Current Status of C2VSim and Related Tools

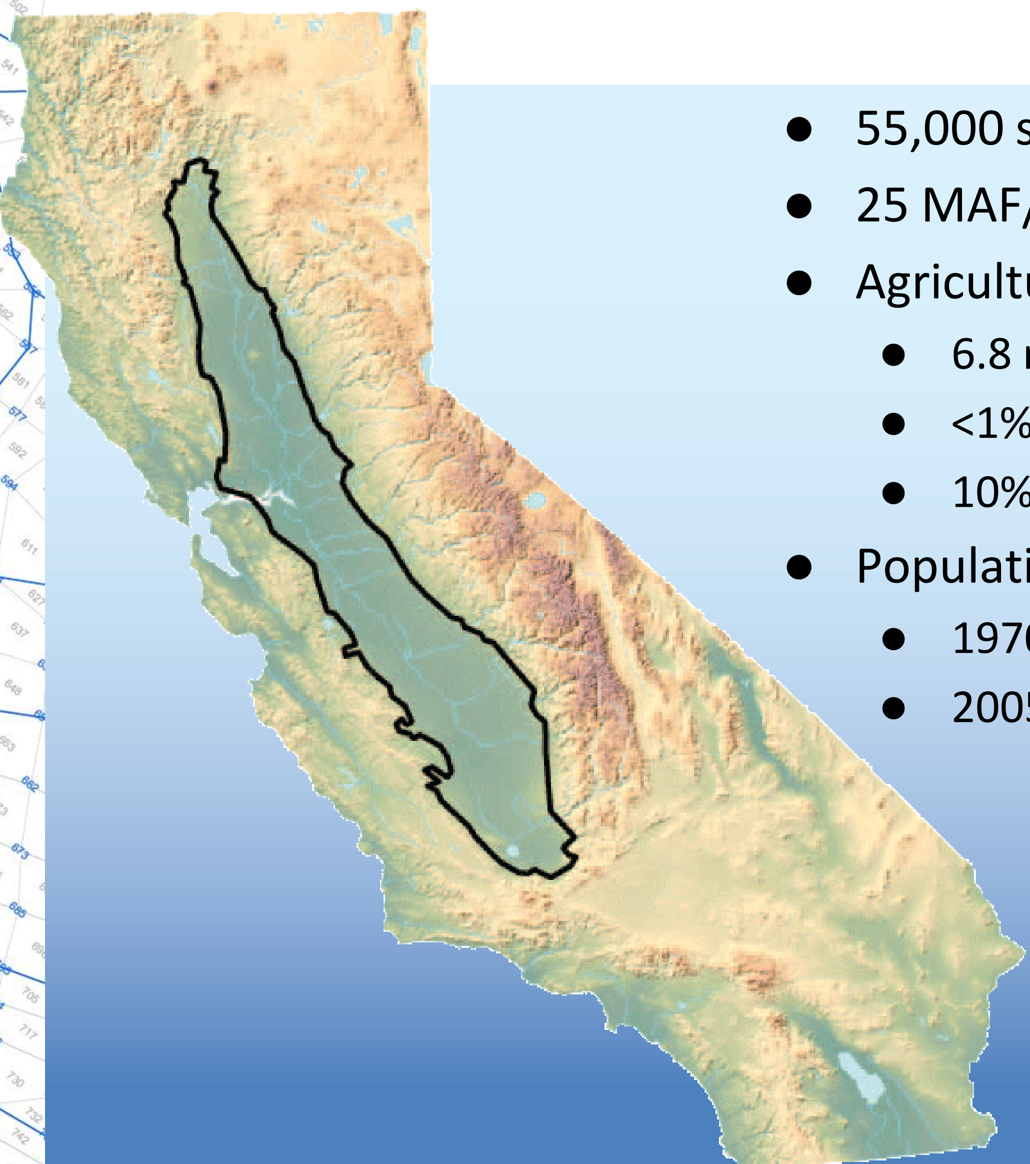
IWFM Users' Group
December 18, 2012

Charles Brush

Modeling Support Branch, Bay-Delta Office

California Department of Water Resources, Sacramento, CA

California's Central Valley



- 55,000 sq. km. (20,000 sq. mi.)
- 25 MAF/yr Surface Water Discharge
- Agricultural Production
  - 6.8 million acres (27,500 sq. km)
  - <1% of US farm land
  - 10% of US crops value in 2002
- Population Growth
  - 1970: 2.9 million
  - 2005: 6.4 million
- Groundwater Pumping
  - ~9 MAF in 2002
  - 10-18% if US pumping
  - Not measured or regulated

C2VSim Development

Derived from the CVGSM model

- WY 1922-1980 Boyle & JM Montgomery (1990)
- WY 1981-1998 CH_2M Hill

Steady modification

- DWR IWFM/C2VSim development began in 2000
- IWFM process and solver improvements
- C2VSim data sets reviewed and refined
- C2VSim input data extended through WY 2009

Calibration

- PEST parameter estimation program
- Three phases: Regional, Local, Nodal
- Calibration Period: WY 1973-2003 in phases 1 & 2, 1922-2004 in phase 3

C2VSim Versions

C2VSim CG 3.02 (R367): Pre-Release Version

- Water Years 1922-2009, monthly time step
- IWFM version 3.02
- Expected release in January 2013

C2VSim FG 3.02 (R356): Draft Version

- Based on C2VSim 3.02 CG of Jan 2012
- Refine rivers, inflows, land use
- Next: Update to R367
- Expected release in Spring 2013

Planned Improvements

- C2VSim 3.02 CG/FG: Extend to WY 2011 or 2012
- C2VSim 4.0 FG: Element-level land use, crop and diversion data

C2VSim Coarse-Grid

"C2VSim CG-3.02"

Finite Element Grid

- 3 Layers or 9 Layers
- 1393 Nodes & 1392 Elements

Surface Water System

- 75 River Reaches, 2 Lakes
- 243 Surface Water Diversions
- 38 Inflows, 11 Bypasses
- 210 Small-Stream Watersheds

