Regional Scale Historical Simulation (1922-2003) of California's Central Valley Water Resources System Using C2VSIM

American Institute of Hydrology
Reno, Nevada
April 24, 2007

Charles Brush

Hydrology & Operations, Bay-Delta Office

California Department of Water Resources

Sacramento, CA

Acknowledgements

Tariq Kadir, Can Dogrul and Michael Moncrief
California Department of Water Resources

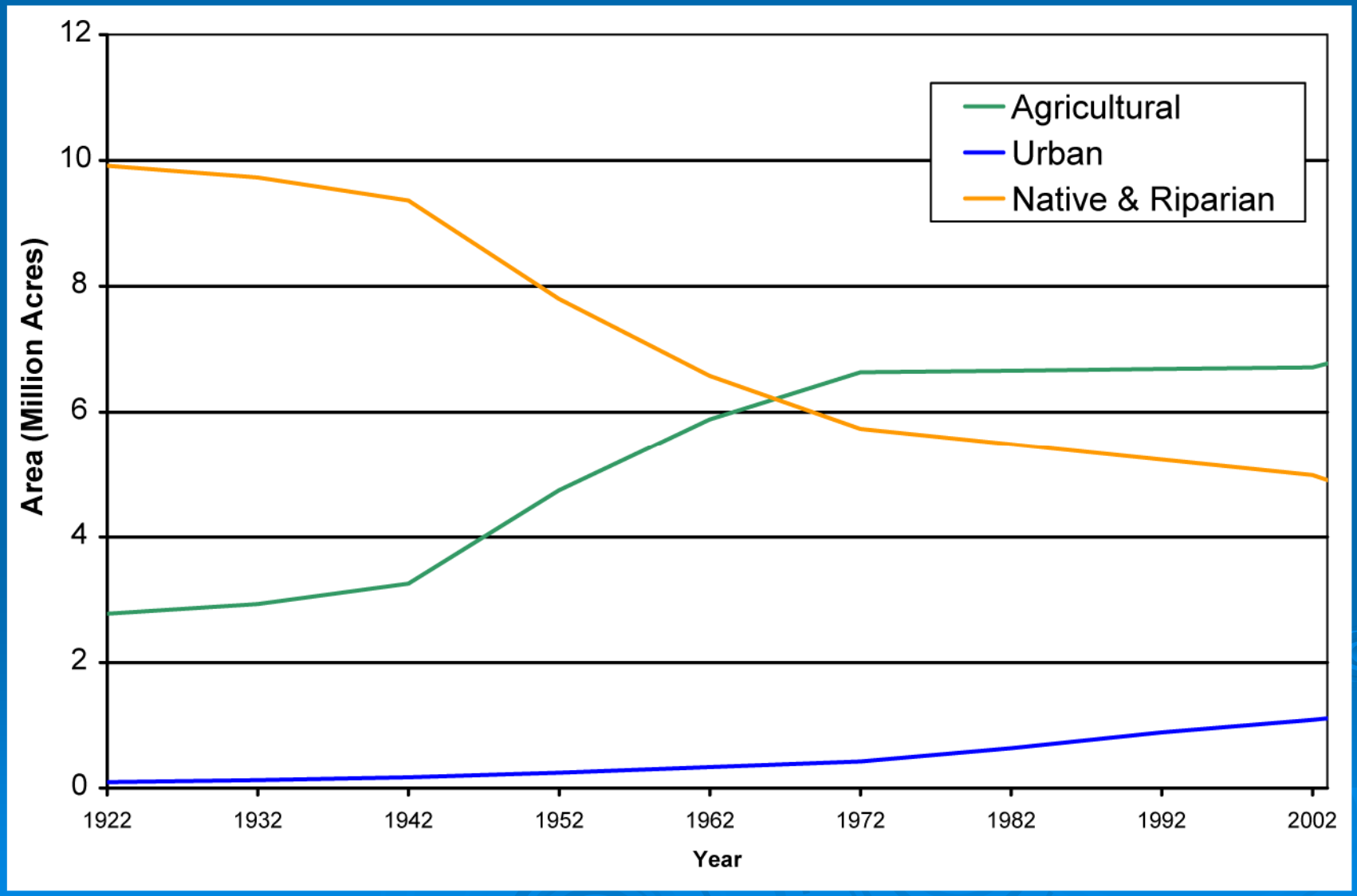
Steve Shultz and Dan Wendell
CH_2MHill

Matt Tonkin
SS Papadopolous & Associates

Outline

- Development of California's Central Valley
- Modeling Tools: IWFM and C2VSIM
- Model Overview
- Model Calibration
- Initial Conditions
- Boundary Conditions
- Selected Results
- Future Work

