C2VSIM Calibration

Key Features and Current Status

November 30, 2006

Charles Brush, Can Dogrul and Tariq Kadir
Hydrology & Operations, Bay-Delta Office
California Department of Water Resources

Outline

- History of C2VSIM
- Model overview
- Calibration progress

C2VSIM History

- 1990 – Enhance IGSM & create CVGSM (1921-1980)
- 1996 – Update CVGSM to (1921-1993)
- 2000 – Multiple versions of IGSM & applications
- 2001 – CWEMF peer review of IGSM
- 2002 – DWR synthesis to IGSM2
- 2005 – IWFM and C2VSIM
- 2005 – C2VSIM integration with CALSIM-III
- 2005 – C2VSIM calibration

2005 – C2VSIM and CALSIM-III

- Objective:

  Incorporate C2VSIM groundwater flow model results into the CALSIM-III reservoir simulation model.

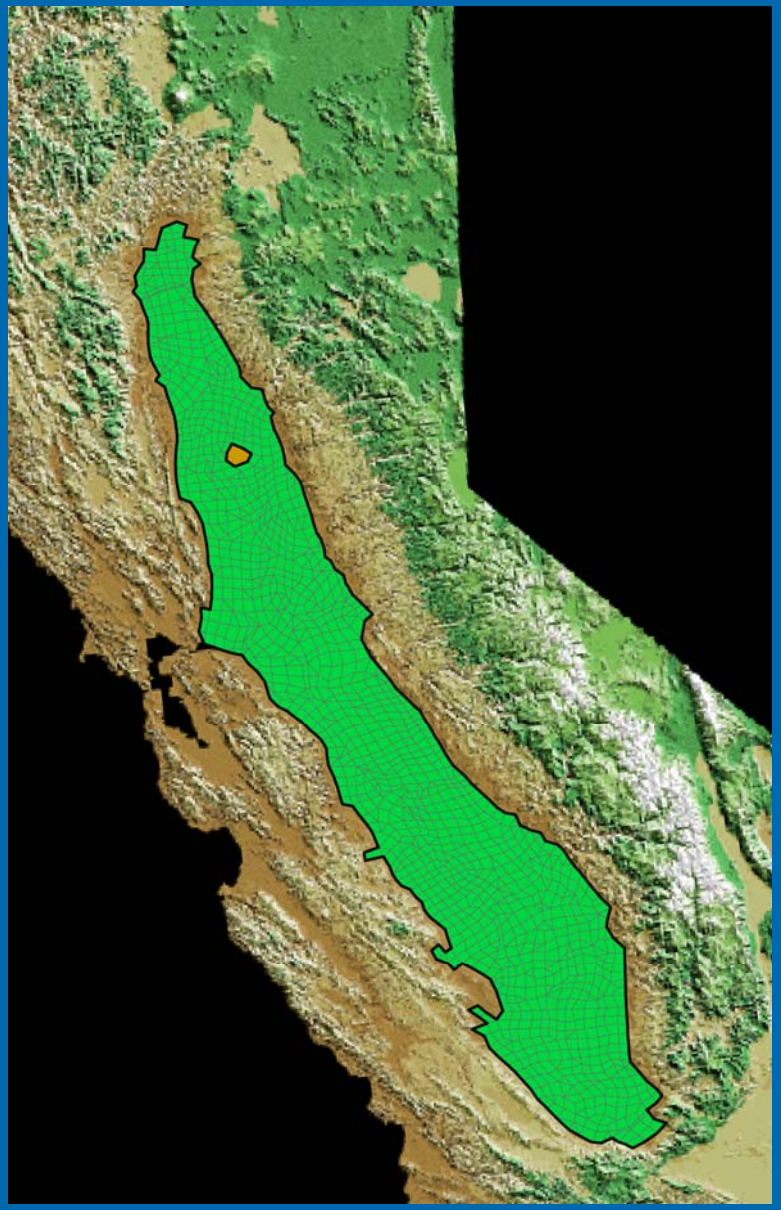
  Consistent model framework with monthly time steps 1921-2003
- IWFM Demand Calculator:
  - Separation of the surficial processes from IWFM to a stand-alone application to generate water budgets for CALSIM-III
- Linear Response Functions:
  - Development of response functions that approximate the stream-aquifer response to specified pumping rates.

C2VSIM Boundaries and Grid

Appx. 20,000 mi^2

1393 nodes
1392 elements

3 layers



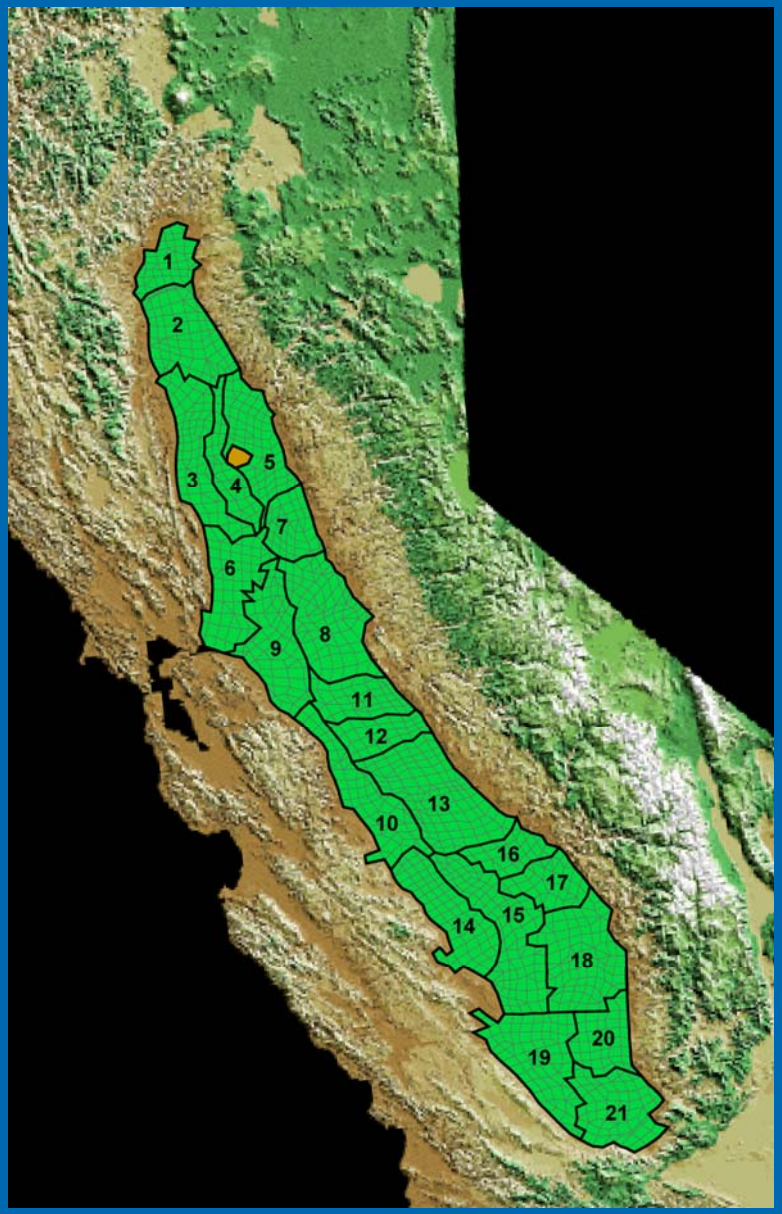
C2VSIM Land Use Process

21 subregions

- Correspond to DWR/USBR DSAs (Detailed Study Areas)

Land Use Types

- Agriculture
- Urban
- Native
- Riparian

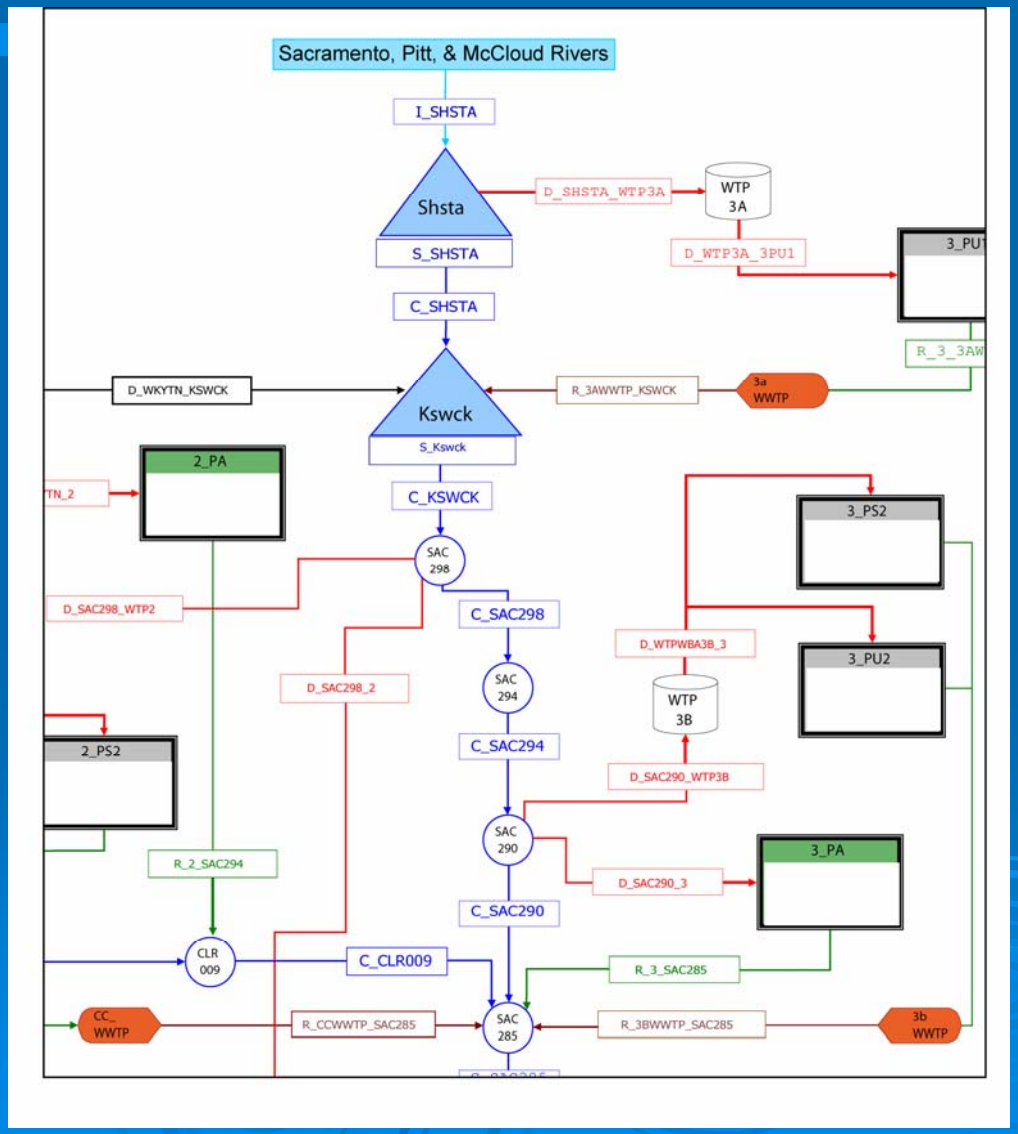


C2VSIM calibration

- Objective:

  Calibrate the groundwater flow model for use with CALSIM-III.
- Development Team:
  - Dan Wendell and Steve Schultz, CH_2MHill
  - Matt Tonkin, SS Papadopolous & Associates
- Process:
  - Phase 1: PEST tools, spring 2005
  - Phase 2:
    - A. Conceptual model update from CVGSM
    - B. Regional calibration for WY 1972-2003

C2VSIM and CALSIM-III



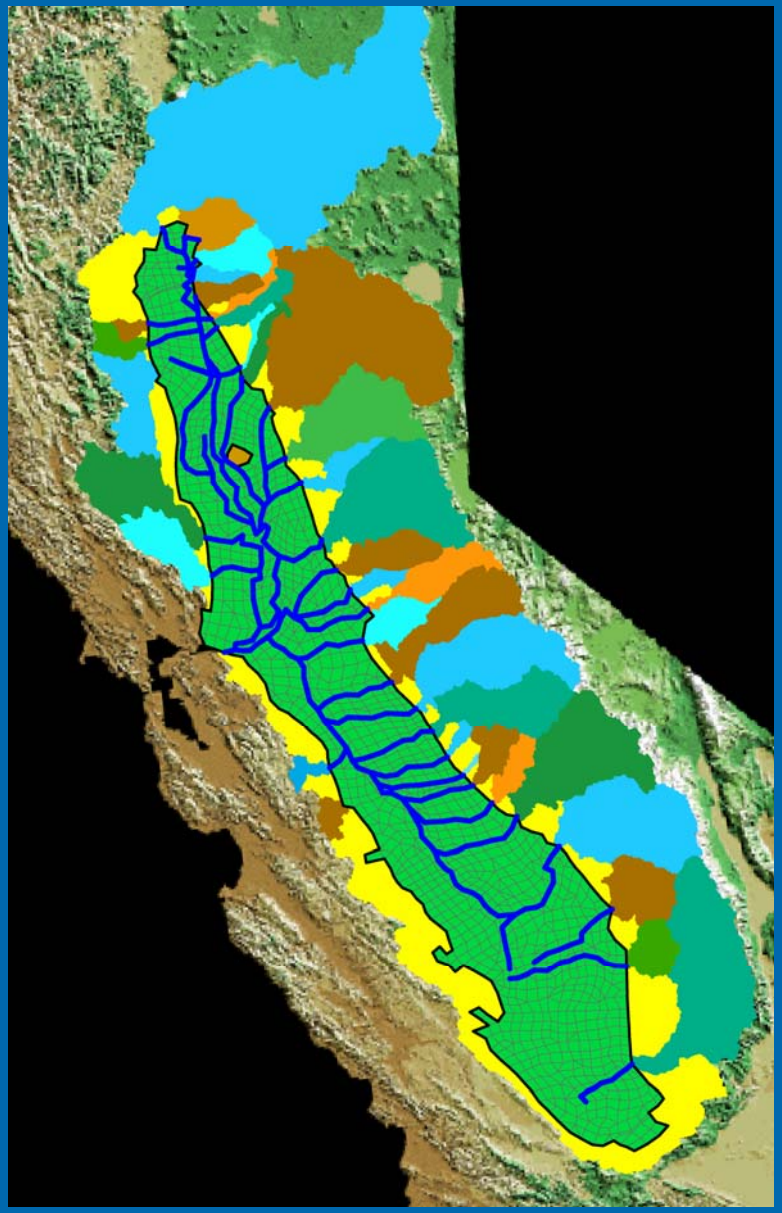
C2VSIM calibration

Update Conceptual Model

- Small watershed delineation
- Precipitation data and stations
- Layering
- Initial heads (10/1972)
- Stream-bed elevations
- Uniform Curve Numbers (rainfall runoff)
- Agricultural root-zone process

