Agriculture and Groundwater Banking for Increasing Water Security

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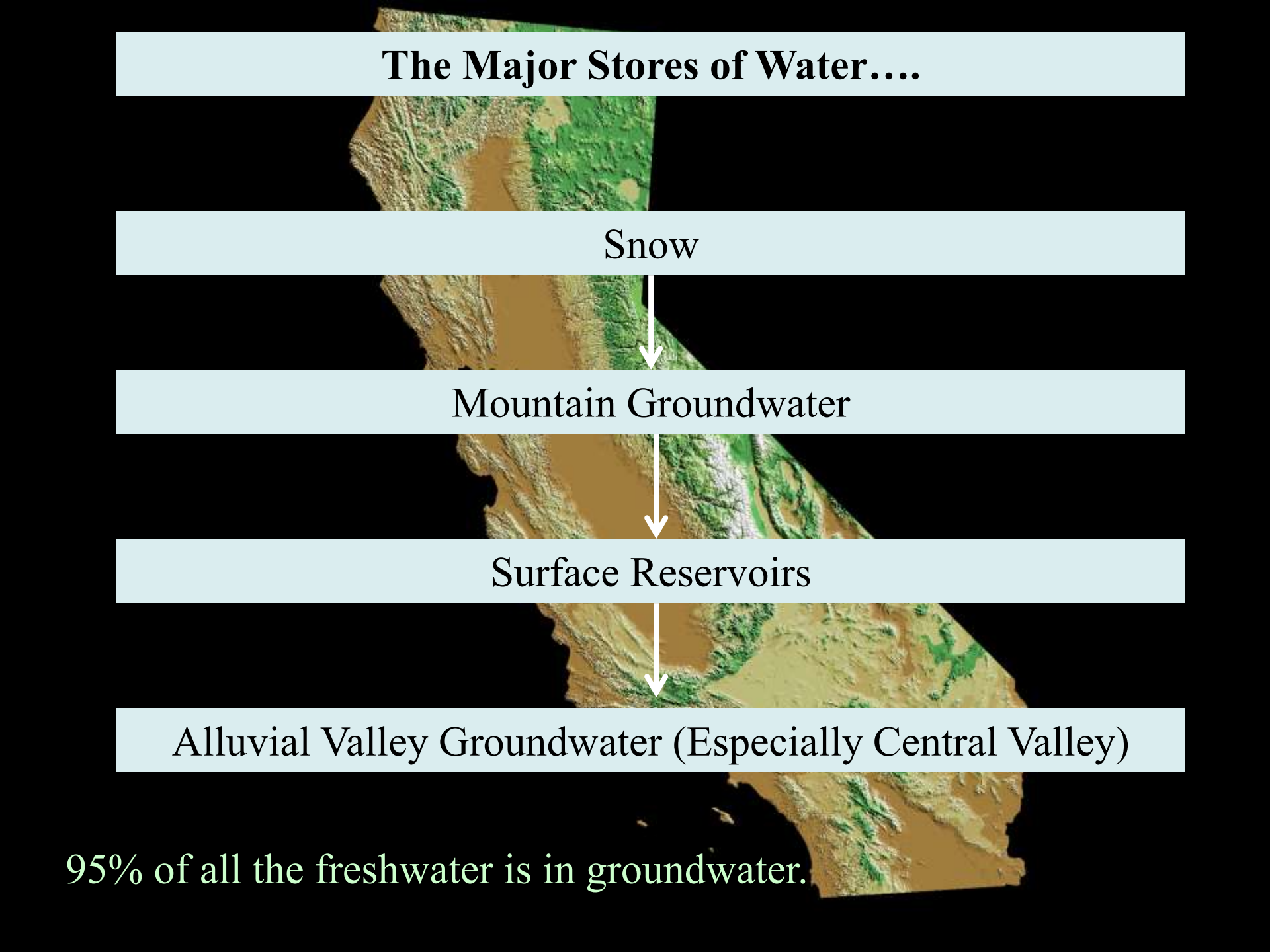
24th Annual FREP WPHA Conference, Modesto, CA
October 28, 2016

The Major Stores of Water….



Snow

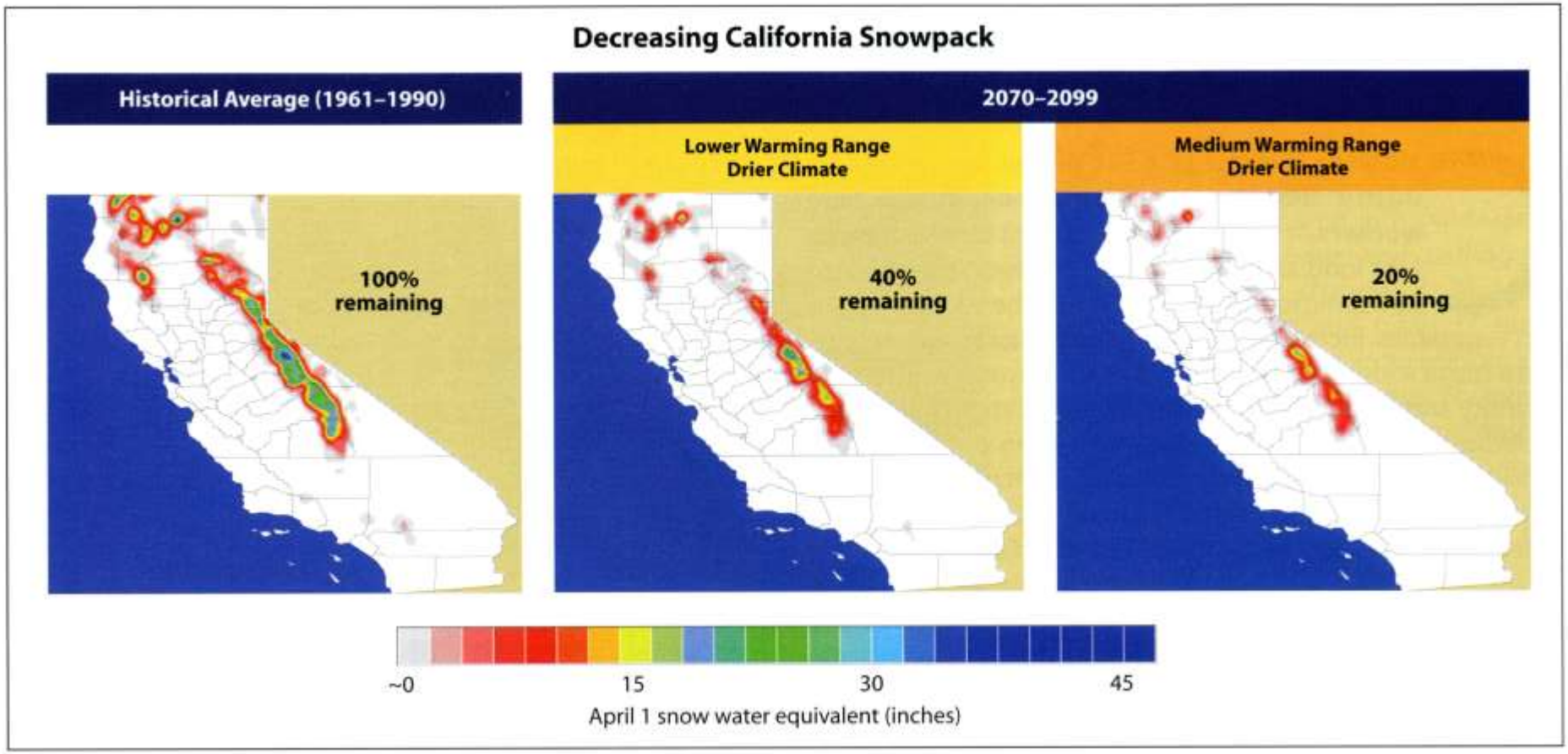
Mountain Groundwater

Surface Reservoirs

Alluvial Valley Groundwater (Especially Central Valley)

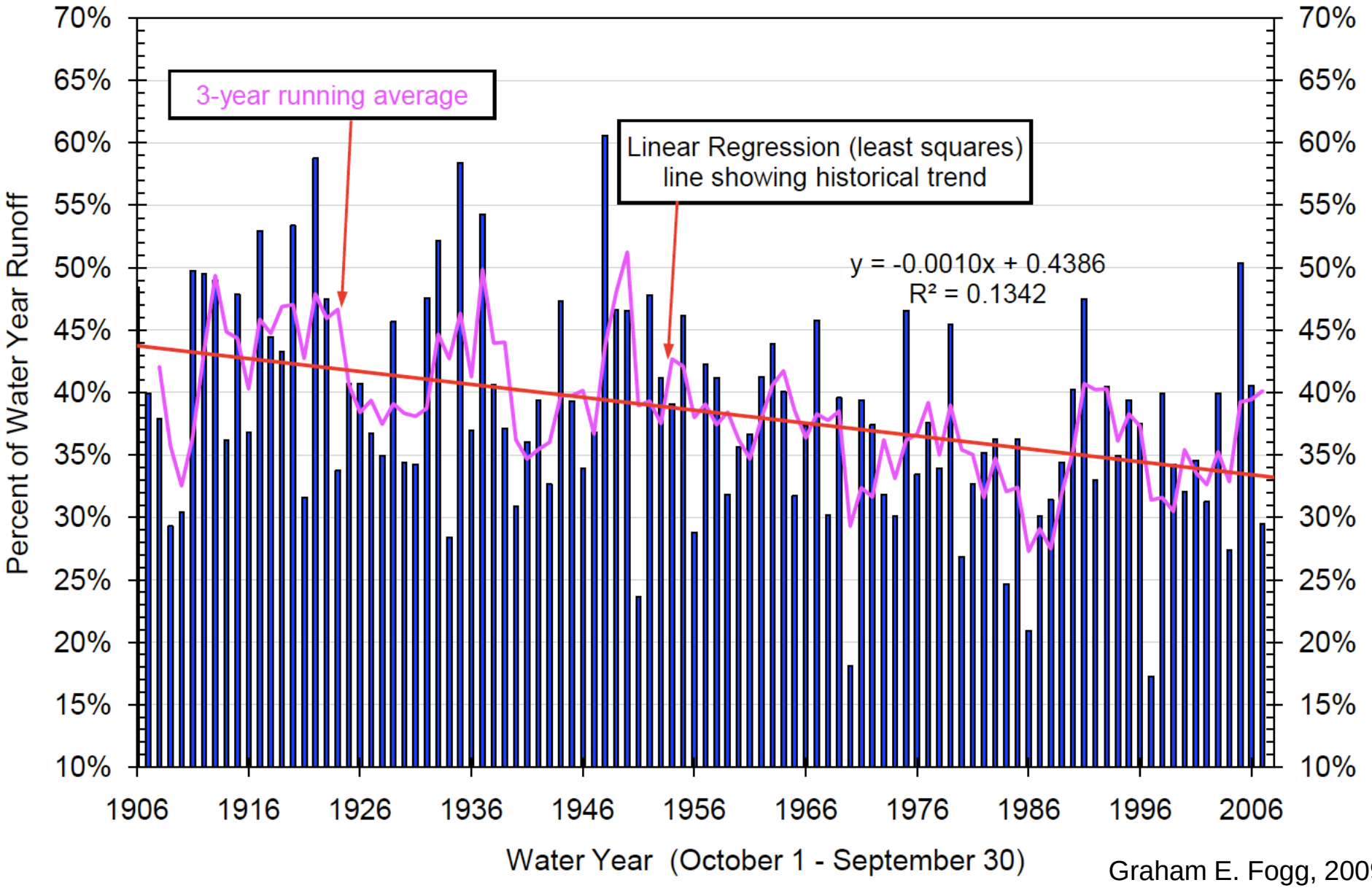
95% of all the freshwater is in groundwater.

