Modesto Subbasin GSP

Surface Water-Groundwater Model Development

Technical Advisory committee (TAC) meeting

Presented on May 13, 2020

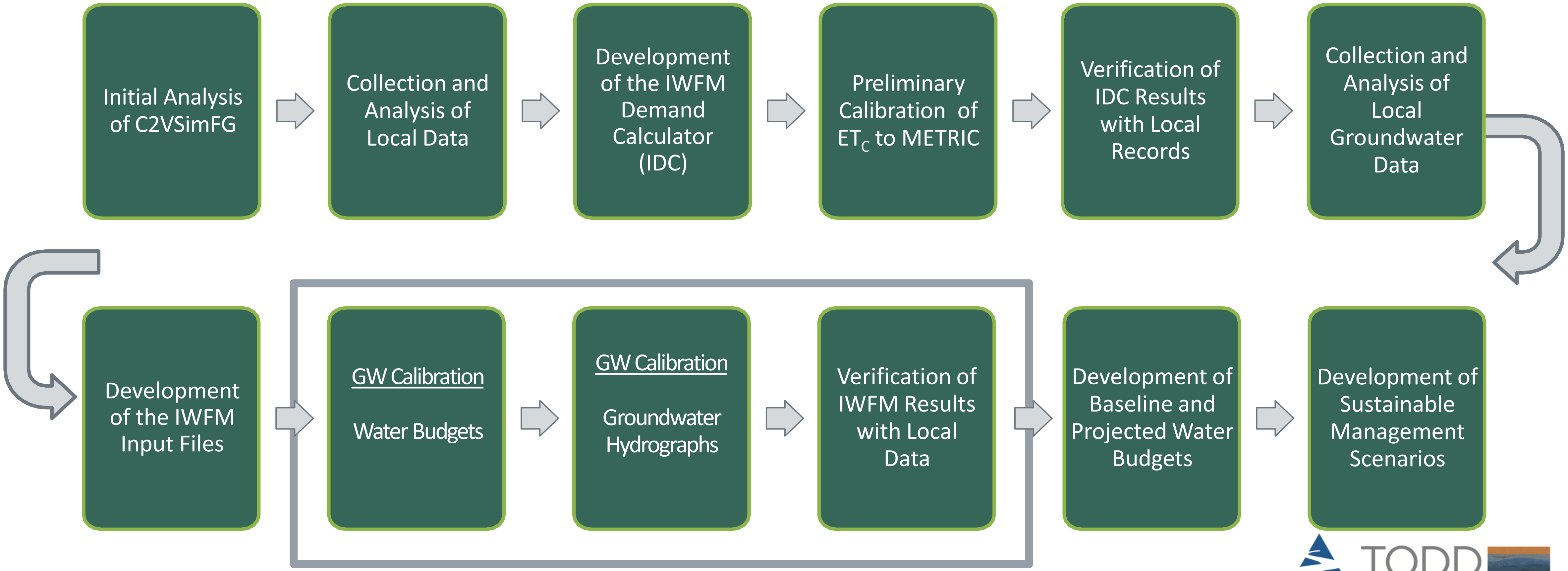
AGENDA

- Model Development
  - Modesto Area Refinements
- Model Calibration
  - Stream-Aquifer Interaction
  - Aquifer Calibration Statistics
  - Hydrographs
- DRAFT Water Budgets
  - Land & Water Use Budgets
  - Stream-Aquifer and Subsurface Flows
  - Groundwater Budgets
- Next Steps

WOODARD &CURRAN TODD GROUNDWATER

Model Development

MODEL DEVELOPMENT PROCESS



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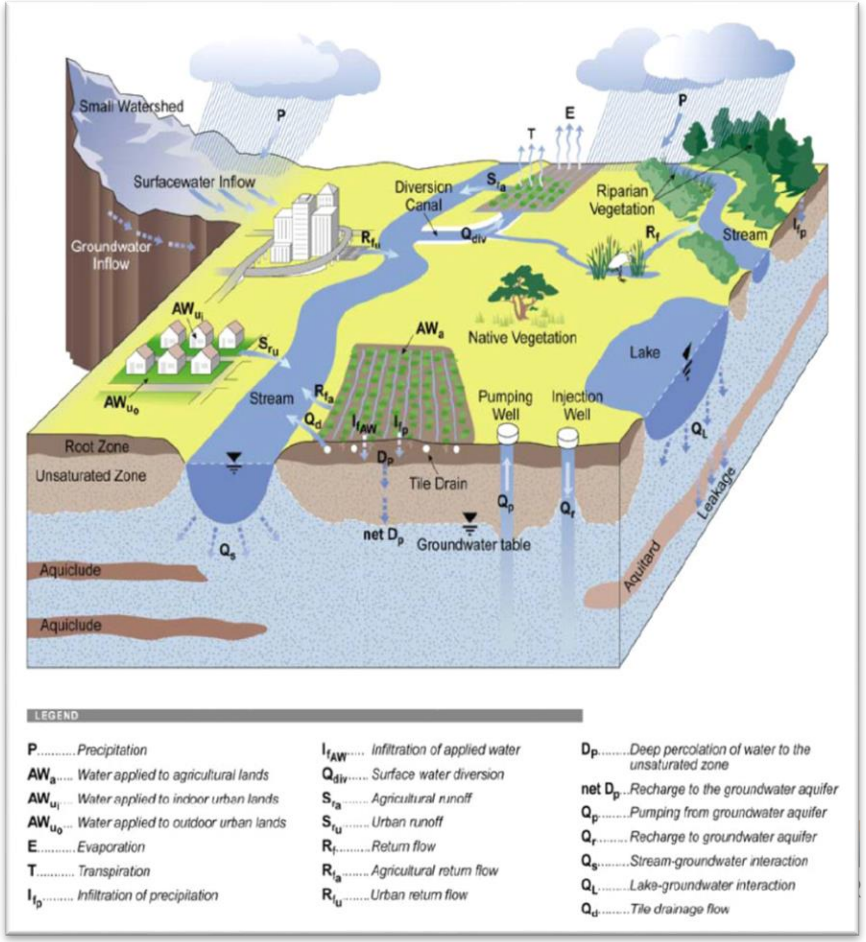
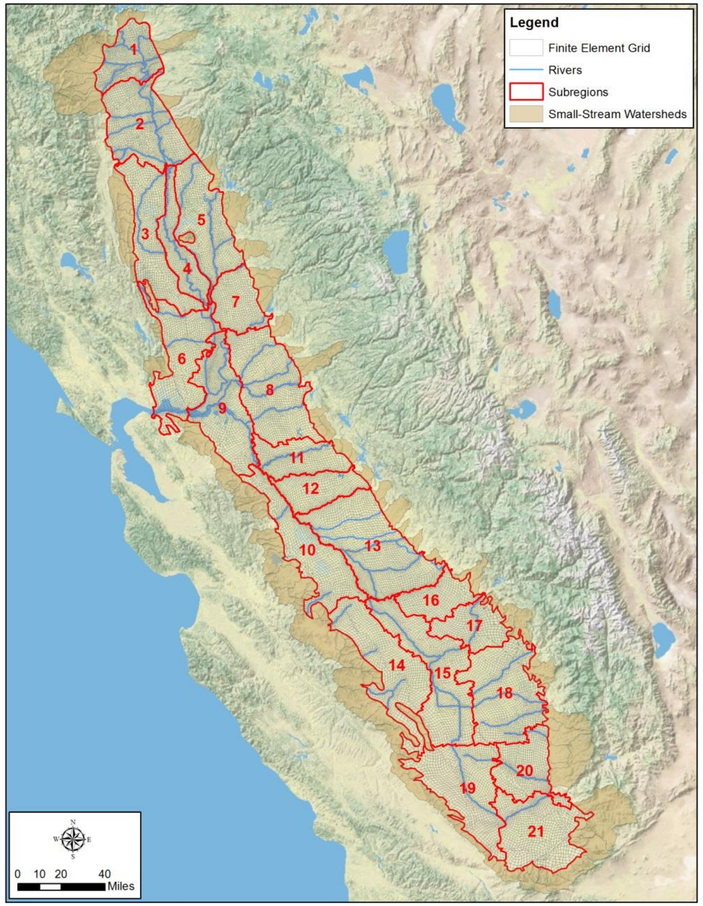
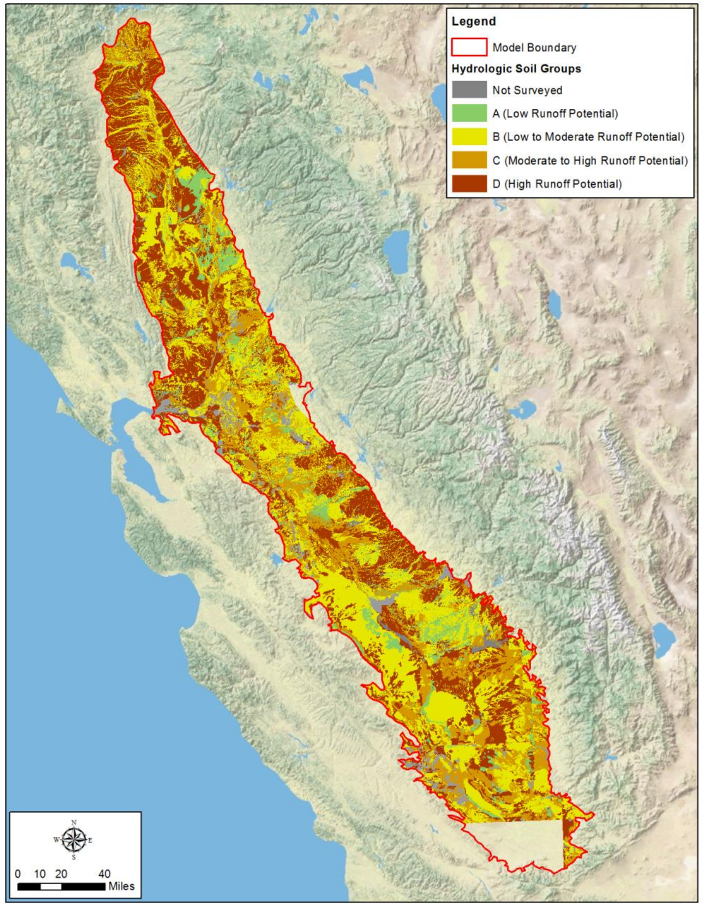
NUMERICAL MODEL PLATFORM

- Integrated Water Flow Model (IWFM)
- Developed and Supported by DWR
- Will be used by DWR to evaluate GSPs
- Used in numerous basins throughout the state including the Turlock and Eastern San Joaquin Subbasins.
- **Recommended by DWR for SGMA and GSP Development**



IWFM in the Central Valley





Grid Statistics

- 30,179 Nodes
  - Agency Boundaries
  - ¼ Mile Discretization
- 32,537 Elements
  - Ave. Size = 400 Acres
- 110 Stream Reaches

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C2VSimFG in the Modesto Subbasin

Grid Statistics

- 694 Nodes
  - Agency Boundaries
  - ¼ Mile Discretization
- 767 Elements
  - Ave. Size = 362 Acres
- 3 Stream Reaches

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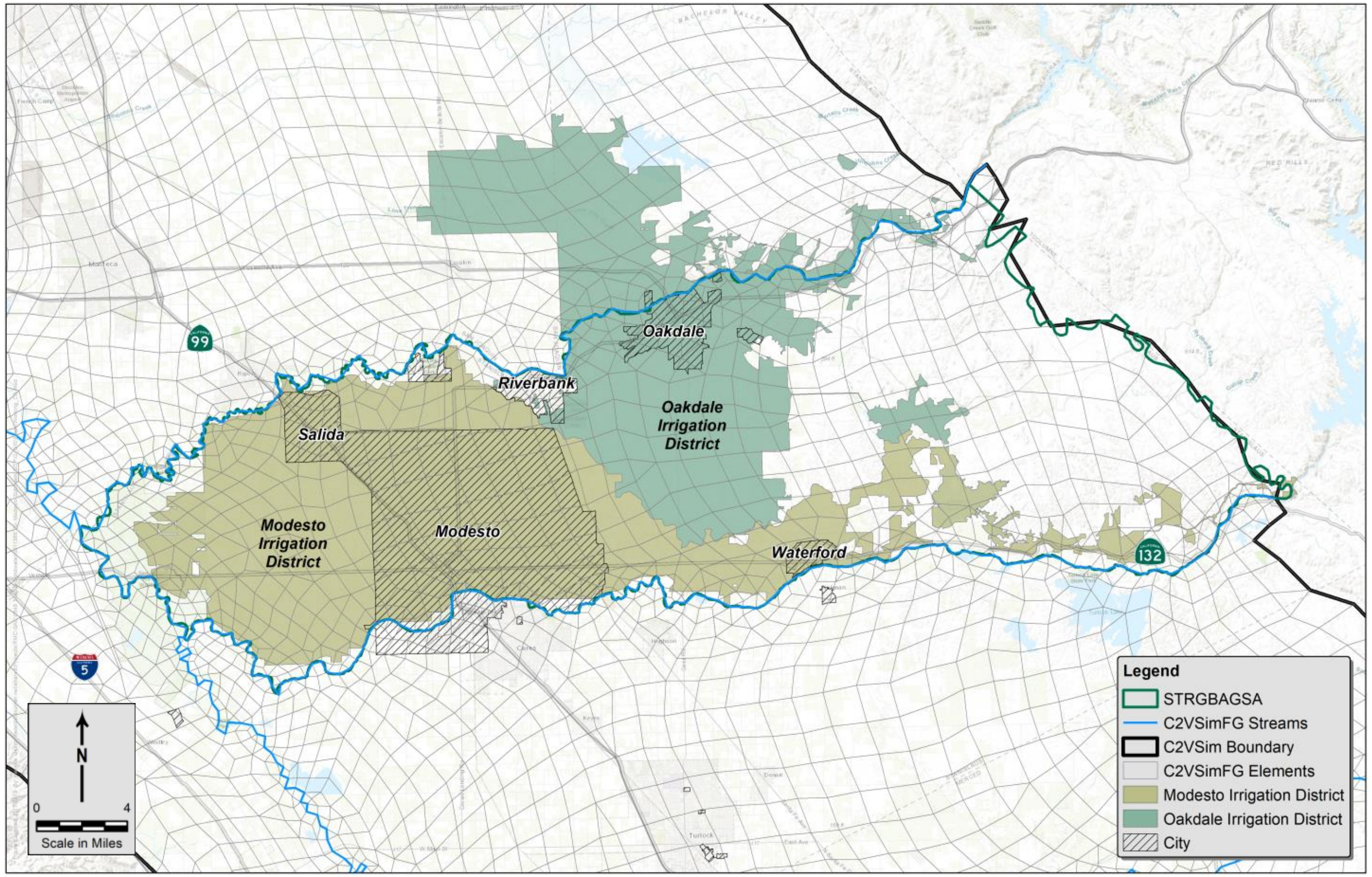
Basic Model Features

- Historical Period: 1922-2015
- Calibration Period: 1991-2015
- Hydrogeologic Layering:
  - 4 Basic Model Layers
  - 3 Principal Aquifers
    1. Upper Aquifer, above Corcoran to the West
    2. Lower Aquifer, below Corcoran to the West
    3. One Principal Aquifer to the East
- Hydrologic Features:
  - Stanislaus, Tuolumne, and San Joaquin Rivers

Modesto Subbasin Water Agencies



- Agricultural Agencies
  - Modesto ID
  - Oakdale ID
- Simulated Urban Areas
  - Modesto
  - Oakdale
  - Riverbank
  - Salida
- Simulated Rural Areas
  - DAU: 206
  - DAU: 207

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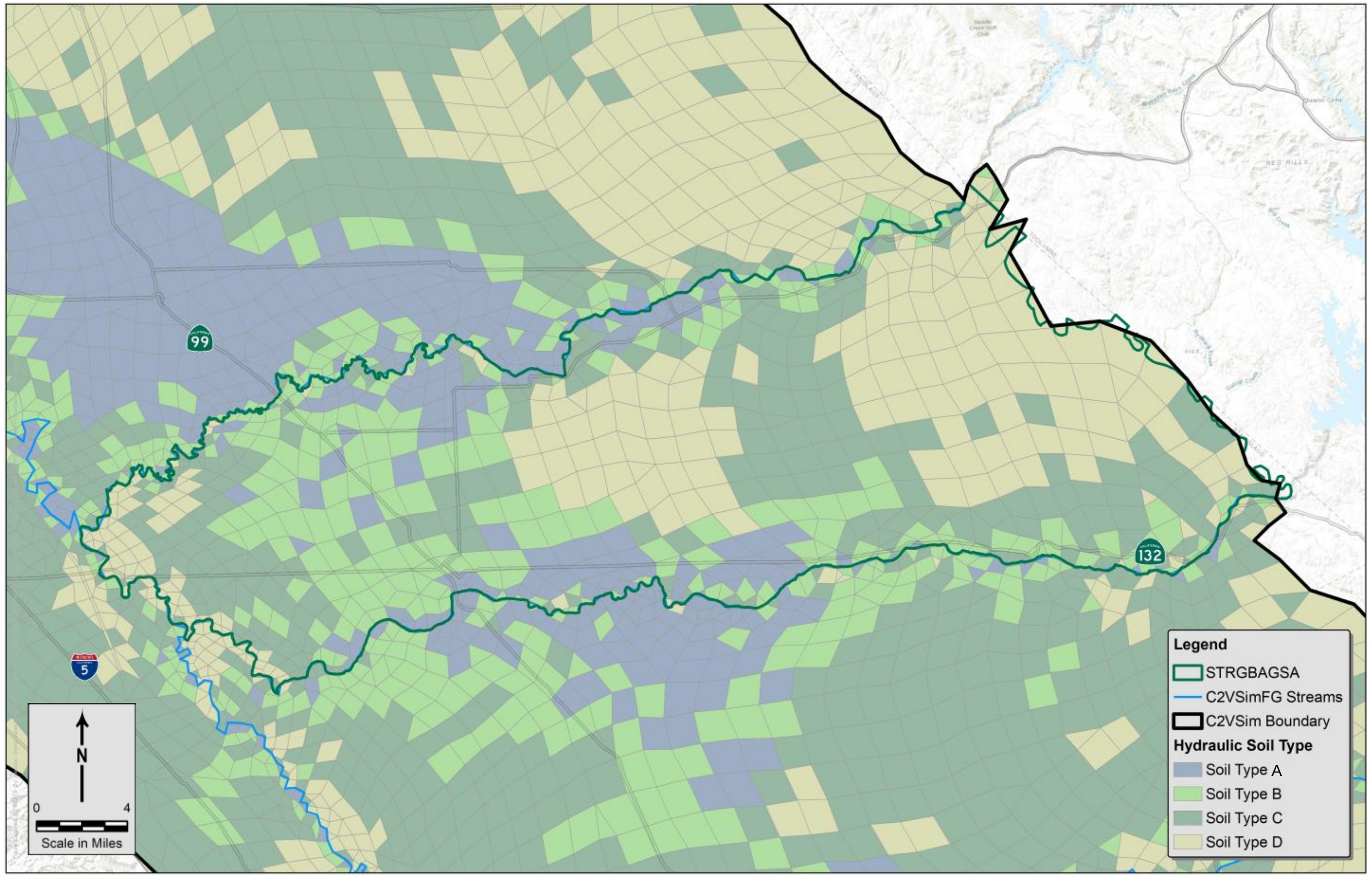
Soil Types & Root-zone Parameters



- Source: USDA NRCS
- Input Parameters
  - Field Capacity
  - Wilting Point
  - Total Porosity
  - Hydraulic Conductivity
  - Pore Size Distribution Index

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Root-Zone Parameters

	Wilting Point	Field Capacity	Porosity	Pore Size Distribution Index	Hydraulic Conductivity[1]
clay loam	0.211	0.350	0.439	0.15	0.3
sandy clay loam	0.153	0.261	0.397	0.16	7.8
loam	0.120	0.241	0.392	0.18	9.9
sandy loam	0.077	0.158	0.384	0.37	19.2
loamy sand	0.022	0.081	0.400	1.02	29.7
sand	0.005	0.038	0.424	2.65	36.7

[1] Units of hydraulic conductivity are in feet per day

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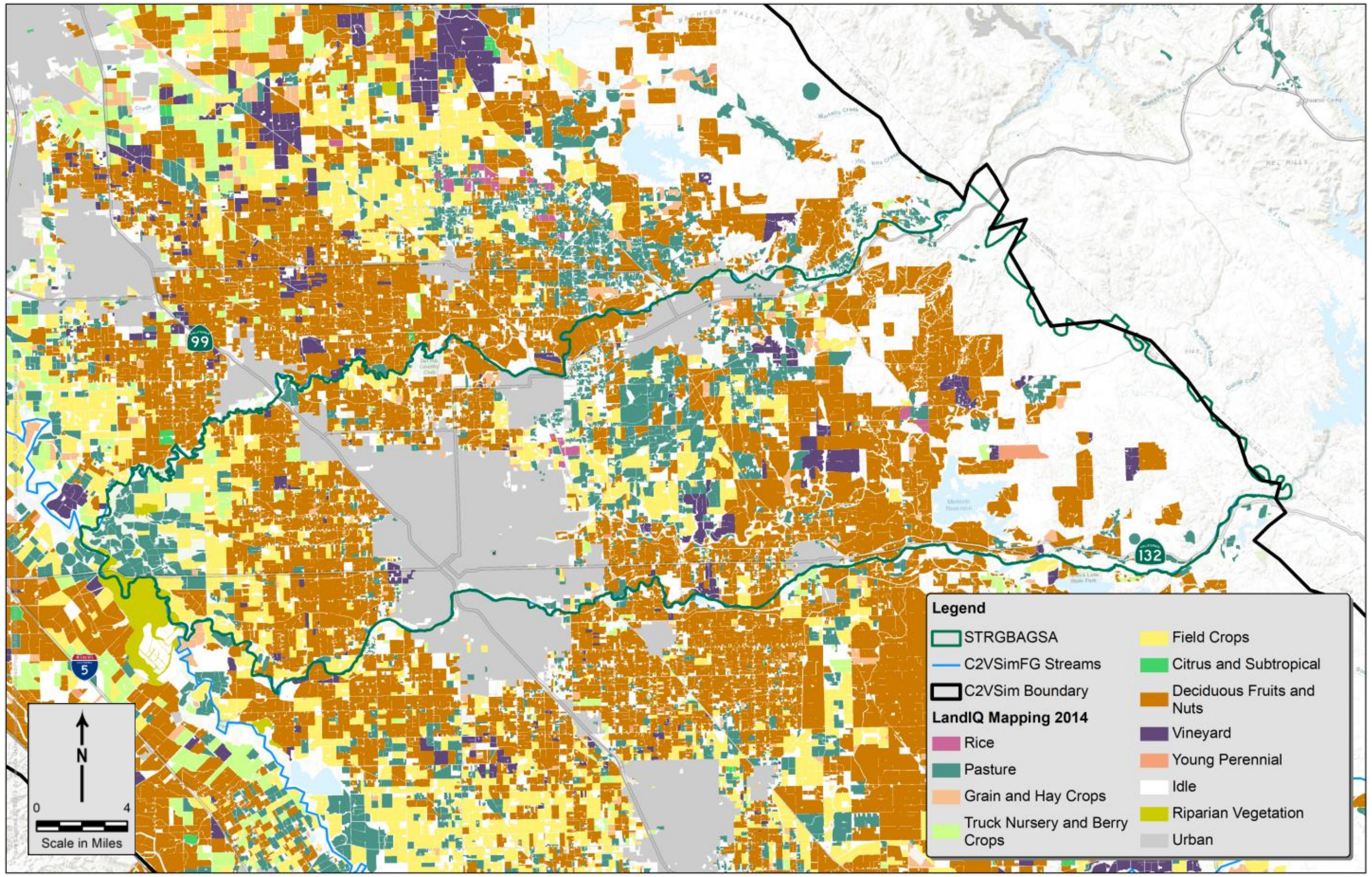
Land Use and Cropping Patterns



