Sacramento Valley Groundwater-Surface Water Simulation Model (SVSim): A New Tool for Evaluating Stream Depletion in the Sacramento Valley

Chris Bonds, PG, CHg

Senior Engineering Geologist

SVSim Project Manager

CALIFORNIA DEPARTMENT OF WATER RESOURCES

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CWEMF 2023 Annual Meeting
April 19, 2023

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Just For Fun, Let's See If We Can Spice Things Up…

So How About…

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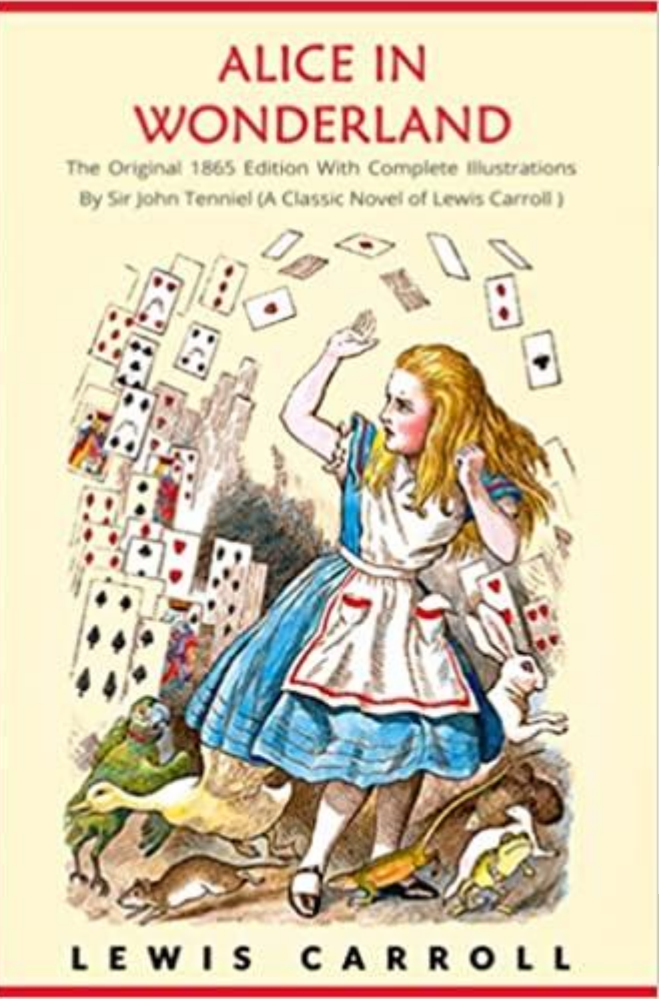

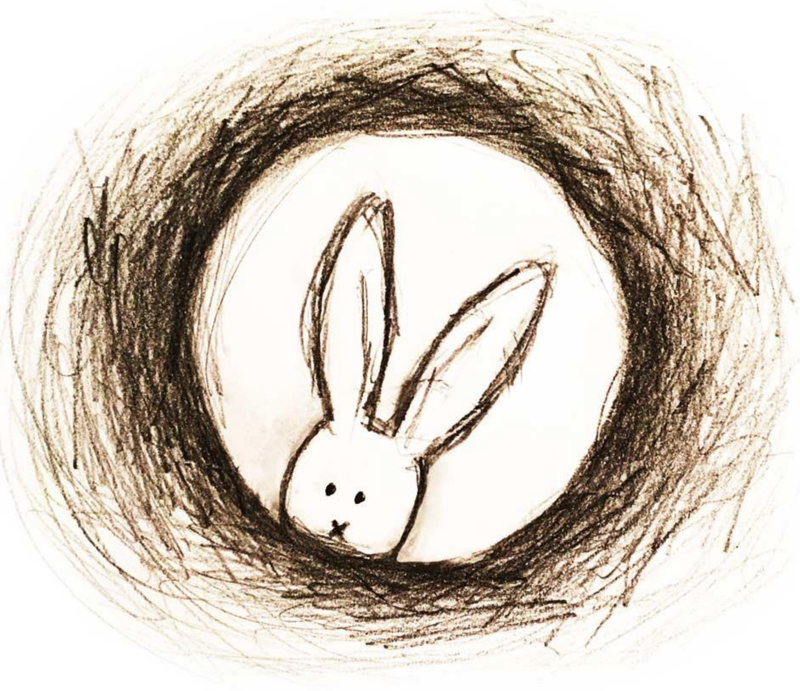

It’s Dark Down There…

Or…Stream Depletion…
Just the Tip of the Iceberg…


Or…If you ain’t got good data, you ain’t got diddly!

Or…Revenge of the Groundwater Nerds

Let’s Go With

Stream Depletion…Another Inconvenient Truth…

SVSim conceived during the 2014 Drought…

SGMA…Initial C2VSim Testing…Hydrogeo. Con. Model…

Develop Model Input Data….Initial Calibration…

More Drought…Interrogate the Data…Wet year 2017…

Oroville Spillways Emergency…Revise Input Data…

Re-Calibrate…2020 GSPs…COVID…Teleworking…

Re-calibrate…Sensitivity Analysis…

Model Documentation…Vaccines…ADA Review and

Remediation…Lengthy Management Review…

2022 GSPs…

*****Public Release of SVSim V 1.0…June 2022*****

Important SVSim Statistics:

Over 7 years in development…

Hundreds of meetings, teleconferences, and calls…

Five (5) Technical Memos…TM-1A through TM-4

2,776 pages of extremely nerdy stuff…

10s of gallons of blood, sweat, and tears…

Project occurred across five (5) DWR Directors…

Multiple task order amendments…

However, the opportunity to work with the world-class SVSim Team was ***Priceless and I Learned So Much!***

SVSim Project Team

- Chris Bonds, Linda Bond
- Saquib Najmus, Mesut Cayar, Frank Qian
- Vivek Bedekar, Leland Scantlebury, Marinko Karanovic, Mashrur Chowdhury, Matt Tonkin
- Tim Durbin, Claire Velayas

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Where can you find SVSim V 1.0 Model Files, Documentation, and other Important Data?

CA Natural Resources Agency (CNRA) Open Data Portal:

https://data.cnra.ca.gov/dataset/svsim

SVSim Project Objectives

- Develop a tool to evaluate project-specific impacts of groundwater substitution transfers on stream depletion in the Sacramento Valley

  - Supports DWRs State Water Project Analysis Office (SWPAO), State Water Contractors (SWCs), water transfer sellers/buyers, and other stakeholders

- Develop a tool to evaluate water budgets, groundwater-surface water interactions, and simulate SGM scenarios

  - Supports DWRs Sustainable Groundwater Management Office (SGMO), GSAs, NGOs, and other interested parties

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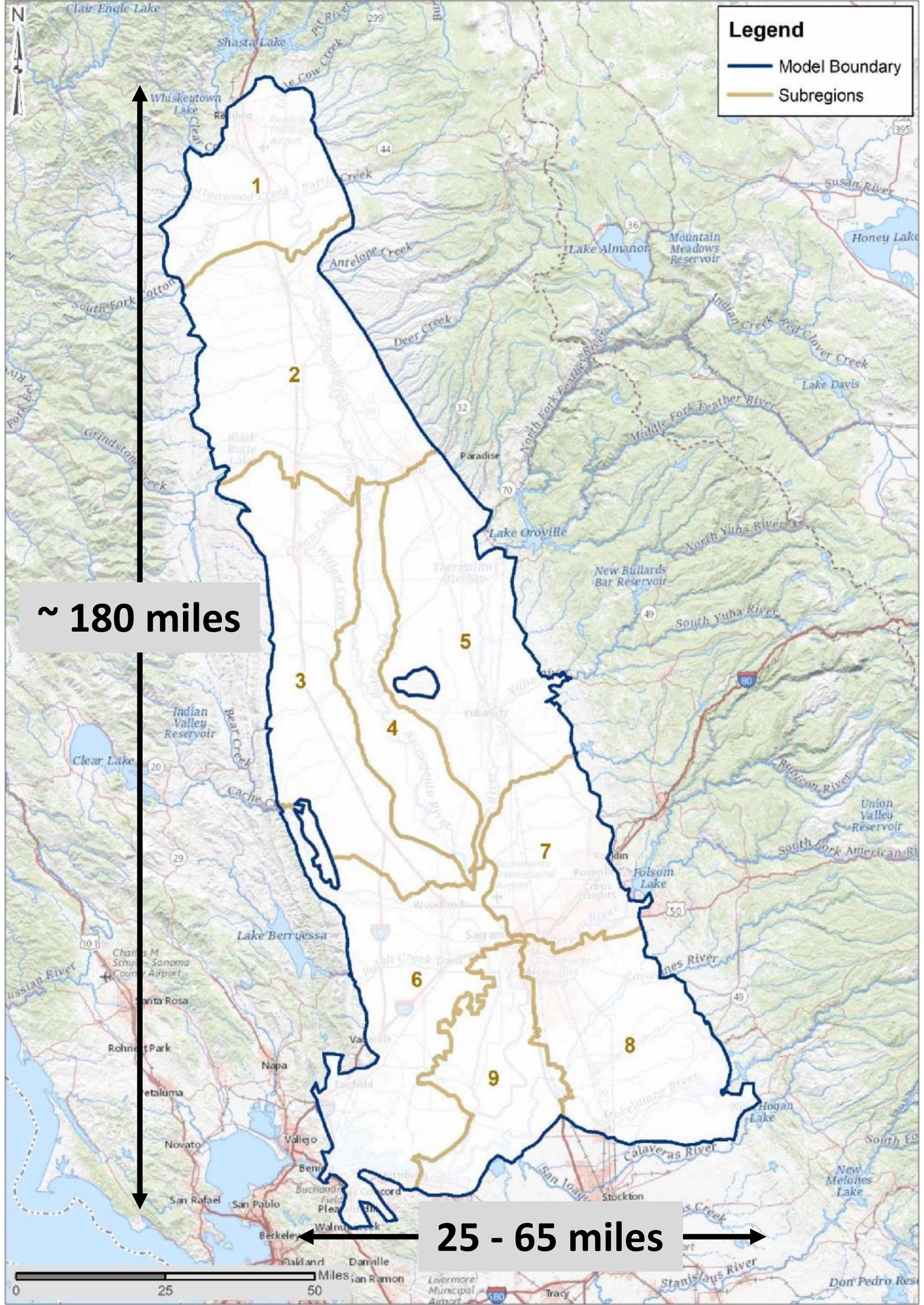
SVSim Features