Compounded by Climate Change



CA Climate Change Center (2006)

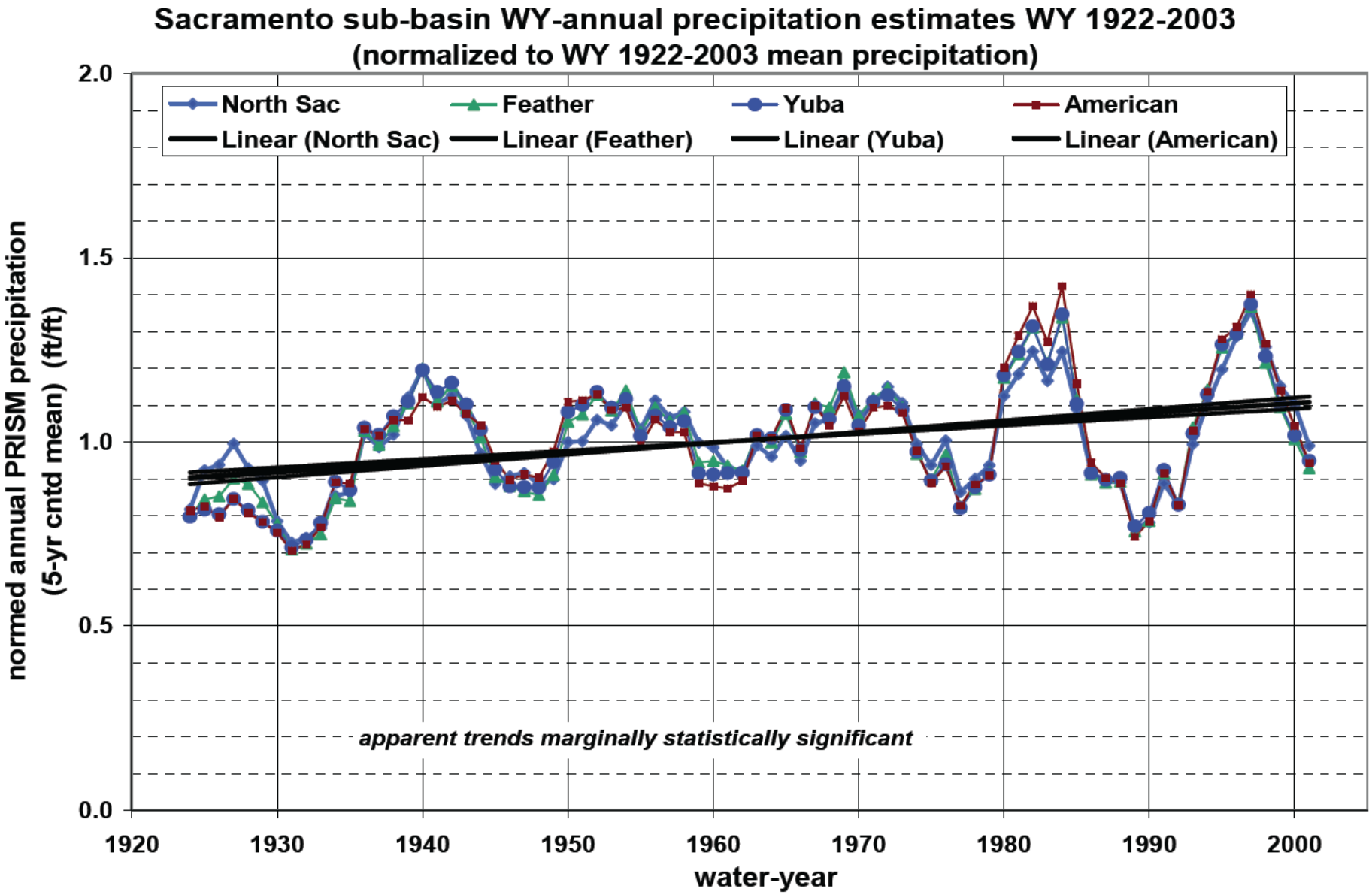
Sacramento River Runoff
April - July Runoff as Percent of Water Year Runoff



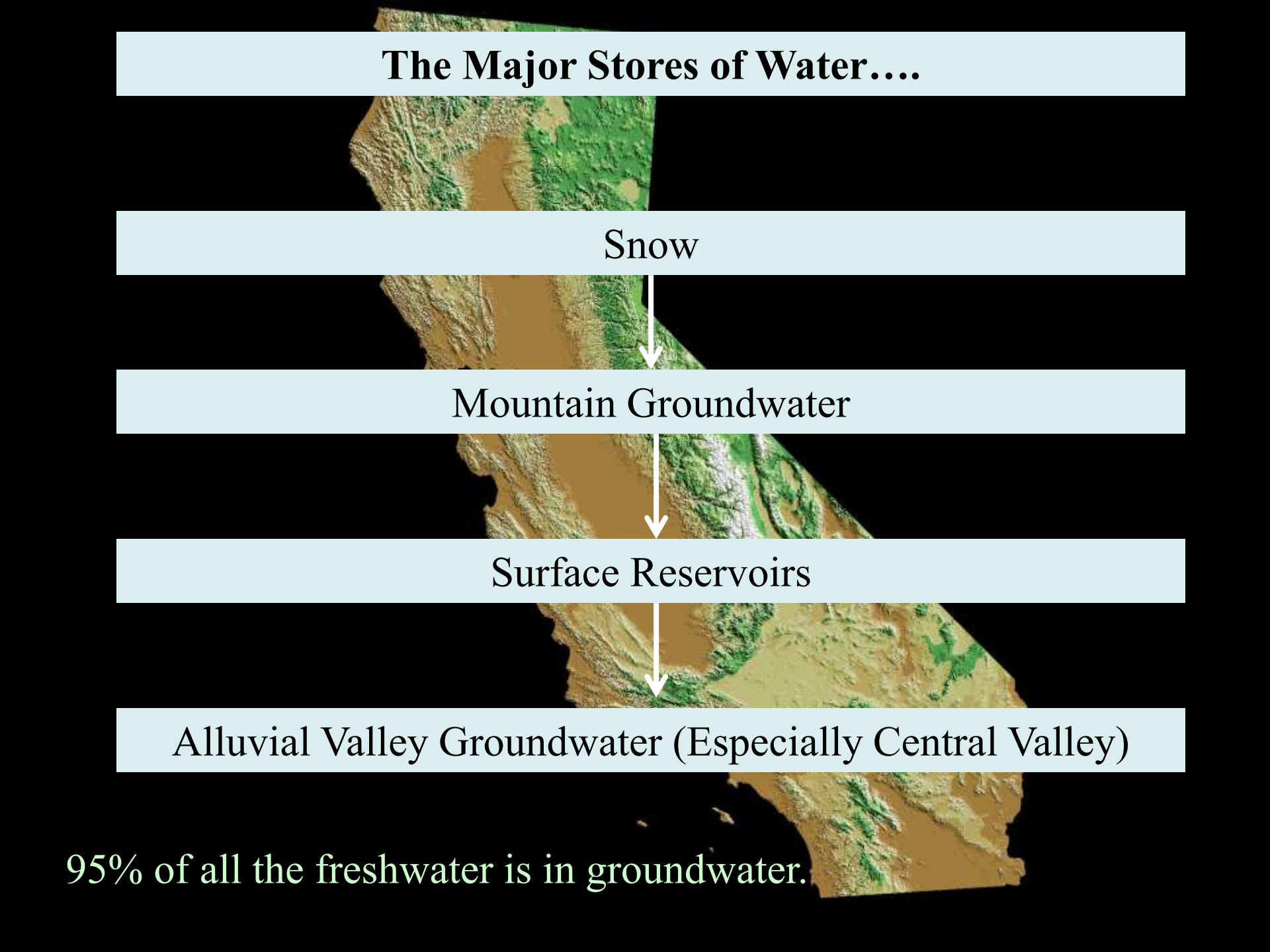
Graham E. Fogg, 2009

http://www.oehha.ca.gov/multimedia/epic/pdf/ClimateChangeIndicatorsApril2009.pdf

Source: DWR, 2008


Sacramento sub-basin WY-annual precipitation estimates WY 1922-2003
(normalized to WY 1922-2003 mean precipitation)
North Sac
Feather
Yuba
American
Linear (North Sac)
Linear (Feather)
Linear (Yuba)
Linear (American)
normed annual PRISM precipitation
(5-yr cntd mean) (ft/ft)
2.0
1.5
1.0
0.5
0.0
1920
1930
1940
1950
1960
1970
1980
1990
2000
water-year
apparent trends marginally statistically significant

The Major Stores of Water….



