WMA

Santa Ynez River Valley Groundwater Basin
Western Management Area
Groundwater Sustainability Agency

April 2021
Numerical Groundwater Model and Model Documentation Workshop

STETSON ENGINEERS INC.

DUDEK

Geosyntec consultants

engineers | scientists | innovators

STETSON ENGINEERS INC.

Housekeeping

- Recording the meeting for the purpose of capturing public feedback
- Recording can be made available upon request
- Opportunities for public feedback and questions throughout the workshop
- Public comments on the GCTM should be submitted to the website:

www.santaynezwater.org

- Slide numbers in lower right

WMA/CMA
Numerical Groundwater Model
& Model Documentation
April 26, 2021

- Numerical Groundwater Model Construction
  - MODFLOW Unstructured Grid
  - Hydrologic Parameters: K, S
  - Boundary Conditions: CHD
  - Inflow to Model: RCH, SFR
  - Outflow from Model: EVT, WEL, SFR
- Model Calibration
  - Measured and Simulated Streamflow Hydrographs
  - Measured and Simulated Groundwater Levels
  - Water Budget

Groundwater Model Uses and SGMA

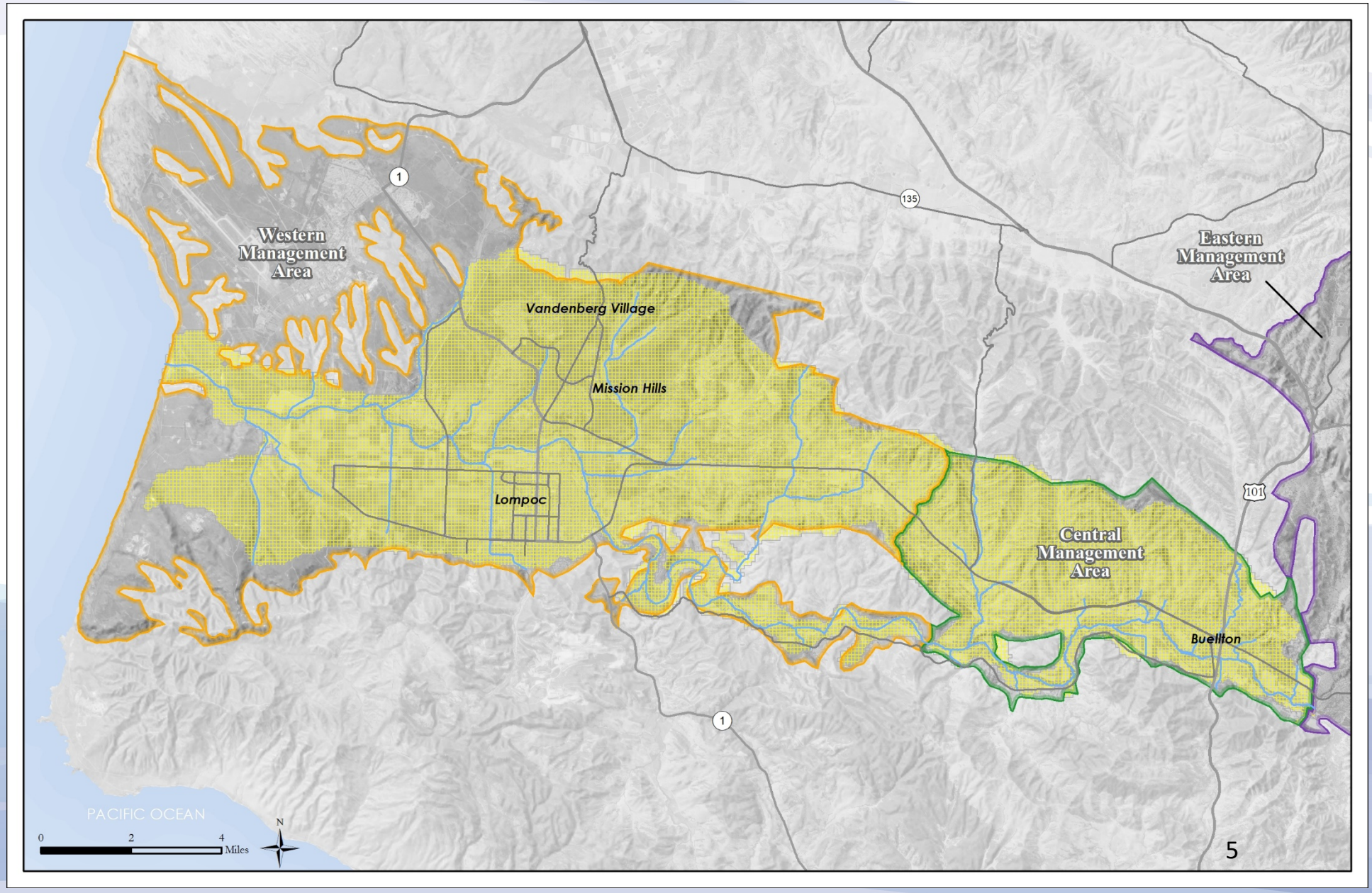
- Simulates occurrence and movement of water: inflows, outflows, and storage changes for WMA, CMA, and 6 subareas (informs the Water Budget);
- Evaluates water resources during wet/dry conditions and seasonal variability;
- Quantitative framework to estimate future management scenarios; and
- Guides development of SGMA Management Criteria triggers and thresholds.

Groundwater Modeling Steps:

- Construct and Calibrate (historical measured data)
- Develop Future Baseline (recent conditions, projected growth; long-term average hydrology)
- Future Management Scenarios (potential projects, climate change)

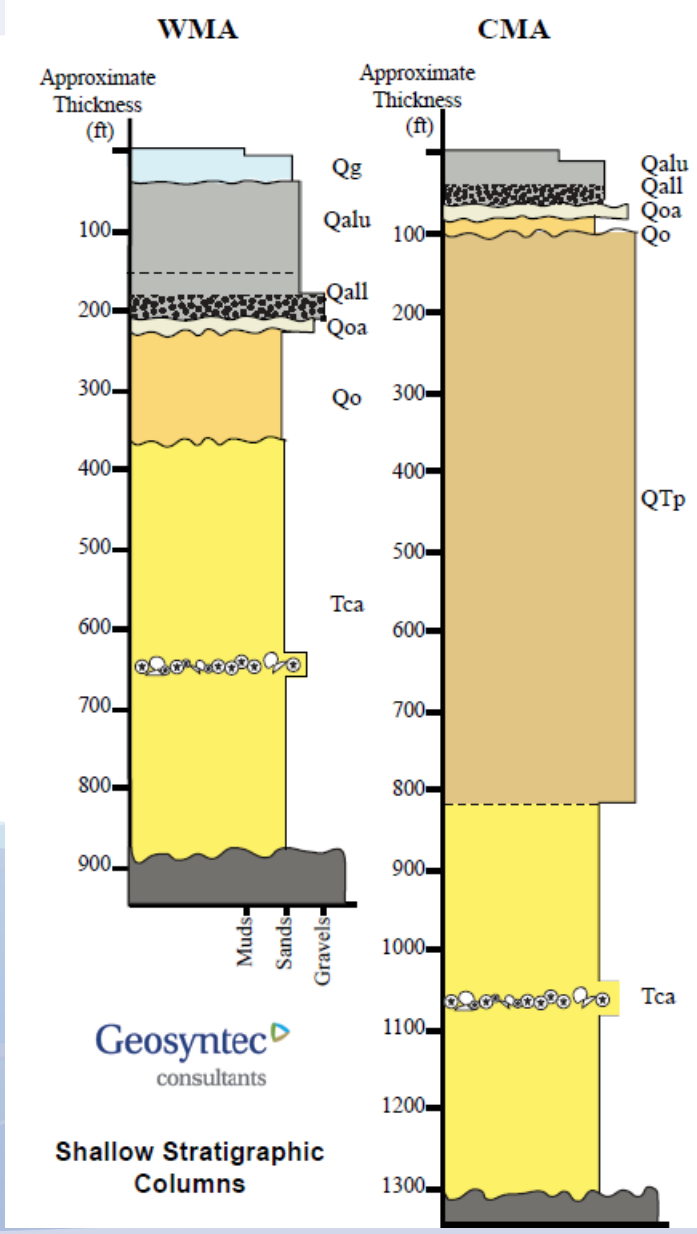
Numerical Groundwater Model Extents

- East-West: near Solvang to Pacific Ocean
- Central and Western Management Areas
- USGS MODFLOW Unstructured Grid
  - 8 Layers based on Geologic Structure
  - 53,265 Model Cells
  - 4-acre Model Cells
  - Monthly Stress Periods
  - 37 Water Years: 1982-2018 (Oct – Sep)



Groundwater Model Structure

- Geosyntec's 3D subsurface geologic model (Leapfrog) used to construct unstructured grid for numerical groundwater model
- Each model layer correlates to a different geological formation (or unit) and identified Principal Aquifer

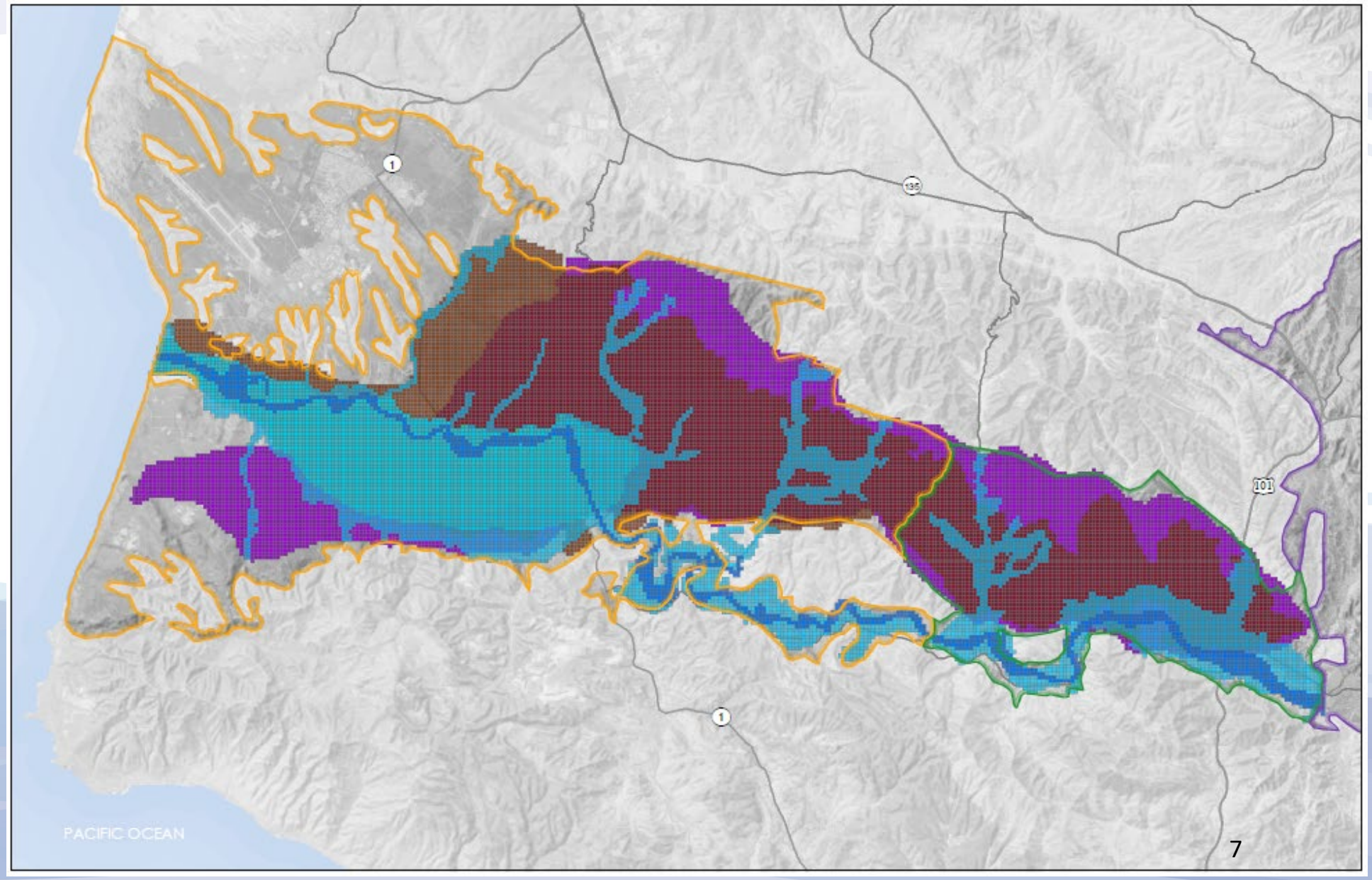


Layer. Geologic Unit

1. River Gravels
2. Qal, Young Alluvium
3. Qal, upper
4. Qal, mid
5. Qal, lower
6. Orcutt Sands
   Paso Robles
7. Careaga SS
   (Graciosa)
8. Careaga SS
   (Cebada)

Model Layer Discretization

Layer	# Model Cells
Layer 1	1,219
Layer 2	7,710
Layer 3	3,035
Layer 4	1,399
Layer 5	1,988
Layer 6	10,910
Layer 7	13,502
Layer 8	13,502
TOTAL	53,265



Model Hydrologic Parameters: Hydraulic Conductivity

Model simulates the occurrence and movement of groundwater
Hydraulic Conductivity (K) ft/day
Storage Coefficient (Sy, Ss) unitless, 1/ft

WMA/CMA Model Hydraulic Conductivity

(K_{xy} / K_z, feet/day)

Geologic Unit	Layer	WMA SYR	CMA SYR	Lompoc Plain	Lompoc Terrace	Lompoc Upland	Santa Rita Upland	Buellton Upland
River Gravels	1	600 / 30	750 / 37.5	600 / 30				
Qal, Young Alluvium	2	360 / 36	360 / 36	55 / 5.5	45 / 4.5	40 / 4	40 / 4	10 / 2
Qal, upper	3			35 / 3.5				
Qal, mid	4			5 / 0.5				
Qal, lower	5			325 / 32.5				
Orcutt / Paso Robles	6			45 / 4.5		25 / 2.5	25 / 2.5	2 / 0.1
Graciosa Careaga	7			40 / 4	15 / 1.5	25 / 2.5	25 / 2.5	2 / 0.1
Cebada Careaga	8			4 / 0.4	1.5 / 0.15	2.5 / 2.5	2.5 / 0.25	1 / 0.1

Model Hydrologic Parameters: Storage Parameters

WMA/CMA Model Storage Parameters

Specific Yield, Sy (unitless)

Storage Coefficient, S (1/foot)

Geologic Unit	Layer	WMA SYR	CMA SYR	Lompoc Plain	Lompoc Terrace	Lompoc Upland	Santa Rita Upland	Buellton Upland
River Gravels	1	0.05 / 5.0E-06	0.05 / 5.0E-06	0.05 / 5.0E-06				
Qal, Young Alluvium	2	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05
Qal, upper	3			0.1 / 1.0E-05				
Qal, mid	4			0.1 / 1.0E-05				
Qal, lower	5			0.1 / 1.0E-05				
Orcutt / Paso Robles	6			0.1 / 1.0E-05		0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05
Graciosa Careaga	7			0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05	0.1 / 1.0E-05
Cebada Careaga	8			0.04 / 4.0E-06	0.015 / 1.5E-06	0.025 / 2.5E-06	0.025 / 2.5E-06	0.1 / 1E-06

