WESTSIM
APPLICATION OF IGSM2 TO THE WESTERN SAN JOAQUIN BASIN

Nigel W.T. Quinn, PhD, PE
U. S. Bureau of Reclamation, MP-700
Berkeley National Laboratory

Jonathan Goetz, PE and Jafar A. Faghih, PE
MWH Americas, Inc.

CWEMF
Asilomar
February 24, 2003

Outline

- WESTSIM Overview
- WESTSIM Data Management System (DMS)
- WESTSIM: An application of IGSM2
- Model Graphical User Interface of WESTSIM DMS
- Zone Budgets
- Conclusions/Future Work

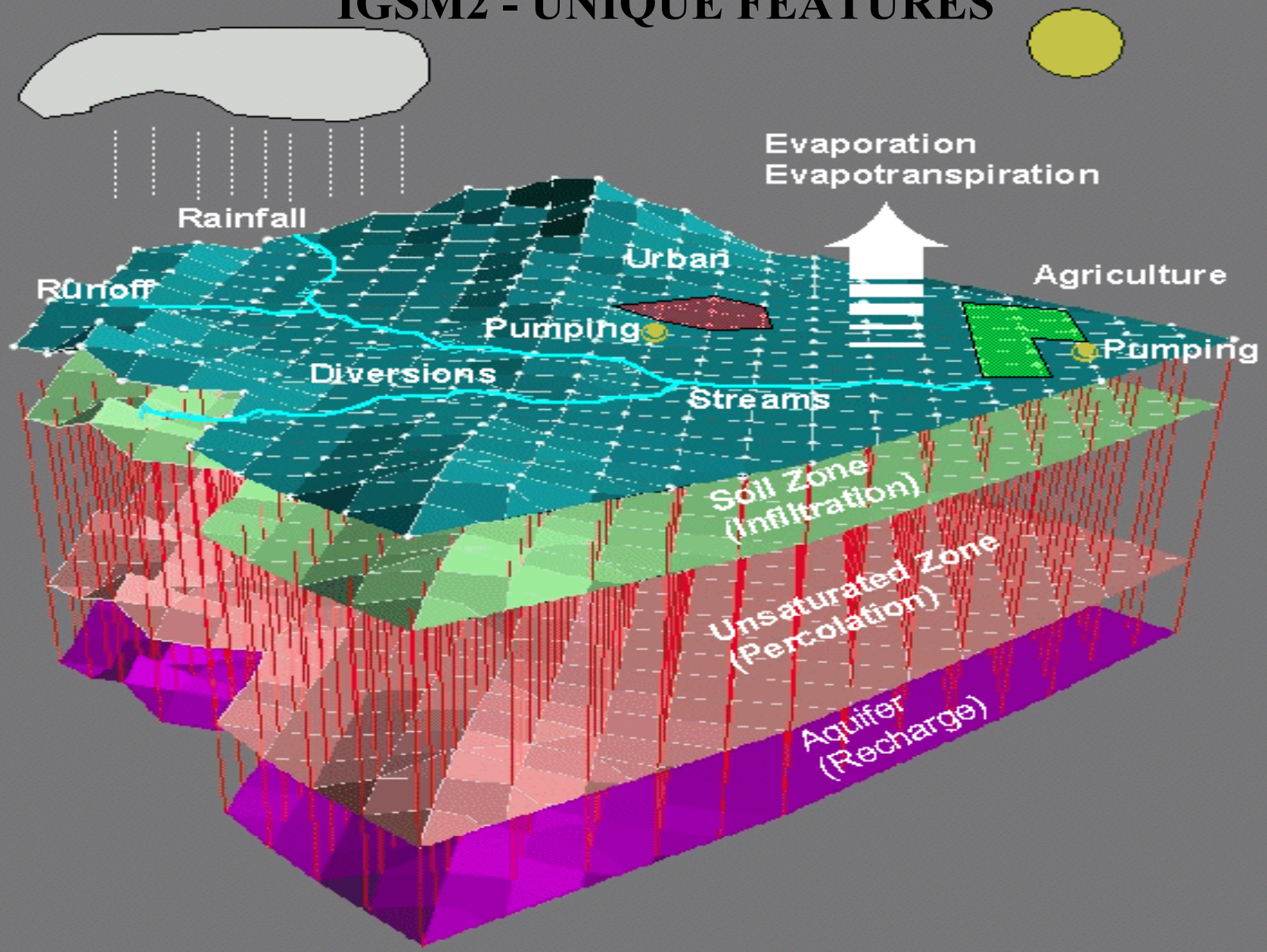
WESTSIM
Overview

WESTSIM MODEL

- West-side of San Joaquin Valley
- Considers land use, agricultural water use efficiency, efficiency,
  river diversions, return flows, small watersheds
- Root zone, shallow semi-confined and confined
  aquifer layers
- Simulates aquifer subsidence
- Monthly/daily model time step

APPLICATIONS : land retirement
conjunctive use planning
safe yield analysis
pumping impacts on subsidence