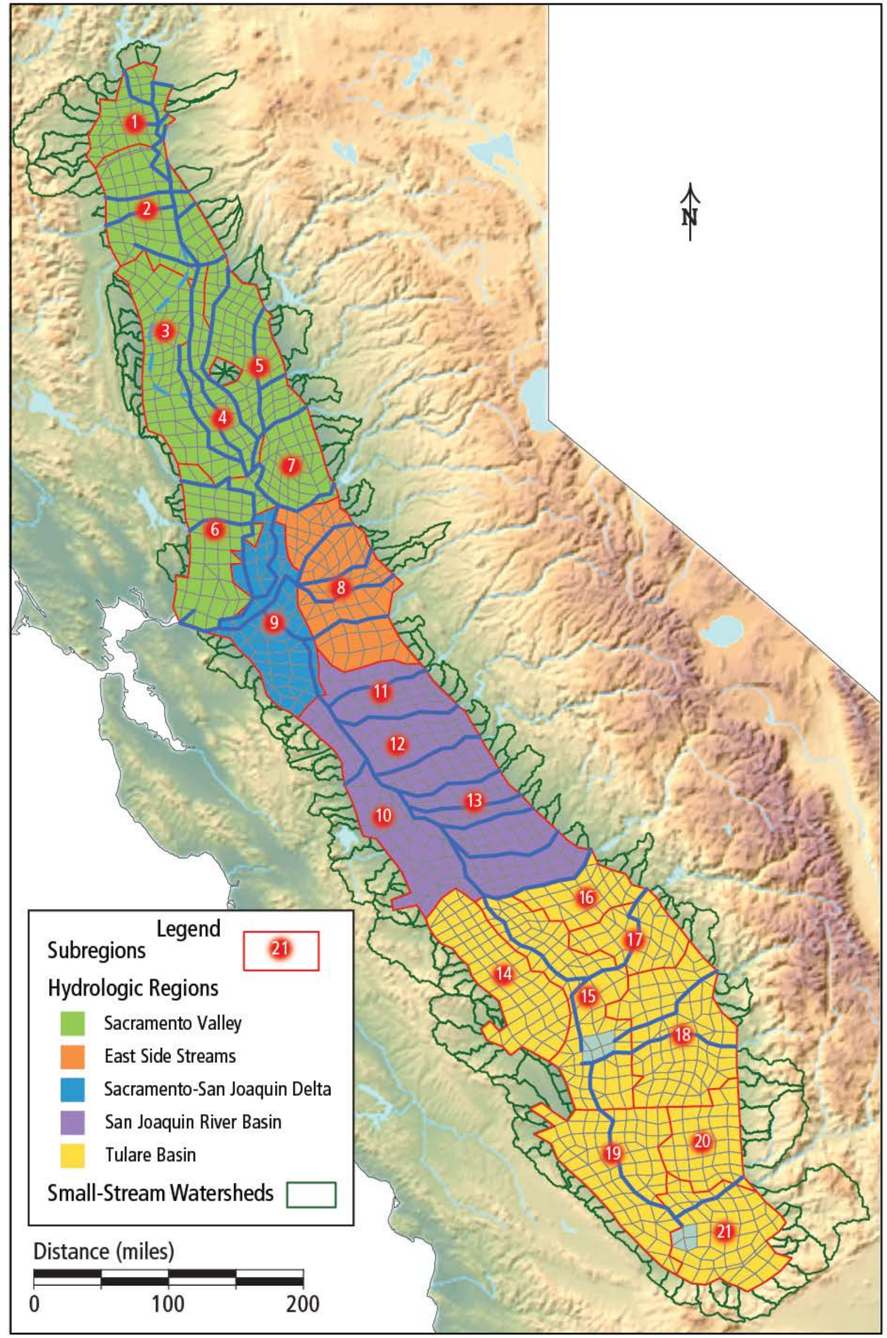
Land Use Process

- 21 Subregions (DSAs)
- 4 Land Use Types

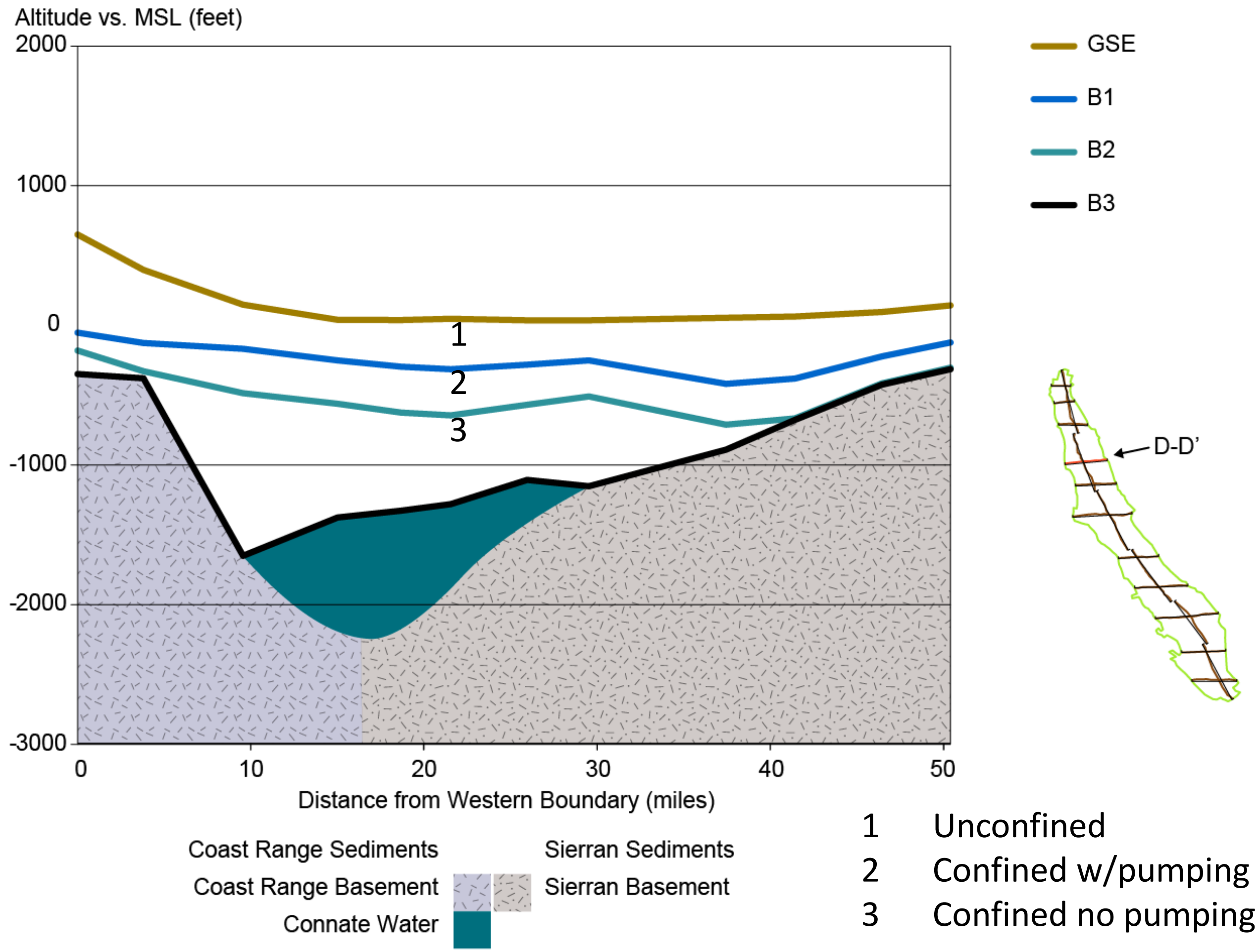
Simulation periods

- 10/1921-9/2009 (88 yrs)
- runs in 3-6 min

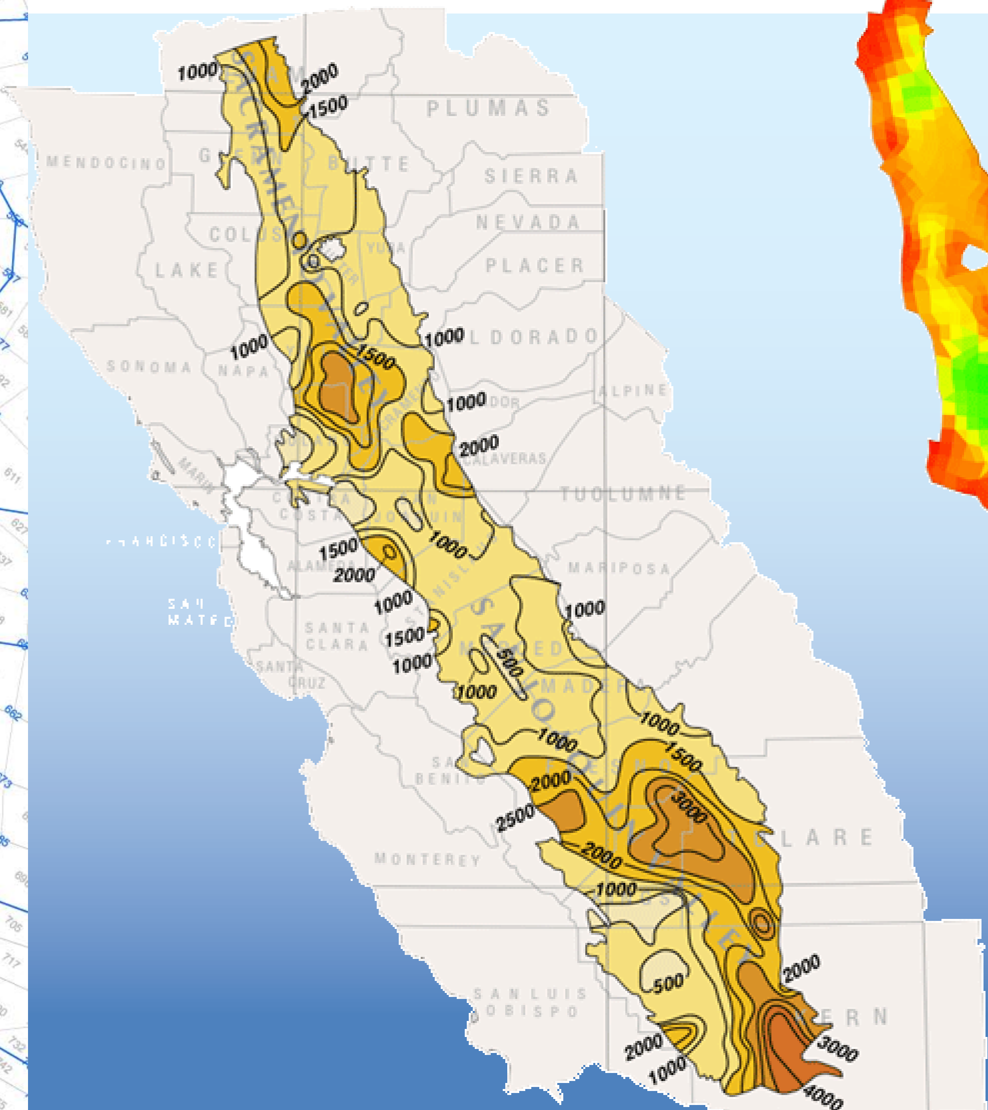
IWFM version 3.02

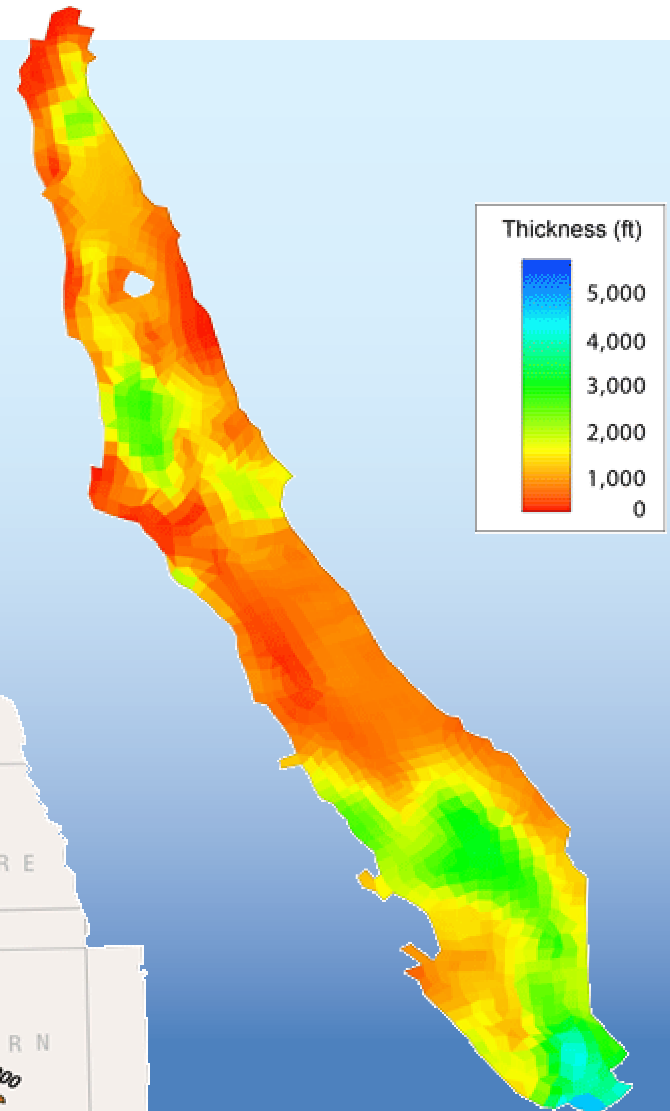


C2VSim Aquifer Layers

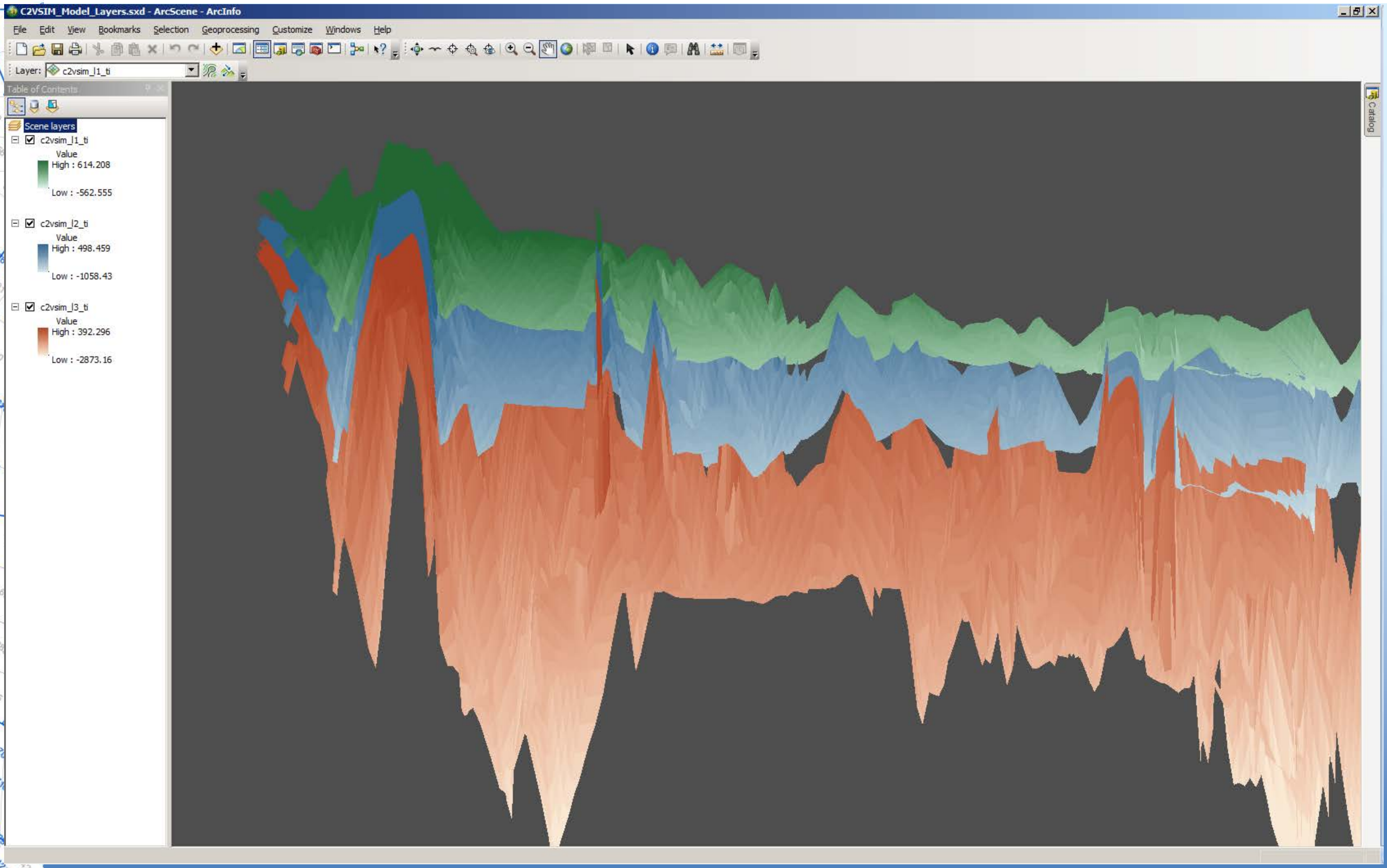


C2VSim Aquifer Thicknesses





C2VSim Aquifer Layers

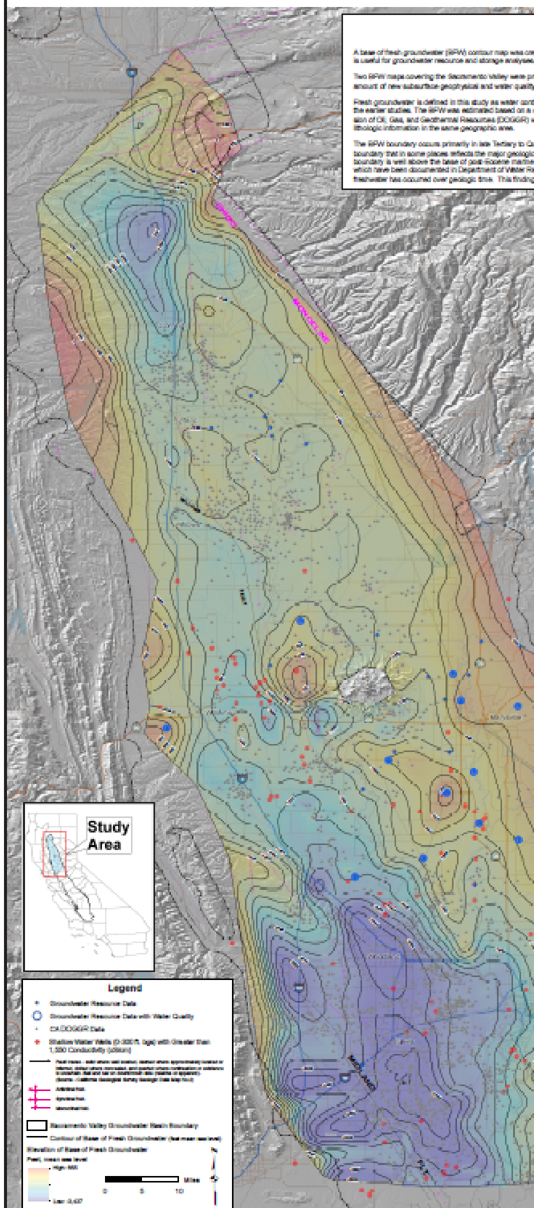


Base of Fresh Groundwater in the Sacramento Valley, California

California Department of Water Resources Report name/#

Steven Springhorn, Nick Hightower, and Tad Bedegrew

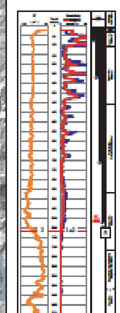
October, 2012



Abstract

A base of fresh groundwater (BFW) contour map was created to identify the approximate lower limit and the thickness of the fresh water aquifer system in the Sacramento Valley. The BFW map is useful for groundwater resource and storage analyses, groundwater modeling, and delineating structural geologic features in the Sacramento Valley.

Criteria for Approximating Base of Fresh Groundwater



Definition of Fresh Groundwater

Data Sources

References

Faults

- Battle Creek Fault
- **Red Bluff Arch**
- Plainfield Ridge Anticline
- Pittsburgh – Kirby Hills – Vaca Fault
- Vernalis Fault
- Graveley Ford Faults
- Visalia Fault
- Pond-Poso Creek Fault
- Edison Fault
- **White Wolf Fault**

Calibrated Parameters

Aquifer nodes
- Conductivity
- Storage
- Subsidence

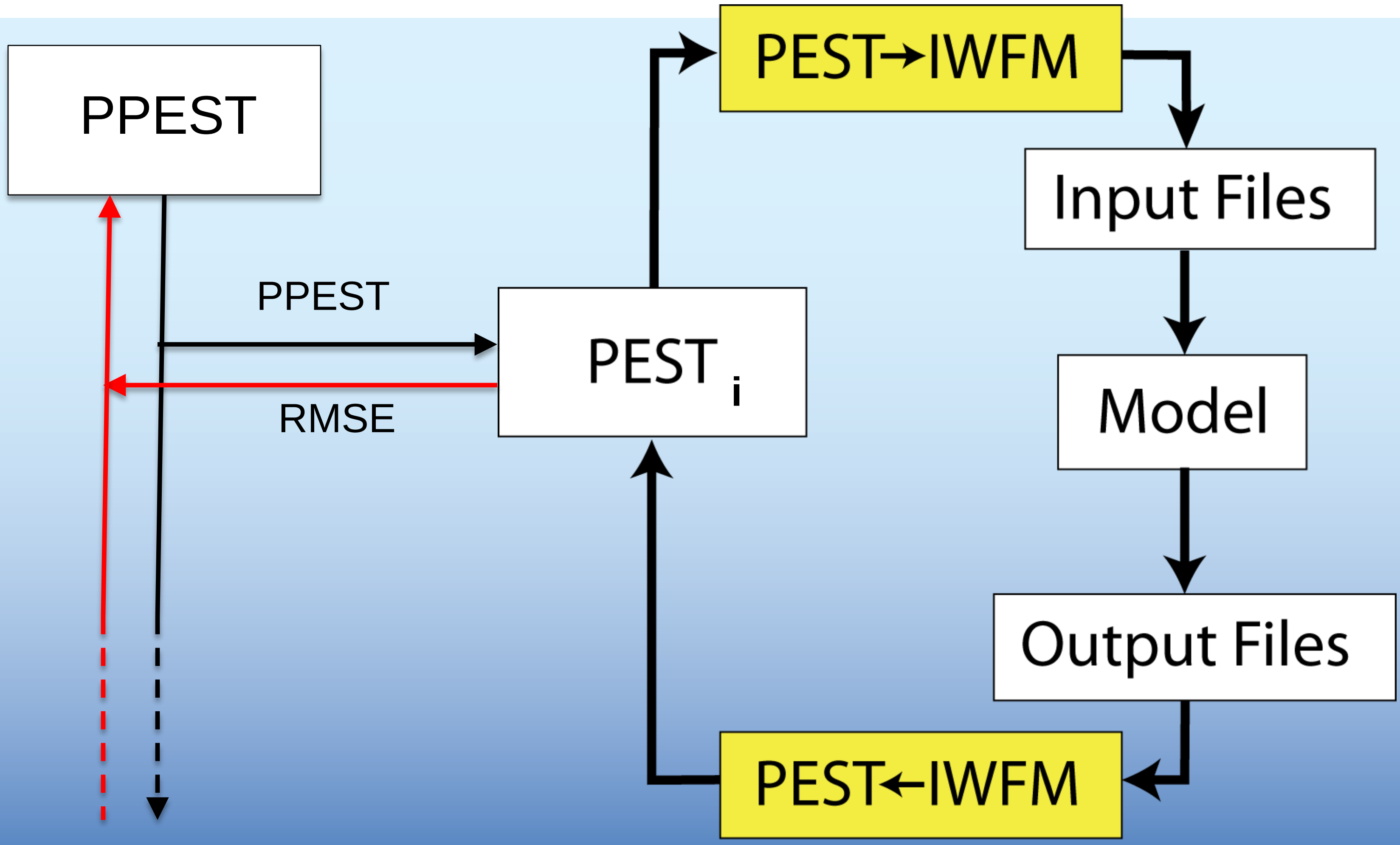
River nodes
- Conductance

Unsaturated Zone
- Porosity
- Conductivity

Soil properties
- Field capacity
- Porosity
- Recharge factor
- Curve Numbers

Small Watersheds
- Field capacity
- Porosity
- Conductivity
- Discharge threshold
- Recession coefficients

Calibration with PPEST



IWFM-PEST Tools

- **Translate parameters from pilot points to IWFM**
  - **CVoverwrite.dat file**
  - **FAC2REALI program**
- **Convert IWFM hydrographs to SMP format**
  - **IWFM2OBS program**
- **Calculate vertical head differences to SMP format**
  - **IWFM2OBS program**
- **Stream-groundwater flows to SMP format**
  - **STACDEP2OBS program**
- **Log-transform surface water hydrographs**
  - **LOG_TRAN_SMP program**

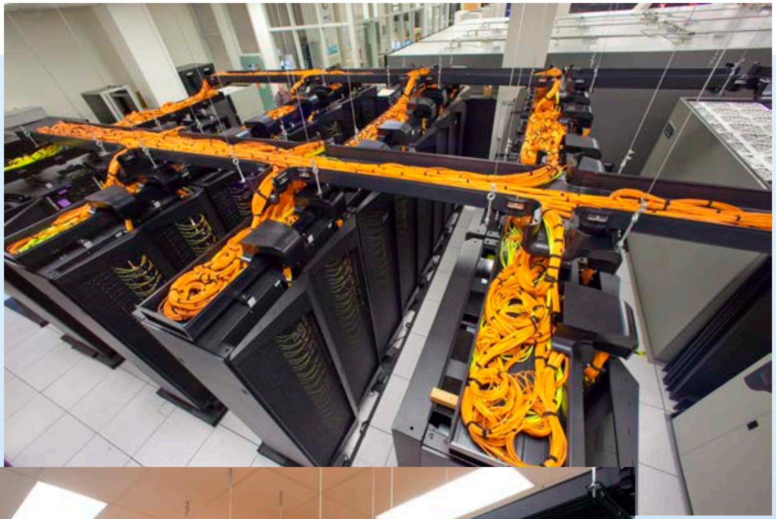
C2VSim Calibration

- **Calibrate parameter values at each model node and layer**

- **Using computers at the USDOE National Energy Research Scientific Computing Center (NERSC)**
  - **Carver**
    - **IBM iDataPlex**
    - **3,200 CPU cores, 34 Tflop/s**

- **Comparison:**

	PPs	Compter	Run Time
R300	137	15 PCs	1 week
R326	394	15 PCs	3 weeks
R346	1393	15 PCs	16 weeks
R346	1393	NERSC	2 weeks



Model Performance

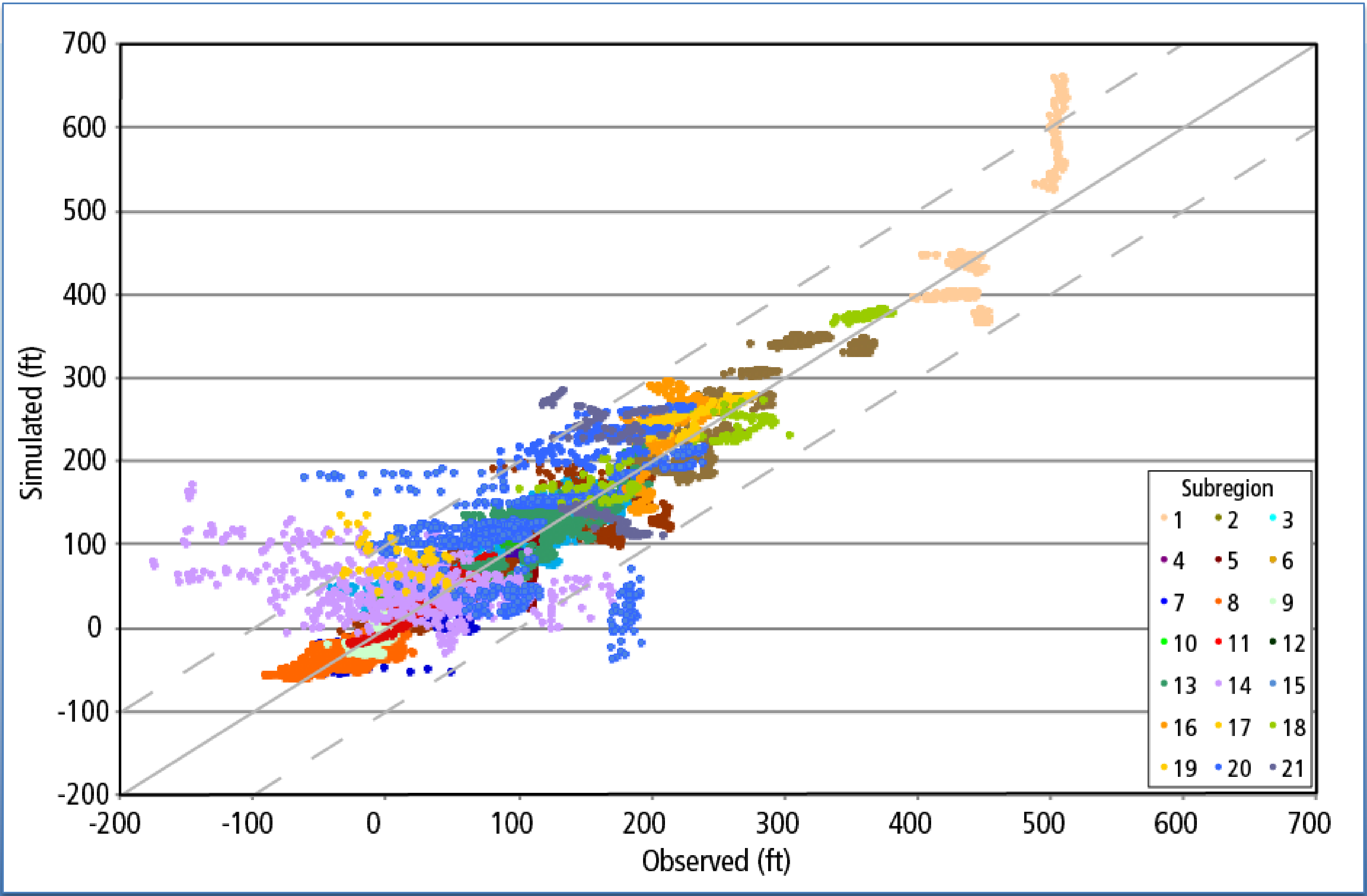
Observation Type	No. Observation Sites	No. Observations	Range
Groundwater heads	1,378	62,981	1,252
Vert. Groundwater Head Difference	163	3,017	698
River Flows	22	5,636	6,561,453
River-Groundwater Flows	33	33	38,117
Subsidence	24	3,700	6.2
TOTAL	1,620	75,367	