- Encompasses Sacramento Valley, Redding Basin, and the Delta
- Area ~7,600 sq. miles
- Split into 9 subregions
- Integrated Water Flow Model (IWFM)
- Simulation period: Oct 1973 - Sep 2015



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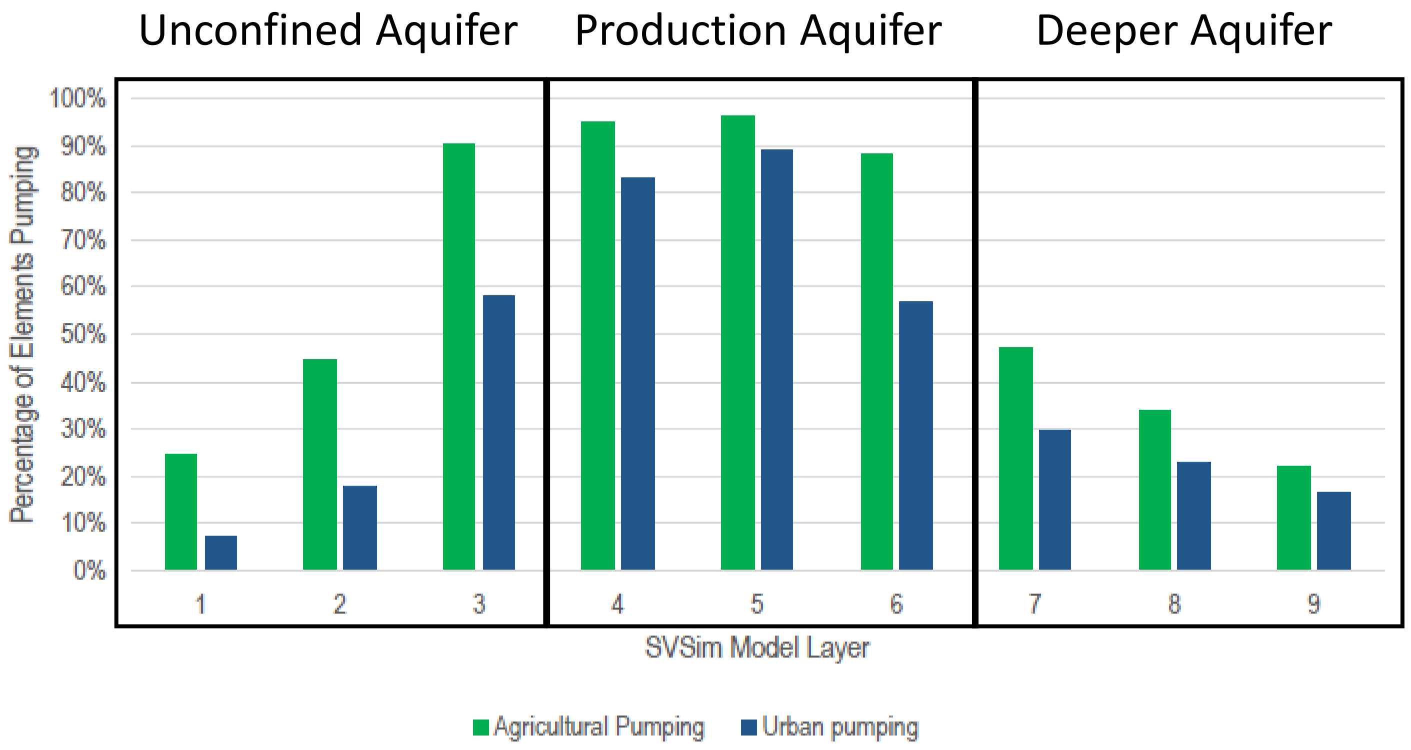
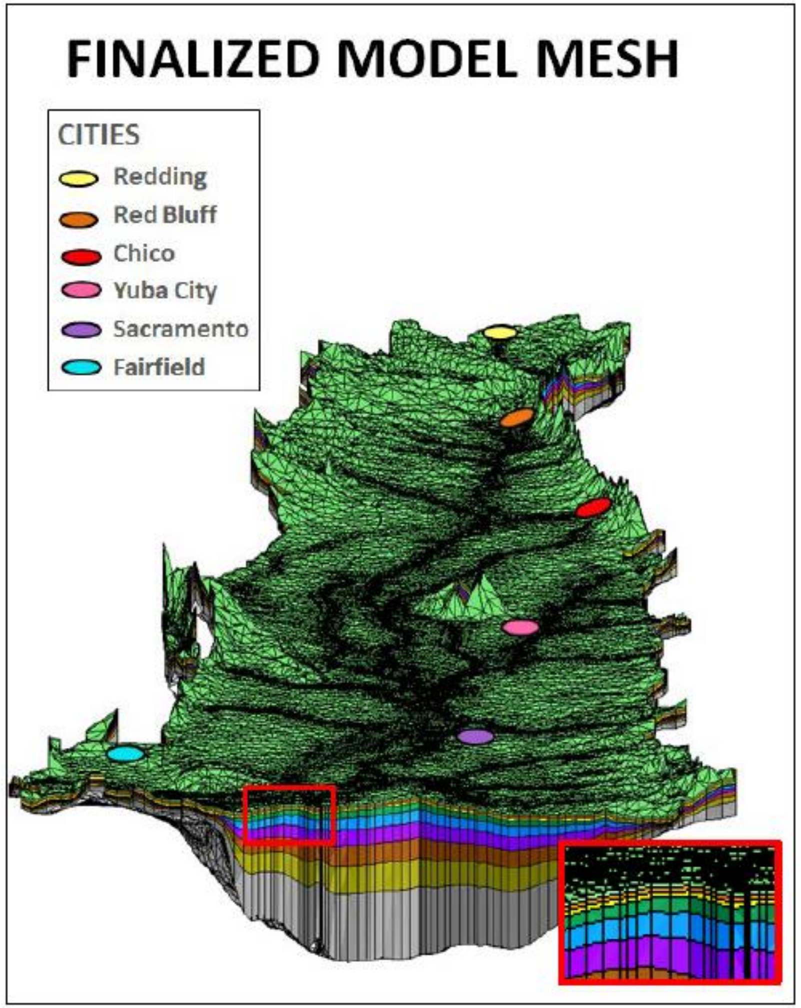
Model Design – Grid and Layering

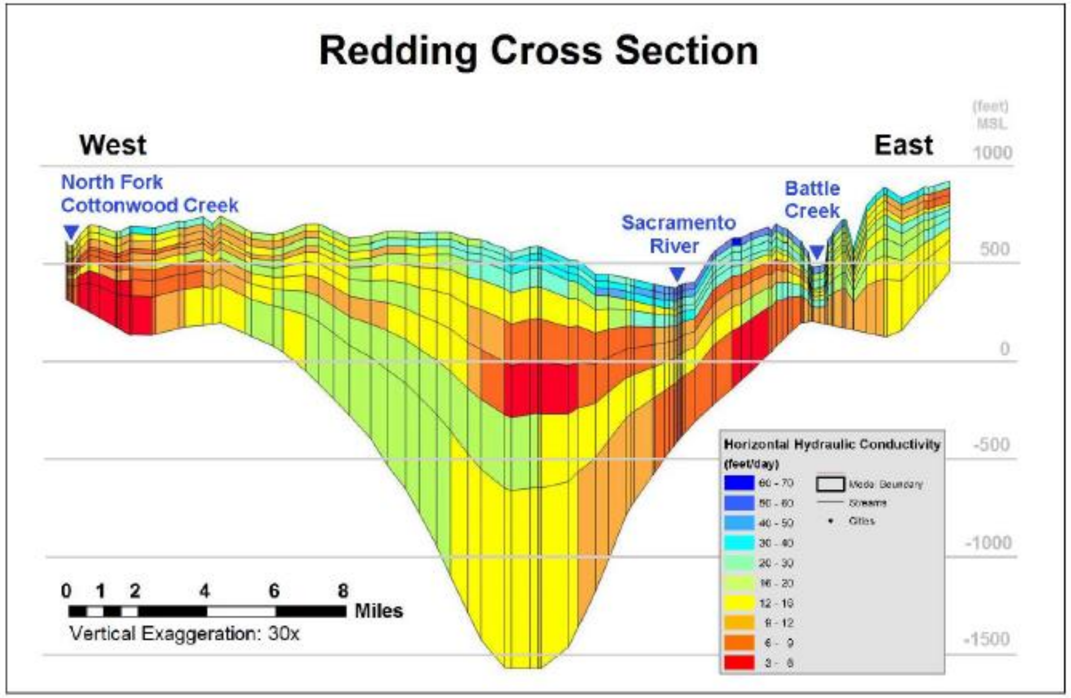
- Finite-element refinement close to streams
- Nine layers
  - Improved accuracy of stream-aquifer gradients
  - Provided more detailed representation of production zone