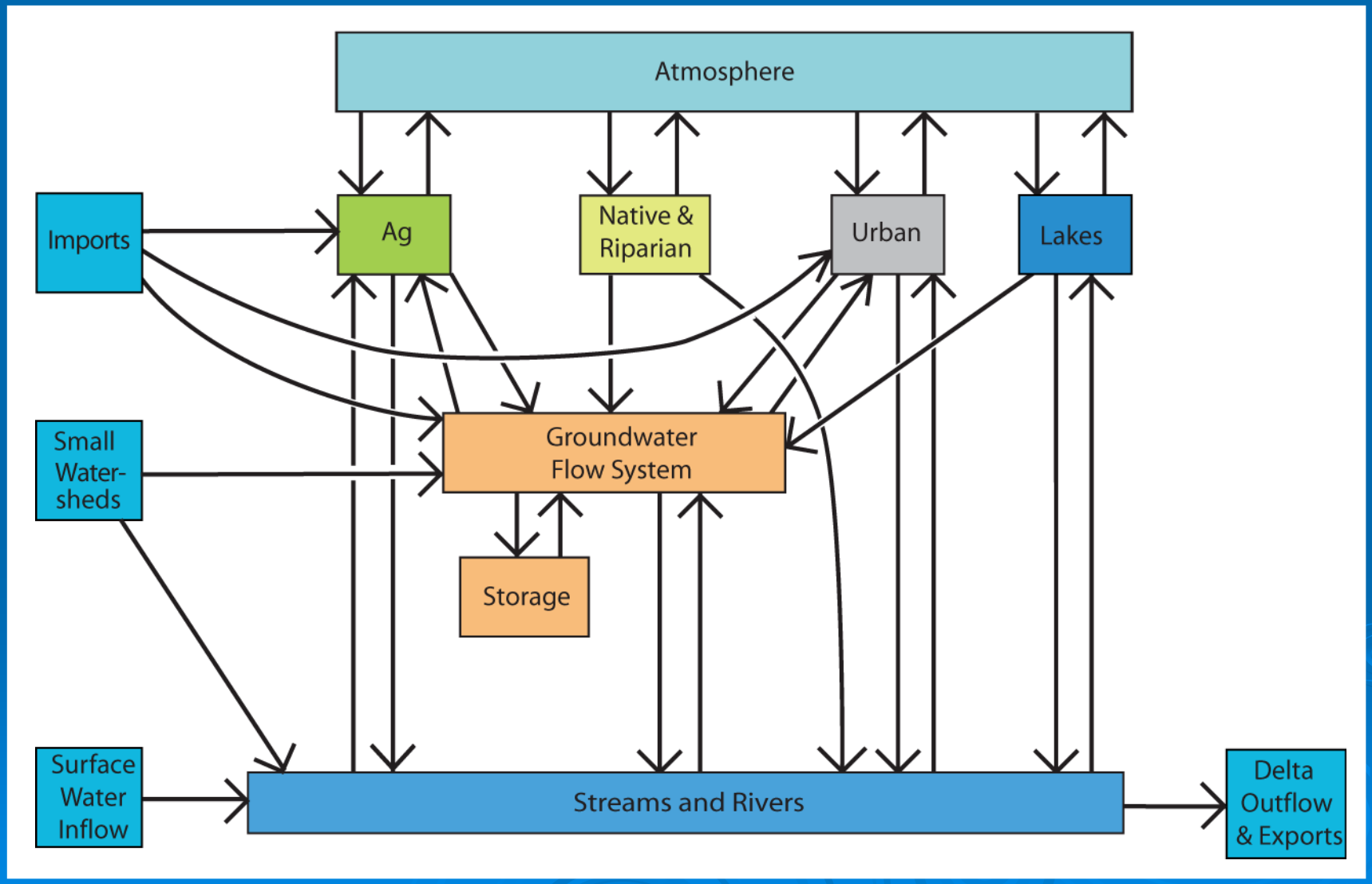
Historical Land Use



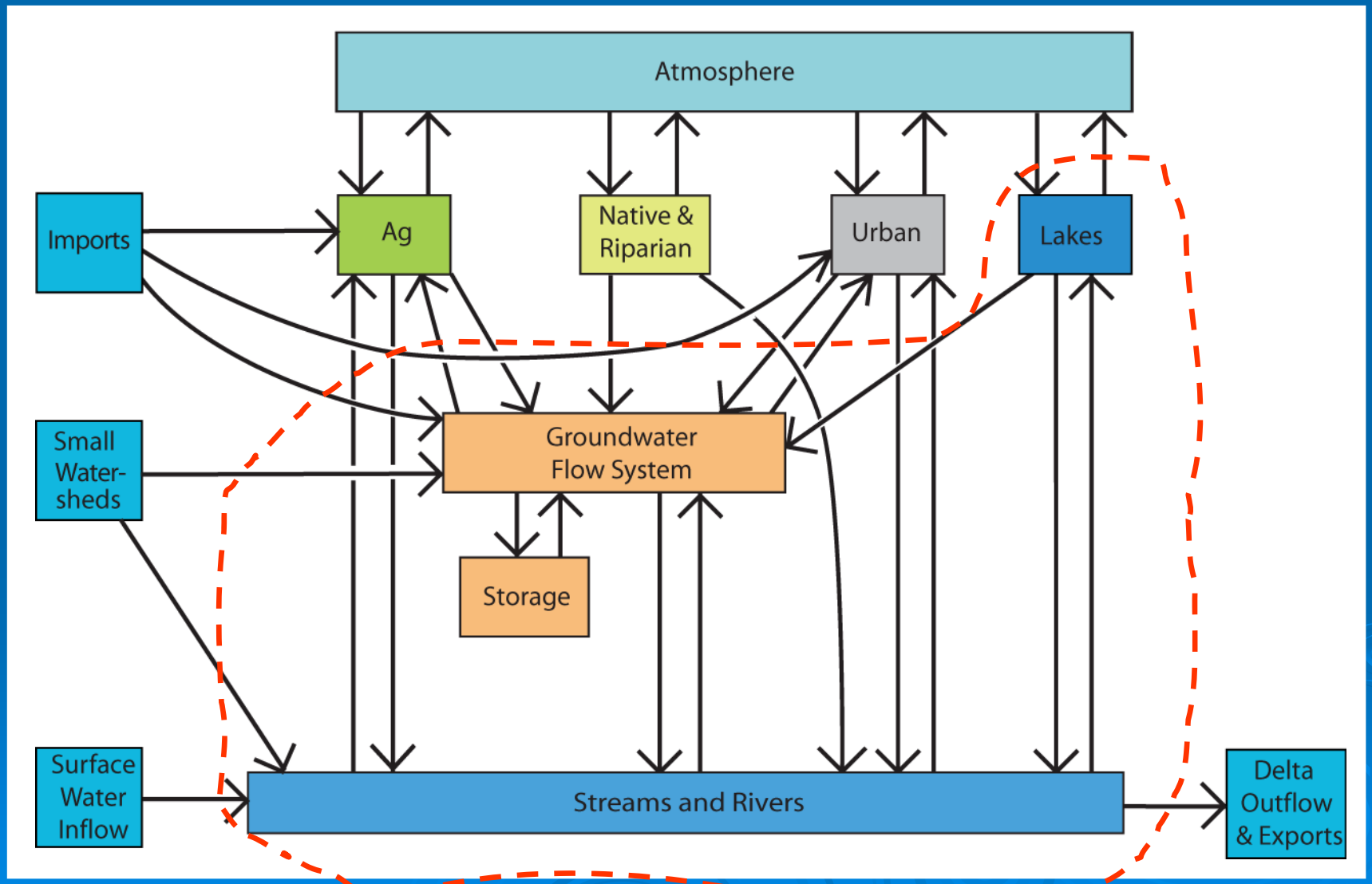
Central Valley Water Development

- 1850 - 1900 Introduction of agriculture
- 1890 - 1930 Local surface water projects
  - Ag expansion, re-purpose mining canals
- 1910 - 1970 Groundwater expansion
  - Ag follows electricity & population
- 1930 - 1980 Large surface water projects
- 1960 - 1990 Switch to surface water
  - Distribution system is completed
- 1980 - present Conjunctive use
  - Groundwater in dry years

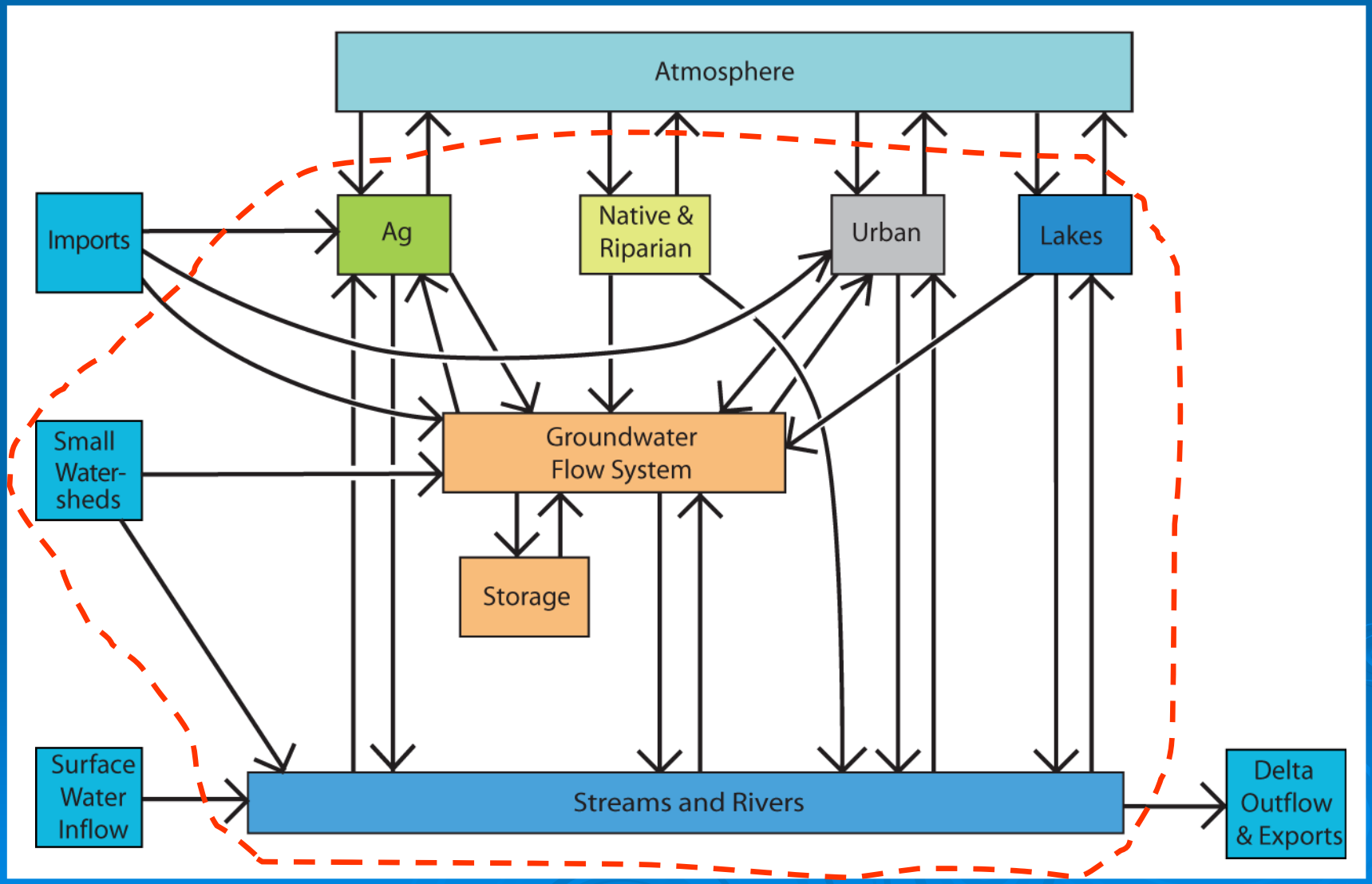
Groundwater Model Components



Groundwater Model Components



Integrated Model Components



IWFM - Integrated Water Flow Model

- Components
  - Groundwater Flow Process
    - Finite Element Grid
    - Saturated and unsaturated flow
  - Land Surface Process
    - Precipitation and Evapotranspiration
    - Land Type and Crop Acreages
    - Irrigation with Surface Water & Groundwater
  - Surface Water Processes
    - Streamflow routing
    - Lakes
    - Surface Water Diversions
  - Inflows from Ungaged Boundary Watersheds
- Outputs:
  - Water Budget Components
  - Estimated Groundwater Pumping

Groundwater Model Components

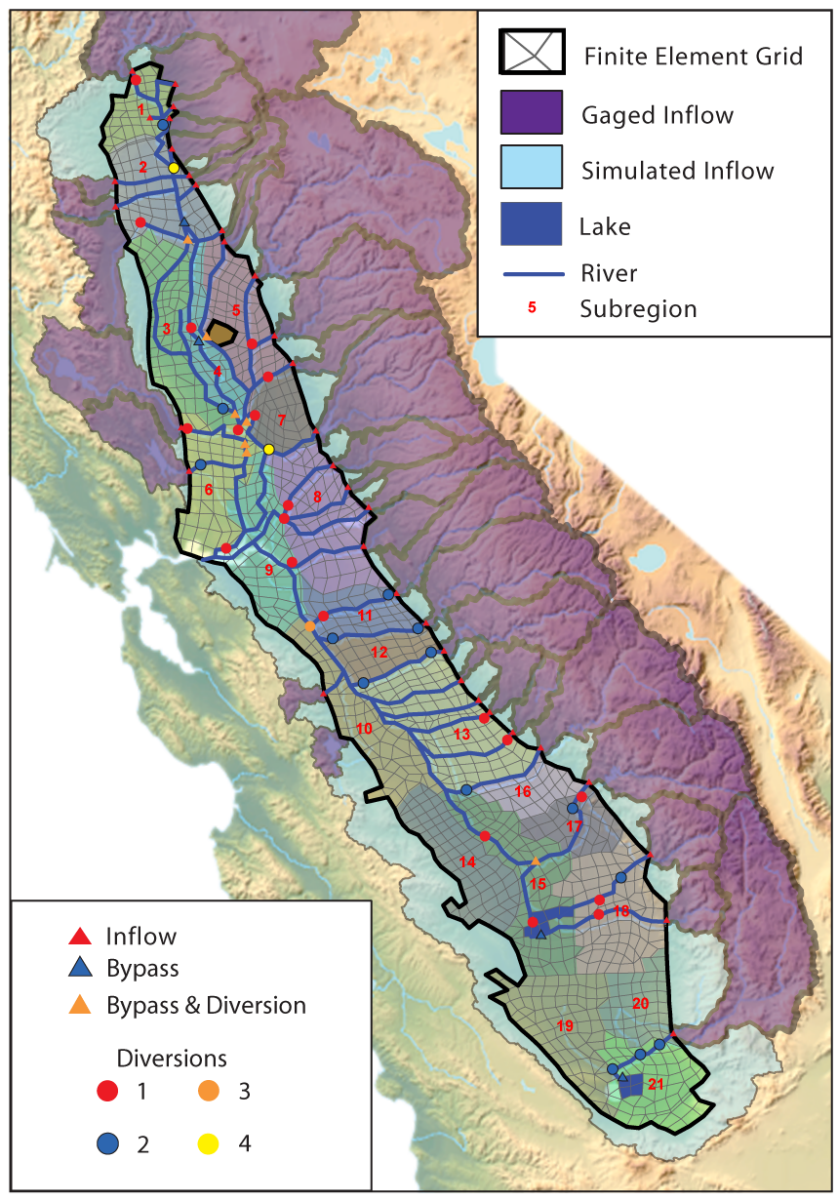
Component	Source
Parameters	calibration: 1972-2003
Initial conditions	water-level observations, 10/1921
Boundary conditions	IWFM water budget requires: - Precipitation and evapotranspiration - Land use acreages & populations - Crop coefficients - Soil type, SCS curve number - Surface water diversions - Pump locations (well database)

