Simulation of Agriculture & Hydrology in the Modesto Region

A cooperative effort between USGS and the Stanislaus &Tuolumne Rivers Groundwater Basin Association

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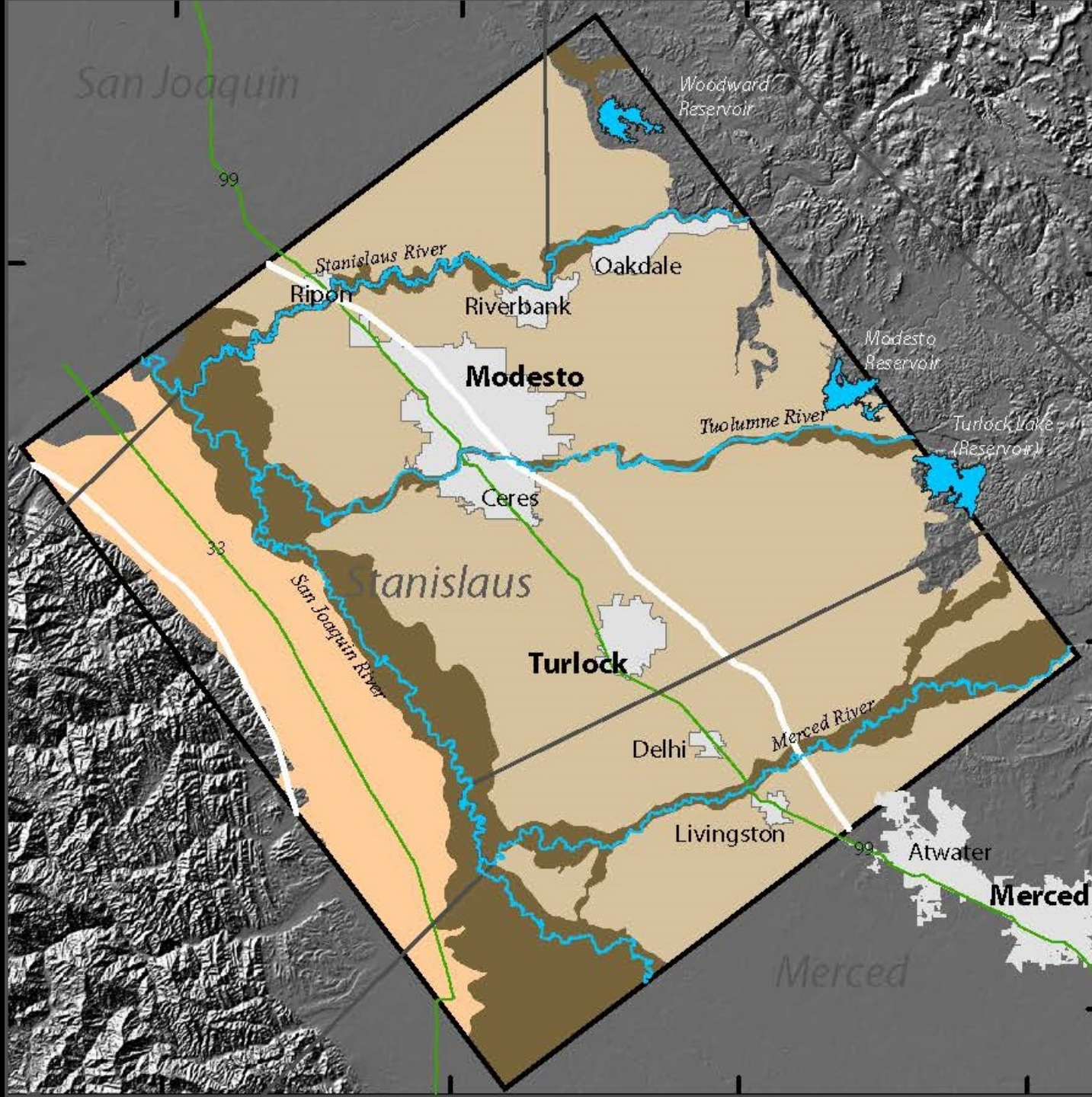
“Essentially, all models are wrong, but some are useful.” George E.P. Box, 1987

Today we’ll discuss:

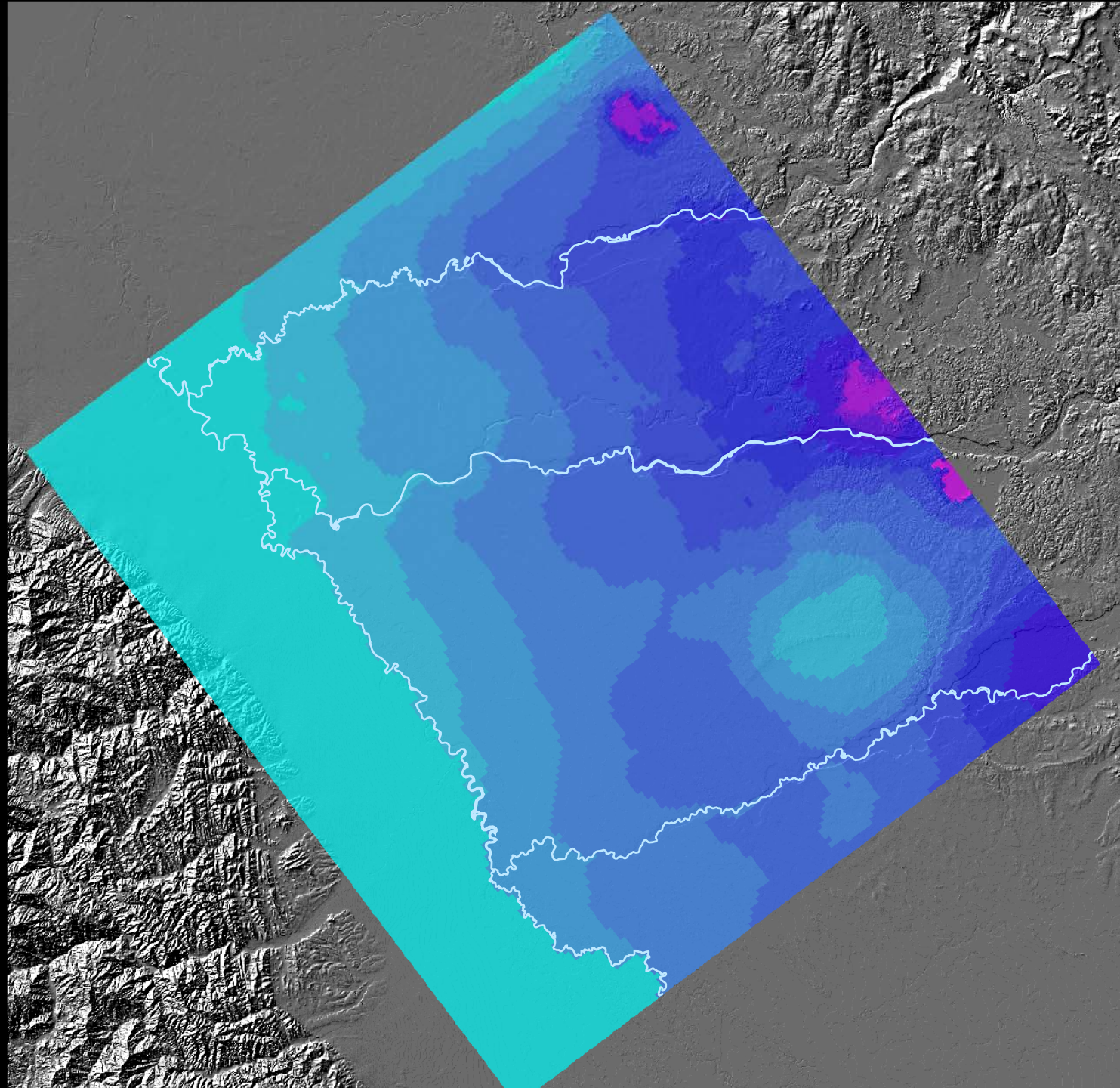
- What went into this model
- What it can and cannot do
- Potential next steps

Study Area


San Joaquin
Woodward Reservoir
99
Stanislaus River
Ripon
Riverbank
Oakdale
Modesto
Modesto Reservoir
Tuolumne River
Turlock Lake (Reservoir)
Ceres
33
Stanislaus
San Joaquin River
Turlock
Merced River
Delhi
Livingston
99
Atwater
Merced
Merced

Hydrologic setting

(Simulated water levels, 15-ft interval, year 2000)