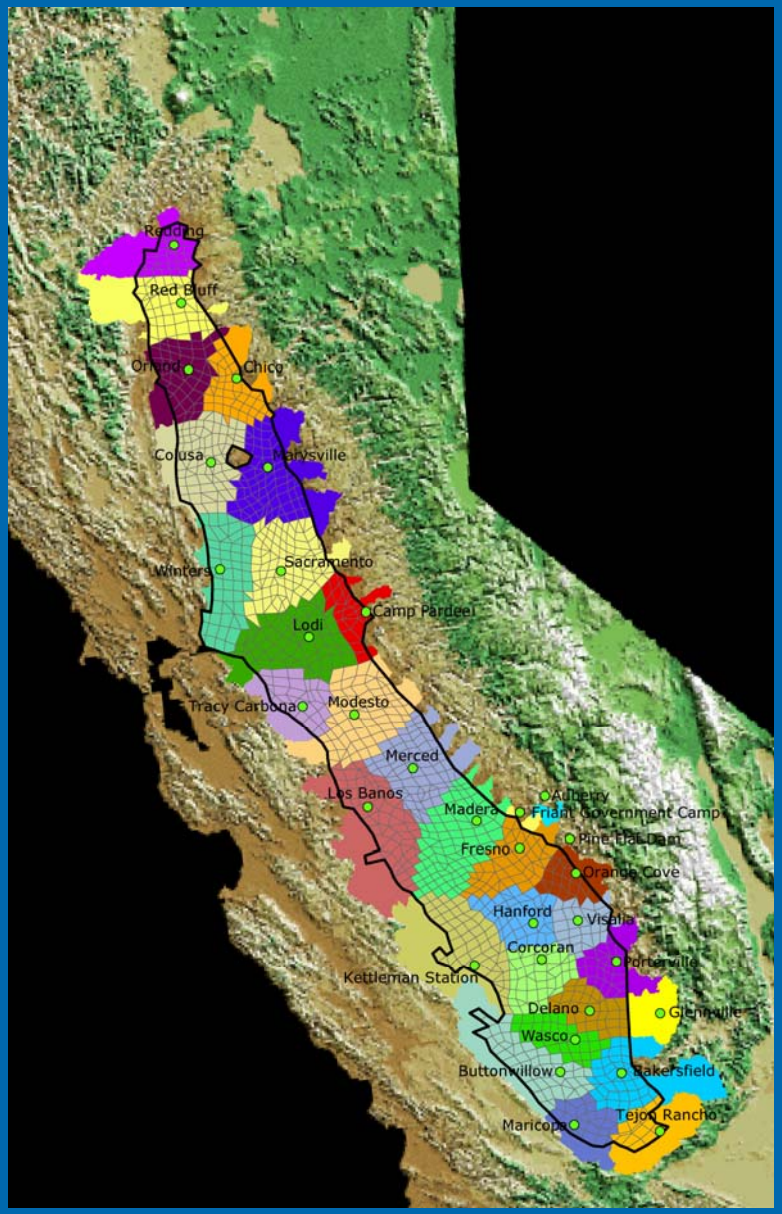
Watersheds and Streams

- Major watersheds have gaged flows to C2VSIM streams
- Minor watersheds treated in IWFM Small Watersheds process



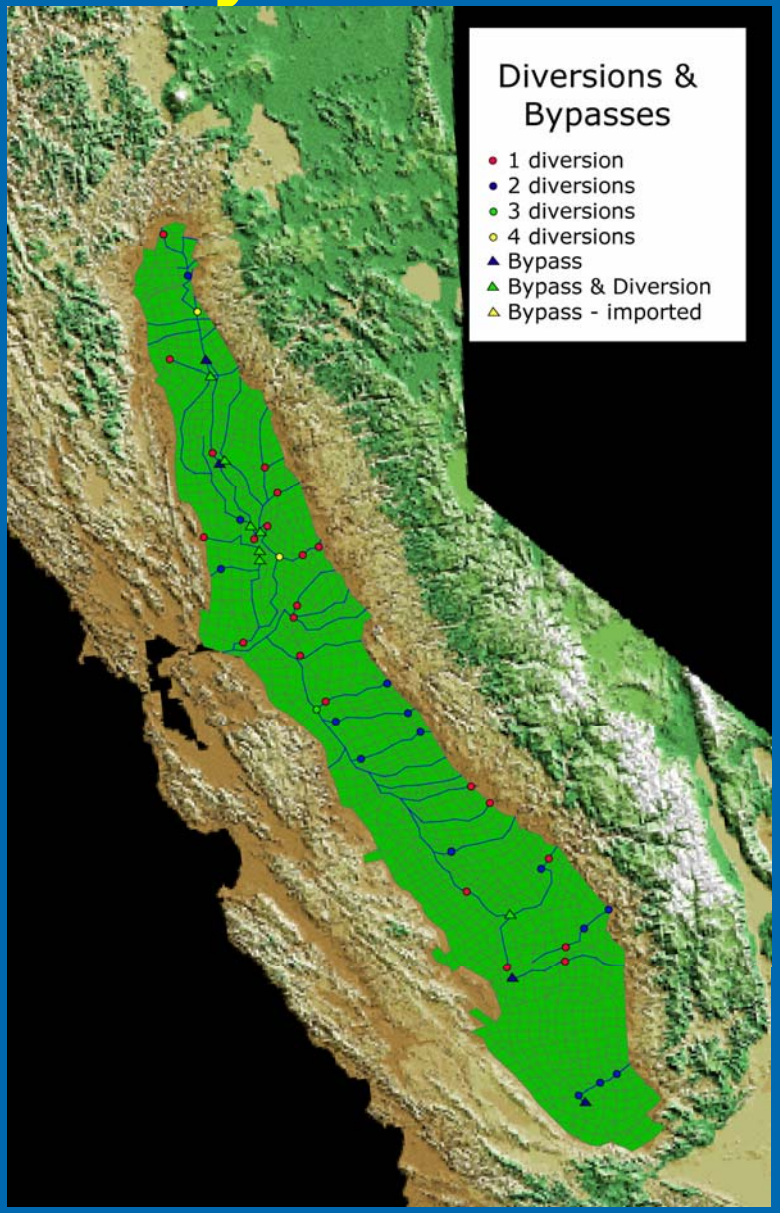
Precipitation Stations and Zones

- 32 precipitation stations
- Monthly precipitation 10/1921-9/2003
- Elemental multipliers to match 1971-2000 PRISM values



Surface Water System

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

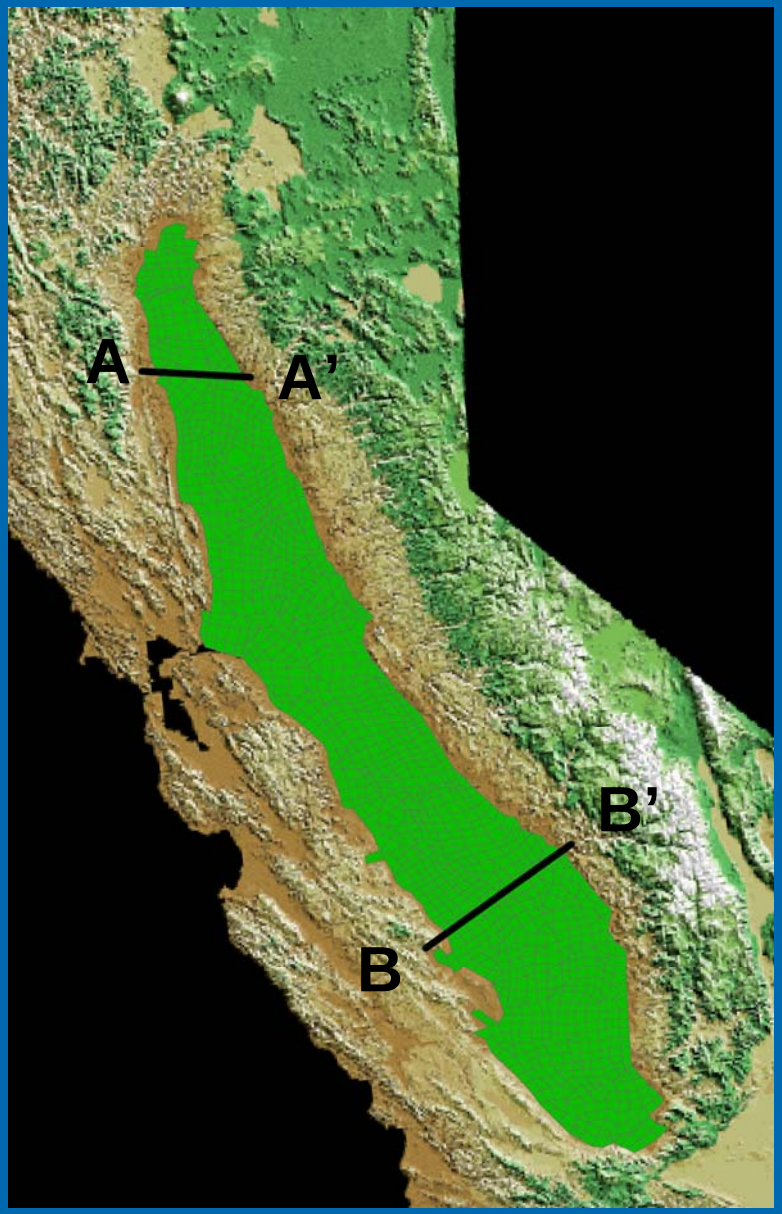


Layering - Cross Sections

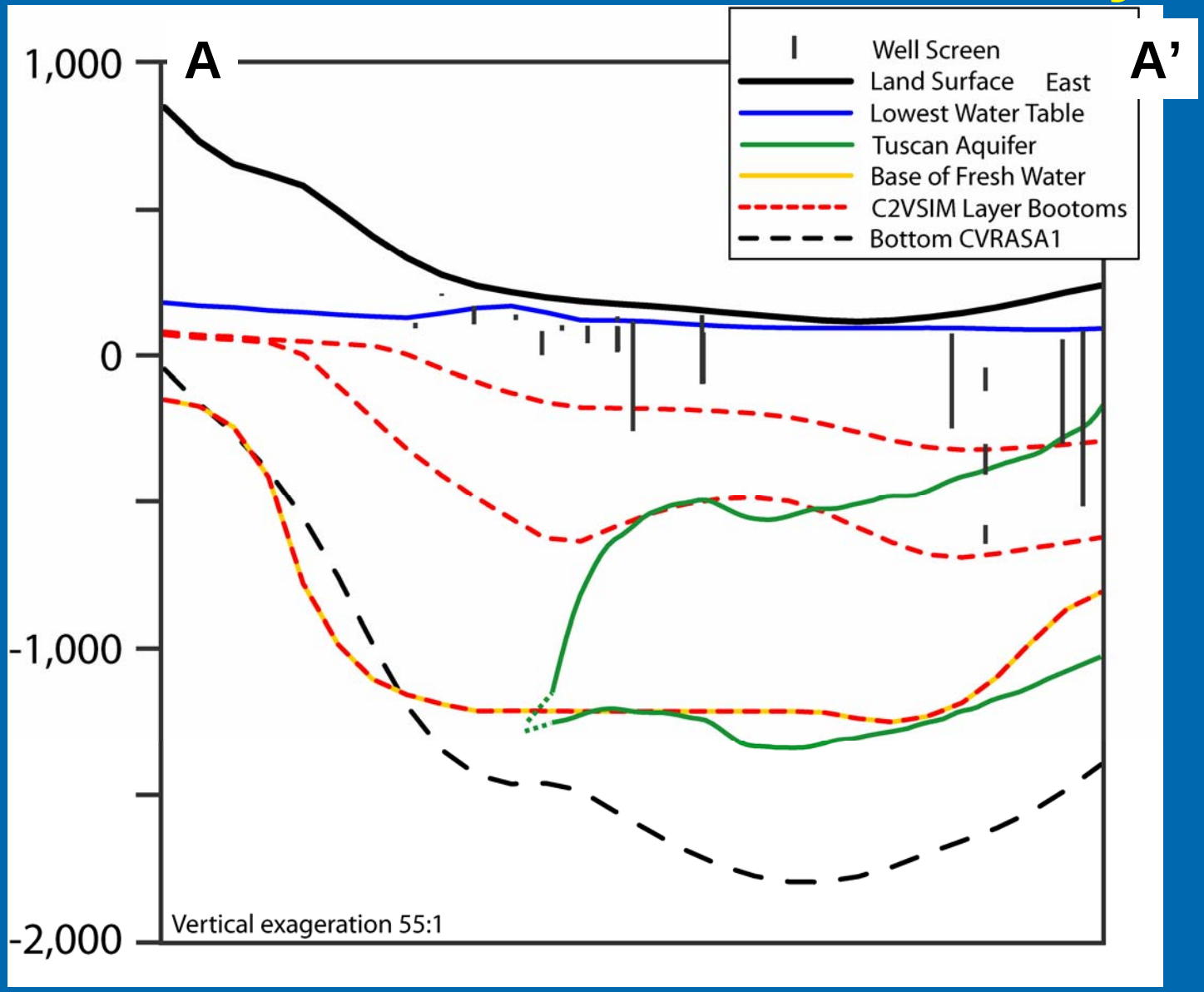
Three model layers

Retain CVGSM layers with modifications:

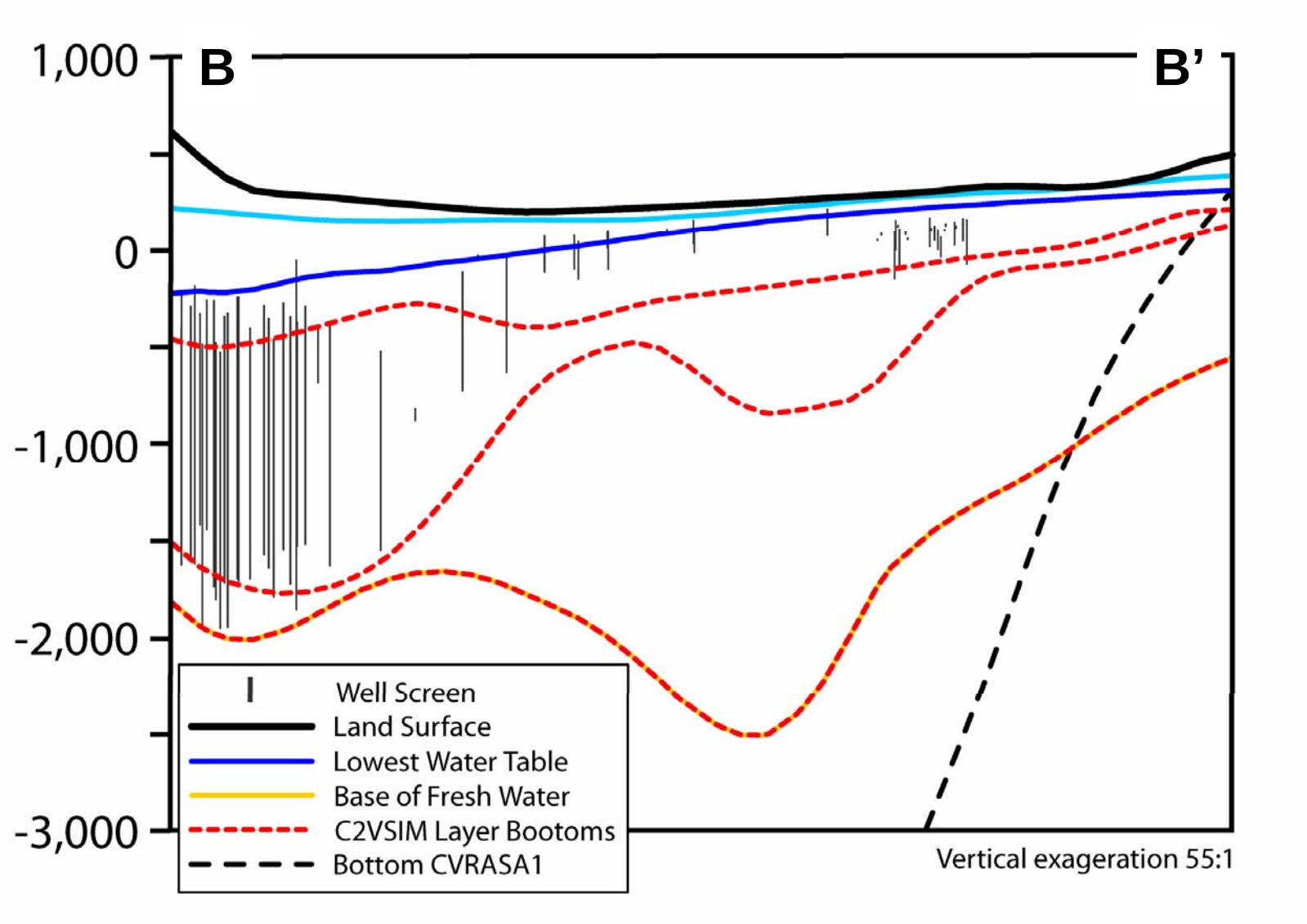
- Bottom of layer 1 - minimum saturated thickness 100 ft
- Bottoms of layers 1 and 2 - Well screens
- Bottom of layer 3 - Base of fresh water



Cross Section – Sacramento Valley

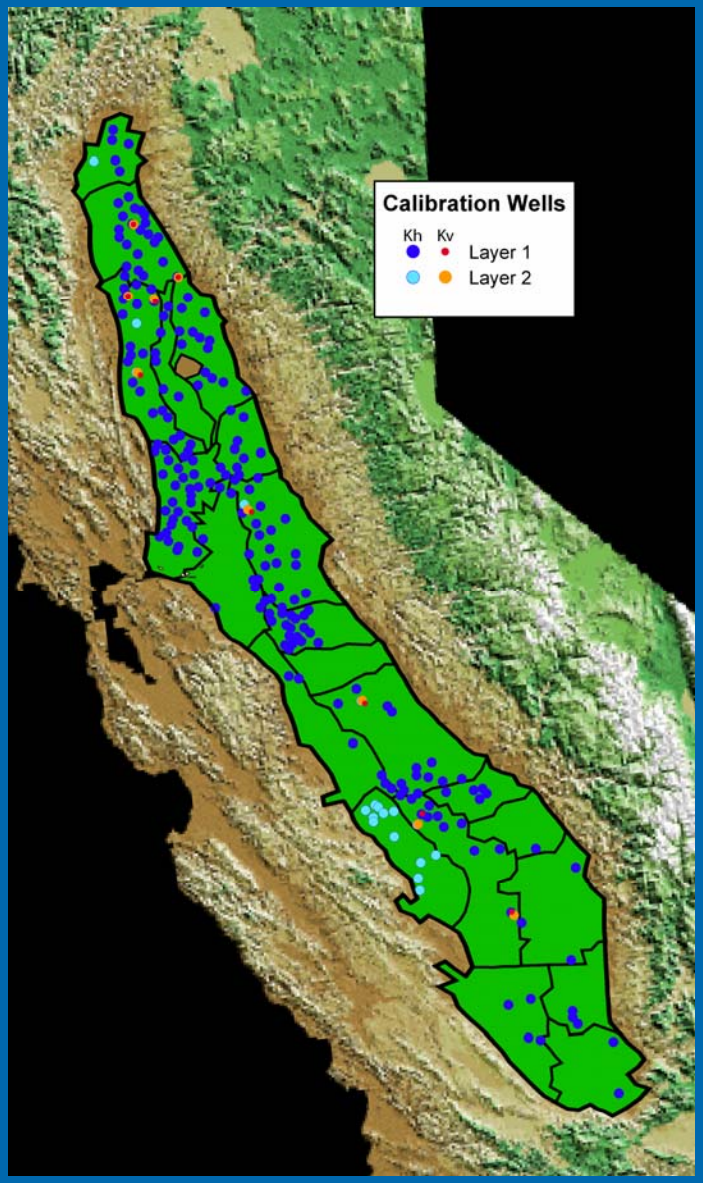


Cross Section – San Joaquin Valley

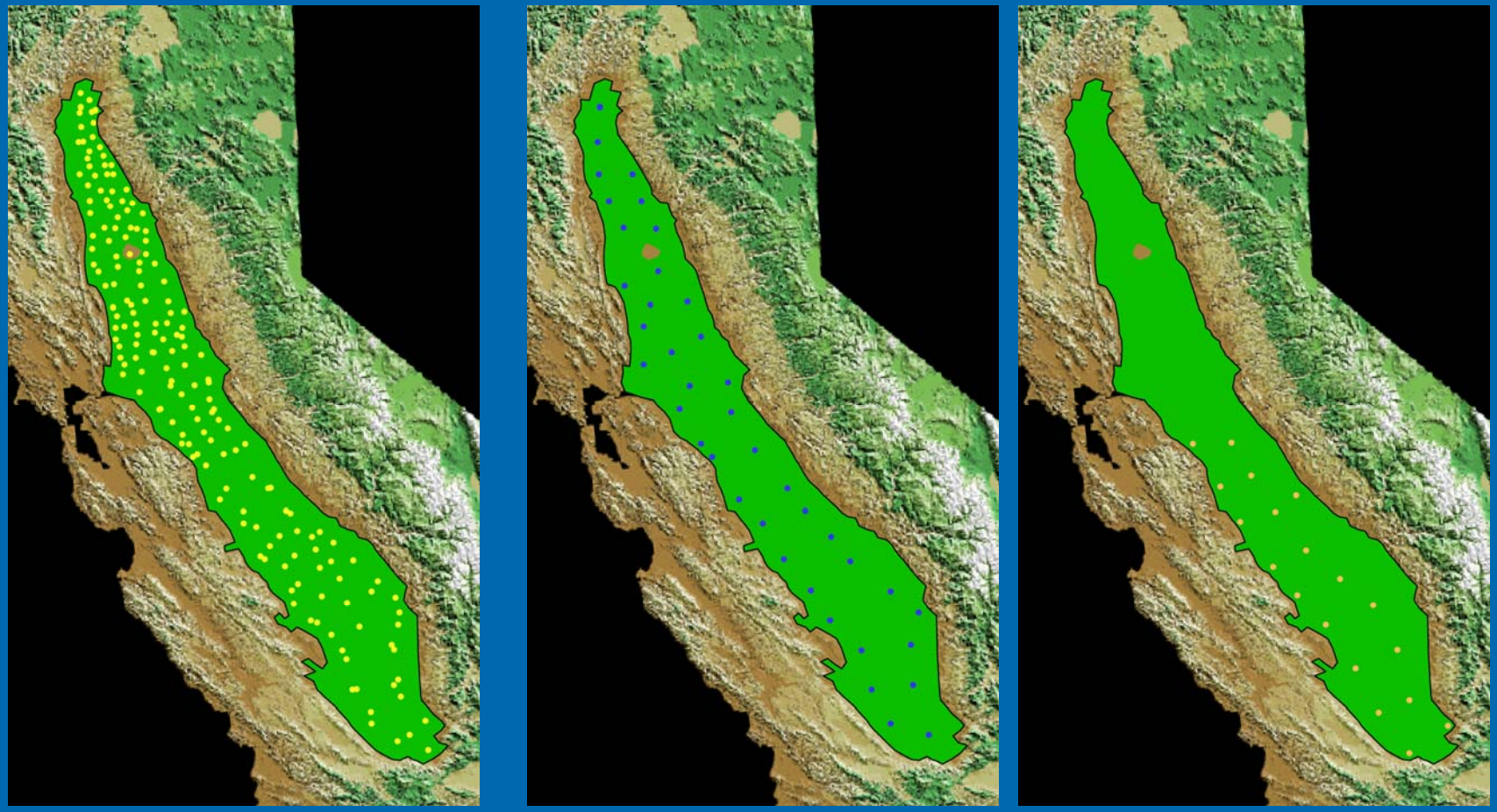


Calibration Data

- 1976 water level maps for layers 1 & 2
- Head observations at 221 wells
  - Single screen coincides with model layering
  - Measurements before 1977 and after 1997
  - No more than one well per model element
- Vertical head gradients at 9 locations
- Average stream accretions and depletions



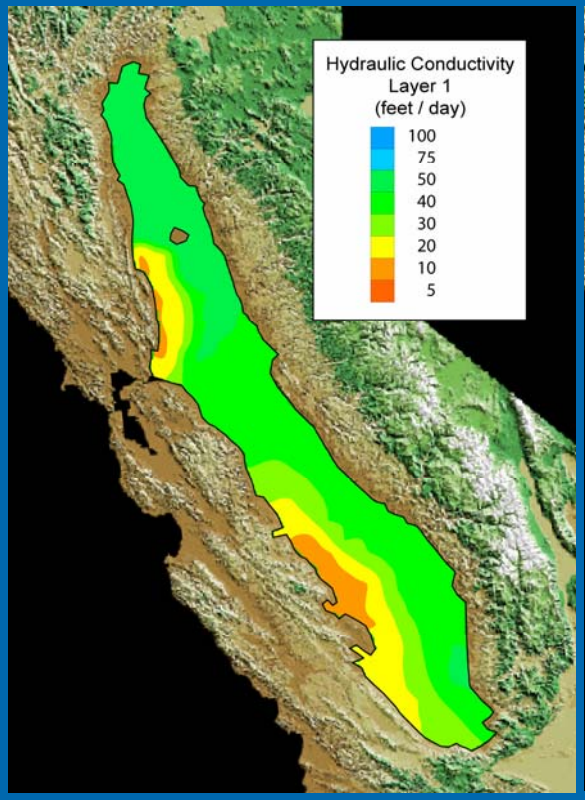
Pilot Points

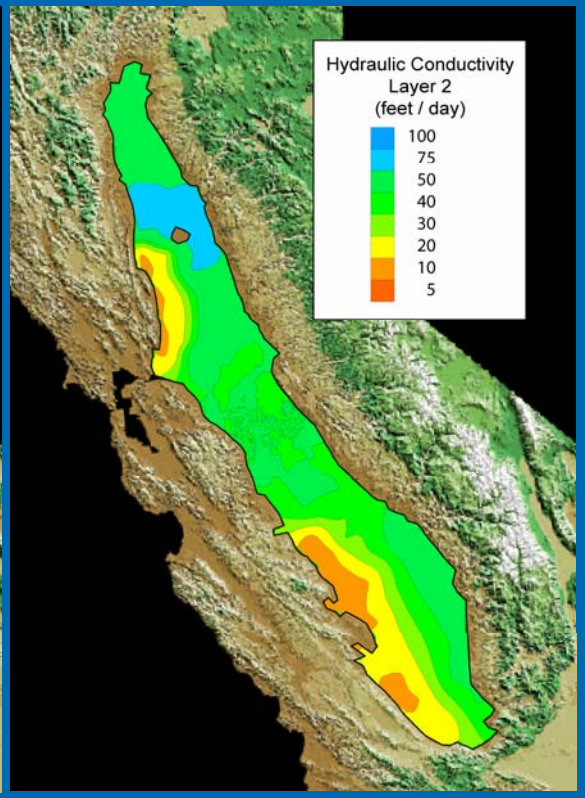


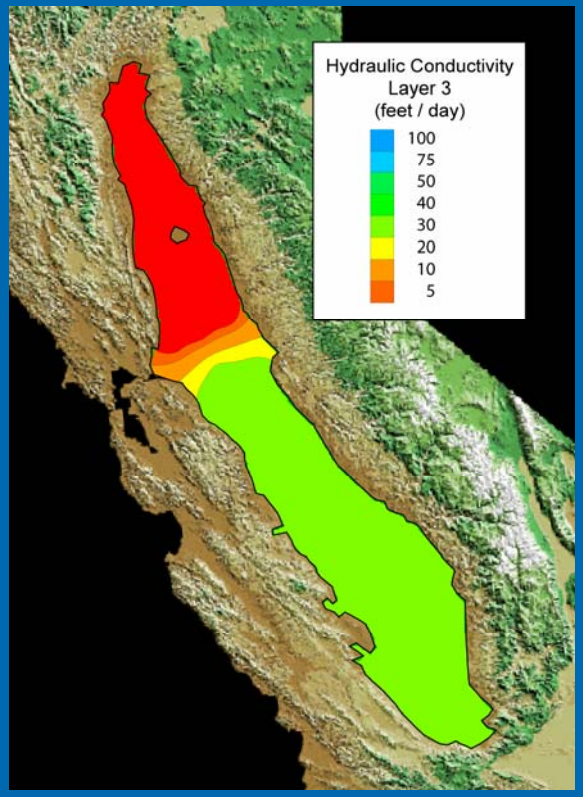
C2VSIM calibration sequence

- Land use process
  - Agricultural root-zone process
  - Curve numbers
- Groundwater flow system
  - Hydraulic conductivity of layers 1 & 2
  - Vertical anisotropy 1:1,000
  - Specific yield in layer 1
  - Specific storage held constant
- Surface water flow system
  - Stream-bed conductivity