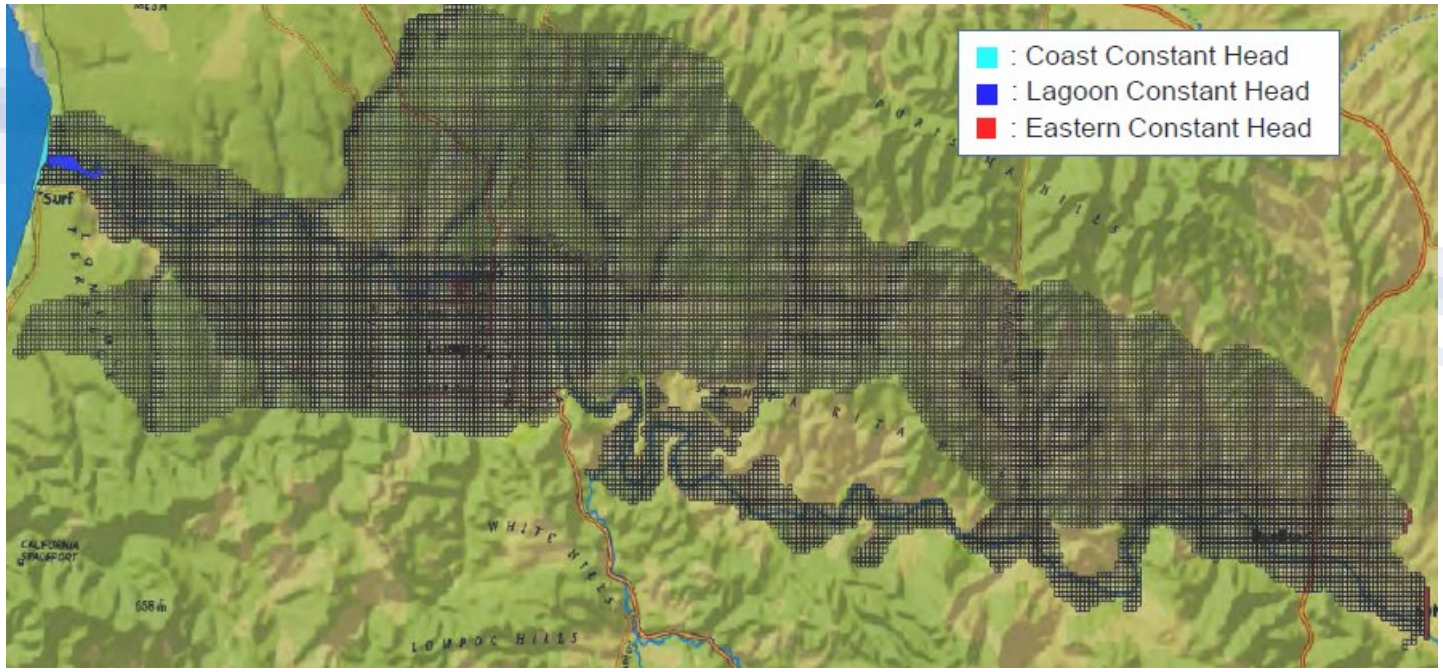
Groundwater Model Boundary Conditions

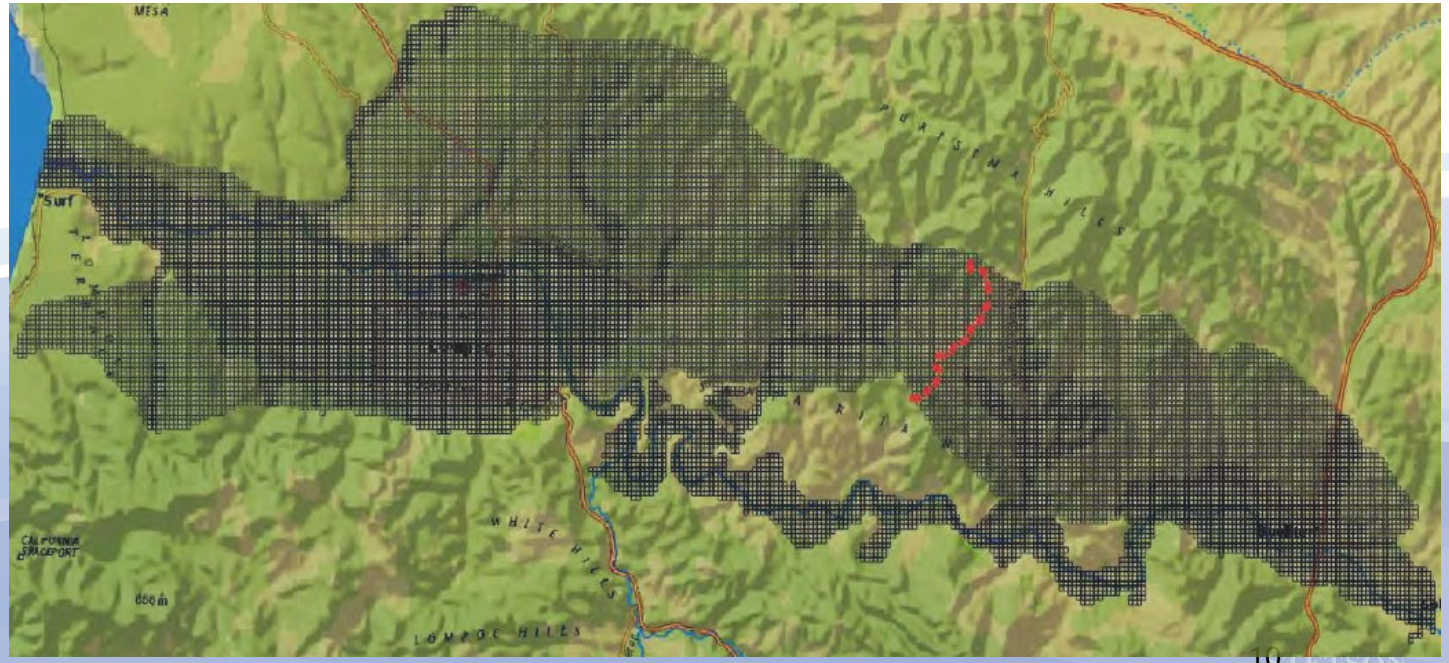
Time Variant Specified Head (CHD):

Eastern Boundary with EMA Pacific Ocean and Lagoon

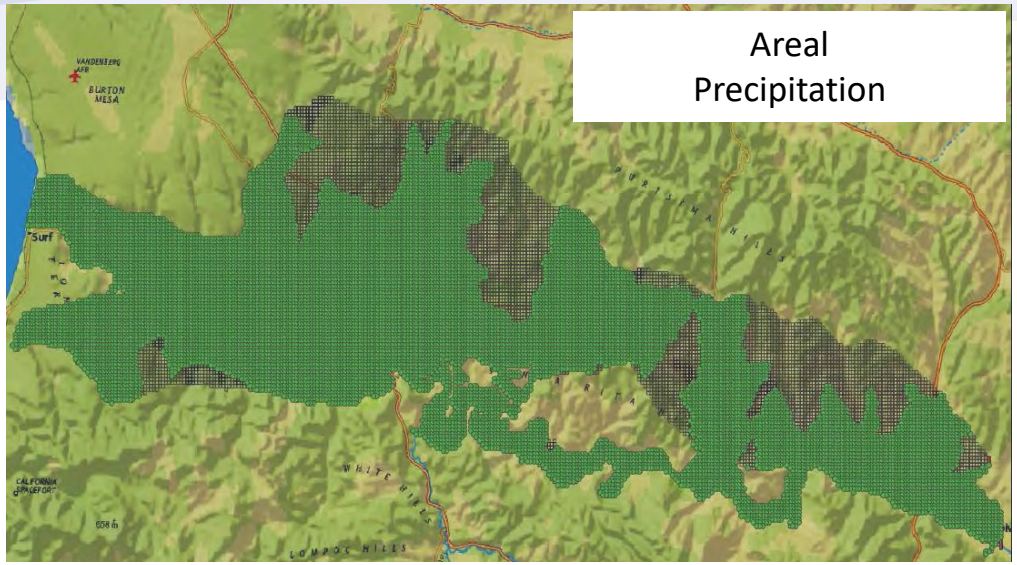
Internal Groundwater Flow Influenced by Low Permeability Model Cells

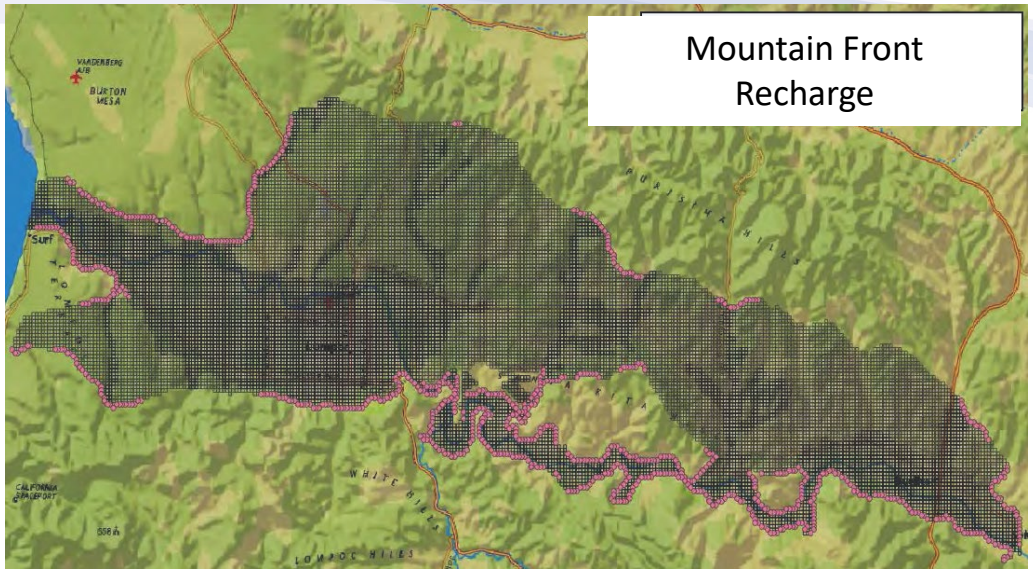
- Between Buellton Upland and Santa Rita Upland
- ~200-300’ Difference in GW Levels

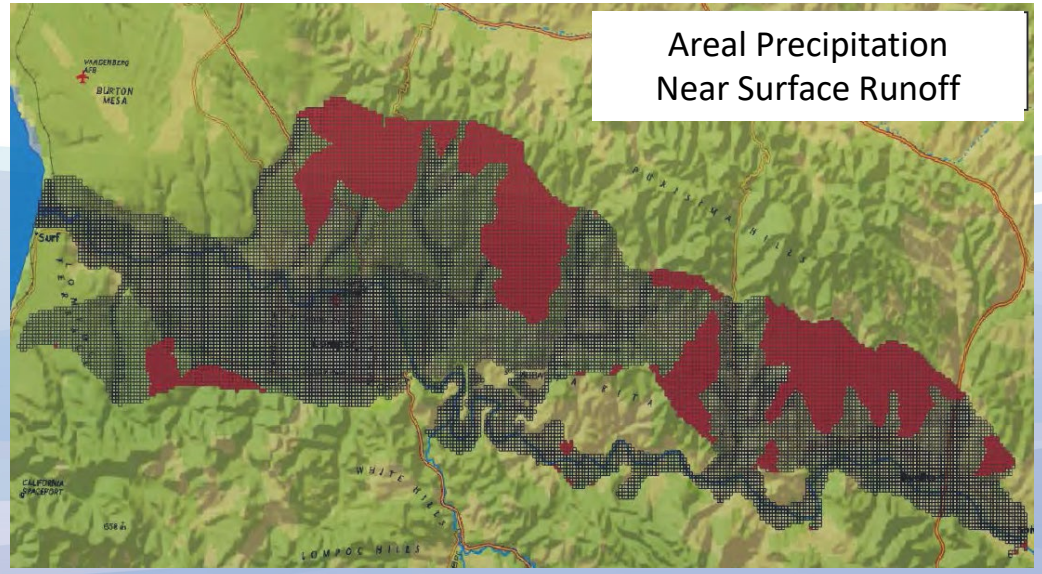


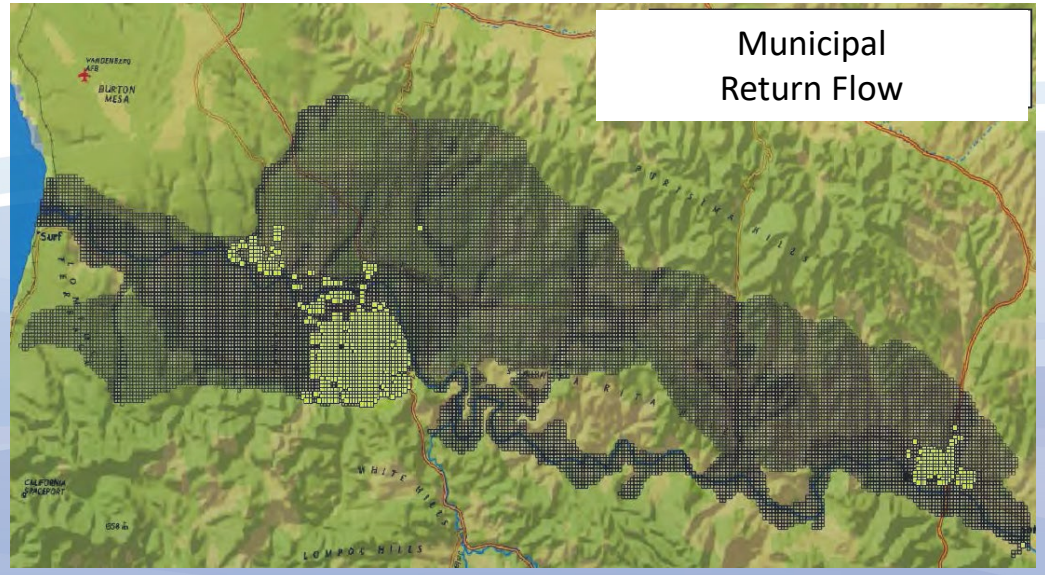


MODFLOW Recharge Package (RCH)





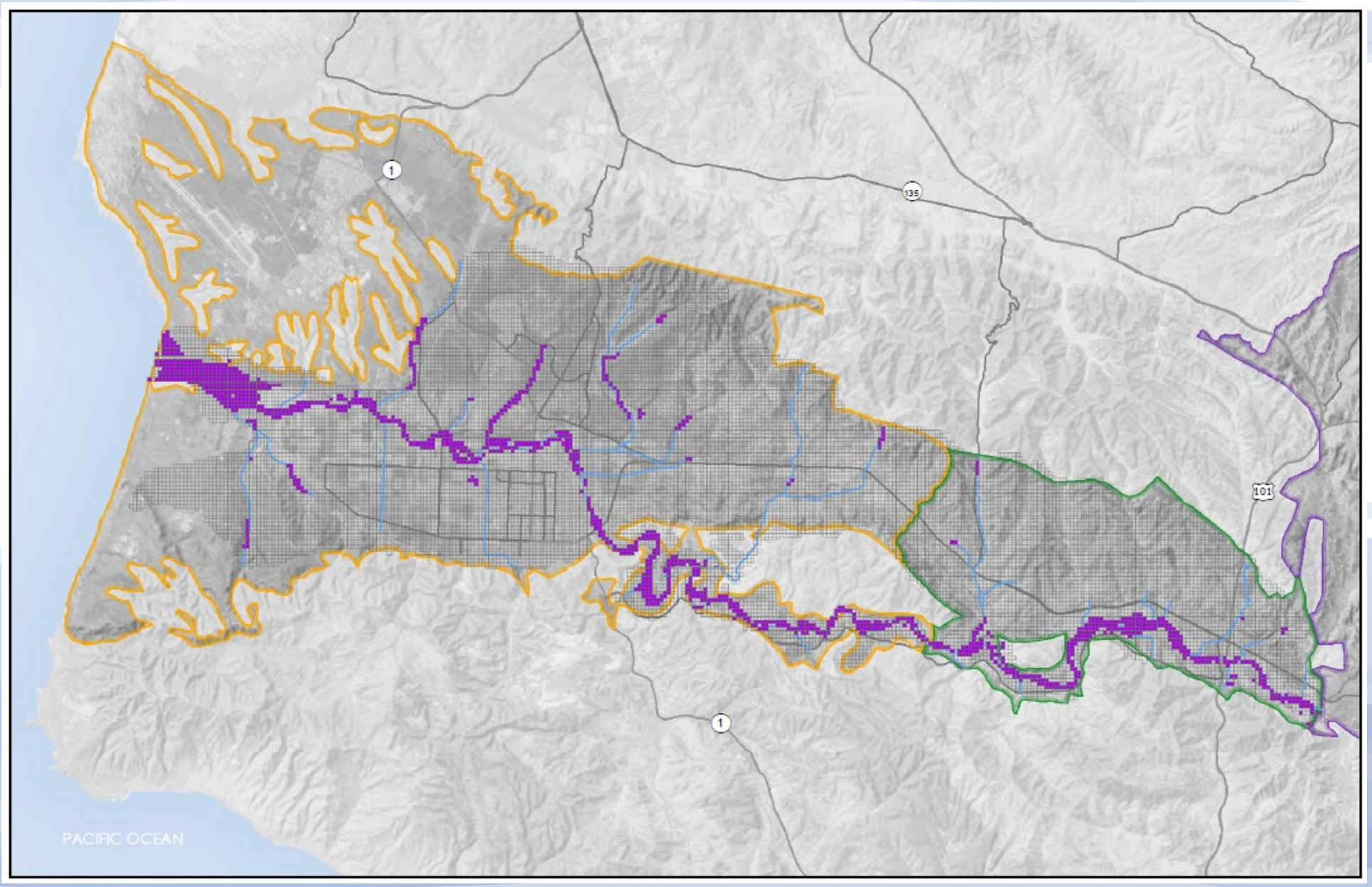




WY 1982-2018 Average Annual Recharge:
20,360 AFY

- Areal Precipitation 10,750 AFY
- Drainage Recharge 4,450 AFY
- Mountainfront Recharge 3,040 AFY
- Municipal Return Flow 2,120 AFY

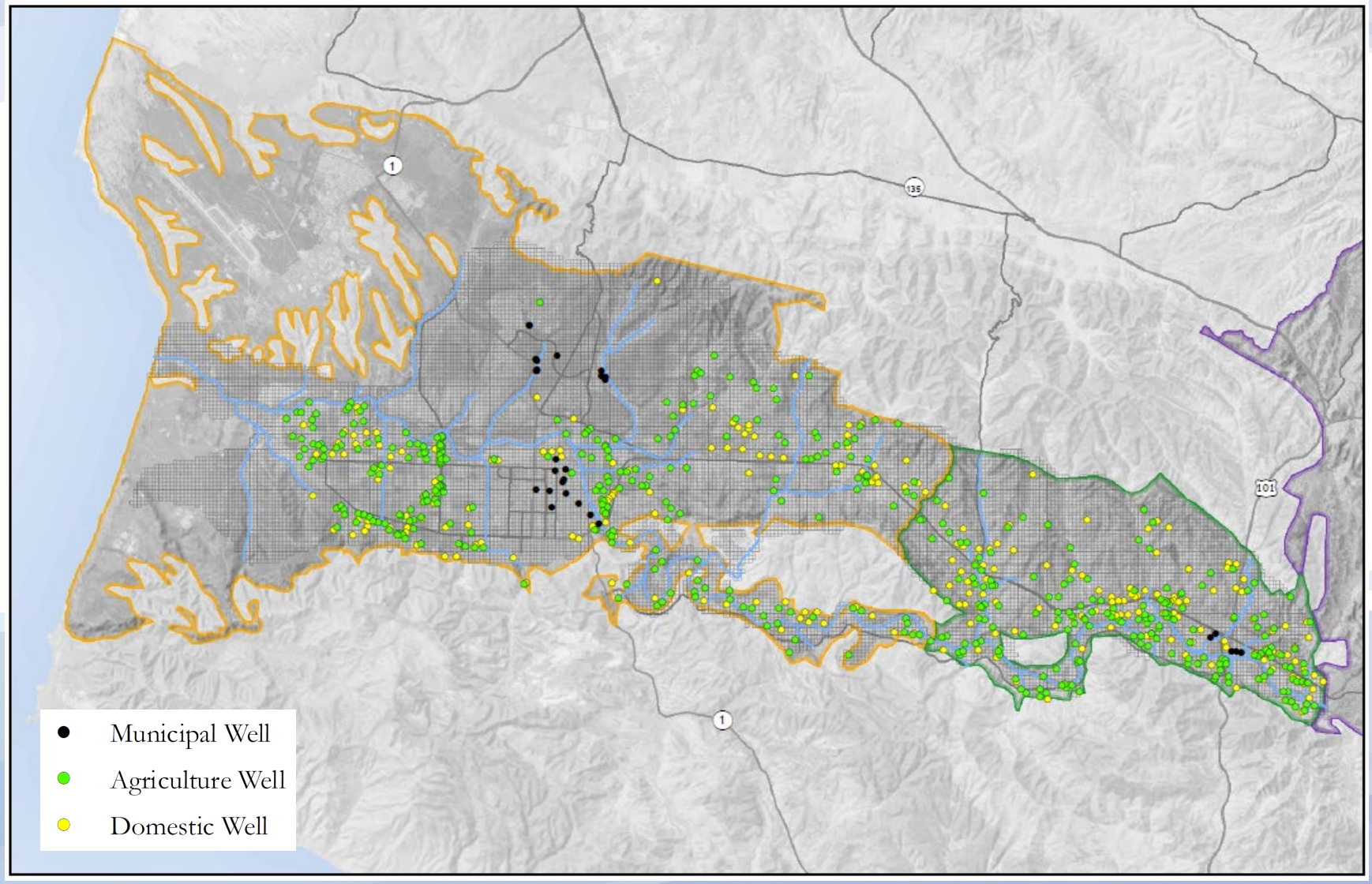
MODFLOW Evapotranspiration Package (EVT)