C2VSIM Model Grid

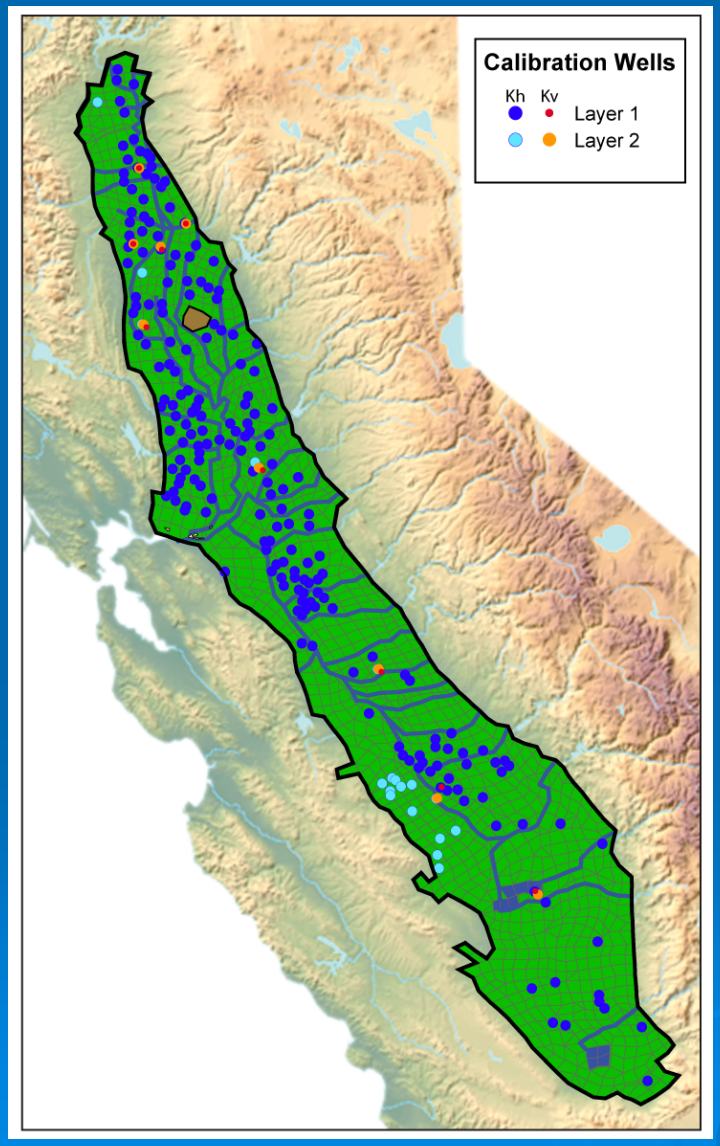
Finite Element Grid
- 3 layers
- 1393 nodes
- 1392 elements

Surface Water System
- 72 stream reaches
- 97 surface water diversion points
- 2 lakes
- 8 bypass canals

Land Use Process
- 21 subregions
- 4 Land Use Types
  - Agriculture
  - Urban
  - Native
  - Riparian

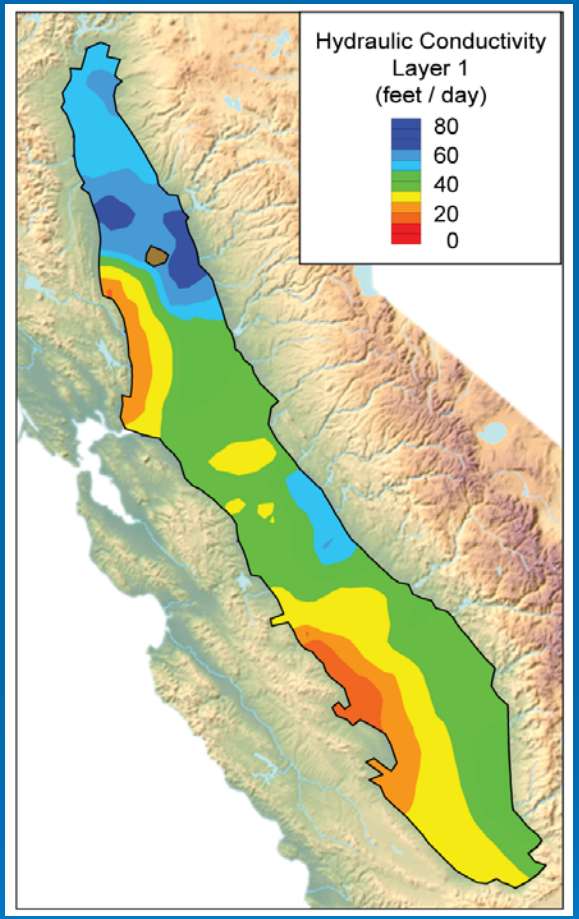


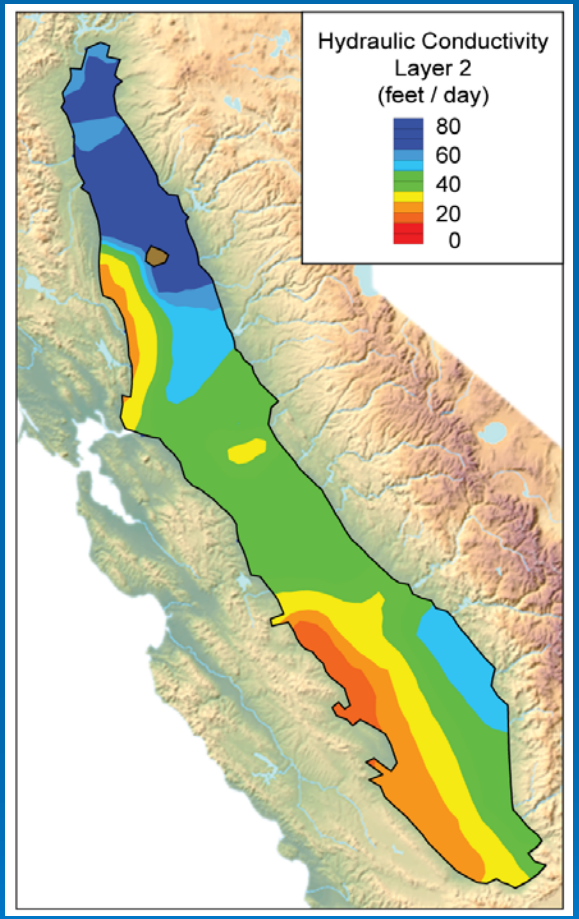
C2VSIM Calibration

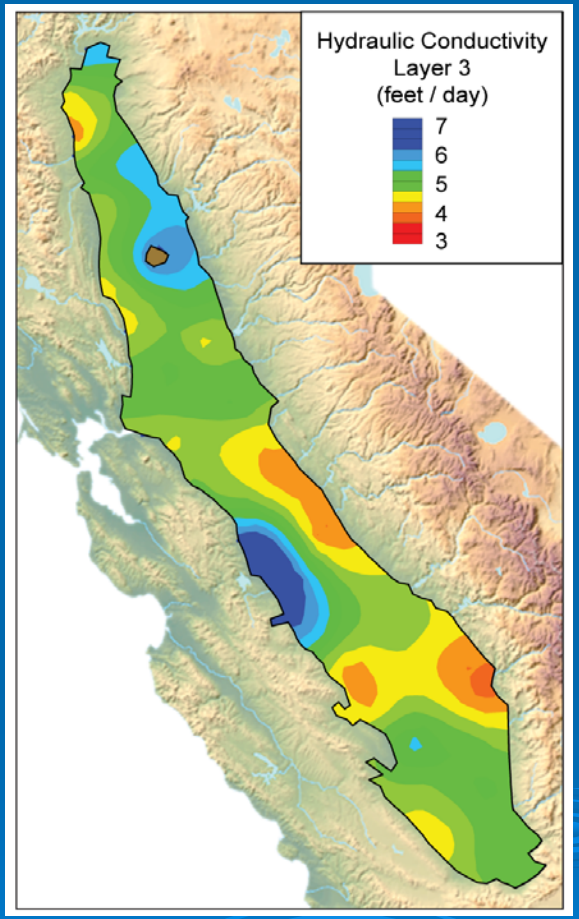


- Water Years 1972-2003
- PEST & regional pilot points
- 1976 head maps, layers 1 & 2
- Head observations at 221 wells
  - Single screen coincides with model layering
  - Measurements 1977-1997
  - No more than one well per model element
- Vertical head gradients at 9 locations
- Average stream accretions and depletions
- Parameters: K_h, K_v, K_s, S_y , S_s