Snow

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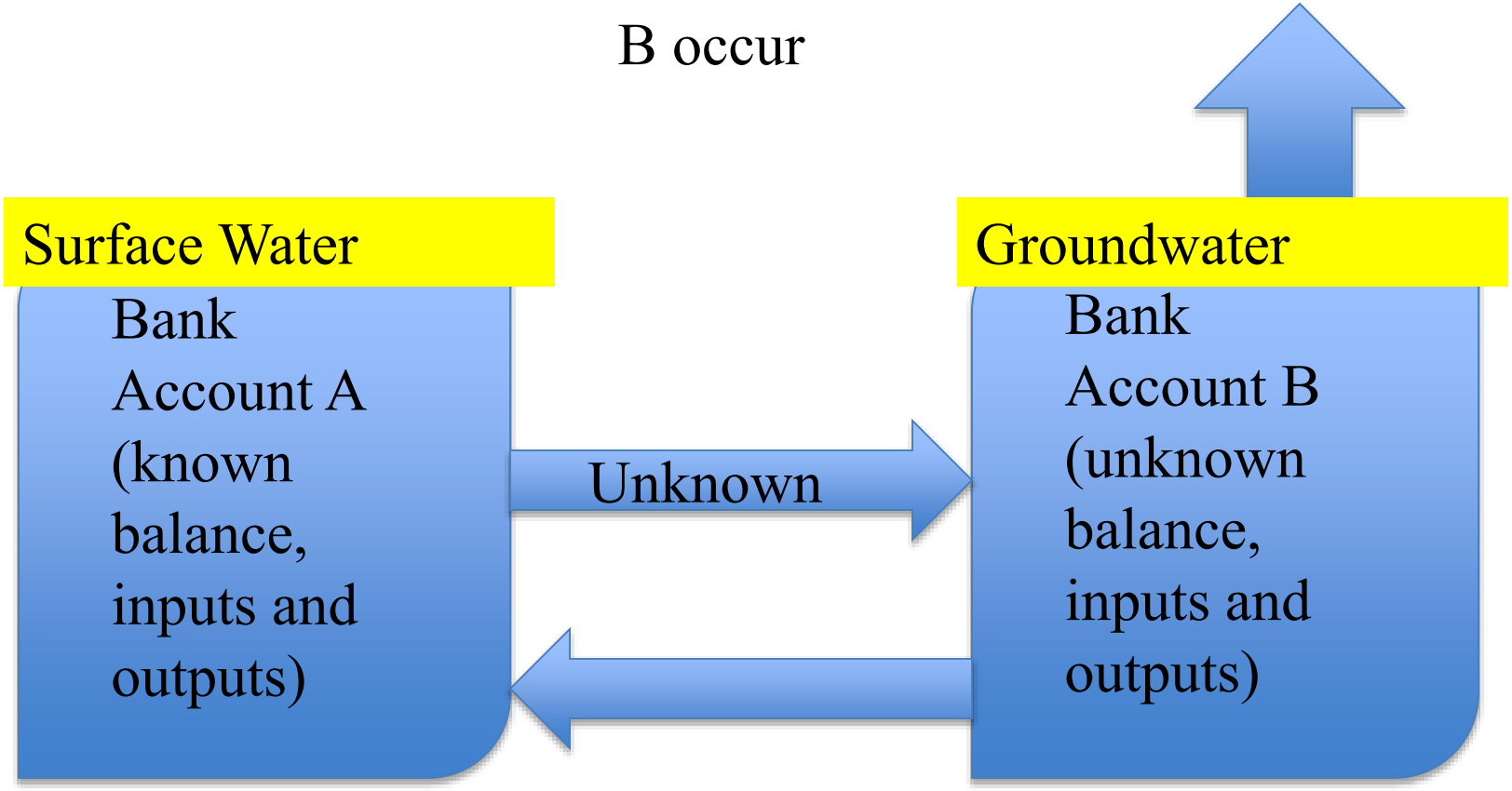
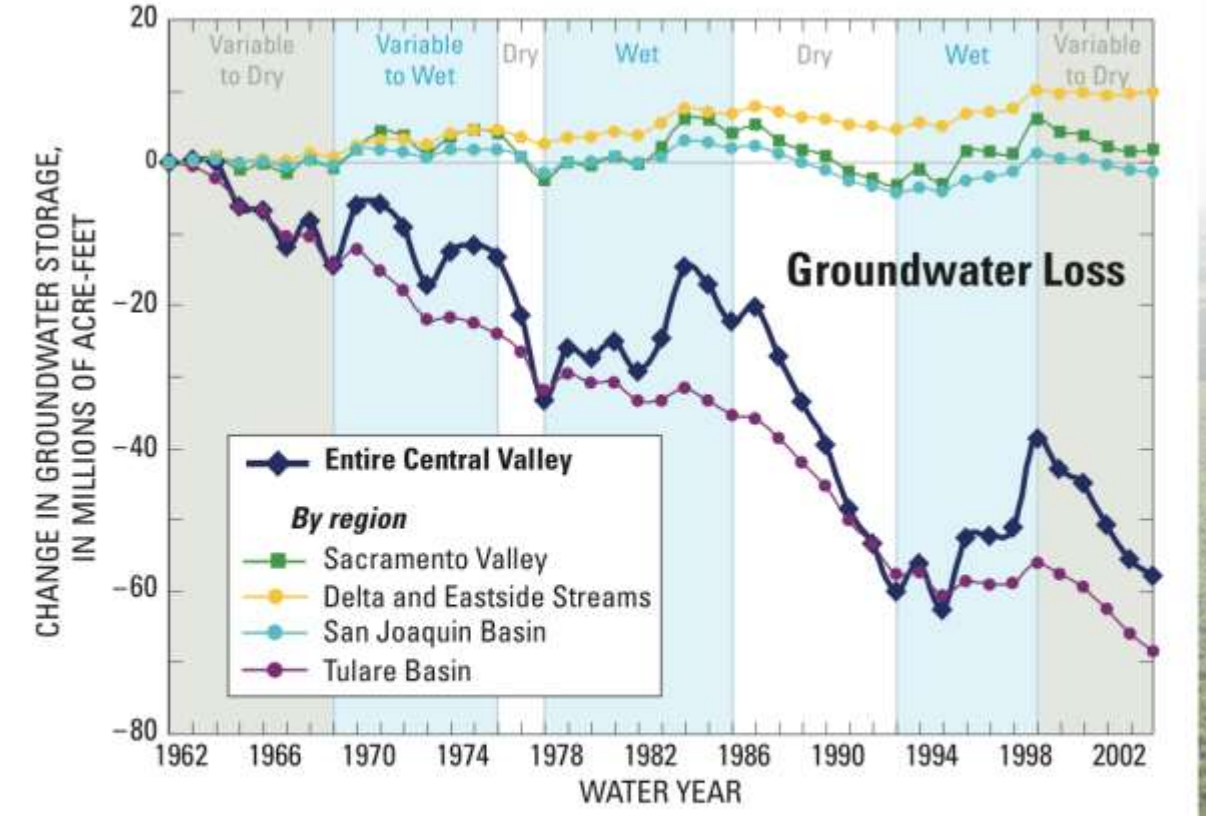
Two Bank Accounts

When Account A is depleted, uncontrolled withdrawals from Account B occur



Groundwater Overdraft Trends, Central Valley



The USGS Groundwater Resources Program funded this study, one of 30 regional aquifer studies the USGS is conducting to assess the Nation's groundwater availability. Intense competition for groundwater resources in California was an important factor in choosing the Central Valley as one of the first studies undertaken and completed.

U.S. Department of the Interior
U.S. Geological Survey

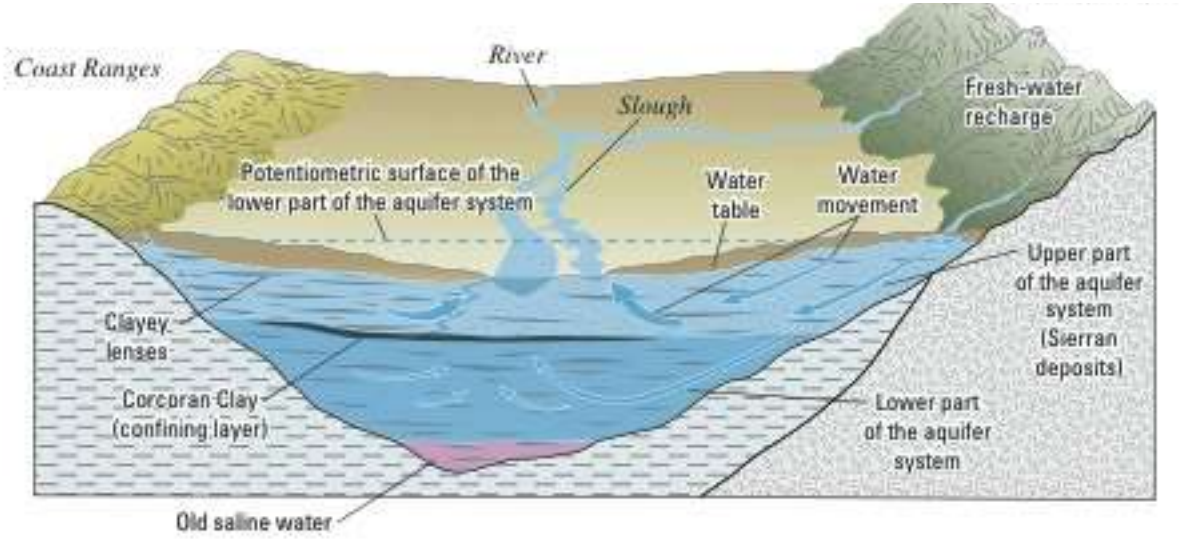
Printed on recycled paper

Fact Sheet 2009–3057
July 2009

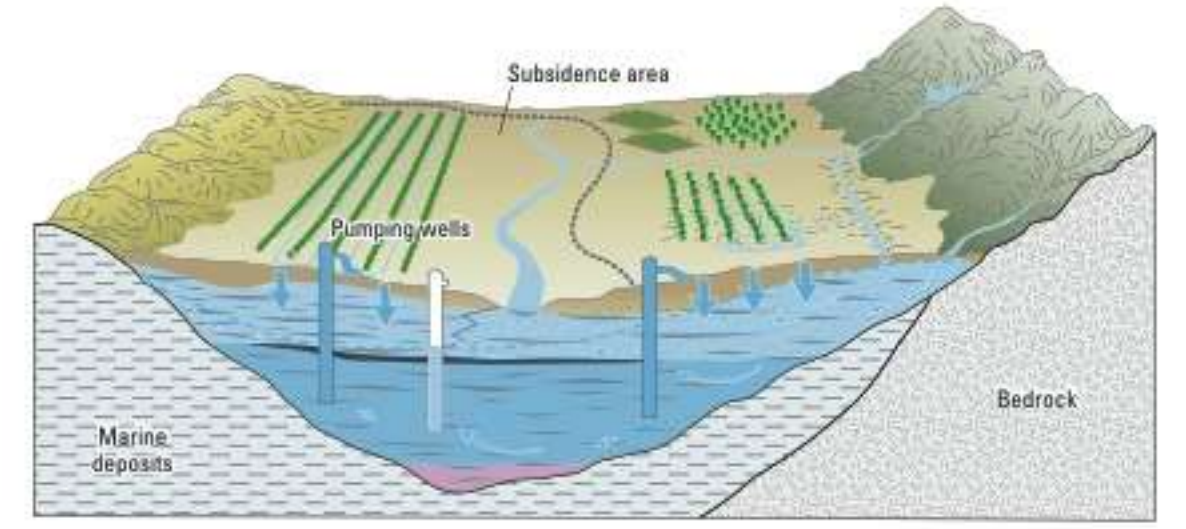
Available Central Valley Storage Volume

- 140 reservoirs can store 42 MAF
- In Central Valley subsurface, room for another 140 MAF

San Joaquin Valley Groundwater (from Faunt, 2009)



Pre-Development



Post-Development

Figure A9. Continued.