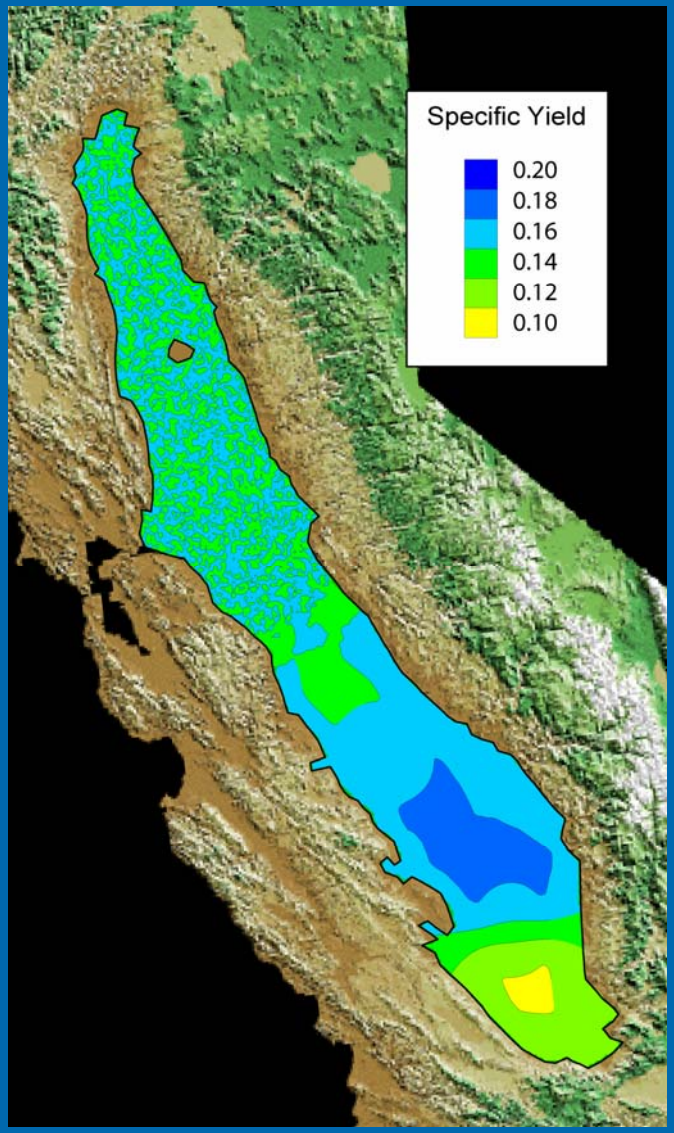
Hydraulic Conductivities

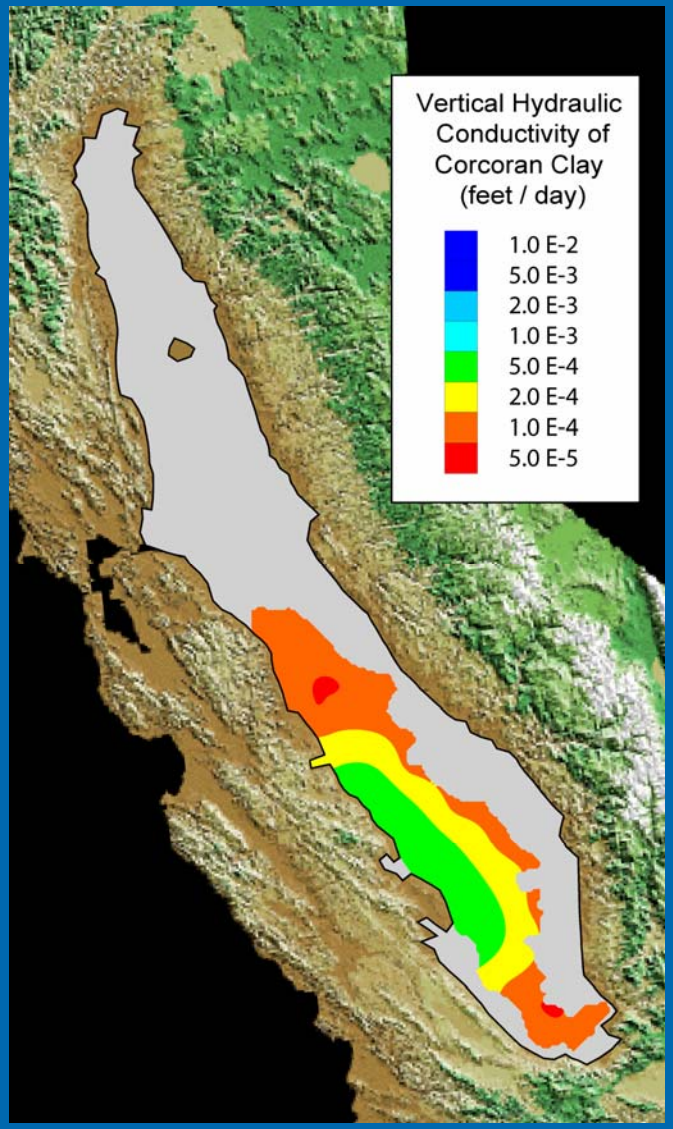




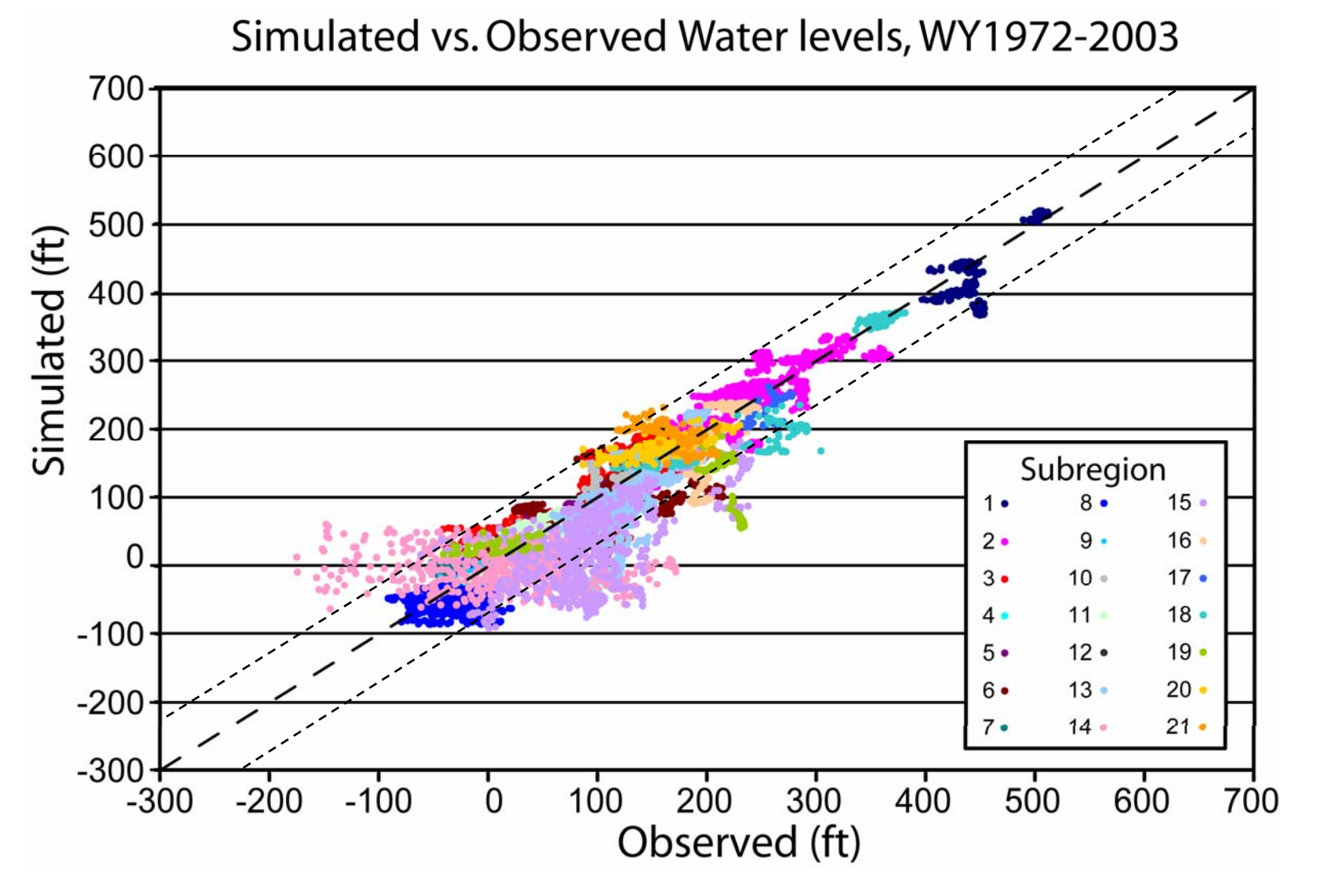


Aquifer Properties

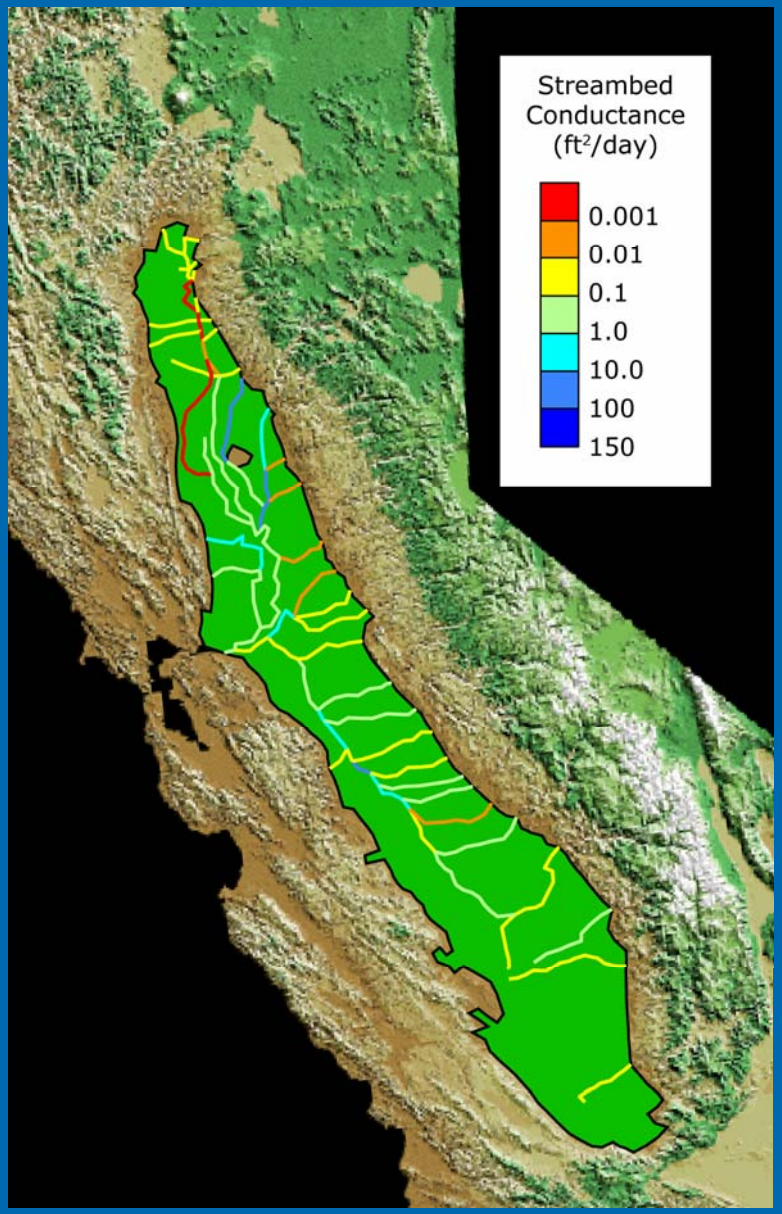




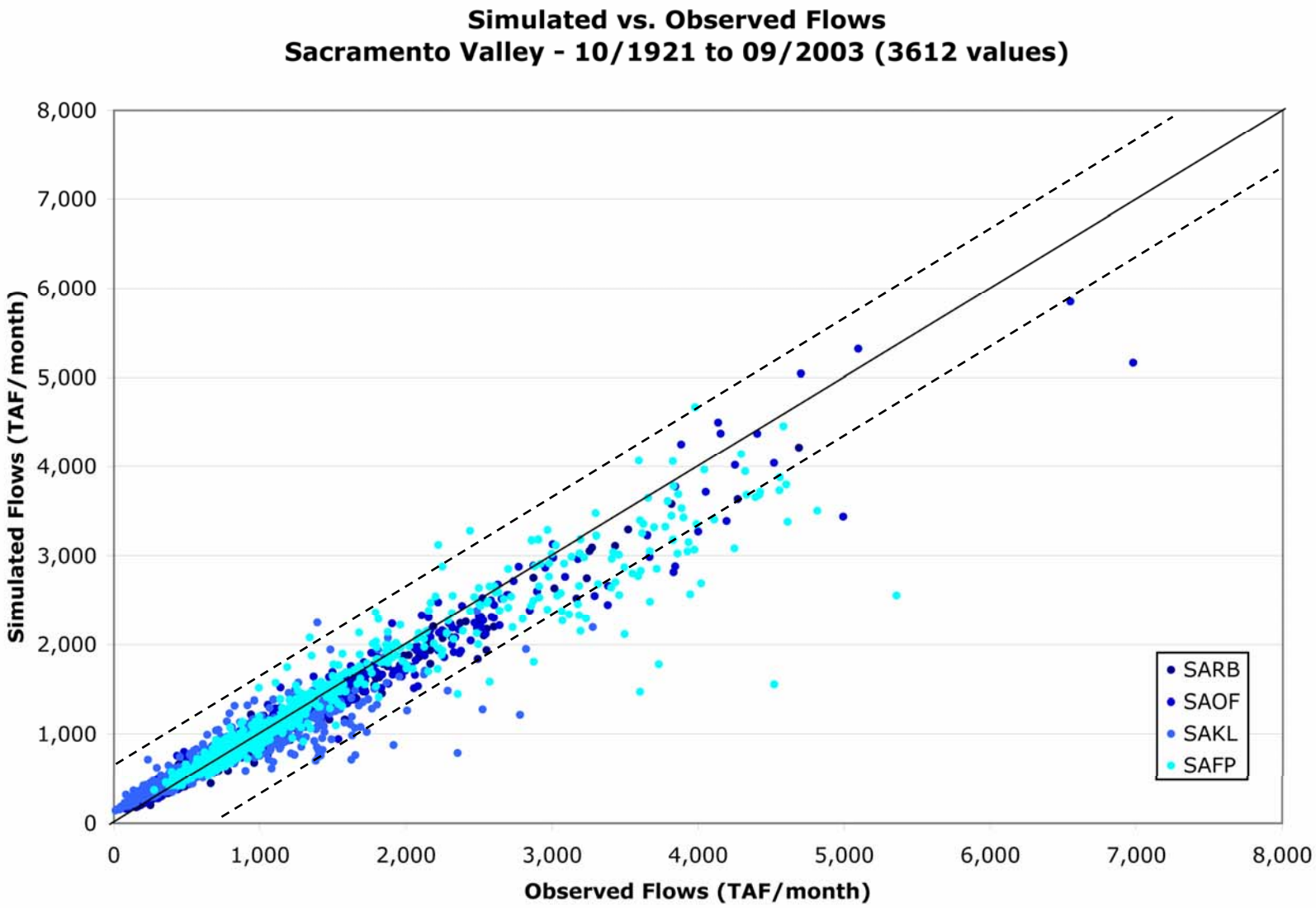
Results - Heads



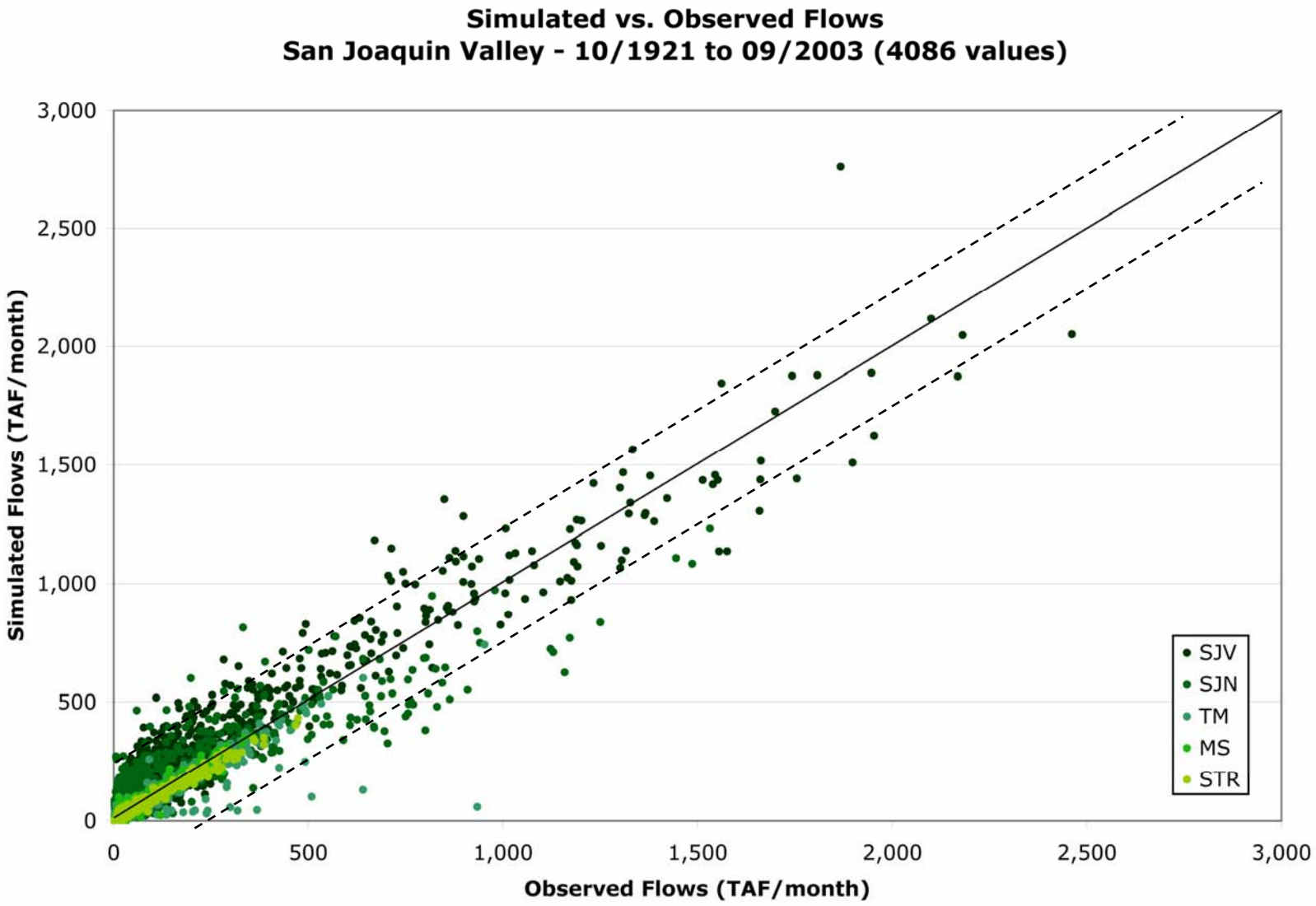
Streambed Conductance



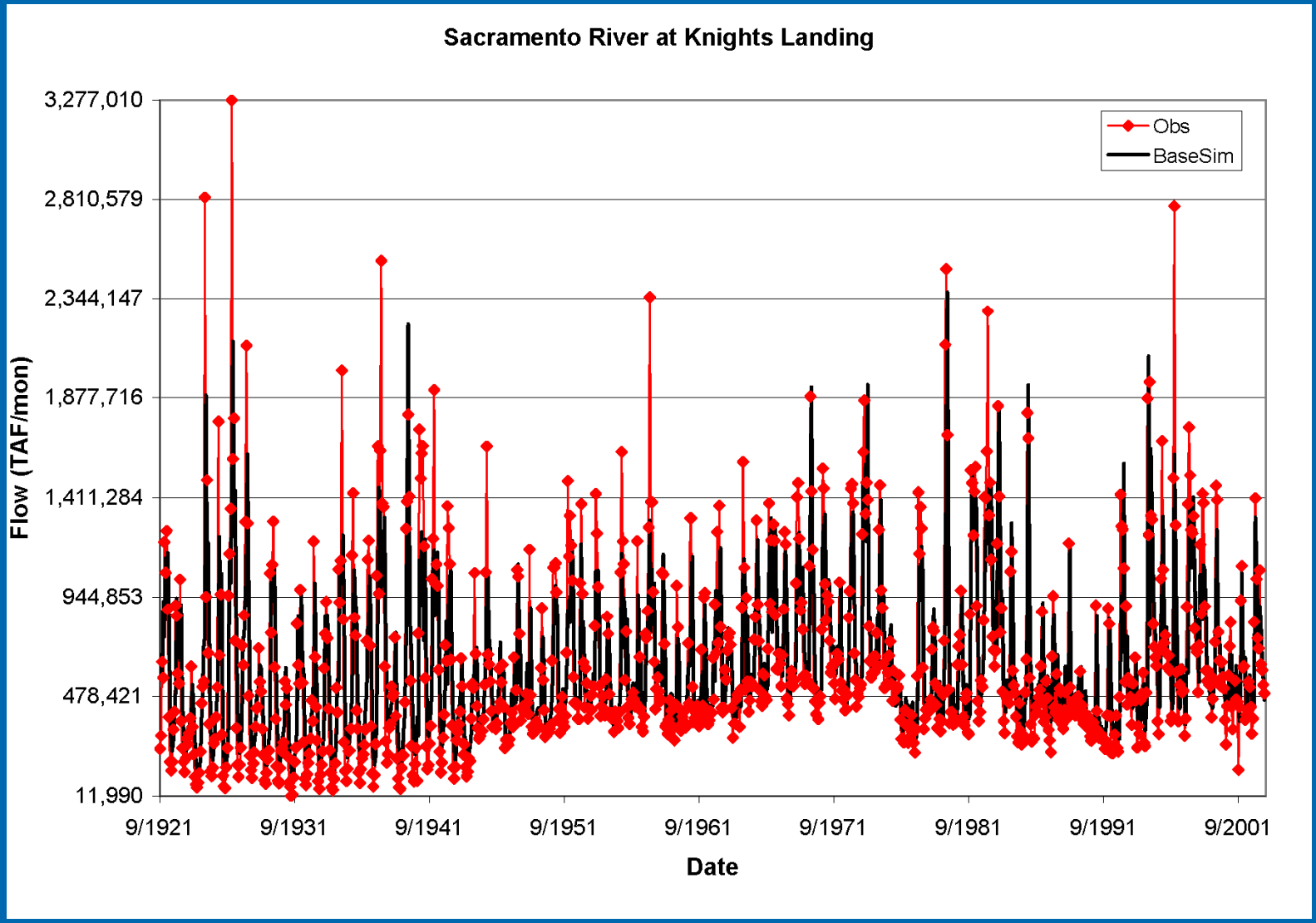
Results - Flows



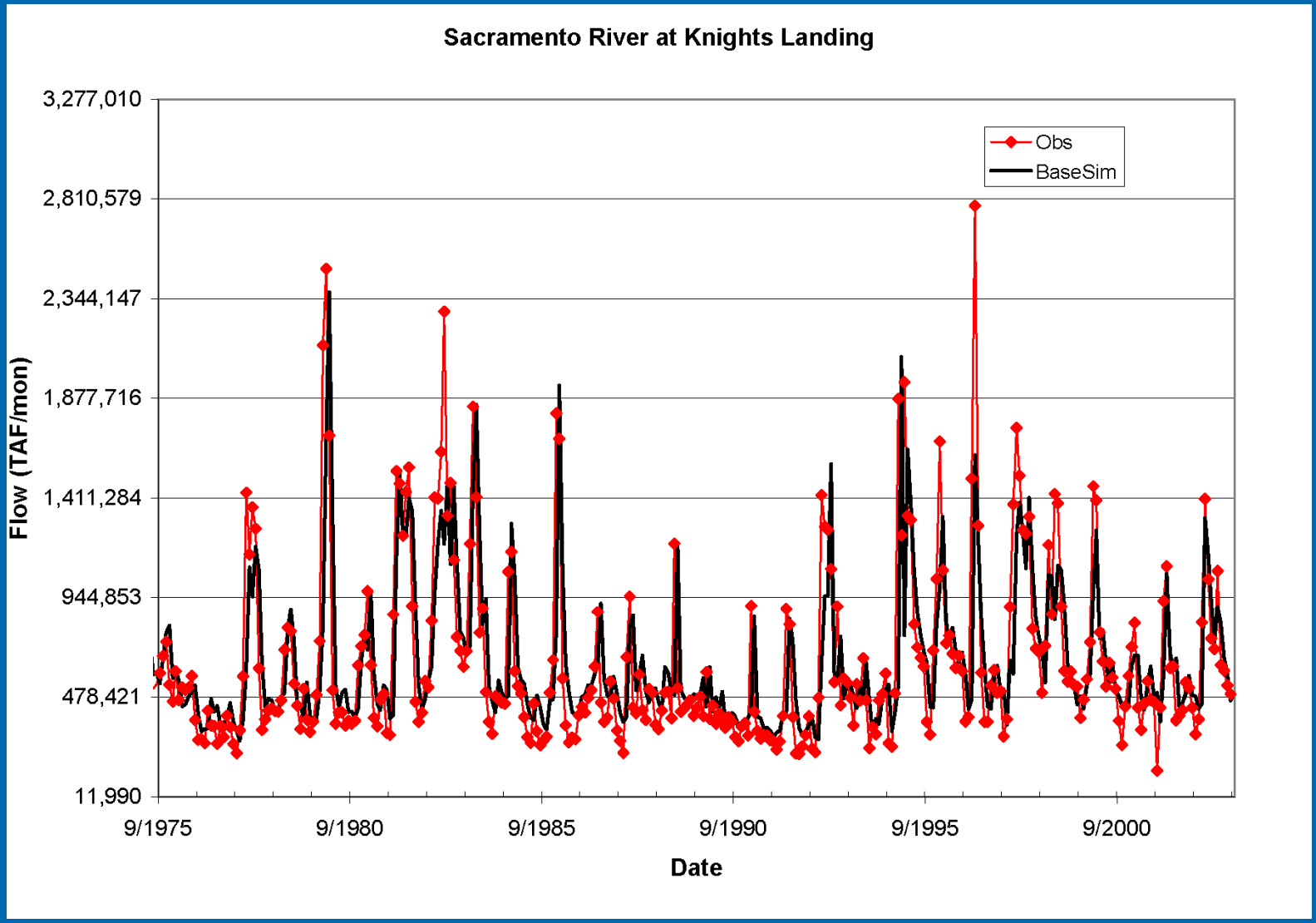