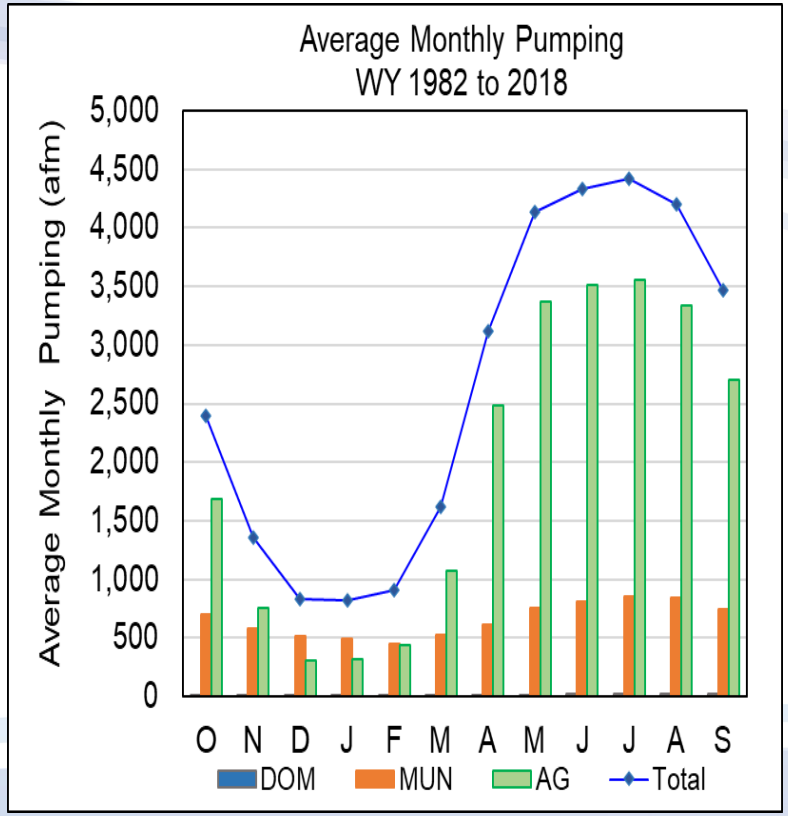


- Model Calculates ET based on Simulated Depth to Water from Land Surface
- Potential ET Rate and Extinction Depth

Month	Potential ET Rate (inches/day)	
	WMA	CMA
Jan	0.06	0.06
Feb	0.07	0.08
Mar	0.11	0.12
Apr	0.14	0.16
May	0.19	0.21
Jun	0.17	0.20
Jul	0.18	0.22
Aug	0.16	0.20
Sep	0.14	0.16
Oct	0.10	0.12
Nov	0.07	0.08
Dec	0.05	0.06

MODFLOW Well Package (WEL)

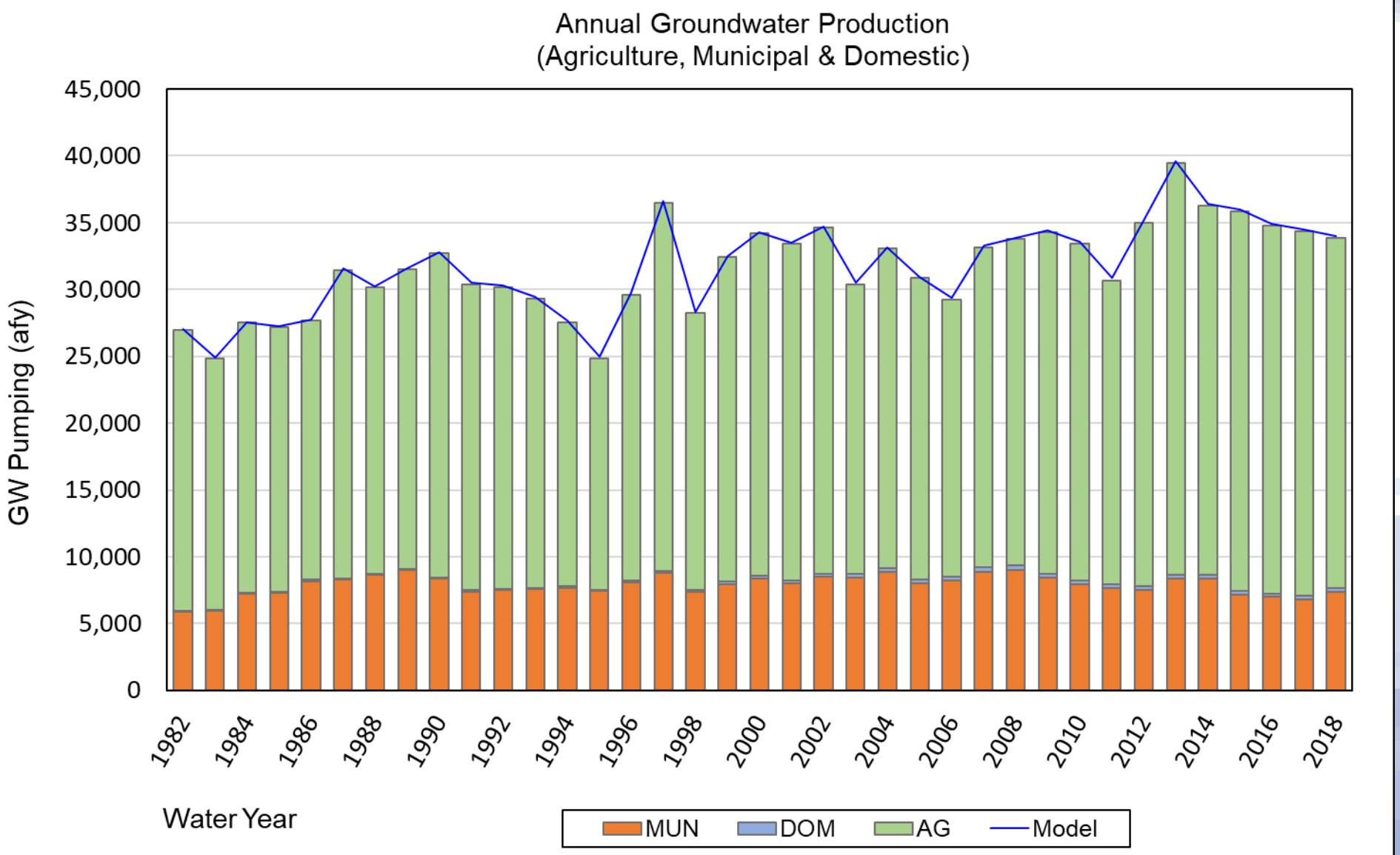




WY 1982-2018 Production Wells

- Municipal 22 wells
- Agricultural 203 wells

MODFLOW Well Package (WEL)

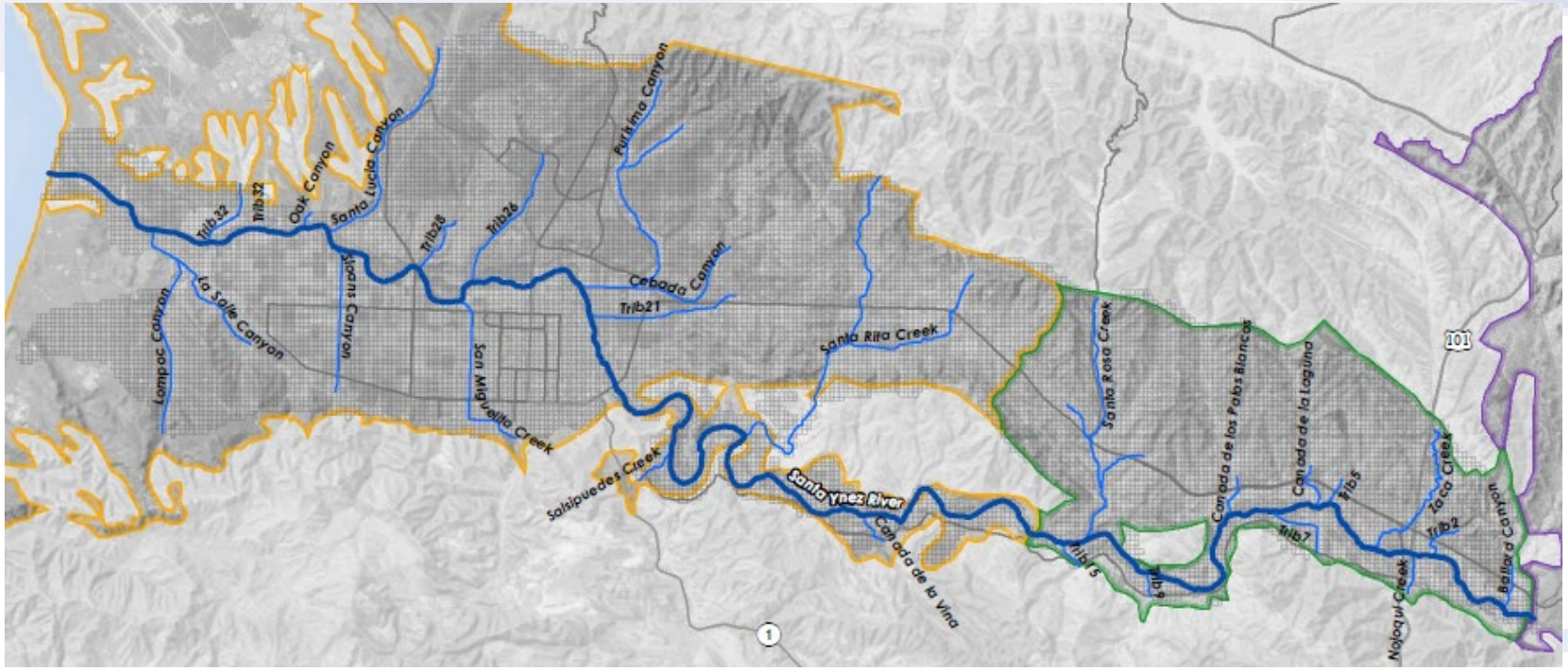


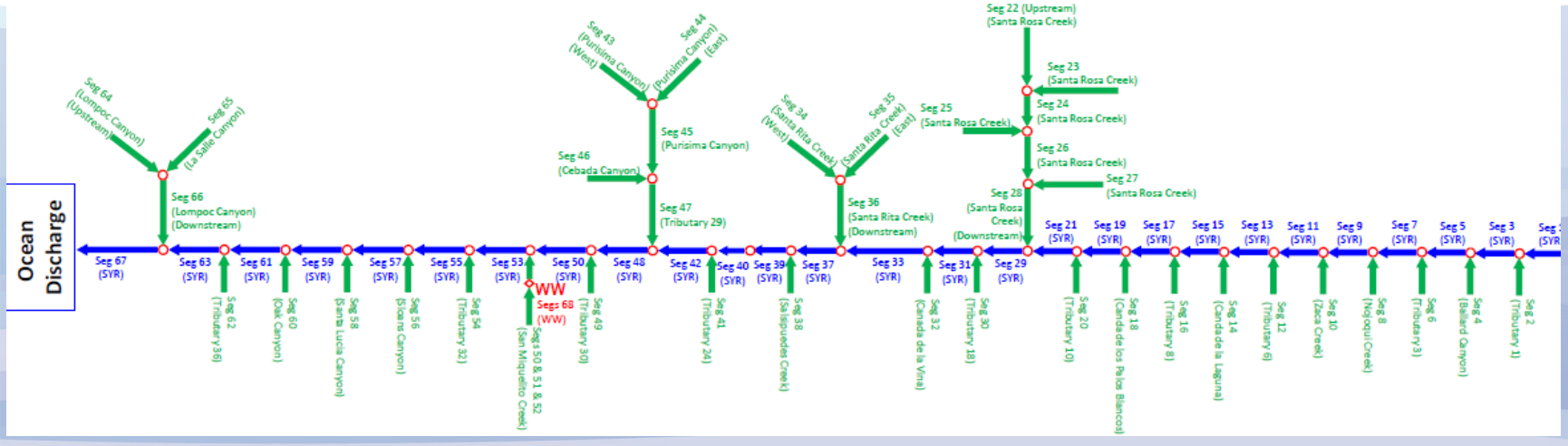
WY 1982-2018 Average Annual Pumping:

31,550 AFY

- Municipal 7,890 AFY
- Domestic 190 AFY
- Agricultural 2,3480 AFY

MODFLOW Streamflow Routing Package (SFR)



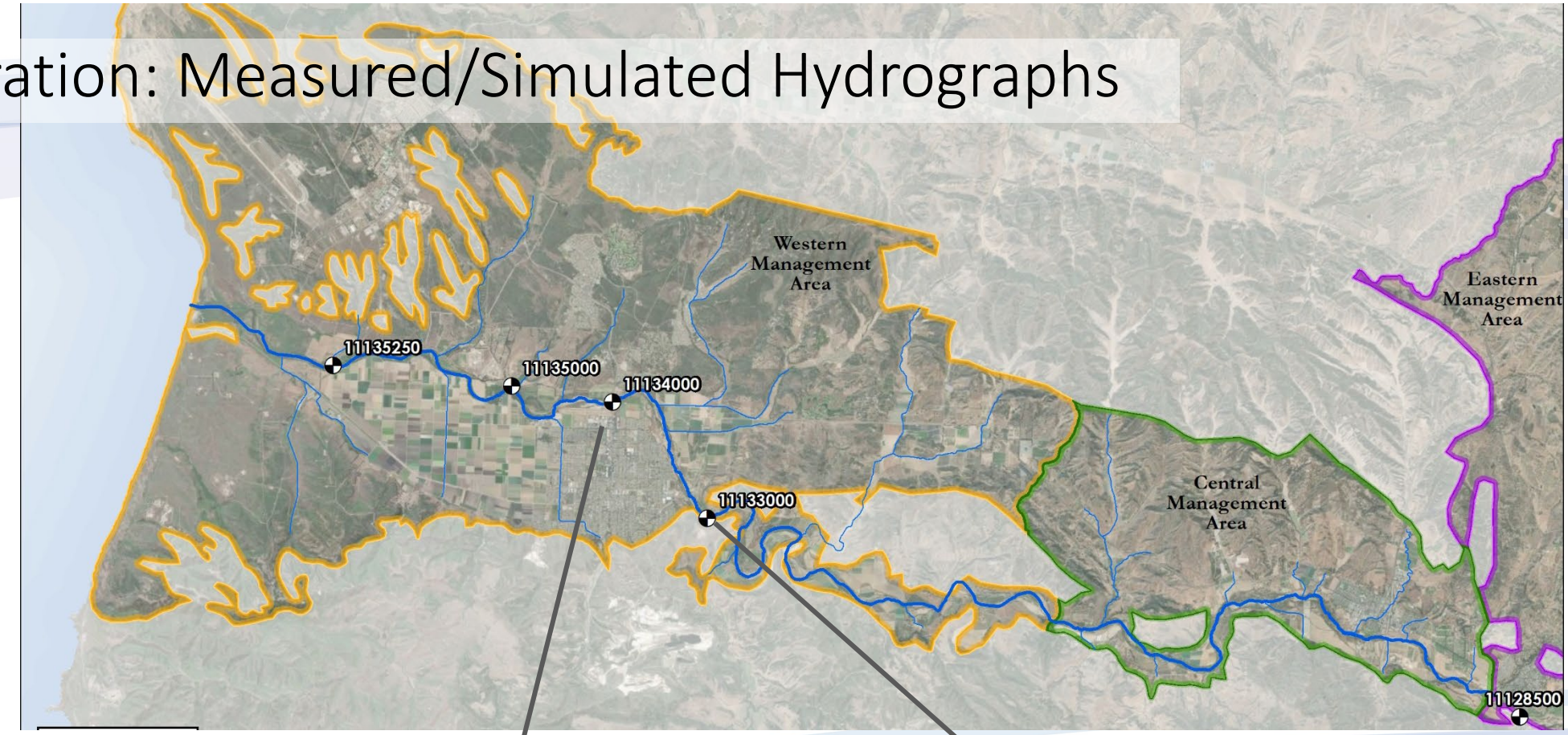


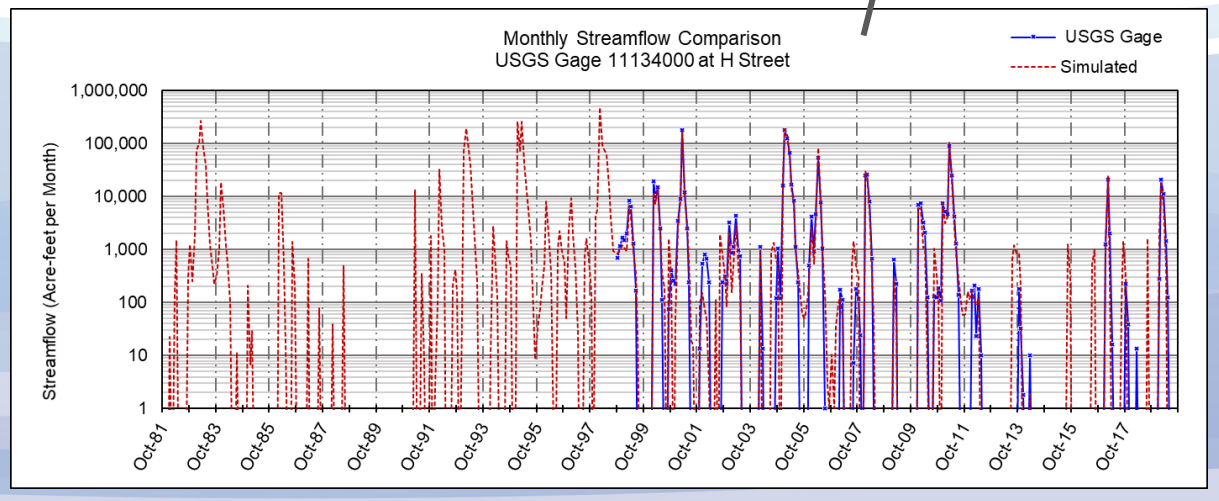
- SW-GW Interface:
  - Stream Seepage
  - Baseflow
- Santa Ynez River
- 28 Side Tributaries
- 1 Wastewater
- 68 Segments
- 1490 Model Cells
- Stream Channel Hydraulics based on Flow/Width/Depth Relationship