Observation Type	Root Mean Squared Error	Residual	RMSE / Range	Residual / Range
Groundwater heads	65.4	2.14	0.052	0.002
Vert. Groundwater Head Difference	96.2	-13.3	0.138	-0.019
River Flows	145,591	-13,720	0.022	-0.002
River-Groundwater Flows	8,875	3,620	0.233	0.095
Subsidence	17.4	-11.5	2.81	-1.86

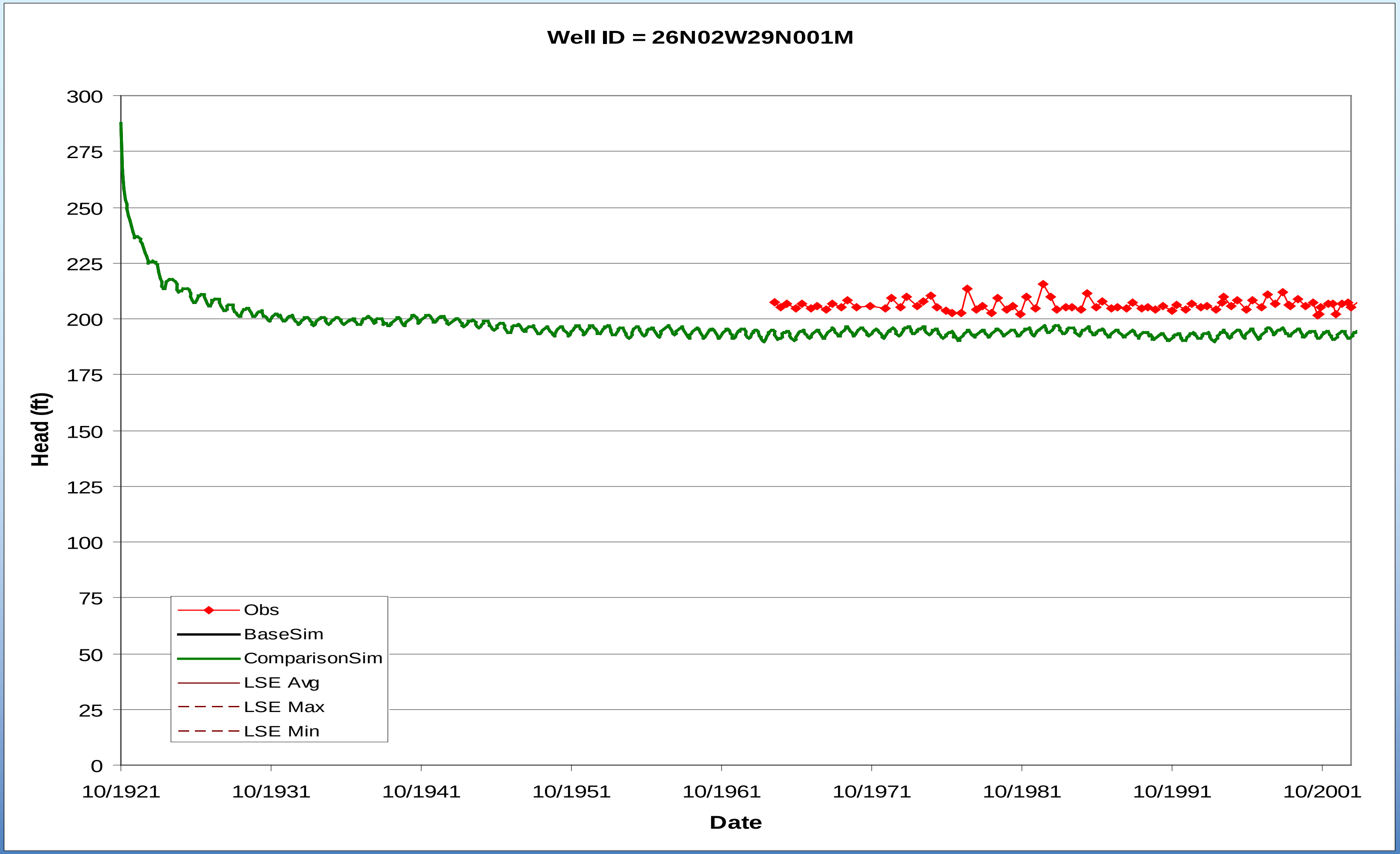
Units: Heads and subsidence in feet, flows in acre-feet

Head and flow observations from October 1975 to September 2003, Subsidence observations from September 1957 to May 2004