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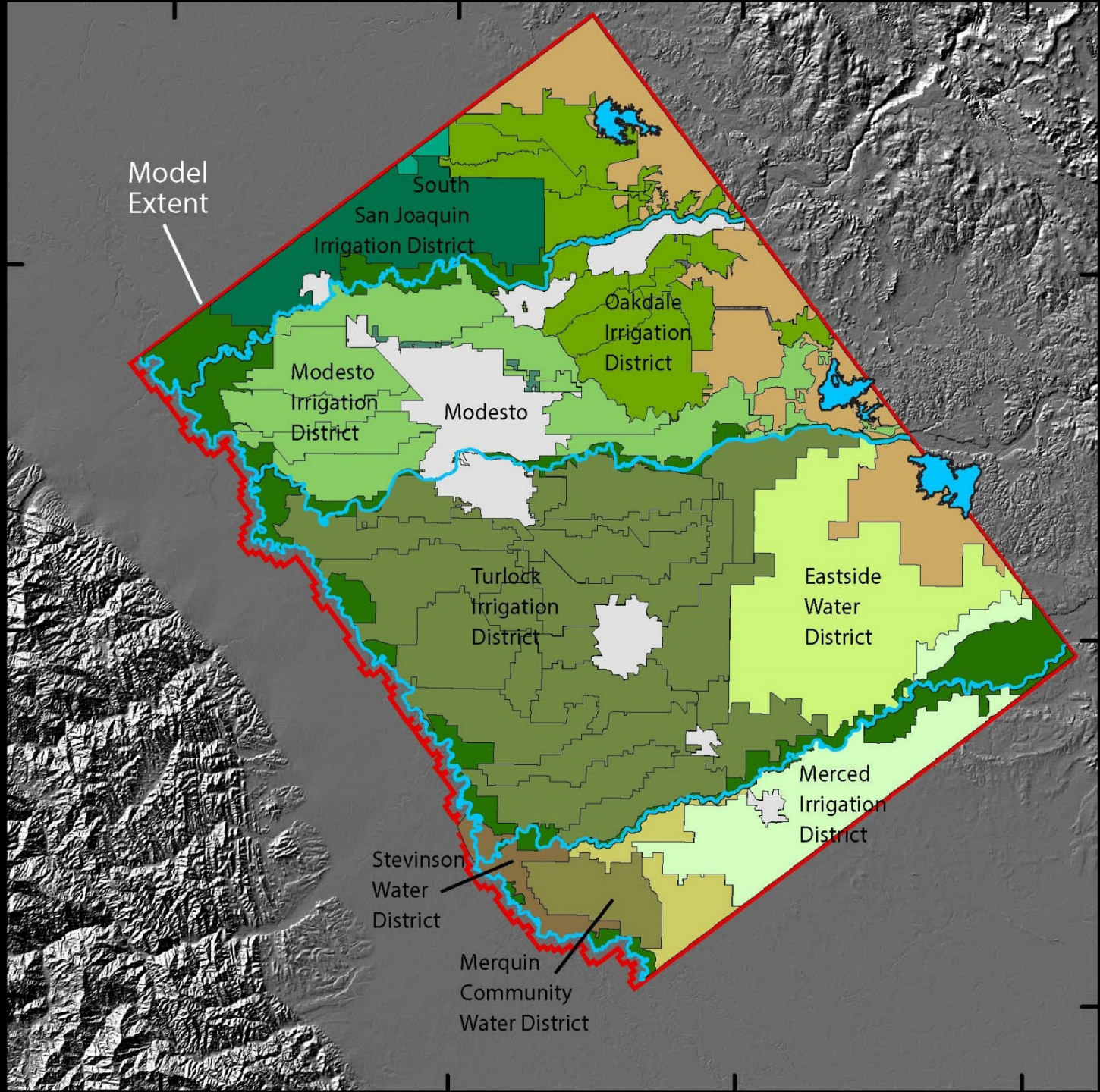
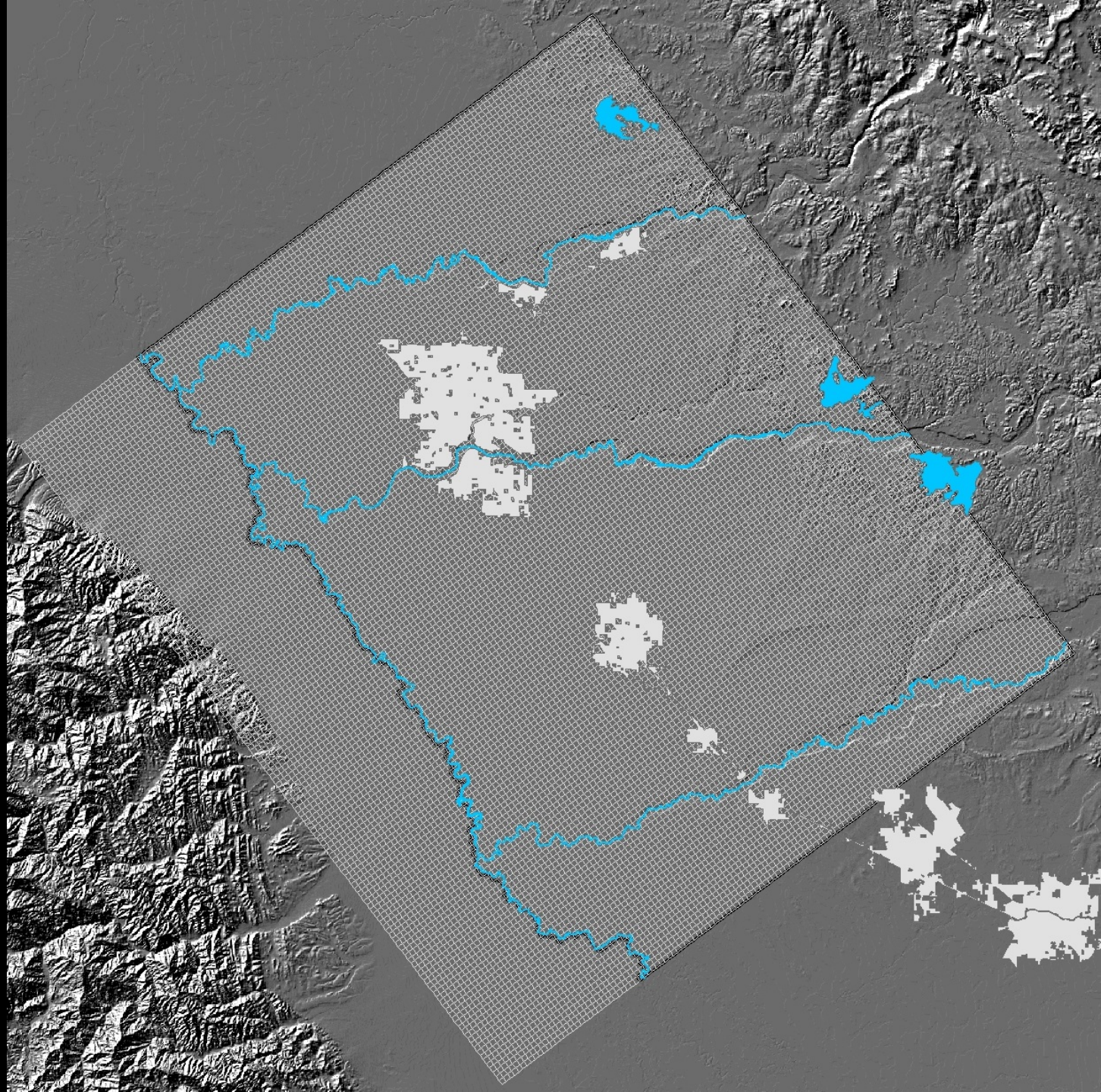
Major entities included in model



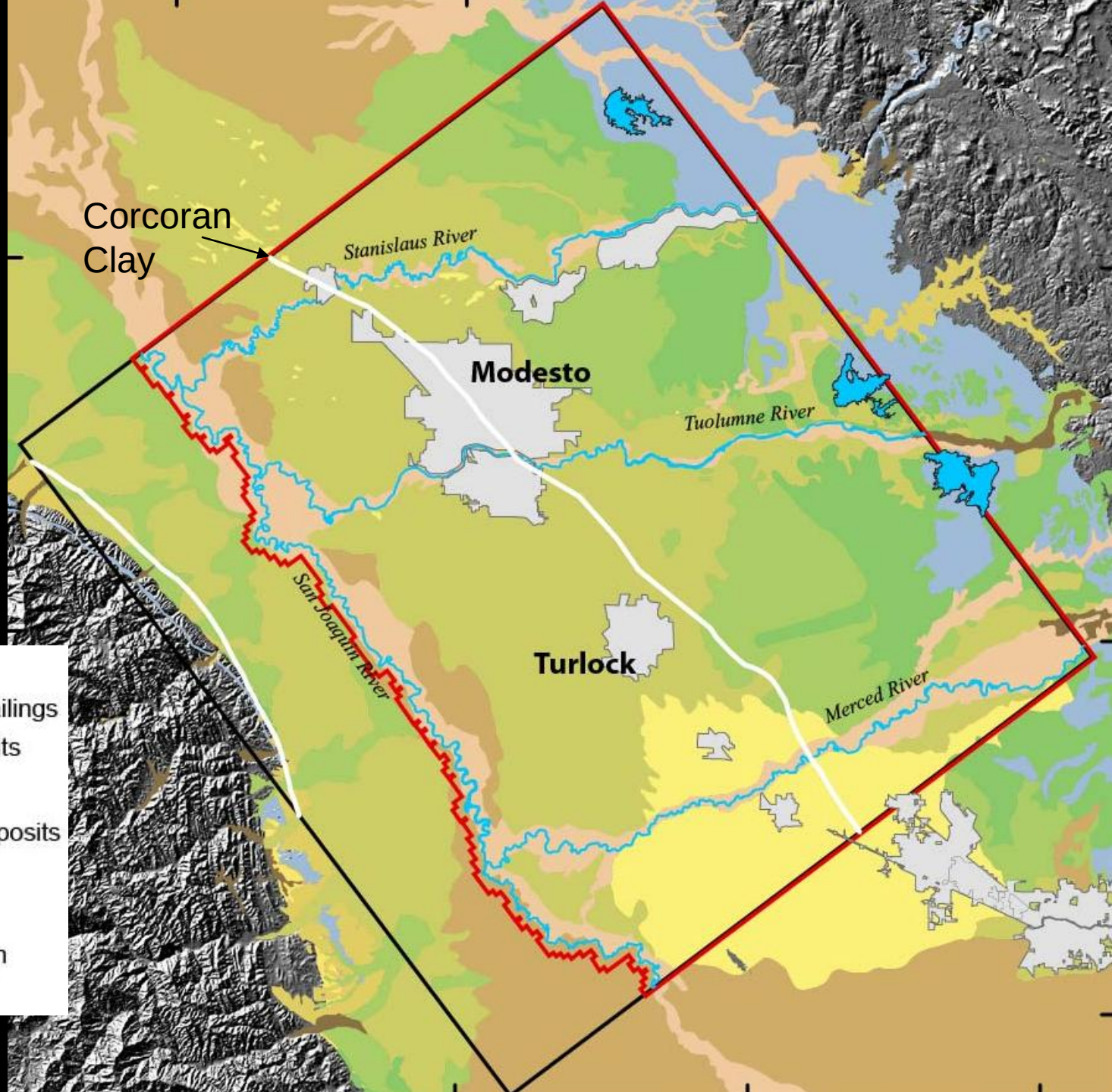
Model Grid

¼-mile grid spacing

16 layers



Local Geology

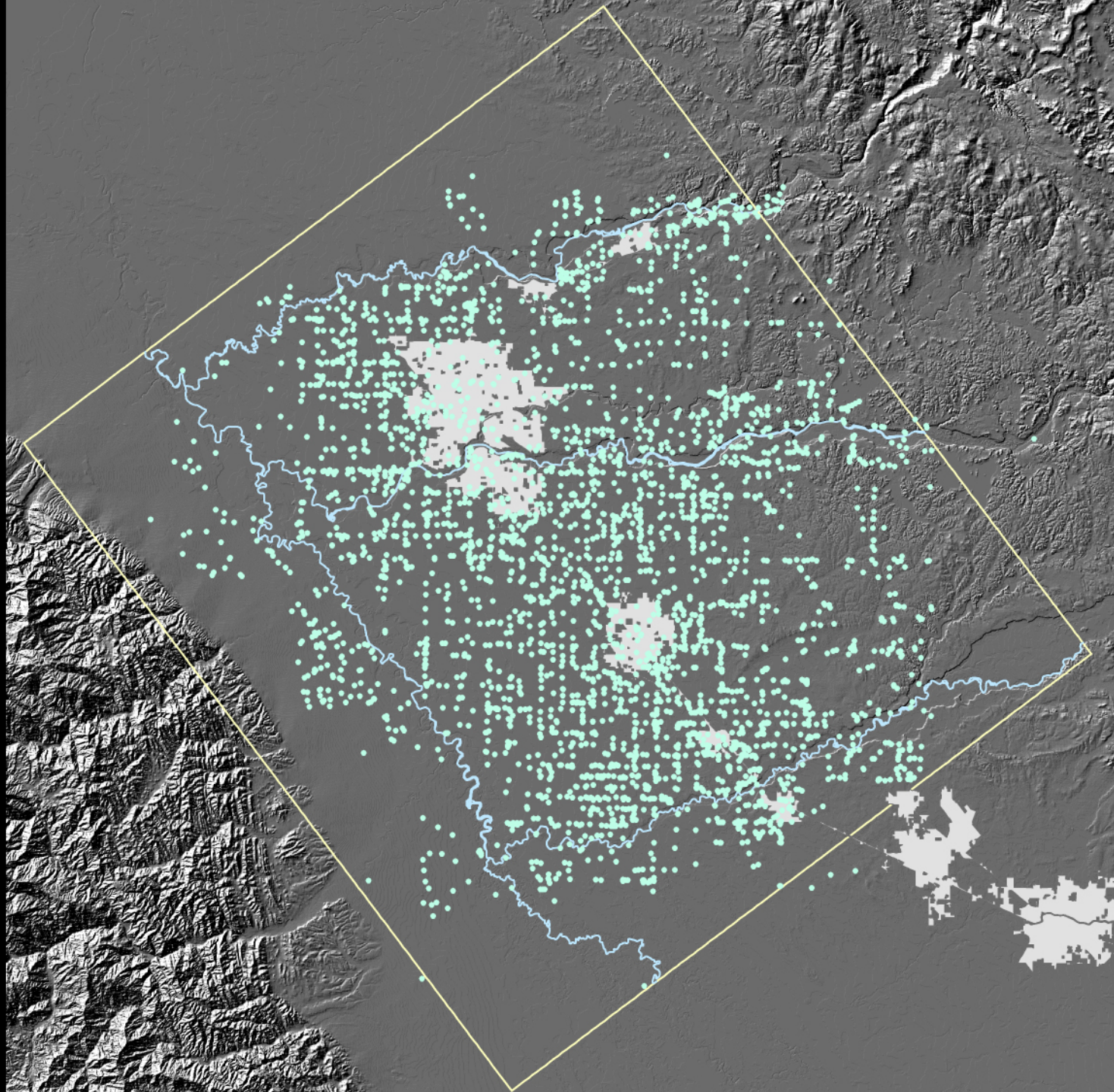


- Dunes
- Alluvium and dredge tailings
- Stream channel deposits
- Flood-basin deposits
- Non-marine terrace deposits
- Modesto Formation
- Riverbank Formation
- Turlock Lake Formation
- Mehrten Formation