Irrigation Increased Recharge by Factor of 2-3

- Pre-development CV recharge ~2.6 MAF*
- Post-development CV recharge ~5.6 MAF*
- Pre-development CV floor river recharge ~-1.2 MAF
- Post-development CV floor river recharge ~1.0 MAF (a gain of 2.2 MAF)

*from C2VSIM

Recharge on Farms and Floodplains

Agricultural Groundwater Banking:

- **Use flood flows and agricultural lands for recharging groundwater during winter months**
- **Capture runoff from high intensity, short-duration rainfall-runoff events large spreading areas are needed**
- **California's Central Valley provides 6 million acres (~24,300 km^2) of irrigated cropland that could serve as spreading grounds for ag-recharge**

1. ***Evaluate suitability of alfalfa for ag-recharge***
2. ***Assess high-magnitude flows for managed aquifer recharge***

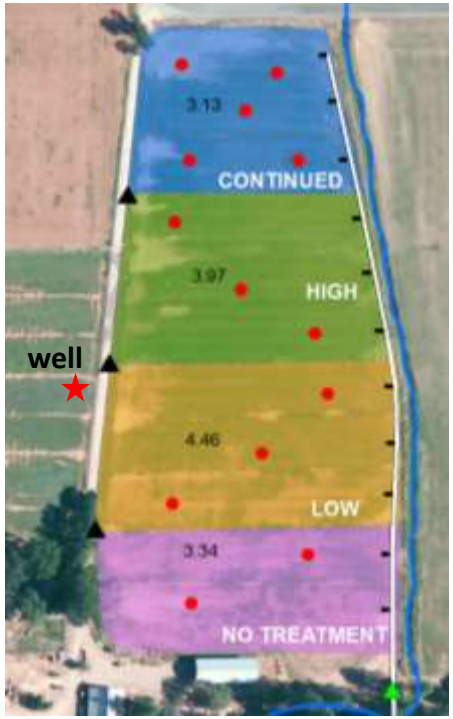
Suitability of alfalfa for ag-recharge: Why alfalfa?

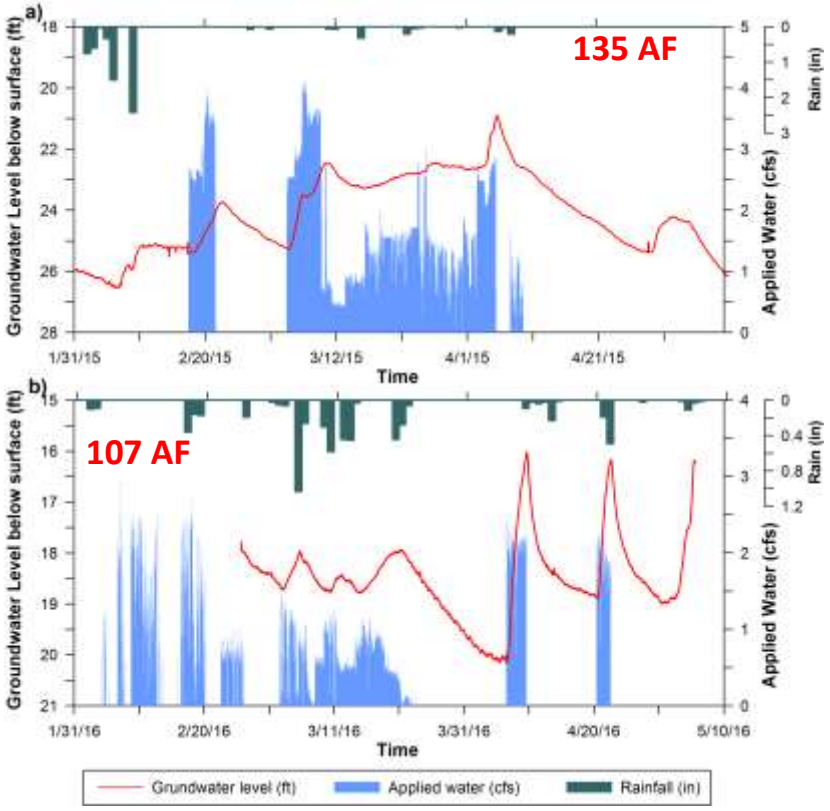
- **Supports $7.6 billion dairy industry**
- **In 2013 largest acreage crop in CA (~ 1 million acres; 4047 km^2) → high likelihood to find land on suitable soils**
- **Relatively low use of fertilizers, pesticides → low risk for leaching**
- **Flood irrigation with surface water more common → allows fast spreading of large water amounts**
- **Conducted flooding experiments in two locations in winter of 2014/15; repeated experiments in Scott Valley in 2015/16**

Flooding tolerance experiments – Scott Valley

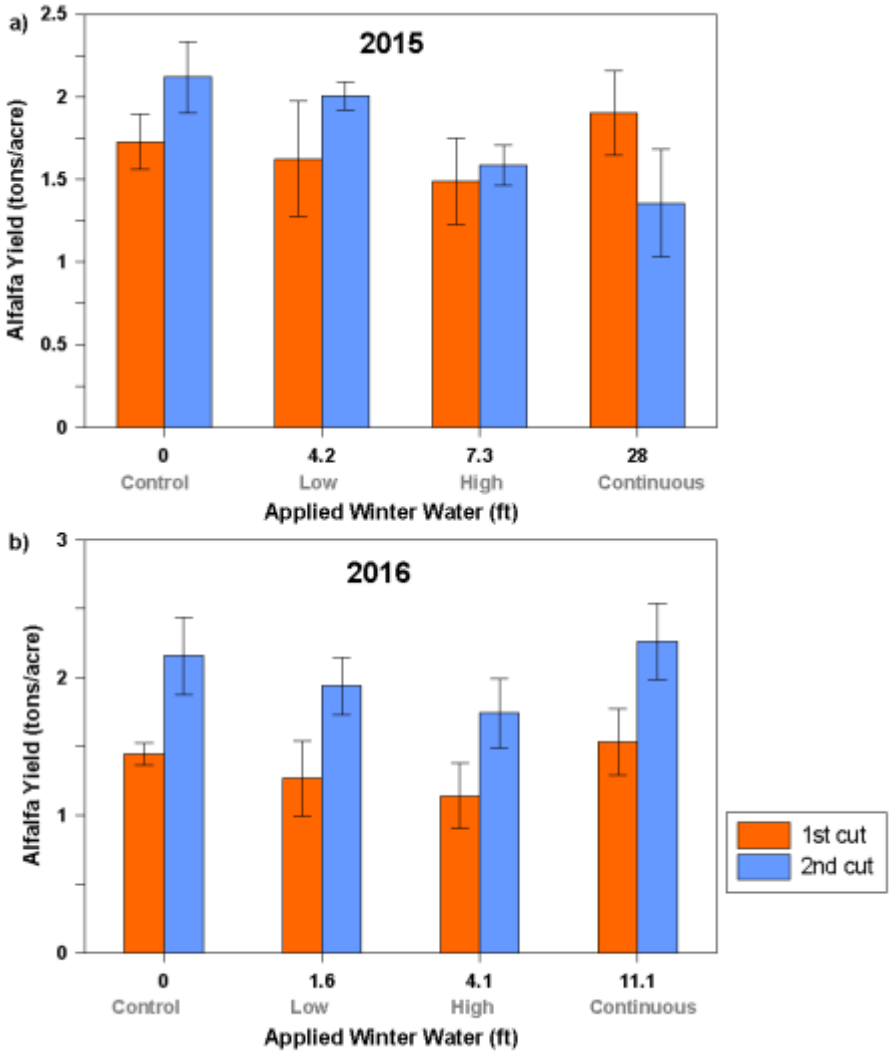
On-farm experiment

- 15 acre (6 ha) field; 9-year old alfalfa stand, flood irrigated, Stoner gravelly sandy loam
- Applied water at 1 ft/wk (Low), 2 ft/wk (High) and continuously (Continued)





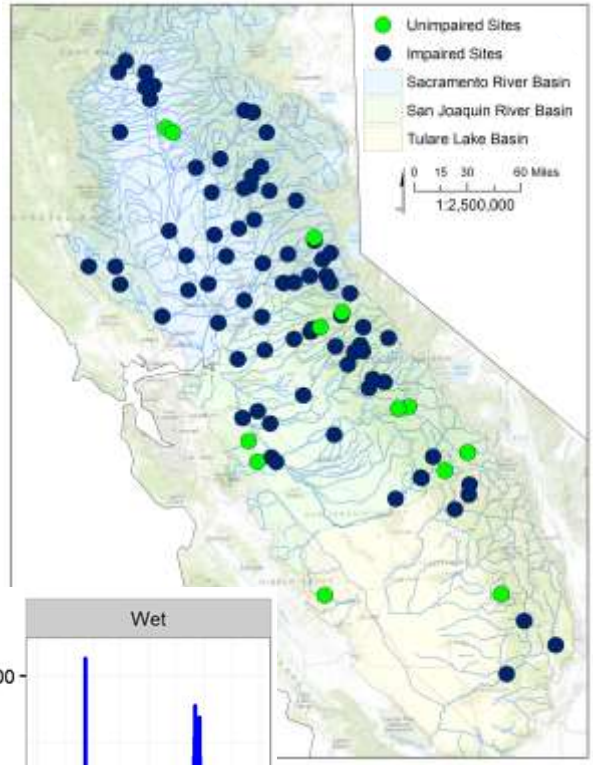
Alfalfa Biomass 2015, 2016

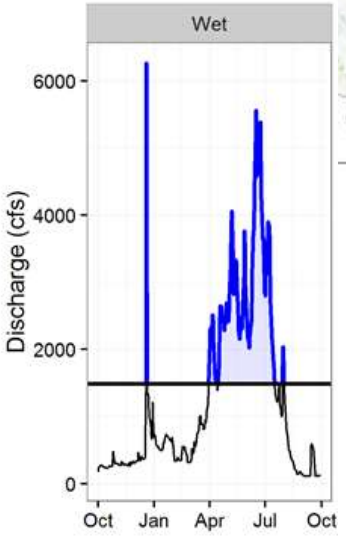


- Alfalfa is a promising crop for ag-recharge if grown on suitable, well draining soils
- Application of up to 29 ft of water caused no discernible difference in alfalfa yield between treatments except for 2nd cutting in 2015
- In CA about 300,000 acres of alfalfa are grown on soils suitable for recharge – applying 6 ft of water would result in 1.6 MAF of recharge (if 90% passed root zone)

High-magnitude flow assessment for MAR

- **Historical daily streamflow records for 93 stream gauges (13 unimpaired, 80 impaired)**
- **90th percentile used to designate "high flows" and is determined from full historical record**
- **Analysis is conducted for different time periods (Nov – Apr, Dec – Feb)**
- **Analysis is conducted for two record lengths:**
  - **Full record of available data**
    → encapsulates long-term climate variability
  - **Post impairment period**
    Current state of the system
    → Sac Valley: 1970 – 2014
    → San Joaquin Valley: 1989 – 2014
- **Estimates are also summarized for different water year types** (SWRCB Decision 1641)