Results - Flows



Results - Flows



Results - Flows

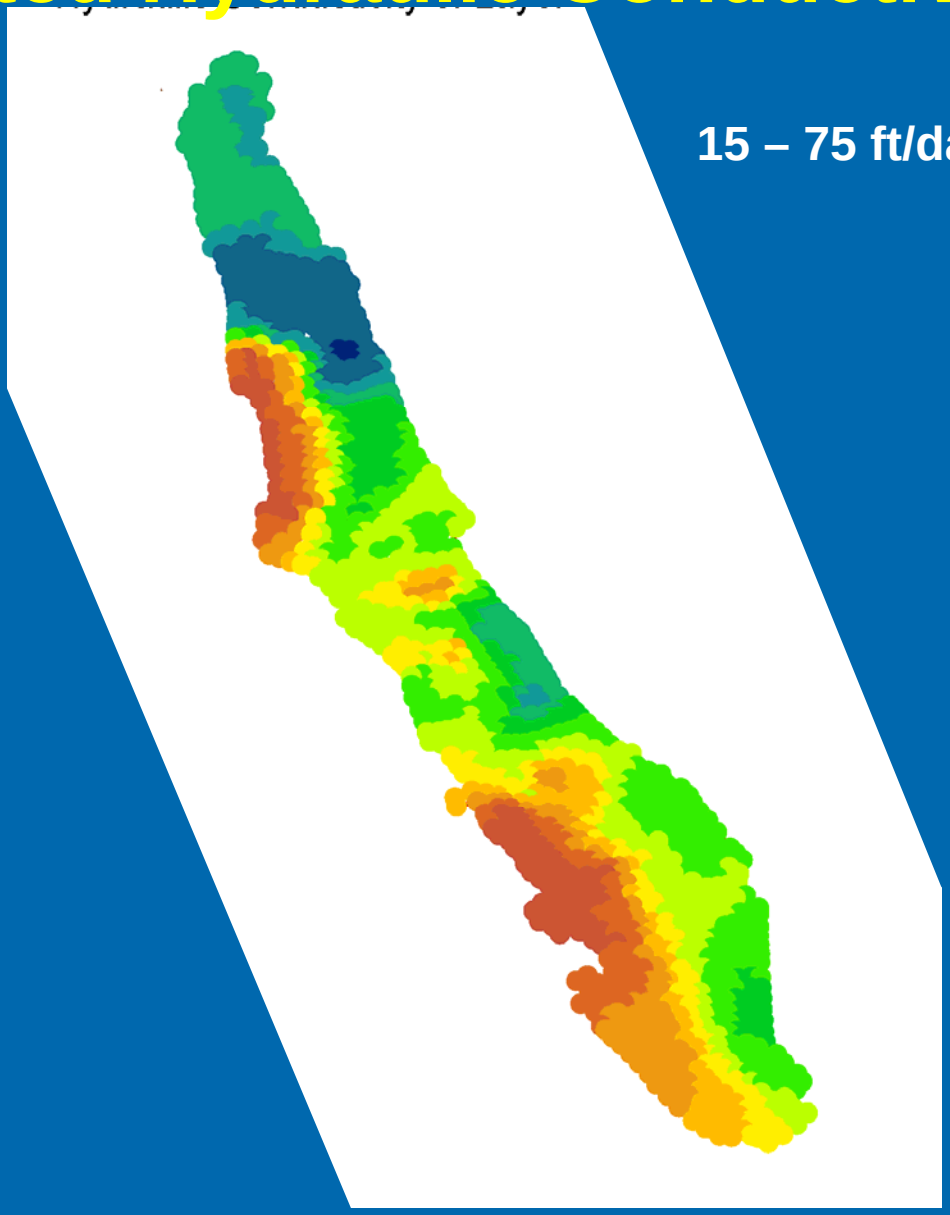


Calibration Data – Phase 2

- Hand-contoured 1921 water level maps
- Calibration Data Set
  - Head observations at 2376 wells
    - Single screen coincides with model layering
    - One or more measurements 1921 – 2003
    - No more than one well per model element
  - [need vertical gradient data 1921-2003]
  - [need additional flow data 1921 – 2003]
- Parameters:

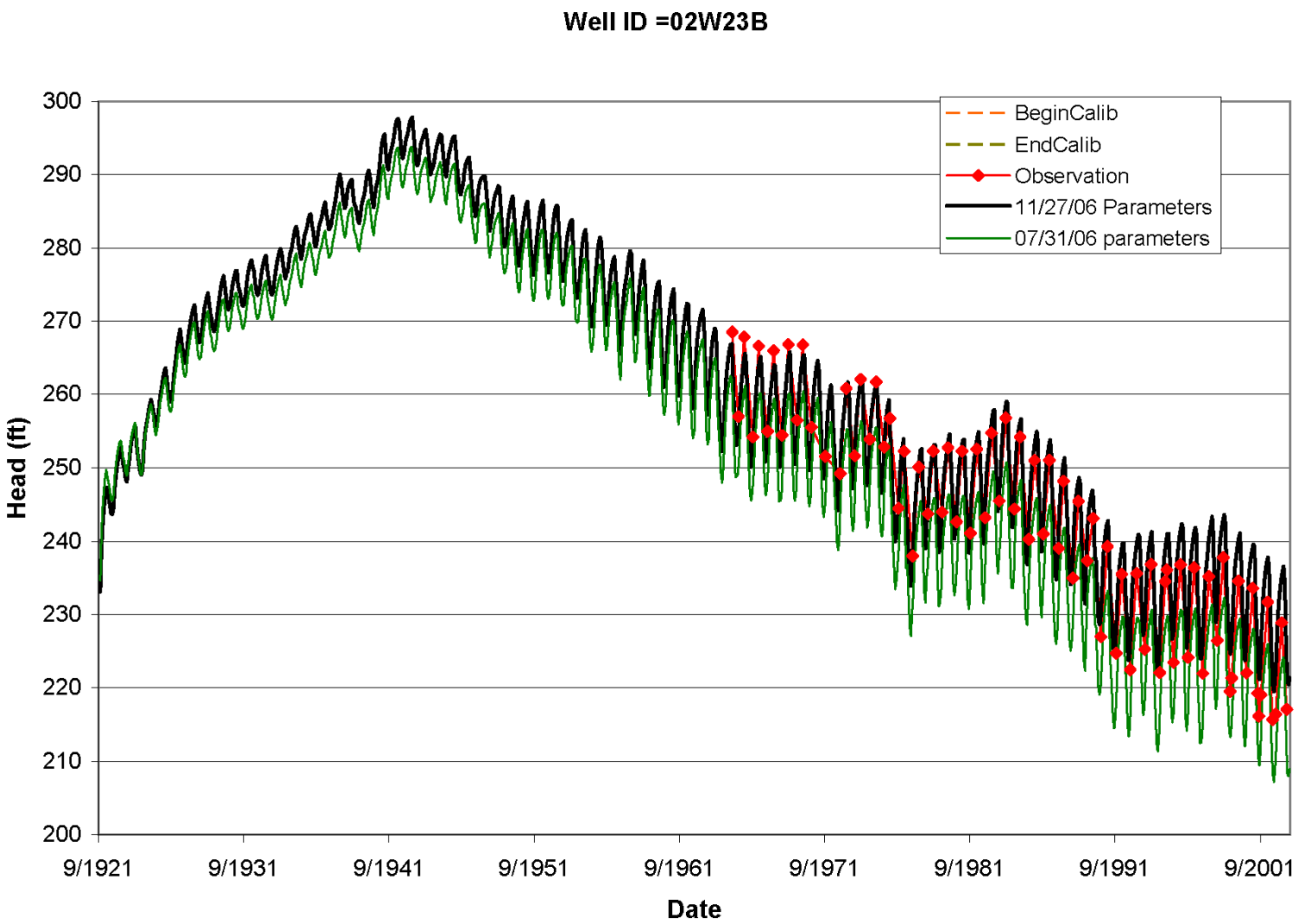
K_h	K_v
S_y	S_s
σ_e	σ_i

Updated Hydraulic Conductivity

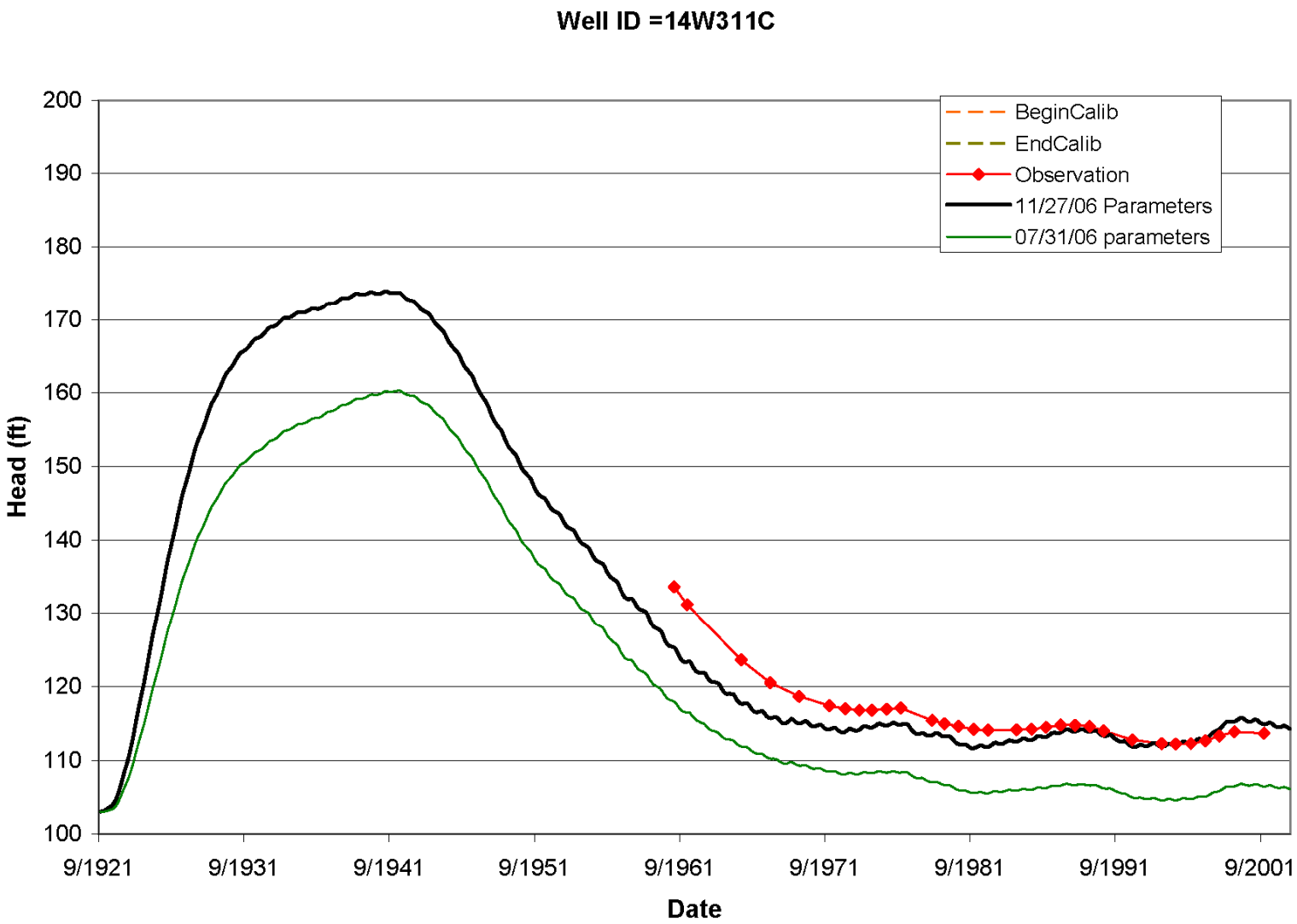


15 – 75 ft/day

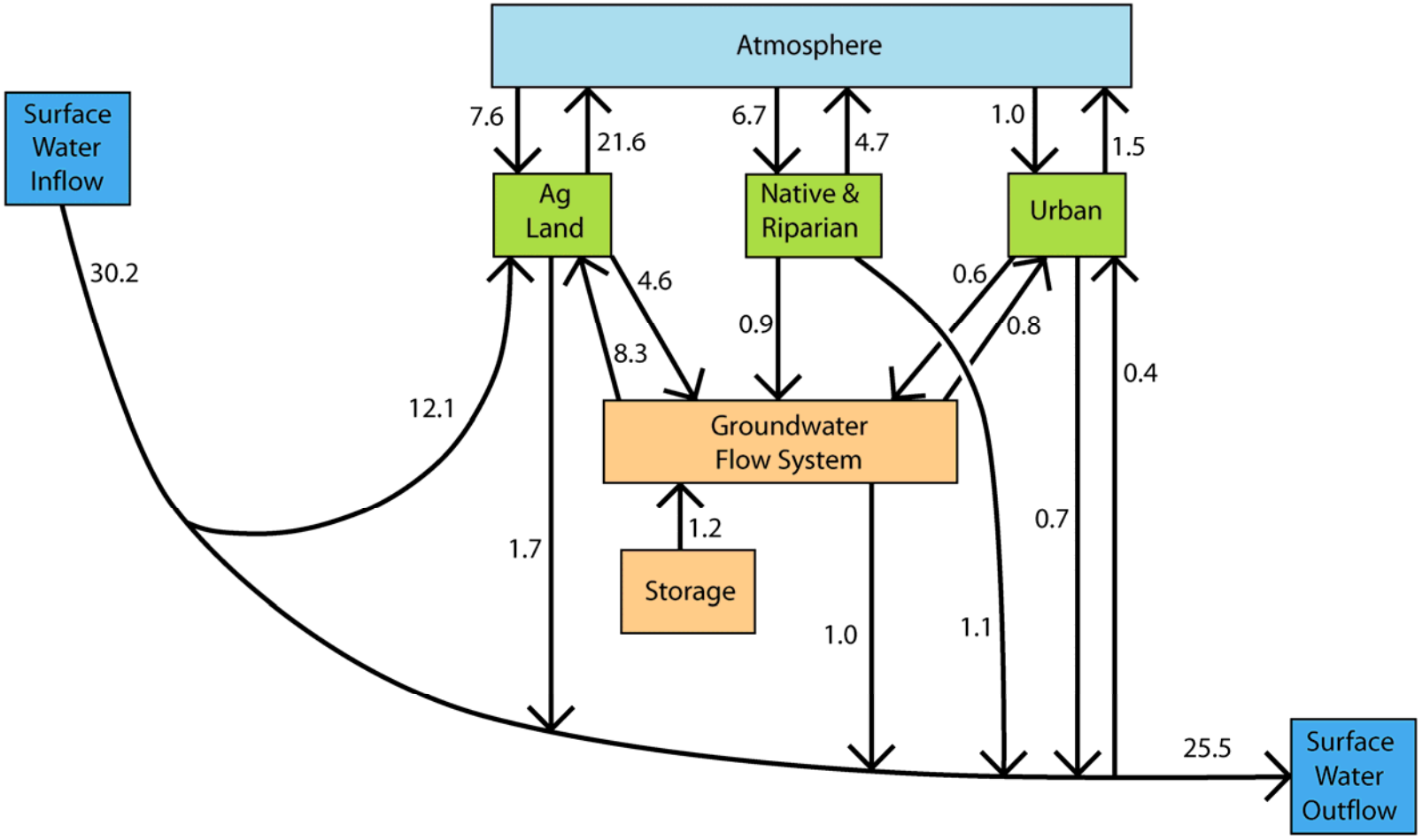
Results - Heads



Results - Heads

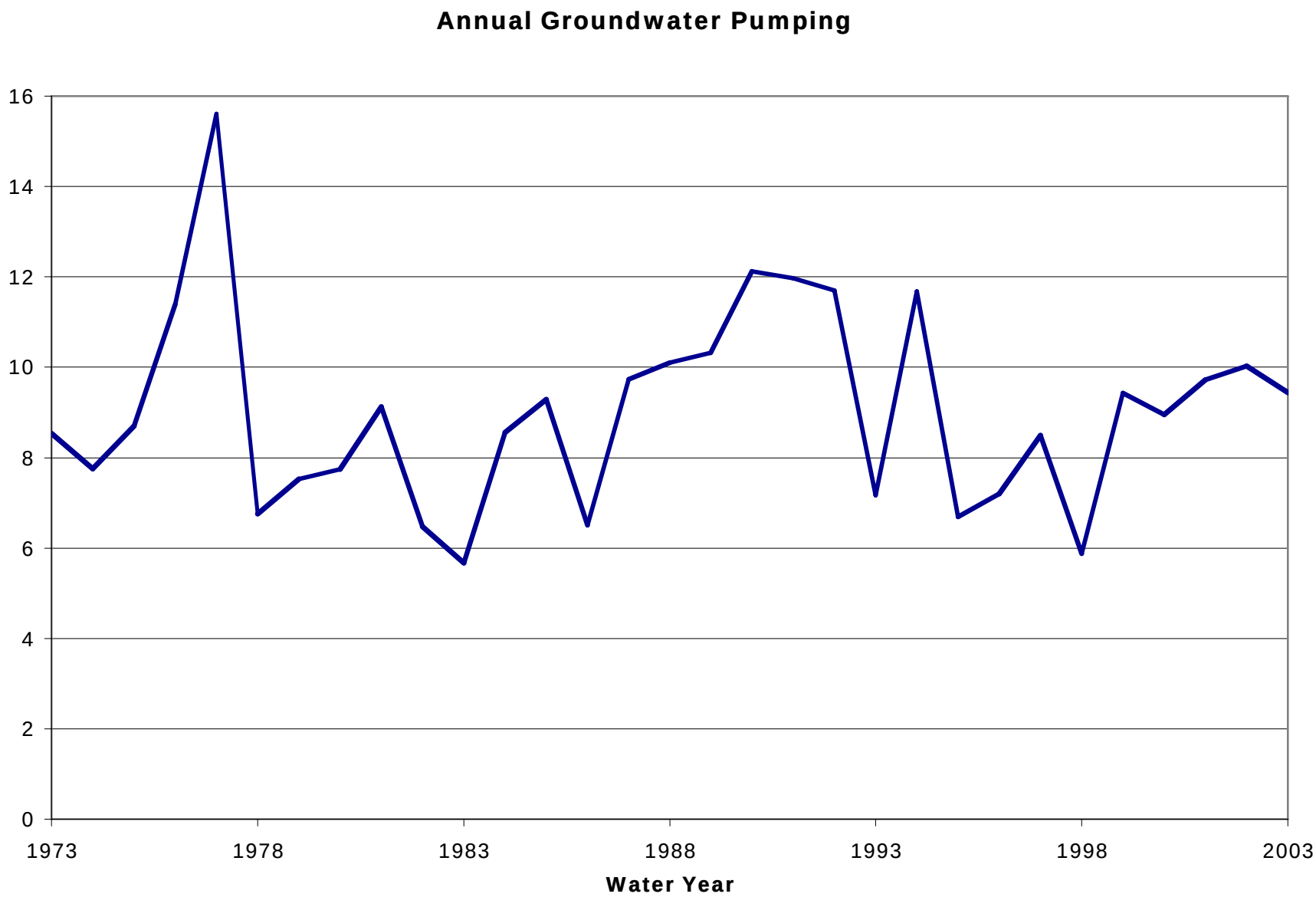


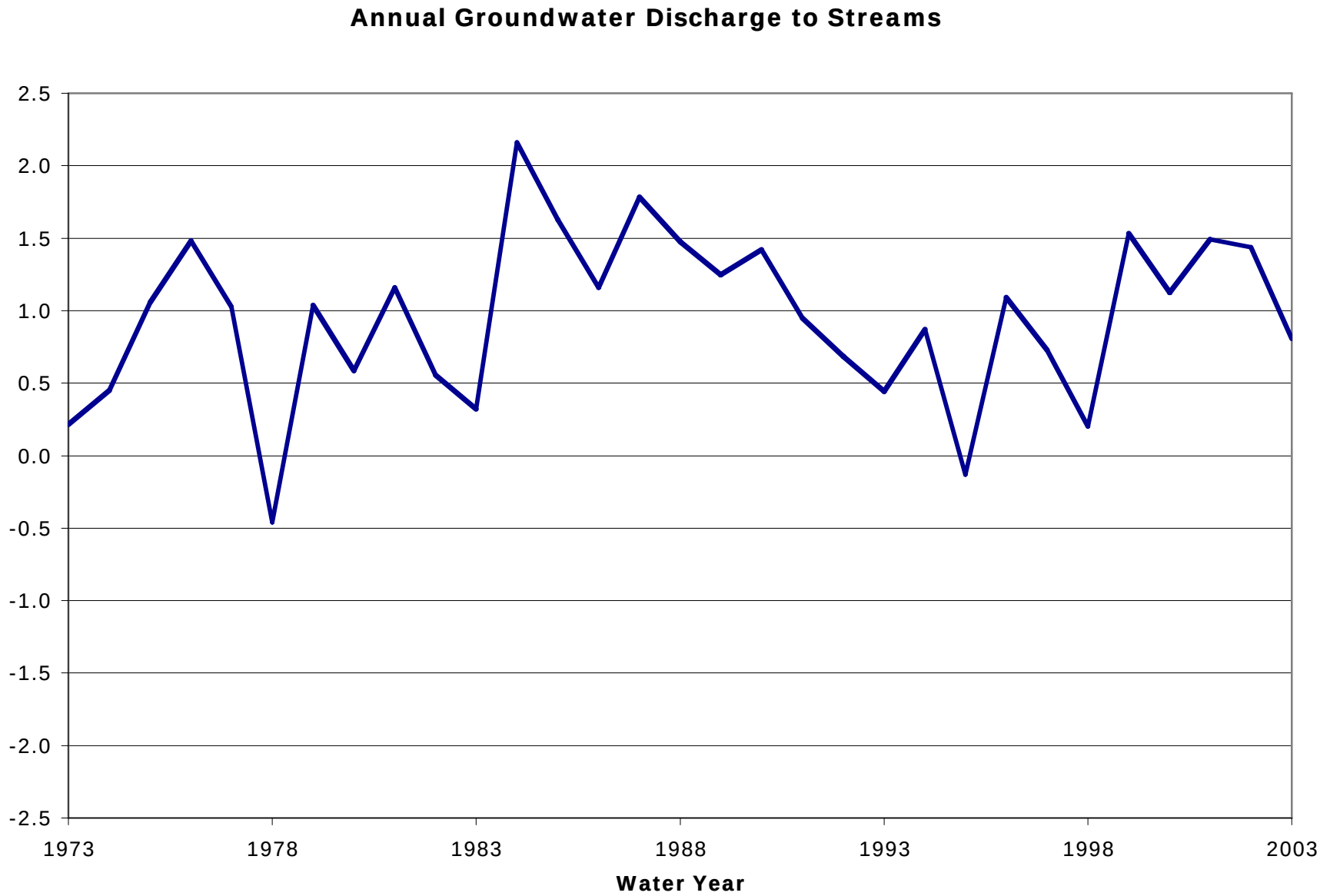
Water Budget

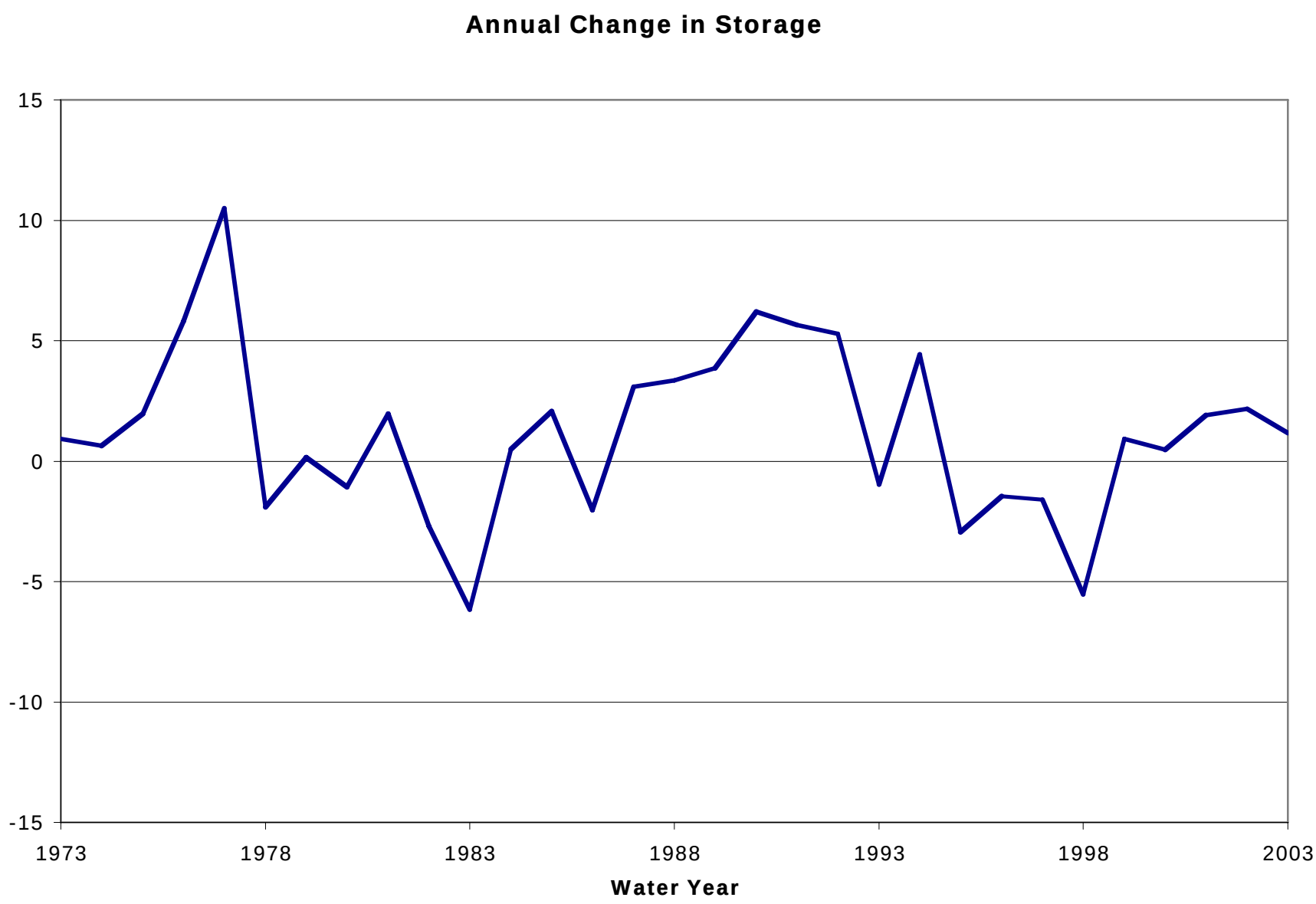


Calibration Results

- Water Levels:
  - Layer 1 generally good
  - Layer 2 high beneath Corcoran Clay
- Spatial correlation of head residuals
  - Reasonable in Sacramento Valley (low on western edge)
  - Low in western San Joaquin Valley
  - High beneath Corcoran Clay
- Simulated water level trends match observed water level trends on a regional basis
- Subregions 14-21 (Tulare Basin & southern San Joaquin Basin)


Annual Groundwater Pumping
16
14
12
10
8
6
4
2
0
1973
1978
1983
1988
1993
1998
2003
Water Year


Annual Groundwater Discharge to Streams
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1973
1978
1983
1988
1993
1998
2003
Water Year


Annual Change in Storage
15
10
5
0
-5
-10
-15
1973
1978
1983
1988
1993
1998
2003
Water Year

Water Budget Items

- C2VSIM pumpage is 20% less than CVGSM and CVRASA pumpage
- C2VSIM shows net groundwater discharge to streams, CVGSM and CVRASA showed net flow from streams to groundwater
- C2VSIM simulated stream accretions and depletions have same sign as observed, and magnitude is close

Future Work

- Local calibration & water budgets for B116 basins
- Streamflow: increase accretions-depletions data set
- Review surface water diversion data (wet-season diversions appear to be high)
- Refine the model grid near streams
- Calibrate small watershed parameters
- Calibrate vertical anisotropy
- Modify pumping distribution (spatial and vertical)
- Adjust weights to reflect measurement accuracy
- Crop ET looks high in subregions 7 & 19

Questions?