Incorporation of Geology into the Model

- Used sediment texture data from over 3,500 boreholes
- Estimated aquifer properties (hydraulic conductivity) for every model cell on basis of sediment texture

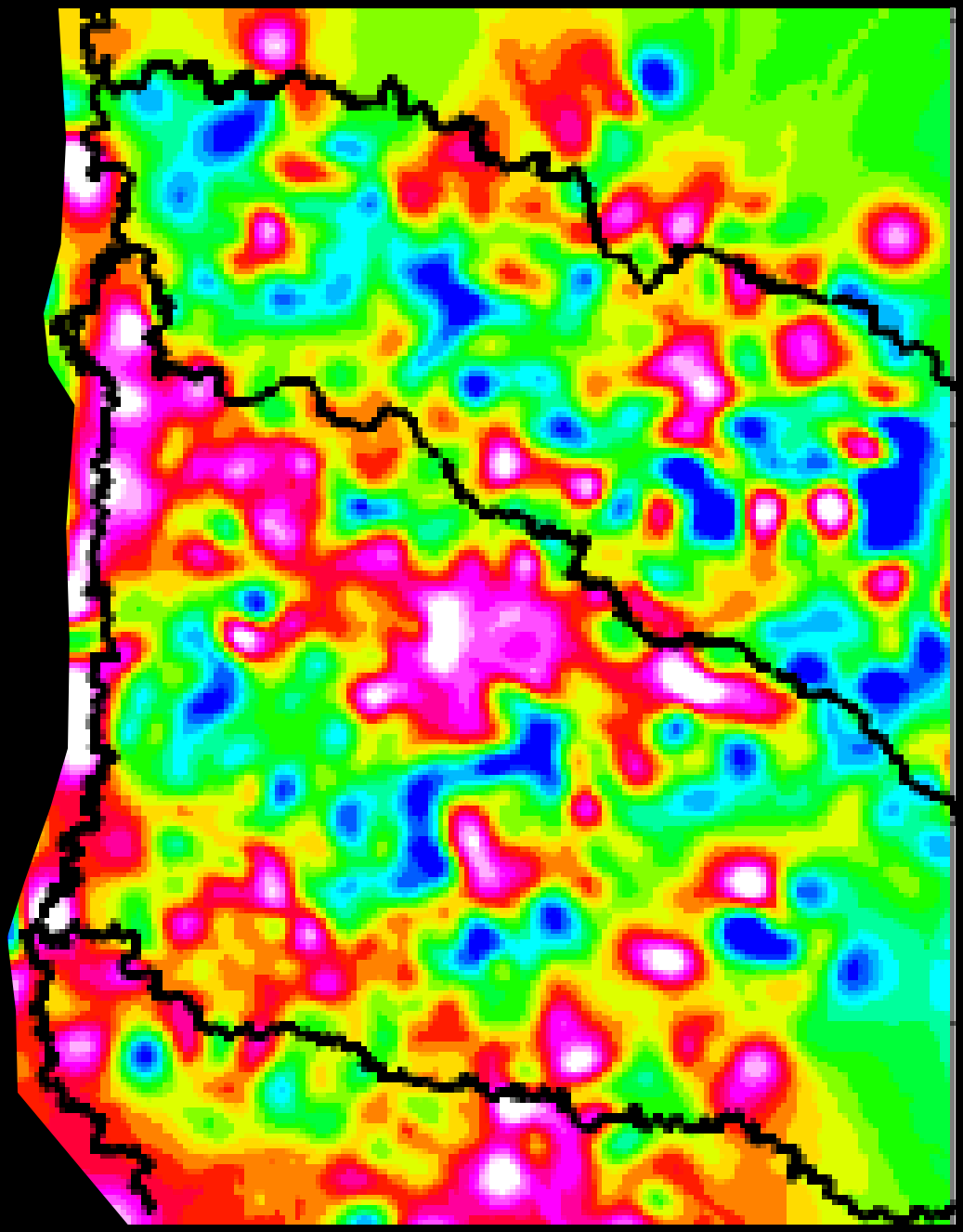
Locations of 3,500 drillers' logs



Sediment texture at 80 ft depth

Hot colors = coarse

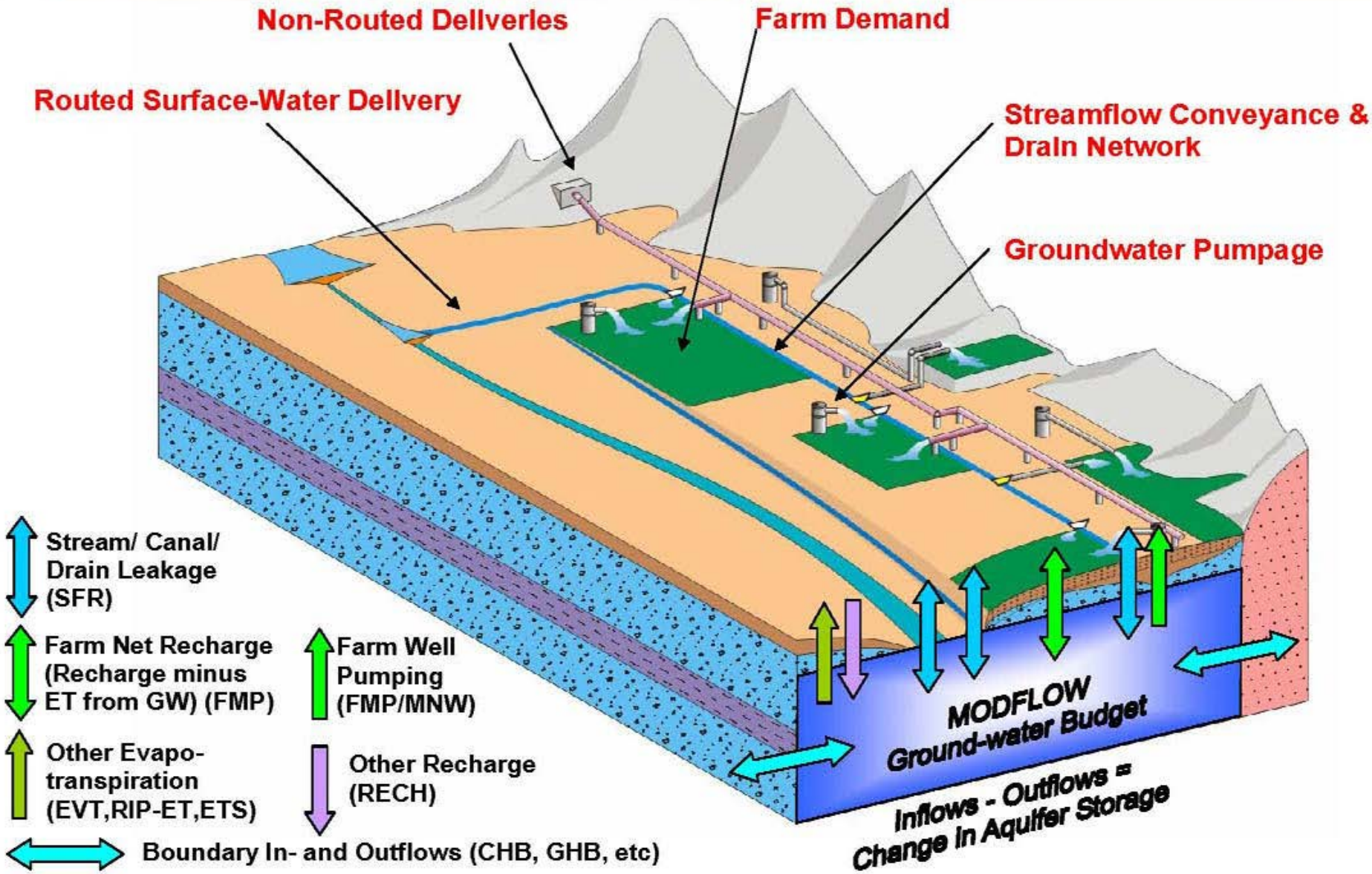
Cool colors = fine



The water budget is dominated by agricultural use → using the Farm Process in MODFLOW-OWHM

Current Features of FMP

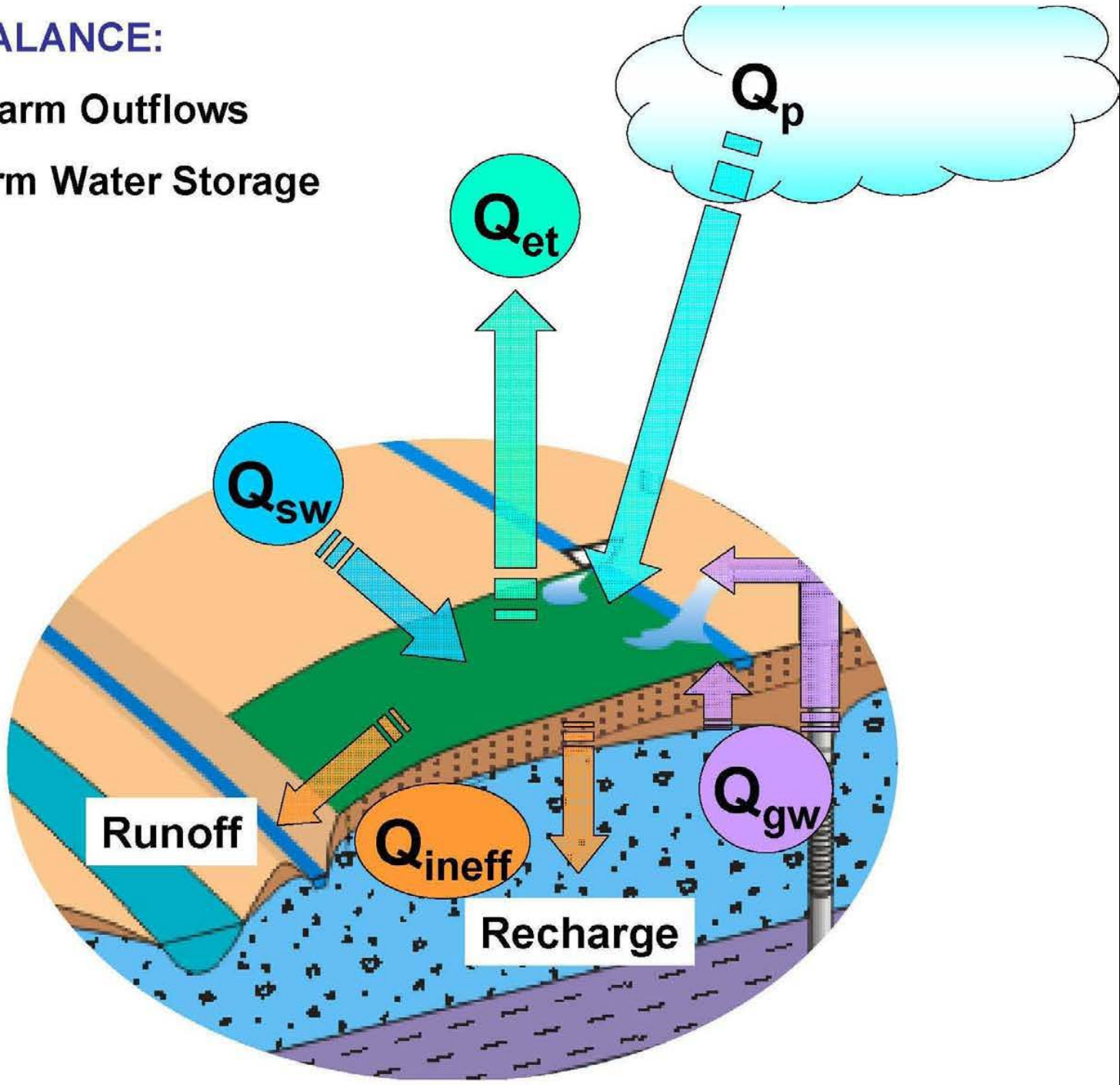
Demand & Supply and Mass Balances



FARM MASS BALANCE:

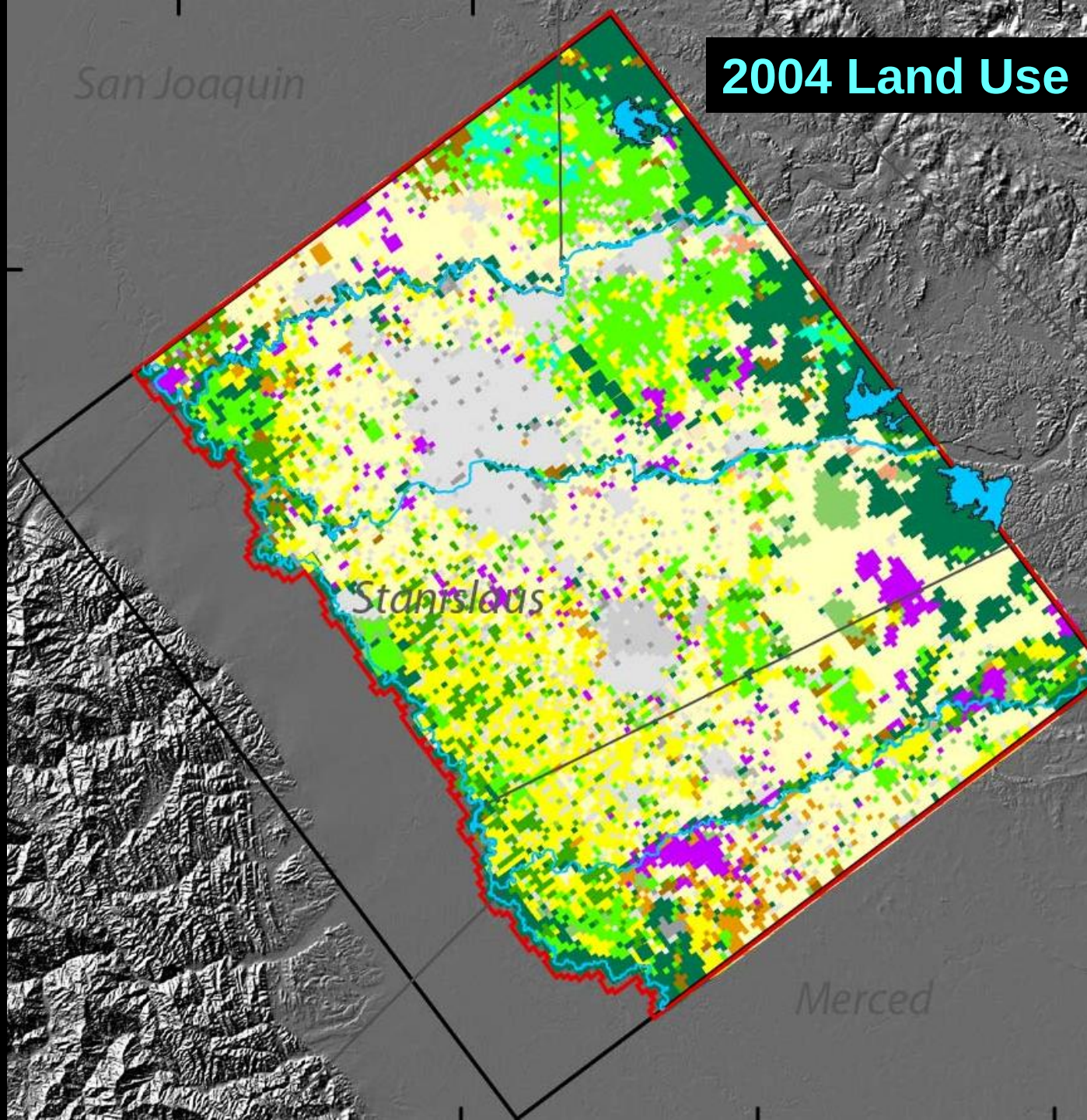
Farm Inflow – Farm Outflows

= Change in Farm Water Storage



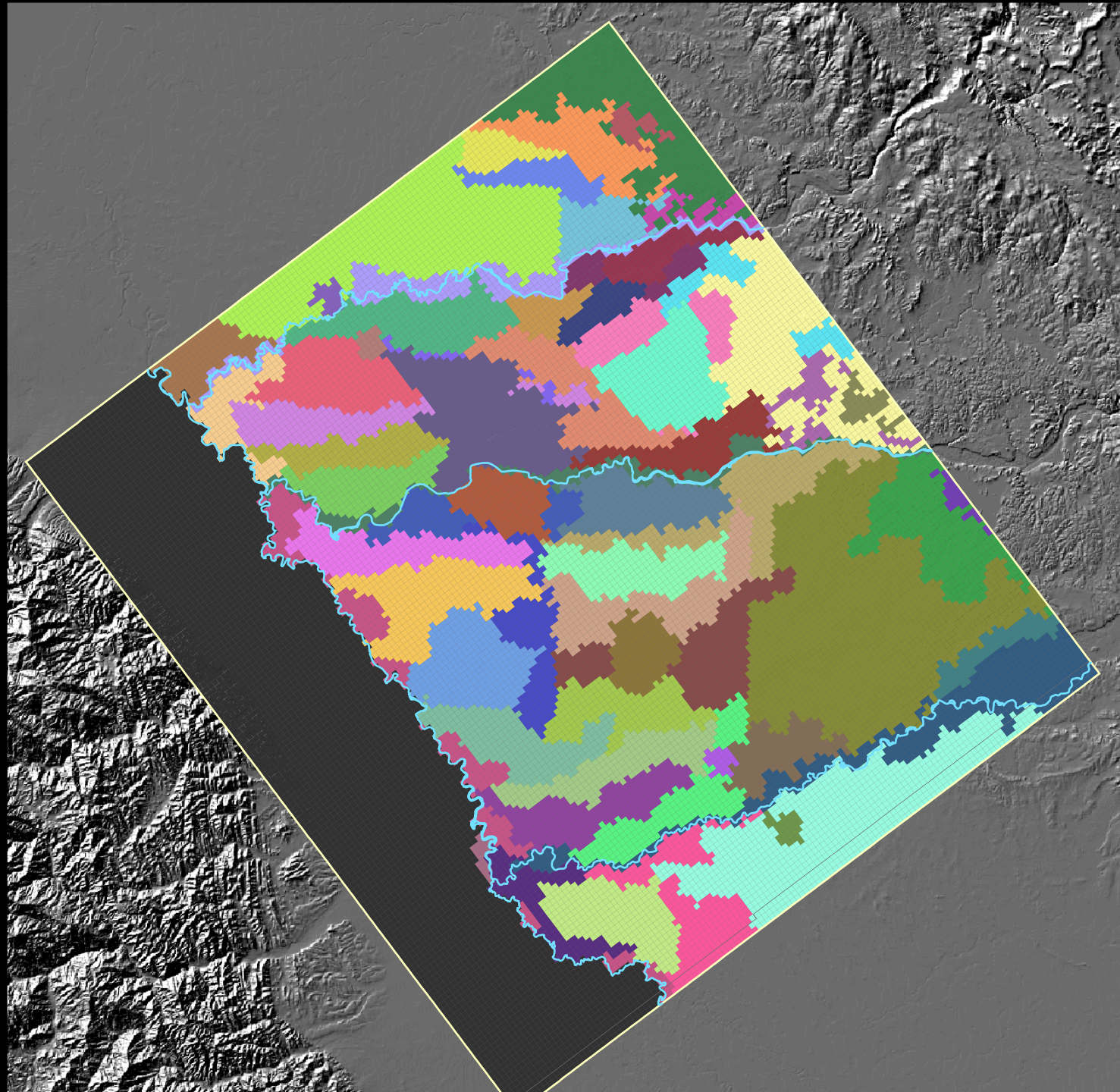
Farm Process input includes:

- Land use (from DWR & Ag Comm's)
- Precip
- ETo
- Kc
- Root depths
- Soil type
- % runoff
- and more