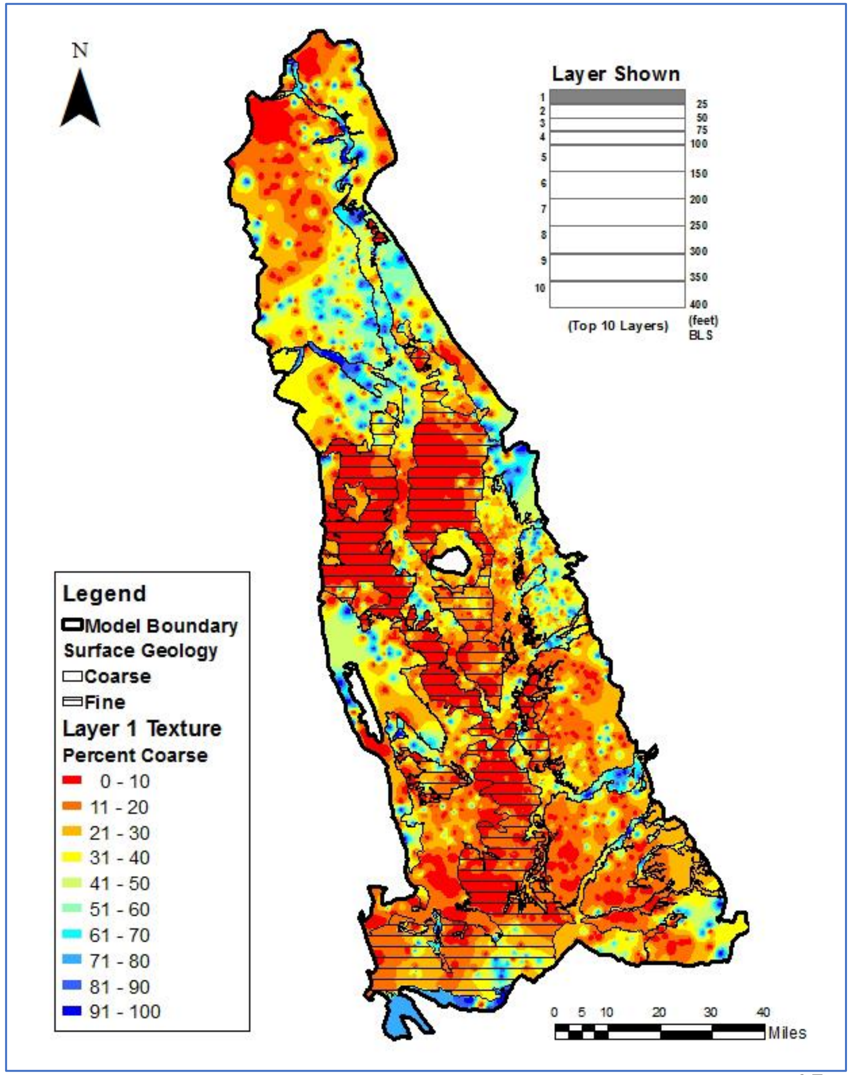




Model Design – Hydrogeology

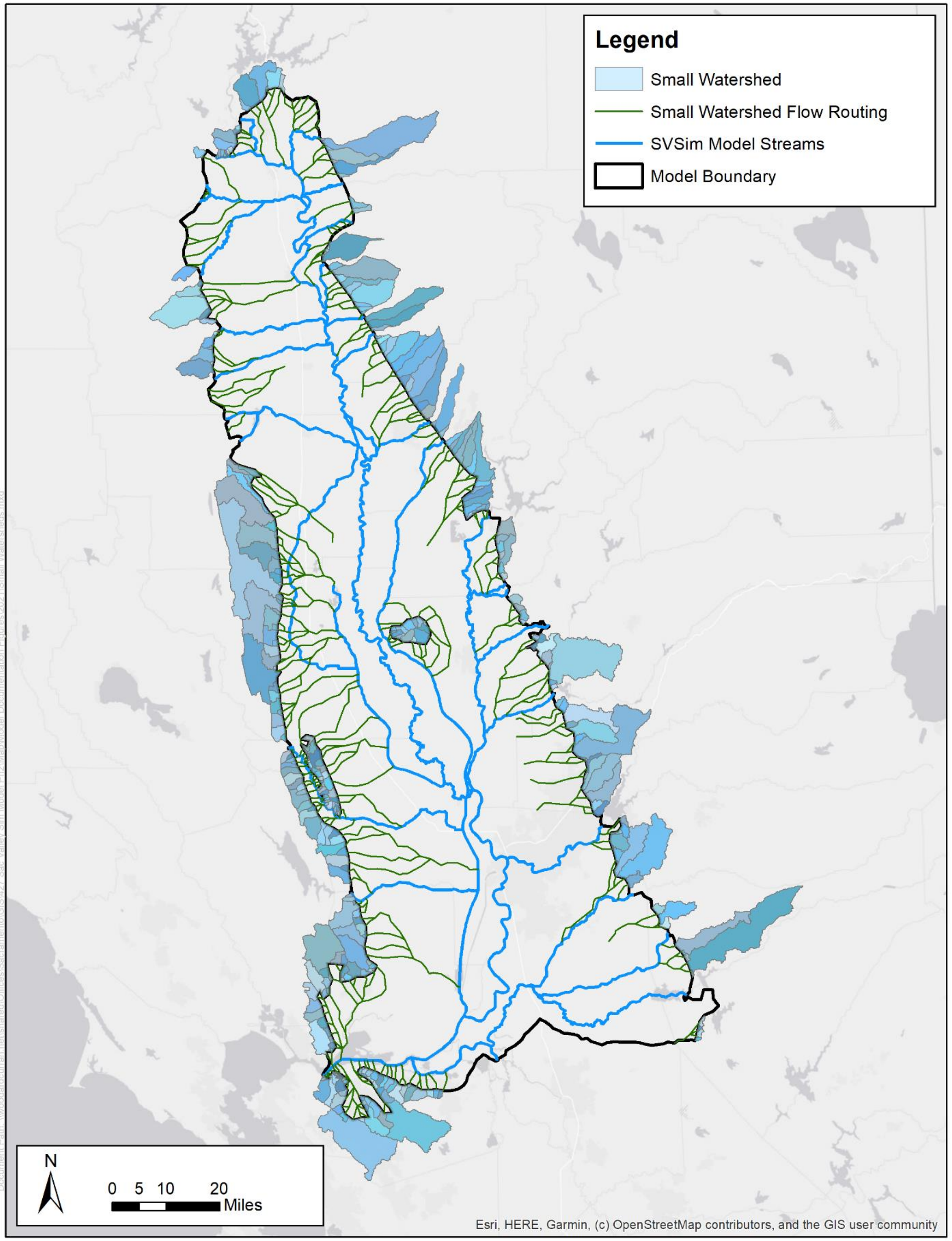
- Hydrogeologic Conceptual Model was defined by the deposition and structure of basin deposits
- Texture defines water transmission properties
- Aquifer parameter input for SVSim was based on a texture analysis of over 4,500 lithologic logs
- The Texture2Par Utility was used to convert the texture data into initial aquifer parameters



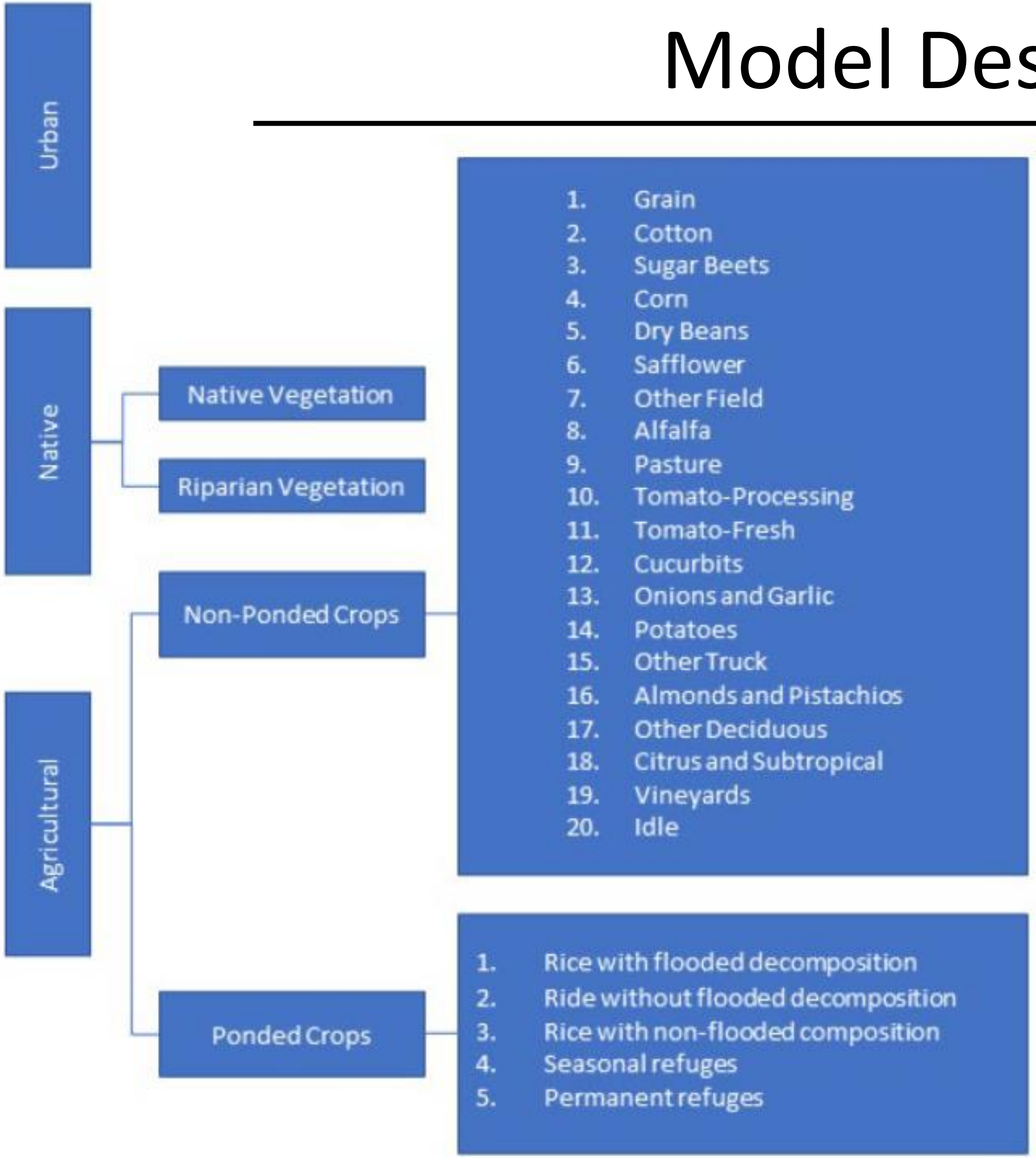


Model Design - Streams

- Stream inflow to the basin specified for regulated streams
- For unregulated streams, inflow from small watersheds to basin are simulated
- Sacramento River network including major tributaries, canals, and bypasses
- Within-basin flows based on CDEC station rating tables
- Three lakes simulated using general-head boundaries
- Flow at the southern boundary specified based on output from C2VSim-FG