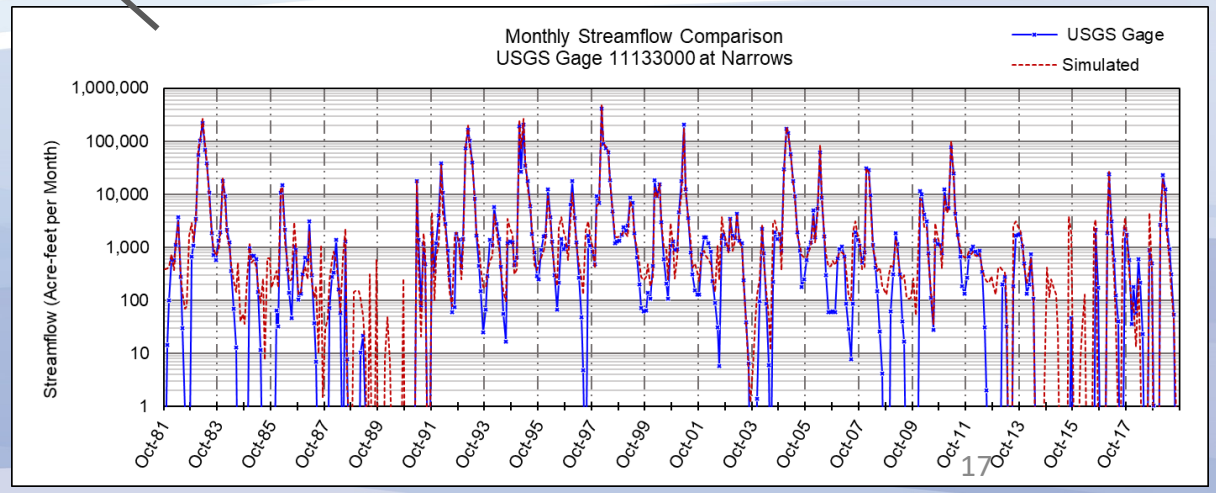
Model Calibration

- Measured and Simulated Streamflow Hydrographs
- Measured and Simulated Groundwater Levels

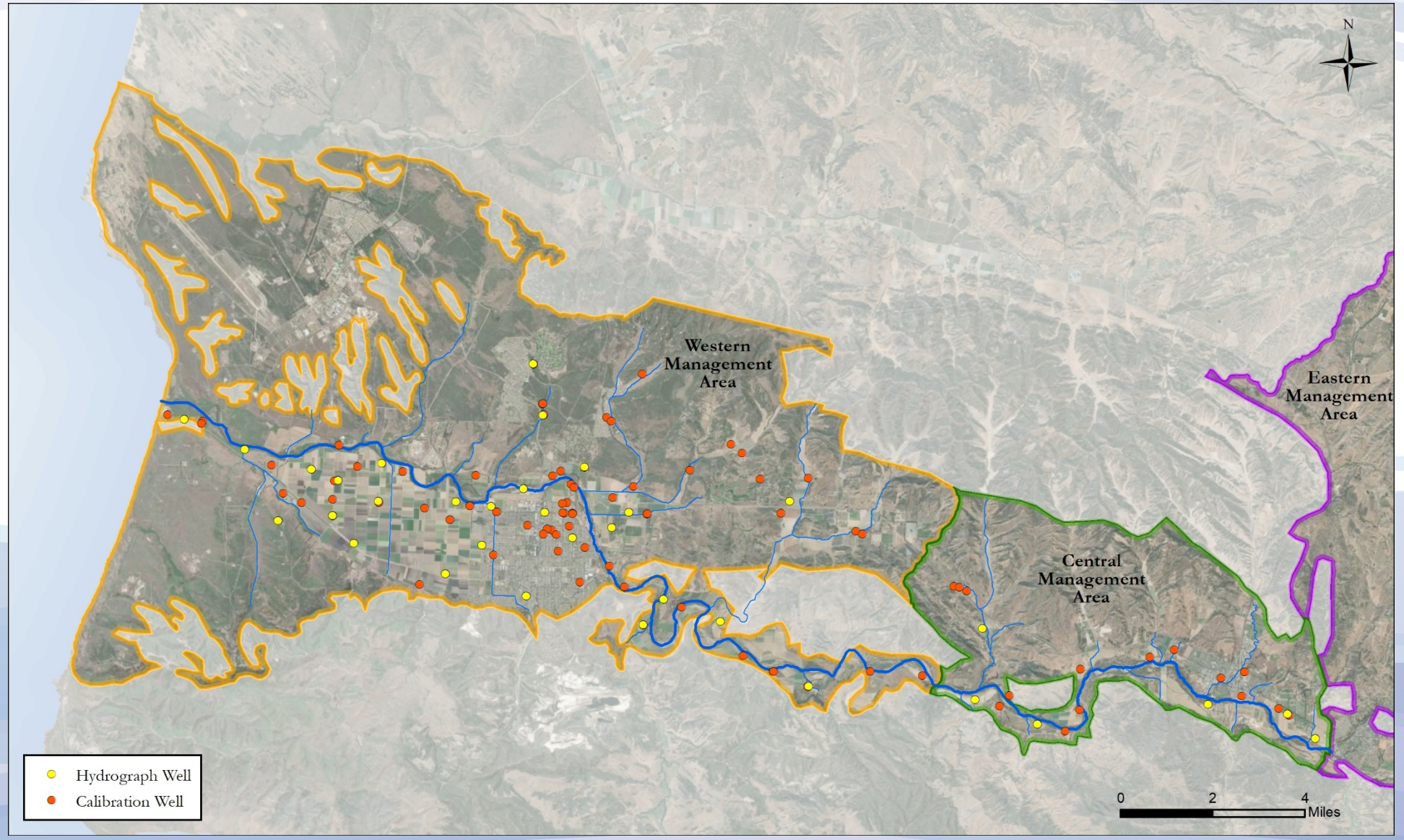
Calibration: Measured/Simulated Hydrographs



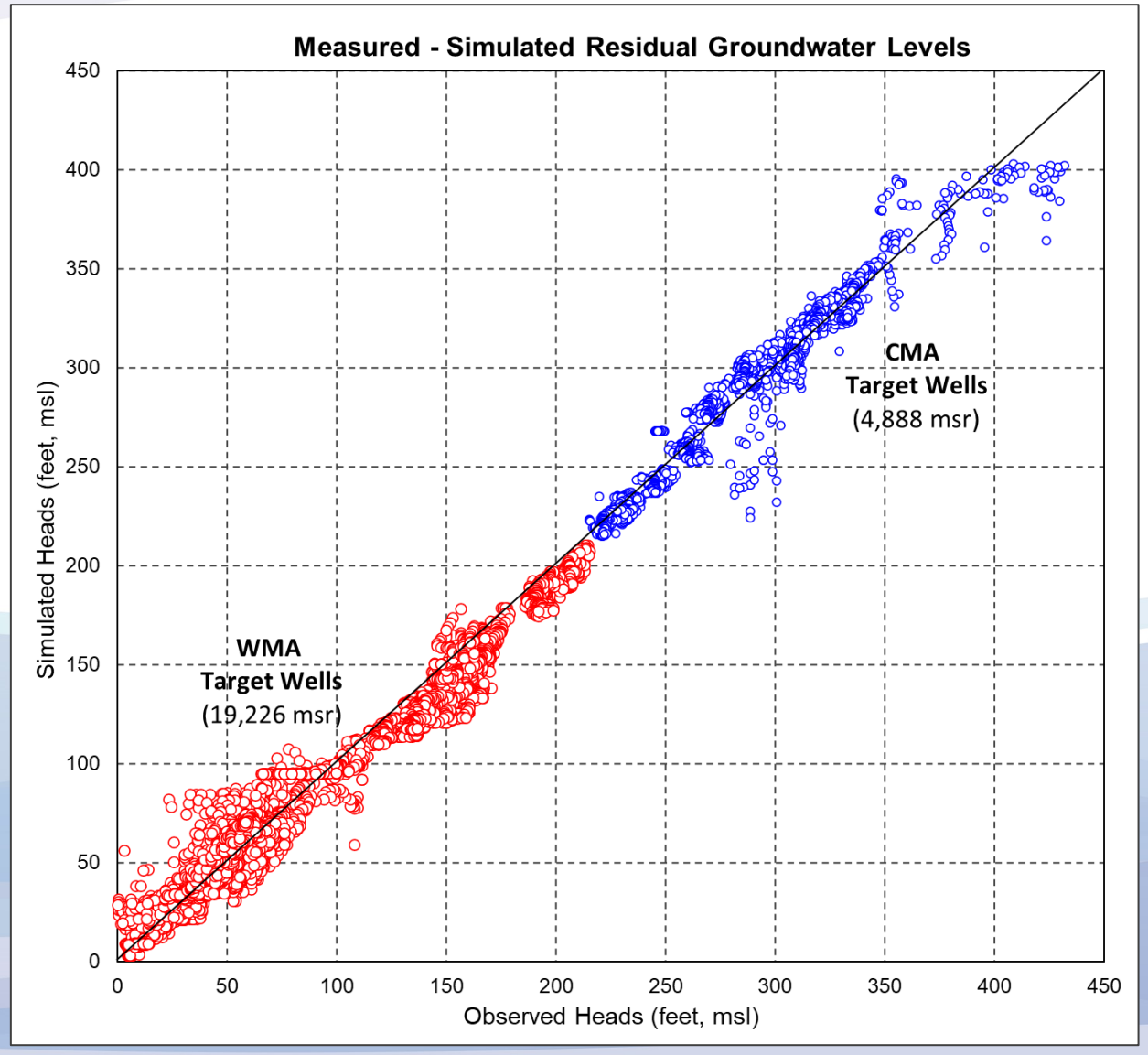




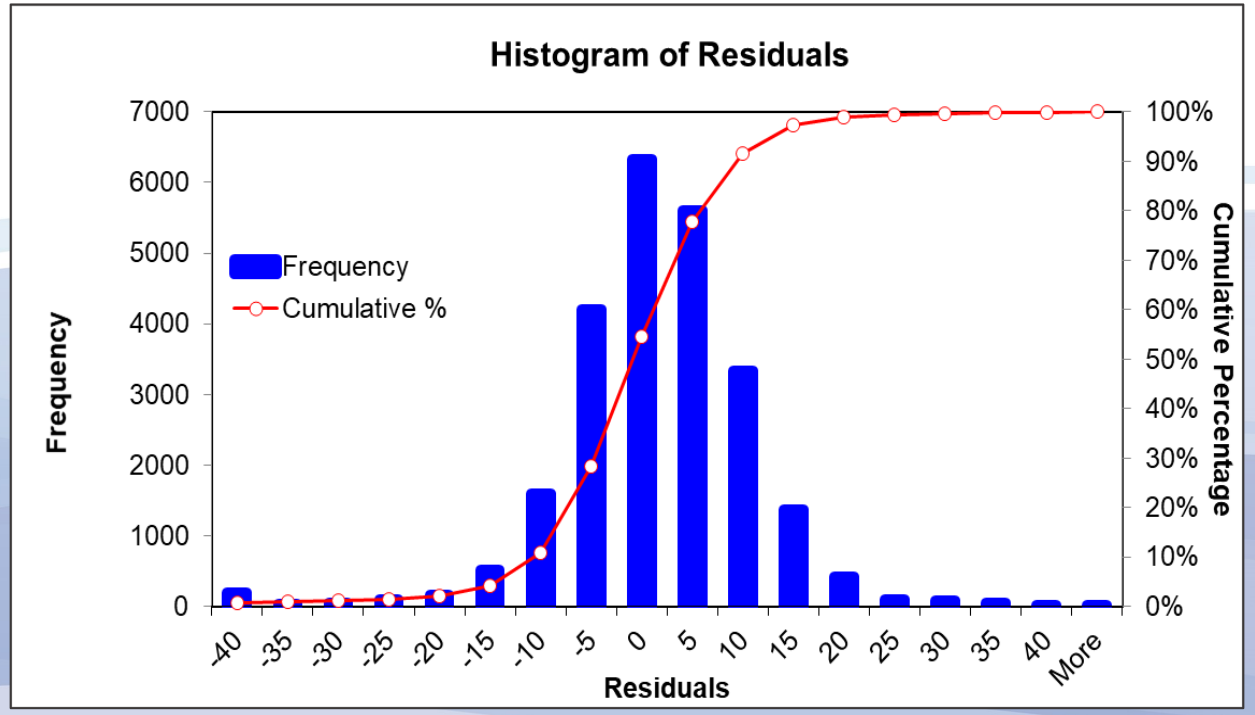
Calibration:
Target Wells Showing Measured/Simulated Hydrographs



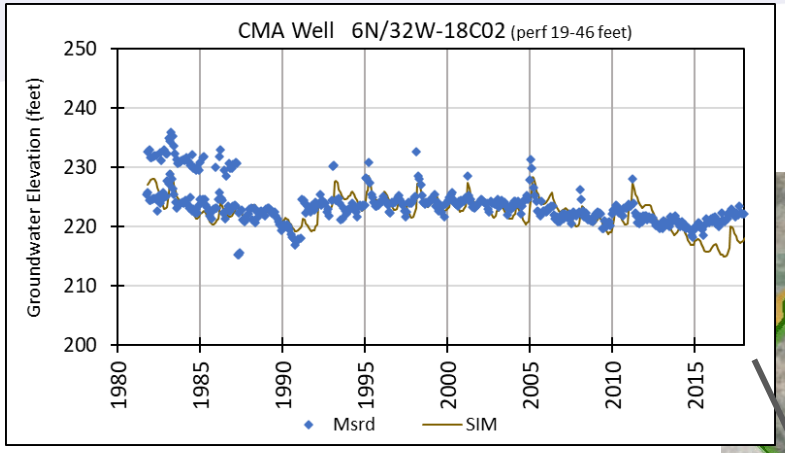
Simulated Groundwater Level Calibration Statistics
24,114 data for 122 wells

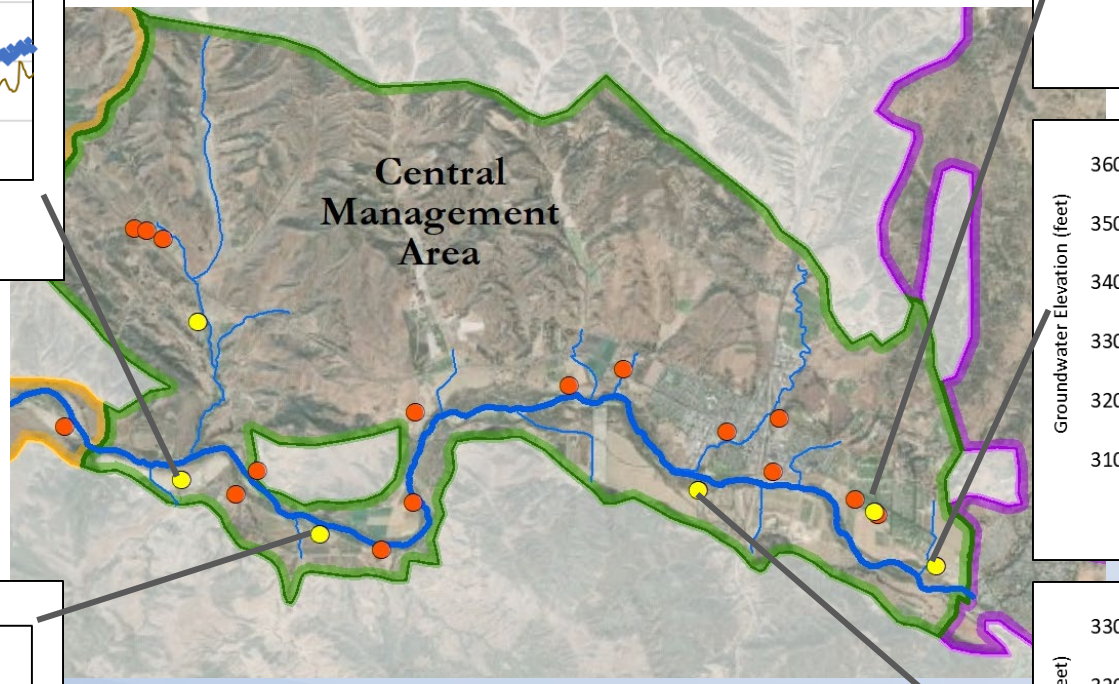


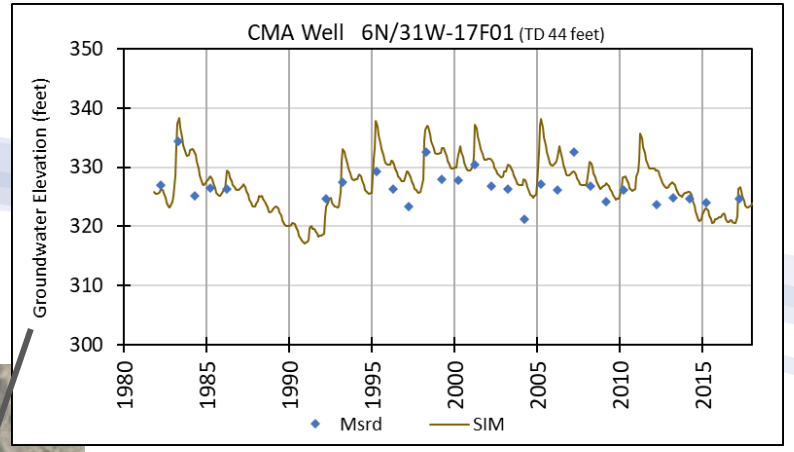
Residual Statistics (msr-sim)			
Mean	-1.06	Range	147.3
Standard Error	0.07	Minimum	-78.7
Median	-0.79	Maximum	68.6
Standard Deviation	10.1	Sum	-25,560
Sample Variance	102.2	Count	24,11
Skewness	-2.0	95% Confdnc Level	0.13