IGSM2 - UNIQUE FEATURES

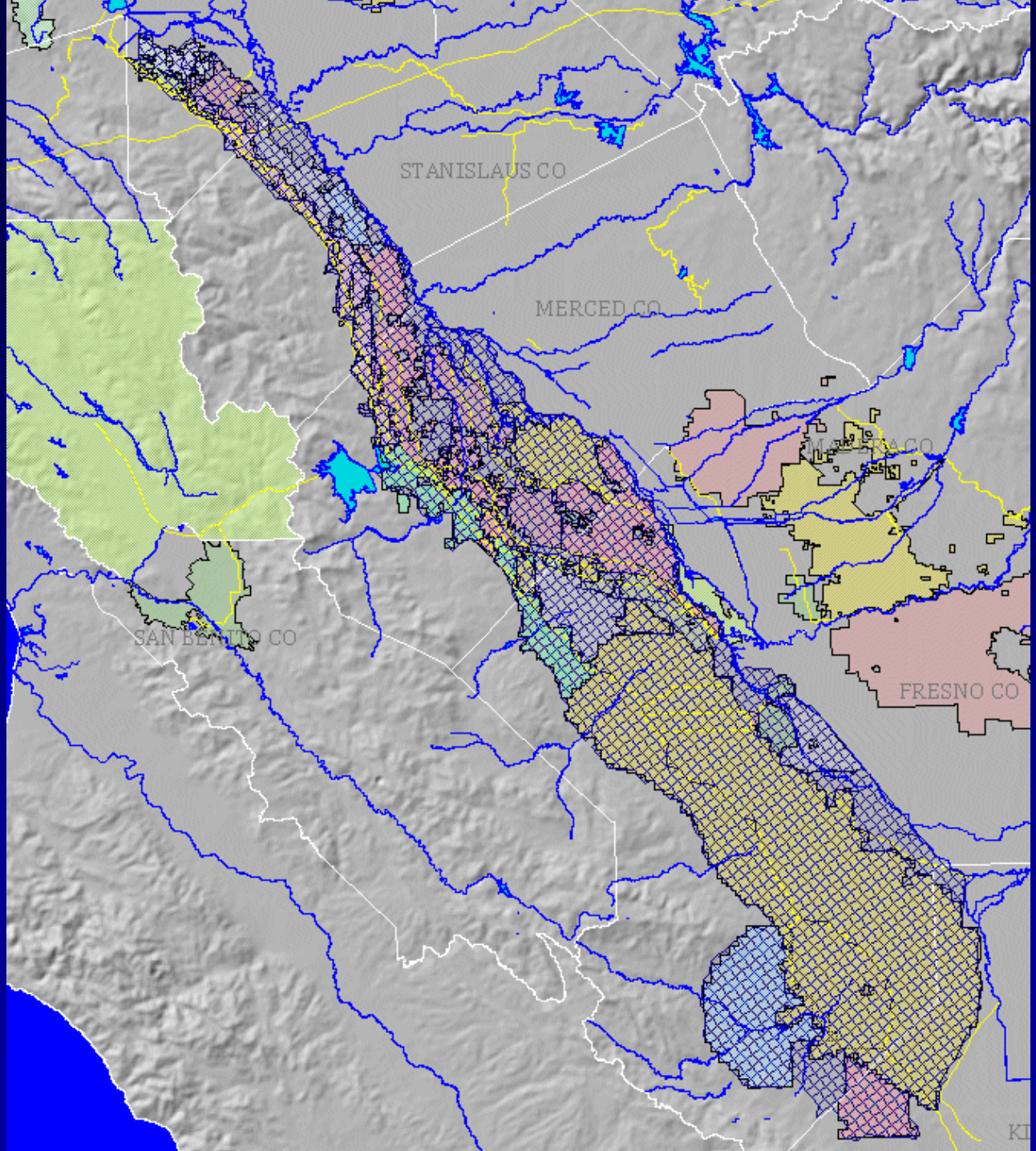


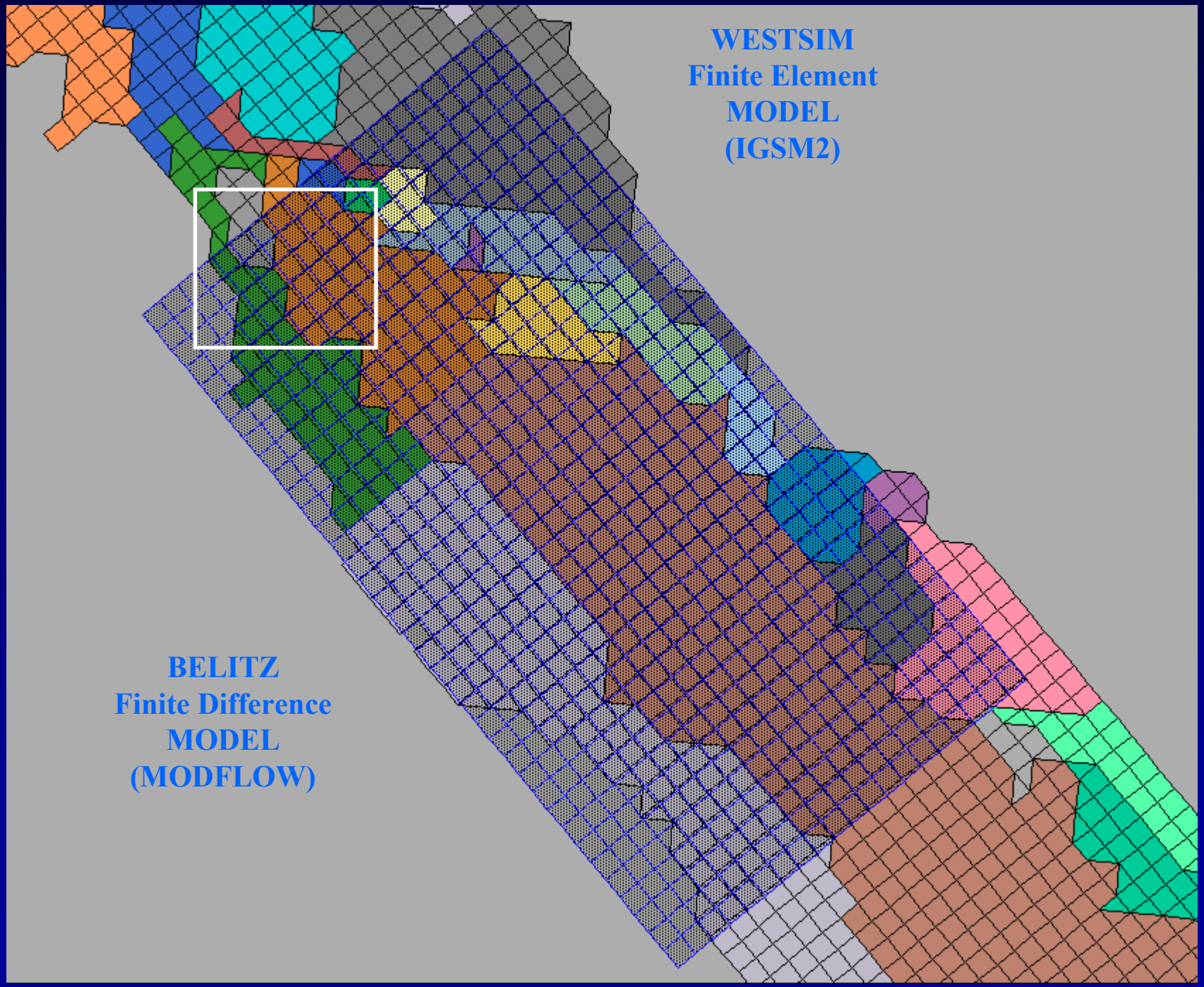
WESTSIM MODEL FEATURES

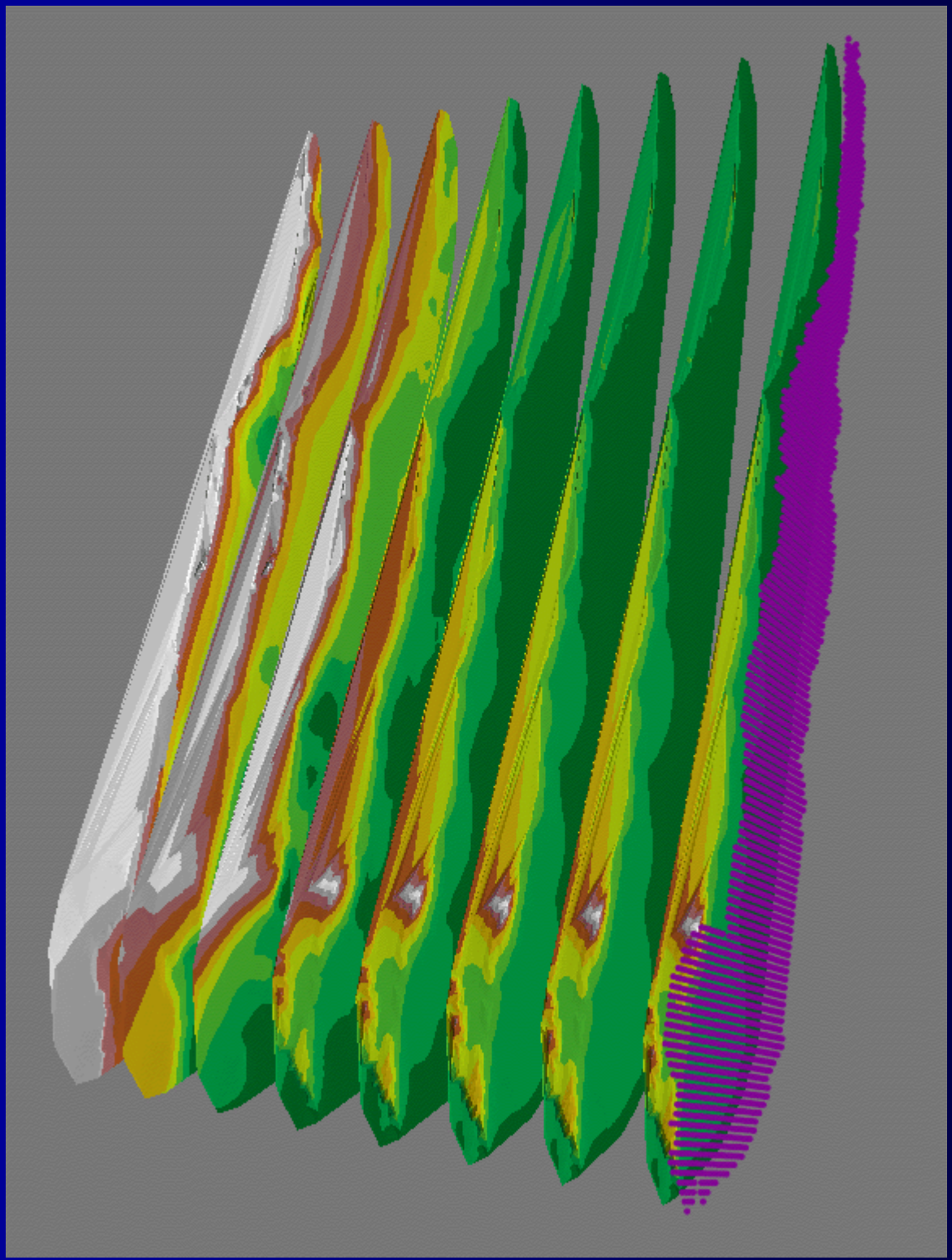
Model region	1,550,874	Acres
Subregions	63	WDs/IDs, Cities, Refuges, Other Unincorporated Areas
Elements	2,602	
Groundwater Nodes	2,716	
Crop types	16	
Aquifer layers	7	5 above Corcoran Clay
Land use types	4	Agricultural, urban, native vegetation, riparian
Streams Modeled	11	
Stream Nodes	278	
Small Watersheds	6	
Rainfall Stations	3	Tracy Carbona, Los Banos, Kettleman City
Simulation Time Step		Daily/Monthly
Water Years of Record		1970-2000