Results: Magnitude

Average total flow above 90th percentile

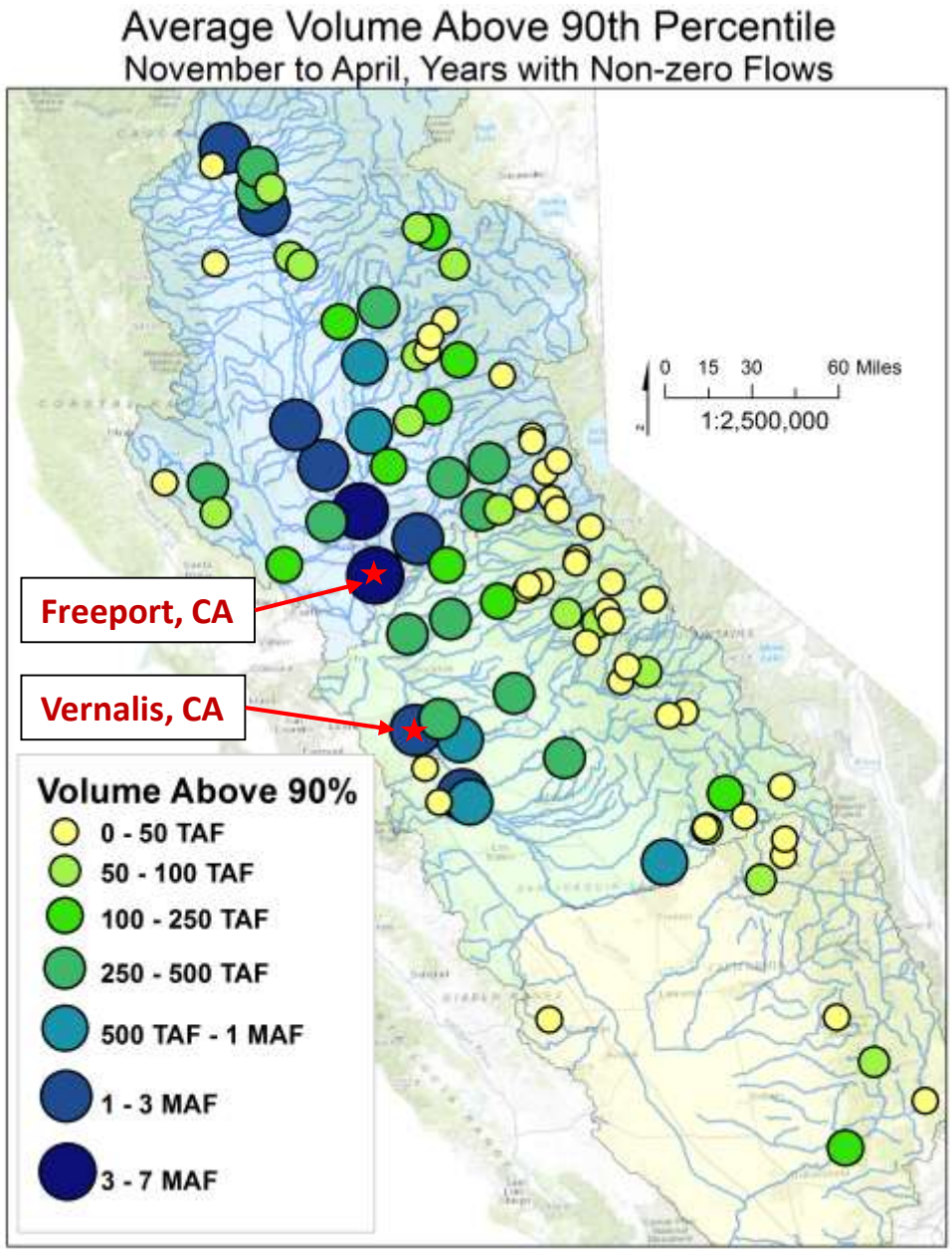
Outlet	Dec-Feb	Nov-Apr
Sac Valley	4.2 MAF	7 MAF
SJ Valley	1 MAF	2.2 MAF

A SINGLE, average wet year in the Sacramento Valley alone can provide over 4 times the annual groundwater overdraft.

30% of years are "wet"

~11 MAF from Nov-Apr

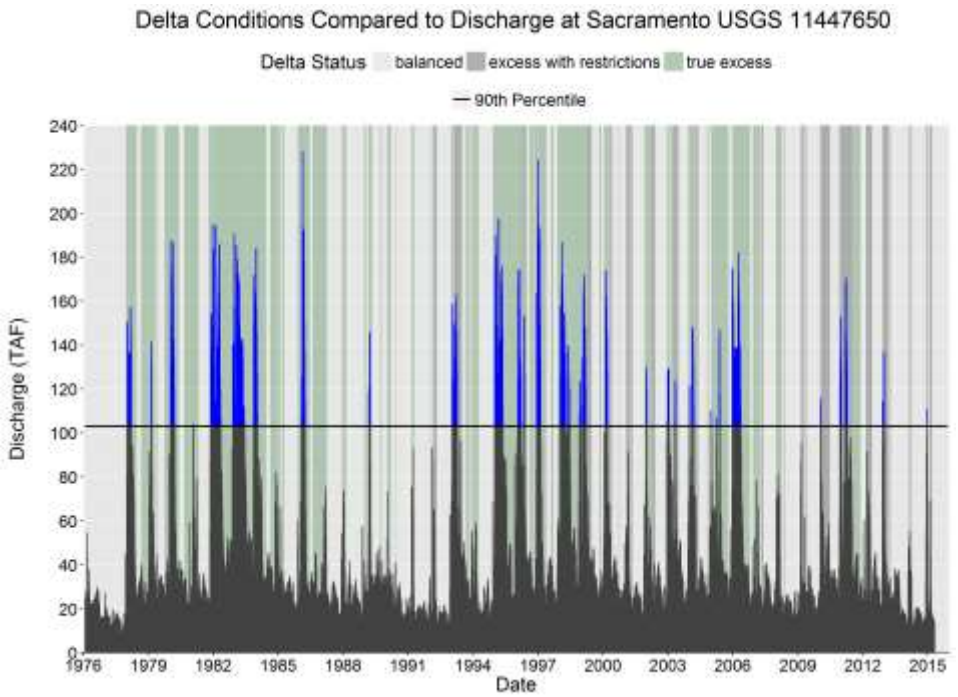
Results are based on post-impairment period



Delta Status

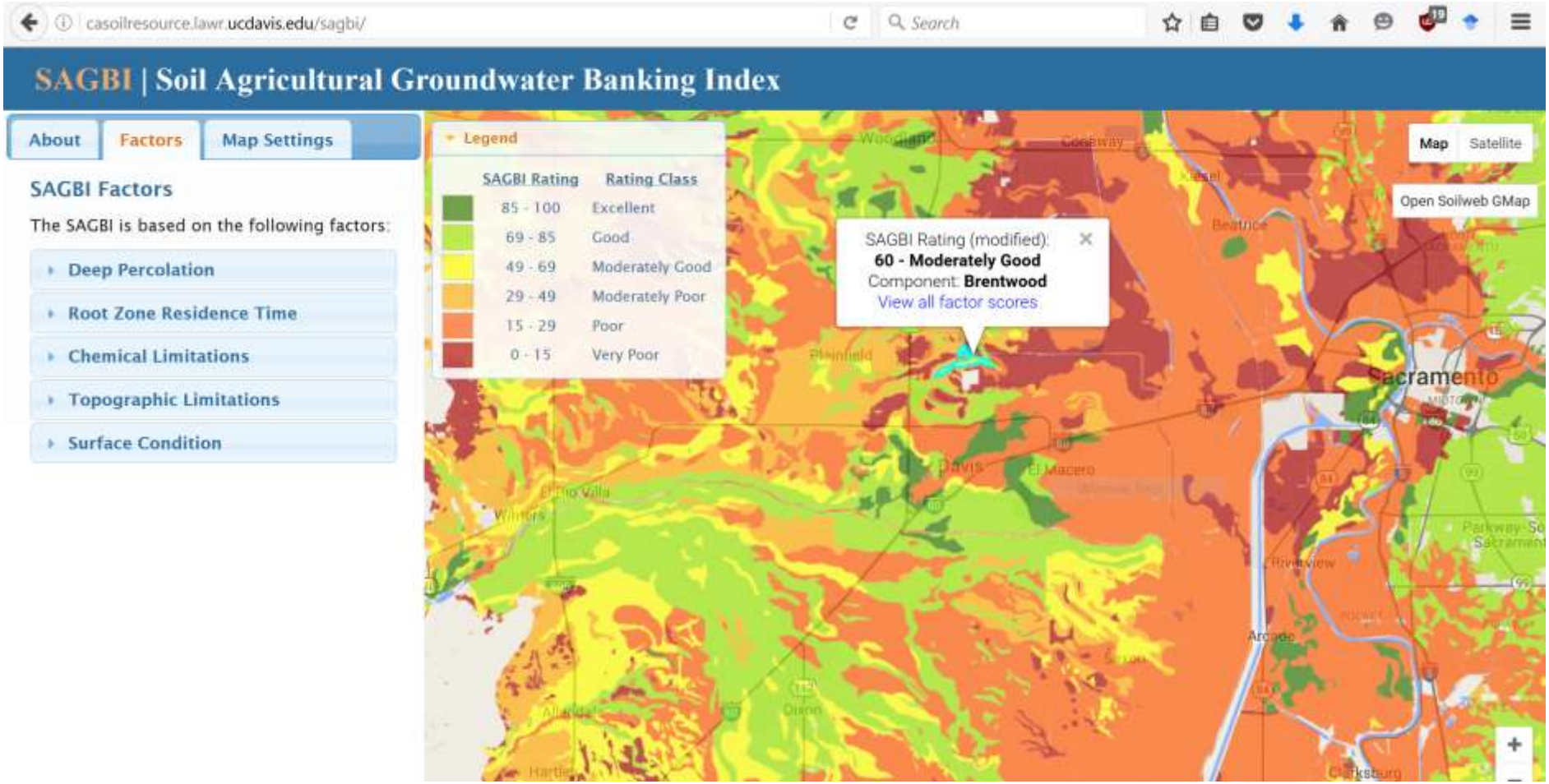
- **Delta status is used to determine if inflows to the Delta meet:**
  - environmental flow requirements
  - the needs of the SWP and CVP
- **DWR determines the Delta status on a daily basis since 1976**
  - Excess
  - Restricted excess (fish or salinity concerns)
  - Balanced

