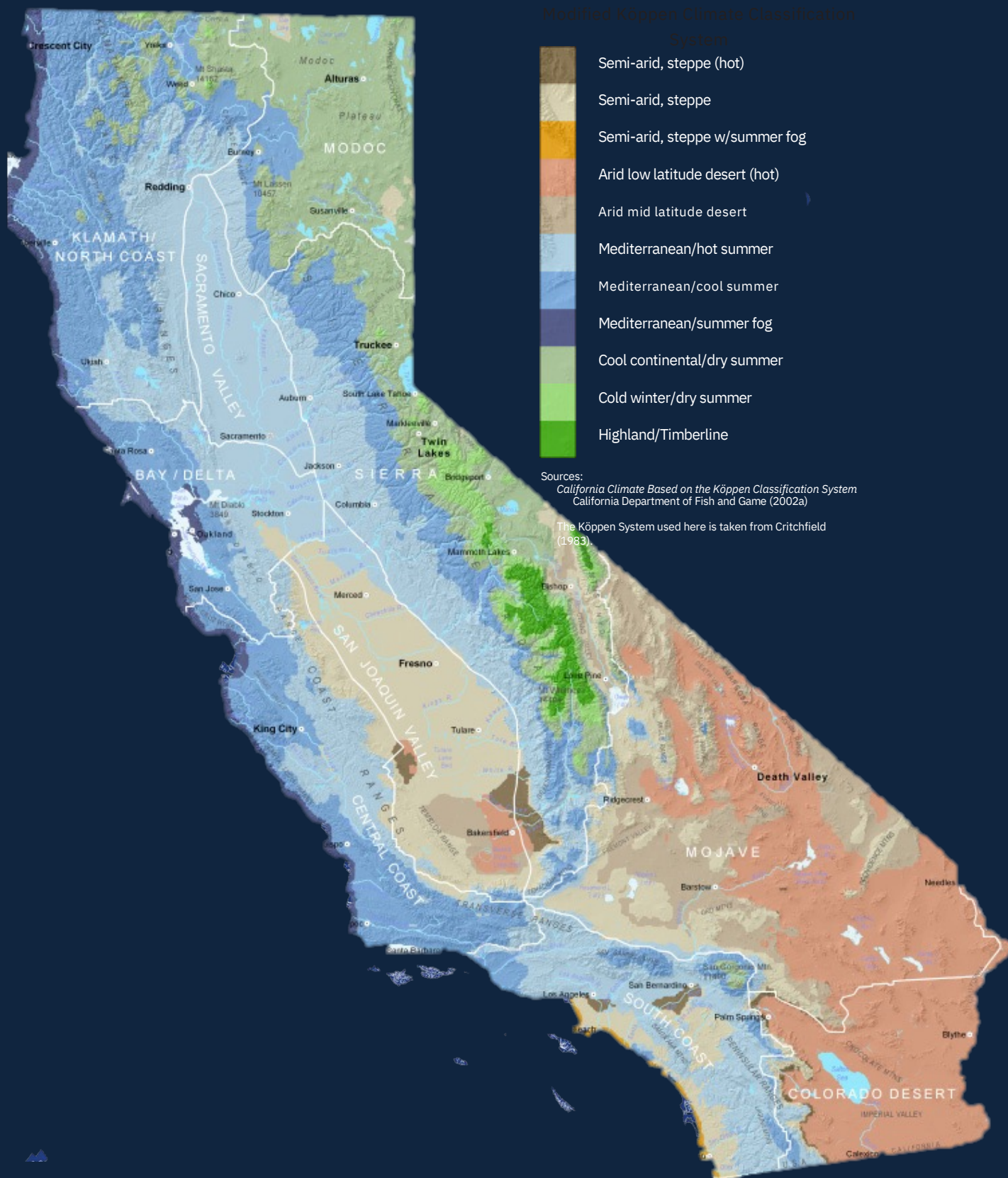
# Climate and Hydro Setting

## Climate

Modified Köppen Climate Classification System



Sources:  
California Climate Based on the Köppen Classification System  
California Department of Fish and Game (2002a)  
The Köppen System used here is taken from Critchfield (1983).



## Climate

CA climate has five major climate types:

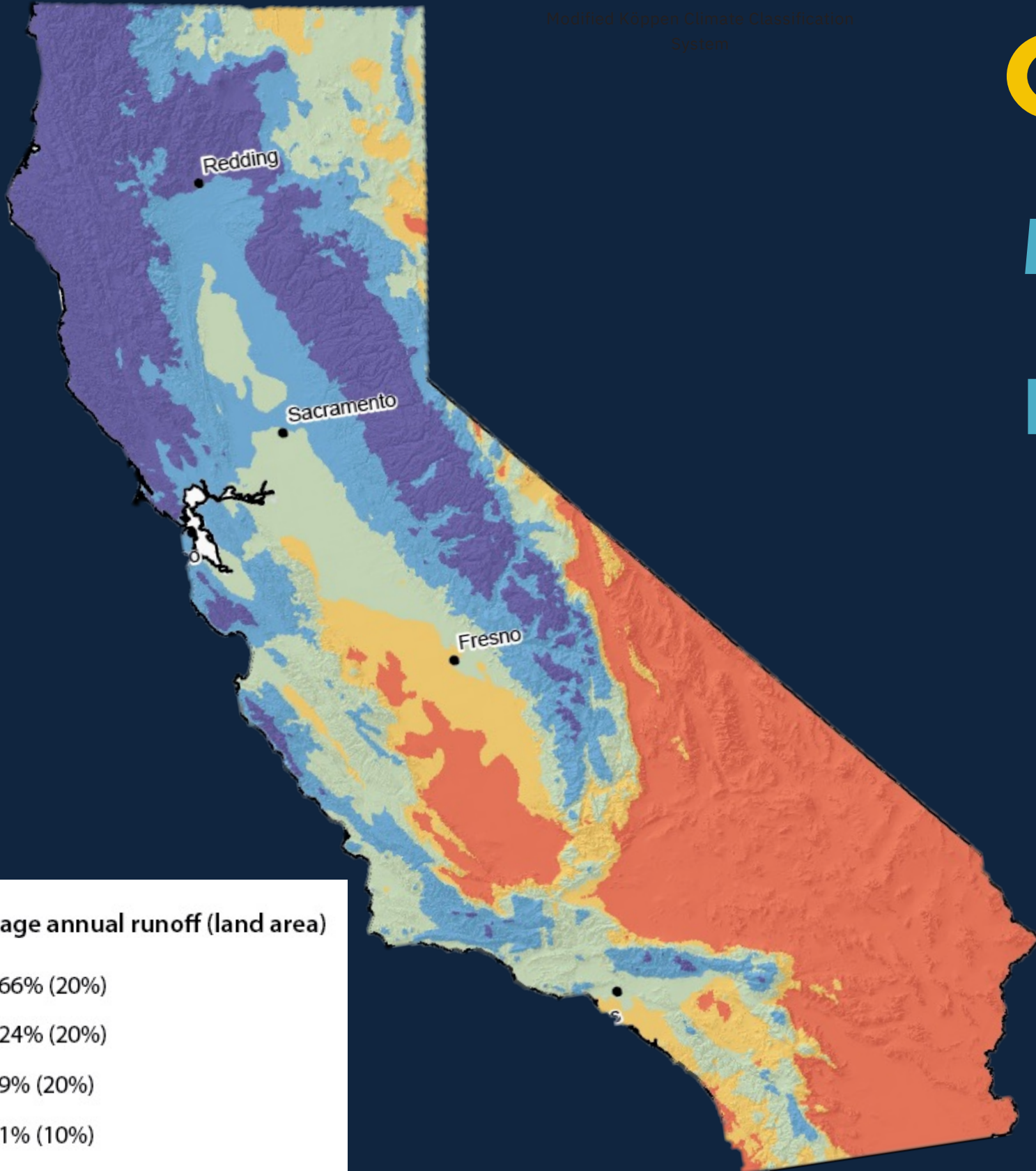
- Mediterranean (wet winters and dry summers)
- Desert
- Cool Interior
- Highland
- Steppe



# California Climate and Hydro Setting

## Climate

Modified Köppen Climate Classification System

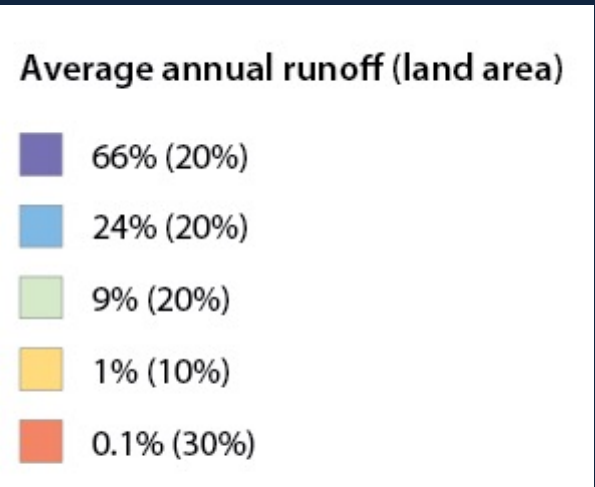


## Mediterranean climate

- Wet winters and dry summers

## Precipitation

- Less than 5 to 200 inches



# California Climate and Hydro Setting



## Mediterranean climate

- Wet winters and dry summers

## Precipitation

- less than 5 to 200 inches

## Hydrologic Regions

- 10 hydrologic regions defined by a natural water flows or drainage areas



# California Climate and Hydro Setting

## Mediterranean climate

- Wet winters and dry summers

## Precipitation

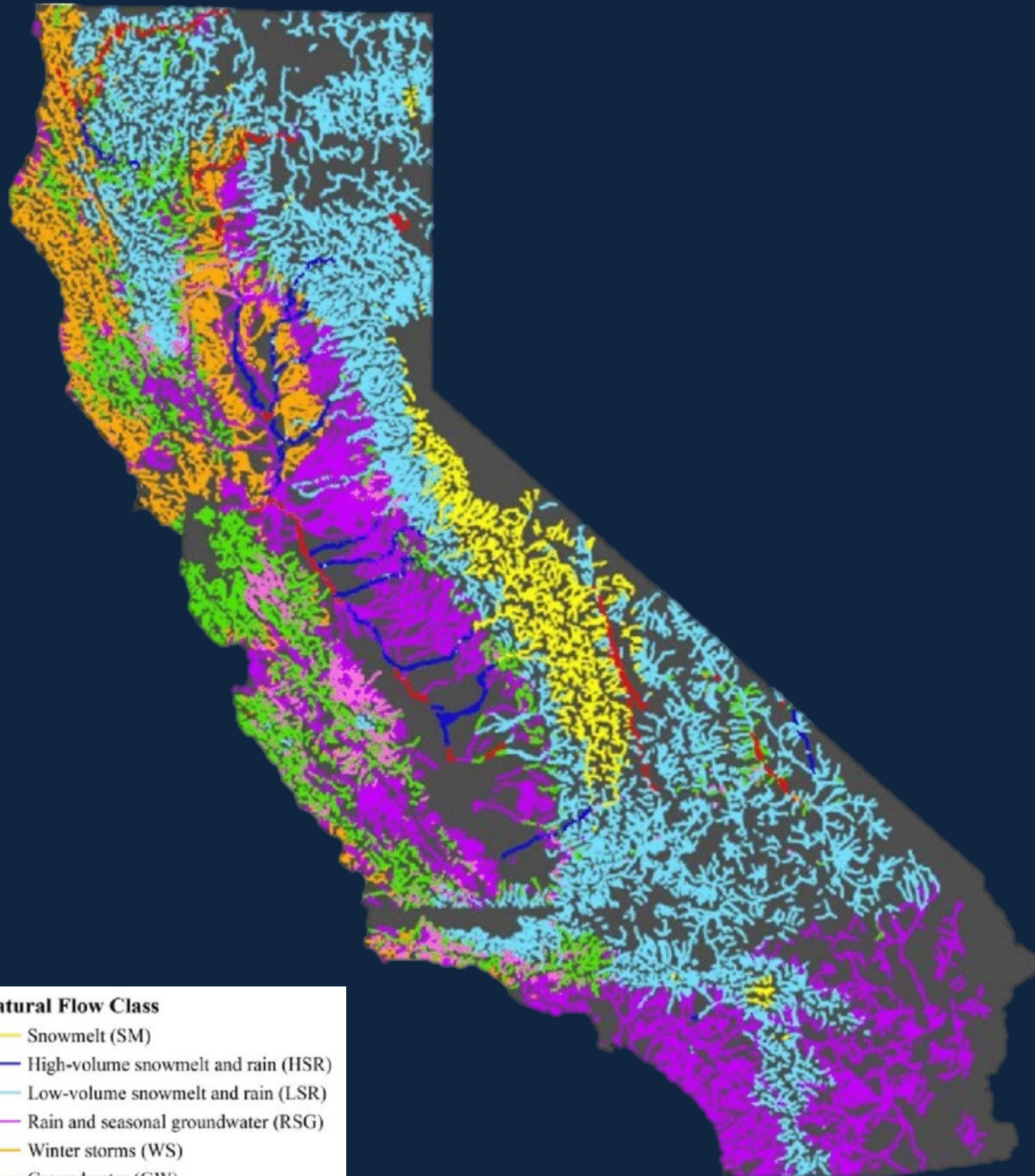
- less than 5 to 200 inches

## Hydrologic Regions

- 10 hydrologic regions defined by a natural water flows or drainage areas

## Surface Water

- Rivers, creeks, lakes, springs
- 8 natural streamflow classes defined by hydrology and geospatial data (Lane, 2017)



Natural Flow Class	
Yellow	Snowmelt (SM)
Blue	High-volume snowmelt and rain (HSR)
Cyan	Low-volume snowmelt and rain (LSR)
Magenta	Rain and seasonal groundwater (RSG)
Orange	Winter storms (WS)
Red	Groundwater (GW)
Green	Perennial groundwater and rain (PGR)
Purple	Flashy, ephemeral rain (FER)



# California Climate and Hydro Setting

## Groundwater

- Lake Me CA has 515 groundwater basins, covering 40% of CA landmass



# California Climate and Hydro Setting

## Groundwater

- Lake Me CA has 515 groundwater basins, covering 40% of CA landmass

## Main Water Use

- Environmental, Agricultural, and Urban Uses.





# California Climate and Hydro Setting

## Groundwater

- Lake Me CA has 515 groundwater basins, covering 40% of CA landmass

## Main Water Use

- Environmental, Agricultural, and Urban Uses.