Available Data

- DWR County Surveys
- DWR Statewide (LandIQ) Land Use
- USDA CropScape
- MID/OID AWMP

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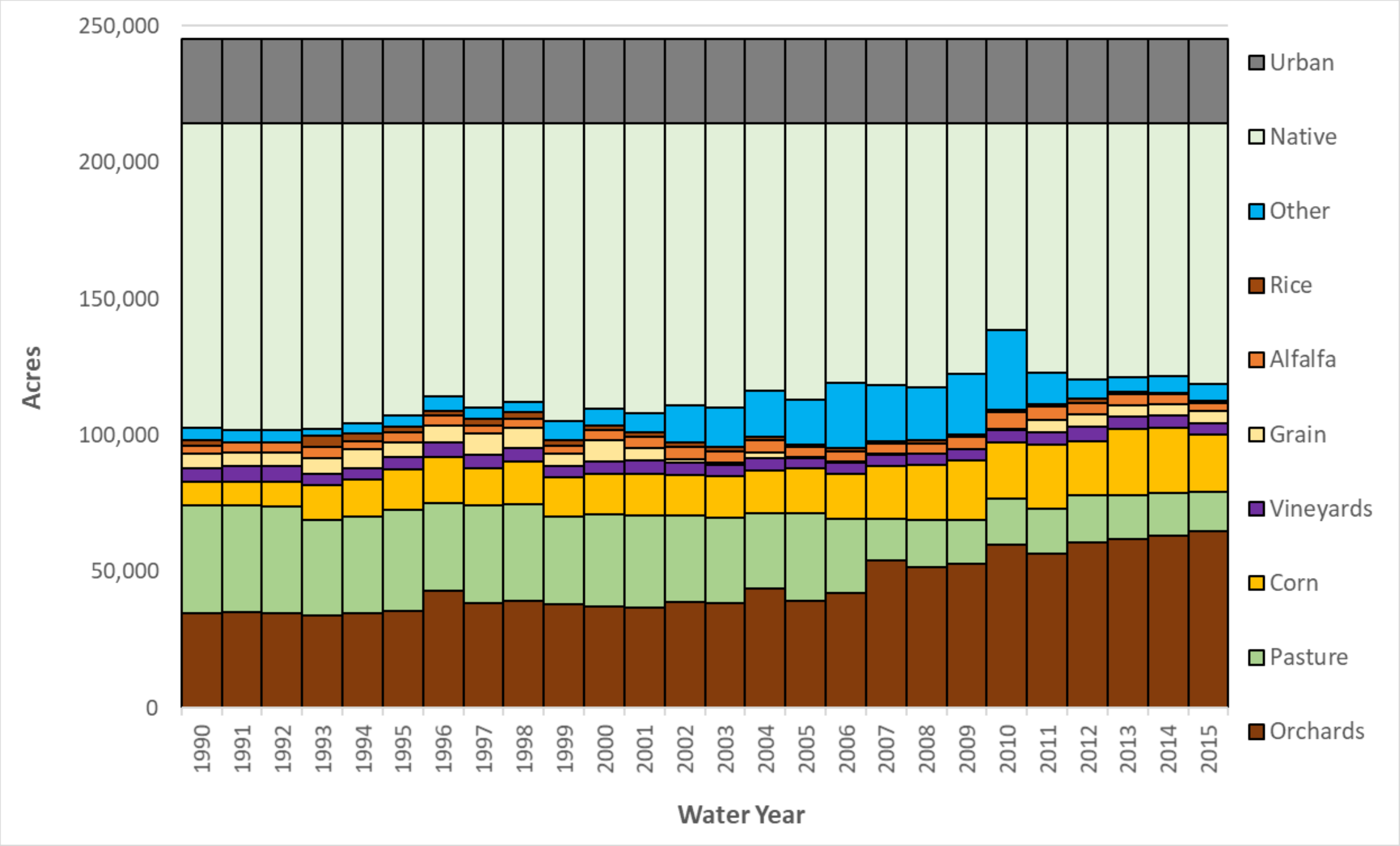
Land Use and Cropping Patterns



Land Use	2015 Acres
Orchards	64,751
Pasture	14,557
Corn	21,053
Vineyards	4,160
Grain	4,257
Alfalfa	3,203
Rice	563
Other	6,253
Total Ag. Acreage	**118,797**
Native	95,712
Urban	30,754
Refuge	0
Total	**245,263**

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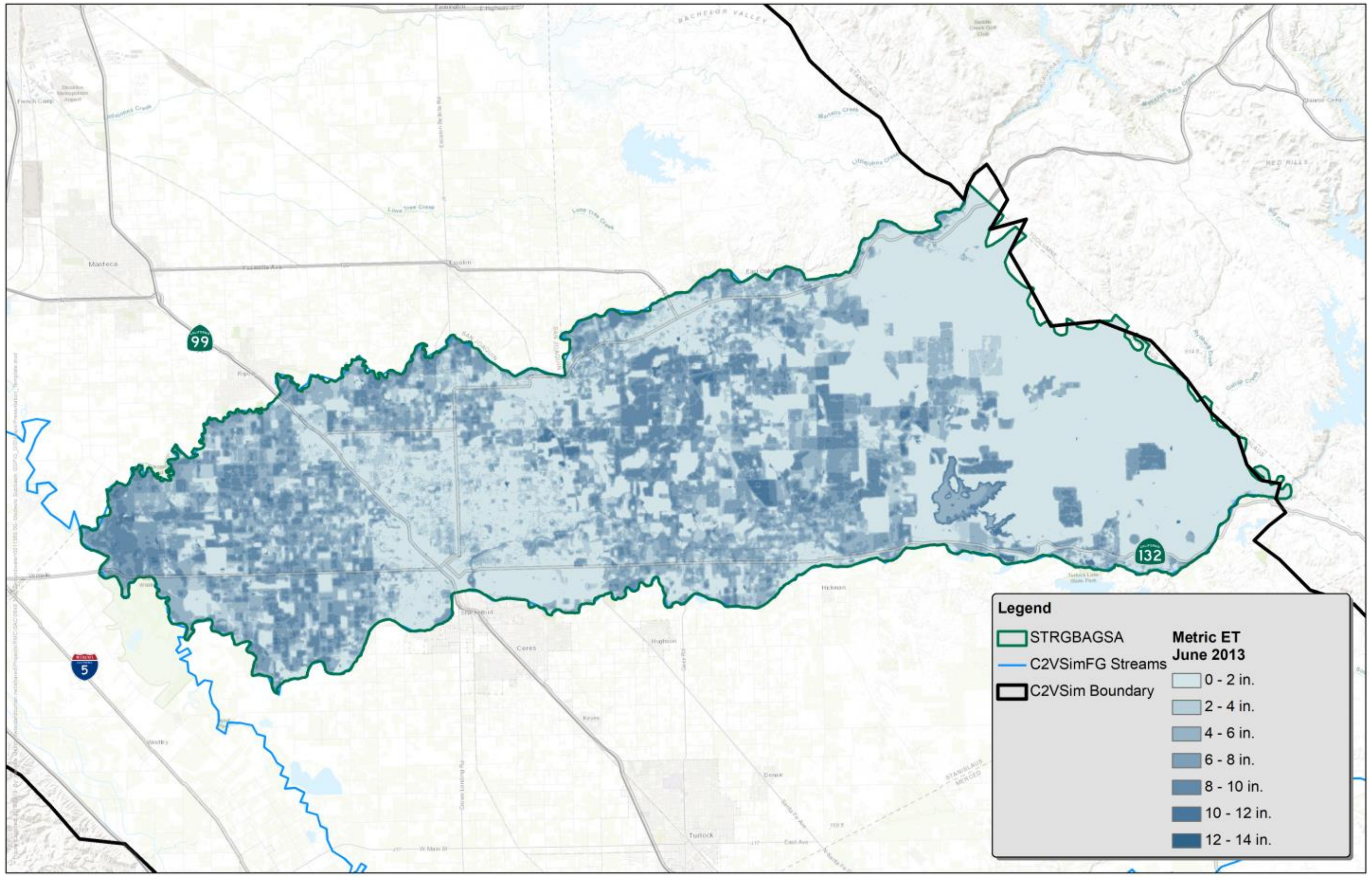
EVAPOTRANSPIRATION



Data Sources

- Irrigation Training and Research Center (ITRC)
- METRIC Remote Sensing (9 Years)
- MID & OID AWMPs

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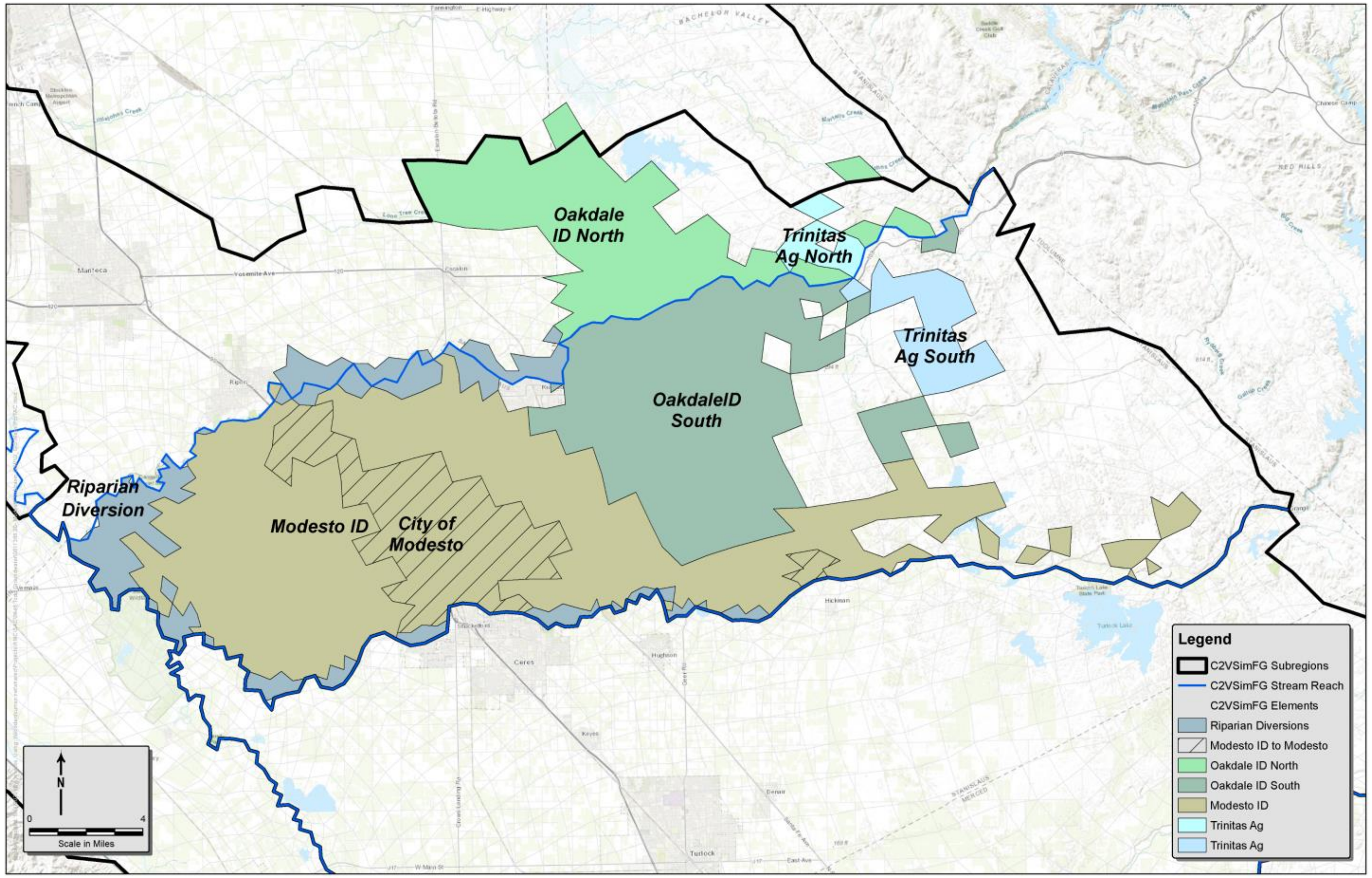
SURFACE WATER SUPPLY



- Agricultural
  - MID 189,569 AFY
  - OID-N 76,921 AFY
  - OID-S 123,570 AFY
  - OID-T$_{(2014+)}$ 3,430 AFY
- Riparian Surface Water
  - Stanislaus 16,520 AFY
  - Tuolumne 5,858 AFY
- Municipal Surface Water
  - MOD$_{(1995+)}$ 20,841 AFY

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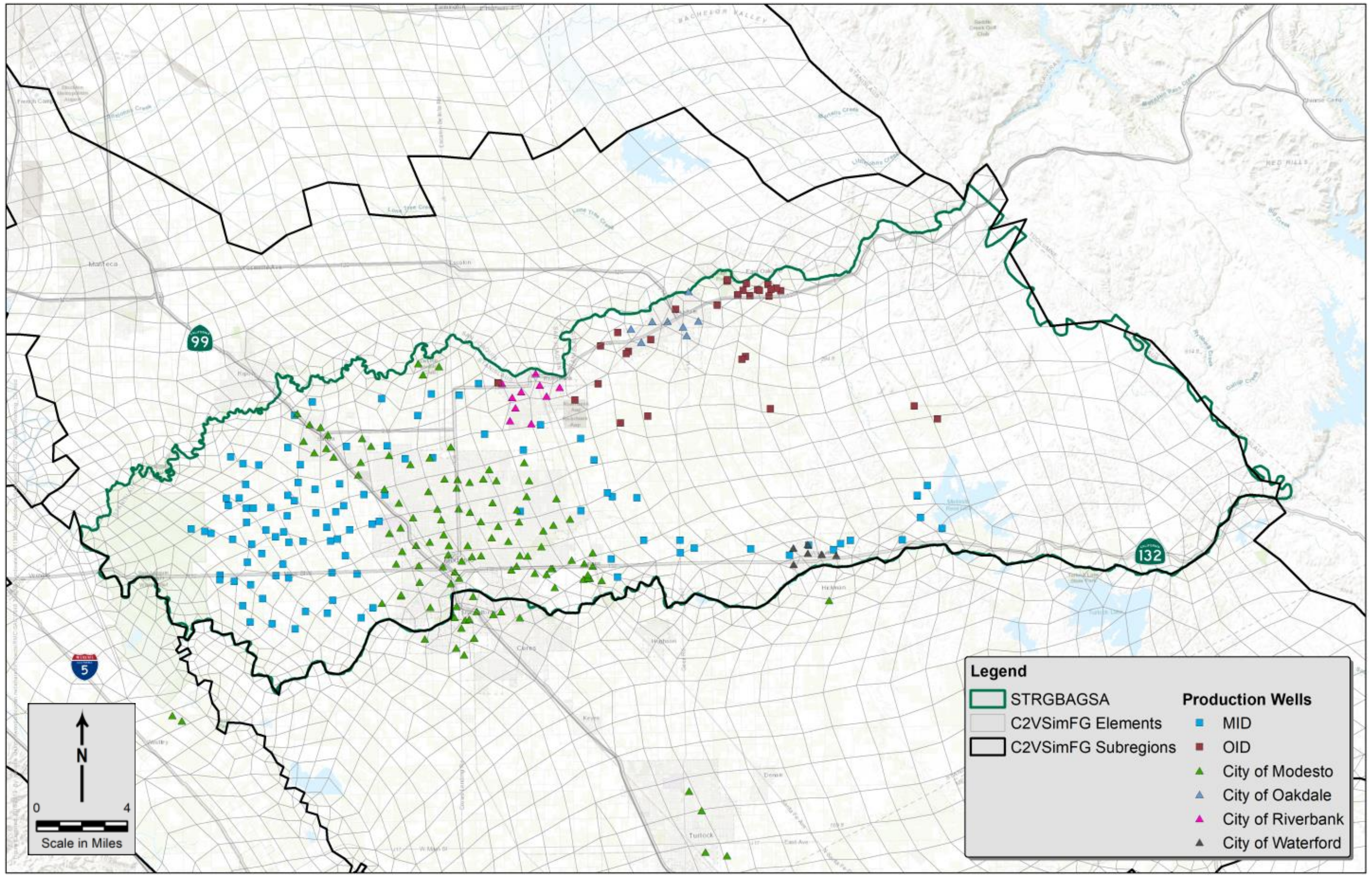
PRODUCTION WELLS IN THE MODESTO SUBBASIN



320 Simulated Wells

- 173 Ag Wells
  - MID: 141
  - OID: 32
- 147 Urban Wells
  - Modesto: 120
  - Riverbank: 11
  - Oakdale: 10
  - Waterford: 6

Note: This map only includes agency pumping, private agricultural and domestic groundwater production is simulated at each element

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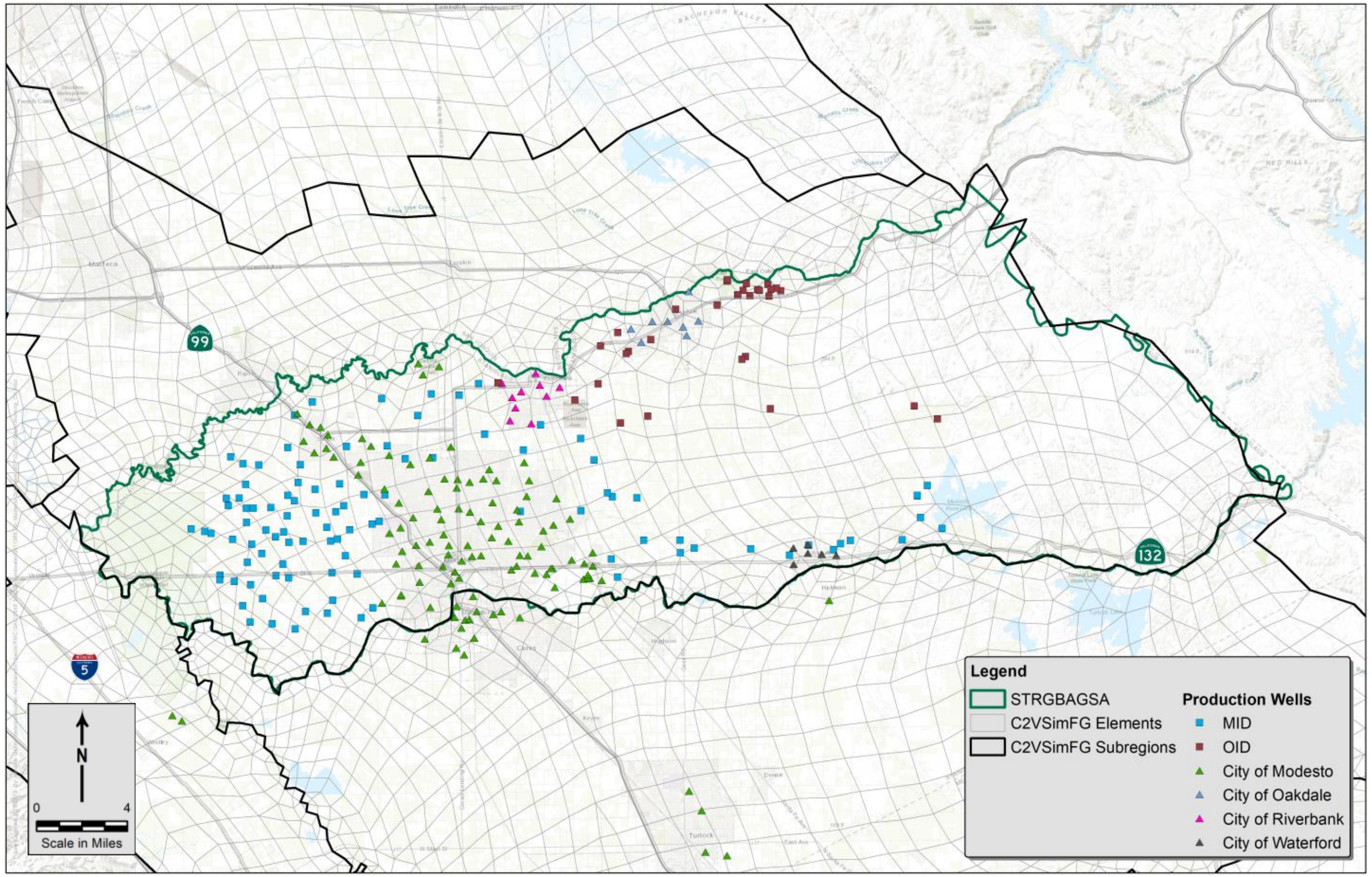
Production Wells in the Modesto Subbasin



- Agricultural
  - MID$_{(1990+)}$ 21,697 AFY
  - OID$_{(2001+)}$ 4,876 AFY
- Municipal
  - Modesto$_{(1995+)}$ 37,329 AFY
  - Oakdale$_{(1995+)}$ 4, 570 AFY
  - Riverbank$_{(2006+)}$ 4,329 AFY
  - Waterford$_{(2005+)}$ 1,643 AFY