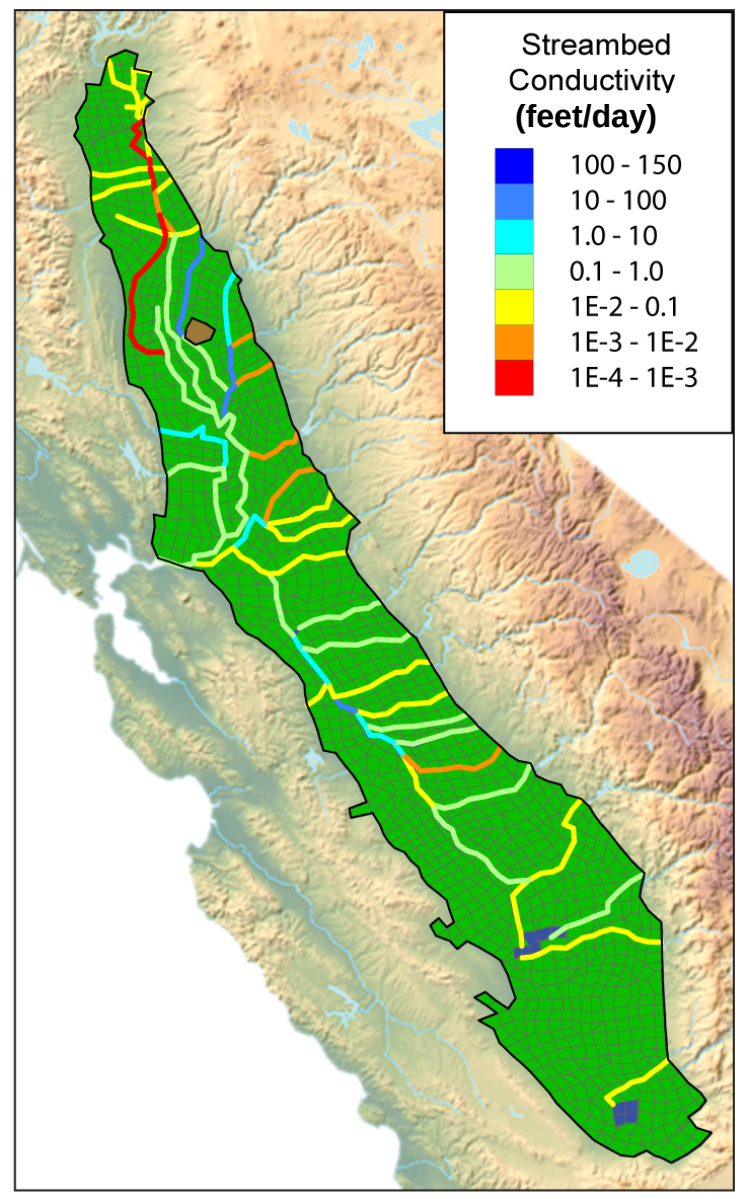
Hydraulic Conductivity



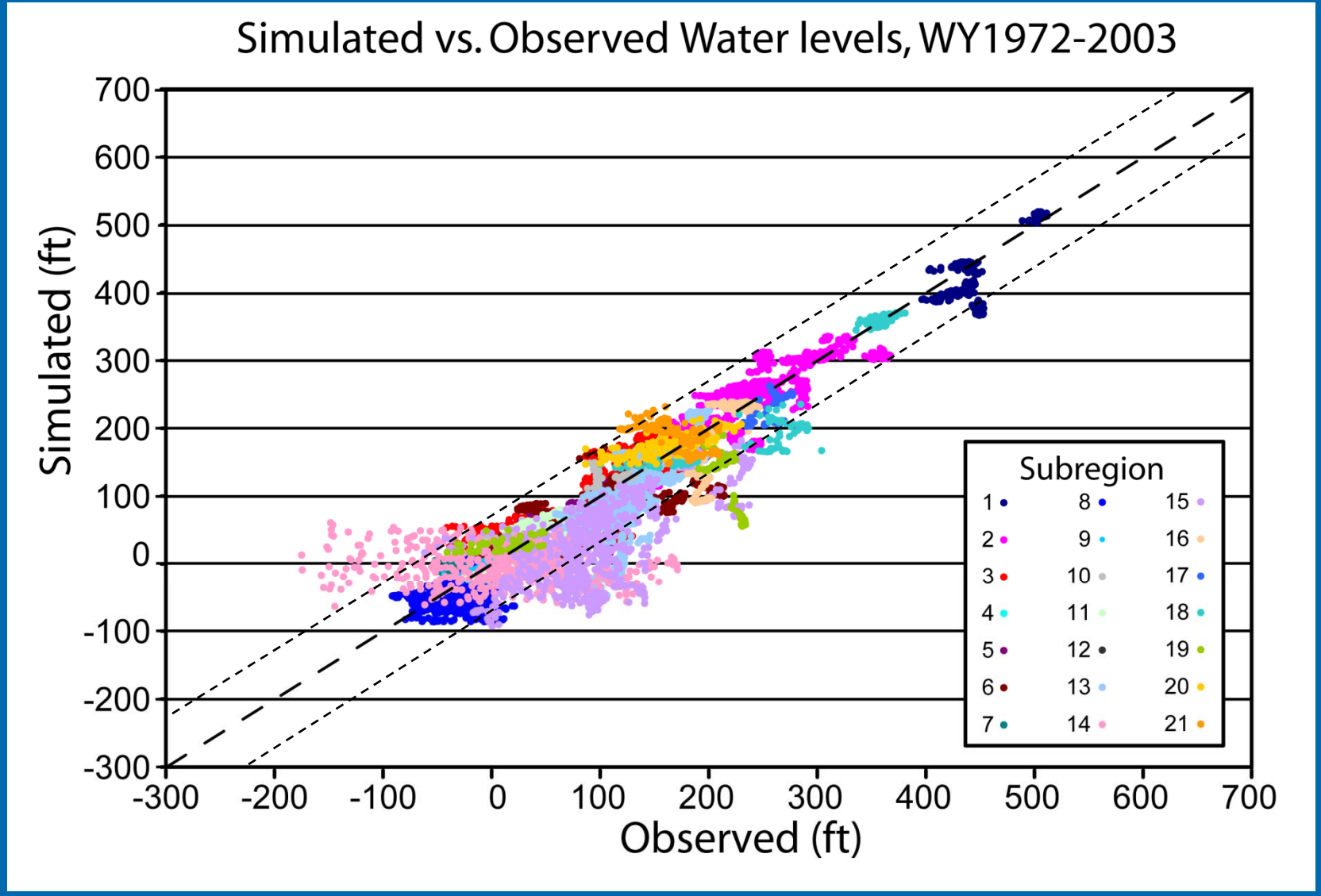




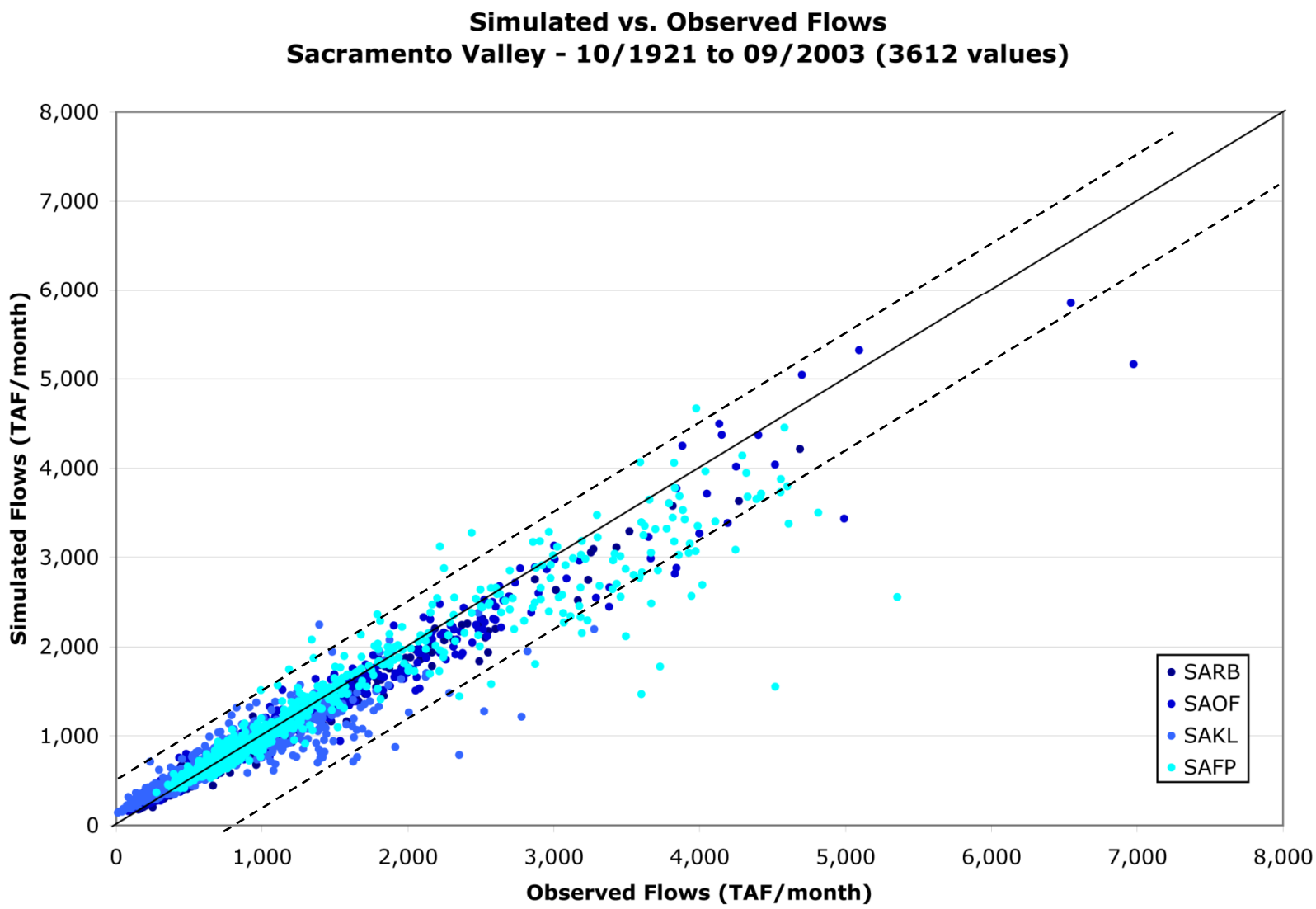
Streambed Conductance



Calibration Results - Heads



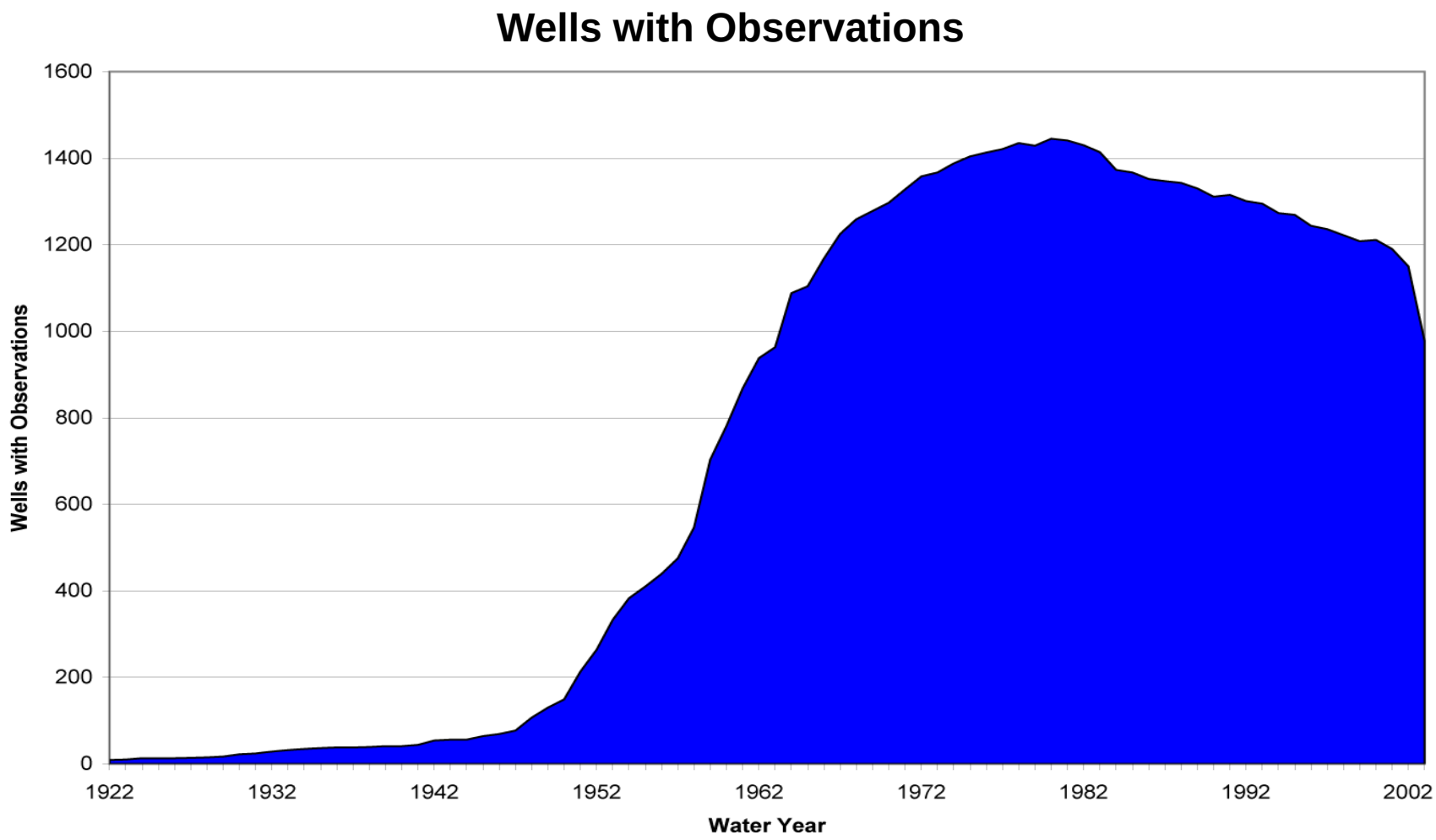
Calibration Results - Flows