Sacramento River at Freeport, CA

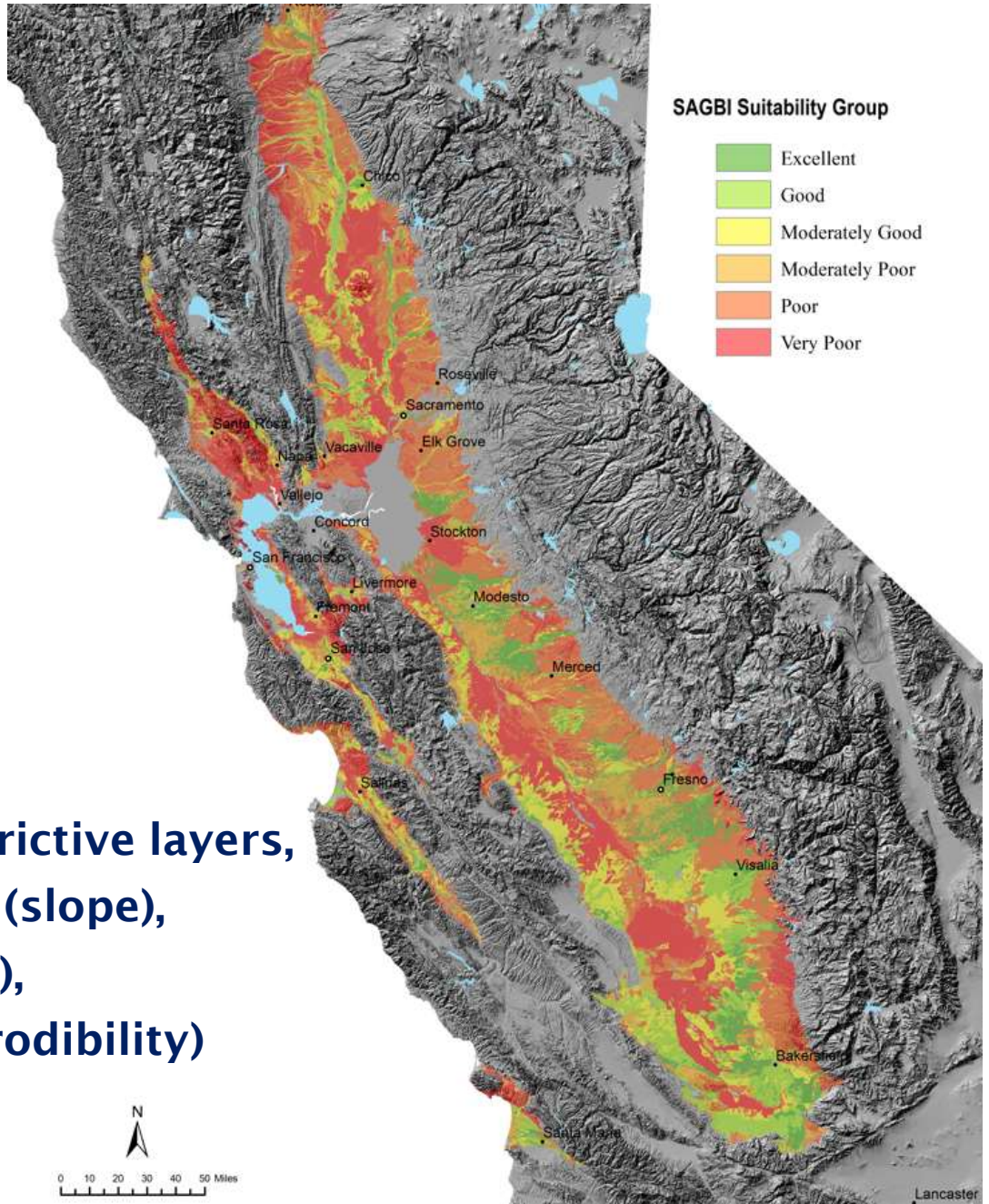


- **At both the outlets of the Sacramento and San Joaquin Basins:**
  - Delta was in excess conditions for 99% of the days with flow above the 90th percentile
- **Delta is in excess conditions more frequently than flow conditions reach the 90th percentile**
  - 41% of days since 1976 in true excess
  - 8% of days flow was above the 90th percentile

Soil Agricultural Groundwater Banking Index (O'Geen et al. 2015, CalAg)



Which soils are suitable



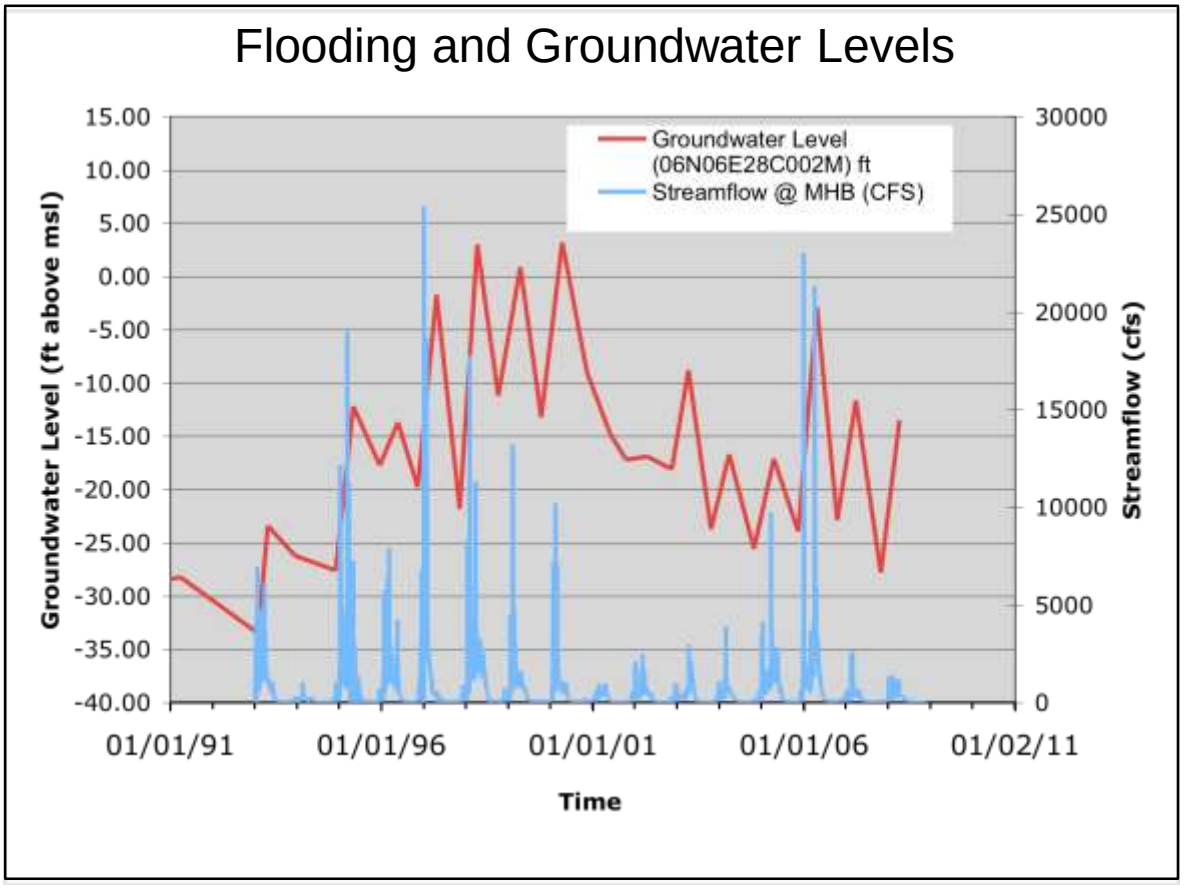
Soil characteristics:

- Hydraulic conductivity
- Occurrence of water restrictive layers,
- Topographic Limitations (slope),
- Chemical Limitations (EC),
- Surface Condition (e.g. erodibility)

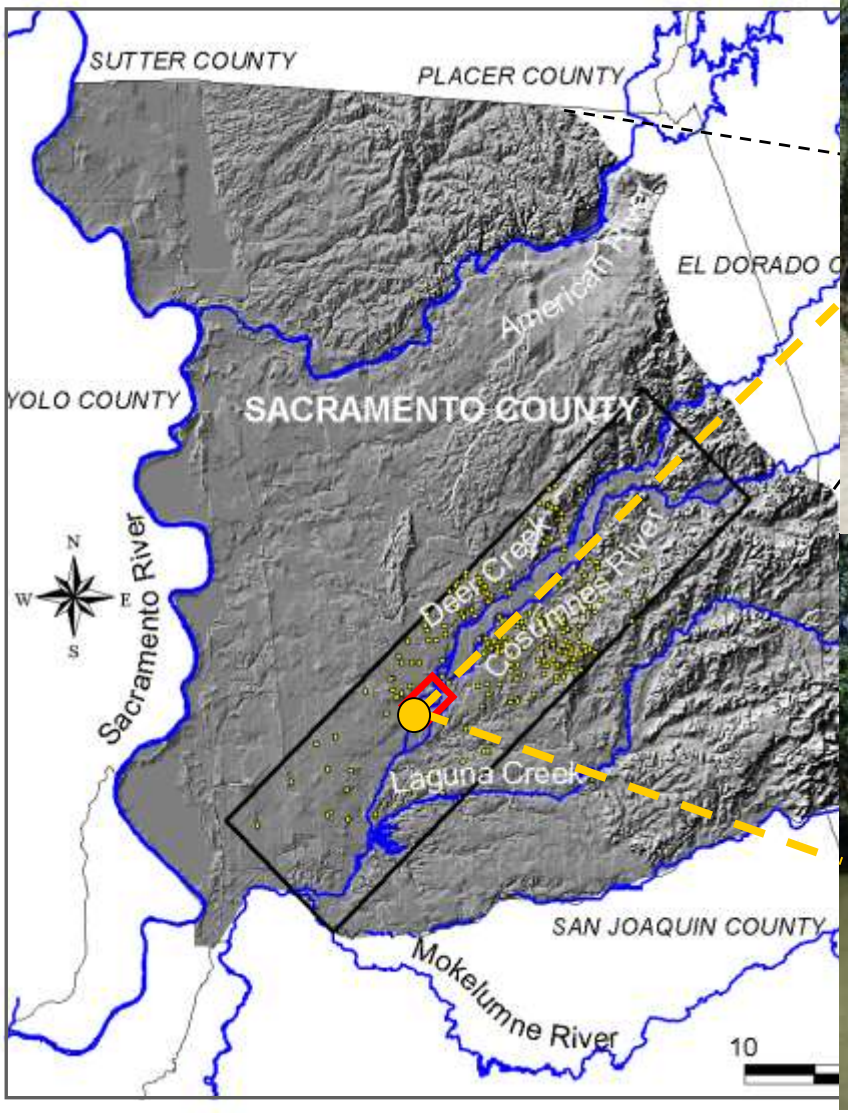
Floodplain Recharge

Climate Change and Groundwater: Higher Flooding Risks BUT Greater Recharge??