## Main Commodities

- Grapes, Strawberries, Nuts, Dairy, Hay, Row Crops, Tomatoes, Carrots, Cattle





# California Climate and Hydro Setting

## Groundwater

- Lake Me CA has 515 groundwater basins, covering 40% of CA landmass

## Main Water Use

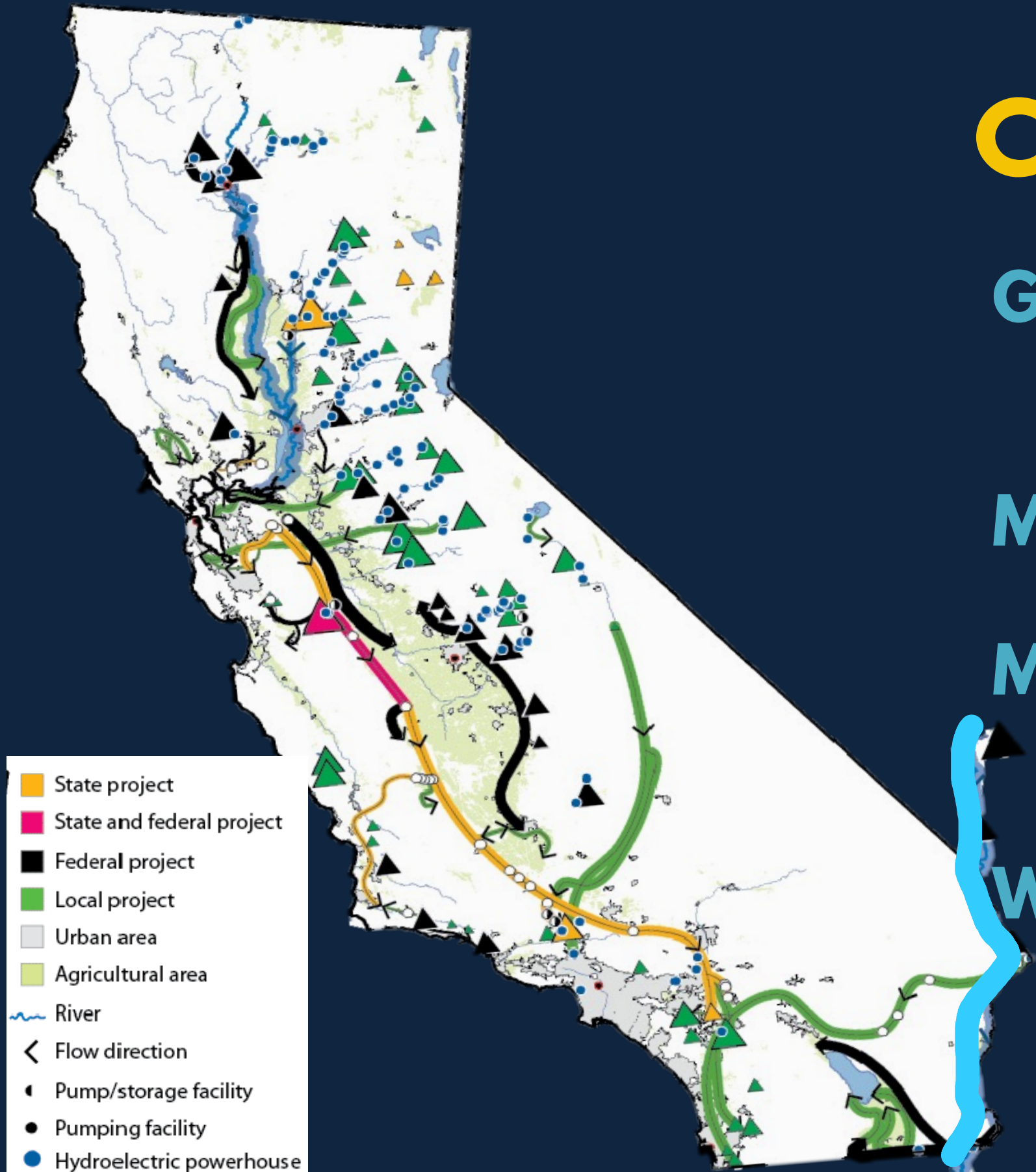
- Environmental, Agricultural, and Urban Uses.

## Main Commodities

- Grapes, Strawberries, Nuts, Dairy, Hay, Row Crops, Tomatoes, Carrots, Cattle

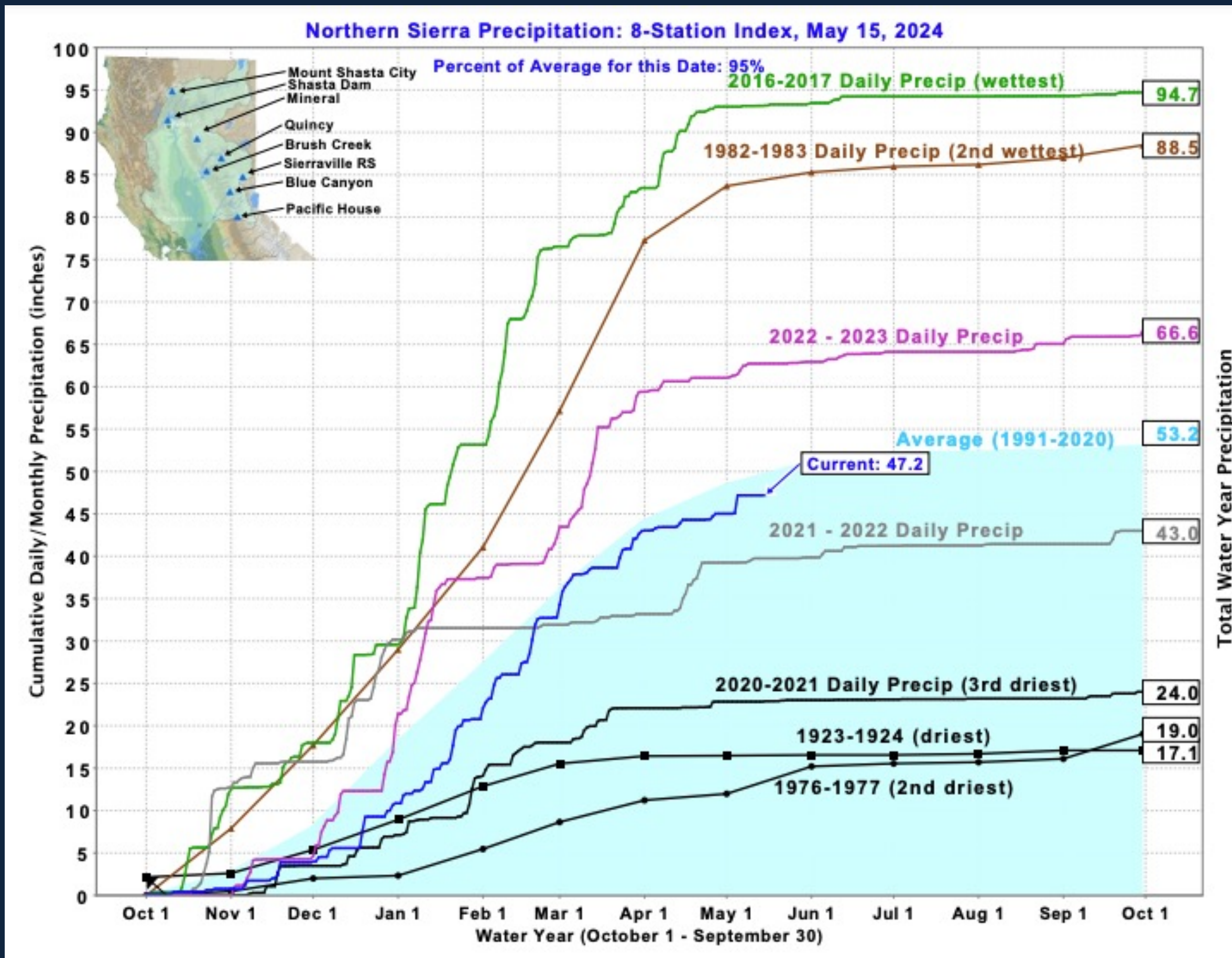
## Water System

- State, Federal, and Local projects (dams, reservoirs, power plants, pumping plants and aqueducts)





# Rainfall index



← Wettest Year

← Average Year

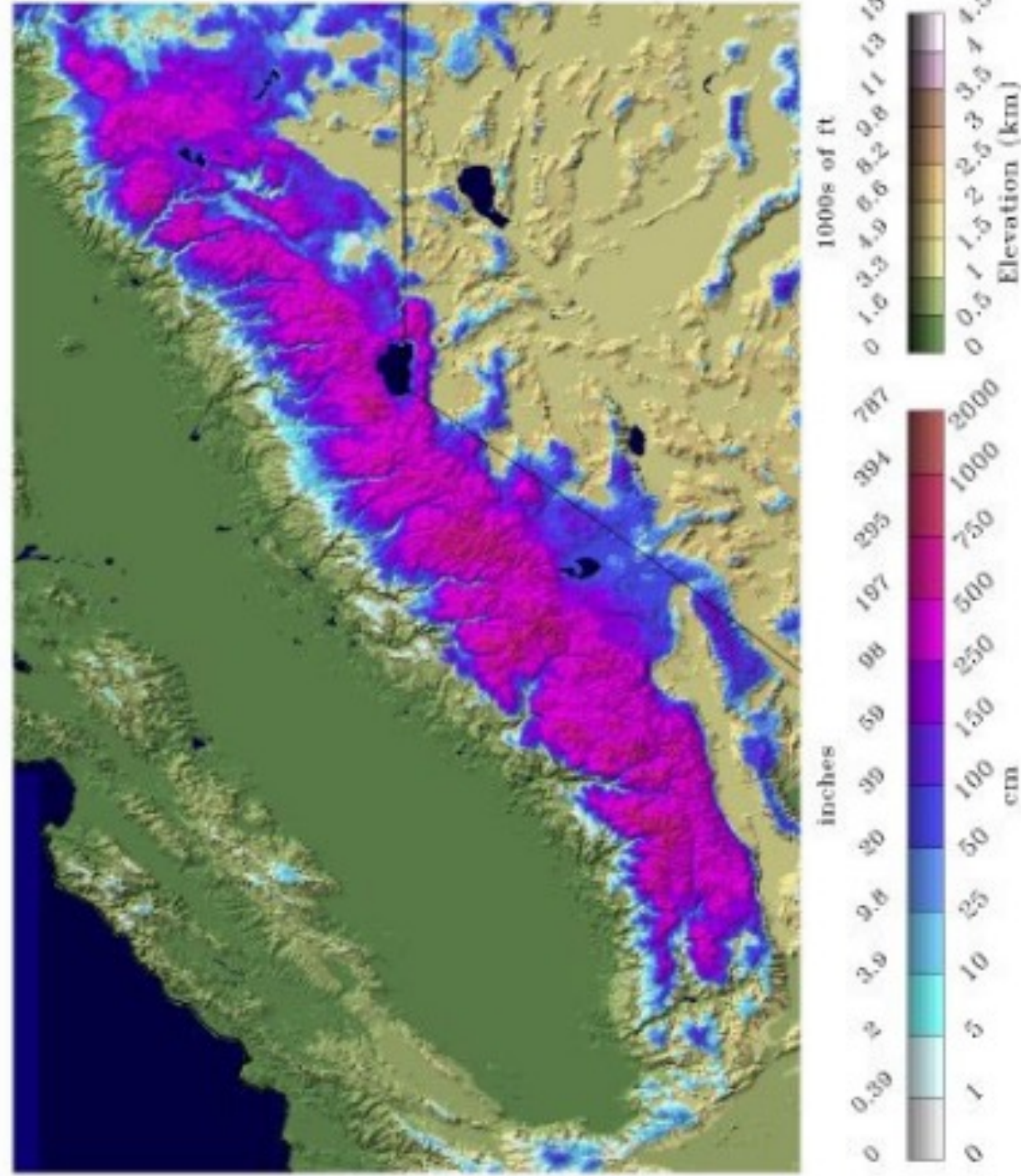
← Driest Year



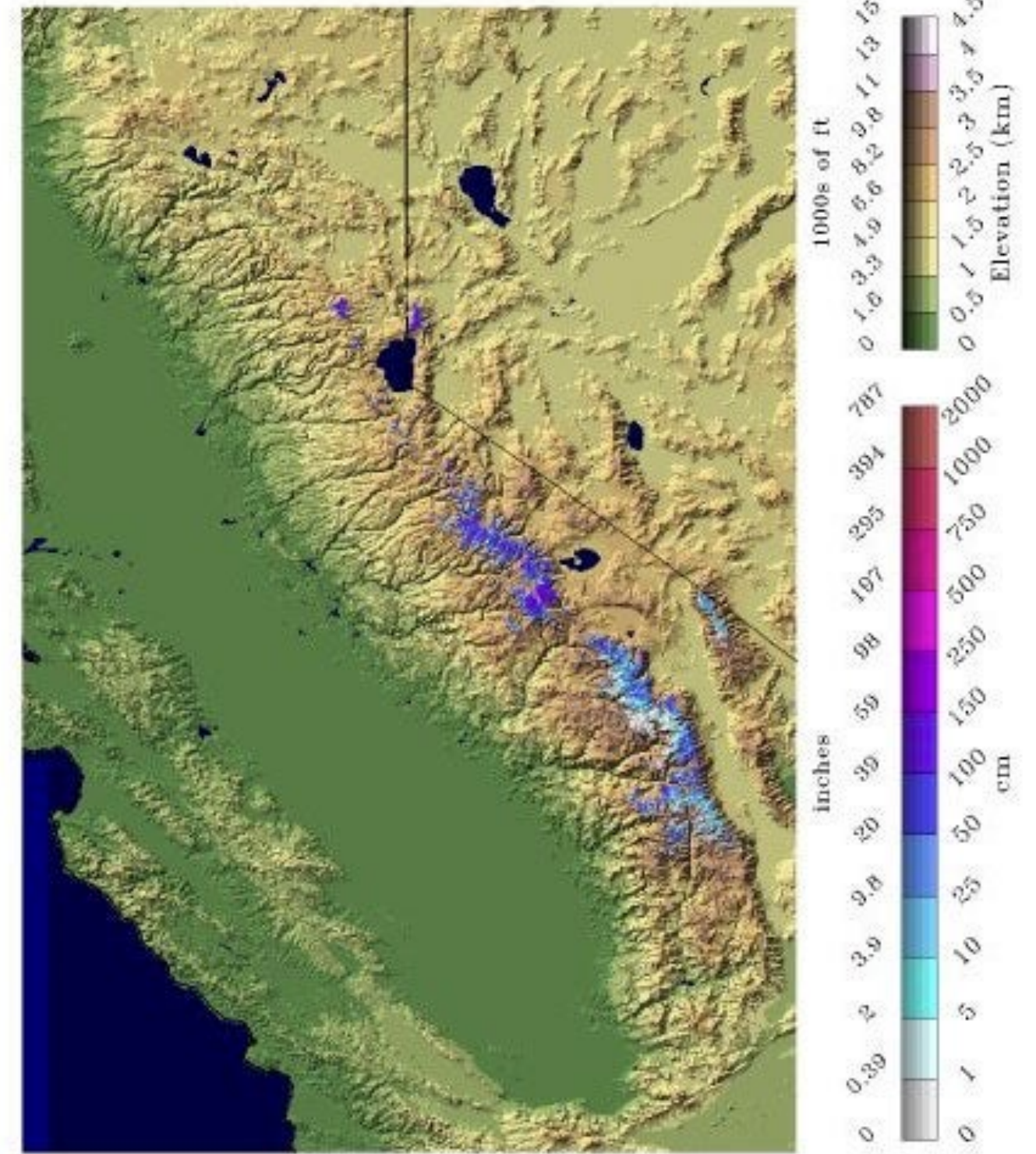
# Snow

- Wet 2011
- Drought { Dry 2012
- Dry 2013
- Dry 2014
- Dry 2015
- Dry 2016
- Wettest 2017
- Dry 2018
- Wet 2019
- Dry 2020
- Dry 2021
- Dry 2022
- Wet 2023