Hydraulic Parameters

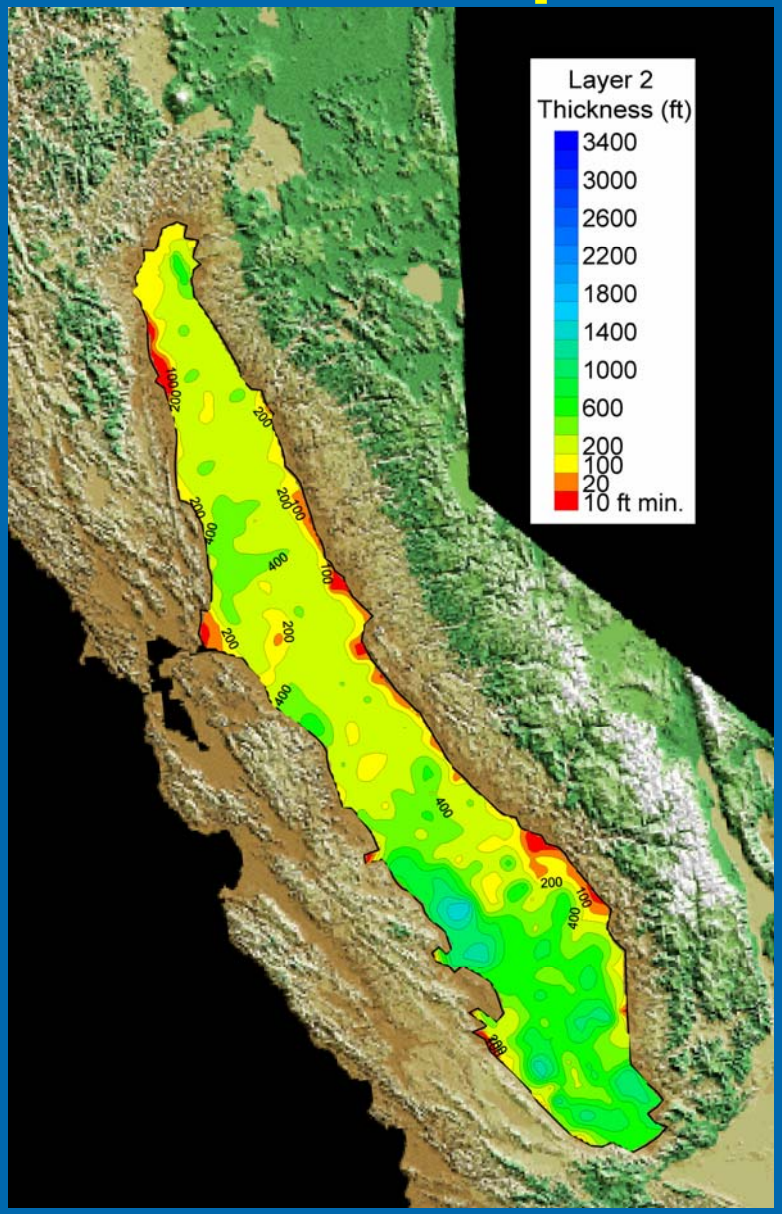
- Horizontal hydraulic conductivity

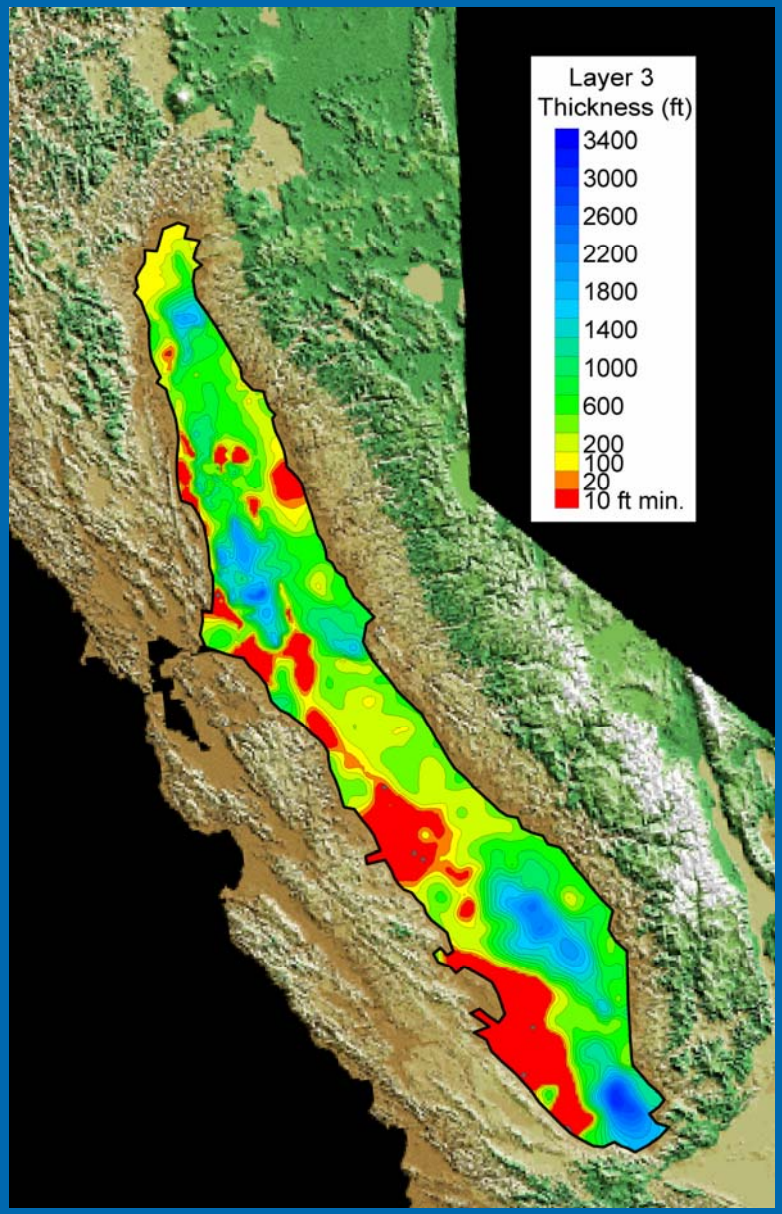
  20 – 80 ft/day in layers 1 and 2

  5 ft/day in layer 3
- Vertical hydraulic conductivity

  $5x10^{-5}$ – $1x10^{-3}$ ft/day
- Specific yield
  - 0.12 – 0.18
- Specific storage
  - $2x10^{-5}$ ft^{-1}

Aquifer Thickness





1990 - IGSM and CVGSM

- Objective:

  Develop a Valley-wide groundwater model capable of predicting the response of the Valley's aquifers to variations in surface water supplies and groundwater demands.
- Time Period: 1922 - 1980
- Development Team:
  - Led by Dr. Young Yoon
  - Montgomery-Watson and Boyle Engineering
- Funding:

  US Bureau of Reclamation, California Department of Water Resources, California State Water Resources Control Board, and Contra Costa Water District.

1996 – CVGSM Update

- Objective:

  Develop a Valley-wide groundwater model capable of predicting the response of the Valley's aquifers to variations in surface water supplies and groundwater demands.
- Time Period: 1922 - 1993
- Development Team:
  - CH_2MHill
- Funding:

  US Bureau of Reclamation, California Department of Water Resources…?

2000 – Multiple versions

- IGSM and CVGSM Extensions
  - WRIME –
  - _____ -

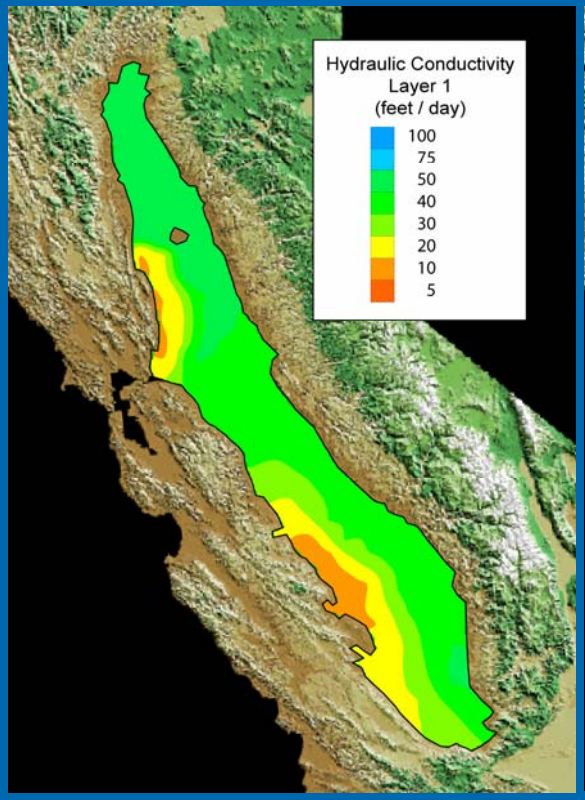
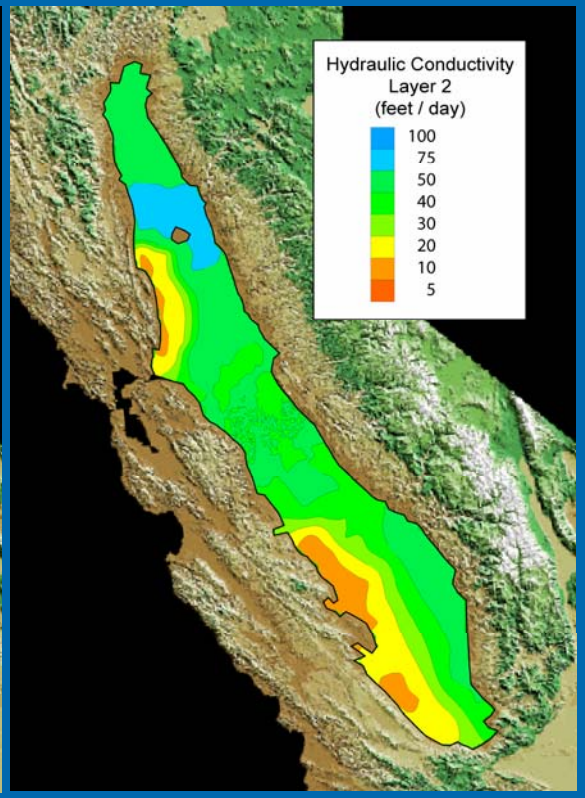
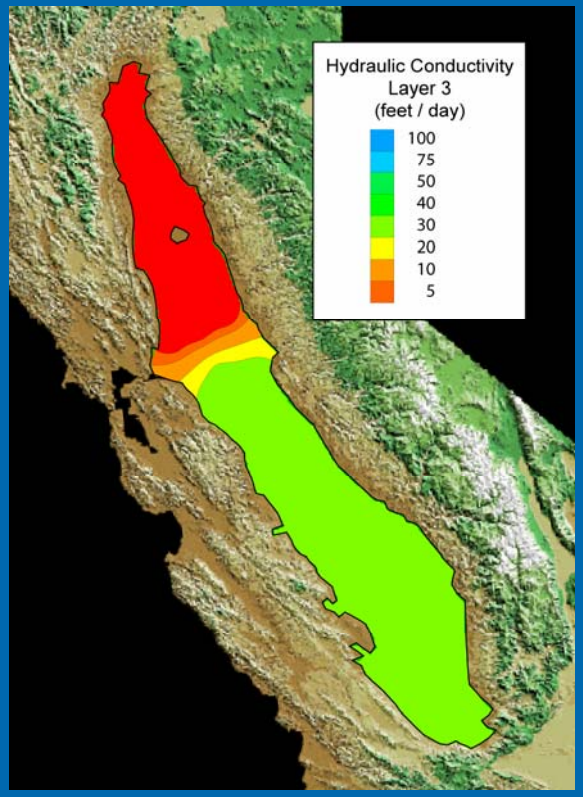
2002 – DWR synthesis & peer review

- Objective:

  Combine the features of various IGSM and CVGSM models into a single comprehensive application and model.
- Development Team:
  - Tariq Kadir, Can Dogrul and Michael Moncrief
- Result:
  - IGSM2 –
  - CVGSM2 –
- Peer review:
  - CWEMF managed a peer review of IGSM2 and CVGSM2
  - Identification of …

2005 – IWFM and C2VSIM

- Objective:

  Combine the features of various IGSM and CVGSM models into a single comprehensive application and model.
- Development Team:
  - Tariq Kadir, Can Dogrul and Michael Moncrief
- Result:
  - IGSM2 –
  - CVGSM2 –
- Peer review:
  - CWEMF managed a peer review of IGSM2 and CVGSM2
  - Identification of …

Hydraulic Conductivities