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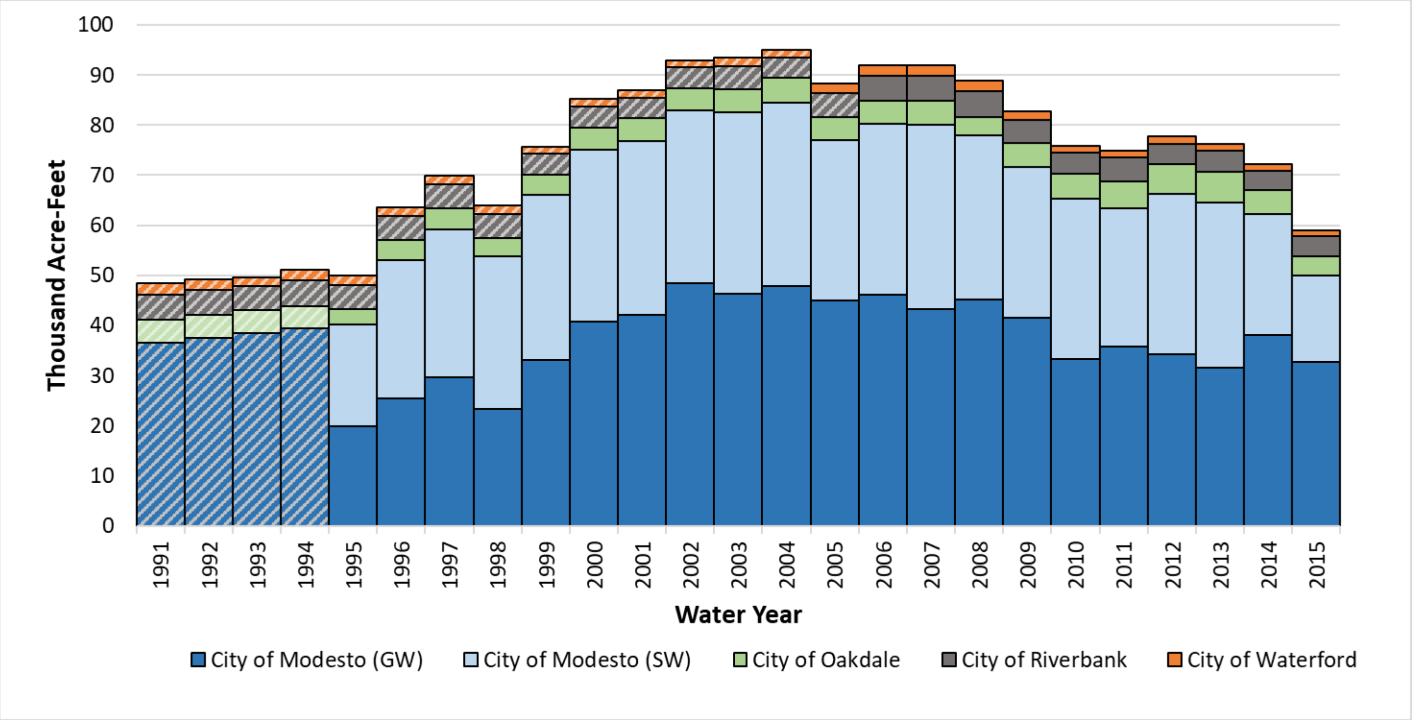
URBAN WATER SUPPLY



*Hatch indicates extrapolated data

Available Data

- Groundwater records
- Surface water records
- Extrapolated early years

- Verified with UWMPs

Note: Urban Water supply does not include domestic wells or small water systems

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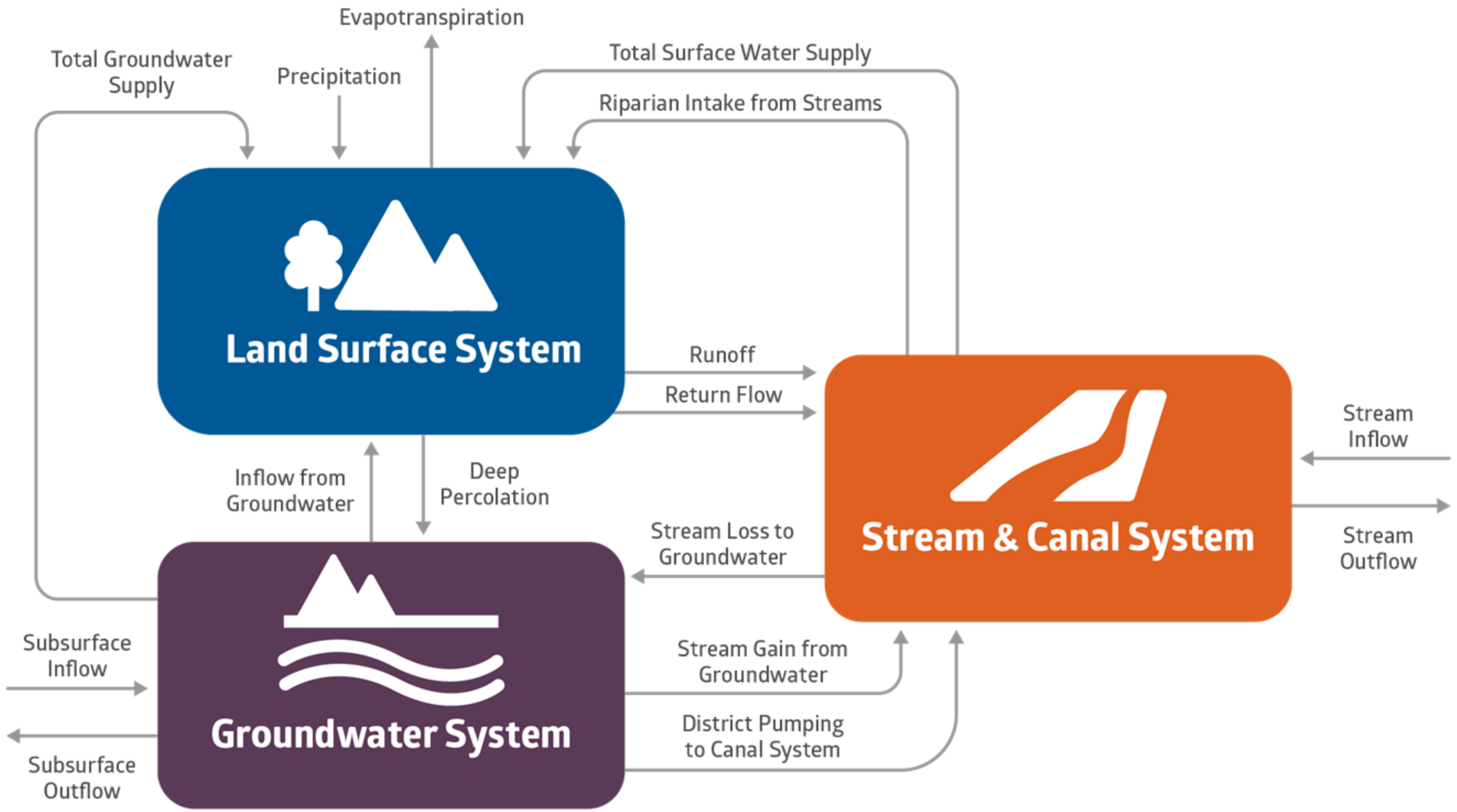
Model Calibration

Model Modules Inter-Relationship



Calibration Process

- Calibration Goals:
  - Produce reasonable and defensible water budgets
  - Match simulated and observed hydrographs at target wells
  - Match simulated and observed streamflow at gaging stations
- Develop reasonable parameters for land surface processes.
- Refine hydrologic parameters for calibration of stream/aquifer systems
- Integrate model modules (IDC and IWFM) to balance land surface and groundwater processes

Modeling Uncertainties

Structural Uncertainties

- Theoretical Concepts and Representation of the Natural and Physical System
- Formulation, Code Development, Solution Techniques and Assumptions
- Representation of Physical Features
- Model Spatial and Temporal Resolution

Data Uncertainties

- Data and Information Accuracy, Data Gaps and Estimations
- Data Spatial and Temporal Resolution

Calibration Uncertainties

- Calibration Approach, Target Characteristics, Accuracy
- Estimates of Hydrologic and Hydrogeologic Parameters

Projection Uncertainties

- Primarily due to Data Projections and Forecasting Methods on:
  - Land Use and Population
  - Water Supply Conditions
  - Climatic Conditions

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Model Limitations

- Spatial resolution and grid size relative to:
  - Physical features (e.g., streams, geologic conditions, jurisdictional boundaries, land surface topography, etc.)
  - Operational features (e.g., wells, canals, land parcels, etc.)
- Spatial and temporal resolution of data
- Data gap analysis
- Modeling a complex physical system

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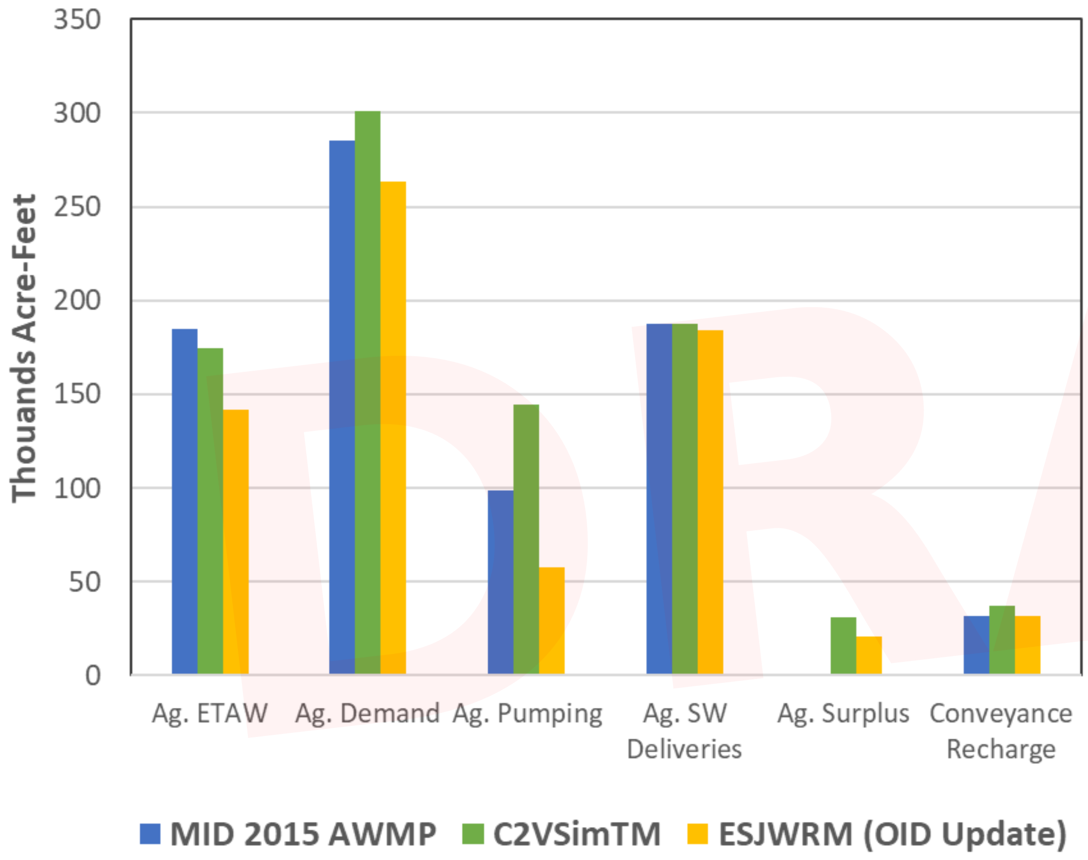
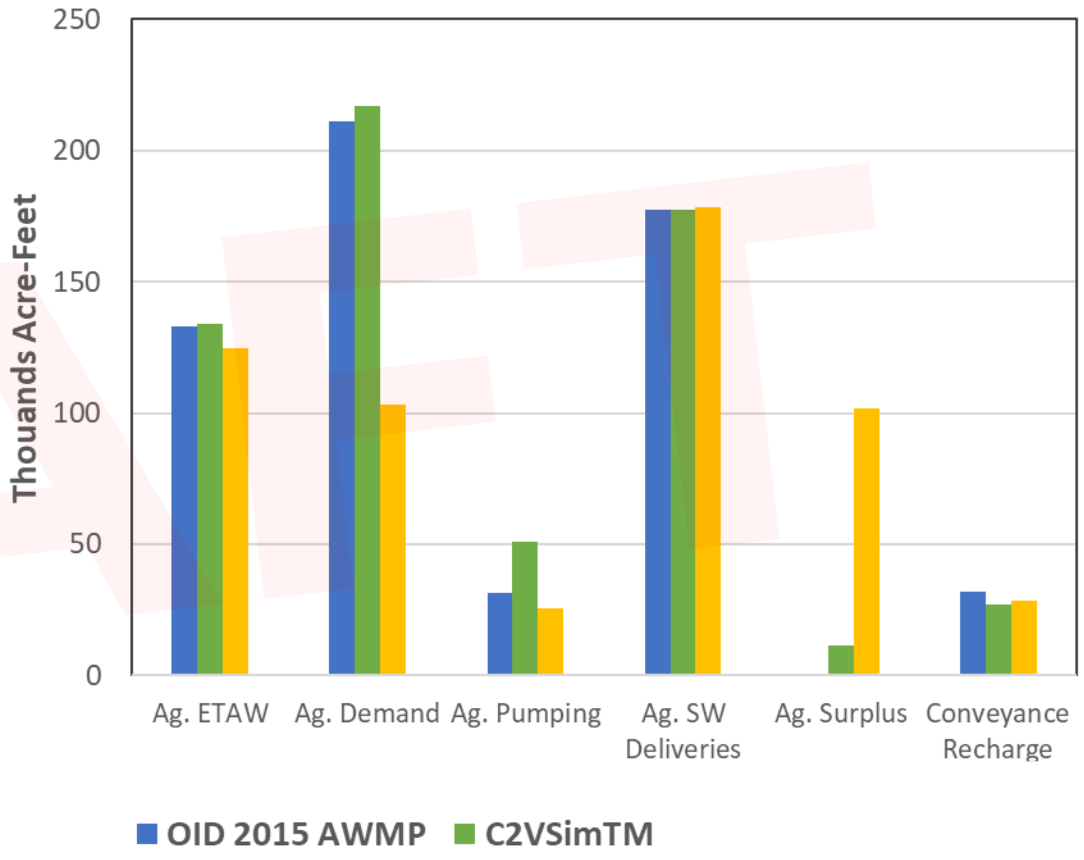
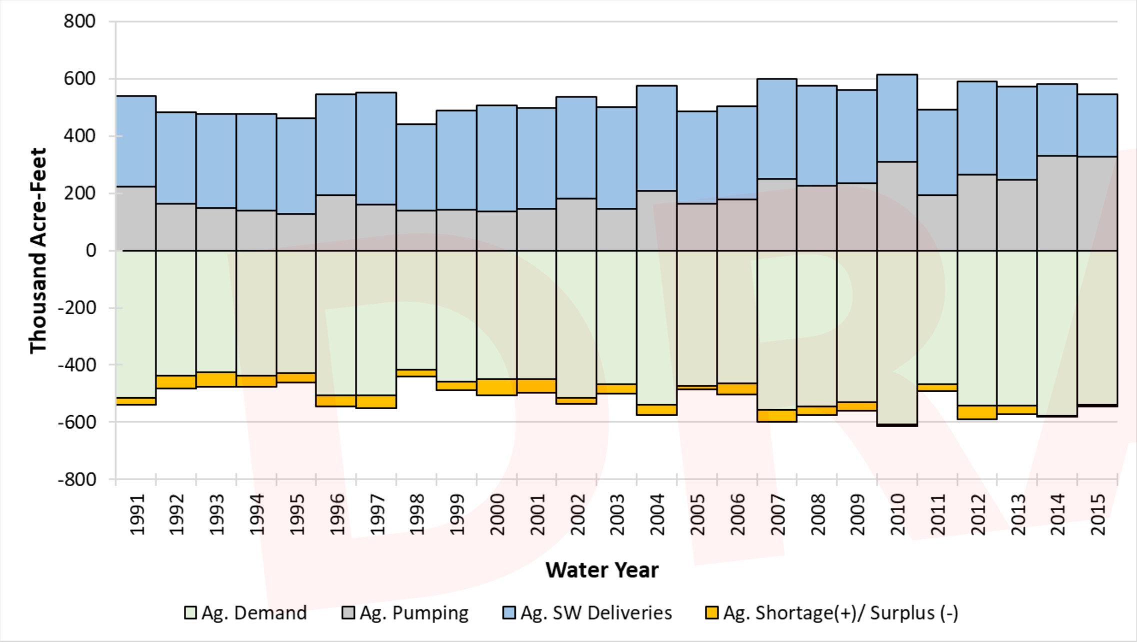
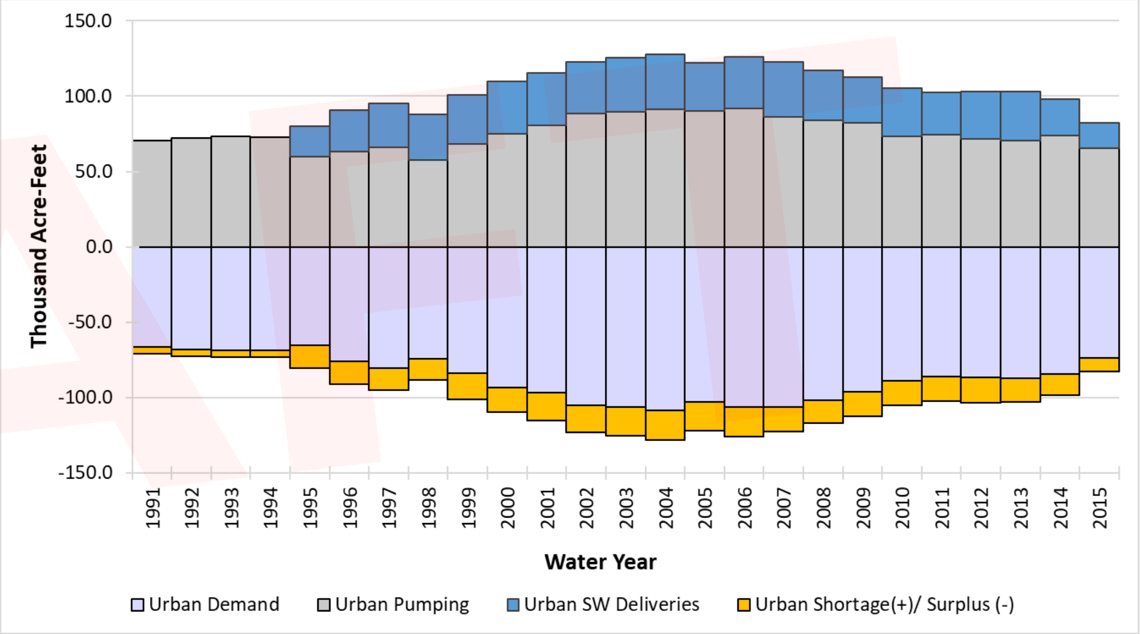
AWMP Comparison





Land & Water Use Budget





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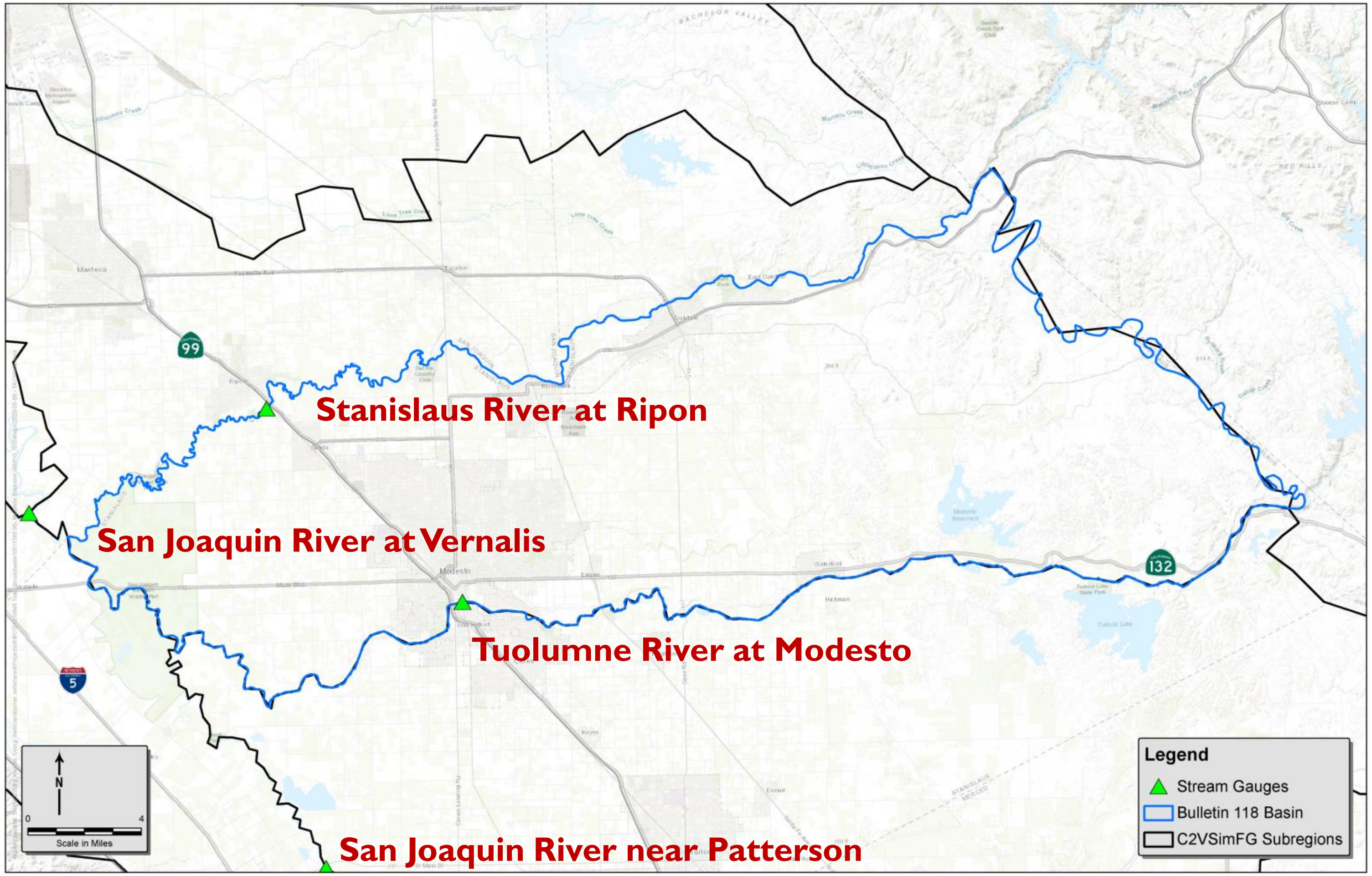
Streamflow Gauges Used in Model Calibration