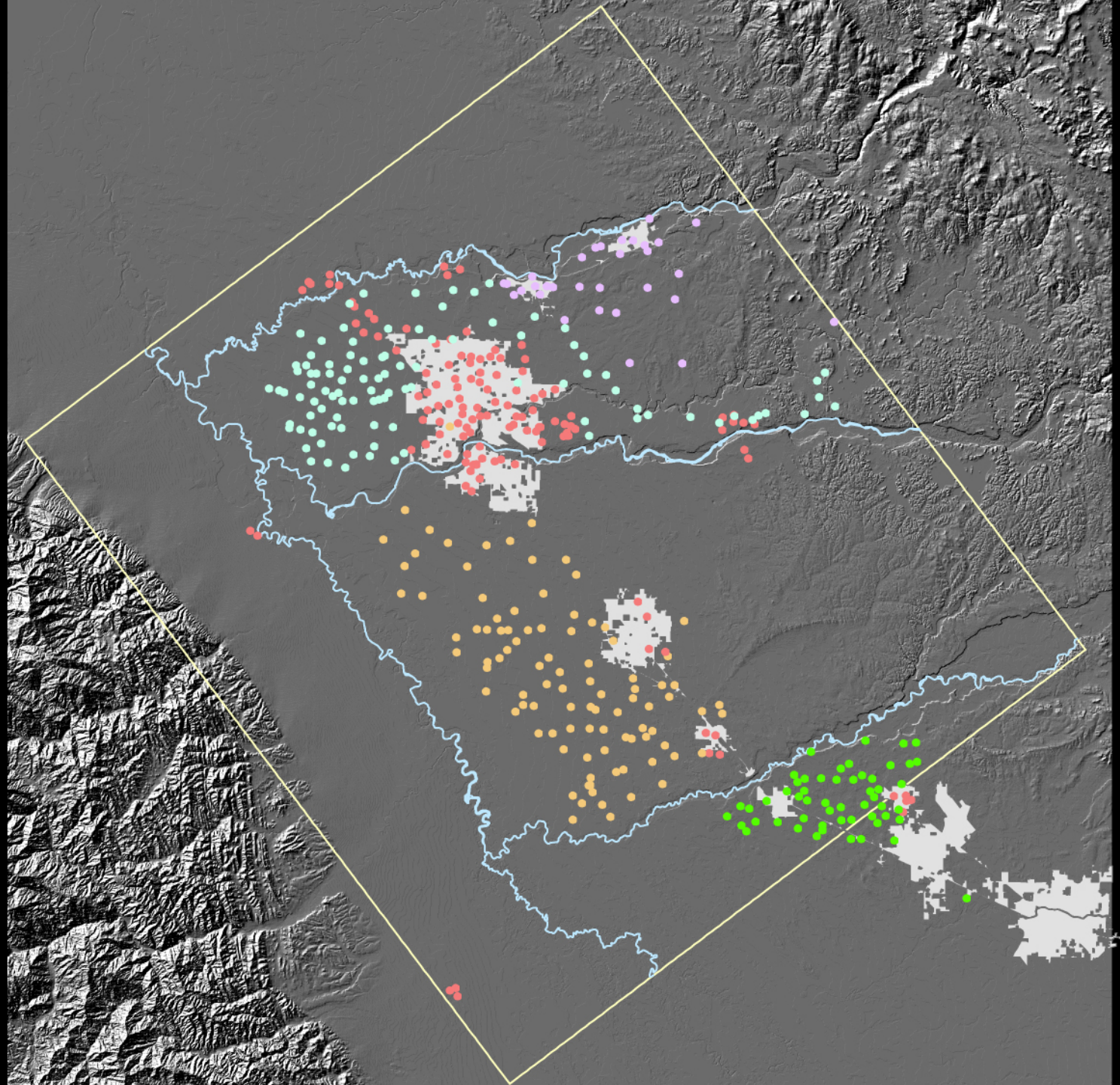
Designation of water budget areas

Based primarily on “known” water deliveries

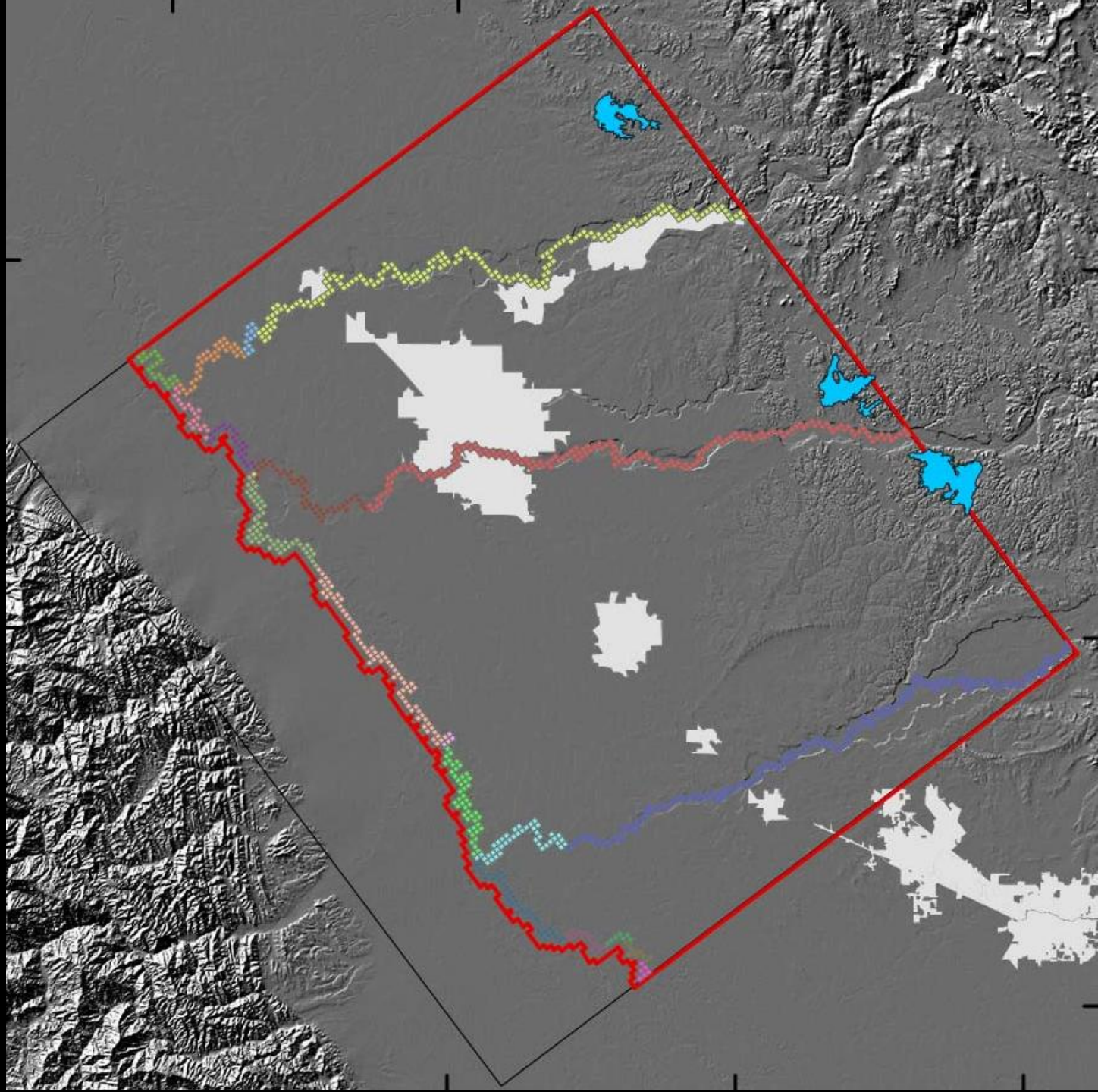


Wells with known pumpage (urban, drainage, and some ag.)

→ Farm Process estimates private irrigation pumpage



Simulation of rivers & stream-aquifer interaction

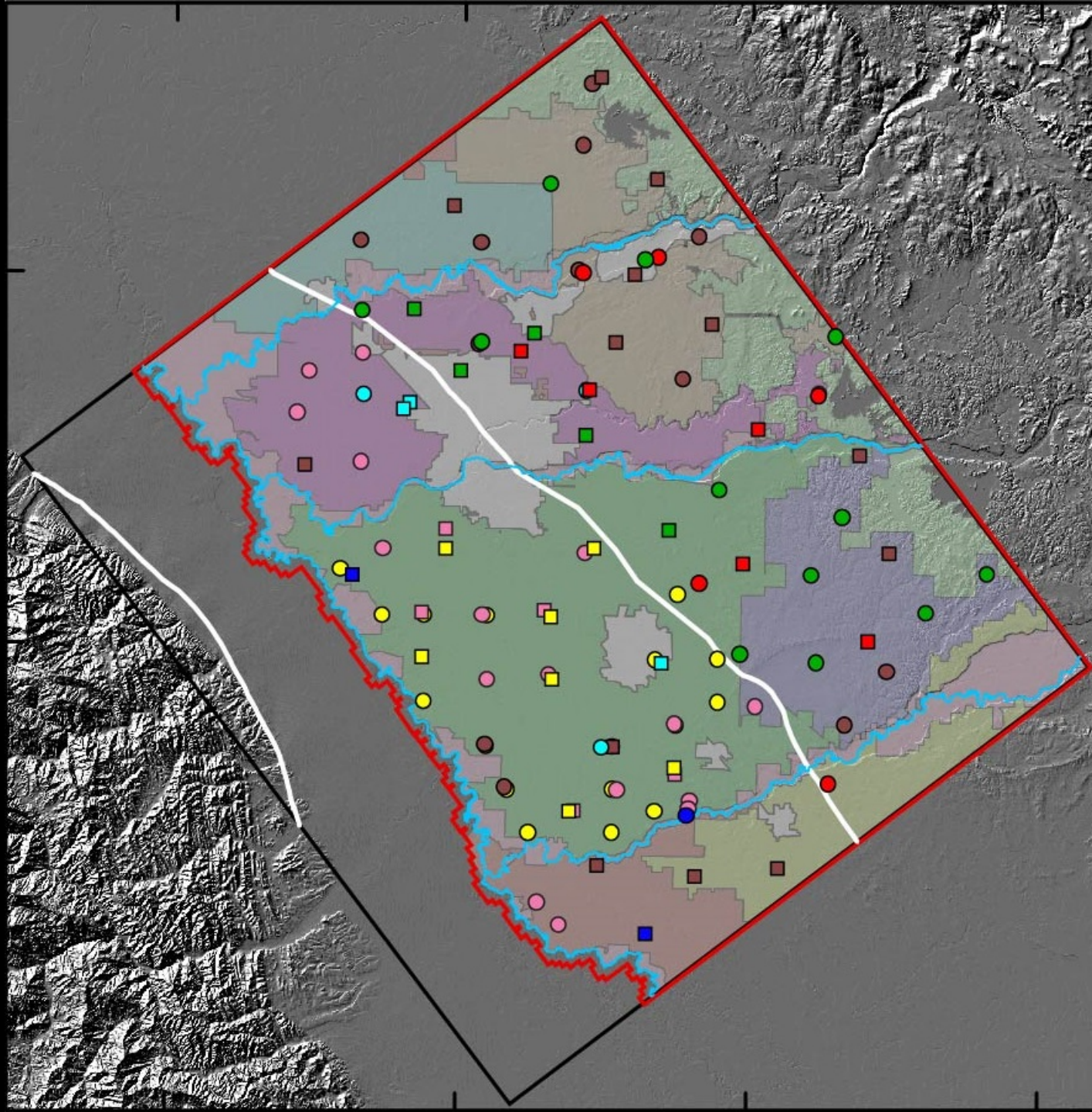


Model Calibration

Purpose: to best match simulated values to measured values by varying model input within a reasonable range

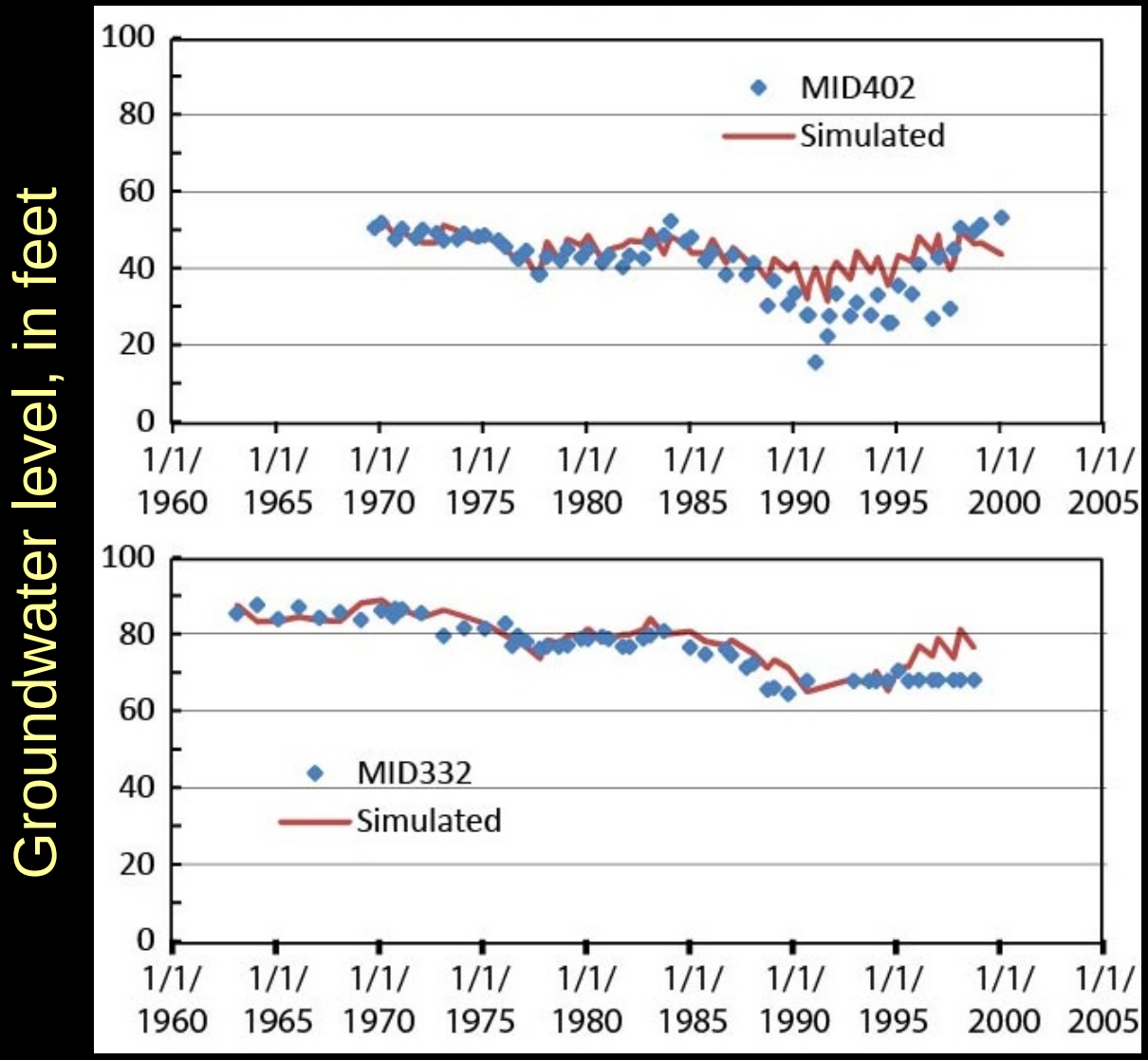
- 4,061 groundwater-level measurements in 109 wells
- 2,739 average monthly streamflows from 6 stream gages (one on each tributary, 3 on the San Joaquin R.)