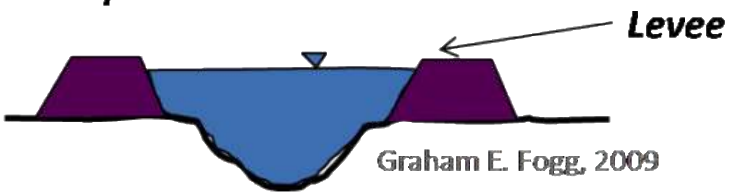
1997, 1995 Flood Events
Sacramento County, CA



Case study - Cosumnes River, California



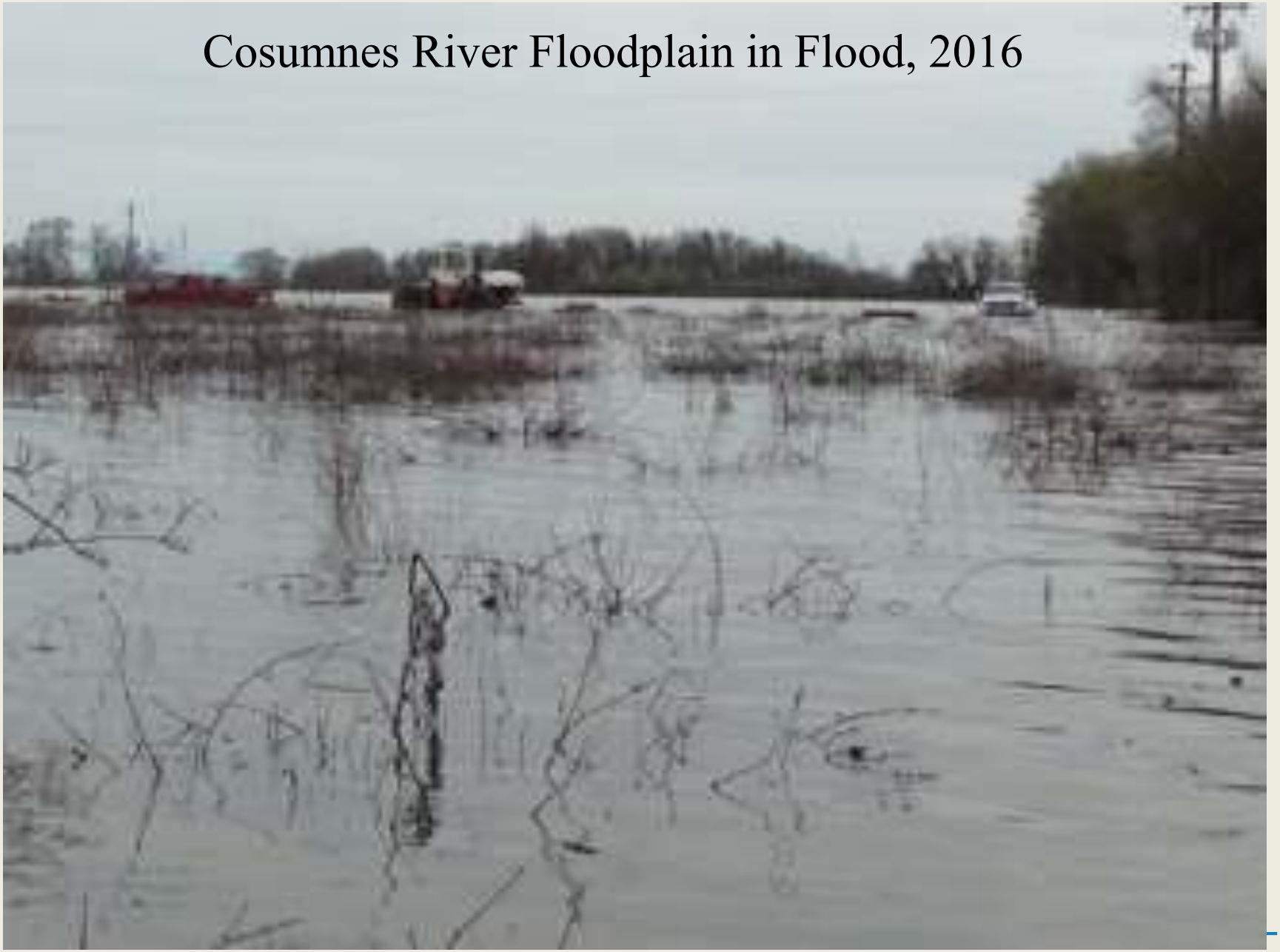
No Floodplain:



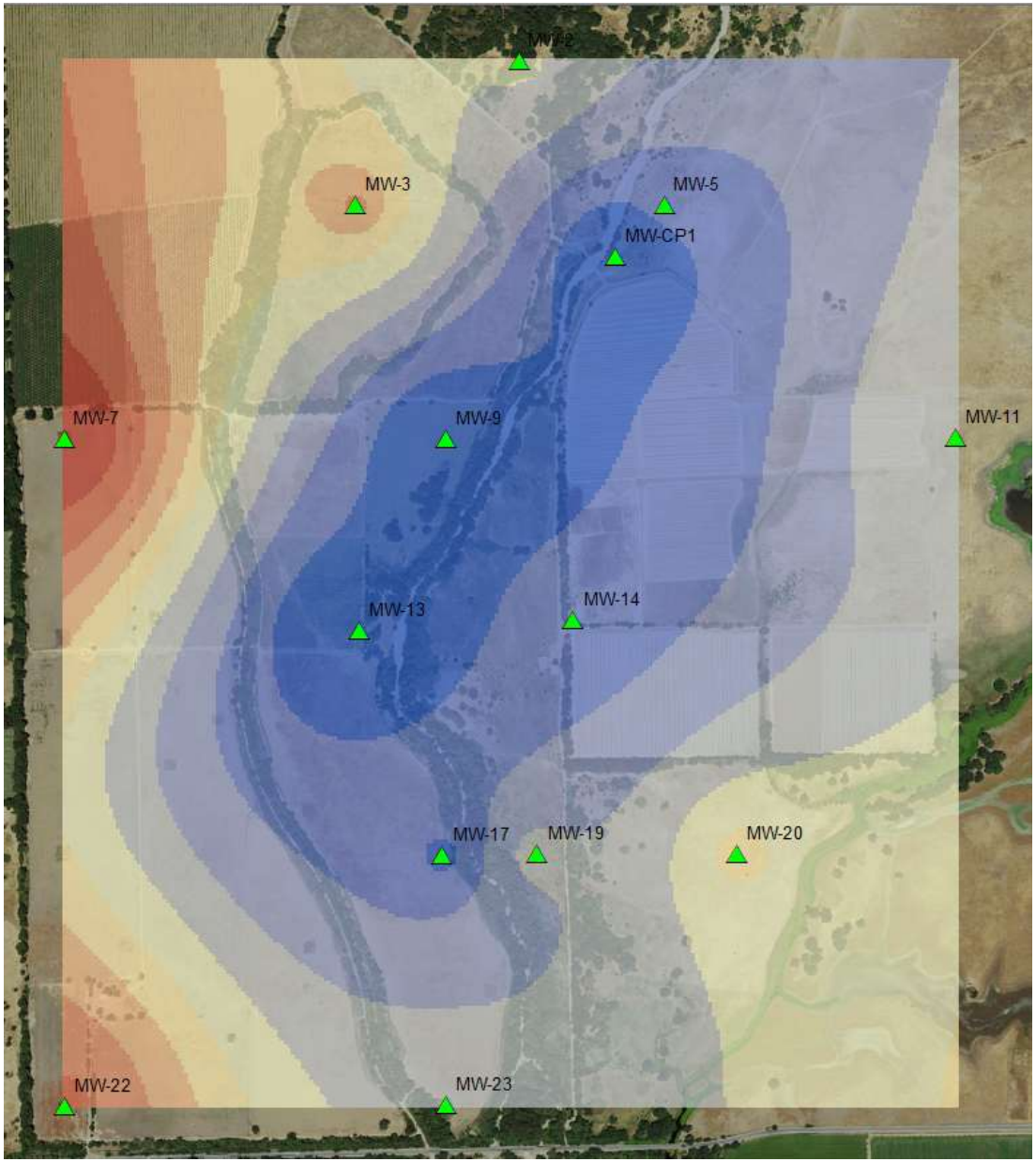
----------VERSUS:----------

Floodplain w/ set-back levees:

Cosumnes River Floodplain in Flood, 2016



Cosumnes River Floodplain Oneto-Denier



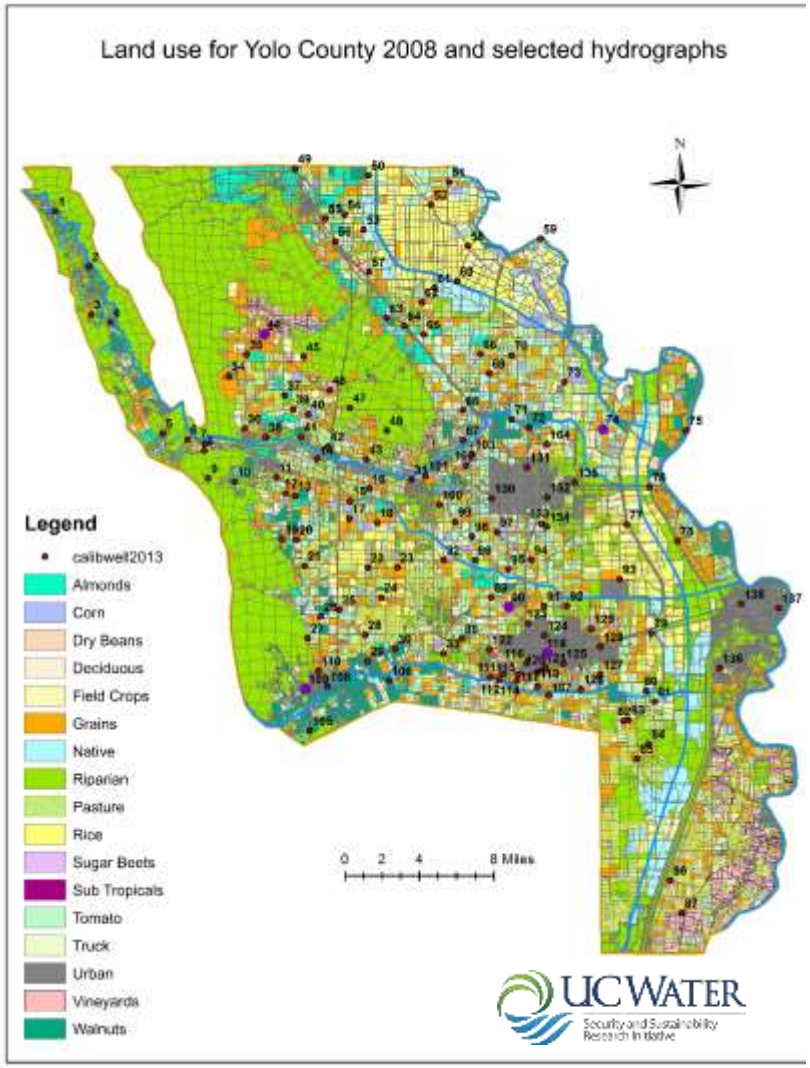
Differenced water elevations snapshots Oct. 11--Mar. 1, 2016