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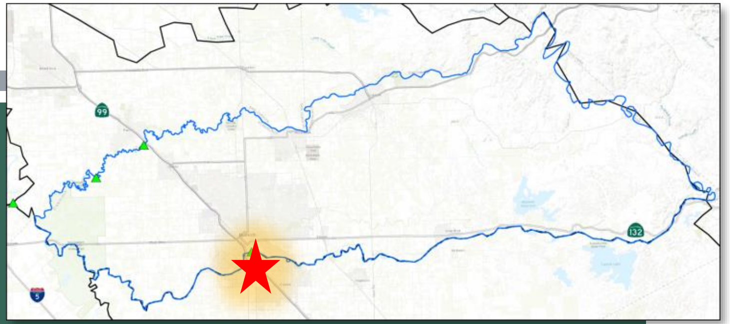
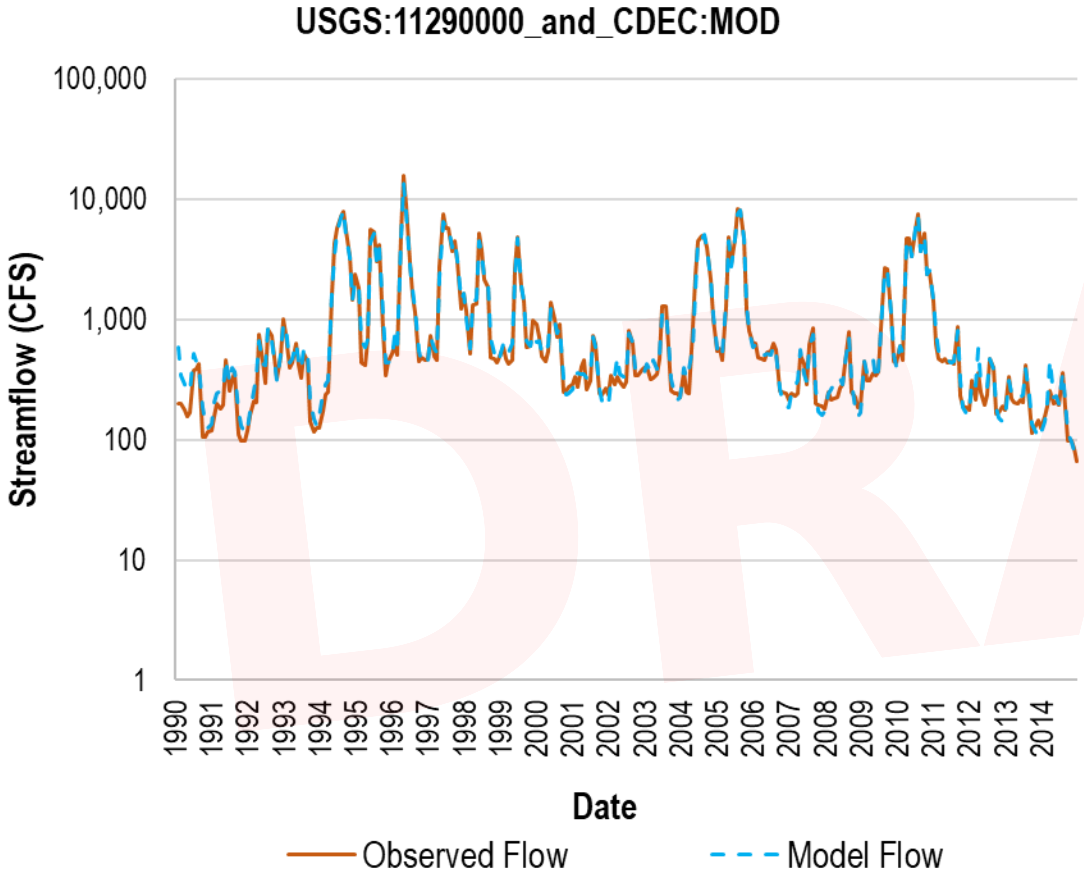
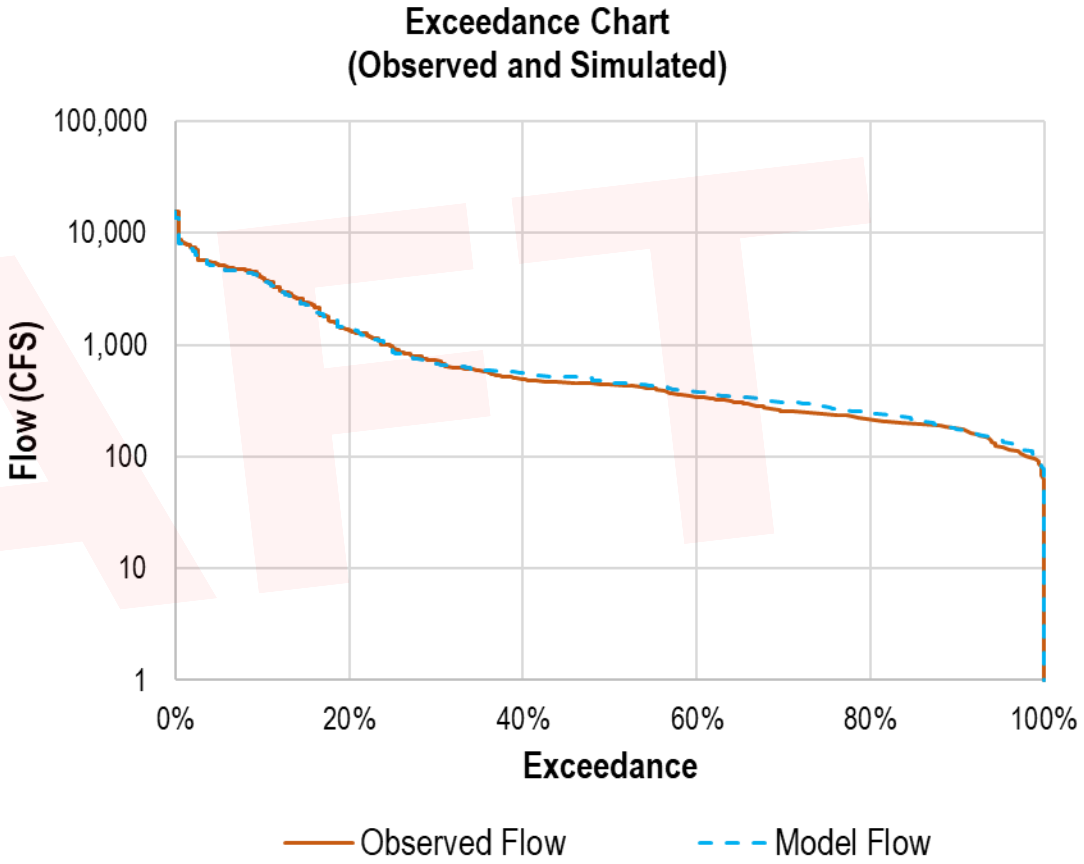
STREAM HYDROGRAPHS

Tuolumne river at Modesto







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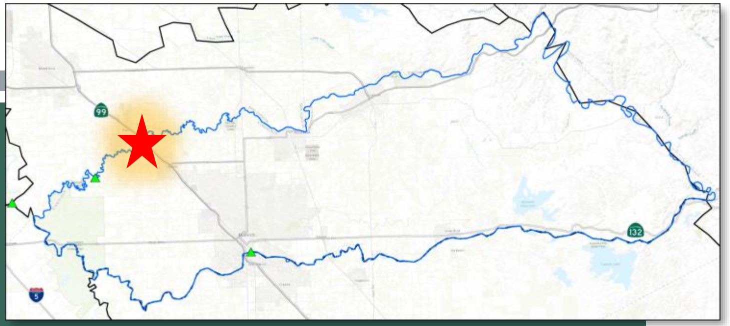
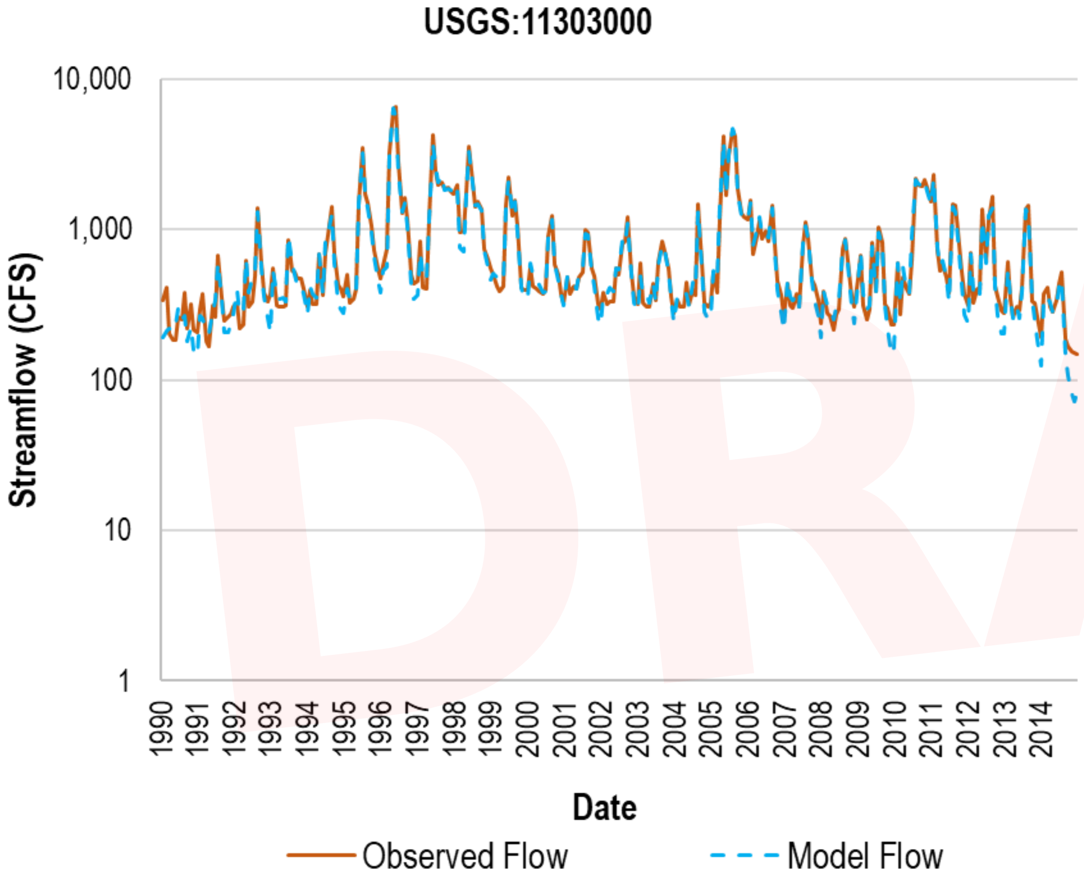
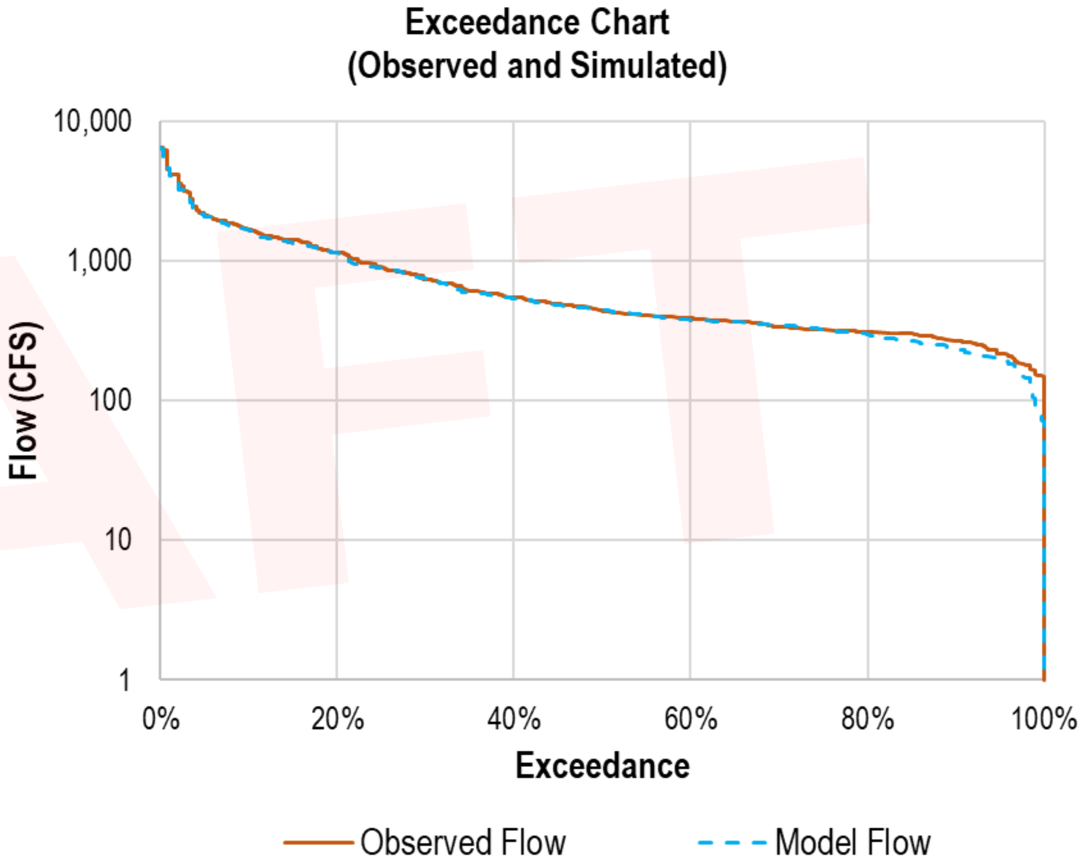
STREAM HYDROGRAPHS