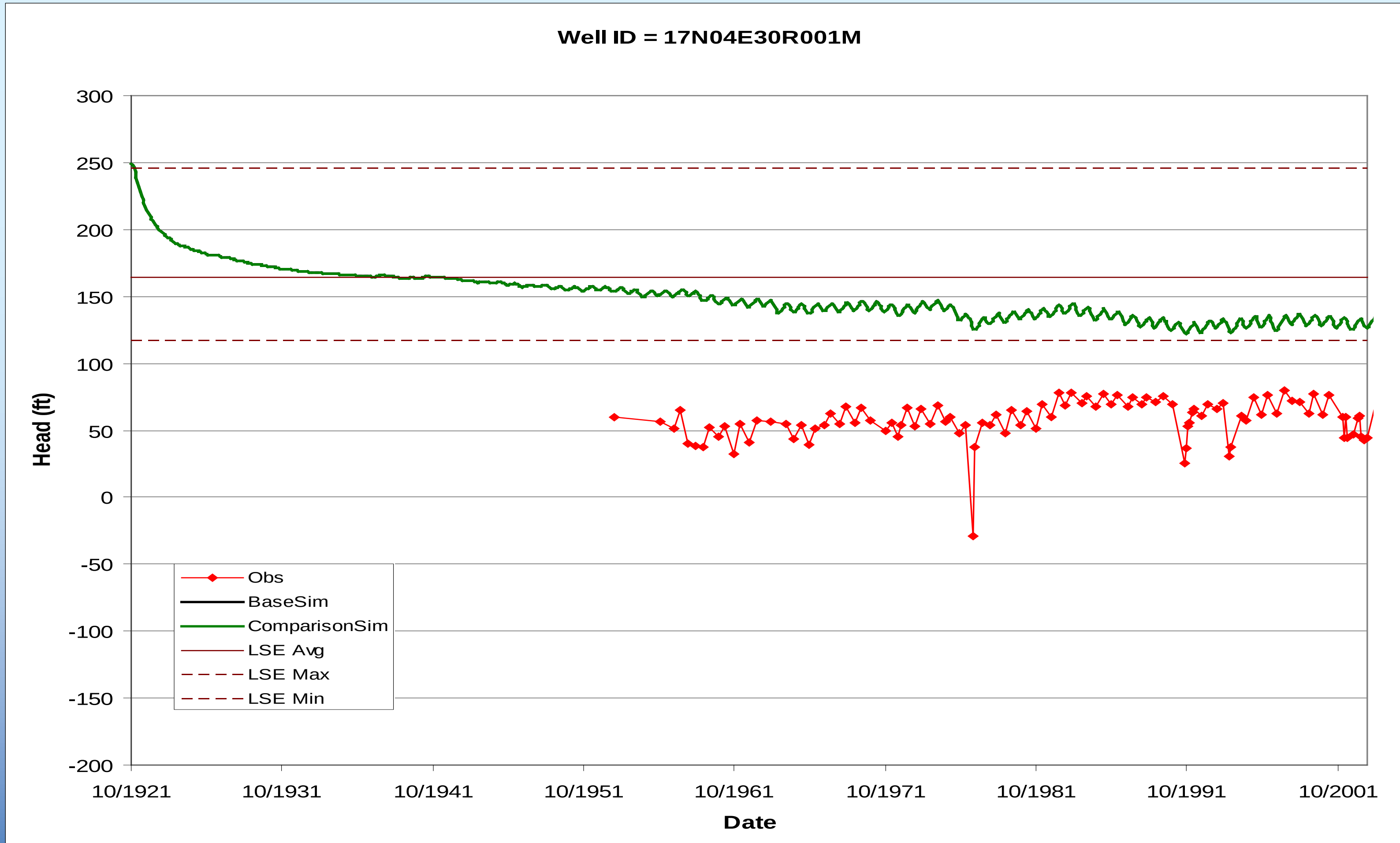
Groundwater Heads



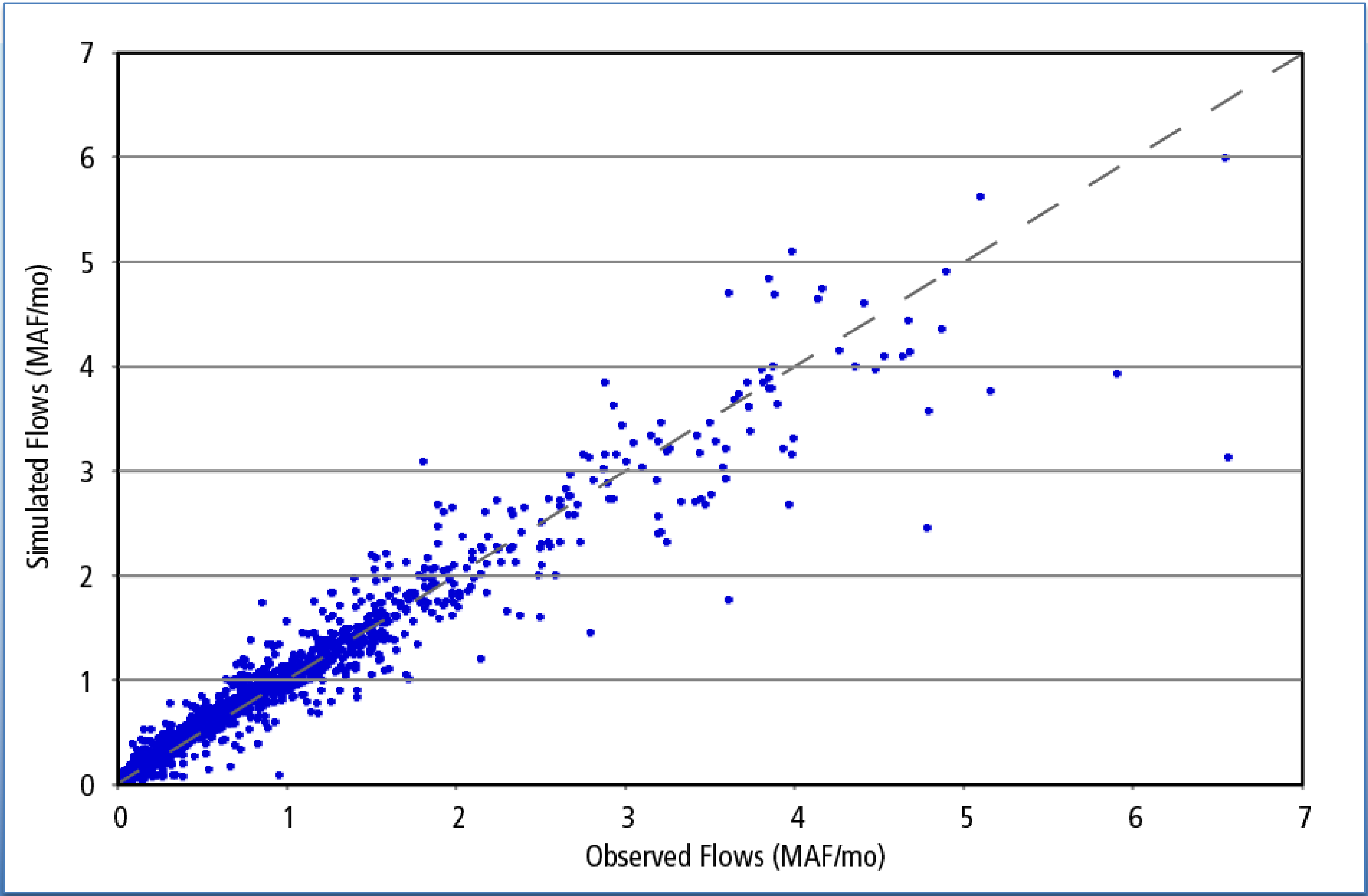
Groundwater Hydrographs



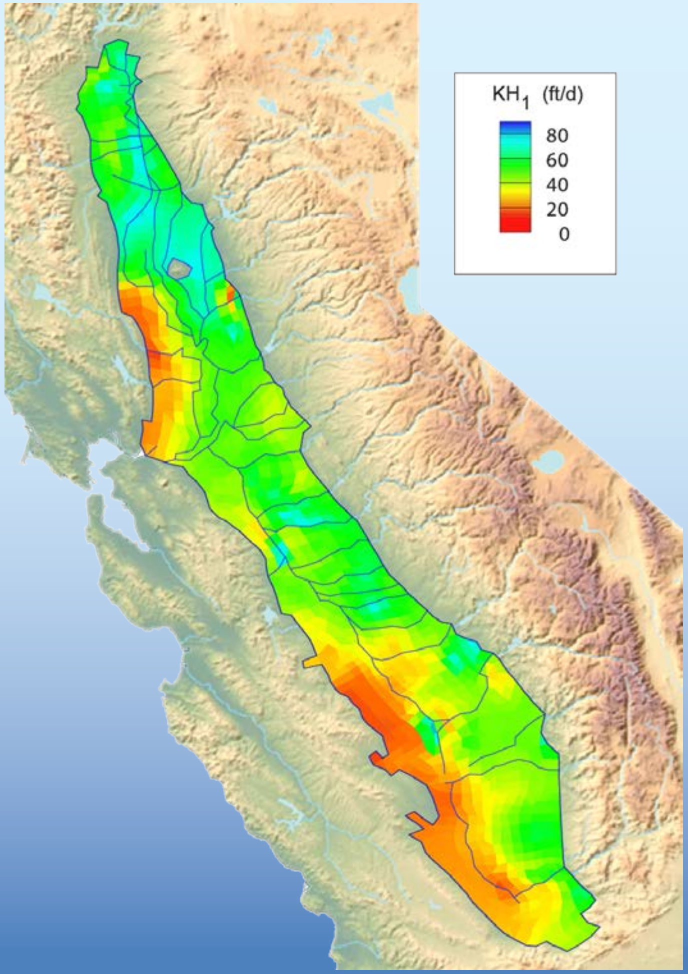
Groundwater Hydrographs

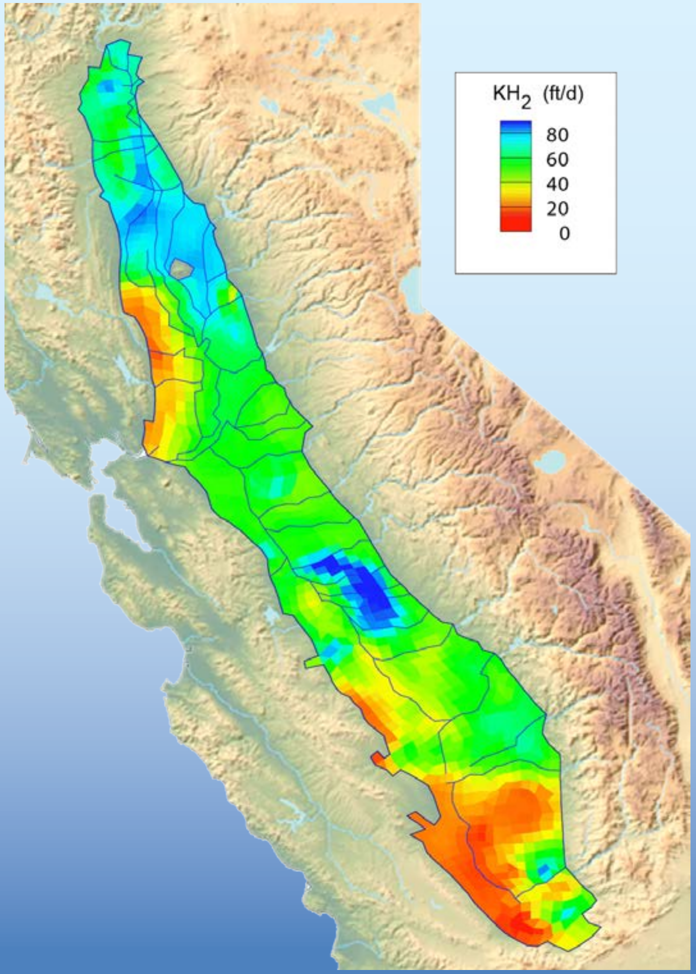


Surface Water Flows

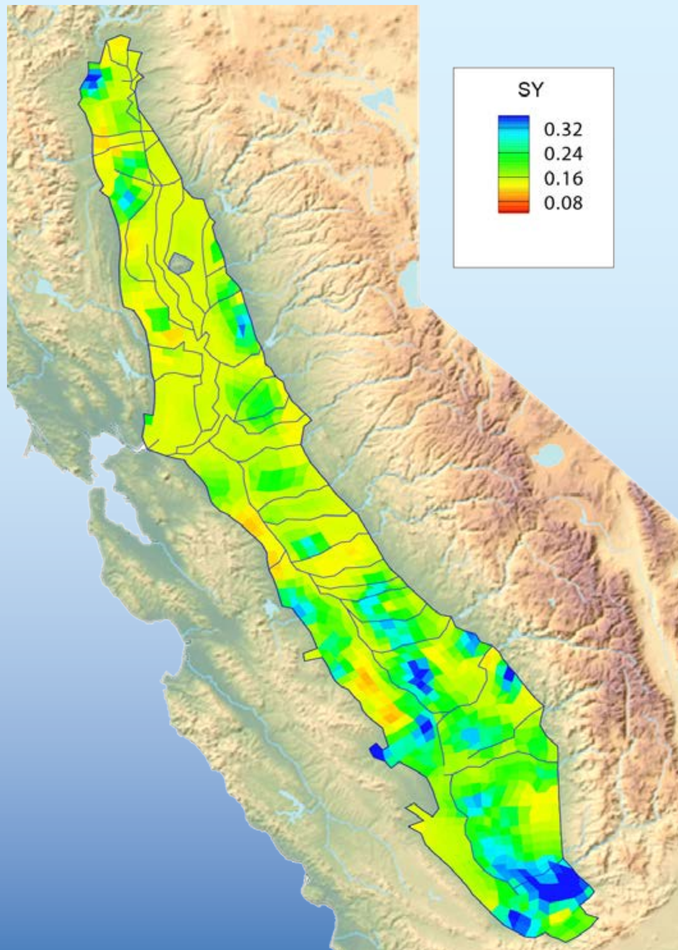


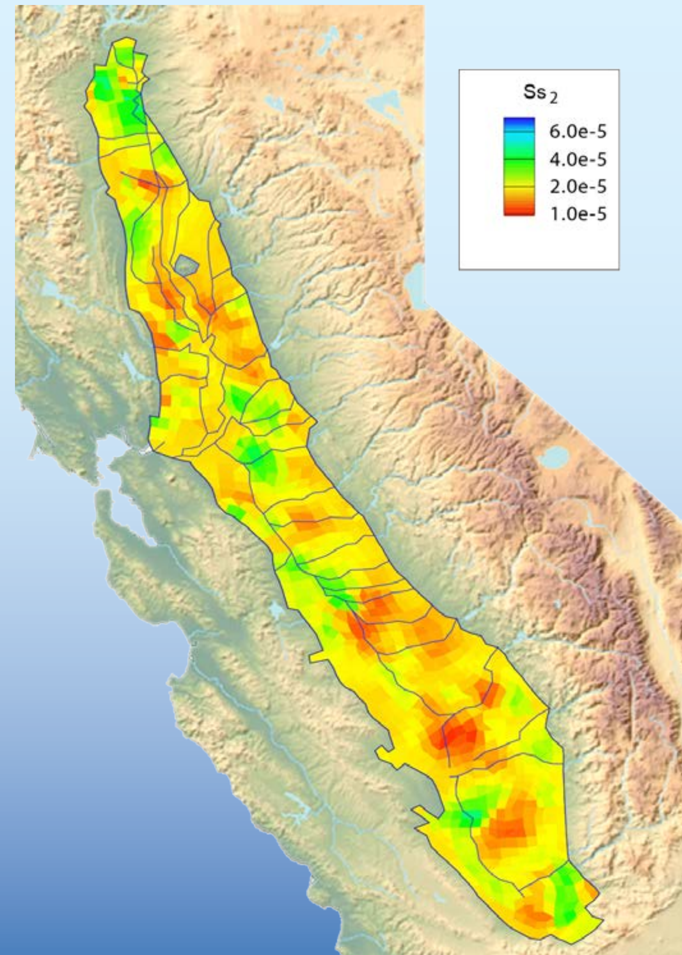
Hydraulic Conductivity



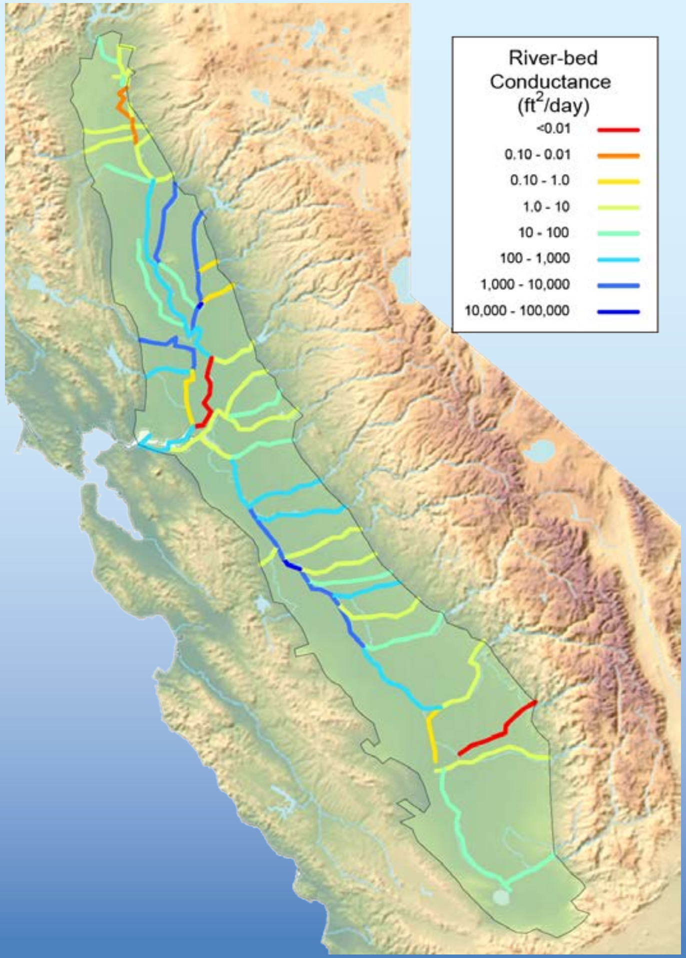


Storage Parameters



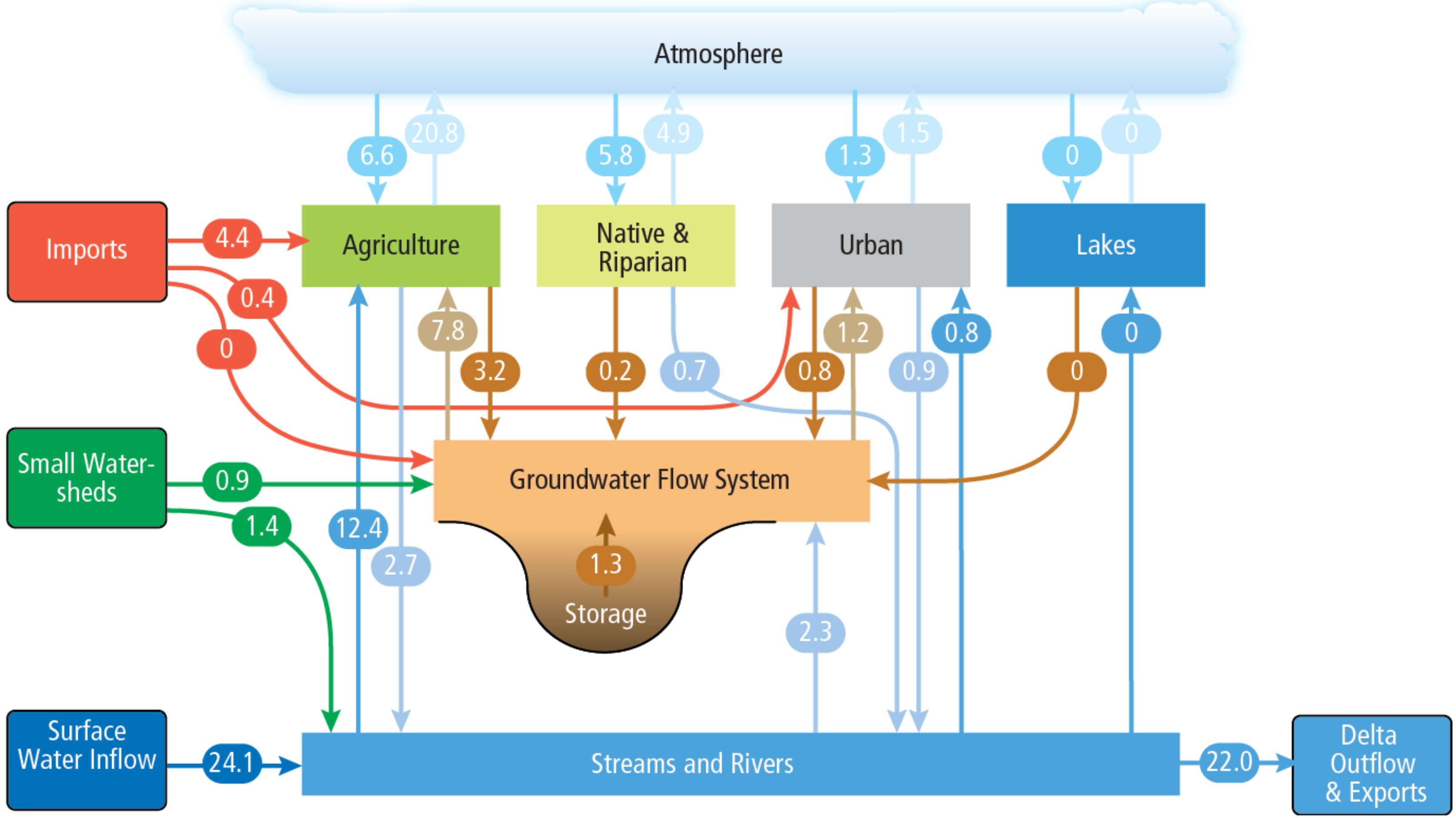


River-Bed Conductance

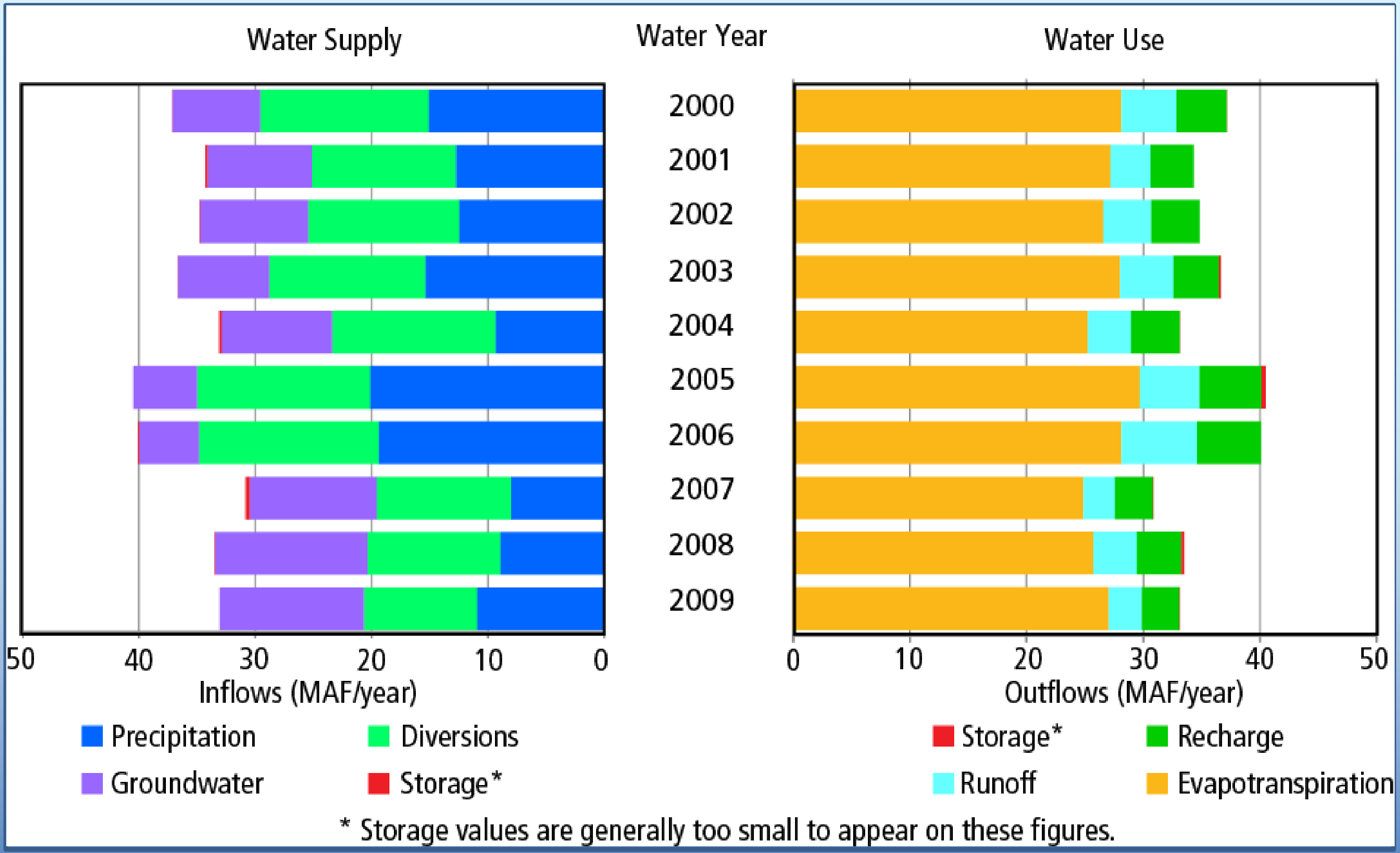


Simulated Annual Water Budget

Average Flows for water years 2000-2009
[Million Acre-Feet/Year]