Model Design – Land Use



- Urban Land Use
- Agriculture and Refuges
  - 20 non-ponded crops
  - 5 ponded rice and refuge
- Native and Riparian Vegetation

More Model Design

- Monthly precipitation based on Parameter-elevation Relationships on Independent Slopes Model (PRISM)
- Potential evapotranspiration based on DWR's CalSimETAW model
- Irrigation periods were input differently for each agricultural land-use
- Groundwater pumping
  - was specified for transfer wells with known pumping
  - was estimated and implemented dynamically within the IWFM code based on water demands calculated by IDC
- 1973 initial conditions were developed using a long-term quasi-steady state model with observed heads as prescribed head boundary conditions
- Calibration period: 1985-2015

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Objectives of Model Calibration

- Develop aquifer parameters that honor the general patterns of geologic texture data obtained from well and boring logs
- Provide reasonable water budgets at both the valley-wide and subregion scales (Stage 1 calibration)
- Reasonably replicate the temporal variations in streamflow
- Capture the general trends of groundwater levels and flow directions (Stage 2 calibration)
- Reasonably replicate the temporal variations in groundwater levels

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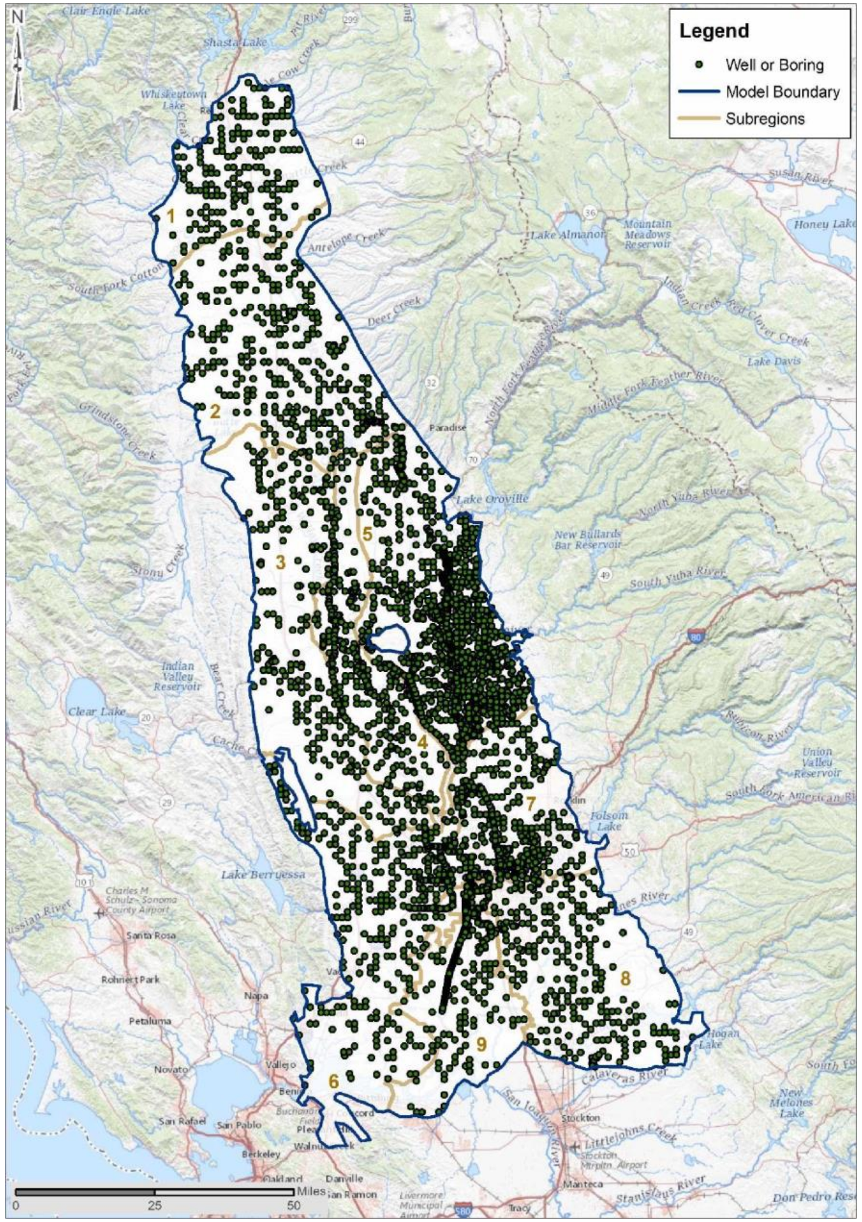
Calibration Parameters

- Root-zone components
  - Conductivity
  - Pore size distribution index
- Small watershed parameters
- Streambed conductance
- Aquifer parameters
  - Texture-based
  - Well logs provide heterogeneity to the entire groundwater system



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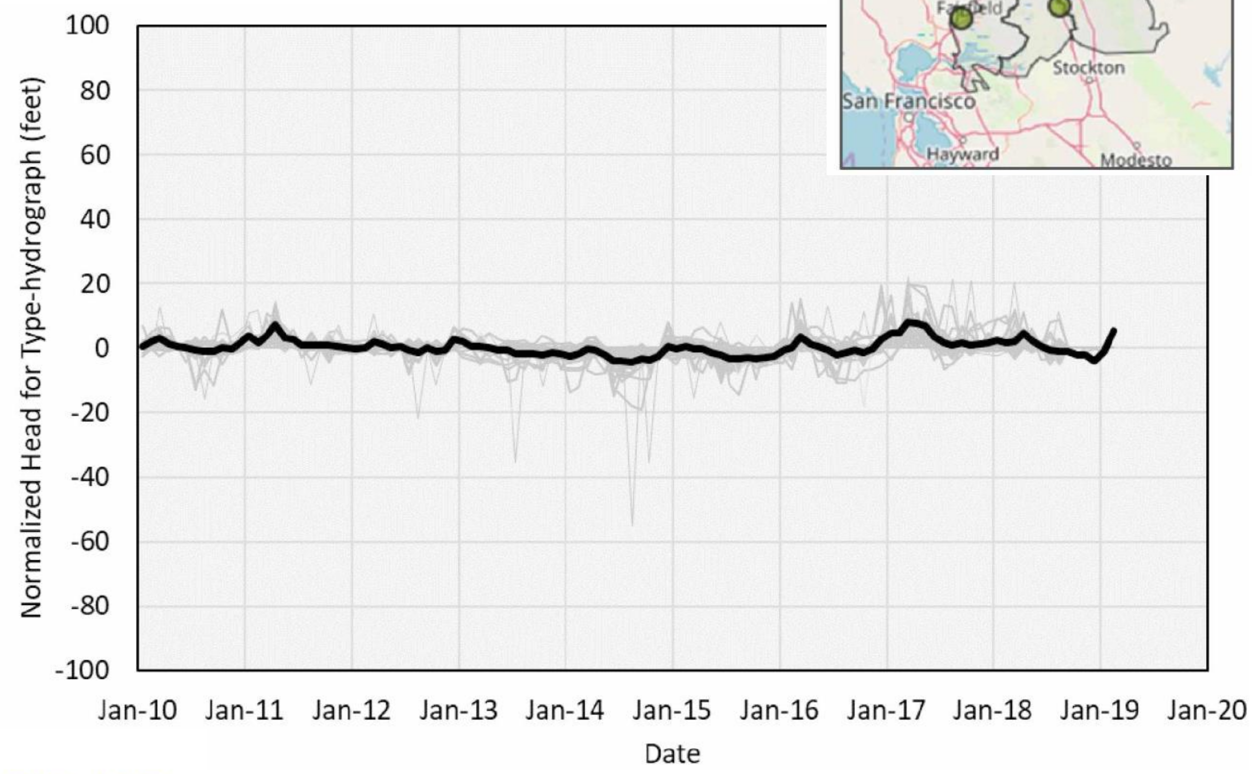
Calibration Targets

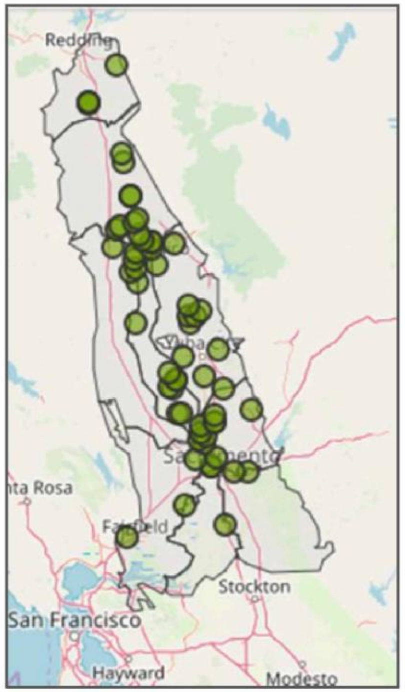
- Agricultural supply requirements
- Irrigation efficiency
- Native vegetation
- Streamflow
- Groundwater heads (actual; running averages)
- **Type-hydrographs**
- **Paired stream-groundwater observations**
- **Vertical head differences**

Calibration Target

- Fuzzy Cluster Analysis (in R) was used for pattern recognition
  - Wells with similar trends were grouped into clusters
  - Type-hydrographs were developed for each cluster

- 654 wells selected for this analysis
- Time Period: 2010-2019
- 19 type-hydrographs developed
- 2-5 type-hydrographs per subregion