Westside of San Joaquin Basin

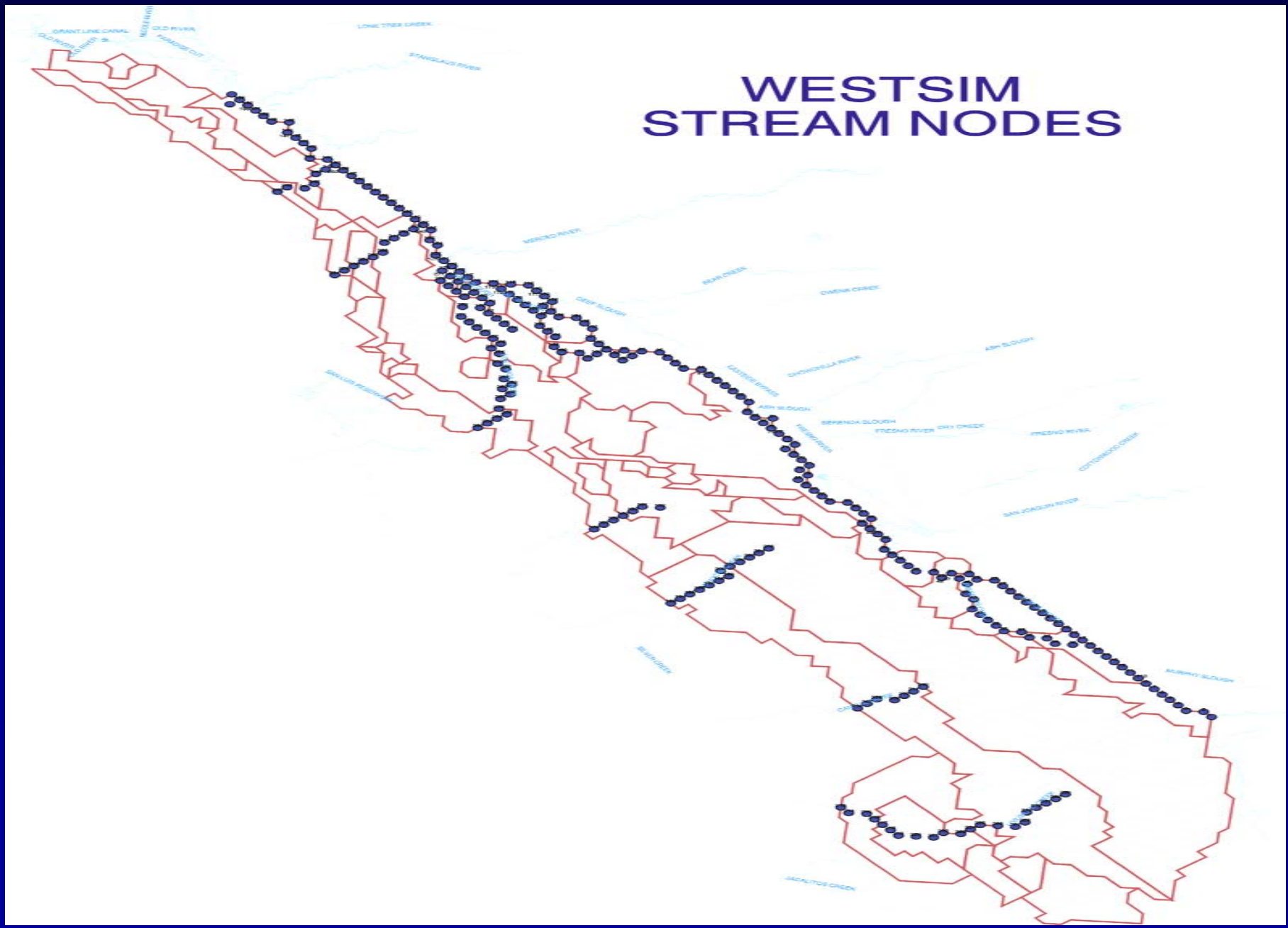
Water Districts as Budget Regions



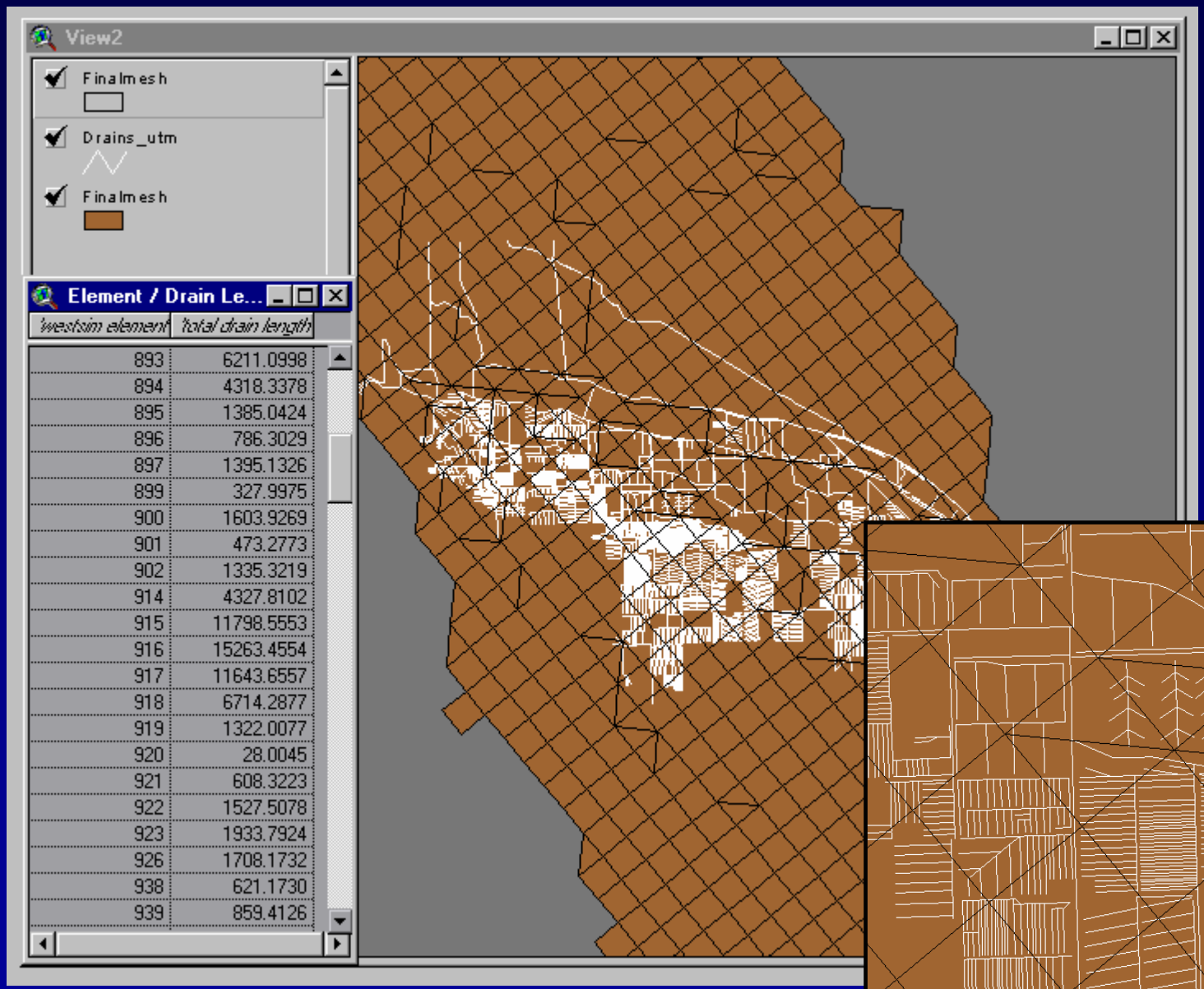

WESTSIM
Finite Element
MODEL
(IGSM2)
BELITZ
Finite Difference
MODEL
(MODFLOW)