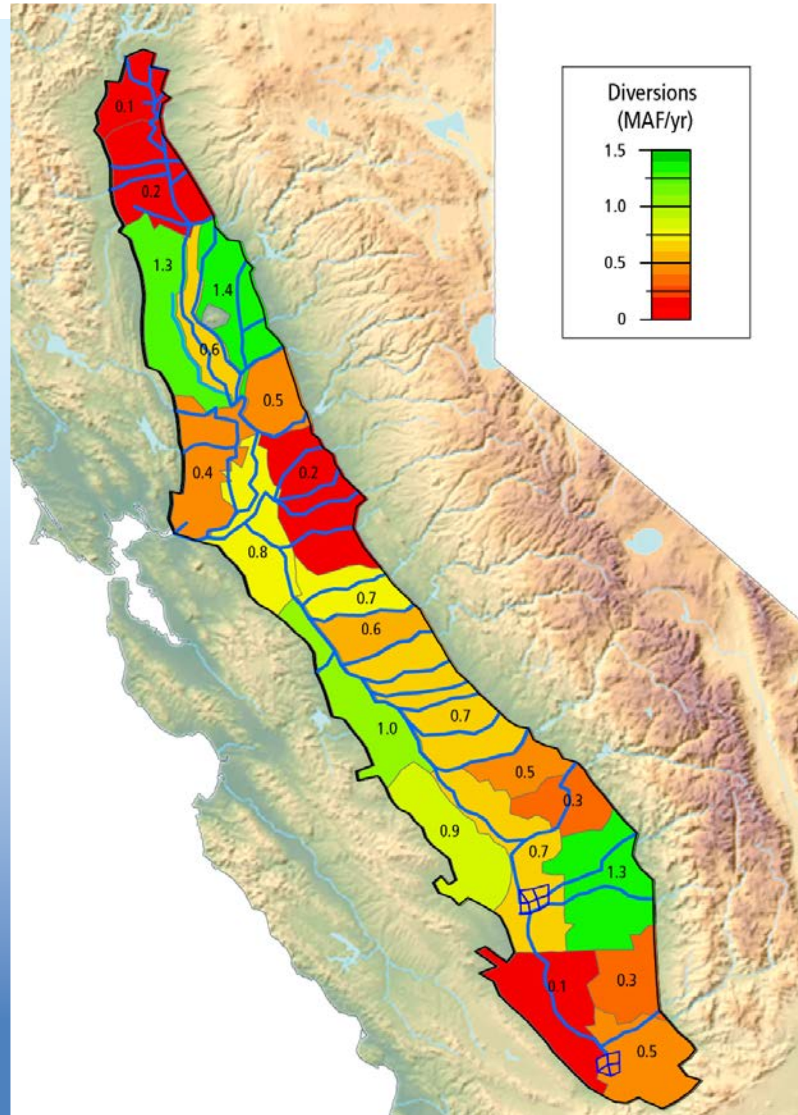


Land-Surface Water Balance



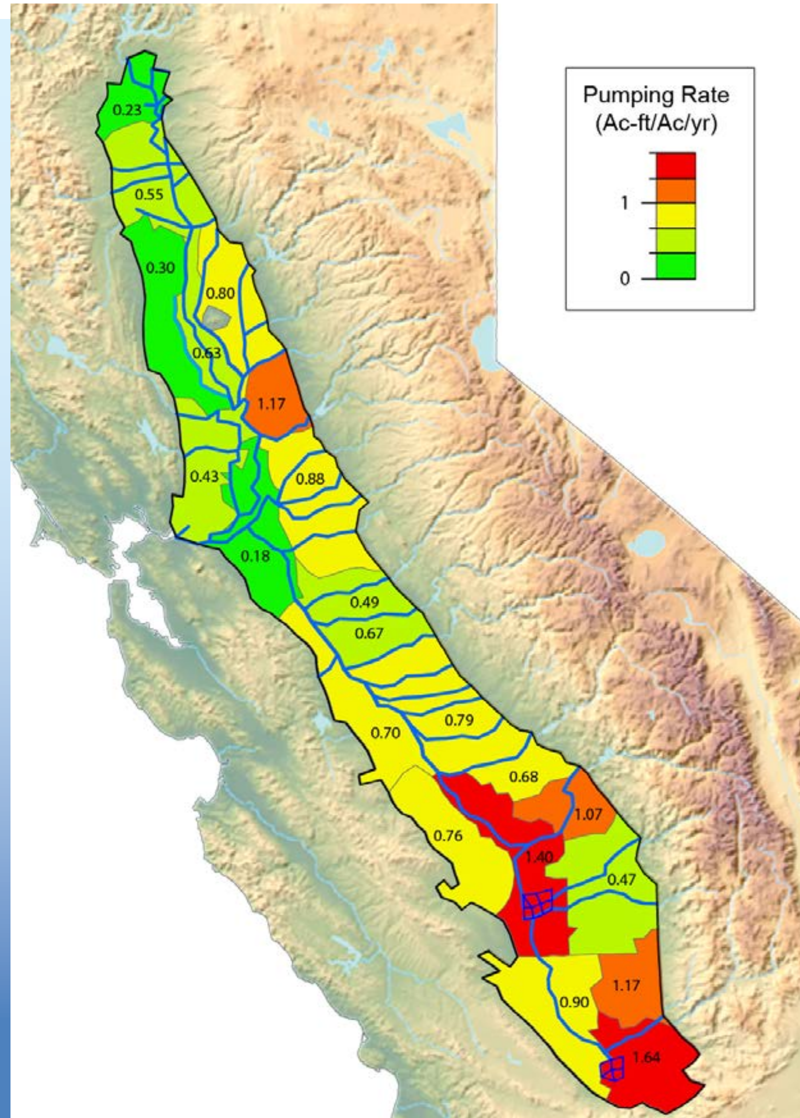
Surface Water Deliveries

2000-2009

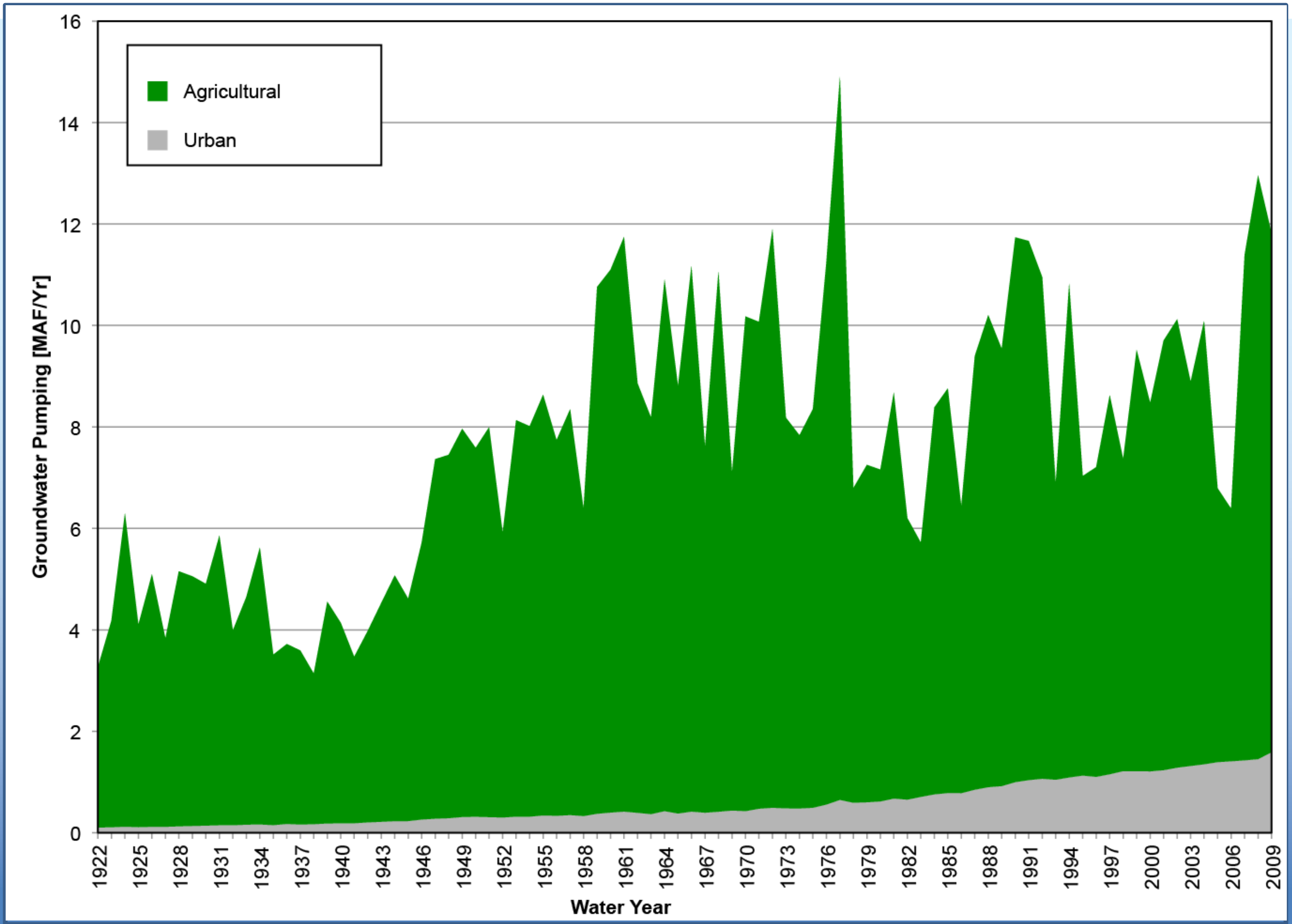


Groundwater Pumping

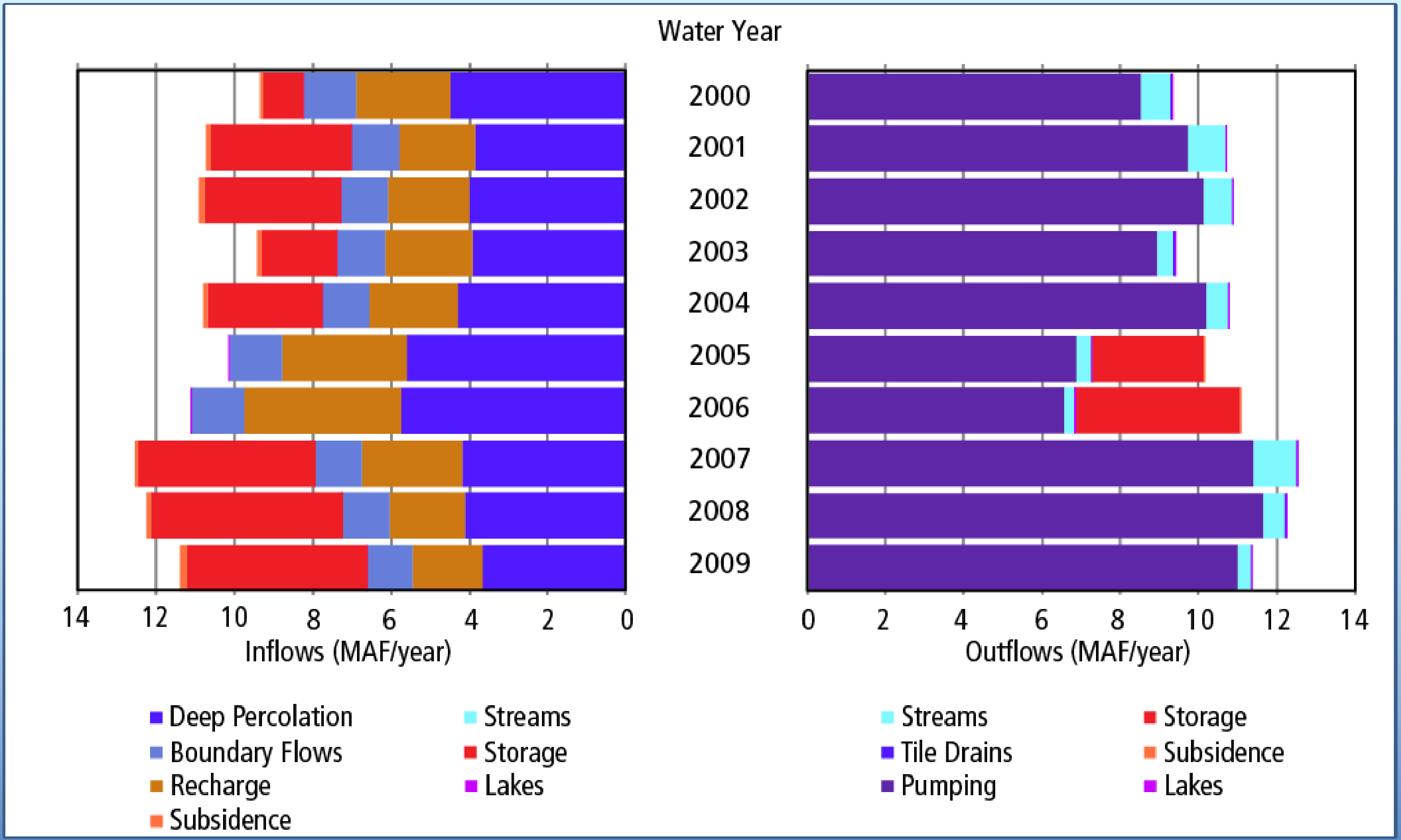
2000-2009



Groundwater Pumping

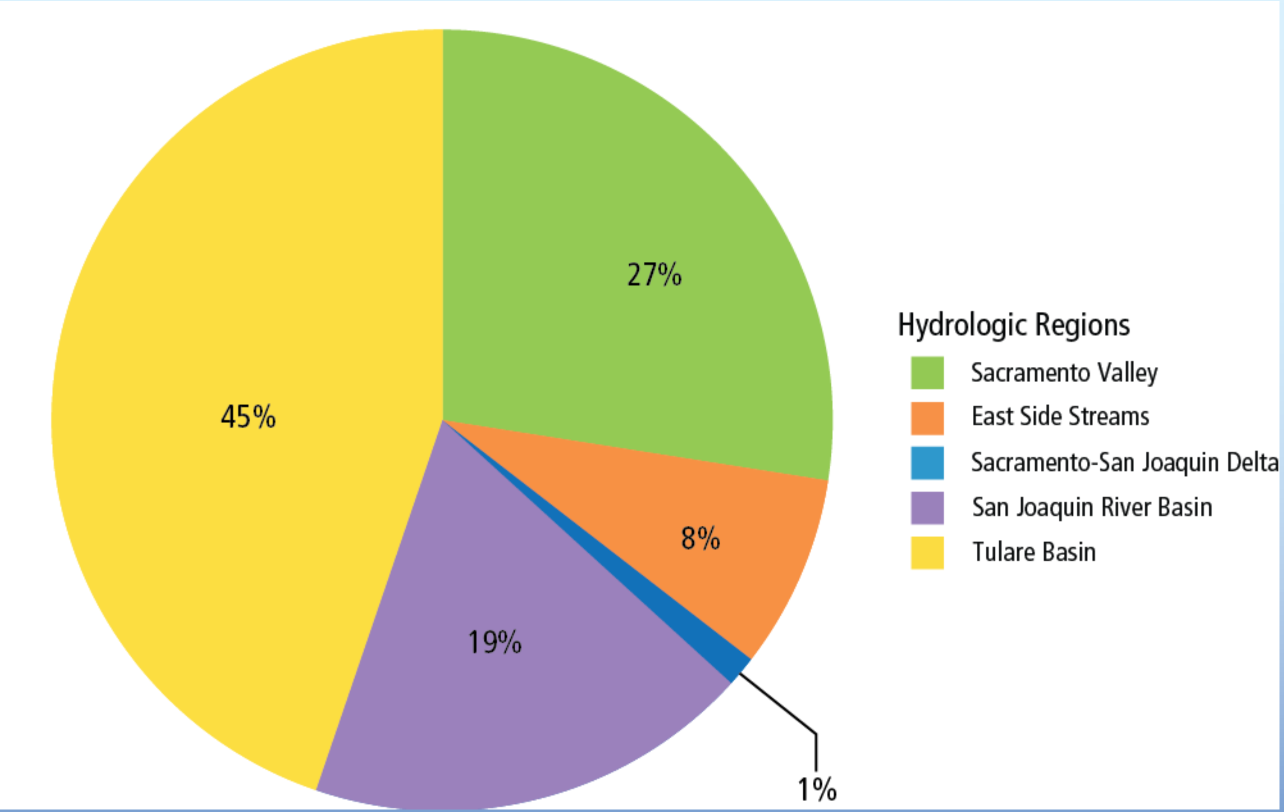


Aquifer Water Balance

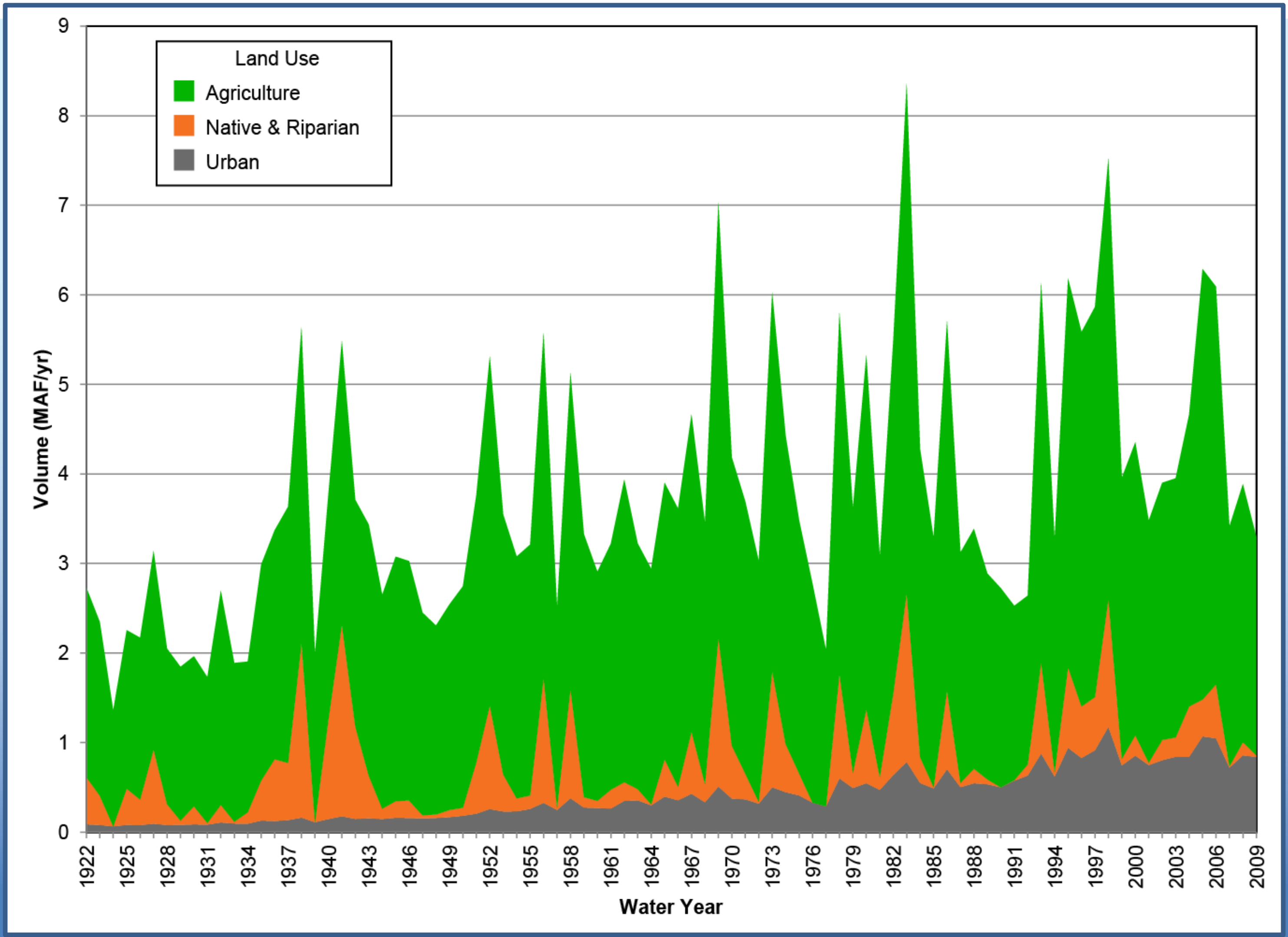


Groundwater Pumping

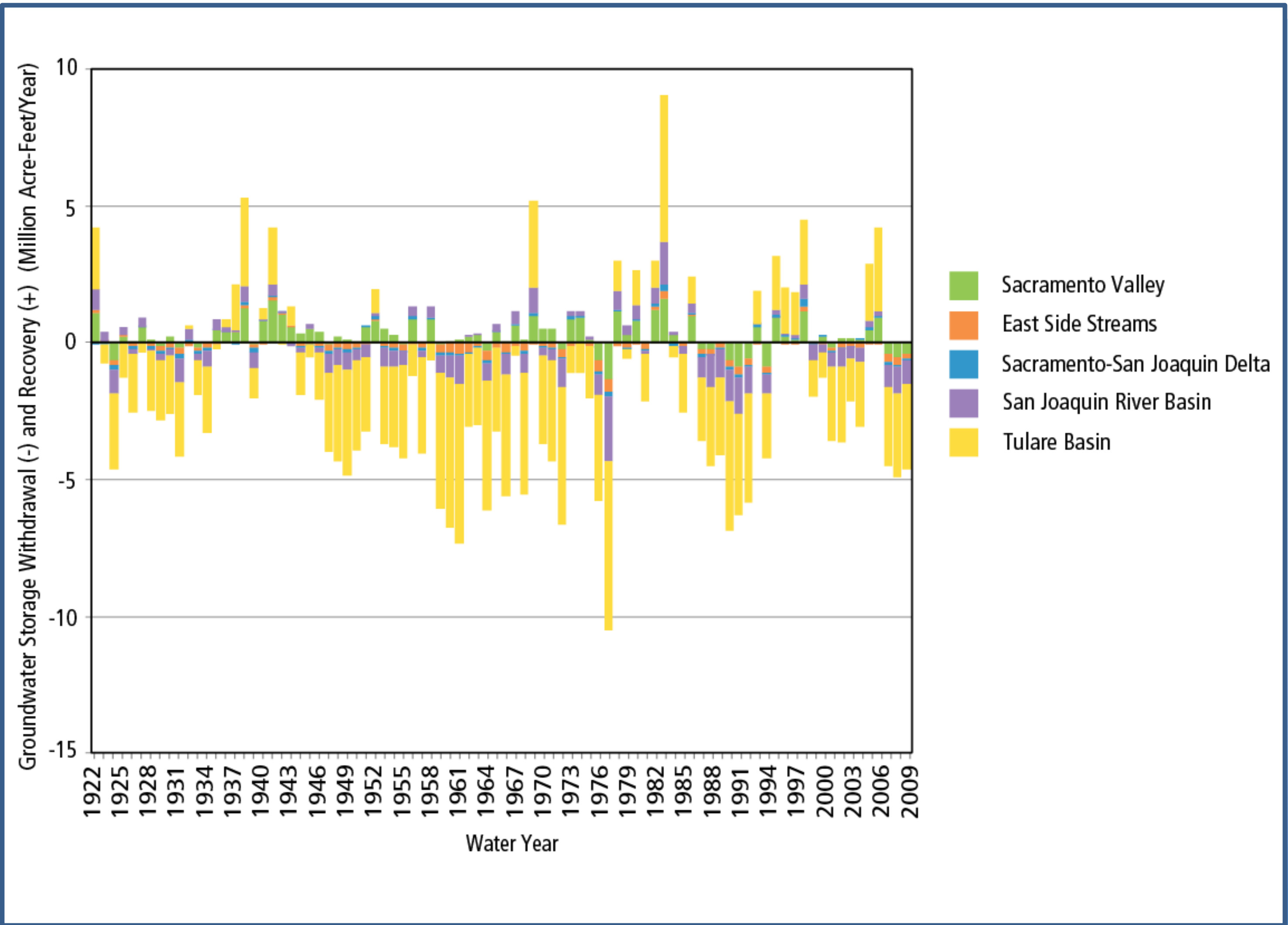
2000-2009



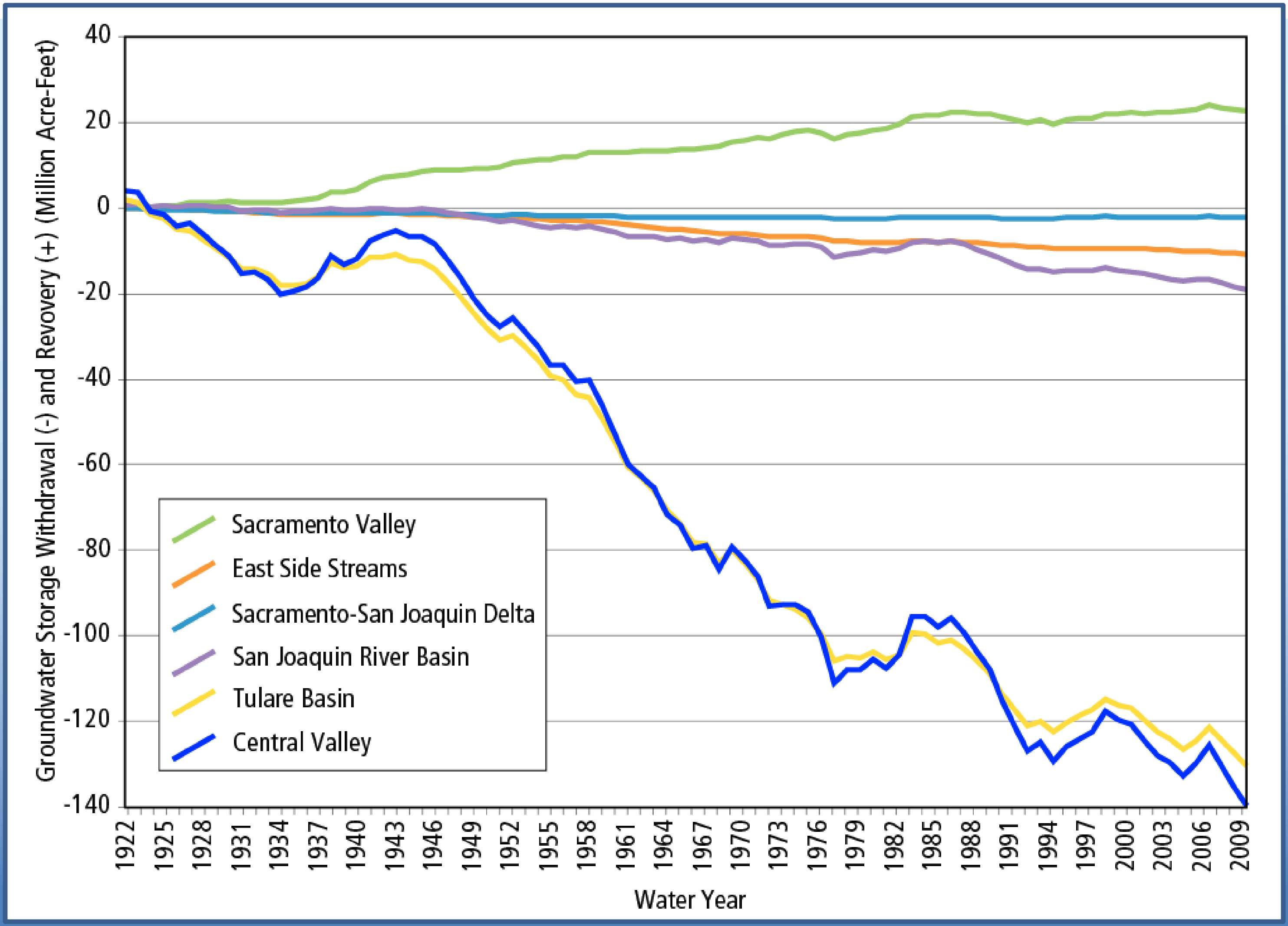
Deep Percolation



Groundwater Depletion

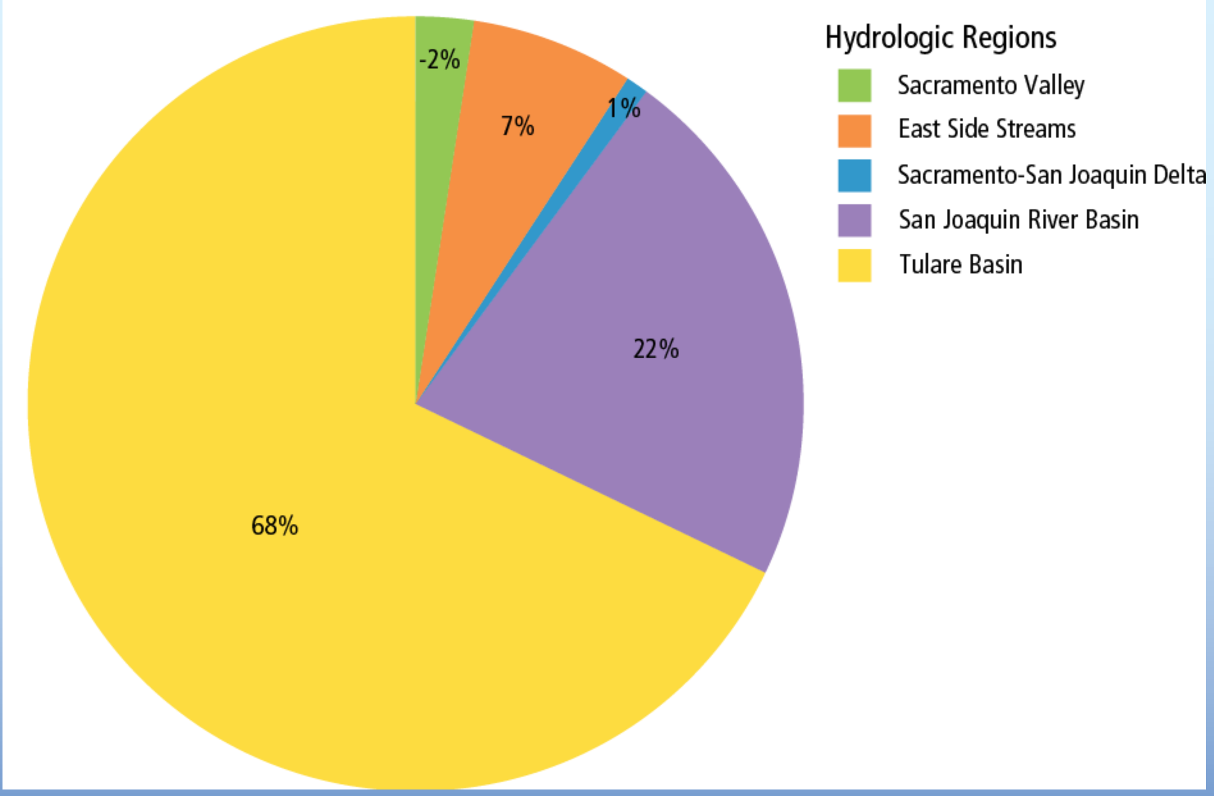


Groundwater Depletion

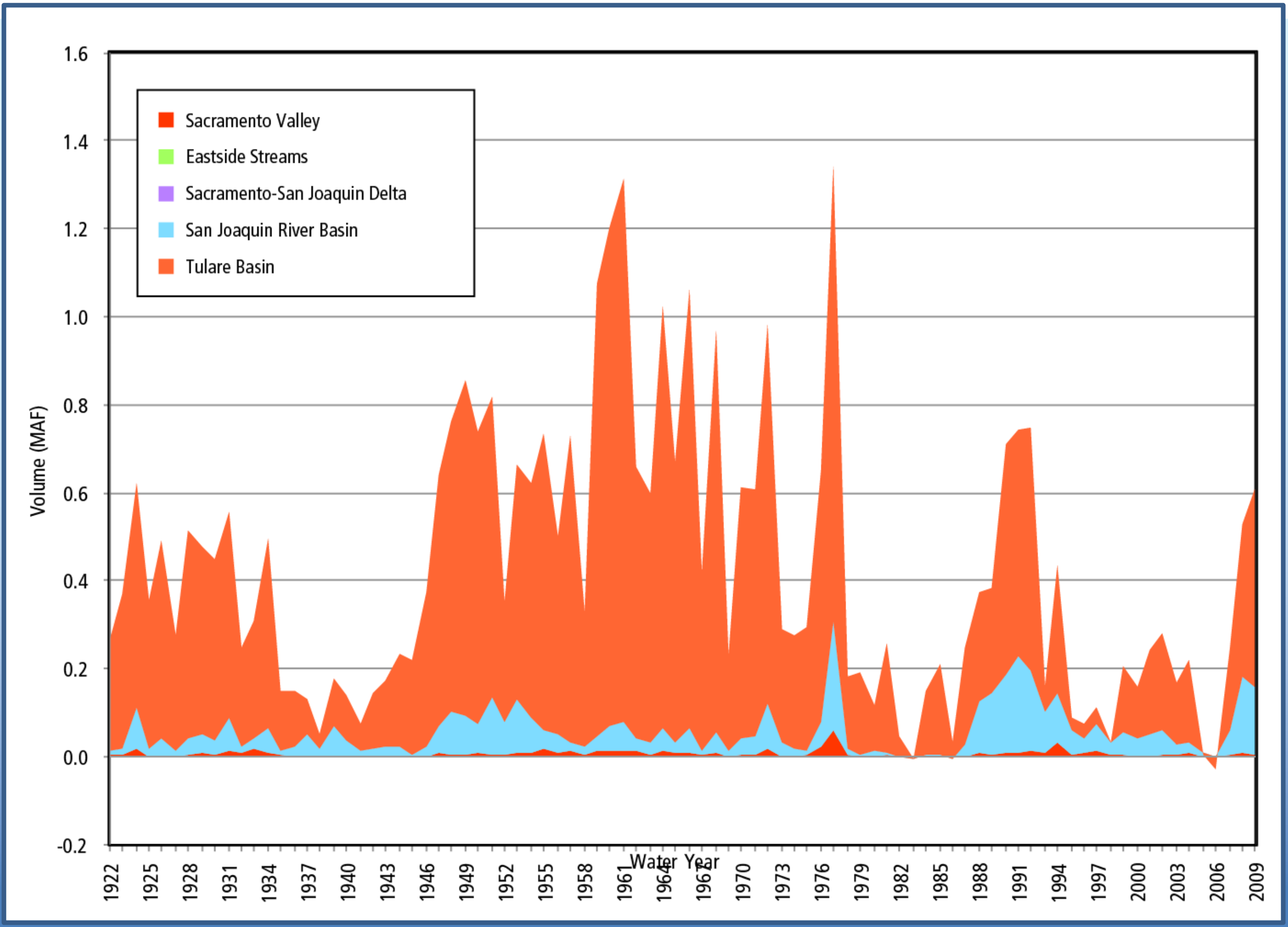


Groundwater Depletion