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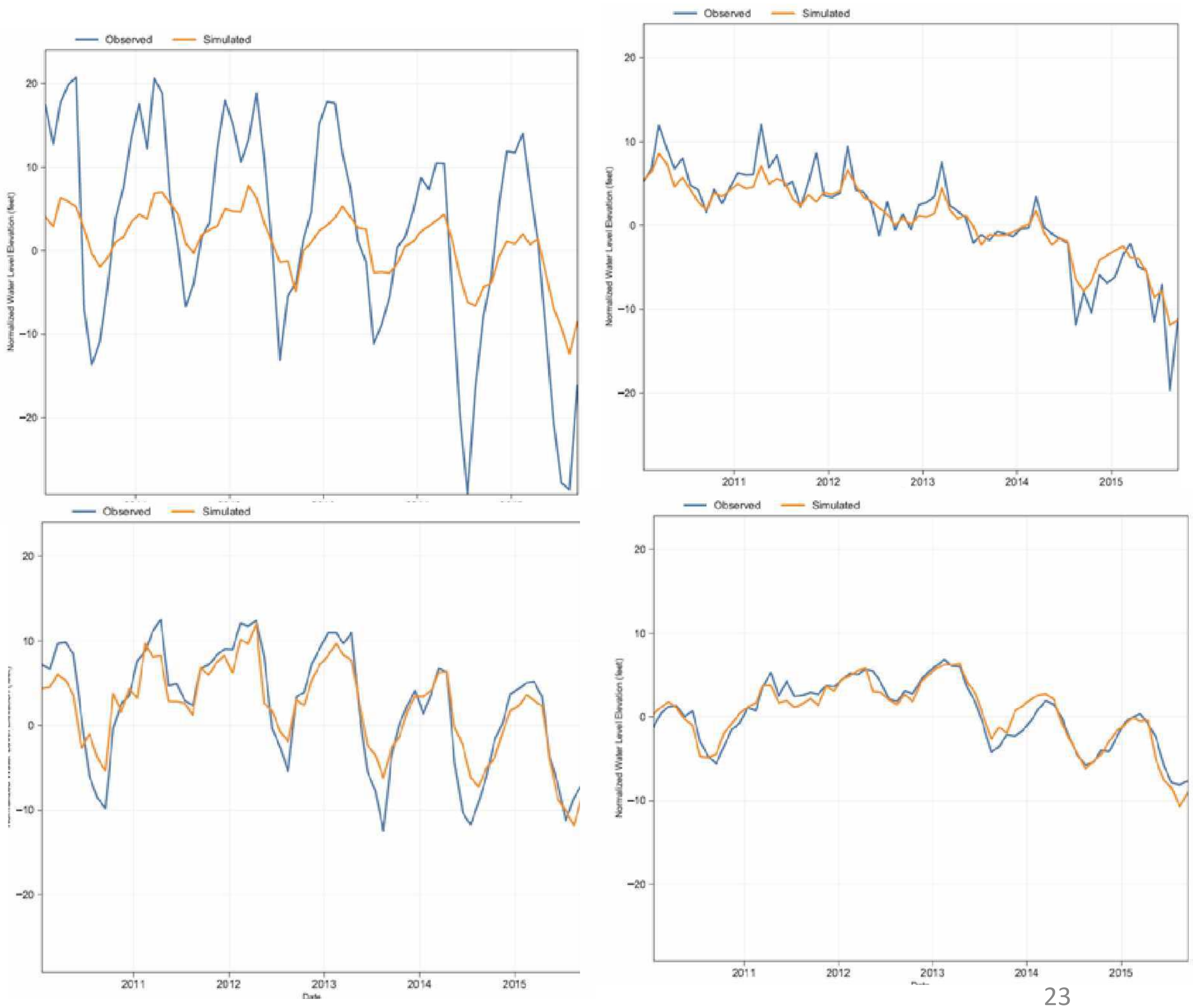
Calibration Results

- Type-hydrographs enabled the calibration process to additionally focus on temporal trends and seasonal (irrigation) patterns in the system.



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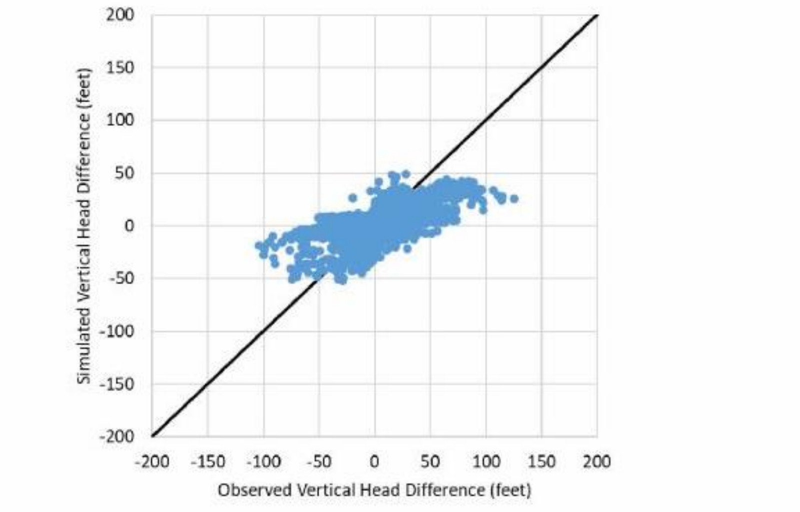
Calibration Results

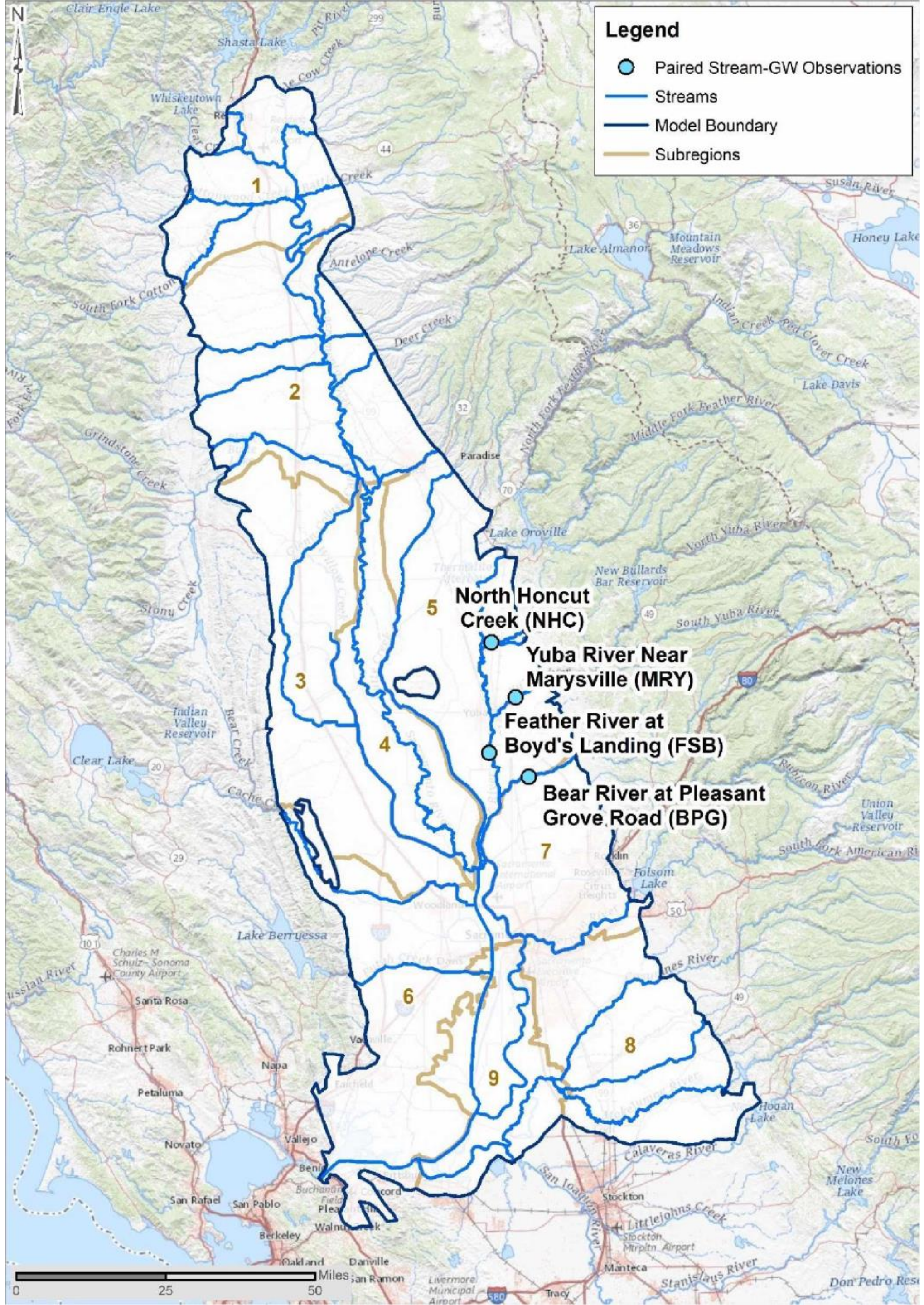
- Paired Stream-groundwater observations

Groundwater head observations guided the calibration of aquifer parameters

Vertical groundwater head differences were used to provide additional observations in estimating horizontal-to-vertical anisotropy



Scatterplot of Vertical Head Differences Between Observations in Paired Screens Within Multi-Completion Wells (All Observations).