## Snow Depth 2023



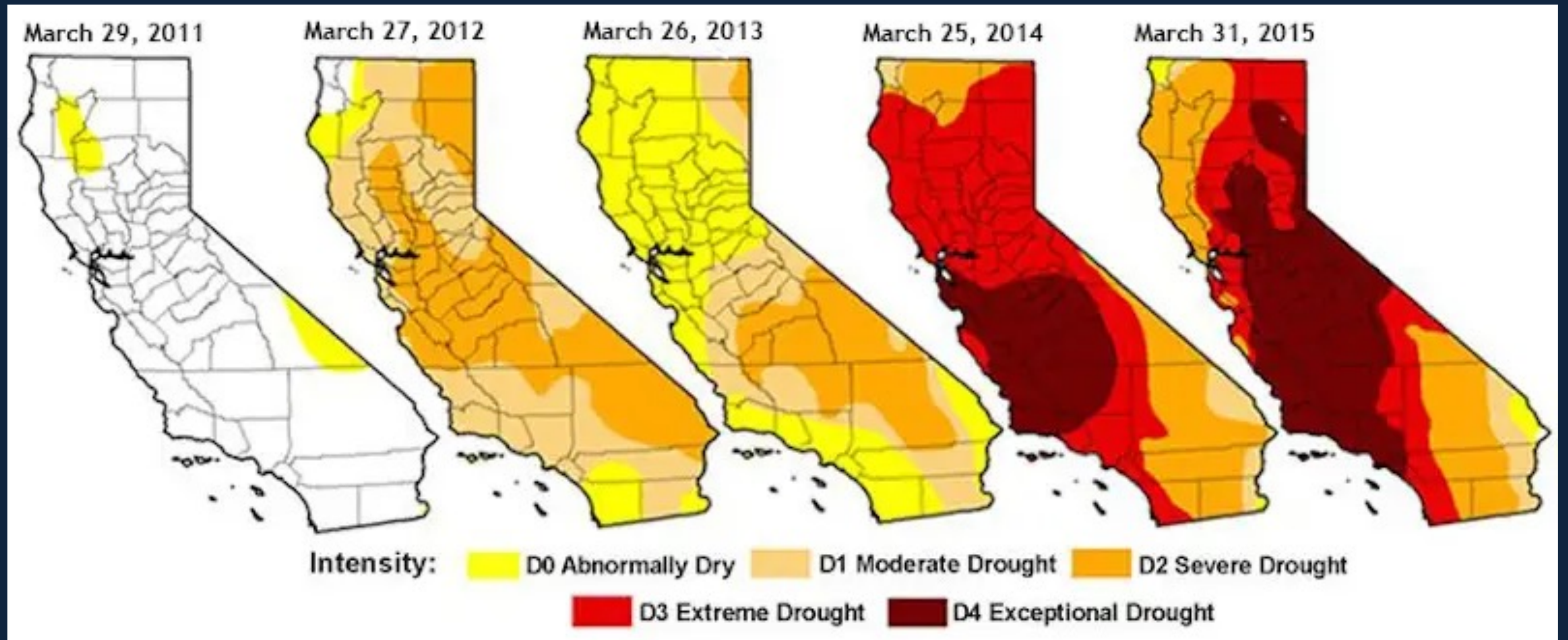
## Snow Depth 2015





# Drought Monitor

**Wet** 2011  
**Drought** { **Dry** 2012  
**Dry** 2013  
**Dry** 2014  
**Dry** 2015  
**Dry** 2016  
**Wettest** 2017  
**Dry** 2018  
**Wet** 2019  
**Dry** 2020  
**Dry** 2021  
**Dry** 2022  
**Wet** 2023

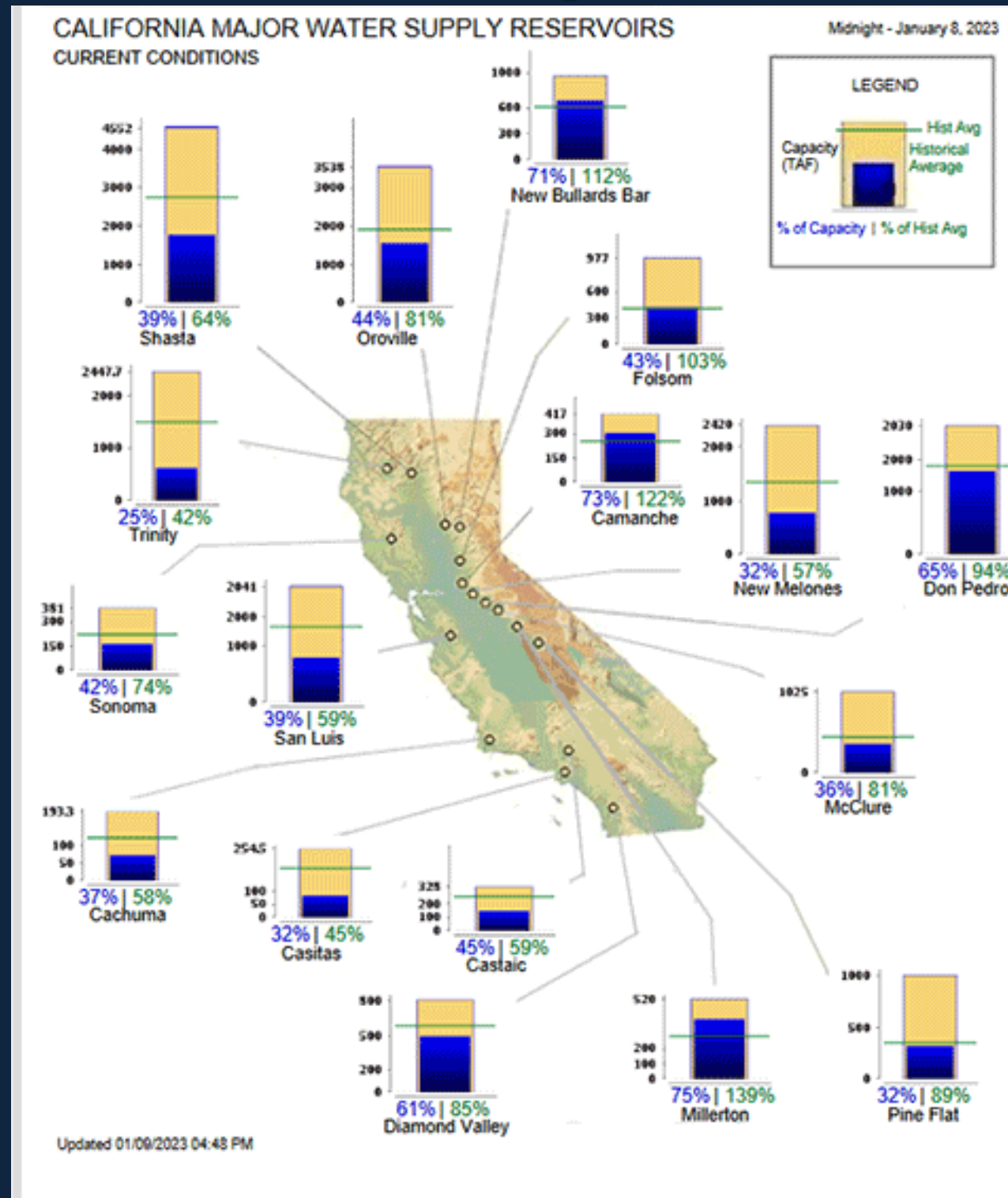




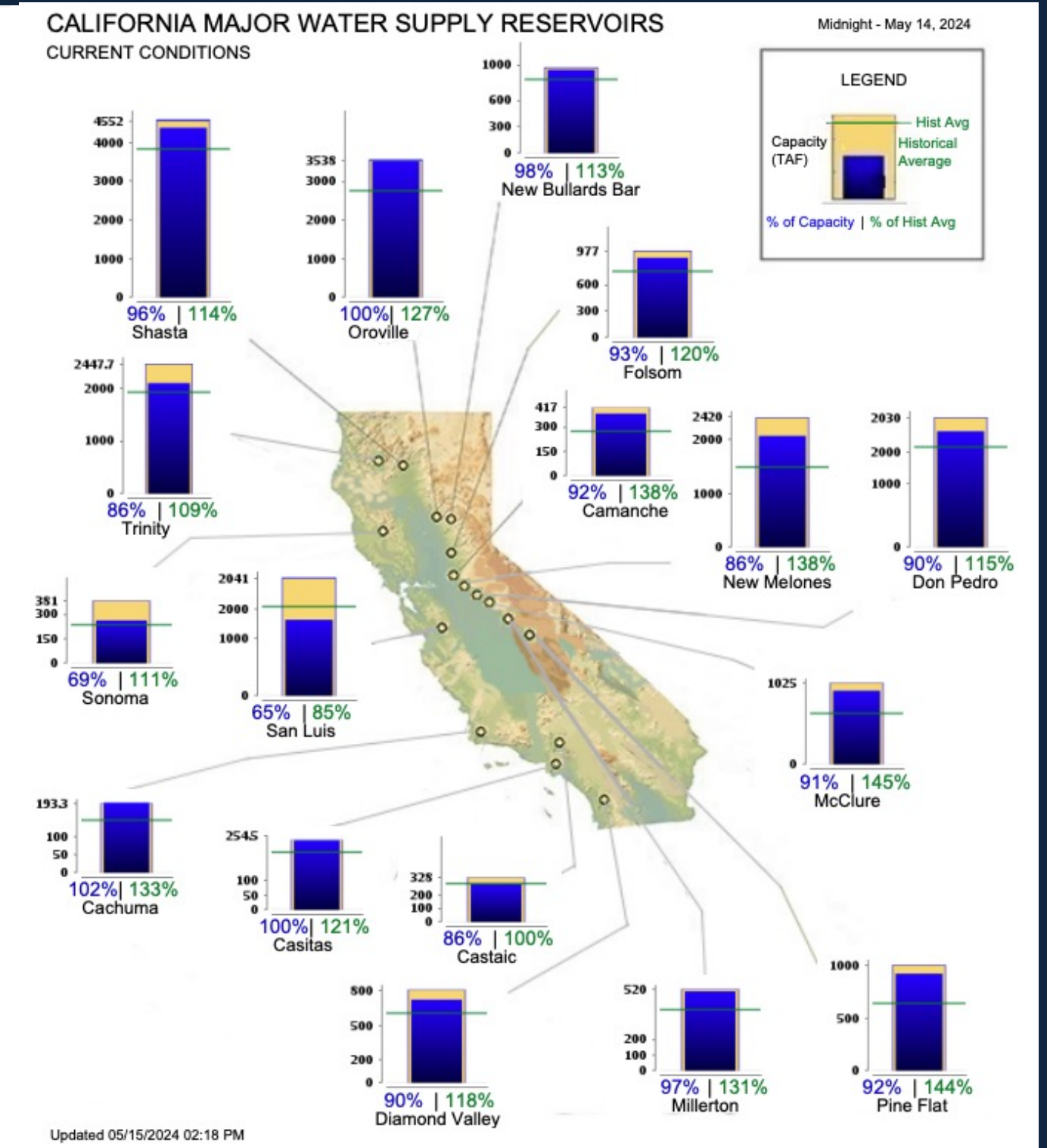
# Reservoir levels

**Wet** 2011  
**Dry** 2012  
**Dry** 2013  
**Dry** 2014  
**Dry** 2015  
**Dry** 2016  
**Wettest** 2017  
**Dry** 2018  
**Wet** 2019  
**Dry** 2020  
**Dry** 2021  
**Dry** 2022  
**Wet** 2023

## January 2023



## May 2024



# California has abundant surface and groundwater resources

## Water Pressures and Challenges



WATER  
QUANTITY  
and  
WATER  
QUALITY



CLIMATE  
CHANGE



# Agenda

1

## California Water Setting

- Climate and Hydrology
- Water Challenges and Pressures
- Water monitoring indices

2

## North Coast Case Study

- Water strategies to balance agriculture and biodiversity needs

# What are we doing in California to balance water resources

Urban and Domestic Water Supply



Agriculture



Fish and Biodiversity

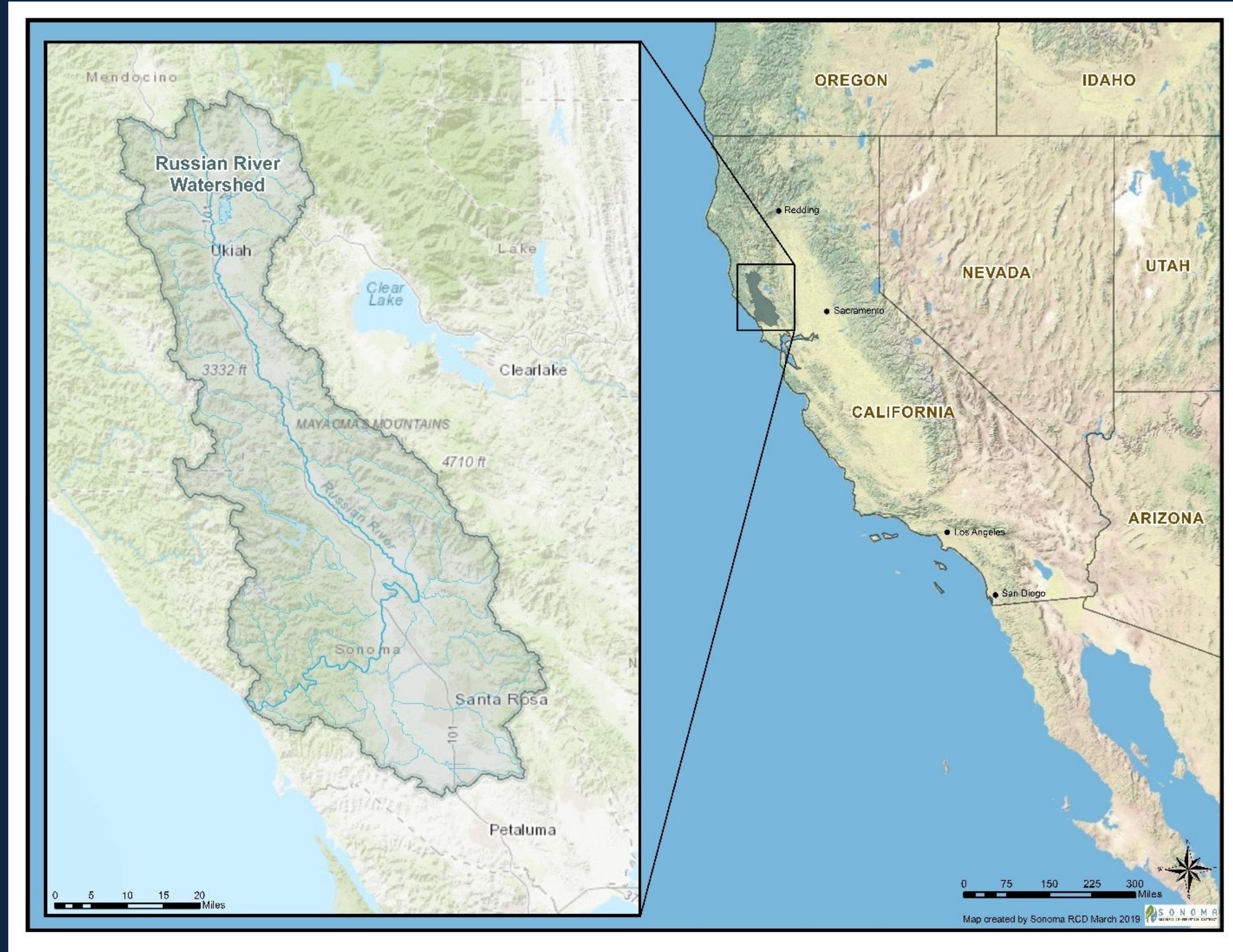


Climate Change





# A story from the North Coast...





# A story from the North Coast...

In **spring of 2008** the upper Russian River watershed faced an unprecedented challenge – a freezing situation that would test the resilience of Mendocino.