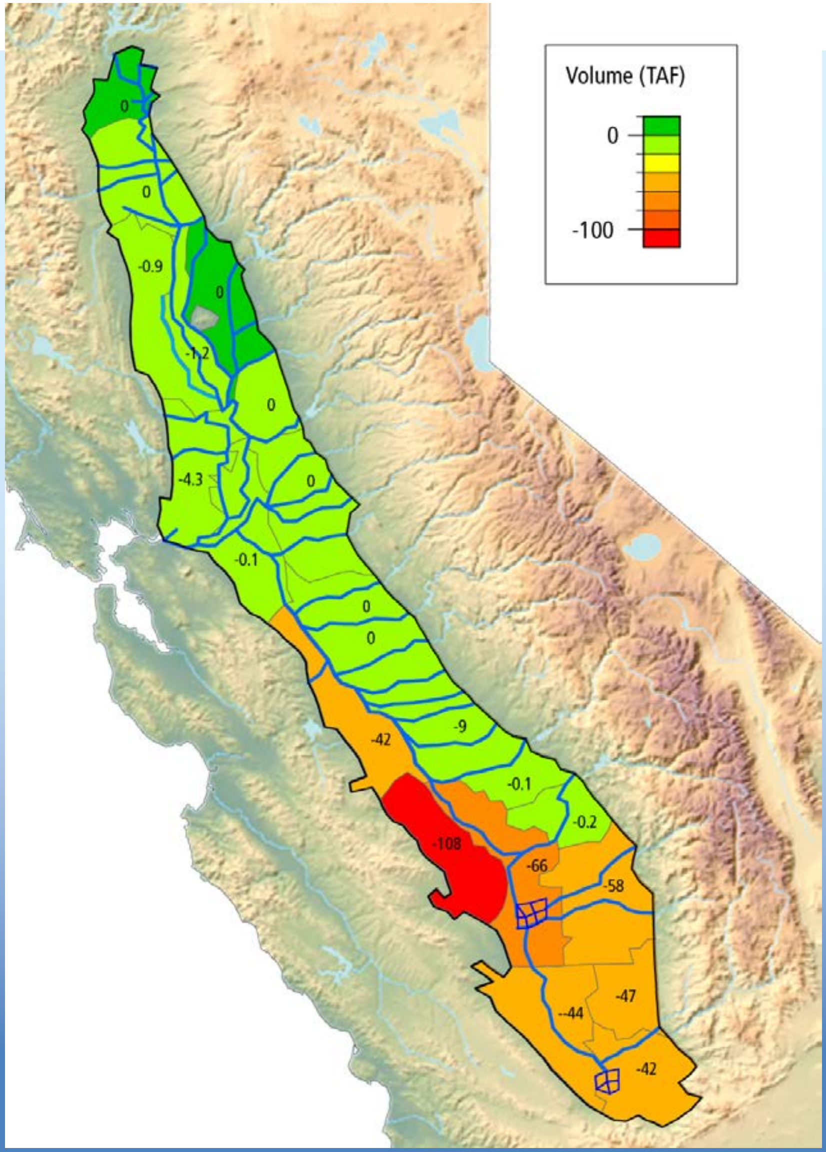
2000-2009



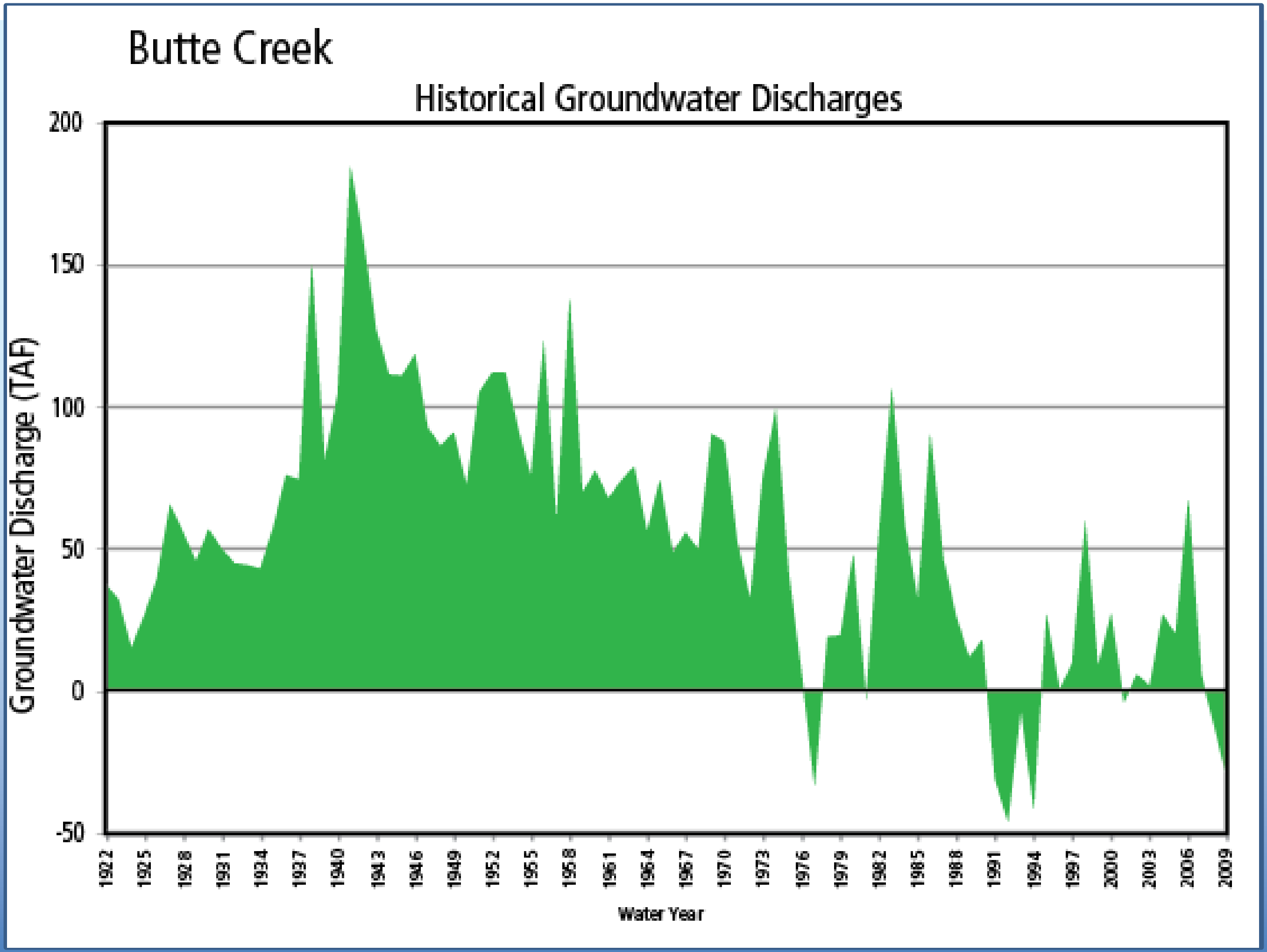
Groundwater Depletion



Subsidence, 2000-2009

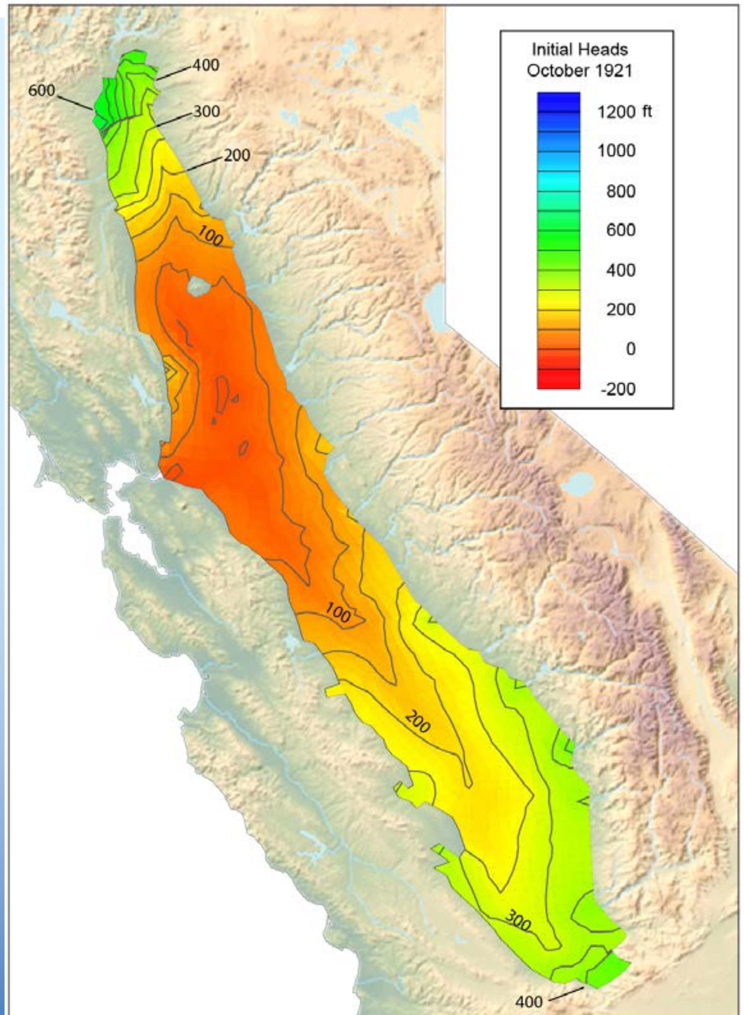


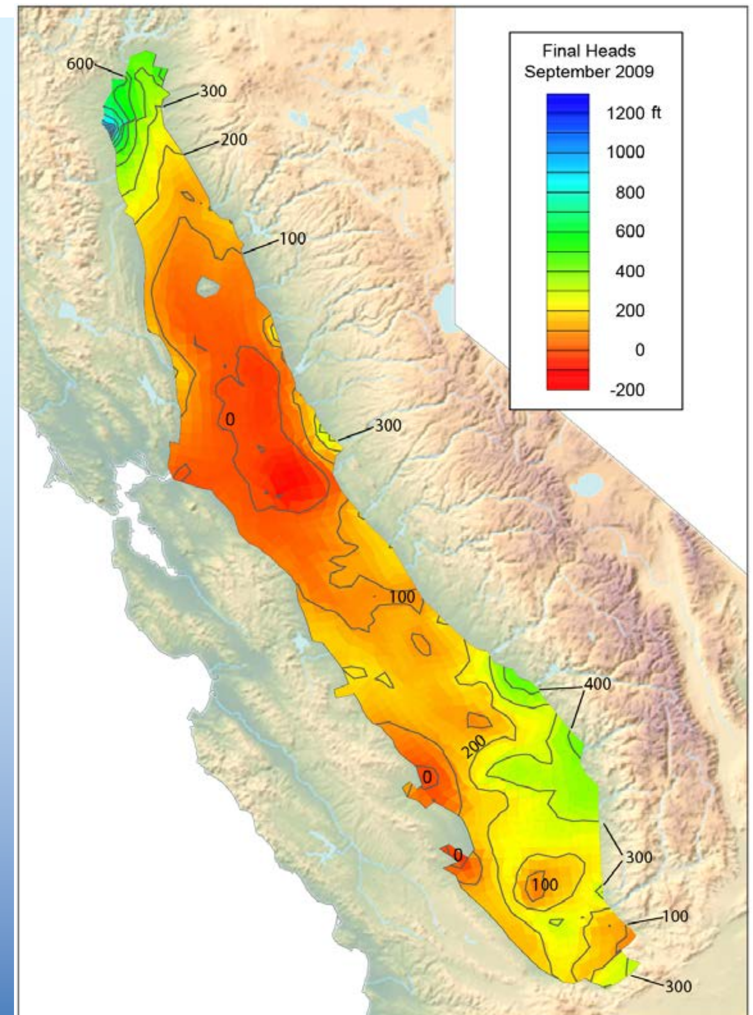
Stream-Groundwater Flows



Water Table Altitude

Produced from IWFM's TecPlot® output files



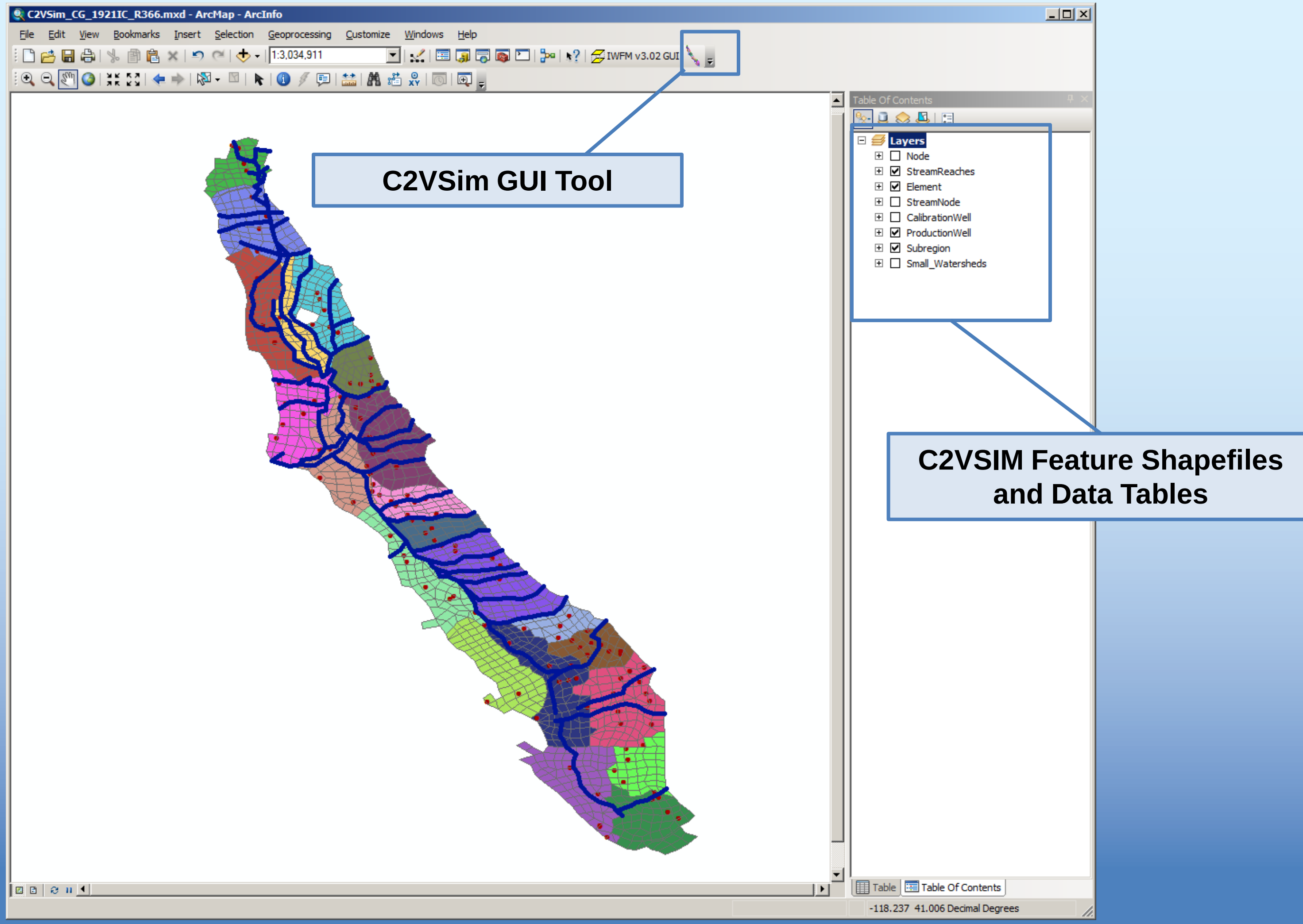


Key Limitations

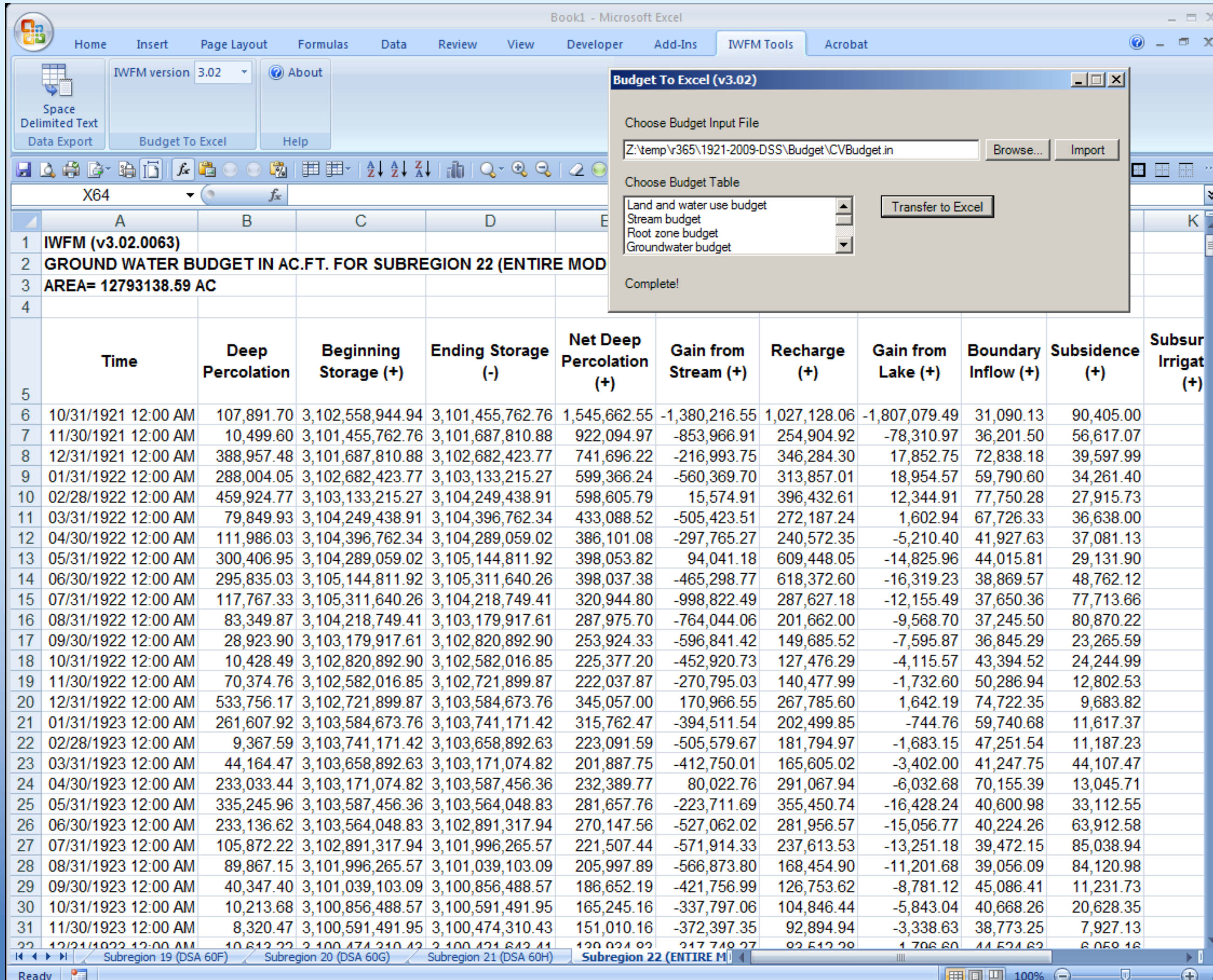
- Time step and stream routing: Stream flow must travel from upstream to downstream within the length of time step for the zero-storage assumption to be valid
- Time step and rainfall runoff: Re-calibrate curve numbers for different time steps (for C2VSim, the input data time step is itself a limitation)