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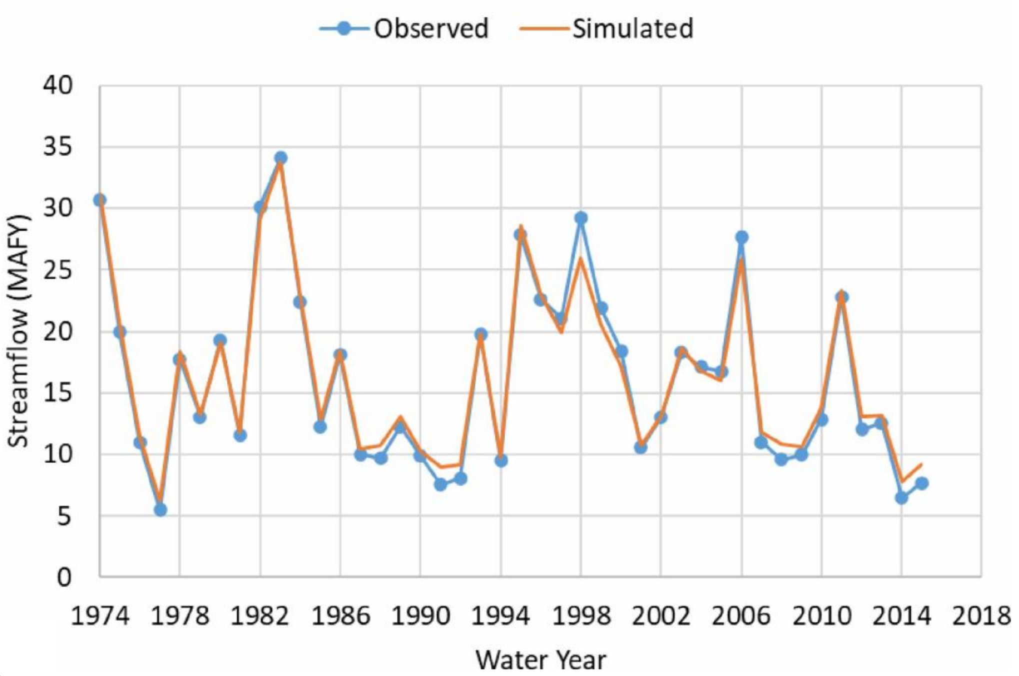
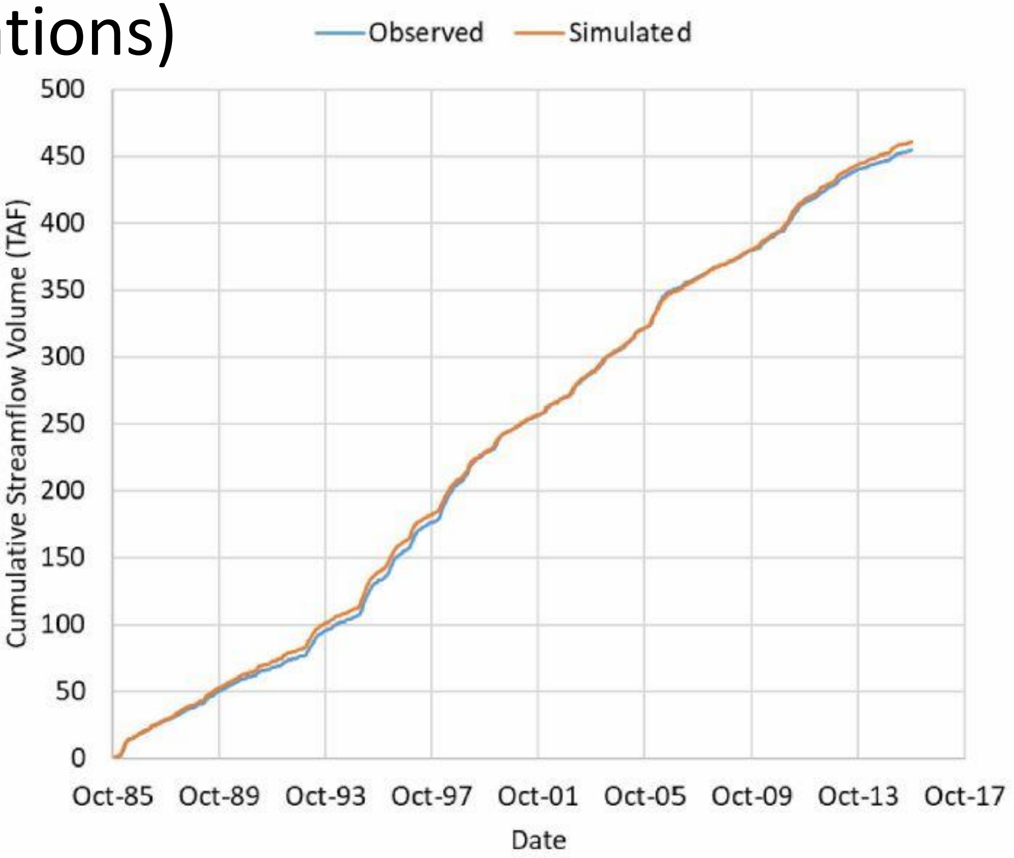
Calibration Results

- Streamflow at Freeport Gage (key monitoring station for Water Right Decision 1641 and water project operations)





Times where flows were underestimated were compensated by periods in which flows were overestimated

Difference between obs and sim flow at Freeport was 1.5% (235 TAF over entire simulation period). Close match indicates an excellent representation of water budgets in SVSim

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Calibration Results

- Groundwater Heads

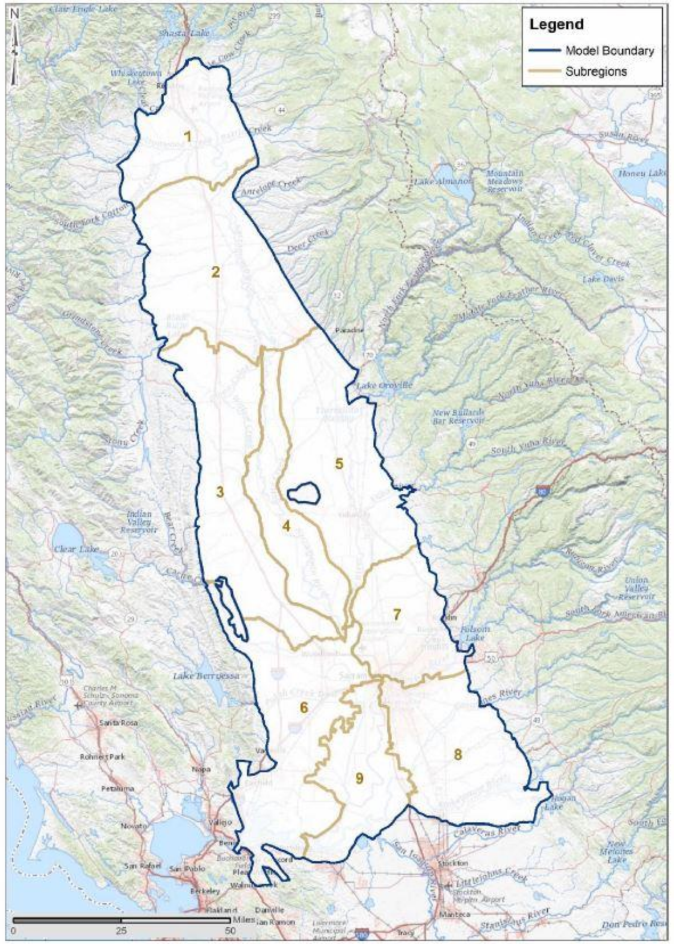
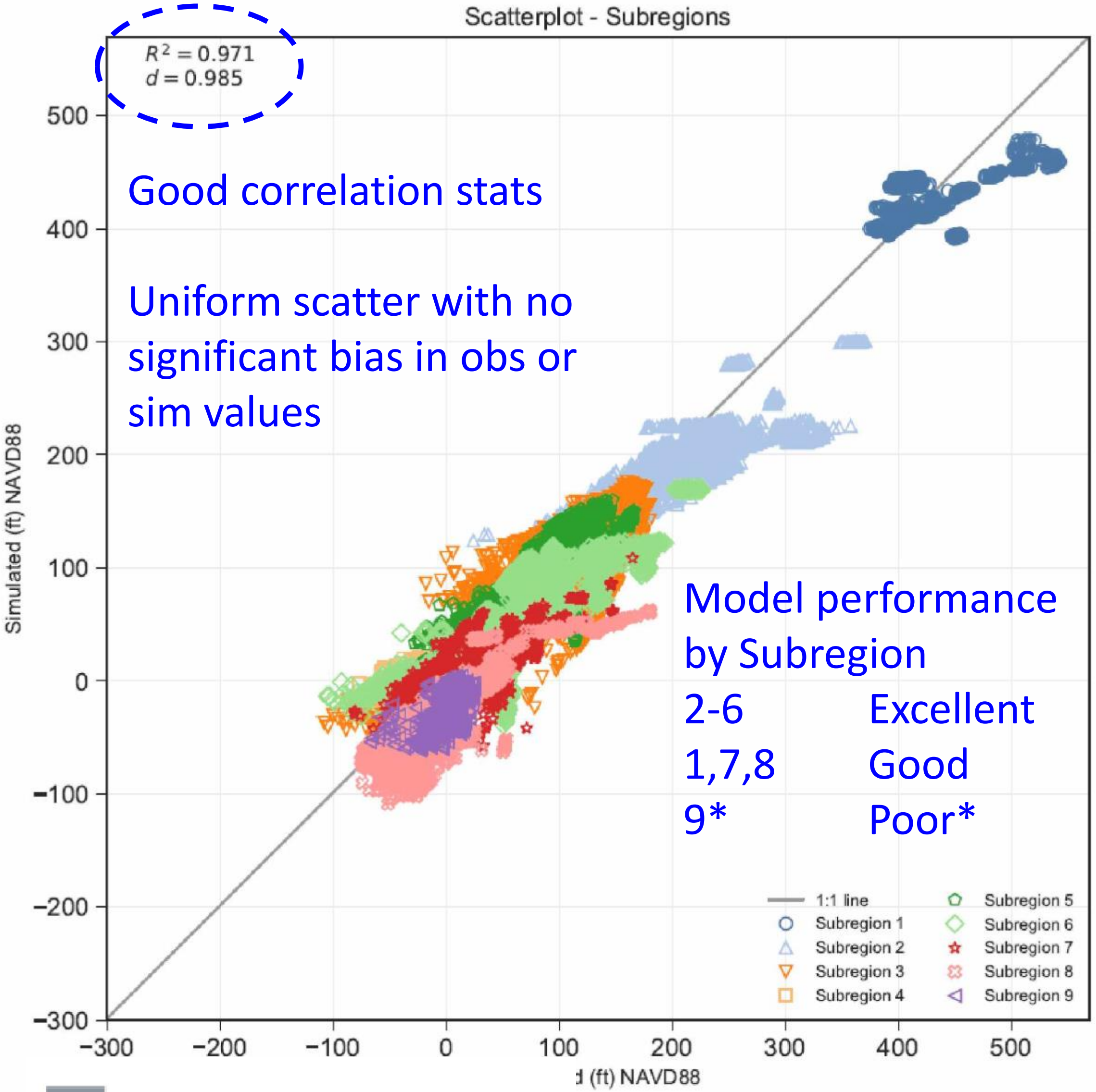