20 nights of frost protection  
required for vineyards and orchards

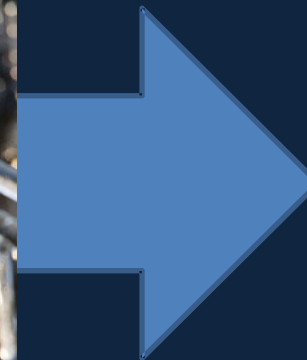


# A story from the North Coast...

In spring of 2008 the upper Russian River watershed faced an unprecedented challenge – a freezing situation that would test the resilience of Mendocino.



20 nights of frost protection  
required for vineyards and orchards

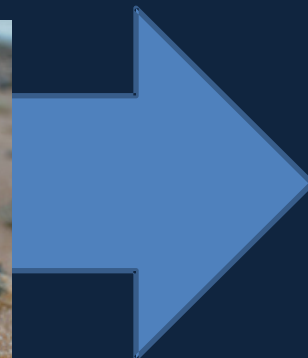
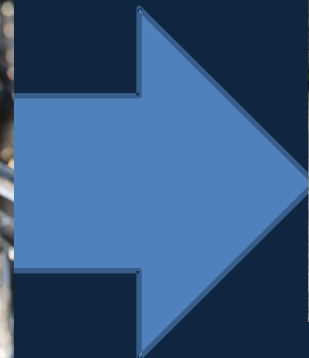


Decrease of streamflow to 85 cfs  
from the usual 200-600 cf.  
stranding of endangered species



# A story from the North Coast...

In spring of 2008 the upper Russian River watershed faced an unprecedented challenge – a freezing situation that would test the resilience of Mendocino.



**NOAA  
FISHERIES**



20 nights of frost protection required for vineyards and orchards

Decrease of streamflow to 85 cfs from the usual 200-600 cf. stranding of endangered species

Moratorium in the use of water for frost protection. Representing in millions of dollar losses for Ag.



# A story from the North...

In spring of 2008 the upper...  
faced an unpre...  
that would t...



20 nights of frost protection  
required for vineyards and orchards



Decrease of streamflow to 85 cfs  
from the usual 200-600 cf.  
stranding of endangered species



Moratorium in the use of water for  
frost protection. Representing in  
millions of dollar losses for Ag.





# Strategies



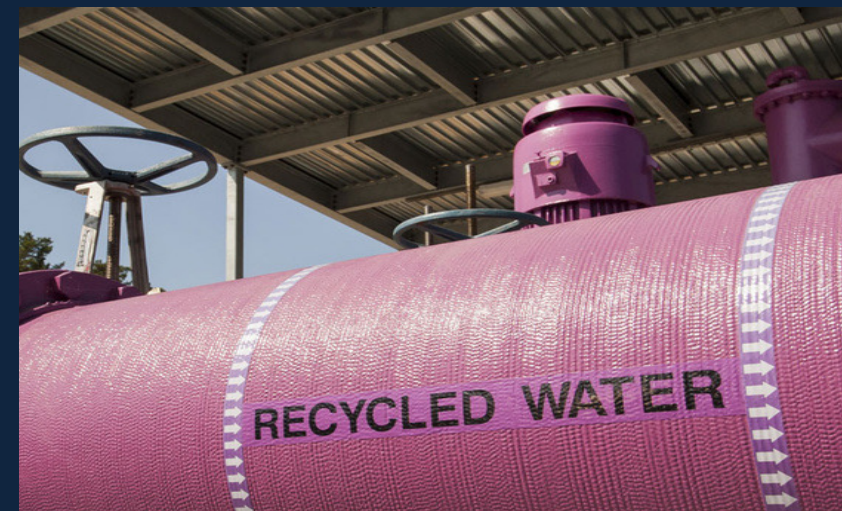
**Weather and Streamflow stations  
for improved frost forecasting**



**Off-stream ponds to be  
used during dry season**



**Creation of stakeholder groups**



**Use of recycled water**



# Additional Strategies



Weather and Streamflow stations for improved frost forecasting



Off-stream ponds to be used during dry season



Creation of stakeholder groups



Use of recycled water



Ukiah Valley Basin  
Groundwater Sustainability Agency

The UVBGSA is a public agency formed to sustainably manage groundwater to comply to the Sustainable Groundwater Management Act (SGMA)



# Additional Strategies



Weather and Streamflow stations for improved frost forecasting



Off-stream ponds to be used during dry season



The UVBGSA is a public agency formed to sustainably manage groundwater to comply to the Sustainable Groundwater Management Act (SGMA)



Creation of stakeholder groups



Use of recycled water



Best practices for efficient irrigation and water quality



# Agenda

1

## California Water Setting

- Climate and Hydrology
- Water Challenges and Pressures
- Water monitoring indices

2

## North Coast Case Study

- Water strategies to balance agriculture and biodiversity needs

3

## Water Strategy for irrigation systems

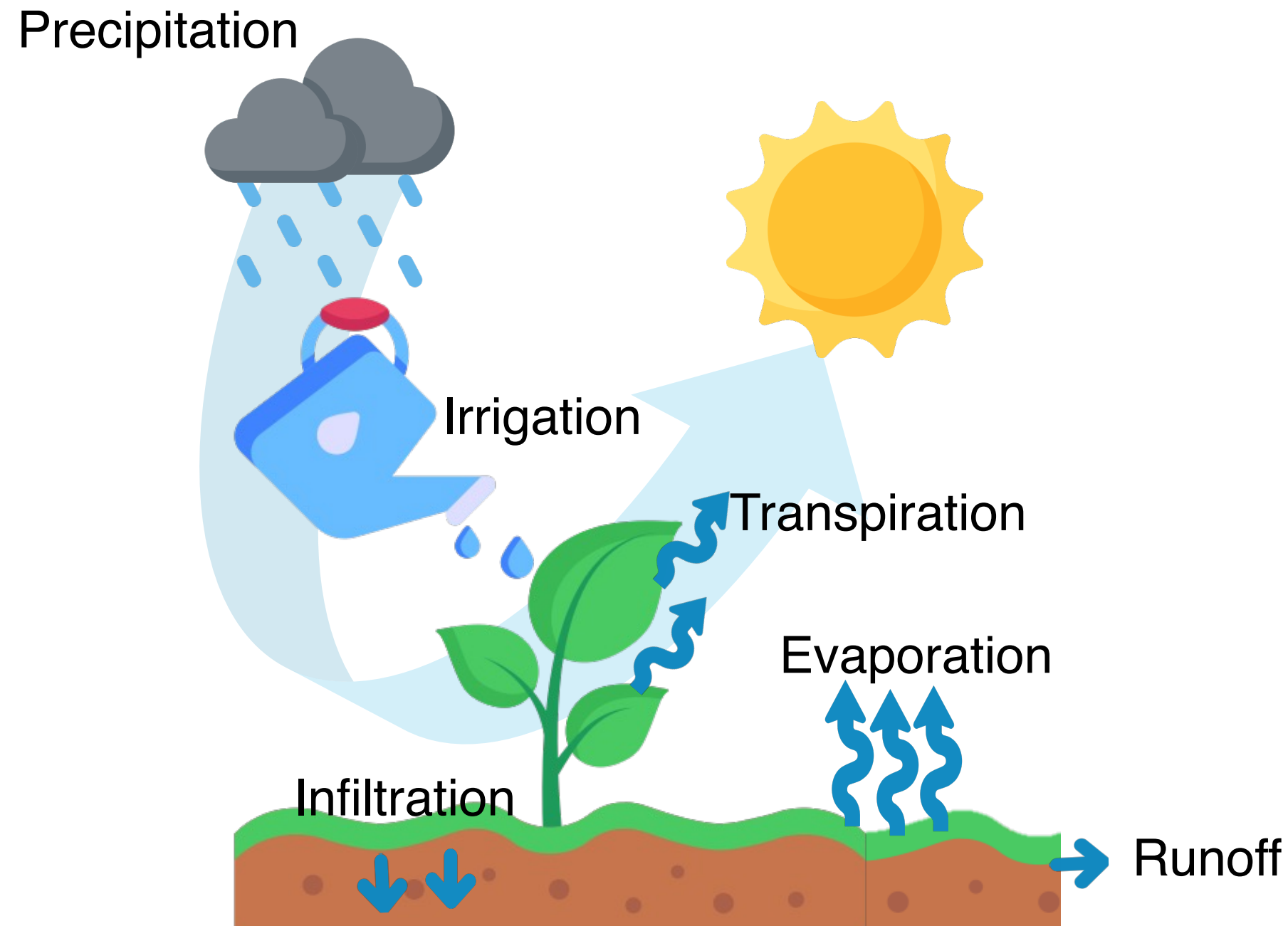
- Water Budget
- Irrigation efficiency methods
- Best practices for improving Water conservation and quality

# Water Strategy for irrigation and water quality





# WATER BUDGET

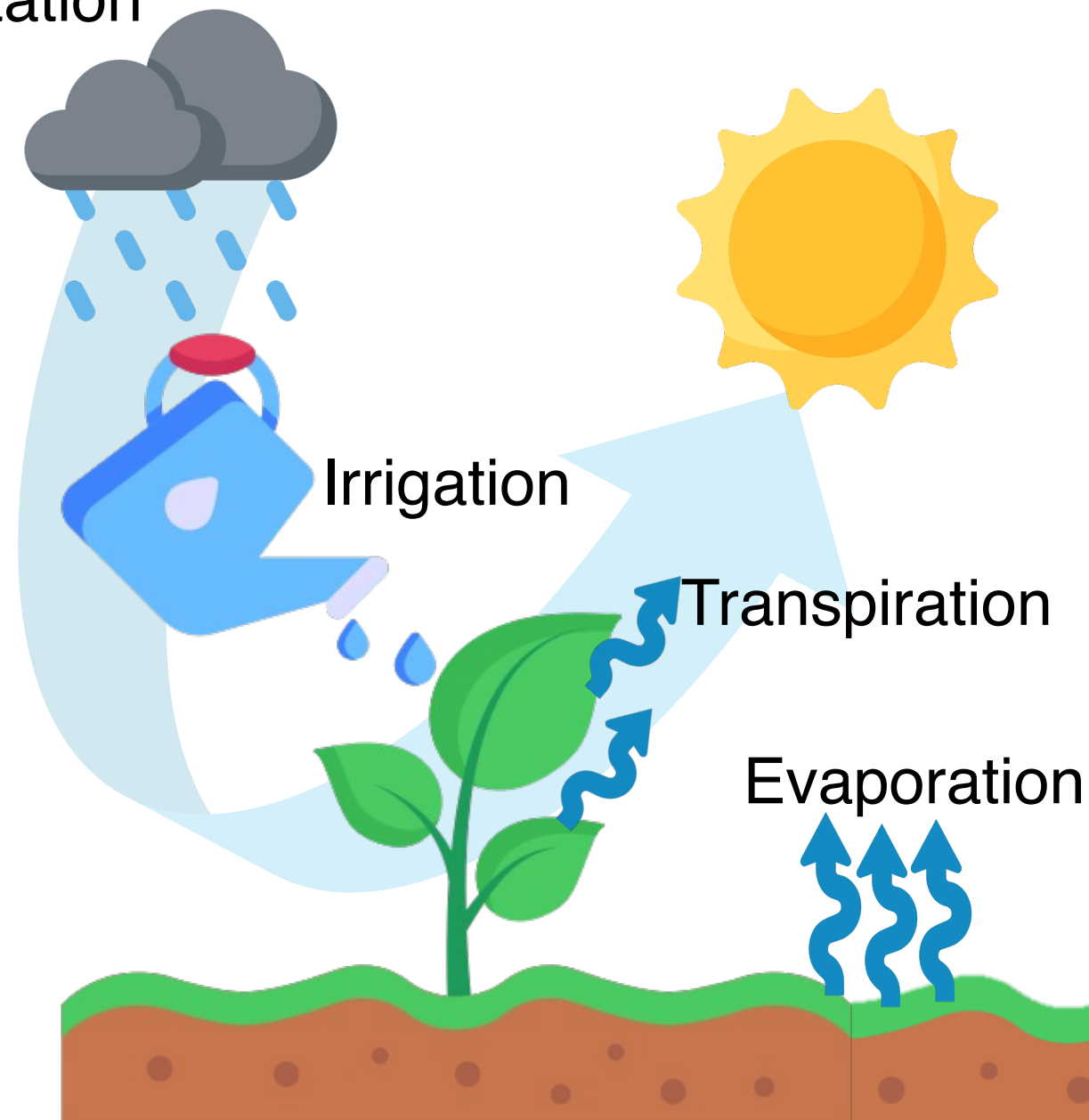


The water budget is a way to measure how much water enters and leaves an area.