Stanislaus River at Ripon

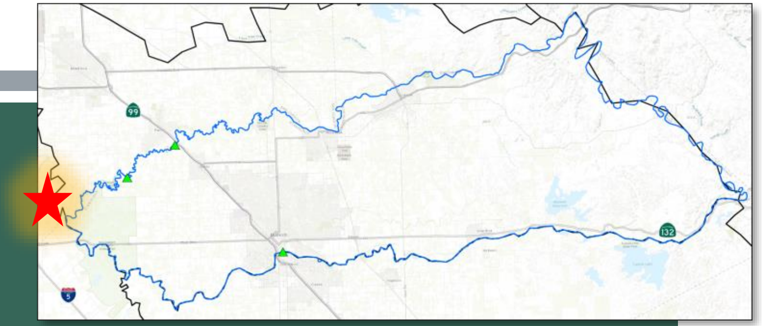


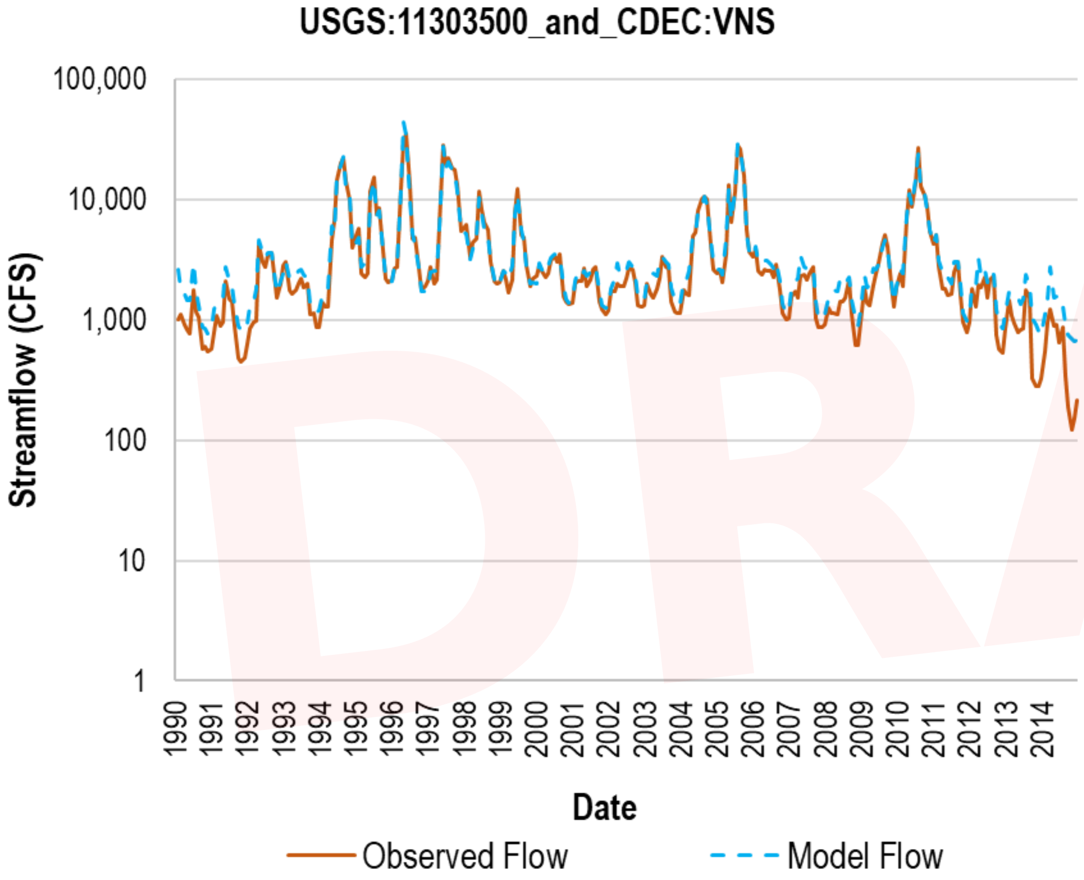


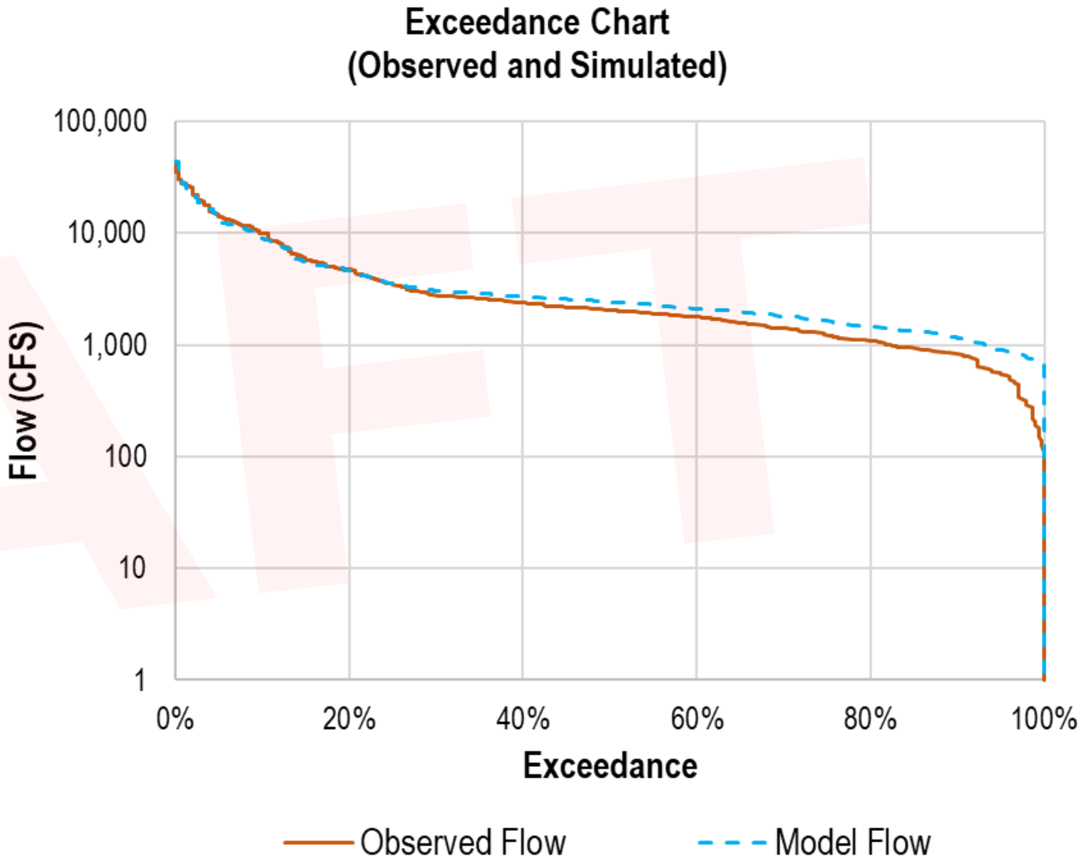


STREAM HYDROGRAPHS

San Joaquin River at Vernalis

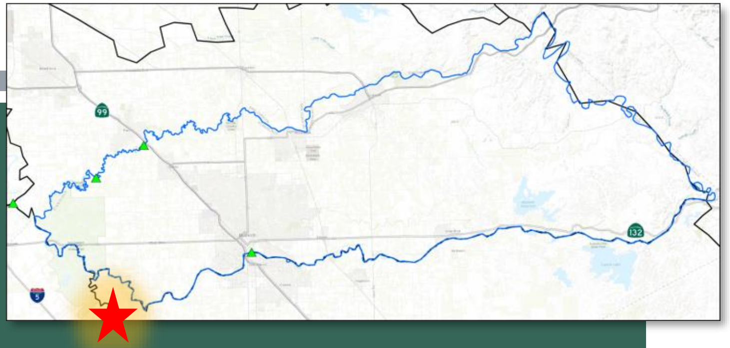


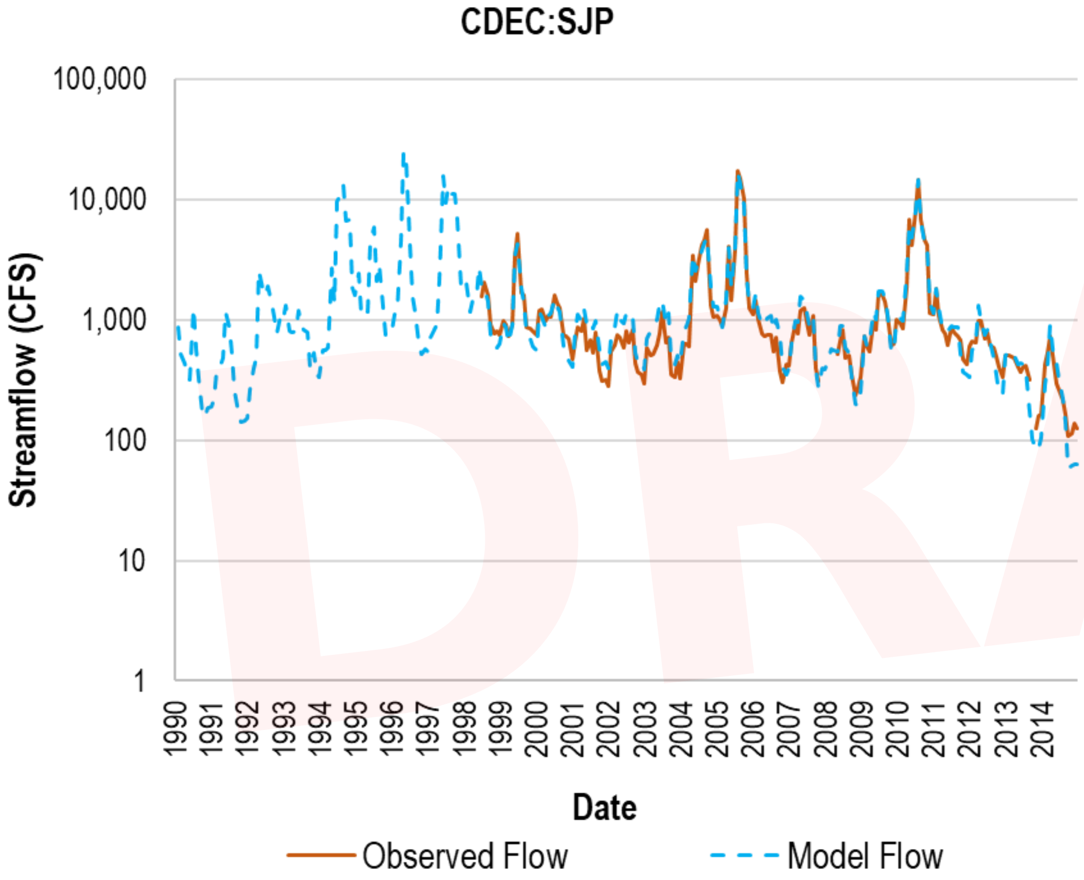


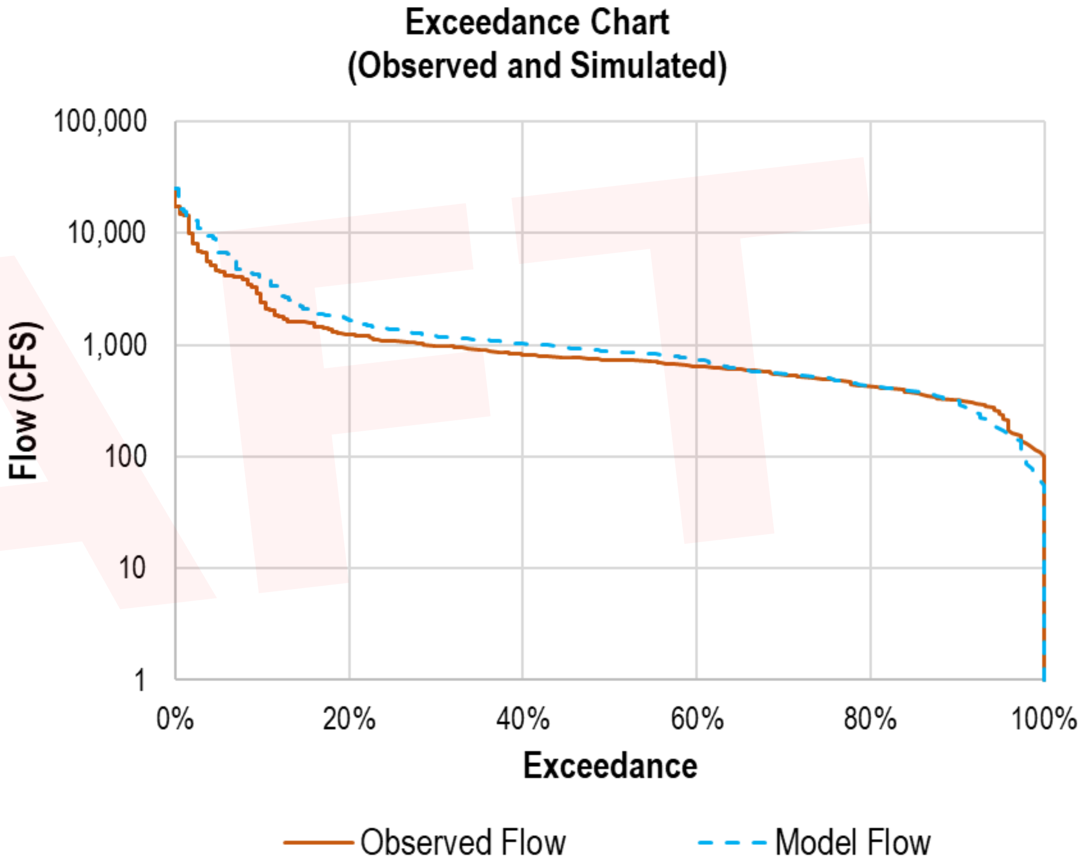


Stream Hydrographs

San Joaquin River near Patterson

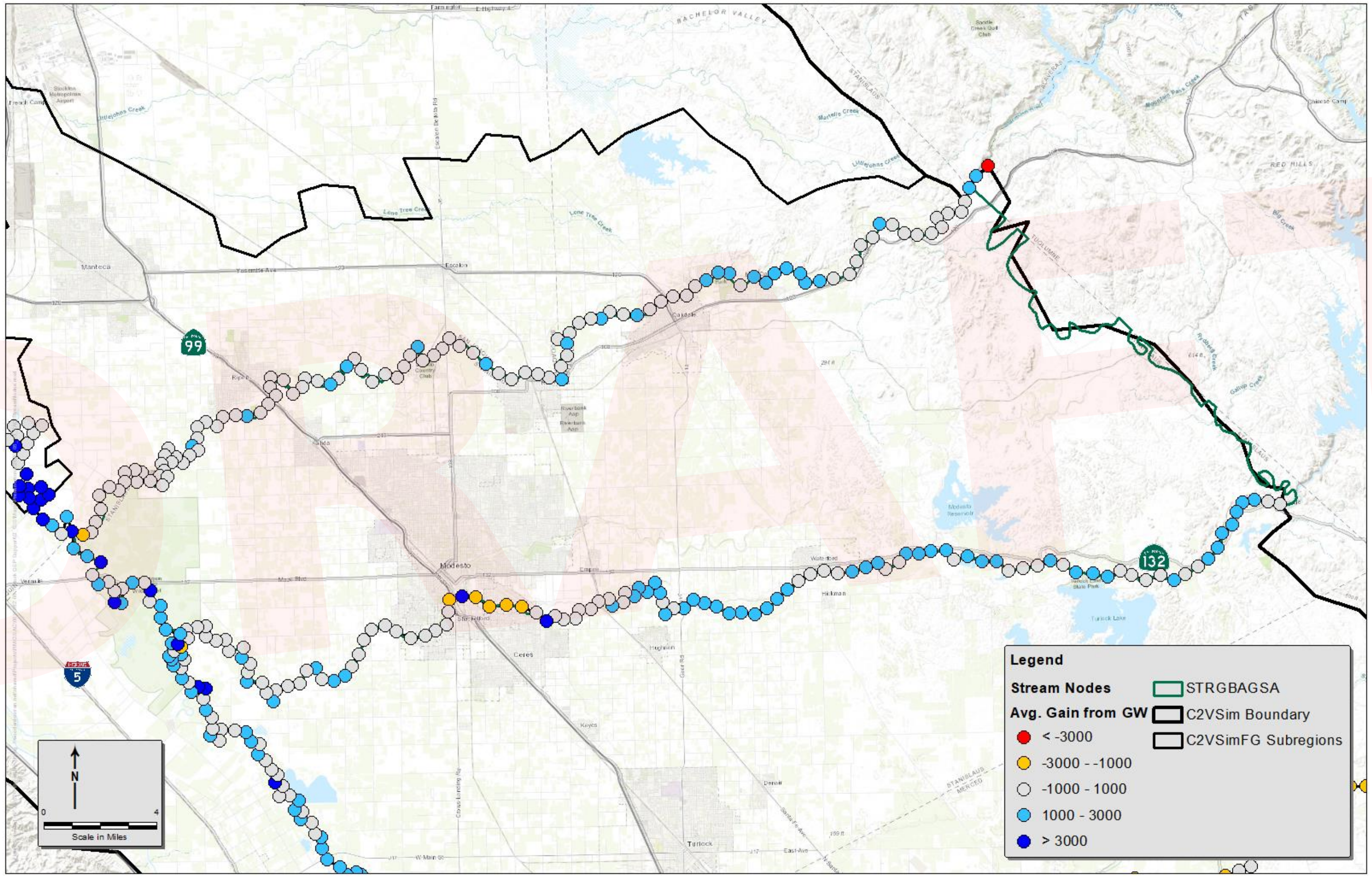






Stream-Aquifer Interaction

Average Annual Gain from Groundwater (AFY)



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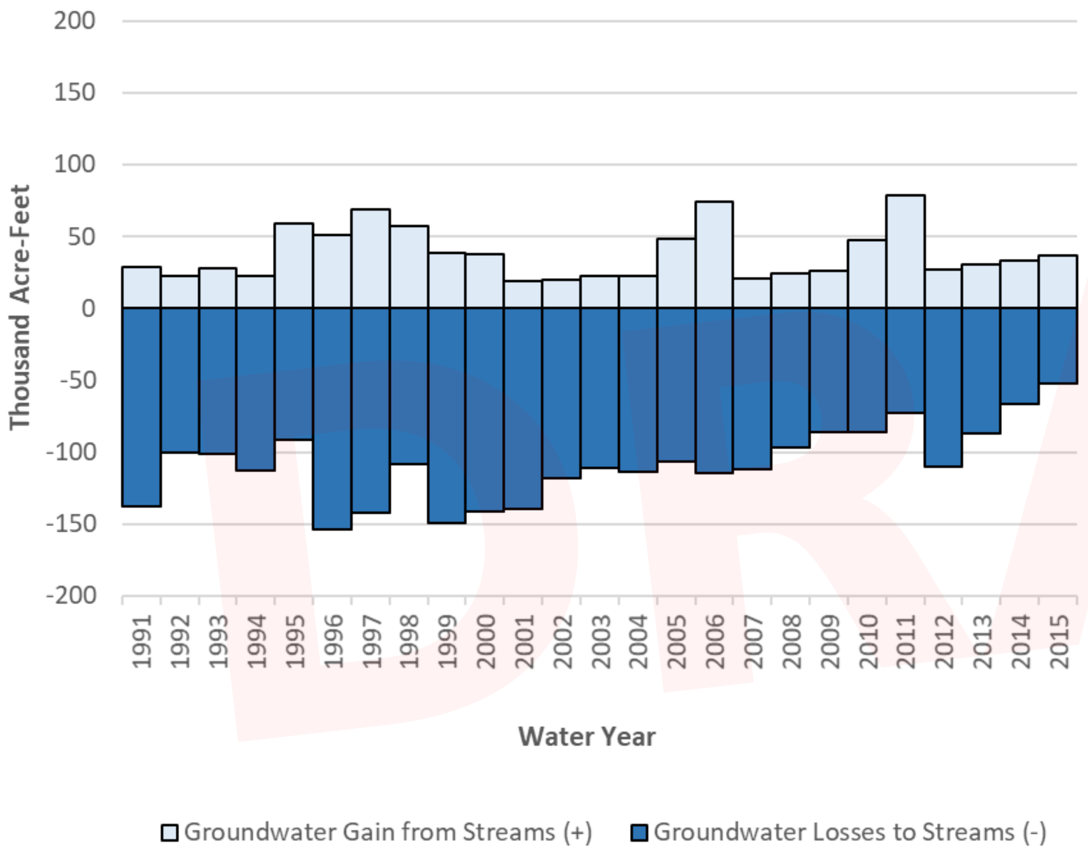
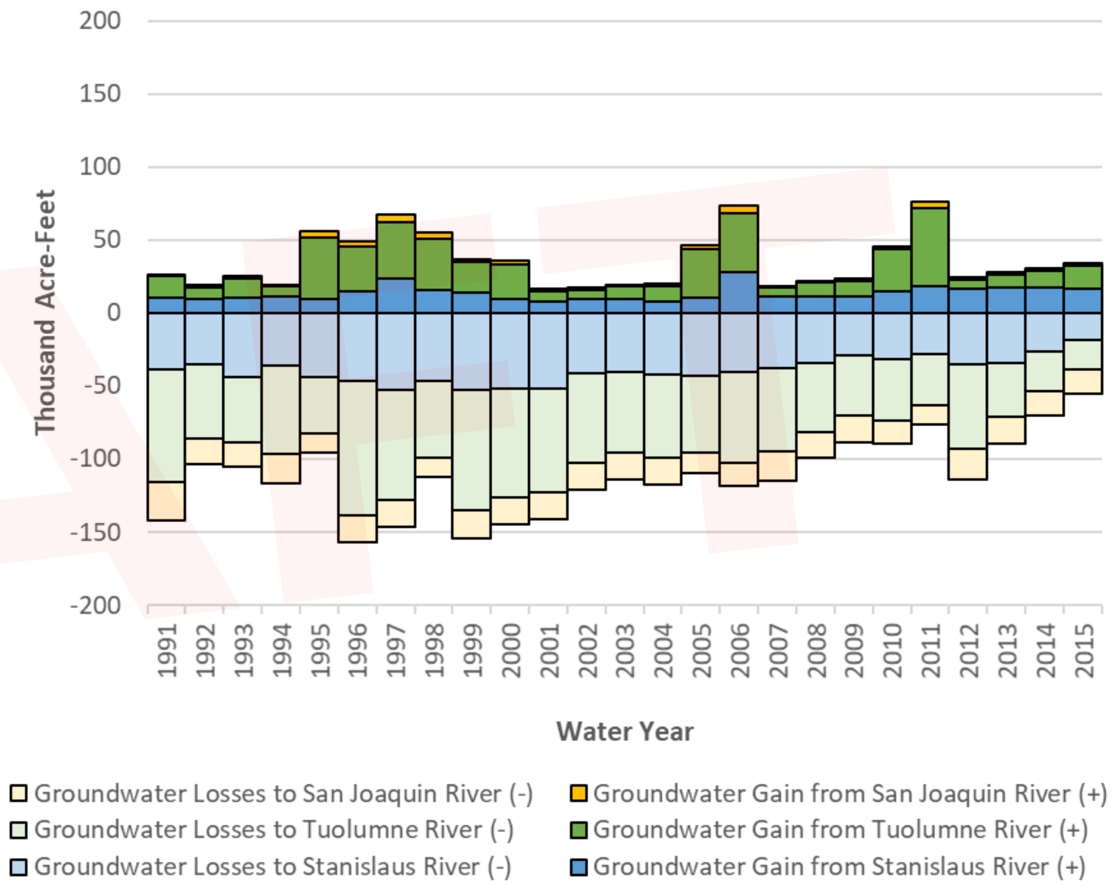
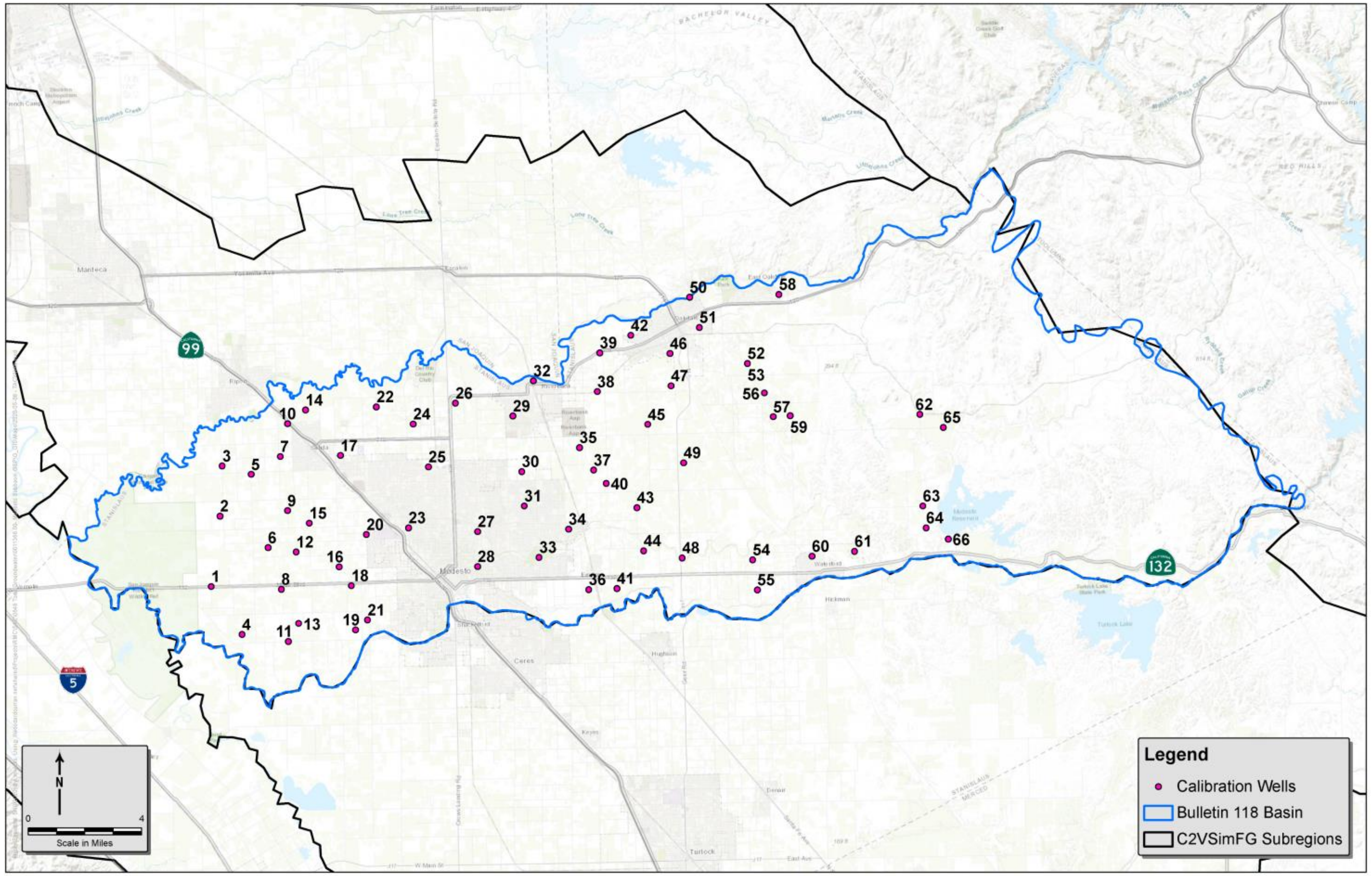
STREAM-GROUNDWATER INTERACTION





Calibration Well Selection



Considerations:

- Period of Record
- Number of observations
- Construction information
- Dedicated monitoring
- Minimal outliers

65 Calibration Wells

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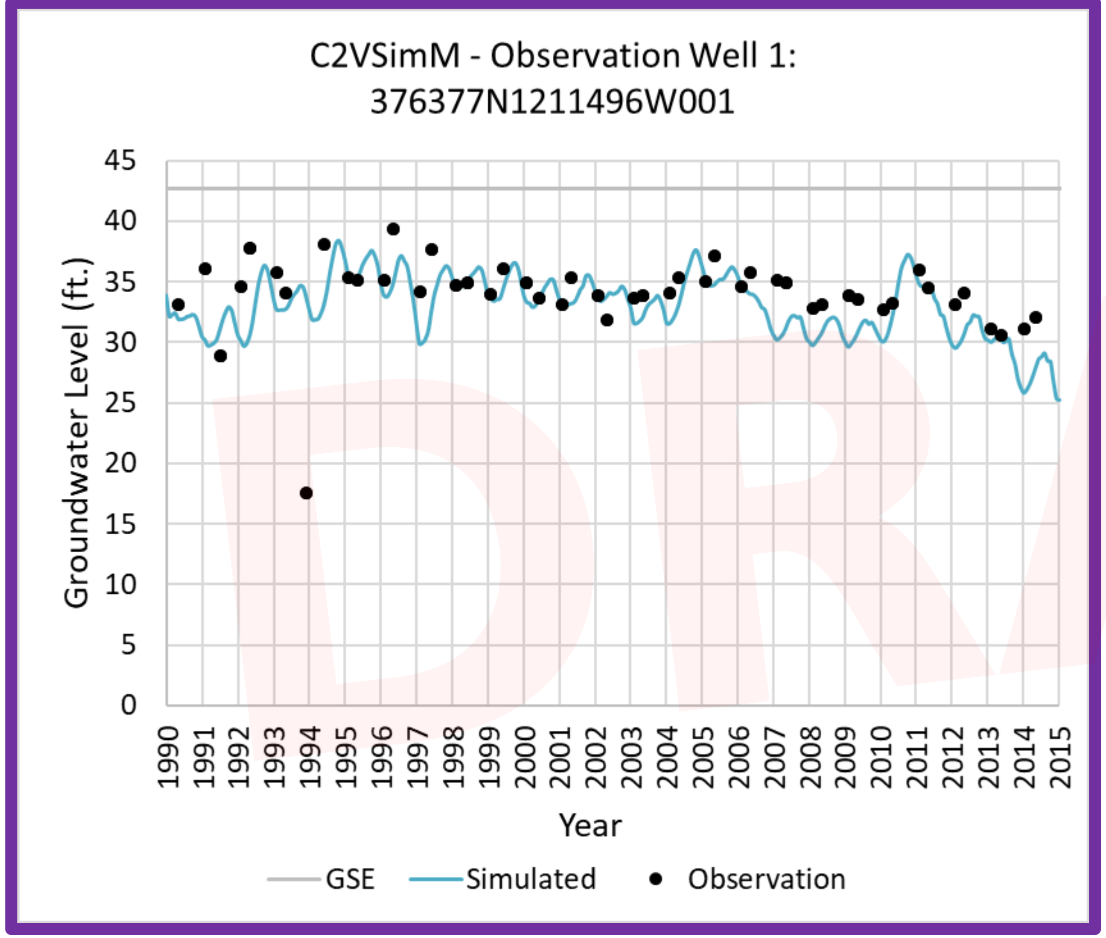
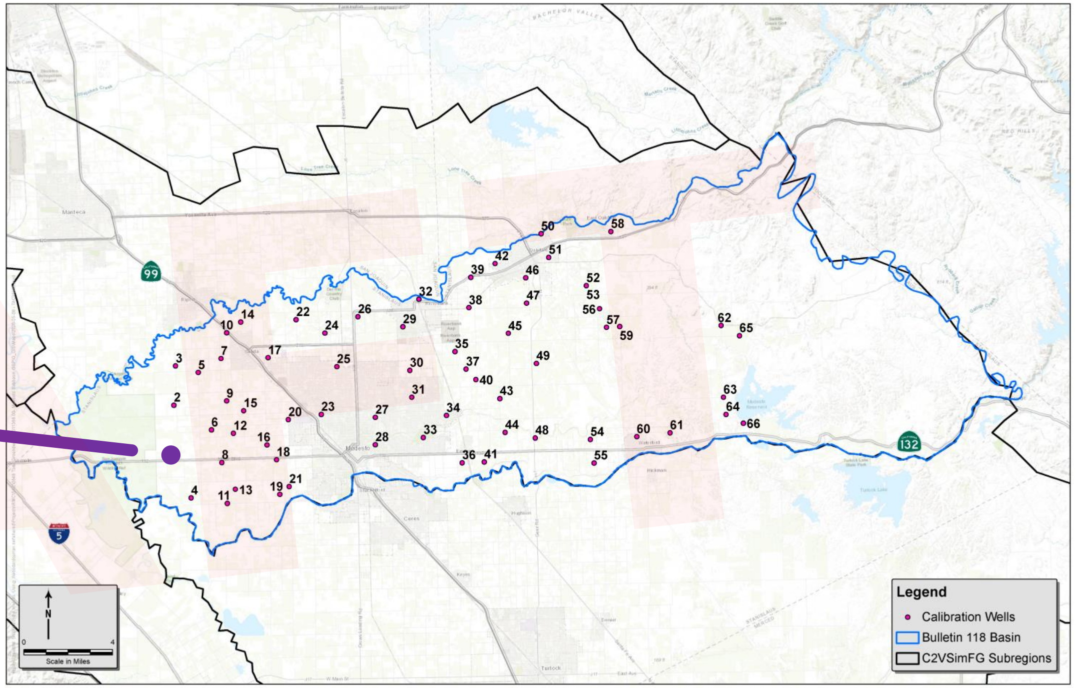
GROUNDWATER HYDROGRAPHS (EXAMPLE)

Western Upper Principal Aquifer (Above Corcoran)