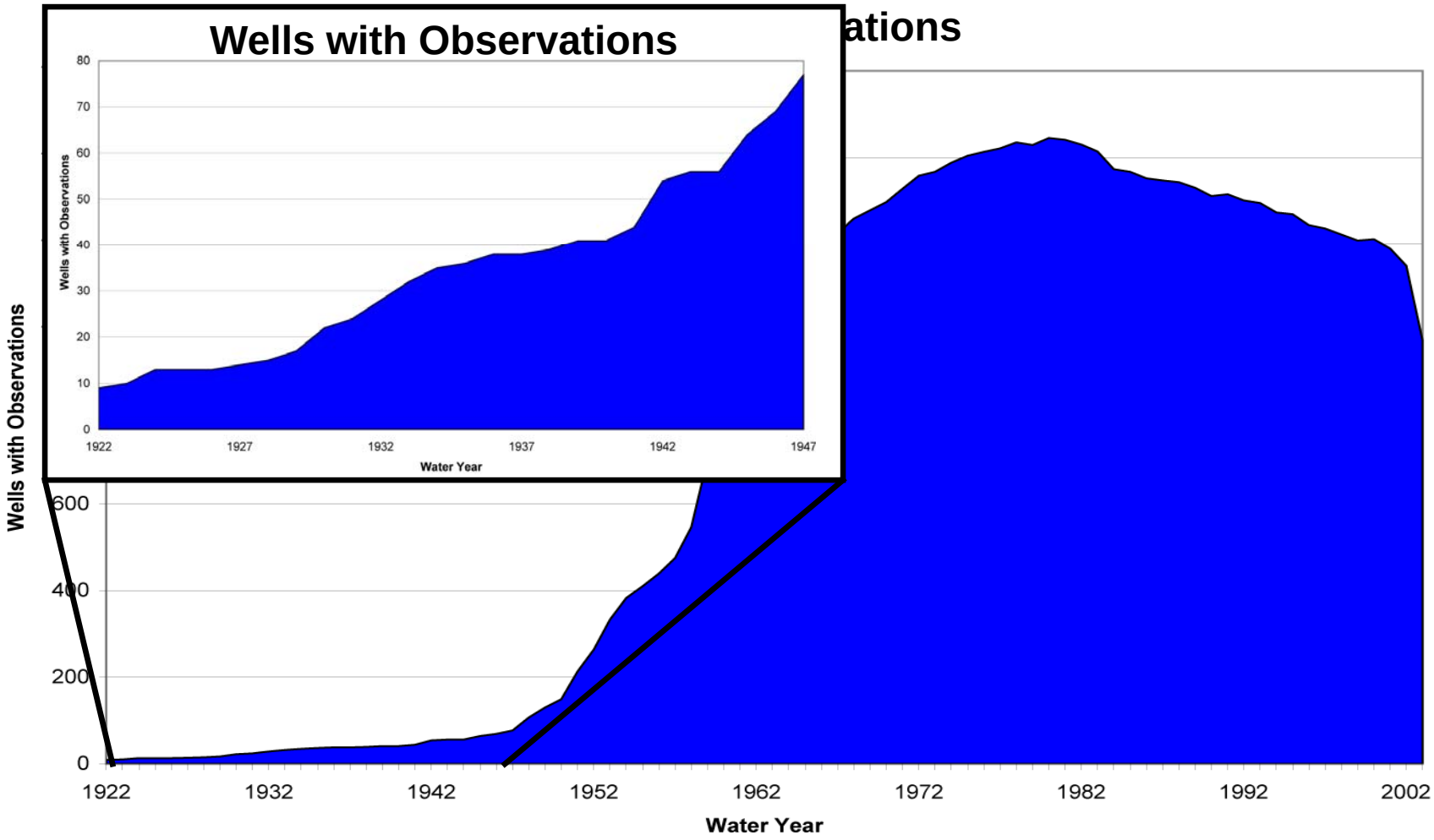
Initial Conditions

- Objective:
  - October 1, 1921 heads at all model nodes
- Problem:
  - Very few head observations
- Solution:
  - Hand-contoured October 1921 water level map
  - Use assumed pre-development gradients
  - Revise initial heads to replicate later observations