Figure 1. SVSim Spatial Extent and Subregions



Good correlation stats

Uniform scatter with no significant bias in obs or sim values

Model performance by Subregion

2-6	Excellent
1,7,8	Good
9*	Poor*

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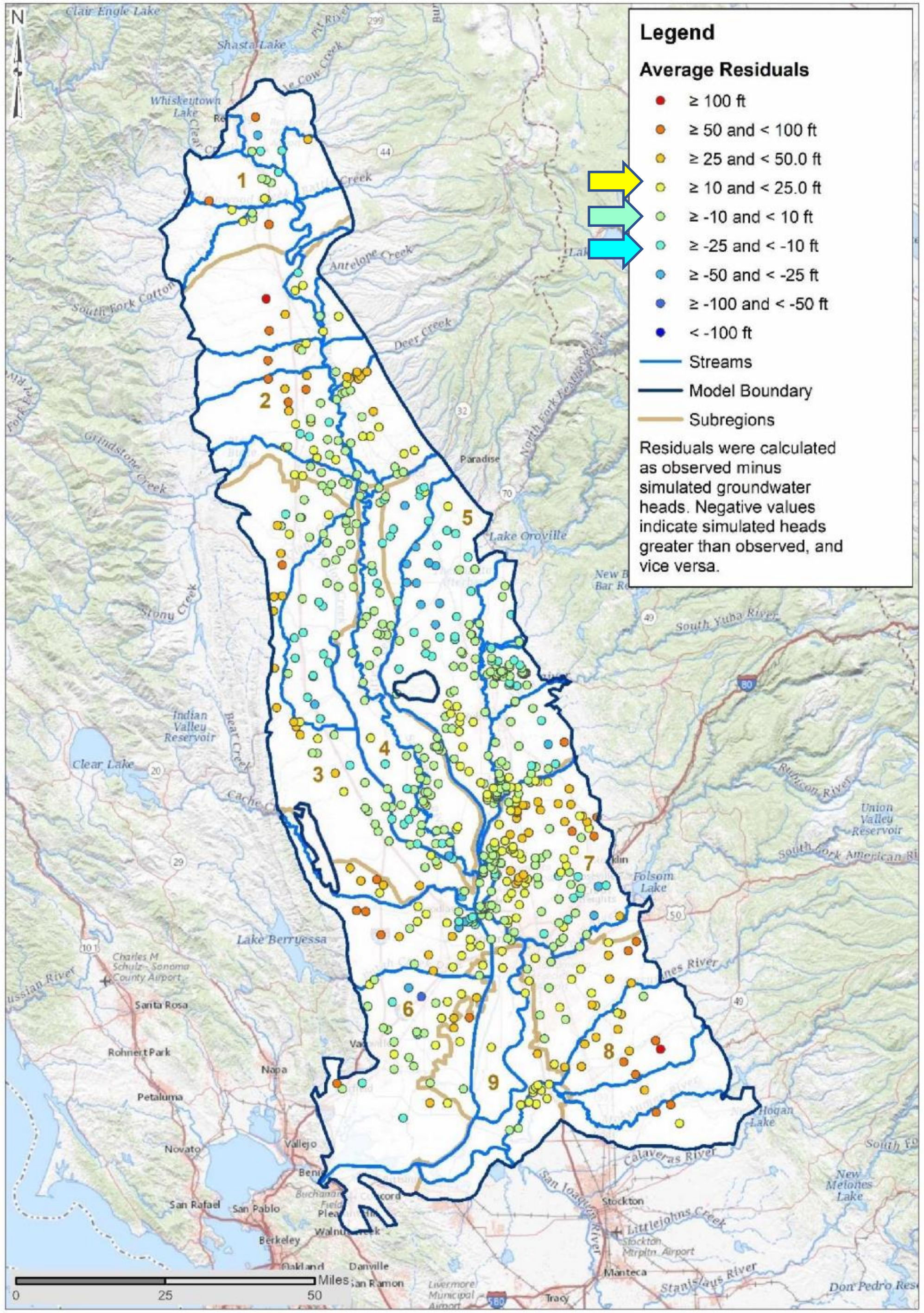
Calibration Results

- Groundwater Heads

- Wells in the central part of the valley generally perform well as shown by their low residuals (meaning a good match between simulated and observed groundwater heads)

- Larger residuals observed towards the periphery of the model

- Reasons for larger residuals include:
  - wells located at higher elevations not well represented,
  - lateral flow boundaries not well represented,
  - missing boundary conditions, or
  - aquifer parameters not well represented



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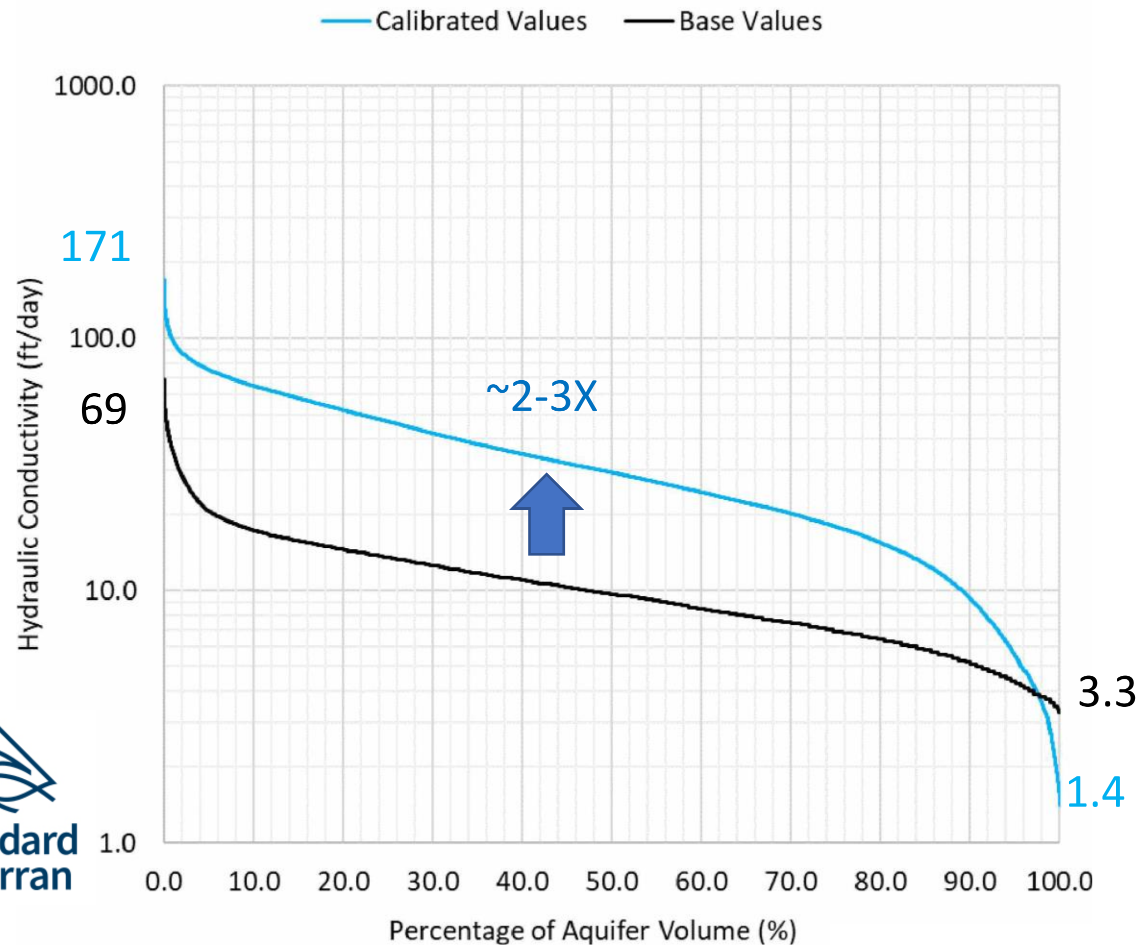
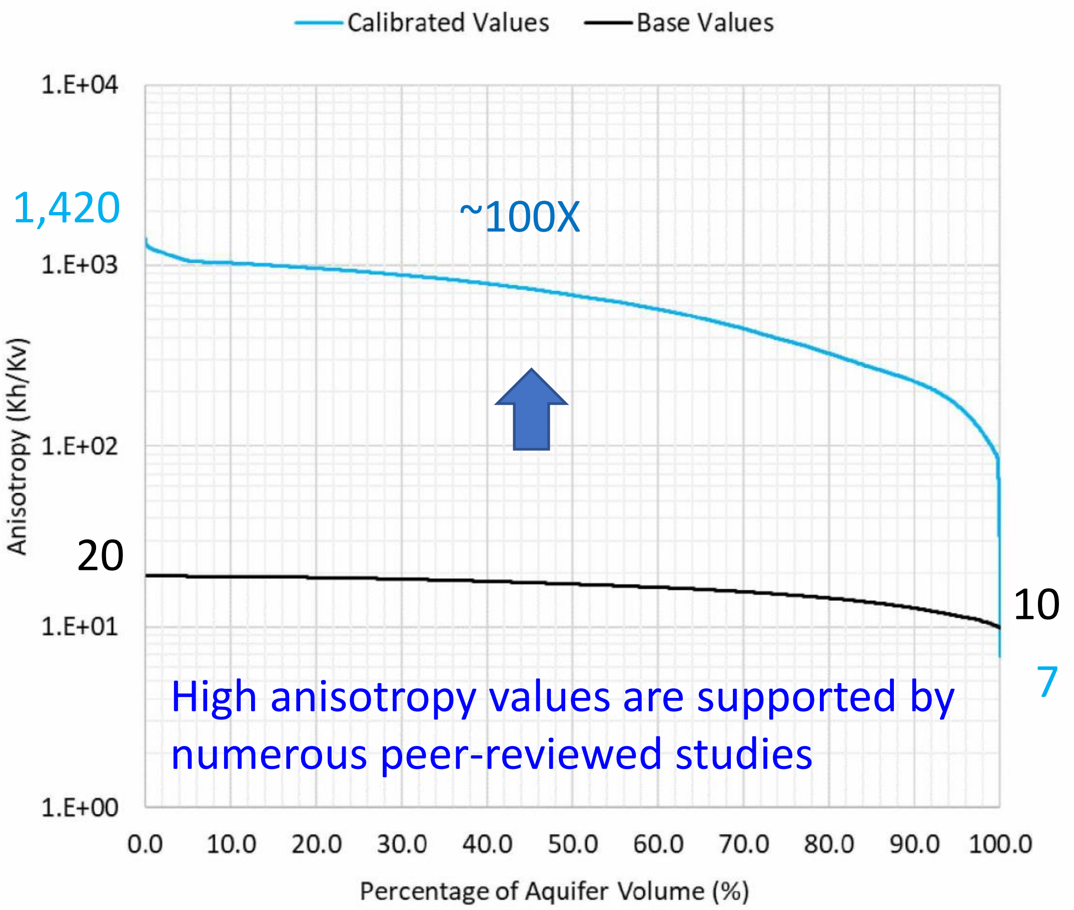
Calibration Results