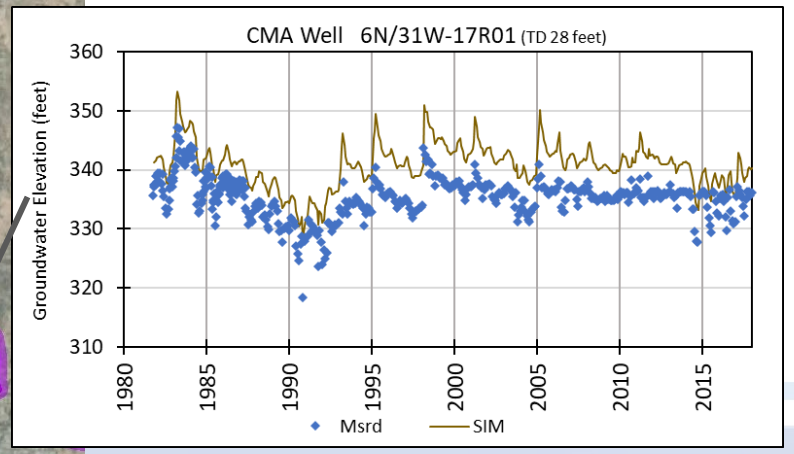


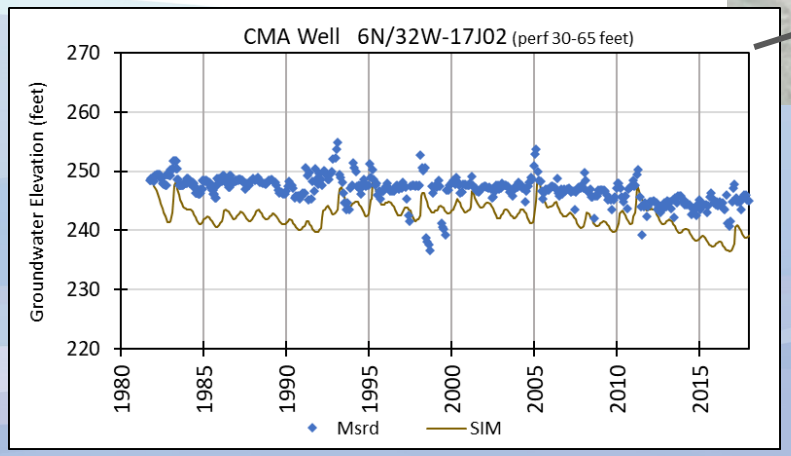
Measured/Simulated Hydrographs

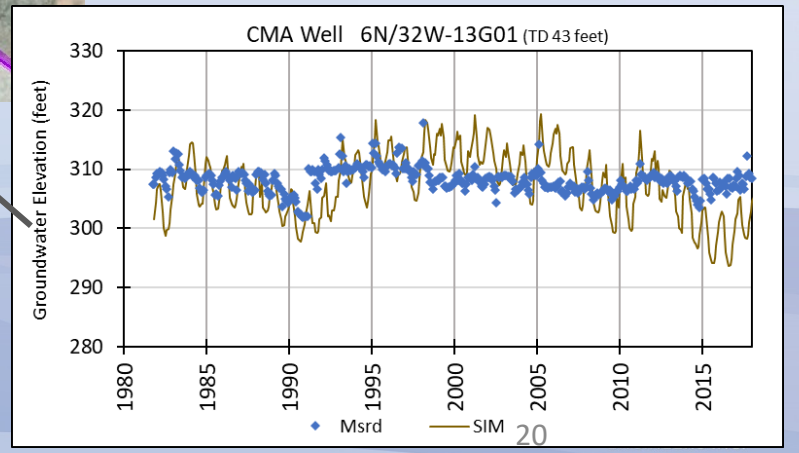




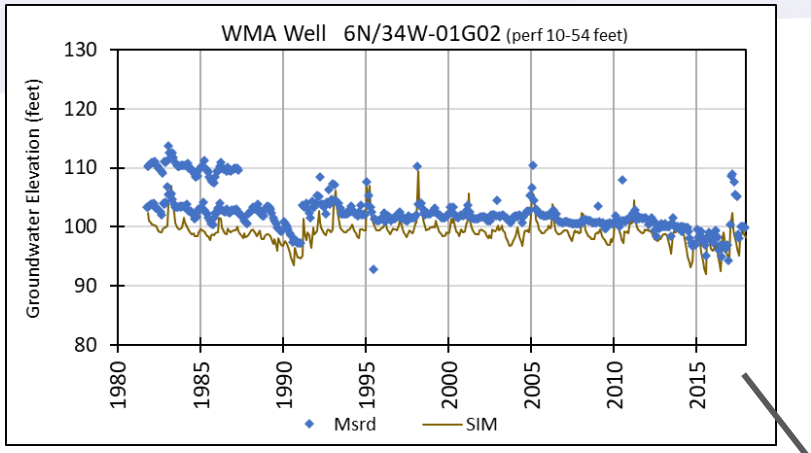


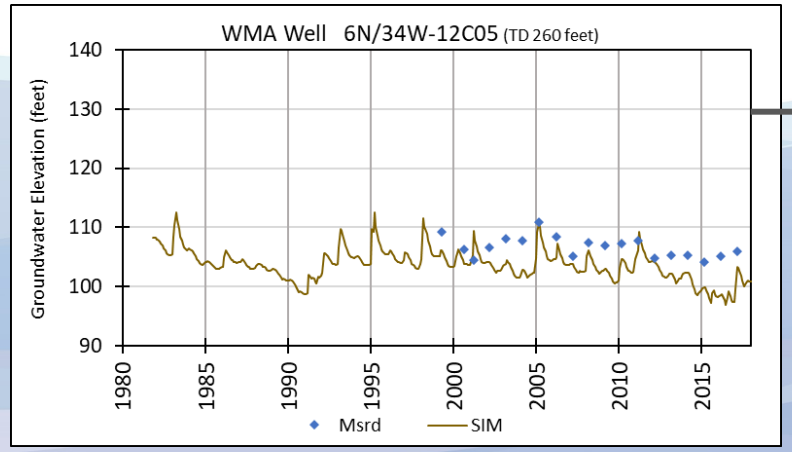


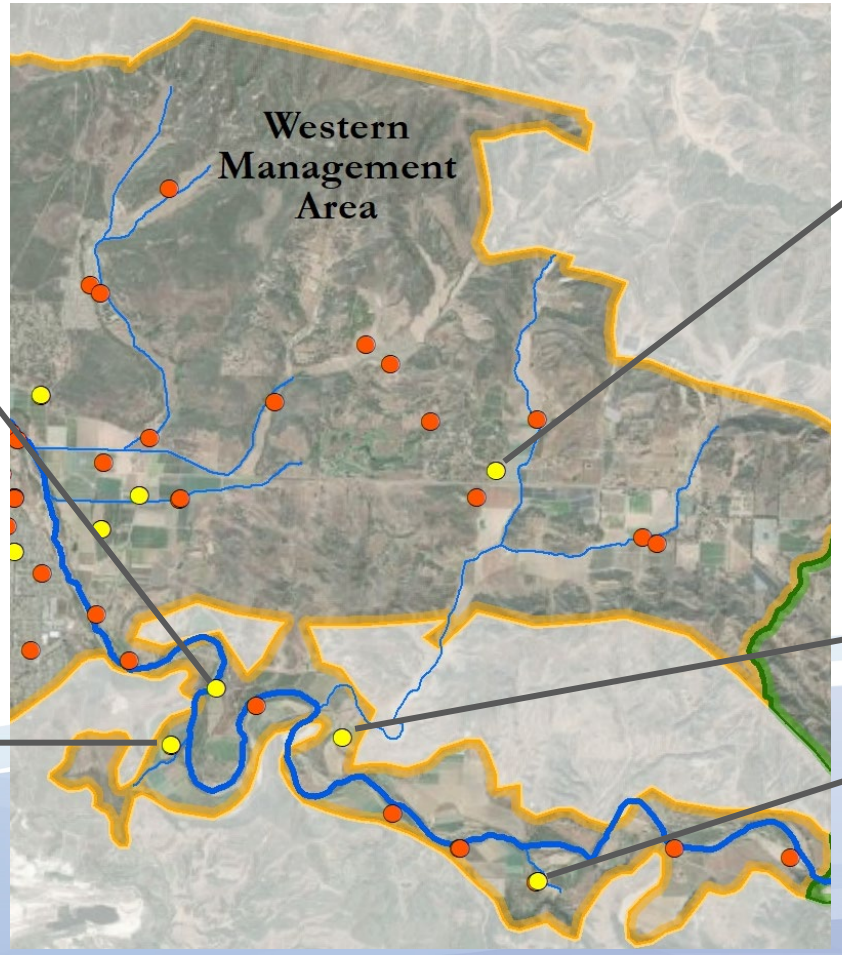


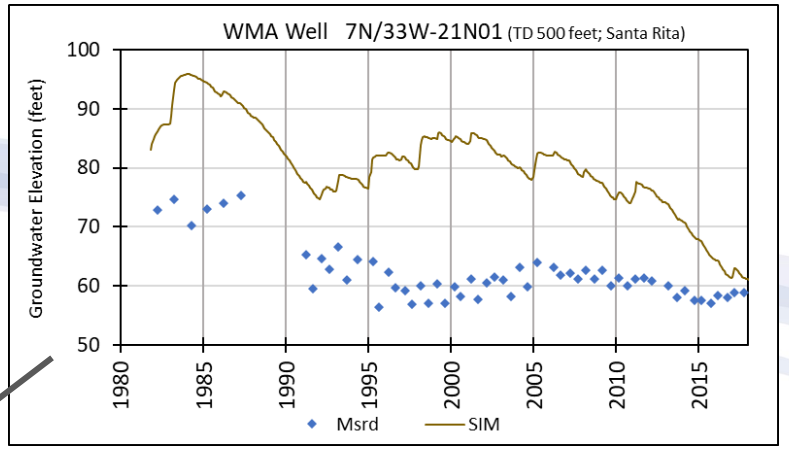


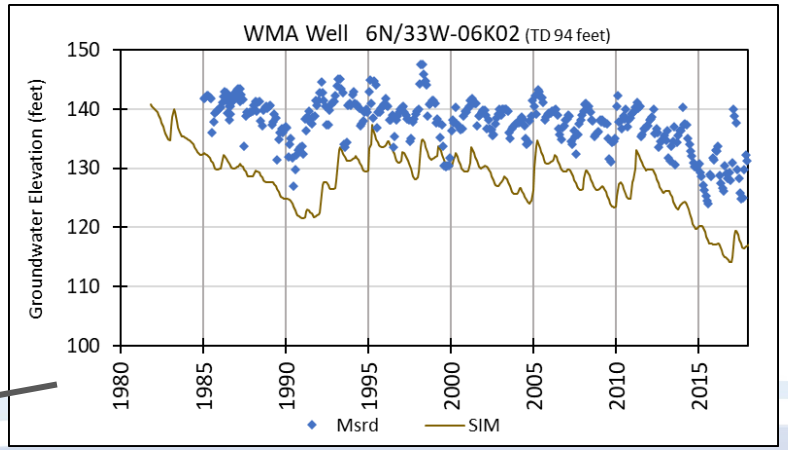
Measured/Simulated Hydrographs

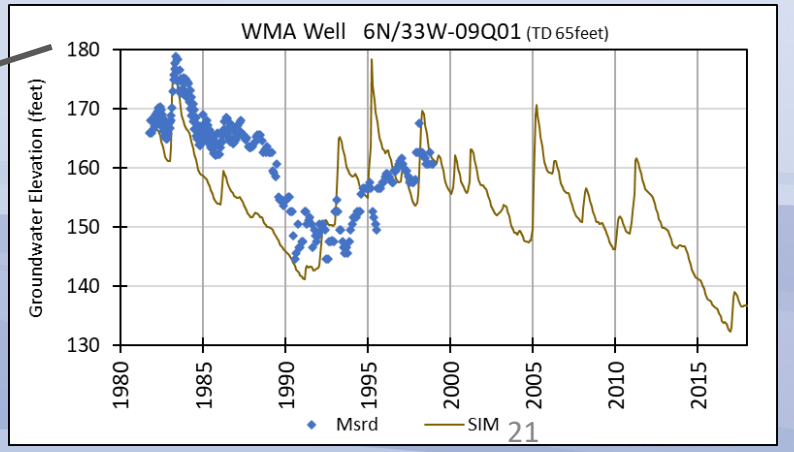




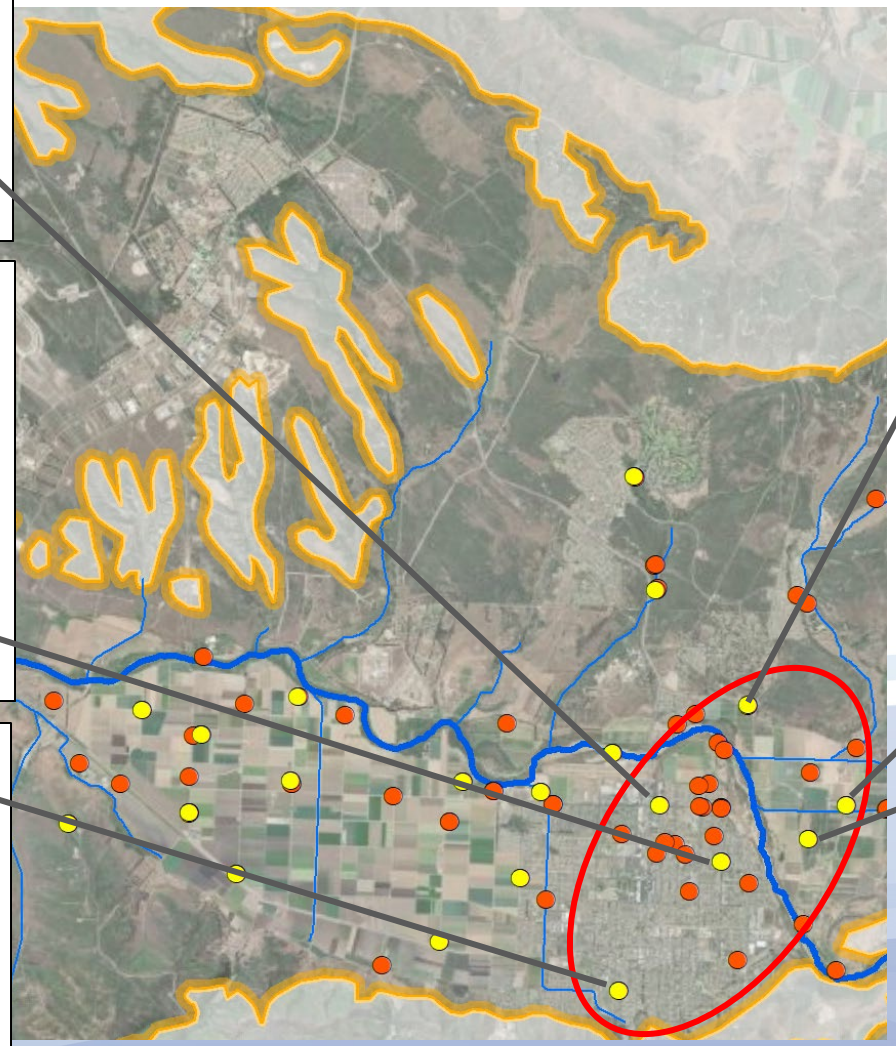


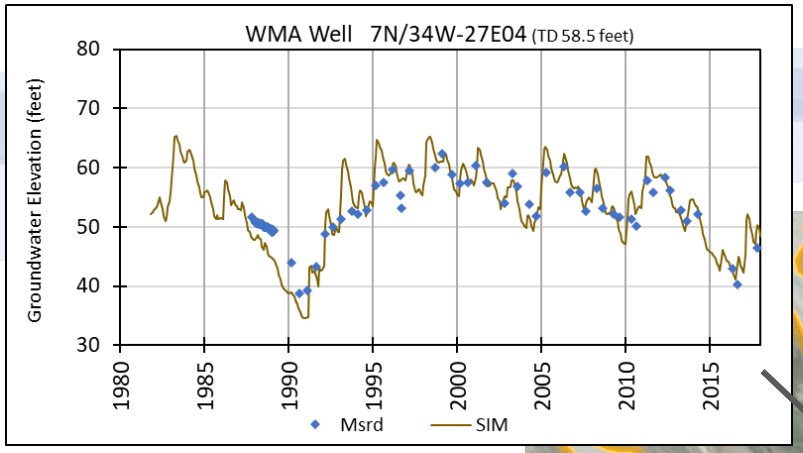


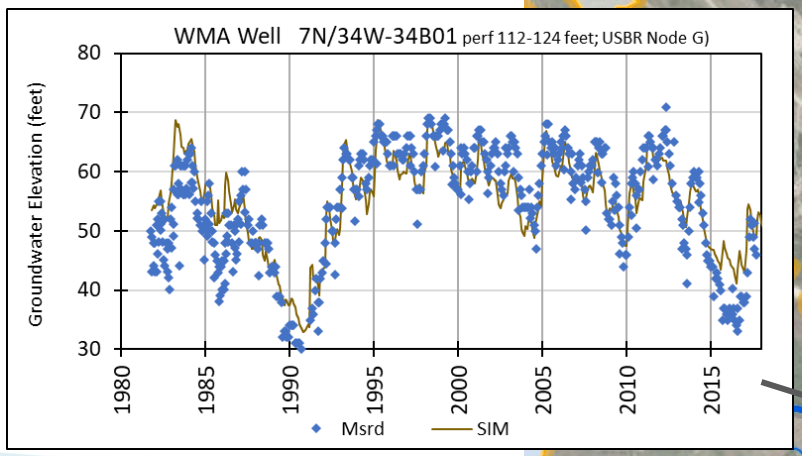


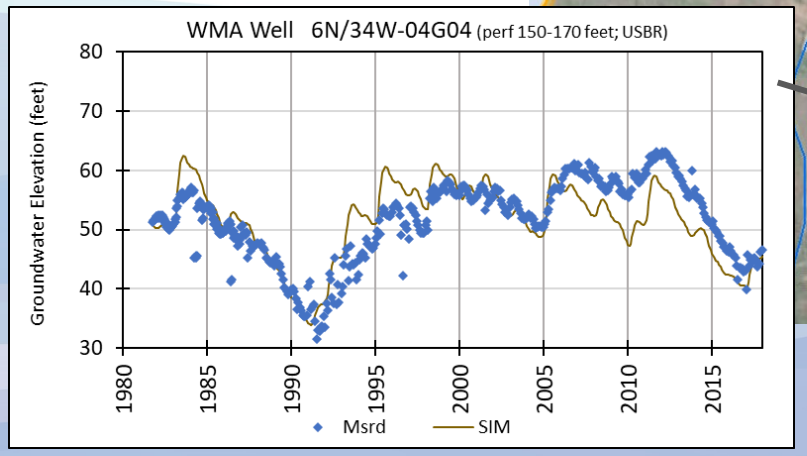