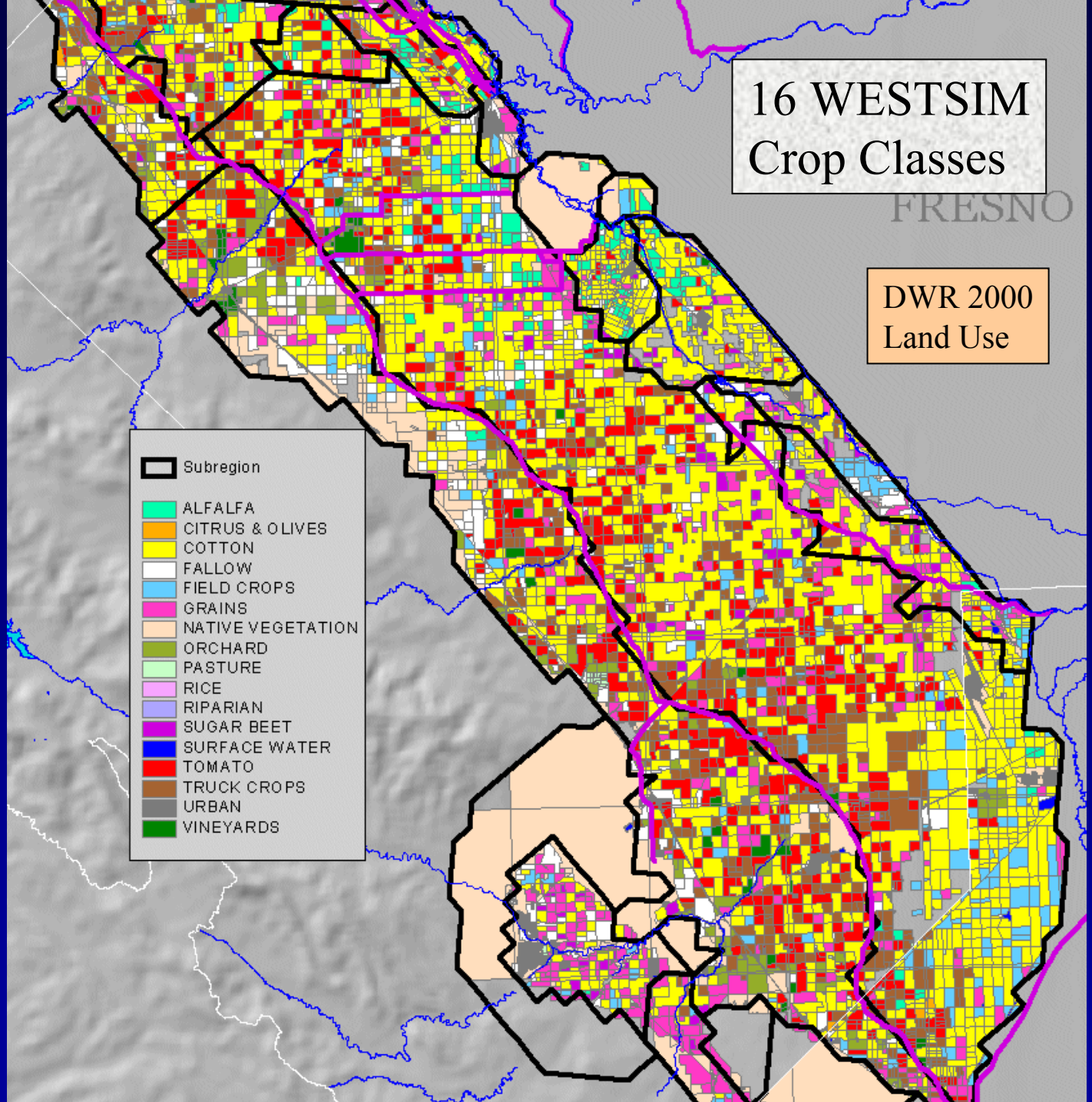
Model Layers - Aquifer Characteristics


WESTSIM
STREAM NODES

Total Drain Length per Element



Subregional Crop Data



WESTSIM
Data Management System
(WESTSIM DMS)

WESTSIM:
An application of IGSM2

Modeling Tool: IGSM2

- Regional water resources management and planning model that simulates surface water, soil moisture accounting in the root zone, flow in the vadose zone, groundwater flow, stream-groundwater interaction, and other components of the hydrologic system.
- Models groundwater flow as a quasi three-dimensional system and solves the governing flow equation using the Galerkin finite element method.
- Land use based approach of calculating water demand.
- Developed by the Modeling Support Branch of the Bay-Delta Office of DWR.

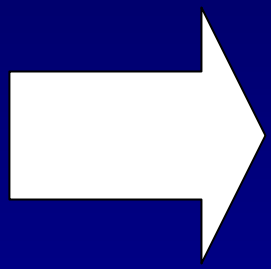
Brief History of the IGSM Code

- Originally developed in 1976 at UCLA by Dr. Young Yoon
- Many revisions and versions were used throughout California, including Central Valley IGSM (CVGSM)
- IGSM 5.0 was Peer Reviewed by CWEMF & UC Davis in 2001-2002.
- Using the results from the Peer Review, DWR, began developing the next generation model, IGSM2
- IGSM2 Version 1.0 was released in December 2002
- IGSM2 Version 2.0 was released December 16-19, 2003

Evolution of WESTSIM Model

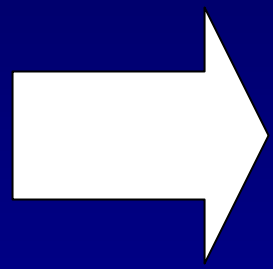
Pre - 2002

USBR developed Grid, Stratigraphy, and assembled Precip., Landuse, ET, Deliveries, Diversions, Urban Demand, Streamflow, Hydrogeologic Parameters,… for historical period of 1970-1993



2002

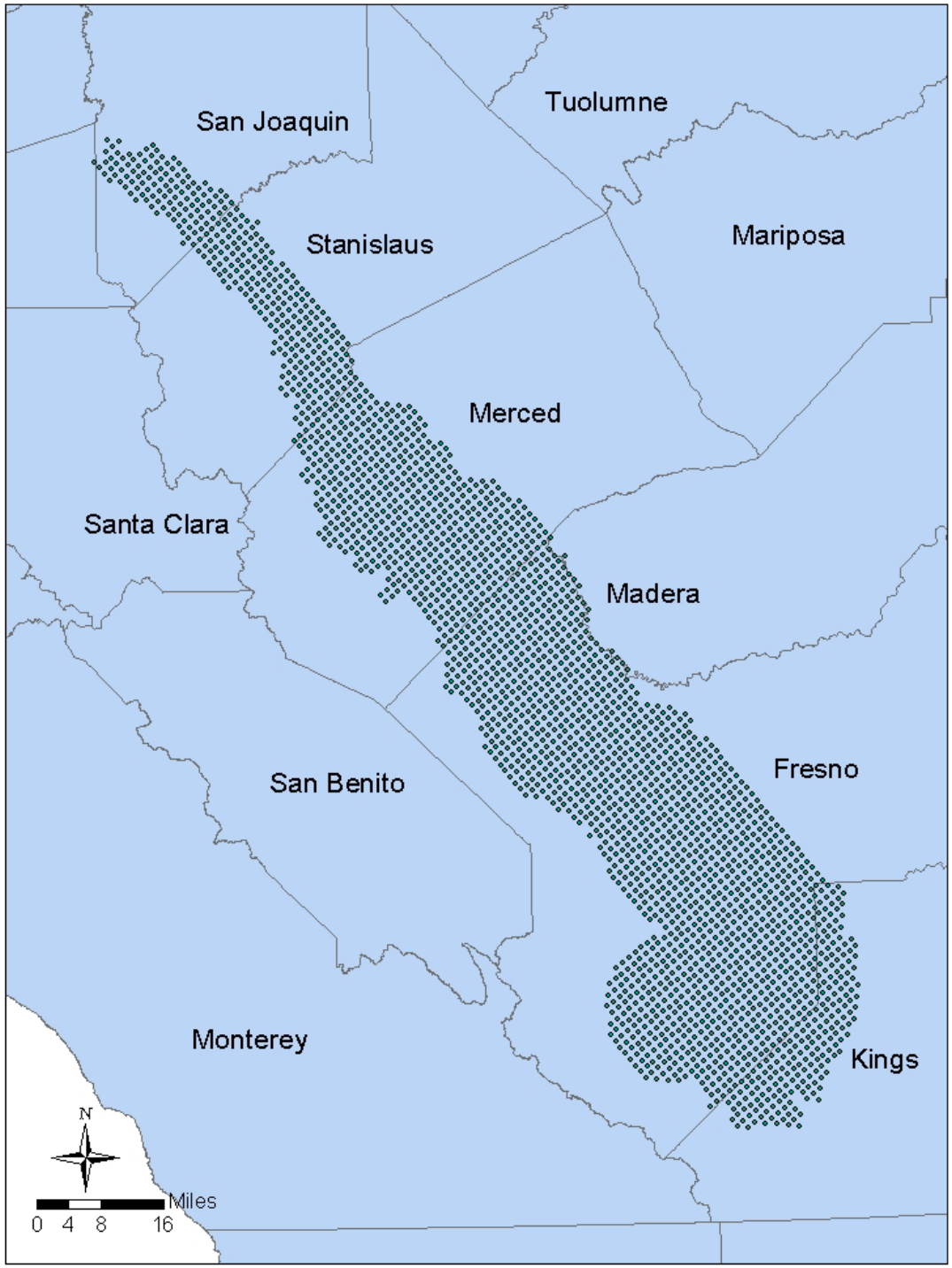
USBR and MWH formatted data to get model running with IGSM 5.0, improved input data, developed some Graphical tools, and completed a preliminary water balance calibration