# WATER BUDGET

## Irrigation

Precipitation



## Evapotranspiration (ET)

Loss of water through  
Evaporation + Transpiration

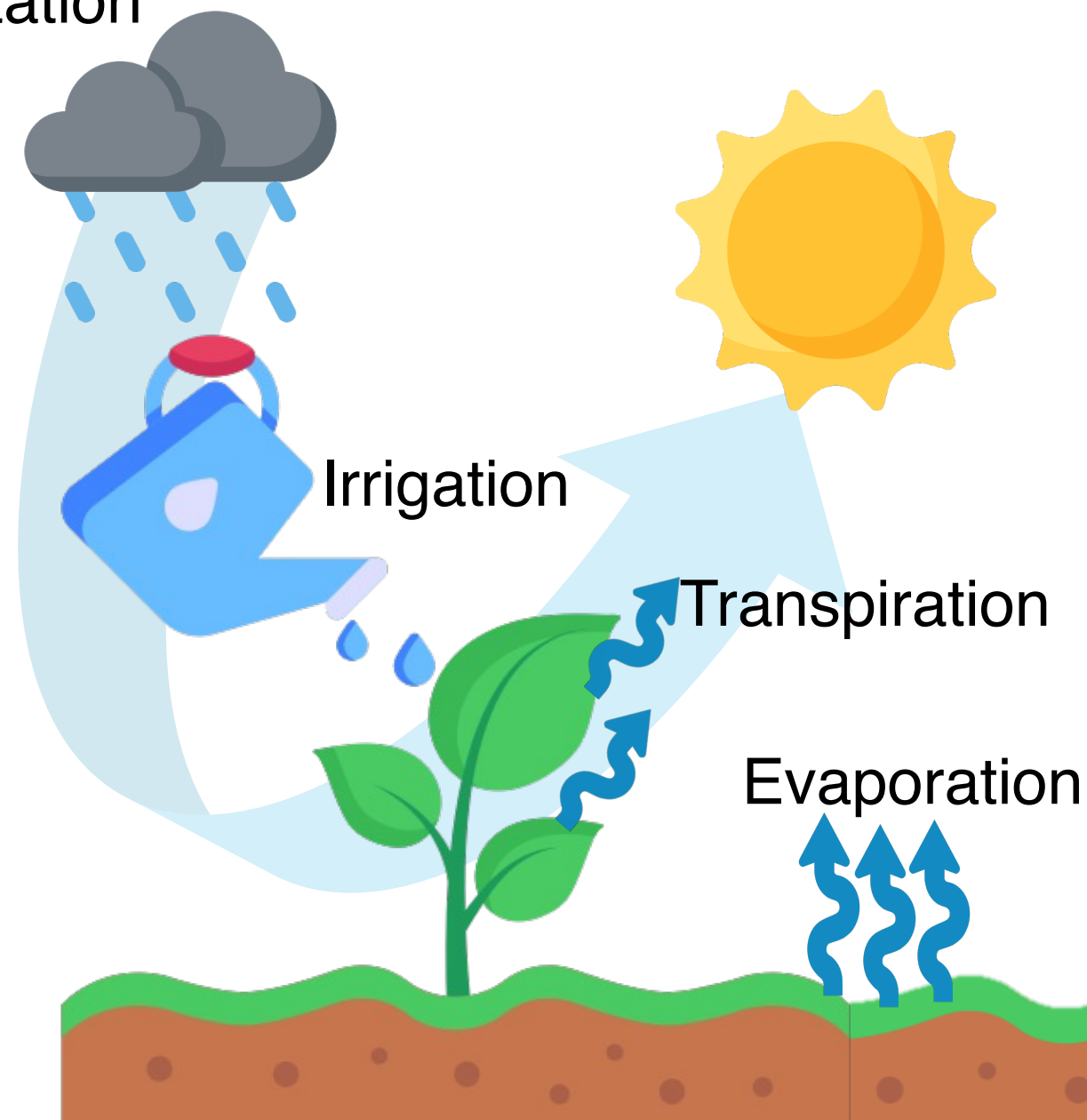




# WATER BUDGET

## Irrigation

Precipitation



## Factors Affecting Evapotranspiration (ET)

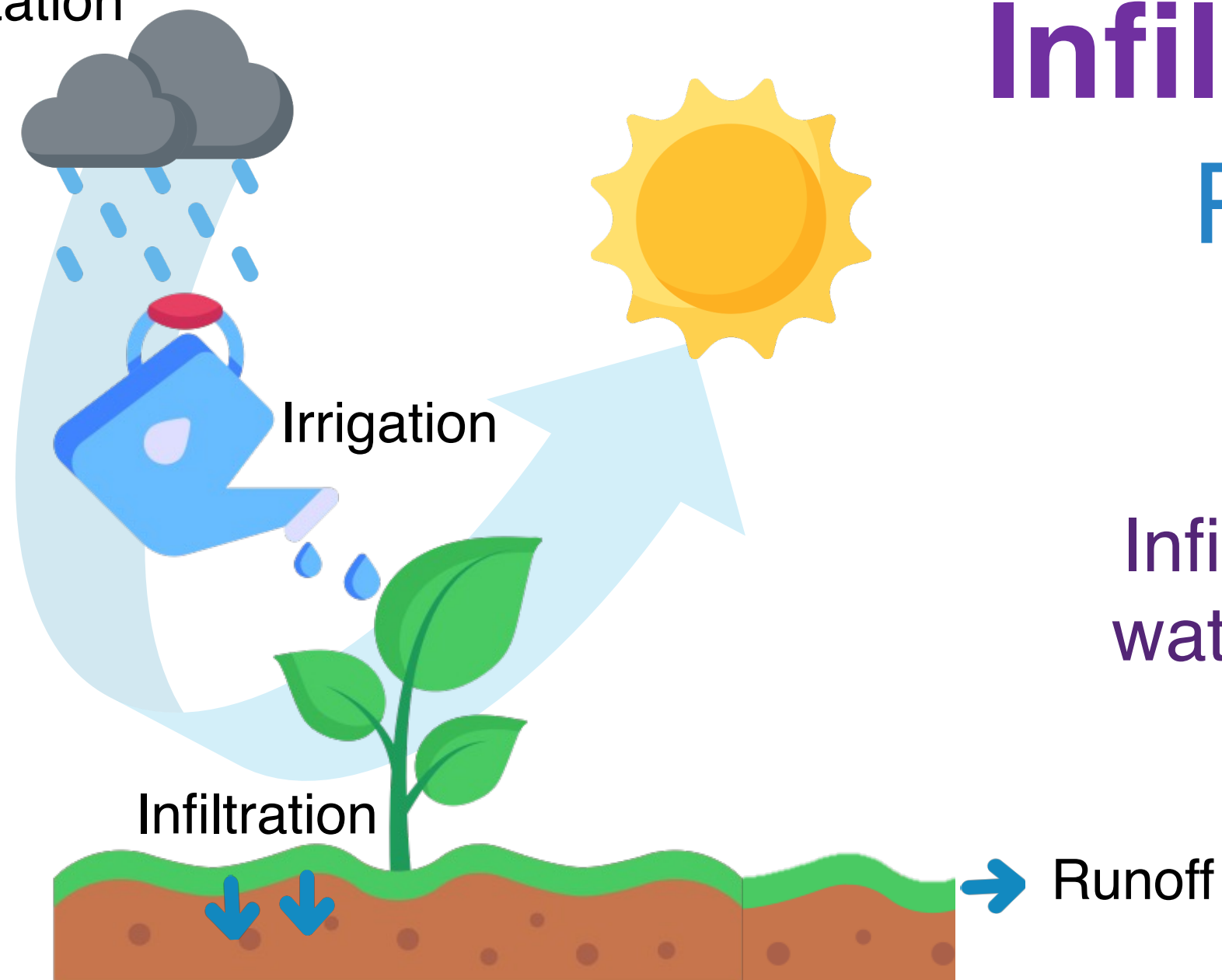
- Temperature
- Wind
- Soil Moisture
- Solar Radiation
- Region / Altitude

**ET = Crop water needs**

# WATER BUDGET

## Water Quality

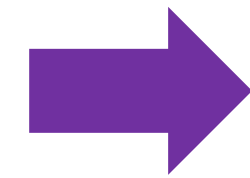
Precipitation



## Infiltration and Runoff Pollutant Transport



Infiltrate in  
water table



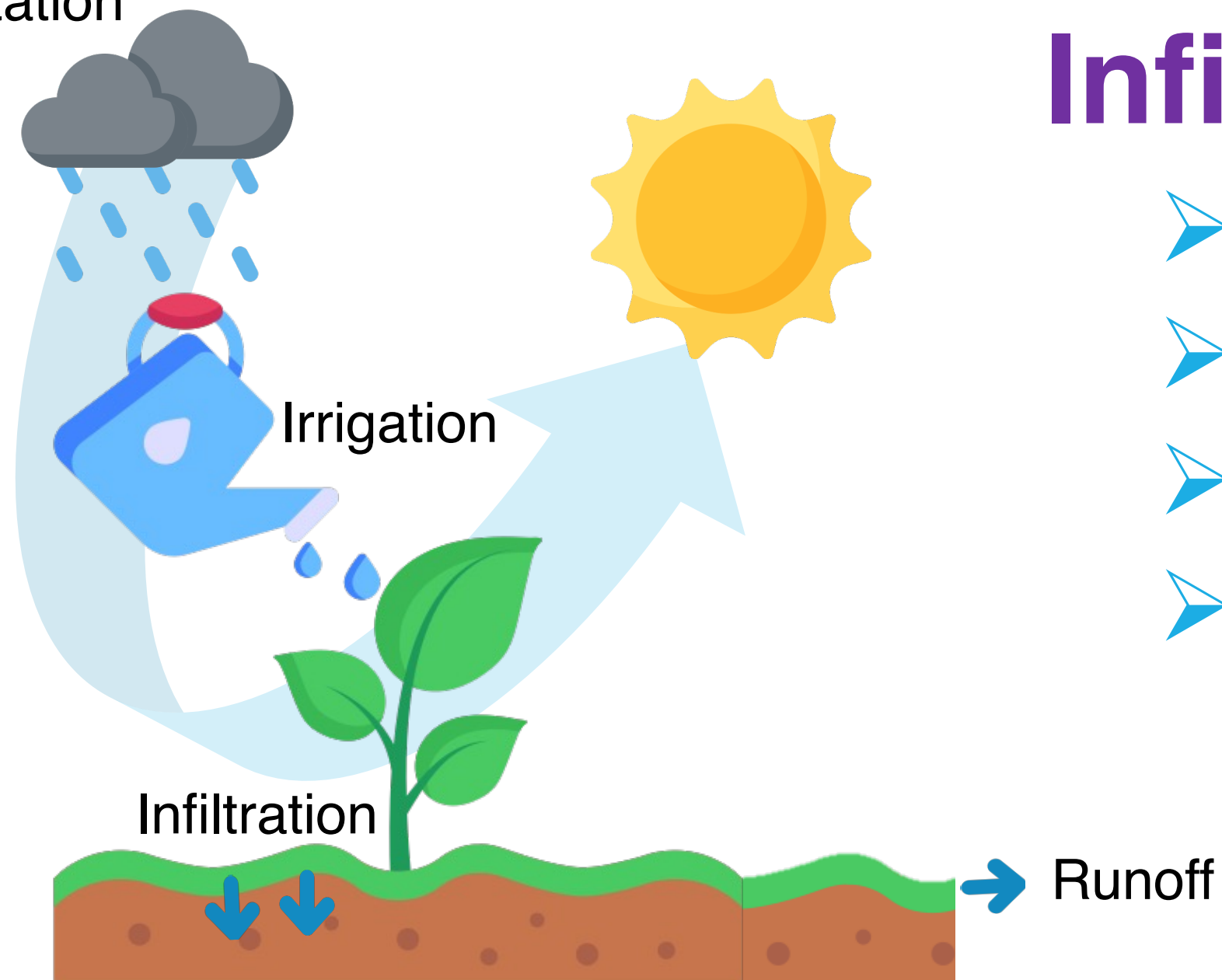
Runoff to streams,  
lakes, ocean



# WATER BUDGET

## Water Quality

Precipitation

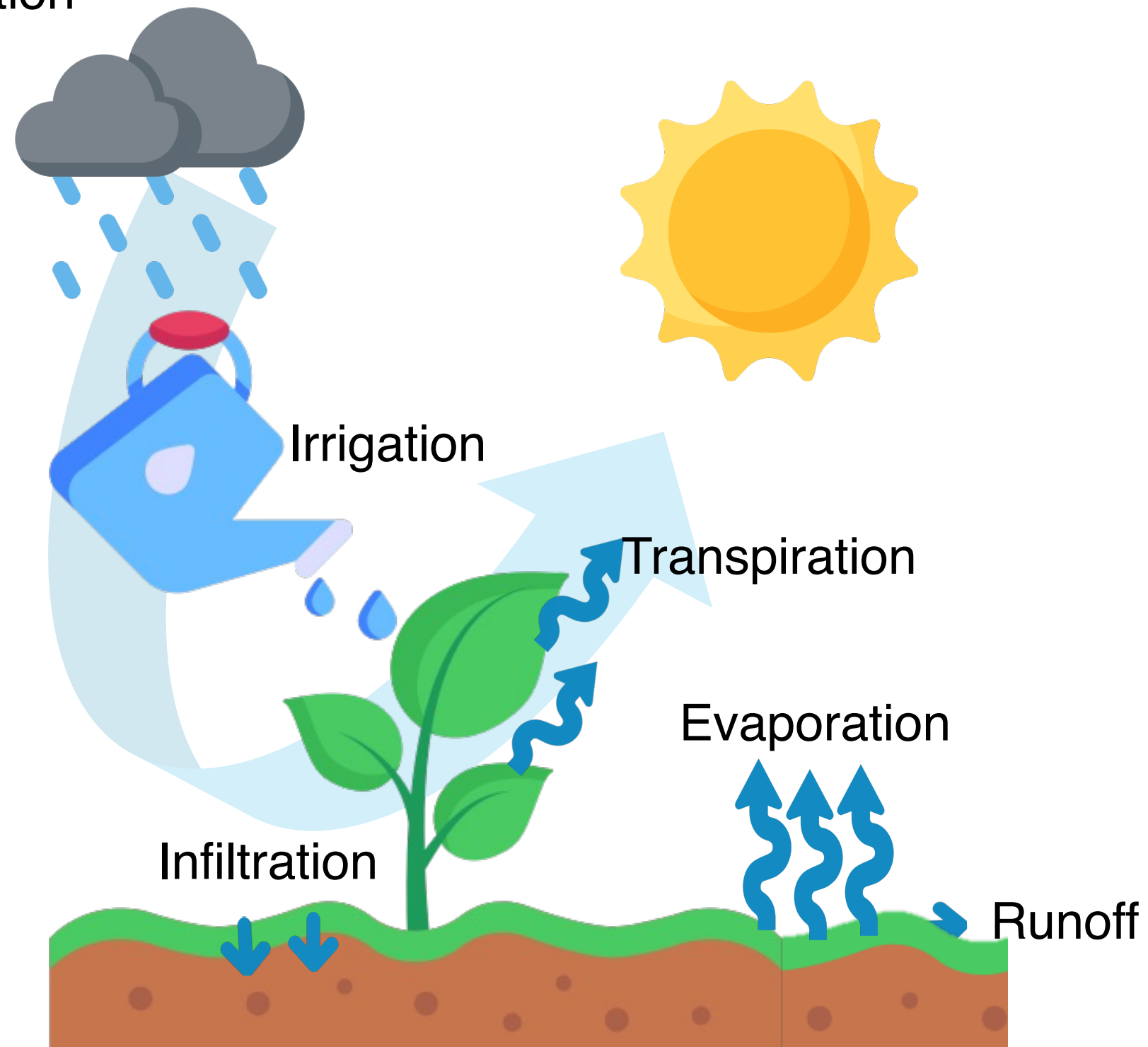


## Factors Affecting Infiltration and Runoff

- Slope
- Permeability
- Saturation of soil
- Vegetation cover

# WATER BUDGET

Precipitation





# BEST PRACTICES FOR IRRIGATION AND WATER QUALITY



Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance

# IRRIGATION EFFICIENCY

Volume of water applied to the crop compared to the volume of water required by the crop for its irrigation requirement.