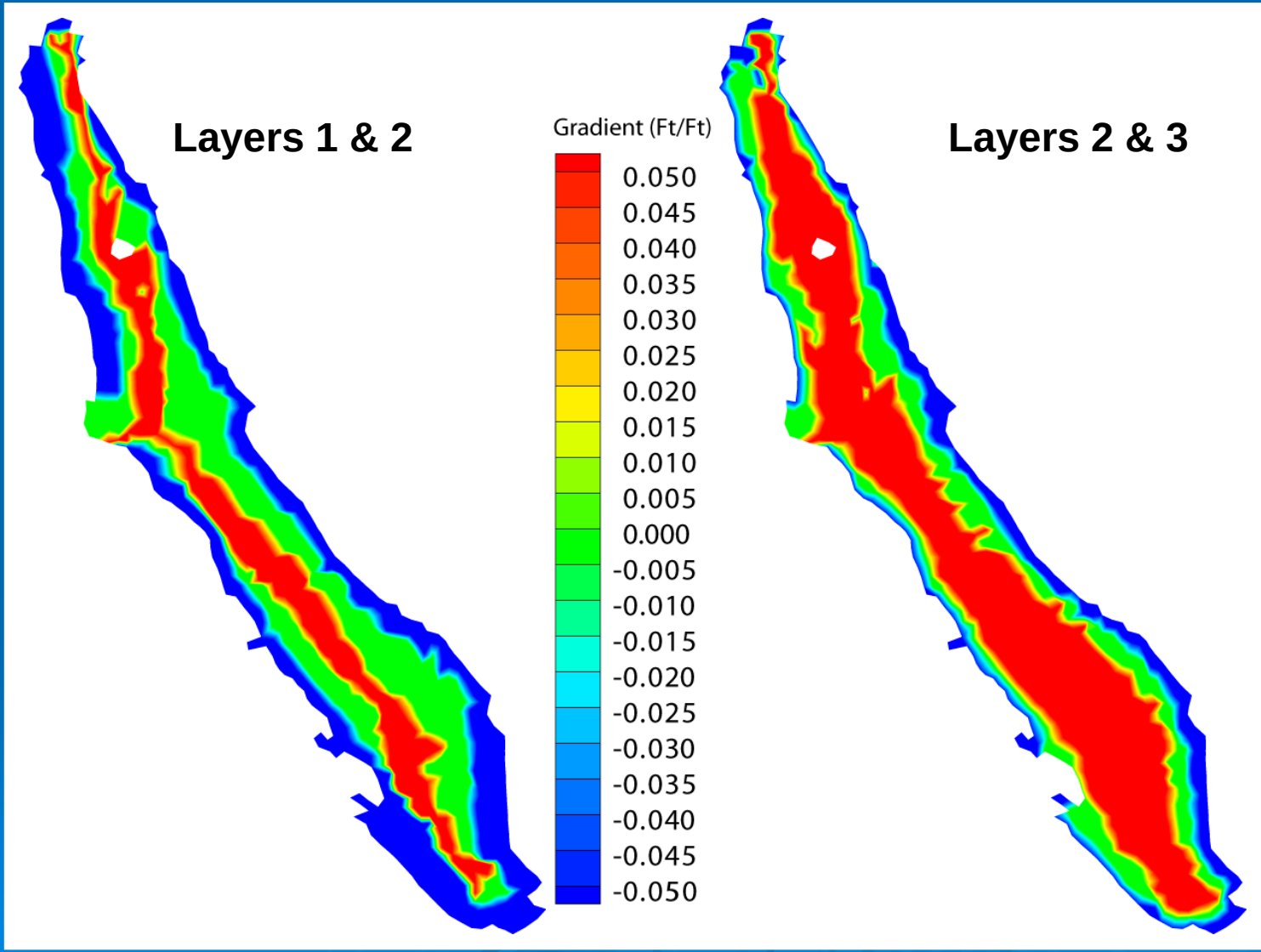
Head Observations



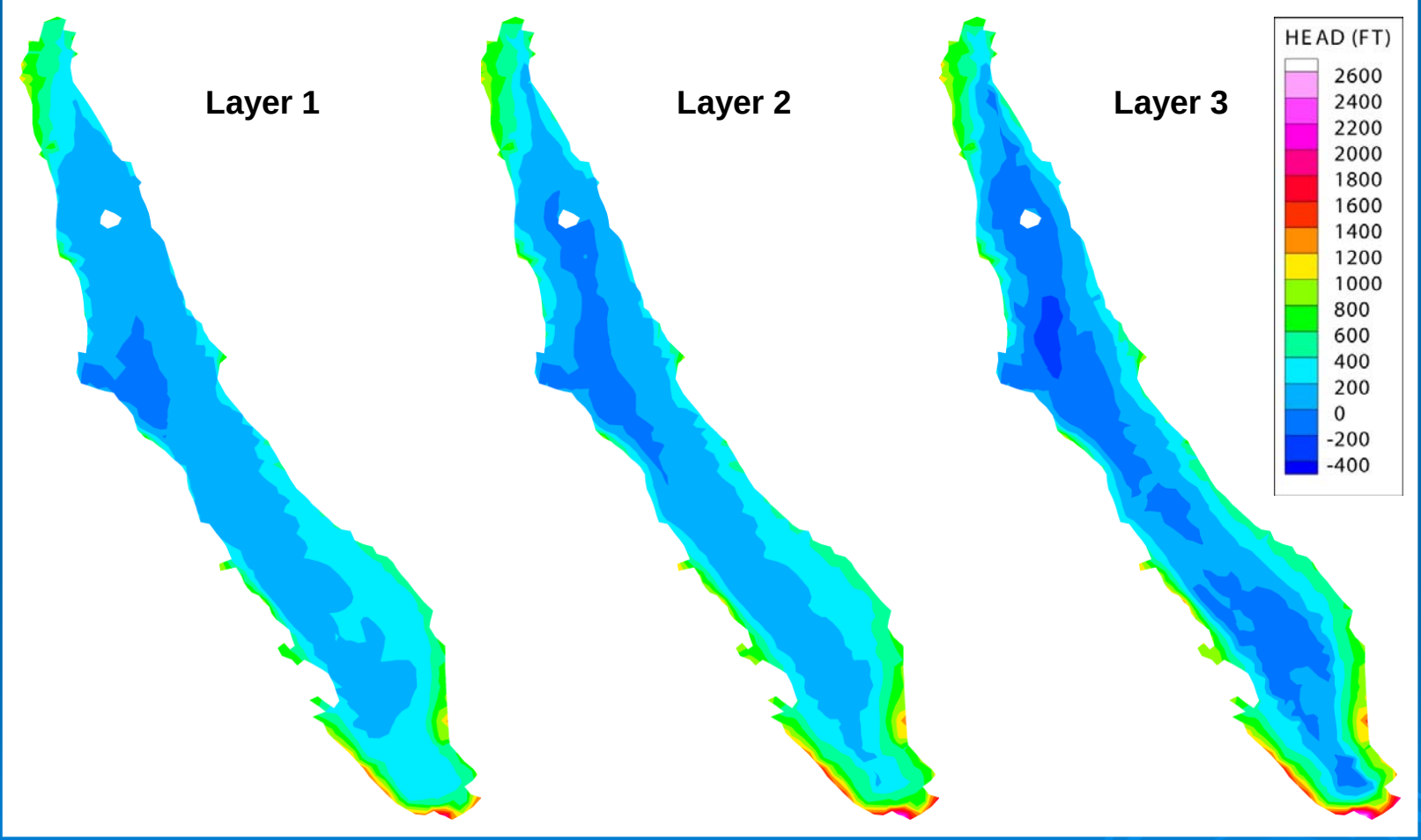
Head Observations



Assumed Head Gradients, October 1921



Initial Heads, October 1921



Boundary Conditions - IWFM

Input Data

Precipitation

Evapotranspiration

Land use & crop acreages

Surface water inflows

Surface water diversions

Parameters

Pumping distribution

Crops: K_c, rooting depth

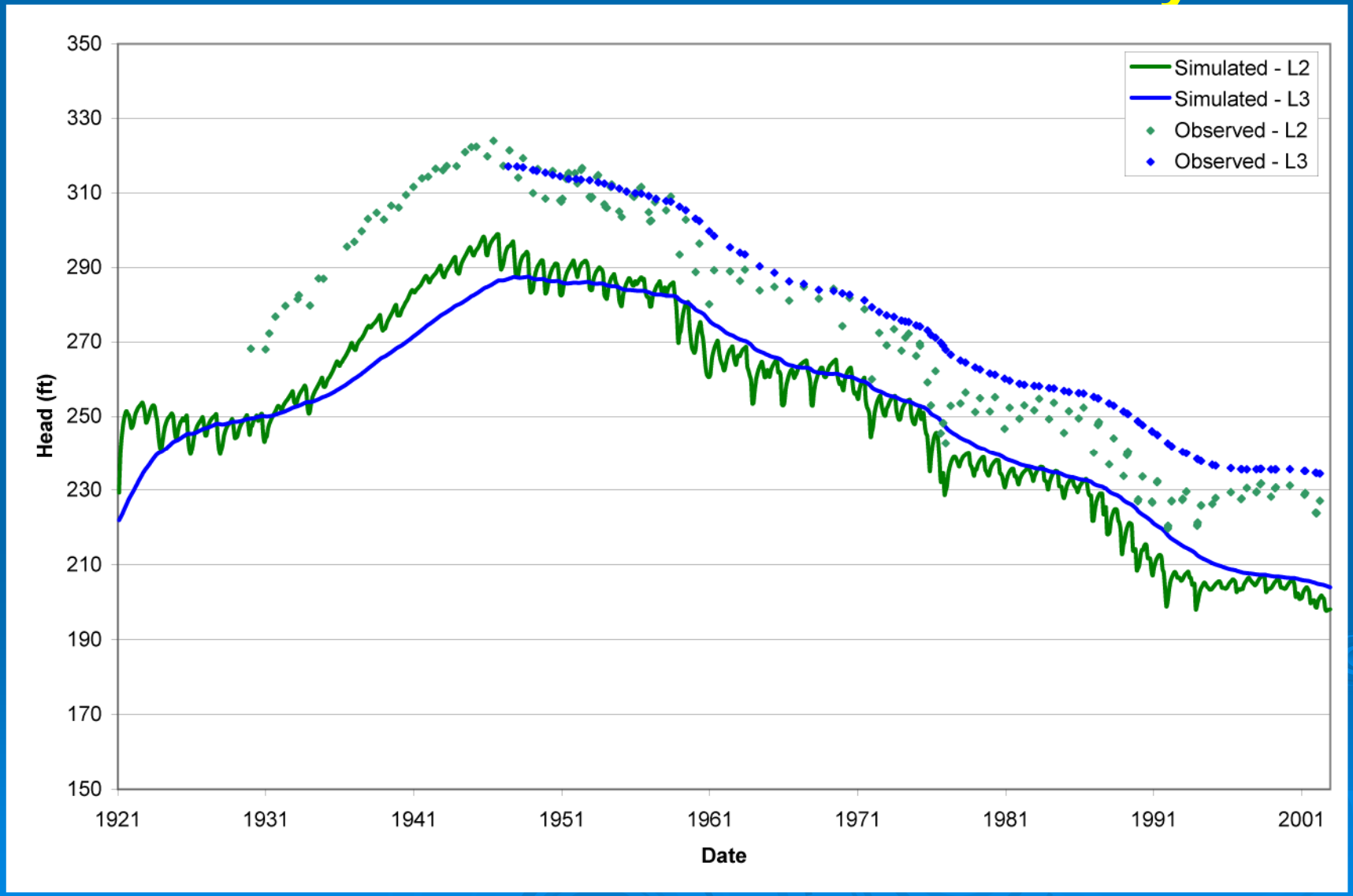
Soils: curve number, K_h

Output

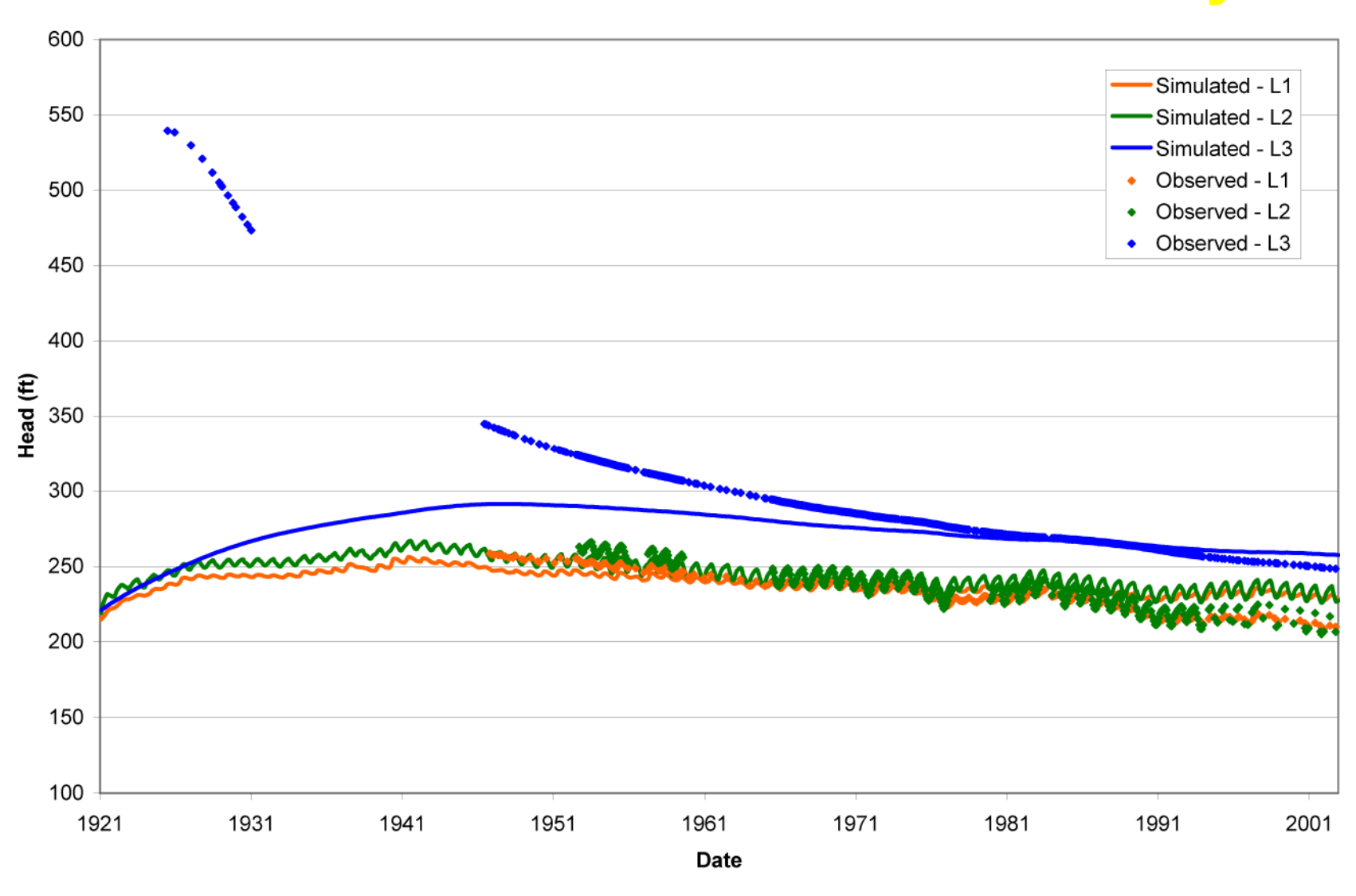
Detailed budgets including:

- Recharge to water table
- Crop water use
- Surface water flows
- Surface water-Groundwater interaction
- Groundwater pumping
- Small watershed inputs

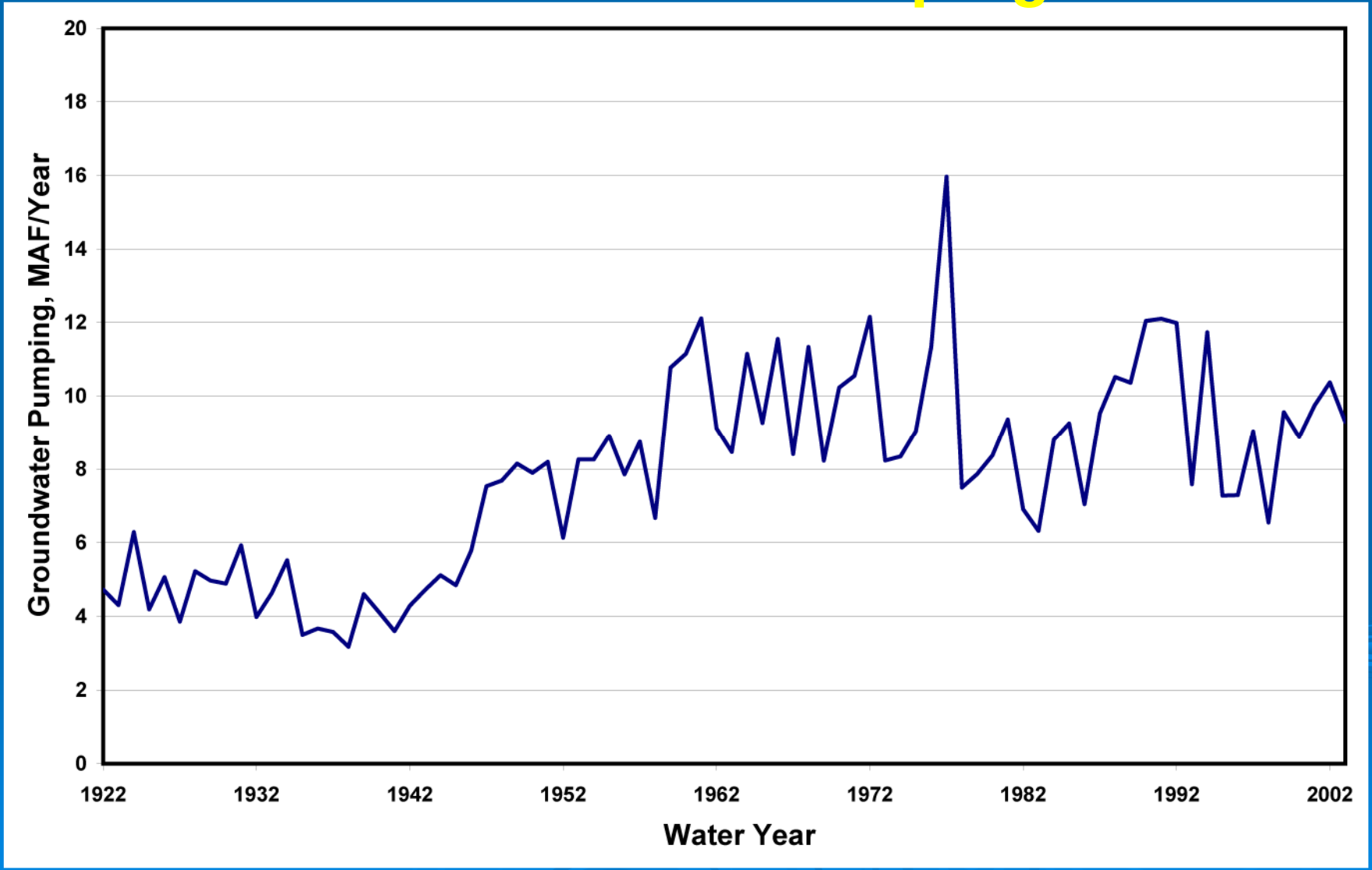
Heads in Eastern Fresno County



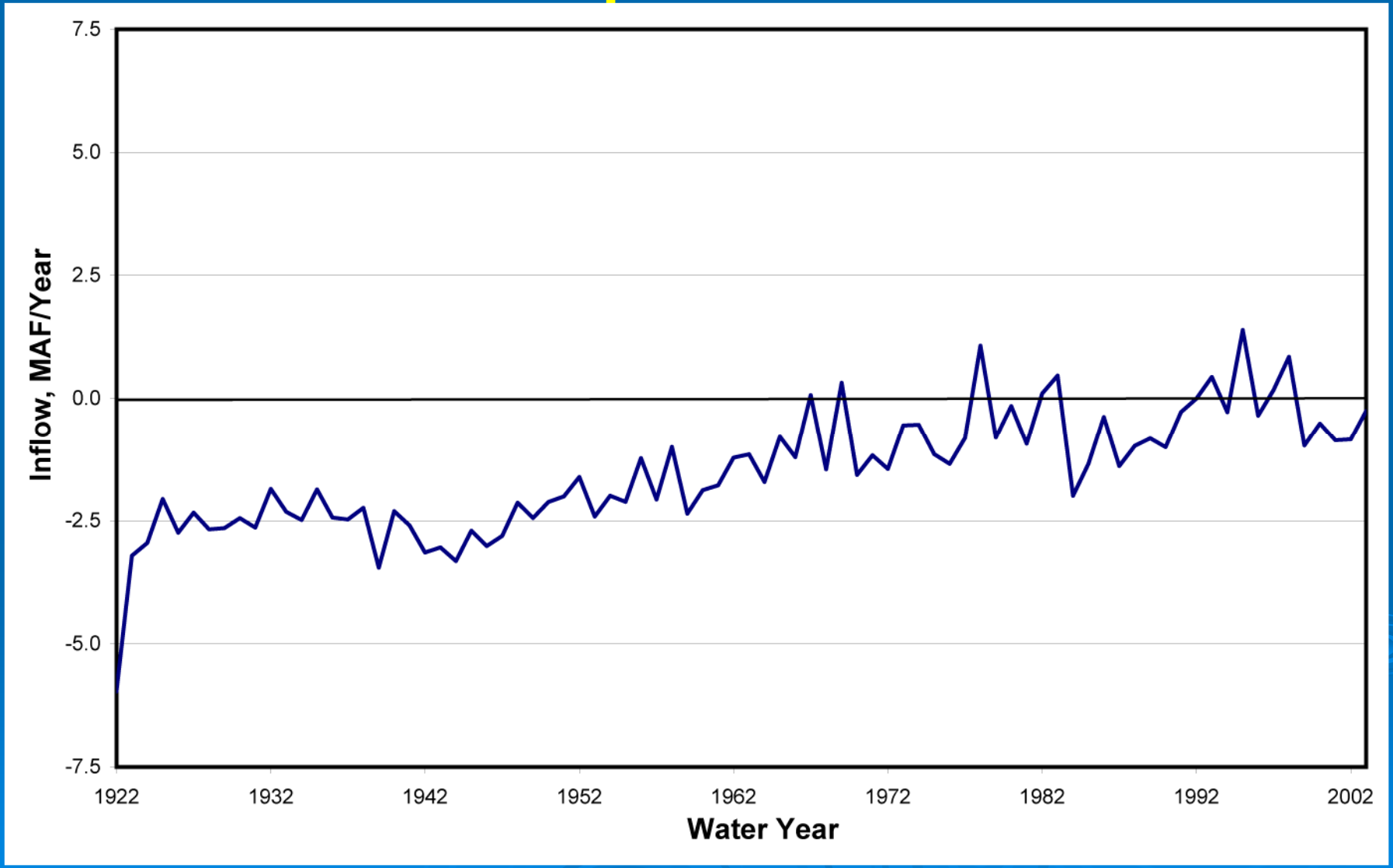
Results – Heads in Tehama County



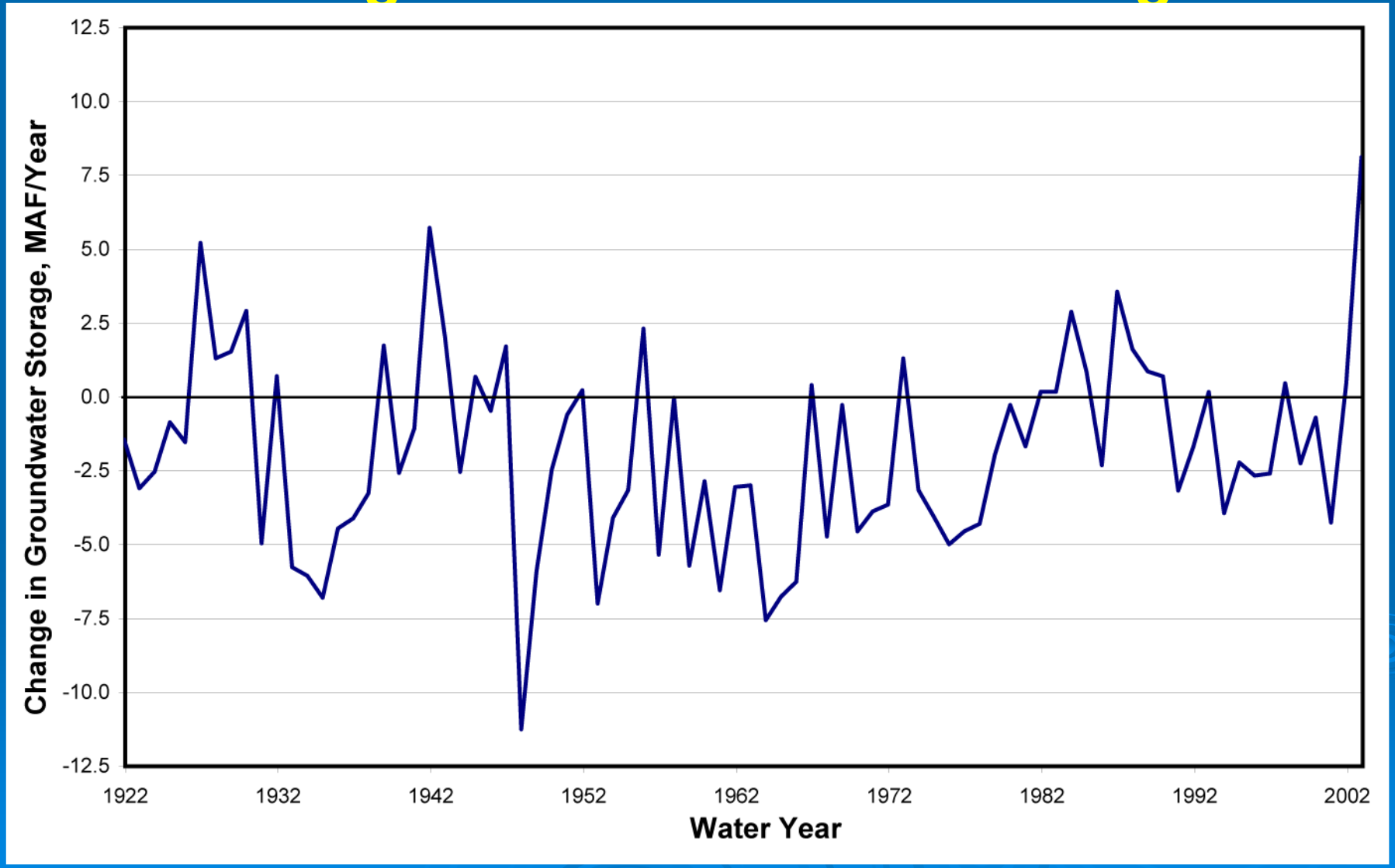
Groundwater Pumping



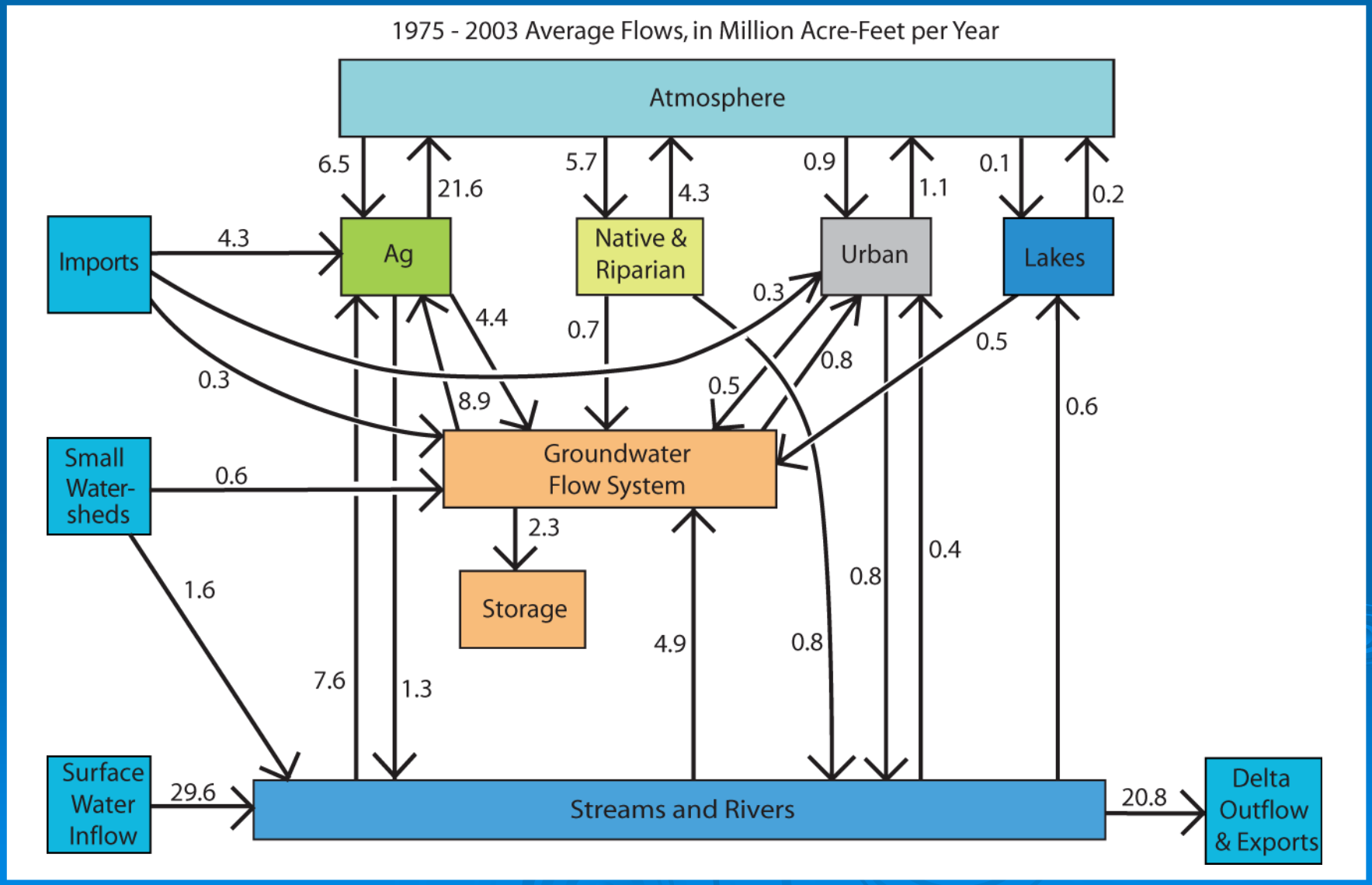
Stream-Aquifer Interaction