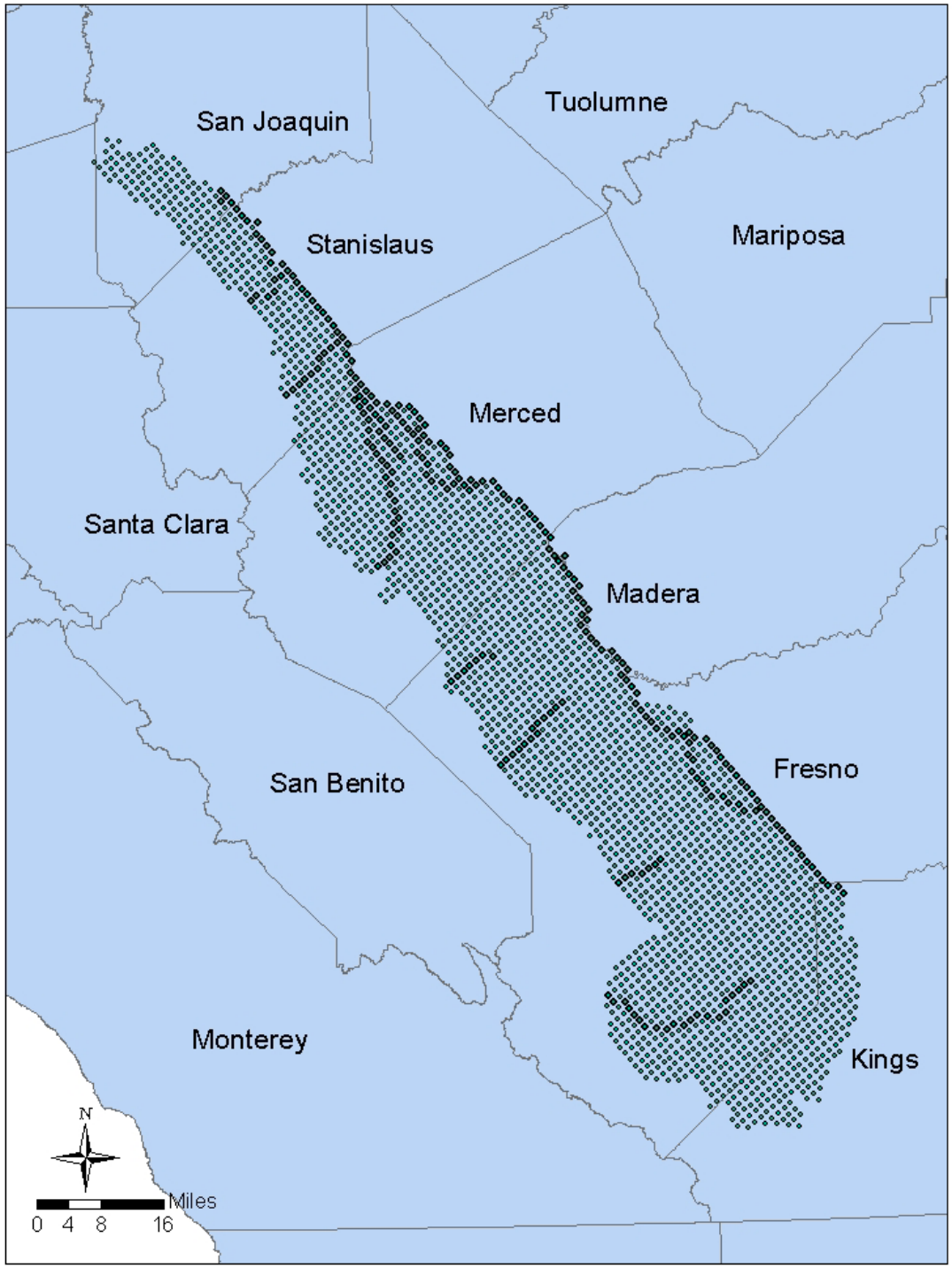
2003

USBR and MWH updated the historical period to 1970-2000, formatted the model to run IGSM2, developed WESTSIM DMS and Graphical User Interface, developed preliminary Zone Budget Outputs