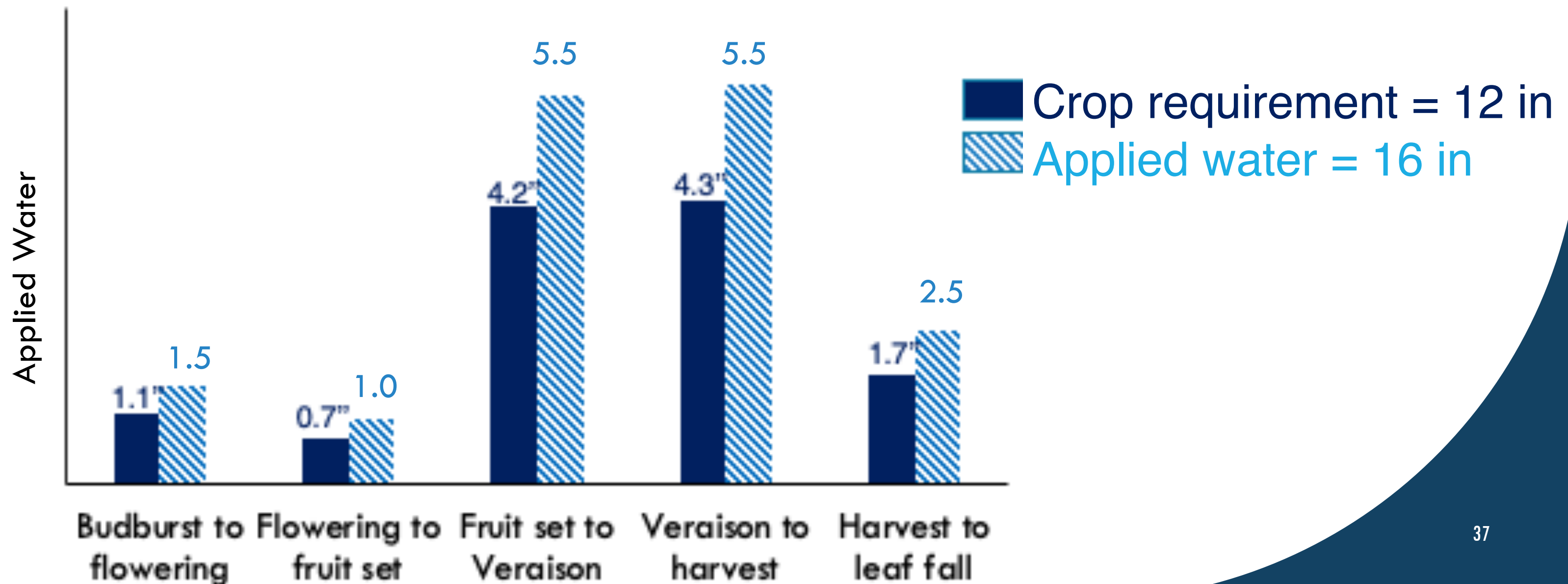
Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# IRRIGATION EFFICIENCY



Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# IRRIGATION EFFICIENCY

How efficient was  
our irrigation  
application?





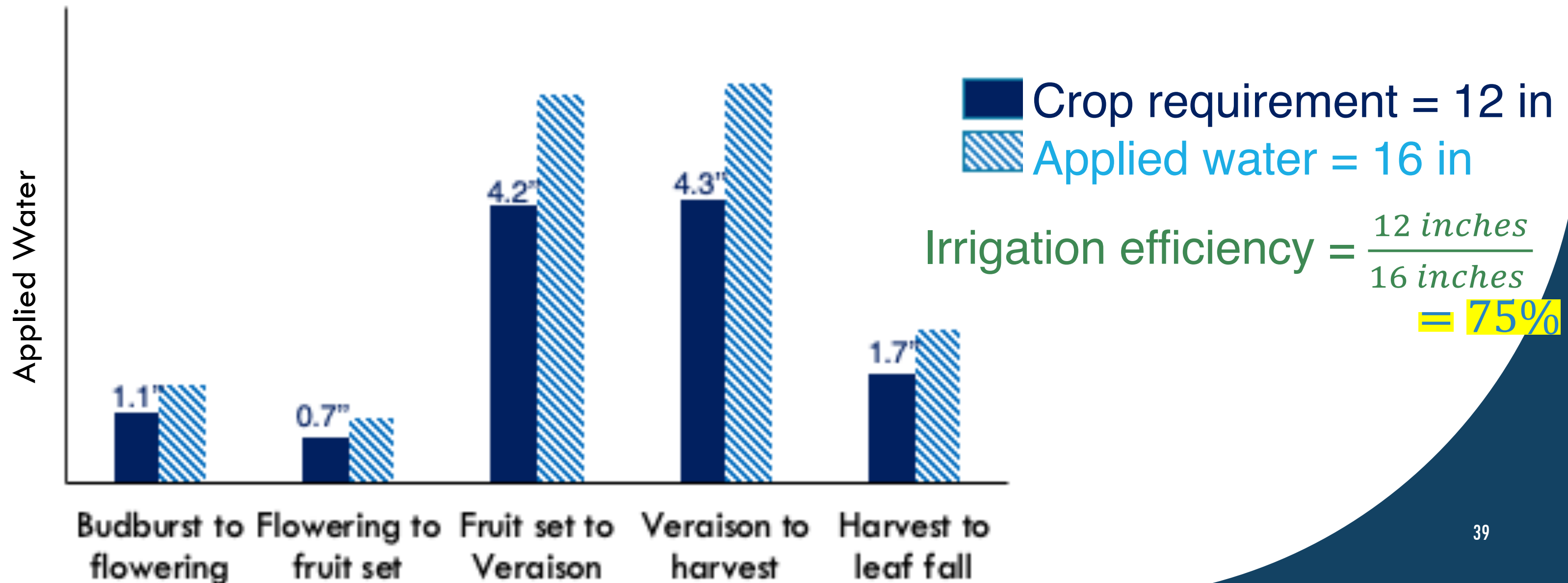
Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# IRRIGATION EFFICIENCY



Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# IRRIGATION EFFICIENCY

Can we improve our irrigation efficiency?



■ Crop requirement = 12 in  
▨ Applied water = 16 in  
Irrigation efficiency =  $\frac{12 \text{ inches}}{16 \text{ inches}} = 75\%$



Efficient  
Practices

Irrigation  
System Design

Irrigation  
Scheduling

Monitoring and  
Maintenance

# Irrigation Systems



## Surface

Application efficiency: 50 – 75%



## Sprinklers

Application efficiency: 70 – 90%



## Microirrigation

Application efficiency: 85 – 95%

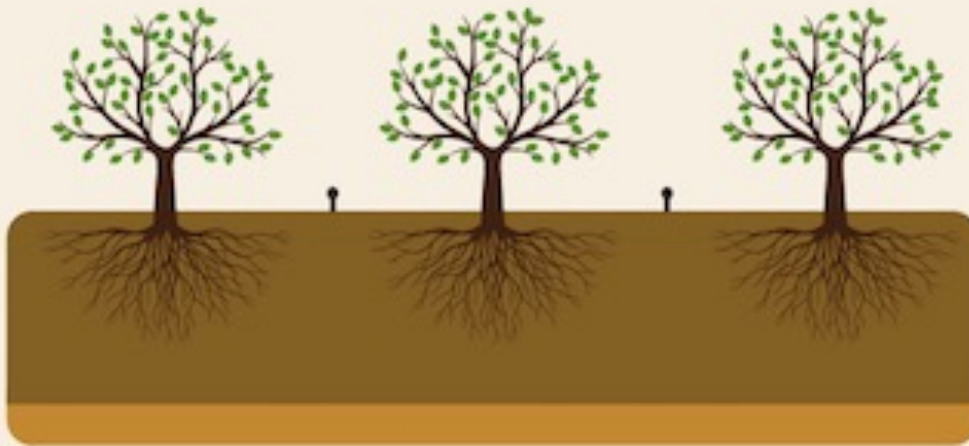
### Factors to think about:

- natural conditions
- type of crop
- type of technology
- previous experience
- required labor inputs
- costs and benefits.

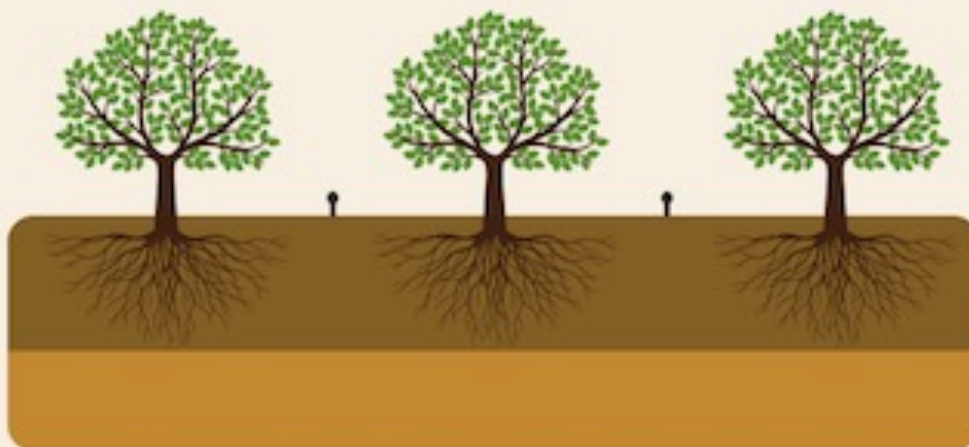
## Irrigation Efficiency vs. Distribution Uniformity



Poor DU & Poor IE



Good DU, Poor IE



Good DU, Good IE

Efficient  
Irrigation  
Practices

Irrigation  
System Design

Irrigation  
Scheduling

Monitoring and  
Maintenance

# Distribution Uniformity

**Distribution Uniformity (DU)** measures how well irrigation water and fertigation is distributed to different areas in the field.

## How to achieve good DU and good IE

- Monitor drip emitter flow rates
- Check pressure at the pump and drip hoses
- Replace plugged emitters or damaged hoses.
- Evaluate DU every 3 to 5 years



Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance

# Irrigation Scheduling

Irrigation scheduling involves planning when and how much water to apply

Efficient  
Irrigation  
Practices

Irrigation  
System Design

Irrigation  
Scheduling

Monitoring and  
Maintenance

# Irrigation Scheduling

Irrigation scheduling involves planning when and how much water to apply

Soil-based



Weather ET-based





Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance

# Irrigation Scheduling

## Weather ET-based



## Crop water Needs

$$ET_{\text{crop}} = ET_{\text{ref}} \times K_{\text{crop}}$$



Evapotranspiration  
of my crop = is my  
crop water needs

Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Irrigation Scheduling

## Weather ET-based

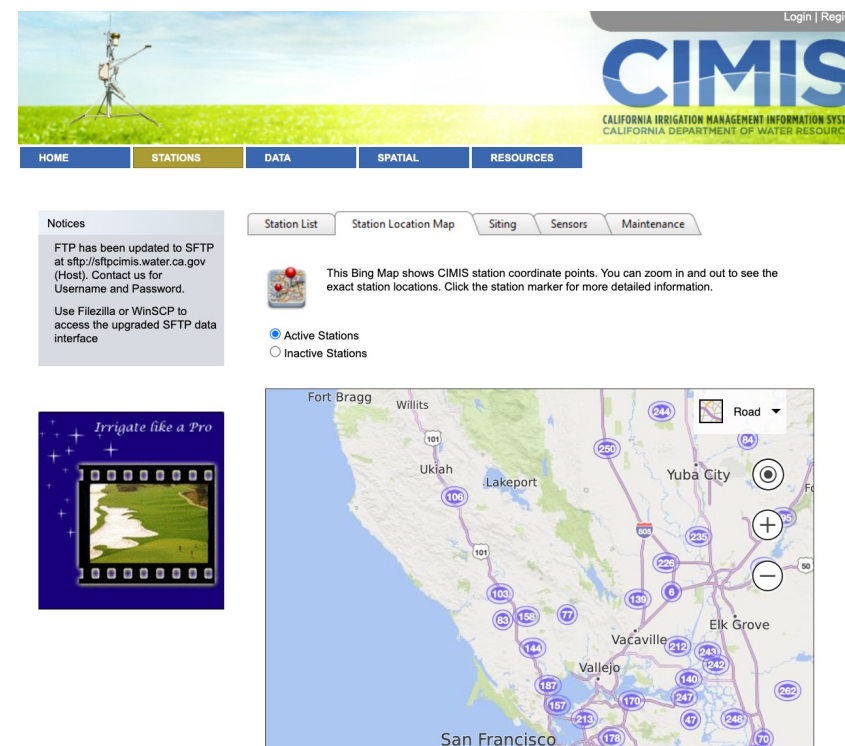


## Crop water Needs

$$ET_{crop} = ET_{ref} \times K_{crop}$$



Reference ET is the water needs of grass





Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Irrigation Scheduling

## Weather ET-based

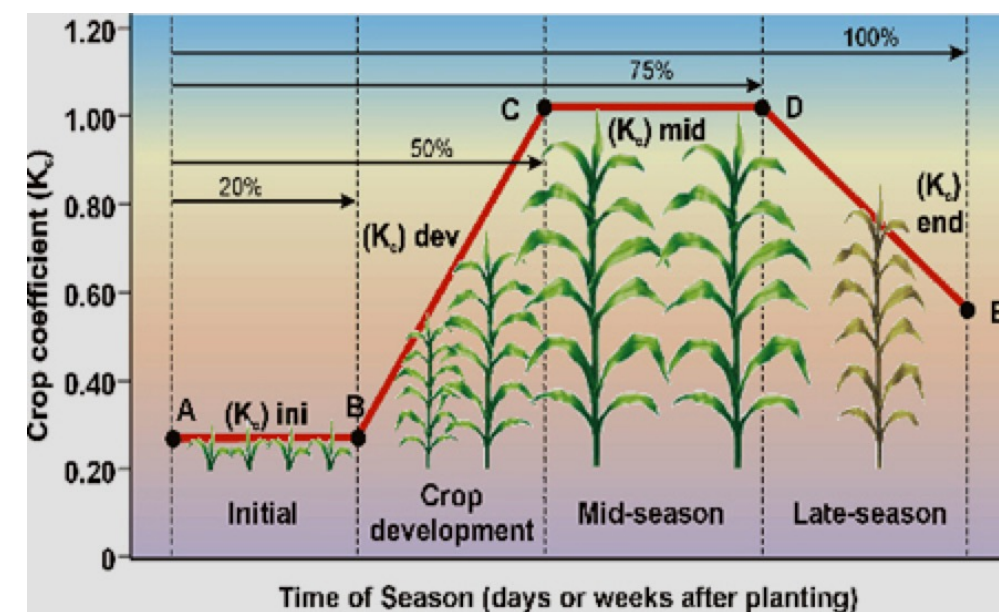


## Crop water Needs

$$ET_{crop} = ET_{ref} \times K_{crop}$$



Kc is the crop coefficient. It represents the integrated changes in plant development



Date	K <sub>c</sub> (W. Gape)
Mar 16-31	0.32
Apr 1-15	0.41
Apr 16-30	0.50
May 1-15	0.59
May 16-31	0.69
June 1-15	0.78
Jun 16-31	0.82
July 1-15	0.82
July 16-31	0.82
Aug 1-15	0.82
Aug 16-31	0.77
Sep 1-15	0.66
Sep 16-30	0.55
Oct 1-15	0.44

Crop Coefficient Values of Wine Grapes  
(UC Cooperative Extension)



Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Irrigation Scheduling Tools

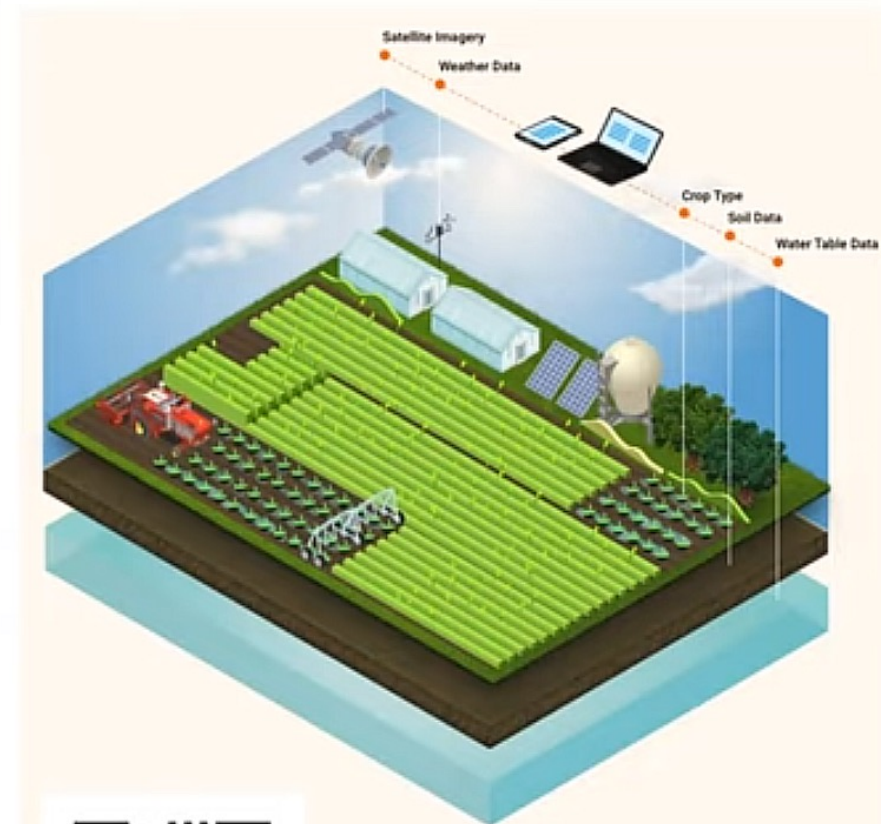
The screenshot shows the CIMIS (California Irrigation Management Information System) website. At the top, there is a navigation bar with links for HOME, STATIONS, DATA, SPATIAL, and RESOURCES. Below this, there are tabs for Station List, Station Location Map, Siting, Sensors, and Maintenance. A map of California is displayed, showing various irrigation stations marked with red dots. A notice on the left side of the page mentions updates to the SFTP interface. The CIMIS logo and name are prominently displayed at the top right of the page.

## CropManage: Online irrigation and nitrogen management decision support

The screenshot shows the CropManage application interface for a 'broccoli example' from October 1, 2022, to March 31, 2023. The interface includes a 'Tasks' tab and a 'History' tab. A list of completed tasks is shown, including irrigation events and tissue samples. The tasks are as follows:

Date	Task	Value
JAN 17	20-0-0-5	10 gal/acre
JAN 16	Tissue Sample	4.1% Nitrogen
JAN 11	Drip	3.3 hr
JAN 6	Drip	3.2 hr
JAN 3	Drip	3.4 hr
DEC 30	Drip	3.1 hr
DEC 28	Drip	3.9 hr
DEC 23	Drip	3.2 hr

At the bottom, there is a 'View all events by:' section with icons for list, calendar, and map views.



[cropmanage.ucanr.edu](http://cropmanage.ucanr.edu)



Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

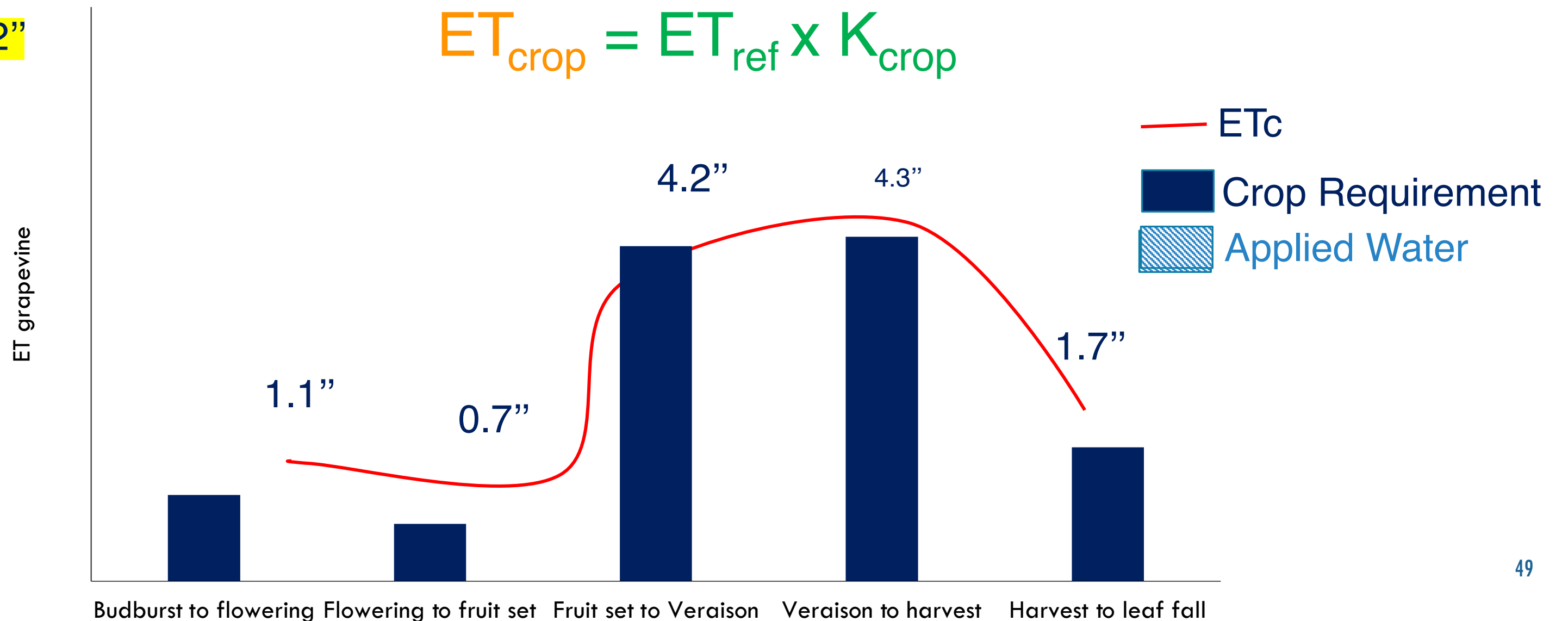
# Irrigation Scheduling

## Weather ET-based

Crop requirement is 12"

### Crop water Needs

$$ET_{crop} = ET_{ref} \times K_{crop}$$



Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Irrigation Scheduling

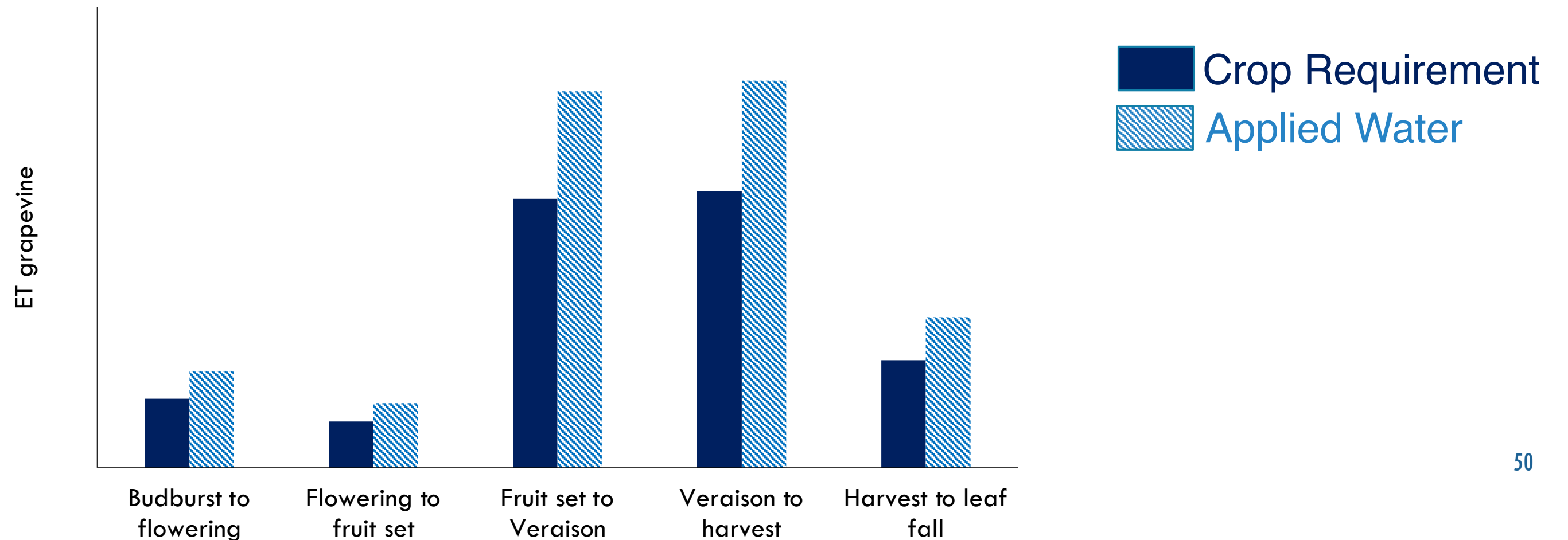
## Weather ET-based

Crop requirement is 12" but initially we applied 16"

Irrigation efficiency  
75%

## Crop water Needs

$$ET_{crop} = ET_{ref} \times K_{crop}$$





Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Irrigation Scheduling

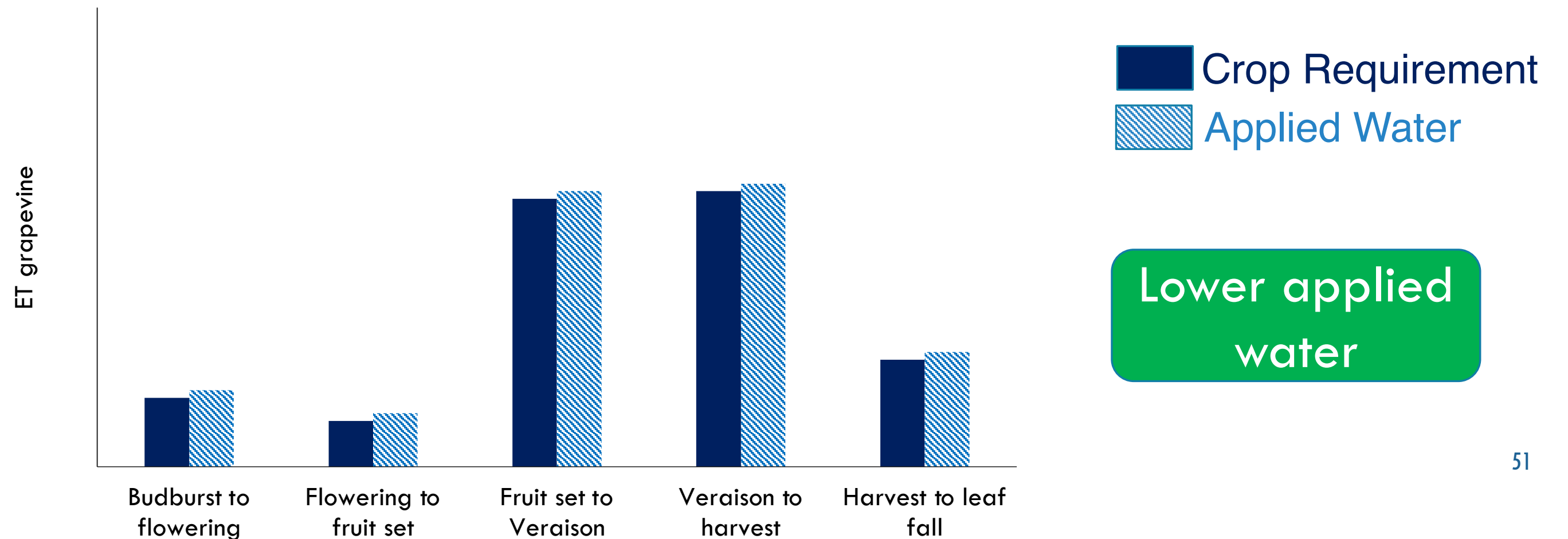
## Weather ET-based

Crop requirement is 12" but now we applied 12.7"

Irrigation efficiency 95%

## Crop water Needs

$$ET_{crop} = ET_{ref} \times K_{crop}$$



## Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance



Efficient Practices

Irrigation Scheduling

Water Quality Practices

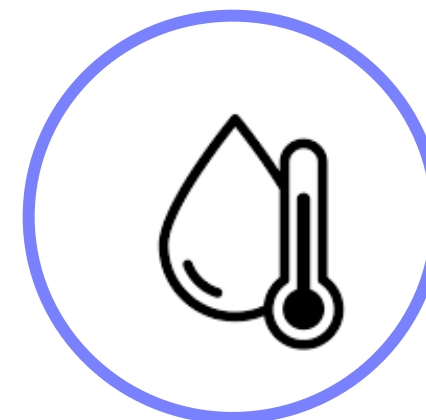
Monitoring and Maintenance

# WATER QUALITY

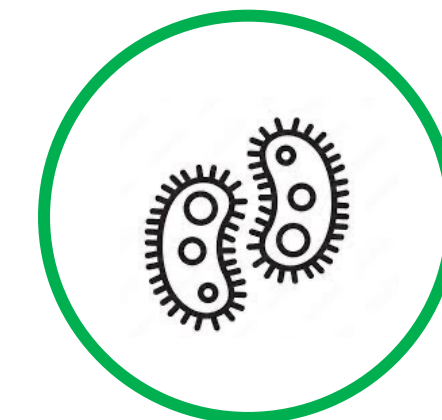
How clean or safe water is based on chemical, physical, and biological properties that determine its suitability for drinking, irrigation, or supporting aquatic life.