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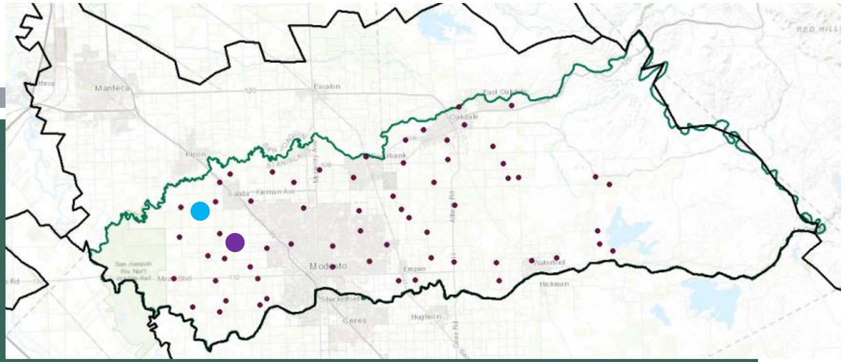
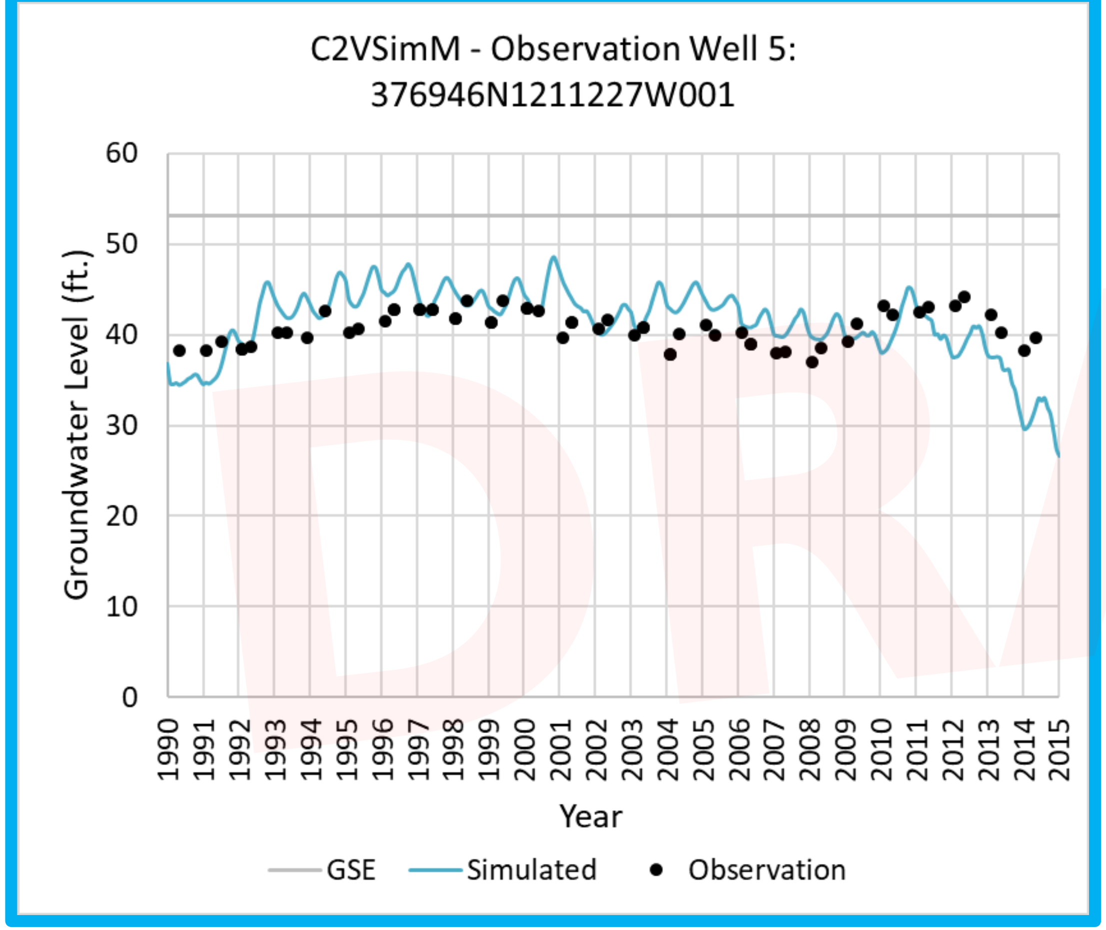
GROUNDWATER HYDROGRAPHS



Western Upper Principal Aquifer (Above Corcoran)



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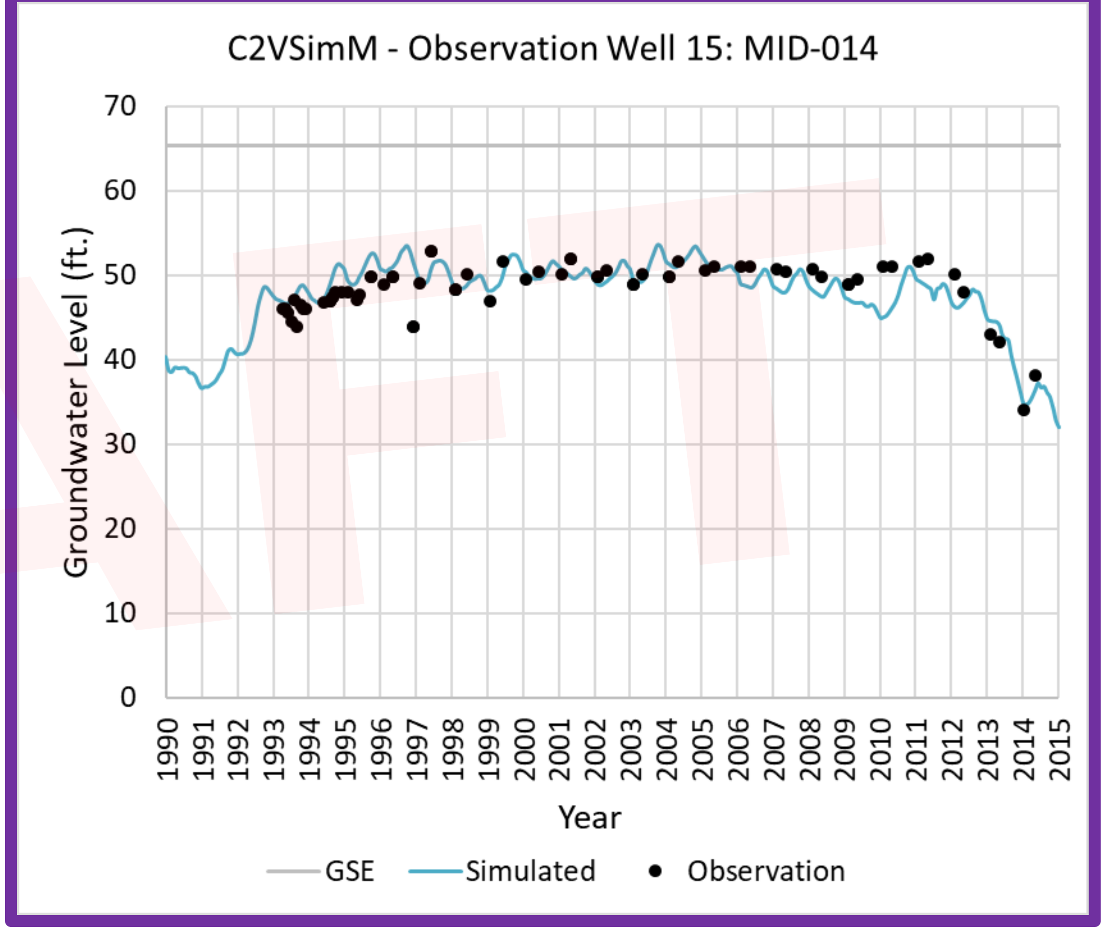
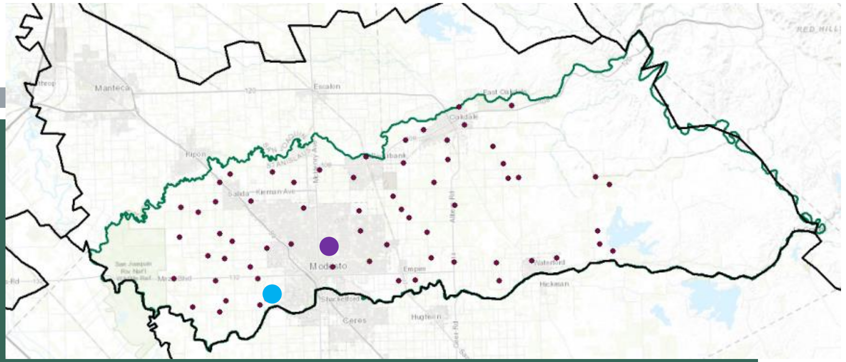
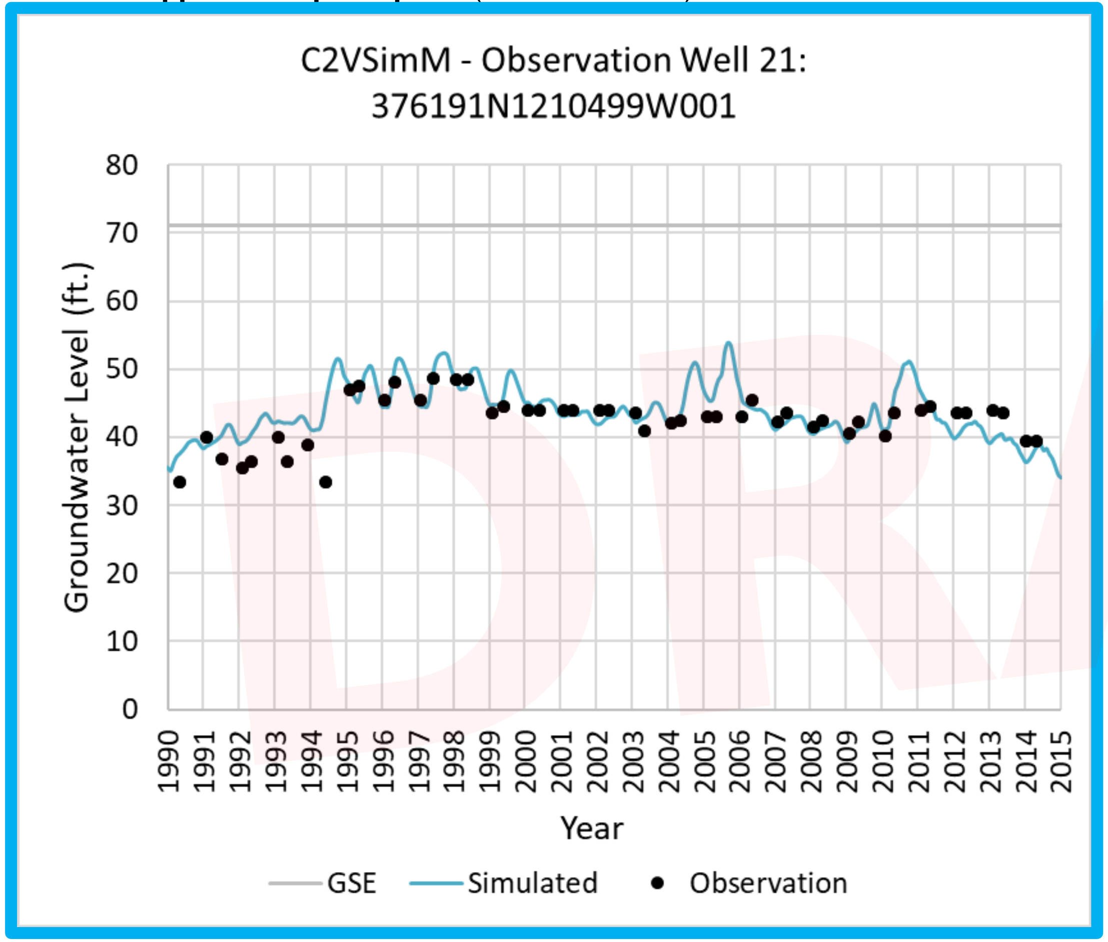


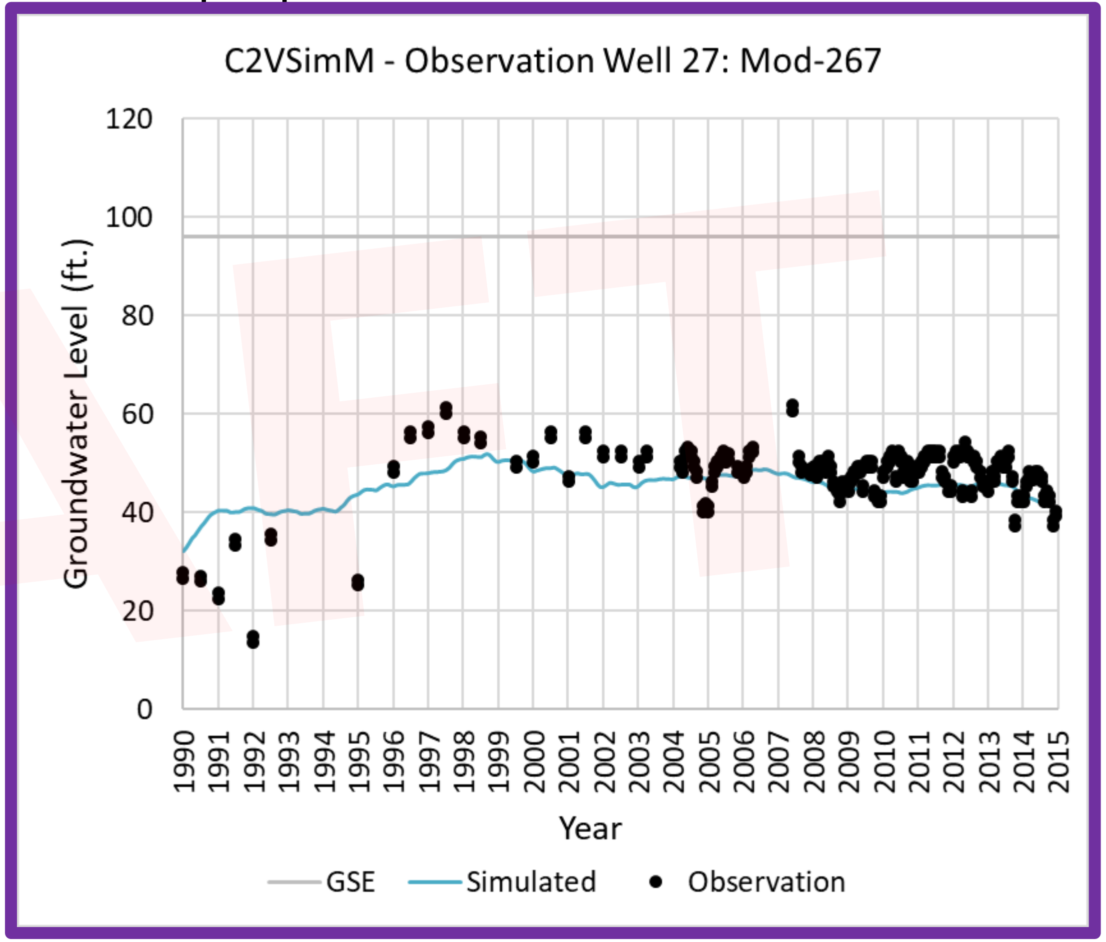
GROUNDWATER HYDROGRAPHS



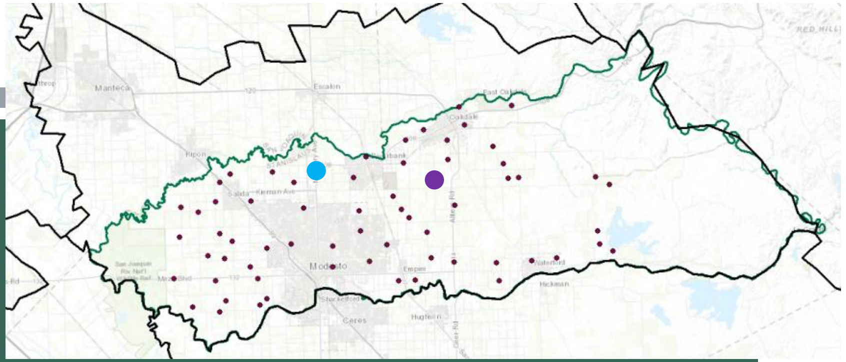
Western Upper Principal Aquifer (Above Corcoran)