- Spatial scale of demand and supply: Demand and supply computations are performed at the subregion level
- Vertical distribution of pumping: Static distribution limits the ability to simulate changes in the pumping depth during simulation period
- Aquifer and root zone thickness: Aquifer thickness should be large compared to root zone thickness to minimize error in case groundwater table is close to ground surface; likely to occur in native and riparian vegetation areas

C2VSim ArcGIS Tool

ArcGIS tool to display model output (based on RMC-WRIME tool)



IWFM Excel Add-In



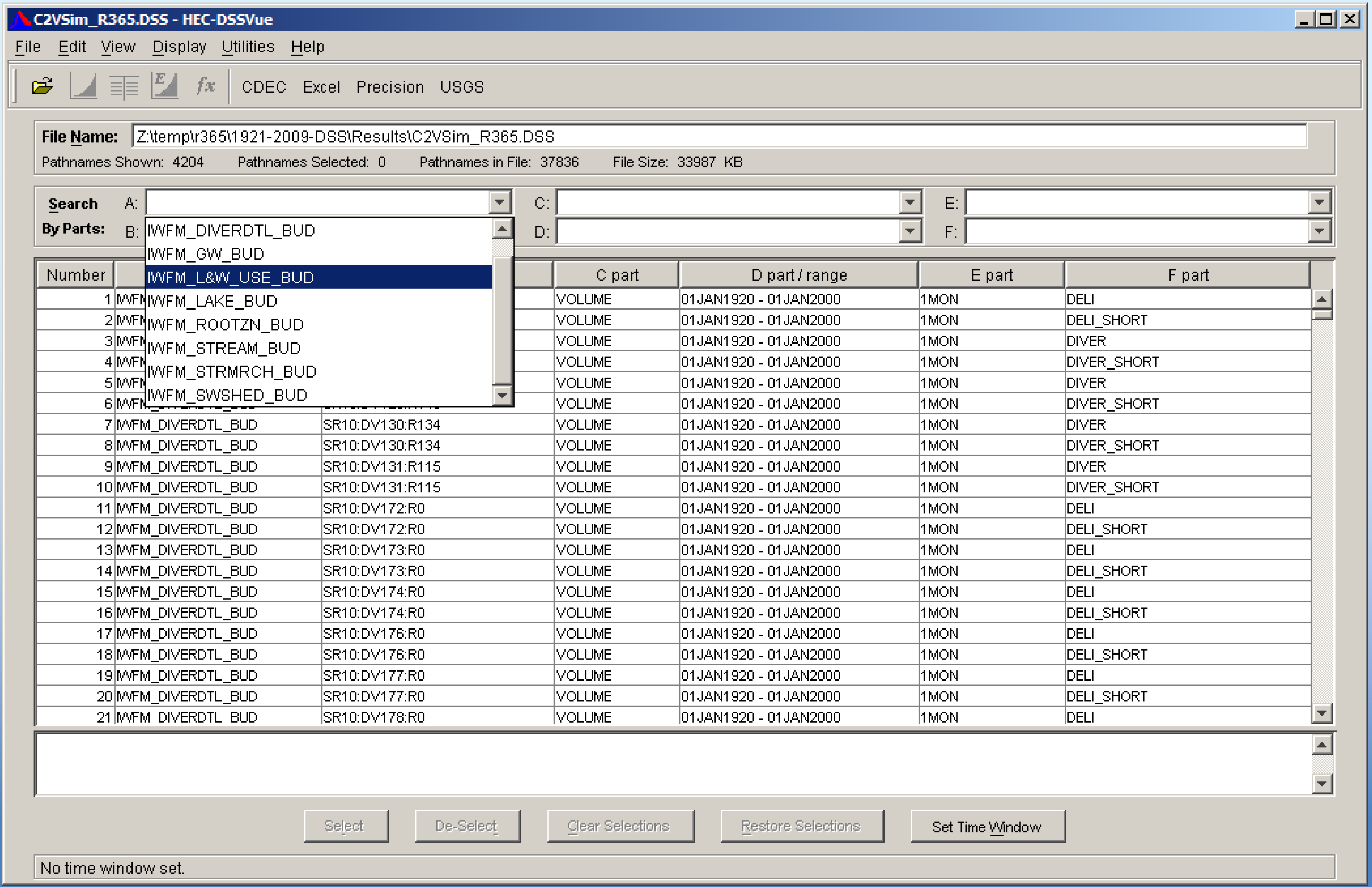
IWFM (v3.02.0063)