**Chemical**



**Physical**



**Biological**

Efficient Practices

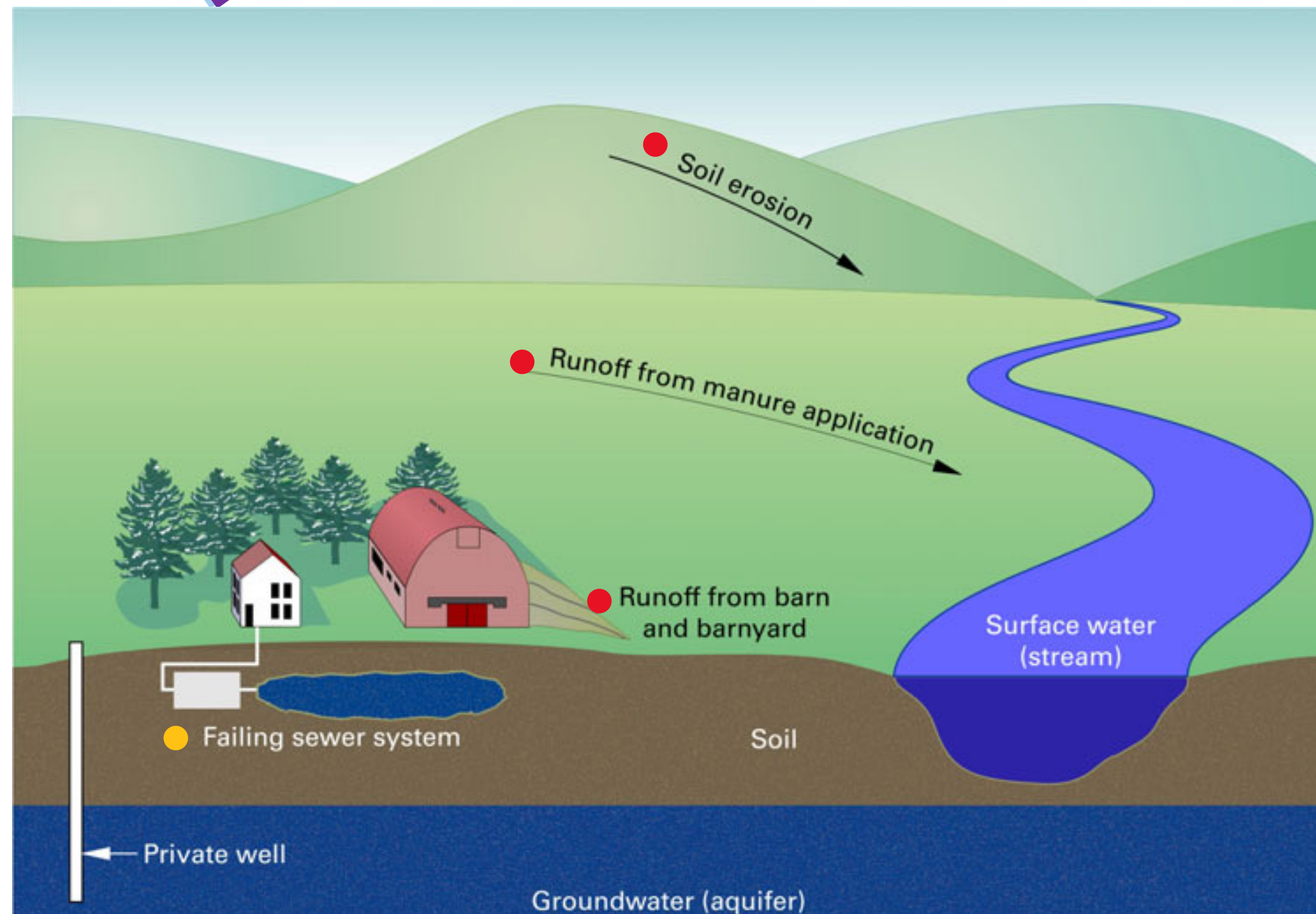
Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# WATER QUALITY

Point Source Pollution



Non Point Source Pollution



Efficient Practices

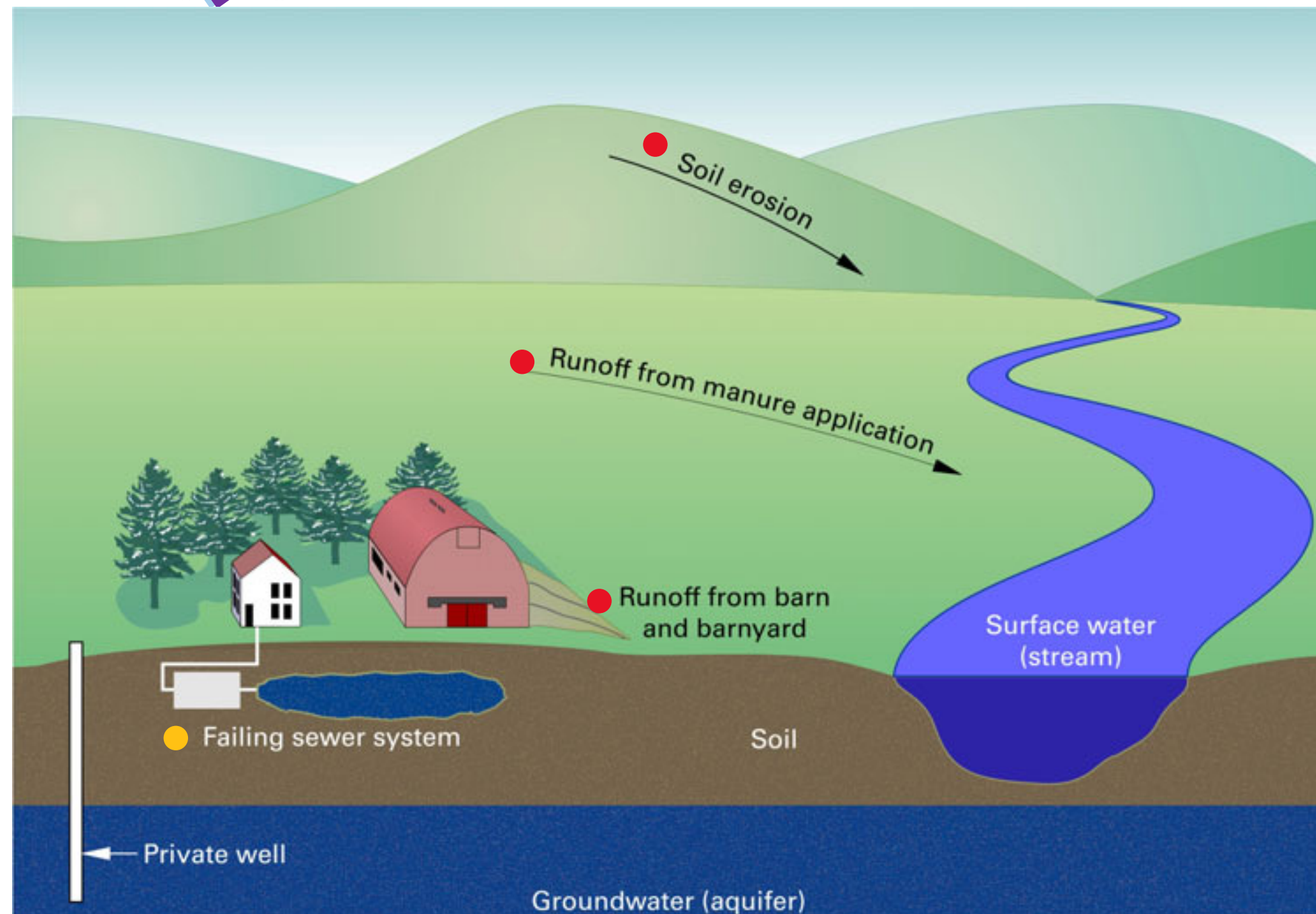
Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# WATER QUALITY

Point Source Pollution



Non Point Source Pollution

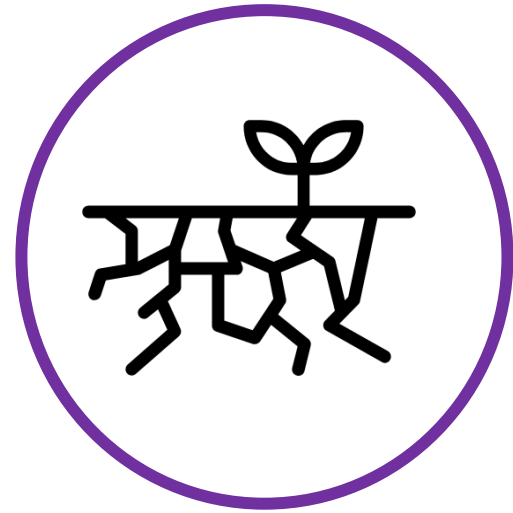


Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance



## Prevent Erosion

- Conservation Tillage
- Cover Crops



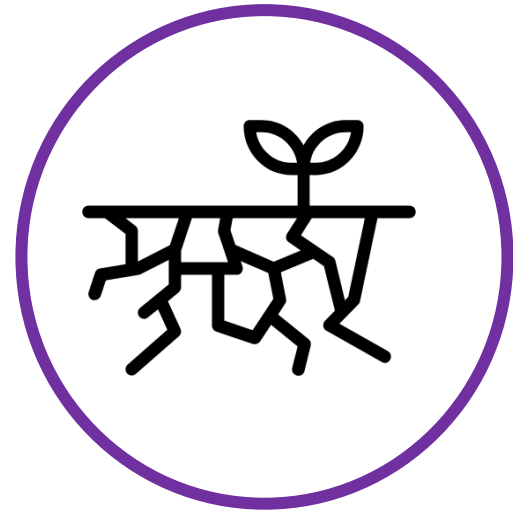


## Efficient Practices

Irrigation Scheduling

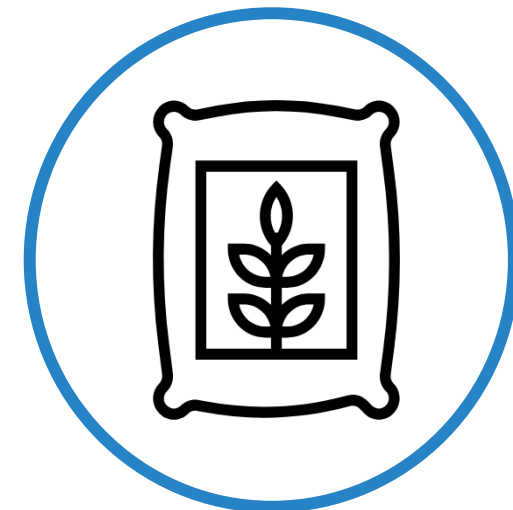
Water Quality Practices

Monitoring and Maintenance



### Prevent Erosion

- Conservation Tillage
- Cover Crops



### Enhance Management

- Integrated Pest and Nutrient Management
- Efficient Irrigation Techniques



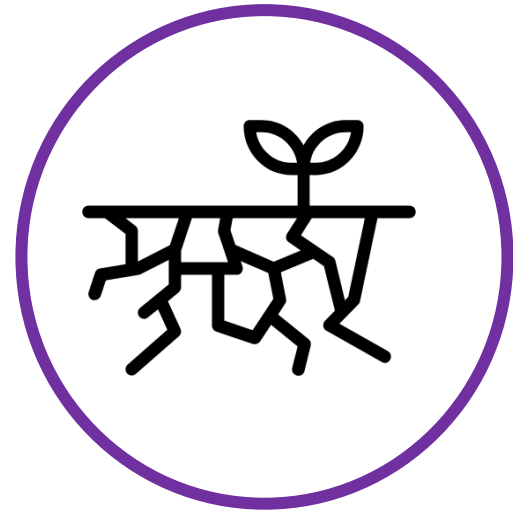


## Efficient Practices

Irrigation Scheduling

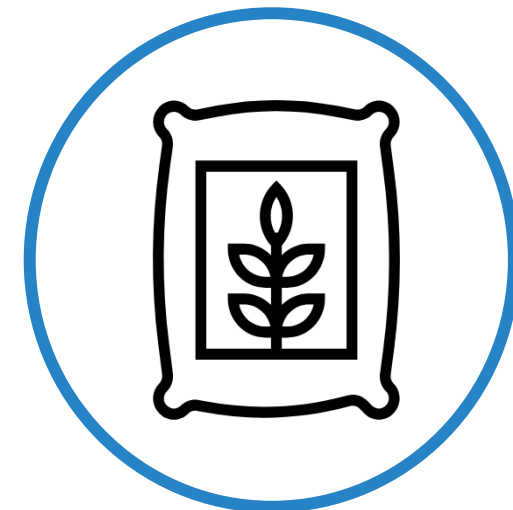
Water Quality Practices

Monitoring and Maintenance



### Prevent Erosion

- Conservation Tillage
- Cover Crops



### Enhance Management

- Integrated Pest and Nutrient Management
- Efficient Irrigation Techniques



### Improve Filtration

- Riparian buffers
- Cover crops/Filter strips



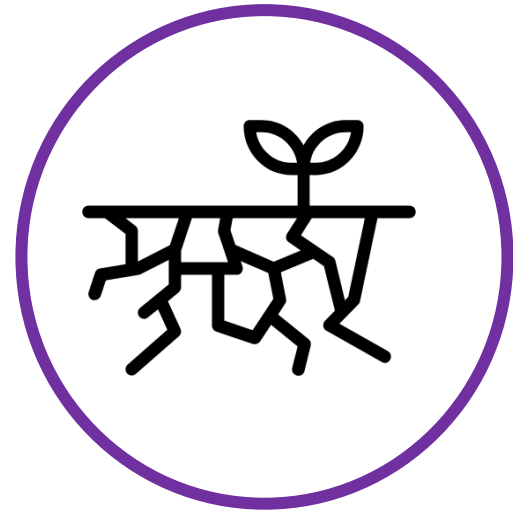


## Efficient Practices

Irrigation Scheduling

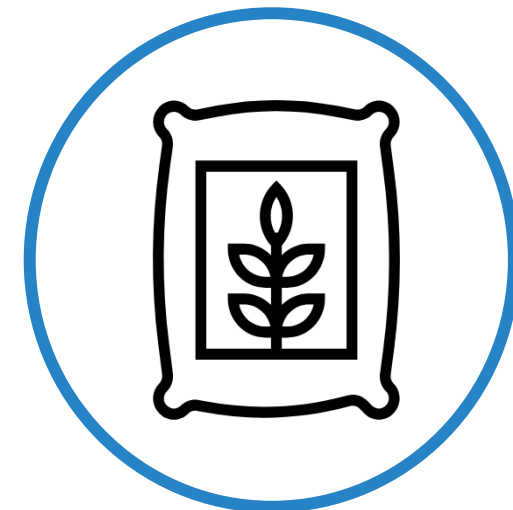
Water Quality Practices

Monitoring and Maintenance



### Prevent Erosion

- Conservation Tillage
- **Cover Crops**



### Enhance Management

- Integrated Pest and Nutrient Management
- Efficient Irrigation Techniques



### Improve Filtration

- Riparian buffers
- **Cover crops**/Filter strips





Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance

## Winter Cover Crops

- Winter Cover Cropping: Growing crops between annual production seasons or perennial tree/vines crops



Aerial photos of orchards with and without cover crops. Courtesy of Andrew Gal, UC Davis.





## Efficient Practices

Irrigation Scheduling

Water Quality Practices

Monitoring and Maintenance

# Winter Cover Crops

		← Confidence Level Based on Availability of Research →		
		Low		High
Water Budget	Inflow	Increased Fog and Dew Capture		Increased Infiltration
	Storage	Increased Percolation	Increased Soil Moisture and Water Storage	
	Outflow		Increased Evapotranspiration (ET)	Decreased Runoff
Water Quality Benefits			Increased Nutrient Scavenging	Decreased Erosion
Management factors determining net water impacts of cover crops			Species Selection	Termination Timing
			Seeding Rate	
			Stacked Practices	

Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance



Efficient  
Practices

Irrigation  
Scheduling

Water Quality  
Practices

Monitoring and  
Maintenance

# Monitoring and Maintenance

Assess your  
irrigation  
system

Install  
monitoring  
devices and  
tools

Inspections  
and  
maintenance

# THANK YOU!

**Laura Garza**

Water and Climate Change advisor

Mendocino and Lake Counties

[legarza@ucanr.edu](mailto:legarza@ucanr.edu)