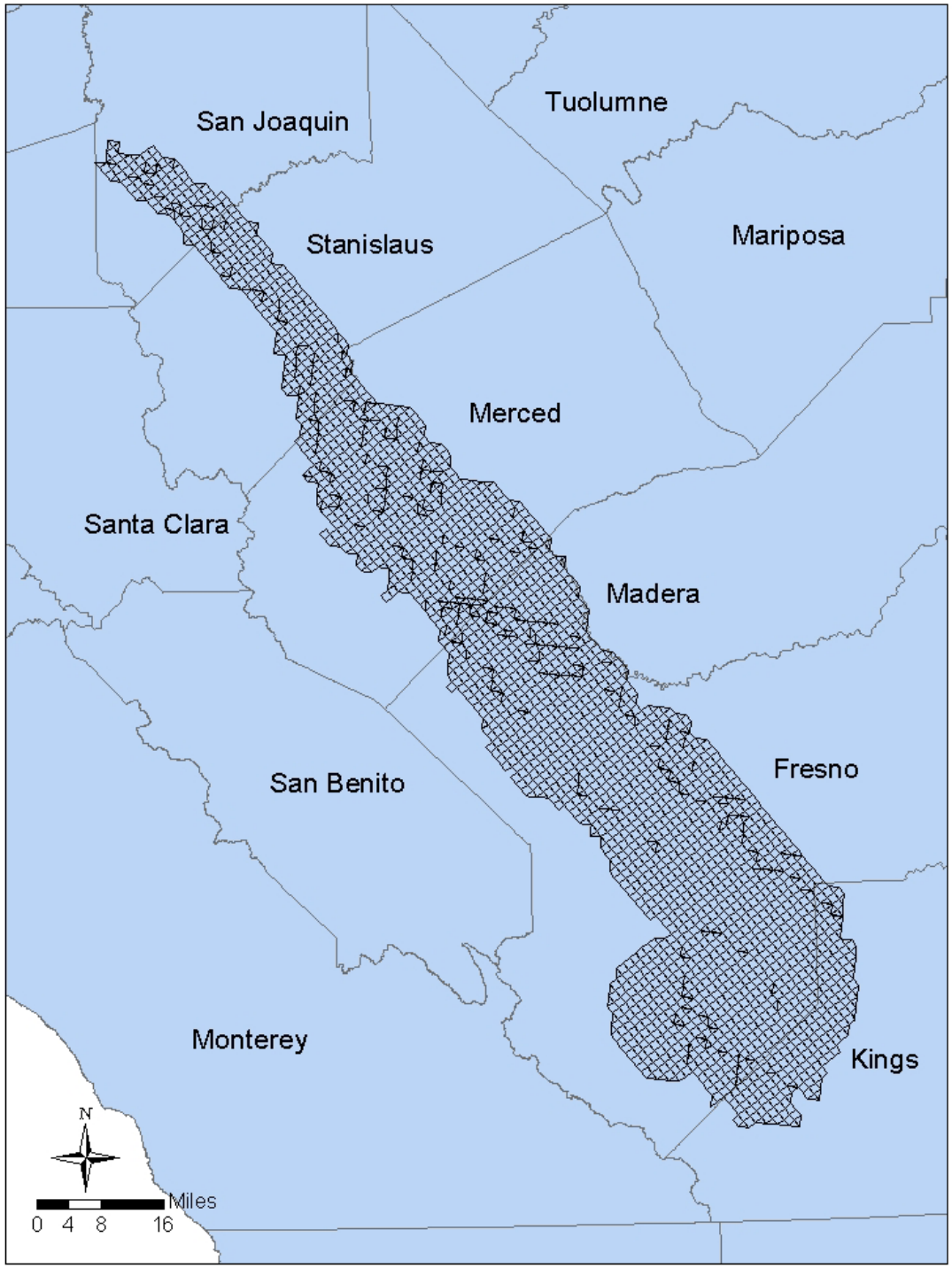
2,602 GW Nodes



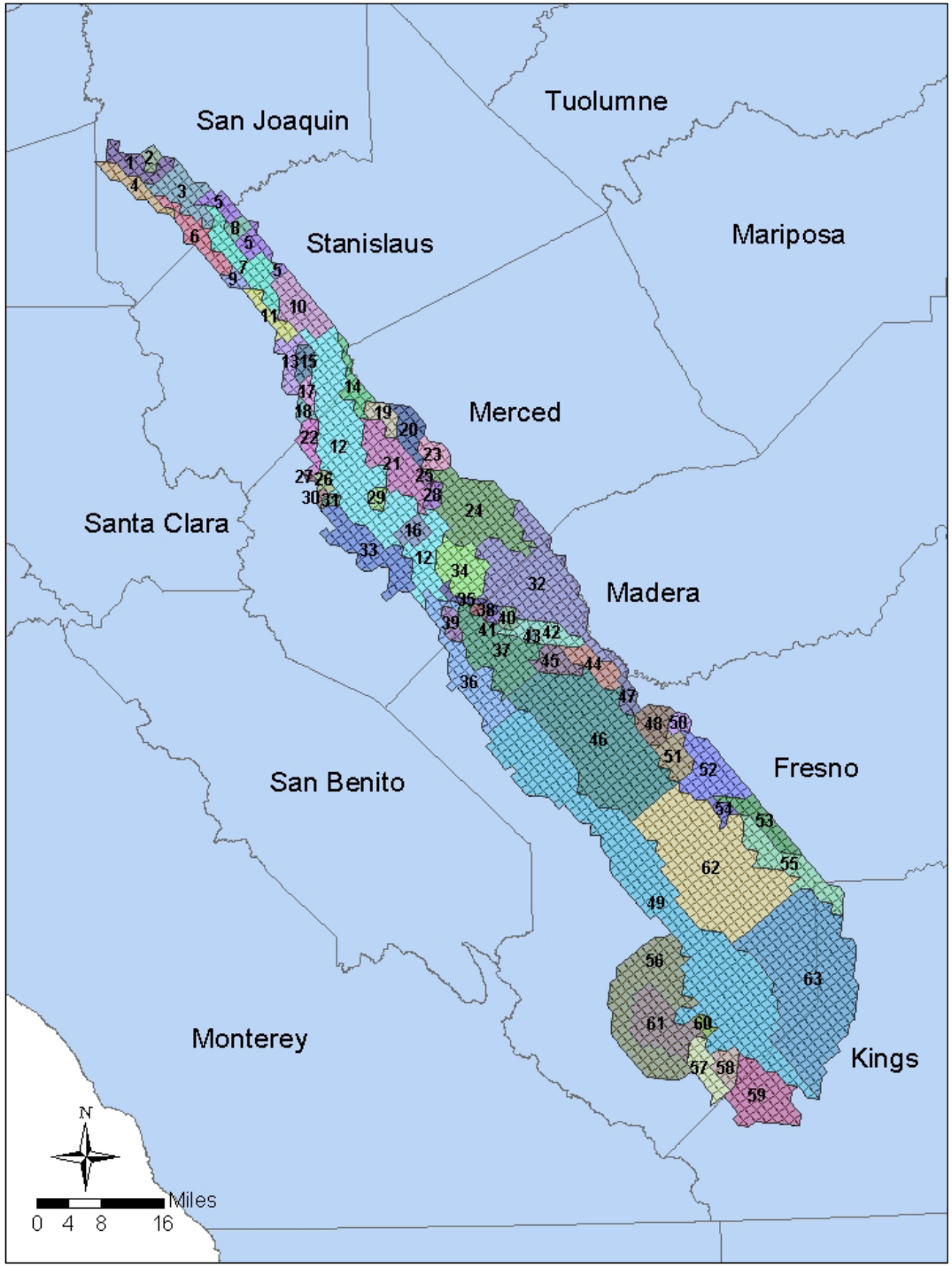
278 Stream Nodes



2,716 Elements



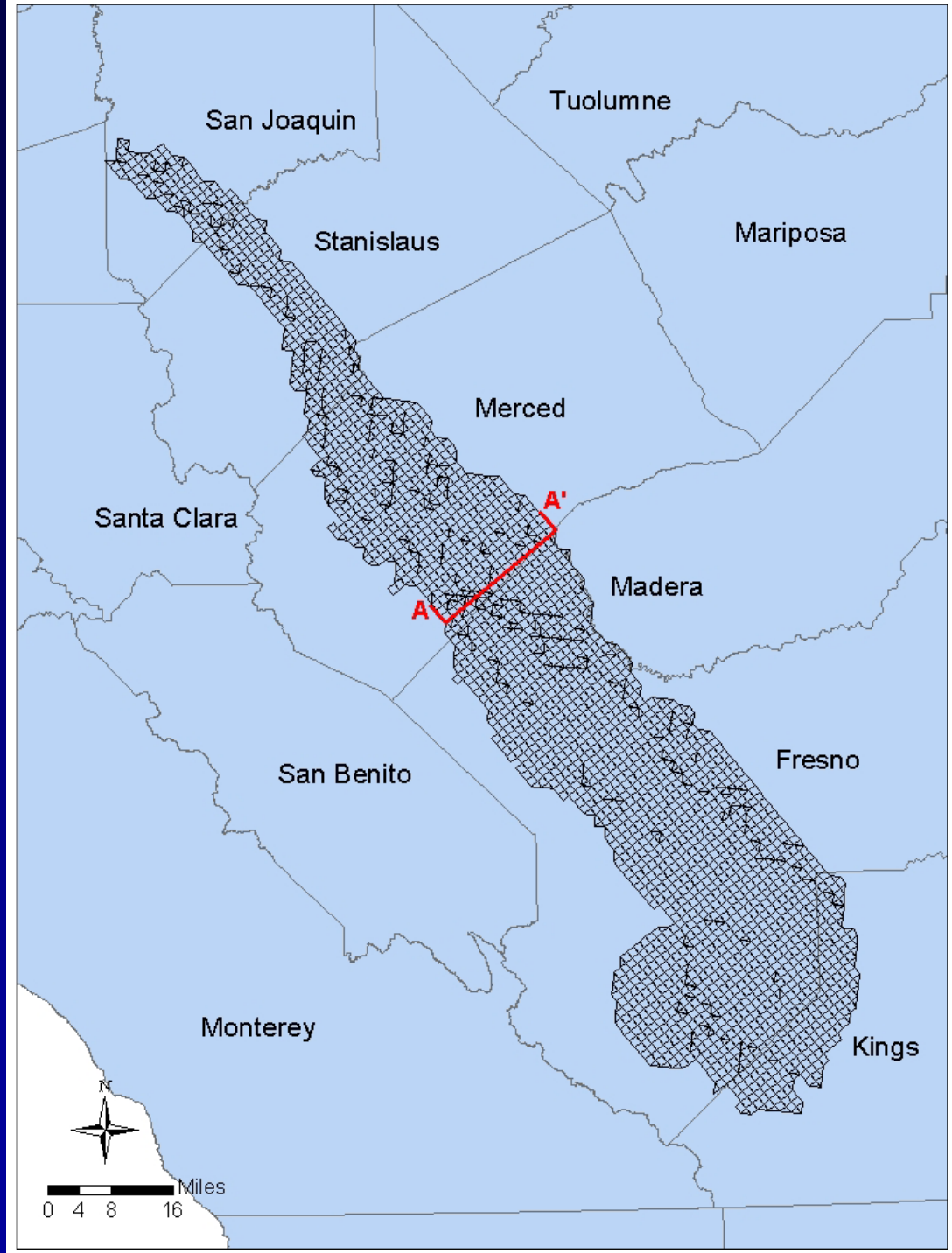
63 Subregions



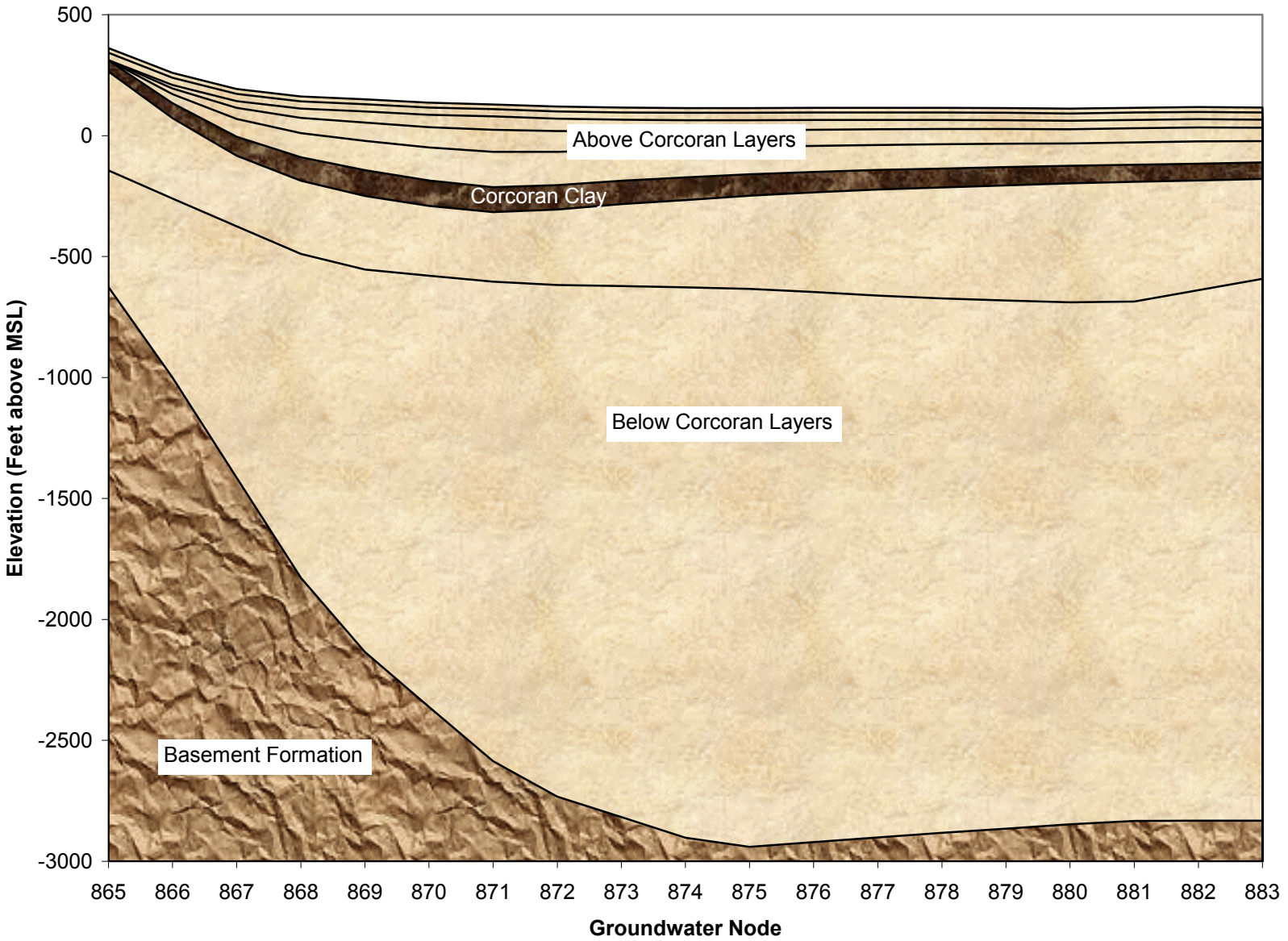
Subregion List

1 - Westside Water District	22 - Mustang Water District	43 - Widren Water District
2 - City of Tracy	23 - San Luis/Kesterson (South)	44 - Firebaugh Canal Co (South)
3 - Banta Carbona Irrigation District	24 - San Luis Canal Company	45 - Broadview Water District
4 - Plainview Water District	25 - Salt Slough	46 - Westlands Water District (Northeast)
5 - San Joaquin\Stanislaus Unincorporated	26 - Quinto Water District	47 - Mendota Water Management Agency
6 - Hospital Water District	27 - Lansdale Water District	48 - Fresno Slough Water District
7 - West Stanislaus Irrigation District	28 - Los Banos Water Management Agency	49 - Westlands Water District (West)
8 - El Solyo Water District	29 - Volta Water Management Agency	50 - Traction Ranch
9 - Kern Canyon Water District	30 - Centinella Water District	51 - Tranquility Irrigation District
10 - Patterson Water District	31 - Romero Water District	52 - James Irrigation District
11 - Del Puerto Water District	32 - Central California Irrigation District (South)	53 - Stinson Water District
12 - Central California Irrigation District (Central)	33 - San Luis Water District (DMC)	54 - Mid Valley Water Authority (North)