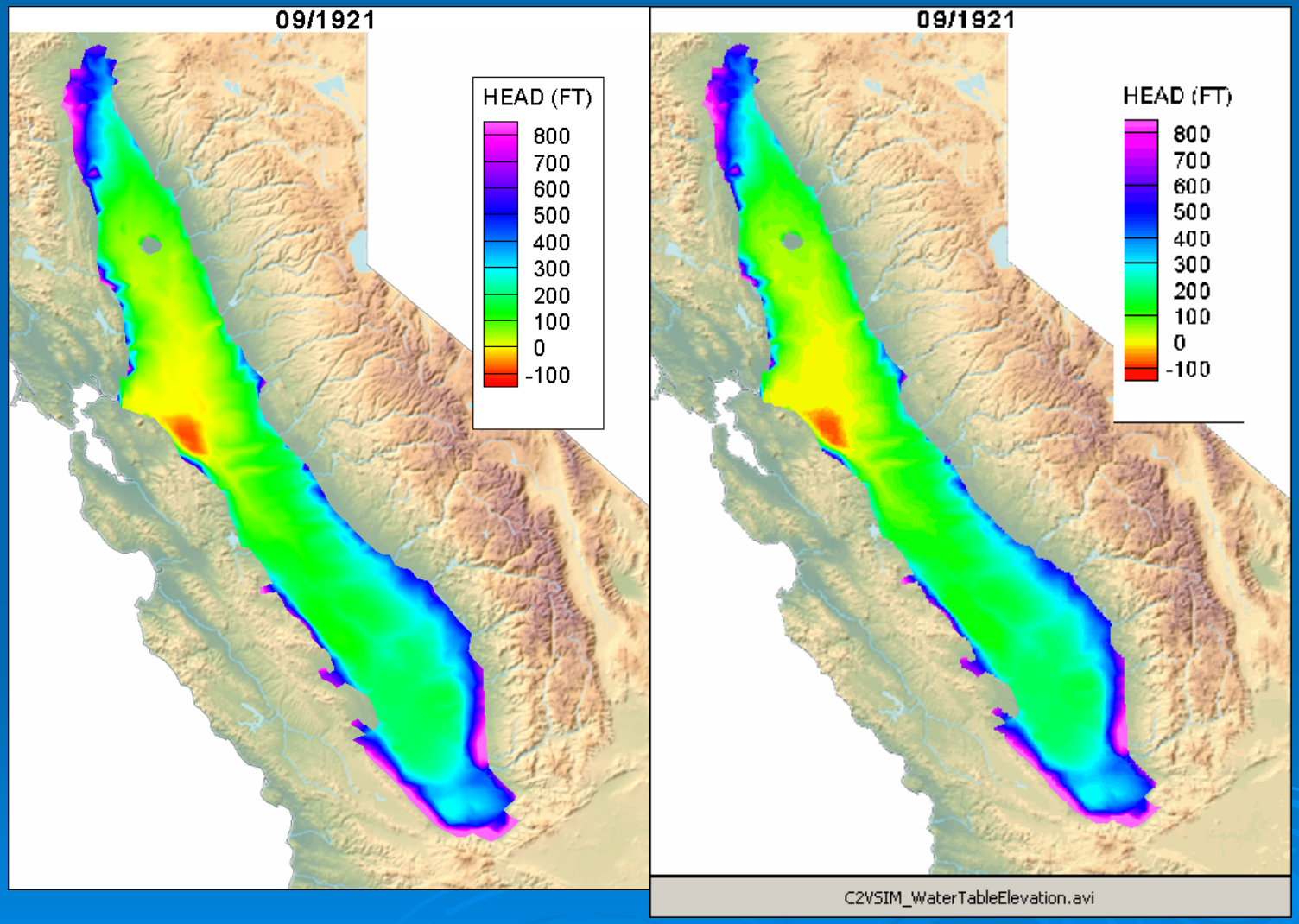
Change in Groundwater Storage



Water Budget



Future Work

- Refine local calibration & water budgets
  - Modify initial heads to match simulated heads
  - Increase accretions-depletions data set
  - Calibrate small watershed parameters
  - Modify pumping distribution (spatial and vertical)
- High wet-season diversions (refuges?)
- Crop ET looks high in some areas

Animation of Water Table Altitude