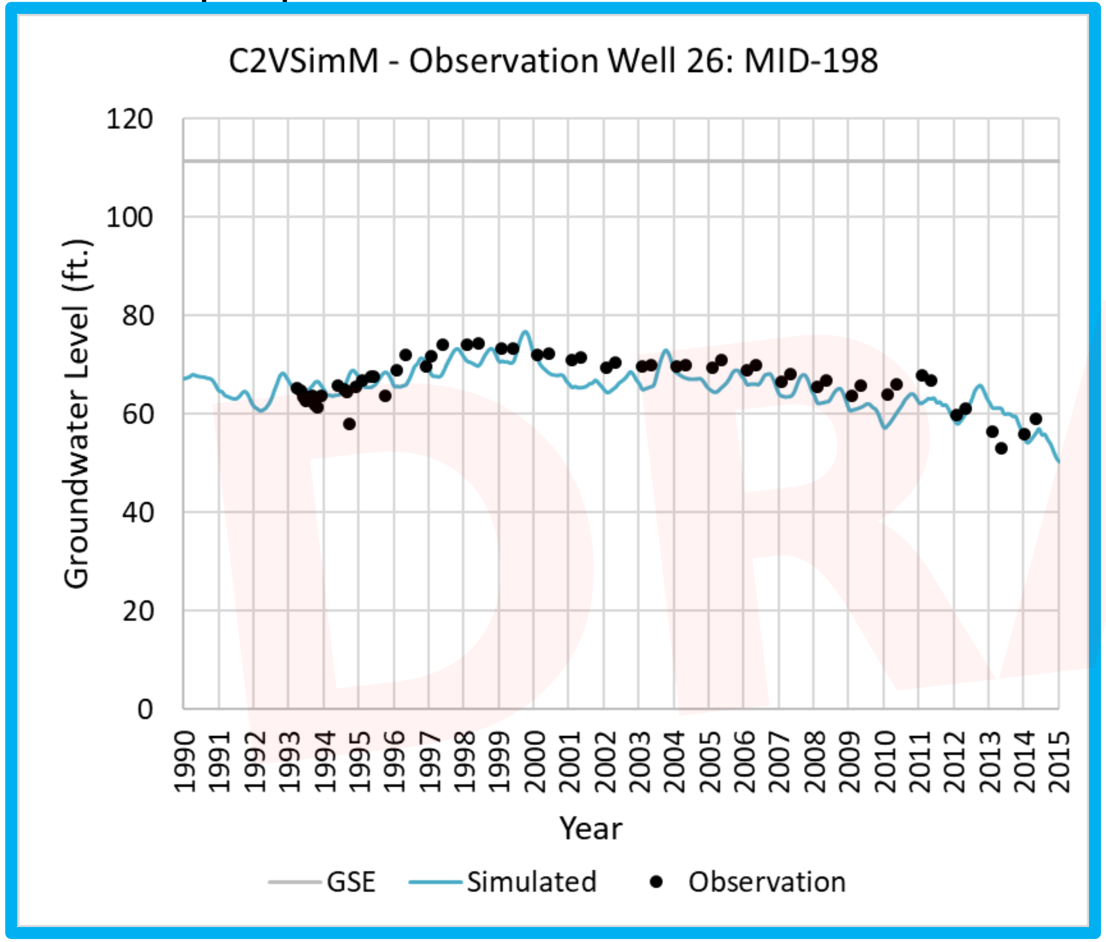
Eastern Principal Aquifer



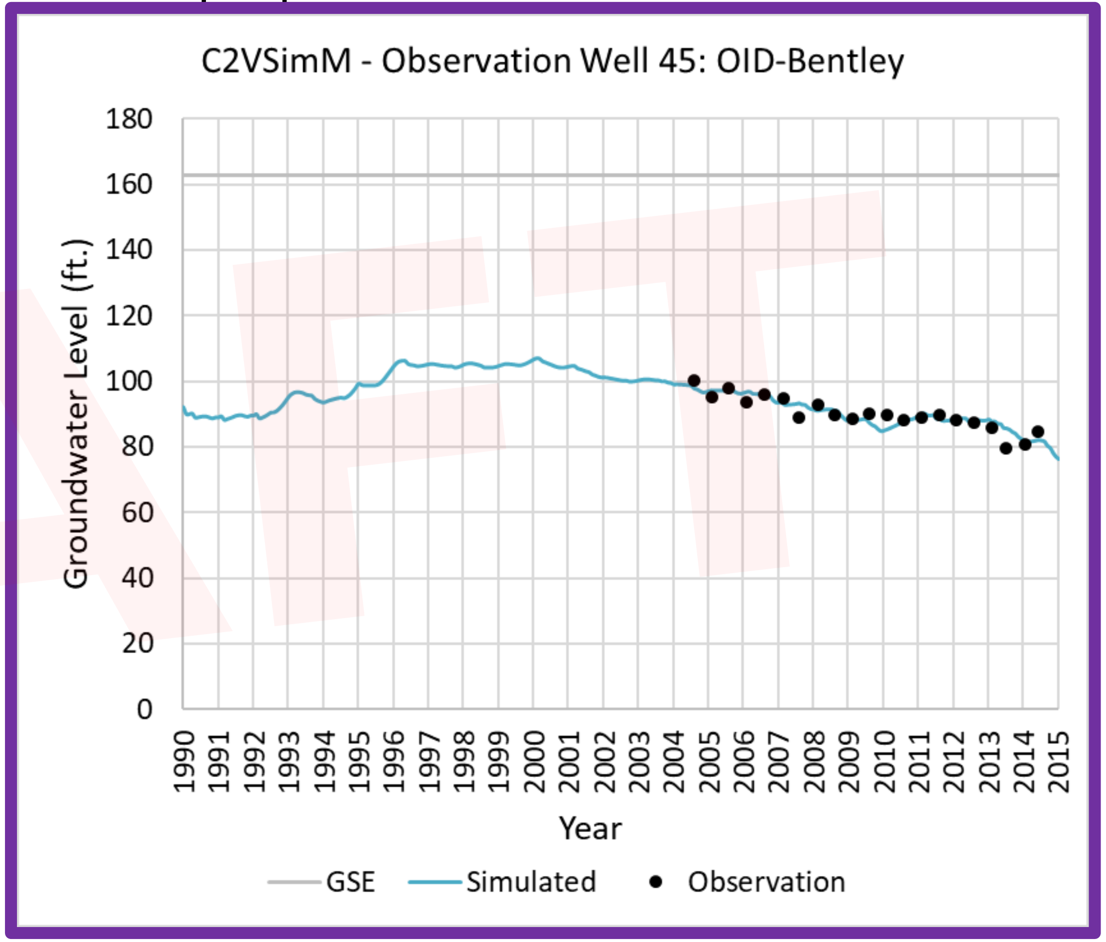
GROUNDWATER HYDROGRAPHS



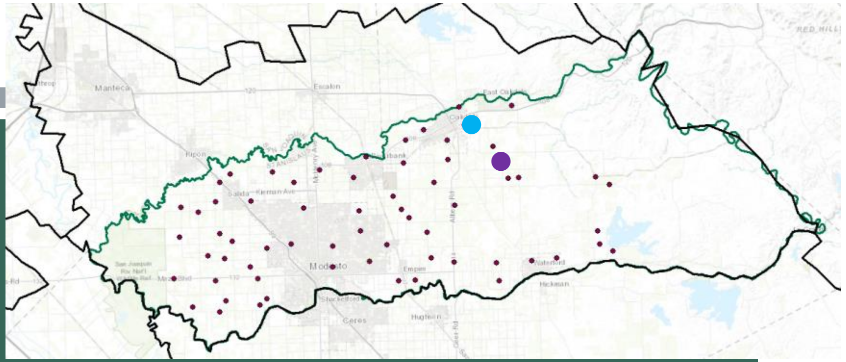
Eastern Principal Aquifer



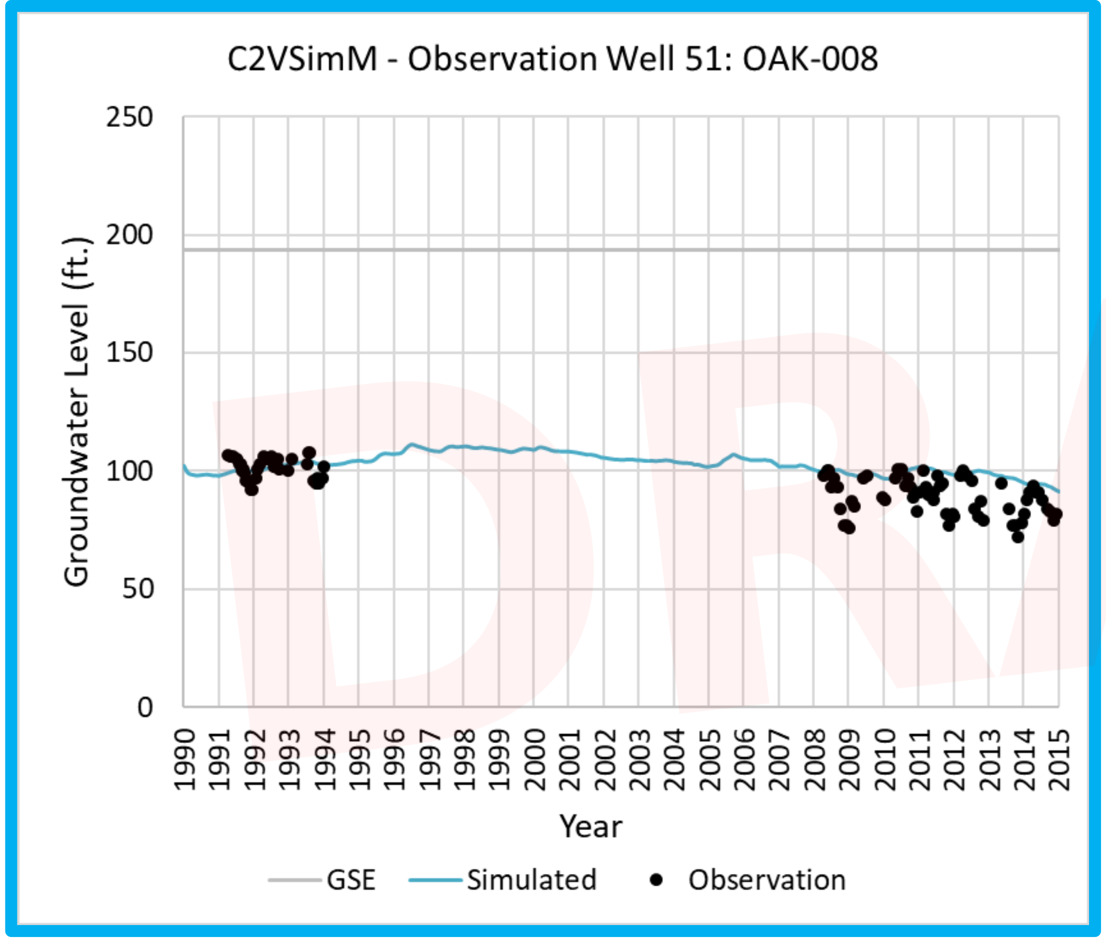
Eastern Principal Aquifer



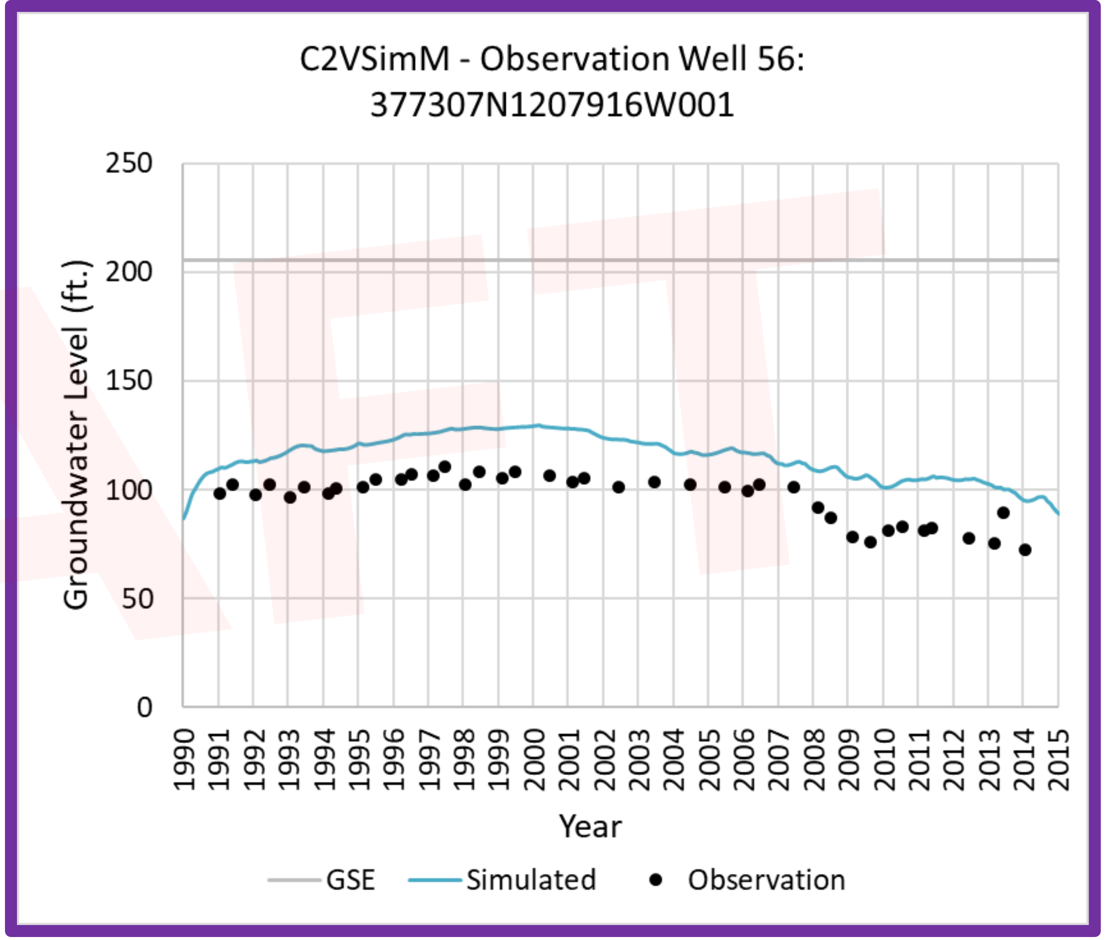
GROUNDWATER HYDROGRAPHS



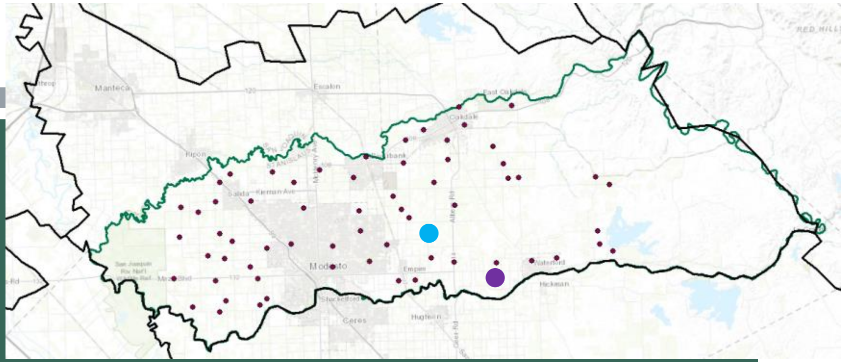
Eastern Principal Aquifer



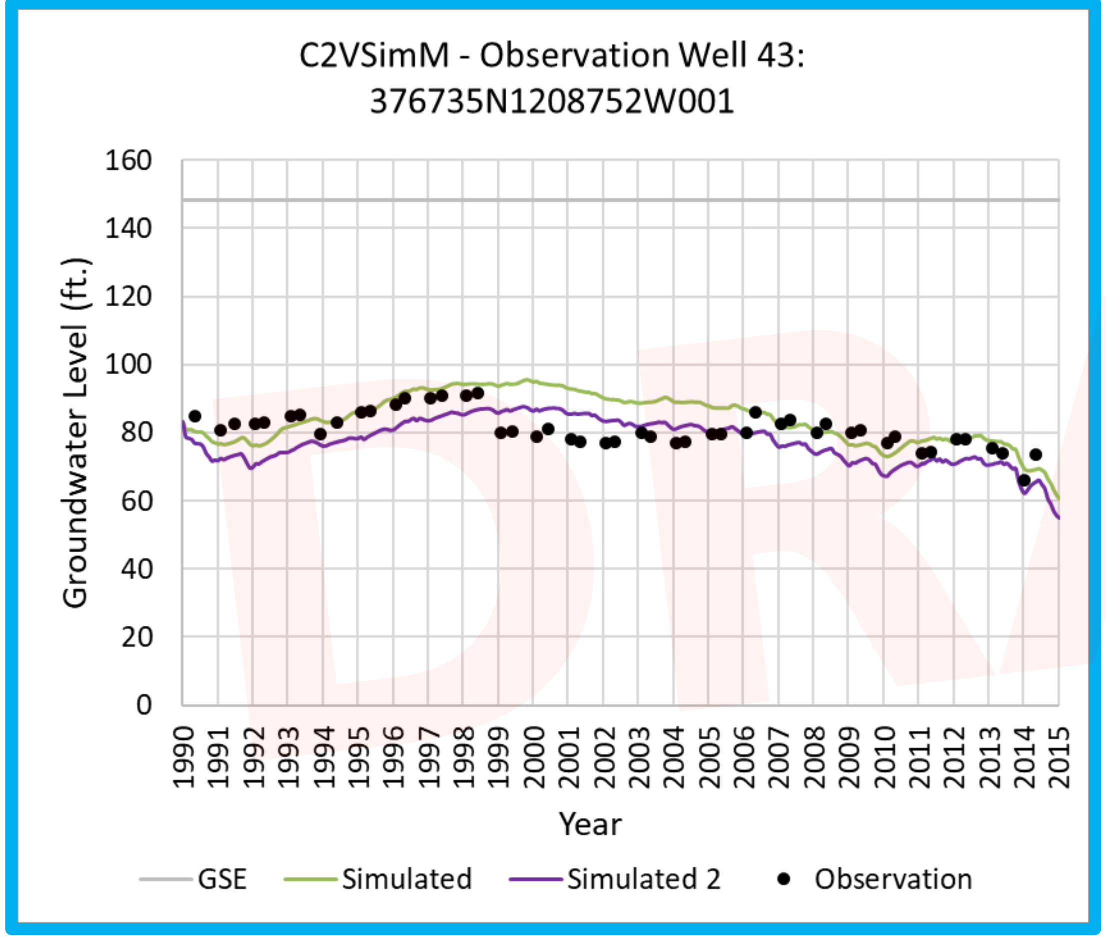
Eastern Principal Aquifer



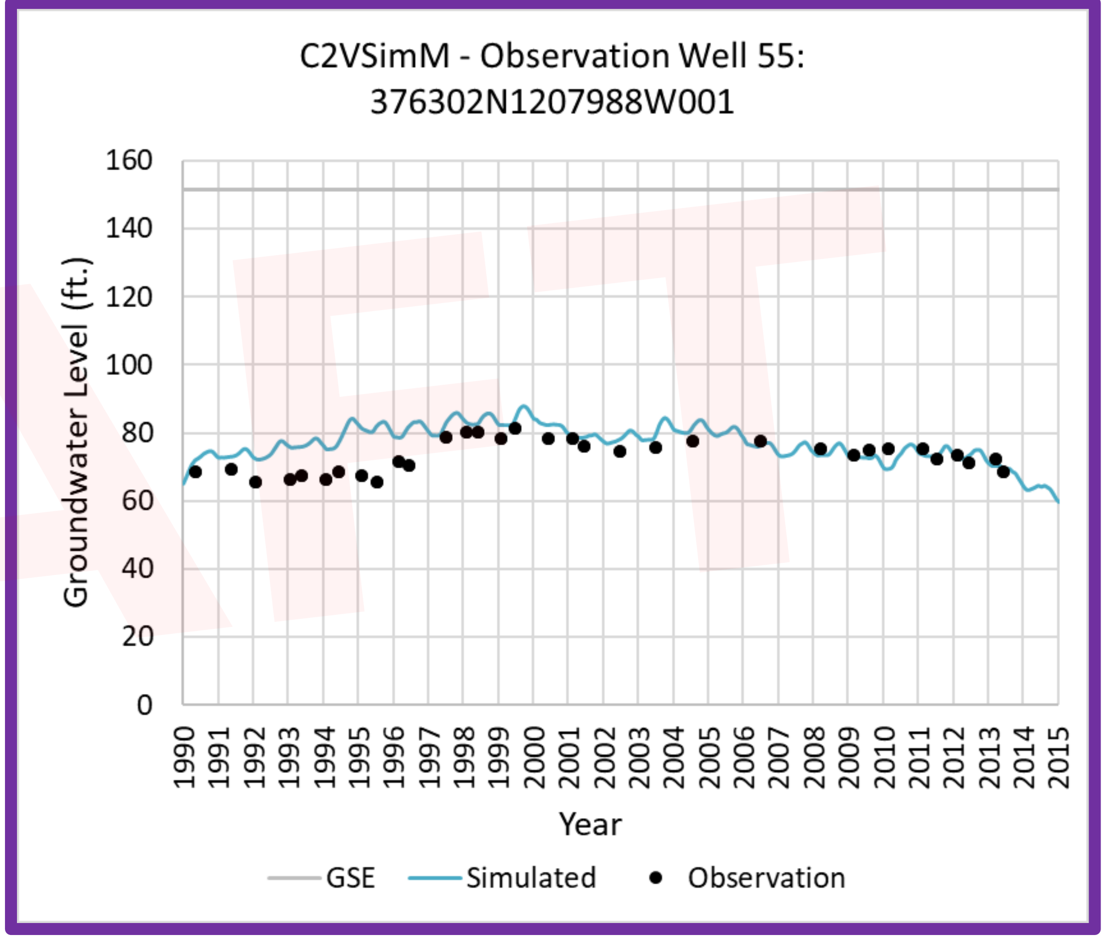
Groundwater Hydrographs



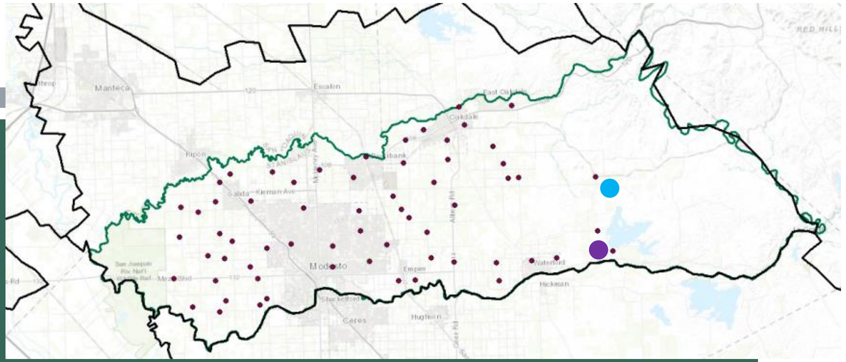
Eastern Principal Aquifer (Multiple Hydrogeological Formations)



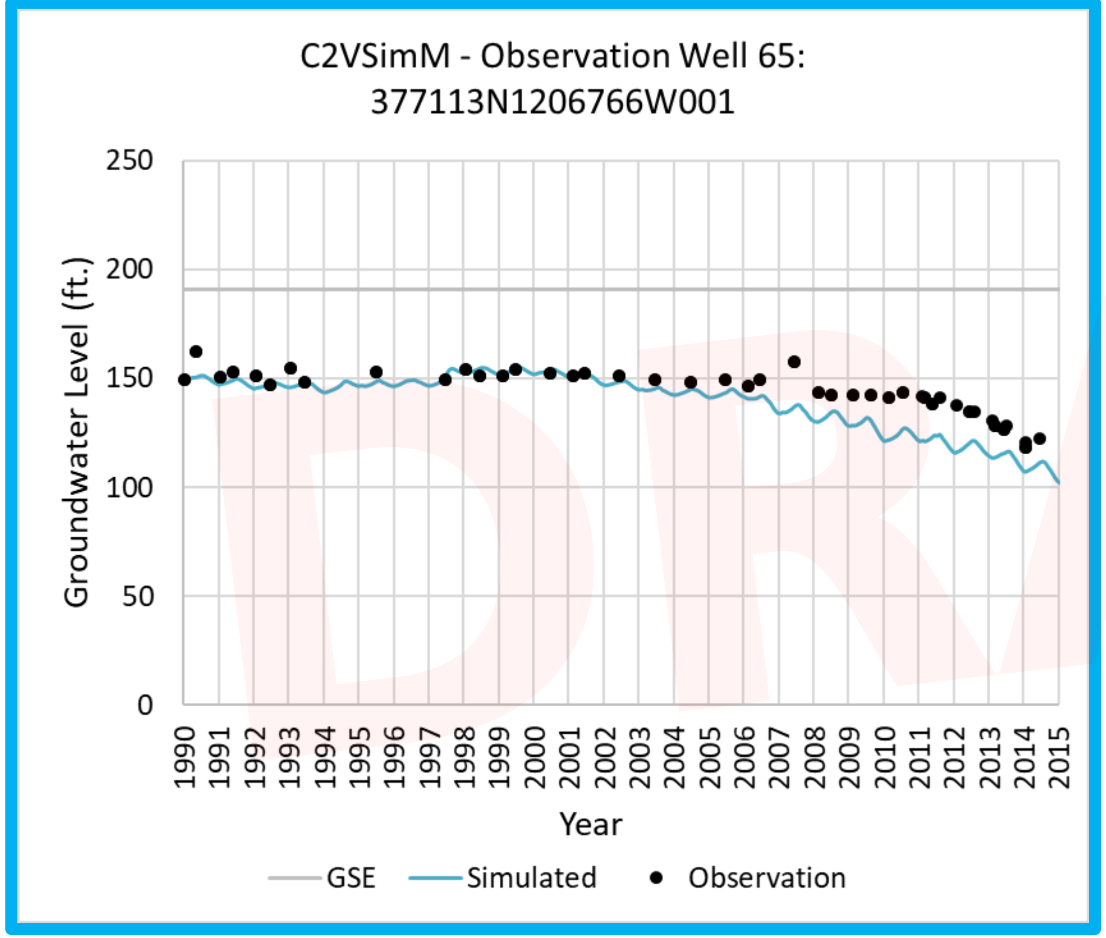
Eastern Principal Aquifer



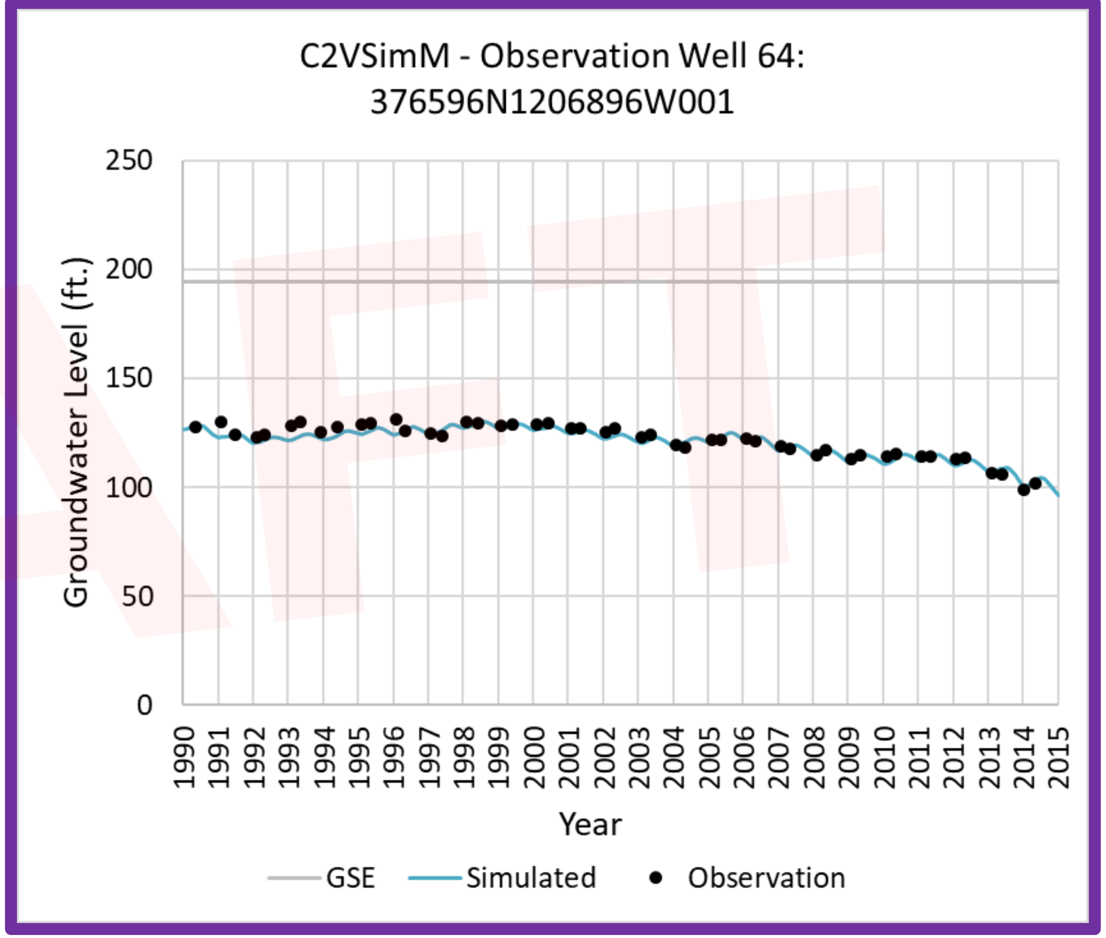
GROUNDWATER HYDROGRAPHS



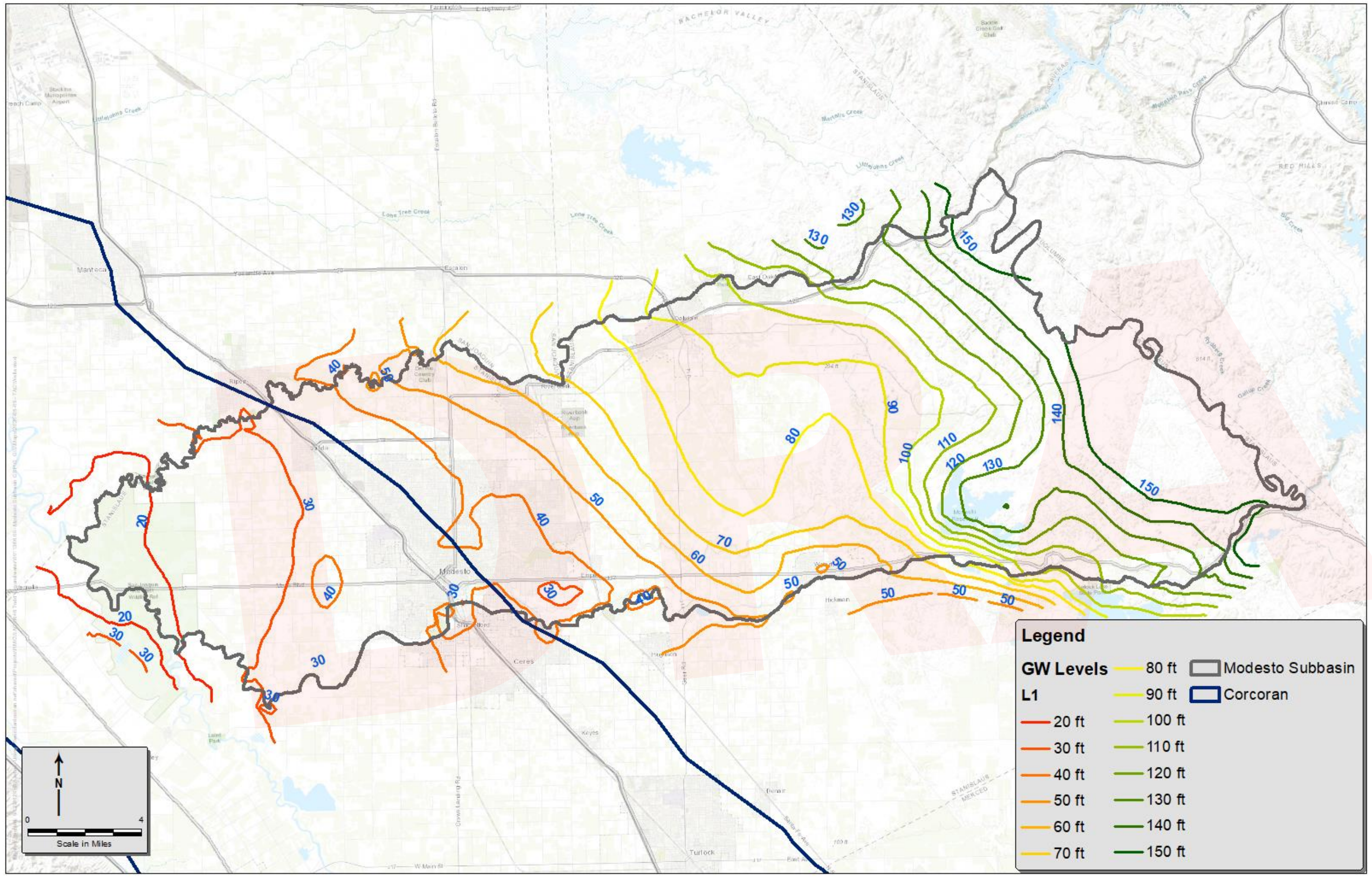
Western Lower Principal Aquifer (Below Corcoran)