13 - Sunflower Water District	34 - Grasslands Water District (South)	55 - Mid Valley Water Authority (South)
14 - Stanislaus\Merced Unicorporated	35 - Eagle Field/CCID Contractors	56 - City of Coalinga (West)
15 - Orestimba Water District	36 - San Luis Water District (SLC)	57 - Pleasant Valley Water District (South)
16 - City of Los Banos	37 - Panoche Water District (DMC/SLC)	58 - Fresno County Unincorporated
17 - Foothill Water District	38 - Eagle Field Water District (South)	59 - City of Avenal
18 - Davis Water District	39 - Pacheco Water District	60 - City of Coalinga (East)
19 - San Luis/Kesterson (North)	40 - Mercy Springs Water District	61 - Pleasant Valley Water District (North)
20 - West Gallo	41 - Oro Loma Water District	62 - Westlands Water District (East)
21 - Grasslands Water District (North)	42 - Firebaugh Canal Co (North)	63 - Westlands Water District (Southeast)

Sample Cross-Section A-A’



Sample Cross-Section A-A’



WESTSIM Input Data Needs

- Hydrogeologic Data (CVGSM, Belitz/Phillips,…)
- Landuse/Cropping Data (DWR Surveys, USBR)
- Precipitation Data (NCDC)
- Evapotranspiration Data (CIMIS)
- Streamflow Data (USGS, DWR)
- Diversion Data (SJRIO2)
- Central Valley Project Deliveries (USBR)
- Crop Efficiencies (CVGSM, StanIGSM)
- Other...

Typical WESTSIM Output Data

- Water Budgets
  - Land and Water Use
  - Groundwater
  - Root Zone Moisture
  - Stream
- Groundwater Surface Elevations
- Stream Flows
- Tile Drain Flows
- Vertical and Horizontal Fluxes