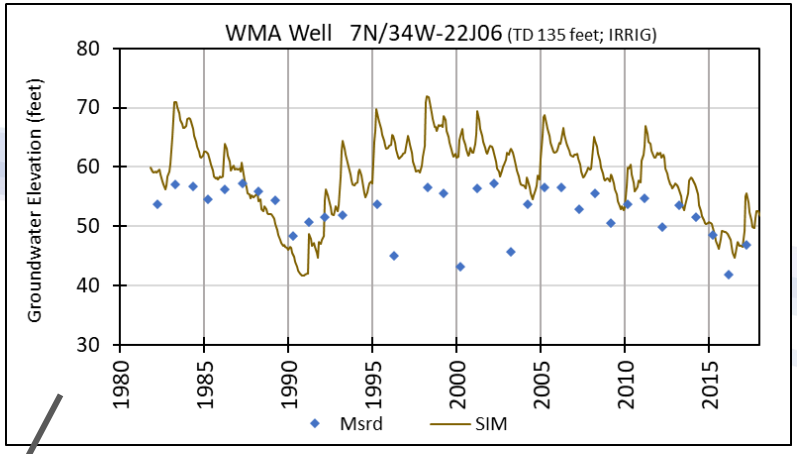
Measured/Simulated Hydrographs

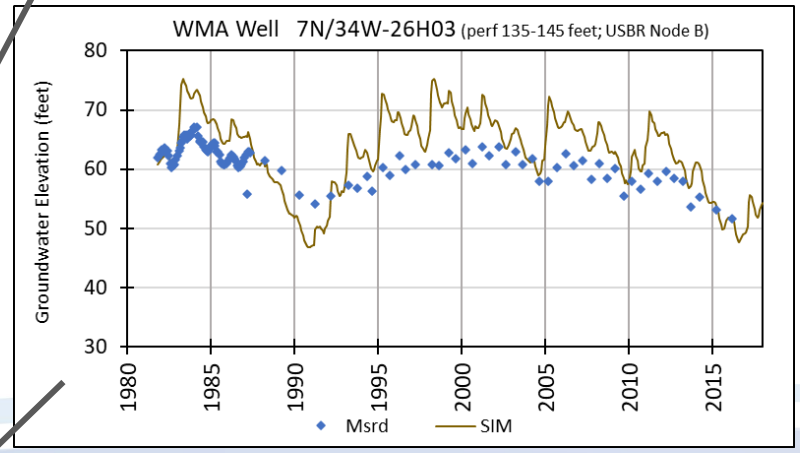


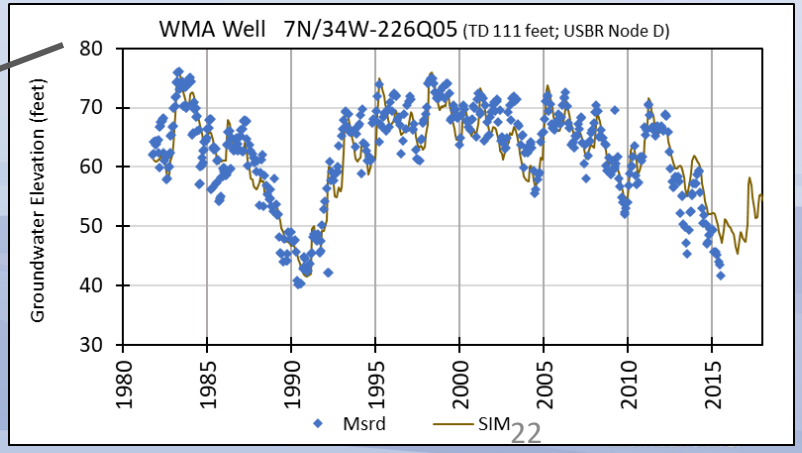




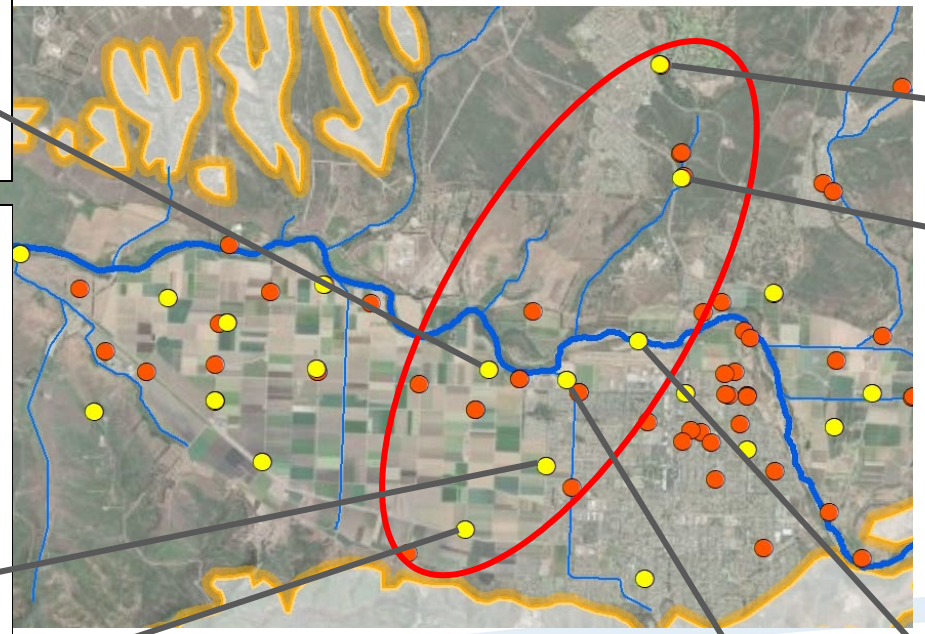


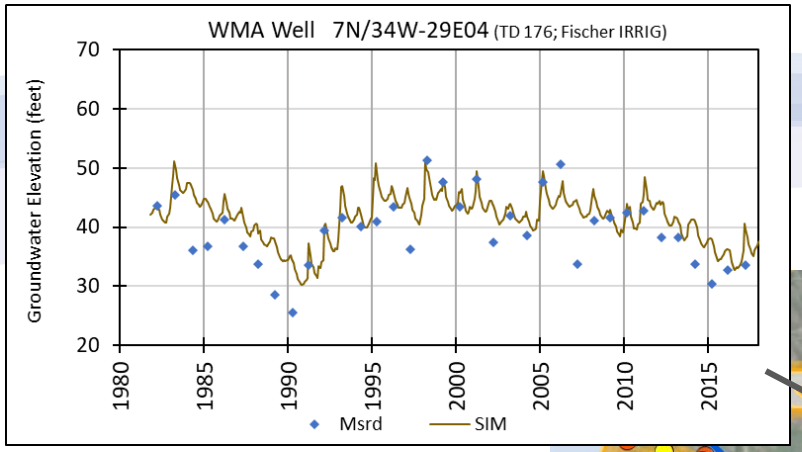


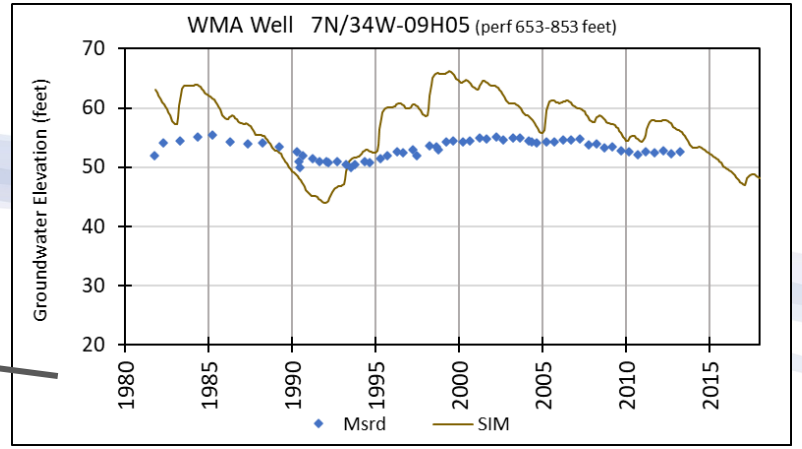


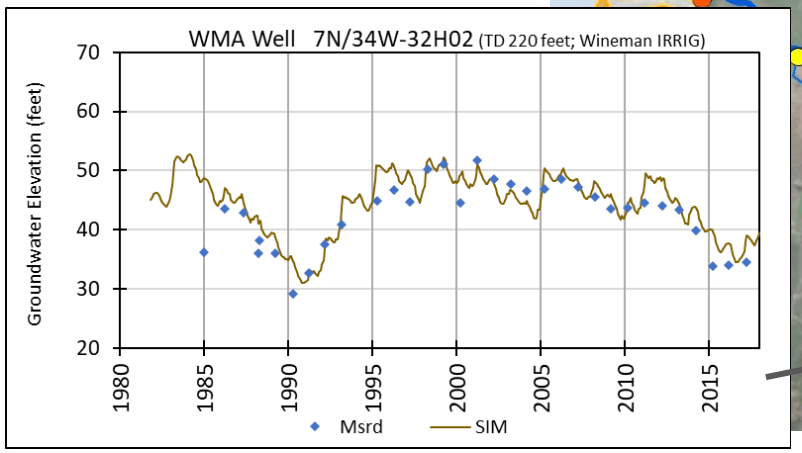


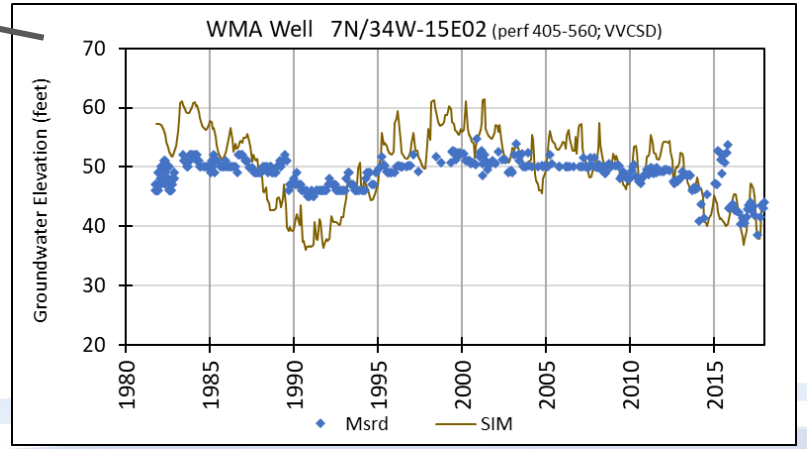
Measured/Simulated Hydrographs

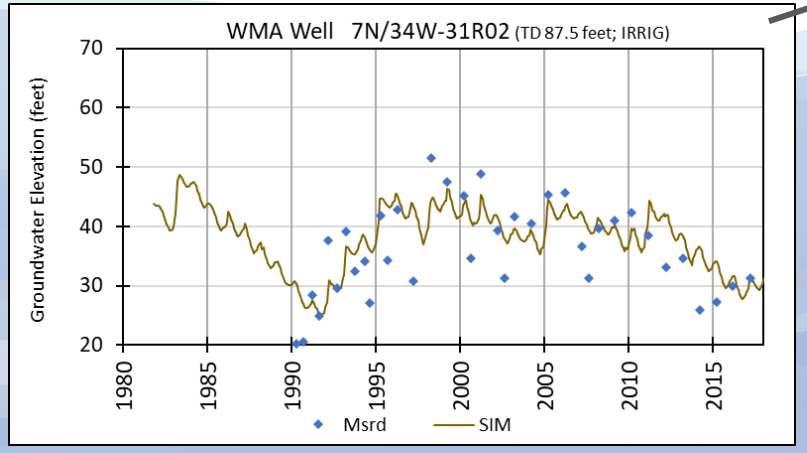


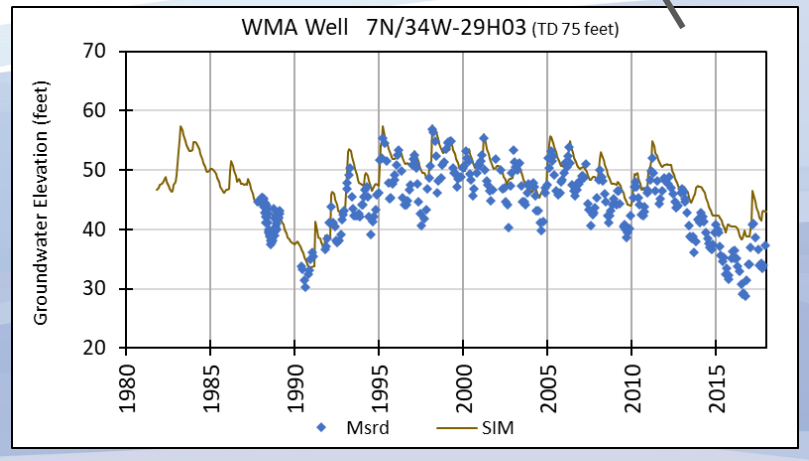


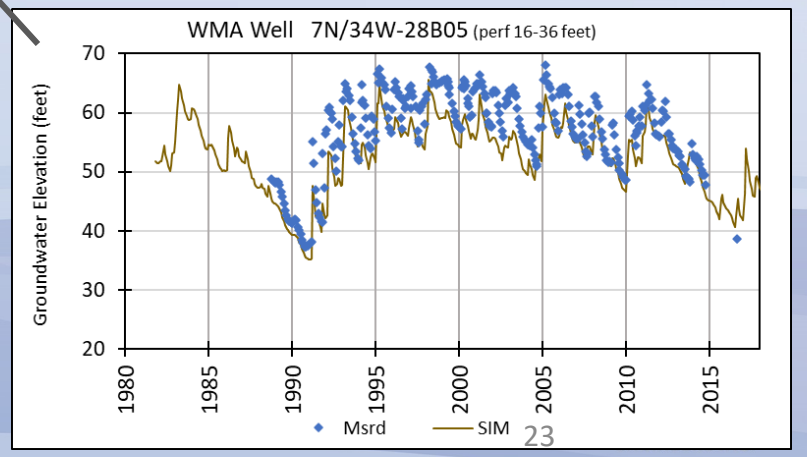




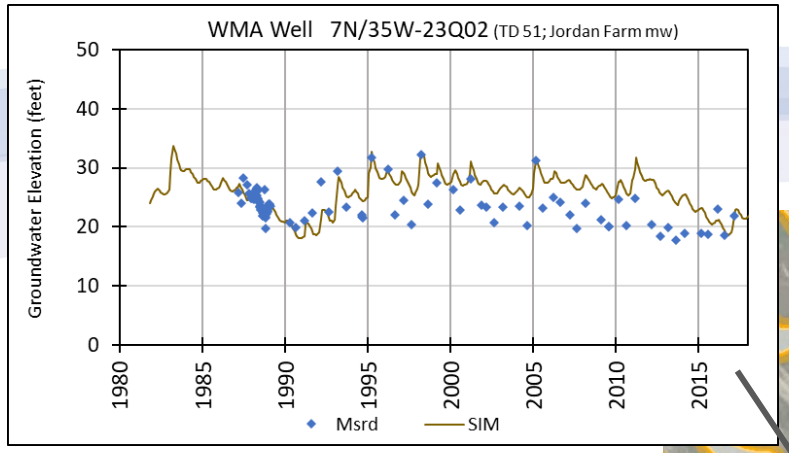


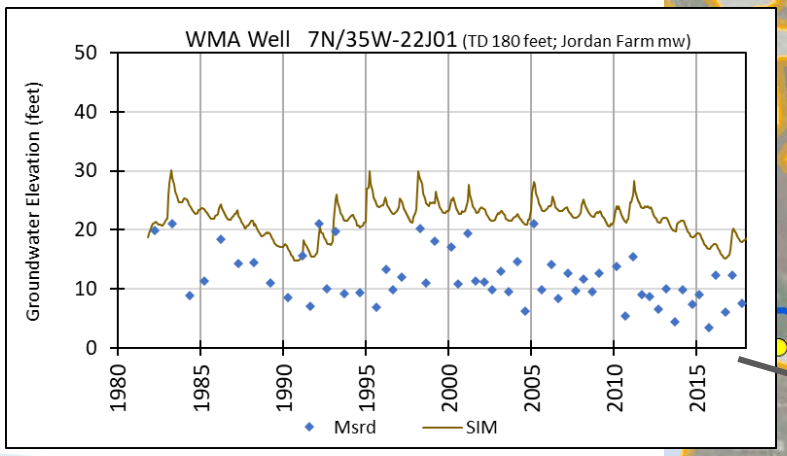


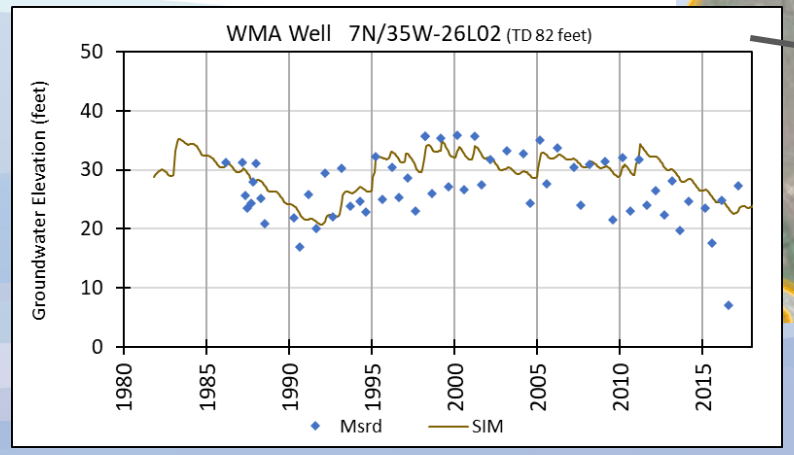