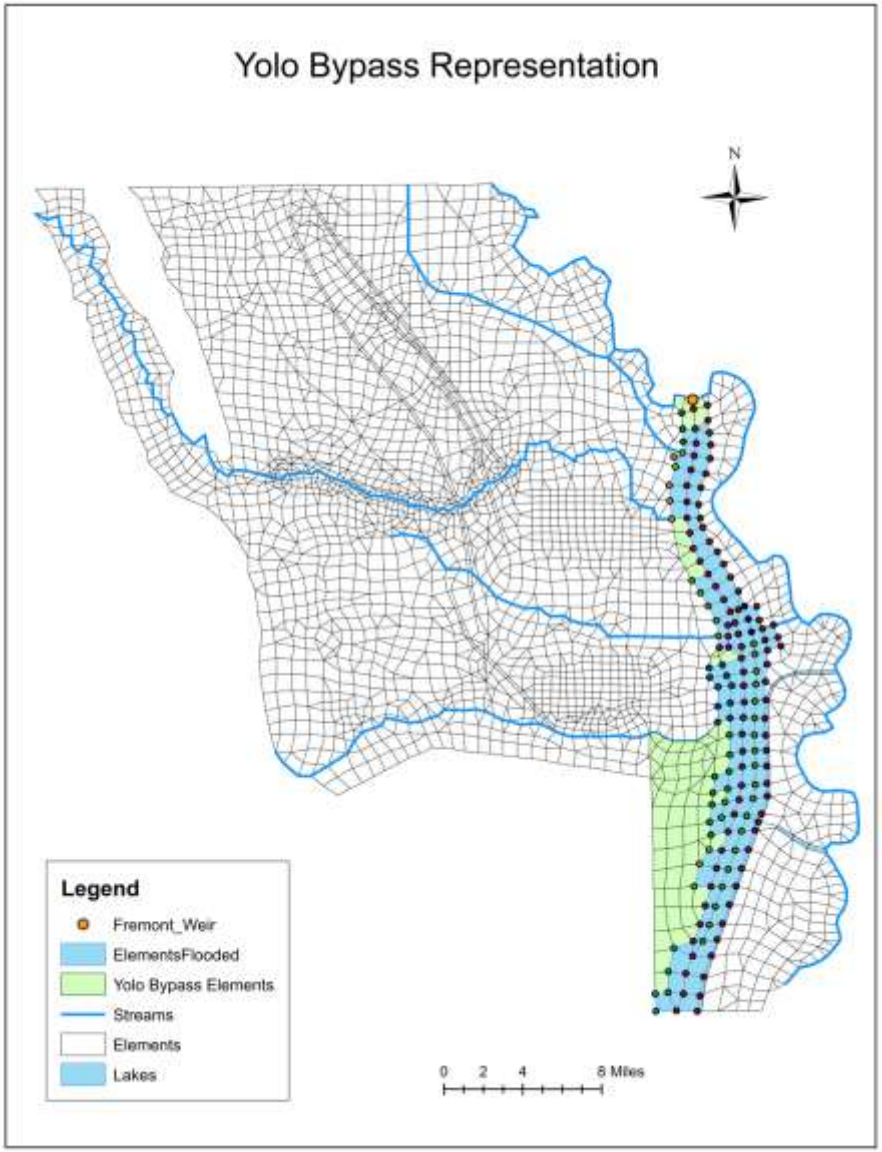
~280 acre-ft recharge over 144 acres. (Sy = 0.18)

3 events per year would yield 840 ac-ft/yr

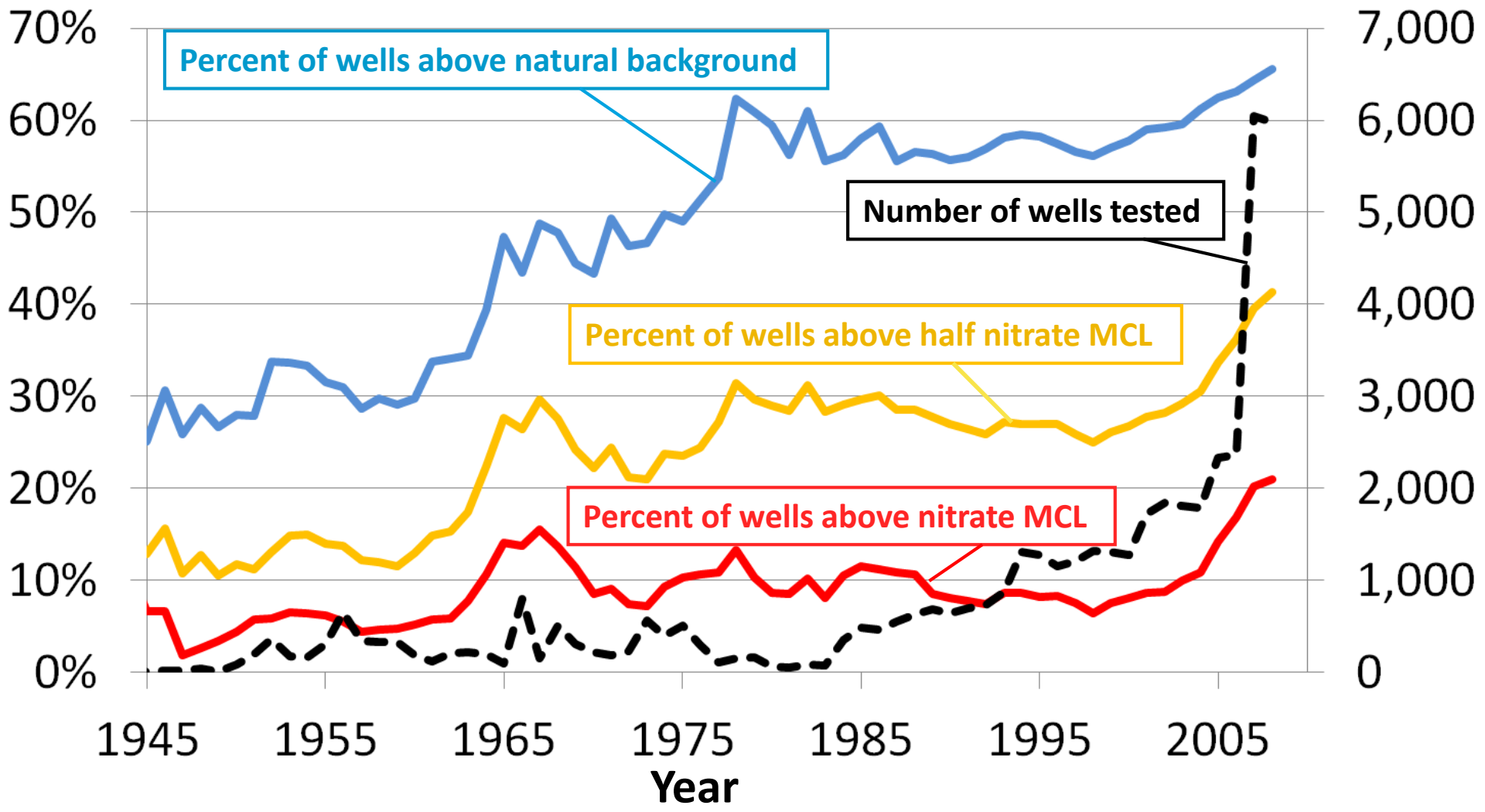
Yolo Bypass in Flood

Flood Recharge Modelng, Yolo Bypass





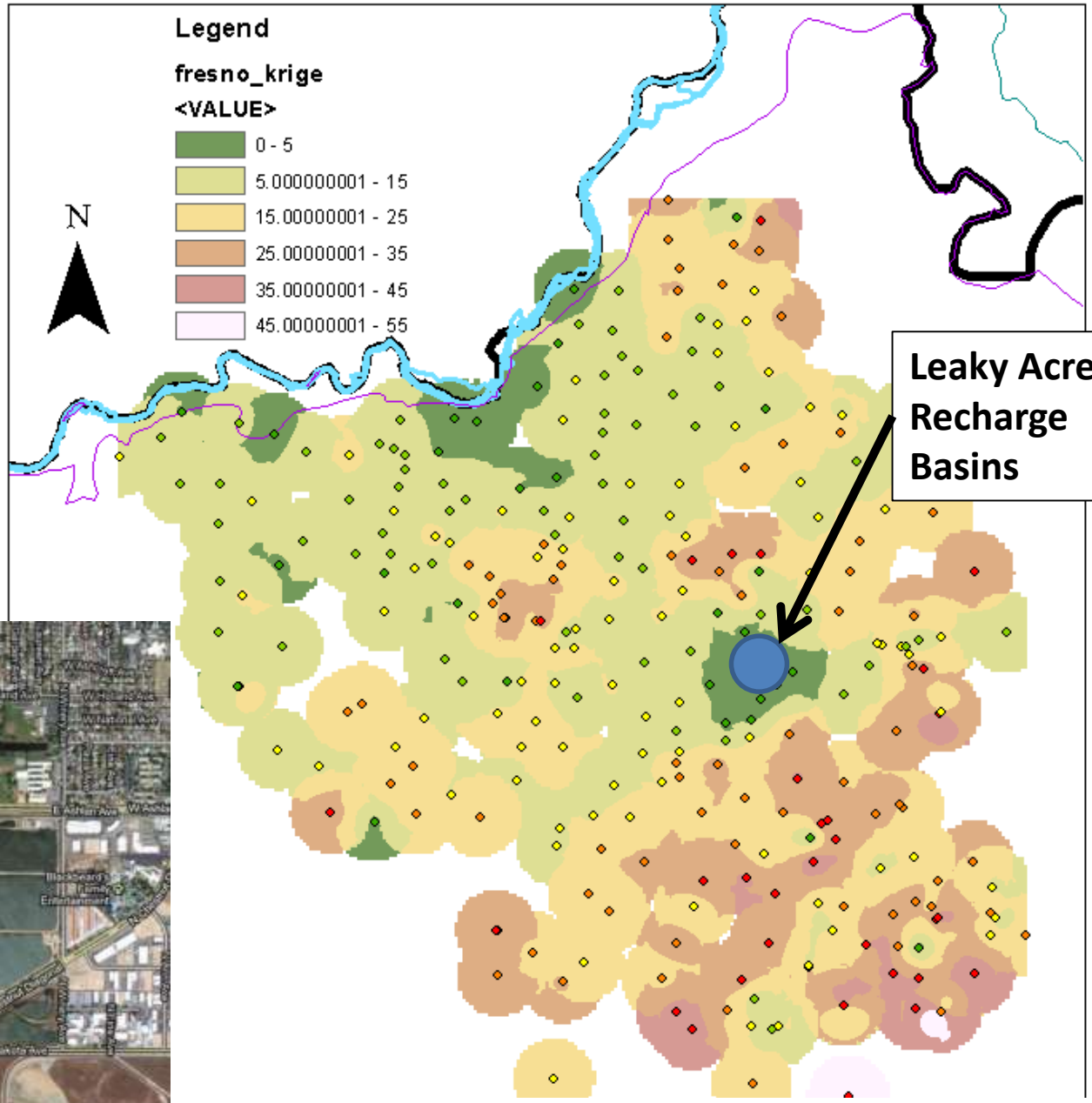
Historic Nitrate Trends, TLB: Exceedance Rate



Beneficial Effects of Clean Recharge (Fresno, CA area)

Work of Dylan Boyle

- Constructed in 1970
- 26 Ponds
- 200 Acres



Summary

- Proactive groundwater management, emphasizing winter recharge is key to CA water security.
- A reimagining of the CA water system and storage is plausible and possible.
- Winter irrigation of suitable lands and floodplain management are viable mechanisms for maximizing total system water storage and security.
- Increasing clean recharge is key for stabilizing and reversing groundwater quality declines.