Groundwater wells used for model calibration



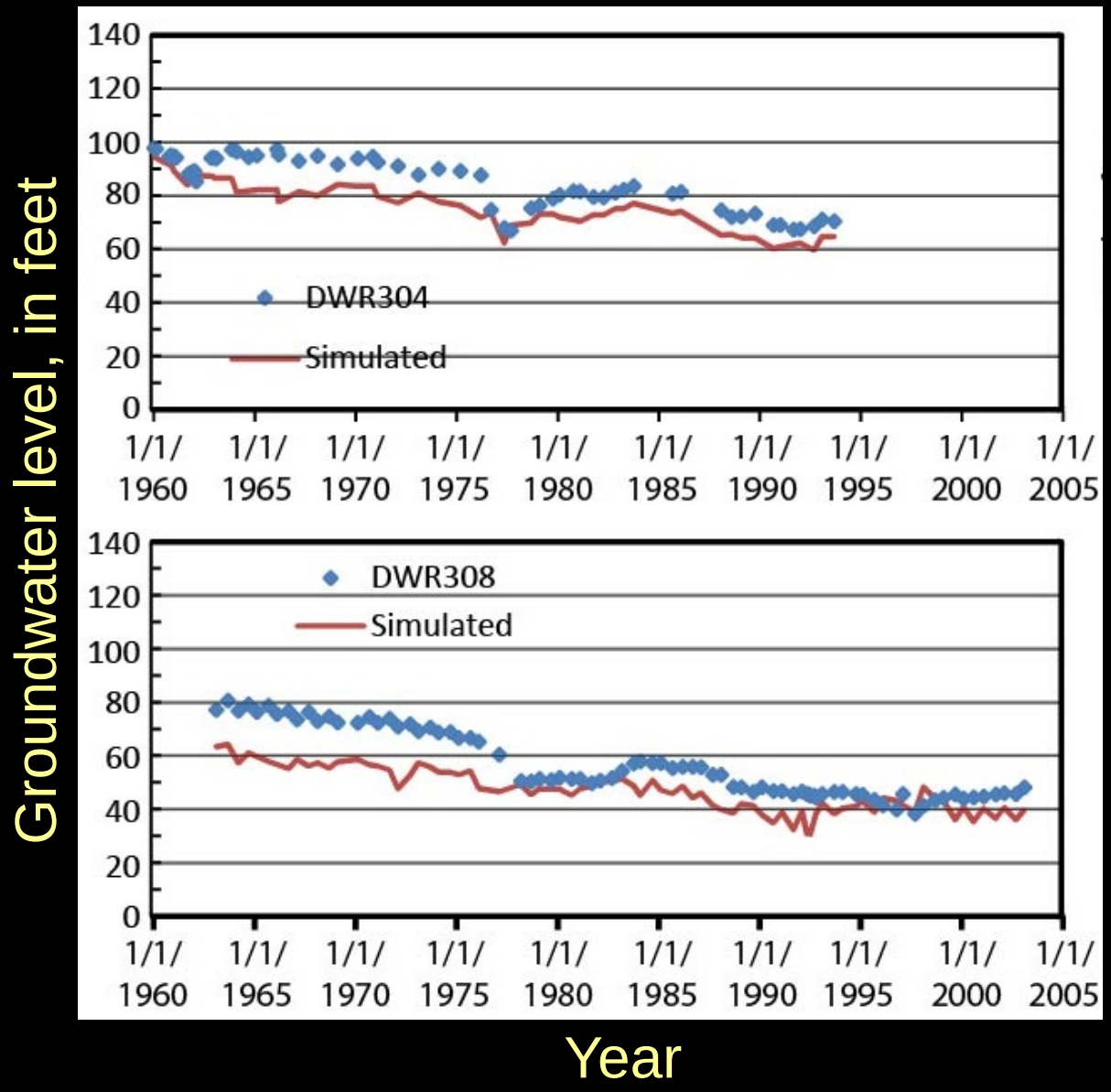
Groundwater -level hydrographs

Modesto ID



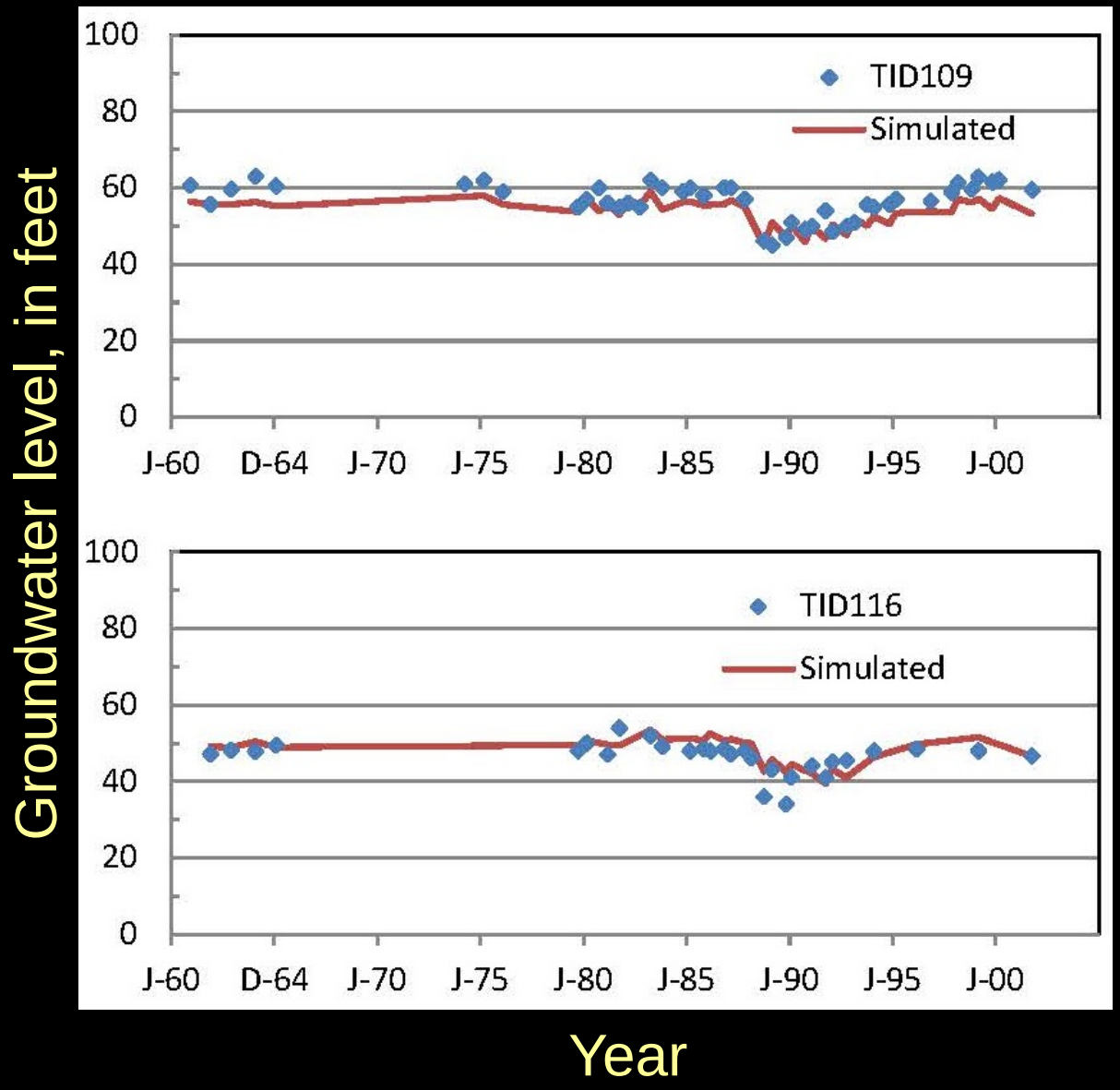
Groundwater -level hydrographs

Oakdale ID



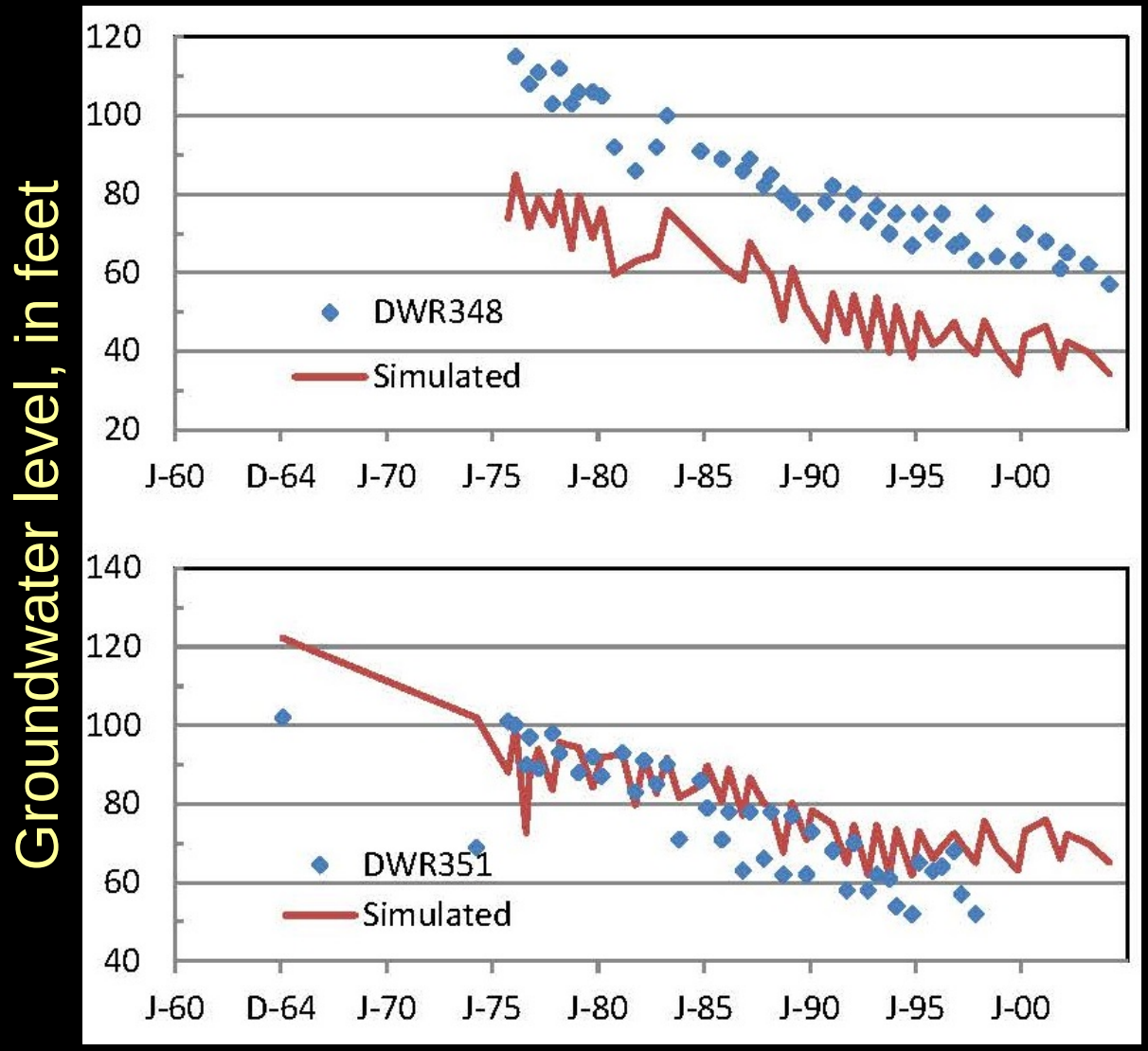
Groundwater -level hydrographs

Turlock ID

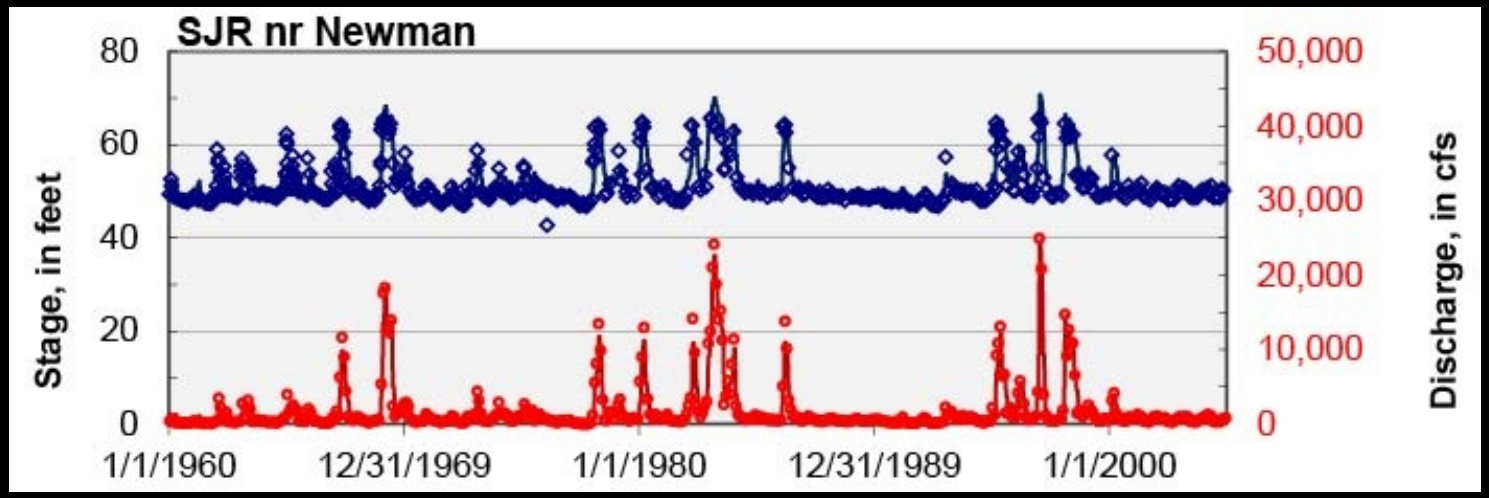


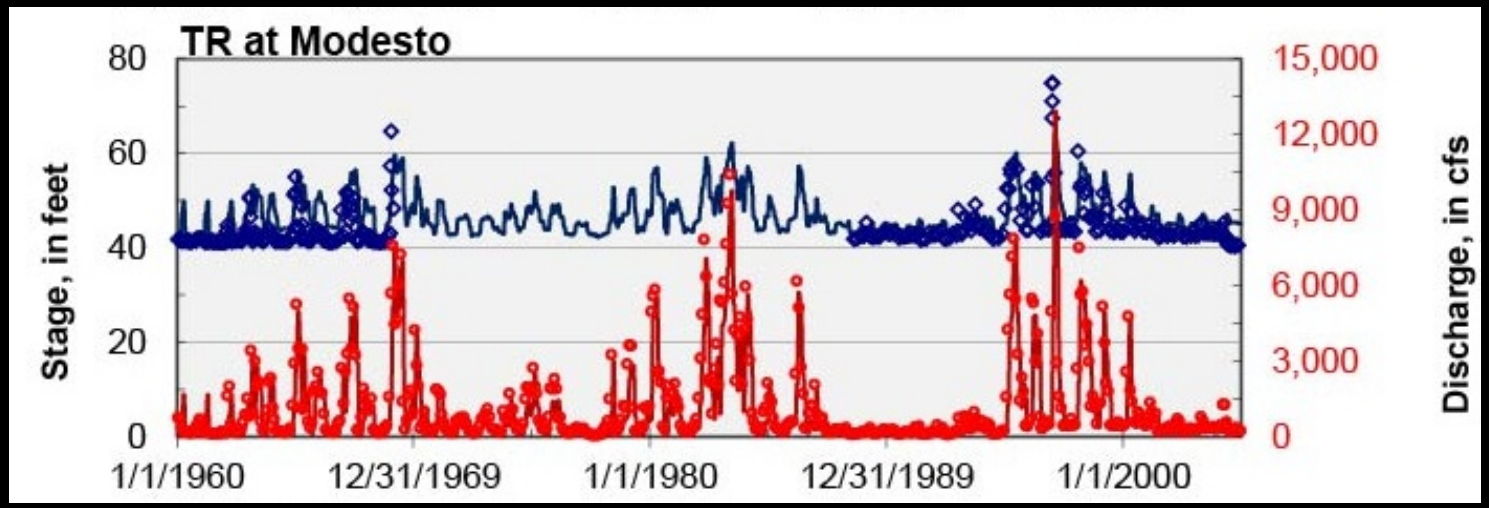
Groundwater -level hydrographs

Eastside WD



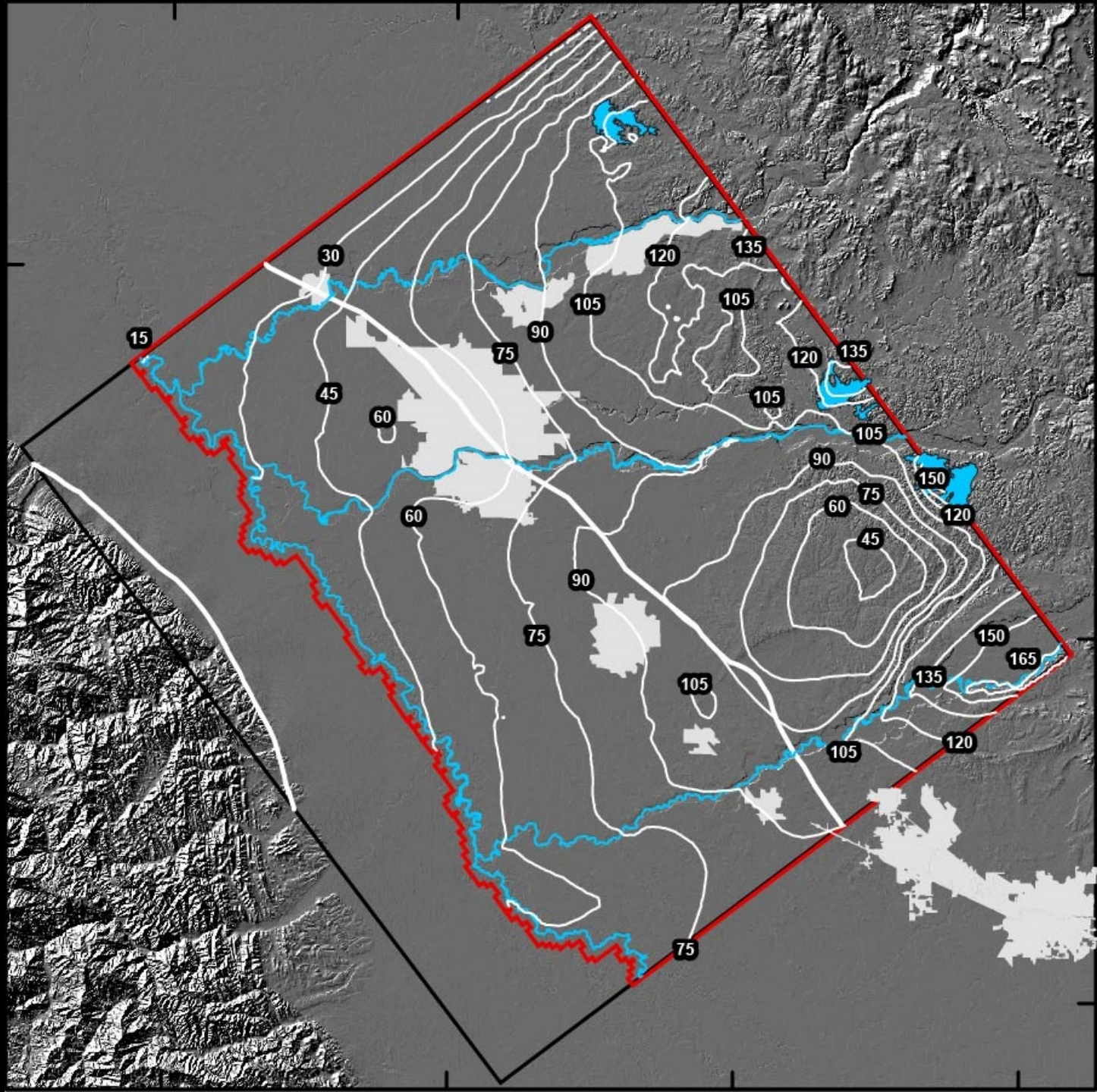
Calibration to streamflow





Preliminary Model Output

Simulated water levels, 15-foot interval, March 2000



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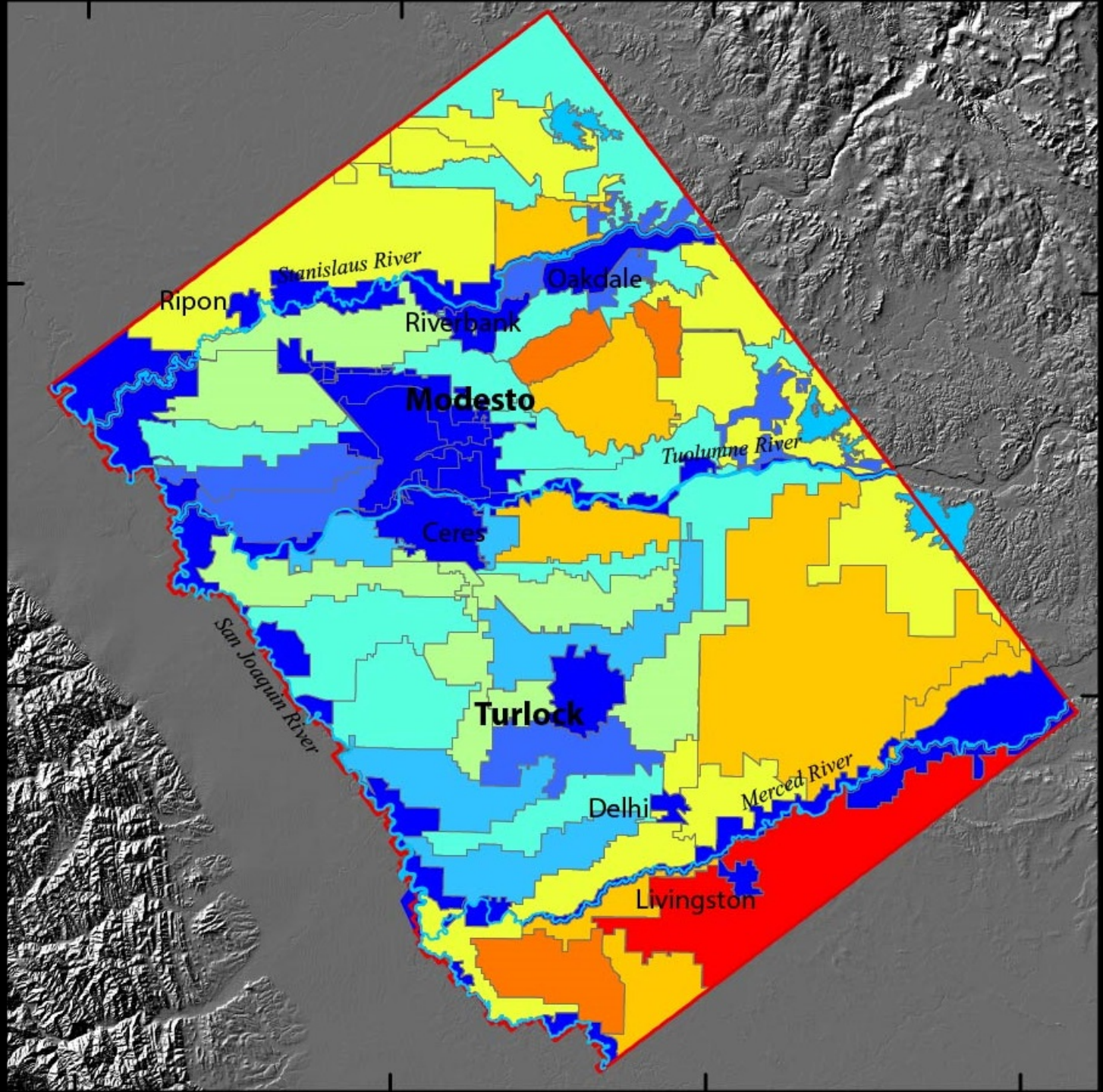
Preliminary Model Output

Simulated private agricultural pumping

Hotter color = more Ag pumping



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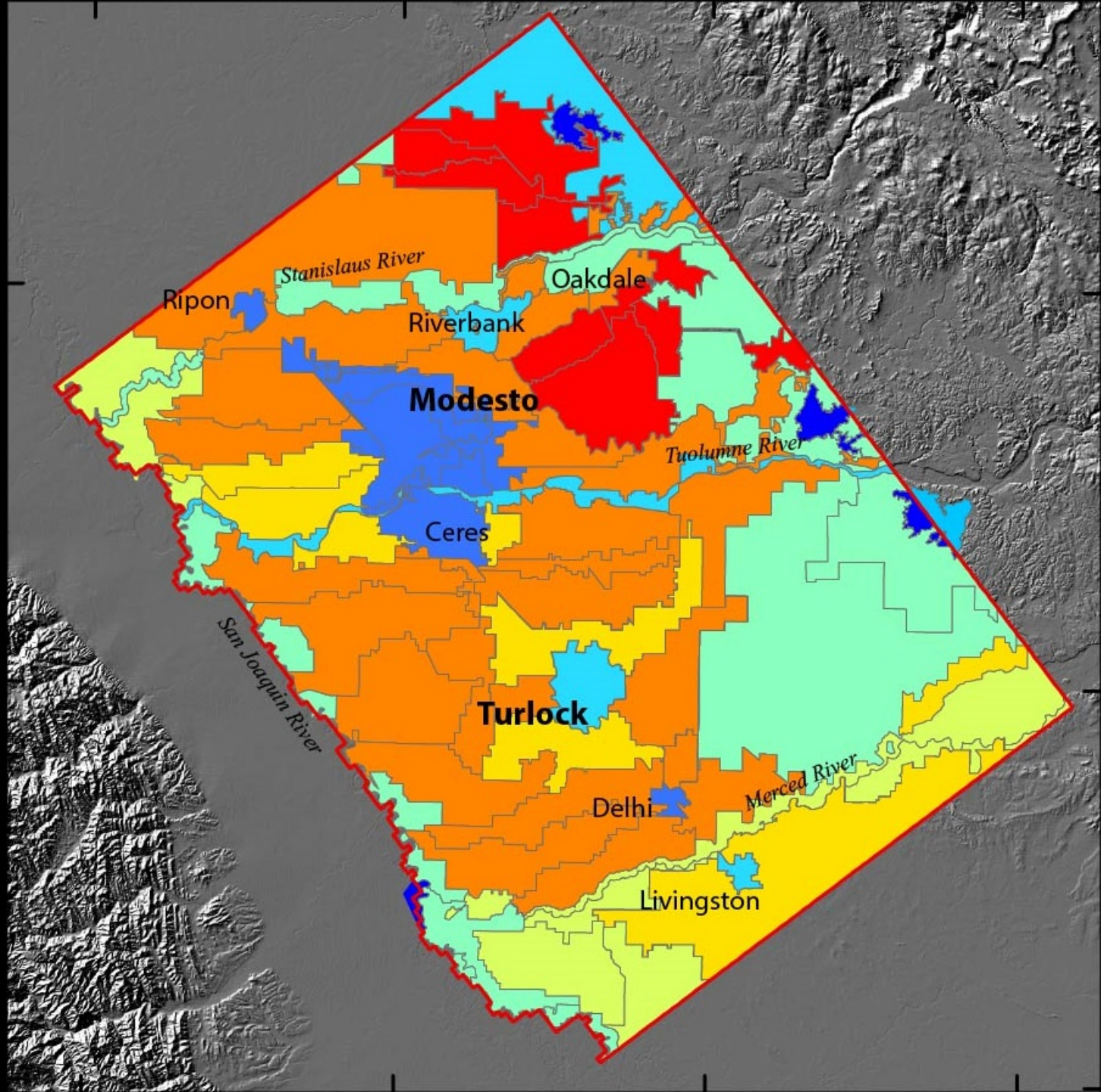