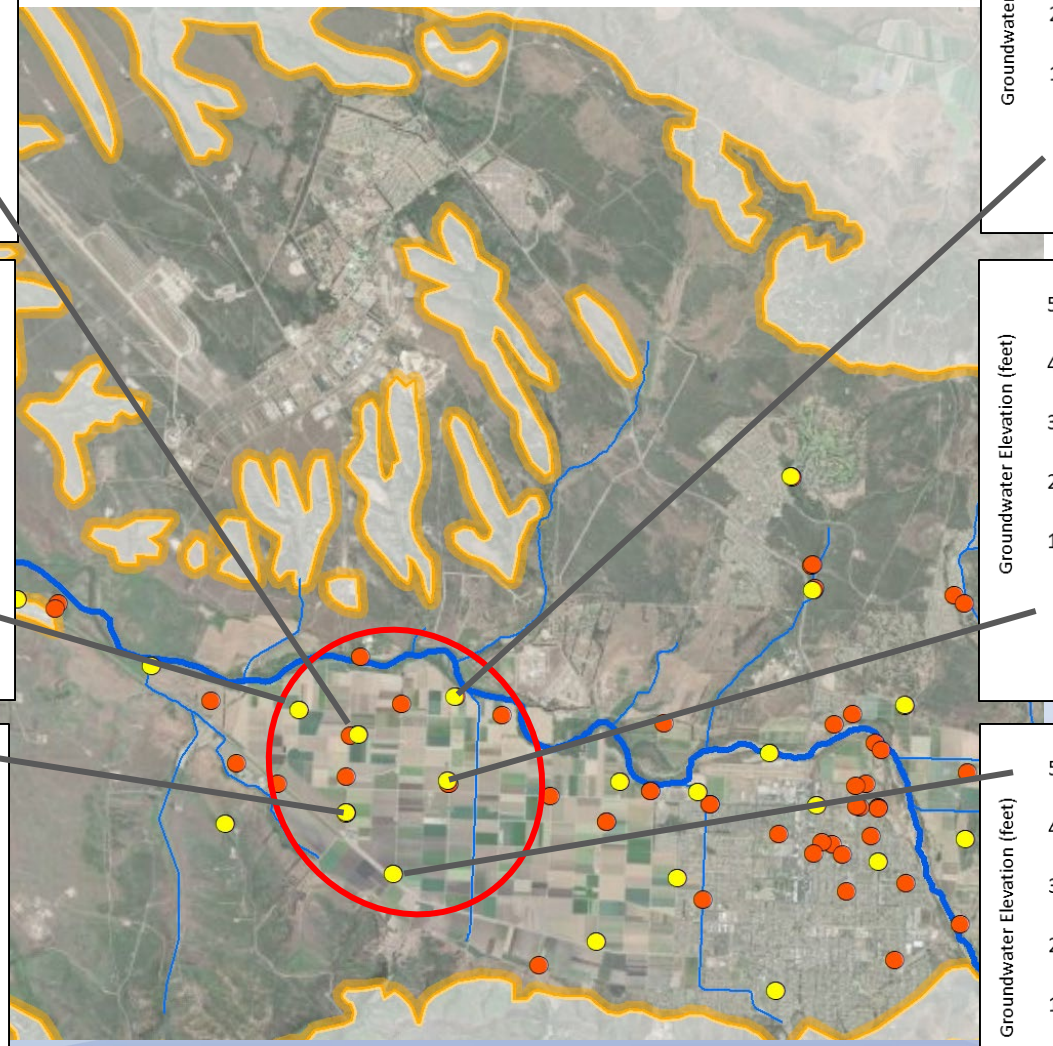


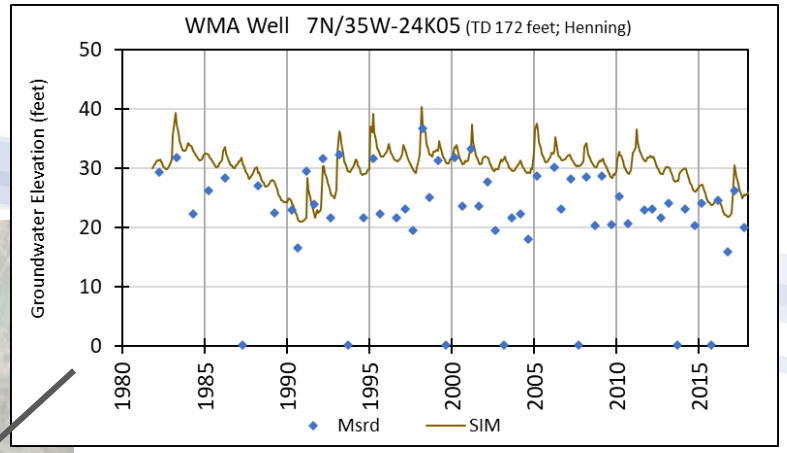
Measured/Simulated Hydrographs

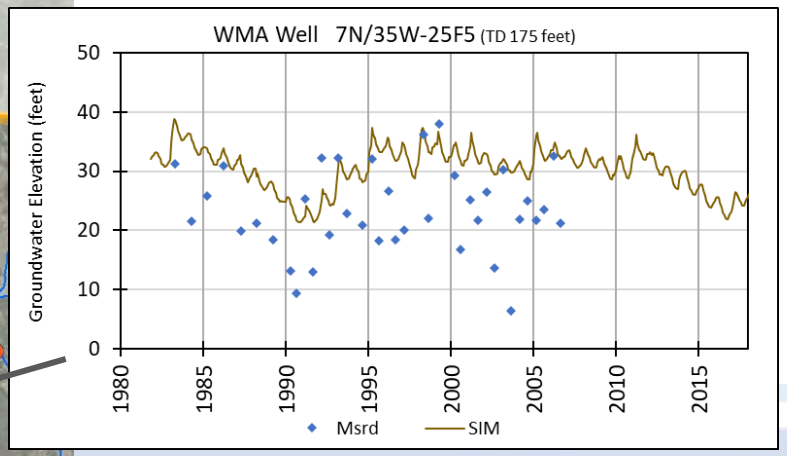


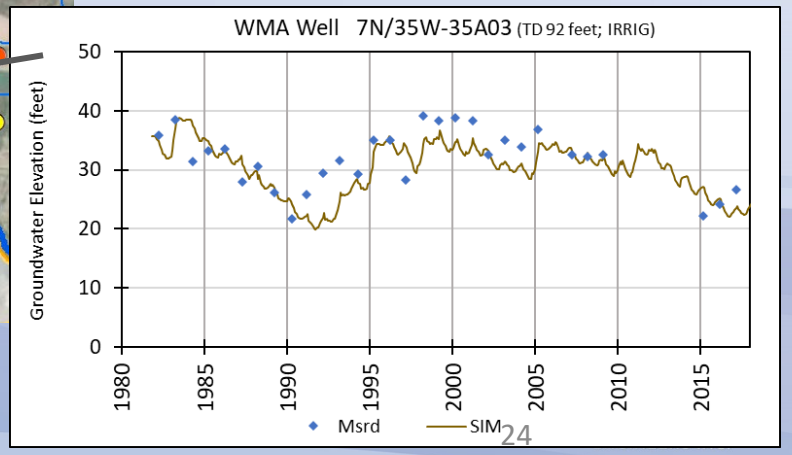




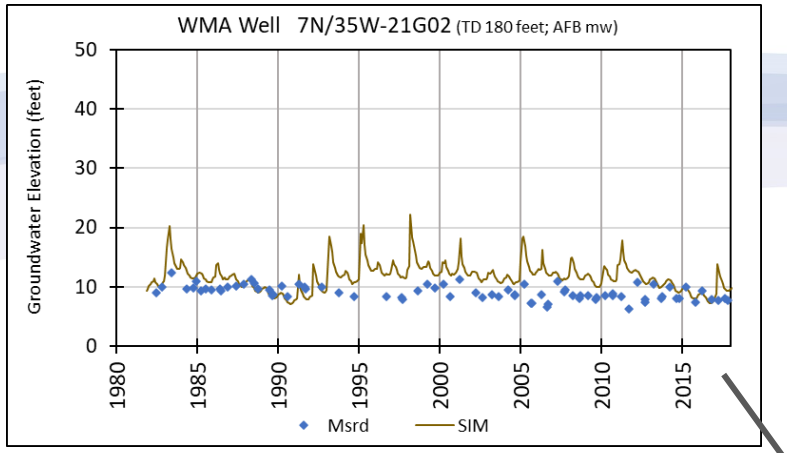


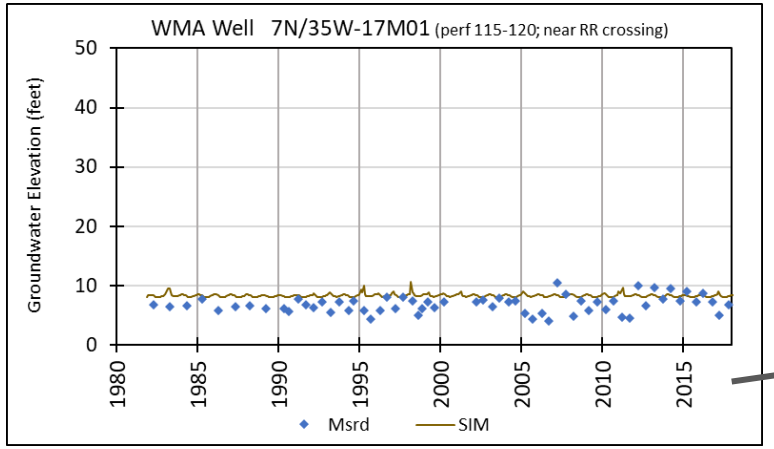


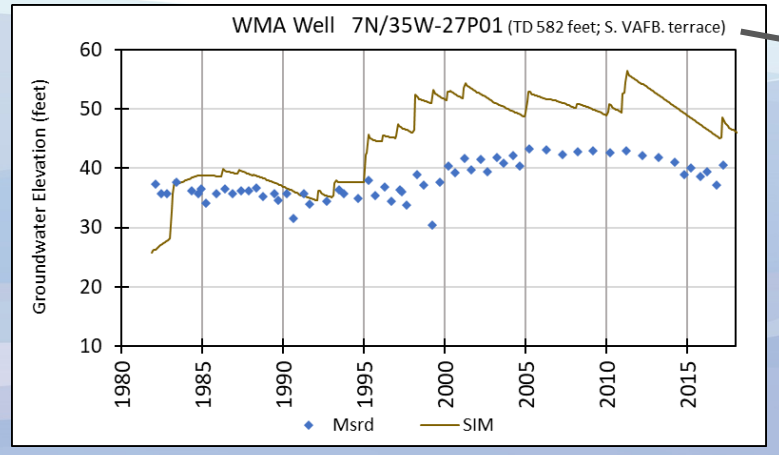


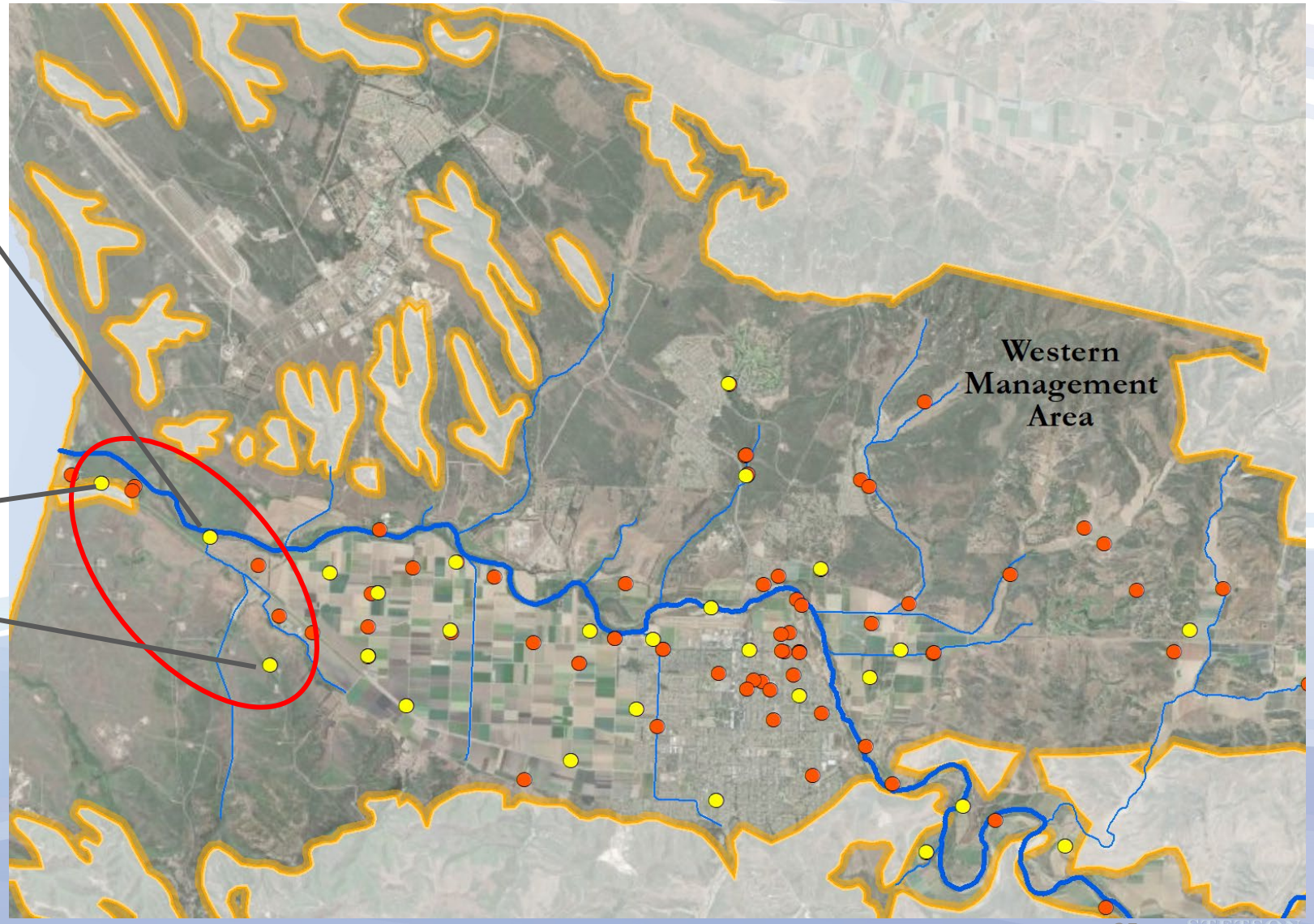


Measured/Simulated Hydrographs









Model Calibration: Sub-Area Groundwater Budgets

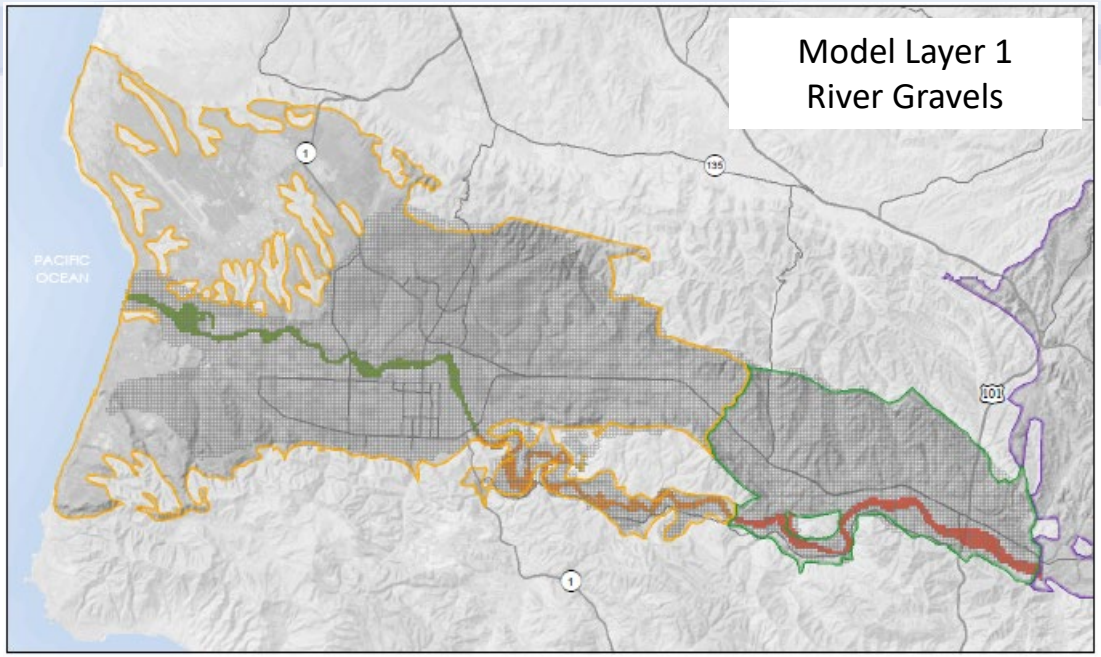
CMA Subarea

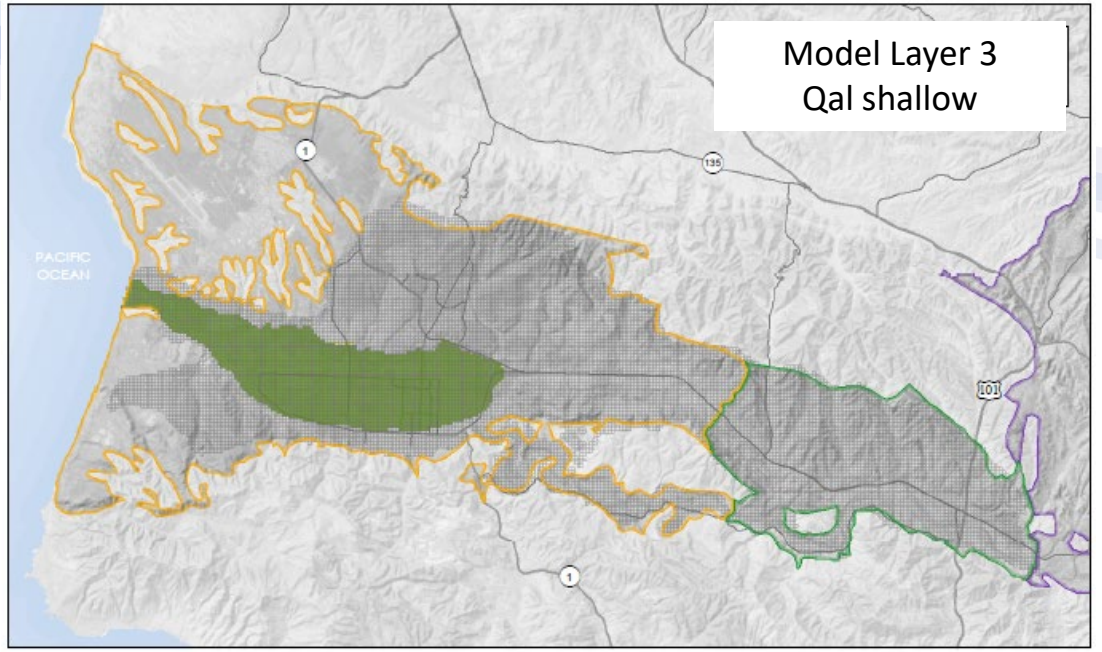
- Santa Ynez River Alluvium
- CMA Lower Aquifer
- Buellton Upland