Model Graphical User Interface of WESTSIM DMS

Zone Budgets

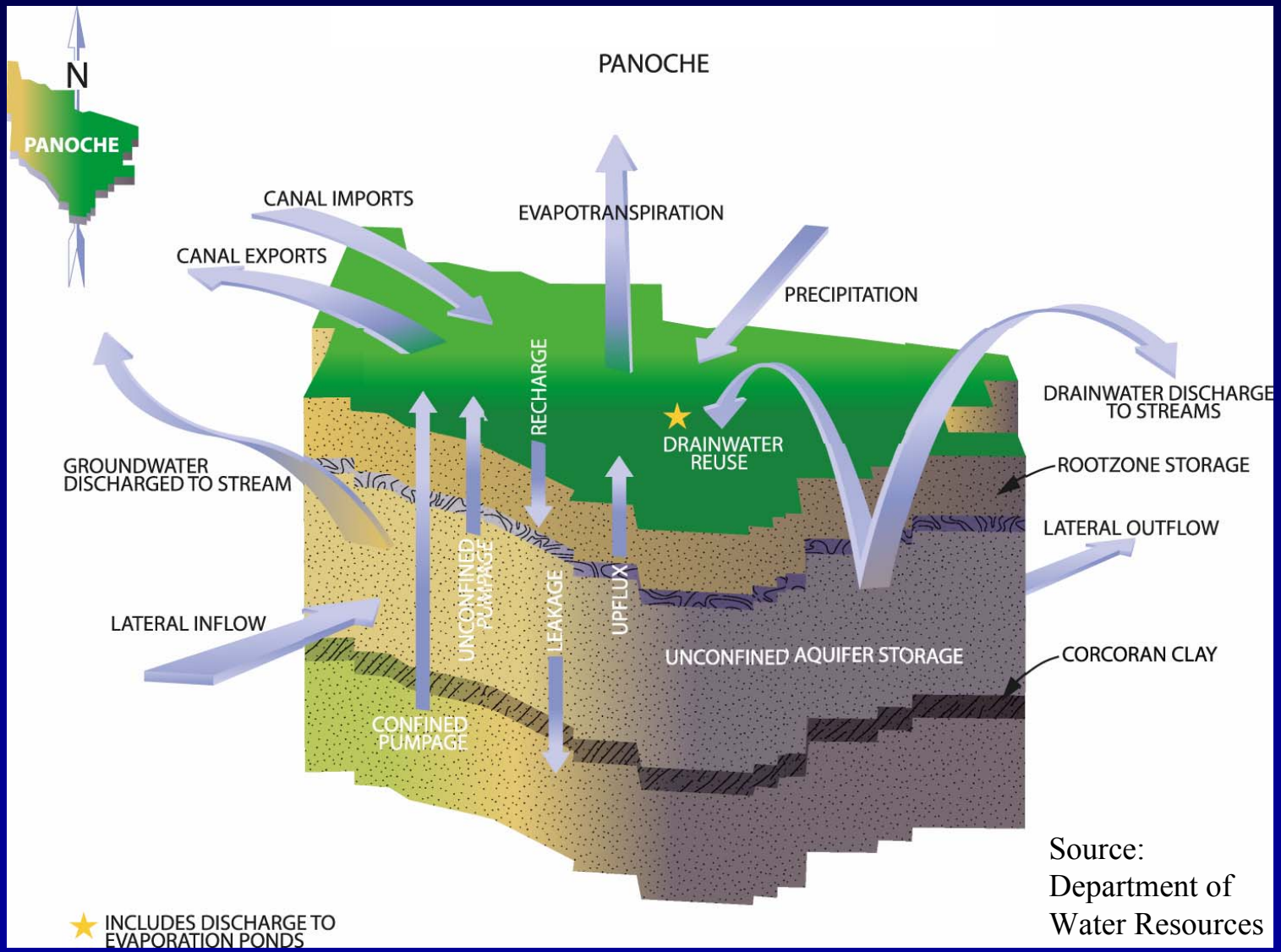
Zone Budgets

- Water Use and Groundwater Budgets in tabular and graphical format.
- Wanted to develop a water balance on a subregion basis to aid in calibration and to encourage interaction with water districts. *(Water Budgets are required for USBR Contract Renewal)*

Water Use Budget

- Demands:
  - Agricultural Demands
  - Urban Demands
- Supplies:
  - River Diversion
  - Groundwater Pumping
  - SW Imports

Groundwater Budget Schematic



Source: Department of Water Resources

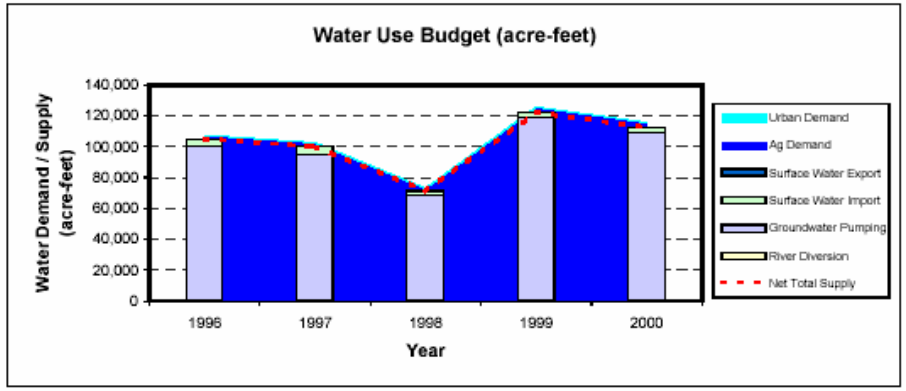
Groundwater Budget

(In - Out = Δ Storage)

- Inflows:
  - Deep Percolation
  - Stream Losses to GW
  - Horizontal Flows In
  - Artificial Recharge
- Outflows:
  - Tile Drainage
  - Groundwater Pumping
  - Stream Gains from GW
  - Horizontal Flows Out

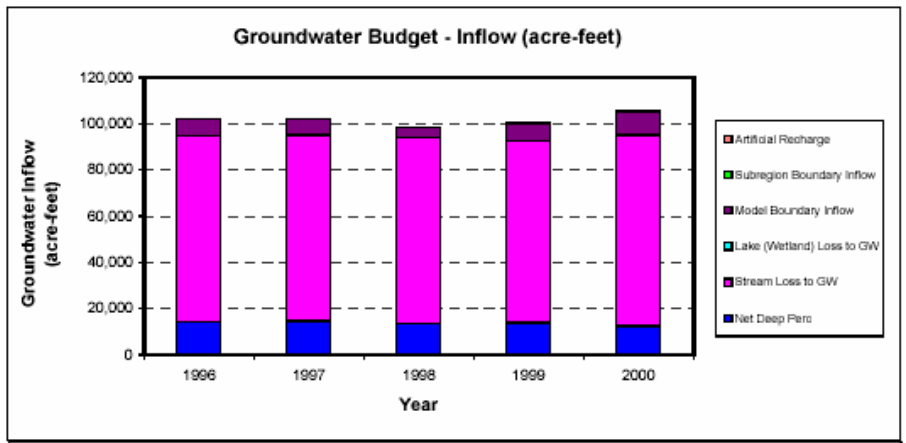
Water Use Budget (acre-feet)
Fresno Slough Water District

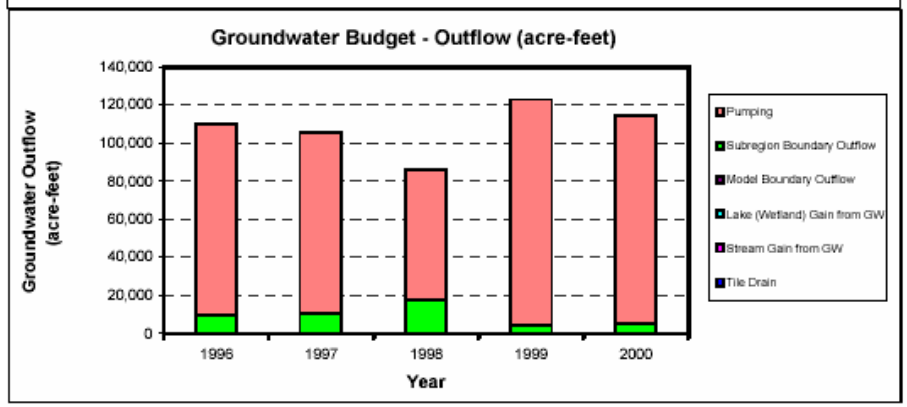
Water Use Budget	1996	1997	1998	1999	2000	5-Year Average
DEMAND						
Ag Demand	107,386	102,525	72,908	125,548	115,651	104,803
Urban Demand	0	0	0	0	0	0
Total Demand	107,386	102,525	72,908	125,548	115,651	104,803
SUPPLY						
River Diversion	0	0	0	0	0	0
Groundwater Pumping	100,170	94,736	68,496	118,719	109,157	98,255
Surface Water Import	4,781	5,292	2,663	3,552	3,258	3,909
Total Supply	104,951	100,028	71,159	122,270	112,415	102,165
Surface Water Export	0	0	0	0	0	0
Non-recoverable Loss						
Net Total Supply	104,951	100,028	71,159	122,270	112,415	102,165
Shortage (Surplus)	2,435	2,497	1,749	3,278	3,236	2,639



Groundwater Budget (acre-feet)
Fresno Slough Water District

Groundwater Budget	1996	1997	1998	1999	2000	5-Year Average
INFLOW						
Net Deep Perc	13,952	14,658	13,234	13,836	12,243	13,584
Stream Loss to GW	80,616	80,542	80,871	78,616	82,868	80,703
Lake (Wetland) Loss to GW	0	0	0	0	0	0
Model Boundary Inflow	7,537	7,130	4,185	7,809	10,278	7,388
Subregion Boundary Inflow	0	0	0	0	0	0
Artificial Recharge	0	0	0	0	0	0
Total Inflow	102,104	102,330	98,290	100,261	105,389	101,675
OUTFLOW						
Tile Drain	0	0	0	0	0	0
Pumping	100,170	94,736	68,496	118,719	109,157	98,255
Stream Gain from GW	0	0	0	0	0	0
Lake (Wetland) Gain from GW	0	0	0	0	0	0
Model Boundary Outflow	0	0	0	0	0	0
Subregion Boundary Outflow	9,434	10,537	17,555	4,222	5,404	9,431
Total Outflow	109,604	105,273	86,051	122,941	114,561	107,686
Change in Storage	-7,499	-2,943	12,239	-22,680	-9,172	-6,011
Change in Storage (AF/acre)	-0.65	-0.26	1.06	-1.97	-0.80	-0.52





DRAFT:
For Discussion Purposes Only

Future Work/Analyses

Future Work

- Final Calibration of Historical Model
  - Meet and present results to Water Districts, USBR,…
- "Baseline" and "What if ?" Analyses
  - Land Retirement
- Modeling Wetlands
- Water Quality (LBNL)
- Other...

Summary

- WESTSIM Model Overview
- WESTSIM DMS Demonstration
- WESTSIM (IGSM2) tool
- Zone Budget Examples
- Future Work

Acknowledgements

- Claire Jacquemin (USBR)
- Can Dogrul, Michael Moncrief, and Tariq Kadir (DWR)
- Ping Chen (MWH)