Preliminary Model Output

Simulated areal recharge

Hotter color = more recharge



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Potential Sources of Model Error & Uncertainty

- Private irrigation pumpage
  - Irrigation efficiency estimated
  - Annual variability in timing of crop demand not accounted for
  - Uncertainty in irrigation deliveries
  - Areal distribution assumed to be even within a water-budget area

Potential Sources of Model Error & Uncertainty cont.

- Northeastern boundary condition
  - Assumed to be no-flow, but model results suggest flow occurs
- Reservoir recharge
  - Simulated leakage from reservoirs lower than estimated
- Etc.

Is this Model Useful?

Yes, it can be used as-is for some purposes, and as a solid foundation for added capabilities. As-is, it can help evaluate:

- Water management options [ideally suited for comparisons]
- Effects of natural or man-made changes on groundwater/stream interactions
- Local issues, by providing regional hydrologic context

Potential Future Improvements & Uses

The model, which runs through 2004, cannot be used to simulate recent development in the foothills. To do this:

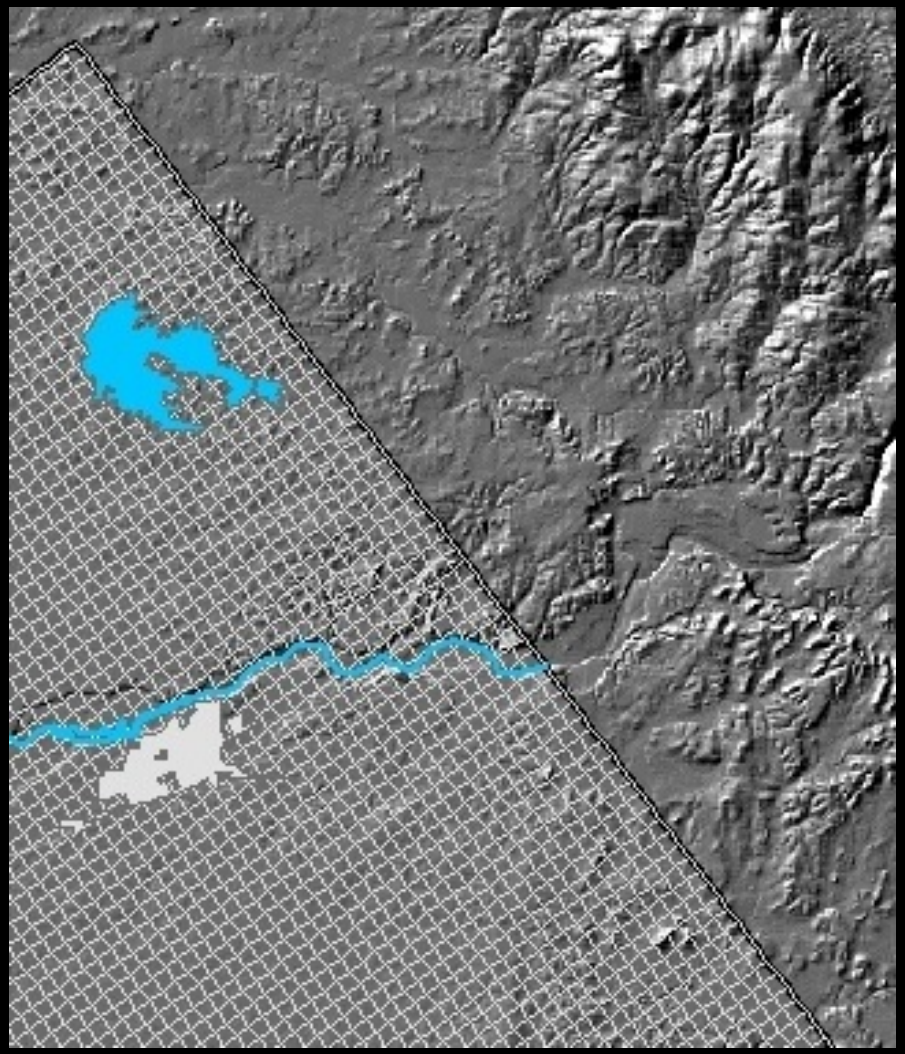
- Update in time
- Expand eastward
- Consider addressing key sources of error at this time

Update the model in time

- Data from districts, cities, DWR, etc. –
  - Deliveries
  - Pumpage
  - Land use
  - Climate
  - Groundwater levels
  - Streamflow
  - ...
- Convert to model format

Eastward expansion of the model

- Geologic information
- Land use
- Climatic data readily available
- The Farm Process will estimate irrigation pumpage



Thank You!
Questions?

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