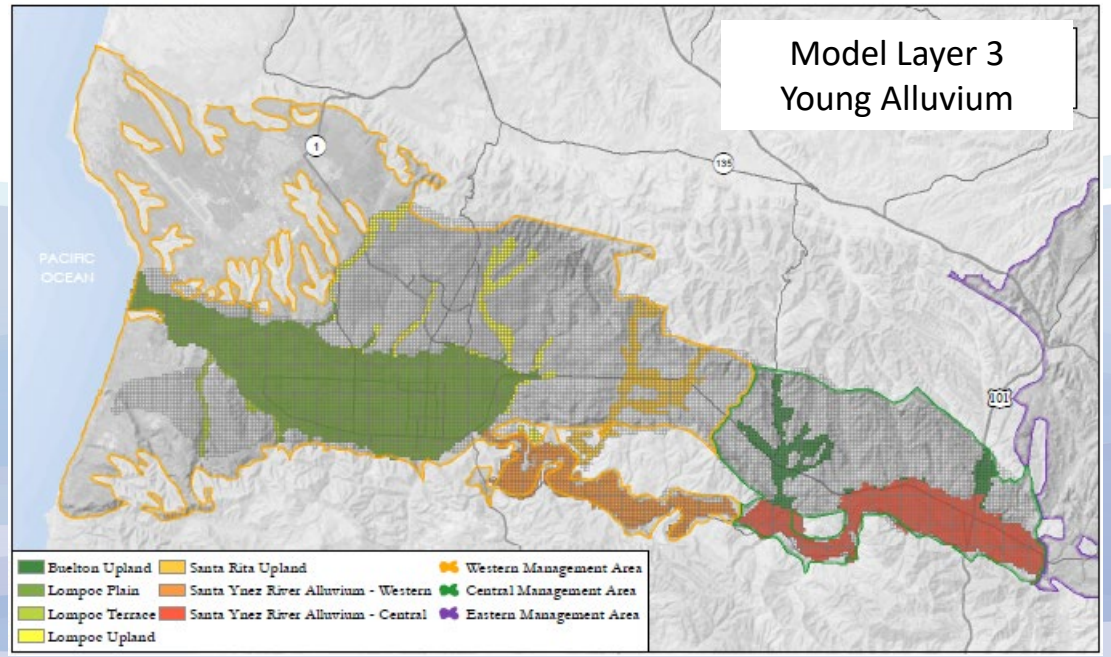
WMA Subarea

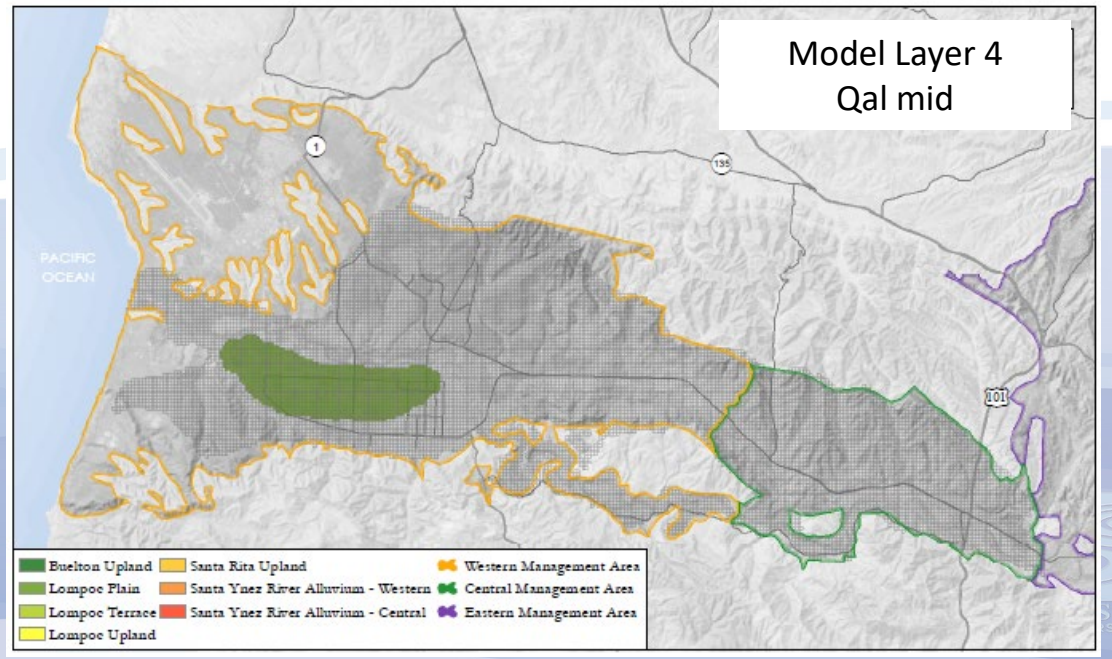
- Santa Ynez River Alluvium
- Lompoc Plain
- Santa Rita Upland
- Lompoc Upland
- Lompoc Terrace

Sub-Areas: Model Layers 1 - 4

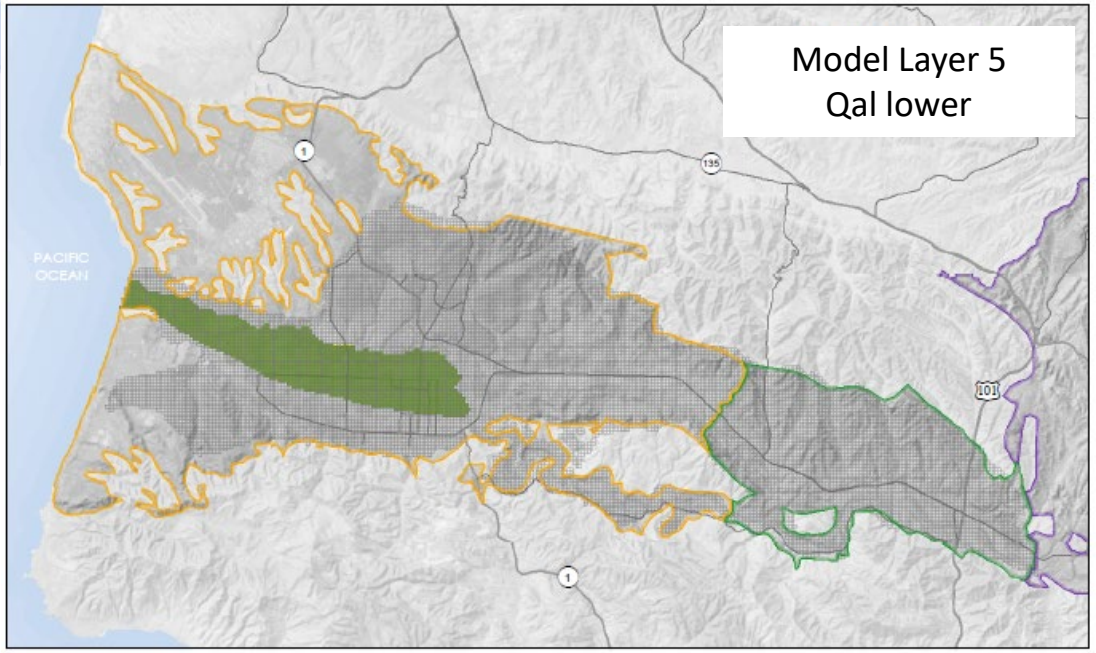


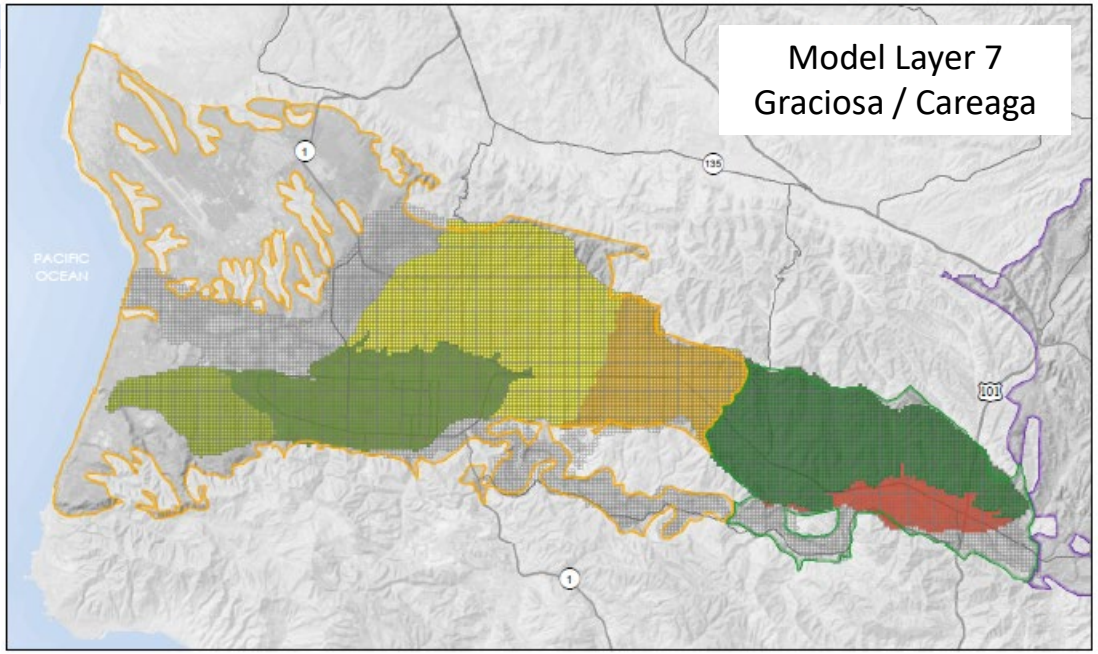


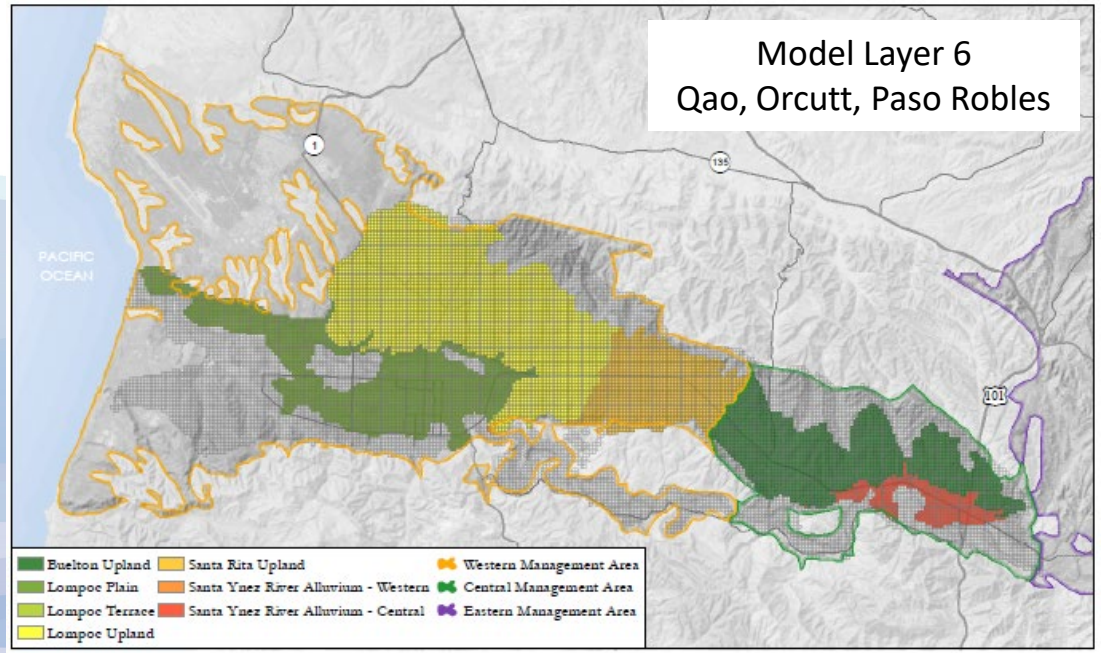


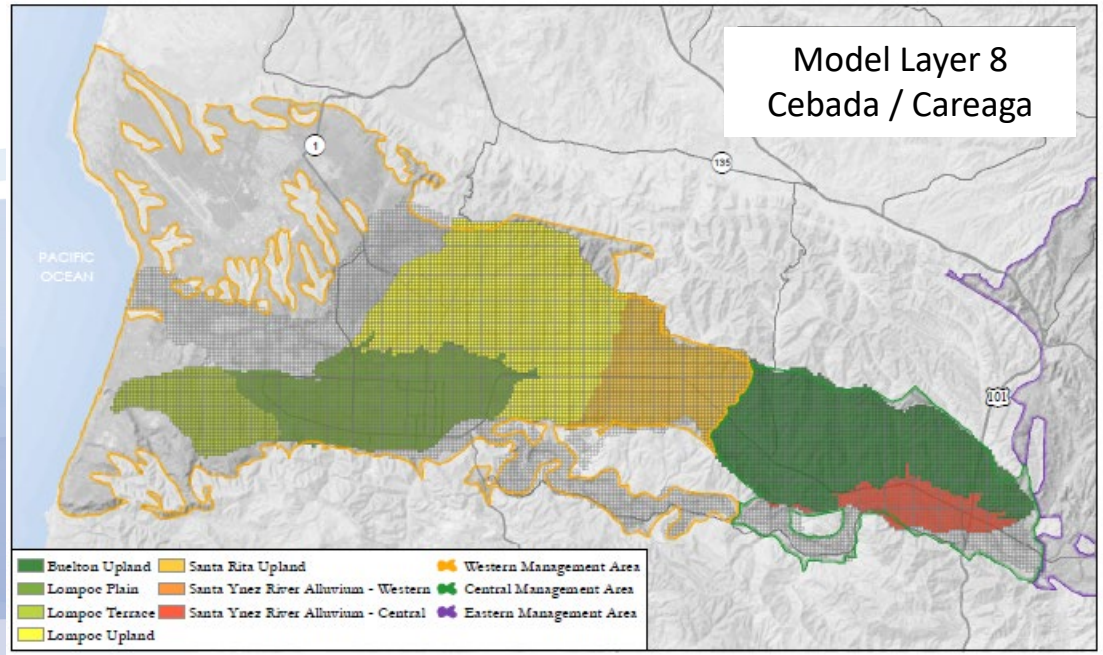


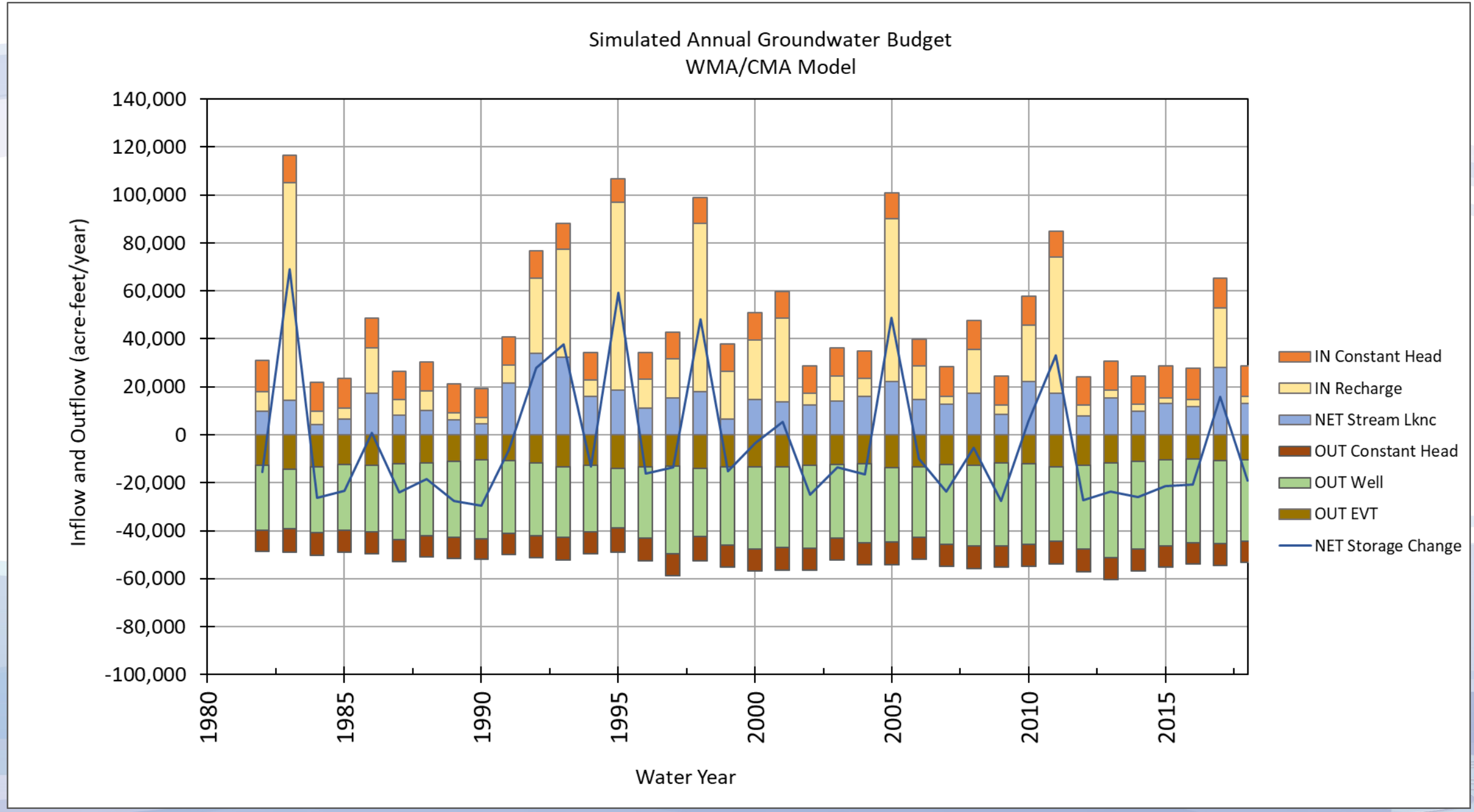
Sub-Areas: Model Layers 5 - 8










Simulated Annual Groundwater Budget
WMA/CMA Model
Inflow and Outflow (acre-feet/year)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
-100,000
1980
1985
1990
1995
2000
2005
2010
2015
Water Year
IN Constant Head
IN Recharge
NET Stream Lknc
OUT Constant Head
OUT Well
OUT EVT
NET Storage Change

Model Documentation (GSP Appendix)

Introduction and Objectives

Model Development

- Code Selection and Documentation
- USG Structure and Construction
  - Hydrologic Properties
  - Boundary Conditions
  - Model Input Parameters
- Calibration Process
  - Simulated/Measured Groundwater Levels
  - Simulated/Measured Streamflow
- Historical Model Results
  - Regional and Sub-Area Groundwater Budgets

Timeline for Completion of Draft Model Documentation

- April 23rd Internal Client Review
- April 30th Public Review

Groundwater Modeling Steps:

The model is a GSP Management Tool to estimate groundwater flow velocities, recharge rates, and model scenarios to predict future groundwater supply and demand based on current groundwater uses.

- Construct and Calibrate (historical measured data)
- Develop Future Baseline (recent conditions, projected growth; balanced hydrology)
- Future Management Scenarios (potential projects, climate change)