GROUND WATER BUDGET IN AC.FT. FOR SUBREGION 22 (ENTIRE MOD

AREA= 12793138.59 AC

Time	Deep Percolation	Beginning Storage (+)	Ending Storage (-)	Net Deep Percolation (+)	Gain from Stream (+)	Recharge (+)	Gain from Lake (+)	Boundary Inflow (+)	Subsidence (+)	Subsur Irrigat (+)
10/31/1921 12:00 AM	107,891.70	3,102,558,944.94	3,101,455,762.76	1,545,662.55	-1,380,216.55	1,027,128.06	-1,807,079.49	31,090.13	90,405.00	
11/30/1921 12:00 AM	10,499.60	3,101,455,762.76	3,101,687,810.88	922,094.97	-853,966.91	254,904.92	-78,310.97	36,201.50	56,617.07	
12/31/1921 12:00 AM	388,957.48	3,101,687,810.88	3,102,682,423.77	741,696.22	-216,993.75	346,284.30	17,852.75	72,838.18	39,597.99	
01/31/1922 12:00 AM	288,004.05	3,102,682,423.77	3,103,133,215.27	599,366.24	-560,369.70	313,857.01	18,954.57	59,790.60	34,261.40	
02/28/1922 12:00 AM	459,924.77	3,103,133,215.27	3,104,249,438.91	598,605.79	15,574.91	396,432.61	12,344.91	77,750.28	27,915.73	
03/31/1922 12:00 AM	79,849.93	3,104,249,438.91	3,104,396,762.34	433,088.52	-505,423.51	272,187.24	1,602.94	67,726.33	36,638.00	
04/30/1922 12:00 AM	111,986.03	3,104,396,762.34	3,104,289,059.02	386,101.08	-297,765.27	240,572.35	-5,210.40	41,927.63	37,081.13	
05/31/1922 12:00 AM	300,406.95	3,104,289,059.02	3,105,144,811.92	398,053.82	94,041.18	609,448.05	-14,825.96	44,015.81	29,131.90	
06/30/1922 12:00 AM	295,835.03	3,105,144,811.92	3,105,311,640.26	398,037.38	-465,298.77	618,372.60	-16,319.23	38,869.57	48,762.12	
07/31/1922 12:00 AM	117,767.33	3,105,311,640.26	3,104,218,749.41	320,944.80	-998,822.49	287,627.18	-12,155.49	37,650.36	77,713.66	
08/31/1922 12:00 AM	83,349.87	3,104,218,749.41	3,103,179,917.61	287,975.70	-764,044.06	201,662.00	-9,568.70	37,245.50	80,870.22	
09/30/1922 12:00 AM	28,923.90	3,103,179,917.61	3,102,820,892.90	253,924.33	-596,841.42	149,685.52	-7,595.87	36,845.29	23,265.59	
10/31/1922 12:00 AM	10,428.49	3,102,820,892.90	3,102,582,016.85	225,377.20	-452,920.73	127,476.29	-4,115.57	43,394.52	24,244.99	
11/30/1922 12:00 AM	70,374.76	3,102,582,016.85	3,102,721,899.87	222,037.87	-270,795.03	140,477.99	-1,732.60	50,286.94	12,802.53	
12/31/1922 12:00 AM	533,756.17	3,102,721,899.87	3,103,584,673.76	345,057.00	170,966.55	267,785.60	1,642.19	74,722.35	9,683.82	
01/31/1923 12:00 AM	261,607.92	3,103,584,673.76	3,103,741,171.42	315,762.47	-394,511.54	202,499.85	-744.76	59,740.68	11,617.37	
02/28/1923 12:00 AM	9,367.59	3,103,741,171.42	3,103,658,892.63	223,091.59	-505,579.67	181,794.97	-1,683.15	47,251.54	11,187.23	
03/31/1923 12:00 AM	44,164.47	3,103,658,892.63	3,103,171,074.82	201,887.75	-412,750.01	165,605.02	-3,402.00	41,247.75	44,107.47	
04/30/1923 12:00 AM	233,033.44	3,103,171,074.82	3,103,587,456.36	232,389.77	80,022.76	291,067.94	-6,032.68	70,155.39	13,045.71	
05/31/1923 12:00 AM	335,245.96	3,103,587,456.36	3,103,564,048.83	281,657.76	-223,711.69	355,450.74	-16,428.24	40,600.98	33,112.55	
06/30/1923 12:00 AM	233,136.62	3,103,564,048.83	3,102,891,317.94	270,147.56	-527,062.02	281,956.57	-15,056.77	40,224.26	63,912.58	
07/31/1923 12:00 AM	105,872.22	3,102,891,317.94	3,101,996,265.57	221,507.44	-571,914.33	237,613.53	-13,251.18	39,472.15	85,038.94	
08/31/1923 12:00 AM	89,867.15	3,101,996,265.57	3,101,039,103.09	205,997.89	-566,873.80	168,454.90	-11,201.68	39,056.09	84,120.98	
09/30/1923 12:00 AM	40,347.40	3,101,039,103.09	3,100,856,488.57	186,652.19	-421,756.99	126,753.62	-8,781.12	45,086.41	11,231.73	
10/31/1923 12:00 AM	10,213.68	3,100,856,488.57	3,100,591,491.95	165,245.16	-337,797.06	104,846.44	-5,843.04	40,668.26	20,628.35	
11/30/1923 12:00 AM	8,320.47	3,100,591,491.95	3,100,474,310.43	151,010.16	-372,397.35	92,894.94	-3,338.63	38,773.25	7,927.13	

HEC-DSS


C2VSim_R365.DSS - HEC-DSSVue
File Edit View Display Utilities Help
CDEC Excel Precision USGS
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Pathnames Shown: 4204 Pathnames Selected: 0 Pathnames in File: 37836 File Size: 33987 KB
Search By Parts: A: B: C: D: E: F:
IWFM_DIVERDTL_BUD
IWFM_GW_BUD
IWFM_L&W_USE_BUD
IWFM_LAKE_BUD
IWFM_ROOTZN_BUD
IWFM_STREAM_BUD
IWFM_STRMRCH_BUD
IWFM_SWSHED_BUD
Number C part D part / range E part F part
1 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DELI
2 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DELI_SHORT
3 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DIVER
4 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DIVER_SHORT
5 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DIVER
6 IWFM VOLUME 01JAN1920 - 01JAN2000 1MON DIVER_SHORT
7 IWFM_DIVERDTL_BUD SR10:DV130:R134 VOLUME 01JAN1920 - 01JAN2000 1MON DIVER
8 IWFM_DIVERDTL_BUD SR10:DV130:R134 VOLUME 01JAN1920 - 01JAN2000 1MON DIVER_SHORT
9 IWFM_DIVERDTL_BUD SR10:DV131:R115 VOLUME 01JAN1920 - 01JAN2000 1MON DIVER
10 IWFM_DIVERDTL_BUD SR10:DV131:R115 VOLUME 01JAN1920 - 01JAN2000 1MON DIVER_SHORT
11 IWFM_DIVERDTL_BUD SR10:DV172:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI
12 IWFM_DIVERDTL_BUD SR10:DV172:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI_SHORT
13 IWFM_DIVERDTL_BUD SR10:DV173:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI
14 IWFM_DIVERDTL_BUD SR10:DV173:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI_SHORT
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20 IWFM_DIVERDTL_BUD SR10:DV177:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI_SHORT
21 IWFM_DIVERDTL_BUD SR10:DV178:R0 VOLUME 01JAN1920 - 01JAN2000 1MON DELI
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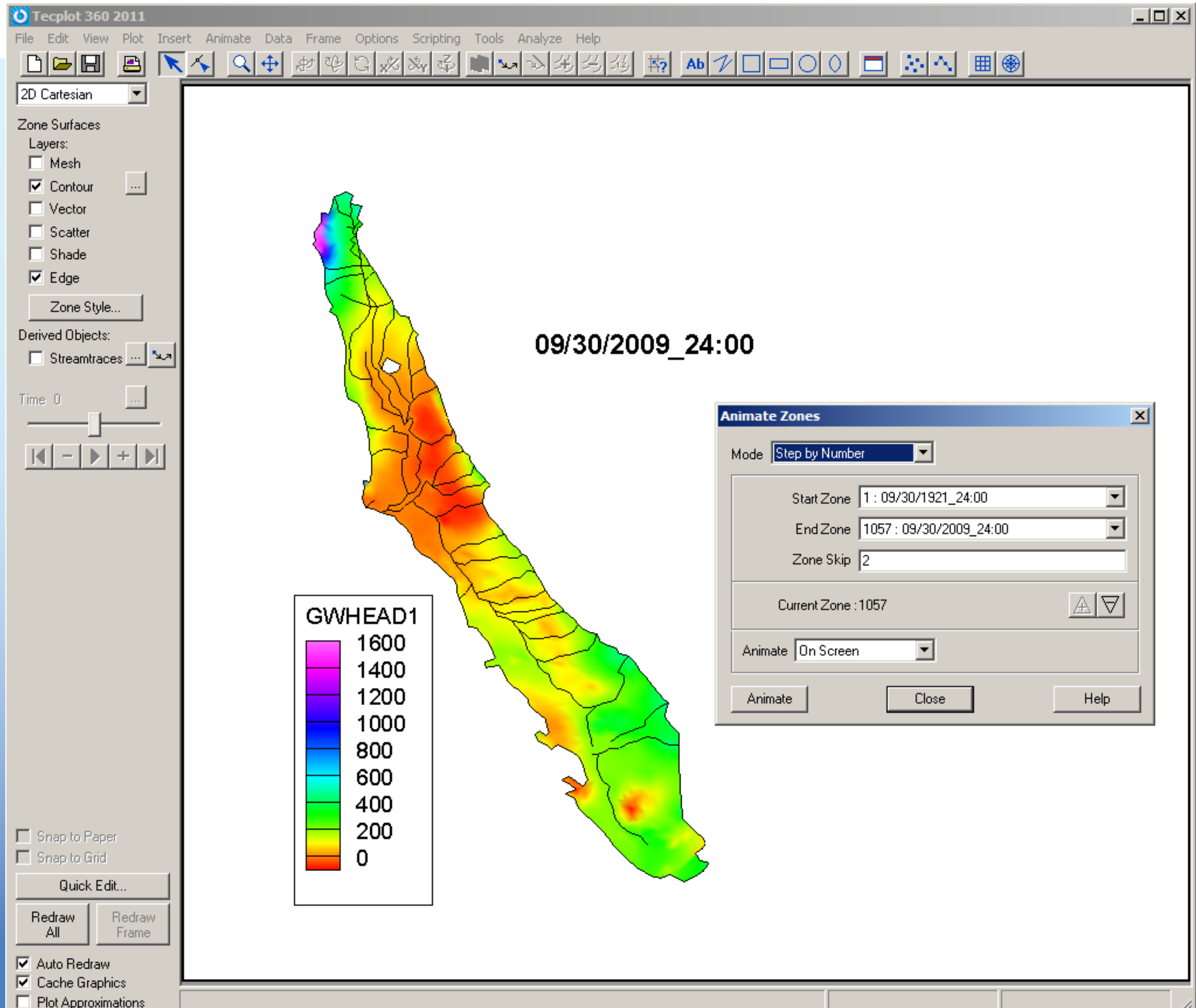
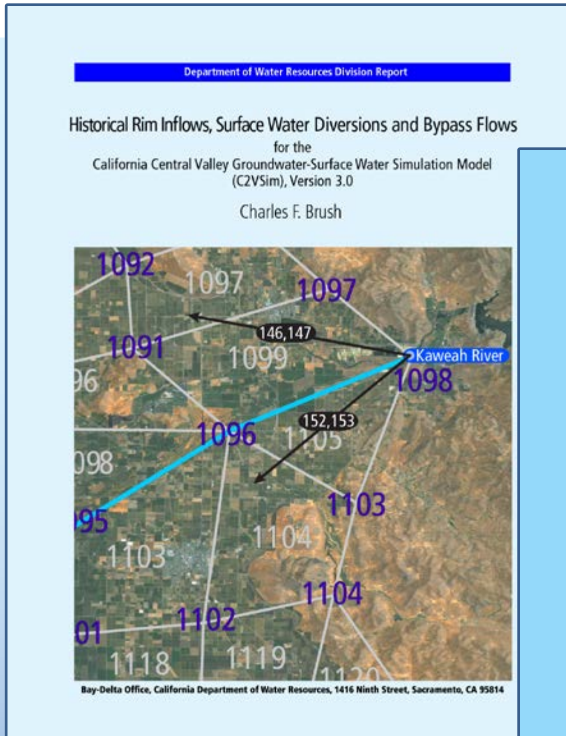
TecPlot-Ready Output



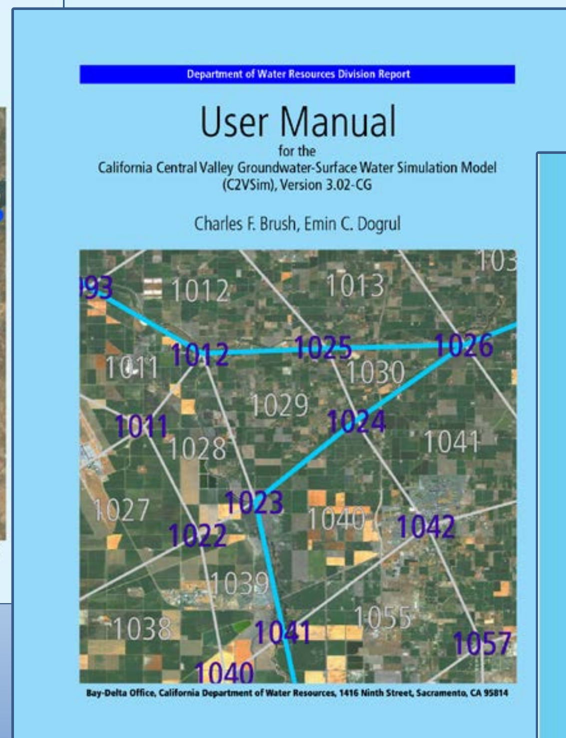
C2VSim Reports


Department of Water Resources Division Report

Historical Rim Inflows, Surface Water Diversions and Bypass Flows
for the
California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.0

Charles F. Brush

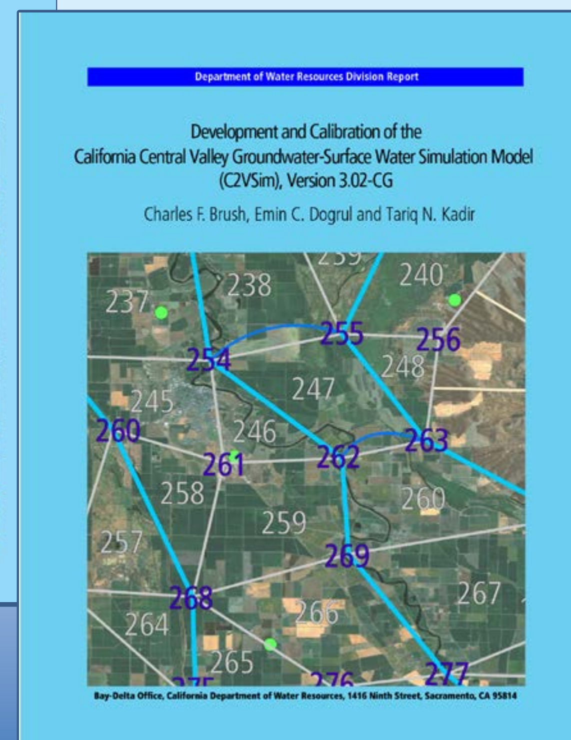
Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814


Department of Water Resources Division Report

User Manual
for the
California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG

Charles F. Brush, Emin C. Dogrul

Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814


Department of Water Resources Division Report

Development and Calibration of the
California Central Valley Groundwater-Surface Water Simulation Model (C2VSim), Version 3.02-CG

Charles F. Brush, Emin C. Dogrul and Tariq N. Kadir

Bay-Delta Office, California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814

C2VSim Coarse Grid

"C2VSim CG-3.02"

DWR Web Site

- Model files
- User Manual
- ArcGIS shapefiles
- C2VSim Tools
- IWFM Application
- IWFM Tools

Support

- **Training**: IWFM and C2VSim workshops will be offered through CWEMF
- **Technical support**: Email and telephone

A Google search for "C2VSim" brings up this page
Links will go 'live' with C2VSim public release

C2VSim Fine Grid

"C2VSim FG-3.02"

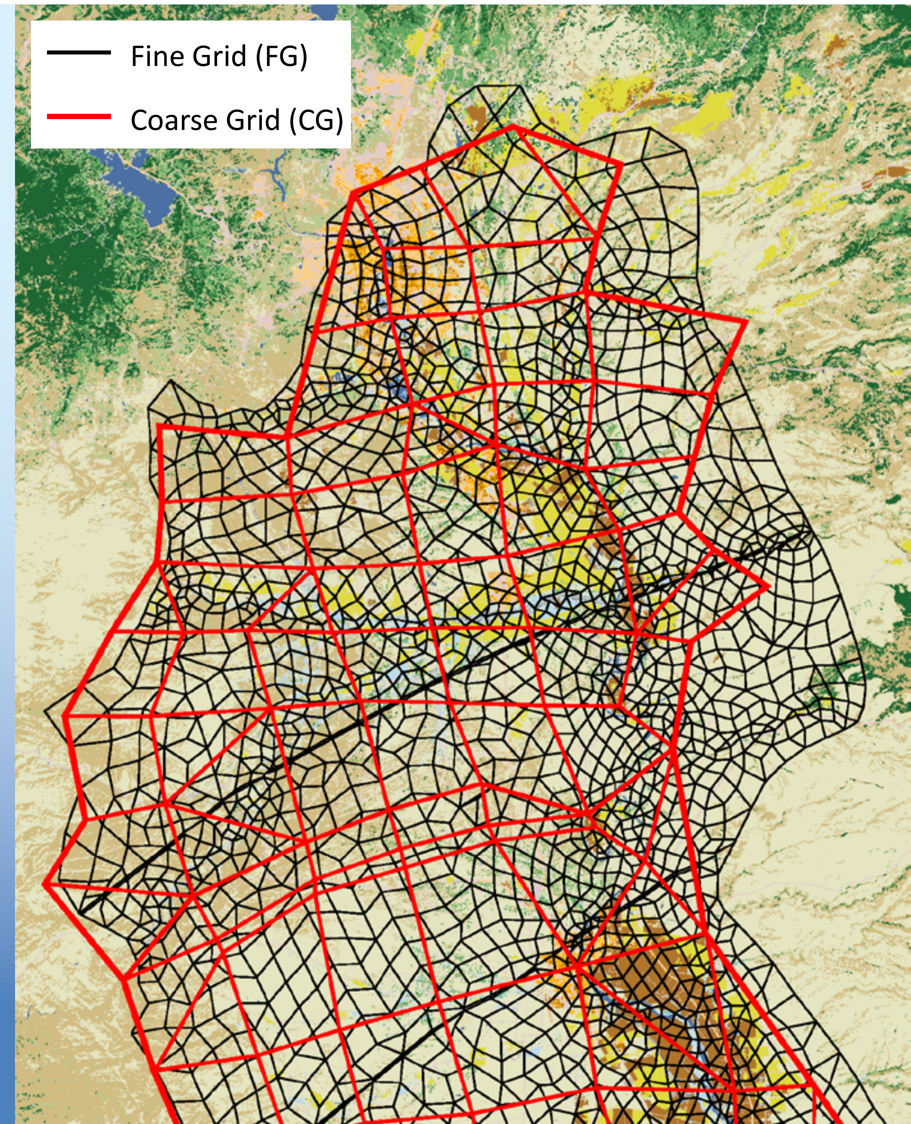
Nodal Spacing:
- 0.5 mi on rivers
- 1.5 mi on edge
- Average 0.6 mi^2

Model grid:
- 32,537 elements
- 30,179 nodes
- 4,529 river nodes

Run times:
- CG 88 yrs in 3-6 min
- FG 88 yrs in appx 6 hrs

Suggested uses:
- CG region-scale analyses
- FG local-scale analyses

Beta release after staff review
- Integrated with C2VSim ArcGIS tool



C2VSim Applications

- CalSim 3 groundwater component
- Integrated Regional Water Management Plans
- Stream-groundwater flows
- Climate change assessments
- Groundwater storage investigations
- Planning studies
- Ecosystem enhancement scenarios
- Infrastructure improvements
- Impacts of operations on Delta flows

Acknowledgements

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currently with: (1) MBK Engineers, (2) Groundwater Dynamics , (3) U. of San Francisco, (4) U. of Edinburgh