Western Lower Principal Aquifer (Below Corcoran)



Model Groundwater Level Contours



Groundwater levels are listed as feet above MSL

- Period: Sep 2015
- Principal Aquifers:
  Western Upper
  (Above Corcoran)
  and
  Eastern
  (Shallow Zones)
- San Joaquin Valley Water Year Index:
  Critical

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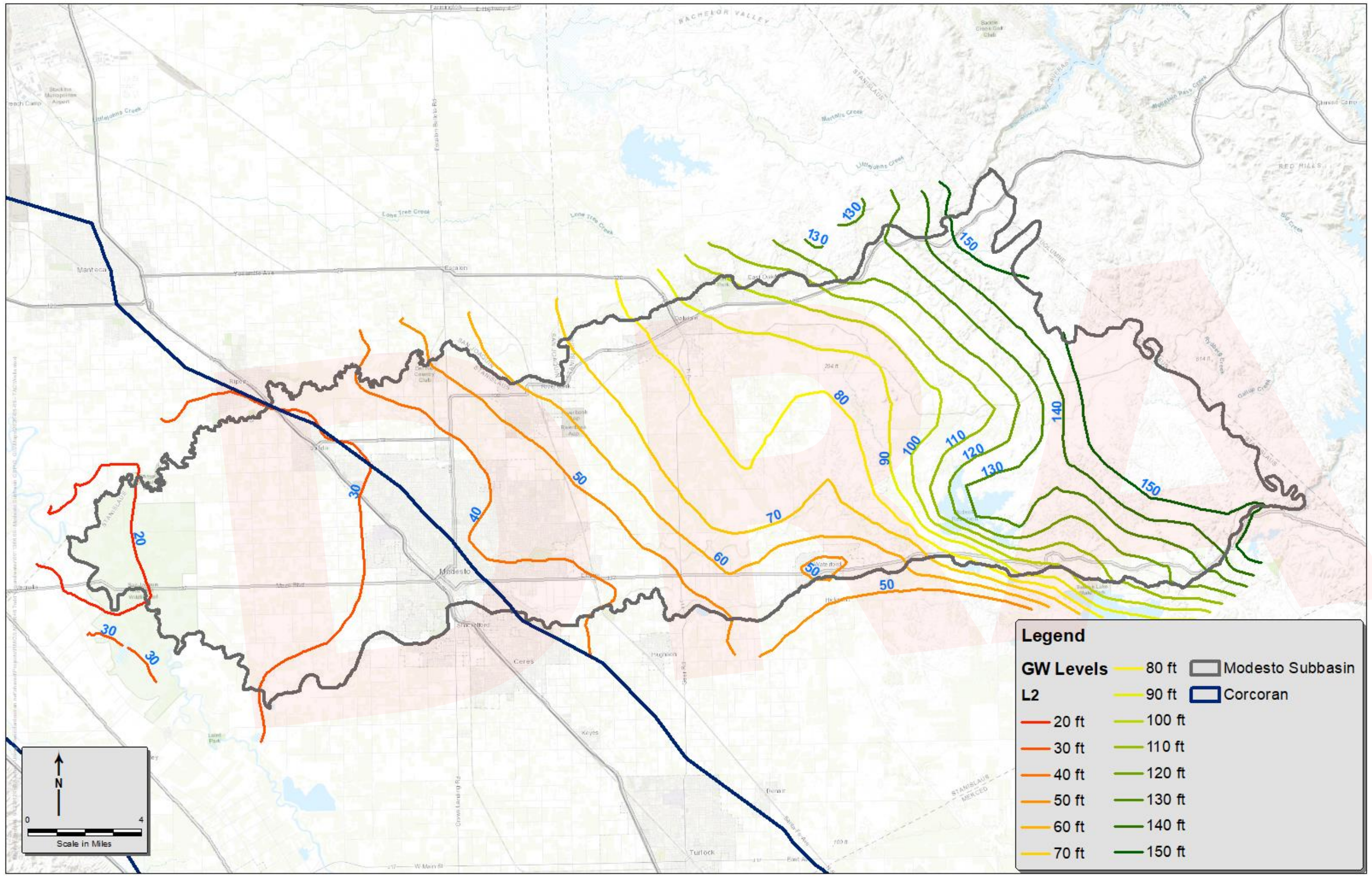
Model Groundwater Level Contours



Groundwater levels are listed as feet above MSL

- Period: Sep 2015
- Principal Aquifers:
  Western Lower
  (Below Corcoran)
  and
  Eastern
  (Deeper Zones)
- San Joaquin Valley Water Year Index:
  Critical

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Upper Aquifer Parameters

	Horizontal Hydraulic Conductivity[1]	Specific Storage	Specific Yield	Corcoran Vertical Conductivity[1]	Aquifer Vertical Conductivity[1]
Minimum	12.11	1.71E-06	0.0500	0.0010	0.0500
First Quartile	24.97	3.72E-05	0.1010	0.0050	0.3194
Average	41.96	7.11E-05	0.1430	0.0081	0.4084
Third Quartile	84.30	9.14E-05	0.1789	0.0148	0.6500
Maximum	100.00	1.00E-04	0.2000	0.0615	7.0000

[1] Units of hydraulic conductivity are in feet per day

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Lower Aquifer Parameters

	Horizontal Hydraulic Conductivity[1]	Specific Storage	Specific Yield	Corcoran Vertical Conductivity[1]	Aquifer Vertical Conductivity[1]
Minimum	6.81	2.21E-06	0.0500	0.0006	0.0149
First Quartile	15.19	4.44E-05	0.0983	0.0034	0.1721
Average	25.26	8.44E-05	0.1369	0.0050	0.2576
Third Quartile	39.18	1.00E-04	0.1695	0.0151	0.4017
Maximum	68.18	1.00E-04	0.2000	0.0560	2.3863

[1] Units of hydraulic conductivity are in feet per day

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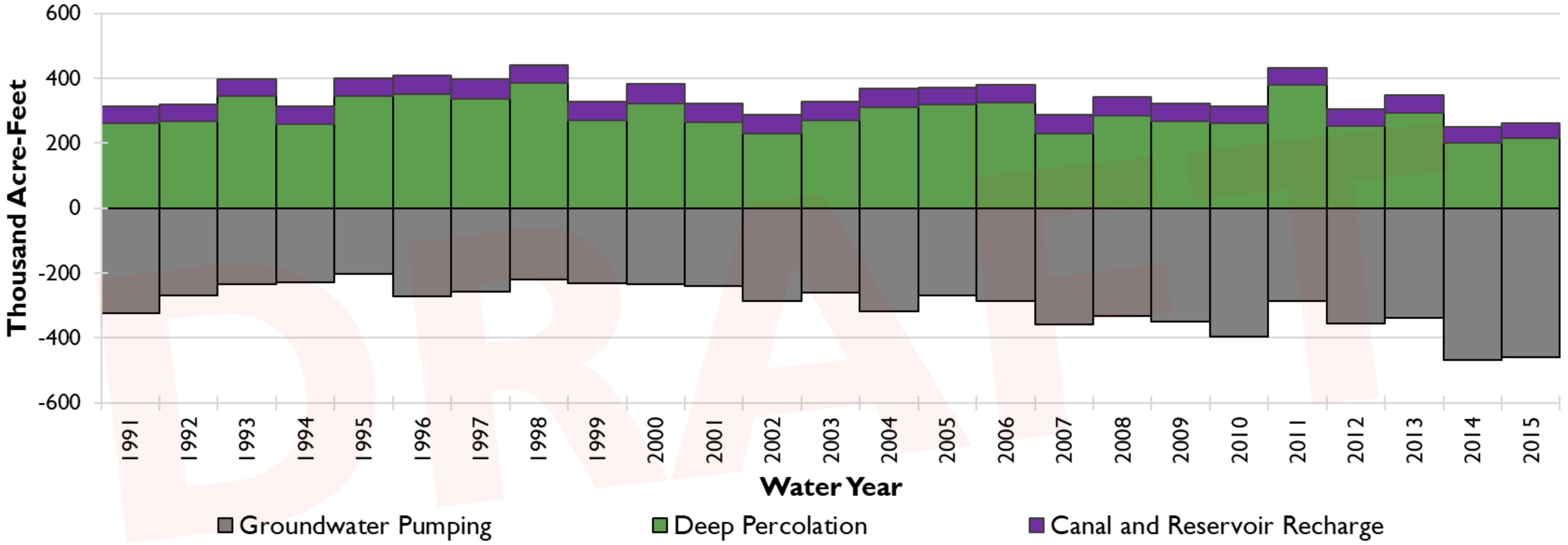
WATER BUDGETS

RECHARGE/EXTRACTION



Deep Percolation: All percolation resulting from precipitation and applied waters across ag, urban, and native lands.
Canal and Reservoir Recharge: Canal and reservoir seepage from Modesto and Oakdale Irrigation Districts and riparian surface water diverters.

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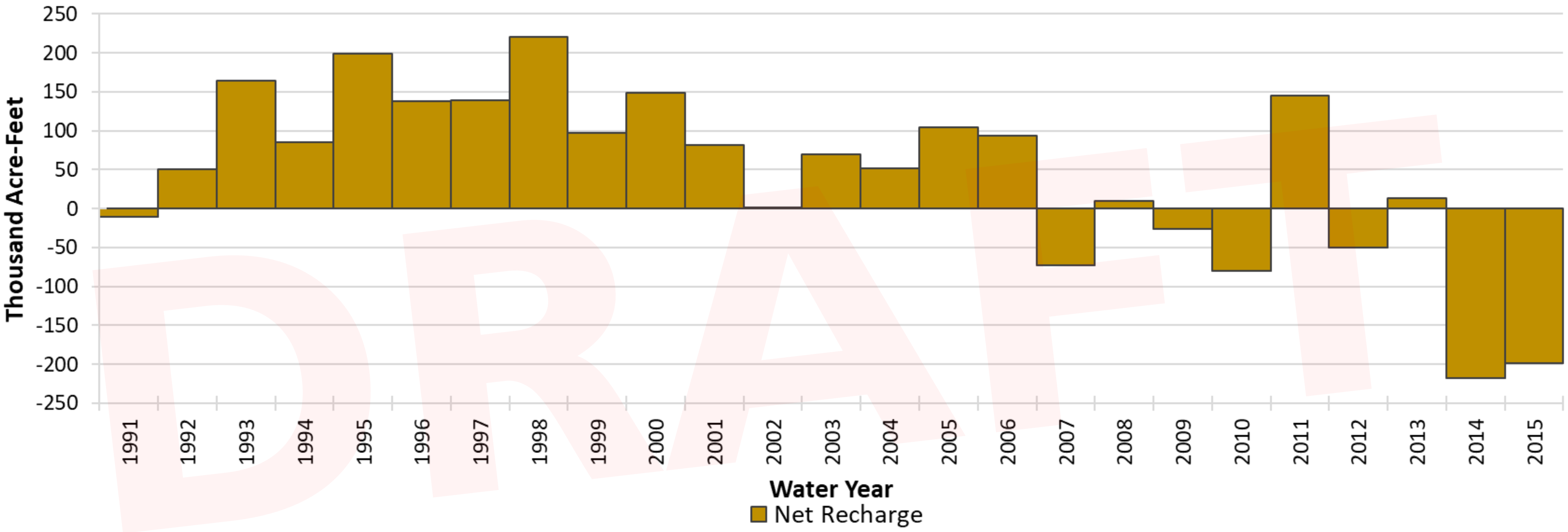
Net Recharge



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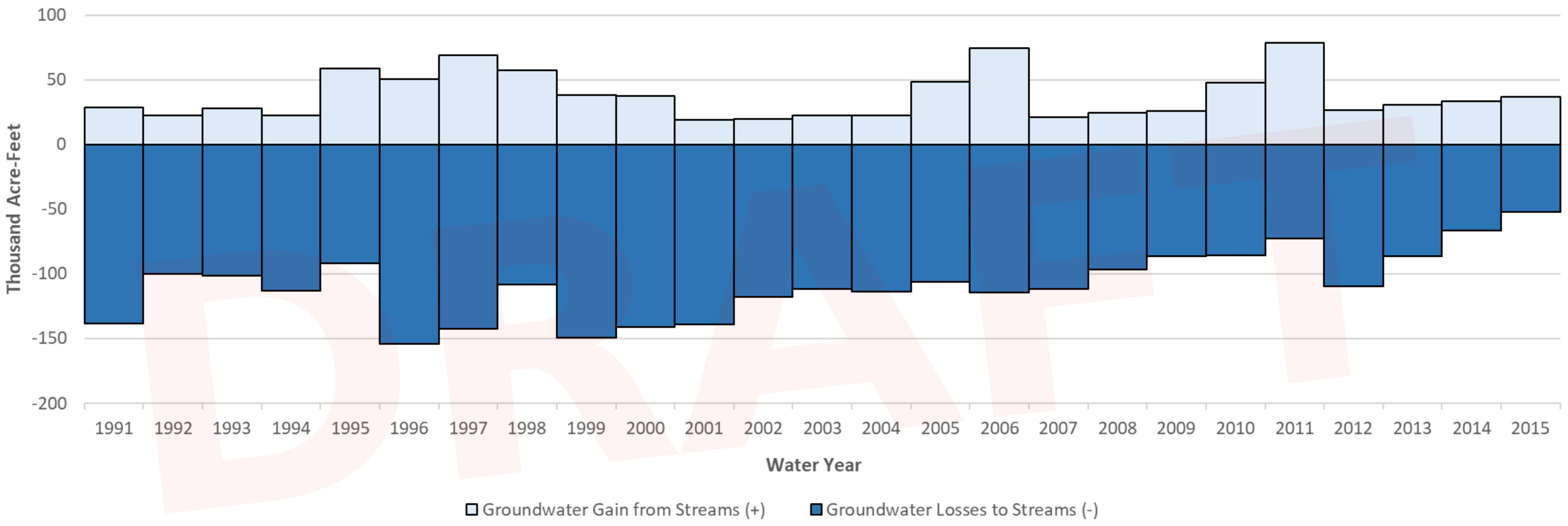
STREAM-GROUNDWATER INTERACTION



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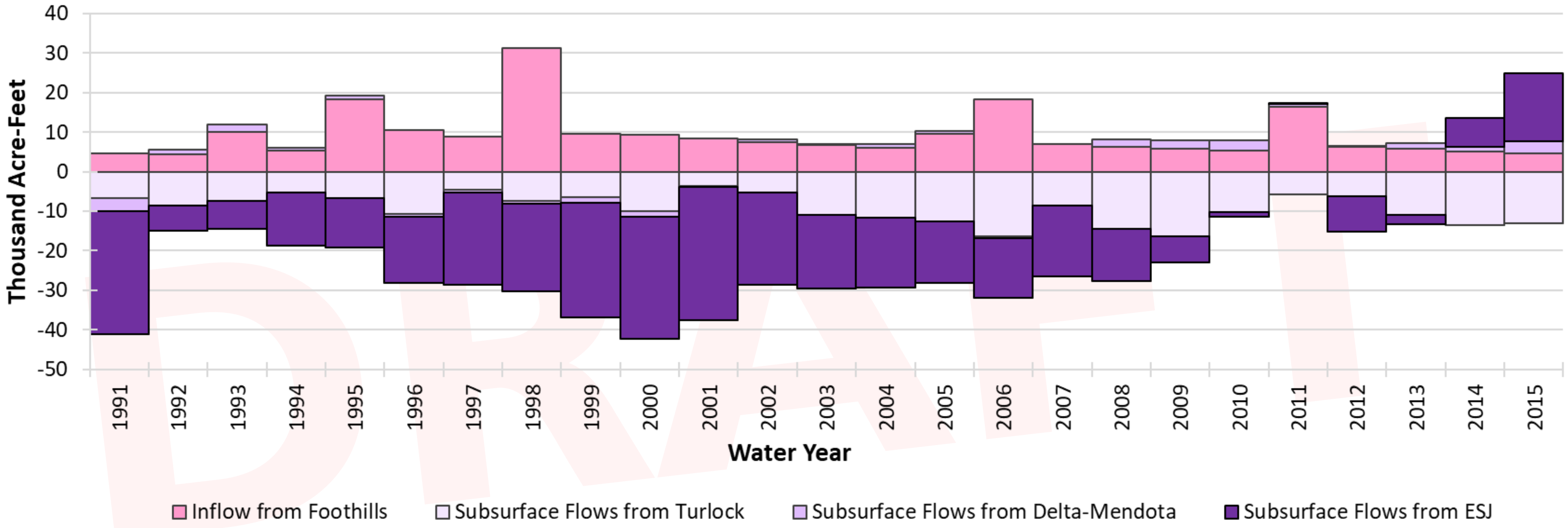
INTER-SUBBASIN FLOW



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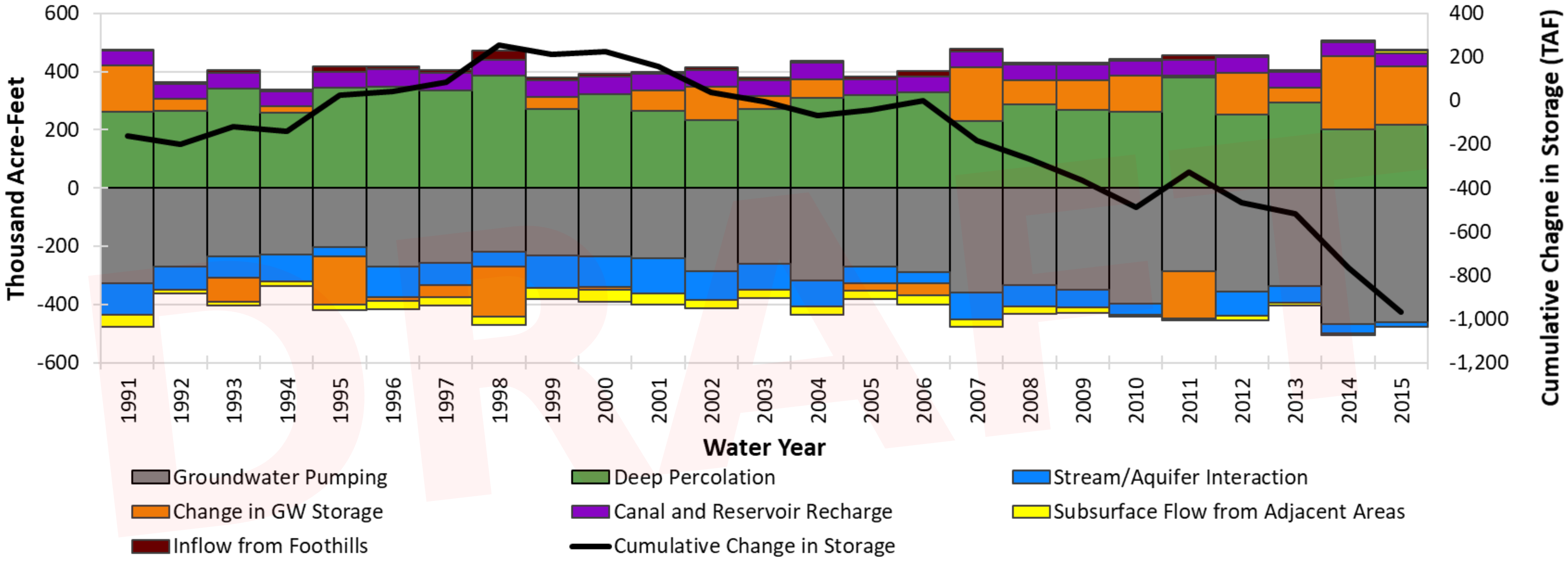
Groundwater Budget



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Next Steps

- Address comments on model calibration, as appropriate
- Coordinate with local subbasins
- Develop baseline model simulations
- Analyze groundwater sustainability management scenarios

Questions?