- Aquifer parameters – Hydraulic Conductivity and Anisotropy





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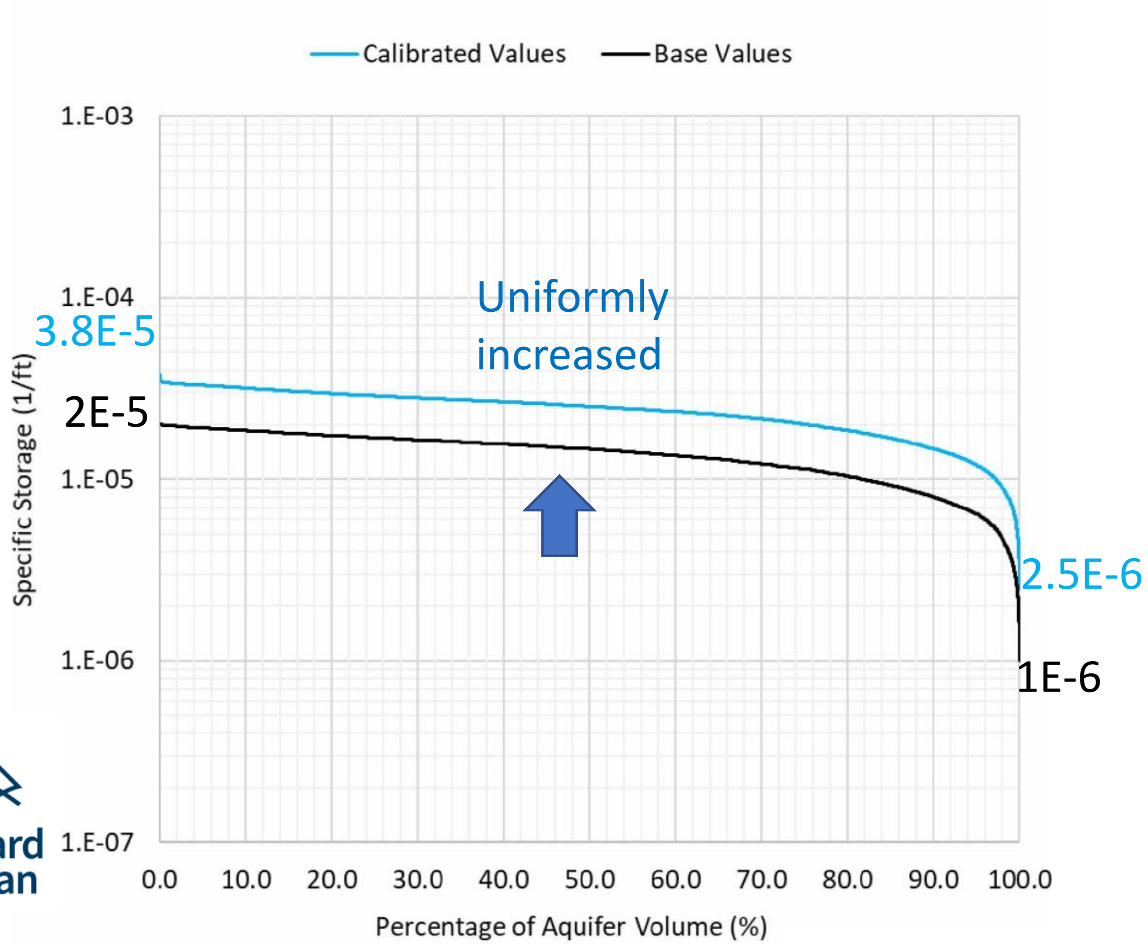
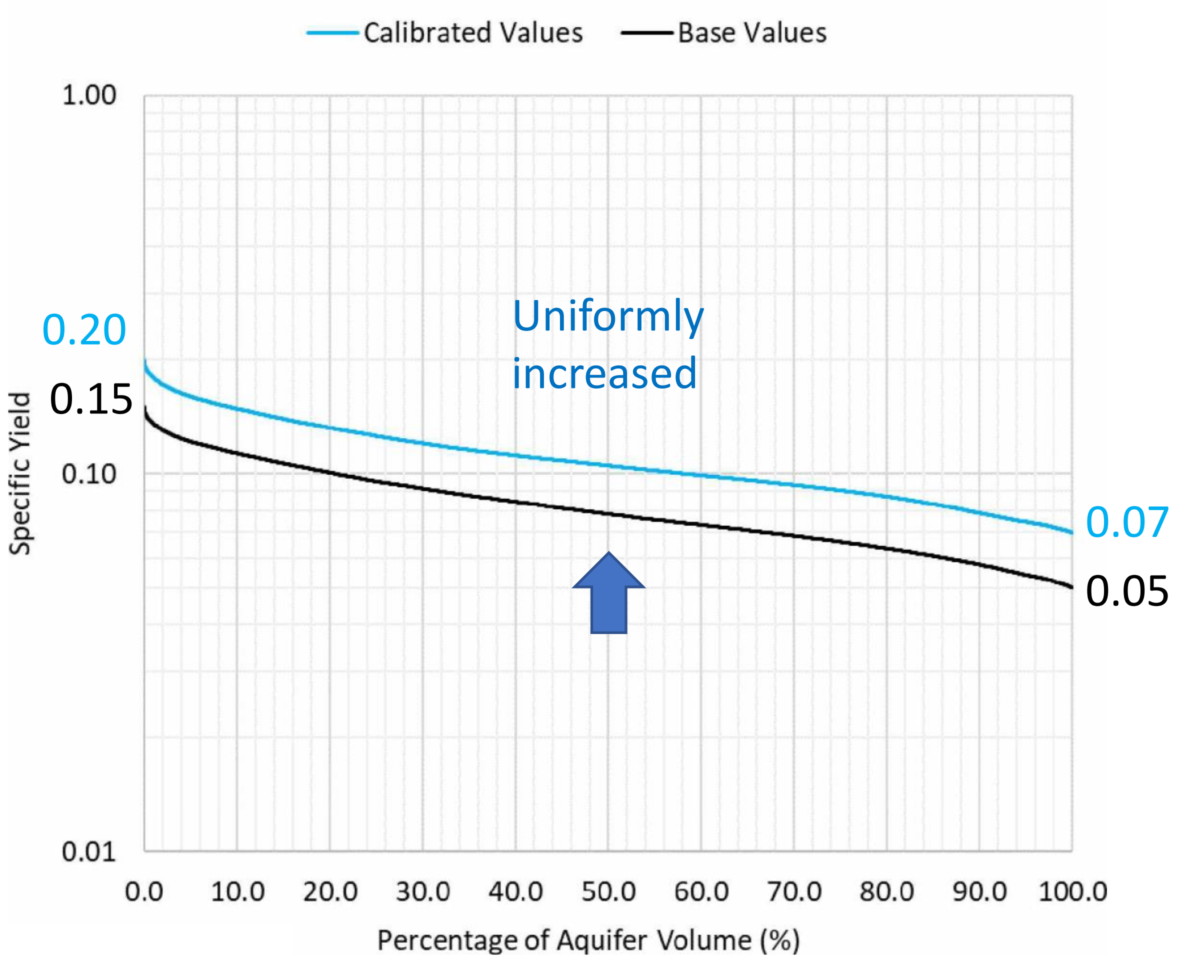
Calibration Results

- Aquifer parameters – Specific Storage and Specific Yield





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Summary

- SVSim provides a calibrated, plausible set of aquifer parameters that are suitable for the primary anticipated applications of the model, evaluating stream depletion caused by groundwater pumping and conducting sustainable groundwater management analyses.

- Calibration results indicate that SVSim reasonably reproduces hydrologic conditions throughout the Sacramento Valley, and further that the model performs well on regional and subregional scales.

- Use of SVSim for detailed analysis of system hydrology on much smaller scales (or for developing boundary conditions for much smaller-scale models) should be accompanied by review and assessment of local-scale model performance.

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Thank you for your Time and Attention

Questions?

Chris Bonds, PG, CHg
SVSim Project Manager
Chris.bonds@water.ca.gov

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